IDEAL POWER


# 30 kW Grid-Resilient Power Conversion Systems

Installation and Operations Manual

# 30B3-4xF
# 30B3-4DF

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| 02.00 | 1/26/15 | n/a | Updated document to reflect new part numbering system: document now supports 2nd generation 3-Port and 2-Port Converters that share a common Hardware platform, as well as common internal Firmware | John M |
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## Glossary of Terms

| Acronym or Term | Full Expression |
|---|---|
| AR | As Required |
| AWG | American Wire Gauge |
| CEC | California Energy Commission |
| CPU | Central Processing Unit |
| CSA | Canadian Standards Association |
| DMM | Digital Multi-Meter |
| FRU | Field Replaceable Unit |
| LCD | Liquid Crystal Display |
| MPPT | Maximum Power Point Tracking |
| PCB | Printed Circuit Board |
| PV | Photovoltaic |
| Battery Converter | Ideal Power Battery Converter IBC-30kW-480 |


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# 1.0 About This Manual

## 1.1 Purpose and Brief Product Overview

The purpose of this manual is to describe the proper operation, maintenance and troubleshooting of the Ideal Power ("IPWR") 30B3-4DF and 30B3-4xF Grid-Resilient Power Converters ("Converter").

Note that both of these Converters share a common Hardware platform, as well as common operating Firmware: the 30B3-4xF is a 2-Port Converter (AC1/DC3); and the 30B3-4DF is a multi-port Converter (AC1/DC2/DC3). The only pertinent difference between the 2 products is that the 30B3-4xF version has its middle DC Port ("DC2') disabled in Firmware, via an IPWR controlled encryption key: allowing power flows only between the remaining AC1 Port and its DC3 Port. The 30B3-4DF Multi-port Converter has no such power flow constraints.

## 1.2 Scope

This manual encompasses the features, commissioning, and field servicing of the Converter. This manual covers only the Converter hardware platform: it does not address configuration, control, monitoring or diagnostics via Modbus. Information about the integration and use of the Converter's Modbus Interface will be made available in separate documents.

## 1.3 Who Should Read This Manual

Qualified personnel tasked with Converter commissioning and field maintenance should read this manual. Such qualified personnel must be trained to deal with the dangers and hazards associated with the maintenance and troubleshooting of high-voltage electrical devices.

## 1.4 How This Manual is organized

Section 2.0 contains important safety instructions.

Section 3.0 provides an overview of key system design considerations.

Section 4.0 describes the Converter AC and DC wiring requirements.

Section 5.0 contains field maintenance and operator servicing procedures.

Section 6.0 details the Front Panel Display.

Section 7.0 defines system fault and status codes.

Section 8.0 provides an overview of the Modbus Interface.

Section 9.0 contains the Converter specifications.

## 1.5 RMA and Service Contact

Do not ship or return the Converter without prior authorization from Ideal Power Inc. Ensure you have registered you warranty online at www.idealpower.com/customers. A Return Material Authorization (RMA)


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number must first be obtained from our customer service department. Use the following contact information for all technical support:

Mail
Ideal Power
4120 Freidrich Lane
Suite 100
Austin, TX 78744
Attn: Technical Support

Email & Phone
For technical support: support@idealpower.com
For warranty claims: warranty@idealpower.com
512.264.1542


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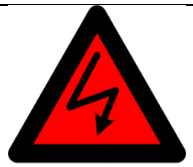
## 2.0 IMPORTANT SAFETY INSTRUCTIONS

**SAVE THESE INSTRUCTIONS.** This manual contains important instructions for the Ideal Power 30B3-4DF and 30B3-4xF Converters that shall be followed during installation.

All wiring must be in accordance with the National Electric Code ANSI/NFPA 70.

The following safety notices are used in this manual:

| | |
|---|---|
|  DANGER | This symbol indicates **HIGH VOLTAGE**. It calls your attention to items or operations that could be dangerous to you and other persons operation this equipment. Read the message and follow the instructions carefully. |
|  WARNING | This symbol is the “Safety Alert” Symbol. **WARNING**: Indicates a potentially hazardous situation that, if not avoided, can result in serious injury or death.<br>Do not proceed beyond a **WARNING** notice until the indicated conditions are fully understood and met. |
|  CAUTION | **CAUTION**: Indicates a potentially hazardous situation that, if not avoided, can result in minor to moderate injury, or serious damage to the product. The situation described in the **CAUTION** may, if not avoided, lead to serious results. Important safety measures are described in **CAUTION** (as well as **WARNING**), so be sure to observe them. |

### 2.1 General Safety Precautions

| | |
|---|---|
|  WARNING | **Personnel Qualification**<br><br>Inspections and operations requiring access to lethal AC or DC voltages, and should only be performed by qualified personnel. |
|  WARNING | **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 unless you are qualified to do so. |
|  WARNING | **Instruction and Code Compliance**<br><br>Failure to install and maintain equipment in accordance with published instructions or applicable electrical codes creates the potential for personal injury, death, or equipment damage.<br>. |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| | |
|---|---|
|  CAUTION | **Electrostatic Discharge (ESD) Damage**<br><br>The Converter contains ESD-sensitive equipment. Failure to use ESD control measures while servicing Battery Converter equipment may result in component damage. |
|  DANGER | To avoid an electric shock, verify that the Converter's external AC and DC disconnects are open (off). A minimum wait time of five minutes is required after opening AC and DC disconnects to assure that the Converter's internal capacitors have discharged to zero voltage before performing any work on the Converter. Utilize lockout procedures to insure that disconnects remain in the off position during all service periods. |
|  DANGER | The enclosure contains exposed high voltage conductors. The enclosure front plates must remain on, except during installation, commissioning or maintenance by trained service personnel. Do not remove the front plates if extreme moisture is present (rain, snow or heavy dew). |

## 2.2 Electrical Safety Precautions and Practices

| | |
|---|---|
|  DANGER | **High Voltage**<br><br>The DC input voltage, AC output voltage, and various intermediate voltages inside the Converter enclosure are of lethal levels. Contact with these voltages may result in serious injury or death. |
|  DANGER | **High Voltage**<br><br>The Converter contains high-voltage DC capacitors. Allow five minutes for all capacitors within the enclosure to discharge after opening the AC and DC disconnect switches. |

*Equipment Configuration*

Improper installation or servicing can create hazardous equipment configurations. Failure to install and maintain equipment in accordance with published instructions or applicable electrical codes creates the potential for personal injury, death, or equipment damage.

*Safe Practices*

Electrical power equipment can cause serious injury, death, or equipment and property damage. The operator must strictly observe all safety rules and take precautionary actions. Safe practices have been developed from past experience in the use of power source equipment. Only qualified personnel should work with this equipment, and lockout procedures should be followed.


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*Shock Prevention*

The DC input voltage present for the Battery Pack or PV Array can be as high as +/- 500 Volts DC for a total of 1000 Volts DC between the two circuits. The AC output voltage is 480 Volts AC.

Bare conductors, terminals, and improperly grounded enclosures can fatally shock a person.
Be sure to follow the following guidelines:

- Ensure that the equipment is adequately installed and grounded per this manual and applicable codes.
- Inspect equipment and replace or repair damaged wiring.
- Only authorized and properly trained personnel should maintain or troubleshoot the Converter. Avoid working alone.
- Use proper safety clothing, procedures and test equipment.
- Avoid working in wet areas. Stand on a dry, insulating surface. Use insulated gloves when working near live conductors.

*Service and Maintenance*

Service and maintain the Converter in accordance with applicable Ideal Power procedures. Discontinue Converter use until all equipment defects and safety hazard have been cured. Replace damaged warning and precautionary labels.

*Fire Prevention*

Do not leave foreign objects in the Converter enclosure. Keep the area around enclosure clear of trash, debris and other combustible materials.

*Electrical Safety Features*

Both Converter types supports the electrical safety features listed in Section 6.

## 2.3 Handling Safety

| | |
|---|---|
|  | **Converter Installation or Removal**<br><br>The 30B3-4DF and 30B3-4xF Converters both weight approximately 125 pounds; and they are designed to be transported and wall-mounted by 2 people, without the use of lift or power equipment. If lift or power equipment is used to move, or lift the Converter, follow all safety rules. Failure to do so could result in personal injury or equipment damage. |
|  <br>CAUTION | **Temporary Storage of Converter, once unpackaged**<br><br>The uninstalled Converter should be placed on its back (the surface which will mount on the wall 3 feet from the ground) after the packaging is removed. |


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## 2.4 Special Symbols

The following symbols are displayed on or in the Converter:

| | |
|---|---|
|  | GROUND – designates a connection point to earth ground. |
|  | DC Positive – designates a connection point to the DC Positive of the Solar Photovoltaic Array |
|  | DC Negative – designates a connection point to the DC Negative of the Solar Photovoltaic Array |
|  | DC Circuit – designates that the circuit intended to be connected to a DC circuit |
|   | AC Circuit – designates that a circuit is an AC, 60 Hz circuit. |
|   | Number of Phases –indicates the number of the phases in the AC circuit |
|  | ON position – designates the ON position of switches and breakers. |
|  | OFF position – designates the OFF position for switches and breakers. |
|   | The ETL mark indicates that the Converters are certified to the UL1741 standard and meets the requirements of the *National Electrical Code* ®. |


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## 3.0 System Design Considerations

### 3.1 Battery Pack Wiring

The 30B3-4DF Converter is has 2 independent DC Ports designed to operate with either a series battery pack that has a center-point ground reference, and/or a PV array wired in the same fashion. This is known as a bipolar configuration: the bipolar arrangement enables Converter input DC bus voltages between two circuits of 1000+ Vdc; while not violating NEC 600 Vdc restrictions typically found in commercial and industrial settings.

A typical 30B3-4DF configuration supporting batteries on the DC3 Port and PV on the DC2 port for is shown in Figure 1 for illustrative purposes only. During the design process, insure that both battery pack and PV array voltages meet the Converters minimum and maximum voltage requirements, as outlined in the specifications section of this manual.

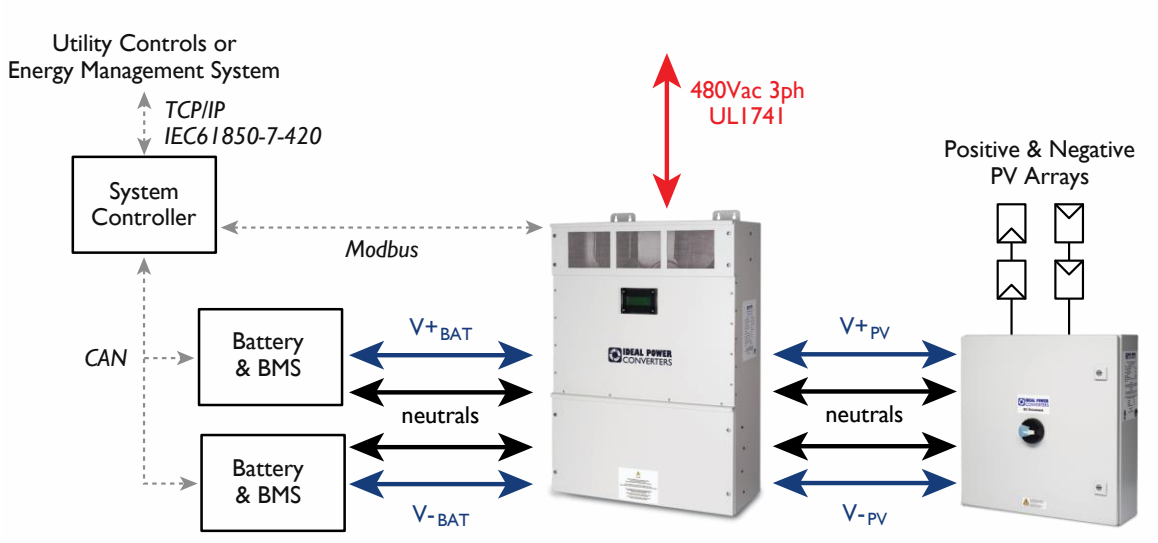


Figure 1: 30B3-4DF Converter Design Example

NOTE: The wiring arrangement for a typical 30B3-4xF Converter would utilize only the DC3 Port battery connection: the DC2 Port is disabled, so the PV connection shown above is NOT supported: do not make external connections to DC2.

*4 Wire Connection*

To ensure NEC compliance, IPWR recommends that the positive and negative pack wiring be in separate conduits (2 current-carrying conductors per conduit) for each active DC Port back to the Converter. If 2000 V rated wire is utilized and your local Inspector approves of such designs, the conductors may share a common conduit. Otherwise 2 independent conduits for each DC Port are recommended as noted above.

Single conduit approval is the responsibility of the system designer. Ideal Power will assume no responsibility for such design approaches: they must be reviewed and approved by local Inspectors, and/or Authorities Having Jurisdiction (AHJ), prior to system deployment.


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## 3.2 External Disconnect

*AC Disconnect*

Note that the 30B3-4DF and 30B3-4xF Converters do not include internal AC disconnects, and individual Converter disconnects are NEC code requirements for high-power battery systems. To meet the AC disconnect requirement, a dedicated 3-phase breaker panel with an integral master disconnect is generally installed adjacent to the Converter(s).

Figure 5 illustrates a typical x4 (120 kW) installation example, which utilizes a dedicated 3-phase AC panel to support both local disconnect and wiring protection requirements for 4 Converters.  50 A 3-phase breakers are recommended.


Figure 2: 120 kW (2-Port Battery Converter Example)


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*DC Disconnect*

The 30B3-4DF and 30B3-4xF Converters do not have integrated DC Disconnects. Note that code requirements for battery power systems vary by jurisdiction: a single DC Disconnect located at the battery pack (and/or PV Array) may suffice, however in many instances, a second disconnect will be required, specifically if the batteries and/or the PV Array are remotely located with respect to the Converter. Check with your local Authorities Having Jurisdiction (AHJ's), to determine system disconnect requirements.

## 3.3 Converter Enclosure

The Converter is designed to be wall-mountable, and should only be installed by certified personnel. Installation locations may be either interior or exterior walls. The enclosure's nominal dimensions are 32.5" high x 23" wide x 10.75" deep. The Converter weighs approximately 125 lbs.

The NEMA 3R rated enclosure includes a sealed electronics compartment. This center electronic compartment is never to be opened or serviced by field personnel. Any attempt to do so will void the manufacturer's warranty.


1. Fan
2. Fan
3. Front Panel Display
4. Electronic Cover Plate (Do Not Remove)
5. Wiring Compartment for AC Port, both DC Ports, and Modbus Cable

Figure 3: Converter Front View

**Fans**: Two fans circulate air through the Converter from the bottom to the top. One fan provides adequate cooling in case of failure of the other fan.

**Display:** The LCD Display is detailed later in this document.

**Electronics Cover Plate**: Do not remove; no field serviceable components inside, removing this panel will void the Battery Converter warranty.

**Bottom Wiring Compartment:** Remove only for initial installation, commissioning and troubleshooting.


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Hazardous DC and AC voltages are present.

## 3.4 Wiring Compartment Overview

The removable bottom panel provides access to the electrically isolated DC and AC wiring connections, as well as Modbus communication interfaces.

The wiring compartment bottom bulkhead is designed to accommodate both DC and AC conduit penetrations, up to 1.5 inches in diameter. All conduit penetrations must be made to the bottom bulkhead, no side conduit access is allowed. When conduit hubs are not provided for a Type 2, 3, 3R, or 3S enclosure, the enclosure, the instruction sheet provided with the enclosure, or the packaging carton shall be marked to indicate that rain tight or wet location hubs that comply with the requirements in the Standard for Conduit, Tubing, and Cable Fittings, UL 514B, are to be used.

- *30B3-4DF installations (Multi-Port Converter version) will utilize all 3-Ports, collectively identified from left to right as AC1, DC2 and DC3.*
- *30B3-4xF installations (2-Port Converter version) will utilize Port's AC1 and DC3 only, do NOT make wiring connections to the middle DC2 Port, which is disabled.*

Warning

When installing wire into the DC compartments ensure that ALL cables are routed away from ground stud to avoid damage to the wire. Ensure all wire is firmly installed upon installation.

## 3.5 Integrated Safety Features

The 30B3-4DF and 30B3-4xF Converter incorporates the following integrated safety features.

Table 1: Converter Safety Features

| Feature | Action |
|---|---|
| Internal wiring compartment safety covers | Prevents access to hazardous voltages and protects internal circuitry. |
| DC input ground fault detection | Takes Converter off-line when DC input ground fault is detected on either of the 2 DC Ports. |
| DC and AC overcurrent and overvoltage detection.<br>AC Frequency out of range | The Converter will shut down immediately if DC input voltages or currents are out of range, or if the AC voltages and currents are out of range. The Converter will also shut down if AC frequency is out of range. |
| Anti-islanding protection | The Converter will shut down immediately during grid outages *Note: A 300 second restart is implemented on all grid events. |


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*Ground Fault Detection*

During Converter operation the two common leg connections of each individual DC Port are connected together, placing battery packs (30B3-4DF and 30B3-4xF), and/or PV Arrays (30B3-4DF only) in series to provide optimum DC working voltage. For each individual DC Port, the negative common leg of the positive pack (and/or PV Array) and the positive common leg of the negative pack (and/or PV Array) remain referenced to ground through a 1 A GFDI fuse in order to detect ground fault conditions. If such conditions are detected, the Converter is automatically taken off-line. The Converter will not attempt to restart until the fault condition is cleared, and AC Power is cycled. If the ground fault detection fuse is blown in either of the DC Ports, the fuse must be replaced in order for the Converter to attempt restart.

*AC Voltage and AC Current Fault Detection*

The output voltage is synchronized to the AC utility line. The Converter operates as a current source following the grid voltage waveform. Should the Converter experience a DC or AC fault condition (voltage or current beyond specification), it is automatically taken off-line. The Converter is shipped from the factory with a default 5-minute restart countdown timer.

*Frequency Fault Detection*

The quality of the power delivered to the utility line meets or exceeds the requirements as specified in IEEE 1547. If the utility frequency or voltage shifts outside the regulatory specified limits, the Converter will automatically detect the condition and shutdown. The restart time in the event of an abnormal condition is field programmable. The Converter is shipped from the factory with a default five-minute restart counter for AC Frequency faults. All restart countdown timers are programmable via the Modbus Interface.

*DC Over/Under Voltage Fault Detection*

The Converter also has DC over-voltage (default is 1000 Vdc) and DC under-voltage (default is 120 Vdc) detection circuitry: if these limits are exceeded the Converter will shut down, or if commanded to make power, will not start. These default limits are easily changed via the Modbus interface.

## 3.6 Regulatory Information

The 30B3-4DF Multi-Port Converter and 30B3-4xF 2-Port Converter are certified to the following standards for the North American market:

- **UL1741**: Standard for Battery Converters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources
- **IEEE1547:** IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
- **National Electric Code** 2011 ANSI/NFPA 70: National Electrical Code (*NEC*)


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### Inverter ratings and specifications:

- **Maximum AC input short circuit current:** 200 Amps Peak
- **Maximum AC input source back feed current to input source:** 40 Amps
- **Maximum AC output fault current and duration:** 199 Amps Peak to Peak; 48 Amps RMS
- **Maximum AC output overcurrent protection:** Fused 50 Amps

### Utility interconnection voltage and frequency trip limits and trip times

- See user guide for voltage limits and trip times interface
- **Default limits per UL1741**
    - Voltage limits: 480 (+110% Vac / - 88% Vac)
    - Frequency limits: 60 Hz (+.5 Hz / -.7 Hz)
    - Declared accuracy for AC Voltage and Frequency:
        - ACV: (+ / -10.4 V)
        - Frequency: (+ / -.02 Hz)
    - Maximum AC Voltage or Frequency Trip Time: 10 cycles

## 4.0 Electrical Connections

Conduit type and wiring gauges should be chosen to comply with local codes. Unlike older IPWR Converters, which featured ¼ inch terminals on each of the Converters AC and DC fuses, requiring a field crimp connection, the 30B3-4DF and the 30B3-4xF now have a terminal connector to compression adapter: supporting bare wire termination and eliminating the need for field crimping.

The Earth Ground connection and the DC common inputs also utilize separate compression terminals: the compression terminal is a bare wire type. – no terminal lug is required for these connections.

| | |
|---|---|
|  **CAUTION** | **Caution:** If the supplied terminal connector adapter is not used, field wiring to fuse posts must be made by an UL-listed ring lug terminal sized for the specified wire gauge on the fused AC and DC connections. The connector must be fixed by using the crimping tool specified by the connector manufacturer. |


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| | |
|---|---|
| CAUTION | **CAUTION:** All field wiring must conform to the codes set forth in the National Electric Code ANSI/NFPA 70. |

## 4.1 Converter Ground

The bottom two mounting ears each contain ¼ inch ground lugs. Connect one of these to the building's Earth Ground.

## 4.2 Observe Safety Procedures

Once the conduit assemblies are completed, and AC and DC Disconnects are verified to be in the OFF position, route and connect AC and DC power cables. Follow standard lockout procedures to ensure installer safety.

| | |
|---|---|
| DANGER | **HIGH VOLTAGE**<br>The AC and DC cables may carry hazardous voltages.<br>Open both the DC and AC disconnect switches and wait five minutes before opening the bottom cover of the unit to access the AC, DC, and Modbus interface connections. |


Figure 4: Wiring Compartment

A. AC L1
B. AC L2
C. AC L3
D. AC Neutral
E. Negative String DC-
F. Negative String common
G. Positive String common
H. Positive string DC+
I. Negative Pack DC-
J. Negative Pack common
K. Positive Pack common
L. Positive Pack DC+

## 4.3 AC Power Connection

Connect the 3-480 Vac phase legs to terminals 1, 2 and 3; (L1, L2, and L3), utilizing the supplied compression


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terminal adapters as described above. The order of the phases is not critical as the Converter will sense and follow the AC grid. All power is made between the phase legs: no neutral connection ("D") is required. Connect the external AC Ground to the terminal labeled "ground". Torque all connections as outlined in Table 3 below.

*Notes:*

1. *Although a neutral connection is not required, the phase legs must be must be balanced, and correctly referenced to one-another: (480 V measured between individual phase legs), and correctly referenced to neutral or earth ground, if no neutral wire is available. (277 V measured from each phase leg to neutral, or earth ground).*

2. *Corner-grounded (often called "b-grounded") Delta connections are not supported! Connecting the Converter to such grounded-leg systems may damage the Inverter and will immediately void the warranty.*

3. *An isolation transformer is required to support corner grounded Delta connections. Contact Ideal Power if you intend to use the Converter in such applications.*

## 4.4 DC Power Connections

- *30B3-4DF installations will utilize both DC Ports, collectively identified as DC2 and DC3.*
- *30B3-4xF installations will utilize DC3 only: do NOT make wiring connections to DC2, which is disabled.*

For both C30B3-4DF and 30B3-4xF applications, utilize DC3 for the battery connection. Connect the Negative Pack DC- to terminal I; connect the Positive Pack DC+ to terminal L. Connect the Negative Pack common to terminal J, and the Positive Pack common to terminal K.

For C30B3-4DF applications, utilize DC2 for the PV array connection. Connect the Negative String DC- to terminal E; connect the Positive String DC+ to terminal H. Connect the Negative String common to terminal F, and the Positive String DC common to terminal G. Torque all connections as outlined in Table 3.

Table 2: Terminal Tightening Torques

| **Terminal Block** | **Location** | **Tightening Torque Inch-pound** |
|---|---|---|
| DC+ common and DC- common compression terminals: Flat screwdriver type | F,G,J and K in the DC2 and DC3 Wiring Compartments | #2-3 AWG: 50<br>#4-6 AWG: 45<br>#8 AWG: 40<br>#10 AWG: 35 |
| Fuse block compression terminals for AC1, AC2, AC3, DC+, and DC- connections: flat screwdriver type | A,B,C,E, H, I and L in the AC1 Wiring Compartment | Same as above |

Torques:

- AC Fussed Block: 48 In-lbs
- AC Neutral Terminal Block: 45 In-lbs
- DC Terminal Block: 48 In-lbs


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- DC Neutral Terminal block: 45 In-lbs
- Control board mounting screws: 1 In-lbs
- Ground stud at the bottom of the unit: 75 In-lbs

## 4.5 Modbus Connection

The center section of the Wiring Compartment is for the use of low-voltage Modbus cabling only. Do not route or place high voltage AC or DC wiring in this area.

## 4.6 Verification of Electrical Connections

The 30B3-4DF and 30B3-4xF Converters have a sophisticated system for detecting and responding to a ground fault. The DC2 Port (30B3-4DF only), and the DC3 Port (both 30B3-4DF and 30B3-4xF) support a bipolar wiring configuration, where the center-tap "common" is referenced to the internal grounding system of the Converter via a dedicated 1 A GDFI fuse. In the presence of a detected ground fault, or blown fuse, the Converter will not attempt to respond to control commands, and a ground-fault condition will be reported on the Front-Panel LCD.

| | |
|---|---|
|  **DANGER** | This symbol indicates **HIGH VOLTAGE**. It calls your attention to items or operations that could be dangerous to you and other persons operation this equipment. Read the message and follow the instructions carefully. |
| WARNING | This symbol is the "Safety" Alert Symbol. **WARNING**: Indicates a potentially hazardous situation that, if not avoided, can result in serious injury or death.<br>Do not proceed beyond a **WARNING** notice until the indicated conditions are fully understood and met. |

## 4.7 Verify AC and DC Wiring

Use the following procedure to verify final Converter wiring after completing the AC, DC and Ground wiring as detailed in Section 5. High voltages are present, and only qualified personnel following safety procedures detailed in section 2 should attempt the following:

1. Open all AC and DC Disconnects
2. Open Wiring Compartment Cover
3. Close external AC Disconnect connected to Port AC1
    a. Using a DMM on the AC voltage scale, verify that 480 Vac three phase power is present on the AC terminals. Measuments from each individual phase-leg to ground should read 277 Vac.
    b. If observed AC measurements do not meet the above requirements, immediately open the AC Disconnect, and remedy AC wiring faults.
4. Close the external DC Disconnect connected to Port DC2 (30B3-4DF applications, not applicable to 30B3-4xF).
    a. Using a DMM on the DC voltage scale, measure the two bipolar inputs: PV open circuit voltages of 500 Vdc positive circiut 1 500 V negative circiut 2 are an absolute maximum.
    b. If observed DC voltages are higher than 500 Vdc, and/or outside of PV array design expectations, open the DC connect, and remedy DC wiring faults


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c. Verify that the Front Panel Display indicates no faults, and that “idle/waiting” is indicated in the status field.
d. Compare Front-Panel Display voltage measurements to DMM observations
e. Utilize the Modbus Interface and the Ideal Power Modbus toolkit to digitally confirm the readings noted above.

5. Close the external DC Disconnect connected to Port DC3 (applicable to 30B3-4DF and 30B3-4xF).
   a. Using a DMM on the DC voltage scale, measure the two bipolar inputs: open circuit battery voltages of 500 Vdc positive/500 V negative are an absolute maximum.
   b. If observed DC voltages are higher than 500 Vdc, and/or outside battery pack design expectations, open the DC Disconnect, and remedy DC wiring faults
   c. Verify that the Front Panel Display indicates no faults, and that “idle” is indicated in the status field.
   d. Compare Front-Panel Display voltage measurements to DMM observations
   e. Utilize the Modbus Interface and the Ideal Power Modbus toolkit to digitally confirm the readings noted above.
6. Replace the Wiring Compartment Cover.

# 5.0 Maintenance and Troubleshooting

## 5.1 Operating and Shutdown Conditions

The Converter is shipped in an idle power state, and will not respond to power export or import commands, as sent over the Modbus Interface, until the following conditions are met:

- All external AC and DC Disconnects are closed.
- No DC Port input ground faults have been detected.
- DC Port input voltages are within the specified operating range, as set by the Modbus Interface.
- AC grid frequency and voltage are within specified UL1741 range, and islanding is not detected.
- There are no sensed fault conditions, as defined in Section 7.

## 5.2 Forced Air Vents

Ensure that the forced air intake and exhaust vents on the bottom front of the Converter are not obstructed. Note that under low-power conditions fan speeds and noise levels are quite low.

## 5.3 Annual Preventive Maintenance

The procedures in this section are to be performed only by qualified personnel.

| | |
|---|---|
|  **DANGER** | **HIGH VOLTAGE**<br>To eliminate high voltages inside the Converter enclosure:<br>• All DC Disconnects must be open.<br>• All AC Disconnects must be open.<br>• Wait at least 5 minutes for internal capacitors to discharge<br>Do not remove the Wiring Compartment cover until the Converter has been rendered safe in this manner. |


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### *Verify Proper Airflow*

Check bottom airflow intake screen and ensure that the forced air intake and exhaust vents on the bottom and at the top front of the Converter are not obstructed. Clean if airflow is restricted, due to dust or other debris.

### *Power Terminals*

Annually, re-torque the power terminals listed to the specified torque levels as shown in table 2.

1. Open both DC Disconnects and lock in the open position.
2. Open the AC Disconnect and lock in the open position.
3. Wait at least 5 minutes for the Converter internal capacitors to discharge to safe voltage levels.
4. Remove the Wiring Compartment cover.
5. Using a calibrated torque wrench fitted with an appropriate driver tip, tighten the terminals listed in to the specified torque levels (stated torque levels conform to UL 1741: Table 66.1). Please refer to Table 2 for specified torque levels.

### *Cooling Fan Inspection*

1. Open AC Disconnect and remove the upper fan cover, clean if necessary
2. Inspect the fans for damage, tight bearings, or debris buildup
3. Replace cover, and restore AC power
4. With the Converter operating, verify that both fans are operating, with no appreciable bearing or mechanical noise
5. If a fan has failed, or is otherwise noisy or suspect, contact Ideal Power for a replacement unit.

## 5.4 Converter Troubleshooting

Do not open the center electronics compartment cover; there are no user-serviceable components inside. Opening this compartment will void the Converter warranty, expose hazardous voltages, and impair performance. The only field serviceable components in the Converter are: AC fuses, DC fuses and DC Ground-Fault fuses. Spare part kits are available for purchase from Ideal Power.

The procedures in this section are to be performed only qualified personnel.

| | |
|---|---|
|  | **HIGH VOLTAGE**<br>To eliminate high voltages inside the Converter enclosure:<br>• The AC Disconnect must be open.<br>• The DC Disconnects must be open.<br>• Wait at least five minutes for capacitors to discharge<br>Do not remove the Wiring Compartment cover until the Converter has been rendered safe in this manner. |


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### *Clearing GFDI Faults*

In the event of a Converter ground fault the Converter will cease exporting or importing power. The fault will be noted on the front panel display. If the fault exceeds 1 A, the ground fault detection fuse will open. The DC2 Port (30B3-4DF only) and the DC3 Port (30B3-4DF and 30B3-4xF) both have their own dedicated ground fault detection circuit and fuse.

If a ground fault is indicated on either DC Port, inspection and repair of wiring should be referred to qualified personnel. Once the ground fault is cleared, check the display for indications that the ground fault is removed. If the display indicates the ground fault interruption fuse has opened, follow the procedure below to replace the ground fault fuse. Use an identical KLKD1 1 A fuse type for replacement.

### *AC Fuse Fault/Dark Front Panel*

If the display is dark, one or more of the AC output fuses, may be open. Follow the fuse inspection and replacement procedure below. If the any of the AC fuses fails again, soon after replacement, contact Ideal Power for assistance.

### *DC Fuse Fault*

DC fuse failures are highly unlikely. Use the following procedure to check the fuses.

### *Fuse Inspection and Replacement*

Use the following procedure to measure the electrical continuity of these fuses. See for fuse locations and types.

1. Open DC Disconnect(s) and lock in the open position.
2. Open the AC Disconnect and lock in the open position.
3. Wait at least 5 minutes for Converter capacitors to discharge to safe voltage levels.
4. Open the Wiring Compartment: by removing 4 cover screws.
5. Using a digital multi-meter (DMM) set to continuity or resistance range; connect across each fuse to determine if the fuse is open (high resistance) or intact (short).
6. Check all AC fuses (3); DC fuses (2 per DC Port); and both GFDI fuses.
7. If a fuse is open, remove it from the fuse holder and replace it with a new fuse of the same rating and type.
8. Replace screws and close the Wiring Compartment.

If any replaced fuse fails immediately after replacement, inspect both AC and DC wiring. Inspection and repair of such wiring should be referred to qualified personnel.


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Table 3: Fuse Chart

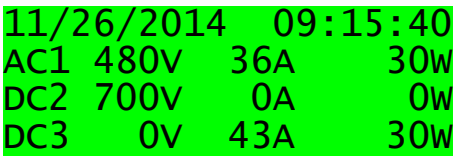
| Fuse Name | AC Fuses | DC Fuses | GFDI Fuse |
|---|---|---|---|
| Fuse Count | 3 | 2 per DC Port | 1 per DC Port |
| Type and Rating | Semiconductor type 50 A, 500 V AC fast Ferraz Shawmut A50QS50-4 or equivalent | Semiconductor type 70 A, 600 V DC fast Ferraz Shawmut A50QS70-4 or equivalent | Littelfuse, KLKD1 1 A |
| Location | Left side of Bottom Wiring Compartment | Middle and right side of Bottom Wiring Compartment | Middle and right side of Bottom Wiring Compartment |
| Fuse Function | Protects 480 V AC outputs against excessive current and wiring shorts | Protects DC inputs against excessive array currents and wiring shorts | Isolates the ground fault current in the event of a detected ground fault condition. |

## 6.0 Front Panel Display

The 4-Line x 20 Character Front Panel Display provides a rich information set to installers, operators, as well as to system designers responsible for developing system-level control and monitoring software. 10 separate system status screens are displayed in a rotating manner. Note that all of the front panel display information is also available via the Modbus serial interface.

### 6.1 Timestamp / Power

The System Timestamp and Port Power screen displays date and time (US – Central Standard Time is the default clock setting), as well as individual port voltage, current and power as detailed in the mockup below.




### 6.2 Mode / Method

The Mode / Method screen details individual port Operating Mode and applicable Port Control Method. After AC and DC Port wiring is completed, the displayed Method for each Port should be “Idle”, indicating that the system remains in a sleep condition, awaiting Modbus configuration and control commands from an external system controller. Note that the mockup below indicates that the external system controller has reconfigured the system to move power between AC1 and DC3.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```
Port Mode   Method
AC1  AC-3W  AC Pwr
DC2  DC     Idle
DC3  DC     Net Pwr
```

## 6.3 AC1 DMM

The AC1 screen displays average line-to-line voltage, as well as all 3 line-to-neutral voltages. It also displays line-to-line AC current, AC power and measured grid frequency.

```
480VAC 30000W 60.0Hz
277Van 480Vab  36.1A
277Vbn 480Vbc  36.1A
277Vcn 480Vca  36.1A
```

## 6.4 Version

The Version screen details the systems firmware revision and release date (line 1); model number (line 2); IPWR product SKU (line 3); and 16 digit Serial Number (line 4).

```
Ver 1108 Dec 11 2014
Mod 30B3-4DF
SKU 16_character_SKU
Ser ABC1111111111111
```

## 6.5 Environmental

The Environmental screen displays case and heatsink temperatures, relative humidity and cooling fan status. Note that all fans are off when the system is idle. There are 2 fan systems: internal, which cools the control board, and related in-cavity electronic components: and external, which cools the power switching core heatsink with outside air. Note that the fans only run when the system is moving power between active Ports: fan speed is proportional to both power transfer levels and heatsink temperature.

```
tCase 60.0C
tHS 70.0C
RH 25.0%
Fans (i)off (e)off
```


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## 6.6 Modbus

The Modbus screen displays the configuration of the Serial RS-485 Modbus Interface. System defaults are displayed in mockup below: RTU (remote terminal unit - cannot be changed); Address (240); Baud (19.2 kHz); E2 (even parity/2 stop bits).

```
RTU MODBUS Settings
Address 240
Baud 19200 E2
```

## 6.7 kWh Summary

Each Port supports bidirectional power flows: this screen provides a lifetime summary of import (power flow into the noted Port, signed negative); export (power out of the noted Port, not signed but positive); and Net (Net = sum of export + import) energy flows in the Converter.

Note that P1 = AC1; P2 = DC2; and P3 = DC3.

```
kWh    In    Out    Net
P1 12345 12345-12345
P2 12345 12345 12345
P3 12345 12345 12345
```

## 6.8 Fault/Status

Line 1 is the most recent fault name; line 2 is the severity; line 3 current status of the fault. The 4th line is the fault limit and the current value reported: both values are in decimal. The right side fault status bits (8 total) are reserved for remote system debug, and are typically not useful for the system installer, or operator.

```
Fault:EF2L  000300A0
lockdown    00000000
occurred    00000000
 17     0   00000000
```

Faults are detailed in the following section: “EF2L” for example indicates that cooling fan 2 is in a locked condition. A separate Modbus User’s Guide further details the scope of the Converter’s fault reporting and fault processing capabilities. A short overview of reported faults is provided in section 7.


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There are 5 levels of fault severity (line 2)

- **lockdown** – indicates that the system aborted and will not restart without external intervention by system controller
- **abort** – indicates that system has shut down (will not export or import power) due to fault condition, but will automatically countdown and restart once fault clears
- **alert** – indicates that abnormal condition noted, but system did not abort, or lockdown
- **alarm** – indicates that system noted a limit violation (such as Port DC over/under voltage, relative to externally programmed min/max limits), but did not abort, or lockdown
- **info** – information only, system not in lockdown, abort, alert, or alarm

There are 4 levels of current status (line 3)

- **faulting** – the Converter is experiencing the indicated fault at the present time
- **occurred** – the fault on line 2 is the most recent fault reported, now clear
- **no_fault** – no fault has been reported since last AC power cycle
- **disabled** – all conditional logic for the specific fault reported has been disabled, so this condition is ignored by Converter's internal fault management processor

As indicated above, line 4 reports the fault limit, and measured fault value. Fault limits are further detailed in the Modbus User's Guide.

## 7.0 Converter Fault/Status Codes

The Fault and Status codes detailed below are shown on the Front Panel Display: Screen 7.10; and are also available via the Modbus Interface.

Table 4: Fault/Status Codes

| # | Name | Description |
|---|---|---|
| 0 | NULL | (NULL) used for software testing or hardware debug |
| 1 | ACSG | AC1 Input Surge fault check |
| 2 | D2SG | DC2 Input Surge fault check |
| 3 | D3SG | DC3 Input Surge fault check |
| 4 | D2GI | DC2 GFDI current fault check |
| 5 | D2GF | DC2 GFDI blown fuse fault check |
| 6 | D3GI | DC3 GFDI current fault check |
| 7 | D3GF | DC3 GFDI blown fuse fault check |
| 8 | D2RI | DC2 RCD current fault check |
| 9 | D3RI | DC3 RCD current fault check |
| 10 | BTMP | Hardware Bad Temp shutdown fault check |
| 11 | FTMP | Heatsink Temp reading fault check |
| 12 | B24V | Hardware Bad Rail shutdown fault check |
| 13 | F24V | 24 V supply reading fault check |
| 14 | IF1L | Internal fan 1 locked fault check |
| 15 | IF2L | Internal fan 2 locked fault check |
| 16 | EF1L | External fan 1 locked fault check |
| 17 | EF2L | External fan 2 locked fault check |
| 18 | ACAB | AC1 A-B overvoltage fault check |
| 19 | ACBC | AC1 B-C overvoltage fault check |


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| | | |
|---|---|---|
| 20 | ACCA | AC1 C-A overvoltage fault check |
| 21 | D2P1 | DC2 (+)side voltage fault check |
| 22 | D2N2 | DC2 (-)side voltage fault check |
| 23 | D3P1 | DC3 (+)side voltage fault check |
| 24 | D3N2 | DC3 (-)side voltage fault check |
| 25 | LKOV | Link voltage (magnitude) fault check |
| 26 | ACFQ | AC1 frequency fault check |
| 27 | D2CT | DC2 current fault check |
| 28 | D3CT | DC3 current fault check |
| 29 | LCMS | Link Common-Mode-Shift fault check |
| 30 | LKPG | Link (+/P/1)-side voltage fault check |
| 31 | LKNG | Link (-/N/2)-side voltage fault check |
| 32 | LKOI | Link current (integrated, magnitude) fault check |
| 33 | LKSV | Link starving fault check |
| 34 | ACAG | AC1 A-gnd voltage fault check |
| 35 | ACBG | AC1 B-gnd voltage fault check |
| 36 | ACCG | AC1 C-gnd voltage fault check |
| 37 | D2PG | DC2 (+)-gnd voltage fault check |
| 38 | D2NG | DC2 (-)-gnd voltage fault check |
| 39 | D3PG | DC3 (+)-gnd voltage fault check |
| 40 | D3NG | DC3 (-)-gnd voltage fault check |
| 41 | LKOZ | Link i-zero crossing during output conduction |
| 42 | CAP1 | IGBT AP1 link shift fault check |
| 43 | CAP2 | IGBT AP2 link shift fault check |
| 44 | CAP3 | IGBT AP3 link shift fault check |
| 45 | CAP4 | IGBT AP4 link shift fault check |
| 46 | CAP5 | IGBT AP5 link shift fault check |
| 47 | CAP6 | IGBT AP6 link shift fault check |
| 48 | CAP7 | IGBT AP7 link shift fault check |
| 49 | CAP8 | IGBT AP8 link shift fault check |
| 50 | CAP9 | IGBT AP9 link shift fault check |
| 51 | CAN1 | IGBT AN1 link shift fault check |
| 52 | CAN2 | IGBT AN2 link shift fault check |
| 53 | CAN3 | IGBT AN3 link shift fault check |
| 54 | CAN4 | IGBT AN4 link shift fault check |
| 55 | CAN5 | IGBT AN5 link shift fault check |
| 56 | CAN6 | IGBT AN6 link shift fault check |
| 57 | CAN7 | IGBT AN7 link shift fault check |
| 58 | CAN8 | IGBT AN8 link shift fault check |
| 59 | CAN9 | IGBT AN9 link shift fault check |
| 60 | CBP1 | IGBT BP1 link shift fault check |
| 61 | CBP2 | IGBT BP2 link shift fault check |
| 62 | CBP3 | IGBT BP3 link shift fault check |
| 63 | CBP4 | IGBT BP4 link shift fault check |
| 64 | CBP5 | IGBT BP5 link shift fault check |
| 65 | CBP6 | IGBT BP6 link shift fault check |
| 66 | CBP7 | IGBT BP7 link shift fault check |
| 67 | CBP8 | IGBT BP8 link shift fault check |
| 68 | CBP9 | IGBT BP9 link shift fault check |
| 69 | CBN1 | IGBT BN1 link shift fault check |
| 70 | CBN2 | IGBT BN2 link shift fault check |


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| | | |
|---|---|---|
| 71 | CBN3 | IGBT BN3 link shift fault check |
| 72 | CBN4 | IGBT BN4 link shift fault check |
| 73 | CBN5 | IGBT BN5 link shift fault check |
| 74 | CBN6 | IGBT BN6 link shift fault check |
| 75 | CBN7 | IGBT BN7 link shift fault check |
| 76 | CBN8 | IGBT BN8 link shift fault check |
| 77 | CBN9 | IGBT BN9 link shift fault check |
| 78 | LKTM | Link state timer fault check |
| 79 | BKST | Bad link blackstart |
| 80 | D2PN | DC2 P->N overvoltage check |
| 81 | D3PN | DC3 P->N overvoltage check |
| 82 | FBAB | A->B conduction forward bias |
| 83 | FBBC | B->C conduction forward bias |
| 84 | FBCA | C->A conduction forward bias |
| 85 | FBAN | A->N conduction forward bias |
| 86 | FBBN | B->N conduction forward bias |
| 87 | FBCN | C->N conduction forward bias |
| 88 | FID2 | DC2 input conduction forward bias |
| 89 | FID3 | DC3 input conduction forward bias |
| 90 | FOD2 | DC2 output conduction forward bias |
| 91 | FOD3 | DC3 output conduction forward bias |
| 92 | AAOV | AC1 Phase A RMS over voltage |
| 93 | ABOV | AC1 Phase B RMS over voltage |
| 94 | ACOV | AC1 Phase C RMS over voltage |
| 95 | AAUV | AC1 Phase A RMS under voltage |
| 96 | ABUV | AC1 Phase B RMS under voltage |
| 97 | ACUV | AC1 Phase C RMS under voltage |
| 98 | ACAI | AC1 Phase A RMS over current |
| 99 | ACBI | AC1 Phase B RMS over current |
| 100 | ACCI | AC1 Phase C RMS over current |
| 101 | ACBI | AC1 Phase B RMS over current |
| 102 | WDOG | FPGA-watchdog over NIOS fault |
| 103 | ICND | input conduction incomplete |
| 104 | OCND | Output conduction incomplete |
| 105 | METH | Invalid method selection |
| 106 | ISLD | Islanding detected (grid-tied) |
| 107 | D2PL | Bad DC2 polarity |
| 108 | D3PL | Bad DC3 polarity |
| 109 | ABOV | Grid-tied AC line A-line B overvoltage |
| 110 | BCOV | Grid-tied AC line B-line C overvoltage |
| 111 | CAOV | Grid-tied AC line C-line A overvoltage |
| 112 | ABUV | Grid-tied AC line A-line B under voltage |
| 113 | BCUV | Grid-tied AC line B-line C under voltage |
| 114 | CAUV | Grid-tied AC line C-line A under voltage |
| 115 | BIFL | Both internal fans locked |
| 116 | BEFL | Both external fans locked |

*No fault conditions, other than externally driven faults such as AC over/under voltage, AC over/under frequency or DC min/max voltage violations are generally encountered during initial system installation.*


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*As noted earlier, the system is installed in an "all Ports idle" configuration state. No Port-to-Port power transfers can or will occur until the system is configured and commanded to move power by an external system controller.*

## 8.0 Converter Removal and Preparation for Shipment

1. Open AC Disconnect.
2. Open DC Disconnect.
3. Wait five minutes for capacitors to discharge.
4. Open the fuse access doors.
5. Disconnect the AC and DC power cables.
6. Disconnect the Conduit connections.
7. Disconnect Modbus Interface cables.
8. Disconnect chassis ground connections.
9. Close the fuse compartment doors.
10. Remove the Converter from the mountings.
11. Package the Converter in IPWR approved packaging (Double wall, B/C fluting box, etc.)

## 9.0 Monitoring, Configuration and Control via Modbus

Monitoring and configuration of the Converter is done via a RS485 Modbus RTU Interface, located in the center segment of the lower wiring compartment. The center segment is isolated from high voltage AC and DC fused terminals per IEEE and UL safety certification requirements. Low voltage conduit connections should be made to the bottom of the wiring compartment. The use of CAT-5, CAT-6 or similar wire type is recommended.

The physical interface utilizes two (2) RJ-45 jacks connected in parallel and wired identically. Each RJ-45 jack supports a 2-wire Modbus RTU connection and allows for daisy-chaining multiple Converters on the same Modbus connection. The pinout assignments for the RJ-45 connectors are shown in Table 5.

Table 5: RJ-45 Pinouts for Modbus Communication

| Pin on RJ-45 | Usage / Description |
|---|---|
| 1 | |
| 2 | Resistor between D0/D1 differential pair lines |
| 3 | |
| 4 | D1, also known as B/B', negative half of differential pair |
| 5 | D0, also known as A/A', positive half of differential pair |
| 6 | |
| 7 | |
| 8 | Common, also known as C/C', signal/power supply common |


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The 2-wire Modbus RTU protocol relies on RS-485 differential signaling. The need for external termination resistors is determined by a number of factors including Modbus run length, number of devices, cable type and selected baud rate. The optional 120-ohm Modbus terminating resistor may interfere with proper operation if installed unnecessarily. A maximum of one terminating resistor should be used if required and should be installed single-ended, not differentially.

Use of the Modbus Interface and related register definitions, as well as IPWR's evaluation and configuration tools are in separate documents.

The DB-9 connector in the center compartment is not intended for customer use. Do not connect to these programming and test interfaces: they are used to for production test purposes, and to update the Converter's firmware.

## 10.0 Specifications

Table 6: Environmental Specifications

| | |
|---|---|
| Ambient air temperature, operating | -25° C to +50° C |
| Ambient air temperature, non-operating and storage | -40° C to +85° C |
| Humidity | 0 to 100% |
| Environmental exposure | NEMA 3R enclosure |

Table 7: Electrical Specifications

| **Bidirectional DC Ports (Ports DC2 & DC3)** | |
|---|---|
| Configuration | Bipolar DC: 4-Wire Interface, with center common |
| Absolute Maximum Voltage | ± 500 VDC per DC circuit Total 1000 V Per Port |
| Minimum Start-up Current | 1 A |
| Operating Voltage Range | ± 100 Vdc to ± 500 Vdc |
| Maximum Power Range | ± 250 Vdc to ± 500 Vdc |
| Maximum Output Power | 30 kW |
| Maximum DC Current | 50 A continuous |
| Ground Fault Detection | DC ground fault (GFDI) on all conductors |
| Maximum Ground Fault Current | 1 A fuse, programmable trip point: 200 mA to 500 mA |
| Transient Overvoltage Protection | Yes, MOV voltage clamps |
| **Bidirectional AC Port (Port AC1)** | |
| Grid Connection | 480 Vac 3-phase line to line: +10% - 88% |


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| | |
|---|---|
| Nominal Voltage | 480 Vac line-to-line<br>277 Vac line-to-neutral |
| Maximum Output Power | 30 kW |
| Maximum Current | 39 A per phase leg |
| Nominal Frequency | 60 Hz |
| Frequency Tolerance | 59.3-60.5 Hz |
| Power Factor | >.96 at rated output power |
| Typical efficiency | > 96% |
| Maximum efficiency | 97% |
| Tare Losses | < 25 W |
| Total Harmonic Distortion | < 4% |


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