Prius as a Back-up Power Source
(How I added an inverter to my 2005 Prius)

I've read about other Prius owners (www.priups.com) connecting a sophisticated inverter to the 201.6 VDC (nominal) traction batteries and getting a significant amount of power from their car.

But my needs were as follows:

- Connect only to the 12 VDC Prius battery for simplicity, and to avoid any warranty related issues related to connecting to the traction batteries.
- Keep my AC power requirements minimal: my home's refrigerator (I don't want to lose my food during an extended power outage), the DSL modem, my Macintosh, and a couple of lamps with compact fluorescent bulbs.
- Make it removable, and all the connections "invisible".

So, the first task was taking some measurements of the 120 VAC appliances I'd like to run from the Prius to see if its 12 VDC system was up to the task. I used a "Kill A Watt" power analyzer (available from many sources on the web) for the larger loads and the nameplate data for the smaller loads.

Appliance	Amps Inrush	Amps Continuous
Refrigerator	8.0	1.7
DSL Modem/Router	0.63	0.63
Macintosh	1.6	1.2
2 Compact Fluorescents	0.24	0.24
Totals	10.47	3.77

What power can the Prius Deliver?

From the 2005 Prius Repair Manual (RM1130U), page 05-487: "The DC/DC converter converts the DC 201.6 V of the HV battery into DC 12 V in order to supply power to the vehicle's lighting, audio and ECU systems. In addition it charges the auxiliary battery". Also from the 2005 Prius Repair Manual (RM1130U), page 03-24: "Converter Operation; Output current; Approximately 80A or less".

Thus, the DC/DC converter can provide 12 VDC at 80 Amps or less to recharge the 12 VDC auxiliary battery; which is where I want to connect the inverter. But, what are the specifications on the 12 VDC battery itself? The 12 VDC battery in my 2005 Prius is a GS brand, part number 46B24R; rated at 45 Amp-Hours for 20 hours, and 330 Cold Cranking Amps.

Thus, I should never draw more than 80 amps continuous from the Prius 12 VDC auxiliary battery, but for brief moments (inrush) I can draw much more (330 Amps!).

Selecting the Inverter

I then began researching 12 VDC to 120 VAC, 60 Hz inverters. As I wanted to run my Macintosh from the inverter, I wanted very clean power; thus I decided a "pure-sine wave" inverter was my choice. Additionally, with "pure-sine wave" power, the refrigerator motor would operate cooler and more efficiently than with the more common and cheaper "modified sine-wave" inverter.

In order to efficiently draw 80 amps from the 12 VDC battery, I chose 2 AWG cables. With only about 84" of total cable length, there still is a calculated loss of about 7.2 watts in the cables.

80 amps x 12 VDC =	960 Watts maximum continuous from the battery
Cable loss =	7.2 Watts
Power to the inverter =	952.8 Watts

With a typical inverter efficiency of 90%; the output from the inverter is 857.5 Watts. Thus, **the maximum continuous AC power I can draw from the inverter is 7.1 Amps at 120 VAC**.

According to my chart above, I require 3.77 Amps continuous; therefore the Prius can deliver what I need.

With the above data, and a bit of internet research, I bought an:

Aims Power, Pure Sine Wave Inverter, part number PWRI100012S
1000 Watt continuous, 3000 Watt surge
$359.00 delivered (www.invertersrus.com, or www.theinverterstore.com)

The Prius 12 VDC battery, with its surge capacity; and the Aims Inverter, with its surge capacity; can easily handle the 10.47 Amps of surge current required from my chart. But, if I simply never turn all my loads on simultaneously; I avoid the high amp surges altogether.

Fusing the system

For protecting the DC/DC converter, the Prius has a very fancy looking (probably very expensive) 100 Amp fuse in the fuse box in the engine compartment. I never want to pop or blow this fuse! Thus, I need a new fuse from the Prius 12 VDC battery to the inverter, sized so the new fuse will blow before the Prius 100 Amp fuse even thinks about blowing.

Cooper-Bussmann makes a series of fuses specifically designed for low voltage DC applications such as this. By studying the trip-curve data, I selected an ANL40 fuse. I know you are thinking this fuse sounds too small, but fuses are not a perfect science, and thus the specifications show an *average* time-current characteristic or a trip range. Some fuses might blow at the low end of the range (143% of the fuse's rated current), and some might blow at the high end of the range (250% of the fuse's rated current).

The Cooper-Bussmann fuses are often quite expensive [the ANL40 is $28.20 from Granger Industrial Supply (www.grainger.com)]. A more economical choice is the ANL40 from Blue Sea Systems (www.bluesea.com, a marine supply manufacturer), at $12.00. I spoke a Blue Sea Systems engineer, and he confirmed that their fuses are equivalent to the Cooper-Bussmann product.

Blue Sea Systems, ANL40 fuse, $12.00 (+shipping)
Blue Sea Systems ANL Fuse Block with Cover, $19.00 (+shipping)
From www.northeastmarineelectronics.com

Disconnecting
I wanted the inverter to be removable, thus I needed a way to disconnect it from the Prius 12 VDC battery. The solution was "Battery Charging Cable Connectors", or these are often called *Anderson* connectors (by Anderson Power Products). The yellow plastic shell designates 12 VDC, and as the smallest connector that comes with a yellow shell is 175 Amps, I chose that connector.

From McMaster-Carr (www.mcmaster.com)
175 Amp, 2 gauge, 2 contacts, yellow; part no. 7043K23; $11.81 **x 2** (+ shipping)
Cover for 175 Amp connector; part no. 7043K16; $6.25 (+ shipping)
Heat-Shrink Tubing, ¾", adhesive-lined; part no.8195K25; $6.53 (+ shipping)

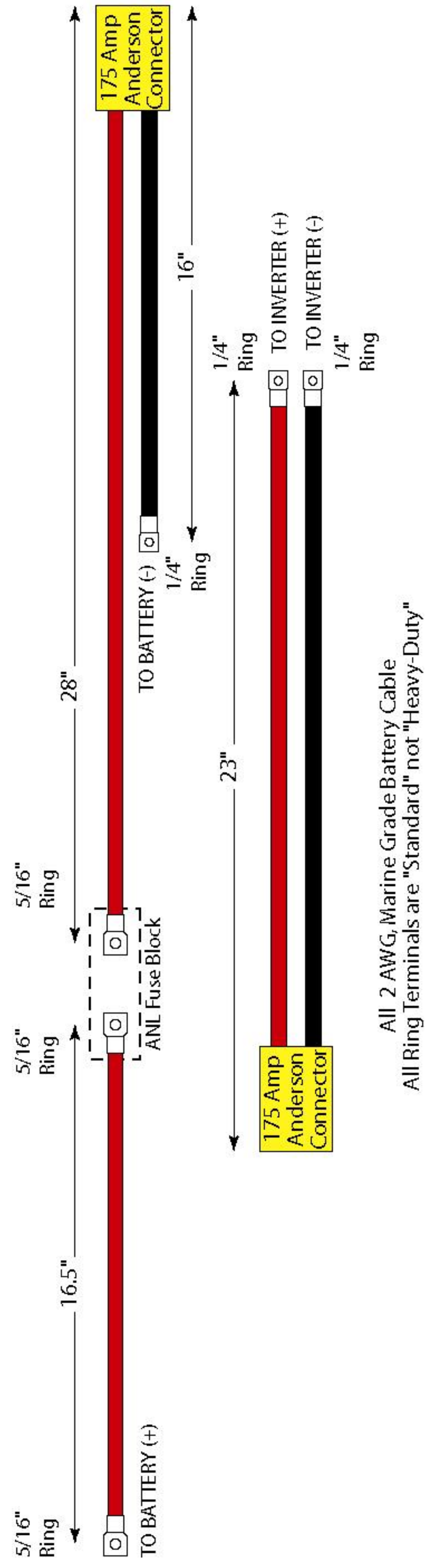
Cable Assembly
As the boating industry does a lot of work with battery based systems, your local marine supply store or boating supply store should have: heavy duty battery cables, the associated ring terminals, and the crimping tool needed for assembly.

I visited a local marine supply store, and as I purchased the raw 2 gauge cables and the crimp-on ring terminals from that store, they were more than happy to let me borrow their crimping tool. A crimping tool is also required to crimp the *Anderson* connector contacts to the cables. I also put ¾" heat-shrink tubing over the connections.

2 gauge battery cables and ring terminals, $56.80

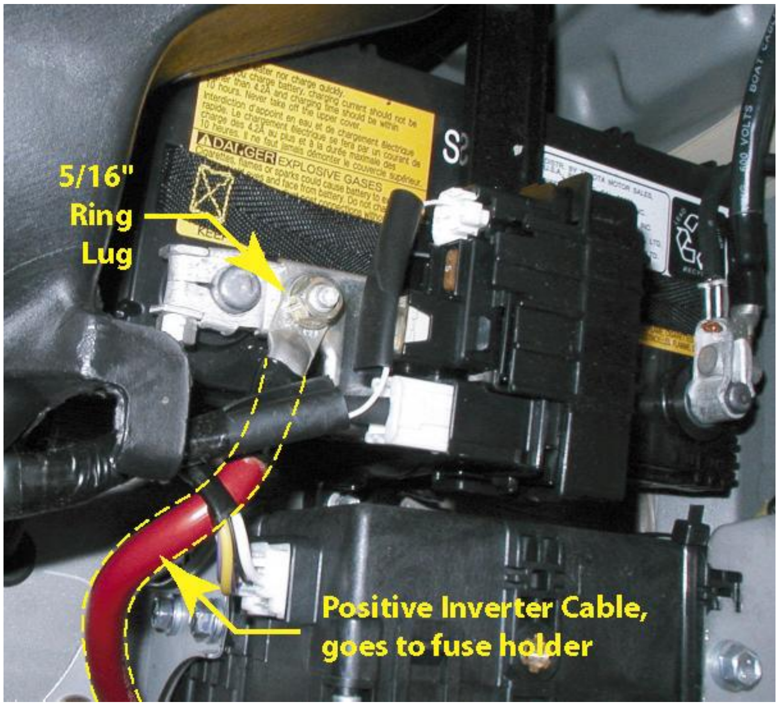
Final Assembly
The positive 5/16" ring terminal connected to the positive terminal of the battery, and at the other end of that cable the other 5/16" ring terminal connected to the ANL Fuse Block. From the ANL Fuse Block, a 5/16" ring terminal connected the positive side of the *Anderson* connector. The ANL Fuse Block was attached with two screws to the Prius body. The negative side of the *Anderson* connector ends in a ¼" ring terminal, which connected to the negative side of the battery. The mating *Anderson* connector was connected to the inverter with ¼" ring terminals.

Below is a diagram of the cable lengths.

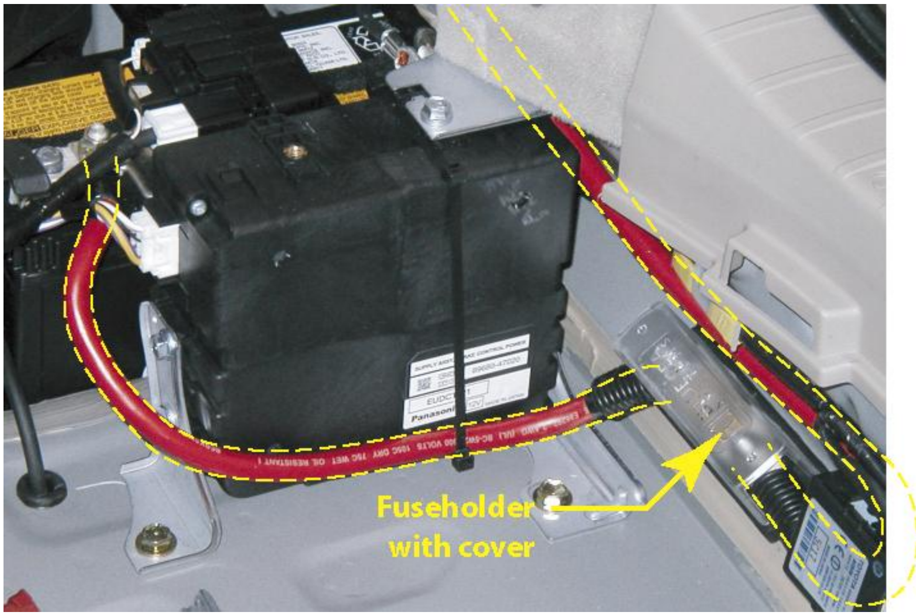

175 Amp Anderson Connector
16"
28"
TO INVERTER (+)
TO INVERTER (-)
1/4" Ring
1/4" Ring
TO BATTERY (-)
1/4" Ring
23"
All 2 AWG, Marine Grade Battery Cable
All Ring Terminals are "Standard" not "Heavy-Duty"
5/16" Ring
ANL Fuse Block
5/16" Ring
175 Amp Anderson Connector
16.5"
TO BATTERY (+)
5/16" Ring

The *Anderson* connector is just behind the right-rear access cover. Note the black "dust cover" for the end of the *Anderson* connector (on a retention cable). Also, a rectangle of foam rubber is wrapped around the *Anderson* connector to minimize any rattling noises

A view of the Prius 12 Volt battery, with the Negative cable attached



The Red Plastic (+) terminal battery cover is removed for clarity,
with the Positive cable attached



The Positive cable and the fuseholder

The Inverter is mounted to a plywood support frame

A spare fuse hangs from the back of the plywood support frame

The plywood has threaded insert. A bolt with large washer, screwed through the Prius D-ring holds the inverter in place

A tie-down strap between another Prius D-Ring and a screw-eye in the plywood, also secure the inverter in place

Mounted on its side, the inverter takes up minimal cargo space.

As planned, the cargo cover hides the inverter from view.

Earth Ground

As with any 120 VAC electrical device, the inverter needs an earth ground so if something goes wrong, a person does not get electrocuted.

In the *Aims Power* inverter: the chassis of the inverter, the female ground "hole" in the 120 VAC outlets, the neutral "slot" in the 120 VAC outlets (i.e. the larger slot), and the negative DC input connection point; ARE ALL COMMONLY CONNECTED TOGETHER. Thus, earth grounding becomes very important, as you are also earth grounding the Prius (via the negative DC input connection point).

While using the Prius as a back-up power source, the Prius will be outside (of course), and I will bring the 120 VAC power into the house via heavy duty, grounded extension cords. Thus, I built a very simple grounding device as a very short extension cord, which has a grounding wire that simply plugs into the wall, thus grounding the entire "Prius Power System" system to the house's earth ground.

Simple grounding device

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