I. COMPONENTS & SYSTEMS

I.A. 1000340.00 APEEM Components Analysis and Evaluation

Principal Investigator: Paul H. Chambon
Oak Ridge National Laboratory (ORNL)
2360 Cherahala Boulevard, Knoxville, TN 37932
Phone: (865) 946-1428
E-mail: chambonph@ornl.gov

DOE Program Manager: David Anderson
Phone: (202) 287-5688
E-mail: david.anderson@ee.doe.gov

I.A.1. Abstract

Objectives

- Support the evaluation of current and proposed electric machine and power electronics technologies in a vehicle context to understand the applicability of a particular powertrain technology to a given vehicle and to determine areas/regions for component design improvement based upon system usage patterns
- Enhance the current benchmarking and prototype evaluation capabilities of DOE APEEM programs with the addition of transient-capable testing facilities for power electronics and electric machinery components.

Major Accomplishments

- Supported DOE APEEM group modeling activities, so that electric machine and power electronics designers know how to use a vehicle simulation tool (Autonomie) to evaluate electric powertrain technologies at the vehicle system
- Initiated the procurement of a dynamometer suitable for electrical component characterization and validation through hardware-in-the-loop testing

Future Achievements

- Perform hardware-in-the-loop testing of electric hybrid powertrain components

✧ ✧ ✧ ✧ ✧

I.A.2. Technical Discussion

Background

Part of the Vehicle System Integration (VSI) Laboratory, Oak Ridge National Laboratory has commissioned a powertrain test cell capable of testing a complete heavy-duty hybrid vehicle powertrain by combining the use of two 500kW dynamometers and a 400kW e-storage unit that can emulate the behavior of a battery. It is also equipped with a hardware-in-the-loop platform to emulate vehicle components not present in the testcell, such that the powertrain behaves as if it were in a real vehicle on real world road conditions; this is referred to as Powertrain-In-the-Loop.

Introduction

Testing electric machine and power electronics technology in the context of a vehicle using a hardware-in-the-loop approach is critical in order to understand transient, application specific, and real world conditions limitations associated with that component. These findings can be used to optimize its design and obtain a better match between the component and the vehicle application in order to achieve improved overall vehicle efficiency.

Approach

This project will provide vehicle engineering support to ORNL's Power Electronics and Electric Machinery (PEEM) group while they conduct simulation studies funded by DOE APEEM (Advanced Power Electronics and Electric Motors) programs.

This project will also specify and procure key components for a testing facility suitable to characterize hybrid traction components in transient operations representative of vehicle conditions thanks to a hardware-in-the-loop set-up. That facility, called component test cell, will be part of ORNL's Vehicle System Integration laboratory.

Results

Vehicle Simulation Support

Training and support was provided to members of the Power Electronics and Electric Machinery group so that they can use the vehicle simulation tool from Argonne National laboratory, Autonomie, to perform vehicle level evaluations of electric powertrain components. Copies of Autonomie were obtained and installed for two members of the PEEM group. Those reseachers were also provided with the model of a Nissan Leaf developed during FY12 for other DOE funded projects. This will be one of the vehicle platforms used to benchmark the vehicle suitability of novel motor concepts developed by APEEM programs.

Testing Facilities Enhancement

A list of requirements was created for the component testcell dynamometer selection:

- About 200kW power level, to be able to handle passenger car engines and traction motors
- High rotational speeds (~14000rpm), to cope with higher speed trend in automotive traction motors.
- Low inertia (<0.5kgm2), to be capable of replicating fast transients (up to 5000rpm/s) experienced by actual components in a vehicle context.
- Remote high speed dyno control interface to integrate dynamometer with external real time platform

The selection team identified the AVL PLP 525/220/12 dynamometer as a suitable trade-off for those requirements:

- 220kW max power
- 12000rpm max speed
- 0.325kgm2 inertia
- High speed CAN interface for remote control

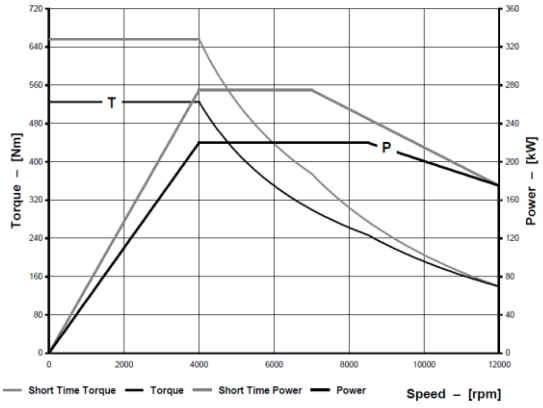

Figure 1: Torque and power curve for AVL PLP 525/220/12 AC dynamometer

The procurement process was initiated and the dynamometer will be commissioned at ORNL in Q2 FY2014 due to the long lead time for that item. The procurement of this dynamometer is also financed by DOE APEEM programs since it will be also supporting their activities once commissioned.

The VSI laboratory is already fitted with an e-storage unit (also known as battery emulator) that is shared with the larger powertrain test cell. The e-storage unit is capable of up to 800V, 600A and 400kW (see Figure 2). It can emulate the behavior of most energy storage systems such that the electric machine under test can be subjected to a variety of operating conditions representative of real world operations.

Figure 2: AVL e-storage unit installed at ORNL VSI laboratory.

The new high speed dynamometer and existing e-storage unit will be integrated with a real time computer running models of virtual vehicles so that the electric machine will behave as if it were fitted under an actual vehicle driving in real world conditions.

To achieve this, the dynamometer and e-storage unit will operate as slaves to the real time computer. The dynamometer is mechanically coupled to the electric machine; it will apply the reaction torque calculated by the vehicle model on the real time computer. The e-storage unit is electrically connected to the electric machine; it will apply the operating voltage calculated by the vehicle model. This arrangement is known as Hardware-In-the-Loop and is described in Figure 3.

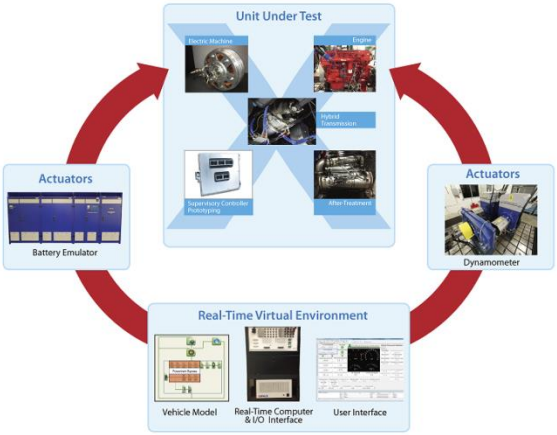

Figure 3: Hardware-In-the-Loop diagram

Conclusions

This project supported vehicle simulation activities within the PEEM group at ORNL so that vehicle considerations are taken into account when designing new advance electric machinery and power electronics components.

Also the specification phase was completed for testing facilities suitable to evaluate those same components on a test cell while still emulating real world conditions, thanks to a high speed transient dynamometer, a battery emulator and a Hardware-In-the-Loop real time platform. The procurement phase was initiated; the commissioning is expected for Q2 of FY14.