December 2011

Technical Newsletter

Merry

Christmas

Hoping that the Christmas Season brings prosperity into your home and business in 2012

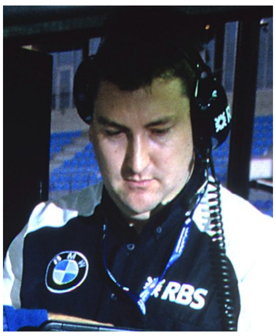
From the AECS team:
Christine, Cunie, Peter, Paul, Stu & Herbert.

Meet some of the team……

2012 will see *AECS* expand in hi-tech staff to accommodate our focus in customer service for our products, technical support and training.

Peter Leijen BE(Hons)

works in the Research and Development department at AECS, developing the tools to quickly and accurately measure and equalise batteries for Lead acid and Li-ion batteries. He will also assist in Product support of AECS Equipment.



Paul Corrbet (Sensor technician Williams F1)

Will be in charge of Product Support and Technical help at AECS. He comes to AECS with his wealth of knowledge in vehicle electronics and equipment. He will assist Herbert in creating, developing and delivering further training programs.

Automotive Electronic Control Systems

AECS

Training, Equipment and Data for Automotive Diagnostic Specialists

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Battery Buggered?

By Peter Leijen

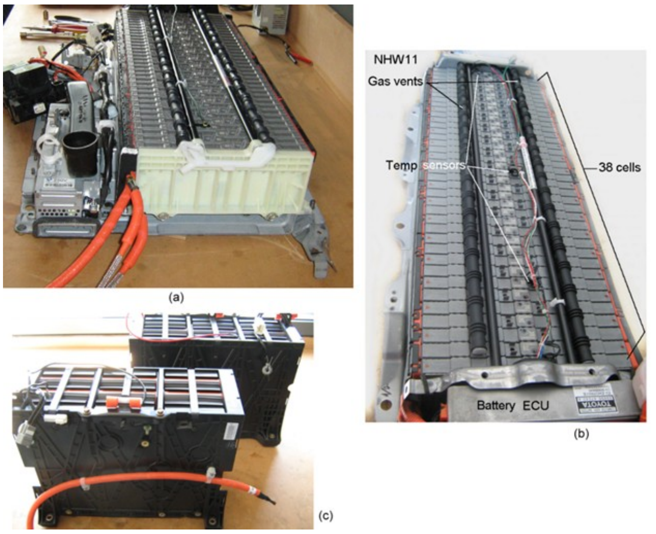
We have all seen them on the road. Nice quiet electric or hybrid electric vehicles such as the Toyota Prius, Honda Inspire, and now the Nissan Leaf or even the Mitsubishi I-MEV. All these vehicles are full of technology. The majority of the public is sceptical about purchasing a new or second hand EV or HEV, because of the stories circulating regarding HV battery related problems and the expenses incurred when fixing such issues.

For my university honours research project I have fully investigated and tested a range of Prius, Estima and Camry NiMH battery packs with differing histories, km's driven, idle time in storage, fire damage etc.

For starters, I am going to simplify a battery and make a basic analogy with an oil drum. Oil drums, like batteries, can be a range of different sizes, 1L, 4L, 20L etc. For a battery, the size is quoted as a milliamp hour (mAh) figure. The capacity can range from 1200 mAh, an ordinary AA battery to 90000 mAh a high capacity EV battery. Now imagine that over time (battery cycle life) the size of the oil drum (capacity of the battery) reduces. This is known as a reduction in battery state of health.

It is also possible that the oil drums (batteries) can be filled to different levels. State of charge is the measure of how "full" the battery is.

On top of this the oil drums can also be filled with various different types of oil, batteries contain different chemical species. The most common to you will be lead acid. The battery packs used in HEV's (e.g. Prius) between 1998 and 2010 contain Nickel Metal Hydride (NiMH).



2010 Camry battery pack (b) 2003 NHW11 Battery pack (c) 1998 NHW10 battery pack

Toyota Prius System

The battery pack of the NHW11 Toyota Prius consists of 38 Nickel Metal Hydride (NiMH) battery blades each of which contain six NiMH cells in series. The battery blade is the smallest replaceable unit within the battery pack. The battery management system of the Prius takes a differential voltage measurement across each pair of blades, the current into the pack is measured, and four temperature measurements are performed throughout the whole pack by the battery management ECU. If any of these measured values fall outside of the working parameters then a fault code is logged. The most common fault codes that the AECS help desk has had to deal with are "leak detected" and "battery levels significantly different".

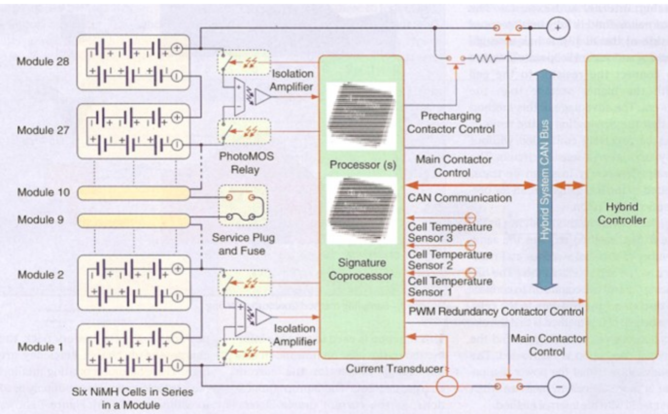


Figure 1: Diagram of a typical Battery Management System for HEVs, for example the 2009 Toyota Prius

The "leak detected" fault code is for example logged when the ECU measures a HV (High Voltage) path to the chassis of the vehicle. To explain this in detail is worth a separate article so I will leave it for now. The "battery levels significantly different" fault code is more interesting to discuss, as this is the code that prompts the technician to, after exhausting all other repair paths, replace the battery pack at a cost of thousands of dollars.

Earlier on in this article, I introduced the oil drum analogy and how the drums, batteries, can be of different sizes and be filled to different levels. So what does the "battery levels significantly different" fault code actually mean?

Capacity (State of Health = SOH) Distribution

The 38 individual battery blades in a battery pack can of course all be of different state of health. I tested many battery packs at the Science and Engineering Department at the University of Waikato and have summarized the most interesting four battery packs as shown in next diagram.

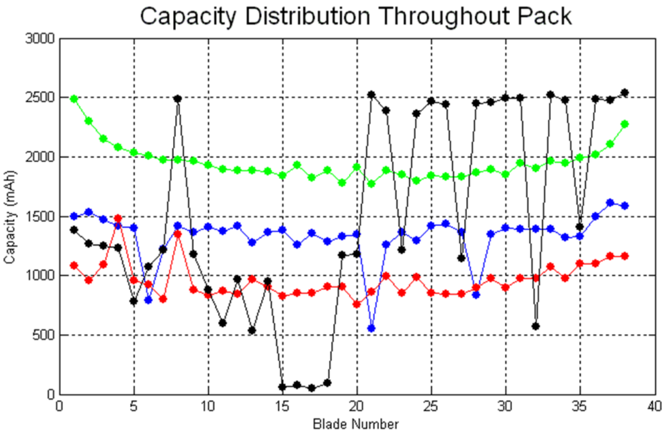


Figure 4: Capacity Distribution throughout four packs tested.

This particular battery pack was tested in our test vehicle and performed as well as the original battery pack that had done over 100,000 km. Therefore, it can be assumed that this battery is of good state of health. The performance was measured by driving the vehicle in EV mode (less than 25km/h) and recording the distance travelled before the ICE (engine) switched on to charge the battery pack, all tests were started at a fixed state of charge (60%) to ensure accurate results. No fault codes were triggered with this battery pack indicating that the battery management ECU accepts a spread of 500 mAh across the battery pack.

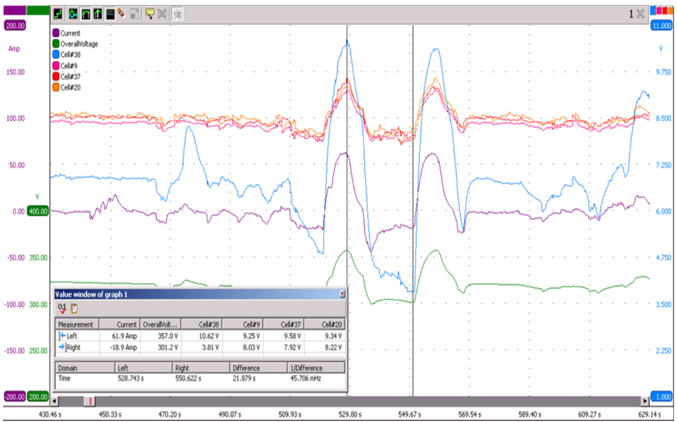
A 1200 mAh battery blade was swapped into the battery pack to further investigate this spread. Again, no fault codes were triggered. However, the performance in EV mode of the vehicle had halved!

Now we can start piecing it together. The battery pack is only as efficient as the battery blade with the lowest state of health (capacity of the oil drum). Hence, the assumption can be made that the vehicle manufacturer matches and balances all battery blades in the battery pack.

Now look at the graph again, the blue and the black traces in particular. The black trace indicates that 30% of the battery blades in a battery pack that is destined for destruction are still of excellent state of health. The blue trace indicates that only a few battery blades have significantly different state of health that severely affects the performance of the vehicle.

Still no fault codes…

Each battery blade contains 6 NiMH cells, one of these 6 cells can also be faulty. What happens when one of these cells becomes short-circuited? The Nickel plates in the cell can get pushed together due to excessive temperatures, pressures or a small piece breaking off.



The scope trace shows 6 differential voltage measurements recorded with the ATS 5004d and ATS 5000 scopes during variable driving conditions. The green trace is the overall voltage of the battery pack, the purple trace is the current through the battery pack and the other traces are of individual battery blades. The blue trace is of particular interest, as it is the voltage of the battery blade that contains the broken cell. The voltage swing of this battery blade is from 3.8 V to 10.6 V! I must also add that the vehicle with this battery blade configuration was able to drive only 10 meters in EV mode compared with 2.5 km for the original battery pack.

As you can imagine this triggered fault codes. The vehicle presented with both “battery levels significantly different” and “battery block 19 is becoming weak” fault codes. This trace shows in an extreme case how the weakest battery blade sacrifices itself i.e. undergoes the most charging and discharging and as a direct result its state of health will deteriorate more amplifying the problem.

So now, we have recreated the problem. The “battery levels significantly different” fault code is triggered by the differences between the battery blade voltages progression but the battery management ECU accepts that the vehicle has a reduction in fuel economy of 50% caused by variations in the state of health of the battery blades.

So how does this concern you?

There are thousands of hybrid vehicles on the road today; they are not going away anymore! Their presence will only increase. Hybrid vehicles will find their way into your workshop.

What do you do with the batteries on these cars? Are you just waiting until the battery fails and then replace it? That would be like not checking or replacing oil in an engine and waiting until the oil light comes on!

Battery failure will be preceded by a period of gradual increasing fuel consumption, for which most workshops have no answer.

I am working in the Research and Development department at AECS and am currently developing the tools required to quickly and accurately measure and equalise the battery blades. Set parameters for each blade and pinpoint which battery blade is causing the poor fuel economy. We are also working on a tool to easily identify new or second-hand replacement battery blades. The tool will also be adaptable to Lead acid and Li-ion batteries.

For *AECS* ltd.
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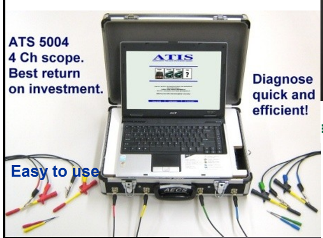

AECS training calendar for 2012

	February		March		April		May
1		1		1		1	Tauranga DMS 1-3
2		2		2		2	Tauranga DMS 1-3
3		3		3		3	Hamilton SCAN
4		4		4		4	Hamilton SCAN
5		5		5		5	
6	*Waitangi day*	6	Auckland SCAN	6	*Good Friday*	6	
7		7	Auckland SCAN	7		7	
8		8	Auckland EMS 11	8		8	
9	Private Training	9	Auckland EMS 11	9	*Easter*	9	
10	Private Training	10		10	*Easter*	10	
11		11		11		11	
12		12		12		12	
13		13	Private Training	13		13	
14		14	Private Training	14		14	
15		15	Private Training	15		15	
16		16		16		16	
17		17		17	Hastings ATS	17	
18		18		18	Hastings ATS	18	
19		19		19	Hastings AIRCON	19	
20	YES!	20		20	Hastings AIRCON	20	
21	YES!	21		21		21	
22	YES!	22		22		22	
23	YES!	23		23		23	
24	YES!	24		24		24	
25		25		25	*Anzac day*	25	
26		26	*otago anniversary*	26		26	
27		27		27		27	
28		28		28		28	Private Training
29		29		29		29	Private Training
30		30		30		30	
31		31				31	

Visit our website for more training in your area. www.aecs.net

Updated: 16 Dec 2011

We also accept MTA Vouchers!

Key

Sundays

Public/school Holidays

ABS = ABS/ Traction Control Systems seminar
EMS1-1 = Engine management Systems 1 (module 1) seminar
EMS1-2 = Engine management Systems 1 (module 2) seminar
HYBRID = Engine management Systems 1 (module 4) seminar (hybrid)
SCAN1 = Scan Tool diagnostics
AED = Automotive Electronic Diagnostic seminar
DMS1-1 = Diesel Management Systems 1 Module 1 seminar
DMS1-2 = Diesel Management Systems 1 Module 2 seminar
DMS1-3 = Diesel Management Systems 1 Module 3 seminar
AIRCON = Air-conditioning training
ATS = Comprehensive Scope training
TBA = To be advised
YES! = Yes diagnostic Network training.

Please note: All effort has been made to ensure the training & course dates are correct, however please contact us first before publishing information from this calendar.

Automotive Electronic Control Systems
AECS
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For enquires or to register for any one of these seminars contact AECS:
Ph:06 874 9077, Fax 06 874 9078 or E– Mail: christine@aecs.net

Name:……………………………………….…..

Name of course enrolling in:…………………………………….………..

Business Name:……………………………………... **Phone Number:…………………………...**

Address:……………………………………………………………………………...…...