Our 2001 Honda Insight Project - From Dead Hybrid to Plug-In Hybrid

This is a photo of "Lulu", the 2001 Honda Insight Hybrid with 275,000 miles on it which we purchased for $1000 from a neighbor. I helped him find this car 7 years ago, when it was for sale nearby. At that point the IMA (Integrated Motor Assist) system that makes it an electric hybrid was failing occasionally, requiring a "system reboot" that involved disconnecting the 12-volt accessory battery. The second owner, our neighbor, continued to drive it and was happy to be getting an average of 50 mpg without bothering to reset the hybrid system. His biggest complaint was a marked lack of acceleration (27.5 % less, like a 4-cylinder losing one) without the extra torque boost from the electric motor. After reading online comments about the widely available "Grid Charger" that was supposed to cure most of these traction battery problems, and after waiting over two years since paying $1000 to reserve an 84 mpg (highway; 49 mpg city) Elio Motors 2-seater trike, we decided to replace our aging rust-bucket '99 Chevy Metro.

Our first purchase for the Honda was new tires all around. Since the 165/65R14 that are standard for this car are so hard to find, expensive, and have such poor longevity, we switched to easily found, far cheaper, and longer-lasting 175/65R14 radials that are 0.4 inches wider and 2.28% larger in circumference, adding 0.25" to the car's ground clearance. We take that into account when calculating speed and mileage.

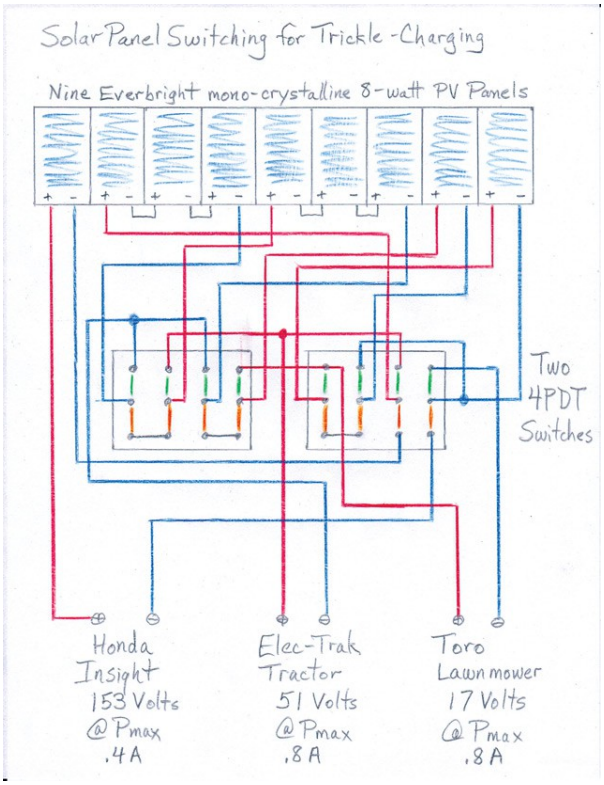
Next I bought a valve cover gasket and adjusted all 12 noisy valves. We also changed the oil (which had always been and will continue to be fully synthetic 0W-20) and the filter, and we changed the synthetic transmission fluid, which hadn't been done in the 7 years our neighbor owned the vehicle.

Battery rejuvenation was on the list next. Even though the IMA system would function normally in town, shutting off and restarting the engine at stop signs and adding a bit of boost on acceleration, we could tell that it was still quite sluggish. The battery level would rise to 100% quickly and drop just as quickly to nearly nothing, indicating really poor capacity. We tried driving the car up a mile+ hill with

nearly 15% slope a few times, and without a fully functional battery assist it involved downshifting into second gear and "flooring it" about halfway up the hill just to maintain the posted speed of 40 mph. The battery level gauge would indicate nearly zero and the "IMA" warning light would come on at the top of the hill, shutting down any of its functions. But spending over $350 for a Grid Charger didn't sit right with a couple who have been living off-Grid with solar (and sometimes wind) electricity for nearly 35 years.

So we purchased some PV (photovoltaic) panels on E-Bay that would do the same low-intensity charging that was advertised for the Grid Charger. The little 8-watt Everbright monocrystalline panels are shown mounted above a Kyocera KC-120 that normally charges our 12-volt electric mower.

I started with 8 panels, wiring them to a switch-box that allowed the panels to either charge the Honda at a very high voltage that matched its battery pack, or could switch it to trickle-charge both our 12-volt mower and our old 36-volt G.E. Elec-Trak electric garden tractor. Here is the wiring diagram:



The red wires indicate positives, the blue negatives, the orange connections in the switches are for the Honda, and the green connections are for the tractor and mower. Although it looks rather complex, adding two 4-pole, double-throw (4PDT) switches didn't add much expense. We simply flip the two switches up to charge the Honda, mid-position is OFF, and down for the tractor and mower. Care must be taken to plug the respective charge cords into their destinations before operating the switches, since handling a live DC source above 50 volts could be fatal! You'll note that there are now nine panels on the rack instead of eight. We added another panel after finding that the voltage sag that always happens with PV panels in hot weather dropped the voltage too low to effectively charge the Honda's traction battery. It can now reach about 196 volts under no load, and typically 180+ volts when charging.

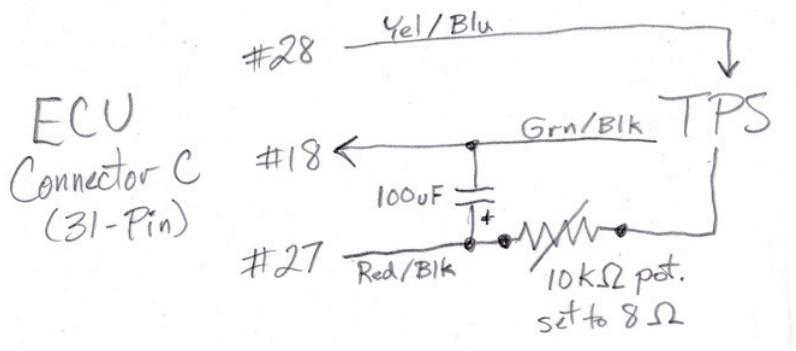
This shows the area above the rear license plate where power enters the car. I used the instructions found on this Grid Charger website to wire into the Honda's pack, adding a separate 12-volt connection to its battery fan. The same 240-volt, 20-amp high-voltage jack is used to operate the battery discharge devices that remove the "memory effect" from the 120, D-cell-sized, NiMH (nickel metal hydride) cells that comprise a traction battery. Trickle-charging the pack above 172 volts fully "tops off" all of the cells, balancing the pack. A combination of three full, slow-charge and progressive, slow-discharge cycles (eventually down to 12 volts) is the recommended process to eliminate the "memory" of the cells and bring back the full capacity of the pack. While waiting for sunny days can slow the process a bit, this set-up still got the job done. The next photo shows the right rear of the interior, where the pack voltage can be monitored, where an external 12-volt source (our house) can plug into the battery fan, keeping all of the cells cool during overcharge, and where the battery can be switched ON or OFF for

both charging and for normal operation of the car. We keep the car charging between uses, since we typically drive only once each week, making the Honda now a plug-in hybrid.

I simply carved a space for a high-voltage rocker switch in the plastic vent cover and routed the 12-volt fan cord (line switch and white connector) and traction battery monitor cord (red) through the vent face. The meter shows a resting voltage (no charge or discharge) of 165.1 volts DC.

The next project involved adding an IMA reset switch to the lower left dash area. Removing an optional switch cover left room to mount a rocker switch that is used to interrupt fuse #18 under the dash. With the car off, we simply toggle the switch to cut power to the IMA computer for 10 seconds, resetting any error codes. The traction battery will cause an error code if even one of the 120 cells overheats or drops low in voltage. If/when a error code crops up we can now conveniently correct it.

Finally, we added a "throttle smoothing circuit" to the wires between connector C (a 31-pin connector, third from the left as you look at the unit) of the engine computer (ECU) under the passenger floor mat and the throttle position sensor under the hood. This keeps the ECU from seeing those inevitable ripples of movement that the driver's foot makes when hitting bumps, etc. By smoothing the input to the computer, the car goes more readily into the famous Honda "lean-burn" mode, keeping highway mileage as high as possible. Where normal fuel/air ratios are around 14:1, lean-burn can cut that fuel consumption rate in half. Of course, adding a cruise control unit could work the same way, but this wasn't a factory option on 5-speed models, and even those controls could introduce some throttle flutter. The circuit diagram follows:



The change in the IMA system, and the overall car performance, both in acceleration and mileage, has been enormous. The battery level gauge is now often nearly full and never empty, even after climbing a steep, long hill. The acceleration from corners is dramatically better. The average mileage has jumped from about 50 mpg to over 60, even on fairly short drives. And that big hill that used to kill the IMA system can now be climbed at 50 mph in third gear, in mid-pedal position, with two passengers and 100 pounds of baggage, showing battery assist all the way up the hill. In technical terms, with the IMA system working we gained only about 9% in horsepower but a whopping 38% in torque. I don't know if we have achieved anywhere near the full factory battery capacity of 6.5 amp-hours, but the results, so far, are FANTASTIC. If the Elio vehicle ever comes into production we'll still get about the same average fuel economy, perhaps a bit better. But we'll also have a brand-new car with a brand-new engine instead of a very high-mileage, highly economic plug-in hybrid. We'll see.

Now that we could easily recondition a Honda hybrid battery pack (at least the 2000-2006 Insights and 2003-2005 Civics), we tried the same process on two other packs. The third one is currently undergoing the process, but driver's reports on the second pack are glowing. He went from around 50 mpg, and a car that threw IMA error codes about every 5 miles, even in flat terrain, to 63+ mpg in a recent 65 mile trip. During one flat 12-mile stretch he reached over 72 mpg. The only complaint was "whiplash" from the added torque. His next report will involve some tries at "hyper-miling", where he attempt to stretch the mileage even further by driving at inconstant speeds, much like a cyclist, taking advantage of downhill stretches and cutting throttle a bit on uphill ones.