Important Product Notice
Please be aware this product series is no longer in active production.

Sales Department
Contact a Phase Technologies technical sales staff member for its replacement.

Toll Free:	866-250-7934	Select #1 for the Sales Department
Phone:	605-343-7934	

Service or Repair
For service or repair related questions or requests – please contact our service department.

Phase Technologies Service Department

Toll Free:	866-250-7934	Select #2 for the Service Department
Phone:	605-343-7934	

Phase Technologies, LLC
231 East Main Street North
Rapid City, SD 57701
www.phasetechnologies.com

SAFETY MESSAGES AND WARNINGS

To ensure safe and reliable operation of the APX Series variable frequency drive, it is important to carefully read this manual, and to read and observe all warning labels attached to the drive before installing the equipment. Please follow all instructions exactly, and keep this manual with the equipment at all times for quick and easy reference.

Definitions of Warning Signs and Symbols

⚠ **CAUTION:** Indicates a potentially hazardous situation that could result in injury or damage to the product.

⚠ **WARNING:** Indicates a potentially hazardous situation that could result in serious injury or death.

⚠ **HIGH VOLTAGE:** Indicates high voltage. The voltage associated with the procedures or operations referenced could result in serious injury or death. Use caution and follow instructions carefully.

READ THESE WARNINGS BEFORE INSTALLING OR OPERATING THE EQUIPMENT!

⚠ **WARNING:** Risk of electric shock. De-energize the unit by disconnecting all incoming sources of power, then wait 5 minutes for internal charges to dissipate before servicing the equipment.

⚠ **HIGH VOLTAGE:** This equipment is connected to line voltages that can create a potentially hazardous situation. Electric shock could result in serious injury or death. This device should be installed only by trained, licensed and qualified personnel. Follow instructions carefully and observe all warnings.

⚠ **WARNING:** This equipment should be installed and serviced by qualified personnel familiar with the type of equipment and experienced in working with dangerous voltages.

⚠ **WARNING:** Installation of this equipment must comply with the National Electrical Code (NEC) and all applicable local codes. Failure to observe and comply with these codes could result in risk of electric shock, fire or damage to the equipment.

⚠ **CAUTION:** The AUX1 and AUX2 terminals are galvanically isolated, with approximately 5V potential between them. DO NOT apply a voltage to the terminals. Use dry contacts only.

⚠ **CAUTION:** Circuit breakers or fuses, proper ground circuits, disconnects and other safety equipment and their proper installation are not provided by Phase Technologies, LLC, and are the responsibility of the end user.

⚠ **CAUTION:** Long leads between the unit and the motor with an unfiltered PWM voltage can lead to dangerous voltage rise from reflected harmonics. Very long leads, such as in deep well submersible pump applications, may require the use of a sine wave filter to remove most of the harmonics from the waveform. Consult the factory or a knowledgeable source on drive filters if your application has more than 50 feet between the drive and the motor.

⚠ **CAUTION:** Failure to maintain adequate clearance may lead to overheating of the unit and cause damage or fire.

⚠ **WARNING:** Suitable for use in a circuit capable of delivering not more than 10 kA RMS symmetrical amperes, 240 V maximum for all models with 240V class input (refer to model nomenclature).

⚠ **WARNING:** Suitable for use in a circuit capable of delivering not more than 10 kA RMS symmetrical amperes, 480 V maximum for all models with 480V class input (refer to model nomenclature).

⚠ **WARNING:** Wire used within the motor circuit and all field wiring terminals must be rated at least 75 C.

⚠ **WARNING:** Use wire size suitable for Class 1 circuits.

⚠ **WARNING:** Input power connections should be made by a qualified electrician into a nominal 240V circuit for models with 240V input, or a nominal 480V circuit for models with 480V input, with adequate current carrying capacity. Branch circuit protection to the drive should be provided by appropriate size fuses or a 2 pole, linked circuit breaker. Circuit breaker and fuse ratings for each model are listed in Table 3-3.

⚠ **WARNING:** These devices are equipped with integral solid state short circuit protection. Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the National Electrical Code and any additional local codes.

⚠ **CAUTION**: Use 600 V vinyl-sheathed wire or equivalent. The voltage drop of the leads needs to be considered in determining wire size. Voltage drop is dependent on wire length and gauge. Use copper conductors only.

⚠ **CAUTION:** Wires fastened to the terminal blocks shall be secured by tightening the terminal screws to a torque value listed in Table 3-2.

⚠ **CAUTION:** The input wire gauge must be sized to accommodate the single-phase input current, which will be significantly larger than the three-phase output current to the load.

⚠ **CAUTION:** The maximum wire gauge for the input terminals is listed in Table 3-2.

⚠ **CAUTION:** Never allow bare wire to contact the metal surfaces.

⚠ **CAUTION:** Never connect AC main power to the output terminals U/T1, V/T2, and W/T3.

⚠ **WARNING:** Under certain conditions, the motor may automatically restart after a trip has stopped it. Make sure power to the drive has been disconnected before approaching or servicing the equipment. Otherwise, serious injury may occur.

⚠ **CAUTION:** Before applying power to the main input terminals of the unit, make certain that at least one of the switches or jumpers connected to AUX1 and AUX2 is open. Otherwise, the motor load may start as soon as the drive is energized.

⚠ **CAUTION:** The AC motor load must be connected directly to the output terminals of the converter. Do not install relays or disconnect switches between the converter and the motor load.

⚠ **CAUTION**: Before the motor is connected to the output terminals, check all output lines for line-to-ground faults using a megger. There is a direct path through the drive circuitry for ground fault currents that can be triggered when power is applied to the input terminals, even though the output switches are not activated. These currents can cause serious damage to drive circuitry and are not covered under warranty.

⚠ **CAUTION**: Electrostatic discharge (ESD) can damage printed circuits and their components. Before touching any printed circuit board, place a hand on a bare metal surface of the unit to discharge any static electricity.

⚠ **CAUTION:** When the ENABLE RESTARTS parameter is enabled the drive will energize in AUTO mode. The motor load will automatically run if AUX1 and AUX2 remote switches are closed. To stop the motor, push the H/O/A key until the display indicates MAN (manual) or OFF, or open AUX1 or AUX2. The RUN and STOP keys only work when in MAN mode. Refer to the section on Keypad and Display for instructions on operating the keypad.

⚠ **CAUTION**: Operating the system in MAN mode on the keypad overrides signals from the pressures switches. Operating the system in this mode may lead to dangerous pressures in closed plumbing systems

⚠ **CAUTION**: Even when the drive complies with IEEE 519 there may be enough high frequency noise on the line to interfere with or even to damage utility smart meters. Consult with your utility or the manufacturer about meter filtering options before operating the drive.

⚠ **CAUTION**: Line filter capacitors should be inspected annually at a minimum. Replacement of the capacitors every three years is recommended. These capacitors suppress electrical noise caused by the switching of the IGBTs. If they are degraded the electrical noise can damage equipment connected to the converter. See Section 8 ROUTINE MAINTENANCE.

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Section 4: Keypad and Display

Section 5: Adjustable Parameters

Section 6: Operation

Section 7: Constant Pressure Systems

Section 8: Troubleshooting

Section 9: Network Communication

CONTACT INFORMATION

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www.phasetechnologies.com

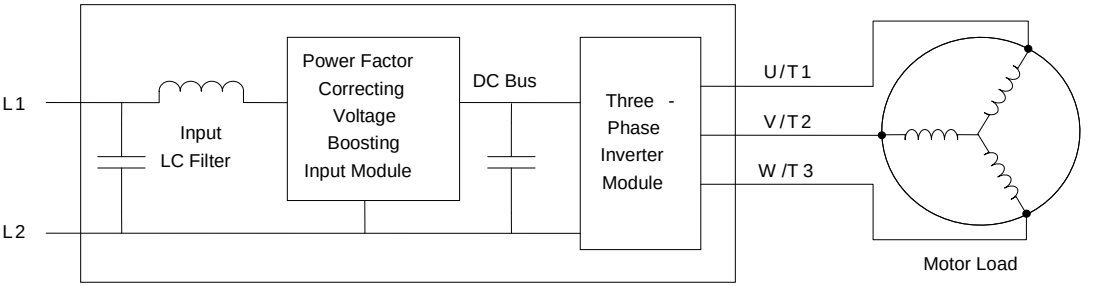
Version 1.8

APX Series variable frequency drives (VFD) are inverter-based devices that convert single-phase input to three-phase variable frequency output to provide speed control for three-phase AC motors. The drives have an active switching input rectifier that gives them several advantages over the typical passive input diode rectifier. APX Series drives are equipped with an LC filter on the line-side module, resulting in very low harmonic distortion of utility power.

1.1 APX Series Design

The simplified block diagram below demonstrates how the APX Series drive converts the incoming single-phase AC power to DC, then utilizes an inverter module to generate three-phase variable voltage and frequency output to control the speed of the motor.

Figure 1 APX Series Block Diagram



Line Side Converter
The single-phase line side converter consists of an IGBT module with an LC filter. This module employs electronic power factor correction, drawing the input current as a sine-wave, eliminating the current distortion and line harmonics associated with a passive diode rectifier bridge. The line side converter can also boost the DC bus voltage, which allows the inverter module to produce 480V output voltage from a 240V line voltage on some models.

Low Line Side Harmonics
All models of the APX Series employ electronic power factor correction on the input module. Electronic power factor correction allows the drive to draw the input current as a sine wave, greatly reducing the current distortion and line harmonics associated with a diode bridge rectifier. Because of its favorable harmonic profile, input line reactors and harmonic filters are NOT REQUIRED on the line side of an APX Series drive. Installations in most cases will comply with IEEE 519, the international standard for allowable harmonic distortion on utility mains.

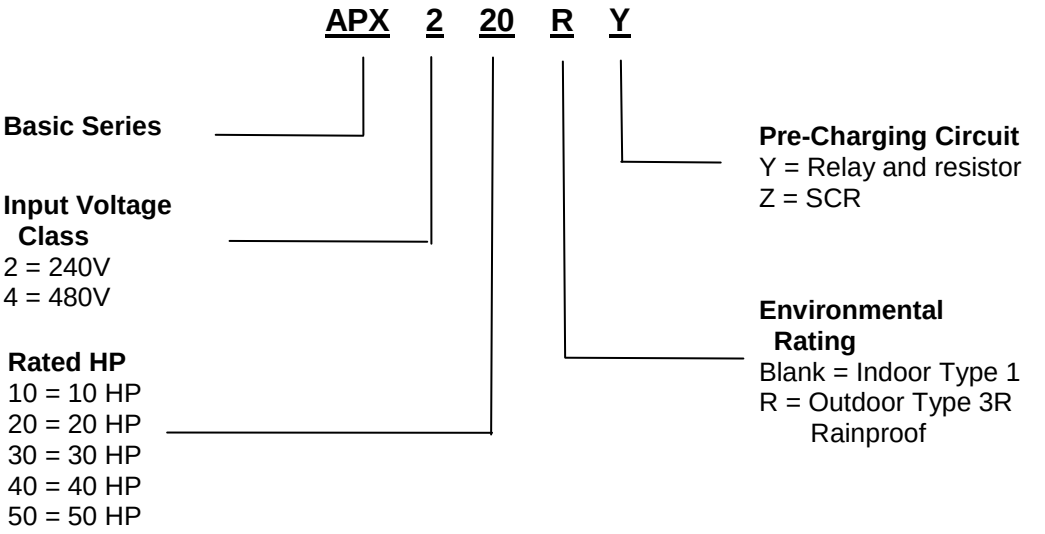
Voltage Boosting
Unlike a diode bridge rectifier, the input module is capable of significantly boosting the voltage on the DC bus. Utilizing this feature, some models of the APX series convert 240V single-phase line voltage to 480V three-phase output. The APX Series includes models rated either 240V or 480V on the line side. All APX Series drives are rated 480V three-phase on the load side.

Load Side Inverter
The APX Series output on the load side is three-phase, pulse width modulated (PWM), variable voltage and frequency. All models are rated 480V on the load side.

⚠ **CAUTION:** The AC motor load must be connected directly to the output terminals of the drive. Do not install relays or disconnect switches between the drive and the motor load.

Fuses or motor overload devices as required by NEC and local safety codes may be installed between the drive and the motor, however the APX Series is equipped with adjustable solid state motor overload protection.

1.2 Model Nomenclature



1.3 Base Models and Ratings

240V Input Models			
Model	**APX210**	**APX220**	**APX230**
Rated Input Voltage	1-phase, 240VAC, 50/60 Hz		
Rated Input Current (A)	50	100	139
Rated Output Voltage	3-phase, 380-480VAC, 50/60 Hz		
Rated Output Current (A)	17	31	46
Rated output KVA (480V)	14.1	25.8	38.2
Nominal out HP	10	20	30
Carrier Frequency*	2-5 kHz adjustable		

480V Input Models					
Model	**APX410**	**APX420**	**APX430**	**APX440**	**APX450**
Rated Input Voltage	1-phase, 480VAC, 50/60 Hz				
Rated Input Current (A)	26	50	70	100	120
Rated Output Voltage	3-phase, 440-480VAC, 50/60 Hz				
Rated Output Current (A)	17	31	46	61	77
Rated output KVA (480V)	14.1	16.6	24.9	50.7	64.0
Nominal out HP	10	20	30	40	50
Carrier Frequency*	2-5 kHz adjustable				

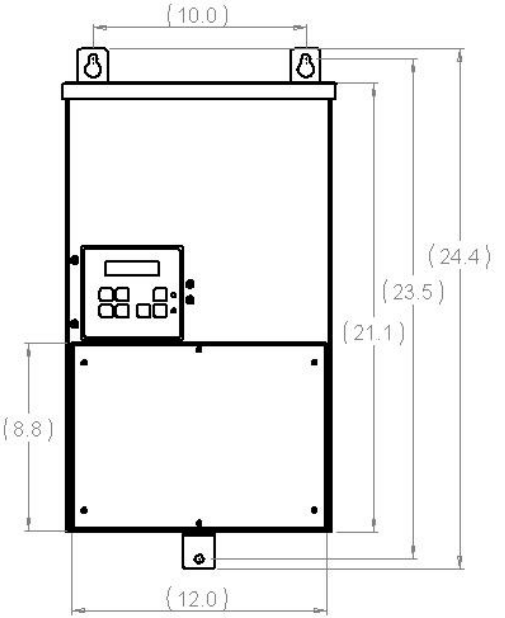
*Factory default for Carrier Frequency is 2 kHz. Carrier Frequency is an adjustable parameter set through the keypad.

1.4 Weights

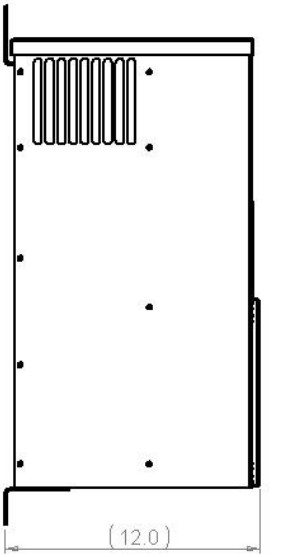
Model / Options	**Weight (lbs)**		**Model / Options**	**Weight (lbs)**
APX210	67		**APX420**	109
With 3R enclosure	70		With 3R enclosure	125
APX220	121		**APX430**	119
With 3R enclosure	138		With 3R enclosure	135
APX230	138		**APX440**	141
With 3R enclosure	155		With 3R enclosure	158
APX410	69		**APX450**	148
With 3R enclosure	72		With 3R enclosure	165

1.5 Dimensional Drawings

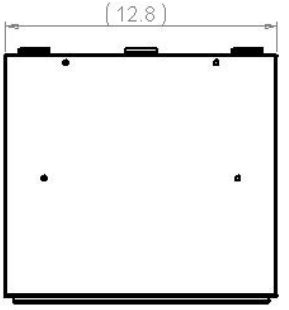
Small Frame (Type 1 Indoor) Includes models APX210, APX410



FRONT VIEW

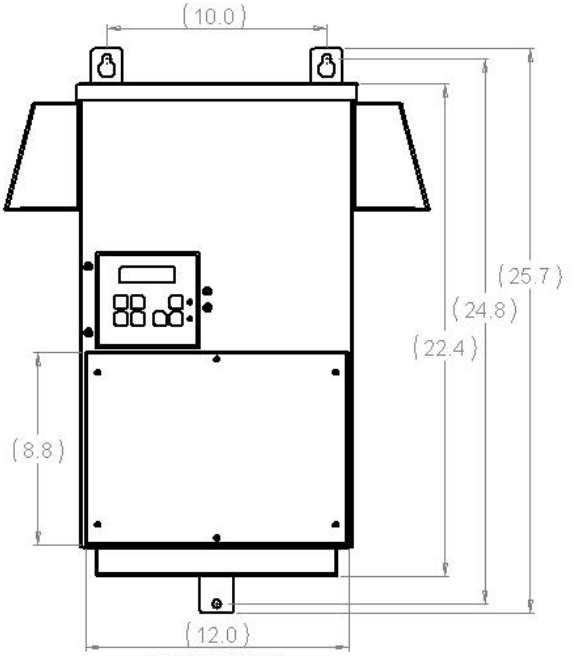


SIDE VIEW

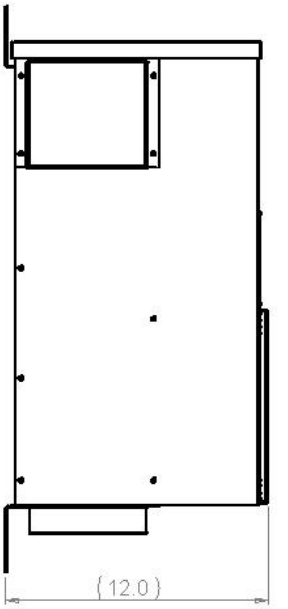


TOP VIEW

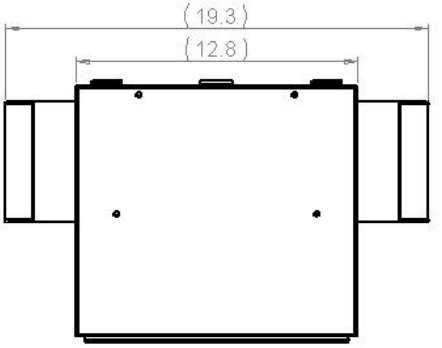
Small Frame (Type 3R Outdoor Rainproof) Includes models APX210R, APX410R



FRONT VIEW

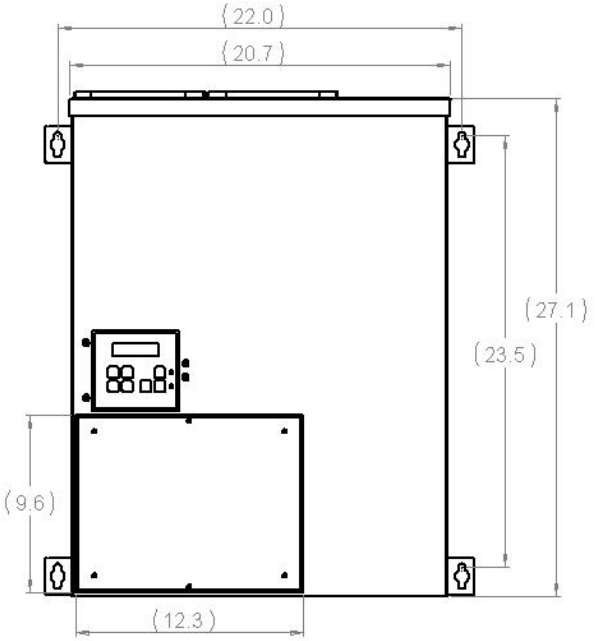


SIDE VIEW

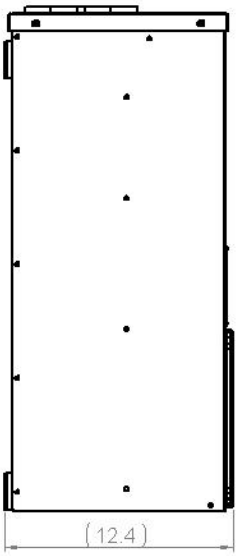


TOP VIEW

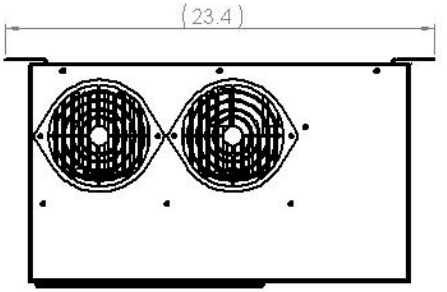
Medium Frame (Type 1 Indoor) Includes models APX420, APX430



FRONT VIEW

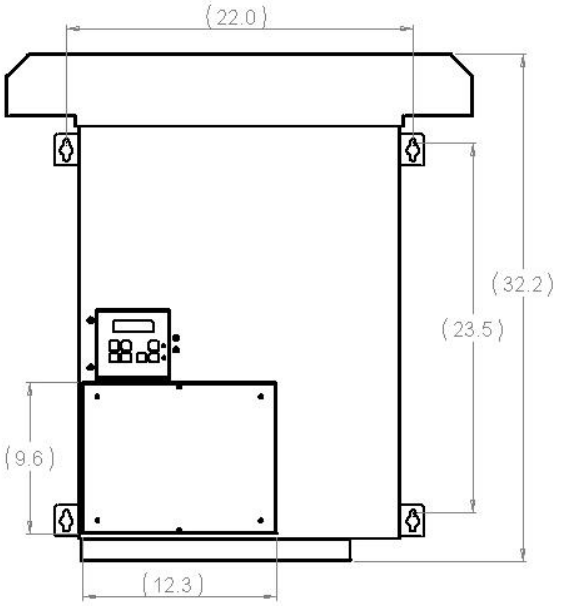


SIDE VIEW

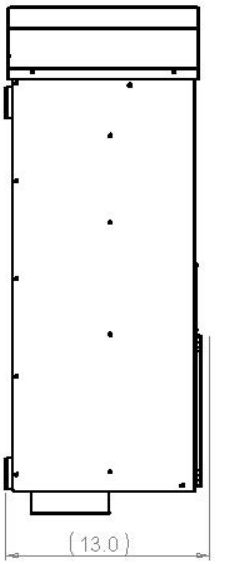


TOP VIEW

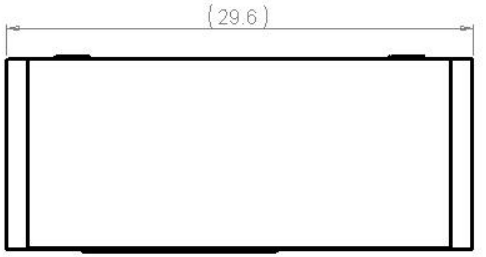
Medium Frame (Type 3R Outdoor) Includes models APX420R, APX430R



FRONT VIEW

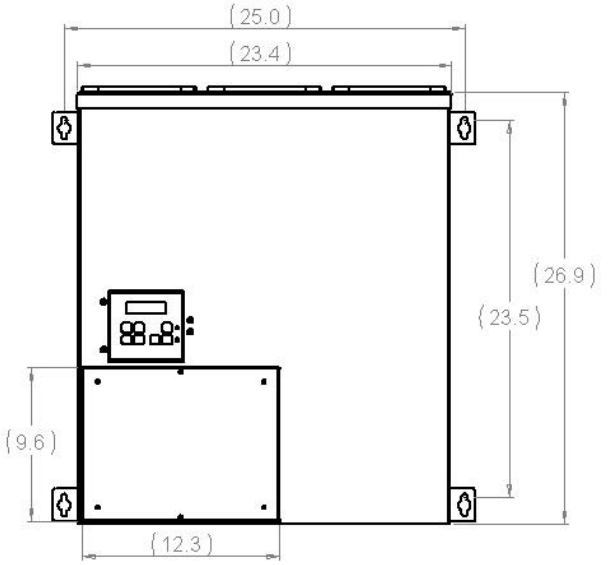


SIDE VIEW

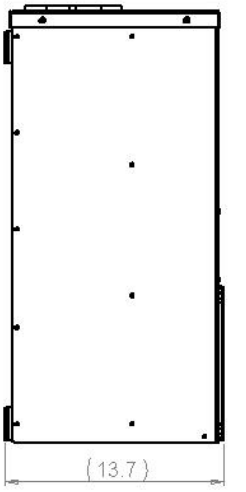


TOP VIEW

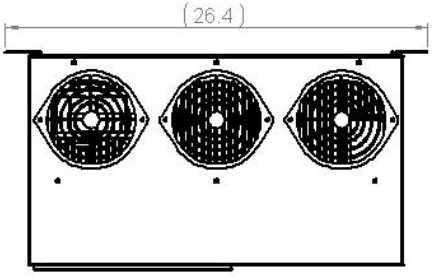
Large Frame Type 1 Indoor Includes models APX220, APX230, APX440, APX450



FRONT VIEW



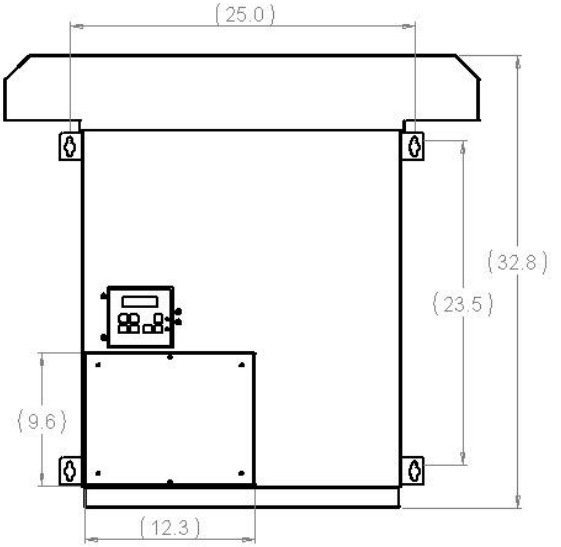
SIDE VIEW



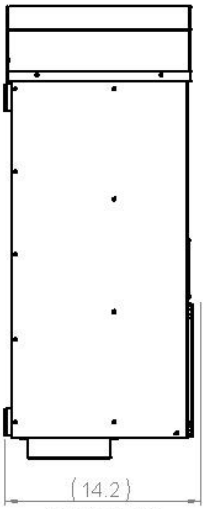
TOP VIEW

Large Frame Type 3R Outdoor Rainproof

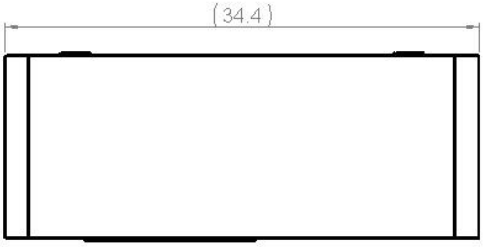
Includes models APX220R, APX230R, APX440R, APX450R



FRONT VIEW



SIDE VIEW



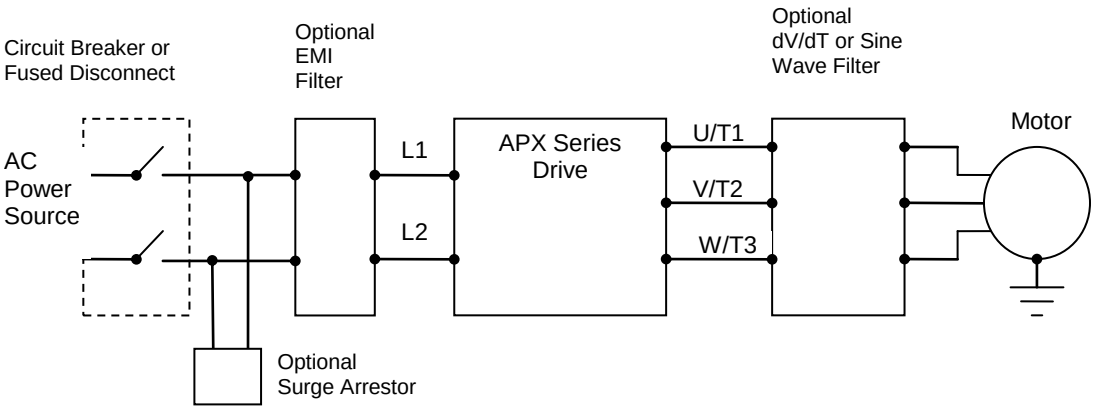
TOP VIEW

2.1 System Configuration

When used in a typical motor application, the APX Series may require the installation of several additional components. Figure 2-1 below illustrates a motor load application with components that may be required. Please remember to follow all applicable NEC and local codes to ensure safety and compliance.

⚠ **CAUTION:** Circuit breakers or fuses, proper ground circuits, disconnects and other safety equipment and their proper installation are not provided by Phase Technologies, LLC, and are the responsibility of the end user.

Figure 2-1 System Configuration



Line Side Harmonics

Because the drives have an actively controlled, power factor corrected input module, input line reactors and harmonic filters are typically not required. The input current is drawn in a sine wave, resulting in very low input current harmonics. Most other VFDs utilize a diode bridge rectifier which induces high levels of distortion in the input current.

APX Series drives are equipped on the line side with an LC filter for low harmonics operation. A drive in most cases will comply with IEE519, the international standard for allowable limits on distortion of AC power mains.

Under certain conditions such as large power supply capacity or abrupt power supply changes, general purpose VFDs may also require an AC reactor on the input side to prevent large peak current flows that can destroy their input diode rectifier. An APX Series drive with

its actively controlled input module does not create these high peak currents and is therefore not susceptible to damage under these conditions. An input line reactor is not recommended.

Surge Arrestor
It is recommended to install a surge arrestor on the line side of an APX Series drive to protect the input stage diodes from damage due to surges on the utility supply. The surge arrestor is typically installed in parallel on input L1 and L2 and can be connected at the input terminals of the drive, at the disconnect or at the service panel. The installation of a surge arrestor has the added advantage of protecting other equipment from surges that is installed on the service.

Mitigating Electromagnetic Interference (EMI)
Devices that utilize power switching electronics, such as APX Series drives, produce high frequency emissions commonly known as electromagnetic interference (EMI). These emissions can be conducted on power cables or emitted (radiated) through the air. Conducted and emitted noise can sometimes interfere with radio signals or sensitive electronic equipment near the installation. The use of shielded cables and rigid metal conduit on both input and output lines between the converter and the motor is recommended to help reduce EMI. An EMI Filter on the input lines helps reduce the radiated and emitted noise that can feed back from the converter to the source power. Contact the factory for assistance in choosing an EMI filter.

⚠ **CAUTION**: Even when the drive complies with IEEE 519 there may be enough high frequency noise on the line to interfere with or damage utility smart meters. Consult with your utility or the manufacturer about meter filtering options before operating the drive.

Output Filters
Some installations may require a load reactor, dV/dT filter or sine wave filter between the drive and the motor. **Output filters are necessary when motor leads exceed 50 ft.** Without filters, long leads allow reflected harmonics to create dangerous voltage spikes that can exceed the insulation rating of the motor cables and windings. Over time, these voltage spikes will degrade the insulation and result in motor faults.

A filter reduces harmonics in the PWM output voltage, smoothing the waveforms to reduce vibration in the motor. Filters also reduce common mode currents in the motor windings that can discharge through motor bearings, causing pitting and premature motor failure.

⚠ **CAUTION**: Long leads between the unit and the motor with an unfiltered PWM voltage can lead to dangerous voltage rise from reflected harmonics. Very long leads, such as in deep well submersible pump applications, may require the use of a sine wave filter to remove

most of the harmonics from the waveform. Consult the factory or a knowledgeable source on drive filters if your application has more than 50 feet between the converter and the motor.

2.2 System Configuration Settings

An APX Series drive is capable of operating several types of systems, including:

- Simple ON/OFF motor control from the keypad or remote switches
- Digital constant pressure water systems
- Analog constant pressure water systems
- Speed control by analog signal, either 0-5 VDC or 4-20 mA
- Combination of analog constant pressure or variable speed control by a potentiometer, selected by a manual switch

Firmware in the drive interprets input signals and other data differently, depending upon the type of system being operated. It is therefore important to select the appropriate system configuration setting either through the Programmable Parameters on the keypad.

Detailed information on setting System Configuration can be found in Section 6.3, *Setting System Configuration*.

3.1 Physical Installation

The drive must be mounted in an upright position with adequate clearance for cooling and maintenance access. See the following Section on Dimensions for details. The mounting surface must be sturdy and capable of bearing the weight of the unit. Fasten the unit to the mounting surface using screws or bolts of an appropriate size through the holes on the mounting brackets.

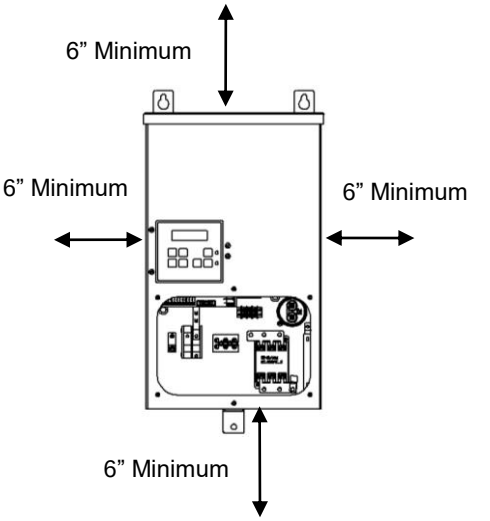
In order to allow for proper cooling and air circulation around the enclosure, maintain minimum clearance of 6 inches on the sides, top and bottom. The drives are cooled by fans with ventilation openings on the top and bottom of the enclosure. The air is pulled in the bottom of the enclosure and expelled out the top.

The surface below the enclosure should be of a non-flammable material and clear of obstacles.

Figure 3-1 Minimum Clearance

⚠ **CAUTION:** Failure to maintain adequate clearance may lead to overheating of the unit and cause damage or fire.

⚠ **CAUTION:** APX Series drives are intended for use in an ambient temperature no higher than 50˚C.



Locate the drawing of your APX Series drive frame size in Section 1.5 for determining dimensions, hole mounting location and clearance.

Integration by UL 508 Panel Shops

APX Series drives are available from the factory in indoor Type 1 or outdoor rainproof Type 3R enclosures.

If the drive is integrated into another enclosure by a UL 508 panel shop, care must be taken to ensure adequate airflow for cooling. If the drive is mounted completely inside the panel, baffles or duct must be employed to prevent the recirculation of exhaust.

⚠ **CAUTION**: Installation of the drive into a panel may increase back pressure created by restricting the flow of air exhausted from the fan. This may significantly reduce air flow through the heat sink, leading to higher internal temperatures and shortened component life. Additional fan(s) may be required.

Ambient temperature rating
APX Series drives are intended for use in an ambient temperature no higher than 50˚C.

3.2 General Wiring Considerations

Installations must comply with all NEC and local electrical code requirements. Please follow all warnings and directions below:

⚠ **WARNING:** Suitable for use in a circuit capable of delivering not more than 10 kA RMS symmetrical amperes, 240 V maximum for all models with 240V class input (refer to model nomenclature).

⚠ **WARNING:** Suitable for use in a circuit capable of delivering not more than 10 kA RMS symmetrical amperes, 480 V maximum for all models with 480V class input (refer to model nomenclature).

⚠ **WARNING:** Wire used within the motor circuit and all field wiring terminals must be rated at least 75˚ C.

⚠ **WARNING:** Use wire size suitable for Class 1 circuits.

⚠ **WARNING:** Input power connections should be made by a qualified electrician into a nominal 240V circuit for models with 240V input, or a nominal 480V circuit for models with 480V input, with adequate current carrying capacity. Branch circuit protection to the

drive should be provided by appropriate size fuses or a 2 pole, linked circuit breaker. Circuit breaker and fuse ratings for each model are listed in Table 3-3.

⚠ **WARNING:** These devices are equipped with integral solid state short circuit protection. Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the National Electrical Code and any additional local codes.

⚠ **CAUTION**: Use 600 V vinyl-sheathed wire or equivalent. The voltage drop of the leads needs to be considered in determining wire size. Voltage drop is dependent on wire length and gauge. Use copper conductors only.

⚠ **CAUTION:** Wires fastened to the terminal blocks shall be secured by tightening the terminal screws to a torque value listed in Table 3-2.

⚠ **CAUTION:** The input wire gauge must be sized to accommodate the single-phase input current, which will be significantly larger than the three-phase output current to the load.

⚠ **CAUTION:** Maximum wire gauge for the input terminals is listed in Table 3-2.

⚠ **CAUTION:** Never allow bare wire to contact the metal surfaces.

⚠ **CAUTION:** Never connect AC main power to the output terminals U/T1, V/T2, and W/T3.

⚠ **CAUTION:** Never connect AC main power or motor leads to the DC bus terminals VPOS, and VNEG.

Table 3-1 Power Terminal Descriptions

Terminal Name	Description
L1, L2	Input power terminals for single-phase input
U/T1, V/T2, W/T3	Output power terminals for three-phase output
GND	Earth safety ground

Table 3-2 Field Wiring Power Terminal Specifications

<table>
<tr><th colspan="6">Input Power Terminals</th></tr>
<tr><th colspan="6">Model</th></tr>
<tr><th colspan="2">APX210, APX410</th><th colspan="2">APX420, APX430</th><th colspan="2">APX220, APX230, APX440
APX450</th></tr>
<tr><th>Wire Size</th><th>Torque</th><th>Wire Size</th><th>Torque</th><th>Wire Size</th><th>Torque</th></tr>
<tr><td rowspan="4">4 – 18 AWG</td><td rowspan="4">16 in. lbs</td><td>2 AWG</td><td>50 in. lbs</td><td>2/0 – 6 AWG</td><td>120 in. lbs</td></tr>
<tr><td>4 – 6 AWG</td><td>45 in. lbs</td><td rowspan="2">8 AWG</td><td rowspan="2">40 in. lbs.</td></tr>
<tr><td rowspan="2">8 AWG</td><td rowspan="2">40 in. lbs</td></tr>
<tr><td rowspan="2">10 – 14 AWG</td><td rowspan="2">35 in. lbs.</td></tr>
<tr><td>10 – 14 AWG</td><td>35 in. lbs.</td></tr>
</table>

Table 3-2 Field Wiring Power Terminal Specifications continued…

<table>
<tr><th colspan="4">Output Power Terminals</th></tr>
<tr><th colspan="4">Model</th></tr>
<tr><th colspan="2">APX210, APX220, APX230,
APX410, APX420, APX430</th><th colspan="2">APX440, APX450</th></tr>
<tr><th>Wire Size</th><th>Torque</th><th>Wire Size</th><th>Torque</th></tr>
<tr><td rowspan="4">4 – 18 AWG</td><td rowspan="4">16 in. lbs.</td><td>2 AWG</td><td>50 in. lbs</td></tr>
<tr><td>4 – 6 AWG</td><td>45 in. lbs</td></tr>
<tr><td>8 AWG</td><td>40 in. lbs</td></tr>
<tr><td>10 – 14 AWG</td><td>35 in. lbs.</td></tr>
</table>

Table 3-3 Input Circuit Breaker and Fuse Ratings

Model	Maximum fuse rating, Class J	Maximum circuit breaker rating, amps
APX410	40 A, 600 V	40 A, 480 V
APX210	70 A, 600 V	70 A, 240 V
APX420	70 A, 600 V	70 A, 480 V
APX220	125 A, 600 V	125 A, 240 V
APX430	90 A, 600 V	90 A, 480 V
APX230	175 A, 600 V	175 A, 480 V
APX440	125 A, 600 V	125 A, 480 V
APX450	150 A, 600 V	150 A, 480 V

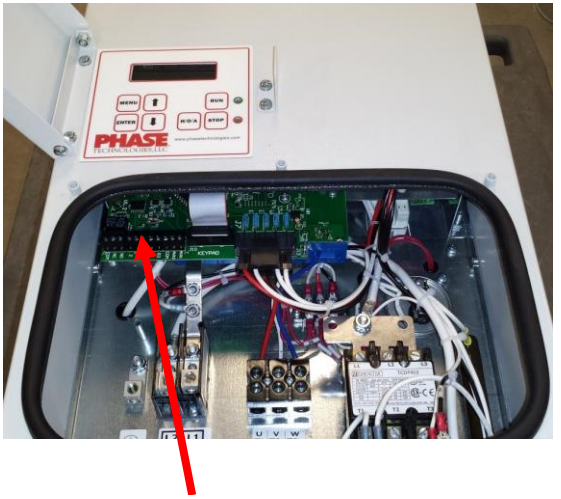
3.3 Control Terminals

An APX Series converter is equipped with Control Terminals that allow a number of control functions, including remote ON/OFF control, digital output signals, remote notification, operation of constant pressure water systems and MODBUS communication. **The correct System Configuration must be selected for proper operation of the different types of control systems! See Table 5-3, Interface Parameters.**

⚠ **WARNING:** All Control circuits are designed for low voltage. Do not connect external circuits with a voltage greater than the voltage specified for each Control Terminal in Table 3-4, Control Terminal Ratings and Descriptions. Disconnect all incoming sources of power, then wait 5 minutes for internal charges to dissipate before servicing the equipment.

⚠ **CAUTION:** The AUX1 and AUX2 terminals are galvanically isolated, with approximately 5V potential between them. DO NOT apply a voltage to the terminals. Use dry contacts only.

Figure 3-2 Control Terminal Panel



Remove the wiring access cover on the front panel to access Control Terminals.

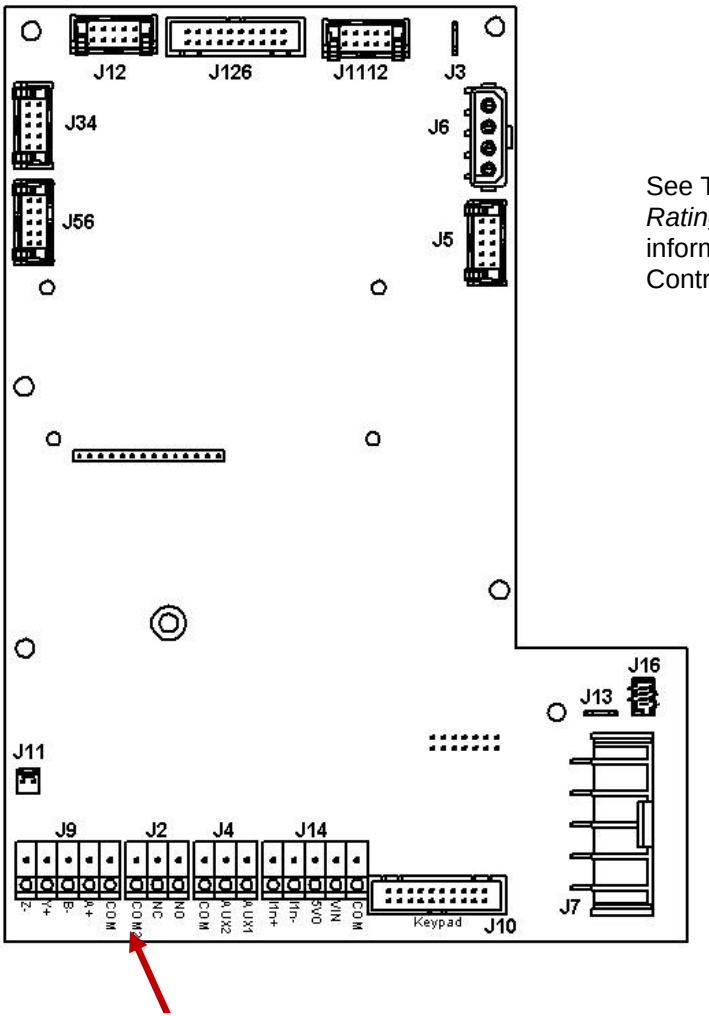
⚠ **WARNING:** Risk of electric shock. De-energize the unit by disconnecting all incoming sources of power, then wait 5 minutes for internal charges to dissipate before servicing the equipment.

Control Terminals are located on removable terminal blocks on the Master Control printed circuit board.

Remove the block for easy connection of control wires. To remove the terminal blocks, simply pull the block from mounting pins soldered into the circuit board.

⚠ **CAUTION:** Use care not to damage other components on the printed circuit board when removing and replacing the Control Terminal blocks.

Figure 3-3 Line Drawing of Control Terminals on MC Printed Circuit Board



See Table 3-4, *Control Terminal Ratings and Descriptions*, for information on the function of Control Terminals

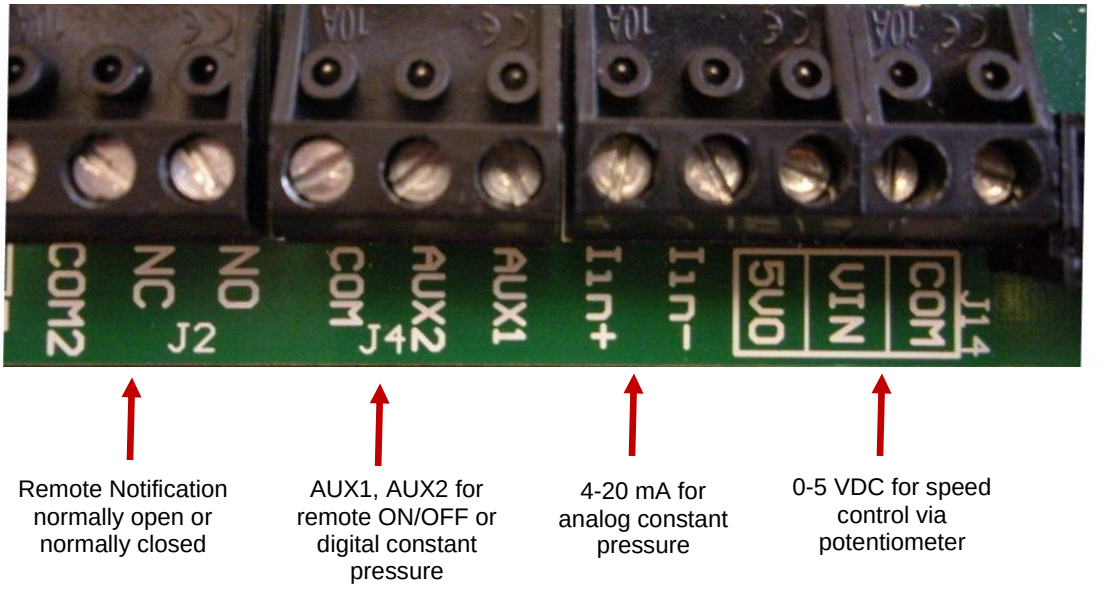
Control Terminals are located on the Master Control printed circuit board located just above the power input terminals.

Table 3-4 Control Terminal Ratings and Descriptions

Terminal	Description	Rating	Comments
COM2	Common		Common terminal for **NC** and **NO** terminals
NC	Normally Closed	Dry contact rated for maximum 30V, 1A	Normally closed remote notification terminal. Function of relay is programmable through parameter ***REMOTE NOTIFY*** in the Interface Parameters menu. See Table 5-3. Terminal can indicate either a fault or motor reaching minimum frequency.
NO	Normally Open	Dry contact rated for maximum 30V, 1A	Normally open remote notification terminal. Function of relay is programmable through parameter ***REMOTE NOTIFY*** in the Interface Parameters menu. See Table 5-3. Terminal can indicate either a fault or motor reaching minimum frequency.
Z	MODBUS	Transmit	MODBUS Protocol
Y	MODBUS	Transmit	MODBUS Protocol
B	MODBUS	Receive	MODBUS Protocol
A	MODBUS	Receive	MODBUS Protocol
G3	MODBUS	Common	Common Terminal for MODBUS
COM	Common		Common terminal for AUX1 and AUX2 terminals
AUX1	Auxiliary 1	< 5 volts, galvanically isolated	Remote ON/OFF terminal 1. Dry contact closure between the terminals will start the drive and connected load. Both **AUX1** and **AUX2** must be closed for the motor to run. In a digital CP system, the primary pressure switch is attached to AUX1.
AUX2	Auxiliary 2	< 5 volts, galvanically isolated	Remote ON/OFF terminal 2. Dry contact closure between the terminals will start the drive and connected load. Both **AUX1** and **AUX2** must be closed for the motor to run. In digital CP systems, the emergency over-pressure limit switch is attached to AUX2.

I in +	4-20 mA positive	4-20 mA	Analog transducer connection for analog constant pressure or proportional motor speed control from a current source. System Configuration must be set to 2 for constant pressure or 4 for proportional speed control. Refer to Table 5-3, *Interface Parameters*, for details. See Figure 3-6 for a connection diagram to Control Terminals.
I in –	4-20 mA negative	4-20 mA	
5 VO	0-5 VDC output	0-5 VDC	5 VDC supply to provide power to a potentiometer. System Configuration must be set to 3. See Figure 3-5 for a connection diagram to Control Terminals.
V In	0-5 VDC input	0-5 VDC	Analog input for motor speed control for 0-5 VDC. Speed is relative to scale of signal from 0 Hz to Maximum Frequency as set in Adjustable Parameter menu (factory default 60 Hz). Connect the wiper terminal of a potentiometer to this terminal. See Figure 3-5 for a connection diagram to Control Terminals.
COM	Common		Common for 0-5 VDC. See Figure 3-5 for a connection diagram to Control Terminals.

Figure 3-4 Control Terminals on MC Printed Circuit Board



0-5 VDC Transducer (Potentiometer)

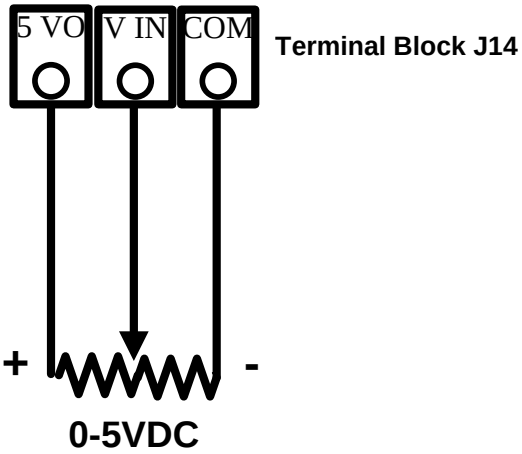
Follow these steps to connect a 0-5 VDC potentiometer to analog input:

1. Using the keypad, set the value of parameter ***SYSTEM CONFIG*** to 3. See Table 5-3, *Interface Parameters*, for details.
2. Connect the negative lead of the potentiometer to Common Terminal on Terminal Block J14
3. Connect the wiper terminal of the potentiometer to the V IN Terminal on Terminal Block J14.
4. Connect the positive lead of the potentiometer to the 5 VO Terminal on Terminal Block J14.

⚠ **CAUTION**: If the 0-5 VDC Control Terminals are short circuited, power will be lost to the keypad. If the drive is in MANUAL RUN mode the drive will not respond to a STOP command on the keypad. Disconnect input power to the drive to stop the motor and then fix the short circuit.

⚠ **CAUTION**: The resistance value of the transducer must be from 5,000 ohms to 20,000 ohms. Resistance below 5,000 ohms will produce a high current in the circuit and may damage components in the circuit.

Figure 3-5 Connection Diagram for 0-5VDC Transducer (Potentiometer)



4-20 mA Analog Transducer

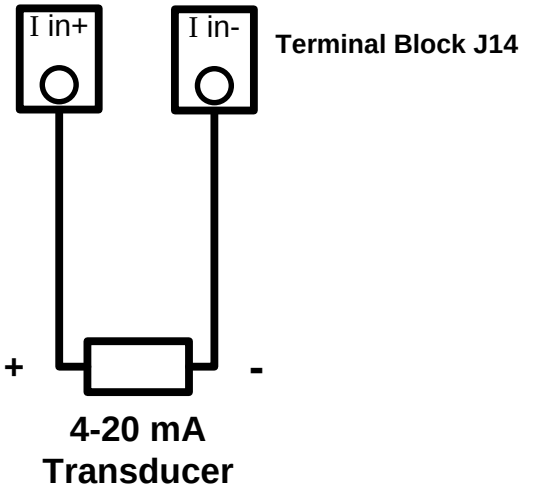
Follow these steps to connect a 4-20 mA transducer:

1. Using the keypad, set the value of parameter ***SYSTEM CONFIG*** to 2 for analog constant pressure or 4 for proportional motor speed control. See Table 5-3, *Interface Parameters*, for details.
2. Connect the positive lead of the transducer to terminal I in+.
3. Connect the negative lead of the transducer to terminal I in-.

⚠ **CAUTION**: A 4-20 mA transducer with the parameter ***SYSTEM CONFIG*** set at 4 results in linear speed control of the motor based on the analog signal from the transducer. This setting will not provide control of a constant pressure water system. For constant pressure control with 4-20mA transducer, ***SYSTEM CONFIG*** must be set at 2. See Section 7, *Constant Pressure Water Systems*, for more information.

⚠ **CAUTION**: If the I in+ and I in- Control Terminals are short circuited, power will be lost to the keypad. If the drive is in MANUAL RUN mode the drive will not respond to a STOP command on the keypad. Disconnect input power to the drive to stop the motor and then fix the short circuit.

Figure 3-6 Connections for 4-20 mA Analog Transducer



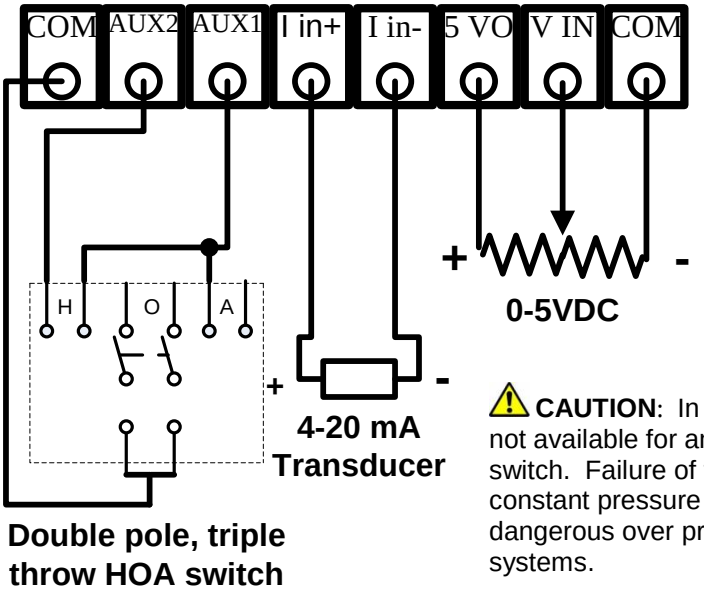
Analog Constant Pressure with Potentiometer and HOA Switch

APX Series drives can be configured with a HOA switch that allows the user to either turn the motor off, control motor speed with a potentiometer or operated in constant pressure mode. Access to the keypad is not required to operate in this mode.

4. Using the keypad, set the value of parameter ***SYSTEM CONFIG*** to 5. See Table 5-3, *Interface Parameters*, for details.
5. Connect the potentiometer and 4-20 mA transducer as in Figures 3-5 and 3-6.
6. Connect a double pole, triple throw HOA switch to AUX1 and AUX2 as depicted in Figure 3-7.
7. Using the keypad, set the drive to operate in AUTO mode.

The mechanical HOA switch allows the user to select between OFF, manual speed control with the potentiometer or analog constant pressure. In the H (manual) position, motor speed is controlled by the potentiometer. In the O (off) position the motor will stop. In the A (auto) position motor speed will be controlled by constant pressure parameters.

Figure 3-7 Connections for Analog Constant Pressure with Potentiometer and HOA Switch



CAUTION: In this configuration AUX2 is not available for an emergency overpressure switch. Failure of the 4-20 mA transducer in constant pressure mode may result in dangerous over pressure in closed plumbing systems.

3.4 Installing Power Cables

⚠ **CAUTION:** Continuous metal conduit should be used on all power cables, both line and load side, to reduce conducted and emitted radiation of electromagnetic interference (EMI). The conduit must be securely grounded to the enclosure of the drive and the motor case.

When it is not practical to use continuous metal conduit, special shielded cables can be used. The shielded cable should be constructed with symmetrical conductors and a copper or aluminum shield covered with an insulating jacket. A good shield results in lower EMI interference and lower motor bearing currents.

Power cables should enter the drive enclosure only through the bottom of the wire cavity which is located below the power terminals. Knockouts are not provided in the enclosure. Appropriately sized conduit openings must be created with a punch.

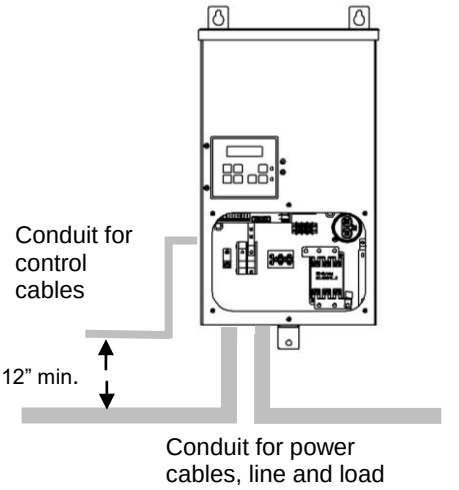
Do not install line-side power cables in the same conduit or cable tray with load side power cables. Also, do not route control cables through the same conduit or cable tray as power cables. A separate conduit entrance for control cables should be created on the left side of the drive near the Control Terminals. This avoids the need for control cables to be routed through the high EMI environment of the drive enclosure.

If the control cables must intersect the power cables, make sure cross at right angles.

Figure 3-4 Routing Power Cables

⚠ **CAUTION:** When possible, avoid routing control cables and power cables in close proximity to avoid coupling EMI onto control cables.

⚠ **CAUTION:** Power cable conduit openings in the enclosure should be made only in the bottom of the enclosure.



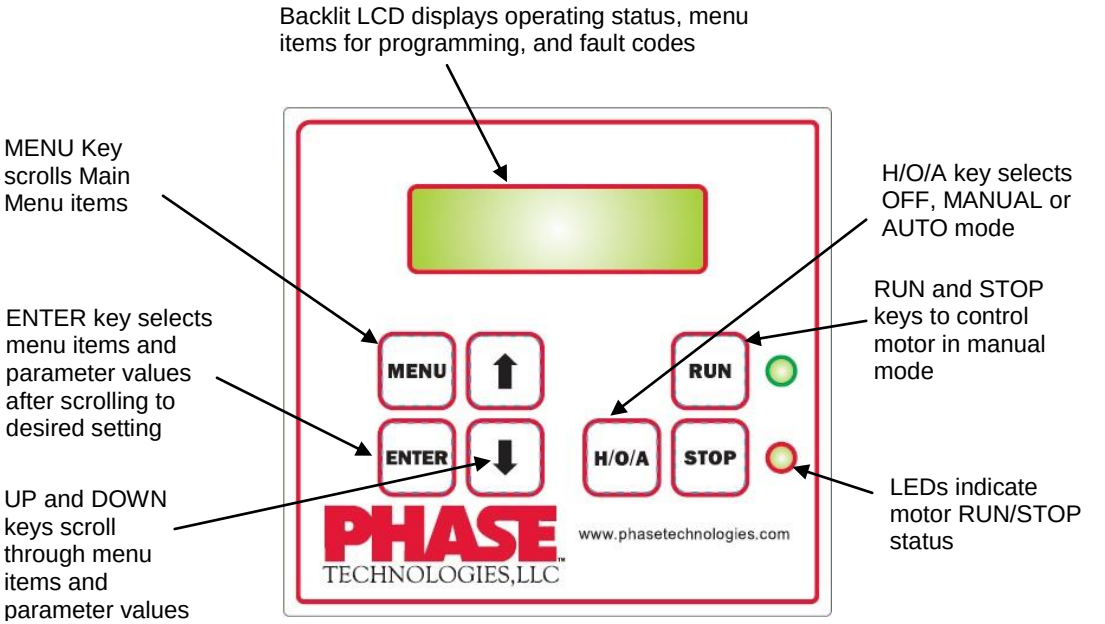
Operation of an APX Series drive is simple and straightforward after completion of physical installation and wiring. Before operating the motor load, several basic settings and procedures must be completed. If desired, extensive features for special operating conditions and for protection of the motor load are available through the keypad.

A power-up test should be performed before the unit and its load are placed in service. Refer to Section 6.1, *Commissioning the Unit*. Before initial power up, it is advisable to become familiar with setting motor overload protection, setting system configuration, and with basic operation of the keypad and display.

4.1 Using the Keypad and Display

An APX Series drive is capable of many advanced, easy to use features that allow the user to protect the motor load from damage, monitor load conditions, log motor run time, trouble shoot the system and more. The keypad is easy to use and understand, with 32 character text messages and an intuitive interface specifically tailored for pumping applications.

Figure 4-1 Keypad & Text Display



Default Display Mode
After two minutes of keypad inactivity, the display will revert to the default display mode, which indicates either AUTO, MANUAL, or OFF mode and the status of the AUX1 and AUX2 remote switch circuits. The default display also indicates the output horsepower (HP), output current in amps (A) and output frequency in Hz.

Password Protecting the Keypad
The keypad can be set up with a password to prevent unauthorized changes in adjustable parameters. The parameter ***PASSWORD SETUP*** (Table 5-3 *Interface Parameters*) is used to protect the keypad. When this parameter has a value of zero the keypad is not protected. To password protect the keypad, enter a password consisting of a number between 1 and 99 as the parameter value. Contact customer service at 605-343-7934 if you lose or forget the password.

⚠ **CAUTION**: If the 4-20 mA or 0-5 VDC Control Terminals are short circuited, power will be lost to the keypad. If the drive is in MANUAL RUN mode the drive will not respond to a STOP command on the keypad. Disconnect input power to the drive to stop the motor and then fix the short circuit.

Keypad Display Messages

Several messages will appear on the display when the unit is initially energized. When the unit has completed its start-up routine, the default display indicating the status of the OFF, AUTO, MAN mode will appear. Start-up display messages are detailed in Table 4-1 below.

Table 4-1 Display of Operating Modes

MODE	DESCRIPTION
AUTO	The factory default operating mode is OFF. The adjustable parameter, ***ENABLE RESTARTS*****,** must be set to 1 to allow automatic re-starts. See Table 5-1, Operating Parameters for details. ⚠ **CAUTION**: In AUTO mode, the motor load will automatically run if both AUX1 and AUX2 remote switches are closed. Open AUX1 or AUX2 to stop the motor or push H/O/A until OFF appears. The RUN and STOP keys only work when in MAN mode.
MANUAL	Activate MANUAL mode by pushing the H/O/A key until ***MAN*** appears on the display. In MANUAL mode the motor load is controlled by using the RUN and STOP keys, which will override the AUX1 and AUX2 remote switches. ⚠ **CAUTION**: Operating the system in MANUAL mode on the keypad overrides signals from the pressures switches. Operating the system in this mode may lead to dangerous pressures in closed plumbing systems. ⚠ **CAUTION**: If the 4-20 mA or 0-5 VDC Control Terminals are short circuited, power will be lost to the keypad. If the drive is in MANUAL RUN mode the drive will not respond to a STOP command on the keypad. Disconnect input power to the drive to stop the motor and then fix the short circuit.
OFF	The factory default operating mode is OFF. The adjustable parameter, ***ENABLE RESTARTS***, must be set to 1 to allow automatic re-starts. Pressing the H/O/A key during operation until ***OFF*** appears on the display will stop the motor load. To start the motor, revert to either AUTO mode or MANUAL mode. Certain faults can also be cleared by pressing the up and down arrow keys at the same time and holding for one second.

4.2 Keypad Main Menu Items

Main Menu items are accessed by pressing MENU on the keypad. Press MENU repeatedly to scroll through the Main Menu items. Press ENTER to view or edit a Main Menu item.

Figure 4-2 Navigating Main Menu Items

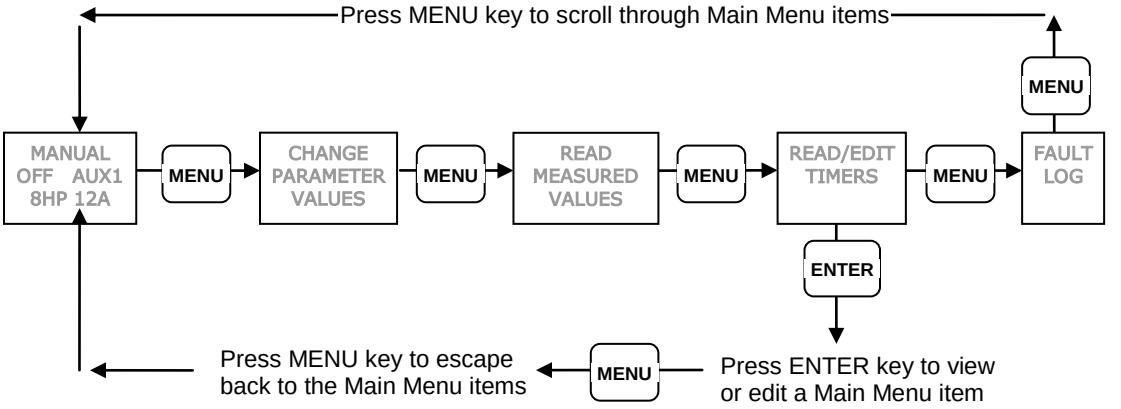


Table 4-2 Main Menu Items

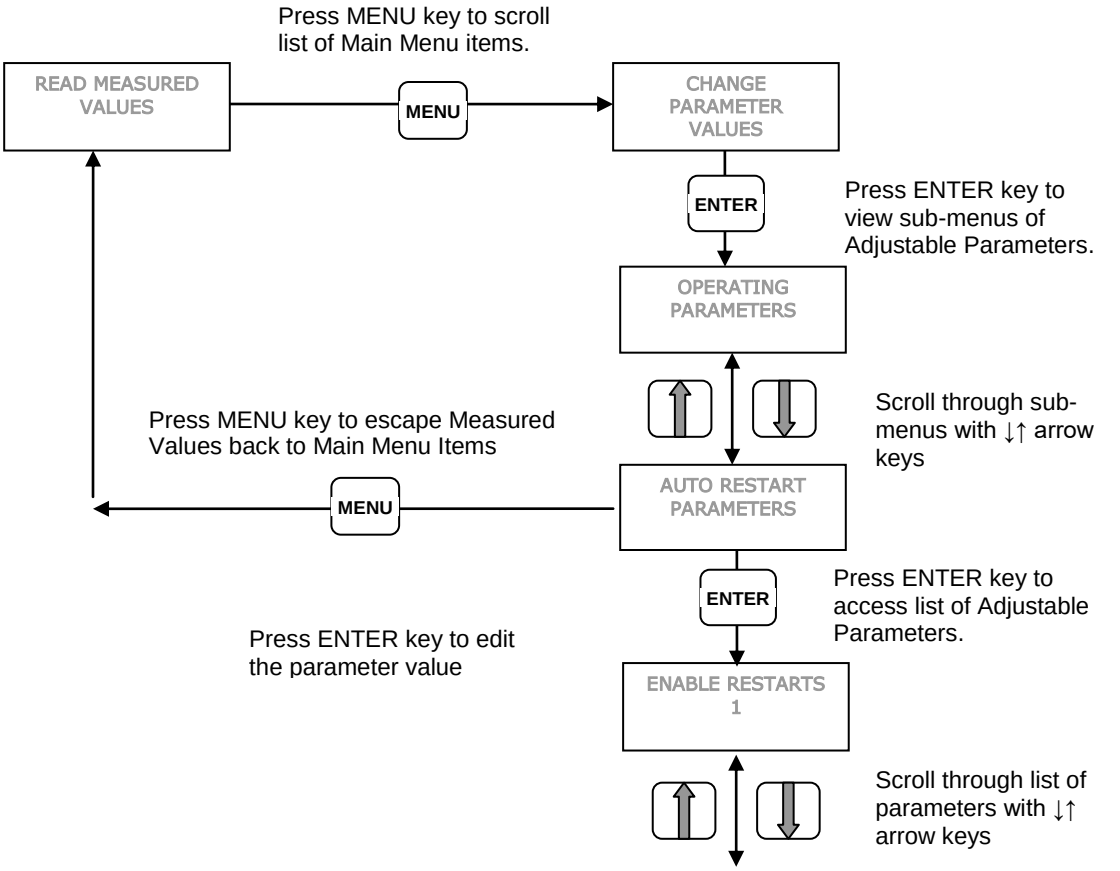
DISPLAY MESSAGE	DESCRIPTION
MANUAL/OFF/AUTO AUX1 AUX2 HP, A, HZ	Display indicates either AUTO, MANUAL, or OFF mode, the status of the AUX1 and AUX2 switch circuits, and other operating parameters. If the drive has faulted and is set to automatically restart, a counter will appear in the display showing the time until restart. After 2 minutes of keypad inactivity, the display will revert to this mode.
CHANGE PARAMETER VALUES	Allows the user to set values for functions such as motor overload settings, dry well condition, time to restart after a fault, etc.
READ MEASURED VALUES	Displays measured values such as output current, input voltage, load power factor, etc.
READ TIMERS	Records motor run time and drive on time
FAULT LOG	Records the number of times a particular fault has occurred.
CLEAR MEMORY	Press ENTER to bring up CLEAR MEMORY menu. Use arrow keys to select RESET TIMERS or CLEAR FAULTS. Clearing faults will clear ALL faults in the log. Press ENTER to clear timers or faults.

Change Parameter Values

The Main Menu item, ***CHANGE PARAMETER VALUES***, leads to several sub-menus that contain adjustable operating parameters. These parameters provide basic functions such as motor overload protection and advanced features that allow you to customize operation of the drive to fit your application.

The following Section 5, *Adjustable Parameters*, contains a complete list of the parameters along with a description of their function and instructions on setting them.

Figure 4-3 Change Parameter Values



Read Measured Values

The display can provide a variety of measured values related to the performance of the drive and its load, such as currents, horsepower, and power factor. To read measured values:

1. Press the MENU key to scroll through menu items until ***READ MEASURED VALUES*** appears on the display.
2. Press ENTER to access this menu item.
3. Use the up and down arrow keys to scroll through the various values that you wish to read.

Programming Tip

Pressing H/O/A key while in menu items will return the display to the default screen.

Figure 4-3 Read Measured Values

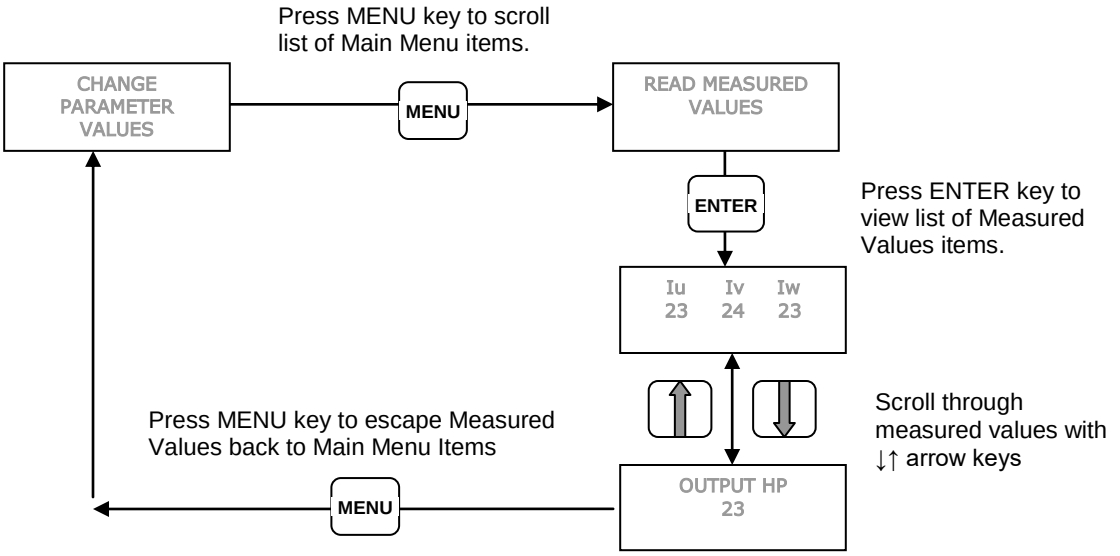


Table 4-3 Measured Values

DISPLAY MESSAGE	DESCRIPTION OF MEASURED VALUE
Iu Iv Iw	Three-phase currents on the output
OUTPUT HP	Output measured in horse power
OUTPUT KWATTS	Output measured in kilowatts
OUTPUT KVA	Output measured in KVA
OUTPUT PF	Power factor of the motor load
BUS CAP VOLTAGE	Voltage of the DC bus
INPUT VOLTAGE	Input voltage AC
INPUT CURRENT	Input current in amps
AUX1 AUX2	ON/OFF status of the remote switch circuits AUX1 and AUX2
FREQUENCY	Output frequency in Hz
MODEL NUMBER	Displays the APX Series product model number
V 5VDC IN	Measures the 0-5 VDC analog control voltage between Control Terminals for 0-5VDC input.
I 20MA IN	Measures 4-20 mA analog control current on Control Terminals for analog current input.
TIME UNTIL START	Displays a timer that counts down the time left to start when the drive is in a time delay upon initial power on.

Read and Edit Timers

The timer function records the motor run time in hours, and the time the drive has been energized. There are two timers for each function, one which can be reset, and one permanent. To view and reset the timers:

1. Press the MENU key to scroll through menu items until ***READ/EDIT TIMERS*** appears on the display.
2. Press ENTER to enter this menu item.
3. Use the up and down arrows to scroll through the clock functions.
4. To reset the clock timers, navigate to the Main Menu item, ***CLEAR MEMORY***, use arrow keys to select ***RESET TIMERS***, then press ENTER

Figure 4-4 Read/Edit Timers

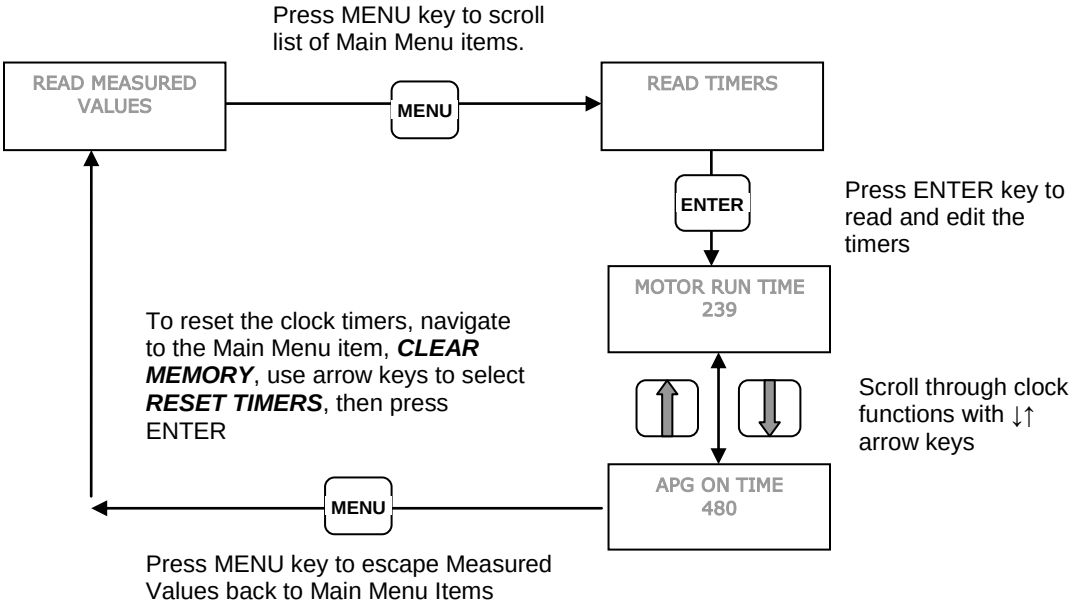


Table 4-5 Timers

TIMER	DESCRIPTION
MOTOR RUN TIME	Logs motor run time in hours.
APX ON TIME	Logs time in hours the AP Series unit is energized.
ALL MOTOR HOURS	Logs total motor run time. Not resettable.
ALL APX HOURS	Logs total time the AP Series unit is energized. Not resettable.

Programming Tip

To reset the timers, navigate to the Main Menu item, ***CLEAR MEMORY***, use arrow keys to select ***RESET TIMERS***, then press ENTER

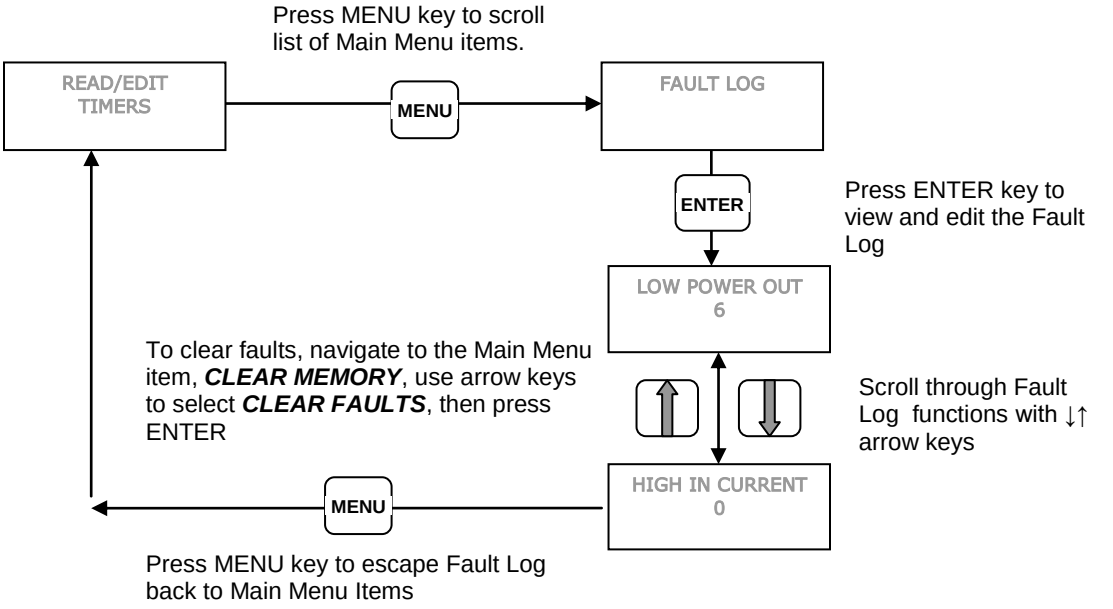
Clear Memory
The ***CLEAR MEMORY*** function in the Main Menu allows you to reset the timers that record motor run time and drive on time, and to reset the Fault Log which counts the number of each particular fault.

Fault Log
The Fault Log records the number of times a particular fault has occurred. For instance, in a remote well pump application, it might be useful to know how many times the unit has tripped due to dry well since the last visit to the site. To view the Fault Log:

1. Press the MENU key to scroll through menu items until ***FAULT LOG*** appears on the display.
2. Press ENTER to access this menu item.
3. Use the up and down arrows to scroll through the fault functions.
4. The fault will appear on the first row of the display, followed by the number of times that fault has occurred.
5. To reset the fault log, navigate to the Main Menu item, ***CLEAR MEMORY***, scroll with arrow keys to select ***CLEAR FAULTS***, then press ENTER.

⚠ **CAUTION**: Clearing faults through the ***CLEAR MEMORY*** menu will clear **ALL** faults in the log!

Figure 4-7 Fault Log



See Section 8.1 *Status Indicators and Fault Codes,* for a complete listing of fault codes.

5.1 Changing Parameter Values

⚠ **WARNING**: When the drive is set to automatically restart after a trip or fault, the main output terminals can energize and the load can start without warning, exposing the user to risk of serious injury. Make certain the input is de-energized or controls to the load are OFF before approaching the equipment. The unit can be programmed to automatically restart after certain faults. The factory default setting does not allow automatic restart. Use caution if automatic restart is allowed for any fault.

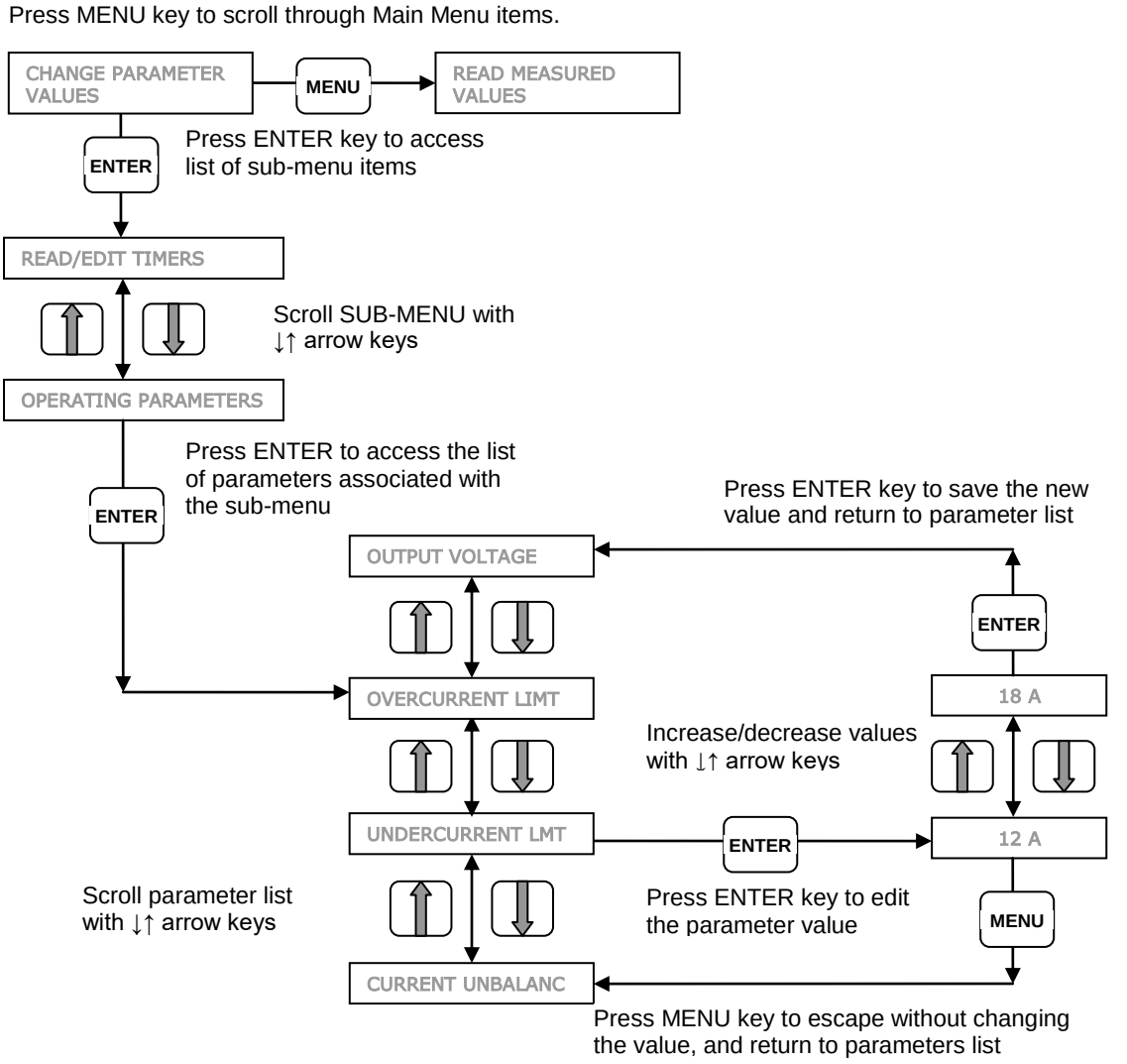
The Change Parameter Values function allows the user to set values for a variety of functions including motor overload settings, number of restarts after a fault, ramp time, maximum frequency, and more. To change parameter values:

1. Press the MENU key to scroll through menu items until ***CHANGE PARAMETER VALUES*** appears on the display.
2. Press ENTER to access this menu item.
3. There are four sub-menu items under ***CHANGE PARAMETER VALUES.*** Use the up and down arrows to scroll through the sub-menu to find the item desired, then press ENTER. See Tables 5-1 through 5-4, for a list of parameters with a description.
4. Use the up and down arrow keys to scroll to the parameter you want to set, press ENTER, then use the up and down arrows to select a new value for that parameter.
5. When the value you want appears on the display, press ENTER to select that value.
6. To escape the parameter without selecting or resetting the value, press the MENU key, which will return you to the list of parameters.

Programming Tip

Press the ENTER key to move to lower levels of the menu outline or to save a new parameter value. Press the MENU key to move to higher levels in the menu outline or to escape a parameter setting without changing the value.

Figure 5-1 Changing Parameter Values



Restore Default Parameter Settings
To restore **ALL (except for REVERSE ROTATION)** adjustable parameters to their default value, press and hold the MENU, ENTER**,**↓**,** ↑ keys at once and hold for three seconds.


Programming Tip
Make sure to press all four keys at once. The display will read "RESETTING". This reset function is disabled while the motor is running. Make certain the motor is stopped before resetting.

⚠ **CAUTION**: Holding all four of these keys down will reset **ALL (except for REVERSE ROTATION)** programmable parameters to the default value. To reset an individual parameter to its default value, you must refer to the appropriate Table of Adjustable Parameters, find the default value, re-enter that value and save it. See Tables 5-1 through 5-4 for a complete list of adjustable parameters, their description and default/minimum/maximum values.

Auto Restarts
The drive can be programmed to automatically restart after certain faults. Using the Auto Restart Parameters (See Table 5-4), you can set a time delay before the drive starts after a fault and select the number of automatic restarts allowed before the unit will remain OFF after a fault.

For example, you may wish to allow 10 automatic restarts after a fault for dry well, but require the drive to remain off for one hour to allow the well to recover before restarting.

When the drive is counting down the time to restart after a fault, the display will indicate the time until restart (in seconds).


Programming Tip
To interrupt the countdown and allow a restart, push and hold both the up arrow key and down arrow key for one second.

When the drive reaches the limit of faults set by the adjustable parameter, it will remain OFF and input power must be cycled OFF/ON to reset the restart counter to zero.


Programming Tip

Any time the input power is cycled OFF/ON, all restart counters will be reset to zero. However, the Fault Log will continue to count the total number of faults. The Fault Log is reset using the ***CLEAR MEMORY*** function in the Main Menu. See Section 4 for more information on the ***CLEAR MEMORY*** function.

⚠ **CAUTION**: Resetting the restart counter by cycling power OFF/ON will reset to zero the count for **ALL** resettable faults. Do not confuse the restart counter with the Fault Log. The Fault Log counts all faults and can only be reset by navigating the Main Menu item ***CLEAR MEMORY***. Clearing the Fault Log will not reset the restart counter.

Table 5-1 Operating Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT/MIN /MAX VALUE
OUTPUT VOLTAGE	Phase-to-phase output voltage, 240V input models	480/360/500
	Phase-to-phase output voltage, 480V input models	480/440/500
RATED HORSEPOWER	Used to set rated HP of the motor load. Necessary for accurate operation of constant pressure systems.	APX_10: 10/1/10
		APX_20: 20/1/20
		APX_30: 30/1/30
		APX440: 40/1/40
		APX450: 50/1/50
MIN FREQUENCY	Minimum output frequency allowed in any steady state condition. Motor accelerates from zero to minimum frequency in 1 second and decelerates from minimum frequency to zero in 1 second. Important in protecting thrust bearing in submersible pumps.	30/5/120
MAX FREQUENCY	Maximum frequency allowed, or target frequency at start-up ramp. This parameter value cannot be set lower than MINIMUM FREQ.	60/1/120
START UP RAMP	Time in seconds from MIN FREQUENCY to MAX FREQUENCY. Ramp speed is linear	5/1/120
SHUTDOWN RAMP	Time in seconds from MAX FREQUENCY to MIN FREQUENCY. Ramp time is linear.	5/1/120
OVERCURRENT LIMT	Setting for motor overload protection, Trip Class 10 curve.	APX_10: 17/3/18
		APX_20: 30/3/32
		APX_30: 46/3/48
		APX440: 61/3/66
		APX450: 76/3/78
DRY WELL CURRENT	Unit shuts down when output current goes below the set value (dry well protection). To use this function for dry well protection, make certain the parameter DRY WELL KW is set at zero.	APX_10: 0/0/18
		APX_20: 0/0/30
		APX_30: 0/0/46
		APX440: 0/0/60
		APX450: 0/0/76
CURRENT UNBALANCE	% current unbalance on output phases, NEMA MG1	80/1/100

Table 5-1 Operating Parameters continued…

DISPLAY MESSAGE	DESCRIPTION	DEFAULT/MIN /MAX VALUE
DRY WELL KW	Unit shuts down when output measured in KW goes below the set value (dry well protection). Generally more accurate than undercurrent. To use this function for dry well protection, make certain the parameter DRY WELL CURRENT is set at zero.	APX_10: 0/0/10
		APX_20: 0/0/20
		APX_30: 0/0/30
		APX440: 0/0/40
		APX450: 0/0/50
SWITCHING FREQ	Switching frequency of the IGBT inverter module	2000/2000/5000
COAST TO STOP	Selects between coast to stop or ramp to stop. Ramp profile is controlled by parameter SHUTDOWN RAMP. YES = coast to stop NO = ramp to stop	YES/NO
GND FAULT DETECT FAULT SENSITIVITY	Detects a fault between any output line and earth. Sensitivity to fault detection is adjustable to avoid nuisance trips. Parameter may be disabled.	disabled/1/9
LINEAR RAMP	THIE FEATURE CAN BE DISABLED WHEN THE VFD IS **NOT** CONTROLLING A SUBMERSIBLE PUMP. Frequency will ramp from stop to the value set by parameter MIN FREQUENCY in one second, when LINEAR RAMP = 1. Submersible pumps suffer damage to the thrust bearing if operated below 30 Hz for more than 1 second. YES = one second ramp time from stop to minimum frequency NO = linear ramp time from stop to maximum frequency. Minimum frequency is still observed while the motor is running.	1/0/1

Table 5-2 Constant Pressure Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT/MIN /MAX VALUE
T OFF	In seconds. Used to prevent short cycling in CP systems. If the motor was off during the last cycle for a period greater than TOFF, the minimum on time of the motor is T1ON. If the motor was off for a period less than TOFF, the minimum on time of the motor is T2ON. Default values give a minimum cycle time of about 1 minute.	30/0/1000
T1 ON	In seconds. See T OFF above. T1ON should be set to be less than T2ON.	15/0/1000
T2 ON	In seconds. See T OFF above. T1ON should be set to be less than T2ON.	60/0/1000
SHUTOFF FREQUENC	As Hz. This parameter value is added to the frequency set by the parameter ***MINIMUM FREQ*** (Table 5-1). The combined value is the frequency at which drive will enter sleep mode when pressure is controlled at the set point.	12/0/100
BOOST AMOUNT	As a % of ***Max Frequency*** for digital CP systems, or as psi for analog CP systems. In digital CP systems, this parameter increases motor speed by the % of the parameter value, for a specified time before the motor shuts down in sleep mode. In analog CP systems the parameter value specifies boost in psi before sleep mode.	0/0/100
PRECHARGE FREQ	In Hz. Sets the maximum frequency applied to the motor during the pre-charge interval.	30/1/120
PRECHARGE TIME	In seconds. Sets the maximum time for pre-charge regardless of any sensor inputs. A setting of zero disables the pre-charge mode.	0/0/30000
PRECHRG psi	Pre-Charge psi. As pounds per square inch. Used only for analog CP systems. Sets pressure as psi within the range of the 4-20 mA transducer. Pre-charge will be terminated when pressure reaches this set point. Should be set less than ***psi SETPOINT***.	20/0/200
psi SETPOINT	psi Setpoint. As psi. For analog CP systems only. This sets the level at which the pressure will be controlled. Must be set as a PSI value within the range of the 4-20 mA transducer. Make sure the value of the parameter ***4-20mA psi MAX*** is set to the maximum psi value of the sensor you are using.	psi: 50/0/200

DISPLAY MESSAGE	DESCRIPTION	DEFAULT/MIN /MAX VALUE
PROPORTNAL GAIN	Multiplier for the analog error signal in an analog constant pressure system. When parameter is set to a value less than 1 the keypad displays ***SIMPLE MODE*** and the controller switches to an algorithm which does not require a gain setting. See Section 7.2, *Troubleshooting Constant Pressure Systems*, for details. When switching to PI control, best results will be obtained by starting with a value of 5 for ***PROPORTNAL GAIN***.	5/1/60
psi ON	As psi. Provides hysteresis during sleep mode. Parameter controls the pressure drop below psi SETPOINT to start motor in sleep mode, e.g. if psi ON = 5 and motor turns off at 50 psi, motor will restart at 45 psi.	5/0/50
4-20mA psi MAX	As psi. This value should be set to the maximum psi of the 4-20 mA transducer being used for constant pressure control i.e. if the transducer has a range of 0-150 psi the parameter should be set to 150. This parameter is critical for accurate pressure control.	150/25/200
INTEGRAL GAIN	Multiplier for the integral term in PI control of analog constant pressure. Used to fine tune control of unstable systems. Parameter is disabled when PROPORTNAL GAIN is set to SIMPLE MODE. See Section 7.2, Troubleshooting Constant Pressure Systems, for details.	50/1/100

Table 5-3 Interface Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT/MIN /MAX VALUE
SYSTEM CONFIG	Sets the system configuration. • 0 = On/off control using AUX1 and AUX2. Both AUX1 and AUX2 must have a contact closure to run. • 1= Digital constant pressure system. • 2 = Analog constant pressure system. • 3 = Motor speed control proportional to the analog signal (0-5 VDC) on Terminals ***5 VO*** and ***V In***. Use for potentiometer speed control. See Figure 3-5. • 4 = Motor speed control proportional the analog signal on Terminals I in+ and I out- (4-20mA). Both AUX1 and AUX2 must be closed to run. • 5 = Analog constant pressure (4-20 mA only) or motor speed control by potentiometer. When AUX1 is open the drive is in OFF mode. If AUX1 is closed, AUX2 selects either constant pressure control, or motor speed control by a potentiometer on the 0-5VDC input. When AUX2 is closed the speed is controlled by the potentiometer. When AUX2 is open the speed is controlled by constant pressure parameters. See Figure 3-7 for details.	0/0/5
TROUBLESHOOTING	Factory assisted use only. Contact manufacturer.	0/0/5
PASSWORD SETUP	Allows keypad functionality to be password protected. When keypad is locked, parameters and values can be viewed but not changed. Parameter value of zero disables password protection	0/0/99
REMOTE NOTIFY	Programmable normally open / normally closed relay. Control Terminals COM, NC, NO. The relay can be programmed to change state for the following conditions: 0 = System Fault 1 = Frequency greater than the value set by parameter ***MINIMUM FREQ*** (see Note 1)	0/0/1
DISABL MAN MODE	Disables manual operation of the drive through the keypad. Operating states are limited to AUTO and OFF. 1 = manual mode disabled	0/0/1
ANALOG IN REVERS	Reverses the scale of the analog signal, both 0-5VDC and 4-20mA. For example, in normal 0-5VDC signal, 0V = low and 5V = high. In reverse, 5V = low and 0V = high. 0 = normal, 1 = reverse	0/0/1

Note 1: This setting is typically used to control ancillary equipment in concert with motor RUN/STOP commands. For example, to control a chlorinator so that it operates only when the motor is pumping water.

Table 5-4 Auto Restart Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT/MIN /MAX VALUE
ENABLE RESTARTS	Controls the ability of the drive to automatically restart after a fault and to initialize in AUTO mode. 0 = no auto restarts and unit will initialize in OFF mode 1 = Auto mode on initialization and auto restarts allowed	0/0/1
DRY WELL DELAY	Time in seconds dry well is allowed before unit trips	4/0/9999
RESTART DELAY 1	Delay in seconds before unit restarts after a trip due to: • CLASS 10 OVERLOAD • OVER CURRENT IN	300/0/9999
RESTART DELAY 2	Delay in seconds before unit restarts after a trip due to: • BUS OVERVOLTAGE • DRY WELL CURRENT • CURRENT UNBALANCE • DRY WELL KW	300/0/9999
RESTART DELAY3	Delay in seconds before unit restarts after a trip due to: • HALL SENSE HIGH • LOW INPUT VOLT • HIGH INPUT VOLT	300/0/9999
RESTARTS CUR OVL	Number of automatic restarts allowed due to overload current trip on the load and line module (see Note 1)	0/0/9999
RESTARTS DRY WELL	Number of automatic restarts allowed due to under current and minimum power trip (see Note 1)	0/0/9999
RESTARTS CUR IMB	Number of automatic restarts allowed due to current imbalance trip (see Note 1)	0/0/9999
RESTARTS UNDER V	Number of automatic restarts allowed due to low input voltage trip (see Note 1)	0/0/9999
RESTARTS OVER V	Number of automatic restarts allowed due to high input voltage trip (see Note 1)	0/0/9999
RESTARTS BUS OV	Number of automatic restarts allowed due to DC bus overvoltage (see Note 1)	0/0/9999
START UP DELAY	Delay in seconds before unit restarts after an input power OFF/ON cycle.	0/0/9999
RESTARTS HALL HI	Number of automatic restarts allowed due to input current high enough to saturate the current measuring device	0/0/9999
RESTART OUT FALT	Number of automatic restarts allowed due to output current high enough to trigger the solid state short circuit protection (output fault) or a measured high output current (output overload)	0/0/20

DISPLAY MESSAGE	DESCRIPTION	DEFAULT/MIN /MAX VALUE
SHORT CYCLE DLY	Delay in seconds before motor starts after a RUN command. Prevents the drive from engaging the motor when it is spooling down during coast-to-stop operation. Delay affects both manual RUN command from the keypad and RUN command from external signals in auto mode. Display will count down seconds until RUN during delay.	3/0/300

Note 1: The restart counter must be cleared to begin counting the number of restarts from zero. Cycle the input power to the drive OFF/ON to reset ALL restart counters.
Note 2: Push the up arrow key and down arrow key simultaneously to interrupt the countdown delay and allow an auto restart.

6.1 Commissioning the Unit

It is always advisable to check the operating status of the drive and its load before commencing regular operation.

Ground Fault Detection
APX Series drives are equipped with a feature to detect a fault between any of the output lines and earth. See Table 5-1, *Operating Parameters*, ***GND FAULT DETECT***, for more information on using this parameter. If a ground fault is strong enough to trigger the parameter ***GND FAULT DETECT***, the drive will not allow the IGBTs to switch. However, this does not protect the drive from damage in all situations. **If a ground fault occurs, immediately disconnect the input power!** Long motor leads and a dV/dT filter can cause nuisance indications of a ground fault. If a megger does not indicate a ground fault the sensitivity of the ground fault detection my need to be reduced by reducing the value of parameter ***GND FAULT DETECT.***

⚠ **CAUTION**: Before the motor is connected to the output terminals, check all output lines for line-to-ground faults using a megger. There is a direct path through the drive circuitry for ground fault currents that can be triggered when power is applied to the input terminals, even though the output switches are not activated. These currents can cause serious damage to drive circuitry and are not covered under warranty.

Initial Operation
Verify the following:

1. The unit is securely attached to the proper mounting surface
2. The unit's input terminals are connected to an appropriate power source
3. An appropriately rated motor is connected to the output terminals
4. The motor is secured and properly mounted

⚠ **WARNING!** The default operating mode when the unit is energized is OFF. If the parameter ENABLE RESTARTS has been set to allow restarts, the unit will energize in AUTO mode. If the external controls are calling for a motor run condition, the motor will start. Make sure either external controls are off before energizing the input, or as soon as the unit has initialized, push the H/O/A key until ***OFF*** appears on the display. Refer to Section 4.1, *Using the Keypad and Display*, for instructions on operating the keypad.

1. If remote or automatic ON/OFF function is required, connect remote switch leads to the AUX1 terminals. An additional remote switch or jumper wire may be connected to the AUX2 terminals.

2. If a Constant Pressure (CP) water system will be operated, connect the pressure sensors to the appropriate Control Terminals. See Section 7, *Constant Pressure Systems* for details.
3. Apply power to the input terminals of the drive by turning on the input circuit breaker or disconnect switch.
4. The LCD text display will scroll through several start-up sequence messages.
5. If the ***ENABLE RESTARTS*** parameter is set to allow restarts, the drive will initialize in AUTO mode and the motor will run when control signals call for a motor run condition. In order to prevent the motor from running at start-up, immediately after initialization, press the H/O/A key until ***OFF*** appears on the display.
6. Confirm that the unit has properly energized, and the display indicates the OFF mode.
7. Using the keypad and display, navigate to the Main Menu item, ***CHANGE PARAMETER VAULES,*** to set the following parameters for basic operation (see Tables 5-1, 5-2, 5-3, 5-4 for details):
   - ***INTERFACE PARAMETERS > SYSTEM CONFIG*** This parameter is critical to the operation of the system. The default setting is for simple ON/OFF operation. See Section 6.3 *System Configuration*, for complete information.
   - ***OPERATING PARAMETERS > RATED HORSEPOWER*** Enter the nameplate HP of the motor load. This parameter is critical to proper operation of CP water systems.
   - ***OPERATING PARAMETERS > OVERCURRENT LIMT*** This parameter sets the motor overload protection. See Section 6.2 *Motor Overload Protection* for complete information.
   - ***AUTO RESTART PARAMETERS > ENABLE RESTARTS*** This parameter enables the drive to initialize in AUTO mode and to restart automatically after a fault. Factory default does not allow auto restarts.
8. Push the H/O/A key until ***MAN*** appears on the display for manual mode, then push RUN to start the motor. In manual mode, the RUN key will override an open AUX terminal or other external control signal. Push the STOP key to stop the motor in manual mode.

⚠ **CAUTION**: In manual mode, pushing the RUN key will override all external control signals, including constant pressure sensors. Dangerous pressure rise in closed plumbing systems is possible.

9. The motor will start with the default acceleration ramp time of 0-30 Hz in one second, then 30-60 Hz in eight seconds.
10. Confirm that the motor rotation is correct. Swapping any two of the output leads will reverse the motor rotation.

11. After initial power-up, use the keypad and display to navigate to ***CHANGE PARAMETER VALUES*** to set any other adjustable parameters you wish to be different from the factory defaults.

6.2 Motor Overload Protection

APX Series drives are equipped with adjustable solid state motor overload protection. Protection is based on a Class 10 trip curve. Motor overload settings are selected by navigating to the appropriate menu item using the keypad and display.

Thermal Memory and Thermal Memory Retention
The motor overload protection is equipped with thermal memory and thermal memory retention capabilities.

THERMAL MEMORY is the ability of an overload protective system to approximate the heating cooling of a protected motor during operation.

THERMAL MEMORY RETENTION maintains the thermal memory upon shutdown or power loss. This includes retention of the last thermal value, and may include an ongoing reduction of this thermal value to reflect the cooling of the motor. This information will be used by the overload protective system to approximate the thermal state of the motor upon restart.

⚠ **CAUTION**: Do not attempt to restart the motor immediately after a motor overload fault. The motor overload protection system uses a timer to approximate motor cooling and may trigger an immediate overload fault if the motor is restarted too soon.

If the drive loses power immediately after a motor overload fault, it will not begin counting down the time that approximates motor cooling until the drive is energized. If the drive faults with a motor overload, it may be necessary to allow time for this countdown before the motor is operated even though the motor has been off for an extended period of time.

Setting Motor Overload Protection with Keypad
To set motor overload protection with the keypad, navigate to the Main Menu item ***CHANGE PARAMETER VALUES > CHANGE OPERATING PARAMETERS > OVERCURRENT LIMT***. Refer to Section 5.1 *Changing Parameter Values,* Table 5-1 *Operating Parameters* for detailed instructions.

6.3 System Configuration

An APX Series drive is capable of operating several types of systems, including constant pressure water systems, and simple ON/OFF control from remote switches. **The correct system configuration must be selected for proper operation of the different types of control systems!**

System configuration is set by navigating to the keypad Main Menu item ***CHANGE PARAMETER VALUES > CHANGE INTERFACE PARAMETERS > SYSTEM CONFIG***. Refer to Section 5.1 *Changing Parameter Values,* Table 5-3, *Interface Parameters,* for detailed instructions. Below is a brief description of each configuration setting:

- **System Configuration = 0**: This is the factory default configuration for basic operation of the drive and allows ON/OFF control of the motor using a dry contact on AUX1 and/or AUX2. Both AUX1 and AUX2 must have a contact closure to run.

- **System Configuration = 1**: Use this setting to operate digital constant pressure systems. Only use digital pressure switches purchased from or approved by Phase Technologies. Refer to Section 7.3, Digital Constant Pressure Systems, for more information on operating the drive in this mode.

- **System Configuration = 2**: Use this setting to operate analog constant pressure systems with a 4-20 mA transducer. Refer to Section 7.4, Analog Constant Pressure Systems, for more information on operating the drive in this mode. Refer to Figure 3-6 for a diagram illustrating connection of the transducer to Control Terminals.

- **System Configuration = 3**: Use this setting for motor speed control by a potentiometer connected to the 0-5 VDC Control Terminals. Refer to Figure 3-5 for a diagram illustrating connection of the potentiometer to Control Terminals.

- **System Configuration = 4**: Use this setting for motor speed control proportional to a 4-20 mA analog signal. The drive will ignore the analog signal until it reaches a value proportional to the speed set by the parameter, MINIMUM FREQ, which has a factory default setting of 30 Hz. For speed control across the full scale range of the analog signal, set MINIMUM FREQ to the minimum value of 5 Hz. Refer to Figure 3-6 for a diagram illustrating connection of the transducer to Control Terminals.

  ⚠ **CAUTION**: This is not a constant pressure control mode. Motor speed will be controlled in a linear fashion proportional to the analog signal.

System Configuration = 5: This setting allows the user to either turn the motor off, control motor speed with a potentiometer or operate in analog constant pressure mode. Access to

the keypad is not required to operate in this mode. A mechanical HOA switch changes the state of AUX1 and AUX2 Control Terminals to change to mode of operation in this configuration. A potentiometer is connected to the 0-5 VDC control Terminals, a 4-20 mA analog transducer is connected to the I+ and I- Control Terminals, and a double pole, triple throw HOA switch is connected to AUX1 and AUX2 Control Terminals.

- AUX1 controls for motor run and stop. When AUX1 is open the motor will stop. When it is closed it will run. AUX2 toggles between analog constant pressure and motor speed control by the potentiometer. When AUX2 is open the drive will operated in analog constant pressure mode. When it is closed the potentiometer will control motor speed. Refer to Figure 3-7 for a diagram illustrating connection of the transducer to Control Terminals.

6.4 Start-Up and Shut-Down Ramp Times

Start-up and shut-down ramp times specify the time required to go from Minimum Frequency to Maximum Frequency or vice versa. Ramp times and profiles are adjustable by changing Operating Parameters through the keypad and text display.

Minimum Frequency
Most submersible pump motor manufacturers require the motor to reach 30 Hz within one second in order to protect the pump from damage. Because the APX Series is frequently used for pumping applications, it has a minimum frequency feature that limits the time the motor runs below the minimum frequency to one second. For example, when the minimum frequency is set to 30 Hz, the motor speed will ramp to 30 Hz in one second, then ramp to the maximum frequency in the default setting in a total of 5 seconds. The ramp times can be changed through the adjustable parameters, ***START UP RAMP*** and ***SHUTDOWN RAMP*** This is depicted in Figure 6-1. **The factory default setting for minimum frequency is 30 Hz.**

When the minimum frequency is set to 5, the motor will ramp from stop to the maximum frequency in 5 seconds in a linear fashion as depicted in Figure 6-2.

To set the minimum frequency, navigate to the keypad Main Menu item, ***CHANGE PARAMETER VALUES > CHANGE OPERATING PARAMETERS > MINIMUM FREQ > 30 Hz***. When this parameter is set to 5 Hz, ramp times will be linear, as depicted in Figure 6-2.

Figure 6-1 Default Start-Up and Shut-Down Ramp Time

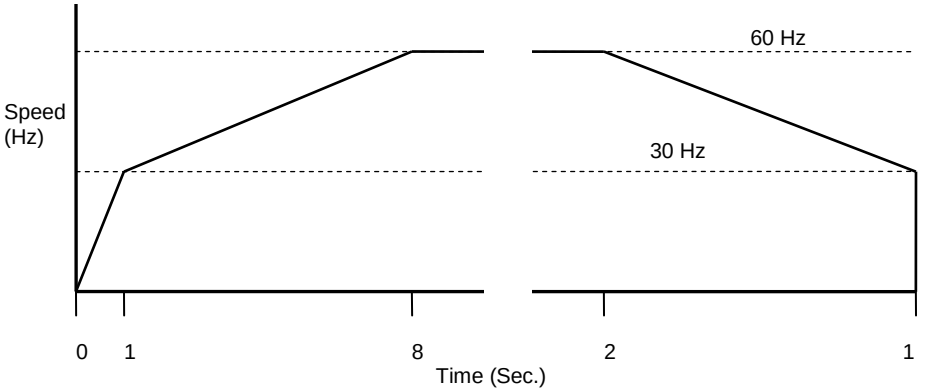
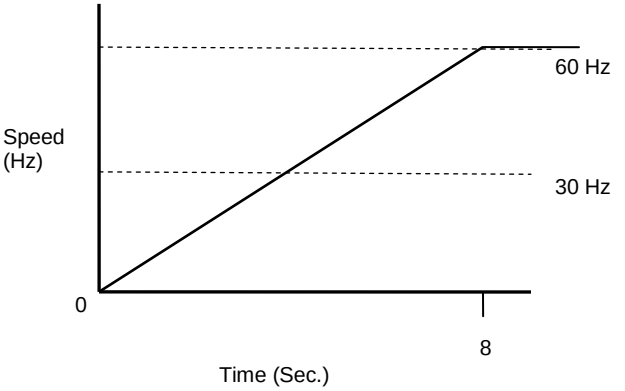


Figure 6-2 Start-Up Ramp with SUBMERSIBLE PUMP disabled



APX drives can be configured as constant pressure (CP) water systems using either an analog pressure transducer (which we will refer to as an analog constant pressure system) or pressure switches (which we will refer to as a digital constant pressure system). A CP water system includes a pressure tank, a pressure gauge to observe system pressure, and pressure switches or sensors

7.1 Control Principles of Constant Pressure Systems

In a CP system, a target pressure for the system is set either on the switch itself (digital CP) or through the keypad (analog CP). Signals from the sensors interact with firmware in the drive controller to control the motor speed and maintain a constant water pressure.

In a strict definition of a constant pressure system, the pump would never turn off. If the pressure differential between pump-on and pump-off was actually zero, the noise fluctuations of the transducer output would cause the motor to cycle constantly between the on and off states. For this reason, most applications will want to accept a small differential pressure in the system in order to prevent either continuous running of the motor, or constant on/off cycling of the motor.

Three basic conditions must be met in order for the pump to shut down and enter sleep mode:

1. The pressure in the system must be at the pressure control point set by the parameter ***psi SETPOINT*** (for analog systems) or at the pressure determined by the setting on the digital pressure switch.
2. The power consumed by the pump must be less than the value of parameter ***SHUTOFF PMIN.***
3. The time expired since the pump started after the last OFF cycle must be greater than parameter ***T1ON*** or ***T2ON.***

Preventing Short Cycling During Low Flow Conditions
When a CP system is in a low flow state, it is desirable to turn the motor off (sleep mode) in order to conserve energy and preserve the motor. The adjustable parameters ***TOFF***, ***T1ON***, ***T2ON, SHUTOFF PMIN, psi ON*** and ***BOOST AMOUNT*** control when the motor is turned off, how long it is off, and also prevent short cycling of the motor at low water flow rates. More information including default values for these parameters can be found in Table 5-2 *Constant Pressure Parameters.*

psi ON and ***BOOST AMOUNT***
The primary method of preventing short cycling is to allow a differential between the pressure at which the pump turns off to enter sleep mode and the pressure at which it restarts. Two parameters, ***psi ON*** and ***BOOST AMOUNT***, control this differential. ***BOOST AMOUNT***

specifies the increase in pressure above ***psi SETPOINT*** just before the pump shuts down to enter sleep mode, while ***psi ON*** specifies the pressure drop below ***psi SETPOINT*** at which the pump restarts. For example, assume ***psi SETPOINT*** = 50, ***BOOST AMOUNT*** = 5, and ***psi ON*** = 5. When the pump is ready to enter sleep mode, the pressure will boost to 55 psi, the pump will shut down, then restart when the pressure falls to 45 psi. These two parameters can be used together or independently to create a dead band in pressure control.

Digital CP systems cannot utilize the ***psi ON*** parameter because the drive receives information from the sensor only when the pressure crosses the pressure set point of the digital sensor. Digital CP systems create a dead band in pressure by relying only on the ***BOOST AMOUNT*** parameter. Unlike analog systems that can measure pressure during the boost, digital systems rely on a specified increase in motor speed for a specified time to achieve a boost in pressure prior to sleep mode. When the System Configuration is set for Digital CP, the value for ***BOOST AMOUNT*** is equal to a per cent increase in maximum allowable motor speed for a specified time. For example, if ***MAX FREQUENCY*** = 60 and ***BOOST AMOUNT*** = 5, the motor speed will increase to 63 Hz (60 x (1+.05) for a time that varies based on boost amount. The user must observe an external pressure gauge to determine if this produces the desired boost amount.

SHUTOFF PMIN

When water flow in the system is low, the pump motor will consume less power than is required to pump larger flows. Since the drive has no means of measuring water flow, change in power consumed by the pump is a surrogate for measuring flow. HP output of the drive below the value of ***SHUTOFF PMIN*** satisfies one of the three conditions that must be met for the pump to shut down in sleep mode. This low power threshold parameter, ***SHUTOFF PMIN***, is defined as a per cent of the rated motor HP. It is important to enter the rated HP of the motor load in the adjustable parameter, ***RATED HP***, so that the system calculates an accurate ***SHUTOFF PMIN***. The default value for ***SHUTOFF PMIN*** is 50% of the rated motor HP.

Determining the proper setting for ***SHUTOFF PMIN*** is critical for the pump to enter sleep mode.

If ***SHUTOFF PMIN*** is too high the pump will short cycle because all three conditions for sleep are satisfied (time for T1ON or T2ON has expired, psi is at setpoint, HP consumed by the pump is below ***SHUTOFF PMIN***).

If ***SHUTOFF PMIN*** is too low the pump will not go to sleep. In submersible pumps there is a risk of damaging the pump if it runs too long with low or no flow of water.

Programming Tip

To determine the lowest safe value for ***SHUTOFF PMIN***, operate the pump with no flow by shutting down the water flow completely, then observe the HP output on the display of the drive. A ***SHUTOFF PMIN*** value that equates to a HP slightly above this observed value should allow the pump to enter sleep mode and to run for extended periods with adequate water flow to cool the pump.

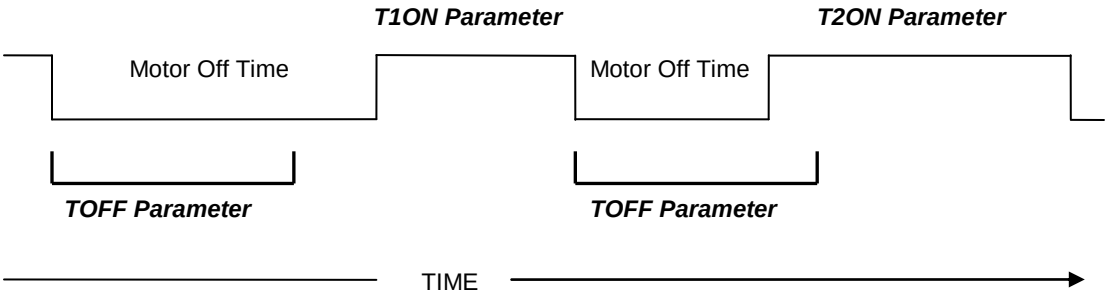
ON/OFF Cycle Timers

The controls also record the length of time the motor remained in the OFF cycle and compare that time to the parameter, ***TOFF***. If the motor-off time during the last OFF cycle was greater than the value of **TOFF,** then the minimum motor-on time will be equal to **T1ON**. If the motor-off time was less than **TOFF**, the minimum motor-on time will be equal to **T2ON**.

In other words, the time of the last OFF cycle determines whether the next ON cycle should be relatively long or relatively short. The graphic in Figure 7-1 demonstrates how the system adjusts the motor-on time in response to motor-off time.

If the HP consumed by the motor is greater than ***SHUTOFF PMIN***, the ***T1ON*** and ***T2ON*** settings will be ignored and the motor will run so long as the HP consumed by the motor remains above the ***SHUTOFF PMIN*** threshold.

Figure 7-1 Motor-On and Motor-Off Times



Fine Tuning With PI Control
PI control is not available when operating in Digital CP mode.

When using an analog pressure transducer for control in constant pressure water systems, it may be desirable to use a proportional-integral (PI) controller in the feedback loop. This type of controller has a proportional gain and integral gain which can be tuned by the user to obtain optimum performance for each particular application. Increase parameter ***PROPORTNAL GAIN*** to switch control from Simple Mode to PI control. It is recommended to start with a parameter value of 5. A proportional gain value too low will result in slow response time to reach the psi setpoint. A value too high will result in overshoot of the psi setpoint and may create wild oscillation of pressure.

First, attempt to control pressure by adjusting parameter ***PROPORTNAL GAIN***, leaving parameter ***INTEGRAL GAIN*** at the default value of 50. If adequate control cannot be obtained by adjusting proportional gain, set proportional gain at the value that gives the best control, then adjust integral gain to improve pressure control.

Emergency Over-Pressure Limit Switch
Both digital and analog CP systems have the option of connecting an emergency over-pressure limit switch to the AUX2 terminals in case the main pressure control system fails. The emergency over-pressure set-point should be at least 10 psi higher than the system control pressure to prevent nuisance tripping.

7.2 Troubleshooting Constant Pressure Systems

A variety of conditions in a plumbing system can lead to less than optimum performance of constant pressure control while using the factory default settings. The default settings are designed to operate a range of plumbing systems, but there can be many variables in a plumbing system that require adjustment of the constant pressure parameters.

In order for the drive to enter sleep mode while operating in constant pressure mode, three conditions must be met:

1. The pressure in the system must be at the pressure control point set by the parameter ***psi SETPOINT*** (for analog systems) or at the pressure determined by the setting on the digital pressure switch
2. The power consumed by the pump must be less than the value of parameter ***SHUTOFF PMIN***
3. The time expired since the pump started after the last OFF cycle must be greater than parameter ***T1ON*** or ***T2ON***

When these conditions have been met, the drive will speed up briefly to boost the pressure above the set-point, then ramp down to stop. The amount of boost is set by parameter ***BOOST AMOUNT***. Boosting the pressure above the set-point allows some time to pass before flow bleeds the pressure down to the set-point, at which point the pump will restart. When setting and testing a constant pressure system, try to operate as close as possible to the normal operating conditions. Low flow in a high capacity system usually requires some adjusting of the parameters.

***SHUTOFF PMIN* Too Low**

A common problem that prevents the pump from stopping is a value too low for ***SHUTOFF PMIN***. The factory default value is 50% of the rated motor HP as determined by the parameter ***RATED HP***. By observing the HP reading on the display, one can determine if the HP consumed by the pump at low flow is greater or less than ***SHUTOFF PMIN***. One can even consider completely turning off all flow in the system for a short period of time to determine how much power the pump consumes when moving no water. Make sure ***SHUTOFF PMIN*** is greater than the HP consumed at low flow.

***SIMPLE MODE* Control**

Phase Technologies has developed a proprietary controller which involves fewer parameters to tune constant pressure performance. When the ***PROPORTNAL GAIN*** parameter is set at the lowest value, the display will read "***SIMPLE MODE***". In ***SIMPLE MODE*** a set of control equations is used which may not require the user to tune the system to obtain acceptable performance. A well tuned PI controller will result in smoother pressure control but may not be required. When the controller is in simple mode the only parameters which affect the pressure control loop are the ***psi SETPOINT, STARTUP RAMP, SHUTDOWN RAMP*** and

BOOST AMOUNT, which function in the same way as they do in the PI control mode. Adjusting ramp times may smooth out any oscillation or overshoot in simple mode. If pressure is not adequately controlled, switch to PI control by increasing parameter ***PROPORTNAL GAIN.***

Using PI Control in an Analog CP System

When using an analog pressure transducer for control in constant pressure water systems, it may be desirable to use a proportional-integral (PI) controller in the feedback loop. This type of controller has a proportional gain and integral gain which can be tuned by the user to obtain optimum performance for each particular application. Increase parameter ***PROPORTNAL GAIN*** to switch control from simple mode to PI control. It is recommended to start with a parameter value of 30, which is in the middle of the parameter range. A proportional gain value too low will result in slow response time to reach the psi setpoint. A value too high will result in overshoot of the psi setpoint and may create wild oscillation of pressure.

First, attempt to control pressure by adjusting parameter ***PROPORTNAL GAIN***, leaving parameter ***INTEGRAL GAIN*** at the default value of 50. If adequate control cannot be obtained by adjusting proportional gain, set proportional gain at the value that gives the best control, then adjust integral gain to improve pressure control.

In general, conceptual terms, proportional gain affects how quickly the system responds to pressure changes and integral gain affects the accuracy of pressure tracking. Adjusting ramp times can also be considered. Increasing ramp time will damp response to pressure changes, while decreasing ramp time will quicken the response.

Pressure Control at Minimum Speed

There is a possibility of conflict between the minimum pump speed setting, controlled by the parameter ***MINIMUM FREQ***, and the pressure setting of the transducer. That is, if under no-flow conditions the pump at its minimum speed setting produces a pressure greater than the desired set-point, either the minimum speed will have to be reduced (not an option with submersible pumps) or the pressure set-point will have to be increased. Most pumps should not produce enough pressure head at 30Hz for this to be an issue.

Boost in a Digital Constant Pressure System

In a digital CP system the drive can only determine the pressure of the system at the set-point. Based on the characteristics of the on/off signals from the switch, which occur at the set-point, it maintains pressure. The parameter ***BOOST AMOUNT*** in a digital system is a per cent increase in speed, not in pressure, because the digital switch cannot determine a pressure beyond its set-point.

In an analog system the ***BOOST AMOUNT*** is a specified psi, so the user can accurately control the boost pressure through the parameter setting on the keypad. For example, if boost of 5 psi above control pressure is desired, simply set parameter ***BOOST AMOUNT*** to 5.

In a digital system ***BOOST AMOUNT*** is an increase in speed for a given time as a per cent of the speed the pump was running when the switch last opened at the set-point. For example, if pressure is controlled at a speed of 30 Hz, a ***BOOST AMOUNT*** value of 10 would be 10% of 30 Hz or 3 Hz. In low flow systems where the pressure is controlled at low speed, the ***BOOST AMOUNT*** value may need to be significantly higher than it would be set in an analog system under the same conditions.

7.3 Digital Constant Pressure Systems

The digital CP system uses a digital pressure switch connected to the AUX1 terminals (see Figures 7-2 and 7-3 for one-line and wiring diagrams). For digital CP systems, the factory default settings will be satisfactory for most CP applications.

Adjusting Parameters in Digital CP Systems
Using the keypad, there are several parameters which can be adjusted to fine tune digital CP systems. These are ***STARTUP RAMP***, ***SHUTDOWN RAMP***, ***MAX FREQUENCY***, ***MINIMUM FREQ***, ***TOFF***, ***T1ON***, ***T2ON***, ***SHUTOFF PMIN***, and ***BOOST AMOUNT***. The use of these parameters has been discussed in the previous section. Table 5-2 also provides more detail.

Digital Constant Pressure Installation Procedures:

1. Install the digital pressure switches in the water line
2. Remove protective rubber boot from each switch, insert factory provided duplex cable through the boot, and connect a twisted pair of wires to the normally closed (NC) and common (C) terminals of the emergency over-pressure switch

⚠ **CAUTION**: The use of shielded cable is recommended. Regular wire may induce capacitance in the line and corrupt the signals from the pressure switches.

3. Attach the cable shield to the Control Terminal Ground post located in the APG enclosure adjacent to the Control Terminals
4. Connect the emergency over-pressure limit switch to the AUX2 Control Terminals
5. Navigate through the keypad Main Menu item ***CHANGE PARAMETER VALUES > INTERFACE PARAMETERS > SYSTEM CONFIG***. Select ***1*** to set the system configuration for a digital CP system.
6. To set the emergency over-pressure limit switch, remove the rubber boot from the switch and pry the plastic plug from the top of the switch housing to access the pressure adjustment screw. Use an Allen wrench to adjust the pressure setting of the switch – jumper the AUX1 terminals and run the pump in the AUTO mode, and observe the pressure gauge, turning the Allen screw to adjust the pressure shut-off point. **The emergency over-pressure limit switch should be set at least 10 PSI higher than the desired constant pressure set point**.
7. Remove the jumper from AUX1 and connect the remaining twisted pair of wires in the shielded cable to the normally closed (NC) and common (C) terminals of the control pressure switch. Connect the switch to the AUX1 Control Terminals, and adjust the constant pressure set point using the same procedure as the emergency over-pressure limit switch.
8. Set the keypad to AUTO mode to operate the system

Figure 7-3 Digital Constant Pressure One-Line Diagram

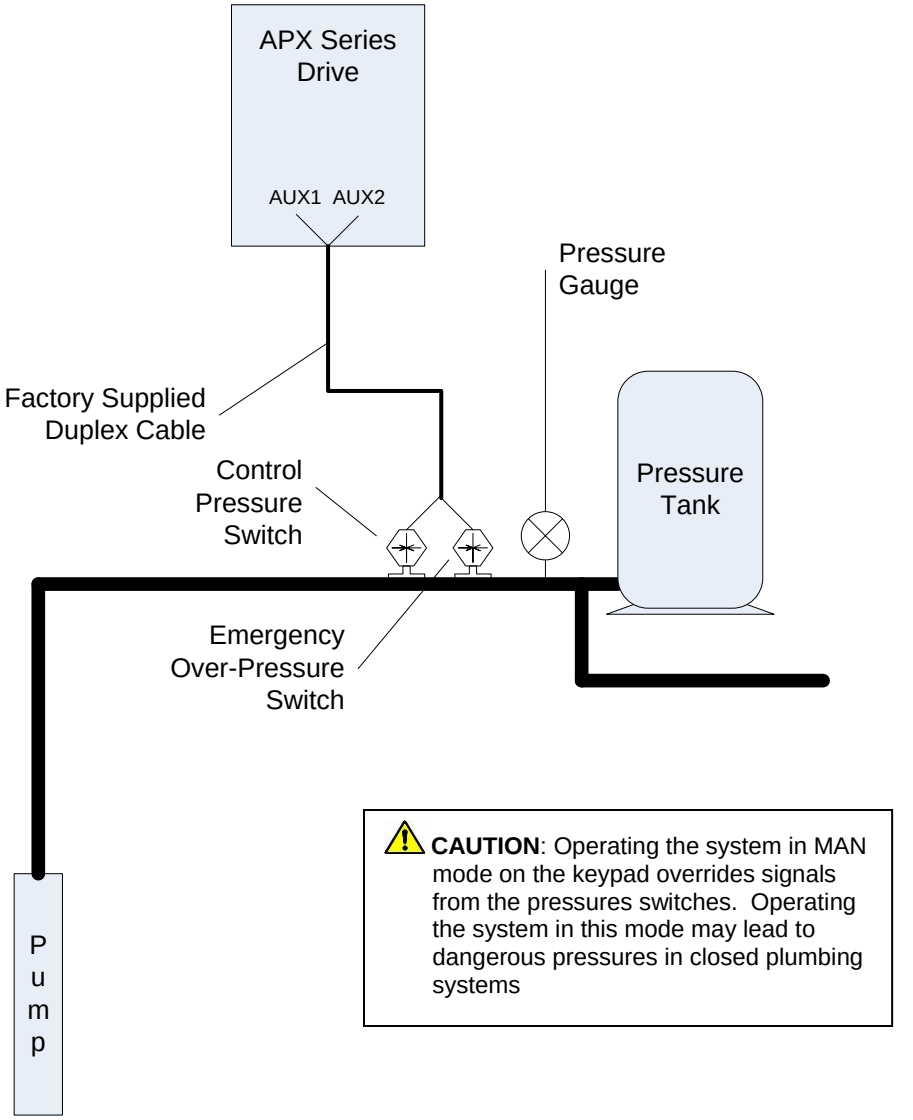
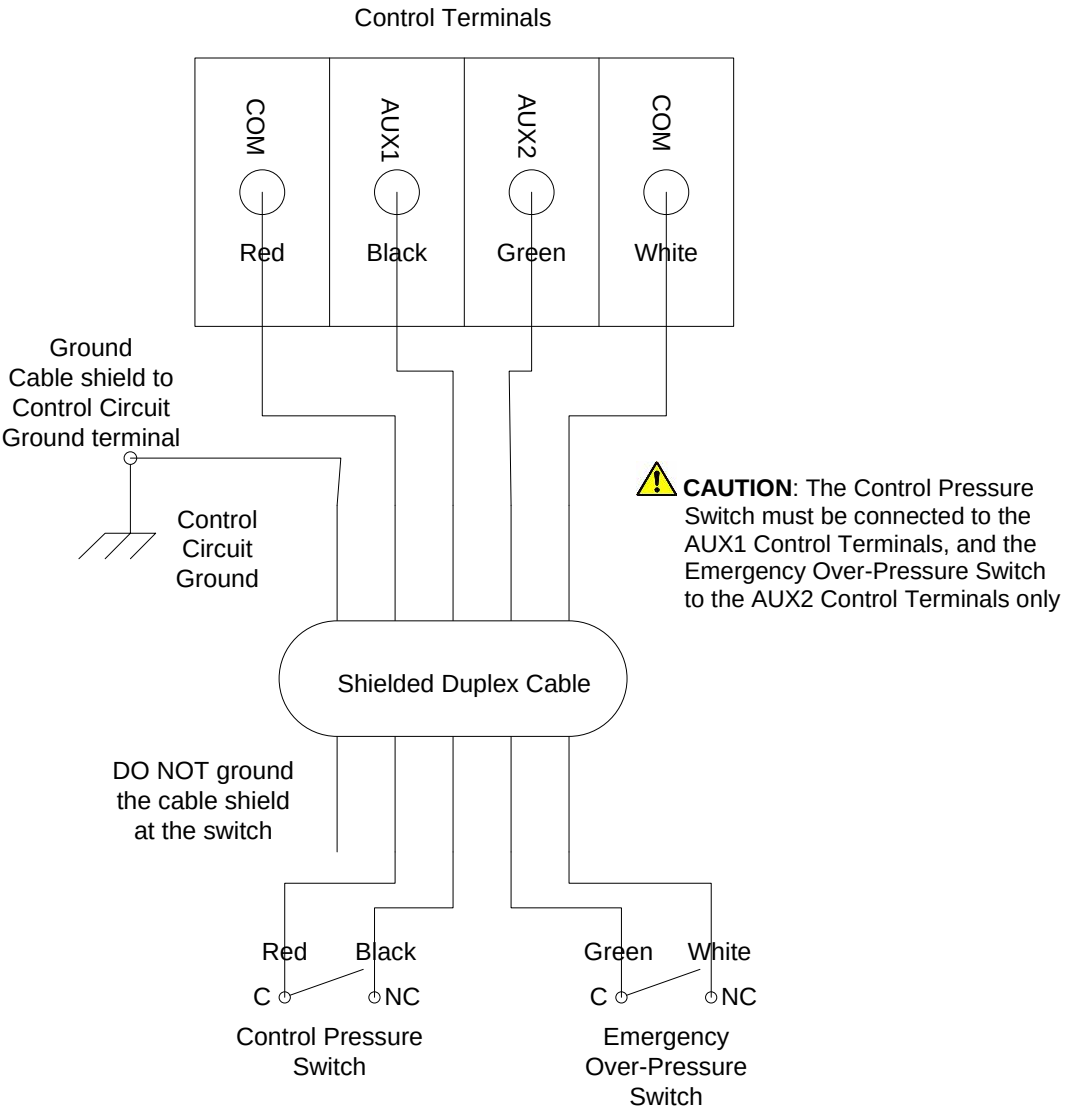


Figure 7-4 Digital Constant Pressure System Schematic



7.4 Analog Constant Pressure Systems

The analog CP system uses an analog pressure transducer connected to the analog input on the Control Terminals (see Figures 7-5 and 7-6 for one-line and wiring diagrams). A normally-closed emergency over-pressure switch connected to the AUX2 terminals is also recommended. These are used in conjunction with the internal firmware of the drive to implement a constant pressure water system.

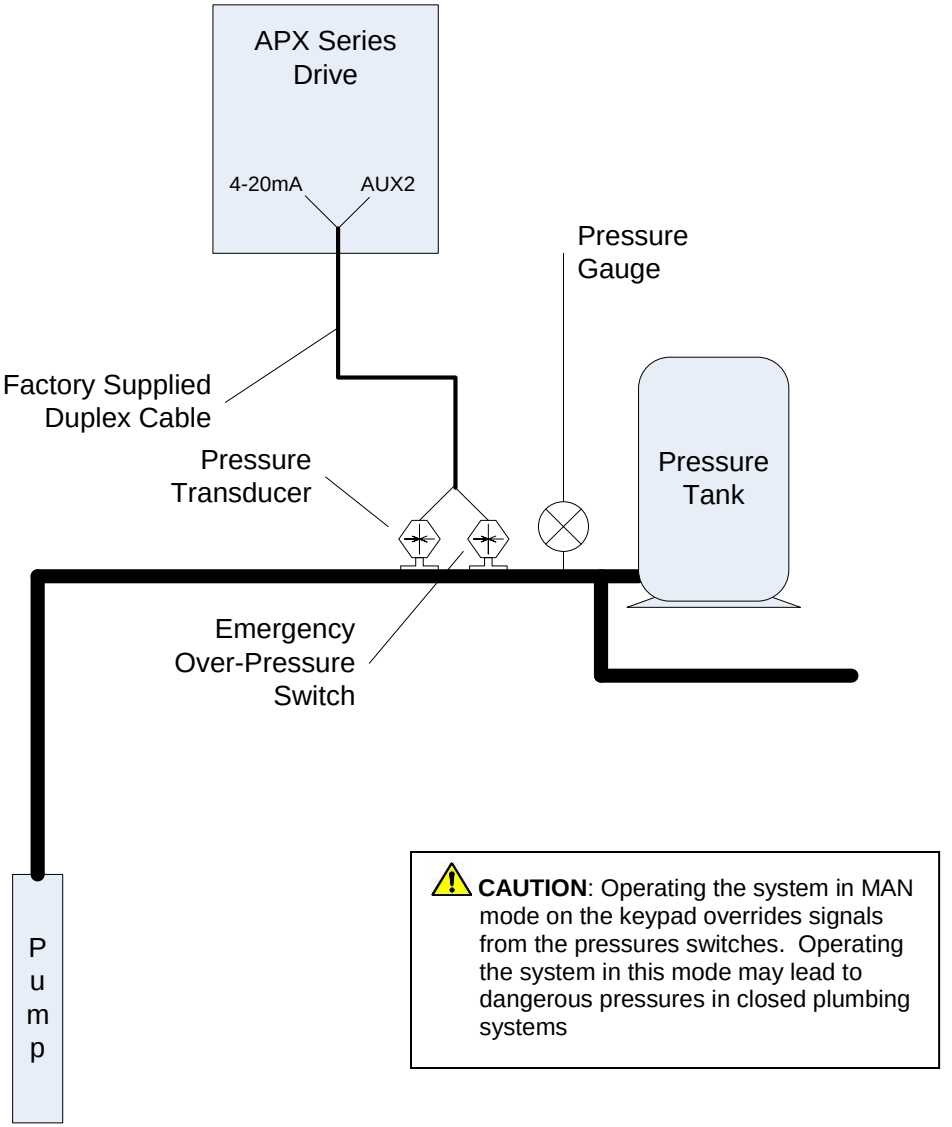
When using an analog pressure transducer for control in constant pressure water systems, it is very common for the system controller to use a proportional-integral (PI) controller in the feedback loop. This type of controller has a gain adjustment which must be tuned by the user to obtain optimum performance for each particular application. 3XD Series drives have this type of controller incorporated in them. However, Phase Technologies has also developed a proprietary controller which does not require tuning. When the ***PROPORTNAL GAIN*** parameter is set at the lowest value, the display will read "***SIMPLE MODE***". This is the default setting of ***PROPORTNAL GAIN***.

In SIMPLE MODE a set of control equations is used which does not require the user to tune the system to obtain acceptable performance. We recommend that you try this first because in most cases it will provide good pressure control and is simpler to set up. A well tuned PI controller will give slightly smoother pressure control and may be necessary to control unstable systems. When the controller is in SIMPLE MODE, the only parameters which affect the pressure control loop are the ***psi SETPOINT*** and the ***BOOST AMOUNT***, which function in the same way as they do in the PI control mode.

In PI control mode the analog signal from the pressure transducer is compared to the parameter ***psi SETPOINT***, which controls the motor speed to maintain constant pressure in the system. In this control scheme, the error signal between the pressure transducer and the internal signal determined by the ***psi SETPOINT*** value is multiplied by the ***PROPORTNAL GAIN***. This signal is then used to determine the motor frequency. If the pressure transducer signal and the internal set-point value were the same, then the motor speed would be zero. High ***PROPORTNAL GAIN*** and ***INTEGRAL GAIN*** values give smaller error in the pressure, but also make the system more susceptible to oscillation.

Additional adjustable parameters including ***MAX FREQUENCY***, ***MINIMUM FREQ***, ***TOFF***, ***T1ON***, ***T2ON***, ***SHUTOFF PMIN***, ***PROPORTNAL GAIN***, ***INTEGRAL GAIN*** and ***BOOST AMOUNT*** help to optimize the performance of the system. The use of these parameters was discussed in the previous section. The unit is shipped with default settings which will work in most applications with no adjustment. As with all systems of this type there are tradeoffs between maintaining a tightly controlled set-point, achieving high motor efficiency and maintaining system stability.

Figure 7-5 Analog Constant Pressure One-Line Diagram



Analog Constant Pressure Installation Procedures:

1. Install the analog pressure transducer and emergency over-pressure switch in the water line
2. Remove protective rubber boot from the over-pressure switch, insert factory provided duplex cable through the boot, and connect a twisted pair of wires to the normally closed (NC) and common (C) terminals of the emergency over-pressure switch

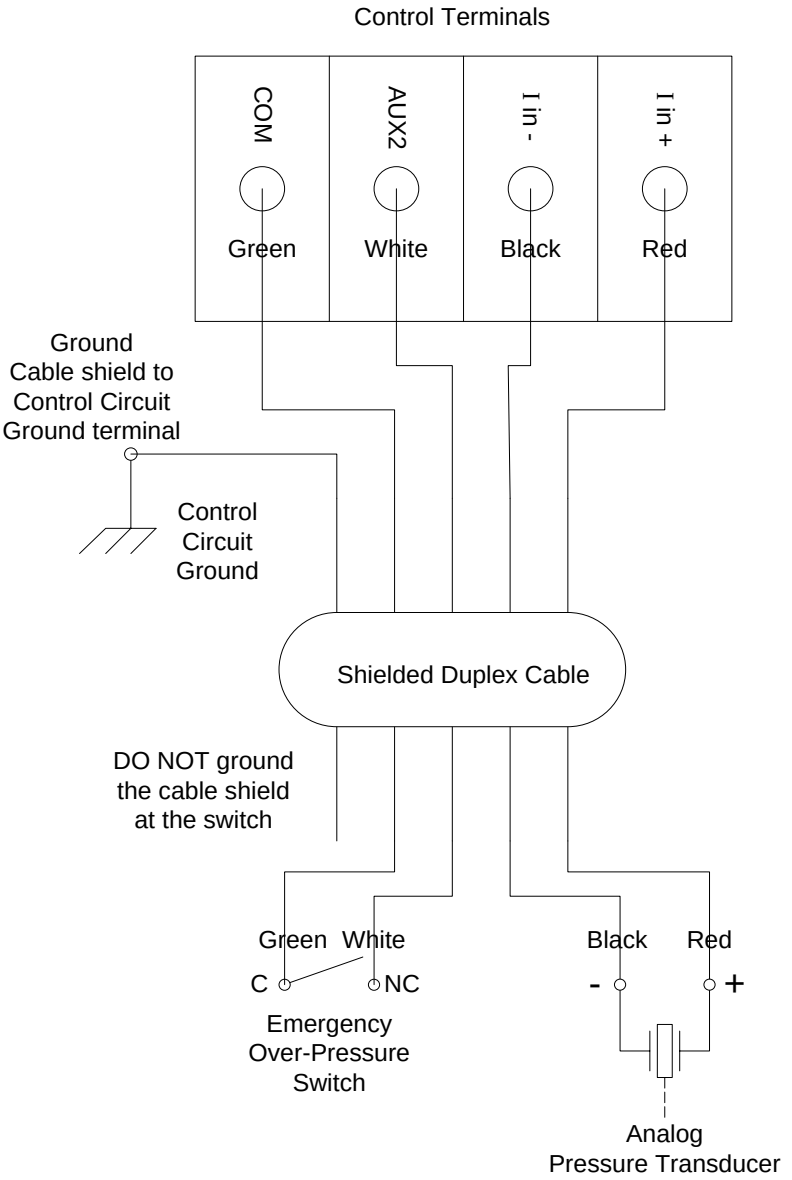
⚠ **CAUTION**: The use of shielded cable is recommended. Regular wire may induce capacitance in the line and corrupt the signals from the pressure switches.

3. Attach the cable shield to the Control Terminal Ground post located in the drive enclosure adjacent to the Control Terminals
4. Connect the emergency over-pressure limit switch to the AUX2 Control Terminals
5. Navigate through the keypad Main Menu item ***CHANGE PARAMETER VALUES > INTERFACE PARAMETERS > SYSTEM CONFIG***. Select ***2*** to set the system configuration for an analog CP system (see Table 5-2 for details)
6. To set the emergency over-pressure limit switch, remove the rubber boot from the switch and pry the plastic plug from the top of the switch housing to access the pressure adjustment screw. Use an Allen wrench to adjust the pressure setting of the switch – jumper the AUX1 terminals and run the pump in the AUTO mode, and observe the pressure gauge, turning the Allen screw to adjust the pressure shut-off point. **The emergency over-pressure limit switch should be set at least 10 PSI higher than the desired constant pressure set point**.
7. Connect the remaining twisted pair of wires to the + and – terminals of the transducer
8. Connect the + terminal of the transducer to the I+ Control Terminal, and the – terminal to the I- Control Terminal.

⚠ **CAUTION**: It is critical that the + terminal of the transducer is connected to the + terminal of the 4-20mA Control Terminal, and likewise for the – terminals.

9. Set the ***psi SETPT*** on the keypad (see Table 5-2 *Constant Pressure Parameters* for details)
10. Set the keypad to AUTO mode to operate the system

Figure 7-6 Analog Pressure System Schematic



7.5 Pre-Charge Mode

When filling a large plumbing system with water, it may be desirable to fill at a slow pump speed so that when the system reaches the full point, water hammer does not cause damage such as sprinkler head blow-off or burst pipes. To achieve this, APX drives are equipped with a pre-charge feature.

Both the digital and analog constant pressure systems can implement a low-flow pre-charge of the system plumbing before the pump is allowed to come to full speed. This feature is disabled if the ***PRECHARGE TIME*** parameter is set to zero. For both types of CP systems, the frequency of the pump will not exceed the value set by the ***PRECHARGE FREQ*** parameter during the pre-charge interval.

In a digital CP system the pre-charge interval is terminated if either the ***PRECHARGE TIME*** is exceeded or the control pressure is reached.

An analog CP system has the same features with the added option that the pre-charge interval will terminate when the system pressure exceeds the setting of the ***PRECHRG psi*** parameter. In this case, the ***PRECHRG psi*** must be lower than the ***psi SETPOINT.***

In both CP systems the pre-charge interval occurs whenever the drive is switched from OFF to AUTO or MANUAL > RUN.

Pre-charge Mode Setup:

1. Navigate through the keypad menu to ***CHANGE PARAMETER VALUES > CONSTANT PRESSURE PARAMETERS > PRECHARGE FREQ*** Enter the Pre-charge frequency
2. Navigate through the keypad menu to ***CHANGE PARAMETER VALUES > CONSTANT PRESSURE PARAMETERS > PRECHARGE TIME***. Enter the Pre-charge time in seconds
3. For analog CP systems only, navigate through the keypad menu to ***CHANGE PARAMETER VALUES > CONSTANT PRESSURE PARAMETERS > PRECHRG psi***. Enter the pre-charge pressure in psi. This value must be lower than the ***psi SETPOINT***
4. Set the keypad to AUTO mode to operate the system

Section 8 Troubleshooting

This section provides information on status indicators that display information about the operating parameters of the system and troubleshooting tips for potential system problems.

⚠ **WARNING!** In some instances, the unit will shut down, then automatically restart when conditions allow. Always disconnect input power from the unit and wait for internal electrical charges to dissipate before performing service on the unit or its connected loads.

⚠ **WARNING:** Risk of electric shock. De-energize the unit by disconnecting all incoming sources of power, then wait 5 minutes for internal charges to dissipate before servicing the equipment.

⚠ **HIGH VOLTAGE:** This equipment is connected to line voltages that can create a potentially hazardous situation. Electric shock could result in serious injury or death. This device should be installed and serviced only by trained, licensed and qualified personnel. Follow instructions carefully and observe all warnings.

Always check the LCD display for fault codes if the drive or its load is not operating. Disconnecting the input power will clear any fault code indication, possibly losing valuable information for troubleshooting.

8.1 Status Indicators and Fault Codes

Fault codes are indicated on the LCD display in 2-row, 32-character text messages. See Table 8-1 for a list of fault codes.

The drive can be programmed to automatically restart after certain faults and a time delay can be programmed before the restart is allowed. To interrupt a time delay countdown and allow auto restart, press both arrow keys on the keypad and hold for one second. To reset the restart counter for ALL faults to zero cycle the input power OFF/ON. Remember that clearing the restart counter does not clear the Fault Log. The Fault Log is cleared through the ***CLEAR MEMORY*** parameter.

⚠ **WARNING:** Certain faults do not allow an auto restart. These faults generally indicate the possibility of damage to the drive and/or the load, or indicate the possibility of a dangerous condition. When a fault occurs, refer to Table 8-1, *Fault Codes*, to determine if the fault allows an auto restart. The number 1 in the notes column indicates that auto restart is not allowed. When this type fault occurs, contact the factory for assistance before restarting. These faults can be cleared only by cycling input power OFF/ON.

⚠ **WARNING:** Unit may restart automatically without warning after a fault when operating conditions permit. Make certain input power is disconnected before servicing the unit or its connected loads.

Clearing a Fault
A fault that allows auto restart can be cleared by either cycling the input power OFF/ON or by pressing and holding both arrow keys when the restart delay is in progress. If the unit is programmed to automatically restart after a particular fault, the display indicates that the unit will restart and will count down the seconds remaining to restart on the display.

For faults that allow an automatic restart, the default number of restarts after a fault is zero. If the end user desires the unit to automatically restart after a fault, the number of restarts allowed and the time between fault and restart must be programmed in the ***CHANGE PARAMETER VALUES > AUTO RESTART PARAMETERS*** for that fault.

The ***ENABLE RESTART*** parameter must also be set to enable restarts in order for the drive to restart automatically after a fault. This parameter also enables to drive to initialize in AUTO mode when the input power has been cycled OFF/ON and the drive is energized. Navigate to this parameter via ***CHANGE PARAMETER VALUES > AUTO RESTART PARAMETERS > ENABLE RESTART***. See Table 5-4 for values in setting the parameter.

Table 8-1 Fault Codes

TEXT MESSAGE	DESCRIPTION / COMMENTS	NOTES
INPUT FAULT	Abnormally high current on line-side module. Possible internal fault. Contact factory.	1
OUTPUT FAULT	Check for short circuit on output lines and load. Contact factory	1
OVER TEMPERATURE	Internal temperature of the drive exceeded safe limits. Check fans and ventilation openings for obstruction. Reduce ambient temperature.	2
BUS OVERVOLTAGE	Sudden and severe regenerative power under high line voltage conditions may result in bus overvoltage. Check line voltage or consider increasing ramp up and ramp down times.	2
HALL SENSE HIGH	A current large enough to exceed the maximum current rating of the hall effect sensor. May indicate a fault in the motor circuit	2
POSSIBLE SHORT	Possible short on output or internal fault. Check output lines and load for short circuit, or contact factory.	1
HIGH INPUT VOLT	Input voltage has exceeded a level for safe operation. Reduce input voltage. General purpose buck/boost transformers are compatible with APX Series drives.	2

TEXT MESSAGE	DESCRIPTION / COMMENTS	NOTES
Class 10 OVERLOAD	Output current has exceeded the value set for ***OVERCURRENT LIMT*** in OPERATING PARAMETERS menu. Check status of motor load. If output current limit is increased, make sure it is within the limit of the motor nameplate. Automatic restarts are set by ***RESTART DELAY 1*** and ***RESTARTS CUR OVL*** in the AUTO RESTART PARAMETERS menu.	P, 2
CURRENT UNBALANCE	Motor current unbalance has exceeded the limit set in ***CURRENT UNBALANC*** under CHANGE PARAMETER VALUES menu. Check motor load for normal operation, or increase current unbalance limit.	P, 2
DRY WELL KW	Real power in kW consumed by the motor load has fallen below the limit set in MINIMUM POWER under CHANGE PARAMETER VALUES menu. Commonly used to detect dry well condition.	P, 2
OVERCURRENT IN	Current on line-side module exceeded rated current. Check for faults or overload in the motor circuit. Low input line voltage may result input module overload. De-rate drive linearly as input voltage decreases from specified voltage. Automatic restarts are set by ***RESTART DELAY 1*** and ***RESTARTS CUR OVL*** in the AUTO RESTART PARAMETERS menu.	2
TEMP SENSE FAULT	Solid state temperature sensor on the heat sink has failed or its cable is disconnected. Contact factory.	1
DRY WELL CURRENT	Motor current has fallen below the value set in ***UNDERCURRENT LIM*** under OPERATING PARAMETERS menu. Commonly used to detect dry well condition.	P, 2
OUTPUT OVERLOAD	Indicates a large and sudden overcurrent event on the output module. Check the motor circuit for faults. Sudden changes in the load may also have occurred such as the closing of a relay that results in an across-the-line start of a motor. Never install relays in the motor circuit.	1
LOW INPUT VOLT	Input voltage has fallen below a level for safe operation of the drive. This fault can also be triggered by a momentary interruption of the input power source.	2
GROUND FAULT	A fault between an output line and earth has been detected. Immediately disconnect input power and check output lines with a megger to verify a fault. Nuisance trip is a possibility. Sensitivity of fault detection can be adjusted by the Operating Parameter ***GND FAULT DETECT***. See Table 5-1 for details.	1
LINE CAP FAIL	Indicates potential failure of capacitor on input L/C filter.	2

P = Fault may be related to an adjustable parameter. Always check the value of the parameter to eliminate nuisance tripping.
1 = Drive has shut down due to a potentially dangerous condition. Drive will remain OFF until input power is cycled OFF/ON. Use caution if the drive is restarted.
2 = ⚠ **WARNING:** Auto restart allowed for this fault. Motor may restart automatically without warning after a fault when operating conditions permit. Make certain input power is disconnected before servicing the unit or its connected loads.

Fault Log
The Fault Log records the number of times a particular fault has occurred. To access the Fault Log, press the MENU key until the Main Menu item, ***FALUT LOG***, appears. Press ENTER key to access the list of faults. The Fault Log will continue to log the number of faults that have occurred until it is reset through the Main Menu item ***CLEAR MEMORY***. Navigate through the Main Menu on the keypad to ***CLEAR MEMORY***, press ENTER, then use the arrow keys to select ***CLEAR FAULTS***, then reset the Fault Log by pressing ENTER. Refer to Section 4, *Fault Log*, for details. The Fault Log is not to be confused with the restart counter. The restart counter is associated with the automatic restart function and is reset whenever the input power is cycled OFF/ON.

Table 8-2 Troubleshooting

PROBLEM	POTENTAIL CAUSE	SOLUTION
Motor not running	Is a fault code indicated?	Based on the fault code, resolve any factors that are likely causing the fault. Clear the fault by pressing both arrow keys on the keypad or by cycling input power OFF/ON.
	Are the remote switches AUX1 and AUX2 closed?	Check the status of the switches or jumpers connected to AUX1 and AUX2 on the Control Terminals. The LCD display indicates the status of AUX terminals in the default display mode. All AUX terminals must be closed for the motor to run in AUTO mode.
	Are the signals to the Control Terminals corrupted?	Shielded cable is required for AUX terminal switch leads longer than 20 ft. Regular wire will induce capacitance in the line and corrupt control signals. Shielded cable is recommended for all Control signal cables.
	Is the keypad in MAN or OFF mode?	The keypad will override signals on the Control Terminals when OFF or MAN is selected. Keypad must be in AUTO mode for external control signals to control the motor.
	Is the maximum frequency set at 0 Hz?	Check the maximum frequency by using the keypad to navigate ***MAIN MENU>CHANGE PARAMETER VALUES>OPERATING PARAMETERS>MAX FREQUENCY***.
	Are the input terminals L1 and L2 energized?	Green LED D9 on the Master Control printed wiring board should be on to indicate board is powered. Green flashing D16 indicates the program is running. If no LEDs are lit on the PWB, check the main input fuses or breaker. Check the secondary circuit fuses. See Figure 8-1, *Fuse Location*
Motor is turning the wrong direction	Phase sequence on output terminals U/T1, V/T2, W/T3 is out of order	Swap any two of the three motor leads on the output terminals.

8.2 Routine Inspection and Maintenance

The unit should be inspected and cleaned at least annually, or more frequently if it is located in an excessively warm or dusty environment.

Power terminals: Inspect for loose connections and tighten to specifications in Table 3-2, Field Wiring Power Terminal Specifications.

Capacitors: Check for leakage or deformation.

⚠ **CAUTION**: Line filter capacitors should be inspected annually at a minimum. Replacement of the capacitors every three years is recommended. These capacitors suppress electrical noise caused by the switching of the IGBTs. If they are degraded the electrical noise can damage equipment connected to the converter.

Overall: Perform a visual inspection checking for things such as discolored wires or terminals, evidence of arcing, loose mounting screws, physical damage to the enclosure, etc.

Fans and heatsinks: Excessive dust buildup on the heatsink and cooling fan impellers may lead to overheating. Lightly brush and vacuum clean.

Instructions for fan replacement: Contact Customer Service for assistance in replacing the cooling fan in the event it should fail. Use only fans approved by Phase Technologies. Unapproved fans may not be able to move enough air to properly cool the unit, leading to component damage.

Line Filter Capacitors:

⚠ **CAUTION:** Line filter capacitors should be inspected annually at a minimum. **Replacement of the capacitors every three years is recommended**. These capacitors suppress electrical noise caused by the switching of the IGBTs. If they are degraded the electrical noise can damage equipment connected to the drive.

Line filter capacitors should be visually inspected and electrically tested on a routine basis. The capacitors can be observed by removing the front cover of the drive. See Figure 8-1 below to identify the line filter capacitors.

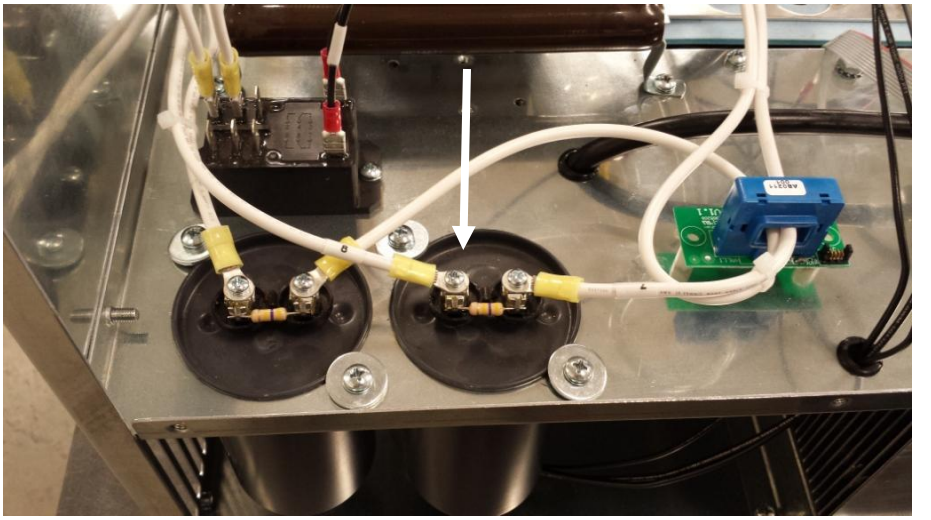
Visually inspect the line filter capacitors and the wires connected to them for any discoloration and for bulges in the canister.

Table 7 Nominal Filter Capacitor Values in MicroFarads (uF) and Voltage

Drive Model	No. of Capacitors	Capacitor Value
APX210	1	60 uF, 370 V
APX220	2	60 uF, 370 V
APX230	3	60 uF, 370 V
APX410	1	30 uF 660 V
APX420	2	30 uF 660 V
APX430	2	30 uF 660 V
APX440	2	50 uF 660 V
APX450	2	50 uF 660 V

Using a multi-meter set to measure capacitance, check the capacitance of each capacitor by measuring between the two terminals on the capacitor. **Remove the wire from at least one terminal of the capacitor in order to obtain an accurate measurement.** Compare to the capacitor value in Table 7. If any capacitor value is less than specified by more than 25% contact Phase Technologies customer support at 605-343-7934 to order replacement capacitors. If you do not have a meter or other means to test the capacitors it is recommended to replace the capacitors every three years as a preventive measure. Do not operate the converter with degraded capacitors!

Figure 8-1 Line Filter Capacitors

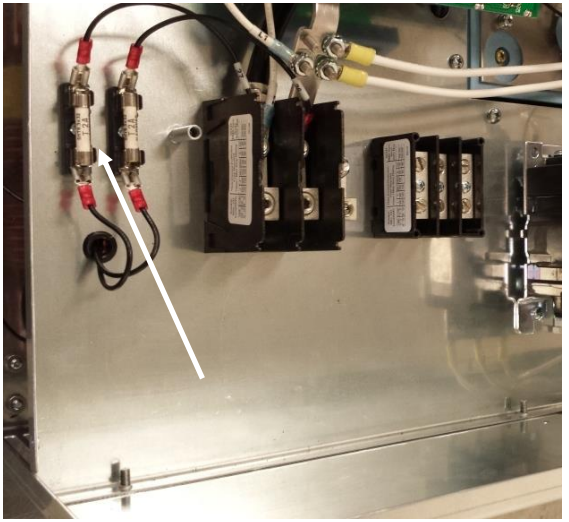


Fuses: There are several field replaceable fuses in the drive. Each fuse is assigned a designator to help identify the fuse. Replacement fuses are available from the factory by contacting Customer Service at 605-343-7934. Refer to Table 8-3 for fuse ratings.

Table 8-3 Fuses

Fuse Designator	Fuse Rating	Comments
F1, F2	250 V, 2 A	Primary and secondary of control transformer. Located on power supply printed circuit board.
F3	250 V, 3A	Primary of control transformer
F4, F5	500 V, 2 A	Only for 480 V input models. Protects the primary of the control transformer.

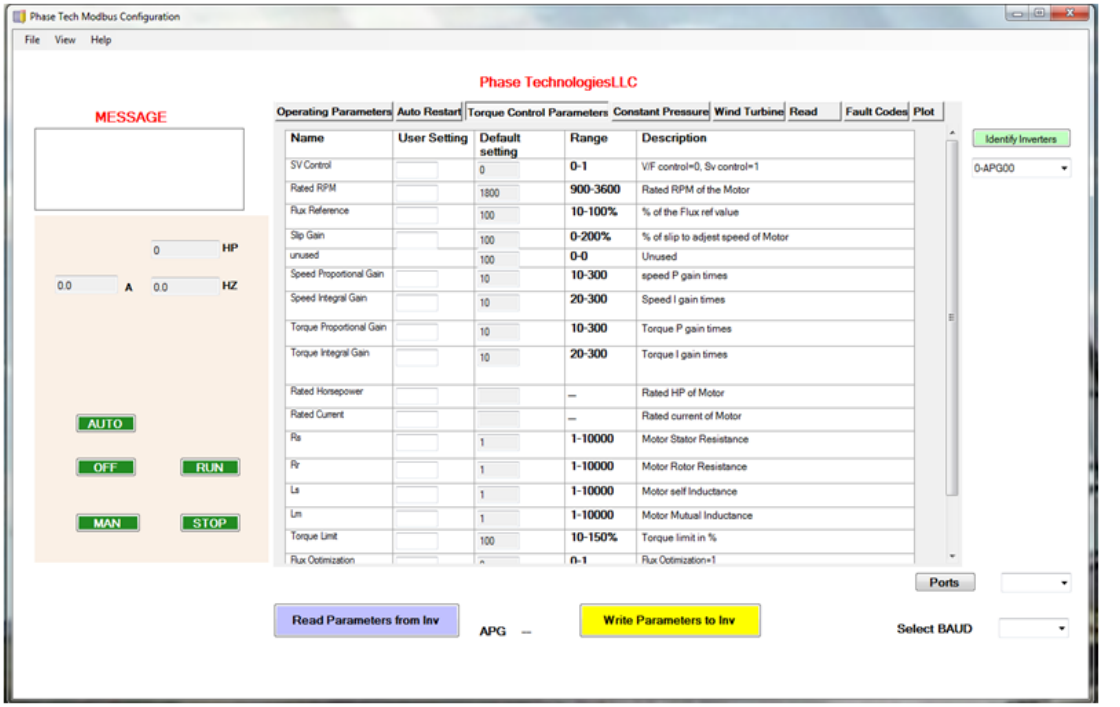
Figure 8-2 Fuse Location



Fuses F4 and F5 are located on the panel behind the wiring access cover

Fuses F1, F2 and F3 are located on the Power Supply printed circuit board. Remove the front cover to gain access

9.1 Windows Compatible Software



Windows compatible software is available that allows the drive to be operated from a personal computer via the MODBUS terminals. An Ethernet connection will allow operation from a remote location.

The application can be downloaded from the manufacturer's web site at www.phasetechnologies.com. Contact the manufacturer for assistance in choosing the hardware necessary for MODBUS or Ethernet communication through the Windows Compatible Software.

LIMITED WARRANTY

Phase Technologies equipment is warranted against defects in material and workmanship for a period of one year. This warranty covers both parts and labor for one year from the date of purchase by the original owner. Phase Technologies will repair or replace (at our option), at no charge, any part(s) found to be faulty during the warranty period specified. The warranty repairs must be performed by/at a Phase Technologies Authorized Service Center or at Phase Technologies LLC, Rapid City, SD.

Obligations of the Original Owner

1. The original Bill of Sale must be presented in order to obtain "in-warranty" service.
2. Transportation to Phase Technologies or an Authorized Service Center is the responsibility of the original purchaser. Return transportation is provided by Phase Technologies.
3. Installations must comply with all national and local electrical codes.

Exclusions of the Warranty

This warranty does not cover any of the following: accident, misuse, fire, flood, and other acts of God, nor any contingencies beyond the control of Phase Technologies, LLC, including water damage, incorrect line voltage, improper installation, missing or altered serial numbers, and service performed by an unauthorized facility. Phase Technologies' liability for any damages caused in association with the use of Phase Technologies' equipment shall be limited to the repair or replacement only of the Phase Technologies' equipment. No person, agent, distributor, dealer, or company is authorized to modify, alter, or change the design of this merchandise without express written approval of Phase Technologies, LLC.

INSTALLATIONS MUST COMPLY WITH ALL NATIONAL AND LOCAL ELECTRICAL CODE REQUIREMENTS.

Notes