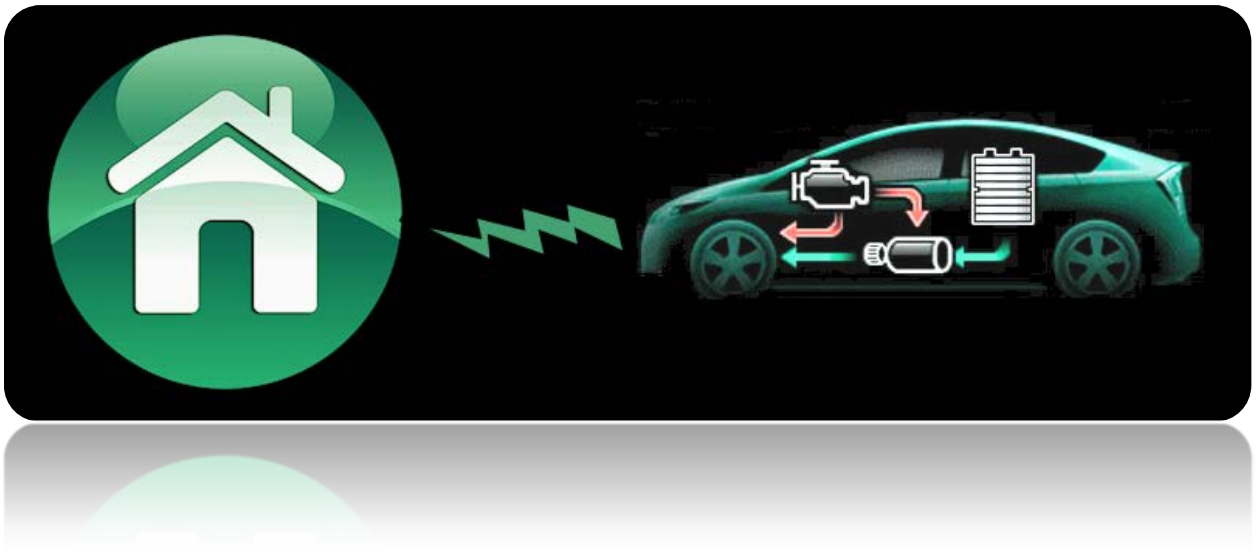
Prius 120VAC Inverter Installation Guide

Using the AIMS Power 240VDC/120VAC 2000W Pure Sine Inverter



This is a general guide for installing a DC-to-AC power inverter in a 2011 Gen III Prius. The inverter is powered by the car's traction battery[1] and provides 120V AC which can power refrigerators, freezers, microwave ovens, lights and other household equipment as long as the total inverter capacity is not exceeded. This guide describes the parts and materials I used and the steps I followed. The total materials cost, including a transfer switch, was about $800.

WARNING: ELECTRICAL SHOCK HAZARD!
Only personnel with experience and qualifications with high voltage electrical systems should perform this work.

Care was taken in developing this guide; however, it is not guaranteed to be complete or correct. This guide is not approved or endorsed by Toyota. Modifications described in this guide may void your vehicle's warranty. Links to internet sites are for general information only – the author is not responsible for the content of the referenced sites. Use this information at your own risk. Even if you perform this installation carefully you could still damage the vehicle and/or injure yourself. Use proper protective equipment, procedures, materials and tools. Test the system thoroughly after installation to ensure the safe and proper operation of all components. The author of this guide is not liable for personal injury or property damage resulting from this modification. Any injuries or damage resulting from this modification are the sole responsibility of the person(s) performing the modification and/or the individual component manufacturers.

Introduction

The high voltage traction battery allows a relatively high power inverter to be used – the small 12V Prius auxiliary battery can only safely power an inverter with about 1000W capacity.

[1] The Prius traction battery is also called the high voltage (HV) battery. It is NOT the 12V auxiliary battery!

A significant advantage of using the Prius to power an inverter is that the gas engine runs only when the traction battery needs to be recharged. The engine cycles on and off as needed to maintain the charge. This results in a very efficient backup power system as compared to a traditional gas powered generator which runs constantly regardless of load.

The computerized Prius battery management system does a fantastic job in preventing damage to the battery. The system keeps the charge level in the ~40% to ~80% range, thus use of an inverter is unlikely to damage the battery or shorten its life.

The inspiration for this was drawn from the great members of PriusChat. The following thread, started by AHetaFan, has a lot of detail on the inverter and many other considerations: http://priuschat.com/threads/my-install-and-review-of-the-aims-prius-2kw-pure-sine-wave-inverter-for-backup-power-generator.122948/. The advice of bwilson4web on PriusChat was also very helpful.

I chose to do a 'removable' installation - the inverter is not mounted in the car and uses a "quick disconnect" electrical fitting. You may want to install it differently so adjust wire lengths accordingly.

I have a traditional gas powered generator and had previously installed a transfer switch. I attached the appropriate connector to the inverter so I could feed the transfer switch from the inverter. Alternatively, you can omit the transfer switch/locking connector and run normal extension cords to the standard duplex outlets on the inverter. Unfortunately, this inverter does not provide split phase 240V AC, so any loads that require 240V AC can't be powered.

There are various YouTube videos that show the disassembly and removal of parts needed to access the traction battery terminals. I won't go into details here but will provide links.

WARNING – THE PRIUS TRACTION BATTERY IS POTENTIALLY LETHAL. USE EXTREME CAUTION WHEN CONNECTING TO OR WORKING WITH THE BATTERY OR ANY WIRING CARRYING BATTERY VOLTAGE!

Inverter

AIMS 240VDC-to-120VAC 2000W Pure Sine Inverter - http://www.ebay.com/itm/AIMS-Prius-2kW-Pure-Sine-Wave-Inverter-for-Backup-Power-Generator-/200841111789

A limited number of these inverters were made and many have the DC Negative (-) input shorted to the case. Fixing the short is relatively easy if you are comfortable working on electronics: http://priuschat.com/threads/my-install-and-review-of-the-aims-prius-2kw-pure-sine-wave-inverter-for-backup-power-generator.122948/page-7#post-1794223. If the case short is not fixed, there can be problems when the inverter case touches the Prius's body. AIMS will fix it under warranty.

Transfer Switch

Transfer Switch Kit - http://www.ebay.com/itm/Reliance-Control-31406CRK-6-Circuit-Portable-Generator-Power-Transfer-Switch-Kit-/370936559524

Fuse Holder

Qty 2 - Inline Fuse Holder - http://www.zorotools.com/g/00010589/k-G1222295/

Fuse

Qty 4 (includes 2 spares) - 15A Semiconductor fuse - http://www.zorotools.com/g/00067030/k-G3537256/
These are specially designed fuses to protect sensitive electronics – they are not traditional 'fast blow' or 'slow blow' fuses.

Connectors

Qty 2 - Anderson SB50 Connector with AWG #10/#12 Gauge Pins - http://www.ebay.com/itm/Anderson-SB50-Connector-Kit-Red-10-12-Awg-6331G2-/370753154988

Connector Cover

Qty 2 – Anderson SB50 dust cover - http://www.ebay.com/itm/DUST-COVER-FOR-ANDERSON-SB50-CONNECTORS-RED-NEW-/280487646544

Wiring Loom

12 feet x 1/4" diameter wiring loom from a local hardware store to protect wiring. *Orange colored loom could be used to be consistent with the Prius color scheme for high voltage connections, but it can be difficult to find*. You can mark the black loom with colored electrical tape at regular intervals if you like.

Crimping Tool

http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=181362072632

Connector

NEMA L14-30 Locking Female Connector (L14-30) - http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=281053055093

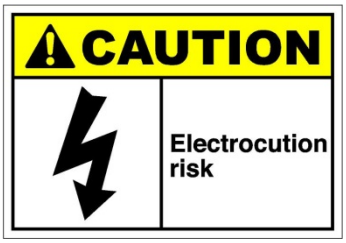
Generator Power Cable

10' generator power cable - http://www.amazon.com/Reliance-PC3010-Generator-7500-Watt-Generators/dp/B000HS2LBQ/

Miscellaneous materials and parts:

- A few feet of 10/3 (10 gauge 3 conductor) heavy duty jacketed power cord for connecting the NEMA locking female connector to the inverter. Use wire with stranded conductors.
- Note that the transfer switch can have the socket installed in the switch itself or remotely. If it is installed remotely, you'll need wire to run between the switch and socket. I ran 10/3 romex about 20 feet from the switch to the socket in my garage.
- 12 Gauge wire to connect the traction battery to the inverter. Since this wire carries 240VDC, ensure the insulation rating is appropriate. 12 gauge wires will safely carry 20 amps, and the inverter only draws slightly over 12 amps during at its 'surge capacity' rating. Use wire with stranded conductors. The inverter has an automotive style 20 amp fuse for the DC input as additional protection.
- Crimp-style terminals to connect the 12 gauge wire to the traction battery. I recommend using vibration resistant 3/8" inner diameter ring crimp terminals. 4 total are needed, 2 for the traction battery and 2 for the inverter.
- Nylon zipties and nylon cable clamps, electrical tape, heat shrink tubing. The cable clamps are used as strain relief for the wires connected to the inverter.

Installation:



Turn the car OFF. Remove the cargo floor panel and tray. **IMPORTANT**: Remove the orange battery safety disconnect plug (Figure 1): https://www.youtube.com/watch?v=N0cjxpS7KeY. Store it in a secure place. You may want to disconnect the 12V battery terminals as an additional safety precaution.

Figure 1 – Prius Battery Safety Disconnect Plug

Remove the parts to expose the traction battery terminals and install the wiring. **Double check that NO VOLTAGE IS PRESENT AT THE BATTERY TERMINALS by using a voltmeter.** This video by David Smith titled 'Toyota Prius Gen III Power Inverter Cable Installation to traction battery" is very helpful: https://www.youtube.com/watch?v=et9iS3Uwxmc. Fuse both the positive (+) and negative (–) wires that you connect to the traction battery. Work your way from the battery toward the back of the car, cutting the wires, insulating connections, putting the wiring in the loom and terminating as you go. The fuse holders take 12 gauge wire at their crimp terminals. Make sure you do a 'pull test' on your crimps! You can view https://learn.sparkfun.com/tutorials/working-with-wire/how-to-crimp-an-electrical-connector for some crimping tips.

I recommend marking the positive (+) fuse holder with red tape or fingernail paint. Put your wires into wiring loom and ziptie the loom to appropriate attachment points. Use high quality electrical tape and heat shrink tubing where appropriate, particularly on the ring terminal crimp connections and the fuse ends. **Be careful to route the wiring and loom so it won't chafe/rub on any sharp edges!** Terminate the wiring with the Anderson connector and tape off the connector ends. You can also inject hot melt glue into the Anderson connector ends prior to taping if you desire. I VERY CAREFULLY tested the wiring at this point by replacing the battery disconnect plug, turning the car on and checking that I had 240VDC with the proper polarity at the connector with a volt meter. I then turned the car OFF, removed the safety disconnect plug and replaced the panels, tray and cargo floor panel. Be sure to tape or otherwise insulate any exposed metal at the DC input thumbscrews on the inverter for safety.

I tested the setup by plugging two small space heaters directly into the inverter that drew about 1800 watts and ran everything for about an hour. I checked that the new wiring did not get warm. I then unplugged the heaters and connected the inverter to the transfer switch and powered the refrigerator and freezer and a few small lights for another hour or so. Everything worked fine.

It is important to have the car powered **OFF** <u>and</u> the inverter switched **OFF** when connecting or disconnecting the inverter to the traction battery cable. You can easily blow the semiconductor fuses if you have the car ON when making the connection. Note that the traction battery is automatically DISCONNECTED from the car's electrical system when the car is powered off ***which means there is no voltage present at the connector.***

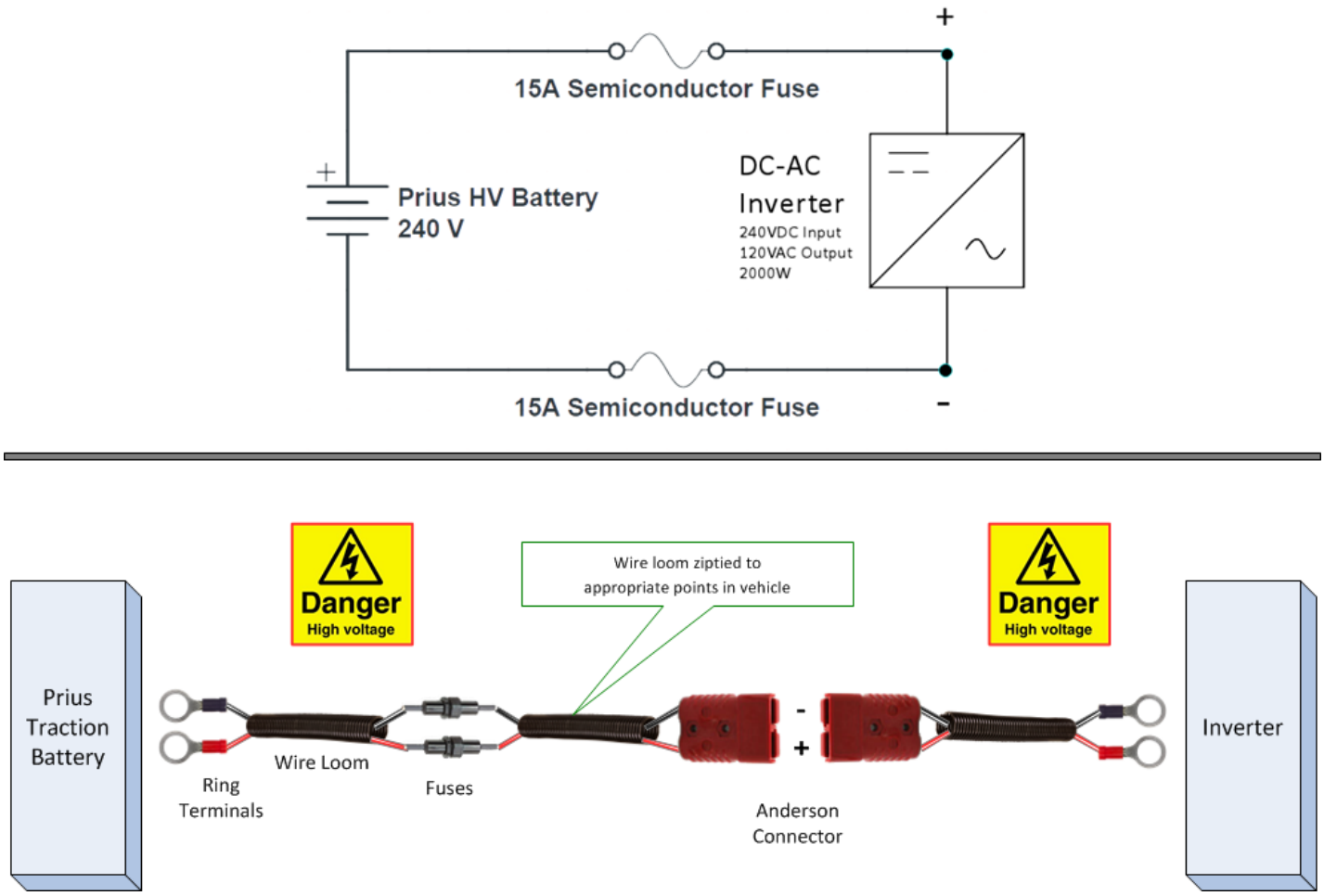


Figure 2 - The electrical schematic and the corresponding wiring harness to connect the inverter to the traction battery

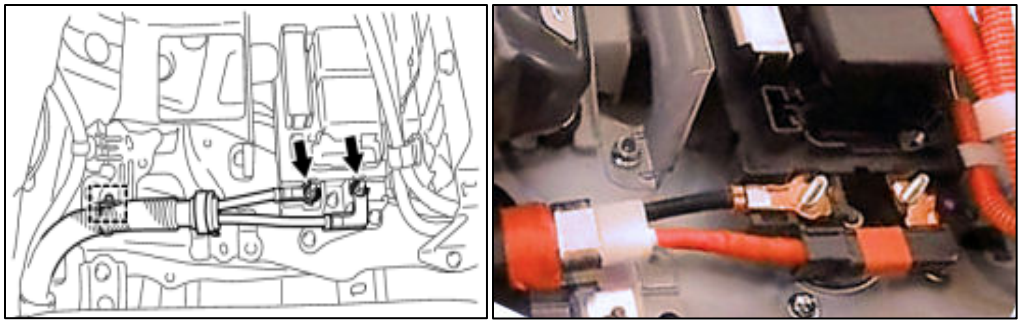


Figure 3 – The exposed traction battery terminals after removal of various panels and covers. ORANGE is the positive (+) terminal and BLACK is the negative (-) terminal. The wiring for connection to the inverter has not been installed in this picture, but the nuts on the connector (black arrows) have been removed. I installed the ring terminals ON TOP of the existing connectors and routed the wiring and loom alongside the existing cable and ziptied them together.

Figure 4 - Business end of the traction battery connection with the rear floor panels removed. Note the fuses (red stripe), capped Anderson connector and warning label. The 12V auxiliary battery is at the top right of the picture with the rear of the car to the right.

Figure 5 - Close up of the fuses split out of the wiring loom. The positive (+) wire is marked with red electrical tape.

Figure 6 - I laminated a clear luggage label tag as a warning label for the cable that connects to the battery and attached it securely to the cable.

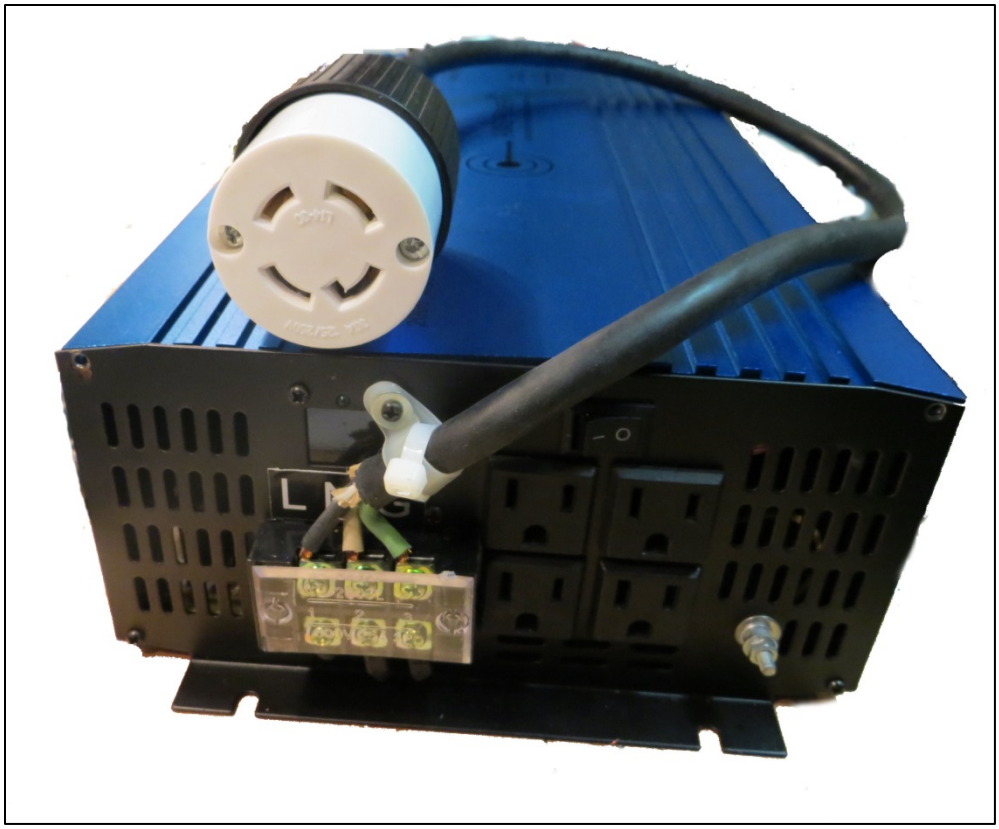


Figure 7 - 120VAC output side of the inverter showing the 'hard wired' connections. Note the cable strain relief and female NEMA connector. The cable is 10 gauge heavy duty power cord. The L (Line), N (Neutral) and G (Ground) labels on the inverter are partially obscured.

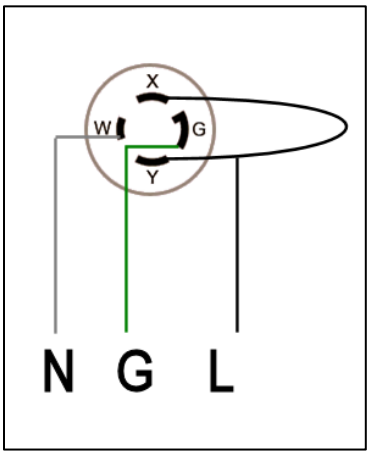


Figure 8 – NEMA Female Connector Wiring. In my installation, I jumped the **X** and **Y** terminals together within the connector to provide 120VAC to both legs (split phase) of the breakers in my transfer switch. On the connector, **G** is ground and **W** is neutral. **X** and **Y** are normally the hot wires for the split phase power. *Your installation may be different, so make sure you wire the socket appropriately.*

Figure 9 – The 240V DC input side of the inverter. Note the strain relief, wiring loom, taped thumbscrew terminals and taped Anderson connector. In the future, I will probably drill a hole in the end plate and make the connections inside the unit rather than using the thumbscrews/ring connectors.

Figure 10 - Inverter with red Anderson connector on the 240VDC input side (right) and the cable for connecting the 120VAC side to the transfer switch (left).

Figure 11 - A little difficult to see, but here is the inverter in use. The cable from the battery comes up from the lower right side of the picture and connects to the inverter. The inverter output on the left is connected to the cable that feeds the transfer switch.

Figure 12 - The socket in the garage for connecting the inverter to the transfer switch.

Figure 13 - Here's the transfer switch (gray box on left) wired to the home's electrical panel. The black cable exiting the right of the transfer switch runs to the socket in the garage.

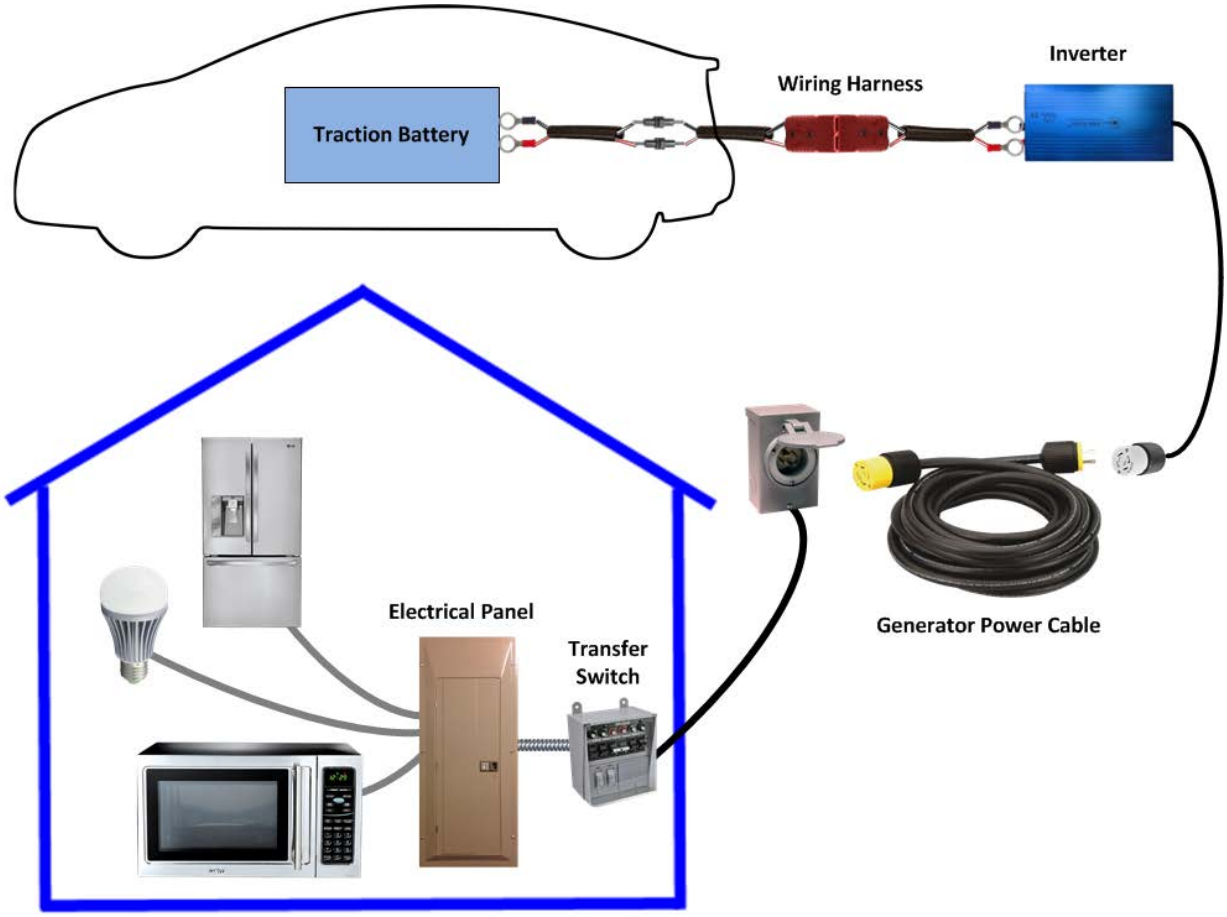


Figure 14 - Overview of the connections

Summary

The inverter runs a refrigerator, furnace fan, and several lights simultaneously without any problem. It should also easily be able to run a small window air conditioner, so in a power outage in the summer, it could come in handy.

Another advantage of having a 'generator on wheels' is the ability to drive to where you need to provide power. You can assist your family, friends and neighbors during power outages by keeping their refrigerators running to prevent food spoilage, recharging battery backed-up medical devices, keeping medications chilled, powering cell phones, cooking food in microwaves, running small heaters, small air conditioners, etc.

Guide by tgtech

Please visit http://PriusChat.com for more guides, tips and other information about your Prius.

Figure 15 - Here's the interior of the inverter. Nice build quality by AIMS.

AIMS 2000 WATT 240 VOLT PURE SINE POWER INVERTER
Model: PWRI2000S240VDC

FEATURES

- 2000 Watt Continuous Power
- 3000 Watt Surge Power
- Compact And Lightweight
- Dual AC Receptacles
- On/Off Switch
- Low Battery Voltage Warning / Shutdown
- Over Temperature Indicator
- Overload Protection
- High Input Voltage Protection With Automatic Shutdown
- Overload Indicator
- Cooling Fan Thermally Controlled
- AC Output Short Circuit Protection

SPECIFICATIONS

- DC Input / Operating Voltage: 180-260 VDC
- Output Voltage: 120 Volts AC
- Output Voltage Regulation: ± 3%
- Output Frequency: 60 Hz
- Battery Low Voltage Alarm: 180 VDC
- High Battery Voltage Shutdown: 250 VDC
- No Load Power Consumption: < 0.02 Amps
- DC Amps – 9A
- AC Amps – 17A
- Full Load Efficiency: 90%
- 1/3 Load Efficiency: 95%
- Ambient Operating Temperature Range: 32° - 104° F
- AC Output Socket Type: Dual Type 2-3 Prong (total of 4 sockets)
- High Input Voltage Protection: 280 VDC
- Low Input Voltage Shutdown: 170 VDC
- Internal Blade Fuse Protection (20A)
- Dimensions: 18½" long x 8¼" wide x 4" high
- Weight: 15 Lbs

Free 1 Year Tech Support

1 Year Warranty Parts and Labor