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OPERATIONS AND MAINTENANCE MANUAL
AIR SPARGE AND SOIL VAPOR EXTRACTION SYSTEM

CHS AUBURN SITE
238 8TH STREET SOUTHEAST
AUBURN, WASHINGTON

Submitted by:
Farallon Consulting, L.L.C.
975 5th Avenue Northwest
Issaquah, Washington 98027

Farallon PN: 301-004

For:
CHS Inc.
763 Willoughby Lane
Stevensville, Montana 59870

November 25, 2019

Prepared by:

Russell Luiten, P.E.
Project Engineer

Reviewed by:

Suzy Stumpf, P.E.
Senior Engineer

SUZANNE E. STUMPF
STATE OF WASHINGTON
49307
REGISTERED
PROFESSIONAL ENGINEER

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APPENDICES

1.0 INTRODUCTION

This operations and maintenance (O&M) manual has been prepared for the air sparge (AS) and soil vapor extraction (SVE) remediation system at the CHS Auburn facility at 238 8th Street Southeast in Auburn, Washington (herein referred to as the CHS Auburn Facility) and contiguous areas where concentrations of petroleum hydrocarbons and related compounds in soil or groundwater from releases at the CHS Auburn Facility exceed applicable cleanup levels (herein collectively referred to as the Site). This O&M manual constitutes the O&M plan as required in Table 3, *Cleanup Action Plan Schedule of Implementation* of the *Final Cleanup Action Plan, CHS Auburn Site, 238 8th Street Southeast and Contiguous Areas, Auburn, Washington* dated May 8, 2018, prepared by the Washington State Department of Ecology (Ecology), as Exhibit B of Consent Decree No. 18-2-15430-8 between Ecology and CHS Inc. with an effective date of June 20, 2018. The remediation system has been constructed as part of the selected cleanup action designed by Farallon Consulting, L.L.C. (Farallon) as described in the Cleanup Action Plan .The existing AS and SVE system was expanded to enhance the remediation of petroleum hydrocarbons present in soil and groundwater at the Site. The cleanup action includes air sparging to treat the groundwater plume area and SVE to recover volatile organic compounds (VOCs) generated by the AS system and to provide vapor mitigation along the building foundation.

The purpose of this O&M manual is to describe normal O&M procedures for the remediation system and to assist in troubleshooting problems that may arise during typical operation. This O&M manual presents the operation, as-built plan set, material components, inspection and safety protocols, and maintenance of the system.

2.0 PROJECT CONTACT INFORMATION

The contacts for this project are as follows.

Project Contacts:	Javan Ruark, L.G., Associate Geologist Farallon Consulting, L.L.C. Phone: (425) 295-0827 Email: jrurak@farallonconsulting.com
	Paul Grabau, L.G., L.H.G., Principal Geologist Farallon Consulting, L.L.C. Phone: (425) 295-0803 Email: pgrabau@farallonconsulting.com
Technical Contact:	Russell Luiten, P.E., Project Engineer Farallon Consulting, L.L.C. Phone: (425) 394-4147 Email: rluiten@farallonconsulting.com
Client Contact:	Jerry Eide CHS Inc. 763 Willoughby Lane Stevensville, Montana 59870 Phone: (406) 360-805 Email: jerry.eide@chsinc.com
Property Contact:	Mark Neville CHS Inc. 238 8th Street Southeast Auburn, Washington 98002 Phone: (253) 351-6855
Regulation Agency Contact:	Jerome Cruz Washington State Department of Ecology 3190 160th Southeast Bellevue, Washington 98008 Phone: (425) 649-7094 Email: jcru461@ecy.wa.gov

3.0 SYSTEM DESCRIPTION

The remediation system consists of two elements: air sparging combined with SVE. AS involves the injection of oxygen through the contaminated water-bearing zone. The injected oxygen removes volatile compounds from saturated soil by volatilizing the contaminants into the unsaturated zone for removal by SVE. Addition of oxygen to the subsurface also will promote biodegradation of dissolved-phase hydrocarbons in groundwater. The SVE system induces a vacuum, creating a pressure and concentration gradient in the subsurface to capture vapors from the unsaturated zone; and provides mitigation for the potential vapor intrusion pathway into the occupied buildings adjacent to the treatment area. A single compressor delivers air to the network of AS wells and a single blower applies a vacuum to the network of SVE wells. The compressor and blower equipment are located in the remediation building at 235 8th Street Southeast in Auburn, Washington.

Two AS/SVE systems are present on the Site. The Perimeter AS/SVE System currently is not operating and consists of a series of AS and SVE wells on the CHS Auburn Facility, south of 8th Street Southeast and west of C Street Southeast. The Central AS/SVE System consists of AS and SVE wells between 7th Street Southeast and 8th Street Southeast, on the parcels west-adjacent to Auburn Way South (Appendix A Sheet EN2.00). The modifications to the AS/SVE systems at the Site discussed herein only pertain to the Central AS/SVE System.

The Central AS System consists of 16 currently active AS wells, CAS-1 through CAS-5, CAS-7, CAS-12, and CAS-14 through CAS-22, that deliver oxygen across the impacted saturated soil zone. As part of the system modifications, AS wells CAS-14 through CAS-22 were installed (Appendix A Sheet EN2.00) in March 2019. The AS wells were constructed in accordance with the *Minimum Standards for Construction and Maintenance of Wells* as established in Chapter 173-160 of the Washington Administrative Code (WAC 173-160). The AS wells were constructed using 2-inch-diameter Schedule 40 polyvinyl chloride casing and 0.010-inch slotted screens. AS wells CAS 1 through CAS-5, CAS-7, CAS-12, and CAS-15 through 17 are screened from 45 to 50 feet below ground surface (bgs) and AS wells CAS-14 and CAS-18 through CAS-22 are screened from 38 to 44 feet bgs. A well schedule is provided in Sheet EN2.00 of Appendix A. Pressure is applied to each AS well by a compressor in the remediation building via buried 2-inch-diameter Schedule 40 polyvinyl chloride pipe or 0.75-inch cross-linked polyethylene pipe.

The Central SVE System consists of five currently active SVE wells, CSVE-1, CSVE-5, CSVE-7, CSVE-9, and CSVE-10, that extract soil vapors from unsaturated soil and collect vapors generated by the stripping of VOCs from saturated soil associated with the AS wells. As part of the system modification, SVE wells CSVE-9 and CSVE-10 were installed (Appendix A Sheet EN2.00) in March 2019. The SVE wells were constructed in accordance with the *Minimum Standards for Construction and Maintenance of Wells* as established in WAC 173-160. The SVE wells were constructed using 4-inch-diameter Schedule 40 polyvinyl chloride casing and 0.010-inch slotted screens. SVE wells CSVE-1, CSVE-5, and CSVE-7 are 2 inches in diameter and screened from 15 to 30 feet bgs, and SVE wells CSVE-9 and CSVE-10 are screened from 5 to 15 feet bgs. A well schedule is provided in Appendix A, Sheet EN2.00. A vacuum is applied to the

SVE wells, creating a pressure gradient in the subsurface to extract and recover volatile compounds that have desorbed from the soil. Vapors from each wellhead are drawn through a 2-inch-diameter polyvinyl chloride pipe to a common collection point at the remediation building. Extracted vapors pass through a moisture separator to remove free water and are then discharged to the atmosphere.

The Central AS/SVE System AS and SVE well locations and the underground piping locations are shown on the system as-built plans, which are provided in Appendix A and include the following:

- EN 0.00 – Title Sheet, Site Location Map, and Drawing Index;
- EN 0.10 – Legend, Symbols, and Abbreviations;
- 1 of 2 – Existing Conditions, Survey Notes;
- 2 of 2 – Existing Conditions, Survey;
- EN 2.00 – Site Plan;
- EN 3.00 – Details;
- EN 3.10 – Details; and
- EN 4.00 – Process and Instrumentation Diagram.

The construction of the expanded AS and SVE system is described in the following sections. The descriptions include a summary of the mechanical equipment, moisture separator, electrical components, and monitoring points.

3.1 REMEDIATION SYSTEM CONSTRUCTION

This section describes the equipment installed as part of the remediation system. The equipment specifications are provided in Appendix B.

3.1.1 Equipment

The following major components compose the system:

1. AS System Compressor
    - Busch Mink 1144BP rotary claw compressor;
    - 7.5-horsepower, 460-volt, three-phase motor;
    - 31.0 pounds per square inch (psi) maximum pressure, 57 standard cubic feet per minute (SCFM) open flow at 60 Hertz (Hz);
    - Full load amps of 11 amps; and
    - Inlet filter/silencer.
2. SVE System Blower
    - Rotron DR555K58 regenerative blower;

- 3.0-horsepower, 230-volt, three-phase motor;
- 115 inches of water-column psi max vacuum, 190 SCFM open flow at 60 Hz;
- Full load amps of 5.6 amps; and
- 8-inch Inlet and Outlet silencer, model no. 550888.

3. Moisture Separator
    - Ametek model MS350BD; and
    - 30-gallon storage capacity.
4. Remediation Building Ventilation
    - Thermostat Robertshaw 803A; and
    - Exhaust Fan Dayton 484X37, 115-volt, single-phase, 1/25-horsepower fan, 600 cubic feet per minute open flow.
5. Electrical
    - Teco Westinghouse F510-4008-C3-4, 460 VAC 3-Phase 8-horsepower variable speed drive system compressor control;
    - Teco Westinghouse F510-4005-C3-4, 460 VAC 3-Phase 5Hp variable speed drive system compressor control;
    - Temperature transmitter MAMAC Systems TE-205, building temperature sensor;
    - Temperature indicator Dwyer Instruments Love TS2-010, building temperature indicator and switch;
    - Control Panel HAND/OFF/AUTO blower enclosure fan and building exhaust fans controls;
    - Power available, high-water-level warning, high room temperature warning, power-loss warning lights;
    - ENM Electro-Mechanical Hour Meter T55B2A-115VAC, compressor and blower total hour meter; and
    - Sensaphone Sentinel Cellular Monitoring system.

Each component of the system is described in detail in the sections below.

3.1.2 Compressor

The system compressor provides pressurized airflow to AS wells. The compressor is a Busch Mink 1144BP three-phase, 7.5 horsepower, 460-volt rotary claw compressor. The compressor is capable of providing a maximum total pressure of 31 psi to the AS system. Operating pressure is anticipated to range from 8 to 15 psi. The compressor is interlocked with the SVE system to shut off the AS compressor if the SVE blower is off. The compressor manual and performance curve are provided in Appendix B.

3.1.3 Blower

The system blower provides vacuum to the SVE wells. The blower is a Rotron DR555K58 three-phase, 3.0 horsepower, 230-volt regenerative blower. The blower is capable of providing a maximum total vacuum of 115 inches of water column to the system. The operating vacuum is anticipated to range from 10 to 30 inches of water column. The blower manual and performance curve are provided in Appendix B.

3.1.4 Moisture Separator

The moisture separator separates entrained water from the air stream. As the water and air mixture flows into the moisture separator tank, water falls out and accumulates in the tank while the air passes through. A high-level shut-off float switch within the tank is interlocked with the SVE system blower to temporarily shut off when the tank is full. The moisture separator has a holding capacity of 30 gallons below the high-level shut-off float switch.

In the case of an alarm and blower shut-down condition, the monitoring system will notify pre-programed emails and phone numbers. The blower will require manual alarm reset after accumulated water is transferred to a holding drum. The moisture separator specifications are provided in Appendix B.

3.1.5 Remediation Building Ventilation

The remediation building ventilation system consists of two wall-mounted 10-inch wall exhaust fans with automatic closing shutters, an adjustable thermostat, and a louvered vent. The temperature in the remediation building will increase from operating motorized equipment. The fans will exchange air in the remediation building with ambient air, cooling the building. A full remediation building air exchange will happen every 2 to 3 minutes with both fans operating. A thermostat in the remediation building controls both exhaust fans, with an anticipated fan operating set point of 70 degrees Fahrenheit. Indoor air temperature is monitored and data-logged by the monitoring system. An adjustable temperature switch, set at 90 degrees Fahrenheit, will shut down the AS and SVE system if remediation building temperature exceeds the set point, and the monitoring system will notify the pre-programmed emails and phone numbers. Exhaust fan and thermostat specifications are provided in Appendix B.

3.1.6 Electrical and Controls

The remediation building is served by a three-phase, 460-volt, 200-amp, 60-Hz electrical service**.** The remediation system control panel is equipped with Variable Frequency Drive (VFD) system blower control, VFD system compressor control, Hand/Off/Auto blower enclosure fan control, Hand/Off/Auto building exhaust fan control, a high-water-level warning light, a power failure warning light, a high remediation building temperature warning light, blower and compressor total runtime meters, a remediation building temperature indicator, and a telemetry monitoring system. Control panel as-built drawings and component product data are provided in Appendix C.

3.1.7 Variable Frequency Drive

The VFDs are mounted on the control panel and allow for adjustments in blower and compressor speeds to manage system airflow rate, pressure, and vacuum. The VFD user manual is provided in Appendix C.

3.1.8 Telemetry System

The system includes a Sensaphone Sentinel Cellular Monitoring system for remote monitoring and alarm notification. The monitoring system is programmed to interpret the electrical signals from switches and transmitters for the AS and SVE systems. The list and locations of switches and transmitters are provided on the process and instrumentation diagram provided in Appendix A. When an alarm detects an alert condition, the monitoring system will notify preprogrammed contacts by text message or email. System operational parameters and alarm conditions can be viewed through the internet-based dashboard. System parameters and alarms are also data-logged through the same service. The monitoring system manual is provided in Appendix C.

4.0 START-UP AND SHUT-DOWN PROCEDURES

This section describes standard system start-up and shut-down procedures.

WARNING:

- **High Voltage** – This treatment system is powered by a 3-phase, 460 volt, 200-amp electrical service. Contact with live wires or electric components can lead to serious injury or death. Motor control and electric service panels should be opened ONLY by electricians or other personnel who possess the specific training and knowledge to service this equipment safely.
- **High Pressures** – The AS system operates under pressure. Caution should be exercised during maintenance operations to assure the AS system is shut off and the pressure has been bled from the system prior to performing maintenance.

4.1 START-UP PROCEDURE

The following procedure applies to start-up of the remediation system:

1. **Power On** – Check the control panel to ensure that the Main Power Disconnect Lever is in the "On" position. Push the System Power button to power the control cabinet.
2. **Check Warning Lights** – Ensure that the "Knockout Tank High Level Alarm," "Control Power Off or Previous Failure," "Blower/Compressor Room High Temp," "Compressor Drive Fault," and/or "Blower Drive Fault" lights are not illuminated. If the lights are illuminated, refer to Section 5, Routine Monitoring and Maintenance, for troubleshooting.
3. **Cooling Fans On** – Set the "Blower Enc Fan Control" and "Bldg Exh Fan Control" to Auto position. Check the building temperature display and setpoint. The AS and SVE system will not start if building temperature is above the setpoint. The building temperature should not exceed 90 degrees Fahrenheit if the system is operating.
4. **Power Drives** – Set the "Comp Drive Control" and "Blower Drive Control" to Auto position. This will provide power to the compressor and blower drives.
5. **Check Drives** – Ensure that there are no errors or alarms associated with the compressor and blower. This can be done by looking at the VFD screens on the control panel.
6. **Turn SVE System On** – Check the blower frequency setpoint on the VFD display and adjust the frequency to 30 Hz or the value specified by the Project Manager. Blower frequency can be adjusted by moving the indicator over the digit place and using the arrow keys to adjust the value. Once the value is selected, press the "Read/Enter" button on the VFD controller. Start the blower by pressing the green "Run" button. Adjust the blower frequency up to 60 Hz or value specified by the Project Manager. Decrease frequency if amperage is within 90 percent of the full load amps of 5.6 amps.

7. **Turn AS System On** – Check the compressor frequency setpoint on the VFD display, and adjust the frequency to 30 Hz or the value specified by the Project Manager. Compressor frequency can be adjusted by moving the indicator over the digit place and using the arrow keys to adjust the value. Once the value is selected, press the "Read/Enter" button on the VFD controller. Start the compressor by pressing the green "Run" button. Adjust the compressor frequency up to 60 Hz or value specified by the Project Manager. Decrease frequency if amperage is within 90 percent of the full load amps of 11 amps.
8. **System On** – Once the system is running, continue with O&M. Refer to Section 4, Start-Up and Shut-Down Procedures.

4.2 SHUT-DOWN PROCEDURE

The following procedure applies to normal system shut-down.

1. **Power Down the Compressor** – Press the red "Stop" button on the compressor VFD controller. Release pressure in AS conveyance piping and wells by slowly opening the air bleed valve on the AS manifold.
2. **Power Down the Blower** – Press the red "Stop" button on the blower VFD controller.
3. **Power Off** – If complete power shutoff is needed, push the red System Power "Off" button to power off the control panel and disengage the Main Power Disconnect Lever.
4. **Cooling Fans Off** – If the building or blower enclosure fans need to be shut off, turn the Hand/Off/Auto switch on the control panel to the Off position.

5.0 ROUTINE MONITORING AND MAINTENANCE

Routine monitoring tasks will be performed monthly. Access to the well network and remediation system components should be maintained to facilitate routine monitoring and maintenance. Farallon is scheduled to visit the Site monthly and preform the following monitoring and maintenance tasks:

1. Recording the following operating parameters upon arrival (field forms are provided in Appendix D):
    - Compressor frequency, amperage, and total run time;
    - Blower frequency, amperage, and total run time;
    - SVE system total vacuum and flow rate;
    - SVE exhaust temperature;
    - SVE well air flow, vacuum, and vapor VOC concentration by photoionization detector;
    - AS system pressure and temperature pre- and post-cooling array; and
    - AS well airflow and pressure.
2. Balancing system flows, vacuums, and pressures to meet the following parameters:
    - Operation of AS wells at a flow rate of approximately 3 to 4 SCFM or as specified by Project Manager; and
    - Operation of SVE wells at settings to be determined by the Project Manager.
3. Recording the following parameters following remediation system balancing:
    - System vacuum and pressure; and
    - Well airflow, vacuum, and pressure.
4. Performing the following system maintenance on the following schedule:

Item No.	Description	Frequency	Performed By	Remarks
1.	Knock-Out Drum	Monthly	Service Technician	Check water level in 55-gallon drum. Inspect drains for any plugs.
2.	SVE Blower Filter	Monthly	Service Technician	Inspect and clean filter as necessary.
3.	AS Compressor Filter	Monthly	Service Technician	Inspect and clean inlet air filter as necessary.
		Annual	Service Technician	Replace inlet air filter.

4.	AS Compressor Gear Oil	Quarterly	Service Technician	Shut down compressor and check gear oil in sight glass.
		20,000 hours	Service Technician	Change gear oil (Busch 5-550 oil).
5.	AS Compressor Cleaning	Semiannual	Service Technician	Inspect and clean housing, fan cowlings, fan wheels, ventilation grilles, and cooling fins.

Additional information on specific maintenance tasks is provided in the following sections.

5.1 SVE SYSTEM VACUUM AND FLOW

SVE system vacuum and flow values will be measured and recorded in accordance with the following procedures:

- **Measure Vacuum and Pressure Differential** – Install an averaging pitot tube in the monitoring port. Use a Dwyer digital manometer with the appropriate operating range to measure static vacuum and pressure differential.
- **Convert Pressure Differential to Flow** – Convert the pressure differential to flow rate and record.

5.2 SVE WELL VACUUM AND FLOW RATES

SVE well control gate valves will be adjusted as required to meet desired system operating parameters, and final operating vacuum and flow rates will be recorded.

5.3 AS SYSTEM PRESSURE AND TEMPERATURE

AS system pressure and temperature will be measure and recorded from pressure and temperature gauges. The temperature should not exceed 100 degrees Fahrenheit at the post-cooling array monitoring point.

5.4 AS WELL PRESSURE AND FLOW RATES

AS well pressure and flow values will be measured and recorded by the AS well pressure gauges and rotameter. Flow measurements for the rotameters are measured from the bottom of the indicators shoulder (widest point). AS well control gate valves will be adjusted as required to meet desired system operating parameters, and final operating pressure and flow rates will be recorded. The rotameter specifications and manual are provided in Appendix B.

5.5 SYSTEM AIR EMISSIONS MONITORING

In accordance with the *Performance Monitoring Plan, CHS Auburn Site, Auburn, Washington* dated February 15, 2019, prepared by Farallon, SVE system air emissions monitoring events will be conducted at start-up and on a quarterly basis for the first four quarters following the start-up of the AS/SVE system. Following the initial four quarters of monitoring, the sampling frequency will be semiannual until either the cleanup levels are achieved or for an additional 4 years, whichever comes first. The SVE system air emissions monitoring will include collecting effluent vapor (air) samples from the SVE system exhaust stack. The effluent vapor emission samples will be collected to establish a baseline for performance monitoring and to document concentrations of air petroleum hydrocarbons and benzene, toluene, ethylbenzene, and total xylenes (BTEX) emitted from the system. The effluent vapor samples will be collected from the SVE exhaust stack using a Tedlar bag or Summa canister and submitted for laboratory analysis for air petroleum hydrocarbons and BTEX by U.S. Environmental Protection Agency Method TO-15.

6.0 TROUBLESHOOTING PROCEDURES

This section provides detailed troubleshooting procedures to be followed in the event of an automatic shut-down of the remediation system for a high-water-level alarm, high remediation building temperature, and/or motor fault(s).

6.1 HIGH-WATER MOISTURE SEPARATOR SHUT-DOWN

A high-water float switch is located in the moisture separator tank to prevent damage to the blower. When the water level in the moisture separator tank reaches approximately half-full, a float switch will shut down the SVE blower and the AS compressor through the interlock, and trigger an alarm callout through the telemetry system.

Following a high-water-level shut-down, a manual restart is required using the following procedures:

1. Empty water collected in the moisture separator to a holding tank.
2. Press the “Alarm Reset” button on the control panel to reset the alarm. The high-water-level warning light should turn off.
3. If the warning light remains illuminated, repeat steps 1 and 2.
4. Turn the Hand/Off/Auto Switches for both the AS compressor and SVE blower to Off.
5. Restart the system using the standard start-up procedure described in Section 4, Start-Up and Shut-Down Procedures.

6.2 HIGH REMEDIATION BUILDING TEMPERATURE SHUT-DOWN

An adjustable temperature switch with transmitter located in the remediation building protects equipment from damage. If temperature in the remediation building exceeds the setpoint, the AS and SVE system will shut down and trigger an alarm callout through the telemetry system. Following a high remediation building temperature shut-down, a manual restart is required using the following procedures:

1. Press the “Alarm Reset” button on the control panel to reset the alarm. The high remediation building temperature warning light should turn off.
2. If the warning light remains illuminated, repeat step 1.
3. Restart the system using the standard start-up procedure described in Section 5, Start-Up and Shut-Down Procedures.

6.3 VARIABLE FEQUENCY DRIVE MOTOR DRIVE FAULT SHUT-DOWN

VFD motor fault can occur for several reasons, causing the blower and/or compressor to shut down. If a VFD motor fault occurs, an alarm condition is triggered resulting in an alarm callout through the telemetry system. Attempts to restart the system from a VFD fault will be made using the following procedures:

1. Press the “Reset” button on the VFD motor control interface.
2. Press the “Alarm Resent” button on the control panel to reset the alarm.
3. Start the system using the standard system start-up procedure described in Section 5, Start-Up and Shut-Down Procedures.
4. If the blower or compressor do not restart and run under normal operational conditions, contact the local technical representative.

7.0 SITE SAFETY

A Health and Safety Plan (HASP) has been developed for the Site, and will be maintained on the Site at all times. The HASP is provided in Appendix E. Any individual performing work at the Site should read and be familiar with the HASP. At a minimum, personal protective equipment, including earplugs, eye protection, and steel-toed boots, should be worn at all times when work is performed in the remediation building.

Directions to the nearest hospital and emergency contact numbers are included in the HASP. Workers should be familiar with the location of the nearest hospital prior to conducting field operations at the Site.

APPENDIX A
REMEDIATION SYSTEM AS-BUILT PLANS

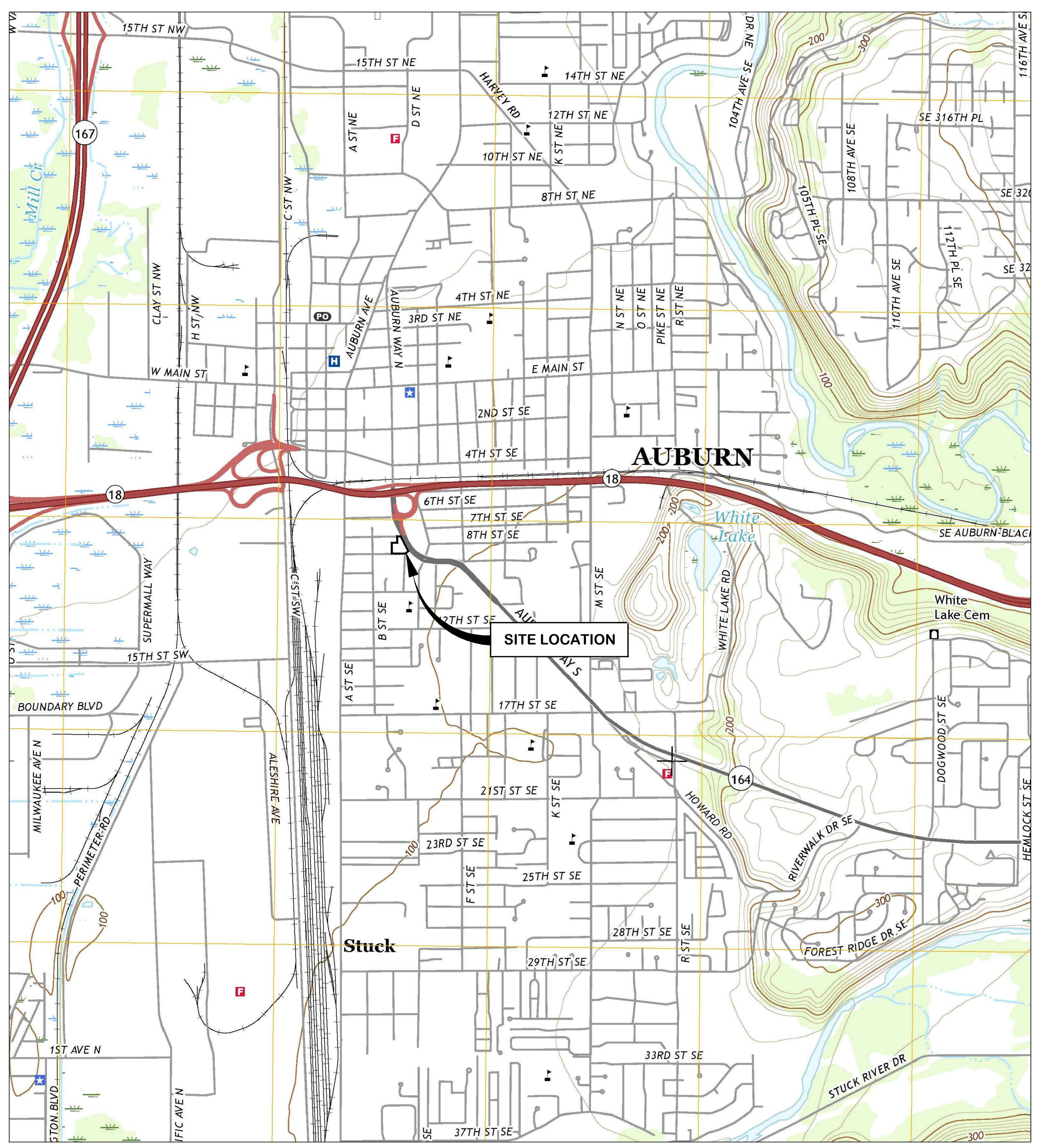
OPERATIONS AND MAINTENANCE MANUAL
AIR SPARGE AND SOIL VAPOR EXTRACTION SYSTEM
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

CHS AUBURN FACILITY
AIR SPARGE AND SOIL VAPOR EXTRACTION
SYSTEM DESIGN SET

238 8TH STREET SOUTHEAST
AUBURN, WASHINGTON

VICINITY MAP



REFERENCE: 7.5 MINUTE USGS QUADRANGLE AUBURN, WASHINGTON, DATED 2017

DIRECTORY

ENVIRONMENTAL CONSULTANT
FARALLON CONSULTING, LLC
975 5TH AVENUE NORTHWEST
ISSAQUAH, WASHINGTON 98027
PROJECT MANAGER: PAUL GRABAU, L.G., P.G.
T: (425) 295-0803
E: PGRABAU@FARALLONCONSULTING.COM

PROJECT ENGINEER
FARALLON CONSULTING, LLC
975 5TH AVENUE NORTHWEST
ISSAQUAH, WASHINGTON 98027
PROJECT ENGINEER: RUSSELL LUITEN, P.E.
T: (425) 394-4147
E: RLUITEN@FARALLONCONSULTING.COM

SURVEYOR
NORTH PEAK ASSOCIATES
18520 23RD DRIVE SOUTHEAST
KIRKLAND, WASHINGTON 98012
CONTACT: RICHARD VAN MOURIK
T: (206) 601-4682
E: RICHV@NORTHPEAKASSOCIATES.COM

OWNER
CHS, INC.
763 WILLOUGHBY LANE
STEVENSVILLE, MONTANA 59780
CONTACT: JERRY EIDE

CONTRACTOR
GLACIER ENVIRONMENTAL SERVICES. INC.
3415 121ST STREET SOUTHWEST
LYNNWOOD, WASHINGTON 98087
SUPERINTENDENT: ALAN HALL
T: (425) 355-2826
E: ALANH@GLACIERENVIRO.COM

DRAWING INDEX

ENVIRONMENTAL

RECORD DRAWING

THIS RECORD DRAWING HAS BEEN PREPARED BY FARALLON CONSULTING, LLC. INFORMATION PRESENTED HEREON IS BASED UPON A COMBINATION OF APPROVED DESIGN PLAN INFORMATION, CONTRACTOR FIELD DRAWINGS, AS-BUILT FIELD SURVEY, AND/OR OTHER RECORD INFORMATION PROVIDED BY OTHERS. NOT ALL INFORMATION HAS BEEN FIELD VERIFIED BY FARALLON CONSULTING, LLC. ANY USER OF THIS RECORD DRAWING IS ADVISED TO FIELD VERIFY ACTUAL FIELD LOCATIONS AND CONDITIONS.

DRAWINGS REVISED BY: LT
REVIEWED BY: ROL/SS
DATE: 06/26/2019

PROJECT REF: ______

THESE PLANS ARE APPROVED FOR CONFORMANCE WITH THE CITY OF AUBURN'S ENGINEERING REQUIREMENTS.

DEV. REVIEW ENGINEER: ______
APPROVED BY: ______
DATE APPROVED: ______

DATE	REVISION/DESCRIPTION	BY	CKD.	APP.
06.26.19	AS BUILTS	LT	SS	ROL
11.12.18	ISSUED FOR PERMIT REVIEW	ROL	SS	CPK

RUSSELL OLIN LUITEN
STATE OF WASHINGTON
54289
REGISTERED
PROFESSIONAL ENGINEER

PREPARED BY:
FARALLON CONSULTING
975 5TH AVENUE NORTHWEST
ISSAQUAH, WA 98027
(425) 295-0800
farallonconsulting.com

PREPARED FOR:
CHS, INC.
763 WILLOUGHBY LANE
STEVENSVILLE, MONTANA 59870

TITLE SHEET, SITE LOCATION MAP, AND DRAWING INDEX

CHS AUBURN SITE
AUBURN, WASHINGTON
APN: 0314160800, 3141600810, & 0835000035

811
Know what's below.
Call before you dig.

PROJECT LOCATION (S,T,R):
PORTIONS OF THE N W1/4 OF
SEC. 019 TWP. 021N, RNG. 05E, W.M.

JURISDICTION FILE NO.:

FARALLON PROJECT NO.:
301-004

SHEET
1 OF 8

EN0.00

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ELECTRICAL ABBREVIATIONS

A/AMP	AMP
AC	ALTERNATING CURRENT
BD	BUS DUCT
C	CURRENT
CB	CIRCUIT BREAKER
CLG	CEILING
DC	DIRECT CURRENT
DIS	DISCONNECT
DP	DOUBLE POLE
DT	DOUBLE THROW
EG	ENCLOSED AND GASKETED
E(OH)	ELECTRICAL (OVERHEAD)
E(UG)	ELECTRICAL (UNDERGROUND)
EMER	EMERGENCY
EPO	EMERGENCY POWER OFF
EMT	ELECTRICAL METALLIC TUBING
EXP	EXPOSED
FBO	FURNISHED BY OTHERS
FLEX	FLEXIBLE METAL CONDUIT
FRN	DUAL ELEMENT FUSE
GEN	GENERATOR
GFIC	GROUND FAULT INTERRUPTER
GND	GROUND
GRC	GALVANIZED RIGID CONDUIT
HOA	HAND–OFF–AUTO SWITCH
IRD	INFRARED DETECTOR
HP	HORSE POWER
HZ	CYCLES PER SECOND
JB	JUNCTION BOX
LFMC	LIQUID TIGHT FLEXIBLE METAL CONDUIT
M	MOTOR/MOTOR STARTER COIL
MCC	MOTOR CONTROL CENTER
MCP	MOTOR CIRCUIT PROTECTOR
NC	NORMALLY CLOSED
NEC	NATIONAL ELECTRIC CODE
NEMA	NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
NF	NON–FUSED
NO	NORMALLY OPEN
OL	OVERLOADS
PBS	PUSHBUTTON
PF	POWER FACTOR
PL	PILOT LIGHT
PLC	PROGRAMMABLE LOGIC CONTROLLER
RC	RIGID CONDUIT
RCPT	RECEPTACLE
SN	SOLID NEUTRAL
SP	SINGLE POLE
ST	SINGLE THROW
SW	SWITCH
TF/TRAN	TRANSFORMER
UF	UNDERFLOOR
UG	UNDERGROUND
V	VOLTS
VFD	VARIABLE FREQUENCY DRIVE
VP	VAPOR PROOF
WHT	WHITE
WP	WEATHER PROOF
XP	EXPLOSION PROOF

STANDARD SYMBOLS

01 / EN1.00 — DETAIL OR SECTION NUMBER/LETTER; DETAIL SHEET NUMBER

STANDARD ABBREVIATIONS

AF	AIR FILTER
AB	AGGREGATE BASE
AC	ASPHALTIC CONCRETE
APPROX	APPROXIMATELY
AF	AIR FILTER
AS	AIR SPARGE
BF	BLIND FLANGE
B.G.S.	BELOW GROUND SURFACE
BLDG	BUILDING
BOP	BOTTOM OF PIPE
BV	BALL VALVE
CAS	CENTRAL AREA AIR SPARGE
CONC	CONCRETE
CPLG	COUPLING
℄/CL	CENTERLINE
CSVE	CENTRAL AREA SOIL VAPOR EXTRACTION
CV	CONTROL VALVE/CHECK VALVE
DC	DOUBLE CONTAINED
ø/DIA	DIAMETER
DWG	DRAWING
DP	DUAL PHASE
DPI	DIFFERENTIAL PRESSURE INDICATOR
EF	EACH FACE
EL/ELEV	ELEVATION
ELEC	ELECTRICAL
ELB	ELBOW
EPDM	ETHYLENE PROPYLENE RUBBER
EXIST/(E)	EXISTING
EXP	EXPANSION
EW	EACH WAY
EA	EACH
FC	FAIL CLOSE
FO	FAIL OPEN
FLXC	FLEXIBLE CONNECTION
FM	FLOW METER
FL	FLOW LINE
FT	FOOT
FUT	FUTURE
FIN GR	FINISHED GRADE
FE	FLANGED END
FNPT	FEMALE NATIONAL PIPE THREAD
GA	GAUGE
GAC	GRANULAR ACTIVATED CARBON
GALV	GALVANIZED
GI	GALVANIZED IRON
GPM	GALLONS PER MINUTE
GR	GRADE
GND	GROUND
GSKT	GASKET
GW	GROUNDWATER
GV	GATE VALVE
HDPE	HIGH DENSITY POLYETHYLENE
HORIZ	HORIZONTAL
HP	HORSEPOWER/HIGH PRESSURE
HR	HOUR
HS	HOSE
HYD	HYDRANT
HOA	HAND OFF AUTOMATIC
ID	INSIDE DIAMETER
IN	INCHES
INV	INVERT
IPS	IRON PIPE SIZE
JT	JOINT
JB	JUNCTION BOX
KO	KNOCK OUT
LSHH	LEVEL SWITCH
M	MOTOR
MAX	MAXIMUM
MH	MANHOLE
MJ	MECHANICAL JOINT
MIN	MINUTE/MINIMUM
MISC	MISCELLANEOUS
MNPT	MALE NATIONAL PIPE THREAD
MP	METER PUMP
MON.PORT	MONITORING PORT
MW	MONITORING WELL
NC	NORMALLY CLOSED
NIC	NOT IN CONTRACT
NO	NORMALLY OPEN
NO.	NUMBER
N	NEW
NTS	NOT TO SCALE
NPDES	NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM
OC	ON CENTER
OD	OUTSIDE DIAMETER
OSHA	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
OVHD	OVERHEAD
#/LB	POUND
PB	PULL BOX
PBF	PROVIDED BY FARALLON
PC	PORTLAND CEMENT
PCC	PORTLAND CEMENT CONCRETE
PG	PRESSURE GAS
PL	PROPERTY LINE/PIPE LINE
PO	PUMP OUT
P	PRESSURE
PRV	PRESSURE RELEASE VALVE
PSI	POUNDS PER SQUARE INCH
PSIA	POUNDS PER SQUARE INCH, ABSOLUTE
PSIG	POUNDS PER SQUARE INCH, GAUGE
PTW	PRESSURE TREATMENT
PVC	POLYVINYL CHLORIDE
PV	PROCESS VARIABLE
PR	PAIR
PUE	PUBLIC UTILITY EASEMENT
R	RADIUS/RISER
RC	REINFORCED CONCRETE
REQ	REQUIRED
REF	REFERENCE
SCH	SCHEDULE
SDR	STANDARD DIMENSION RATIO
SECT	SECTION
SHT	SHEET
SPEC	SPECIFICATION
SQ	SQUARE
STA	STATION
STD	STANDARD
STL	STEEL
SBO	SUPPLIED BY OWNER
ST	SAMPLE TAP
STR	STRAINER
SS	STAINLESS STEEL
STL	STEEL
SVE	SOIL VAPOR EXTRACTION
SW	SWITCH
TYP	TYPICAL
TOC	TOP OF CASING/CURB
TOS	TOP OF STEEL
TOW	TOP OF WALL
UBC	UNIFORM BUILDING CODE
UGPS	UNDERGROUND PULL SECTION
UTIL	UTILITY
V	VALVE/VENT/VOLTS
VAC	VACUUM
VAR	VARIES/VARIABLE
VERT	VERTICAL
VP	VAPOR
VRV	VACUUM RELIEF VALVE
W/	WITH
W/O	WITHOUT
WS	WATER SURFACE/WATER STOP

LEGEND

GENERAL NOTES

1. READ ALL NOTES AND REVIEW ENTIRE PLAN SET PRIOR TO COMMENCEMENT OF WORK ACTIVITIES.
2. ESTABLISH EXACT PROJECT BOUNDARIES PRIOR TO COMMENCEMENT OF WORK, AND RECONFIRM BOUNDARY LINES WHEN COORDINATING WITH NEIGHBORING PROPERTY OWNERS.
3. VERIFY SITE CONTROL POINTS PROVIDED ON PLANS. VERIFY DIMENSIONS AND ORIENTATION PRIOR TO STAKING OF SITE POINTS.
4. A COPY OF THE PROJECT DESIGN DRAWINGS AND SPECIFICATIONS SHALL BE MAINTAINED ON THE JOB SITE AT ALL TIMES.
5. COPIES OF ALL PERMITS SHALL BE MAINTAINED ON THE JOB SITE AT ALL TIMES. THE CONTRACTOR SHALL COMPLY WITH ALL PERMIT REQUIREMENTS.
6. CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING ALL LOCATIONS, DIMENSIONS AND QUANTITIES.
7. UTILITIES SHOWN IN THIS DRAWING SET ARE BASED ON INFORMATION PROVIDED BY OTHERS. INFORMATION SHOWN SHALL BE CONSIDERED APPROXIMATE AND INCOMPLETE. CONTRACTOR SHALL VERIFY ALL UTILITY LOCATIONS PRIOR TO COMMENCEMENT OF WORK ACTIVITIES.
8. THE CONTRACTOR SHALL HAVE A PRIVATE UTILITY LOCATE SERVICE VERIFY ALL UTILITIES AND/OR OTHERWISE FIELD VERIFY EXACT LOCATIONS AND MARK THEIR LOCATIONS ON THE GROUND PRIOR TO STARTING CONSTRUCTION. FARALLON SHALL BE CONTACTED IMMEDIATELY IF A CONFLICT IS FOUND BETWEEN EXISTING UTILITIES AND THE PROJECT DESIGN.
9. ENGINEER SHALL BE NOTIFIED OF DISCREPANCIES BETWEEN CONTRACT DRAWINGS AND ACTUAL SITE CONDITIONS.
10. THE CONTRACTOR SHALL ASSUME RESPONSIBILITY FOR THE JOB SITE CONDITIONS AND ENSURE THE SAFETY OF ALL PERSONS AND PROPERTY FOR THE DURATION OF ON SITE PROJECT WORK. THE CONTRACTOR SHALL PROTECT STRUCTURES, UTILITIES, AND PAVING FROM DAMAGE, DIRECT OR INDIRECT, RESULTING FROM THE WORK. THIS REQUIREMENT SHALL APPLY CONTINUOUSLY OVER THE DURATION OF ON SITE ACTIVITIES AND NOT BE LIMITED TO NORMAL WORKING HOURS.
11. MAINTAIN FULL OPERATION OF PUBLIC ROADWAYS. KEEP CLEAN AND FREE OF DEBRIS, DIRT, AND OTHER PROJECT RELATED ITEMS. SWEEP AS NEEDED TO MEET PROJECT REQUIREMENTS. COORDINATE WITH OWNER AND PIERCE COUNTY ALL DISRUPTIONS TO SERVICES. REPAIR ALL DAMAGE TO MATCH EXISTING CONDITIONS.
12. GENERAL CONTRACTOR AND, IF SUBCONTRACTED, THE EARTHWORK SUBCONTRACTOR ARE RESPONSIBLE FOR ANY EARTHWORK QUANTITY ESTIMATES.
13. ONSITE SOILS MAY ONLY BE USED IN ACCORDANCE WITH PROJECT REQUIREMENTS AND SUBJECT TO APPROVAL OF PROPER COMPLIANCE BY THE PROJECT ENGINEER.
14. REVIEW AND PROPERLY COORDINATE ALL WORK OF ALL DISCIPLINES PRIOR TO CONSTRUCTION, INCLUDING, BUT NOT LIMITED TO, IRRIGATION LINES, SLEEVES, AND UTILITY CONDUITS.
15. ALL EXCAVATIONS SHALL BE PERFORMED IN STRICT ACCORDANCE WITH APPLICABLE U.S. DEPARTMENT OF LABOR OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) AND THE WASHINGTON INDUSTRIAL SAFETY AND HEALTH ACT (WISHA) REGULATIONS. THE CONTRACTOR ASSUMES FULL RESPONSIBILITY FOR THE SAFETY OF ALL CONSTRUCTION OPERATIONS.
16. NO TRENCHES SHALL BE LEFT OPEN WHEN WORK IS NOT IN PROGRESS. ALL OPEN EXCAVATIONS SHALL BE SECURELY FENCED AND COVERED IF SO REQUIRED.
17. THE CONTRACTOR SHALL DISPOSE OF MATERIALS REMOVED FROM THIS SITE AT APPROPRIATE AND PERMITTED RECEIVING FACILITIES.
18. CONFIRM ALL UTILITY ALIGNMENTS AND CROSSINGS PRIOR TO ORDERING MATERIALS AND PRIOR TO STAKING.
19. UPON COMPLETION OF SITE WORK, CLEAN ALL SITE SURFACES (PAVEMENTS, CURBS, STAIRS, WALKS, ETC.).

PIPING, ELECTRICAL AND EQUIPMENT SYMBOLS

GATE VALVE
GLOBE VALVE
BALL VALVE
BUTTERFLY VALVE
CHECK VALVE
DIAPHRAM OPERATED VALVE
S — SOLENOID VALVE
M — MOTOR OPERATED VALVE
PRESSURE REGULATING VALVE
D — DRAIN
WELD CAP
SCREWED CAP
SCREWED PLUG
FLANGE
BLIND FLANGE
REDUCER/INCREASER
DIRECTION OF FLOW
UNION
FLEXIBLE PIPE COUPLING
BLOWER OR FAN
CENTRIFUGAL PUMP
PITOT TUBE
STRAINER
TRAP
AF — FILTER
ø — DIAMETER

FEMALE ADAPTER
S — SILENCER
NEEDLE VALVE
FLOW METER
HOSE BIB
SAMPLE TAP/MONITORING PORT
HEAT EXCHANGER
PRESSURE RELIEF OR AIR RELIEF
VACUUM RELIEF
NO — NORMALLY OPEN
NC — NORMALLY CLOSED
CONDUIT RUN EXPOSED
CONDUIT RUN UNDERGROUND
EXIST CONDUIT RUN UNDERGROUND
MAGNETIC STARTER
DUPLEX RECEPTICAL, 15A; WP–WEATHER PROOF
ETM — ELAPSED TIME METER
FUSE
FUSED DISCONNECT
CAMLOCK CONNECTION
VERTICAL PIPERUN

GROUND
GROUND ROD (3/4" COPPER WELD)
HEATER STRIP
J — JUNCTION BOX, PB–PULLBOX
KWH — KILOWATT HOUR METER
M — MOTOR
MOTOR OVERLOAD
NON–FUSABLE DISCONNECT SWITCH
PILOT LIGHT, R=RED, W=WHITE, G=GREEN
SELECTOR SWITCH AO=AUTO OFF, HOA=HAND OFF AUTO
S — SWITCH, 120–277V, 2–2POLE, 20A
T — THERMOSTAT
TD — TIME DELAY RELAY, CR=CONTROL RELAY
TRANSFORMER
UNDERGROUND PULLBOX
W.P. — WEATHER PROTECTED
120/208V PANEL
277/480V PANEL
*HIGH LIGHT STANDARD
REVISION TO PLANS

INSTRUMENTATION ABBREVIATIONS AND SYMBOLS

INSTRUMENT LEGEND

	FIRST LETTER INITIATING VARIABLE	SUCCEEDING LETTERS OUTPUT FUNCTIONS
A	ANALYSIS	ALARM
B	BURNER	
C	CONDUCTIVITY	CONTROL
D	DENSITY	DIFFERENTIAL
E	POTENTIAL (VOLTS)	PRIMARY ELEMENT
F	FLOW RATE	RATIO (FRACTION)
G	FIRE ALARM	GLASS (SIGHT GAUGE)
H	HAND (MANUALLY)	HIGH
I	CURRENT (AMPERES)	INDICATE
J	POWER	
K	TIME	
L	LEVEL	LEAK, LOW
M	MOISTURE/HUMIDITY	LIGHT (PILOT)
N	EQUIPMENT STATUS	
P	PRESSURE/VACUUM	POINT (TEST CONNECTION)
Q	QUANTITY	INTEGRATE (TOTALIZE)
R		RECORD/PRINT
S	SPEED	SWITCH
T	TEMPERATURE	TRANSMIT
U	MULTIVARIABLE	MULTIFUNCTION
V	VIBRATION/VOLUME	VALVE/DAMPER
W	WEIGHT/FORCE/TORQUE	
X	UNCLASSIFIED	UNCLASSIFIED
Y		RELAY/COMPUTE
Z	POSITION	DRIVE/ACTUATE

INSTRUMENT SYMBOLS

SYMBOL	DESCRIPTION
M	MOTOR
HOA	HAND–OFF–AUTO SELECTOR SWITCH
	LOCALLY MOUNTED INSTRUMENT
	CONTROL PANEL MOUNTED INSTRUMENT
I	INTERLOCK
–10	PLC SHUTDOWN ALARM

RECORD DRAWING

THIS RECORD DRAWING HAS BEEN PREPARED BY FARALLON CONSULTING, LLC. INFORMATION PRESENTED HEREON IS BASED UPON A COMBINATION OF APPROVED DESIGN PLAN INFORMATION, CONTRACTOR FIELD DRAWINGS, AS–BUILT FIELD SURVEY, AND/OR OTHER RECORD INFORMATION PROVIDED BY OTHERS. NOT ALL INFORMATION HAS BEEN FIELD VERIFIED BY FARALLON CONSULTING, LLC. ANY USER OF THIS RECORD DRAWING IS ADVISED TO FIELD VERIFY ACTUAL FIELD LOCATIONS AND CONDITIONS.

DRAWINGS REVISED BY: LT
REVIEWED BY: ROL/SS
DATE: 06/26/2019

PROJECT REF: ____

THESE PLANS ARE APPROVED FOR CONFORMANCE WITH THE CITY OF AUBURN'S ENGINEERING REQUIREMENTS.

DEV. REVIEW ENGINEER: ____
APPROVED BY: ____
DATE APPROVED: ____

DATE	REVISION/DESCRIPTION	BY	CKD.	APP.
11.12.18	ISSUED FOR PERMIT REVIEW	ROL	SS	CPK
06.26.19	AS BUILTS	LT	SS	ROL

RUSSELL OLIN L... STATE OF WASHINGTON 54289 REGISTERED PROFESSIONAL ENGINEER

PREPARED BY: FARALLON CONSULTING
975 5TH AVENUE NORTHWEST
ISSAQUAH, WA 98027
(425) 295-0800
farallonconsulting.com

PREPARED FOR:
CHS, INC.
763 WILLOUGHBY LANE
STEVENSVILLE, MONTANA 59870

PROCESS AND INSTRUMENTATION DIAGRAM

CHS AUBURN SITE
AUBURN, WASHINGTON

APN: 0314160800, 3141600810, & 0835000035

811 Know what's below. Call before you dig.

PROJECT LOCATION (S,T,R):
PORTIONS OF THE N W1/4 OF SEC. 019 TWP. 021N, RNG. 05E, W.M.

JURISDICTION FILE NO.:

FARALLON PROJECT NO.:
301-004

SHEET
2 OF 8

EN0.10

SW 1/4 OF THE SW 1/4, SEC. 18 & NW 1/4 OF THE NW 1/4 SEC. 19, TWP. 21 N., RGE. 5 E., W.M.

SITE NOTES

ADDRESS:
707 & 709 AUBURN WAY SOUTH
AUBURN, WA 98002

PARCEL NOS.:
083500–0035, 314160–0810 AND 314160–0800.

ZONING AGENCY:
CITY OF AUBURN
25 W MAIN STREET
AUBURN, WA 98001
(253) 931–3000

ZONING:
C3 HEAVY COMMERCIAL DISTRICT

FLOOD ZONE:
THIS SITE APPEARS ON NATIONAL FLOOD INSURANCE RATE MAP, DATED MAY 16, 1995, COMMUNITY PANEL NO. 53033C1261F, AND IS SITUATED IN ZONE "X", AREA DETERMINED TO BE OUTSIDE OF THE 500–YEAR FLOODPLAIN.

HORIZONTAL DATUM:
CITY OF AUBURN – NAD 83/91

BASIS OF BEARINGS:
N89°54'37"W BETWEEN THE NORTHWEST CORNER AND THE NORTH QUARTER CORNER OF SECTION 19–21N–5E.

VERTICAL DATUM:
NAVD88

VERTICAL BENCHMARK:
CITY OF AUBURN BENCHMARK: 809–004
4"X4" CONCRETE MONUMENT IN ALLEY BETWEEN 7TH AND 8TH STREET SE
ELEVATION = 93.40'

AREA:
PARCEL A:
SITE AREA AS SHOWN CONTAINS 9,111 SQUARE FEET OR 0.2092 ACRES, MORE OR LESS.

PARCEL B:
SITE AREA AS SHOWN CONTAINS 13,201 SQUARE FEET OR 0.3031 ACRES, MORE OR LESS.

PARCEL C:
SITE AREA AS SHOWN CONTAINS 5,998 SQUARE FEET OR 0.1377 ACRES, MORE OR LESS.

TOTAL:
SITE AREA AS SHOWN CONTAINS 28,310 SQUARE FEET OR 0.6500
ACRES, MORE OR LESS.

SUBSTRUCTURES:
BURIED UTILITIES ARE SHOWN AS INDICATED ON RECORDS MAPS FURNISHED BY OTHERS AND VERIFIED WHERE POSSIBLE BY FEATURES LOCATED IN THE FIELD. WE ASSUME NO LIABILITY FOR THE ACCURACY OF THOSE RECORDS. FOR THE FINAL LOCATION OF EXISTING UTILITIES CRITICAL TO DESIGN, CONTACT THE UTILITY OWNER/AGENCY.

TELECOMMUNICATIONS/FIBER OPTIC DISCLAIMER:
RECORDS OF UNDERGROUND TELECOMMUNICATIONS AND/OR FIBER LINES ARE NOT ALWAYS AVAILABLE TO THE PUBLIC. NORTH PEAK ASSOCIATES LLC HAS NOT CONTACTED EACH OF THE MANY COMPANIES IN THE COURSE OF THIS SURVEY WHICH MAY HAVE UNDERGROUND LINES WITHIN THE ADJACENT RIGHTS–OF WAY. NORTH PEAK ASSOCIATES LLC, DOES NOT ACCEPT RESPONSIBILITY FOR THE EXISTENCE OF UNDERGROUND TELECOMMUNICATIONS/FIBER OPTIC LINES WHICH ARE NOT MADE PUBLIC RECORD WITH THE LOCAL JURISDICTION.

LEGAL DESCRIPTION:

PARCEL A:

LOT 1, BLOCK 2, BITZER'S ADDITION TO THE CITY OF AUBURN, ACCORDING TO THE PLAT THEREOF, RECORDED IN VOLUME 45 OF PLATS, PAGE 10, IN KING COUNTY, WASHINGTON;
TOGETHER WITH A PORTION DESCRIBED AS FOLLOWS:

BEGINNING AT THE INTERSECTION OF THE CENTER LINE OF "C" STREET SOUTHEAST IN THE CITY OF AUBURN (STATE ROAD NO. 5) AND THE SOUTH LINE OF SECTION 18, TOWNSHIP 21 NORTH, RANGE 5 EAST, WILLAMETTE MERIDIAN, SAID LINE BEING THE NORTH LINE OF THE ALLEY LYING BETWEEN 7TH AND 8TH STREET SOUTHEAST;
THENCE SOUTH 89°23'19" WEST 55.86 FEET ALONG SAID SECTION LINE TO THE WESTERLY LINE OF "C" STREET SOUTHEAST AND THE TRUE POINT OF BEGINNING;
THENCE CONTINUING SOUTH 89°23'19" WEST 62.20 FEET;
THENCE NORTH 00°3641" WEST 124.80 FEET TO THE WESTERLY BOUNDARY OF "C" STREET SOUTHEAST;
THENCE SOUTH 27°06'11" EAST 139.44 FEET ALONG THE WESTERLY BOUNDARY OF "C" STREET SOUTHEAST TO THE TRUE POINT OF BEGINNING;
EXCEPT THAT PORTION LYING WITHIN RIGHT OF WAY FOR 7TH STREET SOUTHEAST.

PARCEL B:

LOTS 13, 14 AND 15 IN BLOCK 8 OF HARTS FIRST ADDITION TO THE TOWN OF AUBURN, AS PER PLAT RECORDED IN VOLUME 29 OF PLATS, PAGE 23, RECORDS OF KING COUNTY.

TOGETHER WITH PORTION OF "C" STREET S.E. ADJOINING, AS VACATED UNDER CITY OF AUBURN ORDINANCE NO. 2600 AND ORDINANCE NO. 2658 UNDER RECORDING NOS. 7301120386 AND 7301120392 WHICH, UPON VACATION, ATTACHES TO SAID PROPERTY BY OPERATION OF LAW;

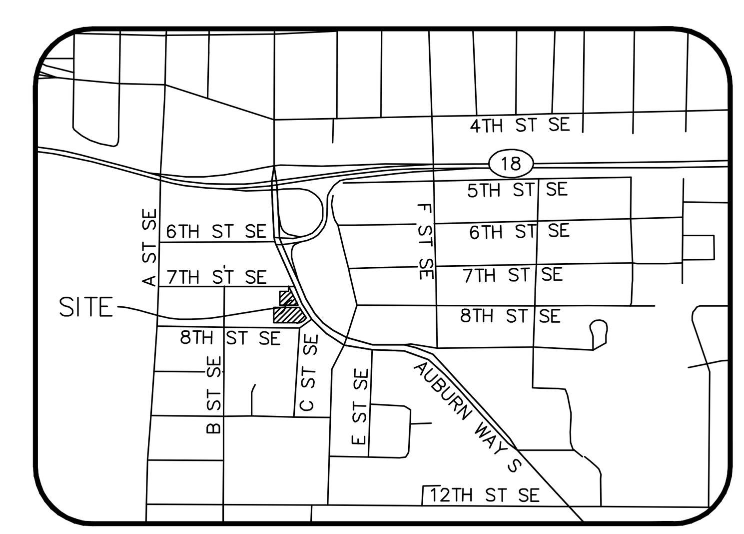
SITUATE IN CITY OF AUBURN, COUNTY OF KING, STATE OF WASHINGTON.

PARCEL C:

LOTS 11 AND 12 IN BLOCK 8 OF HARTS FIRST ADDITION TO THE TOWN OF AUBURN, AS PER PLAT RECORDED IN VOLUME 29 OF PLATS, PAGE 23, RECORDS OF KING COUNTY.

REFERENCES:
1. SR 164 CONSTRUCTION MONUMENT EXHIBIT MAP, ON FILE UNDER DRAWER 500, SEQUENCE 54, WASHINGTON STATE DEPARTMENT OF TRANSPORTATION.
2. RECORD OF SURVEY PERFORMED WARREN T. LAY, P.L.S., RECORDED UNDER KING COUNTY RECORDING NO. 8912139005.

GENERAL NOTES:
1. PRECISION OF CONTROL TRAVERSE IS AT HIGHER LEVEL THAN MINIMUM STANDARDS REQUIRED BY WAC 332–130–090.
2. FIELD SURVEY CONDUCTED USING A COMBINATION OF GPS USING THE WASHINGTON STATE REFERENCE NETWORK (WSRN) AND/OR A 5 SECOND DIRECT READING TOTAL STATION. METHOD: GPS, TRAVERSE AND RADIAL SURVEY.
3. THIS SURVEY WAS PERFORMED WITHOUT THE BENEFIT OF A TITLE REPORT AND DOES NOT PURPORT TO SHOW ALL ENCUMBRANCES OR EASEMENTS THAT MAY BURDEN THE SUBJECT PROPERTY.
4. ALL DISTANCES ARE IN FEET.
5. THIS SURVEY REPRESENTS VISIBLE PHYSICAL IMPROVEMENT CONDITIONS EXISTING ON SEPTEMBER 24, 2018. ALL SURVEY CONTROL INDICATED AS "FOUND" WAS RECOVERED FOR THIS PROJECT IN SEPTEMBER OF 2018.



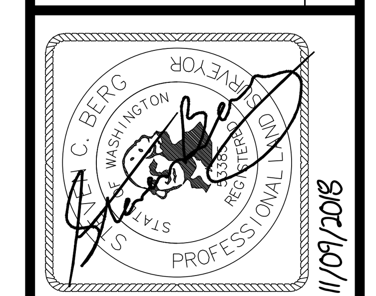
VICINITY MAP
NOT TO SCALE

No.	Revisions	Date	By

Date 11/09/18
Scale N/A
Drawn SB
Designed
Checked RvM

NORTH PEAK ASSOCIATES LLC
PROFESSIONAL LAND SURVEYORS
10512 NE 140TH STREET
KIRKLAND, WA 98034
Phone (206) 601-4682

File path & Name

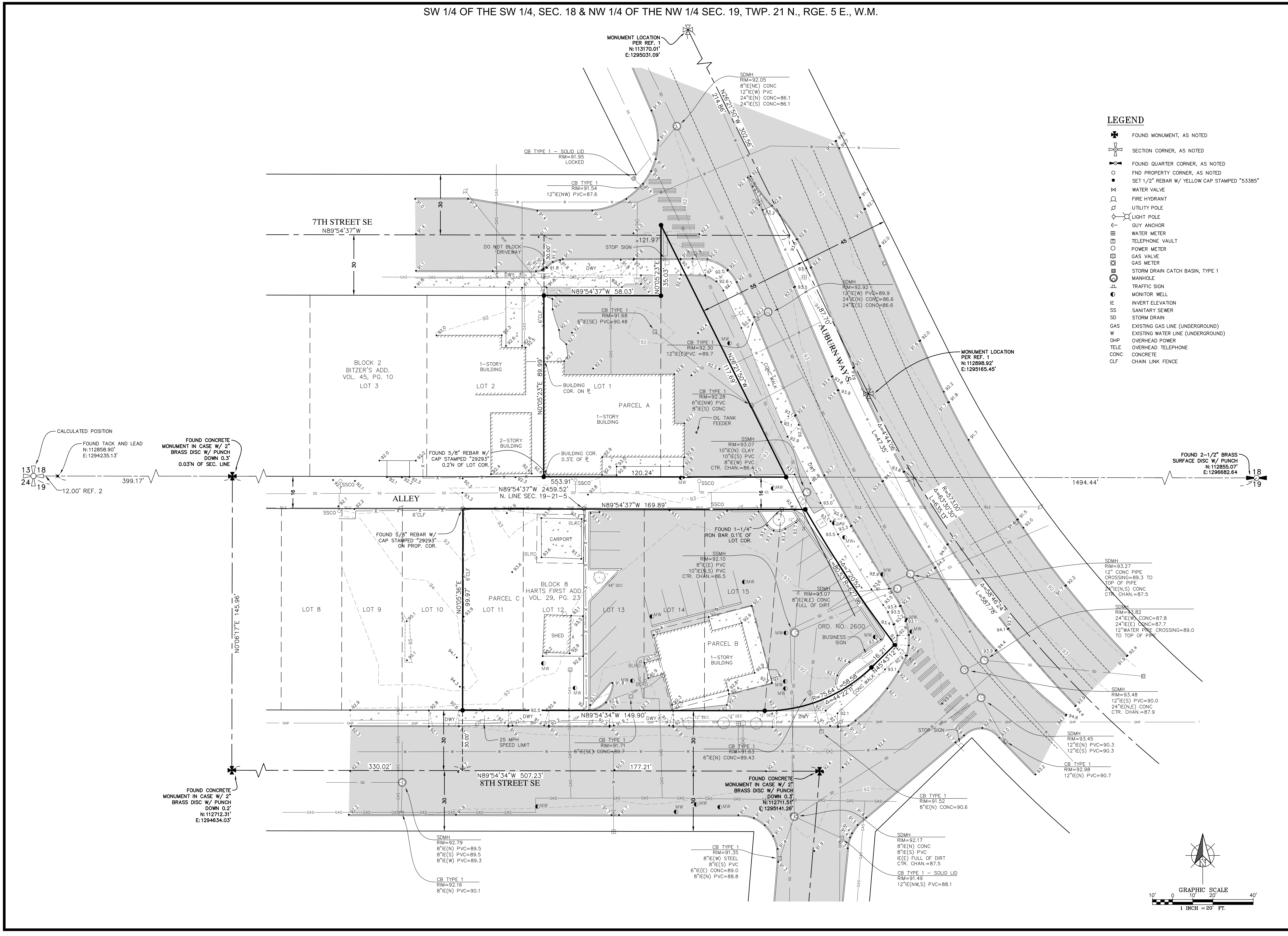


11/09/2018

AUBURN WAY
BOUNDARY & TOPOGRAPHIC SURVEY
FOR
FARALLON CONSULTING, L.L.C.
KING COUNTY WASHINGTON

JOB NO.
18-56

SHEET
1 OF 2



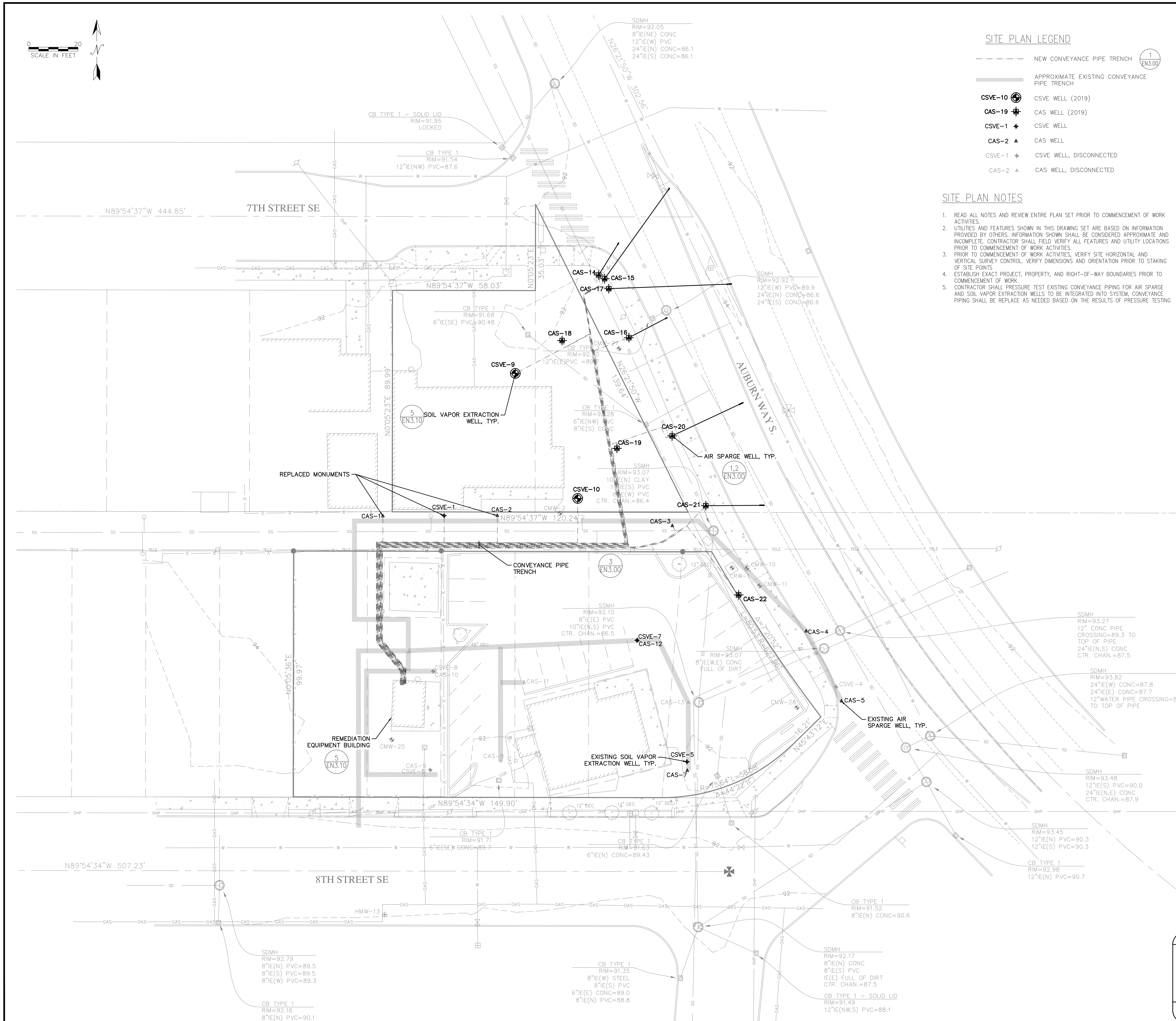
NORTH PEAK ASSOCIATES LLC
PROFESSIONAL LAND SURVEYORS
10512 NE 140TH STREET
KIRKLAND, WA 98034
Phone (206) 601-4682

Date	11/09/18
Scale	1" = 20'
Drawn	SB
Designed	
Checked	RvM

AUBURN WAY
BOUNDARY & TOPOGRAPHIC SURVEY
FOR
FARALLON CONSULTING, L.L.C.
KING COUNTY WASHINGTON

JOB NO. 18-56

SHEET 2 OF 2



SITE PLAN LEGEND

- NEW CONVEYANCE PIPE TRENCH (1 / EN3.00)
- APPROXIMATE EXISTING CONVEYANCE PIPE TRENCH
- CSVE-10 — CSVE WELL (2019)
- CAS-19 — CAS WELL (2019)
- CSVE-1 — CSVE WELL
- CAS-2 — CAS WELL
- CSVE-1 — CSVE WELL, DISCONNECTED
- CAS-2 — CAS WELL, DISCONNECTED

SITE PLAN NOTES

1. READ ALL NOTES AND REVIEW ENTIRE PLAN SET PRIOR TO COMMENCEMENT OF WORK ACTIVITIES.
2. UTILITIES AND FEATURES SHOWN IN THIS DRAWING SET ARE BASED ON INFORMATION PROVIDED BY OTHERS. INFORMATION SHOWN SHALL BE CONSIDERED APPROXIMATE AND INCOMPLETE. CONTRACTOR SHALL FIELD VERIFY ALL FEATURES AND UTILITY LOCATIONS PRIOR TO COMMENCEMENT OF WORK ACTIVITIES.
3. PRIOR TO COMMENCEMENT OF WORK ACTIVITIES, VERIFY SITE HORIZONTAL AND VERTICAL SURVEY CONTROL. VERIFY DIMENSIONS AND ORIENTATION PRIOR TO STAKING OF SITE POINTS
4. ESTABLISH EXACT PROJECT, PROPERTY, AND RIGHT-OF-WAY BOUNDARIES PRIOR TO COMMENCEMENT OF WORK.
5. CONTRACTOR SHALL PRESSURE TEST EXISTING CONVEYANCE PIPING FOR AIR SPARGE AND SOIL VAPOR EXTRACTION WELLS TO BE INTEGRATED INTO SYSTEM, CONVEYANCE PIPING SHALL BE REPLACE AS NEEDED BASED ON THE RESULTS OF PRESSURE TESTING

PROJECT DEMOLITION NOTES

1. ALL UTILITIES SHOWN IN THIS DRAWING SET ARE BASED ON INFORMATION PROVIDED BY OTHERS, INCLUDING RECORD INFORMATION. INFORMATION SHOWN SHALL BE CONSIDERED APPROXIMATE AND INCOMPLETE. CONTRACTOR SHALL FIELD VERIFY ALL UTILITY LOCATIONS PRIOR TO COMMENCEMENT OF WORK ACTIVITIES.
2. PROTECT NEIGHBOR PROPERTY AND ITEMS FROM DAMAGE DUE TO PROJECT RELATED ACTIVITIES.
3. ALL NOTES ON THIS PLAN SHALL BE CONSIDERED TYPICAL AND APPLICABLE TO THE ENTIRE PROJECT AREA, UNLESS OTHERWISE INDICATED. THE CONTRACTOR SHALL BE RESPONSIBLE FOR COORDINATION OF ALL WORK RELATED TO ALL UTILITIES AND FEATURES, WHETHER EXPLICITLY CALLED OUT OR NOT.
4. MAINTAIN FULL OPERATION OF ADJACENT STREETS, AND SIDEWALKS UNLESS OTHERWISE NOTED. KEEP CLEAN AND FREE OF DEBRIS, DIRT, AND OTHER PROJECT RELATED ITEMS. SWEEP AS NEEDED TO MEET PROJECT REQUIREMENTS. COORDINATE ALL DISRUPTIONS TO TRAFFIC WITH THE CITY OF AUBURN AND, AS APPROPRIATE, WSDOT. REPAIR ALL DAMAGE TO MATCH OR BETTER THAN EXISTING CONDITIONS.
5. PROTECT EXISTING OVERHEAD UTILITIES, LIGHTS, AND SIGNALS TO BE RETAINED OR MOVED. COORDINATE ACTIVITIES WITH PSE, CITY OF AUBURN, WSDOT, AND APPROPRIATE FRANCHISE UTILITIES .
6. PROTECT EXISTING UNDERGROUND AND SURFACE UTILITIES TO BE RETAINED OR MOVED. COORDINATE ACTIVITIES WITH APPROPRIATE FRANCHISE UTILITIES.
7. REMOVE FROM THE SITE AND PROPERLY DISPOSE OF ALL PROJECT WASTES, SPOILS, AND RUBBISH IN FULL COMPLIANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL LAWS AND REGULATIONS. OBTAIN ALL PERMITS NECESSARY FOR PROPER AND LEGAL DISPOSAL.
8. NO TRASH OR OTHER MATERIALS, OTHER THAN APPROVED SOILS, SHALL BE DISPOSED OF ON SITE.
9. ALL SAWCUTS SHALL BE NEAT AND TRUE. CLEANUP SAWCUT DUST AND WASTEWATER.
10. WHEN SAWCUTTING CONCRETE, IF PROPOSED SAWCUT LINE IS CLOSER THAN HALFWAY BETWEEN EXISTING CONCRETE JOINTS TO THE NEXT FARTHEST EXISTING CONCRETE JOINT, SHIFT SAWCUT LINE TO THAT NEXT FARTHEST EXISTING CONCRETE JOINT.
11. REMOVE, SAVE AND PROTECT EXISTING STREET SIGNS IF POSSIBLE. RE-INSTALL WITH FINAL RESTORATION. REPLACE ANY THAT ARE DAMAGED AS A RESULT OF THE WORK.

CITY OF AUBURN GENERAL NOTES

1. THIS DEVELOPMENT PROJECT SHALL CONFORM TO THE CITY OF AUBURN'FS REQUIREMENTS AND BE IN ACCORDANCE WITH THE APPROVED PLANS. ANY CHANGES FROM THE APPROVED PLAN WILL REQUIRE APPROVAL FROM THE OWNER, ENGINEER, AND THE CITY.
2. ALL WORKMANSHIP AND MATERIALS SHALL CONFORM TO THE "GWASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) STANDARD SPECIFICATIONS FOR ROAD, BRIDGE, AND MUNICIPAL CONSTRUCTION (CURRENT EDITION),"H EXCEPT WHERE SUPPLEMENTED OR MODIFIED BY THE CITY'FS CONSTRUCTION STANDARDS MANUAL. COPIES OF THE ABOVE DOCUMENTS SHALL BE AVAILABLE AT THE JOB SITE DURING CONSTRUCTION.
3. A PRE-CONSTRUCTION MEETING SHALL BE REQUIRED PRIOR TO THE START OF ALL CONSTRUCTION. CONTACT THE COMMUNITY DEVELOPMENT & PUBLIC WORKS DEPARTMENT AT 253-931-3010, TO SCHEDULE A MEETING.
4. LOCATIONS SHOWN FOR EXISTING UTILITIES ARE APPROXIMATE. THE CONTRACTOR IS CAUTIONED THAT OVERHEAD UTILITY LINES MAY NOT BE SHOWN ON THE DRAWINGS. IT SHALL BE THE CONTRACTOR'FS RESPONSIBILITY TO DETERMINE THE TRUE ELEVATIONS AND LOCATIONS OF ALL UNDERGROUND UTILITIES AND THE EXTENT OF ANY HAZARD CREATED BY OVERHEAD UTILITY LINES. IDENTIFICATION, LOCATION, MARKING, AND RESPONSIBILITY FOR UNDERGROUND FACILITIES OR UTILITIES, IS GOVERNED BY THE PROVISIONS OF CHAPTER 19.122 REVISED CODE OF WASHINGTON (RCW). PRIOR TO STARTING CONSTRUCTION, THE CONTRACTOR SHALL CALL ONE-CALL (811) FOR UTILITY LOCATIONS (WATER, SANITARY SEWER, STORM SEWER, GAS, POWER, TELEPHONE, AND CABLE).
5. IF A PROPOSED ROUTE IS NOT INCLUDED ON THESE PLANS, A PROPOSED ROUTE AND SCHEDULE FOR HAULING MATERIAL TO THE SITE SHALL BE SUBMITTED TO THE CITY FOR APPROVAL PRIOR TO THE START OF CONSTRUCTION. IF THE CITY BELIEVES THAT THE PROPOSED HAUL ROUTE WILL ADVERSELY IMPACT THE STREET NETWORK, A SEPA AMENDMENT MAY BE REQUIRED TO EVALUATE THE IMPACTS AND DETERMINE MITIGATION REQUIREMENTS BEFORE BEGINNING WORK. HAULING MAY BE LIMITED TO APPROPRIATE OFF-PEAK HOURS OR ALTERNATIVE ROUTES, AS DETERMINED BY THE CITY.
6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PUBLIC SAFETY ON AND AROUND THE PROJECT. PRIOR TO THE START OF WORK, ALL METHODS AND EQUIPMENT USED FOR TRAFFIC CONTROL AND STREET MAINTENANCE SHALL BE SUBMITTED TO THE CITY FOR APPROVAL. CONTRACTORS AND THEIR SURETY SHALL BE LIABLE FOR INJURIES AND DAMAGES TO PERSONS AND PROPERTY SUFFERED BECAUSE OF CONTRACTORS OPERATIONS OR NEGLIGENCE CONNECTED WITH THEM.
7. ALL CONSTRUCTION SURVEYING FOR EXTENSIONS OF PUBLIC FACILITIES SHALL BE DONE UNDER THE DIRECTION OF A WASHINGTON LICENSED LAND SURVEYOR OR A WASHINGTON LICENSED PROFESSIONAL CIVIL ENGINEER.
8. CERTIFIED DRAWINGS ARE REQUIRED PRIOR TO PROJECT ACCEPTANCE. REFER TO THE CITY'FS "GRECORD CONSTRUCTION DOCUMENT"H HANDOUT.

CITY OF AUBURN GRADING AND EROSION CONTROL NOTES

1. WITHIN THE CITY OF AUBURN, ALL REQUIRED SEDIMENTATION AND EROSION CONTROL FACILITIES INDICATED ON THE PLANS MUST BE CONSTRUCTED AND IN OPERATION PRIOR TO LAND CLEARING AND/OR OTHER CONSTRUCTION ACTIVITIES. THESE FACILITIES SHALL BE MAINTAINED AND UPGRADED, IF NECESSARY, TO INSURE THAT SEDIMENT-LADEN WATER AND STORM DRAINAGE RUNOFF DOES NOT IMPACT THE ADJACENT PROPERTIES, NATURAL DRAINAGE WAYS, OR THE EXISTING CITY STORM DRAINAGE SYSTEM.
2. THE SOURCES FOR ALL MATERIAL IMPORTED TO THE SITE SHALL BE APPROVED BY THE CITY.
3. THE STORM DRAINAGE DETENTION (RETENTION IF INFILTRATION SYSTEM IS USED), SEDIMENTATION AND EROSION CONTROL FACILITIES DEPICTED ON THE APPROVED DRAWINGS ARE INTENDED TO BE MINIMUM REQUIREMENTS TO MEET ANTICIPATED SITE CONDITIONS. ADDITIONAL DRAINAGE AND EROSION CONTROL FACILITIES MAY BE REQUIRED AS SITUATIONS WARRANT DURING CONSTRUCTION. THE IMPLEMENTATION, MAINTENANCE, REPLACEMENT AND ADDITIONS TO THESE CONTROL SYSTEMS SHALL BE THE RESPONSIBILITY OF THE PERMITEE.
4. THE TEMPORARY EROSION CONTROL FACILITIES, INCLUDING ALL PERIMETER CONTROLS AND THE DETENTION (RETENTION IF INFILTRATION SYSTEM IS USED), CONTROL PONDS, SHALL REMAIN IN PLACE UNTIL FINAL SITE CONSTRUCTION IS COMPLETED. AFTER CITY APPROVAL, THE CONTRACTOR WILL BE RESPONSIBLE FOR REMOVING ALL TEMPORARY FACILITIES.
5. THE CONTRACTOR WILL BE REQUIRED TO WATER THE SITE, AS NECESSARY, TO REDUCE DUST EMISSIONS AS A RESULT OF CONSTRUCTION ACTIVITY.
6. NO TRACKING IN THE ROADWAY IS ALLOWED. IF SEDIMENT IS TRACKED ONTO THE ROAD, THE ROAD SHALL BE THOROUGHLY AND IMMEDIATELY CLEANED BY SHOVELING OR PICKUP SWEEPING. TRANSPORT SEDIMENT TO A CONTROLLED SEDIMENT DISPOSAL AREA. KEEP STREETS CLEAN AT ALL TIMES.
7. ALL AREAS OF ACTIVE EARTHWORK WHICH HAVE THE POTENTIAL FOR EROSION AND SEDIMENTATION IMPACTS ON ADJACENT PROPERTIES, NATURAL DRAINAGE WAYS, OR THE EXISTING CITY STORM DRAINAGE SYSTEM MUST BE STABILIZED ACCORDING TO THE FOLLOWING SCHEDULE: FROM MAY 1 TO SEPTEMBER 30, AREAS AT FINAL GRADE AND THOSE THAT ARE SCHEDULE TO REMAIN UN-WORKED FOR MORE THAN SEVEN (7) DAYS SHALL BE STABILIZED. FROM OCTOBER 1 TO APRIL 30 EARTHWORK ACTIVITIES SHALL BE CONDUCTED IN STAGES IN ORDER TO MINIMIZE SOIL EXPOSURE. EXPOSED SOILS THAT WILL REMAIN UN-WORKED FOR MORE THAN TWO (2) DAYS SHALL BE STABILIZED IMMEDIATELY.

AS/SVE WELL SCHEDULE

WELL ID	APPROXIMATE WELL HEAD LOCATION		DEPTH	APPROXIMATE WELL ANGLE	APPROX. TOTAL WELL LENGTH	SCREEN INTERVAL
	NORTHING	EASTING	(FEET BGS)	(DEG FROM VERT.)	(FEET)	(FEET TOC)
CAS-1	112856.02*	1295000.55*	50	0.0	50.0	48-50
CAS-2	112856.16*	1295047.06*	50	0.0	50.0	47.5-50
CAS-3	112852.06	1295118.14	50	0.0	50.0	47.5-50
CAS-4	112809.26	1295172.55	50	0.0	50.0	47.5-50
CAS-5	112780.83	1295186.88	50	0.0	50.0	47.5-50
CAS-12	112805.53	1295103.96	50	0.0	50.0	47.5-50
CAS-7	112780.24	1295124.63	50	0.0	50.0	47.5-50
CAS-14	112953.94	1295088.24	40	21.0	43.0	42.0-43.0
CAS-15	112952.39	1295090.66	45	45.0	64.0	63.0-64.0
CAS-16	112928.47	1295100.51	46	21.0	49.0	47.0-48.0
CAS-17	112948.38	1295092.36	50	45.0	71.0	69.5-71.0
CAS-18	112927.30	1295073.36	40	0.0	40.0	39.0-40.0
CAS-19	112883.50	1295095.67	40	0.0	40.0	39.0-40.0
CAS-20	112888.56	1295118.09	42	37.0	53.0	50.5-52.0
CAS-21	112860.19	1295131.79	38	32.0	45.0	43.5-45.0
CAS-22	112823.94	1295145.12	44	0.0	44.0	42.5-44.0
CSVE-1	112856.12*	1295025.44*	30	0.0	30.0	15-30
CSVE-5	112756.14	1295124.13	30	0.0	30.0	15-30
CSVE-7	112805.4900	1295103.84	50	0.0	50.0	15-30
CSVE-9	112913.92	1295054.37	15	0.0	15.0	5-15
CSVE-10	112863.14	1295079.72	15	0.0	15.0	5-15

EXISTING WELLS INDICATED BY GRAY TEXT IN THIS TABLE
* DICTATES WELL NOT LOCATED DURING SURVEY, LOCATION APPROXIMATE

RECORD DRAWING

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DRAWINGS REVISED BY: LT
REVIEWED BY: ROL/SS
DATE: 06/26/2019

PROJECT REF: ______

THESE PLANS ARE APPROVED FOR CONFORMANCE WITH THE CITY OF AUBURN'S ENGINEERING REQUIREMENTS.

DEV. REVIEW ENGINEER: ______
APPROVED BY: ______
DATE APPROVED: ______

DATE	REVISION/DESCRIPTION	BY	CKD.	APP.
06.26.19	AS BUILTS	LT	SS	ROL
01.17.19	ADJUSTED WELL AND TRENCH LOCATIONS	ROL	CPK	CPK
11.12.18	ISSUED FOR PERMIT REVIEW	ROL	SS	CPK

PREPARED BY:
FARALLON CONSULTING
975 5TH AVENUE NORTHWEST
ISSAQUAH, WA 98027
(425) 295-0800
farallonconsulting.com

PREPARED FOR:
CHS, INC.
763 WILLOUGHBY LANE
STEVENSVILLE, MONTANA 59870

SITE PLAN

CHS AUBURN SITE
AUBURN, WASHINGTON
APN: 0314600800, 3141600810, & 0835000035

Know what's below. Call before you dig.

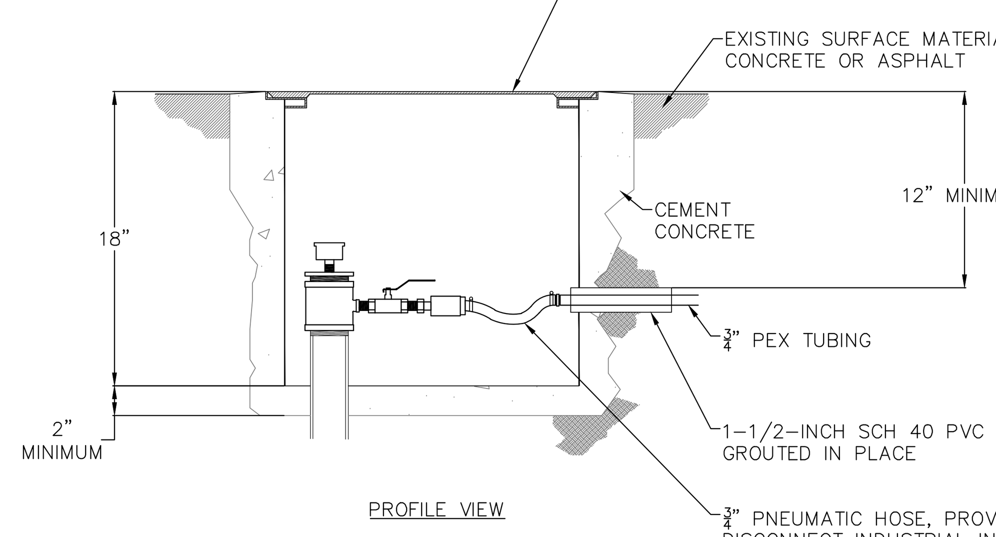
PROJECT LOCATION (S,T,R):
PORTIONS OF THE N W1/4 OF SEC. 019 TWP. 021N, RNG. 05E, W.M.

JURISDICTION FILE NO.:

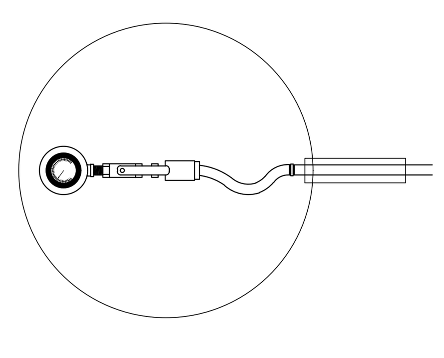
FARALLON PROJECT NO.: 301-004

SHEET 4 OF 8

EN2.00



PROFILE VIEW

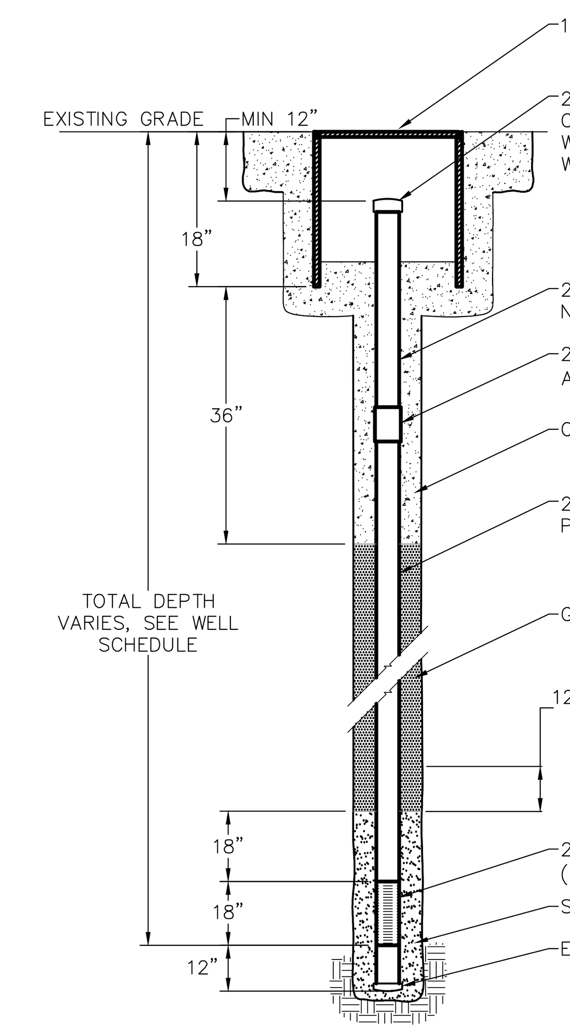


PLAN VIEW

NOTES:
1. IF EXISTING MONUMENT DOES NOT MEET SPECIFICATION, CONTRACTOR SHALL REMOVE EXISTING WELL MONUMENT(S) PRIOR TO INSTALLATION OF NEW MONUMENT(S). CONTRACTOR SHALL PROTECT EXISTING WELL FROM DAMAGE.
2. MONUMENT SHALL BE PLACED MINIMUM OF 2" AND MAXIMUM OF 6" FROM THE MONUMENT WALL.
3. CONTRACTOR SHALL INSTALL MONUMENT IN ACCORDANCE WITH MANUFACTURES'S RECOMMENDATIONS AND GUIDELINES. MONUMENT SHALL BE SET WITH CEMENT CONCRETE AND MINIMUM 2" THICKNESS BOTTOM.
4. MONUMENT TO BE SET ¼" ABOVE EXISTING GRADE AND CEMENT SLOPED TO PROVIDE A SMOOTH TRANSITION.

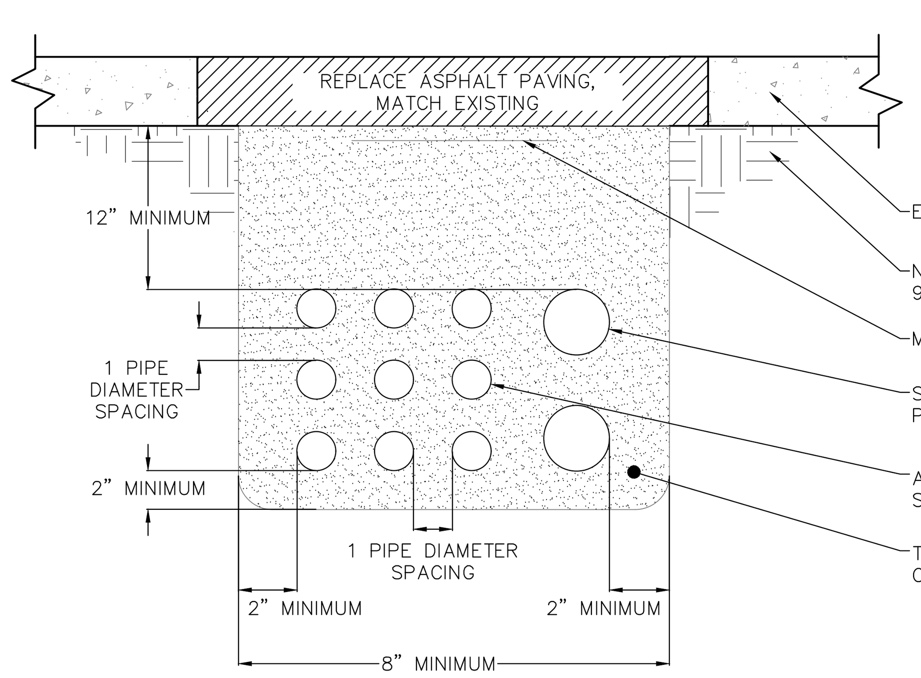
1 EN2.00 AIR SPARGE WELL HEAD CONNECTION DETAIL

NOT TO SCALE



2 EN2.00 AIR SPARGE WELL DETAIL

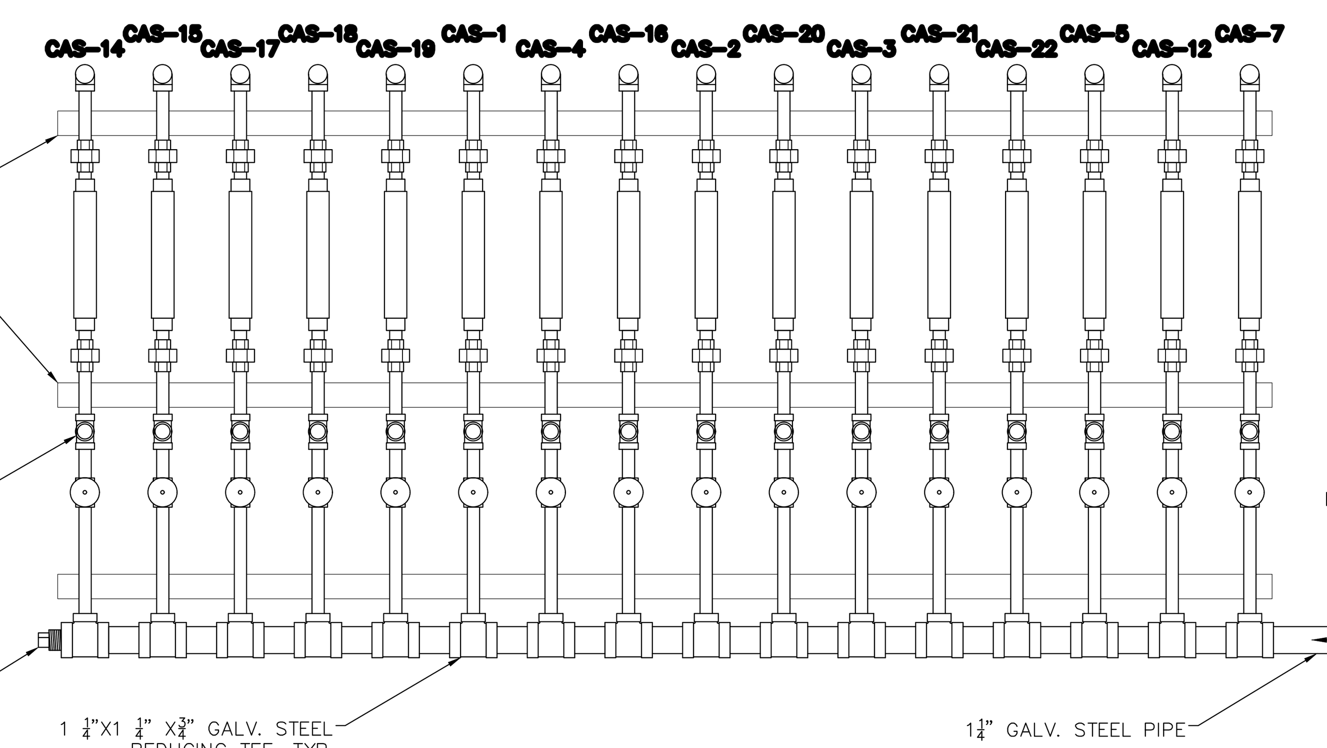
NOT TO SCALE



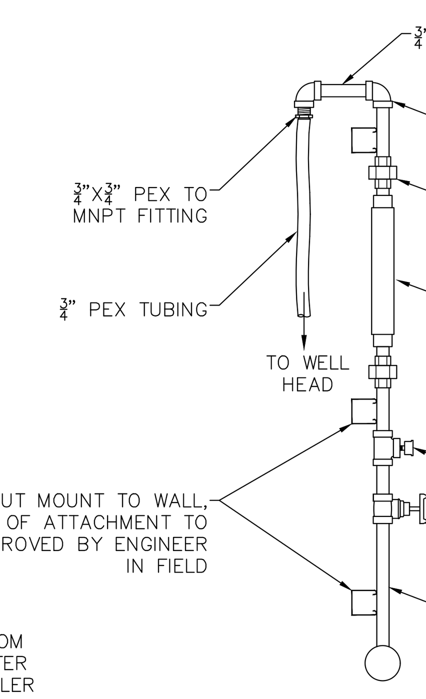
NOTES:
1. PIPES SHALL HAVE ONE PIPE DIAMETER SPACING BETWEEN PIPES OF THE LARGEST PIPE DIAMETER IN TRENCH SECTION.
2. PIPES SHALL HAVE ONE PIPE DIAMETER SPACING FROM EDGE AND BOTTOM OF TRENCH, PIPE DIAMETER SHALL BE THE LARGEST PIPE DIAMETER IN TRENCH SECTION.
3. NEW CONVEYANCE LINES SHALL BE INSTALLED WITH MINIMUM PIPE SLOPE OF 0.2% (2.4 INCH PER 100 FEET) FROM REMEDIATION SHED TO WELL CONNECTION.

3 EN2.00 CONVEYANCE PIPE TRENCH DETAIL

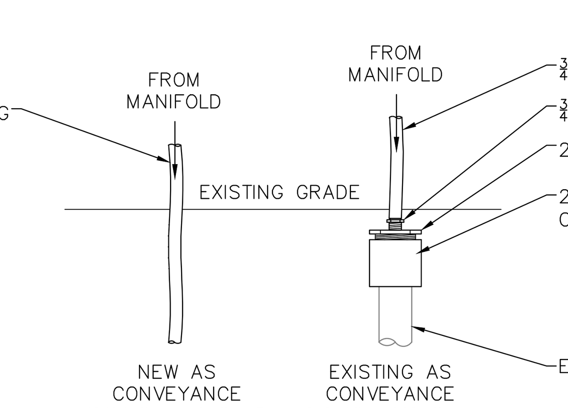
NOT TO SCALE



FRONT VIEW



SIDE VIEW



FLOOR PENETRATION

NOTES:
1. SPACE AS RISER TO MINIMUM NECESSARY TO FABRICATE, OPERATE, AND MAINTAIN CONSIDERING THE SIZE OF TEES, NIPPLES, ELBOWS, UNIONS, AND VALVES.
2. CONTRACTOR SHALL USE AND INSTALL FITTINGS TO MANUFACTURE RECOMMENDATIONS FOR ASSOCIATED PIPE MATERIALS.
3. CONTRACTOR SHALL CONFIRM EXISTING CONVEYANCE PIPING MATERIAL AND SIZING PRIOR TO ACQUIRING FITTINGS

4 EN3.10 AIR SPARGE MANIFOLD DETAIL

NOT TO SCALE

RECORD DRAWING

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DRAWINGS REVISED BY: LT
REVIEWED BY: ROL/SS
DATE: 06/26/2019

PROJECT REF: ______

THESE PLANS ARE APPROVED FOR CONFORMANCE WITH THE CITY OF AUBURN'S ENGINEERING REQUIREMENTS.

DEV. REVIEW ENGINEER: ______
APPROVED BY: ______
DATE APPROVED: ______

DATE	REVISION/DESCRIPTION	BY	CKD.	APP.
06.26.19	AS BUILTS	LT	SS	ROL
11.12.18	ISSUED FOR PERMIT REVIEW	ROL	SS	CPK

RUSSELL OLIN LUNDY STATE OF WASHINGTON 54283 REGISTERED PROFESSIONAL ENGINEER

PREPARED BY:
FARALLON CONSULTING
975 5TH AVENUE NORTHWEST
ISSAQUAH, WA 98027
(425) 295-0800
farallonconsulting.com

PREPARED FOR:
CHS, INC.
763 WILLOUGHBY LANE
STEVENSVILLE, MONTANA 59870

DETAILS

CHS AUBURN SITE
AUBURN, WASHINGTON
APN: 0314100800, 3141600810, & 0835000035

811 Know what's below. Call before you dig.

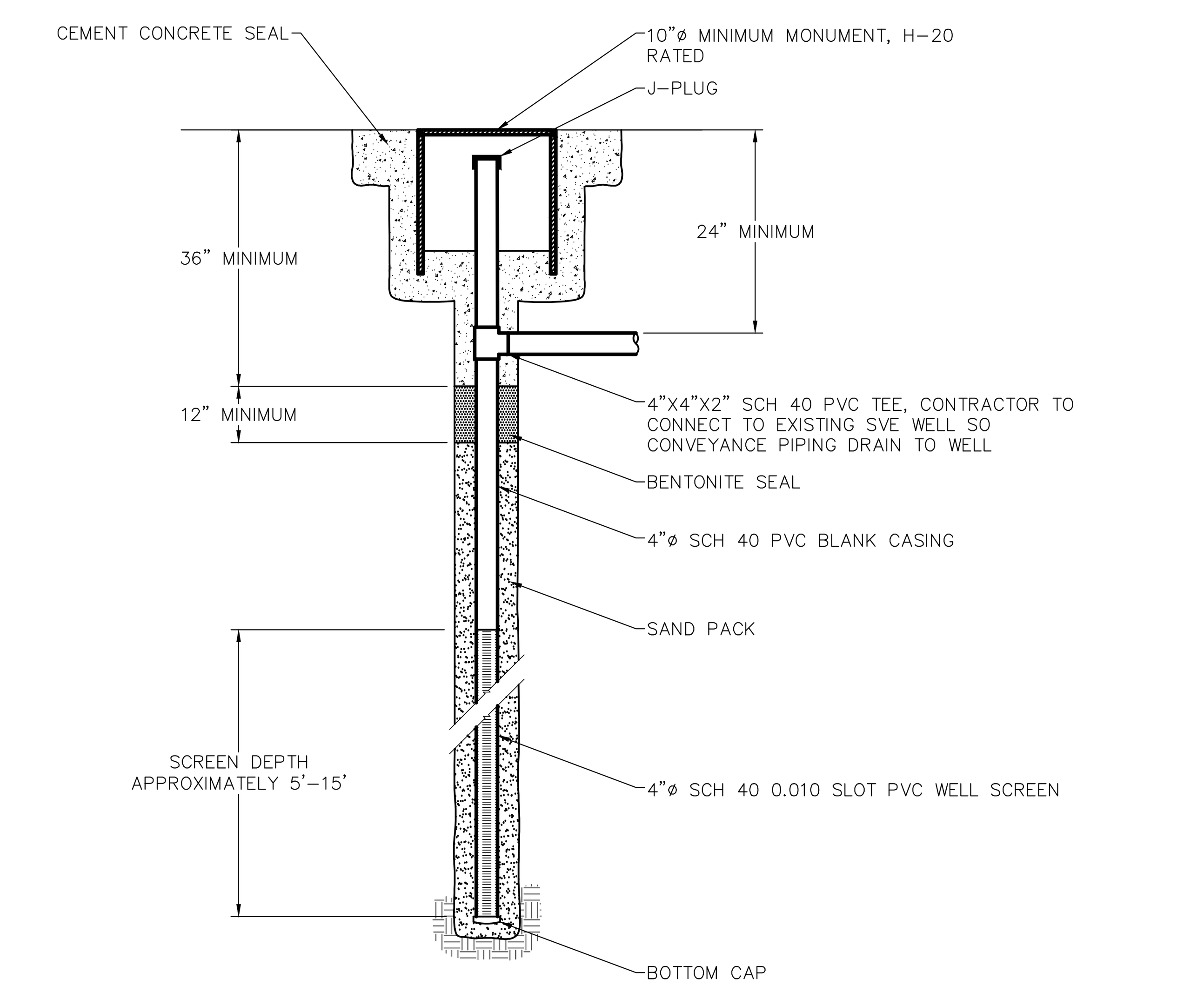
PROJECT LOCATION (S,T,R):
PORTIONS OF THE N W1/4 OF SEC. 019 TWP. 021N, RNG. 05E, W.M.

JURISDICTION FILE NO.:

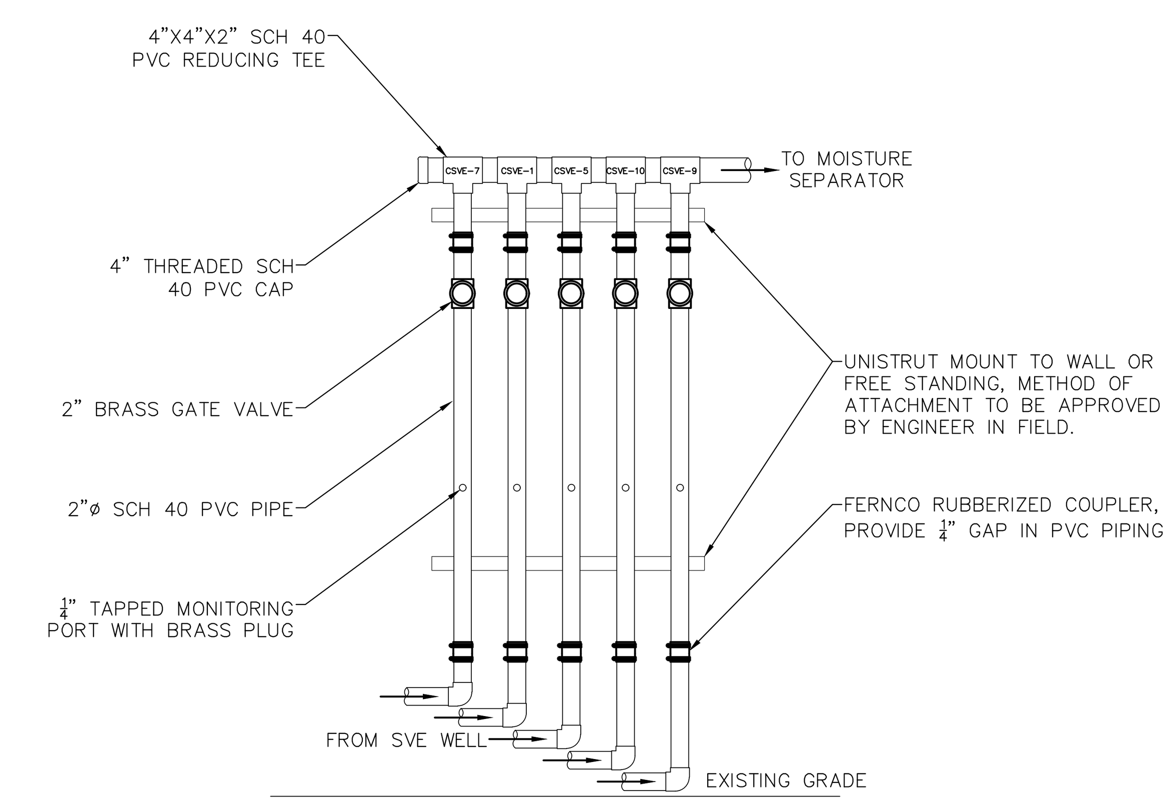
FARALLON PROJECT NO.:
301-004

SHEET
5 OF 8

EN3.00

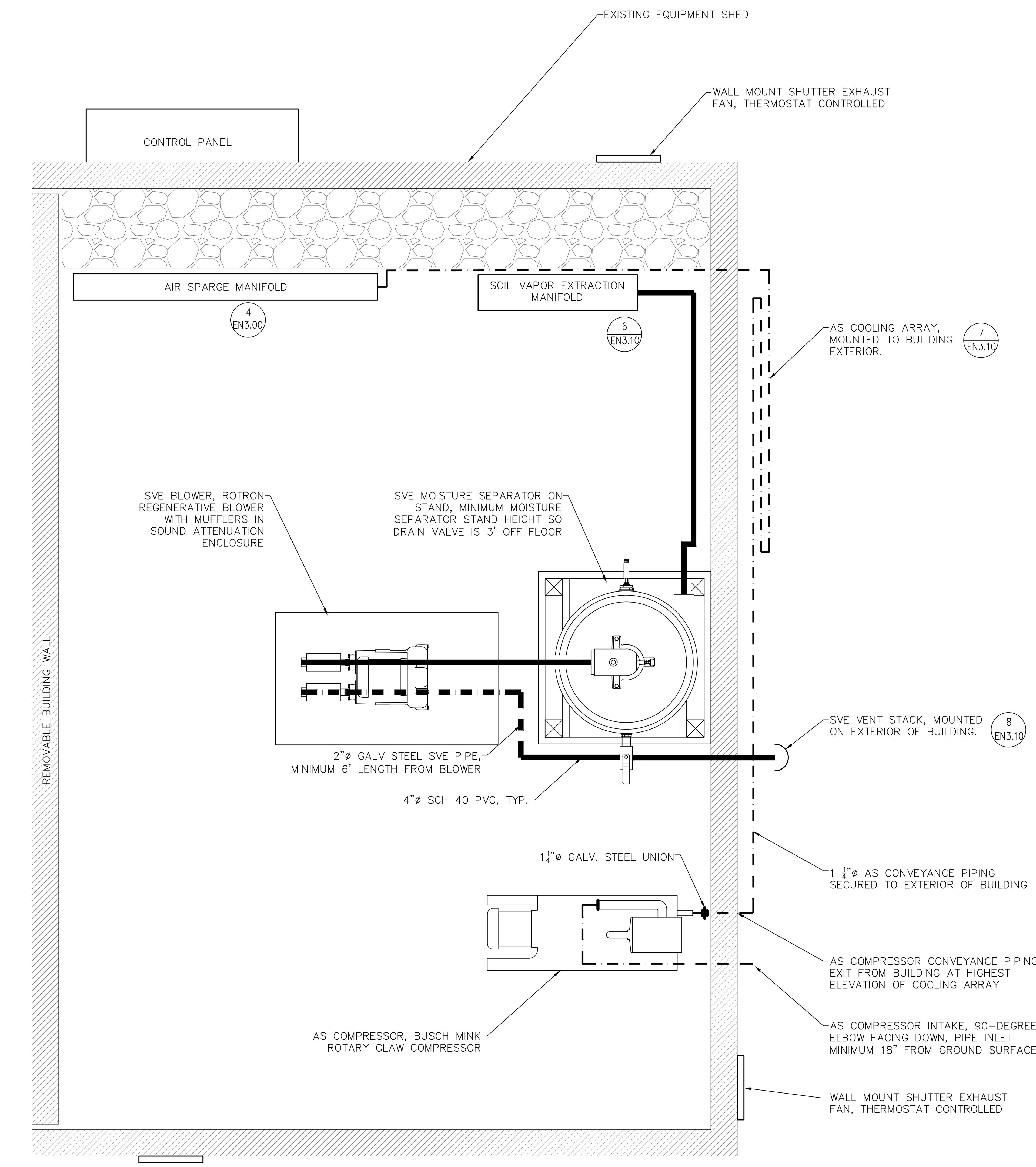


5 EN2.00 SOIL VAPOR EXTRACTION WELL DETAIL
NOT TO SCALE



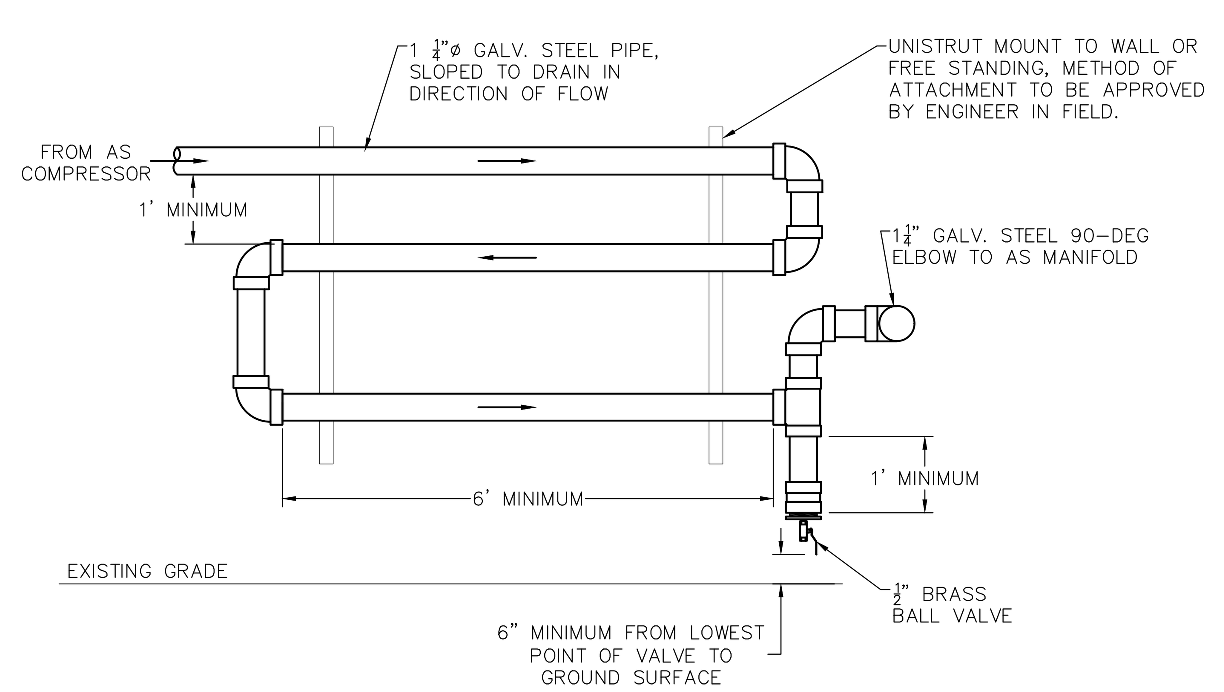
NOTES:
1. SPACE SVE RISER TO MINIMUM NECESSARY TO FABRICATE, OPERATE, AND MAINTAIN CONSIDERING THE SIZE OF TEES, NIPPLES, ELBOWS, AND VALVES.
2. CONTRACTOR SHALL USE AND INSTALL FITTINGS TO MANUFACTURE RECOMMENDATIONS FOR ASSOCIATED PIPE MATERIALS.
3. CONTRACTOR SHALL CONFIRM EXISTING CONVEYANCE PIPING MATERIAL AND SIZING PRIOR TO ACQUIRING FITTINGS

6 EN3.10 SOIL VAPOR EXTRACTION MANIFOLD DETAIL
NOT TO SCALE

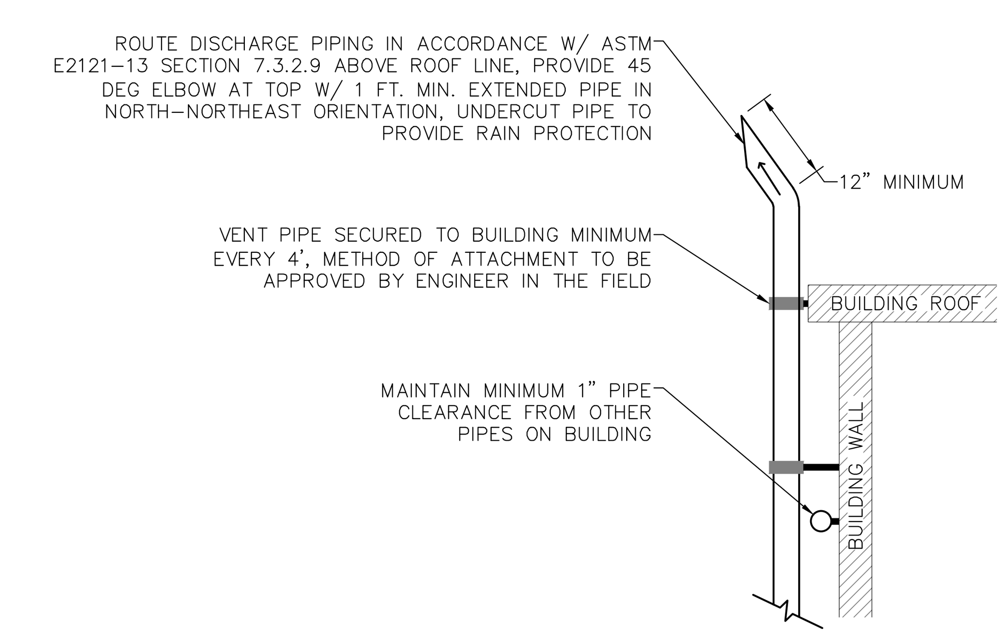


NOTES:
1. CONTRACTOR SHALL REMOVAL ALL UNUSED EXISTING EQUIPMENT FROM SITE AS DIRECTED BY THE ENGINEER.
2. CONTRACTOR SHALL SECURE AND REPAIR WEST BUILDING WALL (REMOVABLE WALL).
3. BUILDING PIPE AND VENT PENETRATIONS SHALL BE WEATHER PROOFED TO MEET LOCAL BUILDING CODES.
4. EQUIPMENT SHALL BE INSTALLED IN A MANNER THAT ALLOWS FOR ACCESS AROUND EQUIPMENT AND FOR MAINTENANCE OF ALL COMPONENTS IN PLACE. UNIONS, RUBBERIZED COUPLERS, AND OTHER QUICK DISCONNECT FITTINGS SHALL BE USED TO ALLOW FOR REMOVAL OF EQUIPMENT AND COMPONENTS.
5. CONTRACTOR SHALL REPAIR AND RESTORE EXISTING LIGHTING FIXTURES IN BUILDING.

N



7 EN3.10 AIR SPARGE COOLING ARRAY DETAIL
NOT TO SCALE



8 EN3.10 VENT STACK DETAIL
NOT TO SCALE

9 EN2.00 REMEDIATION SHED LAYOUT
NOT TO SCALE

RECORD DRAWING
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DRAWINGS REVISED BY: LT
REVIEWED BY: ROL/SS
DATE: 06/26/2019

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DEV. REVIEW ENGINEER:
APPROVED BY:
DATE APPROVED:

DATE	REVISION/DESCRIPTION	BY	CKD.	APP
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JURISDICTION FILE NO.:
FARALLON PROJECT NO.:
301-004
SHEET
6 OF 8
EN3.10

EQUIPMENT LIST

AF-1
INLINE AIR FILTER, BUSCH MINK

AF-2
2"ø FILTERED SILENCER AIR INLET SOLBERG MODEL NO. FS-231P-300 OR ENGINEER APPROVED EQUIVALENT WITH 2"ø BRASS GATE VALVE.

AF-3
4"ø INLINE AIR FILTER, ROTRON MODEL NO. 516465 OR ENGINEER APPROVED EQUIVALENT.

CP-101
BLOWER AND COMPRESSOR CONTROL PANEL. OWNER TO SUPPLY 200 AMP, THREE PHASE ELECTRICAL SERVICE. PROVIDE 7.1Hp AND 3.0Hp VFDs WITH AMPERAGE DISPLAYS. PLACE VFD DISPLAYS ON OUTSIDE OF CONTROL PANEL. PROVIDE ELAPSED TIME METER WITH DISPLAYS ON OUTSIDE OF CONTROL PANEL.

EF-101
WALL MOUNTED SHUTTER EXHAUST FAN CAPABLE OF 600 CFM WITH EXTERIOR CLOSING SHUTTERS.

FI-1
KING INSTRUMENTS ROTOMETER MODEL MO. 7511-2-1-7A02

MS-101
ROTRON CYCLONIC MOISTURE SEPARATOR MODEL NO. MS350BS EQUIPPED W/ SINGLE HIGH LEVEL SWITCH, VACUUM GAUGE, VACUUM RELIEF VALVE; ELEVATE UNIT 3' MINIMUM ABOVE CONCRETE FLOOR ON STAND TO BE APPROVED BY THE ENGINEER; PROVIDE FERNCO CONNECTIONS ON INLET AND DISCHARGE.

PI-1
PRESSURE INDICATOR RANGE AND UNITS: 0-60 PSI

PT-1
PRESSURE TRANSDUCER RANGE AND UNITS: 0-100 PSI

RGB-101
ROTRON REGENERATIVE BLOWER, MODEL NO. DR555K58: 3.0 Hp, 1PH. PLACE BLOWER WITHIN SOUND ENCLOSURE WITH COOLING FAN. INSTALL WITH OVERLOAD PROTECTION.

RC-101
BUSCH MINK ROTARY CLAW COMPRESSOR, MODEL NO. 1144BP: 7.1Hp, 3PH COMPRESSOR. INSTALL WITH OVERLOAD PROTECTION.

S-101
DISCHARGE SILENCER, ROTRON MODEL NO. 550888 OR ENGINEER APPROVED EQUIVALENT.

T-101
PROVIDE A SENSAPHONE SENTINEL MONITORING TELEMETRY SYSTEM. THE TELEMETRY SYSTEM SHALL BE INSTALLED WITHIN THE MAIN CONTROL PANEL OR A NEMA 4 ENCLOSURE TO PROVIDE WEATHER PROTECTION. THE TELEMETRY SHALL BE PROGRAMMED WITH ALARM CONDITIONS AND TRANSDUCER DATA, SYSTEM TO NOTIFY THE OPERATOR IF AN ALARM CONDITION EXISTS.

TI-1
TEMPERATURE INDICATOR RANGE AND UNITS: 50-500 °F

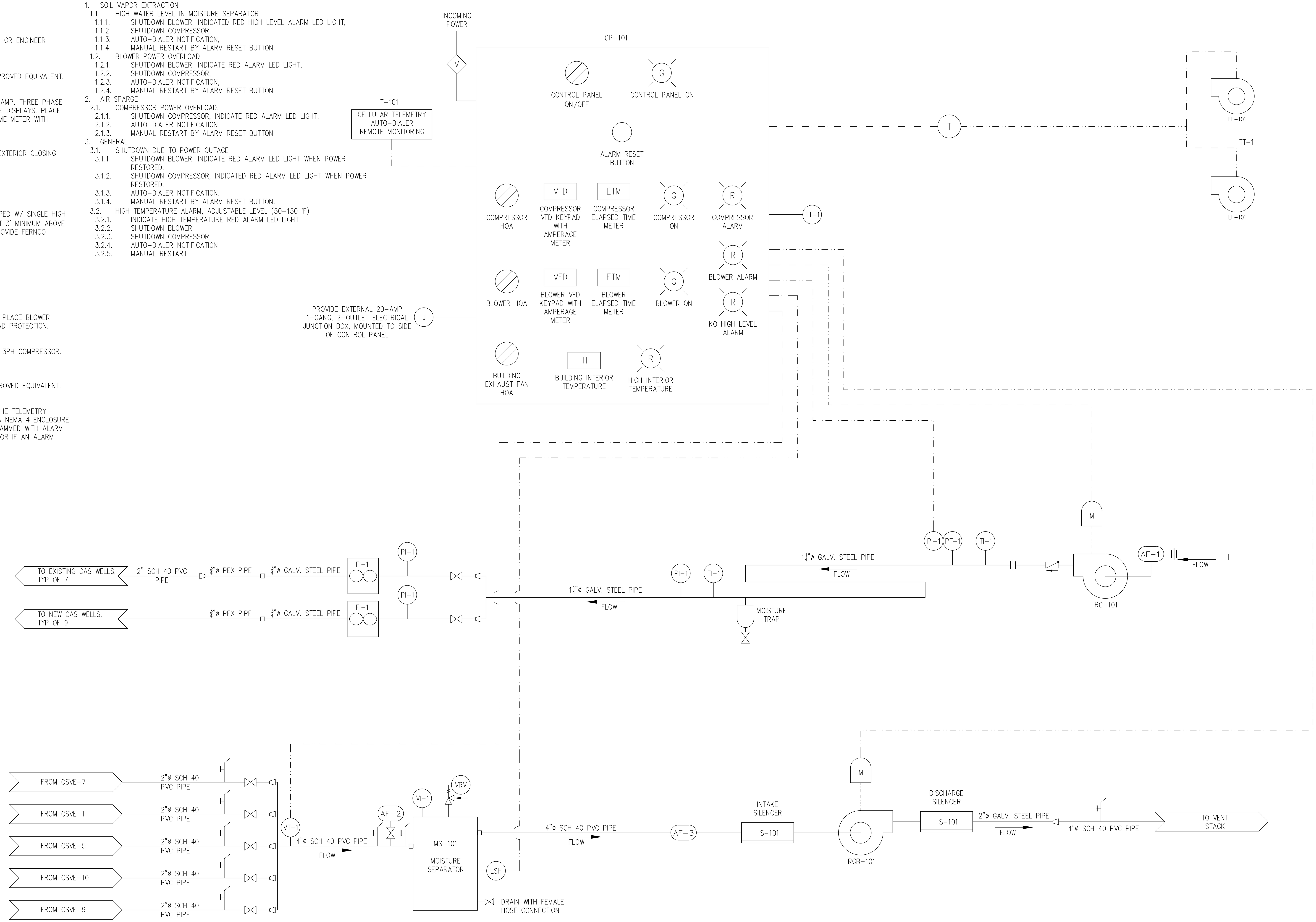
TT-1
TEMPERATURE TRANSMITTER RANGE AND UNITS: -30-140 °F

VI-1
VACUUM INDICATOR RANGE AND UNITS: -100-0 IOW

VT-1
VACUUM TRANSDUCER RANGE AND UNITS: -5-0 PSI

CONTROL LOGIC:

1. SOIL VAPOR EXTRACTION
  1.1. HIGH WATER LEVEL IN MOISTURE SEPARATOR
    1.1.1. SHUTDOWN BLOWER, INDICATED RED HIGH LEVEL ALARM LED LIGHT,
    1.1.2. SHUTDOWN COMPRESSOR,
    1.1.3. AUTO-DIALER NOTIFICATION,
    1.1.4. MANUAL RESTART BY ALARM RESET BUTTON.
  1.2. BLOWER POWER OVERLOAD
    1.2.1. SHUTDOWN BLOWER, INDICATE RED ALARM LED LIGHT,
    1.2.2. SHUTDOWN COMPRESSOR,
    1.2.3. AUTO-DIALER NOTIFICATION,
    1.2.4. MANUAL RESTART BY ALARM RESET BUTTON.
2. AIR SPARGE
  2.1. COMPRESSOR POWER OVERLOAD.
    2.1.1. SHUTDOWN COMPRESSOR, INDICATE RED ALARM LED LIGHT,
    2.1.2. AUTO-DIALER NOTIFICATION.
    2.1.3. MANUAL RESTART BY ALARM RESET BUTTON
3. GENERAL
  3.1. SHUTDOWN DUE TO POWER OUTAGE
    3.1.1. SHUTDOWN BLOWER, INDICATE RED ALARM LED LIGHT WHEN POWER RESTORED.
    3.1.2. SHUTDOWN COMPRESSOR, INDICATED RED ALARM LED LIGHT WHEN POWER RESTORED.
    3.1.3. AUTO-DIALER NOTIFICATION.
    3.1.4. MANUAL RESTART BY ALARM RESET BUTTON.
  3.2. HIGH TEMPERATURE ALARM, ADJUSTABLE LEVEL (50-150 °F)
    3.2.1. INDICATE HIGH TEMPERATURE RED ALARM LED LIGHT
    3.2.2. SHUTDOWN BLOWER.
    3.2.3. SHUTDOWN COMPRESSOR
    3.2.4. AUTO-DIALER NOTIFICATION
    3.2.5. MANUAL RESTART



RECORD DRAWING
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DRAWINGS REVISED BY: LT
REVIEWED BY: ROL/SS
DATE: 06/26/2019

PROJECT REF: ____________

THESE PLANS ARE APPROVED FOR CONFORMANCE WITH THE CITY OF AUBURN'S ENGINEERING REQUIREMENTS.

DEV. REVIEW ENGINEER: ____________
APPROVED BY: ____________
DATE APPROVED: ____________

DATE	REVISION/DESCRIPTION	BY	CKD.	APP.
06.26.19	AS BUILTS	LT	SS	ROL
11.12.18	ISSUED FOR PERMIT REVIEW	ROL	SS	CPK

PREPARED BY:
FARALLON CONSULTING
975 5TH AVENUE NORTHWEST
ISSAQUAH, WA 98027
(425) 295-0800
farallonconsulting.com

PREPARED FOR:
CHS, INC.
763 WILLOUGHBY LANE
STEVENSVILLE, MONTANA 59870

PROCESS AND INSTRUMENTATION DIAGRAM

CHS AUBURN SITE
AUBURN, WASHINGTON
APN: 0314600800, 3141600810, & 0835000035

Know what's below. Call before you dig.

PROJECT LOCATION (S,T,R):
PORTIONS OF THE N.W.1/4 OF SEC. 019 TWP. 021N, RNG. 05E, W.M.

JURISDICTION FILE NO.:

FARALLON PROJECT NO.: 301-004

SHEET 7 OF 8

EN4.00

PART 1 GENERAL

SYSTEM DESCRIPTION

A. FURNISH, DELIVER, INSTALL, TEST, AND START-UP OF AS/SVE SYSTEM AND EQUIPMENT AS SHOWN ON THE DRAWINGS, AS SPECIFIED HEREIN, AND AS REQUIRED TO PROVIDE A COMPLETE AND FULLY FUNCTIONAL TREATMENT SYSTEM. MAJOR COMPONENTS INCLUDE THE SYSTEM BLOWER AND MOTOR, MOISTURE SEPARATOR, AIR COMPRESSOR, CONTROL PANEL, AIR FILTERS, ASSOCIATED PIPING, VACUUM/PRESSURE GAUGES, VALVES, FITTINGS, AND MONITORING PORTS.

SUBMITTALS

A. SUBMIT DATA AND/OR MANUFACTURER CUT SHEETS TO DEMONSTRATE CONFORMANCE TO SPECIFICATION REQUIREMENTS.
B. PRODUCT DATA: SUBMIT MANUFACTURER'S PRODUCT DATA AND INSTALLATION INSTRUCTIONS FOR EACH MATERIAL, COMPONENT, AND/OR PRODUCT USED.
C. OPERATION AND MAINTENANCE DATA: SUBMIT MANUFACTURER'S OPERATION AND MAINTENANCE INSTRUCTIONS, INCLUDING A MAINTENANCE SCHEDULE.
D. SUBMIT FINAL AS-BUILT DRAWINGS.

QUALIFICATIONS

A. TREATMENT EQUIPMENT FURNISHED UNDER THIS SECTION SHALL BE OF MANUFACTURERS WHO HAVE BEEN REGULARLY ENGAGED IN DESIGN AND MANUFACTURE OF THE MATERIAL AND EQUIPMENT FOR AT LEAST 5 YEARS.

DELIVERY, STORAGE, AND HANDLING

A. EQUIPMENT AND MATERIALS FURNISHED UNDER THIS SECTION SHALL BE PREPARED AND PROTECTED FOR SHIPMENT, SHIPPED, AND STORED UNTIL INSTALLATION PER MANUFACTURERS' INSTRUCTIONS.

QUALITY ASSURANCE

A. COMPLY WITH GOVERNING CODES AND REGULATIONS. PROVIDE PRODUCTS OF ACCEPTABLE MANUFACTURERS, WHICH HAVE BEEN IN SATISFACTORY USE IN SIMILAR SERVICE FOR THREE YEARS. USE EXPERIENCED INSTALLERS. DELIVER, HANDLE, AND STORE MATERIALS IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS.

GUARANTEE AND WARRANTY

B. SUPPLIERS OF EQUIPMENT SHALL GUARANTEE PERFORMANCE AT DESIGN CONDITIONS.
C. SUPPLIERS OF EQUIPMENT AND MATERIAL SHALL WARRANT THEM FREE OF DEFECTS IN MATERIAL AND WORKMANSHIP FOR AT LEAST 12 MONTHS FROM INITIAL ACCEPTANCE.

END OF SECTION

PART 2 EARTHWORK

SUMMARY

PERFORM EXCAVATION, FILLING, COMPACTION, AND GRADING OPERATIONS AS REQUIRED FOR BELOW-GRADE IMPROVEMENTS. PROVIDE TRENCHING AND BACKFILL FOR UNDERGROUND WORK AND UTILITIES.
A. PROVIDE SUBBASE MATERIALS, SELECT BACKFILL, COMMON BORROW, AND STRUCTURAL FILL MATERIALS FOR PAVEMENTS, AND RESTORATION AS INDICATED ON THE DRAWINGS.
B. PROVIDE SUITABLE FILL FROM OFF-SITE IF ON-SITE QUANTITIES ARE INSUFFICIENT OR UNACCEPTABLE, AND LEGALLY DISPOSE OF EXCESS FILL OFF-SITE OR ON-SITE AREAS APPROVED BY THE OWNER.

SUBMITTALS

A. PRODUCT DATA: SUBMIT MANUFACTURER'S PRODUCT DATA AND INSTALLATION INSTRUCTIONS FOR EACH MATERIAL AND PRODUCT USED.
B. TEST REPORTS: SUBMIT FOR APPROVAL ALL TEST REPORTS, LISTS OF MATERIALS AND GRADATION PROPOSED FOR USE.

MATERIALS

A. BORROW SOIL: SATISFACTORY ON-SITE SOIL OR SOIL IMPORTED FROM OFF-SITE FOR USE AS FILL OR BACKFILL PER WSDOT STANDARD SPECIFICATION 9-03.14(1)
B. BACKFILL FOR PIPE ZONE BEDDING: IN ACCORDANCE WITH WSDOT STANDARD SPECIFICATION 9-03.12(3)
C. CRUSHED SURFACING TOP COURSE (CSTC): IN ACCORDANCE WITH WSDOT STANDARD SPECIFICATION 9-03.9(3)
D. HOT MIX ASPHALT (HMA) SHALL BE HMA CL. 1/2 IN. PG 64-22 OR AS APPROVED BY THE ENGINEER. HMA SHALL BE INSTALLED IN ACCORDANCE WITH WSDOT STANDARD SPECIFICATION SECTION 5-04.
E. CONCRETE SHALL BE 3000 PSI OR AS APPROVED BY THE ENGINEER.

EXECUTION

A. MAINTAIN STABILITY OF EXCAVATIONS; COORDINATE SHORING AND BRACING AS REQUIRED BY JURISDICTIONAL AUTHORITIES. PREVENT OR INHIBIT SURFACE AND SUBSURFACE WATER FROM ACCUMULATING IN EXCAVATIONS. STOCKPILE SATISFACTORY MATERIALS FOR REUSE AND ALLOW FOR PROPER DRAINAGE.
B. COMPACT MATERIALS AT THE OPTIMUM MOISTURE CONTENT AS DETERMINED BY ASTM D 1557 BY AERATION OR WETTING TO THE FOLLOWING PERCENTAGES OF MAXIMUM DRY DENSITY:
   1. UNPAVED AREAS: TOP 6" OF SUBGRADE AND EACH FILL LAYER TO 90% MAXIMUM DRY DENSITY AS DETERMINED BY ASTM 0698.
C. PLACE ACCEPTABLE MATERIALS IN LIFTS NO MORE THAN 8" FOR MATERIALS COMPACTED BY HEAVY EQUIPMENT AND NOT MORE THAN 4" DEEP FOR MATERIALS COMPACTED BY HAND EQUIPMENT TO SUBGRADES INDICATED AS FOLLOWS:
   1. GRADE TO WITHIN $\frac{1}{2}$" ABOVE OR BELOW REQUIRED SUBGRADE AND WITHIN A TOLERANCE OF $\frac{1}{2}$" IN 10'.
   2. PROTECT NEWLY GRADED AREAS FROM TRAFFIC AND EROSION. RECOMPACT AND REGRADE SETTLED, DISTURBED AND DAMAGED AREAS AS NECESSARY TO RESTORE QUALITY, APPEARANCE, AND CONDITION OF WORK.
   3. CONTROL EROSION TO PREVENT RUNOFF INTO SEWERS OR DAMAGE TO SLOPED OR SURFACED AREAS IN COMPLIANCE WITH THE PROJECT TEMPORARY EROSION AND SEDIMENT CONTROL PLAN AND LOCAL REGULATIONS.
   4. CONTROL DUST TO PREVENT HAZARDS TO ADJACENT PROPERTIES AND VEHICLES. IMMEDIATELY REPAIR OR REMEDY DAMAGE CAUSED BY DUST INCLUDING AIR FILTERS IN EQUIPMENT AND VEHICLES. CLEAN SOILED SURFACES.
   5. DISPOSE OF WASTE AND UNSUITABLE MATERIALS OFF-SITE IN A LEGAL MANNER.
D. ALL PIPING/TUBING SHALL BE SLOPED A MINIMUM OF $\frac{1}{4}$% (3"/100') DOWN TOWARDS EACH WELLHEAD FROM THE MINIMUM COVER DEPTH OF 12 INCHES AT REMEDIATION COMPOUND.
E. SURROUND THE PIPE(S) WITH 6 TO 8 INCHES OF BACKFILL. BACKFILL SHALL BE FREE OF ROCKS WITH A PARTICLE SIZE OF $\frac{1}{2}$ INCH OR LESS.

END OF SECTION

PART 3 PRODUCTS

GENERAL

A. EQUIPMENT AND MATERIALS FURNISHED UNDER THIS SECTION SHALL BE NEW.

SERVICE CONDITIONS

A.	LOCATION:	AUBURN, WASHINGTON
B.	INSTALLATION:	INDOORS/OUTDOORS
C.	AMBIENT AIR TEMPERATURE RANGE:	15 TO 100 DEGREES FAHRENHEIT.
D.	RELATIVE HUMIDITY OF AMBIENT AIR:	40 TO 100 PERCENT

PERFORMANCE REQUIREMENTS

A. MATERIAL AND EQUIPMENT SHALL MEET THE FOLLOWING PERFORMANCE REQUIREMENTS WHEN OPERATING AT SERVICE CONDITIONS LISTED IN THIS SECTION.
B. MATERIAL AND EQUIPMENT SHALL NOT CORRODE, DEFORM, CRACK, BECOME BRITTLE, OR OTHERWISE BECOME UNSERVICEABLE.
C. MATERIAL AND EQUIPMENT SHALL NOT LEAK.
D. MATERIAL AND EQUIPMENT SHALL BE CHEMICALLY RESISTANT FOR INTENDED USE.

EQUIPMENT AND SOUND ENCLOSURE

A. THE EQUIPMENT ENCLOSURE ROOM SHALL BE TEMPERATURE CONTROLLED TO MAINTAIN A TEMPERATURE ABOVE 50 DEGREES FAHRENHEIT AND BELOW 80 DEGREES FAHRENHEIT.
B. PROVIDE A SOUND ATTENUATING ENCLOSURE TO REDUCE NOISE GENERATED BY SVE BLOWER BY A MINIMUM OF 10 dBa.
C. THE SOUND ATTENUATING ENCLOSURE SHALL HAVE VENTILATION FAN(S) AND LOUVER OPENINGS TO ALLOW FOR AIR EXCHANGE INSIDE ENCLOSURE. THE ENCLOSURE SHALL BE INSTALLED TO PROVIDE RECOMMENDED CLEARANCE FOR VENTILATION FROM OTHER EQUIPMENT PER MANUFACTURERS SPECIFICATIONS.
D. THE SOUND ATTENUATION ENCLOSURE SHALL HAVE ACCESS PANELS TO ALLOW FOR MAINTENANCE OF BLOWER AND EQUIPMENT INSIDE OF ENCLOSURE. THE ENCLOSURE SHALL BE INSTALLED WITH ACCESS PANEL(S) UNBLOCKED BY OTHER EQUIPMENT.
E. THE SOUND ATTENUATION ENCLOSURE SHALL BE MOUNTED TO THE FLOOR PER MANUFACTURES SPECIFICATIONS.

SVE BLOWER

A. PROVIDE ONE (1) ROTRON REGENERATIVE BLOWER TYPE DR555, 3.0 HP BLOWER, TO PROVIDE APPROXIMATELY 150 SCFM AT 28 INCHES OF WATER COLUMN.
B. PROVIDE TWO (2) MUFFLERS AT THE INLET AND OUTLET OF THE BLOWER, MUFFLER INNER DIAMETER SHALL MATCH THE BLOWER INLET AND OUTLET DIAMETER.
C. THE BLOWER SHALL BE MOUNTED TO THE FLOOR PER MANUFACTURES SPECIFICATIONS.

MOISTURE SEPARATOR

A. PROVIDE ONE (1) MOISTURE SEPARATOR MODEL NUMBER MS350BS FROM ROTRON AMETEK TECHNICAL AND INDUSTRIAL PRODUCTS. SHALL HAVE HIGH WATER LEVEL SWITCH, CHEMICAL RESISTANCE FLOAT BALL, VACUUM RELIEF VALVE, VACUUM GAUGE (0 TO 100 INCHES OF WATER COLUMN), AND WITHSTAND 12 INCHES OF MERCURY VACUUM.
B. THE MOISTURE SEPARATOR SHALL BE DESIGNED FOR THE SVE SYSTEM CAPABLE OF CONTINUOUS OPERATION WITH A PRESSURE DROP OF LESS THAN SIX INCHES OF WATER COLUMN AT THE RATED FLOW OF APPROXIMATELY 300 SCFM. IT MUST HAVE A LIQUID CAPACITY OF 40 GALLONS BELOW THE WATER LEVEL SHUTOFF SWITCH.
C. THE MOISTURE SEPARATOR SHALL INCORPORATE CYCLONIC SEPARATION TO REMOVE ENTRAINED WATER.

AS COMPRESSOR

A. PROVIDE ONE(1) BUSCH MINK ROTARY CLAW COMPRESSOR MODEL 1144BP, 7.1 HP COMPRESSOR, TO PROVIDE APPROXIMATELY 50 SCFM AT 27 PSI.
B. THE COMPRESSOR AIR INTAKE SHALL INSTALLED TO DRAW AIR DIRECTLY FROM OUTSIDE THE BUILDING.
C. THE COMPRESSOR SHALL BE MOUNTED TO THE FLOOR PER MANUFACTURES SPECIFICATIONS.

ELECTRICAL CONTROL PANEL

A. PROVIDE ONE (1) EQUIPMENT CONTROL PANEL WITH THE FOLLOWING: SYSTEM OPERATING LED LIGHT, CONTROL POWER ON/OFF SWITCH, BLOWER HOA SWITCH, COMPRESSOR HOA SWITCH, BLOWER ALARM LED LIGHT, COMPRESSOR ALARM LED, HIGH WATER KNOCKOUT ALARM LED LIGHT, BLOWER TOTAL RUN TIME ELAPSE METER, COMPRESSOR TOTAL RUN TIME ELAPSE METER, BLOWER VFD WITH AMPERAGE METER, COMPRESSOR VFD WITH AMPERAGE METER.
B. PROVIDE ONE BUILDING TEMPERATURE CONTROL PANEL WITH THE FOLLOWING: FAN HOA SWITCH, FAN ALARM LED LIGHT, ADJUSTABLE THERMOSTAT, AND BUILDING INTERIOR TEMPERATURE INDICATOR.
C. PROVIDE ONE (1) SENSAPHONE SENTINEL MONITORING TELEMETRY SYSTEM (AUTO-DIALER) WITH CELLULAR MODEM.
D. PROVIDE ONE (1) 2-GANG 120V 20 AMP ELECTRICAL OUTLET IN THE EQUIPMENT ROOM.

PIPE, FITTINGS, AND SPECIALTIES

A. PVC PIPE - PIPE SHALL BE SCHEDULE 40, MINIMUM CELL CLASSIFICATION 12545-C, IN ACCORDANCE WITH THE PLANS AND CONFORMING TO ASTM D1785.
   1. PVC JOINTS - THE PIPING SYSTEM SHALL BE JOINED PRIMARILY BY SOCKET-WELD CONNECTIONS, EXCEPT WHERE CONNECTING TO UNIONS, VALVES, AND EQUIPMENT WITH THREADED OR FLANGED CONNECTIONS THAT MAY REQUIRE FUTURE DISASSEMBLY. CONNECTIONS AT THOSE POINTS SHALL BE THREADED AND BACK-WELDED.
   2. PVC FITTINGS - THE SCHEDULE RATING FOR THE FITTINGS SHALL NOT BE LESS THAN THAT FOR THE ASSOCIATED PIPE. FITTINGS SHALL BE ASTM D 1784, PVC CONFORMING TO THE REQUIREMENTS OF ASTM D 2466, SOCKET TYPE, OR ASTM D 2467, SOCKET TYPE. THE THREAD LUBRICANT PROPOSED BY THE CONTRACTOR SHALL BE PROVIDED TO THE ENGINEER FOR APPROVAL. ALL THREADED FITTINGS WILL SUBJECT TO ZERO-TOLERANCE FOR EVEN MINOR LEAKS, DUE TO THE NATURE OF THE PROCESS SYSTEM.
      a. PVC SOLVENT CEMENT - SOCKET CONNECTIONS SHALL BE JOINED WITH PVC SOLVENT CEMENT CONFORMING TO ASTM D 2564. MANUFACTURE AND VISCOSITY SHALL BE AS RECOMMENDED BY THE PIPE AND FITTING MANUFACTURER TO ENSURE COMPATIBILITY. JOINTS SHALL BE PREPARED WITH PRIMERS CONFORMING TO ASTM F 656 PRIOR TO CEMENTING AND ASSEMBLY.

B. GALVANIZED STEEL PIPE - GALVANIZED STEEL PIPE SHALL BE SCHEDULE 40 IN ACCORDANCE WITH THE PLANS AND CONFORMING TO ASTM A-53 SPECIFICATIONS.
   1. GALVANIZED STEEL FITTINGS - THE SCHEDULE RATING FOR FITTINGS SHALL NOT BE LESS THAN THAT FOR THE ASSOCIATED PIPE. FITTINGS SHALL BE THREADED AND MEET ASME B16.3 SPECIFICATIONS FOR GALVANIZED PIPE FITTINGS. THE TREAD LUBRICANT/SEALANT PROPOSED BY THE CONTRACTOR SHALL BE PROVIDED TO THE ENGINEER FOR APPROVAL. ALL THREADED FITTINGS WILL SUBJECT TO ZERO-TOLERANCE FOR MINOR LEAKS DUE TO THE NATURE OF THE PROCESS SYSTEM.

C. PEX PIPE - PEX PIPE SHALL BE IN ACCORDANCE WITH THE PLANS AND CONFORMING TO AWWA C900 SPECIFICATIONS.
   1. PEX FITTINGS - PEX FITTINGS SHALL BE METAL INSERTS SHALL MEET THE REQUIREMENTS OF ASTM F1807.
      a. PEX CRIMP FITTINGS - PEX CRIMP FITTINGS FOR USE WITH COPPER CRIMP RINGS SHALL MEET THE REQUIREMENTS OF ASTM F1807.
      b. PEX COLD EXPANSION FITTINGS - PEX COLD EXPANSION FITTING SHALL MEET THE REQUIREMENTS OF ASTM F1960 FOR PEX REINFORCEMENT RINGS AND ASTM 2080 FOR METAL COMPRESSION SLEEVES.

D. DURAPIPE
   1. DURAPIPE FITTINGS - DURAPIPE FITTINGS SHALL MEET THE REQUIREMENTS OF BS 4346 PART 1.

PART 3 PRODUCTS (CONT'D)

E. VALVES
   1. SVE AIR FLOW CONTROL VALVES SHALL BE MATCHING 2-INCH DIAMETER BRASS GATE VALVES.
   2. MOISTURE SEPARATOR DRAIN VALVE SHALL BE 1-INCH DIAMETER BRASS BALL VALVE.
   3. AS AIR FLOW CONTROL VALVES SHALL BE MATCHING $\frac{3}{4}$-INCH DIAMETER BRASS GATE VALVES.
   4. AS COOLING ARRAY DRAIN TRAP SHALL BE MINIMUM $\frac{1}{2}$-INCH DIAMETER BRASS BALL VALVE.

F. METERS, GAGES, INSTRUMENTS
   1. ALL MONITORING PORTS SHALL BE $\frac{1}{4}$-INCH NPT BRASS BALL VALVE WITH BRASS THREAD TO BARBED TUBING ADAPTOR.
   2. AS FLOW METERS SHALL HAVE A MINIMUM MEASURABLE FLOW RANGE OF 0.5 TO 8.0 SCFM WITH 0.2 SCFM INCREMENTS.
   3. PRESSURE INDICATORS SHALL HAVE A MINIMUM RANGE OF 0 TO 40 PSIG WITH 0.5 PSIG INCREMENTS.
   4. TEMPERATURE INDICATORS SHALL HAVE A MINIMUM RANGE OF 0 TO 200 DEGREE FAHRENHEIT WITH 5 DEGREE INCREMENTS, TEMPERATURE PROBE SHALL BE PLACED WITHIN PROCESS FLOW STREAM THOUGH THREADED FITTING.
   5. VACUUM INDICATORS SHALL HAVE A MINIMUM RANGE OF 0 TO 100" WC WITH 4" WC INCREMENTS.

G. SUPPORT AND ANCHORS
   1. ABOVE GROUND PIPING SHALL BE SUPPORTED WITH UNISTRUT AND PIPE SUPPORTS AT ADEQUATE SPACING TO PREVENT PIPE SAG.
   2. THE BLOWER, COMPRESSOR, AND MOISTURE SEPARATOR MOUNT SHOULD BE MOUNTED AND ANCHORED PER MANUFACTURES SPECIFICATIONS.

END OF SECTION

PART 4 EXECUTION

INSTALLATION

A. INSTALL MATERIALS AND SYSTEMS IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS AND APPROVED SUBMITTALS. INSTALL MATERIALS IN PROPER RELATION WITH ADJACENT CONSTRUCTION AND WITH UNIFORM APPEARANCE FOR EXPOSED WORK. COORDINATE WITH WORK OF OTHER SECTIONS. COMPLY WITH APPLICABLE REGULATIONS AND CODE REQUIREMENTS. PROVIDE PROPER CLEARANCES FOR SERVICING.
B. CLEARLY LABEL AND TAG ALL COMPONENTS.
C. RESTORE DAMAGED FINISHES. CLEAN AND PROTECT WORK FROM DAMAGE.
D. SVE BLOWER
   1. INSTALL THE BLOWER MOTOR ASSEMBLIES IN COMPLIANCE WITH THE MANUFACTURER'S RECOMMENDATIONS, THE REFERENCED CODES, THE DRAWINGS, AND AS SPECIFIED BELOW.
E. WATER KNOCKOUT MOISTURE SEPARATOR
   1. ELEVATED PER DRAWINGS AND SPECIFICATIONS.
   2. PROVIDE TWO (2) FERNCO RUBBER COUPLERS WITH STAINLESS STEEL SLEEVES AT THE INLET AND OUTLET.
F. ELECTRICAL CONTROL PANELS
   1. ALL ELECTRICAL WIRING AND CONTROLS SHALL BE INSTALLED BY A LICENSED ELECTRICIAN QUALIFIED IN SYSTEM CONTROL WIRING. INSTALL IN ACCESSIBLE LOCATION. PROVIDE WIRING DIAGRAMS.

TESTING

A. FUNCTIONAL TESTS
   1. SVE BLOWER, AS COMPRESSOR, AND ALARM CONDITIONS SHALL BE STARTED AND TESTED IN THE PRESENCE OF THE ENGINEER.
   2. PERFORM EQUIPMENT FUNCTIONAL TESTS PER MANUFACTURER'S RECOMMENDED PROCEDURES IN THE PRESENCE OF THE DESIGN ENGINEER.
   3. PRESSURE TEST ALL PIPING IN THE PRESENCE OF THE ENGINEER. ALL SYSTEM PIPING SHALL BE PRESSURE TESTED UNDER THE FOLLOWING CONDITIONS.
      a. VACUUM PIPING - PIPING FOR SVE SYSTEM SHALL MAINTAIN A VACUUM OF 6 PSIG AND LOOSE NO MORE THAN 0.10 PSIG IN 20 MINUTES.
      b. PRESSURE PIPING - PIPING FOR THE AS SYSTEM SHALL MAINTAIN A PRESSURE OF 40 PSIG AND LOOSE NO MORE THAN 0.60 PSIG IN 20 MINUTES
      c. EXISTING CONVEYANCE PIPE - PRIOR TO TRENCHING, CONDUCT PRESSURE TEST AS SPECIFIED IN THIS SECTION.

B. PERFORMANCE TESTS
   1. THE CONTRACTOR SHALL PERFORM A 48-HOUR COMPLETED SYSTEM PERFORMANCE TEST TO DEMONSTRATE INTEGRATED SYSTEM EQUIPMENT FUNCTIONS. PERFORM TEST IN ACCORDANCE WITH EQUIPMENT MANUFACTURER RECOMMENDATIONS AND IN ACCORDANCE WITH PLAN APPROVED BY THE ENGINEER. CONTRACTOR SHALL PROVIDE A QUALIFIED ELECTRICIAN TO BE PRESENT DURING ALL TESTING.

END OF SECTION

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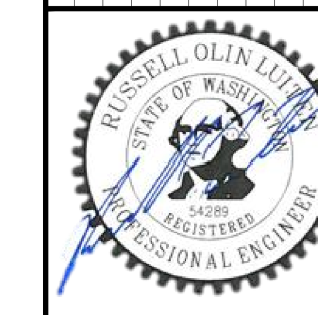

PREPARED BY:
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975 5TH AVENUE NORTHWEST
ISSAQUAH, WA 98027
(425) 295-0800
farallonconsulting.com

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CHS, INC.
763 WILLOUGHBY LANE
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SPECIFICATIONS

CHS AUBURN SITE
AUBURN, WASHINGTON
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SHEET

EN5.00

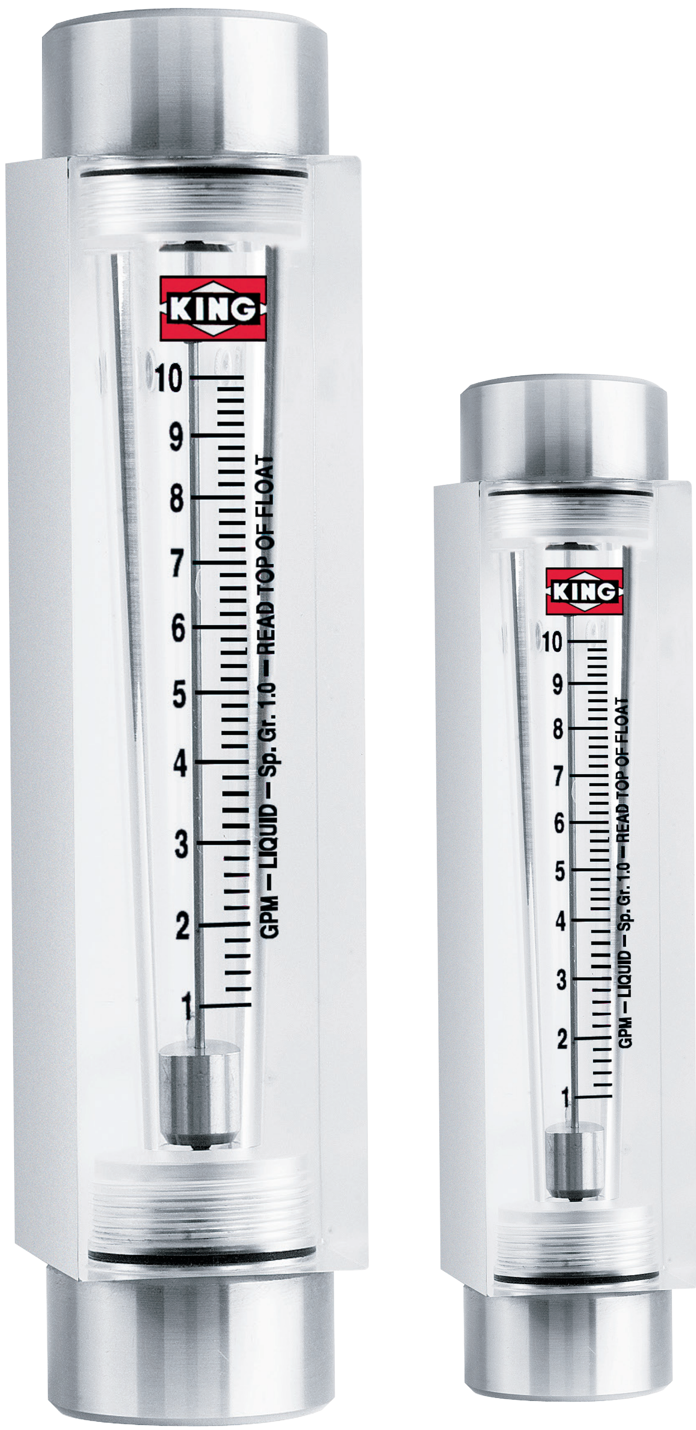
APPENDIX B
EQUIPMENT MANUALS AND COMPONENT SPECIFICATIONS

OPERATIONS AND MAINTENANCE MANUAL
AIR SPARGE AND SOIL VAPOR EXTRACTION SYSTEM
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

7510 / 7511 Series — Acrylic Tube

Acrylic block construction with direct reading scales have white screen printed backs to enhance scale readability. Connections are in-line for easy installation.



DESCRIPTION

Metering Tube	Machined cast acrylic
Internal Components	316L SS
Fitting Material	Standard: PVC Optional: 316L SS, brass
Inlet/Outlet Fittings	FNPT, vertical
O-Ring	Standard: EPR Optional: Buna N, Viton

PERFORMANCE

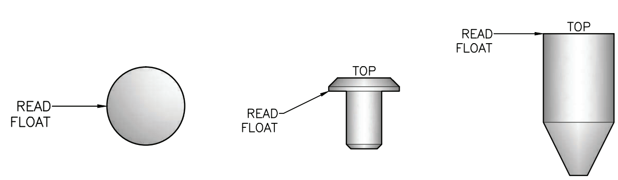
Capacities	Water 7 GPH to 20 GPM Air 2.6 SCFH to 60 SCFM
Scale	50mm, 65mm, 100mm, 127mm, 250mm direct reading
Accuracy	± 6% of full scale flow, 50mm scale ± 5% of full scale flow, 65mm scale ± 4% of full scale flow, 100mm scale ± 3% of full scale flow, 127mm scale ± 2% of full scale flow, 250mm scale
Turndown	10:1
Repeatability	3%, 50 mm scale 2%, 75 mm scale 2%, 100 mm scale 2%, 127 mm scale 0.5%, 250 mm scale
Maximum Temperature	Liquid 130° F (54° C) Gases 100° F (38° C)
Maximum Pressure	Water 125 psig Air 100 psig
Ambient Temperature	33° F to 125° F (1° C to 52° C)

OPTIONS

Certified Calibrations	Conform to ISA RP 16.6
Scales	Any volumetric unit

FLOATS

Options for rotameter float materials and designs extend flow ranges for different fluids within a given rotameter tube design.

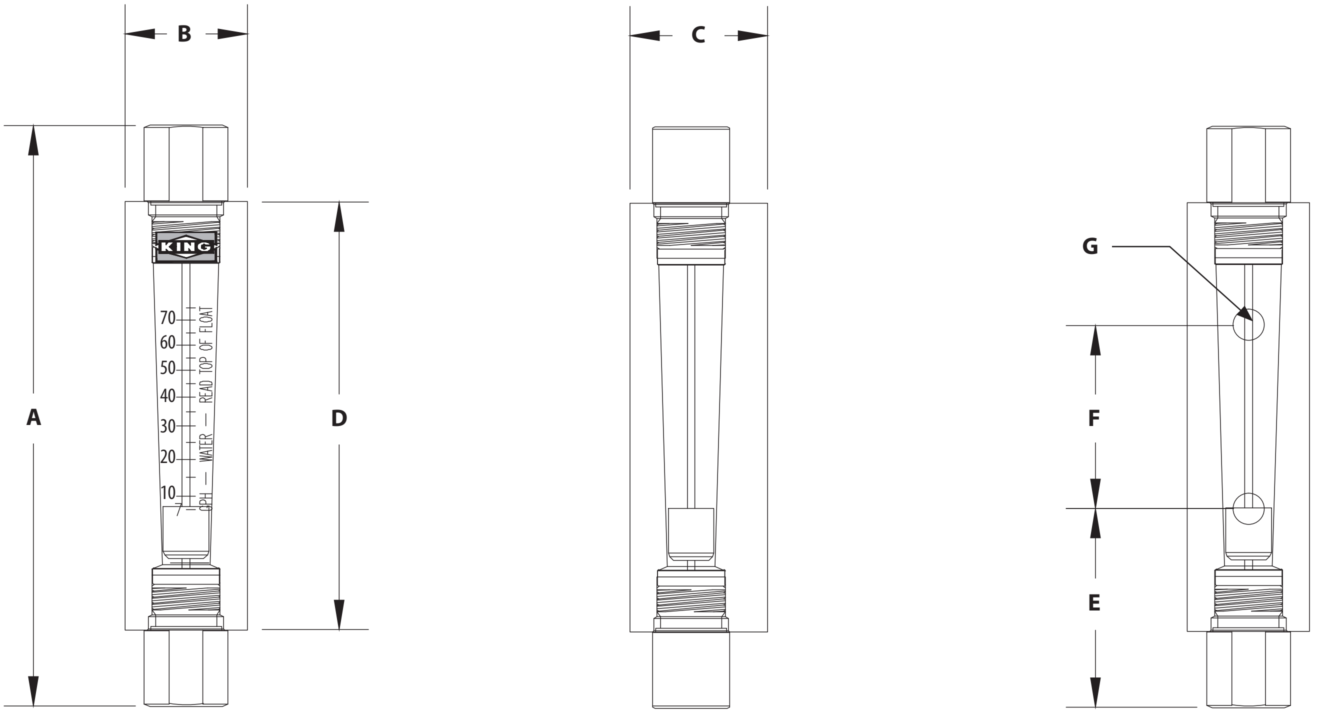


BL **GV** **SL**

CAUTION: *Meters used in gas service are designed to operate at 14.7 psia. Meters used in pressure gas service must be shielded using 3/8" polycarbonate to protect personnel and equipment in the event of tube failure.*

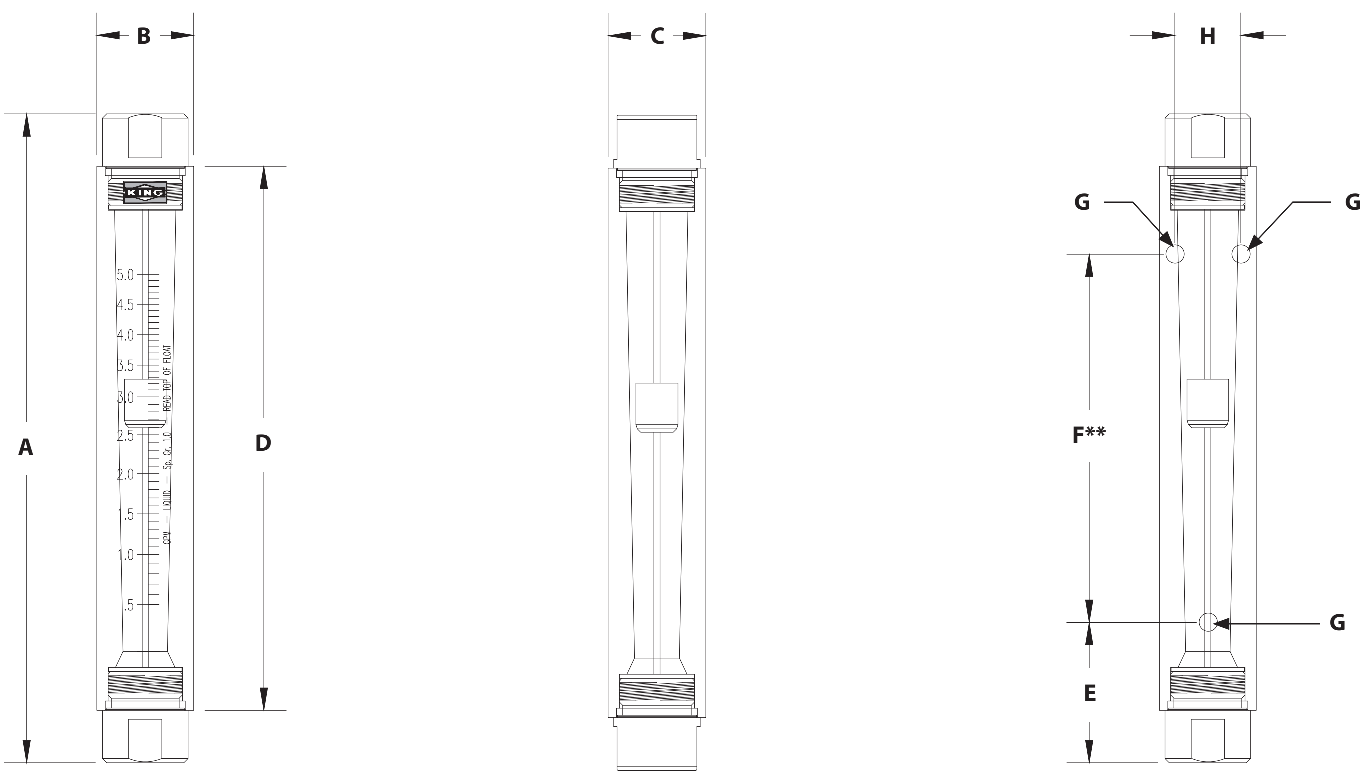
DIMENSION DIAGRAMS

2A Blocks



Front View Side View Back View

2B, 5B, 6A, and 7A Blocks



Front View Side View Back View

Water Order Number	Air Order Number	A	B	C	D	E	F	G	H	Connection Size
		Dimensions (Inches)								
Block #2A*, 50mm (2 Inch) Scale										
2A-02 - 2A-12	2A-01 - 2A-17	4.75	1	1.125	3.50	1	1.50	10-32		1/4″ FNPT*
Block #2B, 65mm (2 1/2 Inch) Scale										
2B-02 - 2B-08	2B-01 - 2B-07	6.50	1.375	1.375	5	1.25	2.50	10-32	.937	1/2″ FNPT
Block #5B, 127mm (5 Inch) Scale										
5B-02 - 5B-08	5B-01 - 5B-07	9.25	1.375	1.375	7.75	1.25	5.25	10-32	.937	1/2″ FNPT
Block #6A, 100mm (4 Inch) Scale										
6A-02 - 6A-06	6A-01 - 6A-03	8.375	1.78	1.812	6.625	1.312	4	10-32	1.25	1″ FNPT
Block #7A, 250mm (10 Inch) Scale										
7A-02 - 7A-08	7A-01- 7A-07	14.78	1.78	1.812	13	2.50	8	10-32	1.25	3/4″ FNPT

**Block 2A has 1/4″ FNPT with brass or stainless steel fitting, 1/4″ MNPT with PVC fittings*

*** 10-32 female thread (mounting screws not supplied)*

Order Number	Float	Flow Water	Order Number	Float	Flow Air
Block #2A, 50mm (2 Inch) Scale					
—		—	2A-01*	BL	2.6 SCFH
—		—	2A-03**	BL	5 SCFH
—		—	2A-05*	BL	10 SCFH
—		—	2A-07*	BL	20 SCFH
2A-02	SL	7 GPH	2A-09**	BL	30 SCFH
2A-04	SL	12 GPH	2A-11	SL	70 SCFH
2A-06	SL	22 GPH	2A-13	SL	100 SCFH
2A-08	SL	44 GPH	2A-15	SL	180 SCFH
2A-10	SL	60 GPH	2A-17	SL	4 SCFM
2A-12	SL	75 GPH	—		—

**These meters have glass ball floats.*

***These meters have stainless steel ball floats.*

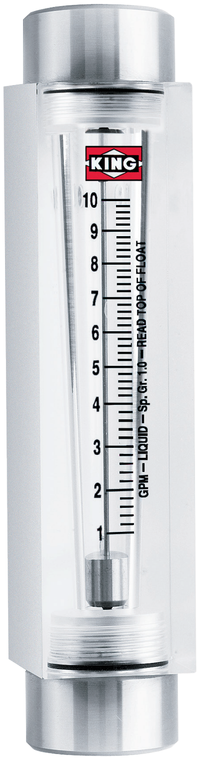
Order Number	Float	Flow Water	Order Number	Float	Flow Air
Block #2B, 65mm (2 1/2 Inch) Scale					
2B-02	GV	1 GPM	2B-01	GV	4 SCFM
2B-04	GV	2 GPM	2B-03	GV	8 SCFM
2B-06	SL	3.6 GPM	2B-05	SL	15 SCFM
2B-08	SL	5 GPM	2B-07	SL	20 SCFM
Block #5B, 127mm (5 Inch) Scale					
5B-02	GV	1 GPM	5B-01	GV	4.2 SCFM
5B-04	GV	2 GPM	5B-03	GV	8.2 SCFM
5B-06	SL	3.5 GPM	5B-05	SL	15 SCFM
5B-08	SL	5 GPM	5B-07	SL	21 SCFM
Block #6A, 100mm (4 Inch) Scale					
6A-02	SL	10 GPM	6A-01	SL	40 SCFM
6A-04	SL	15 GPM	6A-03	SL	60 SCFM
6A-06	SL	20 GPM	—		—
Block #7A, 250mm (10 Inch) Scale					
7A-02	GV	2 GPM	7A-01	GV	8 SCFM
7A-04	GV	3.5 GPM	7A-03	GV	14.8 SCFM
7A-06	GV	5 GPM	7A-05	GV	20 SCFM
7A-08	SL	10 GPM	7A-07	SL	42 SCFM

ORDERING:

Use the following guide to determine the specific product number you require.

7 5 1 ☐	☐	☐	☐☐☐☐
Meter Series	**Fitting Material**	**O-Ring Material**	**Order Number**
7510 - 2A, 6A, 7A	Brass - 1	EPR - 1	See Specifications
7511 - 2B, 5B	PVC - 2	Buna-N - 2	
	316L SS - 3	Viton - 3	

7510 – 7511 Series — Installation Instructions



FLOW METER LIMITED WARRANTY

Meters are warranted against defects in materials and workmanship to the original user for a period of thirteen (13) months from the date of factory shipment, provided the meter is installed, operated and maintained in accordance with King Instrument Company's instructions and recommendations.

This warranty does not apply if failure is caused or contributed to by any of the following: improper handling, improper storage, abuse, unsuitable application of the product, lack of reasonable and necessary maintenance, use exceeding suggested pressure and temperature maximums, improper packaging for return, or repairs made or attempted to be made by anyone other than King Instrument Company, Inc.

KING INSTRUMENT COMPANY, INC. MAKES NO WARRANTY AS TO THE FITNESS OF ITS PRODUCTS FOR SPECIFIC APPLICATIONS.

This warranty is valid for the original end-user only and does not apply to products that have been damaged or modified. This warranty is non-transferrable and is limited to replacement or repair. The liability of King Instrument Company arising out of its supply of the products, or their use, shall not in any case exceed the cost of correcting defects in the products as set forth above.

THIS WARRANTY IS A LIMITED WARRANTY AND SHALL BE IN LIEU OF ANY OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. THERE ARE NO OTHER WARRANTIES WHICH EXIST BEYOND THE DESCRIPTION OR FACE HEREOF.

IN NO EVENT SHALL KING INSTRUMENT COMPANY BE LIABLE FOR LOSS OF PROFITS, INDIRECT, CONSEQUENTIAL OR INCIDENTAL DAMAGES.

Products should be returned, prepaid, to King Instrument Company, Inc. with proof of purchase. Call factory for Return Merchandise Authorization (RMA) number and return instructions.

THIS IS IMPORTANT INFORMATION.
READ IT CAREFULLY BEFORE BEGINNING WORK.

1) Inspect meter for damage that may have occurred during shipping. Report any damage to the container to the freight carrier immediately.

2) Make sure your pressure, temperature, fluid and other requirements are compatible with the meter.

3) Select a suitable location for installation to prevent excess stress on the meter which may result from:

- a) Misaligned pipe.
- b) The weight of related plumbing.
- c) "Water Hammer" which is most likely to occur when flow is suddenly stopped as with quick closing solenoid operated valves. (If necessary, a surge chamber should be installed. This will also be useful in pressure start-up situations.)
- d) Thermal expansion of liquid in a stagnated or valve isolated system.
- e) Instantaneous pressurization which will stress the meter and could result in tube failure.

NOTE: In closed thermal transfer or cooling systems, install the meter in the cool side of the line to minimize meter expansion and contraction and possible fluid leaks at the threaded connections.

4) Handle the meter carefully during installation.

- a) Use an appropriate amount of teflon tape on external pipe threads before making connections. Do not use paste or stick type thread sealing products.
- b) Extreme caution should be exercised when using PVC solvent cement around Acrylic. Acrylic cannot tolerate PVC solvent cement and/or pipe dope. The fumes can cause crazing or cracking of the acrylic. If flowmeters are to be installed in a glued pipe configuration, install flowmeter after all glued fittings are dried and lines are purged of all fumes.
- c) Over tightening of plastic connections may result in fitting damage.

5) Install the meter vertically with the inlet port at the bottom.

6) End fitting must be held secure when installing pipe. Failure to do so can cause damage to the meter itself.

7) Meters with plastic fittings must be installed so that fittings are not made to support any part of the associated plumbing. In addition, meter frame should be fastened to bulkhead, panel or column.

8) Meters used in gas service should have suitable valves plumbed in at the inlet and outlet of the meter. These valves should be no more than 1-1/2 pipe diameters from the meter ports. The valve at the outlet should be used to create back pressure as required to prevent float bounce. It should be set initially and then left alone. The inlet valve should be used for throttling purposes. Depending on the installation, valves may not be essential, but they are most useful in many installations. Remember: To get a correct reading of flow in gas service, it is necessary to know the pressure right at the outlet of the meter (before the valve).

9) Pressure and temperature maximums must never be exceeded.

Maximum Non-Shock Pressure and Temperature		
Fluid	**Temperature**	**Pressure**
Water	130° F	125 psig
Air	100° F	100 psig
Ambient Temp. 33° F -125° F		

CAUTION

- 7510 / 7511 meters are not oxygen cleaned. Use with incompatible fluids may cause o-rings to swell and break.
- O-rings should be replaced if meter is disassembled after it has been in service.
- Extra caution must be exercised when meters are used in high pressure gas cylinder applications. Pressure regulators should be installed at the cylinder and at the inlet of the meter.
- Serious property damage and great personal injury could occur as the result of a meter misused or used in an unsuitable application.

CLEANING

Carefully remove the flowmeter from piping system. Remove the threaded outlet fitting and withdraw the float from the top. All necessary instrument components are now fully accessible for cleaning with a bottle brush and appropriate mild soap solution*. Before the meter is reassembled, inspect all parts for damage. O-rings should be replaced during meter maintenance and cleaning.

To reassemble, carefully guide the float back into the tube. When installing float/guide assembly make certain that the end of the guide fully engages the inlet and/or outlet float stop. Reinstall and tighten fittings in appropriate ports. Reinstall the instrument into the plumbing system after removing the old teflon tape (with a wire brush) and replacing with fresh teflon tape.

*Do not use cleaning agents that will damage float, tube or o-rings.

Meters should be cleaned with a mild soap solution. This will be an effective cleaner of rust stains. Caution must be used so that materials of construction are not damaged by cleaning solutions. Hard water deposits can be removed with 5% acetic acid solution (vinegar).

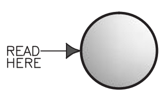
REPAIR

7510 / 7511 meters that require repair should be sent to the factory. Please call for a Return Merchandise Authorization (RMA) number and return instructions.

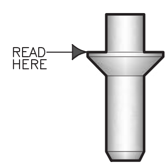
WARNING:

Pressure and temperature ratings are based on a study of the engineering data for particular materials used in construction and on the design of individual models. This information is supplemented by destructive test results. Meters with stainless enclosures must never be operated without shields securely in place. Meters exposed to difficult environments such as those created by certain chemicals, excessive vibration or other stress inducing factors could fail at or below the suggested maximums. Never operate meters above pressure and temperature maximums. It is strongly recommended that all meter installations utilize an appropriate pressure relief valve and/or rupture disc. The pressure settings and locations of these devices should be such that meters cannot be over pressurized. Meter failure could result in damage to equipment and serious personal injury. Always use suitable safety gear, including OSHA approved eye protection when working around meters in service. We are happy to pass along chemical compatibility information that has been published by the manufacturer's of raw materials used in our products; however, this information should not be construed as a recommendation made by King Instrument Company, Inc. for a specific application.

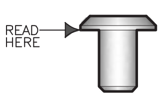
FLOAT TYPES AND ORIENTATIONS



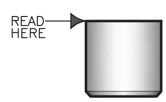
BL FlOAT



GS FLOAT



GV FLOAT



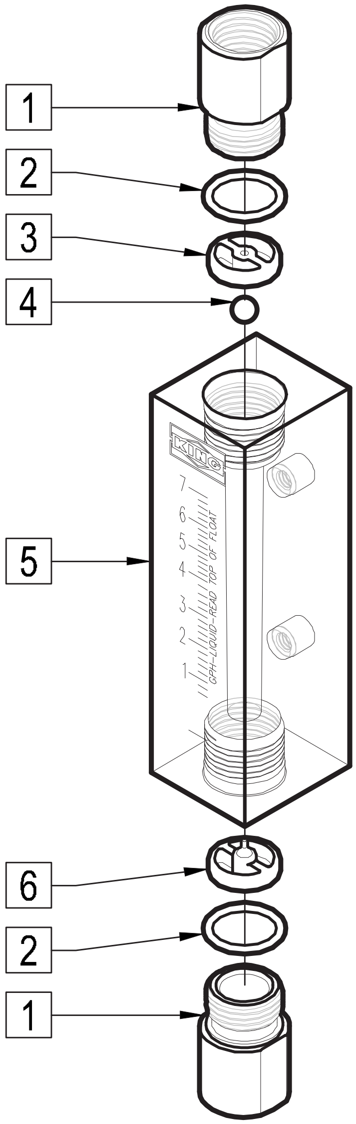
SL FLOAT

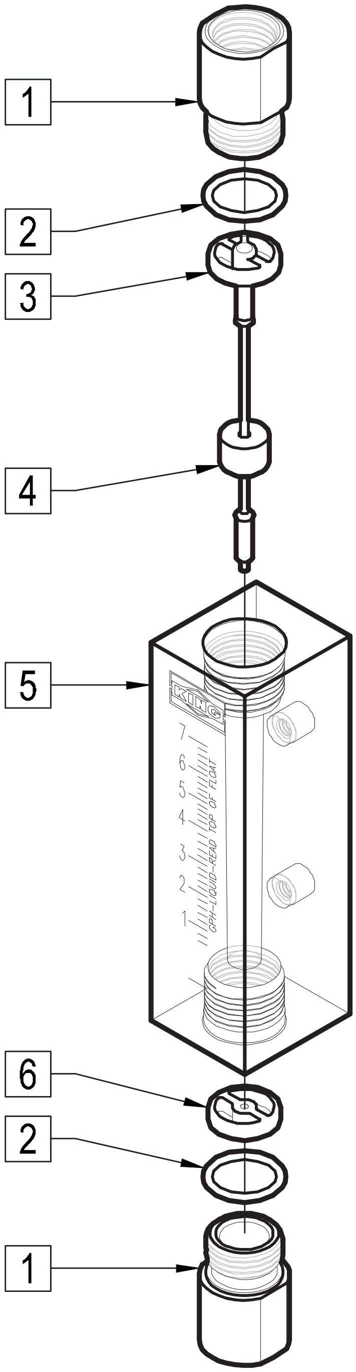
7510/7511 SERIES ASSEMBLY WITHOUT GUIDE ROD PARTS LIST:

1. End Fitting
2. End Fitting O-Ring
3. Outlet Float Stop
4. Float
5. Acrylic Meter Tube
6. Inlet Float Stop

7510/7511 SERIES ASSEMBLY WITH GUIDE ROD PARTS LIST:

1. End Fitting
2. End Fitting O-Ring
3. Outlet Float Stop
   Guide Rod Assembly
4. Float
5. Acrylic Meter Tube
6. Inlet Float Stop





Installation and Operating Instructions

Pressure Pumps
Mink MM 1104, 1144, 1102, 1142 BP

Busch LLC
516 Viking Drive
Virginia Beach, VA 23452
Phone: (757) 463-7800
Fax: (757) 463-7407

P/N 0872.918.119 / 1011

Table of Contents

Preface

Congratulations on your purchase of the Busch compressor. With watchful observation of the field's requirements, innovation and steady development Busch delivers modern vacuum and pressure solutions worldwide.

These operating instructions contain information for

- product description,
- safety,
- transport,
- storage,
- installation and commissioning,
- maintenance,
- overhaul,
- troubleshooting and
- spare parts

of the compressor.

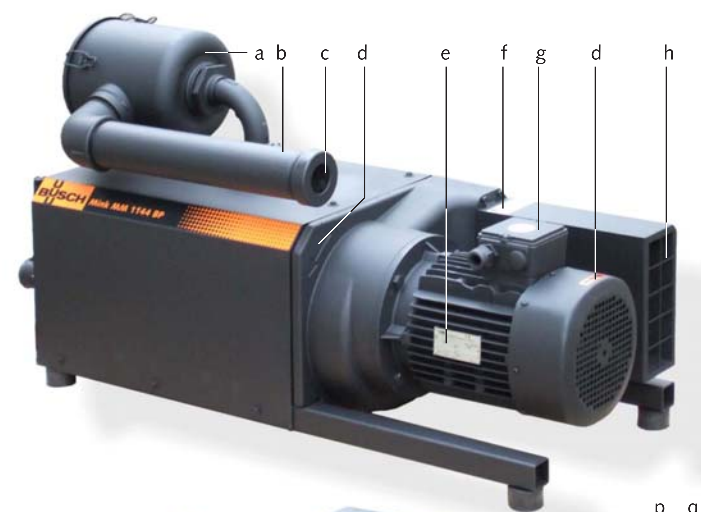
Version drive with integrated frequency inverter:

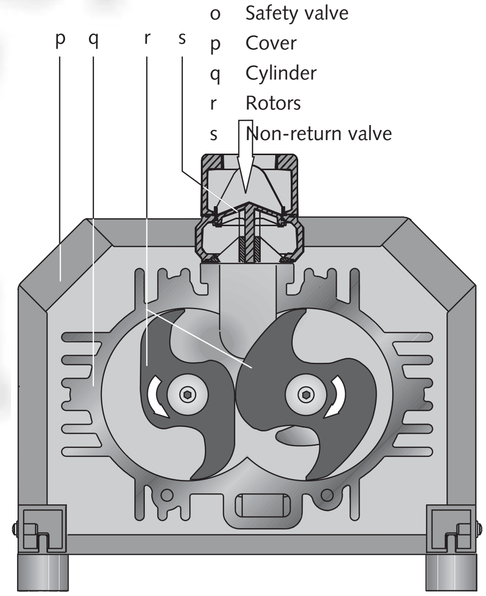
The drive with integrated frequency inverter is subject to a separate instruction manual.

For the purpose of these instructions, "handling" the compressor means the transport, storage, installation, commissioning, influence on operating conditions, maintenance, troubleshooting and overhaul of the compressor.

Prior to handling the compressor these operating instructions shall be read and understood. If anything remains to be clarified please contact your Busch representative!

Keep these operating instructions and, if applicable, other pertinent operating instructions available on site.





a Inlet air filter
b Inlet silencer
c Gas inlet
d Directional arrows
e Nameplate, drive motor
f Nameplate, compressor
g Terminal box
h Cooling air outlet
i Oil sight glass
j Oil drain plug
k Eye bolt
l Cooling air inlet
m Position of condensate drain cock (optional for version “Aqua”)
n Pressure connection
o Safety valve
p Cover
q Cylinder
r Rotors
s Non-return valve

Product Description

Use

The compressor is intended for

– the compression

of

– air and other dry, non-aggressive, non-toxic and non-explosive gases

Conveying media with a lower or higher density than air leads to an increased thermal and/or mechanical load on the compressor and is permissible only after prior consultation with Busch.

Max. allowed temperature of the inlet gas: 40 °C

Standard-version:

The gas shall be free from vapours that would condensate under the temperature and pressure conditions inside the compressor.

Version “Aqua”:

The compressor features the corrosion protection coating CPC and is capable of conveying water vapour (➔ page 8: Conveying Condensable Vapours). Conveyance of other vapours shall be agreed upon with Busch. Conveyance of water or other liquids in liquid phase increases the power consumption and shall therefore be avoided (risk of drive overload).

The compressor is intended for the placement in a non-potentially explosive environment.

The compressor is thermally suitable for continuous operation (100 percent duty).

Max. permissible number of startings per hour: 12

The maximum allowed pressure on the pressure connection (n) is 0.7 ... 2.0 barg (the nameplate of the compressor indicates the valid pressure). By means of process control and/or pressure relief valves it must be made sure that the maximum allowed pressure will not be exceeded.

As a rule ambient pressure must be present at the gas inlet. Deviations are indicated on the nameplate of the compressor.

The safety valve (o) on the compressor protects the compressor against overload only. It is **no** pressure limiting device in terms of EN 1012-1 for the pressure system. It is not designed for frequent use and must therefore not be used as a system pressure regulating valve.

Principle of Operation

The compressor works on the claw principle.

The components are dimensioned such, that on the one hand there is never contact between the two claws or between a claw and the cylinder, on the other hand the gaps are small enough to keep the clearance loss between the chambers low.

In order to avoid the suction of dust, the compressor is equipped with an air filter (a) on the gas inlet.

In order to avoid the suction of solids, the compressor is equipped with a screen in the gas inlet.

In order to avoid reverse rotation after switching off, the compressor is equipped with a non-return valve (s).

The compressor compresses the inlet gas absolutely oil-free. A lubrication of the pump chamber is neither necessary nor allowed.

Cooling

The compressor is cooled by

– radiation of heat from the surface of the compressor
– the air flow from the fan wheel of the drive motor
– the process gas
– the air flow from the fan wheel on the shaft of the compressor

Start Controls

The compressor comes without start controls. The control of the compressor is to be provided in the course of installation.

Safety

Intended Use

Definition: For the purpose of these instructions, “handling” the compressor means the transport, storage, installation, commissioning, influence on operating conditions, maintenance, troubleshooting and overhaul of the compressor.

The compressor is intended for industrial use. It shall be handled only by qualified personnel.

The allowed media and operational limits (→ page 3: Product Description) and the installation prerequisites (→ page 5: Installation Prerequisites) of the compressor shall be observed both by the manufacturer of the machinery into which the compressor is to be incorporated and by the operator.

The maintenance instructions shall be observed.

Prior to handling the compressor these installation and operating instructions shall be read and understood. If anything remains to be clarified please contact your Busch representative!

Safety Notes

The compressor has been designed and manufactured according to state-of-the-art methods. Nevertheless, residual risks may remain. These operating instructions highlight potential hazards where appropriate. Safety notes are tagged with one of the keywords DANGER, WARNING and CAUTION as follows:

DANGER

Disregard of this safety note will always lead to accidents with fatal or serious injuries.

WARNING

Disregard of this safety note may lead to accidents with fatal or serious injuries.

CAUTION

Disregard of this safety note may lead to accidents with minor injuries or property damage.

Noise Emission

For the sound pressure level in free field according to EN ISO 2151 → page 19: Technical Data.

CAUTION

The compressor emits noise of high intensity in a narrow band.

Risk of damage to the hearing.

Persons staying in the vicinity of a non noise insulated compressor over extended periods shall wear ear protection.

Transport

Transport in Packaging

Packed on a pallet the compressor is to be transported with a forklift.

Transport without Packaging

In case the compressor is packed in a cardboard box with inflated cushions:

◆ Remove the inflated cushions from the box

In case the compressor is in a cardboard box cushioned with rolled corrugated cardboard:

◆ Remove the corrugated cardboard from the box

In case the compressor is laid in foam:

◆ Remove the foam

In case the compressor is bolted to a pallet or a base plate:

◆ Remove the bolting between the compressor and the pallet/base plate

In case the compressor is fastened to the pallet by means of tightening straps:

◆ Remove the tightening straps

CAUTION

Do not walk, stand or work under suspended loads.

- Make sure that the eyebolts are in faultless condition (replace damaged, e.g. bent eyebolts with a new ones)
- Make sure that the eyebolts are fully screwed in and tightened by hand
- Attach lifting gear securely to the eyebolts on the synchronising gear (k) and on the drive motor

In case the drive motor comes without an eyebolt or the eyebolt on the drive motor is located at an unfavourable position:

◆ Loop a belt/rope with suitable length and strength around the flange of the drive motor

- Attach the lifting gear to a crane hook with safety latch
- Lift the compressor with a crane

In case the compressor was bolted to a pallet or a base plate:

◆ Remove the stud bolts from the rubber feet

Storage

Short-term Storage

- Make sure that the gas inlet and the pressure connection are closed (leave the provided plugs in)
- Store the compressor

– if possible in original packaging,
– indoors,
– dry,
– dust free and
– vibration free

Conservation

In case of adverse ambient conditions (e.g. aggressive atmosphere, frequent temperature changes) conserve the compressor immediately. In case of favourable ambient conditions conserve the compressor if a storage of more than 3 months is scheduled.

- Make sure that all ports are firmly closed; seal all ports that are not sealed with PTFE-tape, gaskets or o-rings with adhesive tape

Note: VCI stands for “volatile corrosion inhibitor”. VCI-products (film, paper, cardboard, foam) evaporate a substance that condenses in molecular thickness on the packed good and by its electro-chemical properties effectively suppresses corrosion on metallic surfaces. However, VCI-products may attack the surfaces of plastics and elastomers. Seek advice from your local packaging dealer! Busch uses CORTEC VCI 126 R film for the overseas packaging of large equipment.

- Wrap the compressor in VCI film
- Store the compressor

– if possible in original packing,
– indoors,
– dry,
– dust free and
– vibration free.

For commissioning after conservation:

- Make sure that all remains of adhesive tape are removed from the ports
- Commission the compressor as described in the chapter Installation and Commissioning (➔ page 5)

Installation and Commissioning

Installation Prerequisites

CAUTION

In case of non-compliance with the installation prerequisites, particularly in case of insufficient cooling:

Risk of damage or destruction of the compressor and adjoining plant components!

Risk of injury!

The installation prerequisites must be complied with.

- Make sure that the integration of the compressor is carried out such that the essential safety requirements of the Machine Directive 2006/42/EC are complied with (in the responsibility of the designer of the machinery into which the compressor is to be incorporated; ➔ page 15: note in the EC-Declaration of Conformity)

Mounting Position and Space

- Make sure that the environment of the compressor is not potentially explosive
- Make sure that the following ambient conditions will be complied with:

– ambient temperature: 0 ... 40 °C
– ambient pressure: atmospheric

- Make sure that the environmental conditions comply with the protection class of the drive motor (according to the nameplate)
- Make sure that the compressor will be placed or mounted horizontally
- Make sure that the base for placement / mounting base is even
- Make sure that in order to warrant a sufficient cooling there will be a clearance of minimum 1 m between the compressor and nearby walls
- Make sure that no heat sensitive parts (plastics, wood, cardboard, paper, electronics) will touch the surface of the compressor
- Make sure that the installation space or location is vented such that a sufficient cooling of the compressor is warranted

CAUTION

During operation the surface of the compressor may reach temperatures of more than 70 °C.

Risk of burns!

- Make sure that the compressor will not be touched inadvertently during operation, provide a guard if appropriate
- Make sure that the sight glass (i, 76) of the synchronising gear will remain accessible

In case the synchronising gear oil change is planned to be carried out on location:

  - ◆ Make sure that the drain port (j, 80) and the filling port (72) of the synchronising gear will remain easily accessible

Gas Inlet

CAUTION

Intruding foreign objects or liquids can destroy the compressor.

In case the inlet gas can contain dust or other foreign solid particles:

  - ◆ Make sure that a suitable filter (5 micron or less) is installed upstream the compressor (included in scope of delivery)

The following guidelines for the suction line do not apply, if the air to be compressed is taken in right at the compressor.

- Make sure that the suction line fits to the gas inlet (c) of the compressor
- Make sure that the gas will be sucked through a vacuum-tight flexible hose or a pipe

In case of using a pipe:

  - ◆ Make sure that the pipe will cause no stress on the compressor’s connection, if necessary use an expansion joint

- Make sure that the line size of the suction line over the entire length is at least as large as the gas inlet (c) of the compressor

In case the length of the suction line exceeds 2 m it is prudent to use larger line sizes in order to avoid a loss of efficiency and an overload of the compressor. Seek advice from your Busch representative!

Version “Aqua”, if very humid process gases and/or adverse operating cycles bear the risk, that condensates remain in the compressor:

  - ◆ Provide a shut-off valve, a drip-leg and a drain cock in the suction line, so that condensates can be drained from the suction line
  - ◆ Provide a valve for the unthrottled suction of ambient air (ambient air valve) between the shut-off valve and the compressor (in order to dry the compressor after process end).
  - ◆ Make sure that the anti-pulsation chamber is equipped with a condensate drain cock (m) (optional; if the condensate drain cock is missing contact the Busch service)

- Make sure that the suction line does not contain foreign objects, e.g. welding scales

Pressure Connection

- Make sure that the pressure line fits to the pressure connection (n) of the compressor
- Make sure that the pressure connection is connected to a pressure-tight flexible hose or a pipe

- Make sure that the pressure line is designed for 2.0 barg and 250 °C

In case of using a pipe:

  - Make sure that the pipe will cause no stress on the compressor's connection, if necessary use an expansion joint

- Make sure that the line size of the pressure line over the entire length is at least as large as the pressure connection (n) of the compressor

In case the length of the pressure line exceeds 2 m it is prudent to use larger line sizes in order to avoid a loss of efficiency and an overload of the compressor. Seek advice from your Busch representative!

- Make sure that the pressure line either slopes away from the compressor or provide a liquid separator or a drip leg with a drain cock, so that no liquids can back up into the compressor

Electrical Connection / Controls

- Make sure that the stipulations acc. to the EMC-Directive 2004/108/EC and Low-Voltage-Directive 2006/95/EC as well as the EN-standards, electrical and occupational safety directives and the local or national regulations, respectively, are complied with (this is the responsibility of the designer of the machinery into which the compressor is to be incorporated; ➔ page 15: note in the EC-Declaration of Conformity).
- Make sure that the power supply for the drive motor is compatible with the data on the nameplate of the drive motor
- Make sure that an overload protection according to EN 60204-1 is provided for the drive motor
- Make sure that the drive of the compressor will not be affected by electric or electromagnetic disturbance from the mains; if necessary seek advice from the Busch service

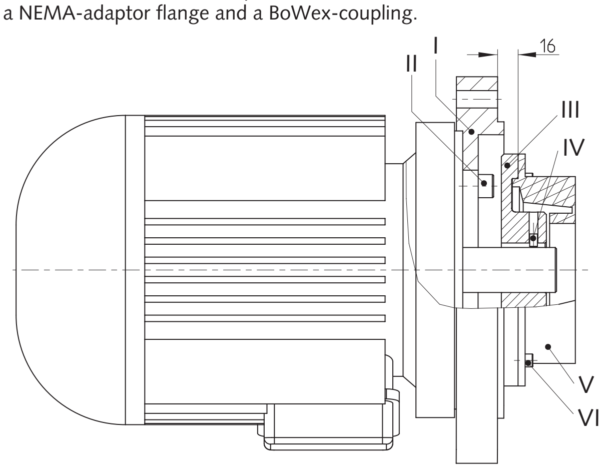
In case of mobile installation:

  - Provide the electrical connection with grommets that serve as strain-relief

Installation

Mounting a NEMA-Motor with BoWex-Coupling

For certain markets the compressor is available without motor, but with a NEMA-adaptor flange and a BoWex-coupling.



- Remove the NEMA-adaptor flange (I) from the compressor
- Pull the elastomer part (V) together with the hub (III) off the shaft of the compressor
- Mount the NEMA-adaptor flange (I) on the motor (the bolts (II) are not part of the Busch scope of delivery)
- Undo the cylinder screws (VI) and remove the elastomer part (V) from the hub (III)
- Make sure that the parallel key is inserted into the motor shaft
- Push the hub (III) onto the motor shaft such that the mounting face of the hub (III) will be located 16±1 mm before the mounting face of the NEMA-adaptor flange (I) (➔ sketch)
- Fasten the hub (III) on the motor shaft using the set screw (IV)
- Apply thread locking agent on the threads of the cylinder screws (VI)
- Mount the elastomer part (V) on the hub (III) with the cylinder screws (VI) and tighten the cylinder screws with 14 Nm
- Mount the motor on the compressor

Mounting

- Make sure that the installation prerequisites (➔ page 5) are complied with
- Set down or mount the compressor at its location

Checking Synchronising Gear Oil

The compressor is delivered with oil filled synchronising gear.

The level shall be slightly above the middle of the sight glass (i, 76).

- Check on the sight glass (i, 76) that the proper amount of oil is filled

Connecting Electrically

WARNING

Risk of electrical shock, risk of damage to equipment.

Electrical installation work must only be executed by qualified personnel that knows and observes the following regulations:
- IEC 364 or CENELEC HD 384 or DIN VDE 0100, respectively,
- IEC-Report 664 or DIN VDE 0110,
- BGV A2 (VBG 4) or corresponding national accident prevention regulation.

CAUTION

The connection schemes given below are typical. Depending on the specific order or for certain markets deviating connection schemes may apply.

Risk of damage to the drive motor!

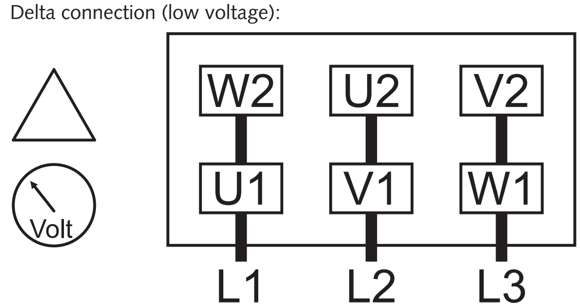
The inside of the terminal box shall be checked for drive motor connection instructions/schemes.

Note: For the connection of a drive with integrated frequency inverter see the separate operating instructions!

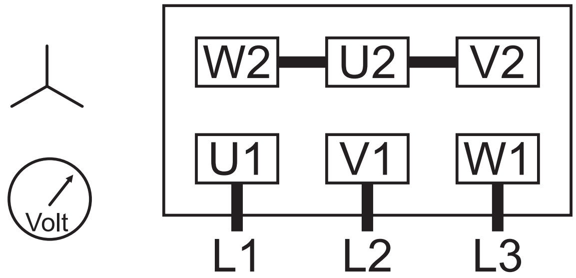
- Electrically connect the drive motor
- Connect the protective earth conductor

Connection Scheme Three-Phase Motor

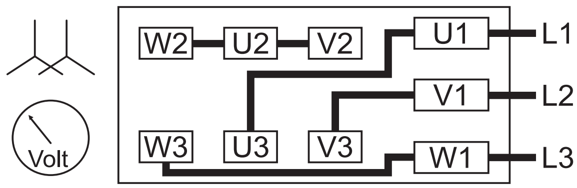
Delta connection (low voltage):



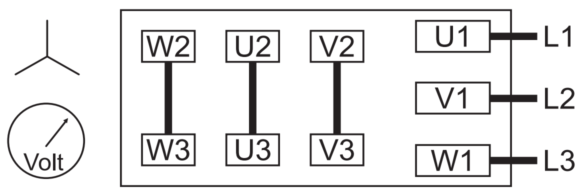
Star connection (high voltage):



Double star connection, multi-voltage motor (low voltage):



Star connection, multi-voltage motor (high voltage):



CAUTION

Operation in the wrong direction of rotation can destroy the compressor in short time.

Prior to starting-up it must be made sure that the compressor is operated in the proper direction (clockwise rotating field).

Version with three-phase motor:

- ◆ Determine the intended direction of rotation with the arrow (stuck on or cast)
- ◆ "Bump" the drive motor
- ◆ Watch the fan wheel of the drive motor and determine the direction of rotation just before the fan wheel stops

If the rotation must be changed:

- ◆ Switch any two of the drive motor wires (three-phase motor)

Connecting Lines/Pipes

- ● Connect the suction line

Installation without suction line:

- ◆ Make sure that the gas inlet (c) is open

- ● Connect the pressure line
- ● Make sure that all provided covers, guards, hoods etc. are mounted
- ● Make sure that cooling air inlets and outlets are not covered or obstructed and that the cooling air flow is not affected adversely in any other way

Recording of Operational Parameters

As soon as the compressor is operated under normal operating conditions:

- ● Measure the drive motor current and record it as reference for future maintenance and troubleshooting work

Operation Notes

Use

CAUTION

The compressor is designed for operation under the conditions described below.

In case of disregard risk of damage or destruction of the compressor and adjoining plant components!

Risk of injury!

The compressor must only be operated under the conditions described below.

The compressor is intended for

– the compression

of

– air and other dry, non-aggressive, non-toxic and non-explosive gases

Conveying media with a lower or higher density than air leads to an increased thermal and/or mechanical load on the compressor and is permissible only after prior consultation with Busch.

Max. allowed temperature of the inlet gas: 40 °C

Standard-version:

The gas shall be free from vapours that would condensate under the temperature and pressure conditions inside the compressor.

Version "Aqua":

The compressor features the corrosion protection coating CPC and is capable of conveying water vapour (➔ page 8: Conveying Condensable Vapours). Conveyance of other vapours shall be agreed upon with Busch. Conveyance of water or other liquids in liquid phase increases the power consumption and shall therefore be avoided (risk of drive overload).

The compressor is intended for the placement in a non-potentially explosive environment.

The compressor is thermally suitable for continuous operation (100 percent duty).

Max. permissible number of startings per hour: 12

The maximum allowed pressure on the pressure connection (n) is 0.7 ... 2.0 barg (the nameplate of the compressor indicates the valid pressure). By means of process control and/or pressure relief valves it must be made sure that the maximum allowed pressure will not be exceeded.

As a rule ambient pressure must be present at the gas inlet. Deviations are indicated on the nameplate of the compressor.

The safety valve (o) on the compressor protects the compressor against overload only. It is **no** pressure limiting device in terms of EN 1012-1 for the pressure system. It is not designed for frequent use and must therefore not be used as a system pressure regulating valve.

CAUTION

During operation the surface of the compressor may reach temperatures of more than 70 °C.

Risk of burns!

The compressor shall be protected against contact during operation, it shall cool down prior to a required contact or heat protection gloves shall be worn.

CAUTION

The compressor emits noise of high intensity in a narrow band.

Risk of damage to the hearing.

Persons staying in the vicinity of a non noise insulated compressor over extended periods shall wear ear protection.

- Make sure that all provided covers, guards, hoods etc. remain mounted
- Make sure that protective devices will not be disabled
- Make sure that cooling air inlets and outlets will not be covered or obstructed and that the cooling air flow will not be affected adversely in any other way
- Make sure that the installation prerequisites (➔ page 5: Installation Prerequisites) are complied with and will remain complied with, particularly that a sufficient cooling will be ensured

Conveying Condensable Vapours

Version "Aqua":

CAUTION

Due to the corrosion protection coating CPC the compressor is capable of conveying water vapour.

Very humid process gases and/or adverse operating cycles can lead to residual condensates, though, which cause corrosion.

If this is the case, it is necessary to counteract residual condensates by warming up the compressor, conveyance of ambient air after process end and regular draining of the anti-pulsation chamber (m).

- ◆ Close the shut-off valve in the suction line
- ◆ Warm up the compressor for approx. 10 minutes

At process start:

- ◆ Open the shut-off valve in the suction line

At the process end:

- ◆ Close the shut-off valve in the suction line
- ◆ Open the ambient air valve
- ◆ Operate the compressor for another approx. 10 minutes
- ◆ Close the ambient air valve

CAUTION

During operation of the compressor the anti-pulsation chamber is under pressure.

Risk of injury when the condensate drain cock is opened!

Drain condensate only when the compressor is shut down and the pressure connection (n) is vented to atmospheric pressure.

- ◆ Regularly drain condensate from the anti-pulsation chamber (m)

Maintenance

DANGER

In case the compressor conveyed gas that was contaminated with foreign materials which are dangerous to health, harmful material can reside in filters.

Danger to health during inspection, cleaning or replacement of filters.

Danger to the environment.

Personal protective equipment must be worn during the handling of contaminated filters.

Contaminated filters are special waste and must be disposed of separately in compliance with applicable regulations.

CAUTION

During operation the surface of the compressor may reach temperatures of more than 70 °C.

Risk of burns!

- Prior to disconnecting connections make sure that the connected pipes/lines are vented to atmospheric pressure

Maintenance Schedule

Note: The maintenance intervals depend very much on the individual operating conditions. The intervals given below shall be considered as starting values which should be shortened or extended as appropriate. Particularly heavy duty operation, such like high dust loads in the environment or in the process gas, other contaminations or ingress of process material, can make it necessary to shorten the maintenance intervals significantly.

Monthly:

- Make sure that the compressor is shut down and locked against inadvertent start up
- Check the inlet air filter (a), if necessary replace

In case of operation in a dusty environment:

- ◆ Clean as described under ➔ page 8: Every 6 Months:

Every 3 Months:

- Make sure that the compressor is shut down
- Check the level of the synchronising gear oil

The level shall be slightly above the middle of the sight glass (i, 76).

The level of the synchronising gear should stay constant over the lifetime of the oil. If the level does fall, the gear is leaky and the compressor requires repair (Busch service).

Every 6 Months:

- Make sure that the housing is free from dust and dirt, clean if necessary
- Make sure that the compressor is shut down and locked against inadvertent start up
- Remove the acoustic enclosure

Note: Make sure that the foam mats do **not** get soaked with water

- Clean the fan cowlings, fan wheels, the ventilation grilles and cooling fins
- Mount the acoustic enclosure

Every Year:

- Make sure that the compressor is shut down and locked against inadvertent start up
- Replace the inlet air filter (a)

- Check the inlet screen, clean if necessary

Note: As there is an inlet air filter upstream the inlet screen, the inlet screen should not show soiling. A soiled inlet screen indicates that the filter is either broken through or improperly inserted.

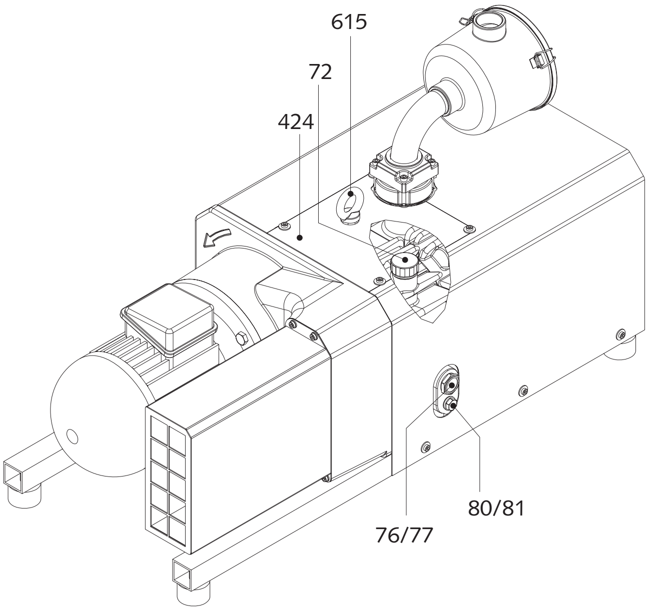
Every 20000 Operating Hours, At the Latest after 6 Years:

Note: The change interval of 20000 operating hours is valid for the gear oil Busch R 550 only. Other gear oils reduce the change interval.

- Change the synchronising gear oil

Changing Synchronising Gear Oil

- Make sure that the compressor is shut down and locked against inadvertent start up



- Remove the eyebolt (k)
- Remove the lid (424)
- Undo the venting valve (72) for venting
- Place a drain tray underneath the drain plug (j, 80)
- Open the drain plug (j, 80) and drain the oil
- Make sure that the seal ring on the drain plug (j, 80) is serviceable, replace if necessary
- Firmly reinsert the drain plug (j, 80) together with the seal ring
- Remove the venting valve (72) completely
- Fill in new gear oil until the level is slightly above the middle of the sight glass (i, 76)
- Make sure that the seal ring on the venting valve (72) is undamaged, if necessary replace the venting valve (72)
- Firmly reinsert the venting valve (72) together with the seal ring
- Mount the lid (424)
- Reinsert the eyebolt (k)
- Dispose of the used oil in compliance with applicable regulations

Overhaul

CAUTION

In order to achieve best efficiency and a long life the compressor was assembled and adjusted with precisely defined tolerances.

This adjustment will be lost during dismantling of the compressor.

It is therefore strictly recommended that any dismantling of the compressor that is beyond of what is described in this manual shall be done by Busch service.

DANGER

In case the compressor conveyed gas that was contaminated with foreign materials which are dangerous to health, harmful material can reside in pores, gaps and internal spaces of the compressor.

Danger to health during dismantling of the compressor.

Danger to the environment.

Prior to shipping the compressor shall be decontaminated as good as possible and the contamination status shall be stated in a "Declaration of Contamination" (form downloadable from www.busch-vacuum.com).

Busch service will only accept compressors that come with a completely filled in and legally binding signed "Declaration of Contamination" (form downloadable from www.busch-vacuum.com).

Removal from Service

Temporary Removal from Service

- Prior to disconnecting pipes/lines make sure that all pipes/lines are vented to atmospheric pressure

Recommissioning

- Observe the chapter Installation and Commissioning (➔ page 5)

Dismantling and Disposal

DANGER

In case the compressor conveyed gas that was contaminated with foreign materials which are dangerous to health, harmful material can reside in pores, gaps and internal spaces of the compressor.

Danger to health during dismantling of the compressor.

Danger to the environment.

During dismantling of the compressor personal protective equipment must be worn.

The compressor must be decontaminated prior to disposal.

- Drain the oil
- Make sure that materials and components to be treated as special waste have been separated from the compressor
- Make sure that the compressor is not contaminated with harmful foreign material

According to the best knowledge at the time of printing of this manual the materials used for the manufacture of the compressor involve no risk.

- Dispose of the used oil in compliance with applicable regulations
- Dispose of the compressor as scrap metal

Troubleshooting

WARNING

Risk of electrical shock, risk of damage to equipment.

Electrical installation work must only be executed by qualified personnel that knows and observes the following regulations:
- IEC 364 or CENELEC HD 384 or DIN VDE 0100, respectively,
- IEC-Report 664 or DIN VDE 0110,
- BGV A2 (VBG 4) or equivalent national accident prevention regulation.

CAUTION

During operation the surface of the compressor may reach temperatures of more than 70 °C.

Risk of burns!

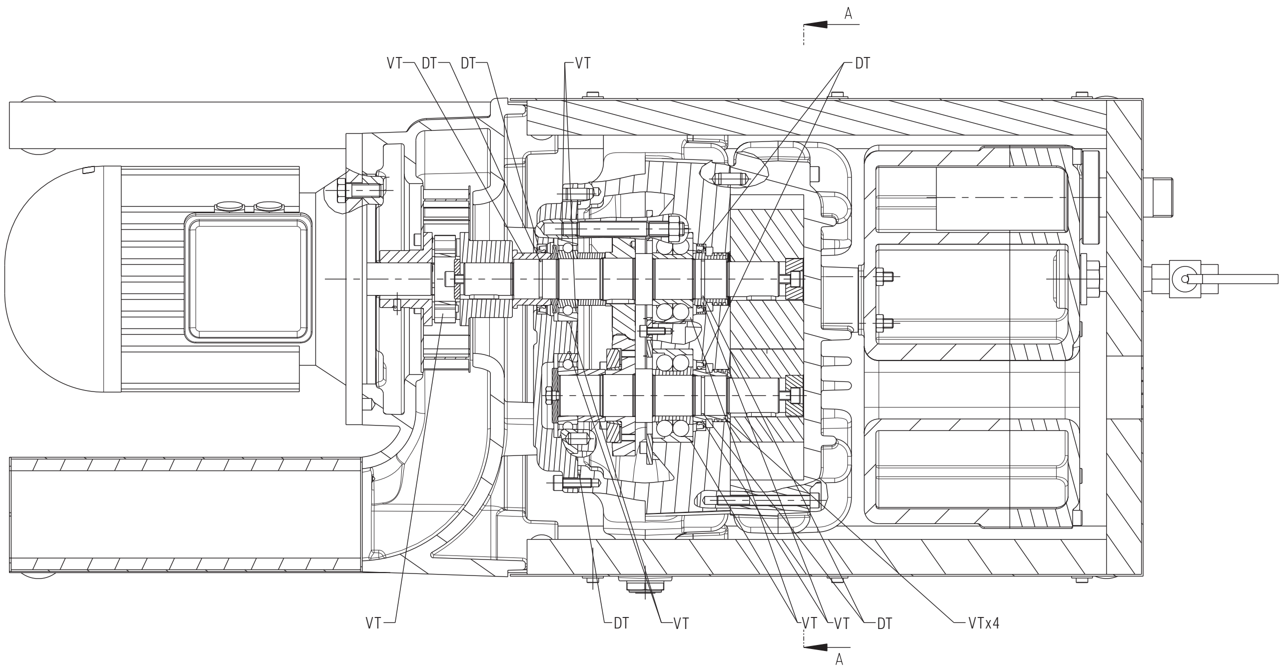
Let the compressor cool down prior to a required contact or wear heat protection gloves.

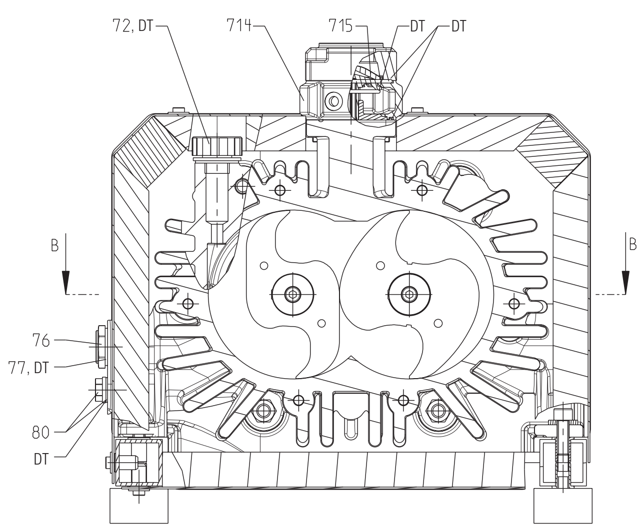
Problem	Possible Cause	Remedy
The compressor does not reach the usual pressure The drive motor draws a too high current (compare with initial value after commissioning) Filling the system takes too long Building up pressure in the system takes too long	The pressure system or pressure line is not leak-tight	Check the hose or pipe connections for possible leak
	The pressure relief valve/regulating system is misadjusted or defective	Adjust, repair or replace, respectively
	The screen in the gas inlet (c) is partially clogged	Clean the screen If cleaning is required too frequently install a filter upstream
	The filter (a) on the gas inlet (c) is partially clogged	Clean or replace the inlet air filter (a), respectively
	Partial clogging in the suction, discharge or pressure line	Remove the clogging
	Long suction, discharge or pressure line with too small diameter	Use larger diameter
	The valve disk of the inlet non-return valve is stuck in closed or partially open position	Disassemble the inlet, clean the screen and the valve (s) as required and reassemble
	Internal parts are worn or damaged	Repair the compressor (Busch service)
The compressor does not start	The drive motor is not supplied with the correct voltage or is overloaded	Supply the drive motor with the correct voltage
	The drive motor starter overload protection is too small or trip level is too low	Compare the trip level of the drive motor starter overload protection with the data on the nameplate, correct if necessary In case of high ambient temperature: set the trip level of the drive motor starter overload protection 5 percent above the nominal drive motor current
	One of the fuses has blown	Check the fuses
	The connection cable is too small or too long causing a voltage drop at the compressor	Use sufficiently dimensioned cable

	The compressor or the drive motor is blocked	Make sure the drive motor is disconnected from the power supply Remove the fan cover Try to turn the drive motor with the compressor by hand If the unit is still frozen: remove the drive motor and check the drive motor and the compressor separately If the compressor is blocked: Repair the compressor (Busch service)
	The drive motor is defective	Replace the drive motor (Busch service) (the proper function of the fan wheel requires the precise adjustment of the coupling on the motor shaft and on the pump shaft; therefore the motor can be mounted by the Busch service only)
The compressor is blocked	Solid foreign matter has entered the compressor	Repair the compressor (Busch service) Make sure the suction line is equipped with a screen If necessary additionally provide a filter
	Corrosion in the compressor from remaining condensate	Repair the compressor (Busch service) Check the process Observe the chapter Conveying Condensable Vapours (➔ page 8)
	Version with three-phase motor: The compressor was run in the wrong direction	Repair the compressor (Busch service) When connecting the compressor make sure the compressor will run in the correct direction (➔ page 6: Installation)
The drive motor is running, but the compressor stands still	The coupling between the drive motor and the compressor is defective	Replace the coupling element (the proper function of the fan wheel requires the precise adjustment of the coupling on the motor shaft and on the pump shaft; therefore the coupling element can be replaced by the Busch service only)
The compressor starts, but labours or runs noisily or rattles The drive motor draws a too high current (compare with initial value after commissioning)	Loose connection(s) in the drive motor terminal box Version with three-phase-motor: Not all drive motor coils are properly connected The drive motor operates on two phases only	Check the proper connection of the wires against the connection diagram (particularly on motors with six coils) Tighten or replace loose connections
	Version with three-phase motor: The compressor runs in the wrong direction	Verification and rectification ➔ page 5: Installation and Commissioning
	Foreign objects in the compressor Stuck bearings	Repair the compressor (Busch service)
The compressor runs very noisily	Defective bearings	Repair the compressor (Busch service)
	Worn coupling element	Replace the coupling element
	Low oil level in the synchronising gear	The synchronising gear is leaky Repair the compressor (Busch service)
	Synchronising gear damaged due to operation with low oil level	Repair the compressor (Busch service)
The compressor runs very hot	Insufficient air ventilation	Make sure that the cooling of the compressor is not impeded by dust/dirt Clean the fan cowlings, the fan wheels, the ventilation grilles and the cooling fins Install the compressor in a narrow space only if sufficient ventilation is ensured

	Ambient temperature too high	Observe the permitted ambient temperatures
	Temperature of the inlet gas too high	Observe the permitted temperatures for the inlet gas
	Insufficient gas transfer	Provide a pressure relief valve
	Mains frequency or voltage outside tolerance range	Provide a more stable power supply
	In case a pressure relief valve/regulating system is installed: The pressure relief valve/regulating system is misadjusted or defective	Adjust, repair or replace, respectively
	Partial clogging of filters or screens Partial clogging in the suction, discharge or pressure line	Remove the clogging
	Long suction, discharge or pressure line with too small diameter	Use larger diameter

Sectional Drawing





Spare Parts

Note: When ordering spare parts or accessories acc. to the table below please always quote the type ("Type") and the serial no. ("No") of the compressor. This will allow Busch service to check if the compressor is compatible with a modified or improved part.

The exclusive use of genuine spare parts and consumables is a prerequisite for the proper function of the compressor and for the granting of warranty, guarantee or goodwill.

Your point of contact for service and spare parts in the United Kingdom:

Busch (UK) Ltd.
Hortonwood 30-35
Telford
Shropshire
TF1 7YB
Tel: 01952 677 432
Fax: 01952 677 423

Your point of contact for service and spare parts in Ireland:

Busch Ireland Ltd.
A10-11 Howth Junction Business Centre
Kilbarrack, Dublin 5
Tel: +353 (0)1 8321466
Fax: +353 (0)1 8321470

Your point of contact for service and spare parts in the USA:

Busch Inc.
516-B Viking Drive
Virginia Beach, VA 23452
Tel: 1-800-USA-PUMP (872-7867)

Your point of contact for service and spare parts in Canada:

Busch Vacuum Technics Inc.
1740, Boulevard Lionel Bertrand
Boisbriand (Montréal)
Québec J7H 1N7
Tel: 450 435 6899
Fax: 450 430 5132

Your point of contact for service and spare parts in Australia:

Busch Australia Pty. Ltd.
30 Lakeside Drive
Broadmeadows, Vic. 3047
Tel: (03) 93 55 06 00
Fax: (03) 93 55 06 99

Your point of contact for service and spare parts in New Zealand:

Busch New Zealand Ltd.
Unit D, Arrenway Drive
Albany, Auckland 1311
P O Box 302696
North Harbour, Auckland 1330
Tel: 0-9-414 7782
Fax: 0-9-414 7783

Find the list of Busch companies all over the world (by the time of the publication of these installation and operating instructions) on ➔ page 20 (rear cover page).

Find the up-to-date list of Busch companies and agencies all over the world on the internet at **www.busch-vacuum.com**.

Pos.	Part	Qty	Part no.
72	Venting valve (=oil fill plug) with seal ring	1	0543 138 026
76	Sight glass	1	0583 000 001
77	Seal ring for sight glass	1	0480 000 271
80	Plug with magnet and seal ring	1	0415 134 870
81	Seal ring for plug with magnet	1	0482 137 352
714	Inlet flange, lower part, with non-return valve	1	0916 102 518
715	Screen	1	0534 000 018
—	Filter cartridge, paper, for inlet filter	1	0532 000 004
—	Safety valve (quote in your order also the ultimate working pressure of the compressor)	1	on request

Spare Parts Kits

Spare parts kit	Part no.
Overhaul kit (incl. set of seals, marking "VT" and "DT")	0993 138 031
Set of seals (marking "DT")	0990 138 032

Oil

Denomination	Busch R 550

EC-Declaration of Conformity

Note: This Declaration of Conformity and the CE-mark affixed to the nameplate are valid for the compressor within the Busch-scope of delivery. When this compressor is integrated into a superordinate machinery the manufacturer of the superordinate machinery (this can be the operating company, too) must conduct the conformity assessment process acc. to the Directive Machinery 2006/42/EC for the superordinate machine, issue the Declaration of Conformity for it and affix the CE-mark.

For maintenance of this Declaration of Conformity of Compressors without a drive may only be used a drive with a written consent of Busch.

We

Busch Produktions GmbH
Schauinslandstr. 1
79689 Maulburg
Germany

declare that compressors **MM 1104, 1144, 1102, 1142 BP**

in accordance with the European Directives:

- "Machinery" 2006/42/EC,
- "Electrical Equipment Designed for Use within Certain Voltage Limits" (so called "Low Voltage") 2006/95/EC,
- "Electromagnetic Compatibility" 2004/108/EC,

have been designed and manufactured to the following specifications:

Standard	Title of the Standard
Harmonised Standards	
EN ISO 12100-1 EN ISO 12100-2	Safety of machinery - Basic concepts, general principles of design - Part 1 and 2
EN ISO 13857	Safety of machinery - Safety distances to prevent hazard zones being reached by the upper and lower limbs
EN 1012-1 EN 1012-2	Compressors and vacuum pumps - Safety requirements - Part 1 and 2
EN ISO 2151	Acoustics - Noise test code for compressors and vacuum pumps - Engineering method (grade 2)
EN 60204-1	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
EN 61000-6-1 EN 61000-6-2	Electromagnetic compatibility (EMC) - Generic immunity standards
EN 61000-6-3 EN 61000-6-4	Electromagnetic compatibility (EMC) - Generic emission standards

Manufacturer	Person authorised to compile the technical file
	A. Riwe
Dr.-Ing. Karl Busch General director	**Andrej Riwe** Technical writer

Technical Data

For motor connection parameters see nameplate

Type	Frequency [Hz]	Ultimate working pressure* [bar (g)]	Nominal motor rating [kW]	Nominal speed [min⁻¹]	Volume flow [m³/h]	Sound pressure level (EN ISO 2151) with silencer, measured at +1.0 bar g [db(A)]	Weight [kg]	Ambient temperature range [°C]	Ambient pressure	Synchronising gear oil qty [l]	Synchronising gear oil filled ex-works
MM 1104 BP	50	1.2	2.2	1500	62	71	~185	0 ... 40	atmospheric	0.85	Busch R 550
			1.8				~190				
		1.8	3.0				~185				
			3.0				~195				
		2.0	4.0				~190 ... 195				
	60	0.8	2.2	1800	75	73	~185				
		1.4	3.4				~190				
		2.0	4.2				~195				
MM 1144 BP	50	0.8	2.2	1500	78	71	~185				
			3.0				~190				
		1.4	3.0				~185				
			4.0				~195				
		2.0	4.0				~190				
			4.5				~210				
	60	0.8	3.4	1800	96	73	~190				
		1.4	4.2				~195				
		2.0	5.3				~210				
MM 1102 BP	50	0.7	4.0	3000	105	78	~190				
			4.5				~210				
		1.4	5.5				~215				
			6.3				~240				
		2.0	7.5				~215 ... ~240				
	60	0.8	5.5	3600	135	81	~210				
		1.5	7.5				~240				
		2.0	9.6								
MM 1142 BP	50	0.8	5.5	3000	140	78	~220				
			6.3				~235				
		1.5	7.5				~215 ... ~235				
		2.0	11.0				~235 ... ~245				
	60	0.8	7.5	3600	175	81	~235				
		1.2	9.6								
		2.0	12.6								

*valid ultimate working pressure see nameplate

Busch – All over the World in Industry

www.busch-vacuum.com

Australia
Busch Australia Pty. Ltd.
30 Lakeside Drive
Broadmeadows, Vic. 3047
Tel: (03) 93 55 06 00
Fax: (03) 93 55 06 99

Austria
Busch Austria GmbH
Industriepark Nord
2100 Korneuburg
Tel: 02262 / 756 65-0
Fax: 02262 / 756 65-20

Belgium
Busch N.V./Busch SA
Kruinstraat 7
9160 Lokeren
Tel: (0)9 / 348 47 22
Fax: (0)9 / 348 65 35

Brazil
Busch do Brasil Ltda.
Rod. Edgard Máximo Zambotto, Km 64
13240-000 Jarinú-SP
Tel: (55) 11-4016 1400
Fax: (55) 11-4016 1077

Canada
Busch Vacuum Technics Inc.
1740, Boulevard Lionel Bertrand
Boisbriand (Montréal)
Québec J7H 1N7
Tel: 450 435 6899
Fax: 450 430 5132

China
Busch Vacuum (Shanghai) Co., Ltd
18 Bin Yang Road, Shanghai
China 200235
Tel: +86 21 6436 1919
Fax: +86 21 5031 5766

Czech Republic
Busch Vakuum s.r.o.
Pra ákova 10
619 00 Horní Heršpice
Brno
Tel.: +420 543 42 48 55
Fax: +420 543 42 48 56

Denmark
Busch Vakuumteknik A/S
Parallelvej 11
8680 Ry
Tel: +45 87 88 07 77
Fax: +45 87 88 07 88

Finland
Busch Vakuumteknik Oy
Sinikellonpolku 3
01300 VANTAA
Tel: 09 774 60 60
Fax: 09 774 60 666

France
Busch France S.A.
Parc Technologique
de Bois Chaland CE 2922
91029 Evry Cedex
Tel: 01 69 89 89 89
Fax: 01 60 86 16 74

Germany
Dr.-Ing. K. Busch GmbH
Schauinslandstr. 1
79689 Maulburg
Tel: (0 76 22) 6 81-0
Fax: (0 76 22) 6 81-194
e-mail: sec.bu@busch.de

Dr.-Ing. K. Busch GmbH
Niederlassung Nord
Ernst-Abbe-Str. 1-3
25451 Quickborn
Tel: (0 41 06) 7 99 67-0
Fax: (0 41 06) 7 99 67-77

Dr.-Ing. K. Busch GmbH
Niederlassung West
Nordring 35
64807 Dieburg
Tel: (0 60 71) 92 82-0
Fax: (0 60 71) 14 71

Dr.-Ing. K. Busch GmbH
Niederlassung Süd-Ost
Gewerbestraße 3
90579 Langenzenn
Tel: (09 01) 90 25-0
Fax: (09 01) 90 25-25

Dr.-Ing. K. Busch GmbH
Außenstelle Zella-Mehlis
Am Rain 11
98544 Zella-Mehlis
Tel: (0 36 82) 46 92 71
Fax: (0 36 82) 46 92 73

Ireland
Busch Ireland Ltd.
A10-11 Howth Junction Business Centre
Kilbarrack, Dublin 5
Tel: 00353 1 832 1466
Fax: 00353 1 832 1470

Italy
Busch Italia S.r.l.
Via Ettore Majorana, 16
20054 Nova Milanese
Tel: 0362 370 91
Fax: 0362 370 999

Japan
Nippon Busch K.K.
1-23-33, Megumigaoka
Hiratsuka City, Kanagawa
Japan 259-1220
Tel: 0463-50-4000
Fax: 0463-50-4004

Korea
Busch Korea Ltd.
392-1 Yangji-Ri, Yangji-Myun,
Yongin-si, Kyunggi-Do
Tel: 031) 321-8114
Fax: 031) 321 4330

Malaysia
Busch (Malaysia) Sdn Bhd.
6 Jalan Taboh 33/22
Shah Alam Technology Park
Section 33
40400 Shah Alam
Selangor D. E.
Tel: 03 5122 2128
Fax: 03 5122 2108

Netherlands
Busch B.V.
Pompmolenlaan 2
3447 GK Woerden
Postbus 2091
3440 DB Woerden
Tel: (0)348 - 462300
Fax: (0)348 - 422939

New Zealand
Busch New Zealand Ltd.
Unit D, Arrenway Drive
Albany, Auckland 1311
P O Box 302696
North Harbour, Auckland 1330
Tel: 0-9-414 7782
Fax: 0-9-414 7783

Norway
Busch Vakuumteknikk AS
Hestehagen 2
1440 Drøbak
Tel: 64 98 98 50
Fax: 64 93 66 21

Poland
Busch Polska Sp. z o.o.
Ul. Chopina 27
87800 Wtoctawek
Tel: (054) 2315400
Fax: (054) 2327076

Singapore
Busch Vacuum Singapore Pte Ltd
20 Shaw Road
#01-03 Ching Shine Building
Singapore 36 79 56
Tel: (65) 6 408 0866
Fax: (65) 6 288 0877

Spain
Busch Ibérica S.A.
C/. Penedès, 47-49
08192 Sant Quirze del Vallès
Tel: 93 721 77 77
Fax: 93 721 42 07

Sweden
Busch Vakuumteknik AB
Bråta Industriområde
435 33 Mölnlycke
Tel: 031 - 338 00 80
Fax: 031 - 338 00 89

Switzerland
Busch AG
Waldweg 22
4312 Magden
Tel: 061 / 845 90 90
Fax: 061 / 845 90 99

Taiwan
Busch Taiwan Corporation
8F, No.5, Lane 155, Sec. 3, Pei Shen Rd.
Shen Keng Hsiang,
Taipei Hsien,
Taiwan (222), R.O.C
Tel: (02) 2662 0775
Fax: (02) 2662 0796

Turkey
VAKUTEK
Emlak Kredi Ishani No: 179
81130 Üsküdar-Istanbul
Tel: (216) 310 0573
Fax: (216) 343 5126

United Kingdom
Busch (UK) Ltd
Hortonwood 30-35
Telford
Shropshire
TF1 7YB
Tel: 01952 677 432
Fax: 01952 677 423

USA
Busch LLC
516 Viking Drive
Virginia Beach, VA 23452
Tel: (757) 463-7800
Fax: (757) 463-7407

Busch Vacuum Pumps and Systems

BUSCH

Mink MM 1104 - 1142 BP

Mink claw compressors have been specially developed to provide reliable compression of air and other gases. Mink claw technology ensures efficient and constant supply of pressure up to 2.0 bar (g) for many industrial applications.

Clean compressed air
The gas is compressed in a non-contact and totally oil-free process due to the state-of-the-art claw technology. This dry compression means that the gas does not get contaminated and can be used in further processes without being filtered or cleaned.

Application-orientated
The performance of Mink claw compressors can be adapted between 0.7 and 2.0 bar (g) for each particular application through the drive selection. This enables an efficient generation of blast and compressed air.

Minimum maintenance effort
An additional benefit of claw technology is the virtually maintenance-free operation due to the oil-free, non-contact operating principle. The need for maintenance, such as the inspection or replacement of worn parts and operating fluids, is completely eliminated. Mink claw compressors are air-cooled.

The excellent reliability and long life cycle of Mink claw compressors are also a result of the oil-free and non-contacting compression. Volumetric flow and pressure remain consistently high throughout the life cycle of the compressor due to the wear-free operation. An ingenious silencing concept enables quiet operation.

Would you like to know more?

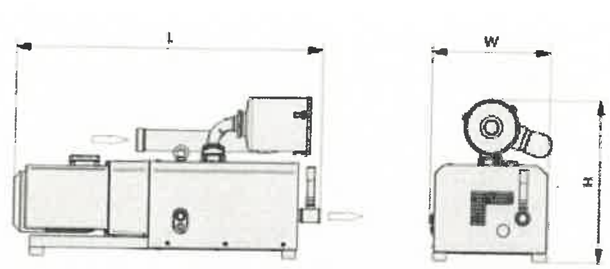
Contact us directly (Busch United States):
+1 757 463 7800

Technical specifications
With Mink compressors, two claw-shaped rotors turn in opposite directions inside the housing. Due to the shape of these claw rotors, the air or gas is sucked in, compressed and discharged. The claw rotors do not come into contact neither with

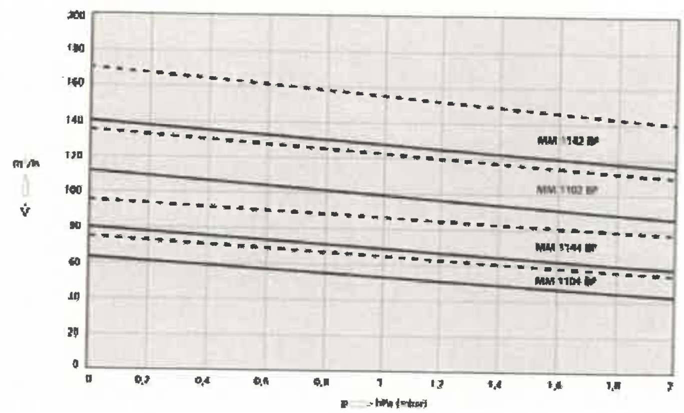
Mink MM 1104 - 1142 BP

Is there anything we can help you with?

each other nor with the cylinder in which they are rotating. Tight clearances between the claw rotors and the housing optimize the internal seal and guarantee a consistently high volume flow. A synchronization gearbox ensures exact synchronization of the claw rotors. A directly flange-mounted asynchronous motor with an efficiency class IE2 / IE3 drives mink compressors. Mink claw compressors are fitted standard with an inlet filter and a pressure relief valve. There are a total of eight different sizes of Mink claw compressors to choose from ranging from 62 to 500 m^3/h.



Volume flow Air at 70 °F. Tolerance: ± 10% ---- 60 Hz



US - 60 Hz

Technical data			Mink MM 1104 BP	Mink MM 1144 BP	Mink MM 1102 BP	Mink MM 1142 BP
Max. flow	SCFM	60 Hz	44	57	79	103
Weight approx. (without motor)	Lbs.		388	411	436	456
Max. pressure (BP)	PSIG	60 Hz	13.0 - 31.0	13.0 - 31.0	13.0 - 31.0	13.0 - 31.0
Nominal motor rating	kW (HP)	60 Hz	2.4 (3.2) - 4.2 (5.6)	3.4 (4.6) - 5.3 (7.1)	6.8 (9.1) - 9.5 (12.7)	9.5 (12.7) - 12.6 (16.9)
Nominal motor speed	RPM	60 Hz	1800	1800	3600	3600
Sound level (ISO 2151)	dB(A)	60 Hz	73	73	81	81*
Dimensions (L x W x H)	inches		42 $^{1}/_{2}$ x 16 $^{15}/_{16}$ x 23 $^{1}/_{4}$	46 $^{7}/_{16}$ x 16 $^{15}/_{16}$ x 23 $^{1}/_{4}$	46 $^{1}/_{4}$ x 16 $^{15}/_{16}$ x 23 $^{1}/_{4}$	4/ $^{7}/_{16}$ x 16 $^{15}/_{16}$ x 23 $^{1}/_{4}$
Gas outlet	NPT		1 ¼"	1 ¼"	1 ¼"	1 ¼"

* complies with accuracy class 2 at operating point of 1.0 bar(g)

Downloads

Mink MM 1104 - 1142 BP

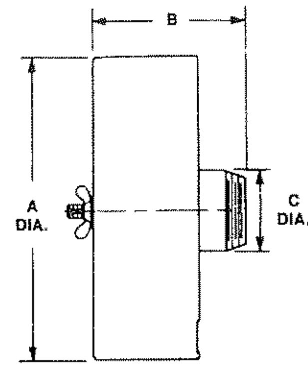
- Instruction Manual, ATEX version, gas tight english (3.8 MB pdf-File)
- Instruction Manual, Gas tight english (491.8 kB pdf-File)
- Instruction Manual, for Vbelt drive english (293.3 kB pdf-File)
- Instruction Manual, english (1.7 MB pdf-File)

Filtration Accessories

Blower Connection Key
NPT – American National Standard Taper Pipe Thread (Male)
NPSC – American National Standard Straight Pipe Thread for Coupling (Female)
SO – Slip On (Smooth – No Threads)

Inlet Filter (Single Connection)

Inlet Filters protect the blower and the air distribution system from dust, and other airborne particles and contaminants. Normally used in pressure systems.



SPECIFICATIONS:

HOUSING – Steel
MEDIA – Polyester
EFFICIENCY – 97-98% (8 to 10 micron particle size)
FILTER ELEMENT – Replaceable (see filter elements)
NOTE: "Z" MEDIA (1 to 3 micron particle size) available

Standard Media Filter P/N	Filter Element	Reference Blower Model	Connection Inlet	Dimensions (Inches) A	B	C	Z Media Filter Part Number
477411	271078	A	2.00 SO	4.56	6.12	2.00	
516466	515132	B	1.00 NPT	6.00	6.50	1.00	517865
515122	515132	C,D	1.50 NPT	6.00	6.50	1.50	517866
515123	515133	E	2.00 NPT	7.75	7.25	2.00	517867
515124	515134	E	2.00 NPT	10.00	12.25	2.00	517868
515125	515134	F	2.50 NPT	10.00	12.50	2.50	517869
515145	515134	G	3.00 NPT	10.00	13.00	3.00	517870
515151	515135	H	4.00 NPT	10.00	14.00	4.00	517871
516511	516515	H	6.00 NPT	16.00	15.00	6.00	517872

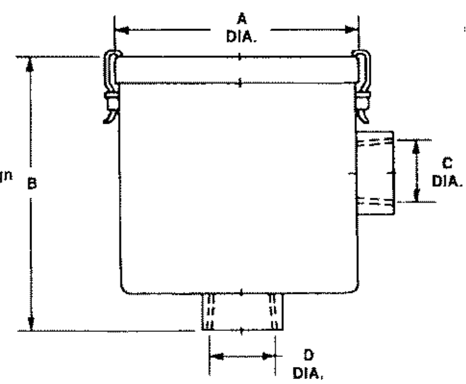
Inline Filter (Dual Connection)

Inline Filters protect the blower from harmful dust and other particles that may be drawn into the blower through the air distribution system. Normally used in vacuum systems.

SPECIFICATIONS:

HOUSING – Steel
MEDIA – Polyester
EFFICIENCY – 97-98% (8 to 10 micron particle size)
FILTER ELEMENT – Replaceable (see filter elements)
NOTE: "Z" MEDIA (1 to 3 micron particle size) available

Inline filter PN 271200 is a straight through design Inlet "C" is directly opposite of outlet "D"



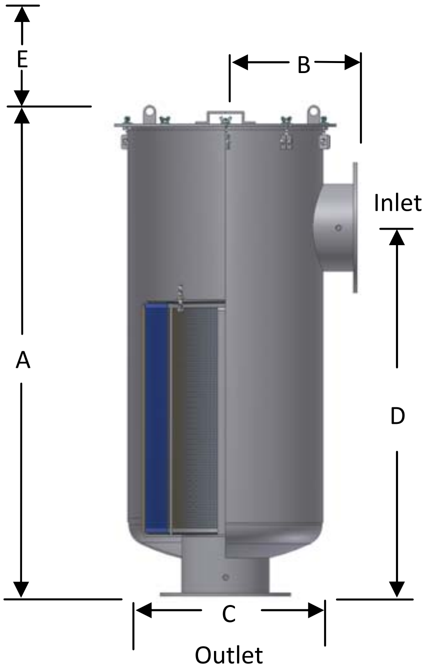
Standard Media Filter P/N	Filter Element	Reference Blower Model	Connection Inlet	Outlet	Dimensions (Inches) A	B	C	D	Z Media Filter Part Number
271200	271078	A	1.75 SO	2.00 SO	5.25	8.31	2.00	1.75	
516461	516434	B	1.00 NPSC-F	1.00 NPSC-F	7.25	6.50	1.00	1.00	517886
515254	516434	C,D	1.50 NPSC-F	1.50 NPSC-F	7.00	6.50	1.50	1.50	517887
515255	516435	E	2.00 NPSC-F	2.00 NPSC-F	8.00	10.25	2.00	2.00	517888
515256	516435	F	2.50 NPSC-F	2.50 NPSC-F	8.00	10.25	2.50	2.50	517889
516463*	515135	G	3.00 NPT-M	3.00 NPT-M	14.00	26.50	3.00	3.00	517890
516465*	515135	H	4.00 NPT-M	4.00 NPT-M	14.00	27.00	4.00	4.00	517891
517611*	516515	H	6.00 NPT-M	6.00 NPT-M	18.00	28.00	6.00	6.00	517892

* Feature 1/4" threaded tap for gauge connection on inlet and outlet

Rev. 2/04

Inlet Vacuum Filters

"L" Style Vacuum Filters
CSL Series 3"- 12" MPT, Flange



Features

- Heavy duty T bolts for easy maintenance
- Rugged all steel construction w/baked enamel finish
- Positive engagement O-ring seal system
- Inlet & outlet 1/4" gauge taps

Benefits

- Large dirty holding capacity and easy field cleaning, especially when mounted horizontally or inverted
- Low pressure drop construction

Technical Specifications

- Vacuum Rating: Gas tight o-ring seal
- Hydrostatically tested to 0.5 bar pressure for vacuum seal
- Temp (continuous): min -15°F (-26°C) max 220°F (104°C)
- Filter change out differential: 15-20" H2O over initial Δ P
- Polyester: 99%+ removal efficiency standard to 5 micron
- Paper: 99%+ removal efficiency standard to 2 micron

Options

- Straight-through configurations
- Various filter media
- Material/Finishes: Stainless steel, Epoxy coating
- Custom connections
- Flange faces free of paint
- Internal surfaces free of paint
- Lifting lugs
- Brackets for optional support legs
- Nameplate bracket

www.solbergmfg.com • sales@solbergmfg.com • Sales: 630.773.1363 • Fax: 630.773.1363

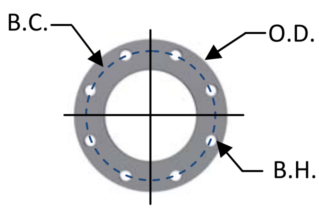
Flange Outlet Connections

Flange Inlet & Outlet	Assembly SCFM Rating	Assembly Part Number Polyester	Paper	Dimensions - inches A	B	C	D	Suggested Service HT. E	Approx. Wt. lbs	Replacement Element Part No. Polyester	Paper	Element SCFM Rating
4"	520	CSL-235P-400F	CSL-234P-400F	27 1/2	9	14	18 1/2	15	62	235P	234P	570
4"	520	CSL-335P-400F	CSL-334P-400F	27 1/2	9	14	18 1/2	20	64	335P	334P	800
5"	800	CSL-245P-500F	CSL-244P-500F	27 7/8	11	18 1/2	19 1/2	15	88	245P	244P	880
5"	800	CSL-345P-500F	CSL-344P-500F	27 7/8	11	18 1/2	19 1/2	20	90	345P	344P	1100
6"	1100	CSL-275P-600F	CSL-274P-600F	29 1/8	12	18 1/2	20 1/2	15	110	275P	274P	1100
6"	1100	CSL-375P-600F	CSL-374P-600F	29 1/8	12	18 1/2	20 1/2	20	113	375P	374P	1500
8"	1800	CSL-377P-800F	CSL-376P-800F	40	14	20 1/4	25 1/2	20	185	377P	376P	1825
10"	2900	CSL-685P-1000F	CSL-384P(2)-1000F*	59 13/16	16	24 1/4	45	33	380	685P	384P (2)	6600
12"	4950	CSL-485P(2)-1200F*	CSL-484P(2)-1200F*	70	16	24 1/4	57	25	465	485P (2)	484P (2)	9410

See Vacuum Filter Technical Data section for sizing guidelines.
* Denotes 2 elements stacked in housing.

Dimension tolerance ± 1/4"

125/150# Pattern Flg	Dimensions - inches O.D.	B.C.	B.H.	No. of Holes	Flange Thickness
4"	9	7 1/2	0.75	8	0.38
5"	10	8 1/2	0.88	8	0.38
6"	11	9 1/2	0.88	8	0.38
8"	13 1/2	11 3/4	0.88	8	0.38
10"	16	14 1/4	1	12	0.5
12"	19	17	1	12	0.5



All flanges are orientated "split center".

O.D.: Outside Dimension
B.C.: Bolt Circle
B.H.: Bolt Hole

Inlet Vacuum Filters

MPT Connections

MPT Inlet & Outlet	Assembly SCFM Rating	Assembly Part Number Polyester	Paper	Dimensions - inches A	B	C	D	Suggested Service HT. E	Approx. Wt. lbs	Replacement Element Part No. Polyester	Paper	Element SCFM Rating
3"	300	CSL-235P-300	CSL-234P-300	27 1/4	9	14	18 1/2	10	47	235P	234P	570
3"	300	CSL-335P-300	CSL-334P-300	27 1/4	9	14	18 1/2	15	50	335P	334P	800
4"	520	CSL-235P-400	CSL-234P-400	27 1/4	9	14	18 1/2	10	52	235P	234P	570
4"	520	CSL-335P-400	CSL-334P-400	27 1/4	9	14	18 1/2	15	55	335P	334P	800
5"	800	CSL-245P-500	CSL-244P-500	27 7/8	11	19	19 1/2	10	82	245P	244P	880
5"	800	CSL-345P-500	CSL-344P-500	27 7/8	11	19	19 1/2	15	88	345P	344P	1100
6"	1100	CSL-275P-600	CSL-274P-600	29 1/8	12	19	20 1/2	10	95	275P	274P	1100
6"	1100	CSL-375P-600	CSL-374P-600	29 1/8	12	19	20 1/2	15	97	375P	374P	1500

See Vacuum Filter Technical Data section for sizing guidelines.

Dimension tolerance ± 1/4"

Note: Model offerings and design parameters may change without notice. See www.solbergmfg.com for most current offering.

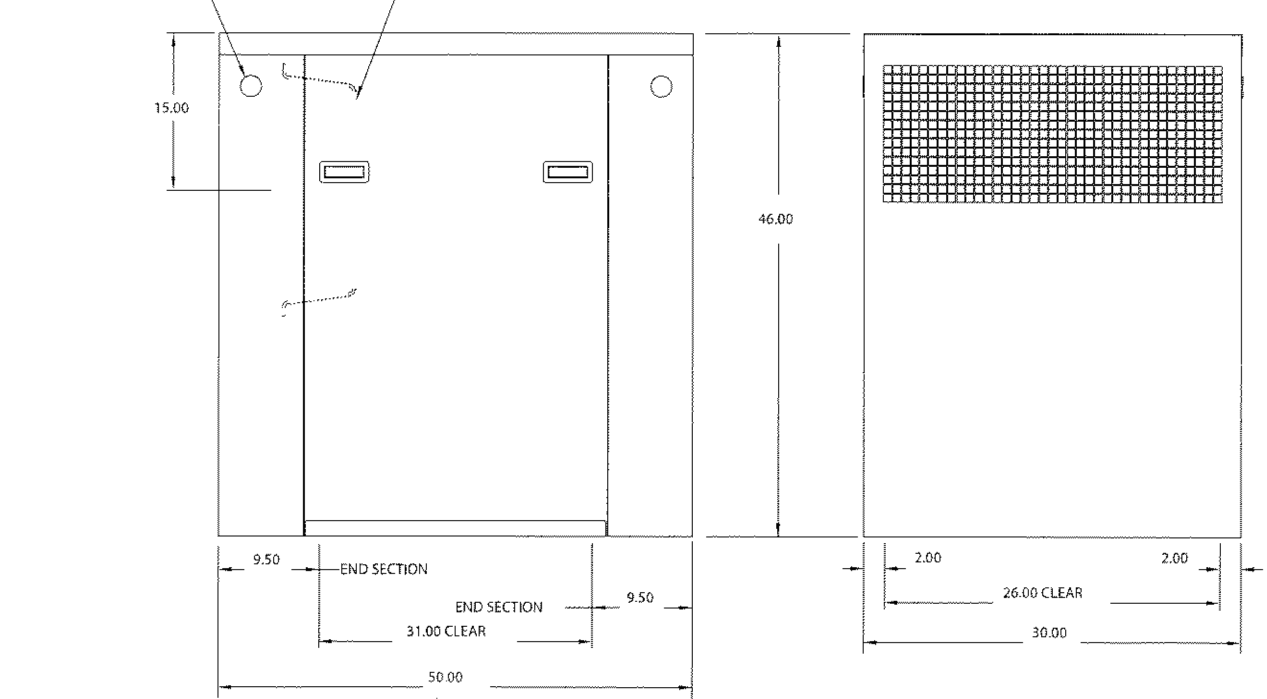
Frameless sound attenuating enclosures are a proven way to reduce regenerative blower mechanical noise when additional mufflers are just not enough. Additional enclosure options are available.

FEATURES:

- Excellent noise reduction (~10 dBa)
- Resistance to elements and aesthetic appearance
- Compact size for ease of installation
- Easy access for routine maintenance (removable roof and sidewalls)

SPECIFICATIONS:

- Roof, floor and walls: Galvanized 16 ga. carbon steel sheet metal
- Louvers and/or hood: Riveted aluminum
- Hardware: Chrome plated aluminum handles with stainless steel fasteners
- Latches: Over center galvanized with adjustable tension and padlock eye
- Sound attenuating material: 2" Rigid polyester foam with mylar facing (rated UL-94)
- Exterior finish: Polyurethane enamel
- Enclosure ventilation: 1/3 HP, 230/460V, 3-phase or 1-phase 50/60 Hz fan, TEFC or XP motors
- Fan guard: Nickel plated wire type



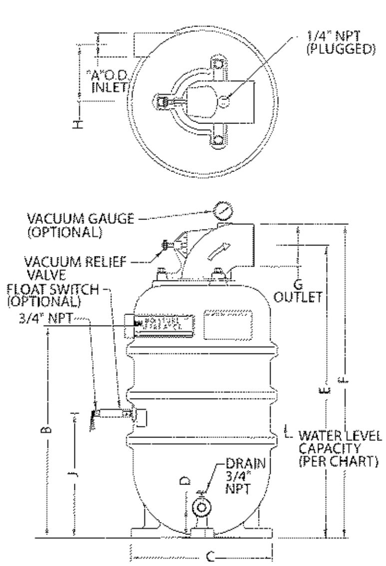
Part No. 552352 shown

Specification	Units	Part/Model Number	
		SAE30W72F	SAE36W72F
		552352	552353
Width	Inches	30	36
	mm	762	914.4
Blower Size	-	656, 707, 757, 808, 858, 909, 979, P9, S9	14, P13, S13, P15, S15
Height	Inches	46	52
	mm	1168.4	1320.8
Length	Inches	50	60
	mm	1270	1524

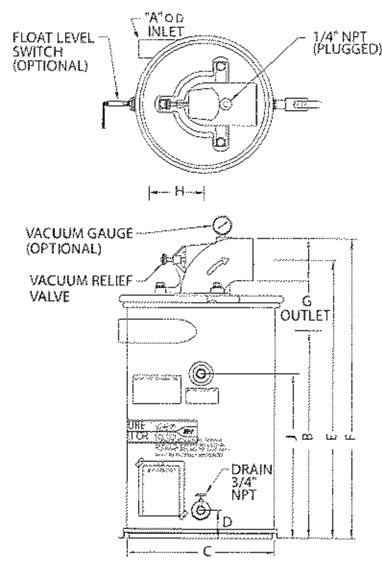
ROTRON®

By separating and containing entrained liquids, ROTRON'S™ moisture separator helps protect our regenerative blowers and the end treatment system from corrosion and mineralization damage. Recommended for all soil vacuum extraction applications.

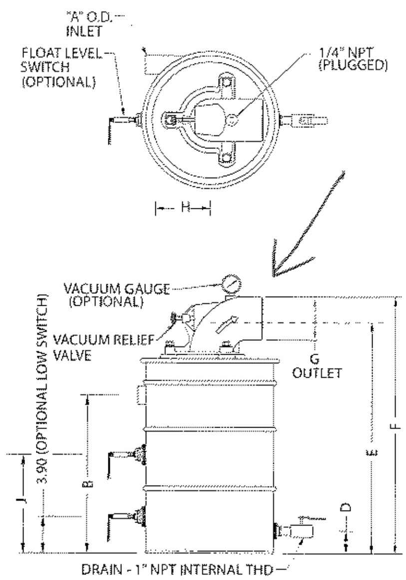
SPECIFICATIONS:
SEPARATION METHOD – High E ciency Cyclonic
RELIEF VALVE MATERIAL – Brass & Stainless Steel
FLOAT MATERIAL – Copper
FLOAT SWITCH – SPDT, Explosion-proof NEMA 7&9, 5 Amp max.



PLASTIC "P" DESIGN



METAL "D" DESIGN



METAL "B" DESIGN

Models without oat switch available. Metal MS200/ 300DS models are not the standard stocked, but are available.

		Part/Model Number							
		MS200PS	MS300PS	MS200DS	MS300DS	MS350BS	MS500BS	MS600BS	MS1000BS
Specification	Units	038519	038520	080086	080087	038357	080660	080659	038914
Dimension A	Inches	2.38	2.88	2.00	2.50	3.25	3.25	4.00	6.00
	mm	60.5	73.2	50.8	63.5	82.6	82.6	101.6	152.4
CFM Max.	CFM	200	300	200	300	350	500	600	1000
	m3/hr	340	510	340	510	595	850	1020	1700
Dimension B	Inches	22.46	22.46	22.12	22.12	28.00	28.00	27.00	31.00
	mm	570.5	570.5	561.8	561.8	711.2	711.2	685.8	787.4
Dimension C	Inches	16.00	16.00	16.75	16.75	23.00	23.00	23.00	27.00
	mm	406.4	406.4	425.5	425.5	584.2	584.2	584.2	685.8
Dimension D	Inches	3.25	3.25	2.75	2.75	4.00	4.00	4.00	4.00
	mm	82.6	82.6	69.9	69.9	101.6	101.6	101.6	101.6
Dimension E	Inches	31.05	31.05	27.92	27.92	37.25	37.37	37.37	47.32
	mm	788.7	788.7	709.2	709.2	946.2	949.2	949.2	1201.9
Dimension F	Inches	33.30	33.30	30.17	30.17	39.50	54.50	54.50	51.70
	mm	845.8	845.8	766.3	766.3	1003.3	1384.3	1384.3	1313.2
Dimension H	Inches	6	6.00	6.56	6.81	9.75	9.75	9.25	10.00
	mm	152.4	152.4	166.6	173	247.7	247.7	235	254
Dimension G	Inches	4.50 OD	4.50 D	4.50 D	4.50 OD	4.50 OD	6.63 ID	6.63 ID	8.62 OD
	mm	114.3	114.3	114.3	114.3	114.3	168.4	168.4	218.9
Dimension J	Inches	13.25	13.25	12.62	12.62	17.50	17.50	17.50	19.88
	mm	336.6	336.6	320.5	320.5	444.5	444.5	444.5	505
Drain Internal Thd	-	3/4	3/4	3/4	3/4	1	1	1	1
Shipping Weight	Lbs	42	42	42	42	82	95	96	150
	Kg	19.1	19.1	19.1	19.1	37.2	43.1	43.5	68

This document is for informational purposes only and should not be considered as a binding description of the products or their performance in all applications. The performance data on this page depicts typical performance under controlled laboratory conditions. AMETEK is not responsible for blowers driven beyond factory specified speed, temperature, pressure, flow or without proper alignment. Actual performance will vary depending on the operating environment and application. AMETEK products are not designed for and should not be used in medical life support applications. AMETEK reserves the right to revise its products without notification. The above characteristics represent standard products. For product designed to meet specific applications, contact AMETEK Technical & Industrial Products Sales department.

AMETEK TECHNICAL & INDUSTRIAL PRODUCTS
75 North Street, Saugerties, NY 12477
USA: +1 215-256-6601 - Europe: +44 (0) 845 366 9664 - Asia: +86 21 5763 1258
Customer Service Fax: +1 215.256.1338
www.ametektip.com

AMETEK® TECHNICAL & INDUSTRIAL PRODUCTS

ROTRON®

2.0 Moisture Separator™ Specifications

2.1 Duty

The moisture separator shall be designed for use in a soil vapor extraction system capable of continuous operation with a pressure drop of less than six inches of water at the rated flow of _____ SCFM. The separator shall be capable of operation under various inlet conditions randing from a fine mist to slugs of water with high efficiency.

2.2 Principle of Operation

The moisture separator shall incorporate cyclonic separation to remove entrained water. The separator must protect against an overflow by fail safe mechanical means. An electrical switch or contact(s) alone is not an acceptable means of protection against overflow, but is a good backup.

2.3 Construction

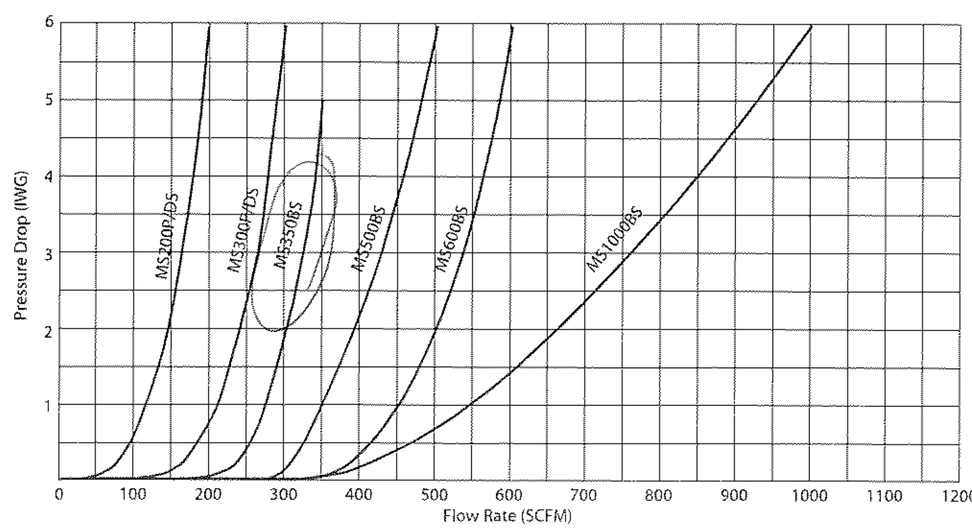
The body of the moisture separator shall be constructed of heavy wall plastic or heavy gauge cold rolled steel. The steel interior and exterior shall be epoxy (powder) coated to resist abrasion, corrosion, and chipping that might expose the surface. The inlet shall be tangentially located and welded to the body. The outlet port shall be constructed of PVC or cast aluminum alloy, flanged and sealed to the center of the top of the separator. The separator shall incorporate a non-sparking copper float ball and an adjustable relief valve to protect against overflow and overheating the blower.

For DR/EN/CP Blower Model	Selector Moisture Separator Model	Liquid-holding Capacity (gallons)	Inlet (OD)	Outlet	Max Vacuum Allow (IHG)
404 454 505 513	MS200PS	7	2.38		12
523 555 633 833	MS200DS	10	2.0	4.5 OD	22
656	MS300PS	7	2.88		12
6 757	MS300DS	10	2.5		
808	MS350BS				
858 1233	MS500BS	40	3.25	6.63 ID	22
909	MS600BS		4.0		
979 14	MS1000BS	65	6.0	8.62 OD	

2.4 Capacity and Dimension

The moisture separator must have a liquid capacity of _____ gallons. The inlet shall be _____ inch OD slip-on type. The outlet shall be _____ inch OD slip-on type.

2.5 Pressure Drop



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75 North Street, Saugerties, NY 12477
USA: +1 215-256-6601 - Europe: +44 (0) 845 366 9664 - Asia: +86 21 5763 1258
Customer Service Fax: +1 215.256.1338
www.ametektip.com

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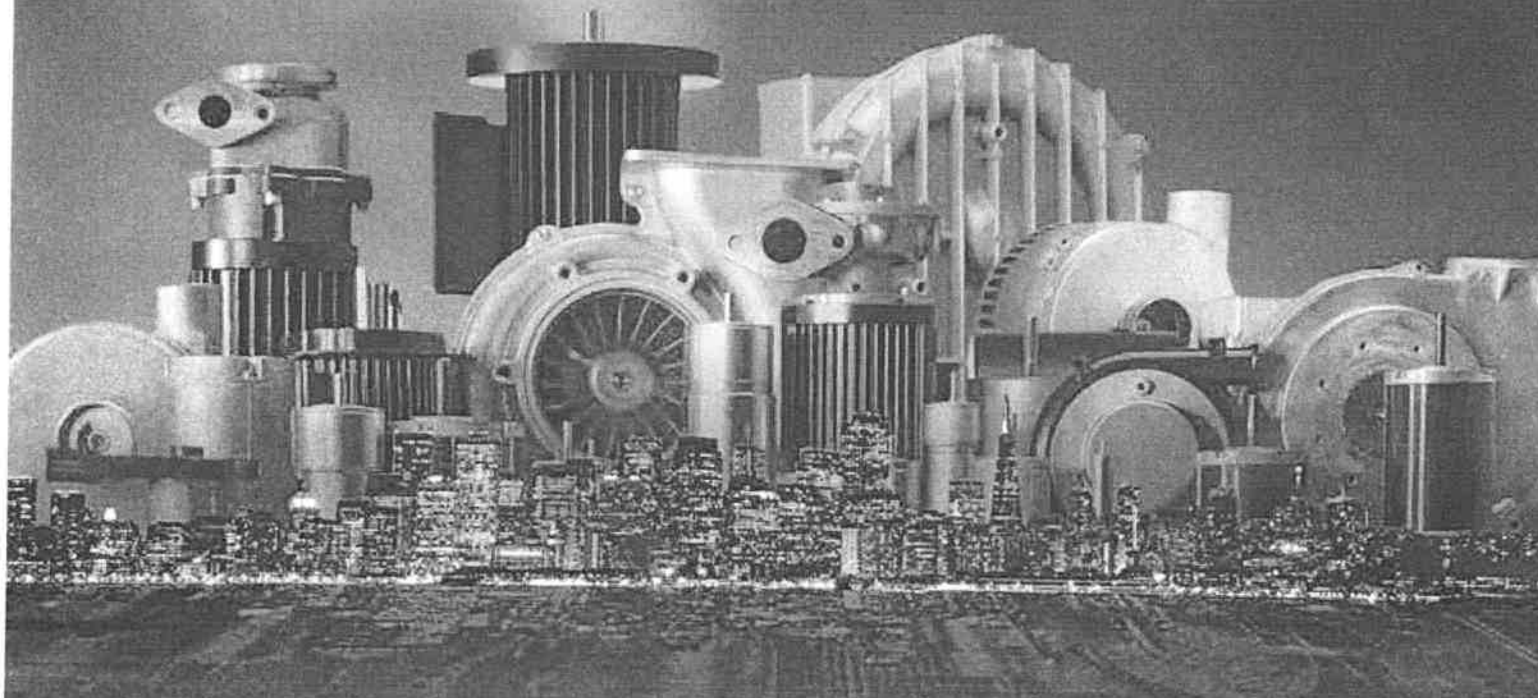
Quote 19933
DR555K58

Glacier Environmental
Phil Stellflug
3415 121st SW
Lynnwood, WA 98087
United States



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T3M Equipment LLC -
2737 SE Hill St
Prineville, OR 97754
541 447 5660
t3m@crestviewcable.com
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PRECISION MOTION CONTROL
DYNAMIC FLUID SOLUTIONS

dunkermotoren advanced motion solutions | Haydon kerk | PITTMAN | Windjammer | Nautilair | ROTRON

Industrial / Chemical Processing Blowers

Model Number: 081098

AMETEK Dynamic Fluid Solutions' ROTRON brand has long been a world leader in regenerative blower technologies, bringing regenerative advantages to a new level, providing quiet, maintenance-free, oil-free operation.

Our industrial blowers include:
Rugged Cast aluminum housing, cover, impeller, and muffler tower
Removable cast iron flanges bolted to a sheet metal manifold
TEFC motos on single-ended models, ODP motors on all double-ended models
Carbon steel shaft and zinc plated hardware
Permanently sealed motor bearings for 20,000-25,000 hours life

Specific to Your Needs
AMETEK can assist you in finding the exact blower to fit your application, but if you are in need of customized solutions, we have engineers willing and ready to help you design the blower that's right for your application.
Some models may use a general model number bulletin. In these situations, the performance data will remain the same, but some features listed may be different. If you have questions about a specific model, please send us a request using the links at the top of the page.

Series	Industrial / Chemical Processing Blowers
Model	DR555K58
Horse Power	3
Motor	TEFC
Voltage	115/230
Phase	Single
Hz	50/60

Max Pressure IWG	115
Max Flow SCFM	190
Max Pressure Kpa	28.612
Max Pressure mbar	286.166
Max Flow litres/sec	89.6211
Max Flow m3/hour	317.11

AMETEK DYNAMIC FLUID SOLUTIONS
100 E. Erie Street, Kent OH 44240
USA: +1 215-256-6601 - Europe: +49 7703 930 909 - Asia: +86 21 5763 1258
www.ametektip.com

AMETEK
PRECISION MOTION CONTROL
DYNAMIC FLUID SOLUTIONS

Accessories

Model Number: 552939

Some models may use a general model number bulletin. In these situations, the performance data will remain the same, but some features listed may be different. If you have questions about a specific model, please send us a request using the links at the top of the page.

Series	Accessories
Model	SAE26W58FOX
Motor	XP

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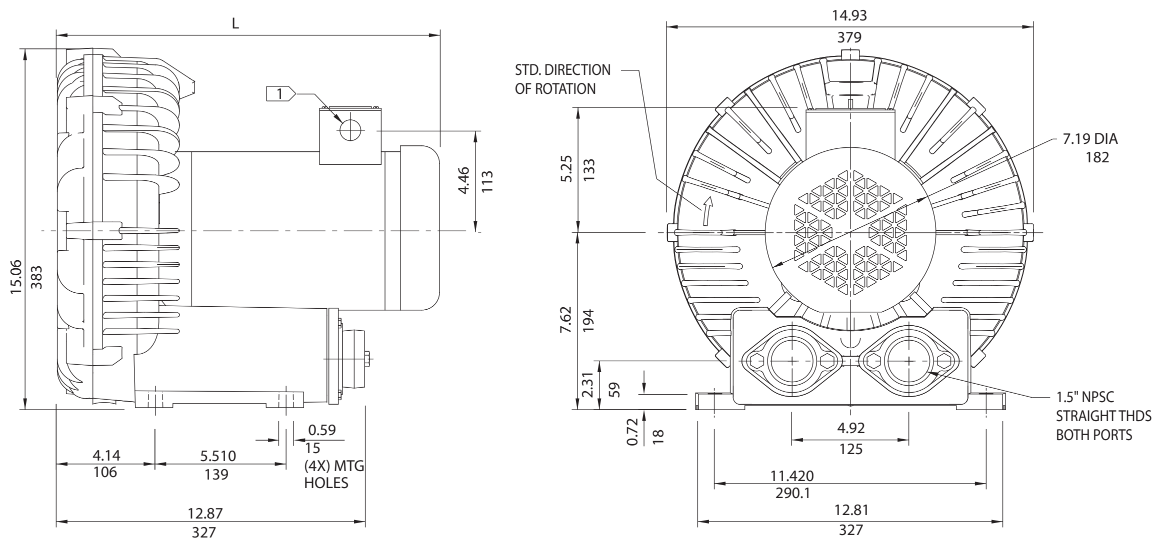
DR 555 & CP 555

ROTRON®

3.0 / 4.0 HP Regenerative Blower



IN / MM

NOTES
1 TERMINAL BOX CONNECTOR HOLE .88 (22) DIA.
2 DRAWING NOT TO SCALE, CONTACT FACTORY FOR SCALE CAD DRAWING.
3 CONTACT FACTORY FOR BLOWER MODEL LENGTHS NOT SHOWN.

MODEL	L (IN/MM)
DR555CK72	17.44/443
DR555K72	16.12/409
DR555K58	17.38/441

		Part/ Model Number					
		DR555CK72	DR555CK86	DR555K72	DR555K58	DR555K86	CP555CS72MLR
Specification	**Units**	081100	081102	081099	081098	081101	038245
Motor Enclosure - Shaft Mtl.	-	TEFC - CS	TEFC - CS	TEFC - CS	TEFC - CS	TEFC - CS	Chem TEFC - SS
Horsepower	-	4.0	4.0	3.0	3.0	3.0	3.0
Voltage	AC	230/460	575	230/460	115/230	575	230/460
Phase - Frequency	-	Three - 60 Hz	Three - 60 Hz	Three - 60 Hz	Single - 60 Hz	Three - 60 Hz	Three - 60 Hz
Insulation Class	-	F	F	F	F	F	F
NEMA Rated Motor Amps	Amps (A)	10/5	4.1	7.6/3.8	25.6/12.8	3	7.6/3.8
Service Factor	-	1.15	1.15	1.15	1.0	1.0	1.15
Max. Blower Amps	Amps (A)	13/6.5	4.2	8.8/4.4	28/14	3.4	8.8/4.4
Locked Rotor Amps	Amps (A)	94/47	80	88/44	194/97	70	88/44
NEMA Starter Size	-	1/0	0	0/0	1.5/1	0	0/0
Shipping Weight	Lbs	113	137	96	91	90	90
	Kg	51.3	62.1	43.5	41.3	40.8	40.8

Voltage - ROTRON motors are designed to handle a broad range of world voltages and power supply variations. Our dual voltage 3 phase motors are factory tested and certified to operate on both: **208-230/415-460 VAC-3 ph-60 Hz** and **190-208/380-415 VAC-3 ph-50 Hz**. Our dual voltage 1 phase motors are factory tested and certified to operate on both: **104-115/208-230 VAC-1 ph-60 Hz** and **100-110/200-220 VAC-1 ph-50 Hz**. All voltages above can handle a ±10% voltage fluctuation. Special wound motors can be ordered for voltages outside our certified range.

Operating Temperatures - Maximum operating temperature: Motor winding temperature (winding rise plus ambient) should not exceed 140°C for Class F rated motors or 120°C for Class B rated motors. Blower outlet air temperature should not exceed 140°C (air temperature rise plus inlet temperature). Performance curve maximum pressure and suction points are based on a 40°C inlet and ambient temperature. Consult factory for inlet or ambient temperatures above 40°C.

Maximum Blower Amps - Corresponds to the performance point at which the motor or blower temperature rise with a 40°C inlet and/or ambient temperature reaches the maximum operating temperature.

AMETEK TECHNICAL & INDUSTRIAL PRODUCTS
75 North Street, Saugerties, NY 12477
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AMETEK® TECHNICAL & INDUSTRIAL PRODUCTS

DR 555 & CP 555

ROTRON®

3.0 / 4.0 HP Regenerative Blower

FEATURES

- Manufactured in the USA - ISO 9001 and NAFTA compliant
- CE compliant - Declaration of Conformity on file
- Maximum flow: 190 SCFM
- Maximum pressure: 115 IWG
- Maximum vacuum: 92 IWG
- Standard motor: 4.0 HP, TEFC
- Cast aluminum blower housing, impeller & cover; cast iron flanges (threaded)
- UL & CSA approved motor with permanently sealed ball bearings
- Inlet & outlet internal muffling
- Quiet operation within OSHA standards

MOTOR OPTIONS

- International voltage & frequency (Hz)
- Chemical duty, high efficiency, inverter duty or industry-specific designs
- Various horsepowers for application-specific needs

BLOWER OPTIONS

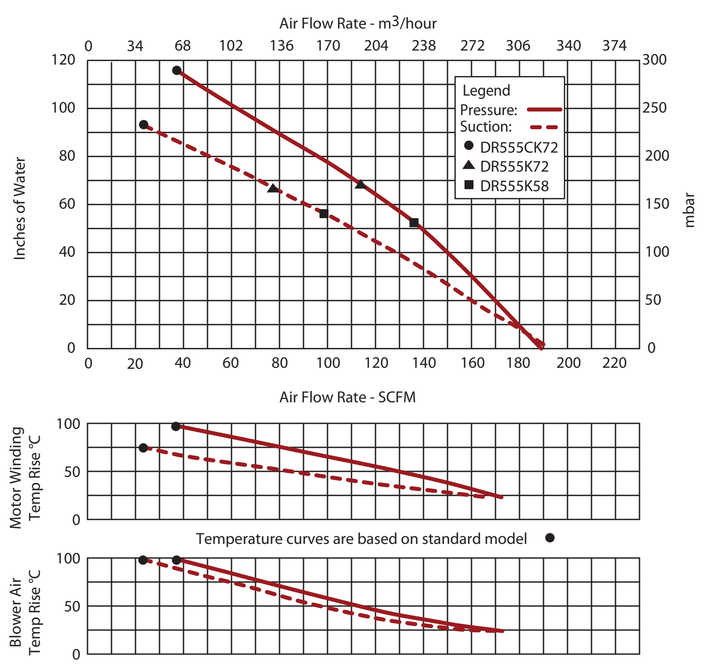
- Corrosion resistant surface treatments & sealing options
- Remote drive (motorless) models
- Slip-on or face flanges for application-specific needs

ACCESSORIES

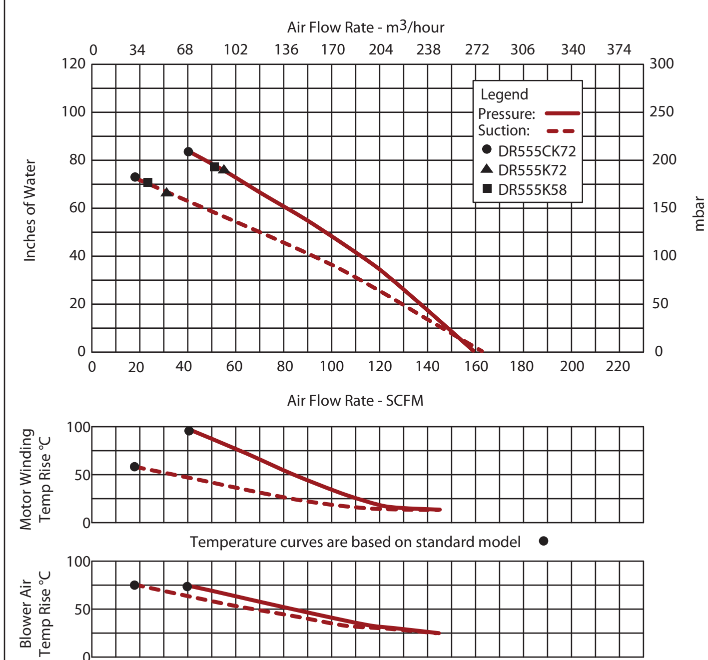
- Flowmeters reading in SCFM
- Filters & moisture separators
- Pressure gauges, vacuum gauges, & relief valves
- Switches - air flow, pressure, vacuum, or temperature
- External mufflers for additional silencing
- Air knives (used on blow-off applications)
- Variable frequency drive package

Blower Performance at Standard Conditions

60 Hz



50 Hz



This document is for informational purposes only and should not be considered as a binding description of the products or their performance in all applications. The performance data on this page depicts typical performance under controlled laboratory conditions. AMETEK is not responsible for blowers driven beyond factory specified speed, temperature, pressure, flow or without proper alignment. Actual performance will vary depending on the operating environment and application. AMETEK products are not designed for and should not be used in medical life support applications. AMETEK reserves the right to revise its products without notification. The above characteristics represent standard products. For product designed to meet specific applications, contact AMETEK Technical & Industrial Products Sales department.

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AMETEK®
TECHNICAL & INDUSTRIAL PRODUCTS

DAYTON

GRAINGER CHOICE

1/25 HP 10"-Dia. 115VACV Shutter Mount Exhaust Fan, 10-1/2" Square Opening Required

Item # **484X37** Mfr. Model # **484X37** Catalog Page # 2927 UNSPSC # **40101502**

Web Price
$115.98 / each

One Time Delivery

1

Add to Cart

+ Add to List |

Shipping Pickup

Available for pickup Thu. Apr 04 estimated after 8:30 AM.

EVERETT Branch #757
Branch Info | Change

Be the first to write a review

Shipping Weight **12.0 lbs.**

How can we improve our Product Images?

Compare

Country of Origin China | *Country of Origin is subject to change.*

Note: Product availability is real-time updated and adjusted continuously. The product will be reserved for you when you complete your order. More

Technical Specs

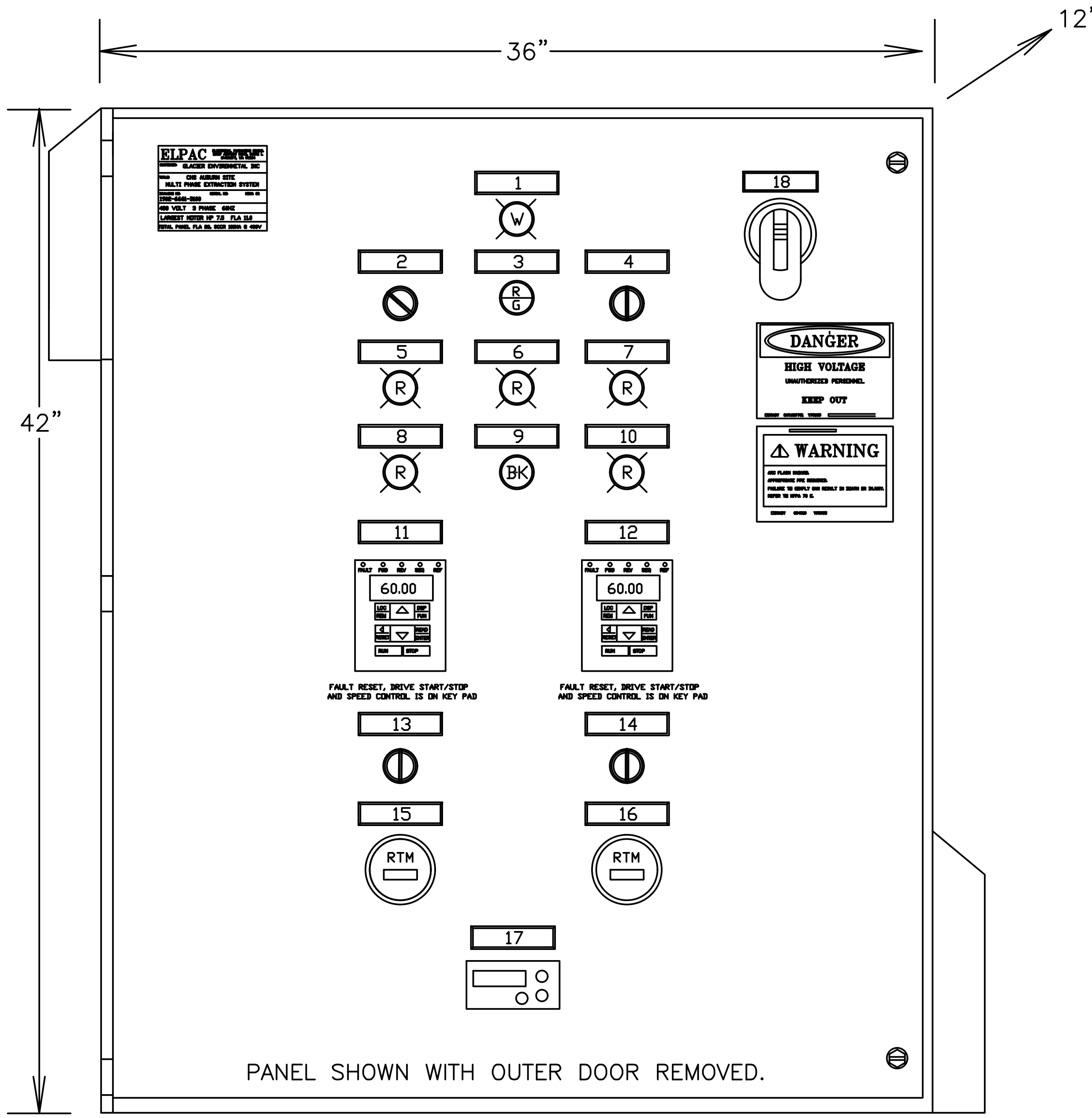
Item	**Shutter Mount Exhaust Fan**	Motor Enclosure	**Totally Enclosed Air-Over**
Blade Dia.	**10"**	Motor Insulation	**Class B**
Number of Speeds	**Variable**	Bearing Type	**Ball**
Fan Voltage	**115VAC**	Height	**13-1/8"**
CFM @ 0.000-In. SP	**600**	Width	**13-1/8"**
Exhaust/Supply Fan Motor HP	**1/25**	Max. Depth	**8"**
Square Opening Required	**10-1/2"**	Frame Material	**Steel**
Exhaust/Supply Fan Item	**Exhaust Fan**	Frame Finish	**Aluminum**
CFM @ 0.125-In. SP	**355**	Blade Material	**Aluminum**
CFM @ 0.250-In. SP	**240**	Guard Material	**Steel**
Sones @ 0.000-In. SP @ 5 Ft.	**6.19**	Wire Guard Finish	**Powder Coated**
Motor RPM	**1550**	Speed Control Item Number	**48C172**
Hz	**60**	Number of Blades	**5**
Phase	**1**	Thermal Protection	**Auto**
		Standards	**UL and C-UL Listed.OSHA-compliant gray polyester powder-coated wire guards**

Full Load Amps	**0.55**	Includes	**Intake Guard**
Max. Ambient Temp.	**104 Degrees F**		
Motor Type	**PSC**		

APPENDIX C
CONTROL PANEL AS-BUILTS AND ELECTRICAL COMPONENT MANUALS

OPERATIONS AND MAINTENANCE MANUAL
AIR SPARGE AND SOIL VAPOR EXTRACTION SYSTEM
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004



LIST OF MATERIALS

ITEM	QTY	DESCRIPTION			MFGR.
	1	ENCLOSURE		CSD423612	HOFFMAN
	1	PAN		CP4236	HOFFMAN
	1	INNER DOOR KIT		CSP4236	HOFFMAN
MD	1	MAIN DISCONNECT	30A	OS30FACC12	ABB
	1	HANDLE		OHB65J6	ABB
	1	SHAFT		OXP6X210	ABB
FU1-3	3	FUSES	30A	LPCC30	BUSS
T1	1	TRANSFORMER	500VA	9070TF500D1	SQUARE D
FU4,5	2	PRIMARY FUSES	4A	FNQR-4	BUSS
FU6	1	SECONDARY FUSE	6A	FNM-6	BUSS
FU4-6	1	FUSE BLOCK	3P	BCCMM603-3PQ	BUSS
VFD	1	COMPRESSOR DRIVE		F510-4008-C3-U	TECO
VFD	1	BLOWER DRIVE		F510-4005-C3-U	TECO
	2	DRIVE KEY CABLE KIT		JNS-CB-02M	TECO
	5	INDICATOR LIGHTS	RED	HW1P-1FQD-R-120V	IDEC
DIALER	1	AUTODIALER		SCD-1200-4G	SENSAPHONE
●	15	TERMINALS		1492-J4	AB
RTM	2	DRIVE RUN TIME METERS		T55B2A-115VAC	ENM
BER,CRT	2	CONTROL RELAY	3P	RH3B-ULAC120V	IDEC
CPR,BFC	2	CONTROL RELAY	3P	RH3B-ULAC120V	IDEC
CR1-2	2	CONTROL RELAY	3P	RH3B-ULAC120V	IDEC
AR1-4	4	CONTROL RELAY	3P	RH3B-ULAC120V	IDEC
	10	RELAY BASES		SR3B-05	IDEC
OUTLET	1	DIALER RECEPTACLE		DMRGR	ALTEC
MMS1	1	MANUAL MOTOR STARTERS		GV2P16 (9-14) AMPS	SQUARE D
MMS2	1	MANUAL MOTOR STARTERS		GV2P10 (4-6.3) AMPS	SQUARE D
MMS1,2	2	MANUAL MOTOR AUX CONTACT		GVAN11	SQUARE D
PB1	1	POWER ON/OFF P.B.		HW7D-B11F1001-GR	IDEC
PB2	1	ALARM RESET P.B.		HW1B-M1F01B	IDEC
TD1	1	TIME DELAY RELAY		RTEP1AF20	IDEC
	1	TIMER SOCKET		SR2P06	IDEC
	1	POWER AVAILABLE IND LIGHT	WHITE	HW1P-1FQD-W-120V	IDEC
RTI	1	ROOM TEMP INDICATOR.		TS2-010	LOVE
TT-1	1	TEMP TRANS TO READOUT		TE-205	MAMAC
TT-1A	1	TEMP TRANS TO DIALER		FGD-0104	SENSAPHONE
		GROUND TERMINALS		1492 JG4	AB
FAN	1	ENCLOSURE COOLING FAN		SK-3241.110	RITTAL
VENT	1	VENT		SK-3240.200	RITTAL
HOOD	2	RAIN HOOD		3240.085	RITTAL
THERM	1	ENCLOSURE THERMOSTAT		SK3110000	RITTAL
THERM	1	ROOM FAN THERMOSTAT		803A	ROBERTSHAW
SS1-4	4	HOA SELECTOR SWITCHES		HW1S-3TF20	IDEC
	2	INDICATOR LIGHTS	RED	HW1P-1FQD-G-120V	IDEC
PB	1	POWER BLOCK		1423570	BUSS

NAMEPLATE SCHEDULE-

1- CONTROL POWER AVAILABLE

2- BLOWER ENC FAN CONTROL
HAND OFF AUTO

3- CONTROL POWER
OFF ON

4- BUILDING EXHAUST FAN CONTROL
HAND OFF AUTO

5- KNOCKOUT TANK
HIGH LEVEL ALARM

6- CONTROL POWER OFF
OR PREVIOUS FAILURE

7- ROOM HIGH TEMP

8-COMPRESSOR DRIVE FAULT

9- ALARM / SYSTEM RESET

10- BLOWER DRIVE FAULT

11- COMPRESSOR DRIVE CONTROL

12- BLOWER DRIVE CONTROL

13- COMPRESSOR DRIVE HOA CONTROL

14- BLOWER DRIVE HOA CONTROL

15- COMPRESSOR DRIVE RUN TIME

16- BLOWER DRIVE RUN TIME

17- BLOWER ROOM TEMPATURE

18- MAIN PANEL DISCONNECT

NOTES

- NOT SUPPLIED BY ELPAC.
- DENOTES TERMINALS INTERNAL TO PANEL.
- DENOTES WIRING EXTERNAL TO PANEL.
- DENOTES WIRING INTERNAL TO PANEL.

GLACIER ENVIROMENTAL INC

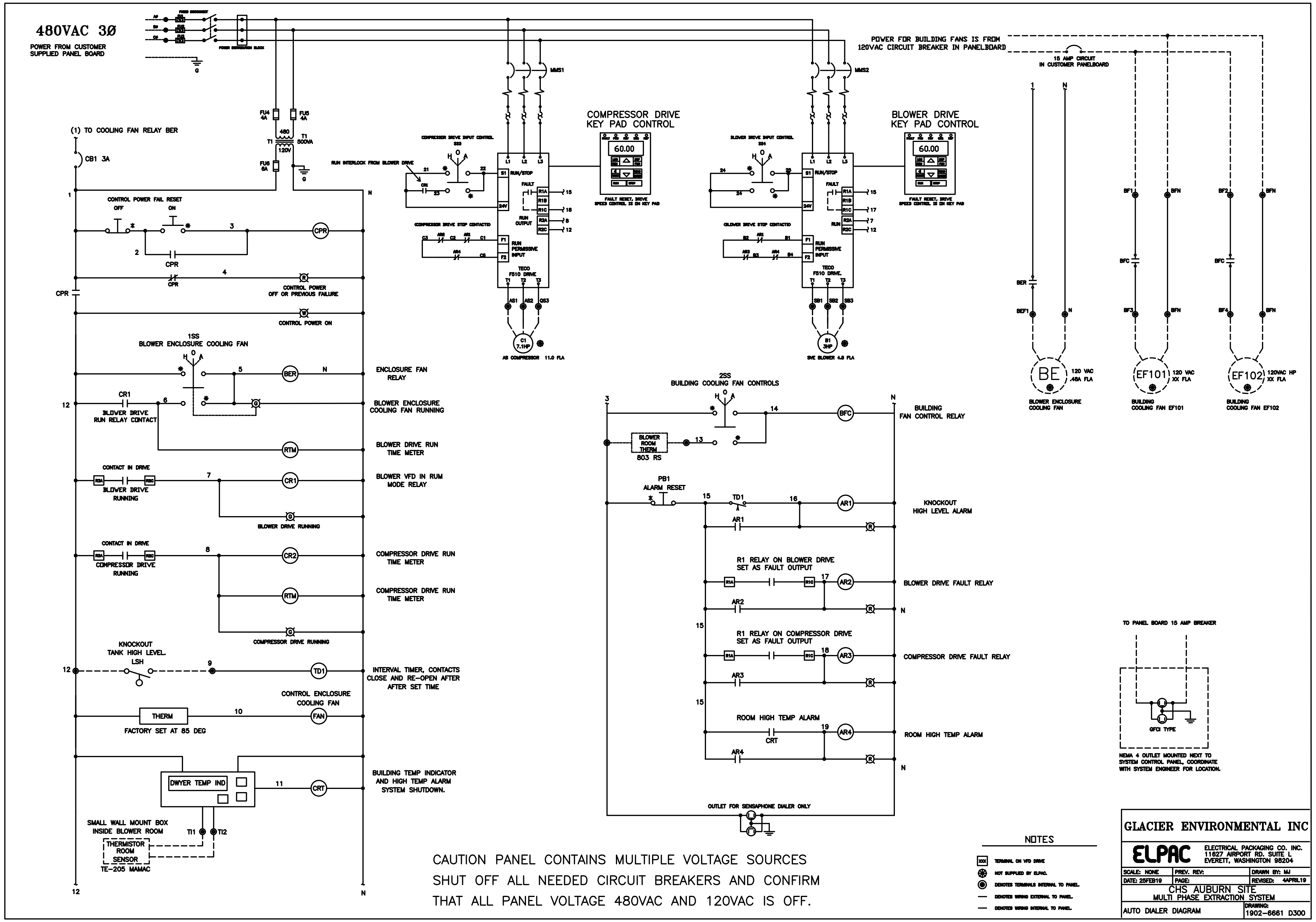
ELPAC ELECTRICAL PACKAGING CO. INC.
11627 AIRPORT RD. SUITE L
EVERETT, WASHINGTON 98204

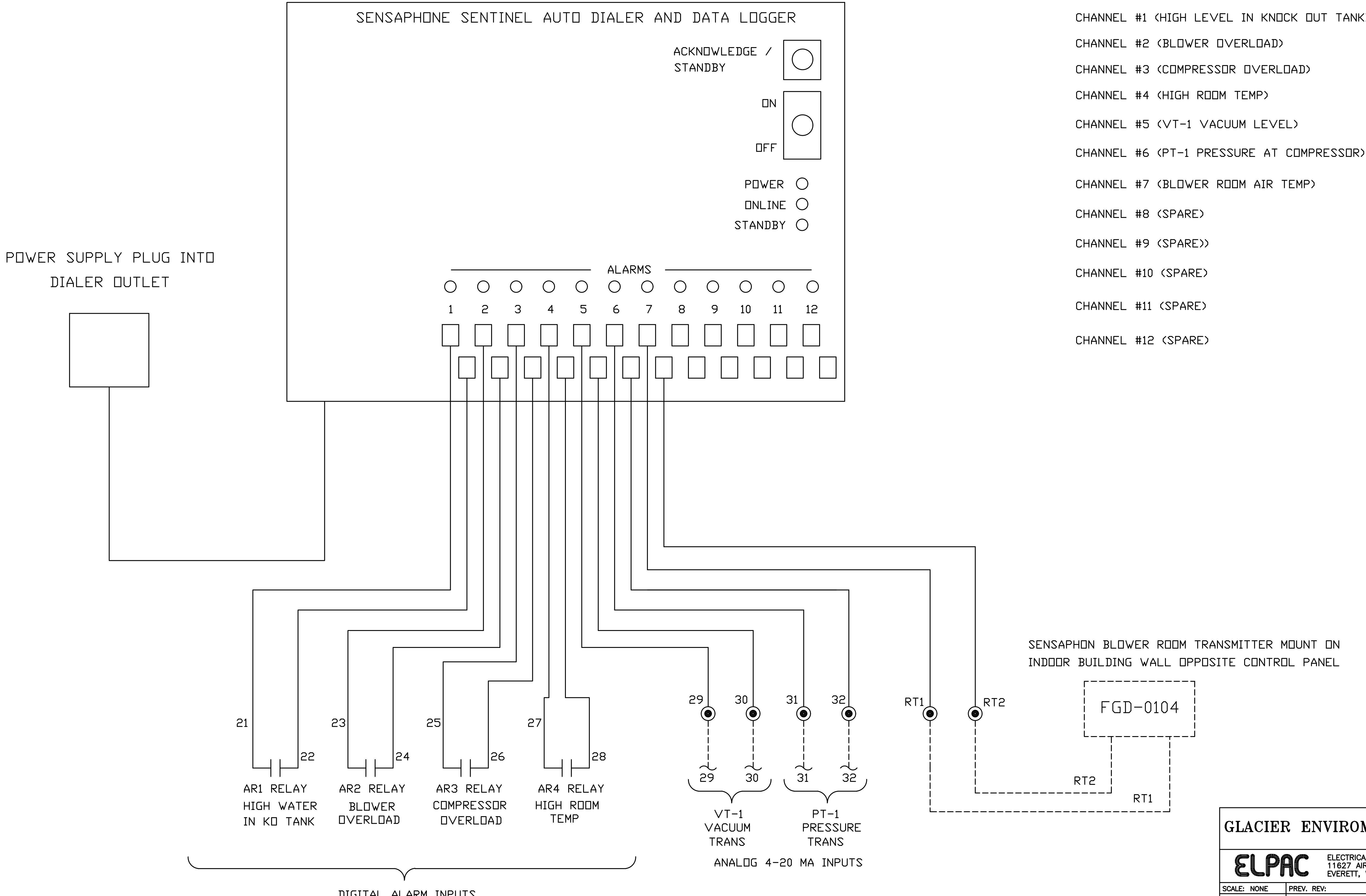
SCALE: NONE	PREV. REV:	DRAWN BY: MJ
DATE: 25FEB19	PAGE:	REVISED: 5APRIL19

CHS AUBURN SITE
MULTI PHASE EXTRACTION SYSTEM

AUTO DIALER DIAGRAM

DRAWING: 1902-6661 D100


480VAC 3Ø
POWER FROM CUSTOMER SUPPLIED PANEL BOARD
COMPRESSOR DRIVE KEY PAD CONTROL
BLOWER DRIVE KEY PAD CONTROL
60.00
POWER FOR BUILDING FANS IS FROM 120VAC CIRCUIT BREAKER IN PANELBOARD
15 AMP CIRCUIT IN CUSTOMER PANELBOARD
(1) TO COOLING FAN RELAY BER
CB1 3A
CONTROL POWER FAIL RESET
OFF
ON
CONTROL POWER OFF OR PREVIOUS FAILURE
CONTROL POWER ON
1SS BLOWER ENCLOSURE COOLING FAN
ENCLOSURE FAN RELAY
BLOWER ENCLOSURE COOLING FAN RUNNING
CR1 BLOWER DRIVE RUN RELAY CONTACT
BLOWER DRIVE RUN TIME METER
CONTACT IN DRIVE BLOWER DRIVE RUNNING
BLOWER VFD IN RUN MODE RELAY
BLOWER DRIVE RUNNING
CONTACT IN DRIVE COMPRESSOR DRIVE RUNNING
COMPRESSOR DRIVE RUN TIME METER
COMPRESSOR DRIVE RUNNING
KNOCKOUT TANK HIGH LEVEL LSH
INTERVAL TIMER, CONTACTS CLOSE AND RE-OPEN AFTER AFTER SET TIME
THERM
FACTORY SET AT 85 DEG
CONTROL ENCLOSURE COOLING FAN
DWYER TEMP IND
BUILDING TEMP INDICATOR AND HIGH TEMP ALARM SYSTEM SHUTDOWN.
SMALL WALL MOUNT BOX INSIDE BLOWER ROOM
THERMISTOR ROOM SENSOR
TE-205 MAMAC
TECO FS10 DRIVE
C1 7.1HP
AS COMPRESSOR 11.0 FLA
B1 3HP
SVE BLOWER 4.8 FLA
2SS BUILDING COOLING FAN CONTROLS
BUILDING FAN CONTROL RELAY
BLOWER ROOM THERM
603 RS
PB1 ALARM RESET
KNOCKOUT HIGH LEVEL ALARM
R1 RELAY ON BLOWER DRIVE SET AS FAULT OUTPUT
BLOWER DRIVE FAULT RELAY
R1 RELAY ON COMPRESSOR DRIVE SET AS FAULT OUTPUT
COMPRESSOR DRIVE FAULT RELAY
ROOM HIGH TEMP ALARM
OUTLET FOR SENSAPHONE DIALER ONLY
BE 120 VAC .48A FLA
BLOWER ENCLOSURE COOLING FAN
EF101 120 VAC XX FLA
BUILDING COOLING FAN EF101
EF102 120VAC HP XX FLA
BUILDING COOLING FAN EF102
TO PANEL BOARD 15 AMP BREAKER
GFCI TYPE
NEMA 4 OUTLET MOUNTED NEXT TO SYSTEM CONTROL PANEL, COORDINATE WITH SYSTEM ENGINEER FOR LOCATION.
NOTES
CAUTION PANEL CONTAINS MULTIPLE VOLTAGE SOURCES
SHUT OFF ALL NEEDED CIRCUIT BREAKERS AND CONFIRM
THAT ALL PANEL VOLTAGE 480VAC AND 120VAC IS OFF.
GLACIER ENVIRONMENTAL INC
ELPAC
ELECTRICAL PACKAGING CO. INC. 11627 AIRPORT RD. SUITE L EVERETT, WASHINGTON 98204
SCALE: NONE
DATE: 25FEB19
DRAWN BY: MJ
REVISED: 4APRIL19
CHS AUBURN SITE
MULTI PHASE EXTRACTION SYSTEM
AUTO DIALER DIAGRAM
1902-6661 D300



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CHS AUBURN SITE
MULTI PHASE EXTRACTION SYSTEM

AUTO DIALER AND DATA LOGGER | DRAWING: 1902-6661 D301

TECO Westinghouse

INVERTER

F510

INSTRUCTION MANUAL

230V Class 3~

Open Chassis / NEMA 1	3.7 - 132 kW 5 - 150 HP

460V Class 3~

Open Chassis / NEMA 1	3.7 - 185 kW 5 - 250 HP

- Read all operating instructions before installing, connecting (wiring), operating, servicing, or inspecting the inverter.
- Ensure that this manual is made available to the end user of the inverter.
- Store this manual in a safe, convenient location.
- The manual is subject to change without prior notice.

DOCUMENT - TECO-F510IM
Ver 01: 2014.07

Table of Contents

Preface

The F510 product is an inverter designed to control a three-phase induction motor. Please read this manual carefully to ensure correct operation and safety aspects to become familiar with the inverter functions.

The F510 inverter is an electrical / electronic product and must be installed and handled by qualified service personnel.

Improper handling may result in incorrect operation, shorter life cycle, or failure of this product as well as the motor.

All F510 documentation is subject to change without notice. Be sure to obtain the latest editions for use or visit our website at www.tecowestinghouse.com , for documentation in Spanish visit www.tecowestinghouse.com.mx

Read this Instruction Manual thoroughly before proceeding with installation, connections (wiring), operation, or maintenance and inspection.

Ensure you have thorough knowledge of the inverter and familiarize yourself with all safety information and precautions before proceeding to operate the inverter. Read the this Instruction Manual for detailed description on parameters.

Please pay close attention to the safety precautions indicated by the warning and caution symbol.

Warning	Failure to ignore the information indicated by the warning symbol may result in death or serious injury.
Caution	Failure to ignore the information indicated by the caution symbol may result in minor or moderate injury and/or substantial property damage.

1. Safety Precautions

1.1 Before supplying Power to the Inverter

Warning

The main circuit must be correctly wired. For single phase supply use input terminals (R/L1, T/L3) and for three phase supply use input terminals (R/L1, S/L2, T/L3). Terminals U/T1, V/T2, W/T3 must only be used to connect the motor. Connecting the input supply to any of the U/T1, V/T2 or W/T3 terminals will cause damage to the inverter.

Caution

- To avoid the front cover from disengaging or other physical damage, do not carry the inverter by its cover. Support the unit by its heat sink when transporting. Improper handling can damage the inverter or injure personnel, and should be avoided.
- To avoid the risk of fire, do not install the inverter on or near flammable objects. Install on nonflammable objects such as metal surfaces.
- If several inverters are placed inside the same control enclosure, provide adequate ventilation to maintain the temperature below 40°C/104°F (50°C/122°F without a dust cover) to avoid overheating or fire.
- When removing or installing the digital operator, turn off the power first, and then follow the instructions in this manual to avoid operator error or loss of display caused by faulty connections.

Warning

This product is sold subject to IEC 61800-3. In a domestic environment this product may cause radio interference in which case the user may need to apply corrective measures.

1.2 Wiring

Warning

- Always turn OFF the power supply before attempting inverter installation and wiring of the user terminals.
- Wiring must be performed by a qualified personnel / certified electrician.
- Make sure the inverter is properly grounded. (230V Class: Grounding impedance shall be less than 100Ω. 460V Class: Grounding impedance shall be less than 10Ω.)
- Please check and test emergency stop circuits after wiring. (Installer is responsible for the correct wiring.)
- Never touch any of the input or output power lines directly or allow any input of output power lines to come in contact with the inverter case.
- Do not perform a dielectric voltage withstand test (megger) on the inverter this will result in inverter damage to the semiconductor components.

Caution

- The line voltage applied must comply with the inverter's specified input voltage. (See product nameplate section 2.1)
- Connect braking resistor and braking unit to the designated terminals. (See section 3.10)
- Do not connect a braking resistor directly to the DC terminals P(+) and N(-),otherwise fire may result.
- Use wire gauge recommendations and torque specifications. (See Wire Gauge and Torque Specification section 3.6)
- Never connect input power to the inverter output terminals U/T1, V/T2, W/T3.
- Do not connect a contactor or switch in series with the inverter and the motor.
- Do not connect a power factor correction capacitor or surge suppressor to the inverter output.
- Ensure the interference generated by the inverter and motor does not affect peripheral devices.

1.3 Before Operation

Warning

- Make sure the inverter capacity matches the parameters 13-00.
- Reduce the carrier frequency (parameter 11-01) If the cable from the inverter to the motor is greater than 80 ft (25m), refer to table 3.14.1. A high-frequency current can be generated by stray capacitance between the cables and result in an overcurrent trip of the inverter, an increase in leakage current, or an inaccurate current readout.
- Be sure to install all covers before turning on power. Do not remove any of the covers while power to the inverter is on, otherwise electric shock may occur.
- Do not operate switches with wet hands, otherwise electric shock may result.
- Do not touch inverter terminals when energized even if inverter has stopped, otherwise electric shock may result.

1.4 Parameter Setting

Caution

- Do not connect a load to the motor while performing a rotational auto-tune.
- Make sure the motor can freely run and there is sufficient space around the motor when performing a rotational auto-tune.

1.5 Operation

Warning

- Be sure to install all covers before turning on power. Do not remove any of the covers while power to the inverter is on, otherwise electric shock may occur.
- Do not connect or disconnect the motor during operation. This will cause the inverter to trip and may cause damage to the inverter.
- Operations may start suddenly if an alarm or fault is reset with a run command active. Confirm that no run command is active upon resetting the alarm or fault, otherwise accidents may occur.
- Do not operate switches with wet hands, otherwise electric shock may result.
- All F510 inverters have an independent external hardware emergency switch, which immediately shuts down the inverter output in the case of danger.
- If automatic restart after power recovery (parameter 07-00) is enabled, the inverter will start automatically after power is restored.
- Make sure it is safe to operate the inverter and motor before performing a rotational auto-tune.
- Do not touch inverter terminals when energized even if inverter has stopped, otherwise electric shock may result.
- Do not check signals on circuit boards while the inverter is running.
- After the power is turned off, the cooling fan may continue to run for some time.

Caution

- Do not touch heat-generating components such as heat sinks and braking resistors.
- Carefully check the performance of motor or machine before operating at high speed, otherwise Injury may result.
- Note the parameter settings related to the braking unit when applicable.
- Do not use the inverter braking function for mechanical holding, otherwise injury may result.
- Do not check signals on circuit boards while the inverter is running.

1.6 Maintenance, Inspection and Replacement

Warning
• Wait a minimum of five minutes after power has been turned OFF before starting an inspection. Also confirm that the charge light is OFF and that the DC bus voltage has dropped below 25Vdc. • Never touch high voltage terminals in the inverter. • Make sure power to the inverter is disconnected before disassembling the inverter. • Only authorized personnel should perform maintenance, inspection, and replacement operations. (Remove any metal jewelry such as watches and rings and use insulated tools.)

Caution
• The Inverter can be used in an environment with a temperature range from 14° -104°F (-10-40°C) and relative humidity of 95% non-condensing. • The inverter must be operated in a dust, gas, mist and moisture free environment.

1.7 Disposal of the Inverter

Caution
• Please dispose of this unit with care as an industrial waste and according to your any local regulations. • The capacitors of inverter main circuit and printed circuit board are considered as hazardous waste and must not be burned. • The Plastic enclosure and parts of the inverter such as the top cover board will release harmful gases if burned.

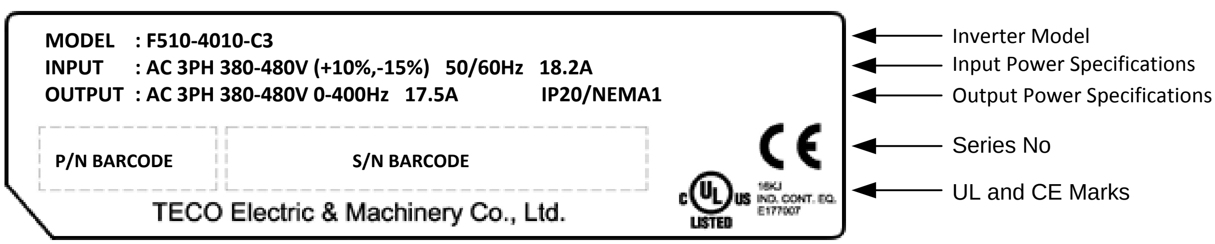
2. Model Description

2.1 Nameplate Data

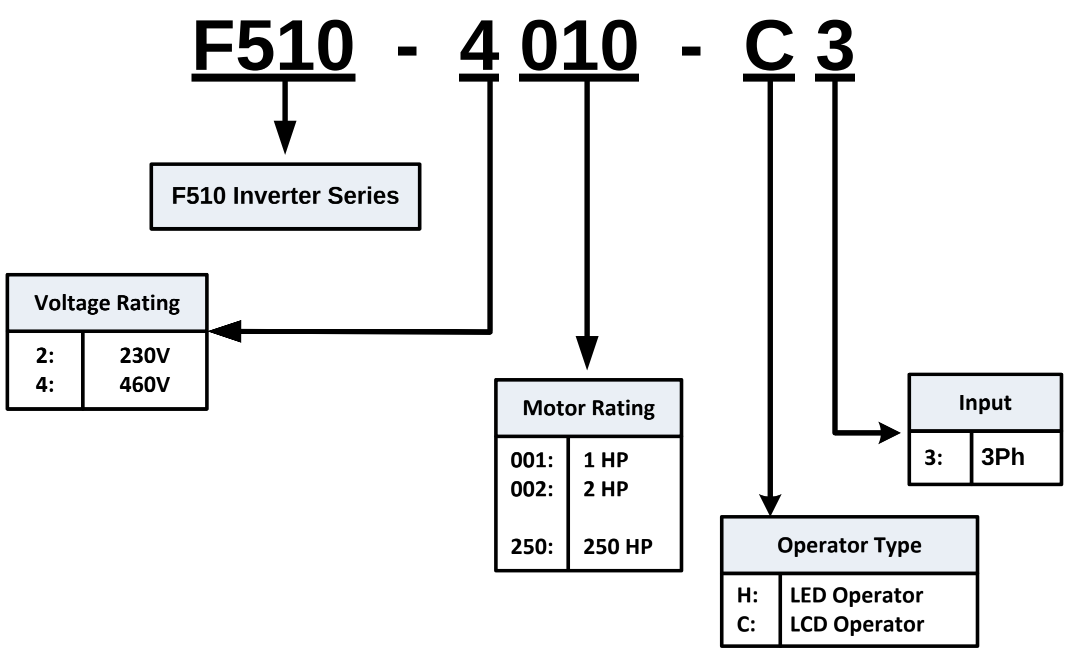
It is essential to verify the F510 inverter nameplate and make sure that the F510 inverter has the correct rating so it can be applied with the proper sized AC motor.

Unpack the F510 inverter and check the following:

(1) The F510 inverter and instruction manual (this document) are contained in the package.
(2) The F510 inverter has not been damaged during transportation there should be no dents or parts missing.
(3) The F510 inverter is the correct ratings as ordered. Check the type and specifications on the main nameplate.
(4) Check that the input voltage range meets the input power requirements.
(5) Ensure that the motor full load amp rating matches the output rating of the inverter.



Model Identification



2.2 Inverter Models – Motor Power Rating (ND – Normal Duty / Variable Torque)

230V Class

Voltage (Vac) & Frequency (Hz)	F510 Model	Motor Power (HP)	Applied Motor (kW)	Operator	
				LED	LCD
3ph 200~240V +10%/-15% 50/60Hz	F510-2005-C3	5	3.7		◎
	F510-2008-C3	7.5	5.5		◎
	F510-2010-C3	10	7.5		◎
	F510-2015-C3	15	11		◎
	F510-2020-C3	20	15		◎
	F510-2025-C3	25	18.5		◎
	F510-2030-C3	30	22		◎
	F510-2040-C3	40	30		◎
	F510-2050-C3	50	37		◎
	F510-2060-C3	60	45		◎
	F510-2075-C3	75	55		◎
	F510-2100-C3	100	75		◎
	F510-2125-C3	125	94		◎
	F510-2150-C3	150	112		◎
	F510-2175-C3	175	130		◎

Shaded Section: Models currently under development

460V Class

Voltage (Vac) / Frequency (Hz)	F510 Model	Motor Power (HP)	Applied Motor (kW)	Operator	
				LED	LCD
3ph 380~480V +10%/-15% 50/60Hz	F510-4005-H3	5	3.7	◎	
	F510-4005-C3	5	3.7		◎
	F510-4008-C3	7.5	5.5		◎
	F510-4010-C3	10	7.5		◎
	F510-4015-C3	15	11		◎
	F510-4020-C3	20	15		◎
	F510-4025-C3	25	18.5		◎
	F510-4030-C3	30	22		◎
	F510-4040-C3	40	30		◎
	F510-4050-H3	50	37	◎	
	F510-4050-C3	50	37		◎
	F510-4060-H3	60	45	◎	
	F510-4060-C3	60	45		◎
	F510-4075-H3	75	55	◎	
	F510-4075-C3	75	55		◎
	F510-4100-H3	100	75	◎	
	F510-4100-C3	100	75		◎
	F510-4125-H3	125	94	◎	
	F510-4125-C3	125	94		◎
	F510-4150-H3	150	112	◎	
	F510-4150-C3	150	112		◎
	F510-4175-H3	175	130	◎	
	F510-4175-C3	175	130		◎
	F510-4215-H3	215	160	◎	
	F510-4215-C3	215	160		◎
	F510-4250-H3	250	185	◎	
	F510-4250-C3	250	185		◎

460V Class (Continued)

Voltage (Vac) / Frequency (Hz)	F510 Model	Motor Power (HP)	Applied Motor (kW)	Operator	
				LED	LCD
3ph 380~480V +10%/-15% 50/60Hz	F510-4300-H3	300	220	◎	
	F510-4300-C3	300	220		◎
	F510-4375-H3	375	280	◎	
	F510-4375-C3	375	280		◎
	F510-4425-H3	425	317	◎	
	F510-4425-C3	425	317		◎
	F510-4535-H3	535	400	◎	
	F510-4535-C3	535	400		◎
	F510-4670-H3	670	500	◎	
	F510-4670-C3	670	500		◎
	F510-4800-H3	800	600	◎	
	F510-4800-C3	800	600		◎

Shaded Section: Models currently under development.

3. Environment and Installation

3.1 Environment

The environment will directly affect the proper operation and the life span of the inverter. To ensure that the inverter will give maximum service life, please comply with the following environmental conditions:

Protection	
Protection Class	IP20 / NEMA 1 or IP00
	NEMA 12
Operating Temperature	Ambient Temperature: (-10°C to +40°C (14 to 104 °F) Without Cover: -10°C to +50°C (14 to 122 °F) If several inverters are placed in the same control panel, provide additional cooling to maintain ambient temperatures below 40°C
Storage Temperature	-20°C - +70°C (-4 to158 °F)
Humidity:	95% non-condensing Relative humidity 5% to 95%, free of moisture. (Follow IEC60068-2-78 standard)
Altitude:	< 3,281 ft. (1000m)
Installation Site:	Avoid exposure to rain or moisture.
	Avoid direct sunlight.
	Avoid oil mist and salinity.
	Avoid corrosive liquid and gas.
	Avoid dust, lint fibers, and metal filings.
	Keep away from radioactive and flammable materials.
	Avoid electromagnetic interference (soldering machines, power machines).
	Avoid vibration (stamping, punching machines etc.). Add a vibration-proof pad if vibration cannot be avoided.
Shock	Maximum acceleration: 1.2G (12m/s^2), from 49.84 to 150 Hz Displacement amplitude : 0.3mm (peak value), from 10 to 49.84 Hz (Follow IEC60068-2-6 standard)

3.2 Installation

When installing the inverter, ensure that inverter is installed in upright position (vertical direction) and there is adequate space around the unit to allow normal heat dissipation as per the following Fig. 3.2.1

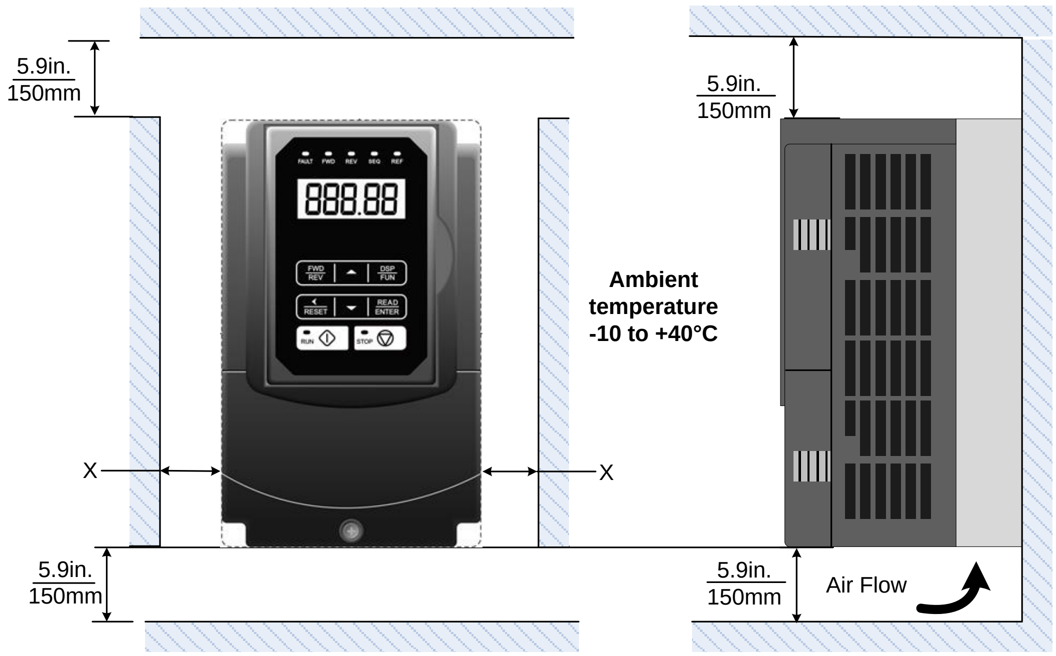


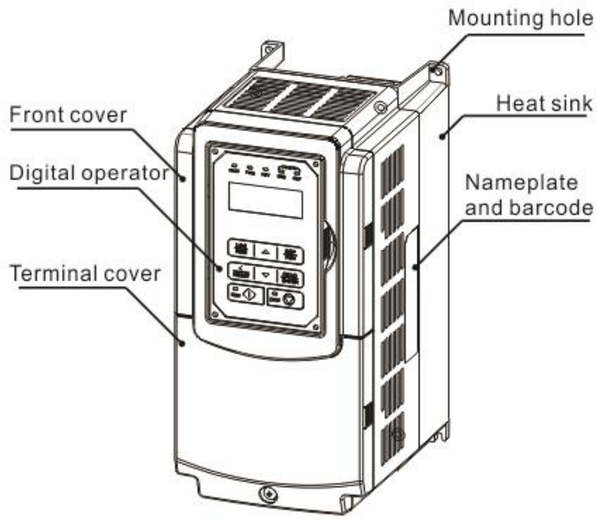
Fig 3.2.1: F510 Installation space

X = 1.18” (30mm) for inverter ratings up to 25HP
X = 1.96” (50mm) for inverter ratings 30HP or higher

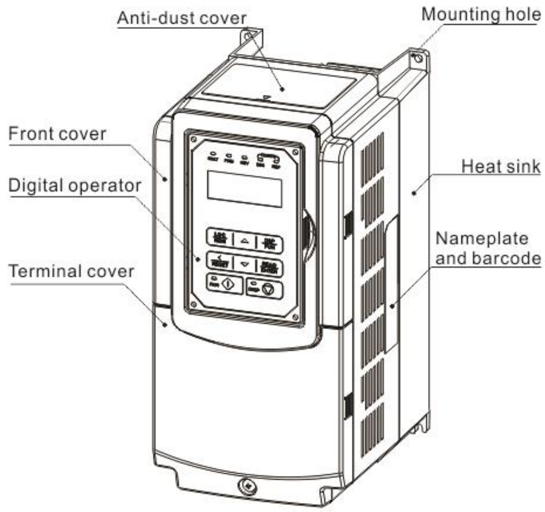
Important Note: The inverter heatsink temperature can reach up to 194°F / 90°C during operation; Use insulation material rated for this temperature.

3.3 External View

(a) 230V 5-7.5HP/ 460V 5-10HP

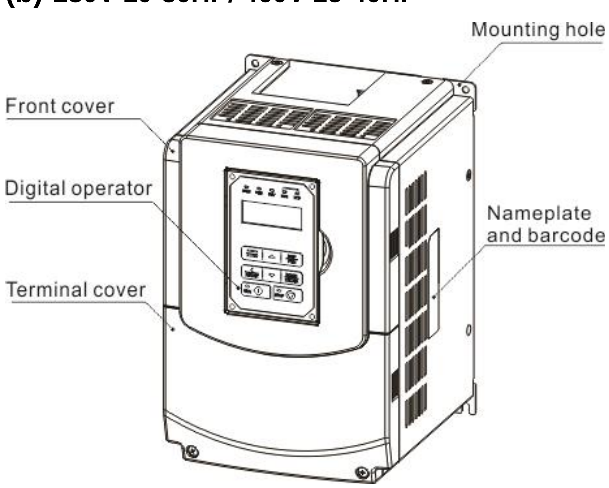


(Wall-mounted type, IEC IP00)

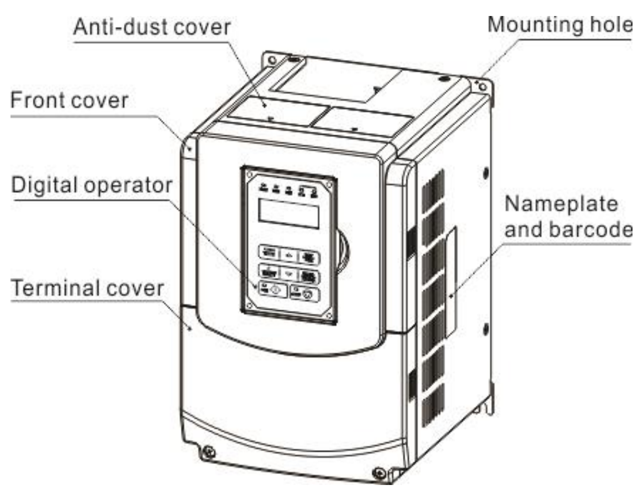


(Wall-mounted type, IEC IP20, NEMA1)

(b) 230V 10-30HP/ 460V 15-40HP

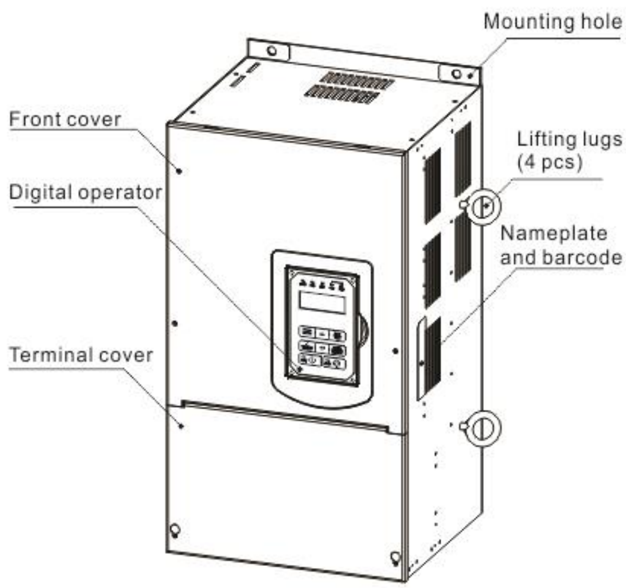


(Wall-mounted type, IEC IP00)



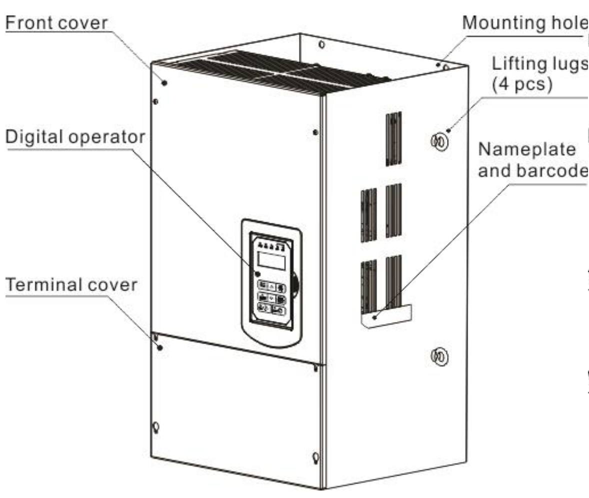
(Wall-mounted type, IEC IP20, NEMA1)

(c) 230V 40-50HP/ 460V 50-75HP

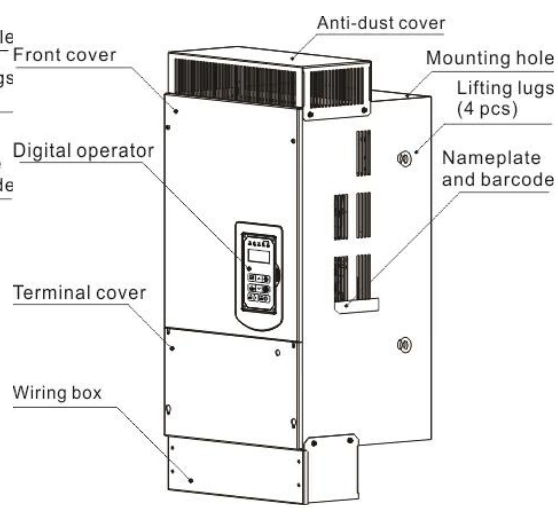


(Wall-mounted type, IEC IP20, NEMA1)

(d) 230V 60-125HP/ 460V 100-250HP



(Wall-mounted type, IEC IP00)



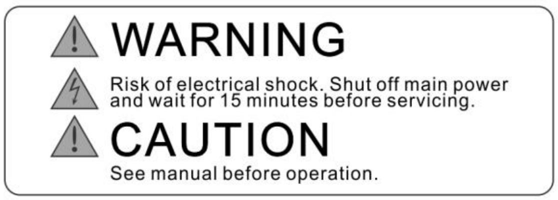
(Wall-mounted type, IEC IP20, NEMA1)

3.4 Warning Labels

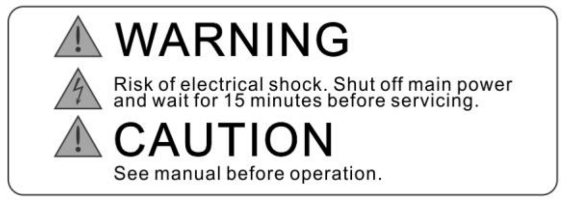
Important: Warning information located on the front cover must be read upon installation of the inverter.

(a) 230V: 5 ~ 7.5HP / 460V: 5 ~ 10HP (IP20)

(b) 230V: 10 ~15HP / 460V: 15 ~ 20HP



(c) 230V: 20 ~ 125HP / 460V: 20 ~ 250HP



(d) 460V: 5 ~ 100HP / 460V: 5 ~ 100HP

3.5 Removing the Front Cover and Keypad

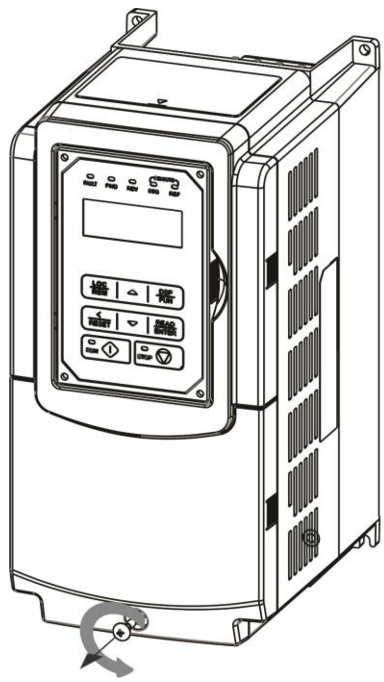
IP00 / IP20

Caution

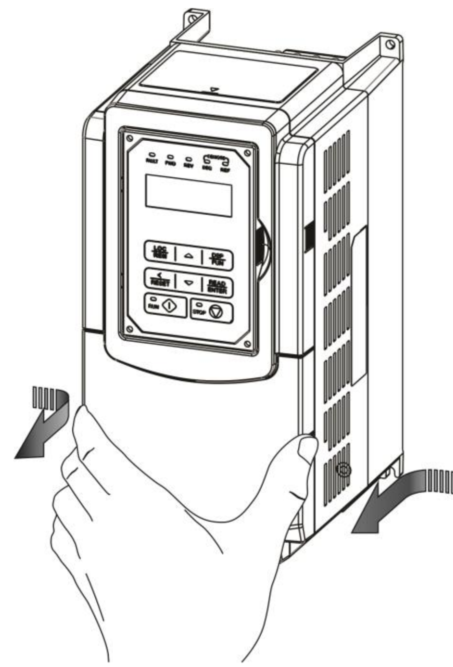
- Before making any wiring connections to the inverter the front cover needs to be removed.
- It is not required to remove the digital operator before making any wiring connections.
- Models 230V, 5 – 30 HP and 460V, 5 – 40 HP have a plastic cover. Loosen the screws and remove the cover to gain access to the terminals and make wiring connections. Place the plastic cover back and fasten screws when wiring connections have been made.
- Models 230V, 40 -125 HP and 460V, 50 – 250 HP have a metal cover. Loosen the screws and remove the cover to gain access to the terminals and make wiring connections. Place the metal cover back and fasten screws when wiring connections have been made.

3.5.1 Standard Type

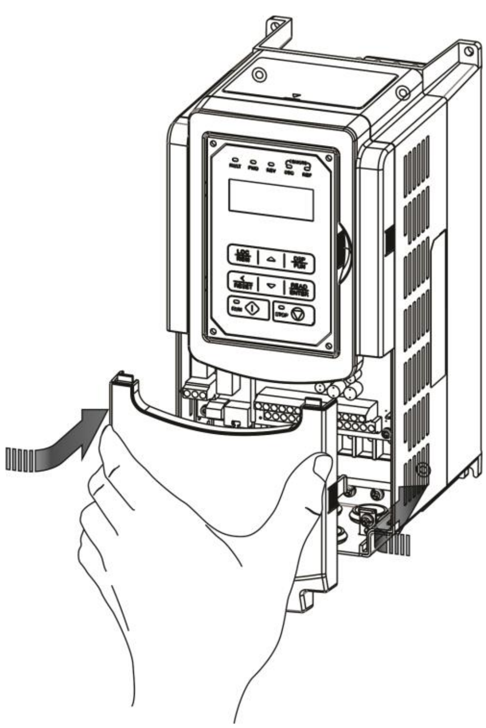
(a) 230V: 5 ~ 7.5 HP / 460V: 5 ~ 10 HP



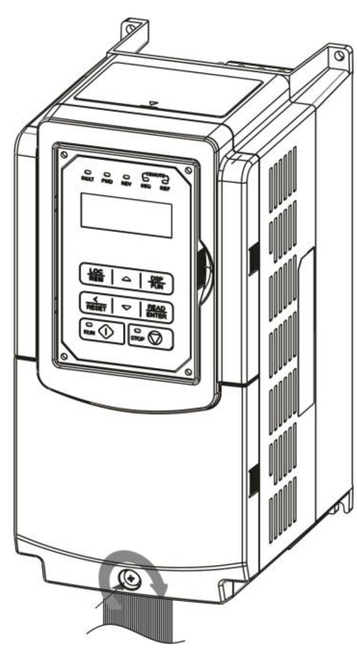
Step 1: Unscrew cover



Step 2: Remove cover

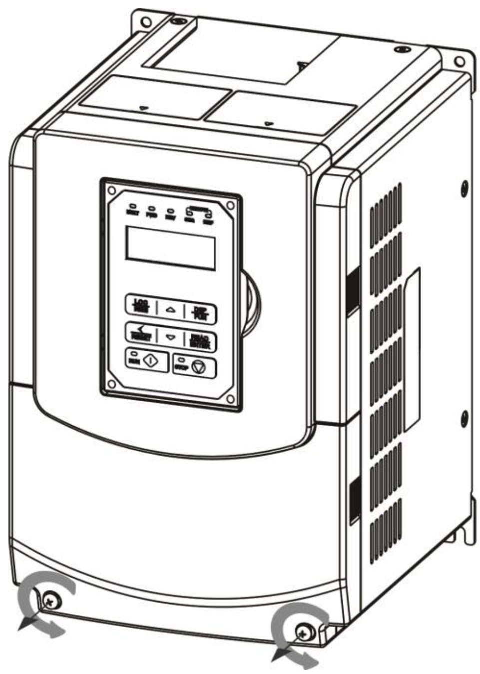


Step 3: Make wire connections and reinstall cover

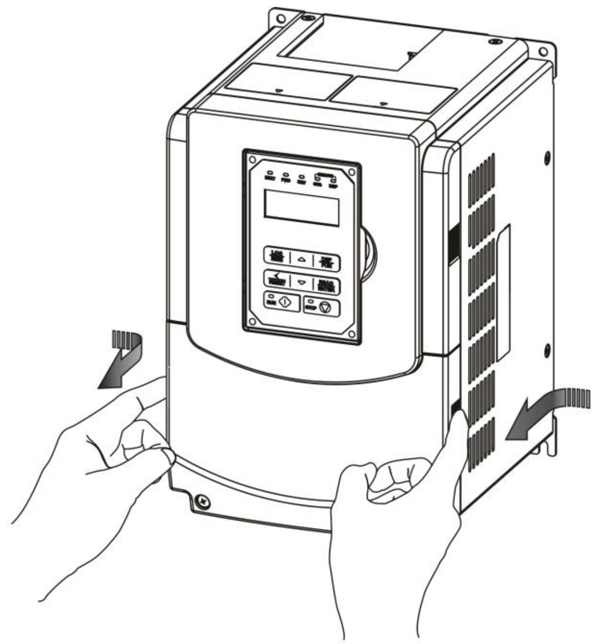


Step 4: Fasten screw

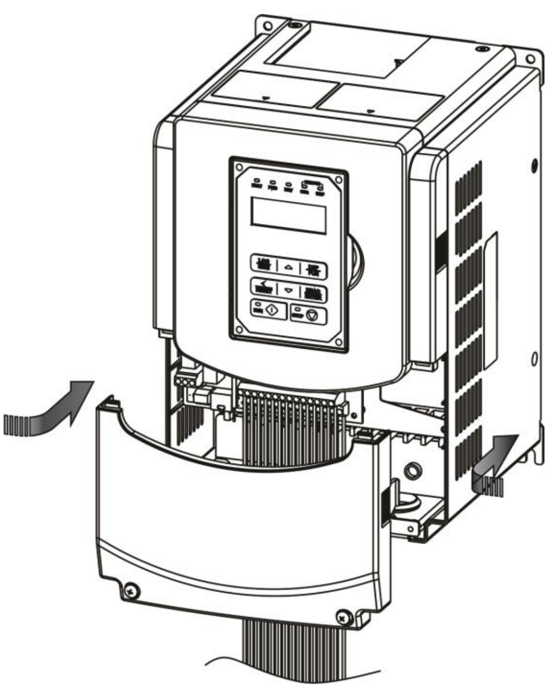
(b) 230V: 5 ~ 7.5 HP / 460V: 5 ~ 10 HP



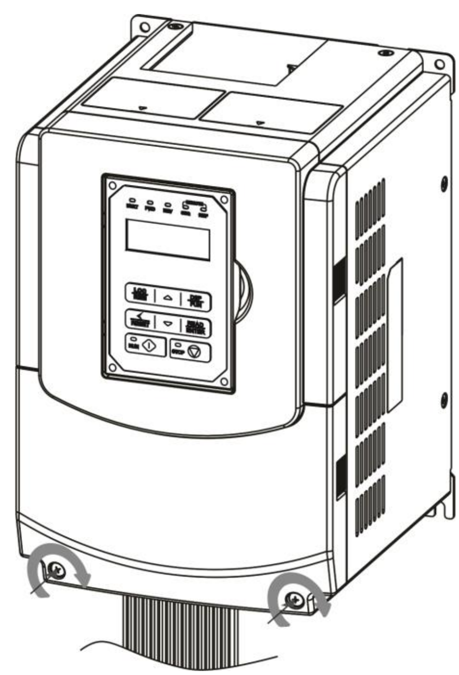
Step 1: Unscrew cover



Step 2: Remove cover

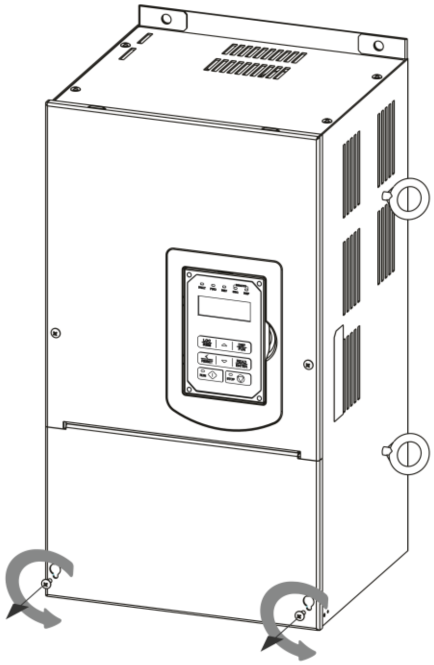


Step 3: Make wire connections and reinstall cover

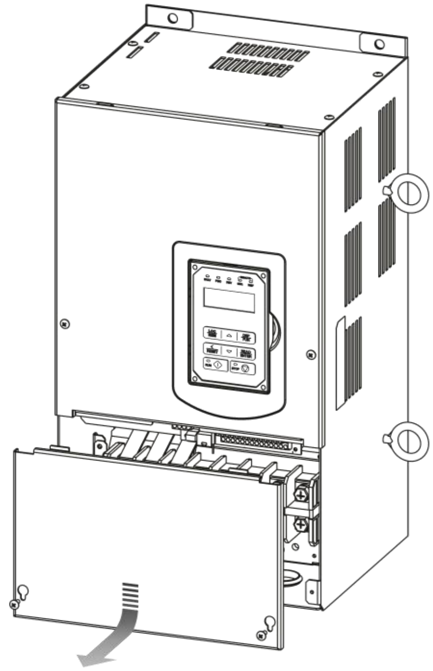


Step 4: Fasten screw

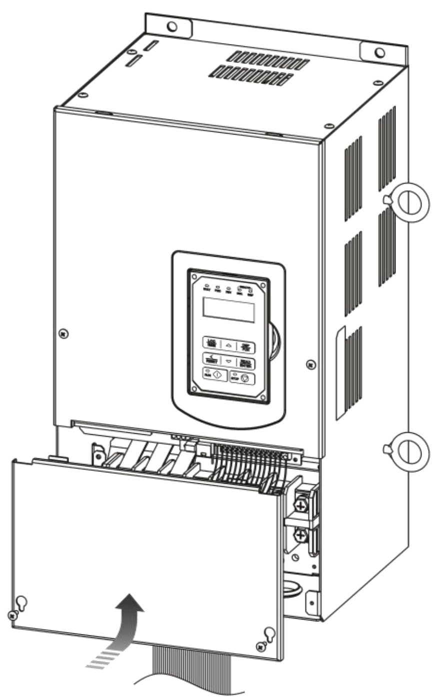
(c) 230V: 40 ~ 50 HP / 460V: 50 ~ 75 HP



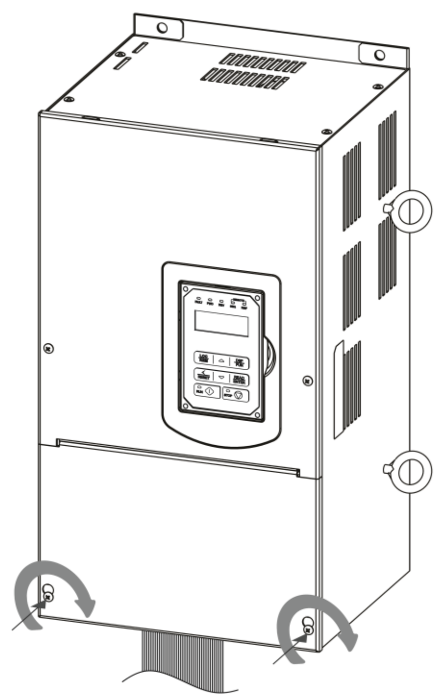
Step 1: Unfasten screw on cover



Step 2: Remove cover

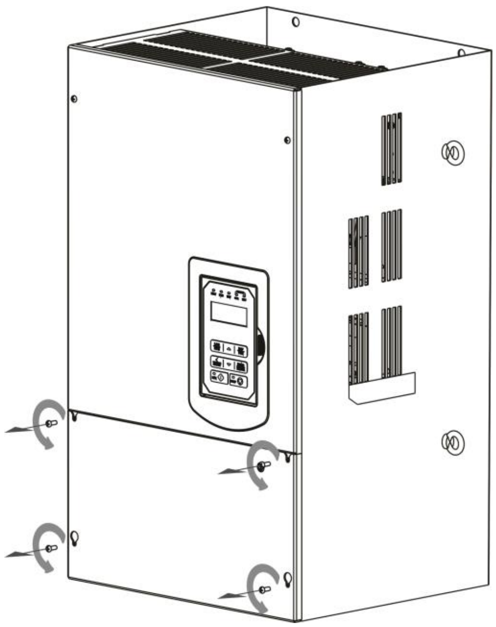


Step 3: Make wire connections and reinstall cover

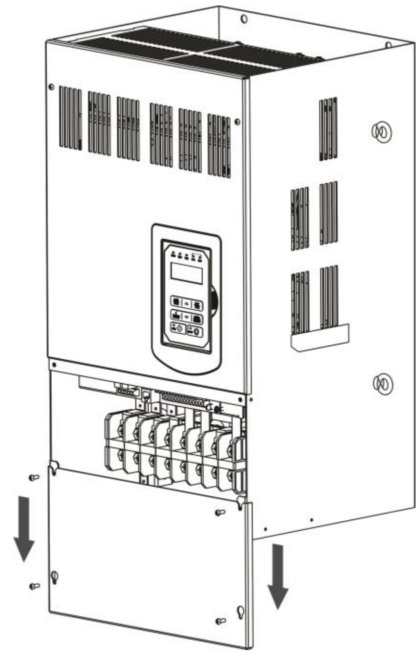


Step 4: Fasten screw

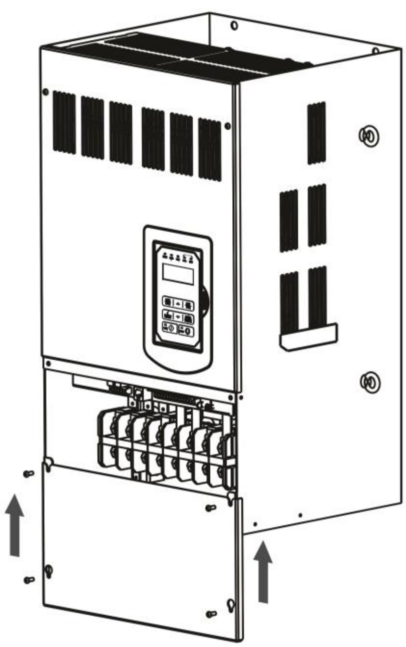
(d) 230V: 60 ~ 125 HP / 460V: 100 ~ 250 HP



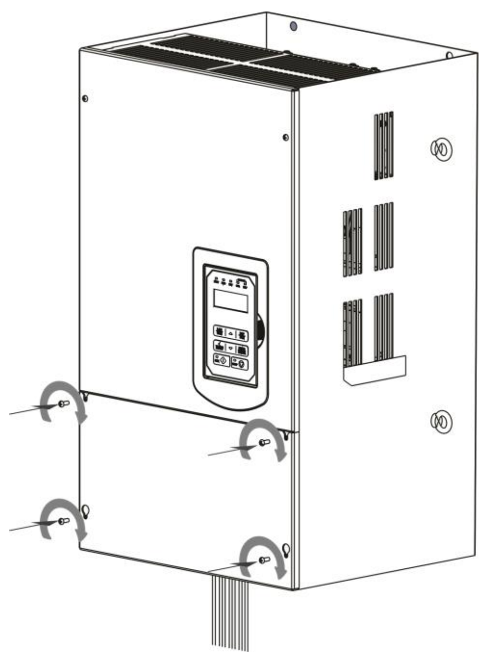
Step 1: Unfasten screw on cover



Step 2: Remove cover



Step 3: Make wire connections and reinstall cover



Step 4: Fasten screw

3.6 Wire Gauges and Tightening Torque

To comply with UL standards, use UL approved copper wires (rated 75° C) and round crimp terminals (UL Listed products) as shown in table below when connecting to the main circuit terminals. TECO recommends using crimp terminals manufactured by NICHIFU Terminal Industry Co., Ltd and the terminal crimping tool recommended by the manufacturer for crimping terminals and the insulating sleeve.

Wire size mm^2 (AWG)	Terminal screw size	Model of the round crimp terminal	Fastening torque in.lbs (kgf.cm)	Model of insulating sleeve	Model of crimp tool
0.75 (18)	M3.5	R1.25-3.5	8.2 to 10 (7.1 to 8.7)	TIC 1.25	NH 1
0.75 (18)	M4	R1.25-4	12.2 to 14 (10.4 to 12.1)	TIC 1.25	NH 1
1.25 (16)	M3.5	R1.25-3.5	8.2 to 10 (7.1 to 8.7)	TIC 1.25	NH 1
1.25 (16)	M4	R1.25-4	12.2 to 14 (10.4 to 12.1)	TIC 1.25	NH 1
2 (14)	M3.5	R2-3.5	8.2 to 10 (7.1 to 8.7)	TIC 2	NH 1 / 9
2 (14)	M4	R2-4	10.4 to 12.1 (12.2 to 14)	TIC 2	NH 1 / 9
2 (14)	M5	R2-5	17.7 to 20.8 (22.1 to 24)	TIC 2	NH 1 / 9
2 (14)	M6	R2-6	22.1 to 26.0 (25.5 to 30.0)	TIC 2	NH 1 / 9
3.5/5.5 (12/10)	M4	R5.5-4	10.4 to 12.1 (12.2 to 14)	TIC 5.5	NH 1 / 9
3.5/5.5 (12/10)	M5	R5.5-5	17.7 to 20.8 (20.4 to 24)	TIC 5.5	NH 1 / 9
3.5/5.5 (12/10)	M6	R5.5-6	22.1 to 26.0 (25.5 to 30.0)	TIC 5.5	NH 1 / 9
3.5/5.5 (12/10)	M8	R5.5-8	53.0 to 57.2 (61.2 to 66.0)	TIC 5.5	NH 1 / 9
8 (8)	M4	R8-4	10.4 to 12.1 (12.2 to 14)	TIC 8	NOP 60
8 (8)	M5	R8-5	17.7 to 20.8 (20.4 to 24)	TIC 8	NOP 60
8 (8)	M6	R8-6	22.1 to 26.0 (25.5 to 30.0)	TIC 8	NOP 60
8 (8)	M8	R8-8	53.0 to 57.2 (25.5 to 30.0)	TIC 8	NOP 60
14 (6)	M4	R14-4	10.4 to 12.1 (12.2 to 14)	TIC 14	NH 1 / 9
14 (6)	M5	R14-5	17.7 to 20.8 (20.4 to 24)	TIC 14	NH 1 / 9
14 (6)	M6	R14-6	22.1 to 26.0 (25.5 to 30.0)	TIC 14	NH 1 / 9
14 (6)	M8	R14-8	53.0 to 57.2 (61.2 to 66.0)	TIC 14	NH 1 / 9
22 (4)	M6	R22-6	22.1 to 26.0 (25.5 to 30.0)	TIC 22	NOP 60/ 150H
22 (4)	M8	R22-8	53.0 to 57.2 (61.2 to 66.0)	TIC 22	NOP 60/ 150H
30/38 (3 /2)	M6	R38-6	22.1 to 26.0 (25.5 to 30.0)	TIC 38	NOP 60/ 150H
30/38 (3 /2)	M8	R38-8	53.0 to 57.2 (61.2 to 66.0)	TIC 38	NOP 60/ 150H
50 / 60 (1/1/0)	M8	R60-8	53.0 to 57.2 (61.2 to 66.0)	TIC 60	NOP 60/ 150H
50 / 60 (1/1/0)	M10	R60-10	88.5 to 104 (102 to 120)	TIC 60	NOP 150H
70 (2/0)	M8	R70-8	53.0 to 57.2 (61.2 to 66.0)	TIC 60	NOP 150H
70 (2/0)	M10	R70-10	88.5 to 104 (102 to 120)	TIC 60	NOP 150H
80 (3/0)	M10	R80-10	88.5 to 104 (102 to 120)	TIC 80	NOP 150H
80 (3/0)	M16	R80-16	8.2 to 10 (7.1 to 8.7)	TIC 80	NOP 150H
100 (4/0)	M10	R100-10	12.2 to 14 (10.4 to 12.1)	TIC 100	NOP 150H
100 (4/0)	M12	R100-12	8.2 to 10 (7.1 to 8.7)	TIC 100	NOP 150H
100 (4/0)	M16	R80-16	12.2 to 14 (10.4 to 12.1)	TIC 80	NOP 150H

3.7 Wiring Peripheral Power Devices

Caution

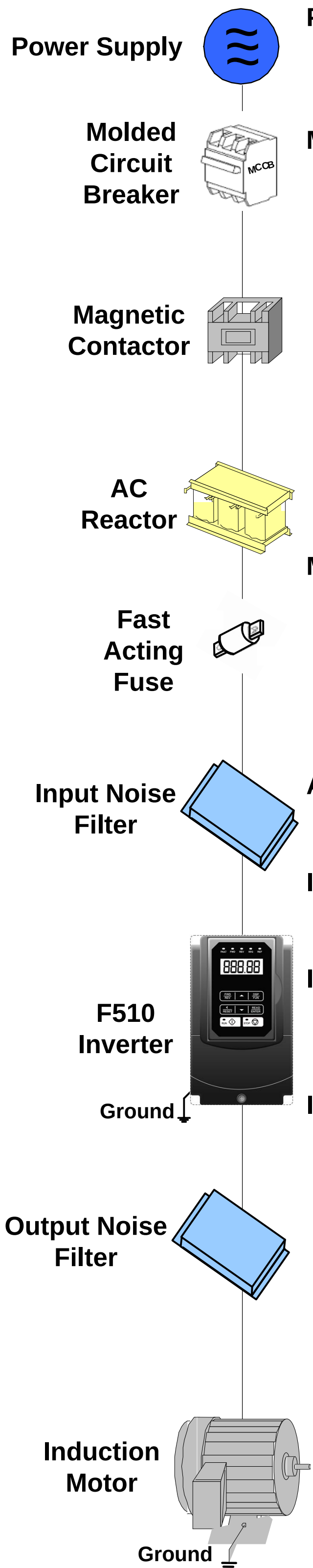
- After power is shut off to the inverter the capacitors will slowly discharge. Do NOT touch and of the inverter circuitry or replace any components until the “CHARGE” indicator is off.
- Do NOT wire or connect/disconnect internal connectors of the inverter when the inverter is powered up or when powered off and the “CHARGE”” indicator is on.
- Do NOT connect inverter output U, V and W to the supply power. This will result in damage to the inverter.
- The inverter must by properly grounded. Use terminal E to connect earth ground and comply with local standards.
- Do NOT perform a dielectric voltage withstand test (Megger) on the inverter this will result in inverter damage to the semiconductor components.
- Do NOT touch any of the components on the inverter control board to prevent damage to the inverter by static electricity.

Caution

- Refer to the recommended wire size table for the appropriate wire to use. The voltage between the power supply and the input of the inverter may not exceed 2%.

  Phase-to-phase voltage drop (V) = $\sqrt{3}$ ×resistance of wire (Ω/km) × length of line m) × current×10^{-3}.
  (km=3280 x feet) / (m=3.28 x feet)

- Reduce the carrier frequency (parameter 11-01) If the cable from the inverter to the motor is greater than 25m (82ft). A high-frequency current can be generated by stray capacitance between the cables and result in an overcurrent trip of the inverter, an increase in leakage current, or an inaccurate current readout.
- To protect peripheral equipment, install fast acting fuses on the input side of the inverter. Refer to section 11.4 for additional information.



Power supply:

- ⚠ Make sure the correct voltage is applied to avoid damaging the inverter.

Molded-case circuit breaker (MCCB) or fused disconnect:

- A molded-case circuit breaker or fused disconnect must be installed between the AC source and the inverter that conforms to the rated voltage and current of the inverter to control the power and protect the inverter.
- ⚠ Do not use the circuit breaker as the run/stop switch for the inverter.

Ground fault detector / breaker:

- ⚠ Install a ground fault breaker to prevent problems caused by current leakage and to protect personnel. Select current range up to 200mA, and action time up to 0.1 second to prevent high frequency failure.

Magnetic contactor:

- Normal operations do not need a magnetic contactor. When performing functions such as external control and auto restart after power failure, or when using a brake controller, install a magnetic contactor.
- ⚠ Do not use the magnetic contactor as the run/stop switch for the inverter.

AC line reactor for power quality:

- When inverters are supplied by a high capacity power source (> 600KVA), an AC reactor can be connected to improve the power factor.

Install Fast Acting Fuse:

- To protect peripheral equipment, install fast acting fuses in accordance with the specifications in section 11 for peripheral devices.

Input Noise filter:

- A filter must be installed when there are inductive loads affecting the inverter. The inverter meets EN55011 Class A, category C3 when the TECO special filter is used. See section 11 for peripheral devices.

Inverter:

- Output terminals T1, T2, and T3 are connected to U, V, and W terminals of the motor. If the motor runs in reverse while the inverter is set to run forward, swap any two terminals connections for T1, T2, and T3.
- ⚠ To avoid damaging the inverter, do not connect the output terminals T1, T2, and T3 to AC input power.
- ⚠ Connect the ground terminal properly. (230V series: Rg <100Ω; 460V series: Rg <10Ω.)

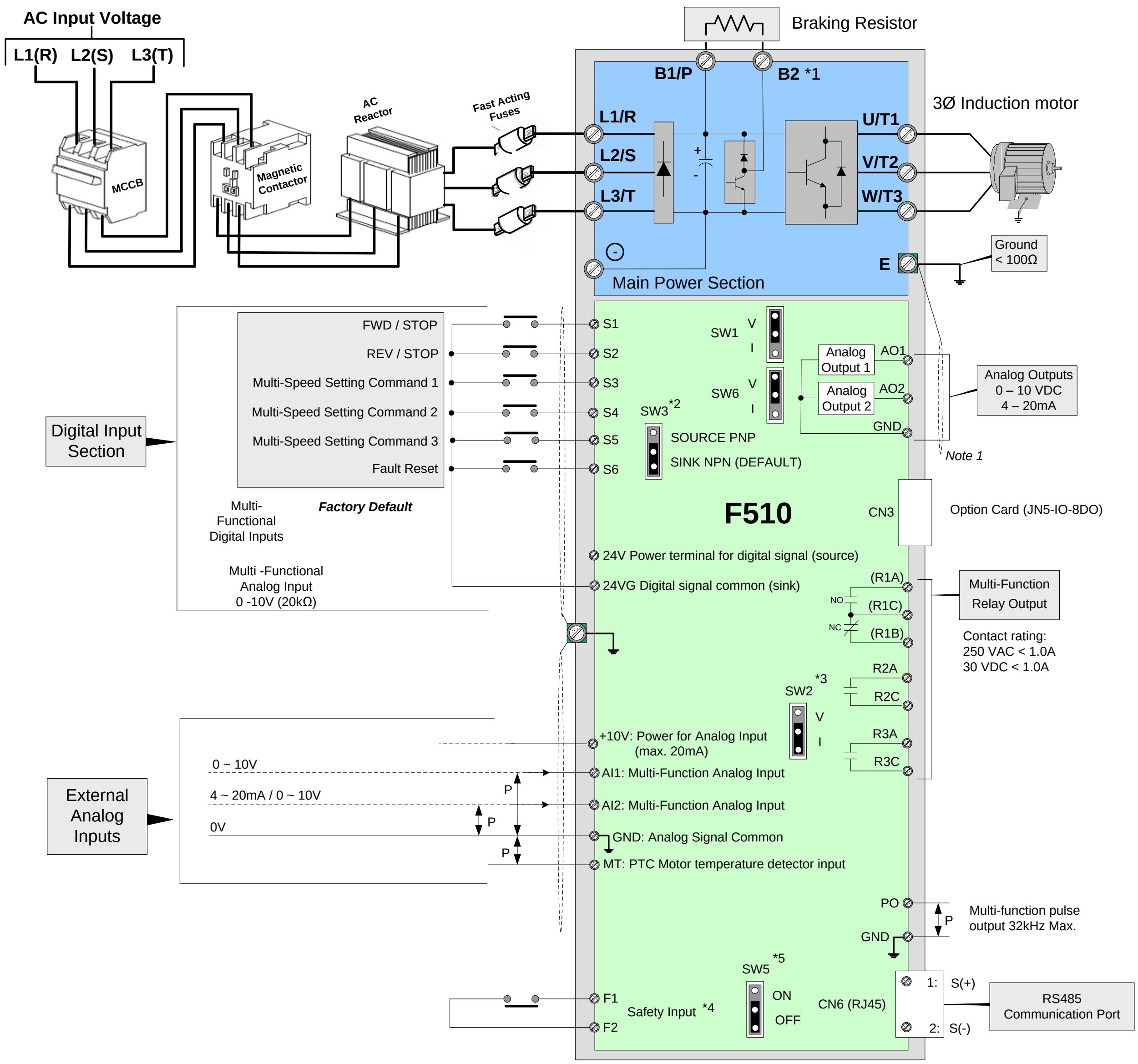
Output Noise filter:

- An output noise filter may reduce system interference and induced noise. See section 11 for peripheral devices.

Motor:

- If the inverter drives multiple motors the output rated current of the inverter must be greater than the total current of all the motors.

3.8 General Wiring Diagram



Notes:

*1: Models IP20 230V 5 ~ 30HP, 460V 5 ~ 40HP have a built-in braking transistor. To use this braking transistor a braking resistor can be connected between B1 and B2.

*2: Use SW3 to select between Sink (NPN, with 24VG common) or Source (PNP, with +24V common) for multi-function digital input terminals S1~S6.

*3: Use SW2 to switch between voltage and current input for Multi-function analog input 2 (AI2).

*4: Safety input F1 and F2 is a normally closed input. This input should be closed to enable the inverter output. To activate this input remove the jumper wire between F1 and F2.

*5. Terminating resistor can be set to ON or bypass (Off). This is used when connecting multiple drives in an RS485 network.

3.9 User Terminals (Control Circuit Terminals)

IP20 Type:

230V: 5 ~ 50 HP, 460V: 5~ 75HP

S(+)	S(-)	S1	S3	S5	24V	+10V	MT	GND	GND	AI1	AI2	
E	24VG	S2	S4	S6	F1	F2	PO	P I	AO1	AO2	E	

R1A	R1B	R1C	
R2A	R2C	R3A	R3C

230V: 60 ~ 125 HP, 460V: 100 ~ 250HP

S(+)	S(-)	S1	S3	S5	24V	+10V	MT	GND	GND	AI1	AI2	
E	24VG	S2	S4	S6	F1	F2	PO	P I	AO1	AO2	E	

R1A	R1B	R1C	R2A	R2C	R3A	R3C

Description of User Terminals

Type	Terminal	terminal function	Signal level / Information
Digital input signal	**S1**	2-Wire Forward Run - stop command (default), multi-function input terminals * 1	Signal Level 24 VDC (opto isolated) Maximum current: 8mA Maximum voltage: 30 Vdc Input impedance: 9.03kΩ
	S2	2-Wire Reverse Run - stop command (default), multi-function input terminals * 1	
	S3	Multi-speed/ position setting command 1 (default), multi-function input terminals * 1	
	S4	Multi-speed/ position setting command 2 (default), multi-function input terminals * 1	
	S5	Multi-speed/ position setting command 3 (default), multi-function input terminal* 1	
	S6	Fault reset input, multi-function input terminal * 1	
24V Power supply	**24V**	Digital signal SOURCE (SW3 switched to mode)	±15%, Max. output current: 250mA (The sum of all loads connected)
	24VG	Common terminal for Digital signals Common point for digital signal SINK (SW3 switched to SINK)	
Analog input signal	**+10V**	Power for external speed potentiometer	±5% (Max. current: 20mA)
	MT	Motor temperature detector for eccternally connected PTC	1330Ω Range, 550Ω return
	AI1	Multi-function analog input for speed reference (0-10V input)	Range 0 to +10V Input impedance: 20KΩ Resolution: 12bit
	AI2	Multi-function analog input terminals *2, SW2 switched between voltage or current input (0~10V)/(4-20mA)	Range 0 to +10V Input impedance: 20KΩ Range 4 to 20 mA Input impedance: 250Ω Resolution: 12bit
	GND	Analog signal ground terminal	----
	E	Shielding wire connecting terminal (Ground)	----
Analog output signal	**AO1**	Multi-function analog output terminals *3 (0~10V/ 4-20mA output)	Range 0 to 10V Max. current: 2mA From 4 to 20 mA
	AO2	Multi-function analog output terminals *3 (0~10V/ 4-20mA output)	
	GND	Analog signals ground terminal	
Type	**Terminal**	**terminal function**	**Signal level / Information**
Pulse output signal	**PO**	Pulse output, Bandwidth 32KHz	Max. Frequency: 32KHz Open Collector output (Load: 2.2kΩ)
	GND	Analog signals ground terminal	----

Pulse input signal	**PI**	Pulse command input, bandwidth is 32KHz	L: from 0.0 to 0.5V H: from 4.0 to 13.2V Max. Frequency: 0 - 32KHz Impedance: 3.89 KΩ
	GND	Analog signals ground terminal	----
Relay output	**R1A-** **R1B-** **R1C-**	Relay A contact (multi-function output terminal) Relay B contact (multi-function output terminal) Relay contact common terminal, please refer to parameter group 03 in this manual for function description.	Rating: 250Vac, 10 mA ~ 1A 30Vdc, 10 mA ~ 1A
	R2A-R2C	Same functions as R1A/R1B/R1C	Rating: 250Vac, 10 mA ~ 1A 30Vdc, 10 mA ~ 1A
	R3A-R3C	Same functions as R1A/R1B/R1C	Rating: 250Vac, 10 mA ~ 1A 30Vdc, 10 mA ~ 1A
Run Permissive Input	**F1**	On: normal operation. Off: stop. (Jumper wired between F1 and F2 has to be removed by using external contact to stop.)	24Vdc, 8mA, pull-up
	F2	Safety command common terminal	24V Ground
RS-485 port	**S (+)**	RS485/MODBUS	Differential input and output
	S (-)		
Grounding	**E (G)**	Grounding to earth Shield the connecting terminal	----

Notes:

*1:Refer to:

- Group 03: External Terminals Digital Input / Output Function Group.

*2:Refer to:

- Group 04 - External Terminal Analog Signal Input (Output) Function Group.

*3:Refer to:

- Group 04 - External Terminal Analog Signal Input (Output) Function Group.

Caution

- Maximum output current capacity for terminal 10V is 20mA.
- Multi-function analog output AO1 and AO2 are intended as analog output meter signals. Do not use them for feedback control.
- Control board's 24V and 10V are to be used for internal control only, Do not use the internal power-supply to power external devices.

3.10 Power Terminals

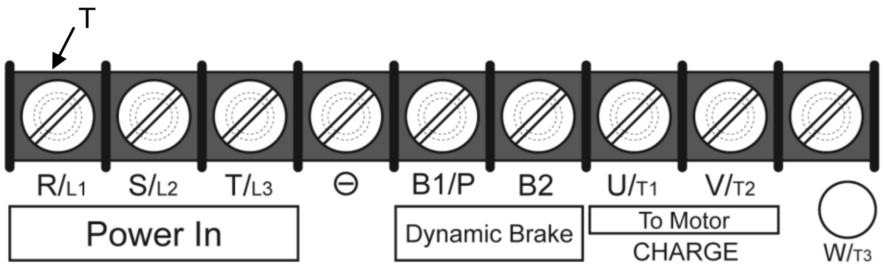
IP00 / IP20 Type

<table>
<tr><th>Terminal</th><th>230V: 5 ~ 30HP
460V: 5 ~ 40HP</th><th>230V: 40 ~ 125HP
460V: 50 ~ 250HP</th></tr>
<tr><td>R/L1</td><td colspan="2" rowspan="3">Input Power Supply (For single phase use terminals R/L1 and S/L2)</td></tr>
<tr><td>S/L2</td></tr>
<tr><td>T/L3</td></tr>
<tr><td>B1／P</td><td rowspan="3">• B1／P－⊖: DC power supply
• B1／P－B2: external braking resistor</td><td rowspan="2">-</td></tr>
<tr><td>B2</td></tr>
<tr><td>⊖</td><td rowspan="2">• ⊕ -⊖: DC power supply or connect braking module</td></tr>
<tr><td>⊕</td><td>-</td></tr>
<tr><td>U/T1</td><td colspan="2" rowspan="3">Inverter output</td></tr>
<tr><td>V/T2</td></tr>
<tr><td>W/T3</td></tr>
<tr><td>E</td><td colspan="2">Ground terminal</td></tr>
</table>

*1. All models 460V 25HP (18.5KW) or below have a built-in braking transistor.
*2. Before connecting DC reactor, please remove factory supplied jumper between terminal ⊕1 and ⊕2.

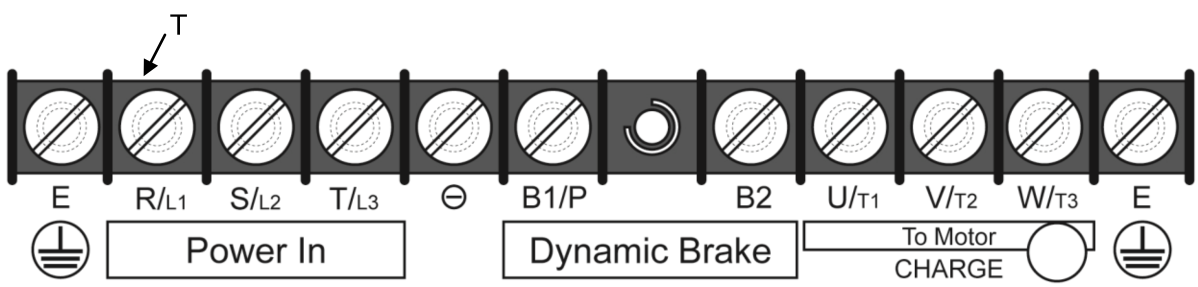
IP20 Type

230V: 5-7.5HP/ 460V: 5-10HP



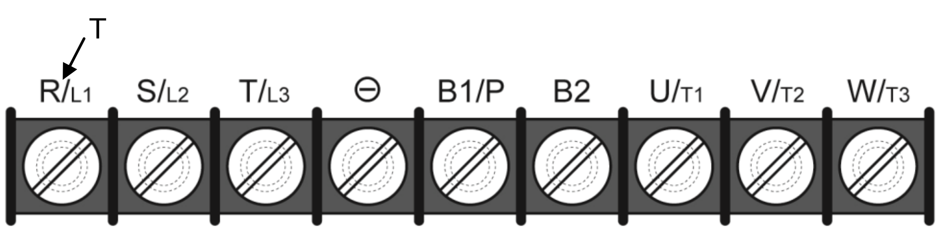
Terminal screw size	
T	⏚
M4	M4

230V: 10-15HP/ 460V: 15- 20HP



Terminal screw size	
T	⏚
M4	M4

230V: 20-30HP/ 460V: 25-40HP



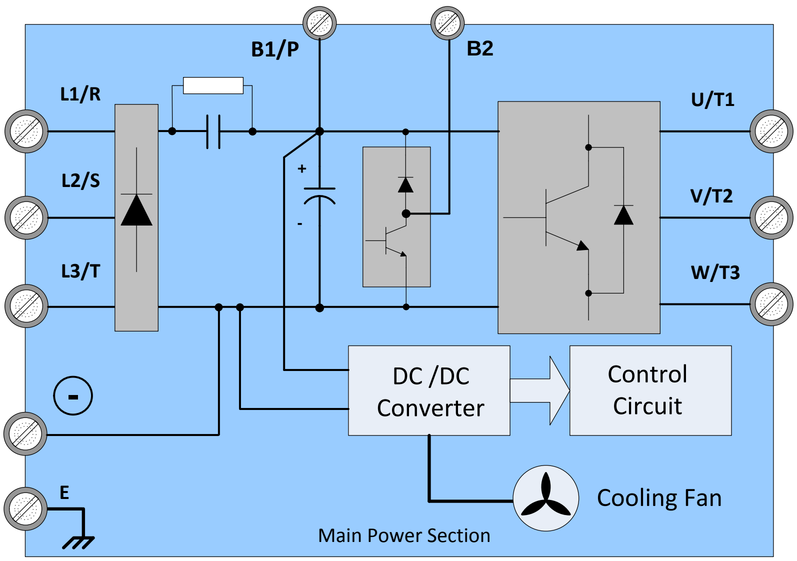
Terminal screw size	
T	⏚
M6	M6

3.11 Input / Output Power Section Block Diagram

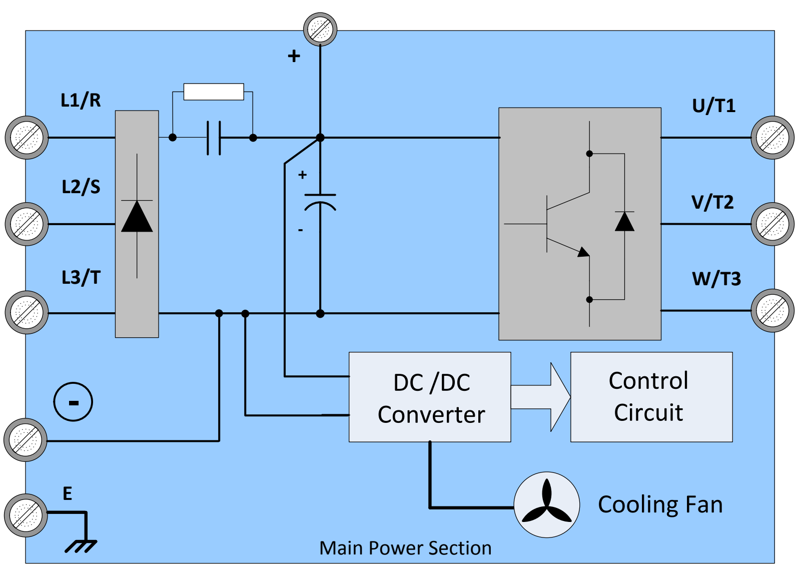
The following diagrams show the basic configuration for IP00/IP20 power sections for the range of horsepower and input voltages. This is shown for reference only and is not a detailed depiction.

IP00/IP20 Type

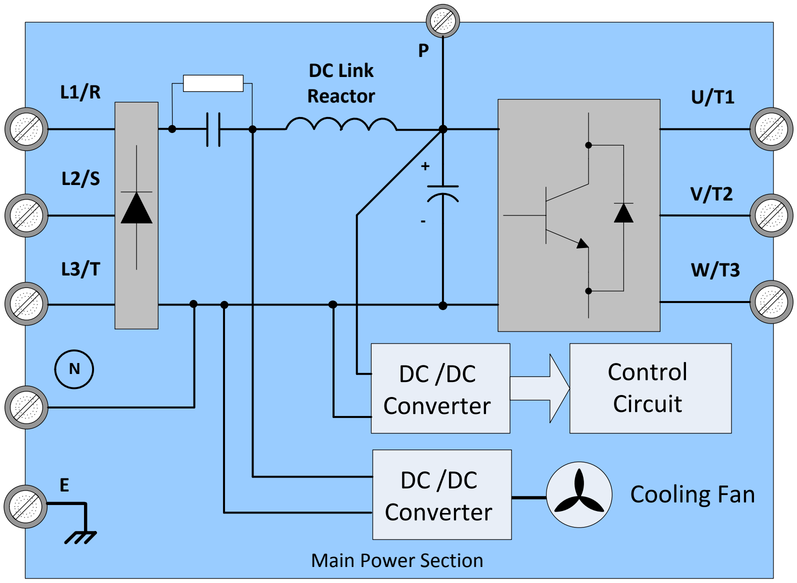
1: 230V: 5 ~ 30 HP / 460V: 5 ~ 40 HP



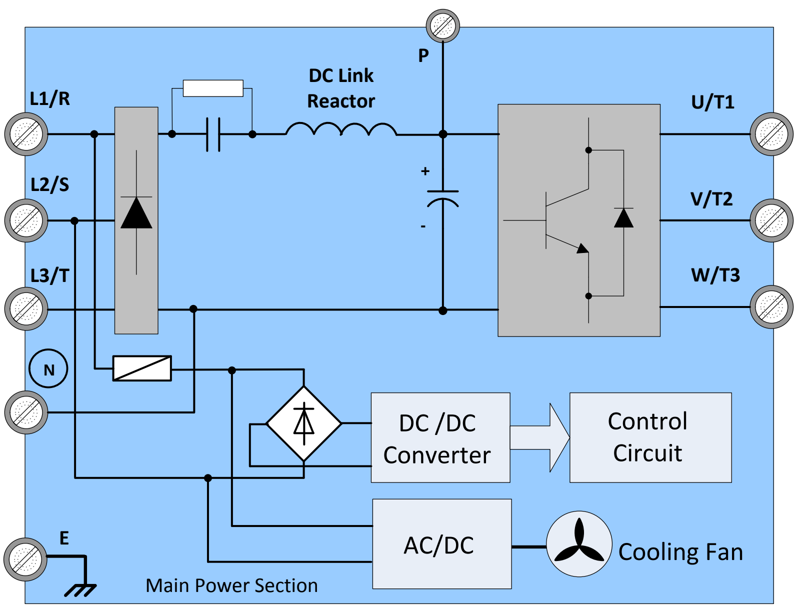
2: 230V: 40 ~ 50 HP / 460V: 50 ~ 76 HP



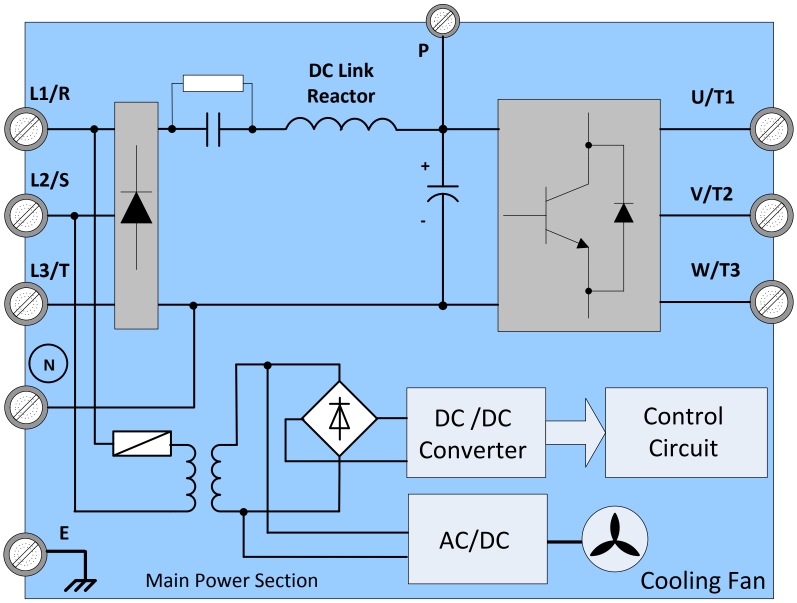
3: 230V: 60 ~ 75 HP / 460V: 100 ~ 125 HP



4: 230V: 100 ~ 125 HP



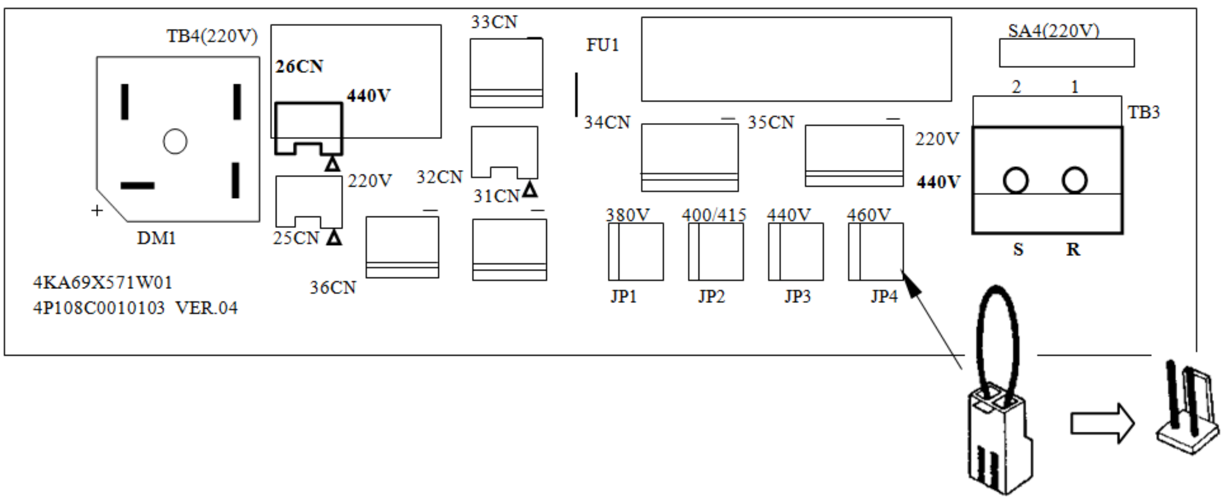
5: 460V: 150 ~ 250 HP



3.11.1 Cooling Fan Supply Voltage Selection (460V class)

The inverter input voltage range of the F510 460V class models ranges from 380 to 480Vac. In these models the cooling fan is directly powered from the power supply. Inverter models F510-4125/ 4150/ 4175/ 4215/ 4250 requires the user to select the correct jumper position based on the inverter input voltage ("460V" is the default position for these models). Please select the correct position according to the input voltage. If the voltage setting is too low, the cooling fan will not provide adequate cooling for the inverter resulting in an over-heat error. If the input voltage is greater than 460Vac, select the "460V" position.

460V: 150 – 250 HP



3.12 Inverter Wiring

Wiring Precautions

! **Danger**	• Do **NOT** remove any protective covers or attempt any wiring while input power is applied. Connect all wiring before applying input power. When making wiring changes after power up, remove input power and wait a minimum of five minutes after power has been turned off before starting. Also confirm that the charge lamp is off and that DC voltage between terminals B1/P or (+) and (-) does not exceed 25V, otherwise **electric shock may result.** • Only authorized personnel should work on the equipment. (Remove any metal jewelry such as watches and rings and use insulated tools.), otherwise **electric shock or injury may result.**

(A) Power input terminals

1. The Input power supply voltage can be connected in any phase sequence to power input terminals R/L1, S/L2, or T/L3 on the terminal block.
2. DO NOT connect the AC input power source to the output terminals U/T1, V/T2 and. W/T3.
3. Connect the output terminals U/T1, V/T2, W/T3 to motor lead wires U/T1, V/T2, and W/T3, respectively.
4. Check that the motor rotates forward with the forward run source. If it does not, swap any 2 of the output cables to change motor direction.
5. DO NOT connect phase correcting capacitors or LC/RC noise filter to the output circuit.

(B) Grounding

1. Connect the ground terminal (E) to ground having a resistance of less than 100Ω.
2. Do not share the ground wire with other devices, such as welding machines or power tools.
3. Always use a ground wire that complies with the local codes and standards for electrical equipment and minimize the length of ground wire.
4. When using more than one inverter, be careful not to loop the ground wire. See exampled below in Fig. 3.12.1.

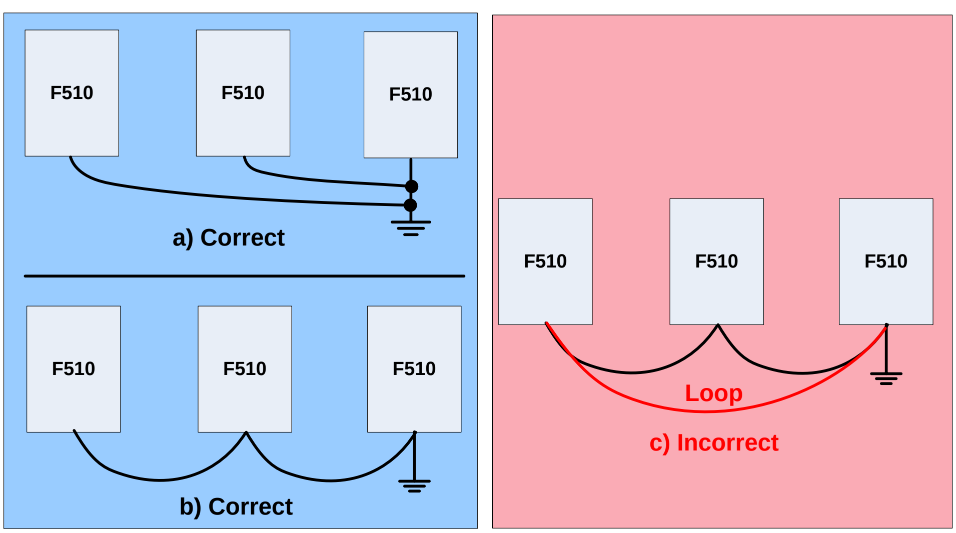


Fig. 3.12.1 Inverter Grounding

3.13 Input Power and Motor Cable Length

The length of the cables between the input power source and /or the motor and inverter can cause a significant phase to phase voltage reduction due to the voltage drop across the cables. The wire size shown in Tables 3.16.1 is based on a maximum voltage drop of 2%. If this value is exceeded, a wire size having larger diameter may be needed. To calculate phase to phase voltage drop, apply the following formula:

Phase-to-phase voltage drop (V) = $\sqrt{3}$ ×resistance of wire (Ω/km) × length of line m) × current×10^{-3}.

(km=3280 x feet)
(m=3.28 x feet)

3.14 Cable Length vs. Carrier Frequency

The allowable setting of the PWM carrier frequency is also determined by motor cable length and is specified in the following Table 3.14.1.

Table 3.14.1 Cable Length vs. Carrier Frequency

Cable length between the inverter and Motor in ft. (m)	<100 (< 30)	100 – 165 (30 – 50)	166 - 328 (50 – 100)	≥ 329 (≥ 100)
Recommended carrier frequency allowed Parameter 11-01	16kHz (max)	10 kHz (max)	5 kHz (max)	2 kHz (max)

3.15 Installing an AC Line Reactor

If the inverter is connected to a large-capacity power source (600kVA or more), install an AC reactor on the input side of the inverter. This also improves the power factor on the power supply side.

3.16 Power Input Wire Size, NFB and MCB Part Numbers

The following table shows the recommended wire size, molded case circuit breakers and magnetic contactors for each of the F510 models. It depends on the application whether or not to install a circuit breaker. The NFB must be installed between the input power supply and the inverter input (R/L1, S/L2, T/L3).

Note: When using ground protection make sure the current setting is above 200mA and trip delay time is 0.1 sec of higher.

Table 3.16.1 Wiring instrument for 230V/460V class (IP00/IP20)

F510 Model				Wire size (mm^2)			NFB*3	MC*3
Power supply	Horse power (HP)	Rated KVA	Rated current (A)	Main circuit *1	Grounding E(G)	Control line*2		
230V 3 Ø	5HP	5.5	14.5	3.5～5.5	3.5～5.5	0.5～2	TO-50EC(30A)	CU-16
	7.5HP	8.0	22	5.5	5.5	0.5～2	TO-50EC(30A)	CU-16
	10HP	11.4	30	8	5.5～8	0.5～2	TO-100S(50A)	CU-18
	15HP	15	42	8	5.5～8	0.5～2	TO-100S(50A)	CU-25
	20HP	21	56	14	8	0.5～2	TO-100S(100A)	CU-50
	25HP	26	69	22	8	0.5～2	TO-100S(100A)	CU-65
	30HP	30	80	22	14	0.5～2	TO-225S(100A)	CU-80
	40HP	42	110	38	14	0.5～2	TO-225S(150A)	CN-100
	50HP	53	138	60	22	0.5～2	TO-225S(175A)	CN-125
	60HP	64	169	80	22	0.5～2	TO-225S(200A)	CN-150
	75HP	76	200	100	22	0.5～2	TO-225S(225A)	CN-180
	100HP	95	250	150	22	0.5～2	TO-400S(300A)	CN-300
	125HP	119	312	200	38	0.5～2	TO-400S(400A)	CN-300
	150HP	152	400	300	38	0.5～2	TO-600S(600A)	S-K400
460V 3 Ø	5HP	7.0	9.2	2～5.5	3.5～5.5	0.5～2	TO-50EC(15A)	CU-18
	7.5HP	8.5	12.1	2～5.5	3.5～5.5	0.5～2	TO-50EC(15A)	CU-18
	10HP	13.3	17.5	3～5.5	3.5～5.5	0.5～2	TO-50EC(20A)	CU-18
	15HP	18	23	5.5	5.5	0.5～2	TO-50EC(30A)	CU-25
	20HP	24	31	8	8	0.5～2	TO-100S(50A)	CU-25
	25HP	29	38	8	8	0.5～2	TO-100S(50A)	CU-35
	30HP	34	44	8	8	0.5～2	TO-100S(50A)	CU-50
	40HP	41	58	14	8	0.5～2	TO-100S(75A)	CU-50
	50HP	55	73	22	8	0.5～2	TO-100S(100A)	CU-65
	60HP	67	88	22	14	0.5～2	TO-100S(100A)	CN-80
	75HP	79	103	38	14	0.5～2	TO-225S(150A)	CN-100
	100HP	111	145	60	22	0.5～2	TO-225S(175A)	CN-150
	125HP	126	168	80	22	0.5～2	TO-225S(225A)	CN-150
	150HP	159	208	150	22	0.5～2	TO-400S(300A)	CN-300
	175HP	191	250	150	22	0.5～2	TO-400S(300A)	CN-300
	215HP	226	296	200	30	0.5～2	TO-400S(400A)	CN-300
	250HP	250	328	250	30	0.5～2	TO-400S(400A)	S-K400

*1. The main circuit terminals: R/L1, S/L2, T/L3 , U/T1, V/T2, W/T3, B1／P, B2, ⊖, ⊕.

*2. Control line is the terminal wire on the control board.

*3. The NFB and MCB listed in the table are of TECO product numbers. Products with same rating from other manufacturers may be used. To reduce electrical noise interference, ensure that on RC surge absorber (R: 10Ω/ 5W, C: 0.1μf/1000VDC) is added to both sides of MCB coil.

Table 3.16.2 Wiring instrument for 230V/460V clas

F510 Model				Wire size(mm^2)			NFB*3	MC*3
Power supply	Horse power (HP)	Rated KVA	Rated current (A)	Main circuit*1	Grounding E(G)	Control line*2		
460V 3 Ø	5HP	7.0	9.2	2～5.5	3.5～5.5	0.5～2	TO-50EC(15A)	CU-18
	7.5HP	8.5	12.1	2～5.5	3.5～5.5	0.5～2	TO-50EC(15A)	CU-18
	10HP	13.3	17.5	3～5.5	3.5～5.5	0.5～2	TO-50EC(20A)	CU-18
	15HP	18	23	5.5	5.5	0.5～2	TO-50EC(30A)	CU-25
	20HP	24	31	8	8	0.5～2	TO-100S(50A)	CU-25
	25HP	29	38	8	8	0.5～2	TO-100S(50A)	CU-35
	30HP	34	44	8	8	0.5～2	TO-100S(50A)	CU-50
	40HP	41	58	14	8	0.5～2	TO-100S(75A)	CU-50
	50HP	55	73	22	8	0.5～2	TO-100S(100A)	CU-65
	60HP	67	88	22	14	0.5～2	TO-100S(100A)	CN-80
	75HP	79	103	38	14	0.5～2	TO-225S(150A)	CN-100
	100HP	111	145	60	22	0.5～2	TO-225S(175A)	CN-150

*1. The main circuit terminals: R/L1, S/L2, T/L3 , U/T1, V/T2, W/T3, B1／P, B2, ⊖, ⊕.

*2. Control line is the terminal wire on the control board.

*3. The NFB and MCB listed in the table are of TECO product numbers. Products with same rating from other manufacturers may be used. To reduce electrical noise interference, ensure that on RC surge absorber (R: 10Ω/ 5W, C: 0.1μf/1000VDC) is added to both sides of MCB coil.

3.17 Control Circuit Wiring

(1) Separate the wiring for control circuit terminals from main circuit wiring for terminals (R/L1, S/L2, T/L3, U/T1, V/T2, W/T3).

(2) Separate the wiring for control circuit terminals R1A-R1B-R1C (or R2A, R2C) (Relay outputs) from wiring for terminals ① - ⑧, A01, A02, GND, DO1, DO2, DOG, +12V, (-12V), AI1, AI2 and GND wiring.

(3) Use shielded twisted-pair cables (#24 - #14 AWG / 0.5 -2 mm^2) shown in Fig. 3.17.1 for control circuits to minimize noise problems. The maximum wiring distance should not exceed 50m (165 ft).

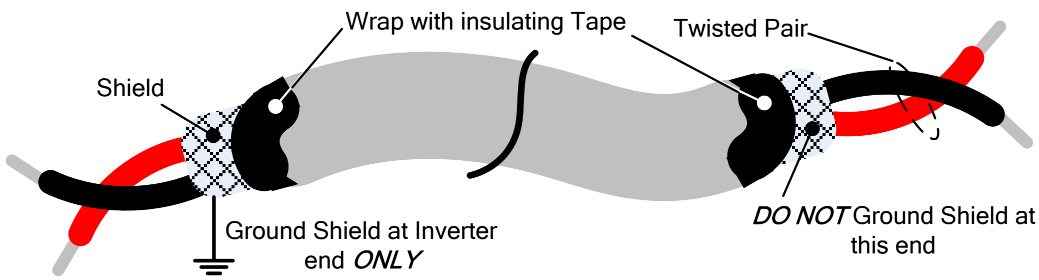


Fig. 3.17.1 Shielded Twisted-Pair

(4) In Section 3.8 the control boards referenced have a jumper SW3 that can select the digital input to terminals ① - ⑧ to be set for SINK or SOURCE. The following Fig. 3.17.2 (a.) – (d.) shows examples for the various SINK / Source interfaces.

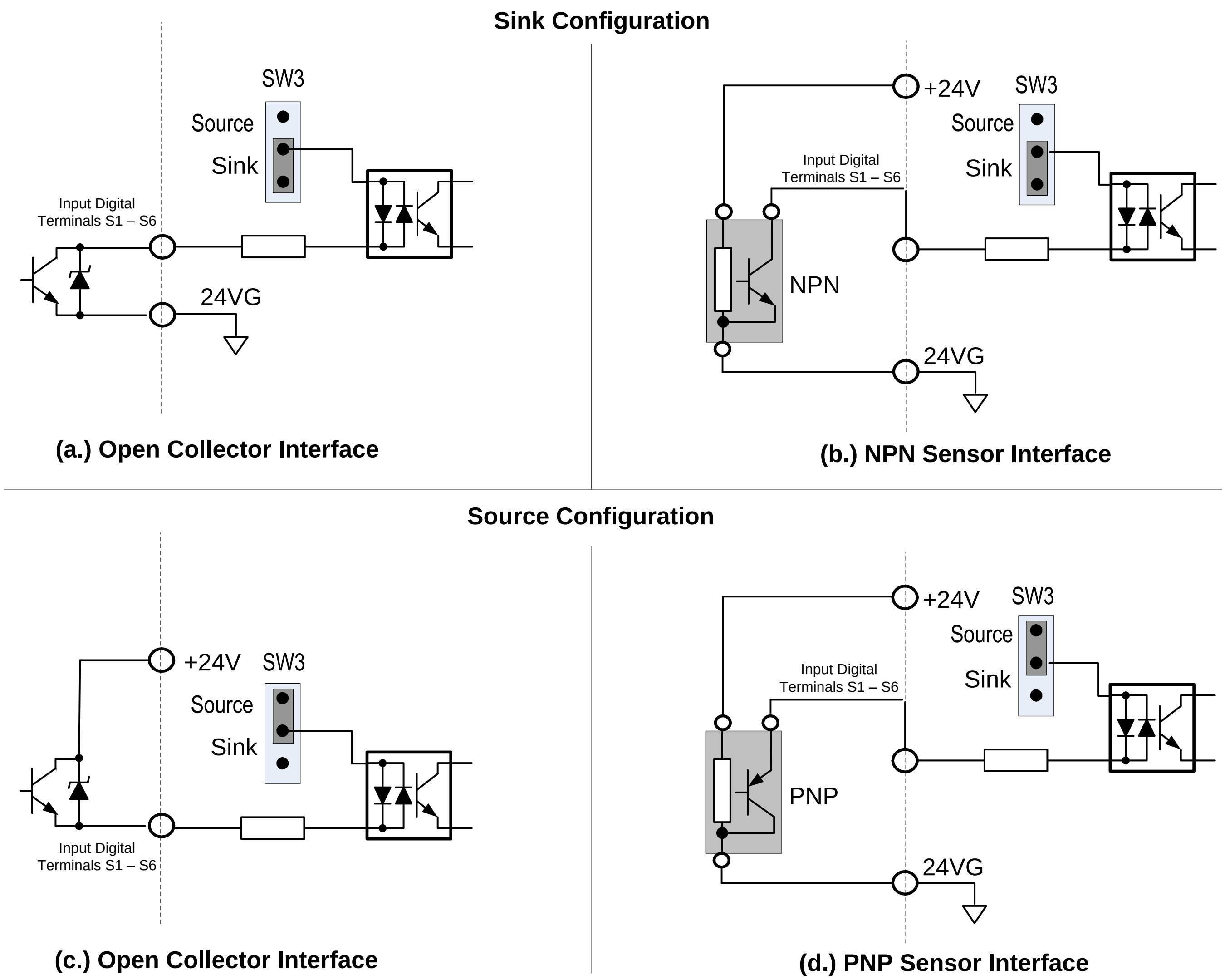


Fig. 3.17.2 Sink / Source Configurations

3.18 Inverter Specification

Basic Specifications 230V class

Inverter capacity (HP)		5	7.5	10	15	20	25	30	40	50	60	75	100	125	150
Output Rated	Rated Output Capacity (KVA)	5.5	8	11.4	15.2	21.3	26.2	30	41.9	52.5	64.3	76.2	95.2	118.8	152
	Rated Output Current (A)	14.5	22	30	42	56	69	80	110	138	169	200	250	312	400
	Maximum Applicable Motor [*1]HP (KW)	5 (3.7)	7.5 (5.5)	10 (7.5)	15 (11)	20 (15)	25 (18.5)	30 (22)	40 (30)	50 (37)	60 (45)	75 (55)	100 (75)	125 (90)	150
	Maximum Output Voltage (V)	3-phase 230V~240V													
	Maximum Output Frequency (Hz)	Based on parameter setting 0.1~400.0 Hz													
Power supply	Rated Voltage, Frequency	3-phase 230V~240V, 50/60Hz													
	Allowable Voltage Fluctuation	-15% ~ +10%													
	Allowable Frequency Fluctuation	±5%													

Basic Specifications 460V class

Inverter capacity (HP)		5	7.5	10	15	20	25	30	40	50	60	75	100	125	150	175	215	250
Output Rated	Rated Output Capacity (KVA)	7.0	8.4	13.3	17.5	23.6	28.9	33.5	41.1	54.8	67	78.4	110	125	158	190	225	250
	Rated Output Current (A)	9.2	12.1	17.5	23	31	38	44	58	73	88	103	145	168	208	250	296	328
	Maximum Applicable Motor *1HP (KW)	5 (3.7)	7.5 (5.5)	10 (7.5)	15 (11)	20 (15)	25 (18.5)	30 (22)	40 (30)	50 (37)	60 (45)	75 (55)	100 (75)	125 (90)	150 (110)	175 (132)	215 (160)	250 (185)
	Maximum Output Voltage (V)	3-phase 380V~480V																
	Maximum Output Frequency (Hz)	Based on parameter setting 0.1~400.0 Hz																
Power supply	Rated Voltage, Frequency	3-phase 380V~480V, 50/60Hz																
	Allowable Voltage Fluctuation	-15% ~ +10%																
	Allowable Frequency Fluctuation	±5%																

*1: Take standard 4-pole induction motor as the base.

*2: F510 model is designed to be used in variable torque (VT) application with overload capability of 120% for 1 min.

The following table shows the maximum output frequency for each control mode.

Control mode	Other settings	Maximum output frequency
V/F	Unlimited	400Hz
SLV	230V 5~15HP, 460V 5~20HP	150Hz
	230V 20~30HP, 460V 25HP	110Hz
	460V 30~40HP	100Hz
	230V 40~125HP, 460V 50~215HP, carrier (11-01) is set as 8K or below 8K.	100Hz
	230V 40~125HP, 460V 50~215HP, carrier (11-01) is set as above 8K.	80Hz
	230V 150~175HP, 460V 250~800HP	100Hz
PMSLV	Unlimited	400Hz

3.19 General Specifications

Control Characteristics	**Operation Modes**	LED keypad with seven-segment display *5 and LCD keypad (Optional HOA LCD keypad); all LCD keypad with parameter copy function
	Control Modes	V/F, SLV, PMSLV with space vector PWM mode
	Frequency Control Range	0.1Hz～400.0Hz
	Frequency Accuracy (Temperature change)	Digital references: ±0.01%(-10 to +40℃), Analog references: ±0.1% (25℃±10℃)
	Speed Control Accuracy	±0.5% (Sensorless Vector Control Mode)[*1]
	Frequency Setting Resolution	Digital references: 0.01Hz , Analog references: 0.06Hz/60Hz
	Output Frequency Resolution	0.01Hz
	Inverter Overload	120%/1 min
	Frequency Setting Signal	DC 0～+10V / 0~20mA or 4～20mA
	Acceleration/ Deceleration Time	0.0～6000.0 seconds (separately set acceleration and deceleration time)
	Voltage, Frequency Characteristics	Custom V/F curve based on parameters
	Braking Torque	About 20%
	Main Control Functions	Auto tuning, Soft-PWM, Over voltage protection, Dynamic braking, Speed search, Restart upon momentary power loss, 2 sets of PID control, Slip Compensation, RS-485 communication standard, Simple PLC function, 2 sets of analog outputs, Safety switch
	Other Functions	Accumulated power-on/ run time, 4 sets of fault history records and latest fault record state, Energy-saving function setting, Phase loss protection, Smart braking, DC braking, Dwell，S curve acceleration and deceleration, Up/Down operation, Modbus, BACnet MS/TP and Metasys N2 communication protocol, Display of multi-engineering unit, Local/ Remote switch, SINK/SOURCE input interface selection, User parameter settings
Protection Function	**Stall Prevention**	Current level can be setting (It can be set separately in acceleration or constant speed; it can be set with or without protection in deceleration)
	Instantaneous Over Current (OC) and Output Short-Circuit (SC) Protection	Inverter stops when the output current exceeds 160% of the inverter rated current
	Inverter Overload Protection (OL2)	If inverter rated current 120%/1min is exceeded, inverter stops. The factory default carrier frequency is 2~4KHZ[*2]
	Motor Overload Protection (OL1)	Electrical overload protection curve
	Over voltage (OV) Protection	If the main circuit DC voltage rises over 410V (230V class)/ 820V (460V class), the motor stops running.
	Under voltage (UV) Protection	If the main circuit DC voltage falls below 190V (230V class) /380V (460V class), the motor stops running.
	Auto-Restart after Momentary Power Loss	Power loss exceeds 15ms. Auto-restart function available after momentary power loss in 2 sec.
	Overheat(OH) Protection	Use temperature sensor for protection.
	Ground Fault (GF) Protection	Use current sensor for protection.
	DC Bus Charge Indicator	When main circuit DC voltage ≧50V, the CHARGE LED turns on.
	Output Phase Loss (OPL) Protection	If the OPL is detected, the motor stops automatically.

Environment Specifications	Installation Location	Indoor (protected from corrosive gases and dust)
	Ambient Temperature	-10~+40℃(14℉~104℉) (IP20/NEMA1 or NEMA12), -10~+50℃(14℉~122℉) (IP00) without de-rating; with de-rating, its maximum operation temperature is 60℃(140℉).
	Storage Temperature	-20~+70℃(-4℉~+158℉)
	Humidity	95％RH or less (no condensation)
	Altitude and Vibration	Altitude of 1000m (3181ft) or below, below 5.9m/s2(0.6G)
Communication Function		Built-in RS-485 as standard (Modbus protocol with RJ45/ BACnet/ Metasys N2)
PLC Function		Built-in
EMI Protection		The built-in noise filter complies with EN61800-3 available for inverters 460V 75HP or below (IP20) / 460V 60HP or below
EMS Protection		in compliance with EN61800-3
Safety Certification	CE Declaration	in compliance with EN61800-3 (CE & RE) and EN61800-5-1 (LVD, Low-Voltage Directive)
	UL Certification	UL508C
Accessories		1 to 8 Pump card, HOA keypad, Profibus card

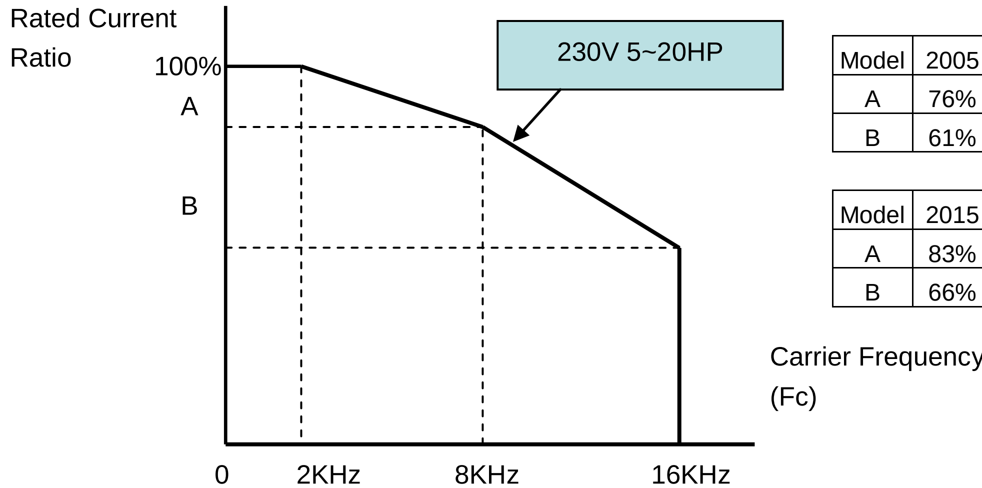
***1: Speed control accuracy will be different from the installation conditions and motor types.**

***2: The factory default carrier frequency varies with each rating rating.**

3.20 Inverter Derating Based on Carrier Frequency

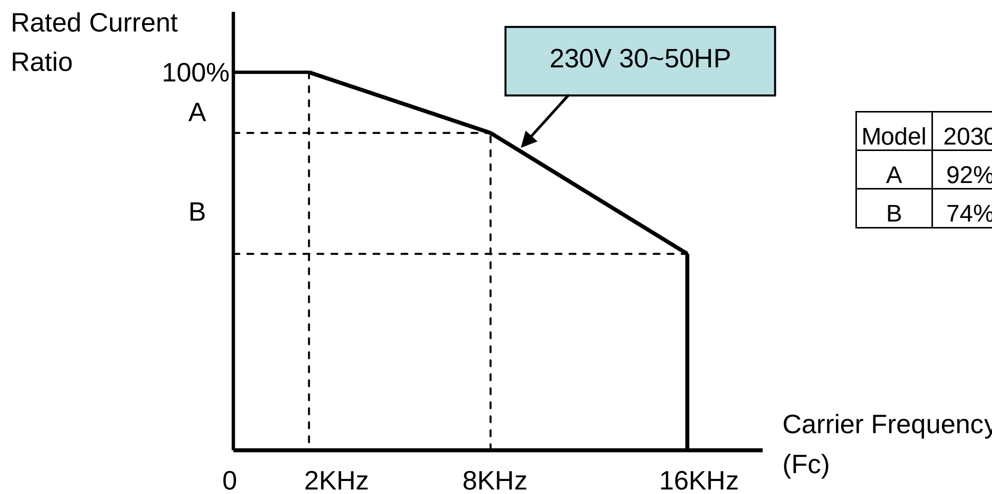
230V Models

Note: Derating curve current of carrier frequency means inverter rated current.

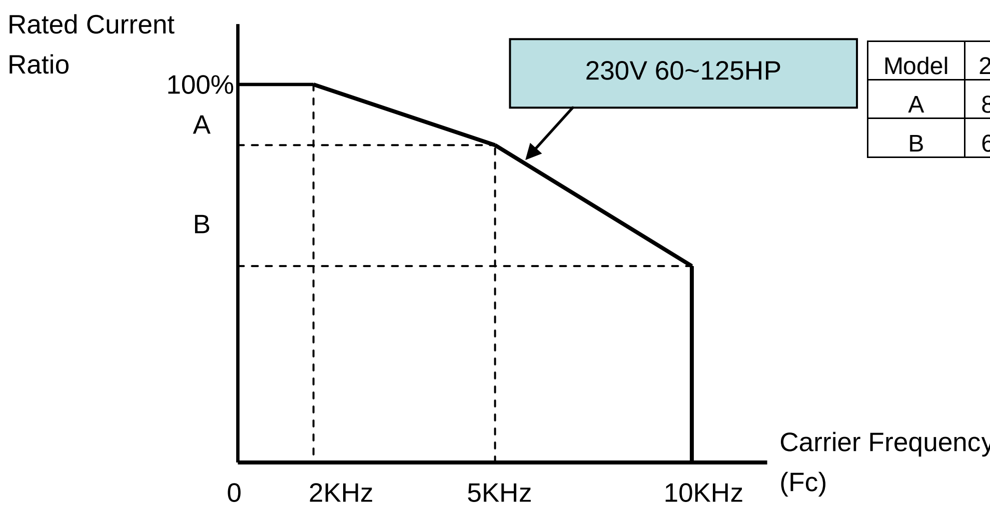


Model	2005	2008	2010
A	76%	83%	83%
B	61%	67%	67%

Model	2015	2020	2025
A	83%	84%	87%
B	66%	67%	70%

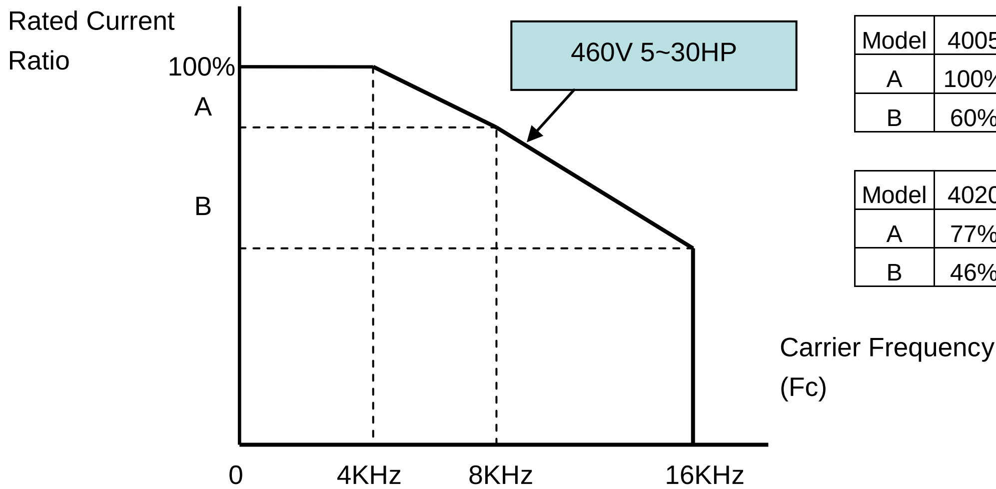


Model	2030	2040	2050
A	92%	77%	83%
B	74%	62%	67%



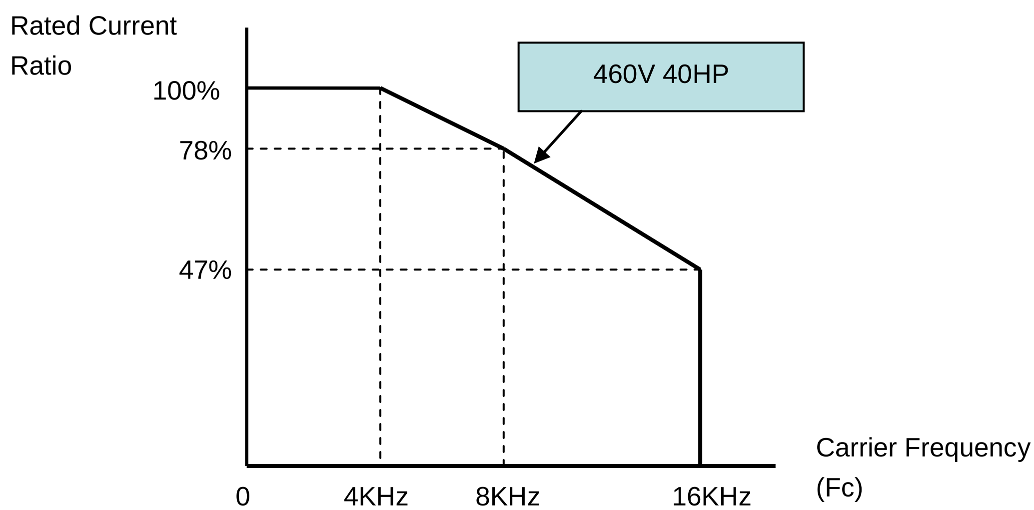
Model	2060	2075	2100	2125
A	85%	90%	86%	91%
B	68%	72%	69%	73%

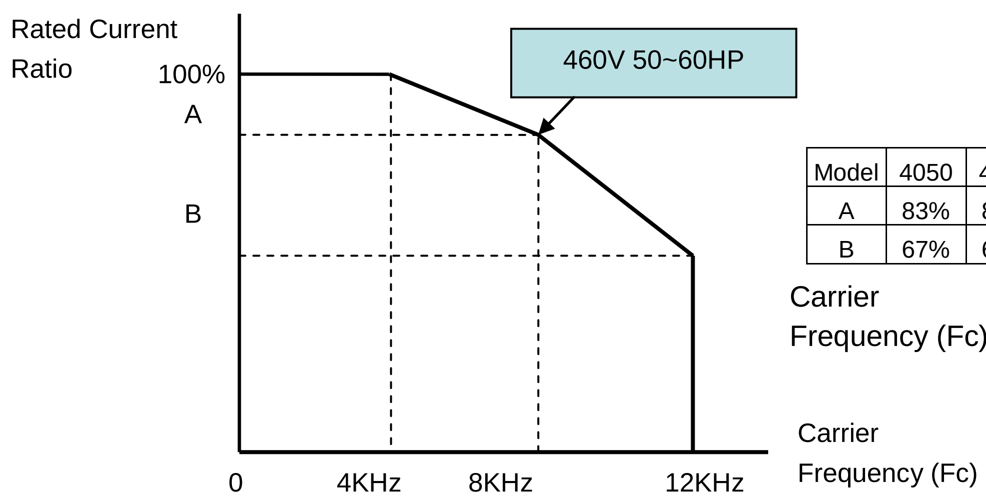
460V Models



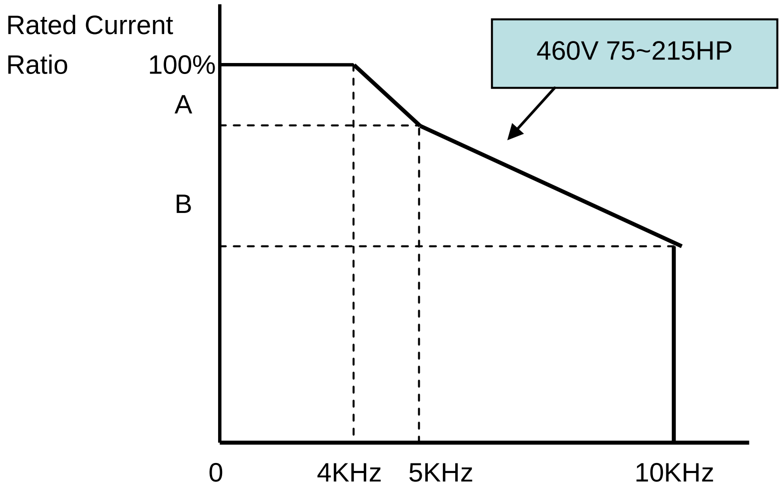
Model	4005	4008	4010	4015
A	100%	83%	85%	78%
B	60%	50%	51%	47%

Model	4020	4025	4030
A	77%	82%	89%
B	46%	49%	53%



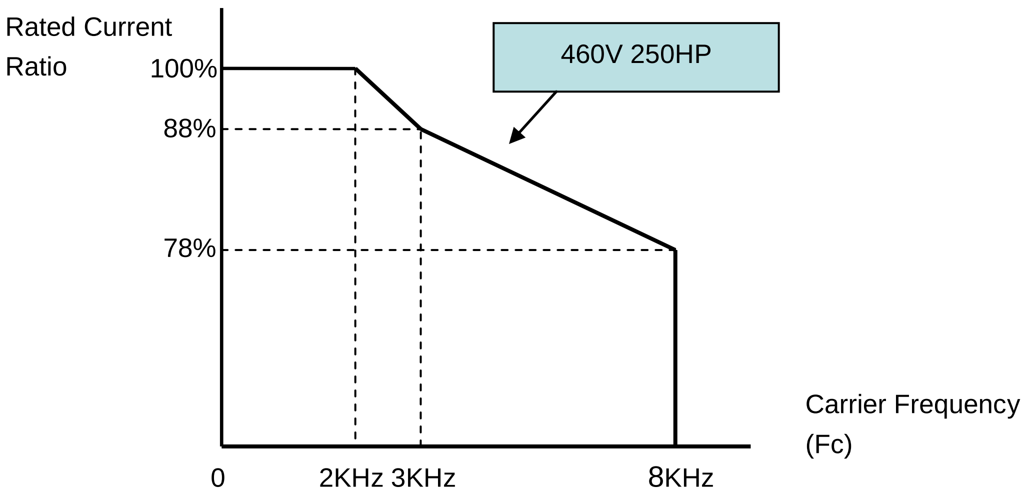


Model	4050	4060
A	83%	85%
B	67%	68%



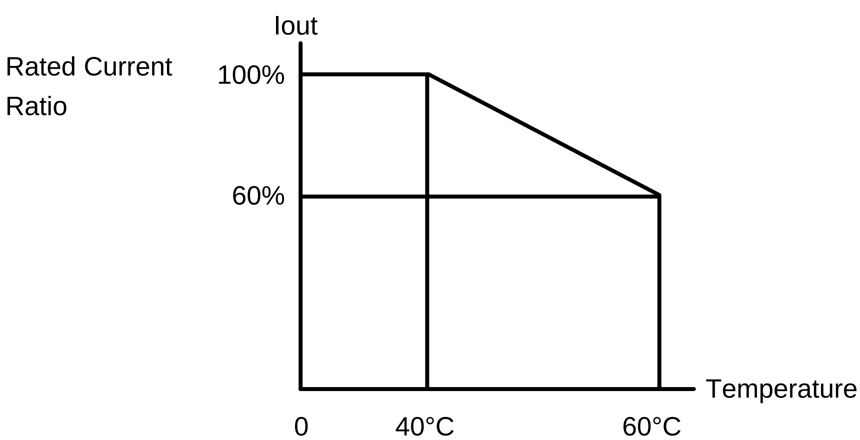
Model	4075	4100	4125
A	88%	81%	91%
B	62%	57%	64%

Model	4150	4175	4215
A	87%	86%	88%
B	61%	60%	61%



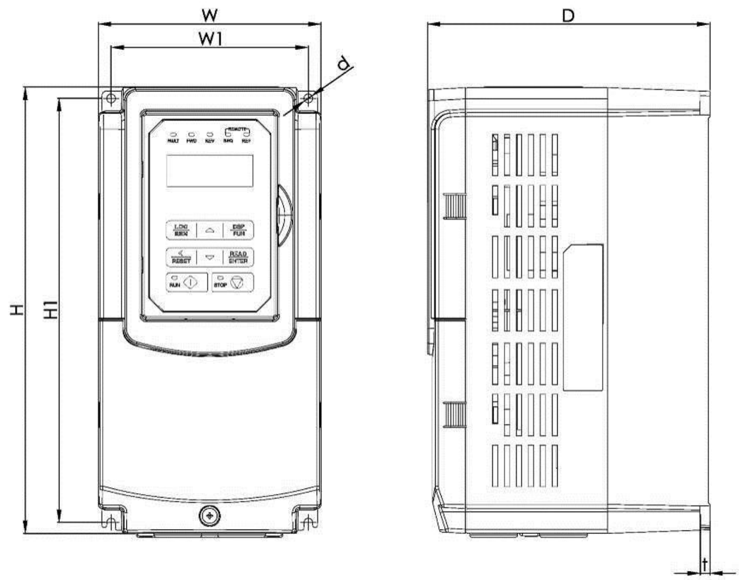
3.21 Inverter Derating Based on Temperature

Note: Adjust the inverter rated current for ambient temperature to ensure the appropriate application.



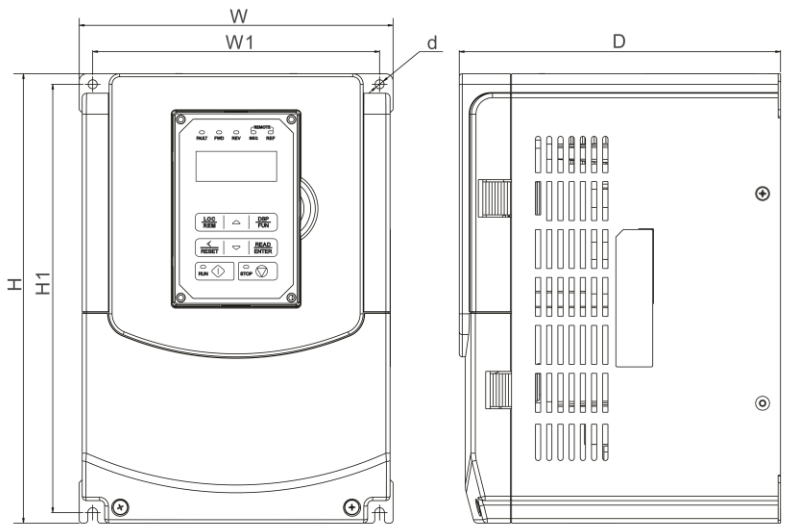
3.22 Inverter Dimensions (IP00 / IP20)

(a) 230V: 5-7.5HP/ 460V: 5-10HP



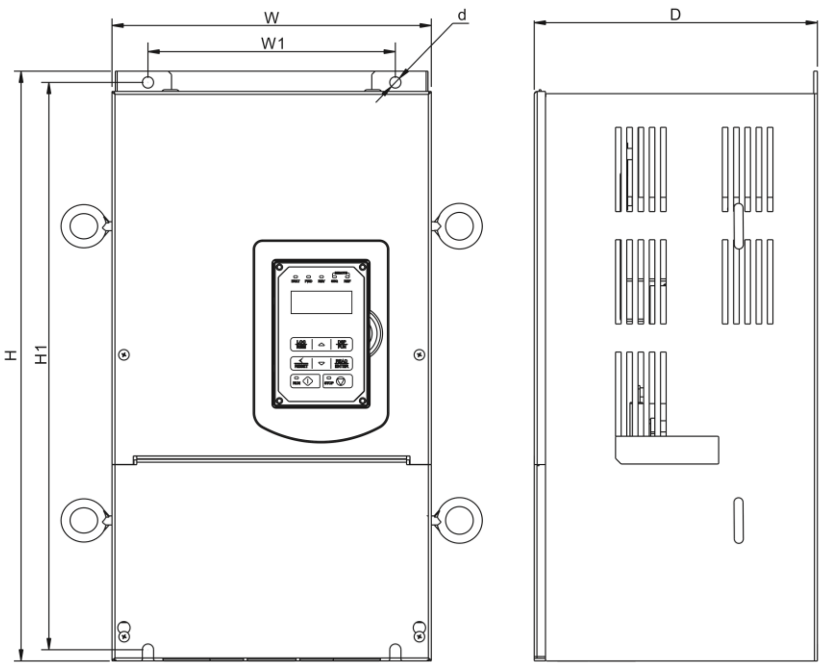
Inverter Model	Dimensions in inch (mm)							
	W	H	D	W1	H1	t	d	NW in lbs (kg)
F510-2005-C3	5.51 (140)	10.98 (279)	6.97 (177)	4.80 (122)	10.51 (267)	0.28 (7)	M6	8.38 (3.8)
F510-2008-C3	5.51 (140)	10.98 (279)	6.97 (177)	4.80 (122)	10.51 (267)	0.28 (7)	M6	8.38 (3.8)
F510-4005-C3	5.51 (140)	10.98 (279)	6.97 (177)	4.80 (122)	10.51 (267)	0.28 (7)	M6	8.38 (3.8)
F510-4008-C3	5.51 (140)	10.98 (279)	6.97 (177)	4.80 (122)	10.51 (267)	0.28 (7)	M6	8.38 (3.8)
F510-4010-C3	5.51 (140)	10.98 (279)	6.97 (177)	4.80 (122)	10.51 (267)	0.28 (7)	M6	8.38 (3.8)

(b) **230V: 10-30HP/ 460V: 15-40HP (IP20)**



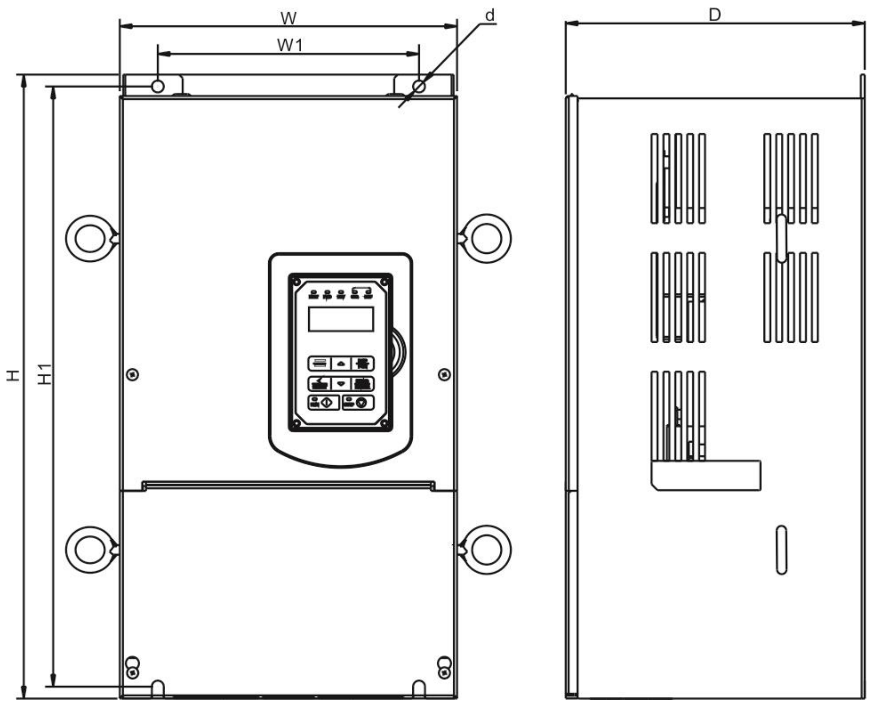
Inverter Model	Dimensions in inch (mm)							
	W	H	D	W1	H1	t	d	NW in lbs (kg)
F510-2010-C3	8.27 (210)	11.81 (300)	8.46 (215)	7.56 (192)	11.26 (286)	0.06 (1.6)	M6	13.67 (6.2)
F510-2015-C3	8.27 (210)	11.81 (300)	8.46 (215)	7.56 (192)	11.26 (286)	0.06 (1.6)	M6	13.67 (6.2)
F510-2020-C3	10.43 (265)	14.17 (360)	8.86 (225)	9.65 (245)	13.39 (340)	0.06 (1.6)	M8	22.05 (10)
F510-2025-C3	10.43 (265)	14.17 (360)	8.86 (225)	9.65 (245)	13.39 (340)	0.06 (1.6)	M8	22.05 (10)
F510-2030-C3	10.43 (265)	14.17 (360)	8.86 (225)	9.65 (245)	13.39 (340)	0.06 (1.6)	M8	22.05 (10)
F510-4015-C3	8.27 (210)	11.81 (300)	8.46 (215)	7.56 (192)	11.26 (286)	0.06 (1.6)	M6	13.67 (6.2)
F510-4020-C3	8.27 (210)	11.81 (300)	8.46 (215)	7.56 (192)	11.26 (286)	0.06 (1.6)	M6	13.67 (6.2)
F510-4025-C3	10.43 (265)	14.17 (360)	8.86 (225)	9.65 (245)	13.39 (340)	0.06 (1.6)	M8	22.05 (10)
F510-4030-C3	10.43 (265)	14.17 (360)	8.86 (225)	9.65 (245)	13.39 (340)	0.06 (1.6)	M8	22.05 (10)
F510-4040-C3	10.43 (265)	14.17 (360)	8.86 (225)	9.65 (245)	13.39 (340)	0.06 (1.6)	M8	22.05 (10)

(c) 230V: 40-50HP/ 460V: 50-75HP (IP00)



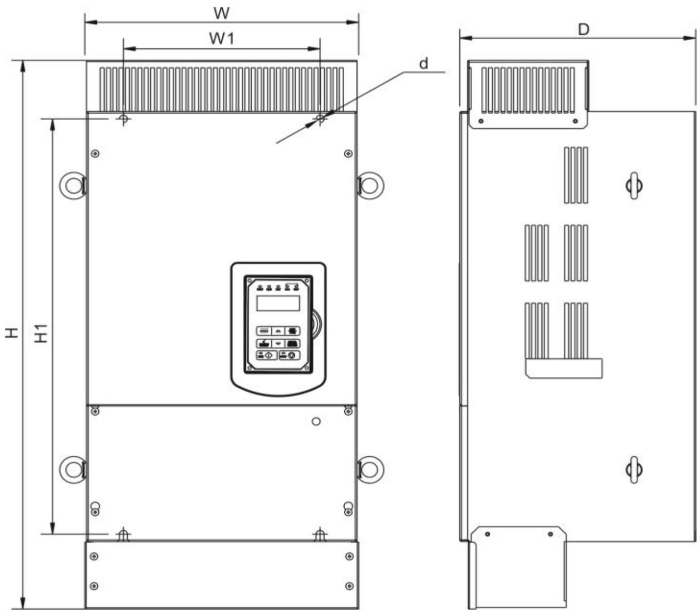
Inverter Model	Dimensions in inch (mm)							
	W	H	D	W1	H1	t	d	NW in lbs (kg)
F510-2040-C3	11.18 (284)	20.67 (525)	9.92 (252)	8.66 (220)	19.88 (505)	0.06 (1.6)	M8	66.14 (30)
F510-2050-C3	11.18 (284)	20.67 (525)	9.92 (252)	8.66 (220)	19.88 (505)	0.06 (1.6)	M8	66.14 (30)
F510-4050-C3	11.18 (284)	20.67 (525)	9.92 (252)	8.66 (220)	19.88 (505)	0.06 (1.6)	M8	66.14 (30)
F510-4060-C3	11.18 (284)	20.67 (525)	9.92 (252)	8.66 (220)	19.88 (505)	0.06 (1.6)	M8	66.14 (30)
F510-4075-C3	11.18 (284)	20.67 (525)	9.92 (252)	8.66 (220)	19.88 (505)	0.06 (1.6)	M8	66.14 (30)

(d) 230V: 60-125HP/ 460V: 100-250HP (IP00)



Inverter Model	Dimensions in inch (mm)							
	W	H	D	W1	H1	t	d	NW in lbs (kg)
F510-2060-C3	13.54 (344)	22.83 (580)	11.81 (300)	9.84 (250)	22.05 (560)	0.06 (1.6)	M10	89.29 (40.5)
F510-2075-C3	13.54 (344)	22.83 (580)	11.81 (300)	9.84 (250)	22.05 (560)	0.06 (1.6)	M10	89.29 (40.5)
F510-2100-C3	18.07 (459)	31.10 (790)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	163.14 (74)
F510-2125-C3	18.07 (459)	31.10 (790)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	163.14 (74)
F510-4100-C3	13.54 (344)	22.83 (580)	11.81 (300)	9.84 (250)	22.05 (560)	0.06 (1.6)	M10	89.29 (40.5)
F510-4125-C3	13.54 (344)	22.83 (580)	11.81 (300)	9.84 (250)	22.05 (560)	0.06 (1.6)	M10	89.29 (40.5)
F510-4150-C3	18.07 (459)	31.10 (790)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	163.14 (74)
F510-4175-C3	18.07 (459)	31.10 (790)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	163.14 (74)
F510-4215-C3	18.07 (459)	31.10 (790)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	163.14 (74)
F510-4250-C3	18.07 (459)	31.10 (790)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	163.14 (74)

(e) 230V: 60-125HP/ 460V: 100-250HP (IP20)



Inverter Model	Dimensions in inch (mm)							
	W	H	D	W1	H1	t	d	NW in lbs (kg)
F510-2060-C3	13.72 (348.5)	29.13 (740)	11.81 (300)	9.84 (250)	22.05 (560)	0.06 (1.6)	M10	97.00 (44)
F510-2075-C3	13.72 (348.5)	29.13 (740)	11.81 (300)	9.84 (250)	22.05 (560)	0.06 (1.6)	M10	97.00 (44)
F510-2100-C3	18.25 (463.5)	43.50 (1105)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	178.57 (81)
F510-2125-C3	18.25 (463.5)	43.50 (1105)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	178.57 (81)
F510-2150-C3	27.17 (690)	39.37 (1000)	16.14 (410)	20.87 (530)	10.43 (265)	37.80 (960)	M10	405.651 (184)
F510-4100-C3	13.72 (348.5)	29.13 (740)	11.81 (300)	9.84 (250)	22.05 (560)	0.06 (1.6)	M10	97.00 (44)
F510-4125-C3	13.72 (348.5)	29.13 (740)	11.81 (300)	9.84 (250)	22.05 (560)	0.06 (1.6)	M10	97.00 (44)
F510-4150-C3	18.25 (463.5)	43.50 (1105)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	178.57 (81)
F510-4175-C3	18.25 (463.5)	43.50 (1105)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	178.57 (81)
F510-4215-C3	18.25 (463.5)	43.50 (1105)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	178.57 (81)
F510-4250-C3	18.25 (463.5)	43.50 (1105)	12.78 (324.5)	12.60 (320)	29.92 (760)	0.06 (1.6)	M10	178.57 (81)

4. Keypad and Programming Functions

4.1 LCD Keypad

4.1.1 Keypad Display and Keys

DISPLAY	**Description**
LCD Display	Monitor inverter signals, view / edit parameters, fault / alarm display.
LED INDICATORS	
FAULT	LED ON when a fault or alarm is active.
FWD	LED ON when inverter is running in forward direction, flashing when stopping.
REV	On when inverter is running in reverse direction, flashing when stopping.
SEQ	LED ON when RUN command is from the external control terminals or from serial communication
REF	LED ON when Frequency Reference command is from the external control terminals or from serial communication

KEYS (8)	Description
RUN	RUN Inverter in Local Mode
STOP	STOP Inverter
▲	Parameter navigation Up, Increase parameter or reference value
▼	Parameter navigation Down, Decrease parameter or reference value
FWD/REV	Used to switch between Forward and Reverse direction
DSP/FUN	Used to scroll to next screen Frequency screen →Function selection→Monitor parameter
◄ / RESET	Selects active seven segment digit for editing with the ▲▼ keys Used to reset fault condition.
READ / ENTER	Used to read and save the value of the active parameter

Auto-Repeat Keys

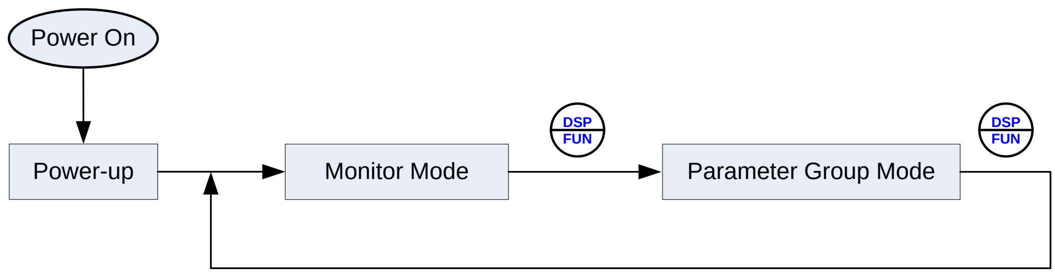
Holding the ▲UP or ▼DOWN key for a longer period of time will initiate the auto-repeat function resulting in the value of the selected digit to automatically increase or decrease.

Note: HOA LCD keypad is available as an option.

4.1.2 Keypad Menu Structure

Main Menu

The A510 inverter main menu consists of two main groups (modes). The DSP/FUN key is used to switch between the monitor mode and the parameter group mode.



Mode	**Description**
Monitor Mode	View inverter status, signals and fault data.
Parameter Group Mode	Access to available parameter groups.

All the available parameter groups are listed in the Parameter Group Mode use the up and down keys to select a group and press Read/Enter key to access its parameters.

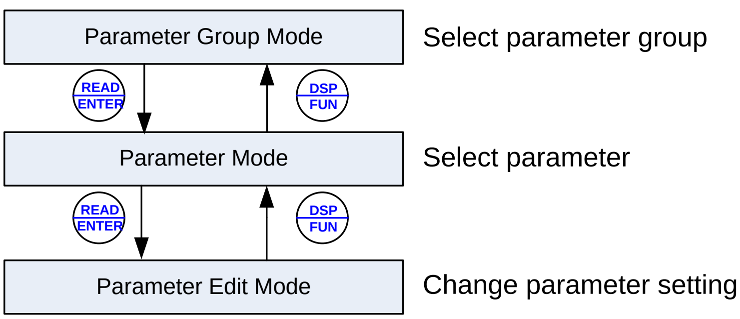


Fig. 4.1.2.1 Parameter Group Structure

Notes:

- Always perform an auto-tune on the motor before operating the inverter in vector control (sensorless vector. Auto-tuning mode will not be displayed when the inverter is running or when a fault is active.

- To scroll through the available modes, parameter groups or parameter list press and hold the up or down key.

Monitor Mode

In monitor mode inverter signals can be monitored such as output frequency, output current and output voltage, etc…) as well as fault information and fault trace. See Fig 4.1.2.2 for keypad navigation.

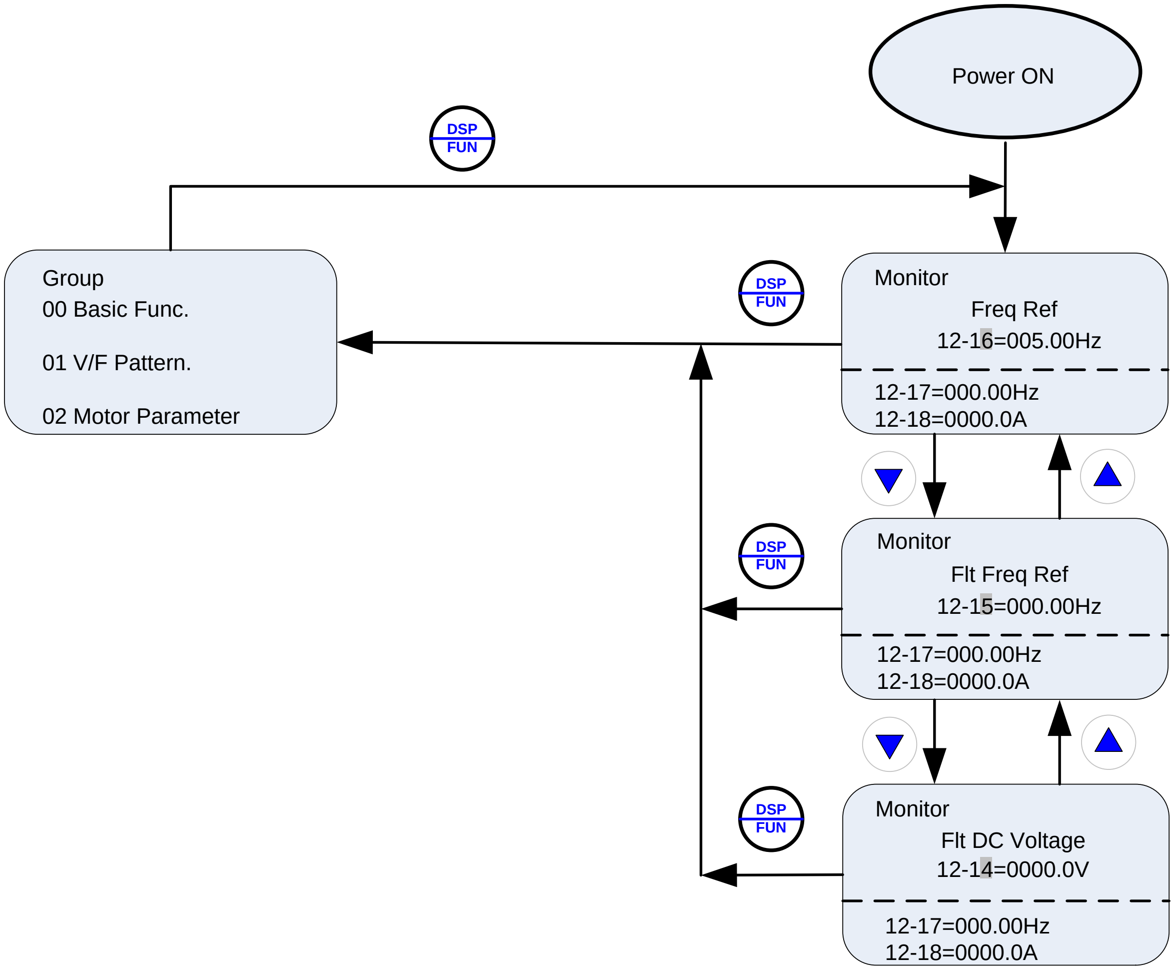


Fig 4.1.2.2 Monitor Mode

Notes:

- To scroll through the available monitor parameter list, press and hold the ▲ (up) or ▼ (down) key.

Programming Mode

In programming mode inverter parameters can be read or changed. See Fig 4.1.2.3 for keypad navigation.

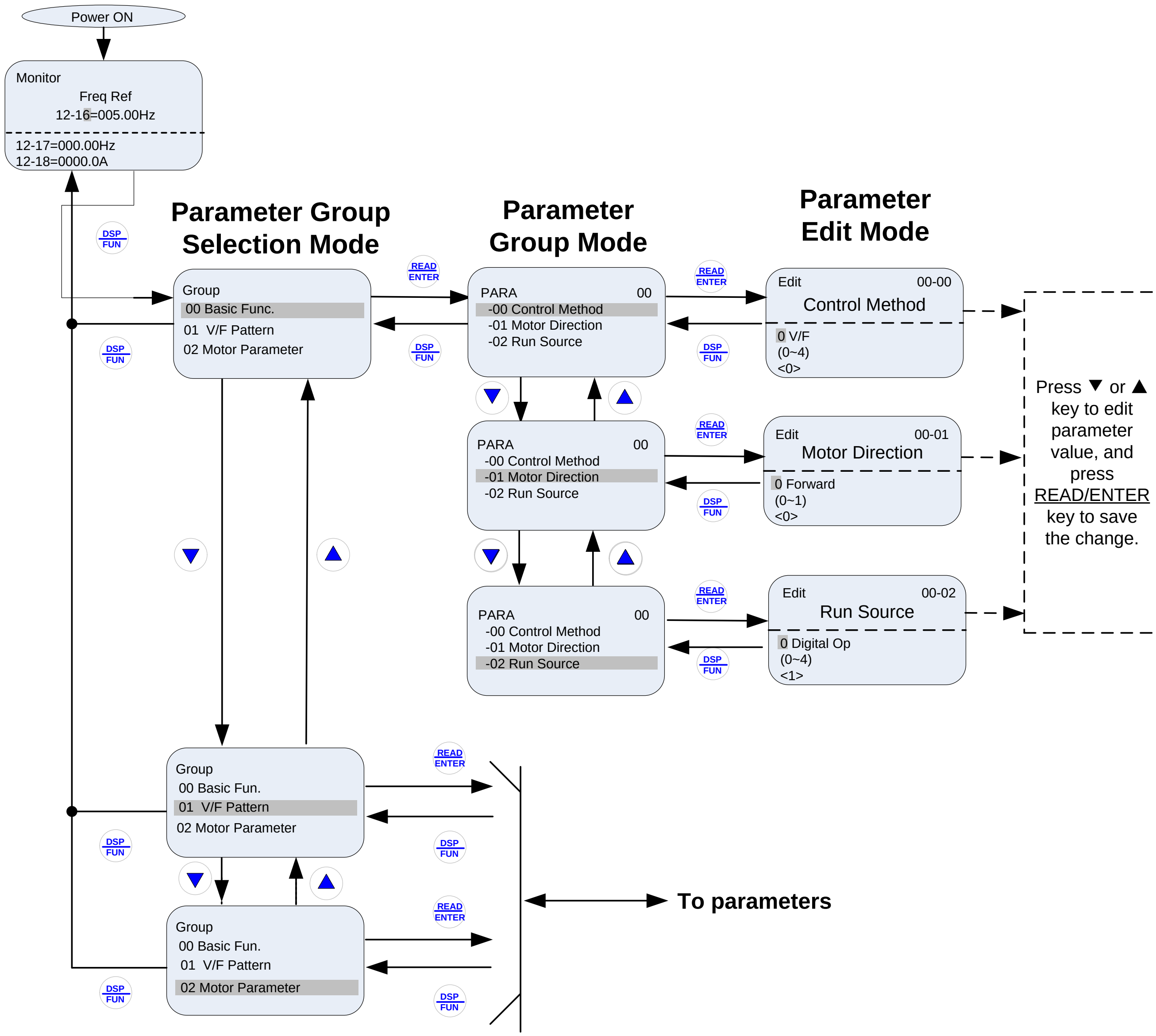


Fig 4.1.2.3 Programming Mode

Notes:

- The parameters values can be changed from the Edit screen with the up, down and < / RESET shift key.
- To save a parameter press the READ/ENTER key.
- Refer to section 4.3 for parameter details.
- Press the ▲ (up) or ▼ (down) key to scroll parameter groups or parameter list.

Auto-tuning Mode (Sensorless Vector Only)

In the auto-tuning mode motor parameters can be calculated and set automatically based on the selected control mode. See Fig 4.1.2.4 for keypad navigation.

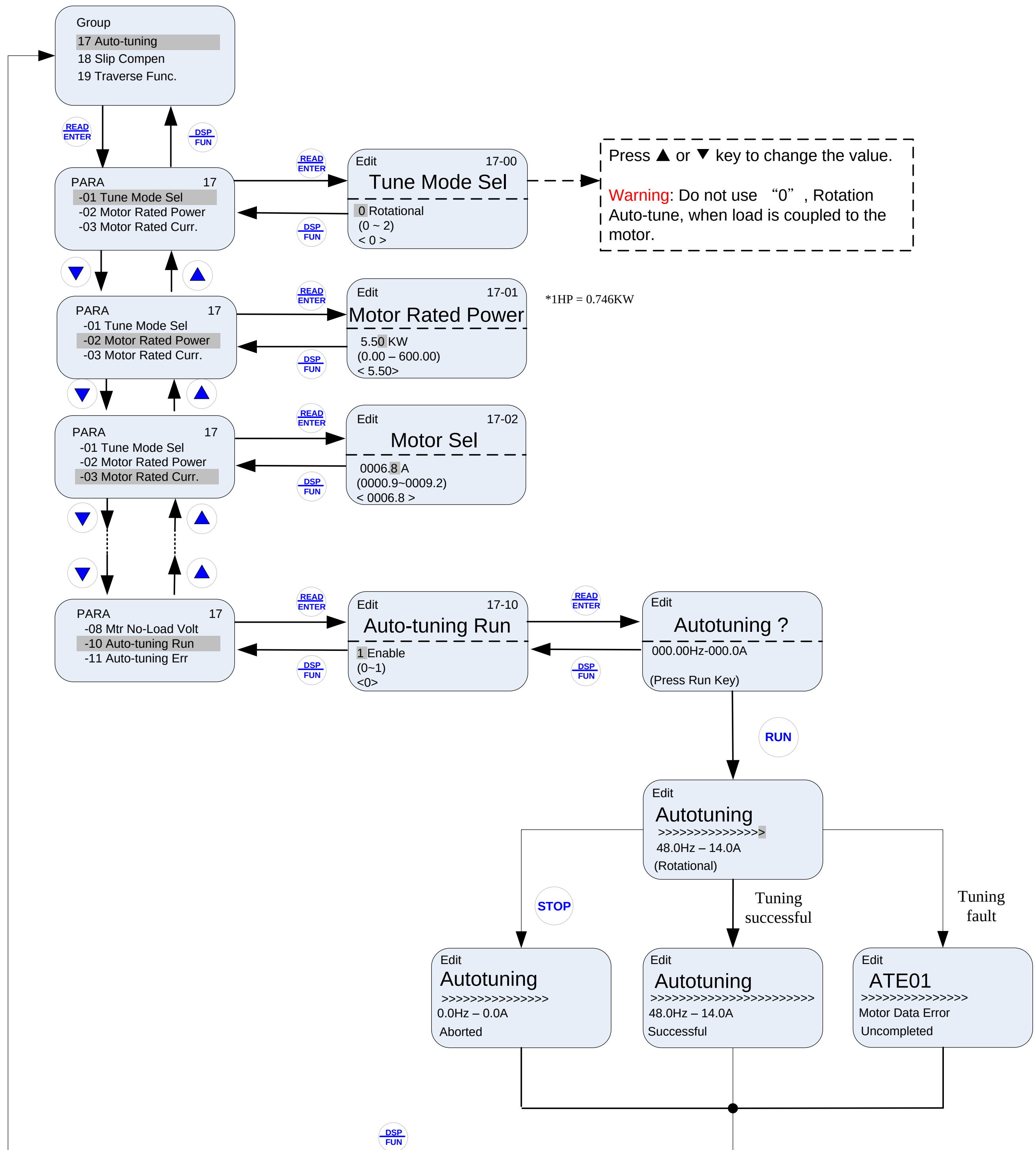


Fig 4.1.2.4 Auto-tuning Mode

Notes:

- Set correct motor parameters by referring to motor nameplate.
- Refer to section 4.3 for parameter details.

Notes:

1. Use the up and down keys to scroll though the auto-tuning parameter list. Depending on the selected control mode in parameter 00-00, some of the auto-tuning parameters will not be accessible. (Refer to the Auto-tuning Group 17 parameters).

2. After entering the motor nameplate rated output power (17-01), rated current (17-02), rated voltage (17-03), rated frequency (17-04), rated speed (17-05) and number of motor poles (17-06), select the automatic tuning mode and press the RUN key to perform the auto-tuning operation. When auto-tuning is successful the calculated motor parameters will be saved into parameter group 02 (motor parameters).

3. (a) “Rotational” will be displayed during rotational auto-tuning (17-00=0) and the motor will rotate during auto-tuning. Ensure that it is safe to operate the motor before pressing the RUN key.
   (b) “Stationary” will be displayed during stationary auto-tuning (17-00=1); the motor shaft does not rotate.
   (c) The RUN LED (in the upper left corner of the RUN key) will be lit during auto-tuning.
   (d) The LCD display shows “>>>” or "Atund" during the auto-tuning process.

4. Press the STOP key on the keypad to abort the auto-tuning operation.

5. In case of an auto-tuning fault, a fault message and the uncompleted message are displayed on the keypad. The RUN LED will be flashing and the motor will coast to stop. (Refer to section 10.4 for the Auto-tuning Faults.) The auto-tuning fault can be cleared by pressing the RESET key after which the keypad displays the auto-tuning mode again.

   All motor parameters (group 02 and group 17 parameters) will revert back to their factory settings if a fault occurs. The motor data must be re-entered before starting the auto-tuning function again. The keypad shows “>>>” during an auto-tuning fault.

6. Upon successful completion of an auto-tune, the RUN LED will turn off. Press the DSP/FUN key to return to the main menu to select the next operation. The auto-tuning procedure takes approximately 50 seconds.

4.2 Parameters

Parameter group	Name
Group 00	Basic Parameters
Group 01	V/F Control Parameters
Group 02	IM Motor Parameters
Group 03	External Digital Input and Output Parameters
Group 04	External Analog Input and Output Parameters
Group 05	Multi-Speed Parameters
Group 06	Automatic Program Operation Parameters
Group 07	Start /Stop Parameters
Group 08	Protection Parameters
Group 09	Communication Parameters
Group 10	PID Parameters
Group 11	Auxiliary Parameters
Group 12	Monitoring Parameters
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Group 14	PLC Parameters
Group 15	PLC Monitoring Parameters
Group 16	LCD Parameters
Group 17	Automatic Tuning Parameters
Group 18	Slip Compensation Parameters
Group 19	Wobble Frequency Parameters
Group 20	Speed Control Parameters
Group 21	Torque And Position Control Parameters
Group 22	PM Motor Parameters
Group 23	Pump, HVAC and Compressor
Group 24	Option Card Parameters

Group 00: Basic Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode V/F	Control Mode SLV	Control Mode PM SLV	Attribute
00-00	Control Mode Selection	0: V/F 2: SLV 5: PM SLV	0	-	O	O	O	*3
00-01	Motor's Rotation Direction	0: Forward 1: Reverse	0	-	O	O	O	*1
00-02	Main Run Command Source Selection	0: Keypad 1: External Terminal (Control Circuit) 2: Communication Control (RS-485) 3: PLC 4: RTC (Real-time Clock)	0	-	O	O	O	
00-03	Alternative Run Command Source Selection	0: Keypad 1: External Terminal (Control Circuit) 2: Communication Control (RS-485) 3: PLC 4: RTC (Real-time Clock)	2	-	O	O	O	
00-04	Language Selection	0: English 1: Simple Chinese 2: Traditional Chinese	0	-	O	O	O	
00-05	Main Frequency Command Source Selection	0: Keypad 1: External Terminal (Analog AI1) 2: Terminal Command UP/ DOWN 3: Communication Control (RS-485) 6: RTC 7. AI2 Auxiliary Frequency	0	-	O	O	O	
00-06	Alternative Frequency Command Source Selection	0: Keypad 1: External Terminal (Analog AI1) 2: Terminal Command UP/ DOWN 3: Communication Control (RS-485) 6: RTC 7. AI2 Auxiliary Frequency	3	-	O	O	O	
00-07	Main and Alternative Frequency Command Modes	0: Main Frequency 1: Main Frequency + Alternative Frequency	0	-	O	O	O	
00-08	Communication Frequency Command Range	0.00-400.00	0.00	Hz	O	O	O	
00-09	Communication Frequency Command Memory Selection	0: Do not save when power is off. 1: Save when power is off.	0	-	O	O	O	
00-11	Selection of PID Lower Limit Frequency	0: PID is bound to lower limit frequency when inverter sleeps. 1: PID is bound to 0Hz when inverter sleeps.	0	-	O	O	O	
00-12	Upper Limit Frequency	0.1~109.0	100.0	%	O	O	O	
00-13	Lower Limit Frequency	0.0~109.0	0.0	%	O	O	O	
00-14	Acceleration Time 1	0.1~6000.0	-	s	O	O	O	*1
00-15	Deceleration Time 1	0.1~6000.0	-	s	O	O	O	*1
00-16	Acceleration Time 2	0.1~6000.0	-	s	O	O	O	*1
00-17	Deceleration Time 2	0.1~6000.0	-	s	O	O	O	*1
00-18	Jog Frequency	0.00~400.00	6.00	Hz	O	O	O	*1
00-19	Jog Acceleration Time	0.1~0600.0	-	s	O	O	O	*1

Group 00: Basic Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
00-20	Jog Deceleration Time	0.1~0600.0	-	s	O	O	O	*1
00-21	Acceleration Time 3	0.1~6000.0	-	s	O	O	O	*1
00-22	Deceleration Time 3	0.1~6000.0	-	s	O	O	O	*1
00-23	Acceleration Time 4	0.1~6000.0	-	s	O	O	O	*1
00-24	Deceleration Time 4	0.1~6000.0	-	s	O	O	O	*1
00-25	Switch-Over Frequency of Acc/Dec Time 1 and Time 4	0.0~400.0	0.0	Hz	O	O	O	
00-26	Emergency Stop Time	0.1~6000.0	5.0	s	O	O	O	
00-28	Command Characteristic Selection of Master Frequency	0: Positive Characteristic (0~10V/4~20mA is corresponding to 0~100%) 1: Negative Characteristic (0~10V/4~20mA is corresponding to 100~0%)	0	-	O	O	O	
00-32	Application Selection Presets	0: Default Value 1: Water Supply Pump 2: Reserved 2: Exhaust fan 3: HVAC 4: Compressor 5: Reserved 6: Reserved 7: Reserved	0	-	O	O	O	
00-33	Modified Parameters (only for LCD)	0: Enable 1: Disable	0	-	O	O	O	
00-41	User Parameter 0	Set 13-06 = 1, and enable user parameter. Setting Range: 01-00 ~24-06 (only used in LCD keypad)	-		O	O	O	
00-42	User Parameter 1		-		O	O	O	
00-43	User Parameter 2		-		O	O	O	
00-44	User Parameter 3		-		O	O	O	
00-45	User Parameter 4		-		O	O	O	
00-46	User Parameter 5		-		O	O	O	
00-47	User Parameter 6		-		O	O	O	
00-48	User Parameter 7		-		O	O	O	
00-49	User Parameter 8		-		O	O	O	
00-50	User Parameter 9		-		O	O	O	
00-51	User Parameter 10		-		O	O	O	
00-52	User Parameter 11		-		O	O	O	
00-53	User Parameter 12		-		O	O	O	
00-54	User Parameter 13		-		O	O	O	
00-55	User Parameter 14		-		O	O	O	
00-56	User Parameter 15		-		O	O	O	

***note1:**

Default value is 1 in software V1.1 or the previous (external control); Default value is 0 in software V1.2 or the following (keypad).

Group 01: V/F Control Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
01-00	V/F Curve Selection	0~FF	6	-	O	X	X	*3
01-02	Maximum Output Frequency	20.0~400.0	60.0	Hz	O	O	O	
01-03	Maximum Output Voltage	230V: 0.1~255.0	230.0	V	O	X	X	
		460V: 0.2~510.0	460.0					
01-04	Middle Output Frequency 2	0.0~400.0	0.0	Hz	O	X	X	
01-05	Middle Output Voltage 2	230V: 0.0~255.0	0.0	V	O	X	X	
		460V: 0.0~510.0						
01-06	Middle Output Frequency 1	0.0~400.0	30	Hz	O	X	X	
01-07	Middle Output Voltage 1	230V: 0.0~255.0	40.2	V	O	X	X	
		460V: 0.0~510.0	80.4					
01-08	Minimum Output Frequency	0.0~400.0	1.5	Hz	O	O	O	
01-09	Minimum Output Voltage	230V: 0.0~255.0	6.9	V	O	X	X	
		460V: 0.0~510.0	13.8					
01-10	Torque Compensation Gain	0.0~2.0	0.5	-	O	X	X	*1
01-11	Selection of Torque Compensation Mode	0: Torque Compensation Mode 0	0	-	O	X	X	
		1: Torque Compensation Mode 1						
01-12	Base Frequency	10.0~400.0	60.0	Hz	O	O	O	
01-13	Base Output Voltage	230V: 0.0~255.0	230.0	V	O	X	X	
		460V: 0.0~510.0	460.0					
01-14	Input Voltage Setting	230V: 155.0~255.0	230.0	V	O	O	O	
		460V: 310.0~510.0	460.0					
01-15	Torque Compensation Time	0~10000	200	ms	O	X	X	

Group 02: IM Motor Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
02-00	No-Load Current	0.01~600.00	KVA	A	O	X	X	
02-01	Rated Current	V/F mode is 10%~200% of inverter's rated current; SLV mode is 25%~200% of inverter's rated current.	KVA	A	O	O	X	
02-03	Rated Rotation Speed (RPM)	0~60000	KVA	Rpm	O	O	X	
02-04	Rated Voltage	230V: 50.0~240.0	230.0	V	O	O	X	
		460V: 100.0~480.0	460.0					
02-05	Rated Power	0.01~600.00	KVA	kW	O	O	X	
02-06	Rated Frequency	10.0~400.0	60.0	Hz	O	O	X	
02-07	Poles	2~16 (Even)	4	-	O	O	X	
02-09	Excitation Current	15.0~70.0	KVA	%	X	O	X	
02-10	Core Saturation Coefficient 1	1~100	KVA	%	X	O	X	
02-11	Core Saturation Coefficient 2	1~100	KVA	%	X	O	X	
02-12	Core Saturation Coefficient 3	80~300	KVA	%	X	O	X	
02-13	Core Loss	0.0~15.0	KVA	%	O	X	X	
02-15	Resistance between Wires (R1)	0.001~60.000	KVA	Ω	O	O	X	
02-19	No-Load Voltage	230V: 50~240	KVA	V	X	O	X	
		460V: 100~480						
02-33	Leakage Inductance Ratio	0.1~15.0	KVA	%	X	O	X	

Group 02: IM Motor Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
02-34	Slip Frequency	0.10~20.00	KVA	Hz	X	O	X	

Group 03: External Digital Input and Output Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
03-00	Multi-function Terminal Function Setting-S1	0: 2-Wire Sequence (ON: Forward Run Command)	0	-	O	O	O	
		1: 2-Wire Sequence (ON: Reverse Run Command)						
03-01	Multi-function Terminal Function Setting-S2	2: Multi-Speed Setting Command 1	1		O	O	O	
		3: Multi-Speed Setting Command 2			O	O	O	
		4: Multi-Speed Setting Command 3			O	O	O	
03-02	Multi-function Terminal Function Setting-S3	5: Multi-Speed Setting Command 4	2		O	O	O	
		6: Forward Jog Run Command			O	O	O	
03-03	Multi-function Terminal Function Setting-S4	7: Reverse Jog Run Command	3		O	O	O	
		8: UP Frequency Increasing Command			O	O	O	
03-04	Multi-function Terminal Function Setting-S5	9: DOWN Frequency Decreasing Command	4		O	O	O	
		10: Acceleration/ Deceleration Setting Command 1			O	O	O	
		11: Inhibit Acceleration/ Deceleration Command			O	O	O	
03-05	Multi-function Terminal Function Setting-S6	12: Main/Alternative Run command Switching	17	-	O	O	O	
		13: Main/Alternative Frequency Command Switching						
		14: Emergency Stop (Decelerate to Zero and Stop)						
		15: External Baseblock Command (Rotation freely to Stop)						
		16: PID Control Disable						
		17: Fault Reset (RESET)						
		18: Reserved		-	-	-	-	
		19: Speed Search 1(from the maximum frequency)		-	O	O	X	
		20: Manual Energy Saving Function		-	O	X	X	
		21: PID Integral Reset		-	O	O	O	
		22~23: Reserved		-	-	-	-	
		24: PLC Input		-	O	O	O	
		25: External Fault						
		26: 3-Wire Sequence (Forward/ Reverse Command)						
		27: Local/ Remote Selection						
		28: Remote Mode Selection						
		29: Jog Frequency Selection						
		30: Acceleration/ Deceleration Setting Command 2						
		31: Inverter Overheating Warning						

Group 03: External Digital Input and Output Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode V/F	SLV	PM SLV	Attribute
		32: Reserved		-	-	-	-	
		33: DC Braking		-	O	X	X	
		34: Speed Search 2 (from Frequency Command)		-	O	X	O	
		35: Timing Function Input		-	O	O	O	
		36: PID Soft Start Disable						
		37~40: Reserved		-	-	-	-	
		41: PID Sleep		-	O	O	O	
		42~46: Reserved		-	-	-	-	
		47: Fire Mode (Forced to Run Mode)		-	O	O	O	
		48: KEB Acceleration		-	O	X	X	
		49: Parameters Writing Allowable		-	O	O	O	
		50: Unattended Start Protection (USP)		-	O	O	O	
		51~52: Reserved		-	-	-	-	
		53: 2-Wire Self Holding Mode (Stop Command)		-	O	O	O	
		54: Switch PID1 and PID2						
		55: RTC Timer Switch						
		56: RTC Offset Switch						
		57: Forced Frequency Run						
		58: Run Permissive Function						
03-08	(S1~S6) DI Scan Time	0: Scan Time 4ms 1: Scan Time 8ms	1	-	O	O	O	
03-09	Multi-Function Terminal (S1-S4 Type Selection)	xxx0b:S1 A Contact xxx1b:S1 B Contact	0000b	-	O	O	O	
		xx0xb:S2 A Contact xx1xb:S2 B Contact						
		x0xxb:S3 A Contact x1xxb:S3 B Contact						
		0xxxb:S4 A Contact 1xxxb:S4 B Contact						
03-10	Multi-Function Terminal (S5-S6 Type Selection)	xxx0b:S5 A Contact xxx1b:S5 B Contact	0000b	-	O	O	O	
		xx0xb:S6 A Contact xx1xb:S6 B Contact						
		x0xxb: Reserved x1xxb: Reserved						
		0xxxb: Reserved 1xxxb: Reserved						
03-11	Relay (R1A-R1C) Output	0: During Running	0	-	O	O	O	
		1: Fault Contact Output						
		2: Frequency Agree						
03-12	Relay (R2A-R2C) Output	3: Setting Frequency Agree (03-13 ± 03-14)	1	-	O	O	O	
		4: Frequency Detection 1 (> 03-13, Hysteresis interval 03-14)			O	O	O	
		5: Frequency Detection 2 (< 03-13, Hysteresis interval 03-14)			O	O	O	
		6: Automatic Restart			O	O	O	

Group 03: External Digital Input and Output Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
		7~8: Reserved			-	-	-	
		9: Baseblock			O	O	O	
		10~11: Reserved			-	-	-	
		12: Over-Torque Detection			O	O	O	
		13: Current Agree						
		14~17: Reserved			-	-	-	
		18: PLC Status			O	O	O	
		19: PLC Control Contact						
		20: Zero Speed						
		21: Inverter Ready						
		22: Undervoltage Detection						
		23: Source of Operation Command						
		24: Source of Frequency Command						
		25: Low Torque Detection						
		26: Frequency Reference Missing						
		27: Timing Function Output						
		28~31: Reserved			-	-	-	
		32: Communication Control Contacts			O	O	O	
		33: RTC Timer 1						
		34: RTC Timer 2						
		35: RTC Timer 3						
		36: RTC Timer 4						
		37: PID Feedback Loss						
		38: Brake Release			X	O	X	
03-13	Frequency Detection Level	0.0~400.0	0.0	Hz	O	O	O	
03-14	Frequency Detection Width	0.1~25.5	2.0	Hz	O	O	O	
03-15	Current Agree Level	0.1~999.9	0.1	A	O	O	O	
03-16	Delay Time of Current Agree Function	0.1~10.0	0.1	s	X	O	X	
03-19	Relay(R1A-R3C)Type	xxx0b: R1 A Contact xxx1b: R1 B Contact	0000b	-	O	O	O	
		xx0xb: R2 A Contact xx1xb: R2 B Contact						
		x0xxb: R3 A Contact x1xxb: R3 B Contact						
03-27	UP/DOWN Frequency Hold/ Adjust Selection	0: Hold Last Set Frequency when Stopped	0	-	O	O	O	
		1: Set Frequency to 0 when Stopped						
		2: Allow Speed Changes from Last Set Frequency when Stopped						
		3: Refresh frequency at acceleration.						
03-30	Pulse Input Selection	0: Common Pulse Input	0	-	O	O	O	
		1: PWM (Pulse Width Modulation)						
03-31	Pulse Input Scaling	50~32000	1000	Hz	O	O	O	*1
03-32	Pulse Input Gain	0.0~1000.0	100	%	O	O	O	*1
03-33	Pulse Input Bias	-100.0~100.0	0.0	%	O	O	O	*1
03-34	Pulse Input Filter Time	0.00~2.00	0.1	Sec	O	O	O	*1
03-37	Timer ON Delay (DI/DO)	0.0~6000.0	0.0	s	O	O	O	
03-38	Timer OFF Delay (DI/DO)	0.0~6000.0	0.0	s	O	O	O	
03-39	Relay (R3A-R3C) Output	Setting range and definition are the	20	-	O	O	O	

Group 03: External Digital Input and Output Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
		same as those of 03-11 and 03-12.						
03-40	Up/down Frequency Width Setting	0.00~5.00	0.00	Hz	O	O	O	
03-41	Torque Detection Level	0~300	10	%	X	O	X	
03-42	Delay Time of Braking Action	0.00~65.00	0.00	s	X	O	X	
03-43	UP/DOWN Acceleration/ Deceleration Selection	0: Acceleration/Deceleration Time 1	0	-	O	O	O	
		1: Acceleration/Deceleration Time 2						

Group 04: External Analog Input and Output Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
04-00	AI2 Source Selection	0: AI2: 0~10V	1	-	O	O	O	
		1: AI2: 4~20mA						
04-01	AI1 Signal Filter Time	0.00~2.00	0.03	s	O	O	O	
04-02	AI1 Gain	0.0~1000.0	100.0	%	O	O	O	*1
04-03	AI1 Bias	-100.0~100.0	0	%	O	O	O	*1
04-05	AI2 Function Setting	0: Auxiliary Frequency	0	-	O	O	O	
		1: Frequency Reference Gain			O	O	O	
		2: Frequency Reference Bias			O	O	O	
		3: Output Voltage Bias			O	X	O	
		4: Coefficient of Acceleration and Deceleration Reduction			O	O	O	
		5: DC Braking Current			O	O	X	
		6: Over-Torque Detection Level			O	O	O	
		7: Stall Prevention Level During Running			O	X	X	
		8: Frequency Lower Limit			O	O	O	
		9: Jump Frequency 4			O	O	O	
		10: Added to AI1			O	O	O	
		11: Positive Torque Limit			X	O	O	
		12: Negative Torque Limit			X	O	O	
		13: Regenerative Torque Limit			X	O	O	
		14: Positive / Negative Torque Limit			X	O	O	
		15: Reserved			-	-	-	
		16: Torque Compensation			X	O	X	
04-06	AI2 Signal Filter Time	0.00~2.00	0.03	s	O	O	O	
04-07	AI2 Gain	0.0~1000.0	100.0	%	O	O	O	*1
04-08	AI2 Bias	-100.0~100.0	0	%	O	O	O	*1
04-11	AO1 Function Setting	0: Output Frequency	0	-	O	O	O	
		1: Frequency Command			O	O	O	
		2: Output Voltage			O	O	O	
		3: DC Voltage			O	O	O	
		4: Output Current			O	O	O	

Group 04: External Analog Input and Output Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode V/F	SLV	PM SLV	Attribute
		5: Output Power			O	O	O	
		6: Motor Speed			O	O	O	
		7: Output Power Factor			O	O	O	
		8: AI1 Input			O	O	O	
		9: AI2 Input			O	O	O	
		10: Torque Command			X	O	O	
		11: q-axis Current			X	O	O	
		12: d-axis Current			X	O	O	
		13: Speed deviation			X	X	O	
		14: Reserved			-	-	-	
		15: ASR Output			X	X	O	
		16: Reserved			-	-	-	
		17: q-axis Voltage			X	O	O	
		18: d-axis Voltage			X	O	O	
		19~20: Reserved			-	-	-	
		21: PID Input			O	O	O	
		22: PID Output			O	O	O	
		23: PID Target Value			O	O	O	
		24: PID Feedback Value			O	O	O	
		25: Output Frequency of the Soft Starter			O	O	O	
		26~27: Reserved			-	-	-	
		28: Communication Control			O	O	O	
04-12	AO1 Gain	0.0~1000.0	100.0	%	O	O	O	*1
04-13	AO1 Bias	-100.0~100.0	0	%	O	O	O	*1
04-16	AO2 Function Setting	Setting range and definition are the same as 04-11	3	-	O	O	O	
04-17	AO2 Gain	0.0~1000.0	100.0	%	O	O	O	*1
04-18	AO2 Bias	-100.0~100.0	0	%	O	O	O	*1
04-19	AO Output Signal Type	0: AO1:0~10V AO2:0~10V 1: AO1:0~10V AO2:4~20mA 2: AO1:4~20mA AO2:0~10V 3: AO1:4~20mA AO2: 4~20mA	0		O	O	O	
04-20	Filter Time of AO Signal Scan	0.00~0.50	0.00	s	O	O	O	*1

Group 05: Multi-Speed Function Group

Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
05-00	Acceleration and Deceleration Selection of Multi-Speed	0: Acceleration and deceleration time are set by 00-14 ~ 00-24 1: Acceleration and Deceleration Time are set by 05-17 ~ 05-48	0	-	O	O	O	
05-01	Frequency Setting of Speed-Stage 0	0.00~400.00	5.00	Hz	O	O	O	*1
05-02	Frequency Setting of Speed-Stage 1	0.00~400.00	5.00	Hz	O	O	O	
05-03	Frequency Setting of Speed-Stage 2	0.00~400.00	10.00	Hz	O	O	O	
05-04	Frequency Setting of Speed-Stage 3	0.00~400.00	20.00	Hz	O	O	O	
05-05	Frequency Setting of Speed-Stage 4	0.00~400.00	30.00	Hz	O	O	O	
05-06	Frequency Setting of Speed-Stage 5	0.00~400.00	40.00	Hz	O	O	O	
05-07	Frequency Setting of Speed-Stage 6	0.00~400.00	50.00	Hz	O	O	O	
05-08	Frequency Setting of Speed-Stage 7	0.00~400.00	50.00	Hz	O	O	O	
05-09	Frequency Setting of Speed-Stage 8	0.00~400.00	5.00	Hz	O	O	O	
05-10	Frequency Setting of Speed-Stage 9	0.00~400.00	5.00	Hz	O	O	O	
05-11	Frequency Setting of Speed-Stage 10	0.00~400.00	5.00	Hz	O	O	O	
05-12	Frequency Setting of Speed-Stage 11	0.00~400.00	5.00	Hz	O	O	O	
05-13	Frequency Setting of Speed-Stage 12	0.00~400.00	5.00	Hz	O	O	O	
05-14	Frequency Setting of Speed-Stage 13	0.00~400.00	5.00	Hz	O	O	O	
05-15	Frequency Setting of Speed-Stage 14	0.00~400.00	5.00	Hz	O	O	O	
05-16	Frequency Setting of Speed-Stage 15	0.00~400.00	5.00	Hz	O	O	O	
05-17	Acceleration Time Setting of Multi Speed 0	0.1~6000.0	10.0	s	O	O	O	
05-18	Deceleration Time Setting of Multi Speed 0	0.1~6000.0	10.0	s	O	O	O	
05-19	Acceleration Time Setting of Multi Speed 1	0.1~6000.0	10.0	s	O	O	O	
05-20	Deceleration Time Setting of Multi Speed 1	0.1~6000.0	10.0	s	O	O	O	

Group 05: Multi-Speed Function Group								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
05-21	Acceleration Time Setting of Multi Speed 2	0.1~6000.0	10.0	s	O	O	O	
05-22	Deceleration Time Setting of Multi Speed 2	0.1~6000.0	10.0	s	O	O	O	
05-23	Acceleration Time Setting of Multi Speed 3	0.1~6000.0	10.0	s	O	O	O	
05-24	Deceleration Time Setting of Multi Speed 3	0.1~6000.0	10.0	s	O	O	O	
05-25	Acceleration Time Setting of Multi Speed 4	0.1~6000.0	10.0	s	O	O	O	
05-26	Deceleration Time Setting of Multi Speed 4	0.1~6000.0	10.0	s	O	O	O	
05-27	Acceleration Time Setting of Multi Speed 5	0.1~6000.0	10.0	s	O	O	O	
05-28	Deceleration Time Setting of Multi Speed 5	0.1~6000.0	10.0	s	O	O	O	
05-29	Acceleration Time Setting of Multi Speed 6	0.1~6000.0	10.0	s	O	O	O	
05-30	Deceleration Time Setting of Multi Speed 6	0.1~6000.0	10.0	s	O	O	O	
05-31	Acceleration Time Setting of Multi Speed 7	0.1~6000.0	10.0	s	O	O	O	
05-32	Deceleration Time Setting of Multi Speed 7	0.1~6000.0	10.0	s	O	O	O	
05-33	Acceleration Time Setting of Multi Speed 8	0.1~6000.0	10.0	s	O	O	O	
05-34	Deceleration Time Setting of Multi Speed 8	0.1~6000.0	10.0	s	O	O	O	
05-35	Acceleration Time Setting of Multi Speed 9	0.1~6000.0	10.0	s	O	O	O	
05-36	Deceleration Time Setting of Multi Speed 9	0.1~6000.0	10.0	s	O	O	O	
05-37	Acceleration Time Setting of Multi Speed 10	0.1~6000.0	10.0	s	O	O	O	
05-38	Deceleration Time Setting of Multi Speed 10	0.1~6000.0	10.0	s	O	O	O	
05-39	Acceleration Time Setting of Multi Speed 11	0.1~6000.0	10.0	s	O	O	O	
05-40	Deceleration Time Setting of Multi Speed 11	0.1~6000.0	10.0	s	O	O	O	
05-41	Acceleration Time Setting of Multi Speed 12	0.1~6000.0	10.0	s	O	O	O	
05-42	Deceleration Time Setting of Multi Speed 12	0.1~6000.0	10.0	s	O	O	O	

Group 05: Multi-Speed Function Group								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
05-43	Acceleration Time Setting of Multi Speed 13	0.1~6000.0	10.0	s	O	O	O	
05-44	Deceleration Time Setting of Multi Speed 13	0.1~6000.0	10.0	s	O	O	O	
05-45	Acceleration Time Setting of Multi Speed 14	0.1~6000.0	10.0	s	O	O	O	
05-46	Deceleration Time Setting of Multi Speed 14	0.1~6000.0	10.0	s	O	O	O	
05-47	Acceleration Time Setting of Multi Speed 15	0.1~6000.0	10.0	s	O	O	O	
05-48	Deceleration Time Setting of Multi Speed 15	0.1~6000.0	10.0	s	O	O	O	

Group 06: Automatic Program Operation Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
06-00	Automatic Operation Mode Selection	0: Disable 1: Execute a single cycle operation mode. Restart speed is based on the previous stopped speed. 2: Execute continuous cycle operation mode. Restart speed is based on the previous stopped speed. 3: After the completion of a single cycle, the on-going operation speed is based on the speed of the last stage. Restart speed is based on the previous stopped speed. 4: Execute a single cycle operation mode. Restart speed will be based on the speed of stage 1. 5: Execute continuous cycle operation mode. Restart speed will be based on the speed of stage 1. 6: After the completion of a single cycle, the on-going operation speed is based on the speed of the last stage. Restart speed is based on the Speed of Stage1.	0	-	O	O	X	
06-01	Frequency Setting of Speed-Stage 1	0.00~400.00	5.00	Hz	O	O	O	*1

Group 06: Automatic Program Operation Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
06-02	Frequency Setting of Speed-Stage 2	0.00~400.00	10.00	Hz	O	O	O	*1
06-03	Frequency Setting of Speed-Stage 3	0.00~400.00	20.00	Hz	O	O	O	*1
06-04	Frequency Setting of Speed-Stage 4	0.00~400.00	30.00	Hz	O	O	O	*1
06-05	Frequency Setting of Speed-Stage 5	0.00~400.00	40.00	Hz	O	O	O	*1
06-06	Frequency Setting of Speed-Stage 6	0.00~400.00	50.00	Hz	O	O	O	*1
06-07	Frequency Setting of Speed-Stage 7	0.00~400.00	50.00	Hz	O	O	O	*1
06-08	Frequency Setting of Speed-Stage 8	0.00~400.00	5.00	Hz	O	O	O	*1
06-09	Frequency Setting of Speed-Stage 9	0.00~400.00	5.00	Hz	O	O	O	*1
06-10	Frequency Setting of Speed-Stage 10	0.00~400.00	5.00	Hz	O	O	O	*1
06-11	Frequency Setting of Speed-Stage 11	0.00~400.00	5.00	Hz	O	O	O	*1
06-12	Frequency Setting of Speed-Stage 12	0.00~400.00	5.00	Hz	O	O	O	*1
06-13	Frequency Setting of Speed-Stage 13	0.00~400.00	5.00	Hz	O	O	O	*1
06-14	Frequency Setting of Speed-Stage 14	0.00~400.00	5.00	Hz	O	O	O	*1
06-15	Frequency Setting of Speed-Stage 15	0.00~400.00	5.00	Hz	O	O	O	*1
06-16	Operation Time Setting of Speed-Stage 0	0.0~6000.0	0.0	s	O	O	X	*1
06-17	Operation Time Setting of Speed-Stage 1	0.0~6000.0	0.0	s	O	O	X	*1
06-18	Operation Time Setting of Speed-Stage 2	0.0~6000.0	0.0	s	O	O	X	*1
06-19	Operation Time Setting of Speed-Stage 3	0.0~6000.0	0.0	s	O	O	X	*1
06-20	Operation Time Setting of Speed-Stage 4	0.0~6000.0	0.0	s	O	O	X	*1
06-21	Operation Time Setting of Speed-Stage 5	0.0~6000.0	0.0	s	O	O	X	*1
06-22	Operation Time Setting of Speed-Stage 6	0.0~6000.0	0.0	s	O	O	X	*1
06-23	Operation Time Setting of Speed-Stage 7	0.0~6000.0	0.0	s	O	O	X	*1

Group 06: Automatic Program Operation Parameters								
Code	**Parameter Name**	**Setting Range**	**Default**	**Unit**	**Control Mode**			**Attribute**
					V/F	**SLV**	**PM SLV**	
06-24	Operation Time Setting of Speed-Stage 8	0.0~6000.0	0.0	s	O	O	X	*1
06-25	Operation Time Setting of Speed-Stage 9	0.0~6000.0	0.0	s	O	O	X	*1
06-26	Operation Time Setting of Speed-Stage 10	0.0~6000.0	0.0	s	O	O	X	*1
06-27	Operation Time Setting of Speed-Stage 11	0.0~6000.0	0.0	s	O	O	X	*1
06-28	Operation Time Setting of Speed-Stage 12	0.0~6000.0	0.0	s	O	O	X	*1
06-29	Operation Time Setting of Speed-Stage 13	0.0~6000.0	0.0	s	O	O	X	*1
06-30	Operation Time Setting of Speed-Stage 14	0.0~6000.0	0.0	s	O	O	X	*1
06-31	Operation Time Setting of Speed-Stage 15	0.0~6000.0	0.0	s	O	O	X	*1
06-32	Operation Direction Selection of Speed-Stage 0	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-33	Operation Direction Selection of Speed-Stage 1	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-34	Operation Direction Selection of Speed-Stage 2	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-35	Operation Direction Selection of Speed-Stage 3	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-36	Operation Direction Selection of Speed-Stage 4	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-37	Operation Direction Selection of Speed-Stage 5	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-38	Operation Direction Selection of Speed-Stage 6	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-39	Operation Direction Selection of Speed-Stage 7	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-40	Operation Direction Selection of Speed-Stage 8	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-41	Operation Direction Selection of Speed-Stage 9	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-42	Operation Direction Selection of Speed-Stage 10	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-43	Operation Direction Selection of Speed-Stage 11	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-44	Operation Direction Selection of Speed-Stage 12	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-45	Operation Direction Selection of Speed-Stage 13	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	

Group 06: Automatic Program Operation Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
06-46	Operation Direction Selection of Speed-Stage 14	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	
06-47	Operation Direction Selection of Speed-Stage 15	0: Stop 1: Forward 2: Reverse	0	-	O	O	X	

Group 07: Start /Stop Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
07-00	Momentary Power Loss/ Fault Restart Selection	0: Disable 1: Enable	0	-	O	O	O	
07-01	Fault Auto-Restart Time	0~7200	0	s	O	O	O	
07-02	Number of Fault Auto-Restart Attempts	0~10	0	-	O	O	O	
07-04	Direct Start at Power up	0:Enable 1:Disable	1	-	O	O	O	
07-05	Delay Time of Direct Start	1.0~300.0	1.5	Sec	O	O	O	
07-06	DC Injection Braking Starting Frequency	0.0~10.0	0.5	Hz	O	O	X	
07-07	DC Injection Braking Current	0~100	50	%	O	O	X	
07-08	DC Injection Braking Time at Stop	0.00~10.00	0.50	s	O	O	X	
07-09	Stop Mode Selection	0: Deceleration to Stop 1: Coast to Stop 2: DC Braking Stop 3: Coast to Stop with Timer	0	-	O	O	O	
07-13	Low Voltage Detection Level	230V: 150~300 460V: 300~600	190 380	V	O	O	O	
07-14	Pre-excitation Time	0.00~10.00	2.00	s	X	O	X	
07-15	Pre-excitation Level	50~200	100	%	X	O	X	
07-16	DC Injection Braking Time at Start	0.00~100.00	0.00	s	O	O	X	
07-18	Minimum Base block Time	0.1~5.0	-	Sec	O	O	O	
07-19	Bi-Direction-Detection Speed Search Operating Current	0~100	50	%	O	O	X	
07-20	One-Direction-Detection Speed Search Operating Current	0~100	20	%	O	O	X	
07-21	Integral Time of Speed Searching	0.1~10.0	2.0	Sec	O	O	X	
07-22	Delay Time of Speed Searching	0.0~20.0	0.2	Sec	O	O	X	
07-23	Voltage Recovery Time	0.1~5.0	2.0	Sec	O	O	X	
07-24	Bi-Direction-Detection Speed	0: Disable	0	-	O	O	X	

Group 07: Start /Stop Parameters

Code	Parameter Name	Setting Range	Default	Unit	Control Mode V/F	Control Mode SLV	Control Mode PM SLV	Attribute
	Search Selection	1: Enable						
07-25	Low voltage Detection Time	0.00~1.00	0.00	Sec	O	O	O	
07-26	Start Selection after Coast to Stop During SLV mode	0: Start with Speed Search 1: Normal Start	0	-	X	O	X	
07-27	Start Selection after Fault during SLV Mode	0: Start with Speed Search 1: Normal Start	0	-	X	O	O	
07-28	Start Selection after External Base Block	0: Start with Speed Search 1: Normal Start	0	-	O	O	X	
07-29	Run Command Available During DC Braking	0: Disable (Run Command isn't available until DC Braking is completely done) 1: Enable	0	-	O	X	X	

Group 08: Protection Parameters

Code	Parameter Name	Setting Range	Default	Unit	Control Mode V/F	Control Mode SLV	Control Mode PM SLV	Attribute
08-00	Stall Prevention Function	xxx0b: Stall prevention is enabled in acceleration. xxx1b: Stall prevention is disabled in acceleration. xx0xb: Stall prevention is enabled in deceleration. xx1xb: Stall prevention is disabled in deceleration. x0xxb: Stall prevention is enabled in operation x1xxb: Stall prevention is disabled in operation 0xxxb: Stall prevention in operation decelerates based on deceleration time 1 1xxxb: Stall prevention in operation decelerates based on deceleration time 2	0000b	-	O	O	O	
08-01	Stall Prevention Level in Acceleration	30~200	120	%	O	O	O	
08-02	Stall Prevention Level in Deceleration	230V: 330~410 460V: 660~820	385 770	V	O	O	O	
08-03	Stall Prevention Level in Operation	30~200	120	%	O	O	O	
08-05	Selection for Motor Overload Protection (OL1)	xxx0b: Motor Overload Protection is disabled xxx1b: Motor Overload Protection is	0001b	-	O	O	O	

Group 08: Protection Parameters

Code	Parameter Name	Setting Range	Default	Unit	Control Mode V/F	Control Mode SLV	Control Mode PM SLV	Attribute
		enabled xx0xb: Cold Start of Motor Overload xx1xb: Hot Start of Motor Overload x0xxb: Standard Motor x1xxb: Inverter motor 0xxxb: Reserved 1xxxb: Reserved						
08-06	Start-up Mode of Overload Protection Operation (OL1)	0: Stop Output after Overload Protection 1: Continuous Operation after Overload Protection.	0	-	O	O	O	
08-08	Automatic Voltage Regulation (AVR)	0: Enable 1: Disable	0	-	O	O	O	
08-09	Selection of Input Phase Loss Protection	0: Disable 1: Enable	0	-	O	O	O	
08-10	Selection of Output Phase Loss Protection	0: Disable 1: Enable	0	-	O	O	O	
08-13	Selection of Over-Torque Detection	0: Over-Torque Detection is Disabled. 1: Start to Detect when Reaching the Set Frequency. 2: Start to Detect when the Operation is Begun.	0	-	O	O	O	
08-14	Selection of Over-Torque Operation	0: Deceleration to Stop when Over-Torque is Detected. 1: Display Warning when Over- Torque is Detected. Go on Operation. 2: Coast to Stop when Over Torque is Detected	0	-	O	O	O	
08-15	Level of Over-Torque Detection	0~300	150	%	O	O	O	
08-16	Time of Over-Torque Detection	0.0~10.0	0.1	Sec	O	O	O	
08-17	Selection of Low-Torque Detection	0: Low-Torque Detection is Disabled. 1: Start to Detect when Reaching the Set Frequency. 2: Start to Detect when the Operation is Begun.	0	-	O	O	O	
08-18	Selection of Low-Torque Operation	0: Deceleration to Stop when Low-Torque is Detected. 1: Display Warning when Low- Torque is Detected. Go on Operation. 2: Coast to Stop when Low-Torque is Detected	0	-	O	O	O	
08-19	Level of Low-Torque Detection	0~300	30	%	O	O	O	
08-20	Time of Low-Torque Detection	0.0~10.0	0.1	Sec	O	O	O	
08-21	Limit of Stall Prevention in Acc	0~100	50	%	O	O	O	

Group 08: Protection Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
	over Base Speed							
08-22	Stall Prevention Detection Time in Operation	2~100	100	ms	O	O	O	
08-23	Ground Fault (GF) Selection	0: Disable 1: Enable	0	-	O	O	O	
08-24	External Fault Operation Selection	0: Deceleration to Stop 1: Coast to Stop 2: Continuous Operation	0	-	O	O	O	
08-25	Detection selection of External Fault	0: Immediately Detect when the Power is Supplied. 1: Start to Detect during Operation	0	-	O	O	O	
08-30	Run Permissive Operation Selection	0: Deceleration to Stop 1: Coast to Stop	0	-	O	O	O	
08-35	Motor Overheat Operation Selection	0: Disable 1: Deceleration to Stop 2: Coast to Stop	0	-	O	O	O	
08-36	PTC Filter Time	0.00 ~ 5.00	0.20	Sec	O	O	O	
08-37	Fan Control Function	0: Start During Operation 1: Immediately Start when Power is Supplier 2: Start During High Temperature*	0	-	O	O	O	
08-38	Delay Time for Fan Off	0~600	60	Sec	O	O	O	
08-39	Delay Time for Motor Overheat Protection	1~300	60	Sec	O	O	O	

*** Models of inverter ratings above 2040 and 4050 in IP20 enclosure do not have this function.**

Group 09: Communication Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
09-00	INV Communication Station Address	1~31	1	-	O	O	O	*2
09-01	Communication Mode Selection	0: MODBUS 1: BACNet 2: METASYS 3: Multi-Pump 4: PROFIBUS (Available when Connect to Profibus Card)	0	-	O	O	O	
09-02	Baud Rate Setting (bps)	0:1200 1:2400 2:4800 3:9600 4:19200	3	-	O	O	O	*2

Group 09: Communication Parameters

Code	Parameter Name	Setting Range	Default	Unit	Control Mode V/F	Control Mode SLV	Control Mode PM SLV	Attribute
		5:38400						
09-03	Stop Bit Selection	0:1 Stop Bit 1: 2 Stop Bit	0	-	O	O	O	*2
09-04	Parity Selection	0: No Parity 1: Even Bit 2: Odd Bit	0	-	O	O	O	*2
09-06	Communication Error Detection Time	0.0~25.5	0.0	S	O	O	O	
09-07	Communication Fault Operation Selection	0: Deceleration to Stop Based on Deceleration Time 1 when Communication Fault Occurs. 1: Coast to Stop when Communication Fault Occurs. 2: Deceleration to Stop Based on Deceleration Time 2 when Communication Fault Occurs. 3: Keep Operating when Communication Fault Occurs.	3	-	O	O	O	
09-08	Comm. Fault Tolerance Count	1~20	1	-	O	O	O	
09-09	Waiting Time	5~65	5	ms	O	O	O	
09-10	Device Instance Number	1 ~ 254	1	-	O	O	O	

Group 10: PID Parameters

Code	Parameter Name	Setting Range	Default	Unit	Control Mode V/F	Control Mode SLV	Control Mode PM SLV	Attribute
10-00	PID Target Value Source Setting	1: AI1 Terminal 2: AI2 Terminal 3: Reserved 4:10-02/12-38 Setting 5: Reserved 6: Refer to the setting of 00-05	4	-	O	O	O	
10-01	PID Feedback Value Source Setting	1:AI1 Terminal 2:AI2 Terminal 3: Reserved	2	-	O	O	O	
10-02	PID Target Value	0.0~100.0	0.0	%	O	O	O	
10-03	PID Control Mode	xxx0b: PID Disable xxx1b: PID Enable xx0xb: PID Positive Characteristic xx1xb: PID Negative Characteristic x0xxb: PID Error Value of D Control x1xxb: PID Feedback Value of D Control	0000b	-	O	O	O	

Group 10: PID Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
		0xxxb: PID Output 1xxxb: PID Output + Frequency Command						
10-04	Feedback Gain	0.01~10.00	1.00	-	O	O	O	*1
10-05	Proportional Gain (P)	0.00~10.00	3.00	-	O	O	O	*1
10-06	Integral Time (I)	0.00~100.00	7.00	s	O	O	O	*1
10-07	Differential Time (D)	0.00~10.00	0.00	s	O	O	O	*1
10-09	PID Bias	-100.0~100.0	0	%	O	O	O	*1
10-10	PID Primary Delay Time	0.00~10.00	0.00	s	O	O	O	*1
10-11	PID Feedback Loss Detection Selection	0: Disable 1: Warning 2: Fault	0	-	O	O	O	
10-12	PID Feedback Loss Detection Level	0~100	0	%	O	O	O	
10-13	PID Feedback Loss Detection Time	0.0~10.0	1.0	s	O	O	O	
10-14	PID Integral Limit	0.0~100.0	100.0	%	O	O	O	*1
10-17	Start Frequency of PID Sleep	0.00~180.00	30.00	Hz	O	O	O	
10-18	Delay Time of PID Sleep	0.0~255.5	0.0	s	O	O	O	
10-19	Frequency of PID Waking up	0.00~180.00	0.00	Hz	O	O	O	
10-20	Delay Time of PID Waking up	0.0~255.5	0.0	s	O	O	O	
10-23	PID Limit	0.00~100.0	100.0	%	O	O	O	*1
10-24	PID Output Gain	0.0~25.0	1.0	-	O	O	O	
10-25	PID Reversal Output Selection	0: Do not Allow Reversal Output 1: Allow Reversal Output	0	-	O	O	O	
10-26	PID Target Acceleration/ Deceleration Time	0.0~25.5	0.0	s	O	O	O	
10-27	PID Feedback Display Bias	-99.99~99.99	0.00	-	O	O	O	
10-28	PID Feedback Display Gain	0.00~100.00	100.00	-	O	O	O	
10-29	PID Sleep Selection	0: Disable 1: Enable 2: Set by DI	1	-	O	O	O	
10-30	Upper Limit of PID Target	0.0 ~ 100.0	100.0	%	O	O	O	
10-31	Lower Limit of PID Target	0.0 ~ 100.0	0.0	%	O	O	O	
10-32	PID Switching Function	0: PID1 1: PID2 2: Switch to PID2 by DI 3: Switch to PID2 By RTC	0		O	O	O	
10-33	PID Maximum Feedback Value	1~10000	999	-	O	O	O	
10-34	Scaling of PID Setpoint	0~4	1	-	O	O	O	
10-35	PID Unit	0: % 1: FPM 2: CFM	0	-	O	O	O	

Group 10: PID Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
		3: PSI						
		4: GPH						
		5: GPM						
		6: IN						
		7: FT						
		8: /s						
		9: /m						
		10: /h						
		11: °F						
		12: inW						
		13: HP						
		14: m/s						
		15: MPM						
		16: CMM						
		17: W						
		18: KW						
		19: m						
		20: °C						
		21: RPM						
		22: Bar						
		23: Pa						
10-36	PID2 Proportional Gain (P)	0.00~10.00	3.00	-	O	O	O	*1
10-37	PID2 Integral Time (I)	0.0~100.0	0.50	s	O	O	O	*1
10-38	PID2 Differential Time (D)	0.00~10.00	0.00	s	O	O	O	*1
10-39	Force Frequency During PID Feedback Loss	00.00~400.00	30.00	Hz	O	O	O	
10-40	Compensation Frequency of PID Sleep Selection	0: Disable	0		O	O	O	
		1: Enable						

Group 11: Auxiliary Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
11-00	Direction Lock Selection	0: Allow Forward and Reverse Rotation	1	-	O	O	O	
		1: Only Allow Forward Rotation						
		2: Only Allow Reverse Rotation						
11-01	Carrier Frequency	0: Carrier Output Frequency Tuning	Inverter KVA*a	-	O	O	O	
		1: 1.5KHz						
		2~16: 2~16KHz						
11-02	Soft PWM Function Selection	0: Disable	1*b	-	O	O	O	
		1: Enable						
11-03	Automatic carrier lowering selection	0: Disable	0	-	O	X	X	
		1: Enable						

Group 11: Auxiliary Parameters

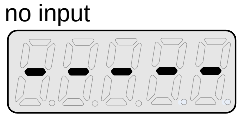
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
11-04	S-curve Time Setting at the Start of Acceleration	0.00~2.50	0.20	s	O	O	O	
11-05	S-curve Time Setting at the End of Acceleration	0.00~2.50	0.20	s	O	O	O	
11-06	S-curve Time Setting at the Start of Deceleration	0.00~2.50	0.20	s	O	O	O	
11-07	S-curve Time Setting at the End of Deceleration	0.00~2.50	0.20	s	O	O	O	
11-08	Jump Frequency 1	0.0~400.0	0.0	Hz	O	O	O	
11-09	Jump Frequency 2	0.0~400.0	0.0	Hz	O	O	O	
11-10	Jump Frequency 3	0.0~400.0	0.0	Hz	O	O	O	
11-11	Jump Frequency Width	0.0~25.5	1.0	Hz	O	O	O	
11-12	Manual Energy Saving Gain	0~100	80	%	O	X	X	
11-13	Keypad Return Time	0~120	60	Sec	O	O	O	
11-18	Manual Energy Saving Frequency	0.00~400.00	0.00	Hz	O	X	X	
11-19	Automatic Energy Saving Function	0: Automatic Energy Saving is Disabled 1: Automatic Energy Saving is Enabled	0	-	O	X	X	
11-20	Filter Time of Automatic Energy Saving	0~200	140	ms	O	X	X	
11-21	Voltage Upper Limit of Energy Saving Tuning	0~100	100	%	O	X	X	
11-22	Adjustment Time of Automatic Energy Saving	0~5000	20	ms	O	X	X	*1
11-23	Detection Level of Automatic Energy Saving	0~100	10	%	O	X	X	
11-24	Coefficient of Automatic Energy Saving	0.00~655.35	KVA[*a]	-	O	X	X	
11-29	Auto De-rating Selection	0: Disable 1: Enable	0	-	O	X	X	
11-30	Variable Carrier Frequency Max. Limit	2~16	KVA[*a]	KHz	O	X	X	
11-31	Variable Carrier Frequency Min. Limit	2~16	KVA[*a]	KHz	O	X	X	
11-32	Variable Carrier Frequency Proportional Gain	00~99	00	-	O	X	X	
11-41	Frequency Reference Loss Operation Selection	0: Decelerate to Stop when Reference Frequency Disappears 1: Operation is Set by 11-42 when Reference Frequency Disappears	0	-	O	O	O	
11-42	Operation Frequency after Frequency Reference Loss	0.0~100.0	80.0	%	O	O	O	
11-43	Hold Frequency at Start	0.0~400.0	0.0	Hz	O	O	O	
11-44	Frequency Hold Time at Start	0.0~10.0	0.0	s	O	O	O	

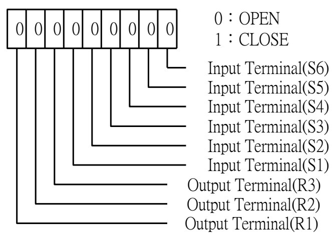
Group 11: Auxiliary Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
11-45	Hold Frequency at Stop	0.0~400.0	0.0	Hz	O	O	O	
11-46	Frequency Hold Time at Stop	0.0~10.0	0.0	s	O	O	O	
11-47	KEB Deceleration Time	0.0~25.5	0.0	s	O	X	X	*1
11-48	KEB Detection Level	230V: 190~210	200	V	O	X	X	
		460V: 380~420	400					
11-51	Braking Selection of Zero Speed	0: Disable	0	-	O	X	X	
		1: Enable						
11-54	Output KWH Initialization	0: Do not Clear Output KWH	0	-	O	O	O	*1
		1: Clear Output KWH						
11-55	STOP Key Selection	0: Stop Key is Disabled when the Operation Command is not Provided by Keypad.	1	-	O	O	O	
		1: Stop Key is Enabled when the Operation Command is not Provided by Keypad.						
11-56	UP/DOWN Selection	0: When UP/DOWN in Keypad is Disabled, it will be Enabled if Press ENTER after Frequency Modification.	0	-	O	O	O	
		1: When UP/DOWN in Keypad is Enabled, it will be Enabled after Frequency Modification.						
11-58	Record Reference Frequency	0: Disable	0	-	O	O	O	*1
		1: Enable						
11-59	Anti-Hunting Protection Gain	0.01~2.50	0.01		O	X	X	
11-60	Upper Limit of Anti-Hunting Protection	0~100	30	%	O	X	X	
11-61	Filter Time of Anti-Hunting Protection	0~100	0		O	X	X	
11-62	Prevention of Oscillation Selection	0: Mode 1 1: Mode 2	1		O	X	X	
11-63	Flux-Enhancing Selection	0: Disable	1		X	O	X	
		1: Enable						

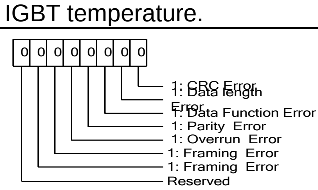
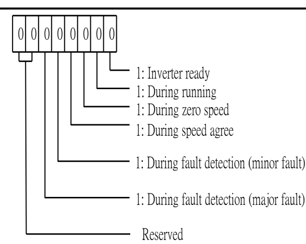
***a: KVA means the default value of this parameter depends on inverter rating.**

***b: Default value is 1 only for V/F mode.**

Group 12: Monitoring Parameters

Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
12-00	Display Screen Selection (LED)	00000~77777 From the left most bit, it displays the selected parameter. Press DSP key successively. 0: No display 1: Output Current 2: Output Voltage 3: DC Bus Voltage 4: Heatsink Temperature 5: PID Feedback 6: AI1 Value 7: AI2 Value	00000	-	O	O	O	*5
12-01	PID Feedback Display Mode (LED)	0: Display the Feedback Value by Integer (xxx) 1: Display the Feedback Value by the Value with First Decimal Place (xx.x) 2: Display the Feedback Value by the Value with Second Decimal Place (x.xx)	0		O	O	O	*5
12-02	PID Feedback Display Unit Setting (LED)	0: xxxxx (no unit) 1: xxxPb (pressure) 2: xxxFL (flow)	0		O	O	O	*5
12-03	Line Speed Display (LED)	0~65535	0	RPM	O	O	O	*5
12-04	Line Speed Display Mode (LED)	0: Display Inverter Output Frequency 1: Line Speed Display at Integer.(xxxxx) 2: Line Speed Display at One Decimal Place. (xxxx.x) 3: Line Speed Display at Two Decimal Places. (xxx.xx) 4: Line Speed Display at Three Decimal Places. (xx.xxx)	0		O	O	O	*5
12-05	Status display of digital input terminal (LED / LCD)	LED display is shown as below no input  correspondences to input and output	-	-	O	O	O	

Group 12: Monitoring Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
		 LCD display is shown as below  						
12-11	Output Current of Current Fault	Display the output current of current fault	-	A	O	O	O	
12-12	Output Voltage of Current Fault	Display the output voltage of current fault	-	V	O	O	O	
12-13	Output Frequency of Current Fault	Display the output frequency of current fault	-	Hz	O	O	O	
12-14	DC Voltage of Current Fault	Display the DC voltage of current fault	-	V	O	O	O	
12-15	Frequency Command of Current Fault	Display the frequency command of current fault	-	Hz	O	O	O	
12-16	Frequency Command	If set via keypad, it only allows monitoring frequency command.	-	Hz	O	O	O	
12-17	Output Frequency	Display the current output frequency	-	Hz	O	O	O	
12-18	Output Current	Display the current output current	-	A	O	O	O	
12-19	Output Voltage	Display the current output voltage	-	V	O	O	O	
12-20	DC Voltage	Display the current DC voltage	-	V	O	O	O	
12-21	Output Power	Display the current output power	-	kW	O	O	O	
12-22	Motor’s Rotation Speed	Display motor’s current rotation speed in VF/SLV mode Motor’s rotation speed = output power x(120/motor’s pole number) In PG/SV mode, motor’s rotation speed is calculated by feedback frequency. Max limit is 65535	-	rpm	O	O	O	
12-23	Output Power Factor	Display the current output power factor	-	-	O	O	O	
12-24	Control Mode	Display control mode 0 : VF 2 : SLV 5 : PM SLV	-	-	O	O	O	

Group 12: Monitoring Parameters								
Code	**Parameter Name**	**Setting Range**	**Default**	**Unit**	**Control Mode**			**Attribute**
					V/F	**SLV**	**PM SLV**	
12-25	AI1 Input	Display the current AI1 input (0V corresponds to 0%, 10V corresponds to 100%,)	-	%	O	O	O	
12-26	AI2 Input	Display the current AI2 input (0V or 4mA corresponds to 0%, 10V or 20mA corresponds to 100%)	-	%	O	O	O	
12-27	Torque Command	Display the current torque command (100% corresponds to motor torque)	-	%	X	O	O	
12-28	Motor Torque Current (Iq)	Display the current q-axis current	-	%	X	O	O	
12-29	Motor Excitation Current (Id)	Display the current d-axis current	-	%	X	O	O	
12-36	PID Input	Display input error of the PID controller (PID target value - PID feedback) (100% corresponds to the maximum frequency set by 01-02 or 01-16)	0.01	%	O	O	O	
12-37	PID Output	Display output of the PID controller (100% corresponds to the maximum frequency set by 01-02 or 01-16)	-	%	O	O	O	
12-38	PID Setpoint	Display the target value of the PID controller (100% corresponds to the maximum frequency set by 01-02 or 01-16)	-	%	O	O	O	
12-39	PID Feedback	Display the feedback value of the PID controller (100% corresponds to the maximum frequency set by 01-02 or 01-16)	-	%	O	O	O	
12-41	Heatsink Temperature	Display the heatsink temperature of IGBT temperature.	-	℃	O	O	O	
12-42	RS-485 Error Code		-	-	O	O	O	
12-43	Inverter Status		101B	-	O	O	O	
12-45	Recent Fault Message	Display current fault message	-	-	O	O	O	
12-46	Previous Fault Message	Display previous fault message	-	-	O	O	O	
12-47	2nd Previous Fault Message	Displays 2nd previous fault message	-	-	O	O	O	
12-48	3rd Previous Fault Message	Displays 3rd Previous Fault Message	-	-	O	O	O	
12-49	4th Previous Fault Message	Displays 4th Previous Fault Message	-	-	O	O	O	
12-50	DIO Status of Current Fault	Display the DI/DO status of current fault	-	-	O	O	O	

Group 12: Monitoring Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
		Description is similar to 12-05						
12-51	Inverter Status of Current Fault	Display the inverter status of current fault Description is similar to 12-43	-	-	O	O	O	
12-52	Trip Time 1 of Current Fault	Display the operation time of current fault, 12-53 shows the days and 12-52 shows the hours.	-	Hr	O	O	O	
12-53	Trip Time 2 of Current Fault		-	day	O	O	O	
12-54	Frequency Command of Previous Fault	Display frequency command of previous fault	-	Hz	O	O	O	
12-55	Output Frequency of Previous Fault	Display output frequency of previous fault	-	Hz	O	O	O	
12-56	Output Current of Previous Fault	Display output current of previous fault	-	A	O	O	O	
12-57	Output Voltage of Previous Fault	Display output voltage of previous fault	-	V	O	O	O	
12-58	DC Voltage of Previous Fault	Display DC voltage of previous fault	-	V	O	O	O	
12-59	DIO Status of Previous Fault	Display DI/DO status of previous fault Description is similar to 12-05	-	-	O	O	O	
12-60	Inverter Status of Previous Fault	Display inverter status of previous fault Description is similar to 12-43	-	-	O	O	O	
12-61	Trip time 1 of last fault	Display the operation time of last time's fault, 12-62 shows the days and 12-61 shows the hours.	-	Hr	O	O	O	
12-62	Trip time 2 of last fault		-	day	O	O	O	
12-63	Recent warning messages	Display the recent warning messages	-	-	O	O	O	
12-64	Previous warning message	Display the previous warning message	-	-	O	O	O	
12-67	Accumulative Energy (kWHr)	0.0 ~ 999.9		kWHr	O	O	O	
12-68	Accumulative Energy (MWHr)	0 ~ 60000		MWHr	O	O	O	
12-69	Accumulative Electricity Price ($)	0 ~ 9999		$	O	O	O	
12-70	Accumulative Electricity Price (10000$)	0 ~ 60000		$	O	O	O	
12-71	Flow Meter Feedback	1 ~ 50000		GPM	O	O	O	
12-72	RTC Date	12.01.01 ~ 99.12.31	12.01.01		O	O	O	
12-73	RTC Time	00:00 ~ 23:59	00:00		O	O	O	
12-74	Operating Pressure Setting	0.01 ~ 25.50	2.00	PSI	O	X	X	
12-75	Pressure Feedback Value	0.01 ~ 25.50	-	PSI	O	X	X	
12-76	No-Load Voltage	0.0 ~ 600.0	-	V	X	O	X	
12-77	Flow Meter Target Setting	1 ~ 50000	-	GPM	O	O	O	
12-79	Pulse Input Percentage	0.0~100.0	-	%	O	O	O	

*** Models of inverter ratings above 230V 50HP (including 50HP) and 460V 75HP (including 75HP) in IP20 enclosure do not include heatsink temperature display.**

*** Maximum upper limit in motor speed (rpm) of parameter 12-22 is 65535.**

Group 13: Maintenance Function Group								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
13-00	Inverter Rating Selection	00H~FFH	-	-	O	O	O	*4
13-01	Software Version	0.0-9.9	-	-	O	O	O	*4
13-03	Cumulative Operation Hours 1	0~23	-	hr	O	O	O	*4
13-04	Cumulative Operation Hours 2	0~65535	-	day	O	O	O	*4
13-05	Selection of Cumulative Operation Time	0: Cumulative time in power on 1: Cumulative time in operation						*1
13-06	Parameters Locked	0: Parameters out of 13-06 are read-only. 1: Only user parameter is enabled. 2: All parameters are writable.						*1
13-07	Parameter Password Function	0~9999	0	-	O	O	O	
13-08	Restore Factory Setting	0: No Initialization 2: 2 wire Initialization (220/440V, 60Hz) 3: 3 wire Initialization (220/440V, 60Hz) 4: 2 wire Initialization (230/415V, 50Hz) 5: 3 wire Initialization (230/415V, 50Hz) 6: 2 wire Initialization (200/380V, 50Hz) 7: 3 wire Initialization (200/380V, 50Hz) 8: PLC Initialization 9: 2 Wire Initialization (230V/460V, 60Hz) 10: 3 Wire Initialization (230V/460V, 60Hz) Others: Reserved	0	-	O	O	O	
13-09	Fault History Clearance Function	0: Do not Clear Fault History 1: Clear Fault History	0	-	O	O	O	*1
13-10	Password Function 2	0 ~ 9999	0		O	O	O	
13-11	C/B CPLD Ver.	0.00~9.99	0.00		O	O	O	
13-12	Option Card Id	0~255	0		O	O	O	
13-13	Option Card CPLD Ver.	0.00~9.99	0.00		O	O	O	
13-14	Fault Storage Selection	0: Auto Restart Fault Messages are not saved in fault history during Auto-Restart. 1: Auto Restart Fault Messages are saved in fault history during Auto-Restart.	0		O	O	O	

Group 14: PLC Setting Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
14-00	T1 Set Value 1	0~9999	0	-	O	O	O	
14-01	T1 Set Value 2（Mode 7）	0~9999	0	-	O	O	O	
14-02	T2 Set Value 1	0~9999	0	-	O	O	O	
14-03	T2 Set Value 2（Mode 7）	0~9999	0	-	O	O	O	
14-04	T3 Set Value 1	0~9999	0	-	O	O	O	
14-05	T3 Set Value 2（Mode 7）	0~9999	0	-	O	O	O	
14-06	T4 Set Value 1	0~9999	0	-	O	O	O	
14-07	T4 Set Value 2（Mode 7）	0~9999	0	-	O	O	O	
14-08	T5 Set Value 1	0~9999	0	-	O	O	O	
14-09	T5 Set Value 2（Mode 7）	0~9999	0	-	O	O	O	
14-10	T6 Set Value 1	0~9999	0	-	O	O	O	
14-11	T6 Set Value 2（Mode 7）	0~9999	0	-	O	O	O	
14-12	T7 Set Value 1	0~9999	0	-	O	O	O	
14-13	T7 Set Value 2（Mode 7）	0~9999	0	-	O	O	O	
14-14	T8 Set Value 1	0~9999	0	-	O	O	O	
14-15	T8 Set Value 2（Mode 7）	0~9999	0	-	O	O	O	
14-16	C1 Set Value	0~65535	0	-	O	O	O	
14-17	C2 Set Value	0~65535	0	-	O	O	O	
14-18	C3 Set Value	0~65535	0	-	O	O	O	
14-19	C4 Set Value	0~65535	0	-	O	O	O	
14-20	C5 Set Value	0~65535	0	-	O	O	O	
14-21	C6 Set Value	0~65535	0	-	O	O	O	
14-22	C7 Set Value	0~65535	0	-	O	O	O	
14-23	C8 Set Value	0~65535	0	-	O	O	O	
14-24	AS1 Set Value 1	0~65535	0	-	O	O	O	
14-25	AS1 Set Value 2	0~65535	0	-	O	O	O	
14-26	AS1 Set Value 3	0~65535	0	-	O	O	O	
14-27	AS2 Set Value 1	0~65535	0	-	O	O	O	
14-28	AS2 Set Value 2	0~65535	0	-	O	O	O	
14-29	AS2 Set Value 3	0~65535	0	-	O	O	O	
14-30	AS3 Set Value 1	0~65535	0	-	O	O	O	
14-31	AS3 Set Value 2	0~65535	0	-	O	O	O	
14-32	AS3 Set Value 3	0~65535	0	-	O	O	O	
14-33	AS4 Set Value 1	0~65535	0	-	O	O	O	
14-34	AS4 Set Value 2	0~65535	0	-	O	O	O	
14-35	AS4 Set Value 3	0~65535	0	-	O	O	O	
14-36	MD1 Set Value 1	0~65535	1	-	O	O	O	
14-37	MD1 Set Value 2	0~65535	1	-	O	O	O	
14-38	MD1 Set Value 3	0~65535	1	-	O	O	O	
14-39	MD2 Set Value 1	0~65535	1	-	O	O	O	
14-40	MD2 Set Value 2	0~65535	1	-	O	O	O	
14-41	MD2 Set Value 3	0~65535	1	-	O	O	O	
14-42	MD3 Set Value 1	0~65535	1	-	O	O	O	

Group 14: PLC Setting Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
14-43	MD3 Set Value 2	0~65535	1	-	O	O	O	
14-44	MD3 Set Value 3	0~65535	1	-	O	O	O	
14-45	MD4 Set Value 1	0~65535	1	-	O	O	O	
14-46	MD4 Set Value 2	0~65535	1	-	O	O	O	
14-47	MD4 Set Value 3	0~65535	1	-	O	O	O	

Group 15: PLC Monitoring Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
15-00	T1 Current Value 1	0~9999	0	-	O	O	O	
15-01	T1 Current Value 2（Mode 7）	0~9999	0	-	O	O	O	
15-02	T2 Current Value 1	0~9999	0	-	O	O	O	
15-03	T2 Current Value 2（Mode 7）	0~9999	0	-	O	O	O	
15-04	T3 Current Value 1	0~9999	0	-	O	O	O	
15-05	T3 Current Value 2（Mode 7）	0~9999	0	-	O	O	O	
15-06	T4 Current Value 1	0~9999	0	-	O	O	O	
15-07	T4 Current Value 2（Mode 7）	0~9999	0	-	O	O	O	
15-08	T5 Current Value 1	0~9999	0	-	O	O	O	
15-09	T5 Current Value 2（Mode 7）	0~9999	0	-	O	O	O	
15-10	T6 Current Value 1	0~9999	0	-	O	O	O	
15-11	T6 Current Value 2（Mode 7）	0~9999	0	-	O	O	O	
15-12	T7 Current Value 1	0~9999	0	-	O	O	O	
15-13	T7 Current Value 2（Mode 7）	0~9999	0	-	O	O	O	
15-14	T8 Current Value 1	0~9999	0	-	O	O	O	
15-15	T8 Current Value 2（Mode 7）	0~9999	0	-	O	O	O	
15-16	C1 Current Value	0~65535	0	-	O	O	O	
15-17	C2 Current Value	0~65535	0	-	O	O	O	
15-18	C3 Current Value	0~65535	0	-	O	O	O	
15-19	C4 Current Value	0~65535	0	-	O	O	O	
15-20	C5 Current Value	0~65535	0	-	O	O	O	
15-21	C6 Current Value	0~65535	0	-	O	O	O	
15-22	C7 Current Value	0~65535	0	-	O	O	O	
15-23	C8 Current Value	0~65535	0	-	O	O	O	
15-24	AS1 Results	0~65535	0	-	O	O	O	
15-25	AS2 Results	0~65535	0	-	O	O	O	
15-26	AS3 Results	0~65535	0	-	O	O	O	
15-27	AS4 Results	0~65535	0	-	O	O	O	
15-28	MD1 Results	0~65535	0	-	O	O	O	
15-29	MD2 Results	0~65535	0	-	O	O	O	
15-30	MD3 Results	0~65535	0	-	O	O	O	
15-31	MD4 Results	0~65535	0	-	O	O	O	
15-32	TD Current Value	0~65535	0	-	O	O	O	

Group 16: LCD Function Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
16-00	Main Screen Monitoring	5~79 When using LCD to operate, the monitored item displays in the first line. (default is frequency command)	16	-	O	O	O	*1
16-01	Sub-Screen Monitoring 1	5~79 (Parameter 12-05~12-79) When using LCD to operate, the monitored item displays in the second line. (default is output frequency)	17	-	O	O	O	*1
16-02	Sub-Screen Monitoring 2	5~79 (Parameter 12-05~12-79) when using LCD to operate, the monitored item displays in the third line. (default is output current)	18	-	O	O	O	*1
16-03	Selection of Display Unit	0~39999: Determine the display way and unit of frequency command 0: Frequency display unit is 0.01Hz 1: Frequency display unit 0.01% 2: Rpm display; motor rotation speed is set by the control modes to select IM (02-07)/ PM (22-03) motor poles to calculate. 3~39: Reserved 40~9999: Users specify the format; Input 0XXXX represents the display of XXXX at 100%. 10001~19999: Users specify the format; Input 1XXXX represents the display of XXX.X at 100%. 20001~29999: Users specify the format; Input 2XXXX represents the display of XX.XX at 100%. 30001~39999: Users specify the format, Input 3XXXX represents the display of X.XXX at 100%.	0	-	O	O	O	
16-04	Selection of Engineering Unit	0: No Unit 1: FPM 2: CFM 3: PSI 4: GPH 5: GPM 6: IN 7: FT 8: /s	0	-	O	O	O	

Group 16: LCD Function Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode V/F	SLV	PM SLV	Attribute
		9: /m						
		10: /h						
		11: °F						
		12: inW						
		13: HP						
		14: m/s						
		15: MPM						
		16: CMM						
		17: W						
		18: KW						
		19: m						
		20: °C						
		21: RPM						
		22: Bar						
		23: Pa						
16-05	LCD Backlight	0~7	5	-	O	O	O	*1
16-07	Copy Function Selection	0: Disabled 1: Read inverter parameters and save to the operator. 2: Write the operator parameters to inverter. 3: Compare parameters of inverter and operator.	0	-	O	O	O	
16-08	Operator Copy Function	0: Do not allow to read inverter parameters and save to the operator. 1: Allow to read inverter parameters and save to the operator.	0	-	O	O	O	
16-09	Operator Removed (LCD) Selection	0: Continue operating when LCD operator is removed. 1: Display fault and stop when LCD operator is removed	0	-	O	O	O	*1
16-10	RTC Function Selection	0: Hide 1: Display	0		O	O	O	
16-11	RTC Date Setting	12.01.01 ~ 99.12.31	12.01.01		O	O	O	
16-12	RTC Time Setting	00:00 ~ 23:59	00:00		O	O	O	
16-13	RTC Timer Function Selection	0: Disable 1: Enable 2: Set by DI	0		O	O	O	
16-14	P1 Start Time	00:00 ~ 23:59	08:00		O	O	O	
16-15	P1 Stop Time	00:00 ~ 23:59	18:00		O	O	O	
16-16	P1 Start Date	1:Mon, 2:Tue, 3:Wed, 4:Thu,:5:Fri,:6:Sat, 7:Sun	1		O	O	O	
16-17	P1 Stop Date		5		O	O	O	
16-18	P2 Start Time	00:00 ~ 23:59	08:00		O	O	O	

Group 16: LCD Function Parameters

Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
16-19	P2 Stop Time	00:00 ~ 23:59	18:00		O	O	O	
16-20	P2 Start Date	1:Mon,2:Tue,3:Wed, 4:Thu,:5:Fri,:6:Sat, 7:Sun	1		O	O	O	
16-21	P2 Stop Date		5		O	O	O	
16-22	P3 Start Time	00:00 ~ 23:59	08:00		O	O	O	
16-23	P3 Stop Time	00:00 ~ 23:59	18:00		O	O	O	
16-24	P3 Start Date	1:Mon,2:Tue,3:Wed, 4:Thu,:5:Fri,:6:Sat, 7:Sun	1		O	O	O	
16-25	P3 Stop Date		5		O	O	O	
16-26	P4 Start Time	00:00 ~ 23:59	08:00		O	O	O	
16-27	P4 Stop Time	00:00 ~ 23:59	18:00		O	O	O	
16-28	P4 Start Date	1:Mon, 2:Tue, 3:Wed, 4:Thu, 5:Fri, 6:Sat, 7:Sun	1		O	O	O	
16-29	P4 Stop Date		5		O	O	O	
16-30	RTC Offset Selection	0: Disable 1: Enable 2: Set by DI	0		O	O	O	
16-31	RTC Offset Time Setting	00:00 ~ 23:59	00:00	-	O	O	O	
16-32	Source of Timer 1	0: None,1:P1, 2:P2,3:P1+P2 4:P3,5:P1+P3, 6:P2+P3,7:P1+P2+P3, 8:P4,9:P1+P4, 10:P2+P4, 11:P1+P2+P4 12:P3+P4 13:P1+P3+P4, 14:P2+P3+P4 15:P1+P2+P3+P4, 16:Off,17:Off+P1 18:Off+P2, 19:Off+P1+P2 20:Off+P3, 21:Off+P1+P3 22:Off+P2+P3 23:Off+P1+P2+P3 24:Off+P4 25:Off+P1+P4 26:Off+P2+P4 27:Off+P1+P2+P4 28:Off+P3+P4 29:Off+P3+P4 30:Off+P2+P3+P4 31:Off+P1+P2+P3+P4	1		O	O	O	
16-33	Source of Timer 2		2		O	O	O	
16-34	Source of Timer 3		4		O	O	O	
16-35	Source of Timer 4		8		O	O	O	
16-36	Selection of RTC Speed	0: Off	0		O	O	O	

Group 16: LCD Function Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
		1: By Timer 1						
		2: By Timer 2						
		3: By Timer 3						
		4: By Timer 4						
		5: By Timer 1+2						
16-37	Run Direction of RTC Speed	xxx0b: RTC Run1 Forward Rotation xxx1b: RTC Run1 Reverse Rotation xx0xb: RTC Run2 Forward Rotation xx1xb: RTC Run2 Reverse Rotation x0xxb: RTC Run3 Forward Rotation x1xxb: RTC Run3 Reverse Rotation 0xxxb: RTC Run4 Forward Rotation 1xxxb: RTC Run4 Reverse Rotation			O	O	O	

Group 17: IM Motor Automatic Tuning Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
17-00	Mode Selection of Automatic Tuning	0: Rotation Auto-tune 1: Static Auto-tune 2: Stator Resistance Measurement 3: Reserved 4: Loop Adjust 5: Rotation Auto-tune (Loop adjust + Stator Resistance + Rotation) 6: Static Auto-tune (Loop adjust + Stator Resistance + Static)	2[*c]	-	O	O	X	
17-01	Motor Rated Output Power	0.00~600.00	-	KW	O	O	X	
17-02	Motor Rated Current	0.1~1200.0	-	A	O	O	X	
17-03	Motor Rated Voltage	230V: 0.0~255.0 460V:0.0~510.0	230 460	V	O	O	X	
17-04	Motor Rated Frequency	10.0~400.0	60.0	Hz	O	O	X	
17-05	Motor Rated Speed	0~24000	KVA[*a]	rpm	O	O	X	
17-06	Pole Number of Motor	2~16 (Even)	4	Pole	O	O	X	
17-08	Motor No-load Voltage	230V: 50~240 460V100~480	KVA[*a]	V	O	O	X	
17-09	Motor Excitation Current	0.01~600.00 (15%~70% motor rated current)	KVA[*a]	A	O	O	X	
17-10	Automatic Tuning Start	0: Disable 1: Enable	0	-	O	O	X	
17-11	Error History of Automatic Tuning	0: No Error 1: Motor Data Error 2. Stator Resistance Tuning Error	0	-	O	O	X	

Group 17: IM Motor Automatic Tuning Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
		3. Leakage Induction Tuning Error						
		4. Rotor Resistance Tuning Error						
		5. Mutual Induction Tuning Error						
		6. Reserved						
		7. DT Error						
		8. Motor Acceleration Error						
		9. Warning						
17-12	Leakage Inductance Ratio	0.1 ~ 15.0	3.4	%	X	O	X	
17-13	Slip Frequency	0.10 ~ 20.00	1.00	Hz	X	O	X	

***c: Default value is 2 in V/F mode while it is 0 in SLV mode.**

***a: KVA means the default value of this parameter will be changed by different capacities of inverter.**

Group 18: Slip Compensation Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
18-00	Slip Compensation Gain at Low Speed	0.00~2.50	0.00*d	-	O	O	X	*1
18-01	Slip Compensation Gain at High Speed	-1.00~1.00	0.0	-	O	O	X	*1
18-02	Slip Compensation Limit	0~250	200	%	O	X	X	
18-03	Slip Compensation Filter Time	0.0~10.0	1.0	Sec	O	X	X	
18-04	Regenerative Slip Compensation Selection	0: Disable 1: Enable	0	-	O	X	X	
18-05	FOC Delay Time	1~1000	100	ms	X	O	X	
18-06	FOC Gain	0.00~2.00	0.1	-	X	O	X	

***d: Default value is 0.00 in V/F mode while it is 1.0 in SLV mode.**

Group 20 Speed Control Parameters*								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
20-00	ASR Gain 1	0.00~250.00	3.00	-	X	O	O	*1
20-01	ASR Integral Time 1	0.001~10.000	SLV: 0.500 PMSLV: 0.08,	Sec	X	O	O	*1
20-02	ASR Gain 2	0.00~250.00	3.00	-	X	O	O	*1
20-03	ASR Integral Time 2	0.001~10.000	SLV: 0.500 PMSLV: 0.08,	Sec	X	O	O	*1
20-04	ASR Integral Time Limit	0~300	200	%	X	O	O	
20-07	Selection of Acceleration and	0: PI speed control will be enabled only	1	-	X	O	X	

Group 20 Speed Control Parameters*								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
	Deceleration of P/PI	in constant speed. For accel/decel, only use P control. 1: Speed control is enabled either in constant speed or accel/decel.						
20-08	ASR Delay Time	0.000~0.500	0.004	Sec	X	O	X	
20-09	Speed Observer Proportional (P) Gain 1	0.00~2.55	0.61	-	X	O	X	*1
20-10	Speed Observer Integral(I) Time 1	0.01~10.00	0.05	Sec	X	O	X	*1
20-11	Speed Observer Proportional (P) Gain 2	0.00~2.55	0.61	-	X	O	X	*1
20-12	Speed Observer Integral(I) Time 2	0.01~10.00	0.06	Sec	X	O	X	*1
20-13	Low-pass Filter Time Constant of Speed Feedback 1	1~1000	4	ms	X	O	X	
20-14	Low-pass Filter Time Constant of Speed Feedback 2	1~1000	30	ms	X	O	X	
20-15	ASR Gain Change Frequency 1	0.0~400.0	4.0	Hz	X	O	O	
20-16	ASR Gain Change Frequency 2	0.0~400.0	8.0	Hz	X	O	O	
20-17	Torque Compensation Gain at Low Speed	0.00~2.50	1.00	-	X	O	X	*1
20-18	Torque Compensation Gain at High Speed	-10~10	0	%	X	O	X	*1
20-33	Constant Speed Detection Level	0.1~5.0	1.0		X	O	O	
20-34	Compensation Gain During Speed Drop	0~25600	0		X	O	X	
20-35	Compensation Time During Speed Drop	0~30000	100	ms	X	O	X	

***: This parameter group is enabled in SLV and PMSLV modes.**

Group 21: Torque Control Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
21-05	Positive Torque Limit	0~160	160	%	X	O	O	
21-06	Negative Torque Limit	0~160	160	%	X	O	O	
21-07	Forward Regenerative Torque Limit	0~160	160	%	X	O	O	
21-08	Reversal Regenerative Torque Limit	0~160	160	%	X	O	O	

<table>
<tr><th colspan="10">Group 22: PM Motor Parameters (PM Control Mode)</th></tr>
<tr><th rowspan="2">Code</th><th rowspan="2">Parameter Name</th><th rowspan="2">Setting Range</th><th rowspan="2">Default</th><th rowspan="2">Unit</th><th colspan="3">Control Mode</th><th rowspan="2">Attribute</th></tr>
<tr><th>V/F</th><th>SLV</th><th>PM SLV</th></tr>
<tr><td>22-00</td><td>Rated Power of PM Motor</td><td>0.00~600.00</td><td>KVA</td><td>kW</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-02</td><td>Rated Current of PM Motor</td><td>0.1~999.9</td><td>KVA</td><td>A</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-03</td><td>Pole Number of PM Motor</td><td>2~96</td><td>6</td><td>poles</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-04</td><td>Rated Rotation Speed of PM Motor</td><td>1~60000
(22-04, 22-06, only need to set one of them, the program will calculate the other.)</td><td>1500</td><td>rpm</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-05</td><td>Maximum Rotation Speed of PM Motor</td><td>1~60000</td><td>1500</td><td>rpm</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-06</td><td>PM Motor Rated Frequency</td><td>0.0~400.0</td><td>75.0</td><td>Hz</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-10</td><td>PM SLV Start Current</td><td>0 ~ 120%
Motor Rated Current</td><td>50</td><td>%</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-11</td><td>DC Injection Current Level</td><td>0 ~ 100%
Motor Rated Current</td><td>40</td><td>%</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-12</td><td>Speed Observer kp Value</td><td>1~10000</td><td>2000</td><td>-</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-13</td><td>Speed Observer kI Value</td><td>1~1024</td><td>40</td><td>-</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-14</td><td>PM Motor stator Resistance</td><td>0.001 ~ 32.767</td><td>1.000</td><td>Ω</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-15</td><td>PM Motor D-axis Inductance</td><td>0.001 ~ 32.767</td><td>1.024</td><td>mH</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-16</td><td>PM Motor Q-axis Inductance</td><td>0.001 ~ 32.767</td><td>1.024</td><td>mH</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-18</td><td>Flux-Weakening Control</td><td>0~100</td><td>0</td><td>%</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-21</td><td>PM Motor Tuning</td><td>0: Disable
1: Enable</td><td>0</td><td>-</td><td>X</td><td>X</td><td>O</td><td></td></tr>
<tr><td>22-22</td><td>Fault History of IPM Motor Tuning</td><td>0. No Error
1~4: Reserved
5: Circuit tuning time out.
6: Reserved
7: Other motor tuning errors
8: Reserved
9: Current Abnormity Occurs while Loop Adjustment.
10: Reserved
11: Stator Resistance Measurement Timeout
12: Reserved</td><td>0</td><td>--</td><td>X</td><td>X</td><td>O</td><td>*4</td></tr>
</table>

Group 23: Pump & HVAC & Compressor Function Parameters

Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
23-00	Function Selection	0: Disable 1: Pump 2: HVAC 3: Compressor	0	-	O	O	O	
23-01	Pump Mode Selection for Single / Multi-Pump system	0: Single Pump 1: Master 2: Slave 1 3: Slave 2 4: Slave 3	0		O	X	X	
23-02	Pump Setpoint	0.01 ~ 650.00	2.00	PSI	O	X	X	
23-03	Maximum Pressure Setting	0.01 ~ 650.00	10.00	PSI	O	X	X	
23-04	Pump Setpoint Source	0: From 23-02/12-74 1: From AI1	0	0	O	X	X	
23-05	Display Mode Selection (LED)	0: Display of Target and Pressure Feedback * 1: Only Display Setpoint 2: Only Display Feedback Pressure	0	%	O	X	X	
23-06	Proportion Gain (P)	0.00~10.00	3.00	-	O	X	X	
23-07	Integral Time (I)	0.0~100.0	7.00	Sec	O	X	X	
23-08	Differential Time (D)	0.00~10.00	0.00	Sec	O	X	X	
23-09	Detection Tolerance of Constant Pressure	0.10 ~ 650.00	0.50	PSI	O	X	X	
23-10	Sleep Frequency of Constant Pressure	0.00 ~ 180.00	30.00	Hz	O	X	X	
23-11	Sleep Time of Constant Pressure	0.0 ~ 255.5	0.0	Sec	O	X	X	
23-12	High Pressure Level	0.00 ~ 650.00	5.00	PSI	O	X	X	
23-13	Warning Time for High Pressure	0.0 ~ 600.0	10.0	Sec	O	X	X	
23-14	Stop Time for High Pressure	0.0 ~ 600.0	20.0	Sec	O	X	X	
23-15	Low Pressure Level	0.00 ~ 650.00	0.50	PSI	O	X	X	
23-16	Warning Time for Low Pressure	0.0 ~ 600.0	10.0	Sec	O	X	X	
23-17	Fault Time for Low Pressure	0.0 ~ 600.0	20.0	Sec	O	X	X	
23-18	Detection Time of Loss Pressure	0.0 ~ 600.0	0.0	Sec	O	X	X	
23-19	Pressure Loss Level	0 ~ 100	0	%	O	X	X	
23-20	Percentage of Pressure Level	0: Pressure Unit Setting 1: Pressure Percentage Setting	0		O	X	X	*9
23-23	Water Usage Detection Function	0: Upward Detection 1: Downward Detection	1	-	O	X X	X X	
23-24	Water Usage Detection Bias	0.0 ~ 65.00	0.1	PSI	O	X	X	
23-25	Water Usage Detection Time	0.0 ~ 200.0	20.0	Sec	O	X	X	
23-26	Acceleration Time of Water Usage Detection	0.1 ~ 6000.0	KVA	Sec	O	X	X	
23-27	Deceleration Time of Water Usage Detection	0.1 ~ 6000.0	KVA	Sec	O	X	X	
23-28	Forced Frequency Command	0.0 ~ 200	0.0	Hz-	O	X	X	

Group 23: Pump & HVAC & Compressor Function Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
23-29	Time of Multi-Pump Switch Over	0 ~ 240	3	Hr	O	X	X	
23-30	Detection Time of Multi-Pump	0.0 ~ 30.0	5.0	Sec	O	X	X	
23-31	Multi-Pump Synchronous Selection	0: Disable 1: Pressure Setpoint and Run/Stop 2: Pressure Setpoint 3: Run/Stop	0		O	X	X	
23-36	Pump Unit Selection	0: PSI 1: inW 3: Bar 4: Pa	0	-	O	X	X	
23-37	Leakage Detection Time	0.0~100.0	0.0	Sec	O	X	X	
23-38	Leakage Detection Variation	0.01~65.00	0.1	PSI	O	X	X	
23-39	Leakage Detection Wake up Level	0.01~65.00	0.5	PSI	O	X	X	
23-41	Local/ Remote Key	0: Disable 1: Enable	1		O	O	O	
23-42	Energy Reset	0: Disable (Energy Accumulating) 1: Enable	0		O	O	O	
23-43	Electricity Price per kWh	0.000 ~ 5.000	0.000	$	O	O	O	
23-44	Pulse Output Selection	0: Disable 1: Unit for 0.1kWh 2: Unit for 1kWh 3: Unit for 10kWh 4: Unit for 100kWh 5: Unit for 1000kWh	0		O	O	O	
23-45	Flow Meter Type	0: Disable 1: Analog Input 2: Pulse Input	1		O	O	O	
23-46	Maximum Rated Flow	1 ~ 50000	10000	GPM	O	O	O	
23-47	HVAC Setpoint	1 ~ 50000	5000	GPM	O	O	O	
23-48	Over Flow Level	0.01 ~ 99.00	80.00	%	O	O	O	
23-49	Warning Time for Over Flow	0.0 ~ 255.0	3.0	Sec	O	O	O	
23-50	Alarm Time for Over Flow	0.0 ~ 255.0	6.0	Sec	O	O	O	
23-51	Low Flow Level	0.01 ~ 99.00	10.00	%	O	O	O	
23-52	Warning Time for Low Flow	0.0 ~ 255.0	3.0	Sec	O	O	O	
23-53	Alarm Time for Low Flow	0.0 ~ 255.0	6.0	Sec	O	O	O	
23-54	Detection Function of Low Suction	0: Disable 1: PID Error 2: Current 3: Current and PID Error	0		O	O	O	
23-55	Detection Time of Low Suction	0 ~ 30.0	10.0	Sec	O	O	O	
23-56	PID Error Level of Low Suction	0 ~ 30	10	%	O	O	O	

Group 23: Pump & HVAC & Compressor Function Parameters								
Code	Parameter Name	Setting Range	Default	Unit	Control Mode			Attribute
					V/F	SLV	PM SLV	
23-57	Current Level of Low Suction(Motor Rated Current)	0 ~ 100	10	%	O	O	O	
23-58	Reaction of Low Suction	0: Disable 1: Warning 2: Fault 3: Fault & Restart	0		O	O	O	
23-59	HVAC Setpoint Source	0: From 23-47/12-77 1: From AI1	0		O	O	O	
23-60	HVAC Unit Selection	0: GPM 1: FPM 3: CFM 4: GPH	0	-	O	X	X	
23-66	Derating of Current Level	10~200	110	%	O	X	X	
23-67	Derating Time	1.0~20.0	10.0	Sec	O	X	X	
23-68	Derating Gain	1~100	90	%	O	X	X	
23-69	OL4 Current Level	10~200	120	%	O	X	X	
23-70	OL4 Delay Time	0~20.0	5.0	Sec	O	X	X	

***Note: With LED keypad, setting of 23-03 needs to be lower than 9.9 PSI in the pump modes; 10-33 is lower than 1000 and 10-34=1 in the PID modes.**

Group 24: Function of 1 to 8 Option Card								
Code	**Parameter Name**	**Setting Range**	**Default**	**Unit**	**Control Mode**			**Attribute**
					V/F	**SLV**	**PM SLV**	
24-00	Function Selection of Relay Card	0: Function of 1 to 8 Relay Card is Disabled 1: Fixed Modes of Inverter Pump: First on and Last off; then Stop All. 2: Fixed Modes of Inverter Pump: Only Stop Inverter Pump. 3: Fixed Modes of Inverter Pump: First on and First Off; then Stop All. 4: Cycle Modes of Inverter Pump: First on and First Off; then Stop All. 5: Cycle Modes of Inverter Pump: Only Stop Inverter Pump. 6: Cycle Modes of Inverter Pump by built-in Relay: First on and First off; then Stop All	0	-	O	O	O	
24-01	Selection of Relay 2-4 Function	xxx0b: Reserved xxx1b: Reserved xx0xb: Relay 2 Disable xx1xb: Relay 2 Enable x0xxb: Relay 3 Disable x1xxb: Relay 3 Enable 0xxxb: Relay 4 Disable 1xxxb: Relay 4 Enable	0000b		O	O	O	
24-02	Selection of Relay 5-8 Function	xxx0b: Relay 5 Disable xxx1b: Relay 5 Enable xx0xb: Relay 6 Disable xx1xb: Relay 6 Enable x0xxb: Relay 7 Disable x1xxb: Relay 7 Enable 0xxxb: Relay 8 Disable 1xxxb: Relay 8 Enable	0000b		O	O	O	
24-03	Detection Time on Fmax (Upper Limit Frequency)	1.0 ~ 600.0	300.0	Sec	O	O	O	*1
24-04	Detection Time on Fmin (Lower Limit Frequency)	1.0 ~ 600.0	300.0	Sec	O	O	O	*1
24-05	Switching Time of Magnetic Contactor	0.1 ~ 20.0	1.00	Sec	O	O	O	*1
24-06	Allowable Bias of Pump Switch	0.0 ~ 20.0	0.0	%	O	O	O	*1
24-07	Pump Control Source Selection	0: Relay Card 1: Control Board (Built-in Relay)	0		O	O	O	

4.3 Description of Parameters

Group 00: Basic Parameters

00-00	Control Mode Selection
Range	【0】: V/F 【1】: Reserved 【2】: SLV 【3】: Reserved 【4】: Reserved 【5】: PMSLV

00-00=0: V/F Mode

Select the required V/F curve (01-00) based on your motor and application.
Perform a stationary auto-tune (17-00=2). If the motor cable length is longer than 50m (165ft), see parameter 17-00 for details.

00-00=2: Sensorless Vector Control

Verify the inverter rating matches the motor rating. Perform rotational auto-tune to measure and store motor parameters for higher performance operation. Perform non-rotational auto-tune if it's not possible to rotate the motor during auto-tune. Refer to parameter group 17 for details on auto-tuning.

00-00=5: PM Sensorless Vector Control

Verify the inverter rating matches the motor rating. Set PM motor data in parameters 22-00 to 22-06. Refer to parameter 22-17 for details on PM Motor tuning. Stall prevention during deceleration is automatically disabled (08-00=xx1xb) when control mode is set to PMSLV. A braking resistor is recommended to be used to prevent the drive from tripping on over voltage due to regenerative energy. A braking module is required for Inverters ratings 230V 30HP, 460V/40HP or greater.
Note: Parameter 00-00 is not affected by drive initialization.

00-01	Motor's Rotation Direction
Range	【0】: Forward 【1】: Reverse

Use the FWD/REV key to change motor direction when Run Command Selection is set to keypad control (00-02 = 0). In keypad control motor direction is set by parameter 00-01. Motor direction is dependent on the motor direction lock selection parameter 11-00.

00-02	Main Run Command Source Selection
00-03	Alternative Run Command Source Selection
Range	【0】: Keypad control 【1】: External terminal control 【2】: Communication control 【3】: PLC 【4】: RTC

Note: To switch the command source between the setting of main (00-02) and alternative (00-03) assign one of the DI (S1 to S6) to be the "Run Command Switch Over" (03-00~03-05=12).

00-02=0: Keypad Control

Use the keypad to start and stop the inverter and set direction with the forward / reverse key. Refer to section 4-1 for details on the keypad.

00-02=1: External Terminal Control

External terminals are used to start and stop the inverter and select motor direction. There are three different types: 2-wire and 3-wire operation and 2-wire self holding (latching) mode.

■ 2-wire operation

For 2-wire operation, set 03-00 (S1 terminal selection) to 0 and 03-01 (S2 terminal selection) to 1

Terminal S1	Terminal S2	Operation
Open	Open	Stop Inverter
Closed	Open	Run Forward
Open	Closed	Run Reverse
Closed	Closed	Stop Inverter, Display EF9 Alarm after 500ms

Parameter 13-08 to 2, 4 or 6 for 2-wire program initialization, multi-function input terminal S1 is set to forward , operation/ stop, and S2 is set for reverse, operation / stop.

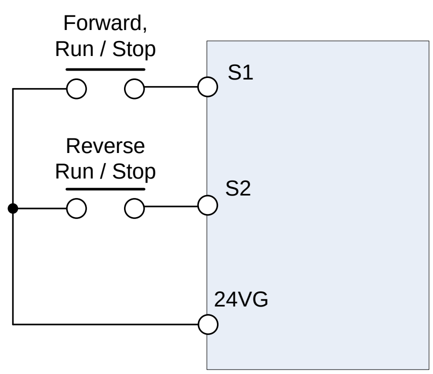


Figure 4.3.1 Wiring example of 2-wire

■ 3-wire operation

For 3-wire operation set any of parameters 03-02 to 03-05 (terminal S3 ~ S6) to 26 to enable 3-wire operation in combination with S1 and S2 terminals set to operation command and stop command.

Parameter 13-08 to 3, 5 or 7 for 3-wire program initialization, multi-function input terminal S1 is set to run operation, S2 for stop operation and S5 for forward/reverse command.

Note: Terminal S1 must be closed for a minimum of 50ms to activate operation.

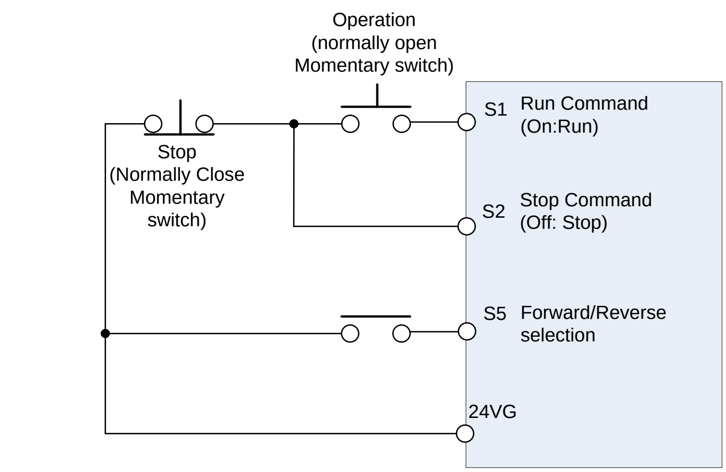


Figure 4.3.2 Wiring example of 3-wire

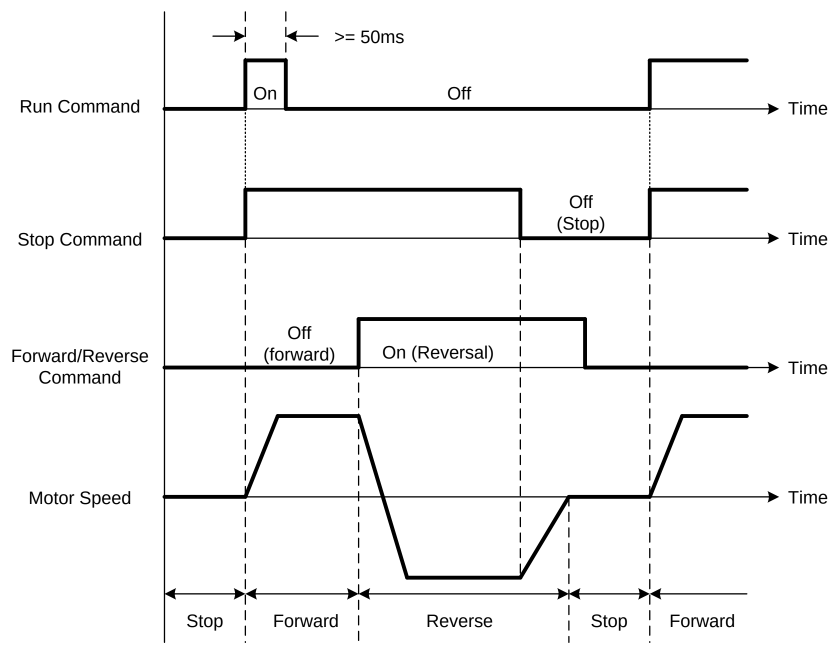
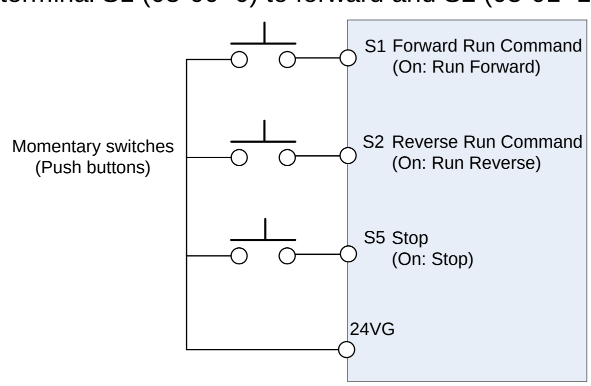


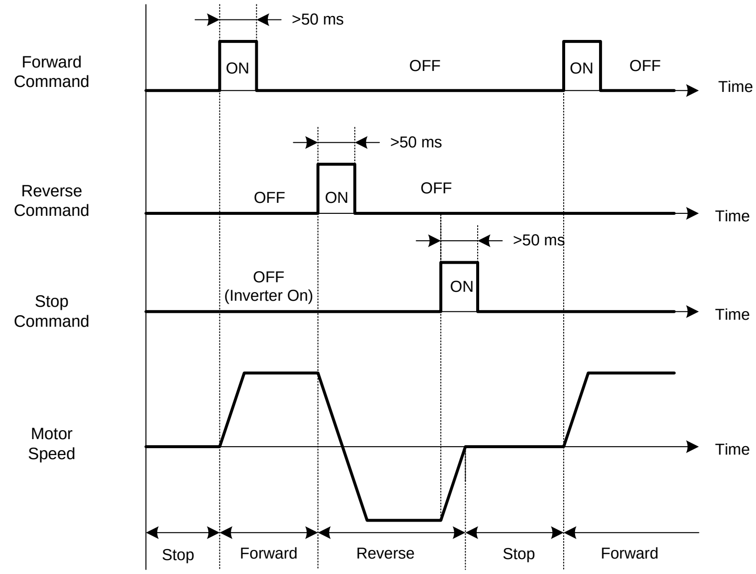
Figure 4.3.3 3-wire operation

■ 2-wire self holding (latching) operation

Set one of parameters, 03-00 to 03-05 (terminal S1 ~ S6), to 53 in order to enable 2-wire self holding operation. After this mode is enabled, set terminal S1 (03-00=0) to forward and S2 (03-01=1) to reverse run command.



Note: Terminal S1, S2 and S5 must be closed for a minimum of 50ms to activate operation. The inverter will display SE2 error when input terminals S1-S6 is set to 53 and 26 simultaneously.



00-03=2: Communication control

The inverter is controlled by the RS-485 port. Refer to parameter group 9 for communication setup.

00-03=3: PLC control

The inverter is controlled by the inverter built-in PLC logic. Refer to section 4.3.

00-03=4: RTC control

The inverter is controlled by RTC timer when run command is set to RTC. Refer to function group 16.

00-04	Language Selection (for LCD only)
Range	【0】: English 【1】: Simple Chinese 【2】: Traditional Chinese

00-05	Main Frequency Command Source Selection
00-06	Alternative Frequency Source Selection
Range	【0】: Keypad 【1】: External control (Analog AI1) 【2】: Terminal UP / DOWN 【3】: Communication control 【4】: Reserved 【5】: Reserved 【6】: RTC 【7】: AI2 Auxiliary frequency

00-05/00-06= 0: Keypad

Use the keypad to enter the frequency reference or by setting parameter 05-01 (frequency reference 1). Note that once the frequency command is switched to alternative frequency reference and 00-06 is set to 0, the frequency can be adjusted using parameter 05-01. Refer to section 4.1.4 for details.

00-05/00-06= 1: External control (Analog Input)

When 04-05=0, give frequency reference command from control circuit terminal AI1 (voltage input). If auxiliary frequency is used, refer to the multi-speed functions.

When frequency reference command is controlled by either AI1 or AI2, the following setup is required:
① 00-05/ 00-06 are set individually to be 1 and 7.
② Set AI2 signal type in 04-00 (AI1 is always 0~10V).
③ Set 04-05=0 (Auxiliary frequency setting).
④ Set multi-function terminal to be 13, then frequency reference command can be switched to AI1 control or AI2 control.

When 04-05=1, frequency reference command from control circuit terminal AI1 (voltage input) or AI2 (current input, set by 04-00).

Use AI1 terminal when voltage input signal is the main frequency reference command.

Use AI2 terminal when current input signal (4-20mA) is the main frequency reference command.

Use analog reference from analog input AI1 or AI2 to set the frequency reference (as shown in Figure 4.3.4). Refer to parameter 04-00 to select the signal type.

	Voltage input	**Current input**	**04-00 Setting (Default = 1)**	**Dipswitch SW2 (Default 'V')**	**Remark** Default 04-05="10"
AI1 – Analog Input 1	0 ~ 10V	------	------	------	------
AI2 – Analog Input 2	0 ~ 10V	------	0: AI2 0~10V	Set to 'V'	Set 04-05="10" (Note)
	-------	4 ~ 20mA	1: AI2 4~20mA	Set to "I"	

Note: Set parameter 04-05 to 10 to add frequency reference AI2 to AI1.

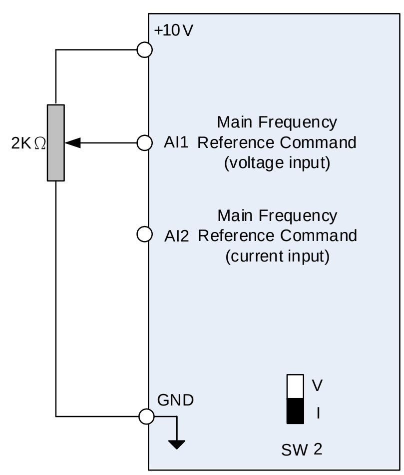


Figure 4.3.4 Analog input as main frequency reference command

00-05/00-06= 2: Terminal UP / DOWN

The inverter accelerates with the UP command closed and decelerates with the DOWN command closed. Please refer to parameter 03-00 ~ 03-05 for additional information.

Note: To use this function both the UP and DOWN command have to be set to any of the input terminals.

00-05/00-06= 3: Communication Control

The frequency reference command is set via the RS-485 communication port using the MODBUS RTU, BACnet or Metasys N2 protocol.

Refer to parameter group 9 for additional information.

00-05/00-06= 6: RTC (Real-time Clock)

Enables RTC control, reference frequency is controlled by the RTC function, refer to parameter group 16 for RTC setup.

00-05/00-06=7: AI2 Auxiliary frequency

When 04-05 is set to 0 (auxiliary frequency), frequency command is set by multi-function analog input AI2. Maximum output frequency (01-02, Fmax) =100%; if 04-05 is not set to 0, the frequency is 0. Refer to page 4-84 for multi-speed operation.

00-07	Main and Alternative Frequency Command Modes
Range	【0】： Main reference frequency 【1】： Main frequency + alternative frequency

When set to 0 the reference frequency is set by the main reference frequency selection of parameter 00-05. When set to 1 the reference frequency is sum of the main reference frequency (00-05) and alternative frequency (00-06).

Note: The inverter will display the SE1 error when 00-07 = 1 and parameter 00-05 and 00-06 are set to the same selection.

When parameter 00-06 is set to 0 (Keypad) the alternative frequency reference is set by parameter 05-01 (Frequency setting of speed-stage 0).

00-08	Communication Frequency Command – READ ONLY
Range	【0.00~400.00】Hz

Display the frequency reference when 00-05 or 00-06 is set to communication control (3).

00-09	Communication Frequency Command Memory
Range	【0】： Do not store the communication frequency command at power down 【1】： Store communication frequency reference at power down

Note: This parameter is only effective when frequency reference is set via communication (00-05 / 00-06 = 3).

00-11	Selection of PID Lower Limit Frequency
Range	【0】: PID minimum frequency is lower limit frequency when inverter sleeps. 【1】: PID minimum frequency is 0Hz when inverter sleeps.

00-11=0: PID minimum frequency is lower limit frequency (00-13).

00-11=1: PID minimum frequency is 0Hz

Note: Refer to parameters 10-17~10-20 for description of the sleep mode function.

00-12	Upper Limit Frequency
Range	【0.1~109.0】%

Set the maximum frequency reference as a percentage of the maximum output frequency. Maximum output frequency depends on motor selection.
Motor 1: Maximum frequency parameter 01-02.
Motor 2: Maximum frequency parameter 01-16.

00-13	Lower Limit Frequency
Range	【0.0~109.0】%

Set the minimum frequency reference as a percentage of the maximum output frequency. Maximum output frequency depends on motor selection. Motor 1: Maximum frequency is set by parameter 01-02 and Motor 2 Maximum frequency is set by parameter 01-16.

Notes:

- When the frequency lower limit is set to a value greater than 0 and the inverter is started the output frequency will accelerate to the frequency lower limit with a minimum frequency defined by parameter 01-08 for motor 1 and parameter 01-22 for motor 2.
- Frequency upper limit has to greater or equal to the frequency lower limit otherwise the inverter will display a SE01 (Set range error).
- Frequency upper and lower limit is active for all frequency reference modes.

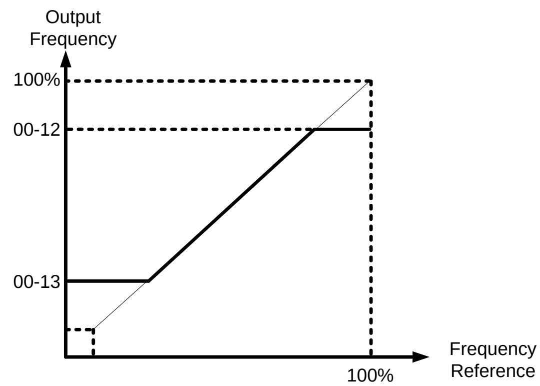


Figure 4.3.5 Frequency reference upper and lower limits

00-14	Acceleration Time 1
Range	【0.1~6000.0】 Sec
00-15	Deceleration Time 1
Range	【0.1~6000.0】 Sec
00-16	Acceleration Time 2
Range	【0.1~6000.0】 Sec
00-17	Deceleration Time 2
Range	【0.1~6000.0】 Sec
00-21	Acceleration Time 3
Range	【0.1~6000.0】 Sec
00-22	Deceleration Time 3
Range	【0.1~6000.0】 Sec
00-23	Acceleration Time 4
Range	【0.1~6000.0】 Sec
00-24	Deceleration Time 4
Range	【0.1~6000.0】 Sec
00-25	Switching Frequency of Acceleration and Deceleration
Range	【0.00~400.00】Hz 【0.0~1200.0】Hz (When 00-31 = 1)

Acceleration time is the time required to accelerate from 0 to 100% of maximum output frequency.
Deceleration time is the time required to decelerate from 100 to 0% of maximum output frequency.
Motor 1: Maximum frequency is set by parameter 01-02 and Motor 2 Maximum frequency is set by parameter 01-16.

Note: Actual acceleration and deceleration times can be affected by the inverter driven load.
The default values for the acceleration, deceleration times are dependent on the inverter size.

Size		Acceleration / Deceleration Default Value
230V Class	460V Class	
5~15HP	5~20HP	10s
20~30HP	25~40HP	15s
40~175HP	50~800HP	20s

A: Select acceleration and deceleration time via the digital input terminals

The following table shows the acceleration / deceleration selected when the digital input function Accel/Decel time 1 (#10) and Accel/Decel time 2 1(#30) are used.

Table 4.3.1 Acceleration / deceleration time selection

Accel/decel time 2 (Set 03-00 ~ 03-05 = 30)	Accel/decel time 1 (Set 03-00 to 03-05 = 10)	Acceleration time	Deceleration time
0	0	Taccc1 (00-14)	Tdec1 (00-15)
0	1	Taccc2 (00-16)	Tdec2 (00-17)
1	0	Taccc3 (00-21)	Tdec3 (00-22)
1	1	Taccc4 (00-23)	Tdec4 (00-24)

0: OFF, 1: ON

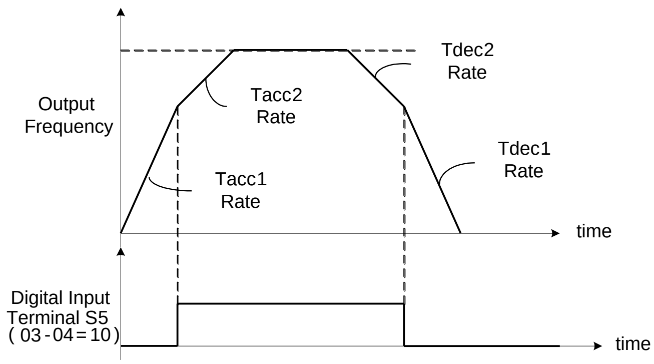


Figure 4.3.6: Terminal S5 switch between Tacc1/Tacc2 and Tdec1/Tdec2

B. Automatically acceleration / deceleration time switch-over based on output frequency

Set acceleration / deceleration switch over frequency parameter 00-25 to a value greater than 0 to automatically switch between Tacc1 (00-14) / Tdec1 (00-23) and Tacc4 (00-24) / Tdec4 (00-15).

Tacc1 (00-14) / Tdec1 (00-23) are active when the output frequency < 00-25 and Tacc4 (00-24) / Tdec4 (00-15) are active when the output frequency >= 00-25. Refer to the Figure 4.3.7 for details.

Note: Multi-function input function #10 (Accel/Decel time 1) and #30 (Accel/Decel time 2) have a higher priority than switch over frequency parameter 00-25.

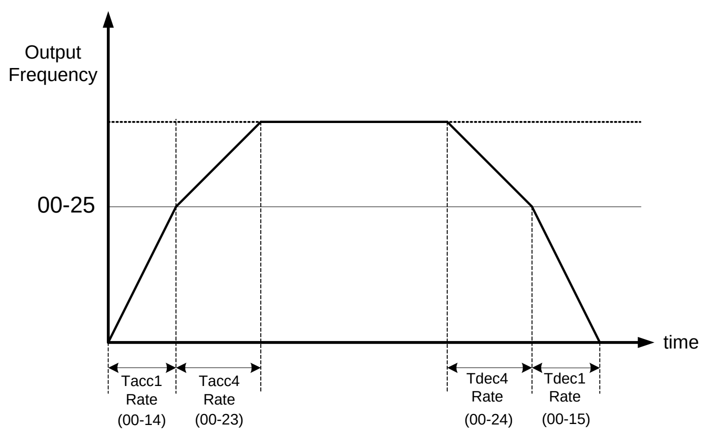


Figure 4.3.7 Automatic acceleration / deceleration time switch-over based on output frequency

00-18	Jog Frequency
Range	【0.00~400.00】Hz 【0.0~1200.0】Hz (When 00-31 = 1)
00-19	**Jog Acceleration Time**
Range	【0.1~0600.0】Sec
00-20	**Jog Deceleration Time**
Range	【0.1~0600.0】Sec

Jog acceleration time (00-19) is the time required to accelerate from 0 to 100% of maximum output frequency. Jog deceleration time (00-20) is the time required to decelerate from 100 to 0% of maximum output frequency. Motor 1: Maximum frequency is set by parameter 01-02 and Motor 2 Maximum frequency is set by parameter 01-16.

The inverter uses the Jog frequency (00-18, default 6.0 Hz) as its frequency reference when jog is active.

00-26	Emergency Stop Time
Range	【0.0~6000.0】 Sec

The emergency stop time is used in combination with multi-function digital input function #14 (Emergency stop). When emergency stop input is activated the inverter will decelerate to a stop using the Emergency stop time (00-26) and display the [EM STOP] condition on the keypad.

Note: To cancel the emergency stop condition the run command has to be removed and emergency stop input deactivated.

Multi-function digital input terminals (03-00 ~ 03-05) are set to 14: When the emergency stop input is activated the inverter will decelerate to a stop using the time set in parameter 00-26.

Note: After an emergency stop command the run command and emergency stop command have to be removed before the inverter can be restarted. Please refer to Figure 4.3.8. The emergency stop function can be used to stop inverter in case of an external event.

Multi-function digital input terminals (03-00 ~ 03-05) set to 15: When the base block input is activated the inverter output will turn off and the motor will coast to a stop.

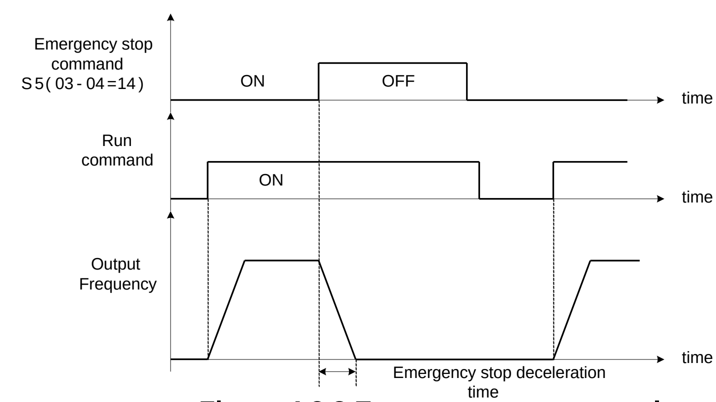


Figure 4.3.8 Emergency stop example

00-28	Selection of Main Frequency Command Characteristic
Range	【0】: Positive characteristic (0~10V/4~20mA = 0~100%) 【1】: Negative / inverse characteristic (0~10V/4~20mA = 100~0%)

00-28= 0: Positive reference curve, 0 – 10V / 4 – 20mA = 0 – 100% main frequency reference.

00-28= 1: Negative reference curve, 0 – 10V / 4 – 20mA = 100 – 0% main frequency reference.

Note: Selection applies to analog input AI1 and AI2.

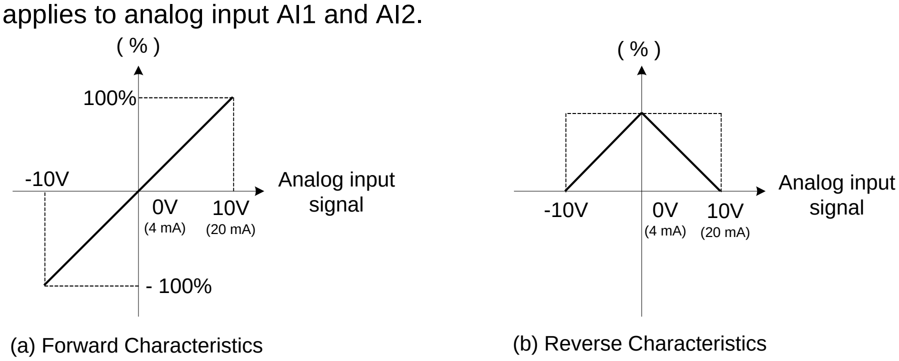


Figure 4.3.9 Positive/negative analog input as main frequency reference command.

00-32	Application
Range	**【0】: Default Value** **【1】: Water supply pump** **【2】: Reserved** **【3】: Exhaust fan** **【4】: HVAC** **【5】: Compressor** **【6】: Reserved** **【7】: Reserved**

Note: If the setting value is changed to 0 (off), it performs 2-wire initialization (60Hz) (200/460V).

(1) Water supply pump

Parameter	Name	Value
00-00	Control mode selection	0 : V/F
11-00	Direction lock selection	1 : Forward direction only
07-00	Momentary stop and restart selection	1 : Enable
08-00	Stall prevention function	xx0xb : Stall prevention is enabled during deceleration
23-00	Function Selection	1: Pump

(3) Exhaust fan

Parameter	Name	Value
00-00	Control mode selection	0 : V/F
11-00	Direction lock selection	1 : Forward direction only
07-00	Momentary stop and restart selection	1 : Enable
08-00	Stall prevention function	xx0xb : Stall prevention is enabled during deceleration

(4) HVAC

Parameter	Name	Value
00-00	Control mode selection	0 : V/F
11-00	Direction lock selection	1 : Forward direction only
11-01	Carrier frequency	8.0kHz
07-00	Momentary stop and restart selection	1 : Enable
11-03	Automatic carrier frequency reduction	1 : Enable
23-00	Function Selection	2: HVAC

(5) Compressor

Parameter	Name	Value
00-00	Control mode selection	0: V/F
11-00	Direction lock selection	1: Forward direction only
00-14	Acceleration time 1	5.0 sec
00-15	Deceleration time 1	5.0 sec
01-07	Middle Output Voltage 1	Half of the maximum voltage
07-00	Momentary stop and restart selection	1: Enable
08-00	Stall prevention function	xx0xb: Stall prevention during deceleration
23-00	Function Selection	3: Compressor

00-33	**Modified Parameters (LCD Keypad Only)**
Range	**【0】: Disable** **【1】: Enable**

This parameter automatically lists all the modified parameters. When set to enable (1), all modified parameter in the advanced mode are shown and can be edited directly. To hide modified parameter overview set parameter 00-33 to 0. This function can display up to 250 modified parameters. If more than 250 parameters are modified only the first 250 will be displayed.

Example: Modify parameter 00-03 (Alternative Run Command Source Selection).

Steps	LCD Display	Descriptions
1	Group 00 Basic Func. 01 V/F Pattern 02 Motor Parameter	The starting parameter group (00) in the setting modes of ▲ (Up)/ ▼ (Down) selection groups.
2	PARA 00 -01. Motor Direction -02. RUN Source -03. Sub RUN Source	Press READ/ ENTER key and ▲ (Up)/ ▼ (Down) to select alternative run command source (00-03).
3	Edit 00-00 Sub RUN Source ▌ Terminal (0 ~4) <2>	Press READ/ ENTER key and adjust the value. The selected setting value will flash.
4	PARA 00 -33. Modify parameter -41. User P1 -42. User P2	Press DSP/ FUN to select modified parameters (00-33).
5	Edit 00-33 Modify parameter ▌ Enable (0 ~1) <0>	Press READ/ ENTER key and value to 1 (Modified parameter overview is enabled.) The selected setting value will flash.
6	Modify 00 00-03. Sub RUN Source 00-33. Modify parameter	Press DSP/ FUN back to the advanced modes.

■ **User Parameter Setting (00-41 ~ 00-56) (LCD Keypad)**

00-41	**User Parameter 0 Function Setting**
00-42	**User Parameter 1 Function Setting**
00-43	**User Parameter 2 Function Setting**
00-44	**User Parameter 3 Function Setting**
00-45	**User Parameter 4 Function Setting**
00-46	**User Parameter 5 Function Setting**
00-47	**User Parameter 6 Function Setting**
00-48	**User Parameter 7 Function Setting**
00-48	**User Parameter 8 Function Setting**
00-50	**User Parameter 9 Function Setting**
00-51	**User Parameter 10 Function Setting**
00-52	**User Parameter 11 Function Setting**
00-53	**User Parameter 12 Function Setting**
00-54	**User Parameter 13 Function Setting**
00-55	**User Parameter 14 Function Setting**
00-56	**User Parameter 15 Function Setting**

- User parameter (00-41 ~ 00-56) can be used to create a custom parameter list. Select up to 16 parameters from parameters 01-00 to 24-06.
- When the parameter 13-06 is set to 1 or 2, the custom parameter list 00-41 ~ 00-56 can be changed.
- The customer parameter list 00-41 ~ 00-56 can only be changed in the advanced modes while the drive is not running.
- To exit the user parameter menu, press RESET key followed by the DSP/FUN key to select parameter Group 13.

Example 1: Set 03-00 (Multi-function terminal Function Setting-S1) to user parameter 0 (00-41)

Steps	LCD Display	Descriptions
1	Group 00 Basic Func. 01 V/F Pattern 02 Motor Parameter	Select the start parameter group (00) in the advanced modes.
2	PARA 00 -41. User P0 -42. User P1 -43. User P2	Press (READ/ ENTER) key and ▲ (Up) / ▼ (Down) to select user parameter 0 (00-41).
3	Edit 00-41 User P0=00-41 00-41 User P0 <00-01 - 24-07>	Press (READ/ ENTER) key to edit parameter 00-41. * The selected setting value will flash.
4	Edit 00-41 User P0=00-41 03-00 S1 Function Sel <00-01 - 24-07>	Press ◄ (Left) / ► (Right) and ▲ (Up) / ▼ (Down) key to select parameter 03-00 (Multi-function terminal Function Setting-S1)
5	Edit 00-41 User P0= 03-00 03-00 S1 Function Sel <00-01 - 24-07>	Press (READ/ ENTER) key to save parameter 00-41 set to 03-00. Digit stops flashing and displays shows **User P0 = 03-00**; (Multi-function terminal Function Setting-S1) has now been added to the user parameter list (00-41).
6	Monitor Freq Ref 12-16=000.00Hz -------------------------------------- 12-17=000.00Hz 12-18=0000.0A	Press (DSP/ FUN) key to the display main screen. If the BACK key is not pressed within one minute, the screen will automatically revert back to the monitor mode as shown here to the left. The time to revert back to the monitor mode can be set with parameter 16-06.

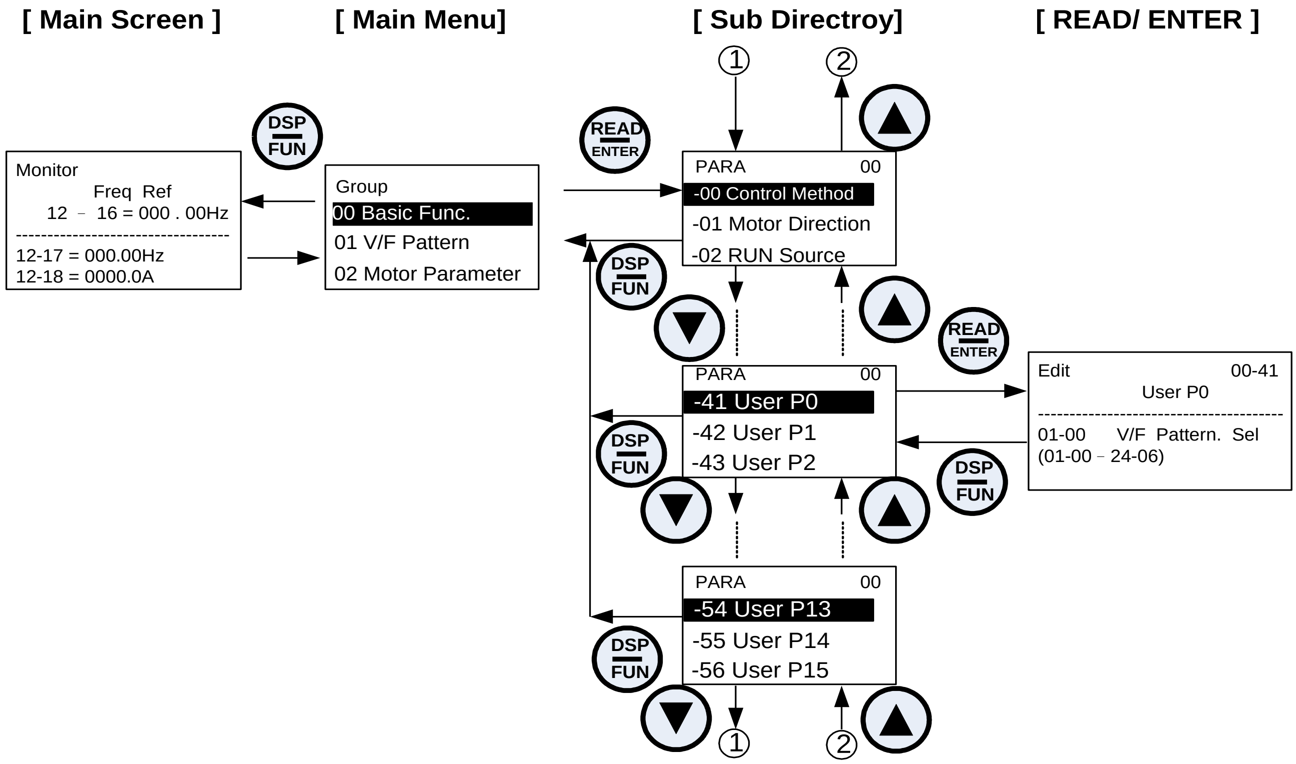
Example 2: After one or more user parameters in 00-41 ~ 00-56 are set, user parameters settings are as follows.

Step	LCD Display	Descriptions
1	Group 13 Driver Status 14 PLC Setting 15 PLC Monitor	Select the start parameter group (03) in the advanced mode.
2	PARA 13 -06. Access Level -07. Password 1 -08. Initialize	Press (READ/ ENTER) and ▲ (Up) / ▼ (Down) key to select access level parameter (13-06).
3	Edit 13-06 Access Level -------------------------------------- 1 User Level (0~2) < 2 >	Press (READ/ ENTER) key to edit access level (13-06). * The selected setting value will flash.
4	─ADV─ G01-02 Access Level 1 User Level (0-2) < 2 >	Press ▲ (Up) / ▼ (Down) key to change setting to 1 (13-06=1, user level) and press (READ/ ENTER) key to save the setting, After 13-06 has been set the digit stops flashing and the screen shows the modified value. A few seconds later, the selected digit will flash again. User level (13-06=1) displays one or more parameters set in the user parameters of 00-41 ~ 00-56. If no user parameters are set, 13-06 cannot be set to a value of 1. When user level is selected only group 00 User functions and group 13 Driver status are available.
5	PARA 13 -06. Access Level	Press (DSP/FUN) key exit edit mode.
6	Group 00.User Function	Press (DSP/FUN) key to go back to the parameter group selection. Use ▲ (Up) key to select Group 00 User Function.
7	Monitor Freq Ref 12-16=000.00Hz -------------------------------------- 12-17=000.00Hz 12-18=0000.0A	Press (DSP/ FUN) key to go back to the main screen. To exit user parameter menu, press RESET key and DSP/FUN key to select parameter Group 13.
8	Group 00. User Function00 U 13.Driver Status	Only parameter 13-06 can be modified together with group 00 to edit user parameters.

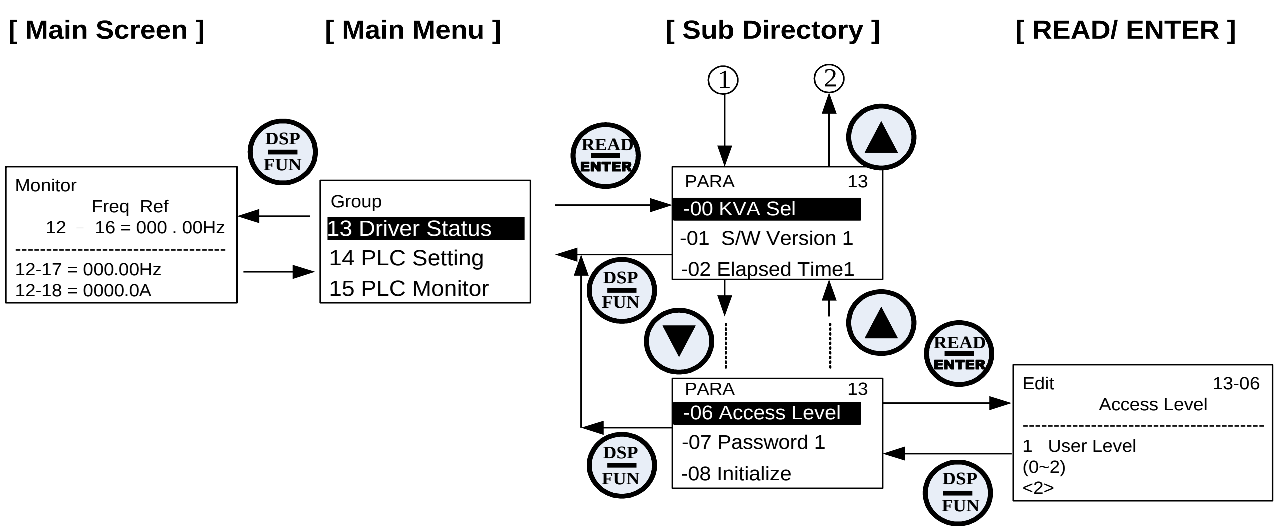
9	PARA 00 -41. S1 Function Sel	Press (READ/ ENTER) key and ▲ (Up) / ▼ (Down) key to select user parameter 0 (00-41) display.
10	Edit 00-41 S1 Function Sel 06 FJOG (00~57) < 00 > < 03-00 >	Press (READ/ ENTER) key to enter edit mode for parameter 00-41. *The selected setting value will flash. In this example, 03-00 (Multi-function terminal Function Setting S1) has been set as a user parameter (00-41). The original parameter group of the user parameter is shown on the display on the bottom right.
11	Edit 00-41 S1 Function Sel 00 2-Wire (FWD-RUN) (00~57) < 00 > < 03-00 >	Press ▲ (Up) / ▼ (Down) key to change the value of parameter 03-00 to 2. Use (READ/ ENTER) key to save the new value to 0041 and 03-00. The new value stops flashing when the new value has been saved successfully.
12	Monitor Freq Ref 12-16=000.00Hz --------------------------------------- 12-17=000.00Hz 12-18=0000.0A	Press (DSP/FUN) key exit to the main screen. If DSP/ FUN key is not pressed within one minute, , the screen will automatically revert back to the monitor mode as shown here to the left. The time to revert back to the monitor mode can be set with parameter 16-06.

User Parameter Run Mode Structure

A. Parameters in Group 0~24 can be set as user parameters except parameter 00-00 and 00-41~00-56.



Note: When 13-06=1 (User level) only parameters defined by the user parameters of 00-41 ~ 00-56 are shown.



Group 01-V/F Control Parameters

01-00	V/F Curve Selection
Range	【0~FF】

The V/F curve selection is enabled for V/F mode. Make sure to set the inverter input voltage parameter 01-14.

There are three ways to set V/F curve:
(1) 01-00 = 0 to E: choose any of the 15 predefined curves (0 to E).
(2) 01-00 = 0F, use 01-02~01-09 and 01-12 ~ 01-13, with voltage limit.
(3) 01-00 = FF: use 01-02~01-09 and 01-12 ~ 01-13, without voltage limit.

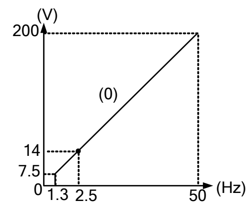
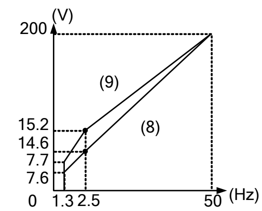
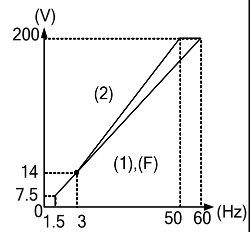
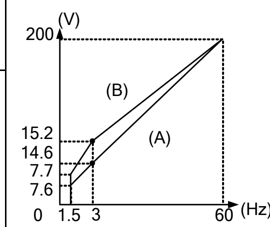
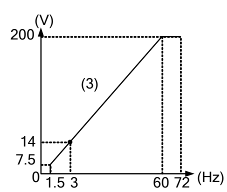
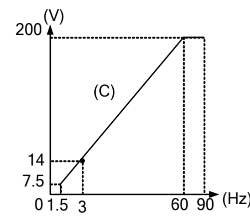
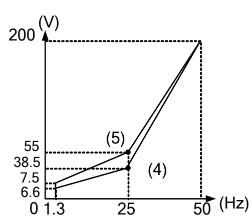
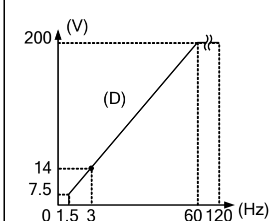
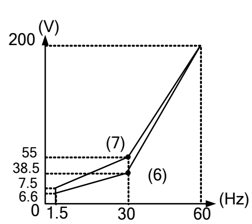
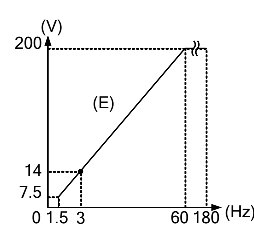
The default parameters (01-02 ~ 01-09 and 01-12 ~ 01-13) are the same when 01-00 is set to F (default) and 01-00 is set to 1.

Parameters 01-02 ~ 01-13 are automatically set when any of the predefined V/F curves are selected.

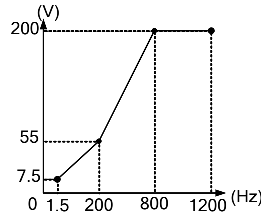
This parameter will be affected to reset by the initialization parameter (13-08).

Consider the following items as the conditions for selecting a V/F pattern.
(1) The voltage and frequency characteristic of motor.
(2) The maximum speed of motor.

Table 4.3.2: 5 - 30HP V/F curve selection

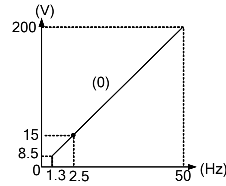
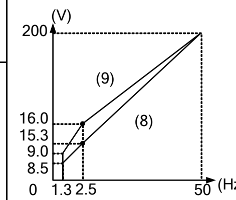
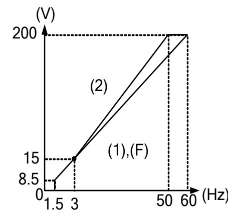
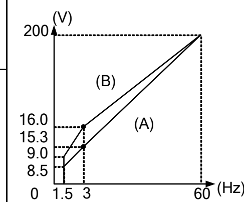
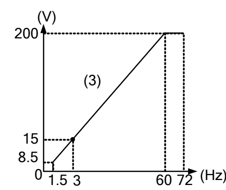
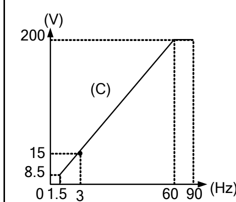
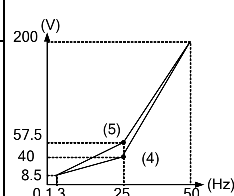
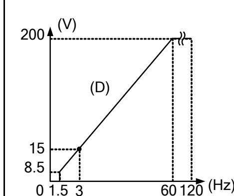
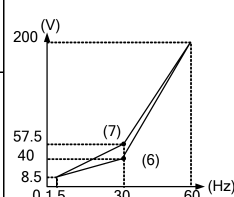
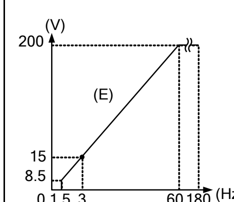
Type	Specification		01-00	V/F curve [*1]	Type	Specification		01-00	V/F [*1]
General purpose	50Hz		0		High Staring Torque‡	50Hz	Low Starting Torque	8	
						50Hz	High Starting Torque	9	
	60Hz	60Hz Saturation	1			60Hz	Low Starting Torque	A	
	60Hz	60Hz Saturation	F						
	60Hz	50Hz Saturation	2			60Hz	High Starting Torque	B	
Variable Torque Characteristic	72Hz		3		Constant-power torque(Reducer)	90Hz		C	
	50Hz	Variable Torque 1	4			120Hz		D	
	50Hz	Variable Torque 2	5						
	60Hz	Variable Torque 3	6 (Def. Val.)			180Hz		E	
	60Hz	Variable Torque 4	7						

‡Select high starting torque only for the following conditions.
(1) The power cable length is > 150m (492ft).
(2) Voltage drop at startup is high.
(3) An AC reactor is used on the input side or output side of the inverter.
(4) Motor power lower than the inverter rated power.

Type	Specification	01-00	V/F curve[*1]
Rated Horsepower Torque (Reducer)	1200Hz	F	

*1. Values shown are for 230V class inverters; double the values for 460V class inverters.

Table 4.3.3: 40HP and above V/F curve selection

Type	Specification		01-00	V/F curve*1	Type	Specification		01-00	V/F curve*1
General purpose	50Hz		0		High Staring Torque‡	50Hz	Low Starting Torque	8	
							High Starting Torque	9	
	60Hz	60Hz Saturation	1			60Hz	Low Starting Torque	A	
			F						
		50Hz Saturation	2				High Starting Torque	B	
Variable Torque Characteristic	72Hz		3		Constant-power torque(Reducer)	90Hz		C	
	50Hz	Variable Torque 1	4			120Hz		D	
		Variable Torque 2	5						
	60Hz	Variable Torque 3	6 (Def. Val.)			180Hz		E	
		Variable Torque 4	7						

*1. Values shown are for 230V class inverters; double the values for 460V class inverters.

‡Select high starting torque only for the following conditions.
(1) The power cable length is > 150m (492ft).
(2) Voltage drop at startup is high.
(3) An AC reactor is used on the input side or output side of the inverter.
(4) Motor power lower than the inverter rated power.

01-02	**Maximum Output Frequency**
Range	**【20.0~400.0】Hz**
01-03	**Maximum Output Voltage**
Range	**230V:【0.1~255.0】V** **460V:【0.2~510.0】V**
01-04	**Middle output frequency 2**
Range	**【0.0~400.0】Hz**
01-05	**Middle Output Voltage 2**
Range	**230V:【0.0~255.0】V** **460V:【0.0~510.0】V**
01-06	**Middle Output Frequency 1**
Range	**【0.0~400.0】Hz**
01-07	**Middle Output Voltage 1**
Range	**230V:【0.0~255.0】V** **460V:【0.0~510.0】V**
01-08	**Minimum Output Frequency**
Range	**【0.0~400.0】Hz**
01-09	**Minimum Output Voltage**
Range	**230V:【0.0~255.0】V** **460V:【0.0~510.0】V**
01-12	**Base Frequency**
Range	**【10.0~400.0】Hz**
01-13	**Base Output Voltage**
Range	**230V:【0.0~255.0】V** **460V:【0.0~510.0】V**

V/F curve setting (01-02 ~ 01-09 and 01-12 ~ 01-13)

Select any of the predefined V/F curves setting ‘0’ to ‘E’ that best matches your application and the load characteristic of your motor, choose a custom curve setting ‘F’ or ‘FF’ to set a custom curve.

Important:

Improper V/F curve selection can result in low motor torque or increased current due to excitation.

For low torque or high speed applications, the motor may overheat. Make sure to provide adequate cooling when operating the motor under these conditions for a longer period of time.

If the automatic torque boost function is enabled (parameter 01-10), the applied motor voltage will automatically change to provide adequate motor torque during start or operating at low frequency.

Custom V/F Curve Setting:

A custom curve selection allows users to set parameters 01-02 ~ 01-13 whereas a predefined curve selection does not.

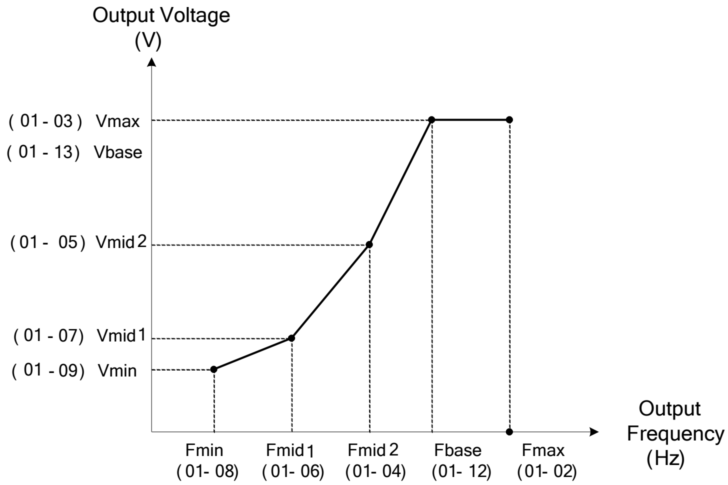


Figure 4.3.10 Custom V/F curve

When setting the frequency related parameters for a custom V/F curve values make sure that:

$$\underset{(01\text{-}02)}{F_{\mathbf{max}}} > \underset{(01\text{-}12)}{F_{\mathbf{base}}} > \underset{(01\text{-}04)}{F_{\mathbf{mid2}}} > \underset{(01\text{-}06)}{F_{\mathbf{mid1}}} > \underset{(01\text{-}08)}{F_{\mathbf{min}}}$$

The ‘SE03’ V/F curve tuning error is displayed when the frequency values are set incorrectly.

When 01-04 and 01-05 (or 01-18 and 01-09) are set to 0, the inverter ignores the set values of Fmin2 and Vmin2.

When the control mode is changed parameter 00-00, 01-08 (F_{min}) and 01-09 (V_{min}) will automatically be changed to the default setting of the selected control mode.

SLV (Sensorless vector control)

Enter the motor data in parameter group 17 for SV and SLV control mode (00-00) and perform auto-tuning.

In the SLV mode the V/F curve normally does not have to be re-adjusted after a successful auto-tune.

The maximum output frequency setting 01-02 (Fmax), base frequency 01-12 (Fbase) or minimum output frequency 01-08 (Fmin) can be adjusted but the voltage is automatically adjusted by the internal current controller.

Set the base frequency (01-12, Fbase) to the motor rated frequency on the motor nameplate.

Perform the auto-tuning procedure after adjusting parameters 02-19 or 17-04 to reduce the voltage at no-load operation.

Motor jitter can be reduced by lowering the no-load voltage. Please note that lowering the no-load voltage increases the current at no-load.

01-10	Torque Compensation Gain
Range	【0.0~2.0】

In V/F mode the inverter automatically adjusts the output voltage to adjust the output torque during start or during load changes based on the calculated loss of motor voltage.

The rate of adjustment can be changed with the torque compensation gain parameter.

Refer to the torque compensation gain adjustment shown in Figure 4.3.11.

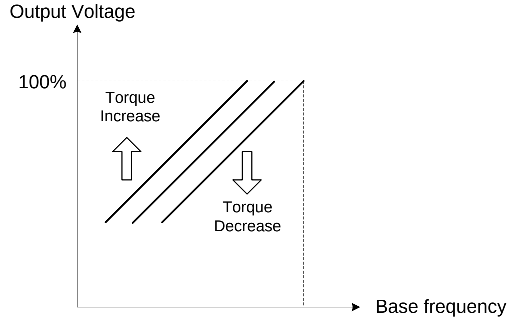


Figure 4.3.11 Torque compensation gain to increase/decrease output torque

Increase value when:

- The wiring between the inverter and the motor is too long
- The motor size is smaller than the inverter size

Note: Gradually increase the torque compensation value and make sure the output current does not exceed inverter rated current.

Reduce value when:

- When experiencing motor vibration

Important:

Confirm that the output current at low speed does not exceed the rated output current of the inverter.

01-11	Selection of Torque Compensation Mode
Range	0: Torque Compensation Mode 0 1: Torque Compensation Mode 1

01-11=0: General torque compensation mode.

01-11=1: High-speed torque compensation mode (120~160Hz).

Torque compensation level decreases when the frequency increases. Compensation for range 0~120Hz is the same as torque compensation mode 0.

01-14	Input Voltage Setting
Range	230V:【155.0~255.0】V 460V:【310.0~510.0】V

Sets the inverter input voltage (E.g. 230V / 208V / 230V / 240V or 380V / 415V / 440V / 460V / 480V).

This parameter is used as a reference for predefined V/F curve calculation (01-00 = 0 to E), over-voltage protection level, stall prevention, etc…

01-15	Torque Compensation Time
Range	【0~10000】ms

Sets the torque compensation delay time in milliseconds.

Only adjust in the following situations:

Increase value when:

- When experiencing motor vibration

Decrease value when:

- When motor torque response is too slow

Group 02: IM Motor Parameter

02-00	**No-load Current**
Range	**【0.01~600.00】A**
02-01	**Rated Current**
Range	**V/F mode is 10%~200% of inverter's rated current. SLV mode is 25%~200% of inverter's rated current.**
02-03	**Rated Rotation Speed**
Range	**【0~60000】rpm**
02-04	**Rated Voltage**
Range	**230V:【50.0~240.0】V** **460V: 【100.0~480.0】V**
02-05	**Rated Power**
Range	**【0.01~600.00】KW**
02-06	**Rated Frequency**
Range	**【10.0~400.0】Hz**
02-07	**Poles**
Range	**【2~16】(Even)**
02-09	**Excitation Current**
Range	**【15.0~70.0】%**
02-10	**Core Saturation Coefficient 1**
Range	**【1~100】%**
02-11	**Core Saturation Coefficient 2**
Range	**【1~100】%**
02-12	**Core Saturation Coefficient 3**
Range	**【80~300】%**
02-13	**Core Loss**
Range	**【0.0~15.0】%**
02-15	**Resistance between Wires**
Range	**【0.001~60.000】Ω**
02-19	**No-Load Voltage**
Range	**230V:【50~240】V** **460V:【100~480】V**
02-33	**Leakage Inductance Ratio**
Range	**【0.1~15.0】%**
02-34	**Slip Frequency**
Range	**【0.1~20.0】Hz**

In most case no adjustment is required after performing an auto-tune except when using the inverter in special applications (e.g. machine tool, positioning, etc…).

Please refer to parameter group 22 for permanent magnet motor parameters.

(1) Number of motor poles (02-07)
Set the number of motor pole according to the motor nameplate.

(2) Motor rated power (02-05)
Set the motor power according to the motor nameplate.

(3) Motor rated current (02-01)
Set the motor rated current according to the motor nameplate.

(4) Motor rated voltage (02-04)
Set the motor rated voltage according to the motor nameplate.

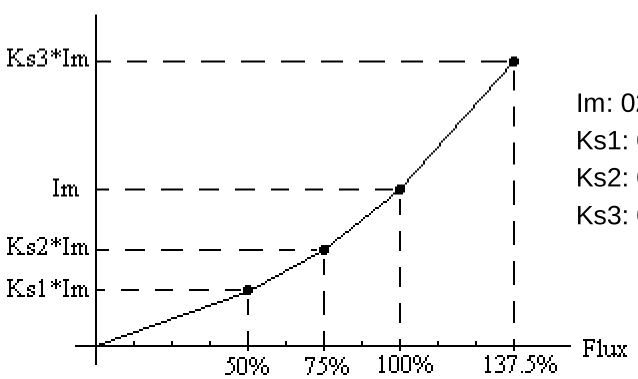
(5) Rated frequency of motor (02-06)
Set the motor rated frequency according to the motor nameplate.

(6) Rated rotation speed of motor (02-03)
Set the motor rpm according to the motor nameplate.

(7) No-load motor voltage (02-19)
Parameter determines the rated flux during motor's rated rotation in SLV control mode. Set the value of this parameter to the same value as parameter 17-08 (02-19 for motor 2). A value of 10~50V below the input voltage level ensures that the motor is capable of providing adequate torque performance when operating at nominal speed (or higher speed). Setting the value to small can result in a reduction in no-load current, weakened motor flux and an increase in motor current while the motor is loaded.

(8) Motor excitation current (02-09)
- This parameter is automatically set via auto-tuning. It required manual adjustment without auto-tuning.
- Start tunig from 33% when doing manual adjustment. If the output value of no-load voltage (12-67) is higher than the setting value of no-load voltage (17-08), the motor excitation current is adjusted downward; if the value (12-67) is lower than the value (17-08), the motor excitation current is adjusted upward.
- Adjust the value of motor excitation current (02-09) will change the value of the motor leakage inductance (02-17) and motor mutual inductance (02-18).

(9) Setting of motor core saturation coefficients 1, 2 and 3 (02-10, 02-11, 02-12)
These parameters are automatically set during auto-tune. No adjustment required. Parameters are set to 50% for 02-10, 75% for 02-11 and 137.5% for 02-12 to reduce the impact of core saturation. The motor core's saturation coefficient is defined as a percentage of the motor excitation current. When the motor flux reaches 137.5% level, the core's saturation coefficient shall be greater than 137.5%. When the motor flux is 50% or 75%, the core's saturation coefficient is required to be less than 50% and 75%.



Im: 02-09 Motor Excitation Current
Ks1: 02-10 Motor Core Saturation Coefficients 1
Ks2: 02-11 Motor Core Saturation Coefficients 2
Ks3: 02-12 Motor Core Saturation Coefficients 3

Figure 4.3.12-a Y-equivalent model of an induction motor

(10) Motor core loss (02-13)
Set motor core loss as the percentage of the motor rated power.

$$\%\,W_{core}\,(02\text{-}13) = \frac{3 \times \text{Motor core loss (watt)}}{\text{Motor rated power (watts, 02-05)}} \times 100\%$$

Note: In V/F mode motor core loss (02-13) is used to for torque compensation.

(11) Motor line to line resistance (02-15)

(12) Motor no-load current (02-00).
Value is calculated based on the motor rated frequency (17-05) and motor rated current (17-03).

In V/F control mode, the output current is greater than the no-load current with slip compensation is enabled.

Note: The value of 02-01 needs to be greater than the value set in parameter 02-00, otherwise warning message "SE01" out of range error will be displayed.

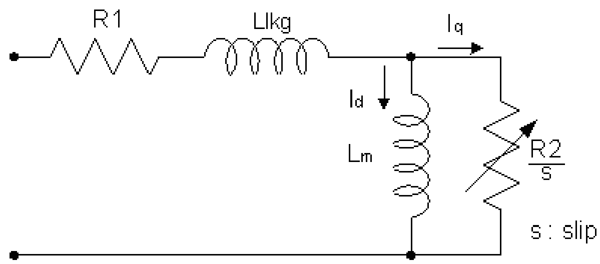


Figure 4.3.12-b Y-equivalent model of an induction motor

(13) Motor Leakage Inductance Ratio (02-33)

- This parameter is set by the conversion of manual adjustment function. This adjustment does not have the magnetic function. Normally, it does not require adjustment.
- Definition of leakage inductance ratio is the ratio of leakage inductance to rotor inductance. If default setting is 3.4%, adjust this ratio changes the parameter of motor leakage inductance. The formula of this ratio is as follows:

$$\xi = \frac{LlKg}{Lr}$$

- When the ratio of leakage inductance is too high or too low, it may cause the motor jittering with different sound and without operation. The general setting range is 3.0%~5.0% and 4.0% is the relatively common value for motor operation normally. The ratio of leakage inductance is adjusted depending on different motor types.

(14) Motor Slip Frequency (02-34)

- This parameter is set by the conversion of manual adjustment function. This adjustment does not have the magnetic function. Normally, it does not require adjustment.
- The default setting is 1Hz and the value of motor slip frequency is obtained from motor nameplate. Take 4-pole motor with 60Hz for example,

Synchronous speed is $N = \frac{120 \times Frequence}{Pole} = \frac{120 \times 60}{4} = 1800$ rpm and the rated speed in the motor nameplate is 1700 rpm, then $Slip = \frac{1800 - 1700}{60} = 1.67Hz$.

Note: Adjusting the motor slip frequency changes the parameter of rotor resistance and the value of slip frequency is adjusted depending on different motor types.

Group 03: External Digital Input and Output Parameters

03-00	Multi-function terminal function setting – S1
03-01	Multi-function terminal function setting – S2
03-02	Multi-function terminal function setting – S3
03-03	Multi-function terminal function setting – S4
03-04	Multi-function terminal function setting – S5
03-05	Multi-function terminal function setting – S6
Range	【0】： 2-Wire Sequence (ON: Forward Run Command) 【1】： 2-Wire Sequence (ON: Reverse Run Command) 【2】： Multi-Speed Setting Command 1 【3】： Multi-Speed Setting Command 2 【4】： Multi-Speed Setting Command 3 【5】： Multi-Speed Setting Command 4 【6】： Forward Jog Run Command 【7】： Reverse Jog Run Command 【8】： UP Frequency Increasing Command 【9】： DOWN Frequency Decreasing Command 【10】： Acceleration/ Deceleration Setting Command 1 【11】： Inhibit Acceleration/ Deceleration Command 【12】： Main/Alternative Run command Switching 【13】： Main/Alternative Frequency Command Switching 【14】： Emergency Stop (Decelerate to Zero and Stop) 【15】： External Baseblock Command (Rotation freely to Stop)*1 【16】： PID Control Disable 【17】： Fault Reset (RESET) 【18】： Reserved 【19】： Speed Search 1(from the maximum frequency)*1 【20】： Manual Energy Saving Function 【21】： PID Integral Reset 【22】~【23】： Reserved 【24】： PLC Input 【25】： External Fault 【26】： 3-Wire Sequence (Forward/ Reverse Command) 【27】： Local/ Remote Selection 【28】： Remote Mode Selection 【29】： Jog Frequency Selection 【30】： Acceleration/ Deceleration Setting Command 2 【31】： Inverter Overheating Warning 【32】： Reserved 【33】： DC Braking*1 【34】： Speed Search 2 (from Frequency Command)*1 【35】： Timing Function Input 【36】： PID Soft Start Disable 【37】~【40】： Reserved 【41】： PID Sleep 【42】~【46】： Reserved 【47】： Fire Mode (Forced to Run Mode) 【48】： KEB Acceleration 【49】： Parameters Writing Allowable

	【50】：Unattended Start Protection (USP) **【51】~【52】：Reserved** **【53】：2-Wire Self Holding Mode (Stop Command)** **【54】：Switch PID1 and PID2** **【55】：RTC Time Enable** **【56】：RTC Offset Enable** **【57】：Forcing Frequency Run** **【58】：Run Permissive Function**

***1: Selections 15, 19, 33, and 34 are not available in PM motor control mode.**

Refer to the multi-function digital input and related parameters in the following Fig. 4.3.13

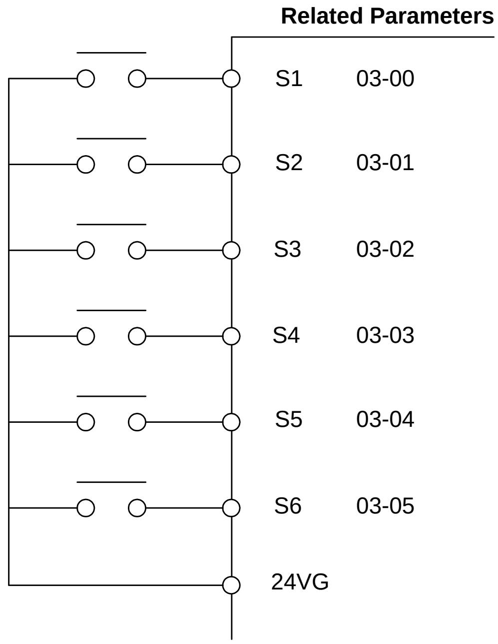


Figure 4.3.13 Multi-function digital input and related parameters

Table 4.3.4 Multi-function digital input setting (03-00 ~ 03-05) ("O": Enable, "X": Disable)

Value	Function		Description	Control mode		
	Name	LCD Display		V/F	SLV	PM SLV
0	2-wire type (Forward operation)	2-Wire (FWD-RUN)	2- wire (ON : Forward operation command).	O	O	O
1	2-wire type (Reverse operation)	2-Wire (REV-RUN)	2- wire (ON : Reverse operation command).	O	O	O
2	Multi-Speed Setting Command 1	Muti-Spd Ref 1	Multi-Speed Reference 1	O	O	O
3	Multi-Speed Setting Command 2	Muti-Spd Ref 2	Multi-Speed Reference 2	O	O	O
4	Multi-Speed Setting Command 3	Muti-Spd Ref 3	Multi-speed Reference 3	O	O	O
5	Multi-Speed Setting Command 4	Muti-Spd Ref 4	Multi-speed Reference 4	O	O	O
6	Forward Jog Run Command	FJOG	ON: Forward operation in jog mode (00-18)	O	O	O
7	Reverse Jog Run Command	RJOG	ON: Reverse operation in jog mode (00-18)	O	O	O
8	UP Frequency Increasing Command	UP command	ON: Command of output frequency increasing (only used by support of DOWN command).	O	O	O
9	DOWN Frequency Decreasing Command	DOWN command	ON: Command of output frequency decreasing (only used by support of UP command).	O	O	O
10	Acceleration/ Deceleration Setting Command 1	Acc/Decel Time Selection 1	Acceleration/deceleration time selection command1	O	O	O
11	Inhibit Acceleration/ Deceleration Command	ACC/DEC Inhibit	ON: Acceleration/deceleration prohibition	O	O	O
12	Main/Alternative Run command Switching	Run Change Sel	Run command source is set by alternative run command (00-03).	O	O	O
13	Main/Alternative Frequency Command Switching	Freq Change Sel	Frequency command source is set by alternative frequency command (00-06).	O	O	O
14	Emergency Stop (Decelerate to Zero and Stop)	E-Stop	ON: Emergency stop input	O	O	O
15	External Baseblock Command (Rotation freely to Stop)	Ext. BB	ON: Inverter base interdiction	O	O	O
16	PID Control Disable	PID Disable	ON: PID control disable	O	O	O
17	Fault Reset	Fault Reset	Fault reset	O	O	O
18	Reserved	Reserved	Reserved	-	-	-
19	Speed Search 1(from the maximum frequency)	Speed Search 1	ON: Search the speed from the maximum output frequency	O	O	O
20	Manual Energy Saving Function	Energy saving	ON: Manual energy saving control is based on the settings of 11-12 and 11-18.	O	X	O
21	PID Integral Reset	PID I-Reset	ON: PID integral value reset	O	O	O
22~23	Reserved	Reserved	Reserved	-	-	-
24	PLC input	PLC Input	ON: Digital PLC input	O	O	O
25	External fault	Ext. Fault	ON: External fault alarm	O	O	O

Value	Function		Description	Control mode		
	Name	LCD Display		V/F	SLV	PM SLV
26	3-Wire Sequence (Forward/ Reverse Command)	3-Wire (FWD/REV)	3-wire control (forward/reverse command). ON: Reverse; OFF: Forward. When the parameter is set to 26，terminal S1 and terminal will become operation command and stop command respectively, and their original functions will be closed.	O	O	O
27	Local/ Remote Selection	Local/Remote	ON: Local mode (via the digital operator) OFF: Frequency command and operation command will be determined according to the setting of parameter (00-02 and 00-05)	O	O	O
28	Remote Mode Selection	Remote Mode Sel	ON: RS-485 communication OFF: Control circuit terminal	O	O	O
29	Jog Frequency Selection	JOG Freq Ref	ON: Selection jog frequency command	O	O	O
30	Acceleration/ Deceleration Setting Command 2	Acc/Decel Time Selection 2	Acceleration/deceleration time selection command2	O	O	O
31	Inverter Overheating Warning (OH2)	Overheat Alarm	ON: Inverter overheat alarm (OH2) input(will display OH2)	O	O	O
32	Reserved	Reserved	Reserved	-	-	-
33	DC Braking	DC Brake Command	ON: Perform DC braking	O	O	O
34	Speed Search 2 (from Frequency Command)	Speed Search 2	ON: Search speed from set frequency	O	O	O
35	Timing Function Input	Timer Input	.Set the time function at 03-33, 03-34 .Set the time function output at 03-11, 03-12	O	O	O
36	PID Soft Start Disable	PID SFS Disable	ON: PID slow-start off	O	O	O
37~40	Reserved	Reserved	Reserved	-	-	-
41	PID Sleep	PID Sleep	ON: PID Sleep	O	O	O
42~46	Reserved	Reserved	Reserved	-	-	-
47	Fire Mode (Forced to Run Mode)	Fire Mode	ON: Turn off hardware and software fault or alarm protection (a special application of HVAC)	O	O	O
48	KEB Acceleration	KEB Accel.	ON: KEB acceleration start	O	X	X
49	Parameters Write-in Allowed	Write Enabled	ON: All parameters are writable. OFF: Except reference frequency (00-05) all parameters are write-protected.	O	O	O
50	Unattended Start Protection (USP)	USP	ON: After power is input，the inverter ignores the operation command OFF: After power is input，the inverter will return the operation status before power is cut off.	O	O	O
51~52	Reserved	Reserved	Reserved	-	-	-
53	2-Wire Self Holding Mode (Stop Command)	2-Wire (STOP)	2-Wire Self Holding Mode (ON: Stop Command).	O	O	O
54	Switch PID1 and PID2	PID 2 Enable	ON: PID1 enabled OFF: PID2 enabled	O	O	O

Value	Function		Description	Control mode		
	Name	LCD Display		V/F	SLV	PM SLV
55	RTC Time Enable	RTC Timer Switch	ON:RTC Time Function Enabled	O	O	O
56	RTC Offset Enable	Offset Time Switch	ON:RTC Offset Enabled	O	O	O
57	Forcing Frequency Run	Force Freq Cmd	ON: Run on Forcing Frequency (23-28) OFF: Determine frequency reference and run command depending on the setting of parameter (00-02 and 00-05)	O	O	O
58	Run Permissive Function	Safety Function	ON: Stop on the setting of 08-30	O	O	O

03-0X =00: 2-wire control: forward operation

03-0X =01: 2-wire control: reverse operation. Refer to the 2-wire operation mode in Figure 4.3.1.

03-0X =02: Multi-speed setting command 1.

03-0X =03: Multi-speed setting command 2.

03-0X =04: Multi-speed setting command 3.

03-0X =05: Multi-speed setting command 4.

03-0X =29: Jog frequency selection (setting =29).

Select frequency reference using the multi-function digital input.

Table 4.3.5 Multi-speed operation selection

Speed	Multi-function digital input (S1 ~ S6) *3					Frequency selection
	Jog frequency reference	Multi-speed frequency 4	Multi-speed frequency 3	Multi-speed frequency 2	Multi-speed frequency 1	
1	0	0	0	0	0	Frequency command 1 (05-01) or main speed frequency*2
2	0	0	0	0	1	Auxiliary speed frequency or frequency reference 2 (06-01)
3	0	0	0	1	0	Frequency command 3 (06-02)
4	0	0	0	1	1	Frequency command 4 (06-03)
5	0	0	1	0	0	Frequency command 5 (06-04)
6	0	0	1	0	1	Frequency command 6 (06-05)
7	0	0	1	1	0	Frequency command 7 (06-06)
8	0	0	1	1	1	Frequency command 8 (06-07)
9	0	1	0	0	0	Frequency command 9 (06-08)
10	0	1	0	0	1	Frequency command 10 (06-09)
11	0	1	0	1	0	Frequency command 11(06-10)
12	0	1	0	1	1	Frequency command 12 (06-11)
13	0	1	1	0	0	Frequency command 13 (06-12)
14	0	1	1	0	1	Frequency command 14(06-13)
15	0	1	1	1	0	Frequency command 15 (06-14)
16	0	1	1	1	1	Frequency command 16 (06-15)
17	1*1	—	—	—	—	Jog frequency command (00-18)

0: OFF, 1: ON, —: Ignore

*1. Jog frequency terminal has a higher priority than multi-speed reference 1 to 4.

*2. When parameter 00-05=0 (frequency reference input = digital operator), multi-speed frequency 1 will be set by 05-01 frequency reference setting1). When parameter 00-05=1 (frequency reference input=control circuit terminal), multi-speed frequency command 1 is input through analog command terminal AI1 or AI2).

*3. Multi-speed operation is disabled when PID is enabled.

Wiring Example: Fig. 4.3.14 and 4.3.15 show an example of a 9-speed operation selection.

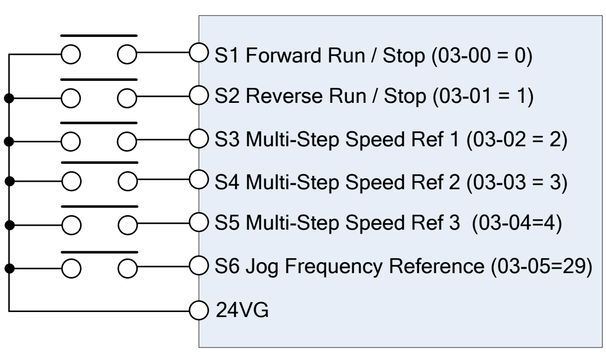


Figure 4.3.14 Control Terminal Wiring Example

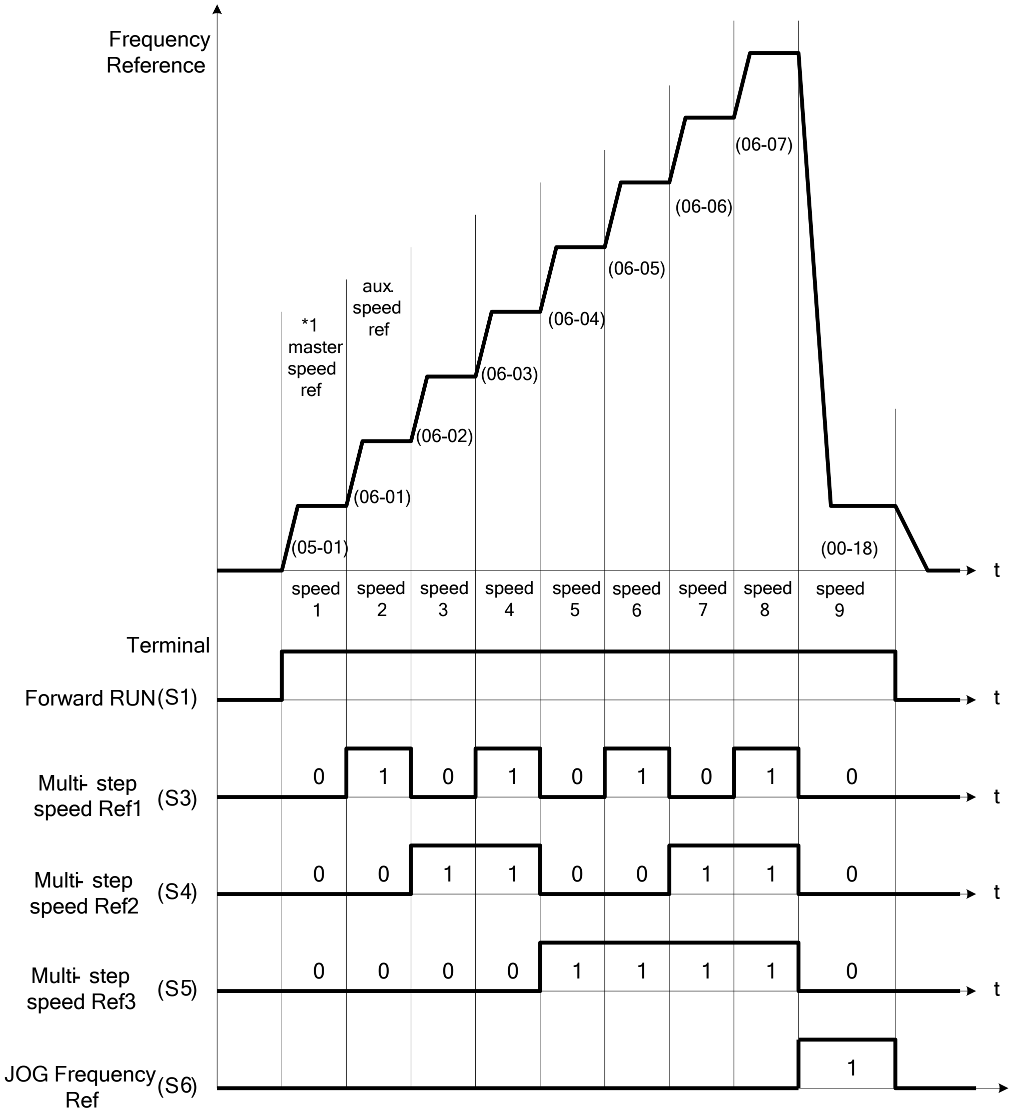


Figure 4.3.15 9-speed timing diagram

*1. When 00-05=1, multi-speed frequency reference is set by analog input AI1 or AI2.

03-0X =06: Forward jog run command, uses jog frequency parameter 00-18.

Notes:
- Jog command has a higher priority than other frequency reference commands.
- Jog command uses stop mode set in parameter 07-09 when Jog command is active > 500ms.

03-0X =07: Reverse jog run command, uses jog frequency parameter 00-18.

Notes:
- Jog command has a higher priority than other frequency reference commands.
- Jog command uses stop mode set in parameter 07-09 when Jog command is active > 500ms.

03-0X =08: UP frequency command; set parameter 00-05 Frequency command to 2 to activate. Refer to parameter 11-56 for UP/DOWN mode.

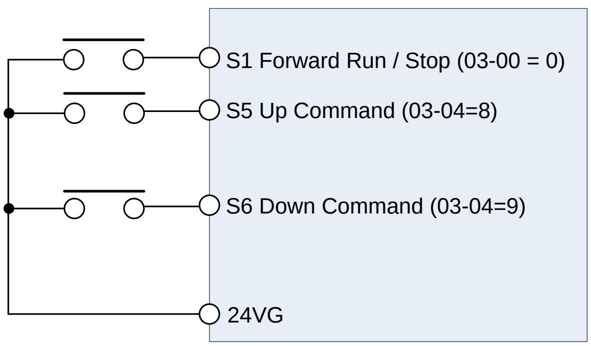
03-0X =09: Down frequency command; set parameter 00-05 Frequency command to 2 to activate. Refer to parameter 11-56 for UP/DOWN mode.

Note: UP/DOWN frequency command follows standard acceleration and deceleration times Tacc1 / Tdec1 (00-14, 00-15) or Tacc2 / Tdec 2 (00-16, 00-17) and requires both UP and DOWN functions 08 and 09 to be programmed to the digital input terminals.

Note: SE02 DI terminal Error will be displayed when:

- When only the UP or DOWN command function is programmed to the digital inputs.
- When both UP and DOWN command are activated simultaneously.

For the examples of UP/DOWN control wiring and operation, please refer to Figure 4.3.16 and 4.3.17.



UP Command (Terminal S5)	1	0	0	1
Down Command (Terminal S6)	0	1	0	1
Operation	Accel (UP)	Decel (DWN)	Hold	Hold

Figure 4.3.16 UP/DOWN wiring and operation example

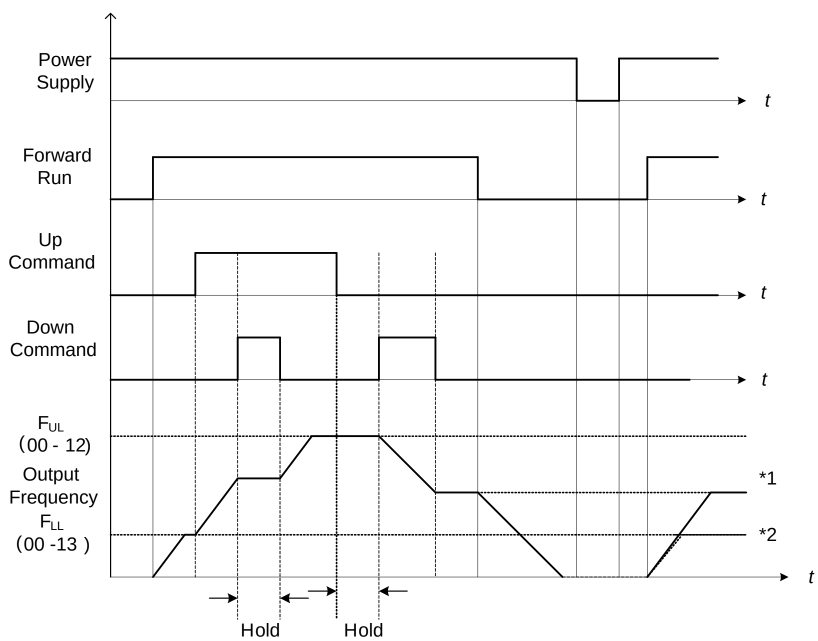


Figure 4.3.17 Up / Down command timing diagram

UP / DOWN Command Operation

When the Forward Run command is active and the UP or Down command is momentarily activated the inverter will accelerate the motor up to the lower limit of the frequency reference (00-13).

When using the UP / Down command, the output frequency is limited to the upper limit of frequency reference (00-12) and the lower limit of frequency reference (00-13).

The UP / DOWN command uses acceleration 1 or 2 / deceleration time 1 or 2 for normal operation Tacc1 / Tdec1 (00-14, 00-15) or Tacc2 / Tdec 2 (00-16, 00-17).

Refer to 03-40 UP/ DOWN frequency width setting for using other functions of UP/ DOWN.

Frequency reference retention is active when parameter 11-58 is set to 1 and the frequency reference is saved when power is lost and retrieved when power is restored.

(1). When 11-58 = 1 and the operation command is active, the output frequency will accelerate to the previously stored frequency command.
(2). When 11-58 = 0 and the operation command is active, the output frequency will accelerate to the lower limit of frequency reference (00-13).

03-0X =10: Acceleration/deceleration 1 selection

03-0X =30: Acceleration/deceleration 2 selection
Refer to the "multi-function digital input terminals select acceleration/ deceleration time” in Table 4.3.1 and Figure 4.3.6.

03-0X =11: Inhibit acceleration/deceleration command (hold command)

When activated suspends the acceleration / deceleration operation and maintains the output frequency at current level.

If 11-58 = 1, the frequency reference value is saved when the acceleration/deceleration inhibit command is active. Deactivating the acceleration / deceleration inhibit command resumes acceleration / deceleration.

If 11-58 = 1, the frequency reference value is saved when the acceleration/deceleration inhibit command is active and even when powering down the inverter.

Refer to Fig.4.3.18. for example.

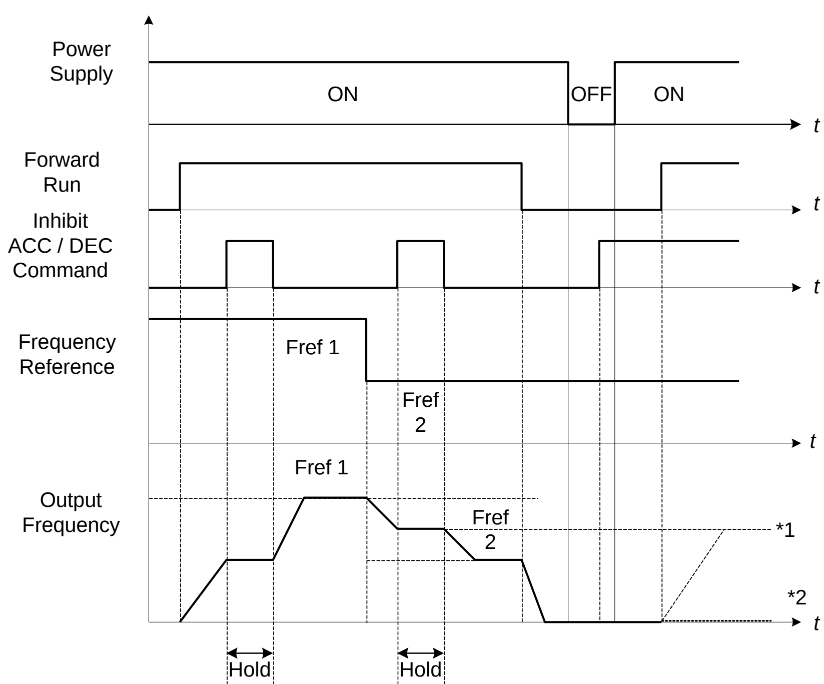


Figure 4.3.18 Inhibit acceleration / deceleration command operation

*1. When 11-58 = 1, and acceleration / deceleration inhibit command is activated, the frequency reference is stored even when powering down the inverter. When a run command is given (e.g. run forward) and the acceleration / deceleration inhibit command is active, the inverter will accelerate to the previously stored frequency reference.

*2. When 11-58 = 0, and a run command is and the acceleration / deceleration inhibit command is active, the frequency reference and output frequency will remain at zero.

03-0X =12: Main/Alternative Run command Switching

Run command source is set by alternative run command (00-03) when function terminal is active. When function terminal is set to 27 (Local/ Remote control selection), the priority will higher than the switch of main/ alternative run command.

03-0X =13: Main/Alternative Frequency Command Switching
Frequency command source is set by alternative frequency command (00-06) when function terminal is active. When function terminal is set to 27 (Local/ Remote control selection), the priority will higher than the switch of main/ alternative frequency command.

03-0X =14: Emergency stop (decelerate to zero and stop)
Refer to the "deceleration time of emergency stop" of parameter 00-26.

03-0X =15: External Baseblock Command (coast to stop)
Execute the base block command by the use of ON / OFF way of multi-function digital input terminal, and prohibit the inverter output.

During run: When an external base block command is activated, the keypad displays "BBn BaseBlock (Sn)", indicating the inverter output is turned off (n indicates the digital input number 1 – 6). Upon removing the base block signal, the motor will run at the frequency reference. If speed search from frequency reference is active the inverter output frequency starts from the frequency reference and searches for the coasting motor speed and continue to operate. If speed search is not active the output frequency starts at 0Hz.

During deceleration: When an external base block command is activated, the keypad displays "BBn BaseBlock (Sn)", indicating the inverter output is turned off (n indicates the digital input number 1 – 6). Upon removing the base block signal, the motor is stopped or will coast to a stop and the inverter will remains in the stop condition.

During acceleration: When an external base block command is activated, the keypad displays "BBn BaseBlock (Sn)", indicating the inverter output is turned off (n indicates the digital input number 1 – 6). Upon removing the base block signal, the motor will run at the frequency reference. If speed search from frequency reference is active the inverter output frequency starts from the frequency reference and searches for the coasting motor speed and continue to operate. If speed search is not active the output frequency starts at 0Hz.

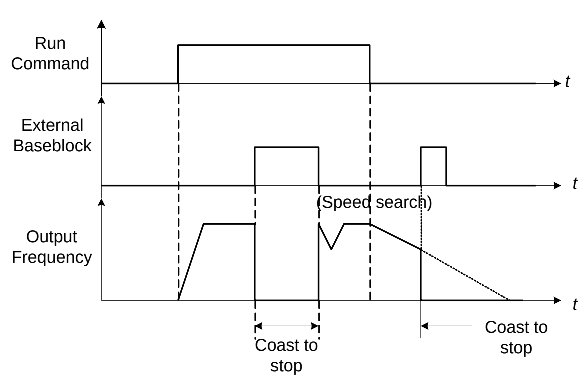


Figure 4.3.19 External base block operation

03-0X =16: PID control disable.

03-0X =17: Fault reset

The output becomes active when the inverter trips on a fault. Upon an inverter fault the inverter output will turn off (base block) and the keypad displays the dedicated fault message.

When fault occurs, the following actions can be used to reset the fault:

1. Program one of the multi-function digital inputs (03-00 to 03-05) to 17 (reset fault) and active input.*****
2. Press the reset key of the digital operator (RESET).*****
3. Recycle power to the inverter. ***Important Note:*** If a run command is active during power-up, the inverter will start running automatically.

***** To reset an active fault the run command has to be removed.

03-0X =19: Speed Search 1 (from the maximum frequency).

03-0X =34: Speed Search 2 (from the frequency command).

Refer to the "speed search" function in the parameter group 7 (start/ stop control function).

03-0X =20: Energy saving enabled
Manual energy savings function is set with parameters 11-12 and 11-18.
For the manual energy saving operation refer to Figure 4.3.78.

03-0X =21: PID integral reset

03-0X =25: External fault

Activating the external fault input will turn off the inverter output and the motor will coast to a stop. The keypad displays the external fault message "EFn Ext. Fault (Sn)", where n is the input terminal number.

03-0X =27: Local / Remote control selection.
Switch between Local (keypad) or Remote (control circuit terminals or RS485) frequency reference. Use parameter 00-05 (Main frequency command source selection) and 00-02 (Run command selection) to select the input source. When PID is enabled (10-03=XXX1), parameter 10-00 (target value source) is used. If 23-00=1, make sure to set the value of parameter 23-04. If 23-00=2, make sure to set the value of parameter 00-02 and 23-59.

Note: In 3-wire operation terminal S1 and S2 are reserved for run/stop operation and the Local / Remote function can only be set to digital input terminals S3 to S6 (03-02 to 03-05).

Note: To switch between local and remote the inverter has to be stopped.

Input	Mode	Frequency Reference / Run/Stop Command Source
ON	Local	- Frequency reference and Run-Stop from keypad. - LEDs SEQ and REF are off. - When PID is enabled, REF indicator OFF, PID target value is set by the keypad.
OFF	Remote	- Frequency reference source selected by parameter 00-05 and Run-Stop source selected by parameter 00-02. - LEDs SEQ and REF are on. - When PID is enabled, REF indicator ON, PID target value is set by control terminal AI1.

03-0X =28: Remote mode selection

Switch between terminal source and communication (RS-422/RS-485) source for frequency reference and operation command.

In Remote mode, indicators of SEQ and REF are on; Use terminals AI1 and AI2 to control the frequency command and terminals S1, S2 or communication terminal RS-485 to control the operation command.

Input	Mode	Frequency Reference / Run/Stop Command Source
ON	Communication	- Frequency reference and run/stop command control via communication (RS-422/RS-485).
OFF	Terminal	- Frequency reference source from AI1 / AI2 input (00-05=1) and Run-Stop command from terminals S1 / S2 (00-02=1).

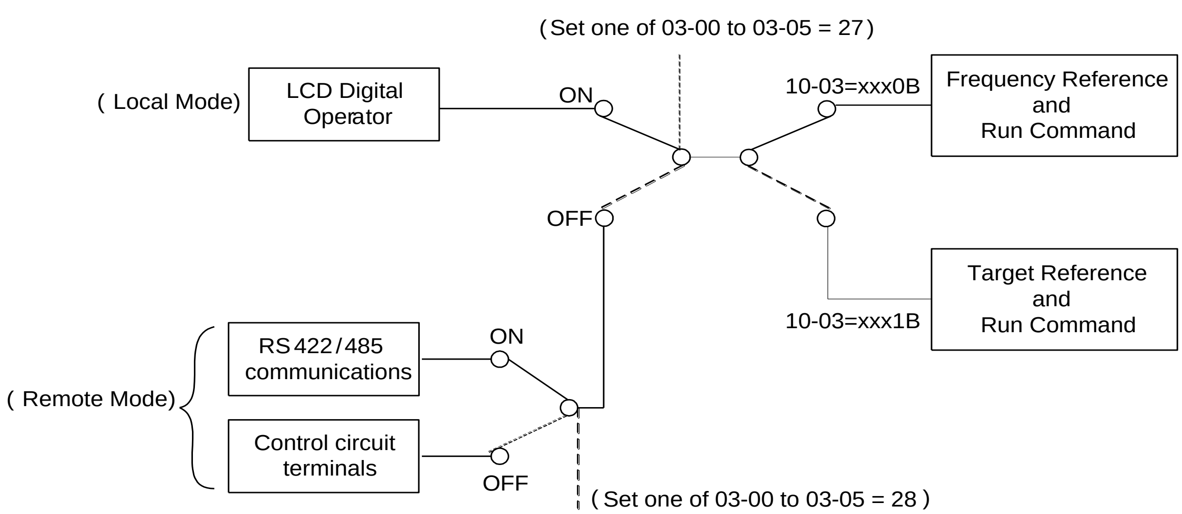


Figure 4.3.20 Remote mode operation selection

To switch the frequency reference and operation command input between communication RS-485 and control terminals the following parameters have to be set:

1. 00-05=1 (use control terminal AI1 or AI2 as reference frequency source)
2. 00-02=1 (use control terminal S1 or S2 for operation command)
3. Set one of the digital input terminals (03-02 to 03-05) to 28 (Operation selection of remote mode)

03-0X =24: PLC Input

Input is used for the PLC ladder logic. Ladder diagram can be modified using the F510 TECO Link software.

03-0X =26: 3-Wire Sequence (Forward/ Reverse Command)

When the digital input terminals (S3~S6) is set to 26, terminal S1 and S2 will become the run command and stop command. Refer to Fig.4.3.2.

03-0X =29: Jog Frequency Selection

When 00-18 (Jog Frequency) is set up, the inverter depends on this frequency for command when it is ON.

03-0X =30: Acceleration/ Deceleration Setting Command 2

When it is ON, the inverter will be active depends on the acceleration time 2 of 00-16 and deceleration time 2 of 00-17.

03-0X =31: Inverter overheat warning

When input is active the inverter displays warning message "OH2" and continues operation. Deactivating the input reverts back to the original display. Warning message does not require resetting the inverter.

03-0X =33: DC braking

When input is active DC-Injection braking is enabled during start and stopping of the inverter.
DC Injection braking is disabled when a run or jog command is active. Refer to the DC braking time diagram in Fig.4.3.21.

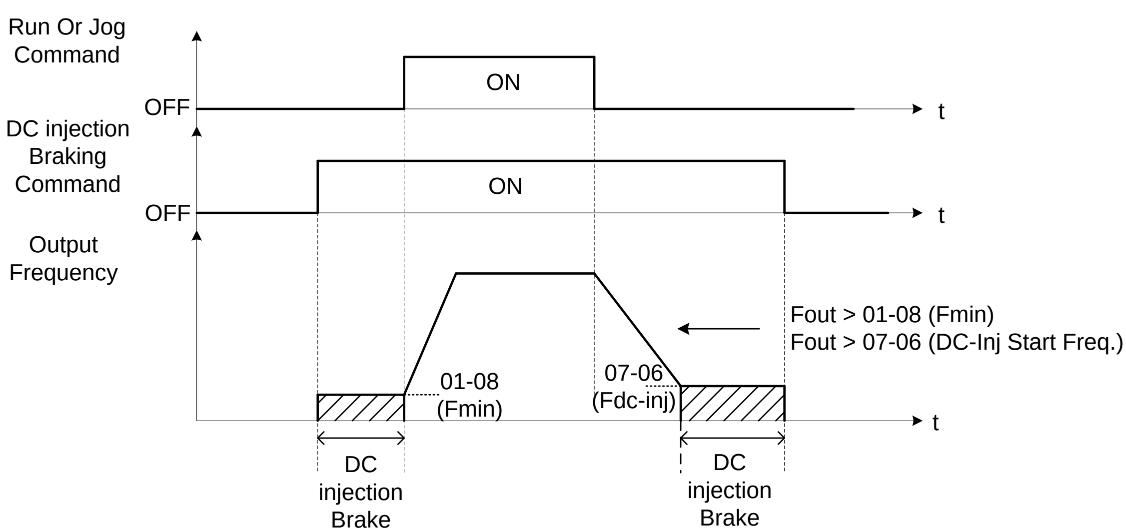


Figure 4.3.21 DC braking timing diagram

03-0X =35: Timing function
Refer to the "time function" parameter 03-37 and 03-38.

03-0X =36: PID Soft start disable
Refer to the "PID Control" function of PID function parameter group 10.

03-0X =47: Fire mode (Forced operation mode)
When input is active the inverter disables all warnings and hardware protection except SC. This function is commonly used in commercial applications where the inverter controls an exhaust fan and needs run until destruction in case of a fire.

03-0X =48: KEB acceleration
When input is active enables KEB (Kinetic Energy Braking) during acceleration. Refer to the parameter description of 11-47 and 11-48. Note: To enable set parameter 11-47 to a value greater than 0.

03-0X =49: Parameters write-in allowed
When input is active allows parameter to be changed.

Note: When none of the digital input terminals are set to function 49, parameter write-in protection is controlled by parameter 13-06.

Input	Parameter Save
ON	Parameters Write Enabled
OFF	Parameters Write Protected

03-0X =50: Unattended Start Protection (USP)

When input is active prevents inverter from starting automatically when a run command is present at time of power-up. Please refer to Fig.4.3.21a for more details.

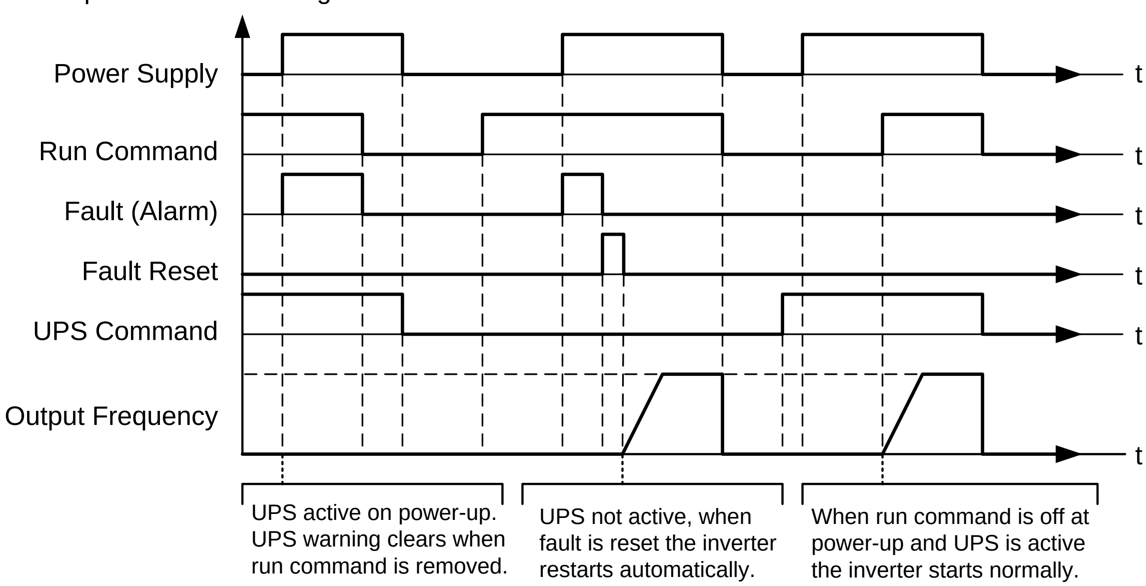


Figure 4.3.21a Unattended Start Protection

03-0X =53: 2-Wire Self Holding Mode (Stop Command).

Refer to the “2-wire operation with hold function” of parameter 00-02.

03-0X =54: Switch PID1 and PID2
Switch PID1 to PID2 when PID2 is active.

03-0X =55: RTC Time Enable

When input is active, enable RTC Timer.

Note: Parameter 16-13 (RTC timer function) has to be set to 2 (DI setting) for this input function to work.

03-0X =56: RTC Offset Enable

When input is active enables RTC Timer Offset set by parameter 16-31.

Note: Parameter 16-30 (RTC timer function) has to be set to 2 (DI setting) for this input function to work.

03-0X =57: Forced Frequency Run

When input is active and PID (10-03) is enabled forces the drive to run at a frequency reference set by parameter 23-28. This function is can be used for feedback loss detection.

03-0X =58: Run Permissive Function

When input is active, inverter will stop using the stop mode set in parameter 08-30.

03-08	(S1~S6) DI Scan Time
Range	【0】 Scan Time 4ms 【1】 Scan Time 8ms

Set the digital input CPU scan time. The digital input signal needs to be present for the minimum scan time to qualify as an enabled command.

Note: For noisy environments select scan time of 8ms (results in a slower response time).

03-09	Multi-function Terminal S1-S4 Type Selection
Range	【xxx0b】: S1 A contact 【xxx1b】: S1 B contact 【xx0xb】: S2 A contact 【xx1xb】: S2 B contact 【x0xxb】: S3 A contact 【x1xxb】: S3 B contact 【0xxxb】: S4 A contact 【1xxxb】: S4 B contact

03-10	Multi-function Terminal S5-S6 Type Selection
Range	【xxx0b】: S5 A contact 【xxx1b】: S5 B contact 【xx0xb】: S6 A contact 【xx1xb】: S6 B contact

Parameter 03-09 and 03-10 selects the digital input type between a normally open and a normally closed switch/contact.

Each bit of 03-09/03-10 presents an input：

03-09=	**<u>0</u>**	**<u>0</u>**	**<u>0</u>**	**<u>0</u>**	**0**：normally open switch
	s4	**s3**	**s2**	**s1**	**1**：normally closed switch
03-10=	**<u>x</u>**	**<u>x</u>**	**<u>0</u>**	**<u>0</u>**	**0**：normally open switch
			s6	**s5**	**1**：normally closed switch

Example: S1 and S2 wired to a normally closed contact / switch set 03-09=0011.

Do not set the operation command parameter 00-02 to terminal control before setting the digital input type. Failure to comply may cause death or serious injury.

03-11	**Relay (R1A-R1C) Output**
03-12	**Relay (R2A-R2C) Output**
03-39	**Relay (R3A-R3C) Output**
Range	**【0】：During Running** **【1】：Fault Contact Output** **【2】：Frequency Agree** **【3】：Setting Frequency Agree (03-13±03-14)** **【4】：Frequency Detection 1** **(> 03-13, Hysteresis interval is the setting value of 03-14)** **【5】：Frequency Detection 2** **(< 03-13, Hysteresis interval is the setting value of 03-14)** **【6】：Automatic Restart** **【7】~【8】：Reserved** **【9】：Baseblock** **【10】~【11】：Reserved** **【12】：Over-Torque Detection** **【13】：Current Agree** **【14】~【17】：Reserved** **【18】：PLC Status** **【19】：PLC Control** **【20】：Zero Speed** **【21】：Inverter Ready** **【22】：Undervoltage Detection** **【23】：Source of Operation Command** **【24】：Source of Frequency Command** **【25】：Low Torque Detection** **【26】：Frequency Reference Missing** **【27】：Timing Function Output** **【28】~【31】：Reserved** **【32】：Communication Control Contacts** **【33】：RTC Timer 1** **【34】：RTC Timer 2** **【35】：RTC Timer 3** **【36】：RTC Timer 4** **【37】：Detection Output of PID Feedback Loss** **【38】：Brake Release**

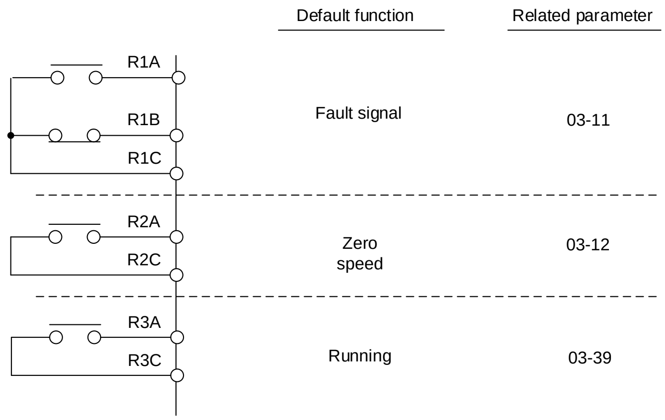


Figure 4.3.22 Multi-function digital output and related parameters

Table 4.3.6 Description of multi-function digital output

Value	Function		Description	Control Mode		
	Name	LCD Display		V/F	SLV	PM SLV
0	During Running	Running	ON: During running (Run Command is ON)	O	O	O
1	Fault Contact Output	Fault	ON: Fault contact output (except CF00 and CF01)	O	O	O
2	Frequency Agree	Freq. Agree	ON: Frequency agree (frequency agree width detection is set by 03-14)	O	O	O
3	Setting Frequency Agree	Setting Freq Agree	ON: Output frequency = allowed frequency detection level (03-13) ± frequency bandwidth (03-14)	O	O	O
4	Frequency Detection 1	Freq. Detect 1	ON: Output frequency > 03-13, Hysteresis interval is the setting value of 03-14 ON: Output frequency> 03-13, Hysteresis interval is the setting value of 03-14	O	O	O
5	Frequency Detection 2	Freq. Detect 2	OFF: During acceleration: Output frequency >= 03-13 + 03-14 ON: During deceleration: Output frequency < 03-13	O	O	O
6	Automatic Restart	Auto Restart	ON: the period of automatic restart	O	O	O
7~8	Reserved	Reserved	Reserved	-	-	-
9	Baseblock	Baseblock	ON: During baseblock	O	O	O
10~11	Reserved	Reserved	Reserved	-	-	-
12	Over-Torque Detection	Over Torque	ON: Over torque detection is ON	O	O	O
13	Current Agree	Current Agree	ON: Output current > 03-15	O	O	O
14~17	Reserved	Reserved	Reserved	-	-	-
18	PLC Status	PLC statement	ON: when 00-02 is set to 3 (PLC operation command source)	O	O	O
19	PLC Control	Control From PLC	ON: Control from PLC	O	O	O

Value	Function		Description	Control Mode		
	Name	LCD Display		V/F	SLV	PM SLV
20	Zero Speed	Zero Speed	ON: Output frequency < Minimum output frequency (Fmin)	O	O	O
21	Inverter Ready	Ready	ON: Inverter ready (after power on, no faults)	O	O	O
22	Undervoltage Detection	Low Volt Detected	ON: DC bus voltage = < Low-voltage warning detection level (07-13)	O	O	O
23	Source of Operation Command	Run Cmd Status	ON: Operation command from LED digital operator (local mode)	O	O	O
24	Source of Frequency Command	Freq Ref Status	ON: Reference frequency from LED digital operator (local mode)	O	O	O
25	Low Torque Detection	Under Torque	ON: Low-torque detection is ON	O	O	O
26	Frequency Reference Missing	Ref. Loss.	ON: Reference frequency loss	O	O	O
27	Timing Function Output	Timer Output	Set time function parameter to 03-33 and 03-34，and the time function input is set by parameter from 03-00 and 03-05	O	O	O
28~31	Reserved	Reserved	Reserved	-	-	-
32	Communication Control Contacts	Control From Comm	ON: DO is set by communication control.	O	O	O
33	RTC Timer 1	RTC Timer 1	ON: 16-36 (RTC Speed Selection) selects Timer 1 and 16-32 (Source of Timer 1) is active in the set time.	O	O	O
34	RTC Timer 2	RTC Timer 2	ON: 16-36 (RTC Speed Selection) selects Timer 2 and 16-33 (Source of Timer 2) is active in the set time.	O	O	O
35	RTC Timer 3	RTC Timer 3	ON: 16-36 (RTC Speed Selection) selects Timer 3 and 16-34 (Source of Timer 3) is active in the set time.	O	O	O
36	RTC Timer 4	RTC Timer 4	ON: 16-36 (RTC Speed Selection) selects Timer 4 and 16-35 (Source of Timer 4) is active in the set time.	O	O	O
37	Detection Output of PID Feedback Loss	PID Fbk Loss	ON: PID Feedback Loss	O	O	O
38	Brake Release	Brake Relase	ON: Brake Release	X	O	X

03-1X=0: During Running

OFF	Run command is OFF and the inverter is stopped.
ON	Run command is ON or output frequency is greater than 0.

03-1X=1: Fault contact output

Output is active during fault condition.
Note: Communication error (CF00, CF01) do not activate the fault contact.

03-1X=2: Frequency Agree

Output is active when the output frequency falls within the frequency reference minus the frequency detection width (03-14).

03-1X=3: Setting Frequency Agree

Output is active when the output frequency falls within the frequency detection width (03-14) of the set frequency detection level (03-13).

03-1X=4: Frequency detected 1

Output is active when the output frequency rises above the frequency detection level (03-13) + frequency detection width (03-14) and deactivates when the output frequency falls below frequency detection level (03-13).

03-1X=5: Frequency detected 2

Output is active when the output frequency is below the frequency detection level (03-13) + frequency detection width (03-14) and turns off when the output frequency falls below frequency detection level.

03-1X=6: Automatic restart.

Output is active during an auto-restart operation.

03-1X=9: Baseblock (B.B.)

Output is active when the inverter output is turned off during a Baseblock command.

03-1X=12: Over torque detected (Normally Open)

Output is active during an over torque detection see parameters 08-13 ~ 08-16.

03-1X=25: Low torque detected (Normally Open)

Output is active during low torque detection see parameters 08-17 ~ 08-20.

03-1X=13: Current Agree

When the output current is larger than that in 03-15 and its duration is higher than that in 03-16, this function will be ON.

03-1X=18: PLC status (setting =18)

Output is c when operation command parameter (00-02) is set to 3: PLC Control.

03-1X=19: PLC control contact

Output is controlled by the PLC logic

03-1X=20: Zero-speed

Output is active during zero-speed

Active	Output frequency >=minimum output frequency (01-08, Fmin)
Off	Output frequency is <=the minimum output frequency

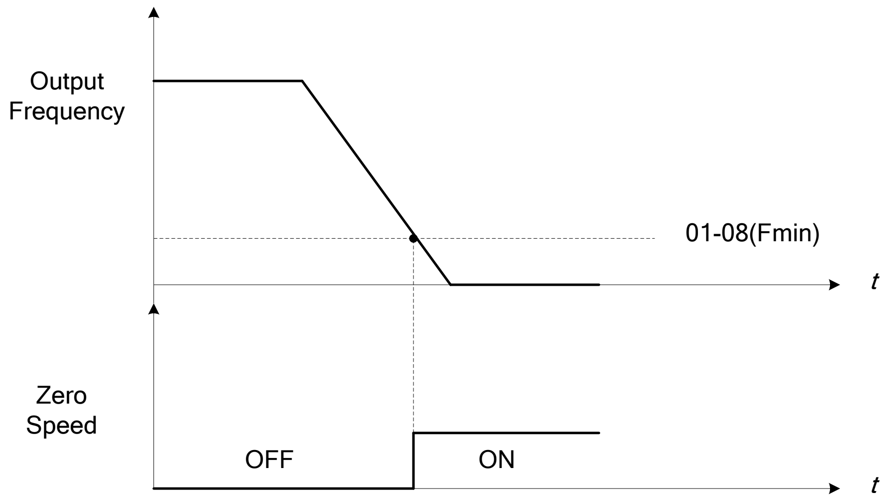


Figure 4.3.23 Zero-speed operation

03-1X=21: Inverter Ready

Output is active when no faults are active and the inverter is ready for operation.

03-1X=22: Undervoltage Detection

Output is active when the DC bus voltage falls below the low voltage detection level (07-13).

03-1X=23: Source of operation command

Output is active in local operation command.

OFF	Remote mode: 00-02 = 1 or 2, or any one of the multi-function digital input terminals (S1 to S6) set to function 5 (LOCAL / REMOTE control) is OFF. SEQ LED of the keypad is ON.
ON	Local mode: 00-02 = 0, or any one of the multi-function digital input terminals (S1 to S6) set to function 5 (LOCAL / REMOTE control) is active. SEQ LED of the keypad is OFF.

03-1X=24: Source of frequency command

Output is active in local frequency command.

OFF	Remote mode: 00-05 = 1 or 2, or any one of the multi-function digital input terminals (S1 to S6) set to function 5 (LOCAL / REMOTE control) is OFF. REF LED of the keypad is ON.
ON	Local mode: 00-05 = 0, or any one of the multi-function digital input terminals (S1 to S6) set to function 5 (LOCAL / REMOTE control) is active. REF LED of the keypad is OFF.

03-1X=26: Frequency reference missing

Output is active when the frequency reference is lost. When parameter 11-41 is set to 0 the inverter will decelerate to a stop. When parameter 11-41 is set to 1 operation will continue at the value of parameter 11-42 times the last know frequency reference.

03-1X=27: Time function output

Output is controlled by timer function see parameter 03-37 and 03-38.

03-1X=32: Communication control contacts

Output is active when communication control is active.

03-1X=37: Detection Output of PID Feedback Loss

When PID feedback loss occurs (refer to parameters setting 10-11~10-13), this function will be ON.

03-1X=38: Brake Release

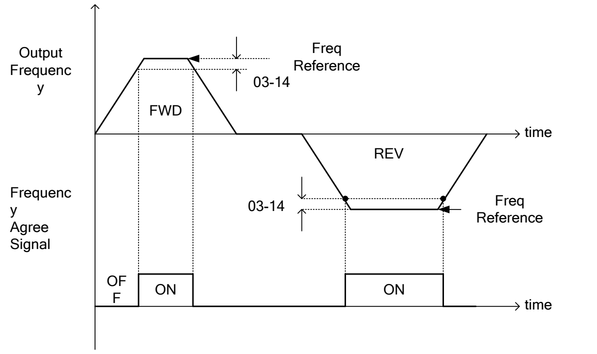
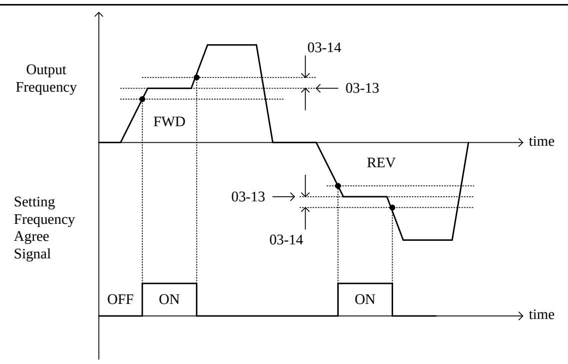
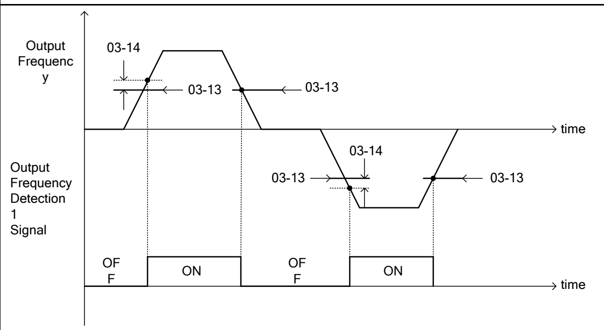
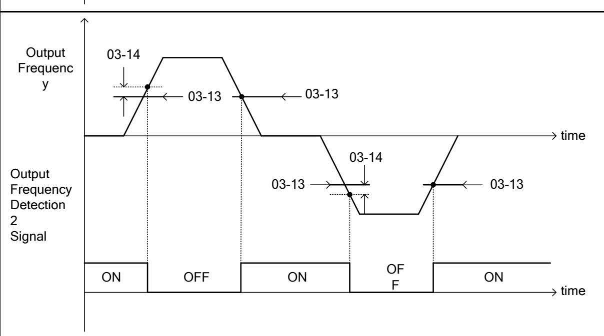
When this function is ON, Break release is enabled. Refer to parameters descriptions of 03-41~03-42.

03-13	**Frequency Detection Level**
Range	**【0.0~400.0】 Hz** **【0.0~1200.0】 Hz (when 00-31 = 1)**
03-14	**Frequency Detection Width**
Range	**【0.1~25.5】 Hz**

Frequency Detection Level: set the multi-function output terminals R1A-R1C, R2A-R2C or R3A-R3C to the desired detection level and bandwidth for use with multi-function output functions 2 to 5.

The time charts for the Frequency Agree Detection operation are shown in the following Table 4.3.7.

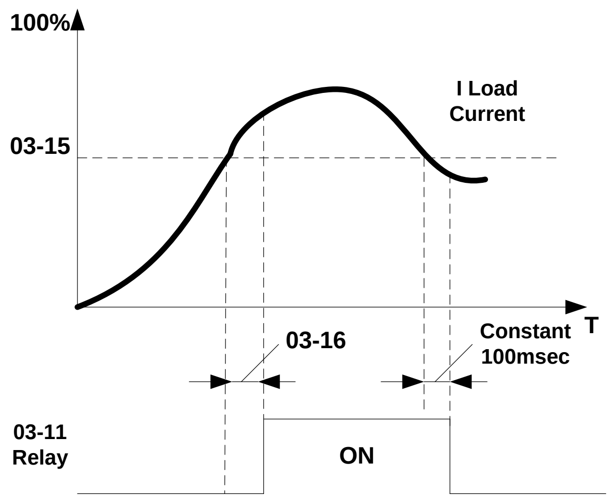
Table 4.3.7 Frequency Detection Operation

Function	Detection operation of frequency confirmation	Description
Frequency agree		• If output frequency is higher than the value of Frequency Detection Level (03-13) + Frequency Detection Width (03-14), the signal of output frequency detection 1 is ON. • If output frequency is lower than Frequency Detection Level (03-13), the signal of output frequency detection 1 is OFF. • If output frequency value falls between (03-13) and (03-13) + (03-14), the signal of output frequency detection 1 is the same as the previous value. • Any of the digital outputs function (03-11, 03-12 or 03-39) can be set to 4 (Output Frequency Detection 1).
Set frequency agree		• If output frequency is higher than the value of Frequency Detection Level (03-13) + Frequency Detection Width (03-14), the signal of output frequency detection 1 is OFF. • If output frequency is lower than Frequency Detection Level (03-13), the signal of output frequency detection 1 is ON. • If output frequency value falls between (03-13) and (03-13) + (03-14), the signal of output frequency detection 2 is the same as the previous value. • Any of the digital outputs function (03-11, 03-12 or 03-39) can be set to 5 (Output Frequency Detection 2).
Output frequency detection 1		• Output is active when the output frequency rises above the frequency detection level (03-13) + frequency detection width (03-14) and deactivates when the output frequency falls below frequency detection level (03-13). • Any of the digital outputs function (03-11, 03-12 or 03-39) can be set to 4 (Output frequency detection 1).
Output frequency detection 2		• Output is active when the output frequency is below the frequency detection level (03-13) + frequency detection width (03-14) and turns off when the output frequency falls below frequency detection level. • Any of the digital outputs function (03-11, 03-12 or 03-39) can be set to 5 (Output frequency detection 2).

03-15	Current Agree Level
Range	【0.1~999.9】 A
03-16	Delay Time of Current Agree Detection
Range	【0.1~10.0】 Sec

- **03-11=13**：Relay is active when output current is larger than that in 03-15.
- **03-15**：The setting value **(0.1~15.0)** depends on motor rated current.
- **03-16**：The unit of the setting value **(0.1~10.0)** is second. The delay time of relay signal from ON to OFF is 100ms (constant).

Timing Diagram:



03-19	Relay (R1A-R3C) Type
Range	【xxx0b】：R1 A contact 【xxx1b】：R1 B contact 【xx0xb】：R2 A contact 【xx1xb】：R2 B contact 【x0xxb】：R3 A contact 【xx1xb】：R3 B contact

Parameter 03-19 selects the digital output type between a normally open and a normally closed contact.
Each bit of 03-19 presents an output：

03-19= **0** **0** **0** **0** **0:** normally open contact
R3 **R2** **R1** **1:** normally close contact

Example: R1 normally closed and R2 normally open contact set 03-19=xx001.

03-27	UP/DOWN Frequency Hold/ Adjust Selection
Range	【0】：Keep UP/DOWN frequency when stopping. 【1】：Clear UP/DOWN frequency when stopping. 【2】：Allow frequency UP/DOWN when stopping. 【3】：Refresh frequency at acceleration.

03-27=0: When the run command is removed the UP/DOWN frequency reference before deceleration is stored. The next time the run command is applied the output frequency will ramp up to the previously stored frequency reference.

03-27=1: When the run command is removed the UP/DOWN frequency reference command is cleared (set to 0). The next time the run command is applied the output frequency will start at 0.

03-27=2: UP/DOWN command is active when run command is not active.

03-27=3: Keep the state of frequency command not to be cleared. When Run Command re-sends, press UP/DOWN key before the run frequency reaches the frequency command, press UP/ DOWN key, then:

- When 03-40 = 0, Frequency Command is set by Run Frequency.
- When 03-40≠0, Frequency Command is set by the values of Run Frequency plus the setting frequency of 03-40.

03-30	**Pulse Input Selection**
Range	**【0】：Common Pulse Input** **【1】：PWM (Pulse Width Modulation)**

There are two modes in pulse input selection:

03-30=0: Common Pulse Input

Pulse Input (PI) = the selected frequency divided by pulse input scaling (set by 03-31), corresponding to the maximum output frequency of motor 1 (01-02).

Note: Monitor parameter 12-79 (pulse input percentage) displays the proportional relationship between input signal and 03-31 (pulse input scaling).

03-30=1: PWM (Pulse Width Modulation)

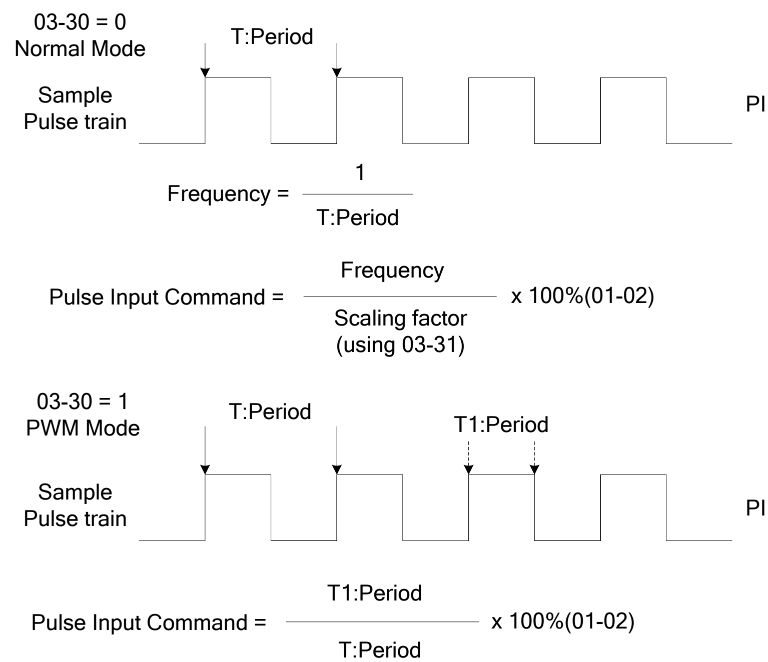
It is required to input the correct frequency.

PWM= positive edge pulse time divided by previous pulse time period, corresponding to the maximum output frequency of the motor 1 (01-02).

Note: Monitor parameter 12-79 (pulse input percentage) displays the proportional relationship between the positive edge of input signal and time period.

Note: Tolerance range of pulse time period in PWM modes is ±12.5%. If it is over than the range, it is inactive.

Pulse input selection diagram:



03-31	Pulse Input Scaling
Range	【50~32000】Hz

Pulse input scaling, 100% = Maximum pulse frequency.

03-32	Pulse Input Gain
Range	【0.0~1000.0】%

Target value (03-03) in % = Pulse input frequency scaled to 100% based on maximum pulse frequency (03-31) times the gain (03-32) + bias (03-33).

03-33	Pulse Input Bias
Range	【-100.0~100.0】%

Target value (03-03) in % = Pulse input frequency scaled to 100% based on maximum pulse frequency (03-31) times the gain (03-32) + bias (03-33).

03-34	Pulse Input Filter Time
Range	【0.00~2.00】Sec

* Refer to Fig.4.3.24 for the pulse input specification.

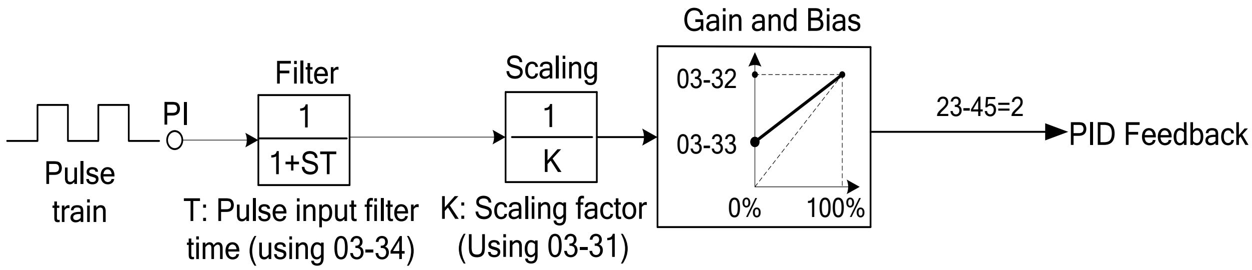


Figure 4.3.24 Pulse input adjustment

Set Pulse Input Setup as Flow Meter Input

Set parameter 23-45 (Flow Meter Feedback) to 2 (Pulse Input) to use the pulse input terminal PI for a flow meter pulse input. Refer to the description of parameter group 23 for details. Next set the pulse input scaling (03-31), enter the pulse input frequency to match the maximum output frequency. Adjust the pulse input filter time (03-34) to compensate for interference or noise.

03-37	Timer ON Delay (DI/DO)
Range	【0.0~6000.0】Sec
03-38	Timer OFF Delay (DI/DO)
Range	【0.0~6000.0】Sec

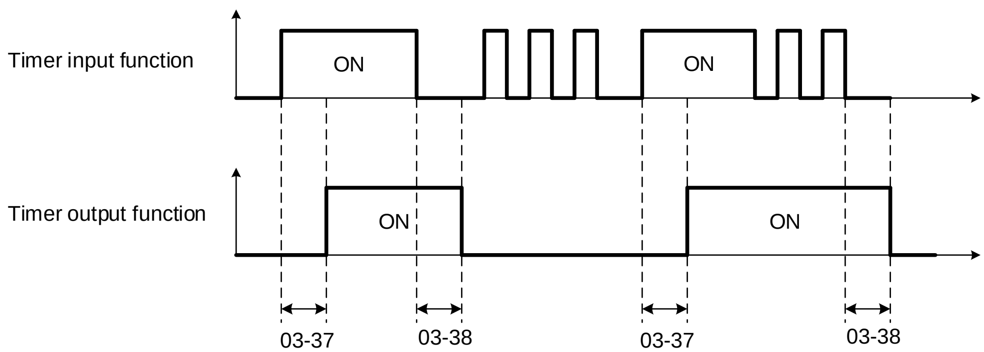
Enable the timer function by setting one of multi-function input parameters 03-00~03-05 (S1 to S6) to 35 (timer function input) and one of multi-function output parameters 03-11, 03-12, 03-39 (R1A-R1C to R3A- R3C) to 27 (timer function output).

The timer function can be used to implement a timer relay. Use timing parameter 03-37 and 03-38 to set the timer ON / OFF delay.

Timer output is turned ON when the multi-function timer input is ON for the time specified in parameter 03-37.

Timer output is turned OFF after the multi-function timer input is OFF for the time specified in parameter 03-38.

Timing example:

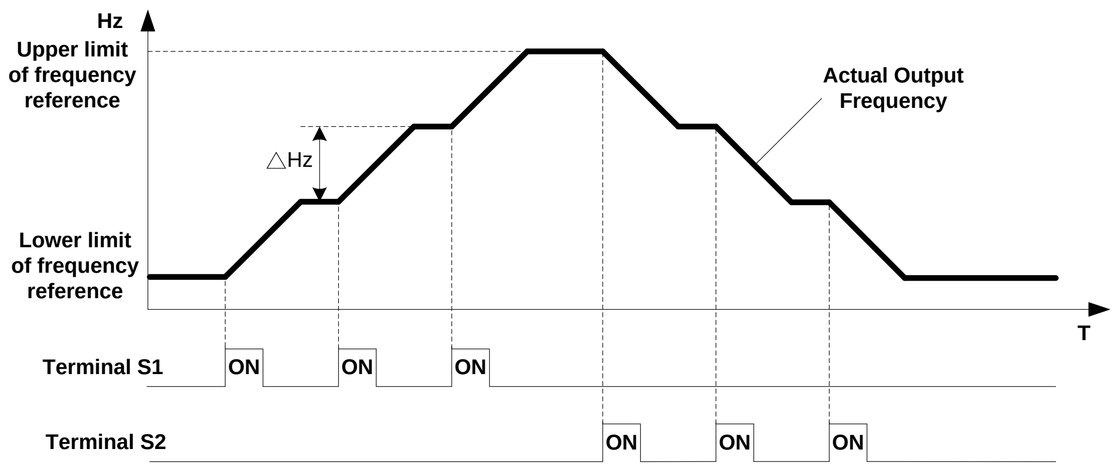


03-40	Up/down Frequency Width Setting
Range	【0.00~5.00】Hz

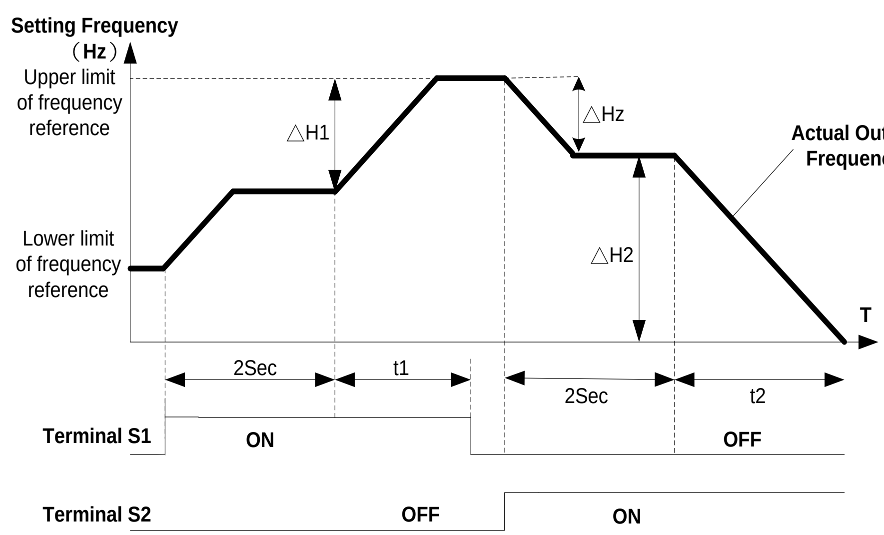
For example: Set terminal **S1：03-00=【8】(Up Frequency Increasing Command), S2：03-01=【9】(DOWN Frequency Decreasing Command) and 03-40=【△】Hz.**

Mode1: When 03-40 is set to 0Hz, the standard up/down function is active, as shown in Fig. 4.3.17.

Mode2: When 03-40 is set to a value greater than 0Hz and terminal is active less than 2 sec. will result in a frequency change of △**Hz** (setting frequency 03-40).



Mode3: When 03-40 greater than 0Hz and input terminal is active for more than 2 sec, frequency will ramp using the acceleration/ deceleration times.



Notes:

△H1: Increase frequency reference and accelerate to new frequency, t1: terminal active during acceleration.

△H2: Decrease frequency reference and decelerate to new frequency, t2: terminal active during deceleration.

$$\Delta H1 = \frac{\text{Upper Limit Frequency}}{\text{Acceleration Time2}} \times \text{Terminal Conduction Time(t1)}$$

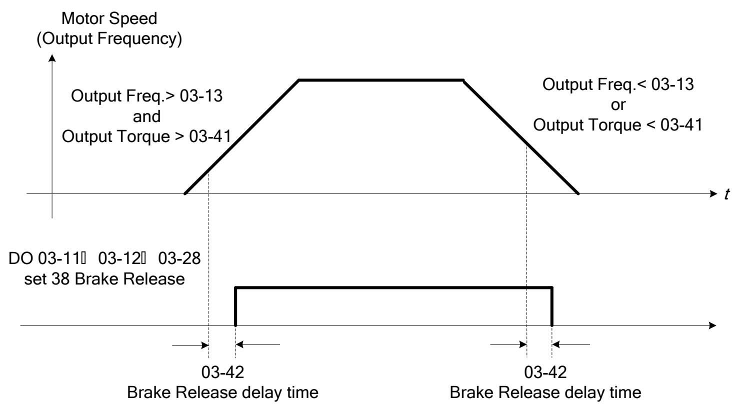
$$\Delta H2 = \frac{\text{Lower Limit Frequency}}{\text{Deceleration Time2}} \times \text{Terminal Conduction Time(t2)}$$

03-41	Torque Detection Level
Range	【0~300】%
03-42	Delay Time of Braking Action
Range	【0.00~65.00】Sec

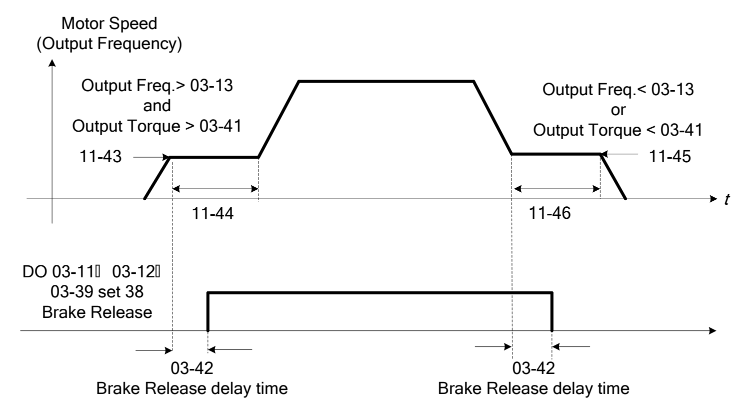
Brake Release Function:

The brake release function requires uses frequency agree as shown in the following figure.

When output frequency is greater than frequency detection level (03-13) and output torque is greater than torque detection level (03-41) for the time specified in 03-42 (delay braking action delay time) the brake will release.



It is recommended to use the start and stop frequency lock function (11-43~11-46), as shown in the following figure:



03-43	UP/DOWN Acceleration/ Deceleration Selection
Range	【0】: Acceleration/Deceleration Time 1 【1】: Acceleration/Deceleration Time 2

Select acceleration/ deceleration time for the UP/DOWN function. Example: △H1 (set frequency increment at acceleration) and △H2 (set frequency increment at deceleration).

Group 04 External Analog Input and Output Parameters

04-00	AI Input Source Selection
Range	【0】: AI2 0~10V 【1】: AI2 4~20mA
04-01	AI1 Signal Filter Time
Range	【0.00~2.00】Sec
04-02	AI1 Gain
Range	【0.0~1000.0】%
04-03	AI1 Bias
Range	【-100~100.0】%
04-05	AI2 Function Setting
Range	【0】: Auxiliary Frequency 【1】: Frequency Reference Gain 【2】: Frequency Reference Bias 【3】: Output Voltage Bias 【4】: Acceleration and Deceleration Scaling 【5】: DC Braking Current* 【6】: Over-Torque Level 【7】: Stall Prevention Level During Running 【8】: Frequency Reference Lower Limit 【9】: Jump Frequency 4 【10】: Added to AI1 【11】: Positive Torque Limit 【12】: Negative Torque Limit 【13】: Regenerative Torque Limit 【14】: Positive / Negative Torque Limit 【15】: Reserved 【16】: Torque Compensation
04-06	AI2 Signal Filter Time
Range	【0.00~2.00】Sec
04-07	AI2 Gain
Range	【0.0~1000.0】%
04-08	AI2 Bias
Range	【-100.0~100.0】%

Refer to the followings for the details of parameter 04-00 (AI input signal type)
① AI2=0~10V, Set 04-00=0, set SW2 on the control board to V.
② AI2=0~20mA, Set 04-00=0, set SW2 on the control board to I.
③ AI2=4~20mA, Set 04-00=1, set SW2 on the control board to I.
④ AI2=2~10V, Set 04-00=1 or 3, set SW2 on the control board to V.

(1) Analog Input Level Adjustment AI1, AI2 (04-02, 04-03, 04-07, 04-08)

Each analog input AI1and AI2 has a separate gain and bias parameter associated with it.

Analog input signal AI1 can be adjusted with parameter 04-02 and 04-03; Analog input signal AI2 can be adjusted with parameter 04-07 and 04-08. Refer to Fig.4.3.25.

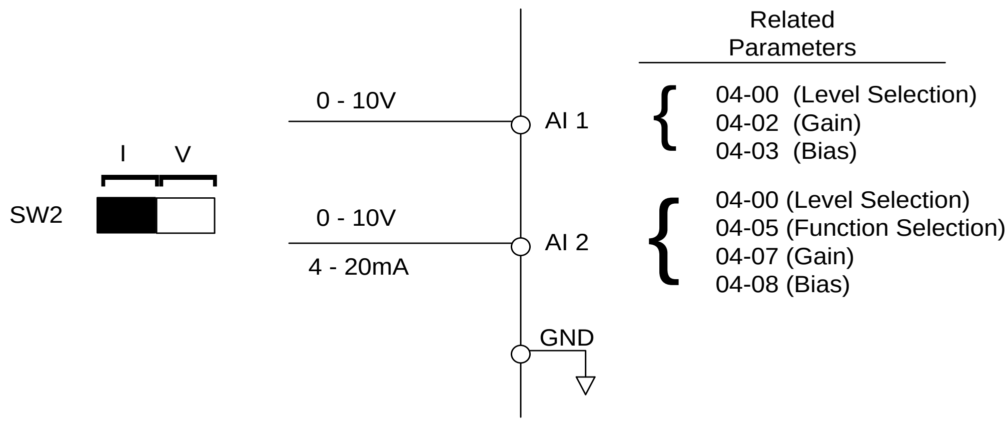


Figure 4.3.25 Analog inputs and related parameters

Gain setting: Sets the level in % that corresponds to a 10V or 20mA signal at the analog input.

Bias setting: Sets the level in % that corresponds to a 0V or 4mA signal at the analog input.

Use both gain and bias setting to scale the input signal.

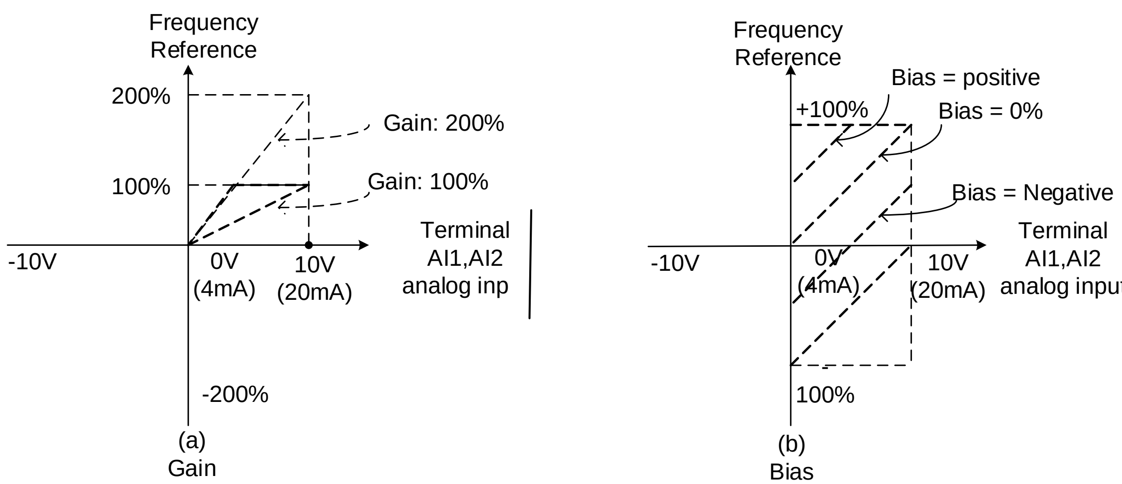


Figure 4.3.26 Gain and bias operations (for frequency reference signal)

(2) AI1 signal filtering time (04-01)

(3) AI2 signal filtering time (04-06)

All analog inputs (AI1, AI2) have a 1st order programmable input filter that can be adjusted when noise is present on each of the incoming analog signal to prevent erratic drive control.

The filter time constant (range: 0.00 to 2.00 seconds) is defined as the time that the input step signal reaches 63% of its final value.

Note: Increasing the filter time causes the drive operation to become more stable but less responsive to change to the analog input.

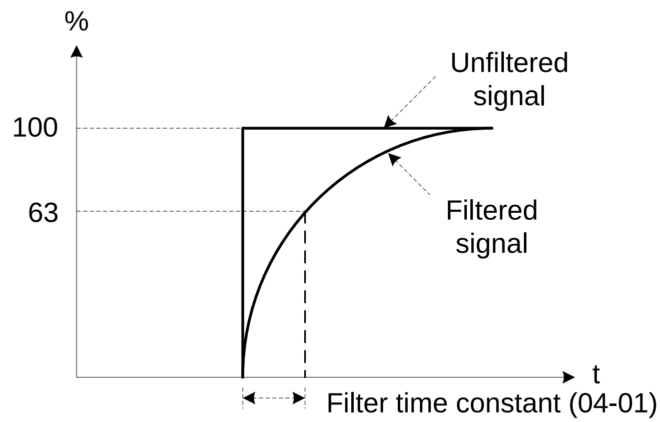


Figure 4.3.27 Filter time constant

(4) AI2 function setting (04-05)

AI2 is multi-function analog input terminal function selection. Refer to Table 4.3.8 for function overview

Table 4.3.8 Multi-function analog input list (04-05 setting)

Value	Function		Description	Control mode		
	Name	LCD Display		V/F	SLV	PM SLV
0	Auxiliary Frequency	AUX.Freq Ref	Max Output Frequency (01-02, Fmax) =100%	O	O	O
1	Frequency Reference Gain (FGAIN)	Freq Ref Gain	Aggregated gain＝ AI1 = 04-02 * FGAIN	O	O	O
2	Frequency Reference Bias (FBIAS)	Freq Ref Bias	Aggregated bias＝ AI1 = 04-03 * FBIAS	O	O	O
3	Output Voltage Bias (VBIAS)	Output Volt Bias	Aggregate output voltage =V/F curve voltage ＋ VBIAS	O	X	O
4	Coefficient of Acceleration and Deceleration Reduction (K)	Tacc/Tdec Scaling	Actual acceleration and deceleration time = accel. and decal. time / K	O	O	O
5	DC Braking Current*	DC Inj Current	Adjust the DC braking current (0 ~ 100%) based on analog input. When the inverter rated current = 100%, DC braking current 07-07 is disabled.	O	O	O
6	Over-Torque Detection Level	Over Tq Level	Change over-torque detection level based on over-torque detection level, at this time, 08-15 is disabled.	O	O	O
7	Stall Prevention Level During Running	Run Stall Level	Adjust the action level (30% ~ 200%) of stall prevention in operation based on analog input. The inverter rated current =100%	O	X	O
8	Frequency Lower Limit	Ref. Low Bound	Adjust the lower limit (0 ~ 100%) of frequency command based on analog input, the maximum output = 100%. The lower limit of frequency command is the greater one of the actual frequency command’s lower limit 00-13 or the multi-function analog input.	O	O	O
9	Jump Frequency 4	Jump Freq 4	Jump frequency 4. 100% = maximum output frequency	O	O	O

Value	Function		Description	Control mode		
	Name	LCD Display		V/F	SLV	PM SLV
10	Added to AI1	Add to AI1	Added to AI1. 100% = maximum output frequency	O	O	O
11	Positive Torque Limit	Positive Tq Limit	100% = Motor's rated torque	X	O	O
12	Negative Torque Limit	Negative Tq Limit	100% = Motor's rated torque	X	O	O
13	Regenerative Torque Limit	Regen. Tq Limit	100% = Motor's rated torque	X	O	O
14	Positive / Negative Torque Limit	+/- Tq Limit	100% = Motor's rated torque	X	O	O
15	Torque Limit	Tq Limit	100% = Motor's rated torque	X	X	X
16	Torque Compensation	Tq Compensation	100% = Motor's rated torque	X	O	X
17	Reserved	No Function	Reserved	O	O	O

04-05=0: Auxiliary frequency

When parameter 00-05 = 1 (main frequency from external control) the auxiliary speed reference frequency can be activated via the multi-speed input commands (see table 4.3.5). The auxiliary frequency command can be set via AI2. The maximum output frequency is set by 01-02, Fmax =100%.

04-05=1: Frequency Reference Gain (FGAIN)

Multi-function analog input AI2 can be used to adjust the frequency reference gain of analog input AI1.
The total frequency reference gain of terminal AI1 is the internal gain set by parameter 04-02 times FGAIN.
The maximum frequency reference for AI1 is 100%.

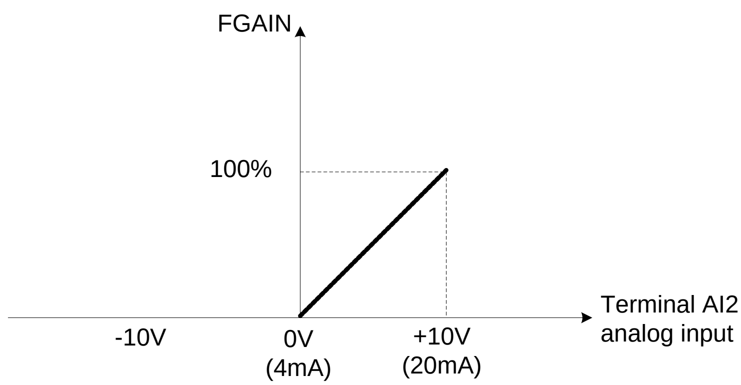


Figure 4.3.28 Frequency gain adjustment

Example:

When the internal gain of AI1 (04-02) is set to 100% and AI2 to 5V (for example FGAIN = 50%), the reference frequency of terminal AI1 will be 50%, as shown in Fig. 4.3.29.

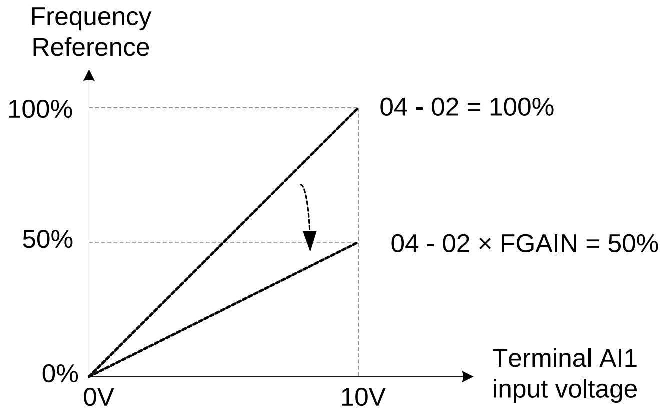


Figure 4.3.29 Frequency reference gain adjustment (example)

04-05=2: Frequency Reference bias (FBIAS)
Multi-function analog input terminal AI2 can be used to adjust the frequency reference bias of AI1.
The total frequency reference bias of terminal AI1 is the sum of internal bias set by parameter 04-03 and FBIAS.
The maximum frequency reference for AI1 is 100%.

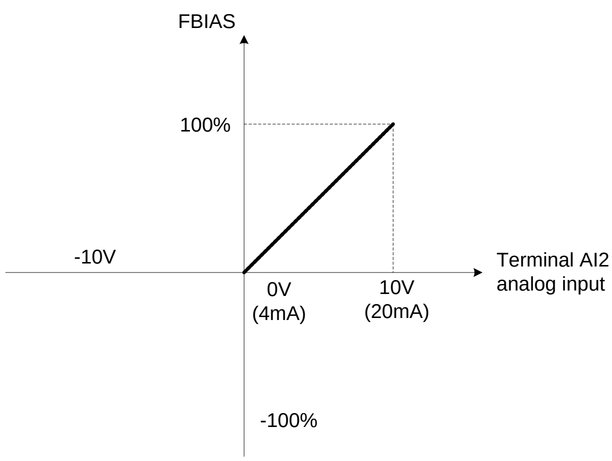


Figure 4.3.30 Bias adjustment

Example:
Terminal AI1 input is 0V, 04-02 = 100% (AI1 gain), 04-03 = 0% (AI1 bias) and terminal AI2 input is 3V. The reference frequency will be 30% as shown in Fig.4.3.31.

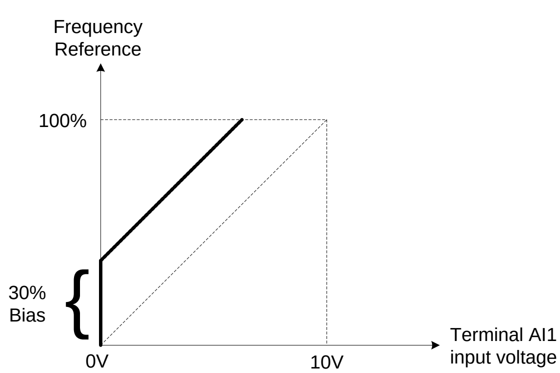


Figure 4.3.31 Frequency Reference bias adjustment (example)

04-05=3: Output Voltage Bias (VBIAS)

Multi-function analog input AI2 can be used to adjust the output voltage. The total output voltage of inverter is the sum of output voltage based on the selected V/F curve and VBIAS.

The maximum output voltage is set by 01-03, Vmax = 100%.

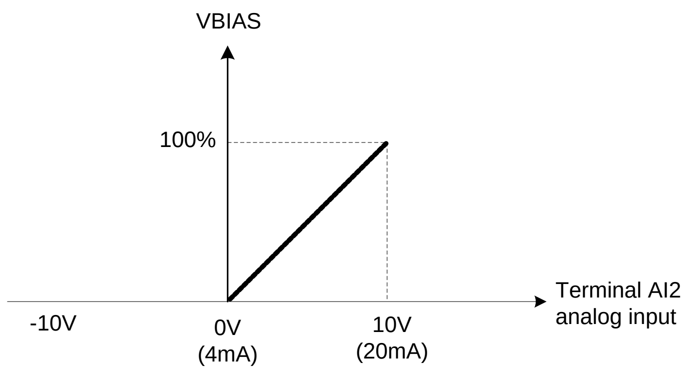


Figure 4.3.32 Bias adjustment

04-05=4: Acceleration and deceleration coefficient (K)

Multi-function analog input AI2 can be used to adjust the acceleration and deceleration time coefficient. The actual acceleration and deceleration time is calculated as follows:

$$\text{Actual accel /decel time} = \frac{\text{Acceleration / Deceleration time (00-14 ~ 00-17, 00-21~ 00-24)}}{\text{K}}$$

Acceleration/ Deceleration time setting is 100% (00-14~00-17, 00-21~00-24).

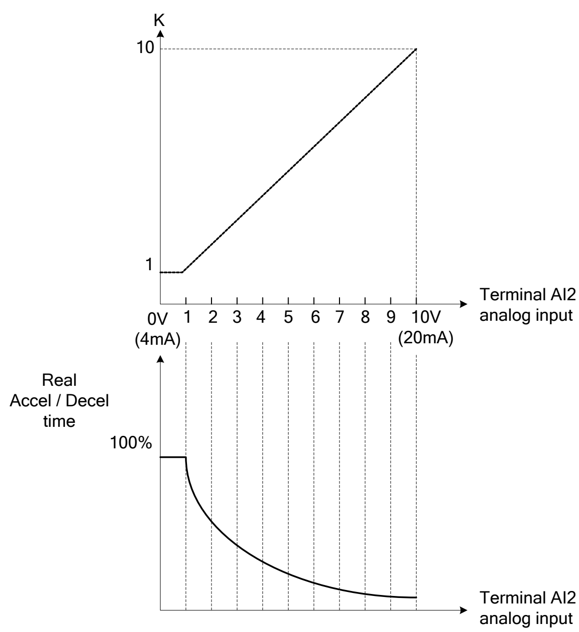


Figure 4.3.33 Acceleration / deceleration time reduction coefficient

04-05=5: DC braking current
Multi-function analog input AI2 can be used to adjust the DC Injection braking current.
DC braking current parameter 07-07 setting should be set to 0% to use this function.
The inverter rated current = 100%

Note: When using the permanent magnet (PM) motor, there will be no options of setting 5.

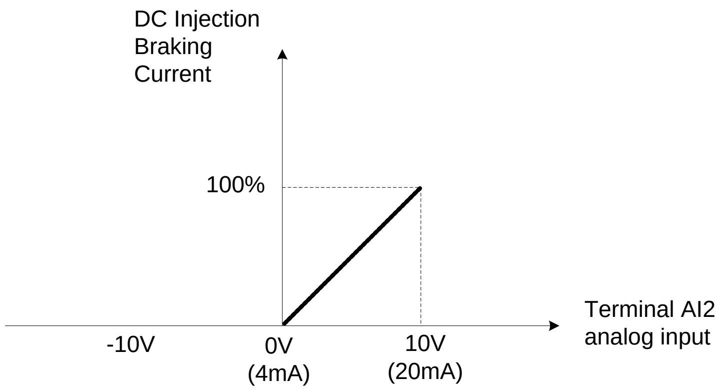


Figure 4.3.34 DC braking current adjustment

04-05=6: Over-torque detection level
Multi-function analog input AI2 can be used to adjust the over-torque detection level.
100% of inverter rated current (V/F control mode)
100% motor rated torque (SLV control mode)
If the multi-function analog input is used to adjust the over-torque level, the internal over-torque detection level (08-15) is disabled.

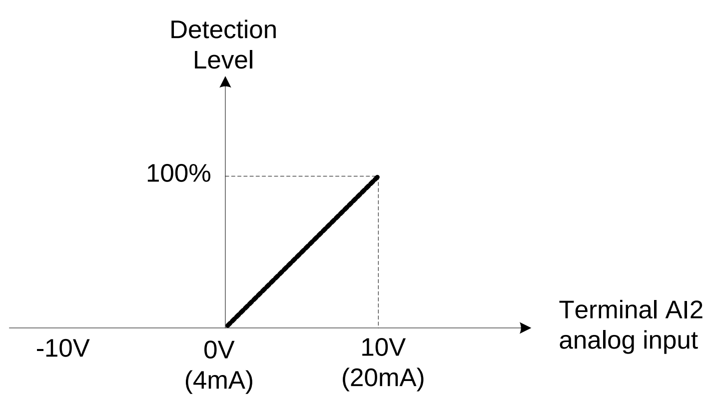


Figure 4.3.35 Over-torque/less torque detection level adjustment

4-05=7: Stall prevention level during running
Multi-function analog input AI2 can be used to adjust the stall prevention level during operation.
Inverter rated current = 100%. When AI2 is set to control stall prevention level (04-05 = 7) and parameter 08-03 (Stall prevention level during operation) is used, then the lesser of the two value becomes the active stall prevention level during operation.

Example: If the motor power is less than that of the inverter, the operation and the stall prevention of the motor will be based on the factory settings, multi-function analog input AI2 can be used to reduce the stall prevention level during operation.

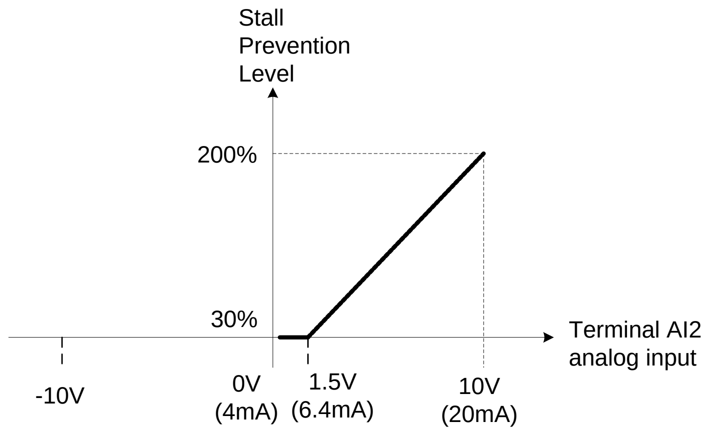


Figure 4.3.36 Stall prevention level adjustment during operation

04-05=8: Frequency lower limit

Multi-function analog input AI2 can be used to adjust the lower limit of frequency reference.
Maximum output frequency (Fmax, 01-02) = 100%. The actual lower limit is determined by the maximum value of 00-13 (frequency lower limit) and level of the multi-function analog input AI2.

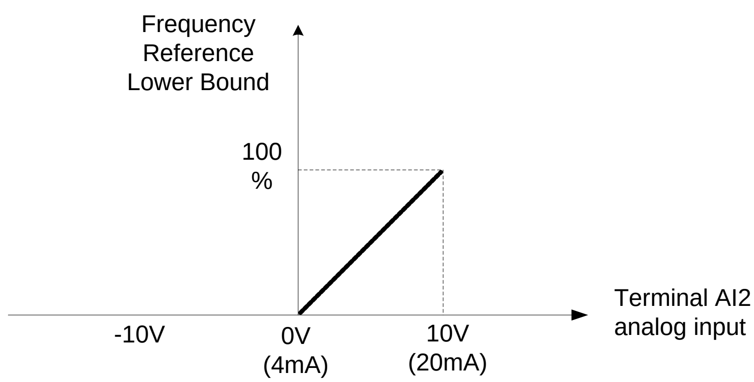


Figure 4.3.37 Adjustment of lower limit of frequency reference

04-05=9: Jump frequency 4

Multi-function analog input AI2 can be used to adjust Jump frequency 4.

Maximum output frequency (01-02, Fmax) = 100%. Setting 11-08 ~ 11-10 to 0.0Hz turns of the Jump frequency function.

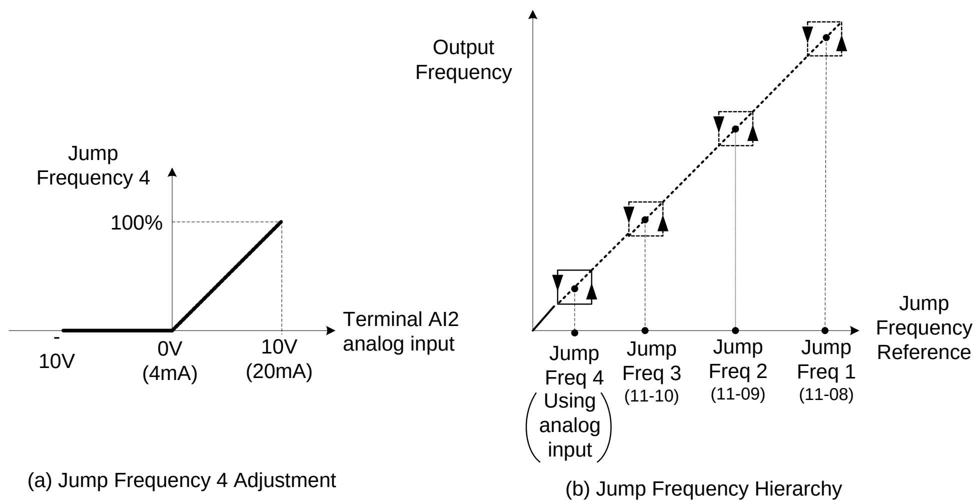


Figure 4.3.38 Jump frequency 4 setting operation

04-05=10: Added to AI1

Multi-function analog input AI2 can be used as a bias level for analog input AI1.

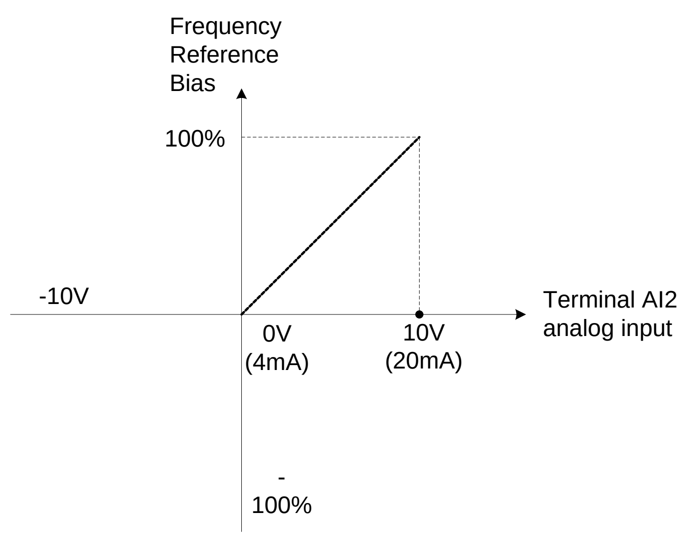


Figure 4.3.39 Added to AI1 as a bias operation

Example:

04-02 (AI1 gain) = 100%, 04-03 (AI2 gain) = 0%, and terminal AI2 level is 2V. If input terminal AI1 is 0V, the internal reference frequency of terminal AI1 will be 20 %

04-05=11: Positive torque limit

Multi-function analog input AI2 can be used to adjust the positive torque limit.

04-05=12: Negative torque limit

Multi-function analog input AI2 can be used to adjust the negative torque limit.

04-05=13: Regenerative torque limit

Multi-function analog input AI2 can be used to adjust the regenerative torque limit.

04-05=14: Positive / negative torque limits

Multi-function analog input AI2 can be used to adjust both the positive and negative torque limit.

For more details on torque limits, please refer to parameter group 21 - torque control group.

04-05=15: Torque limit of speed control

Multi-function analog input AI2 can be used to adjust the torque limit in closed loop vector mode.

04-05=16: Torque compensation of speed control

Multi-function analog input AI2 can be used to adjust the torque compensation in closed loop vector mode.

For more details on the torque control functions, please refer to parameter group 21 - torque control group.

04-11	AO1 Function Setting
Range	【0】: Output Frequency 【1】: Frequency Reference 【2】: Output Voltage 【3】: DC Voltage 【4】: Output Current 【5】: Output KW 【6】: Motor Speed 【7】: Output PF (Power Factor) 【8】: AI1 Input 【9】: AI2 Input 【10】: Torque Command 【11】: q-axis Current 【12】: d-axis Current 【13】: Speed Deviation 【14】: Reserved 【15】: ASR Output 【16】: Reserved 【17】: q-axis Voltage 【18】: d-axis Voltage 【19】~【20】: Reserved 【21】: PID Input 【22】: PID Output 【23】: PID Setpoint 【24】: PID Feedback Value 【25】: Output Frequency of the Soft Starter 【26】: Reversed 【27】: Reversed 【28】: Communication Control
04-12	**AO1 Gain**
Range	【0.0~1000.0】%

04-13	AO1 Bias
Range	【-100.0~100.0】%
04-16	AO2 Function Setting
Range	Setting range and definition are the same as those of 04-11.
04-17	AO2 Gain
Range	【0.0~1000.0】%
04-18	AO2 Bias
Range	【-100.0~100.0】%
04-19	AO Output Source Type Selection
Range	【0】: AO1 0~10V AO2 0~10V 【1】: AO1 0~10V AO2 4~20mA 【2】: AO1 4~20mA AO2 0~10V 【3】: AO1 4~20mA AO2 4~20mA

For the analog output and related parameters, refer to Fig.4.3.40.

Related Parameters

AO1 { 04-11 (Function Selection)
04-12 (Gain)
04-13 (Bias)

AO2 { 04-16 (Function Selection)
04-17 (Gain)
04-18 (Bias)

Figure 4.3.40 Analog outputs and related parameters

Analog output AO1 and AO2 adjustment (04-12, 04-13 and 04-17, 04-18)

Signal: Use parameter 04-11 to select the analog output signal for AO1 and parameter 04-16 to select the analog output signal for AO2.

Gain: Use parameter 04-12 to adjust the gain for AO1 and parameter 04-17 to adjust the gain for AO2.
Adjust the gain so that the analog output (10V/20mA) matches 100% of the selected analog output signal (04-11 for AO1 and 04-16 for AO2).

Bias: Use parameter 04-13 to adjust the bias for AO1 and parameter 04-18 to adjust the bias for AO2.
Adjust the bias so that the analog output (0V/4mA) matches 0% of the selected analog output signal (04-11 for AO1 and 04-16 for AO2).

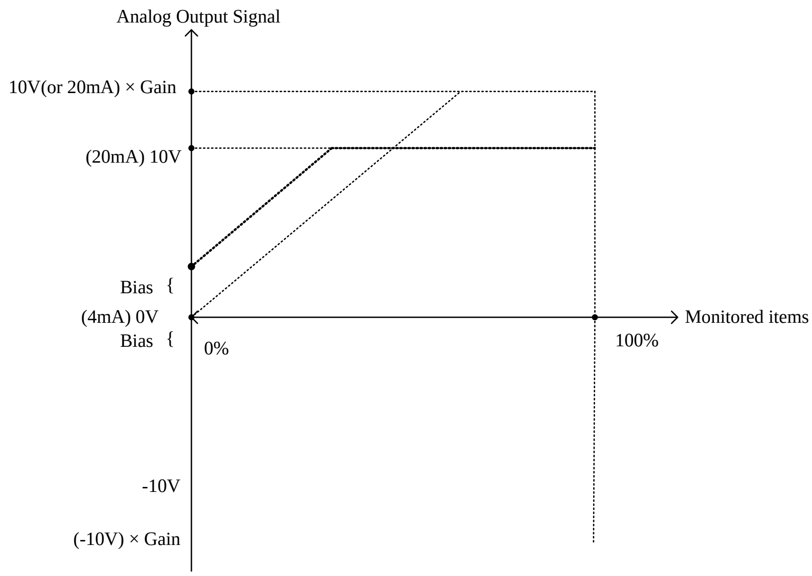


Figure 4.3.41 Analog output level adjustment

Table 4.3.9 Selection of analog output terminals function (04-11 and 04-16)

04-11, 04-16 Parameter setting	Function (Keypad display)	Monitoring Parameters Group 12	Control Mode		
			VF	SLV	PM SLV
0	Output Freq	12-17	O	O	O
1	Freq Ref	12-16	O	O	O
2	Output Voltage	12-19	O	O	O
3	DC Voltage	12-20	O	O	O
4	Output Current	12-18	O	O	O
5	Output KW	12-21	O	O	O
6	Motor Speed	12-22	O	O	O
7	Output PF	12-23	O	O	O
8	AI1 Input	12-25	O	O	O
9	AI2 Input	12-26	O	O	O
10	Torque Ref	12-27	X	O	O
11	Current Iq	12-28	X	O	O
12	Current Id	12-29	X	O	O
13	Speed Deviation	12-30	X	O	O
14	Reserved	-	X	X	X
15	ASR Output	12-32	X	X	X
16	Reserved	-	X	X	X
17	Voltage Ref Vq	-	X	O	O
18	Voltage Ref Vd	-	X	O	O
19~20	Reserved	-	X	X	X
21	PID Input	12-36	O	O	O
22	PID Output	12-37	O	O	O
23	PID Setpoint	12-38	O	O	O
24	PID Feedback	12-39	O	O	O
25	Output Freq (SFS)	-	O	O	O

04-11, 04-16 Parameter setting	Function (Keypad display)	Monitoring Parameters Group 12	Control Mode		
			VF	SLV	PM SLV
26~27	Reserved	-	X	X	X
28	Comm Control	-	O	O	O

04-20	Filter Time of AO Signal
Range	【0.00~0.50】Sec

This function is used for filtering out momentary change of analog output signal.

Note: When this function is added, it will decrease the system reaction but increase interference protection.

Group 05: Multi-Speed Parameters

05-00	Acceleration and Deceleration Selection of Multi-Speed
Range	**【0】: Acceleration and deceleration time are set by 00-14 ~ 00-24 (Tacc/Tdec 1~4)** **【1】: Acceleration and Deceleration Time are set by 05-17 ~ 05-48 (Independent)**

05-00=0: Standard Acceleration and deceleration times parameters 00-14 ~ 00-17 / 00-21 ~ 00-24 are used for multi-speed 0 ~ 15.

05-00=1: Each multi-speed uses a dedicated acceleration and deceleration time parameters 05-17 ~ 05-48. There are two different modes for acceleration / deceleration timing when 05-00 is set to 1, see time example on the next page.

Acceleration time calculation formula

$$\text{Time it takes to reach set frequency} = \frac{\text{Acceleration time x (set frequency - output frequency)}}{\text{Maximum output frequency}}$$

Deceleration time calculation formula

$$\text{Time it takes to reach set frequency} = \frac{\text{Deceleration time x (output frequency - set frequency)}}{\text{Maximum output frequency}}$$

Maximum output frequency: Parameter 01-00=F, maximum output frequency set by 01-02, 01-00 ≠ F, maximum output frequency determined by V/F curve selected (50.0 / 60.0 / 90.0 / 120.0 / 180.0).

Example: 01-00=01 (50Hz (maximum output frequency), 05-02=10 Hz (multi-step speed 0), 05-17=5.0s (Acceleration time), 05-18=20.0 sec. (Deceleration time).

Acceleration time calculation formula

$$\text{Time it takes to reach set frequency} = \frac{5.0 \text{ x } 10 \text{ Hz}}{50 \text{ Hz}} = 1.0 \text{ sec.}$$

Deceleration time calculation formula

$$\text{Time it takes to reach set frequency} = \frac{20.0 \text{ x } 10 \text{ Hz}}{50 \text{ Hz}} = 4.0 \text{ sec.}$$

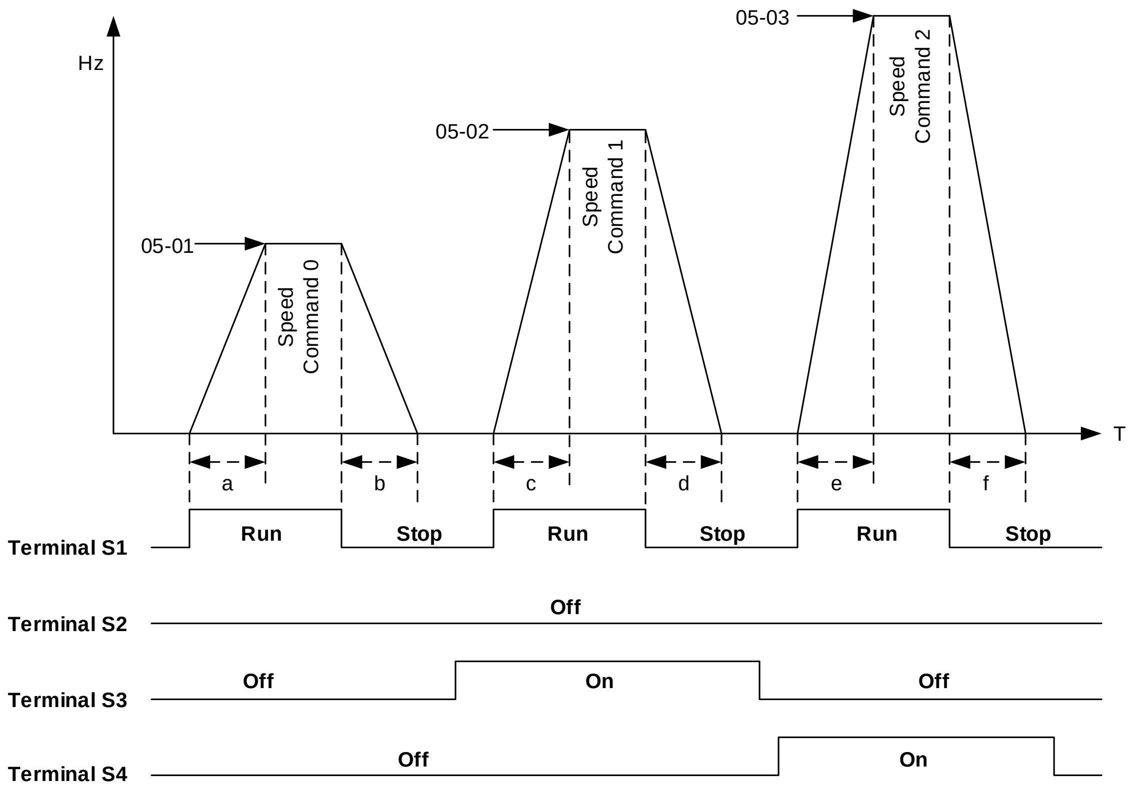
Example: Acceleration / deceleration timing when 05-00 is set to 1. In this example the following parameters are set:

00-02=1 (External Terminal Operation**)**
03-00=0 (Terminal S1: Forward /Stop)
03-01=1 (Terminal S2: Reversal /Stop)
03-02=2 (Terminal S3: Speed 1)
03-03=3 (Terminal S4: Speed 2)
03-03=4 (Terminal S5: Speed 3)

Note: When multi-step speed control is recommended to set parameter 04-05 is set to 10 (Added to AI1. When multi-step speed control is used and parameter 04-05 is set to 0 the frequency reference becomes AI2.

Acceleration / Deceleration Calculation Mode 1:

If the run command is cycled on and off, acceleration and deceleration time (a ~ f) is calculated based on the active speed command as follows:

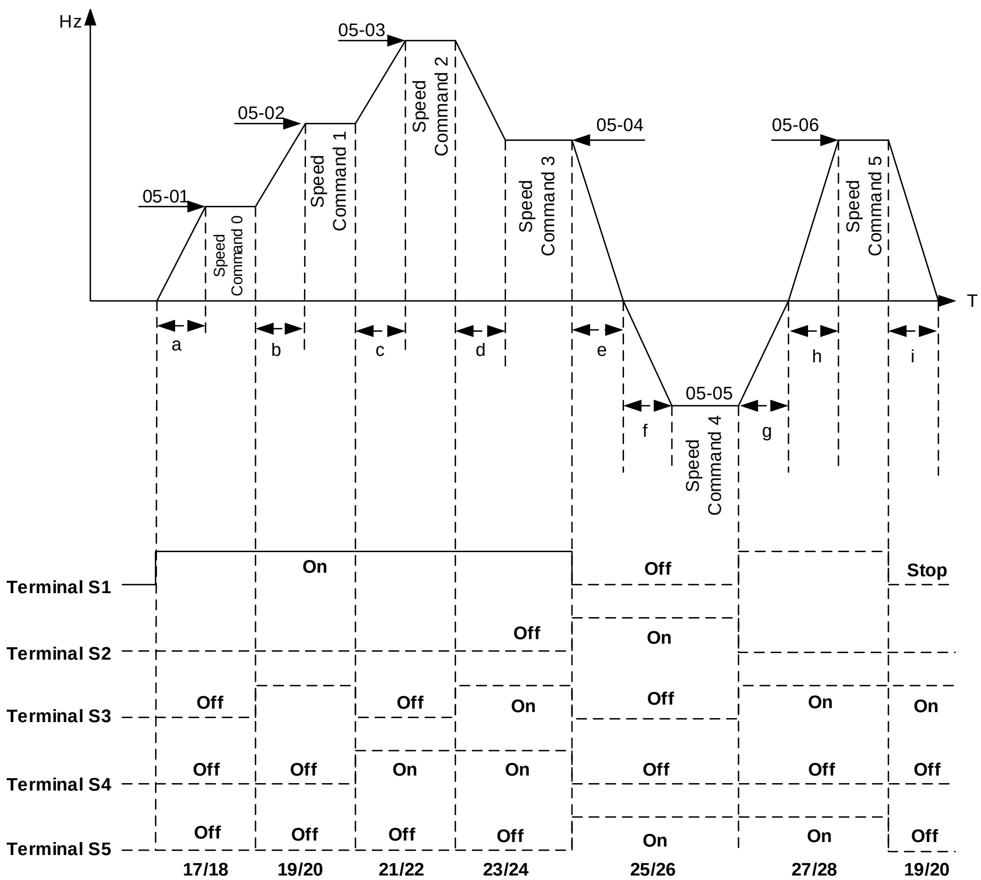


$$a = \frac{(05\text{-}17) \times (05\text{-}01)}{(01\text{-}02)} \qquad b = \frac{(05\text{-}18) \times (05\text{-}01)}{(01\text{-}02)} \qquad c = \frac{(05\text{-}19) \times (05\text{-}02)}{(01\text{-}02)} \quad \text{in sec.}$$

$$d = \frac{(05\text{-}20) \times (05\text{-}02)}{(01\text{-}02)} \qquad e = \frac{(05\text{-}21) \times (05\text{-}03)}{(01\text{-}02)} \qquad f = \frac{(05\text{-}22) \times (05\text{-}03)}{(01\text{-}02)} \quad \text{in sec.}$$

Acceleration / Deceleration Calculation Mode 2:

If the run command is remains on, acceleration and deceleration time (a ~ f) is calculated based on the active speed command as follows:



$$a = \frac{(05\text{-}17) \times (05\text{-}01)}{(01\text{-}02)} \quad b = \frac{(05\text{-}19) \times [(05\text{-}02)-(05\text{-}01)]}{(01\text{-}02)} \quad c = \frac{(05\text{-}21) \times [(05\text{-}03) - (05\text{-}02)]}{(01\text{-}02)} \text{ in sec.}$$

$$d = \frac{(05\text{-}24) \times [(05\text{-}03) - (05\text{-}04)]}{(01\text{-}02)} \quad e = \frac{(05\text{-}26) \times (05\text{-}04)}{(01\text{-}02)} \quad f = \frac{(05\text{-}25) \times (05\text{-}05)}{(01\text{-}02)} \text{ in sec.}$$

$$g = \frac{(05\text{-}27) \times (05\text{-}05)}{(01\text{-}02)} \quad h = \frac{(05\text{-}27) \times (05\text{-}06)}{(01\text{-}02)} \quad i = \frac{(05\text{-}19) \times (05\text{-}06)}{(01\text{-}02)} \text{ in sec.}$$

05-01	**Frequency Setting of Speed-Stage 0**
05-02	**Frequency Setting of Speed- Stage 1**
05-03	**Frequency Setting of Speed- Stage 2**
05-04	**Frequency Setting of Speed- Stage 3**
05-05	**Frequency Setting of Speed- Stage 4**
05-06	**Frequency Setting of Speed- Stage 5**
05-07	**Frequency Setting of Speed- Stage 6**
05-08	**Frequency Setting of Speed- Stage 7**
05-09	**Frequency Setting of Speed- Stage 8**
05-10	**Frequency Setting of Speed- Stage 9**

05-11	**Frequency Setting of Speed- Stage 10**
05-12	**Frequency Setting of Speed- Stage 11**
05-13	**Frequency Setting of Speed- Stage 12**
05-14	**Frequency Setting of Speed- Stage 13**
05-15	**Frequency Setting of Speed- Stage 14**
05-16	**Frequency Setting of Speed- Stage 15**
Range	**【0.0~400.00】 Hz**

05-17	**Acceleration time setting for multi speed 0**
05-18	**Deceleration time setting for multi speed 0**
05-19	**Acceleration time setting for multi speed 1**
05-20	**Deceleration time setting for multi speed 1**
05-21	**Acceleration time setting for multi speed 2**
05-22	**Deceleration time setting for multi speed 2**
05-23	**Acceleration time setting for multi speed 3**
05-24	**Deceleration time setting for multi speed 3**
05-25	**Acceleration time setting for multi speed 4**
05-26	**Deceleration time setting for multi speed 4**
05-27	**Acceleration time setting for multi speed 5**
05-28	**Deceleration time setting for multi speed 5**
05-29	**Acceleration time setting for multi speed 6**
05-30	**Deceleration time setting for multi speed 6**
05-31	**Acceleration time setting for multi speed 7**
05-32	**Deceleration time setting for multi speed 7**
05-33	**Acceleration time setting for multi speed 8**
05-34	**Deceleration time setting for multi speed 8**
05-35	**Acceleration time setting for multi speed 9**
05-36	**Deceleration time setting for multi speed 9**
05-37	**Acceleration time setting for multi speed 10**
05-38	**Deceleration time setting for multi speed 10**
05-39	**Acceleration time setting for multi speed 11**
05-40	**Deceleration time setting for multi speed 11**
05-41	**Acceleration time setting for multi speed 12**
05-42	**Deceleration time setting for multi speed 12**
05-43	**Acceleration time setting for multi speed 13**
05-44	**Deceleration time setting for multi speed 13**
05-45	**Acceleration time setting for multi speed 14**
05-46	**Deceleration time setting for multi speed 14**
05-47	**Acceleration time setting for multi speed 15**
05-48	**Deceleration time setting for multi speed 15**
Range	**【0.1~6000.0】 Sec**

Group 06: Automatic Operation Parameters

06-00	Automatic Operation Mode Selection
Range	【0】**:** Disable 【1, 4】**:** Execute a single cycle operation. 【2, 5】**:** Execute continuous cycle operation. 【3, 6】**:** After completion of a single cycle, the on-going operation speed is based on the speed of the last stage. **1 to 3:** After a stop the inverter will continue where it left off when run command is re-applied. **4 to 6:** After a stop the inverter will start at step 1 when run command is re-applied.

Automatic operation mode uses frequency reference parameters 05-01, 06-01~06-15, operation time parameters 06-16 ~ 06-31 and direction of operation parameters 06-32~06-47.

Note: The automatic operation mode is disabled when any of the following functions are enabled:

- Frequency wobbling function
- PID function
- Parameters 06-16 to 06-31 are set to 0.

Notes:

- When automatic operation mode is enabled multi-step speed reference command 1~4 (03-00~03-07=2~5) is disabled.
- Frequency of multi-step speed 0 is set by 05-01.
- Acceleration/deceleration time is set by parameter 00-14 and 00-15 in automatic operation mode.

Automatic operation frequency reference settings	
06-01	Frequency Setting of Speed-Stage 1
06-02	Frequency Setting of Speed -Stage 2
06-03	Frequency Setting of Speed -Stage 3
06-04	Frequency Setting of Speed -Stage 4
06-05	Frequency Setting of Speed -Stage 5
06-06	Frequency Setting of Speed -Stage 6
06-07	Frequency Setting of Speed -Stage 7
06-08	Frequency Setting of Speed -Stage 8
06-09	Frequency Setting of Speed -Stage 9
06-10	Frequency Setting of Speed -Stage 10
06-11	Frequency Setting of Speed -Stage 11
06-12	Frequency Setting of Speed -Stage 12
06-13	Frequency Setting of Speed -Stage 13
06-14	Frequency Setting of Speed -Stage 14
06-15	Frequency Setting of Speed -Stage 15
Range	0.00~400.00 Hz

Automatic operation time settings	
06-16	**Operation Time Setting of Speed-Stage 0**
06-17	**Operation Time Setting of Speed-Stage 1**
06-18	**Operation Time Setting of Speed-Stage 2**
06-19	**Operation Time Setting of Speed-Stage 3**
06-20	**Operation Time Setting of Speed-Stage 4**
06-21	**Operation Time Setting of Speed-Stage 5**
06-22	**Operation Time Setting of Speed-Stage 6**
06-23	**Operation Time Setting of Speed-Stage 7**
06-24	**Operation Time Setting of Speed-Stage 8**
06-25	**Operation Time Setting of Speed-Stage 9**
06-26	**Operation Time Setting of Speed-Stage 10**
06-27	**Operation Time Setting of Speed-Stage 11**
06-28	**Operation Time Setting of Speed-Stage 12**
06-29	**Operation Time Setting of Speed-Stage 13**
06-30	**Operation Time Setting of Speed-Stage 14**
06-31	**Operation Time Setting of Speed-Stage 15**
Range	**0.0~6000.0 Sec**

Automatic operation direction settings	
06-32	**Operation Direction Selection of Speed-Stage 0**
06-33	**Operation Direction Selection of Speed-Stage 1**
06-34	**Operation Direction Selection of Speed-Stage 2**
06-35	**Operation Direction Selection of Speed-Stage 3**
06-36	**Operation Direction Selection of Speed-Stage 4**
06-37	**Operation Direction Selection of Speed-Stage 5**
06-38	**Operation Direction Selection of Speed-Stage 6**
06-39	**Operation Direction Selection of Speed-Stage 7**
06-40	**Operation Direction Selection of Speed-Stage 8**
06-41	**Operation Direction Selection of Speed-Stage 9**
06-42	**Operation Direction Selection of Speed-Stage 10**
06-43	**Operation Direction Selection of Speed-Stage 11**
06-44	**Operation Direction Selection of Speed-Stage 12**
06-45	**Operation Direction Selection of Speed-Stage 13**
06-46	**Operation Direction Selection of Speed-Stage 14**
06-47	**Operation Direction Selection of Speed-Stage 15**
Range	**0:** Stop, **1:** Forward, **2:** Reversal

Example 1: Automatic operation mode – Single cycle

In this example the inverter executes a single cycle and then stops.

Parameter Settings:

06-00 = 1 (Single cycle operation)
06-32~06-34 = 1 (Forward for operation stage 0 - 2)
06-47 = 2 (Reversal for operation stage 15)
06-35~06-46 = 0 (Stop for operation frequency stage 3 - 14)
05-01 = 15 Hz (Operation frequency stage 0: 15 Hz)
06-01 = 30 Hz (Operation frequency stage 1: 30 Hz)
06-02 = 50 Hz (Operation frequency stage 2: 50 Hz)
06-15 = 20 Hz (Operation frequency stage 15: 20 Hz)
06-16 = 20 sec (Operation time stage 0: 20 sec)
06-17 = 25 sec (Operation time stage 1: 25 sec)
06-18 = 30 sec (Operation time stage 2: 30 sec)
06-31 = 40 sec (Operation time stage 15 :40 sec)

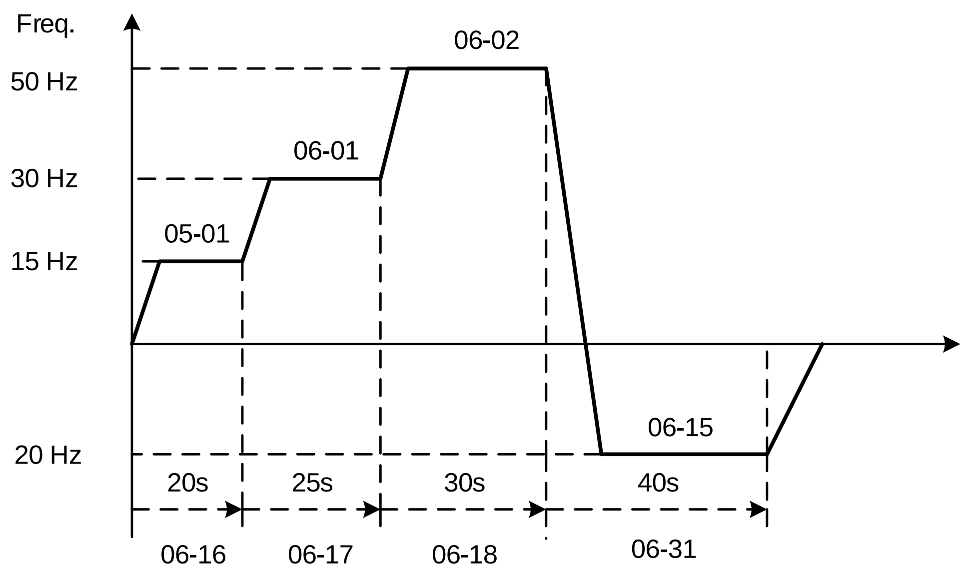


Figure 4.3.42 Single cycle automatic operation (stop)

Example 2: Automatic operation mode – Continuous cycle

In this example the inverter repeats the same cycle.

Parameter Settings:

06-00 = 2 or 5 (Continuous cycle operation)
06-01~06-47= Enter same setting as that of Example 1.

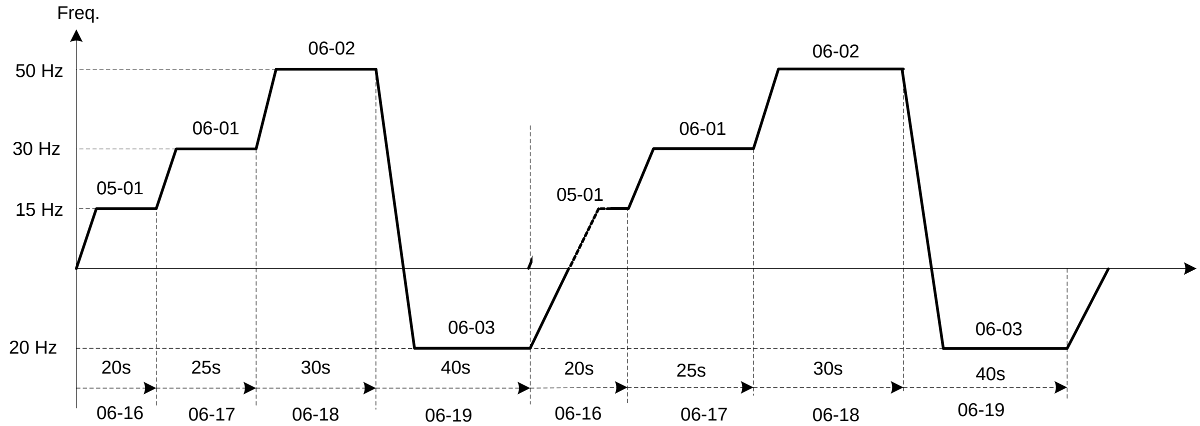


Figure 4.3.43 Periodic automatic operation

Example 3: Automatic operation mode – Single cycle and continue running at last speed of the cycle

In this example the inverter executes a single cycle and continue running at last speed of the cycle.

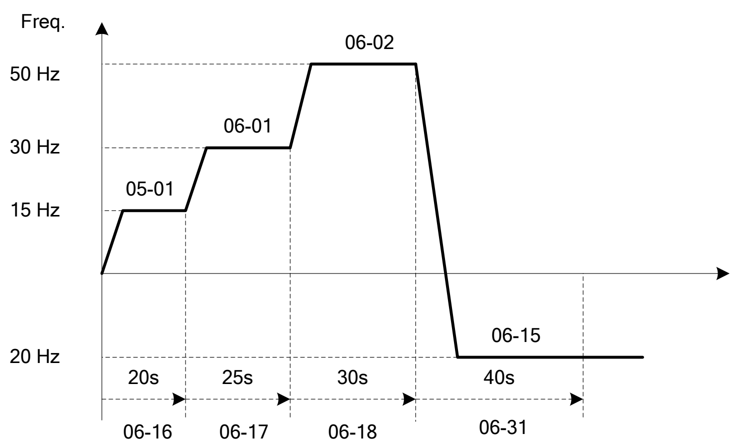
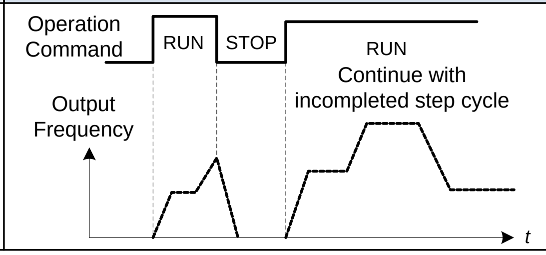
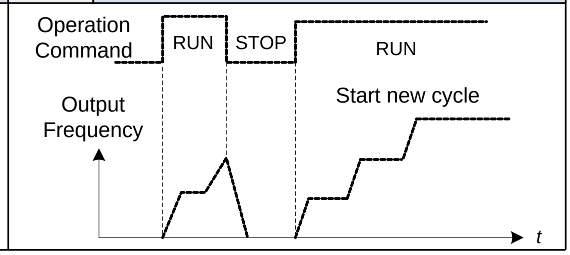


Figure 4.3.44 Single cycle automatic operation (continuous)

06-00= 1 to 3:
After a stop the inverter will start with the incomplete step when the run command is re-applied.

06-00= 4 to 6:
After a stop the inverter will start with the first step of the cycle when the run command is re-applied.

06-00	1 to 3	06-00	4 to 6
Output Frequency			

Notes:

- Acceleration/ deceleration time is set with parameters 00-14 and 00-15 in automatic operation mode.
- If the setting value of parameters 06-16~06-31 is 0, automatic operation mode is not active.

Group 07: Start /Stop Parameters

07-00	Momentary Power Loss/Fault Restart Selection
Range	【0】: Disable 【1】: Enable

07-00=0: Inverter trips on "UV" fault if power loss time is greater than 8ms.

07-00=1: Inverter restarts after restarting the power at the momentary power loss.

Note: When 07-00=1, inverter restores motor operation when is re-applied even if momentary power loss has occurred.

07-01	Fault Auto-Restart Time
Range	【0~7200】 Sec

07-01 = 0 sec.: Automatic restart time interval is set by minimum baseblock time (07-18).
07-01 <07-18: Automatic restart time interval is set by minimum baseblock time (07-18).
07-01> 07-18: Automatic restart time interval is set by fault reset time (07-01).

Note:
Automatic restart time interval is defined by time set in 07-18 plus 07-01 and the speed search delay time (07-22).

Refer to Fig.4.3.45 for setting automatic restart interval.

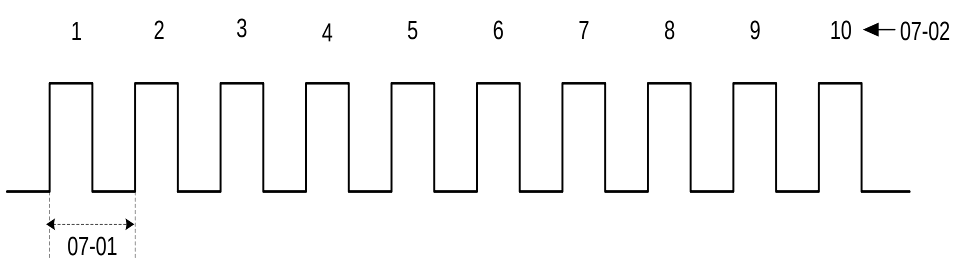


Figure 4.3.45 Automatic restart operation

07-02	Number of Fault Auto-Restart Attempts
Range	【0~10】

When the automatic restart function is enabled the internal automatic restart attempt counter is reset based on the following actions:

a) No fault occurs in 10 minutes or longer after the automatic restart
b) Reset command to clear fault via input terminal or using the keypad (ex: press reset/ ◄ key)
c) Power to the inverter is turned off and back on again

Note:
Multi-function digital output R1A-R1C, R2A-R2C, R3A-R3C can be programmed to activate during an automatic reset attempt, refer to parameter 03-11, 03-12 and 03-39.

Automatic restart operation:

a) Fault is detected. The inverter turn off the output, displays the fault on the keypad and waits for the minimum baseblock time parameter 07-18 to expire before accepting another run / automatic restart command.

b) After the minimum baseblock time (07-18) has expired, the active fault is reset and a speed search operation is performed. The time between each fault restart attempt is set by parameter 07-01.
c) When the total numbers of restart attempts exceed the number of automatic restart attempts set in parameter 07-02, the inverter will turn off the output and the fault contact is activated.

Please refer to Figure 4.3.46 for the automatic restart operation.

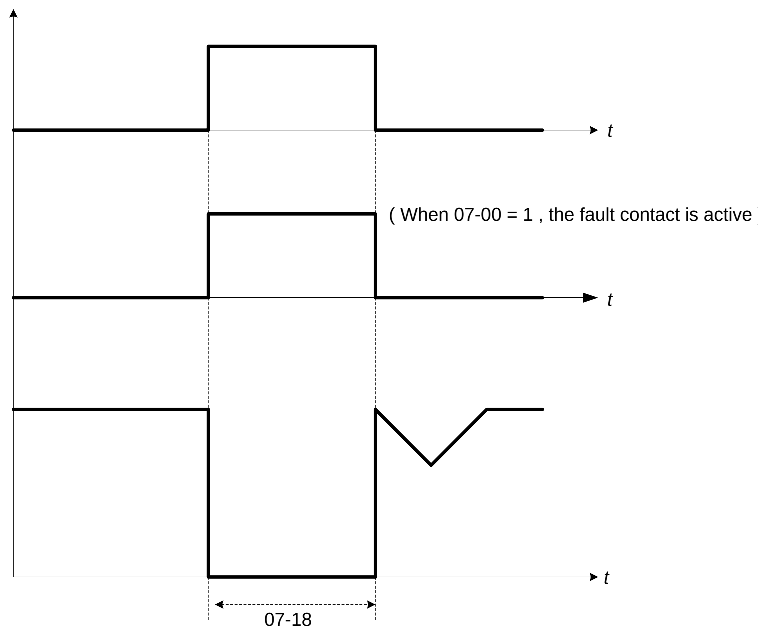


Figure 4.3.46 Auto-restart operation

The automatic restart function is active for the following faults. Please note that when the fault is not listed in the table the inverter will not attempt an automatic restart.

<table>
<tr><th>Parameter Name</th><th colspan="2">Faults</th><th>Numbers of Restart</th></tr>
<tr><td>07-00</td><td colspan="2">UV (under voltage)</td><td>Unlimited</td></tr>
<tr><td>07-01

07-02</td><td>OC (over current)
OL1 (motor overload)
UT (Under torque detection)
IPL (input phase loss)
GF (ground failure)</td><td>OV (overvoltage)
OL2 (Inverter overload)
OT (Over-torque detection)
OPL (Output phase loss)</td><td>Depends on parameter 07-02</td></tr>
</table>

Notes:
1. Fault restart function contains momentary power loss restart and auto reset restart.
2. Refer to chapter 10 for troubleshooting and fault diagnostics.
3. Refer to speed search function (07-19~07-24) for information on the available speed search modes.

Note:
Automatic restart function is only active in the state of no harm to the safety or to the application devices.

Warning - Excessively use of the automatic restart function can damage the inverter.

07-04	Direct Start at Power Up
Range	【0】: Enable (Start inverter when run signal is active at power-up) 【1】: Disable

07-04 = 0:
Starts inverter (run motor) when signal run is present at power-up.

07-04 =1:
Inverter will not start when run signal is active at power-up (STP1 will flash). To run the inverter remove the run command signal and re-apply run command again.

07-05	Delay Time of Direct Start
Range	【1.0~300.0】 Sec

When 07-04 = 0, the inverter (run motor) will start when signal run is present at power-up after timer specified by parameter 07-05 has expired.

Warning:

- When run signal is active, 07-04 = 0 and run command source is set to external control (00- 02/00- 03 = 1) it is recommended to remove run command at power down to prevent damage to the drive and injury to the user.

07-06	DC Injection Braking Starting Frequency
Range	【0.0~10.0】Hz

DC injection braking start frequency is the level the output frequency has to reach before DC braking injection function is activated.

07-07	DC Injection Braking Current
Range	【0~100】%

DC Injection braking current as percentage of the inverter rated current. Increasing this level will increase the amount of heat generated by the motor windings. Do not set this parameter higher than the level necessary to hold the motor shaft.

07-08	DC Injection Braking Time at Stop
Range	【0.00~10.00】Sec

Duration of DC injection braking is during a stop operation. DC injection braking at stop is disabled when parameter 07-08 is set to 0 sec.

07-16	DC Injection Braking Time at Start
Range	【0.00~100.00】Sec

Duration of DC injection braking is during a start operation. DC injection braking at start is disabled when parameter 07-16 is set to 0 sec.

DC Injection Braking Operation

When DC Injection braking is active DC voltage is applied to the motor, increasing the braking current and resulting in an increase in the strength of the magnetic field trying to lock the motor shaft.

To enable DC injection braking during a start operation set the DC injection braking current (07-07) and the DC injection braking time (07-16) at start to a value greater than 0. DC injection braking at start can be used to prevent “wind milling effect” in fan applications.
To enable DC injection braking during a stop operation set the DC injection braking current (07-07) and the DC injection braking time at stop (07-08) to a value greater than 0.

Notes:
- When parameter 07-16 is set to 0 sec. the inverter will start from the minimum output frequency.
- Increasing the DC braking time (07-08, 07-16) can reduce the motor stop time.
- Increasing the DC braking current (07-07) can reduce the motor stop time.
- During stop operation: If the DC braking start frequency < minimum output frequency (01-08), DC braking is activated when the output frequency reaches the minimum output frequency level.
- DC Injection braking cannot be used in sensor vector control (SV).

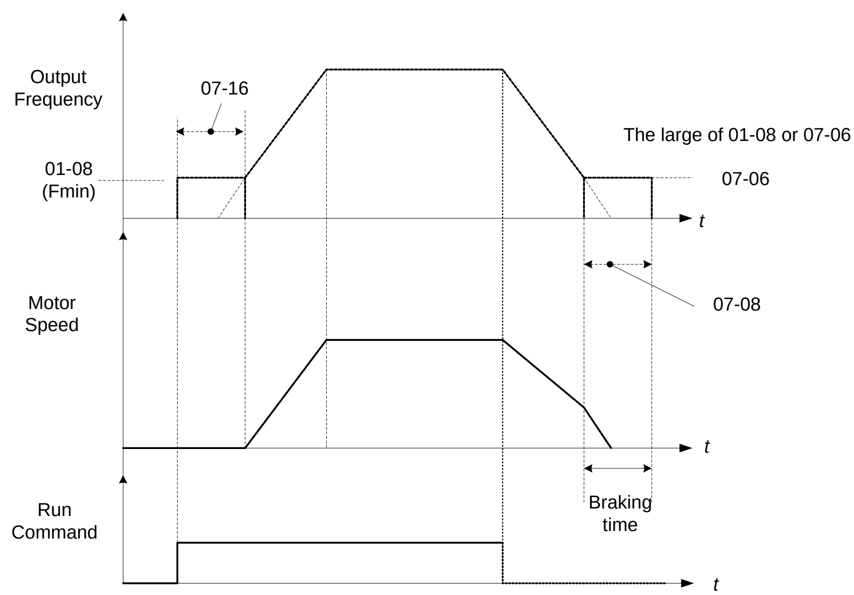


Figure 4.3.47 DC braking operation

DC braking operation can be controlled via any one of the multi-function input terminals (03-00 to 05) function 33. Refer to Fig. 4.3.47 for DC braking operation.

DC braking current can be controlled via the multi-function analog input (04-05) function 5. Refer to Fig. 4.3.34.

07-09	Stop Mode Selection
Range	【0】: Deceleration to Stop 【1】: Coast to Stop 【2】: DC Braking Stop 【3】: Coast to Stop with Timer

When a stop command is issued the inverter stops according to the stop mode selected. There are four types of stop modes,

Note: When using the permanent magnet motor, only the option of deceleration to stop mode is available.

07-09=0: Deceleration to stop

When a stop command is issued, the motor will decelerate to the minimum output frequency (01-08) Fmin and then stop. Deceleration rate depends on the deceleration time (factory default: 00-15).

When the output frequency reaches the DC braking stop frequency (07-06) or the minimum output frequency (01-08), DC injection braking is activated and the motor stops.

$$\text{Deceleration time} = \frac{\text{Output frequency when stop command is issued}}{\text{Maximum output frequency } F_{max} \text{ (01-02)}} \times \text{deceleration time setting}$$

Note: S curve setting will add to the overall stop time

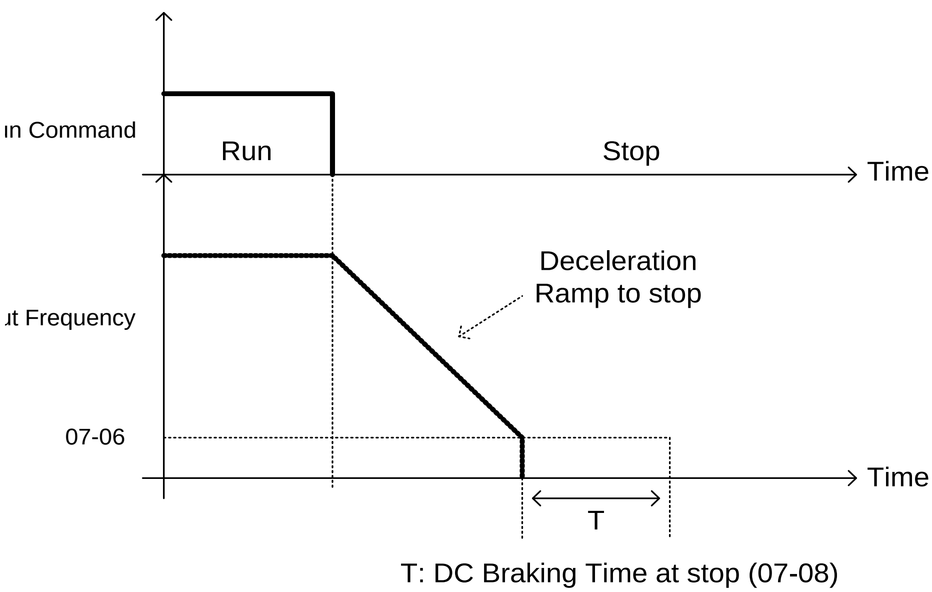


Figure 4.3.48 Deceleration to stop

07-09=1: Coast to stop

When a stop command is issued, the motor will coast to a stop. Stop time depends on motor load and friction of the system.

The inverter waits for the time set in the minimum baseblock time (07-18) before accepting the next run command.

In SLV mode (00-00=2) the speed search function is automatically enabled upon the next run command.

Note: When using a mechanical brake set parameter 07-26 to 1.

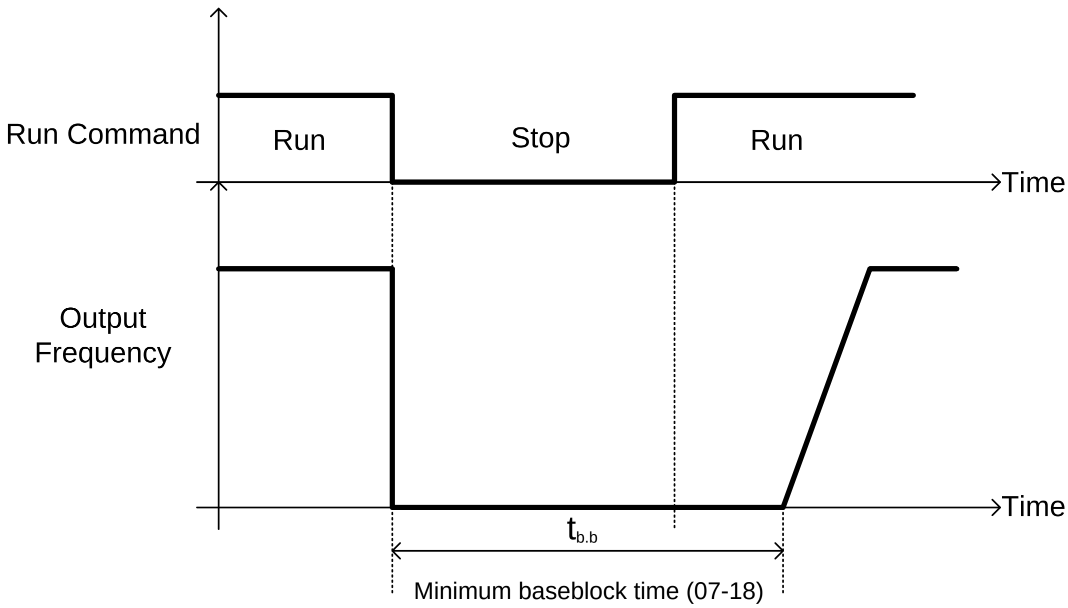


Figure 4.3.49 Coast to stop

07-09=2: DC braking to stop

When a stop command is issued, the inverter will turn off the output (Baseblock) and after the minimum Baseblock time (07-18) has expired activate DC braking (07-07). Refer to Fig.4.3.50.

The DC braking time (tDCDB) of Figure 4.3.50 is determined by the value of 07-08 (DC Braking start time) and the output frequency at the time the stop command was issued.

$$t_{DCDB} = \frac{(07\text{-}08) \times 10 \times \text{output frequency}}{\text{Fmax } (01\text{-}02)}$$

Note: Increase the minimum Baseblock time (07-18) in case an Overcurrent trip occurs during the DC braking.

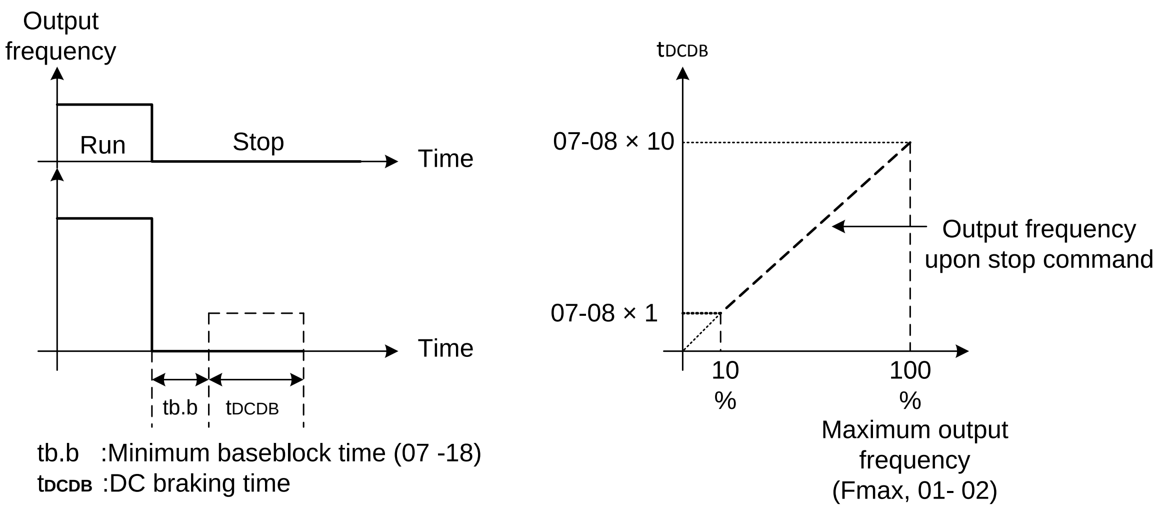


Figure 4.3.50 DC braking to stop

07-09=3: Coast to stop with timer

When a stop command is issued the motor will coast to a stop after the minimum Baseblock time (07-18) has expired. The inverter ignores the run command until the total time of the timer has expired.

The total time of the timer is determined by the deceleration time (00-15, 17, 22 or 24) and the output frequency upon stop. Refer to Fig.4.3.51

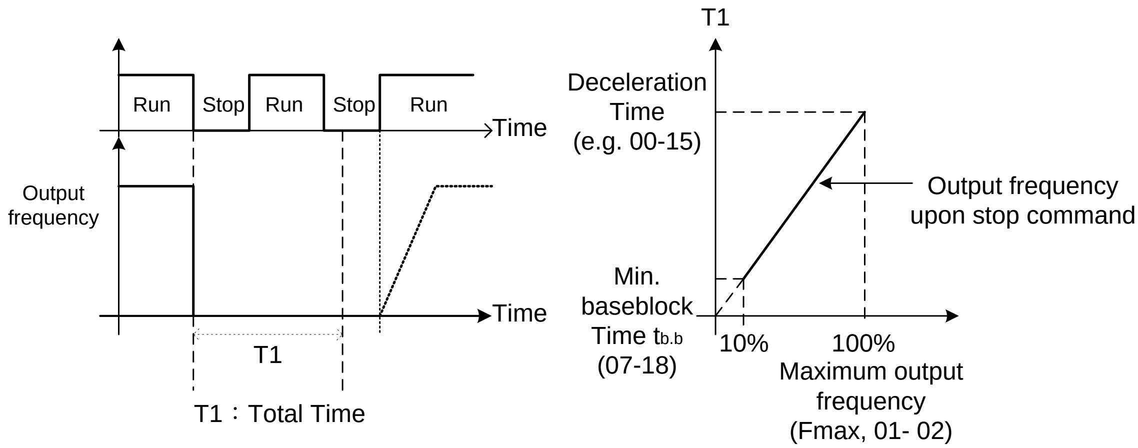


Figure 4.3.51 Coast to stop with timer

07-13	Low Voltage Detection Level
Range	【230V】: 150~300V 【460V】: 300~600V
07-25	Low voltage Detection Time
Range	【0.00~1.00】Sec

Adjust the 07-13 voltage level from 150 to 300 Vdc (for 230V series) or from 300 to 600 Vdc (for 460V series).

When the AC input voltage is lower than the 07-13 value (07-13/ 1.414 = AC voltage detection level) for the time specified in 07-25 the low-voltage error "UV" will displayed. If 07-25 = 0.00 sec., the UV error will be displayed immediately.

Set preventive measures:

- The inverter input voltage will limit the output voltage. If the input voltage drops excessively, or if the load is too big, the motor may stall.
- If the input voltage drops below the value set in 07-13 then the output is turned off momentarily. The inverter will not automatically start when power is restored.

07-14	Pre-excitation Time
Range	【0.00~10.00】Sec
07-15	Pre-excitation Level
Range	【50~200】%

If a high starting torque is required for the application, especially for a large horsepower motors, the pre-excitation operation can be used to pre-flux (magnetize) the motor.

07-14: Pre-excitation time

When an operation command (forward or reverse) is activated, the inverter will automatically start pre-excitation based on the time set in parameter 07-14.

The time for the flux to reach 100% is a function value of motor's electrical time constant (See figure 4.3.52).

Electrical time constant (quadratic by-pass circuit time constant) can be calculated by motor parameter setting (group 02)

$$\text{Electrical time constant T2} = \frac{\text{Motor leakage inductance (02-17) + motor mutual inductance (02-18)}}{\text{Motor rotor resistance (02-16)}}$$

Set the pre-excitation time (07-14) based on the electrical time constant T2

07-15: Pre-excitation initial level

Use the pre-excitation initial level (07-15) to provide a higher excitation current during the pre-excitation time (07-14), which will increase the speed and stability for motors.

In order to quickly magnetize the motor, reduce the pre-excitation time (07-14) and set the pre-excitation level (07-15) to a high level.

If 07-15 is set greater than 100%, providing a high excitation current during the pre-excitation time (07-14), motor's magnetization time is shorted. When the setting reaches 200%, magnetization is reduced by roughly half.

A high pre-excitation level (07-15) might result in excessive motor sound during pre-excitation.

When the flux reaches 100%, pre-excitation current reverts back to 100% and pre-excitation is completed.

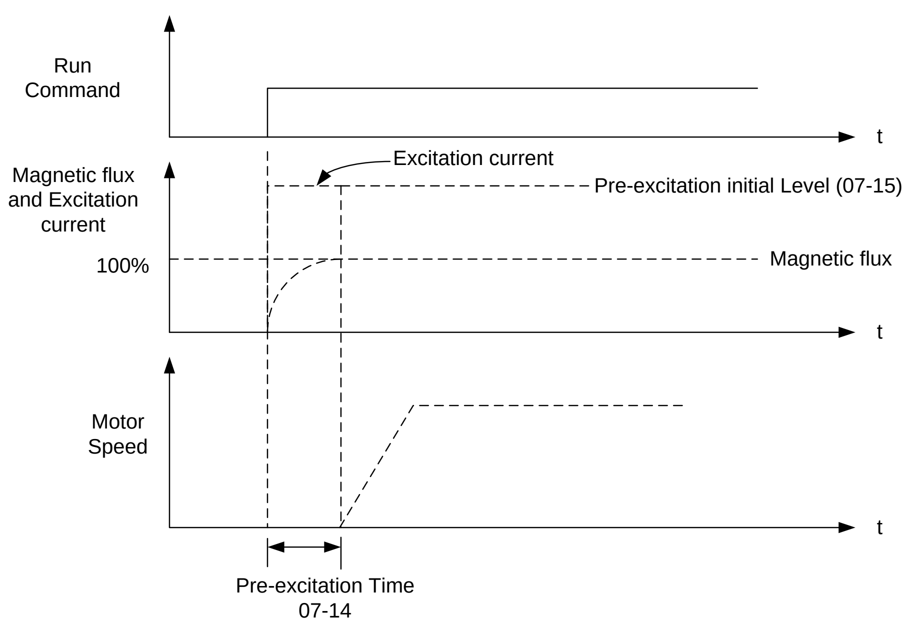


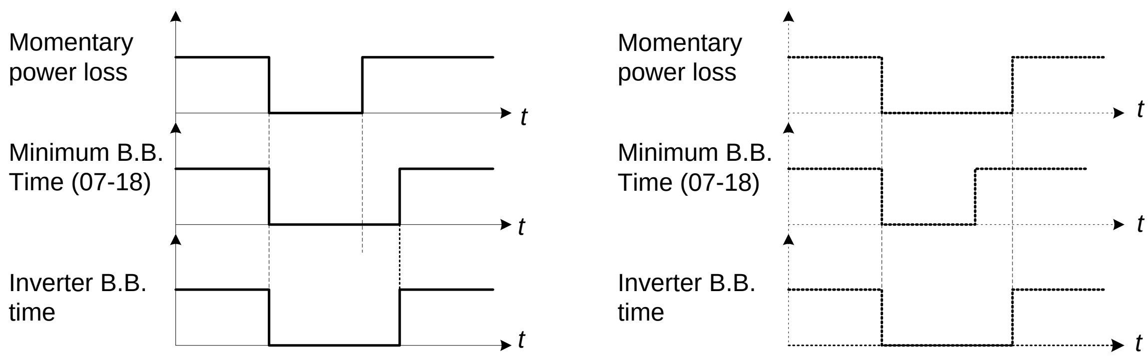
Figure 4.3.52 Pre-excitation operation

07-18	Minimum Base block Time
Range	【0.1~5.0】Sec

In case of a momentary power failure, the inverter continues to operate after the power has been restored when parameter 07-00 is set to 1. Once the momentary power failure is detected; the inverter will automatically shut down the output and maintain B.B for a set time (07-18).

It is expected that after the minimum base block time has expired the residual voltage to be almost zero.

When the momentary power failure time exceeds the minimum base block time (07-18), the inverter will automatically perform a speed search upon return of power. Refer to the following figure 4.3.53.



(a) Minimum baseblock time (07-18) greater than momentary power loss time

(b) Minimum baseblock time (07-18) is shorter than momentary power loss time

Figure 4.3.53 Minimum B.B time and momentary power loss time

Minimum base block time (07-18) is also used to for the DC braking function in combination with speed search as follows:

- Set the minimum base block time required (07-18).
- Execute speed search or DC braking function.
- Increase minimum Baseblock time if over-current "OC" condition occurs.
- After speed search is completed, normal operation continues.

07-19	Bi-Direction-Detection Speed Search Operating Current
Range	【0~100】%
07-20	One Direction-Detection Speed Search Operating Current
Range	【0~100】%
07-21	Integral Time of Speed Searching
Range	【0.1~10.0】Sec
07-22	Delay Time of Speed Search
Range	【0.0~20.0】Sec
07-23	Voltage Recovery Time
Range	【0.1~5.0】Sec

07-24	Bi-Direction-Detection Speed Search Selection
Range	【0】: Disable 【1】: Enable
07-26	**Start Selection after Coast to Stop during SLV mode**
Range	【0】: Speed search start 【1】: Normal Start
07-27	**Start Selection after Fault during SLV Mode**
Range	【0】: Speed search start 【1】: Normal Start
07-28	**Start after External Base Block**
Range	【0】: Speed search start 【1】: Normal Start

Speed search function is used to find the speed of a coasting motor and continue operation from that point. The speed search function is active after a momentary power loss.

Speed Search from Multi-function digital inputs

Set the multi-function digital input to external speed search command 1 or 2. External speed search command 1 (value = 19) and 2 (value = 34) cannot be set at the same time, otherwise "SE02" (digital input terminal error) warning occurs.

Speed search function must be enabled before applying the run command to ensure proper operation. See relay logic in Fig. 4.3.54.

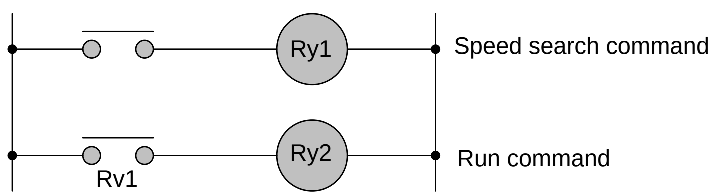


Figure 4.3.54 Speed search and operation commands

Notes: Speed Search Operation
- The speed search cannot be used when the motor rated power is greater than the inverter rated power.
- The speed search cannot be used when the motor rated power is two inverter sizes smaller than the inverter currently used.
- The speed search cannot be used in combination with a high-speed motor.
- In V/F mode, it is necessary to perform a static auto-tune.
- In SLV mode, it is necessary to perform a rotational auto-tune. Perform a static auto-tune when using long motor leads.

Speed search uses current detecting. Use parameter 07-24 to select detection direction.

07-19: Speed Direction Search Operating Current

- Used in bidirectional speed search only (07-24 = 1).
- Set bidirectional current level.

- Increase value if speed search is not successful at low speeds (above 5Hz)
  Note: If value is too high may cause DC braking effect.

07-20: Speed Search Operating Current
- Can be used for bidirectional (07-24 = 1) or unidirectional (07-24 = 0) speed search.
- Sets speed search current Level.
- The set value must be lower than the excitation current (02-09) and must equal to the no-load current. If the no-load current is unknown it is recommended to set value at 20%.
- Excessive speed search current will cause inverter output to saturate.
- It is recommended to use speed search in case of a momentary power loss. Increase the minimum base block time (07-18) in case of an over-current condition.

07-21: Integral time of speed searching

- Can be used for bidirectional (07-24 = 1) or unidirectional (07-24 = 0) speed search.
- Set the integral time during speed search.
- If OV occurs, increase the set value to increase the speed search time. Decrease the value if a quick start is required

07-22: Delay time of speed search

- Use delay time when using a contactor on the inverter output side.
- The inverter speed search starts after the delay time expires.
- Speed search delay time is disabled when set to 0.0 sec. (07-22 = 0.0)

07-23: Voltage recovery time

- Sets the voltage recovery time.
- Sets the time for the inverter to restore the output voltage from 0V to the specified V/f level after speed search function is completed.

07-24: Direction-Detection Speed Search Selection

07-24=0: Disable Direction-Detection Speed Search
Speed search is executed using speed search operating current defined in parameter 07-20. In case speed search is not successful (e.g. motor speed is too low) a speed search time-out warning is displayed. Set 07-19 to value greater than 0 to enable DC braking at speed search if a time-out occurs frequently.

07-24=1: Enable Direction-Detection Speed Search

At start the current controller will send a step current to the motor (07-19) to determine the motor direction. Once direction is determined the current controller will perform a speed search using speed search operating current defined in parameter 07-20. Speed search is executed after a momentary power loss (external speed search command 2, 03-00 to 03-05 = 34) or from max. frequency (external speed search command 1, 03-00 to 03-05 = 19). Speed search direction will follow the speed command.

07-26: SLV Speed Search Function

- In SLV mode (00-00 = 2) set the stop mode to the coast stop (07-09 = 1) or to the coast to stop with timer (07-09 = 3). After a stop command is issued (coast to stop or coast to stop with times) the speed search function is automatically activated for the next start.

07-26=0: Speed search start (No mechanical brake is installed)

07-26=1: Normal Start (Mechanical brake is installed)

07-27: Start Selection after fault during SLV mode

07-27=0: Speed search start: Speed search is executed after a fault in SLV mode.

07-27=1: Normal start: Speed search is not enabled.

Note: Set the parameter to 1 (normal start) after a fault has occurred and a mechanical brake is used to stop the motor.

07-28: Start after external Baseblock

07-28=0: Speed search start: Speed search is executed after base block is removed.

07-28=1: Normal start: Speed search is not enabled.

Notes:

- Set parameter to 1 for the control mode of SLV mode (00-00 = 2) when the external base block active time is longer than the time the motor needs to come to a complete stop. After the external base block command is removed the inverter will accelerate from min. frequency.
- The inverter has no choices but can only normally start when using permanent magnetic motor.

■ Speed search based on current detection

(a) Speed search at starting

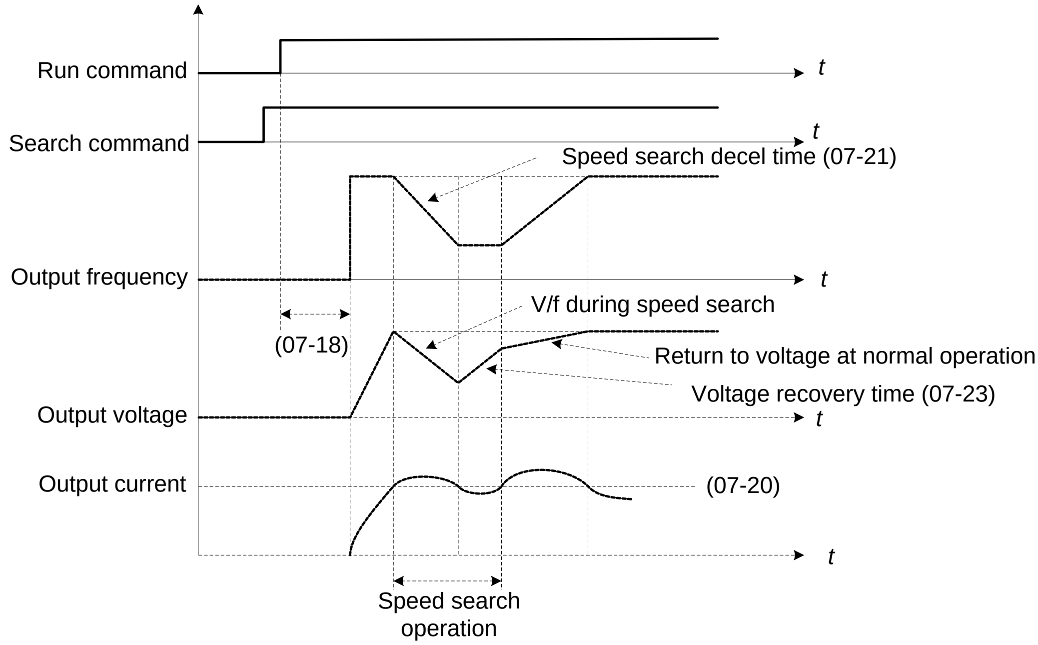


Figure 4.3.55 Speed search at starting

(b) Speed search in recovery period of momentary power failure

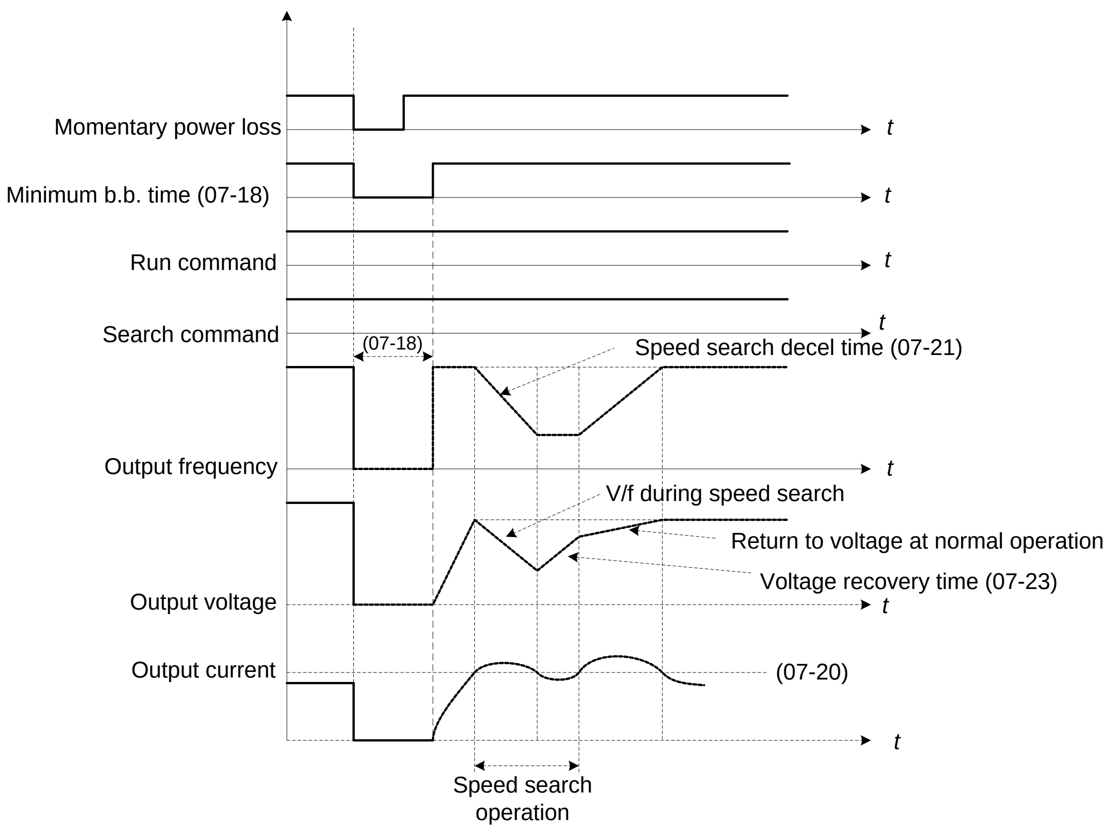


Figure 4.3.56 Speed search in recovery period of momentary power failure

Notes:

- If the minimum base block time (07-18) is longer than the momentary power failure time, the speed search starts operation after the minimum base block time (07-18).
- If the minimum base block time (07-18) is too short, the speed search operation begins immediately after power has been restored.

07-29	Run Command Available During DC Braking
Range	**【0】:** Disable (Run command is disregarded until the DC braking is completed) **【1】:** Enable

When 07-29 is set to 0 the run command input is ignored until DC braking is completed.

When 07-29 is set to 1 the run command input overrides the DC braking function.

Group 08: Protection Parameters

08-00	Stall Prevention Function
Range	【xxx0b】: Stall prevention is enabled in acceleration. 【xxx1b】: Stall prevention is disabled in acceleration. 【xx0xb】: Stall prevention is enabled in deceleration. 【xx1xb】: Stall prevention is disabled in deceleration. 【x0xxb】: Stall prevention is enabled in operation. 【x1xxb】: Stall prevention is disabled in operation. 【0xxxb】: Stall prevention in operation decelerates based on deceleration time 1 【1xxxb】: Stall prevention in operation decelerates based on deceleration time 2
08-01	Stall Prevention Level in Acceleration
Range	【30~200】%
08-02	Stall Prevention Level in Deceleration
Range	【330~410】V : 230V 【660~820】V : 460V
08-03	Stall Prevention Level in Operation
Range	【30~200】%
08-21	Limit of Stall Prevention in Acc over Base Speed
Range	【0~100】%
08-22	Stall Prevention Detection Time in Operation
Range	【2~100】msec

Stall prevention during acceleration (08-00=xxx0b)

Prevents the inverter from faulting (Overcurrent, Motor overload, Inverter overload) when accelerating with heavy loads.

When the inverter output current reaches the level set in parameter 08-01 minus 15% the acceleration rate starts to decrease. When the inverter output current reaches the level set in parameter 08-01 the motor stops accelerating. Refer to Fig.4.3.57 for more information.

Notes:
- Reduce stall prevention level during acceleration (08-01) in case the motor stalls (when the motor power is smaller than the inverter rating.
- The inverter rated output current should be set to 100%.

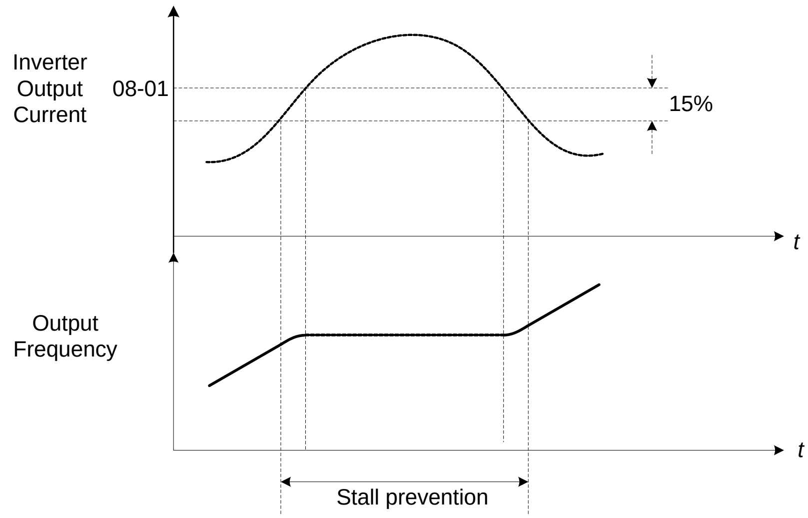


Figure 4.3.57 Stall prevention during acceleration

If the motor is used in the constant power (CH) region, the stall prevention level (08-01) is automatically reduced to prevent the stall.

Stall prevention level during acceleration (Constant horsepower)

$$\text{Stall Prev. Lev. Acceleration (CH)} = \frac{\text{Stall prevention level in acceleration (08-01) x Fbase (01-12)}}{\text{Output frequency}}$$

Parameter 08-21 is the stall prevention limit value in Constant Horsepower region. Refer to Fig.4.3.58.

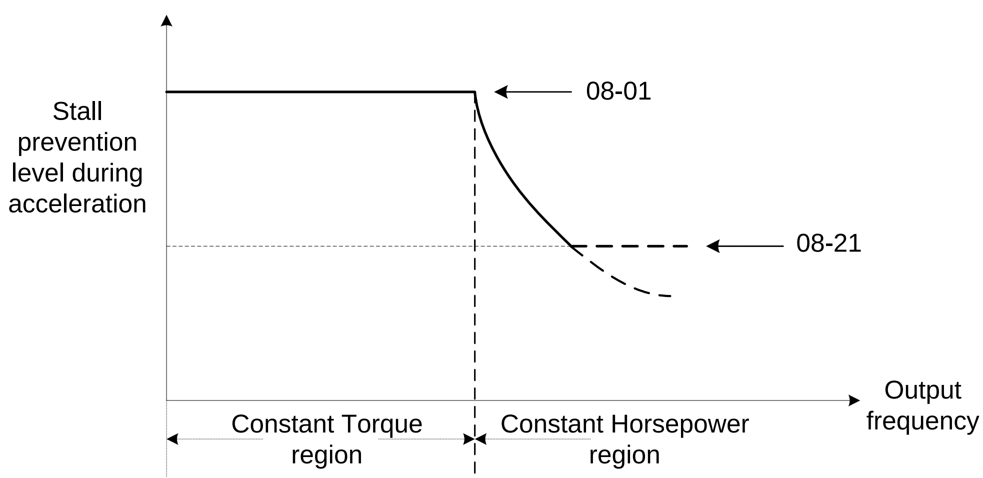


Figure 4.3.58 Stall prevention level and limit in acceleration

Stall prevention selection during deceleration (08-00=xx0xb)

Stall prevention during deceleration automatically increases the deceleration time according based on the DC-bus voltage to prevent over-voltage during deceleration. Refer to Fig.4.3.59 for stall prevention during deceleration

When the DC-bus voltage exceeds the stall prevention level deceleration will stop and the inverter will wait for the DC-bus voltage to fall below the stall prevention level before continuing deceleration. Stall prevention level can be set by 08-02, see Table 4.3.10.

Table 4.3.10 Stall prevention level

Inverter model	08-02 default value
230V class	385VDC
460V class	770VDC

Note: When using external braking (braking resistor or braking module) disable stall prevention during deceleration (08-00 to xx1xb).

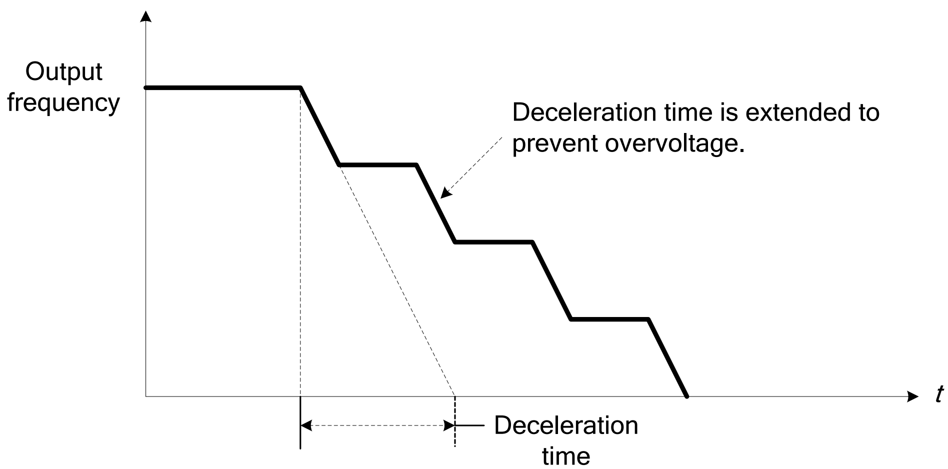


Figure 4.3.59 Stall prevention selection in deceleration

Stall prevention selection during run (08-00=x0xxb)

Stall prevention during run can only be used in V/F or SLV control mode.

This function prevents the motor from stalling by automatically reducing the output frequency during run.

If the inverter output current rises above the level set in parameter 08-03 for the time specified in parameter 08-22, the inverter output frequency is automatically decreased following deceleration time 1 (00-15) or deceleration time 2 (00-17).

When the inverter output current falls below the level set in parameter (08-03) minus 2%, normal operation continues and the output frequency increases to the frequency reference using the acceleration time 1 or acceleration time 2. Refer to the following Fig.4.3.60.

Note: The stall prevention level during run can be set by using multi-function analog input AI2 (04-05=7).

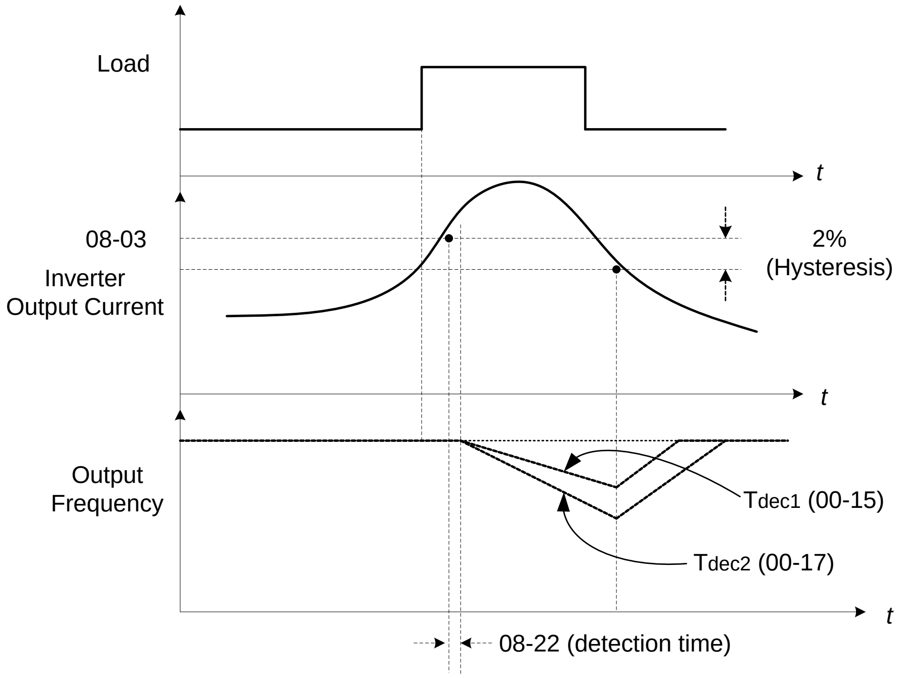


Figure 4.3.60 Stall prevention selection in operation

08-05	Selection for Motor Overload Protection (OL1)
Range	【xxx0b】: Motor Overload Protection is disabled. 【xxx1b】: Motor Overload Protection is enabled. 【xx0xb】: Cold Start of Motor Overload 【xx1xb】: Hot Start of Motor Overload 【x0xxb】: Standard Motor 【x1xxb】: Special motor 【0xxxb】: Reserved 【1xxxb】: Reserved

The motor overload protection function estimates the motor overload level based on the output current, output frequency, motor characteristics and time. The motor overload trip time depends on the motor rated current when the output frequency is higher than 60Hz.

On inverter power-up the motor overload protection internal thermal accumulation register is automatically reset.

To use the built-in motor overload protection function parameter 02-01 (motor rated current) has to match the motor rated current on the motor nameplate.

Turn off the motor overload protection when using two or more motors connected to the inverter (set 08-05 = xxx0b), and provide external overload protection for each motor (e.g. thermal overload switch).

With cold start enabled (08-05 = xx0xb), motor overload protection occurs in 5 and a half minutes when operating the motor at 150% of the motor rated current at an output frequency greater than 60Hz.

With hot start enabled (08-05 = xx1xb), motor overload protection occurs in 3 and a half minutes when operating the motor at 150% of the motor rated current at an output frequency greater than 60Hz.

Refer to the following Fig.4.3.61 for an example of motor overload protection standard curve.

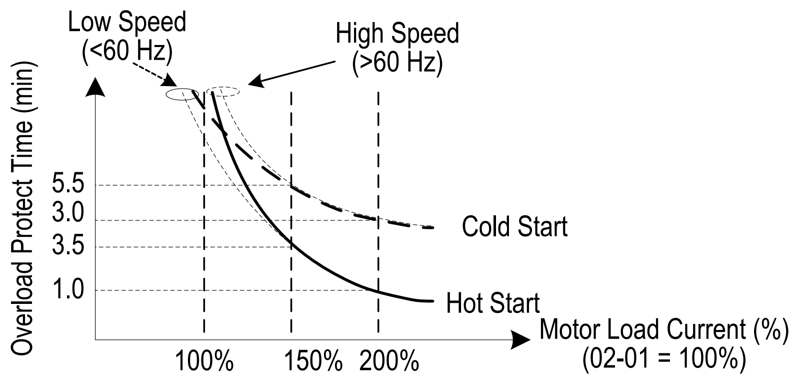


Figure 4.3.61 Motor overload protection curve (example: standard motor)

When using force cooled motors (Special inverter motor), thermal characteristics are independent of the motor speed, set 08-05 = x1xxb.

When 08-05 = x1xxb, overload protection function is based on motor rated current for output frequencies between 6 and 60Hz. If the output frequency is lower than 1Hz, the overload protection function uses 83% of the motor rated current to determine an overload condition.

When 08-05 = x0xxb, overload protection function is based on 70% of the motor rated current for an output frequency of 20Hz. If the output frequency is lower than 1Hz, the overload protection function uses 40% of the motor rated current to determine an overload condition.

Refer to Fig.4.3.62 for motor overload rating at different output frequencies.

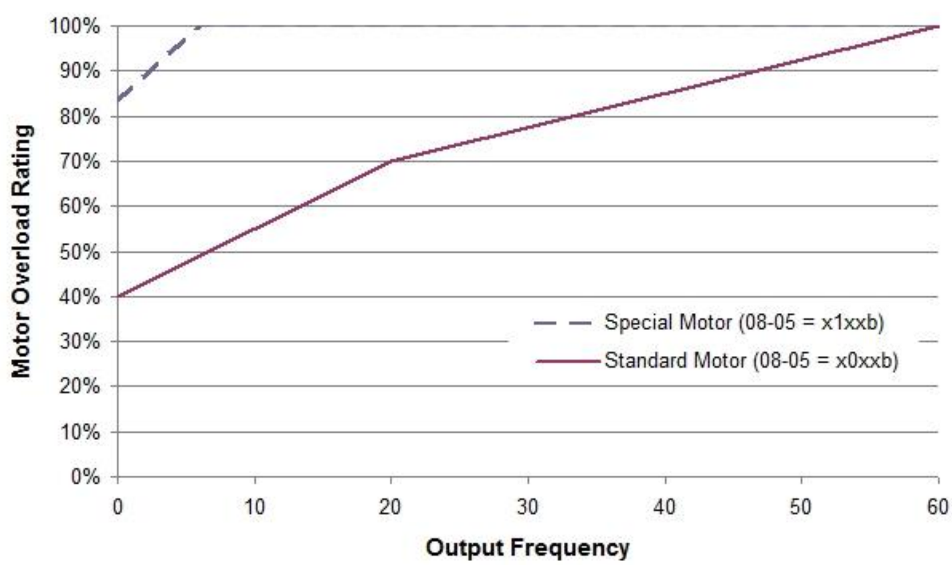


Figure 4.3.62 Motor overload rating at different output frequencies

08-06	Start-up mode of overload protection operation (OL1)
Range	【0】: Stop Output after Overload Protection 【1】: Continuous Operation after Overload Protection.

08-06=0: When the inverter detects a motor overload the inverter output is turned off and the OL1 fault message will flash on the keypad. Press RESET button on the keypad or activate the reset function through the multi-function inputs to reset the OL1 fault.

08-06=1: When the inverter detects a motor overload the inverter will continue running and the OL1 alarm message will flash on the keypad until the motor current falls within the normal operating range.

08-08	Automatic Voltage Regulation (AVR)
Range	【0】: AVR is enabled 【1】: AVR is disabled

Automatic voltage regulation stabilizes the motor voltage independent of fluctuation to the input voltage.

08-08=0: Automatic voltage regulation is active.

08-08=1: Automatic voltage regulation is not active, motor voltage follows the input voltage fluctuation.

08-09	Selection of Input Phase Loss Protection
Range	【0】: Disable 【1】: Enable

08-09=0: Input phase loss detection is disabled.

08-09=1: Input phase loss detection is enabled. Keypad shows "IPL input Phase Loss" (IPL), when an input phase loss is detected the inverter output is turned off and the fault contact is activated.

Note: The input phase loss detection is disabled when the output current is less than 30% of the inverter rated current.

08-10	Selection of Output Phase Loss Protection
Range	【0】: Disable 【1】: Enable

08-10=0: Output phase loss detection is disabled.

08-10=1: Output phase loss detection is enabled. Keypad shows "OPL Output Phase Loss" (OPL), when an output phase loss is detected the inverter output is turned off and the fault contact is activated.

Note: The output phase loss detection is disabled when the output current is less than 10% of the inverter rated current.

08-13	**Selection of Over-Torque Detection**
Range	**【0】: Over-Torque Detection is Disabled.** **【1】: Start to Detect when Reaching the Set Frequency.** **【2】: Start to Detect when the Operation is Begun.**
08-14	**Selection of Over-Torque Operation**
Range	**【0】: Deceleration to Stop when Over- Torque is Detected.** **【1】: Display Warning when Over- Torque is Detected. Go on Operation.** **【2】: Coast to Stop when Over Torque is Detected.**
08-15	**Level of Over-Torque Detection**
Range	**【0~300】%**
08-16	**Time of Over-Torque Detection**
Range	**【0.0~10.0】Sec**
08-17	**Selection of Low-Torque Detection**
Range	**【0】: Low-Torque Detection is Disabled.** **【1】: Start to Detect when Reaching the Set Frequency.** **【2】: Start to Detect when the Operation is Begun.**
08-18	**Selection of Low-Torque Operation**
Range	**【0】: Deceleration to Stop when Low- Torque is Detected.** **【1】: Display Warning when Low- Torque is Detected. Go on Operation.** **【2】: Coast to Stop when Low-Torque is Detected.**
08-19	**Level of Low-Torque Detection**
Range	**【0~300】%**
08-20	**Time of Low-Torque Detection**
Range	**【0.0~10.0】Sec**

The over torque detection function monitor the inverter output current or motor torque and can be used to detect increase in inverter current or motor torque (e.g. heavy load).

The low torque detection function monitor the inverter output current or motor torque and can be used to detect a decrease in inverter current or motor torque (e.g. belt break).

The torque detection levels (08-15, 08-19) are based on the inverter rated output current (100% = inverter rated output current) when operating the inverter in V/F control mode and motor output torque (100% = motor rated torque) when operating the inverter in SLV control mode.

Over-torque detection

Parameter 08-13 selects over-torque detection function. An over-torque condition is detected when the output current / torque rises above the level set in parameter 08-15 (Over-torque detection level) for the time specified in parameter 08-06 (Over-torque detection time).

08-13=0: Over-torque detection is disabled.

08-13=1: Over-torque detection is enabled when the output frequency reaches the set frequency.

08-13=2: Over-torque detection is enabled during running.

Parameter 08-14 selects the way the inverter acts when an over-torque condition is detected.

08-14=0: When an over-torque condition is detected the inverter displays and over-torque detection fault and the motor decelerates to a stop.

08-14=1: When an over-torque condition is detected the inverter displays an over-torque detection alarm and continues to run.

08-14=2: When an over-torque condition is detected the inverter displays and over-torque detection fault and the motor coasts to a stop.

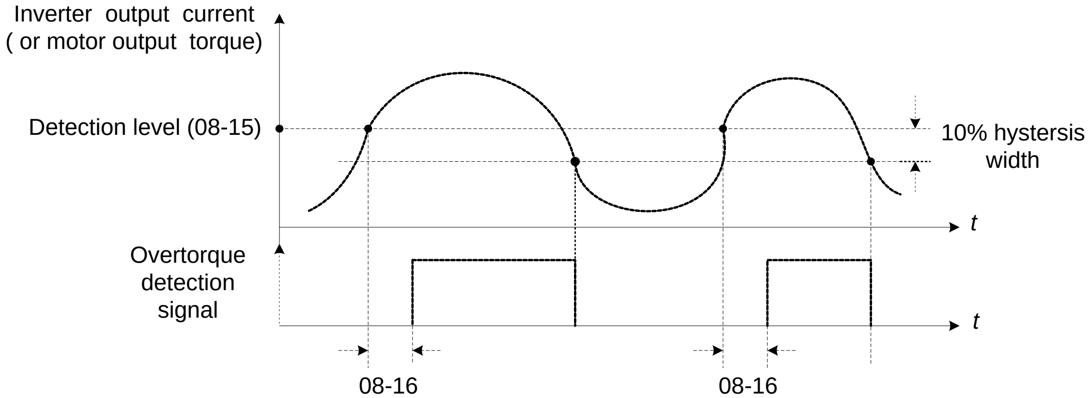


Figure 4.3.63 Over-torque detection operation

Low-torque detection

Parameter 08-18 selects low-torque detection function. An low-torque condition is detected when the output current / torque falls below the level set in parameter 08-19 (low-torque detection level) for the time specified in parameter 08-20 (Low-torque detection time).

08-17=0: Low-torque detection is disabled.

08-17=1: Low-torque detection is enabled when the output frequency reaches the set frequency.

08-17=2: Low-torque detection is enabled during running.

Parameter 08-18 selects the way the inverter acts when an over-torque condition is detected.

08-18=0: When a low-torque condition is detected the inverter displays and low-torque detection fault and the motor decelerates to a stop.

08-18=1: When a low-torque condition is detected the inverter displays a low-torque detection alarm and continues to run.

08-18=2: When a low-torque condition is detected the inverter displays and low-torque detection fault and the motor coasts to a stop.

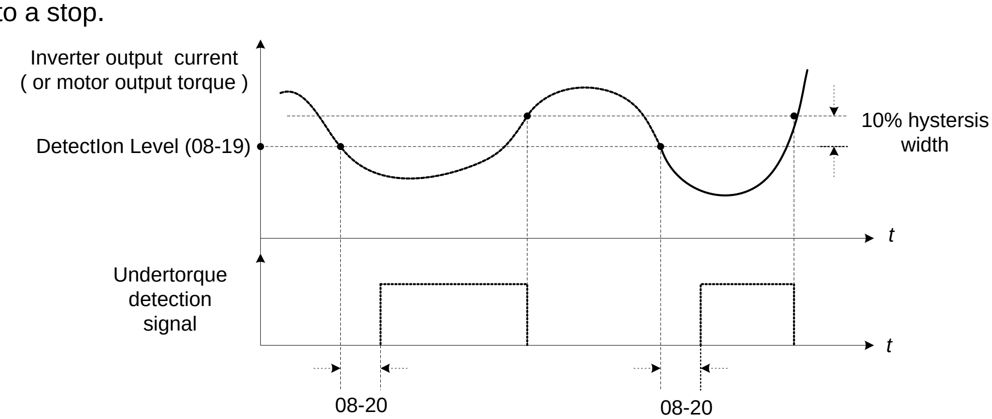


Figure 4.3.64 Low torque detection operation

Over and low torque detection condition can be output to the multi-function digital outputs (R1A-R1C, R2A-R2C, R3A-R3C) by setting parameters 03-11, 03-12 and 03-39 to 12 or 25. Refer to Fig. 4.3.65 for more information.

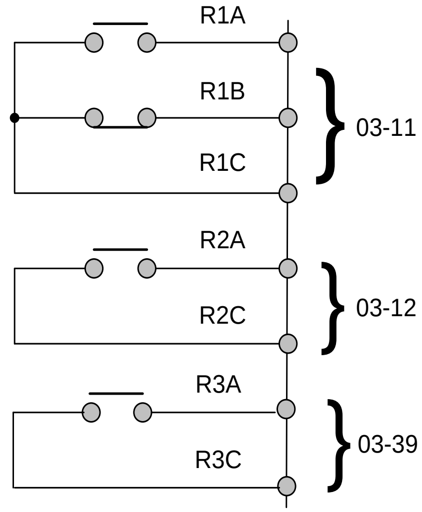


Figure 4.3.65 Over-torque / low torque detection multi-function digital output terminal

08-23	Ground Fault (GF) Selection
Range	【0】: Disable 【1】: Enable

If the inverter leakage current is greater than 50% of inverter rated current and the ground fault function is enabled (08-23), the keypad will display a "GF Ground Fault" (GF), motor will coast to a stop and fault contact is activated.

08-24	External Fault Operation Selection
Range	【0】: Deceleration to Stop 【1】: Coast to Stop 【2】: Continuous Operation

When multi-function digital input terminal is set to 25 (the external fault) and this terminal signal is triggered off, parameter 08-24 (Operation Selection of External Fault) can be selected to stop it. The selection of stop modes is the same as 07-09.

08-25	Detection selection of External Fault
Range	【0】: Immediately Detect when the Power is Supplied 【1】: Start to Detect during Operation

The reason for the detection of external faults is determined by parameter 08-25.

- When 08-25=0, faults are immediately detected at power up.
- When 08-25=1, faults are detected when the inverter is running.

08-30	Safety Function Operation Selection
Range	【0】: Deceleration to Stop 【1】: Coast to Stop

If multi-function digital input terminal is set to 58 (Safety Function), inverter will stop based parameter 08-30 stop method selection.

08-37	Fan Control Function
Range	【0】: Start During Operation 【1】: Immediately Start when Power is supplied 【2】: Start During High Temperature
08-38	Delay Time of Fan Off
Range	【0~600】Sec

08-37=0: Start at Operation

Fan is on when inverter is running.
When the inverter stops the fan will stop after the delay time specified in 08-38 has expired.

08-37=1: Permanent Start

When the inverter is at power on, fan will start permanently.

08-37=2: Start at High Temperature

If the heatsink temperature is higher than that of internal temperature setting the fan will start immediately.
If the temperature is lower than internal temperature value or the delay time Fan Off (08-38) has expired the fan will be turned off.

Note: Fan control function is disabled for models of 40HP or the above (230V) and 50HP or the above (460V) for IP20 series

08-35	Motor Overheat Operation Selection
Range	【0】: Disable 【1】: Deceleration to Stop 【2】: Coast to Stop
08-36	PTC Filter Time
Range	【0.00 ~ 5.00】
08-39	Delay Time of Motor Overheat Protection
Range	【1 ~ 300】Sec

Motor overheat protection can be detected by using a PTC (positive temperature coefficient) thermistor.

PTC Thermistor connects to terminals MT and GND. If the motor is overheating, the keypad displays error code OH4.

08-35=0: Motor overheat fault selection is disabled.

08-35=1, 2: When motor overheats the inverter will trip and the motor will stop running.

Motor overheating is detected when PTC value rises above1330Ω and the time specified by 08-38 has expired. The keypad will display an “OH4 Motor overheat” and fault output is activated.

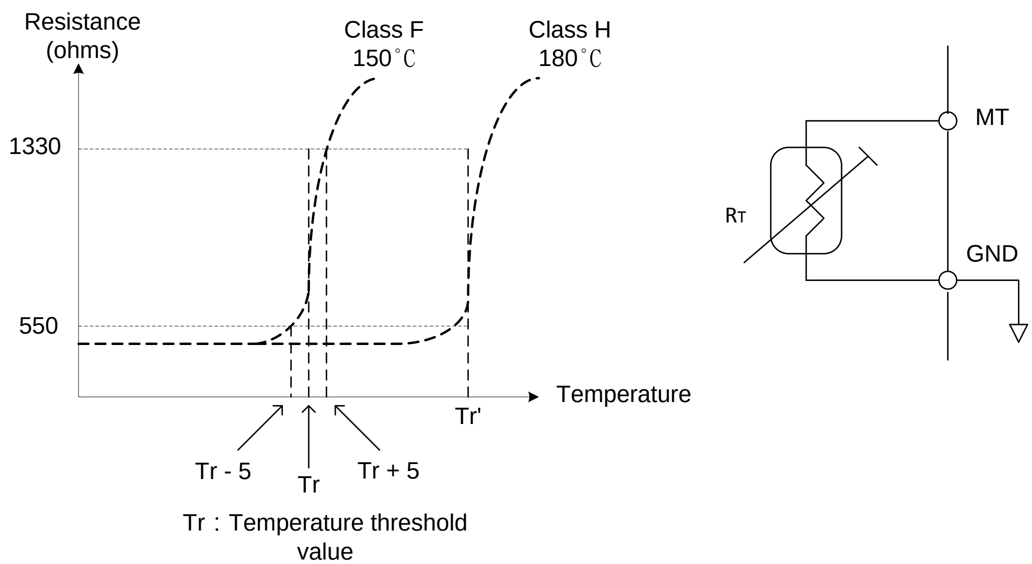
When the value of thermistor of PTC is $R_T < 550\Omega$ display (OH4) is reset.

Note: The stop mode of the inverter fault is set by 08-35.
08-35=1: Deceleration to stop when the inverter fault occurs.
08-35=2: Coast to stop when the inverter fault occurs

Notes:

- If no PTC thermistor is connected to MT and GND, the keypad will display an “OH4 Motor overheat.”
- The value of the external PTC thermistor is in compliance with British National Standard.
  When Tr is 150°C in class F and 180°C in class H,
  a. Tr －5°C RT<= 550Ω
  b. Tr ＋5°C：RT>=1330Ω

Refer to Fig. 4.3.66 for the connecting between the corresponding temperature of thermistor of PTC and terminals.



(a) PTC Thermistor Characteristics

(b) PTC Thermistor Connections

Figure 4.3.66 Protection of motor overheating

Group 09: Communication Parameters

09-00	INV Communication Station Address
Range	【1~31】
09-01	Communication Mode Selection
Range	【0】: MODBUS 【1】: BACnet 【2】: Metasys 【3】: Multi PUMP 【4】: PROFIBUS
09-02	Baud Rate Setting (bps)
Range	【0】: 1200 【1】: 2400 【2】: 4800 【3】: 9600 【4】: 19200 【5】: 38400
09-03	Stop Bit Selection
Range	【0】: 1 Stop Bit 【1】: 2 Stop Bits
09-04	Parity Selection
Range	【0】: No Parity 【1】: Even Bit 【2】: Odd Bit
09-06	Communication Error Detection Time
Range	【0.0~25.5】Sec
09-07	Fault Stop Selection
Range	【0】: Deceleration to Stop Based on Deceleration Time 1 【1】: Coast to Stop when Communication Fault Occurs. 【2】: Deceleration to Stop Based on Deceleration Time 2 【3】: Keep Operating when Communication Fault Occurs.
09-08	Comm. Fault Tolerance Count
Range	【1~20】
09-09	Waiting Time
Range	【5~65】msec
09-10	Device Instance Number
Range	1~254

The Modbus communication port RJ45 (S+, S-) can be used to monitor, control, program and trouble-shoot the inverter. The built-in RS-485 can support the following communication protocol:

- Modbus communication protocol
- BACnet communication protocol (Refer to section 4.6 for more details)
- Metasys communication protocol (Refer to section 4.7 for more details)
- Pump in Parallel Connection (Refer to parameter group 23 for more details)
- Profibus communication protocol (Refer to section 11.7 Profibus communication option card for more details and this function is required to install Profibus card to be enabled.

Modbus communication can perform the following operations, independent of the frequency command selection (00-05) setting and operation command selection (00-02) setting:

- Monitor inverter signals
- Read and write parameters.
- Reset fault
- Control multi-function inputs

Modbus (RS-485) communication specification:

Items	Specification
Interface	RS-485
Communication type	Asynchronous (start - stop synchronization)
Communication parameters	Baud rate: 1200, 2400, 4800, 9600, 19200 and 38400 bps Data Length: 8 bits (Fixed) Parity: options of none, even and odd bit. For even and odd selection stop bit is fixed at 1 bit.
Communication protocol	Modbus RTU / ASCII
Number of inverters	Maximum 31 units

Communication wiring and setup

(1) Turn off power to the inverter.
(2) Connect communication lines of the controller to the inverter (RJ45).
(3) Turn power on.
(4) Set the required communication parameters (09-00) via the keypad.
(5) Turn off power to the inverter and wait until keypad is completely off.
(6) Turn power on
(7) Start communication between controller and inverter.

Modbus (485) communication architecture

(1) Modbus communication configuration uses a master controller (PC, PLC), communicating to a maximum of 31 inverters.
(2) The master controller is directly connected to the inverter via the RS-485 interface. If the master controller has a RS-232, a converter must be installed to convert signals to RS-485 to connect the master controller to the inverter.
(3) A maximum 31 inverters can be connected to a network, following the Modbus communication standard.

Communication Parameters:

09-00: Inverter station addresses: Range 1-31

09-02: RS-485 communication baud rate setting
= 0: 1200 bps (bits / second)
= 1: 2400 bps
= 2: 4800 bps
= 3: 9600 bps
= 4: 19200 bps
= 5: 38400 bps

09-03: Stop bit selection
= 0: 1 stop bit
= 1: 2 stop bits

09-04: Parity selection of RS-485 communication
= 0: No parity.
= 1: even parity.
= 2: odd parity.

09-06: RS-485 communication error detection time

09-07: Stop selection of RS-485 communication failure
= 0: Deceleration to stop by deceleration time 00-15
= 1: Coast to stop
= 2: Deceleration to stop using the deceleration time of 00-26 (emergency stop time)
= 3: Continue to operate (only shows a warning message, press the stop button to stop operation)

09-08: Comm. fault tolerance count
When the number of communication errors exceeds the value set in parameter 09-08 the inverter will display the comm. Fault alarm.

09-09: Wait time of inverter transmission
Sets the inverter response delay time. This is the time between the controller message and the start of the inverter response message. Refer to Fig. 4.3.67. Set the controller receive time-out to a greater value than the wait time parameter (09-09).

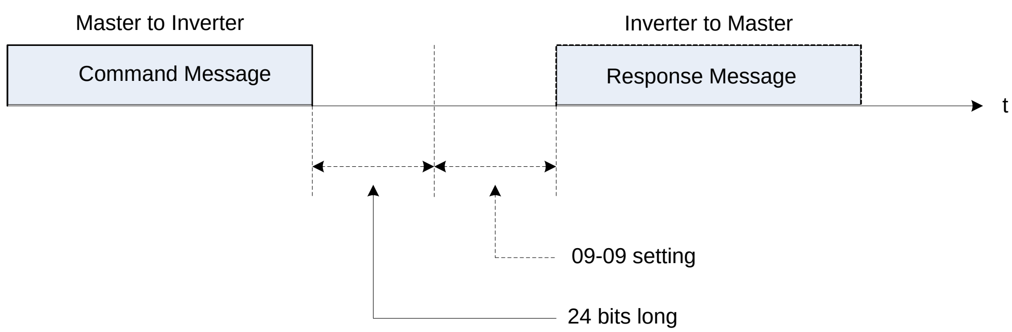


Figure 4.3.67 Communication Message Timing

Group 10: PID Parameters

10-00	PID Target Value Source Setting
Range	【1】: AI1 Input 【2】: AI2 Input 【3】: Reserved 【4】: 10-02/12-38 Value 【5】: Reserved 【6】: Refer to the Setting of 00-05

Operation Pressure Setting (23-02) or Target Value of Flow Meters (PUMP or HVAC function selection) can be set as PID's target value only when 10-00=0 and 23-00=1 or 2.

When 10-00=1 or 2, signal source proportional is corresponding to PID target via analog input terminal. For example, 0~10V is corresponding to the target of 0~100% so 2V is equivalent with the target value of 20%.

For normal use of PID, set 10-00 to 4 and set PID target value in parameter 10-02.

When 10-00=4, in addition to the percentage setting of 10-02 (PID target value), it allows PID setting (12-38) in the main screen monitor. The maximum target value is set via parameter 10-33 (PID maximum feedback value), the decimals are set via parameter 10-34 (PID decimal width) and the unit is set via parameter 10-35 (PID unit). For example:
When 10-33 = 999, 10-34 = 1, 10-35 = 3 and 10-02 = 10%, then 12-38 = 9.9 PSI displayed in the main screen monitor. User can also modify the value of 12-38 in the main screen monitor but the maximum value is 99.9 PSI (depending on the setting value of 10-33).

When 10-00=6, active frequency command (main frequency command) is used for the PID setpoint.

10-01	PID Feedback Value Source Setting
Range	【1】: AI1 Input 【2】: AI2 Input 【3】: Reserved

Note: Parameter 10-00 and 10-01 cannot be set to the same source. If both parameters are set to the same source the keypad will show a SE05 alarm.

10-02	PID Target Value
Range	【0.0~100.0】%
10-03	PID Control Mode
Range	【xxx0b】: PID Disable 【xxx1b】: PID Enable 【xx0xb】: PID Positive Characteristic 【xx1xb】: PID Negative Characteristic 【x0xxb】: PID Error Value of D Control 【x1xxb】: PID Feedback Value of D Control 【0xxxb】: PID Output 【1xxxb】: PID Output +Frequency Command

When 10-03 is set to xxx 0b, PID will is disabled; if it is set to xxx1b, PID is enabled.

Note:

- LCD keypad will be switched automatically (16-00).
- Main Screen Monitoring will be changed to PID Setting (12-38).
- Sub-Screen Monitoring 1 will be changed to PID Feedback (12-39).
- Sub-Screen Monitoring 2 will be changed to Output Frequency (12-17).

At this time, if the setting is disabled, it will be switched automatically back to frequency command as the main page. When switching to PID setting in the LED keypad, it displays the modes selection of parameter 23-05.

Note: when 23-05=0, set the value in the conditions of 10-33 < 1000 and 10-34=1, or the inverter will display the signal of PID setting error (SE05).

When 10-03 is set to xx0xb, PID output occurs forward; if it is set to xx1xb, PID output occurs reversely. If PID feedback value is lower than the target value when PID output is set to be reverse, the output frequency is lower.

When 10-03 is set to x1xxb, PID control for feedback differential value is enabled; if it is set to x0xxb, basic PID control is enabled. Refer to Fig.4.3.69 and Fig.4.3.70.

When 10-03 is set to 0xxxb, PID output is enabled and it is corresponding to the frequency of 01-02 at 100%.

When 10-03 is set to 1xxxb, PID output and frequency command are enabled. The frequency command percentage (01-02) is added to the PID output during run.

10-04	Feedback Gain
Range	【0.01~10.00】
10-05	Proportional Gain (P)
Range	【0.00~10.00】
10-06	Integral Time (I)
Range	【0.0~100.0】Sec
10-07	Differential Time (D)
Range	【0.00~10.00】Sec
10-09	PID Bias
Range	【-100~100】%
10-10	PID Primary Delay Time
Range	【0.00~10.00】%
10-14	PID Integral Limit
Range	【0.0~100.0】%
10-23	PID Limit
Range	【0.00~100.0】%
10-24	PID Output Gain
Range	【0.0~25.0】
10-25	PID Reversal Output Selection
Range	【0】: Do not Allow Reversal Output 【1】: Allow Reversal Output
10-26	PID Target Acceleration/ Deceleration Time
Range	【0.0~25.5】Sec

PID Adjustments

Gain control: The error signal (deviation) between the input command (set value) and the actual control value (feedback). This error signal or deviation is amplified by the proportional gain (P) to control the offset between the set value and the feedback value.

Integral control: The output of this control is the integral of the error signal (difference between set value and feedback value) and is used to minimize the offset signal that is left over from the gain control. When the integral time (I) is increased, the system response becomes slower.

Differential control: This control is the inverse from integral control and tries to estimate the behavior of the error signal by multiplying the error with the differential time. The result is added to the PID input. Differential control slows down the PID controller response and may reduce system oscillation. **Note:** Most applications that PID control (fan and pump) do not require differential control.
Refer to Fig. 4.3.68 for PID control operation

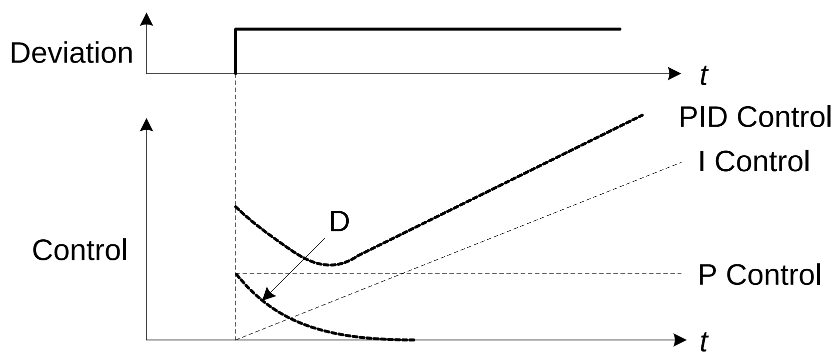


Figure 4.3.68 PID Control

PID Control Type

The inverter offers two types of PID control:

(a) PID control with differential feedback: (10-03 = x1xxb)

Make sure to adjust the PID parameters without causing system instability. Refer to Fig. 4.3.69 for PID control for feedback value differential.

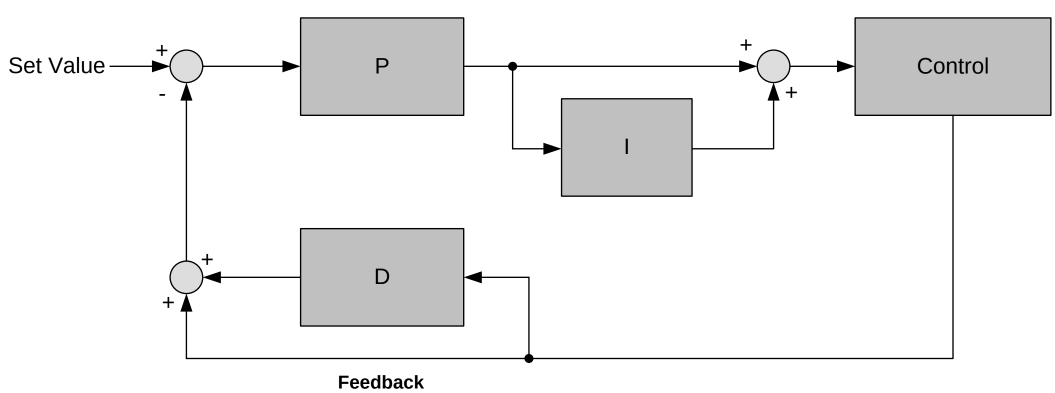


Figure 4.3.69 PID control for feedback differential value

(b) Basic PID control: (10-03 = x0xxb)

This is the basic type of PID control. Refer to the Fig. 4.3.70.

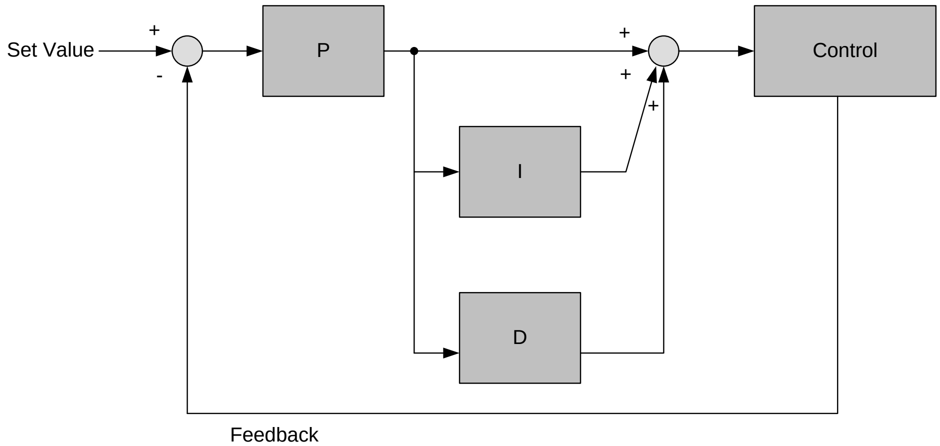


Figure 4.3.70 Basic PID control

PID Setup

Enable PID control by setting parameter 10-03, PID target value (10-00) and PID feedback value (10-01).

To use PID control set frequency command selection 00-05 to 4.

10-00: PID target value
= 0: keypad Input
= 1: analog AI1 Input (default)
= 2: analog AI2 Input
= 3: Reserved
= 4:10-02

10-01: PID feedback value
= 1: Analog AI1 Input
= 2: Analog AI2 Input
= 3: Reserved

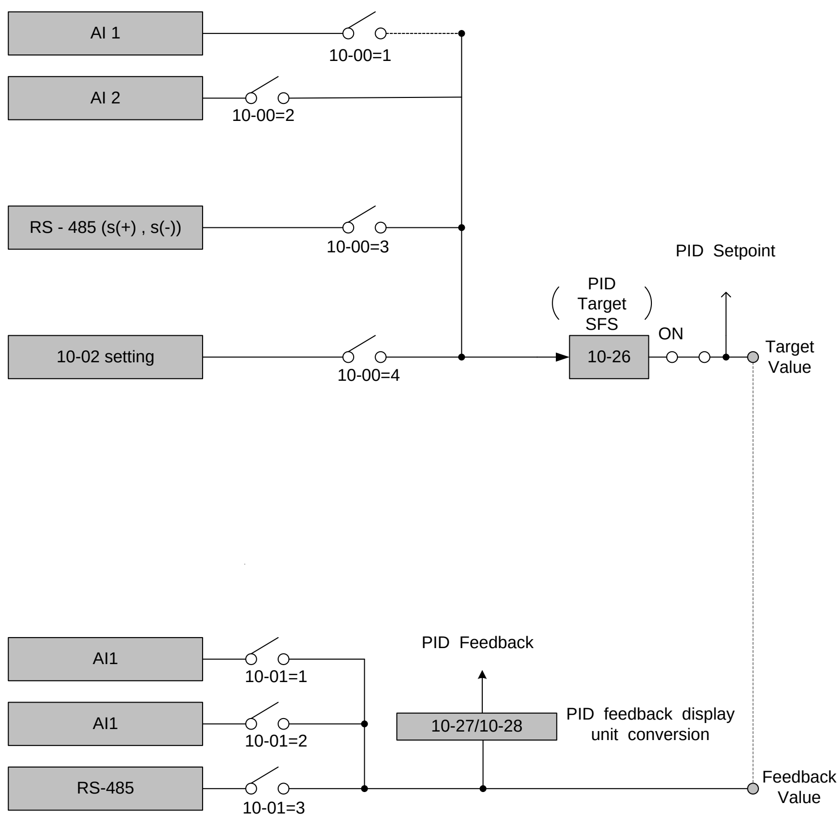


Figure 4.3.71 PID input selection

PID Control Setting

PID control block diagram.

The following figure shows the PID control block diagram.

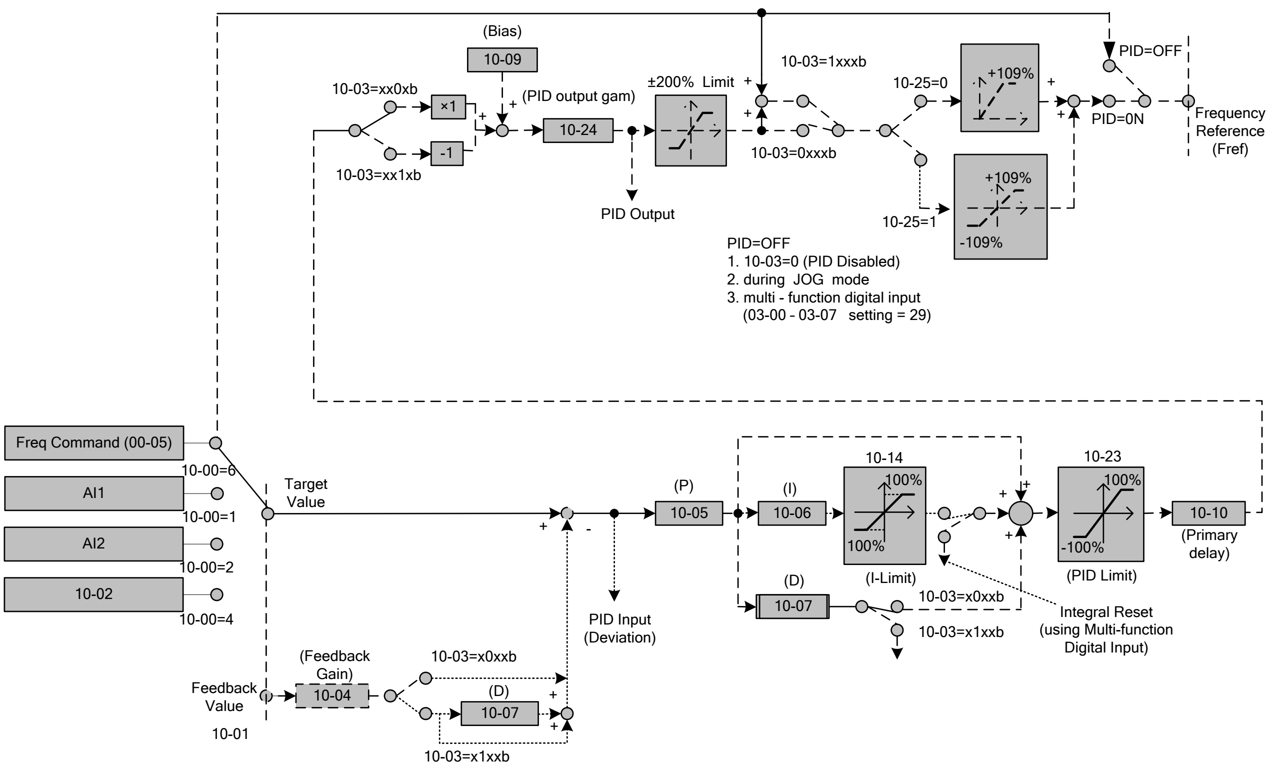


Figure 4.3.72 PID control block diagram

PID Tuning

Use the following procedures to start PID control,
(1) Enable PID control (set 10-03 to a value greater than "xxx0b").
(2) Increase the proportional gain (10-05) to 1.0
(3) Decrease the integral time (10-06) to 10.0
(4) Increase the differential time (10-07) to 0.0
(5) Check system response.

The PID control serves to maintain a given process within certain limits whether it is pressure, flow etc. To do this the feedback signal (e.g. pressure transducer) is compared to the set value and the difference becomes the error signal for the PID control.

The PID control then responds by trying to minimize this error. The error is multiplied times the value of the proportional gain set by parameter **10-05**. An increased gain value results in a larger error. However, in any system as the gain is increased there is a point that the system will become unstable (oscillate).

To correct this instability, the response time of the system may be slowed down by increasing the **Integral time** set by parameter **10-06**. However slowing the system down too much may be unsatisfactory for the process.

The end result is that these two parameters in conjunction with the acceleration time (**01-14**) and deceleration (**01-15**) times require to be adjusted to achieve optimum performance for a particular application.

PID output polarity can be selected with parameter 10-03 (setting = xx0xb: PID output forward, setting = xx1xb: PID output reversal). When the PID output is set for reverse operation the output frequency decreased when the PID target value increases.

PID feedback value can be adjusted using parameter 10-04 (PID feedback gain) as well as with the analog input gain and bias for terminal AI1 or AI2.

10-14: PID integral limit: Used to limit the integral output to prevent motor stall or damage to the system in case of a rapid change in the feedback signal. Reduce the value of 10-14 to increase the inverter response.

10-23: PID limit: Used to limit the output of the PID control. Maximum output frequency is 100%.

10-10: Primary delay time: Low pass filter situated after the PID limit block that can be used to prevent PID output resonance. Increase the time constant to a value greater than the resonance frequency cycle and reduce time constant to increase the inverter response.

10-09: PID bias: Used to adjust the offset of the PID control. The offset value is added to the frequency reference as compensation. Use parameter **10-24** (PID output gain) to control the amount of compensation.

In case the PID control output value goes negative, parameter 10-25 (PID reversal output selection) can be used to reverse the motor direction.

Note: The PID output remains at zero when reverse operation is disabled.

10-26: PID target SFS: Sets the PID target value acceleration and deceleration ramp time. The PID target SFS can be disabled by setting the multi-function digital inputs 03-00 ~ 03-05 to 36 (PID target SFS is off). Reduce the acceleration / deceleration time in case load resonance or system instability is encountered.

PID Fine Tuning

All PID control parameters are related to each other and require to be adjusted to the appropriate values. Therefore, the procedure achieving the minimum steady-state is shown as following:

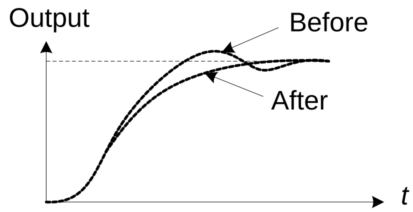
(1) Increase or decrease the proportion (P) gain until the system is stable using the smallest possible control change.

(2) The integral (I) reduces the system stability which is similar to increasing the gain. Adjust the integral time so that the highest possible proportional gain value can be used without affecting the system stability. An increase in the integral time reduces system response.

(3) Adjust the differential time if necessary to reduce overshoot on startup. The acceleration / deceleration time can also be used for the same purpose.

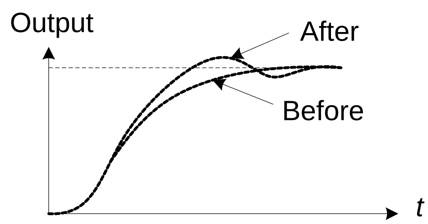
Fine-tuning PID control parameters:

(1) Reduce overshoot



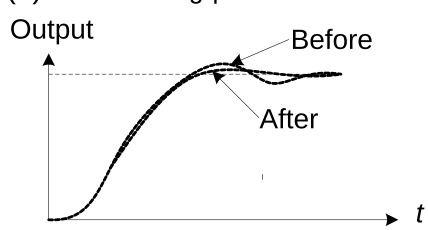
In case overshoot occurs, reduce the derivative time (D) and increase the integral time (I).

(2) Stabilize PID control



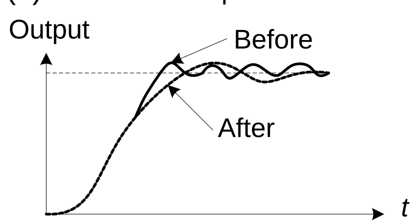
To quickly stabilize the PID control, reduce the integral time (I) and increase the differential time (D) in case overshoot occurs.

(3) Reduce long-period oscillation



Adjust the integral time (I) in case of long-periodical system oscillation.

(4) Reduce short-period oscillation



Adjusting the differential time (D) and proportional (P) gain when experiencing short-periodical oscillation.

10-11	PID Feedback Loss Detection Selection
Range	【0】: Disable 【1】: Warning 【2】: Fault
10-12	PID Feedback Loss Detection Level
Range	【0~100】%
10-13	PID Feedback Loss Detection Time
Range	【0.0~10.0】Sec

The PID control function provides closed-loop system control. In case PID feedback is lost, the inverter output frequency may be increase to the maximum output frequency.

It is recommended to enable to the PID feedback loss when the PID function is used.

PID feedback loss detection

10-11=0: Disable

10-11=1: Warning
A feedback loss condition is detected when the PID feedback value falls below the value set in parameter 10-12 (PID feedback loss detection level) for the time set in parameter 10-13 (PID feedback loss detection time). PID feedback loss warning message "Pb" will be displayed on the keypad and the inverter will continue to operate.

10-11=2: Fault
A feedback loss condition is detected when the PID feedback value falls below the value set in parameter 10-12 (PID feedback loss detection level) for the time set in parameter 10-13 (PID feedback loss detection time). PID feedback loss fault message "Fb" will be displayed on the keypad, the inverter stops and the fault contact is activated.

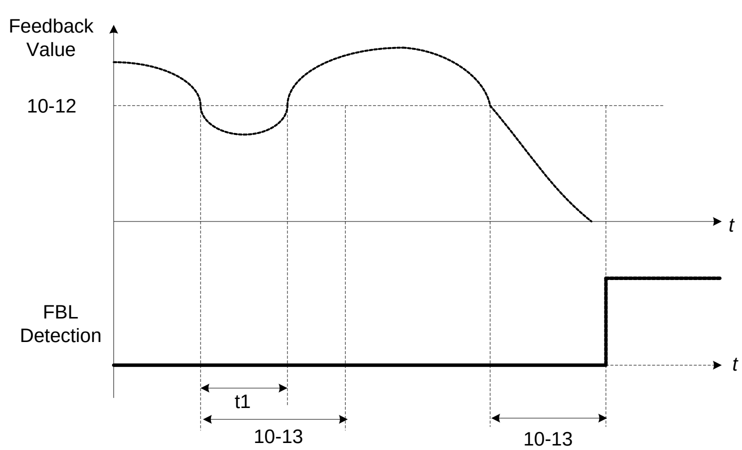


Figure 4.3.73 PID feedback loss detection

10-17	Start Frequency of PID Sleep
Range	【0.00~180.00】Hz
10-18	Delay Time of PID Sleep
Range	【0.0~255.5】Sec
10-19	Frequency of PID Waking up
Range	【0.00~180.00】Hz
10-20	Delay Time of PID Waking up
Range	【0.0~255.5】Sec
10-29	PID Sleep Selection
Range	【0】: Disable 【1】: Enable 【2】: Set by DI
10-40	Compensation Frequency of PID Sleep Selection
Range	【0】: Disable 【1】: Enable

The PID Sleep function is used to stop the inverter when the PID output falls below the PID sleep level (10-17) for the time specified in the PID sleep delay time parameter (10-18).

The inverter wakes up from a sleep condition when the PID output (Reference frequency) rises above the PID wake-up frequency (10-19) for the time specified in the PID wake-up delay time (10-20).

Use parameter 10-29 to enable / disable PID sleep function.

10-29 =0: PID Sleep function is disabled.

10-29 =1: PID sleep operation is based on parameters of 10-17 and 10-18.

10-29 =2: PID sleep mode is enabled by multi-function digital input

Refer to Fig.4.3.74 (a) and (b) for PID sleep / wakeup operation.

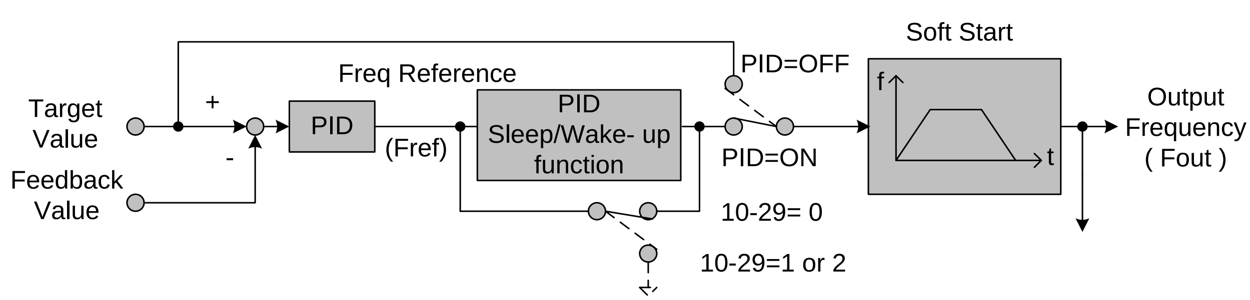


Figure 4.3.74: (a) PID control bock diagram

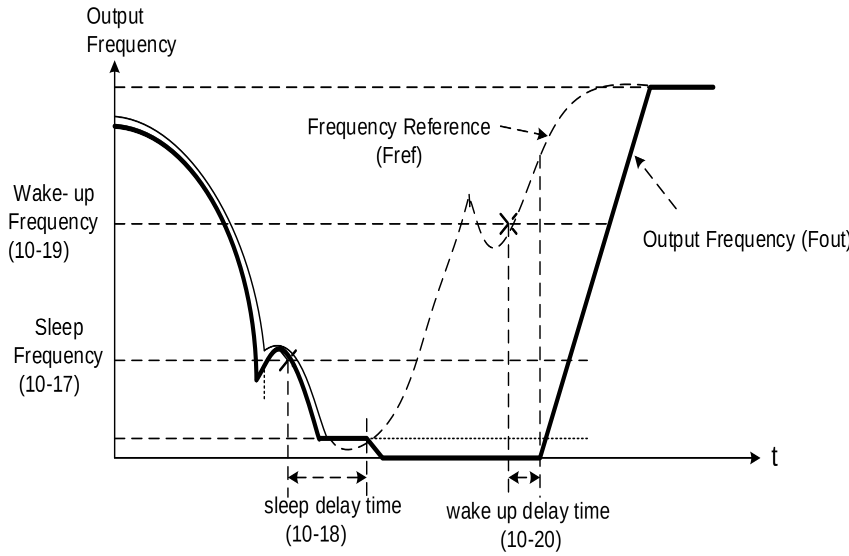


Figure 4.3.74: (b) Timing diagram of PID sleep / wakeup

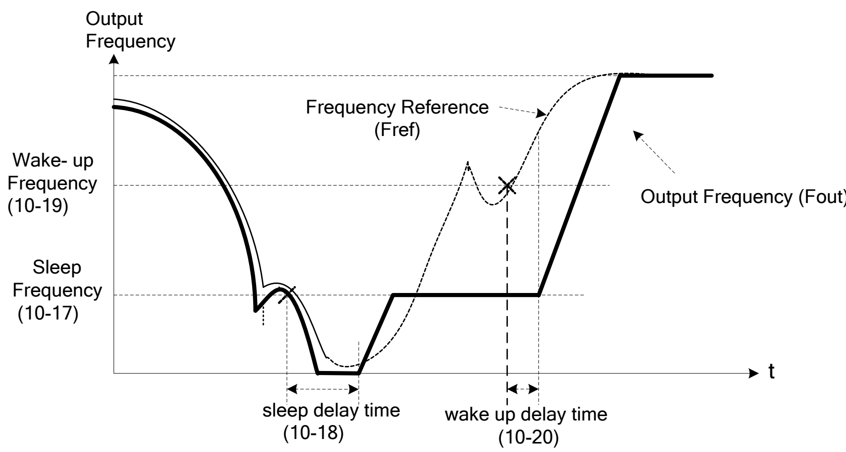


Figure 4.3.74: (c) Timing diagram of PID sleep frequency/ wakeup

When PID enters sleep mode the output frequency will directly go to 0Hz.

Notes:

- Refer to Fig. 4.3.74: (b) for parameter 10-40=0. The PID sleep timer is enabled when the output frequency (Fout) falls below the PID sleep frequency (10-17). When the sleep timer reaches the set PID sleep delay time (10-18) the inverter will decelerate to a stop and enter the sleep mode.
- Refer to Fig.4.3.74: (c) for parameter 10-40=1. The PID sleep timer is enabled when the output frequency (Fout) falls below the PID sleep frequency (10-17). When the sleep timer reaches the set PID sleep delay time (10-18), the motor will gradually run to PID sleep frequency set by 10-17. (Only applies when using a fixed frequency.)
- While sleep mode is active and the motor has stopped, the internal PID control is still in operating. When the reference frequency increases and exceeds the wakeup frequency parameter 10-19 for the time specified in the wakeup delay time parameter 10-20, the inverter will restart and the output frequency will ramp up to the reference frequency.
- Parameter 10-00 and 10-01 cannot be set to the same source. If both parameters are set to the same source the keypad will show a SE05 alarm.

10-27	PID Feedback Display Bias
Range	【-99.99~99.99】
10-28	PID Feedback Display Gain
Range	【0.00~100.00】

PID Feedback Display Scaling

The PID feedback signal can be scaled to represent actual engineering units. Use parameter 10-28 to set the feedback signal gain for the feedback signal range maximum and parameter 10-27 to the feedback signal minimum.

Example:

Feedback signal is a pressure transducer (4-20mA) with a range of 0 – 200 PSI
4mA = 0 PSI, 20mA = 200 PSI.

Set parameter 10-27 to 0.0 minimum of transducer range (0%).
Set parameter 10-28 to 2.0 maximum of transducer range (100%).

Refer to the Fig.4.3.75 for displaying the unit conversion.

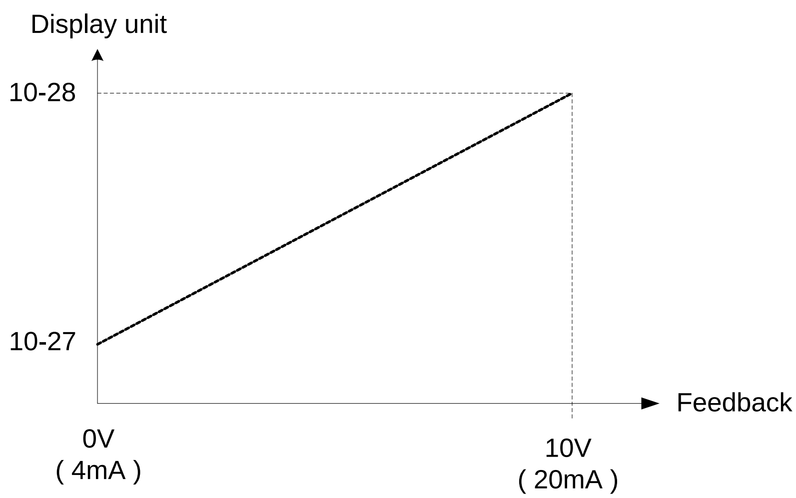


Figure 4.3.75 Feedback signal scaling

10-30	Upper Limit of PID Target
Range	【0 ~ 100】%
10-31	Lower Limit of PID Target
Range	【0 ~ 100】%

PID target value will be limited to the upper and lower limit range of PID target.

10-32	PID Switching Function
Range	【0】: PID1 【1】: PID2 【2】: Switch to PID2 by DI 【3】: Switch to PID2 by RTC

10-32=0: PID 1 function is enabled.

PID target value is set by 10-02 and proportional gain, integral time and differential time are set by 10-05, 10-06 and 10-07.

10-32=1: PID 2 function is enabled.
PID target value is set by 10-02 and proportional gain, integral time and differential time are set by 10-36, 10-37 and 10-38.

10-32=2: Set by Digital Input

If the digital input terminal is enabled (digital multi-function terminal is set to 54), PID1 will switch to PID2.

10-32=3: Set by RTC
When RTC timer is enabled, PID1 will switch to PID2.

10-33	**PID Maximum Feedback Value**
Range	**【1~10000】**

Function of PID maximum feedback value is the 100% corresponding value of 10-02.

10-34	**PID Scaling**
Range	**【0~4】**

Function of PID decimal width enables the user to set the decimal point.

For example, if it is set to 1, the keypad displays the first decimal place XXX.X. If it is set to 2, the keypad displays the second decimal place XX.XX.

10-35	**PID Unit**
Range	**【0~23】**

PID unit enables the user to select the unit for PID target value.

When 10-35=0, parameter of 12-38 will be used by the unit of %.

10-36	**PID2 Proportional Gain (P)**
Range	**【0.00~10.00】**
10-37	**PID2 Integral Time (I)**
Range	**【0.0~100.0】Sec**
10-38	**PID2 Differential Time (D)**
Range	**【0.00~10.00】Sec**

Refer to the PID function for more details of PID2 description.

10-39	**Force Frequency During PID Feedback Loss**
Range	**【0~400】Hz**

When the warning of PID feedback disconnection occurs, frequency command output depends on the parameter 10-39. When the disconnection warning is removed, PID control restores.

Group 11: Auxiliary Parameters

11-00	Direction Lock Selection
Range	【0】: Allow Forward and Reverse Rotation 【1】: Only Allow Forward Rotation 【2】: Only Allow Reverse Rotation

If motor operation direction is set to 1 or 2, the motor can only operate in that specific direction. Run command in opposite direction is disabled.

Forward or reverse commands can be issued via the control terminals or keypad when 11-00 is set to 0.

Note: The reverse rotation selection can be used in fan and pump application where reverse rotation is prohibited.

11-01	Carrier Frequency
Range	【0】: Carrier Output Frequency Tuning 【1】: 1.5 KHz 【2~16】2~16 KHz

Notes:
(1) Value 1 to 16 represents KHz.
(2) When 11-01=0, variable carrier frequency is used see parameter 11-30~11-32.
(3) For SLV mode, the minimum value of 11-01 is 4 kHz.
(4) Setting range is determined by the inverter rating (13-00).
(5) Refer to section 3 inverter derating based on carrier frequency.
(6) A low carrier frequency increases motor noise but reduces motor losses and temperature.
(7) A low carrier frequency decreases RFI, EMI interference and motor leakage current.

Refer to the carrier frequency Table 4.3.11.

Table 4.3.11 Carrier frequency settings

Carrier frequency (11-01=1 to 16))	1.5KHz--6K--10K--16KHz		
Motor noise	High	--------------------	low
Output current waveform	Non-sinusoidal	--------------------	sinusoidal (better)
Noise interference	Low	--------------------	high
Leakage current	Low	---------------------	high

If wire length between the inverter and the motor is too long, the high-frequency leakage current will cause an increase in inverter output current, which might affect peripheral devices. Adjust the carrier frequency to avoid this as shown in Table 4.3.12.

Table 4.3.12 Wire length and carrier frequency

Wire length	< 30 Meter (98ft)	up to 50 Meter (164 ft)	up to 100 Meter (328ft)	> 100 Meter > 328ft
Carrier frequency (11-01 value)	Max. value 16KHz (11-01=14KHz)	Max. value 10KHz (11-01=10KHz)	Maxi. value 5KHz (11-01=5KHz)	Max. value 2KHz (11-01=2KHz)

Notes:
- Reduce the carrier frequency if the torque does not match the speed.
- In V/F control mode, the carrier frequency is determined by parameters 11-30 (Carrier frequency max. limit), 11-31 (Carrier frequency lower limit) and 11-32 (Carrier frequency proportional gain).

11-02	Soft PWM Function Selection
Range	【0】: Disable 【1】: Enable

11-02=0: Soft-PWM control disabled.

11-02=1: Soft-PWM control enabled. Soft-PWM control can improve audible noise produced by the motor. Soft-PWM also limits RFI noise to a minimum level. The default setting of Soft-PWM control is disabled. When Soft-PWM is enabled, the maximum carrier frequency is limited to 8 kHz.

11-03	Automatic Carrier Lowering Selection
Range	【0】: Disable 【1】: Enable

11-03=0: Automatic carrier frequency reduction during an overheat condition is disabled.

11-03=1: Carrier frequency is automatically lowered in case the inverter heatsink overheats and returns to carrier frequency set in parameter 11-01 when the inverter temperature returns to normal. See section 3.5 for more information.

11-04	S-curve Time Setting at the Start of Acceleration
11-05	S-curve Time Setting at the End of Acceleration
11-06	S-curve Time Setting at the Start of Deceleration
11-07	S-curve Time Setting at the End of Deceleration
Range	【0.00~2.50】Sec

The S curve function for acceleration / deceleration is used to reduce mechanical impact caused by the load during momentary starting and stopping of the inverter. To use the S curve function set the time for acceleration start point (11-04), acceleration end point (11-05), deceleration start point (11-06) and deceleration end point (11-07). Refer to Fig.4.3.76 for more information.

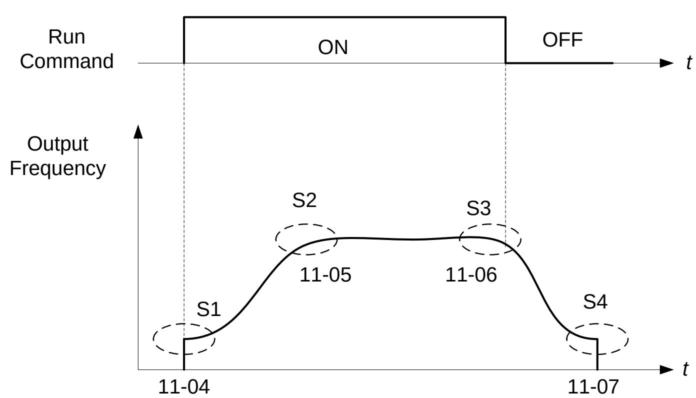


Figure 4.3.76 S curve characteristic

Total acceleration and deceleration time when the S curve is used:

$$\text{Accelerating time} = \text{Accelerating time 1 (or 2)} + \frac{(11\text{-}04) + (11\text{-}05)}{2}$$

$$\text{Deceleration time} = \text{Deceleration time 1 (or 2)} + \frac{(11\text{-}06) + (11\text{-}07)}{2}$$

11-08	Jump Frequency 1
11-09	Jump Frequency 2
11-10	Jump Frequency 3
Range	【0.0~400.0】Hz
11-11	Jump Frequency Width
Range	【0.0~25.5】Hz

These parameters allow "jumping over" of certain frequencies that can cause unstable operation due to resonance within certain applications.

Note: Prohibit any operation within the jump frequency range. During acceleration and deceleration the frequency is continuous without skipping the jump frequency.

To enable jump frequency 1 – 3 (11-08 – 11-10) set the frequency to a value greater than 0.0 Hz.

Use the jump frequency width (11-11) to create a jump frequency range. Refer to Fig.4.3.77.

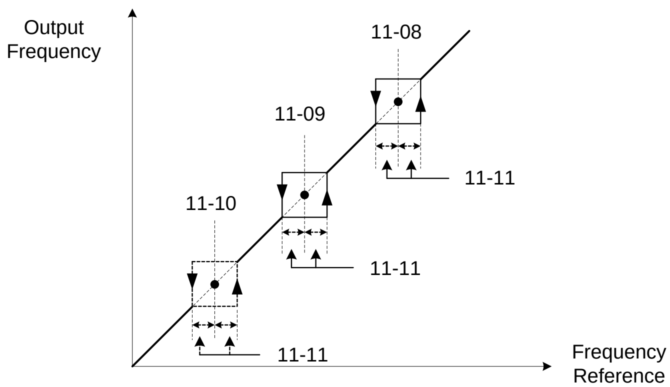


Figure 4.3.77 Jump frequency operation

Jump frequency via Analog Input.

Set parameter 04-05 (AI2 function selection) to 9 (frequency jump setting 4) to control the jump frequency via analog input AI2. Refer to Fig. 4.3.38.

Note: When jump frequency overlap the sum of the overlapped jump frequencies will be used as the jump frequency range. Refer to Fig.4.3.78.

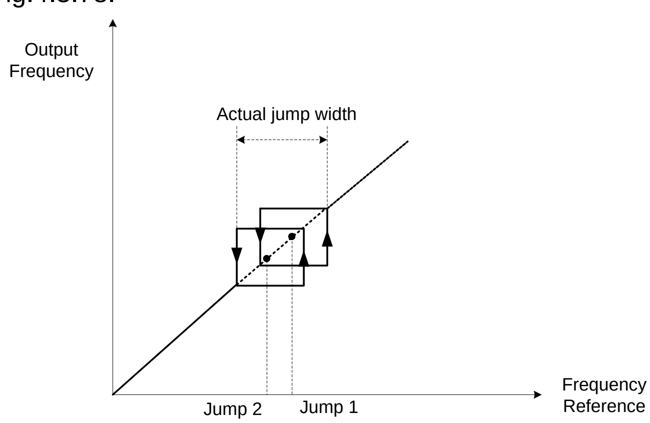


Figure 4.3.78 Jump frequency overlap

11-13	Keypad Return Time
Range	【0~120】Sec

If the keypad is not pressed within the time set by 11-13, it will automatically return to the mode screen.

When it is set to 0, function of automatic return key is off. Press the return key to return to the previous directory.

11-12	Manual Energy Saving Gain
Range	【0~100】%
11-18	Manual Energy Saving Frequency
Range	【0.00~400.00】Hz

Manual energy savings reduces the output voltage to save energy.

To enable manual energy savings set one of the multi-function digital input (03-00 to 03-05) to 20 and activate the input or use parameter 11-18 to set the manual energy savings activation frequency.

When the output frequency rises above the value set in parameter 11-18 manual energy savings function is enabled. Setting parameter 11-18 manual energy savings frequency to 0.0 Hz disables the manual energy savings frequency activation function. Refer to figure 4.3.88 for more information.

Note: Only use manual energy savings functions in combination with variable torque loads (e.g. Fans, pumps).

Manual energy saving gain (11-12) determines the output voltage of the inverter when manual energy savings is enabled. Output voltage is percentage gain times the V/F voltage.

Manual energy saving control uses the voltage recovery time (07-23) to change the output voltage

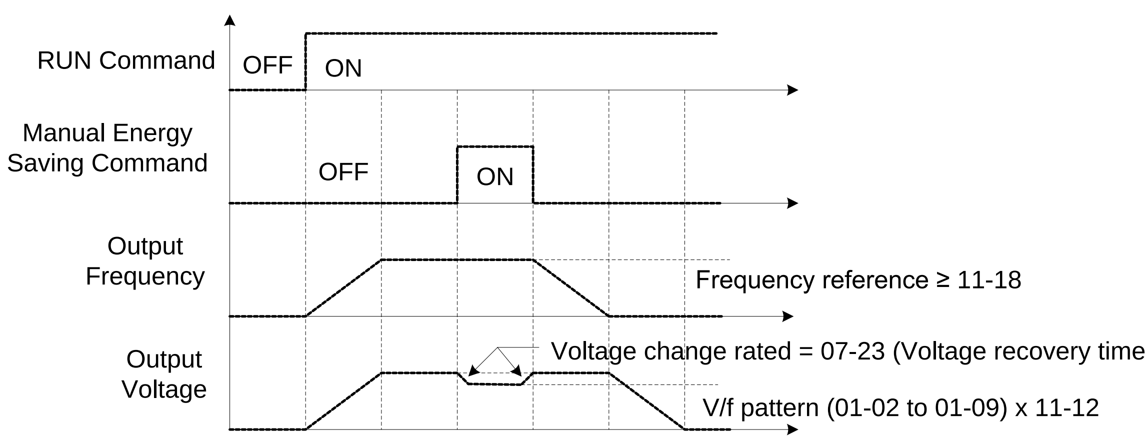


Figure 4.3.79 Manual energy saving operation

11-19	**Automatic Energy Saving Function**
Range	**【0】: Automatic Energy Saving is Disabled.** **【1】: Automatic Energy Saving is Enabled.**
11-20	**Filter Time of Automatic Energy Saving**
Range	**【0~200】msec**
11-21	**Voltage Upper Limit of Energy Saving Tuning**
Range	**【0~100】%**
11-22	**Adjustment Time of Automatic Energy Saving**
Range	**【0~5000】msec**
11-23	**Detection Level of Automatic Energy Saving**
Range	**【0~100】%**
11-24	**Coefficient of Automatic Energy Saving**
Range	**【0.00~655.35】**

In the V/F control mode the automatic energy saving (AES) function automatically adjusts the output voltage and reduces the output current of the inverter to optimize energy savings based on the load.

The output power changes proportional to the motor load. Energy savings is minimal when the load exceeds 70% of the output power and savings become greater when the load decreases.

The parameter of automatic energy saving function has been set at the factory before shipment. In general, it is no need to adjust. If the motor characteristic has significant difference from the TECO standard, please adjust the following parameters:

Enable Automatic Energy Savings Function

(1) To enable automatic energy saving function set 11-19 to 1.
(2) Filter time of automatic energy saving (11-20)
(3) Commissioning parameter of energy saving (11-21 to 11-22)

In AES mode, the optimum voltage value is calculated based on the load power requirement but is also affected by motor temperature and motor characteristic.

In certain applications the optimum AES voltage needs to be adjusted in order to achieve optimum energy savings. Use the following AES parameters for manual adjustment:

11-21: Voltage limit value of AES commissioning operation

Sets the voltage upper limit during automatic energy saving. 100% corresponds to the settings of parameter 01-03 (Maximum Output Voltage) depending on the inverter class used. Refer to the Fig.4.3.80.

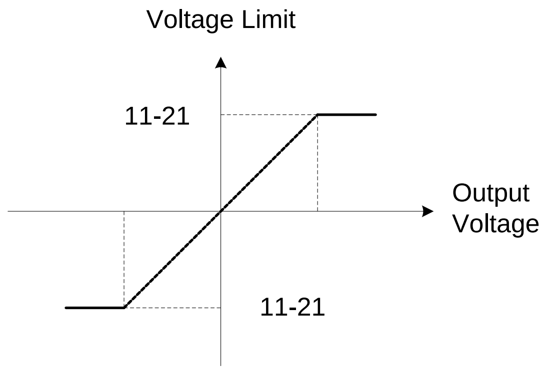


Figure 4.3.80 Voltage limit value of commissioning operation

11-22: Adjustment time of automatic energy saving
Set sample time constant for measuring output power.
Reduce the value of 11-22 to increase response when the load changes.
Note: If the value of 11-22 is too low and the load is reduced the motor may become unstable.

11-23: Detection level of automatic energy saving
Set the automatic energy saving output power detection level.

11-24: Coefficient of automatic energy saving
The coefficient is used to tune the automatic energy saving. Adjust the coefficient while running the inverter on light load while monitoring the output power. A lower setting means lower output voltage.

Notes:
- If the coefficient is set to low the motor may stall.
- Coefficient default value is based on the inverter rating. Set parameter 13-00. If the motor power does not match the inverter rating.

11-29	Auto De-rating Selection
Range	【0】: Disable 【1】: Enable

The automatic de-rating function automatically reduces the output frequency by 30% of the nominal motor speed when the inverter detects an overheat condition.

Automatic de-rating function depends on the automatic carried frequency reduction selection (11-03).

If automatic carrier frequency reduction is disabled (11-03=0), the output frequency is reduced by 30% of the nominal motor speed when an overheat condition is detected.

If automatic carrier frequency reduction is enabled (11-03=1), the output frequency is reduced by 30% of the nominal motor speed when the carrier frequency is at its minimum setting.

11-29=0: Auto de-rating selection disabled, carrier frequency is based on 11-01 or 11-03.

11-29=1: Auto de-rating selection is enabled.

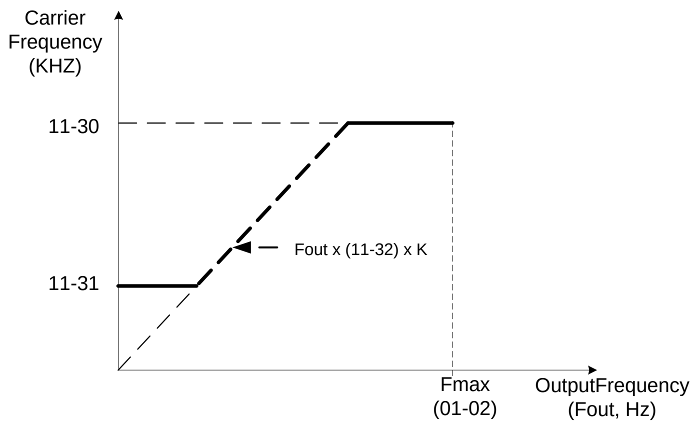
11-30	Variable Carrier Frequency Max. Limit
Range	【0~16】KHz
11-31	Variable Carrier Frequency Min. Limit
Range	【0~16】KHz

11-32	Variable Carrier Frequency Proportional Gain
Range	**【00~99】**

Carrier frequency method depends on the selected control mode.

Control Mode	Variable Carrier Frequency (11-01 = 0)	Fixed Carrier Frequency (11-01 = 2-16 kHz)
V/F	Available	Available
SLV	Not available	Available

Variable carrier frequency can be adjust with parameter 11-30 ~ 11-32.



K is a coefficient; the value of K is based on the following based on the maximum carrier frequency:

K=1: when 11-30 < 5 KHz
K=2: when 10 KHz > 11-30 ≥ 5 KHz
K=3: when 11-30 ≥ 10KHz

Notes:
- In V/F control mode if the speed and torque are constant, the variable carrier frequency mode (11-01=0) can be selected to reduce the carrier frequency based on output frequency.
- If the carrier frequency proportional gain (11-32) > 6 and 11-30 < 11-31, error message "SE01" out of range will appear on the keypad.
- If the minimum limit (11-31) is set higher than the maximum limit (11-30), the minimum limit will be ignored and the carrier frequency will be set at the highest limit (11-30).
- In fixed carrier frequency mode (11-01 = 2-16) parameters 11-30, 11-31 and 11-32 are not used.
- In SLV control mode, the maximum limit of the carrier frequency is fixed at 11-30.

11-41	Frequency Reference Loss Operation Selection
Range	**【0】 : Decelerate to Stop when Reference Frequency Disappears** **【1】 : Operation is Set by 11-42 when Reference Frequency Disappears**
11-42	**Operation Frequency after Frequency Reference Loss**
Range	**【0.0~100.0】%**

A reference frequency loss is detected when the frequency command falls 90% within 360ms.

When 11-41=1, main frequency command is compared to the previous value during the 360ms.

When the frequency loss occurs, inverter will operate depending on the following estimated frequency command.

Reference frequency command = the frequency command prior to frequency loss × the level set in parameter 11-42

Descriptions of frequency loss function:

1) When inverter is on operation and source of selected analog command disappears, the command acts depending on the setting of parameter 11-42.

2) When reference command restores to the level prior to frequency loss, inverter will restore to the previous state.

Notes:
1. Frequency command (11-42) is corresponding to the maximum output frequency of motor 1 (01-02) when reference frequency disappears.
2. The frequency reference loss can only be used for analog signals (1: AI1; 7:AI2) set by the main frequency source (00-05).

Refer to Fig.4.3.81 for the operation of multi-function digital output (03-11~03-12) when a frequency reference loss occurs.

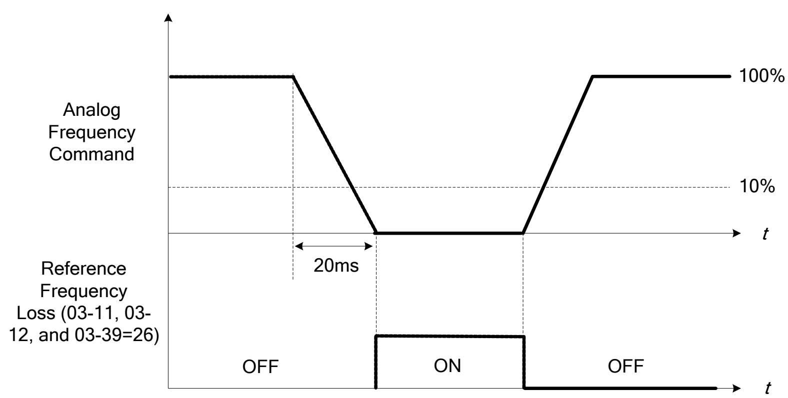


Figure 4.3.81 Operation for reference frequency loss

11-43	**Hold Frequency at Start**
Range	**【0.0~400.0】Hz**
11-44	**Frequency Hold Time at Start**
Range	**【0.0~10.0】Sec**
11-45	**Hold Frequency at Stop**
Range	**【0.0~400.0】Hz**
11-46	**Frequency Hold Time at Stop**
Range	**【0.0~10.0】Sec**

The hold function is used to temporarily hold the reference frequency in order to prevent stalling the motor or preventing an over current condition during starting or stopping due to load conditions.

During start the inverter will operate at the hold frequency at start for the time specified in the parameter 11-44 in order to establish the magnetic flux.

Note: Acceleration and deceleration time do not include the start and stop hold time. Refer to the Fig. 4.3.82.

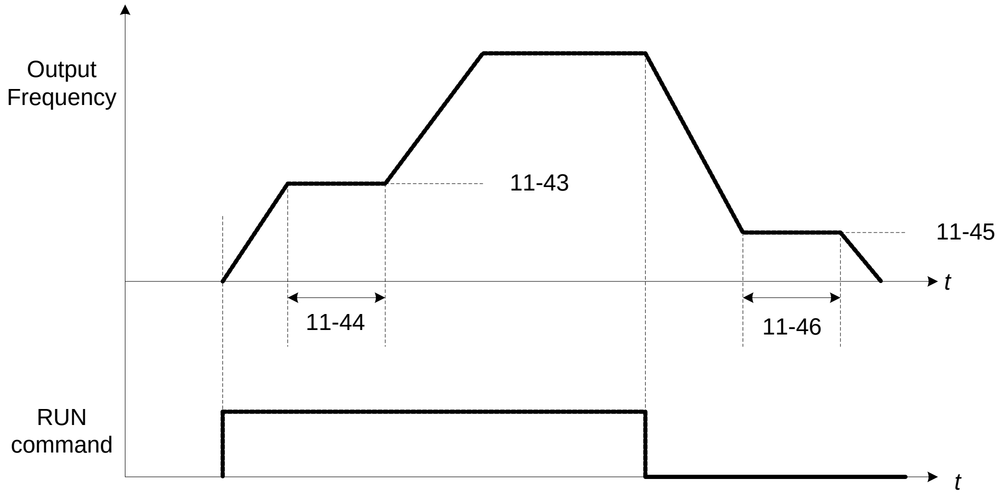


Figure 4.3.82 Reserved function

When the inverter is in stop mode, this function can also be used to prevent wind milling. In addition, it can be used for the purpose of braking using the motor to consume the braking energy resulting in a better controlled stop. Refer to the DC brake parameter 07-16 for DC braking during start.

Notes:

- The hold function at start is inactive when the hold frequency at start (11-43) is set to a value less than Fmin (01-08).
- The hold function at stop is inactive when the hold frequency at stop (11-45) is set to a value less than Fmin (01-08).

11-47	**KEB Deceleration Time**
Range	**【0.0~25.5】Sec**
11-48	**KEB Detection Level**
Range	**【190~210】V : 230V** **【380~420】V : 460V**

KEB function can be used to keep the inverter from tripping on a under voltage condition due to a momentary power-loss. To enable the KEB function set parameter 11-47 to a value greater than 0.0 sec.

Upon detection of a power-loss the inverter uses the KEB deceleration time (11-47) to decelerate the motor and using the regenerative energy from the motor to maintain the DC-bus at a nominal level.

11-48: KEB detection level

If the DC-bus voltage falls below the value set in 11-48, the KEB is activated and the inverter starts decelerating according to the value set in 11-47.

To accelerate back to the original output frequency one of the digital inputs (03-00 to 03-05) set for 48 (KEB acceleration) has to be activated and the DC voltage has to rise above 11-48 + delta V (Delta V = +10V for 230V series, Delta V = +20 V for 460V series).

Refer to the example in Fig.4.3.83.

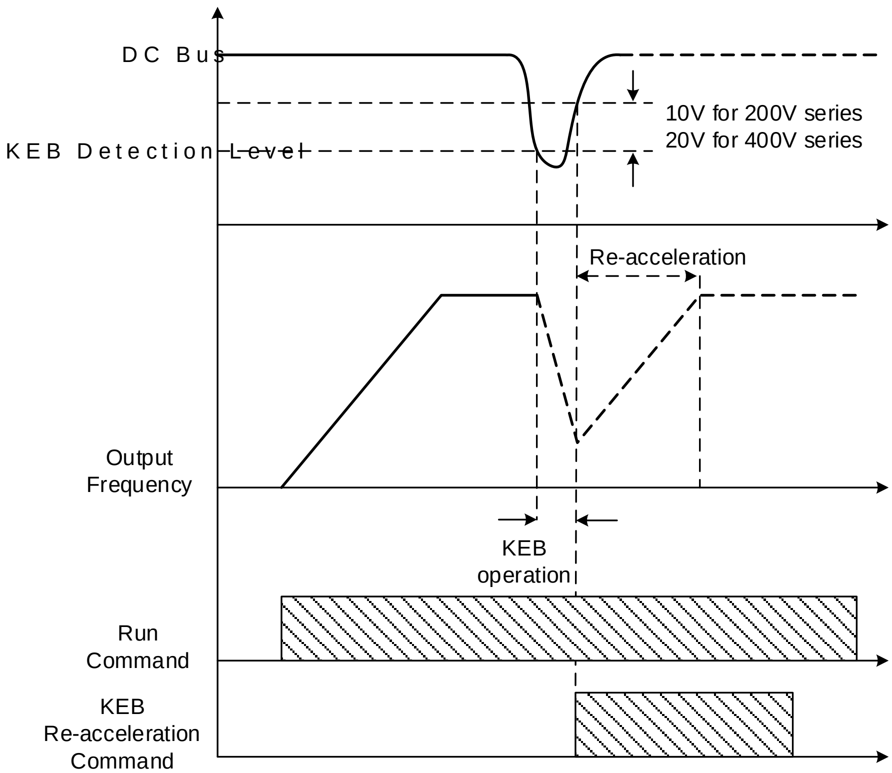


Figure 4.3.83 KEB operation

11-51	Braking Selection of Zero Speed
Range	【0】: Disable 【1】: Enable

11-51: Operation selection of zero-speed braking

In V/F control mode, the DC braking operation can be used to hold the motor shaft.
Set 11-51 to select zero-speed braking operation to 1 to enable this function.

To use DC braking operation set parameter 00-02 (operation command selection) to 1 and parameter 00-05 (frequency reference selection) to 1, the operation command and frequency reference are now set for external control. When the frequency reference is 0V (or less than 4mA), and the operation command is turned on, the zero-speed 'DC' braking operation is activated and holding torque is generated using DC braking.

Refer to Fig.4.3.84 for more information on zero-speed DC braking operation.

Note: DC braking 07-07 is limited to 20% of the inverter rated current.

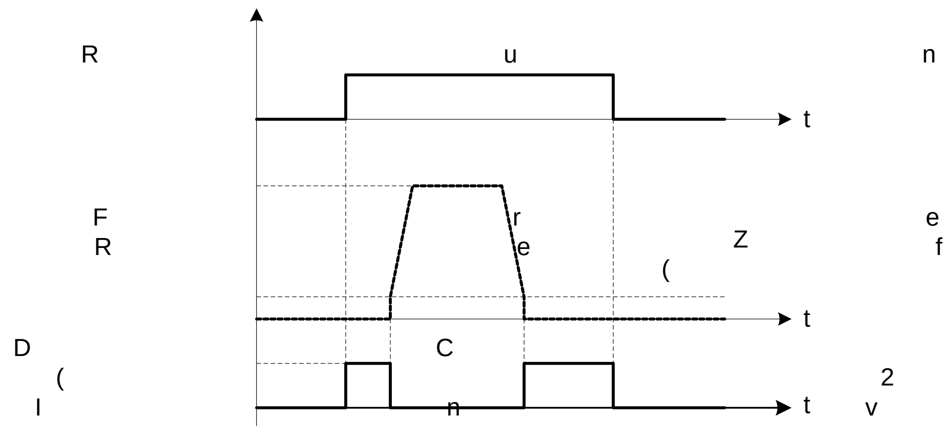


Figure 4.3.84 Zero-speed braking operation

11-54	Output kwh Initialization
Range	【0】: Do not Clear Output KWH 【1】: Clear Output KWH

Reset the cumulative energy (KWHr) (12-67) and the cumulative energy (MWHr) (12-68) via parameter 11-54.

11-55	STOP Key Selection
Range	【0】: Stop Key is Disabled when the Operation Command is not Provided by Keypad. 【1】: Stop Key is Enabled when the Operation Command is not Provided by Keypad.

11-55= 0: Stop button disabled when operation command is set for terminals (00-02=1) or communication (00-02=3).
11-55= 1: Stop button enabled.

11-56	UP/DOWN Selection
Range	【0】: When UP/DOWN on Keypad is Disabled, ENTER must be pressed after changing the Frequency Reference. 【1】: When UP/DOWN on Keypad is Enabled, Frequency Reference will change immediately upon pressing the UP or Down key.

11-56= 0: Changing the reference frequency on the keypad in UP/DOWN control requires the ENTER button to be pressed for the inverter to accept the modified reference frequency.

11-56= 1: Changing the reference frequency on the keypad in UP/DOWN control immediately changes the reference frequency and there for the output frequency.

Note: The reference frequency can be changed (up or down) via the keypad or by setting one of multi-functional digital input terminals (03-00 to 03-05) to 8 and 9. Refer to instructions of
(03-00 to 03-05 = 8 or 9).

11-58	Record Reference Frequency
Range	**【0】: Disable** **【1】: Enable**

This function is enabled only when one of multi-function digital input terminals (03-00 to 03-05) is set to 11 (ACC / DEC disabled) or two MFIT are set to 8 and 9 (up / down). Refer to the figure 4.3.18 to disable acceleration / deceleration, and figure 4.3.17 for up / down operation.

11-59	Anti-hunting Protection Gain
Range	**【0.01~2.50】**

Gradually increase the setting value with the unit of 0.01 when the motor is driven leading to the occurrence of oscillation under the state of normal duty.

11-60	Upper Limit of Anti-hunting Protection
Range	**【0~100】%**

Function of prevention of oscillation upper limit is required to be within the setting value.

11-61	Filter Time of Anti-hunting Protection
Range	**【0~100】**

Adjust the response of oscillation function. That is, adjust once delay time parameter of prevention oscillation function.

11-62	Prevention of Oscillation Selection
Range	**【0】: Mode 1** **【1】: Mode 2**

11-62 =0: The response to prevention oscillation is slower.
11-62= 1: The response to prevention oscillation is faster.

11-63	Flux-Enhancing Selection
Range	**【0】: Disable** **【1】: Enable**

11-63=0: Flux-enhancing disabled.

11-63=1: Flux-enhancing enabled.

Group 12: Monitoring Parameters

<table>
<tr><th>12-00</th><th colspan="2">Display Screen Selection (LED)</th></tr>
<tr><td rowspan="5">Range</td><td colspan="2">Highest bit => <u>0</u> <u>0</u> <u>0</u> <u>0</u> <u>0</u> <= lowest bit
The value range of each bit is 0~7 from the highest bit to the lowest bit,</td></tr>
<tr><td>【0】: No display</td><td>【1】: Output Current</td></tr>
<tr><td>【2】: Output Voltage</td><td>【3】: DC Bus Voltage</td></tr>
<tr><td>【4】: heatsink Temperature</td><td>【5】: PID Feedback</td></tr>
<tr><td>【6】: AI1 Value</td><td>【7】: AI2 Value</td></tr>
</table>

Note: The highest bit is used for power-up monitor. The 4 least significant bits can be used to customize the display sequence see section 4.1.3.

12-01	PID Feedback Display Mode (LED)
Range	**【0】: Display the Feedback Value by Integer (xxx)** **【1】: Display the Feedback Value by the Value with First Decimal Place (xx.x)** **【2】: Display the Feedback Value by the Value with Second Decimal Places (x.xx)**
12-02	**PID Feedback Display Unit Setting (LED)**
Range	**【0】: xxxxx(no unit)** **【1】: xxxPb(pressure)** **【2】: xxxFL(flow)**

12-03	Line Speed Display (LED)
Range	**【0~65535】RPM**
12-04	**Line Speed Display Mode (LED)**
Range	**【0】: Display Inverter Output Frequency** **【1】: Line Speed Display at Integer.(xxxxx)** **【2】: Line Speed Display at One Decimal Place. (xxxx.x)** **【3】: Line Speed Display at Two Decimal Places. (xxx.xx)** **【4】: Line Speed Display at Three Decimal Places. (xx.xxx)**

12-04=0

Inverter displays the line speed at stop, operation or the modification of frequency.

12-04≠0

12-03 is set to the maximum line speed and corresponds to the maximum output frequency.

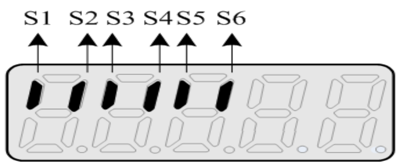
For example, if the line speed display of 12-03 is 1800, the keypad display is 900 when frequency output is 30Hz.

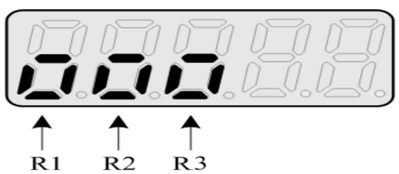
12-05	Status Display of Digital Input Terminal (LED/LCD)
Range	Read-only

Terminals S1-S6 are represented using two segments of each digit. Segment turns on when input is active. The bottom segments of each of the first three digits are used to represent the digital outputs (R1, R2, R3). Segments turn on when output is active.

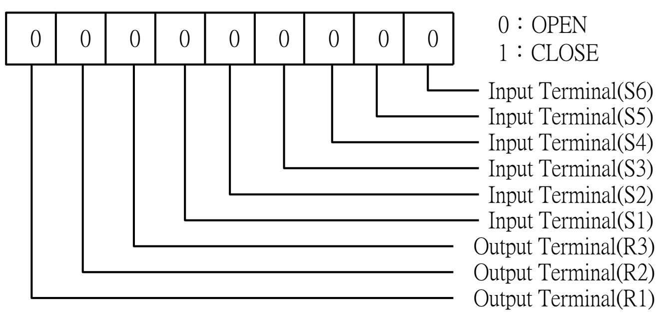
When operation command is changed to PLC, press RUN key and it will light up.

Example1: S1~S6, R1, R2 and R3 are ON





Example2: S1~S6, R1, R2 and R3 are OFF



Note: Refer to section 4.3 for other monitor parameters 12-11~12-79.

Monitor parameters 12-67 (KWHr) and 12-68 (MWHr) is the display of accumulative energy.

Note: Parameter 11-54 can clear the monitor parameter.

Monitor parameter 12-76 (No-load voltage) is required to refer to the descriptions of parameter 02-09(Motor 1 excitation current) and 17-09 (Motor excitation current).

Group 13 Maintenance Function Group

13-00	Inverter Rating Selection
Range	00H~FFH

Inverter model	13-00 display	Inverter model	13-00 display
F510-2005-XXX	205	F510-4005-XXX	405
F510-2008-XXX	208	F510-4008-XXX	408
F510-2010-XXX	210	F510-4010-XXX	410
F510-2015-XXX	215	F510-4015-XXX	415
F510-2020-XXX	220	F510-4020-XXX	420
F510-2025-XXX	225	F510-4025-XXX	425
F510-2030-XXX	230	F510-4030-XXX	430
F510-2040-XXX	240	F510-4040-XXX	440
F510-2050-XXX	250	F510-4050-XXX	450
F510-2060-XXX	260	F510-4060-XXX	460
F510-2075-XXX	275	F510-4075-XXX	475
F510-2100-XXX	2100	F510-4100-XXX	4100
F510-2125-XXX	2125	F510-4125-XXX	4125
F510-2150-XXX	2150	F510-4150-XXX	4150
F510-2175-XXX	2175	F510-4175-XXX	4175
		F510-4215-XXX	4215
		F510-4250-XXX	4250

13-01	Software Version
Range	0.0-9.9

13-03	Cumulative Operation Hours 1
Range	【0~23】hours
13-04	Cumulative Operation Hours 2
Range	【0~65535】days
13-05	Selection of Cumulative Operation Time
Range	【0】: Cumulative time at power on 【1】: Cumulative time during operation

13-05= 0: Inverter logs the time while the inverter is powered-up.

13-05= 1: Inverter logs the time when the inverter is running.

13-06	Parameters Locked
Range	**【0】: Parameters other then 13-06 are read-only** **【1】: Only user parameter are enabled.** **【2】: All parameters are writable.**
13-07	**Parameter Password Function**
Range	**Reserved**
13-08	**Restore Factory Setting**
Range	**【0】: No Initialization** **【1】: Reserved** **【2】: 2 Wire Initialization (220/440V, 60Hz)** **【3】: 3 Wire Initialization (220/440V, 60Hz)** **【4】: 2 Wire Initialization (230/415V, 50Hz)** **【5】: 3 Wire Initialization (230/415V, 50Hz)** **【6】: 2 Wire Initialization (200/380V, 50Hz)** **【7】: 3 Wire Initialization (200/380V, 50Hz)** **【8】: PLC Initialization** **【9】: 2 Wire Initialization (230V/460V, 60Hz)** **【10】: 3 Wire Initialization (230V/460V, 60Hz)** **【Others】: Reserved**

Use parameter 13-08 to initialize the inverter to factory default. It is recommended to write down the modified parameters before initializing the inverter. After initialization, the value of 13-08 will return to zero automatically.

13-08=2: 2-wire initialization (220V/440V)

Multi-function digital input terminal S1 controls forward operation / stop command, and S2 controls reverse operation / stop command. Refer to Fig.4.3.1.

Inverter input voltage (01-14) is automatically set to 220V (230V class) or 440V (460V class).

Inverter maximum frequency (01-12) is automatically set to 60Hz.

13-08=3: 3-wire initialization (220V/440V)

Multi-function digital input terminal S5 controls the forward / reverse direction, terminal S1 (Start Command) and S2 (Normally Closed Stop Command) are set for 3-wire start/stop. Refer to Figure 4.3.2 and Figure 4.3.3 for 3-wire type operation mode.

Inverter input voltage (01-14) is automatically set to 220V (230V class) or 440V (460V class).

Inverter maximum frequency (01-12) is automatically set to 60Hz.

13-08=4: 2-wire initialization (230V/415V)

Multi-function digital input terminal S1 controls forward operation / stop command, and S2 controls reverse operation / stop command. Refer to Fig.4.3.1.

Inverter input voltage (01-14) is automatically set to 230V (230V class) or 415V (460V class).

Inverter maximum frequency (01-12) is automatically set to 50Hz.

13-08=5: 3-wire initialization (230V/415V)

Multi-function digital input terminal S5 controls the forward / reverse direction, terminal S1 (Start Command) and S2 (Normally Closed Stop Command) are set for 3-wire start/stop.

Inverter input voltage (01-14) is automatically set to 230V (230V class) or 415V (460V class).

Inverter maximum frequency (01-12) is automatically set to 50Hz.

13-08=6: 2-wire initialization (230V/380V)

Multi-function digital input terminal S1 controls forward operation / stop command, and S2 controls reverse operation / stop command. Refer to Fig.4.3.1.

Inverter input voltage (01-14) is automatically set to 230V (230V class) or 380V (460V class).

Inverter maximum frequency (01-12) is automatically set to 50Hz.

13-08=7: 3-wire initialization (230V/380V)

Multi-function digital input terminal S5 controls the forward / reverse direction, terminal S1 (Start Command) and S2 (Normally Closed Stop Command) are set for 3-wire start/stop.

Inverter input voltage (01-14) is automatically set to 230V (230V class) or 380V (460V class).

Inverter maximum frequency (01-12) is automatically set to 50Hz.

13-08=8: PLC initialization

Clear built-in PLC ladder logic and related values.

13-08=9: 2 wire initialization (230V/460V, 60Hz)

Setting similar to 2 wire Initialization (13-08=2). The input voltage (01-14) is set to 230V (230V class) or 460V (460V class) automatically and the maximum frequency of 01-12 is set to 60Hz.

13-08=10: 3 wire initialization (230V/460V, 60Hz)

It is the same as 3 wire Initialization (13-08=3). The input voltage (01-14) will be set to 230V (230V class) or 460V (460V class) automatically and the maximum frequency of 01-12 will be set to 60Hz automatically.

Note: The default value of 13-08 is 9 (230V/460V, 60Hz) for F510 Filter Model (IP20).

13-09	Fault History Clearance Function
Range	【0】: Do not Clear Fault History 【1】: Clear Fault History

13-09=1: Clear inverter fault history including (12-11~12-15/12-45~12-64)

13-10	Password Function 2
Range	0 ~ 9999

13-11	C/B CPLD Ver.
Range	【0.00~9.99】

This parameter displays CPLD version on the control board.

13-12	Option Card Id
Range	【0~255】

Displays option card ID code:

【0】: None
【1】: PG-L
【2】: PG-O
【3】: PG-PM
【4】: PG-PMS
【5】: PG-PMR
【6】: CM-P
【7】: CM-C
【8】: IO-8DO

13-13	Option Card CPLD Ver.
Range	【0.00~9.99】

This parameter displays option card CPLD version.

13-14	Fault Storage Selection
Range	**【0】:** Auto Restart Fault Messages are not saved in fault history during Auto-Restart. **【1】:** Auto Restart Fault Messages are saved in fault history during Auto-Restart.

13-14=0,

Fault messages are not saved in fault history (12-46~12-49) while the auto restart function is active.

13-14=1,

Fault messages are saved in fault history (12-46~12-49) while the auto restart function is active.

Group 14: PLC Setting Parameters

14-00	T1 Set Value 1
14-01	T1 Set Value 2（Mode 7）
14-02	T2 Set Value 1
14-03	T2 Set Value 2（Mode 7）
14-04	T3 Set Value 1
14-05	T3 Set Value 2（Mode 7）
14-06	T4 Set Value 1
14-07	T4 Set Value 2（Mode 7）
14-08	T5 Set Value 1
14-09	T5 Set Value 2（Mode 7）
14-10	T6 Set Value 1
14-11	T6 Set Value 2（Mode 7）
14-12	T7 Set Value 1
14-13	T7 Set Value 2（Mode 7）
14-14	T8 Set Value 1
14-15	T8 Set Value 2（Mode 7）
Range	【0~9999】

14-16	C1 Set Value
14-17	C2 Set Value
14-18	C3 Set Value
14-19	C4 Set Value
14-20	C5 Set Value
14-21	C6 Set Value
14-22	C7 Set Value
14-23	C8 Set Value
Range	【0~65535】

14-24	AS1 Set Value 1
14-25	AS1 Set Value 2
14-26	AS1 Set Value 3
14-27	AS2 Set Value 1
14-28	AS2 Set Value 2
14-29	AS2 Set Value 3
14-30	AS3 Set Value 1
14-31	AS3 Set Value 2
14-32	AS3 Set Value 3
14-33	AS4 Set Value 1
14-34	AS4 Set Value 2
14-35	AS4 Set Value 3
Range	【0~65535】

14-36	**MD1 Set Value 1**
14-37	**MD1 Set Value 2**
14-38	**MD1 Set Value 3**
14-39	**MD2 Set Value 1**
14-40	**MD2 Set Value 2**
14-41	**MD2 Set Value 3**
14-42	**MD3 Set Value 1**
14-43	**MD3 Set Value 2**
14-44	**MD3 Set Value 3**
14-45	**MD4 Set Value 1**
14-46	**MD4 Set Value 2**
14-47	**MD4 Set Value 3**
Range	**【0~65535】**

Please refer to section 4.5 for more details of built-in PLC function.

Group 15: PLC Monitoring Parameters

15-00	**T1 Current Value 1**
15-01	**T1 Current Value 2（Mode 7）**
15-02	**T2 Current Value 1**
15-03	**T2 Current Value 2（Mode 7）**
15-04	**T3 Current Value 1**
15-05	**T3 Current Value 2（Mode 7）**
15-06	**T4 Current Value 1**
15-07	**T4 Current Value 2（Mode 7）**
15-08	**T5 Current Value 1**
15-09	**T5 Current Value 2（Mode 7）**
15-10	**T6 Current Value 1**
15-11	**T6 Current Value 2（Mode 7）**
15-12	**T7 Current Value 1**
15-13	**T7 Current Value 2（Mode 7）**
15-14	**T8 Current Value 1**
15-15	**T8 Current Value 2（Mode 7）**
Range	**【0~9999】**

15-16	**C1 Current Value**
15-17	**C2 Current Value**
15-18	**C3 Current Value**
15-19	**C4 Current Value**
15-20	**C5 Current Value**
15-21	**C6 Current Value**
15-22	**C7 Current Value**
15-23	**C8 Current Value**
Range	**【0~65535】**

15-24	**AS1 Results**
15-25	**AS2 Results**
15-26	**AS3 Results**
15-27	**AS4 Results**
15-28	**MD1 Results**
15-29	**MD2 Results**
15-30	**MD3 Results**
15-31	**MD4 Results**
15-32	**TD Current Value**
Range	**【0~65535】**

Group 16: LCD Function Parameters

16-00	Main Screen Monitoring
Range	【5~79】
16-01	Sub-Screen Monitoring 1
Range	【5~79】
16-02	Sub-Screen Monitoring 2
Range	【5~79】

At power-up the inverter shows two monitor section on the display, main monitor section and t two sub-screen monitor sections (smaller font).

Choose the monitor signal to be displayed on the main-screen monitor screen using parameter 16-00, and the monitor signals to be displayed on the sub-screen monitor with parameters 16-01 and 16-02, similar to monitor parameters 12-5 ~ 12-79.

Note: The setting value of 16-00, 16-01 and 16-02 can be modified, except in PID mode (refer to the setting description of parameter 10-03) and PUMP modes (refer to the setting description of parameter 23-00).

16-03	Selection of Display Unit
Range	【0】: Display unit is Hz (Resolution is 0.01Hz) 【1】: Display unit is % (Resolution is 0.01%) 【2】: Rpm display; to calculate motor poles for V/f and SLV are set by 02-07, PM mode is by 22-03 【40~9999】: 100% is XXXX with no decimals (integer only) 【10001~19999】: 100% is XXX.X with 1 decimal 【20001~29999】: 100% is XX.XX with 2 decimals 【30001~39999】: 100% is X.XXX with 3 decimals
16-04	Selection of Engineering Unit
Range	【0】: No Unit 【1】: FPM 【2】: CFM 【3】: PSI 【4】: GPH 【5】: GPM 【6】: IN 【7】: FT 【8】: /s 【9】: /m 【10】: /h 【11】: °F 【12】: inW 【13】: HP 【14】: m/s 【15】: MPM 【16】: CMM 【17】: W 【18】: KW 【19】: m

	【20】: °C **【21】: RPM** **【21】: RPM** **【22】: Bar** **【23】: Pa**

16-03: Display unit of digital operator

Set the units of the following items to be displayed, the frequency reference (05-01, 00-18, 06-01~06-15) and the monitoring frequency 12-16, 12-17 (Output frequency)

16-04: Display unit of engineering

When 16-03 = 00040-39999, engineering units are enabled. The displayed set range and the frequency range of unit (05-01, 06-01~06-15) as well as the monitoring frequency (12-16, 12-17) are changed by parameters 16-04 and 16-03.

<table>
<tr><th>16-03</th><th colspan="4">Set / displayed contents</th></tr>
<tr><td>0</td><td colspan="4">0.01 Hz</td></tr>
<tr><td>1</td><td colspan="4">0.01 % (maximum output frequency 01-02=100%)</td></tr>
<tr><td>2</td><td colspan="4">RPM (RPM = 120 x reference frequency / numbers of motor pole. The numbers of motor pole is set by 02-07 for control modes of V/F or SLV and is set by 22-03 in PMSLV.)</td></tr>
<tr><td rowspan="6">00040
-
39999</td><td colspan="4">Set the decimal point by using the fifth place.
i.e. □ □□□□
Sets full display scaling excluding decimals
Set the number of decimal places
⇨
00040 - 09999 : □□□□ (Integer only e.g. 1000)
10001 - 19999 : □□□. □ (1 decimal place e.g. 10.0)
20001 - 29999 : □□. □□ (2 decimal places, e.g. 10.00)
30001 - 39999 : □. □□□ (3 decimal places, e.g. 10.000)

<example></td></tr>
<tr><td>16-03</td><td>Display</td><td>Display unit</td><td>Display example</td></tr>
<tr><td>00040
-
09999</td><td>□□□□</td><td rowspan="4">use
16-04 setting</td><td>Example: 100 % speed is 0200
> set 16-03=00200 (from 05-01, 06-01 to 06-15, set range from 0040 to 9999).
> set 16-04=0 (no unit)</td></tr>
<tr><td>10001
–
19999</td><td>□□□. □</td><td>Example: 100 % speed is 200.0 CFM
> set 16-03=12000 (05-01, 06-01 to 06-15, set range from 0000 to 9999).
> set 16-04=2 (CFM)
> 60% speed will be displayed as 120.0 CFM</td></tr>
<tr><td>20001
–
29999</td><td>□□. □□</td><td>Example: 100 % speed is 65.00ºC
> set 16-03=26500 (05-01, 06-01 to 06-15, set range from 0000 to 9999)
> set 16-04=20 (ºC)
> 60% of speed is displayed as 39.00 ºC</td></tr>
<tr><td>30001
-
39999</td><td>□. □□□</td><td>Example: 100 % speed is 2.555 m/s
> set 16-03=32555
> set 16-04=14 (m/s)
> 60% speed is displayed as 1.533 m/s</td></tr>
</table>

16-05	LCD Backlight
Range	【0~7】

Adjust the screen contrast of the digital operator. If it is set to 0, the screen backlight is turned off.

16-07	Copy Function Selection
Range	**【0】: Disable (Do not copy parameters)** **【1】: Read (read inverter parameters and save to the operator)** **【2】: Write (write the operator parameters to inverter)** **【3】: Verify (Compare parameters of inverter and operator)**
16-08	Selection of Allowing Reading
Range	**【0】: Disable (Do not allow to read inverter parameters and save to the operator)** **【1】: Enable (Allow to read inverter parameters and save to the operator)**

LCD digital operator with built-in memory (EEPROM) can be used to store and retrieve parameters:

(1) Read: Save inverter parameters to the digital operator (INV → OP).
(2) Write: Write the parameters from the digital operator to the inverter and save (OP → INV).
(3) Verify: Compare the inverter parameters against the parameters in the digital operator.

16-07=0: No action

16-07=1: Read (all parameters are copied from the inverter to the keypad).

16-07=2: Write (all parameter are copied from the keypad to the inverter).

16-07=3: Verify (Compare the set value of the inverter to the parameter of the digital operator).

Set 16-08 = 0, to prevent the saved parameter data stored in the digital operator from accidentally being overwritten.

When parameter 16-08=0 and the read operation is executed (16-07=1) a warning message of "RDP Read Prohibited" will be displayed on the keypad and the read operation is cancelled.

Refer to the following steps for copy function operation.

For the write-in operation requires the following items to match.
(1) Software version
(2) Control method
(3) Inverter type
(4) Inverter rated capacity and voltage

Set one of the parameters 03-00 to 03-05 (multi-function digital input selection) to 49 (Enable the parameter write-in function) to enable or disable the parameter write-in function.

When terminal is active, parameters can be copied from the digital operator to the inverter. When the terminal is not active inverter parameters are prohibited from write-in, excluding the reference frequency (00-05).

Note: Set parameter 16-11 (RTC date setting) and 16-12 (RTC time setting) after parameters are copied from the operator to the inverter (OP→INV).

■ READ：Copy inverter parameters to the keypad

Steps	LCD Display (English)	Description
1	Group 14 PLC Setting 15 PLC Monitor 16 LCD Keypad Func.	Select the copy function group (16) from the group menu.
2	PARA 16 -07：Copy Sel -08：READ Sel -09：Keypad Loss Sel	Press the Read / Enter key and select parameter (16-07) copy sel.
3	Edit 16-07 Copy Sel 0 Normal (0 - 3) < 0 >	Press the Read / Enter key to display the data setting / read screen (LCD display is inversed).
4	Edit 16-07 Copy Sel 1 READ (0 - 3) < 0 >	Change the set value to 1 (read) by using the up arrow key.
5	-ADV- READ INV → OP	• Use Read / Enter key to enable the read operation, the display is shown as the left. • The bottom of LCD display will show a bar to indicate the read progress s.
6	-ADV- READ COMPLETE	"READ COMPLETE" will be displayed on the keypad when reading was successful.
	RDP Read Prohibited	• The error message of "RDP Read Prohibited" may occur on the keypad when reading parameters from the inverter is prohibited. • If the error is displayed, press any key to remove the error message and go back to parameter 16-07.
7	Edit 16-07 Copy Sel 1 READ (0 - 3) < 0 >	When DSP/FUN key is pressed, the display returns to parameter 16-07.

■ WRITE: Copy Keypad parameters to the Inverter

Steps	LCD Display (English)	Description
1	Group 14 PLC Setting 15 PLC Monitor 16 LCD Keypad Func.	Select the copy function group (16) from the group menu.
2	PARA 16 -07：Copy Sel -08：READ Sel -09：Keypad Loss Sel	Press the Read / Enter key and select parameter (16-07) copy sel.
3	Edit 16-07 Copy Sel 0 Normal (0 ~ 3) < 0 >	Press the Read / Enter key to display the data setting / read screen (LCD display is inversed).
4	Edit 16-07 Copy Sel 2 WRITE (0 ~ 3) < 0 >	Change the set value to 2 (write) by using the up arrow key.
5	-ADV- WRITE INV → OP	• Use Read / Enter key to enable the read operation, the display is shown as the left. • The bottom of LCD display will show a bar to indicate the read progress.
6	-ADV- WRITE COMPLETE	"WRITE COMPLETE" will be displayed on the keypad when writing was successful.
	WRE Write Error	• The error message of "WRE Write Error " may occur on the keypad when writing parameters to the inverter is prohibited. • If the error is displayed, press any key to remove the error message and go back to parameter 16-07.
7	Edit 16-07 Copy Sel 2 WRITE (0 ~ 3) < 0 >	When DSP/FUN key is pressed, the display returns to parameter 16-07.

■ Verify: Compare Inverter Parameters against Keypad Parameters.

Steps	LCD Display (English)	Description
1	Group 14 PLC Setting 15 PLC Monitor 16 LCD Keypad Func.	Select the copy function group (16) from the group menu.
2	PARA 16 -07：Copy Sel -08：READ Sel -09：Keypad Loss Sel	Press the Read / Enter key and select parameter (16-07) copy sel.
3	Edit 16-07 Copy Sel 0 Normal (0 ﹣ 3) < 0 >	Press the Read / Enter key to display the data setting / read screen (LCD display is inversed).
4	Edit 16-07 Copy Sel 3 VERIFY (0 ﹣ 3) < 0 >	Change the set value to 3 (verify) by using the up arrow key.
5	-ADV- VERIFY INV → OP	• Use Read / Enter key to enable the read operation, the display is shown as the left. • The bottom of LCD display will show a bar to indicate the read progress.
6	-ADV- VERIFY COMPLETE	"VERIFY COMPLETE" will be displayed on the keypad when writing was successful.
	VERY Verify Error	• The error message of "VERY Verify Error " may occur on the keypad when writing parameters to the inverter is prohibited. • If the error is displayed, press any key to remove the error message and go back to parameter 16-07.
7	Edit 16-07 Copy Sel 3 VERIFY (0 ﹣ 3) < 0 >	When DSP/FUN key is pressed, the display returns to parameter 16-07.

16-09	Selection of Operator Removed (LCD)
Range	**【0】: Keep Running** **【1】: Stop**

16-09=0: Continue operating when keypad is removed.

16-09=1: Trip inverter when keypad is removed while operating in local mode.

16-10	RTC Function Selection
Range	**【0】: Hide** **【1】: Show**
16-11	**RTC Set Date**
Range	**【12.01.01 ~ 99.12.31】**
16-12	**RTC Set Time**
Range	**【00:00 ~ 23:59】**

Set the internal clock before using the function of Real Time Clock (RTC).

RTC date setting is determined by parameter 16-11 and RTC time setting is determined by parameter 16-12.

RTC is displayed in the top of the keypad and refer to Fig.4.3.85 for the selection of RTC time display (16-10) is set to 1.

Monitor 00:00
Freq Ref
12-16 = 000.00 Hz

12-17 = 000.00 Hz
12-18 = 0000.0A

Figure 4.3.85 RTC Time Display (Example)

Notes:

- RTC is disabled if the keypad is removed from the inverter.

- The RTC continues to run regardless of the RTC function being displayed using parameter 16-10 (RTC Time Display Setting).

Users can apply the parameters 12-72 and 12-73 to monitor the specific RTC date and time.

The Real-time Clock has the following functions:
- Four times per day
- Four weeks
- Timer offset function (preset time)
- Timer enable via multi-function digital input
- Selection for constant time and speed
- Timer enabled multi-function digital output

16-13	RTC Timer Function Selection
Range	**【0】: Disable** **【1】: Enable** **【2】: Enable by DI**

16-14	P1 Start Time
16-15	P1 Stop Time
16-18	P2 Start Time
16-19	P2 Stop Time
16-22	P3 Start Time
16-23	P3 Stop Time
16-26	P4 Start Time
16-27	P4 Stop Time
Range	【00:00 ~ 23:59】
16-16	P1 Start Date
16-17	P1 Stop Date
16-20	P2 Start Date
16-21	P2 Stop Date
16-24	P3 Start Date
16-25	P3 Stop Date
16-28	P4 Start Date
16-29	P4 Stop Date
Range	【1】: Monday 【2】: Tuesday 【3】: Wednesday 【4】: Thursday 【5】: Friday 【6】: Saturday 【7】: Sunday
16-30	RTC Offset Selection
Range	【0】: Disable 【1】: Enable 【2】: Set by DI
16-31	RTC Offset Time Setting
Range	【00:00 ~ 23:59】
16-32	Source of Timer 1
16-33	Source of Timer 2
16-34	Source of Timer 3
16-35	Source of Timer 4
Range	【0~31】: Refer to Table 4.3.13
16-36	Selection of RTC Speed
Range	【0】: Off 【1】: By Timer 1 【2】: By Timer 2 【3】: By Timer 3 【4】: By Timer 4 【5】: By Timer 1+2

16-37	Run Direction of RTC Speed
Range	【xxx0 B】: RTC Run1 Forward Rotation 【xxx1 B】: RTC Run1 Reverse Rotation 【xx0x B】: RTC Run2 Forward Rotation 【xx1x B】: RTC Run2 Reverse Rotation 【x0xx B】: RTC Run3 Forward Rotation 【x1xx B】: RTC Run3 Reverse Rotation 【0xxx B】: RTC Run4 Forward Rotation 【1xxx B】: RTC Run4 Reverse Rotation

Source of timer can be selected to link multiple time periods and one time period can be set to multiple timers.

Timer is set by the following steps:

① **Start the timer:**

Timer starts via the setting of RTC timer function (16-13).

② **Set the time period:**

Set the start, stop time and date. If the start time is equal to the stop time the timer is disabled.

③ **Enable timer:**

Set time period for the specific timer (16-32~16-35).

④ **Link to parameters:**

The timer can be linked to the relay output. Only one relay output can be linked to one timer (e.g. 03-11, 03-12 and 03-39, 16-36).

Note: If the stop time is set to 12:00, Motor stops at from 12:01.

Refer to Fig.4.3.86 for RTC parameter structure.

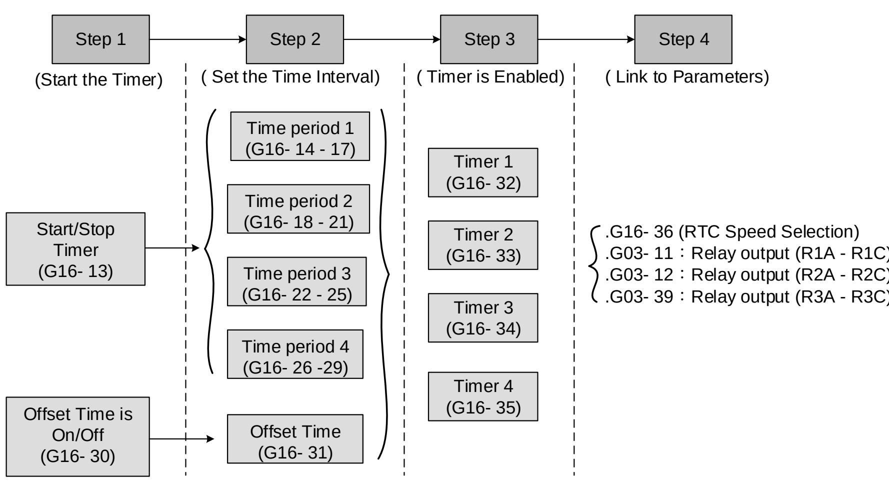


Figure 4.3.86 RTC structure

Refer to the following Table 4.3.13 for the selection of timer operation cycle.

Table 4.3.13 Set Time period for timer function

16-32 ~ 16-35	O	P4	P3	P2	P1	Timer Function	Display
0	0	0	0	0	0	Without the selection of timer	None
1	0	0	0	0	1	Time Period 1	P1
2	0	0	0	1	0	Time Period 2	P2
3	0	0	0	1	1	Time Period 1 and 2	P1+P2
4	0	0	1	0	0	Time Period 3	P3
5	0	0	1	0	1	Time Period 1 and 3	P1+P3
6	0	0	1	1	0	Time Period 2 and 3	P2+P3
7	0	0	1	1	1	Time Period 1 , 2 and 3	P1+P2+P3
8	0	1	0	0	0	Time Period 4	P4
9	0	1	0	0	1	Time Period 1 and 4	P1+P4
10	0	1	0	1	0	Time Period 2 and 4	P2+P4
11	0	1	0	1	1	Time Period 1 , 2 and 4	P1+P2+P4
12	0	1	1	0	0	Time Period 3 and 4	P3+P4
13	0	1	1	0	1	Time Period 1 , 3 and 4	P1+P3+P4
14	0	1	1	1	0	Time Period 2 , 3 and 4	P2+P3+P4
15	0	1	1	1	1	Time Period 1 , 2 , 3 and 4	P1+P2+P3+P4
16	1	0	0	0	0	Offset selection	Offset (O)
17	1	0	0	0	1	Offset and time period 1	O+P1
18	1	0	0	1	0	Offset and time period 2	O+P2
19	1	0	0	1	1	Offset and time period 1 and 2	O+P1+P2
20	1	0	1	0	0	Offset and time period 3	O+P3
21	1	0	1	0	1	Offset and time period 1 and 3	O+P1+P3
22	1	0	1	1	0	Offset and time period 2 and 3	O+P2+P3
23	1	0	1	1	1	Offset and time period 1 , 2 and 3	O+P1+P2+P3
24	1	1	0	0	0	Offset and time period 4	O+P4
25	1	1	0	0	1	Offset and time period 1 and 4	O+P1+P4
26	1	1	0	1	0	Offset and time period 2 and 4	O+P2+P4
27	1	1	0	1	1	Offset and time period 1 , 2 an 4	O+P1+P2+P4
28	1	1	1	0	0	Offset and time period 3 and 4	O+P3+P4
29	1	1	1	0	1	Offset and time period 1 , 3 and 4	O+P1+P3+P4
30	1	1	1	1	0	Offset and time period 2 , 3 and 4	O+P2+P3+P4
31	1	1	1	1	1	Offset and time period 1 , 2 , 3 and 4	O+P1+P2+P3+P4

Reference frequency and motor rotation direction are controlled by RTC function.

16-36=0: RTC speed selection is disabled.

16-36=1: Timer 1 is enabled.

Reference frequency = Frequency Setting of Speed-Stage 0 (05-01)

16-36=2: Timer 2 is enabled.

Reference frequency = Frequency Setting of Speed-Stage 0 (05-01)

16-36=3: Timer 3 is enabled.

Reference frequency = Frequency Setting of Speed-Stage 0 (05-01)

16-36=4: Timer 4 is enabled.

Reference frequency = Frequency Setting of Speed-Stage 0 (05-01)

16-36=4: Timer 1 and 2 are enabled.

Frequency reference is controlled by the simultaneous operation of timer 1 and 2.

Notes:
- The inverter runs using the start of a specific timer without being affected by other timers.
- The RTC speed setting (16-36) is affected by timer period 1 to 4 (P1~P4) using RTC rotation direction (16-37).

Example:
When the selection of RTC speed is set to 5 (timer 1+2), source of run command (00-02) and source of frequency command (00-05) are required to be set to RTC to have the frequency reference be controlled by RTC timer 1 and 2.

Refer to Table 4.3.14 for more information.

Note: Selection of RTC Rotation Direction (16-37) depends on Motor Direction Lock Selection(11-00).

Table 4.3.14 Reference frequency is determined by timer 1 and 2

Timer 1	Timer 2	Main Frequency Command Source Selection (00-05)	Source of frequency setting	Selection of rotation direction
0	0	6(RTC)	Set by frequency setting of speed-stage 0 (05-01)	By RTC 1 (16-37)
1	0	6(RTC)	Set by frequency setting of speed-stage 1 (06-01)	By RTC 2 (16-37)
0	1	6(RTC)	Set by frequency setting of speed-stage 2 (06-02)	By RTC 3 (16-37)
1	1	6(RTC)	Set by frequency setting of speed-stage 3 (06-03)	By RTC 4 (16-37)

RTC function is disabled when:

- Multi-function terminal (03-00~03-05) is set to fire mode.
- KEB function is enabled
    - ■ Source of main frequency of RTC function is according to Table 4.3.14 and also can refer to main and alternative frequency command modes (00-07).
    - ■ If main run command source selection (00-02) is set to 0~3 (0: keypad, 1: external terminal, 2: communication control, 3: PLC), refer to Table 4.3.15 for the relationship between main run command and RTC timer status.

Table 4.3.15 Relationship between main run command and RTC timer status

Main run command 00-02	RTC timer x status	Inverter status
0~3	0	Inverter cannot run (without run command)
0~3	1	Inverter cannot run (without run command)
4	0	Inverter cannot run (RTC timer is disabled)
4	1	Inverter runs and rotates depending on the function of 16-37.

RTC timer example:

Inverter running on Monday between 6:00 AM to 10:00 PM.
Inverter running on Tuesday to Friday between 8:00 AM to 8:00 PM.
Inverter running on Saturday between 8:00 AM to 6:00 PM.
Inverter running on Sunday between 8:00 AM to 12:00 PM.
Motor running on weekdays (Mon. to Fri.) at speed 1 and on weekends at speed 2.

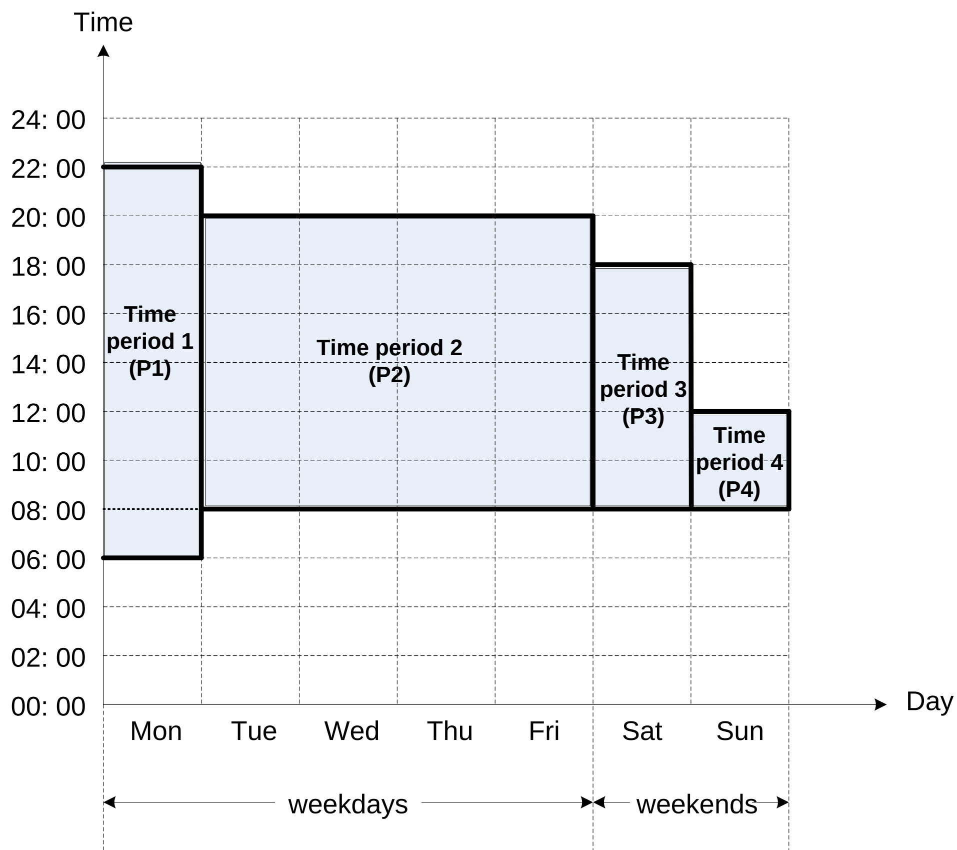


Figure 4.3.87 RTC timer (example)

① **Start up the timer in the parameter group 16** (Set the internal time first to enable this function).
Set the correct date and time in the parameters 16-11 and 16-12 and set parameter 16-13 to 1(enable RTC timer function).

② **Set time period 1 (P1)**
Start time 1: 16-14 = 06:00:00 (6:00 AM)
Stop time 1: 16-15 = 22:00:00 (10:00 PM)
Start date 1: 16-16 = 1 (Monday)
Stop date 1: 16-17 = 1 (Monday)

③ **Set time period 2 (P2)**
Start time 2: 16-18 = 08:00:00 (8:00 AM)
Stop time 2: 16-19 = 20:00:00 (8:00 PM)
Start date 2: 16-20 = 2 (Tuesday)
Stop date 2: 16-21 = 5 (Friday)

④ **Set time period 3 (P3)**
Start time 3: 16-22 = 08:00:00 (8:00 AM)
Stop time 3: 16-23 = 18:00:00 (6:00 PM)
Start date 3: 16-24 = 6 (Saturday)
Stop date 3: 16-25 = 6 (Saturday)

⑤ **Set time period 4 (P4)**
Start time 4: 16-26 = 08:00:00 (8:00 AM)
Stop time 4: 16-27 = 12:00:00 (12:00 AM)
Start date 4: 16-28 = 7 (Sunday)
Stop date 4: 16-29 = 7 (Sunday)

⑥ **Timer 1 is enabled to set all the time periods (P1, P2, P3, P4)**
16-32 = 15: Source of timer 1 = P1 + P2 + P3 + P4)

⑦ **Selection of RTC speed is determined by timer 1**
16-36 = 1: Timer 1 is enabled.
Frequency setting is speed-stage 0 (05-01).
Rotation direction (16-37) is set to 0000b.
Then, the rotation direction of time period 1~4 (P1~P4) is corresponding to the setting of 16-37.

⑧ **Choose two constant speeds (speed 1 & speed 2)**
16-36 = 5: Timer 1+2 is enabled.
When timer 1 is enabled, frequency setting is speed-stage 1; while timer 2 is enabled, frequency setting is speed-stage 2.
Rotation direction (16-37) is set to 0000b.
Then, when timer 1 and timer 2 are active, direction of motor rotation is forward rotation.

Note: Select RTC offset (16-30) and set RTC offset time (16-31) to enable the offset time. Inverter runs depending on the arranging time period to timer function. Refer to the following Fig.4.3.88.

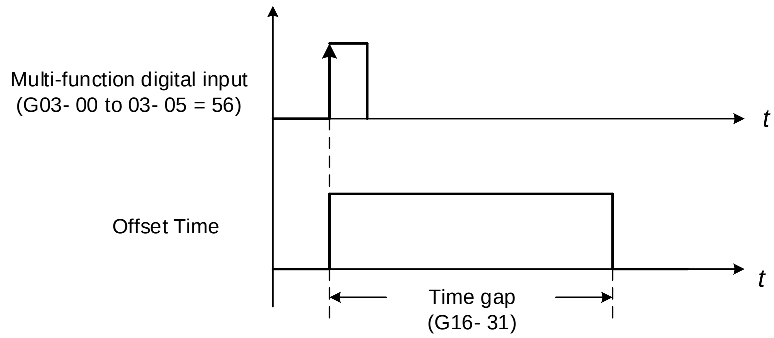


Figure 4.3.88 Operation of offset time

Example:

Inverter runs at the time period defined by P1:

When 16-36=1 (selection of RTC speed is set to timer 1) and 16-32=17 (offset + PI), RTC offset (16-30) is controlled by DI and the offset time is set via 16-31. Activate the DI and RTC will immediately turn on.

If the timer source is set to 15 (P1+P2+P3+P4), press “STOP” key at the time period 1 (P1). Normally the RTC will start automatically at the beginning of the next time period (P2) but it can be setup to start via a DI (16-30 = 2). The inverter and RTC start running again when activating the DI.

Notes:

If the “STOP” key is pressed within the time period the inverter can be re-started by:

- Setting the RTC offset selection (16-30) to 2 (set by DI) and set DI to 56 (RTC Offset Enable).
- Setting the RTC offset (16-30) to enabled.

Note:

RTC Accuracy:

Temperature	Deviation
+25 ºC (77 ºF)	+/-3 sec./ day
-20 / +50ºC (-4/ 122ºF)	+/-6 sec./ day

Group 17: IM Motor Automatic Tuning Parameters

17-00	Mode Selection of Automatic Tuning
Range	【0】: Rotation Auto-Tune 【1】: Static Auto-Tune 【2】: R1 Tuning (Stator Resistance Measurement) 【4】: Loop Adjust (Current Loop PID Adjustment) 【5】: Rotation Auto-Tune (with Loop Adjust, Stator Resistance, and Rotation) 【6】: Static Auto-Tuning (with Loop Adjust, Stator Resistance, and Static)
17-01	Motor Rated Output Power
Range	【0.00~600.00】KW
17-02	Motor Rated Current
Range	10%~200% of the inverter rated current in V/F control mode 25%~200% of the inverter rated current in SLV control mode
17-03	Motor Rated Voltage*1
Range	【0.0~255.0】V: 230V 【0.0~510.0】V: 460V
17-04	Motor Rated Frequency*2
Range	【10.0~400.0】Hz
17-05	Motor Rated Speed
Range	【0~24000】rpm
17-06	Pole Number of Motor
Range	【2~16】pole (Even)
17-08	Motor No-load Voltage
Range	【50~240】V: 220V 【100~480】V: 440V
17-09	Motor Excitation Current
Range	【0.01~600.00】A (15%~70% motor rated current)
17-10	Automatic Tuning Start
Range	【0】: Disable 【1】: Enable
17-11	Error History of Automatic Tuning
Range	【0】: No Error 【1】: Motor Data Error 【2】: Stator Resistance Tuning Error 【3】: Leakage Induction Tuning Error 【4】: Rotor Resistance Tuning Error 【5】: Mutual Induction Tuning Error 【6】: Reserved 【7】: DT Error 【8】: Motor Acceleration Error 【9】: Warning
17-12	Leakage Inductance Ratio
Range	【0.1~15.0】%
17-13	Slip Frequency
Range	【0.10~20.00】Hz

***1. Values of motor rated voltage are for 230V class, double the values for 460V class.**

***2. The setting range of motor rated frequency is 0.0 to 400.0 Hz.**

Auto-tuning

Based on the motor nameplate set the motor rated output power (17-01), motor output rated current (17-02), motor rated voltage (17-03), motor rated frequency (17-04), motor rated speed (17-05) and number of motor poles (17-06) to perform an auto-tune.

- Automatic tuning mode selection (17-00)

17-00=0: Perform rotational auto-tune (High performance auto-tune)

17-00=1: Perform a static non-rotational auto-tune
Motor does not rotate during auto-tuning and this tuning causes lower power at low speed.

17-00=2: Perform stator resistance non-rotational auto-tune (V/F mode) when using long motor leads.
This tuning causes lower power at low speed.

17-00=3: Reserved

17-00=4: Performance improvement (speed and torque regulation) in vector control mode

- Motor rated output power (17-01)
  Set by inverter capacity (13-00)

- Motor rated current (17-02)
  Set by inverter capacity (13-00)
  Set the range to 10 %~200 % of the inverter rated current.

- Motor rated voltage (17-03)

- Motor rated frequency (17-04)

- Motor rated speed (17-05)

When tuning a special motor (e.g. constant power motor, high-speed spindle motor), with a motor rated voltage or rated motor frequency that is lower than a standard AC motor, it is necessary to confirm the motor nameplate information or the motor test report.

Prevent the inverter output voltage from saturation when the motor rated voltage is higher than the inverter input voltage (see Example 1).

Example 1: Motor rated voltage (440V/60Hz) is higher than the inverter input voltage (380V/50 Hz).

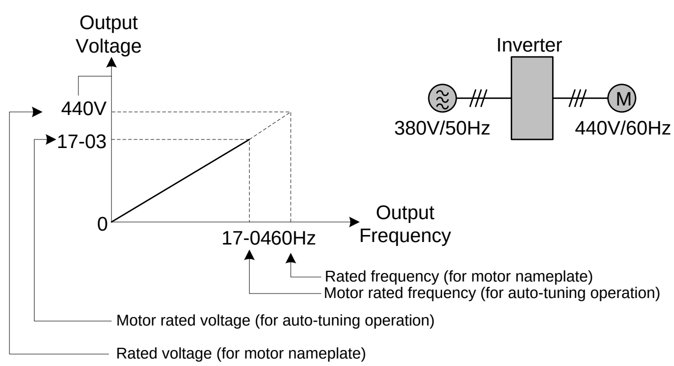


Figure 4.3.89 Rated voltage and frequency settings

Step 1: Set motor rated voltage, 17-03=440V.
Step 2: Set no-load voltage, 17-08=360V, lower the input voltage by 20V when operating in torque control.
Step 3: Set motor rated frequency:

$$17\text{-}04 = (\text{Rated frequency of motor nameplate}) \times \frac{(\text{Inverter input power voltage})}{(\text{Rated frequency of motor nameplate})} = 60\text{Hz} \times \frac{380\text{V}}{440\text{V}} = 51.8\text{Hz}$$

Step 4: Automatically tuning
Parameter 01-12 (Fbase) is automatically set during auto-tuning. Parameter 01-12 (Fbase) is set to the motor rated frequency.

Step 5: Set the 01-12 (Fbase) to the motor rated frequency on the motor nameplate. If the maximum output frequency (01-02, Fmax) and base frequency (01-12, Fbase) are different, set the maximum output frequency when the auto- tuning (01-02, Fmax) is completed.

When the inverter input voltage (or frequency) is higher than the motor rated voltage (or frequency), set the motor rated voltage (17-03) and the motor rated frequency (17-04) to the rated frequency on the motor nameplate.

Example 2: The inverter input voltage and frequency (440V/50Hz) are higher than the motor rated voltage and frequency (380V/33Hz), set 17-03 to 380V (rated motor voltage) and 17-04 to 33Hz (motor rated frequency).

■ Number of poles (17-06)
Set the motor pole number with its range is 2, 4, 6, 8 and 16 poles.

■ Motor no-load voltage (17-08)
a) Motor no-load voltage is mainly used in SLV mode, set to value 10~50V lower than the input voltage to ensure good torque performance at the motor rated frequency.
b) Set to 85 ~ 95% of the motor rated voltage. In general, the no-load voltage can be closer to the motor rated voltage for larger motors, but cannot exceed the motor rated voltage.
c) The motor no-load voltage can be set to a value greater than the actual input voltage. In this case the motor can only operates under relatively low frequency. If the motor operates at the rated frequency an over voltage condition may occur.
d) The higher the motor power the higher the no-load voltage is.
e) A smaller no-load voltage will reduce the no-load current.
f) When load is applied the magnetic flux is weakened and the motor current increases.
g) A higher no-load voltage results in a higher no-load current.
h) When load is applied the magnetic flux weakens and the motor current increases. Increasing the magnetic flux generates back EMF and results in poor torque control.

■ Motor excitation current (17-09)
a) Only the static-type or stator resistance measurement auto-tuning (17-00=1 or 17-00=2) can be set. This data can be obtained by manual tuning. Normally, it does not require adjusting.
b) Motor excitation current is used for non-rotational auto-tuning.
c) The setting range of motor excitation current is 15%~70% of the motor rated current.
d) If this parameter is not set, the inverter calculates the motor related parameters.

■ Automatic tuning start (17-10)
Set parameter 17-10 to 1 and press ENTER the inverter will display “Atrdy” for Auto-tune ready. Next, press

RUN key to start the auto-tune procedure. During auto-tuning the keypad will display “Atune “for Auto-tune in progress. When the motor is successfully tuned, the keypad shows "AtEnd".

■ Error history of automatic tuning (17-11)
If auto-tuning fails the keypad will display the AtErr" message and the auto-tune cause is shown in parameter 17-11. Refer to section 5 for troubleshooting and possible automatic tuning error causes.

Note: The motor tuning error history (17-11) shows the tuning result of the last auto-tune. No error is displayed when auto-tune is aborted or when the last auto-tune was successful.

■ Motor Leakage Inductance Ratio (17-12)

a) Only stator resistance measurement auto-tuning (17-00=2) can be set. Data can be obtained by manual tuning. Normally, it does not require adjustment.
b) Mainly used during non-rotational auto-tuning. The default setting is 3.4%. It is required to perform an auto tune to save the adjusted value into parameter 02-33.
c) If this parameter is not set, the inverter automatically calculates the motor related parameters.

■ Motor Slip Frequency (17-13)
a) Only stator resistance measurement auto-tuning (17-00=2) can be set. Data can be obtained by manual tuning. Normally, it does not require adjustment.
b) Mainly used for non-rotational auto-tuning. The default setting is 1Hz. It is required to perform an auto tune to save the adjusted value into parameter 02-34.
c) If this parameter is not set, the inverter automatically calculates the motor related parameters.

Notes:
- Perform the “Stator resistance measurement” (17-00=2) auto-tune if the inverter/motor leads are longer than 167ft (50m).
- For the best performance in vector control mode perform the rotary-type automatic tune (17-00=0) first (using short motor leads between the inverter and motor) and a “Stator resistance measurement” (17-00=2) next.
- If a rotary auto-tune (17-00=0) cannot be performed, manually enter the mutual induction (02-18), excitation current (02-09), core saturation compensation factor 1 - 3 (02-11 - 02-13).
- Perform the “Stator resistance measurement” (17-00=2) in V/F control when inverter/motor leads are longer than 167ft (50m).

Group 18: Slip Compensation Parameters

18-00	Slip Compensation Gain at Low Speed
Range	【0.00~2.50 】
18-01	Slip Compensation Gain at High Speed
Range	【-1.00~1.00】
18-02	Slip Compensation Limit
Range	【0~250】%
18-03	Slip Compensation Filter Time
Range	【0.0~10.0】sec
18-04	Regenerative Slip Compensation Selection
Range	【0】: Disable 【1】: Enable
18-05	FOC Delay Time
Range	【1~1000】msec
18-06	FOC Gain
Range	【0.00~2.00】

Slip compensation automatically adjusts the output frequency based on the motor load to improve the speed accuracy of the motor mainly in V/F mode.

The slip compensation function compensates for the motor slip to match the actual motor speed to the reference frequency.

Slip compensation adjustment in V/F mode

18-00: Slip compensation gain at low speed

The adjustment of slip compensation gain at low speed follows the below procedure:

1. Set the rated slip and the motor no-load current (02-00).
2. Set the slip compensation (18-00) to1.0 (factory default setting is 0.0 in V / F control mode)
3. For the operation with a load attached, measure the speed and adjust the slip gain (18-00) accordingly (increase in steps of 0.1).
   - If the motor speed is lower than frequency reference, increase the value of 18-00.
   - If the motor speed is higher than frequency reference, decrease the value of 18-00.

When the output current is greater than the no-load current (02-00), the slip compensation is enabled and the output frequency increases from f1 to f2. Refer to Fig.4.3.90., the slip compensation value is calculated as follows:

$$\text{Slip compensation value} = \text{Motor rated sync induction rotation difference} \times \frac{[\text{Output current (12-08)} - \text{motor no-load current (02-00)}]}{[\text{Motor output rated current (02-01)} - \text{motor no-load current (02-00)}]}$$

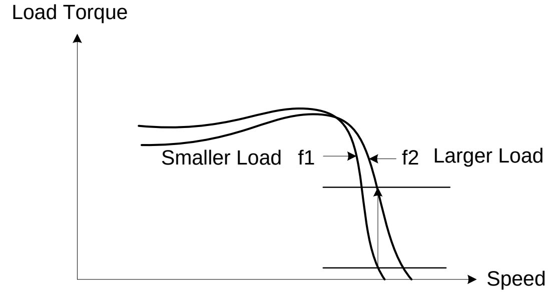


Figure 4.3.90 Slip compensation output frequency

18-02: Slip compensation limit
Sets slip compensation limit in constant torque and the constant power operation (Fig.4.3.91).
If 18-02 is 0%, the slip compensation limit is disabled.

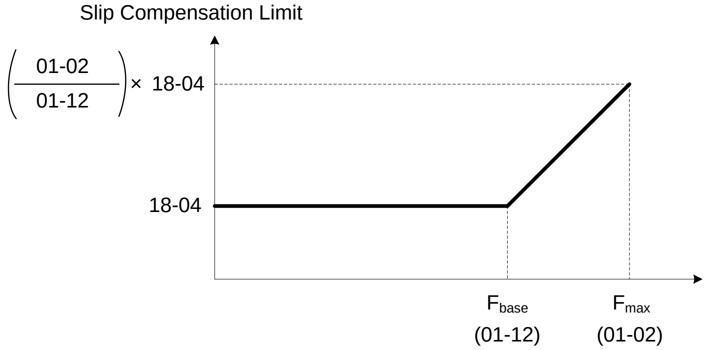


Figure 4.3.91 Slip compensation limit

When the slip compensation gain 18-00 at low speed is adjusted, and the actual motor speed is still lower than the reference frequency, the motor may be limited by the slip compensation limit.

Note: Make sure that the slip compensation limit 18-02 does not exceed the maximum allowed system limit.

18-03: Slip compensation filter

Set slip compensation filter time in V/F mode

18-04: Regenerating slip compensation selection

The selections to enable or disable the slip compensation function during regeneration.

To enable slip compensation during regeneration caused by deceleration (SLV mode), set 18-04 to 1 in case speed accuracy is required. When the slip compensation function is used regenerative energy might increase temporarily (18-04= 1) therefore a braking module might be required.

SLV mode adjustment

18-00: Slip compensation gain

a) Slip compensation can be used to control the full rang speed accuracy under load condition.
b) If the speed is lower than 2 Hz and the motor speed decreases, increase the value of 18-00.
c) If the speed is lower than 2 Hz and the motor speed increases, reduce the value of 18-00.

Slip compensation gain uses a single value for the whole speed range. As a result the slip compensation accuracy at low speed is high but slight inaccuracies might occur at high speeds.

Adjust parameter 18-02 together with the compensation value or continue to adjust 18-00 if the speed accuracy at higher speed is not acceptable. Please note adjusting these parameters might impact the accuracy at lower speeds.

The impact of 18-00 on the torque and the speed are shown in Fig.4.3.92.

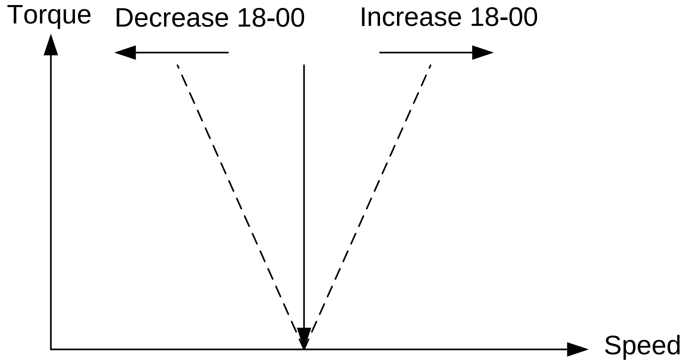


Figure 4.3.92 18-00 Effect on the torque and speed

18-01: Slip compensation gain at high speed

It is not required to adjust the Slip compensation gain at high speed if the motor is loaded. After adjusting parameter 18-00 it is recommended to increase the reference frequency and check the motor speed. In case of a speed error increase the value of 18-01 to adjust the compensation. Increase the motor rated frequency (01-12 base frequency) and increase the value of 18-01 to reduce the speed error. If the speed accuracy becomes worse due to an increase in motor temperature it is recommended to use a combination of 18-00 and 18-01 for adjustment.

Compared to 18-00, 18-01 serves as a variable gain for the full speed range. Parameter 18-01 determines the slip compensation at the motor rated speed and is calculated follows:

$$\text{Slip compensation gain} = \text{Slip compensation gain at low speed} + \frac{[\text{Slip compensation gain at high speed x frequency reference}]}{[\text{Motor rated frequency}]}$$

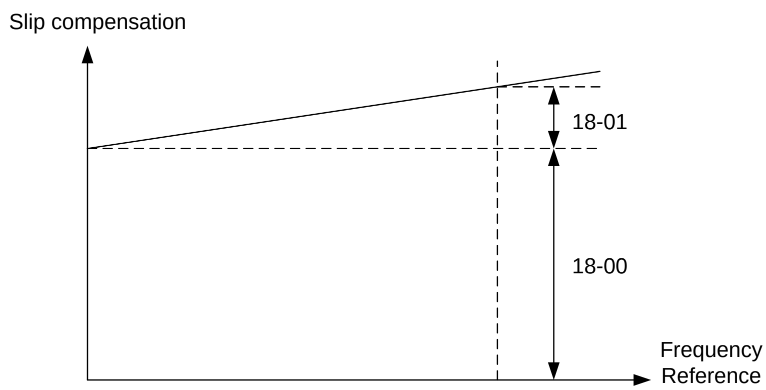


Figure 4.3.93 18-00/18-01 Slip compensation gain versus frequency reference

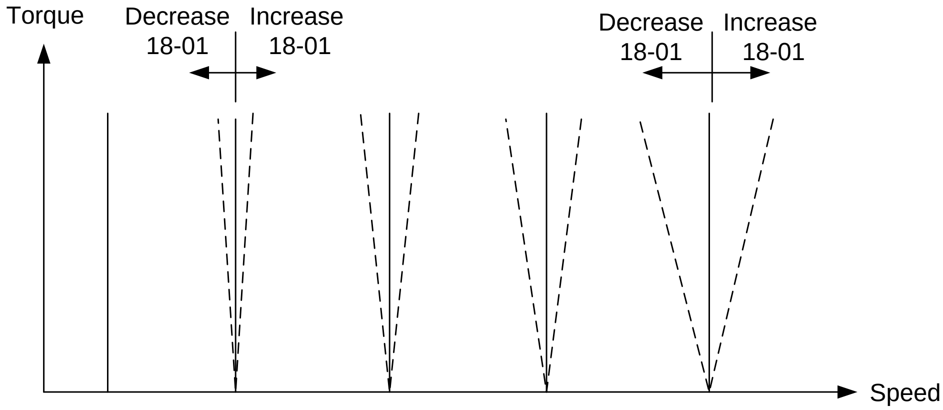


Figure 4.3.94 18-01 Effect on torque speed curve

18-05: FOC (Flux Orient Control) delay time

In the SLV mode, the slip compensation of the magnetic flux depends on the torque current and excitation current. If the motor load rises above 100% while running at the motor rated frequency, the motor voltage and resistance drops sharply, which may cause the inverter output to saturate and current jitter occur. The magnetic flux slip compensation will independently control the torque current and the excitation current to prevent increasing and decreasing of the current (jitter). For slow speed or fixed speed operation, 18-05 may be increased. For fast operation adjust 18-06.

18-06: Slip compensation gain

If the motor is jittering at the rated frequency under full load, the value of 18-06 may gradually be reduced to zero to reduce current jitter.

Group 20 Speed Control Parameters

20-00	**ASR Gain 1**
Range	**【0.00~250.00】**
20-01	**ASR Integral Time 1**
Range	**【0.001~10.000】Sec**
20-02	**ASR Gain 2**
Range	**【0.00~250.00】**
20-03	**ASR Integral Time 2**
Range	**【0.001~10.000】Sec**
20-04	**ASR Integral Time Limit**
Range	**【0~300】%**
20-07	**Selection of Acceleration and Deceleration of P/PI**
Range	**【0】: PI speed control will be enabled only in constant speed. For accel/decel, only use P control.** **【1】: Speed control is enabled either in constant speed or accel/decal.**
20-08	**ASR Delay Time**
Range	**【0.000~0.500 】Sec**
20-09	**Speed Observer Proportional (P) Gain 1**
Range	**【0.00~2.55】**
20-10	**Speed Observer Integral(I) Time 1**
Range	**【0.01~10.00】Sec**
20-11	**Speed Observer Proportional (P) Gain 2**
Range	**【0.00~2.55】**
20-12	**Speed Observer Integral(I) Time 2**
Range	**【0.01~10.00】Sec**
20-13	**Low-pass Filter Time Constant of Speed Feedback 1**
Range	**【1~1000】mSec**
20-14	**Low-pass Filter Time Constant of Speed Feedback 2**
Range	**【1~1000】mSec**
20-15	**ASR Gain Change Frequency 1**
Range	**【0.0~400.0】Hz**
20-16	**ASR Gain Change Frequency 2**
	【0.0~400.0】Hz
20-17	**Torque Compensation Gain at Low Speed**
Range	**【0.00~2.50】**
20-18	**Torque Compensation Gain at High Speed**
Range	**【-10~10】%**
20-33	**Constant Speed Detection Level**
Range	**【0.1~5.0】%**

The following figure an overview of the automatic speed regulator (ASR) block.

SLV control mode:

The ASR function adjusts the output frequency to control the motor speed to minimize the difference between the frequency reference and actual motor speed.

The ASR controller in SLV mode uses a speed estimator to estimate the motor speed. In order to reduce speed feedback signal interference, a low-pass filter and speed feedback compensator can be enabled.

The ASR integrator output can be disabled or limited. The ASR output is passed through a low-pass filter.

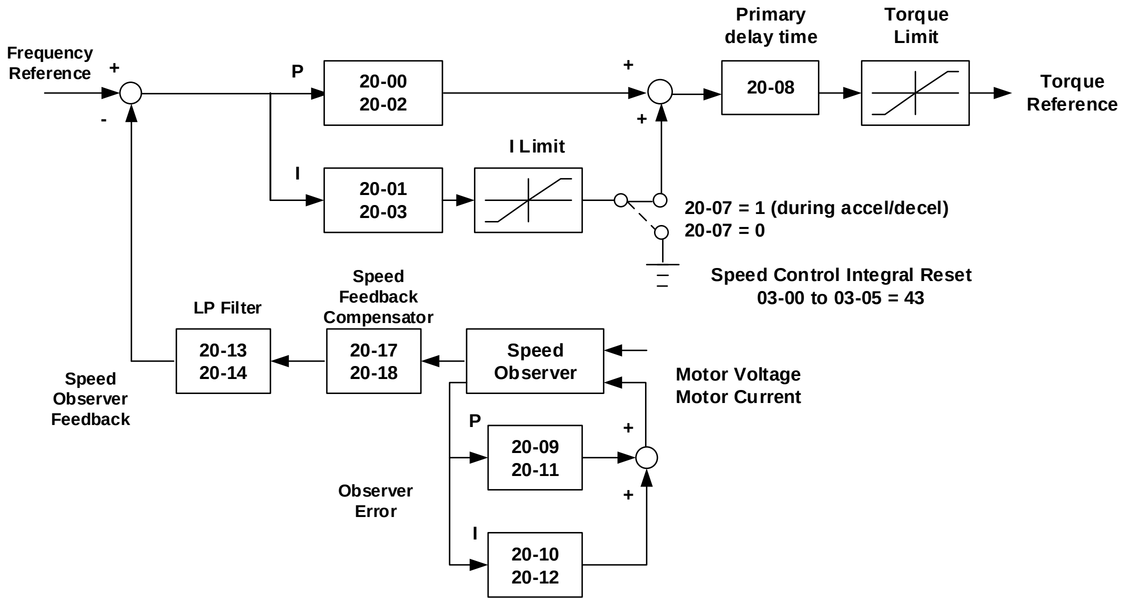


Figure 4.3.95 ASR block diagram (SLV mode)

ASR setting (SLV control mode)

In SLV mode the ASR gain is divided into a high-speed and low-speed section. The speed controller has a high-speed gain 20-00/20-01 and a low-speed gain 20-02/20-03 that can be set independently.

a) The high/low switch frequency can be set with parameter 20-15 and 20-16. Similar to the ASR gain, the speed estimator has a high-speed gain 20-09/20-10 and a low-speed gain 20-11/20-12.
b) The speed estimator has a low-pass filter to reduce the speed feedback interference, parameter 20-13 and 20-14 are active at high speed as well as low speed. The switch between the high-speed and the low-speed is set by parameter 20-15 and 20-16.
c) 20-17 sets the low-speed compensation gain of the speed feedback.
d) 20-18 sets the high-speed compensation gain of the speed feedback.
e) When the frequency reference is rises above the value set in 20-16, the ASR gain used is set by parameters 20-00 and 20-01.
f) When the frequency reference falls below the value set in 20-15, the ASR gain used is set by parameters 20-02 and 20-03.
g) Gain time constant is adjusted linearly when the speed command falls within the range of 20-15 to 20-16, for a smooth operation.

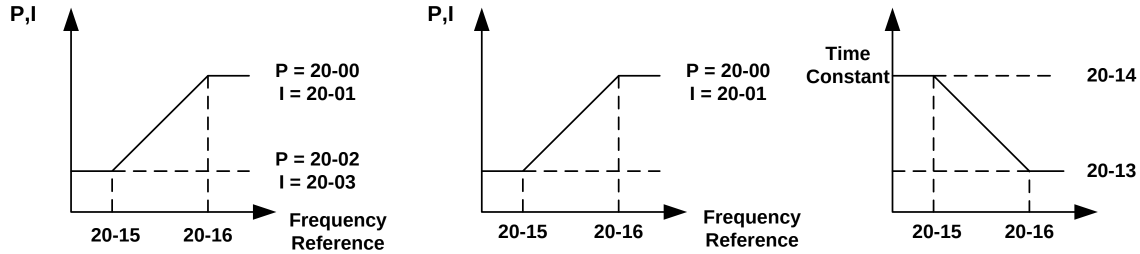


Figure 4.3.96 ASR gain setting (SLV mode)

Tuning the speed control gain

a. Gain adjustment at minimum output frequency
- Motor is running minimum output frequency (Fmin, 01-08).
- Adjust the Maximum ASR proportional gain 2 (20-02) without causing instability.
- Adjust the Minimum ASR integration time 2 (20-03) without causing instability.
- Ensure the output current is lower than 50% of inverter rated current. If the output current is more than 50% of inverter rated current, decrease the setting value of parameter 20-02 and increase the value of 20-03.

b. Gain adjustment at maximum output frequency
- Motor is running at maximum output frequency (Fmax, 01-02).
- Adjust the Maximum ASR proportional gain1 (20-00) without causing instability.
- Adjust the Minimum ASR integration time 1 (20-02) without causing instability.

c. Gain adjustment of accel./ decel. integral control
- When 20-07=1, enabled for automatic speed regulation at constant speed and during acceleration / deceleration.
- Integral control makes the motor speed react as possible reach to the target speed but may cause instability. Refer to Fig. 4.3.97 & Fig.4.3.98.

When 20-07=1, Enable ASR Proportion (P) and Integer (I) control during accel/ decel. / constant speed operation.

When 20-07=0, Enable ASR Proportion (P) and Integer (I) control only during constant speed operation and ASR P control during acceleration / deceleration.

Parameter 20-33 (Constant Speed Detection Level) is used to set a constant speed detection bandwidth active only when 20-07 is set 0 and frequency command source is set to analog input. Adjust the value of parameter 20-33 to compensate for noise during constant speed operation.

During ASR gain tuning, the multi-function analog output (AO1 and AO2 terminal) can be used to monitor the output frequency and motor speed (as shown in Fig.4.3.96).

SLV mode gain tuning (20-00~20-03, 20-09~20-18)

a) Complete the parameter tuning in normal operation.
b) Increase ASR proportional gain 1 (20-00), ASR proportional gain 2 (20-02), carefully monitor system stability.

Use parameter 20-00 and 20-02 to adjust the speed response for each cycle. Tuning the settings of 20-00, 20-02 can increase system response, but may cause system instability. See Fig.4.3.97.

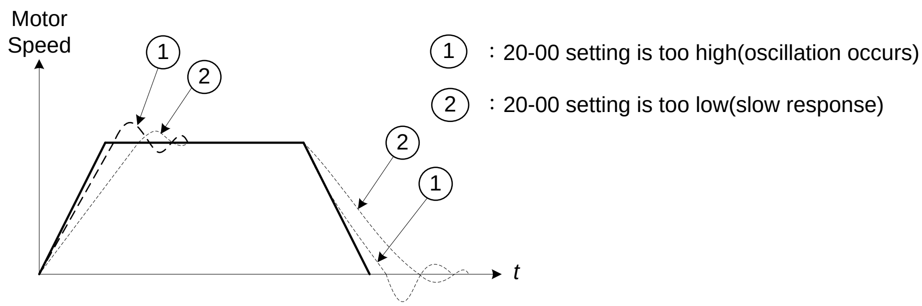


Figure 4.3.97 System response of ASR proportion gain

a) Reduce ASR integral time 1(20-01), ASR integral time 2 (20-02) and carefully monitor system stability.
   1. A long integral time will result in poor system response.
   2. If the integral time setting is too short, the system may become unstable Refer to the following figure.

While tuning ASR P and I gain the system may overshoot and an over voltage condition can occur. A braking unit (braking resistor) can be used to avoid an over voltage condition.

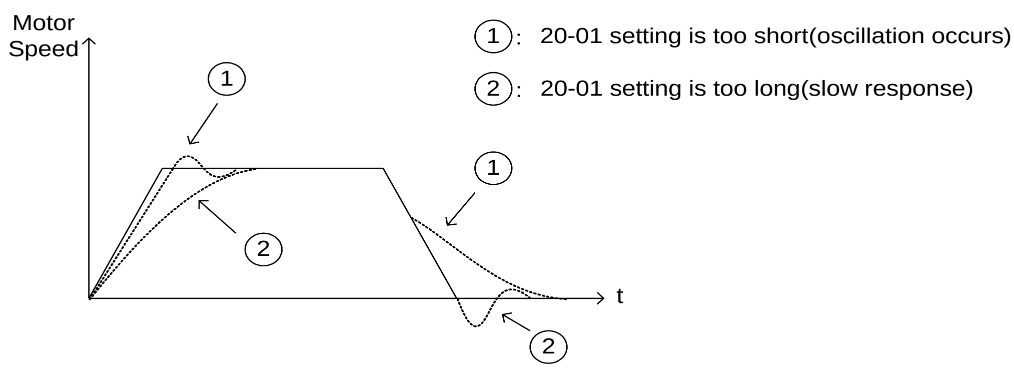


Figure 4.3.98 The response of ASR integral time

Both low-speed ASR gain and the high-speed gain can be set to the same values and only require to be adjusted in case of system instability.

In case tuning of the ASR P and I gain 20-00~20-03 does not improve the system response, reduce the low-pass filter time constant 20-13~20-14 to increase the bandwidth of the feedback system and re-tune the ASR gain.

- Tune low-speed low-pass filter time constant 20-14, make sure the reference frequency is below parameter 20-15 value.
- Tune high-speed low-pass filter time constant 20-13 at frequency reference, make sure the reference frequency is above parameter 20-16 value.
- Increasing the low-pass filter time constant can limit the bandwidth of the speed feedback system and may reduce the system response. Increasing the low-pass time reduces the speed feedback signal interference but may results in sluggish system response when the load suddenly changes. Adjust the low-pass filter time if the load stays fairly constant during normal operation. The low bandwidth of the speed feedback must be supported by the low gain of ASR to ensure the stable operation.
- Decreasing the low-pass filter time constant may increase the bandwidth of the speed feedback and the system response. Decreasing the low-pass time may increase the speed feedback interference resulting in system instability when the load suddenly changes. Decrease the low-pass filter time is a quick system response is required for rapidly changing loads. The high bandwidth of the speed feedback allows for a relative high ASR gain.

- In case tuning 20-00 ~ 20-03 and the low-pass filter time constant 20-13 do not improve the system response time, tuning the PI gain 20-09 ~ 20-12 of the speed estimator may be required.
- Setting a high gain for the speed estimator (high proportion (P) gain and small integral (I) time) increases the bandwidth of the speed feedback, but may cause speed feedback interference resulting in system instability.
- Setting a low gain for the speed estimator (small proportion (P) gain and high integral (I) time) decreases the bandwidth of the speed feedback, may improve speed feedback interference resulting in a more stable system.
- The default values for the ASR can be used in most applications, no adjustment is required. Adjusting the low-pass filter time and speed estimator gains requires a good understanding of the overall system.
- Parameter 20-15 sets the gain switch frequency at low-speed and parameter 20-16 sets the gain switch frequency at high-speed.
- Operating at a speed below 20-15 will result in a larger excitation current for low-speed operation accuracy. When the frequency reference rises above 20-16, the inverter will output the rated excitation current at the no-load voltage (02-19).
- For general purpose applications parameter 20-15 should be set to a value of 5 ~ 50% of the motor base frequency.
- If this value is too high, the inverter output may saturate. Parameter 20-16 should be set to a value of 4Hz or more above the value of 20-08.
- When experiencing speed jitter at high speed and stable operation during mid-range speed while operating a heavy load (>100%), it is recommended to reduce the no-load voltage (02-19) or tune the FOC parameters (18-05 ~ 18-06).
- Parameter 20-17 and 20-18 are for compensating speed feedback at low speed and high speed.
- Use parameter 20-17 to adjust the torque compensation gain for the low speed range. By tuning 20-17an offset is added to the torque-speed curve. Increase 20-17 when the no-load speed is lower than the frequency reference. Decrease 20-17 when the no-load speed is higher than the frequency reference. The effect on the torque-speed curve from 20-17 is shown as the following figure:

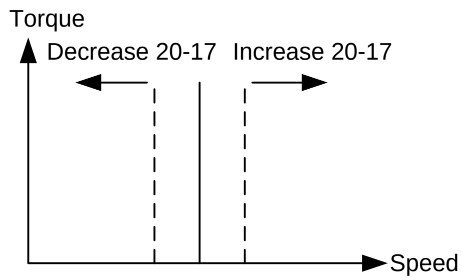


Figure 4.3.99 Effect on the torque-speed curve from 20-17

- Use parameter 20-18 to adjust the torque compensation gain for middle to high speed range. For most general purpose applications it is not necessary to adjust the 20-18. By tuning 20-18an offset is added to the torque-speed curve. Increase 20-18 when the no-load speed is lower than the frequency reference. Decrease 20-18 when the no-load speed is higher than the frequency reference. The effect on the torque-speed curve from 20-18 is shown as the following Fig.4.3.100.

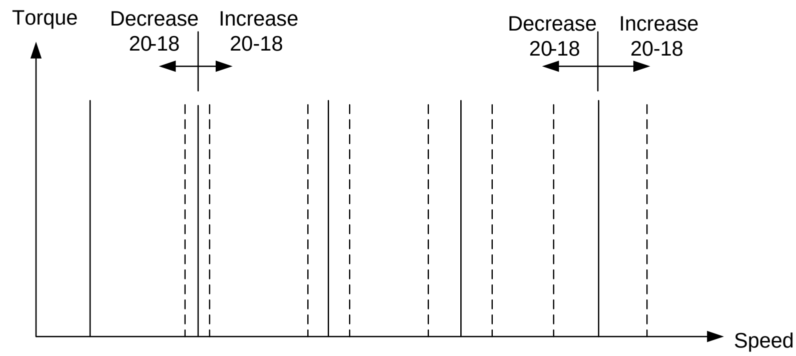


Figure 4.3.100 Effect on the torque-speed curve from 20-17

- ASR main delay time (20-08).
  - a) Does not required to be adjusted for general purpose applications
  - b) When the set value of 20-08 is set high, the speed response and therefore system response will decrease improving system stability.

a. ASR Integral Time Limit (20-04)
  - a) Setting a small value may prevent system response when the load suddenly changes.

Note:

- Specification for no-load speed circuit bandwidth in vector control:
  1. 50 Hz is for control modes of SV / PMSV.
  2. 10 Hz is for control modes of SLV / PMSLV.
- Speed response is affected by kp adjustment, inertia, load and motor temperature and the bandwidth will decrease slightly while controlling the application.

20-34	**Compensation Gain During Speed Drop**
Range	**【0.00~25600】**
20-35	**Compensation Time During Speed Drop**
Range	**【0~30000】mSec**

Decreasing the torque compensation value can reduce the response of the ASR during a momentary change in load. Refer to Fig. 4.3.97 & Fig. 4.3.98.

20-34 Compensation Gain During Speed Drop:

The effect of the Compensation Gain During Speed Drop is the same as the proportional gain of ASR (20-00, 20-02) but active only during the Compensation Time During Speed Drop (20-35) for large speed fluctuation to prevent the system instability.

20-35 Compensation Time During Speed Drop:

This time constant used to prevent system instability cause by parameter 20-34. Note increased compensation time can lead to a slower output response which is can affect derating compensation in negative way.

The recommended setting value of 20-34 is 30~50 and that of 20-35 is 50~100ms.

Group 21 Torque Control Parameters

21-05	**Positive Torque Limit**
Range	**【0~160】%**
21-06	**Negative Torque Limit**
Range	**【0~160】%**
21-07	**Forward Regenerative Torque Limit**
Range	**【0~160】%**
21-08	**Reversal Regenerative Torque Limit**
Range	**【0~160】%**

Torque limit can be set in two ways:

- Use torque limit parameters (21-05 to 21-08) to set a fixed torque limit.
- Set the torque limit by using the multi-function analog input (AI2).

There are four torque limits that can be set separately, one for each quadrant:

(I) Positive torque limit in forward direction (21-05 positive torque limit)
(II) Positive torque limit of reverse direction (21-08 negative torque limit)
(III) Negative torque limit in reverse direction (21-06 forward regenerating torque limit)
(IV) Negative torque limit in forward direction (21-07 reversal regenerating torque limit)

Refer to Fig.4.3.101.

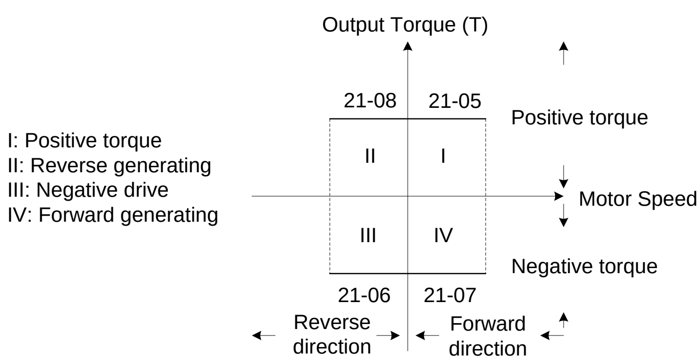


Figure 4.3.101 Torque limit setting

Torque limit setting by using multi-function analog input AI2 (04-05)

Table 4.3.16 Torque limit analog input

04-05 (AI2)	Function
11	Positive torque limit
12	Negative torque limit
13	Regenerative torque limit (for both forward and reversal directions).
14	Positive/negative torque limit (positive and negative detection torque limit)

Set the analog input terminal (AI2) signal level (04-00), gain (04-07) and bias (04-08)

The default setting for the analog input AI2 is 0 -10V representing 0 – 100% of the motor rated torque).

Fig.4.3.102 shows the relationship between the output torque and the torque limit.

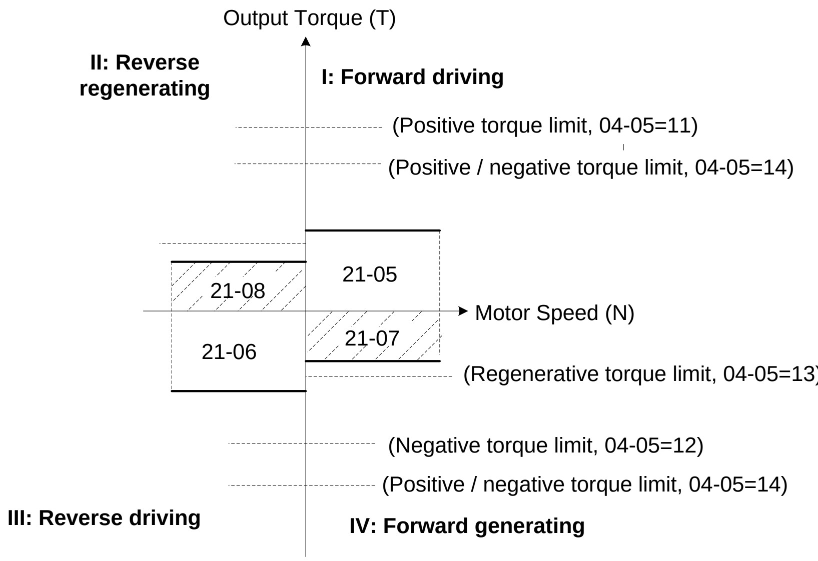


Figure 4.3.102 Analog input torque limit (AI2)

When the analog input is set to positive torque limit (value = 11) the torque limit is active in the third and fourth quadrant.in the reverse direction (regenerative torque in the second quadrant).

When the analog input is set to negative torque limit (value = 12) the torque limit is active in the third and fourth quadrant.

When the analog input is set to regenerative torque limit (value = 13) the torque limit is active in the second and fourth quadrant can be controlled.

When the analog input is set to positive/negative torque limit (value = 14) the torque limit is active in all four quadrants.

When the analog input is at maximum (10V or 20mA), the torque limit is 100% of the motor rated torque. In order to increase the torque limit above 100% the analog input gain (04-07) has to set to a value greater than 100%. For example: 160.0% of the gain will result in the torque limit of 160% of motor rated torque at 10V (20mA) analog input level.

Group 22: PM Motor Parameters (PM Control Mode)

22-00	Rated Power of PM Motor
Range	【0.00~600.00】Kw
22-02	Rated Current of PM Motor
Range	25%~200% of inverter's rated current
22-03	Pole Number of PM Motor
Range	【2~96】Poles
22-04	Rated RPM of PM Motor
Range	【1~60000】rpm
22-05	Maximum RPM of PM Motor
Range	【1~60000】rpm
22-06	PM Motor Rated Frequency
Range	【0.0~400.0】Hz
22-10	PM SLV Start Current
Range	【0.0 ~ 120.0】%
22-11	DC Injection Current Level
Range	【0.0 ~ 100.0】%
22-12	Speed Observer kp Value
Range	【1 ~ 10000】
22-13	Speed Observer kI Value
Range	【1 ~ 1024】
22-14	PM Motor Stator Resistance
Range	【0.001 ~ 30.000】Ω
22-15	PM Motor D-axis Inductance
Range	【0.01 ~ 300.00】mH
22-16	PM Motor Q-axis Inductance
Range	【0.01 ~ 300.00】mH
22-18	Flux-Weakening Control
Range	【0 ~ 100】%

The PM parameter group can be restored to factory default be initializing the inverter (13-08).

PM motor rated power (22-00)

Set the motor power according to the motor nameplate.

PM motor rated current (22-02)

Set the motor full load according to the motor nameplate.

PM motor pole number (22-03)

Set the number of motor poles according to the motor nameplate.

PM motor rated speed (22-04)

Set parameter 22-04 or 22-06, the inverter will automatically calculate one or the other.

Set the motor rated speed in rpm according to the motor nameplate.

Note:
Only set parameter 22-04 or 22-06, the inverter will automatically calculate the other one.

Formula: n (22-04) = 120*f (22-06) / P(22-03)

PM motor maximum rotation speed (22-05)

Set the maximum motor rated speed in rpm according to the motor nameplate.

PM motor rated frequency (22-06)

Set the motor rated frequency according to the motor nameplate.

PM SLV Start Current (22-10)

Set the torque current at start up as % of motor rated current.

DC Injection Current (22-11)

Set the auto-tuning DC injection current of the permanent magnet (PM) motor as % of motor rated current.

Speed Estimation kp Value (22-12) & Speed Estimation kI Value (22-13)

Performance of speed response adjustment:

The higher the setting value is, the faster the motor response becomes; may result in instability of the motor load.

The lower the setting value is, the larger the speed deviation becomes. So, please adjust the proper setting value depending on the field apparatus.

PM Armature Resistance (22-14)

Set the motor resistance per phase in unit of 0.001Ω. This parameter is automatically set during motor auto-tuning (22-21).

Note: The motor resistance is different from the line resistance.

PM Motor D-axis Inductance (22-15)

Set motor D-axis inductance in unit of 0.01mH. This parameter is automatically set during motor auto-tuning (22-21).

PM Motor Q-axis Inductance (22-16)

Set motor Q-axis inductance in unit of 0.01mH. This parameter is automatically set during motor auto-tuning (22-21).

Flux-Weakening Control (22-18)

If motor maximum rotation speed (22-05) is greater than motor rated rotation speed (22-04), the inverter automatically uses flux-weakening control. Parameter value is maximum flux-weakening level in percentage of the motor rated current.

22-21	PM Motor Tuning
Range	【0】: Disable 【1】: Enable
22-22	**Fault History of IPM Motor Tuning**
Range	【0】: No Error 【5】: Circuit tuning time out 【6】: Reserved 【7】: Other motor tuning errors 【8】: Reserved 【9】: Current Abnormity Occurs while Loop Adjustment 【10】: Reserved 【11】: Stator Resistance Measurement is Timeout 【12】: Reserved

SLV PM Motor Tuning (22-21)

WARNING!

Sudden start: The inverter and motor may start unexpectedly during Auto-Tuning, which could result in death or serious injury. Make sure the area surrounding of the motor and load are clear before proceeding with Auto-Tuning.

WARNING! Electric Shock Hazard

High voltage is applied to the motor when performing an auto-tune, even when the motor is stopped, which could result in death or serious injury. Do not touch the motor before performing the auto-tuning procedure is completed.

WARNING! Holding Brake

Do not perform an auto-tuning procedure when the motor is connected to a brake this may result in incorrect motor data calculation. Disconnect the motor and the load and confirm that the motor can freely run.

a) Use parameter 22-21 to select tuning mode.
b) Next press the enter key to go to the PM motor tuning screen. The keypad will display the message of "IPrdy" (Ready to Tune).
c) Press run to start the PM motor tuning. The keypad will display the “IPtun" message during auto-tune.
d) If the motor is successfully tuned, the message of "IPEnd " will be displayed. If auto-tune is aborted with the stop key, the operator will display the message of " IPbrd " (PM motor tuning aborted).

Fault History of SLV PM Motor Tuning (22-22)

Parameter 22-22 shows the PM motor tuning fault history. If PM motor tuning has failed, the “IPErr” message is shown on the keypad (PM motor tuning failure). Refer to section 10 for the possible error causes and trouble shooting.

PM motor tuning fault history (22-22) only stores the result of the last auto-tune performed .If auto-tuning was successful or aborted no error will be displayed.

Group 23: Pump & HVAC & Compressor Function Parameters

23-00	Function Selection
Range	**【0】: Disable** **【1】: Pump** **【2】: HVAC** **【3】: Compressor**

Dedicated Pump and HVAC modes are available. To use these modes the PID function has to be enabled beforehand (10-03=xxx1b). Each application has their own parameter group these groups become available after the application settings is enabled. Parameters 23-01 to 23-39 are used for a Pump application; 23-45 to 23-58 are for HVAC and 23-66 to 23-70 are for a compressor application.

The main screen (16-00, 16-01, and 16-02) of LCD keypad automatically changes based on the application function selected as shown in the table below:

	Pump mode 23-00=1	HVAC mode 23-00=2	Compressor 23-00=3
16-00	Pump setpoint 12-74	HVAC setpoint 12-77	Frequency reference 12-16
16-01	Pump feedback 12-75	HVAC feedback 12-71	Output frequency 12-17
16-02	Output frequency 12-17	Output frequency 12-17	Output current 12-18

Notes:

- Enable PID (10-03 = xxx1b) before using Pump and HVAC function
- Parameter 10-03 will automatically be set to xxx1b after 23-00 is set to 1 or 2; and will return to xxx0b when 23-00 is set 0.
- In Compressor mode, the frequency command, 00-05 is automatically set to 1 (refer to AI1) and can't be set to 5 (PID). The middle output voltage (01-07) is automatically set to half of the maximum output voltage and parameter 01-00 will be hidden.

23-01	Pump mode selection for single / multi pump system
Range	**【0】: Single Pump** **【1】: Master** **【2】: Follower 1** **【3】: Follower 2** **【4】: Follower 3**

Parameter changes become active after restarting the drive. For wiring and parameter configuration please refer to chapter 3.3.4. Refer to fig. 4.3.111 for example of multi-pump application.

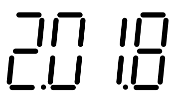
23-02	Pump setpoint
Range	【0.10 ~ 650.00】PSI
23-03	Maximum Pressure Setting
Range	【0.10 ~ 650.00】PSI
23-04	Pump Setpoint Source
Range	【0】: From 23-02/12-74 【1】: From AI1

The maximum pressure value depends on the pressure transducer used by the pump system. Parameter 23-02 is limited based on the maximum pressure setting (23-03). Pressure setpoint is selected by parameter 23-04.
Note: Refer to Appendix A for a detailed wiring of the system.

23-05	Display Mode Selection (for LED keypad)
Range	【0】: Display Setpoint and Pressure Feedback 【1】: Only Display Setpoint 【2】: Only Display Feedback Pressure

Both setpoint and feedback pressure can be displayed separately.

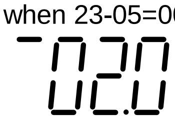
① When 23-05=0000：Led keypad displays pressure setting value and pressure feedback value.



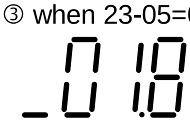
The most left two digits is the setpoint value and the two right most digits is the pressure feedback value on the LED keypad.

Note: When 23-00=2 (HVAC), the value shown on the display is the actual divided by 10000. Example: Display value is 5.0 means 5000GPM.

② when 23-05=0001：Led keypad only displays the setpoint value.



③ when 23-05=0002：Led keypad only displays the pressure feedback value.



Note:

When the setpoint value is greater than 10, the setpoint value is displayed an “integer” number instead of a decimal number for 10-33 set to a value less than 1000 and 10-34=1 in PID mode.

23-06	Proportion Gain (P)
Range	【0.00~10.00】
23-07	Integral Time (I)
Range	【0.0~100.0】Sec
23-08	Differential Time (D)
Range	【0.0~100.0】Sec

- PID parameters can be changed while the inverter is running.

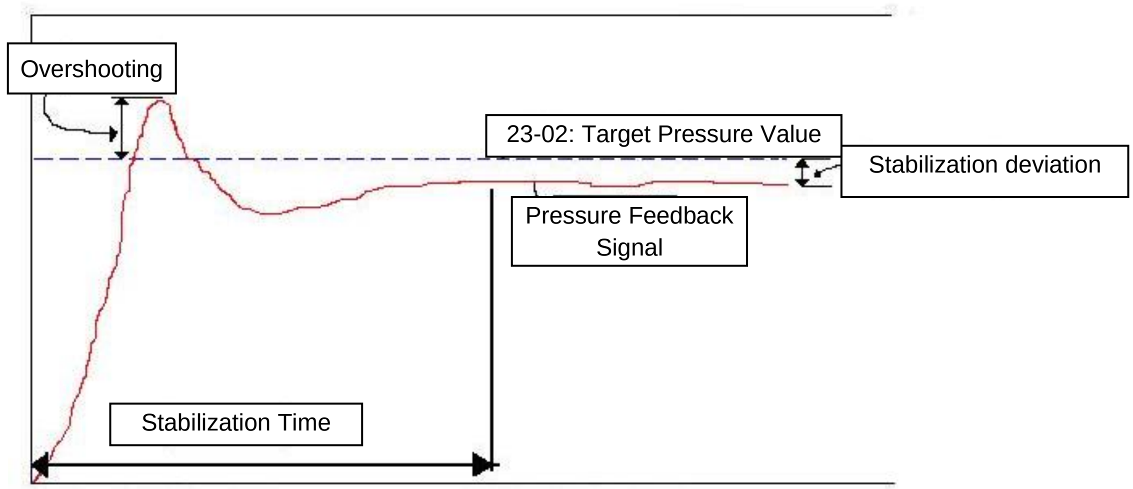


Figure 4.3.103 Response of pressure feedback signal

Table 4.3.17 PID parameter adjustment guidelines

		Increase Setting Value	**Decrease Setting Value**	**Note**
Proportional Gain (P)	Advantage	Improve response time	Reduce oscillation	Improve the settling time
	Disadvantage	Pressure may become unstable/oscillation	Slow down the response	
Integral Time (I)	Advantage	Improve the feedback variation	Fast response	Improve the stabilized deviation
	Disadvantage	Slow down response	System easily gets unstable	
Differential Time (D)	Advantage	Avoid overshoot	More stable	Improve the overshoot
	Disadvantage	System easily gets unstable	Large Overshoot	

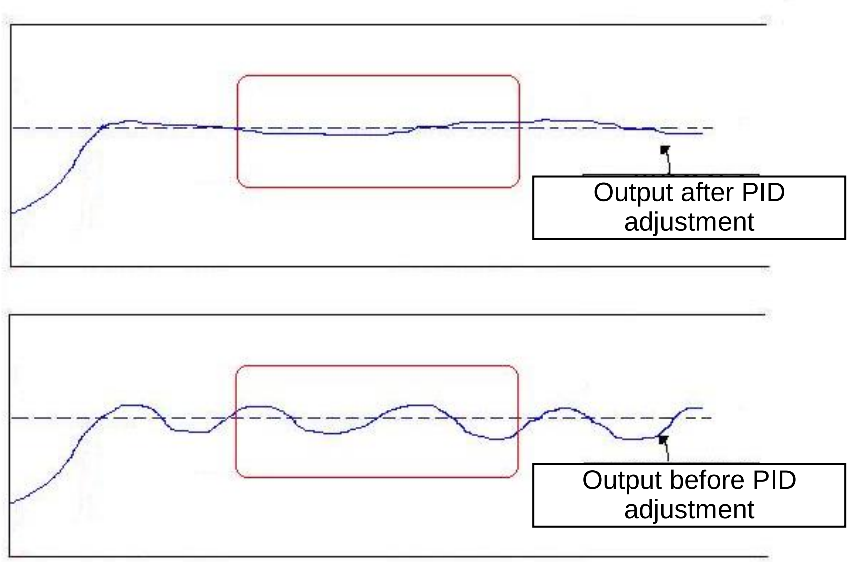


Figure 4.3.104 Response of feedback signal before/after PID adjustment

23-09	Constant Pressure Detection Tolerance
Range	【0.10~650.00】PSI
23-10	Sleep Frequency of Constant Pressure
Range	【0.0~180.0】Hz
23-11	Sleep Time of Constant Pressure
Range	【0.0~255.5】Sec

Inverter output frequency will decrease down to the sleep frequency when the pressure feedback value is greater than the Pump setpoint. Inverter output frequency increases when the pressure feedback value is smaller than (23-02) - (23-09).

The inverter will go to sleep (decelerate to zero) when the output frequency stays at the level defined by the Sleep Frequency of Constant Pressure (23-10) for the time specified by the Sleep Time of Constant Pressure (23-11).

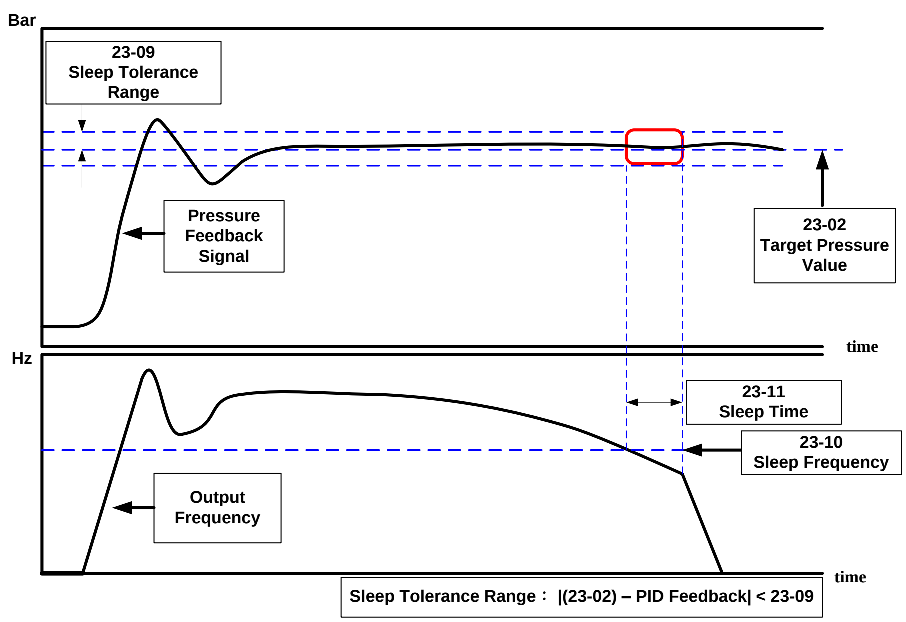


Figure 4.3.105 System response of constant pressure

23-12	High Pressure Level
Range	【0.10 ~ 650.00】PSI
23-13	Warning Time for High Pressure
Range	【0.1 ~ 255.0】Sec
23-14	Fault Time for High Pressure
Range	【0.1 ~ 255.0】Sec

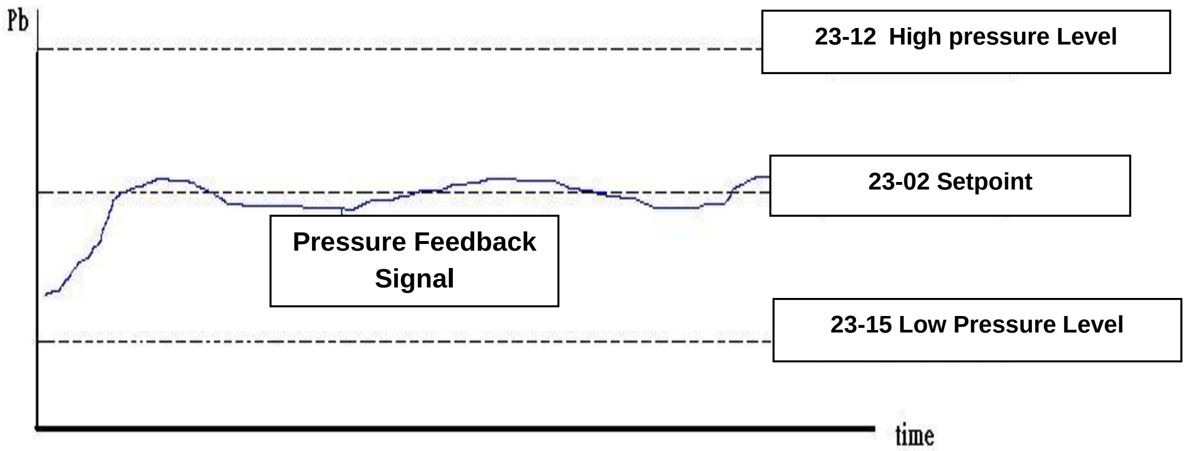


Figure 4.3.106 General situation for feedback signal

The inverter will trip on a High Pressure Fault (OPbFt) when the pressure feedback signal is greater than the High Pressure Level (23-12) for the time specified in Fault Time for High Pressure (23-14). A High Pressure warning (HIPb) is shown on the keypad when the High Pressure timer exceeds the time specified in Warning Time for High Pressure (23-13). The High Pressure Fault timer will reset when the pressure feedback falls below High Pressure Level (23-12) and start again from 0 when the feedback increases above the High Pressure Level (23-12).

Note: If 23-13=0, high-pressure protection function will be disabled.

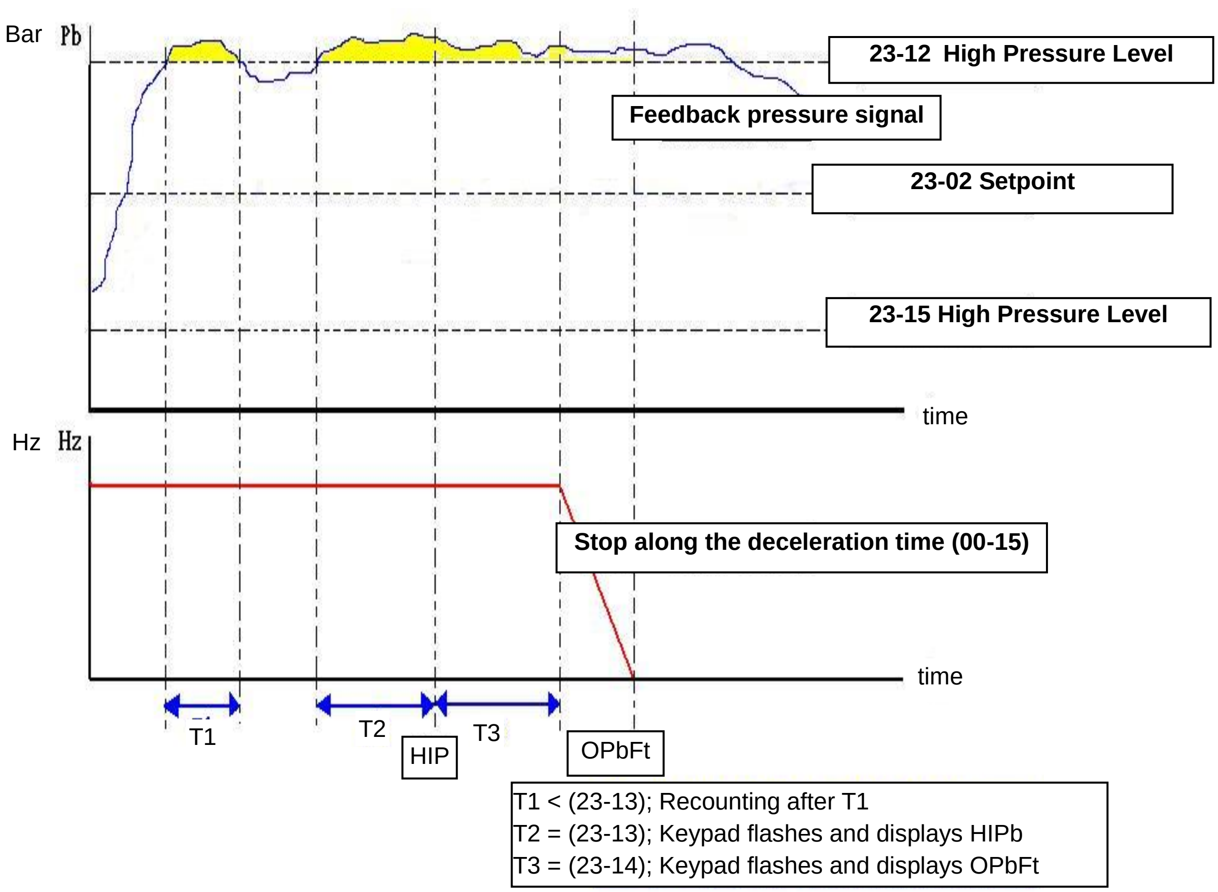


Figure 4.3.107 Process of warning and alarm when feedback higher than 23-12

23-15	Low Pressure Level
Range	【0.10 ~650.00】PSI
23-16	Warning Time for Low Pressure
Range	【0.1 ~ 255.0】Sec
23-17	Fault Time for Low Pressure
Range	【0.0 ~ 600.0】Sec

The inverter will trip on a Low Pressure Fault (LPbFt) when the pressure feedback signal falls below the Low Pressure Level (23-15) for the time specified in Fault Time for Low Pressure (23-17). A Low Pressure warning (LoPb) is shown on the keypad when the Low Pressure timer exceeds the time specified in Warning Time for Low Pressure (23-16). The Low Pressure Fault timer will reset when the pressure feedback rises above the Low Pressure Level (23-15) and start again from 0 when the feedback falls below the Low Pressure Level (23-15).

Note: If 23-16=0, low-pressure protection function will be disabled.

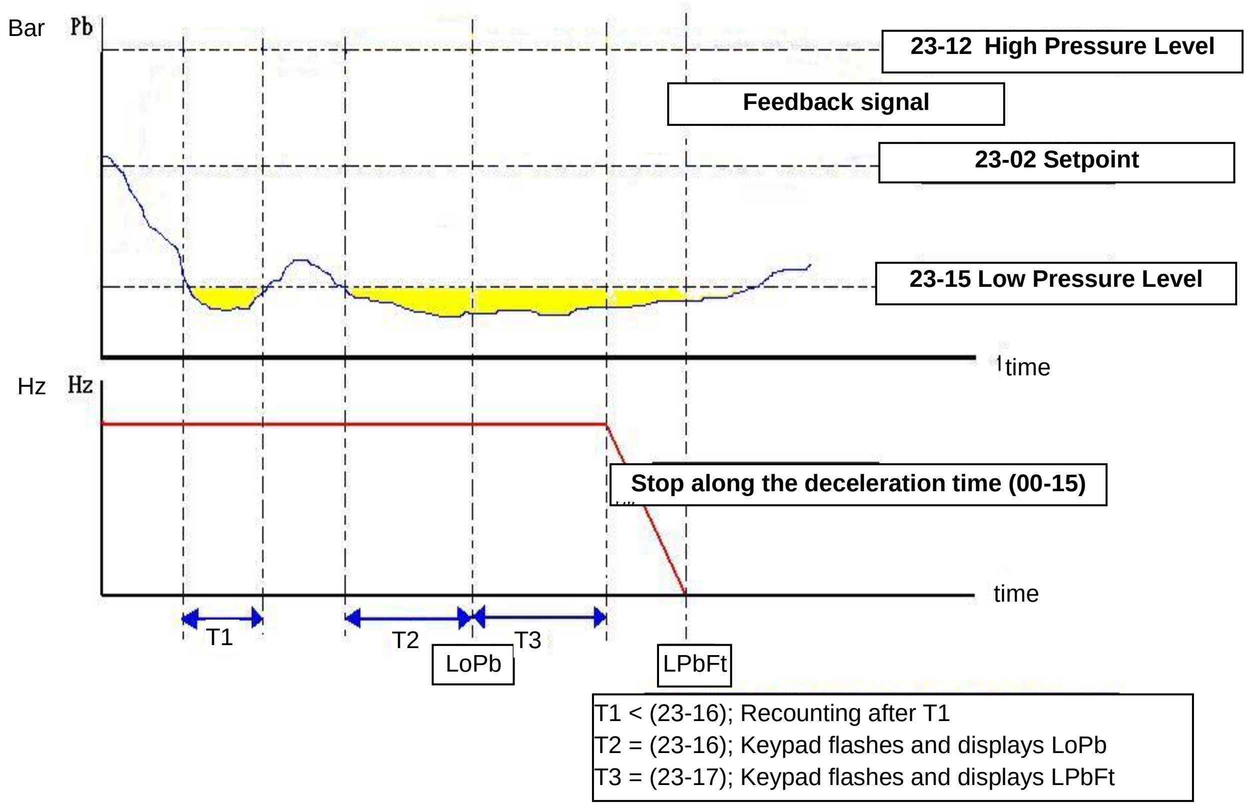


Figure 4.3.108 Process of warning and alarm when feedback lowers than 23-15.

23-18	Detection Time of Pressure Loss
Range	【0.0 ~ 600.0】Sec
23-19	Pressure Loss Level
Range	【0 ~ 100.0】%

23-19 = 0: Disable feedback pressure signal loss.

23-19 > 0: If the feedback pressure value falls below the value of 【(setpoint) x (23-19)】 for the time specified in detection time (23-18), the inverter faults on a FBLSS fault.

Note: This function is similar to the PID feedback loss, 10-11; Use function 10-11 if the inverter is required to keep running when feedback pressure is lost.

23-20	Percentage of Pressure Level *1
Range	【0】Pressure Unit 【1】Percentage Unit

***1: Available in firmware V1.1.**

23-20=0:
Engineering units for parameters 23-09, 23-12, 23-15, 23-24, 23-38 and 23-39 defined by 23-36.

23-20=1:
Engineering units for parameters 23-09, 23-12, 23-15, 23-24, 23-38 and 23-39 change to percentage (%). 100% scaling is equal to the maximum pressure setting (23-03). Example, 23-03=60 Psi, 23-12=80%, means that high pressure level is 48 PSI (60 x 0.8=48).

23-23	Water Usage Detection function
Range	【0】: Upward Detection 【1】: Downward Detection
23-24	Water Usage Detection Bias
Range	【0.0 ~ 65.00】PSI
23-25	Water Usage Detection Time
Range	【0.0 ~ 200.0】Sec
23-26	Acceleration Time of Water Usage Detection
Range	【0.0 ~ 600.0】Sec
23-27	Deceleration Time of Water Usage Detection
Range	【0.0 ~ 600.0】Sec

Acceleration time of water usage detection (23-26) and deceleration time of water usage detection (23-27) use e acceleration time 2 (00-16) and the deceleration time 2 (00-17). Setting 23-26 changes the setting of 00-16 and 23-27 changes the value of 00-17. Do not use multi acc/dec function while pump application function is active.

23-25 = 0.0 (sec) disables the water usage detection function. The water usage detection function can be used to shorten the time it takes for the inverter to go sleep during limited or no water usage.

Extend the water detection time 23-25 when the water usage duty cycle increases, to avoid cycling in and out of sleep mode resulting in unstable system pressure.

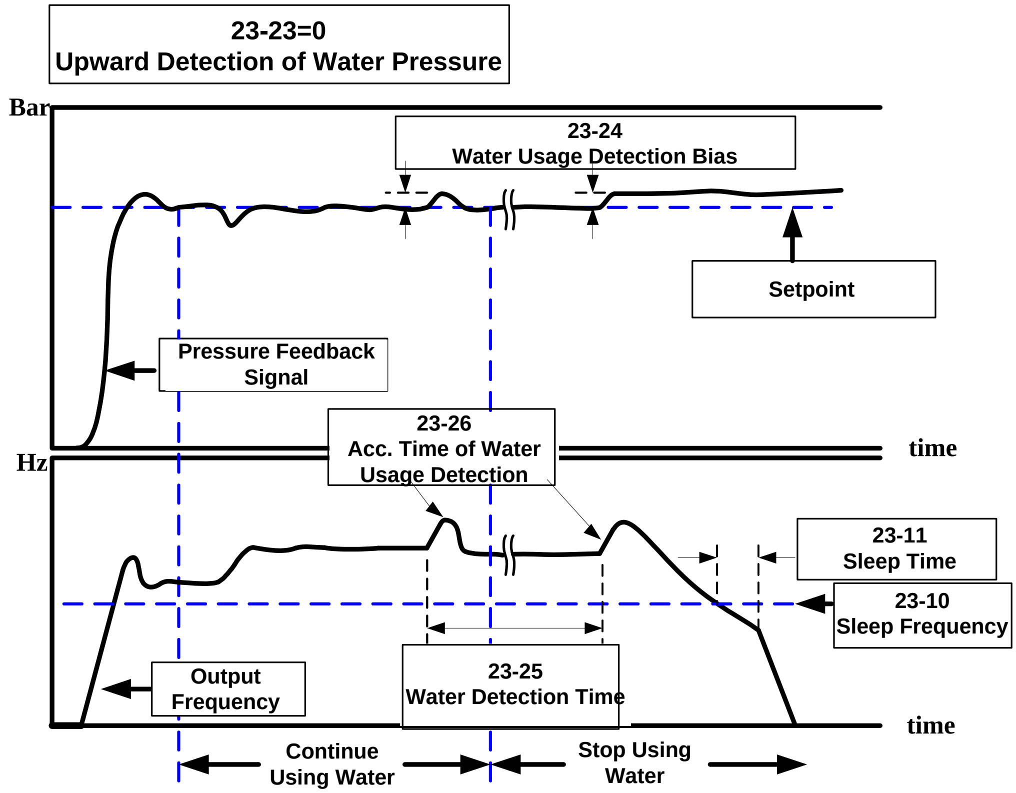


Figure 4.3.109 Process of upward detection of water pressure

For the water usage detection using upward detection mode, the output frequency is increased using the Acceleration Time of Water Usage Detection (23-26) until the pressure reaches a value of setpoint + 23-24.

The inverter will go to sleep if during the water usage detection cycle (23-25) the system pressure level stays above the setpoint; otherwise the PID function will decrease the output frequency (motor speed) to decrease the system pressure.

Reduce Water Usage Detection Bias (23-24) to reduce pressure instability during continued water usage. Please note that reducing the Water Usage Detection Bias (23-24) will extend the time it takes before the inverter detects a sleep condition when water usage is minimal or shutoff.

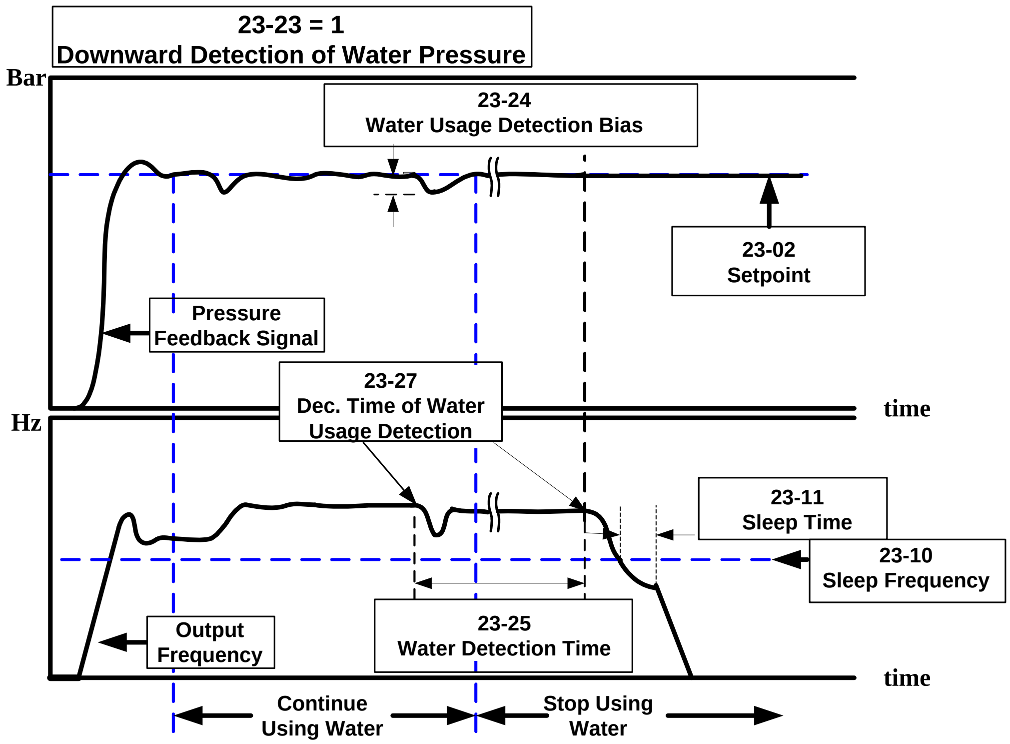


Figure 4.3.110 Process of downward detection of water pressure

For the water usage detection using downward detection mode, the output frequency is decreased using the Deceleration Time of Water Usage Detection (23-27) until the pressure reaches setpoint + 23-24.

The inverter will go to sleep if during this cycle (23-25) the system pressure is maintained; otherwise the PID function will increase the output frequency (motor speed) to increase the system pressure.

Increase 23-25 to improve system pressure oscillation caused by the water usage detection function.

Example: The system goes to sleep when it has a small leak and the pressure decreases during deceleration. For the inverter to re-accelerate depends on whether it reaches the sleep frequency first or if the pressure reaches the setpoint - 23-24 first.

Table 4.3.18 Guide for comparison of water pressure detection direction

	Advantage	Disadvantage
Upward detection	● Keep the pressure above the target pressure during this process. ● For strict and precise applications	● Using standard sleep mode the system will hardly go to sleep when water is shut-off or only a small amount of water is used. ● In the multi-pump mode, followers hardly go into sleep mode.
Downward detection	● Goes into sleep mode quickly in a situation where water is turned off or a small amount of water is used. ● In the multi-pump mode, regulate the pumps to provide optimum operation for the purpose of energy saving. ● In multi-pump mode, the order of startup is Master, Follower 1, Follower 2, and Follower 3. The process of going to sleep mode is to turn off Follower3 , Follower 2, Follower 1 and the Master. After the switching time 23-29 expires the system alternates Master and Follower (lag pump) inverters to increase pump life expectancy.	● Pressure fluctuations may occur during this process if user inappropriately regulates 23-24 and 23-27.

23-28	Forced Frequency Command
Range	【0.0 ~ 200.0】Hz

This function is available when PID mode (10-03) is enabled. Configure one of the multi-function digital inputs to be 16 (PID disable), and one set one to be 57 (forced frequency command). Turn ON the DI while PID is disabled, the inverter output frequency uses setting of 12-16; next turn-on the DI using the forced frequency command function, the frequency will follow the value set in 23-28.

This function is available in Pump, HVAC, and PID mode. It can be used to detect a pressure signal loss (disconnect) condition. **Note**: When the inverter operated in this mode it cannot be stopped by pressing the stop button.

23-29	Time of Multi-Pump Switch Over
Range	【0 ~ 240】hour
23-30	Detection Time of Multi-Pump
Range	【0.0 ~ 30.0】Sec
23-31	Multi-Pump Synchronous Function
Range	【0】: Disable 【1】: Pressure Setpoint and Run/ Stop 【2】: Pressure Setpoint 【3】: Run/Stop

In multi-pump mode, the Master, Follower 1, Follower 2, and Follower 3 will automatically alternate to the next available one in sequence after all the drives have entered sleep mode for the time specified in 23-29.

When parameter 23-31 is set to 1 or 3, Detection Time of Multi-Pump (23-30) becomes active. If the system pressure is unable to meet the pressure setpoint - 23-09 within the time specified in 23-30, the Master will turn-on the next available follower (Lag pump).

23-31=0: Disabled.

23-31=1: Setpoint and Run/ Stop

Setpoint and Run/Stop command are modified and controlled by Master; Followers (Lag pumps) follow Master's command. Stop button on Followers (Lag Pumps) is still available, and can be used as an emergency stop.

23-31=2: Setpoint

Setpoint is modified / controlled by Master; Followers (Lag pumps) follow Master's setpoint.

23-31=3: Run/Stop

Run/ Stop command is controlled by Master, Followers (Lag pumps) follow Master's command. Stop button on Followers (Lag pump) is still available and can be used as an emergency stop.

Note: To change the setpoint on the Master requires pressing ENTER key to modify the pressure setting of all the followers (Lag pumps).

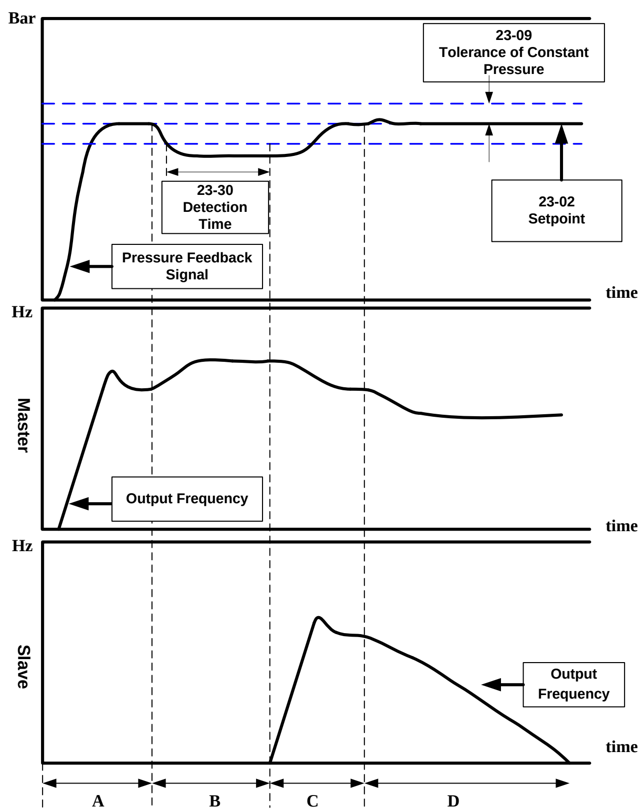


Figure 4.3.111 Dual pumps start up process

A: Master start running first and follower (Lag pump) is waiting.
B: The pressure drops, but the time specified in 23-30 has not yet expired, Follower (Lag pump) is waiting to come online.
C: Master wakes up the next available Follower (Lag pump) to start running after the time specified in 23-30 has expired to increase the system pressure.
D: The output frequency of both Master and Follower (Lag pump) decrease when pressure falls within the specified bandwidth (23-09). The Follower (Lag pump) will go into sleep before the master.

Notes:

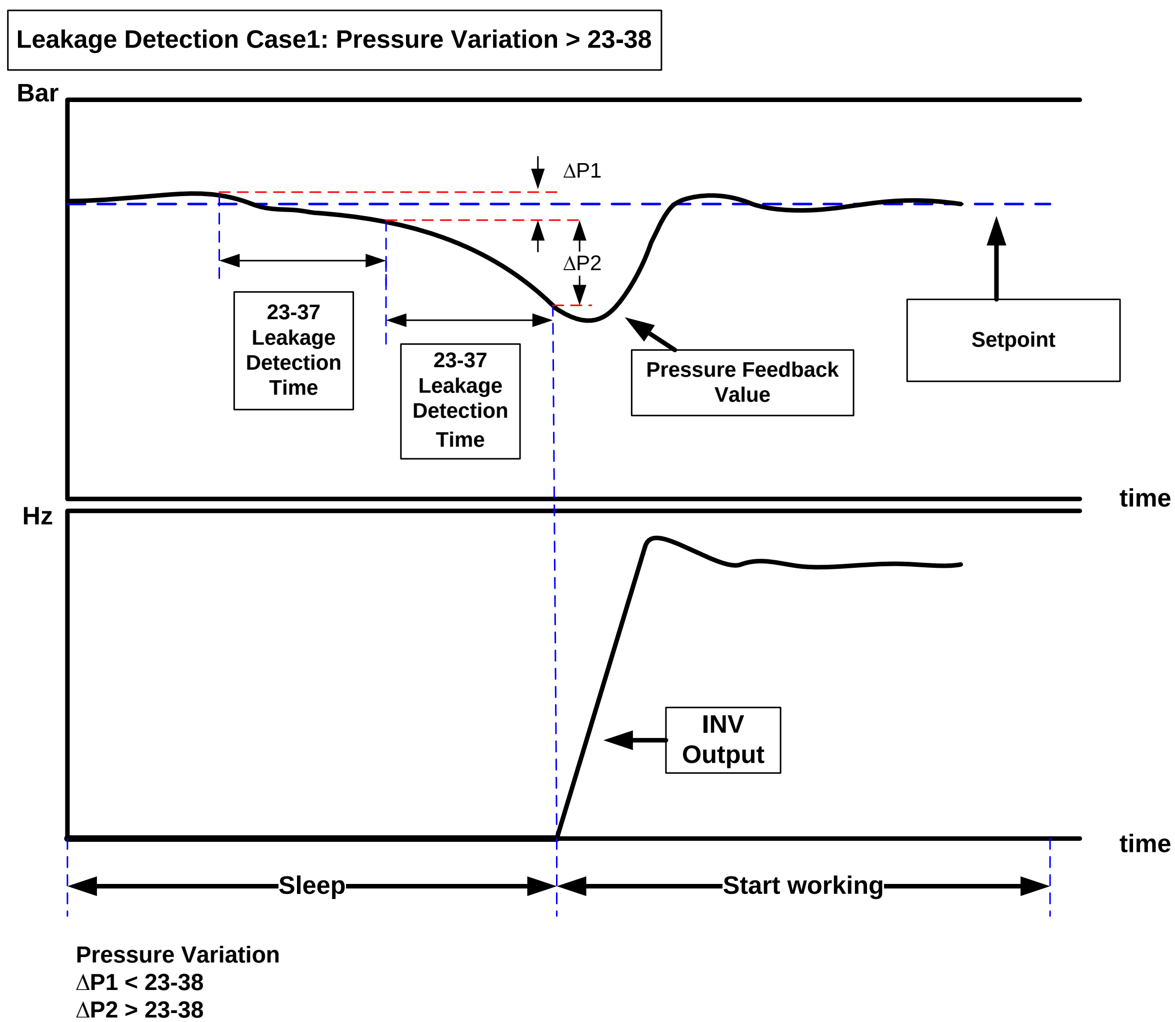
- When both inverters are in sleep mode for the time specified in switching time (23-29), the master and Follower (Lag pump) will alternate.

- In multi-pump mode only one of the inverters can be set as the master (23-01 = 1).

23-36	Pump Unit Selection
Range	【0】: PSI 【1】: inW 【3】: Bar 【4】: Pa

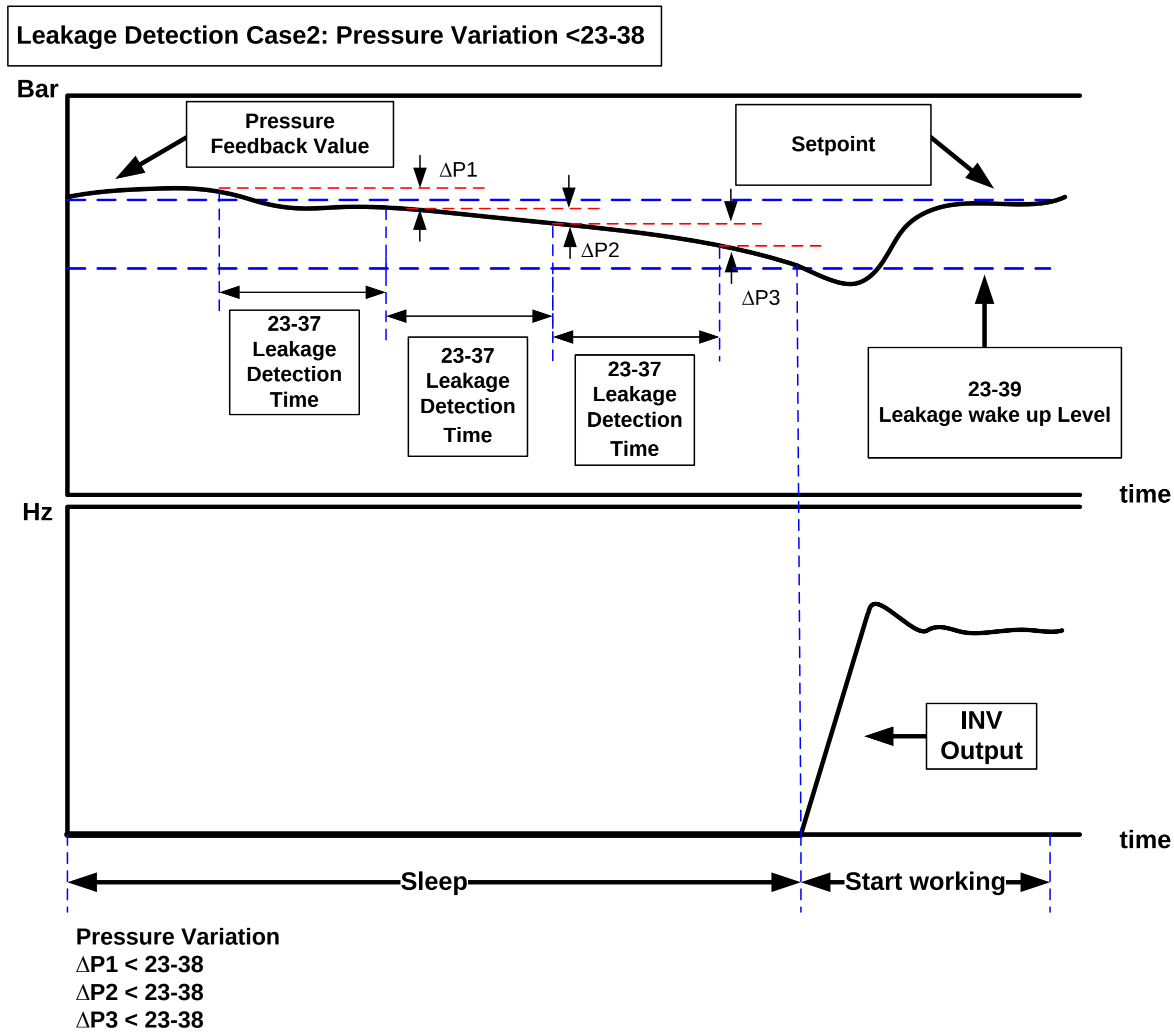
Engineering unit for parameters 23-02, 23-09, 23-12, 23-15, 23-24, 23-38 and 23-39 are set by parameter (23-36).

23-37	Leakage Detection Time
Range	【0.0~100.0】
23-38	Leakage Detection Variation
Range	【0.01~65.00】
23-39	Leakage Detection Wake up Level
Range	【0.01~65.00】



Notes:
- When 23-37 = 0.0 (sec), function is disabled.
- When the inverter is in sleep mode, pressure may drop over time due to a leak. The inverter will start when pressure variation is greater than the value set in parameter 23-38 for the time specified in 23-37.

- Leakage detection is available only in single pump mode.



Notes:

- When 23-37 = 0.0 (sec), function is disabled.
- When the inverter is in sleep mode, pressure may drop over time due to a leak. The inverter will start when pressure drops below he value set in parameter 23-38 for the time specified in 23-37. The inverter starts if pressure variation is smaller than that of 23-38 or pressure falls outside the bandwidth specified by parameter 23-39 during the detection time.
- Properly adjust the leakage detection parameters 23-37, 23-38 and 23-39 to prevent system from cycling on and off caused by leak.
- Leakage detection is available only in single pump mode.

23-41	Local/ Remote Key
Range	【0】：Disable 【1】：Enable

When enabled allows user to switch between local and remote operation.

Input source selection is determined by the source of frequency command (00-05) and the operation modes (00-02).

23-41=0: Disable

Frequency command is controlled by terminal AI1 and AI2 and run command is controlled by terminal S1, S2 or RS485. SEQ and REF lights are on.

23-41=1: Enable

User can use the FWD/REV key to switch between Local and Remote operation.

Frequency command is controlled by the keypad when SEQ and REF signal light are off.

Note: Local mode is controlled by the keypad and remote mode is controlled by control circuit terminals or RS485 connection.

23-42	**Energy Reset**
Range	**【0】: Disable (Energy Accumulating)** **【1】: Enable**
23-43	**Energy Price per KWH ($ / kWhr)**
Range	**【0.000~5.000】**
23-44	**Pulse Output Selection**
Range	**【0】: Disable** **【1】: Per 0.1kWh** **【2】: Per 1kWh** **【3】: Per 10kWh** **【4】: Per 100kWh** **【5】: Per 1000kWh**

When inverter starts up, user can view energy usage in parameter 12-67 (unit: kWHr) and 12-68 (unit: MWHr). Reset energy usage by setting parameter 23-42 to 1.

Set the price per kWh in parameter 23-43 and view total cost in parameter 12-69 and 12-70.

The pulse output (23-44) can be set to output a pulse based on energy usage in kWh. The pulse output signal on condition lasts for 200ms independent of the selection in 23-44.

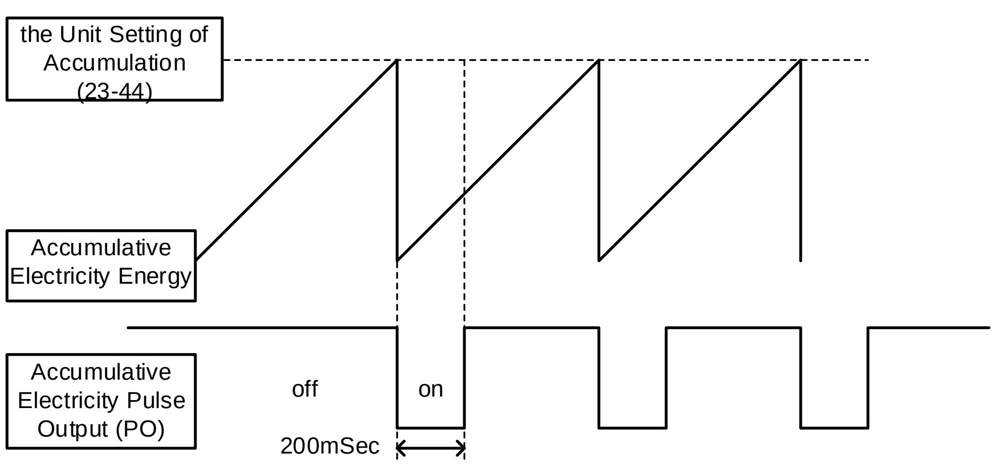


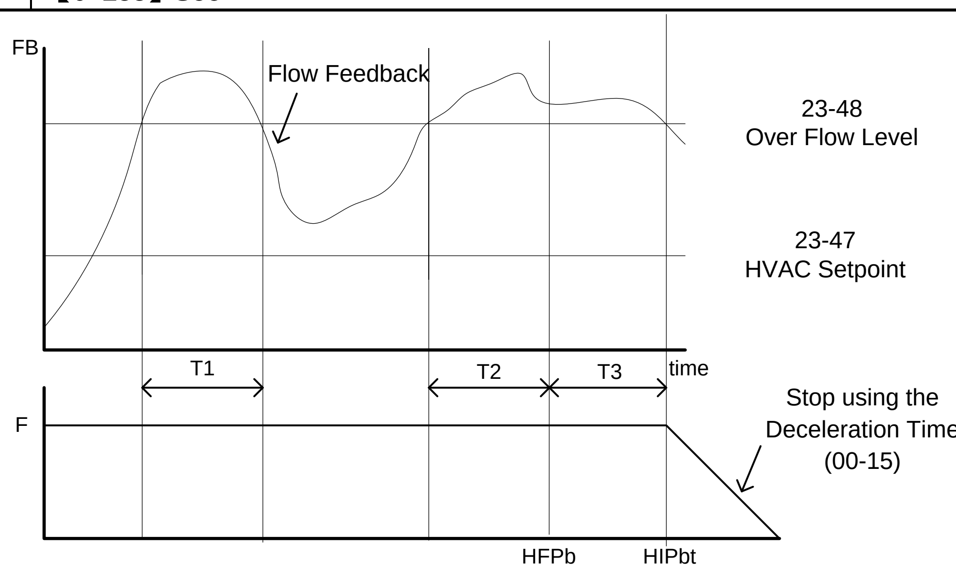
Figure 4.3.112 Accumulative electricity pulse output

23-45	Flow Meter Type
Range	【0】: None 【1】: Analog Input 【2】: Pulse Train Input
23-46	**Maximum rated Flow**
Range	【1~10000】GPM
23-47	**HVAC Setpoint**
Range	【1~10000】GPM
23-59	**HVAC Setpoint Source**
Range	【0】: From 23-47/12-77 【1】: From AI1

The value of maximum rated flow (23-46) depends on the flow meter used in the system. Parameter 23-47 range depends on the maximum flow rate set in parameter 23-46. The signal type of the flow meter is selected by 23-04.

Note: HVAC mode works when PID mode is enabled (10-03=xxx1b) and 23-00=2.

23-48	Over Flow Level
Range	【0.01~99.00】%
23-49	**Warning Time for Over Flow**
Range	【0~255】Sec
23-50	**Alarm Time for Over Flow**
Range	【0~255】Sec



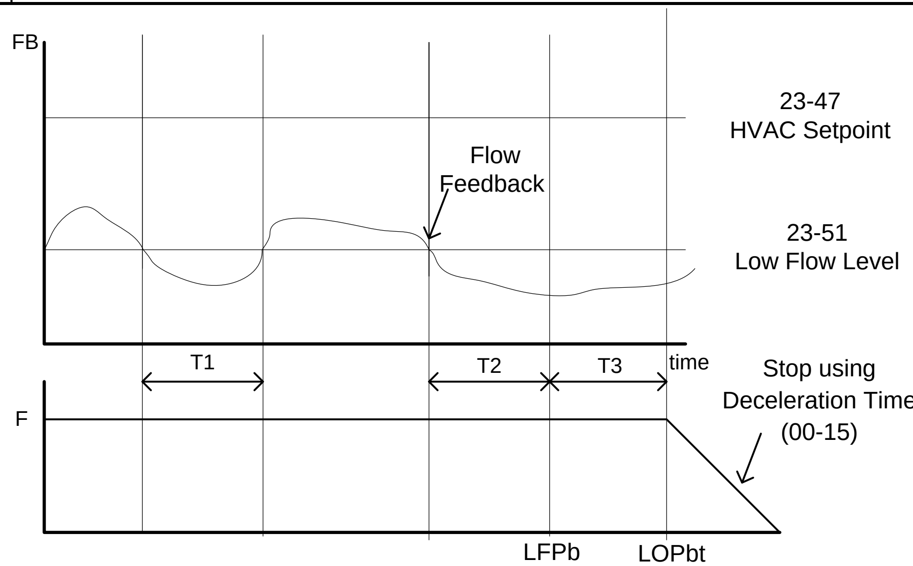
T1 < (23-49): Restart timer after T1.
T2 = (23-49): Keypad flashes and displays HFPb
T3 = (23-50): Keypad flashes and displays HIPbt

Figure 4.3.113 Over flow warning / stop

When flow level feedback is higher than the over flow level specified in parameter 23-48 for a time specified in 23-50 the inverter will trip on a HIPbt fault. The inverter displays a warning (HFPb) on the keypad when the flow level feedback is higher than the over flow level specified in parameter 23-48 for a time specified in 23-49. The internal timers for fault and alarm are reset to 0 when the flow level falls below the over flow level (23-48).

Note: Set parameter 23-50 to 0 to disable over flow protection.

23-51	Low Flow Level
Range	【0.01~99.00】%
23-52	Warning Time for Low Flow
Range	【0~255】Sec
23-53	Alarm Time for Low Flow
Range	【0~255】Sec



T1 < (23-52): Recounting after T1.
T2 = (23-52): Keypad flashes and displays LFPb
T3 = (23-53): Keypad flashes and displays LOPbt

Figure 4.3.114 Low flow warning / stop

When flow level feedback falls below the low flow level specified in parameter 23-51 for a time specified in 23-53 the inverter will trip on a LOPbt fault. The inverter displays a warning (LFPb) on the keypad when the flow level feedback falls below the low flow level specified in parameter 23-51 for a time specified in 23-52. The internal timers for fault and alarm are reset to 0 when the flow level rises above the low flow level (23-51).

Note: Set parameter 23-52 to 0 to disable over flow protection.

23-54	Detection Function of Low Suction
Range	【0】: Disable 【1】: PID Error 【2】: Current 【3】: PID Error and Current
23-55	Detection Time of Low Suction
Range	【0~30.0】Sec
23-56	PID Error Level of Low Suction
Range	【0 ~ 30】%
23-57	Current Level of Low Suction (Motor Rated Current)
Range	【0 ~ 100】%
23-58	Action of Low Suction
Range	【0】: Disable 【1】: Warning 【2】: Fault 【3】: Fault & Restart

Low suction detection can be used to detect for example a condition where there is insufficient water in the supply tank. Use parameter 23-58 to set the inverter action when a low suction condition is detected. Set low suction signal in parameter 23-54. Refer to Fig.4.3.115 for low suction block diagram.

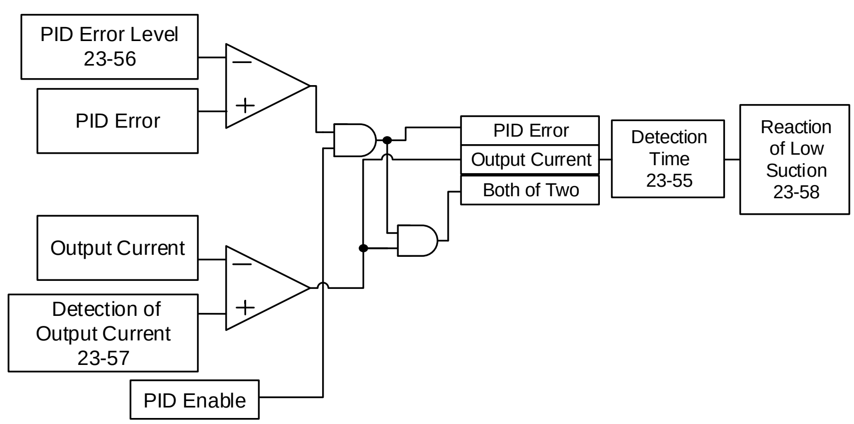


Figure 4.3.115 Function block of low suction protection

Table 4.3.19 the detection logic of low suction

23-54	Detection Signal	
	PID Error	Output Current
1	1	0
2	0	1
3	1	1

- When 23-Detection Function of Low Suction is set to =1, (Detect PID Error), PID Error is used for low suction detection.
- When 23-54 Detection Function of Low Suction is set to =2, (Detect Current), output current is used for low suction detection.
- When 23-54 Detection Function of Low Suction is set to =3, both PID Error and Output Current are used for low suction detection.

Table 4.3.20 shows messages on the keypad during a low suction detection

Table 4.3.20 Detection signal of water used

23-58	Inverter Status	Keypad Signal	Error Signal
0	Running	None	None
1	Running	LSCFT(Flash)	Warning of Low Suction
2	Stop	LSCFT	Jump to Error for Low Suction
3	Stop and Restart	LSCFT	Jump to Error for Low Suction and Restart

Note: Low suction state is detected if signal is higher than PID error level or lower than output current.

.

23-60	HVAC Unit Selection
Range	【0】: GPM 【1】: FPM 【3】: CFM 【4】: GPH

Engineering unit for parameters 12-7, 12-77, 23-46 and 23-47 is set by parameter 23-60.

23-66	Derating of Current Level
Range	【10 ~ 200】%
23-67	Derating Time
Range	【1.0 ~ 20.0】Sec
23-68	Derating Gain
Range	【1~100】%
23-69	OL4 Current Level
Range	【10~200】%
23-70	OL4 Delay Time
Range	【0.0 ~ 20.0】Sec

In water-cooled chiller application operating the compressor at rated current for 1 to 2 minutes can easily cause damage to compressor, the inverter therefor incorporates a two- stage protection function to protect the compressor.

First Stage Protection:

When the inverter is at constant speed and the current is higher than the derating level (23-66) (percentage of rated current of the compressor), for the time specified in 23-67 the inverter will reduce the frequency reference command to reduce the current load. The new frequency reference is derating gain (23-68) x frequency reference. When the current falls below the derating of current level (23-66), output frequency will be restored to the original frequency reference. When the derating cycle repeats more than 3 times the output frequency will be set to the last known derating frequency until the current is falls below the derating level (23-66).

Example:

Set 23-66=80%, 23-67=10sec, 23-68=90%, frequency command is 60Hz and the rated current of compressor is 30A.

When the output current=27A, greater than 24A (30A*80%), 10 sec (derating time) passes, and the output frequency decreases to 54 Hz (frequency command 60Hz*90%)

Next the output current decreases to 25A, but is still higher than 24A; another 10 sec passes, the adjust frequency reference now becomes 48.6 Hz (60Hz * 90% x 90%)

Next the output current decreases to 23A lower than 24A, therefor the output frequency is restored to 60Hz and the current rises back to 27A. When cycle repeat more than three times, the output frequency will stop at 48.6Hz and the output current decreases to 23A.

Protection of second stage:

When the current reaches the over load detection level (23-69) for the time specified in 23-70 the inverter will decelerate to a stop and display an OL4 fault (Compressor Overload).

Note: It is recommended that the rated current of compressor is required to be lower than that of inverter.

Group 24: Function of 1 to 8 Option Card

24-00	Functional Selection of Relay Card
Range	**【0】: Disabled.** **【1】: Fixed Modes of Inverter Pump: First on and Last off; then Stop All.** **【2】: Fixed Modes of Inverter Pump: Only Stop Inverter Pump.** **【3】: Fixed Modes of Inverter Pump: First on and First Off; then Stop All.** **【4】: Cycle Modes of Inverter Pump: First on and First Off; then Stop All.** **【5】: Cycle Modes of Inverter Pump: Only Stop Inverter Pump.** **【6】: Cycle modes of Inverter Pump by built-in Relay: First on and First off; then Stop All.**

The inverter with built-in PID controller in combination with a programmable logic controller (PLC) is commonly used in the pumping industry. The 1 to 8 pump option card can be used for constant pressure pumping systems without the need of an external controller. The inverter offers optimum pressure regulation using the built-in PID controller.

There are two basic operation modes for 1 to 8 relay card, and one mode using the relays on the inverter control board:

① Fixed modes of inverter pump:

In this mode, the inverter directly controls one pump; the other pumps are switched across the line and controlled by the inverter's 1 to 8 relay option card. Pumps 2 – 8 (Lag Pumps) are added when demand is required. See Fig 4.3.126 for the wiring diagram.

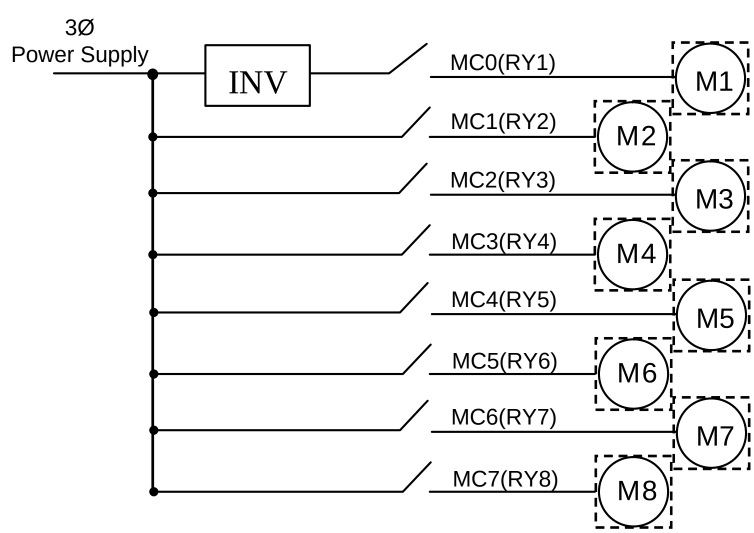


Figure 4.3.116 Fixed modes of inverter pump

② **Cycle modes of inverter pump:**

Up to 4 pumps are controlled sequentially by a single inverter. See fig 4.3.127 for the wiring diagram.

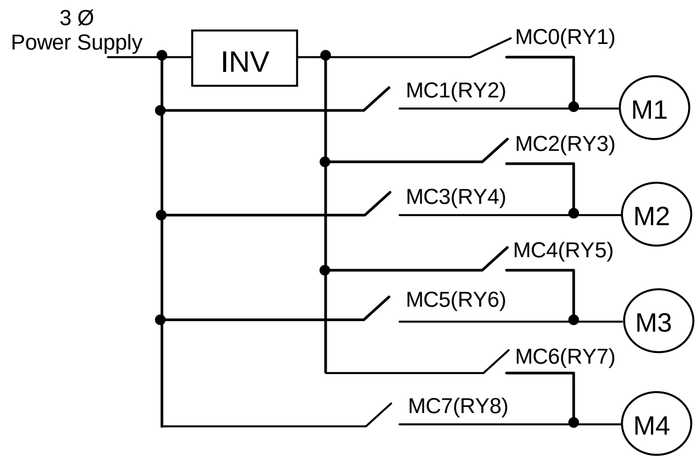


Figure 4.3.117 Cycle modes of inverter pump

③ **Cycle modes of inverter pump using built-in relays:**

Up to 3 pumps can be controlled using the three relays on the inverter control board to perform the cycle mode control without the need of the 1 to 8 relay card. See fig 4.3.128 for the wiring diagram.

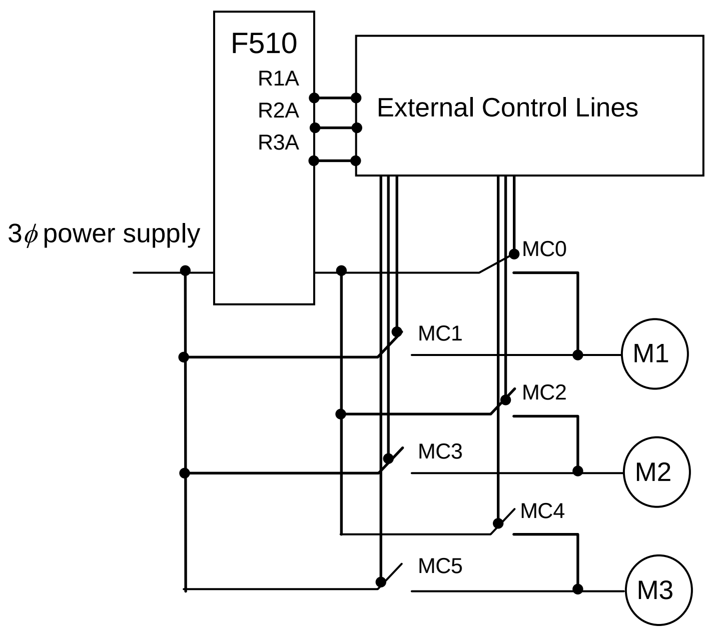


Figure 4.3.118 Cycle modes of inverter pump by built-in relay

24-00=0: 1 to 8 relay card is disabled.

24-00 = 1: Fixed modes of inverter pump, first on and last off; then stop all.

When the system pressure matches the setpoint for the time specified in 24-03, the auxiliary lag pumps turn off in order of first on last off. This mode can be used for motors with different ratings. See the timing chart in fig 4.3.120 and 4.3.121.

24-00=2: Fixed modes of inverter pump only stop inverter pump.

This mode works similar to mode 1, 24-00=1, except when inverter is stopped the auxiliary lag pumps that are running stay running (Relays stay ON).

24-00=3: Fixed modes of inverter pump, first on and first off; then stop all.

When the system pressure matches the setpoint for the time specified in 24-03, the auxiliary lag pumps turn off in order of first on first off. This mode can be used for motors with equal ratings.

24-00=4: Cycle modes of inverter pump, first on and first off; then stop all.

Motors are controlled by the inverter in sequence and turn off in order of first on first off. See the timing chart in fig 4.3.122 and 4.3.123.

24-00=5: Cycle modes of inverter pump, only stop the Inverter pump.

This mode works similar to mode 4, 24-00=4, except when inverter is stopped the auxiliary lag pumps that are running stay running (Relays stay ON).

24-00=6: Cycle modes of inverter pump by built-in relay: first on and first off; then stop all.

This mode is only active when 24-07=1, and works similar to mode 4, 24-00=4 except this mode uses the built-in relays on the inverter control card . See the timing chart in fig 4.3.124 and 4.3.125

Notes:

- If the 1 to 8 pump card is not installed, parameter 24-00 cannot be set (default 0).
- Set 24-07=1 first, before 24-00 can be changed even without installing the 1 to 8 pump card.
- PID function has to be enabled before performing group 24:
- PID function is enabled by setting parameter 10-03 PID control mode (10-03) to xxx1b (PID enable). Set PID setpoint source (10-00) to 4 and the setpoint in parameter 10-02. If the feedback signal source (10-01) is set to 2 (AI2) and the AI input signal type (04-00) is set to 0 (AI2: 0~10V) requires SW2 to be set to position V on the control board.
- PID disable (03-00~03-05 = 16) and Force Frequency Command (03-00~03-05 = 57) by DI are disabled when using function group 24.

24-01	Selection of Relay 2-4 Function
Range	【xxx0b】: Reserved 【xxx1b】: Reserved 【xx0xb】: Relay 2 Disable 【xx1xb】: Relay 2 Enable 【x0xxb】: Relay 3 Disable 【x1xxb】: Relay 3 Enable 【0xxxb】: Relay 4 Disable 【1xxxb】: Relay 4 Enable
24-02	Selection of Relay 5-8 Function
Range	【xxx0b】: Relay 5 Disable 【xxx1b】: Relay 5 Enable 【xx0xb】: Relay 6 Disable 【xx1xb】: Relay 6 Enable 【x0xxb】: Relay 7 Disable 【x1xxb】: Relay 7 Enable 【0xxxb】: Relay 8 Disable 【1xxxb】: Relay 8 Enable

- **Fixed modes of inverter pump:**

In the fixed modes of inverter pump, RY1 is always used and RY2~RY8 can be used when required.

Inverter decelerates to the lower limit frequency (00-13*01-02) when relays switch ON, PID function is temporarily disabled until the frequency reaches the lower limit, and vice versa; inverter accelerates to upper limit frequency (00-12*01-02) when relays switch OFF, PID function is temporarily disabled until the frequency reaches the upper limit.

- **Cycle modes of inverter pump:**

In the cycle modes, two relays make a pair (RY1/RY2, RY3/RY4, RY5/RY6, RY7/RY8), up to 4 pairs. Both relays in one pair have to be enabled otherwise the relay pair does not work.

Inverter stops output, switches output to control the next motor and switches supply power to the previous motor (by turning ON relay, RY2, RY4, RY6 or RY8) when the pump system requires more pumps to maintain the pressure. When pressure is stable, then inverter keeps running and turns off the relays (pumps) as needed. Note: set switching time for magnetic contactor (24-05), time needed to switch motor from inverter to across the line.

- **Cycle modes of inverter pump by built-in relay:**

In this mode RY1 is always used and RY2~RY3 is used when required. 24-01 can only be set 0xxx (Relay 4 cannot be set.) and 24-02 is not visible.

24-03	Detection Time on Fmax (Upper Limit Frequency)
Range	【1.0 ~ 600.0】Sec

The inverter turns on the next pump (relay/motor) when the inverter output frequency is equal to the upper limit frequency (00-12 x 01-02) for the time specified in 24-03. This value depends on the response of the system. Note: When the value of the Detection Time on Fmax is set too low may result in the system to become unstable.

24-04	Detection Time on Fmin (Lower Limit Frequency)
Range	【1.0 ~ 600.0】Sec

The inverter turns off the last pump (relay/motor) when the inverter output frequency is equal to the lower limit frequency (00-13 x 01-02) for the time specified in 24-04. This value depends on the response of the system. Note: When the value of the Detection Time on Fmin is set too low may result in the system to become unstable.

24-05	Switching Time of Magnetic Contactor
Range	【0.1~2.00】Sec

When a motor originally controller by the inverter is switched over to commercial AC power supply or when the motor is originally driven by the commercial AC power supply is switched by the inverter, parameter 24-05 is used to prevent the condition that both the inverter and commercial AC power are connected together resulting in a short circuit between the inverter output and AC power supply.

Generally, the off-to-on time of magnetic contactor is longer than the on-to-off time. So 24-05 should be set to a value greater than the turn-on time of the relay on relay card plus the turn-on time of magnetic contactor.

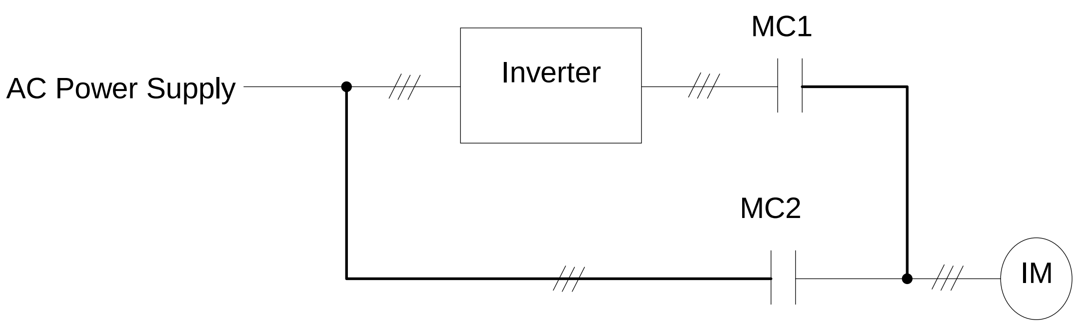


Figure 4.3.119 Diagram of a single cycle mode inverter pump

24-06	Relay Frequency Bias
Range	【0.0~20.0】%

Parameter 24-06 allows the system to switch the relays on 1 to 8 relay card on or off quicker. Example, 00-12 = 80%, and 00-13 = 20%, then:

- If 24-06 = 0%, the output frequency needs to reach 80% of the maximum frequency to turn the relay on; the output frequency needs to reach 20% of the minimum frequency to turn the relay off.
- If 24-06 = 5%, the output frequency needs to reach 75% of the maximum frequency to turn the relay on; the output frequency needs to reach 25% of the minimum frequency to turn the relay off.

24-07	Pump Control Source Selection
Range	【0】: Relay card 【1】: Control board

24-07 = 0: Use 1 to 8 relay option card

24-07 = 1: Use built-in relays on control board

If 1 to 8 relay card is unavailable:

① 24-00 range is 1~3 and 6.

② 24-01 is set to 0xxx (Relay 4 is disabled).

③ 24-02 is set to 0000 (Relay 5~8 are disabled).

Note: Set 24-00, 24-01, 24-02 and 24-07 as described above to avoid programming errors.

Refer to the following table for controlling the maximum number of pumps for different settings of 24-00 and 24-07.

Setting value of 24-00	Inverter pump Modes	No. of relay required by one pump	24-07=0 (Relay in 1 to 8 pump card)	24-07=1 (Relay in the control board)
1-3	Fixed Modes	1	8 PUMP	3 PUMP
4,5	Cycle Modes	2	4 PUMP	None
6	Cycle Modes	1	None	3 PUMP

- Function for R1A becomes Relay1 and parameter 03-11 is not used.
- Function for R2A becomes Relay2 and parameter 03-12 is not used.
- Function for R3A becomes Relay3 and parameter 03-39 is not used.

- The following examples are the timing chart for switching ON/OFF relays in fixed mode. Set 24-00=1, 24-06=0, enable the PID function and Relay1 to Relay 4 on the 1 to 8 relay card. Motor 1 is connected to inverter and motor 2~4 are connected to AC power supply. MC of AC power supply is controlled by the external circuit control. Wiring diagram refer to Fig. 4.3.126.

✧ Output frequency (Fout) reaches Fmax (00-12*01-02) for the time specified in 24-03, Relay 2 turns on, motor 2 starts running. Motor 1 decelerates to Fmin (00-13*01-02) after relay 2 turns on; when Fmin is reached PID control turns on again.

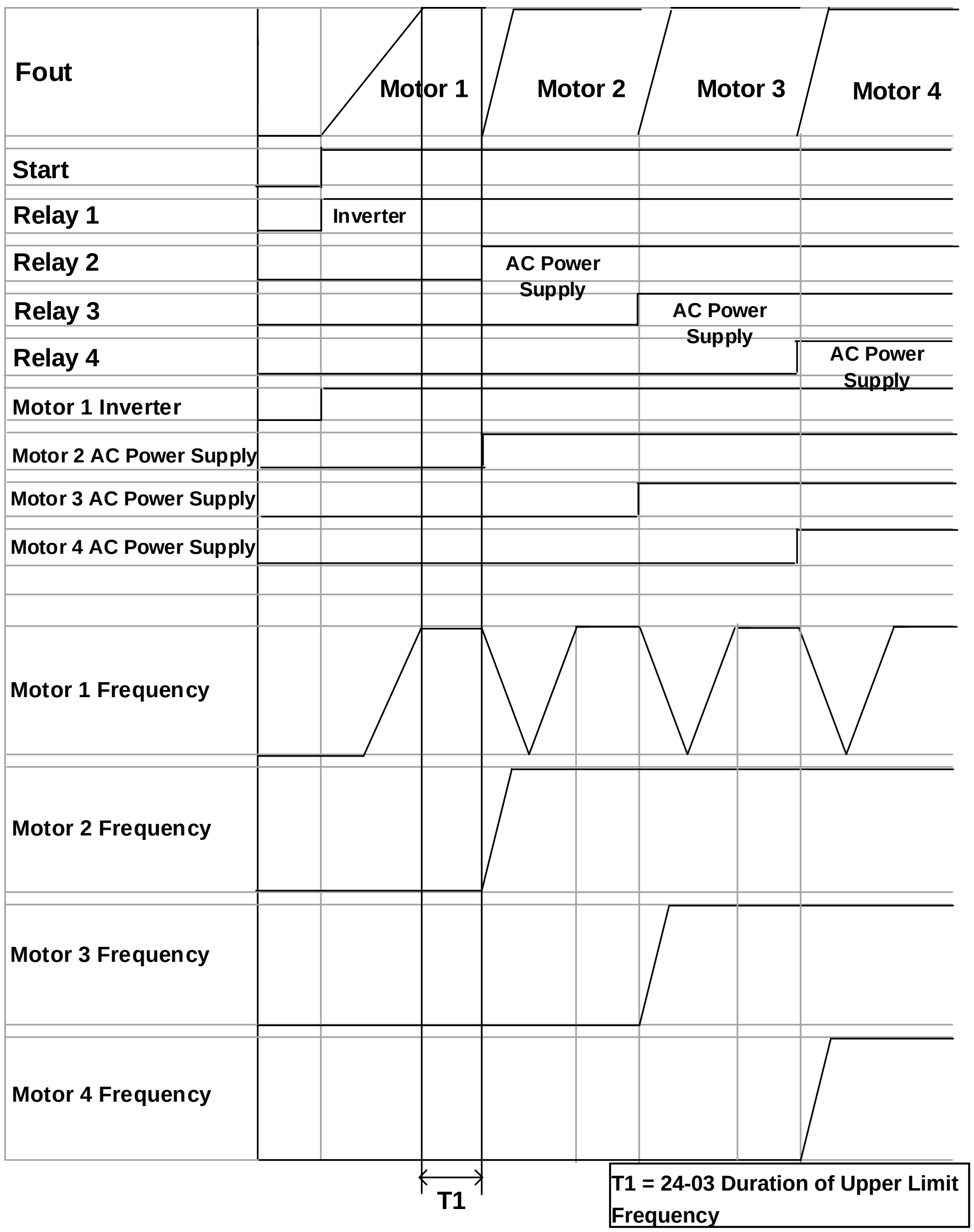


Figure 4.3.120 Timing chart of switching ON relays in fixed mode

✧ Output frequency (Fout) decreases to the Fmin (00-13*01-02) for the time specified in 24-04, relay 4 turns off and motor 4 coasts to stop. Motor 1 accelerates to Fmax (00-12*01-02) after relay 4 turns off; when Fmax is reached PID control turns on again.

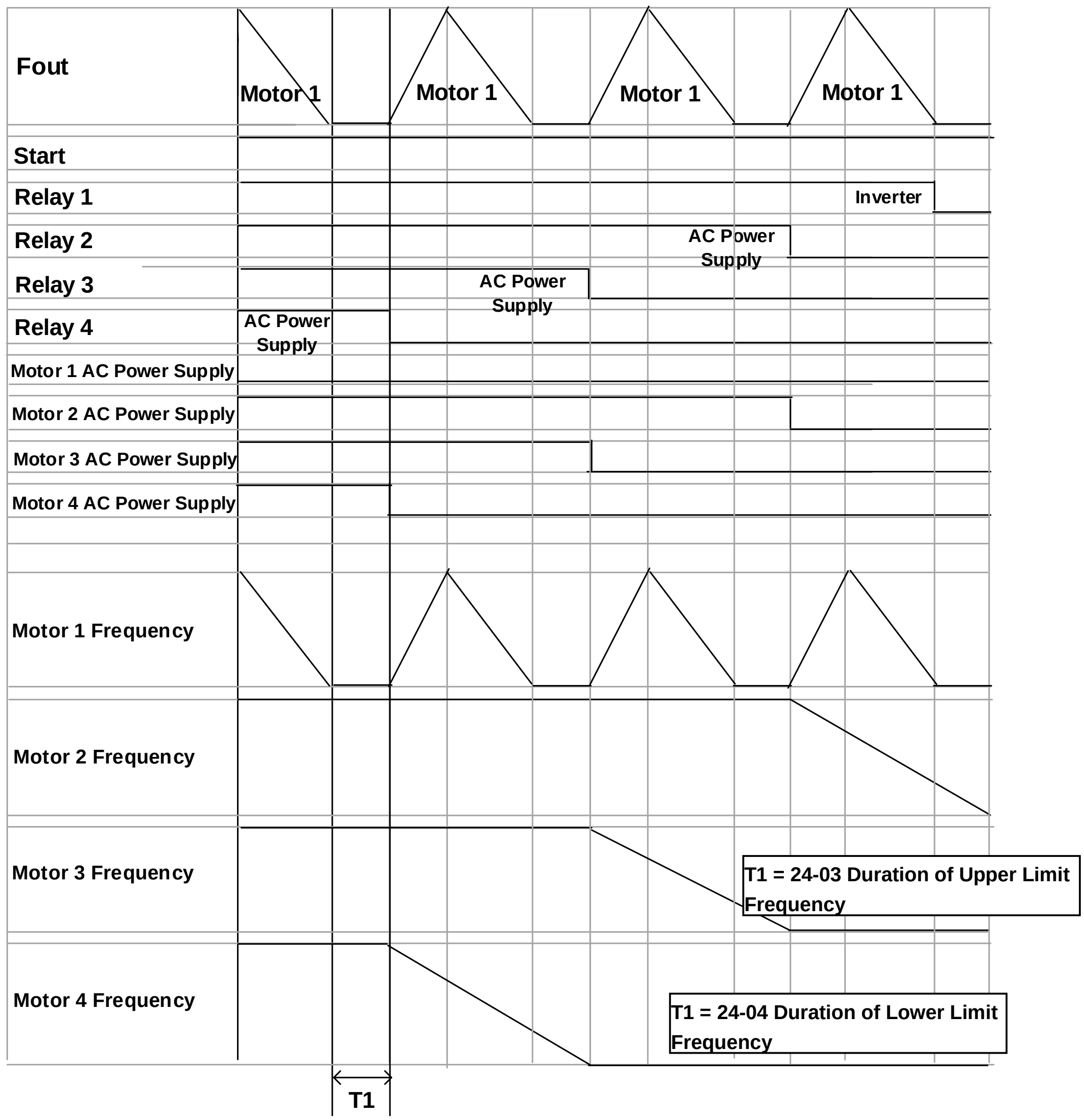


Figure 4.3.121 Timing chart of switching OFF relays in fixed mode

- The following examples are the timing chart of switching relays on and off in cycle modes. Set 24-00=1, 24-06=0, enable the PID function and Relay 1 to Relay 4 on the 1 to 8 pump card. Fig 4.3.119 is the timing diagram of cycle mode operation; please refer to Appendix A for a detailed wiring of the system.

✧ Output frequency (Fout) reaches Fmax (00-12*01-02) for the time specified in Fmax (24-03), relay 1 turns off and inverter output turns off.

✧ Relay 1 and Relay 2 turn on and the inverter starts running after the MC switching time, 24-05 has expired.

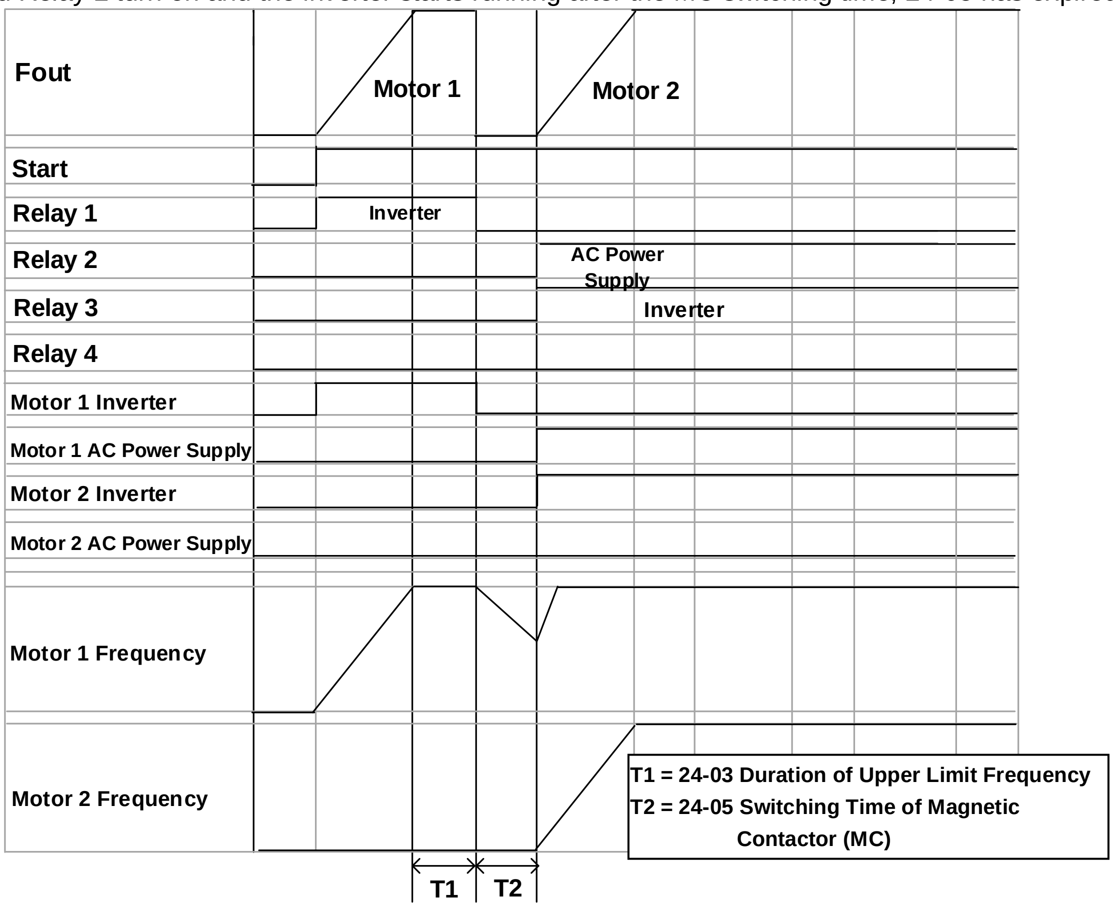


Figure 4.3.122 Timing chart of switching ON relays in cycle mode

✧ Output frequency (Fout) reaches Fmin (00-13*01-02) for the time specified in 24-04, relay 2 turns off and the inverter accelerates to Fmax (00-12*01-02). When Fmax is reached PID control is turned on again. If the feedback is still higher than the setpoint motor 2 will decelerate to Fmin again.

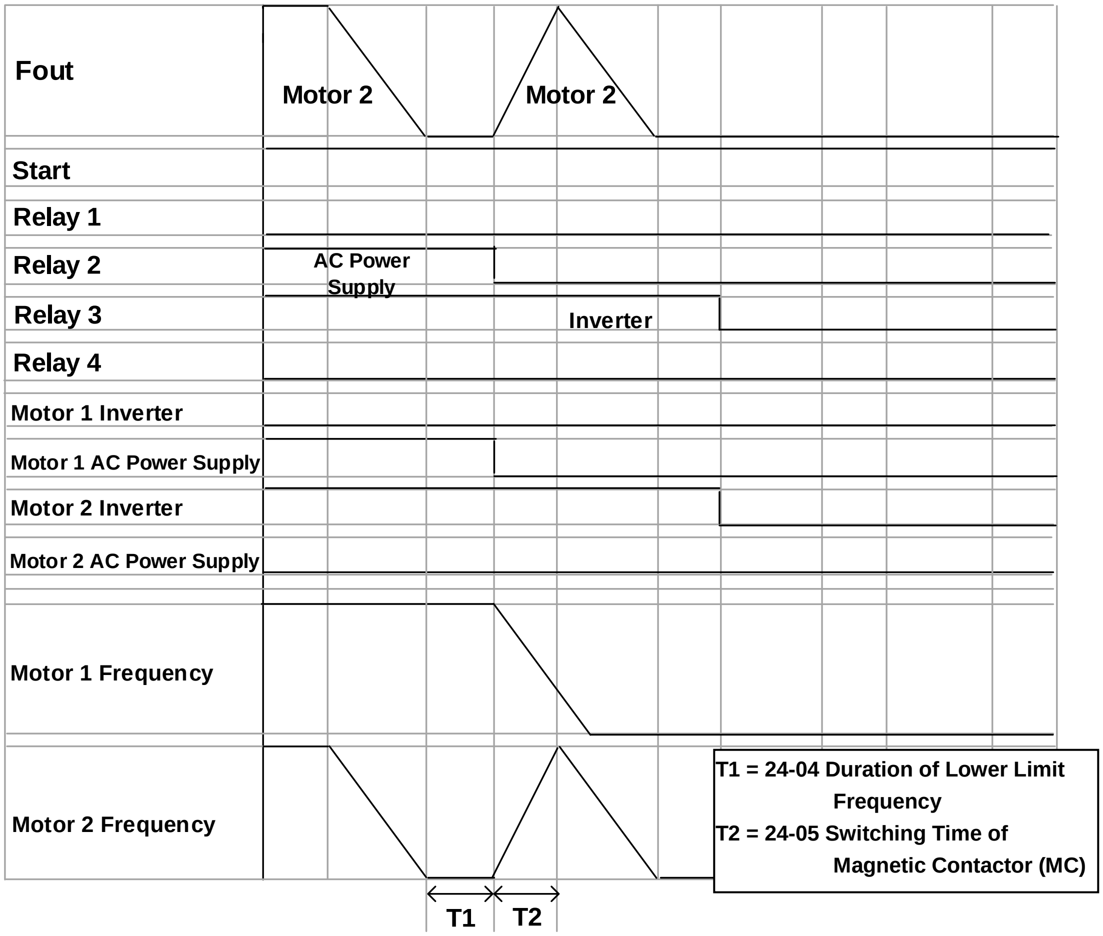


Figure 4.3.123 Timing chart of switching OFF the relays in cycle mode

- The following examples are the timing charts for switching relays on and off in cycle mode using the built-in relays. Set 24-00=1, 24-06=0, enable the PID function. Relay1 to Relay3 are now set to operate as R1A to R3A. Fig 4.3.118 is the timing diagram of this mode; please refer to Appendix A for a detailed wiring diagram of the system.

✧ Output frequency (Fout) reaches the upper limit frequency (00-12) for the detection time specified in 24-03, relay 1 turns off and the inverter output turns off.

✧ Although relay 2 turns on in advance, the inverter does not start and relay 1 does not turn on until twice the MC switching time (24-05) has expired.

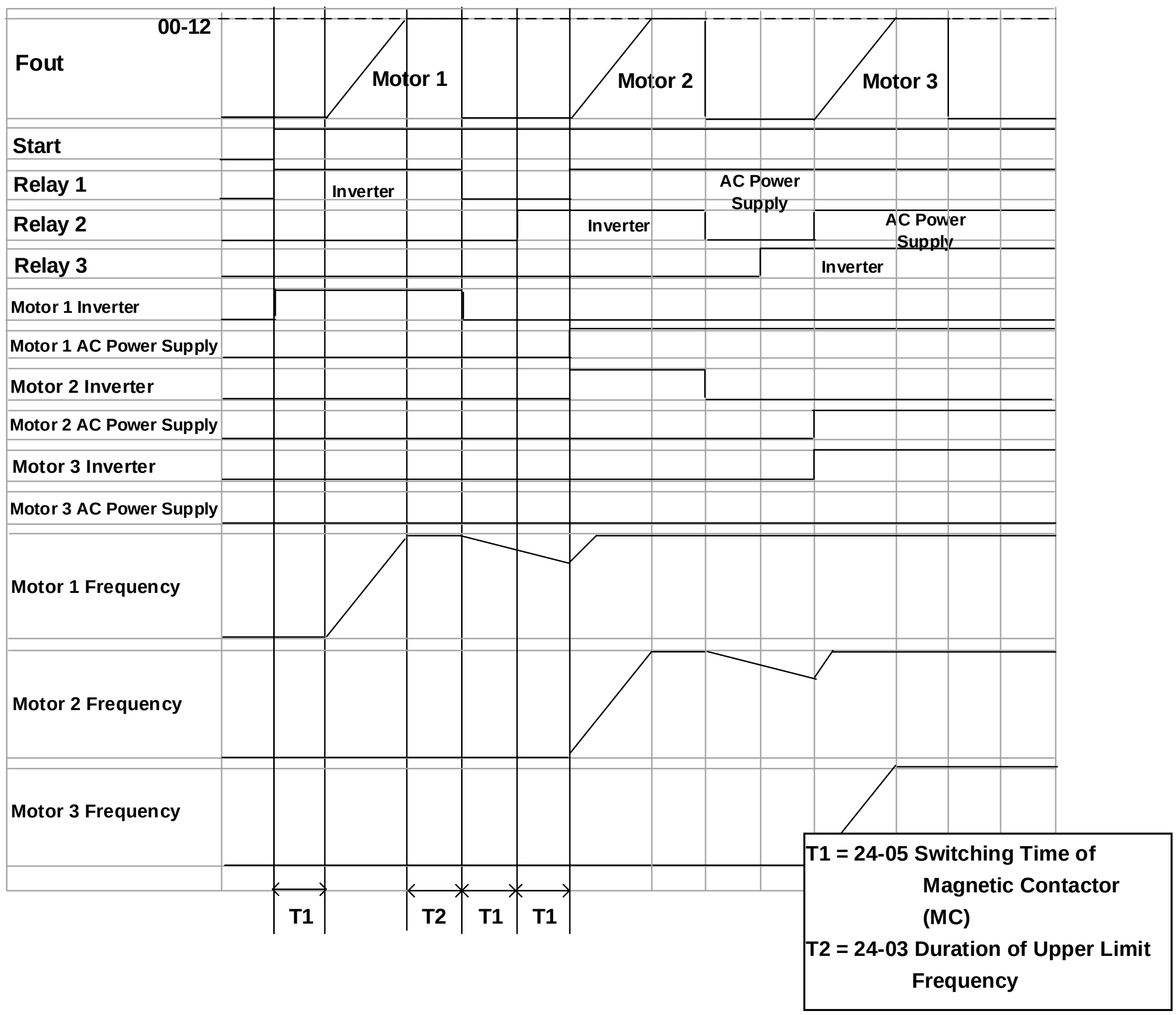


Figure 4.3.124 Timing chart for switching ON/OFF relays using the built-in relays

✧ When pressure feedback signal is higher than the setpoint, output frequency (Fout) starts decreasing. Relay 1 turns off when the output frequency reaches the lower limit frequency (00-13*01-02) for the time specified in 24-04.

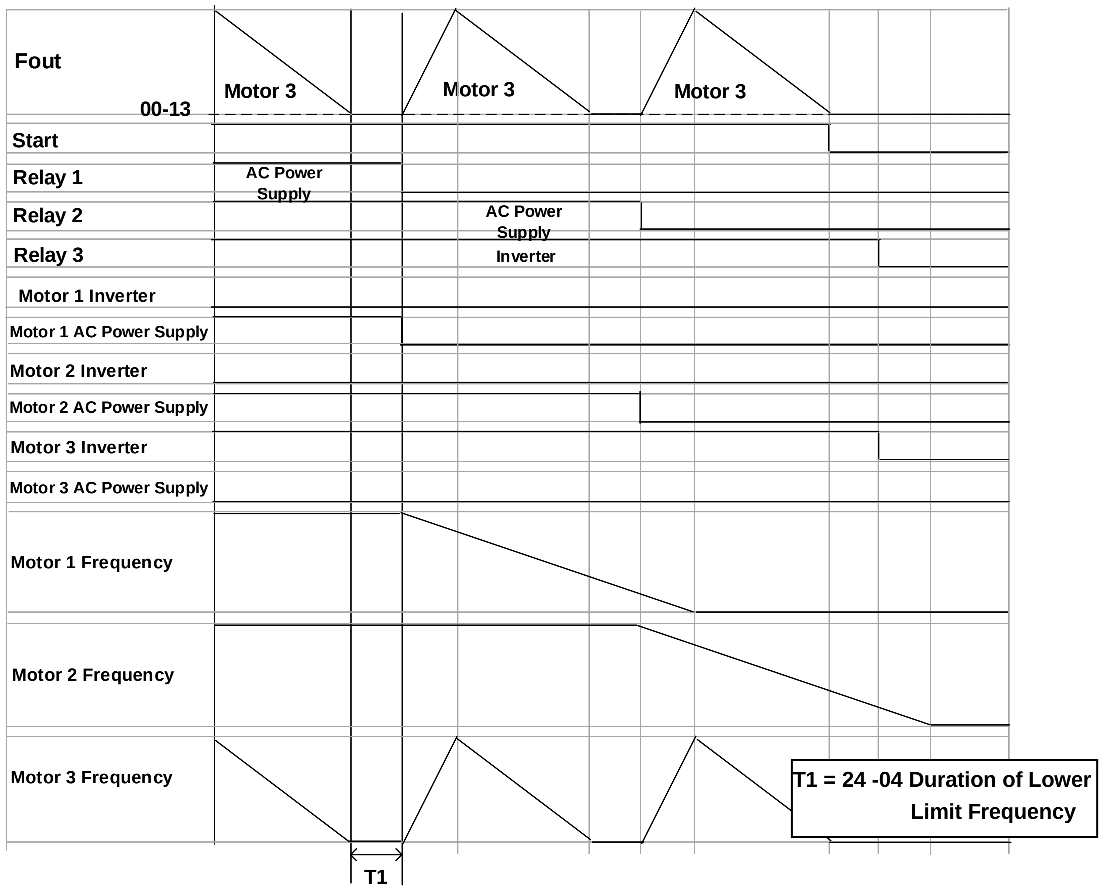


Figure 4.3.125 Timing using relays on the control card

■ Wiring for 1 to 8 Pump Card and 1 to 3 Relay Modes

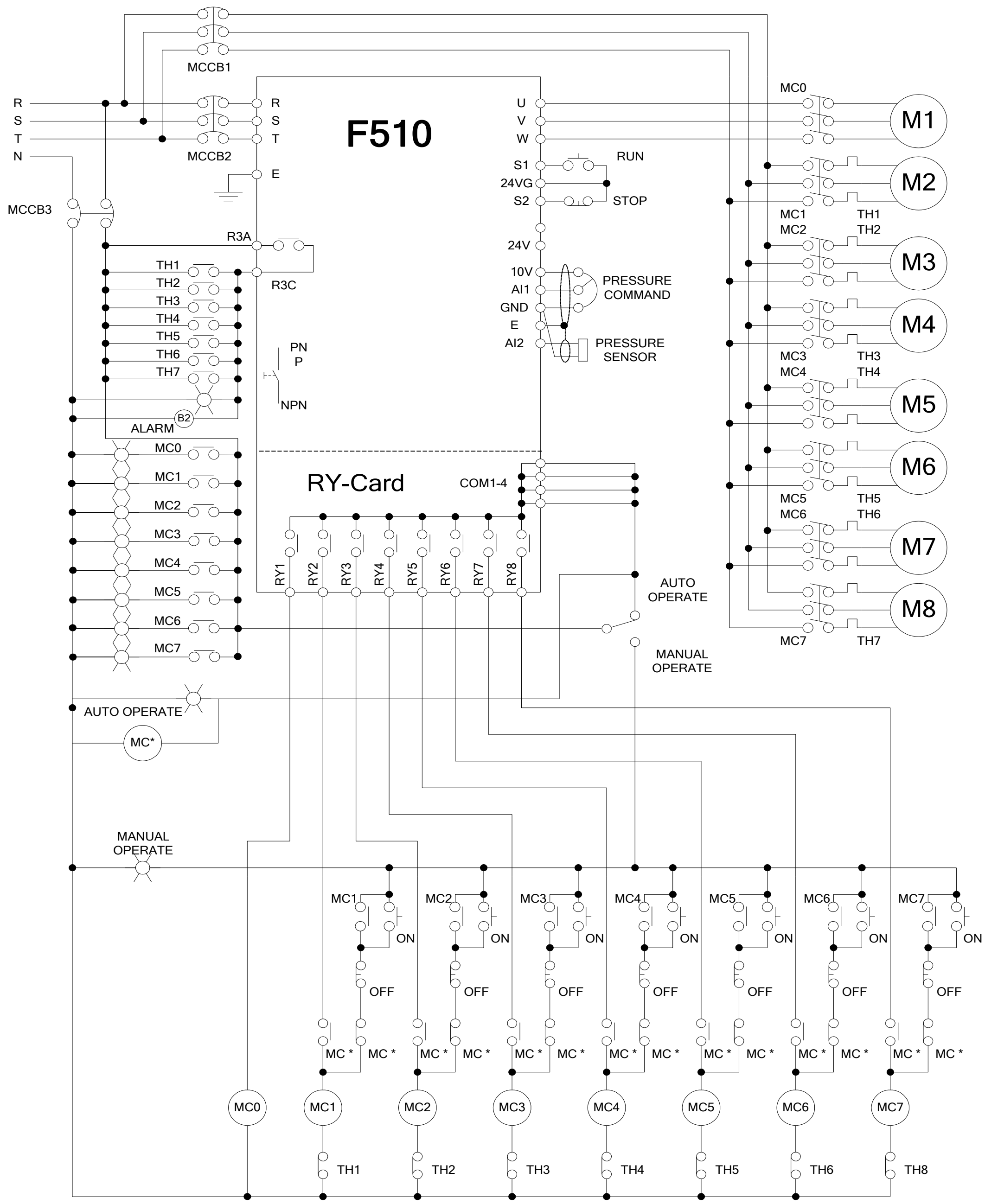


Figure 4.3.126 Fixed mode inverter pump wiring using 1 to 8 option card

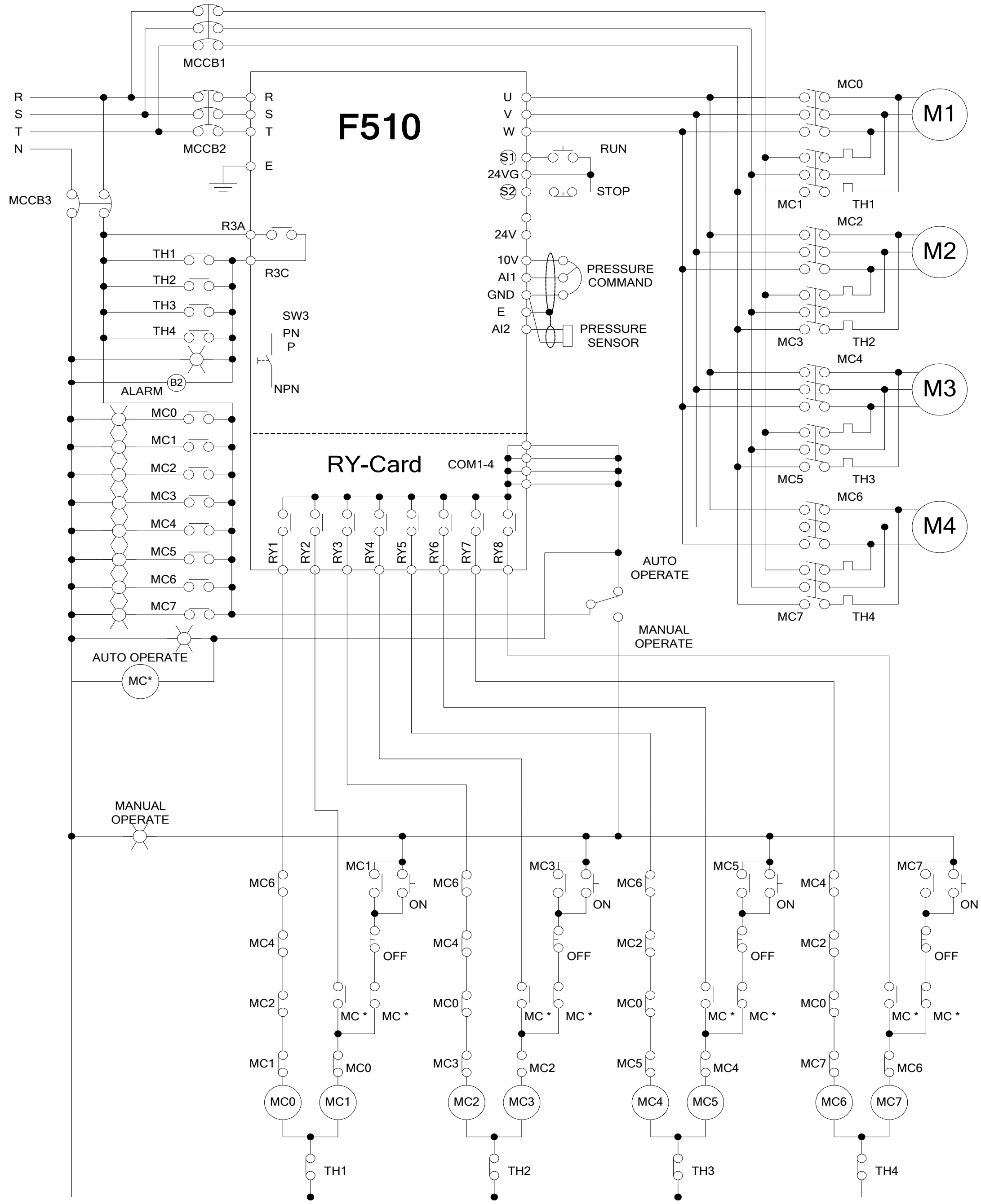


Figure 4.3.127 Cycle mode inverter pump wiring using 1 to 8 option card

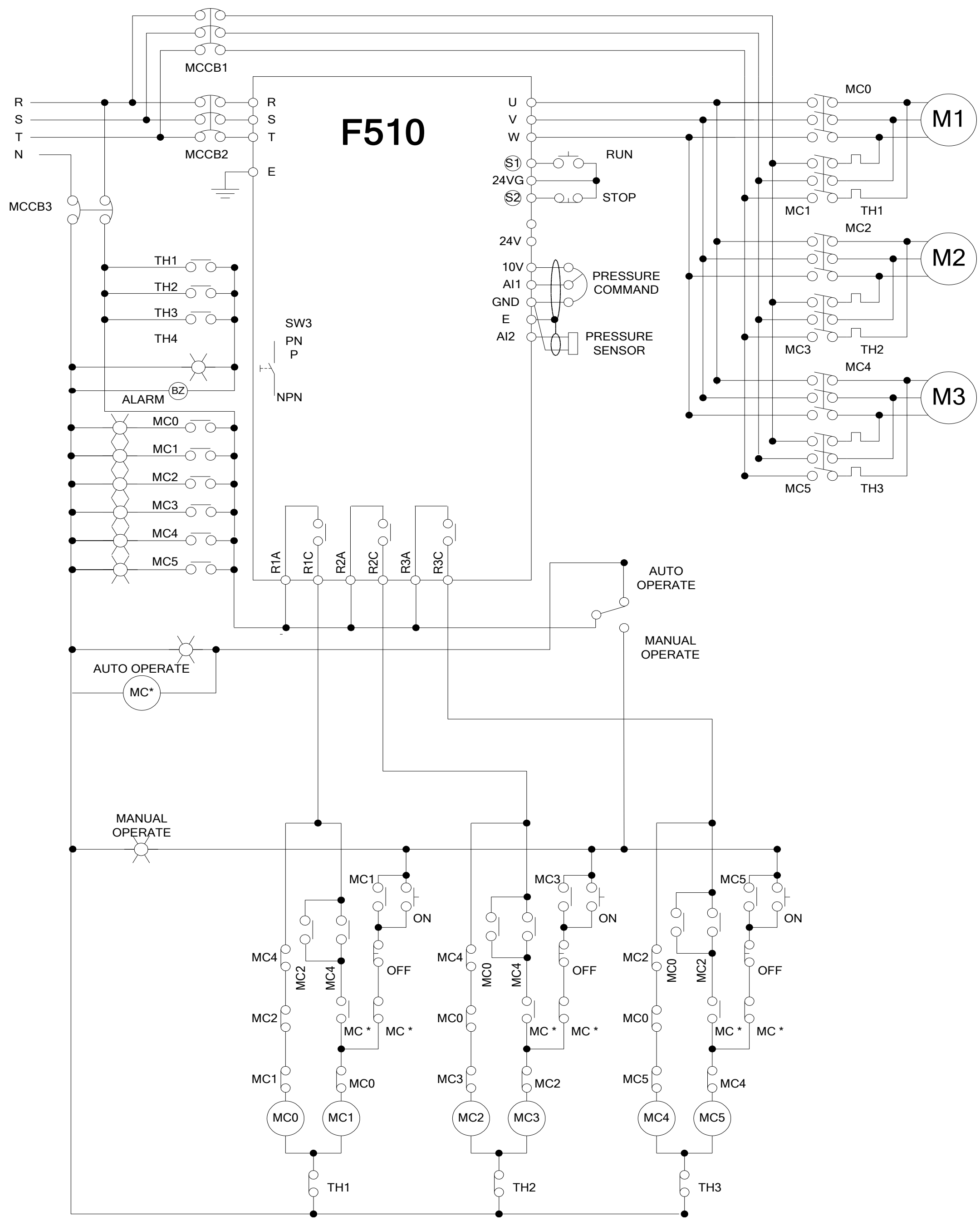


Figure 4.3.128: Cycle mode inverter pump wiring using relays on the control card

5. Check motor rotation and direction

This test is to be performed solely from the inverter keypad. Apply power to the inverter after all the electrical connections have been made and protective covers have been re-attached. At this point, **DO NOT RUN THE MOTOR**, the keypad should display as shown below in Fig. 5.1 and the speed reference 12-16=00**5.00Hz** should be blinking at the parameter code “12-16”.

Important: Motor rotation and direction only applies to standard AC motors with a base frequency of 60Hz. For 50Hz or other frequency AC motors please set the max frequency and base frequency in group 01 accordingly before running the motors.

Fig 5.1: Keypad (Stopped)

Fig 5.2: Keypad (Running)

Next press the **RUN** key, see Fig 5.2. The motor should now be operating at low speed running in forward (clockwise) direction. The parameter code 12-17 shown at the bottom left corner of the screen will change from 12-17=000.00Hz to 12-17=005.00Hz. Next press **STOP** key to stop the motor.

If the motor rotation is incorrect, power down the inverter.

After the power has been turned OFF, wait at least ten minutes until the charge indicator extinguishes completely before touching any wiring, circuit boards or components.

Using Safety precaution, and referring to section 3.8 exchange any two of the three output leads to the motor (U/T1, V/T2 and W/T3). After the wiring change, repeat this step and recheck motor direction.

6. Speed Reference Command Configuration

The inverter offers users several choices to set the speed reference source. The most commonly used methods are described in the next sections.

Frequency reference command is selected with parameter 00-05.

00-05: Main Frequency Command (Frequency Source)

This function sets the frequency command source.

Setting Range: 0 to 7

To set parameter 00-05:
- After power-up press the **DSP/FUN** key
- Select **00 Basic Fun**
- Press **READ/ ENTER** key
- Select parameter -05 with the **UP/DOWN** ▲ and ▼ keys and press the **READ/ ENTER** key.

In the parameter list move cursor to 00-05 with the **UP/DOWN** keys and press **READ/ ENTER** key to select.

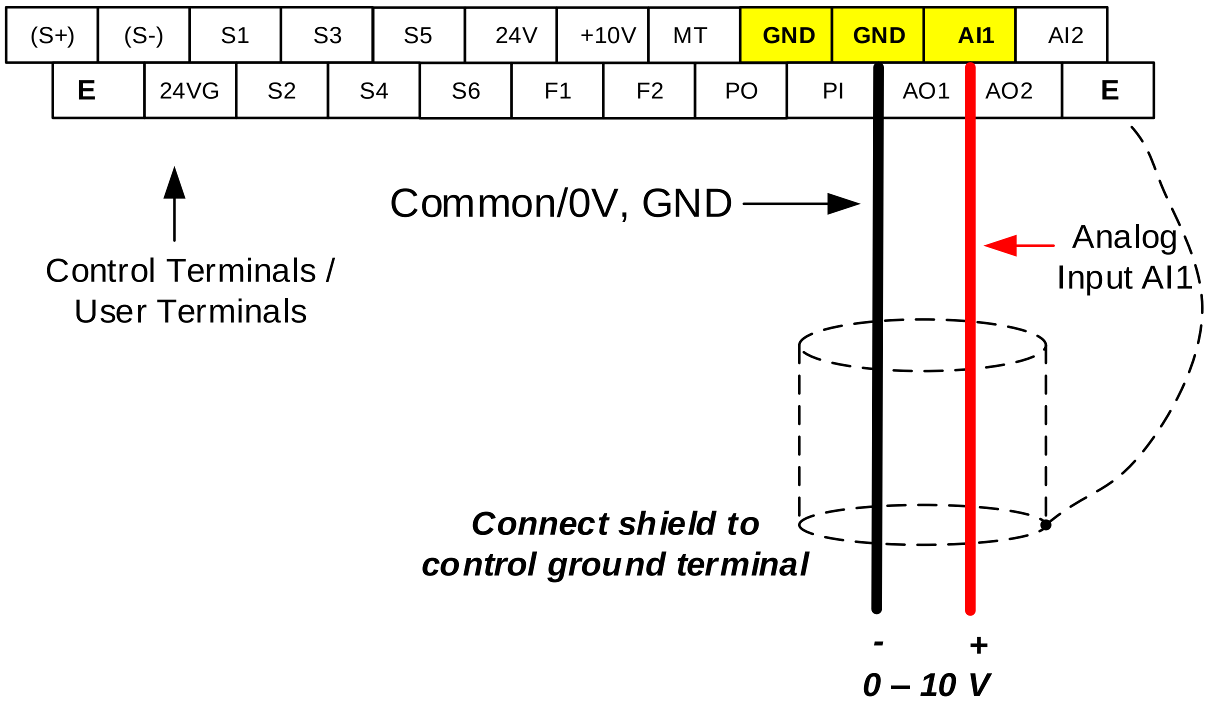
00-05	Main Frequency Command Source Selection
Range	**0:** Keypad **1:** External control (analog) **2:** Terminal UP / DOWN **3:** Communication control **6:** RTC **7:** AI2 Auxiliary Frequency

6.1 Reference from Keypad

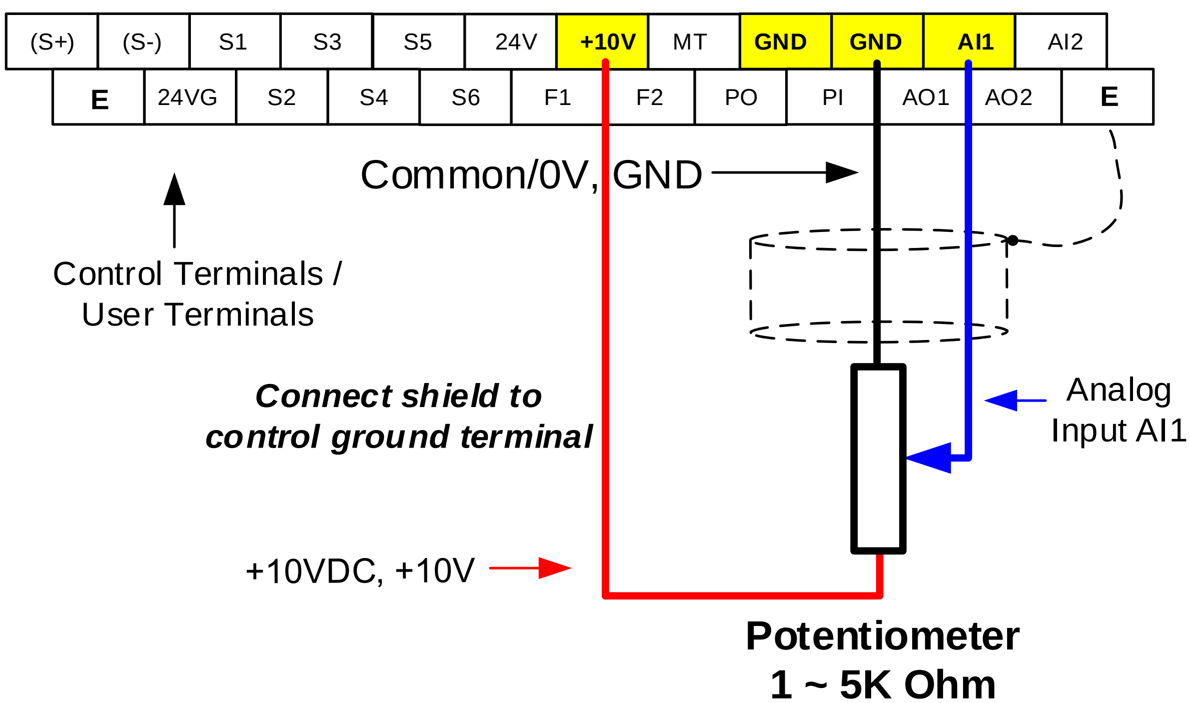
Speed reference from the keypad is the default setting. Press the **READ/ ENTER** key first and use the </RESET, ▲ and ▼ keys to change the speed reference.

6.2 Reference from External Analog Signal (0-10V / 4-20mA)

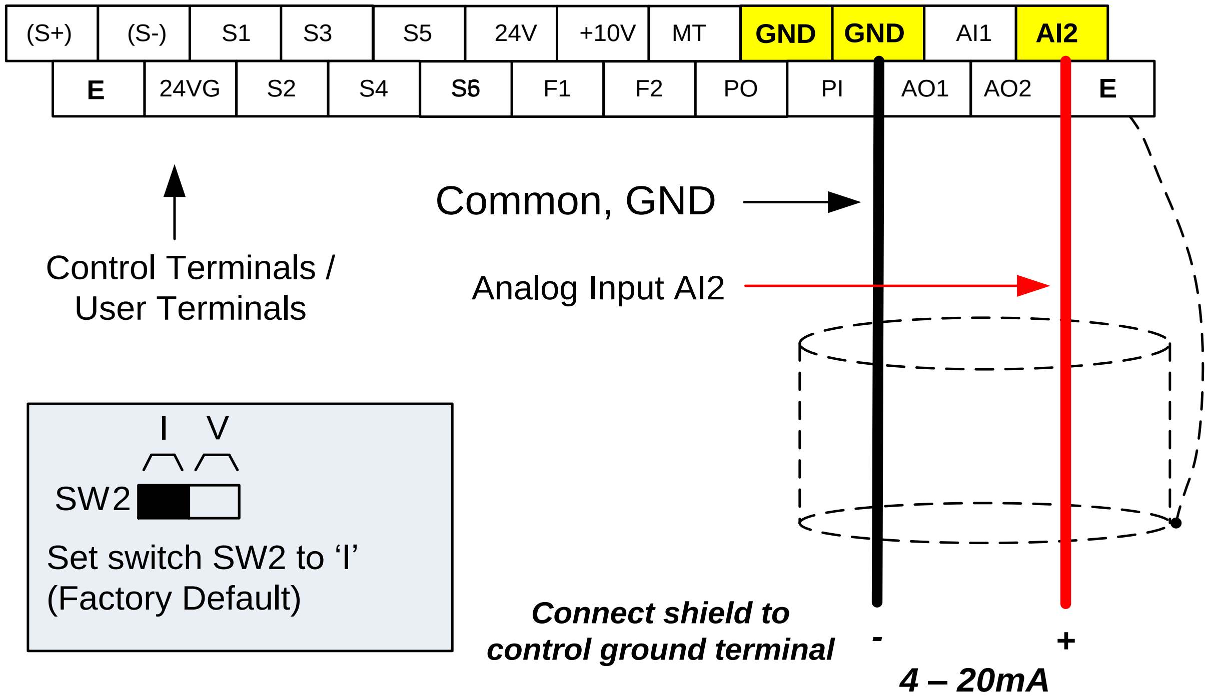
Analog Reference: 0 – 10 V (Setting 00-05 = 1)



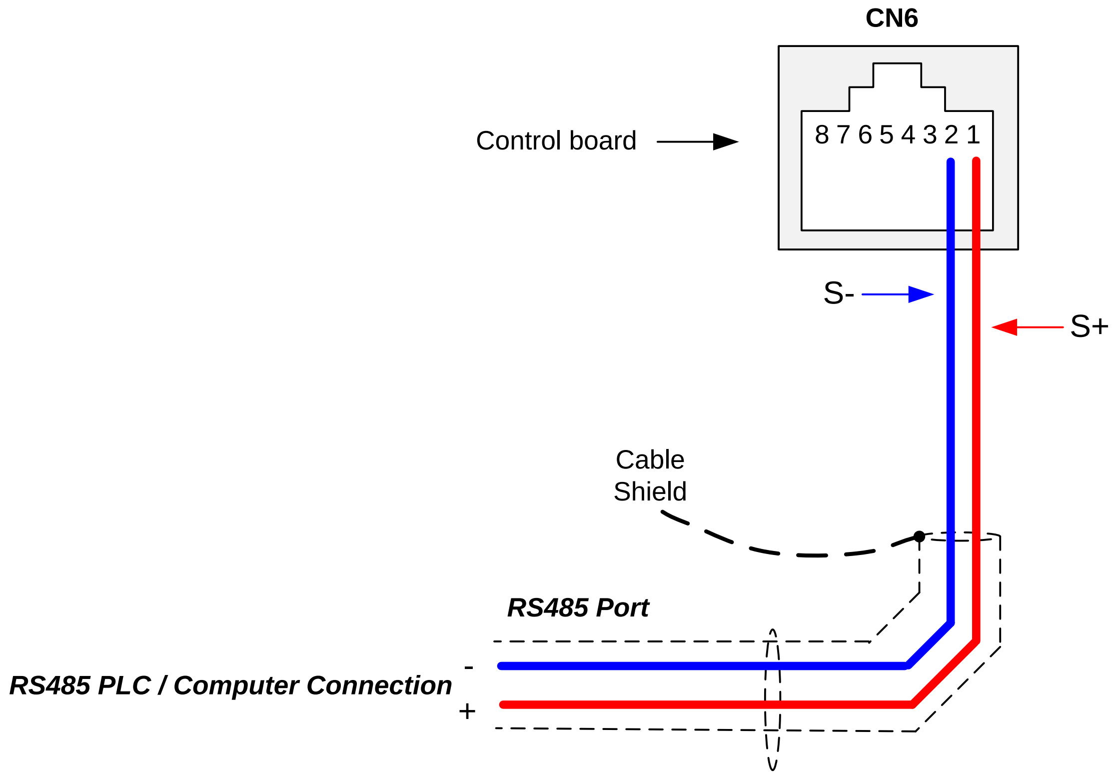
Analog Reference: Potentiometer / Speed Pot (Setting 00-05 = 1)



Analog Reference: 4 – 20mA (Setting 00-05 = 1)



6.3 Reference from Serial Communication RS485 (00-05=3)



To set the speed reference for the inverter via serial communication parameter 00-05 has be set to “3” for frequency command via serial communication.

Default Communication Setting is: Address “1”, 9600 Bits/sec, 1 Start Bit, 1 Stop Bit, and No Parity

The serial communication link function uses RS485 Modbus RTU protocol and allows for:

1) Monitoring (data monitoring, function data check).
2) Frequency setting.
3) Operation command (FWD, REV, and other commands for digital input).
4) Write function data.

Frequency Reference Command Register

Inverter Frequency Reference Register: 2502 (Hexadecimal) - Bit 0 – Bit 15: 0.00 ~ 400.00 Hz

Examples:

Frequency Reference Command: 10.00 Hz (Inverter Node Address: 01)

Command String (hexadecimal): 01 06 25 02 03 E8 23 B8

To set the frequency reference to 10.00, a value of ‘1000’ (03E8h) has to be send to the inverter.

Frequency Reference Command: 30.00 Hz (Inverter Node Address: 01)

Command String (hexadecimal): 01 06 25 02 0B B8 24 44

To set the frequency reference to 30.00, a value of ‘3000’ (0BB8h) has to be send to the inverter.

Frequency Reference Command: 60.00 Hz (Inverter Node Address: 01)

Command String (hexadecimal): 01 06 25 02 17 70 2D 12

To set the frequency reference to 60.00, a value of ‘6000’ (1770h) has to be send to the inverter

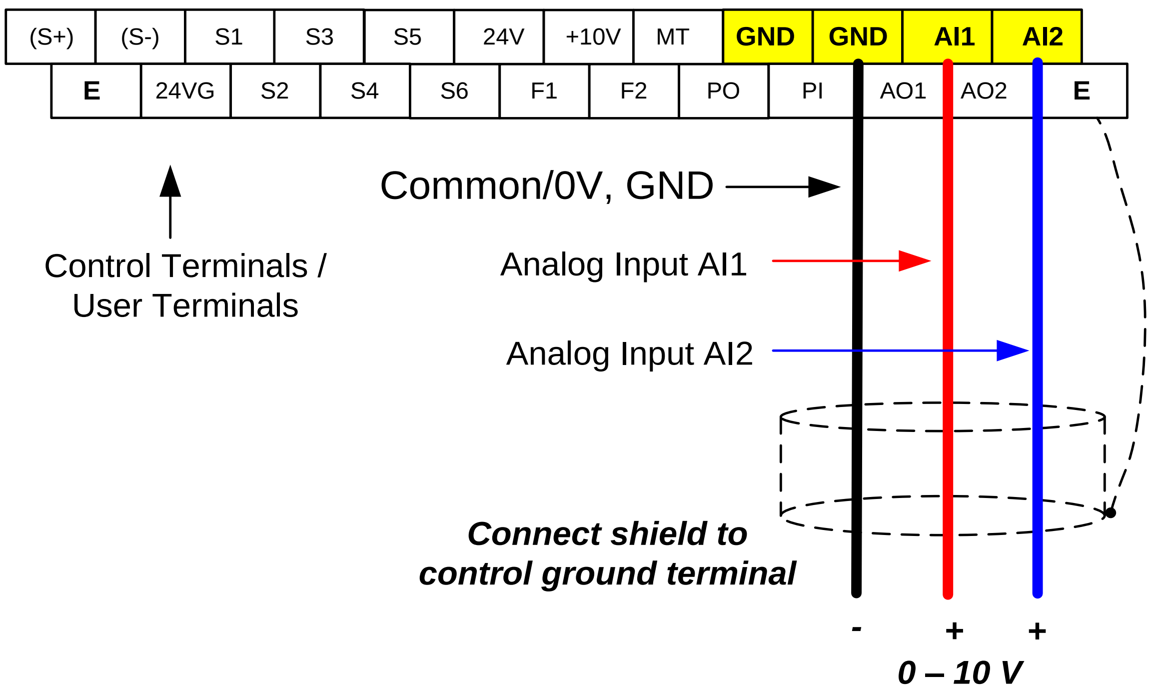
Note: The last 2 bytes of the command strings consist of a CRC16 checksum, please refer to section 4.5 of the instruction manual for additional information.

6.4 Reference from two Analog Inputs

Analog input AI1 is used as master frequency reference and analog input AI2 is used as auxiliary frequency reference.

Analog Reference AI1: 0 – 10 V (Setting 00-05 = 1)
Analog Reference AI2: 0 – 10 V (Setting 00-06 = 7)

AI1 – Analog Input 1	AI2 – Analog Input 2	04-00 Setting (Default = 1)	Dipswitch SW2 (Default 'V')
0 ~ 10V	0 ~ 10V	0	Set to 'V'
0 ~ 10V	4 ~ 20mA	1	Set to 'I'



6.5 Change Frequency Unit from Hz to rpm

Enter the number of motor poles in 16-03 to change the display units from Hz to rpm.

16-03	Display unit
Range	**0:** Display unit is Hz (Resolution is 0.01Hz) **1:** Display unit is % (Resolution is 0.01%) **2~39:** Display unit rpm, (uses number of motor poles to calculate) **40~9999:** 100% is XXXX with no decimals (integer only) **10001~19999:** 100% is XXX.X with 1 decimal **20001~29999:** 100% is XX.XX with 2 decimals **30001~39999:** 100% is X.XXX with 3 decimals

Example: Motor poles 4, 16-03 = 4.

7. Operation Method Configuration (Run / Stop)

The inverter offers users several choices to run and stop from different sources. The most commonly used methods are described in the next sections.

Operation command is selected with parameter 00-02.

00-02: Run Command Selection

This function sets the frequency command source.

Setting Range: 0 to 4

To set parameter 00-01:
- After power-up press the **DSP/FUN** key
- Select **00 Basic Fun**
- Press **READ/ ENTER** key
- Select parameter -01 with the **UP/DOWN** ▲ and ▼ keys and press the **READ/ ENTER** key.

In the parameter list move cursor to 00-01 with the **UP/DOWN** keys and press **READ/ ENTER** key to select.

00-02	Run Command Selection
Range	**0:** Keypad control **1:** External terminal control **2:** Communication control **3:** PLC **4:** RTC

7.1 Run/Stop from the Keypad (00-02=0) – Default Setting

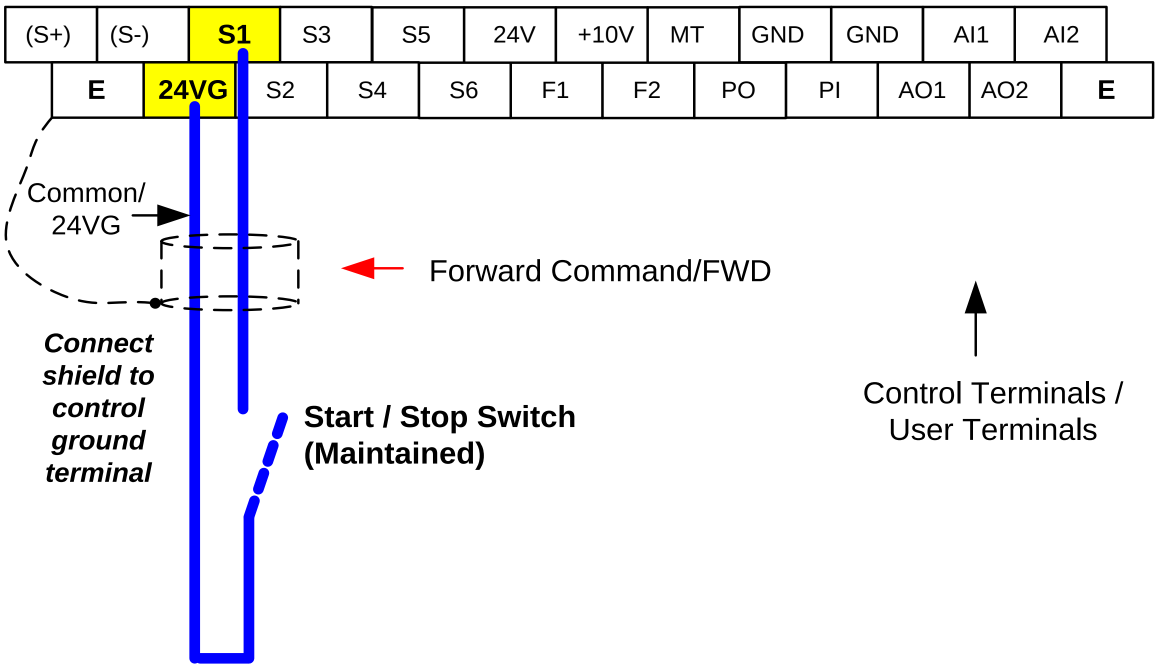
Use the **RUN** key to run the drive in forward direction and the **FWD/REV** key to change the motor direction. (Note: to disable reverse direction set parameter 11-01 to 1)

Press **STOP** key to stop the inverter. (Note: Stop method can be set with parameter 07-09, default is **deceleration to stop)**.

7.2 Run/Stop from External Switch / Contact or Pushbutton (00-02=1)

Use an external contact or switch to Run and Stop the inverter.

Permanent Switch / Contact



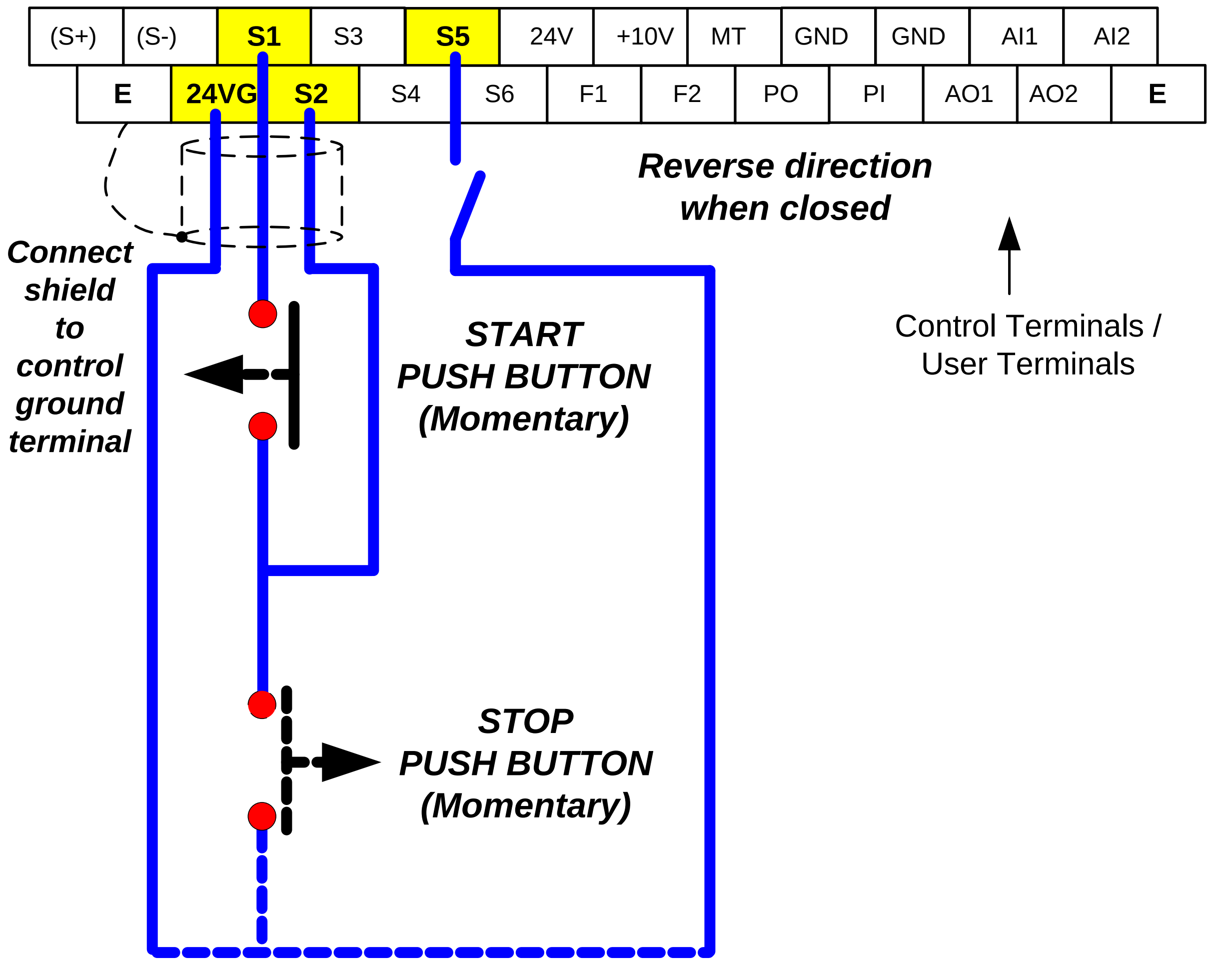
Momentary Contacts (Push Buttons)

Use push button / momentary switch to Run and Stop the inverter.

Set parameter 13-08 to 3, 5 or 7 for 3-wire program initialization, multi-function input terminal S1 is set to run operation, S2 for stop operation and S5 for forward/reverse command.

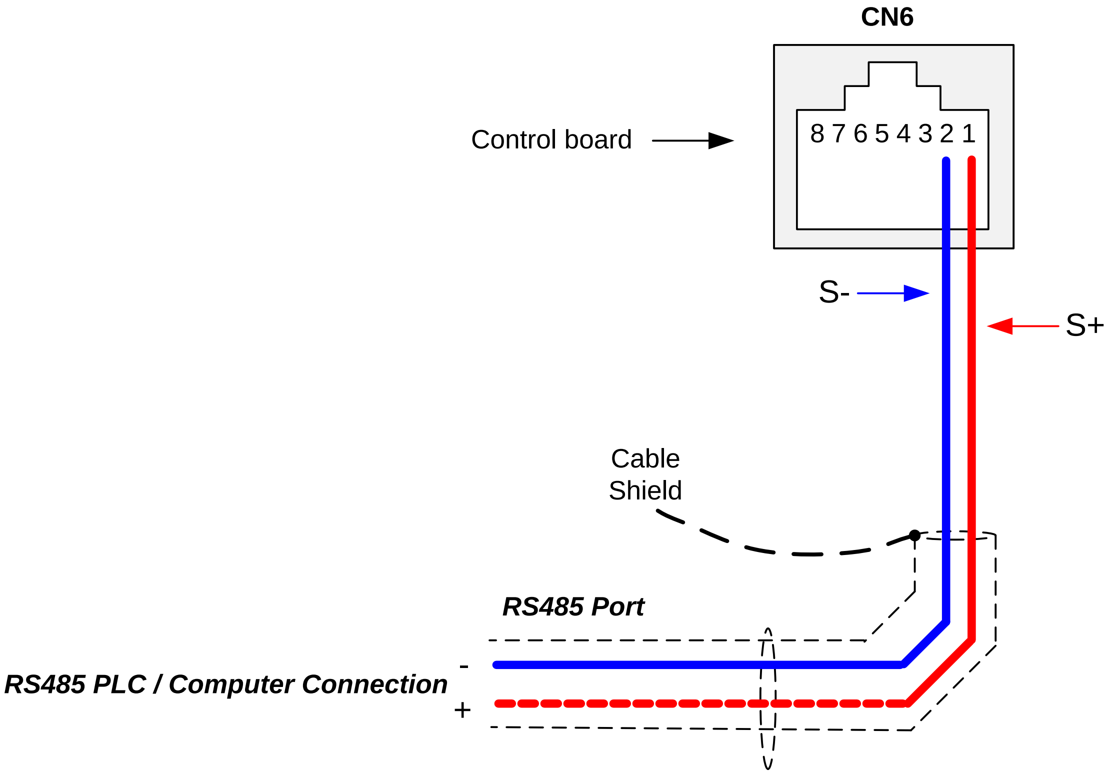
00-01 Operation Method = 1

03-05 Terminal S5 Function = 26



Note: Stop mode selection can be set with parameter 07-09, default is **deceleration to stop**.

7.3 Run/Stop from Serial Communication RS485 (00-02=3)



To control (Run/Stop) the inverter via serial communication parameter 00-02 has be set to either a “3” for communication control.

Default Communication Setting is: Address “1”, 9600 Bits/sec, 1 Start Bit, 1 Stop Bit, and No Parity

The serial communication link function uses RS485 Modbus RTU protocol and allows for:
1) Monitoring (data monitoring, function data check).
2) Frequency setting.
3) Operation command (FWD, REV, and other commands for digital input).
4) Write function data.

Command Register

Inverter Command Register: 2501 (Hexadecimal)

Bit 0: Run Forward

Bit 1: Run Reverse

Bit 2 ~ Bit 15: Refer to the chapter XX of this manual

Examples:

Run Forward Command (Inverter Node Address: 01)

Command String (hexadecimal): 01 06 25 01 00 01 12 C6

Run Reverse Command (Inverter Node Address: 01)

Command String (hexadecimal): 01 06 25 01 00 03 93 07

Stop Command (Inverter Node Address: 01)

Command String (hexadecimal): 01 06 25 01 00 00 D3 06

Note: The last 2 bytes of the command strings consist of a CRC16 checksum, please refer to section 4.5 of the instruction manual for additional information.

8. Motor and Application Specific Settings

It is essential that before running the motor, the motor nameplate data matches the motor data in the inverter.

8.1 Set Motor Nameplate Data (02-01, 02-05)

02-05 Rated power of motor 1

The nominal motor rated capacity is set at the factory. Please verify that the motor name plate data matches the motor rated capacity shown in parameter 02-05. The setting should only be changed when driving a motor with a different capacity.

Range: 0.00 to 600.00 kW (1HP = 0.746 kW)

To set parameter 02-05:

- After power-up press the **DSP/FUN** key
- Select **02 Motor Parameter**
- Press **READ/ ENTER** key
- Select parameter -01 with the **UP/DOWN ▲** and ▼ keys and press the **READ/ ENTER** key.

Default values vary based on the inverter model.

02-01 Rated current of motor 1

The motor rated current is set at the factory based on the inverter model. Enter the motor rated current from the motor nameplate if it does not match the value shown in parameter 02-01.

Setting range: 0.01 to 600.00A

To set parameter 02-01:

- After power-up press the **DSP/FUN** key
- Select **02 Motor Parameter**
- Press **READ/ ENTER** key
- Select parameter -01 with the **UP/DOWN ▲** and ▼ keys and press the **READ/ ENTER** key.

8.2 Acceleration and Deceleration Time (00-14, 00-15)

Acceleration and Deceleration times directly control the system dynamic response. In general, the longer the acceleration and deceleration time, the slower the system response, and the shorter time, the faster the response. An excessive amount of time can result in sluggish system performance while too short of a time may result in system instability.

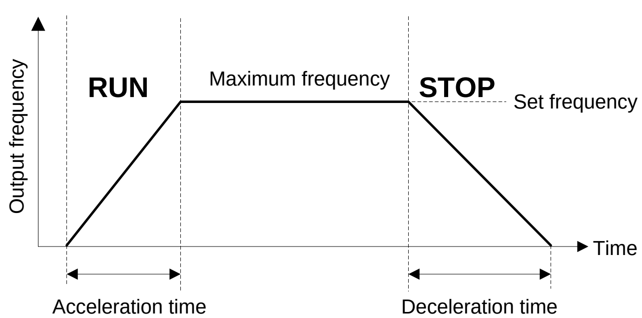
The default values suggested normally result in good system performance for the majority of general purpose applications. If the values need to be adjusted, caution should be exercised, and the changes should be in small increments to avoid system instability.

00-14 Acceleration time 1
00-15 Deceleration time 1

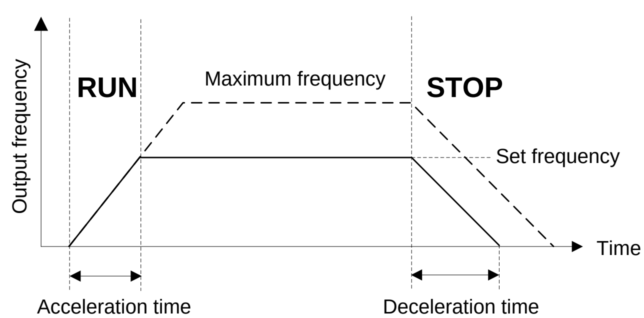
These parameters set the acceleration and deceleration times of the output frequency from 0 to maximum frequency and from maximum frequency to 0.

To set parameter 00-14 or 00-15:
- After power-up press the **DSP/FUN** key
- Select **00 Basic Fun**
- Press **READ/ ENTER** key
- Select parameter -14 or -15 with the **UP/DOWN** ▲ and ▼ keys and press the **READ/ ENTER** key.

Acceleration and deceleration times are represented by the three most significant (high order) digits. Set acceleration and deceleration times with respect to maximum frequency. The relationship between the set frequency value and acceleration/deceleration times is as follows:



Set Frequency = Maximum Frequency



Set Frequency < Maximum Frequency

Note: If the set acceleration and deceleration times are set too low, the torque limiting function or stall prevention function can become activated if the load torque and or inertia are relatively high. This will prolong the acceleration and or deceleration times and not allow the set times to be followed. In this case the acceleration and or the deceleration times should be adjusted.

8.3 Automatic Energy Savings Function (11-19)

In the V/F control mode the automatic energy saving (AES) function automatically adjusts the output voltage and reduces the output current of the inverter to optimize energy savings based on the load.

The output power changes proportional to the motor load. Energy savings is minimal when the load exceeds 70% of the output power and savings become greater when the load decreases.

The parameter of automatic energy saving function has been set at the factory before shipment. In general, it is no need to adjust. If the motor characteristic has significant difference from TECO standard, please refer to the following commands for adjusting parameters:

Enable Automatic Energy Savings Function

To set parameters 11-19 to 11-24:

- After power-up press the **DSP/FUN** key
- Select **11 Auxiliary Function Group**
- Press **READ/ ENTER** key
- Select parameter -19 to -24 with the **UP/DOWN ▲** and **▼** keys and press the **READ/ ENTER** key.

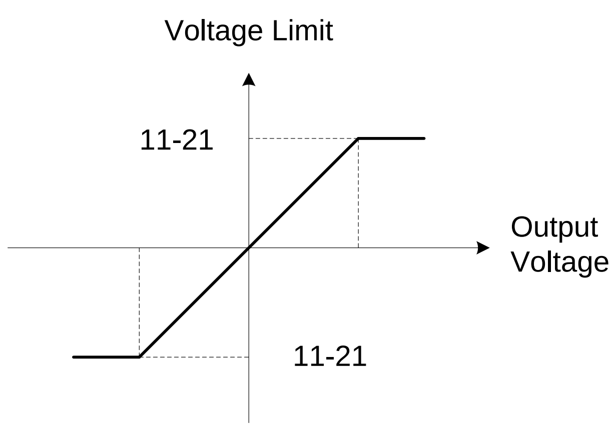
(1) To enable automatic energy saving function set 11-19 to 1.
(2) Filter time of automatic energy saving (11-20)
(3) Commissioning parameter of energy saving (11-21 to 11-22)

In AES mode, the optimum voltage value is calculated based on the load power requirement but is also affected by motor temperature and motor characteristic.

In certain applications the optimum AES voltage needs to be adjusted in order to achieve optimum energy savings. Use the following AES parameters for manual adjustment:

11-21: Voltage limit value of AES commissioning operation

Sets the voltage upper limit during automatic energy saving. 100% corresponds to 230V or 460V depending on the inverter class used.



Voltage limit value of commissioning operation

11-22: Adjustment time of automatic energy saving
Sets sample time constant for measuring output power.
Reduce the value of 11-22 to increase response when the load changes.
Note: If the value of 11-22 is too low and the load is reduced the motor may become unstable.

11-23: Detection level of automatic energy saving
Sets the automatic energy saving output power detection level.

11-24: Coefficient of automatic energy saving
The coefficient is used to tune the automatic energy saving. Adjust the coefficient while running the inverter on light load while monitoring the output power. A lower setting means lower output voltage.

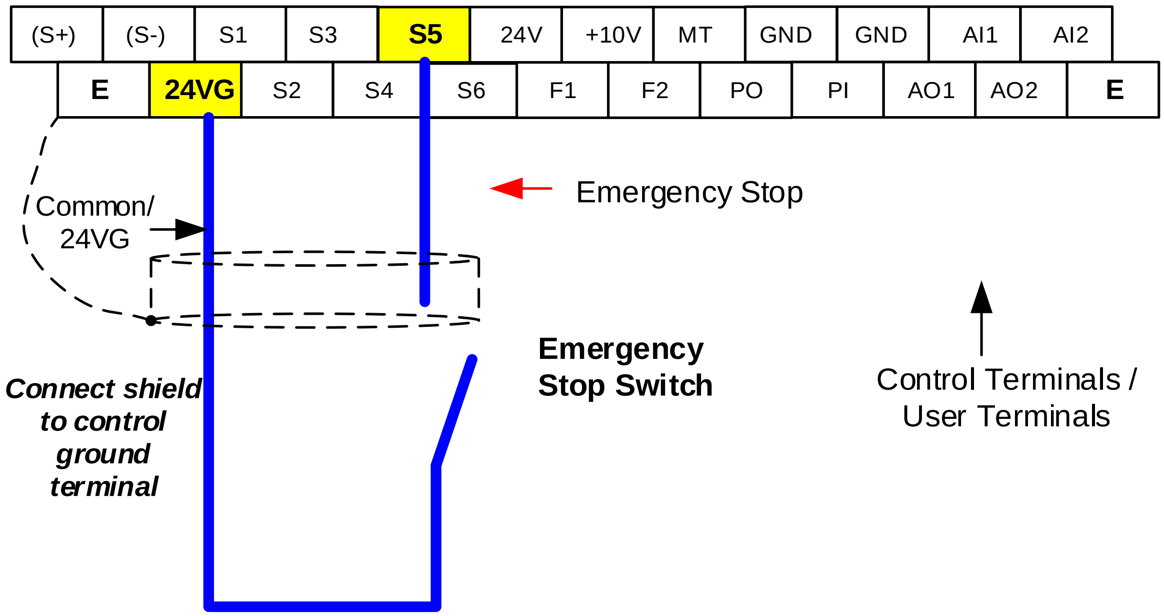
Notes:
- If the coefficient is set to low the motor may stall.
- Coefficient default value is based on the inverter rating. Set parameter 13-00. If the motor power does not match the inverter rating.

8.4 Emergency Stop

The emergency stop time is used in combination with multi-function digital input function #14 (Emergency stop). When emergency stop input is activated the inverter will decelerate to a stop using the Emergency stop time (00-26) and display the [EM STOP] condition on the keypad.

Note: To cancel the emergency stop condition the run command has to be removed and emergency stop input deactivated.

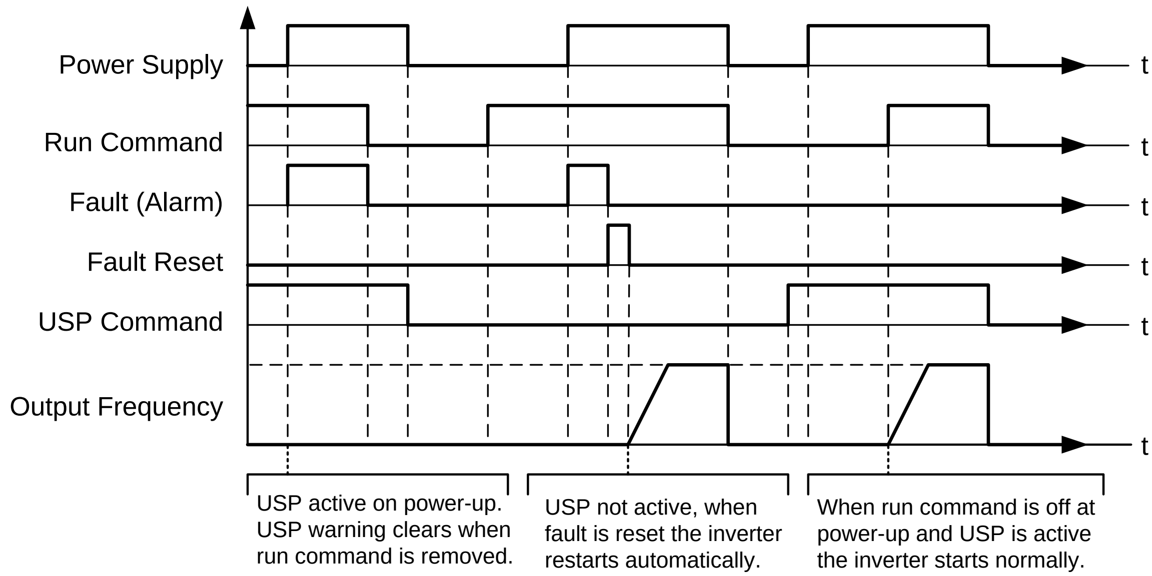
Example: Emergency Stop Switch set for input terminal S5 (03-04 = 14).



00-26	Emergency stop time
Range	0.0~6000.0 Sec

8.5 Direct / Unattended Startup

The unattended startup function prevents the inverter from starting automatically when a run command is present at time of power-up. To use USP command set one of the multi-function digital input functions to #50 (USP Startup).



Unattended Startup Protection

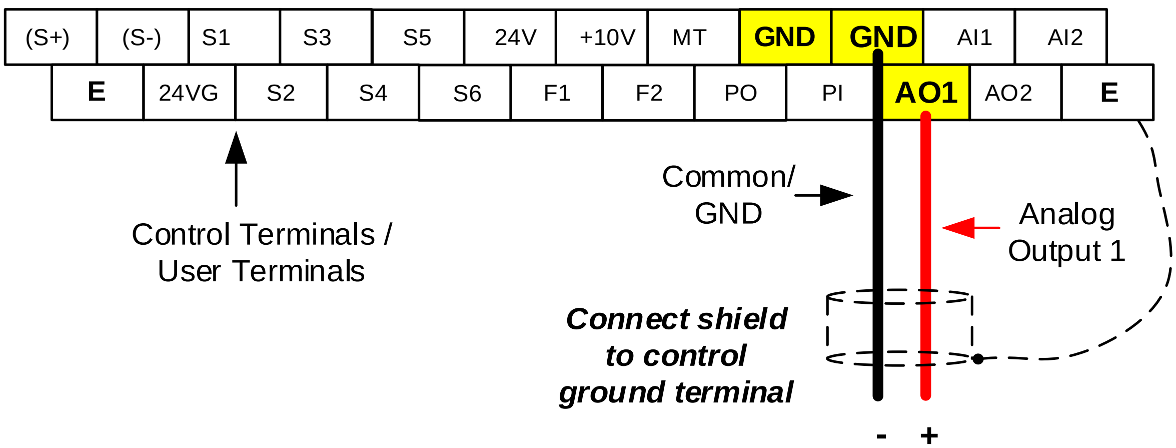
8.6 Analog Output Setup

Signal: Use parameter 04-11 to select the analog output signal for AO1 and parameter 04-16 to select the analog output signal for AO2.

Gain: Use parameter 04-12 to adjust the gain for AO1 and parameter 04-17 to adjust the gain for AO2.
Adjust the gain so that the analog output (10V/20mA) matches 100% of the selected analog output signal (04-11 for AO1 and 04-16 for AO2).

Bias: Use parameter 04-13 to adjust the bias for AO1 and parameter 04-18 to adjust the bias for AO2.
Adjust the bias so that the analog output (0V/4mA) matches 0% of the selected analog output signal (04-11 for AO1 and 04-16 for AO2).

Example: Analog Output 1 Wiring



04-11	AO1 function Setting	
Range	**0:** Output frequency **1:** Frequency command **2:** Output voltage **3:** DC voltage **4:** Output current **5:** Output power **6:** Motor speed **7:** Output power factor **8:** AI1 input **9:** AI2 input **10:** Torque command **11:** q -axis current **12:** d-axis current **13:** Speed deviation	**14:** Reserved **15:** ASR output **16:** Reserved **17:** q-axis voltage **18:** d-axis voltage **19:** Reserved **20:** Reserved **21:** PID input **22:** PID output **23:** PID target value **24:** PID feedback value **25:** Output frequency of the soft starter **26:** Reserved **27:** Reserved

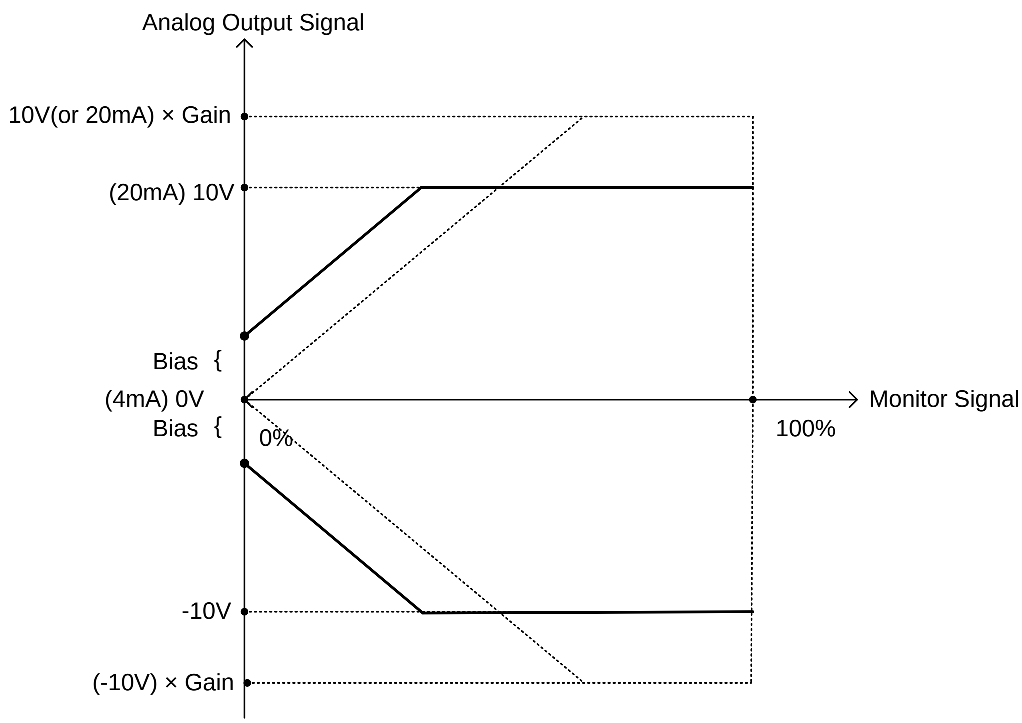
04-12	AO1 gain value
Range	0.0~1000.0%

04-13	AO1 bias-voltage value
Range	-100.0~100.0%

04-16	AO2 function Setting
Range	See parameter 04-11

04-17	AO2 gain value
Range	0.0~1000.0%

04-18	AO2 bias-voltage value
Range	-100.0~100.0%



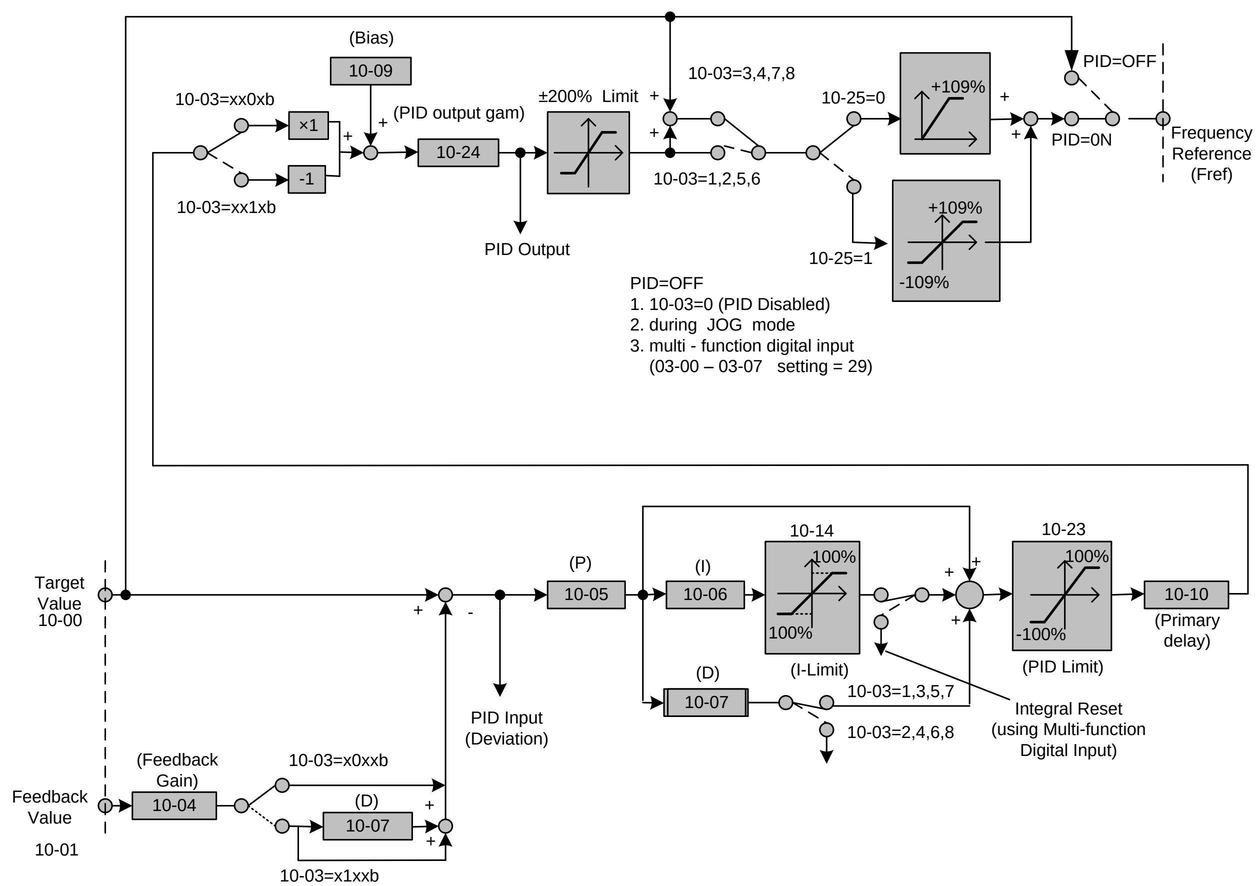
Analog output level adjustment

9. Using PID Control for Constant Flow / Pressure Applications

9.1 What is PID Control?

The PID function in the inverter can be used to maintain a constant process variable such as pressure, flow, temperature by regulating the output frequency (motor speed). A feedback device (transducer) signal is used to compare the actual process variable to a specified setpoint. The difference between the set-point and feedback signal is called the error signal.

The PID control tries to minimize this error to maintain a constant process variable by regulating the output frequency (motor speed).



The amplitude of the error can be adjusted with the Proportional Gain parameter 10-05 and is directly related to the output of the PID controller, so the larger gain the larger the output correction.

Example 1:	**Example 2:**
Gain = 1.0	Gain = 2.0
Set-Point = 80%	Set-Point = 80%
Feedback = 78%	Feedback = 78%
Error = Set-point - Feedback = 2%	Error = Set-point - Feedback = 2%
Control Error = Gain x Error = 2%	Control Error = Gain x Error = 4%

Please note that an excessive gain can make the system unstable and oscillation may occur.

The response time of the system can be adjusted with the Integral Gain set by parameter 10-06. Increasing the Integral Time will make the system less responsive and decreasing the Integral Gain Time will increase response but may result in instability of the total system.

Slowing the system down too much may be unsatisfactory for the process. The end result is that these two parameters in conjunction with the acceleration (00-14) and deceleration (00-15) times are adjusted to achieve optimum performance for a particular application.

For typical fan and pump applications a Proportional Gain (10-05) of 2.0 and an Integral Time (10-06) of 5.0 sec is recommended.

10-03 PID control mode

PID control can be enabled by setting parameter 10-03 to 'xxx1b'

10-03	PID control mode
Range	**xxx0b:** PID disable **xxx1b:** PID enable **xx0xb:** PID positive characteristic **xx1xb:** PID negative characteristic **x0xxb:** PID error value of D control **x1xxb:** PID feedback value of D control **0xxxb:** PID output **1xxxb:** PID output +target value

Commonly used PID control modes

0001b: Forward operation: PID operation enabled, motor speeds increases when feedback signal is smaller than set-point (most fan and pump applications)

0011b: Reverse operation: PID operation enabled, motor slows down when feedback signal is smaller than set-point (e.g. level control applications)

To set parameter 10-03:
- After power-up press the **DSP/FUN** key
- Select **10 PID Control**
- Press **READ/ ENTER** key
- Select parameter -03 with the **UP/DOWN ▲** and **▼** keys and press the **READ/ ENTER** key.

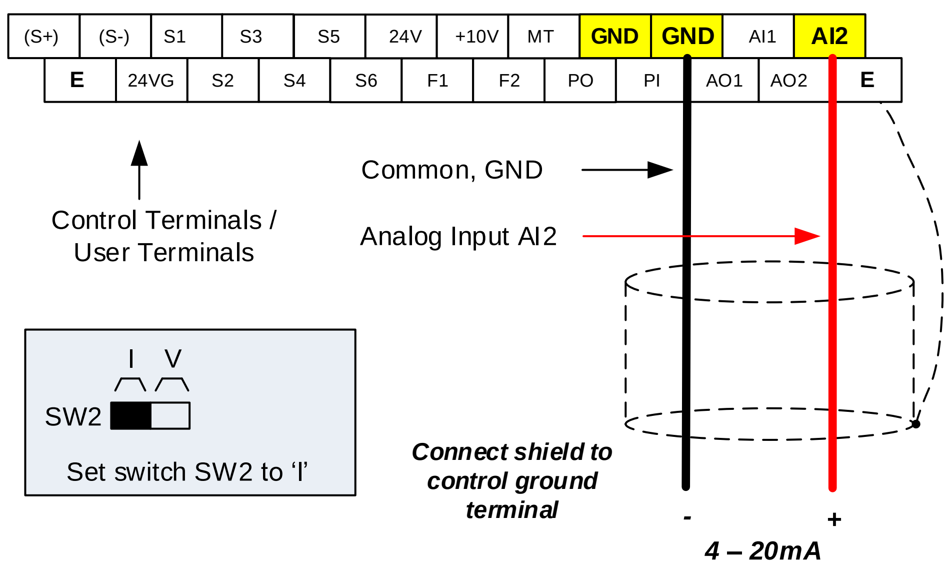
Important: To use the PID function parameter 00-05 (Main Frequency Command Source Selection) has to be set to 5 for PID reference.

9.2 Connect Transducer Feedback Signal (10-01)

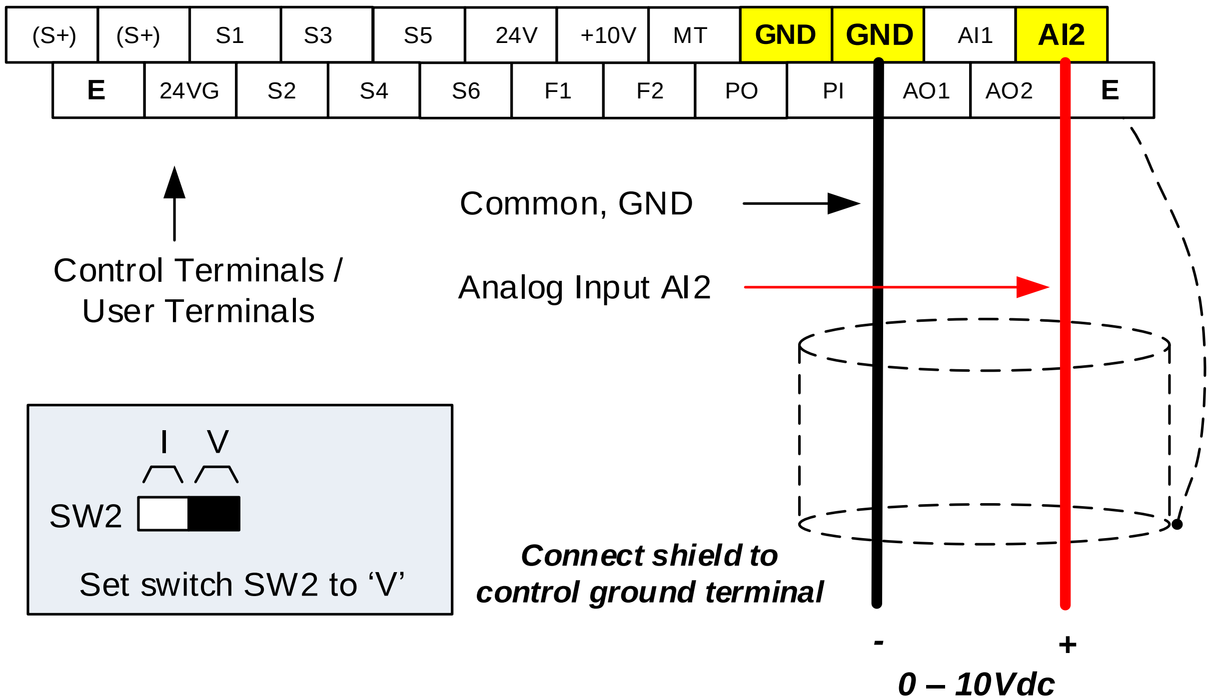
The PID function in the inverter

Depending on the type of feedback transducer used, the inverter can be setup for either 0-10V or a 4-20mA feedback transducer.

Feedback Signal 4 – 20mA (10-01 = 2) – SW2 = I



Feedback Signal 0 – 10V (10-01 = 1) – SW2 = V



9.3 Engineering Units

The PID setpoint scaling can be selected with parameter 16-03 and 16-04.

Example: 0 – 200.0 PSI Setpoint, set 16-03 to 12000 (1 decimal, range 0 – 200) and 16-04 to 2 (PSI).

9.4 Sleep / Wakeup Function

The PID Sleep function can be used to prevent a system from running at low speeds and is frequently used in pumping application. The PID Sleep function is turned on by parameter 10-29 set to 1. The inverter output turns off when the PID output falls below the PID sleep level (10-17) for the time specified in the PID sleep delay time parameter (10-18).

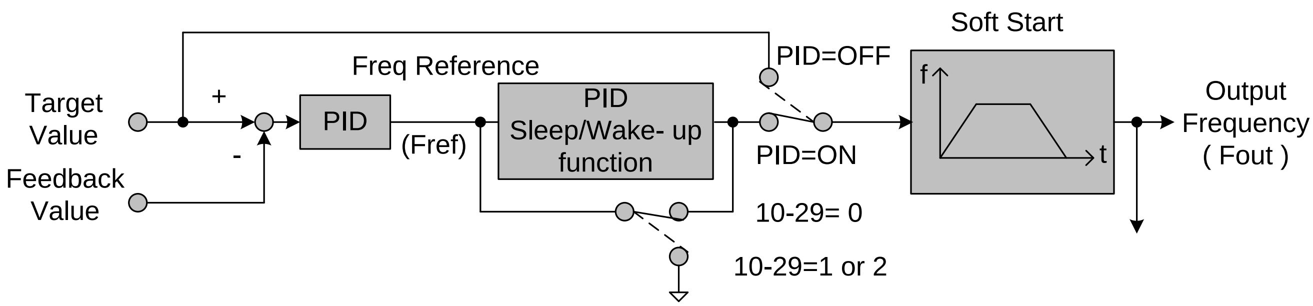
The inverter wakes up from a sleep condition when the PID output (Reference frequency) rises above the PID wake-up frequency (10-19) for the time specified in the PID wake-up delay time (10-20).

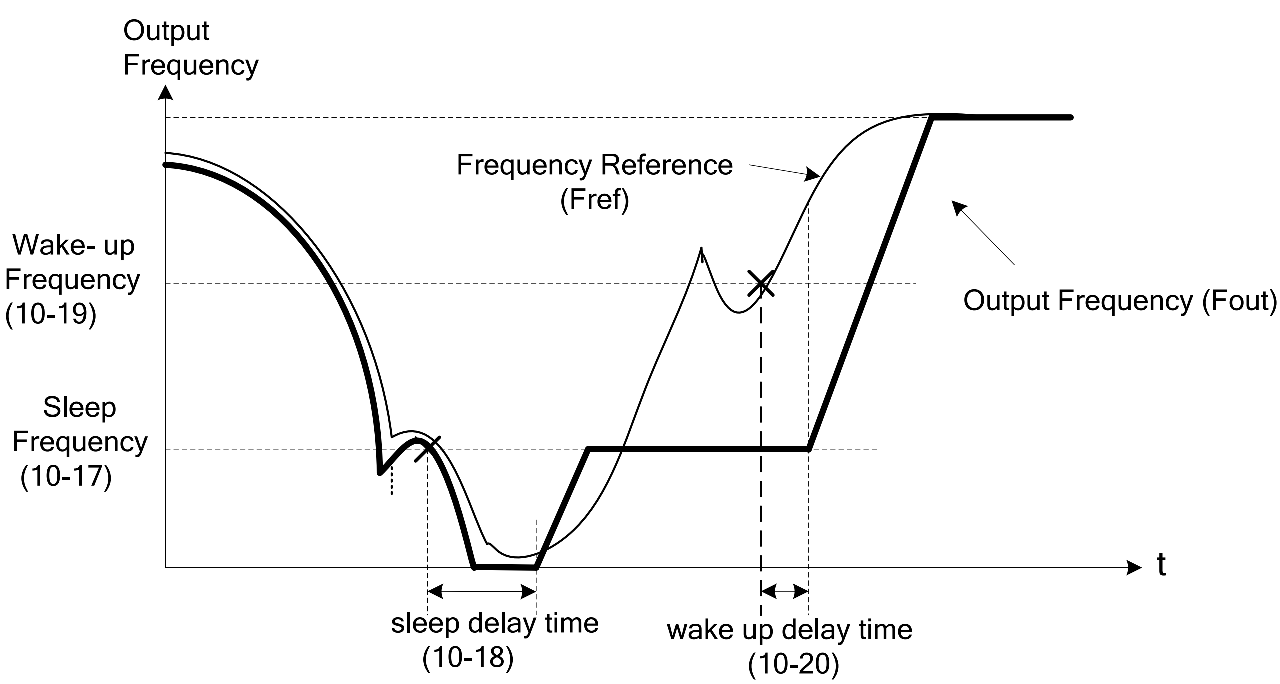
10-29 =0: PID Sleep function is disabled.

10-29 =1: PID sleep operation is based on parameters of 10-17 and 10-18.

10-29 =2: PID sleep mode is enabled by multi-function digital input

Refer to figure 4.3.74 (a) and (b) for PID sleep / wakeup operation.





PID Sleep Function

10. Troubleshooting and Fault Diagnostics

10.1 General

Inverter fault detection and early warning / self-diagnosis function. When the inverter detects a fault, a fault message is displayed on the keypad. The fault contact output energizes and the motor will coast to stop (The stop method can be selected for specific faults).

When the inverter detects a warning / self-diagnostics error, the digital operator will display a warning or self-diagnostic code, the fault output does not energize in this case. Once the warning is removed, the system will automatically return to its original state.

10.2 Fault Detection Function

When a fault occurs, please refer to Table 10.2.1 for possible causes and take appropriate measures.

Use one of the following methods to restart:
1. Set one of multi-function digital input terminals (03-00, 03-07) to 17 (Fault reset); activate input
2. Press the reset button on the keypad.
3. Power down inverter wait until keypad goes blank and power-up the inverter again.

When a fault occurs, the fault message is stored in the fault history (see group 12 parameters).

Table 10.2.1 Fault information and possible solutions

LED display	Description	Cause	Possible solutions
OC **over current** 	The inverter output current exceeds the overcurrent level (200% of the inverter rated current).	• Acceleration / Deceleration time is too short. • Contactor at the inverter output side. • A special motor or applicable capacity is greater than the inverter rated value. • Short circuit or ground fault.	• Extend acceleration / deceleration time. • Check the motor wiring. • Disconnect motor and try running inverter.
SC **short circuit** 	Inverter output short circuit or ground fault.	• Short circuit or ground fault (08-23 = 1). • Motor damaged (insulation). • Wire damage or deterioration.	• Check the motor wiring. • Disconnect motor and try running inverter.
GF **Ground fault** 	The current to ground exceeds 50% of the inverter rated output current (08-23 = 1, GF function is enabled).	• Motor damaged (insulation). • Wire damage or deterioration. • Inverter DCCT sensors defect.	• Replace motor. • Check the motor wiring. • Disconnect motor and try running inverter. • Check resistance between cables and ground. • Reduce carrier frequency.

LED display	Description	Cause	Possible solutions
OV Over voltage	DC bus voltage exceeds the OV detection level: 410Vdc: 230V class 20Vdc: 460V class (For 440V class, if input voltage 01-14 is set lower than 460V, the OV detection value will is decreased to 700Vdc).	• Deceleration time set too short, resulting in regenerative energy flowing back from motor to the inverter. • The inverter input voltage is too high. • Use of power factor correction capacitors. • Excessive braking load. • Braking transistor or resistor defective. • Speed search parameters set incorrectly.	• Increase deceleration time • Reduce input voltage to comply with the input voltage requirements or install an AC line reactor to lower the input voltage. • Remove the power factor correction capacitor. • Use dynamic braking unit. • Replace braking transistor or resistor. • Adjust speed search parameters.
UV Under voltage	DC bus voltage is lower than the UV detection level or the pre-charge contactor is not active while the inverter is running. 190Vdc: 230V class; 380Vdc: 460V class (The detection value can be adjusted by 07-13).	• The input voltage is too low. • Input phase loss. • Acceleration time set too short. • Input voltage fluctuation. • Pre-charge contactor damaged. • DC bus voltage feedback signal value not incorrect.	• Check the input voltage. • Check input wiring. • Increase acceleration time. • Check power source • Replace pre-charge contactor • Replace control board or complete inverter.
IPL input phase loss	Phase loss at the input side of the inverter or input voltage imbalance, active when 08-09 = 1 (enabled).	• Wiring loose in inverter input terminal. • Momentary power loss. • Input voltage imbalance.	• Check input wiring / faster screws. • Check power supply.
OPL output phase loss	Phase loss at the output side of the inverter, active when 08-10 = 1 (enabled).	• Wiring loose in inverter output terminal. • Motor rated current is less than 10% of the inverter rated current.	• Check output wiring / faster screws. • Check motor & inverter rating.
OH1 Heatsink overheat	The temperature of the heat sink is too high. Note: when OH1 fault occurs three times within five minutes, it is required to wait 10 minutes before resetting the fault.	• Ambient temperature too high. • cooling fan failed • Carrier frequency set too high. • Load too heavy.	• Install fan or AC to cool surroundings. • Replace cooling fan. • Reduce carrier frequency. • Reduce load / Measure output current
OL1 Motor overload	Internal motor overload protection tripped, active when protection curve 08-05 = xxx1.	• Voltage setting V/F mode too high, resulting in over-excitation of the motor. • Motor rated current (02-01) set incorrectly. • Load too heavy.	• Check V/f curve. • Check motor rated current • Check and reduce motor load, check and operation duty cycle.

LED display	Description	Cause	Possible solutions
OL2 Inverter overload OL2	Inverter thermal overload protection tripped. If an inverter overload occurs 4 times in five minutes, it is required to wait 4 minutes before resetting the fault.	• Voltage setting V/F mode too high, resulting in over-excitation of the motor. • Inverter rating too small. • Load too heavy.	• Check V/f curve. • Replace inverter with larger rating. • Check and reduce motor load, check and operation duty cycle.
OT Over torque detection Ot	Inverter output torque is higher than 08-15 (over torque detection level) for the time specified in 08-16. Parameter 08-14 = 0 to activate.	• Load too heavy.	• Check over torque detection parameters (08-15 / 08-16). • Check and reduce motor load, check and operation duty cycle.
UT Under torque detection ut	Inverter output torque is lower than 08-19 (under torque detection level) for the time specified in 08-20. Parameter 08-18 = 0 to activate.	• Sudden drop in load. • Belt break.	• Check under torque detection parameters (08-19 / 08-20). • Check load / application.
CE communication error CE	No Modbus communication received in for the time specified in 09-06 (communication error detection time). Active when 09-07(= 0 to 2).	• Connection lost or wire broken. • Host stopped communicating.	• Check connection • Check host computer / software.
FB PID feedback loss Fb	PID feedback signal falls below level specified in 10-12 (PID feedback loss detection level) for the time specified in 10-13 (Feedback loss detection time). Active when parameter (10-11 = 2).	• Feedback signal wire broken • Feedback sensor broken.	• Check feedback wiring • Replace feedback sensor.
STO Safety switch StO	Inverter safety switches open.	• Terminal board Input F1 and F2 are not connected • 08-30 is set to 1: Coast to stop and digital input (58) is active.	• Check F1 and F2 connection

LED display	Description	Possible causes	Corrective action
DEV Speed deviation SS1	Inverter safety switches open.	• When 08-30 is set to 0: Deceleration to stop, and digital input (58) is active.	• Check if digital terminal (58) is active.
EF1 External fault (S1) EF1	External fault (Terminal S1) Active when 03-00= 25, and Inverter external fault selection 08-24=0 or 1.	• Multifunction digital input external fault active.	• Multi-function input function set incorrectly. • Check wiring
EF2 External fault (S2) EF2	External fault (Terminal S2) Active when 03-01= 25, and Inverter external fault selection 08-24=0 or 1.		
EF3 External fault (S3) EF3	External fault (Terminal S3) Active when 03-02= 25, and Inverter external fault selection 08-24=0 or 1.		
EF4 External fault (S4) EF4	External fault (Terminal S4) Active when 03-03= 25, and Inverter external fault selection 08-24=0 or 1.		
EF5 External fault (S5) EF5	External fault (Terminal S5) Active when 03-04= 25, and Inverter external fault selection 08-24=0 or 1.		
EF6 External fault (S6) EF6	External fault (Terminal S6) Active when 03-05= 25, and Inverter external fault selection 08-24=0 or 1.		
CF07 Motor control fault CF07	Motor control fault	• SLV mode unable to run motor.	• Perform rotational or stationary auto-tune • Increase minimum output frequency (01-08)
FU fuse open Fu	DC bus fuse blown DC fuse (Models 230V 50HP and above, 460V 75HP and above) open circuit.	• IGBT damaged. • Short circuit output terminals.	• Check IGBTs • Check for short circuit at inverter output. • Replace inverter.

LED display	Description	Possible causes	Corrective action
LOPBT **Low flow fault** LOPbt	Low flow fault	• The feedback signal is disconnected. • Feedback value is lower than minimum flow limit.	• Check feedback signal connection. • Check if feedback value is lower than minimum flow limit (23-51).
HIPBT High flow fault HI Pbt	High flow fault	• Feedback value is greater than maximum flow value.	• Check feedback value • Check if feedback value is lower than maximum flow limit (23-48).
LPBFT Low pressure fault LPbFt	Low pressure fault	• The feedback signal is not connected. • Feedback value is lower than minimum feedback value.	• Check feedback signal connection. • Check if feedback value is lower than minimum limit (23-15).
OPBFT High pressure fault OPbFt	High pressure fault	• Feedback value is greater than maximum feedback value.	• Check feedback signal connection. • Check if feedback value is greater than maximum limit (23-12).
LSCFT Low suction fault LSCFt	Low suction fault	• Low water flow or not enough suction • Difference between setpoint and feedback value is too high. • Output current is too lowl.	• Check water flow • Check feedback value • Check output current
CF00 Operator Communication Error LCD display only*	LCD keypad data communication fault	• No communication between LCD keypad and inverter for more than 5 seconds after power up.	• Disconnect the keypad and then reconnect. • Replace the control board • Check keypad cable
CF01 Operator Communication Error 2 LCD display only*	LCD keypad data communication fault	• Communication errors between LCD keypad and inverter for more than 2 seconds.	• Disconnect the keypad and then reconnect. • Replace the control board • Check keypad cable
CT Fault CtEr	Input voltage fault	• Abnormal input voltage, too much noise or malfunctioning control board.	• Check input voltage signal and the voltage on the control board.
Double Communication Error CF20	Both Profibus and Modbus communication selected	• Two communication protocols are active simultaneously.	• Select only one communication protocol.

10.3 Warning / Self-diagnosis Detection Function

When the inverter detects a warning, the keypad displays a warning code (flash).
Note: The fault contact output does not energize on a warning and the inverter continues operation. When the warning is no longer active the keypad will return to its original state.

When the inverter detected a programming error (for example two parameters contradict each other of are set to an invalid setting), the keypad displays a self-diagnostics code.

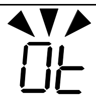
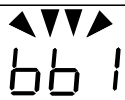
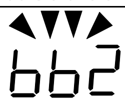
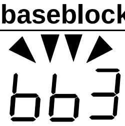
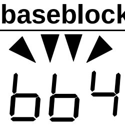
Note: The fault contact output does not energize on a self-diagnostics error. While a self-diagnostics code is active the inverter does not accept a run command until the programming error is corrected.

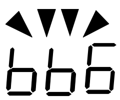
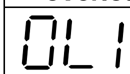
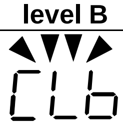
Note: When a warning or self- diagnostic error is active the warning or error code will flash on the keypad. When the RESET key is pressed, the warning message (flash) disappears and returns after 5 sec. If the warning or self-diagnostic error still exists.

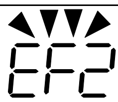
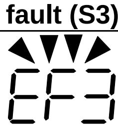
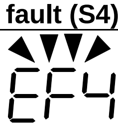
Refer to Table 10.3.1 for and overview, cause and corrective action for inverter warnings and self-diagnostic errors.

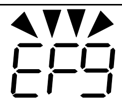
Table 10.3.1 warning / self-diagnosis and corrective actions

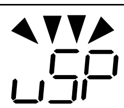
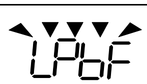
LED display	Description	Possible causes	Corrective action
OV (flash) Over voltage 	DC bus voltage exceeds the OV detection level: 410Vdc: 230V class 820Vdc: 460V class (for 440V class, if input voltage 01-14 is set lower than 460V, the OV detection value will is decreased to 700Vdc)	• Deceleration time set too short, resulting in regenerative energy flowing back from motor to the inverter. • The inverter input voltage is too high. • Use of power factor correction capacitors. • Excessive braking load. • Braking transistor or resistor defective. • Speed search parameters set incorrectly.	• Increase deceleration time • Reduce input voltage to comply with the input voltage requirements or install an AC line reactor to lower the input voltage. • Remove the power factor correction capacitor. • Use dynamic braking unit. • Replace braking transistor or resistor. • Adjust speed search parameters.
UV (flash) under voltage 	DC bus voltage is lower than the UV detection level or the pre-charge contactor is not active while the inverter is running. 190Vdc: 230V class; 380Vdc: 460V class (the detection value can be adjusted by 07-13)	• The input voltage is too low. • Input phase loss. • Acceleration time set too short. • Input voltage fluctuation. • Pre-charge contactor damaged. • DC bus voltage feedback signal value not incorrect.	• Check the input voltage. • Check input wiring. • Increase acceleration time. • Check power source • Replace pre-charge contactor • Replace control board or complete inverter.
OH2 (flash) Inverter over heating warning	Inverter overheat warning Multi-function digital input set to 32. (Terminal S1 ~ S8) Active when 03-00 ~ 03-07 = 31).	• Multifunction digital input overheat warning active.	• Multi-function input function set incorrectly. • Check wiring

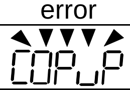
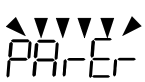
LED display	Description	Possible causes	Corrective action
			
OT (flash) over torque detection 	Inverter output torque is higher than 08-15 (over torque detection level) for the time specified in 08-16. Parameter 08-14 = 0 to activate.	• Load too heavy.	• Check over torque detection parameters (08-15 / 08-16). • Check and reduce motor load, check and operation duty cycle.
UT (flash) under torque detection 	Inverter output torque is lower than 08-19 (under torque detection level) for the time specified in 08-20. Parameter 08-18 = 0 to activate.	• Sudden drop in load. • Belt break.	• Check under torque detection parameters (08-19 / 08-20). • Check load / application.
bb1 (flash) External baseblock 	External base block (Terminal S1)	• Multifunction digital input external baseblock active.	• Multi-function input function set incorrectly. • Check wiring
bb2 (flash) External baseblock 	External base block (Terminal S2)		
Bb3 (flash) External baseblock 	External base block (Terminal S3)		
Bb4 (flash) External baseblock 	External base block (Terminal S4)		

LED display	Description	Possible causes	Corrective action
bb5 (flash) External baseblock 	External base block (Terminal S5)	• Multifunction digital input external baseblock active.	• Multi-function input function set incorrectly. • Check wiring
bb6 (flash) External baseblock 	External base block (Terminal S6)		
OL1 Motor overload 	Internal motor overload protection tripped, active when protection curve 08-05 = xxx1.	• Voltage setting V/F mode too high, resulting in over-excitation of the motor. • Motor rated current (02-01) set incorrectly. • Load too heavy.	• Check V/f curve. • Check motor rated current • Check and reduce motor load, check and operation duty cycle.
OL2 Inverter overload 	Inverter thermal overload protection tripped. If an inverter overload occurs 4 times in five minutes, it is required to wait 4 minutes before resetting the fault.	• Voltage setting V/F mode too high, resulting in over-excitation of the motor. • Inverter rating too small. • Load too heavy.	• Check V/f curve. • Replace inverter with larger rating. • Check and reduce motor load, check and operation duty cycle
CE (flash) communication error 	No Modbus communication received for 2 sec. Active when 09-07=3.	• Connection lost or wire broken. • Host stopped communicating.	• Check connection • Check host computer / software.
CLB over current protection level B 	Inverter current reaches the current protection level B.	• Inverter current too high. • Load too heavy.	• Check load and duty cycle operation.

LED display	Description	Possible causes	Corrective action
Retry (flash) retry 	Automatic reset activated, warning is displayed until restart delay time set (07-01) expires.	• Parameter 07-01 set to a value greater than 0. • Parameter 07-02 set to a value greater than 0.	• Warning disappears after automatic reset.
F1 (flash) External fault (S1) 	External fault (Terminal S1) Active when 03-00= 25, and Inverter external fault selection 08-24=2.	• Multifunction digital input external fault active and parameter 08-24 = 2 for operation to continue.	• Multi-function input function set incorrectly. • Check wiring • Multi-function input function set incorrectly. • Check wiring
EF2 (flash) External fault (S2) 	External fault (Terminal S2) Active when 03-01= 25, and Inverter external fault selection 08-24=2.		
EF3 (flash) External fault (S3) 	External fault (Terminal S3) Active when 03-02= 25, and Inverter external fault selection 08-24=2.		
EF4 (flash) External fault (S4) 	External fault (Terminal S4) Active when 03-03= 25, and Inverter external fault selection 08-24=2.		
EF5 (flash) External fault (S5) 	External fault (Terminal S5) Active when 03-04= 25, and Inverter external fault selection 08-24=2.		
EF6 (flash) External fault (S6) 	External fault (Terminal S6) Active when 03-05= 25, and Inverter external fault selection 08-24=2.		

LED display	Description	Possible causes	Corrective action
EF9 (flash) error of forward/reversal rotation 	Forward run and reverse run are active within 0.5 sec of each other. Stop method set by parameter 07-09.	● Forward run and reverse run active (see 2-wire control).	● Check run command wiring
SE01 Rang setting error 	Parameter setting falls outside the allowed range.	● Some parameter ranges are determined by other inverter parameters which could cause an out of range warning when the dependency parameter is adjusted. Example: 02-00 > 02-01, 02-20 > 02-21, 00-12 > 00-13 etc…).	● Check parameter setting.
SE02 Digital input terminal error 	Multi-function input setting error.	● Multi-function digital input terminals (03-00 to 03-07) are set to the same function (not including ext. fault and not used.) or ①UP/DOWN commands are not set at the same time(they must be used together). ②UP/DOWN commands (08 and 09) and ACC/DEC commands (11) are set at the same time. ③Speed search 1(19，maximum frequency) and Speed search 2 (34，from the set frequency）are set at the same time.	● Check multi-function input setting.
SE03 V/f curve error 	V/f curve setting error.	● V/F curve setting error. ① 01-02 > 01-12 > 01-06 >01-08; ● (Fmax) (Fbase) (Fmid1) (Fmin) ②01-16 > 01-24 > 01-20 > 01-22; ● (Fmax2) (Fbase2)(Fmid1) (Fmin2)	● Check V/F parameters
SE05 PID selection error 	PID selection error.	● 10-00 and 10-01are set to the same analog input 1 (AI1) or 2 (AI2)	● Check parameters 10-00 and 10-01.

LED display	Description	Possible causes	Corrective action
HPErr **Model selection error** 	Inverter capacity setting error: Inverter capacity setting 13-00 does not match the rated voltage.	• Inverter capacity setting does not match voltage class (13-00).	• Check inverter capacity setting 13-00.
SE09 **PI setting error** 	Inverter PI setting error	• Inverter pulse input selection (03-30) selection conflicts with PID source (10-00 and 10-01).	• Check pulse input selection (03-30) and PID source (10-00 and 10-01).
FB **(flash)** **PID feedback breaking** 	PID feedback signal falls below level specified in 10-12 (PID feedback loss detection level) for the time specified in 10-13 (Feedback loss detection time). Active when parameter (10-11 = 1).	• Feedback signal wire broken • Feedback sensor broken.	• Check feedback wiring • Replace feedback sensor.
USP **(flash)** **Unattended Start Protection** 	Unattended Start Protection (USP) is enabled (enabled at power-up.)	• USP at power-up (activated by multi-function digital input) is enabled. The inverter will not accept a run command. • While the warning is active the inverter does not accept a run command. (See parameter 03-00 - 03-08 = 50).	• Remove run command or reset inverter via multi-function digital input (03-00 to 03-07 = 17) or use the RESET key on the keypad to reset inverter. • Activate USP input and re-apply the power.
LFPB **Low flow error** 	Low flow error	• The feedback signal is not connected. • Due to HVAC feedback value is lower than limit of minimum flow.	• Check feedback signal is correct and with right connection. • Check if feedback value is lower than limit of minimum flow.
HFPB High flow error 	High flow error	• Due to HVAC feedback value is lower than limit of maximum flow.	• Check feedback signal is correct. • Check if feedback value is lower than limit of maximum flow.
LPBFT Low pressure error 	Low pressure error	• The feedback signal is not connected. • Due to feedback value of pump pressure is lower than limit of minimum flow.	• Check feedback signal is correct and with connection. • Check if feedback value of pressure is lower than limit of minimum pressure.

LED display	Description	Possible causes	Corrective action
OPBFT **High pressure error** 	High pressure error	• Due to feedback value of pump pressure is lower than limit of maximum flow.	• Check feedback signal is correct. • Check if feedback value of pressure is lower than limit of maximum pressure.
LSCFT Low suction error 	Inadequate suction error	• Insufficient water of supply tank leads to insufficient suction. • PID difference is higher than its level or current is lower than output current level.	• Check if water of supply tank is enough, and water supply is regular. • Check PID difference is higher than its level or current is lower than output current level
FIRE **Fire override mode** 	Fire override mode	• Fire override mode is active	• None • (Fire override mode is not a kind of warning).
SE10 **PUMP/HVAC Setting error** 	PUMP/HVAC settings of inverter error	• PUMP selection of inverter (23-02)> (23-03). • HVAC selection of inverter (23-46)> (23-47).	• Check pump selection of inverter (23-02) and (23-03) settings. • Check HVAC selection of inverter (23-02) and (23-03) settings.
COPUP PUMP communication breaking error 	Breaking error of multiple pumps communication	• Communication breaking or disconnection of pump cascade control.	• Check if it has setting issue or is not properly connected.
Parameter Setting Error 	Parameter setting error	• Error of Parameter setting occurs.	• Refer to the instruction manual or this parameter is selected to be disabled.
Warning of Direct Start	When 07-04 is set to 1, the inverter cannot start directly but displays the warning signal.	• Set the digital input terminal (S1~S6) to run and simultaneously set 07-04=1.	• Check the digital input terminal and disconnect it. Then reconnect the DI terminal after the setting delay time (07-05) ends.

10.4 Auto-tuning Error

When a fault occurs during auto-tuning of a standard AC motor, the display will show the “AtErr” fault and the motor stops. The fault information is displayed in parameter 17-11.

Note: The fault contact output does not energize with an auto-tuning fault. Refer to Table 10.4.1, for fault information during tuning, cause and corrective action.

Table 10.4.1 Auto-tuning fault and corrective actions

<table>
<tr><th>Error</th><th>Description</th><th>Cause</th><th>Corrective action</th></tr>
<tr><td>01</td><td>Motor data input error.</td><td>• Motor Input data error during auto-tuning.
• Inverter output current does not match motor rated current.</td><td>• Check the motor tuning data (17-00 to 17-09).
• Check inverter capacity</td></tr>
<tr><td>02</td><td>Motor lead to lead resistance R1 tuning error.</td><td rowspan="5">• Auto-tuning is not completed within the specified time
• Auto-tuning results fall outside parameter setting range.
• Motor rated current exceeded.
• Motor was disconnected.</td><td rowspan="5">• Check the motor tuning data (17-00 to 17-09).
• Check motor connection.
• Disconnect motor load.
• Check inverter current detection circuit and DCCTs.
• Check motor installation.</td></tr>
<tr><td>03</td><td>Motor leakage inductance tuning error.</td></tr>
<tr><td>04</td><td>Motor rotor resistance R2 tuning error.</td></tr>
<tr><td>05</td><td>Motor mutual inductance Lm tuning error.</td></tr>
<tr><td>07</td><td>Deadtime compensation detection error</td></tr>
<tr><td>06</td><td>Motor encoder error</td><td>• PG feedback noise</td><td>• Check motor rated current.
• Check PG card grounding.</td></tr>
<tr><td>08</td><td>Motor acceleration error (Rotational type auto-tuning only).</td><td>• Motor fails to accelerate in the specified time (00-14= 20sec).</td><td>• Increase acceleration time (00-14).
• Disconnect motor load.</td></tr>
<tr><td>09</td><td>Other</td><td>• No load current is higher than 70% of the motor rated current.
• Torque reference exceeds 100%.
• Errors other than ATE01~ATE08.</td><td>• Check the motor tuning data (17-00 to 17-09).
• Check motor connection.</td></tr>
</table>

10.5 PM Motor Auto-tuning Error

When a fault occurs during auto-tuning of a PM motor, the display will show the “IPErr” fault and the motor stops. The fault information is displayed in parameter 22-18.

Note: The fault contact output does not energize with an auto-tuning fault. Refer to Table 10.5.1, for fault information during tuning, cause and corrective action.

Table 10.5.1 Auto-tuning fault and corrective actions for PM motor

Error	Description	Cause	Corrective action
01	Magnetic pole alignment tuning failure (static).	• Inverter output current does not match motor current.	• Check the motor tuning data (22-02). • Check inverter capacity
02 - 04	**Reserved**		
05	Circuit tuning time out.	• System abnormality during circuit tuning.	• Check for active protection functions preventing auto-tuning.
06	Encoder error	• PG feedback noise	• Check motor rated current. • Check PG card grounding.
07	Other motor tuning errors.	• Other tuning errors.	• Check the motor tuning data (22-02). • Check motor connection.
08	**Reserved**		
09	Current out of range during circuit tuning.	• Inverter output current does not match motor current.	• Check the motor tuning data (22-02). • Check inverter capacity
10	**Reserved**		
11	Parameter tuning time out.	• Error relationship between voltage and current.	• Check if value for parameter 22-11 is set too low, value cannot exceed 100% of the inverter rated current. • Check motor connection.

11. Inverter Peripheral devices and Options

11.1 Braking Resistors and Braking Units

Inverters ratings 230V 5 ~ 30HP / 460V 5 ~ 40HP *IP20) have a built-in braking transistor. For applications requiring more braking torque an external braking resistor can be connected to terminals B1 / P and B2; for inverter ratings above 230V 40HP / 460V 50HP (IP20), an external braking unit (connected to ⊕ - ⊖ of the inverter) and a braking resistor (connected to two ends of the detection module B-P0) is required.

Table 11.1 List of braking resistors and braking units (IP20)

Inverter			Braking unit		Braking resistor				Braking torque (Peak / Continues)	Minimum resistance	
V	HP	Rated Current (A)	Model	Qty Req	Part Number	Resistor specification	Qty Req.	Resistor dimensions (L*W*H)mm		(Ω)	(W)
3ϕ 230V	5	14.5	-	-	JNBR-390W40	390W/40Ω	1	395*34*78	126%,10%ED	25	680
	7.5	21	-	-	JNBR-520W30	520W/30Ω	1	400*40*100	114%,10%ED	21	800
	10	30	-	-	JNBR-780W20	780W/20Ω	1	400*40*100	126%,10%ED	18	900
	15	40	-	-	JNBR-2R4KW13R6	2400W/13.6Ω	1	535*50*110 (*2 pcs)	124%, 10%ED	11	1500
	20	56	-	-	JNBR-3KW10	3000W/10Ω	1	615*50*110 (*2 pcs)	126%, 10%ED	9.5	1800
	25	69	-	-	JNBR-4R8KW8	4800W/8Ω	1	535*50*110 (*4 pcs)	126%, 10%ED	7.2	2400
	30	79	-	-	JNBR-4R8KW6R8	4800W/6.8Ω	1	535*50*110 (*4 pcs)	124%, 10%ED	6.5	2400
	40	110	JNTBU-230	2	JNBR-3KW10	3000W/10Ω	2	615*50*110 (*4 pcs)	126%, 10%ED	2.7	3000
	50	138	JNTBU-230	2	JNBR-3KW10	3000W/10Ω	2	615*50*110 (*4 pcs)	105%, 10%ED	2.7	3000
	60	169	JNTBU-230	2	JNBR-4R8KW6R8	4800W/6.8Ω	2	535*50*110 (*8 pcs)	124%, 10%ED	*note1	
	75	200	JNTBU-230	3	JNBR-4R8KW8	4800W/8Ω	3	535*50*110 (*12 pcs)	124%, 10%ED	*note1	
	100	250	JNTBU-230	3	JNBR-4R8KW6R8	4800W/6.8Ω	3	535*50*110 (*12 pcs)	116%, 10%ED	*note1	
	125	312	JNTBU-230	4	JNBR-4R8KW6R8	4800W/6.8Ω	4	535*50*110 (*16 pcs)	119%,10%ED	*note1	
	150	400	JNTBU-230	5	JNBR-4R8KW6R8	4800W/6.8Ω	4	535*50*110 (*16 pcs)	108%,10%ED	*note1	

Inverter			Braking unit		Braking resistor				Braking torque (Peak / Continues)	Minimum resistance	
V	HP	Rated Current (A)	Model	Qty Req	Part Number	Resistor specification	Qty Req.	Resistor dimensions (L*W*H)mm		(Ω)	(W)
3ϕ 460V	5	9.2	-	-	JNBR-400W150	400W/150Ω	1	395*34*78	133%, 10%ED	60	1200
	7.5	11.1	-	-	JNBR-600W130	600W/130Ω	1	400*40*100	107% ,10%ED	60	1200
	10	17.5	-	-	JNBR-800W100	800W/100Ω	1	535*50*110	105%,10%ED	43	1600
	15	23	-	-	JNBR-1R6KW50	1600W/50Ω	1	615*50*110	133%, 10%ED	43	1600
	20	31	-	-	JNBR-1R5KW40	1500W/40Ω	1	615*50*110	126%, 10%ED	39	1600
	25	38	**-**	**-**	JNBR-4R8KW32	4800W/32Ω	1	535*50*110 (*4 pcs)	126%, 10%ED	22	3000
	30	44	**-**	**-**	JNBR-4R8KW27R2	4800W/27.2Ω	1	535*50*110 (*4 pcs)	124%, 10%ED	13.5	4800
	40	54	-	-	JNBR-6KW20	6000W/20Ω	1	615*50*110 (*4 pcs)	124%, 10%ED	13.5	4800
	50	72	JNTBU-430	2	JNBR-4R8KW32	4800W/32Ω	2	535*50*110 (*8 pcs)	126%, 10%ED	11	3000
	60	88	JNTBU-430	2	JNBR-4R8KW27R2	4800W/27.2Ω	2	535*50*110 (*8 pcs)	124%, 10%ED	11	3000
	75	103	JNTBU-430	2	JNBR-6KW20	6000W/20Ω	2	615*50*110 (*8 pcs)	133%, 10%ED	11	3000
	100	145	JNTBU-430	3	JNBR-4R8KW27R2	4800W/27.2Ω	3	535*50*110 (*12 pcs)	113%, 10%ED	*note1	
	125	165	JNTBU-430	3	JNBR-6KW20	6000W/20Ω	3	615*50*110 (*12 pcs)	121%, 10%ED	*note1	
	150	208	JNTBU-430	3	JNBR-6KW20	6000W/20Ω	3	615*50*110 (*12 pcs)	104%, 10%ED	*note1	
	175	250	JNTBU-430	5	JNBR-4R8KW27R2	4800W/27.2Ω	5	535*50*110 (*20 pcs)	109%, 10%ED	*note1	
	215	296	JNTBU-430	6	JNBR-4R8KW27R2	4800W/27.2Ω	6	535*50*110 (*24 pcs)	107%, 10%ED	*note1	
	250	328	JNTBU-430	5	JNBR-6KW20	6000W/20Ω	5	615*50*110 (*20 pcs)	105%,10%ED	*note1	

***1:** Minimum resistance is the acceptable minimum value of the braking resistor for a single braking unit.

Note: Keep sufficient space between inverter, braking unit and braking resistor and ensure proper cooling is provided for.

11.2 AC Line Reactors

An AC line reactor can be used for any of the following:

- Capacity of power system is much larger than the inverter rating.
- Inverter mounted close to the power system (in 33ft / 10 meters).
- Reduce harmonic contribution (improve power factor) back to the power line.
- Protect inverter input diode front-end by reducing short-circuit current.
- Minimize overvoltage trips due to voltage transients.

Please select the AC line reactor based on the inverter rating according to the following table.

Table11.2.1 List of AC Line Reactors

Model		AC reactor		
Voltage	**HP**	**Part Number**	**Inductance Value (mH)**	**Rated Current (A)**
3ϕ 230V	5	JNACL0P71M15A2	0.71mH	15A
	7.5	JNACL0P53M20A2	0.53mH	20A
	10	JNACL0P35M30A2	0.35mH	30A
	15	JNACL0P265M40A2	0.265mH	40A
	20	JNACL0P18M60A2	0.18mH	60A
	25	JNACL0P13M80A2	0.13mH	80A
	30	JNACL0P12M90A2	0.12mH	90A
	40	JNACL0P09M120A2	0.09mH	120A
	50	JNACL0P07M160A2	0.07mH	160A
	60	JNACL0P05M200A2	0.05mH	200A
	75	JNACL0P044M240A2	0.044mH	240A
	100	JNACL0P038M280A2	0.038mH	280A
	125	JNACL0P026M360A2	0.026mH	360A
3ϕ 460V	5/7.5	JNACL2P2M10A4	2.2mH	10A
	10	JNACL1P42M15A4	1.42mH	15A
	15	JNACL1P06M20A4	1.06mH	20A
	20	JNACL0P7M30A4	0.7mH	30A
	25	JNACL0P53M40A4	0.53mH	40A
	30	JNACL0P42M50A4	0.42mH	50A
	40	JNACL0P36M60A4	0.36mH	60A
	50	JNACL0P26M80A4	0.26mH	80A
	60	JNACL0P24M90A4	0.24mH	90A
	75	JNACL0P18M120A4	0.18mH	120A
	100	JNACL0P15M150A4	0.15mH	150A
	125	JNACL0P11M200A4	0.11mH	200A
	150	JNACL0P09M250A4	0.09mH	250A
	175/215	JNACL0P06M330A4	0.06mH	330A
	250	JNACL0P05M400A4	0.05mH	400A

Note: AC reactors listed in this table can only be used for the inverter input side. Do not connect AC reactor to the inverter output side. Both 230V class 60HP～125HP (IP20) and 460V class 100HP～425HP (IP20) have built-in DC reactors. If required by the application an AC reactor may be added.

11.2.1 AC Line Reactors Dimensions (230V)

1. Standard: In Compliance with JEC-2210 (Ver. 1990)
2. Insulation Level: H Level
3. Phase: 3-phase
4. Voltage: 200~240V
5. Insulation Resistance: below 0.2~1.1KV AC 4000V/1Min
6. Type: MR-DL (for input terminal)
7. Dimensions:

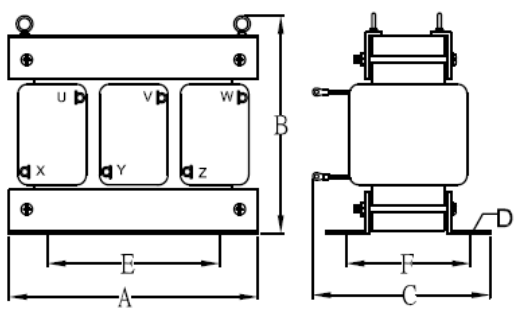


Figure 1

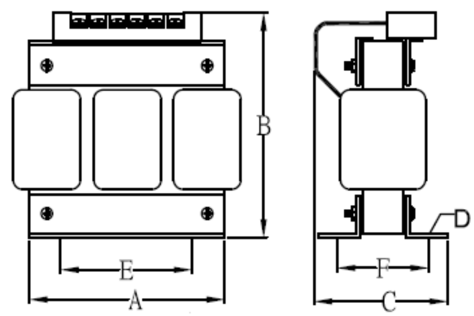


Figure 2

Voltage (V)	Inductance Value (mH)	Rated Current (A)	Dimensions (mm)						Figure	NW (Kg)
			A	B	C	D	E	F		
3ϕ 230V	0.71mH	15A	150	145	85	6	60	65	Figure 2	3.5
	0.53mH	20A	150	145	85	6	60	65	Figure 2	3.5
	0.35mH	30A	150	125	120	6	60	65	Figure 1	3.5
	0.265mH	40A	150	125	130	6	60	75	Figure 1	4.5
	0.18mH	60A	150	125	130	6	60	75	Figure 1	4.5
	0.13mH	80A	180	150	150	6	90	75	Figure 1	7
	0.12mH	90A	180	150	150	6	90	75	Figure 1	7
	0.09mH	120A	180	150	160	6	90	85	Figure 1	8
	0.07mH	160A	230	180	170	10	160	90	Figure 1	16
	0.05mH	200A	230	180	180	10	160	100	Figure 1	18
	0.044mH	240A	230	180	190	10	160	110	Figure 1	23
	0.038mH	280A	230	180	200	10	160	120	Figure 1	25
	0.026mH	360A	280	250	230	10	160	135	Figure 1	30

11.2.2 AC Line Reactors Dimensions (460V)

1. Standard: In Compliance with JEC-2210 (Ver. 1990)
2. Insulation Level: H Level
3. Phase: 3-phase
4. Voltage: 380~600V
5. Insulation Resistance: below 0.2~1.1KVAC 4000V/1Min
6. Type: MR-DL (for input terminal)
7. Dimensions

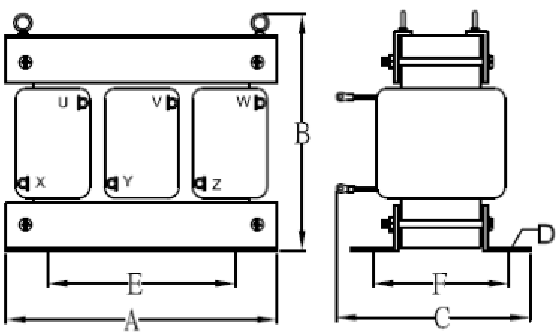


Figure 1

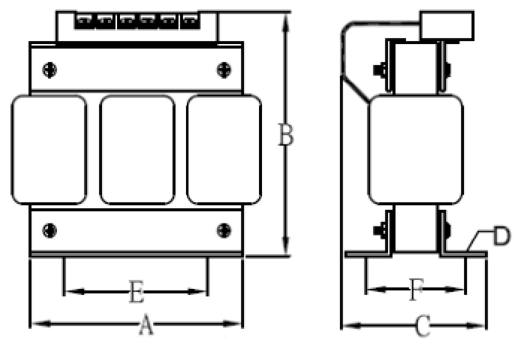


Figure 2

Voltage (V)	Inductance Value (mH)	Rated Current (A)	Dimensions (mm)						Figure	NW (Kg)
			A	B	C	D	E	F		
3ϕ 460V	2.2mH	10A	150	145	85	6	60	65	Figure 2	3.5
	1.42mH	15A	150	145	85	6	60	65	Figure 2	3.5
	1.06mH	20A	150	145	95	6	60	75	Figure 2	4.5
	0.7mH	30A	150	125	130	6	60	75	Figure 1	4.5
	0.53mH	40A	180	150	150	6	90	75	Figure 1	7
	0.42mH	50A	180	150	160	6	90	85	Figure 1	8
	0.36mH	60A	180	150	160	6	90	85	Figure 1	8.5
	0.26mH	80A	230	190	170	8	160	85	Figure 1	12
	0.24mH	90A	230	190	180	8	160	95	Figure 1	15
	0.18mH	120A	230	190	190	8	160	105	Figure 1	18
	0.15mH	150A	230	180	200	10	160	120	Figure 1	25
	0.11mH	200A	280	250	230	10	160	135	Figure 1	30
	0.09mH	250A	280	250	230	10	160	135	Figure 1	33
	0.06mH	330A	320	260	240	10	170	140	Figure 1	42
	0.05mH	400A	320	260	240	10	170	140	Figure 1	45

11.3 Input Noise Filters

Install a noise filter on power supply side to eliminate noise transmitted between the power line and the inverter. The inverter noise filter shown in table 11.3.1 and 11.3.2 below meets the EN61800-3 class A specification. 460V inverter class models can be ordered with integrated noise filter.

Table 11.3.1 Input Noise Filter Specifications and Ratings (IP20)

Inverter size		Noise filter			
Input voltage	**HP**	**Model**	**Rated current**	**Dimension**	**Part Number**
3ϕ 230V	1HP/2HP	FS32125-11-99	11	263.8*45*70	4KA53X079T01
	3HP/5HP	FS32124-23-99	23	290*50*85	4KA53X080T01
	7.5HP/10HP	FS32123-42-99	42	330*85*90	4KA53X081T01
	15HP	FS32125-61-99	61	318*80*135	4KA53X082T01
	20HP/25HP	FS32125-86-99	86	360*95*90	4KA53X083T01
	30HP/40HP	FS32125-150-99	150	320*226.5*86	4KA53X084T01
	50HP/60HP	FS32125-232-99	232	320*226.5*86	4KA53X095T01
	75HP/100HP	FS32125-343-99	343	320*226.5*86	4KA53X096T01
3ϕ 460V	1HP/2HP/3HP	FS32128-8-99	8	63.5*130*92	4KA53X085T01
	5HP/7.5HP	FS32127-19-99	19	85.5*140*91.2	4KA53X086T01
	10HP/15HP	FS32126-33-99	33	100.7*210*101	4KA53X087T01
	20HP/25HP/30HP	FS32126-63-99	63	138.3*256.2*129.3	4KA53X088T11
	40HP/50HP/60HP	FS32126-112-99	112	150*283*125.8	4KA53X089T11
	75HP/100HP	FS32126-181-99	181	320*226.5*86	4KA53X097T01
	125HP/150HP/175HP/215HP	FS32126-361-99	361	320*226.5*86	4KA53X098T01
	250HP/300HP/375HP/425HP	FS6101-800-99	800	C/F	4H000D1910004

B. Input or Output Noise Filter (EMI Suppression Zero Phase Core)

- Part Number: 4H000D0250001
- Select a matched ferrite core to suppress EMI noise according to the required power rating and wire size.
- The ferrite core can attenuate high frequencies in the range of 100 kHz to 50 MHz, as shown in figure 11.4.1 below, and therefore should minimize the RFI generated by the inverter.
- The zero-sequence noise ferrite core can be installed either on the input side or on the output side. The wire around the core for each phase should be wound by following the same convention and in one direction. The more turns without resulting in saturation the better the attenuation. If the wire size is too large to be wound, all the wiring can be grouped and put through several cores together in one direction.

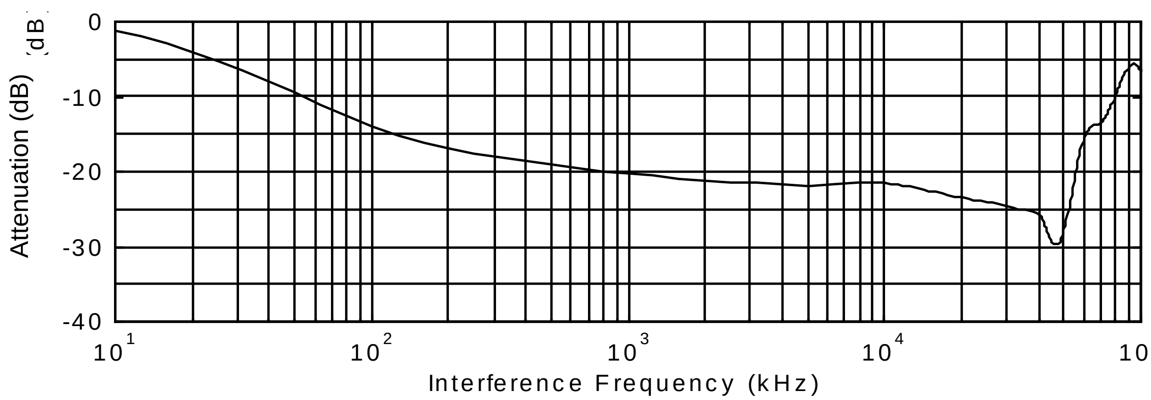


Fig. 11.4.1 Frequency attenuation characteristics (10 windings case)

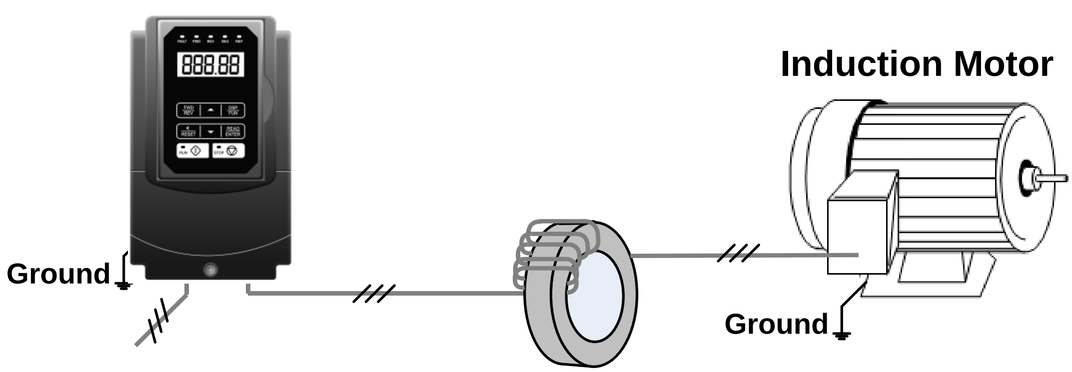


Fig. 11.4.2 Example of EMI Suppression Zero Phase Core Application

Note: All the wiring of phases U/T1, V/T2, W/T3 must pass through the same zero-phase core without crossing over.

11.4 Input Current and Fuse Specifications

230V class (IP20)

Model	Horse power	KVA	100% of rated output current	Rated input current	Fuse rating
F510-2005-C3	5	5.5	14.5	16	30
F510-2008-C3	7.5	8.0	21	22.3	45
F510-2010-C3	10	11.4	30	31.6	60
F510-2015-C3	15	15	40	41.7	80
F510-2020-C3	20	21	56	60.9	125
F510-2025-C3	25	26	69	75	150
F510-2030-C3	30	30	79	85.9	175
F510-2040-C3	40	42	110	119.6	225
F510-2050-C3	50	53	138	150	275
F510-2060-C3	60	64	169	186	325
F510-2075-C3	75	76	200	232	400
F510-2100-C3	100	95	250	275	500
F510-2125-C3	125	119	312	343	600
F510-2150-C3	150	152	400	440	800

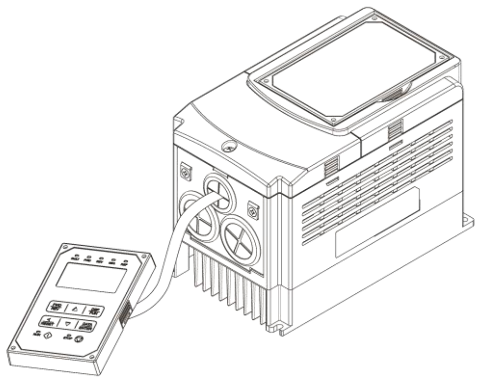
460V class (IP20)

Model	Horse power	KVA	100% of rated output current	Rated input current	Fuse rating
F510-4005-C3	5	7.0	9.2	9.6	20
F510-4008-C3	7.5	8.5	11.1	11.6	20
F510-4010-C3	10	13.3	17.5	18.2	30
F510-4015-C3	15	18	23	24	40
F510-4020-C3	20	24	31	32.3	50
F510-4025-C3	25	29	38	41.3	70
F510-4030-C3	30	34	44	47.8	80
F510-4040-C3	40	41	54	58.7	100
F510-4050-C3	50	55	72	75	125
F510-4060-C3	60	67	88	95.7	150
F510-4075-C3	75	79	103	112	200
F510-4100-C3	100	111	145	141	250
F510-4125-C3	125	126	165	181	300
F510-4150-C3	150	159	208	229	350
F510-4175-C3	175	191	250	275	500
F510-4215-C3	215	226	296	325	600
F510-4250-C3	250	250	328	360	700

11.5 Other Options

A. Blank cover and keypad extension cable

When used for remote control purposes, the keypad can be removed and remotely connected with an extension cable. Extension cables are available in the following lengths: 1m (3.3ft), 2m (6.6ft), 3m (10ft), and 5m (16.4ft).



Name	Model	specification
LED digital operator wire	JN5-CB-01M	**1m (3.3ft)**
	JN5-CB-02M	**2m (6.6ft)**
	JN5-CB-03M	**3m (10ft)**
	JN5-CB-05M	**5m (16.4ft)**

When using a remote mount keypad a blank cover can be installed in place of the original keypad to prevent dust and debris from entering the inverter.

Blank keypad cover

Name	Model	specification
Blank cover	JN5-OP-A03	Blank cover

B. 1 to 8 Pump Card

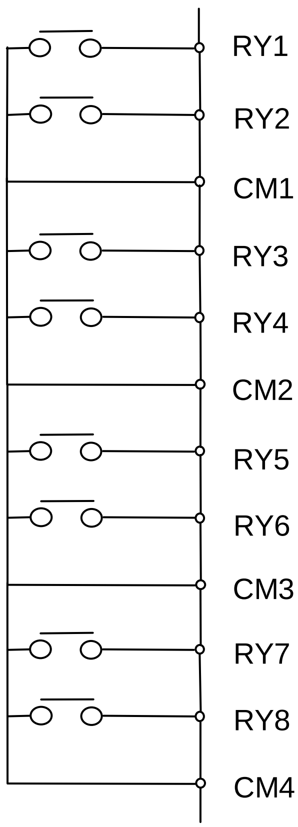
Refer to instruction manual of the option card on how to install.

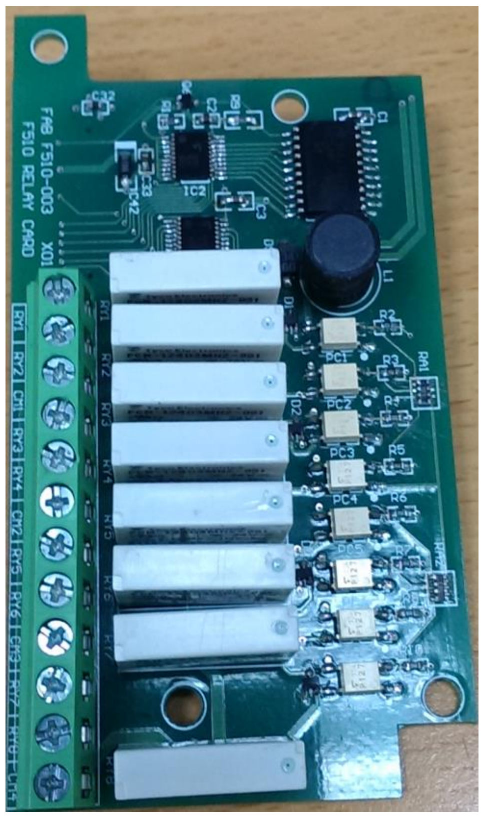
JN5-IO-8DO Card: 8 Relay Output Card.

Terminals of JN5-IO-8DO:

Terminal	Description
RY1~RY8	Relay1~Relay8 Form A output
CM1~CM4	Common terminal output

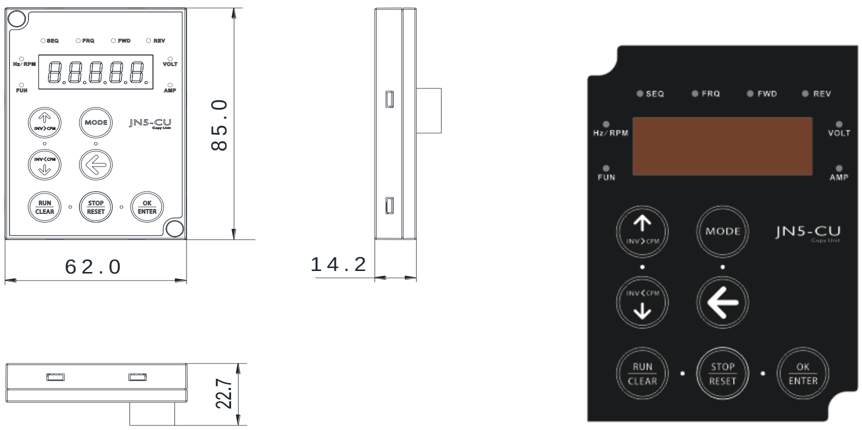
Wiring of JN5-IO-8DO (Example):





C. Copy Unit (JN5-CU)

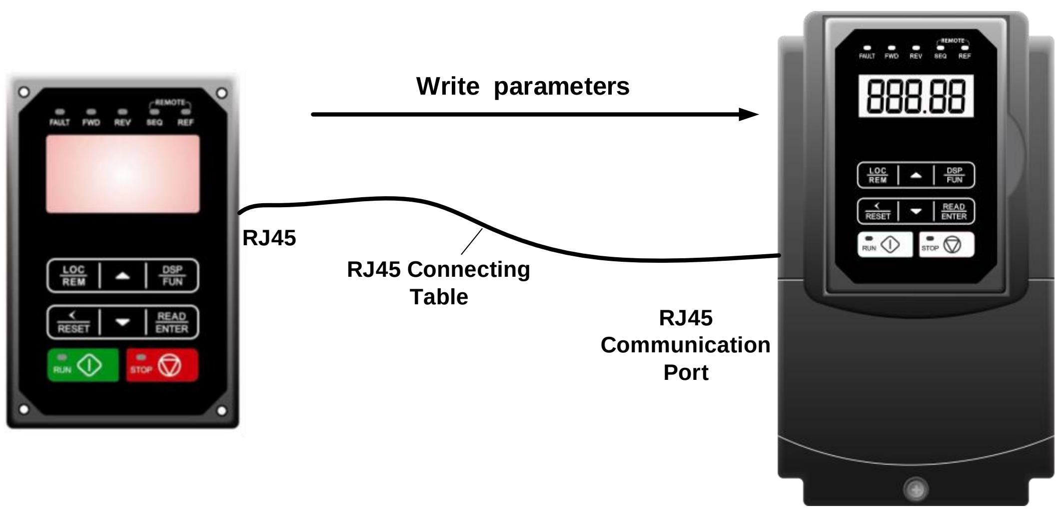
The copy unit is used to copy an inverter parameter setup to another inverter. The copy unit saves time in applications with multiple inverters requiring the same parameter setup.



Copy Unit (JN5-CU) dimensions

D. Copy Module (JN5-CU-M)

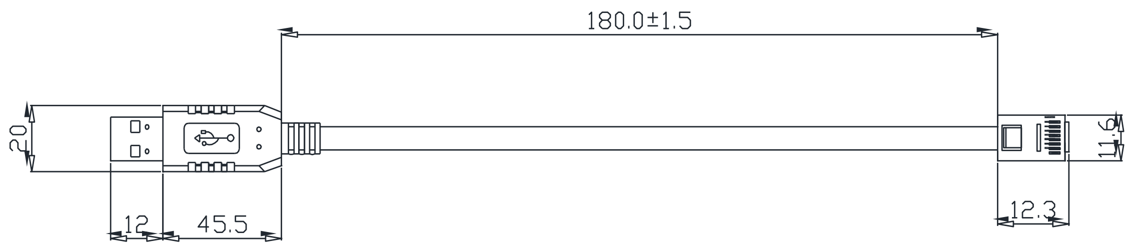
The copy module is used to copy up to 128 parameters from one inverter to another inverter.



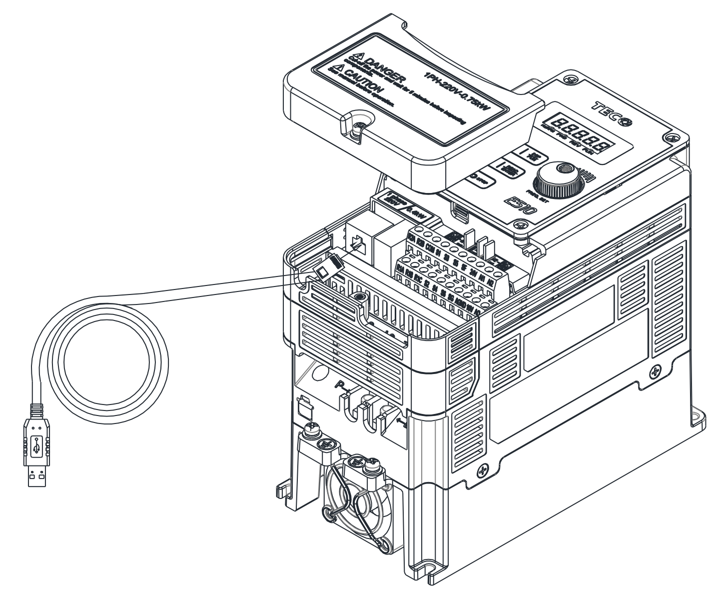
E. RJ45 to USB Communication Cable (6ft / 1.8m) (JN5-CM-USB)

The communication cable is used to communicate with the TECO Link software directly to the inverter using the PC USB port.

- Cable:



- Connect to the RS45 port:



11.6 Communication options

(a) PROFIBUS communication interface module (JN5-CM-PDP)

For wiring example and communication setup refer to JN5-CM-PDP communication option manual.

(b) DEVICENET communication interface module (JN5-CM-DNET)

For wiring example and communication setup refer to JN5-CM-DNET communication option manual.

(c) CANopen communication interface module (JN5-CM-CAN)

For wiring example and communication setup refer to JN5-CM-VAN communication option manual.

(d) TCP-IP communication interface module (JN5-CM-TCPIP)

For wiring example and communication setup refer to JN5-CM-TCPIP communication option manual.

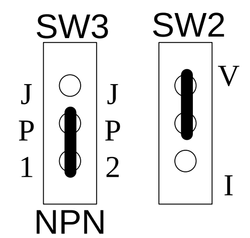
Appendix A: Single and Multi-Pump Wiring

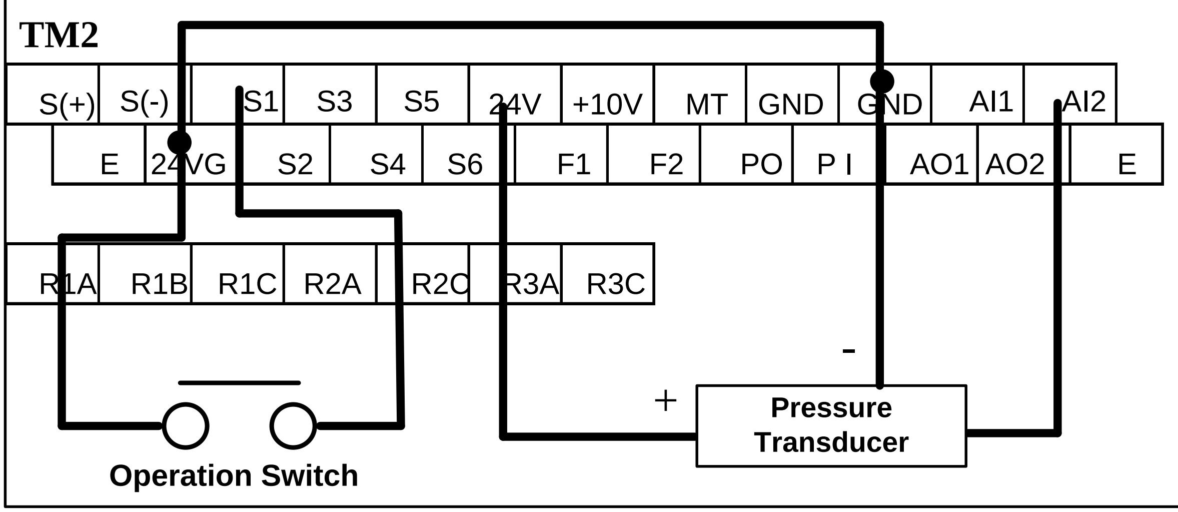
- **PUMP Wiring Diagram for Pressure Sensor of Voltage Type**

Single Pump:

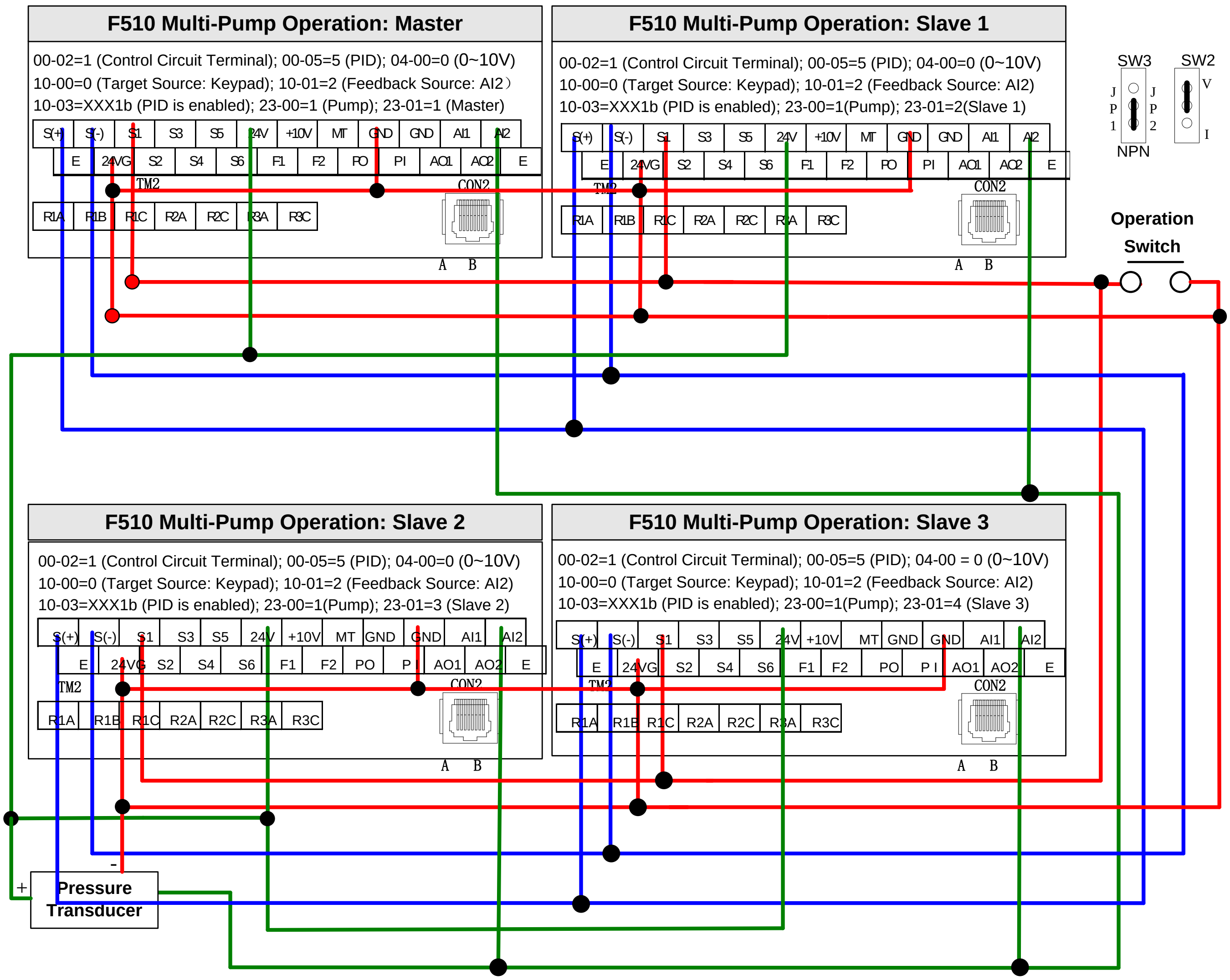
F510 Single Pump Operation

00-02 = 1 (Control Circuit Terminal); 00-05 = 5 (PID)
04-00 = 0 (0~10V); 10-00=0 (Target Source: Keypad)
10-01 = 2 (Feedback Source: AI2)
10-03 = XXX1b（PID is enabled)
23-00 = 1 (Pump); 23-01 = 0 (Single Pump)



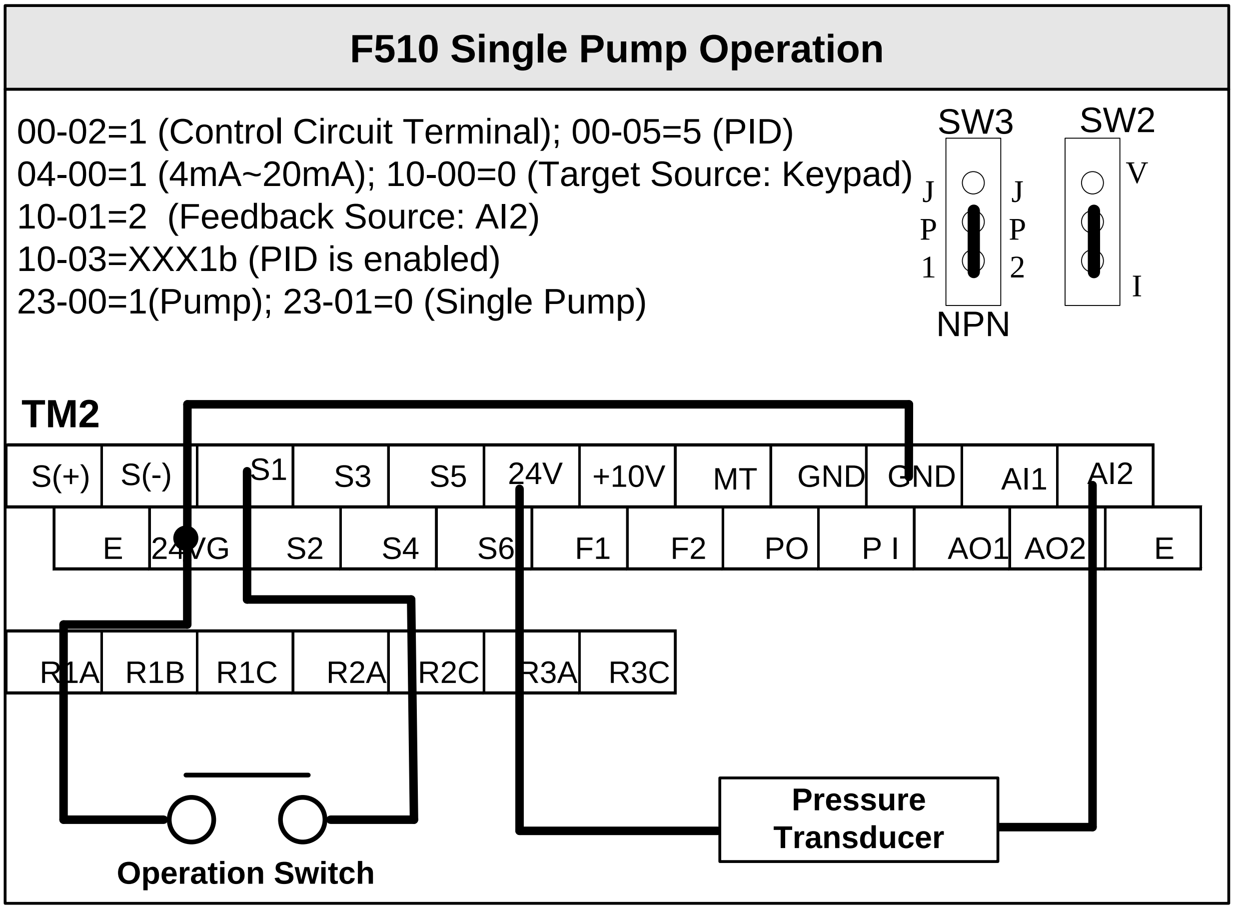


Multi-Pump:

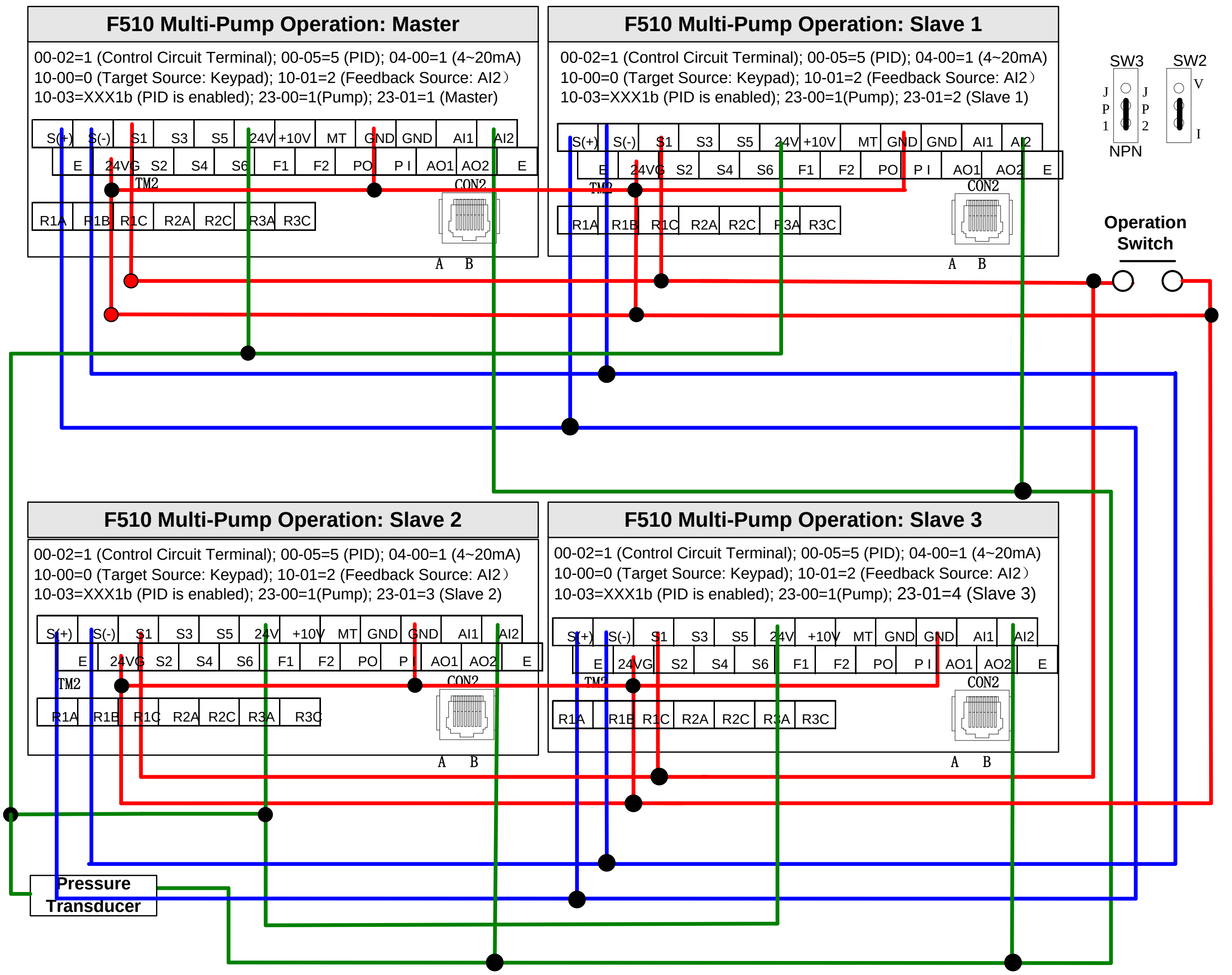

F510 Multi-Pump Operation: Master
00-02=1 (Control Circuit Terminal); 00-05=5 (PID); 04-00=0 (0~10V)
10-00=0 (Target Source: Keypad); 10-01=2 (Feedback Source: AI2)
10-03=XXX1b (PID is enabled); 23-00=1 (Pump); 23-01=1 (Master)
F510 Multi-Pump Operation: Slave 1
00-02=1 (Control Circuit Terminal); 00-05=5 (PID); 04-00=0 (0~10V)
10-00=0 (Target Source: Keypad); 10-01=2 (Feedback Source: AI2)
10-03=XXX1b (PID is enabled); 23-00=1(Pump); 23-01=2(Slave 1)
F510 Multi-Pump Operation: Slave 2
00-02=1 (Control Circuit Terminal); 00-05=5 (PID); 04-00=0 (0~10V)
10-00=0 (Target Source: Keypad); 10-01=2 (Feedback Source: AI2)
10-03=XXX1b (PID is enabled); 23-00=1(Pump); 23-01=3 (Slave 2)
F510 Multi-Pump Operation: Slave 3
00-02=1 (Control Circuit Terminal); 00-05=5 (PID); 04-00 = 0 (0~10V)
10-00=0 (Target Source: Keypad); 10-01=2 (Feedback Source: AI2)
10-03=XXX1b (PID is enabled); 23-00=1(Pump); 23-01=4 (Slave 3)
S(+) S(-) S1 S3 S5 24V +10V MT GND GND AI1 AI2
E 24VG S2 S4 S6 F1 F2 PO PI AO1 AO2 E
TM2
CON2
R1A R1B R1C R2A R2C R3A R3C
A B
SW3
SW2
JP1
JP2
V
I
NPN
Operation Switch
Pressure Transducer
+
-

■ **PUMP Wiring Diagram for Pressure Sensor of Current Type**

Single Pump:



Multi-Pump:



Notes:

1. Check position of dip switch SW2 and SW3.
2. It is required to reconnect after setting Master/ Follower.
3. 24VG and GND have to be connected together.
4. When the communication mode is selected for multiple pumps in parallel connection (09-01=3), baud rate settings (09-02) of both Master and Follower have to be the same. Refer to parameter 23-31.
5. When wiring pressure sensor to multi-pump units make sure to set Follower parameter 04-07(AI2 Gain) =252.0% and 04-08(AI1 Bias) =25.0%.

Appendix B: UL Instructions

Danger

Electric Shock Hazard

Do not connect or disconnect wiring while the power is on.
Failure to comply will result in death or serious injury.

Warning

Electric Shock Hazard

Do not operate equipment with covers removed.
Failure to comply could result in death or serious injury.
The diagrams in this section may show inverters without covers or safety shields to show details. Be sure to reinstall covers or shields before operating the inverters and run the inverters according to the instructions described in this manual.

Always ground the motor-side grounding terminal.
Improper equipment grounding could result in death or serious injury by contacting the motor case.

Do not touch any terminals before the capacitors have fully discharged.
Failure to comply could result in death or serious injury.
Before wiring terminals, disconnect all power to the equipment. The internal capacitor remains charged even after the power supply is turned off. After shutting off the power, wait for at least the amount of time specified on the inverter before touching any components.

Do not allow unqualified personnel to perform work on the inverter.
Failure to comply could result in death or serious injury.
Installation, maintenance, inspection, and servicing must be performed only by authorized personnel familiar with installation, adjustment, and maintenance of inverters.

Do not perform work on the inverter while wearing loose clothing, jewelry, or lack of eye protection.
Failure to comply could result in death or serious injury.
Remove all metal objects such as watches and rings, secure loose clothing, and wear eye protection before beginning work on the inverter.

Do not remove covers or touch circuit boards while the power is on.
Failure to comply could result in death or serious injury.

Warning

Fire Hazard

Tighten all terminal screws to the specified tightening torque.
Loose electrical connections could result in death or serious injury by fire due to overheating of electrical connections.

Do not use an improper voltage source.
Failure to comply could result in death or serious injury by fire.
Verify that the rated voltage of the inverter matches the voltage of the incoming power supply before applying power.

Do not use improper combustible materials.
Failure to comply could result in death or serious injury by fire. Attach the inverter to metal or other noncombustible material.

NOTICE

Observe proper electrostatic discharge procedures (ESD) when handling the inverter and circuit boards.
Failure to comply may result in ESD damage to the inverter circuitry.

Never connect or disconnect the motor from the inverter while the inverter is outputting voltage.
Improper equipment sequencing could result in damage to the inverter.

Do not use unshielded cable for control wiring.
Failure to comply may cause electrical interference resulting in poor system performance. Use shielded twisted-pair wires and ground the shield to the ground terminal of the inverter.

Do not modify the inverter circuitry.
Failure to comply could result in damage to the inverter and will void warranty. TECO is not responsible for any modification of the product made by the user. This product must not be modified.

Check all the wiring to ensure that all connections are correct after installing the inverter and connecting any other devices.
Failure to comply could result in damage to the inverter.

❖ UL Standards

The UL/cUL mark applies to products in the United States and Canada and it means that UL has performed product testing and evaluation and determined that their stringent standards for product safety have been met. For a product to receive UL certification, all components inside that product must also receive UL certification.

UL/cUL Mark

❖ UL Standards Compliance

This inverter is tested in accordance with UL standard UL508C and complies with UL requirements. To ensure continued compliance when using this inverter in combination with other equipment, meet the following conditions:

■ Installation Area

Do not install the inverter to an area greater than pollution severity 2 (UL standard).

■ Main Circuit Terminal Wiring

UL approval requires crimp terminals when wiring the inverter's main circuit terminals. Use crimping tools as specified by the crimp terminal manufacturer. TECO recommends crimp terminals made by NICHIFU for the insulation cap.

The table below matches inverter models with crimp terminals and insulation caps. Orders can be placed with a TECO representative or directly with the TECO sales department.

Closed-Loop Crimp Terminal Size

Drive Model F510	Wire Gauge mm2 , (AWG)		Terminal	Crimp Terminal	Tool	Insulation Cap
	R/L1, S/L2, T/L3	U/T1, V/T2, W/T3	Screws	Model No.	Machine No.	Model No.
2008	5.5 (10)		M4	R5.5-4	Nichifu NH 1 / 9	TIC 5.5
2015	14 (6)		M4	R14-6	Nichifu NOP 60	TIC 8
2030	38 (2)		M6	R38-6	Nichifu NOP 60 / 150H	TIC 22
2050	80 (3/0)		M8	R80-8	Nichifu NOP 60 / 150H	TIC 60
2075	150 (4/0)		M8	R150-8	Nichifu NOP 150H	TIC 80
2125	300 (4/0)*2		M10	R150-10	Nichifu NOP 150H	TIC 100
4010	5.5 (10)		M4	R5.5-4	Nichifu NH	9-Jan
4020	8 (8)		M6	R8-6	Nichifu NOP 60	TIC 8
4040	22 (6)		M6	R22-6	Nichifu NOP 60 / 150H	TIC 14
4075	60 (2)		M8	R60-8	Nichifu NOP 60 / 150H	TIC 38
4125	150 (3/0)		M8	R150-8	Nichifu NOP 150H	TIC 80
4250	300 (4/0)*2		M10	R150-10	Nichifu NOP 150H	TIC 100

❖ **Type 1**

During installation, all conduit hole plugs shall be removed, and all conduit holes shall be used.

Note: Contact TECO for inverter ratings 2125 - 2150 and 4250 - 4425.

230V Class

Drive Model F510	Fuse Type	
	Manufacturer: Bussmann / FERRAZ SHAWMUT	
	Model	Fuse Ampere Rating (A)
200 V Class Three-Phase Drives		
2005	Bussmann 50FE	690V 50A
2008	Bussmann 50FE	690V 50A
2010	Bussmann 63FE	690V 63A
2015	FERRAZ SHAWMUT A50QS100-4	500V 100A
2020	Bussmann 120FEE / FERRAZ A50QS150-4	690V 120A / 500V 150A
2025	FERRAZ SHAWMUT A50QS150-4	500V 150A
2030	FERRAZ SHAWMUT A50QS200-4	500V 200A
2040	FERRAZ SHAWMUT A50QS250-4	500V 250A
2050	FERRAZ SHAWMUT A50QS300-4	500V 300A
2060	FERRAZ SHAWMUT A50QS400-4	500V 400A
2075	FERRAZ SHAWMUT A50QS500-4	500V 500A
2100	FERRAZ SHAWMUT A50QS600-4	500V 600A
2125	FERRAZ SHAWMUT A50QS700-4	500V 700A

460V Class

Drive Model F510	Fuse Type	
	Manufacturer: Bussmann / FERRAZ SHAWMUT	
	Model	Fuse Ampere Rating (A)
400 V Class Three-Phase Drives		
4005	Bussmann 16CT	690V 16A
4008	Bussmann 25ET	690V 25A
4010	Bussmann 40FE	690V 40A
4015	Bussmann 50FE	690V 50A
4020	Bussmann 63FE	690V 63A
4025	Bussmann 80FE	500V 80A
4030	Bussmann 100FE / FERRAZ A50QS100-4	690V 100A / 500V 100A
4040	Bussmann 120FEE	500V 120A
4050	FERRAZ SHAWMUT A50QS150-4	500V 15A
4060	FERRAZ SHAWMUT A50QS200-4	500V 200A
4075	FERRAZ SHAWMUT A50QS250-4	500V 250A
4100	FERRAZ SHAWMUT A50QS300-4	500V 300A
4125	FERRAZ SHAWMUT A50QS400-4	500V 400A
4150	FERRAZ SHAWMUT A50QS500-4	500V 500A
4175	FERRAZ SHAWMUT A50QS600-4	500V 600A
4215	FERRAZ SHAWMUT A50QS700-4	500V 700A
4250	FERRAZ SHAWMUT A50QS700-4	500V 700A

❖ **Motor Over Temperature Protection**

Motor over temperature protection shall be provided in the end use application.

■ **Field Wiring Terminals**

All input and output field wiring terminals not located within the motor circuit shall be marked to indicate the proper connections that are to be made to each terminal and indicate that copper conductors, rated 75°C are to be used.

■ **Inverter Short-Circuit Rating**

This inverter has undergone the UL short-circuit test, which certifies that during a short circuit in the power supply the current flow will not rise above value. Please see electrical ratings for maximum voltage and table below for current.

• The MCCB and breaker protection and fuse ratings (refer to the preceding table) shall be equal to or greater than the short-circuit tolerance of the power supply being used.
• Suitable for use on a circuit capable of delivering not more than (A) RMS symmetrical amperes for.DiJ2.lHp in 240 / 480 V class drives motor overload protection.

Horse Power (Hp)	Current (A)	Voltage (V)
1 - 50	5,000	240 / 480
51 - 200	10,000	240 / 480
201 - 400	18,000	240 / 480
401 - 600	30,000	240 / 480

❖ Inverter Motor Overload Protection

Set parameter 02-01 (motor rated current) to the appropriate value to enable motor overload protection. The internal motor overload protection is UL listed and in accordance with the NEC and CEC.

■ 02-01 Motor Rated Current

Setting Range Model Dependent
Factory Default: Model Dependent

The motor rated current parameter (02-01) protects the motor and allows for proper vector control when using open loop vector or flux vector control methods (00-00 = 2 or 3). The motor protection parameter 08-05 is set as factory default. Set 02-01 to the full load amps (FLA) stamped on the nameplate of the motor. The operator must enter the rated current of the motor (17-02) in the menu during auto-tuning. If the auto-tuning operation completes successfully (17-00 = 0), the value entered into 17-02 will automatically write into 02-01.

■ 08-05 Motor Overload Protection Selection

The inverter has an electronic overload protection function (OL1) based on time, output current, and output frequency, which protects the motor from overheating. The electronic thermal overload function is UL-recognized, so it does not require an external thermal overload relay for single motor operation.
This parameter selects the motor overload curve used according to the type of motor applied.

08-05	Selection for motor overload protection (OL1)
Range	**xxx0b:** Motor overload is disabled **xxx1b:** Motor overload is enabled **xx0xb:** Cold start of motor overload **xx1xb:** Hot start of motor overload **x0xxb:** Standard motor **x1xxb:** Special motor

Sets the motor overload protection function in 08-05 according to the applicable motor.

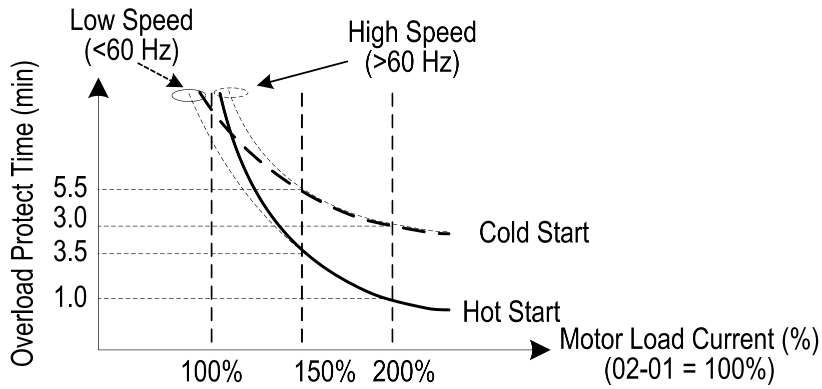
08-05 = ---OB: Disables the motor overload protection function when two or more motors are connected to a single inverter. Use an alternative method to provide separate overload protection for each motor such as connecting a thermal overload relay to 1he power line of each motor.

08-05 = --1-B: The motor overload protection function should be set to hot start protection characteristic curve when the power supply is turned on and off frequently, because the thermal values are reset each time when the power is turned off.

08-05 = -0—B: For motors without a forced cooling fan (general purpose standard motor), the heat dissipation capability is lower when in low speed operation.

08-05 = -1—B: For motors with a forced cooling fan (inverter duty or VIF motor), the heat dissipation capability is not dependent upon the rotating speed.

To protect the motor from overload by using electronic overload protection, be sure to set parameter 02-01 according to the rated current value shown on the motor nameplate.
Refer to the following "Motor Overload Protection Time" for the standard motor overload protection curve example: Setting 08-05 = -0--B.



■ **08-06 Motor Overload Operation Selection**

08-06	Start-up mode of overload protection operation (OL1)
Range	**0:** Stop output after overload protection **1:** Continuous operation after overload protection.

08-06=0: When the inverter detects a motor overload the inverter output is turned off and the OL1 fault message will flash on the keypad. Press RESET button on the keypad or activate the reset function through the multi-function inputs to reset the OL1 fault.

08-06=1: When the inverter detects a motor overload the inverter will continue running and the OL1 alarm message will flash on the keypad until the motor current falls within the normal operating range.

UL- Additional Data

Closed-Loop Crimp Terminal Size

Drive Model F510	Wire Gauge mm2 (AWG)		Terminal	Crimp Terminal	Tool	Insulation Cap
	R/L1, S/L2, T/L3	U/T1, V/T2, W/T3	Screws	Model No.	Machine No.	Model No.
2175	152 (300)*2		M12	R150-12*2	Nichifu NOP 150H	TIC 150
4300	203 (400)*2		M12	R200-12S*2	Nichifu NOH 300K	TIC 200
4375	253 (500)*2		M12	R325-12S*2	Nichifu NOH 300K	TIC 325
4425	253 (500)*2		M12	R325-12S*2	Nichifu NOH 300K	TIC 325

❖ Type 1

During installation, all conduit hole plugs shall be removed, and all conduit holes shall be used

Recommended Input Fuse Selection

Drive Model F510	Fuse Type	
	Manufacturer: Bussmann / FERRAZ SHAWMUT	
	Model	Fuse Ampere Rating (A)
200 V Class Three-Phase Drives		
2150	Bussmann 170M5464	690V 800A
2175	Bussmann 170M5464	690V 800A

Drive Model F510	Fuse Type	
	Manufacturer: Bussmann / FERRAZ SHAWMUT	
	Model	Fuse Ampere Rating (A)
400 V Class Three-Phase Drives		
4300	Bussmann 170M5464	690V 800A
4375	Bussmann 170M5464	690V 800A
4425	Bussmann 170M5466	690V 1000A
4425	Bussmann 170M5466	690V 1000A

TECO

INVERTER

F510

Teco-Westinghouse Motor Company
5100 N. IH-35
Round Rock, Texas 78681
1-800-279-4007
www.tecowestinghouse.com

TECO Electric & Machinery Co., Ltd.
10F., No.3-1, Yuancyu St., Nangang District,
Taipei City 115, Taiwan
Tel: +886-2-6615-9111
Fax: +886-2-6615-0933
www.teco.com.tw

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SENTINEL
CLOUD BASED MONITORING

INSTALLATION AND SETUP GUIDE
VERSION 2.3

SENSAPHONE®
REMOTE MONITORING SOLUTIONS

First Edition, version 2.2, May 2017

Written and produced by SENSAPHONE®.

Please address comments on this publication to:

SENSAPHONE®

901 Tryens Road

Aston, PA 19014

Important Safety Instructions

Your Sentinel has been carefully designed to give you years of safe, reliable performance. As with all electrical equipment, however, there are a few basic precautions you should take to avoid hurting yourself or damaging the unit:

- Read the installation and operating instructions in this guide carefully. Be sure to save it for future reference.
- Read and follow all warning and instruction labels on the product itself.
- To protect the Sentinel from overheating, make sure all openings on the unit are not blocked. Do not place on or near a heat source, such as a radiator or heat register.
- Do not use your Sentinel near water, or spill liquid of any kind into it.
- Be certain that your power source matches the rating in the specifications of this manual. If you're not sure of the type of power supply to your facility, consult your dealer or local power company.
- Do not allow anything to rest on the power cord. Do not locate this product where the cord will be abused by persons walking on it.
- Do not overload wall outlets and extension cords, as this can result in the risk of fire or electric shock.
- Never push objects of any kind into this product through ventilation holes as they may touch dangerous voltage points or short out parts that could result in a risk of fire or electric shock.
- To reduce the risk of electric shock, do not disassemble this product, but return it to Sensaphone Customer Service, or another approved repair facility, when any service or repair work is required. Opening or removing covers may expose you to dangerous voltages or other risks. Incorrect reassembly can cause electric shock when the unit is subsequently used.
- If anything happens that indicates that your Sentinel is not working properly or has been damaged, unplug it immediately and follow the procedures in the manual for having it serviced. Return the unit for servicing under the following conditions:
    1. The power cord or plug is frayed or damaged.
    2. Liquid has been spilled into the product or it has been exposed to water.
    3. The unit has been dropped, or the enclosure is damaged.
    4. The unit doesn't function normally when you're following the operating instructions.
- To reduce the risk of fire or injury to persons, read and follow these instructions:
    1. Use only the specified type and size battery.
    2. Do not dispose of the battery in a fire. The cell may explode. Check with local codes for possible special disposal instructions.
    3. Do not open or mutilate batteries. Released electrolyte is corrosive and may cause damage to the eyes or skin. It may be toxic if swallowed.
    4. Exercise care in handling batteries in order not to short the battery with conducting materials such as rings, bracelets, and keys. The battery or conductor may overheat and cause burns.
    5. Remove main power connections before replacing the battery.

FCC Requirements

Part 15: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

2 YEAR LIMITED WARRANTY

PLEASE READ THIS WARRANTY CAREFULLY BEFORE USING THE PRODUCT.

THIS LIMITED WARRANTY CONTAINS SENSAPHONE'S STANDARD TERMS AND CONDITIONS. WHERE PERMITTED BY THE APPLICABLE LAW, BY KEEPING YOUR SENSAPHONE PRODUCT BEYOND THIRTY (30) DAYS AFTER THE DATE OF DELIVERY, YOU FULLY ACCEPT THE TERMS AND CONDITIONS SET FORTH IN THIS LIMITED WARRANTY.

IN ADDITION, WHERE PERMITTED BY THE APPLICABLE LAW, YOUR INSTALLATION AND/OR USE OF THE PRODUCT CONSTITUTES FULL ACCEPTANCE OF THE TERMS AND CONDITIONS OF THIS LIMITED WARRANTY (HEREINAFTER REFERRED TO AS "LIMITED WARRANTY OR WARRANTY"). IF YOU DO NOT AGREE TO THE TERMS AND CONDITIONS THIS WARRANTY, INCLUDING ANY LIMITATIONS OF WARRANTY, INDEMNIFICATION TERMS OR LIMITATION OF LIABILITY, THEN YOU SHOULD NOT USE THE PRODUCT AND SHOULD RETURN IT TO THE SELLER FOR A REFUND OF THE PURCHASE PRICE. THE LAW MAY VARY BY JURISDICTION AS TO THE APPLICABILITY OF YOUR INSTALLATION OR USE ACTUALLY CONSTITUTING ACCEPTANCE OF THE TERMS AND CONDITIONS HEREIN AND AS TO THE APPLICABILITY OF ANY LIMITATION OF WARRANTY, INDEMNIFICATION TERMS OR LIMITATIONS OF LIABILITY.

1. **WARRANTOR**: IN THIS WARRANTY, WARRANTOR SHALL MEAN "DEALER, DISTRIBUTOR, AND/OR MANUFACTURER."

2. **ELEMENTS OF WARRANTY**: THIS PRODUCT IS WARRANTED TO BE FREE FROM DEFECTS IN MATERIALS AND CRAFTSMANSHIP WITH ONLY THE LIMITATIONS AND EXCLUSIONS SET OUT BELOW.

3. **WARRANTY AND REMEDY**: TWO-YEAR WARRANTY — IN THE EVENT THAT THE PRODUCT DOES NOT CONFORM TO THIS WARRANTY AT ANY TIME DURING THE TIME OF TWO YEARS FROM ORIGINAL PURCHASE, WARRANTOR WILL REPAIR THE DEFECT AND RETURN IT TO YOU AT NO CHARGE.

THIS WARRANTY SHALL TERMINATE AND BE OF NO FURTHER EFFECT AT THE TIME THE PRODUCT IS: (1) DAMAGED BY EXTRANEOUS CAUSE SUCH AS FIRE, WATER, LIGHTNING, ETC. OR NOT MAINTAINED AS REASONABLE AND NECESSARY; OR (2) MODIFIED; OR (3) IMPROPERLY INSTALLED; OR (4) MISUSED; OR (5) REPAIRED OR SERVICED BY SOMEONE OTHER THAN WARRANTORS' AUTHORIZED PERSONNEL OR SOMEONE EXPRESSLY AUTHORIZED BY WARRANTOR'S TO MAKE SUCH SERVICE OR REPAIRS; (6) USED IN A MANNER OR PURPOSE FOR WHICH THE PRODUCT WAS NOT INTENDED; OR (7) SOLD BY ORIGINAL PURCHASER.

LIMITED WARRANTY, LIMITATION OF DAMAGES AND DISCLAIMER OF LIABILITY FOR DAMAGES: THE WARRANTOR'S OBLIGATION UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AT THE WARRANTOR'S OPTION AS TO REPAIR OR REPLACEMENT. IN NO EVENT SHALL WARRANTORS BE LIABLE OR RESPONSIBLE FOR PAYMENT OF ANY INCIDENTAL, CONSEQUENTIAL, SPECIAL AND/OR PUNITIVE DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO ANY LABOR COSTS, PRODUCT COSTS, LOST REVENUE, BUSINESS INTERRUPTION LOSSES, LOST PROFITS, LOSS OF BUSINESS, LOSS OF DATA OR INFORMATION, OR FINANCIAL LOSS, FOR CLAIMS OF ANY NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS IN CONTRACT, BREACH OF WARRANTY OR TORT, AND WHETHER OR NOT CAUSED BY WARRANTORS' NEGLIGENCE. IN THE EVENT THAT IT IS DETERMINED IN ANY ADJUDICATION THAT THE LIMITED WARRANTIES OF REPAIR OR REPLACEMENT ARE INAPPLICABLE, THEN THE PURCHASER'S SOLE REMEDY SHALL BE PAYMENT TO THE PURCHASER OF THE ORIGINAL COST OF THE PRODUCT, AND IN NO EVENT SHALL WARRANTORS BE LIABLE OR RESPONSIBLE FOR PAYMENT OF ANY INCIDENTAL, CONSEQUENTIAL, SPECIAL AND/OR PUNITIVE DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO ANY LOST REVENUE, BUSINESS INTERRUPTION LOSSES, LOST PROFITS, LOSS OF BUSINESS, LOSS OF DATA OR INFORMATION, OR FINANCIAL LOSS, FOR CLAIMS OF ANY NATURE, INCLUDING BUT NOT LIMITED TO CLAIMS IN CONTRACT, BREACH OF WARRANTY OR TORT, AND WHETHER OR NOT CAUSED BY WARRANTORS' NEGLIGENCE.

WITHOUT WAIVING ANY PROVISION IN THIS LIMITED WARRANTY, IF A CIRCUMSTANCE ARISES WHERE WARRANTORS ARE FOUND TO BE LIABLE FOR ANY LOSS OR DAMAGE ARISING OUT OF MISTAKES, NEGLIGENCE, OMISSIONS, INTERRUPTIONS, DELAYS, ERRORS OR DEFECTS IN WARRANTORS' PRODUCTS OR SERVICES, SUCH LIABILITY SHALL NOT EXCEED THE TOTAL AMOUNT PAID BY THE CUSTOMER FOR WARRANTORS' PRODUCT AND SERVICES OR $250.00, WHICHEVER IS GREATER. YOU HEREBY RELEASE WARRANTORS FROM ANY AND ALL OBLIGATIONS, LIABILITIES AND CLAIMS IN EXCESS OF THIS LIMITATION.

INDEMNIFICATION AND COVENANT NOT TO SUE: YOU WILL INDEMNIFY, DEFEND AND HOLD HARMLESS WARRANTORS, THEIR OWNERS, DIRECTORS, OFFICERS, EMPLOYEES, AGENTS, SUPPLIERS OR AFFILIATED COMPANIES, AGAINST ANY AND ALL CLAIMS, DEMANDS OR ACTIONS BASED UPON ANY LOSSES, LIABILITIES, DAMAGES OR COSTS, INCLUDING BUT NOT LIMITED TO DAMAGES THAT ARE DIRECT OR INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL, AND INCLUDING ATTORNEYS FEES AND LEGAL COSTS, THAT MAY RESULT FROM THE INSTALLATION, OPERATION, USE OF, OR INABILITY TO USE WARRANTORS' PRODUCTS AND SERVICES, OR FROM THE FAILURE OF THE WARRANTORS' SYSTEM TO REPORT A GIVEN EVENT OR CONDITION, WHETHER OR NOT CAUSED BY WARRANTORS' NEGLIGENCE.

YOU AGREE TO RELEASE, WAIVE, DISCHARGE AND COVENANT NOT TO SUE WARRANTORS, THEIR OWNERS, DIRECTORS, OFFICERS, EMPLOYEES, AGENTS, SUPPLIERS OR AFFILIATED COMPANIES, FOR ANY AND ALL LIABILITIES POTENTIALLY ARISING FROM ANY CLAIM, DEMAND OR ACTION BASED UPON ANY LOSSES, LIABILITIES, DAMAGES OR COSTS, INCLUDING BUT NOT LIMITED TO DAMAGES THAT ARE DIRECT OR INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL, AND INCLUDING ATTORNEYS FEES AND LEGAL COSTS, THAT MAY RESULT FROM THE INSTALLATION, OPERATION, USE OF, OR INABILITY TO USE WARRANTORS' PRODUCTS AND SERVICES, OR FROM THE FAILURE OF THE WARRANTORS' SYSTEM TO REPORT A GIVEN EVENT OR CONDITION, WHETHER OR NOT CAUSED BY WARRANTORS' NEGLIGENCE, EXCEPT AS NECESSARY TO ENFORCE THE EXPRESS TERMS OF THIS LIMITED WARRANTY.

EXCLUSIVE WARRANTY: THE LIMITED WARRANTY OR WARRANTIES DESCRIBED HEREIN CONSTITUTE THE SOLE WARRANTY OR WARRANTIES TO THE PURCHASER. ALL IMPLIED WARRANTIES ARE EXPRESSLY DISCLAIMED, INCLUDING: THE WARRANTY OF MERCHANTABILITY AND THE WARRANTY OF FITNESS FOR A PARTICULAR USE AND THE WARRANTY OF FITNESS FOR A

PARTICULAR PURPOSE AND THE WARRANTY OF NON-INFRINGEMENT AND/OR ANY WARRANTY ARISING FROM A COURSE OF DEALING, USAGE, OR TRADE PRACTICE.

IT MUST BE CLEAR THAT THE WARRANTORS ARE NOT INSURING YOUR PREMISES OR BUSINESS OR GUARANTEEING THAT THERE WILL NOT BE DAMAGE TO YOUR PERSON OR PROPERTY OR BUSINESS IF YOU USE THIS PRODUCT. YOU SHOULD MAINTAIN INSURANCE COVERAGE SUFFICIENT TO PROVIDE COMPENSATION FOR ANY LOSS, DAMAGE, OR EXPENSE THAT MAY ARISE IN CONNECTION WITH THE USE OF PRODUCTS OR SERVICES, EVEN IF CAUSED BY WARRANTORS' NEGLIGENCE. THE WARRANTORS ASSUME NO LIABILITY FOR INSTALLATION OF THE PRODUCT AND/OR INTERRUPTIONS OF THE SERVICE DUE TO STRIKES, RIOTS, FLOODS, FIRE, AND/OR ANY CAUSE BEYOND SELLER'S CONTROL, FURTHER SUBJECT TO THE LIMITATIONS EXPRESSED IN ANY LICENSE AGREEMENT OR OTHER AGREEMENT PROVIDED BY WARRANTORS TO PURCHASER.

THE AGREEMENT BETWEEN THE WARRANTORS AND THE PURCHASER, INCLUDING BUT NOT LIMITED TO THE TERMS AND CONDITIONS HEREIN SHALL NOT BE GOVERNED BY THE CONVENTION FOR THE INTERNATIONAL SALE OF GOODS. WHERE APPLICABLE, THE UNIFORM COMMERCIAL CODE AS ADOPTED BY THE STATE OF DELAWARE SHALL APPLY.

4. **PROCEDURE FOR OBTAINING PERFORMANCE OF WARRANTY**: IN THE EVENT THAT THE PRODUCT DOES NOT CONFORM TO THIS WARRANTY, THE PRODUCT SHOULD BE SHIPPED OR DELIVERED FREIGHT PREPAID TO A WARRANTOR WITH EVIDENCE OF ORIGINAL PURCHASE.

5. **LEGAL REMEDIES AND DISCLAIMER**: SOME JURISDICTIONS MAY NOT ALLOW, OR MAY PLACE LIMITS UPON, THE EXCLUSION AND/OR LIMITATION OF IMPLIED WARRANTIES, INCIDENTAL DAMAGES AND/OR CONSEQUENTIAL DAMAGES FOR SOME TYPES OF GOODS OR PRODUCTS SOLD TO CONSUMERS AND/OR THE USE OF INDEMNIFICATION TERMS. THUS, THE EXCLUSIONS, INDEMNIFICATION TERMS AND LIMITATIONS SET OUT ABOVE MAY NOT APPLY, OR MAY BE LIMITED IN THEIR APPLICATION, TO YOU. IF THE IMPLIED WARRANTIES CAN NOT BE EXCLUDED, AND THE APPLICABLE LAW PERMITS LIMITING THE DURATION OF IMPLIED WARRANTIES, THEN THE IMPLIED WARRANTIES HEREIN ARE TO BE LIMITED TO THE SAME DURATION AS THE APPLICABLE WRITTEN WARRANTY OR WARRANTIES HEREIN. THE WARRANTY OR WARRANTIES HEREIN MAY GIVE YOU SPECIFIC LEGAL RIGHTS THAT WILL DEPEND UPON THE APPLICABLE LAW. YOU MAY ALSO HAVE OTHER LEGAL RIGHTS DEPENDING UPON THE LAW IN YOUR JURISDICTION.

6. **CHOICE OF FORUM AND CHOICE OF LAW**: IN THE EVENT THAT A DISPUTE ARISES OUT OF OR IN CONNECTION WITH THIS LIMITED WARRANTY, THEN ANY CLAIMS OR SUITS OF ANY KIND CONCERNING SUCH DISPUTES SHALL ONLY AND EXCLUSIVELY BE BROUGHT IN EITHER THE COURT OF COMMON PLEAS OF DELAWARE COUNTY, PENNSYLVANIA OR THE UNITED STATES DISTRICT COURT FOR THE EASTERN DISTRICT OF PENNSYLVANIA.

REGARDLESS OF THE PLACE OF CONTRACTING OR PERFORMANCE, THIS LIMITED WARRANTY AND ALL QUESTIONS RELATING TO ITS VALIDITY, INTERPRETATION, PERFORMANCE AND ENFORCEMENT SHALL BE GOVERNED BY AND CONSTRUED IN ACCORDANCE WITH THE LAWS OF THE STATE OF DELAWARE, WITHOUT REGARD TO THE PRINCIPLES OF CONFLICTS OF LAW.

Effective date 02/25/2015

PHONETICS, INC. d.b.a. SENSAPHONE

901 Tryens Road

Aston, PA 19014
Phone: 610.558.2700 Fax: 610.558.0222
www.sensaphone.com

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CHAPTER 1: INSTALLATION

INTRODUCTION

Congratulations on your purchase of the Sentinel Monitoring System. The system is designed to be an easy, cost–effective, cloud–based monitoring and data logging system to notify you when equipment or conditions go awry. The internet browser–based programming makes the device easy to use from any computer or tablet. Monitored conditions can include temperature, humidity levels, pressure, flow, leak detection, UPS systems, and more. The system allows multiple users to be notified immediately of any detected problems. Notification can occur via voice call, e–mail or SMS (text message), however voice calls and text messages require a premium subscription plan. The internal battery backup system insures the unit will continue to run if main power fails.

FEATURES

The Sentinel includes the following key features:

- Twelve sensor inputs to monitor environmental conditions and/or alarm contacts from other equipment.
- 10/100BASE-T Ethernet port.
- Battery backup for uninterrupted performance.
- Compact design allows wall-mount or weatherproof installation.
- Notification via e–mail, text message (optional) and voice call (optional).
- Relay output capable of automatic or manual control.
- Cloud–based user interface for programming, data storage, and alarm delivery.
- Available in optional weatherproof NEMA 4X enclosure
- Available with cellular modem in weatherproof NEMA 4X enclosure

TECHNICAL SUPPORT

If any questions arise upon installation or operation of the Sentinel, please contact the Sensaphone Technical Service Department at 610.558.2700 and have the following information available:

- Date of purchase ___________________
- Serial number ___________________

Technical support is available from 8:00 AM to 5:00 PM, M-F, eastern time.

ABOUT THIS MANUAL

This manual comprises the instructions necessary to install and setup the Sentinel. You should thoroughly read this manual to establish a basic understanding of the system and keep it as a reference.

INSTALLATION AND CONFIGURATION

PHYSICAL DESCRIPTION

The Sentinel is housed in a 5.5” x 5.5” x 1.5” enclosure, which can be easily mounted on a wall or back panel.

LAYOUT

The Sentinel has connections for twelve sensor inputs, an Ethernet port, and 12VDC power. See figure below:

Figure 1: Front Panel Layout of the Sentinel

1) Acknowledge/Standby Button
2) On/Off Switch
3) Power, Online, Standby LEDs
4) Alarm LEDs
5) Power Jack
6) Ethernet Jack
7) Sensor Input Terminal Strip
8) Relay Output Input

RJ-45 10/100BASE-T ETHERNET PORT

This jack is for connecting to your network so that the device can communicate with the Sentinel servers. Two LEDs indicate when the Sentinel has a valid link (green) and transmitted/received data (yellow).

SENSOR INPUTS

The sensor inputs labeled zones 1-12 are designed to interface with normally open/normally closed devices, 2.8K or 10K temperature sensors and 4-20mA transducers.

POWER ON LED (GREEN)

This light indicates that the Sentinel unit is powered and operational.

ALARM LEDS (RED)

The Alarm LEDs indicate if an alarm exists.

ONLINE LED (GREEN)

This light indicates that the Sentinel unit is communicating with the Sentinel servers.

STANDBY LED (YELLOW)

This light indicates that the Sentinel unit is in standby mode.

ACKNOWLEDGE/ STANDBY BUTTON

When an unacknowledged alarm exists (as indicated by a blinking red alarm LED), briefly press the button and the alarm LED will stop blinking, indicating that the alarm is acknowledged. To enter Standby mode, press and hold the button for at least 5 seconds until the Standby LED lights up, then release. To exit from Standby mode, hold the button down for 5 seconds until the Standby LED turns off.

INSTALLATION

This section provides information on:

- Operating environment
- Installation
- Connecting sensors
- Network Configuration

PARTS REQUIRED

- Screwdriver and #8 screws
- Network Hub, Switch, or Router that supports 10 or 100 BASE-T with Internet access
- Computer w/Internet Connection

OPERATING ENVIRONMENT

Before you install the Sentinel be sure that your operating environment meets the physical requirements of the equipment.

Operating Temperature:	32° – 122° Fahrenheit (0° – 50° C)
Humidity:	5 – 90 %RH, non-condensing
Power:	115VAC 50/60 Hz outlet within 6’

POWER

Connect the included DC power supply to the power jack on the Sentinel and then plug the power adapter into a 115V AC power outlet.

NETWORK CONFIGURATION

The Sentinel requires an Internet connection to operate. Using the included network cable, connect the Sentinel to your 10/100 network hub, switch, or router. Note that your network must support DHCP for initial configuration. You can change it to a Static IP later if required (see chapter 2). The green ONLINE LED should light up within a few minutes indicating that the device has connected to the Sensaphone.net servers.

> Technical Info: The Sentinel communicates over port 443 (the standard TCP port that is used for websites which use SSL encryption), so this must be open for outbound communication. The device also makes use of port 123 for clock synchronization (NTP), so this must be open for UDP outbound.

WALL MOUNT INSTALLATION

The Sentinel can be wall mounted using dry wall anchors and (4) #8 screws. Follow the steps below:

1) Install four drywall anchors (if necessary). Attach the Sentinel using four #8 tapping screws. See Figure 2 for dimensions.

2) Attach sensors to the zone terminals.

3) Plug the power adaptor into a 115VAC 50/60Hz outlet.

4) Connect a CAT5 cable to the Ethernet port and connect to a 10/100 network hub, switch or router.

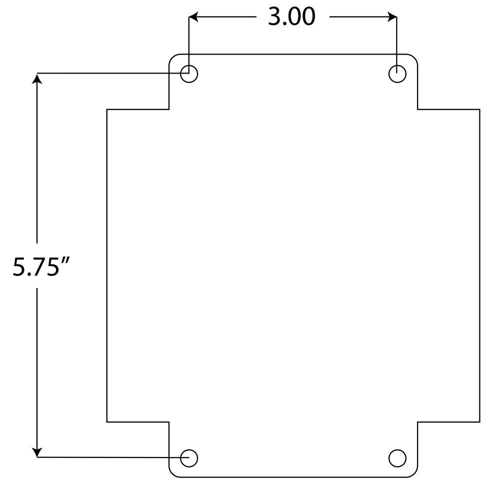


Figure 2: Sentinel mounting dimensions

CONNECTING SENSORS

The Sentinel is compatible with a wide variety of sensors including normally open/normally closed contacts, 2.8K and 10K temperature sensors, and 4–20mA current sources. Compatible sensors and accessories are shown on the Sentinel website. Sensors may be connected while the device is powered on or off. A proper size screwdriver is provided for your convenience. Contact Sensaphone or your Sensaphone reseller for assistance in selecting sensors for your monitoring requirements. A list of sensors and accessories is shown in Appendix B. Follow the instructions below to properly wire and configure the inputs for each type of electrical signal.

Warning: The inputs are designed to work with low voltage signals. DO NOT connect voltages greater than 3.3V to the inputs. DO NOT connect 120VAC to the inputs.

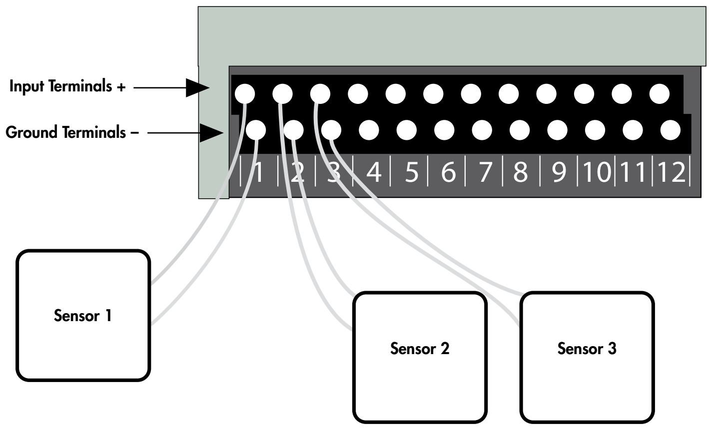
GENERAL WIRING CONSIDERATIONS

Most dry contact sensors can be connected to the Sentinel using inexpensive 2-conductor twisted-pair cable as small as #24 AWG. For temperature and 4–20mA sensors, use the wire chart below as a reference for selecting the appropriate wire gauge. Note that if the sensor is located far from the unit or if you are running cable in an electrically noisy environment, you should seriously consider using shielded cable. This will shield the signal from electrical interference, thereby preventing false readings and/or damage to the unit. For your convenience, Sensaphone has 22 gauge shielded cable available in 50’ lengths (part number FGD-0010). To minimize electrical noise coupling between sensor wires and other wiring, follow the guidelines listed below:

- Route the power supply and network cables to the unit by a separate path then the wiring to the sensor inputs. Where paths must cross, their intersection should be perpendicular.
- Do not run sensor wiring and AC power in the same conduit.
- Segregate wiring by signal type. Bundle wiring with similar electrical characteristics together.
- If shielded cable is used, tie the shield to the input ground terminal.

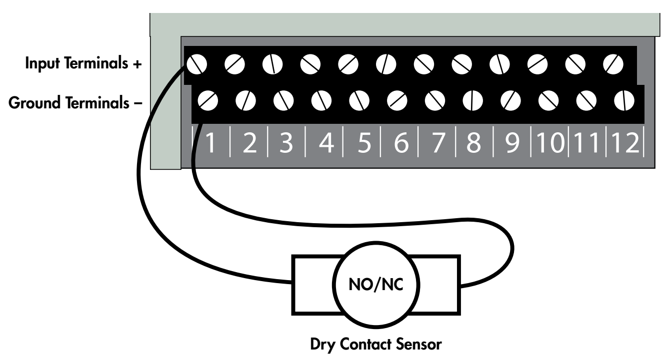
Wiring Distance	Minimum Wire Gauge
700’	#24 AWG
1500’	#22 AWG
2500’	#20 AWG

The zone terminal strip has an upper and lower level for connecting up to 12 sensors. The lower level terminals are all “ground” and are electrically connected together. The upper terminal strip is the positive connection for each sensor. See illustration below.



NORMALLY OPEN / NORMALLY CLOSED DRY CONTACTS

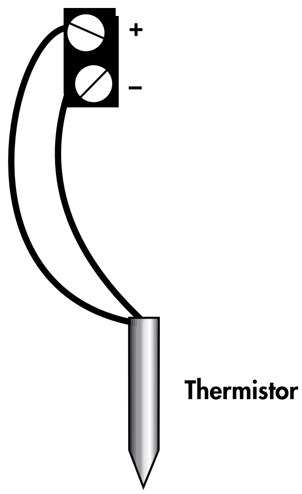
Dry contact sources consist of alarm relays or switches that are isolated and have no external voltage applied. These devices can be connected directly to the zone terminals without regard for polarity. Choose a zone and connect the wires to the corresponding screw terminals for that zone. The following figure shows how to connect a dry contact sensor:



Wiring a Dry Contact Sensor

2.8K/10K TEMPERATURE SENSORS

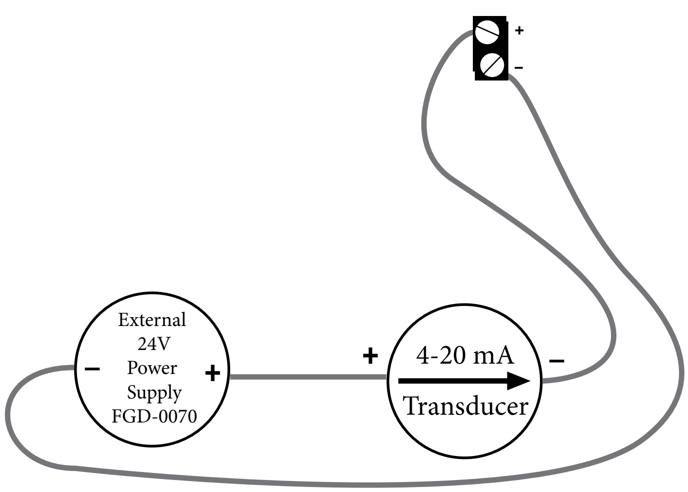
The Sentinel is compatible with 2.8K/10K temperature sensors that match the curve data listed in the tables in Appendix D. The monitoring temperature range of the 2.8K thermistor is -109 to 115ºF (-85º to 57ºC) and the 10K thermistor is -87° to 168°F (-66° to 76°C). Temperature sensors can be connected directly to the zone terminals without regard for polarity. Choose an alarm input and connect the wires to the corresponding screw terminals for that zone. 2.8K and 10K temperature sensors are available from Sensaphone. See Appendix B for part numbers. The figure below shows how to connect a temperature sensor:



Wiring a Temperature Sensor

4–20MA CURRENT LOOP TRANSDUCERS

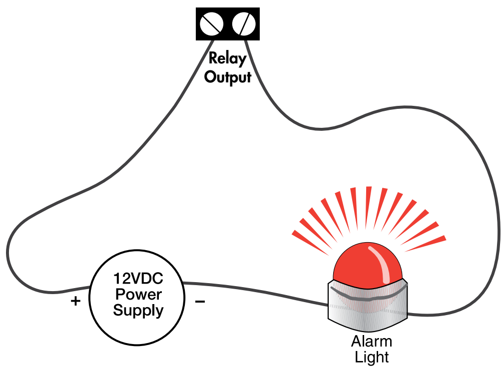
The inputs on the Sentinel are compatible with transducers that produce an analog output current of 4 to 20mA. Such transducers are available to measure tank and well levels, extreme temperatures, air pressure, water pressure, flow, voltage, current, rotational speed, etc. Contact our technical support department for assistance regarding your monitoring requirements (877-373-2700 or support@sensaphone.com). Follow the wiring diagrams below for connecting a 4–20mA device:



Wiring a 4–20mA device using an external 24 VDC supply.

RELAY OUTPUT WIRING

The Sentinel includes a relay output (switch) that can be used to turn on a light, siren, or other device whenever an alarm occurs. The output is a normally–open (i.e. off) dry contact that can be used for low voltage switching. The relay is rated for up to 30VAC/VDC 1 Amp. A sample wiring diagram is shown below:



The relay can be controlled manually (via the website or App) or automatically based on specific inputs or alarms. See chapter 3 for details.

BATTERY BACKUP

The Sentinel has an internal rechargeable battery backup pack (part #BAT-0032) which will provide up to 8 hours of backup time in the event of a power failure. The unit will charge the battery and monitor its charge level. The percent charge can be viewed on the website. The Sentinel contains circuitry to protect the battery from deep discharge damage and will disconnect the battery when all of its available energy has been expended. The battery backup module should last 4 to 5 years.

MEMORY/CLOCK BATTERY

The Sentinel contains a CR2 lithium battery to backup certain values in SRAM memory as well as the real-time clock. This battery should last between 5-10 years depending on how much time the device is powered off. {Note: Units manufactured prior to May 2016 contain a CR2032 lithium coin cell which has an estimated life of 2 - 5 yrs}.

RESETTING THE SENTINEL TO FACTORY DEFAULT SETTINGS

In the event that you can no longer connect to your Sentinel, you can reset the unit to factory defaults. On the bottom of the unit is a small hole. Beneath the hole is a push button. Insert a paper clip or similar item into the hole and push the button for 5 seconds while the device is powered on. The Sentinel will erase all of its programming and then reboot automatically. Alternatively you can also reset the device to defaults from the Sensaphone.net website. Go to the Manage Devices page, under the Admin menu. Select the device, choose Reset to Default Values from the drop down, and click Submit.

CHAPTER 2: SET UP

When your Sentinel "Online" LED is lit you can continue with the following website section.

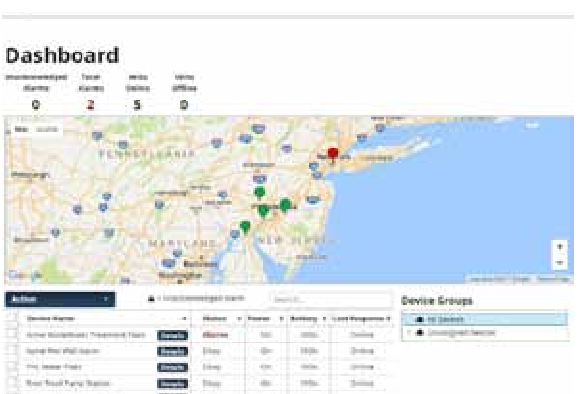
1. Open an internet browser and go to www.sensaphone.net.
2. Fill in the form to create a new account.

3. Once you are logged in, click *Admin*, then *Manage Devices*. In the "Add a Device" section, enter the Serial Number of your Sentinel and enter a device name. Click the *Add Device* button when finished.

Your Sentinel is now online with the Sensaphone.net website. Read the section below to learn how to view status and program your device.

DESCRIPTION OF WEB PAGES

DASHBOARD



The dashboard will list all of the devices on your account. This page is automatically updated with the most current information available.

The numbers at the top will show how many Unacknowledged Alarms, Current Alarms, Units Online, and Units Offline that currently exist for all devices on your account.

The map will show the location of any device on your account that has an address or GPS location listed. You can hover over the icon to see the device name and status. If the icon for the device is green, your device status is OK. If it is red, your device has alarms. You can click on the icon to show the zones for the selected device.

The device table will display all devices on your account. Click on the *Details* button to display and configure the zones for that device. You can also use the search box above the table to search through the table, or click on the table column headers to sort the data.

Device Name – The name of the device

Status – The current status of the device (Okay, Alarms, Offline, or Standby) If the device has any unacknowledged alarms, a symbol will be displayed in this column

Power – Displays if the device is On or Off (--- will display if the device is offline)

Battery – The current percentage of the device battery (--- will display if the device is offline)

Last Response – The time that the device last connected to the server

STANDBY MODE

Standby mode puts the Sentinel in a temporary state such that no alarms will be detected, allowing onsite personnel to perform maintenance or other tasks that may have triggered an alarm otherwise. Standby mode can be entered using the Action drop down on the Dashboard page or via the pushbutton on the front of the unit. Standby mode will persist for the duration of time entered on the Device Configure screen and will automatically exit once the time expires. When using the pushbutton you must depress the button for 5 seconds. The Standby LED will light up to indicate that the device is in Standby mode. You can also exit Standby mode using the same methods.

Standby – Allows you to put the selected devices into Standby mode

Enter – Put the Sentinel in Standby mode for the length of time that is set on the Device Configure page

Enter (Untimed) – Put the Sentinel in Standby mode until you disable it

Exit – Take the device out of Standby mode

DEVICE DETAILS

The device details page displays the sensor values for your Sentinel. This page is automatically updated with the most current information available. At the top of the page are buttons to access the *Configuration*, *Alarm Delivery* and *Logs*.

At the top of the page, you will see the device name, description, address and alarm status.

You will also see all of the zones for your device in the table.

Zone – The name of the zone

Value – The current value of the zone

Status – The current status of the zone

Min/Max – Displays the highest and lowest values recorded

If the device has any unacknowledged alarms, a symbol will be displayed in the status column

The Action dropdown menu provides options that allow you to interact with your device, such as acknowledging alarms, resetting pulse count, runtime and min/max values, and putting the device into standby mode.

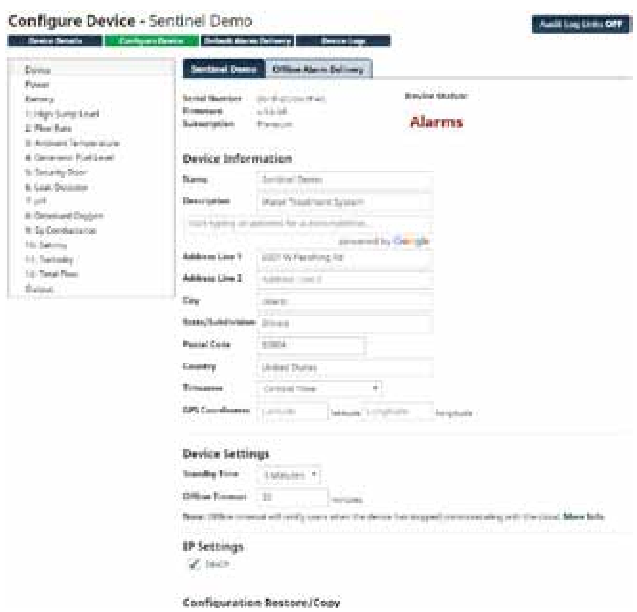
CONFIGURE DEVICE

At the top of the dashboard, click *Configure Device* to go to the device and zone programming screens.

The box on the left will display all of your configureable zones, as well as Device (for general device settings), Power, Battery and Relay Output. As you select an option, the form on the right will change to display the appropriate data. Complete the address so that the Sentinel icon will be displayed at the appropriate location on the dashboard map.

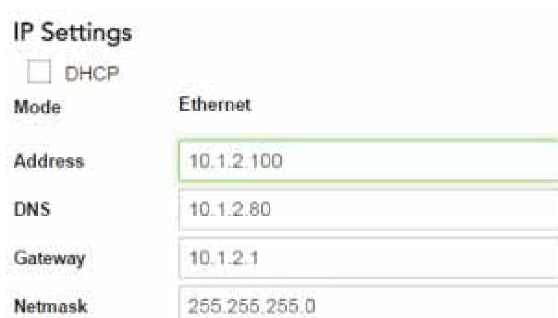
This page also contains settings for the *Device Offline* alarm and for *Standby Mode*. The *Device Offline* alarm will notify you if your devices stops communicating with the sensaphone.net servers for the programmed time duration.

Once you have completed your programming, click on the *Save Settings* button at the bottom of the page.



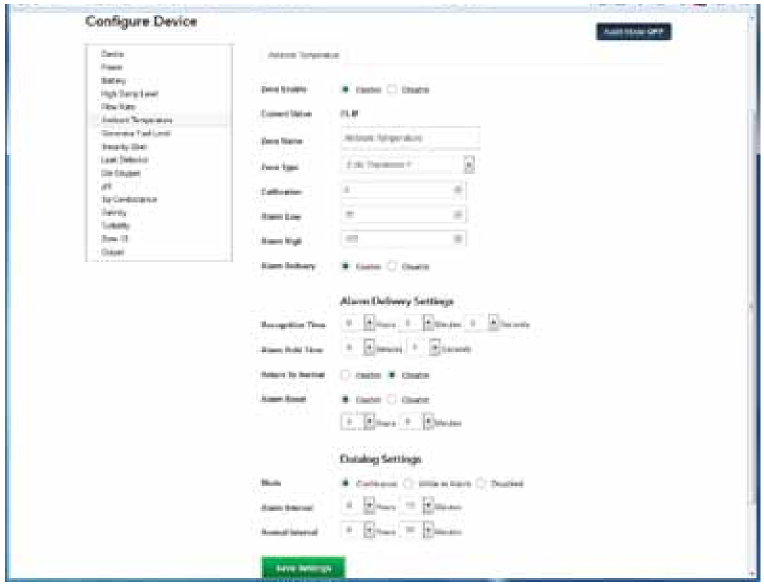
Configuring a Static IP Address

If you would like to assign your device a Static IP address, go to the Configure Device page and scroll down to the IP Settings section. Uncheck the DHCP box and the network settings will appear so that you can enter a Static IP address, Gateway, etc... Click Save to have the new settings take effect.



Zone Programming

Select the zone you would like to configure from the box from the left. A sample screen for a temperature sensor is shown below.



ZONE PARAMETER DEFINITIONS

Enable/Disable: This setting determines if the Zone is being used (Enabled) or not (Disabled). Selecting Disabled will remove the gauge from the Summary screen.

Name: Enter a name for the sensor you are monitoring which describes its purpose and/or location. The name will appear on the Device Details screen as well as on alarm messages.

Type: Choose the type of sensor you are connecting to the Zone input. For temperature sensors choose either degrees F or C.

Units: The Units field is used to describe the units of measure for the value being monitored. When Temperature is selected the Units field will automatically display F (Fahrenheit) or C (Celsius). When a 4-20mA type is selected you can enter the appropriate text for the monitored condition (e.g. %RH, PSI, GPM, RPM,…). When you select Normally Open (NO) or Normally Closed (NC) you can choose from several preset descriptions for the Open and Closed state of the input. The first word always describes the Open state of the contact and the second the Closed state. If you choose Custom you can enter your own text for the Open and Closed states. To do this simply type the words into the lower Units field and separate them with a slash (/). For example, "Slow/Fast", "Safe/Danger", "Dry/Wet".

Calibration: This field can be used to offset the Zone value either positive or negative if there is some error in the reading.

Alarm Low: This is used to determine the low level at which a temperature or 4–20mA Zone has reached the alarm threshold. The value must fall below the Alarm Limit to trip an alarm.

Alarm High: This is used to determine the high level at which a temperature or 4–20mA Zone has reached the alarm threshold. The value must exceed the Alarm Limit to trip an alarm.

Table Low: The Table Low value is used to define the lower range (4mA) of your 4-20mA sensor.

Table High: The Table High value is used to define the upper range (20mA) of your 4-20mA sensor.

Alarm Delivery Enable/Disable: When Enabled, alarm messages will be delivered, if set to Disabled alarm messages will not be delivered.

Recognition Time: This is the length of time that an alarm condition must be present before a valid alarm exists and message delivery is started.

Alarm Hold Time: When an alarm occurs, the *Alarm Hold Time* will latch the alarm condition for the programmed time period, thus preventing redundant alarms from sending additional notification messages. This is useful for alarms that are likely to trip several times within a short time period, such as motion detectors.

Return to Normal Enable/Disable: This feature instructs the Sentinel to send a message when a zone input has changed from an alarm condition back to a normal condition. Anyone who received the original alarm message will also be sent the Return-to-Normal message.

Alarm Reset Enable/Disable: This setting enables or disables the Alarm Reset Feature. The Alarm Reset feature is used to re-send alarm messages in the event that a fault condition is not corrected in a timely fashion. If an alarm continues to exist for the duration of the programmed Reset Time (see below) the alarm will reset (reactivate) and the alarm message delivery process will begin all over again. This is an optional feature.

Alarm Reset Time: This is the time allowed for an alarm's fault condition to be corrected before the Sentinel resets (reactivates) the alarm and begins the message delivery process all over again. It is recommended that this be set to no lower than 30 minutes to prevent numerous messages from being sent.

Datalogging Mode: The Sentinel has two modes of data logging for each zone: Continuous or While In Alarm. In Continuous mode the unit will log the value of the input on a fixed time interval all the time. The Normal Interval sets the logging rate while the value is within the normal range. The Alarm Interval sets the logging rate while the value is an alarm condition. By choosing the While In Alarm mode you can choose to have the unit only log values when it exceeds the alarm limits.

Alarm Datalog Interval: This is the interval that data will be logged while the input is beyond the programmed alarm limits. (Note: this is regardless of the programmed Alarm Recognition Time).

Normal Datalog Interval: This is the interval that data will be logged while the input is within the programmed alarm limits. To maximize the available memory for datalogging, set the Datalog Interval for each zone to multiples of each other. For example, Zone 1 can be set to 10 minutes, Zone 2 to 30 minutes, Zone 3 to 60 minutes, etc…

MANAGE USERS

The sensaphone.net website allows you to set up users that will be linked to your account. Each user can be configured to have their own login for website access and/or be contacted for alarms. In addition, you can choose to give alarm acknowledgement capability to each user.

There are several levels of permissions that can be assigned to each user. You can also enter contact information for alarm delivery purposes. From the main menu, select *Users*, then *Manage Users*. To add a new user, click on the *Add User* button. The example below shows a user setup as an administrator with four contact destinations.

The following defines the various permission levels:

Administrator – Full site access, all devices on your account

Supervisor – Gives the user access to the Dashboard, device-specific pages (for example, Device Details), Manage Users, and Manage User Groups, but for only the devices you choose for them (chosen under the Device Groups section of the form). Supervisors will have the ability to create new users, but they can only give the users Supervisor access or lower.

User – Gives the user access to the Dashboard, but only shows the devices you choose for them (chosen under the Device Groups section of the form)

None – No access to the website

Alarm Delivery – Choose whether you would like the user to be able to receive alarm notifications or not.

Disabled – No alarm delivery

Inform Only – User is notified about the alarm, but cannot acknowledge it

Allow Acknowledgement – User is notified about the alarm and is able to acknowledge it

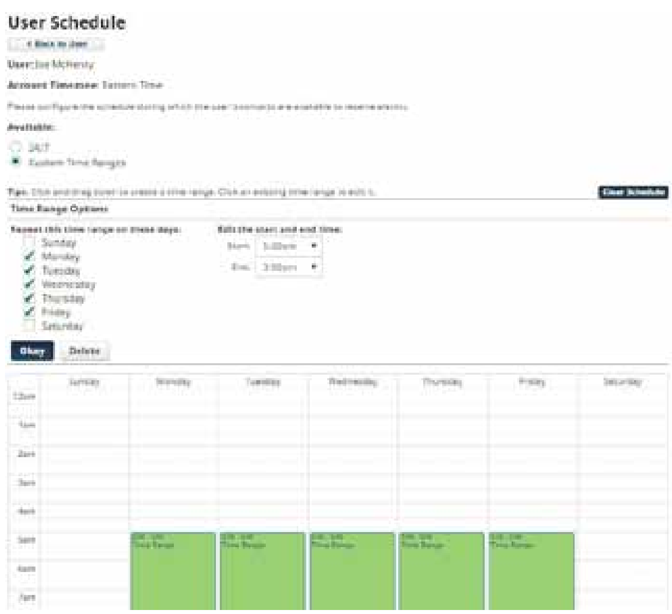
User Information

Next, enter details about this user. The user's name is the only required information.

Contact Details

The *Contact Details* section is where you enter the telephone numbers, text numbers, and email addresses to send alarm messages. {*Note that phone calls and text messages require a Premium Ethernet or Cellular subscription. Email alarm delivery is free*}. A '1' in the beginning of the telephone number is not required. To add additional contacts click "Add Contact". Be sure to add all of your possible contact methods in this section. You can choose which ones get used on the *Default Alarm Delivery Schedule or Zone Alarm Delivery Schedul*e.

You can also create a time schedule to limit when you'll receive alarm messages. There is an overall *User Schedule* as well as individual Schedules for each contact. The default setting for all schedules is enabled, 24/7. In the sample screen below, the highlighted section shows the times when this user will be contacted for alarms:



*Note that if you configure both a User Schedule and individual Contact Schedules, there must be overlap in order for alarm messages to be delivered.

Login Details

Users will login with an email address and password. Enter this information in the *Login Details* section. In the event that a user forgets his/her password they can use the reset password feature on the main login page.

Device Access

For accounts with multiple users and/or devices, you can choose to limit a user's access to selected devices. In the *Device Access* section, choose which units this User can access. See sample screen below:

Click on 'Save Changes' once you are finished.

MANAGE USER GROUPS

Allows you to set up groups of users that can be used on other site pages.

Select the group you wish to edit from the dropdown menu, or select *Create New Group* to make a new group.

Make sure to give each group a unique, descriptive name so they can be easily referenced.

Click on the plus icon to add users to the group. A pop up modal window will show that will list all the alarm users you have added to your account from the Manage Users page (see that page description for more information).

You can select an entire user (all destinations listed under that user at the time of the alarm will be notified) or individual destinations of the user.

Click on the red X icon to remove that user from the group.

Once you are finished adding and removing users, click on the *Save Group* button at the bottom of the page.

ALARM DELIVERY

The Alarm Delivery section is where you configure the people that will be contacted when an alarm occurs. You can setup a *Default Alarm Delivery Schedule* (i.e. contact list) for each device or you can create a separate *Zone Alarm Delivery Schedule* for each individual zone. A combination of both can also be used (e.g. some zones use the default schedule and others use a custom schedule). The first step is to configure your Users and Contacts as described in the *Manage Users* section. If you haven't completed that step please do it first.

Default Alarm Delivery Schedule

To get started select a device from the Dashboard and click *Details*. Next click the *Default Alarm Delivery* button. Click the *Add Destination* button to select people from your User list. You can select all of the User contacts or just a few if desired. See sample screen below:

Continue clicking the *Add Destination* button to add additional User's to the list. If you would like to insert a delay between the first User (or group of Users) and the next User, click the *Add Tier* button and enter the delay time. Users in this Tier will not be contacted until the delay time expires. Click *Save Changes* when your schedule is complete.

*Note that the Tier Delay timer starts at the time the alarm occurs. If the alarm is acknowledged before the delay time expires then Users in the 2nd Tier (and beyond) will not receive the alarm message. See sample programming screen below:

Zone Alarm Delivery Schedule

A Zone Alarm Delivery Schedule is an alarm contact list that only applies to one specific zone. You can create a separate Zone Alarm Delivery Schedule for each individual zone if required. To configure a *Zone Alarm Delivery Schedule* select a Zone from the *Device Details* page. Then click the *Zone Alarm Delivery* tab on the right. Select *Custom* to configure a contact list for the selected zone. Follow the steps as described above to complete the schedule.

Quick-Add Destinations

Quick-Add Destinations are those that can be easily entered to the notification list without creating a User Account. Note, however, that destinations added here will be inform-only (e.g. **cannot acknowledge alarms**). This entry method is useful for sending messages to people who do not require a user account in the system but may want to be informed when a particular alarm occurs.

Alarm Acknowledgment

Alarms can be acknowledged from the dashboard page by selecting a device using the checkboxes next to each device, and then clicking the "Action" drop-down at the top of the screen. You can acknowledge both Device Offline alarms or Zone alarms. Devices with 'Unacknowledged' alarms are identified with an exclamation point within a triangle. Once the alarm is acknowledged this symbol will disappear. You can acknowledge multiple alarms on multiple devices at the same time. Alarms can also be acknowledged during telephone calls by entering 555 when prompted, or by replying to alarm messages sent via email, or by replying to a text message with the letters "Ack".

LOGS

The Sentinel includes an Alarm Log and Data Log. The Alarm Log lists all alarm activity for the selected device. You can narrow down the messages by individual zones or you can select multiple zones. The Data Log contains the recorded values for each zone based on the parameters you set up on the Zone Configuration screens. You can display the values on the screen as well as graph them. There is also an option to Save the data to a file. To get to the Device Logs section, click the *Details* button from the Dashboard for the device you would like to view, then click the *Device Logs* button.

Alarm Log – Shows the history of all alarm notifications that were sent for the device

Data Log – Show the history of all logged zone values and statuses for the device

Export Data - Allows you to save selected Alarm Log or Data Log records in either CSV or pdf format. Note that CSV formatted files can be opened in Microsoft Excel.

Note that for Normally Open and Normally Closed zone types, the Sentinel will record a “0” when the input is presented with an open circuit and a “1” when the input has a closed circuit. Depending on your sensor and programming, this may represent either a normal or alarm condition.

DEVICE MANAGEMENT

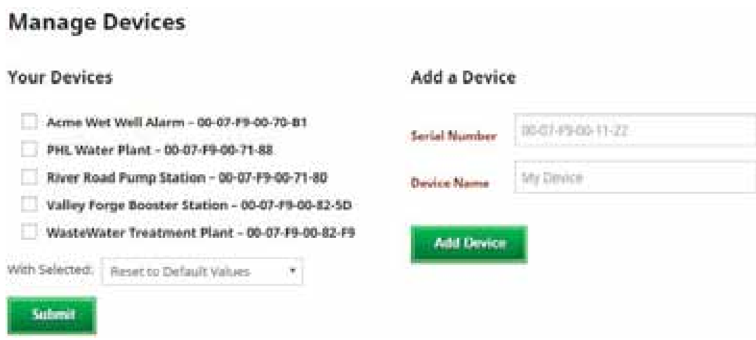
You can add, modify, and remove Sentinel devices from your account on the Manage Devices screen. From the main menu select Admin, then Manage Devices. Listed below are the device-related actions that can be done.

Adding Devices - To add a new device to your account, enter the device serial number (located on the bottom of the unit in the format 00:07:F9:00:00:00) and give the device a name, then click *Add Device*.

Reboot Device - To reboot your device, select it from the list to the left and then choose Reboot Device from the drop down box at the bottom of the page, then click Submit. Your Sentinel will reboot and then reconnect within a few minutes. Your Sentinelgramming will remain intact.

Remove From Account - To remove a device from your account, select it from the list to the left and then choose Remove from Account from the drop-down box at the bottom of the page. Then click *Submit.*

Reset to Default Values - To reset a device to default settings, select it from the list to the left and then choose *Reset to Default Values* from the drop-down box at the bottom of the page. Then click *Submit.* Allow several minutes for your device to complete the reset process.



DEVICE GROUPS

In cases where you have many devices and many users it may be desirable to create Device Groups. These can make it easier to assign device permissions to specified Users. From the main menu select Admin, then Device Groups. In the main window, you will see a list of all your devices and any groups you may have already created. Devices are shown with a green device icon and groups are shown with a black icon. You can have multiple groups, and you can even have groups within a group. If a device icon is lined up on the left-most side of the window, they are not in a group.

To add a new group, click on the Add Group button at the top of the page. A 'New Group' icon will appear in the list. You can rename the group by right clicking on it and selecting Rename. To move a device into a group, click on the device and drag it into the group. Continue adding devices until you're finished, then click Save Groups.

The blue number shown on the group icon shows how many devices are within that group. To remove a group, right click on the group and select Delete. Any devices in that group will be moved up one level. For example, if a group that had two devices was deleted, the two devices would be shifted to the left and would no longer be in any group. You can also click and drag a device or group to reorder them. To search through your devices click on Filters. You can choose to hide any device or group that does not match your search, and you can choose to only search through your devices and not your groups. Once you are finished editing your groups, click on the Save Groups button at the bottom of the page.

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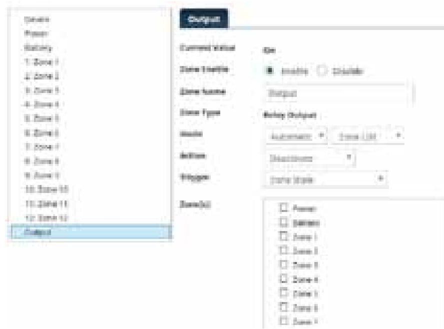
CHAPTER 3: CONFIGURING THE RELAY OUTPUT

The Sentinel includes a relay output that can be used to control a light, siren, or other low voltage device. The output can be configured to switch either manually or automatically when a zone changes state or exceeds the alarm limits. To program the output click *Output* from the *Device Details* or *Configure Device* screen. The following configuration page will appear:



Enter a Name so that you'll know what the Output will be controlling. The Output can operate in Manual mode or Automatic mode. In manual mode you can turn the relay ON or OFF through the web page or the mobile App. To manually switch the relay output, click in the State field and select either ON or OFF, then click *Save Changes*. The change request will be sent to the Sentinel and the *Current Value* will update after the output change has successfully completed.

In Automatic mode the relay can be programmed to turn-on automatically when certain conditions are met. Listed below is a description of the parameters that apply to the automatic modes.

Input Selection - Next to the Automatic mode selection box is another drop-down that allows you to select which zones will control the output. There are four options (Zone List, Type List, All Inputs, and Limit: Zones).

Zone List: This option allows you to individually select which zones will cause the output to switch. Check the boxes next to the desired zones.

Type List: This option allows you select zones based on the zone Type. For example, you could have all of the zones configured for Temperature control the output.

All Inputs: This option selects all of the inputs (zones).

Limit: Zones: This option allows you to independently control the output based on the value of one or two zones using greater-than, less-than, or equal-to comparison statements. A separate Output-On and Output-Off instruction can be configured with its own comparison value. See sample below:

Action - This setting determines what the Output will do when the selected zone (or zones) exceeds the alarm limits. You can have the relay Activate (turn-on), Deactivate (turn-off), or Cycle (ON under normal conditions, momentarily OFF for 10 seconds when an alarm condition occurs, then back ON).

Trigger - The trigger determines what will cause the output to change state. There are 3 options to choose from which are described below:

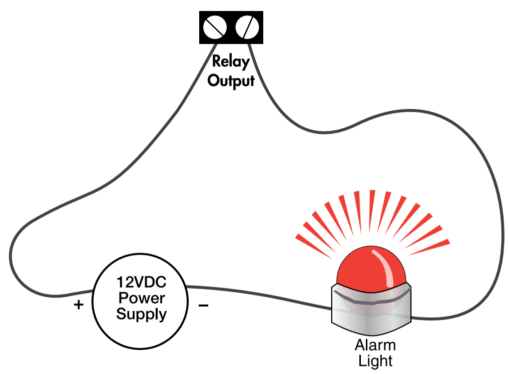
Unacknowledged Alarms: Choosing this option will make the Output change to the setting defined by the Action for as long as an Unacknowledged Alarm persists on the selected zones. Once the alarm is acknowledged the Output will revert back to its normal position.

Alarm Condition: Choosing this option will make the Output change to the setting defined by the *Action* for as long as the selected input(s) remain in Alarm, regardless of acknowledgement. Once the selected zones return to their normal state the Output will revert back to its normal position.

Zone State: Choosing this option will make the output change to the setting defined by the *Action* as soon as the selected zones exceed the alarm limits. In other words, the alarm recognition time is not enforced, and the Output will change instantly. Once the selected zones return to their normal state the Output will revert back to its normal position.

Relay Output Wiring

The relay output can be used to turn on a light, siren, or other low voltage device. The relay is rated for up to 30VAC/VDC 1 Amp. A sample wiring diagram is shown below:



APPENDIX A: WEEKLY TESTING PROCEDURE

We recommend that you test your Sensaphone weekly to be sure it is functioning properly. This will ensure that when a problem arises the Sensaphone will be ready to alert the appropriate personnel.

There are several tests that can be performed:

1.) Create an alarm on each zone by tripping all connected sensors.

Temperature sensors: Heat or cool the sensor.

Motion sensors: Have someone walk in front of the sensor.

Door/window sensors: open the door/window.

Water sensors: Apply a small amount of water beneath the sensor or use a wet towel and touch it to the sensor probes.

Humidity sensors: Raise the humidity around the sensor by holding a cup of very hot water beneath the sensor.

2.) Allow the unit to contact all programmed users. This will make sure that the Sensaphone is programmed properly. It will also prepare personnel to respond appropriately when they receive a message from the Sensaphone.

3.) Test the battery (if installed) by unplugging the AC adapter and making sure that the Sensaphone continues to function. Keep the AC adapter unplugged so that a Power Failure alarm occurs. Plug in the AC adapter after the unit has finished.

4.) Keep a log of your tests, noting the date and whether the Sentinel passed in each category tested. An example of such a log is shown below. (See "Test Log" at the end of this manual.)

WEB600 Test Log

Date	Inputs		Alarm		Battery		
07/19/09	Pass ☒	Fail ☐	Pass ☒	Fail ☐	Pass ☒	Fail ☐	Bob H
08/20/09	Pass ☒	Fail ☐	Pass ☒	Fail ☐	Pass ☒	Fail ☐	Alex G.
09/19/09	Pass ☒	Fail ☐	Pass ☒	Fail ☐	Pass ☒	Fail ☐	Bob H.
	Pass ☐	Fail ☐	Pass ☐	Fail ☐	Pass ☐	Fail ☐	
	Pass ☐	Fail ☐	Pass ☐	Fail ☐	Pass ☐	Fail ☐	

If you require assistance, call Sensaphone Technical Support at 610-558-2700.

APPENDIX B: ACCESSORIES

The sensors listed below are available from Sensaphone, and represent the most commonly used zone devices. Other dry contact sensors, designed for more specialized applications, may also be used. Commercial or industrial electrical supply houses can provide devices to monitor virtually any condition. For further information, contact Sensaphone Customer Service at 610-558-2700.

Part #	Description	Part #	Sensor/Switch
BAT-0032	Sentinel Battery	FGD-0100	2.8k Remote Temperature Sensor
FGD-0006	Magnetic Reed Switch	FGD-0101	2.8k Weatherproof Temperature Probe
FGD-0007	Passive Infra-Red Detector	FGD-0102	10k Weatherproof Temperature Probe
FGD-0010	50’ two-conductor #22AWG shielded Cable	FGD-0103	10k Indoor Decorator
FGD-0013	Spot Water Detector	FGD-0104	10k Outdoor Air Weatherproof
FGD-0022	Temp° Alert	FGD-0205	Multi-Point Wireless I/O System
FGD-0027	Humidistat	FGD-0301	Pressure Sensor
FGD-0049	Smoke Detector with Built-in Relay	FGD-0303	Vibration Sensor
FGD-0052	Humidity 4-20mA Transmitter		
FGD-0053	24VDC Power Supply		
FGD-0054	Power-Out Alert		
FGD-0056	Zone Water Detector w/Water Rope		
FGD-0063	Additional 10’ Water Rope for FGD-0056		
FGD-0065	Carbon Monoxide Sensor		
FGD-0066	Air Quality Sensor		
FGD-0067	Surge Suppressor		
FGD-0070	Power supply with battery backup		

APPENDIX C: SPECIFICATIONS

ALERT ZONES

Number of Zones: 12

Zone Connector: terminal block

Zone Types: N.O./N.C. contact, 2.8K Thermistor (-109° to 115ºF, -85º to 57ºC) And 10K Thermistor (-87° to 168°F; -66° to 76°C), and 4-20mA (-80,000.0 to 80,000.0

Zone Characteristics: 28.7KΩ to 3.3V (temperature/contact) or 250 Ohms to ground (4-20mA)

A/D Converter Resolution: 12 bits ±2 LSB

Zone Protection: 5.5VDC Metal Oxide Varistor with fast acting diode clamps.

Pulse Counting: 1ms minimum duration, 1 pulse-per-second maximum rate

RELAY OUTPUT

Rated for 1A 30VAC/ 1A 30VDC Maximum

DATA LOGGING

1 minute to 24 hour sampling rate

User programmable channel selection

Zones 1 – 12

Battery

Input Power

LED INDICATORS

Power: On steady when the unit is powered on.

Alarm: Off when no alarm exists.

Ethernet Link and Activity LEDs

Online

Standby

COMMUNICATION TYPE:

10/100 BASE-T Ethernet with SSL encryption

POWER SUPPLY

Power Supply: 120VAC/12VDC 50/60Hz 6W wall plug-in transformer w/6’ cord.

Power Consumption: 2 Watts

Power Protection: Metal Oxide Varistor

BATTERY BACKUP

Rechargeable Battery: Internal 8 Hr NiMH Battery Pack (Part # BAT-0032).

Memory/Clock Battery: Internal 5-10 yr CR2 lithium (Part # BAT-0033).

ENVIRONMENTAL

Operating Temperature: 32–122° F (0–50° C)

Operating Humidity: 0–90% RH non-condensing

Storage Temperature: 32°–140° F (0–60° C)

PHYSICAL

SCD-1200

Enclosure: Powder-coated aluminum enclosure with tabs for wall or panel mounting

Physical Dimensions: 5.5" x 5.5" x 1.5" (140 mm x 140 mm x 38 mm)

Weight: 1 lb. (0.45 kg)

SCD-1200-CD, -SD (Weatherproof)

Enclosure: High impact polycarbonate, UL Type 4X/6P (IP66/68)

Physical Dimensions: 9.5" x 11.1" x 3.5" (241 mm x 282 mm x 89 mm)

Weight: 6 lb. (2.72 kg)

SCD-1200-4Gxxxx (Weatherproof w/Cellular Modem)

Enclosure: High impact polycarbonate, UL Type 4X (IP66)

Physical Dimensions: 12.0" x 13.7" x 7.4" (305 mm x 348 mm x 188 mm)

Weight: 14 lb. (6.35 kg)

APPENDIX D: THERMISTORS

2.8K THERMISTOR DATA

Degrees Celsius	Resistance (Ohms)
-50	187,625
-40	94,206
-30	49,549
-20	27,180
-10	15,491
0	9,142
10	5,572
20	3,498
30	2,256
40	1,491
50	1,009
60	697
70	490
80	351

10K THERMISTOR DATA

Degrees Celsius	Resistance (Ohms)
-50	441.3K
-40	239.8K
-30	135.2K
-20	78.91K
-10	47.54K
0	29.49K
10	18.79K
20	12.25K
30	8,194K
40	5,592
50	3,893
60	2,760
70	1,990
80	1,458
90	1,084
100	816.8
120	481.8
130	376.4
140	297.2
150	237.0

APPENDIX E: RETURNING THE UNIT FOR REPAIR

In the event that the Sentinel does not function properly, we suggest that you do the following:

1) Record your observations regarding the Sentinel's malfunction.

2) Call the Technical Service Department at 610-558-2700 prior to sending the unit to Sensaphone for repair.

If the unit must be sent to Sensaphone for Servicing, please do the following:

1) Unplug the AC power supply from the wall outlet and disconnect all sensors from the alert zones.

2) Carefully pack the unit to avoid damage in transit. Use the original container (if available) or a sturdy shipping box.

3) You must include the following information to avoid shipping delays:

a) Your name, address and telephone number.

b) A note explaining the problem.

4) Ship your package to the address below:

SERVICE DEPARTMENT

SENSAPHONE

901 Tryens Road

Aston, PA 19014

5) Ship prepaid and insured via UPS or US Mail to ensure a traceable shipment with recourse for damage or replacement.

APPENDIX F: TEST LOG

Date	Inputs	Alarms	Battery			Tested By
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	
	Pass Fail	Pass Fail	Pass Fail	Pass Fail	Pass Fail	

Date	Inputs	Alarms	Battery			Tested By
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
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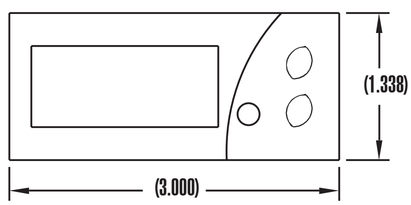
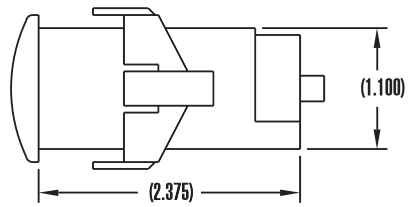
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	
	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	Pass ☐ Fail ☐	

Series TS2 Digital Temperature Switch

Specifications - Installation and Operating Instructions





DESCRIPTION

Monitor and control temperature for heating and cooling applications with the Series TS2 Digital Temperature Switch. The Series TS2 offers twelve programmable functions to customize the unit to fit application requirements. Use the 16 Amp SPDT relay output to drive a motor, compressor, or fan. Designed with the OEM in mind, the TS2 offers the ability to configure multiple units with the touch of a button.

Programming multiple units is quick and easy. Simply program one switch with the desired parameter settings and connect the configuration key (sold separately) to the back of the unit. Press the button on the configuration key and download the parameter settings. Connect the key to the other switches to upload the stored settings with the push of a button.

The TS2 features set point adjustments, static defrost timing, compressor mean time, hysteresis, and ambient probe adjustment. Security protection is offered using a password code. The Series TS2 Digital Temperature Switches are designed to operate with PTC (1000Ω @ 25°C) probes sold separately.

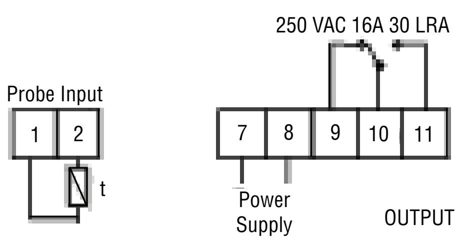
INSTALLATION

The thermostat must be installed by authorized professionals. It should be located in a place free of vibrations, impacts, water and corrosive gases.

A hole measuring 71 x 29 mm must be cut in the panel where the thermostat is to be fitted (apply silicone to make it leaktight). Then, the fixing cups must be fitted, sliding them onto the thermostat until secure. Do not force tightening of the screw if the U-brackets are used. The connections must be covered with the rear cover for this.

WIRING INSTRUCTIONS

Avoid installing the probe's cables in proximity with any power cable. If the length of the probe cables measures more than 100 meters, a recalibration adjustment must be made (parameter P1).



SPECIFICATIONS

Probe Range: -58 to 302°F (-50° to 150°C).
Input: PTC thermistor 1000Ω @ 25°C.
Output: SPDT relay rated 16A @ 240 VAC resistive.
Horsepower Rating (HP): 1 HP.
Control Type: ON/OFF.
Power Requirements: 115 VAC, 230 VAC, 12 VAC/VDC or 24 VAC/VDC (depending on model).
Accuracy: ±1°C.
Display: 3-digit, Red, 1/2″ digits.
Resolution: ±1 digit.
Memory Backup: Nonvolatile memory.
Ambient Operating Temperature: 14 to 158°F (-10 to 70°C).
Storage Temperature: -4 to 176°F (-20° to 80°C).
Weight: 2.3 oz (65 g).
Agency Approvals: CE, cUR, UR.

FRONT OPERATION PUSH BUTTONS

Pushing SET once gives access to the SP. Pushing for 8 seconds gives way to the requested code. After entering the correct code, all parameters are accessible. This button alternates between text parameters and their value. It validates the modified parameters. When pressed with DOWN, it exits parameter programming.

Pressing this arrow allows the user to go to the next parameter or increase the value viewed on the display. When pressed for 8 seconds, it activates or deactivates defrosting.

Pressing this arrow allows the user to go to the previous parameter or decreases the value viewed on the display. When pressed for 8 seconds, it activates or deactivates the continuous cooling cycle. When pressed simultaneously with SET, it exits the programming mode.

LOVE CONTROLS DIVISION
DWYER INSTRUMENTS INC.
P.O. BOX 338 - MICHIGAN CITY, INDIANA 46360, U.S.A.

Phone: 219/879-8000 www.love-controls.com
Fax: 219/872-9057 e-mail:love@love-controls.com

PROGRAMMING PARAMETERS

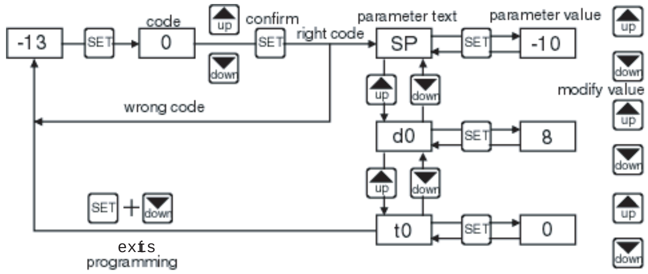
Access only to Set Point SP (without code protection):

- Press and release SET. SP text appears on the display.
- Press SET again. The real value is shown on the display.
- Modify the value using the UP and DOWN keys.
- Press SET to store the new SP value.
- Press SET and DOWN to quit programming, or wait 1 minute for the controller to TIMEOUT.

Access to all parameters (code protected):

- Press SET for 8 seconds. The access code value 00 is shown on the display.
- Using the UP and DOWN buttons, select the code (factory-set code is 00).
- Press SET to enter the code. If it is correct, the first parameter label will be shown on the display (SP).
- Move to the desired parameter with the UP and DOWN keys.
- Press SET to see the value.
- Modify the value with the UP and DOWN keys.
- Press SET to enter it, and exit to next parameter.
- Press SET and DOWN to quit programming, or wait 1 minute for the controller to TIMEOUT.

SETTING THE KEYBOARD CODE TO ZERO



The keyboard code can be set to zero by holding the SET key and turning the controller off then on again.

LED INDICATIONS

Out: This indicates that the compressor is connected. It waits the programmed minimum stop time of the compressor.

Def: This indicates that defrosting is activated.

MESSAGES DISPLAY

In normal operation, the probe temperature will be shown. In case of alarm or error, the following messages will be shown:

- Er- Memory error.
- -- Short-circuited probe error.
- oo- Open probe error.

	Description	Units	Range
SP	Set point	degrees	r1 to r2
r0	Differential or hysteresis	degrees	1 to 20°
r1	Lower value for set point	degrees	-50 to 150°C -58 to 302°F
r2	Higher value for set point	degrees	-50 to 150°C -58 to 302°F
d0	Heating or cooling control	option	Ht/Co
d2	Time for defrosting	minutes	0 to 59´
d8	Interval time between defrosting	hours	0 to 24
c0	Minimum stop time for compressor	minutes	0 to 59´
c1	Continuous cycle time	hours	0 to 24
c2	ON time of fault cycle	minutes	0 to 999
c3	OFF time of fault cycle	minutes	0 to 999
P1	Ambient probe adjustment	degrees	-10° to 10°
P4	Decimal point	option	yes/no
H5	Parameter access code	numeric	0 to 255
H6	Ambient probe type	option	ptc/ntc
t0	Maximum temperature on display	degrees	-50 to 150°C -58 to 302°F

PARAMETERS

PARAMETER DESCRIPTIONS

SP = Set Point. Temperature wished to regulate the machine. Can vary from r1 to r2.

r0 = Differential

For heating control if temperature is > SP then output is OFF. When the temperature drops to <SP - r0 the output is ON.

For cooling control if temperature is < SP then output is OFF. When the temperature increases to > SP + r0 the output is ON.

r1 = Lower Set Point Limit

r2 = Higher Set Point Limit

d0 = Heat or Cooling Control. Ht = heating control, Co = cooling control.

d2 = Defrosting Time Remaining, in minutes. If d2 = 0, defrosting will not start.

d8 = Interval Between Two Defrostings, in hours.

c0 = Minimum time for compressor to be OFF. Minimum time from when the compressor stops till it connects again.

c1 = Continuous Cycle Time. The remaining time for a continuous cold cycle.

c2 = ON time of fault cycle, during probe error.

c3 = OFF time of fault cycle, during probe error.

P1 = Ambient Probe Calibration. Offsets degrees to adjust the ambient probe.

P4 = Decimal Point. Display decimal point in normal operation. Always present in parameter menus.

H5 = Access Code to Parameters. Factory-set as 00.

H6 = Ambient Probe Type. Sets probe type to be NTC or PTC.

t0 = Temperature Display Limit. Maximum temperature shown on the display, although the real temperature can be greater.

OPERATION IN CASE OF ERROR

If the probe or thermostat memory should fail, the compressor will be connected for 5 minutes ON then 5 minutes OFF.

MAINTENANCE

CLEANING

Clean the surface of the display controller with a soft, damp cloth. Never use abrasive detergents, petrol, alcohol or solvents.

REPAIRS

After final installation of the TS Series Digital Temperature Switch, no routine maintenance is required. A periodic check of system calibration is recommended. The devices are not field repairable and should be returned to the factory if recalibration or other service is required. After first obtaining a Returned Goods Authorization (RGA) number, send the material, freight prepaid, to the following address. Please include a clear description of the problem plus any application information available.

Dwyer Instruments,Inc.
Attn: Repair Department
102 Highway 212
Michigan City, IN 46360 U.S.A

Printed in U.S.A. 7/14

FR# R0-443771-00 Rev. 4

LOVE CONTROLS DIVISION
DWYER INSTRUMENTS INC.
P.O. BOX 338 - MICHIGAN CITY, INDIANA 46360, U.S.A.

Phone: 219/879-8000 www.love-controls.com
Fax: 219/872-9057 e-mail:love@love-controls.com

10K Series

OUTDOOR AIR TEMPERATURE SENSOR

Minimize radiant energy effects

The 10K Outdoor Air Weatherproof Temperature sensor is a sensitive temperature element with a stainless steel tube sheathe. It is mounted inside a ventilated, treated weather–resistant PVC shield to minimize radiant energy effects and mounted on a weatherproof outlet box for easy outdoor installation. Accurate to ±0.36°F (0.2°C) with a sensing range of -30° to 140°F. 8’ of 24AWG wire included

TECH SPECS

Name	Outdoor Air Temperature Sensor
Sensor Temperature Range	-30° to 140°F | -34° to 60°C
Accuracy	± .36°F | ±.2°C
Connection	Hardwired
Housing	PVC Shield, Weatherproof Metal Outlet Box
Dimensions	9 x 3 x 2” | 228 x 76 x 51mm
Sensor Series	10K Series

All specifications subject to change without notice

Product Name	Part Number
10K Type Outdoor Air Temperature Sensor	FGD-0104

MADE IN USA

Family owned and made in the USA since 1985

901 Tryens Road
Aston, PA 19301
Phone: 877-373-2700
Web: sensaphone.com

ProSense® SPTD25 Series Pressure Transmitters

Part No. SPTD25-20-0100H

The ProSense SPTD25 pressure transmitter series is engineered to meet many industrial, commercial, and OEM pressure measurement applications. The all-stainless steel thin film sensing element provides very fast response time and can be used to sense any compatible media. With a robust design resistant to vibration, shock, and EMI/RFI, the SPTD25 series provides high accuracy over a wide compensated temperature range. Pressure sensing ranges from 100 to 5000 psig are available with a ¼ inch NPT male threaded process connection and a linear 4-20 mA output with an M12 quick-disconnect electrical connection.

Applications

- Process control & automation
- Pump & compressor control
- Hydraulic systems
- Pneumatic systems
- Engine monitoring
- Presses
- Machine tools

Features

- All-stainless steel sensing element
- Fast response time
- Pressure ranges from 100 to 5000 psig
- 1/4 inch NPT male threaded process connection
- 4-20 mA output
- M12 quick-disconnect electrical connection
- UL508 listed, CE marked
- 3-year warranty

NOTE: CHECK THE CHEMICAL COMPATIBILITY OF THE SENSOR'S WETTED PARTS WITH THE MEDIUM TO BE MEASURED.

ProSense SPTD25 Series Pressure Transmitters				
Part Number	**Description**	**Pcs/Pkg**	**Wt (lb)**	**Price**
SPTD25-20-0100H	Pressure transmitter, 4 to 20 mA output, 0 to 100 psig range, 1/4" NPT male port, M12 connector	1	0.1	$100.00
SPTD25-20-0200H	Pressure transmitter, 4 to 20 mA output, 0 to 200 psig range, 1/4" NPT male port, M12 connector	1	0.1	$100.00
SPTD25-20-0300H	Pressure transmitter, 4 to 20 mA output, 0 to 300 psig range, 1/4" NPT male port, M12 connector	1	0.1	$100.00
SPTD25-20-0500H	Pressure transmitter, 4 to 20 mA output, 0 to 500 psig range, 1/4" NPT male port, M12 connector	1	0.1	$100.00
SPTD25-20-1000H	Pressure transmitter, 4 to 20 mA output, 0 to 1000 psig range, 1/4" NPT male port, M12 connector	1	0.1	$100.00
SPTD25-20-3000H	Pressure transmitter, 4 to 20 mA output, 0 to 3000 psig range, 1/4" NPT male port, M12 connector	1	0.1	$100.00
SPTD25-20-5000H	Pressure transmitter, 4 to 20 mA output, 0 to 5000 psig range, 1/4" NPT male port, M12 connector	1	0.1	$100.00

ProSense SPTD25 Series General Specifications	
Housing Material	Stainless steel 316L (DIN 1.4404); Stainless steel 17-4PH (DIN 1.4542); Polyamide (PA)
Materials (wetted parts)*	Stainless steel 17-4PH (DIN 1.4542)
Operating Temperature	–40 to 194°F (–40 to 90°C)
Medium Temperature	–40 to 194°F (–40 to 90°C)
Storage Temperature	–40 to 212°F (–40 to 100°C)
Protection	IP 67 / IP 69K
Accuracy[1]	< ± 0.5% of full range
Linearity[2]	< ± 0.1% (BFSL) / < ± 0.2% (LS)
Hysteresis	< ± 0.2%
Repeatability[3]	< ± 0.05%
Long-Term Stability[4]	< ± 0.1%

** Not cleaned for oxygen service*
[1] Zero point and span error, non-linearity, hysteresis
[2] BFSL = Best fit straight line / LS = limit value setting
[3] With temperature fluctuations <10°C
[4] In % of the span / 6 months

ProSense SPTD25 Series Pressure Transmitters

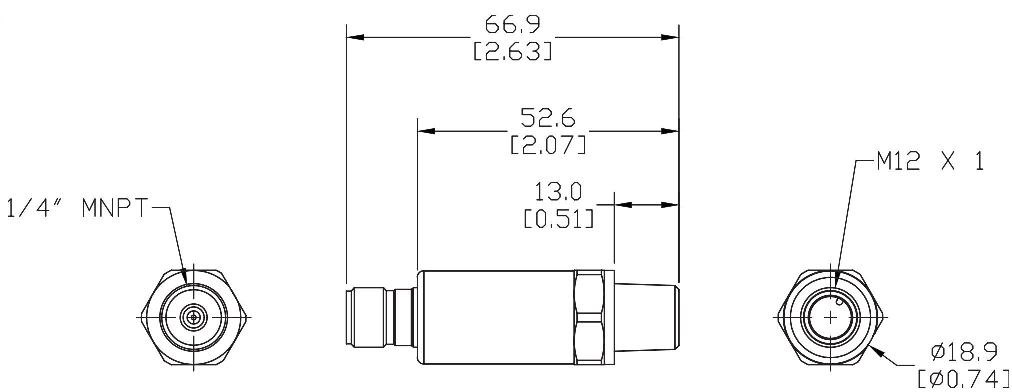
ProSense SPTD25 Series General Specifications Continued	
Operating Voltage	8.5 to 36 VDC*
Analog Output	4 to 20 mA
Maximum Load	[(supply voltage - 8.5) / 21.5 mA]Ω | For example: [(24VDC - 8.5) / 0.0215] = 720Ω
IEC Protection Class	Class III
Step Response Time Analog Output	1 ms
Short-Circuit Proof	yes
Overload Protection	yes
Reverse Polarity Protection	yes
Insulation Resistance	> 100 MΩ: (500 VDC)
Shock Resistance	50g (DIN 60068-2-27, 11ms)
Vibration Resistance	20g (DIN 60068-2-6, 10 - 2000 Hz)
EN 61000-4-2 ESD	4 kV / 8 kV AD
EN 61000-4-3 HF Radiated	30 V/m
EN 61000-4-4 Burst	2kV
EN 61000-4-6 HF Conducted	10V
EC Pressure Equipment Directive 97/23/EC	Article 3, section 3: Group 2 Non-Hazardous, Non-flammable, Non-oxidizing
EMC	DIN EN 61000-6-2; DIN EN 61000-6-3
MTTF (Years)	784
Min. Pressure Cycles	60 million lifetime (at 1.2 times the nominal pressure)
Agency Approvals	cULus (E320431), CE, RoHS

*** per EN50178, SELV, PELV***

WARNING! AVOID STATIC AND DYNAMIC OVERPRESSURE EXCEEDING THE GIVEN OVERLOAD PRESSURE.
EXCEEDING THE BURSTING PRESSURE FOR EVEN A SHORT TIME CAN CAUSE DESTRUCTION OF THE UNIT AND POSSIBLE INJURIES!

Dimensions

mm [inches]



See our website www.AutomationDirect.com for complete Engineering drawings.

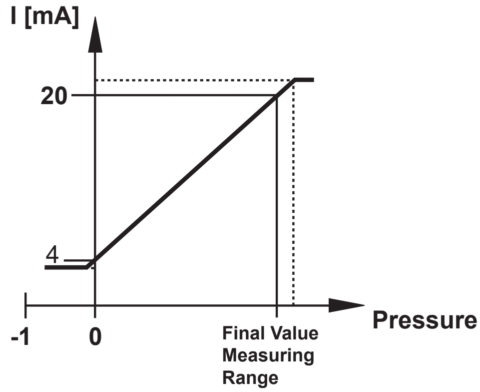
ProSense® SPTD25 Series Pressure Transmitters

Pressure Ratings

Applications (Type of Pressure: Gauge Pressure, Liquids and Gases)			
Part Number	***Final Value of the Measuring Range***	***Static Proof Pressure Resistance (Max. Permissible Pressure)***	***Bursting Pressure***
	Psig	***Psig***	***Psig***
SPTD25-20-0100H	100	250	2900
SPTD25-20-0200H	200	580	6525
SPTD25-20-0300H	300	940	8700
SPTD25-20-0500H	500	1450	11600
SPTD25-20-1000H	1000	2500	13050
SPTD25-20-3000H	3000	7250	14500
SPTD25-20-5000H	5000	14500	24650

All SPTD25 series transmitters can withstand vacuum down to -14.5 psig

Current Output 4-20 mA



In the measuring range the output signal is between 4 and 20mA. If the system pressure is above or below the measuring range, the analog output performs as follows:

- System pressure above the measuring range: 20...25mA non-linear
- System pressure below the measuring range: 4...3mA non-linear

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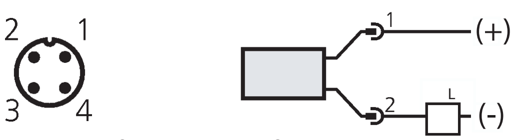
SPTD25-20 Wiring Diagrams



Cable Assembly Wiring Colors:
Pin 1 - Brown +
Pin 2 - White - Out
Pin 3 - Blue, not used
Pin 4 - Black, not used

See Proximity Sensor section for cable specs

Note: Wiring colors are based on AutomationDirect CD12L and CD12M 4-pole cable assemblies.

The TDH41 Series Low Cost OEM Vacuum and Compound Range Pressure Transducer

SERIES: TDH41

APPLICATIONS

- Hydraulic / Mobile Hydraulic
- Pneumatic Systems
- Food and Beverage Industry
- Pumps and Compressors
- Energy and water management
- Construction and Agricultural Equipment

DESCRIPTION

The TDH41 Series Pressure Transducer utilizes piezoresistance technology in an all stainless steel body. It is compact in size, has long term stability, ease of installation and is very economical as well as reliable.

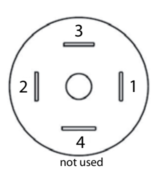
The TDH41 sets a new price-performance standard for low cost, high volume commercial and industrial applications.

FEATURES

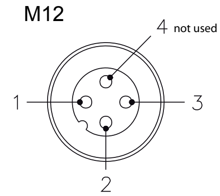
- Vacuum to 85 psi Ranges
- Various Outputs
- Compact Design
- 316 Stainless steel Housing
- Low Cost
- Industrial 1% Accuracy
- Custom Outputs and Ranges Available
- OEM Tested and Approved
- Low power consumption

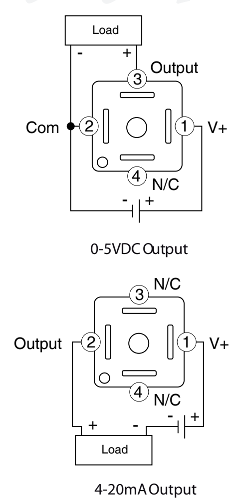
ELECTRICAL CONNECTIONS

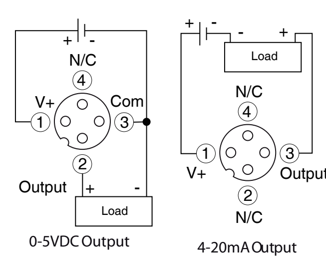
Signal	Function	Color	Pin	Electrical Connector
0-5V	Supply V + Com Output	Red Black White	1 2 3	DIN 4 pin (9.4)
4-20mA	Supply V + Output	Red Black	1 2	



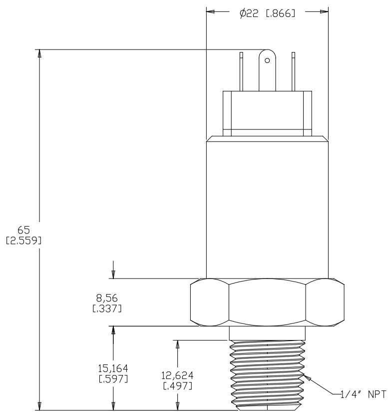
Signal	Function	Color	Pin	Electrical Connector
0-5V	Supply V + Output + Com	Brown White Blue	1 2 3	M12
4-20mA	Supply V + Output	Brown Blue	1 3	

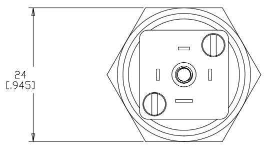






DIMENSIONS





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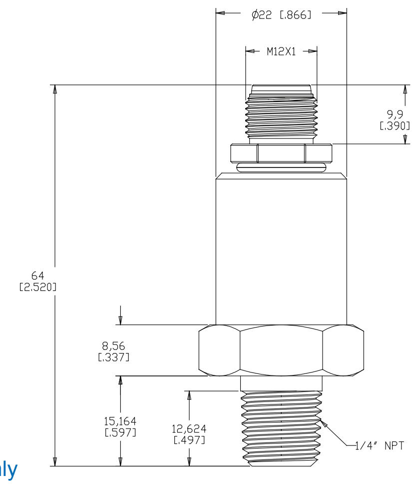

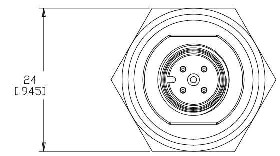

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Dimensions are in mm [inches] and for reference only

SPECIFICATIONS

Performance @ 25°C (77 °F)	
Accuracy	1% FS, BFSL
Stability	0.2% FS
Thermal Error	1% FS
Compensated Temperatures	-10 to 75 ° C (14 to 167 ° F)
Operating Temperatures	-20 to 80 ° C (-4 to 176 ° F)
Current Consumption	Approx 4mA for 0-5 & 0.5-4.5 voltage output, 11mA for 0-10 voltage output, 23mA for current output (4-20mA)
Zero and Span Offset Tolerance	1.5%
Shock	50g, 11ms, 1/2 sign
Vibration	11g peak from 10 to 400 Hz
Reverse Polarity Protection	Yes

Mechanical Configuration	
Pressure Port	1/4 NPT (standard) *
Electrical Connection	9.4 mini DIN, 3 pin Packard *
Ingress Rating	IP65 with T-Direct standard 9.4 DIN cable
Housing	316 stainless steel
Diaphragm Material	316 SS - Vac-0, Vac-15, Vac-45 Ceramic - Vac-85
Sealing Material	Neoprene
Approvals	CE

Input	
Supply Voltage / (Output)	8-28 VDC (0-5V, 4-20mA) 5 VDC (0.5-4.5V) 12-36 VDC (0-10V)
Pressure Range	Vacuum to 85 psig*
Proof Pressure	1.5 x full scale
Burst Pressure	3 x full scale
Fatigue Life	More than 4 million cycles

For best performance use shielded cables.

Mating connectors and cable assemblies sold separately.

* Consult factory for further OEM options.

ORDERING

Series	Output	PressureType	Pressure Range	Pressure Port	Electrical Connection	Accuracy
TDH41	B	G	V000	03	D00	5
			(psi)			
	B = 4-20mA C = 0-5V (3 wire) **	G = Gauge	Vac-0= V000 Vac-15= V015 Vac-45= V045 Vac-85= V085 **	03= 1/4"NPT Male **	D00= 4 pin 9.4 DIN Q= M12 **	5= 0.4%

**= Consult factory for further OEM options

Pressure ranges and outputs listed above are quick ship versions

REV: 11.17

APPENDIX D
FIELD FORMS

OPERATIONS AND MAINTENANCE MANUAL
AIR SPARGE AND SOIL VAPOR EXTRACTION SYSTEM
CHS AUBURN FACILITY
238 8TH Street Southeast
Auburn, Washington

Farallon PN: 301-004

SVE AND AS SYSTEM MONITORING FORM

System Running	YES/NO	
Visual Inspection of System	YES/NO	
Building Temperature		deg F

AS System

Compressor Run Time		hours
Compressor Running Amps		amps
Compressor Frequency		Hz
Pre-Cooling Array Temperature		deg F
Post-Cooling Array Temperature		deg F
System Pressure		psi

SVE System

Blower Run Time		hours
Blower Running Amps		amps
Blower Frequency		Hz
System Vacuum (Pre KO)		iowc
System Vacuum (Post KO)		iowc
System Flow		dp
System Flow		scfm
Discharge VOC		ppm
Blower Effluent Temp		deg F
KO Level		gallons
KO Storage Tank		% full

Maintenance Schedule

	Conducted Last	Frequency
Inline Blower Filter Inspection		Monthly
Compressor Filter Inspection		Monthly
Compressor Filter Replacement		Annually
Compressor Oil Check		Quarterly
Compressor Oil Change		20,000 Hours
Compressor Surface Cleaning		Quarterly

SVE Well	Vacuum (iowc)	dp (iowc)	Flowrate (scfm)	PID (ppm)
CSVE-1				
CSVE-5				
CSVE-7				
CSVE-9				
CSVE-10				

AS Wells	Pressure (psi)	Flowrate (scfm)
CAS-1		
CAS-2		
CAS-3		
CAS-4		
CAS-5		
CAS-7		
CAS-14		
CAS-15		
CAS-16		
CAS-17		
CAS-18		
CAS-19		
CAS-20		
CAS-21		
CAS-22		
	Total:	

APPENDIX E
SITE HEALTH AND SAFETY PLAN

OPERATIONS AND MAINTENANCE MANUAL
AIR SPARGE AND SOIL VAPOR EXTRACTION SYSTEM
CHS Auburn Facility
238 8TH Street Southeast
Auburn, Washington

Farallon PN: 301-004

Washington
Issaquah | Bellingham | Seattle
Oregon
Portland | Bend | Baker City
California
Oakland | Folsom | Irvine

HEALTH AND SAFETY PLAN

FIELD ACTIVITIES
CHS AUBURN FACILITY
238 8TH STREET SOUTHEAST
AUBURN, WASHINTON

Submitted by:
Farallon Consulting, L.L.C.
975 5th Avenue Northwest
Issaquah, Washington 98027

Farallon PN: 301-004

For:
CHS, Inc.
763 Willoughby Lane
Stevensville, Montana 59870

March 6, 2019

HEALTH AND SAFETY PLAN
REVIEW AND APPROVAL

Client: CHS, Inc.
Type of Work: Various Field Activities
Start Date: March 11, 2019

Facility Name: CHS Auburn Facility
Project Number: 301-004
End Date: September 11, 2019

Plan Expiration Date: September 11, 2019 (Last day of expected field work or no longer than 6 months)

APPROVED BY:

	Signature	Date
Javan Ruark Project Manager		March 6, 2019
Joseph Rounds Health and Safety Coordinator		March 6, 2019
Paul Grabau Principal-in-Charge		March 6, 2019

This Health and Safety Plan (HASP) was written for the use of Farallon Consulting, L.L.C. (Farallon) and its employees. It may be used also by trained and experienced Farallon subcontractors as a guidance document. However, Farallon does not guarantee the health or safety of any person entering this site.

Due to the potentially hazardous nature of the site and the activities occurring thereon, it is not possible to discover, evaluate, or provide protection for all possible hazards that may be encountered. Strict adherence to the health and safety guidelines set forth herein will reduce, but does not eliminate, the potential for injury. The health and safety guidelines in this HASP were prepared specifically for this site, its conditions, purposes, dates of field work, and personnel, and must be amended if conditions change.

Farallon claims no responsibility for the use of this HASP by others. This HASP will provide useful information to subcontractors and will assist them in developing their own HASP, but it should not be construed as a substitute for their own HASP. Subcontractors should sign this HASP (see Attachment 1, *Health and Safety Plan Acknowledgment and Agreement Form*) as an acknowledgement of hazard information and as notice that this HASP does not satisfy their requirement to develop their own HASP.

CONTENTS

ATTACHMENTS

1.0 SITE-SPECIFIC INFORMATION

Information specifically pertaining to the project site, the scope of work for the project, and related safety concerns are discussed in this section.

1.1 BACKGROUND INFORMATION

Farallon Consulting, L.L.C. (Farallon) has prepared this Health and Safety Plan (HASP) for the property at 238 8th Street Southeast in Auburn, Washington (herein referred to as the Site). The Site is occupied by a CHS facility, which operates as a retail store and warehouse with retail fuel sales, with five operational underground storage tanks. The Site formerly operated as a retail and wholesale outlet for bulk petroleum products, pesticides, herbicides, fertilizer products, and other retail merchandise. Bulk fuel transfer and transportation operations also were formerly conducted at the Site. In 1994, there were reportedly 15 underground storage tanks (USTs), 12 aboveground storage tanks, and 3 multipump fueling stations located on the CHS (former Cenex Marketing and Supply, Inc.) property. Environmental investigations and remedial activities have been conducted at and around the Site since 1994 following the discovery of petroleum hydrocarbons impacts to soil and groundwater on an adjacent property.

1.2 SCOPE OF WORK

This HASP was prepared for the use of Farallon personnel while performing the following tasks at the Site in accordance with the Farallon's Standard Operating Procedures (SOPs):

- Subsurface investigation activities to further evaluate subsurface conditions in soil and groundwater at the Site, including:
    - Observation of the advancement of borings and installation of groundwater monitoring or remediation wells;
    - Logging of subsurface soil conditions according to Farallon field procedures and standards;
    - Collection of subsurface soil or reconnaissance groundwater samples; and
    - Observation of safe work practices.
- Construction observation activities during the installation and/or modification of remediation equipment at the Site, including:
    - Observation of remediation system equipment installation or modification;
    - Direction of subcontractors during system installation or modification;
    - Measurement and verification of construction design specifications;
    - Conducting an air sparge pilot test; and
    - Observation of safe work practices.

- Periodic groundwater monitoring and sampling activities at new or existing permanent groundwater monitoring wells.

The tasks will be conducted in a manner consistent with the methods and assumptions outlined in the SOPs.

1.3 SITE-SPECIFIC SAFETY CONCERNS

This phase of the project involves boring and monitoring well installation, construction observation, system operations and maintenance activities, and groundwater sampling activities. Specific hazards that the field employee(s) will encounter on this project include, but are not limited to:

- Working around heavy equipment;
- Working with hand tools and small mechanical equipment;
- Pedestrian traffic;
- Truck traffic;
- Pinch points;
- Work exclusion zone safety;
- Slips, trips, and falls;
- Loud noise;
- Chemical exposure related to contaminated soil, groundwater, and windblown dust; and
- Environmental hazards, including exposure to sun, heat, and cold.

2.0 DRUG AND ALCOHOL POLICY

It is Farallon's policy to maintain a drug-free workplace. Farallon has a responsibility to all of its staff members to provide a safe and inoffensive work environment, and a responsibility to its clients to provide accurate and consistent service. For these reasons, Farallon prohibits the following behavior by staff members in the field:

- Use of tobacco in any form by any person at any time in sensitive or hazardous areas that may pose a health and safety or environmental risk. The Site Health and Safety Officer (SHSO) may designate an area away from hazards that is safe for tobacco use.
- Possession or consumption of alcohol and/or marijuana, or being under the influence of alcohol and/or marijuana during field activities.
- Abuse of prescription and/or over-the-counter drugs in such a manner as to negatively impact performance or field safety.
- Possession, use, sale, or being under the influence of illicit drugs while in the field or during any work hours.

Violation of any of the above codes of conduct is grounds for immediate removal from the project Site and discipline in accordance with Farallon company policy. If an incident occurs as a result of an employee's actions, drug and alcohol testing will be performed in accordance with Farallon company policy.

3.0 WEAPONS POLICY

Farallon employees, contractors, subcontractors, and their employees working at the Site are to ensure that they do not bring weapons onto the work site. Weapons include but are not limited to guns, knives, and explosives. Tools that are used during the course of field events, including but not limited to box knives, are exempt from this weapons policy. All vehicles and persons can be subjected to search while working at the property.

Failure to comply with the weapons policy can result in disciplinary action for the individual(s) involved in accordance with Farallon company policy.

4.0 INCIDENT PREPAREDNESS AND RESPONSE

Farallon employees and subcontractors working at the Site must be prepared to respond appropriately to an incident involving injury, illness, death, spills, or utility breaches. This section outlines the degree of preparedness required for employees at a work site, and describes the actions to be taken in the event of a health and safety incident.

4.1 HEALTH AND SAFETY PREPAREDNESS

All individuals working at the Site are required to be familiar with the contents of this HASP. Additionally, the items on the following health and safety preparedness list should be reviewed prior to the commencement of work and during daily health and safety meetings:

- The directions to the hospital (provided in Attachment 2);
- The locations of first aid kits, personal eye washes, and fire extinguishers (located in Site vehicles);
- The locations of the keys to Site vehicles; and
- Hand sign language providing for the immediate stoppage of work (such as a horizontal hand movement in front of the neck).

Additional topics for daily health and safety meetings are included in Attachment 3, Potential Topics for Daily Health and Safety Meeting. Participation in daily health and safety meetings should be documented in Attachment 4, Daily Health and Safety Briefing Log.

4.2 INJURY OR ILLNESS

If an injury or illness occurs, the following actions should be taken, regardless of the severity of the injury or illness:

- Stop work.
- Determine whether emergency response staff (e.g., fire, ambulance) are necessary. If so, dial 911 on a cell phone or the closest available telephone. Describe the location of the injured person and provide other details as requested. If an individual requires non-emergency medical care at a hospital, follow the directions to the nearest hospital, which are provided in Attachment 2. IF EMERGENCY MEDICAL CARE IS NEEDED, CALL 911.
- Administer first aid to the individual immediately, using the first aid kit provided in the Site vehicle. Use the bloodborne pathogens kit and personal eyewash, as needed.
- Notify the SHSO immediately. The SHSO is responsible for preparing and submitting an Incident Report form to Farallon's Health and Safety Coordinator (HSC) within 24 hours of the incident, and for notifying the employee's supervisor and the Principal-in-Charge. The Incident Report form is provided in Attachment 5.

- ***All incidents must be reported to the HSC within 24 hours; however, the actual investigation need not be completed within 24 hours*. A telephone message that includes the date, time, and general incident circumstances should be left at one of the following numbers if the HSC cannot be reached directly**:
    - HSC work phone: (425) 295-0800
    - HSC cell phone: (206) 484-2748
    - If the HSC cannot be located, contact the Principal-in-Charge
- The SHSO will assume responsibility during a medical emergency until emergency response personnel arrive at the Site.

4.3 REPORTING PROCEDURES FOR MINOR CUTS, SCRATCHES, BRUISES, ETC.

Every occupational illness or injury is to be reported immediately by the employee to the SHSO. The SHSO is to complete the Incident Report form provided in Attachment 5, and report the incident to the HSC.

4.4 NEAR MISSES

A near miss is defined as an incident in which no personal injury is sustained and no property damage is incurred, but in which injury and/or property damage could have occurred under slightly different timing or location.

In the event of a near miss, the following actions are to be taken:

- Stop work if there is immediate danger of injury or property damage;
- Report the near miss to the SHSO as soon as practicable;
- Resume work upon satisfactory resolution of the near-miss condition, if work was stopped, and document the corrective action(s) taken by the SHSO; and
- Complete and submit the Near Miss Report and Safety Observation Report form in Attachment 6 to the HSC within 2 business days.

4.5 MEDICAL INCIDENTS NOT REQUIRING AMBULANCE SERVICE

Medical incidents not requiring ambulance services include injuries and conditions such as minor lacerations and sprains. In the event of an injury, an illness, or a condition that does not require ambulance service, the following actions are to be taken:

- Stop work.
- Administer first aid as necessary to stabilize the individual for transport to the hospital.
- The SHSO is to facilitate prompt transportation of the individual to the hospital. Directions to the nearest hospital are provided in Attachment 2.

- A representative of Farallon or the subcontractor is to drive the individual to the medical facility and remain at the facility until the individual is able to return to the work site, or arrangements for further care have been established.
- If the driver is not familiar with the route to the hospital, a second person who is familiar with the route is to accompany the driver and the injured employee to the hospital.
- If it is necessary for the SHSO to accompany the injured employee to a medical facility, provisions must be made for another employee who is trained and certified in first aid to act as the temporary SHSO before work at the work site can resume.
- If the injured employee is able to return to the work site the same day, he/she is to bring a statement from the doctor that provides the following information:
    - Date of incident
    - Employee's name
    - Diagnosis
    - Date he/she is able to return to work, and whether regular or light duty
    - Date he/she is to return to the doctor for a follow-up appointment, if necessary
    - Signature and address of doctor
- The SHSO is to complete the Incident Report form provided in Attachment 5, and report the incident to the HSC.
- If the injured employee is unable to return to the work site the same day, the employee who transported him/her should bring the statement from the doctor back to the work site. The information on this statement should be reported to the HSC immediately.

4.6 EMERGENCY CASES REQUIRING AMBULANCE SERVICE

In the event of an injury or illness that requires emergency response and transport to a hospital by ambulance the following actions should be taken:

- **Dial 911** to request ambulance service;
- Notify the SHSO;
- Administer first aid until the ambulance service arrives;
- One designated company representative should accompany the injured employee to the medical facility and remain there until final diagnosis, treatment plan, and other relevant information has been obtained; and
- The SHSO is to complete the Incident Report form provided in Attachment 5, and report the incident to the HSC immediately.

4.7 EMPLOYEE DEATH, OR HOSPITALIZATION OF ONE OR MORE EMPLOYEES

The procedures outlined in Section 6.2 should be followed in the event of an employee injury or illness. If an employee fatality occurs, the HSC, local emergency personnel, and the coroner must be notified **immediately**. **The HSC will initiate the required State of Washington Department of Labor and Industries and Occupational Safety and Health Administration (OSHA) notifications within 8 hours of a fatality or the hospitalization of one or more employees.**

4.8 RESPONSE TO SPILLS OR UTILITY BREACHES

The location of underground utilities (e.g., product, sewer, telephone, fiber optic) and facilities (e.g., underground storage tanks, septic tanks, utility vaults) is to be noted prior to commencement of intrusive subsurface work activities. Use the public and private locate services as required and complete the Utility Clearance Log (Attachment 7). If a utility line or tank is breached or a spill or release occurs, the event is to be documented on the Incident Report form provided in Attachment 5 as soon as possible. The date, time, name of the person(s) involved, actions taken, and discussions with other affected parties are to be included. The SHSO, Project Manager (PM), and client are to be notified immediately. The PM is to notify the regulatory authority and/or utility company, as necessary.

In the event of a spill or release, the following actions should be taken:

- Stay upwind of the spill or release.
- Don appropriate personal protective equipment (PPE).
- Turn off equipment and other sources of ignition.
- Turn off pumps and shut valves to stop the flow or leak.
- Plug the leak or collect drippings, if possible.
- Use sorbent pads to collect the product and impede its flow, if possible.
- Dial 911 or telephone the local fire department immediately if a fire or another emergency situation develops.
- Inform the Farallon PM of the situation.
- Determine whether the client would like Farallon to repair the damage or would rather use an emergency repair contractor.
- Advise the client of spill discharge notification requirements, and establish who will complete and submit the required forms. ***Do not report or submit information to an agency without the client's consent.*** Document each interaction with the client and regulators, and note in writing names, titles, authorizations, refusals, decisions, and commitments to any action.

- Do not transport or approve transportation of contaminated soils or product until proper manifests have been completed and approved. Be aware that soil and/or product may meet criteria for hazardous waste.
- Do not sign manifests as a generator of wastes. Contact the PM to discuss waste transportation.

4.9 NOTIFICATIONS

A spill or release requires completion of an Incident Report form (provided in Attachment 5) per Farallon's Health and Safety program. **The PM must involve the client and/or generator in the incident reporting process. The client and/or generator is under obligation to report the incident to the appropriate government agency(ies). If the spill extends into waterways, the Coast Guard and the National Response Center must be notified immediately by the client or with client permission (1-800-424-8802).**

4.10 SHUTOFF VALVES AND/OR SWITCHES FOR UTILITIES AND PRODUCTS

Before starting work, locate, discuss, and list on the Daily Health and Safety Briefing Log the locations of utility and product line shutoff valves and switches on the work site. Review the location of shutoff valves and switches with other field personnel before beginning work.

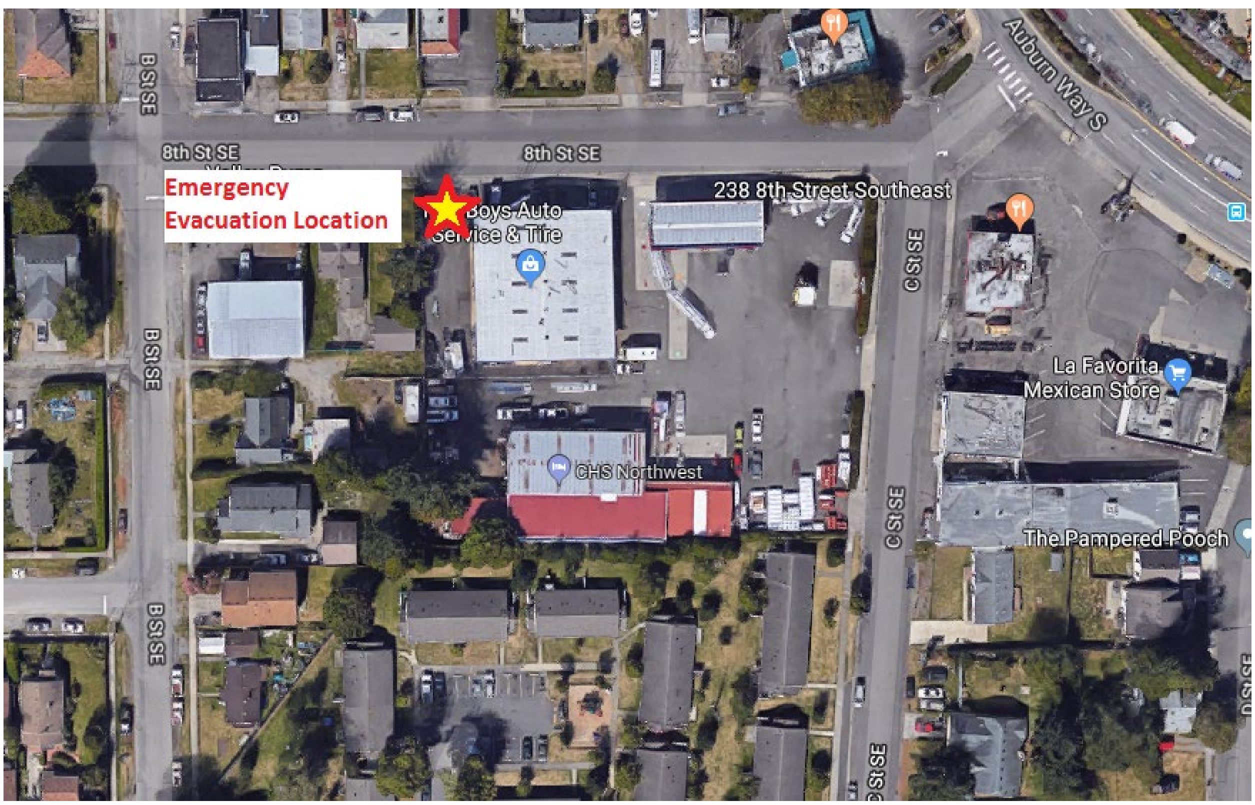
5.0 EMERGENCY RESPONSE AND EVACUATION PLAN

Farallon personnel and subcontractors working on the Site are to be aware of Site-specific emergency and evacuation procedures, including alarm systems and evacuation plans and routes. If an incident occurs that requires emergency response, such as a fire or spill, **CALL 911 and request assistance**. Farallon staff, subcontractors, and/or others working in an area where an emergency occurs are to evacuate to a safe location away from the incident area, preferably upwind, and take attendance.

For this project, the emergency evacuation gathering location is the northwestern corner of the Site as indicated by the star below.

If the emergency causes the route to be obstructed, Farallon personnel and subcontractors are to move to an open area upwind of the hazard area, and remain there until instructed by emergency response personnel (e.g., police, fire, ambulance personnel, paramedics) to do otherwise.

Subcontractors have the responsibility to account for their own employees and provide requested information to emergency response personnel immediately upon request. Farallon staff, subcontractors, and/or contractors may not reenter the scene of the emergency without specific approval from emergency response personnel.



6.0 LOCAL EMERGENCY CONTACT NAMES AND TELEPHONE NUMBERS

Local emergency response personnel can be contacted at the following numbers. Directions and a map to the hospital are included in Attachment 2.

Emergency Contact	Name and Location	Telephone No.
Hospital	Multicare Auburn Medical Center 202 North Division Street Auburn, Washington 98001	(253) 833-7711
Police	Auburn Police Department 340 East Main Street, Suite 201 Auburn, Washington 98002	**911** or (253) 288-2121
Fire	Valley Regional Fire Authority 1101 D Street Northeast Auburn, Washington 98002	**911** or (253) 288-5900
National Response Center		**1-800-424-8802**
Washington State Department of Ecology		**(360) 407-6300**
Poison Control		**1-800-222-1222**

7.0 PROJECT PERSONNEL AND RELEVANT INFORMATION

The following section provides contact information for the project and the HSC and client-specific health and safety requirements. Farallon field personnel training and medical surveillance dates are included in Attachment 8.

7.1 PROJECT PERSONNEL CONTACT INFORMATION

Questions about this project that are posed by neighbors, the press, or other interested parties should be directed to the Principal-in-Charge at Farallon: (425) 295-0803.

PERSONNEL TITLE PERSONNEL NAME PERSONNEL CONTACT INFORMATION	GENERAL PROJECT RESPONSIBILITIES
Health and Safety Coordinator Joseph Rounds Office: (425) 295-0800 Cell: (206) 484-2748	Provide support in implementing HASP. Provide immediate support upon notice of any incident.
Principal-in-Charge Paul Grabau Office: (425) 295-0803 Cell: (360) 319-9257	Provide immediate support upon notice of any incident.
Project Manager Javan Ruark Office: (425) 295-0827 Cell: (425) 765-1898	Provide immediate support upon notice of any incident.
Client Contact Office: (406) 777-0114 Cell: (651) 261-2153	Provide known analytical data from work performed by others. Provide notice of Site hazards. Provide access to Site. Provide information regarding available emergency supplies at the Site.

8.0 POTENTIAL CHEMICAL EXPOSURE

Farallon employees working at the Site may become exposed to the chemicals listed in the table below. These chemicals are present either due to current Site activities or due to the presence of contamination. This table should be reviewed prior to the start of work and questions directed to the SHSO. Air monitoring may be required at the Site based on the scope of work for the project. The Farallon Project Manager and SHSO will let the Farallon Field Scientists know if air monitoring will be required for the scope of work.

The air monitoring table and forms are included in Attachment 9.

POTENTIAL AIRBORNE CHEMICALS ON SITE FOR THIS PROJECT REVIEW THIS TABLE AND CONTACT THE SHSO WITH ANY QUESTION						
Chemical (or Class)	**OSHA PEL ACGIH TLV**	**Other Pertinent Limits**	**Properties**	**Routes of Exposure or Irritation**	**Acute Health Effects**	**Chronic Health Effects/ Target Organs**
Methyl tertiary-butyl ether (MTBE)	No PEL established. TLV – 40 ppm	AIHA WEEL – 100 ppm	Flammable liquid with a distinctive, disagreeable odor.	Inhalation; dermal; ingestion.	Irritated nose, throat; headache; dizziness; nausea; sleepiness.	CNS, liver, kidney, gastrointestinal damage; potential carcinogen.
Toluene	PEL – 200 ppm TLV – 50 ppm	NIOSH REL – 100 ppm TWA; 150 ppm STEL ILDH – 500 ppm	Sweet, pungent, benzene-like odor.	Eye contact.	Skin (dermatitis); eye, respiratory tract irritant; headache; dizziness; weakness; fatigue.	CNS; liver; kidneys; skin.
Benzene	PEL – 1 ppm TLV – 0.5 ppm (skin)	PEL STEL – 5 ppm IDLH – 500 ppm	Characteristic benzene odor.	Inhalation; dermal; ingestion; eye contact.	Skin (dermatitis); eye, respiratory tract irritant; headache; dizziness; nausea.	Carcinogen; CNS; eye damage; bone marrow; blood; skin; leukemia.
Naphthalene	PEL – 10 ppm TLV – 10 ppm	TLV STEL – 15 ppm NIOSH REL – 10 ppm REL STEL – 15 ppm IDLH – 250 ppm	Mothball-like odor.	Inhalation; dermal; ingestion; eye contact.	Skin, eye, mucous membrane irritant; nausea.	Eyes; blood; skin; liver; kidneys; RBC; CNS.

POTENTIAL AIRBORNE CHEMICALS ON SITE FOR THIS PROJECT REVIEW THIS TABLE AND CONTACT THE SHSO WITH ANY QUESTION						
Chemical (or Class)	**OSHA PEL ACGIH TLV**	**Other Pertinent Limits**	**Properties**	**Routes of Exposure or Irritation**	**Acute Health Effects**	**Chronic Health Effects/ Target Organs**
Xylenes	PEL – 100 ppm TLV – 100 ppm	TLV STEL – 500 ppm NIOSH REL – 100 ppm NIOSH REL STEL – 100 ppm IDLH – 900 ppm	Aromatic odor.	Inhalation; dermal; ingestion; eye contact.	Throat, skin irritant (dermatitis); headache; nausea; drowsiness; fatigue.	CNS, liver, kidneys, skin, gastrointestinal damage; eye damage.
Ethylbenzene	PEL – 100 ppm TLV – 100 ppm	PEL STEL – 125 ppm TLV STEL – 125 ppm NIOSH REL – 100 ppm REL STEL – 125 ppm IDLH – 800 ppm	Pungent, aromatic odor.	Inhalation; dermal; ingestion; eye contact.	Skin, eye, mucous membrane irritant; headache; dizziness; drowsiness.	Eyes; respiratory tract; skin; CNS; blood; kidneys; liver.

NOTES:
°F = degrees Fahrenheit
ACGIH = American Conference of Governmental Industrial Hygienists
AIHA = American Industrial Hygiene Association
AIHA WEEL = AIHA-set workplace environmental exposure limits
C = ceiling limit
CNS = central nervous system
CVS = cardiovascular system
IDLH = immediately dangerous to life or health
mg/m3 = milligrams per cubic meter
NIOSH = National Institute for Occupation Safety and Health
OSHA = Occupation Safety and Health Administration
PEL = permissible exposure limit
ppm = parts per million
RBC = red blood cells
REL = recommended exposure limit set by NIOSH
Skin = skin absorption
STEL = short-term exposure limit
TLV = threshold limit value set by ACGIH
TWA = time-weighted average

9.0 POTENTIAL SITE HAZARDS AND APPROPRIATE PRECAUTIONS

Activities listed may be associated with work performed by others. The information contained in this section is for the use of Farallon personnel and not intended for use by others. The following tables list potential hazards and appropriate precautions associated with planned field work.

The following are a few basic guidelines to remember while performing field work at the Site:

- No eating, drinking, or smoking on the Site;
- No wearing contact lenses on the Site;
- No facial hair that will interfere with proper respirator fit when respirators are required; and
- A safety meeting will be held every day, even if only one person is working on the project on a given day.

9.1 ENVIRONMENTAL DRILLING

Job Steps	Personal Protective Equipment	Potential Hazards	Critical Actions
Clear drilling locations.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, and work gloves.	Traffic hazards. Overhead or underground installations. Product releases. Property damage. Occupant inconvenience.	• Refer to Utility Clearance Log (**Attachment 7**). • Coordinate with Site Manger (or designee) to minimize potential conflicts. • Review proposed locations against available construction drawings and known utilities, tanks, product lines, etc. • Mark out the proposed borehole locations. • Call underground utility locating service for public line location clearance and obtain a list of utilities being contacted. If necessary, coordinate private line locator for private property. • Develop a traffic control plan with the client and local agencies, as applicable, which may include use of cones, barrier tape, jersey barriers, etc.

Job Steps	Personal Protective Equipment	Potential Hazards	Critical Actions
Mobilize with equipment/supplies suitable for drilling.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, and work gloves.	Vehicle accident. Lifting hazards. Delay or improper performance of work due to improper equipment on Site.	• Begin each work day with tailgate safety meeting. • Follow safe driving procedures. • Employ safe lifting procedures. • Verify that subcontractors are aware of their responsibilities for labor, equipment, and supplies. • Review permit conditions.
Visually clear proposed drilling locations.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, and work gloves.	Underground or overhead installations.	• Complete Utilities and Structures checklist on the Utility Clearance Log (provided in **Attachment 7**) and adjust drilling locations as necessary.
Set up necessary traffic control.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, and work gloves.	Struck by vehicle during placement. Vehicle accident resulting from improper placement of traffic control equipment.	• Use buddy system for implementing traffic control plan, such as setting out cones and tape to define the safety area.
Assist with setup of rig.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, and work gloves.	Vehicle accident during rig movement. Damage caused by rig while accessing set-up location. Contact with overhead installations. Soft terrain. Unexpected rig movement.	• All staff should know the location of the kill switch for the drilling rig. • Verify a clear pathway to the drilling location and clearance for raising mast. • Provide hand signals and guidance to the driver, as needed, to place rig. • Visually inspect rig (e.g., fire extinguisher on board, no oil or other fluid leaks, cabling and associated equipment in good condition, pressurized hoses secured with whip-checks or adequate substitute, jacks in good condition). • Use wooden blocks under jacks to spread load, if necessary. Chock wheels.

Job Steps	Personal Protective Equipment	Potential Hazards	Critical Actions
Set up exclusion zone(s) and work stations (drilling and logging and/or sample collection).	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, and work gloves.	Struck by vehicle during setup. Slip or fall hazards.	• Implement exclusion zone setup. Set up work stations with clear walking paths to and from rig. Use safety tape and cone(s).
Clear upper 5 feet of drilling location using post-hole digger or hand auger.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, and work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, and chemical-resistant apron as required.	Back strain. Exposure to chemical hazards. Hitting an underground utility. Repetitive motion.	• Keep full-face respirator with organic vapor cartridges readily accessible. • Initiate air quality monitoring in accordance with the air monitoring protocol presented in **Attachment 9**. • Stand upwind to avoid exposure when possible. • Use the organic vapor monitor aggressively to track the airborne concentration of contaminants close to potential sources such as the core when it is raised from the hole, the core when opened, etc. • Evaluate any soil samples inside a resealable plastic bag at arm's length. DO NOT EVALUATE THE SAMPLE IN THE OPEN, IN ORDER TO AVOID UNNECESSARY EXPOSURE. • Use correct lifting techniques and tools. • Complete the Pre-Drilling section of the Borehole Clearance Review form.

Job Steps	Personal Protective Equipment	Potential Hazards	Critical Actions
Drilling.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Back strain. Heat or cold. Eye injury. Noise. Exposure to chemical hazards. Breaching an underground utility. Trip or fall. Equipment failure.	• Stand clear of operating equipment. • Use correct lifting techniques. • Monitor air quality in accordance with the air monitoring protocol presented in **Attachment 9**. • Monitor drilling progress. • Keep work area clear of tripping or slipping hazards. • Perform periodic visual inspections of drill rig.
Collect samples in accordance with sampling plan.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Back strain. Heat or cold. Eye injury. Noise. Exposure to chemical hazards. Breaching an underground utility. Trip or fall. Equipment failure.	• Stand clear of operating equipment. • Use correct lifting techniques. • Monitor air quality in accordance with the air monitoring protocol presented in **Attachment 9**. • Monitor drilling progress. • Keep work area clear of tripping or slipping hazards. • Perform periodic visual inspections of drill rig.

Job Steps	Personal Protective Equipment	Potential Hazards	Critical Actions
Manage cuttings.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Back strain. Heat or cold. Eye injury. Noise. Exposure to chemical hazards. Breaching an underground utility. Trip or fall. Equipment failure.	• Stand clear of operating equipment. • Use correct lifting techniques. • Monitor air quality in accordance with the air monitoring protocol presented in **Attachment 9**. • Monitor drilling progress. • Keep work area clear of tripping or slipping hazards. • Perform periodic visual inspections of drill rig.
Backfill borehole.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Back strain. Trip hazards. Eye injury from splashing or release of pressurized grout.	• Mix grout to specification and completely fill the hole. • Use proper lifting techniques. • Keep work area clear of tripping hazards. • Verify presence of and/or authorization by required grouting inspectors.
Develop well.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Physical injury from mechanical failure, drill rig, or air compressor. Trip hazards. Exposure to contaminants. Electric shock.	• Verify that equipment is in good working order and that pressurized hoses are whip-checked. • Keep full-face respirator with organic cartridges readily accessible. • Keep work area orderly. • Any generators must be equipped with a ground fault circuit interrupter (GFCI).

Job Steps	Personal Protective Equipment	Potential Hazards	Critical Actions
Gauge water levels and product thickness in wells, where applicable.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Back strain. Inhalation or dermal exposure to chemical hazards. Repetitive motion.	• Have full-face respirator with organic cartridges readily accessible. • Conduct air quality monitoring in accordance with the protocol presented in **Attachment 9.** • Maintain a safe distance from the well head. • Bend at knees rather than at the waist.
Purge well(s) and collect purge water.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Back strain. Inhalation or dermal exposure to chemical hazards. Slip or fall. Contaminated water spill.	• Use proper lifting techniques. • Use PPE, and adhere to air monitoring guidelines as presented in **Attachment 9**. • Keep work area clear of tripping or slipping hazards. • Store purge water in appropriate containers.
Collect groundwater samples in accordance with sampling plan.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Cross-contamination. Back strain. Inhalation or dermal exposure to chemical hazards. Slip or fall. Improper labeling or storage of samples. Injury from broken sample bottle (cuts or acid burns).	• Decontaminate sampling equipment between each well (unless disposable). • Use proper lifting techniques. • Have full-face respirator with organic cartridges within 3 to 5 feet of working location, and readily accessible. • Label samples in accordance with sampling plan. • Keep samples stored in appropriate containers, at correct temperature, and away from work area. • Handle bottles carefully.

Job Steps	Personal Protective Equipment	Potential Hazards	Critical Actions
Dispose of or store any purge water on the Site.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Back strain. Exposure to contaminants.	• Use suitable equipment to transport water (e.g., pumps, drum dollies). • Have full-face respirator with organic cartridges within 3 to 5 feet of working location, and readily accessible. • Label storage containers properly, and locate in an isolated area away from traffic and other Site functions. • Coordinate off-Site disposal (where applicable).
Clean the Site; demobilize.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Traffic. Lifting hazards.	• Use buddy system to remove traffic control, as necessary. • Leave the Site clear of refuse and debris. • Clearly mark or barricade any borings that need topping off or curing at a later time. • Notify Site personnel of departure, final well locations, and any cuttings and/or purge water left on the Site. • Use proper lifting techniques.
Package and deliver samples to laboratory.		Back strain. Traffic accidents.	• Handle and pack bottles carefully (e.g., bubble wrap bags). • Use proper lifting techniques. • Apply safe driving practices.
Typical work.	Steel-toed and -shank shoes, hard hat, safety glasses with side shields, hearing protection, reflective safety vest, leather gloves for non-chemical aspects of work. Chemical-resistant gloves and apron if chemical exposure is suspected.	Weather-related incidents: automobile accidents, slips or falls.	• Check weather reports daily. Project visits are not to be performed during inclement weather. Sampling may be performed during light rain mist. Wear raincoats. • Drive at speed limit or less, as needed, to keep a safe distance from vehicle in front. Avoid short stops.

Job Steps	Personal Protective Equipment	Potential Hazards	Critical Actions
Typical work.		Cold stress.	• For temperatures below 40°F, adequate insulating clothing must be worn. If the temperature is below 20°F, workers will be allowed to enter a heated shelter at regular intervals. Warm, sweet drinks should be available. Coffee intake should be limited. • No one should begin work or return to work from a heated shelter with wet clothes. • Workers should be aware of signs of cold stress, such as heavy shivering, pain in fingers or toes, drowsiness, or irritability. Onset of any of these signs is an indication that immediate return to a heated shelter is needed. • Refer to ACGIH TLV Booklet for the section on Cold Stress.
Typical work.		Heat stress.	• Discuss health effects and symptoms during daily health and safety meetings. • Drink water regularly (at least one cup every 20 to 30 minutes, depending upon level of effort and the PPE worn). • Refer to ACGIH TLV booklet for heat stress guidance, especially regarding PPE, type of work, and frequency of breaks. • Breaks should be taken in an area cooler than the work area. • Monitor temperature and relative humidity using a wetbulb globe temperature (WBGT) meter.

Job Steps	Personal Protective Equipment	Potential Hazards	Critical Actions
A safety meeting will be held every day, even if only one person is working on the project on a given day.			• Topics are to always include the work scheduled for the day and restatement of hazards and the means to avoid them. Other topics may include sampling in general, and advances in technology and how they may be applied to the project. • Use the *Daily Health and Safety Briefing Log* in **Attachment 4** to log the topics discussed.

9.2 EXCAVATION ACTIVITIES

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Clear excavation locations.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Traffic hazards. Overhead and underground installations. Product releases. Property damage. Dealer inconvenience.	• Refer to Utility Clearance Log. • Coordinate with facility contact (or designee) to minimize potential conflicts. • Review proposed locations against available construction drawings and known utilities, tanks, product lines, etc. • Mark out the proposed excavation locations. • Call the underground utility locating service for public line location clearance. Obtain a list of utilities being contacted. If necessary, coordinate private line locator for private property.
Set up necessary traffic control.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Being struck by vehicle during placement. Vehicle accident as a result of improper traffic control equipment placement.	• Use buddy system to place traffic control. • Implement traffic control plan as required.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Set up exclusion zone(s) and stockpile area and establish work areas/heavy equipment pathways.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Injury or exposure to public or other Site personnel. Slip or fall hazards. On-Site vehicular accident with heavy equipment.	• Implement exclusion zone set-up instructions. • Establish clear walking paths between work stations.
Hand digging/post-holing where necessary to expose and protect underground installations as needed.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Damage to lines and associated physical hazards or property damage. Back strain. Injury or vehicle damage from falling into a hole.	• Use hand tools whenever possible. • Use proper lifting techniques. • Barricade or cover holes until job has been completed.
Assist with set up of heavy equipment.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Damage caused by heavy equipment while accessing set-up location. Being struck by equipment.	• Verify a clear pathway to excavation and stockpiling locations. • Provide hand signals and guidance to driver as needed to place rig. • Visually inspect equipment (e.g., fire extinguisher on board, no oil or other fluid leaks, cabling and associated equipment in good condition, pressurized hoses secured with whip-checks or adequate substitute, jacks in good condition). • Maintain eye contact with operator.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Commence excavation.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Heat or cold exposure. Exposure to chemical hazards. Hitting an underground or overhead utility. Flammable or oxygen-deficient atmosphere from accumulated vapors. Trip or fall. Side wall cave-in. Equipment failure. Noise.	• Monitor weather conditions and take breaks as needed for cold or hot weather. • Conduct air monitoring as presented in **Attachment 9.** Include Lower Explosive Limit (LEL) and oxygen (O_2) monitoring. If >10% LEL or O_2 <19.5%, discontinue work or ventilate area with explosion-proof equipment. • Maintain required excavation set-backs for workers and equipment. • Monitor condition of side walls and surrounding ground conditions. • Keep work area clear of tripping or slipping hazards. Perform periodic visual inspections of heavy equipment and keep equipment a minimum of 5 feet from excavation edge, or 1 foot away from the edge for every foot of depth, if greater than 5 feet deep. • Perform necessary soil classification. Slope or bench walls, or shore excavation to prevent cave-in. Keep all spoils more than 2 feet from excavation edge. Keep excavation entry controlled and equipped with required ladders and crosswalks.
Collect samples in accordance with sampling plan.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Cave-in of side wall if entering excavation. Injury from heavy equipment. Exposure to Site contaminants.	• Stay out of excavation whenever possible (collect samples from backhoe bucket). • Use agreed-upon hand signals with heavy equipment operators. • Monitor air around excavation in accordance with the protocol presented in **Attachment 9**.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Store excavated materials according to Site-specific requirements.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Exposure to public. Traffic hazard, obstruction, or inconvenience to business operation. Improper storage or disposal.	• Have necessary storage containment and labeling available on the Site. • Place materials in isolated location away from traffic and other Site functions. • Stockpile excavated materials on suitable plastic or in appropriately designed container. Cover with plastic, and barricade access to waste in accordance with local regulations. • Coordinate proper disposal off the Site, where applicable.
Backfill excavation.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Being struck by heavy equipment. Side wall collapse. Damage or accidents resulting from subsequent subsidence.	• Use agreed-upon hand signals with heavy equipment operators. • Compact soils to meet specifications. • Maintain eye contact with equipment operators.
Clean the Site; demobilize.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Traffic. Safety hazard left on the Site. Lifting hazards.	• Use buddy system to remove traffic control, as necessary. • Leave Site clear of refuse and debris. • Notify business personnel of departure. • Use proper lifting techniques or use mechanical assistance.
Package and deliver samples to laboratory.		Back strain. Traffic accidents.	• Handle and pack bottles carefully (e.g., bubble wrap bags). • Use proper lifting techniques. • Apply safe driving practices.

Job Steps	**Personal Protective Equipment**	**Potential Hazard**	**Critical Actions**
General			
Typical work.	Steel-toed and -shank shoes, hard hat, safety glasses with side shields, hearing protection, reflective safety vest, and leather gloves for non-chemical aspects of the work. If equipment contamination is suspected, wear chemical-resistant gloves during decontamination of equipment.	Weather-related incidents: automobile accidents, slips or falls.	• Check weather reports daily. Project visits are not to be performed during inclement weather. Sampling may be performed during light rain mist. Wear raincoats. • Drive at the speed limit or less as needed to keep safe distance from vehicle in front. Avoid short stops.
A safety meeting will be held each day, even if only one person is working on the project on any given day.			• Topics are always to include the work scheduled for that day, and restatement of hazards and the means to avoid them. Other topics may include sampling in general, and advances in technology and how they may be applied to the project. • Use the *Daily Health and Safety Briefing Log* provided in **Attachment 4** to log the topics discussed.

9.3 MONITORING WELL SAMPLING/GAUGING

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Mobilize with equipment/supplies suitable for sampling.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Vehicle accident. Lifting hazards. Delay or unsafe performance of work due to lack of necessary equipment on Site. Cross-contamination of wells.	• Follow safe driving procedures. • Use proper lifting techniques. • Review work plan to determine equipment/supply needs. • Verify that all sampling/gauging equipment has been decontaminated. • Bring ice for sample storage. • Review the HASP. • Gather the necessary PPE.
Set up necessary traffic control.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Struck by vehicle during placement. Vehicle accident as a result of improper traffic-control equipment placement.	• Use buddy system for placing traffic control. Refer to the traffic control plan section of the HASP (which may include specific requirements based on encroachment permit).
Set up exclusion zone(s).	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Struck by vehicle. Slip or fall hazards to workers.	• Face incoming traffic. • Implement exclusion zone setup instructions of the HASP (e.g., barricades, caution tape, cones). • Set up work area free of trip hazards.
Gauge water levels and product thickness (where applicable) in wells.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Back strain. Inhalation of, or dermal exposure to, chemical hazards. Repetitive motion.	• Wear required PPE. • Initiate air quality monitoring in accordance with the HASP. • Maintain a safe distance from wellhead. • Bend at knees rather than at waist.

Job Steps	**Personal Protective Equipment**	**Potential Hazard**	**Critical Actions**
Purge well(s) and collect purge water.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Cross-contamination. Back strain. Inhalation of, or dermal exposure to, chemical hazards. Slip or fall. Contaminated water spill.	• Decontaminate purging equipment between each sampling location. • Use proper lifting techniques. • Use PPE and conduct monitoring in accordance with the HASP. • Keep work area clear of tripping or slipping hazards. • Store purge water in appropriate containers.
Collect samples in accordance with sampling plan.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Cross-contamination. Back strain. Inhalation of, or dermal exposure to, chemical hazards. Slip or fall. Improper labeling or storage. Injury from broken sample bottle (e.g., cut or acid burn).	• Decontaminate sampling equipment between each well (unless disposable equipment). • Use proper lifting techniques. • Use PPE in accordance with the HASP. • Label samples in accordance with sampling plan. • Keep samples stored in suitable containers, at correct temperature, and away from work area. • Handle bottles carefully.
Dispose of or store purge water on the Site.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves. Respirator with organic vapor cartridges, chemical-resistant gloves, chemical-resistant apron as required.	Back strain. Exposure to contaminants. Damage or injury from improper use of on-Site treatment system equipment. Improper storage or disposal.	• Use suitable equipment to transport water (e.g., pumps, drum dollies). • Wear PPE in accordance with the HASP. • Review any necessary instructions for use of on-Site treatment systems. • Label storage containers properly and locate in an isolated area away from traffic and other Site functions. • Coordinate off-Site disposal, where applicable.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Clean the Site; demobilize.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Traffic. Safety hazard left on the Site. Lifting hazard.	• Use buddy system to remove traffic control, as necessary. • Leave the Site clear of refuse and debris. • Notify business personnel of departure, and of any purge water left on the Site. • Use proper lifting techniques.
Package and deliver samples to laboratory.		Bottle breakage. Back strain.	• Handle and pack bottles carefully (e.g., bubble wrap bags). • Use proper lifting techniques.

9.4 GROUNDWATER EXTRACTION AND/OR SOIL VAPOR EXTRACTION SYSTEM INSTALLATION

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Mark out the proposed trenching and aboveground structure locations. Call utility service clearance. Coordinate private line locator for private property.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Traffic hazards. Overhead and underground lines and installations. Electrocution. Explosion. Product release. Property damage. Interruption of utility services.	• Review proposed location map before arriving on the Site. • Refer to Borehole Clearance Review form and coordinate with Site Manager (or designee) to minimize potential conflicts. • Contact utility service at least two full working days before drilling and/or digging. • Identify utilities to be contacted. Review proposed locations against available construction drawings and known utilities, tanks, product lines, etc. • Perform preliminary Site visit, where possible.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Cut pavement.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Traffic hazard. Contact with utilities. Eye injury from flying debris. Back strain when moving equipment. Noise. Underground lines.	• Identify and barricade work area. • Avoid underground installations. • Wear eye and hearing protection. • Use proper lifting techniques and assistance when moving equipment (lift gate on truck may be necessary). • Watch traffic.
Excavate trench and equipment pad footprint, as necessary.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Injury or accident from heavy equipment. Injury from damaging underground lines. Back strain. Collapse of trench onto workers. Vehicle or foot traffic hazards. Falling into open trench. Tripping hazards. Being struck by equipment. Noise. Potential chemical hazards.	• Maintain a line of sight with vehicle operator. Use agreed-upon hand signals and work paths with operators. • Hand-excavate and protect underground lines that are in immediate path of trench. • Use proper lifting techniques, and back support when hand digging. • Use shoring/benching/sloping of trench walls if workers will have head and shoulders below top of trench (always for more than 5 feet deep, but may be required for less than 5 feet). • Maintain adequate access/egress locations for workers in trench. • Keep trench covered in non-active work areas and between work shifts. • Heed vehicle backup alarm and establish eye contact with operator. • Keep work area tidy.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Install groundwater extraction and/or soil vapor extraction (SVE) hose and piping.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Collapse of trench onto workers. Vehicle or foot traffic hazards. Falling into open trench. Tripping hazards. Lifting hazards. Power tool hazards.	• Use shoring/benching/sloping of trench walls if workers will have head and shoulders below top of trench (always for more than 5 feet deep, but may be required for less than 5 feet). • Maintain adequate access/egress locations for workers in trench. • Keep trench covered in non-active work areas and between work shifts. • Use proper lifting techniques. • Keep work area tidy. • Watch for traffic.
Pressure test piping (primary and secondary conduit, as required).	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Eye injury. Flying and loose debris. Noise.	• Don't over pressurize piping (usually less than 10 pounds per square inch). • Verify security of end caps. • Watch for traffic.
Install electrical line and conduit to well heads.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Collapse of trench onto workers. Vehicle or foot traffic. Falling into open trench. Trip hazards. Lifting hazards. Power tool hazards.	• Use shoring/benching/sloping of trench walls if workers will have head and shoulders below top of trench (always for more than 5 feet deep, but may be required for less than 5 feet). • Maintain adequate access/egress locations for workers in trench. • Keep trench covered in non-active work areas and between work shifts. • Use proper lifting techniques. • Keep work area tidy. • Watch for traffic.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Backfill and pave trench.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Injury from heavy equipment. Leg or foot injury from compaction equipment. Accident or damage resulting from future subsidence. Traffic hazards. Noise.	• Maintain a line of sight with equipment operators. Use agreed-upon hand signals. • Wear suitable PPE during compaction. • Perform compaction of backfill according to specifications. • Watch for traffic.
Construct treatment equipment pad.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Damage from heavy equipment. Trip hazards. Body position/lifting hazards. Traffic hazards. Noise.	• Use agreed-upon hand signals with truck operator. • Keep work area free of debris. • Keep supplies orderly. • Watch for traffic.
Place and attach major equipment components.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Injury from transport equipment. Back strain when moving equipment. Injury from power tool use. Traffic.	• Keep clear of equipment when large components are being set in place. • Use mechanical assistance as needed to position equipment. • Wear suitable PPE when bolting equipment to pad. • Watch for traffic.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Connect groundwater extraction and/or SVE hose and piping and associated valves, sampling ports, and gauges.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Eye or other injury from hand tool use. Body position/lifting hazards. Injury from power tool use. Traffic.	• Wear standard PPE. • Use proper lifting techniques. • Watch for traffic.
Install electrical control panel, equipment wiring and conduit, and system controls.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Electrical shock/electrocution. Fire from faulty wiring. Back strain when lifting panel into place. Injury from power tool use. Traffic.	• Use lock-out/tag-out procedures to isolate main power supply. • Do not perform electrical work in rain. Keep work surfaces dry, especially in standing locations. • Use proper lifting techniques. • Wear standard PPE. • Watch for traffic.
Install fencing or other system enclosure.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Back strain. Injury from power tool use. Tripping hazards. Traffic.	• Use proper lifting techniques. Obtain assistance, as needed. • Wear standard PPE. • Keep fencing and other materials neatly stacked until ready for installation. • Watch for traffic.
Place required labeling and signage.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Emergencies from fire, or from rupture of piping or other containment structures. Traffic.	• Indicate emergency contact and telephone number. • Clearly label emergency shut-off switch(es). • Properly label any hazardous materials (e.g., H2O2, petroleum-collection containers). • Watch for traffic.

Job Steps	**Personal Protective Equipment**	**Potential Hazard**	**Critical Actions**
Clean the Site, demobilize, and secure system.	Reflective vest, steel-toed and -shank shoes, hard hat, safety glasses with side shields, ear plugs or muffs, work gloves.	Traffic hazards. Nuisance or safety hazard left on the Site. Lifting hazards.	• Use proper lifting techniques. • Watch for traffic. • Leave the Site clean of refuse and debris. • Notify business personnel of departure.

9.5 AIR SPARGING/SOIL VAPOR EXTRACTION SYSTEM OPERATION AND MAINTENANCE

Job Steps	**Personal Protective Equipment**	**Potential Hazard**	**Critical Actions**
Mobilize with proper equipment/supplies for operation and maintenance (O&M).	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves.	Vehicle accident. Lifting hazards. Delay or improper performance of work due to improper equipment on Site.	• Follow safe driving procedures. • Employ safe lifting procedures. • Make sure subcontractors are aware of their responsibilities for labor, equipment, and supplies. • Review HASP and permit conditions and gather necessary PPE.
Set up necessary traffic control.	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves.	Struck by vehicle during placement. Vehicle accident as a result of improper traffic control equipment placement.	• Use buddy system for placing traffic control, if necessary. Reference traffic control plan section of HASP (may include specific requirements based on permits).

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Unload and set up test equipment.	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves.	Struck by vehicle. Trip hazards. Accident when maneuvering equipment. Lifting hazard. Electrical hazard. Adverse impacts to station sales.	• Place equipment away from pump islands or other high traffic areas. • Store hoses and electrical cords neatly and protect with traffic control equipment (e.g., cones, barricades). • Provide hand signals and guidance to driver, as needed, when placing testing equipment trailers or other large equipment. • Visually inspect equipment (e.g., fire extinguisher on board/available on the Site, no damaged hoses or electrical lines, pressurized hoses secured with whip-checks or adequate substitute, all vapor and/or water hoses firmly connected, equipment grounded). • Use proper lifting techniques. • Use GFCI on generators or other electrical equipment. • Inspect cords.
Set up exclusion zone(s) and work station.	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves.	Struck by vehicle during setup. Slip/fall hazards.	• Implement exclusion zone setup instructions of HASP. • Set up work station with clear walking paths to all testing locations. • Face oncoming traffic.
Gauge water levels and product thickness (where applicable).	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves.	Back strain, inhalation, or dermal exposure to chemical hazards. Repetitive motion. Eye injury from back pressure in wells. Traffic hazards.	• Wear any additional PPE and initiate air quality monitoring in accordance with HASP. • Maintain safe distance from wellheads. • Bend at knees, rather than waist. • Decontaminate equipment between measurements. • Face oncoming traffic.

Job Steps	**Personal Protective Equipment**	**Potential Hazard**	**Critical Actions**
Commence performing O&M.	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves.	Explosion or fire. Trip hazards. Unauthorized release of contaminants. Eye injury from pressurized air or shrapnel from burst piping. Burn from heated piping or motors. Clothing caught on turning vanes on compressor and shaft. Exposure to contaminants (e.g., inhalation, dermal contact). Noise. Electrical hazards.	• Follow equipment-specific operation instructions. • Ensure that connections with barbed fittings on pressure gauges are secure. • Be conscious of amount of torque placed on PVC connections to avoid breaking. • Monitor pressure conditions; do not exceed pressure ratings for any component involved. • Watch proximity to heated piping and contact with mufflers, motors, manifolds. • Monitor influent vapor and oxygen concentrations, if applicable. • Keep work area tidy and free of loose equipment. • Monitor treatment system and collect data to ensure discharge is within permit parameters and capacity of any storage containers (e.g., concentrations, flow rates). • Wear PPE in accordance with HASP (including ear protection, as necessary). • Ensure lockout/tagout of all electrical equipment that may be handled. • Use GFCI on generators and other electrical equipment. • Inspect cords.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Shut down system (if necessary).	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves.	Unauthorized release of contaminants from back pressure. Eye injury from pressurized air or shrapnel from burst piping. Burn from heated piping or motors. Exposure to contaminants (e.g., inhalation, dermal contact).	
Collect samples in accordance with sampling plan.	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves.	Cross-contamination, improper sample labeling or storage, exposure to Site contaminants. Repetitive motion. Cuts from colorimetric tubes. Body position.	• Label samples in accordance with sampling plan. Keep samples stored in proper containers, at correct temperature, and away from work area. • Perform air monitoring and wear proper PPE.
Store waste (e.g., water, carbon canisters) in accordance with Site-specific requirements.	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves	Back strain. Traffic hazard. Improper storage or disposal. If disposing through on-Site treatment system, damage or injury from improper use of equipment.	• Use proper equipment to transport waste containers (e.g., pumps, drum dollies). • Have proper storage containment and labeling available on the Site. Place materials in isolated location away from traffic and other Site functions. • Label waste. • Coordinate proper disposal off the Site (where applicable). • Review instructions for use of on-Site treatment systems.

Job Steps	Personal Protective Equipment	Potential Hazard	Critical Actions
Clean the Site; demobilize.	Safety glasses or goggles, hard hat, steel-toed and -shank boots, hearing protection, gloves.	Traffic hazard. Lifting hazards. Safety hazard left on the Site.	• Use buddy system, as necessary, to remove traffic control. • Use proper lifting techniques. • Leave the Site clean of refuse and debris. • Notify station personnel of departure and location of any stored waste.

10.0 WASTE CHARACTERISTICS

Waste anticipated to be generated on the Site:

Type(s): ☒ Liquid ☒ Solid ☐ Sludge ☐ Other ______________________________

The approximate volume for each anticipated waste stream:

Waste: Soil cuttings Approximate Volume: Thirty-five 55-gallon drums

Waste: Purge/Development water Approximate Volume: Ten 55-gallon drums

Characteristics:

☐ Corrosive ☐ Flammable/Ignitable ☐ Radioactive ☒ Toxic

☐ Reactive ☐ Unknown ☐ Other *(specify)* ____________________________

11.0 TRAFFIC CONTROL

Project work will require Farallon personnel or subcontractors to enter road rights-of-way or areas of uncontrolled traffic access, such as parking lots open to the public. When work is to be performed in these areas, traffic control will be implemented. The specific traffic control devices and layout to be used are described in Attachment 10, Traffic Control Plan.

Work on the Site will aldo be conducted in areas of uncontrolled traffic access. Traffic control/warning devices will be placed around the work area to prevent undesirable interface between pedestrian and automotive traffic and project workers and equipment. These devices may include:

- Cones;
- Tubular markers;
- Barricades;
- Temporary fencing; and
- Barricade tape.

The traffic control/warning devices will be placed around the work in such a way that traffic access is inhibited (i.e., place cones less than 8 feet apart so cars cannot easily drive through work area without moving a cone). Barricade tape or temporary fencing will be used to inhibit access to the work area in locations where pedestrians will be encountered.

ATTACHMENT 1
HEALTH AND SAFETY PLAN ACKNOWLEDGEMENT AND AGREEMENT FORM

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

HEALTH AND SAFETY PLAN ACKNOWLEDGMENT AND AGREEMENT FORM

(All Farallon and subcontractor personnel must sign on a daily basis.)

This Health and Safety Plan (HASP) has been developed for the purpose of informing Farallon employees of the hazards they are likely to encounter on the project site, and the precautions they should take to avoid those hazards. Subcontractors and other parties at the site must develop their own HASP to address the hazards faced by their own employees. Farallon will make a copy of this HASP available to subcontractors and other interested parties to fully disclose hazards we may be aware of, and to satisfy Farallon's responsibilities under the Occupational Safety and Health Administration (OSHA) Hazard Communication standard. Similarly, subcontractors and others on site are required to inform Farallon of any hazards they are aware of or that their work on site might possibly pose to Farallon employees, including but not limited to Material Safety Data Sheets for chemicals brought on site. This plan should NOT be understood by contractors to provide information pertaining to all of the hazards that a contractor's employees may be exposed to as a result of their work.

All parties conducting site activities are required to coordinate their activities and practices with the project Site Health and Safety Officer (SHSO). Your signature below affirms that you have read and understand the hazards discussed in this HASP, and that you understand that subcontractors and other parties working on site must develop their own HASP for their employees. Your signature also affirms that you understand that you could be prohibited by the SHSO or other Farallon personnel from working on this project for not complying with any aspect of this HASP. The SHSO will be noted on the sheet below on a daily basis.

HEALTH AND SAFETY PLAN ACKNOWLEDGMENT AND AGREEMENT FORM					
Check for SHSO	**Name**	**Title**	**Signature**	**Company**	**Date**

HEALTH AND SAFETY PLAN ACKNOWLEDGMENT AND AGREEMENT FORM					
Check for SHSO	**Name**	**Title**	**Signature**	**Company**	**Date**

ATTACHMENT 2
DIRECTIONS TO HOSPITAL

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

DIRECTIONS TO HOSPITAL

238 8th St SE
Auburn, WA 98002

1. Head west on 8th St SE toward B St SE — 0.2 mi
2. Turn right onto A St SE — 0.4 mi
3. Turn left onto 1st St SE — 305 ft
4. Turn right at the 1st cross street onto S Division St — 0.2 mi
5. Turn right at 2nd St NW — 167 ft

MultiCare Auburn Medical Center
4939, 202 N Division St, Auburn, WA 98001

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

ATTACHMENT 3
POTENTIAL TOPICS FOR DAILY HEALTH AND SAFETY MEETING

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

POTENTIAL TOPICS FOR DAILY HEALTH AND SAFETY MEETING

- ☐ Emergency response plan, emergency vehicle (full of fuel) and muster point
- ☐ Route to medical aid (hospital or other facility)
- ☐ Work hours. Is night work planned?
- ☐ Hand signals around heavy equipment
- ☐ Traffic control
- ☐ Pertinent legislation and regulations
- ☐ Above- and below-ground utilities (energized or de-energized)
- ☐ Material Safety Data Sheets
- ☐ Reporting an incident: to whom, what, why, and when to report
- ☐ Fire extinguisher and first aid kit locations
- ☐ Excavations, trenching, sloping, and shoring
- ☐ Personal protective equipment and training
- ☐ Safety equipment and training
- ☐ Emergency telephone location(s) and telephone numbers (in addition to 911)
- ☐ Eye wash stations and washroom locations
- ☐ Energy lock-out/tag-out procedures. Location of "kill switches," etc.
- ☐ Weather restrictions
- ☐ Site security. Site hazards. Is special waste present?
- ☐ Traffic and people movement
- ☐ Working around machinery (both static and mobile)
- ☐ Sources of ignition, static electricity, etc.
- ☐ Stings, bites, large animals, and other nature-related injuries and conditions
- ☐ Working above grade
- ☐ Working at isolated sites
- ☐ Decontamination procedures (for both personnel and equipment)
- ☐ How to prevent falls, trips, sprains, and lifting injuries
- ☐ Right to refuse unsafe work
- ☐ Adjacent property issues (e.g., residence, business, school, daycare center)

ATTACHMENT 4
DAILY HEALTH AND SAFETY BRIEFING LOG

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

DAILY HEALTH AND SAFETY BRIEFING LOG

PROJECT INFORMATION	
Farallon PN:	Project Name:
Site Address:	City/State:
MEETING INFORMATION	
Conducted By:	Weather:
Major Job Task:	Date:

DAILY EQUIPMENT CHECKLIST		
☐ Site Check In	☐ First Aid Kit Location(s)	☐ Ear Plugs (if required)
☐ Proper ID/Safety Credentials	☐ Fire Extinguisher Location(s)	☐ Hand Protection (if required)
☐ Hard Hat	☐ Eye Wash Station	☐ Face Shield (if required)
☐ Safety Glasses	☐ Traffic Control (if needed)	☐ Respirator (if required)
☐ Orange Reflective Vest (H or X back BNSF)		☐ ___________________________
☐ Safety Toe Boots (lace up and leather BNSF)		☐ ___________________________

HEALTH AND SAFETY BRIEFING	
☐ Head Count (No. of employees:)	☐ Chemical/Contaminant Hazards
☐ Emergency Response	☐ Health Hazards
☐ Who will...? (Provide names below.) Call 911: Alternate to call 911: Provide First Aid/CPR:	☐ Environmental Hazards ☐ Physical Hazards ☐ Slips, Trips, and Falls ☐ Utility Locates
☐ Emergency Exits/Rally Points/Hospital Route	☐ Utility/Product Shut-Off Valves/Switches
☐ Site Security and Exclusion Zone	☐ Near Miss Reporting (reminder to look)
☐ Vehicle/Equipment-Specific Safety Practices	☐ Incident Reporting (procedures and forms)
☐ Stop Work Authority	☐ Traffic Control
☐ Excavation Safety (if applicable)	☐ HASP Reviewed and Signed

OTHER SITE-SPECIFIC HEALTH AND SAFETY ISSUES DISCUSSED
1)
2)
3)
4)
5)

DAILY HEALTH AND SAFETY BRIEFING ATTENDEES		
NAME	**COMPANY**	**SIGNATURE**

ATTACHMENT 5
INCIDENT REPORT FORM

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

FARALLON CONSULTING

Washington
Issaquah | Bellingham | Seattle

Oregon
Portland | Bend | Baker City

California
Oakland | Folsom | Irvine

INCIDENT REPORT FORM

This report must be completed by the employee or Health and Safety Coordinator (HSC) immediately upon learning of the incident. The completed report must be reviewed and signed by Project Principal, within 24 hours of the incident, even if the employee is not available to review and sign. The employee or employee's doctor must submit a copy of the doctor's report to Joe Rounds within 24 hours of the initial exam and any subsequent exams. After hours or weekends, please call Joe Rounds: Mobile (206) 484-2748. Document the incident with photographs if possible. For environmental releases, discuss possible regulatory spill reporting with the Project Principal.

EMPLOYEE INFORMATION	
Employee Name:	Employee Title:
Employment Status: ☐ Full-Time ☐ Part-Time ☐ Hourly-As-Needed	Years Employed at Farallon Consulting, L.L.C. (Farallon)?

INCIDENT TYPE			
☐ Fatality	☐ Industrial Non-Recordable	☐ Spill/Leak	☐ General Liability
☐ Lost Workday (LW)	☐ Non-Industrial	☐ Product Integrity	☐ Vandalism/Criminal Activity
☐ Restricted Duty	☐ Off-the-Job Injury	☐ Equipment	☐ Notice of Violation
☐ OSHA Medical or Illness w/o LW	☐ Motor Vehicle Accident	☐ Business Interruption	☐ Other
☐ First Aid	☐ Fire		

INCIDENT DESCRIPTION	
Date of incident, injury, or onset of illness: Click or tap to enter a date.	Time of incident, injury or onset of illness: ☐AM ☐ PM
Brief description of incident. Provide full incident details on Page 2.	
Describe the equipment, materials, or chemicals that directly harmed the party (e.g., the machine employee struck against or which struck employee; the vapor inhaled, or material swallowed; what the employee was lifting, pulling, etc.):	
Date employer notified: Click or tap to enter a date.	Time employer notified: ☐ AM ☐ PM
To whom reported?	

INJURY OR ILLNESS INFORMATION	
Exact Location of Incident (address, geographical location, floor, building, etc.):	
County:	On Employer's premises? ☐ Yes ☐ No
Describe the specific injury or illness (e.g., puncture, cut, contusion, strain, fracture, skin rash, etc.):	
Body part(s) affected (e.g., back, left wrist, right eye, etc.):	
Name and address of Health Care Provider:	Phone No.:
Treated in Emergency Room: ☐ Yes ☐ No	Hospitalized Overnight as Inpatient: ☐ Yes ☐ No

Injury/Illness Severity	**Time Loss (Check all that apply.)**	**Workday Phase**
☐ No treatment required.	☐ No time loss. ☐ Return to work the next day.	☐ Performing normal work duties. ☐ During meal period.
☐ First aid only.	☐ Restricted activity. Begin date:	☐ During rest period. ☐ Entering/leaving work area or site.
☐ Professional medical treatment.	Return date:	☐ Chronic exposure.
☐ Fatality. Enter date: Click or tap to enter a date.	☐ Lost workday, not at work. Begin date: Return date:	☐ Other, specify:

MOTOR VEHICLE ACCIDENT (MVA)		
Professional Driver? ☐ Yes ☐ No	Total Years Driving:	Company Vehicle? ☐ Yes ☐ No
Vehicle Type:	Vehicle Owner (not Farallon):	Vehicle License Plate:
No. of Vehicles Towed:	No. of Injuries:	No. of Fatalities:
Insurance information for other driver(s):		
Witness Name:	Address:	Phone No.:
Witness Name:	Address:	Phone No.:

THIRD PARTY PROPERTY DAMAGE (INCLUDING UTILITIES – PLEASE PROVIDE PHOTOS)		
Owner Name for Damaged Property:	Address:	Phone No.:
Description of Damage:		
Property Owner Insurance information:		
Witness Name:	Address:	Phone No.:
Witness Name:	Address:	Phone No.:

Detailed Description of Events
(Use space below to provide full detailed description of incident. Include Specific Activity During Incident (Lifting, Pushing, Walking, etc.)

SIGNATURES OF EMPLOYEE AND REVIEWERS			
Name (print):	**Signature:**	**Title:**	**Date:**
Employee:			
Employee's Group Manager:			
Regional Operations Manager:			
Farallon Corporate Health and Safety Coordinator:			
Entered into Database By:	**Date:**		

ATTACHMENT 6
NEAR MISS AND SAFETY OBSERVATION REPORT

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

NEAR MISS AND SAFETY OBSERVATION REPORT

This report is to be filled out by any employee involved in or witnessing a near miss, or making a safety observation. A near miss is an occurrence that did not result in any personal injury, property damage, environmental release, or production interruption, but could have under slightly different circumstances. A safety observation is witnessing any activity that places a person or property at risk of injury, accident, or damage but does not fit the definition of a near miss. These are very important indicators of potentially harmful future accidents, and provide valuable insights to preventing personal injury and/or property damage.

PROJECT INFORMATION	
Farallon PN:	Project Name:
Site Address:	City/State:
NEAR MISS/SAFETY OBSERVATION INFORMATION	
Employee Completing Report:	
Date: Click or tap to enter a date.	Time: ☐AM ☐ PM
Near Miss Category: Choose an item.	
Exact Location:	
Description of Potential Incident or Hazard:	
Corrective Action Taken:	
Lessons Learned:	
SIGNATURES AND NOTIFICATIONS	
Date employer notified: Click or tap to enter a date.	Time employer notified: ☐ AM ☐ PM
To whom reported?	
Employee Signature:	Date:
HSC Signature:	Date:
Entered into Database By:	Date:

ATTACHMENT 7
UTILITY CLEARANCE LOGS

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

UTILITY CLEARANCE LOG

Project Name: ______________________________ **Project Number:** ____________________

Location: __________________________________ **Date of Work:** ______________________

Instructions. This log must be completed by a Farallon staff member **before** any Farallon-directed excavation (e.g., test pit excavation) or drilling operation.

DRILLING OR EXCAVATION WORK MAY NOT COMMENCE UNTIL UTILITY LOCATES HAVE BEEN COMPLETED
(see the One-Call Utility Locate Request Procedure on the following page)

Farallon is responsible for having underground utilities and structures located and marked when drilling or directing test pit excavation operations. Any drilling or excavation within 2 feet of a marked utility must be done with hand tools.

Owners of underground utilities are required by law to mark underground facilities on public and private property. Owners of underground utilities are **not required** to mark existing service laterals or appurtenances. Utility owners in Washington are required to subscribe to the One-Call service.

Private utility locate services must be hired to locate service laterals and other buried utilities (e.g., on-Site electric distribution lines, irrigation pipes) on private property.

Re-mark after 10 days or maintain as appropriate.

Utility Locate Checklist

☐ Attach map showing drilling and/or excavation sites and known utilities

☐ Attach copy of One-Call Utility Notification Ticket (http://www.searchandstatus.com/)

One-Call Utility Notification Ticket Number: ____

☐ Attach copy of Side Sewer Card (available for City of Seattle; check municipality for availability)

☐ Attach copy of Private Locate Receipt

☐ Photograph all excavation and/or drilling locations and download to project file

☐ Review utilities with Site Contact:

Name:______________________________ Phone: ___________________________________

Utilities and Structures

Utility Type	**Utility Name**	**Public Utilities Marked (Y/N)**	**Private Utilities/Laterals Marked (Y/N)**	**Marking Method** (flags, wooden stakes, paint on pavement, etc.)
Petroleum product lines				
Natural gas line				
Water line				
Sewer line				
Storm drain				
Telephone cable				
Electric power line				
Product tank				
Septic tank/drain field				
Other				

Farallon Consulting, L.L.C.

Field Team Leader: ___________________________________ Date: _________________________

Electric = **RED**	*Gas-Oil-Steam =* **YELLOW**	*Comm-CATV =* **ORANGE**	*Water =* **BLUE/PURPLE**	*Sewer =* **GREEN**	*Temp Survey =* **PINK**

ONE-CALL UTILITY LOCATE REQUEST PROCEDURE

THE ONE-CALL UTILITY NOTIFICATION CENTER REQUIRES 48 HOURS NOTICE TO MARK UTILITIES BEFORE YOU CAN DIG OR DRILL

Washington: 1-800-424-5555
Oregon: 1-800-332-2344

Washington state law states that "before commencing **any** excavation," the excavator or driller must provide notice to all owners of underground utilities by use of the One-Call locator service, and that the excavator or driller shall not dig or drill until all known utilities are marked. To fully comply with the law, you **must** take the following steps:

1. **Call before you dig or drill:** Notify the One-Call Utility Notification Center (OCUNC) a minimum of 48 hours (2 full business days) before digging or drilling. Provide the following **required** information:
   a. Your name and phone number, company name and mailing address, and Farallon Account Number 25999.
   b. The type of work being done.
   c. Who the work is being done for.
   d. The county and city where the work is being done.
   e. The address or street where the work is being done.
   f. Marking Instructions: "Generally locate entire site including rights-of-way and easements."

   Provide the following information <u>if applicable or requested</u>:
   a. The name and phone number of an alternate contact person.
   b. If the work is being done within 10 feet of any overhead power lines.
   c. The nearest cross street.
   d. The distance and direction of the work site from the intersection.
   e. Township, range, section, and quarter section of the work site.
2. **Record the utilities that will be notified:** OCUNC will tell you the utilities that are on or adjacent to the work site, based on their database. Record the name(s) of the utility on the reverse side of this form.
3. **After the 48-hour waiting period, confirm that the utility locations have been marked:** Before digging or drilling, walk the work site and confirm that the utility companies have marked the utility locations in the field.
4. **If a locate appears to be missing:** If a utility locate appears to be missing and the utility company has not notified you that there are no utilities in the area, call OCUNC and:
   a. Provide the OCUNC locate number.
   b. Clearly state which utility has not been marked. The call is being recorded.
   c. Ask for a contact person at that utility.
   d. Call the contact person for the missing utility locate: Determine why there is no utility locate in the field.

Electric =	*Gas-Oil-Steam =*	*Comm-CATV =*	*Water =*	*Sewer =*	*Temp Survey =*
RED	**YELLOW**	**ORANGE**	**BLUE/PURPLE**	**GREEN**	**PINK**

e. **Record the reason(s) for the missing locate(s):** There are valid reasons that locates do not appear in the field (e.g., there are no utilities located on the work site or the utility has been abandoned). However, IF THEY ARE LATE, **YOU MUST WAIT** TO DRILL OR DIG. If the utility fails to mark a locate within the required 48 hours (2 full business days), the utility is liable for delay costs.

5. **Hand dig within 2 feet of a marked utility:** When digging or drilling within 2 feet of any marked utility, the utility must be exposed first by using hand tools.
6. **Record reason(s) for missing locate(s)**: There may be reasons that locates do not appear in the field (e.g., no utilities are located on the site, utility has been abandoned). Record the reason given. IF THEY ARE LATE – YOU WAIT TO DRILL OR DIG. If the utility failed to mark within the required two days, they are liable for delay costs.

FARALLON CONSULTING, L.L.C.
975 5th Avenue Northwest
Issaquah, Washington
98027

TELEPHONE CONVERSATION
Date: ____________________ **Time:** __________
Project Name: ______________________________
Job No.: ___________________________________
Phone No.: **1-800-424-5555 WA, 1-800-332-2344 OR**
____
Prepared By/Initials: ______________________
Call: ☐ **Placed** ☐ **Received**

Contact/Title: ____

Agency/Region: One-Call Utility Notification Center

PROJECT: ____

1. Your name and the Farallon Account No. #25999: ______________________________

2. What is the type of work being conducted (e.g., environmental drilling, test pit excavation)?

____

3. Who is the property owner? ____

4. County and city were work is being done? __________________________________

5. Address or street where work is taking place? ______________________________

____

6. Nearest cross street? ____

7. Distance and direction of the work site from the intersection? ____________________

8. Marking Instructions (generally locate on entire Site, including rights-of-way and easements): ____

____

____

9. What time and date will the locate be completed? _____________________________

10. Utility Locate Request Number? ____

11. Utilities that will be notified? ____

____

12. Any Overhead Concerns? ____

____

____

cc:____ **Page**__________ **of**__________

Note: Bold indicates required information.

ATTACHMENT 8
FARALLON FIELD PERSONNEL TRAINING DATES

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

Health and Safety
Certifications and Training

Name	Medical Monitoring		Annual/Biennial	Resp. Clearance	Respirator Fit Test	CPR	First Aid	Fire Extinguisher Training	Expiration Dates		Harassment Training	GHS Training	Lead Awareness	8 Hour Supervisor	40 Hour Training Taken (Initial)	8 Hour Refresher
	Date of Last Exam	Next Exam Due							BNSF E-Railsafe (Bi-annual)	BNSF Contractor Orientation (Annual)						
Bailey, Amber	04/19/17	04/19/19	B	04/19/17	04/14/17	11/02/18	11/02/18	06/16/16	12/06/19	11/28/19	06/04/18		04/14/17	10/30/17	11/22/13	02/07/19
Banfield, Chantal	10/15/18	10/15/20	B	10/15/18		11/02/18	11/02/18	06/14/17	06/14/19	11/13/19	10/16/18				10/11/18	01/25/19
Bowser, Matthew	04/12/17	04/12/19	B	04/12/17	04/18/17	11/02/18	11/02/18	05/16/16	07/21/19	07/30/19	05/11/18		04/14/17	10/30/17	06/11/15	01/29/19
Brown, Stuart	05/11/17	05/11/19	B	08/23/18	05/11/17	01/11/17	01/11/17	06/28/11			05/09/18		05/11/17	06/28/11	09/08/08	01/25/19
Burns, Anastasia	04/26/18	04/25/20	B	04/26/18	07/01/16	11/02/18	11/02/18	05/16/16	01/25/20	04/25/19	05/08/18			10/30/17	09/15/14	01/26/18
Charney, Ryan								02/11/19			02/11/19			02/06/18	01/03/15	
Cordell, Phil	08/27/18	08/27/20	B	08/27/18		04/05/17	04/05/17	09/17/18			09/11/18			06/20/08	11/15/05	01/25/19
Denning, Arik	07/06/18	07/06/20	B	07/06/18	07/06/18			07/31/18			07/18/18				04/06/14	01/25/19
Emahiser, Parker	04/18/17	04/18/19	B	04/18/17	05/09/17	12/21/17	12/21/17	05/16/16			06/07/18		05/08/17		02/17/13	01/25/19
Ferreira, Gabriela	03/19/18	03/18/20	B	03/19/18		01/04/18	01/04/18	03/26/18			05/10/18				09/18/15	01/31/19
Fisco, Gavin	08/08/18	08/07/20	B	08/08/18	08/08/18	09/26/16	09/26/16	05/18/16			05/17/18			12/12/14	05/04/07	01/25/19
Garvin, Paul	03/13/18	03/12/20	B	03/13/18		09/22/17	09/22/17	08/29/16	12/04/19	01/29/19	07/13/18			10/30/17	06/22/12	01/25/19
Luiten, Russell	04/19/17	04/19/19	B	04/19/17	04/12/17	11/02/18	11/02/18	05/17/16	11/15/19	12/29/18	09/13/18		04/14/17	12/19/17	6/2012?	01/25/19
Ostrom, Ryan	04/11/17	04/11/19	B	04/11/17	02/12/15	11/02/18	11/02/18	06/06/16	11/15/19	07/31/18	05/07/18		04/14/17	10/30/17	05/09/13	01/25/19
Pehlivan, Yusuf	05/03/17	05/03/19	B	05/13/17	05/03/17	10/19/17	10/19/17	05/04/17			06/29/18		05/02/17	02/02/13	10/17/09	01/25/19
Peters, Greg	06/07/17	06/07/19	B	06/07/19	06/07/17	11/02/18	11/02/18	06/12/17	01/31/20	01/30/19	05/08/18		06/08/17		03/12/17	01/25/19
Rayl, Katie	10/17/17	10/17/19	B	10/17/17	10/17/17	10/10/16	10/10/16	10/26/17			05/08/18		10/26/17		11/19/14	01/25/19
Roskamp, Melissa	12/20/18	12/19/20	B	12/20/18							01/02/19				07/26/13	01/25/19
Scott, Ken	01/18/18	01/18/20	B	01/18/18	04/14/17	11/02/18	11/02/18	09/02/16	04/19/19	04/04/19	05/09/18		04/14/17	02/17/05	09/01/95	01/25/19
Taylor, Brenden	04/24/18	04/23/20	B	04/24/18		03/01/18	03/01/18	08/23/16		05/11/17	05/22/18			04/17/09	07/18/06	01/25/19
Thompson, Lisa	11/30/18	11/29/20	B	11/30/18		10/07/18	10/07/18		12/11/20	12/12/19	11/28/18				12/07/18	02/05/19
Turpen, Nate	06/14/17	06/14/19	B	06/14/17		01/16/18	01/16/18	06/14/17	10/24/19	11/19/19	07/06/18		06/13/17		06/09/17	01/25/19
Wishnoff, Benjamin						11/24/15	04/16/16	06/24/16			06/29/18			06/09/15	05/29/07	01/25/19

ATTACHMENT 9
AIR MONITORING TABLE AND FORMS

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004

ACTION LEVEL TABLE FOR AIR MONITORING

The Air Monitoring table (following page) presents protocol for monitoring ambient air for constituents of concern and other parameters that may affect worker safety. Please note the following with respect to use of this table:

- The Level for Respirator Use indicates the concentration at which a respirator must be donned. It does not require that the job stop. The respirator is a piece of equipment that is to be used while determining why a concentration has reached that level. Implement engineering controls such as water mist, spray foam, plastic cover, etc. to reduce the concentration.
- The Level for Work Stoppage indicates the concentration at which work on the job must stop. Determine why a concentration has reached that level, and how it can be decreased. Site evacuation is not necessary at this level. Stopping work does not imply that the concentration level will decrease. Implement engineering controls to reduce the concentration; resume work when it is safe to do so.
- These values can be modified under particular Site conditions and with specific knowledge of the contaminant(s). Should such conditions arise, contact Farallon's Health and Safety Officer at (425) 295-0800.

AIR MONITORING

Chemical (or Class)	Monitoring Equipment	Task	Monitoring Frequency and Location	Level for Respirator Use	Level for Work Stoppage
Volatile Organic Vapors	Flame ionization detector (FID)/photoionization detector (PID) as appropriate for chemicals of concern. Read manual to determine. Draeger Tube for vinyl chloride (Model 1/a; Part Number 67 28031). Draeger Tube for benzene (Model 0.5/a).	From start of mobilization to completion and demobilization.	Sampling should be continuous during the project while disturbing potentially contaminated soil, uncovering and/or removing tanks and piping, or drilling —at least every 15 minutes in the breathing zone. Sample at the exclusion zone boundaries every 30 minutes. Continuously sample during each soil and groundwater sampling interval. If 10 parts per million (ppm) in breathing zone, collect a Draeger Tube for benzene and/or vinyl chloride (depending upon contaminants of concern).	20 ppm above background sustained in breathing zone for 2 minutes, and no benzene and/or vinyl chloride tube discoloration. If a color change appears on the tube for benzene or vinyl chloride at 10 ppm on FID/PID, don respirator. If no Draeger Tube is available, the level for respirator use is to be 5 ppm.	50 ppm above background in breathing zone and no vinyl chloride or benzene tube discoloration. Stop work if tube indicates > 1 ppm for benzene or vinyl chloride. If no Draeger Tube is available, stop work at 25 ppm.
Metals (Dust and Particulates)	XRF Spectrometer as appropriate for metals of concerns. Read manual to determine. Laboratory analysis for specific metals known to potentially be at levels exceeding respiratory protection requirements.	From start of mobilization to completion and demobilization.	Sampling should be continuous during the project while disturbing potentially contaminated soil at least every 15 minutes in the breathing zone. Sample at the exclusion zone boundaries every 30 minutes. Continuously during each sampling interval or excavation lift (as possible).	1 mg/m3 for mercury. Any detectable concentration of cadmium less than the PEL of 0.005 mg/m3. 0.5 mg/m3 for lead.	2.5 mg/m3 for mercury. Any concentration exceeding 0.005 mg/m3 for cadmium. 50 mg/m3 for lead.

AIR MONITORING EQUIPMENT CALIBRATION/CHECK LOG

Date	Instrument/ Model No.	Serial No.	Battery Check OK?	Zero Adjust OK?	Calibration Gas (ppm)	Reading (ppm)	Leak Check	Performed By	Comments

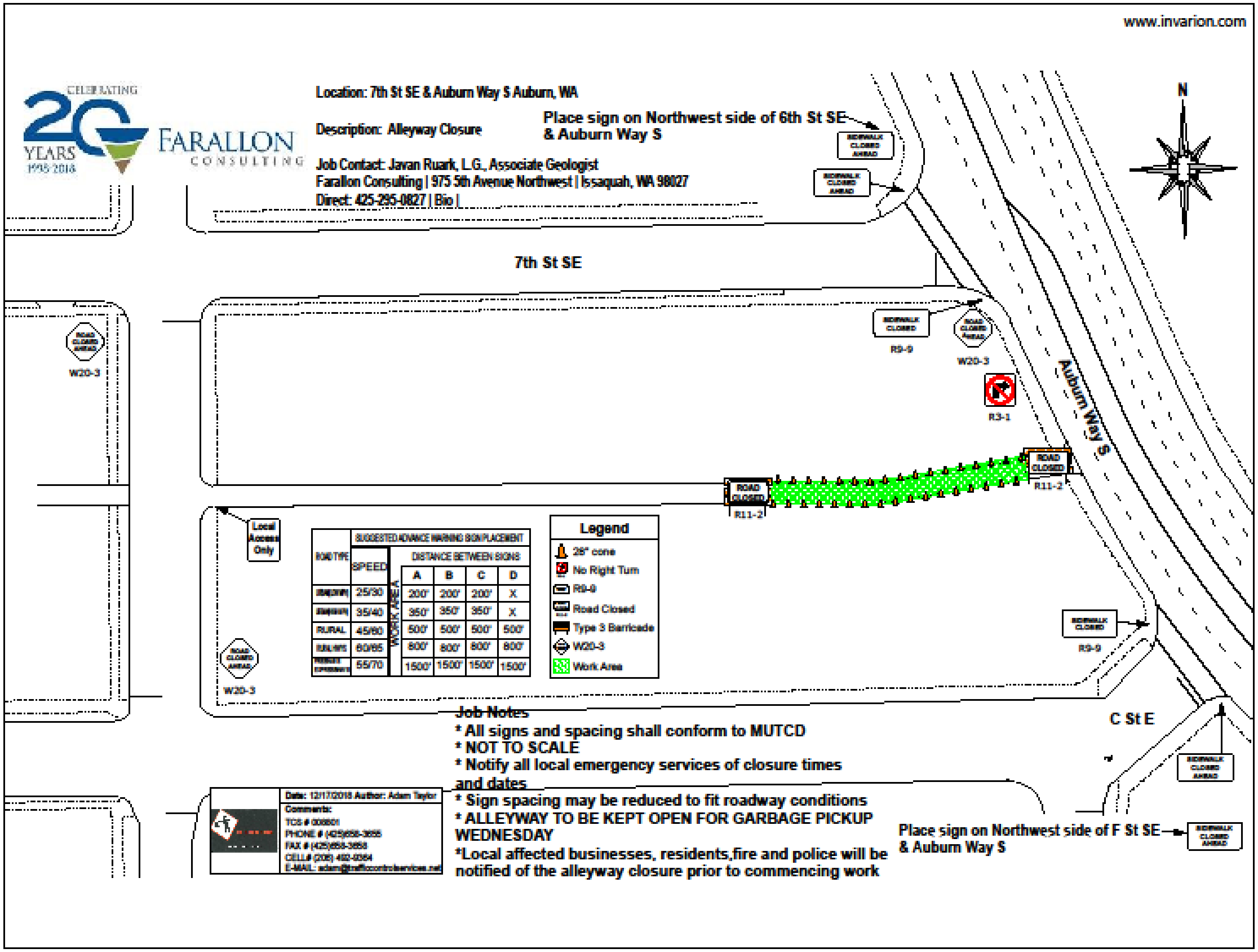
AIR MONITORING LOG

Date	Time	Location	Source/Area/ Breathing Zone	Instrument	Concentration/Units	Sampled by

ATTACHMENT 10
TRAFFIC CONTROL PLAN

HEALTH AND SAFETY PLAN
CHS Auburn Facility
238 8th Street Southeast
Auburn, Washington

Farallon PN: 301-004



ROAD TYPE	SPEED	WORK AREA	A	B	C	D
			SUGGESTED ADVANCE WARNING SIGN PLACEMENT			
			DISTANCE BETWEEN SIGNS			
[illegible]	25/30		200'	200'	200'	X
[illegible]	35/40		350'	350'	350'	X
RURAL	45/60		500'	500'	500'	500'
RURAL HWYS	60/65		800'	800'	800'	800'
[illegible]	55/70		1500'	1500'	1500'	1500'

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