PHASE PERFECT®
Residential
PRO SERIES

MANUAL

230 V | 2 - 5 HP

SAFETY MESSAGES AND WARNINGS

To ensure safe and reliable operation of the Phase Perfect® Residential, 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 **Table 7** and **Table 8.**

⚠ **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 6.

⚠ **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 Residential Phase Converter.

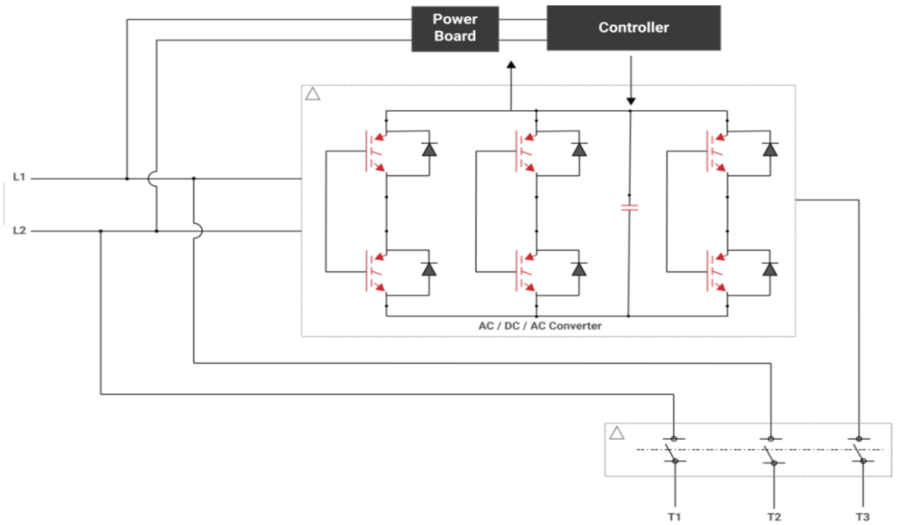

Figure 1 – Phase Perfect Residential Phase Converter Schematic

2 MODELS AND RATINGS

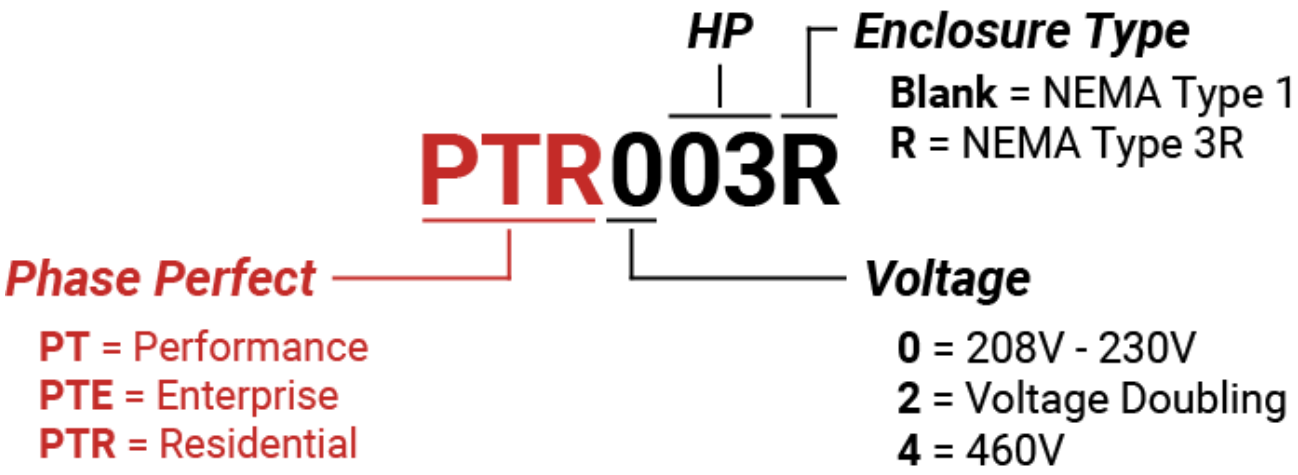

Figure 2 – Model Nomenclature

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	-10°C (14°F) to 50°C (122°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)
PTR002	2	3	187-260	Equal to Input	13	7.5	68/232	213
PTR003	3	4.5	187-260		19	11		312
PTR005	5	6.7	187-260		28	16		454

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			Approx. Weight (lbs)
	Height (in)	Width (in)	Depth (in)	Height (in)	Width (in)	Depth (in)	
PTR002	17	14	7	18.5	14	12	50
PTR003							
PTR005							

1. Dimensions are approximate. See drawings in **Section 6** for details.

2.3 Motor Starting/Overload Capabilities

All Phase Perfect Residential digital phase convertors are rated to across the line start motors up to the nameplate horsepower rating of the convertor. 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.

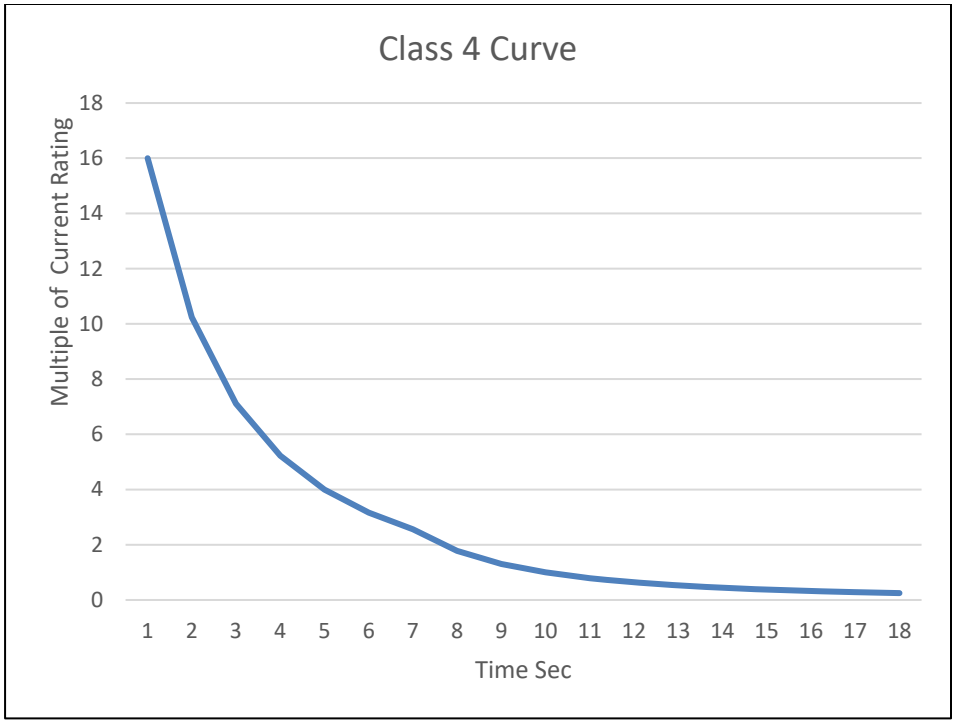

Figure 3 – Class 4 Overload Curve

Table 4 – Class 4 Overload Limits

Model	Rated Current (A)	Allowable Current (A) @ Specified Time		
		1 sec	4 sec	10 sec
PTR002	7.5	60	30	19
PTR003	11	88	44	28
PTR005	16	128	64	41

3 INSTALLATION

3.1 Mounting Your New Phase Perfect Residential

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**.

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

Some PTR converters may 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 Residential 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 5** 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 5 – Circuit Breaker and Ground Wire Sizing

Model	Recommended Circuit Breaker (A)	Min. Copper Ground Wire Size (AWG)	Min. Aluminum Ground Wire Size (AWG)
PTR002	20	12	10
PTR003	25	10	8
PTR005	40	10	8

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

3.8 Connecting Source Power

Table 6 – 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)
PTR002	8 AWG	10 AWG
PTR003		
PTR005		

3.9 Wire Sizing

Use **Table 6** 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 Residential 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.

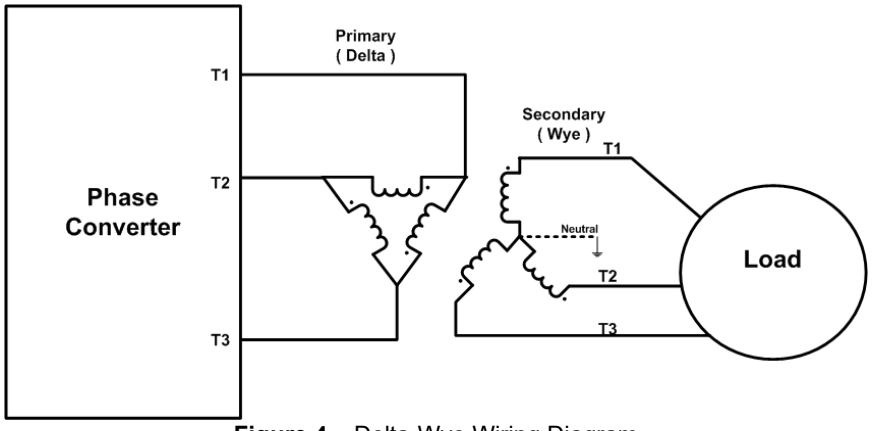

Figure 4 – Delta-Wye Wiring Diagram

Table 7 – PTR Input Power Terminal Specifications

Model	Wire Range	Torque (in-lb)	Tool
PTR002	26 – 6 AWG	10.5	Phillips
PTR003			
PTR005			

Table 8 – PTR Output Power Terminal Specifications

Model	Wire Range	Torque (in-lb)	Tool
PTR002	26 – 6 AWG	10.5	Phillips
PTR003			
PTR005			

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 9** below.

Table 9 – 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 5** below.

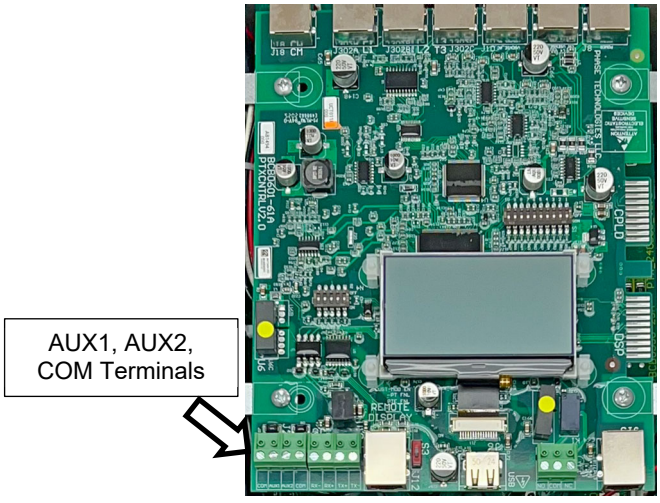

Figure 5 – Control Terminal Locations

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

⚠ **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 10 – 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 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.

4.1 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:

4.2 Power terminals

Periodically, inspect for loose connections and tighten to specifications in **Table 7**.

4.3 Capacitors

Check for leakage or deformation.

4.4 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.

4.5 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 11**, contact Phase Technologies for replacement.

Table 11 – PTR Nominal Filter Capacitor Values in MicroFarads (μF)

Model	Nominal Capacitance (μF)	50% Capacitance (μF)
PTR002	9.4	4.7
PTR003		
PTR005		

5 TROUBLESHOOTING

5.1 Fault Codes

Table 12 – 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
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.

5.2 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.

5.3 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 13**. 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 13 – 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

5.4 Troubleshooting Tips

If a fault occurs, a fault code will be displayed on the LCD screen. See **Table 12** for a list of fault codes. Fault codes generally indicate that an issue exists independent of the phase converter.

Table 14 – 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 Error! Reference source not found. Error! Reference source not found. for more information.
Load not operating	Fault code displayed	Use **Table 12** 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 Error! Reference source not found. Error! Reference source not found. for more information.
	Overcurrent fault	Check load specs to ensure PTR 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.

6 DIMENSIONAL DRAWINGS

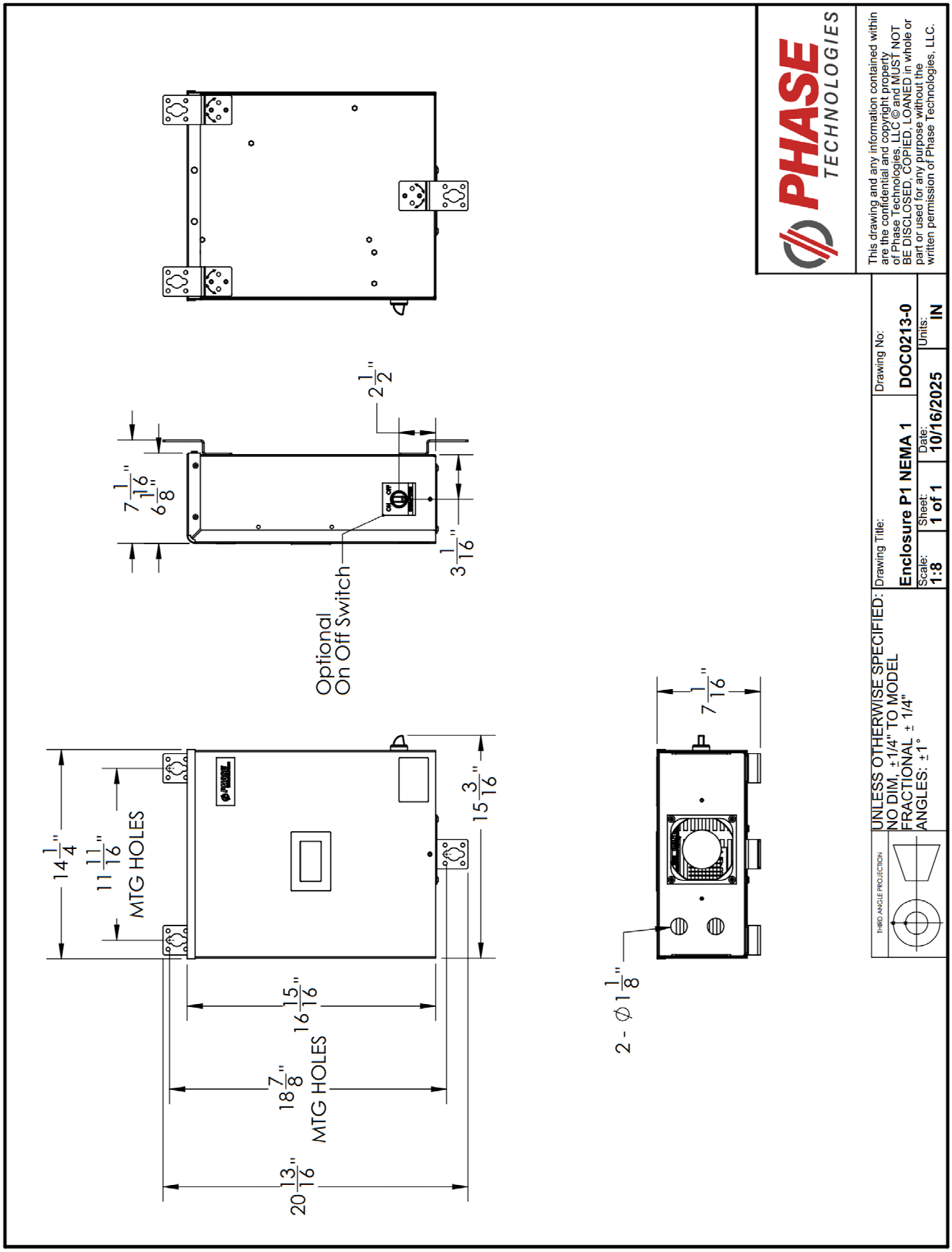

Figure 6 – PTR NEMA 1 Dimensions

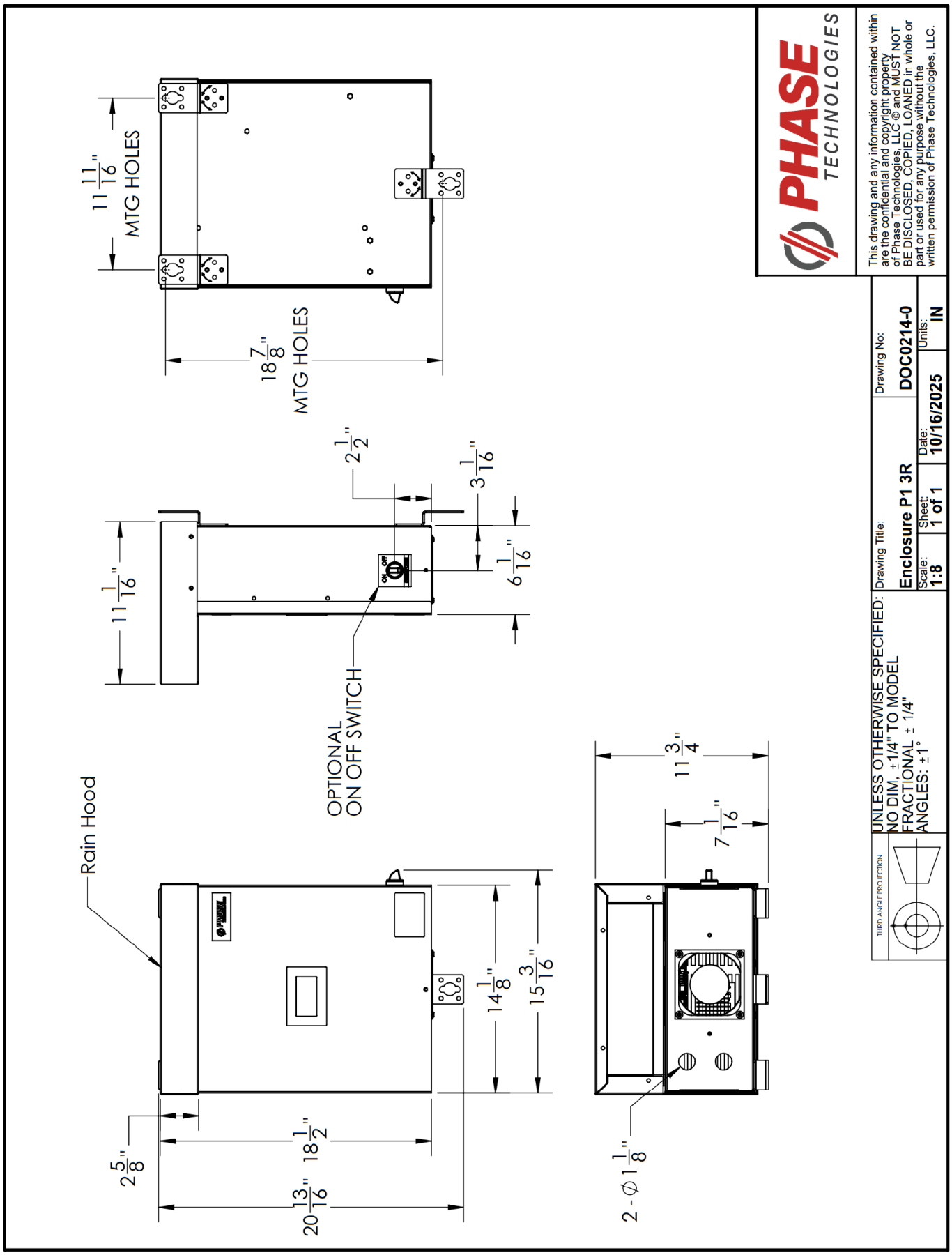

Figure 7 – PTR NEMA 3R Dimensions

7 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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