Rose-Hulman Institute of Technology
Vehicle Development Process
Model-Based Design Center of Excellence

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ChallengeX

Rose-Hulman undergraduate students will develop a hybrid powertrain utilizing alternative fuels to *increase the fuel economy* and *decrease the tailpipe emissions* of a Chevrolet Equinox.
Step 1 – Choose the most complicated architecture possible!

- Motor 1 (M1):
  - 60 kW Peak
  - 30 kW Cont.
  - 240 Nm - Max

- Motor 2 (M2):
  - 60 kW Peak
  - 30 kW Cont.
  - 240 Nm - Max

- Planetary Gear
  - 1.73 Ring to Sun Ratio

- Engine

- 70 kW VM Motori Diesel

- Differential
  - 3.46 Ratio

- Right Rear Tire

- Left Rear Tire

Similar to the Toyota Prius
Only team doing it!
14/17 are PTTR
Help!

• How does a team of undergraduates with no experience:
  – Understand the basic operation of the power train?
  – Size components?
  – Build a controller?
  – Test a controller?
  – Implement controller on a target?
  – (What is a target anyway?)
Answer – Model-Based Design

• Build a Model
• Simulate Model (SIL)
• Targeting w/Auto Code Gen
• Real Time Simulations (HIL, PIL,TIL)
• Deployment and Testing
• Verification and Validation
Model-Based Design with Simulink

“Software-in-the-Loop”
One computer running one simulation
Real-Time Simulations

“Hardware-in-the-Loop”
Real-time target with FIFO “network”

- LabVIEW shell running a separate RTW generated DLLs for both plant and HVSC
- Remote simulation monitoring and control using a PC running LabVIEW

Laptop
(Simulation Output & Driver Controls)

National Instruments PXI Chassis

PLANT

FIFO

HVSC

TCP/IP
Real-Time Simulations with Network Comm.

“Target-in-the-Loop”
Two real-time targets with CAN network

- Use actual in-vehicle driver input methods
- Allows identification of effect of network latency on vehicle operation
Deployment on MotoTron ECU555

- MotoTron MotoHawk used to Access Hardware Facilities
- Auto Code Generation with GHS Compiler
Verification And Validation

• Monte Carlo Analysis
• System Test
• Data Collection
  – MotoTron ISDL
  – Programmed in Simulink and MotoTron MotoHawk
  – Data Conversion and Post-processing with Matlab
Model-Based Design Center of Excellence

- Supported by Several Companies
- Generate Academic Courses
- Generate Industry Short Courses
- MBD Workshops at Conferences
- National Information Center
- Teach faculty how to teach MBD
Model-Based Systems Design Courses at Rose-Hulman

• Junior Level Quarter Course
  – Model-Based Design of Motor Generator System (On Display)
  – With MathWorks and Freescale

• Senior Level Quarter Course
  – Model-Based Design of a Series Hybrid-Electric Vehicle
  – With MathWorks and MotoTron
Introduction to MBD Course

- Model-Based Design for a small system
- Simulink Simulations
- Real-time simulations with xPC
- Deploy controller on MPC5553 target
- PIL Real-Time Simulations
- Test controller on physical system
- Model Verification
- DoE - Improve Motor and Generator Models
- Model Refinement and Re-Verification
Advanced MBD Course

• Modeling a series hybrid-electric vehicle
• Introduction to V&V (HIL, PIL, TIL)
• Real-Time Simulations (xPC, etc)
• Introduction to CAN
• TIL Simulations (Not Real-Time)
• HIL Simulations (Real-Time)
• Sensors and Interfacing
• Deployment on Series HEV Test Platform
• Data Collection
Questions