Battery Hardware in the Loop

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"This presentation does not contain any proprietary or confidential information"
Battery Hardware in the Loop (BHIL): A real battery (energy storage) in a virtual vehicle

Parameters:
Vehicle mass, drive cycle, Architecture, Component Power ratings, etc

PLANT

dSpace
Vehicle Controller

Vehicle Simulation Model

Test Facility

Environmental Chamber

Communication

Electric power

Feedback via CAN: voltage, current, temperature, SOC, available power, etc
Hardware description

- Virtual Vehicle (dSPACE), DAQ (NI – Compact Rio).
- ABC-150 HVDC power supply
- JCS – VL41M (72 cells, 260 V nominal, 41 Ah, liquid cooled)
Significance of Battery HIL: component evaluation and systems integration

Battery testing: (performed at module Level)
- Performance tests (e.g. HPPC)
- Calendar life tests

Battery evaluation in a flexible vehicle systems context

AND/OR

Vehicle System response to various Vehicle conditions

Battery evaluation in a vehicle (vehicle Benchmarking)

Frozen controls, vehicle platform
Accomplishments in FY07 – funding $400K

1. Impact of different charger ratings on battery ‘roundtrip efficiency’.

2. Validation of ANL developed VL41M model With BHIL

3. Sensitivity of Charge sustaining FE to operation at different SOCs

3. All electric range for a midsize, crossover and SUV with the VL41M at 20 °C
Accomplishments in FY08 – total funding $500K-
total funding spent - $150K

- Battery HIL (phase 2): Expanded set-up with a state of the art DC power supply and environmental chamber.
- Impact of cold temperature on the EV range using a VL41M.
- WFO with SK Energy – impact of modifications of BMS on vehicle fuel economy and battery.

<table>
<thead>
<tr>
<th>Initial battery temperature</th>
<th>EV range (miles)</th>
<th>Rise in temperature (degrees C)</th>
</tr>
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<tbody>
<tr>
<td>20</td>
<td>17.3</td>
<td>9</td>
</tr>
<tr>
<td>0</td>
<td>15.7</td>
<td>14</td>
</tr>
<tr>
<td>-7</td>
<td>15</td>
<td>16</td>
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Future Work for FY08 and Beyond

- Impact of different blended mode strategies (rates of SOC depletion) on battery temperature rise (battery life) vis-à-vis improvement in petroleum displacement.

- Evaluation of vehicle controls and battery energy management for extreme cold and hot battery conditions to more fully investigate observations made with ANL on-road data on HEVs and PHEVs over wide extremes of ambient temperatures.

- Battery Evaluation in a systems context:
  - Evaluation of other PHEV batteries in a vehicle system.
  - Create a standard ‘evaluation matrix’ for comparison of batteries as a system, which includes
    - State of charge window
    - Temperature rise
    - Regen versus state of charge, temperature
    - Charging efficiency, time.
What is the Value of Battery HIL and Support to Other Vehicle Technology Activities

**OEMs, USABC**
System level evaluation of batteries. Comparison of battery technology.

**Battery Manufacturers**
Evaluation of battery management controller. Battery thermal design and management.

**Battery HIL**

**PSAT**
Validation of battery models. Furthering energy management strategies to include battery life impacts and cold/hot temperature effects.

**MATT**
1. Validation of battery models.
2. Complements PHEV emissions work.

**PHEV test procedure development (SAE J1711)**
Study and understanding of non-linear battery behavior important.

**Backbone for other Energy Storage experiments; e.g. Ultra capacitor-Battery HIL**
To Summarize:

- Advanced energy sources are the enablers of PHEV technology, and yet remain the main technical challenge.

- Battery issues such as sizing/chemistry effects on life, cost and extreme temperature performance are directly linked to battery usage in a vehicle (i.e., battery systems integration is as important as cell development).

- Battery HIL is an ideal tool for
  - Understanding the vehicle system integration issues that exist.
  - Evaluating the impact of cell level development on a system level.
Publications


