

AR&D

Automotive Research and Design

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[June 2011 eNewsletter](#)

[July 2011 eNewsletter](#)

[August 2011 eNewsletter](#)

Hybrid & Electric Vehicle Battery System Analysis & Diagnostics:

Battery Pack State-of-Health Checks or Reconditioning

As technical education institutions and the automotive aftermarkets continue to mature in the advanced technology vehicle markets, more and more focus is being placed on the Hybrid Electric Vehicle (HEV) energy system (i.e., battery pack system). Battery systems may need to be tested, conditioned, or rebuilt over its service life to ensure that the vehicle maintains high levels of performance and reliability. The focus on analyzing battery pack systems as a maintenance plan or, as a reconditioning/rebuild plan, has been accelerated because it can affect vehicle performance & fuel economy and can be attributed to the following conditions:

WEBINARS

We are pleased to announce the dates of our first Complimentary Webinars!

Click [HERE](#) for the full Complimentary Webinar catalog and to register for sessions.

**10/12/2011 (Weds.) 7:00pm-8:00pm
ET:**

Automotive Electrical Basics Applied to Hybrid Vehicle Systems: Looking back before moving forward.

**11/09/2011 (Weds.) 7:00pm-8:00pm
ET:**

Intro to Diagnosing HEV Machine Failures using the AT33EV Motor Circuit Analysis Tool

- Poor acceleration
- Driveline shudder during hard acceleration events
- Lack of overall performance
- Reduced fuel economy in city driving
- Malfunction indicator may be "ON" or "OFF" when these conditions occur

The two areas to be considered when discussing the testing or conditioning of a battery pack system is **Power** and **Energy**. It is common knowledge among battery groups and specialists that the capacity (energy) and power (performing work) of Nickel Metal Hydride (NiMH) cells and modules can drift, degrade, or be reduced over time. The energy loss of a NiMH cell is often referred to as Apparent Capacity Loss (ACL) which can cause battery cell capacities to become diminished and unbalanced over the life of the battery pack. The battery pack can also suffer from power losses due to increased corrosion or increases in cell resistance.

Therefore, as educational institutions and the automotive aftermarket continue to venture into the HEV and electric vehicle (EV) arenas it will become extremely important that technicians understand the relationships of battery energy and power, and how these two aspects affect vehicle performance. When applying Predictive Maintenance (PM) to battery system analysis & testing the battery capacity and power is tested and provides the vehicle owner a test report to review the battery system performance as a method of determining the "next steps" in vehicle maintenance or repair.

Although automotive manufacturers of HEV/EV provide some high level tests and diagnostics that can be accessed by using a serial data (i.e., scan) tool, these tests may not access all battery modules for testing, nor are these tests comprehensive enough to advise a customer whether their system is in good condition, in need of reconditioning, or replacement. In the battery industry, the defacto standard to test batteries is using power and energy (load) tests to acquire the actual battery module capacity and its ability to provide power. It is impossible to test each cell in a module because, the battery modules are sealed and do not permit external access points for testing. Therefore, batteries in the field can only be tested at the module level.

For example, a NiMH battery module may have six (6) cells within the module. The nominal voltage for a NiMH cell is 1.2 volts. Therefore, the battery module has 6 cells @ 1.2V/cell = 7.2V nominal. To properly test batteries for energy and power the AR&D Battery Testing & Analysis Equipment (BDU) will be used as an example of how to perform these tests. The first test to be performed will be the **power test**. The BDU will safely control a battery loading sequence with a specified load to measure the power capability of the battery modules. The second test to be performed is the **energy test**. The BDU will discharge the battery modules to zero percent (0%) State-of-Charge (SOC) and measure battery terminal voltage, at a specified load, during the discharging processes.

After the power and energy tests are completed the BDU will provide discharge (curve) signatures for both tests so that the technician can evaluate the performance all of the battery modules for their

(Part 1 of 3-Part Series)

**11/21/2011 (Mon.) 7:00pm-8:00pm
ET:**

How Do These Automotive Hybrid Systems
Work Anyhow?

**12/05/2011 (Mon.) 7:00pm-8:00pm
EST**

Diagnosing Hybrid Vehicle Electric Machine
(Transmission) Failures- (Part 2 of 3)

**01/18/2012 (Wed.) 7:00pm-8:00pm
EST**

Diagnosing Hybrid Vehicle Electric Machine
(Transmission) Failures

(Part 3 of 3)



HEV Tip of the Month

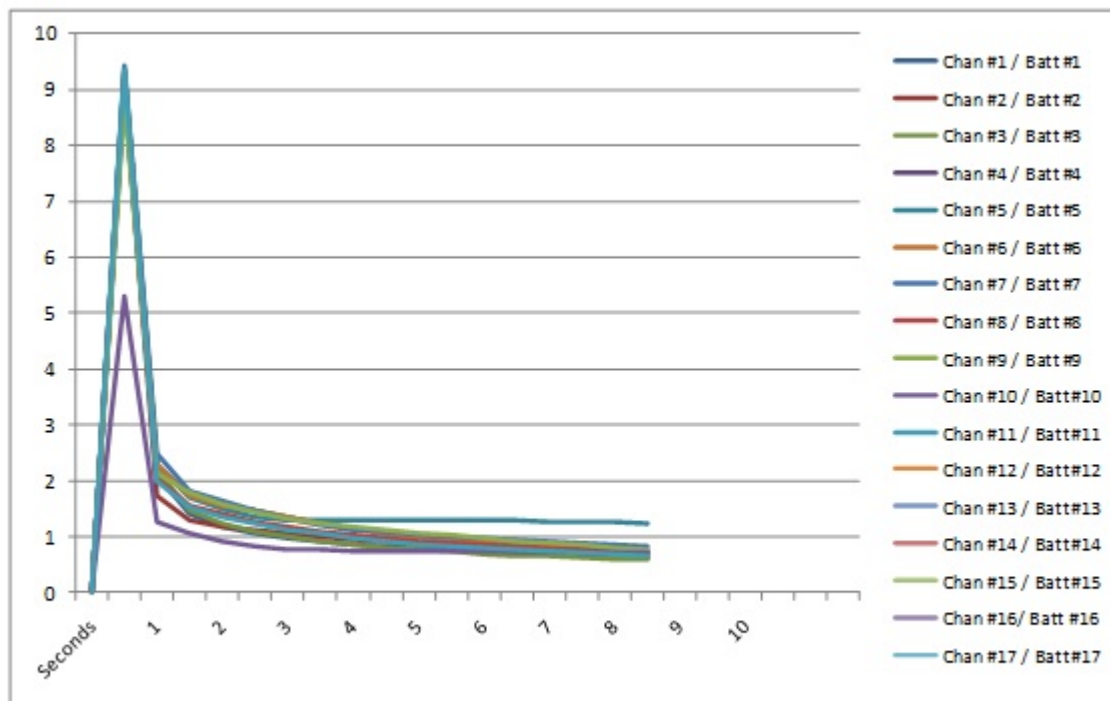
Corroded battery terminals, bus bars, and cable terminals can be cleaned with borax based soap to neutralize the potassium

individual test performance. Now, let's discuss the tests.

Power Testing

The first test that is performed is the Power test. It determines how much electrical power (i.e., how much work) can be delivered/transferred to the electric propulsion system. This important metric determines how much electric assist (hp) during an acceleration event that the electric propulsion system can provide to the engine. This test also helps in determining if a battery pack is power limited (but, not necessarily energy limited) – a key analysis and diagnostic metric for “lack of power” complaints. Battery pack power level can affect acceleration performance and overall fuel economy of an HEV/EV. At the conclusion of the Power Test, the BDU will provide a signature for the user to determine state of health (SOH) of each module, and further determine how to repair/rebuild the battery pack. Total time to perform the power test with the AR&D BDU is approximately 20 minutes for a typical hybrid battery pack.

Figures 1 and 2 provide examples of performing a controlled battery power test on a 2007 Honda Civic Hybrid during a PM check (or reconditioning/rebuild) and how this can result in significant increases in battery power performance results. Figure 1 illustrates the power test before cycling the battery pack (no power available). Cycling is defined as a complete discharge and recharge of the battery pack.



hydroxide electrolyte (NiMH Batteries). One example of borax based soap is SBS 21 (manufactured by DEBUS Inc.).



AR&D will be attending the the Automatic Transmission Rebuilders Association Powertrain Expo at the Las Vegas Hilton on October 27-31! Click on the photo above to download a FREE PASS into the Trade Show !

HEV News

[Not Sure About Buying an EV? Just Rent It First!](#)

[Ten Percent Electric Vehicles by 2020? No Sweat, Utility CEO Says](#)

[Green with EN-V – is this the future of urban mobility?](#)

[Comparing Hybrid Cars to Traditional Ones](#)

[Ford, Toyota Partner on Hybrid Truck/SUV Programs](#)

Fuel Update

Figure 1. Honda Civic hybrid power test one

Figure 2 illustrates the battery pack after one cycle of the battery pack. There is significantly more power available with a perfect power discharge signature for the 11 module groups tested (total of 22 modules).

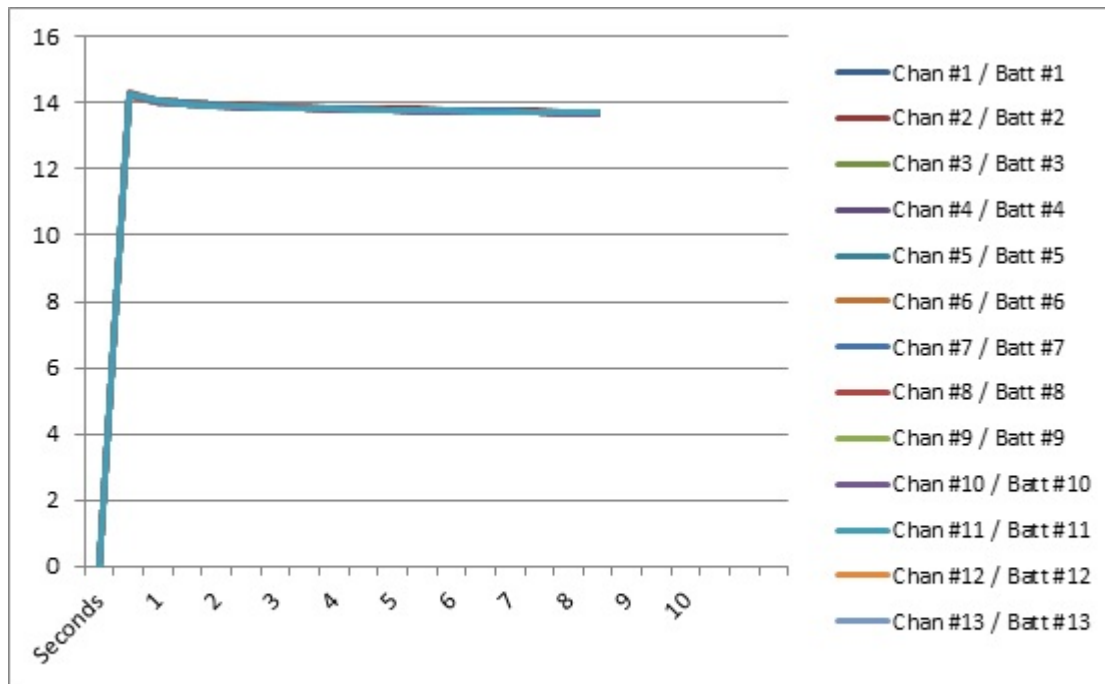


Figure 2. Honda Civic hybrid power test two

Energy Test

The Energy test determines the true State-of-Charge (SOC) / Amp•hour capacity of each battery module or, module group, to determine if there are weak battery cells then compares this data to the battery specifications. This will determine the overall energy condition of the battery pack. The Energy test analyzes how much capacity each battery module is able to store/deliver to the electric propulsion system – a key metric in how much torque the electric propulsion system can produce to assist the internal combustion engine or, how long the vehicle can

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Year 2012 Training Schedule

Click on the above thumbnail to view the training schedule for the upcoming year.

AR&D has two satellite schools we schedule HEV TTT courses to support summer availability.



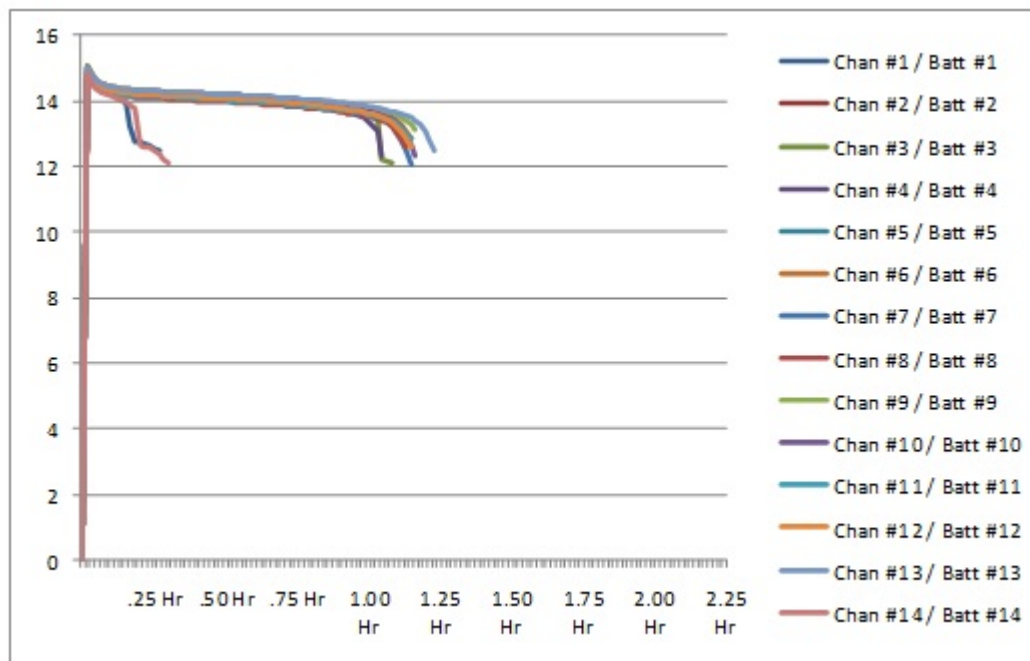
Madison Area Technical College

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operate in an electric-only mode. Energy storage in the battery modules affects overall fuel economy and can also have an effect on HEV/EV acceleration performance.

Total time for the BDU to perform the Energy Test is approximately one hour for a typical hybrid battery pack. Total time for a technician to set-up and execute the energy test is approximately 15 minutes. At the conclusion of the Energy Test, the BDU will provide the technician a signature for the user to determine each module state of health, and further determine how to repair/rebuild the battery pack.

Figures 3, 4, and 5 provide a sequence of battery cycling signatures on a 2005 Toyota Prius battery pack. This battery pack began with power and energy testing as part of a PM SOH check but, resulted in a full battery reconditioning activity. Figure 3 illustrates the first energy discharge indicating that there are significant problems with two of the battery modules (left side of graph) and less significant issues with two other modules when it was tested during the PM SOH check. This indicates a severe battery pack capacity problem.



Portland Community College

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We provide you with equipment specifically designed to analyze and diagnose Hybrid and Electric Vehicle Systems.

[Click here](#) for more information.



The All Test Pro® 33EV is the most powerful tool to analyze and diagnose any 3-phase motor-generator on an a hybrid or electric vehicle. Click on the photo above to learn about its functions and how to use them.

Figure 3. Toyota Prius hybrid energy test one

The customer indicated that they wanted to pursue a battery reconditioning in lieu of purchasing a new or rebuilt battery pack. Figure 4 illustrates a second battery discharge (after the battery pack had been charged to 98% SOC before discharging with the high voltage charger). Note that the battery module capacities of the modules, including the poor performing modules shown in Figure 3, have increased significantly.

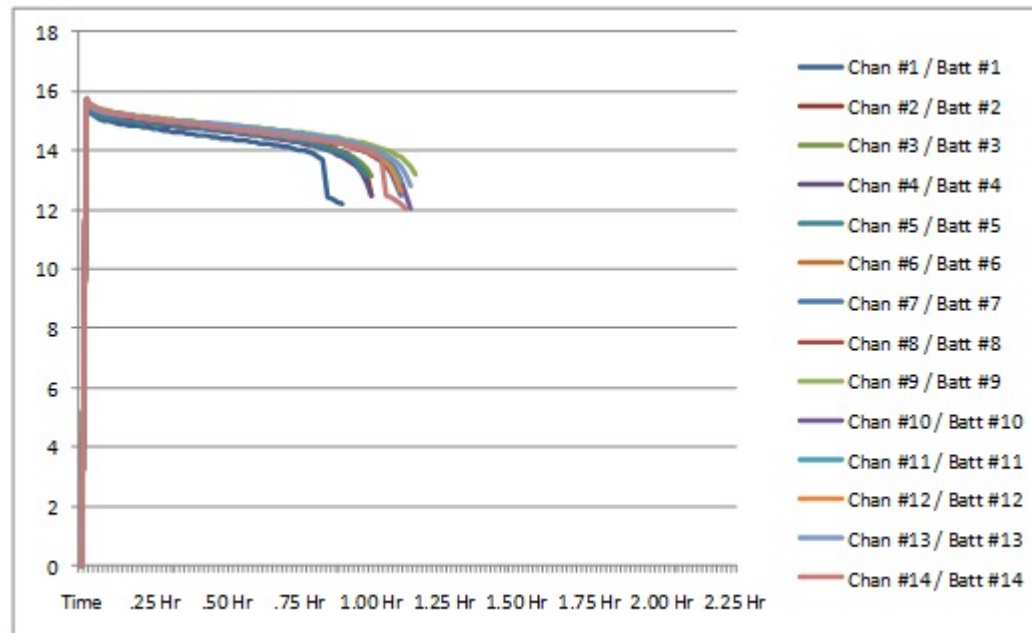
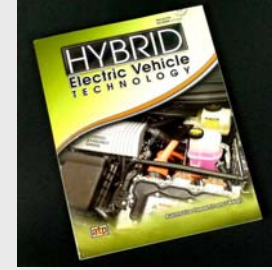


Figure 4. Toyota Prius hybrid energy test two

Figure 5 illustrates the battery pack after a fourth discharge (battery pack had been charged to 98% SOC before discharging with the high voltage charger). Note that the battery module capacities of the modules indicate a perfect signature.



Are you looking to implement HEV curriculum into your class offerings?

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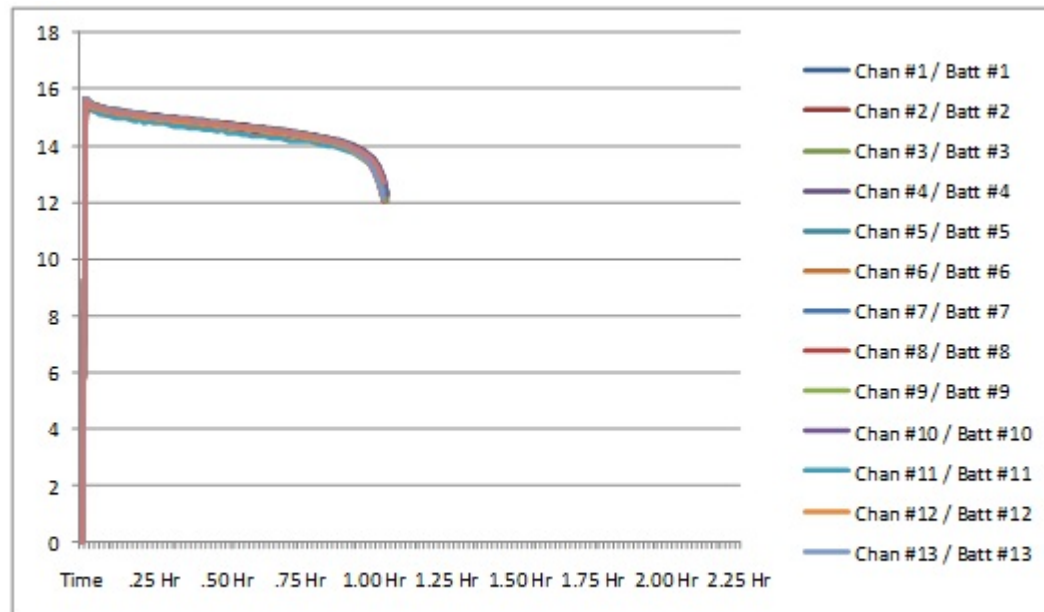


Figure 5. Toyota Prius hybrid energy test four

The total **technician** time dedicated to reconditioning the Toyota Prius battery pack was approximately 3.0 hours (includes 1.8 hours to remove and replace battery). Total time the customer was without the vehicle was 1.5 days, mostly due to the time required to cycle the battery pack - discharge and recharge it. Cost of a battery pack from Toyota is approximately \$2800.00. Cost of the reconditioning was significantly less. Therefore, the cost of the reconditioning can be valued at a cost significantly lower than a new battery pack. And the reconditioned battery pack will provide great service life. Battery PM SOH checks, reconditioning, or rebuilding offers a wonderful business opportunity for the automotive aftermarket, and for educational institutions to instruct this service technology to students.

By using proper methods of cycling the battery pack (i.e., discharging and charging) the power and energy levels in the two battery pack examples were recovered with no battery modules replaced. In this Newsletter, we did not broach the subject of battery pack rebuilding. There are a few more steps in rebuilding a battery pack such as, replacing battery modules and matching battery module capacities to the existing battery pack to ensure proper balancing (to keep the MIL turned OFF). We will leave this to a future Newsletter topic. Performing battery pack PM SOH or reconditioning is a very easy process that you can do.....and, it is a very profitable proposition for those interested in adding it to their business portfolio!!!

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Until next time remember - knowledge is **POWER**



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