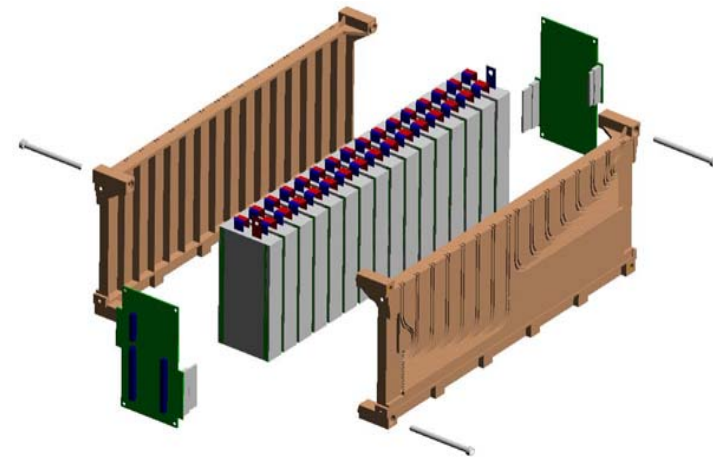


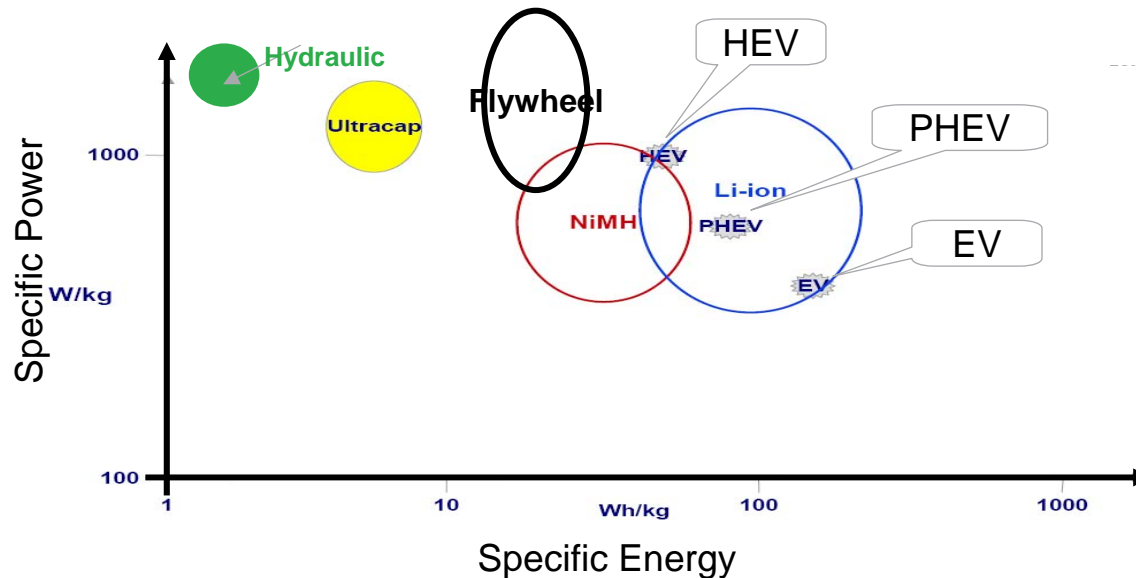
Battery Management System

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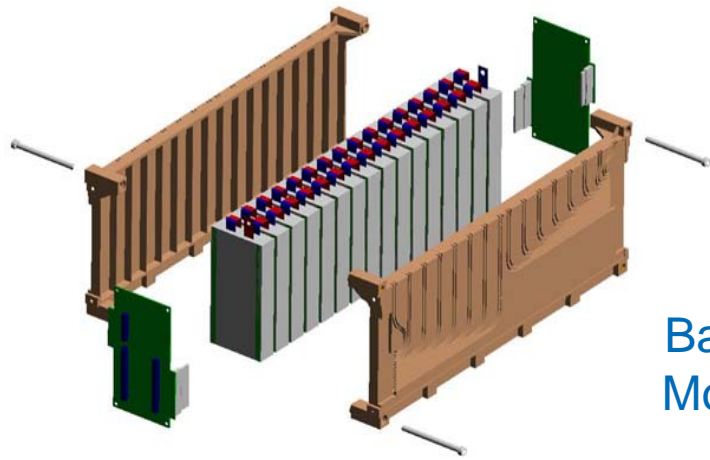
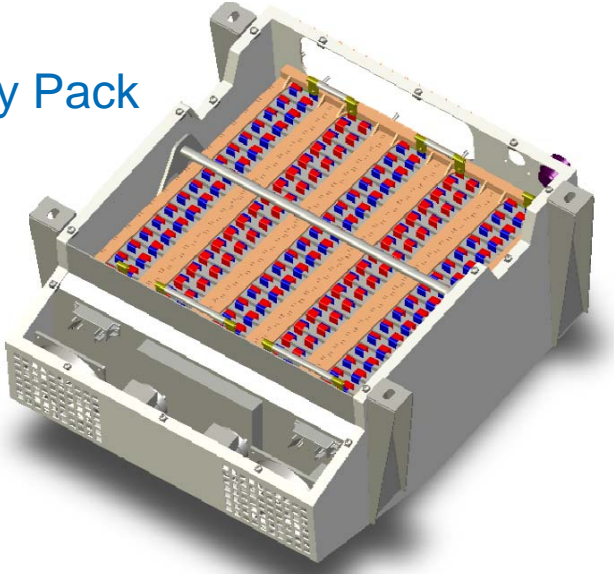
Energy Storage is a Primary Enabler for HEVs, PHEVs, EVs



- The Power and Energy requirements of the Energy Storage System dictate what technologies might be suitable for that application.
- The Energy Storage System needs a management system that will let it be used by external applications, and that will allow it to meet life and functional requirements.
- Ricardo has developed a rapid prototyping battery management system that supports a variety of technologies
 - Ultracaps
 - NiMH
 - Several Li Ion chemistries

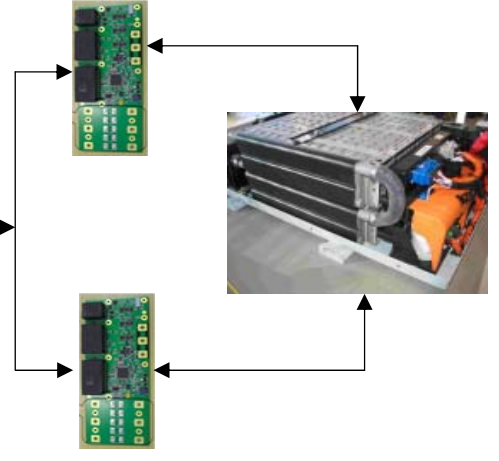
A Battery Pack is Composed of Modules, with each Module Being Monitored and Controlled

Battery Pack



Battery Module

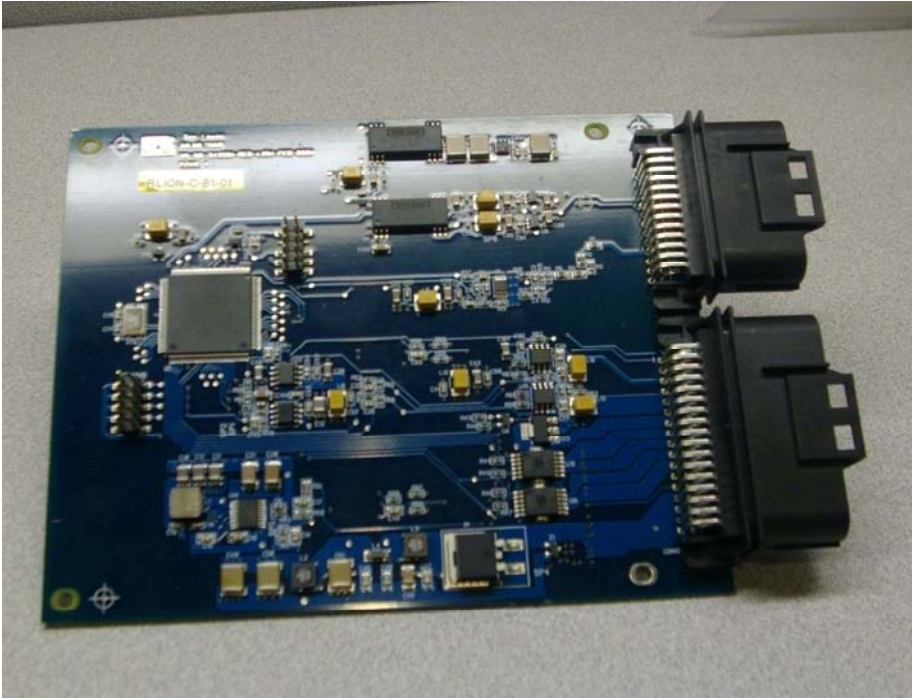
Vehicle
Communication
↔
System



Master Controller (rCube + Contactor Board)

Slave Controllers (VTBM)

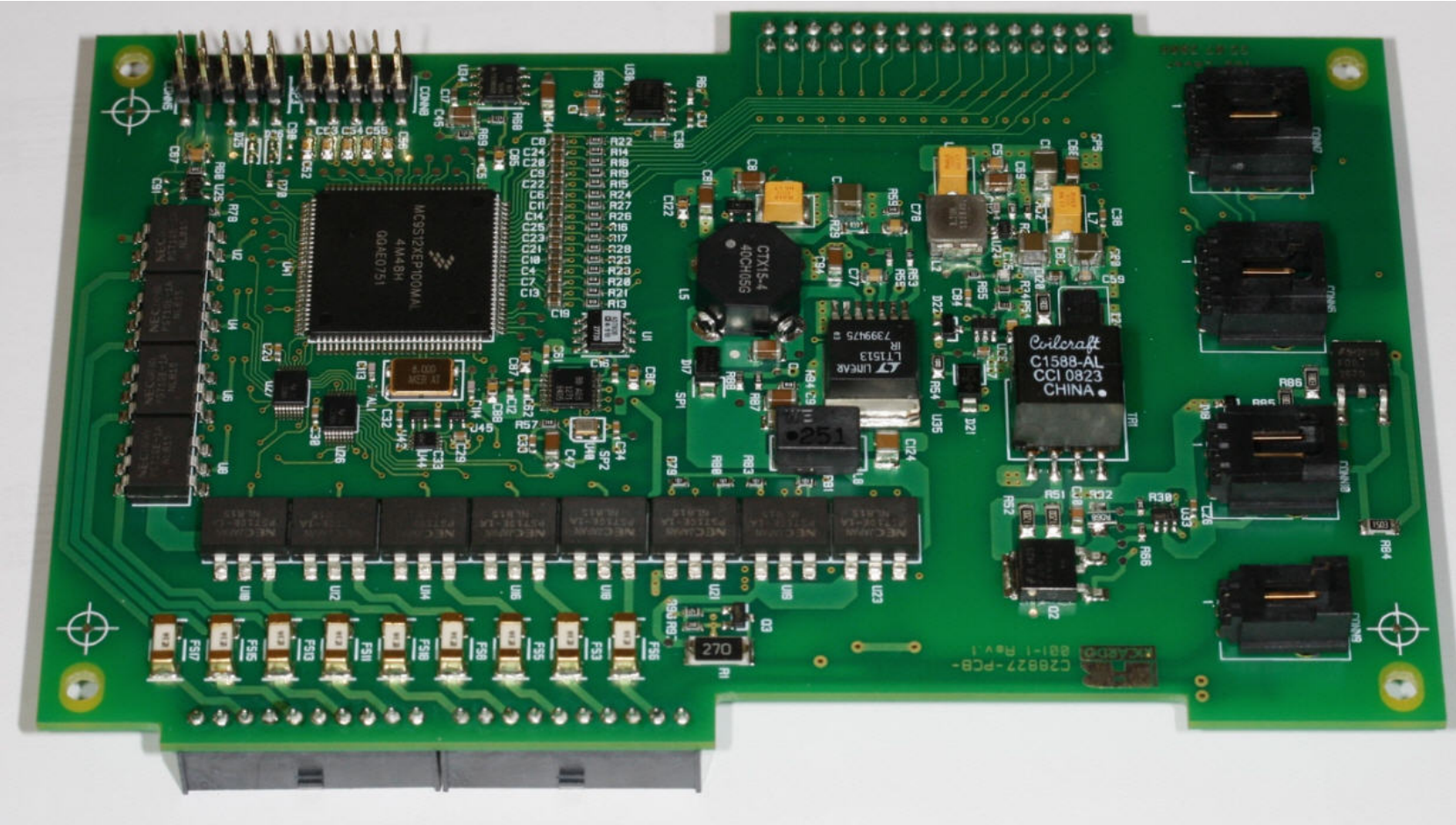
Contactorm Board and rCube Rapid Prototyping Controller



Contactor Board and rCube Functionality

- Developed as part of Ricardo's Red Lion Research program
 - Designed for maximum flexibility to accommodate rapid prototyping of battery packs.
 - Jointly the rCube and the Contactor Board function as the Master Controller.
- General functionality
 - The rCube is a rapid prototyping controller that houses high level functionality such as State of charge estimation, State of health reporting, diagnostics and communication with the vehicle controller.
 - High level control algorithms are developed in a model based environment, simulated and then autocoded and downloaded onto the rCube.
 - The Contactor Board controls the battery pack contactor relays, performs leakage detection and contains ground fault interrupt functionality.
 - The Contactor Board has a powerful microprocessor that is capable of housing the high level control algorithms, once they have been rapidly developed using the rCube.
- High scalability
 - Supports Ultracaps, NiMH, and several types of Li Ion cell chemistry
 - Can handle battery pack voltages up to 1000V
 - High redundancy of the system

Voltage Temperature Balance Module (VTBM)



VTBM Functionality

- General functionality
 - There is one VTBM board per battery module.
 - The VTBM board can measure up to 16 cell voltages and 16 cell temperatures.
 - The VTBM performs the charge balancing function to maintain similar states of charge in the cells of the module.
 - The VTBM communicates with the contactor board via CAN, and receives cell balancing commands from it.
- Performance information
 - <1mV cell voltage measurement precision.
 - <1°C temperature measurement precision
 - Active charge balancing efficiency >90%