PVPowered™

PVP35kW & PVP50kW Inverter

INSTALLATION & OPERATION MANUAL

97-600100-27-C

Preface

PV Powered

PV Powered designs, manufactures and markets the solar power industry's most reliable photovoltaic solar inverter solutions. We've assembled a highly experienced solar power electronics design team. Our vision is to spur the widespread adoption and success of solar power, by assisting our distributors, dealers and installers in this dynamic market while ensuring that our products are the best supported, easiest to install and most reliable solar inverters in the industry. Our innovative approach to performance monitoring provides secure and easy access to system performance and inverter status over the Internet.

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Revisions and Certification

For applicability of technical information with your specific product, contact PV Powered Customer Service and Technical Support at support@pvpowered.com.

Safety Information and Conventions

Designation of Danger, Warning and Caution

DANGER

The Danger statement is used to inform the installer/operator of a situation requiring the utmost attention. Failure to heed this warning will result in serious injury or death to personnel and destruction of equipment.

WARNING

The Warning statement is used to inform the installer/operator of a situation requiring serious attention. Failure to heed this warning may result in serious injury or death to personnel and destruction of equipment.

CAUTION

The Caution statement is used to inform the installer/operator of a situation requiring attention. Failure to heed this Caution may result in injury to personnel and damage to equipment.

Acronyms and Abbreviations

A/D	Analog to Digital Conversion
ANSI	American National Standards Institute
CFM	Cubic Feet per Minute
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
DSP	Digital Signal Processor
DVI	Digital Video Interface
EMI	Electromagnetic Interference
ESD	Electro Static Discharge
GFDI	Ground Fault Detector Interruptor
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated Gate Bipolar Transistor
IP	Internet Protocol
LOTO	Lockout Tagout
MCM	1000 Circular Mils Utilized in Wire Sizing
MPPT	Maximum Power Point Tracking
NEC	National Electric Code
NFPA	National Fire Protection Association
PCB	Printed Circuit Board
PLL	Phase Lock Loop
PPE	Personal Protective Equipment
PV	Photovoltaic
PVM	PV Monitoring
PWM	Pulse Width Modulation
RMS	Root Mean Squared
UL	Underwriter's Laboratory
VAC	Voltage Alternating Current
VDC	Voltage Direct Current
VFD	Vacuum Fluorescent Display

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1. Introduction

1.1 Design Features

The PVP35kW and PVP50kW Inverters are designed to act exclusively as grid-tied inverters for photovoltaic (PV) systems. This means the inverter must be tied to the utility grid and a photovoltaic system in order to operate properly and it is not suitable for any other applications (such as a battery back-up or wind powered systems). The inverters contain everything needed to convert the DC voltage generated by a solar array into AC electrical power. Because the inverters are tied to a local utility source, if local electrical load exceeds the power generated by the solar array, the grid automatically supplies the additional electricity needed. Likewise, if the inverters produce more power than is needed, it feeds the excess power back into the electrical grid.

This manual provides all the information necessary to successfully install and operate the PVP35kW and PVP50kW Inverters.

Easy Installation

The PVP35kW and PVP50kW Inverters are built for easy installation. To minimize installation efforts, these inverters feature an integrated isolation transformer and integrated AC and DC disconnects in a compact single cabinet. The unit can be ordered with a range of DC subcombiner options for maximum adaptability.

Simple, Innovative Design

The PVP35kW and PVP50kW Inverters are a fully integrated solution with standard integrated data monitoring. The modular design enables rapid field service and upgrades. The inverters can quickly and easily be installed in any preferred location, indoors or out.

Adaptability

The PVP35kW and PVP50kW Inverters' DC Maximum Power Point Tracking (MPPT) range is 295VDC to 595VDC. The maximum input voltage is 600VDC.

Versatility

The PVP35kW and PVP50kW Inverters are designed for flexibility. They can be used for a range of commercial applications and can accommodate most PV system configurations.

1.2 Product Characteristics

See *Appendix A - Specifications* for the product specifications information.

1.3 Product Features

The design of the PVP35kW and PVP50kW Inverters includes:

- Anti-islanding protection
- EMI output filtration
- Field-selectable voltage and frequency trip points
- Remote monitoring

Anti-islanding Protection

An advanced anti-islanding monitoring function prevents the inverters from feeding power to the utility grid in the event of a utility outage.

EMI Output Filters

The PVP35kW and PVP50kW Inverters utilize EMI output filters to prevent electromagnetic interference.

AC Overcurrent Protection

The PVP35kW and PVP50kW Inverters current monitoring system constantly monitors the AC current within the unit, limiting the inverter's current output.

AC and DC Disconnects

The PVP35kW and PVP50kW Inverters feature integrated AC and DC disconnects. Both disconnects are UL98 listed and load-break rated, a feature not commonly offered for DC side disconnects.

Remote Monitoring

All PV Powered commercial inverters come with a standard Ethernet data acquisition and communications interface module. With a high speed connection, this module can provide PV system performance data in the following ways:

1. Subscribe to the standard monitoring service on the mypvpower.com web site. This recommended method allows the user to track the PV system and inverter information online. This secure web site is provided by PV Powered and the Basic Monitoring Service is available to all registered users.
2. Provide data to third party data monitoring solutions providers.

1.4 Major Components and Functional Parts Descriptions

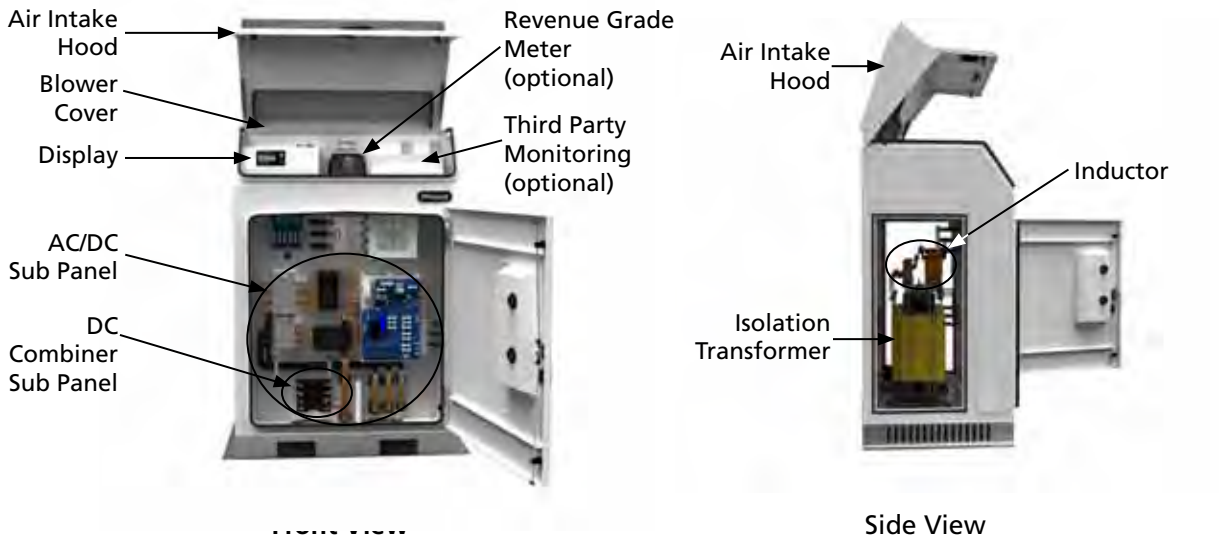


Figure 1-1 PVP35kW and PVP50kW Inverters

Main Enclosure

The modular design of these inverters make them easy to access and service. The main enclosure (Figure 1-1) is comprised of two main sections:

1. The upper compartment contains the following:
   - Circuit board card cage
   - User interface board
   - Power supply
   - Active cooling system
   - Third party data monitoring (optional)
   - Revenue grade meter (optional)
2. The lower and magnetics compartments house the following:
   - Power conversion electronics for converting the DC input power into AC output power.
   - DC Combiner Sub Panel contains the optional fused subcombiner and the positive, negative and ground bars.
   - AC/DC Sub Panel with integrated DC ground fault detector interrupter and DC disconnect, the DC line filter, DC contactor and the AC disconnect.
   - AC line filter, AC contactor, AC and DC surge protection and AC connection points.
3. Magnetics Compartment contains the isolation transformer and inductors.

Power Module Assembly

These inverters use Insulated Gate Bipolar Transistors (IGBTs) for converting DC power into three-phase AC power. The inverter is protected by overcurrent, over-voltage and over-temperature detection controls. If a protection system is activated, the power module will cease power conversion and send an interrupt signal to the Digital Signal Processor (DSP).

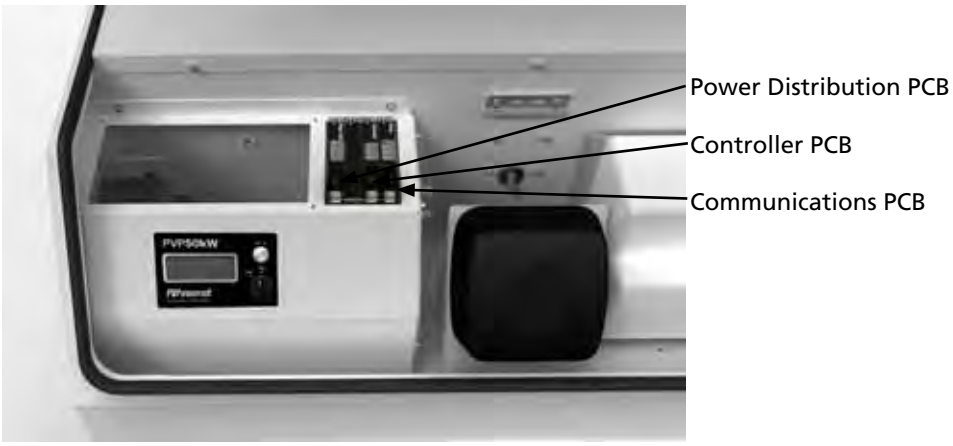


Figure 1-2 Card Cage Assembly

The Card Cage Assembly (Figure 1-2) is designed to enable fast and easy service and also acts as an EMI shield to ensure signal integrity on the following four PCBs:

1. Communications PCB – Provides serial, internet and Modbus communications.
2. Power Distribution PCB – Distributes the required logic level voltages for use throughout the inverter.
3. Controller PCB – Contains a powerful DSP that controls sine wave generation, logic functions and protection activities. All analog and digital inputs and outputs are routed to the Controller PCB and fed to the DSP.
4. User Interface PCB - Provides connection points for Ethernet, RS-485, RS-232 and diagnostic test points, in addition to the location to access inverter status and remote enable/disable commands.

Active Cooling

The inverters come with a variable-speed blower which operates as needed to keep the internal components within preset temperature limits. The blower is located under a shroud below the air intake hood of the inverter.

Housekeeping Transformer

The housekeeping transformer, located in the bottom right of the magnetics compartment, is a voltage conversion device that transforms line voltage to 120VAC to 240VAC for use within the inverter.

Isolation Transformer

The inverters come equipped with an integral isolation transformer (Figure 1-1, Rear View). The isolation transformer is designed for class-leading inverter efficiency.

Inductor

The inductors (Figure 1-1, Side View) are used to filter the AC waveform generated by the power module, effectively reducing high frequency noise.

AC/DC Sub Panel

The AC landing, filtering and sense fusing takes place in the AC/DC sub panel (Figure 1-3). The AC/DC sub panel also includes the AC contactor, AC disconnect, AC and DC surge modules and the soft-start circuit. In addition, the DC subcombiner, DC disconnect, DC contactor and DC line filter are located on this panel.

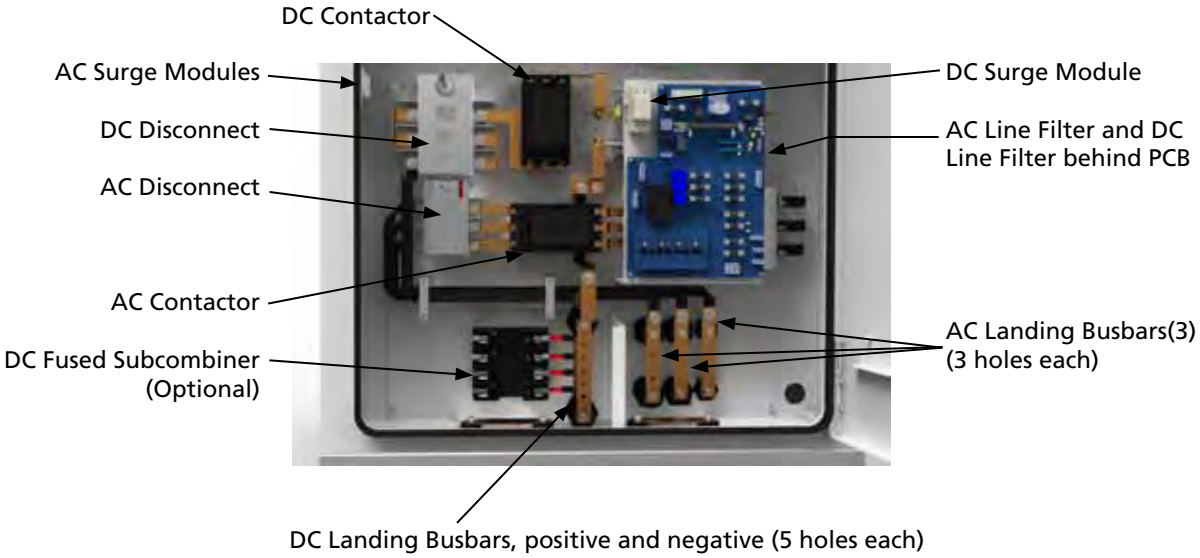


Figure 1-3 AC/DC Sub Panel

HV Distribution PCB

The HV Distribution PCB (Figure 1-4) is located on the AC/DC sub panel. This PCB contains:

- Soft-start circuitry
- Fusing for the soft-start circuit
- Fusing for the AC Sense Circuit and 48 VDC power supply
- Contactor fusing
- GFDI fuse

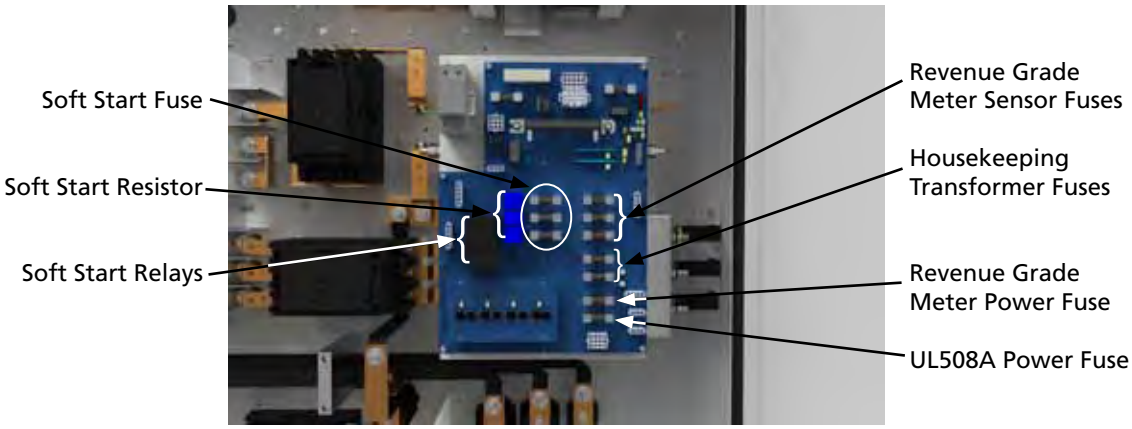


Figure 1-4 HV Distribution PCB

WARNING

Risk of Electrical Shock. The GFDI functions using a 2A fuse for the PVP35kW and a 3A fuse for the PVP50kW to connect or bond the solar array Negative (or the solar array Positive, if using a positively grounded panel array) to earth ground on the HV Distribution PCB.

If the ground fault current exceeds 2A for the PVP35kW or 3A for the PVP50kW between the grounded array terminal and the earth ground, the fuse will open and disconnect the solar panels from their ground reference, interrupting the ground fault. In this situation, the inverter will cease operation, display a fault message and the LED on the HV Distribution PCB will illuminate red. If a ground fault current is measured but is less than the ground fault fuse rating, the inverter will indicate a ground fault warning.

Operator Interface Controls/Vacuum Fluorescent Display

The Vacuum Fluorescent Display (VFD) provides multiple information screens to the user.

Views and Basic Block Diagram of the Inverter

See *Appendix C - Mechanical Drawings* for multiple views of the inverter.

2. Safety

2.1 General Safety

IMPORTANT SAFETY INSTRUCTIONS: This product has been engineered and manufactured to ensure your personal safety. Improper use may result in potential electrical shock or burns. Read and follow all instructions for installation, use and servicing of this product. Read all safety warnings before installing or operating the inverter.

Symbols Utilized within the Inverter

Item Type	Symbol
Direct Current Supply	⎓
Alternating Current Supply	∿
Phase	⏀ or ∅
Equipment Grounding Conductor	⏚
On or Off	⏻

Table 2-1 Inverter Symbols

SAVE THESE INSTRUCTIONS: This manual contains important instructions for the PVP35kW and PVP50kW Inverters that must be followed during installation and maintenance of the inverter.

DANGER
Risk of Electrical Shock. High voltages are present within the inverter cabinet. Both AC and DC disconnects must be in the OFF position when working on the unit. Wait five minutes to discharge high voltage before opening the front panels of the inverter.

DANGER
Risk of Electrical Shock. When exposed to light, PV arrays create electrical energy that could cause a hazardous condition.

DANGER
Risk of Electrical Shock. Before connecting the inverter to the electrical utility grid, your utility company must grant approval. Only qualified electricians should make the connection to the utility grid.

CAUTION
Risk of Electrical Shock. All electrical installations should be accomplished in accordance with local electrical codes and the National Electrical Code (NEC), ANSI/NFPA 70.

2.2 Electrical Safety

Islanding Prevention - Electrical Safety Features

The inverter is designed for safety, reliability and efficiency. Power for the inverter control circuitry is drawn from the utility grid. This ability, along with an advanced anti-islanding scheme, ensures power can never be generated during a utility grid failure. The isolation transformer guarantees isolation of the utility grid and PV modules. The inverter also incorporates an integral ground fault detector/interrupter (GFDI) circuit.

Handling, Service and Maintenance

Only qualified personnel should perform the transportation, installation and initial operation and maintenance of the inverter in accordance with NEC ANSI/NFPA 70, as well as all state and local code requirements. Follow all national and state accident prevention regulations.

WARNING
Crush Hazard. The inverters have a specific balance point that correlates to their Center of Gravity. While the units meet UL1741 Stability tests, they should not be tipped beyond 10° of tilt, as the unit could topple over and crush anyone trapped underneath.

WARNING
Risk of Amputation. The inverter contains a high volume blower capable of high rotational speeds. Do not operate this inverter without the blower cover in place. Keep away from unguarded blower blades.

WARNING
Risk of Burn. The inverter components can become extremely hot during normal operation.

WARNING
Risk of Damage to Equipment. The inverter contains Electro Static Discharge (ESD) sensitive circuitry. Discharge any static charge potential, by touching bare skin to earth ground, prior to contacting any internal components.

Equipment Precaution/ Warning Labels

Observe all warning decals, placards and symbols posted within the inverter for safe operation.

Disconnect Switches

The unit is equipped with both AC and DC Disconnect (power OFF) switches to stop power conversion within the inverter unit. Before accessing the interior of the cabinet, these switches must be in the off position. Since these disconnects only stop power conversion within the unit, both the DC (photovoltaic array) and AC (utility grid) circuits must be isolated in order to fully ensure the inverter is de-energized. See *2.5 De-energize/ Isolation Procedures* on page 11 for information on how to perform this task.

DANGER
AC and DC voltages will still be present at the inverter AC and DC landing points unless utility connection circuit breaker and PV array inputs are disconnected.

DANGER
Risk of Electrical Shock. Allow five (5) minutes for internal power to dissipate prior to entering the enclosure cabinet. Ensure all terminals are voltage free with the use of a multimeter.

2.3 Personal Safety

Safety Zone

Ensure any personnel entering a safety zone within a four foot area around any operating inverter wear appropriate Personal Protective Equipment (PPE) as mandated by national, state and local authorities.

Medical and First Aid Treatment

Personnel working in and around operating power generation equipment should be trained in Arc Flash Hazard, Fire Extinguisher selection and use, First Aid, Cardio Pulmonary Resuscitation (CPR) and Automated External Defibrillator (AED) use (if available).

Safety Equipment

Minimum Requirements

Authorized service personnel performing operations on this unit should have the following available:

- Consult NFPA 70E for PPE requirements on switch gear operating at less than 600V
- Electrical Hazard Footwear (ANSI Z41/Z85 rated)
- Lock Out Tag Out (LOTO) Kit
- Appropriate meter to verify the circuits are safely de-energized (1000VAC and DC rated, minimum)
- Any other equipment as applicable to your operation as required by national, state and local regulations

2.4 Wiring Requirement

WARNING
In accordance with the NEC, ANSI/NFPA70, connect only to a circuit provided with a properly rated branch circuit overcurrent protection. Recommended ratings are:

- PVP35kW/208VAC - 150A
- PVP35kW/480VAC - 60A
- PVP50kW/208VAC - 200A
- PVP50kW/480VAC - 100A

Fire and Explosion Prevention

Care must be exercised when installing DC and AC hookups within the inverter. Follow all instructions in this manual to ensure proper and safe operation of this unit.

DANGER
Risk of Electrical Shock. In the event of a fire, disconnect power to the inverter and do not attempt to use a water based fire extinguisher. Utilize only a Class C extinguisher rated for electrical fire.

Wiring Information

All wiring methods and materials shall be in accordance with the NEC ANSI NFPA 70 as well as all state and local code requirements. Use only conductors with an insulation rating of 90°C (minimum).

The inverter is available with 208VAC and 480VAC output. The inverter is interfaced with the utility grid at the AC landing within the AC section on the front right side of the inverter. These terminals require the use of a UL-approved crimp-on type ring terminal or a UL-approved compression type lug certified for use with the chosen interface cables. Ensure similar cables run together in conduit runs and through gland plates, which allows any inductive currents produced to be cancelled out. For proper torque values of terminal lugs mounting hardware, see *Appendix D - Limits and Fault Codes.*

CAUTION
Risk of Equipment Damage. There shall be no connection of the AC Neutral terminals (H0 and X0) on the main transformer. These connections shall be left floating.

The inverter is interfaced with the DC photovoltaic array in the DC Combiner sub panel. Do not connect the negative pole on a negatively grounded system of the PV array directly to ground, as this will bypass the critical GFDI and violate the NEC. The DC Combiner sub panel includes a positive, negative and ground busbar. The inverter can also be ordered with an optional fused subcombiner. The standard busbar has one row of

3/8” holes for lug connections. The fused subcombiner has individual input terminals for each fuse block. These fuse block terminals require the use of a torque wrench to properly install the chosen interface cables. For proper torque values of DC subcombiner box wire mounting hardware, see *Appendix D - Limits and Fault Codes*.

This equipment is intended to be installed as part of a permanently grounded electrical system as per the NEC ANSI/NFPA 70 as well as all state and local requirements. A copper clad earth grounding electrode must be installed within three feet (one meter) of the unit. The AC ground busbar located in the AC section, lower front cabinet, must be used as the single point connection to the earth grounding electrode for the inverter system.

AC overcurrent protection for the utility interconnect (grid-tied) must be provided by installers as part of the installation. The following overcurrent protection device ratings are recommended:

- PVP35kW/208VAC - 150A
- PVP35kW/480VAC - 60A
- PVP50kW/208VAC - 200A
- PVP50kW/480VAC - 100A

2.5 De-energize/Isolation Procedures

De-energize

The following procedure should be followed to de-energize the inverter for maintenance:

DANGER
AC and DC voltages will still be present at the inverter AC and DC landing points unless utility connection circuit breaker and PV array inputs are disconnected.

DANGER
Risk of Electrical Shock. Allow five (5) minutes for internal power to dissipate prior to entering the enclosure cabinet. Ensure all terminals are voltage free with the use of a multimeter.

1. Open the upper section of the inverter by lifting the air intake hood to access the ON/OFF switch.
2. Turn the ON/OFF switch on the front display to the OFF position.
3. Position the AC Disconnect lever to the OFF position as shown in Figure 2-1.
4. Position the DC Disconnect lever to the OFF position as shown in Figure 2-1.
5. Open the utility connection circuit breaker (not shown).
6. Disconnect the PV using the external PV disconnect (not shown).
7. Install LOTO devices on the equipment as necessary to comply with LOTO requirements.

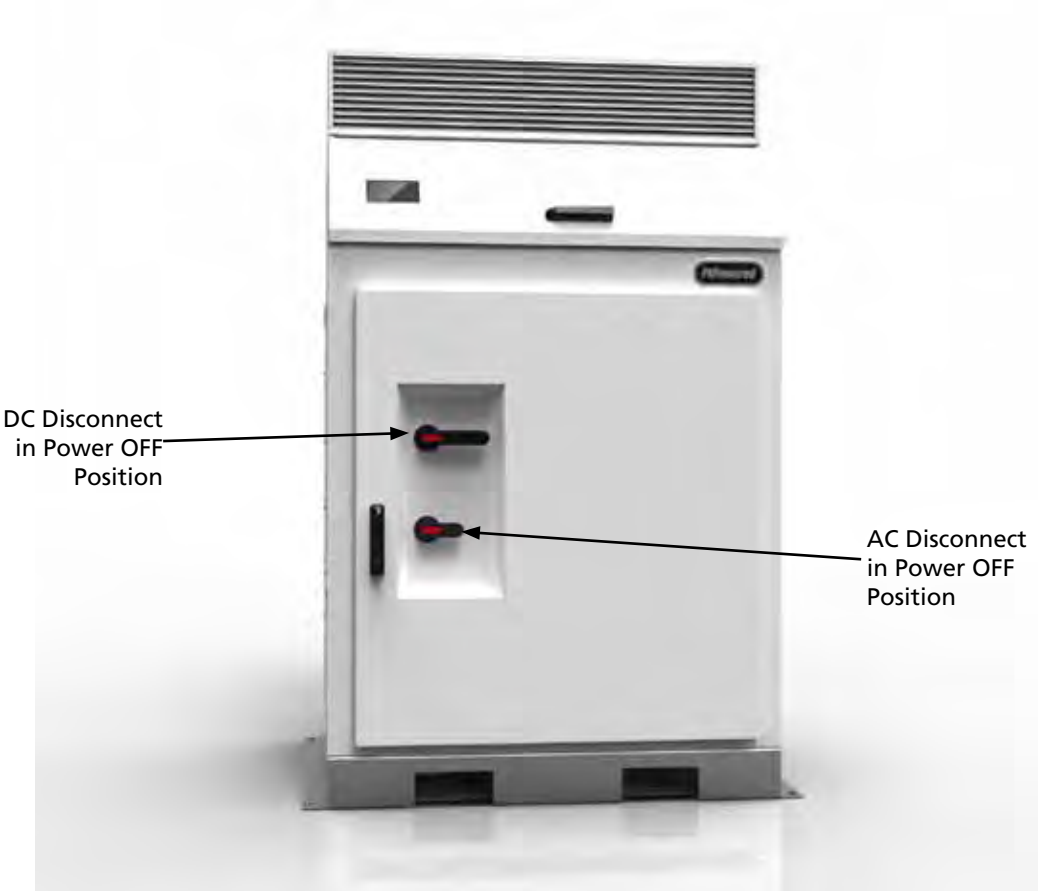


Figure 2-1 Inverter in the De-energized State

3. Planning

3.1 General Requirements

Installation of this equipment should only be performed by qualified technicians. Installers must meet all local and state code requirements for licensing and training for the installation of Electrical Power Systems with AC and DC voltages to 600 volts.

The inverter must be anchored to a flat, solid surface such as a concrete pad. The mounting pad may be required to meet local seismic requirements. See *Appendix C - Mechanical Drawings* for concrete pad mounting specifications for seismic zone 4 rating.

Planning

Planning for a system requires complete understanding of the processes involved to successfully install the inverters and meet all required local, state and national codes.

3.2 Location and Clearances

Location

Select a suitable location to install the inverter. The inverter must be installed on a flat, solid surface, such as a concrete pad. The inverter should be located as close to the array as possible to minimize the DC wire length.

Left and Right Sides

PV Powered recommends providing a minimum of six (6) inches of clearance on one side of the inverter and 36 inches on the other side (working clearances must also comply with NEC 110.26) to allow access to the external mounting flanges. The installer may select which side has a 36 inch clearance. The 36 inches will provide future access to the magnetics section for retorquing bolts and thermal scans of connections. However, the 36 inches on the side is not a NEC setback requirement. Six (6) inches on each side is an acceptable installation practice.

Rear

A rear clearance of three (3) inches is required behind the inverter to allow room for full opening of the blower cover.

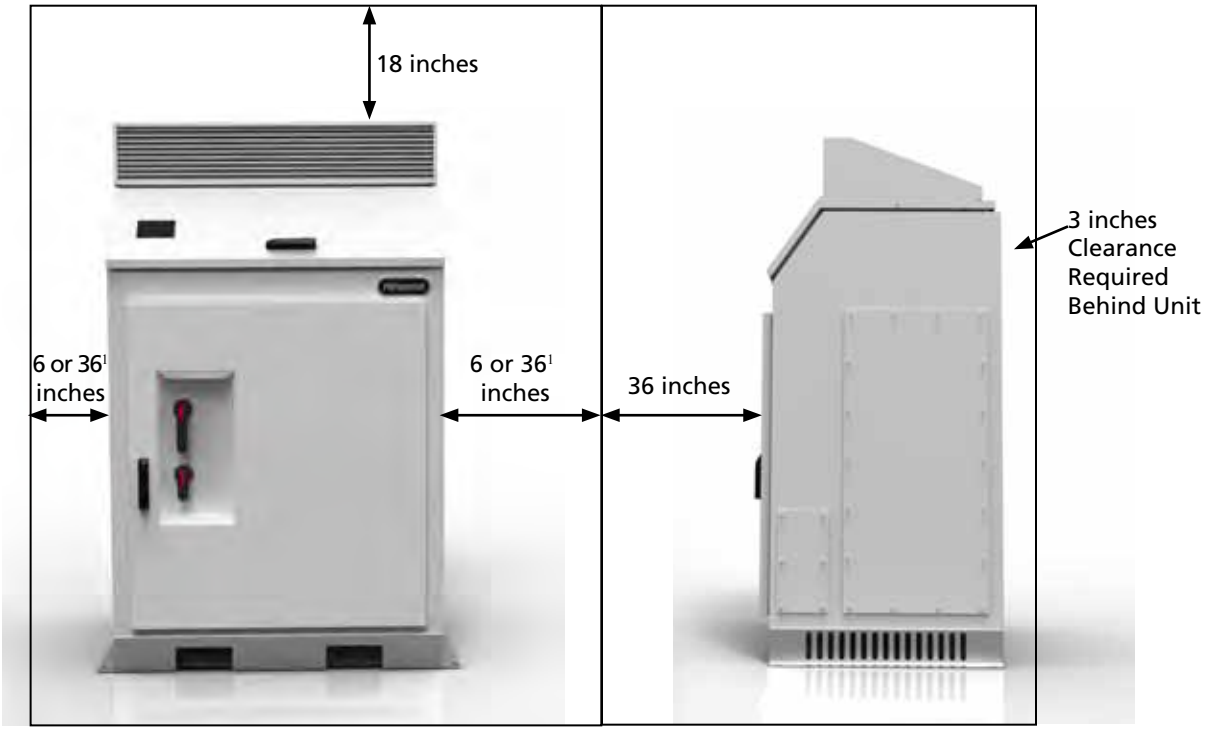
Front

A front clearance of three (3) feet is required to open and maintain the unit per NEC 110.26.

Top

A top clearance of 18 inches above the air intake hood is required to maintain the filters and blowers.

Clearances are shown in the figure below.



1. Only one side, right or left, is recommended to have the full 36"clearance while the remaining side must have 6". The above example demonstrates 6" on the left with 36" on the right side. This allows access to the magnetics section for retorquing bolts and thermal scan of connections. This is not an NEC setback requirement and 6" on each side is an acceptable installation practice.

Figure 3-1 Inverter Clearances

3.3 Conduits and Conductors

All the external conduits and conductors are to be supplied by the installer. See *Appendix C - Mechanical Drawings* for inverter gland plate locations. The gland plates must be in place for operation of the inverter.

All interconnect wiring and power conductors interfacing to the inverter must be in accordance with the NEC ANSI/NFPA 70 and any applicable state and local codes.

Large gauge wire must conform to the minimum bend radius specified in the NEC, Article 373-6B, Ninth Edition.

All conductors shall be rated for 90°C (minimum).

External Cable Interfaces: Entry through bottom or side gland plates. See *Appendix C - Mechanical Drawings* for details.

3.4 Environmental Requirements

The unit may be installed either indoors or outdoors. If the installation of the inverter is outdoors, all interconnect conduit and fittings must be rated NEMA 4 (same as inverter rating) as required by the NEC. For hot locations a shade structure should be placed over the unit in order to reduce thermal stress and extend the product's life.

Inverter power output will be de-rated for ambient temperatures in excess of 50°C/122°F.

Clearances: Front = 3 feet, Rear = 3 inches, Sides = 6 to 36 inches, Top = 18 inches.

Cooling Air Requirements: The maximum cooling air flow rate is 750 CFM. No external intake or exhaust air ports in the building are required if volume needs are met.

The maximum heat rejection rates for the inverters are:

- PVP35kW is 6,600 BTU/hr.
- PVP50kW is 8,500 BTU/hr.

3.5 Grounding and Neutral Requirements

PV Array Frame Grounding

The inverter incorporates an integral GFDI device. The PV array safety ground (frame ground) may be attached to the grounding busbar provided. The grounding busbar is located below the DC sub panel in the front left of the inverter cabinet. The PV array is grounded internally by means of the GFDI.

DANGER

Do not connect the PV negative or positive conductors to the ground busbars provided. The PV array is grounded through the integral GFDI. Connecting the PV array positive or negative conductors to ground at any other point in the system would defeat the ground fault protection circuit.

The inverter is shipped pre-configured with positive or negative PV array grounding based on the preference provided at the time of order.

CAUTION

The inverter may be factory configured for either positive or negative ground. It may NOT be field configured to a different grounding once it is shipped from the factory. To identify if your inverter is configured for positive or negative ground read the label next to the DC landing busbar. Verify that the grounding configuration matches your installation grounding plan. If you need to reconfigure the ground, contact PV Powered for assistance. DO NOT ground either DC lead at the time of installation. This will defeat the integral GFDI circuit.

System Neutral

WARNING
The AC output/neutral must not be bonded to ground within the equipment.

NOTE: The inverter has been certified to UL1741 for installation without a neutral conductor. Do NOT pull a neutral conductor from the AC service panel to the inverter.

Tools Required

The following tools are required to complete the installation of the inverter:

- 9/16 inch socket wrench
- 9/16 inch open-ended wrench
- 3/8 inch, 3/16 inch, 5/16 inch and 5/32 inch Allen wrenches (Allen wrench adaptor for a socket wrench recommended)
- Digital multimeter (1000V rated)
- 1/4 inch flat blade (common) screwdriver
- #1 and #2 Phillips screwdriver
- Wire strippers
- Utility knife
- 0-50 foot/pound torque wrench
- 600 volt rated fuse puller/pliers
- Tools for installing anchor bolts
- RJ45 crimping tool (if making a custom CAT5 cable)

3.6 Grid Interconnection

Utility Connection Requirements

Review all NEC 690, local codes and utility requirements before installing the inverter. NEC 690 has specific requirements for the size of the electrical service and the amount of current that is allowed to be fed into the panel by the inverter.

Contact your Local Utility

Contact your electrical utility before connecting the inverter to ensure there are no local restrictions or special requirements. Your local utility company may require specific inspections, equipment, or other procedures not covered in this document.

Voltage Outputs

These inverters are designed to be connected to three phase power. The AC output voltage will be factory configured for 208 or 480VAC in Y (WYE) configuration. The inverter is NOT compatible with delta systems. Do not attempt to change the output voltage of the inverter.

AC and DC power requirements are shown in *Appendix C - Mechanical Drawings*.

3.7 Monitoring

These inverters are equipped with a Data Monitoring Module that can be used to post data to the internet via a broadband Ethernet connection or by connecting to a local Modbus network via RS-485 and Modbus TCP. To use the Modbus communications option refer to *Chapter 5, Modbus Network Installation*. To connect the Data Monitoring Module to the site's LAN, refer to section *4.9 Performance Monitoring and Networking*. For instructions on installing and using the Data Monitoring Module, or if your site does not have a broadband Ethernet connection available, contact PV Powered Customer Service and Technical Support at 1-877-312-3832 for assistance.

3.8 DC Subcombiner (Optional)

The inverter comes with standard positive and negative busbars for landing DC inputs from the PV array. Optional fused subcombiners are available. The inverters can be ordered with the following options:

Model	PVP35kW	PVP50kW
DC Subcombiner Options	1 x 200A 2 x 100A 3 x 70A 5 x 50A	2 x 150A 3 x 100A 4 x 70A 5 x 60A
Total Amps	Up to 350A	Up to 350A

Table 3-1 Inverter Subcombiner Options

No Fuse Option

It is the responsibility of the installer to provide proper fuse protection for the DC input circuit if an optional fused subcombiner is not selected.

3.9 PV Array Input

The PV array open circuit voltage should never exceed 600 volts DC. The PV Powered web site at www.pvpowered.com includes a string calculator. Contact your system installer or PV Powered if you require additional assistance.

4. Installation

4.1 Handling and Unpacking

This section describes the required safe handling and unpacking procedures for the PVP35kW and PVP50kW Inverters. Always follow the recommendations in this section to prevent accidental damage or injury.

WARNING

Heavy Equipment. PVP35kW Inverters weigh up to 1,200 pounds with pallet and packaging. PVP50kW Inverters weight up to 1,500 pounds with pallet and packaging. If the inverter is lifted incorrectly, it may result in death. In addition, improper handling may result in serious damage to the inverter and may also void the warranty. Keep all doors securely closed while moving the inverter. Only use lifting equipment that is rated for the weight of the inverter. Only use the specified lifting points.

Handling

The inverter can be handled using a forklift or pallet jack that is rated to handle a minimum of 1,200 pounds for the PVP35kW and 1,500 pounds for the PVP50kW.

To unload the inverter from the delivery vehicle onsite:

- Lift and move the inverter using the shipping pallet. Do not penetrate the packaging or use the inverter base for unloading.

  Leave the inverter on its shipping pallet with its protective plastic wrap in place until it is time to install.

When the inverter is ready to be placed in its mounting location, complete the following steps:

1. Remove the protective plastic wrap.
2. Remove all bolts that anchor the inverter to the pallet.
3. Plan for a safe move by first considering the inverter's center of gravity.

   Note: The center of gravity is toward the back, lower third of the inverter. See Appendix C - Mechanical Drawings to view the center of gravity location.

4. Lift the inverter off the pallet using the forklift slots on the front or back. (No side forklift slots are available.)

   The front and back of the inverter base each have two fork slots that are 7.5" wide and 20" apart on center.

4.2 Pre-Installation Inspection Steps

Before placing and installing the inverter, it should be inspected to identify possible external and internal shipping damage. If a problem is identified during any of these inspection steps please contact PV Powered's Customer Service and Technical Support at 1-877-312-3832, or email support@pvpowered.com.

Step 1: External Inspection

Inspect the shipping materials and inverter for any cosmetic or structural damage. Specifically look for any structural damage or crushing of the base and doors. Confirm all doors open freely and easily.

Step 2: AC/DC Sub Panel Compartment

1. For each busbar in the AC and DC compartments, check the integrity of the busbar connections and terminals.

Figure 4-1 Busbars and Busbar Connection Inspection

2. Ensure the cable connections are plugged in and fully seated.

Figure 4-2 Inspection of Cable Connections

3. Inspect and pull test all cable screw terminal connections.

Figure 4-3 Pull Test of Cable Screw Terminal Connection

4. Inspect the screens at the bottom of this compartment for damage or debris.

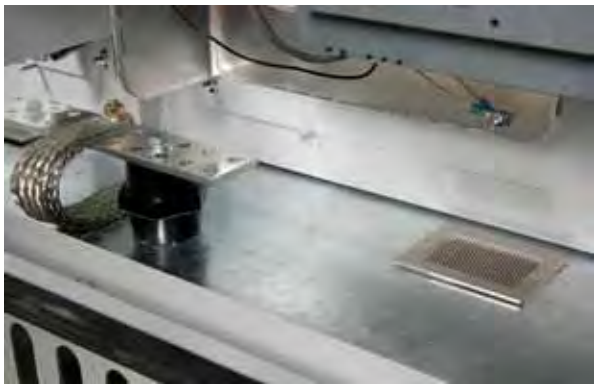


Figure 4-4 Screen Inspection

If any loose wires are found during the inspections, and the location of the connection is unknown, contact PV Powered's Customer Service and Technical Support.

Step 3: Upper Active Cooling Compartment

1. Ensure all air filters are fully seated.

Figure 4-5 Air Filter Check

This completes the pre-installation inspection.

WARNING
Before installing the inverter, make sure the pre-installation steps have been completed and no issues have been identified.

4.3 Conduit Entry

AC and DC cables can be brought into the inverter through the bottom or side gland plates as shown in *Appendix C - Mechanical Drawings*.

WARNING
All penetrations in the inverter cabinet must be through the five gland plates which are provided for the sole purpose of providing a safe and convenient way to bring wiring in to and out of the inverter. Penetrating the inverter housing in any other location besides the gland plates voids the warranty.

Using Gland Plates for Cable Entry and Exit

All power cabling and communications wiring must enter and exit via the inverter cabinet's gland plates. There are gland plates on the AC and DC sides of the inverter for bottom and side entry. In addition, there is a communications gland plate on the upper right side of the inverter. Each gland plate location is selected to ensure safe installation, proper airflow and prevention of dust, debris, moisture, insect and animal incursion. Do not penetrate the cabinet at any other location. All gland plated need to be installed for proper operation of the inverter.

To use a gland plate:

1. Select the size(s) and location(s) of the hole(s) that need to be punched.
2. Remove the gland plate while taking care not to damage the weatherproof gasket material on the back side of the plate. Punch holes as needed.
3. Attach watertight NEMA 4 hubs to the holes. Replace the gland plate taking care to evenly seat the gasket material against the cabinet.
4. Tighten screws until snug. Do not overtighten.

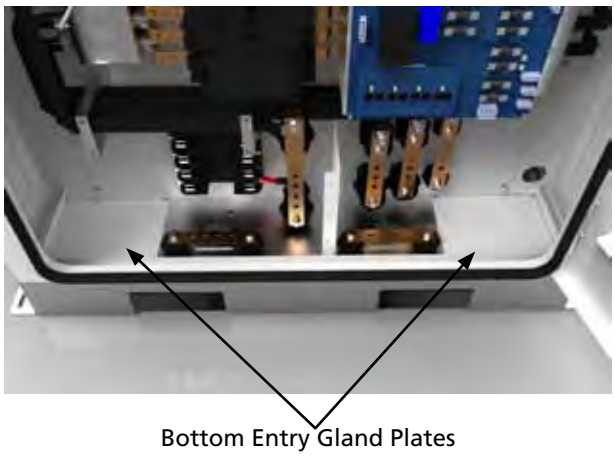


Figure 4-6 Bottom Entry Gland Plates

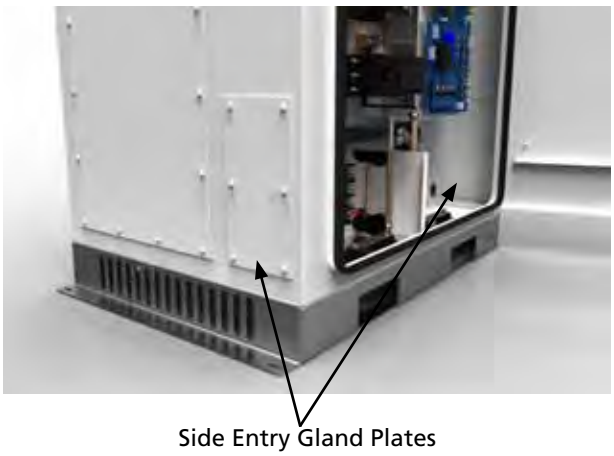


Figure 4-7 Side Entry Gland Plates

4.4 Setting and Anchoring

The inverter base is designed to allow a properly rated forklift to lift it from the front or back.

1. Lift the inverter with a forklift by positioning the forks under the enclosure and through the openings in the bottom of the inverter.
2. Position the inverter to the preferred location.

   Alternate methods of lifting and positioning the inverter may be used at the discretion of the installer. Such methods may include the use of a crane with a sling rated for the weight of the inverter.

3. Secure the inverter to the concrete base by setting the anchoring hardware through each of the four holes in the external mounting flange as shown in sheet two of *Appendix C - Mechanical Drawings*.

   Important: Grade 8 hardware required. See Figure D-1 in Appendix D for a detailed diagram.

   The flanged inverter base allows the unit to be anchored after positioning.

4.5 Electrical Connections

Proceed with making the electrical connections of the inverter once it has been properly secured to the concrete slab. Terminal connections for the inverter are located inside the unit. When facing the inverter:

- DC terminals are located on the left side. The positive and negative busbars have five (5) holes apiece.
- AC terminals are on the right side. Each AC busbar has three (3) holes.

The AC and DC busbars accept standard terminal lug-crimped wires mounted to the busbar fittings with standard 3/8” mounting hardware. Refer to Figure 4-9.

For the optional fused subcombiners, the wire is inserted directly into the fuse holder assembly. Accepted cables sizes for each subcombiner lug option are shown in Table D-10 in *Appendix D - Limits and Fault Codes*.

The inverter is a NEMA 4 enclosure. Use only rain-tight or wet-location conduit hubs and install these hubs as shown in the following figure.

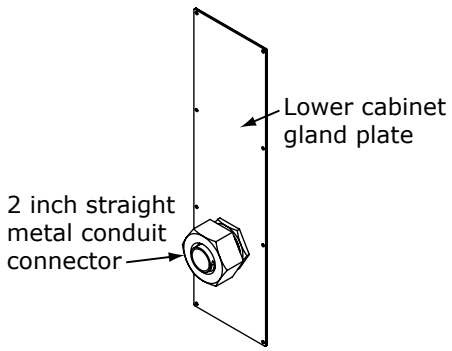


Figure 4-8 Conduit Hub Installation

IMPORTANT: Use rain-tight or wet-location conduit hubs that comply with the requirements in the Standard for Fittings for Conduit and Outlet Boxes, UL 514B.

DANGER
Electrical connections must comply with local electrical codes, the National Electric Code (NEC) and ANSI/NFPA 70. Voltage drop and other considerations may dictate that larger wire sizes be used.

DANGER
Make sure the main breaker in the main utility breaker box is switched OFF before wiring the inverter. This breaker should be switched ON only after all wiring has been properly connected and inspected.

4.6 AC Wiring

WARNING
Follow the order listed in this section to wire the inverter. Failure to do so may result in hazardous voltages or disconnection of contacts.

CAUTION
The National Electrical Code (NEC) requires that the inverter be connected to a dedicated circuit with no other outlets or devices connected to the same circuit. See NEC Section 690-64(b)(1). The NEC also places limitations on the size of the inverter and the manner in which it is connected to the utility grid. See NEC Section 690-64(b)(2).

CAUTION
To reduce the risk of fire, the following overcurrent branch-circuit ratings are recommended:

- PVP35kW (208VAC) inverter to a circuit with a 150 amp maximum
- PVP35kW (480VAC) inverter to a circuit with a 60 amp maximum
- PVP50kW (208VAC) inverter to a circuit with a 200 amp maximum
- PVP50kW (480VAC) inverter to a circuit with a 100 amp maximum

Branch-circuit overcurrent protection should be sized in accordance with the National Electrical Code (NEC), ANSI/NFPA 70.

CAUTION
The input and output circuits are isolated from the enclosure. System grounding, when required by Sections 690-41, 690-42 and 690-43 of the National Electric Code (NEC), ANSI/NFPA 70-1999, is the responsibility of the installer.

WARNING
The AC output/neutral must not be bonded to ground within the equipment.

NOTE: *The inverter is certified to UL1741 for installation without a neutral conductor. Do NOT pull a neutral conductor from the AC service panel to the inverter.*

The inverter is designed for use with 208 and 480 Y (WYE), three-phase power grids. The voltage output is not selectable on these units. Do not attempt to change the AC output voltage once it is set at the factory.

Use the National Electric Code to select the appropriate AC wire sizing for your application. Correct wire sizing requires, at a minimum, considerations for ampacity, temperature and conduit. In addition wire should be sized to minimize voltage drop. Install the inverter on a dedicated branch circuit with a recommended circuit breaker rating as specified in the following table. Refer to Table D-10 in Appendix D for more information.

Model	208VAC	480VAC
PVP35kW	150A	60A
PVP50kW	200A	100A

Table 4-1 Branch Breaker Size Recommendations

The inverter does not have internal AC fusing so it is important to size the branch circuit protection appropriately.

When an inverter is installed on a 208VAC electrical panel, the operational voltage range is 183VAC – 228VAC and for a 480VAC panel, the range is 422VAC – 528VAC. Voltages outside this range will cause the inverter to fault on a high or low voltage condition.

Connecting the AC Wiring to the Inverter

The four AC busbars, Phases A, B, C and Ground are located in the lower right of the AC/DC panel. Refer to Figure 4-9. Each phase busbar is vertically mounted and the ground bar is at the bottom of the cabinet and mounted horizontally. Each busbar has three 3/8” diameter holes spaced 1” apart vertically. Use 3/8” hardware to secure the lugs of the outgoing AC cables to the busbar. Torque hardware to 40 ft-lbs.

The AC and DC connections are made through the user selected gland plates (plates and dimensions are shown in *Appendix C - Mechanical Drawings*).

Connecting to the Electrical Grid

DANGER
Make sure the main breaker at the AC service panel is switched OFF before connecting the AC wires to the inverter. This breaker should be switched ON only after all wiring has been properly connected.

CAUTION

To avoid an increase in AC voltage to unacceptable values while the inverter is connected, the grid impedance value at the connection point should be as low as possible. By keeping the grid impedance value low, the system will achieve higher efficiency.

The inverter is connected to the electrical grid using four wires:

- Phase A voltage
- Phase B voltage
- Phase C voltage
- Ground

Do NOT connect a neutral wire to the WYE point of the isolation transformer.

The AC termination busbars in the inverter are terminated in the AC disconnect located within the lower enclosure on the right side.

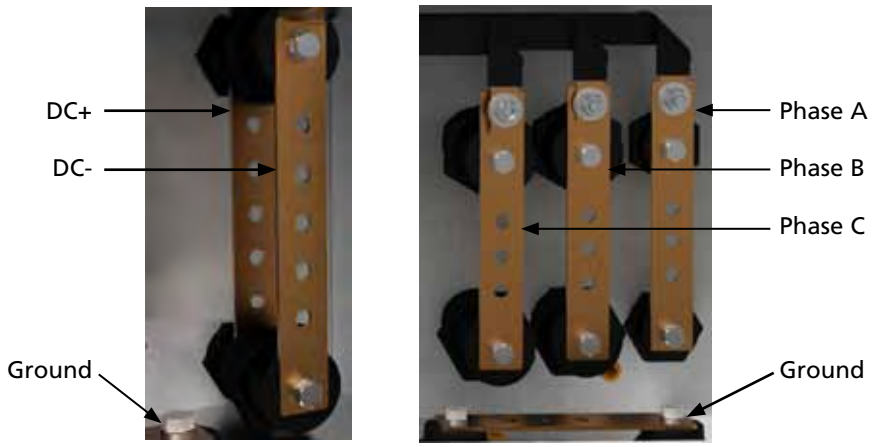


Figure 4-9 DC and Phase Inverter Connections

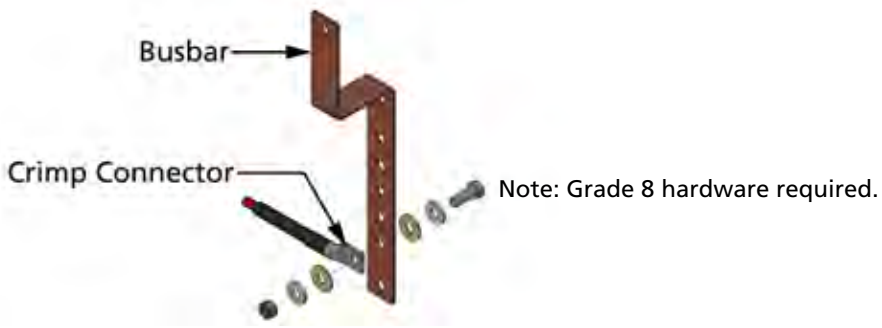


Figure 4-10 Busbar Connections

WARNING
Do not connect a neutral wire to the WYE point of the isolation transformer. Doing so will cause the inverter to malfunction and will void the warranty.

AC Wiring Procedure

1. Remove the protective plastic cover with a 5/32 Allen wrench.
2. Run the conduit from the main breaker panel to the desired gland plate on the inverter and insert the fitting in the gland plate and fasten with a locking nut.
3. Feed the PHASE A, PHASE B, PHASE C and GROUND wires through the conduit and into the right side conduit opening of the inverter.
4. Connect the GROUND wire to the terminal marked 'EARTH GROUND' inside the inverter.
5. Connect the wire from Phase A of the AC panel to the terminal marked 'PHASE A' on the AC terminal inside the inverter. Refer to Figure 4-9 for the location and Figure 4-10 for making the connection.
6. Connect the wire from Phase B of the AC panel to the terminal marked 'PHASE B' on the AC terminal inside the inverter. Refer to Figure 4-9 for the location and Figure 4-10 for making the connection.
7. Connect the wire from Phase C of the AC panel to the terminal marked 'PHASE C' on the AC terminal inside the inverter. Refer to Figure 4-9 for the location and Figure 4-10 for making the connection.
8. Ensure all connections are wired correctly and properly torqued. Tighten the AC terminal screws to 40 ft-lbs.
9. Reinstall the protective plastic cover.

Adjustable Voltage Range

The inverter is factory calibrated to the voltage and frequency limits detailed in *Appendix D - Limits and Fault Codes*. These limits are adjustable and can be set by PV Powered field technicians.

4.7 DC Wiring

DANGER
Before proceeding with the DC wiring, confirm that the PV array has been disconnected from the inverter using the external DC disconnect.

DANGER
Make sure the PV array polarity and voltage between the positive and negative cables are correct before connecting the PV array cables to the DC terminal block.

The three DC busbars, Positive, Negative and Ground are located in the lower left of the AC/DC panel. Refer to Figure 4-9. The positive and negative bars are vertically mounted and the ground bar is at the bottom of the cabinet and mounted horizontally. Each busbar has 3/8" diameter holes spaced 1" apart vertically. Use 3/8" hardware to secure the lugs of the incoming DC cables to the busbar. Torque hardware to 40 ft-lbs. See Appendix D, Table D-10 for wire sizing limits for inverters with an optional, fused subcombiner.

DC Input Voltage

Calculate the maximum open circuit (no load) voltage for each series module connection. FOR ALL TEMPERATURE CONDITIONS, THE OPEN CIRCUIT VOLTAGE FOR EACH SERIES CONNECTION MUST BE LESS THAN OR EQUAL TO 600 VDC. Contact PV Powered if you require assistance calculating the maximum DC input voltage for your array at your specific location.

DC Inputs

Each DC input connection must be wired to deliver the same input voltage.

DC Wiring Procedure

Follow these steps to wire the DC inputs from the PV panels to the inverter. Refer to Figure 4-9.

DANGER
Rick of Electrical Shock. When exposed to light, PV arrays create electrical energy that could cause a hazardous condition.

1. Disconnect power to the DC wiring by disconnecting the PV outside the inverter before starting the DC wiring.
2. Keep track of the array positive and negative leads and clearly mark each.
3. Route the PV array leads through the conduit to the desired entry gland plate on the DC side of the inverter.
4. Connect the PV frame ground wire(s) to the ground lug on the point marked ⏚ in the lower left side of the cabinet.
5. Connect positive DC lead(s) to the positive terminals located on the busbar or fuse holder as applicable. Refer to Figure 4-9. The DC landing torque spec is 40 ft-lbs.
6. Connect negative DC lead(s) directly to the negative terminals located on the busbar or fusing as shown in Figure 4-9. The DC landing torque specification is 40 ft-lbs.
7. Energize the DC cables.
8. Using a voltmeter, check the PV array positive leads and confirm the voltage is positive when referenced to the negative leads. The reading should not exceed your calculated series V_{OC} total.
9. De-energize the DC cables.

4.8 Using Integrated Input and Output Contacts

There are two addressable contacts available to the installer in the PVP35kW and PVP50kW inverters.

- Disable contact – This contact can be used to remotely disconnect the inverter. The most common use for this contact is to shut down the inverter based on the output of a fire alarm panel. This contact is normally closed. The customer will need to provide a 5V, 5mA tolerant relay.

  Note: A jumper is installed in this contact to allow normal operation if the contact is not used. Do not remove jumper unless this contact is used and connected.

- Status contact – This contact provides an output to indicate if the inverter is producing power. This contact is normally open. The customer will need to provide 120VAC (maximum), 1A (maximum) source.

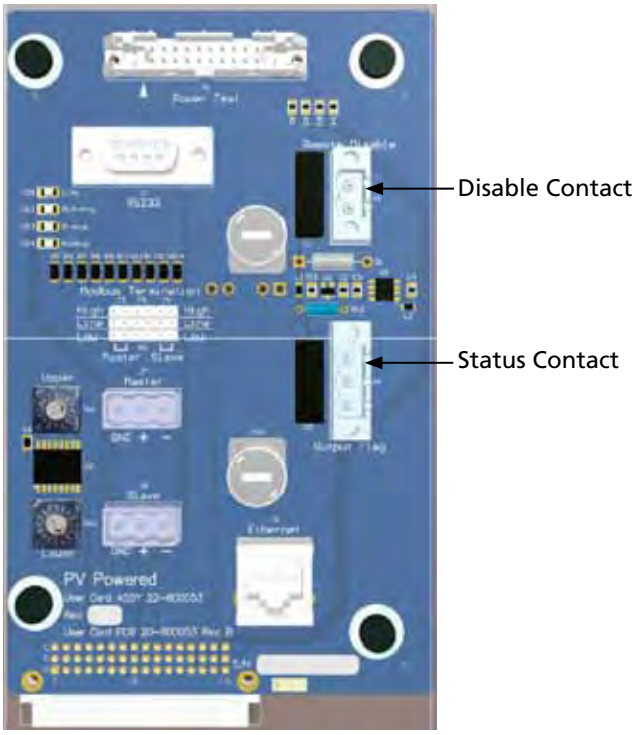


Figure 4-11 User Interface PCB

4.9 Performance Monitoring and Networking

The inverter has an integrated Data Monitoring Module. The Data Monitoring Module enables access to the inverter performance data in two ways. First, basic performance data can be accessed using a free web-based monitoring service provided by PV Powered. Second, the Data Monitoring Module can deliver data to a third party monitoring system over a Modbus RS-485 or Modbus TCP network.

Ethernet Network Connection

PV Powered offers a free basic monitoring service through the mypvpower.com web site. Internet service must be set up properly at the installation site before the inverter can be accessed online. The Data Monitoring Module supports only hard-wired CAT5 solutions to the inverter. It does *NOT* support wireless configurations. To access the mypvpower data monitoring information, customers need to provide a broadband Ethernet connection to the inverter, based on the following specifications:

- Provide a DHCP-enabled broadband internet connection that is always ON. This can be cable internet, a DSL line, or equivalent.
- Requires a hard-wired, Ethernet-enabled connection available at the inverter location. Internet service should be connected using one of the following preferred methods:
  - Hard wire an outdoor-rated, shielded CAT5 Ethernet cable between the inverter Data Monitoring Module and the DHCP-enabled Internet connection.
  - If multiple inverters are commissioned to a single site, you can use an Ethernet hub located in an outdoor-rated enclosure to distribute Ethernet cables to the inverters.

NOTE: The Data Monitoring Module does not support dial-up modem connectivity.

NOTE: Some complex networks might require a system administrator to add the inverter to the network.

IMPORTANT: The Ethernet cable must comply with T-568B standards. This is the only configuration supported by the Data Monitoring Module. Other wiring configurations will not work. Refer to the following figure.

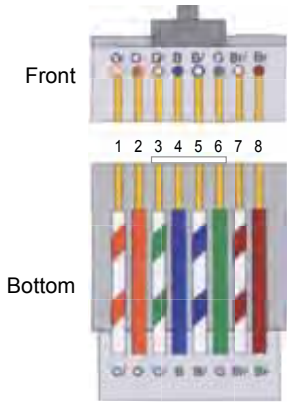


Figure 4-12 T-568B Compliant Ethernet Cable

Connecting the Ethernet Cable to the Internet

Use the following steps to complete the connection of the Data Monitoring Module:

1. Route the Ethernet (CAT5) cable from the Internet-enabled router, at the gland plate location on the upper portion of the inverter, using the proper conduit and hub connectors. Refer to section *4.3 Conduit Entry* for instructions on how to properly use gland plates.

2. Plug the Ethernet cable into the Ethernet port on the User Interface PCB located under the air intake hood on the right side of the card cage cover. Refer to the following figure.

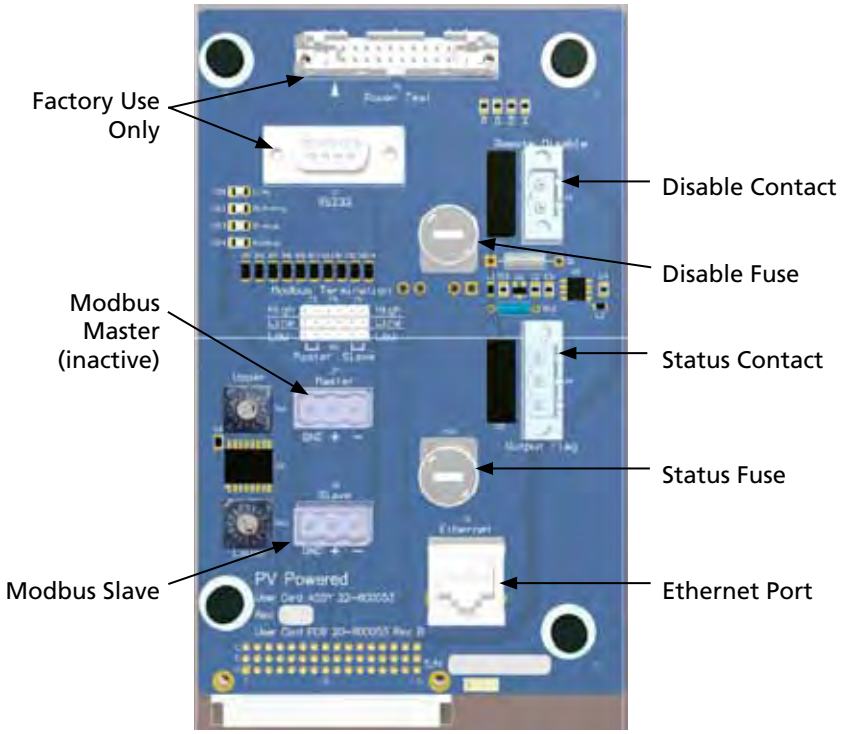


Figure 4-13 User Interface PCB Components

When the Internet connection is established, go to www.mypvpower.com to register the inverter and begin using the monitoring tools. Contact PV Powered if additional information is needed on how to use this online tool.

Advanced Networking and Troubleshooting

All PV Powered commercial inverters come standard with an Ethernet port that is intended to be connected to the Internet. The PV Powered commercial inverter operates as an Internet appliance. The inverter communicates with the PV Powered Data Center using https (port 443). Communications is one way – the inverter only communicates externally to the PV Powered Data Center. Typically the inverter will post 1Kb to 2Kb of data via web service call to the data center every 15 minutes. If there is an inverter fault, the inverter may post data more frequently for a short period of time.

Below is a list of requirements to establish inverter communications with the PV Powered Data Center. Connectivity must be established before registration on www.mypvpower.com is attempted.

- Connect the inverter's Ethernet port to a hub or router. Ethernet cables must meet the T-568B wiring standard and must be less than 300 feet in length. See Figure 4-12.
- Provide DHCP server access to the inverter. The inverter requires DHCP to establish its IP address.
- Provide a path to the Internet for https (port 443) from the inverter. The MAC address

for the inverter can be found on the side of the communications PCB. To see the MAC address the communications PCB must be removed (turn power off first) from the card cage assembly.

- Verify connectivity using the following information:
  1. Check the status light. It should be in a solid on state.

     The status light is located on the front cover of the User Interface PCB in the left side of the upper electronics compartment.

  2. Verify the inverter's MAC address has been assigned an IP address by the network.
  3. Register the inverter at www.mypvpower.com.

Most connectivity problems relate to wiring issues or corporate security settings blocking the inverter from accessing the Internet. Wiring problems are usually the result of a poor crimp, wire that exceeds 300 ft., or pinched wires somewhere between the inverter and the hub or router.

PV Powered recommends using pre-made cables whenever possible. If a cable must be hand-crimped, we recommend testing the cable with a cable tester such as a Fluke LinkRunner™ Pro Network Multimeter (LPRO1000). Verify the cable's integrity by connecting a laptop to the cable at the inverter and verify is has access to the Internet.

Corporate network problems will require support from your corporate IT department where the inverter is installed. The most common problem is the inverter has not been provided with DHCP or server access using port 443.

Troubleshooting communications issues can also be accomplished using the four LED lights on the Communications PCB. For detailed LED communications light troubleshooting see section *7.6 Communication PCB Status Light Operation*.

Modbus via RS-485 and TCP

For instructions on how to use the Modbus network option, refer to *Chapter 5, Modbus Network Installation*.

5. Modbus Network Installation

5.1 Overview

PV Powered commercial inverters can communicate via Modbus RS-485 and Modbus TCP/IP. This chapter explains how to communicate with a PV Powered commercial inverter on a Modbus network through either RS-485 or TCP/IP. This chapter is written for PV installers, electricians, controls contractors and Modbus network programmers.

5.2 Modbus Communication Protocol

Modbus is a serial communications protocol and is the most commonly used means of monitoring and communicating between devices in the PV industry. The Modbus protocol allows for communication between a Modbus master device and multiple Modbus slave devices connected to the same network. The physical layer of the Modbus network is a twisted pair shielded conductor for RS-485 and CAT5 Ethernet for TCP/IP.

5.3 Networking Using the Modbus TCP/IP Option

The following steps are required to set up a Modbus TCP/IP network for your PV Powered inverter:

- Field Installation Process

  This step can be completed onsite by a PV installer or an electrician that does not have working knowledge of a Modbus network:

  - Consult the facility IT administrator for network device installation support and coordination.
  - Install the Modbus network communications cabling.
- Modbus Network Configuration Process

  This step can be done onsite or remotely and should be completed by the Modbus network programmer:

  - Set the IP addresses and Port ID for TCP/IP.
  - Configure the point maps for slave devices.

5.4 Modbus TCP/IP Installation Process

Disconnect the power to the inverter before starting the installation.

DANGER

AC and DC voltages will still be present at the inverter AC and DC landing points unless utility connection circuit breaker and PV array inputs are disconnected.

Step 1: Installing the Modbus Cable for TCP/IP

A. Route an Ethernet cable from a network port in the facility that has been approved by the network administrator, through the data monitoring gland plate on the right side of the inverter, using the appropriate water-tight conduit connections.

The data monitoring gland plate is a flat piece of metal covering the holes in the side of the inverter. Remove the gland plate and cut a hole in the desired location to allow access for the cable. Replace the gland plate.

B. Connect the Modbus Ethernet cable to the Ethernet port on the User Interface PCB. The User Interface PCB is located on the right side of the circuit board card cage in the upper section of the inverter. See Figure 5-1 for the location of the Ethernet port.

5.5 Modbus TCP/IP Network Configuration Process

Step 2: Assigning the IP Address and Port ID

A. Contact the facility's IT Network Administrator (or person with similar responsibilities) to assign an IP Address to each inverter.

B. The Modbus master will need to communicate through Port 502.

For advanced users, a static IP address can be assigned. Contact PV Powered Technical Support for assistance.

5.6 Networking Using the Modbus RS-485 Option

The following steps are required to set up a Modbus RS-485 network for your PV Powered commercial inverter. The first part of the installation can be completed by a PV installer or electrician that does not have working knowledge of a Modbus network. These steps are:

A. Field installation process (to be performed on-site)

The first three steps can be completed by a PV installer that does not have working knowledge of a Modbus network:

- Installing the Modbus network wiring.
- Configuring end-of-line termination and network biasing.
- Setting the Modbus address for each slave inverter.

Note: The contractor responsible for network programming will need to provide the slave addresses prior to setting the Modbus address for each slave inverter.

The final part of the RS-485 installation process is the Modbus network configuration. These steps should be completed by the Modbus network programmer. The last two steps are:

- Setting the device addresses.
- Configuring point maps for slave devices.

5.7 Modbus RS-485 Installation Process

Disconnect the power to the inverter before starting the installation.

DANGER
AC and DC voltages will still be present at the inverter AC and DC landing points unless utility connection circuit breaker and PV array inputs are disconnected.

Step 1: Installing the Modbus Cable for RS-485 Installations

Connections are made using shielded insulated, 18-24ga twisted-pair communication cable that has a characteristic impedance of 120 ohms. If the RS-485 network will not pass through any high voltage (>300V) areas, then 300V rated cable may be used in the low voltage data monitoring compartment of the inverter. Check with your local inspector or project engineer if you need assistance in determining this requirement. Some appropriate 300V data cables include:

- Belden 3105A (1P22ga shielded)
- Belden 3082A (1P15ga + 1P18ga shielded)

Belden 7897A (1P15ga + 1P18ga shielded) is an example of a 600V rated cable that may also be used; others exist as well.

A. Route the cable from your master device on your RS-485 Modbus network through the data monitoring gland plate on the right side of the inverter using the appropriate water-tight conduit connections. The gland plate is a flat piece of metal covering the holes in the side of the inverter. Remove the data monitoring gland plate and cut a hole in the desired location to allow access for the cable. Replace the gland plate.

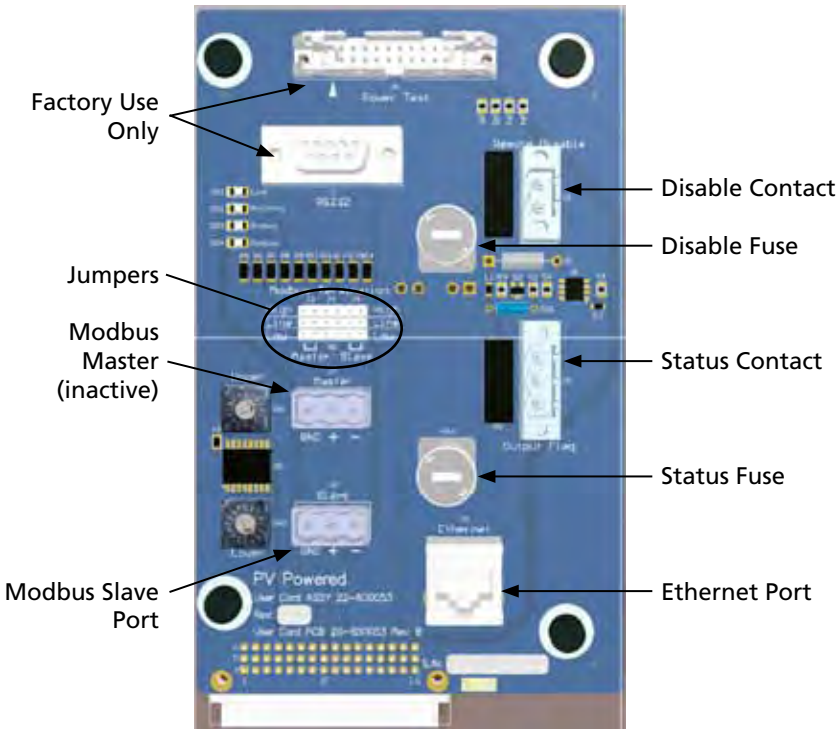


Figure 5-1 User Interface PCB with Modbus Slave Port Location

B. Connect the Modbus cable.

The end of the Modbus cable connects to the Modbus slave port connector on the User Interface PCB. See Figure 5-1 for the location of the Modbus slave port.

Connect the plus (+) cable to all plus (+) connections and the minus (-) cable to all other minus (-) connections so they correspond throughout the network.

Note: The Modbus master connections are not enabled at this time.

C. Connect a ground reference line to the terminal labeled "GND" on the Modbus slave connector. The shield of a communications cable may be used for this reference as long as the shield is connected to earth ground at one point only. It is recommended that PV Powered devices have common ground connections when possible.

Note: Some Modbus devices do not have a shield or reference input. In these cases the device most often uses the DC power supply (-) as the RS-485 reference. It may be necessary to place an RS-485 isolator on these devices or power them from a common DC supply that has its DC (-) referenced to earth ground at the same point where the network cable shield is earthed.

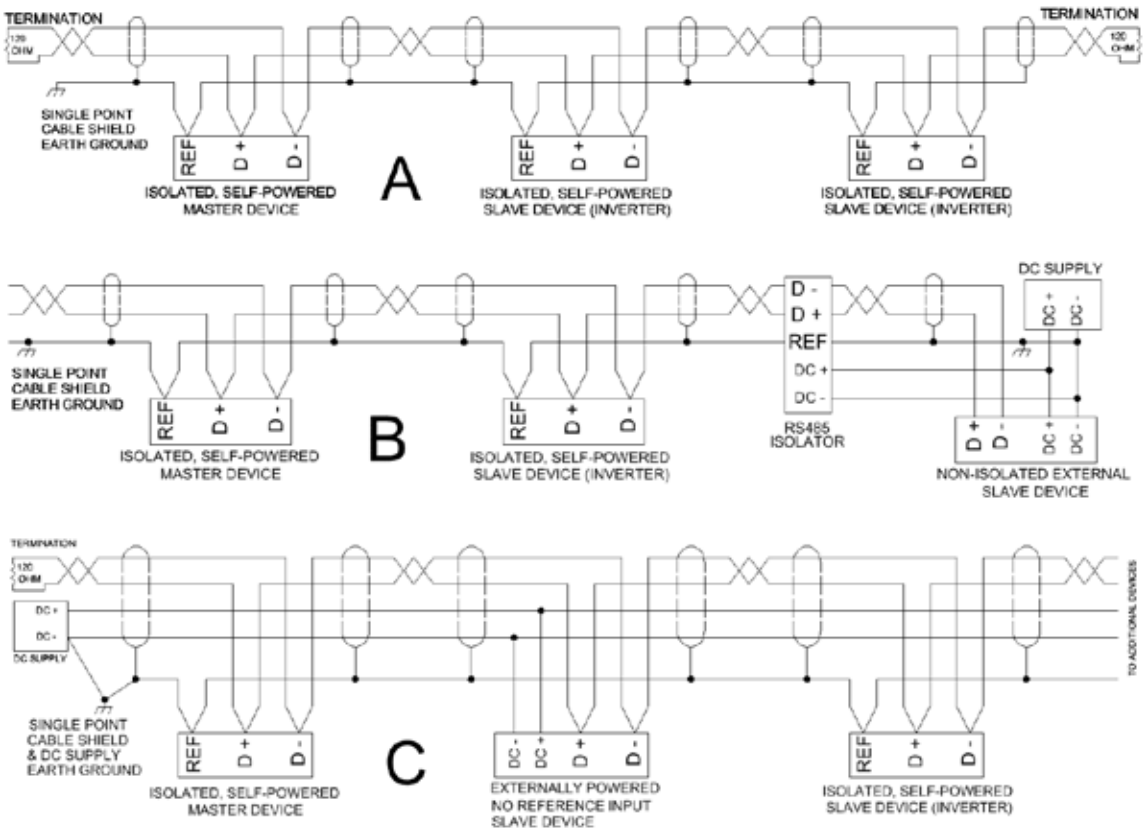


Figure 5-2 Daisy Chain Layout for RS-485 Network

When multiple inverters or other Modbus slave devices are connected to a single Modbus master device, the multiple devices need to be connected in a daisy chain as shown in Figure 5-2.

Note: When multiple devices are wired to the network the network shield must be terminated to earth ground at one point on the network, typically at the beginning or the end. For device connections the shield must be rewired to provide a continuous shield and isolated from ground.

Step 2: Using Jumpers to Set the Pins for RS-485 Installation

By default, the termination pins have three slave jumpers installed in the J3 - Master positions and three jumpers in the J5 - Slave positions when the inverter is shipped. (Note: Master is not enabled at this time.)The location of the jumpers can determine the following settings:

- Terminate the network
- Set jumpers for the center inverter(s) on the network
- Turn on biasing

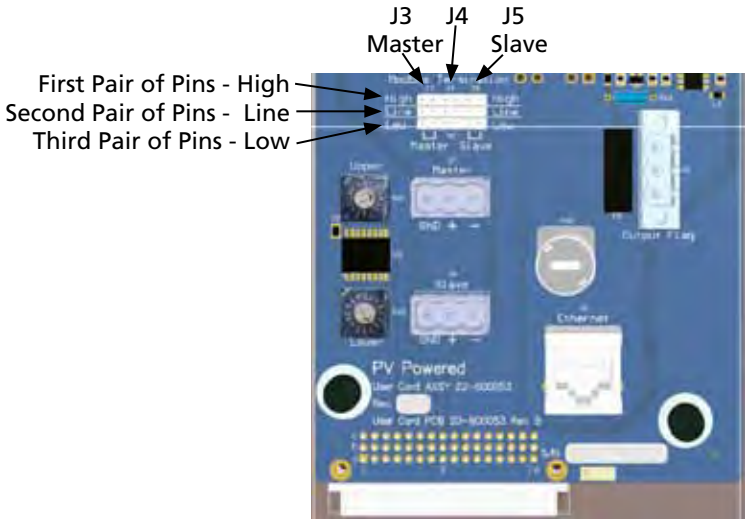


Figure 5-3 Location of Jumpers J3, J4 and J5 on the User Interface PCB

Jumper Setting Options

A. Terminate the network.

The performance of the Modbus network may require each end of the network to be terminated using 120 ohm termination resistors. When the network is long, relative to the RS-485 bit rate in use, bus terminations must be installed. The network length is determined by the total backbone cable length, and not necessarily the line-of-sight between the two furthest apart devises.

RS-485 / Modbus Bit Rate	Maximum Network Length without Termination Feet (Meters)	Maximum Network Length with Termination Feet (Meters)
9600 bps	1000 (305)	4000 (1200)
19200 bps	500 (152)	4000 (1200)
38400 bps	250 (76)	4000 (1200)
57600 bps	150 (46)	4000 (1200)

Table 5-1 Maximum Network Length per Modbus Bit Rate

If bus termination is desired and the inverter is on the end of the Modbus network, you may use the built-in bus termination resistors.

- To enable an inverter's bus termination, place the J5 "Line" jumper on its outboard pins. See Table 5-2 for the pin locations.

	J3	J4	J5
High		X	
Line			X
Low		X	

Table 5-2 Termination Enabled (for End Device)

B. Set the jumpers for the center inverters on the network.

- J5 - remove all three jumpers from the J5 pins for any inverter in the middle of the network, and place the jumpers in the J4 neutral position.

	J3	J4	J5
High		X	
Line		X	
Low		X	

Table 5-3 No Biasing or Termination (Default Setting)

C. Set the biasing.

Biasing sets the voltage levels on the data lines of an inactive or idle network. It is very important that at least one device on the network provides biasing. On shorter networks with fewer installed devices, biasing may only be needed on the device furthest away from the master. Longer networks that are terminated on both ends may require two devices to have their biasing enabled. To use the inverter's built-in biasing set the following jumpers:

- J5 - install a jumper on the first pair of pins labeled "High".
- J5 - install a jumper on the last pair of pins labeled "Low".

	J3	J4	J5
High			X
Line		X	
Low			X

Table 5-4 Biasing Enabled

Alternative: Terminate the network and enable biasing.

If an end inverter on the network requires both termination and biasing to be enabled, set the following jumpers:

- J5 - install a jumper on the first pair of pins labeled "High".
- J5 - install a jumper on the first pair of pins labeled "Line".
- J5 - install a jumper on the last pair of pins labeled "Low".

	J3	J4	J5
High			X
Line			X
Low			X

Table 5-5 Biasing and Termination Enabled (for End Device)

Step 3: Setting the Modbus Address for Each Slave Device

A Modbus network containing slave devices requires a unique address for each slave. This allows the master device to identify and communicate with each slave. The Modbus network administrator must assign an unique Modbus address to each PV Powered inverter.

To set the address:

A. Determine each slave address.

The addresses are represented using the hexadecimal representation of digits 0 through 9 and letters A through F. For example, slave 1 is set to 01h, slave 10 is set to 0Ah, and so forth. Refer to the following inverter address conversion Table 5-6 to select a unique address for each slave device by locating the number of the slave device in the "Address" column. Move right to the "Switch" column to find the converted address value of this slave device.

Note: 0 is not an allowed address.

Address	**Switch**		**Address**	**Switch**		**Address**	**Switch**		**Address**	**Switch**		**Address**	**Switch**	
Decimal	Hex		Decimal	Hex		Decimal	Hex		Decimal	Hex		Decimal	Hex	
	1	**2**		**1**	**2**		**1**	**2**		**1**	**2**		**1**	**2**
1	0	1	21	1	5	41	2	9	61	3	D	81	5	1
2	0	2	22	1	6	42	2	A	62	3	E	82	5	2
3	0	3	23	1	7	43	2	B	63	3	F	83	5	3
4	0	4	24	1	8	44	2	C	64	4	0	84	5	4
5	0	5	25	1	9	45	2	D	65	4	1	85	5	5
6	0	6	26	1	A	46	2	E	66	4	2	86	5	6
7	0	7	27	1	B	47	2	F	67	4	3	87	5	7
8	0	8	28	1	C	48	3	0	68	4	4	88	5	8
9	0	9	29	1	D	49	3	1	69	4	5	89	5	9
10	0	A	30	1	E	50	3	2	70	4	6	90	5	A
11	0	B	31	1	F	51	3	3	71	4	7	91	5	B
12	0	C	32	2	0	52	3	4	72	4	8	92	5	C
13	0	D	33	2	1	53	3	5	73	4	9	93	5	D
14	0	E	34	2	2	54	3	6	74	4	A	94	5	E
15	0	F	35	2	3	55	3	7	75	4	B	95	5	F
16	1	0	36	2	4	56	3	8	76	4	C	96	6	0
17	1	1	37	2	5	57	3	9	77	4	D	97	6	1
18	1	2	38	2	6	58	3	A	78	4	E	98	6	2
19	1	3	39	2	7	59	3	B	79	4	F	99	6	3
20	1	4	40	2	8	60	3	C	80	5	0	100	6	4

Table 5-6 Inverter Address Conversion for Switches 1 and 2

B. Set the switch address on each slave device.

The slave address for each PV Powered inverter is set using two rotary switches. Each switch is hexadecimal, containing 0 through 9, followed by A through F. Set the switches using the following guideline:

- The first switch is always set to the value in the "1" column below the "Switch" heading in Table 5-6.
- The second switch is always set to the value in the "2" column below the "Switch" heading in Table 5-6.

For example, if you are setting the address of the first slave device, inverter 1 of your network, to the hexadecimal address 05, the first switch is set to 0, the first digit of the hexadecimal address, and the second switch is set to 5, the second digit of the address.

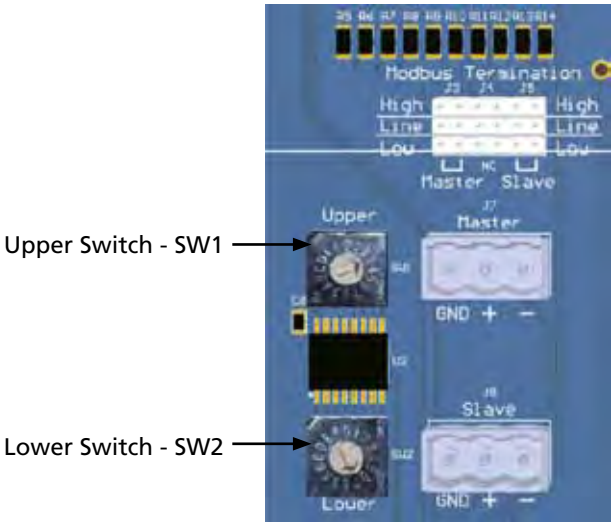


Figure 5-4 Rotary Switches for Setting the Inverter Number

The switches are located near the center of the User Interface PCB and are labeled SW1 and SW2 as they appear in Figure 5-4.

If you need more device addresses than the 100 listed in Table 5-6, refer to a complete digital to hexadecimal conversion table.

Note: Some Modbus master devices do not allow addresses above the decimal value of 126. PV Powered recommends keeping the number of slave devices between 2 and 100.

Modbus RS-485 Network Configuration Process

Step 4: Setting the Communication Parameters

This step is part of the network configuration process that should be completed by the Modbus network programmer. The RS-485 Modbus master communication settings need to be set to the values in Table 5-7. This allows your Modbus master device to communicate with the inverter. Follow the instructions in the manual for your master device to complete these settings.

Parameter	Setting
Baud	9600
Parity	N
Data bits	8
Stop bit	1
Flow control	None

Table 5-7 Communications Settings [1]

Step 5: Using Modbus Commands

This step is part of the network configuration process that should be completed by the Modbus network programmer. PV Powered inverters provide basic Modbus commands. The supported commands are listed in the following table.

Command Name	Command Number	Description
Read Holding Register	03	Retrieves the voltage, power and energy values from the inverter.
Write (Preset) Single Register	06	Enables/disables the inverter.
Return Slave ID	17	Returns a text string containing the ID number of the inverter.

Table 5-8 Supported Modbus Commands

Format of Modbus Commands and Responses

Each of the Modbus commands in Section 5.8 contains two tables. The first table describes the format of a Modbus command request while the second table contains the format of the command's response. This section also provides additional information about these commands and their valid registers.

5.8 Modbus Register Maps

Read Holding Register

The **Read Holding Register** command is used frequently. Typically the Modbus master continually reads the values from registers containing the desired information.

1. Higher baud rates can be selected using Modbus or PVM Sync. Contact PV Powered Technical Service.

Command Information	Command Layout
Modbus slave address	nn (1-126)
Command number	03
First register MSB	xx
First register LSB	xx
Number of registers MSB	xx
Number of registers LSB	xx
CRC LSB	xx
CRC MSB	xx

Table 5-9 Format for Read Holding Register, command 03

Response Information	Response Layout
Modbus slave address	nn (1-126)
Command number	03
Number of bytes of data	n
Fist register MSB	xx
First register LSB	xx
Second register MSB	xx
Second register LSB	xx
Nth register MSB	xx
Nth register LSB	xx
CRC LSB	xx
CRC MSB	xx

Table 5-10 Format for Read Holding Register, response to command 03

Write Single Register

The **Write Single Register** command is used to write to one of the command registers found in Table 5-19. Using this command does not change the inverter's data in registers described in Table 5-15, Table 5-16, Table 5-17 or Table 5-18.

Command Information	Command Layout
Modbus slave address	nn (1-126)
Command number	06
First register MSB	xx
First register LSB	xx
Data MSB	xx
Data LSB	xx

Command Information	Command Layout
CRC LSB	xx
CRC MSB	xx

Table 5-11 Format for Write Single Register, command 06

Response Information	Response Layout
Modbus slave address	nn (1-126)
Command number	06
Number of bytes of data	n
First register MSB	xx
First register LSB	xx
Data MSB	xx
Data LSB	xx
CRC LSB	xx
CRC MSB	xx

Table 5-12 Format for Write Single Register, response to command 06

Return Slave ID

Command Information	Command Layout
Modbus slave address	nn (1-126)
Command number	11h

Table 5-13 Format for Return Slave ID, command 11h

The Slave ID command returns the ASCII string "**xxPVP Inverter IDxxxxx**", for example "**0x50,0xFF,PVP Inverter ID02860910080321**". The first "**xx**" represents two non-ASCII bytes, representing the following information:

Byte 1: 0x50 - An identifier byte for PVP inverters

Byte 2: 0x00 - If communication with the inverter is down,

0xFF - If communication with the inverter is okay.

Byte 3 through byte n: Contains "**PVP Inverter IDxxxxx**".

Response Information	Response Layout
Modbus slave address	nn (1-126)
Command number	11h
Number of bytes of data	n
Data 1	xx
Data 2	xx

Response Information	Response Layout
Data n	xx
CRC LSB	xx
CRC MSB	xx

Table 5-14 Format for Return Slave ID, response to command 11h

Modbus Register Maps

The following tables list the Modbus registers with their location and a description of the data stored in the register. For more information describing the data format contained in the "Format" column of each table, see Table 5-22 at the end of this chapter.

Description	Start Register	End Register	Nbr. of Registers	MB Address	Format	Range	Notes
Modbus base address = 0							
Inverter ID number	0	7	8	40001	ASCII	16 char.	Unique number for each inverter
Firmware version	8	11	4	40009	ASCII	8 char.	Example: V1.9
Map version	13	13	1	40014	UINT 16	2	Increment sequentially as the map changes
Inverter configuration	14	14	1	40015	UINT 16	Bit-mapped	See Table 5-16
Inverter serial number	15	24	10	40016	ASCII	20 char.	Matches SN label

Table 5-15 Fixed information registers

Inverter Configuration	Bit Mapping	Instructions
AC Volts = 208	0x0001	
AC Volts = 240	0x0002	
AC Volts = 480	0x0004	
Transformer tap position	0x0008	Set if Tap at 265V, Clear if Tap at 295V (Default = 295V)
Transformer wiring configuration	0x0010	Set if wired as Delta, Clear if wired as Wye (Default = Wye)
Utilitimeter installation flag	0x0100	Set if meter is installed, Clear if not installed (Default = not installed)

Table 5-16 Inverter Configuration

Description	Start Register	End Register	Nbr. of Registers	MB Address	Format	Range
Modbus base address = 1000						
VoltsA L-N	1000	1001	2	41001	FLOAT	+/- 32bit IEEE754
VoltsB L-N	1002	1003	2	41003	FLOAT	+/- 32bit IEEE754
VoltsC L-N	1004	1005	2	41005	FLOAT	+/- 32bit IEEE754
Current A	1006	1007	2	41007	FLOAT	+/- 32bit IEEE754
Current B	1008	1009	2	41009	FLOAT	+/- 32bit IEEE754
Current C	1010	1011	2	41011	FLOAT	+/- 32bit IEEE754
DC input voltage	1012	1013	2	41013	FLOAT	+/- 32bit IEEE754
DC input current	1014	1015	2	41015	FLOAT	+/- 32bit IEEE754
Line frequency	1016	1017	2	41017	FLOAT	+/- 32bit IEEE754
Line kW	1018	1019	2	41019	FLOAT	+/- 32bit IEEE754
Total kWH	1020	1021	2	41021	UINT 32	0 - 4.29 e9
PV input voltage	1022	1023	2	41023	FLOAT	+/- 32bit IEEE754
DC kW (calculated)	1024	1025	2	41025	FLOAT	+/- 32bit IEEE754

Table 5-17 Data Registers

Description	Start Register	End Register	Nbr. of Registers	MB Address	Format	Range	Notes
Modbus base address = 2000							
Inverter operating status (state)	2100	2100	1	42101	UINT 16	Bit mapped	See Table 5-20
Main fault	2101	2101	1	42102	UINT 16	Bit mapped	See Table D-3
Drive fault	2102	2102	1	42103	UINT 16	Bit mapped	See Table D-4
Voltage fault	2103	2103	1	42104	UINT 16	Bit mapped	See Table D-5
Grid fault	2104	2104	1	42105	UINT 16	Bit mapped	See Table D-6
Temperature fault	2105	2105	1	42106	UINT 16	Bit mapped	See Table D-7
System fault	2106	2106	1	42107	UINT 16	Bit mapped	See Table D-8
System warnings	2107	2107	1	42108	UINT 16	Bit mapped	See Table D-9
PVM status codes	2108	2108	1	42109	UINT 16	Bit mapped	See Table 5-21

Table 5-18 Status and Fault Code Registers

Note: See Appendix D - Limits and Fault Codes for fault code information.

To set the following command registers, you need to use the **Write Single Register** command.

Description	Start Register	End Register	Nbr. of Registers	MB Address	Format	Range	Notes
Modbus base address = 3000							
Clear fault command	3000	3000	1	43001	UINT 16	CF hex	Write this value to clear faults and try a restart.
Disable inverter[1]	3001	3001	1	43002	UINT 16	DD hex	Write 0xDD to disable Write 0xEE to enable
Enable inverter	3002	3002	1	43003	UINT 16	EE hex	Write 0xDD to disable Write 0xEE to enable
Reset data comm section	3003	3003	1	43004	UINT 16	99 hex	Write 99 hex to this register to reset the Comm X PCB.

Table 5-19 Command Registers

1. Reading this register returns 0 after bootup, or either DD after a disable or EE hex after an enable command is sent.

Response values for status and fault registers

The following tables contain the status and fault bitmap information for each status and fault code register in Table 5-18. The command's response values are returned as hexadecimal values which you need to convert to the decimal value in order to understand the returned information.

Description	Hex Value	Decimal Value
Modbus register number = 42101		
Sleep state	0	0
Startup delay state	1	1
AC precharge state	2	2
DC precharge state	3	3
Idle state	4	4
Power track state	5	5
Reserved	6	6
Reserved	7	7
Reserved	8	8
Fault state	9	9
Initialization state	A	10
Disabled state	B	11
Latching fault state	C	12

Table 5-20 Inverter Status (protocol state) Values

In Table 5-21 each type of fault in the "Description" column in the above table can have a value of "0" indicating no fault or a "1" indicating a fault.

Description	Bit Nbr.	Hex Value	Decimal Value
Modbus register number = 42005			
OK		0	0
Rebooting		1	1
Inverter communication fault		2	2
Web post fault		4	4
DNS server fault		5	5

Table 5-21 Inverter Data Comm Status Word

Data Format	Description	Notes
ASCII	Two ASCII characters per register	For a text string the left most character is in the lowest register number.
UINT16	Unsigned integer: 16 bits	Range: 0 to 65535
SINT16	Signed integer: 16 bits	Range: -32767 to +32767
UINT 32 (requires two registers)	Unsigned integer: 32 bits	Range: 0 to 4,294,967,295
SINT 32 (requires two registers)	Signed integer: 32 bits	Range: -2,147,483,647 to +2,147,483,647
FLOAT (requires two registers)	IEEE 754 standard 32-bit floating point number	

Table 5-22 Data formats for registers

Information about the Data Monitoring Module

For additional information on how to use the Modbus Data Monitoring Module, contact PV Powered Customer Service and Technical Support at 1-877-312-3832.

6. Operation

6.1 Start Up Procedure

WARNING
Before turning on the inverter, ensure that the front panels are closed properly.

To start the inverter, complete the following steps in order:

1. Prior to engaging the disconnect switches, check the polarity of the DC positive and negative connections to ensure they are wired correctly and confirm the PV panel open circuit voltage is at or below 600 VDC.
2. Close the inverter's doors.
3. Turn on the external AC connection to the inverter.
4. Turn on the external DC disconnect to provide DC power to the inverter.
5. Turn the ON/OFF switch to the OFF position.

   The ON/OFF switch is located under the upper door.
6. Turn the inverter's AC disconnect to the power ON position. Refer to Figure 6-1.

   The display on the upper front panel should now be active. The display is shown in Figure 6-3.
7. Turn the inverter's DC disconnect to the power ON position. Refer to Figure 6-1.
8. Turn the ON/OFF switch to the ON position.
9. Close the upper door.

After five minutes, the inverter starts to produce power into the AC grid if all the necessary operating conditions are met.

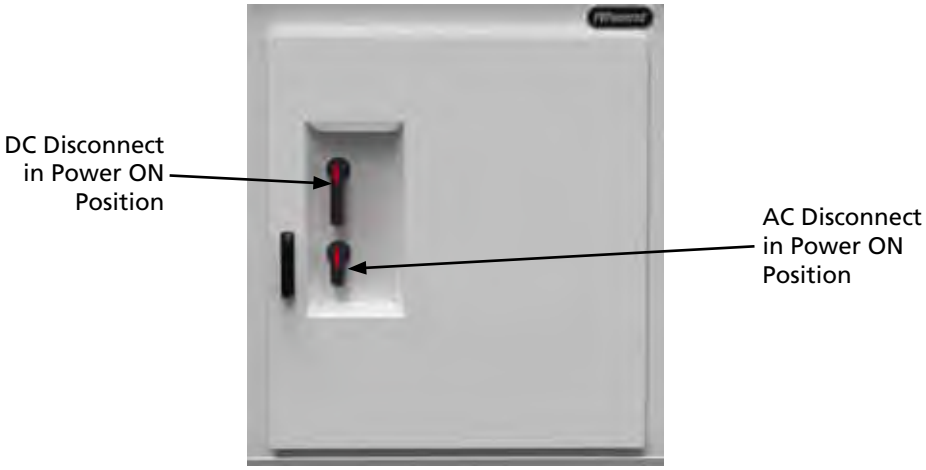


Figure 6-1 AC and DC Disconnect Power ON

6.2 Inverter Operating States

The PVP35kw and PVP50kW each have nine operating states. The inverter will transition from one state to another only as shown in Figure 6-2. Each operating state is described below.

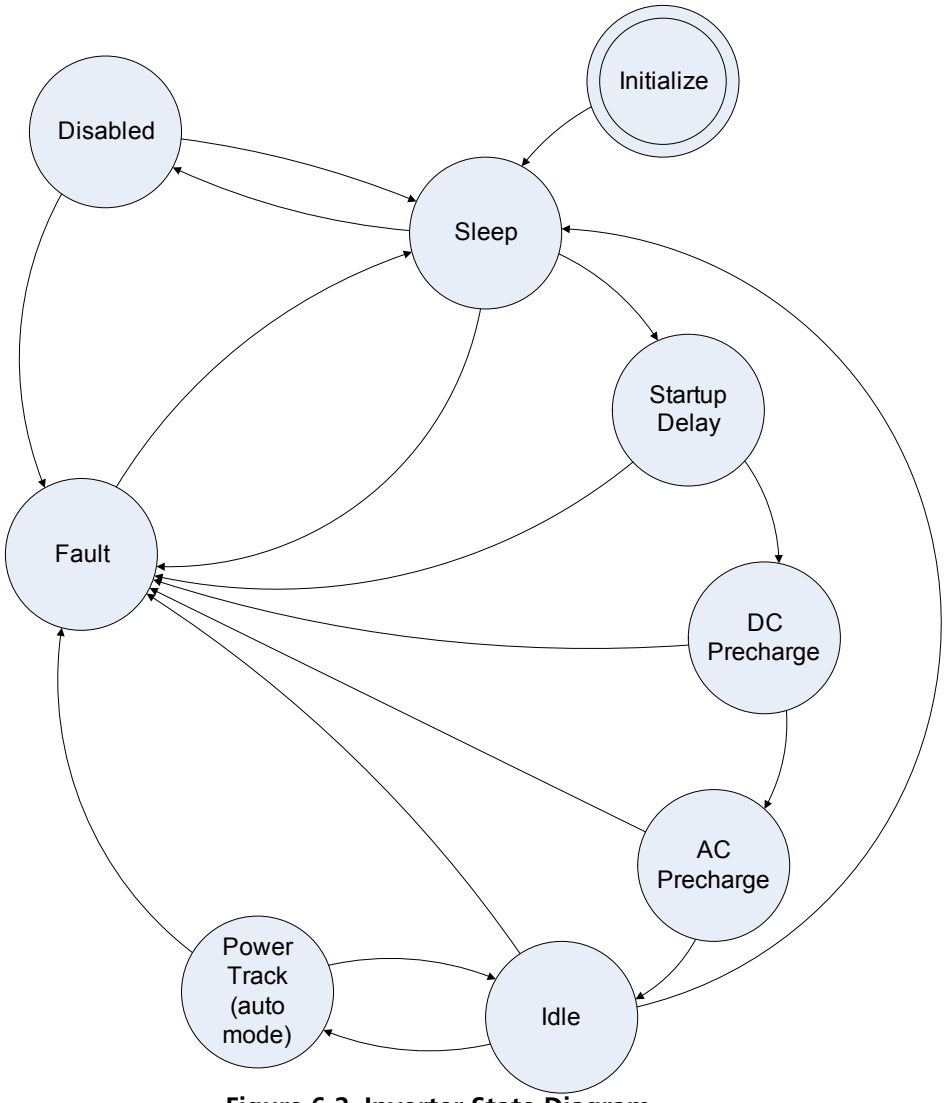


Figure 6-2 Inverter State Diagram

Initialize

The inverter enters this state after a reset or power cycle. Variables and devices are initialized and I/O ports set. When initialization is complete, the inverter enters the Sleep state.

Disabled

The inverter enters this state when the front-panel switch is in the “OFF” position or when a disable command is received over the serial port. If a fault condition occurs, the inverter switches to the Fault state. When the fault is cleared and the condition no longer exists, the inverter returns to the disabled state. The inverter displays a message on the

screen indicating the inverter is disabled. When an enable command is received or the front-panel switch is changed to the “enable” position, the inverter switches to the sleep state. The inverter will also enter the disabled state when the “remote disable” relay is open.

Fault

The inverter enters this state when any fault condition occurs. The inverter can enter this state from any other state except initialize. Unless the fault is latching, the inverter clears the fault when the fault condition subsides. The inverter displays the fault codes and messages indicating the current fault conditions.

If the fault is latching, the inverter switches to the latched fault state. The inverter enters this state when a latching fault condition occurs. The inverter displays the fault codes and messages indicating the current fault conditions. When the fault is cleared, the inverter switches to the sleep state.

Sleep

In this state, the inverter is enabled but the DC voltage is below the minimum operating window. When the PV input voltage rises above the ‘start’ voltage, the inverter switches to the startup delay state.

Startup Delay

In this state, the inverter delays a specified time and then enters the idle state. The delay depends on the conditions prior to the sleep state and the time taken to reach this state from the previous shutdown. If a grid interactive fault occurred on the previous shutdown, the inverter will remain in this state for 5 minutes.

DC Precharge

In this state, the inverter closes the DC precharge-contactor, which limits inrush current into the DC bus capacitors. When the DC bus voltage reaches the PV input voltage and is greater than the DC start voltage, the inverter switches to the AC precharge state.

AC Precharge

In this state, the inverter closes DC main contactor and the AC precharge-contactor, which limits inrush current into the transformer. Once the transformer is magnetized, the AC main contactor is closed the AC pre-charge contactor is opened. After a short delay, the inverter switches to the idle state.

Idle

In this state, the inverter disables the drive PWM and displays a message indicating that the inverter is idle. The inverter switches to the power tracking state when the DC voltage is above the DC start voltage. If a fault condition occurs, the inverter switches to the fault state. If the DC voltage drops below the minimum, the inverter switches to the sleep state.

Power Track

In this state, the inverter operates in voltage control mode using the maximum power point tracking (MPPT) function. If a fault occurs, the inverter switches to the fault state.

6.3 Display Screens and Display Operation

Display Screens

The inverter display provides the operator with information about the current state of the inverter. There are five sets of screens that may display depending on the state of the inverter. The five states are: Startup, Power Track (normal power production state), Fault, Warning and Disabled. Each of the display screens for each state are shown in Figures 6-4 through 6-8. If there is a series of display screens associated with the inverter state then the inverter will continuously scroll through these screens.

If a fault occurs, the display also provides a fault code that corresponds to a set of pre-defined fault descriptions as detailed in *Appendix D - Limits and Fault Codes*.

Figure 6-3 Display

Figure 6-4 Startup State Screen

Screen 1: Product **Screen 2: State** **Screen 3: DC Values**

Screen 4: AC Values **Screen 5: Power Values**

Figure 6-5 Power Track State Screens

Screen 1: Fault Code(s) **Screen 2: Fault Text** **Screen 3: Contact Information**

Figure 6-6 Fault State Screens

Figure 6-7 Warning State Screen

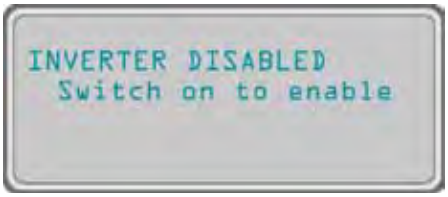


Figure 6-8 Disabled State Screen

Display Operation

The inverter display normally scrolls through a series of display screens based on the current state of the inverter.

- To pause the display on a specific screen press the “Pause/Scroll” button on the display.
- To resume the scroll function press the “Pause/Scroll” button again.

6.4 Ground Fault Interrupt Device

The inverter is equipped with a GFDI (Ground Fault Detector/Interrupter). The purpose of the GFDI is to detect a ground fault (unintended current flow from the solar panels to earth ground) and in this event, disable the inverter.

WARNING

For the GFDI circuit to function as designed, the solar array safety ground must not be connected to the PV array positive or negative leads.

Bonding the safety ground to the grounded leg of the array anywhere but through the inverter will cause the GFDI circuit to be bypassed. This would defeat the operation of the GFDI and potentially create an unsafe operating condition.

The GFDI functions using a 2A fuse for the PVP35kW and a 3A fuse for the PVP50kW to connect or bond the solar array Negative (or the solar array Positive, if using a positively grounded panel array) to earth ground on the HV Distribution PCB.

If the ground fault current exceeds the fuse rating between the grounded array terminal and the earth ground, the fuse will open and disconnect the solar panels from their ground reference, interrupting the ground fault. In this situation, the inverter will cease operation and display a fault message (see *Appendix D - Limits and Fault Codes*). Additionally, the LED on the HV Distribution PCB will illuminate.

Figure 6-9 Ground Fault Error Message

If the inverter displays a ground fault as shown in Figure 6-9, turn OFF the AC and DC to the inverter and refer to *Chapter 7, Maintenance & Troubleshooting*.

6.5 Shutdown Procedure

To shutdown the inverter, complete the following steps in order:

1. Turn the inverter's ON/OFF switch to the OFF position.

   The ON/OFF switch is located under the upper door.

2. Turn the AC disconnect to the power OFF position by rotating the AC power lever to the position shown in Figure 2-1. The display on the upper front panel should be inactive.
3. Turn the DC disconnect to the power OFF position by rotating the DC power lever to the OFF position shown in Figure 6-10.
4. Open the utility connection circuit breaker.
5. Disconnect the PV array connection to the inverter using the external PV disconnect.

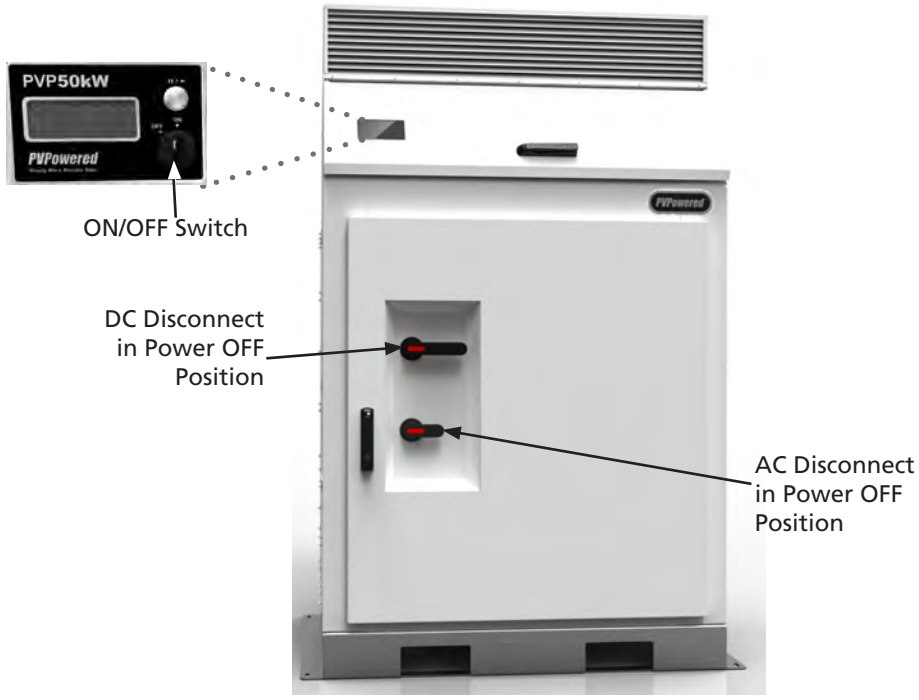


Figure 6-10 AC and DC Disconnect Power OFF

DANGER

Risk of Electrical Shock. Allow five (5) minutes for internal power to dissipate prior to entering the enclosure cabinet. Ensure all terminals are voltage free with the use of a multimeter.

7. Maintenance & Troubleshooting

DANGER
AC and DC voltages will still be present at the inverter AC and DC landing points unless utility connection circuit breaker and PV array inputs are disconnected.

DANGER
Before attempting any maintenance or troubleshooting, turn OFF AC and DC power to the inverter.

7.1 Visual Inspection

PV Powered recommends visually inspecting the inverter every time it is serviced. Start by observing the front, back and sides of the inverter for damage, foreign objects, or dust and debris that may have accumulated around the inverter. Remove dirt and debris from the area around the inverter at least every six months.

7.2 Annual Preventative Maintenance

Maintenance Checklist

The following maintenance should be performed annually by a qualified service person. See *Appendix E - Annual Maintenance Requirements Checklist* for a checklist of these required maintenance items.

A. General Inspection & Cleaning

1. Record general site conditions.
2. Record inverter performance data from inverter display.
3. Record environmental conditions.
4. Remove dirt and debris from underneath the inverter.
5. Inspect and clean interior of inverter.
6. Inspect air filter and clean or replace.
7. Confirm the presence of product documentation.

B. Connections and Wiring

8. Complete visual inspection of electrical connections and wiring.
9. Complete mechanical inspection of connections and wiring.
10. Measure torque of all electrical connections and re-torque as needed.
11. Complete thermal scan of inverter connections, wiring and electronics.

C. Testing

12. Confirm the inverter operating modes including standby, startup and on.
13. Confirm power supply and transformer output.
14. Validate display data accuracy.

D. Repair or Replace

15. Repair or replace items that have been determined to be near the end of their useful life.

E. Reporting

16. Complete preventative maintenance report and recommendation.

F. Documentation of Annual Preventative Maintenance Checklist

Complete the maintenance checklist included in Appendix E and save the information for your records. This checklist is also available on the www.pvpowered.com web site.

Maintaining the Blower Intake Filters

PV Powered recommends an annual inspection of the blower intake filters. Inspection may be required more often depending on the location of the inverter.

The air intake hood is mounted on gas shocks. It must be in the open position to access the air intake filters. There are two air intake filters mounted behind the electronics section in the back of the upper cabinet.

1. Remove the two filters by loosening the two 5/32” Allen head bolts nuts on each filter bracket.
2. Clean the filters by vacuuming or blowing out using an air hose with a diffuser.
3. After cleaning, inspect the filters for damage to the filters or brackets.

   Contact PV Powered if you wish to replace the filters or brackets.
4. Reinsert the filters and close the air intake hood.

Figure 7-1 View of Blower Intake Filters and Brackets

7.3 Maintaining the Electronics Section Air Filters

There are three secondary air filters in the electronics section to ensure long PCB life. The air filters are located under the blower cover behind the card cage.

Use the following instructions to access the secondary air filter and refer to Figure 7-2.

1. Turn off the inverter and follow the LOTO procedure.
2. Remove the blower cover by removing the six, three in front and three in back, 5/32" Allen head bolts. This will expose the air filters.
3. Remove the four screws on each air filter.
4. Clean each filter with compressed air or soap and water.
5. Once the filters are clean and dry, replace each filter and the blower cover.

If the filter needs to be replaced, call PV Powered Technical Support at 1-877-312-3832, or email support@pvpowered.com.

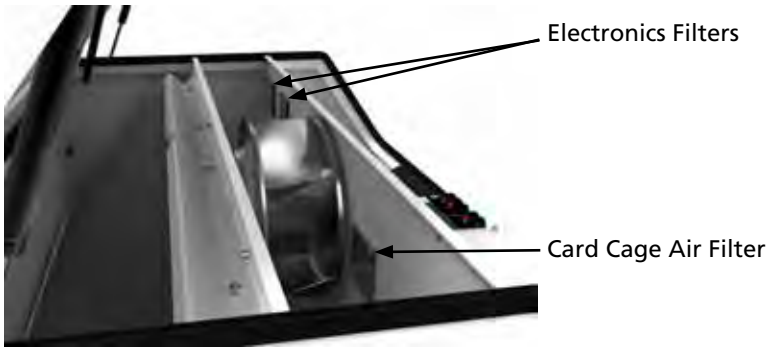


Figure 7-2 Electronics Section Air Filters

7.4 Faults and Warnings

The display screen is the primary indicator of a possible problem with the inverter. If a fault has occurred the inverter will cease power production until the fault is cleared. A fault may be a latching or non-latching fault. A non-latching fault will be automatically cleared if the fault condition is resolved and the inverter will restart automatically after completing its startup sequence. A latching fault requires manual intervention to restart the inverter.

If the inverter has faulted, the display screen will show the corresponding fault information in a series of three or more screens.

- The first screen – displays the fault code(s)
- The second screen – displays a text description of the fault(s).
- The third screen – displays technical support contact information.

The display will then cycle back to the first screen. A sample series of screens is shown in Figure 7-3 below.

The complete list of fault codes are provided in *Appendix D - Limits and Fault Codes* as a guide.

Identifying the Inverter's Fault Codes

Startup

Upon startup, the inverter will automatically scroll between the startup screens shown in Figure 7-3.

Figure 7-3 Example of the Startup Fault Display Screens

In addition, the inverter can also detect and display inverter warnings. Warnings are displayed if a condition is detected that does not require the inverter to shut down but may require attention. A sample warning screen is shown below in Figure 7-4.

A complete list of warnings can be found in *Appendix D - Limits and Fault Codes*.

Figure 7-4 Fault Example Screen

7.5 Troubleshooting Faults

WARNING
These servicing instructions are for use by qualified personnel only. To reduce the risk of electric shock, do not perform any servicing other than that specified in the operating instructions for someone of your qualifications.

Before performing advanced troubleshooting, the inverter must be deenergized as described in *6.5 Shutdown Procedure*.

DANGER
Risk of Electrical Shock. Allow five (5) minutes for internal power to dissipate prior to entering the enclosure cabinet. Ensure all terminals are voltage free with the use of a multimeter.

Prior to conducting the following troubleshooting steps, perform a visual inspection targeting loose or disconnected wires, fuses, other connections or hardware problems. If the visual inspection reveals potentially unsafe conditions, discontinue troubleshooting and contact PV Powered Technical Support at 1-877-312-3832, or email support@pvpowered.com prior to proceeding.

AC Under Voltage Fault

If the inverter displays an AC Under Voltage fault *and* all the voltages going into the inverter are within the tolerances specified in *Appendix A - Specifications*, refer to the troubleshooting tips below.

1. If the main branch circuit breaker is not tripped, check the small fuses located on the HV Distribution PCB (there are nine in three sets of three). If one or more of these fuses have opened, replace them with like parts (600VAC, 10A or 20A as required).
2. If any of the fuses were open, visually inspect the wiring. Look for frayed wires, carbon marks indicating a short, or burned traces on the PCBs. If any of these conditions are present, **DO NOT START THE INVERTER**. Call PV Powered Technical Support at 1-877-312-3832, or email support@pvpowered.com for replacement parts or service.

Ground Fault

The inverter is equipped with a GFDI (Ground Fault Detector/Interrupter). The purpose of the GFDI is to detect a ground fault (unintended current flow from the solar panels to earth ground) and in this event, disable the inverter.

WARNING
For the GFDI circuit to function as designed, the solar array safety ground must not be connected to the PV array positive or negative leads.

Bonding the safety ground to the grounded leg of the array anywhere but through the inverter will cause the GFDI circuit to be bypassed. This would defeat the operation of the GFDI and potentially create an unsafe operating condition.

The GFDI functions using a 2A fuse for the PVP35kW and a 3A fuse for the PVP50kW to connect or bond the solar array Negative (or the solar array Positive, if using a positively grounded panel array) to earth ground on the HV Distribution PCB.

If the ground fault current exceeds the fuse rating between the grounded array terminal and the earth ground, the fuse will open and disconnect the solar panels from their ground reference, interrupting the ground fault. In this situation, the inverter will cease operation and show a ground fault message on the inverter. Additionally, the LED on the HV Distribution PCB will illuminate.

If the inverter displays a ground fault, turn the ON/OFF switch on the display to OFF, then turn off the AC and DC to the inverter.

A ground fault may be caused by the following:

1. A configuration error during commissioning.
2. Switching the grounded conductor in the DC disconnect. For a negatively grounded system, the positive leg should be broken in the DC disconnect. For a positively grounded system, the negative leg should be broken in the DC disconnect.
3. A pinched wire in the installation connecting some part of the array or DC wiring to earth ground.
4. In the case of a multiple inverter installation, mismatched array strings.

Repairing a Ground Fault

DANGER
Risk of Electrical Shock. Allow five (5) minutes for internal power to dissipate prior to entering the enclosure cabinet. Ensure all terminals are voltage free with the use of a multimeter.

DANGER
Verify that no shock hazard exists between both fuse terminals and earth ground before removing the fuse. A 600V rated fuse pulling device is required.

Open the front door and find the HV Distribution PCB in the upper right (Figure 1-4). Inspect the fuse for continuity using a multimeter. If the fuse is open, a ground fault exists outside the inverter. Identify and repair the ground fault and replace the fuse. Close the door and restart the inverter following the instructions described in *6.1 Start Up Procedures*.

If the fuse is not open, continue troubleshooting by following the steps below. With the ground fault fuse removed:

1. Remove the fuse and check it for continuity. If the meter indicates no continuity then a ground fault likely exists.
   - Check the DC voltage between the grounded terminal of the array and earth ground. The voltage should be less than 30 volts with the GFDI fuse removed. If the voltage is higher than 30 volts, a ground fault likely still exists. Check the array wiring. For the best results, perform this test with the DC disconnect in both the ON and OFF positions.
   - Make sure the grounded leg of the solar array is not disconnected in the DC disconnect.
2. Once the ground fault condition has been eliminated, verify the voltage between earth ground and the grounded side of the PV array is less than 30 volts.
3. Ensure the DC disconnect is in the OFF position and install the new GFDI fuse.
4. Follow section *6.1 Start Up Procedure* to restart the inverter.

If the ground fault cannot be eliminated, contact PV Powered Technical Support at 1-877-312-3832, or email support@pvpowered.com.

7.6 Communication PCB Status Light Operation

Communication PCB LED Lights

All PV Powered commercial inverters include four status LED lights to help troubleshoot system operation:

Link – Indicates presence of a hardware Ethernet connection

Activity (or ACT) – Indicates internet traffic

Status – Indicates communication status

Modbus – Indicates activity on the Modbus network

Figure 7-5 Status LED Lights

Link LED Operation and Signaling

- The Link LED remains on if a hardware Ethernet connection is found.
- The LED is off if there is no hardware Ethernet connection.
- There are no flash codes for the Link LED.

Activity LED Operation and Signaling

- The Activity LED (called ACT on some circuit PCBs) flashes to indicate the presence of internet traffic.
- There are no flash codes for the Activity LED.

Status LED Operation and Signaling

- During the startup sequence the Status LED is on solid for a few seconds, then flashes quickly for several seconds while the communications device looks for an Internet connection.
- After a few seconds, the Status LED flashes more slowly while serial communication is established with the inverter's main processor.
- Once serial communication is established, the Status LED should remain on unless a fault occurs.

The Status LED will flash status codes if any problem is found.

- Each code is a comprised of a series of three flashes, followed by a pause.
- Each flash can be either a short or long flash. A short flash is approximately 0.2 seconds and a long flash is approximately 0.5 seconds.
- The pause between flashes is one second.

The following list provides the status codes and their meaning.

Status	Flash Code
Normal Operation	On steady, no flashing
Serial Communication Fault	Short-Long-Short
DNS Failure	Long-Short-Short
Network Connection Fault	Short-Short-Long

Table 7-1 Status LED Flash Codes

Status LED Code Descriptions

Normal Operation: Inverter communications are operating normally.

Serial Communication Fault: The Communications PCB in the inverter communicates with the inverter's main processor via serial communication. If the Communications PCB cannot establish communication with the main processor, the Serial Communication Fault code will flash.

Note: It is normal for this status code to flash for a few seconds during startup.

DNS Failure: The inverter uses a DNS (Domain Name System) server to resolve the IP address of the PV Powered database when it posts the data, once every 15 minutes. If the

DNS server cannot be found, or does not return a valid IP address, the DNS Failure code will flash for a minute or so while the inverter is trying to post. After several retries, the inverter will try to force a post to a hardcoded IP address. If this post succeeds, the LED will go back to normal operation until the next post again tries to connect to the DNS server.

Network Connection Fault: This status code flashes when the inverter cannot post data to the PV Powered database server. The Network Connection Fault status code starts flashing only after the inverter has tried to post data to the PV Powered server. The Status LED may indicate normal operation before this occurs. This can happen in the following circumstances:

- The network cable is not connected
- The network does not have a DHCP server or the DHCP server did not give a valid IP address to the inverter
- The PV Powered server is down for maintenance
- Any other network problem that does not allow the post to make it to the PV Powered server

Modbus LED Operation and Signaling

If the inverter is connected as a slave device on a Modbus network, the Modbus LED will flash quickly whenever there is activity on the network. The quick flashes will be seen even if the Modbus commands are not addressed to the inverter. These quick flashes enable the installer to troubleshoot the system by verifying that communications are occurring on the network. If the inverter sees and responds to a message that is addressed to it, the flashes will be longer in duration. A series of longer (slower) flashes indicates the inverter is responding to the Modbus master request.

Periodic short and long flashes will be seen when communications occur on a Modbus network that contains multiple Modbus slave devices.

If only short flashes are seen:

- Check the inverter Modbus address switches and make sure they correspond to the address programmed into the Modbus master.
- Confirm that the baud rate and other communication parameters of the Modbus master are set correctly.

For further Modbus network configuration details see *Appendix E - Annual Maintenance Requirements Checklist*.

7.7 Controller PCB Status Light Operation

There are three lights on the front of the Controller PCB.

1. If the green light is on:
   - The inverter is on and ready to produce power.
2. If the red light is on:
   - Solid red — the inverter is in a faulted condition that will be auto reset by the inverter if the fault condition is cleared.

- Flashing red — there is a latching fault. A latching fault requires manual intervention prior to the inverter restart.

  If the red light is on or flashing, a fault code should be shown on the display. See *Appendix D - Limits and Fault Codes* for a description of the fault codes.

3. If the PWMEnable light is on, the inverter is producing power.

Appendix A - Specifications

Model	PVP35kW	PVP50kW
AC Characteristics		
Continuous power (AC)	35kW	50kW
Grid type	208VAC, 480VAC 3 phase, 4 wire Y (not compatible with delta service)	
Maximum output fault current and duration	TBD	302.1A, 82MS
Nominal AC voltages (VAC)	208 Y, 480 Y	
AC maximum continuous current (A)	208VAC-100, 480VAC-43	208VAC-141, 480VAC-61
CEC efficiency (%)	208VAC-95.5, 480VAC-95.5	208VAC-96.0, 480VAC-96.0
Peak efficiency (%)	TBD	208VAC-96.7, 480VAC-97.2
Frequency range	59.3 - 60.5Hz	
AC voltage range set points (default)	(-12% to +10%)	
AC operating range (V)	208: 183 – 228VAC 480: 422 – 528VAC	
Power factor at full power	> .99	
THD (%)	< 3%	
Standby losses (W)	<33	
Utility interconnect voltage trip limits and times	See Appendix D	
Utility frequency trip limits and times	See Appendix D	
DC Characteristics		
Maximum array short circuit current (DC)	350A	
Nominal DC current (A)	125	178
Subcombiner DC fuse options	350A Max.	
MPPT range	295-595	
Maximum V_{oc}	600	
Startup voltage	330	
General Specifications		
Cooling	Forced Convection	
Operating ambient temperature range (°C)	-30 to 50°	
Standby/storage ambient temperature range (°C)	-40 to 60°	
Limits of accuracy time measurement	+/- 0.1 sec	
Enclosure rating	NEMA 4	
Dimensions (H x W X D in inches)	67 1/8 x 48 3/4 x 29 1/2	73 5/8 x 48 3/4 x 24 1/2
Maximum weight (lbs.)	1,200	1,500
Relative humidity (%)	0-95%, non-condensing	
Maximum heat rejection rate (BTU/hr)	6,600	8,500
Maximum blower air flow rate (CFM)	750	
Altitude (ft)	6,000	
Display	VFD 4x20	
Interface options	RS-485, Ethernet	

Model	PVP35kW	PVP50kW
Communications protocol	TCP/IP, Modbus	
Standard warranty	10 years	
Certifications & Compliances [1,2]	UL1741, IEEE519, IEEE929, IEEE1547, FCC Class A	
Construction	Powder coated steel with hot-dipped zinc base	
Isolation transformer	Yes	
Options		
UL approved positive grounding	Yes	
Commercial grade data monitoring solutions	Yes	
Preventative maintenance program	Yes	
Extended warranty- 20 Year	Yes	
Range of integrated fused sub-array combiners	Yes	

Table A-1 Product Specifications Data

Notes:
1. The PVP35kW and PVP50kW Inverters comply with FCC Part 15 Class A conducted requirements.
2. The PVP35kW and PVP50kW Inverters are designed to meet or exceed NEC Article 690 and UL1741-2005 Static Inverters and Charge Controllers for use in Photovoltaic Power Systems, which includes testing for IEEE 1547.1-2005, IEEE 929-2000 and IEEE519-2000.

Limits:
Limits of accuracy of voltage measurement and energy production measurements +/- 5%
Limits of accuracy of frequency measurement +/- 0.1Hz

Appendix B - Wiring Diagram

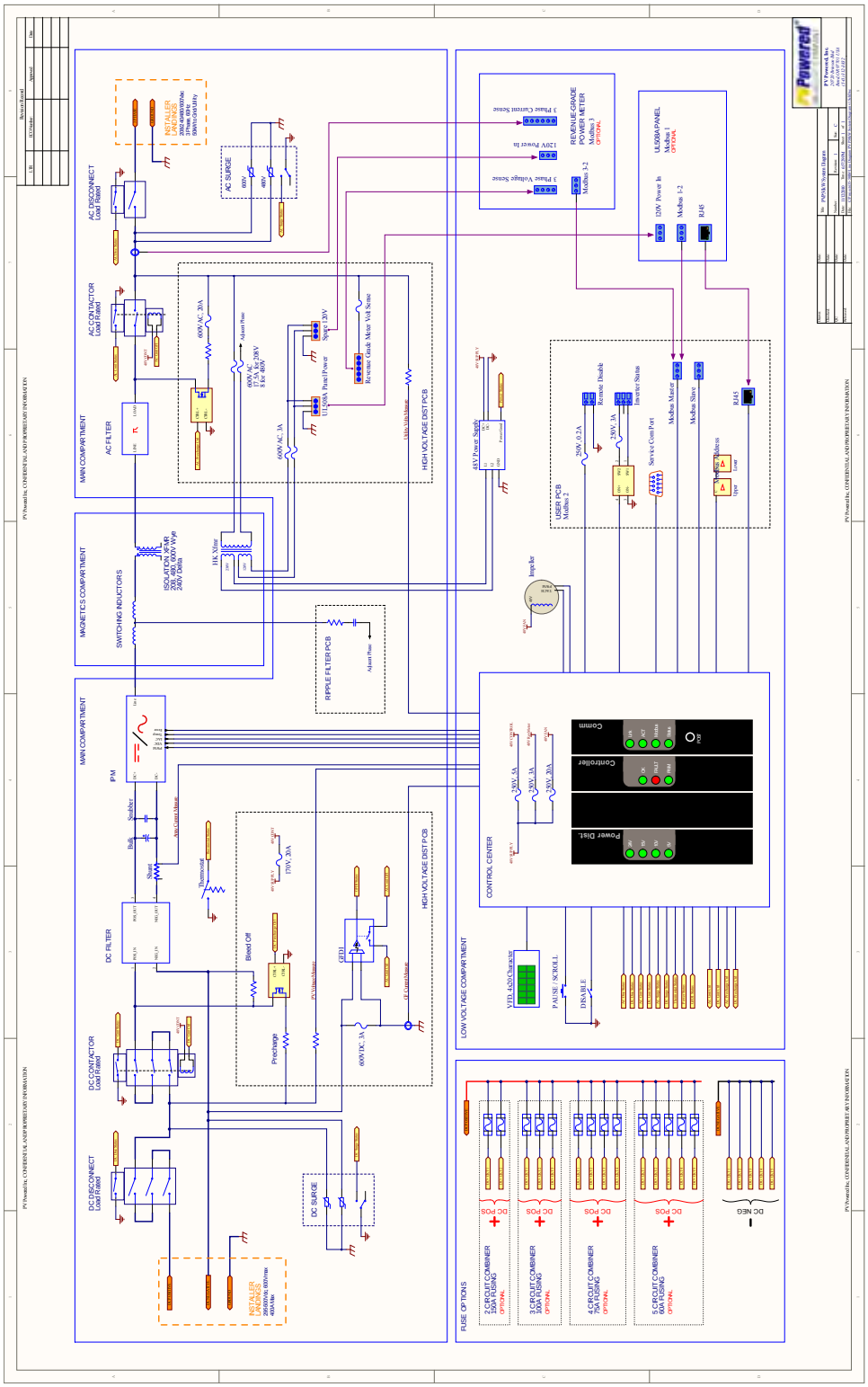


Figure B-1 Wiring Diagram

Appendix C - Mechanical Drawings

Refer to the following pages for mechanical drawings of the PVP35kW and PVP50kW.

C.1 PVP35kW Mechanical Drawings

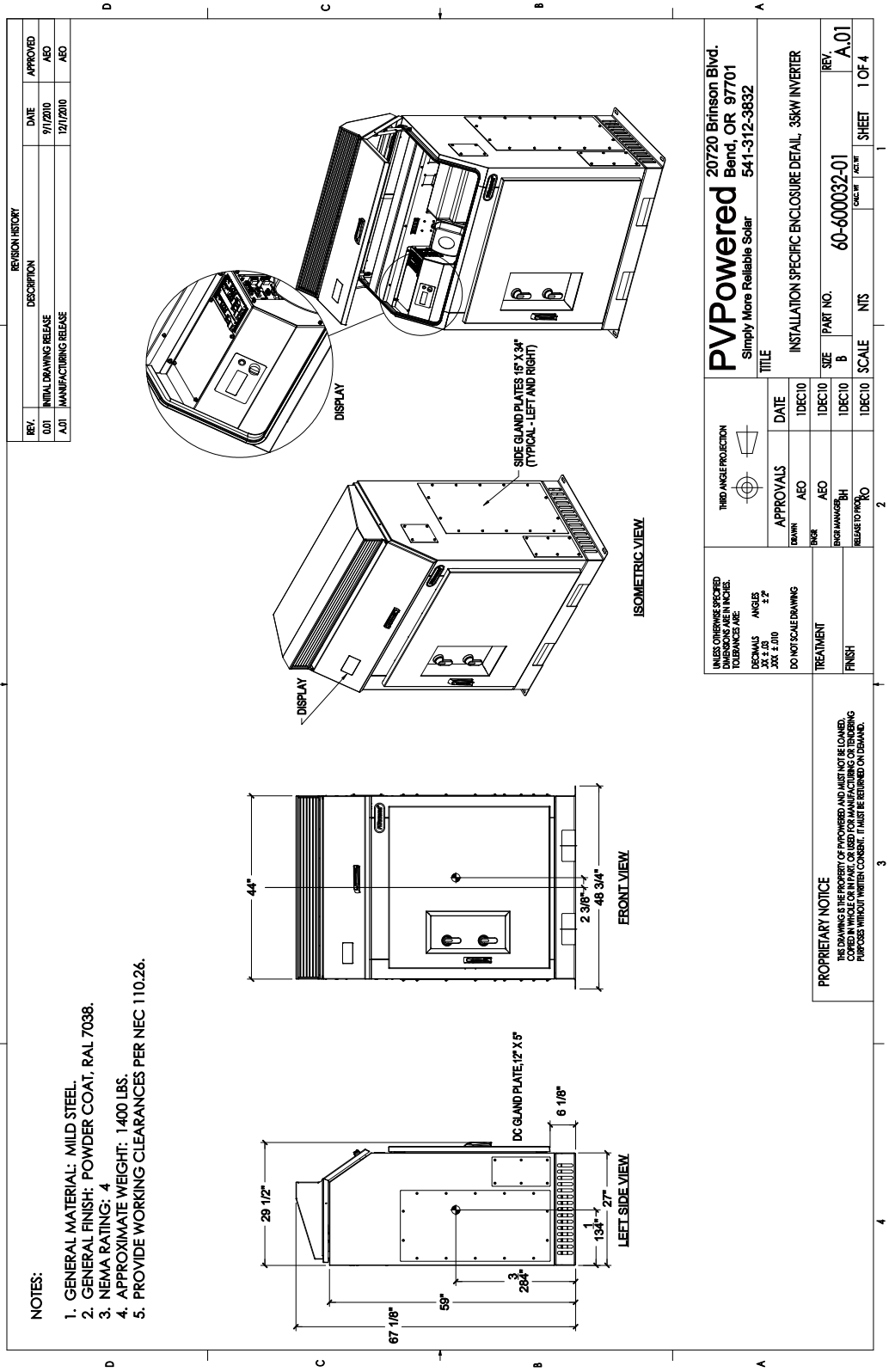


Figure C-1 PVP35kW Mechanical Drawing - View 1

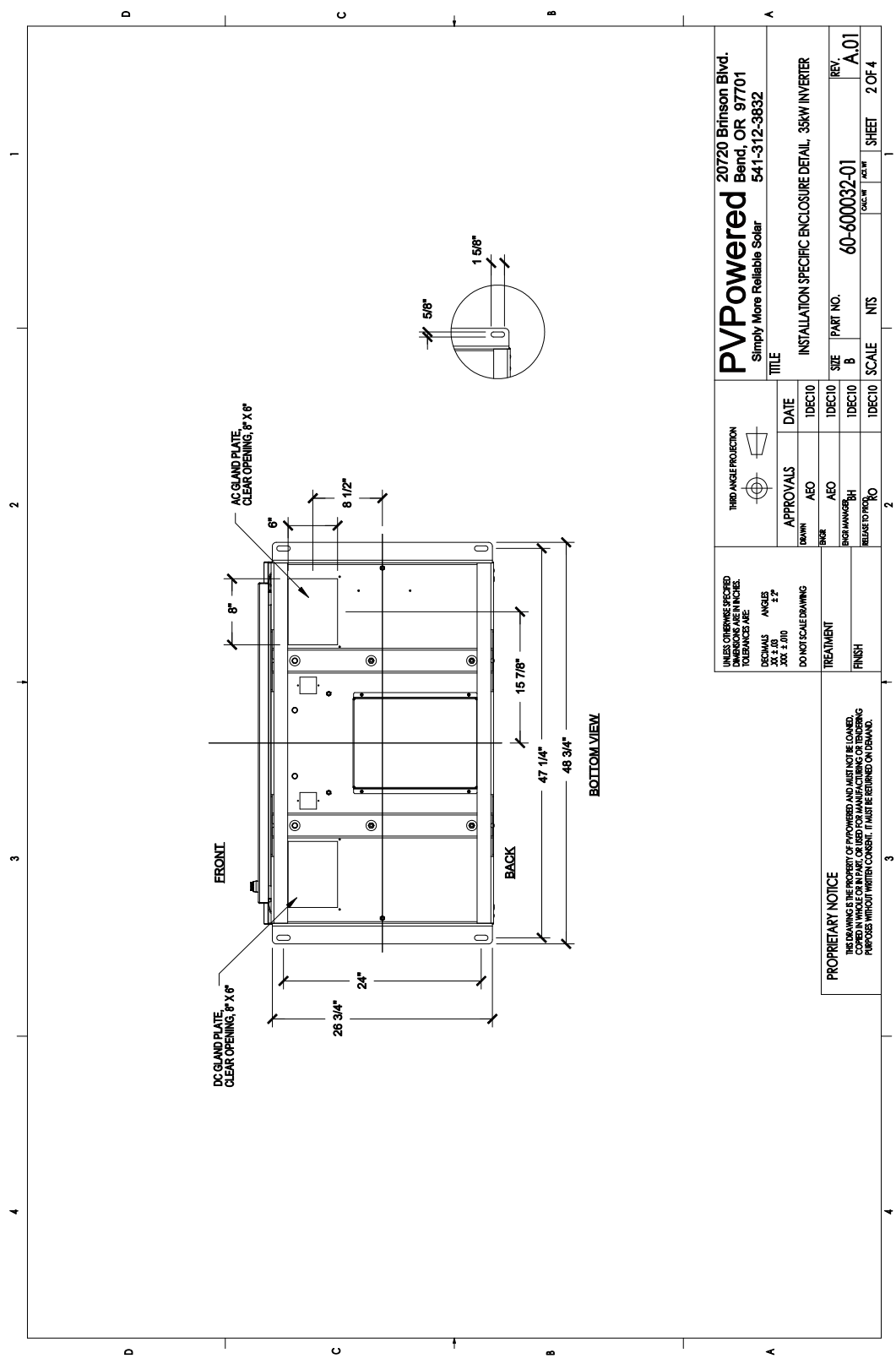


Figure C-2 PVP35kW Mechanical Drawing - View 2

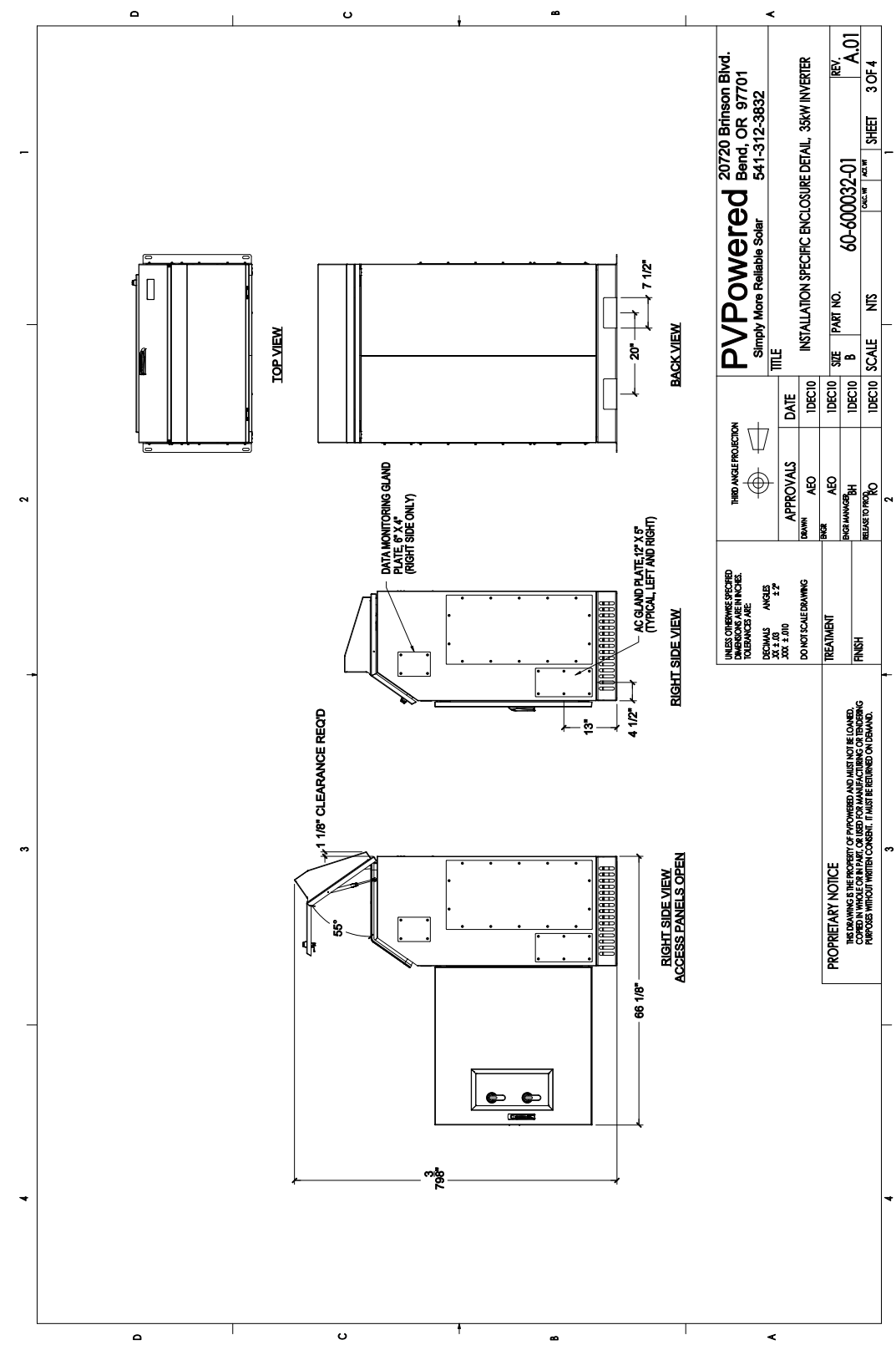


Figure C-3 PVP35kW Mechanical Drawing - View 3

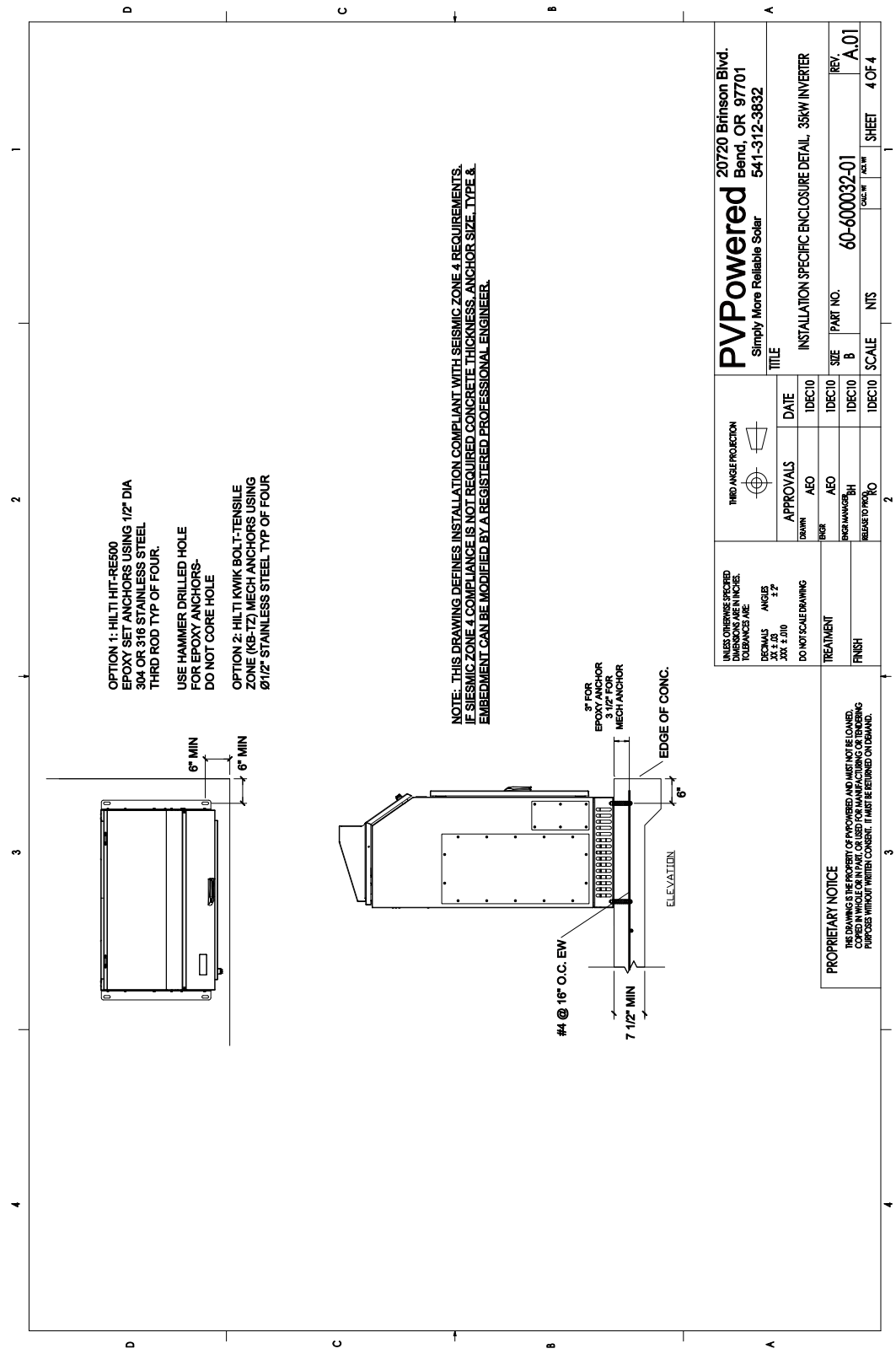


Figure C-4 PVP35kW Mechanical Drawing - View 4

C.2 PVP50kW Mechanical Drawings

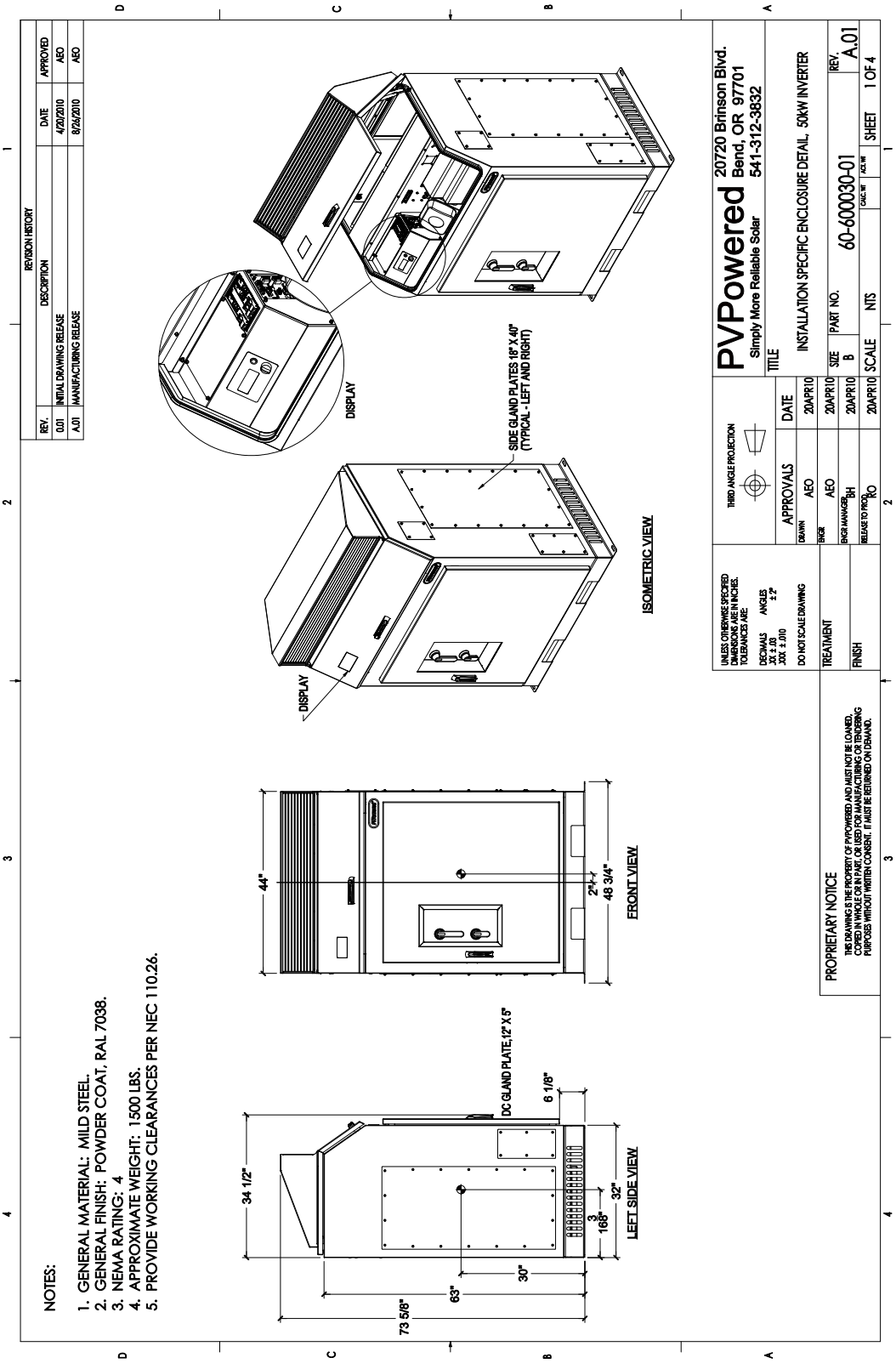


Figure C-5 PVP50kW Mechanical Drawing - View 1

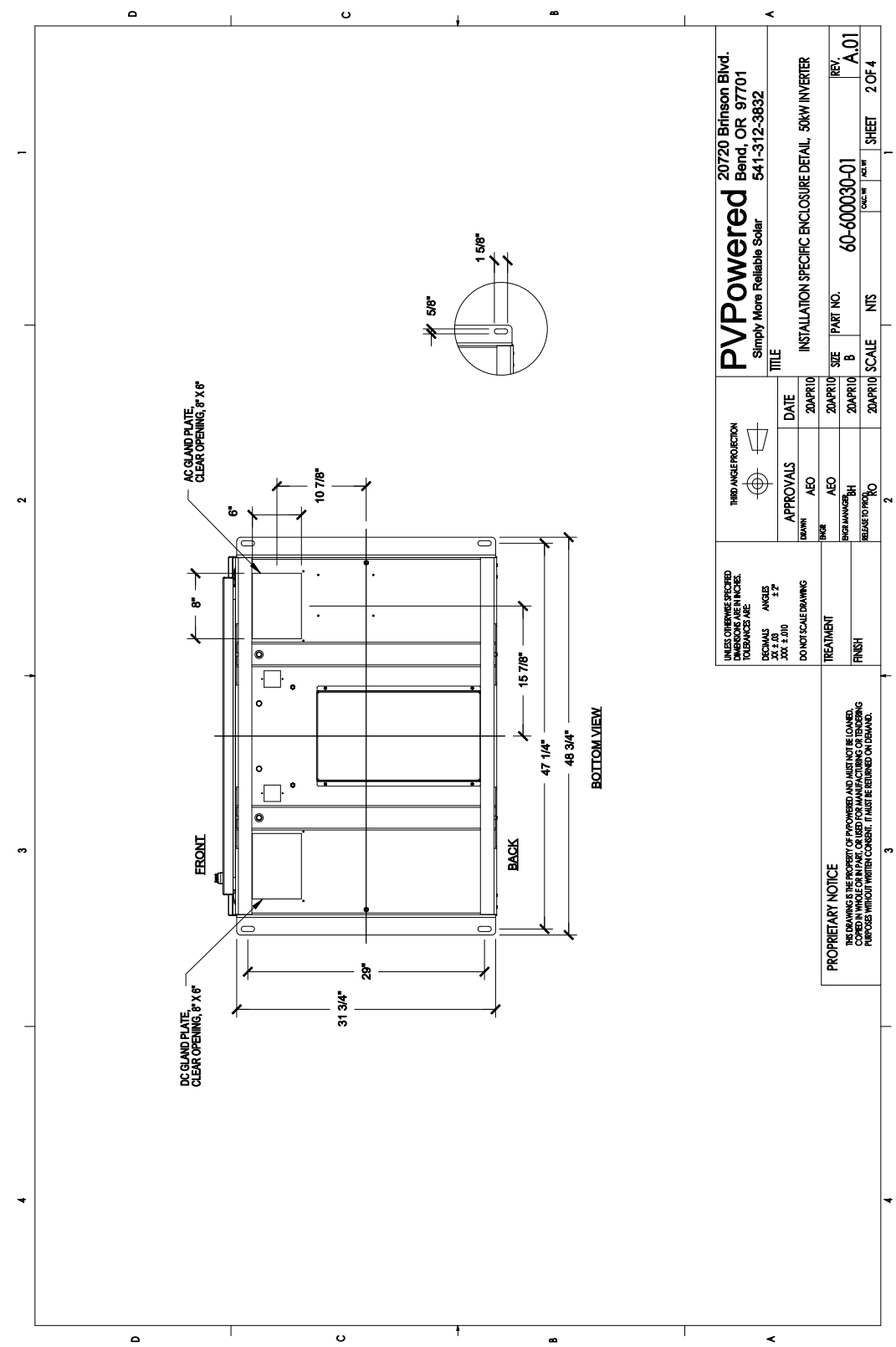


Figure C-6 PVP50kW Mechanical Drawing - View 2

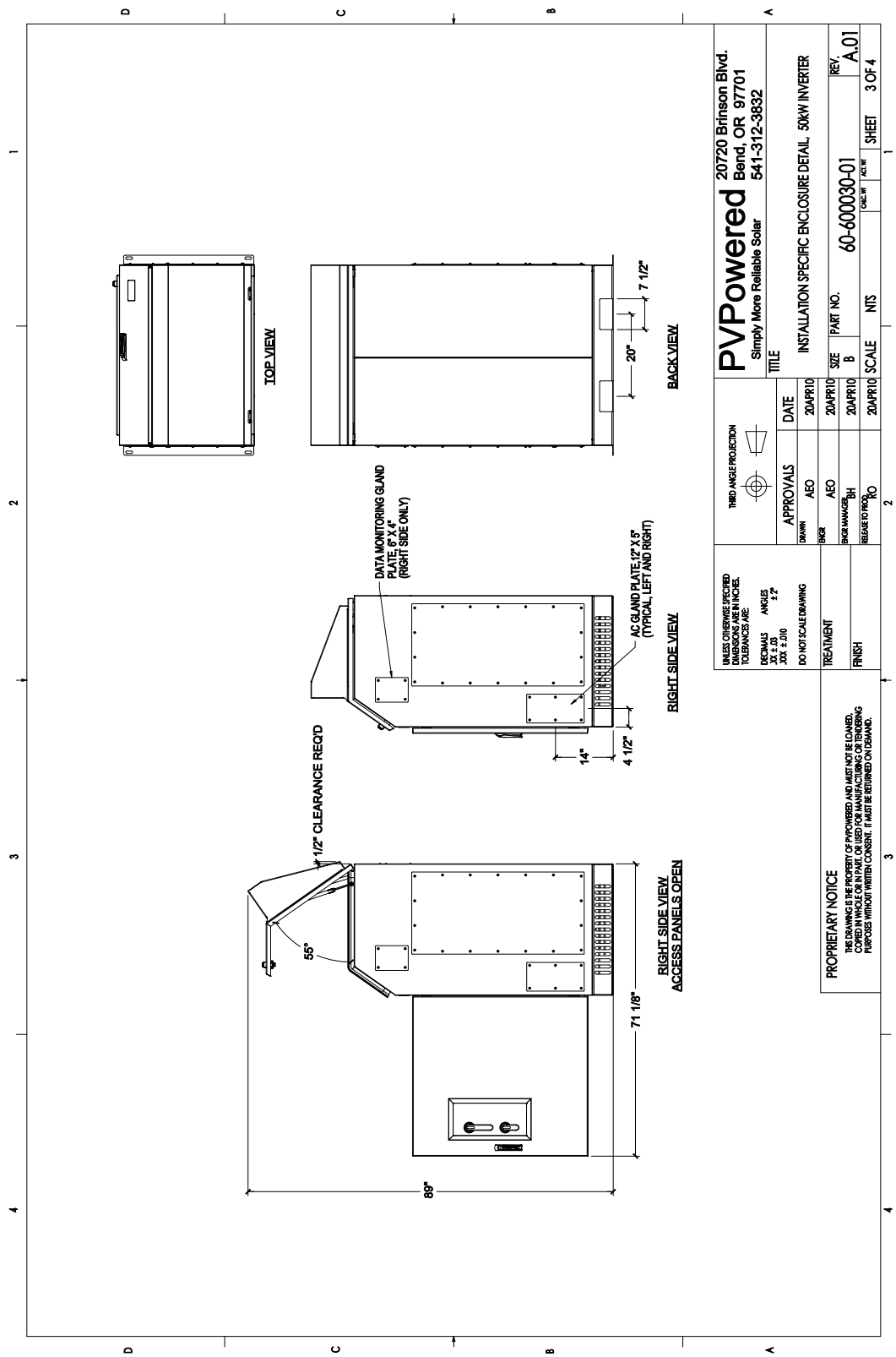


Figure C-7 PVP50kW Mechanical Drawing - View 3

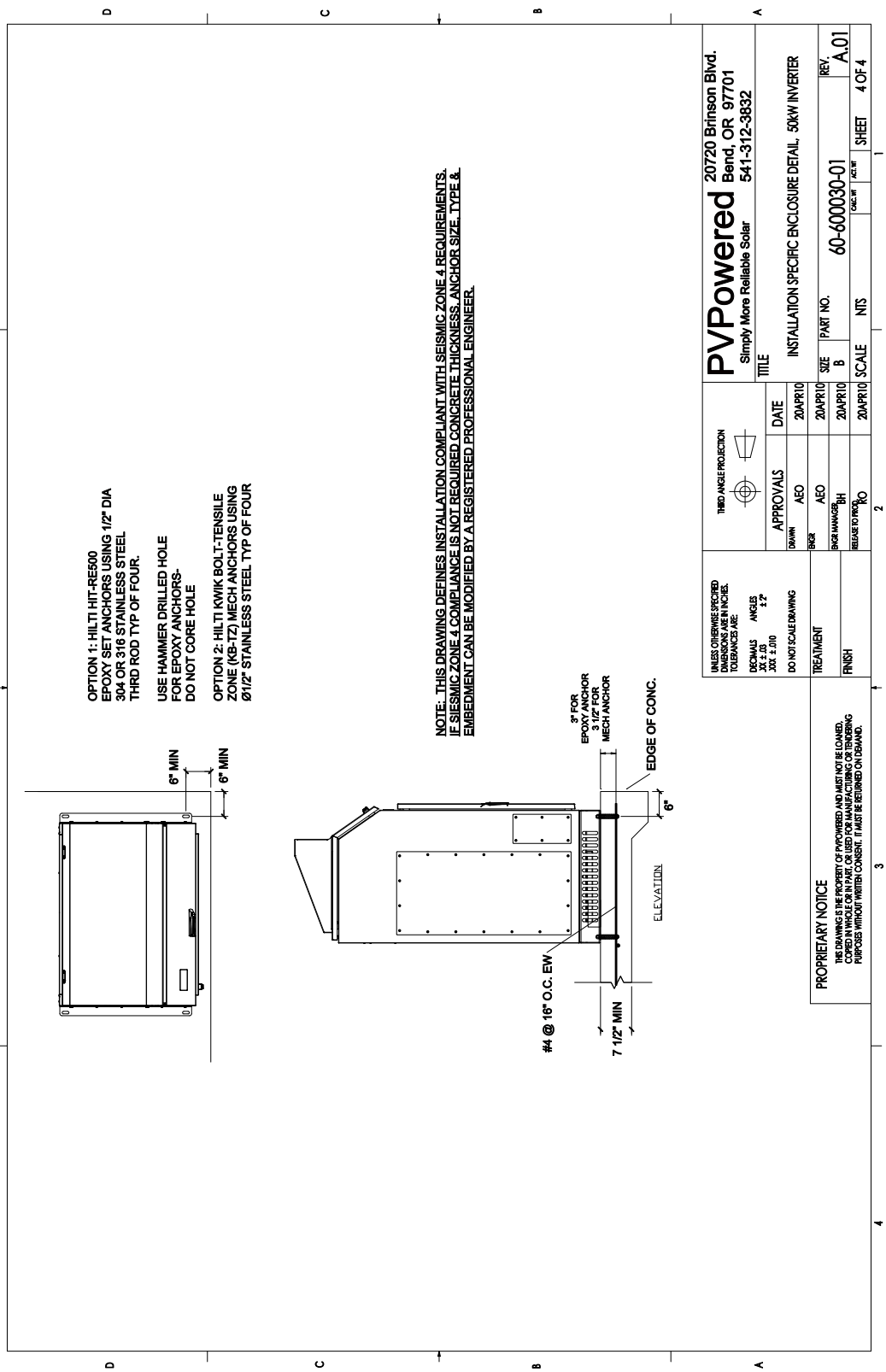


Figure C-8 PVP50kW Mechanical Drawing - View 4

Appendix D - Limits and Fault Codes

Condition	Factory setting (VAC) or (Hz)	Range (VAC)	Maximum Trip Time (s)
208VAC Configuration			
Voltage phase high	132.0	132.0 – 141.6	1.0
Voltage phase low	105.6	94.0 – 105.6	2.0
Voltage phase fast high	144.0	144.0 – 156.0	0.16
Voltage phase fast low	60.0	60.0	0.16
480VAC Configuration			
Voltage phase high	304.8	304.8 – 326.9	1.0
Voltage phase low	243.9	216.1 – 243.9	2.0
Voltage phase fast high	332.5	332.5 – 360.2	0.16
Voltage phase fast low	138.6	138.6	0.16
All Configurations			
Line frequency low	59.3 Hz	59.3	0.16
Line frequency high	60.5 Hz	60.5	0.16

Table D-1 Voltage and Frequency Limits

Condition	Adjustable Setting (VAC) or (Hz)
AC Voltage Field Adjustable Trip Points (% of Normal)	-12% to +10%
Accessible Range of Low Frequency Setting (Hz) (Limits of Accuracy Frequency Measurement +/-0.1 Hz)	Adjustable low trip 57.5-59.8 High trip fixed at 60.5
Accessible range of Trip Times (Limits of Accuracy Time Measurement +/- 0.1 sec.)	.16 to 300 seconds

Table D-2 Adjustable Voltage and Frequency Limits

Fault Variables

The PVP35kW and PVP50kW firmware utilizes one, 16-bit variable (fault) to indicate a fault condition. Each bit in this fault variable represents the fault type or category. The bit assignments and specific fault variables for the fault categories are as follows:

Description	Hexadecimal Value (Modbus)
Drive protection fault	0001
Voltage fault	0002
Grid fault	0004
Temperature fault	0008
System fault	0010

Table D-3 Main Fault Categories

For each fault category, another fault variable further specifies which fault has occurred within this category. The following tables list the faults for each category (variable).

The following table lists the drive protection faults.

Hexadecimal Value	Fault Name	Fault Description
0001	DRIVE PROTECT FLT	Drive protection fault
0040	HW OVERCURRENT	Peak over-current
0200	RMS OVERCURRENT A	RMS over-current, phase A
0400	RMS OVERCURRENT B	RMS over-current, phase B
0800	RMS OVERCURRENT C	RMS over-current, phase C
1000	DC OVERVOLTAGE	DC input voltage high
2000	DC UNDERVOLTAGE	DC input voltage low (while online

Table D-4 Drive Protection Faults (DRV)

The following table lists the temperature faults.

Hexadecimal Value	Fault Name	Fault Description
0001	HEATSINK TEMP	Module heat-sink temperature high
0040	BOARD TEMP HI	Control board temperature high
0100	MAGNETICS TEMP HI	Magnetics temperature high
0200	AMBIENT TEMP LOW	Ambient temperature low
0400	MAG TEMP LOW	Magnetics temperature low
0800	IPM TEMP HIGH	Power module temperature high

Table D-5 Temperature Fault (TMP)

The following table lists the voltage faults.

Hexadecimal Value	Fault Name	Fault Description
0001	VAC OVER PEAK	Peak AC voltage high
0008	PLL FAULT	Control PLL fault
0020	DC OVER VOLTAGE	DC voltage high
1000	DC PRECHARGE	DC precharge fault
2000	PV-DC DELTA	PV input and DC bus voltage delta

Table D-6 Voltage Fault (VLT)

The following table lists the grid faults.

Hexadecimal Value	Fault Name	Fault Description
0001	AC FAST UNDERVOLT A	Fast AC voltage low, phase A
0002	AC FAST UNDERVOLT B	Fast AC voltage low, phase B
0004	AC FAST UNDERVOLT C	Fast AC voltage low, phase C
0008	AC SLOW UNDERVOLT A	Slow AC voltage low, phase A
0010	AC SLOW UNDERVOLT B	Slow AC voltage low, phase B
0020	AC SLOW UNDERVOLT C	Slow AC voltage low, phase C
0040	AC FAST OVERVOLT A	Fast AC voltage high, phase A
0080	AC FAST OVERVOLT B	Fast AC voltage high, phase B
0100	AC FAST OVERVOLT C	Fast AC voltage high, phase C
0200	AC SLOW OVERVOLT A	Slow AC voltage high, phase A
0400	AC SLOW OVERVOLT B	Slow AC voltage high, phase B
0800	AC SLOW OVERVOLT C	Slow AC voltage high, phase C
1000	AC UNDER FREQ	Low frequency fault
2000	AC OVER FREQ	High frequency fault

Table D-7 Grid Fault (GRD)

The following table lists the miscellaneous system faults.

Hexadecimal Value	Fault Name	Fault Description
0001	GROUND FAULT	Ground fault
0002	AC CONTACTOR	AC contactor fault
0004	DC CONTACTOR	DC contactor fault
0008	WD TIMER	Watchdog fault
0010	CPU LOAD	CPU load fault
0020	RESTART LIMIT	Too many fault restarts

Hexadecimal Value	Fault Name	Fault Description
0040	CONFIGURATION	Configuration fault
0080	CURRENT IMBALANCE	AC current imbalance
0100	AC VOLTAGE SENSE	No AC voltage detected
0400	THERMAL SWITCH	Thermal switch open
0800	DISCONNECT OPEN	DC disconnect is open

Table D-8 System Faults (SYS)

The following table lists the system warnings.

Hexadecimal Value	Fault Name	Fault Description
0001	FAN WARNING	Fan warning
0008	MAG HI TEMP WARNING	Magnetics high temperature warning
0010	HI TEMP PWR LIMIT	Power foldback warning
0020	DELTA TEMP WARNING	Heatsink delta temperature warning
0080	GFI CURRENT WARNING	GFDI current warning
0100	SURGE WARNING	Surge protection warning
0400	DC CURRENT WARNING	Negative DC current warning

Table D-9 System Warnings

DC Subcombiner Inputs

The following table reflects proper DC wire sizing and torque values per subcombiner application:

Fuse Block Maximum Amperage	Maximum Wire Size	Required Torque	Terminal Temp. Rating
200	Al/Cu: 350kcmil - #6	Al/Cu: 31.25 ft-lbs (375 in-lbs)	75°C
100	Al/Cu: 2/0 - #6	Al: 8.33 ft-lbs (100 in-lbs)	75°C
		Cu: 5 ft-lbs (60 in-lbs)	75°C
60	Al/Cu: #2 - #14	Al/Cu: 3.75 ft-lbs (45 in-lbs)	75°C
Direct to busbar	No wire size limit. Use Grade 8, 3/8" hardware.	Al/Cu: 40 ft-lbs	90°C

Table D-10 Subcombiner Wire Sizing and Torque Values

AC & DC Bus Landing Hardware

The following diagram details the installation of the input wiring to the busbars.

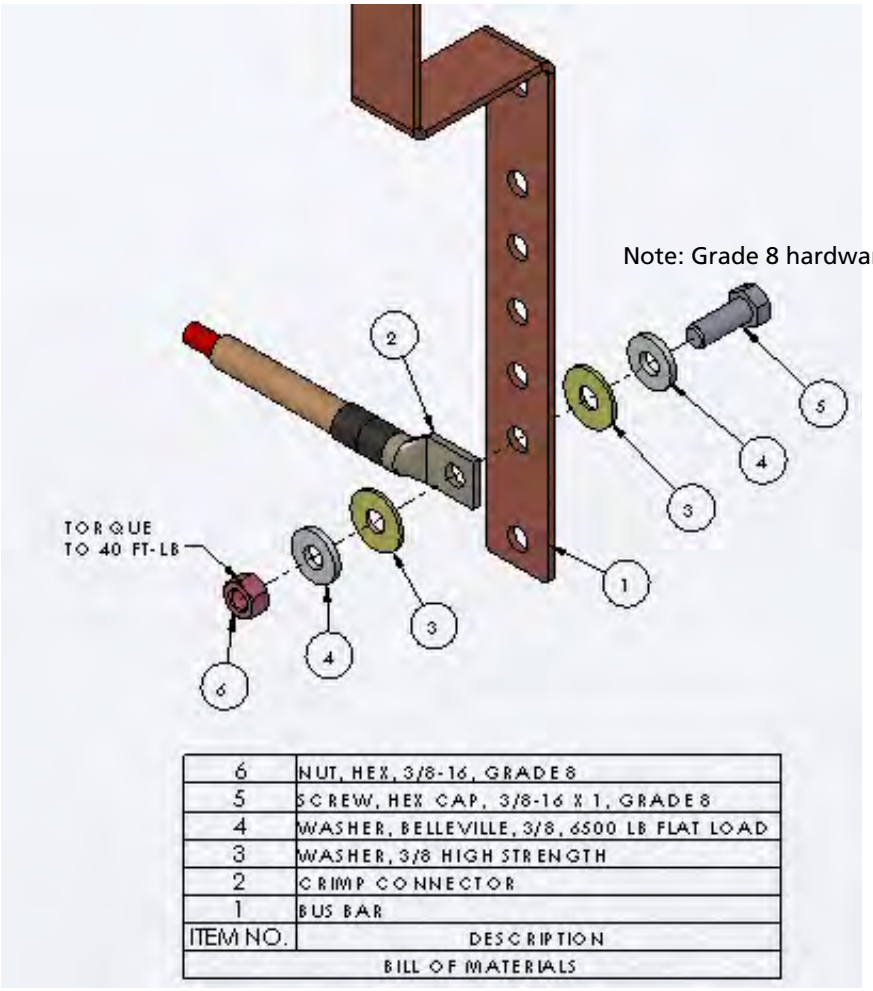


Figure D-1 AC and DC Bus Landing Hardware with Torque Value

Appendix E - Annual Maintenance Requirements Checklist

Item #	Requirement	✔
A	**General Inspection & Cleaning**	
1	Record general site conditions	
2	Record inverter performance data from inverter display	
3	Record environmental conditions	
4	Remove dirt and debris from underneath inverter	
5	Inspect and clean interior of inverter	
6	Inspect air filter and replace or clean	
7	Confirm presence of product documentation	
B	**Connections and Wiring**	
8	Complete visual inspection of electrical connections and wiring	
9	Complete mechanical inspection of connections and wiring	
10	Measure torque of all electrical connections and re-torque as needed	
11	Complete thermal scan of inverter connections, wiring and electronics	
C	**Testing**	
12	Confirm inverter operating modes including standby, startup and on	
13	Confirm power supply and transformer outputs	
14	Validate display data accuracy	
D	**Repair or Replace**	
15	Repair or replace items that have been determined to be near end of their useful life	
E	**Reporting**	
16	Complete preventative maintenance report and recommendations	

Table E-1 Annual Maintenance Requirements Checklist

Appendix F - Efficiency Curves

F.1 PVP50kW - Efficiency Curves

Input Voltage (Vdc)		Power Level (%; kW) 10% 5.00	20% 10.00	30% 15.00	50% 25.00	75% 37.50	100% 50.00	Wtd
Vmin	295	95.0	96.7	96.6	96.6	96.0	95.3	96.2
Vnom	341	94.4	96.3	96.3	96.3	95.8	95.2	95.9
Vmax	480	92.7	95.5	95.4	95.6	95.2	94.7	95.2

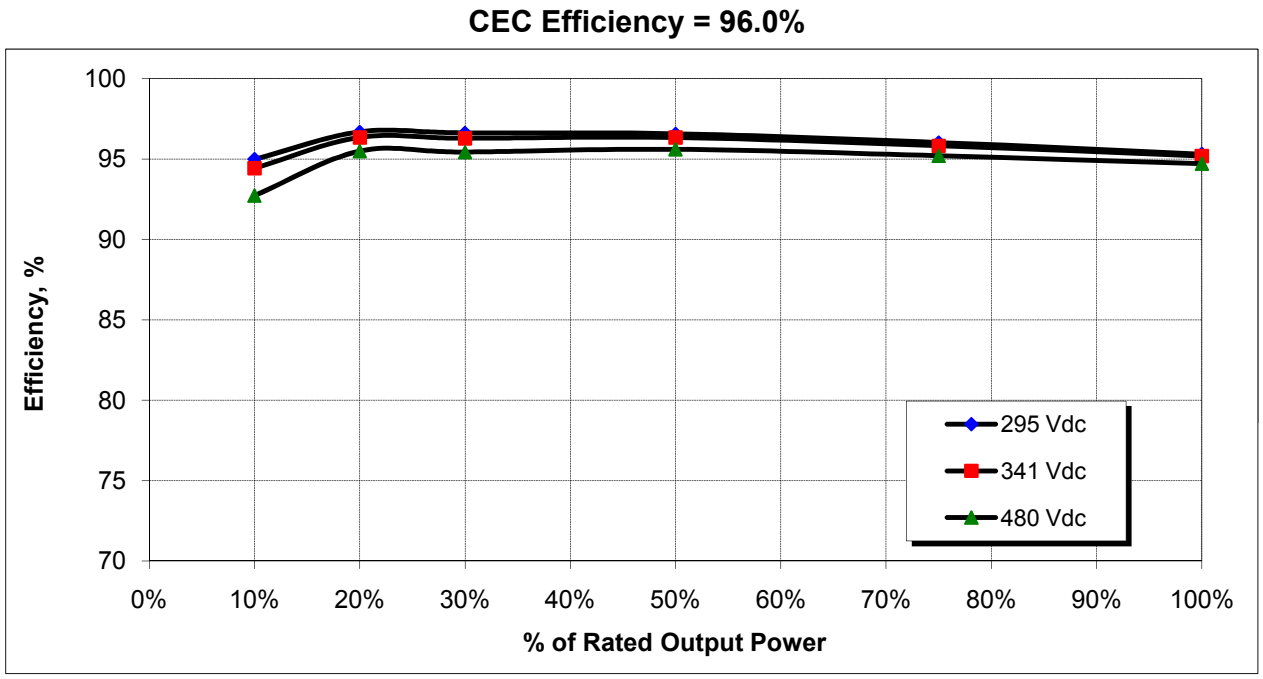


Figure F-1 PVP50kW-208 Efficiency Curves

Input Voltage (Vdc)		Power Level (%; kW) 10% 5.00	20% 10.00	30% 15.00	50% 25.00	75% 37.50	100% 50.00	Wtd
Vmin	295	95.7	96.8	97.2	97.0	96.4	95.9	96.6
Vnom	341	95.2	96.5	97.0	96.8	96.2	95.8	96.4
Vmax	480	93.8	95.6	96.3	96.0	95.6	95.3	95.7

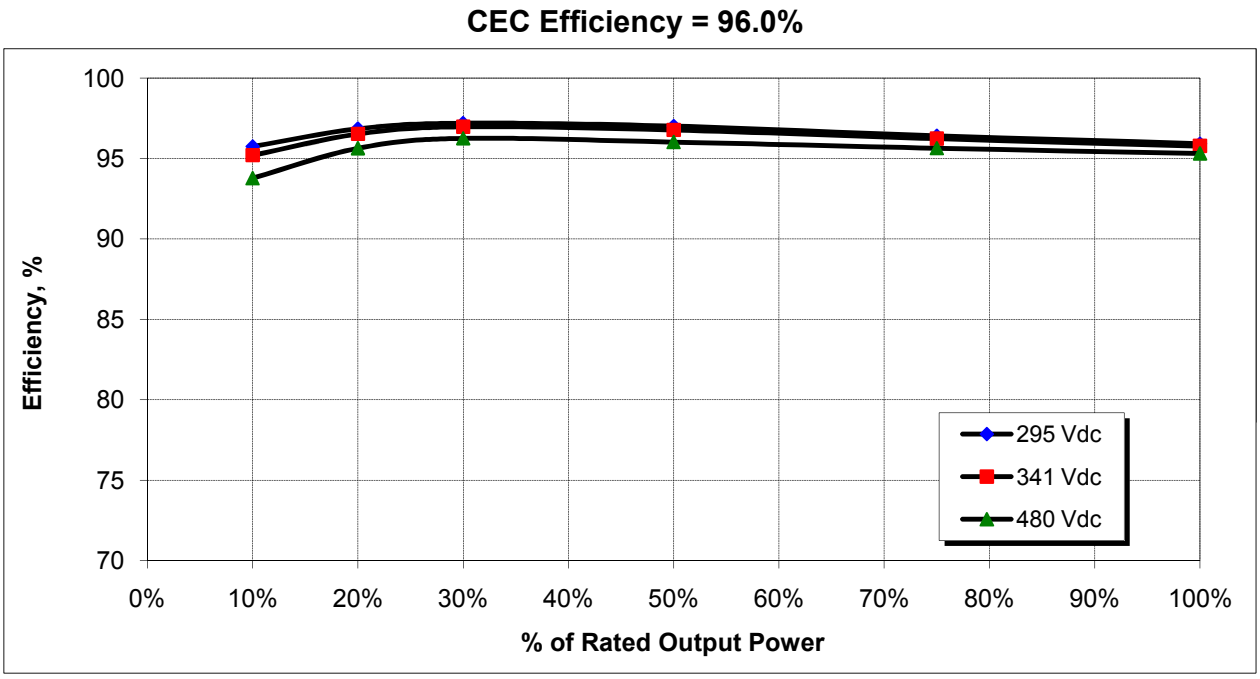


Figure F-2 PVP50kW-480 Efficiency Curves

Limited Warranty

THIS 10-YEAR LIMITED COMMERCIAL WARRANTY (the "10-Year Warranty") covers defects in your PV Powered commercial inverter caused by material or manufacturing faults for a 10-year period. The warranty period for the 10-Year Warranty begins on the date you commission your PV Powered commercial inverter, or 6 months after the date of purchase, whichever comes first. The 10-Year Warranty applies to the base model commercial inverter and all customer purchased options that were manufactured by PV Powered. The 10-Year Warranty does not apply to customer purchased optional equipment that was not manufactured by PV Powered. Optional equipment not manufactured by PV Powered will be covered by the original manufacturer's warranty.

The 10-Year Warranty may be transferred to subsequent owners, except that the 10-Year Warranty shall be void if, without prior approval of PV Powered, either (i) the PV Powered commercial inverter is moved from its original installation location or (ii) the overall PV system design is altered.

In satisfaction of its obligations under the 10-Year Warranty, PV Powered will, at its discretion, repair or replace the defective component(s) free of charge, as long as PV Powered is notified of the defect during the warranty period. PV Powered reserves the right to inspect the faulty component(s) and determine if the defect is due to material or manufacturing flaws. PV Powered also reserves the right to charge for service time expended if the defect is due to any cause other than a material or manufacturing flaw.

The 10-Year Warranty does not cover defects or damage caused by:

- Normal wear and tear.
- Shipping or transportation damages.
- Improper installation.
- Exposure to unsuitable environmental conditions, including but not limited to damage due to lightning strikes.
- Unauthorized or abnormal use or operation.
- Negligence or accidents, including but not limited to lack of maintenance or improper maintenance.
- Material or workmanship not provided by PV Powered or its authorized service centers.
- Relocation of the commercial inverter from its original installation location or alteration of the overall PV system design without prior approval of PV Powered.
- Acts of God, such as earthquake, flood or fire.

The 10-Year Warranty does not cover costs related to the removal, installation, or troubleshooting of your electrical systems.

PV Powered will, at its discretion, use new and/or reconditioned parts in performing warranty repair and in building replacement products. PV Powered reserves the right to use parts or products of original or improved design in the repair or replacement. If PV Powered repairs or replaces a product, PV Powered's warranty continues for the remaining portion of the original warranty period or 90 days from the date of repair, whichever period expires later. All replaced products and all parts removed from repaired products become the property of PV Powered.

PV Powered covers the parts, travel and labor necessary to repair the product within the United States and Canada.

If your product requires troubleshooting or warranty service, contact your installer or dealer. If you are unable to contact your installer or dealer, or the installer or dealer is unable to provide service, contact PV Powered directly at 1-877-312-3848, or support@pvpowered.com.

EXCEPT FOR THIS 10-YEAR WARRANTY, PV POWERED EXPRESSLY MAKES NO WARRANTIES WITH RESPECT TO THE PV POWERED INVERTER, EXPRESS AND IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTY OF MERCHANTABILITY, THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTIES THAT MAY HAVE ARISEN FROM COURSE OF DEALING OR USAGE OF TRADE.

TO THE MAXIMUM EXTENT PERMITTED BY LAW, PV POWERED'S AGGREGATE MONETARY LIABILITY TO YOU FOR ANY REASON AND FOR ANY AND ALL CAUSES OF ACTION, WHETHER IN CONTRACT, TORT OR OTHERWISE, WILL NOT EXCEED THE AMOUNT PAID TO PV POWERED FOR THE PV POWERED INVERTER(S) COVERED BY THIS 10-YEAR WARRANTY. PV POWERED WILL NOT BE LIABLE UNDER ANY CAUSE OF ACTION, WHETHER IN CONTRACT, TORT OR OTHERWISE, FOR ANY INDIRECT, SPECIAL, INCIDENTAL, CONSEQUENTIAL, OR PUNITIVE DAMAGES, EVEN IF PV POWERED HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THE PRICE FOR THE PV POWERED INVERTER AND PV POWERED'S OBLIGATIONS UNDER THIS 10-YEAR WARRANTY ARE CONSIDERATION FOR LIMITING PV POWERED'S LIABILITY.

IN THE EVENT OF A DISPUTE BETWEEN PV POWERED AND ANY PARTY COVERED UNDER THIS WARRANTY, TO THE MAXIMUM EXTENT ALLOWED BY LAW, SUCH PARTY AGREES TO RESOLVE ANY AND ALL SUCH DISPUTES USING BINDING ARBITRATION IN ACCORDANCE WITH THE COMMERCIAL ARBITRATION RULES AND EXPEDITED PROCEDURES OF THE AMERICAN ARBITRATION ASSOCIATION, WITH THE PLACE OF ARBITRATION TO BE BEND, OREGON. UNLESS OTHERWISE AGREED IN WRITING, THE ARBITRATOR SHALL BE DRAWN FROM THE NATIONAL ENERGY PROGRAM PANEL OF THE AMERICAN ARBITRATION ASSOCIATION. THE PRICE FOR THE INVERTER AND PV POWERED'S OBLIGATIONS UNDER THIS 10-YEAR WARRANTY ARE CONSIDERATION FOR THIS BINDING ARBITRATION PROVISION.

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