OutBack POWER™

member of The Group™

# Radian Series Inverter/Charger

## GS7048E

GRIDHybrid™

DESIGNED FOR FLEXgrid™ OPERATION

## Installation Manual

## About OutBack Power Technologies

OutBack Power Technologies is a leader in advanced energy conversion technology. OutBack products include true sine wave inverter/chargers, maximum power point tracking charge controllers, and system communication components, as well as circuit breakers, batteries, accessories, and assembled systems.

## Grid/Hybrid™

As a leader in off-grid energy systems designed around energy storage, OutBack Power is an innovator in Grid/Hybrid system technology, providing the best of both worlds: grid-tied system savings during normal or daylight operation, and off-grid independence during peak energy times or in the event of a power outage or an emergency. Grid/Hybrid systems have the intelligence, agility and interoperability to operate in multiple energy modes quickly, efficiently, and seamlessly, in order to deliver clean, continuous and reliable power to residential and commercial users while maintaining grid stability.

## Designed for FLEXgrid™ Operation

Selected OutBack Power products are designated as designed for FLEXgrid operation for their ability to support the design and operation of a Grid/Hybrid system. FLEXgrid products perform or manage functions including system communication, control, programming, charging, energy storage, and power conversion.

Only OutBack Power makes Grid/Hybrid systems and FLEXgrid products.

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## Date and Revision


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## Part Number


900-0144-01-00 Rev A

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# Introduction

## Audience

These instructions are for use by qualified personnel who meet all local and governmental code requirements for licensing and training for the installation of electrical power systems with AC and DC voltage up to 600 volts. This product is only serviceable by qualified personnel.

## Welcome to OutBack Power Technologies

Thank you for purchasing the OutBack Radian Series Inverter/Charger. This product offers a complete power conversion system between batteries and AC power. It can provide backup power, sell power back to the utility grid, or provide complete stand-alone off-grid service.

- Designed for FLEXgrid™ operation as part of an OutBack Grid/Hybrid™ system
- Battery-to-AC inverting which delivers single-phase power (220 to 240 Vac at 50 or 60 Hz)
- Can continuously produce 7 kVA (30 Aac)
- Mounts easily with supplied mounting plate
- All terminals exit at the bottom of the inverter, allowing the installer to use a single distribution box; the GS Load Center (GSLC) is specifically designed for this purpose
- Uses spring-based AC terminals instead of screw-based terminals; this eliminates torque requirements and periodic re-tightening
- Uses the MATE3™ System Display and Controller (sold separately) for user interface as part of a Grid/Hybrid system
- Features versatile mounting locations for the MATE3, HUB, FLEXmax charge controller, and GSLC
- The venting on the cover allows mounting of multiple Radian inverter/chargers side by side with zero clearance required between them
- Up to 10 Radian inverter/chargers can be stacked together

**Figure 1 GS7048E Inverter/Charger**

**NOTE**: This product has a settable AC output range. In this book, many references to the output refer to the entire range. However, some references are made to 230 Vac or 50 Hz output. These are intended as examples only.

# Components and Accessories

**IMPORTANT:**

This product is not compatible with the OutBack MATE or MATE2 System Display and Controller. Use of these products is not supported with the Radian Series.

**Table 1 Components and Accessories**

| Included in Box | |
|---|---|
| Radian Series Installation Manual (this book) | RTS (Remote Temperature Sensor) |
| Radian Series Operator's Manual | Hardware Kit |
| Mounting Bracket | |
| **Optional Components for Attachment to Radian Inverter** | |
| MATE3 System Display and Controller | FLEXmax 60 or FLEXmax 80 Charge Controller |
| FW-MB3 (MATE3 bracket) | FW-CCB or FW-CCB2 (charge controller brackets) |
| GSLC (GS Load Center), GSLC175-230, or GSLC175-PV-230 | OutBack HUB4 or HUB10 |


**Figure 2 Radian Inverter and Accessories**

# Planning

## Applications

The Radian Series Inverter/Charger is a FLEXgrid product which is intended for both off-grid and grid-interactive (Grid/Hybrid) applications. It is designed to use a battery bank to store energy. It can work in conjunction with photovoltaic (PV) panels to harvest solar energy, as well as wind turbines and other renewable sources. These sources charge the battery, which in turn is used by the inverter.

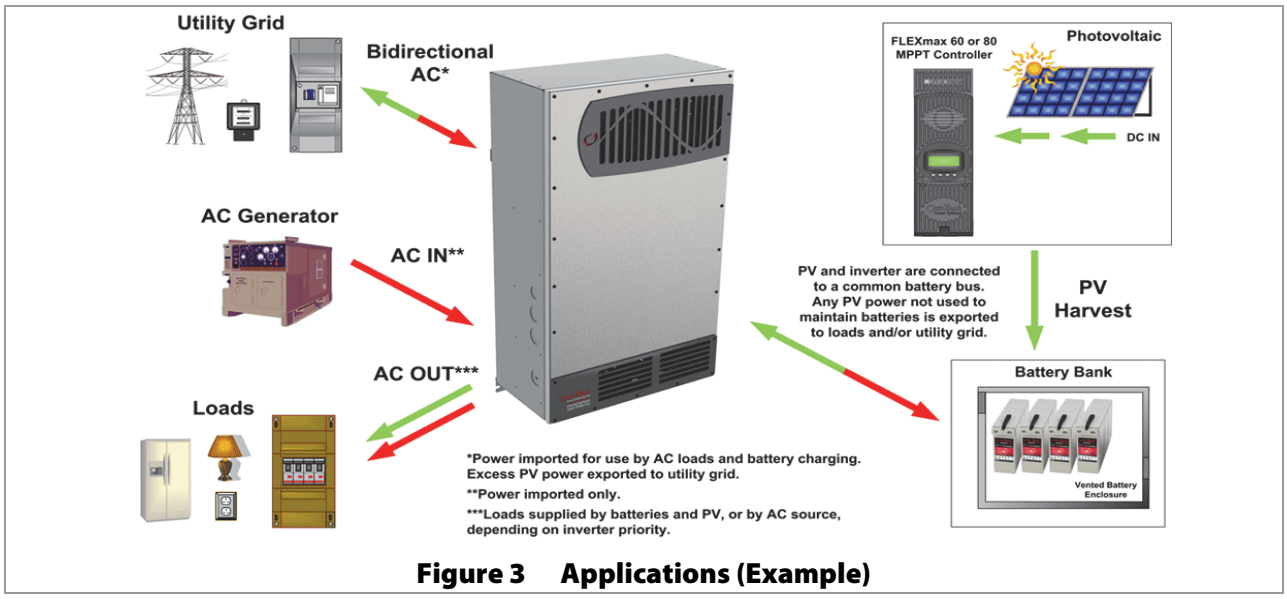


**Figure 3 Applications (Example)**

The Radian inverter has six modes of operation. Each mode has functions and priorities that are intended for a designated application. Each of the Radian's two AC inputs can be set to a different operating mode, so that different applications can be supported.

**NOTE**: See the *Radian Series Inverter/Charger Operator's Manual* for additional information on these modes, including the benefits of using each mode.

- ***Generator***: This mode is intended for an AC generator. It is designed to accept any AC generator regardless of power or regulation mechanism. The Radian will charge from the generator even when the generator is undersized or substandard.
- ***Support***: This mode is intended for systems that use the utility grid or a generator. However, size, wiring, or other limitations may require temporary assistance to run very large loads. The Radian adds inverter and battery power to the AC source to ensure that the loads receive the power they require.
- ***Grid Tied***: This mode is intended for grid-interactive systems. When renewable energy sources charge the batteries above a selected "target" voltage, the Radian inverter will send the excess energy to any loads. If the loads do not use all the excess energy, then the Radian will return that energy to the utility grid.
- ***UPS*** (Uninterruptible Power Supply): This mode is intended for systems whose main focus is to maintain power to the loads without any interruption during a transfer to, or from, the AC input. The speed of response in this mode has been increased so that if the AC input power is disconnected or a scheduled disconnect occurs the response time will be minimized.

- ***Backup***: This mode is intended for systems that have the utility grid available. This source will flow through the Radian inverter to power the loads unless utility power is lost. If utility grid power is lost, then the Radian inverter will supply energy to the loads from the battery bank until the power is back online.
- ***Mini Grid***: This mode is intended for systems that have the utility grid as an input and a sizable amount of renewable energy production. The system will run off the renewable energy production until the battery voltage falls to a specified low level. When this occurs, the Radian inverter will connect to the utility grid, which will power the loads. The Radian inverter will disconnect from the utility grid when the batteries are sufficiently recharged.

# Renewable Energy

The Radian Series Inverter/Charger cannot connect directly to photovoltaic arrays, wind turbines, or other renewable sources. As a required part of a Grid/Hybrid system, the batteries are the inverter's primary source of power. However, if the renewable sources are used to charge the batteries, the inverter can use their energy by drawing it from the batteries.

The renewable source is always treated as a battery charger, even if all of its power is used immediately. The renewable source must have a charge controller or some way to prevent overcharging. OutBack Power's FLEXmax charge controllers can be used for this purpose, as can other products. The GSLC will facilitate the mechanical and electrical connections for up to two FLEXmax charge controllers, or electrical connections for two FLEXmax Extreme charge controllers.

# Battery Bank

When planning a battery bank, consider the following:

- **Cables:** Recommendations for battery cable size and length are shown on page 17. The maximum length will determine the placement of the battery bank. Other local codes or regulations may apply and may take priority over OutBack recommendations.
- **Battery Type:** The Radian inverter/charger works best with lead-chemistry batteries intended for deep discharge. These include batteries for marine, golf-cart, and forklift applications. They also include gel-cell batteries and absorbed glass-mat (AGM) batteries. OutBack Power recommends the use of batteries designed specifically for renewable energy applications. Automotive batteries are strongly discouraged and will have a short life if used in inverter applications. Nickel-based batteries are discouraged due to limitations in the Radian charger. Lithium-based batteries and other advanced battery technologies may require special considerations. Please contact OutBack Technical Support at **+1.360.618.4363** before implementing advanced battery technologies.
- The Radian inverter/charger is designed to work with a 48-volt battery bank. Before constructing a battery bank, confirm the nominal voltage of individual batteries.
- **Bank Size:** In backup or off-grid applications, the battery bank size should be calculated based on expected loads and run time.
  - ~ To prevent the inverter's charger from overcharging, the minimum recommended battery bank size is 350 amp-hours for every Radian inverter/charger installed on the system.
  - ~ If other charging devices are present, the minimum bank size should be determined by adding the inverter(s) charge rate to any other chargers and multiplying the result by five. Example: If the system's combined charge rate was 160 Adc, the minimum battery bank size should be 800 amp-hours.
- Systems intended to bridge short-term outages can use smaller battery banks. In these cases, the bank can be as low as 200 amp-hours per inverter. However, the charge rate must be decreased to half the inverter's maximum using the MATE3. (See the MATE3 manual.) One of the following conditions must also be true.
  - ~ The system is equipped with a backup generator that is programmed for automatic start, or
  - ~ Typical grid loss is 30 minutes or less, or
  - ~ The loads are less than 2 kW.

**NOTE:** If support time or load size are disproportionate to the bank size, they will cause inverter shutdown due to low battery voltage after a short time. These conditions could be detrimental to the life of a small battery bank. If this is true, the recommendations from the previous page apply instead.

- **Charger Settings and Maintenance:** A vented enclosure for the battery bank may be required by electric code and is recommended in most cases for safety reasons. It may be necessary to use a fan to ventilate the battery enclosure. (See the *Operator's Manual* for vent fan applications.)
- Batteries must be regularly maintained according to the instructions of the battery manufacturer.

**IMPORTANT:**

Battery charger settings need to be correct for a given battery type. Always follow battery manufacturer recommendations. Making incorrect settings, or leaving them at factory default settings, may cause the batteries to be undercharged or overcharged.

**CAUTION: Hazard to Equipment**

Batteries can emit vapors which are corrosive over long periods of time. Installing the inverter in the battery compartment may cause corrosion which is not covered by the product warranty. (Sealed batteries may be an exception.)

# Generator

The Radian inverter/charger can work with any single-phase generator that delivers reliable AC power at the appropriate voltage and frequency. Inverters stacked for three-phase output can work with three-phase generators.

- The Radian inverter/charger can provide a start signal to control an automatic start generator. If automatic generator starting is required, the generator must be an electric-start model with automatic choke and two-wire start capability. (See page 23.) For other configurations, additional equipment may be required.
- In any configuration, the inverter may need to be programmed using the MATE3 according to the specifications of the generator and the requirements of the system. (See the *Radian Series Inverter/Charger Operator's Manual* and the *MATE3 Owner's Manual*.) Parameters to be programmed may include generator size, automatic starting requirements, and potential fluctuations in generator AC voltage.

## Generator Sizing

A generator should be sized to provide enough power for all the loads and the battery charger.

- Available generator power may be limited by ratings for circuit breakers and/or generator connectors. The maximum allowed AC circuit breaker size is 50 Aac per Radian inverter/charger.
- The generator must be able to provide current to all inverters. Minimum generator wattage[1] is usually recommended to be twice the wattage of the inverter system. Many generators may not be able to maintain AC voltage or frequency for long periods of time if they are loaded more than 80% of rated capacity.
- A generator that is to be installed in a building usually should not have a bond between the neutral and ground connections. The generator should only be bonded if there is a specific need. Local or national electric codes may require the neutral and ground to be bonded at the main electrical panel. See page 18 for more information on neutral-ground bonding.

[1]This is the wattage value after deratings for the following: peak versus continuous power, load power factor considerations, fuel type, altitude, and ambient temperature.

# Maintenance Bypass Switching

Inverter systems are often equipped with AC maintenance bypass switches or interlocks. If the inverter system ever needs to be shut down or removed, the AC sources and loads must be disconnected. A bypass device allows the AC source to deliver power directly to the loads, bypassing the inverter. This can minimize disruption to the system and avoids the need for extensive rewiring.

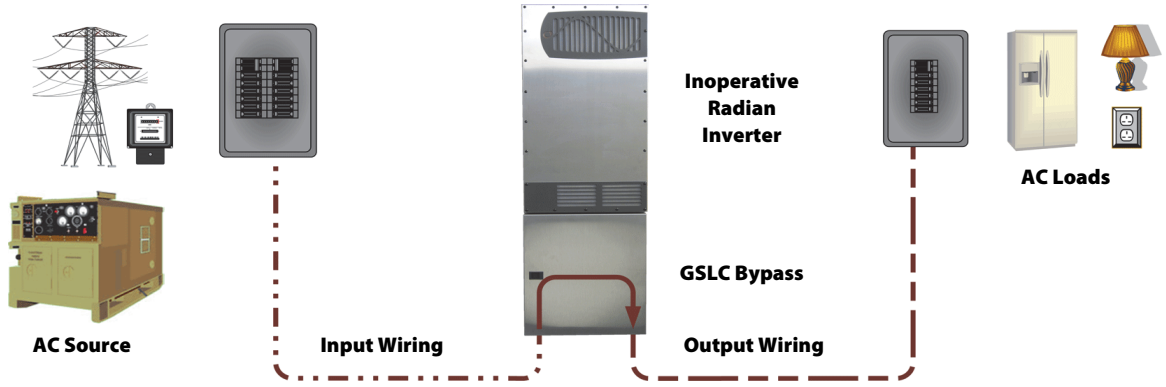


**Figure 4 Bypass Switching**

The GSLC (see page 4) can be equipped with bypass circuit breakers for this purpose. However, if multiple Radian inverters are stacked in a single system, then the bypass function must be simultaneous for all inverters. The GSLC bypass kits operate independently, not simultaneously, and should not be installed in this kind of application. Both manual and automatic double-throw bypass switches are commonly available in a range of sizes and options. These are highly recommended for systems with more than a single inverter.

**WARNING: Shock Hazard or Equipment Damage**

Using independent bypass devices on multiple inverters can result in power being routed to inappropriate places. This could create an electric shock hazard or damage the equipment.

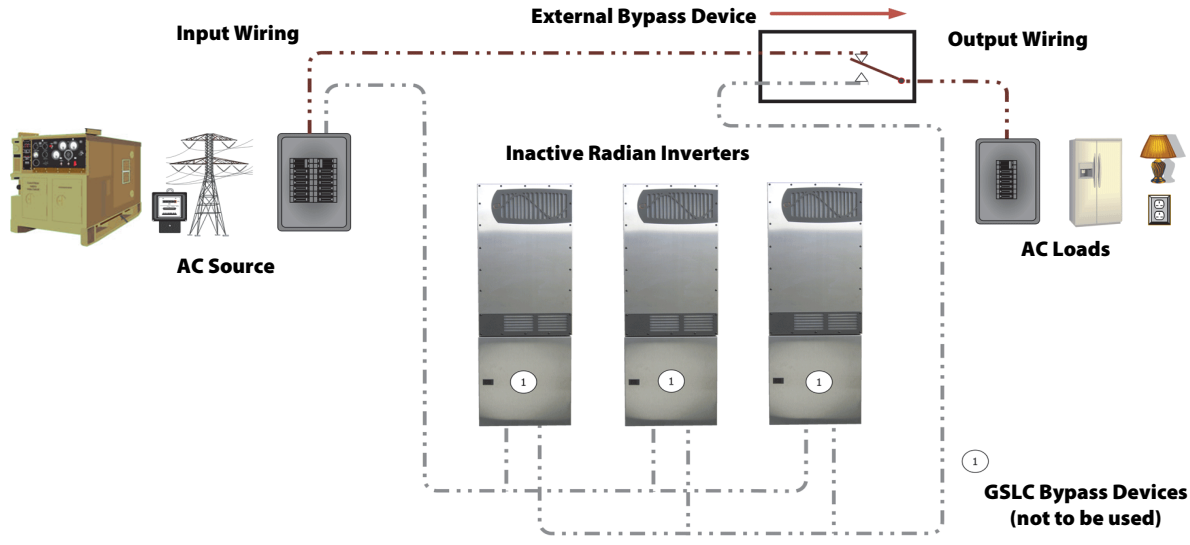


**Figure 5 Bypass Switching for Multiple Inverters**

# Installation

## Location and Environmental Requirements

Radian Series Inverter/Chargers must be located in a weather-proof enclosure or enclosed area. It is not designed for exposure to water or excessive wind-blown dust and debris. It carries an IP (Ingress Protection) rating of 20.

- The Radian inverter must be wall-mounted in an upright position. The inverter is not approved for mounting in any other position or orientation.
- Recommended minimum clearance is 5 to 10 cm (2 to 4") for the front and top of the inverter.
- The sides and bottom may be enclosed or obscured with no restriction when mounting other Radian Series Inverter/Chargers or accessory devices.
- The Radian inverter will function best if operated in a temperature range of –20°C to 25°C (32°F to 77°F). At temperatures up to 50°C (122°F), all inverter components meet their specifications, but the inverter's power is derated. It can function in environments as cold as –40°C (–40°F) and as warm as 60°C (140°F), but it may not meet all component specifications. This temperature range also applies to storage.
- The specifications are listed in the *Radian Series Inverter/Charger Operator's Manual*.

## Dimensions

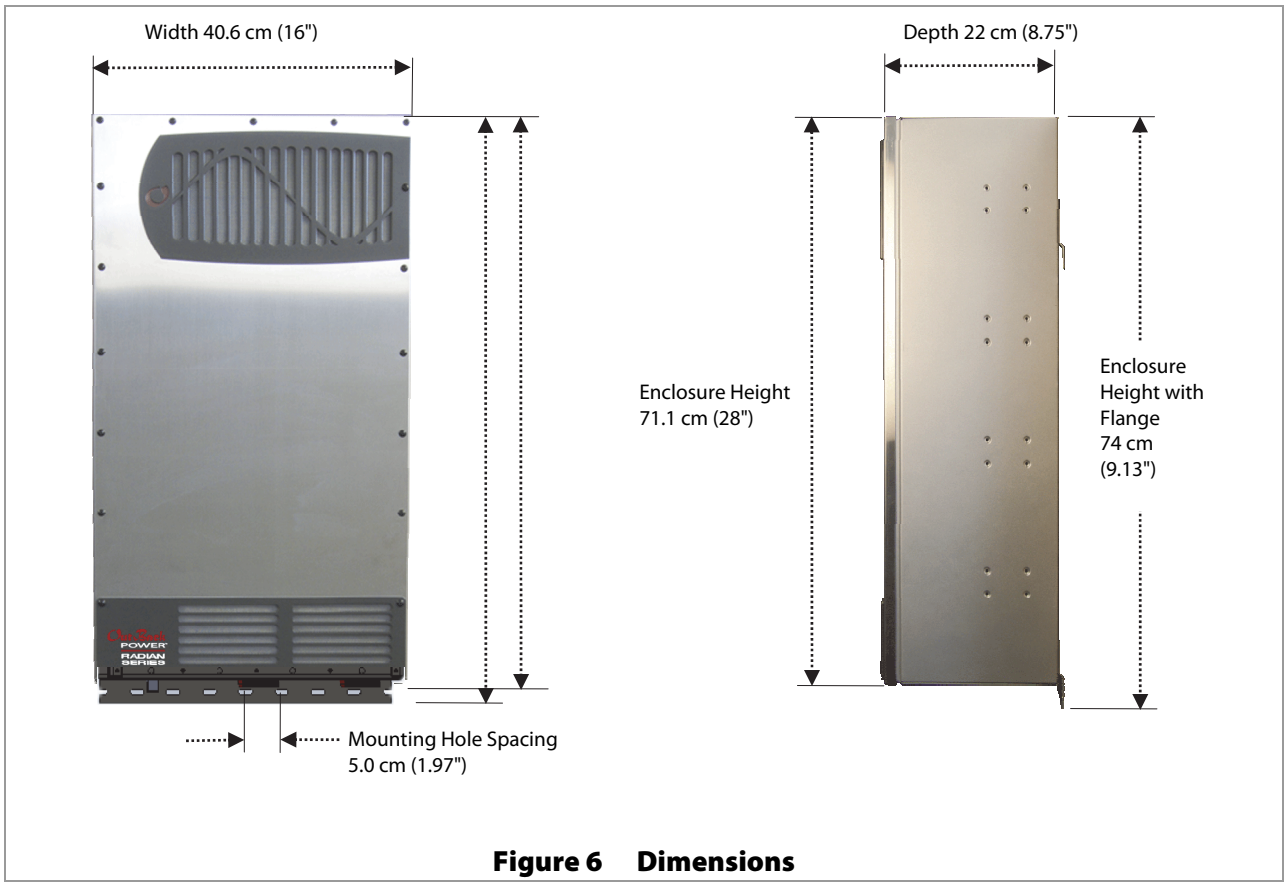


**Figure 6 Dimensions**

# Tools Required

The following tools may be required for this installation:

- Wire cutters/strippers
- Assorted torque wrenches, ratchet wrenches, and sockets (metric and standard)
- Assorted insulated screwdrivers
- DVM or voltmeter

# Mounting

- At least two people are needed to install the Radian inverter/charger. The unit weighs 56.8 kg (125 lb).
- Mount and secure each component before attaching any wiring. Local or national wiring codes may require the bottom of the inverter to be enclosed. The GSLC was specifically designed for this purpose.
- Avoid large air gaps behind the Radian inverter/charger and its mounting plate. These can result in louder mechanical noise during heavy inverting or charging. Mount the plate on a flat, solid mounting surface.

**IMPORTANT:**

Use correct fasteners to secure the mounting plate and the Radian inverter/charger to the mounting surface. OutBack cannot be responsible for damage to the product if it is attached with inadequate fasteners.

The Radian inverter/charger comes equipped with a mounting plate, as shown in Figure 7.

**The Radian inverter is mounted using these steps.**

1. The mounting plate is to be screwed or bolted directly to a solid mounting surface such as wall studs. (See Figure 7.) Lag screws are provided for this purpose.
   - ~ The plate is designed to mount on wall studs with a spacing of 40.6 cm (16"). If the studs have a different spacing, it is recommended that plywood or similar material be installed over the studs. The mounting plate can be installed on the plywood surface.
   - ~ If multiple Radian inverter/chargers are being installed, all mounting plates should be installed first. The inverters can be mounted and secured one at a time when this is done.

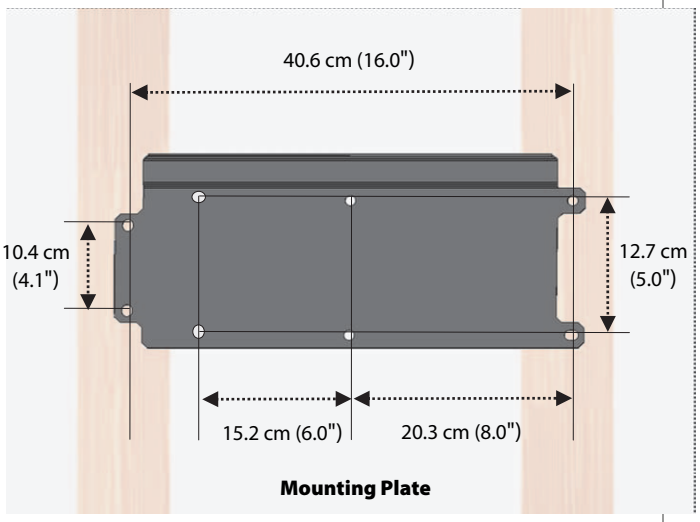


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**Figure 7 Installing the Mounting Plate**

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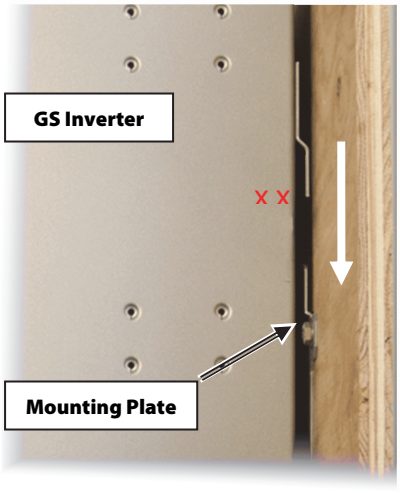



2. Place the Radian inverter against the wall and slide it directly over the upper lip of the mounting plate. The inverter's mounting flange should come to rest within the lip so that it hangs securely.

   To assist in alignment, dimples have been placed on the side of the unit to mark the lower edge of the flange. In the picture to the left, the two X symbols show the location of the dimples.

3. Align the left edge of the inverter with the left edge of the mounting plate. This will expose the right edge of the plate, allowing easy installation of another Radian inverter/charger in the future. All additional inverters are mounted to the right of the existing unit.

   The unit shown to the right is not aligned with the mounting plate, as the plate is still visible. In this example, it should slide to the left so that the plate is entirely covered.

**NOTE**: If the GSLC is used with the Radian inverter, the following step should be omitted.

4. Once aligned, secure the Radian inverter to the stud using a lag screw (provided) in the left corner of the inverter's bottom flange. Securing the inverter this way will prevent it from dislodging from the mounting plate in the event of an earthquake or similar event.


**NOTE**: The left corner is used for securing the inverter to a stud. If the Radian inverter is mounted on plywood or a similar wide-area mounting surface as shown, any of the slots in the mounting flange may be used.

**WARNING: Shock Hazard**

When the inverter is used with other metal chassis, make sure that all chassis are grounded appropriately. (See the grounding instructions on page 15.) Grounding other chassis may involve metal-to-metal contact or separate ground wires.

**Figure 8 Mounting the Inverter**

# Accessory Mounting

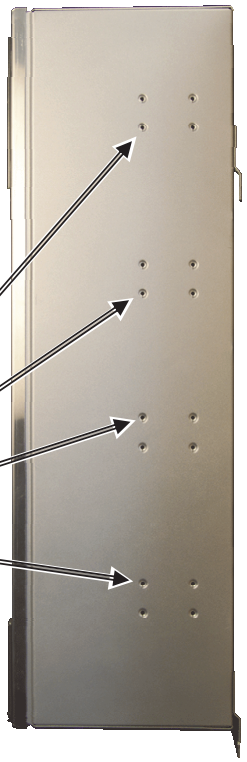
The Radian inverters can support the mounting of several accessories. The inverter can mount the MATE3 system display and the HUB on its left side, and up to two FLEXmax controllers on its right side.

The FLEXmax controllers and the HUB products can also mount on the sides of the GSLC. (The HUB is shown mounted to the GSLC in the picture to the right.) For more information, see the *GS Load Center Installation Manual*.

The GSLC connects to the Radian inverter using four keyhole slots. The keyhole slots fit over four screws on the bottom of the inverter that will secure the GSLC to the inverter when they are tightened. The GSLC should be secured to the wall using screws or wall anchors. The GSLC also makes a mechanical connection to the inverter using bus bars that bolt to the Radian's DC terminals. Other connections are wired as necessary.

**For the MATE3:**
To fit on the Radian inverter's left side, the MATE3 requires the FW-MB3 mounting bracket. Holes are provided on the upper and lower left side to attach the FW-MB3. For more information, see the FW-MB3 instruction sheet.

**For the HUB:**
To fit on the Radian inverter's left side, the HUB uses two mounting holes and three knockouts.



**For the FLEXmax charge controller:**
To fit on the Radian inverter's right side, the FLEXmax charge controllers require the FW-CCB or FW-CCB2 mounting brackets. To accommodate many possible mounting requirements, four sets of mounting holes have been provided for the brackets.

**NOTE:** The OutBack FLEXmax Extreme should be installed on the wall to either side of the GSLC for direct wiring access and does not require additional brackets.

**Figure 9 Mounting for Accessories**

# Removing Front Cover

The front cover must be removed in order to access the Radian inverter's AC terminals and other connections. These include the Remote and Batt Temp ports, as well as several sets of auxiliary terminals.

Twenty-two machine screws are located around the perimeter. Remove these screws with a Phillips screwdriver. Once they are removed, the cover can be lifted off.

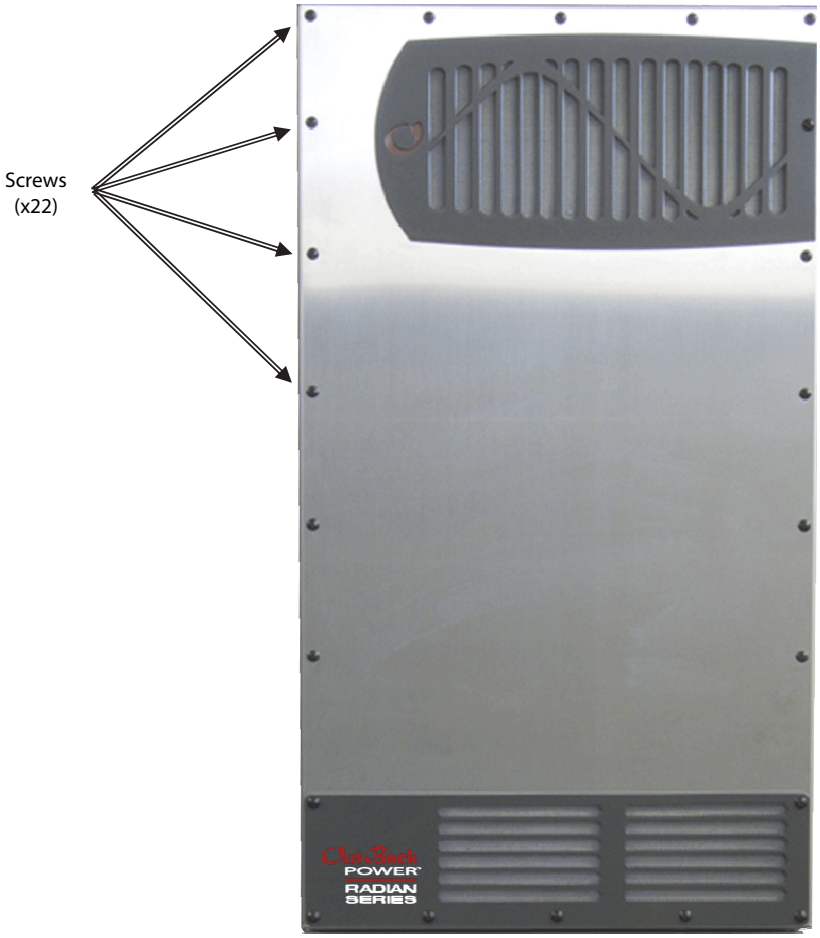


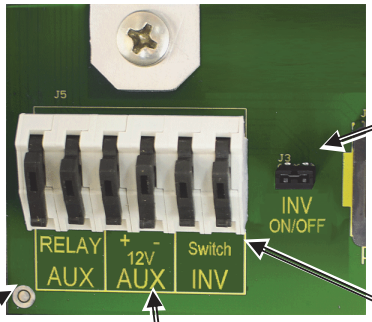

**Figure 10 Removing the Front Cover**

**NOTE:** The Radian inverter may ship with only a few screws installed to make it easier to perform the initial installation. If this is done, the remaining screws will be included in the hardware kit.

# Terminals and Ports

**RIBBON CABLES**: Connects the Radian's power modules and control board. See Warning below.


**DC TERMINALS**: Connects to the battery cables and DC system. There are two DC positive and two DC negative terminals. Each DC positive terminal requires separate cables and separate overcurrent protection. See page 17 for instructions.




**ON/OFF INV JUMPER (J3):** Overrides the **SWITCH INV** terminals when installed. When installed, the inverter is ON. The ON or OFF states can then only be controlled by the MATE3. **NOTE:** J3 is installed to the ON position during manufacture, but the Radian inverter is given an external OFF command at the same time. Its initial state will be OFF.

**RELAY AUX**: Relay contacts with no voltage (10 amps at 250 Vac or 30 Vdc). The relay can be switched on and off for many functions. See page 21 for details. See the MATE3 manual for programming instructions.

**12V AUX**: Delivers 12 Vdc up to 0.7 amps (8.4 watts). The output can be switched on and off for many functions. See page 21 for details. See the MATE3 manual for programming instructions.

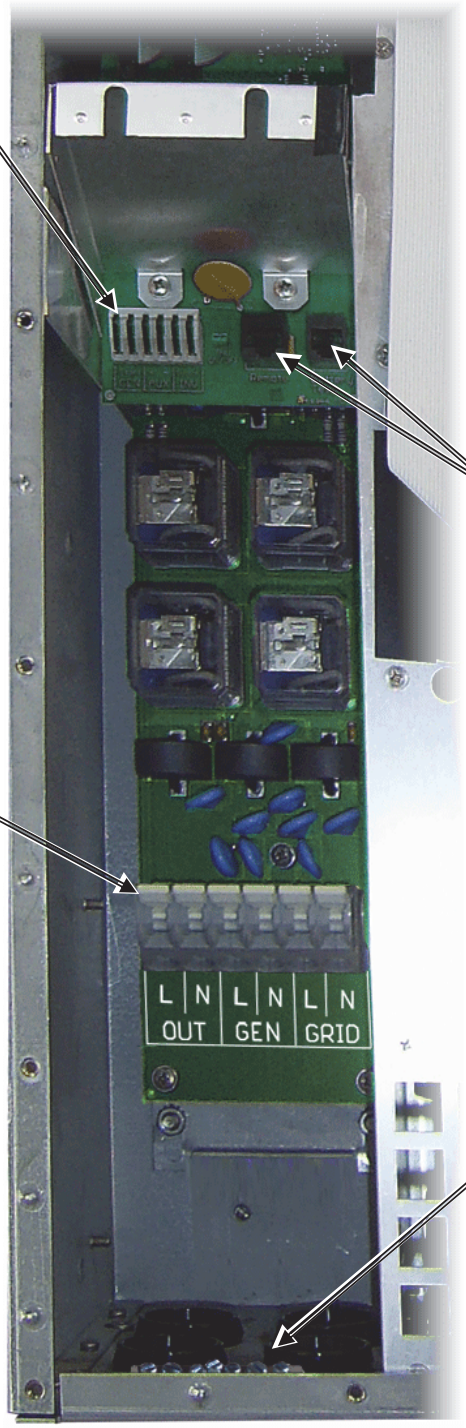
**SWITCH INV**: Receives wires for a manual on/off switch to control the inverter. See page 20 for instructions.
**NOTE:** The ON/OFF INV jumper (J3) overrides these terminals when installed. (See above.)

**Figure 11 DC Terminals, Ribbon Cables, and Auxiliary Terminals**

### WARNING: Shock Hazard and Equipment Damage

It may be necessary to remove the ribbon cables in the course of servicing the Radian. (This is detailed in a separate document.) The cables must never be removed until all power has been disconnected from the Radian for a minimum of one minute. If the cables are removed prematurely, the Radian's capacitors will retain a sizable charge, which can cause electrical shock or severe equipment damage during normal handling. This damage is not covered under the unit's warranty.

**CONTROL WIRING TERMINAL BLOCK:** Receives control wires for a variety of functions, including generator control. See facing page for terminal descriptions.




**REMOTE and BATTERY TEMP PORTS**: Receive the RJ45 and RJ11 plugs from the MATE3 system display and Remote Temp Sensor. See page 20 for instructions.

**AC TERMINAL BLOCK**: Receives AC input wires for two input sources. Also receives AC output wires. All neutral wires are electrically common. See page 18 for instructions.

**GROUND BUS**: Receives ground wires from multiple locations. See page 16 for instructions.

**Figure 12 AC Terminals, Ports, and Ground Bus**

## WARNING: Shock Hazard

After installation, do not remove the covers while the inverter has any source of power. See the *Operator's Manual* for the shutdown procedure before removing the covers.

# Wiring

It will be necessary to remove knockouts from the chassis to run wires. Bushings are included with the hardware kit to protect the wires. Make sure to install these bushings in the holes.

## Grounding

**WARNING: Shock Hazard**

- The unit must be connected to a permanent wiring system that is grounded according to the IEC 60364 TN standard.
- This unit meets the IEC requirements of Protection Class I.
- If a bond is made between neutral and ground, make sure only one bond is present in the AC system at any time. Some codes require the bond to be made at the main panel only. (The GSLC is equipped with its own bond, which may need to be removed.)

**WARNING: Shock Hazard**

For all installations, the negative battery conductor should be bonded to the grounding system at only one point. If the OutBack GFDI is present, it can provide the bond. (The GSLC is also equipped with its own bond, which may need to be removed.)

**IMPORTANT:**

Most OutBack products are not designed for use in a positive-grounded system. If it is necessary to build a positive-grounded system with OutBack products, contact OutBack Technical Support at **+1.360.618.4363** before proceeding. Additionally, consult the online forum at **www.outbackpower.com/forum/**, where this subject has been discussed extensively.

**Table 2 Ground Conductor Size and Torque Requirements**

| Terminal Location | Minimum Conductor Size | Torque Requirements |
|---|---|---|
| **Ground TBB** | 16 $mm^2$ or #6 AWG (0.025 $in^2$) | 2.8 Nm (25 in-lbs) |

The inverter's ground terminal bus bar (TBB) may be used for making all ground connections to other parts of the system. Examples include inverter equipment grounding, generator grounding, load panel grounding, and main earth ground wire.

This TBB accepts up to 25 $mm^2$ or #4 AWG (0.033 $in^2$) wire.

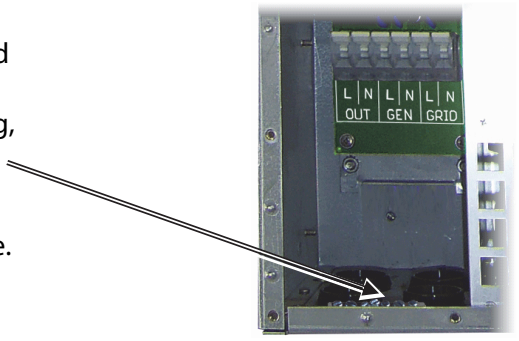



**Figure 13 Chassis Ground TBB**

# DC Wiring ⎓

**WARNING: Shock Hazard**

Use caution when working in the vicinity of the inverter's battery terminals.

**CAUTION: Equipment Damage**

Never reverse the polarity of the battery cables. Always ensure correct polarity.

**CAUTION: Fire Hazard**

- Always install a circuit breaker or overcurrent device on each DC positive (+) conductor to protect the DC system.
- Never install extra washers or hardware between the mounting surface and the battery cable lug. The decreased surface area can build up heat.

**IMPORTANT:**

- Table 3 contains OutBack's recommendations for minimum cable sizes. Other codes may supersede OutBack's requirements. Consult local codes for final size requirements.
- The short-circuit current rating of the DC circuitry is 8975 Adc.

**Table 3 DC Conductor Size and Torque Requirements**

| Inverter | Nominal DC Amps (Minimum, per breaker) (Derated 125%) | Conductor Size (Minimum, per breaker) | Breaker Size |
|---|---|---|---|
| GS7048E | 91 | 70 $mm^2$ or 2/0 AWG (0.105 $in^2$) | 175 Adc/AIC 10kA |
| **Terminal Location** | | **Torque Requirements** | |
| Inverter DC Terminals | | 6.9 Nm (60 in-lb) | |
| Battery Terminals | | See battery manufacturer's recommendations | |

When installing DC cables:

- Make certain DC circuit breakers are turned to the off position, or fuses are removed, before proceeding.
- Battery positive (+) and negative (–) cables should be no longer than 3 meters (10 feet) each, to minimize voltage loss and other effects.
- The modular construction of the Radian requires the use of two DC circuit breakers or fuses.
- The cables for each overcurrent device must **each** be sized appropriately. Alternately, a single cable or bus may be used if sized to the minimum total ampacity.
- The cables listed above are for each inverter in a system. In a system with multiple inverters, each inverter requires its own cables and overcurrent devices of the size indicated.
- Install all overcurrent devices on the positive cable.
- Tie, tape, or twist positive and negative cables together to reduce self-inductance. Run positive and negative cables through the same knockouts and conduit.
- The inverter's battery terminal is a threaded hole which accepts a hex bolt (provided). Install battery cable lug, washers, and bolt in the order illustrated. The battery cable lug must be the first item installed. It must make solid contact with the surface. It should have a 0.79 cm (5/16") diameter hole.

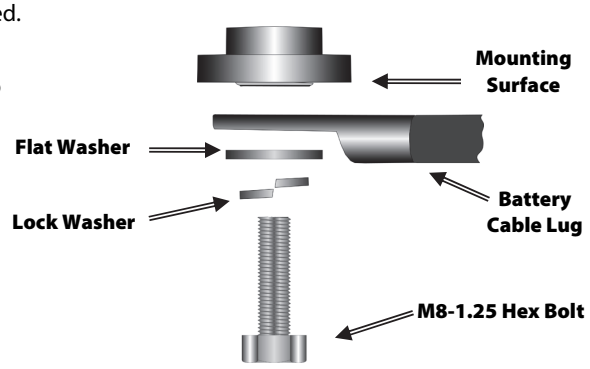



**Figure 14 DC Cable Hardware (underside of inverter)**

# AC Wiring

**WARNING: Shock Hazard**

Ensure there is no more than one AC neutral-ground bond at any time. Local or national codes may require the bond to be made at the main panel only. The GSLC is equipped with its own bond, which may need to be removed.

**IMPORTANT:**

- The AC input and output must be protected with branch-rated circuit breakers of up to 50 Aac maximum size to meet local code requirements.
- The short-circuit current rating of the AC output is 109 Aac.

The Radian inverter/charger's AC terminal block has nine positions for AC wires. The minimum recommended wire size is 10 $mm^2$ or #8 AWG (0.013 $in^2$). Larger wire gauges may be required for specific conditions. The largest size that can be used with the terminals is 16 $mm^2$ or #6 AWG (0.021 $in^2$).

The inverter makes its AC connections using spring-loaded clamps. It is necessary to strip approximately 1.3 cm (½ inch) of insulation from the end of each wire. Other tools are not required.

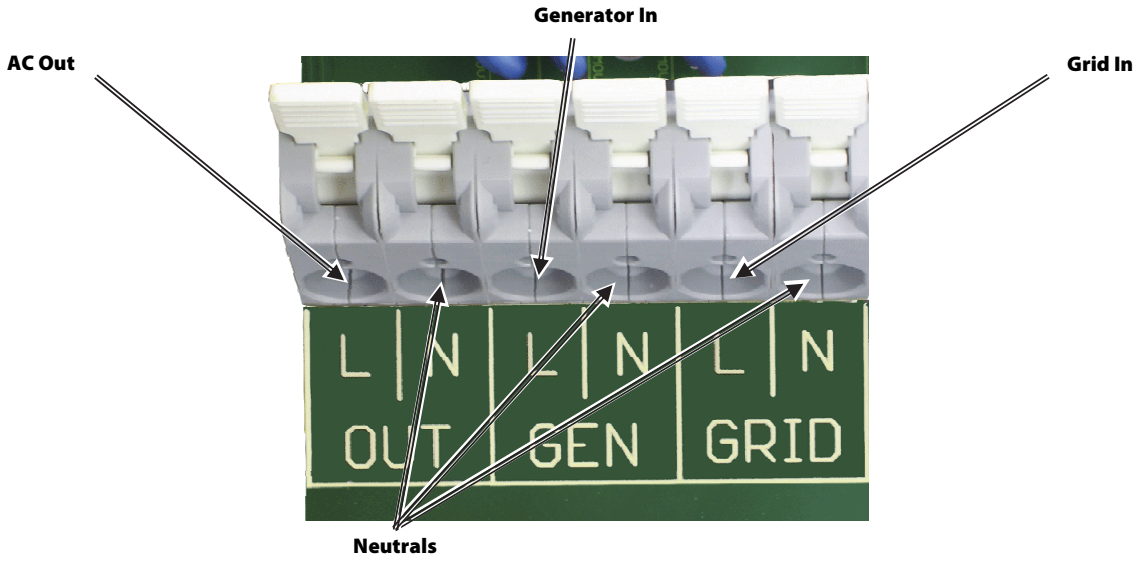



**Figure 15 AC Terminals**

The terminals labeled **L** are used to connect to the "hot" or "line" wires. All system wiring must comply with national and local codes and regulations.

Three neutral (**N)** terminals are available. These terminals are electrically common. Any of them can be used to connect to neutral wires from various parts of the system. The most common connections are to the neutral bus on the main panel or utility grid service, the neutral bus on the output load panel, the neutral bus in the GSLC, and the neutral wire from a generator.

**NOTE:** The terminals are labeled for grid and generator due to common conventions, not because of inverter requirements. Each input can accept any AC source as long as it meets the requirements of the Radian inverter and the selected input mode. (See the *Operator's Manual).* If necessary, the **Gen** terminals can accept grid power. The opposite is also true.

The Radian can accept input voltages that range between (nominal) 220 Vac, 230 Vac, or 240 Vac (single-phase only). The range of input acceptance may need to be adjusted to the nominal voltage of the system so that inappropriate voltages are not accepted.

The AC source(s) can power both battery charger and loads if sized correctly. Use the source amperage to determine actual maximum draw. Size input circuit breakers accordingly.

The terminals labeled **Out** are used to connect the Radian inverter to the load circuits. These terminals also transfer power from an input source if it is available. Size load circuit breakers accordingly.

A Ground TBB is also available if multiple ground connections are needed (see Figure 13 on page 16).

**WARNING: Shock Hazard**

During an error shutdown, the inverter's output terminals are not live. However, if the inverter recovers from a shutdown, the terminals will become live without notice. Several error shutdowns can be recovered automatically, including ***Low Battery V***, ***High Battery V***, and ***Over Temperature***. See the *Radian Series Inverter/Charger Operator's Manual.*

## AC Sources

The inverter's transfer relay is normally set to provide inverter power to the output. When an AC source is present and accepted, the transfer relay switches to transfer the AC source power to the loads. (See the *Radian Series Inverter/Charger Operator's Manual* for the inverter's acceptance criteria.)

The Radian inverter has connections for two AC sources for ease of installation. Each source is transferred with a separate relay. However, internally it can only connect to one AC source at a time. It cannot use both utility grid and generator power at the same time. If presented with two sources of power, the default setting is to accept the source connected to the GRID terminals. (See the MATE3 manual for instructions on changing the source priority.)

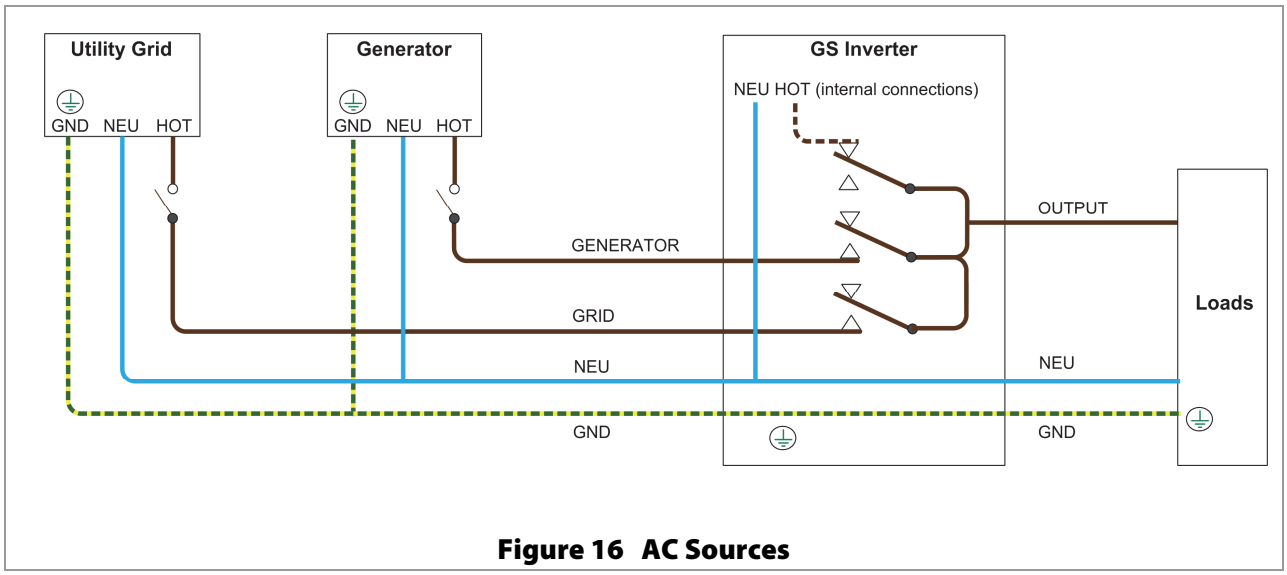
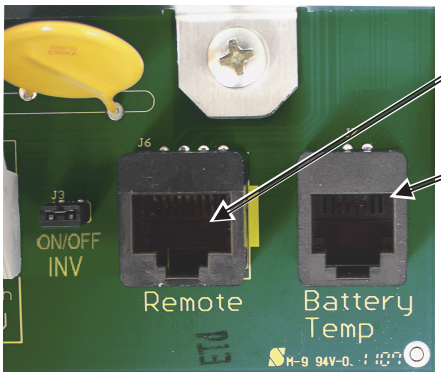



**Figure 16 AC Sources**

# Accessory Wiring

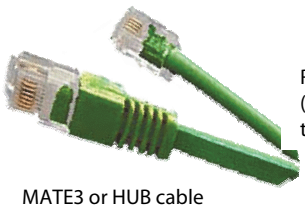



Remote port

Battery Temp port

The upper board has ports for both the Remote Temperature Sensor (RTS) and the MATE3 system display. The system display port is labeled Remote. The RTS port is labeled Battery Temp.

If a HUB Communications Manager is in use, it occupies the inverter's Remote port.



RTS cable
(RJ11, 4-conductor, telephone)

MATE3 or HUB cable
(RJ45, 8-conductor, CAT5 non-crossover)

See the *Operator's Manual* for more information on the RTS.

**Figure 17 Accessory Connections**

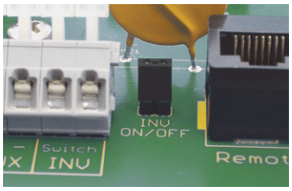
Additional Ports

MATE port

When a HUB communications manager occupies the inverter's Remote port, the MATE3 connects directly to the HUB's MATE port.

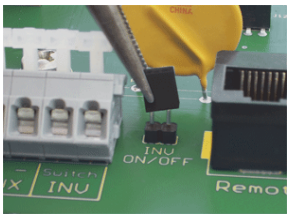
Inverters connect to ports 1 and above. Charge controllers and other devices connect to additional ports after the last inverter is connected. See Stacking on page 27 for information on connecting inverters. See the HUB manual for other devices.

The **ON/OFF INV** jumper bridges two pins. This jumper (J3) parallels the two **Switch INV** terminals on the terminal block. If either set of connections is closed, the inverter is on. (Although the jumper is factory-installed to the on position, the inverter is given an off command before leaving the factory and will initially be off.)



**Jumper On**

**Jumper Off**



Removing the jumper will turn the inverter off if it is not already. To remove the jumper, use long-nose pliers or a similar tool.

Once the plastic **ON/OFF INV** jumper has been removed, the **Switch INV** terminals on the terminal block can be used to wire a manual on/off switch.

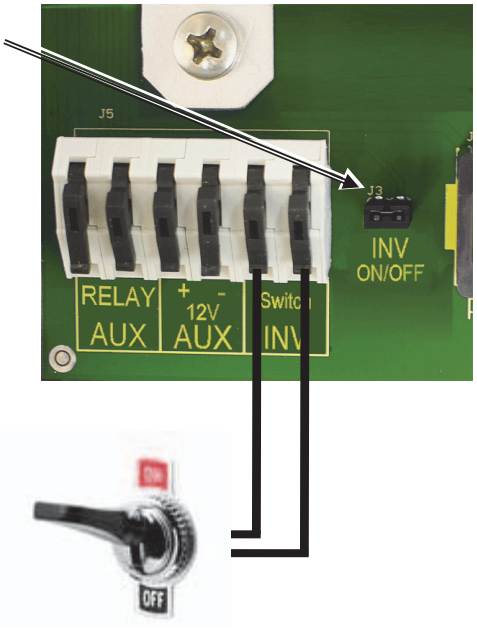



**Figure 18 ON/OFF Jumper and Connections**

# AUX Wiring

The Radian inverter has two sets of terminals which can respond to different criteria and control many functions. These include cooling fans, vent fans, load diversion, fault alarms, and the Advanced Generator Start (AGS) function.

The **12V AUX** terminals are a switched 12 Vdc power supply. They can control any of the Auxiliary Output functions available in the MATE3.

The **12V AUX** terminals can supply up to 0.7 amps at 12 Vdc (8.4 watts). This is sufficient to drive a small fan or a relay controlling a larger device. The terminals accept wire up to #14 AWG (0.0032 $in^2$) or 2.5 $mm^2$. This circuit contains electronic overcurrent protection, which resets after being overloaded. No additional fuses are required for the 12V AUX terminals.

The **RELAY AUX** terminals are "dry" relay contacts with no voltage. Their most common function is to serve as a switch for the start circuit of an automatic generator using the AGS function. However, they can be programmed for other auxiliary functions as well. These terminals can conduct up to 10 amps at up to 30 Vdc or 250 Vac.

**CAUTION: Equipment Damage**

This circuit has no overcurrent protection. A fuse of no larger than 10 amps must be installed to protect the circuit. Since the internal circuitry of the **RELAY AUX** terminals do not incorporate overcurrent protection, it is the responsibility of the installer to ensure the circuit is protected. Internal failure that results from lack of protection is not covered by the Radian warranty.

Each set of terminals has its own set of programmed criteria.

**NOTE:** The menus for each set of terminals have identical options available, but can control independent functions. For example, the **RELAY AUX** terminals can be used for the AGS function, while the **12V AUX** terminals can simultaneously be used to control a vent fan in the battery box.

Note also that the control logic for the terminals is not always located in the same device. The inverter's Auxiliary Output functions are located within the inverter itself. Although they require the system display (MATE3) for programming, they will function even if the MATE3 is removed. However, the programming for AGS is located within the MATE3 and will not work if the MATE3 is removed. Other devices may be able to control the inverter's terminals. See the appropriate manuals for more information.

For generator control, see page 23. For all other functions, see the *MATE3 Owner's Manual* and the *Radian Series Inverter/Charger Operator's Manual*.)

In this example, the **12V AUX** terminals directly drive a 12-volt vent fan. The + and – wires on the fan are connected to the **AUX** terminals.

**NOTE:** If another device is used, such as a larger fan, it must not draw more than 0.7 amps.

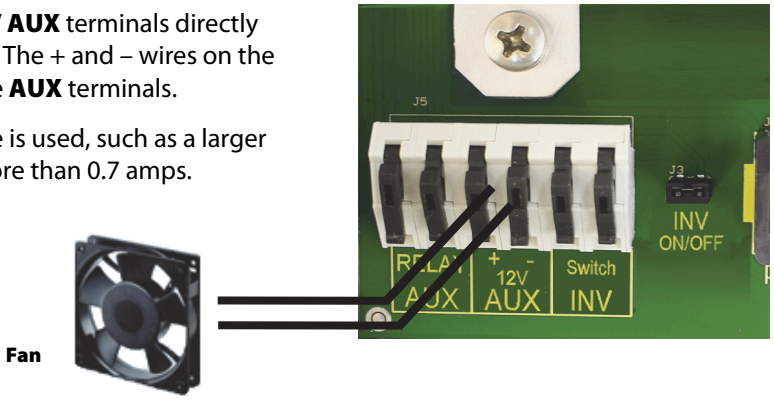
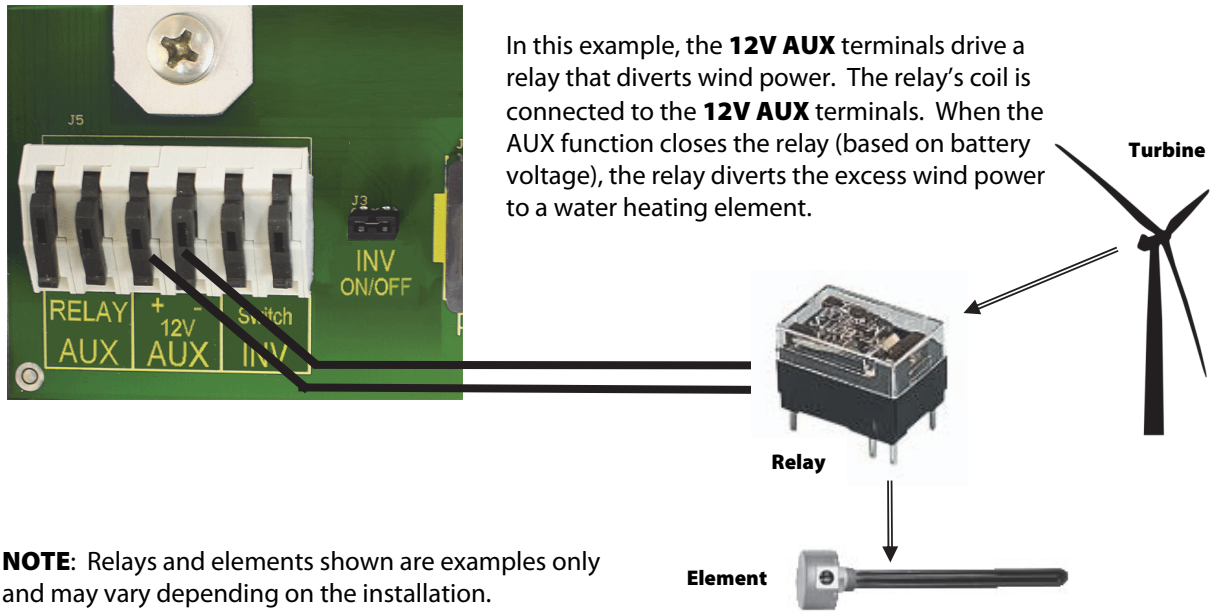



**Figure 19 AUX Connections for Vent Fan (Example)**




In this example, the **12V AUX** terminals drive a relay that diverts wind power. The relay's coil is connected to the **12V AUX** terminals. When the AUX function closes the relay (based on battery voltage), the relay diverts the excess wind power to a water heating element.

**NOTE**: Relays and elements shown are examples only and may vary depending on the installation.

**Figure 20 AUX Connections for Diversion (Example)**

# Automatic Generator Start (AGS)

The **RELAY AUX** terminals can most easily perform "two-wire" generator start. A two-wire-start generator is the simplest type, where the cranking and starting routine is automated. It usually has a single switch with two positions that is turned ON to start, OFF to stop.

## Two-Wire-Start (RELAY AUX Terminals)

The **RELAY AUX** terminals can be wired in place of the generator's start switch as shown below. This method is only advised if the generator's starting circuit is triggered by continuity. (This circuit must use fewer than 10 amps.)

**CAUTION: Equipment Damage**

This circuit has no overcurrent protection. A fuse of no larger than 10 amps must be installed to protect the circuit. Since the internal circuitry of the **RELAY AUX** terminals do not incorporate overcurrent protection, it is the responsibility of the installer to ensure the circuit is protected. Internal failure that results from lack of protection is not covered by the Radian warranty.

In other cases, or in the case of a three-wire-start generator, the AGS function should use the **12V AUX** terminals instead, in conjunction with a three-to-two wire converter. (See pages 24 and 25.)

Either the MATE3 or the FLEXnet DC battery monitor can be programmed to perform automatic generator start using these terminals. See the MATE3 or FLEXnet DC owner's manuals for programming instructions.

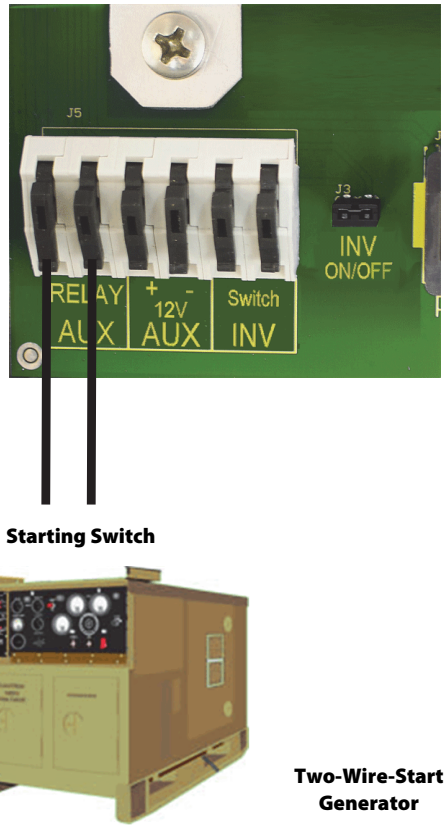



**Figure 21 Two-Wire Generator Start (RELAY AUX)**

## Two-Wire-Start (12V AUX Terminals)

The 12 Vdc signal provided by the **12V AUX** terminals can be switched on and off to provide a start signal. It is not usually recommended to connect the **AUX** terminals directly to the generator, but to use the **12V AUX** terminals to energize the coil of a 12 Vdc automotive or similar relay.

The OutBack FLEXware Relay Assembly depicted in Figure 22 is sold for this purpose. The relay contacts can serve in place of the generator's start switch. The battery shown below is depicted for clarity. In most cases, it is part of the generator's internal starting circuit and is not an external component.

The drawing below is one example of a possible arrangement. Specific arrangements, relays, and other elements depend on the requirements of the installation and of the generator.

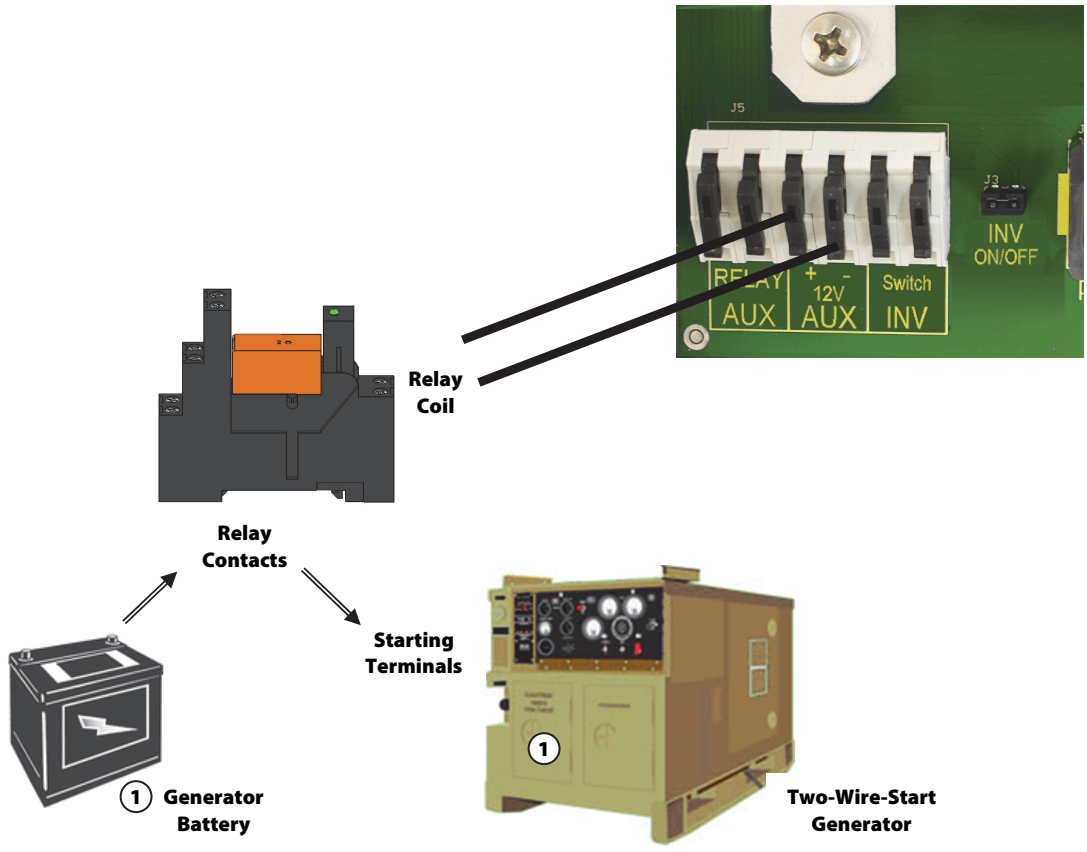



**Figure 22 Two-Wire Generator Start (12V AUX)**

## Three-Wire-Start

A “three-wire-start” generator has two or more starting circuits. It usually has a separate switch or position for cranking the generator. A three-wire generator has fewer automated functions than a two-wire. It usually requires multiple controls for starting, running, or stopping. The inverter terminals cannot control this type of generator without using a three-wire to two-wire conversion kit.

Atkinson Electronics **(http://atkinsonelectronics.com)** is one company that makes these kits. The Atkinson GSCM-Mini is intended to work with OutBack inverters.

**NOTE:** The conversion kit requires a 12-volt signal which the **RELAY AUX** terminals cannot provide. The **12V AUX** terminals may be used to operate the conversion kit, as shown in Figure 23 .

If the **AUX** terminals are being used for another purpose, it may be necessary for the **RELAY AUX** terminals to control an external relay and 12-volt source in conjunction with the conversion kit. The wiring and requirements for this arrangement will depend on the circumstances.

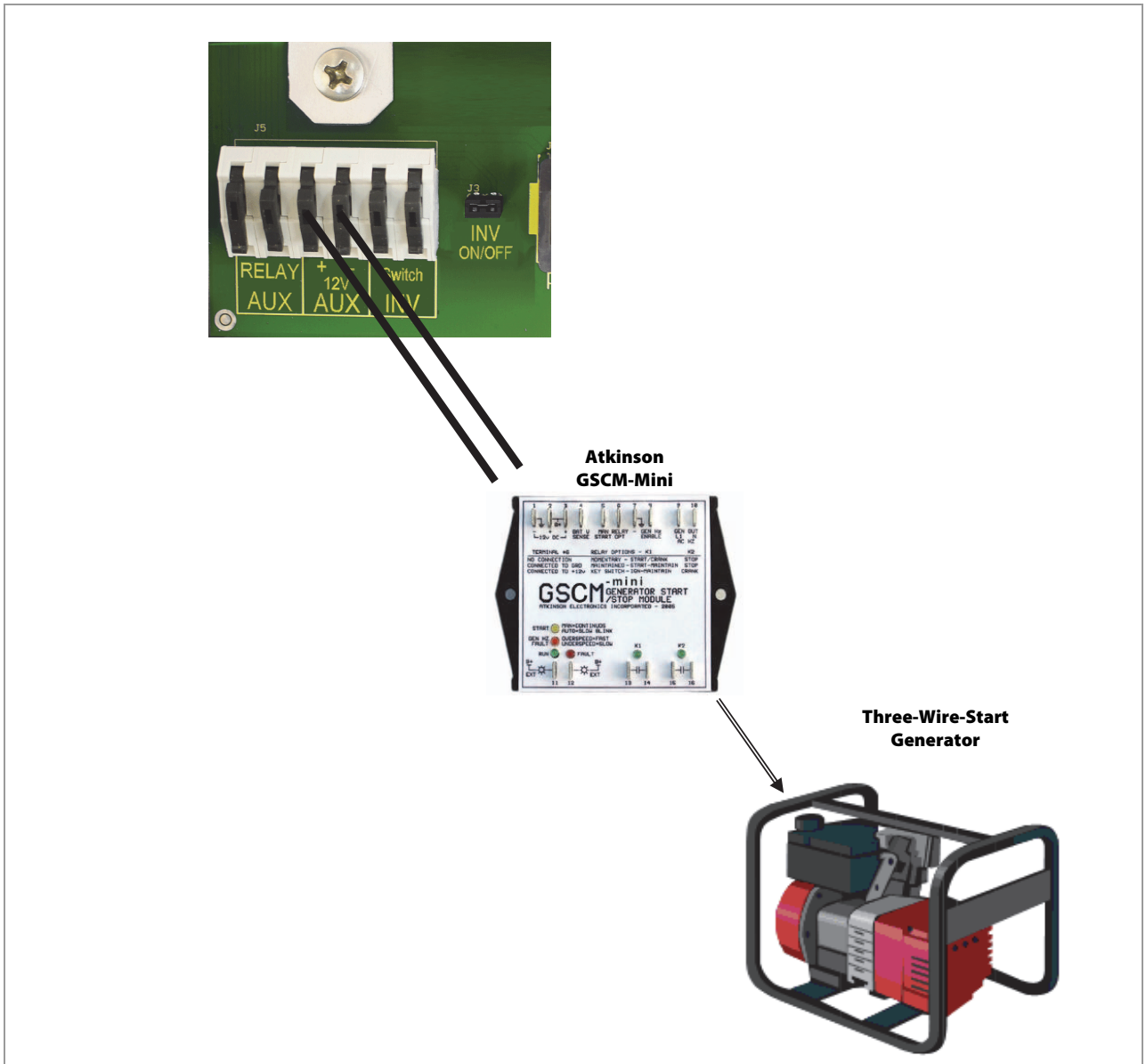
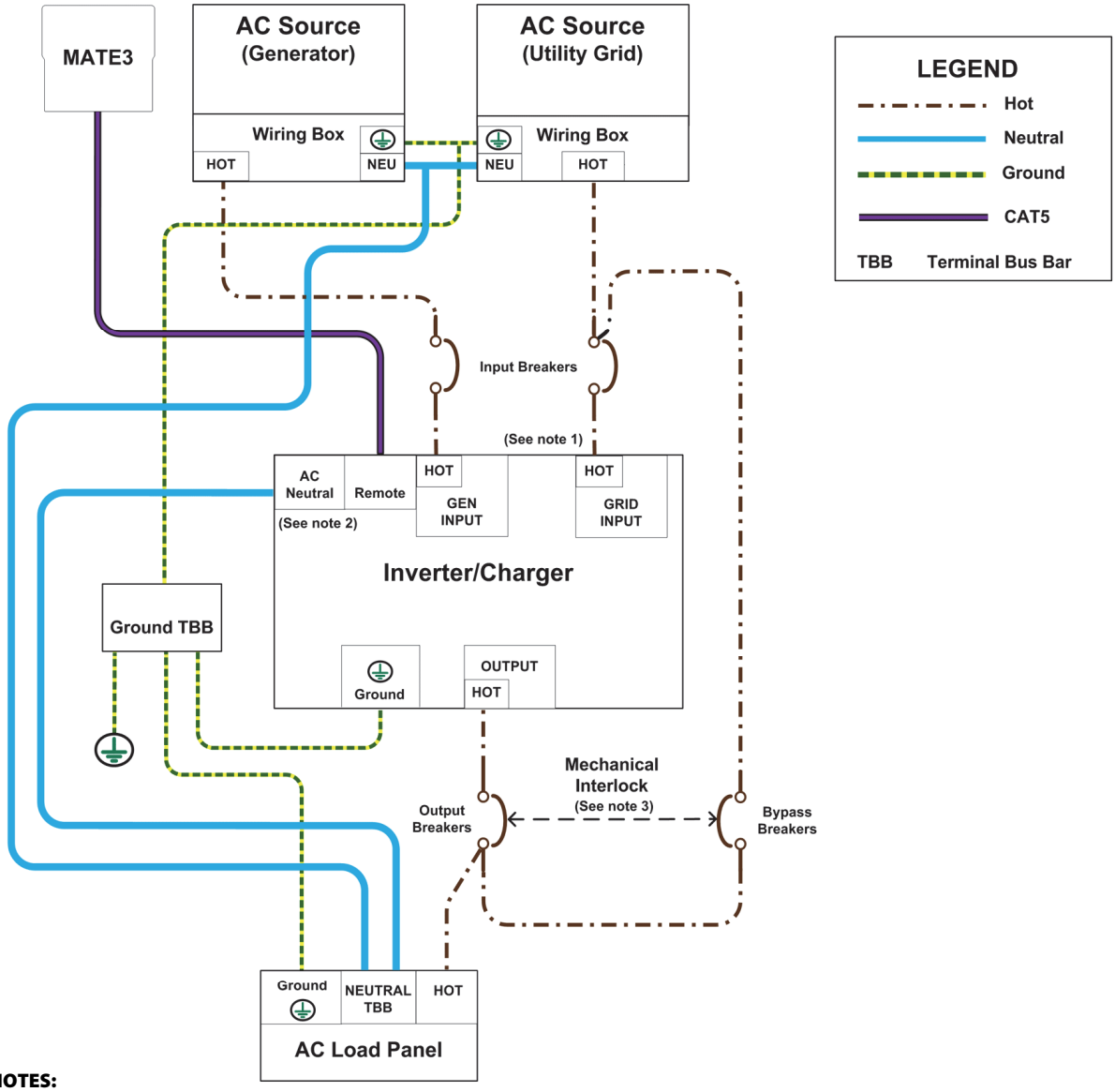



**Figure 23 Three-Wire Generator Start (Example)**

# Single-Inverter AC Installations

When installing an inverter AC system, the following rules must be observed.

- All overcurrent devices in building-based installations must be sized for 50 Aac or less.
- All wiring in building-based installations must be sized for 50 Aac or more.
- All output circuit breakers must be sized appropriately for loads and inverter wattage.




**NOTES:**

1. The Radian inverter has connections for two AC input sources, although the inverter can only accept one source at a time.
2. The Radian inverter has separate neutral connections for grid input, generator input, and output. These are electrically common. If an external neutral bus exists (as shown in the AC Load Panel above), not all of the Radian neutral connections need to be made.
3. Maintenance bypass switching assemblies are commonly used so that the inverter can be taken offline, if necessary, without shutting down the entire system. These assemblies usually include an interlock mechanism that isolates AC lines from each other.
4. The GS Load Center (GSLC) can be used as both an input conduit box and an AC load center, with a common neutral terminal bus bar (TBB). It can also host maintenance bypass switches for one inverter.

**Figure 24 Single-Inverter Wiring**

# Multiple-Inverter AC Installations (Stacking)

Installing multiple inverters in a single AC system supports larger loads than a single inverter can handle. This requires stacking. Stacking inverters does not refer to physically placing one on top of another. It refers to how they are wired within the system and then programmed to coordinate activity. Stacking allows all units to work together as a single system. The GS7048E inverter/charger can stack up to ten units in parallel. Three units can be stacked for three-phase output.

**Stacking Connections**

Stacking requires an OutBack HUB Communications Manager, as well as the OutBack MATE3 system display. A system using four or fewer components may use the HUB4. Systems using up to ten components require the HUB10. All interconnections are made using CAT5 non-crossover cable.

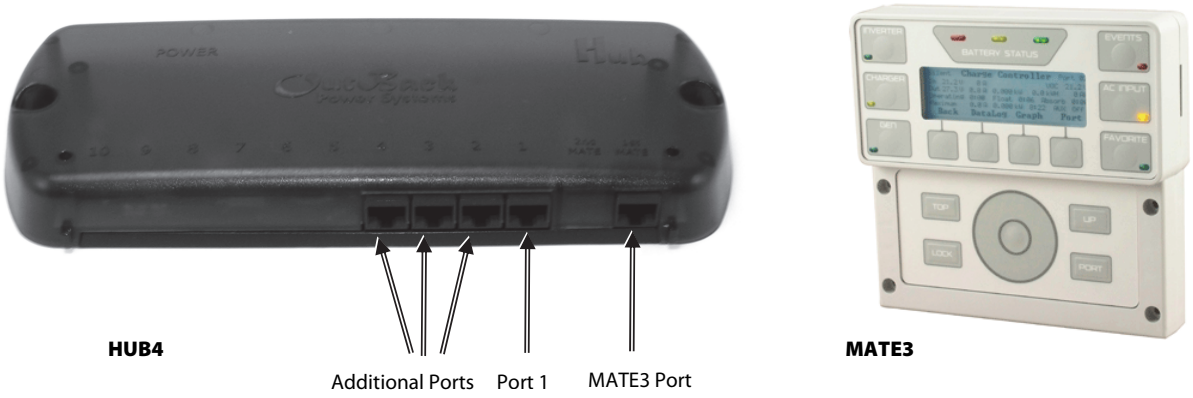



**Figure 25 OutBack Communications Manager and System Display**

Each inverter must be assigned a stacking mode depending on the configuration. Modes are described below.

- The master provides the primary output phase. Other inverters in the system base their phase on that of the master. If the master shuts off, all other inverters also shut off. The master must sense and connect to an AC source before other inverters can connect. In all cases, the master inverter must be connected to port 1 on the communications manager.

  In a parallel-stacked or OutBack-stacked system, the master tends to be the most heavily used unit.

There are two types of slave modes.

- A "classic" slave is used for stacking when the slave operates semi-independently of the master. Although the master sets the phase relationship, the slave creates an output independent of the master. This type of system is used for three-phase stacking.

  Classic-stacked inverters can go into Search mode independently of the master if necessary.

- An "OutBack" slave is used for parallel systems. All slaves are in phase with the master.

  All slave outputs are pulse-width-matched to be precisely synchronized with the master inverter. This avoids potential backfeed.

  OutBack slaves can be placed in Power Save mode when not in use. They are activated by the master inverter as needed. For this reason, the master is normally the only inverter to enter Search mode.

Slaves connect to ports 2 and above on the communications manager. See the MATE3 manual for other port restrictions pertaining to stacking. In general, it is always important to keep track of units and ports for programming purposes.

Programming involves using the MATE3 to assign a status and stacking value to the inverter on each port. These assignments can be changed at any time as long as the master is connected to port 1.

**IMPORTANT:**

- The master inverter must always be connected to port 1 on the communications manager. Connecting it elsewhere, or connecting a slave to port 1, will result in backfeed or output voltage errors which will shut the system down immediately.
- Installing multiple inverters without stacking them (or stacking them incorrectly) will result in similar errors and shutdown.
- Although stacking allows greater capacity, the loads, wiring, and overcurrent devices must still be sized appropriately. Overloading may cause circuit breakers to open or the inverters to shut down.

## Parallel Stacking (Dual-Stack and Larger)

In parallel stacking, two or more inverters are stacked to create a single, common AC bus.

- The slave outputs are controlled directly by the master and cannot operate independently.
- All inverters share a common input (AC source) and run loads on a common output.
- Slave inverters can go into Power Save mode when not in use. The master will activate individual slaves based on load demand. This reduces idle power consumption and improves system efficiency.
- Up to ten inverters may be installed in a parallel arrangement. The example on this page shows three inverters. The wiring diagram on the next page shows two.

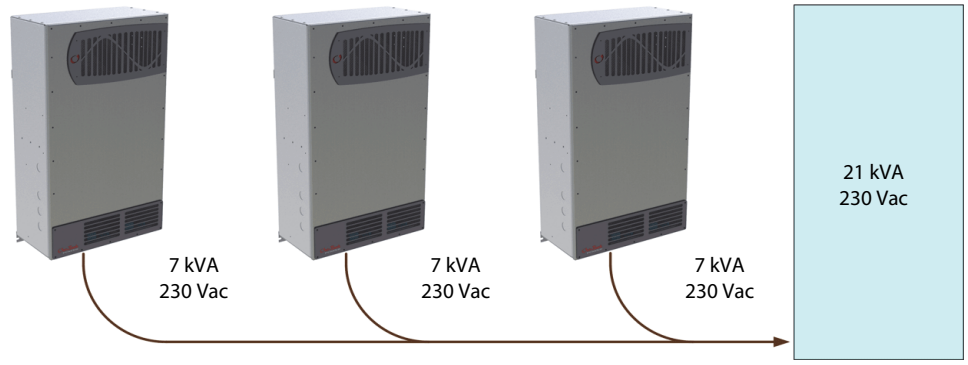
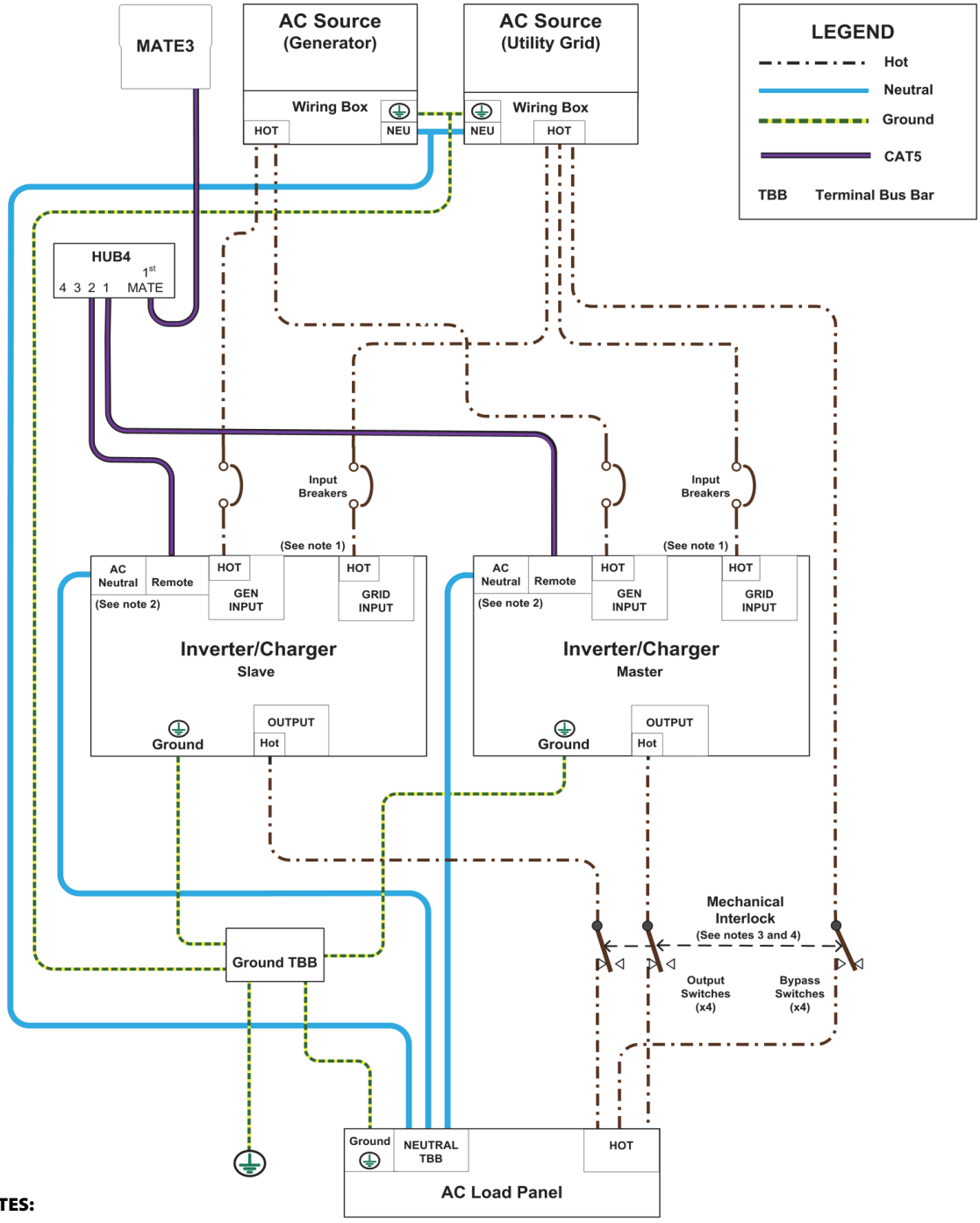



**Figure 26 Example of Parallel Stacking Arrangement (Three Inverters)**

When installing a parallel system, the following rules must be observed.

- Parallel stacking requires the MATE3 system display and a communications manager.
- One inverter,and one inverter only, is always the master and is programmed as ***Master***. This is the default setting. (See the MATE3 manual for programming.)
- The master must be connected to port 1 of the communications manager. Other inverters must not be selected as master.
- All slave inverters, regardless of number, should be selected as ***Slave*** during programming.
- All overcurrent devices must be sized for 50 Aac or less.
- All wiring must be sized for 50 Aac or more.
- All output circuit breakers must be sized appropriately for loads and inverter wattage.
- The AC input (generator or utility grid) must be a single-phase output at the proper voltage and frequency.




**NOTES:**

1. The Radian inverter has connections for two AC input sources, although the inverter can only accept one source at a time.
2. The Radian inverter has separate neutral connections for grid input, generator input, and output. These are electrically common. If an external neutral bus exists (as shown in the AC Load Panel above), not all of the Radian neutral connections need to be made.
3. Maintenance bypass switching assemblies are commonly used so that the inverter can be taken offline, if necessary, without shutting down the entire system. These assemblies usually include an interlock mechanism that isolates AC lines from each other.
4. When multiple inverters are stacked, the GS Load Center (GSLC) for each inverter can be wired together to serve as a common input conduit box and AC load center. However, the GSLC bypass switching assemblies are only sized for single inverters and cannot work in conjunction with each other. The GSLC bypass assemblies should not be used with multiple inverters present. (See page 8.) An external bypass assembly must be used instead. Larger external assemblies are available from other manufacturers.

**Figure 27 Parallel Wiring**

## Three-Phase Stacking (Three Inverters)

In three-phase stacking, inverters are stacked to create three 230 Vac outputs (or equivalent voltage) in a wye configuration.

- The three outputs operate independently of each other. Each can run in independent Search mode if desired, although this does not normally occur when three-phase loads are connected.
- The output of each inverter is 120° out of phase from the others. Any two outputs produce 400 Vac between them. The outputs can be used to power three-phase loads when all inverters work together.
- Only three inverters, one per phase, may be installed in a three-phase arrangement.

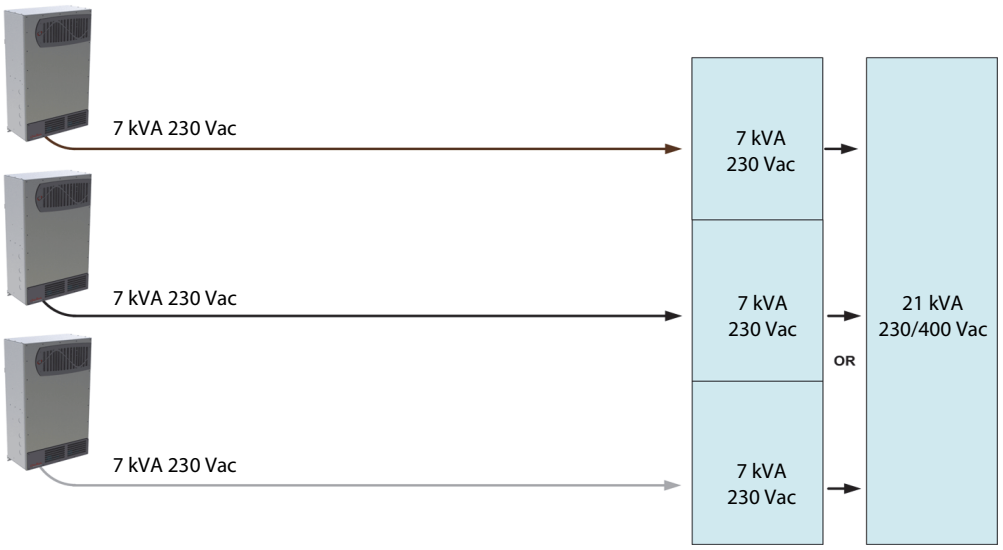


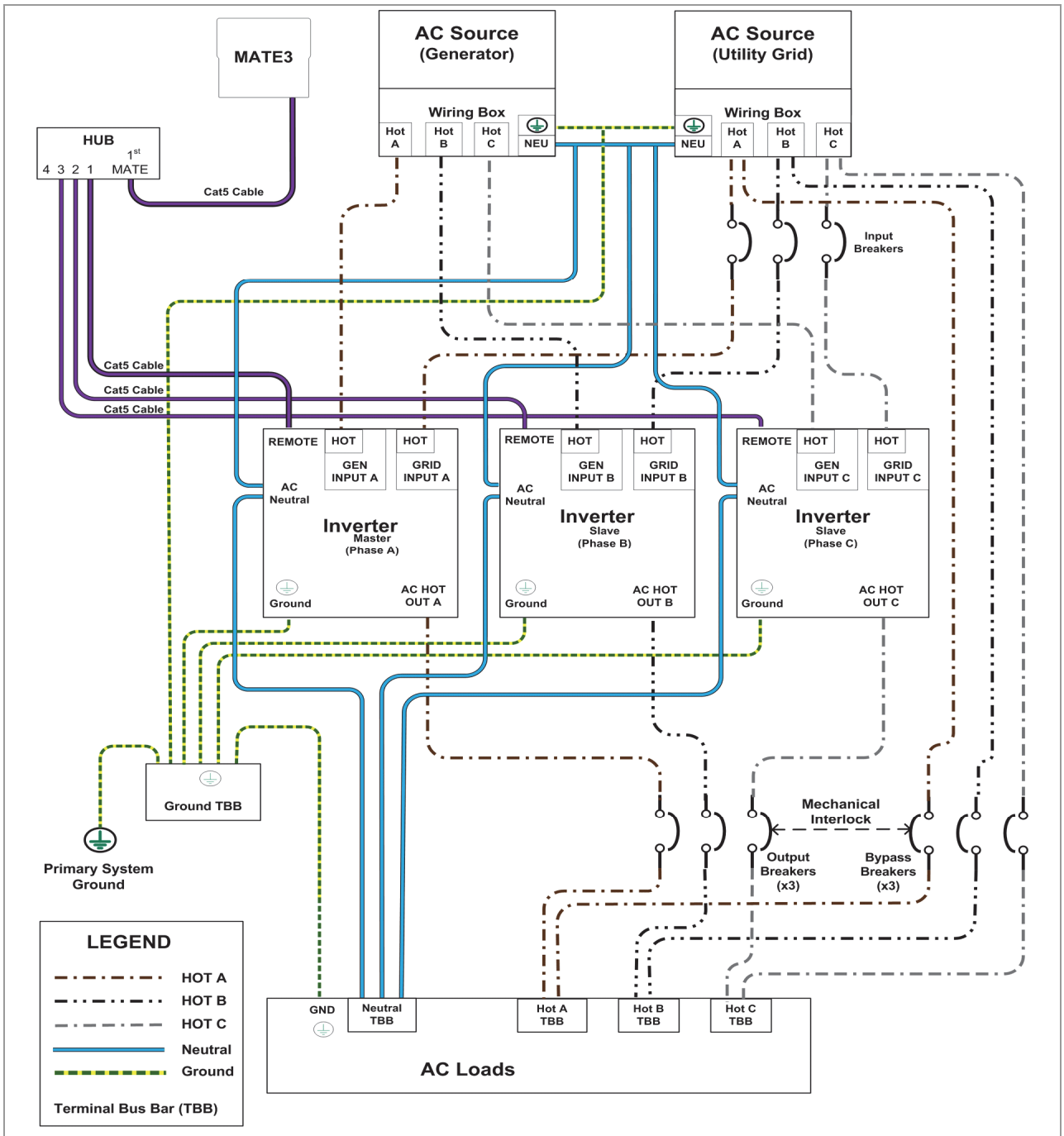

**Figure 28 Example of Three-Phase Stacking Arrangement (Three Inverters)**

When installing a three-phase system, the following rules must be observed.

- Three-phase stacking requires a system display and a communications manager.
- One inverter, and one inverter only, is always the master and is programmed as ***Master***. This is the default setting. (See the MATE3 manual for programming.)
- The master must be connected to port 1 of the communications manager. Other inverters must not be selected as master.
- One slave inverter must be programmed as ***B Phase Master***. The other must be programmed as ***C Phase Master***. (See the system display manual for programming.)
- The inverters should be wired to the loads and to the AC sources in phase order. The master must be phase A, the first slave should be phase B, and the second slave should be phase C.
- All overcurrent devices must be sized for 50 Aac or less. All wiring must be sized for 50 Aac or more.
- All output circuit breakers must be sized appropriately for loads and inverter wattage.
- All inverters must be of the same model.
- The AC input (generator or utility grid) must be 230/400 Vac at 50 Hz (a three-phase wye configuration).

**IMPORTANT:**

Although the HUB manual states that it is necessary to move the jumper to the three-phase position, that statement is not applicable for this model. The jumper must be left in its original position.




**NOTES:**

1. The Radian inverter has connections for two AC input sources, although the inverter can only accept one source at a time.
2. The Radian inverter has separate neutral connections for grid input, generator input, and output. These are electrically common. If an external neutral bus exists (as shown in the AC Load Panel above), not all of the Radian neutral connections need to be made.
3. Maintenance bypass switching assemblies are commonly used so that the inverter can be taken offline, if necessary, without shutting down the entire system. These assemblies usually include an interlock mechanism that isolates AC lines from each other.
4. When multiple inverters are stacked, the GS Load Center (GSLC) for each inverter can be wired together to serve as a common input conduit box and AC load center. However, the GSLC bypass switching assemblies are only sized for single inverters and cannot work in conjunction with each other. The GSLC bypass assemblies should not be used with multiple inverters present. (See page 8.) An external bypass assembly must be used instead. Larger external assemblies are available from other manufacturers.
5. Wiring colors shown here may be different from wiring standards.

**Figure 29 Three-Phase Wiring**

# Functional Test

Once the mounting, wiring, and other installation steps are completed, proceed to the *Radian Series Inverter/Charger Operator's Manual*. The *Operator's Manual* has steps for system commissioning. These include powering up and performing a functional test on the inverter system, as well as powering down and adding new devices to an existing system.

Refer to the *MATE3 Owner's Manual* for programming instructions and menus.

### When commissioning a grid-interactive system for use in Australia:

To meet the standard AS4777.3, the acceptance settings shall not exceed the following. The factory default settings meet these requirements.

**Table 4 AS4777.3 Acceptance Settings**

| Minimum Voltage | Maximum Voltage | Minimum Frequency | Maximum Frequency |
|---|---|---|---|
| 200 Vac | 270 Vac | 45 Hz | 55 Hz |

# Terms, Definitions, and References

## Definitions

The following is a list of initials, terms, and definitions used with this product.

**Table 5 Terms and Definitions**

| Term | Definition |
|---|---|
| 12V AUX | Auxiliary connection that supplies 12 Vdc to control external devices. |
| AC | Alternating Current; refers to voltage produced by the inverter, utility grid, or generator |
| AIC | Ampere Interrupting Capacity; the rated maximum current a circuit breaker can interrupt without damage |
| AGS | Advanced Generator Start |
| AS | Australian Standards |
| Communications manager | Multi-port device such as the OutBack HUB4 or HUB10, used for connecting multiple OutBack devices on a single remote display; essential for stacking inverters |
| DC | Direct Current; refers to voltage produced by the batteries or renewable source |
| DVM | Digital Voltmeter |
| FLEXgrid™ | Product technology which supports Grid/Hybrid systems |
| GFDI | Ground Fault Detector Interruptor; a safety device for PV systems |
| GND | Ground; a permanent conductive connection to earth for safety reasons; also known as Chassis Ground, Protective Earth, PE, Grounding Electrode Conductor, and GEC |
| Grid/Hybrid™ | System technology which optimizes both grid-interactive and off-grid options |
| Grid-interactive, grid-intertie, grid-tie | Utility grid power is available for use and the inverter is a model capable of returning (selling) electricity back to the utility grid |
| GSLC | GS Load Center; the wiring box for the Radian (GS) inverter |
| HUB | A line of OutBack communications manager products |
| IEC | International Electrotechnical Commission; an international standards organization |
| MATE3 | An OutBack system display, used for monitoring, programming and communicating with the inverter |
| NEU | AC Neutral; also known as Common |
| Off-grid | Utility grid power ***is not*** available for use |

**Table 5 Terms and Definitions**

| Term | Definition |
|---|---|
| PV | Photovoltaic |
| RELAY AUX | Auxiliary connection that uses switch (relay) contacts to control external devices. |
| RTS | Remote Temperature Sensor; accessory that measures battery temperature for charging |
| System display | Remote interface device (such as the MATE3), used for monitoring, programming and communicating with the inverter; also called "remote system display" |
| Utility grid | The electrical service and infrastructure supported by the electrical or utility company; also called "mains", "utility service", or "grid" |

# References

This product meets the following standards:

- IEC 61000-6-1 (EMC Standard: Immunity for Residential, Commercial, and Light-Industrial Environments)
- IEC 61000-6-3 (EMC Standard: Emissions for Residential, Commercial, and Light-Industrial Environments)
- IEC 61000-3-2 (EMC Standard: Limits on Harmonic Current Emissions)
- IEC 61000-3-3 (EMC Standard: Limitation of Voltage Changes, Voltage Fluctuations, and Flicker in Public Low-Voltage Supply Systems )
- IEC 62477 (Safety Requirements for Power Electronic Converter Systems and Equipment)
- AS3100 (General Requirements for Electrical Equipment)
- AS4777 (Grid Connection of Energy Systems via Inverters)

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