

Power System Test Bed for Ground Vehicles

Joint Services Power Expo

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Joshua Baer

joshua.baer@lmco.com

Thomas Byrd, Senior Fellow

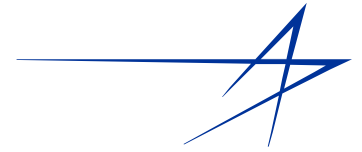
tom.e.byrd@lmco.com

Introduction



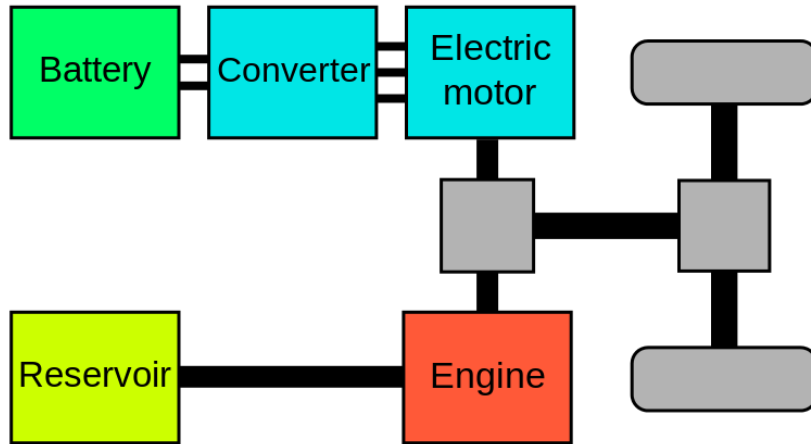
- **DOD products require more power and are limited by alternators**
- **With more and more vehicles adapting parallel and electric hybrid approaches, as well as more electronic loads being added, there is a growing need for power generation and storage that is more than just the traditional alternator and lead acid battery**
- **How can these power needs be obtained?**
- **How will these new power devices integrate with existing equipment?**
- **How can companies be encouraged to strive to use Wide Band Gap electronics to advance State of the Art?**

Introduction Continued



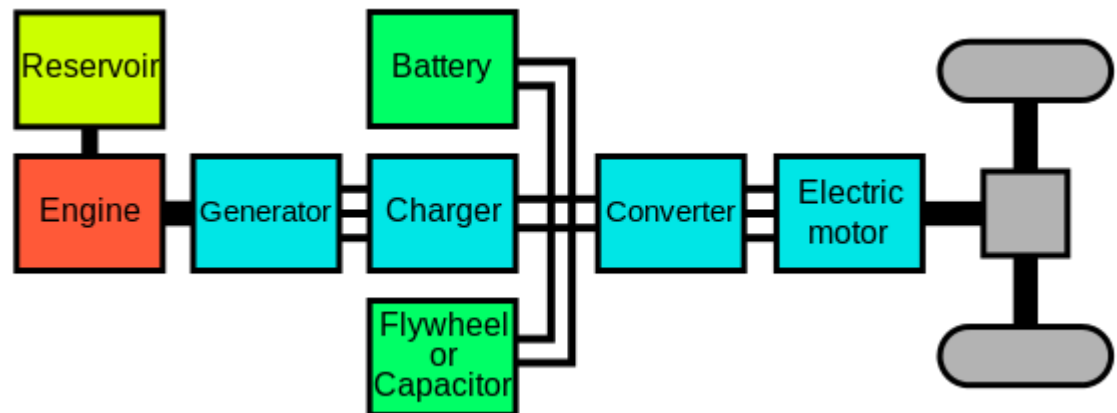
- **The available option for WBG power electronics is currently very limited and their technology readiness level is currently 3 or lower. To encourage WBG power electronics development and acceptance, we propose a vehicle electronics power test bed which will start with the current state of the art silicon technology as the base, but will be used as a base to integrate, prove out, and increase the TRL to level 6 of the emerging WBG segment**

Parallel and Series Hybrid



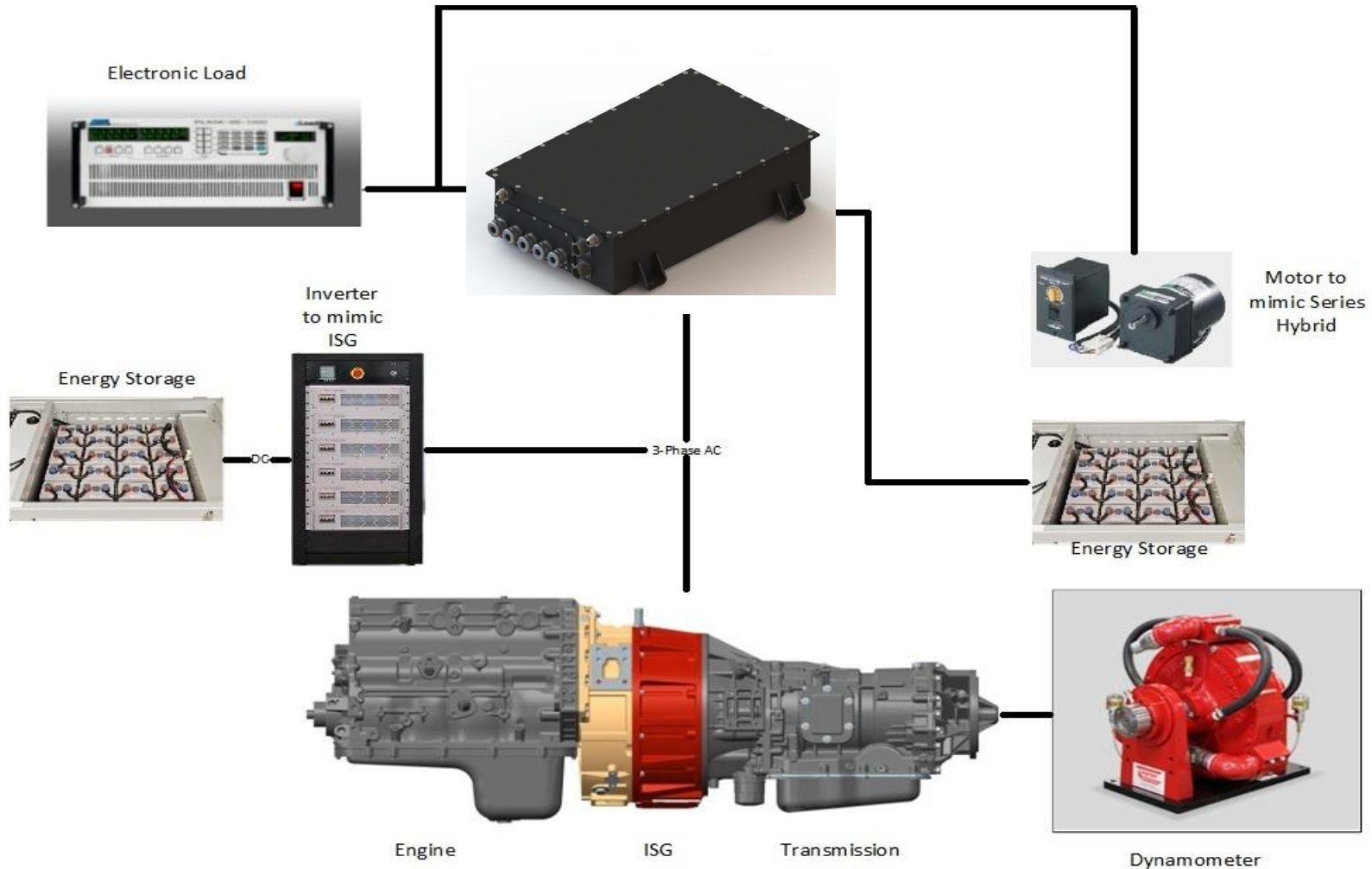
Example of a Parallel Hybrid Vehicle

Example of a Series Hybrid Vehicle



Vehicle Test Bed Architecture needs to be flexible enough to test for both types of hybrids

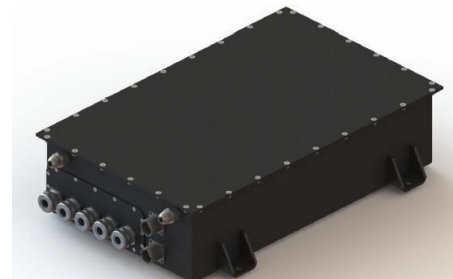
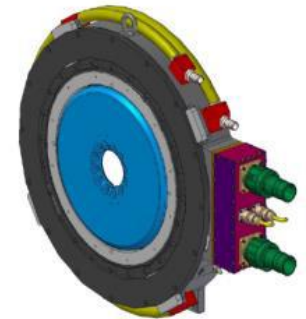
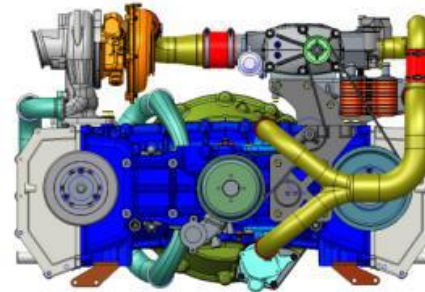
Vehicle Test Bed Architecture



Power Generation



- Engine
- Integrated Starter Generator (ISG)
 - Takes the place of a traditional alternator
 - Higher power available
 - Directly in line with the drive train
- Bidirectional Inverter
 - Takes the power from the ISG and makes it useful for the vehicle
 - Provides ISG cranking pulse for start up



Photos from TARDEC, GVPM Industry Day Presentation, 4/21/16

Loads and Energy Storage



- **Loads**
 - **Mechanical**
 - **Dynamometer- Allows full testing of engine loading with varying RPM and Torque loads**
 - **Electrical**
 - **Electronics load- Can mimic hotel loads and dynamic loads for the entire spectrum of vehicles**
 - **Electric Motor**
 - **Series Hybrid mimic**
 - **Parallel Hybrid: ability to test multiple motor options for integration with vehicle inverter/PCU**



Loads and Energy Storage Cont.



- **Energy Storage**

- **Various Chemistries can be inserted**
- **Vehicle inverter/PCU integration**
- **Easy to instrument for current testing**

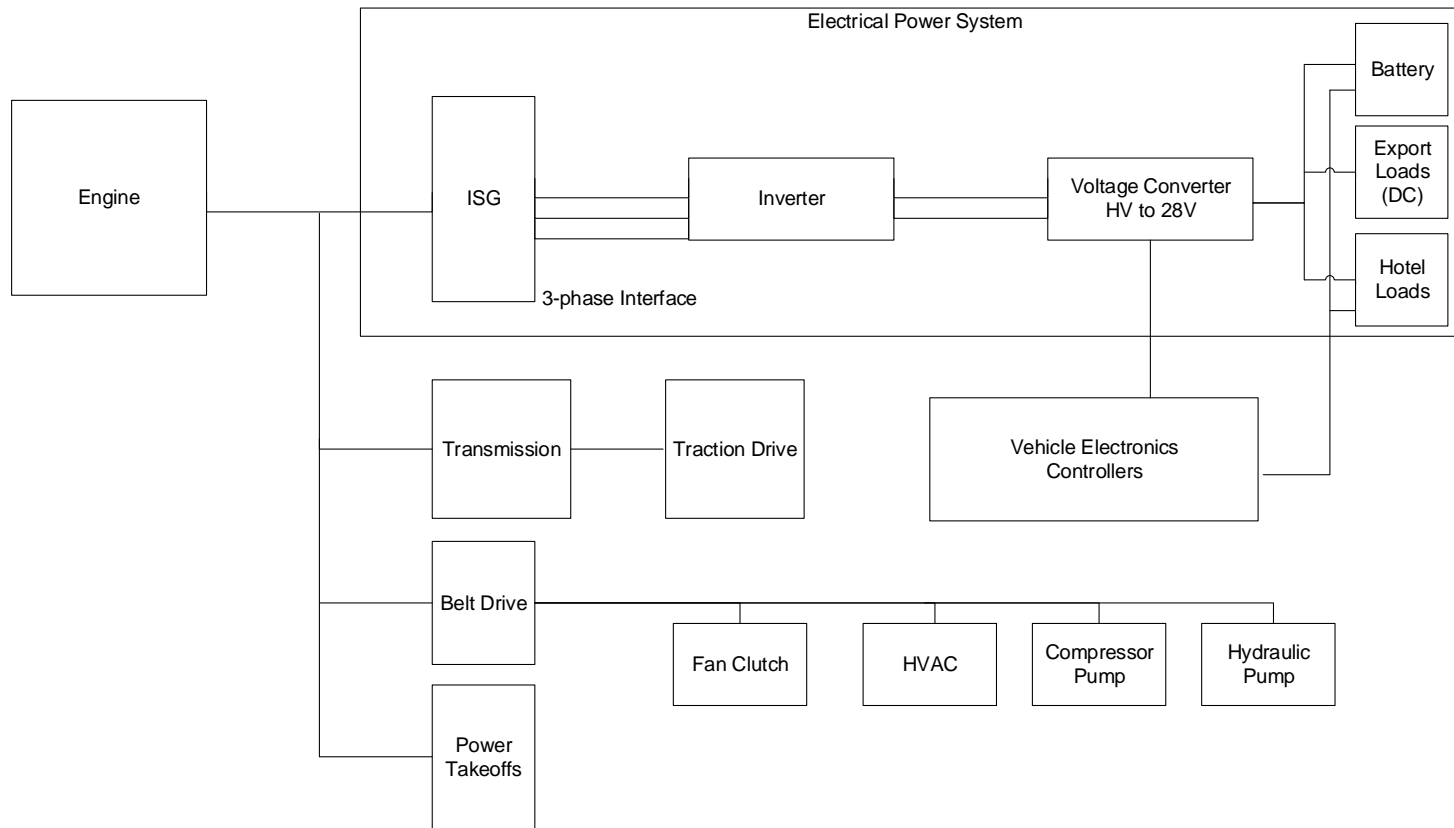


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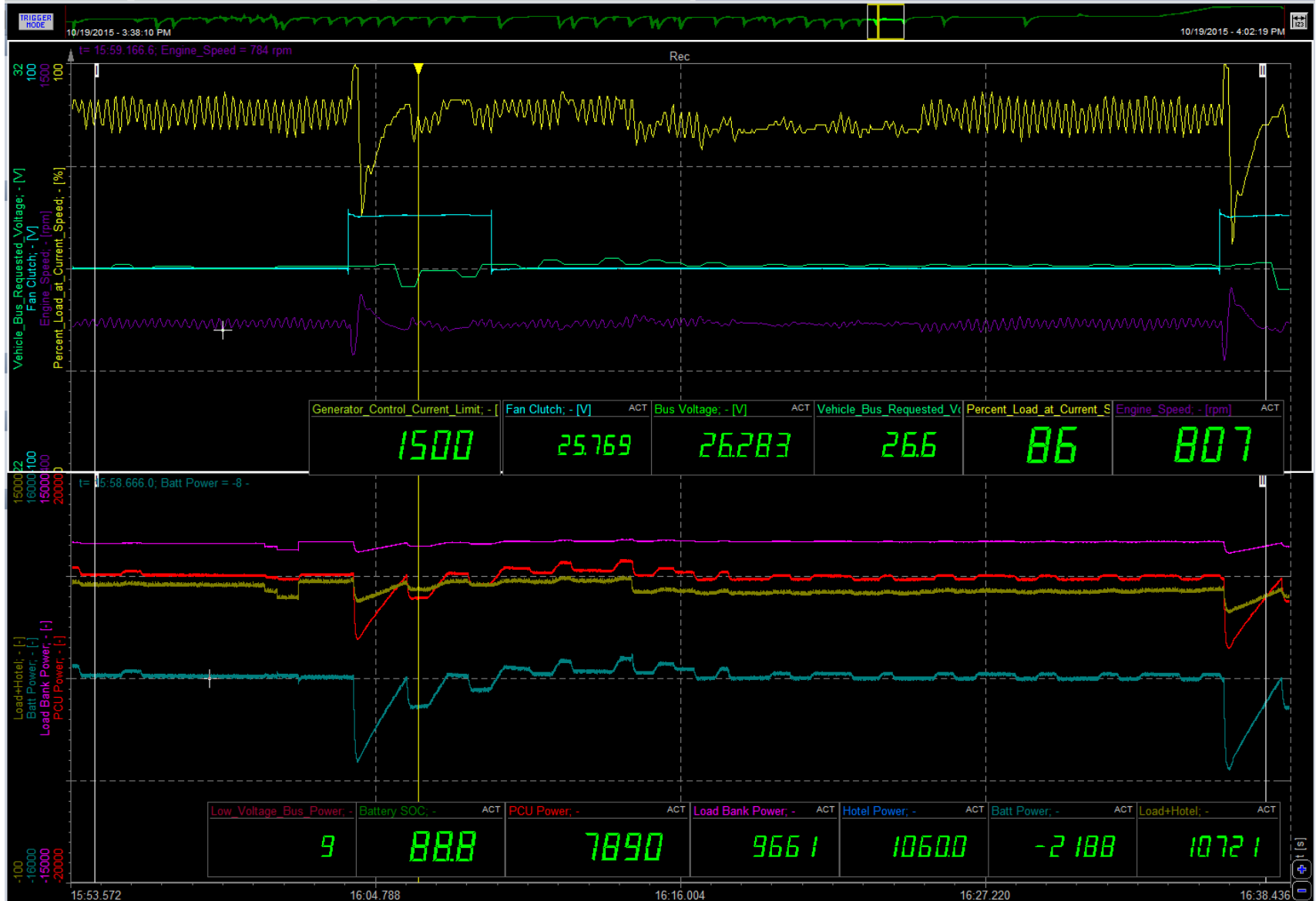
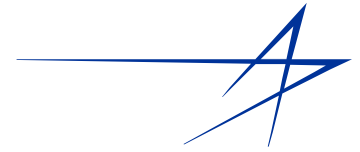
Real World use for the Test Bed



Ground Vehicle Power System Diagram



Fan Clutch Loading



1.5kW to 10kW load stepping



Bi-Directional Power Conversion



Project Objectives:

- 30kW – 5 ea. 6kW Modules
- Power Density (Goal: 5kW/L)
- Input Voltage: 800V
- Output Voltage 28V
- Switching Frequency: 100kHz
- Cooling: Forced Air or Liquid
- Efficiency: 95%
- SiC MOSFET on Primary
 - Wolfspeed
- GaN MOSFET on Secondary
 - GaN Systems or Transphorm

LMCO + JDES + NC State University

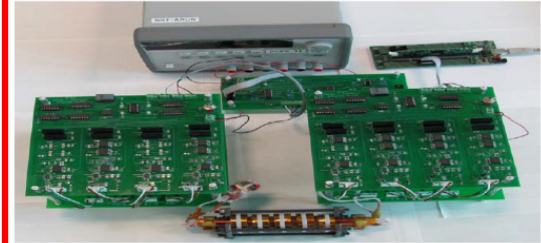
Project title: High Power Density WBG Devices (SiC and GaN) Based Bidirectional, Isolated DC-DC Converter for Auxiliary Power in Heavy Vehicle Applications

Objectives: To demonstrate high power density SiC and GaN based bidirectional DC-Dc converter for automotive applications

Major Milestones: 4-5kW high power density DC-DC converter

Major Equipment Acquisition: 1200/1700C SiC MOSFET, 100V GaN MOSFETS, HF magnetics

Deliverables: Grid connection and dynamic performance of MV SiC MOSFET converter, report



TPOC: Tom Byrd, Kevin Larsen, Subhashish Bhattacharya
Email: sbhatta4@ncsu.edu
Phone: 919-744-1428 (cell)

WBG Technology Impact

- SiC/ GAN MOSFET based high power density converter
- Automotive applications
- Hybrid and fully electric vehicles
- Market segments impacted: automotive
- Time frame for commercialization: 2 years

More WBG Impact and Additional impacts

- Impact on the cost of WBG compared to Silicon, energy efficiency, green energy solutions
- Potential for Job Creation, Economic impact
- Workforce Development and Education if applicable

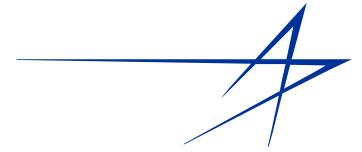
PowerAmerica

Call for Projects

August 2015

Vehicle Test Bed would allow verification of ideas and designs without having it in full mechanically finished format

Conclusion



- **Growing need for vehicle power generation and storage that is more than just the traditional alternator and lead acid battery**
- **Vehicle Test Bed eases integration of new technology**
- **It is possible to make a test bed architecture that model the various types of hybrids**
- **Fully controllable test conditions and instrumentation**

