LHX SERIES | DXL SERIES

VARIABLE FREQUENCY DRIVES

OPERATION & INSTALLATION MANUAL

UNCOMMON VALUE

PHASE TECHNOLOGIES

SAFETY MESSAGES AND WARNINGS

To ensure safe and reliable operation of Phase Technologies variable frequency drives, it is important to carefully read and understand this manual and to read and observe all warning labels attached to the drive before installing the equipment. Please follow all instructions exactly and always keep this manual with the equipment 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 EQUIPMENT!

WARNING: Risk of electric shock. De-energize the unit by disconnecting all incoming sources of power, then wait for the time specified on the drive warning label, 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** through **AUX4** terminals are galvanically isolated, with approximately 5V potential between them. DO NOT apply voltage to the terminals. Use dry contacts only.

CAUTION: Circuit breakers or fuses, proper ground circuits, disconnect 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 motor protection filters if your motor is more than 50 feet from the drive.

⚠ **CAUTION:** Failure to maintain adequate clearance for free flow of cooling air 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 65 kA RMS symmetrical amperes, 460 VAC.

⚠ **WARNING:** Wire used within the motor circuit and all field wiring terminals must be rated at least 60 °C.

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

⚠ **WARNING:** Input power connections should be made by a qualified electrician into a nominal 460V circuit for models with 460V input, with adequate current carrying capacity. Branch circuit protection to the drive should be provided by appropriate size fuses or circuit breaker. Circuit breaker and fuse ratings for each model are listed in **Table 2**, **Table 3**, and **Table 4**.

⚠ **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 2**, **Table 3**, and **Table 4.**

⚠ **CAUTION:** The maximum wire gauge for the input and output terminals are listed in **Table 2**, **Table 3**, and **Table 4**.

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

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

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

⚠ **WARNING:** Ingesting coin cell batteries can cause severe internal injuries or death. Store batteries out of reach of children, seek immediate medical attention if ingestion occurs, and follow any other consensus medical advice.

⚠ **CAUTION:** Use caution when applying power to the main input terminals of the unit. If the drive is programmed to allow automatic restarts, the drive will initialize in AUTO mode and 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 drive. Do not install relays, disconnect switches, or wire nuts between the drive 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**: Before touching any printed circuit board, place a hand on a bare metal surface of the unit to discharge any static electricity. Electrostatic discharge (ESD) can damage printed circuits and their components.

⚠ **CAUTION:** When the parameter, ***1.2.1 ENABLE RESTARTS,*** is set to YES, the drive will energize in AUTO mode. The motor load may automatically run as soon as the drive is energized. To stop the motor, push the STOP/OFF key until the display indicates 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 MANUAL mode on the keypad overrides remote signals from any remote controls. Operating the system in this mode may lead to dangerous pressures in closed plumbing systems.

TABLE OF CONTENTS

1 INTRODUCTION

Phase Technologies' variable frequency drives (VFDs) are inverter-based devices that convert AC power to a three-phase variable frequency output which provides speed control for three-phase AC motors. The drives offer advanced motor control features through an intuitive, easy-to-use interface.

The following block diagrams demonstrate how the drives convert incoming AC power to DC, then utilize an inverter module to generate three-phase variable voltage and frequency output to control the speed of a motor.

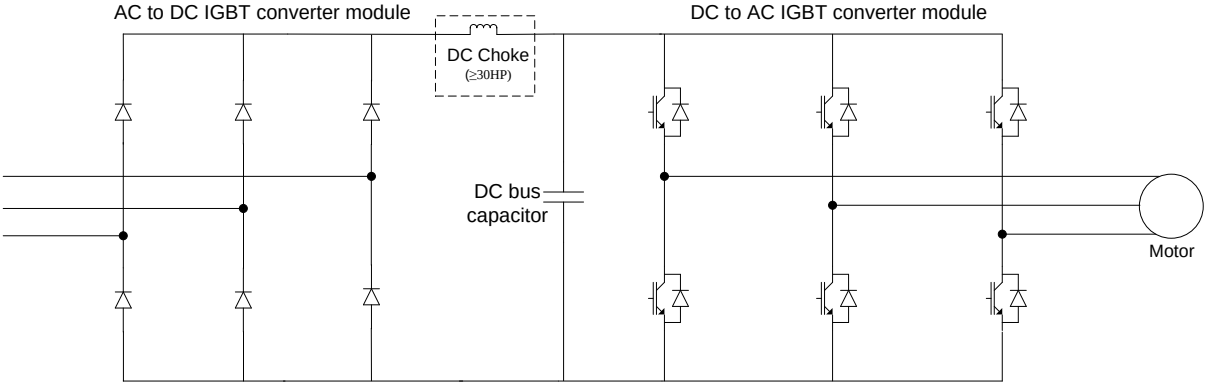


Figure 1 – DXL Series Block Diagram

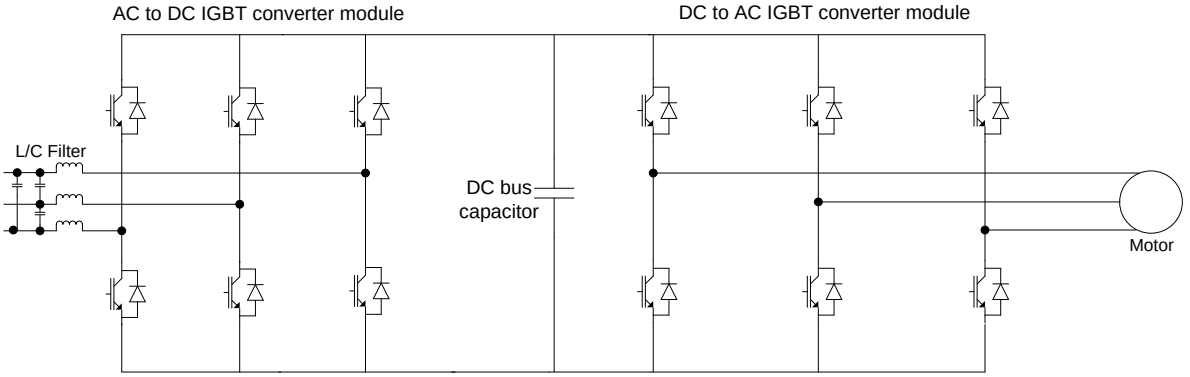


Figure 2 – 3LHX Series Block Diagram

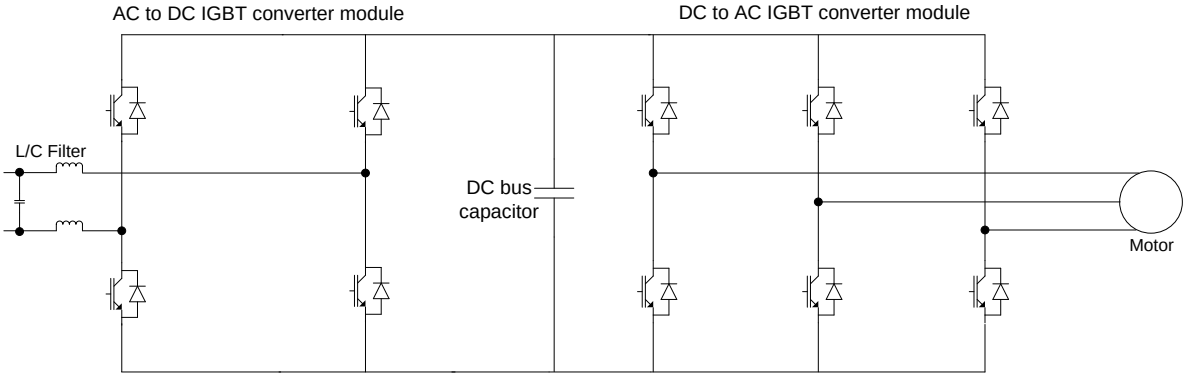


Figure 3 – 1LHX Series Block Diagram

FEATURES

Low Line Side Harmonics (IEEE 519-2014 Compliant) – 1LHX & 3LHX Models Only
All models of the LHX series employ active front end (AFE) technology. Active switching of the input IGBTs 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, additional input line reactors and harmonic filters are NOT REQUIRED on the line side of the drive. Installations at 80% load or greater will comply with IEEE 519, the international standard for allowable harmonic distortion on utility mains.

Voltage Doubling
The input module of DXL and LHX drives is capable of significantly boosting the voltage on the DC bus. Utilizing this feature, some models of the series convert 230 V single-phase or 230 V three phase line voltage to 460 V three-phase output.

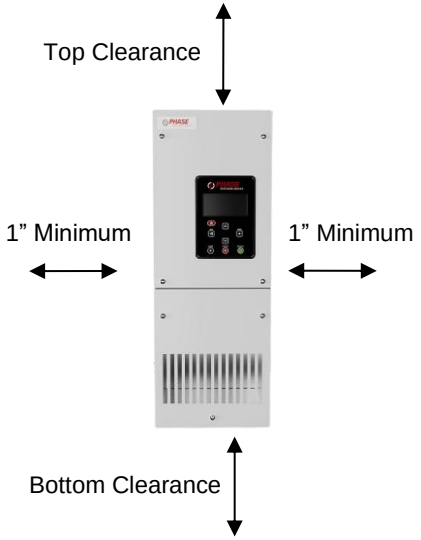
2 INSTALLATION

2.1 Mounting

The drive must be mounted in an upright position with adequate clearance for cooling and maintenance access. The mounting surface must be sturdy, non-flammable, 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. Lifting hooks are provided on the top of some enclosures.

To allow for proper cooling and air circulation around the enclosure, maintain minimum clearances depicted in **Figure 4**. Locate the frame size of your drive in **Table 2 - Table 4**. The drives are cooled by fans with ventilation openings on the sides or bottom of the enclosure. The surface around the enclosure should be of a non-flammable material and clear of obstacles. Locate the drawing of your drive model in **Section 9** for dimensions and mounting hole locations. **Figure 4** details the minimum drive clearances required for mounting.

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



Minimum Clearances by Frame Size		
Frame	**Top Clearance**	**Bottom Clearance**
D1	4 in	6 in
D3/L2	6 in	6 in
D4/L3	8 in	8 in
D5/L4	12 in	10 in
L5	16 in	12 in

Figure 4 – Minimum Clearances

Ambient Temperature Rating

DXL and LHX Series drives are intended for use in ambient temperatures of up to 40˚C (104°F). Operation up to 50˚C (122˚F) is permissible with 2% output current de-rate per 1˚C.

2.2 General Wiring Considerations

Installations must comply with all NEC and local electrical code requirements. Circuit breaker and fuse sizes listed in **Table 2 - Table 4** are maximum allowable sizes, not recommended sizes. The NEC dictates that circuit breakers must be rated at least 25% higher than the input current rating.

Table 1 – Power Terminal Descriptions

Terminal Name	Description
L1, L2, L3	Input power terminals
U, V, W	Output power terminals
GND	Earth safety ground

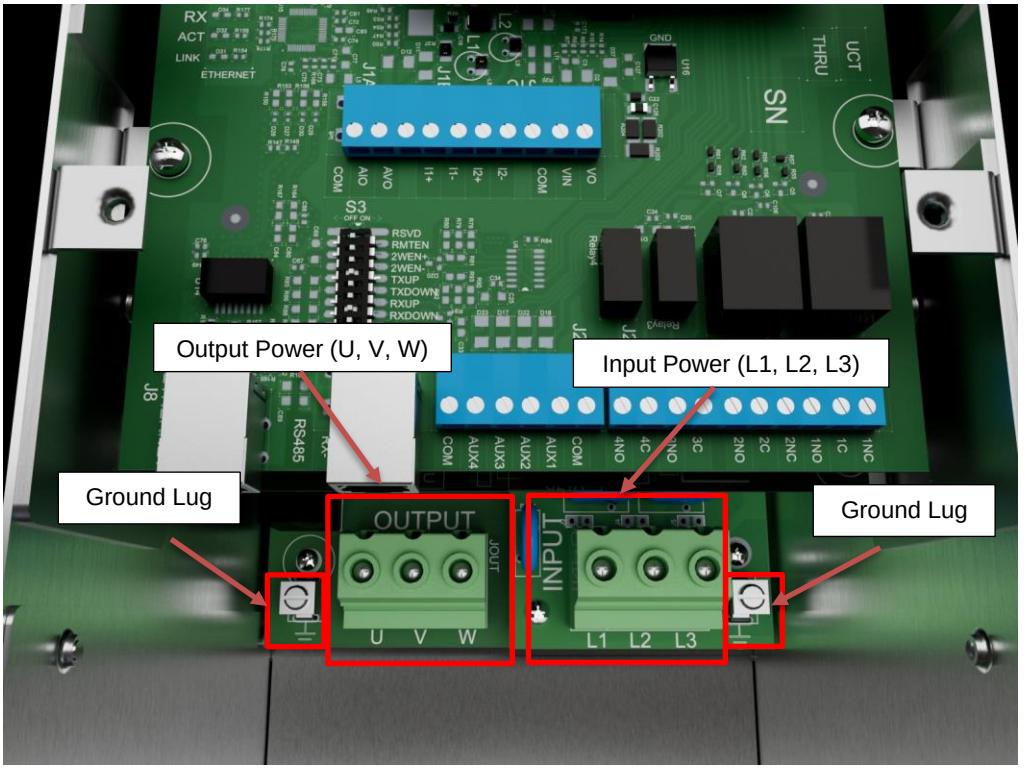


Figure 5 – D1/L1 Frame Size Power Terminal Location

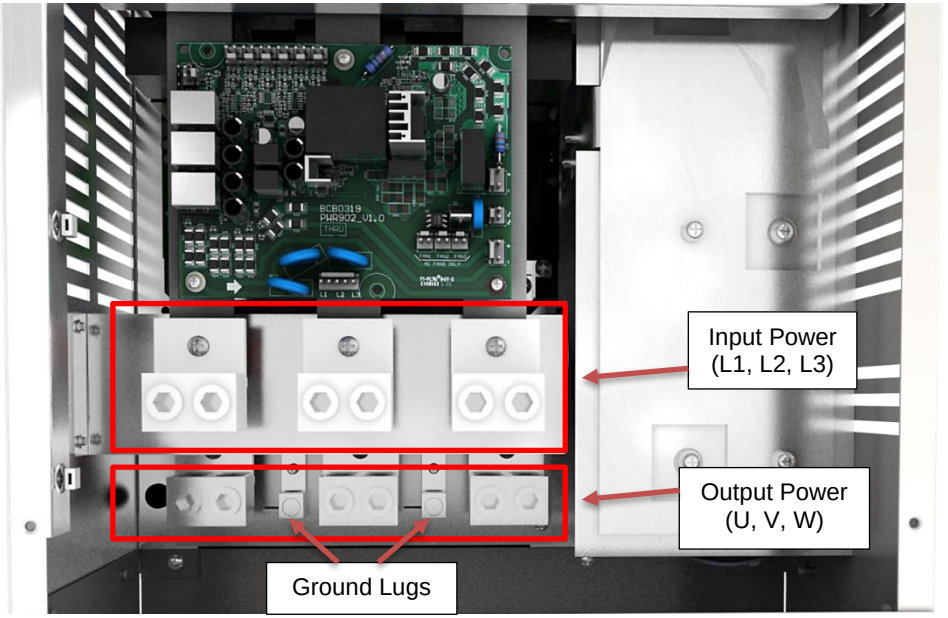


Figure 6 – D3/L2 Frame Size Power Terminal Location

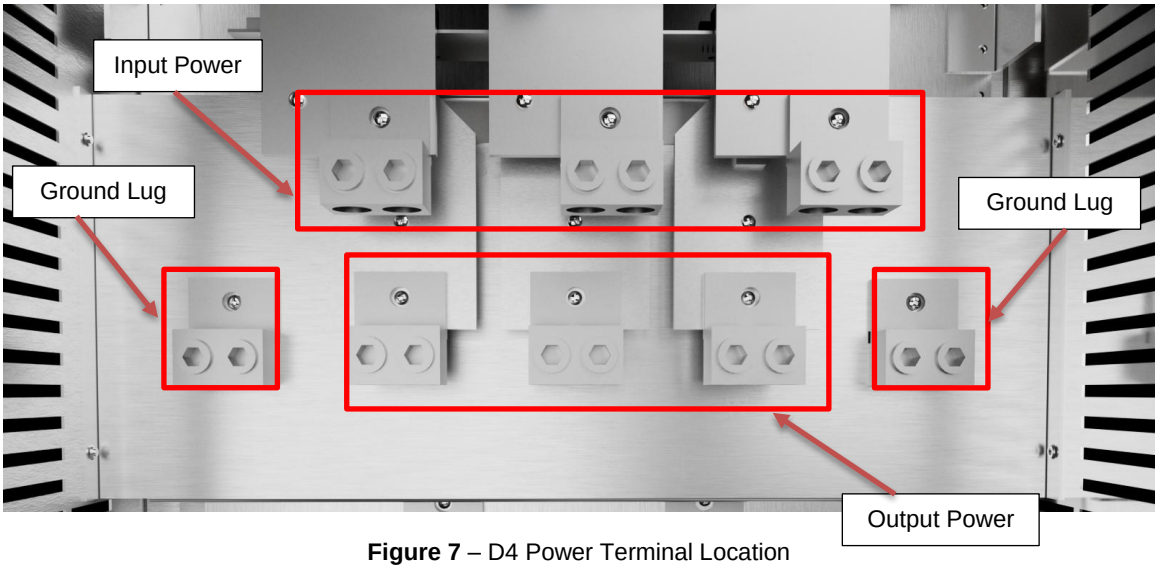


Figure 7 – D4 Power Terminal Location

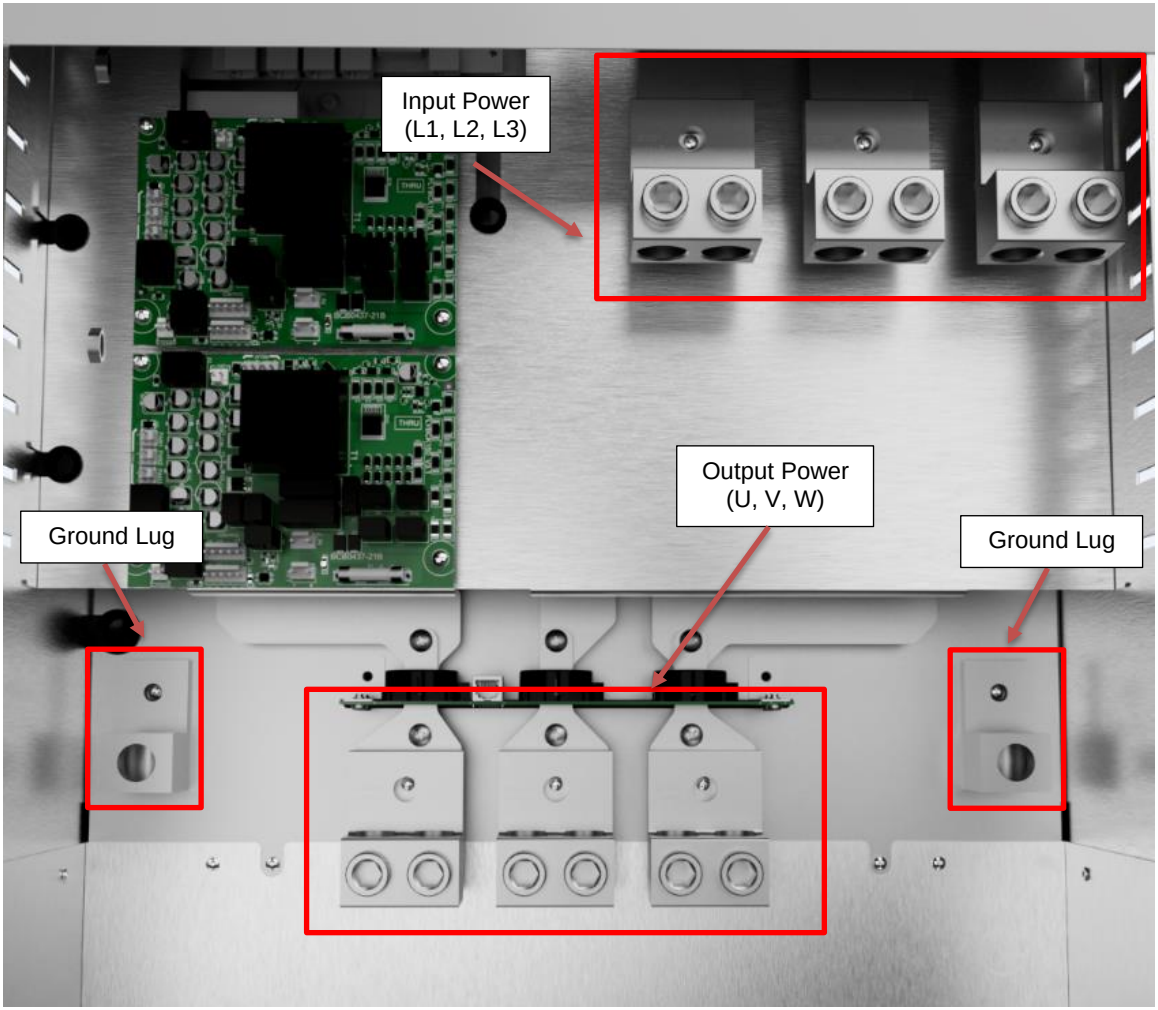


Figure 8 - L3 Power Terminal Locations

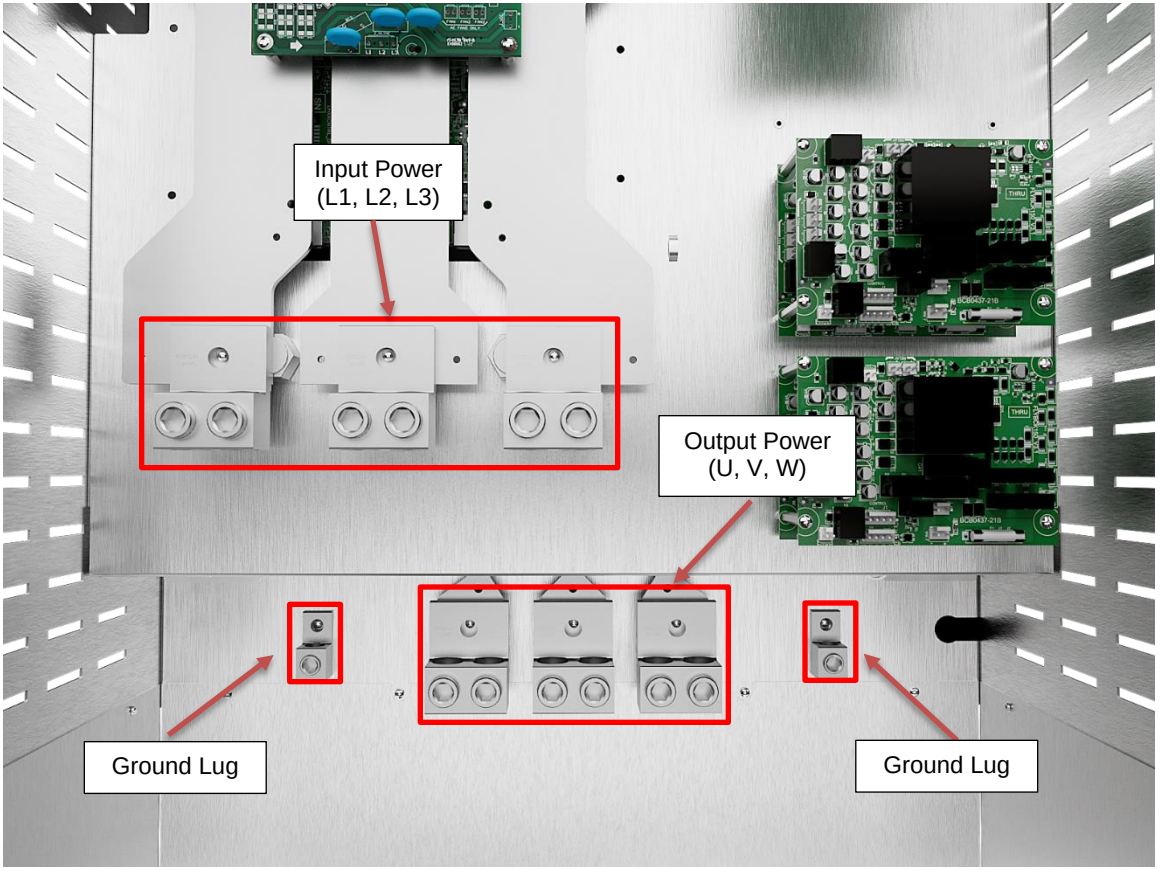


Figure 9 – L4 Power Terminal Locations

Table 2 – DXL Frame Size, Input Circuit Breaker, and Fuse Ratings (Inverse Time Circuit Breaker)

Model	Frame Size	Input			Output			Maximum Circuit Breaker / Fuse Rating Class J
		Wire Size Range[1][2]		Torque (lb·in)	Wire Size Range[1][2]		Torque (lb·in)	
		Min	Max		Min	Max		
DXL005	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	50 A, 600 V
DXL007	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	50 A, 600 V
DXL010	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	60 A, 600 V
DXL015	D1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	100 A, 600 V
DXL020	D1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	125 A, 600 V
DXL025	D1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	150 A, 600 V
DXL030	D1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	200 A, 600 V
DXL205	D1	16 AWG	2 AWG	17.5	16 AWG	6 AWG	10	60 A, 600 V
DXL207	D1	16 AWG	2 AWG	17.5	16 AWG	6 AWG	10	100 A, 600 V
DXL210	D1	16 AWG	2 AWG	17.5	16 AWG	6 AWG	10	125 A, 600 V
DXL215	D1	16 AWG	2 AWG	17.5	16 AWG	6 AWG	10	175 A, 600 V
DXL405	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	25 A, 600 V
DXL407	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	25 A, 600 V
DXL410	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	40 A, 600 V
DXL415	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	50 A, 600 V
DXL420	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	60 A, 600 V
DXL425	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	80 A, 600 V
DXL430	D1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	100 A, 600 V
DXL440	D1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	125 A, 600 V
DXL450	D1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	150 A, 600 V
DXL460	D3	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	175 A, 600 V
DXL475	D3	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	225 A, 600 V
DXL4100	D3	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	300 A, 600 V
DXL4125	D3	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	350 A, 600 V
DXL4150	D3	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	400 A, 600 V
DXL4200	D3	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	500 A, 600 V
DXL4250	D3	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	600 A, 600 V
DXL4300	D4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	700 A, 600 V
DXL4350	D4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	800 A, 600 V
DXL4400	D4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	1000 A, 600 V
DXL4500	D4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	1200 A, 600 V

(1) For a given terminal, **do not** use conductors larger than the maximum wire size range.

(2) Min/max wire sizes represent range that terminal block can accept. These sizes are not recommended wire sizes.

Table 3 – 3LHX Frame Size, Input Circuit Breaker, and Fuse Ratings (Inverse Time Circuit Breaker)

Model	Frame Size	Input			Output			Maximum Circuit Breaker / Fuse Rating Class J
		Wire Size Range[1][2]		Torque (lb·in)	Wire Size Range[1][2]		Torque (lb·in)	
		Min	Max		Min	Max		
3LHX005	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	40 A, 600 V
3LHX007	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	50 A, 600 V
3LHX010	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	60 A, 600 V
3LHX015	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	100 A, 600 V
3LHX020	L1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	125 A, 600 V
3LHX025	L1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	150 A, 600 V
3LHX030	L1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	200 A, 600 V
3LHX205	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	40 A, 600 V
3LHX207	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	50 A, 600 V
3LHX210	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	60 A, 600 V
3LHX215	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	100 A, 600 V
3LHX220	L1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	125 A, 600 V
3LHX225	L1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	150 A, 600 V
3LHX230	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	200 A, 600 V
3LHX240	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	250 A, 600 V
3LHX250	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	300 A, 600 V
3LHX260	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	400 A, 600 V
3LHX275	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	450 A, 600 V
3LHX2100	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	600 A, 600 V
3LHX405	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	20 A, 600 V
3LHX407	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	25 A, 600 V
3LHX410	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	40 A, 600 V
3LHX415	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	50 A, 600 V
3LHX420	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	60 A, 600 V
3LHX425	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	80 A, 600 V
3LHX430	L1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	100 A, 600 V
3LHX440	L1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	125 A, 600 V
3LHX450	L1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	150 A, 600 V

Model	Frame Size	Input			Output			Maximum Circuit Breaker / Fuse Rating Class J
		Wire Size Range[1][2]		Torque (lb·in)	Wire Size Range[1][2]		Torque (lb·in)	
		Min	Max		Min	Max		
3LHX460	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	200 A, 600 V
3LHX475	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	225 A, 600 V
3LHX4100	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	300 A, 600 V
3LHX4125	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	350 A, 600 V
3LHX4150	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	400 A, 600 V
3LHX4200	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	500 A, 600 V
3LHX4250	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	600 A, 600 V
3LHX4300	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	800 A, 600 V
3LHX4350	L4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	800 A, 600 V
3LHX4400	L4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	1000 A, 600 V
3LHX4450	L4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	1000 A, 600 V
3LHX4500	L4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	1200 A, 600 V
3LHX4600	L5	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	1600 A, 600 V
3LHX4700	L5	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	1600 A, 600 V
3LHX4900	L5	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	2500 A, 600 V

(1) For a given terminal, **do not** use conductors larger than the maximum wire size range.

(2) Min/max wire sizes represent range that terminal block can accept. These sizes are not recommended wire sizes.

Table 4 – 1LHX Frame Size, Input Circuit Breaker, and Fuse Ratings (Inverse Time Circuit Breaker)

Model	Frame Size	Input			Output			Maximum Circuit Breaker / Fuse Rating Class J
		Wire Size Range[1][2]		Torque (lb·in)	Wire Size Range[1][2]		Torque (lb·in)	
		Min	Max		Min	Max		
1LHX005	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	50 A, 600 V
1LHX007	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	80 A, 600 V
1LHX010	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	100 A, 600 V
1LHX015	L1	16 AWG	2 AWG	17.5	16 AWG	6 AWG	10	150 A, 600 V
1LHX020	L1	16 AWG	2 AWG	17.5	16 AWG	2 AWG	17.5	200 A, 600 V
1LHX205	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	50 A, 600 V
1LHX207	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	70 A, 600 V
1LHX210	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	110 A, 600 V
1LHX215	L1	16 AWG	2/0 AWG	50	16 AWG	6 AWG	10	150 A, 600 V
1LHX220	L1	16 AWG	2/0 AWG	50	16 AWG	6 AWG	10	200 A, 600 V
1LHX225	L1	16 AWG	2/0 AWG	50	16 AWG	6 AWG	10	250 A, 600 V
1LHX230	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	300 A, 600 V
1LHX240	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	400 A, 600 V
1LHX250	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	500 A, 600 V
1LHX260	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	600 A, 600 V
1LHX405	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	25 A, 600 V
1LHX407	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	40 A, 600 V
1LHX410	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	50 A, 600 V
1LHX415	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	70 A, 600 V
1LHX420	L1	16 AWG	6 AWG	10	16 AWG	6 AWG	10	100 A, 600 V
1LHX425	L1	16 AWG	2 AWG	17.5	16 AWG	6 AWG	10	125 A, 600 V
1LHX430	L1	16 AWG	2 AWG	17.5	16 AWG	6 AWG	10	150 A, 600 V
1LHX440	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	200 A, 600 V
1LHX450	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	250 A, 600 V
1LHX460	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	300 A, 600 V
1LHX475	L2	6 AWG	250 KCMIL	375	6 AWG	250 KCMIL	375	350 A, 600 V
1LHX4100	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	500 A, 600 V
1LHX4125	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	600 A, 600 V
1LHX4150	L3	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	700 A, 600 V
1LHX4200	L4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	800 A, 600 V
1LHX4250	L4	6 AWG	2x350 KCMIL	375	6 AWG	2x350 KCMIL	375	1000 A, 600 V

(1) For a given terminal, **do not** use conductors larger than the maximum wire size range.

(2) Min/max wire sizes represent range that terminal block can accept. These sizes are not recommended wire sizes.

2.3 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. If any conduit holes remain unused, they must be covered with a 3R hole plug to maintain the NEMA 3R rating.

Mitigating Electromagnetic Interference (EMI)
Devices that utilize power switching electronics, such as VFDs, 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 the output lines between the drive and the motor is recommended to help reduce EMI.

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 and lower motor bearing currents.

Routing Power Cables

Power cables should enter only through the bottom of the drive enclosure directly beneath the power terminals. Enclosures are supplied with conduit openings.

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. Unused conduit holes must be covered with a conduit hole plug.

Routing Control Wires

A separate, smaller conduit opening is supplied for control cables. If the control cables must intersect the power cables, make sure they cross at right angles.

⚠ **CAUTION:** Avoid routing control cables near power cables to avoid coupling EMI onto control cables.

⚠ **CAUTION** Use an appropriately sized hole punch. Do not use a hole saw to create openings! Metal filings may damage the drive and void the warranty.

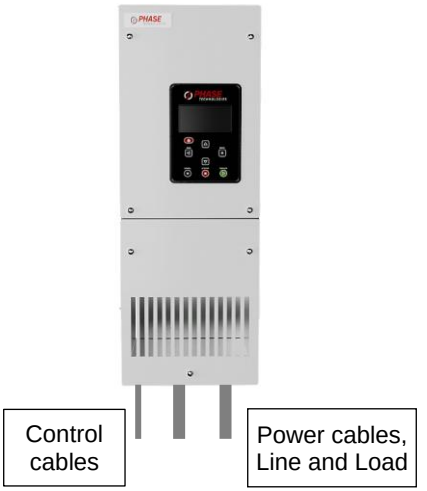


Figure 10 – Routing Power and Control Cables

2.4 Backup Generator

Backup generators used with LHX products must be sized to maintain 60 Hz ± 4 Hz at full load. If using a backup generator and automatic transfer switch to power the VFD, a delay timer must be used when switching between power sources. The delay must be long enough for the VFD screen to go dark before re-applying power – approximately 20 – 30 seconds.

2.5 Output Filters

Some installations may require a dV/dt filter or sine wave filter between the drive and the motor. **Output filters are typically only 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 insulation and result in motor failure.

An output 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 motor manufacturer or a knowledgeable source on motor protection filters if your application has more than 50 feet between the drive and the motor.

2.6 Control Terminals

The drives are equipped with Control Terminals that allow several control functions, including remote ON/OFF control, digital output signals, remote notification, and operation of constant pressure water systems. **The correct *1.3.1 SYSTEM CONFIG* must be selected for proper operation of the different types of control systems!** See **Table 19** for details.

⚠ **WARNING:** Do not connect Control Terminals to external circuits with voltage greater than that specified for each Control Terminal in **Table 5**. De-energize the unit by disconnecting all incoming sources of power, then wait for the time specified on the drive warning label, before servicing the equipment.

⚠**CAUTION:** The AUX1 – AUX4 terminals are galvanically isolated, with approximately 5 V potential between them. DO NOT apply voltage to the terminals. Use dry contacts only.

Customer terminals are located on the Control Board of each drive. **Figure 11** shows where the Control Terminals are located on the Control Board for each system. See **Table 5** for information on the function of control terminals.

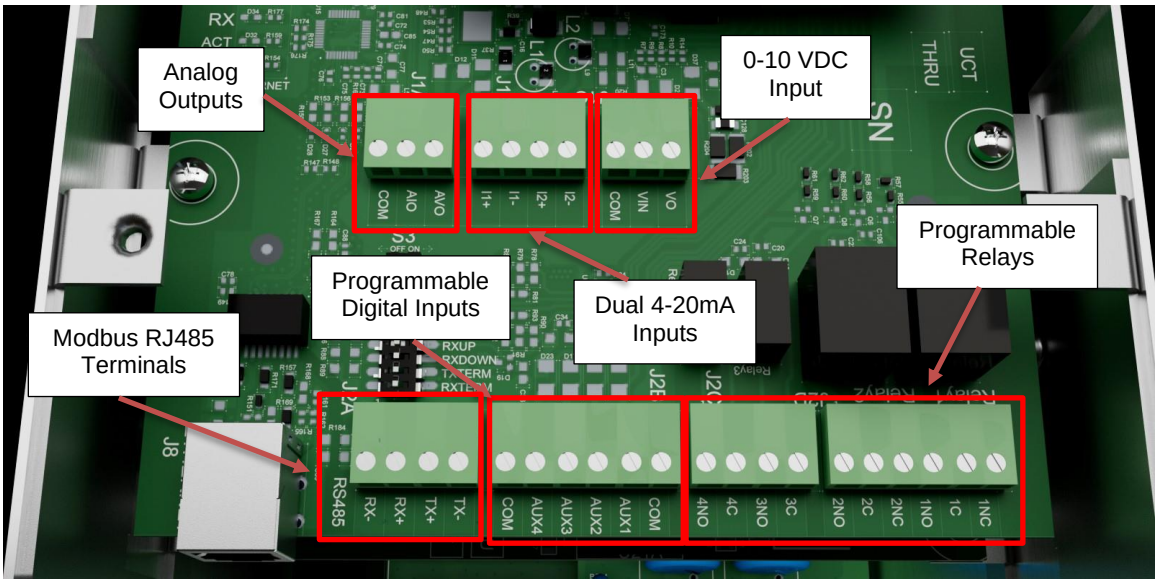


Figure 11 – Control Terminals

Figure 12 – Control Wiring Diagram

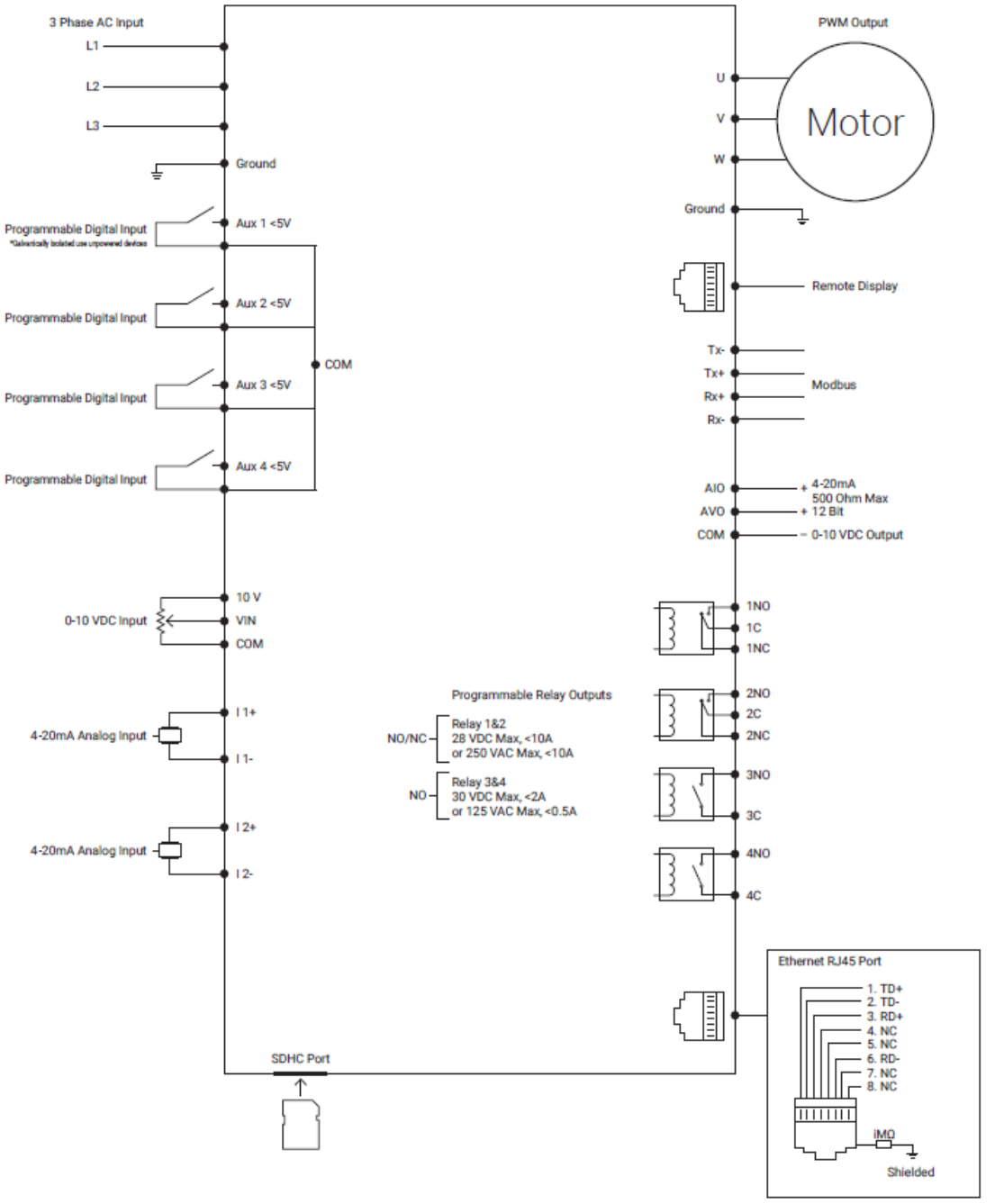


Table 5 – Control Terminal Ratings and Descriptions

Terminal Designator	Description	Rating	Comments
1NO	Normally Open Relay	30 VDC or 277VAC, 10A	Relay controlled by the conditions set in Parameter ***1.3.4 PROGRAM RELAY 1***. See **Table 19** for programming instructions.
1NC	Normally Closed Relay		
1C	Common		Common terminal for ***1NC*** and ***1NO*** terminals. **CAUTION:** Do not use as common for other terminals.
2NO	Normally Open Relay		Relay controlled by the conditions set in Parameter ***1.3.5 PROGRAM RELAY 2***. See **Table 19** for programming instructions.
2NC	Normally Closed Relay		
2C	Common		Common terminal for **2NC** and **2NO** terminals. **CAUTION:** Do not use as common for other terminals.
3NO	Normally Open Relay	30 VDC, 2A or 125VAC, 0.5A	Normally open relay controlled by the conditions set in Parameter ***1.3.6 PROGRAM RELAY 3***. See **Table 19** for programming instructions.
3C	Common		Common terminal for **3NO** terminal. **CAUTION:** Do not use as common for other terminals.
4NO	Normally Open Relay		Normally open relay controlled by the conditions set in Parameter **1.3.7 *PROGRAM RELAY 4***. See **Table 19** for programming instructions.
4C	Common		Common terminal for **4NO** terminal. **CAUTION:** Do not use as common for other terminals.
AUX1	Auxiliary 1	< 5 Volts galvanically isolated	Programmable digital input. Commonly used for RUN/STOP command. See **Table 19** for details.
AUX2	Auxiliary 2		
AUX3	Auxiliary 3		
AUX4	Auxiliary 4		
COM	Common	-	Common for all terminals except programmable relays.
I 1+	4-20 mA Positive	4-20 mA	Analog transducer connection for analog constant pressure or proportional motor speed control from a current source. See **Figure 13** for a connection diagram to control terminals.
I 1–	4-20 mA Negative		
I 2+	4-20 mA Positive		
I 2–	4-20 mA Negative		
10 V	0-10 VDC Output	0-10 VDC	10 VDC supply to provide power to a potentiometer. See **Figure 14** for a connection diagram to control terminals.
VIN	10 VDC		Analog input for motor speed control for 0-10 VDC. Speed is relative to scale of signal from 0 Hz to ***1.1.2 MAXIMUM FREQUENCY*** as set in Adjustable Parameter menu (default 60 Hz). Connect the wiper terminal of a potentiometer to this terminal. See **Figure 14** for a connection diagram.
COM	Common		Common for 0-10 VDC. See **Figure 14** for a connection diagram.
IOUT	4-20 mA Output	500 Ω, 12-bit resolution	4-20 mA analog output. Programmable via ***1.3.47 Analog Output Control***, found under PID Parameters. See **Table 23**.
VOUT	0-10 VDC Output	20 mA	0-10 VDC analog output. Programmable via ***1.3.47 Analog Output Control***, found under PID Parameters. See **Table 23**.
COM	Common	-	Common for analog output signals, ***IOUT*** and ***VOUT***.

4-20 mA Analog Input

Motor speed can be controlled with 4-20 mA analog input through control terminals **I1** and **I2**. A 4-20 mA pressure transducer is also commonly used for constant pressure control through these terminals.

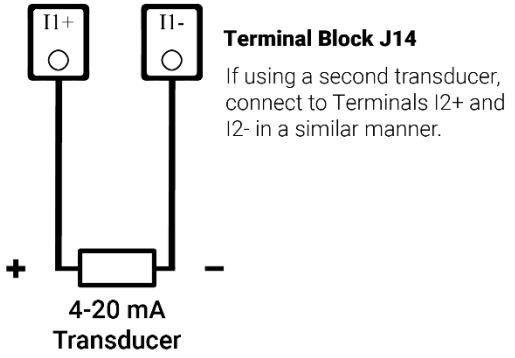
4-20 mA Transducer Connection:

1. Using the keypad, set the value of parameter ***1.3.1 SYSTEM CONFIG*** to 2, 3, 4 or 6 depending on the desired mode of operation. See **Figure 13a**, **Table 19**, and **Section 5.5** for details.
2. Connect the positive lead of the transducer to terminal I1+ or I2+
3. Connect the negative lead of the transducer to terminal I1- or I2-
4. AUX terminals must be closed to run.

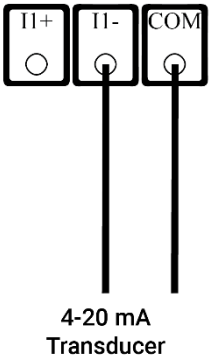
4-20 mA Transducer with External Voltage Source Connection:

1. Using the keypad, set the value of parameter ***1.3.1 SYSTEM CONFIG*** to 2, 3, 4 or 6 depending on the desired mode of operation. See **Figure 13b**, **Table 19**, and **Section 5.5** for details.
2. Connect the positive lead of the transducer to terminal I1- or I2-
3. Connect the negative lead of the transducer to COM
4. AUX terminals must be closed to run.

⚠ **CAUTION**: A 4-20 mA transducer with the parameter ***1.3.1 SYSTEM CONFIG*** set at 6 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 4-20 mA transducer, refer to **Section 6.1** for more information.



a. 4-20 mA Transducer Connection



b. 4-20 mA Transducer with External Voltage Source

Figure 13 – Control Terminal Connection Diagram for 4-20 mA Control

0-10 VDC Analog Input

Motor speed can be controlled with a 0-10 VDC signal through control terminals **VO**, **VIN** and **COM**. When using a speed potentiometer (variable resistor) the drive provides a DC source voltage. Speed control can also be accomplished with an external DC voltage signal.

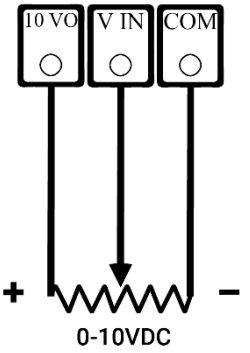
Potentiometer connection:

1. Using the keypad, set the value of parameter ***1.3.1 SYSTEM CONFIG*** to 7. Refer to **Figure 14a** for terminal connection details.
2. Connect the negative lead of the potentiometer to COM
3. Connect the wiper terminal of the potentiometer to VIN
4. Connect the positive lead of the potentiometer to 10V
5. AUX terminals must be closed to run

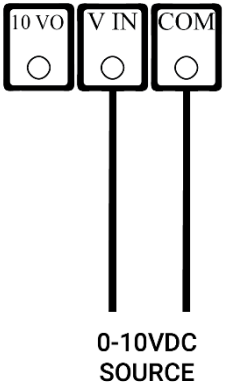
External DC voltage signal:

1. Using the keypad, set the value of parameter ***1.3.1 SYSTEM CONFIG*** to 5. Refer to **Figure 14b** for terminal connection details.
2. Connect negative lead to COM
3. Connect positive lead to VIN

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



a. Potentiometer Connection Diagram



b. External DC Voltage Connection Diagram

Figure 14 – Control Terminal Connection Diagram for 0-10 VDC Control

PID Control with Potentiometer and HOA Switch

The 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 operate in constant pressure mode. Access to the keypad is not required to operate in this mode.

Using the keypad, set parameter ***1.3.1 SYSTEM CONFIG*** to 7. See **Figure 15** and **Table 19** for details.

1. Connect the potentiometer and 4-20 mA transducer.
2. Connect a double pole, triple throw HOA switch to AUX1 and AUX3.
3. Using the keypad, set the drive to operate in AUTO mode by pressing the MANUAL button until the screen shows “AUTO”.
4. AUX2 and AUX4 must be closed to run.

The mechanical HOA switch allows the user to select between OFF, manual speed control with the potentiometer or analog constant pressure. In the H (Hand/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.

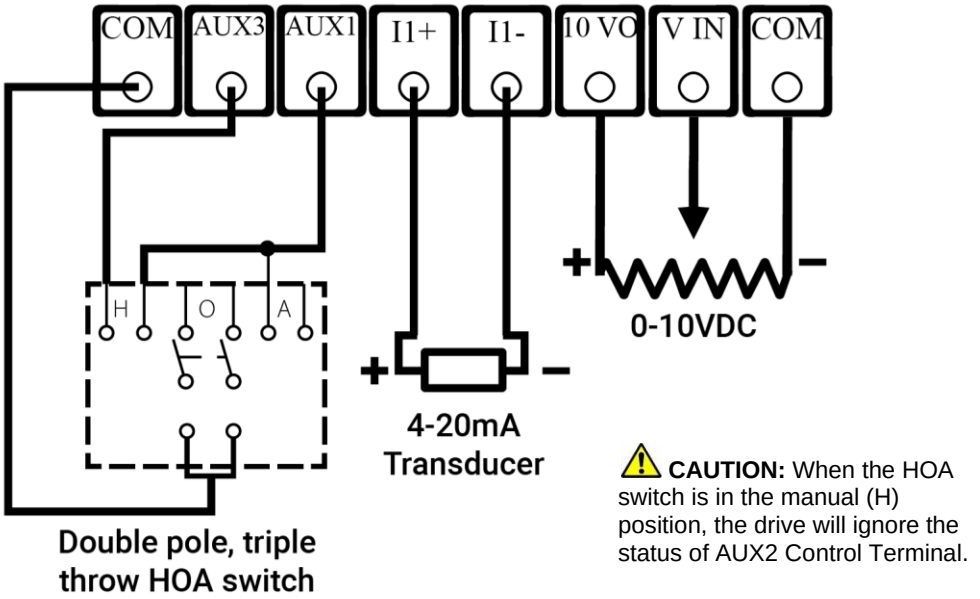


Figure 15 – Connections for PID Control with Potentiometer and HOA Switch

3 KEYPAD & DISPLAY

Before operating the motor load, several basic settings and procedures must be completed. If desired, extensive features for motor protection and special operating conditions are available through the keypad. Before initial power up, it is advisable to become familiar with setting motor overload protection and setting ***1.3.1 SYSTEM CONFIG*** with basic operation of the keypad and display.

3.1 Using the Keypad and Display

DXL and LHX drives are 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, troubleshoot the system, and more. Open and NEMA 1 drives are equipped with an onboard display and keypad, installed on the interface control board.

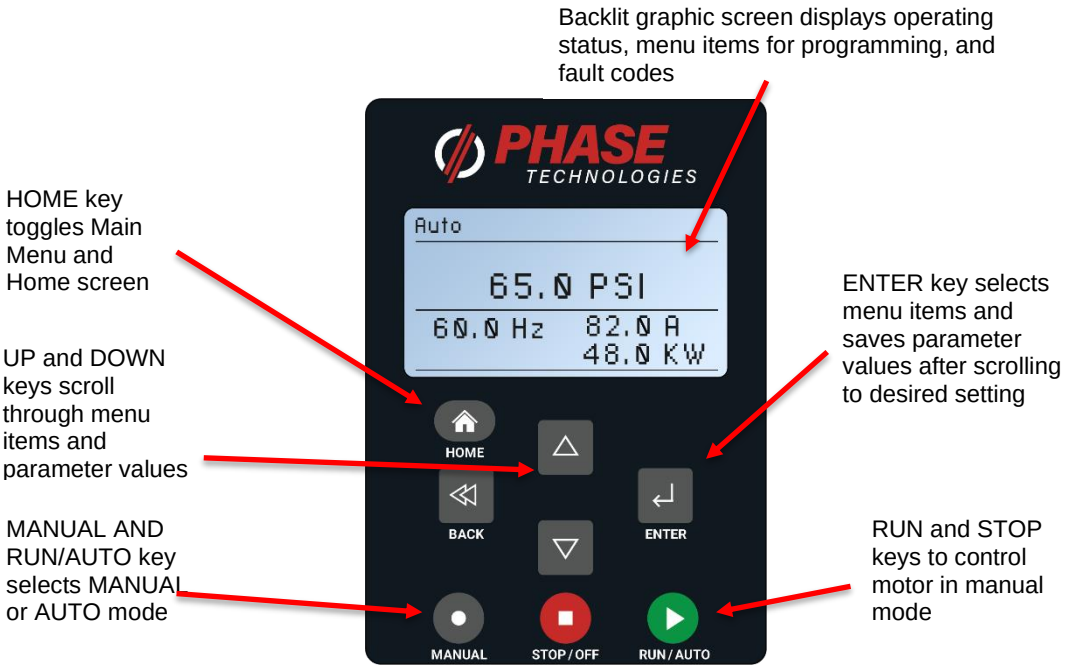


Figure 16 – Keypad and Graphic Display

Remote Display
A remote display kit can be purchased to operate DXL and LHX drives, when installed in a panel or for a more comfortable programming experience. To use a remote display, turn the drive off and connect an RJ45 cable from the drive's control board terminal, "J12 REMOTE DISPLAY," located on the top left of the control board, to the "BLK" terminal on the remote display. When the drive is powered back on, it will recognize the remote display and will automatically connect to it. If this does not happen automatically, turn the drive off, locate the DIP switch array on the control board labeled, "S3," push the DIP switch labeled "RMTEN" to the right, and then power the drive back on. This will force the drive to use the remote display.

Display Modes
After two minutes of keypad inactivity, the display will revert to the default display mode. Information on the display will vary based on the operating mode of the drive. When operating in AUTO mode with the factory default ***1.3.1 SYSTEM CONFIG*** set to 0, the display will indicate output kilowatts (kW), output amps (A), and output frequency (Hz), or will show the status of the AUX1 and AUX2 inputs, if they are not both providing RUN commands.

Password Protecting the Keypad
The keypad can be set up with a password to prevent unauthorized changes in adjustable parameters. The parameter ***1.3.20 PASSWORD SETUP*** (**Table 19**) is used to protect the keypad. When this parameter is set to 0 the keypad is not protected. Contact customer service at 605-343-7934 if you lose or forget the password.

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 6** below.

Table 6 – Display of Operating Modes

MODE	DESCRIPTION
AUTO	The factory default operating mode is OFF. The adjustable parameter, ***1.2.1 ENABLE RESTARTS*****,** must be set to YES to allow automatic re-starts. See **Table** 16 for details. ⚠ **CAUTION**: In AUTO mode, the motor load will automatically run if both AUX1 and AUX2 remote switches are open. Close AUX1 or AUX2 to stop the motor or push STOP/OFF key. ⚠ **CAUTION**: **By default, AUX1 and AUX2 are programmed to run when open.** See ***1.3.8 AUX1 SELECT*** and ***1.3.19 AUX2 SELECT*** to change this setting.
MANUAL	Activate MANUAL mode by pushing the MANUAL key until ***MANUAL*** appears on top left of the display. In MANUAL mode the motor load is controlled by using the RUN and STOP keys, which will override all external control signals. Manual control of the drive through the keypad can be disabled through the parameter ***1.3.3 DISABLE MANUAL MODE***. See **Table 19**, for details. ⚠ **CAUTION**: Operating the system in MANUAL mode on the keypad overrides signals from all external controls, including pressures switches. Operating the system in this mode may lead to dangerous operating conditions such as extreme pressure in closed plumbing systems.
OFF	The factory default operating mode is OFF. The adjustable parameter, ***1.2.1 ENABLE RESTARTS***, must be set to YES to allow automatic re-starts. To exit AUTO mode, press the STOP/OFF key. If the motor is running, it will stop. To restart the motor, revert to either AUTO mode or MANUAL mode. Certain faults can also be cleared by pressing and holding both the UP and DOWN arrow keys for one second.

3.2 Keypad Main Menu Items

The HOME key toggles between the Home screen (operating status screen) and the Main Menu items. Use the UP and DOWN arrows to scroll through the Main Menu items. Press ENTER to view or edit a Main Menu item. **Table 7** contains a brief description of Main Menu items, followed by in-depth instructions on the use and function of each Main Menu item.

Table 7 – Main Menu Items

DISPLAY MESSAGE	DESCRIPTION
1 CHANGE PARAMETER VALUES	Allows the user to set values for functions such as motor overload settings, under current, time to restart after a fault, etc.
3 READ MEASURED VALUES (RMV)	Displays measured values such as output current, input voltage, load power factor, etc.
4 READ TIMERS	Records motor run time and drive on time.
5 RESTART LOG	A resettable fault log that records the number of times a particular fault has occurred. The number of faults counted in this log can be cleared through the CLEAR MEMORY menu.
6 FAULT LOG	Records the number of times a particular fault has occurred and records the time and date of the 20 most recent faults. FAULT LOG cannot be reset by the user.
7 CLEAR MEMORY	This function clears the Restart Log and Timers. All fault counters in the Restart Log will be reset to zero. If any number of automatic restarts have been allowed through parameters in the Auto Restart Parameters (See **Table 18**), the counter on these faults will be reset to zero.
9 SETUP WIZARD	This allows the user to quickly set up common control schemes: Constant Pressure Control, Flow Control, Tank Level Control, Pump Down Control, Suction Pump Control, and HVAC Control. Using these wizards will allow adequate control of most systems, but if additional fine-tuning is needed, see lists of adjustable parameters in **Section 3.9**.
11 ALARMS	A resettable log that records the number of times alarms occur. This is also where different operating conditions can be programmed to trigger a Fault or an Alarm.
12 FILE SYSTEM	Opens the SD card menu for importing and exporting settings or reprogramming firmware.

3.3 Change Parameter Values

The Main Menu item, ***1 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 customized operation of the drive to fit the specific application.

Section 4 contains a complete list of the parameters along with a description of their function and instructions on setting them.

3.4 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 HOME key to access Main Menu items, and then scroll with arrow keys until ***3 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.

Table 8 – Measured Values

DISPLAY MESSAGE	DESCRIPTION OF MEASURED VALUE
3.1 Iu Iv Iw	Three-phase output currents, measured in Amps (A)
3.2 OUTPUT HP	Output measured in horsepower (HP)
3.3 OUTPUT kW	Output measured in kilowatts (kW)
3.4 OUTPUT kVA	Output measured in kilovolt amperes (kVA)
3.5 OUTPUT PF	Power factor of the motor load
3.6 FREQUENCY	Output frequency in Hertz (Hz)
3.11 BUS CAP VOLTAGE	Voltage of the DC bus, measured in Volts DC (VDC)
3.12 INPUT VOLTAGE	Input voltage, measured in Volts AC (VAC)
3.13 I1, I2, I3 In	Input current measured in Amps (LHX systems only)
3.18 MODEL NUMBER	Indicates model number of the product and the firmware version of the Interface and Driver digital signal processors (DSP).
3.19 AUX1 AUX2	ON/OFF status of the remote switch circuits AUX1 and AUX2
3.20 AUX3 AUX4	ON/OFF status of the remote switch circuits AUX3 and AUX4
3.21 10VDC INPUT	Measures the 0-10 VDC analog control voltage between Control Terminals for 0-10 VDC input.
3.22 4-20 mA Input, I1, I2	Measures 4-20 mA analog control current on I1 and I2Control Terminals for analog current input.
3.23 MOTOR RPM	Displays the current RPM of the fan load. Parameter ***1.1.28 MOTOR RPM*** must be programmed for this to display a reading.

DISPLAY MESSAGE	DESCRIPTION OF MEASURED VALUE
3.24 IGBT CASE TEMP	Insulated-gate bipolar transistor (IGBT) case temperature in degrees Celsius.
3.25 STARTUP DELAY	Displays a timer that counts down the time left to start when the drive is in a time delay due to a fault condition.
3.26 REAL-TIME CLOCK	Date/Time
3.27 RUN TIMER	Time until next restart if drive is waiting for a timer to expire.
3.28 CONNECTION STRENGTH	DSP communication strength. If below, 100%, check Control Board connections and/or improve grounding. Only visible when ***1.3.29 TROUBLESHOOTING*** is set to "2".
3.29 INT BOOT FIRMWARE CRC	The boot loader version internal to the Interface DSP.
3.30 DRV BOOT FIRMWARE CRC	The boot loader version internal to the Driver DSP.

3.5 Read Timers

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

1. Press MENU to scroll through menu items until **4 READ 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.

Table 9 – Timers

TIMER	DESCRIPTION
4.1 Motor Run Time	Logs motor run time in hours.
4.2 Drive On Time	Logs time in hours the drive is energized
4.3 All Motor Hours	Logs total motor run time. Not resettable.
4.4 All Drive Hours	Logs total time the drive is energized. Not resettable.
4.5 Cycle Counters (Updated Weekly)	Logs the number of times the load has started in total, in the last year, and in the last month. Counts update once per week.
4.6 Cycle Counters (Updated Daily)	Logs the number of times the load has started in the last week, the previous day, and the current day. Counts update once per day.

Programming Tip

To reset the timers, navigate to the Main Menu item, **7 CLEAR MEMORY**, use arrow keys to select ***RESET TIMERS***, and then press ENTER

3.6 Restart Log

The Restart Log records the number of times each fault has occurred. The faults counters in the Restart Log are resettable and are tied to faults that allow programmable automatic restarts. These automatic restarts are

programmed through ***1.2 AUTO RESTART PARAMETERS***, which is a sub-menu of the Main Menu item ***1 CHANGE PARAMETER VALUES***.

For instance, in a water well pump application, it might be useful to protect the pump from dry well condition by setting the ***1.1.10 UNDER CURRENT*** parameter (found in the ***1.1 OPERATING PARAMETERS*** menu) so that the drive shuts down and registers a ***1.1.10 UNDER CURRENT*** fault in the Restart Log.

The drive can also be programmed to automatically restart after a delay to allow the well to recover. Both the delay time and number of restarts can be programmed in ***1.2 AUTO RESTART PARAMETERS***. The Restart Log allows the user to monitor the type and number of faults that have occurred. If the number of ***1.1.10 UNDER CURRENT*** faults exceeds the number of automatic restarts allowed, the drive will remain OFF until power is cycled off and back on.

To view the Restart Log:

1. Press the HOME key, then use the UP and DOWN arrows to scroll through menu items until ***5 RESTART LOG*** appears on the display.
2. Press ENTER to access this menu item.
3. Use the UP and DOWN arrows to scroll through the faults.
4. The fault will appear on the first row of the display, followed by the number of times that fault has occurred.

To clear the Restart Log and reset all Auto Restart fault counters:

1. Press the HOME key, then use the UP and DOWN arrows to scroll through the Main Menu items until ***7 CLEAR MEMORY*** appears on the display.
2. Press ENTER.
3. Use the UP and DOWN arrows to find ***7.1 CLEAR RESTART LOG***.
4. Press ENTER to clear the Restart Log and reset all Auto Restart fault counters.

CAUTION: Clearing the Restart Log through the ***7 CLEAR MEMORY*** menu will clear ALL faults in the Restart Log and all fault counters in the will be reset to zero.

When the drive has faulted and is programmed to automatically restart after a time delay, the display will count down the remaining time to start. Press and hold both the UP and DOWN arrows for one second to interrupt the countdown and start the motor.

If the drive has faulted and no auto restart is allowed, the display will indicate the type of fault that has occurred on the top line and the second line will read ***RESTART? ENTER***. Press ENTER to clear the fault and restart the load.

The number and type of faults are also recorded in the Fault Log. In this Log each fault is recorded with a time and date stamp (up to the most recent 20 faults). The Fault Log is permanent and cannot be cleared. See the following section for more information on the Fault Log.

3.7 Fault Log

The Fault Log is a permanent record of drive faults. The number of faults cannot be reset by the user. Faults will be stamped with the time and date the fault occurred, up to a total of 20 times for each fault. After the 20th fault, the oldest time-stamped fault will be replaced with the most recent.

The Fault Log is a Main Menu item. Press the HOME key, then use the arrow keys to scroll until ***6 FAULT LOG*** appears. Press ENTER to view the list of faults, using the arrow keys to scroll through the list.

Programming Tip

A maximum of 20 time and date stamps can be applied to any given fault. After the 20th fault, the oldest fault time stamp will be erased and replaced by the most recent. The drive will continue to count faults up to a maximum of 9,999 for each individual fault.

3.8 Clear Memory

The ***7 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 Restart Log which counts the number of each fault.

1. Press HOME, then use the arrow keys to scroll until ***7 CLEAR MEMORY*** appears on the display.
2. Press ENTER to enter this menu item.
3. Use the UP and DOWN arrows to find either ***7.1 CLEAR RESTART LOG*** or ***7.2 RESET TIMERS***.
4. Press ENTER to reset the selected function.

3.9 Setup Wizards

The Setup Wizard selection will be shown upon the first initialization of the VFD and can be accessed through the keypad at any time by scrolling through the Main Menu Items to the ***9 SETUP WIZARD*** menu.

Setup Wizards allows users to quickly setup commonly used control schemes. See the following tables for Setup Wizard walkthrough:

9.1 Constant Pressure Control (**Table 10**)
9.2 Flow Control (**Table 11**)
9.3 Tank Level Control (**Table 12**)
9.4 Pump Down Setup (**Table 13**)
9.5 Suction Pump Setup (**Table 14**)
9.6 HVAC Setup (**Table 15**)

The wizards will guide users through a list of commonly used parameters for the control method selected. Using these wizards will allow adequate control of most systems, but if additional fine-tuning is needed, see lists of adjustable parameters in **Section 4**.

Table 10 – 9.1 Constant Pressure Control Wizard

PROMPT	DESCRIPTION
Run Constant Pressure Wizard?	Press the "**Enter**" key to go through the wizard. Press "**Home**" key to return to Home screen.
Max Analog Sensor Range	This is the maximum value of the psi sensor being used. Phase Technologies sensors have a maximum value of 150 psi.
Analog Setpoint 1	The pressure, in psi, that the drive will attempt to maintain.
Submersible Pump	**ENABLE THIS FEATURE WITH SUBMERSIBLE PUMPS.** Frequency will ramp from stop to the value set by parameter ***1.1.1 MIN FREQUENCY*** in one second. Submersible pumps suffer damage to the thrust bearing if operated below 30 Hz for more than 1 second.
Disable Manual Mode	Disables manual operation of the drive through the keypad.
Overcurrent Limit	Setting for motor overload protection, Trip Class 10 curve.

Table 11 – 9.2 Flow Control Wizard

PROMPT	DESCRIPTION
Run Flow Control Wizard?	Press the “Enter” key to go through the wizard. Press “Home” key to return to Home screen.
Max Analog Sensor Range	This is the maximum value of the GPM sensor being used.
Analog Setpoint 1	The flow, in Gallons Per Minute (GPM), that the drive will attempt to maintain.
Force Sleep Threshold	This value is added to the value ***1.4.1 ANALOG SETPOINT 1***. The combined flow is the value the drive will stop the motor load at and enter sleep mode.
Wake Up Threshold	This value is subtracted from ***1.4.1 ANALOG SETPOINT 1*** and is the flow when the VFD will start the motor load again.
Sleep Frequency	In Hz. This parameter value is added to the frequency set by the parameter ***1.1.1 MINIMUM FREQUENCY***. The combined value is the frequency at which drive will enter sleep mode when GPM is controlled at the set point.
Submersible Pump	**ENABLE THIS FEATURE WITH SUMBERSIBLE PUMPS.** Frequency will ramp from stop to the value set by parameter ***1.1.1 MIN FREQUENCY*** in one second. Submersible pumps suffer damage to the thrust bearing if operated below 30 Hz for more than 1 second.
Disable Manual Mode	Disables manual operation of the drive through the keypad.
Overcurrent Limit	Setting for motor overload protection, Trip Class 10 curve.

Table 12 – 9.3 Tank Level Control Wizard

PROMPT	DESCRIPTION
Run Tank Level Control Wizard?	Press the “Enter” key to go through the wizard. Press “Home” key to return to Home screen.
Max Analog Sensor Range	This is the maximum value of the sensor being used.
Analog Setpoint 1	The height, in feet, that the drive will attempt to maintain.
Force Sleep Threshold	This value is added to the value ***1.4.1 ANALOG SETPOINT 1***. The combined height is the value the drive will stop the motor load at and enter sleep mode.
Wake Up Threshold	This value is subtracted from ***1.4.1 ANALOG SETPOINT 1*** and is the height when the VFD will start the motor load again.
Sleep Frequency	In Hz. This parameter value is added to the frequency set by the parameter ***1.1.1 MIN FREQUENCY***. The combined value is the frequency at which drive will enter sleep mode when level is controlled at the set point.
Submersible Pump	**ENABLE THIS FEATURE WITH SUMBERSIBLE PUMPS.** Frequency will ramp from stop to the value set by parameter ***1.1.1 MIN FREQUENCY*** in one second. Submersible pumps suffer damage to the thrust bearing if operated below 30 Hz for more than 1 second.
Overcurrent Limit	Disables manual operation of the drive through the keypad.
Sleep Frequency	Setting for motor overload protection, Trip Class 10 curve.

Table 13 – 9.4 Pump Down Setup Wizard

PROMPT	DESCRIPTION
Run Pump Down Setup Wizard?	Press the “Enter” key to go through the wizard. Press “Home” key to return to Home screen.
Max Analog Sensor Range	This is the maximum value of the sensor being used.
Analog Setpoint 1	The height, in feet, that the drive will attempt to maintain.
Force Sleep Threshold	This value is subtracted from the value ***1.4.1 ANALOG SETPOINT 1***. The resulting height is the value when the drive will stop the motor load at and enter sleep mode.
Wake Up Threshold	This value is added to ***1.4.1 ANALOG SETPOINT 1.*** The combined value is the height when the VFD will start the motor load again.

Sleep Frequency	In Hz. This parameter value is added to the frequency set by the parameter ***1.1.1 MIN FREQUENCY***. The combined value is the frequency at which drive will enter sleep mode when level is controlled at the set point.
Submersible Pump	**ENABLE THIS FEATURE WITH SUMBERSIBLE PUMPS.** Frequency will ramp from stop to the value set by parameter ***1.1.1 MIN FREQUENCY*** in one second. Submersible pumps suffer damage to the thrust bearing if operated below 30 Hz for more than 1 second.
Overcurrent Limit	Disables manual operation of the drive through the keypad.
Sleep Frequency	Setting for motor overload protection, Trip Class 10 curve.

Table 14 – 9.5 Suction Pump Setup Wizard

PROMPT	DESCRIPTION
Run Suction Pump Setup Wizard?	Press the “Enter” key to go through the wizard. Press “Home” key to return to Home screen.
Max Analog Sensor Range	This value should be set to the maximum value of the 4-20 mA transducer being used for suction pressure control. i.e. if the transducer has a range of 0-150 psi, the parameter should be set to 150.
Analog Setpoint 1	In psi. Used only for transducers wired to 1_2. The pressure setting where any value lower will trigger a fault.
Low Pressure Fault Level	In psi. This is the inlet pressure that will signify a loss of suction pressure and trigger a fault.
Suction Pressure Time	In seconds. The time at which the pressure must remain below ***1.4.40 Low Pressure Fault Level*** before triggering a fault.
Submersible Pump	**ENABLE THIS FEATURE WITH SUMBERSIBLE PUMPS.** Frequency will ramp from stop to the value set by parameter ***1.1.1 MIN FREQUENCY*** in one second. Submersible pumps suffer damage to the thrust bearing if operated below 30 Hz for more than 1 second.
Disable Manual Mode	Disables manual operation of the drive through the keypad.
Overcurrent Limit	Setting for motor overload protection, Trip Class 10 curve.

Table 15 – 9.6 HVAC Setup Wizard

PROMPT	DESCRIPTION
Run HVAC Setup Wizard?	Press the “Enter” key to go through the wizard. Press “Home” key to return to Home screen.
Speed Reference	Select whether the speed reference will be a 4-20 mA signal or a 0-10 VDC signal.
Min Frequency	In Hz. The lowest frequency the drive will operate the load at. If submersible pump is chosen, the drive will ramp from stop to the value set by parameter ***1.1.1 MIN FREQUENCY*** in one second.
Max Frequency	In Hz. The maximum frequency that the drive will operate the load at.
Disable Manual Mode	Disables manual operation of the drive through the keypad.
Overcurrent Limit	Setting for motor overload protection, Trip Class 10 curve.
Motor RPM	Set the nameplate RPM rating of the motor.

4 ADJUSTABLE PARAMETERS

4.1 Changing Parameter Values

⚠ **WARNING**: When the drive is set to automatically restart after a fault, the 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 before approaching the equipment.

The ***1 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, and more. To change parameter values:

1. Press the HOME key until ***1 CHANGE PARAMETER VALUES*** appears on the display.
2. Press ENTER to access this menu item.
3. Use the UP and DOWN arrows to scroll through the sub-menu to find the item desired, then press ENTER. See **Table 17** through **Table 24** for a list of parameters.
4. Use the UP and DOWN arrow keys to scroll to the desired parameter, press ENTER, then use the UP and DOWN arrows to change the value.
5. When the value you want appears on the display, press ENTER to set the value or BACK to cancel.

4.2 Restore Default Parameter Settings

⚠ **CAUTION**: The drive output must be stopped before resetting. Failure to do so may result in damage to the drive or equipment.

To restore **ALL** adjustable parameters (except for ***1.1.14 REVERSE ROTATION***, ***1.3.20 PASSWORD SETUP***, ***1.1.16 SWITCHING FREQUENCY,*** and ***1.3.19 ENABLE 1PH INPUT***) to their default value, press and hold the BACK and ENTER keys at once and hold for three seconds. If a password is configured, you will be prompted to enter the password first. You will then be prompted to press ENTER for yes or BACK for no.

⚠ **CAUTION**: 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 **Section 4** for a complete list of parameters, their description, and default/minimum/maximum values.

4.3 Auto Restarts

The drive can be programmed to automatically restart after certain faults. Using the ***1.2 AUTO RESTART PARAMETERS*** (**Table 18**), 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.

> *Example*: You wish to allow 10 automatic restarts after a fault but want the drive to wait 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 and DOWN keys for one second. The load will start immediately.

When the drive reaches the limit of faults set by the adjustable parameter, it will remain OFF and the display will indicate the type of fault on the top line. The second line will read ***RESTART? ENTER***. Press ENTER to clear the fault and restart the load. The fault counters in the ***5 Restart Log*** will all be reset to zero. See **Section 3.6** for more information. Some faults do not allow auto restart. The display will read ***NO AUTO RESTART***. See **Section 3.7**, **Fault Log**, for more information.

4.4 All Parameters List

To aid in troubleshooting, a numbered parameter list containing all parameters is available for use. Some parameters are visible that are not always used. In this case, the word “Disabled” is shown, and programming functionality is disabled for that parameter. To access ***1.7 ALL PARAMETERS***:

1. Press the HOME key to access Main Menu items, and then scroll with arrow keys until ***1 CHANGE PARAMETER VALUES*** appears on the display.
2. Press ENTER to access this menu item.
3. Use the UP and DOWN arrow keys to scroll to ***1.7 ALL PARAMETERS***.
4. Press ENTER to access this menu item.

4.5 Changed Parameter List

This is a list of all parameters that have been changed from their default values. This allows for quick and easy programming of previously changed parameter values. The total number of changed parameters and the index of changed parameters will be displayed at the top of the screen. If there are no changed parameters, then “No Changed Parameters” will be shown. To access

1. Press the HOME key to access Main Menu items, and then scroll with arrow keys until ***1 CHANGE PARAMETER VALUES*** appears on the display.
2. Press ENTER to access this menu item.
3. Use the UP and DOWN arrow keys to scroll to ***1.8 CHANGED PARAMETERS***.
4. Press ENTER to access this menu item.

4.6 File System

DXL and LHX Series products are equipped with an SD card terminal that can be used to Import and Export Parameters as well as install firmware upgrades or custom firmware. SD cards must be Micro SD or SDHC type, 32 GB or smaller, and formatted as FAT16 or FAT32. Firmware files will be .hex format and parameter data files will be saved as a .CSV file.

⚠ **CAUTION**: SD card must be inserted while drive is **powered off**. Failure to do so may result in injury or damage to the product. Power may be applied while SD card is inserted, but the system must be powered off before removing the SD card from the terminal. Always turn power to the system off and wait for the discharge time specified on the front label to allow the DC bus to discharge before working in the enclosure.

With the drive powered off, locate the SD card terminal on the control board. **Figure 17** below shows the SD card terminal on a DXL and LHX control board. Insert the SD card into the terminal, replace the enclosure cover, and apply power to the drive.

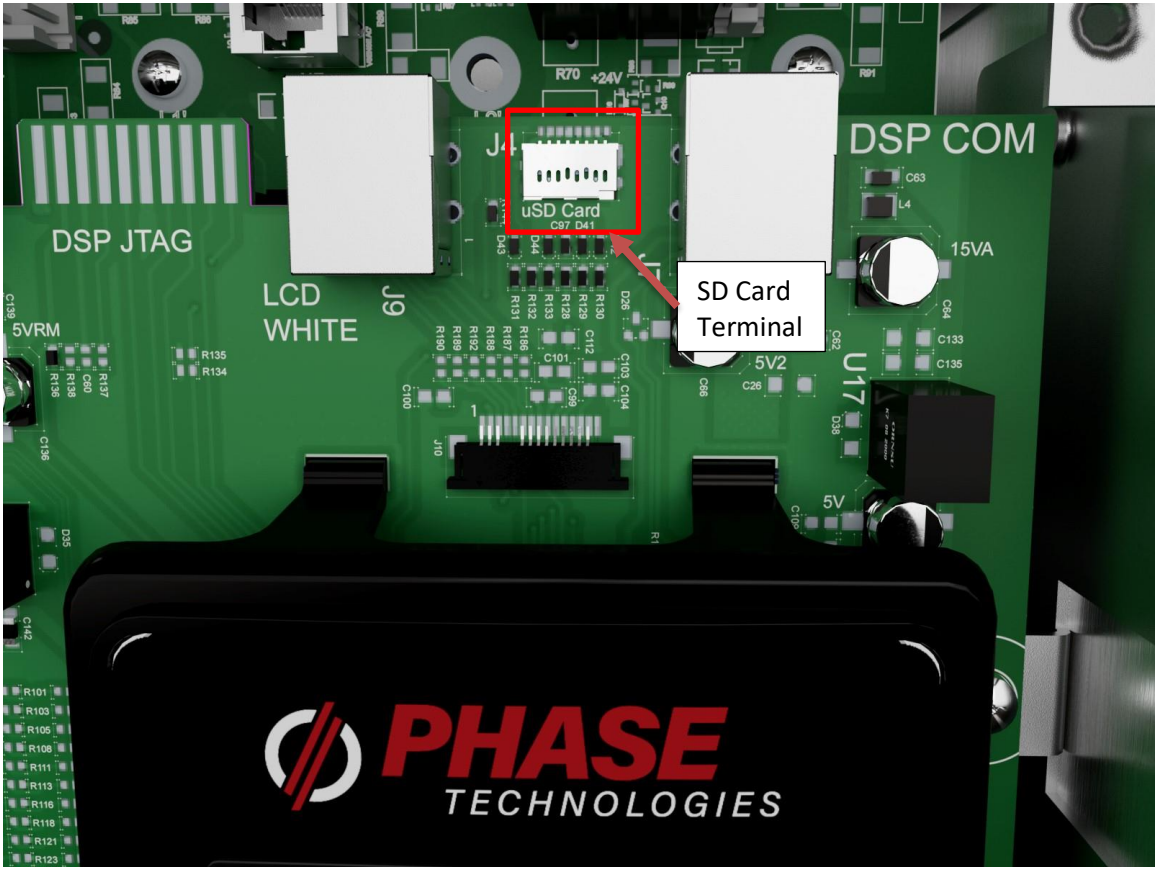


Figure 17 – SD Card Terminal on DXL and LHX Control Board

Export Parameter Data

1. From the HOME screen, press ENTER, then scroll down to ***12 FILE SYSTEM*** and press **ENTER**.
2. Use the up and down arrows to select ***12.1 EXPORT PARAMETER DATA*** on the display and press **ENTER**.
3. Parameter data will be exported to a .CSV file on the SD card. If the export was successful, the display will show **EXPORT SUCCESSFUL**. If the screen shows **EXPORT UNSUCCESSFUL**, cycle power and retry steps 1 – 3.
4. The file can now be used to import parameters to another VFD. The file can also be opened on a personal computer using an SD Card Reader to view and troubleshoot parameter settings.

The file format of the parameter data will be a .CSV file, which can be opened by Microsoft Excel. **Table 16** below shows the format of the exported parameter data. Information about the drive model and the export date will be shown in the top left. Next, Adjustable Parameters will be listed, along with their current, default, minimum, and maximum values. A column on the far right will denote whether the parameter has been changed or if it remains at the default setting.

Table 16 – Exported Parameter Data

Model Info: 3PH LH420 SW 12.0.1.0					
Drive Family: LHDX					
Firmware Family: Production					
Date/Time: 25/20/2064 33:83:24					
Boot Firmware: 01.00					
Boot CRC: 0xB63E5EFF					
All Parameters					
Name	Current	Default	Minimum	Maximum	Changed
Output Voltage	480	480	200	530	
Overcurrent Limit	30	30	3	32	
Dry Well Current	0	0	0	30	
Current Unbalance	80	80	1	100	
Min Frequency	33	30	5	120	Yes
Restart Delay	60	60	0	9999	

Measured Parameters will be the next set of data shown. These are values measured at the time of data export. Continuing down, Changed Parameters will be shown followed by the number of times the control board has been reprogrammed via SD card and a software version history. Last, the Fault Log will show any stored faults and their associated date and time stamp.

Import Parameter Data

The exported Parameter Data files can be used to apply the same parameters to other drives. This will exclude any parameters that are model-specific, such as ***1.1.9 OVERCURRENT LIMIT***. To export parameter data:

1. From the HOME screen, press ENTER, then scroll down to ***12 FILE SYSTEM*** and press **ENTER**.
2. Use the up and down arrows to select ***12.2 IMPORT PARAMETER DATA*** on the display and press **ENTER**.
3. Next, select whether you want to import Model-specific data, which includes **Overcurrent Limit, Under Current Limit, Switching Frequency, Motor Rated HP**, and **Motor Rated Current**.
4. Use the Up and Down arrows to select the file of parameters to be applied and press **ENTER**.
5. If the parameter import is successful, the display will show **IMPORT SUCCESSFUL**. If the screen displays **IMPORT UNSUCCESSFUL**, cycle power and retry steps 1 – 5.

Reprogram Firmware

If needed, the SD card terminal can be used to reprogram the firmware of the VFD for software upgrades or custom features. DXL and LHX drives have two Digital Signal Processors (DSPs) that contain the firmware to control the system which will both require reprogramming. Firmware files will have a suffix of “DRV” for Drive Control or “INT” for Interface Control.

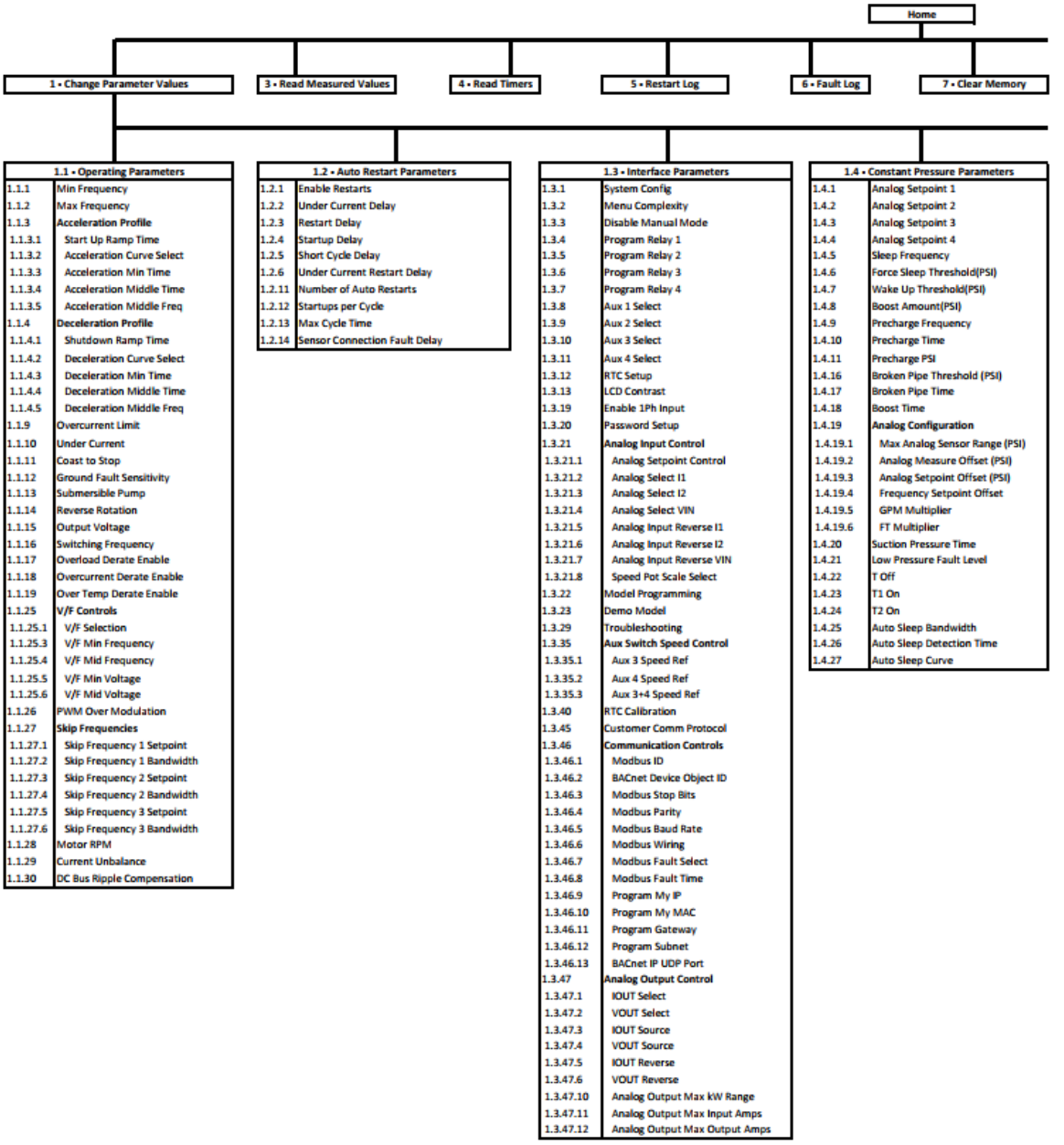
The firmware version of Phase Technologies drives can be found by pressing **ENTER** on the home screen and then scrolling up or down to ***3 READ MEASURED VALUES*** and pressing **ENTER**. Under ***3 READ MEASURED VALUES***, there will be a heading called ***3.18 MODEL NUMBER***, which will show the VFD model and current firmware versions

To reprogram a DXL or LHX:

1. From the HOME screen, press ENTER, then scroll down to ***12 FILE SYSTEM*** and press **ENTER**.
2. Use the up and down arrows to select ***12.3 REPROGRAM FIRMWARE*** on the display and press **ENTER**.
3. Use the up and down arrows to select the “DRV” firmware file for reprogramming and press **ENTER**.
4. If the file chosen contains the proper firmware for the VFD model, reprogramming will begin. Reprogramming firmware will take several minutes. If the LEDs, labeled TX and RX, on the INTF board are flashing, that means that the reprogramming process is underway.
5. If the reprogram is successful, the display will show ***SUCCESSFUL, PRESS ENTER TO RESET***.
6. If the display shows **UNSUCCESSFUL**, cycle power and retry steps 1 – 5.
7. Press **ENTER** and the drive will reboot with the new software version.
8. Repeat the steps above, this time choosing the “INFT” firmware file.

The firmware versions for both “DRV” and “INTF” can be verified by going to ***3 READ MEASURED VALUES***.

4.7 Menu Structure Overview

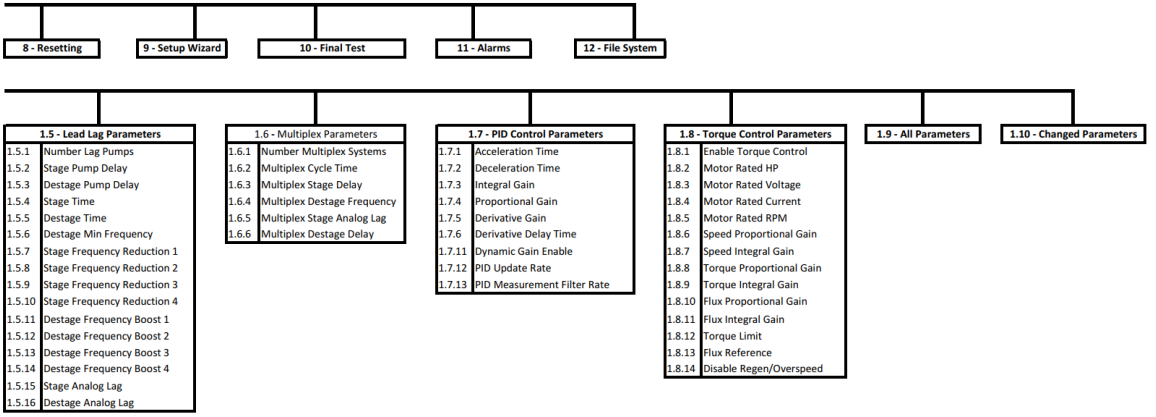


1.1 • Operating Parameters	
1.1.1	Min Frequency
1.1.2	Max Frequency
1.1.3	**Acceleration Profile**
1.1.3.1	Start Up Ramp Time
1.1.3.2	Acceleration Curve Select
1.1.3.3	Acceleration Min Time
1.1.3.4	Acceleration Middle Time
1.1.3.5	Acceleration Middle Freq
1.1.4	**Deceleration Profile**
1.1.4.1	Shutdown Ramp Time
1.1.4.2	Deceleration Curve Select
1.1.4.3	Deceleration Min Time
1.1.4.4	Deceleration Middle Time
1.1.4.5	Deceleration Middle Freq
1.1.9	Overcurrent Limit
1.1.10	Under Current
1.1.11	Coast to Stop
1.1.12	Ground Fault Sensitivity
1.1.13	Submersible Pump
1.1.14	Reverse Rotation
1.1.15	Output Voltage
1.1.16	Switching Frequency
1.1.17	Overload Derate Enable
1.1.18	Overcurrent Derate Enable
1.1.19	Over Temp Derate Enable
1.1.25	**V/F Controls**
1.1.25.1	V/F Selection
1.1.25.3	V/F Min Frequency
1.1.25.4	V/F Mid Frequency
1.1.25.5	V/F Min Voltage
1.1.25.6	V/F Mid Voltage
1.1.26	PWM Over Modulation
1.1.27	**Skip Frequencies**
1.1.27.1	Skip Frequency 1 Setpoint
1.1.27.2	Skip Frequency 1 Bandwidth
1.1.27.3	Skip Frequency 2 Setpoint
1.1.27.4	Skip Frequency 2 Bandwidth
1.1.27.5	Skip Frequency 3 Setpoint
1.1.27.6	Skip Frequency 3 Bandwidth
1.1.28	Motor RPM
1.1.29	Current Unbalance
1.1.30	DC Bus Ripple Compensation

1.2 • Auto Restart Parameters	
1.2.1	Enable Restarts
1.2.2	Under Current Delay
1.2.3	Restart Delay
1.2.4	Startup Delay
1.2.5	Short Cycle Delay
1.2.6	Under Current Restart Delay
1.2.11	Number of Auto Restarts
1.2.12	Startups per Cycle
1.2.13	Max Cycle Time
1.2.14	Sensor Connection Fault Delay

1.3 • Interface Parameters	
1.3.1	System Config
1.3.2	Menu Complexity
1.3.3	Disable Manual Mode
1.3.4	Program Relay 1
1.3.5	Program Relay 2
1.3.6	Program Relay 3
1.3.7	Program Relay 4
1.3.8	Aux 1 Select
1.3.9	Aux 2 Select
1.3.10	Aux 3 Select
1.3.11	Aux 4 Select
1.3.12	RTC Setup
1.3.13	LCD Contrast
1.3.19	Enable 1Ph Input
1.3.20	Password Setup
1.3.21	**Analog Input Control**
1.3.21.1	Analog Setpoint Control
1.3.21.2	Analog Select I1
1.3.21.3	Analog Select I2
1.3.21.4	Analog Select VIN
1.3.21.5	Analog Input Reverse I1
1.3.21.6	Analog Input Reverse I2
1.3.21.7	Analog Input Reverse VIN
1.3.21.8	Speed Pot Scale Select
1.3.22	Model Programming
1.3.23	Demo Model
1.3.29	Troubleshooting
1.3.35	**Aux Switch Speed Control**
1.3.35.1	Aux 3 Speed Ref
1.3.35.2	Aux 4 Speed Ref
1.3.35.3	Aux 3+4 Speed Ref
1.3.40	RTC Calibration
1.3.45	Customer Comm Protocol
1.3.46	**Communication Controls**
1.3.46.1	Modbus ID
1.3.46.2	BACnet Device Object ID
1.3.46.3	Modbus Stop Bits
1.3.46.4	Modbus Parity
1.3.46.5	Modbus Baud Rate
1.3.46.6	Modbus Wiring
1.3.46.7	Modbus Fault Select
1.3.46.8	Modbus Fault Time
1.3.46.9	Program My IP
1.3.46.10	Program My MAC
1.3.46.11	Program Gateway
1.3.46.12	Program Subnet
1.3.46.13	BACnet IP UDP Port
1.3.47	**Analog Output Control**
1.3.47.1	IOUT Select
1.3.47.2	VOUT Select
1.3.47.3	IOUT Source
1.3.47.4	VOUT Source
1.3.47.5	IOUT Reverse
1.3.47.6	VOUT Reverse
1.3.47.10	Analog Output Max kW Range
1.3.47.11	Analog Output Max Input Amps
1.3.47.12	Analog Output Max Output Amps

1.4 • Constant Pressure Parameters	
1.4.1	Analog Setpoint 1
1.4.2	Analog Setpoint 2
1.4.3	Analog Setpoint 3
1.4.4	Analog Setpoint 4
1.4.5	Sleep Frequency
1.4.6	Force Sleep Threshold(PSI)
1.4.7	Wake Up Threshold(PSI)
1.4.8	Boost Amount(PSI)
1.4.9	Precharge Frequency
1.4.10	Precharge Time
1.4.11	Precharge PSI
1.4.16	Broken Pipe Threshold (PSI)
1.4.17	Broken Pipe Time
1.4.18	Boost Time
1.4.19	**Analog Configuration**
1.4.19.1	Max Analog Sensor Range (PSI)
1.4.19.2	Analog Measure Offset (PSI)
1.4.19.3	Analog Setpoint Offset (PSI)
1.4.19.4	Frequency Setpoint Offset
1.4.19.5	GPM Multiplier
1.4.19.6	FT Multiplier
1.4.20	Suction Pressure Time
1.4.21	Low Pressure Fault Level
1.4.22	T Off
1.4.23	T1 On
1.4.24	T2 On
1.4.25	Auto Sleep Bandwidth
1.4.26	Auto Sleep Detection Time
1.4.27	Auto Sleep Curve

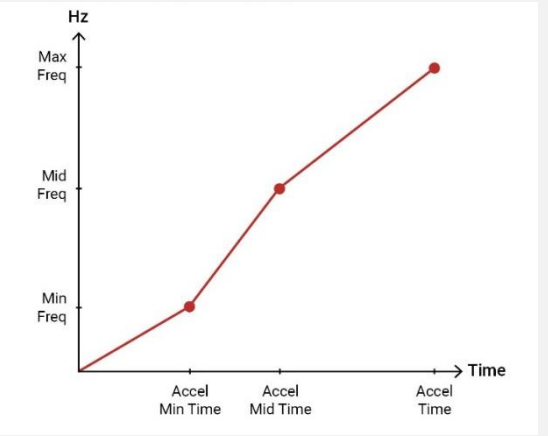

8 - Resetting
9 - Setup Wizard
10 - Final Test
11 - Alarms
12 - File System
1.5 - Lead Lag Parameters
1.5.1 Number Lag Pumps
1.5.2 Stage Pump Delay
1.5.3 Destage Pump Delay
1.5.4 Stage Time
1.5.5 Destage Time
1.5.6 Destage Min Frequency
1.5.7 Stage Frequency Reduction 1
1.5.8 Stage Frequency Reduction 2
1.5.9 Stage Frequency Reduction 3
1.5.10 Stage Frequency Reduction 4
1.5.11 Destage Frequency Boost 1
1.5.12 Destage Frequency Boost 2
1.5.13 Destage Frequency Boost 3
1.5.14 Destage Frequency Boost 4
1.5.15 Stage Analog Lag
1.5.16 Destage Analog Lag
1.6 - Multiplex Parameters
1.6.1 Number Multiplex Systems
1.6.2 Multiplex Cycle Time
1.6.3 Multiplex Stage Delay
1.6.4 Multiplex Destage Frequency
1.6.5 Multiplex Stage Analog Lag
1.6.6 Multiplex Destage Delay
1.7 - PID Control Parameters
1.7.1 Acceleration Time
1.7.2 Deceleration Time
1.7.3 Integral Gain
1.7.4 Proportional Gain
1.7.5 Derivative Gain
1.7.6 Derivative Delay Time
1.7.11 Dynamic Gain Enable
1.7.12 PID Update Rate
1.7.13 PID Measurement Filter Rate
1.8 - Torque Control Parameters
1.8.1 Enable Torque Control
1.8.2 Motor Rated HP
1.8.3 Motor Rated Voltage
1.8.4 Motor Rated Current
1.8.5 Motor Rated RPM
1.8.6 Speed Proportional Gain
1.8.7 Speed Integral Gain
1.8.8 Torque Proportional Gain
1.8.9 Torque Integral Gain
1.8.10 Flux Proportional Gain
1.8.11 Flux Integral Gain
1.8.12 Torque Limit
1.8.13 Flux Reference
1.8.14 Disable Regen/Overspeed
1.9 - All Parameters
1.10 - Changed Parameters

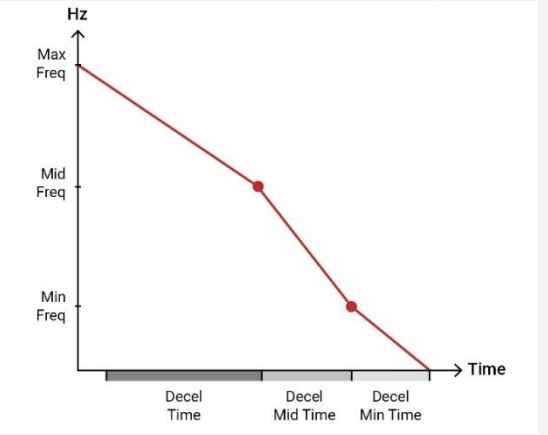
4.8 Parameter Tables

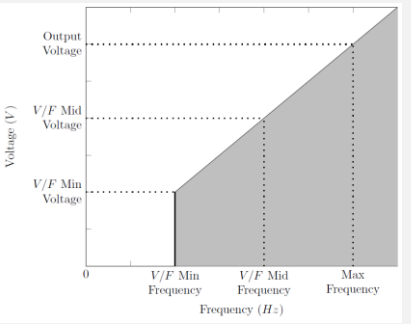
Table 17 – 1.1 Operating Parameters

$ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **STANDARD**.

@ **-** Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **ADVANCED.**

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.1.1 Min Frequency	Minimum output frequency allowed except during startup ramp. When the SUBMERSIBLE PUMP parameter is enabled, frequency will ramp from stop to ***1.1.1 MIN FREQUENCY*** in one second. Important in protecting thrust bearings in submersible pumps.	30 Hz (5-120)
1.1.2 Max Frequency	Maximum frequency allowed, or target frequency at start-up ramp. This value cannot be lower than ***1.1.1 MIN FREQUENCY***.	60 Hz (5-120)
1.1.3 Acceleration Profile @	**Press ENTER to see the following parameters related to Acceleration Profile. This sub-menu is only visible if *1.3.2 MENU COMPLEXITY* is set to Advanced. Otherwise, only *1.1.3.1 START UP RAMP TIME* will be visible.**	
1.1.3.1 Start Up Ramp Time	Time from ***1.1.1 MIN FREQUENCY*** to ***1.1.2 MAX FREQUENCY*** in System Config 0 and 4. Ramp speed is linear. See ***1.7.1 ACCELERATION TIME*** for analog control.	12 sec (1-120)
1.1.3.2 Acceleration Curve Select @	Select how many points occur on the startup ramp profile. Options are: **0 – max**: linear ramp from 0 to ***1.1.2 MAX FREQUENCY***. **0 – min – max**: ***1.1.1 MIN FREQUENCY*** acts as a mid-point between 0 and ***1.1.2 MAX FREQUENCY***. **0 – min – mid – max**: Adds an additional mid point to the ramp profile.	0 - Max
1.1.3.3 Acceleration Min Time @	Use these parameters to set a multi-speed acceleration profile according to the chart below.  	1 sec (0.5-120)
1.1.3.4 Acceleration Middle Time @		6 sec (1-120)
1.1.3.5 Acceleration Middle Frequency @		45 Hz (5-120)
1.1.4 Deceleration Profile @	**Press ENTER to see the following parameters related to Deceleration Profile. This sub-menu is only visible if *1.3.2 MENU COMPLEXITY* is set to Advanced. Otherwise, only *1.1.4.1 SHUT DOWN RAMP TIME* will be visible.**	
1.1.4.1 Shut Down Ramp Time	Time from ***1.1.2 MAX FREQUENCY*** to ***1.1.1 MIN FREQUENCY*** when motor receives a STOP command. Ramp time is linear. Factory default setting enables the ***1.1.11 COAST TO STOP*** parameter which disables the ***1.1.4 DECELERATION PROFILE*** .	3 sec (1-120)

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.1.4.2 Deceleration Curve Select @	Select how many points occur on the deceleration ramp profile. **max – 0**: linear ramp from ***1.1.2 MAX FREQUENCY*** to zero. **max – min – 0**: ***1.1.1 MIN FREQUENCY*** acts as a mid-point between ***1.1.2 MAX FREQUENCY*** and zero. **max – mid – min – 0**: Adds an additional mid point to the ramp profile.	Max – Min
1.1.4.3 Deceleration Min Time @	Use these parameters to set a multi-speed deceleration profile according to the chart below. ***1.1.11 COAST TO STOP*** must be NO.  	6 sec (1-120)
1.1.4.4 Deceleration Middle Time @		6 sec (1-120)
1.1.4.5 Deceleration Middle Frequency @		45 Hz (5-120)
1.1.9 Overcurrent Limit	Setting for motor overload protection, Trip Class 10 curve. Running below 25% of the rating of the system is not recommended and will adversely affect motor protection.	Drive Rated Current (3 A – 105% Drive Rated Current)
1.1.10 Under Current	Unit shuts down when output current goes below the set value (commonly used for dry well protection). Value can be adjusted while load is running. Drive must be running at ***1.1.2 MAX FREQUENCY*** to engage this protection.	Disabled (0 A – 90% Rated Current)
1.1.11 Coast to Stop	Selects between coast to stop or ramp to stop. Ramp profile is controlled by parameter ***1.1.4 DECELERATION PROFILE***. YES = coast to stop, NO = ramp to stop.	Yes
1.1.12 Ground Fault Sensitivity	Detects fault between any output line and earth. Sensitivity to fault detection is adjustable to avoid nuisance trips. Lower value equals lower sensitivity to fault detection. (0 = Disabled)	0 (0-9)
1.1.13 Submersible Pump	**ENABLE THIS FEATURE WITH SUMBERSIBLE PUMPS.** Frequency will ramp from stop to the value set by parameter ***1.1.1 MIN FREQUENCY*** in one second. Submersible pumps suffer damage to the thrust bearing if operated below 30 Hz for more than one second. YES = one second ramp time from stop to minimum frequency NO = linear ramp from stop to ***1.1.2 MAX FREQUENCY***. ***1.1.1 MIN FREQUENCY*** is observed while motor is running.	Yes
1.1.14 Reverse Rotation	Reverses motor direction by changing sequence of output phases. Setting will not change after a factory reset.	Default: Standard ABC Reverse ACB
1.1.15 Output Voltage @	Output voltage on main motor terminals. This can be used on DXL drives ONLY to decrease voltage. This can be used on LHX drives however, to decrease or increase output voltage.	240 V (100-270) 480 V (200-530)

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.1.16 Switching Frequency $	Switching frequency of the IGBT inverter module. Range varies based on the rated HP of the drive. Also known as Carrier Frequency. Setting will not change after a factory reset.	**5-100 HP:** 4 kHz (2k-5k) **125-400 HP:** 2 kHz (1.5k-5k) **600+ HP:** 1.5 kHz (1.5k-5k) **2XD:** 3 kHz (2k-8k)
1.1.17 Overload Derate Enable $	During heavy startups, drive frequency will slow down to avoid Output Overload fault. The screen will say **OVERLOAD DERATE** when conditions apply. Setting can be disabled or set to react SLOW, MEDIUM, or FAST.	Slow (Disabled – Fast)
1.1.18 Overcurrent Derate Enable $	Drive frequency will slow down to maintain ***1.1.9 OVERCURRENT LIMIT***. Screen will display **OVERCURRENT DERATE** when conditions apply.	Yes
1.1.19 Over Temp Derate Enable $	Drive frequency will slow down to avoid drive over temperature fault. Screen will display **OVER TEMP DERATE** when conditions apply.	Yes
1.1.25 V/F Controls $	**Press ENTER to see the following parameters related to V/F Control.**	
1.1.25.1 V/F Selection	Controls the relationship between voltage and frequency when starting a motor for different applications. **Standard**: Voltage and frequency are proportional. Torque is constant. **Soft Start 1**: Limits voltage during initial ramp to reduce inrush current. Torque is reduced. **Soft Start 2:** Exaggerated **Soft Start** ramp to reduce inrush current and torque more than **Soft Start 1**. **Soft Start 3:** Exaggerated **Soft Start** ramp to reduce inrush current and torque more than **Soft Start 2**. **Torque Boost**: Boosts voltage during initial ramp to increase startup torque.	Standard
1.1.25.3 V/F Min Frequency	Use these settings to customize the V/F ramp profile based on the following graph. These settings can only be used when V/F Selection is set to **5 = Custom**. 	15 Hz (3-55)
1.1.25.4 V/F Mid Frequency		30 Hz (3-55)
1.1.25.5 V/F Min Voltage		240 V: 30 V (0-240) 480 V: 60 V (0-480)
1.1.25.6 V/F Mid Voltage		240 V: 120 V (0-240) 480V: 240 V (0-480)
1.1.26 PWM Over Modulation @	Output voltage may be lower than the input voltage because of losses from a filter or input reactor. Use this parameter to boost output voltage on DXL systems if necessary. On LHX systems, increasing the parameter ***1.1.15 OUTPUT VOLTAGE*** is a better option.	0 % (0-25)

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.1.27 Skip Frequencies @	**Press ENTER to see the following parameters related to Skip Frequencies.**	
1.1.27.1 Skip Frequency 1 Setpoint	Sets the first frequency to skip during acceleration and deceleration ramps.	Disabled (0 - ***1.1.2 MAX FREQUENCY***)
1.1.27.2 Skip Frequency 1 Bandwidth	Sets the width of the frequency band to be skipped. Skipped frequencies will center around ***1.1.27.1 SKIP FREQUENCY SETPOINT 1***.	0 Hz (0-300)
1.1.27.3 Skip Frequency 2 Setpoint	Sets the second frequency to skip during acceleration and deceleration ramps.	Disabled (0 - ***1.1.2 MAX FREQUENCY***)
1.1.27.4 Skip Frequency 2 Bandwidth	Sets the width of the frequency band to be skipped. Skipped frequencies will center around ***1.1.27.3 SKIP FREQUENCY SETPOINT* 2**.	0 Hz (0-300)
1.1.27.5 Skip Frequency 3 Setpoint	Sets the third frequency to skip during acceleration and deceleration ramps.	Disabled (0 - ***1.1.2 MAX FREQUENCY***)
1.1.27.6 Skip Frequency 3 Bandwidth	Sets the width of the frequency band to be skipped. Skipped frequencies will center around ***1.1.27.5 SKIP FREQUENCY SETPOINT* 3**.	0 Hz (0-300)
1.1.28 Motor RPM @	**Only visible after using the HVAC Wizard for setup.** RPM as shown on motor nameplate.	1,800 (60 – 20,000)
1.1.29 Current Unbalance @	Percent current unbalance allowed on output phases.	80 % (1 – 100)
1.1.30 DC Bus Ripple Compensation @	When enabled, this allows output voltage to vary to keep current stable. Disabling this feature will result in stable output voltage but current may oscillate.	Enable

$ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **STANDARD**.

@ **-** Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **ADVANCED.**

Table 18 – 1.2 Auto Restart Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.2.1 Enable Restarts	Allows the drive to automatically restart after a fault using last known run command. NO = no auto restarts and unit will initialize in OFF mode YES = Auto mode on initialization and auto restarts allowed	Yes
1.2.2 Under Current Delay	Time ***1.1.10 UNDER CURRENT*** is allowed before unit trips.	4 sec (0-9999)
1.2.3 Restart Delay	Delay before unit restarts after any fault trip other than Under Current. See ***1.2.6 UNDER CURRENT RESTART DELAY*** for more information.	15 sec (0-9999)
1.2.4 Startup Delay	Delay before a restart after an input power OFF/ON cycle.	0 sec (0-9999)
1.2.5 Short Cycle Delay	Delay after drive goes from ON to OFF. Prevents the drive from engaging the motor when it is spooling down during coast-to-stop operation. Display will count down seconds until RUN.	3 sec (0-300)
1.2.6 Under Current Restart Delay	Delay before unit restarts after an ***UNDERCURRENT*** fault. Commonly used to allow a well to recharge after a dry well condition.	0 min (0-7 days)
1.2.11 Number of Auto Restarts $	Number of automatic restarts allowed after a fault trip.	10 (1-9999)
1.2.12 Startups Per Cycle $	Number of startup sequence attempts the drive will perform after power is cycled within the time specified under ***1.2.13 MAX CYCLE TIME.*** After the max startups is reached, the drive will wait for ***1.2.13 MAX CYCLE TIME*** to expire or for power to be cycled to attempt another restart.	0 (0-10)
1.2.13 Max Cycle Time $	Maximum amount of time the drive will attempt to perform the startup sequence. After ***1.2.13 STARTUPS PER CYCLE*** is reached, this timer will need to expire or power will need to be cycled before drive will attempt another restart.	60 min (0-7 days)
1.2.14 Sensor Connection Fault Delay @	Delay when the 4-20mA signal is lost before ***SENSOR CONN FAIL*** fault is triggered.	10 sec (0-300)

$ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **STANDARD**.

@ **-** Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **ADVANCED.**

Table 19 – 1.3 Interface Parameters

<table>
<tr><th>DISPLAY MESSAGE</th><th>DESCRIPTION</th><th>DEFAULT [UNITS]
(MIN - MAX)</th></tr>
<tr><td>1.3.1 System Config

(see Section 5.5, System Configuration for detailed information)</td><td>Determines the operating mode of the drive.

0 = ON/OFF control using AUX1 and AUX2. Both AUX1 and AUX2 must have a contact closure to run.
1 = Analog Constant Pressure control using 4-20 mA input.
2 = Analog Constant Pressure with redundant sensors and up to two psi setpoints. Control setpoint will change based on the states of AUX3, as shown in the table below.
<table>
<tr><th>AUX3</th><th>PSI Setpoint</th></tr>
<tr><td>Off</td><td>1</td></tr>
<tr><td>On</td><td>2</td></tr>
</table>
3 = Analog Constant Pressure with redundant sensors and up to four psi setpoints. Control setpoint will change based on the states of AUX3 and AUX4, as shown in the table below.
<table>
<tr><th>AUX3</th><th>AUX4</th><th>PSI Setpoint</th></tr>
<tr><td>Off</td><td>Off</td><td>1</td></tr>
<tr><td>On</td><td>Off</td><td>2</td></tr>
<tr><td>Off</td><td>On</td><td>3</td></tr>
<tr><td>On</td><td>On</td><td>4</td></tr>
</table>
4 = Speed Reference I1. Speed control is proportional to 4-20 mA signal applied to I1 terminals.
5 = Speed Reference I2. Speed control is proportional to 4-20 mA signal applied to I2 terminals.
6 = Speed Pot 0-10VDC. Speed control is proportional to 0-10 VDC signal applied to VIN and COM terminals.
7 = Analog constant pressure with HOA and speed pot
<table>
<tr><th>AUX3</th><th>Function</th></tr>
<tr><td>Off</td><td>Analog Constant Pressure</td></tr>
<tr><td>On</td><td>Speed control</td></tr>
</table>
8 = Analog constant pressure (4-20 mA only) with dual sensors
<table>
<tr><th>AUX3</th><th>PSI Setpoint</th></tr>
<tr><td>Off</td><td>Analog Constant Pressure</td></tr>
<tr><td>On</td><td>Backup Sensor</td></tr>
</table>
9 = HOA Speed reference selector
<table>
<tr><th>AUX1</th><th>AUX3</th><th></th></tr>
<tr><td>On</td><td>On</td><td>0-10 VDC Speed Reference</td></tr>
<tr><td>On</td><td>Off</td><td>I1 4-20 mA Speed Reference</td></tr>
</table>
See Section 5.5, for more details.</td><td>0 (0-6)</td></tr>
<tr><td>1.3.2 Menu Complexity</td><td>Determines what parameters are shown or hidden. Simple will be adequate for most applications but more complex programming requires additional parameters to be visible. Parameters visible in Standard mode will be followed by “$” on the display. Parameters visible in Advanced mode will be followed by “@” on the display.</td><td>Simple</td></tr>
</table>

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.3.3 Disable Manual Mode	Disables manual operation of the drive through the keypad. Operating states are limited to AUTO and OFF. YES = MANUAL mode disabled.	Yes
1.3.4 Program Relay No 1	Programmable normally open / normally closed relay. Control Terminals 1NC, 1NO, and COM. The relay can be programmed to change state for the following conditions: **0 = System Fault**: State will change when drive faults. **1 = Lag Pump**: Lag/Duplex is controlling the relay. **2 = Modbus Control**: Customer Modbus is controlling the relay. Modbus Control commands will override current settings except when configured to state 1 or 7. **3 = Pump Fault**: e.g. motor overload, under current, etc. **4 = Output Active**: Relay activates when VFD frequency is greater than zero. **5 = Damper**: Relay activates when AUX1 is closed in the Auto run-mode. **6 = Pre-lube Oiler**: Relay energizes when a RUN command is given in either Manual or Auto mode. The drive will count down from ***1.3.30 OILER ON-DELAY TIMER*** and then begin outputting. Once the drive reaches ***1.1.1 MIN FREQUENCY***, the relay will de-energize. **7 = Jockey Pump**. Relay will not participate in lead/lag or multiplex pump control. Instead, relay will change states when motor frequency is greater than 0, and open when it is exactly 0. **This setting is only available for *Program Relay 1*.**	0 (0-7)
1.3.5 Program Relay No 2	Programmable normally open / normally closed relay. Control Terminals 2NC, 2NO, and COM. See Parameter ***1.3.4 PROGRAM RELAY 1*** above for description of values.	0 (0-6)
1.3.6 Program Relay No 3	Programmable normally open relay. Control Terminals 3NO, 3C. See Parameter ***1.3.5 PROGRAM RELAY 2*** above for description of values.	0 (0-6)
1.3.7 Program Relay No 4	Programmable normally open relay. Control Terminal 4NO, 4C. See Parameter ***1.3.5 PROGRAM RELAY 2*** above for description of values.	0 (0-6)

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.3.8 AUX1 Select 1.3.9 AUX2 Select	Programmable digital inputs. Generally used for motor Run/Stop control. **0 = RUN/STOP** (On = RUN, Off = STOP) **1 = RUN/STOP** (Off = RUN, On = STOP) **2 = Always in Run Mode** **3 = Latching Relay**. When the connection between the AUX terminal and COM is opened the drive will stop the motor and display a fault on the screen. The motor will remain stopped even if the connection is closed. The fault must be cleared by pressing the ENTER key. The function of these inputs can change when certain System Configuration settings are chosen. See **Section 5.5.** When the drive is in AUTO mode and stopped, the display will show: A1▮ A2_ A3▮ A4_ The symbol _ indicates that the input is off and the symbol ▮ indicates the input is on. In the example above, AUX1 and AUX3 are ON.	1 (0-3)

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.3.10 AUX3 Select 1.3.11 AUX4 Select	Programmable digital inputs. Generally used for motor Run/Stop control. **0 = RUN/STOP** (On = RUN, Off = STOP) **1 = RUN/STOP** (Off = RUN, On = STOP) **2 = Always in Run Mode** **3 = Latching Relay**. When the connection between the AUX terminal and COM is opened the drive will stop the motor and display a fault on the screen. The motor will remain stopped even if the connection is closed. The fault must be cleared by pressing the ENTER key. **4 = Reverse Rotation**. When the circuit changes states, the motor will ramp down for (30 seconds + ***1.2.5 SHORT CYCLE DELAY***), then ramp back up in the opposite rotation. When open, the drive will run in standard rotation, closed will run in reverse rotation. **5 = Reverse Latching Relay**. When the connection between the AUX terminal and COM is **closed** the drive will stop the motor and display a fault on the screen. The motor will remain stopped even if the connection is opened. The fault must be cleared by pressing the ENTER key. **6 = Speed Reference**. Used in conjunction with **1.3.35 AUX SWITCH SPEED CONTROL**, multiple speeds can be programmed and controlled based on the open/closed states of AUX3 and AUX4. **7 = Fireman's Override Mode** Closing the AUX will override current settings to run the load at Max Frequency. This will bypass all VFD and motor protections and run the drive until failure, to assist with building evacuation. All other external run/stop commands including from the keypad will be ignored. **8 = Fireman's Override Reverse**. Closing the AUX will override current settings to run the load in **reverse of normal operation** at Max Frequency. This will bypass all VFD and motor protections and run the drive until failure, to assist with building evacuation. All other external run/stop commands including from the keypad will be ignored. **9 = System Config Special Function**. This will automatically be set when ***1.3.1 SYSTEM CONFIG*** is set for 2, 3, 5, and 6. See **Section 5.5** for details. The function of these inputs can change when certain System Configuration settings are chosen. See **Section 5.5**. When the drive is in AUTO mode and stopped, the display will show: A1▉ A2_ A3▉ A4_ The _ symbol indicates that the input is off and the ▉ symbol indicates the input is on. In the example above, AUX1 and AUX3 are ON.	2 (0-7)
1.3.12 RTC Setup	Real-Time Clock MO/DD/YR H:M:SS Enter button moves the character to the right, use UP and DOWN keys to select the number.	Date and Time
1.3.13 LCD Contrast	Used to adjust the contrast of the graphic display.	40 (30-59)

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.3.19 Enable 1Ph Input [$]	For DXL systems ONLY. Used for oversized systems intended for single-phase input to run a 3-phase motor. Set to YES for single-phase input. When enabled, output current is reduced by half. Setting will not change after a factory reset.	No
1.3.20 Password Setup [$]	Allows keypad function to be password protected. When keypad is locked, it will prompt for a user-defined four-digit password. A parameter value of "0000" disables password protection. Each digit can go from 0 to F: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F. Press enter to select the next digit. Setting will not change after a factory reset.	No Default (User Defined)
1.3.21 Analog Input Control [$]	**Press ENTER to see the following parameters related to Analog Input Control.**	
1.3.21.1 Analog Setpoint Control	Allows a dynamic control setpoint, determined by an analog input. **Disabled**: Analog input does not affect the control setpoint. **Analog Control**: The analog input determines the control setpoint. **Frequency**: The analog input determines the frequency setpoint.	Disabled
1.3.21.2 Analog Select I1	Determines how the I1 analog input is used. **Measurement**: I1 is used as feedback to control the PID loop for constant pressure, flow control, etc. **Setpoint Control**: I1 is used to set the control setpoint. **Backup Measurement**: I1 acts as a backup measurement in case the primary sensor fails. **Backup Setpoint Control**: I1 acts as a backup setpoint control in case the primary setpoint control fails.	Disabled
1.3.21.3 Analog Select I2	Same options as ***1.3.21.2 ANALOG SELECT I1*** above, but for I2.	Disabled
1.3.21.4 Analog Select VIN	Same options as ***1.3.21.2 ANALOG SELECT I1*** above, but for 10 VDC input.	Disabled
1.3.21.5 Analog Input Reverse I1	Reverses the scale of the I1 input.	No
1.3.21.6 Analog Input Reverse I2	Reverses the scale of the I2 input.	No
1.3.21.7 Analog Input Reverse VIN	Reverses the scale of the 10 VDC input.	No
1.3.21.8 Speed Pot Scale Select	Changes the frequency range that the speed pot operates over. **0 – Max Frequency**: Speed will ramp linearly from zero to ***1.1.2 MAX FREQUENCY*** based on the analog input value. **Min Frequency – Max Frequency**: Speed will jump to ***1.1.1 MIN FREQUENCY*** and then ramp linearly to ***1.1.2 MAX FREQUENCY*** based on the analog input value.	0 – Max Freq
1.3.22 Model Programming [@]	In rare instances, a model will need to be changed. This ***SHOULD ONLY*** be used under the direction of Phase Technologies.	Set by Factory
1.3.23 Demo Model [@]	Allows unit to be programmed as a demo model so that they do not switch IGBTs and do not fault for input faults. This ***SHOULD ONLY*** be used under the direction of Phase Technologies. Requires factory password to unlock.	No
1.3.24 Disable Active Front End [@]	Only for 3LHX systems powered by generators. Disables input switching to reduce compatibility issues between 3LHX and generator.	No

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.3.29 Troubleshooting @	Used to access Advanced Parameters and clear memory. **0 – 3** = Reserved for factory use **4** = Clear Run Timers **5** = Clear Fault Log	0 (0-5)
1.3.30 Oiler On-Delay Timer @	Hidden until one of the PROGRAM RELAY parameters is set to **6: Pre-Lube Oiler**. Determines the length of time, after a RUN command, that a relay will be energized before the main VFD output is turned on.	20 sec (3-300)
1.3.35 Aux Switch Speed Control @	**Press ENTER to see the following parameters related to AUX Switch Speed Control.**	
1.3.35.1 Aux 3 Speed Ref	The speed the drive will run at when only AUX3 is closed.	60 Hz (5-300)
1.3.35.2 Aux 4 Speed Ref	The speed the drive will run at when only AUX4 is closed.	60 Hz (5-300)
1.3.35.3 Aux 3+4 Speed Ref	The speed the drive will run at when both AUX3 and AUX4 are closed.	60 Hz (5-300)
1.3.40 RTC Calibration @	Used to adjust the RTC drift by seconds per day.	0 (-31-31)
1.3.45 Customer Comm Protocol @	Used to select the desired communication protocol. Options are: Modbus IP, Modbus RTU, BACnet MS/TP, BACnet IP.	Modbus IP
1.3.46 Communication Controls @	**Press ENTER to see the following parameters related to Modbus.**	
1.3.46.1 Modbus ID	Address of the drive for a Modbus network.	1 (0-247)
1.3.46.2 BACnet Device Object ID	Used to set the ID of the device object.	20000 (20000-20500)
1.3.46.3 Modbus Stop Bits	Number of bits transmitted after each character to detect the end of the character.	1 (1-2)
1.3.46.4 Modbus Parity	Sets how the parity of the character's data frame is set.	None (Odd-Even)
1.3.46.5 Modbus Baud Rate	Serial baud rate or the rate at which information is transferred.	19200 (2400- 57600)
1.3.46.6 Modbus Wiring	Select between using 2-wire or 4-wire Modbus configuration.	4-wire
1.3.46.7 Modbus Fault Select	Select how the drive responds when serial communication is lost. Options are disabled, to fault, or stop the output of the VFD without faulting.	Disabled
1.3.46.8 Modbus Fault Time	In seconds. Select how long serial communication loss persists before Modbus Fault Selection state takes effect.	0 sec (0-120)
1.3.46.9 Program My IP	Sets the IP address of the drive.	N/A
1.3.46.10 Program My MAC	Sets the MAC address of the drive. The default is unique for all units.	N/A
1.3.46.11 Program Gateway	Sets the Gateway IP for the network.	N/A

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.3.46.12 Program Subnet	Sets the Subnet mask for the network.	N/A
1.3.46.13 BACnet IP UDP Port	Sets the port used for BACnet communication. Screen will display numeric value and hexadecimal equivalent.	47808 (47808-47823)
1.3.47 Analog Output Control @	**Press ENTER to see the following parameters related to Analog Output Control.**	
1.3.47.1 IOUT Select	Used to turn on and select the range of the IOUT signal. Options are 0-20 mA and 4-20 mA.	4-20 mA
1.3.47.2 VOUT Select	Used to turn on and select the range of the VOUT signal. Options are 0-10 VDC and 0-5 VDC.	0-10 VDC
1.3.47.3 IOUT Source	Used to select what the IOUT signal corresponds to. Options are: **Hz** = Output speed. 0 to 100% of ***1.1.2 MAX FREQUENCY.*** **Output Amps** = Output current. 0 – 100% of ***1.3.47.12 ANALOG OUTPUT MAX OUTPUT AMPS.*** **kW =** Real power output of drive. 0-100% of ***1.3.47.10 ANALOG OUTPUT MAX KW RANGE.*** **Analog Msrmnt** = Transducer measurement level. 0 – 100% of ***1.4.19.1 MAX ANALOG SENSOR RANGE.*** **I1 Input** = a direct copy of the I1 input. **I2 Input** = a direct copy of the I2 input. **VIN** = a copy of the VIN input, as a ratio of VIN / 10V.	I1 Input
1.3.47.4 VOUT Source	Used to select what the VOUT signal corresponds to. Options are: **Hz** = Output speed. 0 to 100% of ***1.1.2 MAX FREQUENCY.*** **Output Amps** = Output current. 0 – 100% of ***1.3.47.12 ANALOG OUTPUT MAX OUTPUT AMPS.*** **kW =** Real power output of drive. 0-100% of ***1.3.47.10 ANALOG OUTPUT MAX KW RANGE.*** **Analog Msrmnt** = Transducer measurement level. 0 – 100% of ***1.4.19.1 MAX ANALOG SENSOR RANGE.*** **I1 Input** = a copy of the I1 input, as a ratio of I1 / 20. **I2 Input** = a copy of the I2 input, as a ratio of I2 / 20. **10 VIN** = a direct copy of the VIN input.	10 VIN
1.3.47.5 IOUT Reverse	Reverses the scale of the IOUT signal.	No
1.3.47.6 VOUT Reverse	Reverses the scale of the VOUT signal.	No
1.3.47.10 Analog Output Max kW Range	Sets the maximum kW value associated with the maximum analog output. For instance, if using a 4-20 mA transducer, 20 mA would be associated with this value. If the analog output is reversed, then 4 mA would correspond to this value.	Model Specific (0.1-10000)
1.3.47.11 Analog Output Max Input Amps	Sets the maximum Input Current value associated with the maximum analog output. For instance, if using a 4-20 mA output, 20 mA would be associated with this value. If the analog output is reversed, then 4 mA would correspond to this value.	Model Specific (1-1200)
1.3.47.12 Analog Output Max Output Amps	Sets the maximum Output Current value associated with the maximum analog output. For instance, if using a 4-20 mA output, 20 mA would be associated with this value. If the analog output is reversed, then 4 mA would correspond to this value.	Model Specific (1-1200)

$ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **STANDARD**.

@ **-** Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **ADVANCED.**

Programming Tip

Constant Pressure parameters are only displayed when System Configuration has been set for constant pressure. The parameter ***1.3.1 SYSTEM CONFIG*** is in the ***1.3 INTERFACE PARAMETERS*** sub-menu. See **Table 19** for details.

Table 20 – 1.4 Constant Pressure Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.4.1 Analog Setpoint 1	For PID controlled systems only. This sets the level at which the pressure/flow/level will be controlled. Must be set within the range of the 4-20 mA transducer. Make sure that ***1.4.19.1 ANALOG SENSOR RANGE*** is set to the maximum value of the sensor you are using. Up to four psi set points can be used depending upon the System Configuration. See Section 5.5 for details.	50 psi (0 – 500) 200 GPM (0.1 – 3,200) 5 ft (0 – 5,000)
1.4.2 Analog Setpoint 2		
1.4.3 Analog Setpoint 3		
1.4.4 Analog Setpoint 4		
1.4.5 Sleep Frequency	This parameter value is added to the frequency set by ***1.1.1 MIN FREQUENCY*****.** The combined value is the frequency at which drive will enter sleep mode, after a 6 second delay, when pressure is controlled at the setpoint, and after the minimum ON time has been satisfied.	7 Hz (0-30)
1.4.6 Force Sleep Threshold	This value is added to the setpoint. The combined value is the pressure/flow/level at which drive will stop the motor load. Motor will restart when the value falls to the value set by parameter ***1.4.7 WAKE UP THRESHOLD***.	20 psi (0-500) 100 GPM (0.1–32,000) 1 ft (0.01–10,000)
1.4.7 Wake Up Threshold	This controls the drop below Setpoint to start motor in sleep mode, e.g. if this is set to 5 and motor turns off at 50 psi, motor will restart at 45 psi.	5 psi (0-50) 100 GPM (0.1 – 32,000) 1 ft (0 – 5,000)
1.4.8 Boost Amount	The parameter value specifies an increase above the setpoint before sleep mode.	0 psi (0-100) 0 GPM (0-32,000) 0 ft (0-5,000)
1.4.9 Precharge Frequency	Sets the maximum frequency applied to the motor during the precharge interval.	30 Hz (1-120)
1.4.10 Precharge Time	Sets the maximum time for precharge regardless of any sensor inputs. A setting of zero disables the precharge mode.	0 min (0-30,000)
1.4.11 Precharge PSI	Used only for analog CP systems. Precharge will be terminated when pressure reaches this setpoint. Should be set less than ***1.4.1 ANALOG SETPOINT 1***.	20 psi (0-200)
1.4.16 Broken Pipe Threshold [$]	Level at which drive will determine that there is a broken pipe. Value of zero disables this feature.	0 psi (0-150) 0 GPM (0.1-3,200) 0 ft (-50-50)
1.4.17 Broken Pipe Time [$]	Specifies the time that the system must remain below the value set by ***1.4.16 BROKEN PIPE THRESHOLD*** to trigger a fault. A value of 0 disables Broken Pipe protection.	0 min (0-9999)
1.4.18 Boost Time [$]	The maximum amount of time the drive will attempt to boost. After reaching Boost Time, the drive will go to sleep.	3 sec (0-60)

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.4.19 Analog Config $	**Press ENTER to see the following parameters related to Analog Configurations.**	
1.4.19.1 Max Analog Sensor Range	This value should be set to the maximum value of the 4-20 mA transducer being used for analog control i.e. if the transducer has a range of 0-150, this parameter should be set to 150. This parameter is critical for accurate control.	150 psi (50-500) 400 GPM (0.1-3,200) 10 ft (0.01-100)
1.4.19.2 Analog Measure Offset	Used to calibrate the reading the VFD registers from a 4-20 mA transducer if a manual measurement is not equal to VFD reading. For example, if VFD reads 40 psi, but manual measurement shows 50 psi, this should be set to +10.	0 psi (-50 – 50) 0 GPM (-1,000-1000) 0 ft (-50-50)
1.4.19.3 Analog Setpoint Offset	Used to calibrate the reading that the VFD registers from a 4-20 mA transducer when ***ANALOG SELECT I1/I2*** is set to Setpoint Control. For example, if the intended setpoint is 50 psi, but the VFD reads the setpoint is 40 psi, ***1.4.38.7 PSI SETPOINT OFFSET*** should be set to +10.	0 psi (-50 – 50) 0 GPM (-1,000-1,000) 0 ft (-50-50)
1.4.19.4 Frequency Setpoint Offset	Used to calibrate the Frequency Setpoint if the drive reading differs from the intended value. For example, if the intended Frequency setpoint is 55 Hz but the drive runs at 52 Hz, this parameter should be set to +3.	0 Hz (-30 – 30)
1.4.19.5 GPM Multiplier	Moves the decimal to change the scale of the sensor and setpoint being used.	0.1 (0.01-1)
1.4.19.6 FT Multiplier		0.01 (0.01-1)
1.4.20 Suction Pressure Time	The time at which the pressure must remain below ***1.4.21 LOW PRESSURE FAULT LEVEL*** before triggering a fault.	0 sec (0-1800)
1.4.21 Low Pressure Fault Level	Used only for transducers wired to I_2. The pressure setting where any lower value will trigger a fault.	15 psi (0-200)
1.4.22 T OFF @	Used to prevent short cycling in CP systems. If the motor was off during the last cycle for a period greater than ***1.4.22 TOFF***, the minimum on time of the motor is ***1.4.23 T1 ON***. If the motor was off for a period less than ***1.4.22 TOFF***, the minimum on time of the motor is ***1.4.24 T2 ON***. Default values give a minimum cycle time of about 1 minute.	30 sec (0-9999)
1.4.23 T1 ON @	See ***1.4.22 TOFF*** above. Must be set less than ***1.4.24 T2 ON***.	15 sec (0-1000)
1.4.24 T2 ON @	See ***1.4.22 TOFF*** above. Must be greater than ***1.4.25 T1 ON***.	60 sec (0-1000)
1.4.25 Auto Sleep Bandwidth @	As a percentage of setpoint. This determines when Auto Sleep can activate. If this is set to 10% and the setpoint is 50 psi, Auto Sleep can activate within 45 – 55 psi.	1.5% (0-100)
1.4.26 Auto Sleep Detection Time @	The length of time the analog measurement is within ***1.4.25 AUTO SLEEP BANDWIDTH*** before Auto Sleep activates.	3 sec (1-300)
1.4.27 Auto Sleep Curve @	Sets how quickly frequency decreases during Auto Sleep.	18 (1-999)

$ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **STANDARD**.

@ **-** Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **ADVANCED.**

Programming Tip

Lead/Lag Parameters are only displayed when ***1.3.1 SYSTEM CONFIGURATION*** has been set for constant pressure AND when ***1.3.2 MENU COMPLEXITY*** has been set to **Standard** or **Advanced**. More information on can be found in **Section 6.4**.

Table 21 – 1.5 Lead/Lag Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.5.1 Number Lag Pumps $	Sets the number of auxiliary pumps that are connected to the relays on the control board. The relays will be called for in order, starting with Relay 1.	0 (0-4)
1.5.2 Stage Pump Delay $	Delay before the system will call for a pump to be staged in.	4 sec (0-3600)
1.5.3 Destage Pump Delay $	Delay before the system will destage a pump when pressure is maintained at ***1.1.1 MIN FREQUENCY*** of the primary pump.	4 sec (0-3600)
1.5.4 Stage Time $	This is the interval for which the system will reduce its frequency by ***1.5.7 – 1.5.10 STAGE FREQUENCY REDUCTION.***	4 sec (0-3600)
1.5.5 Destage Time $	This is the interval for which the system will increase its frequency by ***1.5.11 – 1.5.14 DESTAGE FREQUENCY BOOST***.	4 sec (0-3600)
1.5.6 Destage Min Frequency $	***1.1.1 MIN FREQUENCY*** of primary pump plus this amount to destage.	45 Hz (Min Freq – Max Freq)
1.5.7 Stage Freq Reduction 1 $	Reduces frequency of primary pump for the duration of the ***1.5.4 STAGE TIME*** when the specified pump is staged in.	5 Hz (0-120)
1.5.8 Stage Freq Reduction 2 $		5 Hz (0-120)
1.5.9 Stage Freq Reduction 3 $		5 Hz (0-120)
1.5.10 Stage Freq Reduction 4 $		5 Hz (0-120)
1.5.11 Destage Freq Boost 1 $	Increases frequency of primary pump for the duration of the DESTAGE TIME when the specified pump is destaged.	5 Hz (0-120)
1.5.12 Destage Freq Boost 2 $		5 Hz (0-120)
1.5.13 Destage Freq Boost 3 $		5 Hz (0-120)
1.5.14 Destage Freq Boost 4 $		5 Hz (0-120)
1.5.15 Stage Analog Lag $	Allows the system to fall below the control psi by this amount before the system starts counting ***1.5.4 STAGE TIME.*** Assumes max Hz.	6 PSI (0-200) 31 GPM (0.1-3,200) 0.6 ft (0-500)
1.5.16 Destage Analog Lag $	Allows the system to exceed the control psi by this amount before the system starts counting ***1.5.5 DESTAGE TIME.*** Assumes min Hz.	3 PSI (0-200) 10 GPM (0.1-3,200) 0.3 ft (0-500)

$ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **STANDARD**.

Programming Tip

Multiplex Parameters are only displayed when ***1.3.1 SYSTEM CONFIGURATION*** has been set for constant pressure AND when ***1.3.2 MENU COMPLEXITY*** has been set to **Standard** or **Advanced**. More information on can be found in **Section 6.4**.

Table 22 – 1.6 Multiplex Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.6.1 Number Multiplex Systems $	Sets the number of auxiliary pumps that are connected to the relays on the control board. The relays will be called for in order, starting with Relay 1.	0 (0-4)
1.6.2 Multiplex Cycle Time $	Determines the run time for each cycle of both primary and secondary pump, in clock time, NOT running time. ***1.6.1 NUMBER MULTIPLEX SYSTEMS*** must be set above 0 for this to be operational.	1 day (0-9999 days)
1.6.3 Multiplex Stage Delay $	Delay before the system will call for a pump to be staged in, when the current drive cannot maintain setpoint.	30 sec (0-1 hour)
1.6.4 Multiplex Destage Frequency $	***1.1.1 MIN FREQUENCY*** of primary pump plus this amount to destage.	Min Frequency + 22 Hz (Min Freq – Max Freq)
1.6.5 Multiplex Stage Analog Lag $	Allows the system to fall below the control setpoint by this amount before the system starts counting ***1.6.3 MULTIPLEX STAGE DELAY.*** Assumes max Hz.	Setpoint – 6 PSI (0-200) Setpoint – 35 GPM (0.1-3,200) Setpoint – 0.6 ft (0-500)
1.6.6 Multiplex Destage Delay @	Delay before the system will destage a pump when pressure is maintained at ***1.1.1 MIN FREQUENCY*** of the primary pump.	10 sec (0-1 hour)
1.6.7 Multiplex Destage Analog Lag @	Allows the system to rise above the control setpoint by this amount before the system starts counting ***1.6.6 MULTIPLEX DESTAGE DELAY.*** Assumes frequency is below **1.6.4 MULTIPLEX DESTAGE FREQUENCY**.	Setpoint + 0 PSI (0-200) Setpoint + 0.1 GPM (0.1-3,200) Setpoint + 0 ft (0-500)

$ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **STANDARD**.

@ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **ADVANCED.**

Programming Tip

PID Control Parameters are only displayed when ***1.3.1 SYSTEM CONFIGURATION*** has been set for one of the PID loop control schemes (Constant Pressure, Flow Control, Tank Level Control, Pump Down Control, or Suction Pump Control).

Table 23 – 1.7 PID Control Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.7.1 Acceleration Time	Defines the ramp up time from ***1.1.1 MIN FREQUENCY*** to ***1.1.2 MAX FREQUENCY*** during analog control.	12 sec (1-120)
1.7.2 Deceleration Time	Defines the ramp down time from ***1.1.2 MAX FREQUENCY*** to ***1.1.1 MIN FREQUENCY*** during analog control.	5 sec (1-120)
1.7.3 Integral Gain	Multiplier for the integral term in PI control of analog CP. Used to fine tune control of unstable systems. Increase for faster response times and to reduce the steady state error. Changes should be made in small increments, or the system may become unstable.	12 (0-100)
1.7.4 Proportional Gain @	Multiplier for the analog error signal in an analog CP system. A higher value will make the control respond faster to larger error signals, but going too high may make the system unstable.	5 (1 – 60)
1.7.5 Derivative Gain @	Used to reduce overshoot and oscillation by dampening oscillations. Should be used only when necessary because it can amplify noise in the transducer signal and may cause the system to become unstable.	0 (0-100)
1.7.6 Derivative Delay Time @	This parameter disables the derivative term during initial operation for the time set. This can be useful if the measured analog signal changes rapidly during startup.	5 sec (0-300)
1.7.11 Dynamic Gain Enable @	Allows the program to dynamically control derivative and integral gains as the setpoint is approached.	No
1.7.12 PID Update Rate @	Affects how quickly the PID loop reacts to changes. A higher value will react slower.	3 (3-100)
1.7.13 PID Measurement Filter Rate @	Controls how fast the PID measurements are filtered. Increasing this value will result in more filtering of the PID measurements, but going too high may cause the drive to filter out necessary data points.	75 (50-200)

$ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **STANDARD**.

@ **-** Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** is set to **ADVANCED.**

Programming Tip

Torque Control Parameters are only displayed when ***1.3.2 MENU COMPLEXITY*** has been set to **Advanced**.

Table 24 – 1.8 Torque Control Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.8.1 Enable Torque Control @	**YES**: Torque control **NO**: V/f control	No
1.8.2 Motor Rated HP @	Nameplate HP rating of the motor.	Model Specific
1.8.3 Motor Rated Voltage @	Nameplate voltage rating of the motor.	230 or 460 V (208 – 550)
1.8.4 Motor Rated Current @	Nameplate current rating of the motor.	Model Specific
1.8.5 Motor Rated RPM @	Nameplate RPM rating of the motor.	1,800 RPM (1,000 – 4,000)
1.8.6 Speed Proportional Gain @	Proportional gain for speed adjustment.	100 (10 – 200)
1.8.7 Speed Integral Gain @	Integral gain for speed adjustment.	100 (10 – 200)
1.8.8 Torque Proportional Gain @	Proportional gain for torque adjustment.	100 (10 – 200)
1.8.9 Torque Integral Gain @	Integral gain for torque adjustment.	100 (10 – 200)
1.8.10 Flux Proportional Gain @	Proportional gain for flux adjustment.	100 (10 – 200)
1.8.11 Flux Integral Gain @	Integral gain for flux adjustment.	100 (10 – 200)
1.8.12 Torque Limit @	Sets the allowable limit for motor torque.	100 (10 – 200)
1.8.13 Flux Reference @	Magnetic flux of the motor.	100 (10 – 200)
1.8.14 Disable Regen@ (LHX only) 1.8.14 Overspeed@ (DXL only)	**For LHX:** this prevents the motor from developing negative torque, which leads to regenerative power. ⚠ CAUTION! The motor will increase RPM to avoid regen, exceeding ***1.1.2 MAX FREQUENCY***. Can be enabled if backflow causes BUS OVERVOLTAGE. **YES**: disables regenerative power to allow overspeed **NO**: regenerative power is possible **For DXL:** this allows the motor to increase RPM to avoid high bus voltage. **YES**: overspeed is possible **NO**: disables overspeed	No

@ - Parameters are only visible when ***1.3.2 MENU COMPLEXITY*** then selecting **ADVANCED.**

5 OPERATION

5.1 Commissioning the Unit

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

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.

Setup Wizard
Upon the first initialization of the unit (or after restoring factory defaults of all parameters) the drive will prompt the user to select or decline a Setup Wizard. Setup Wizards allows users to quickly setup commonly used control schemes: Constant Pressure Control, Flow Control, Tank Level Control, Pump Down Control, and Suction Pump Control. The wizards will guide users through a list of commonly used parameters for the control method selected. Use the UP and DOWN keys to select which control method you would like to set up then press ENTER. If you would rather program the drive manually, press HOME to skip this step.

5.2 VFD Setup Procedure

1. If remote or automatic ON/OFF function is required, connect remote switch leads to the AUX1 and COM terminals. An additional remote switch or jumper wire may be connected to the AUX2 and COM terminals. The **AUX1 to COM and AUX2 to COM jumper wires will already be installed by the factory, remove as needed for pressure switches or remote ON/OFF switches.**

2. If a Constant Pressure (CP) water system will be operated, connect the pressure sensors to the appropriate Control Terminals. See **Section 5.5**, *System Configuration,* and **Section 6**, *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 graphic display will scroll through several start-up sequence messages.

5. If the ***1.2.1 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. To prevent the motor from running at start-up, immediately after initialization, press the STOP/OFF key until ***OFF*** appears on the display or open AUX1 or AUX2.

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, ***1.1 CHANGE PARAMETER VALUES*****,** to set the following parameters for basic operation:

- ***1.3 INTERFACE PARAMETERS → 1.3.1 SYSTEM CONFIG*** This parameter is critical to the operation of the system. The default setting is for simple ON/OFF operation. See **Section 5.5**, *System Configuration*, for complete information.

- ***1.1 OPERATING PARAMETERS → 1.1.9 OVERCURRENT LIMIT*** This parameter sets the motor overload protection. See **Section 5.4**, *Motor Overload Protection,* for complete information.

- ***1.2 AUTO RESTART PARAMETERS → 1.2.1 ENABLE RESTARTS*** This parameter enables the drive to initialize in AUTO mode and to restart automatically after a fault. Factory default allows auto restarts.

8. Push the MANUAL key until ***MANUAL*** 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 twelve 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 ***1 CHANGE PARAMETER VALUES*** to set any other adjustable parameters you wish to be different from the factory defaults.

5.3 Ground Fault Sensitivity

These drives are equipped with a feature to detect a fault between any of the output lines and earth. If a ground fault is strong enough to trigger the parameter ***1.1.12 GROUND FAULT SENSITIVITY***, 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 may need to be reduced by reducing the value of parameter ***1.1.12 GROUND FAULT SENSITIVITY.***

⚠ **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.

⚠ **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 STOP/OFF key until ***OFF*** appears on the display. Refer to **Section 3.1**, *Using the Keypad and Display*, for instructions on operating the keypad.

5.4 Motor Overload Protection

These 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.

Setting Motor Overload Protection with Keypad
To set motor overload protection with the keypad, navigate to the Main Menu item **1 CHANGE PARAMETER VALUES → 1.1 OPERATING PARAMETERS → *1.1.9 OVERCURRENT LIMT***.

5.5 System Configuration

The drive can operate 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 ***1 CHANGE PARAMETER VALUES → 1.3 INTERFACE PARAMETERS → 1.3.1 SYSTEM CONFIG.*** Refer to **Section 4.1**, *Changing Parameter Values,* and **Table 19**, *Interface Parameters,* for detailed instructions. Below is a brief description of each configuration setting:

- ***1.3.1 System Configuration* = 0**: **Basic RUN/STOP operation**. This is the factory default configuration for basic operation of the drive that allows RUN/STOP control of the motor in AUTO mode using a dry contact on AUX1 and/or AUX2. Both AUX1 and AUX2 must have a contact closure to run. AUX3 and AUX4 can be enabled if needed.

- ***1.3.1 System Configuration* = 1**: **Analog Constant Pressure**. Use this setting to operate analog constant pressure systems with a 4-20 mA transducer. Refer to **Section 6.3**, *Analog Constant Pressure Systems*, for more information on operating the drive in this mode. Refer to **Figure 13** for a diagram illustrating connection of the transducer to Control Terminals.

- ***1.3.1 System Configuration* = 2**: **Analog Constant Pressure with redundant sensors and up to two PSI Setpoints**. This configuration allows the use of two 4-20 mA transducers. The primary sensor is connected to the *I1*+ and *I1*- Control Terminals, with the backup sensor connected to the *I2*+ and *I2*- Control

Terminals. If the primary sensor fails, the backup sensor will automatically take over control of constant pressure at the same settings.

Up to two control setpoints can be used in this configuration. Enter the value of these set points in the Constant Pressure parameter, ***1.4.1 PSI SETPOINT 1*** – ***1.4.2 PSI SETPOINT 2***. The table below show what setpoint the system will follow based on the configuration of the **AUX3**. **AUX1 and AUX2 must also be closed for the system to run.**

Table 25 – System Configuration 2 Setpoints

AUX3	PSI Setpoint
Off	1
On	2

- ***1.3.1 System Configuration* = 3**: **Analog Constant Pressure with redundant sensors and up to four PSI Setpoints**. This configuration allows the use of two 4-20 mA transducers. The primary sensor is connected to the *I1+* and *I1-* Control Terminals, with the backup sensor connected to the *I2+* and *I2-* Control Terminals. If the primary sensor fails, the backup sensor will automatically take over control of constant pressure at the same settings.

  Up to four control setpoints can be used in this configuration. Enter the value of these set points in the Constant Pressure parameter, ***1.4.1 PSI SETPOINT 1*** – ***1.4.4 PSI SETPOINT 4***. The table below show what setpoint the system will follow based on the configuration of the **AUX3** and **AUX4** terminals. **AUX1 and AUX2 must also be closed for the system to run.**

Table 26 – System Configuration 3 Setpoints

AUX3	AUX4	Psi Setpoint
Off	Off	1
On	Off	2
Off	On	3
On	On	4

- ***1.3.1 System Configuration* = 4**: **Speed Reference I1.** Use this setting for motor speed control by an external 4-20 mA source connected to the I1 Control Terminals. Refer to **Figure 13** for a diagram illustrating connection of the transducer to Control Terminals. The drive will ignore the analog signal until it reaches a value proportional to the speed set by the parameter, ***1.1.1 MIN FREQUENCY***, which has a factory default setting of 30 Hz. For speed control across the full-scale range of the analog signal, set ***1.1.1 MIN FREQUENCY*** to the minimum value of 5 Hz. AUX1 and AUX2 must be closed to run in this System Configuration.

- ***1.3.1 System Configuration* = 5**: **Speed Reference I2.** Use this setting for motor speed control by an external 4-20 mA source connected to the I2 Control Terminals. Refer to **Figure 13** for a diagram illustrating connection of the transducer to Control Terminals, but use I2 terminals instead of I1. The drive will ignore the analog signal until it reaches a value proportional to the speed set by the parameter, ***1.1.1 MIN FREQUENCY***, which has a factory default setting of 30 Hz. For speed control across the full-scale range of the analog signal, set ***1.1.1 MIN FREQUENCY*** to the minimum value of 5 Hz. AUX1 and AUX2 must be closed to run in this System Configuration.

- ***1.3.1 System Configuration* = 6**: **Speed Pot Control.** Use this setting for motor speed control by a potentiometer or an external 0-10 VDC source connected to the 0-10 VDC Control Terminals. Refer to **Figure 14** for a diagram illustrating connection of the potentiometer or the voltage source to Control Terminals. The drive will ignore the DC analog signal until it reaches a value proportional to the speed set by the parameter, ***1.1.1 MIN FREQUENCY***, which has a factory default setting of 30 Hz. For speed control across the full-scale range of the analog signal, set ***1.1.1 MIN FREQUENCY*** to the minimum value of 5 Hz. AUX1 and AUX2 must be closed to run in this System Configuration.

- ***1.3.1 System Configuration* = 7: Analog Constant Pressure with HOA and Speed Potentiometer.** This setting allows the user to either turn the motor off, control motor speed with a potentiometer, or operate in analog constant pressure mode using an HOA switch. Access to the keypad is not required to operate in this mode. A mechanical HOA switch changes the state of AUX1 and AUX3 Control Terminals to change to mode of operation in this configuration. A potentiometer is connected to the 0-10 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 AUX3 Control Terminals.

- AUX1 controls for motor run and stop. When the switch is in the OFF position AUX1 is open and the motor will stop. When it is closed (either HAND or AUTO position) the motor will run. AUX3 toggles between analog constant pressure and motor speed control by the potentiometer. When the switch is in the AUTO position and AUX3 is open the drive will operate in analog constant pressure mode. When the switch is in the HAND position it is closed, and the potentiometer will control motor speed. This is illustrated in the table below.

Table 27 – Function of VFD based on AUX3 status

AUX3	Function
Off	Analog Constant Pressure
On	Speed control

- Refer to **Figure 13** for a diagram illustrating connection of the transducer to Control Terminals. AUX2 must be closed to run in the Analog CP Mode (Auto), and AUX 2.

- ***1.3.1 System Configuration* = 8: Analog Constant Pressure Swap Sensors**. This configuration allows the use of two 4-20 mA transducers. The primary sensor is connected to the *I1+* and *I1-* Control Terminals, with the backup sensor connected to the *I2+* and *I2-* Control Terminals. If the primary sensor fails, the backup sensor will automatically take control of constant pressure at the same settings. The sensor being used can also be determined based on the state of AUX3, shown in the table below.

Table 28 – Primary sensor based on AUX3 status

AUX3	PSI Setpoint
Off	Analog Constant Pressure
On	Backup Sensor

The System Configuration must be in any of the constant pressure modes to enable Pre-Charge of the plumbing system or Lead/Lag pump control. See **Section 6.3**, *Pre-Charge* and **Section 6.4**, *Lead/Lag Pump Control* for more information.

5.6 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. The factory default setting for ***1.1.3.1 STARTUP RAMP TIME*** is 12 seconds and ***1.1.4.1 SHUTDOWN RAMP TIME*** has been disabled by the default ***1.1.11 COAST TO STOP*** setting of NO.

***SUBMERSIBLE PUMP* Parameter and Minimum Frequency**

Most submersible pump motor manufacturers require the motor to reach 30 Hz within one second to protect the thrust bearing. The parameter, ***1.1.13 SUBMERSIBLE PUMP***, limits the time the motor runs below 30 Hz to one second. Refer to **Section 4.1** for detailed instructions. When ***1.1.13 SUBMERSIBLE PUMP*** is set to YES, the motor speed will ramp to minimum frequency in one second, then ramp to the maximum frequency in a total of 12 seconds. The ramp time can be changed through the adjustable parameter, ***1.1.3.1 START UP RAMP TIME***. The default ramp is shown in **Figure 18**.

The factory default setting for *1.1.13 SUBMERSIBLE PUMP* is YES and *1.1.1 MIN FREQUENCY* is 30 Hz. When the ***1.1.13 SUBMERSIBLE PUMP*** parameter is set to NO, the motor will ramp from stop to the maximum frequency in 12 seconds in a linear fashion as depicted in **Figure 19**. To set the minimum frequency, navigate to ***1.1.1 MIN FREQUENCY***.

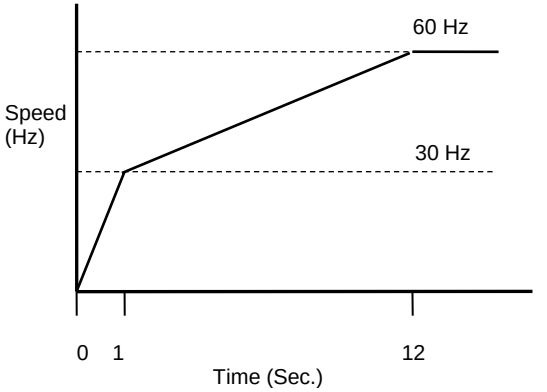


Figure 18 – Default Start-Up Ramp Time (***1.1.13 SUBMERSIBLE PUMP*** parameter enabled)

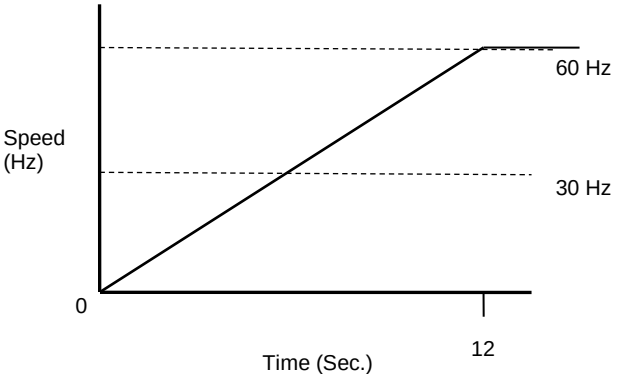


Figure 19 – Start-Up Ramp Time (***1.1.13 SUBMERSIBLE PUMP*** parameter disabled)

⚠ **CAUTION:** Most submersible pump motor manufacturers require the motor to reach 30 Hz within one second to protect the motor from damage. Factory default ramp time is 0-30 Hz in one second, followed by the selected ramp time from 30 Hz to maximum frequency.

5.7 Motor Control Methods (V/f vs. Torque Control)

Advanced motor control methods can be selected through Operating Parameters found in **Table 23**.

V/f Controls
V/f, or volts per Hertz, control is the simplest motor control method and is the default operating mode of the drive. V/f control requires limited motor data to the drive and is the only control method that will allow multiple motors to be operated by one drive. If multiple motors are operated, they must all stop and start together.

Compared to open loop vector torque control, V/f control has limited starting torque. Even so, this method is adequate for most variable torque applications such as fans and pumps.

The simplicity of V/f control results in speed regulation approximately 2-3% of maximum frequency compared to about 0.2% for open loop vector control. Again, this level of speed regulation is adequate for most applications.

Torque Control
Open loop vector control independently controls motor speed and torque much like DC motors. Compared to V/f control, the motor can develop higher torque at lower speeds. Open loop vector control has a quicker speed response for better control of dynamic loads and superior speed regulation when precise control is required.

It is important that accurate motor information is provided to the drive for open loop vector control. Be sure to enter the motor nameplate values for the parameters ***1.8.2 Motor Rated Voltage***, ***1.8.3 Motor Rated Current*** and ***1.8.4 Motor Rated RPM*** when this mode is selected.

1.7.12 Torque Limit
This parameter allows the user to select a motor torque limit that is less than or greater than 100% of motor torque. Torque limits can be used to prevent damage to the motor and the loads it operates. This parameter is applicable for both motoring mode (positive torque) and regenerative mode (negative torque). The drive will reduce motor speed to avoid exceeding the torque limit.

1.7.13 Flux Reference
Torque is equal to flux times current. Flux reference to the motor is automatically calculated by the inverter using the motor parameters. Users can adjust the flux reference from 10% to 200% of the calculated flux reference. This parameter might be used when the drive experiences overcurrent trying to start a heavy load. At light loads, using the rated flux values decreases the efficiency of the drive. By using flux optimization, the efficiency of the drive increases when operating below rated load.

Flux reference can greatly affect the performance of the system. A flux reference that is too low results in smaller torque production in the motor with large stator currents. If flux reference is too higher, the result is high ripple in torque, large stator currents and low efficiency. Caution should be exercised when adjusting this parameter. Make changes in small increments and monitor motor performance.

6 Constant Pressure Systems

DXL and LHX drives can be configured as constant pressure (CP) water systems using an analog pressure transducer (analog constant pressure system). A CP water system includes a pressure tank, a pressure gauge to observe system pressure, and pressure switches or sensors.

6.1 Control Principles of Constant Pressure Systems

In a CP system, a target pressure for the system is set through the keypad. Signals from the sensors interact with firmware to control the motor speed and maintain 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 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 to prevent either continuous running of the motor or constant on/off cycling of the motor.

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

1. The value (PSI, GPM, FT) in the system must be at the value control point set by the parameter ***1.4.1 ANALOG SETPOINT 1*** or at the value determined by the setting on the analog sensor.
2. The frequency is below ***1.4.5 SLEEP FREQUENCY*** (as defined as ***1.1.1 MIN FREQUENCY*** + input value) or measured value is above ***1.4.6 FORCE SLEEP THRESHOLD*** (defined as ***1.4.1 ANALOG SETPOINT 1*** + the input value**.**
3. The time expired since the pump started after the last OFF cycle must be greater than parameter ***1.4.23 T1 ON*** or ***1.4.24 T2 ON.***

Preventing Short Cycling During Low Flow Conditions

When a CP system is in a low flow state, it may be desirable to turn the motor off (sleep mode) to conserve energy and preserve the motor. The adjustable parameters ***1.4.23 T OFF***, ***1.4.23 T1 ON***, ***1.4.24 T2 ON***, ***1.4.5 SLEEP FREQUENCY***, ***1.4.6 FORCE SLEEP THRESHOLD***, ***1.4.7 WAKE UP THRESHOLD***, and ***1.4.8 BOOST AMOUNT*** control when the motor is turned off, how long it is off, and prevent short cycling of the motor at low flow rates. More information including default values for these parameters can be found in **Table 20**.

1.4.7 WAKE UP THRESHOLD and ***1.4.8 BOOST AMOUNT***

The primary method to prevent short cycling is to allow a differential between the desired value (PSI, GPM, FT) at which the pump turns off and the value at which it restarts. Two parameters, ***1.4.7 WAKE UP THRESHOLD*** and ***1.4.8 BOOST AMOUNT***, control this differential. ***1.4.8 BOOST AMOUNT*** specifies the increase in value above ***1.4.1 ANALOG SETPOINT 1*** just before the pump shuts down to enter sleep mode, while ***1.4.7 WAKE UP THRESHOLD*** specifies the value drop below ***1.4.1 ANALOG SETPOINT 1*** at which the pump restarts.

For example, assume ***1.4.1 ANALOG SETPOINT 1*** = 50 psi, ***1.4.8 BOOST AMOUNT PSI*** = 5, and ***1.4.7 WAKE UP THRESHOLD*** = 5. When the pump is ready to enter sleep mode, the pump will boost to 55 psi, then restart when the value falls to 45 psi.

These two parameters can be used together or independently to create a dead band in pressure control***. 1.4.6 FORCE SLEEP*** and ***1.4.5 SLEEP FREQUENCY*** can also be set to tell the drive when to enter sleep mode. ***1.4.6 FORCE SLEEP THRESHOLD*** (analog CP only) is the system pressure at which the drive will go to

sleep. ***1.4.6 FORCE SLEEP THRESHOLD*** is additional system protection in analog CP. This is a value (entered) + the ***1.4.1 ANALOG SETPOINT 1***.

For example, the default value for ***1.4.6 FORCE SLEEP THRESHOLD*** is 20 psi. If the ***1.4.1 ANALOG SETPOINT 1*** is 50 psi, the drive will stop if pressure reaches 70 psi.

Similarly, ***1.4.5 SLEEP FREQUENCY*** can be used to put the drive to sleep. ***1.4.5 SLEEP FREQUENCY*** is defined as a value (entered) + ***1.1.1 MIN FREQUENCY.*** As constant pressure is achieved and the drive slows down, the unit will go to sleep when ***1.4.5 SLEEP FREQUENCY*** is achieved. It is recommended that ***1.4.7 WAKE UP THRESHOLD*** and ***1.4.5 SLEEP FREQUENCY*** values be entered after observing the system.

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, ***1.4.23 T OFF***. If the motor-off time during the last OFF cycle was greater than the value of ***1.4.23 T OFF*** **,** then the minimum motor-on time will be equal to ***1.4.23 T1 ON***. If the motor-off time was less than ***1.4.23 T OFF*** , the minimum motor-on time will be equal to ***1.4.24 T2 ON***.

In other words, the time of the last OFF cycle determines whether the next ON cycle should be relatively long or relatively short. **Figure 20** demonstrates how the system adjusts the motor-on time in response to motor-off time.

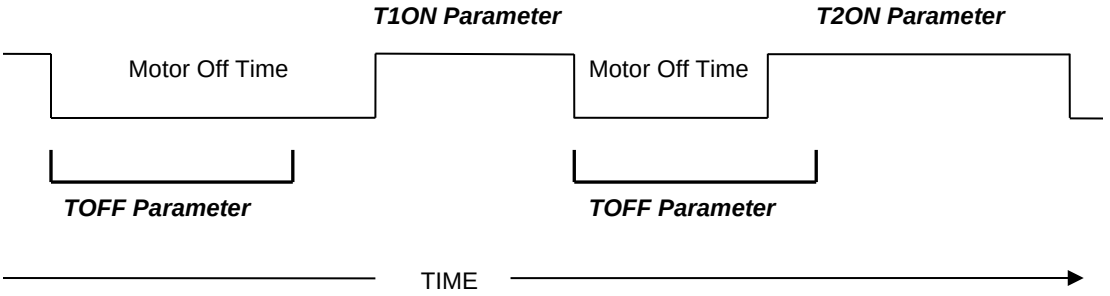


Figure 20 – Motor On and Motor Off Times

Fine Tuning with PI Control

The stability of the constant pressure system (i.e., its tendency **not** to exhibit pressure oscillations) is determined by parameters set on the keypad, the flow rate of the pump, and the volume of the pressure tank. Stability of a system with a large maximum flow rate and a small pressure tank will be more difficult to control and may require de-tuning the system to accept larger variations in the system pressure and longer response times.

Pressure control is achieved by adjusting the values of ***1.7.4 ProPORTIONAL GAIN*** and **1.7.3 Int*EGRAL GAIN.*** Larger values for ***1.7.4 ProPORTIONAL GAIN*** and **1.7.3 Int*EGRAL GAIN*** give smaller error in the

pressure, but also make the system more susceptible to oscillation. The following pages will provide more information on tuning PI control.

Emergency Over-Pressure Limit Switch

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 setpoint should be at least 10 psi higher than the system control pressure to prevent nuisance tripping.

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 application.

First, attempt to control pressure by adjusting parameter ***1.7.4 ProPORTIONAL GAIN***, leaving parameter ***1.7.3 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, ***1.7.4 ProPORTIONAL GAIN*** impacts how quickly the system responds to pressure changes and ***1.7.3 IntEGRAL GAIN*** impacts 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.

For difficult to control systems, a derivative term can be introduced for PID control, which can help control pressure oscillation and overshoot. Increase the value of parameter ***1.7.5 DerIVATIVE GAIN*** to a value greater than zero to enable PID control. This parameter should be used only when necessary as it tends to amplify noise in the transducer signal. The system may become unstable. The parameters ***1.7.12 PID UPDATE RATE*** and ***1.7.13 PID MEASUREMENT FILTER RATE*** help to prevent overshoot.

⚠ **CAUTION:** Long ramp times can interfere with PI control of constant pressure. It is advisable to start with factory default ramp times.

Pressure Control at Minimum Speed

There is a possibility of conflict between the minimum pump speed setting, controlled by the parameter ***1.1.1 MIN FREQUENCY***, 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.

6.2 PerfectPressure™ Setup – Analog Constant Pressure

Upon the first initialization of the unit (or after restoring factory defaults of all parameters using the Two Button Reset Procedure, page 29) the drive will prompt the user to select or decline a quick setup for constant pressure. The display will read **RUN CONSTANT PRESSURE WIZARD? YES(ENTER)/NO(BACK)**. Press

the ENTER key to set up PerfectPressure or the HOME key to decline. Basic parameters for analog constant pressure can be set without navigating through the complete menu options.

Follow this procedure to set up PerfectPressure:

1. **RUN CONSTANT PRESSURE WIZARD? YES (ENTER) / NO (HOME)** – Press the ENTER key to proceed.
2. ***1.4.38.1 MAX PSI SENSOR RANGE*** – This parameter sets the range of the 4-20mA pressure sensor. The factory default is 150 since the standard sensor provided by the factory has a maximum range of 150 psi. If necessary, use the arrow keys to change the value, then press ENTER, or simply press ENTER to proceed.
3. ***1.4.1 ANALOG SETPOINT 1*** – This value determines the pressure you want to maintain. The factory default is 50 psi. Use the arrow keys to change if desired. Press ENTER to proceed.
4. ***1.1.13 SUBMERSIBLE PUMP*** – This parameter sets the ramp profile for a submersible pump. **YES = submersible pump, NO = vertical pump.** For submersible pumps, the frequency accelerates from 0-30 Hz in one second, then follows the ramp time from 30 Hz to maximum frequency. If NO is selected the frequency will increase in a linear fashion from zero to max frequency.
5. ***1.2.1 ENABLE RESTARTS – YES (ENTER) / NO (HOME) –*** enabling restarts controls the ability of the drive to automatically restart after a power failure. The drive will initialize in **AUTO** mode after power is restored if **YES** is selected. If **NO** is selected, the drive will remain **OFF** when power is restored.
6. ***1.1.9 OVERCURRENT LIMIT –*** Setting for motor overload protection (service factor amp rating for the motor).

⚠ **CAUTION:** Most submersible pump motor manufacturers require the motor to reach 30 Hz within one second to protect the pump from damage. Selecting NO for the parameter above will override the factory default ramp time of 0-30 Hz in one second.

This quick setup of constant pressure should provide good pressure control in most situations. It is advisable to read the entire section on constant pressure control for a complete explanation of constant pressure control methods in DXL and LHX Series drives. Refer to **Table 20**, for expanded menu options to fine tune the constant pressure system.

6.3 Analog Constant Pressure Systems

The analog CP system uses an analog pressure transducer connected to the analog input on the Control Terminals (see **Figure 21 for** wiring diagram). 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) or proportional-integral-derivative (PID) 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 application. DXL and LHX Series drives have this type of controller incorporated in them.

In PI control mode the analog signal from the pressure transducer is compared to the parameter ***1.4.1 ANALOG SETPOINT 1***, 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

1.4.1 ANALOG SETPOINT 1 value is multiplied by the ***1.7.4 ProPORTIONAL 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 ***1.7.4 ProPORTIONAL GAIN*** and ***1.7.3 IntEGRAL GAIN*** values give smaller error in the pressure, but also make the system more susceptible to oscillation.

Additional adjustable parameters found in the Constant Pressure menu 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 many 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.

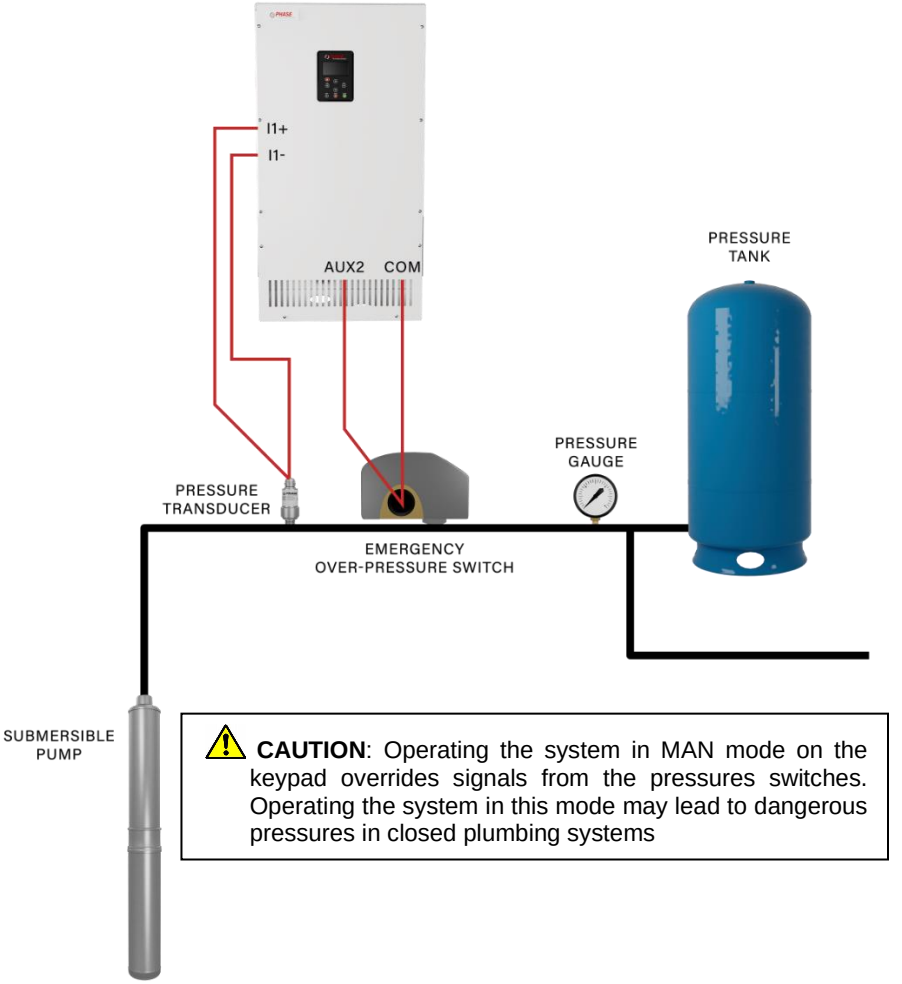


Figure 21 – Analog Constant Pressure One-Line Diagram

Basic 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 I terminals of the 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 Terminal and COM (common). Use a jumper wire to connect AUX2 and COM if no limit switch is present. Also, jumper AUX1 to COM if no external switch is connected to it.
5. Navigate through the keypad to ***1.3.1 SYSTEM CONFIG***. Select ***2*** to set the system configuration for an analog CP system (see **Table 20** 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 positive terminal of the transducer to the I1+ Control Terminal, and the negative terminal to the I1- Control Terminal.
9. If a redundant analog transducer is used, connect it to the I2+ and I2- Terminals in likewise fashion. See **Section 5.5** for instructions on using an additional analog sensor.

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

10. Set the ***1.4.1 ANALOG SETPOINT 1*** on the keypad (see **Table 20** for details)
11. Set the keypad to AUTO mode to operate the system.

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, DXL and LHX drives are equipped with a pre-charge feature.

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 ***1.4.10 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 ***1.4.9 PRECHARGE FREQUENCY*** parameter during the pre-charge interval.

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 ***1.4.11 PRECHARGE*** **PSI** parameter. In this case, the ***1.4.11 PRECHARGE*** **PSI** must be lower than the ***1.4.1 ANALOG SETPOINT 1.***

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 ***1.4.9 PRECHARGE FREQUENCY*** Enter the Pre-charge frequency

2. Navigate through the keypad menu to ***1.4.10 PRECHARGE TIME***. Enter the Pre-charge time in seconds

3. For analog CP systems only, navigate through the keypad menu to ***1.4.11 PRECHARGE PSI***. Enter pre-charge pressure in psi. This value must be lower than the ***1.4.1 ANALOG SETPOINT 1***

4. Set the keypad to AUTO mode to operate the system.

6.4 Lead/Lag Pump Control

When any analog constant pressure system configuration is selected, the Lead/Lag menu is available. See **Table 21** for lead/lag control options. Up to four additional pumps can be controlled through programmable relays on the main control printed circuit board. When the parameter ***1.5.1 NUMBER LAG PUMPS*** is greater than 0, all four relays will convert to control of lead/lag constant pressure.

⚠ **CAUTION**: Activation of lead/lag control overrides the function of all programmable relays. Any function of these relays set up through the Interface Parameters (**Table 19**) will be disabled.

Lead/lag control in pumping systems is a common practice to maintain pressure with highly variable flow. The system is typically configured with a master pump controlled by a VFD operating in constant pressure mode, and with auxiliary pumps that are controlled by the drive. The auxiliary pumps typically operate across-the-line at 60 Hz. They may be equipped with a soft starter to mitigate inrush currents.

If the master pump cannot maintain system pressure it will call for an auxiliary pump by closing a relay on the Control Terminals. DXL and LHX Series drives can control up to four auxiliary pumps. There are features to reduce oscillations and ensure smooth staging and destaging pumps.

Lead/Lag Set-up
System Configuration must be set to one of the constant pressure modes when using lead/lag control. See **Section 5.5**, *System Configuration* for details. Lead/lag control is enabled when the number of lag pumps is set to a value greater than zero in the parameter ***1.5.1 NUMBER LAG PUMPS***.

Programming Steps:
1. Use the keypad to navigate to ***1.5.1 NUMBER LAG PUMPS*** and use the arrow keys to set the number of auxiliary pumps in the system.
2. If necessary, adjust the remaining Lead/Lag parameters after reading the following description of their functions, or after operating conditions dictate.

Lag pumps are turned on and off, or "staged" and "destaged" by programmable relays accessed through the Control Terminals. The drive calls for lag pumps in ascending order, beginning with Relay 1. **Figure 22**, provides a wiring diagram.

Lead Lag Parameters (**Table 21**) are used to smoothly stage the pumps in and out, mitigating pressure oscillation, short cycling, and water hammer. When the master pump cannot maintain pressure, the drive will stage in an auxiliary pump. The drive will destage the pump when flow increases pressure beyond the control point.

Two conditions must be met to stage a pump:

1. The system measured value (PSI, GPM, FT) has decreased to a value equal to ***1.4.1 ANALOG SETPOINT 1*** minus ***1.5.15 STAGE ANALOG LAG***. For example, if the ***1.4.1 ANALOG SETPOINT 1*** is 50 psi and you want to stage a pump in at 45 psi, ***1.5.15 STAGE ANALOG LAG*** should be set to a 5.
2. The time set by ***1.5.2 STAGE PUMP DELAY*** has expired. This delay allows momentary drop in system measured value without calling for a pump to stage in.

Pumps are staged in the following sequence:
1. The relay will open to destage the pump.
2. The speed of the master pump will increase to a value equal to ***1.1.1 MIN FREQUENCY*** plus ***1.5.11 DESTAGE FREQUENCY BOOST 1***. For example, if ***1.1.1 MIN FREQUENCY*** is 30 Hz and ***DESTAGE FREQUENCY BOOST 1*** is 5 Hz, the pump speed will be reduced to 35 Hz.
3. The master pump will operate at increased speed for a period set by ***1.5.5 DESTAGE TIME***.
4. When ***DESTAGE TIME*** has expired the system will resume normal constant pressure control.

Pumps are destaged when the drive has slowed the master pump to maintain control pressure/flow/tank level and the auxiliary pump(s) causes a rise in pressure/flow/tank level.

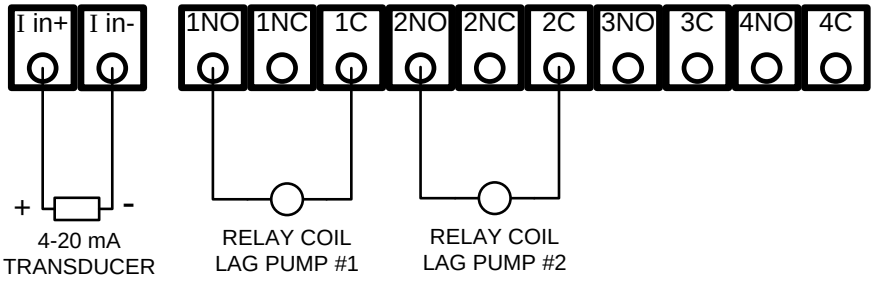
Three conditions must be met to destage a pump:
1. The system measured value (PSI, GPM, FT) has increased to the value set by ***1.5.16 DESTAGE ANLOG LAG*** above ***1.4.1 ANALOG SETPOINT 1***. For example, if ***1.4.1 ANALOG SETPOINT 1*** is 500 GPM and ***1.5.16 DESTAGE ANALOG LAG*** is 50 the pump will destage at 550 GPM.
2. The time set by ***1.5.3 DESTAGE PUMP DELAY*** has expired. This delay prevents destaging the auxiliary pump due to momentary overshoot.
3. The drive frequency to the master pump is between ***1.1.1 MIN FREQUENCY*** and the value of ***1.5.6 DESTAGE MIN FREQUENCY*** plus ***1.1.1 MIN FREQUENCY***. For example, if ***1.1.1 MIN***

FREQUENCY is 30 Hz and ***1.5.6 DESTAGE MIN FREQUENCY*** is 5 Hz, the pump will destage at 35 Hz.

Pumps are destaged in the following sequence:

1. The system measured value will increase by the value set by ***1.5.11 DESTAGE FREQUENCY BOOST 1***. This boost in motor power allows the PI constant pressure loop to react faster to the drop in value when the pump turns off.
2. The system will destage the pump
3. The system will continue to boost the motor power set by ***1.5.11 DESTAGE FREQUENCY BOOST 1*** for a period set by ***1.5.5 DESTAGE TIME***.
4. The system will resume normal constant pressure control.

6.5 Duplex / Multiplex Control



Use the relays in order, beginning with Relay 1.

CAUTION: The relays are rated 0-30 VDC or 120VAC, 0.5 amp. Direct control of the coil on a magnetic motor starter will likely cause damage to the relay and the main control printed circuit board. Use of a secondary control relay, such as an ice cube relay, may be necessary to control the lag pump motor starter.

Figure 22 – Connecting Duplex/Multiplex Systems

When any analog constant pressure system configuration is selected, the ***1.4 CONSTANT PRESSURE PARAMETERS*** and ***1.5 LEAD LAG PARAMETERS*** menus are available. Up to four additional VFDs can be controlled through the relays. When the parameter ***1.5.1 NUMBER LAG PUMPS*** is greater than 0, relays will convert to control of lead/lag or duplex/multiplex constant pressure in sequence. *Example: If 2 lag pumps are entered, Relay 1 & Relay 2 will now be used for Lead/Lag pump control.* In addition, the constant pressure parameter ***1.4.41 DUPLEX CYCLE TIME*** must be greater than 0 for Multiplex control to be active.

When operating in Multiplex Control, the main VFD will assume the role of Master, and all auxiliary VFDs controlled through the relays are known as Slaves. The Master and Slave VFDs will operate in constant pressure mode.

If the Master VFD senses that system pressure cannot be maintained, it will call for a Slave VFD by closing a relay on the Control Terminal. DXL and LHX Series drives can control up to four auxiliary VFDs.

In Multiplex control, the Master VFD might not always be the drive that is operating. The point of a multiplex system is to rotate the use of each available VFD. This is done so that a single drive or pump does not degrade at a faster rate than other drives or pumps in that system. The Master VFD will decide when to stage or destage a VFD. The first pump to be staged in, and the last pump to be destaged, is called the Default VFD.

Multiplex Setup
System configuration must be set to one of the constant pressure modes when using multiplex control. See **Section 5.5**, *System Configuration*, for details. Multiplex control is enabled when ***1.5.1 NUMBER LAG PUMPS*** is greater than 0, and ***1.4.41 DUPLEX CYCLE TIME*** is greater than 0.

Programming Steps:

1. Use the keypad to navigate to ***1.5.1 NUMBER LAG PUMPS*** and use the arrow keys to set the number of auxiliary drives in the system.
2. Navigate to ***1.4.41 DUPLEX CYCLE TIME***, use the arrow keys to set how often the Default drive position will change.
3. If necessary, adjust the remaining Lead/Lag parameters after reading the following description of their functions, or after operating conditions dictate.

In Multiplex control, the Master VFD will utilize the Lead/Lag Parameters and logic similar to lead/lag control in order to decide when to turn on/off a VFD. More detail on the logic behind these decisions will be given in a later section.

It is recommended to run all auxiliary pumps on VFDs, otherwise pressure instability may occur. The Primary Auxiliary Pump could turn on/off resulting in the system pressure oscillating from **(*1.4.1 ANALOG SETPOINT 1 – 1.5.15 STAGE ANALOG LAG*)** to **(*1.4.1 ANALOG SETPOINT 1 + 1.5.16 DESTAGE ANALOG LAG*)**.

The Master VFD stages in VFDs in a different order depending on which VFD is the Primary. When the Master VFD is not the Primary, it will ALWAYS be the second drive to be staged in. The tables below will illustrate the order of the VFDs to be staged or destaged for different values of ***1.5.1 NUMBER LAG PUMPS***.

The Primary drive position will rotate based on the parameter ***1.4.41 DUPLEX CYCLE TIME***.

Master + 1 Slave VFD		
Rotation	**Primary Drive**	**VFD Order**
1st Rotation	Master	M <=> 1
2nd Rotation	Slave VFD 1	1 <=> M

Master + 2 Slave VFD		
Rotation	**Primary Drive**	**VFD Order**
1st Rotation	Master	M <=> 1 <=> 2
2nd Rotation	Slave VFD 1	1 <=> M <=> 2
3rd Rotation	Slave VFD 2	2 <=> M <=> 1

Master + 3 Slave VFD		
Rotation	**Primary Drive**	**VFD Order**
1st Rotation	Master	M <=> 1 <=> 2 <=> 3

2nd Rotation	Slave VFD 1	1 <=> M <=> 2 <=> 3
3rd Rotation	Slave VFD 2	2 <=> M <=> 3 <=> 1
4th Rotation	Slave VFD 3	3 <=> M <=> 1 <=> 2

Master + 4 Slave VFD		
Rotation	**Primary Drive**	**VFD Order**
1st Rotation	Master	M <=> 1 <=> 2 <=> 3 <=> 4
2nd Rotation	Slave VFD 1	1 <=> M <=> 2 <=> 3 <=> 4
3rd Rotation	Slave VFD 2	2 <=> M <=> 3 <=> 4 <=> 1
4th Rotation	Slave VFD 3	3 <=> M <=> 4 <=> 1 <=> 2
5th Rotation	Slave VFD 4	4 <=> M <=> 1 <=> 2 <=> 3

Two conditions must be met to stage in a VFD:

1. The system has decreased to a value (PSI, GPM, FT) equal to ***1.4.1 ANALOG SETPOINT 1*** minus ***1.5.15 STAGE ANALOG LAG***. ***NOTE:*** Primary Slave VFDs and Primary Master Drives will ignore the ***1.5.2 STAGE PUMP DELAY*** parameter, and immediately stage in if the system pressure drops below the threshold.
2. The time set by ***1.5.2 STAGE PUMP DELAY*** has expired. This delay allows a momentary drop in system pressure without calling for a drive to stage in.

Steps To Stage A Drive:

1. The selected drive will be staged in. The selected drive is based on the order given in the tables above. This will either close the Slave VFD's corresponding relay or move the Master VFD out from sleep mode.
2. The speed of the master pump will decrease to a value equal to ***1.1.2 MAX FREQUENCY*** minus the corresponding ***1.5.7 STAGE FREQUENCY REDUCTION 1***.
3. The Master VFD will operate at a reduced speed for a period set by ***1.5.4 STAGE TIME***.
4. When ***1.5.4 STAGE TIME*** has expired the system will resume normal constant pressure control.

   Note: The Master VFD does NOT have corresponding ***1.5.7 STAGE FREQUENCY REDUCTION 1*** or ***1.5.4 STAGE TIME*** parameters.

Destaging:

Drives are destaged when the drive has slowed the master pump to maintain control pressure and the Slave VFD(s) causes a rise in pressure.

Three conditions must be met to destage a VFD:

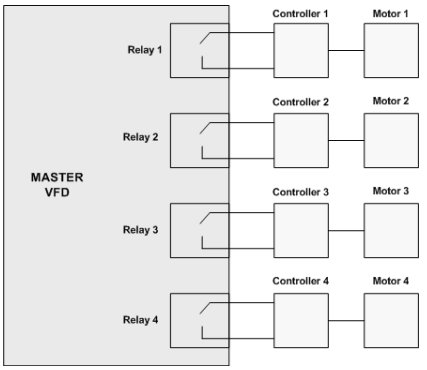
1. The system measured value (PSI, GPM, FT) has increased to the value set by ***1.4.1 ANALOG SETPOINT 1*** plus ***1.5.16 DESTAGE ANALOG LAG***.
2. The time set by ***1.5.3 DESTAGE PUMP DELAY*** has expired. This delay prevents destaging VFDs due to momentary pressure overshoot.

The Master drive frequency is between ***1.1.1 MIN FREQUENCY*** and the value of ***1.1.1 MIN FREQUENCY*** plus ***1.5.6 DESTAGE MIN FREQUENCY***.

Steps To Destage A Drive:

1. The selected drive will be destaged. The selected drive is based on the order given in the tables above. This will either open the Slave VFD's corresponding relay or set the Master VFD to sleep mode.

2. The frequency of the master pump will increase by ***1.5.11 DESTAGE FREQUENCY BOOST 1***.
3. The Master VFD will operate at an increased speed for a period set by ***1.5.5 DESTAGE TIME***.
4. When ***1.5.5 DESTAGE TIME*** has expired the system will resume normal constant pressure control.



Note:
Only one controller is necessary for Lead/Lag or Multiplex but up to four are available.

Figure 23 – Lead/Lag or Multiplex Block

Note: Setting ***1.3.4 PROGRAM RELAY 1*** to **6: JOCKEY PUMP**, will cause Relay 1 to not participate in lead/lag or multiplex control. The order pumps are staged or destaged will remain the same, except the Master will skip Relay 1. Relay 1 will also never become the Primary when it is set to Jockey Pump.

6.6 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 requires adjustment of the constant pressure parameters.

For the drive to enter sleep mode while operating in CP mode, three conditions must be met:

1. The pressure in the system must be at the pressure control point set by the parameter ***1.4.1 ANALOG SETPOINT 1*** (for analog systems) or at the pressure determined by the setting on the digital pressure switch.
2. The frequency is below ***1.4.5 SLEEP FREQUENCY*** (as defined as ***1.1.1 MIN FREQUENCY*** + input value) or measured pressure is above ***1.4.7 WAKE UP THRESHOLD*** (as defined as ***1.4.1 ANALOG SETPOINT 1*** + the input value)**.**
3. The time expired since the pump started after the last OFF cycle must be greater than parameter ***1.4.23 T1 ON*** or ***1.4.24 T2ON***.

When these conditions have been met, the drive will go to sleep. The duration of which the drive is asleep depends on the rate at which the system bleeds down and the width of the dead band. 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 (and vice versa) usually requires some adjusting of the parameters.

7 TROUBLESHOOTING

This section provides information on fault codes 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 for the time specified on the drive warning label, 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 display for fault codes if the drive or its load is not operating. Disconnecting the input power could potentially clear any fault code indication, possibly losing valuable information for troubleshooting.

7.1 Fault Codes

Fault codes are indicated on the graphic display. See **Table 29** 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. The load will start immediately. The Restart Log is a resettable fault log that can be used to monitor faults that allow auto restart. Use the Clear Memory function to reset the Restart Log and set all fault counters to zero. See Section 4.2, Keypad Main Menu Items, for more information on Restart Log and Clear Memory function.

⚠ **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 this type of fault occurs, the display will read ***NO AUTO RESTART***. Refer to **Table 29**, *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 of fault occurs, contact the factory for assistance before restarting or troubleshoot the system thoroughly. **These faults can be cleared only by cycling input power OFF/ON or by pressing both arrow keys for 3 seconds.**

⚠ **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.

7.2 Clearing a Fault

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. The countdown can be interrupted by pressing and holding the UP and DOWN arrow keys. The load will immediately restart.

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 under ***1.2.2 NUMBER OF AUTO RESTARTS***.

If the drive has exceeded the programmed number of auto restarts, or if auto restarts have not been enabled, the display will indicate the fault on the top line and the second line will read ***RESTART? ENTER***. Press ENTER to clear the fault and restart the load. The fault counters in the Restart Log will all be reset to zero. See **Section 3.6**, *Restart Log*, for more information.

The ***1.2.1 ENABLE RESTART*** parameter allows 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. The factory default setting allows auto restarts. See **Table 19** for more information.

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 this type fault occurs, the display will read ***NO AUTO RESTART***. When this type fault occurs, contact the factory for assistance before restarting or troubleshoot the system thoroughly. **These faults can be cleared only by cycling input power OFF/ON or by holding the UP and DOWN arrow keys for 3 seconds.**

There are several conditions where the drive will indicate a fault, but the fault will not be recorded in the fault log. These faults occur only when the drive is energized from utility mains and is initializing. If any condition including ground fault, pre-charge fail, high input voltage or low input voltage is detected, the display will indicate the fault and wait for the condition to resolve before entering normal operating mode. If these conditions occur after the drive has initialized, a fault will be logged and can be cleared in the normal manner.

 **WARNING:** The drive may start automatically without warning when operating conditions permit. Make certain input power is disconnected before servicing the unit or its connected loads.

Table 29 – Fault Codes

MESSAGE	DESCRIPTION / COMMENTS	PARAM RELATED (1)	NO AUTO RESTARTS (2)
Alarm Fault	Triggered when an alarm occurs that has been set to Fault via the ***11 ALARMS*** menu.	X	
AUX1 Latch Fault	Switch connected to AUX1 input has closed. Drive will remain off until fault is cleared. See parameter ***1.3.8 AUX 1 SELECT***.	X	X
AUX2 Latch Fault	Switch connected to AUX2 input has closed. Drive will remain off until fault is cleared. See parameter ***1.3.19 AUX 2 SELECT***.	X	X
AUX3 Latch Fault	Switch connected to AUX3 input has closed. Drive will remain off until fault is cleared. See parameter ***1.3.10 AUX 3 SELECT***.	X	X
AUX4 Latch Fault	Switch connected to AUX4 input has closed. Drive will remain off until fault is cleared. See parameter ***1.3.11 AUX 4 SELECT***.	X	X
Broken Pipe Fault	Indicates the possibility of a broken pipe. Fault is triggered when drive cannot reach the Analog Setpoint. Check parameter ***1.4.16 BROKEN PIPE THRESHOLD*** to eliminate the possibility of nuisance fault.	X	
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. Will trip if bus reaches 470 VDC on 230V systems or 930VDC on 460V systems.		
Bus Voltage Unbalance	The DC bus voltages are more than 10% unbalanced. Can be caused by bus cap failure.		
Comm Error	Interface and Drive boards are experiencing a communication failure. Check RJ45 cable between Interface and Drive boards.		
CPLD Error	CPLD is not running. If cycling power does not clear the fault, the Drive board needs to be replaced. 3LHX may be reprogrammed to run as a DXL to bypass the fault. Contact factory for assistance.		
Current Unbalance	Motor current unbalance has exceeded the ***1.1.29 CURRENT UNBALANCE*** limit. Check motor load for normal operation. Fault can be bypassed by increasing parameter ***1.1.29 CURRENT UNBALANCE***.	X	
DAC Error	Triggered if DSP's internal comparators read faulty data. If cycling power several times does not clear the fault, the Drive board needs to be replaced. 3LHX may be reprogrammed to run as a DXL to bypass the fault. Contact factory for assistance.		X
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 fault. The sensitivity of fault detection can be adjusted by the parameter ***1.1.12 GROUND FAULT SENSITIVITY***.	X	X
High Input Voltage	Input voltage has exceeded the following levels for 10 seconds: 264VAC for 230V systems, 520VAC for 460V systems. Reduce input voltage.		
Input 1Ph Fault	Indicates a loss of phase on the input 3-phase lines, or severe voltage unbalance. If the system is intended to be powered by single-phase, set ***1.3.19 ENABLE 1PH INPUT*** to YES.	X	
Input CM Connection Fault	Cables to input current measurement (CM) boards disconnected. Power system down and check cable to input CM boards.		X

MESSAGE	DESCRIPTION / COMMENTS	PARAM RELATED (1)	NO AUTO RESTARTS (2)
Input Fault	Sudden high input current or internal fault. Input IGBT desat protection triggers this fault.		
Input Overload	Triggered instantly when input current is greater than 2x rated current or when input current is greater than 1.4x rated current for three seconds, based on Class 10 Trip Curve. Check for reduced input voltage as this may increase input current. May also be caused by high current in the motor circuit.		
IP Hall Sense Hi	Current exceeded the maximum rating of the input CM board. May be caused by low input voltage, a locked rotor, or internal fault.		
Low Input Voltage	Input voltage has fallen below a level for safe operation of the drive. Will trip on startup if input voltage is below 190VAC for 230V systems or below 440VAC for 460V systems.		
Low Suction Fault	PSI measured below ***1.4.40 LOW PRESSURE FAULT LEVEL*** for longer than specified ***1.4.39 SUCTION PRESSURE TIME***.	X	
Motor Overload	Output current has exceeded the value set by parameter ***1.1.9 OVER CURRENT LIMIT***. Check motor load. Ensure that ***1.1.18 OVERCURRENT DERATE ENABLE*** is set to YES.	X	
OP Hall Sense Hi	Current exceeded the maximum rating of the output CM board. May indicate a fault in the motor circuit or internal fault.		
Output CM Connection Fault	Cables to output current measurement (CM) boards disconnected. Power system down and check cable to output CM board.		X
Output Fault	High current as measured by the IGBT. Check for short circuit on output lines and load. Output IGBT desat protection triggers this fault.		
Output Overload	Indicates a large and sudden overcurrent on the output module. Check motor circuit for faults. The overcurrent may be of a very short duration that cannot be captured by amp meters. Ensure that ***1.1.17 OVERLOAD DERATE ENABLE*** is set to YES. If an output filter is installed, verify it is wired correctly.	X	
Over Temperature	Internal temperature of IGBT has exceeded 113°F. Reduce ambient temp. Check fan operation and ventilation openings for obstruction. Ensure that ***1.1.19 OVER TEMPERATURE DERATE ENABLE*** is set to YES.	X	
PLL Fault (Phase Lock Loop)	Unable to lock onto the frequency of incoming power. Caused by grid distortion, unstable frequency, or an undersized generator. Cycling power OFF/ON can clear the fault if caused by an isolated incident.		
Sensor Connection Fail	4-20mA or 10VDC analog signal is not present on Control Terminals. This could indicate failure of the analog sensor or a disconnected sensor cable.		
Temp Sense Fault	Temperature sensor on the IGBT has failed or its cable is disconnected. Turn power off and check cables to IGBTs.		
Under Current	Motor current has fallen below the value set by parameter ***1.1.10 UNDER CURRENT***. Commonly used to detect a dry well condition.	X	

1 = Fault may be related to an adjustable parameter. Always check the value of the parameter to eliminate nuisance tripping.

2 = No automatic restarts allowed. The drive has shut down due to a potentially dangerous condition. Drive will remain OFF until fault is cleared. Turn power off and troubleshoot the system before restarting.

7.3 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, ***6 FAULT 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 ***5 RESTART LOG*** or ***7 CLEAR MEMORY***. 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 30 – Troubleshooting

PROBLEM	POTENTAIL CAUSE	SOLUTION
Unit does not power up	Circuit breaker tripping	If incoming circuit breaker continually trips when VFD starts, the breaker and cable sizes should be sized by a certified electrician. Consider increasing breaker size.
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 ENTER on the keypad or by cycling input power OFF/ON.
	Are the remote AUX switches 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 set to ON 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 MANUAL mode is selected. Keypad must be in AUTO mode for external control signals to control the motor.
	Is MAX FREQUENCY set to 0 Hz?	Check the parameter ***1.1.2 MAX FREQUENCY***.
	Are the input terminals energized?	Check the input circuit breaker and fuses.
Motor is turning the wrong direction	Phase sequence on output terminals U, V, W is out of order	Swap any two of the three motor leads on the output terminals **OR** use parameter ***1.1.6 REVERSE ROTATION*** via keypad.
Real Time Clock (RTC) clearing or not providing fault time stamps	Dead battery	Replace CR2032 battery, located on the Interface control board to the left of the graphic display.

8 ROUTINE INSPECTION AND MAINTENANCE

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

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.

Power terminals: Inspect for loose connections and tighten to specifications in **Table 2** - **Table 4**.

Capacitors: Check for leakage or deformation.

Fans and heatsinks: Excessive dust buildup on the heatsink and cooling fan impellers may lead to overheating. Lightly brush and vacuum clean. 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 fail to cool the unit properly, risking component damage.

Battery
The drive is equipped with a battery that provides power to a real-time clock. The clock allows faults to be stamped with time and date. The battery is located on the control printed circuit board. It is a button cell lithium battery rated at 3.0V, type CR2032. The battery should last many years under normal operating conditions. If the battery fails, the drive will continue to operate normally; losing only the ability to timestamp faults and provide timed operation of programmable relays.

9 MODELS AND RATINGS

9.1 Global Specifications

The DXL and LHX Series drives are engineered to minimize heat and noise losses, which contribute to inefficiencies. These drives consistently achieve efficiencies exceeding 98%.

Table 31 – Global Specifications

Specs		Range
Input Frequency		50/60 Hz
Output Frequency		5 - 120 Hz
Switching Frequency*	**5 - 10 HP:**	2 - 5 kHz
	125+ HP:	1.5 - 5 kHz
	DXL VD:	2 - 8 kHz

*Switching Frequency is an adjustable parameter set through the keypad (See **Table 17**).

DXL drives can be powered by a single-phase input, but the output current will be de-rated by half. Parameter ***1.3.19 ENABLE 1PH INPUT*** must be set to YES.

9.1.1 Derating Operating Temperature at High Elevations

Peripheral cooling components of the DXL and LHX Series drives operate at decreased effectiveness at higher elevations. At elevations of 3,300 feet (1,000 m) and lower, the drive can reach its full rated current. Current must be derated by 1% for every 400 feet above 3,300 ft. See **Figure 24** for details.

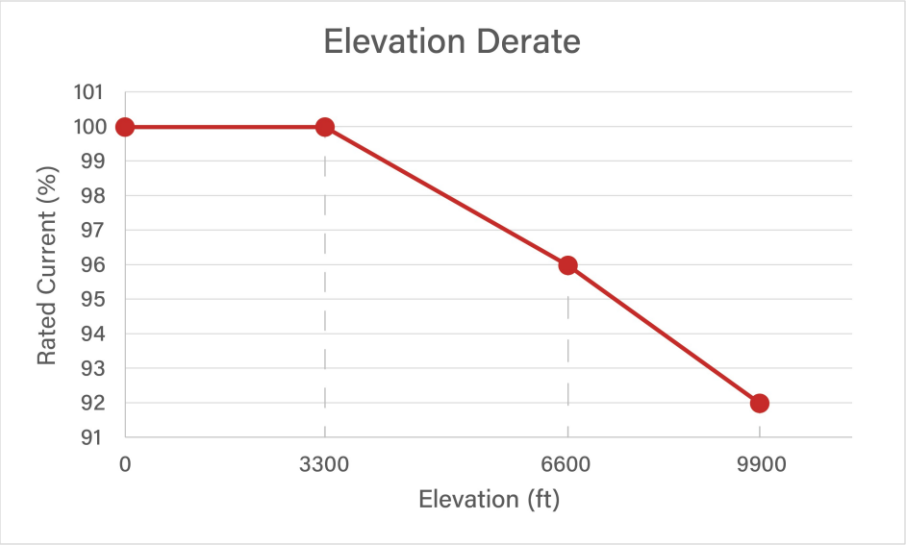


Figure 24 – Elevation Derate Chart

9.2 DXL Model Nomenclature

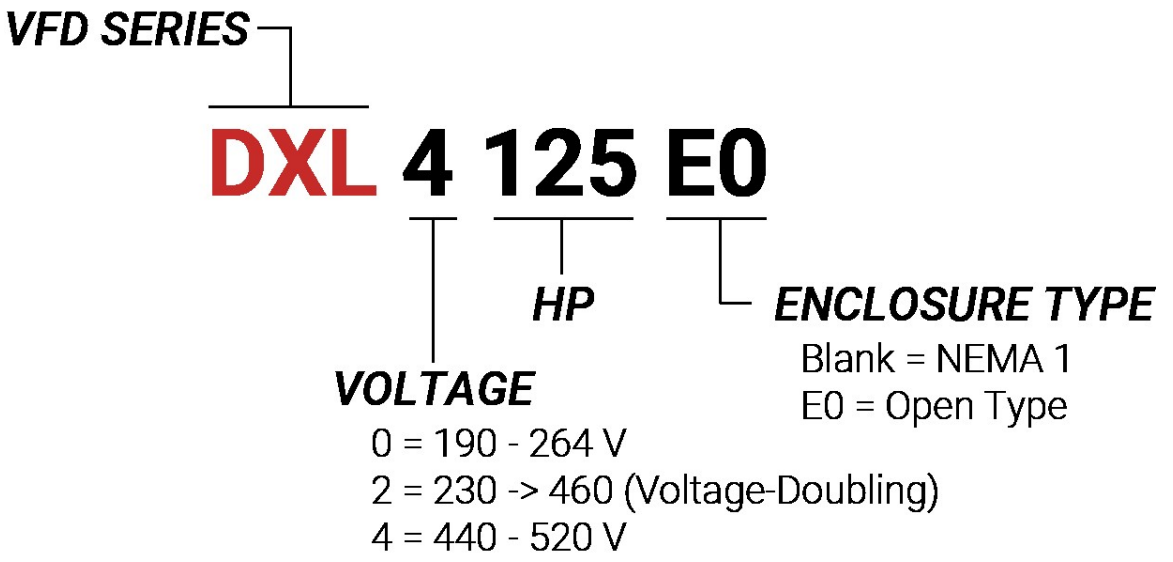


Figure 25 – DXL Series Nomenclature

Table 32 – DXL Ratings

Model	Frame Size	Rated HP (kW)	Rated Input Voltage[1]	Rated Output Voltage[3]	Rated Input/Output Current
DXL005	D1	5 (3.7)	200-240 V, 3-phase	0-V_{IN}, 3-phase	18 A
DXL007	D1	7.5 (5)	200-240 V, 3-phase	0-V_{IN}, 3-phase	24 A
DXL010	D1	10 (7.5)	200-240 V, 3-phase	0-V_{IN}, 3-phase	31 A
DXL015	D1	15 (11)	200-240 V, 3-phase	0-V_{IN}, 3-phase	46 A
DXL020	D1	20 (15)	200-240 V, 3-phase	0-V_{IN}, 3-phase	61 A
DXL025	D1	25 (18.5)	200-240 V, 3-phase	0-V_{IN}, 3-phase	75 A
DXL030	D1	30 (22)	200-240 V, 3-phase	0-V_{IN}, 3-phase	91 A
DXL205[2]	D1	5 (3.3)	200-240 V, 1-phase	0-2 x V_{IN}, 3-phase	30 A / 9 A
DXL207[2]	D1	7.5 (5)	200-240 V, 1-phase	0-2 x V_{IN}, 3-phase	52 A / 13 A
DXL210[2]	D1	10 (7.5)	200-240 V, 1-phase	0-2 x V_{IN}, 3-phase	64 A / 18 A
DXL215[2]	D1	15 (11)	200-240 V, 1-phase	0-2 x V_{IN}, 3-phase	87 A / 24 A
DXL405	D1	5 (3.7)	200-480 V, 3-phase	0-V_{IN}, 3-phase	9 A
DXL407	D1	7.5 (5)	200-480 V, 3-phase	0-V_{IN}, 3-phase	13 A
DXL410	D1	10 (7.5)	200-480 V, 3-phase	0-V_{IN}, 3-phase	18 A
DXL415	D1	15 (11)	200-480 V, 3-phase	0-V_{IN}, 3-phase	24 A
DXL420	D1	20 (15)	200-480 V, 3-phase	0-V_{IN}, 3-phase	31 A

Model	Frame Size	Rated HP (kW)	Rated Input Voltage[1]	Rated Output Voltage[3]	Rated Input/Output Current
DXL425	D1	25 (18.5)	200-480 V, 3-phase	0-V_{IN}, 3-phase	38 A
DXL430	D1	30 (22)	200-480 V, 3-phase	0-V_{IN}, 3-phase	46 A
DXL440	D1	40 (30)	200-480 V, 3-phase	0-V_{IN}, 3-phase	61 A
DXL450	D1	50 (37)	200-480 V, 3-phase	0-V_{IN}, 3-phase	77 A
DXL460	D3	60 (45)	200-480 V, 3-phase	0-V_{IN}, 3-phase	86 A / 91 A
DXL475	D3	75 (55)	200-480 V, 3-phase	0-V_{IN}, 3-phase	101 A / 107 A
DXL4100	D3	100 (75)	200-480 V, 3-phase	0-V_{IN}, 3-phase	134 A / 142 A
DXL4125	D3	125 (90)	200-480 V, 3-phase	0-V_{IN}, 3-phase	163 A / 172 A
DXL4150	D3	150 (110)	200-480 V, 3-phase	0-V_{IN}, 3-phase	188 A / 198 A
DXL4200	D3	200 (150)	200-480 V, 3-phase	0-V_{IN}, 3-phase	237 A / 250 A
DXL4250	D3	250 (185)	200-480 V, 3-phase	0-V_{IN}, 3-phase	288 A / 304 A
DXL4300	D4	300 (220)	200-480 V, 3-phase	0-V_{IN}, 3-phase	346 A / 365 A
DXL4350	D4	350 (260)	200-480 V, 3-phase	0-V_{IN}, 3-phase	394 A / 415 A
DXL4400	D4	400 (300)	200-480 V, 3-phase	0-V_{IN}, 3-phase	454 A / 478 A
DXL4500	D4	500 (375)	200-480 V, 3-phase	0-V_{IN}, 3-phase	560 A / 590 A

(1) Single Phase Input Voltage will result in 50% decrease in Rated Output Current compared to Input Current, see section **9.2.1 DXL Single Phase Input** for more information. Single phase and 3-phase input voltage is acceptable.
(2) DXL Series Voltage Doubling drives require single phase input voltage. See section **9.2.2 DXL Voltage Doubling** for more information.
(3) V_{IN} refers to input voltage.

9.2.1 DXL Single Phase Input

For the DXL Series drives, when supplied with single-phase input voltage, the rated output current experiences a 50% decrease relative to the rated input current. Note: Interface Parameter ***1.3.19 ENABLE 1PH INPUT*** must be configured to "Yes" when single phase input voltage is supplied to a DXL drive.

To illustrate, consider the DXL007 drive with a single-phase 230 V input voltage, which will yield a 3-phase 230 V output voltage at a current rating of 12 A, which is 50% of the rated output current, shown in **Table 32**.

9.2.2 DXL Voltage Doubling

For the DXL Series Voltage Doubling drives (i.e. DXL210), single-phase input voltage is required. The 3-phase output voltage will be approximately double that of the input voltage. Note: Interface Parameter ***1.3.19 ENABLE 1PH INPUT*** is not an applicable parameter for DXL Series Voltage Doubling drives.

To illustrate, consider the DXL210 drive with a single-phase 230 V input voltage with a 64 A input current, which will yield a 3-phase 460 V output voltage at an 18 A output current, shown in **Table 32**.

9.3 3LHX Model Nomenclature

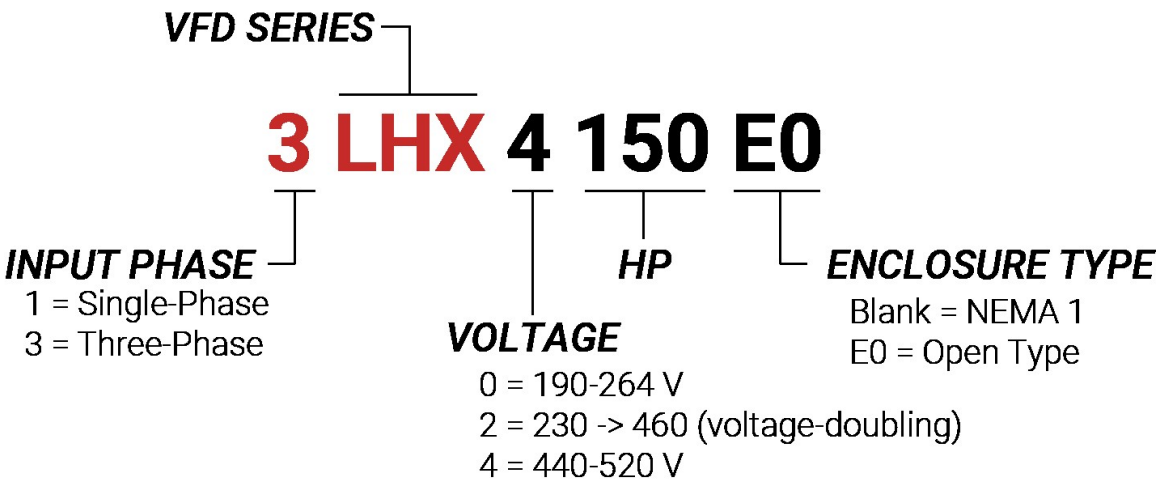


Figure 26 – LHX Series Nomenclature

Table 33 – 3LHX Series Ratings

Model	Frame Size	Rated HP (kW)	Rated Input Voltage	Rated Output Voltage	Rated Input/Output Current
3LHX005	L1	5 (4)	230 V, 3-phase	230 V, 3-phase	18 A
3LHX007	L1	7 (5)	230 V, 3-phase	230 V, 3-phase	25 A
3LHX010	L1	10 (7.5)	230 V, 3-phase	230 V, 3-phase	31 A
3LHX015	L1	15 (11)	230 V, 3-phase	230 V, 3-phase	46 A
3LHX020	L1	20 (15)	230 V, 3-phase	230 V, 3-phase	61 A
3LHX025	L1	25 (18.5)	230 V, 3-phase	230 V, 3-phase	75 A
3LHX030	L1	30 (22)	230 V, 3-phase	230 V, 3-phase	91 A
3LHX205	L1	5 (4)	230 V, 3-phase	460 V, 3-phase	18 A / 9 A
3LHX207	L1	7.5 (5)	230 V, 3-phase	460 V, 3-phase	25 A / 13 A
3LHX210	L1	10 (7.5)	230 V, 3-phase	460 V, 3-phase	30 A / 18 A
3LHX215	L1	15 (11)	230 V, 3-phase	460 V, 3-phase	46 A / 25 A
3LHX220	L1	20 (15)	230 V, 3-phase	460 V, 3-phase	60 A / 31 A
3LHX225	L1	25 (18.5)	230 V, 3-phase	460 V, 3-phase	77 A / 38 A
3LHX230	L2	30 (22)	230 V, 3-phase	460 V, 3-phase	91 A / 46 A
3LHX240	L2	40 (30)	230 V, 3-phase	460 V, 3-phase	121 A / 61 A

Model	Frame Size	Rated HP (kW)	Rated Input Voltage	Rated Output Voltage	Rated Input/Output Current
3LHX250	L2	50 (37)	230 V, 3-phase	460 V, 3-phase	154 A / 77 A
3LHX260	L3	60 (45)	230 V, 3-phase	460 V, 3-phase	182 A / 91 A
3LHX275	L3	75 (55)	230 V, 3-phase	460 V, 3-phase	214 A / 107 A
3LHX2100	L3	100 (75)	230 V, 3-phase	460 V, 3-phase	284 A / 142 A
3LHX405	L1	5 (4)	460 V, 3-phase	460 V, 3-phase	9 A
3LHX407	L1	7.5 (5)	460 V, 3-phase	460 V, 3-phase	13 A
3LHX410	L1	10 (7.5)	460 V, 3-phase	460 V, 3-phase	18 A
3LHX415	L1	15 (11)	460 V, 3-phase	460 V, 3-phase	25 A
3LHX420	L1	20 (15)	460 V, 3-phase	460 V, 3-phase	31 A
3LHX425	L1	25 (18.5)	460 V, 3-phase	460 V, 3-phase	38 A
3LHX430	L1	30 (22)	460 V, 3-phase	460 V, 3-phase	46 A
3LHX440	L1	40 (30)	460 V, 3-phase	460 V, 3-phase	61 A
3LHX450	L1	50 (37)	460 V, 3-phase	460 V, 3-phase	77 A
3LHX460	L2	60 (45)	460 V, 3-phase	460 V, 3-phase	91 A
3LHX475	L2	75 (55)	460 V, 3-phase	460 V, 3-phase	107 A
3LHX4100	L2	100 (75)	460 V, 3-phase	460 V, 3-phase	142 A
3LHX4125	L2	125 (90)	460 V, 3-phase	460 V, 3-phase	172 A
3LHX4150	L2	150 (110)	460 V, 3-phase	460 V, 3-phase	198 A
3LHX4200	L3	200 (150)	460 V, 3-phase	460 V, 3-phase	250 A
3LHX4250	L3	250 (185)	460 V, 3-phase	460 V, 3-phase	304 A
3LHX4300	L3	300 (220)	460 V, 3-phase	460 V, 3-phase	362 A
3LHX4350	L4	350 (260)	460 V, 3-phase	460 V, 3-phase	415 A
3LHX4400	L4	400 (299)	460 V, 3-phase	460 V, 3-phase	478 A
3LHX4450	L4	450 (336)	460 V, 3-phase	460 V, 3-phase	515 A
3LHX4500	L4	500 (373)	460 V, 3-phase	460 V, 3-phase	590 A
3LHX4600	L5	600 (447)	460 V, 3-phase	460 V, 3-phase	730 A
3LHX4700	L5	700 (522)	460 V, 3-phase	460 V, 3-phase	830 A
3LHX4900	L5	900 (671)	460 V, 3-phase	460 V, 3-phase	960 A

9.4 1LHX Model Nomenclature

See **Figure 26** for 1LHX Series naming convention.

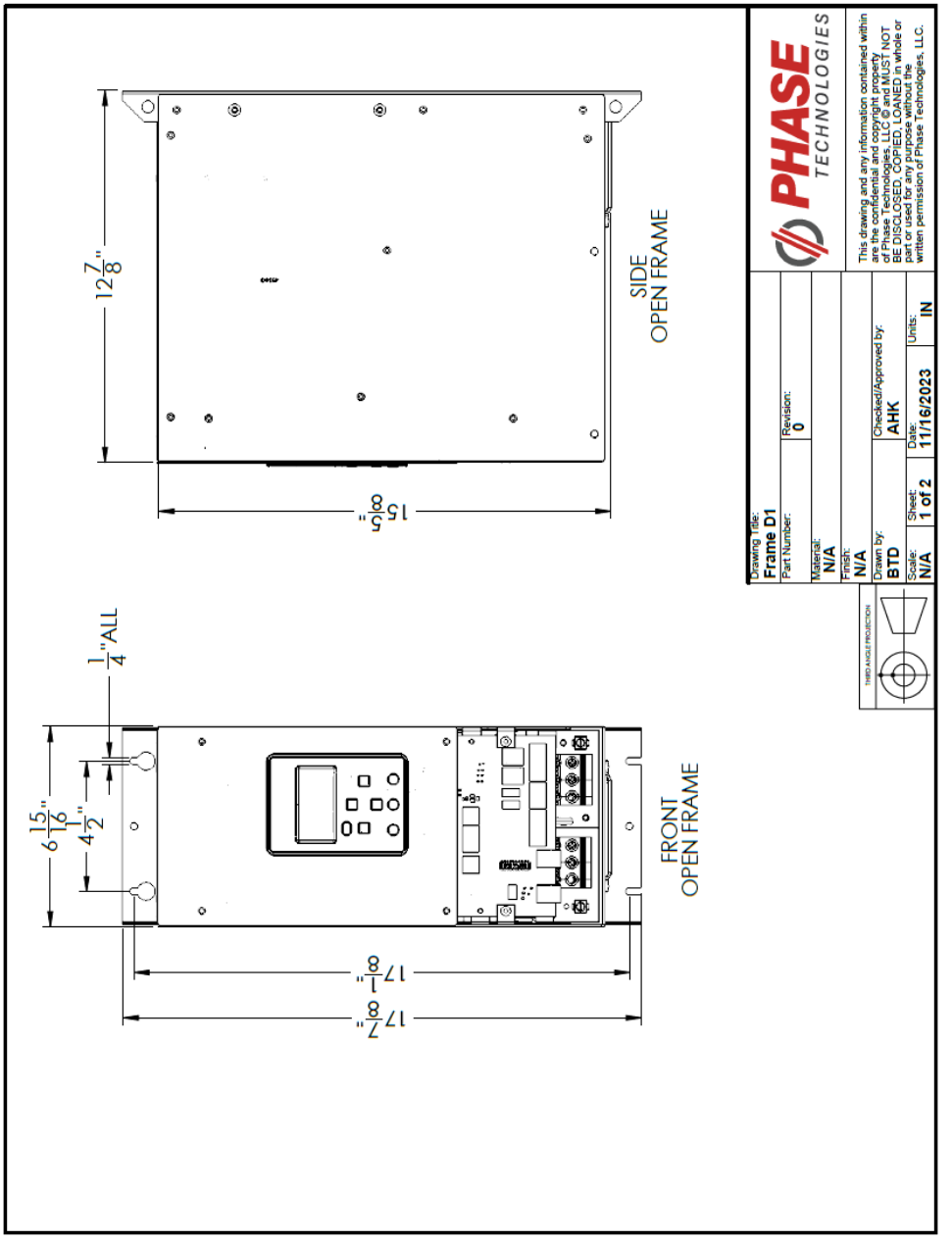
Table 34 – 1LHX Series Ratings

Model	Frame Size	Rated HP (kW)	Rated Input Voltage	Rated Output Voltage	Rated Input/Output Current
1LHX005	L1	5 (4)	230 V, 1-phase	230 V, 3-phase	26 A / 18 A
1LHX007	L1	7.5 (5)	230 V, 1-phase	230 V, 3-phase	37 A / 25 A
1LHX010	L1	10 (7.5)	230 V, 1-phase	230 V, 3-phase	48 A / 31 A
1LHX015	L1	15 (11)	230 V, 1-phase	230 V, 3-phase	72 A / 46 A
1LHX020	L1	20 (15)	230 V, 1-phase	230 V, 3-phase	97 A / 62 A
1LHX205	L1	5 (4)	230 V, 1-phase	460 V, 3-phase	26 A / 9 A
1LHX207	L1	7.5 (5)	230 V, 1-phase	460 V, 3-phase	37 A / 13 A
1LHX210	L1	10 (7.5)	230 V, 1-phase	460 V, 3-phase	50 A / 18 A
1LHX215	L1	15 (11)	230 V, 1-phase	460 V, 3-phase	67 A / 24 A
1LHX220	L1	20 (15)	230 V, 1-phase	460 V, 3-phase	97 A / 31 A
1LHX225	L1	25 (18.5)	230 V, 1-phase	460 V, 3-phase	115 A / 38 A
1LHX230	L2	30 (22)	230 V, 1-phase	460 V, 3-phase	139 A / 46 A
1LHX240	L2	40 (30)	230 V, 1-phase	460 V, 3-phase	196 A / 61 A
1LHX250	L3	50 (37)	230 V, 1-phase	460 V, 3-phase	226 A / 77 A
1LHX260	L3	60 (45)	230 V, 1-phase	460 V, 3-phase	282 A / 91 A
1LHX405	L1	5 (4)	230 V, 1-phase	460 V, 3-phase	13 A / 9 A
1LHX407	L1	7.5 (5)	230 V, 1-phase	460 V, 3-phase	19 A / 13 A
1LHX410	L1	10 (7.5)	230 V, 1-phase	460 V, 3-phase	26 A / 18 A
1LHX415	L1	15 (11)	230 V, 1-phase	460 V, 3-phase	36 A / 25 A
1LHX420	L1	20 (15)	460 V, 1-phase	460 V, 3-phase	48 A / 31 A
1LHX425	L1	25 (18.5)	460 V, 1-phase	460 V, 3-phase	60 A / 38 A
1LHX430	L1	30 (22)	460 V, 1-phase	460 V, 3-phase	72 A / 46 A
1LHX440	L2	40 (30)	460 V, 1-phase	460 V, 3-phase	98 A / 61 A
1LHX450	L2	50 (37)	460 V, 1-phase	460 V, 3-phase	121 A / 77 A
1LHX460	L2	60 (45)	460 V, 1-phase	460 V, 3-phase	143 A / 91 A
1LHX475	L2	75 (55)	460 V, 1-phase	460 V, 3-phase	170 A / 107 A
1LHX4100	L3	100 (75)	460 V, 1-phase	460 V, 3-phase	226 A /142 A
1LHX4125	L3	125 (90)	460 V, 1-phase	460 V, 3-phase	273 A / 172 A
1LHX4150	L3	150 (110)	460 V, 1-phase	460 V, 3-phase	315 A / 198 A
1LHX4200	L4	200 (150)	460 V, 1-phase	460 V, 3-phase	398 A / 250 A
1LHX4250	L4	250 (185)	460 V, 1-phase	460 V, 3-phase	483 A / 304 A

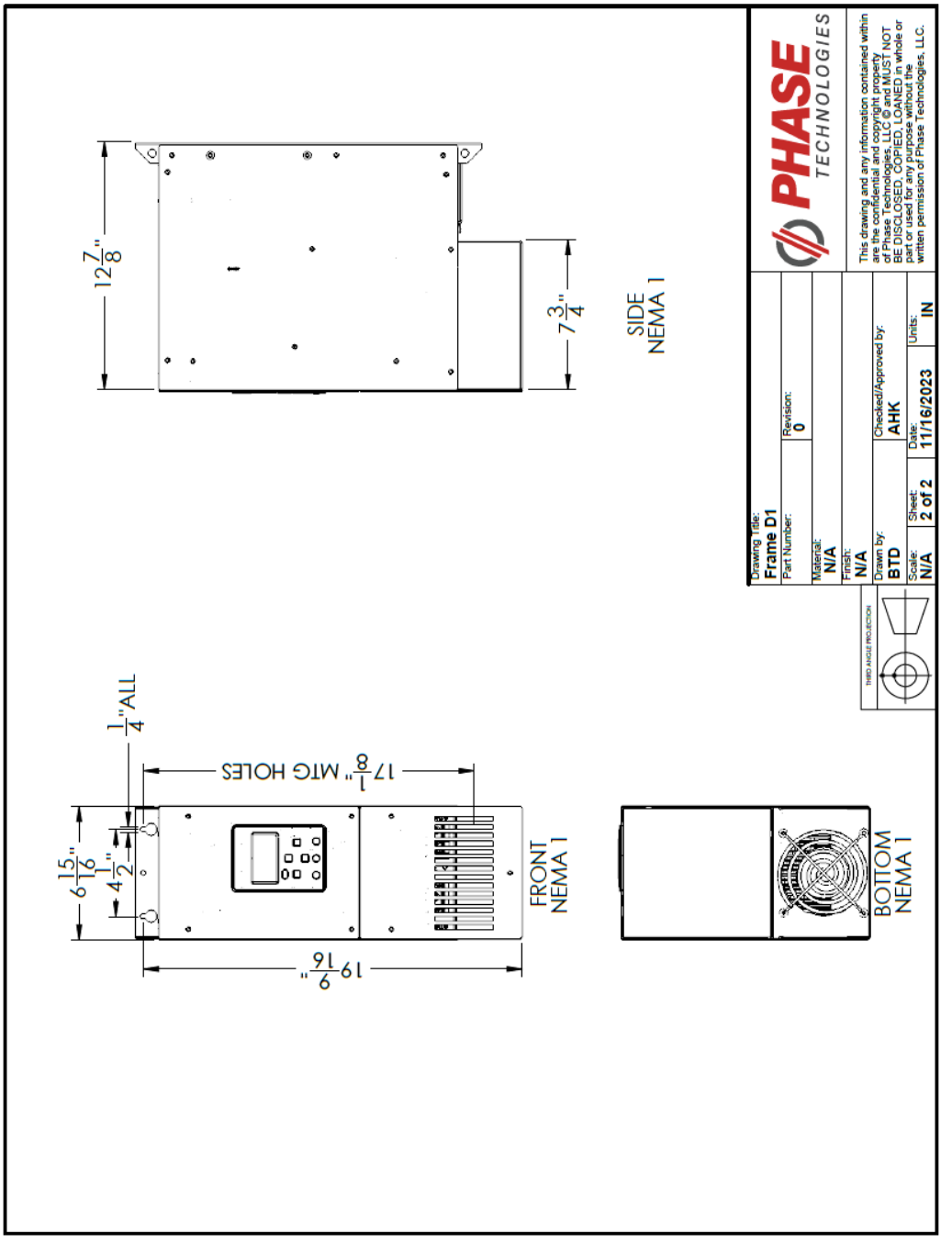
9.5 Dimensional Drawings

See **Table 32 - Table 34** to identify the frame size for each model.

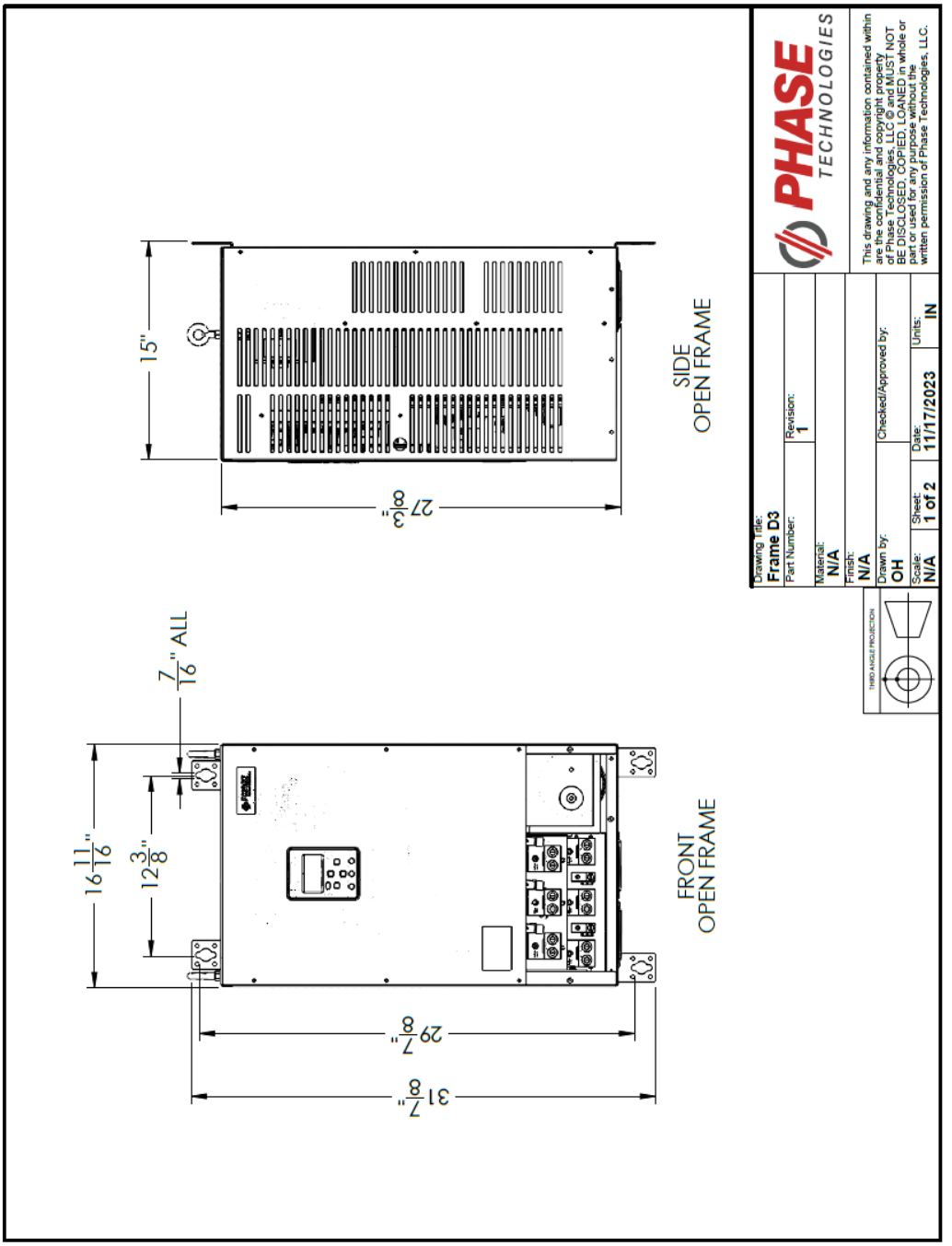
9.5.1 D1 Open Frame Dimensions



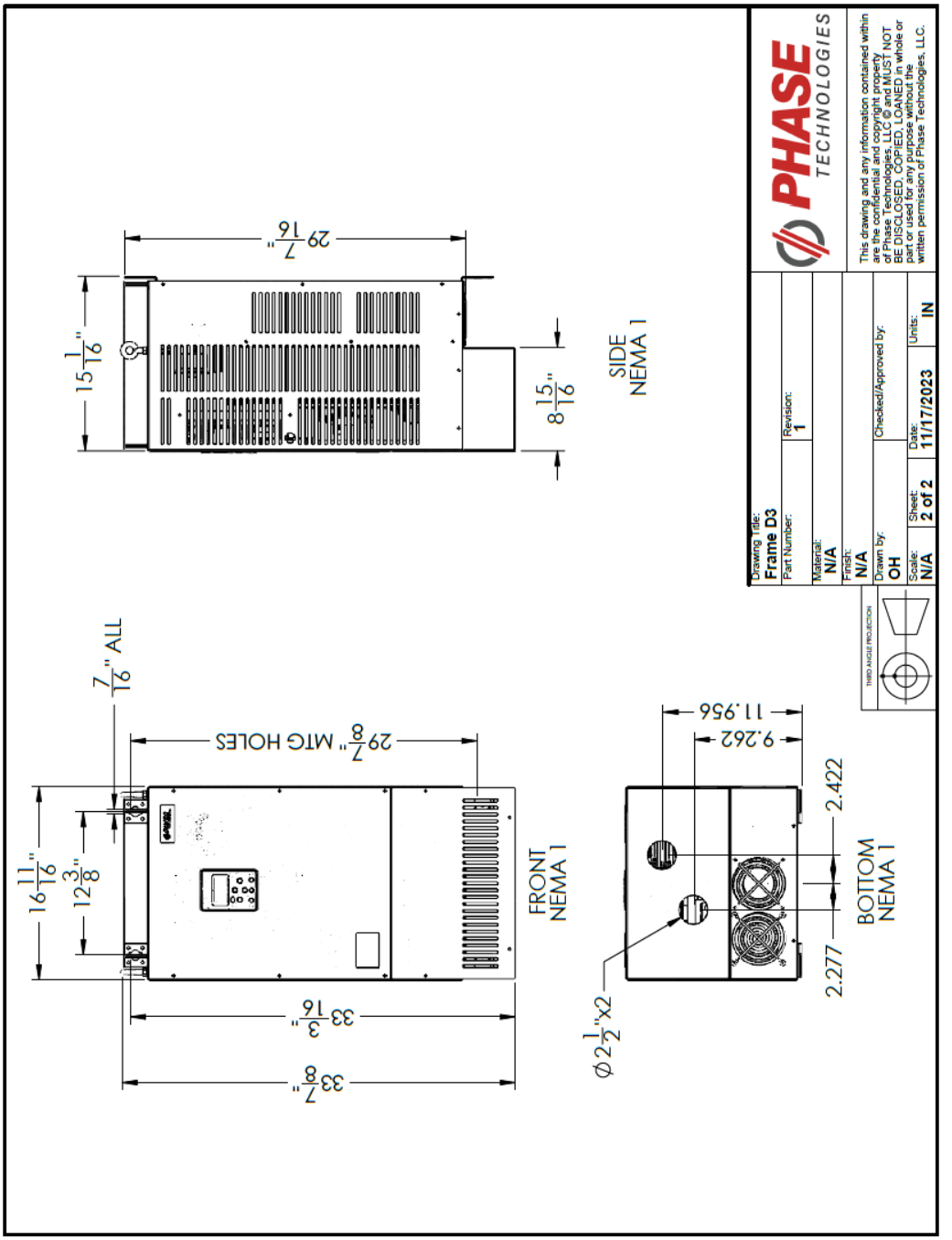
9.5.2 D1 NEMA 1 Frame Dimensions



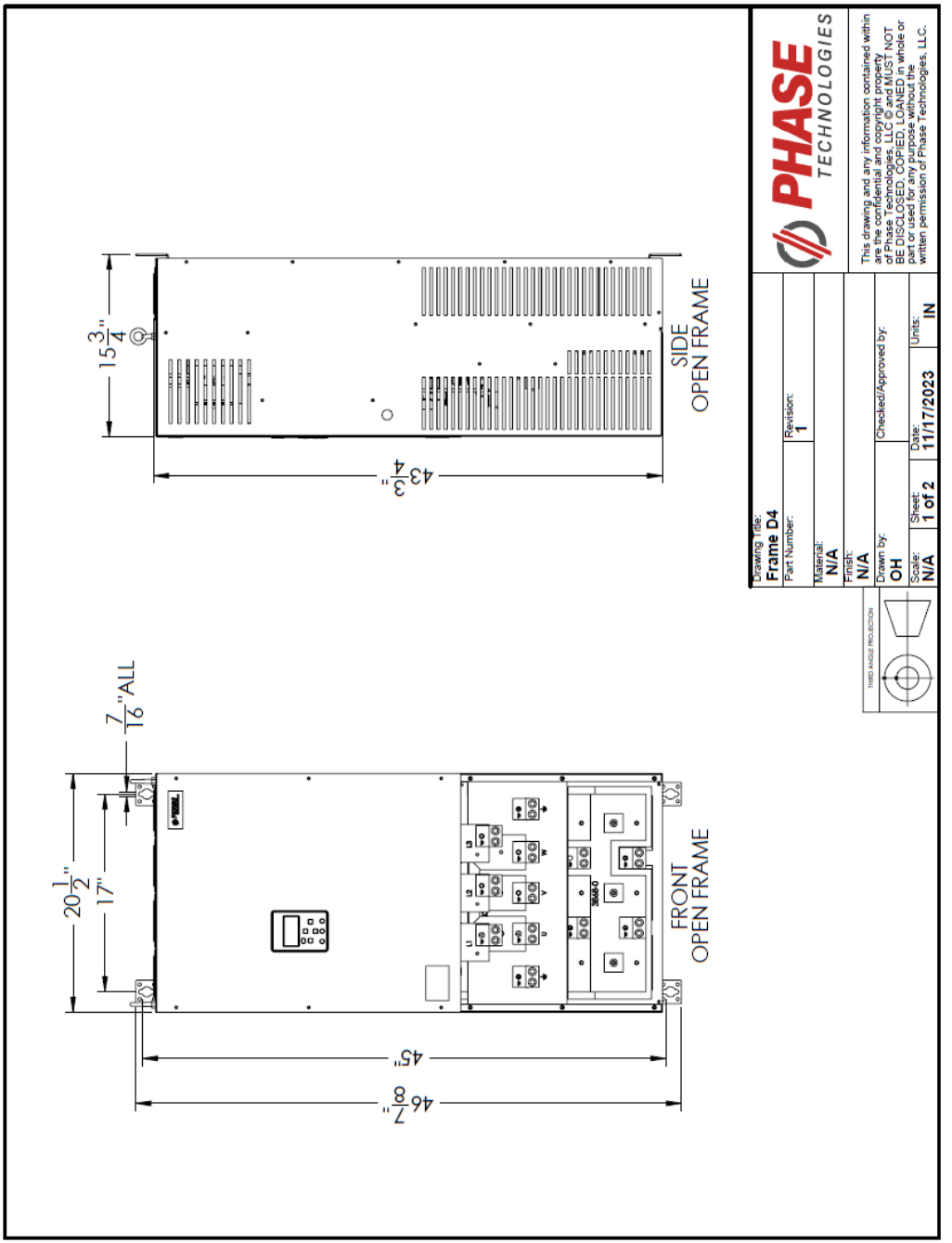
9.5.3 D3 Open Frame Dimensions



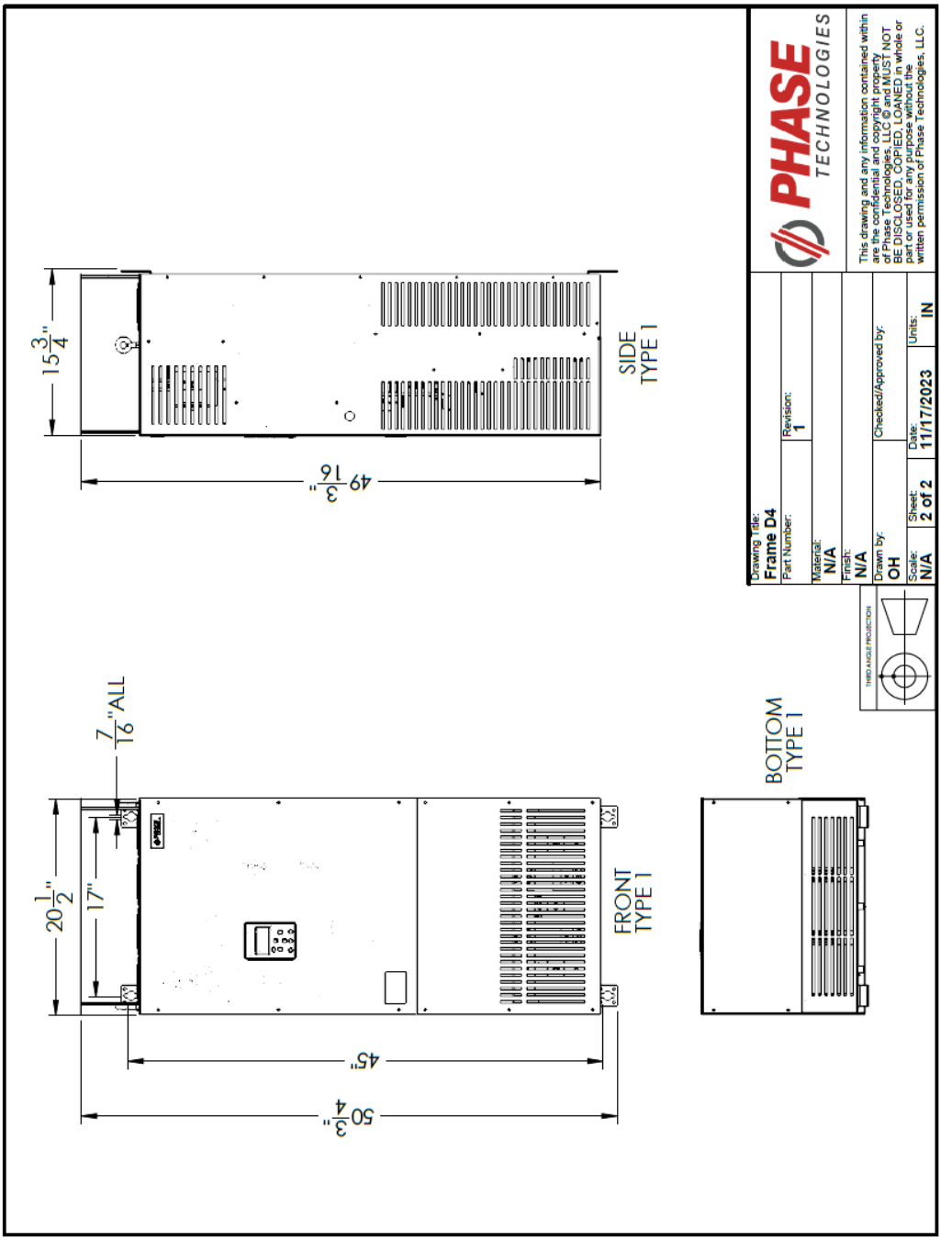
9.5.4 D3 NEMA 1 Frame Dimensions



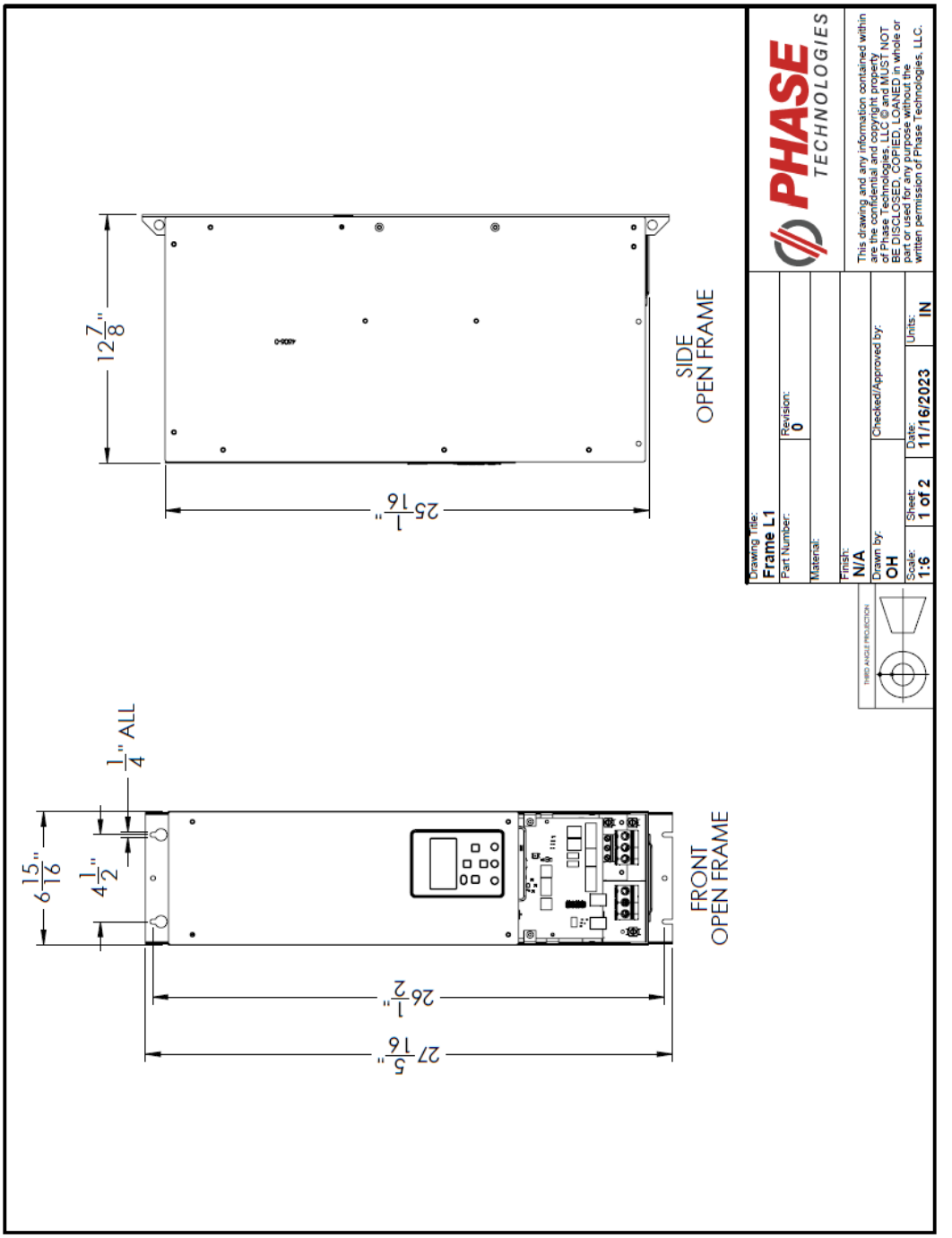
9.5.5 D4 Open Frame Dimensions



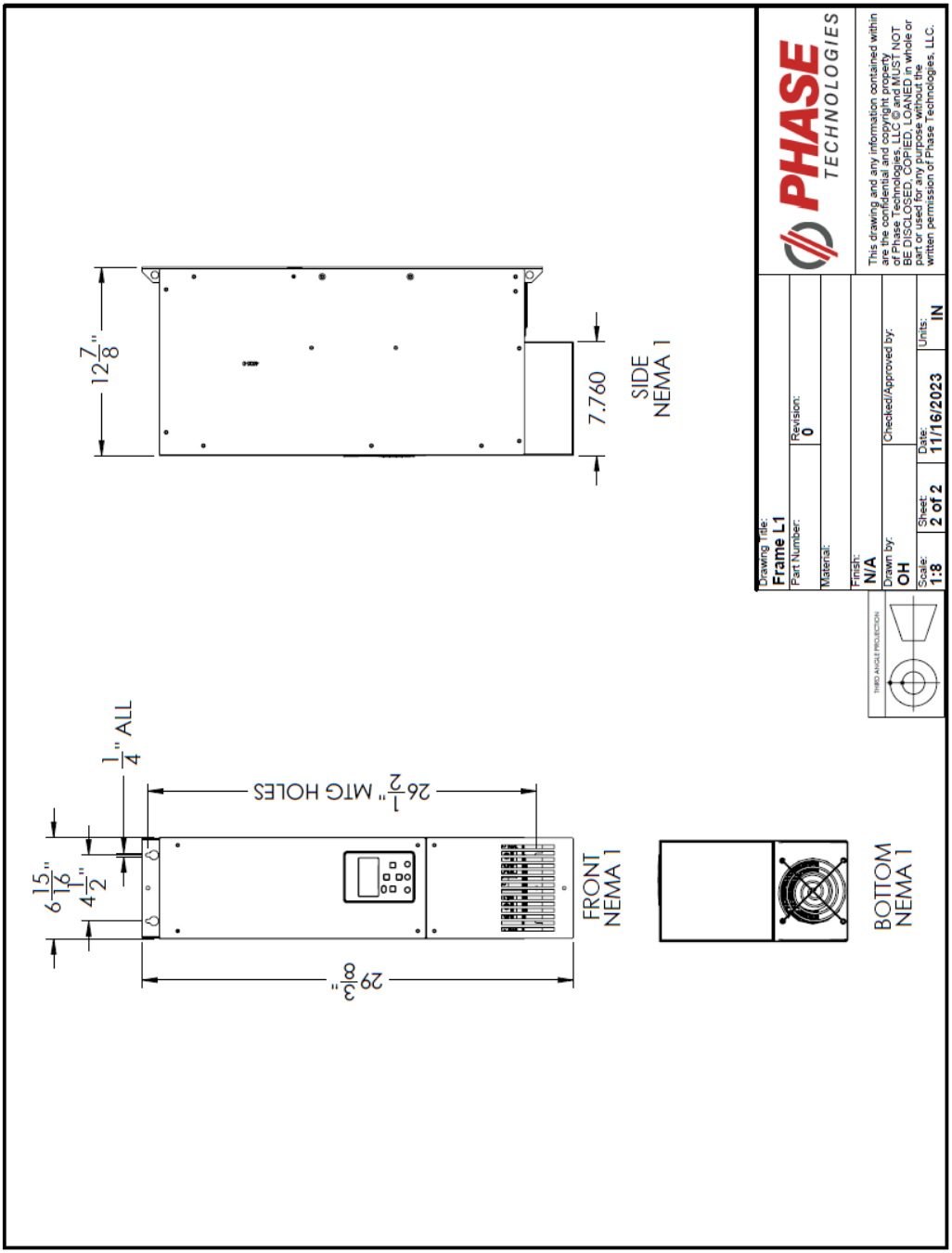
9.5.6 D4 NEMA 1 Frame Dimensions



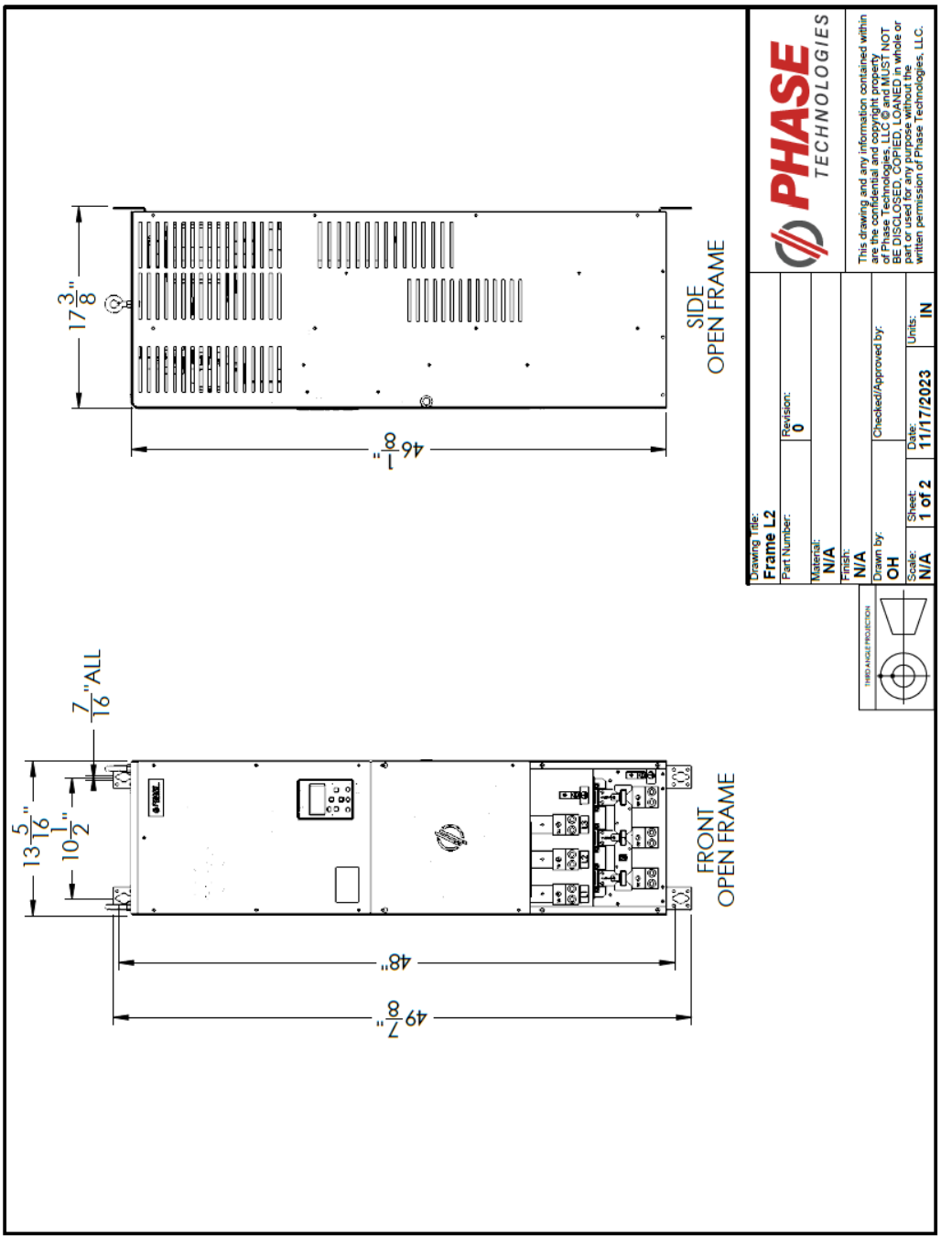
9.5.7 L1 Open Frame Dimensions



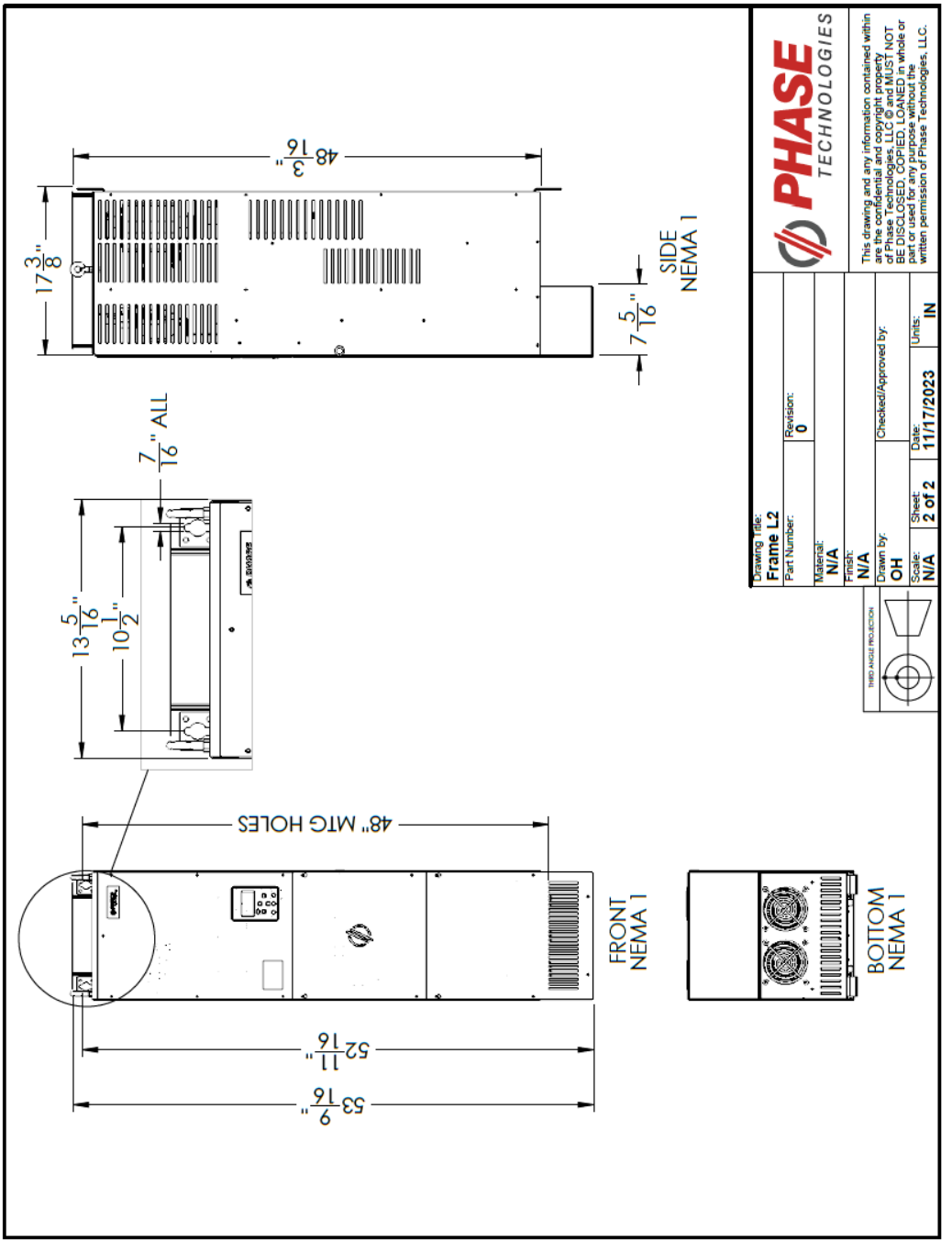
9.5.8 L1 NEMA 1 Frame Dimensions



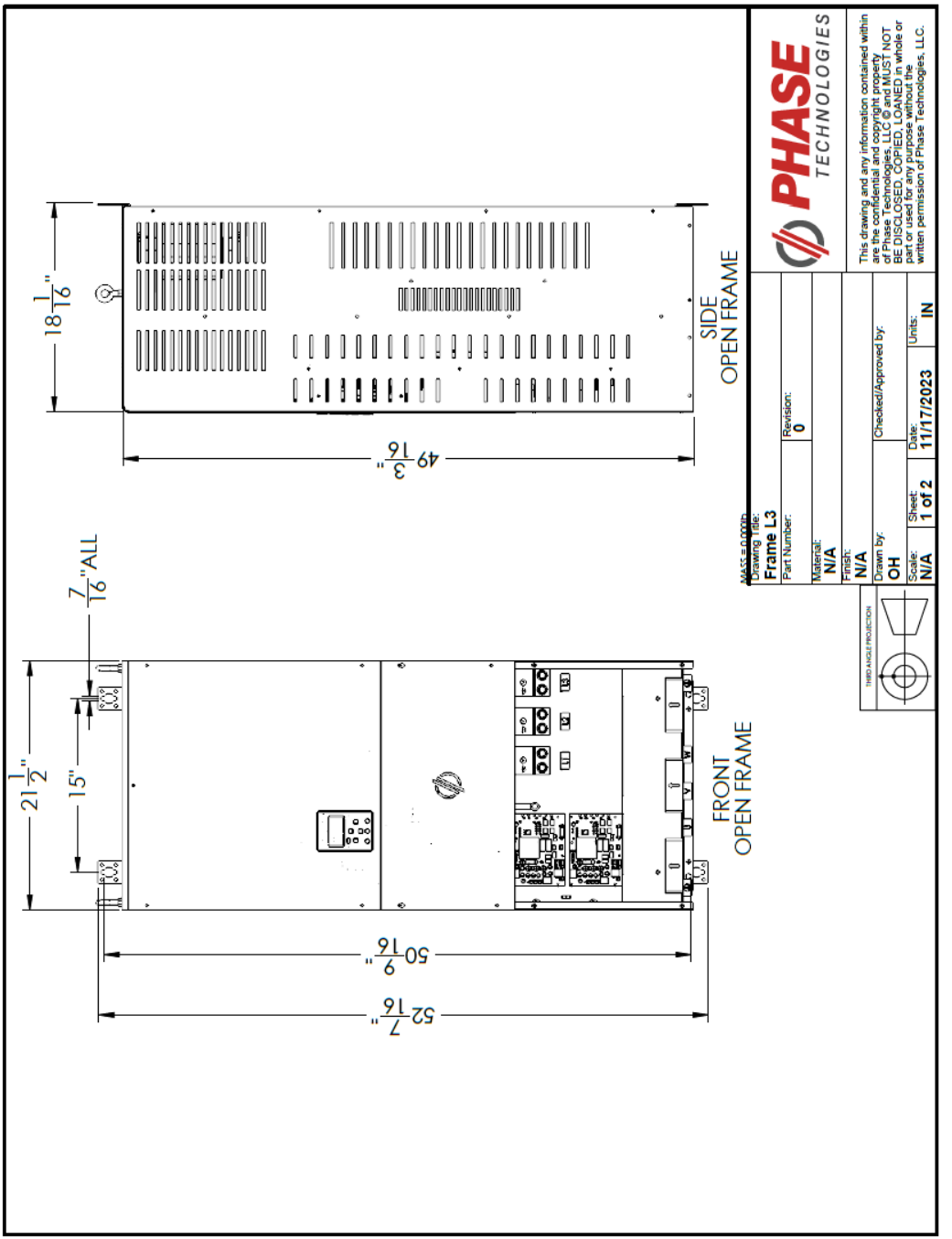
9.5.9 L2 Open Frame Dimensions



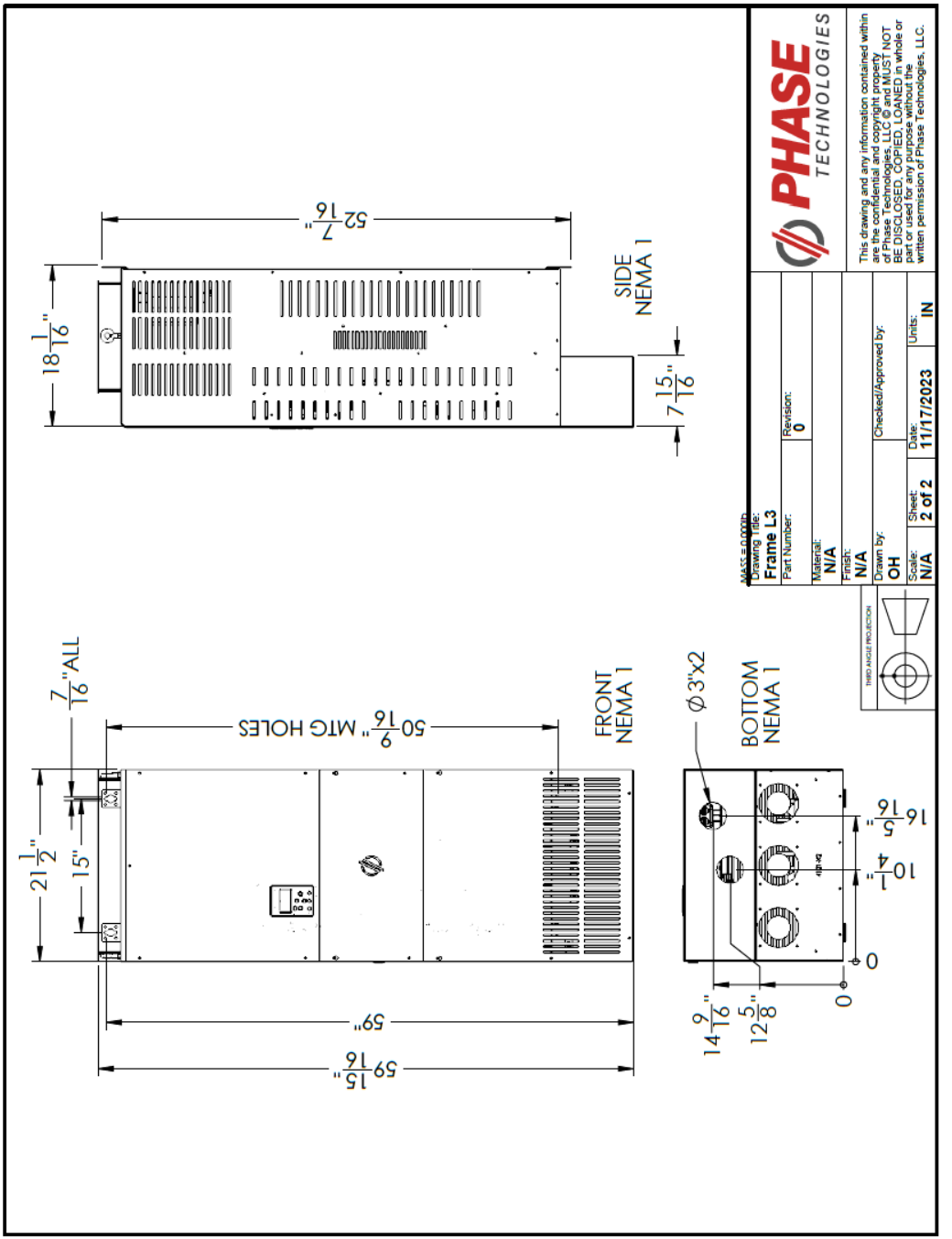
9.5.10 L2 NEMA 1 Frame Dimensions



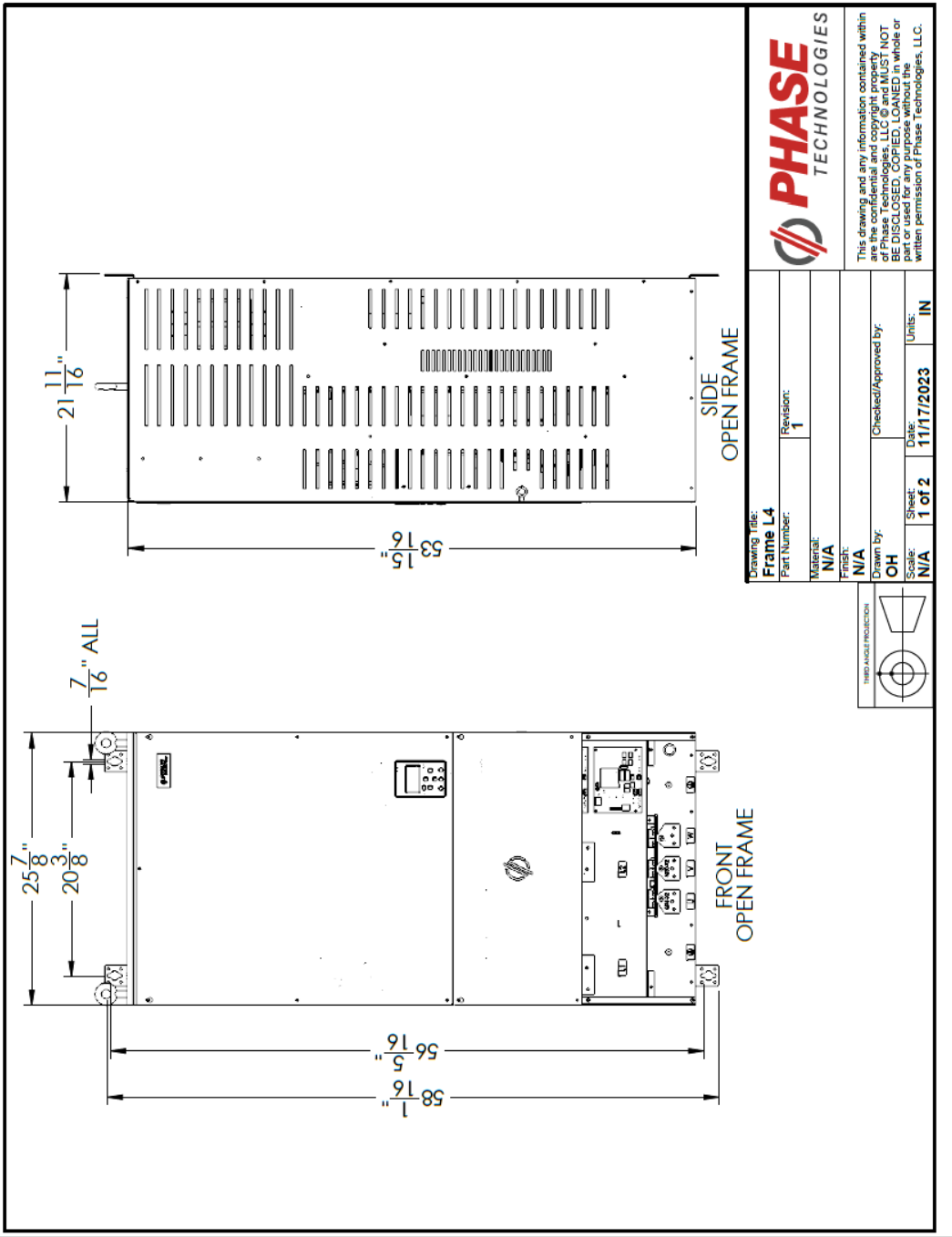
9.5.11 L3 Open Frame Dimensions



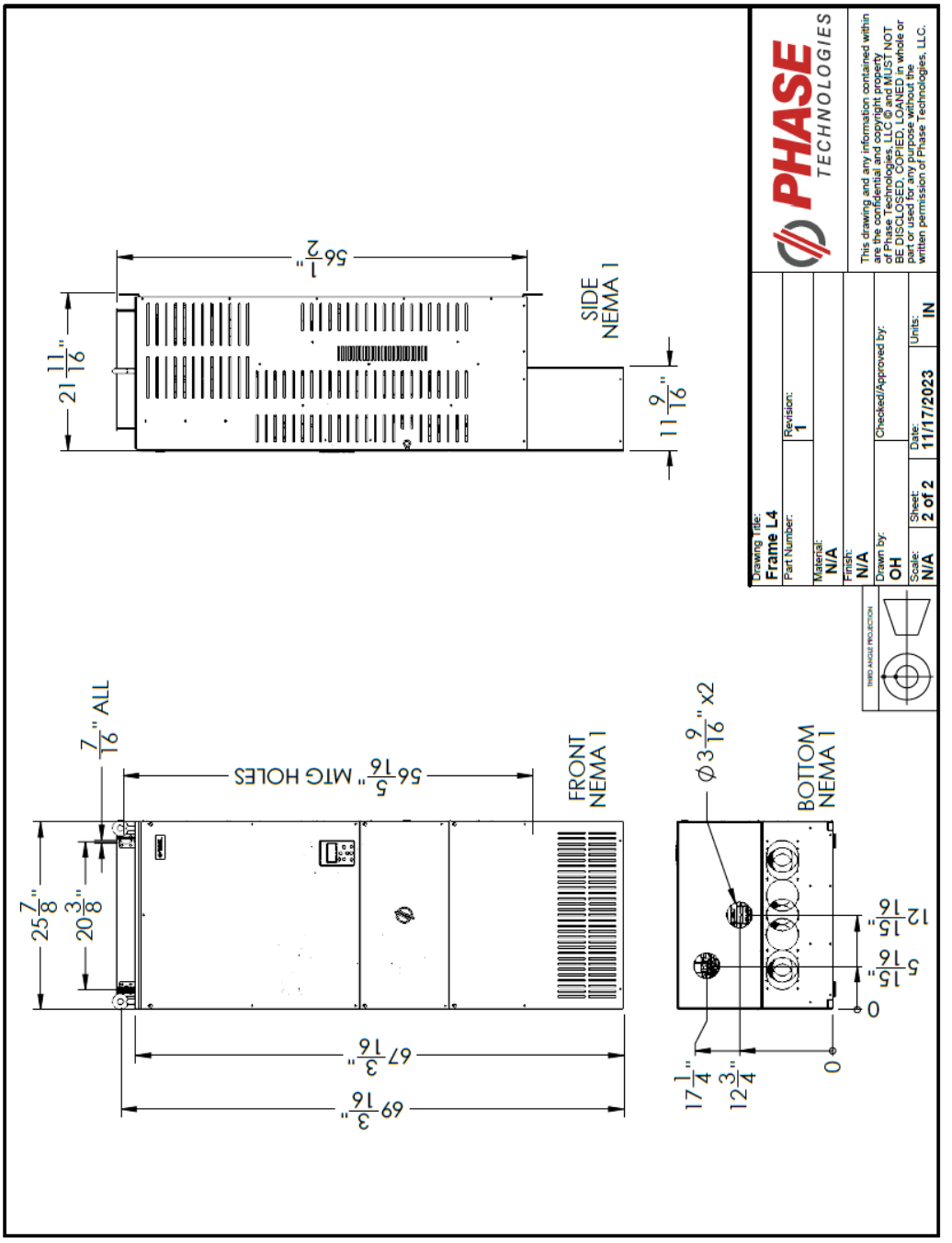
9.5.12 L3 NEMA 1 Frame Dimensions



9.5.13 L4 Open Frame Dimensions



9.5.14 L4 NEMA 1 Frame Dimensions



LIMITED WARRANTY

Phase Technologies' DXL and LHX Series drives are warranted against defects in material and workmanship for a period of two years. This warranty covers both parts and labor (at Phase Technologies) for two years 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 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 damage caused in association with the use of Phase Technologies' equipment shall be limited to the repair or replacement only of 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.

Forum Selection

Any suit, claim, or cause of action arising from this document or any Phase Technologies product, will be governed by the laws of the State of South Dakota. It is agreed that jurisdiction and venue for all disputes will be the federal or state courts of South Dakota.

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