System Integration and Validation

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Project ID: APE055

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Overview

Timeline

- Start – FY13
- Finish – FY15
- Percent Complete: 22%

Budget

- Total project funding
  - DOE share – 100%
- Funding for FY12:
  - $0 K
- Funding for FY13:
  - $350 K

Barriers & Targets

- Measurement of system and component efficiencies during transient conditions.
- Most commercially available power measurement systems have limitations in refresh rates, continuous monitoring, and customizability.
- Incorporation of custom-made Glidcop material in scaled IM rotor due to fabrication challenges and retention requirements.
- This project helps with program planning and the establishment and verification of all DOE targets.

Partners

- ORNL Team members
  - Cliff White
  - Chester Coomer
  - Steven Campbell
  - David Smith
  - Paul Chambon
- ANL
- NREL

Project Objectives/Relevance

- **Overall Objective:** Use ORNL's hardware-in-the-loop (HIL) system as rigorous testing platform for development of next generation traction drive systems (TDS).
  - Validate traction drive system performance using five standard or custom drive cycles.
  - Provide feedback for DOE VTO APEEM program planning, target setting, and identifying R&D gaps.
  - Propose traction drive system refinements that address R&D gaps for the VTO APEEM program.
- **FY13 Objectives** (FY13)**:**
  - Design and fabricate universal circuit boards needed for operation on HIL system.
  - Work jointly with ORNL's Vehicle Systems Integration (VSI) laboratory staff to define the needs of a high performance dynamometer and other HIL components.
  - Perform bench-top HIL testing with induction motors and switched reluctance motors.

Milestones

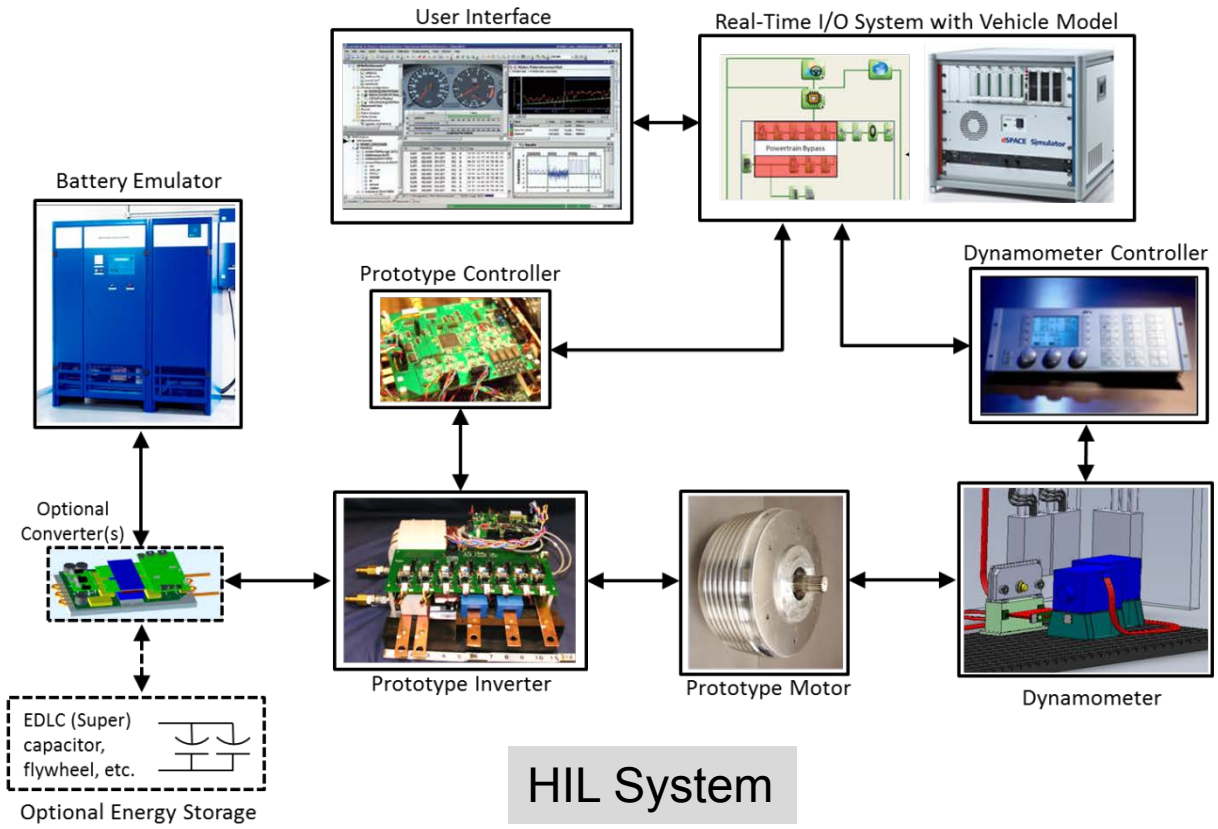
Date	Milestones and Go/No-Go Decisions	Status
September 2013	Milestone: Perform comparison studies of custom IM rotor technologies on bench top HIL unit and summarize test results in technical report.	On track.
September 2013	Go/No-Go decision: Controls compatible for performance testing.	

Approach/Strategy (1)

- Use HIL system as rigorous testing platform for development of next generation converters, inverters, and motors for traction drive systems (TDS).
  - Validate TDS performance using five standard or custom drive cycles.
  - Provide feedback for DOE VTO APEEM program planning, target setting, and identifying R&D gaps.
  - Propose TDS refinements that address R&D gaps for the VTO APEEM program.
- System emulates drive cycle conditions by generating the appropriate torque (throughout a drive cycle speed reference profile) for environmental conditions (temperature, head-wind grade, etc) and a given vehicle profile.
  - Drive-line matching: impacts of various transmission/transaxle, EV, or even HEV power split options.
  - Various energy storage options.
  - Emulation of various types of vehicles.

Approach/Strategy (2)

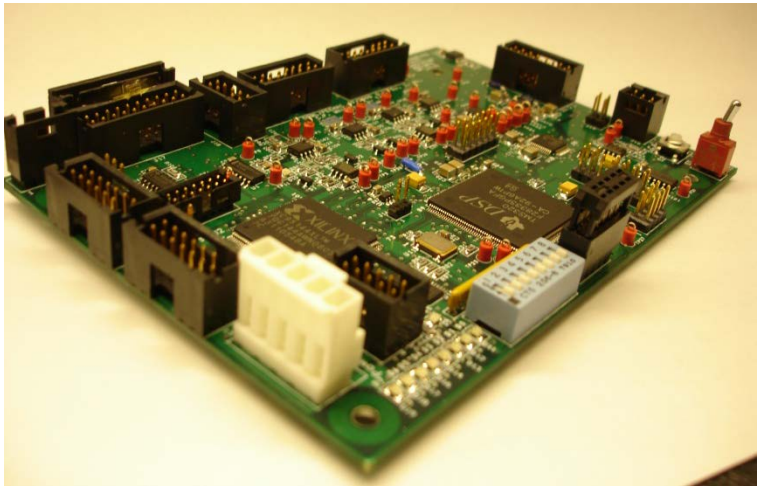
- Utilize VSI Lab battery emulator to assess impacts of converter and motor designs upon battery operation can be fully assessed.
  - E.g. Current ripple, high voltage, etc.
- Identify requirements and impacts of energy storage and matching.
  - Dc-dc (e.g. boost) can be emulated or implemented.
  - Emulation of various storage capabilities and power flow arrangements.
    - Super capacitor, flywheel, etc.
- Emulate or implement actual components.
  - Converter, energy storage, etc.
  - ICE or battery from ORNL, ANL, industry, etc.

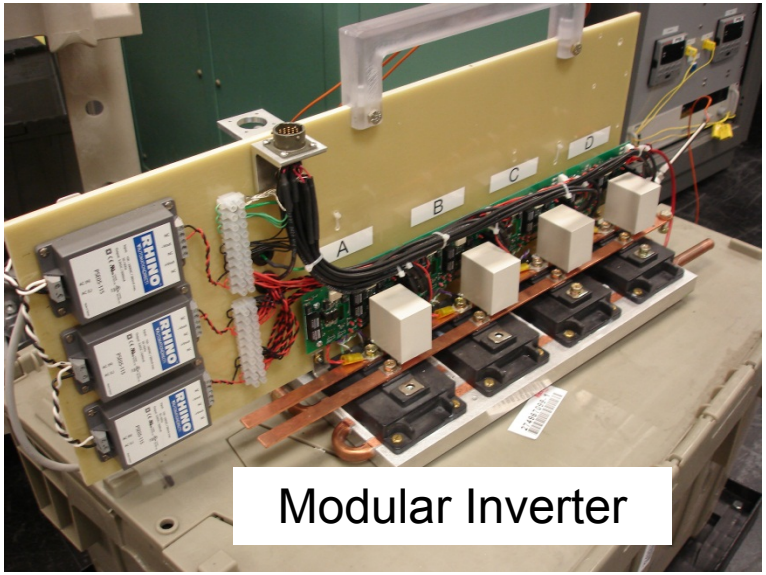


Technical Accomplishments (1)

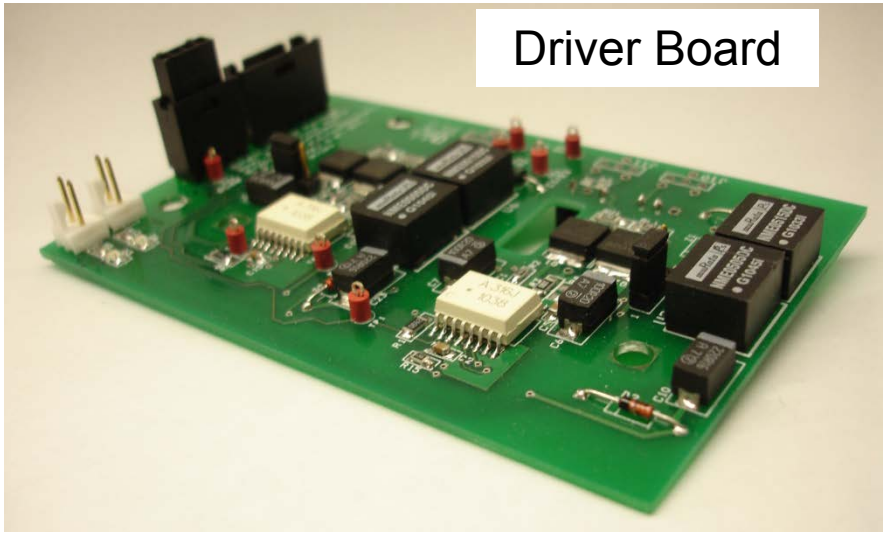
- Developed universal control board
  - Leveraged previous work by ORNL's Gui-Jia Su/Lixin Tang/Cliff White.
  - Modified design to fit project needs.
- Modular inverter assembled and ready for testing
  - Driver boards leveraged previous work by ORNL's Madhu Chinthavali/Cliff White.

Universal Control Board





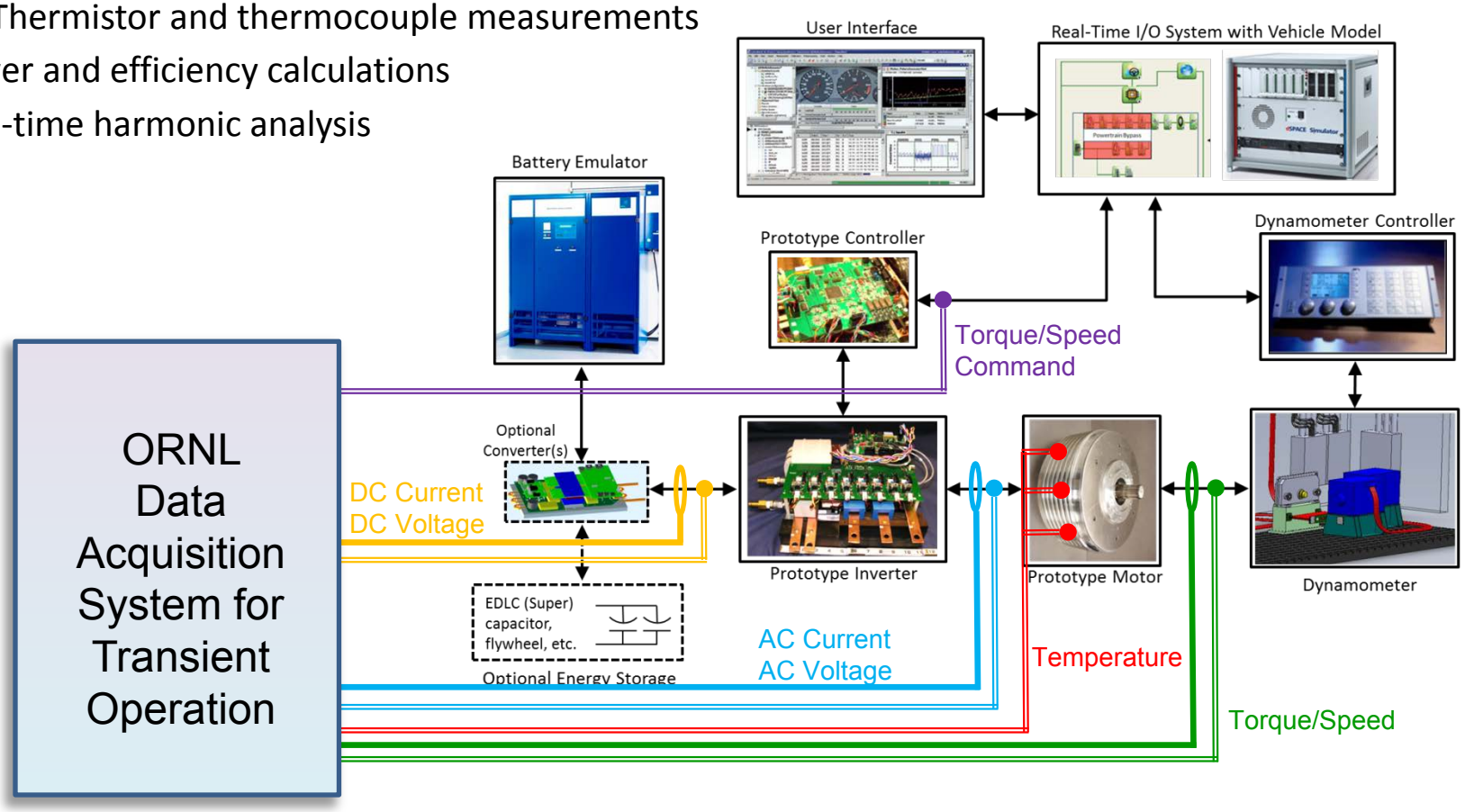
Modular Inverter



Driver Board

Technical Accomplishments (2)

- Development of measurement system and data acquisition system initiated
  - Capable of continuously streaming measurement data.
    - Current (ac and dc)
    - Voltage (ac and dc)
    - Torque and Speed
    - Thermistor and thermocouple measurements
  - Power and efficiency calculations
  - Real-time harmonic analysis



Collaborations and Coordination

Organization	Type of Collaboration/Coordination
DOE VTO Vehicle Systems Program (ORNL)	• ORNL VSI Lab – David Smith, Paul Chambon, PT Jones. – The Vehicle Systems Integration (VSI) lab at ORNL fosters DOE VTO cross-cutting activities in core areas such as Vehicle Systems, Advanced Combustion and Emissions, Fuels Technologies, and Advanced Power Electronics and Electric Motors. – This project will help identify additional test equipment needs. – Combines efforts on vehicle emulation with traction drive system requirements.
DOE VTO Vehicle Systems Program (ANL) 	• ANL vehicle testing – Henning Lohse-Busch, Erik Rask, Ted Bohn. – System parameters from vehicle testing. – Vehicle profiling (inertia, loss coefficients (drag, rolling, etc.)). – E.g. Specify battery characteristics so VSI battery emulator can be programmed to represent commercial on-the-road pack.
	• Thermal management information.

Future Work

- **Remainder of FY13**
  - Complete development of dynamic inverter-motor-controls.
  - Continue development of dynamic measurement and data acquisition system.
  - Perform bench-top HIL testing with induction machines.
  - Perform bench-top HIL testing with switched reluctance motor.
- **FY14**
  - Conduct drive-cycle testing of components on ORNL's VSI laboratory HIL system.

Summary

- **Objective/Relevance:** Use ORNL's hardware-in-the-loop (HIL) system as rigorous testing platform for development of next generation traction drive systems (TDS).
- **Approach:** Use HIL system as rigorous testing platform for development of next generation traction drive systems (TDS).
  - Validate TDS performance using five standard or custom drive cycles.
  - Provides feedback for DOE VTO APEEM program planning, target setting, and identifying R&D gaps.
  - Propose TDS refinements that address R&D gaps for the VTO APEEM program.
- **Collaborations:** Interactions are ongoing with several national laboratories and DOE Vehicle Systems Program.
- **Technical Accomplishments:** Completed universal control board design, initiated development of dynamic controls, prepared modular inverter, and initiated measurement system developments.
- **Future work:** FY13 efforts are on track, and FY14 plans are in place.