Formula Hybrid

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Intro

Series hybrid using a capacitor bank

- Control
  - Turn driver inputs into outputs
  - Maintain efficient operation of the internal combustion engine (ICE) under load
- Monitoring
  - Maintain safe operation
- Information
  - Provides driver and off-track team with live updates of the vehicle diagnostics

Problem Description

- Driver Inputs
- System Status Interface
- Motor/Generator/Motor Controllers
- Engine Feedback Loop
- Accumulator Management System

Problem/Solution - Driver Inputs

Problem

- False fault errors continuously reported due to noise signals and absence of error margins.
- Conversion of Brake Pedal into Hydraulic Pressure Transducer

Solution

- Improved error margins included in the maximum and minimum threshold of the system
- Transducer is very different from the brake pedal therefore, adjustments such as gain factors would be needed to allow for seamless integration

Problem/Solution - System Status Interface

Problem

- LCD
  - Brightness/Color Contrast
  - Glare-reduction
  - Error message overflow
  - Error-controller mapping
- RF Transmission System
  - Comma List system clarity
  - Necessity for Data log for analysis

Solution

- LCD
  - Higher current 3.3V supply for brightness
  - Code manipulation for color contrast/error overflow reduction
  - Coding system for error-controller mapping
  - Application of Glare-reducing Shield
- RF Transmission System
  - Implement GUI and Data log
  - Possible implementation of Auto-save in Data log

Problem/Solution - Motor/Gen/Controller

Problem

- Differentiating left and right Kelly controllers
- No way to tell which controller's message will be read next in the FIFO

Solution

- Use CAN-interpreting O-scope to verify that there is no address
- Utilize unused switch status bits to differentiate controllers

Problem/Solution - Engine Feedback Loop

Problem

- Signal noise
- Prototyped sensor board
- Simplistic algorithm

Solution

- Shielded cables
- Dedicated PCB
- More complex algorithm
  - Multiple operating regions
  - More inputs (from accumulators)

Problem/Solution - Accumulator Management System

Goal: Maintain equal voltage drops across each capacitor and eliminate low voltage shutdown

Problem

- Manufacturing tolerances on capacitance and ESR can affect voltage divide between capacitors
- AMS prevents generator charging and cells removed from HV system in shutdown event
- Passive cell balancing dissipates extra charge instead of reallocating

Solution

- Implement active cell balancing
- Measure capacitance and ESR values of ultracapacitors (pending available equipment)
- Add a high voltage low dropout regulator
- Replace current limiting resistors with fuses in cell junctions to handle increased current needs

Demonstrated Features

- Driver Inputs
  - Mitigation of false error signals
  - Incorporation of hydraulic pressure transducer
- Engine Feedback Loop
  - Stable RPM under changing load
  - More inputs allowing for multiple control states
- Motor/Controller/Generator
  - Torque vectoring (once addressing issue is solved)
- System Status Interface
  - LCD improvements and Transmission System GUI with data log
- Accumulator Management
  - Active cell balancing to minimize low-voltage shutdown events

Technologies

To obtain:

- Quad/Dual Supercapacitor Auto Balancing (SAB™) MOSFET Array ($22)
  - http://www.aldinc.com/pdf/ALD810025.pdf
- 5 A Fuses ($1.66)
  - https://www.mouser.com/datasheet/2/240/Littelfuse_Smart_Glow_MINI_Blade_datasheet-1291256.pdf

- Circuit boards - modified motherboard
- Understanding previously utilized technologies like isolated SPI in depth would be important to contribute improvement to the previous iteration of the project.

Engineering Content

Classes: Power Systems, Electric Vehicles, Control Systems, and Embedded Systems.

Hardware:
Integration of all of the subsystems into a working car
Updated design of the motherboard and new design for RPM sensor board
Redesigned balancing boards for ultracapacitors

Software:
Better control algorithms
Solving communication problem with Kelly controllers
Updated onboard and offboard user interface

Conclusion

- Hybrid car electrical system design is a collaborative effort between past senior design teams and the current ND Hybrid team
- Project has real customer with real requirements provided by Formula SAE organization
- Hope to have a drivable hybrid vehicle by the end of the year