PHASE PERFECT®

DIGITAL PHASE CONVERTER - GEN4 USER MANUAL

SAFETY MESSAGES AND WARNINGS

To ensure safe and reliable operation of the Phase Perfect®, it is important to carefully read this manual and to observe all warning labels attached to the unit before installing. Please follow all instructions exactly and keep this manual with the unit 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:** The voltage associated with the procedures 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. More than one disconnect switch may be required to de-energize the equipment before servicing.

⚠ **WARNING:** Risk of electric shock. De-energize the unit by disconnecting all incoming sources of power, then wait 30 minutes for internal charges to dissipate before servicing the equipment.

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

⚠ **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.

⚠ **WARNING:** Grounding electrodes must be installed such that earth resistance is 25 Ohms or less, as specified by the NEC section 250-56. If surge protection is installed, earth resistance must be 3 Ohms or less for full effect. Failure to meet these requirements could result in serious injury or death and will void the manufacturer's warranty.

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

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

⚠ **WARNING:** Input power connections should be made by a qualified electrician into circuit with adequate voltage and current carrying capacity for the model. Branch circuit protection to the unit should be provided by appropriately sized fuses or a 2-pole circuit breaker.

⚠ **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 only copper conductors.

⚠ **CAUTION:** Wires fastened to the terminal blocks shall be secured by tightening the terminal screws to a torque value listed in Error! Reference source not found. **-** Error! Reference source not found..

⚠ **CAUTION:** The input wire gauge must be sized for the single-phase input current, which will be significantly larger than the three-phase output current to the load. The minimum wire gauge for the input terminals is listed in Table 7.

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

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

⚠ **WARNING:** Under certain conditions, the motor load may automatically restart after a fault occurs. Make sure power to the converter has been disconnected before servicing the equipment, or serious injury may occur.

Contents

1 THEORY OF OPERATION

L1 and L2 of the single-phase input pass directly through the phase converter to provide two legs of the three-phase output. The input module charges a DC bus from the input lines. The output module uses power from the DC bus to generate the third leg of the three-phase output. The third leg is generated to limit voltage imbalance between the three legs to ≤ 2%. Voltage imbalance is calculated according to the NEMA MG1 standard.

$$V_{ib} = \frac{V_{\max difference}}{V_{avg}}$$

Where:

$$V_{avg} = \frac{V_{T1T2} + V_{T2T3} + V_{T3T1}}{3}$$

$$V_{\max difference} = MAX\ of\ (|V_{T1T2} - Vavg|, |V_{T2T3} - Vavg|, |V_{T3T1} - Vavg|)$$

1.1 Block Diagram

The diagram in **Figure 1** illustrates the basic design schematic of the Phase Perfect Digital Phase Converter.

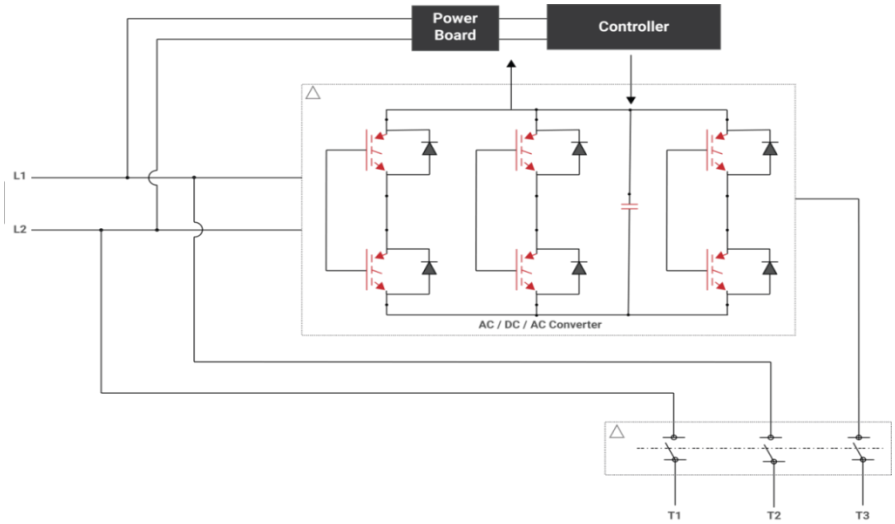


Figure 1 – Phase Perfect Digital Phase Converter Schematic

1.2 Identifying GEN 4 Phase Perfect

To determine if your phase converter is a GEN 4 model, locate the model label sticker on the interior side of the front cover. This identification label contains critical product information and specifications. GEN 4 units are clearly marked with "GEN 4" designation prominently displayed on this label sticker.

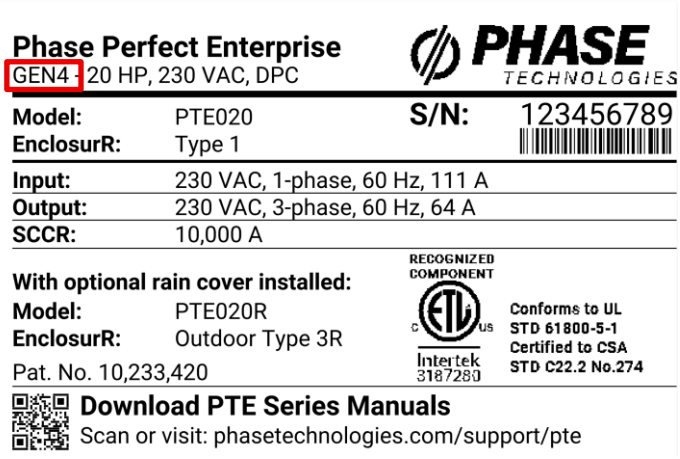


Figure 2 – PTE Label

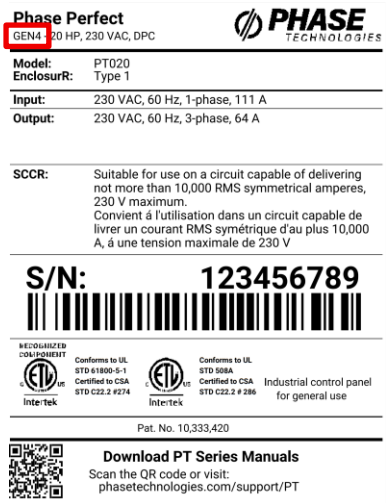


Figure 3 – PT Label

2 MODELS AND RATINGS

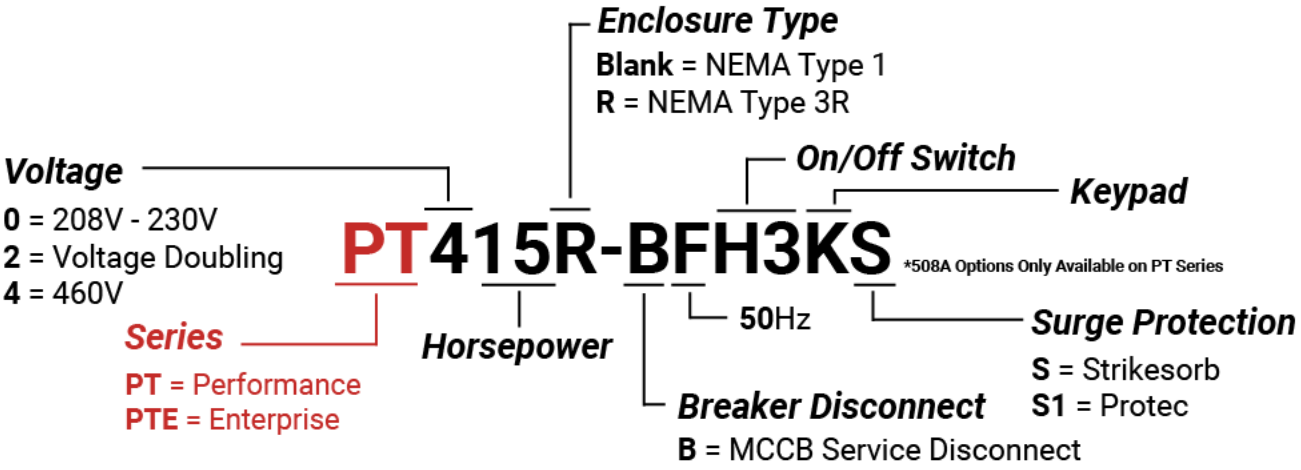


Figure 4 – Model Nomenclature

2.1 Specifications

Table 1 – General Specifications

Output Voltage – Standard Models	Approx. equal to input voltage
Output Voltage – Voltage Doubling Models	Approx. 2x input voltage
Output Voltage Imbalance	≤2%
Operating Temperature – PT	-10°C (14°F) to 50°C (122°F)
Operating Temperature – PTE	-10°C (14°F) to 40°C (104°F)
Operating Temperature – PTS	-10°C (14°F) to 40°C (104°F)
Storage Temperature	-20°C (-4°F) to 60°C (140°F)
Efficiency – Standard Models	98.7%
Efficiency – Voltage-Doubling Models	95.0%
Short Circuit Withstand Rating	10kA
Start Delay on Power Up	2 sec

Table 2 – Models and Ratings

Model	Power (HP)	Output (kVA)	Input Voltage Range (VAC)	Output Voltage (VAC)	Max AC Input Current (A)	Max Steady State Output Current (A)	Standby Power/Energy (W/BTU/hr)	Full Load Energy Loss (BTU/hr)
PT005	5	7.5	187-260	Equal to Input	31	18	68/232	339
PT007	7.5	10.8			45	26	70/239	479
PT010	10	14.9			62	36	74/252	661
PT015	15	21.2			90	52	77/263	897
PT020	20	26.6			111	64	80/273	1,180
PT030	30	39.4			165	95	175/597	1,752
PT040	40	54.0			225	130	190/648	2,395
PT050	50	68.5			286	165	235/802	3,043
PT060	60	78.9			329	190	260/887	3,500
PT075	75	99.7			416	240	300/1,024	4,427
PT207	7.5	10.8		Approx. 2x Input Voltage	45	13	200/682	1,938
PT210	10	14.9			62	18	320/1,092	2,685
PT215	15	22.4			94	27	435/1,484	4,029
PT220	20	26.6			111	32	550/1,876	4,777
PT230	30	39.4			159	46	800/2,730	6,771
PT407	7.5	10.8	440-520	Equal to Input	2	13	52/177	479
PT410	10	14.9			32	18	68/232	661
PT415	15	22.4			48	27	71/242	994
PT420	20	26.6			55	32	74/252	1,180
PT430	30	38.2			80	46	87/297	1,694
PT440	40	50.7			105	61	180/614	2,249
PT450	50	64			134	77	190/648	2,839
PT460	60	75.6			157	91	220/751	3,358
PT475	75	88.9			185	107	270/921	3,992
PT4100	100	118			246	142	300/1,024	5,239
PT4125	125	147.5			298	172	325/1,109	6,486
PT4150	150	164.4			343	198	330/1,126	7,305
PT4175	175	183			399	230	350/1,194	8,117

2.2 Mechanical Specifications

Outer dimensions of enclosures are shown in the table below. See line drawings at the end of this manual for details.

Table 3 – PTE Enclosure Specifications

Model	NEMA 1			NEMA 3R		
	Height (in)	Width (in)	Depth (in)	Height (in)	Width (in)	Depth (in)
PTE005	17	14	7	18.5	8	12
PTE007						
PTE010	26	8	12	29	8	19
PTE015						
PTE020						
PTE207	31	10	15	35	10	24
PTE210						
PTE215						
PTE407	26	8	12	29	8	19
PTE410						
PTE415						
PTE420						
PTE430						

1. Dimensions are approximate. See drawings in **Section 9** for details.

Table 4 – PT Enclosure Specifications

Model	NEMA 3R		
	Height (in)	Width (in)	Depth (in)
PT010R	33	20	14
PT015R			
PT020R			
PT030R	44	26	18
PT040R			
PT050R	49	35	22
PT060R			
PT075R			
PT220R	44	26	18
PT407R	33	20	14
PT410R			
PT415R			
PT420R			
PT430R			
PT440R	44	26	18
PT450R			
PT460R			
PT475R			
PT4100R	49	35	22
PT4125R			
PT4150R			
PT4175R			

1. Dimensions are approximate. See drawings in **Section 9** for details.

2.3 Motor Starting/Overload Capabilities

All Phase Perfect digital phase convertors are rated to across the line start motors up to the nameplate horsepower rating of the convertor except for 50 HP models and larger. Motor starting capability is approximately equivalent to an across the line starter using a Class 10 thermal overload. This capability is accomplished using a Class 4 thermal overload characteristic with a proprietary algorithm that limits inrush current on the manufactured leg during startup to prevent nuisance tripping. During startup, voltage is folded back when current exceeds 400% of Full Load Amps (FLA) of the converter. Below 400% of FLA, a Class 4 thermal overload curve and thermal measurements, on the IGBTs, control overload tripping.

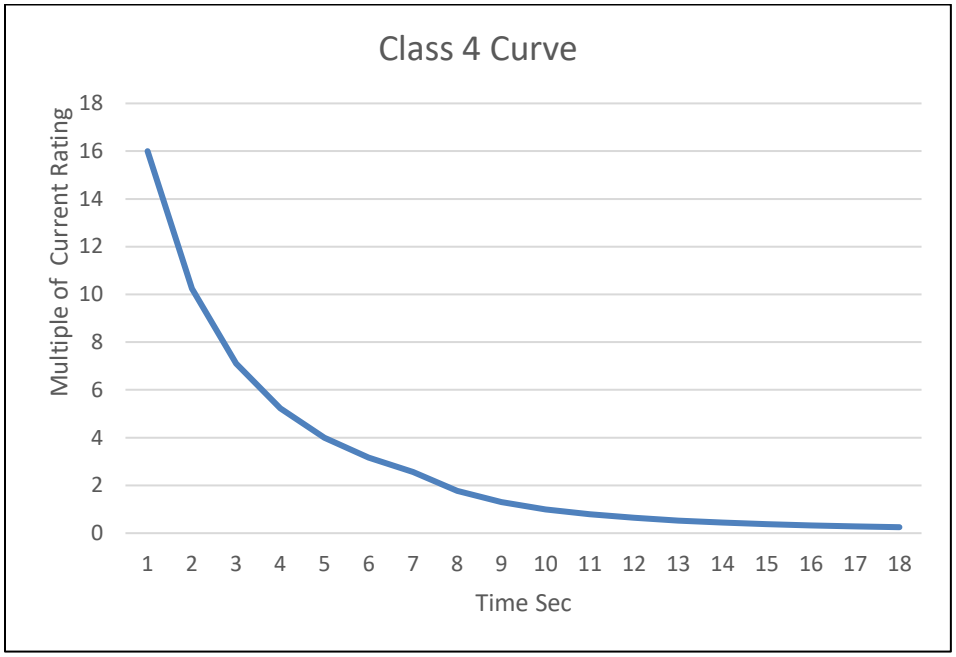


Figure 5 – Class 4 Overload Curve

Table 5 – Class 4 Overload Limits

Model	Rated Current (A)	Allowable Current (A) @ Specified Time		
		1 sec	4 sec	10 sec
PT005	18	144	72	46
PT007	26	208	104	66
PT010	36	288	144	91
PT015	52	416	208	132
PT020	64	512	256	162
PT030	95	760	380	240
PT040	130	1,040	520	329
PT050	165	1,320	660	417
PT060	190	1,520	760	481
PT075	240	1,920	960	607
PT207	13	104	52	33
PT210	18	144	72	46
PT215	27	216	108	68
PT220	32	256	128	81
PT230	46	368	184	116
PT407	13	104	52	33
PT410	18	144	72	46
PT415	27	216	108	68
PT420	32	256	128	81
PT430	46	368	184	116
PT440	61	488	244	154
PT450	77	616	308	195
PT460	91	728	364	230
PT475	107	856	428	271
PT4100	142	1,136	568	359
PT4125	172	1,376	688	435
PT4150	198	1,584	792	501
PT4175	220	1,760	880	557

3 INSTALLATION

3.1 Mounting Your New Phase Perfect

Proper installation of the unit is important to the performance and normal operating life of the unit. The unit should be installed in a location free from:

- Corrosive gases or liquids
- Excessive vibration
- Airborne metallic particles

Mount the unit to a solid, non-flammable surface capable of bearing the weight using the mounting brackets provided with the unit. Model weights are found in **Table 3** and **Table 4**.

3.2 Mounting Bracket Installation

For shipping purposes, mounting brackets may be installed upside down, or shipped separately in a bag. If the mounting brackets are not installed in an upright position, remove the mounting screws, turn to an upright position, and then fasten the screws tightly.

3.3 NEMA 3R Rain Hoods

PTE converters can be ordered in NEMA 1 indoor or NEMA 3R outdoor rated enclosures. Exterior openings on the top and sides of enclosure must be covered by a rain hood to be NEMA 3R outdoor rated. If the unit is being installed outdoors, install the supplied rain hood before operation. Installing products outdoors without the proper rain hood will void the manufacturer warranty.

3.4 Proper Ventilation

To maintain air circulation for adequate cooling, minimum clearance around the unit must be maintained. Allow six inches on each side and top, and at least 18 inches below.

Ensure air intake and exhaust openings are not obstructed. If the unit is mounted in a small room, cabinet, or building, ensure there is adequate ventilation to provide sufficient cooling.

3.5 Service Entrance Equipment

Phase Perfect phase converters are suitable for use as service equipment when the molded case circuit breaker (MCCB)/disconnect, service ground conductor terminal, and grounding electrode conductor are factory installed and the converter is labeled “Suitable for use as Service Equipment.” Consult local electrical code for installation guidance.

3.6 Source Branch Circuit Protection

If a circuit breaker is not factory installed, branch circuit protection must be installed in the circuit sourcing the phase converter. See **Table 6** for recommended circuit breaker sizing. Fuses may be used for circuit protection, consult local electrical code for proper sizing. Installation of a disconnection means within sight of the phase converter is recommended.

3.7 Grounding

- Properly ground the phase converter according to local electrical code.
- Connect the ground lug to the branch circuit or service ground conductor.
- Ground the phase converter with an adequately sized conductor according to local electrical code.
- Ground wire recommendations based on solid to semi-rigid stranded copper wire.

Table 6 – Circuit Breaker and Ground Wire Sizing

Model	Recommended Circuit Breaker (A)	Min. Copper Wire Size (AWG)	Min. Aluminum Wire Size (AWG)
PT005	40	10	8
PT007	60	10	8
PT010	80	8	6
PT015	125	6	4
PT020	150	6	4
PT030	225	4	2
PT040	300	4	2
PT050	400	3	1

PT060	500	2	1/0
PT075	600	1	2/0
PT207	60	10	8
PT210	80	8	6
PT215	125	6	4
PT220	150	6	4
PT230	200	6	4
PT407	30	10	8
PT410	40	10	8
PT415	60	10	8
PT420	70	8	6
PT430	100	8	6
PT440	150	6	4
PT450	175	6	4
PT460	200	6	4
PT475	250	4	2
PT4100	400	3	1
PT4125	400	3	1
PT4150	400	3	1
PT4175	500	2	1/0

1. See terminal markings for additional wire size and torque information.

3.8 Connecting Source Power

Table 7 – Input Wiring

Wire size recommendations based on 600 VAC copper wire, rated either 60°C or 75°C. Assuming 104°F (40°C) ambient and no more than 3 current carrying conductors in raceway or earth (directly buried). If phase converter will be in warmer environments, consult NEC Handbook for temperature correction factor.

Model	Input Wire (Copper)	
	Min. Wire Gauge (60 °C)	Min. Wire Gauge (75 °C)
PT005	8 AWG	10 AWG
PT007	4 AWG	6 AWG
PT010	3 AWG	4 AWG
PT015	1/0 AWG	1 AWG
PT020	-	1/0 AWG
PT030	300 kcmil	4/0 AWG
PT040	-	350 kcmil
PT050	2 x 250 kcmil	2 x 3/0 AWG
PT060	2 x 300 kcmil	2 x 250 kcmil
PT075	2 x 500 kcmil	2 x 350 kcmil
PT207	4 AWG	6 AWG
PT210	3 AWG	4 AWG
PT215	1/0 AWG	1 AWG
PT220	-	1/0 AWG
PT230	-	4/0 AWG
PT407	10 AWG	10 AWG
PT410	8 AWG	8 AWG
PT415	4 AWG	6 AWG
PT420	4 AWG	4 AWG
PT430	1 AWG	3 AWG
PT440	-	1/0 AWG
PT450	-	2/0 AWG

PT460	250 kcmil	3/0 AWG
PT475	350 kcmil	250 kcmil
PT4100	2 x 250 kcmil	2 x 3/0 AWG
PT4125	2 x 250 kcmil	2 x 3/0 AWG
PT4150	2 x 250 kcmil	2 x 3/0 AWG
PT4175	2 x 250 kcmil	2 x 3/0 AWG

3.9 Wire Sizing

Use **Table 7** to find minimum guidelines on properly sizing input conductors according to local electrical code. The voltage drop from the supply to the converter should be limited to 3% to ensure proper starting and operation of motor loads. Increase the wire gauge to provide adequate voltage to the load. Ensure the wire gauge is suitable to the terminal block.

Use the following formula to calculate line voltage drop.

$$V_{drop} = \ wire\ resistance\left(\frac{\Omega}{ft}\right) * \ wire\ length\ (ft) * \ current$$

3.10 Generator Power

Phase Perfect phase converters can be powered by a generator, but it is recommended that generator be sized 150% of the phase converter rating for proper operation. If a generator will be used for backup power, a delay timer must be used to allow the phase converter to completely shut down before transferring to a new power source. This delay should be a minimum of 15 seconds.

3.11 Connecting the Load

Do not connect single-phase loads to the manufactured leg, T3. This places unnecessary load on the phase converter and may violate electrical code in some areas. Apply overload and short circuit protection to protect load side conductors, motors, and other attached loads according to local electrical code. For some motor loads and wiring configurations load side short circuit protection may not be required. Consult local electrical code for guidance.

Important Note:
If the connected load requires a wye configured power source with a neutral connection, the load must be connected to the phase converter using a delta-wye isolation transformer.

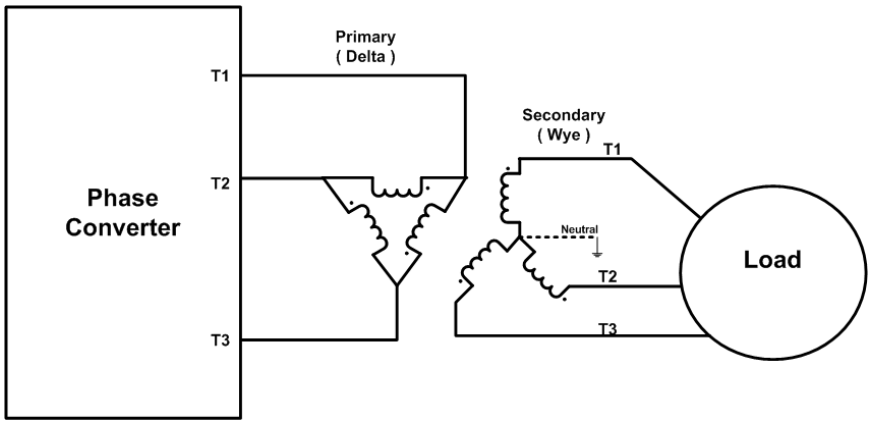


Figure 6 – Delta-Wye Wiring Diagram

Table 8 – PTE Input Power Terminal Specifications

Model	Wire Range	Torque (in-lb)	Tool
PTE005	26 – 6 AWG	10.5	Phillips
PTE007	20 – 2 AWG	17.5	
PTE010			
PTE015	16 – 2/0 AWG	48	T25 Torx
PTE020			
PTE207	20 – 2 AWG	17.5	Phillips
PTE210			
PTE215	16 – 2/0 AWG	48	T25 Torx
PTE407	20 – 2 AWG	17.5	Phillips
PTE410			
PTE415	16 – 2/0 AWG	48	T25 Torx
PTE420			
PTE430			

Table 9 – PTE Output Power Terminal Specifications

Model	Wire Range	Torque (in-lb)	Tool
PTE005	26 – 6 AWG	10.5	Phillips
PTE007			
PTE010	4 – 18 AWG	16	
PTE015			
PTE020			
PTE207			
PTE210			
PTE215			
PTE407			
PTE410			
PTE415			
PTE420			
PTE430	20 – 2 AWG	17.5	Phillips

Table 10 – PT Input Power Terminal Specifications

Model	Input Terminal Block			Optional Circuit Breaker	
	Wire Range	Torque (in-lb)	Tool	Wire Range	Torque (in-lb)
PT010	2/0 – 6 AWG 8 AWG 10 – 14 AWG	120 40 35	3/16” Hex	14 – 10 AWG 8 6 – 3 AWG 2 – 1 AWG	32 40 48 56
PT015				14 AWG 12 – 10 AWG 8 – 2/0 AWG	36 48 134
PT020					
PT030	350 kcmil – 6 AWG	275	5/16” Hex	1/0 – 2/0 AWG 3/0 – 4/0 AWG 250 – 300 kcmil	255 351 358
PT040				1/0 – 300 kcmil 350 – 600 kcmil	358 478
PT050	500 kcmil 400 – 2 AWG 4 AWG	375	3/8” Hex		
PT060				2/0 – 350 kcmil 3/0 – 500 kcmil	40.5
PT075					
PT220	2/0 – 6 AWG 8 AWG 10 – 14 AWG	120 40 35	3/16” Hex	14 – 10 AWG 8 6 – 3 AWG 2 – 1 AWG	32 40 48 56
PT230	350 kcmil – 6 AWG	275	5/16” Hex		
PT407	4 – 6 AWG 8 AWG 10 – 14 AWG	35 25 20	Flat Head		
PT410					
PT415					
PT420					
PT430	2/0 – 6 AWG 8 AWG 10 – 14 AWG	120 40 35	3/16” Hex		
PT440				14 AWG 12 – 10 AWG 8 – 2/0 AWG	36 48 134
PT450				14 AWG 12 – 10 AWG 8 – 2/0 AWG	36 48 134
PT460	350 kcmil – 6 AWG	275	5/16” Hex		
PT475					
PT4100	500 kcmil 400 – 2 AWG 4 AWG	375	3/8” Hex	1/0 – 300 kcmil 350 – 600 kcmil	358 478
PT4125					
PT4150					
PT4175					

Table 11 – PT Output Power Terminal Specifications

Model	Wire Range	Torque (in-lb)	Tool
PT010	4 – 6 AWG 8 AWG 10 – 14 AWG	35 25 20	Flat Head
PT015			
PT020	2/0 – 6 AWG 8 AWG 10 – 14 AWG	120 40 35	3/16” Hex
PT030			
PT040			
PT050	350 kcmil – 6 AWG	275	Phillips
PT060			
PT075			
PT220	4 – 6 AWG 8 AWG 10 – 14 AWG	35 25 20	Flat Head
PT230			
PT407			
PT410			
PT415			
PT420			
PT430			
PT440	2/0 – 6 AWG 8 AWG 10 – 14 AWG	120 40 35	3/16” Hex
PT450			
PT460			
PT475			
PT4100	350 kcmil – 6 AWG	275	Phillips
PT4125			
PT4150			
PT4175			

3.12 Connecting to Field Wiring Terminals

Open the front cover/door of the enclosure to gain access to the wiring panel. Input/output terminals are labeled as shown in **Table 12** below.

Table 12 – Power Terminal Descriptions

Terminal Name	Description
L1, L2	Single phase input power terminals
T1, T2, T3	3 Phase output power terminals, T3 is the “manufactured” leg.
GND	Earth ground

3.13 Routing Power Cables

Continuous metal conduit should be used for all power cables to reduce radiated electromagnetic interference (EMI). The conduit must be securely grounded to the converter enclosure and the motor case. Conduit hubs should be IMC or rigid steel conduit and be UL listed.

Route power cables through the supplied openings in the bottom of the enclosure, using appropriate conduit or strain relief devices. If any conduit holes remain unused, they must be covered with 3R hole plugs to maintain the NEMA 3R rating.

Important Note: If new openings are cut, be sure to completely remove all resulting metal shavings.

3.14 On/Off Control Wiring

The output of the converter can be controlled with a switch connected between the AUX1 or AUX2 and COM terminals. If installed, remove the factory installed jumper wire and replace with a switch. Jumper wire can be seen in **Figure 7** below.

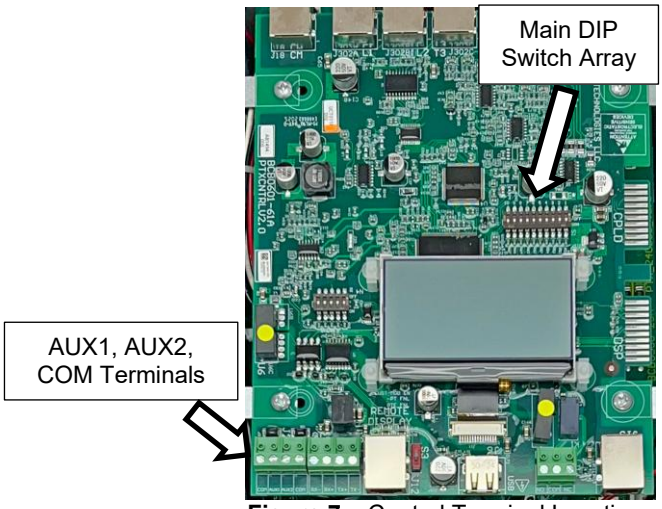


Figure 7 – Control Terminal Locations

When AUX1 to COM or AUX2 to COM is closed, the output is energized after a delay of approximately two seconds. When AUX1 and AUX2 to COM are open, the output of the converter will be de-energized. The diagram in **Figure 8** illustrates the UL508A panel shop and customer installed options including an ON/OFF control switch. Unused conduit holes must be filled with a conduit hole plug.

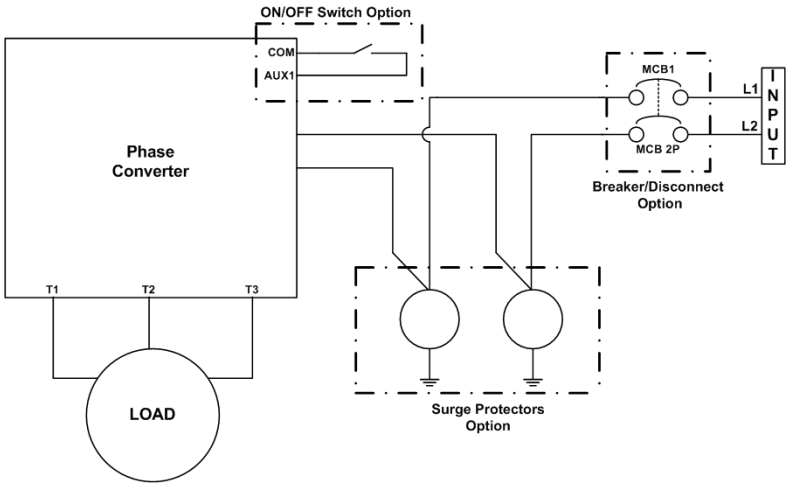


Figure 8 – Panel Shop Options

⚠ **WARNING!** When the converter is turned OFF using a switch on the AUX terminals, dangerous voltage may still be present on the input lines and elsewhere inside the enclosure. **Never open the enclosure or perform maintenance on the unit or connected loads when the incoming power to the phase converter is ON, regardless of the switch setting.**

Table 13 – Control Terminal Ratings and Descriptions

Terminal	Description	Rating	Notes
AUX1	Auxiliary Input 1	Dry contact type Pullup Voltage < 5 volts, galvanically isolated	Digital input. Commonly used for ON/OFF control of output.
AUX2	Auxiliary Input 2		
COM	Common		Common for AUX terminals.

⚠ **CAUTION!** Electrostatic discharge (ESD) can damage electronic components. Discharge ESD prior to touching the board or making connections. To discharge ESD, touch your hand to unpainted metal on the enclosure.

4 OPERATION

4.1 Operating Modes

WARNING! Make sure the input power disconnect switch is in the OFF position before opening the front cover to the unit. Opening the front cover with the switch in the ON position exposes the user to the risk of electric shock.

WARNING: Risk of electric shock. Disconnect all incoming sources of power and wait 30 minutes before opening the front cover to change DIP switches.

DIP switches can be used to program Phase Perfect converters for different operating modes. The DIP switch array is located above the LCD screen on the control board. DIP switch settings must be changed while the converter is **OFF**.

4.2 DIP Switch Programming

See **Figure 7** on page 12 for DIP switch location. Turning DIP1 to the ON position will prevent High/Low Input Voltage Faults and PLL Faults regardless of DIP9/10 settings. The converter will no longer fault due to high or low input voltage conditions.

Turning DIP9 ON (DIP10 must be OFF) will allow the operating mode of the converter to be changed by turning on DIP switches as shown below. Each operating mode is detailed in the following pages. Switches must be turned ON while the converter is de-energized. Upon powering back up, the screen will display what features have been changed.

Table 14 – Operating Modes (DIP9 must be ON)

DIP Switch ON	Operating Mode
2	Infinite Restarts
1 & 3	Fold Back Voltage (see **Section 4.4** for details)
4	Transformer Mode
5	Disable Auto Restarts*
6	AUX1 Forced ON
8	Clear Restart Log

* - Takes priority over Infinite Restarts

4.3 Infinite Restarts

Infinite Restarts will allow the converter to restart an unlimited number of times after faults occur. This function is recommended for critical applications, such as elevators, where continuous operation is essential to prevent passengers from being stranded.

4.4 Fold Back Voltage

By default, the generated leg of the Phase Perfect converters will ramp voltage during motor starts. Disabling Fold Back Voltage will force the generated leg to maintain nominal voltage during heavy startups. This setting should only be used if the load is tripping due to a drop in input voltage. See the table below for information on programming Fold Back Voltage using DIP switches.

Table 15 – Fold Back Voltage Programming

DIP1	DIP3	Result
OFF	OFF	Fold Back Voltage Disabled
OFF	ON	Low Fold Back Voltage
ON	OFF	High Fold Back Voltage

4.5 Transformer Mode

Transformer Mode will drop the voltage of T3 and ramp slower than normal, during heavy startups such as when powering large transformers.

4.6 Disable Auto Restarts

This feature will prevent the converter from restarting automatically after a fault occurs. This feature will take priority if **Disable Auto Restarts** and **Infinite Restarts** are both turned on.

4.7 Fault Log

To view the Fault Log, turn on DIP switches 2, 5, and 9 while all others are OFF. Faults will then scroll across the display.

5 Keypad and Display

Phase Perfect converters can now be purchased with an optional keypad that allows feature and operating mode programming.

5.1 Using the Keypad and Display

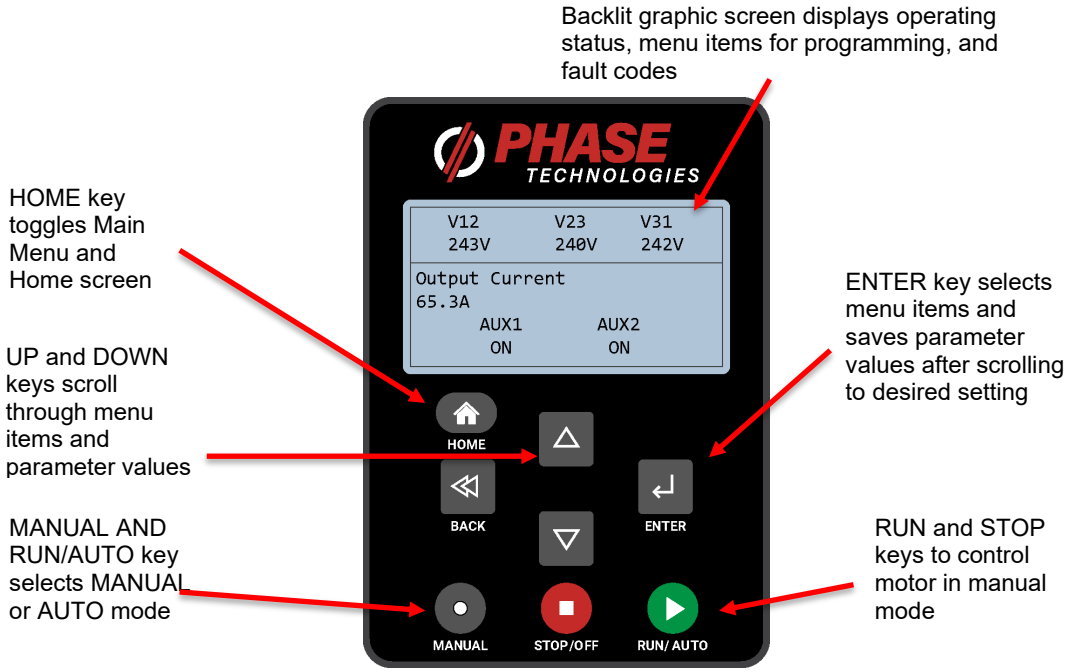


Figure 9 – Keypad and Graphic Display

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. When operating in the factory default mode, the display will scroll through several screens, indicating line-to-line voltages for all three phases, T3 Output Current (generated leg), Bus Cap Voltage, IGBT Case Temperature, System On Time, and the status of the AUX1 and AUX2 inputs.

Password Protecting the Keypad
The keypad can be set up with a password to prevent unauthorized changes in adjustable parameters. The parameter ***1.3.2 PASSWORD SETUP*** 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.

5.2 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 16** contains a brief description of Main Menu items, followed by in-depth instructions on the use and function of each Main Menu item.

Table 16 – Main Menu Items

DISPLAY MESSAGE	DESCRIPTION
1 CHANGE PARAMETER VALUES	Allows the user to set values for features such as Fold Back Voltage and Transformer Mode.
3 READ MEASURED VALUES (RMV)	Displays measured values such as output current, input voltage, IGBT case temperature, etc.
4 READ TIMERS	Records the time the converter is powered on.
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.

DISPLAY MESSAGE	DESCRIPTION
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, the counter on these faults will be reset to zero.
12 FILE SYSTEM	Opens the menu for importing and exporting settings or reprogramming firmware.

5.3 Change Parameter Values

The Main Menu item, ***1 CHANGE PARAMETER VALUES***, leads to several sub-menus that contain adjustable operating parameters. These parameters provide features that allow customized operation of the converter to fit the specific application.

5.4 Read Measured Values

The display can provide a variety of measured values related to the performance of the converter 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 17 – Measured Values

DISPLAY MESSAGE	DESCRIPTION OF MEASURED VALUE
3.1 Output Current	T3 (generated leg) output current, measured in Amps (A)
3.2 Bus Cap Voltage	Voltage of the DC bus, measured in Volts DC (VDC)
3.3 V12, V23, V31	Output voltages, measured in Volts AC (VAC). V12 represents the voltage between L1 and L2.
3.4 Model Number	Indicates model number of the product and the firmware version on the control board.
3.5 Aux1 Aux2	ON/OFF status of the remote switch circuits AUX1 and AUX2
3.6 IGBT Case Temp	Insulated-gate bipolar transistor (IGBT) case temperature in degrees Celsius.
3.7 Startup Delay	Displays a timer that counts down the time left to start when the converter is in a time delay due to a fault condition.
3.8 Boot Firmware CRC	The boot loader version internal to the DSP.
3.9 DIP States	Displays the status of the DIP switches used for programming different operating modes. “0” indicates OFF and “1” indicates ON.

5.5 Read Timers

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

1. Press HOME to scroll through menu items until **4 READ TIMERS** appears on the display.
2. Press ENTER to enter this menu item.

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

5.6 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.

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.

If the converter 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. The Fault Log is permanent and cannot be cleared. See the following section for more information on the Fault Log.

5.7 Fault Log

The Fault Log is a permanent record of faults. The number of faults cannot be reset by the user. After the 20th fault, the oldest 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.

5.8 Clear Memory

The ***7 CLEAR MEMORY*** function in the Main Menu allows you to reset the timer that records Converter 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.

6 ADJUSTABLE PARAMETERS

6.1 Changing Parameter Values

⚠ **WARNING**: When the converter 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. 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.
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.

6.2 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.

6.3 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 ***1.10 CHANGED PARAMETERS***.
4. Press ENTER to access this menu item.

6.4 File System

Phase Perfect Gen 4 products are equipped with a USB terminal that can be used to Import and Export Parameters as well as install firmware upgrades or custom firmware. Firmware files will be .hex format and parameter data files will be saved as a .CSV file.

⚠ **CAUTION**: USB device must be inserted while converter is **powered off**. Failure to do so may result in injury or damage to the product. Power may be applied while USB device is inserted, but the system must be powered off before removing the USB 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 converter is powered off, locate the USB terminal on the control board. **Figure 10** below shows the USB terminal on a PT control board. Insert the USB device into the terminal, replace the enclosure cover, and apply power to the converter.

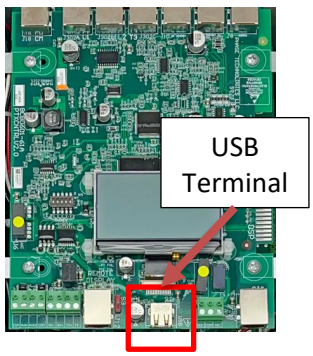


Figure 10 – USB Terminal on PT Control Board

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 USB device. 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 PT. The file can also be opened on a personal computer 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. Information about the 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.

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 USB device and a software version history. Last, the Fault Log will show any stored faults.

Import Parameter Data

The exported Parameter Data files can be used to apply the same parameters to other converters. 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. 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 USB terminal can be used to reprogram the firmware of the converter for software upgrades or custom features.

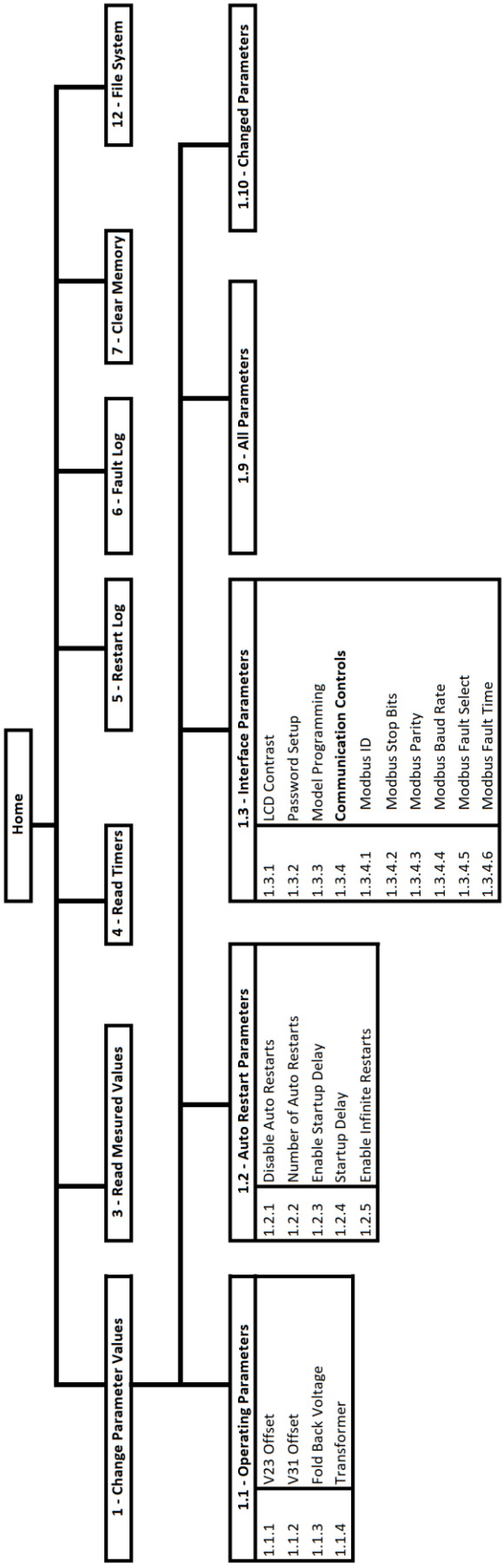
The firmware version of Phase Technologies converters can be found by pressing **ENTER** on the home screen and then scrolling up or down to ***3 READ MEASURED VALUES*** and pressing **ENTER**. Under ***3 READ MEASURED VALUES***, there will be a heading called ***3.4 MODEL NUMBER***, which will show the model and current firmware versions

To reprogram a Gen 4 PT:

1. Turn power to the system OFF and insert the USB device into the USB port at the bottom of the control board.
2. Reapply power to the converter.
3. From the HOME screen, press ENTER, then scroll down to ***12 FILE SYSTEM*** and press **ENTER**.
4. Use the up and down arrows to select ***12.5 REPROGRAM FIRMWARE*** on the display and press **ENTER**.
5. Use the up and down arrows to select the firmware file for reprogramming and press **ENTER**.
6. If the file chosen contains the proper firmware for the converter model, reprogramming will begin. Reprogramming firmware will take several minutes. If the LEDs, labeled TX and RX, on the control board are flashing, that means that the reprogramming process is underway.
7. If the reprogram is successful, the display will show ***SUCCESSFUL, PRESS ENTER TO RESET***.
8. If the display shows **UNSUCCESSFUL**, cycle power and retry steps 1 – 5.
9. Press **ENTER** and the converter will reboot with the new software version.

The firmware update can be verified by going to ***3 READ MEASURED VALUES***.

6.5 Menu Structure Overview



6.6 Parameter Tables

Table 18 – 1.1 Operating Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.1.1 V23 Offset	Adjusts the display reading of the line-to-line voltage between L2 and T3 so that the converter can be calibrated to match a manual voltage measurement. This will not change actual voltage of the converter.	0 (-100 – 100)
1.1.2 V31 Offset	Adjusts the display reading of the line-to-line voltage between L1 and T3 so that the converter can be calibrated to match a manual voltage measurement. This will not change actual voltage of the converter.	0 (-100 – 100)
1.1.3 Fold Back Voltage	Disabling Fold Back Voltage will force the generated leg to maintain nominal voltage during heavy startups. This setting should only be used if the load is tripping due to a drop in input voltage. Yes High and Yes Low will allow the voltage to drop during startups.	Yes High
1.1.4 Transformer	A setting of YES will drop the voltage of T3 and ramp slower than default, during heavy startups such as when powering large transformers.	No

Table 19 – 1.2 Auto Restart Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.2.1 Disable Auto Restarts	A setting of YES will prevent the converter from automatically restarting after faults occur.	No
1.2.2 Number of Auto Restarts	Number of automatic restarts allowed after faults occur. After reaching this number of faults, the converter will remain in a fault condition until power is cycled.	9 (1 – 9,999)
1.2.3 Enable Startup Delay	Delay before a restart after incoming power is cycled off and on.	No
1.2.4 Startup Delay	The length of time the converter will wait to restart after power is cycled.	2 min (1 – 30)
1.2.5 Enable Infinite Restarts	Infinite Restarts will allow the converter to restart an unlimited number of times after faults occur. This function is recommended for critical applications, such as elevators, where continuous operation is essential to prevent passengers from being stranded.	No

Table 20 – 1.3 Interface Parameters

DISPLAY MESSAGE	DESCRIPTION	DEFAULT [UNITS] (MIN - MAX)
1.3.1 LCD Contrast	Used to adjust the contrast of the graphic display.	40 (30-59)
1.3.2 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)
1.3.3 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
1.3.4 Communication Controls	**Press ENTER to see the following parameters related to Modbus.**	
1.3.4.1 Modbus ID	Address of the converter for a Modbus network.	1 (0-247)
1.3.4.2 Modbus Stop Bits	Number of bits transmitted after each character to detect the end of the character.	1 (1-2)
1.3.4.3 Modbus Parity	Sets how the parity of the character’s data frame is set.	None (Odd-Even)
1.3.4.4 Modbus Baud Rate	Serial baud rate or the rate at which information is transferred.	19200 (2400-57600)
1.3.4.5 Modbus Fault Select	Select how the converter responds when serial communication is lost. Options are disabled, to fault, or stop the output of the converter without faulting.	Disabled
1.3.4.6 Modbus Fault Time	In seconds. Select how long serial communication loss persists before Modbus Fault Selection state takes effect.	0 sec (0-120)

7 ROUTINE INSPECTION AND MAINTENANCE

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 only be installed and serviced by trained and licensed personnel. Follow instructions carefully and observe all warnings.

WARNING! Under certain operating conditions, the converter will shut down and automatically restart. Always disconnect input power from the unit and wait 30 minutes for charge to dissipate before performing service on the converter or connected loads.

7.1 Overall

Perform visual inspection, checking for things such as discolored wires or terminals, evidence of arcing, loose mounting screws, physical damage to the enclosure, etc. The converter should be inspected and cleaned annually or more frequently if located in a hot or dirty environment. Special attention should be given to the following:

7.2 Power terminals

Periodically, inspect for loose connections and tighten to specifications in **Table 8** and **Table 10**.

7.3 Capacitors

Check for leakage or deformation.

7.4 Fans and Heat Sinks

Excessive dust buildup on heat sink or fan impellers may lead to overheating. Lightly brush and vacuum. Contact Customer Service for assistance in replacing cooling fans. Use only fans approved by Phase Technologies. Unapproved fans may lead to component damage.

7.5 Fuses

Fuses are used to power the 230 VAC enclosure fans in PT models. Each fuse is assigned a designator, indicated by its label. Contact the Phase Technologies Service Department for replacement fuses. See table below for fuse ratings.

Table 21 – Fuse Information

Fuse Designator	Location	250 V Fuse Rating
F1	Fuse Board	3.15 A
F2	Fuse Board	3.15 A

7.6 Line Filter Capacitors

Line filter capacitors are part of the inductor/capacitor (L/C) filters and should be routinely monitored and replaced if degraded. Failure of the L/C filter can lead to increased harmonic levels, which may damage equipment connected to converter. Visually inspect the line filter capacitors and connecting wires for any discoloration or bulges in the canisters.

If the capacitance of either is below the **50% Capacitance** value in **Table 22**, contact Phase Technologies for replacement.

Table 22 – PT Nominal Filter Capacitor Values in MicroFarads (μF)

Model	Nominal Capacitance (μF)	50% Capacitance (μF)
PT005	9.4	4.7
PT007		
PT010	18.8	9.4
PT015		
PT020		
PT030	45	22.5
PT040		
PT050	60	30
PT060		
PT075		
PT207	30	15
PT210		
PT215		
PT220		
PT230		
PT407	15	7.5
PT410		
PT415		
PT420		
PT430		
PT440	30	15
PT450		
PT460	45	22.5
PT475		
PT4100	60	30
PT4125		
PT4150		
PT4175		

8 TROUBLESHOOTING

8.1 Fault Codes

Table 23 – Fault Codes

Text	Description/Comments	Restart
BUS OVERVOLTAGE	Sudden and severe regenerative power under high line voltage may result in bus overvoltage.	Auto
CLASS 4 OVERLOAD	Output current exceeded operating limit.	Auto
CM BOARD FAULT	Connection from Control board to Hall Sensor isn't properly connected. Power down unit, reconnect, and restart.	Auto
HALL SENSE HIGH	Current exceeded the maximum rating of the Hall sensor. May indicate a fault in the motor circuit.	Auto
HIGH INPUT VOLT	Input voltage has exceeded a safe operating level. Reduce input voltage.	Auto
IGBT FAULT	Check for short circuit on input and output lines and load. Contact Phase Technologies.	Auto
LOW INPUT VOLT	Input voltage has fallen below a safe operating level.	Auto
OUTPUT OVERLOAD	A large and sudden overcurrent event on the output module. Check motor circuit for faults.	Auto
OVER TEMPERATURE	Internal temperature of the converter exceeded safe operating limits. Check fans and ventilation openings for obstruction. Reduce ambient temperature.	Auto
OVERCURRENT INPUT	Input current exceeded the operating limit.	Auto
PLL FAULT	Phase-Locked Loop occurs when input frequency is ± 7 Hz of 60 Hz. Check input frequency.	Auto
PRECHARGE FAIL	Pre-charge circuit has failed to charge bus capacitors.	Manual
STIR FAN FAIL	PT420 and PTE420QT only. Temperature sensor near inductor has exceed safe operating limits. Wait for temperature to drop to safe level.	Auto
TEMP SENSE FAULT	Temperature sensor on the heat sink has failed or its cable is disconnected.	Manual[1]
UNBALANCE BUS VOL	Potential damage to a bus capacitor or degradation of the bus balancing resistor.	Auto
VOLTAGE UNBALANCE	Output voltage difference between pass-through legs and generated leg is greater than 50 V.	Manual[1]

1. Faults will automatically restart if Infinite Restart mode is enabled.

8.2 Faults: Manual Restart

These faults generally indicate damage to the converter and/or the load. They may also indicate a potentially dangerous condition. When this type of fault occurs, the display will indicate the fault message and the converter output will remain off.

⚠ **CAUTION!** Contact Phase Technologies for assistance before restarting or troubleshoot the system thoroughly before power cycling the converter.

⚠ **WARNING!** Risk of electric shock. De-energize the unit by disconnecting all incoming sources of power, then wait 30 minutes for internal charges to dissipate before servicing the equipment.

8.3 Fault Log

The Fault Log records faults with number of occurrences. To access the Fault Log, wire a dry contact switch between AUX3 and COM (now called SW3), and wire a dry contact switch between AUX4 and COM (now called SW4). Standard light switches will work. Next, set SW3 and SW4 per **Table 24**. There are two fault logs – Master and User Fault Log.

Master Fault Log:
A non-resettable count of all faults over the life of the main circuit board

User Fault Log:
A resettable count of faults. Each fault type is limited to a count of 10. On the 11th fault, the unit will display the appropriate fault and the LCD screen will display "RESET? PWR CYCLE".

Power cycling the unit will reset the fault back to zero.

Table 24 – Modes for SW3 and SW4 (ON = up, OFF = down)

SW3	SW4	Result
OFF	OFF	Factory default: LCD screen will scroll various operating parameters. **UNIT WILL OPERATE WHILE IN THIS MODE.**
ON	OFF	LCD screen will show Master Fault Log (non-resettable count of all faults). **UNIT WILL NOT OPERATE WHILE IN THIS MODE.**
ON	ON	LCD screen will show User Fault Log (resettable count of all faults). **UNIT WILL NOT OPERATE WHILE IN THIS MODE.**
OFF	ON	Reserved

8.4 Troubleshooting Tips

If a fault occurs, a fault code will be displayed on the LCD screen. See **Table 23** for a list of fault codes. Fault codes generally indicate that an issue exists independent of the phase converter.

Table 25 – Troubleshooting

Problem	Potential Cause	Solution
No power	Incoming circuit breaker continually trips	IGBT troubleshooting
	Blown fuses	If fuses are blown, this may also require replacing filter capacitors and/or the power board if the MOV's are damaged. See **7.5 Fuses** for more information.
Load not operating	Fault code displayed	Use **Table 23** for more information and guidance on fault codes. Clear the fault by power cycling the converter. Remove the load to determine if the issue is internal or external to the unit.
	AUX1 and AUX2 open	Check the jumper or switches connected to the AUX1 and/or AUX2 inputs
	Signals to the Control Terminals corrupted	Shielded cable is required for AUX terminal leads longer than 20 ft.
	Input terminals L1 and L2 not energized	Check the main input fuses or breaker. Check the secondary circuit fuses. See **7.5 Fuses** for more information.
	Overcurrent fault in elevator application	Check elevator specs to ensure PT is sized correctly.
Motor is spinning backwards	Phase sequence to motor is wrong.	Swap any two of the three motor leads.
LED lights flickering or other electrical noise issues	Electromagnetic interference issues	Ensure that problem does not persist when PT is powered off. Check and improve grounding. See this document for a more detailed list of potential solutions.

9 DIMENSIONAL DRAWINGS

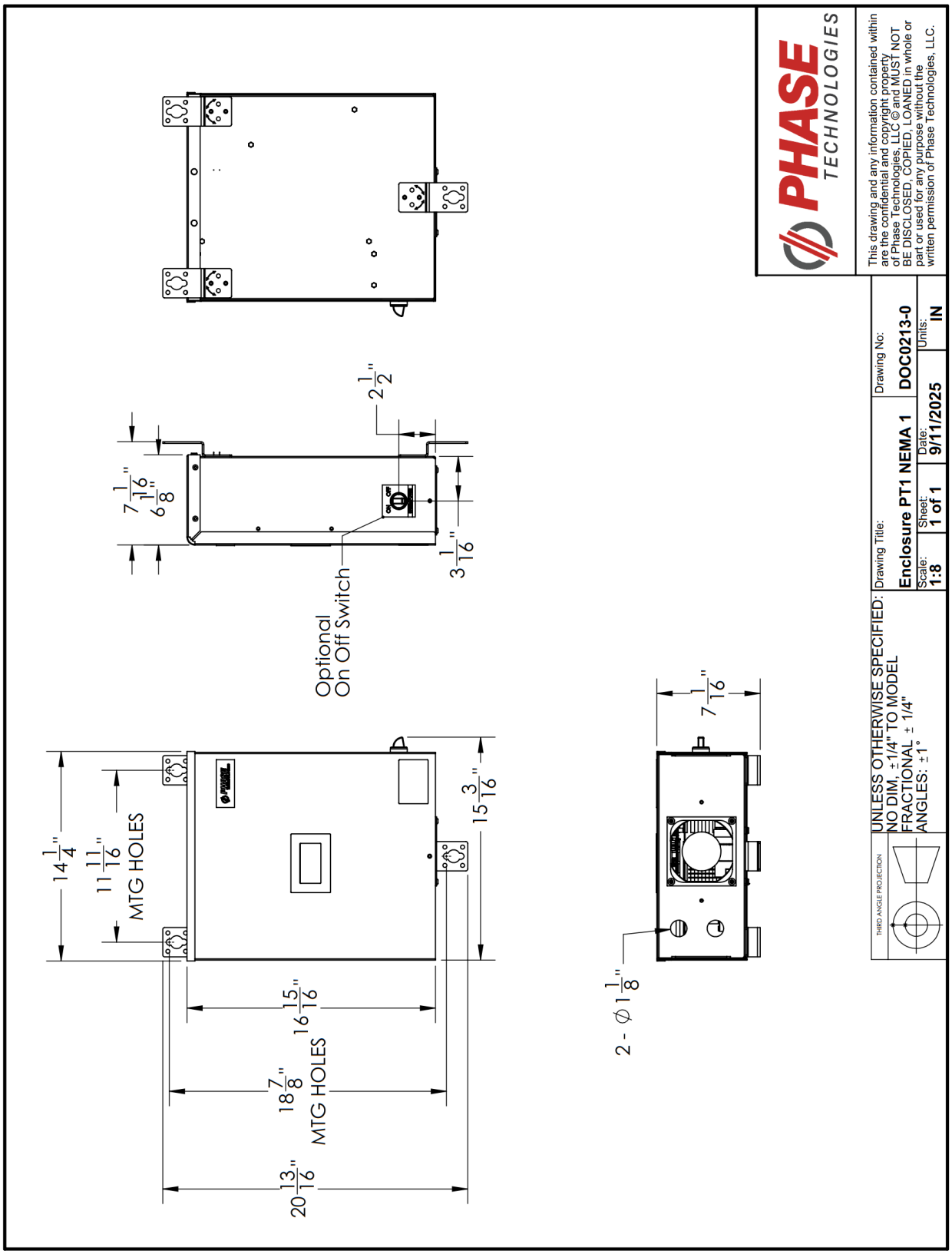


Figure 11 - ENC P1 NEMA 1 Dimensions

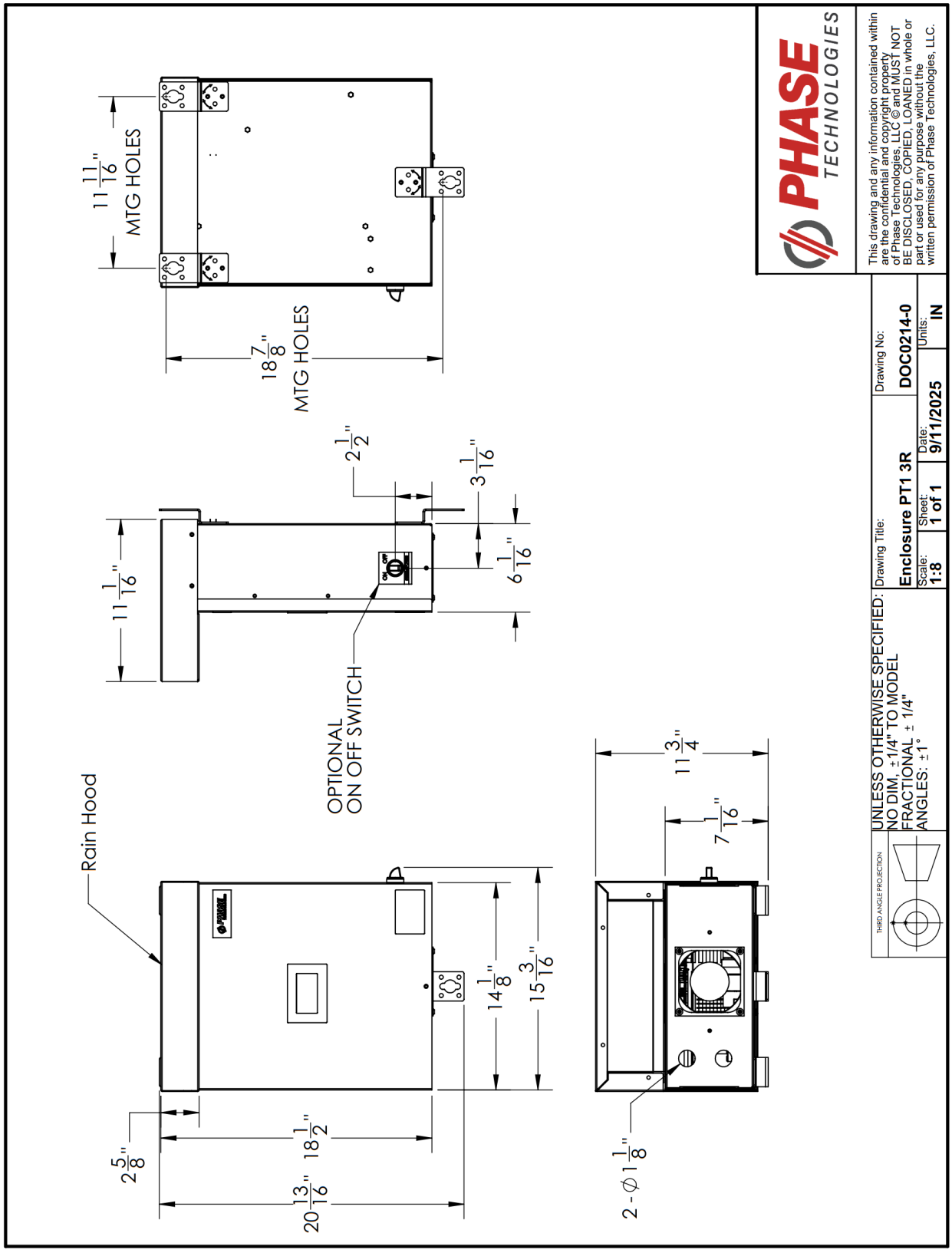


Figure 12 – ENC P1 NEMA 3R Dimensions

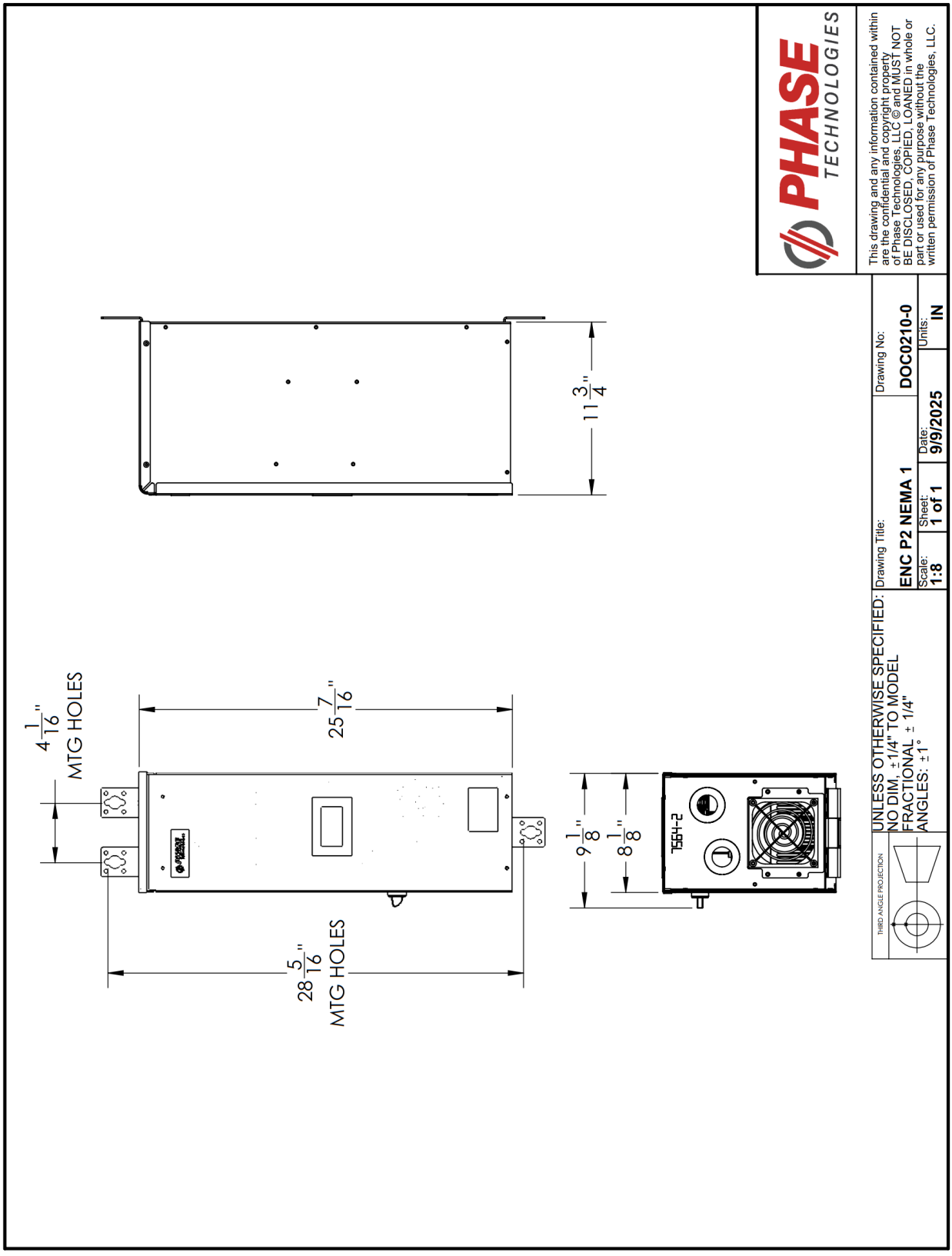


Figure 13 – ENC P2 NEMA 1 Dimensions

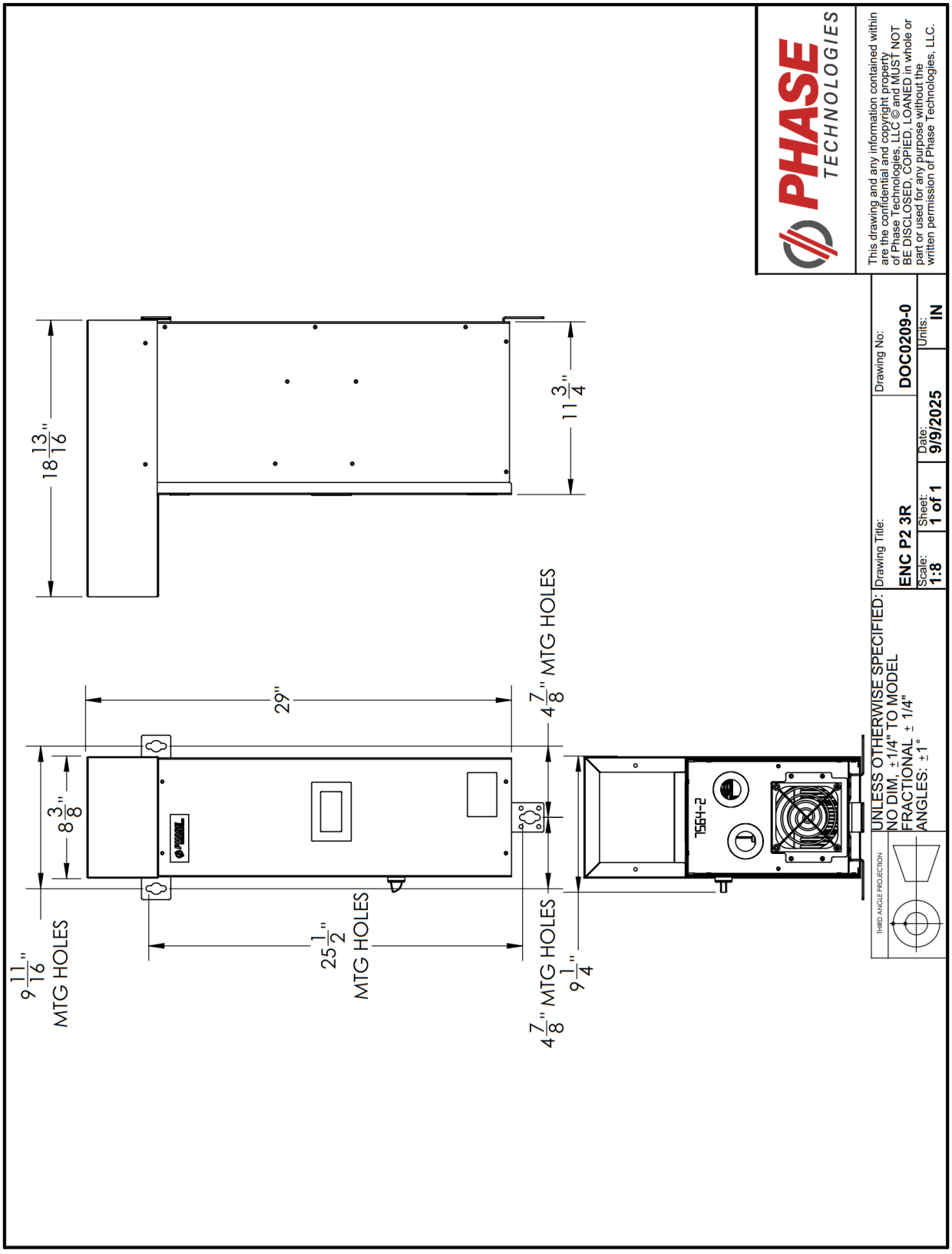


Figure 14 – ENC P2 NEMA 3R Dimensions

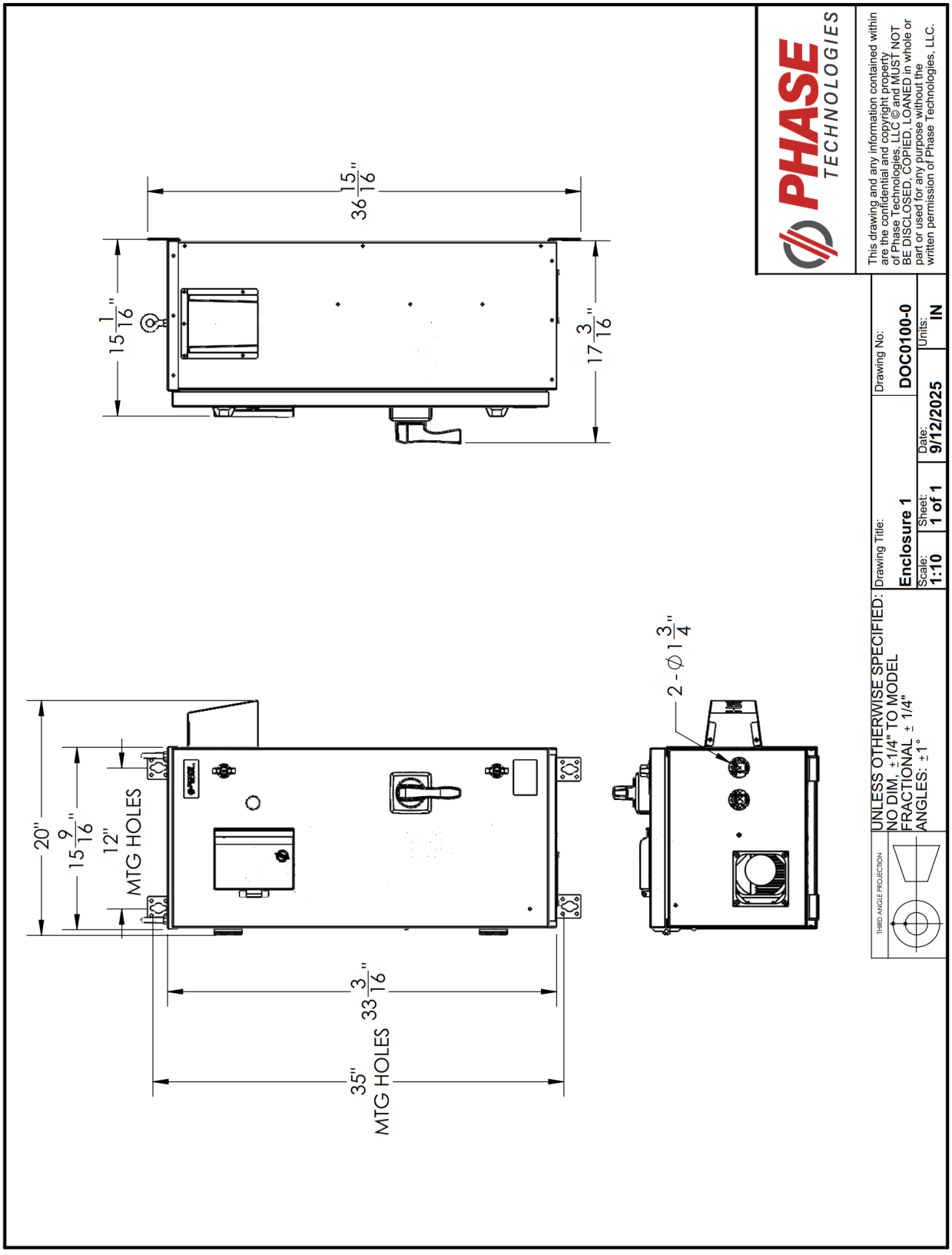


Figure 15 – ENC1 NEMA 3R Dimensions

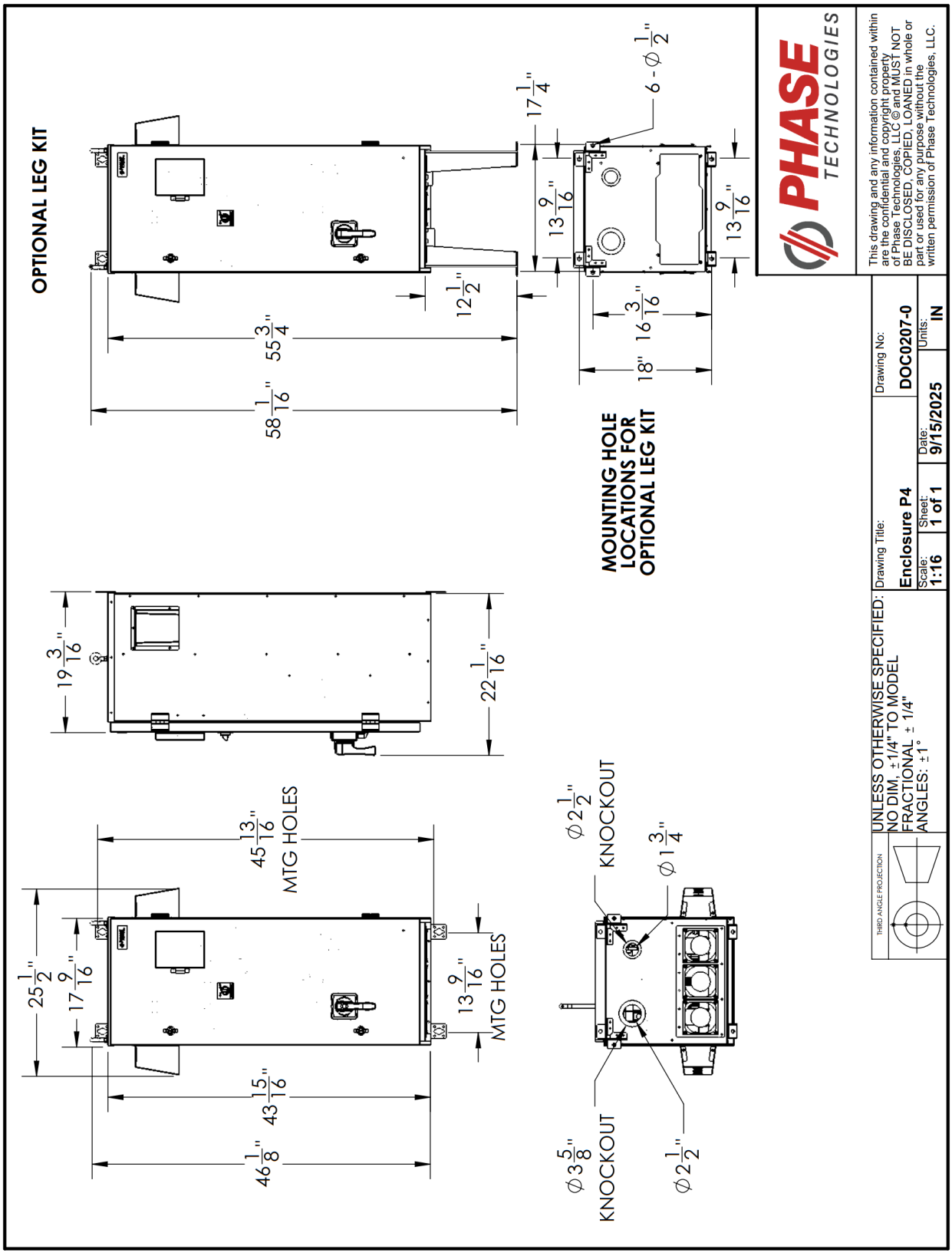


Figure 16 – ENC P4 Dimensions

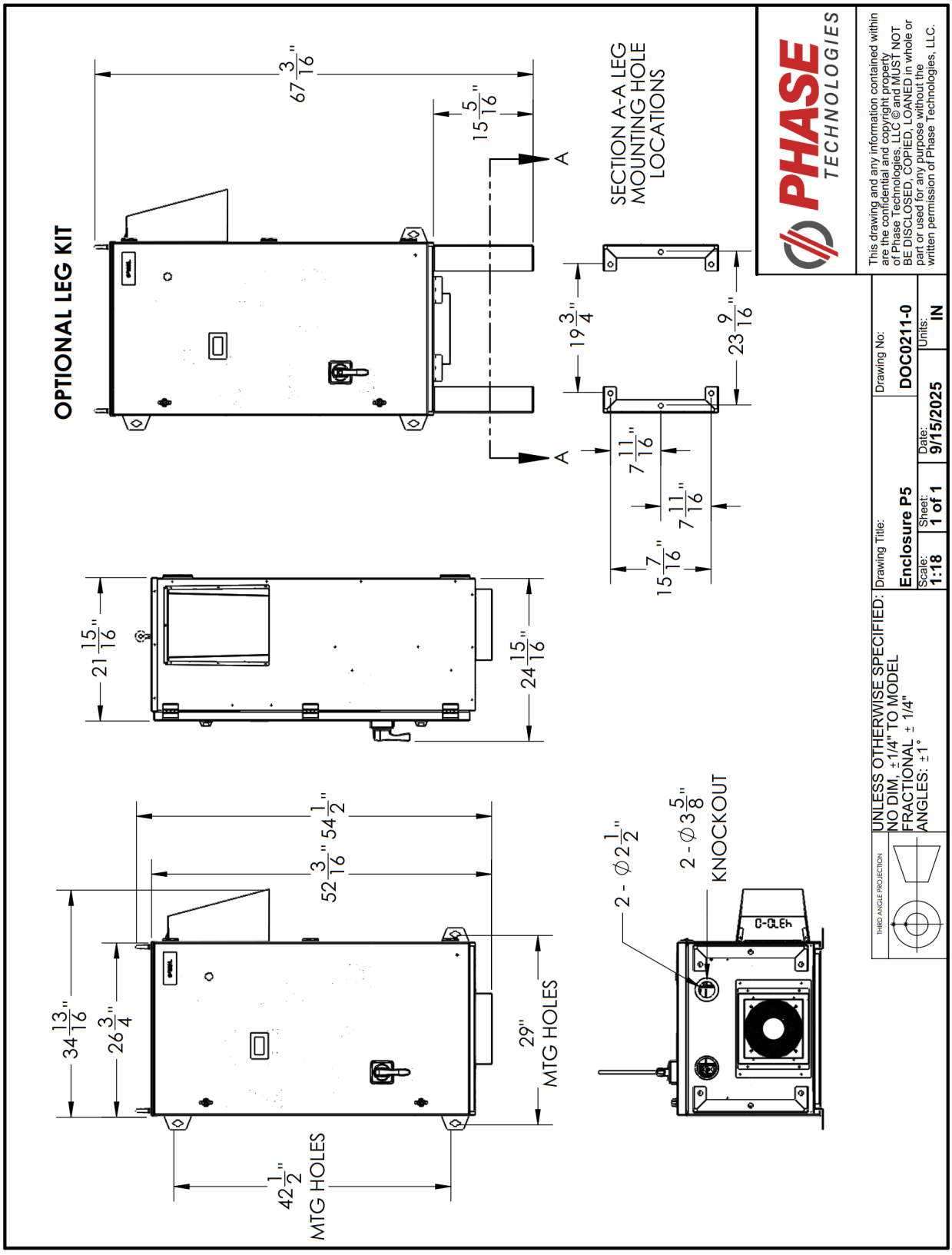


Figure 17 – ENC P5 NEMA 3R Dimensions

10 WARRANTY POLICY

LIMITED WARRANTY

This Limited Warranty applies to the following
Phase Technologies' product lines:

Phase Perfect® Digital Phase Converters
One Year Warranty

Phase Perfect Digital Phase Converters are warranted against defects in material and workmanship. This warranty covers both parts and labor from the date of purchase from Phase Technologies. 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 Customer

1. The original Bill of Sale must be presented to obtain "in-warranty" service. Transportation to Phase Technologies or an Authorized Service Center is the responsibility of the purchaser. Return transportation is provided by Phase Technologies.

2. 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 does this warranty cover any contingencies beyond the control of Phase Technologies, LLC, including: water damage, incorrect line voltage, improper installation, missing or altered serial numbers, and service performed by an unauthorized facility.

Phase Technologies' liability for any damages caused in association with the use of Phase Technologies' equipment shall be limited to the repair or replacement only of the Phase Technologies' equipment. No person, agent, distributor, dealer, or company is authorized to modify, alter, or change the design of this merchandise without express written approval of Phase Technologies, LLC.

Installations must comply with all national and local electrical code requirements.

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