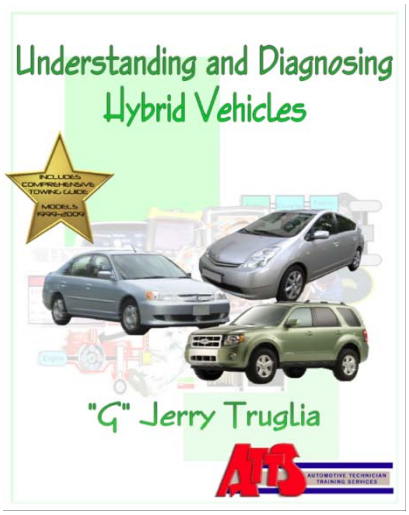
Preparing For Hybrids

Are you ready to work on hybrid vehicles? Don't fear working on these electrical machines since they are not really hard to diagnosis and repair. With almost every vehicle manufacturer producing a hybrid vehicle its time you get into diagnosing and repairing these vehicles.

In this article we will cover what you need to succeed in diagnosing and repairing hybrid vehicles. Here is what you will need to be successful, safe and make money. I suggest some good training, information, internet access, scan tools, insulation tester/megameter, labscope, amp clamp and safety equipment. Make sure you understand what is needed before attempting any diagnosis or High Voltage (HV) repairs on hybrid vehicles. Precautions must be taken before attempting to diagnose or repair any component that has orange or blue high voltage wires connected to it.

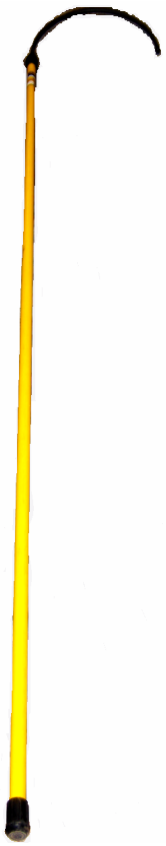
Let's get started with the most important information for you to be successful, profitable and safe.

• Training is very important since it will provide you with safety and repair information that you will need to diagnose and repair hybrid vehicles. I suggest that you attend a good hands on class that will allow you to experience using different information systems, equipment, factory and aftermarket scan tools, meters, scopes to name a few. The question is how do you know its good training or just hype? There is always someone out there telling you "they're the best" and then when you go to their class it's less than you paid for. I suggest that you do your homework and check around before you spend your hard earned money. Some hands on training providers that I can attest to that do a good job are Automotive Technician Training Services (ATTS) with me G Truglia, (Fig 1) Delphi with Dave Hobbs, and Automotive Research and Design with Dr. Mark Quarto. Technician BEWARE, be careful when selecting a training class especially when they cost around $1500.00 or more.



• Safety gloves that must be rated for 1000 volts/Class "0" with covers cost about $110.00 or so and should be tested when the gloves may have been compromised or the date that is stamped on the gloves is expired. Your life and family depends on these gloves as well as other safety equipment. Cost for recertification is approximately $25.00 and turnaround time is a few days. Always wear these HV (High Voltage) gloves (Fig 2) when working on any high voltage part of the vehicle or until the high voltage has been disabled. Caution, the HV

battery always has power, just like a flash light even when the switch is off the batteries (if good) still have voltage. Make sure to check the HV gloves covers (outer leather covers) for any cuts or holes flowed by checking the HV gloves for pinholes by using the roll up test (capture air in the glove while rolling it up). In my opinion if you think the glove has been compromised send it out to be professional test rather than risking it.



• It always a good idea to wear safety goggles to protect your eyes.

• You will also need this funny looking yellow pole to the left that is called a "pull pole" or "rescue pole" (Fig 3) that is a must to have in a shop that is working on hybrid vehicles. What's it for? It's an insulated hook that's used to pull someone that is being electrocuted off the high voltage vehicle he/she is working on.

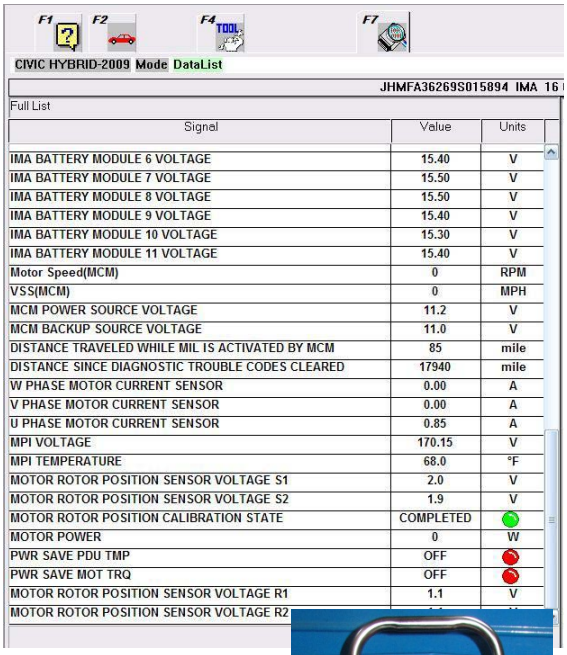
• Make sure to clock (Fig 4) the wheels since many hybrids are silent and will move without making any noise. Think of it as a golf cart, silent. Install wheel chocks on a minimum of one wheel to prevent vehicle movement.

• Use a Megameter insulation tester to test cables and electric motors. The meter reads Ohms from 0.01 MΩ to 2 GΩ and performs insulation test with 50, 100, 250, 500 (default), and 1000 V source. Use a CAT III (Fig 5) certified DVOM on ALL cables, capacitors and high voltage batteries—other meters are not built to do the job while protecting you.

• Make sure that you have a labscope that can handle the high voltage. The labscope scopes that can handle the HV voltage are Fluke, (Fig 6) EScope with special CAT III leads and PICO also with a special lead kit.

• Scan Tools
Besides a good aftermarket tools such as; OTC Nemisys/Genisys/Pegisys,

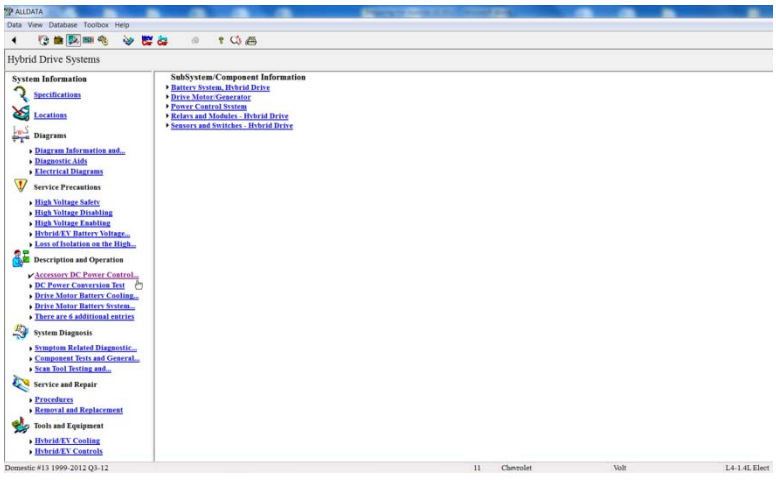
or, Snap On Solus/Modis/Verus, dealer level tools such as the GM Tech2/MDI, Ford IDS, Honda HDS (Fig 7) and Toyota Techstream to name a few. These tools will provide you with important information such as battery per module voltage, motor generator output and bi-directional control to name a few.



Signal	Value	Units
IMA BATTERY MODULE 6 VOLTAGE	15.40	V
IMA BATTERY MODULE 7 VOLTAGE	15.50	V
IMA BATTERY MODULE 8 VOLTAGE	15.50	V
IMA BATTERY MODULE 9 VOLTAGE	15.40	V
IMA BATTERY MODULE 10 VOLTAGE	15.30	V
IMA BATTERY MODULE 11 VOLTAGE	15.40	V
Motor Speed(MCM)	0	RPM
VSS(MCM)	0	MPH
MCM POWER SOURCE VOLTAGE	11.2	V
MCM BACKUP SOURCE VOLTAGE	11.0	V
DISTANCE TRAVELED WHILE MIL IS ACTIVATED BY MCM	85	mile
DISTANCE SINCE DIAGNOSTIC TROUBLE CODES CLEARED	17940	mile
W PHASE MOTOR CURRENT SENSOR	0.00	A
V PHASE MOTOR CURRENT SENSOR	0.00	A
U PHASE MOTOR CURRENT SENSOR	0.85	A
MPI VOLTAGE	170.15	V
MPI TEMPERATURE	68.0	°F
MOTOR ROTOR POSITION SENSOR VOLTAGE S1	2.0	V
MOTOR ROTOR POSITION SENSOR VOLTAGE S2	1.9	V
MOTOR ROTOR POSITION CALIBRATION STATE	COMPLETED	
MOTOR POWER	0	W
PWR SAVE PDU TMP	OFF	
PWR SAVE MOT TRQ	OFF	
MOTOR ROTOR POSITION SENSOR VOLTAGE R1	1.1	V
MOTOR ROTOR POSITION SENSOR VOLTAGE R2		

• High Voltage battery tester and charger is something you will want to invest in. We all realize that hybrid vehicles are getting older, just like us. They both have something in common as the both get older, problems develop. High Voltage batteries have a problem with holding there charge level and holding the battery pack balanced. There are a couple of ways to go forward in this area. One is to purchase an inexpensive battery load tester (Fig 8) and a good battery charger, (Fig 9) such as the Associated Intellamatic. This is what I use to load test the HV batteries and recharge them. I also use a temperature gun and small cooling fan to make sure the batteries do not get too hot. Total cost less of all the equipment that I use is about $1000.00. The other more professional way is to use the Battery Pack Power and Energy Tester that is built by Dr. Mark Quarto. The price for this unit is about $11K or so that provides graphs while loading and charging the HV batteries.

• Information is something that you need to make a successful diagnosis and repair. I start with AllData (Fig 10) since it has an in depth deal of information and an explanation that provides critical information. Identifix, Iatn and Google are also other good sources that might help you. When you have exhausted the pre-mention resources go to www.NASTF.org and click on the OE website for the vehicle that you are working on.



Safety Warning: Remember, high voltage orange or blue cables run under hybrid vehicles from their engine compartment to the rear of the vehicle. BE AWARE! Setting the lift wrong can do major damage to the HV system.

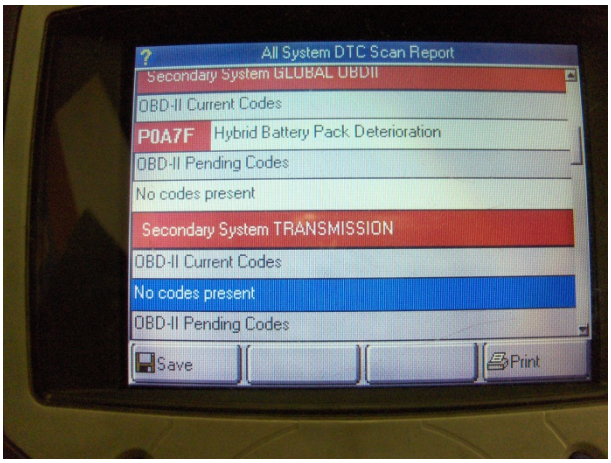
Some common problems that you may encounter in the shop are;

Tires should be rotated every 5,000 to 6,000 miles, make sure that the correct tires that are made for hybrid vehicles are installed on the vehicle. A common mistake that is installing the wrong tires (non-low rolling resistance tires) that causes fuel mileage to suffer. When you are checking the tires you can also check the brakes looking for signs of rust on the front and back of the rotors. Rusted rotors are common since the pads are not used all that much do to regenerative braking. It's a good idea to clean up the rusted rotors with a sanding disk and check the brake hardware for rusting, clean and lubricate as necessary.

On Ford/Mercury/Mazda (Escape style vehicles hybrids) check the rear HVAC air filter that is located on the left rear pillar, a dirty filter can cause hybrid problems. Also make sure the AC system is working properly since on these vehicles from vehicle year 2005 to 2009 the AC is very important since it cools the HV battery pack and computers.

Case Studies;

The vehicle is a 2009 Honda Civic Hybrid with 35495 miles where the customer was complaining of low power, poor mileage and poor performance. The first thing I did was interview her, asked if this was something that just happened, was it on flat or hilly roads, temperature effected, did she notice the HV battery level and where any dash lights on. The answers to all the question was yes, so I connected my scan tool and scanned the vehicles computers. The result was a P0A7F (Fig 11) DTC, Battery Module Deterioration was set for the illuminated IMA (Integrated Motor Assist) being displayed. Having come across this DTC before, I knew that there were multiple fixes so I checked AllData for TSBs to see which one may apply. The one I found recommended reflashing the MCM (Motor Control Module) and maybe replacing the HV battery pack. I proceeded to install the new software and perform a HV battery charge/rebalance. There are a couple ways to perform the charge/rebalance of the HV battery pack. The rebalance can be easy or hard to perform so I chose the easiest first which involves either using your scan tool or on some vehicles removing the fuse that powers the MCM. The other method is more involved that requires removing the battery pack and discharging each sticks and recharging them. The discharger cycle helps isolate and identify the weakest



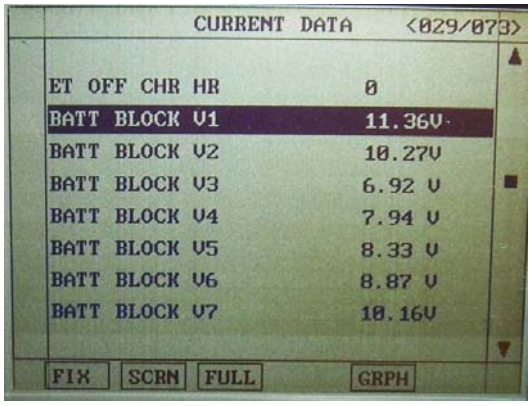
sticks that will need to be charge and discharge multiple times. Needless to say you need special training and equipment to perform this procedure. I decided to go with the easy charge/rebalance especially since this vehicle had low mileage and at the time was only a year and a half year old. Remember never over complicate any diagnosis or repair, if you can use a shovel to dig a ditch why are you using a backhoe to do the job. The same is true on this hybrid diagnosis and repair. I knew that if the owner when back to the dealer, the dealer would try the easiest repair first, a reflash and HV charge/rebalance of the battery pack. The dealer would most likely change the HV battery only if the easy HV charge/rebalance did not work. FYI, dealers do not open, take batteries apart or replace bad battery sticks.

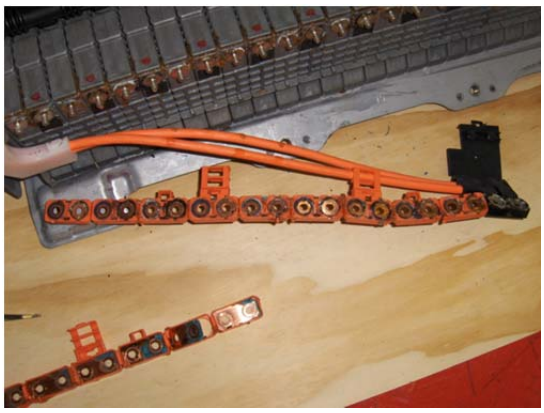
To fix this problem I proceeded to reset the MCM (Motor Control Module) in order to reset the battery pack memory. My next step was to race the engine up to 3500 rpms until the HV battery meter on the dash reached the full mark. Once the battery reached the full mark I did the same reset procedure to the MCM 2 more time before taking the vehicle for a test drive. That‘s all it took to fix this problem Honda hybrid and make the customer happy.

Our next problem vehicle was a 2008 Ford Escape 4X4 Hybrid with 89296 on it and a warning message of "HIGH MOTOR TEMPERATURE" - "STOP SAFELY NOW" (Fig 12) on the odometer display. The owner of this vehicle was driving along normally when he noticed the vehicle slowing down due to a power loss. The dash was lit up with a MIL and a Red Triangle along with the messages in the odometer display. His next step was to move the vehicle off to the right of the road and shut the engine off. The vehicle owner opened the hood, check all the fluids and found nothing abnormal. He then tried to start the engine up but nothing happened. Remember on this vehicle the engine is started by the hybrid Motor Generator, MG for short. He thought that the in High Voltage shut off switch might have tripped but it did not. The High Voltage shut off switch (Fig 13) is just like the Ford fuel pump Inertia switch. The purpose of the High Voltage switch is to shut the power if the vehicle was involved in an accident. After checking all the pre-mention enough time went by allowing the MG electronic to cool down where the engine now stated up. He then drove the vehicle down to my training center just in the nick of time because the vehicle was about to shut off again. This was good for me since it was a picture perfect moment. As you can see I was able to capture the "STOP SAFELY NOW" picture on my smartphone. The problem that causes this is related to the inverter pump not working right, or worn to the point of not working at all. The pump’s job is to flow coolant

keeping HV electronics from getting too hot. The HV system protects itself by displaying the message while reducing power before finally shutting down the power. The fix for this vehicle was a piece of cake, all I had to do is unbolt the old pump, install the new one, refill with the Ford proper coolant, bleed HV cooling system and clear the DTCs. This vehicle was now ready to go back on the road.

Our last problem vehicle is a 2001 Prius whose dash looked like a Christmas tree display besides exhibiting poor mileage and performance. Well we would all agree after interviewing the owner a visual inspection would be my next step and then of course connecting a scan tool. The scan tool displayed a P3000 HV Battery Malfunction DTC along with low HV battery block voltage (Fig 14). This is a common problem on the GEN 1 Prius since the batteries are of the old design and are known to fail. My next step would be explaining to vehicle owner the problem with their HV battery and preparing them for a very expensive repair. Since the vehicle owner already had the vehicle to the Toyota dealer the HV battery problem was not a shock to him. He explained that the dealer provided him with an estimate of $4200.00 plus possible extras. Now my job was to explain and convince him that I was capable of repairing his Prius. The repair would involve rebuilding his HV battery pack, clearing DTCs and balancing the battery pack. I explained I would be able to do the repair and guarantee it for a reasonable price that would be considerable lower than the dealer. Once he agreed I proceeded to remove the 100 pound HV battery from the vehicle. The next step would be to load test and possible charge each of the 19 packs / 38 cells if they were good enough. The HV battery should have a total of approximately 274 volts. I found the copper bus bar and terminal ends connections total corroded (Fig 15) as well as leaking batteries. With most of the cell leaking that ruled out using them so I tested only the ones that were not leaking. I had some good GEN 1 HV battery cells in stock that I tested, loaded, and retested a few times. Donor cells (good used) are the best way to rebuild this HV battery pack while keeping the DTC from coming back. You must be wondering why I would not use new HV cells, well one reason and the most important is new cells can cause a HV battery imbalance problem. The other reason was at the time Toyota did not sell HV cells or battery packs to the aftermarket. I believe that has changed but I still rather use good used cells and rebuild the HV battery saving the owner $ and making me more profit. Now just changing cells is not going to cut it since we still had the corroded copper bus bar connectors. To clean up the copper bus bars you





can use a wire brush, ultrasonic cleaner or carefully use an air scuffing pad. I also use Stabilant 22 (contact cleaner) to assure that all the battery terminals make a good connection. Now my job was to make sure that each cell/pack was able to hold a charge maintaining about 7.2/14.4 volts (Fig 16) each. Since my HV battery was able to hold a good charge after a few discharge/charge cycles I installed it in the vehicle, cleared all DTC, started the vehicle up and test drove. The vehicle is still running well three plus years later.