ROSE-HULMAN
INSTITUTE OF TECHNOLOGY

Curricular Innovation in MIL, SIL, & HIL

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Outline

- Introduction to Rose-Hulman
- ATS Program
- MBSD Lab
- Current Curriculum
- Future Plans
- Questions

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Introduction to Rose-Hulman Institute of Technology

Our Legacy

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

- Founded in 1874 by Chauncey Rose
  - Railroad industrialist
  - Needed rail engineers
- The Terre Haute School of Industrial Science
- 1875 - Rose Polytechnic
- 1971 – Rose-Hulman Institute of Technology
- 2000 – U.S. News #1 Ranking

Mission & Vision

- ***"to provide our students with the world's best undergraduate education in engineering, mathematics and science in an environment of individual attention and support."***


- ***"to be the best in engineering, mathematics and science education, to make an impact upon the world in which we live, and to be a leader in every aspect in the delivery of education and the development of tomorrow's leaders."***

Academic Themes

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

- Academic Excellence
- Students Come First
- Faculty Who Teach
- Engaging Culture
- Co-Curricular Activities

Numbers

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

• Total Enrollment	1888
• Average Class Size	20
• Academic Majors	16
• Median SAT Score	1320
• Internships	85%
• Placement Rate	96%
• Average Salary	$59,636

10% enter Advanced Transportation Sector

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Advanced Transportation Systems Program

Mission

- *To be the world leader in producing undergraduate engineers uniquely qualified to be immediate producers and rapid risers in the Advanced Transportation sector.*

Why Rose-Hulman?

- Top undergraduate engineering college for 13 years in a row
- Eight of top 10 employers are Advanced Transportation
  - Caterpillar, Chrysler, Cummins, Ford, GM, NAVSEA Crane, Rockwell-Collins, Rolls-Royce
- Rich Indiana automotive heritage
- Indiana encouraging advanced transportation industry

Student Innovation Center

Competition Teams

EcoCAR2

Rose Efficient Vehicle

Team Rose Motorsports

Human Powered Vehicle

Design Build Fly

Gran Prix Engineering

Focus Areas

- Model-Based System Design (MBSD)
- Electric Machines
- Combustion Science
- Diesel Technology
- Powertrain Design
- Energy Storage
- Materials & Manufacturing

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Model Based System Design Lab

MBSD

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- $650,000 lab sponsored by The MathWorks, Freescale, and Woodward
- Established in 2007
- Only one in Indiana; one of few in US
- Technical work includes
  - Development of hybrid vehicle plants and controllers
  - Design of engine controller
  - Modeling of pressure drops in transmission
- Arose directly from ChallengeX AVTC

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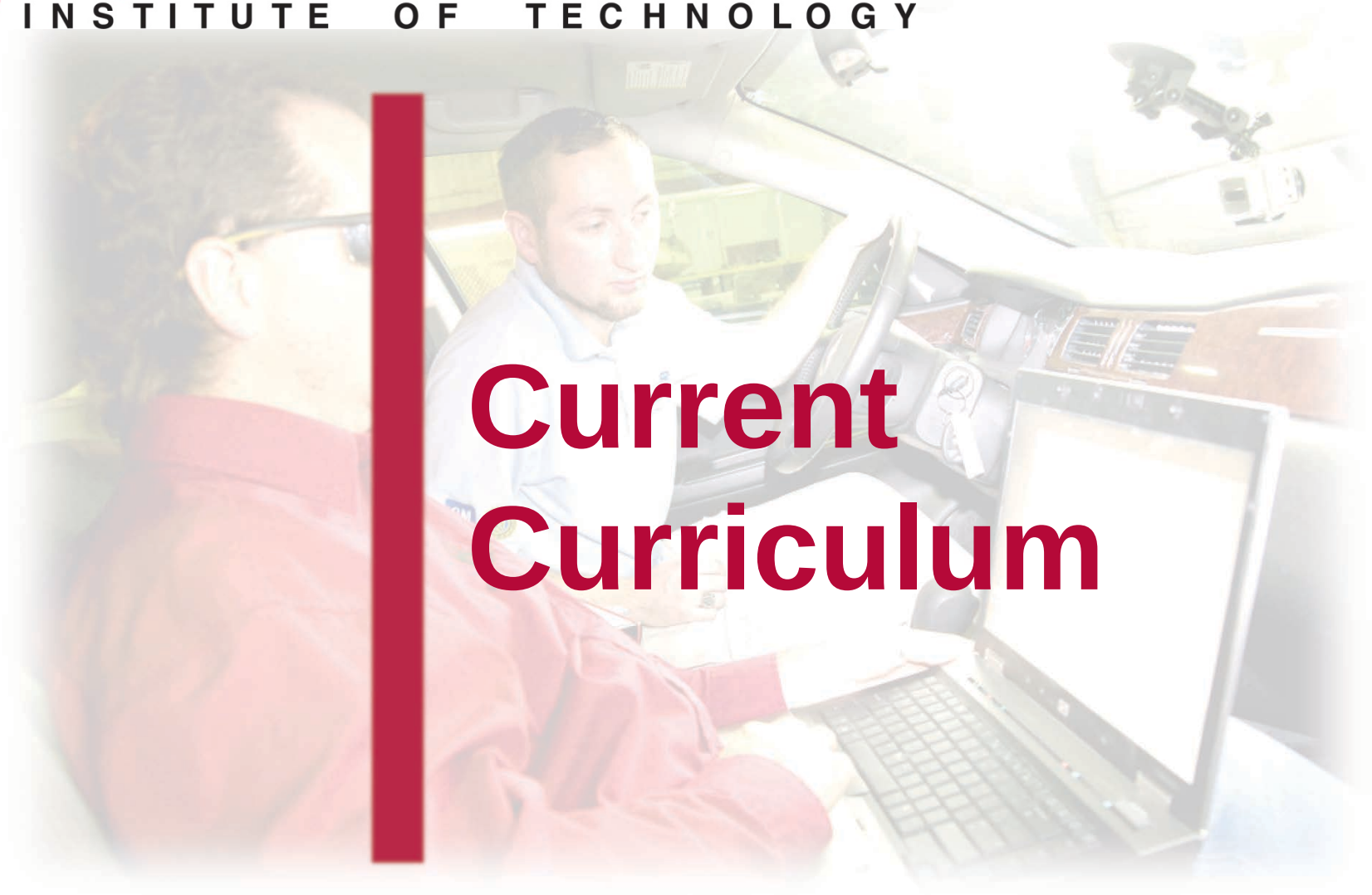
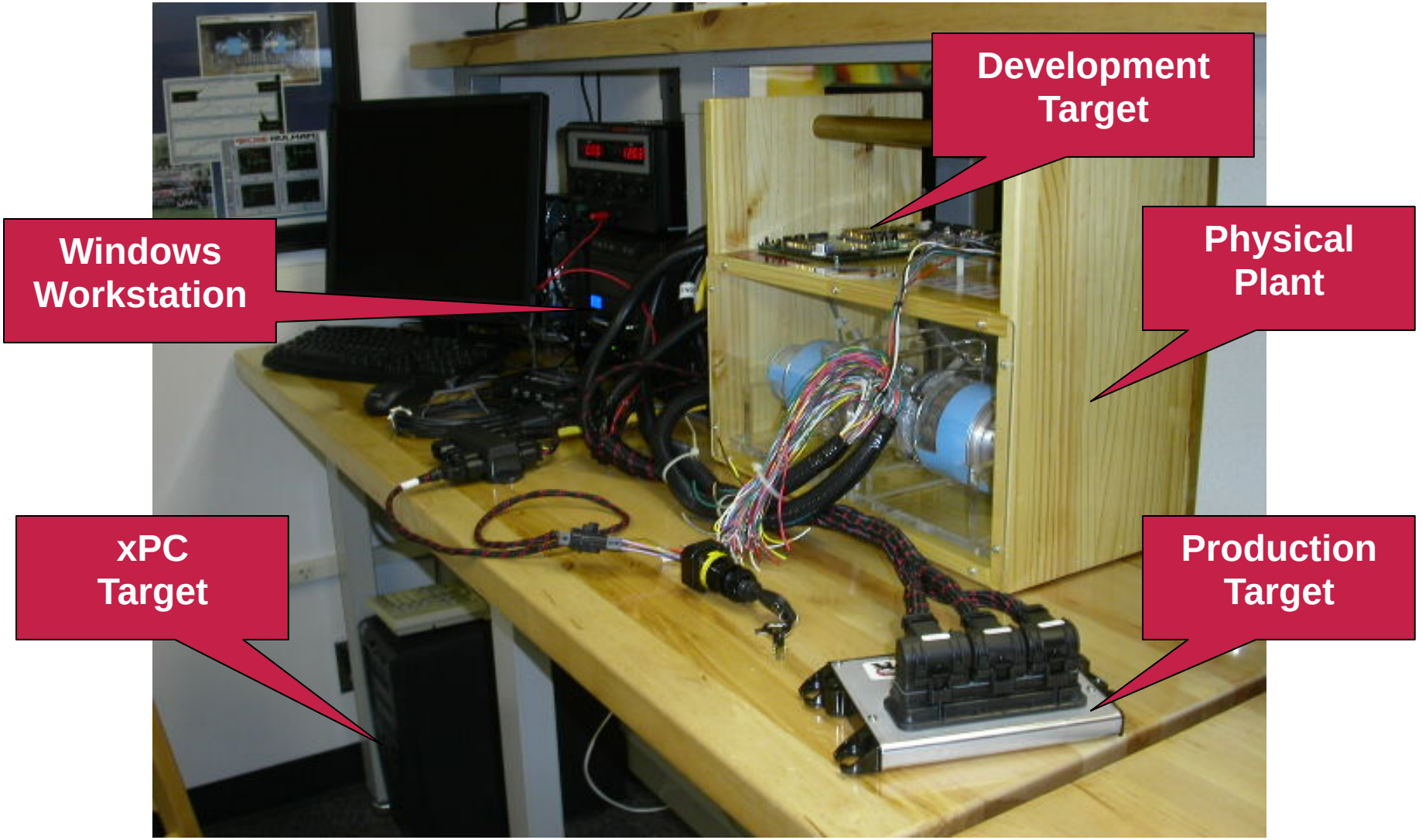


Current Curriculum

Introductory Course

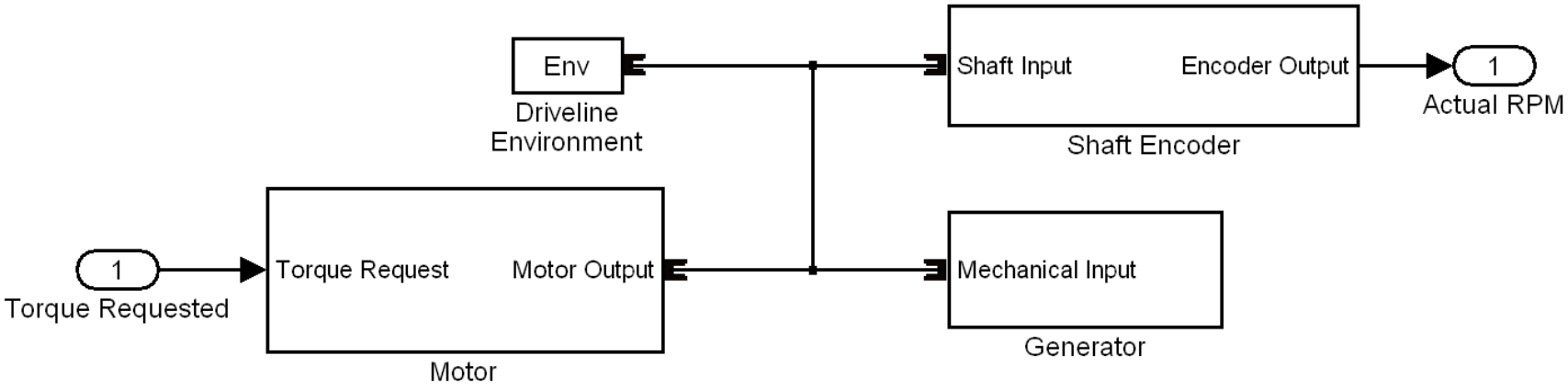
- MBSD of an Electric Genset
  - Use a very simple system
    - Easy to understand components
    - Easy to predict behavior
  - Focus on the MBSD process
    - Start with incredibly simple models
    - Make incremental changes
    - Verify!
  - Experience the MIL/SIL/HIL process

Introductory Course



Introductory Course

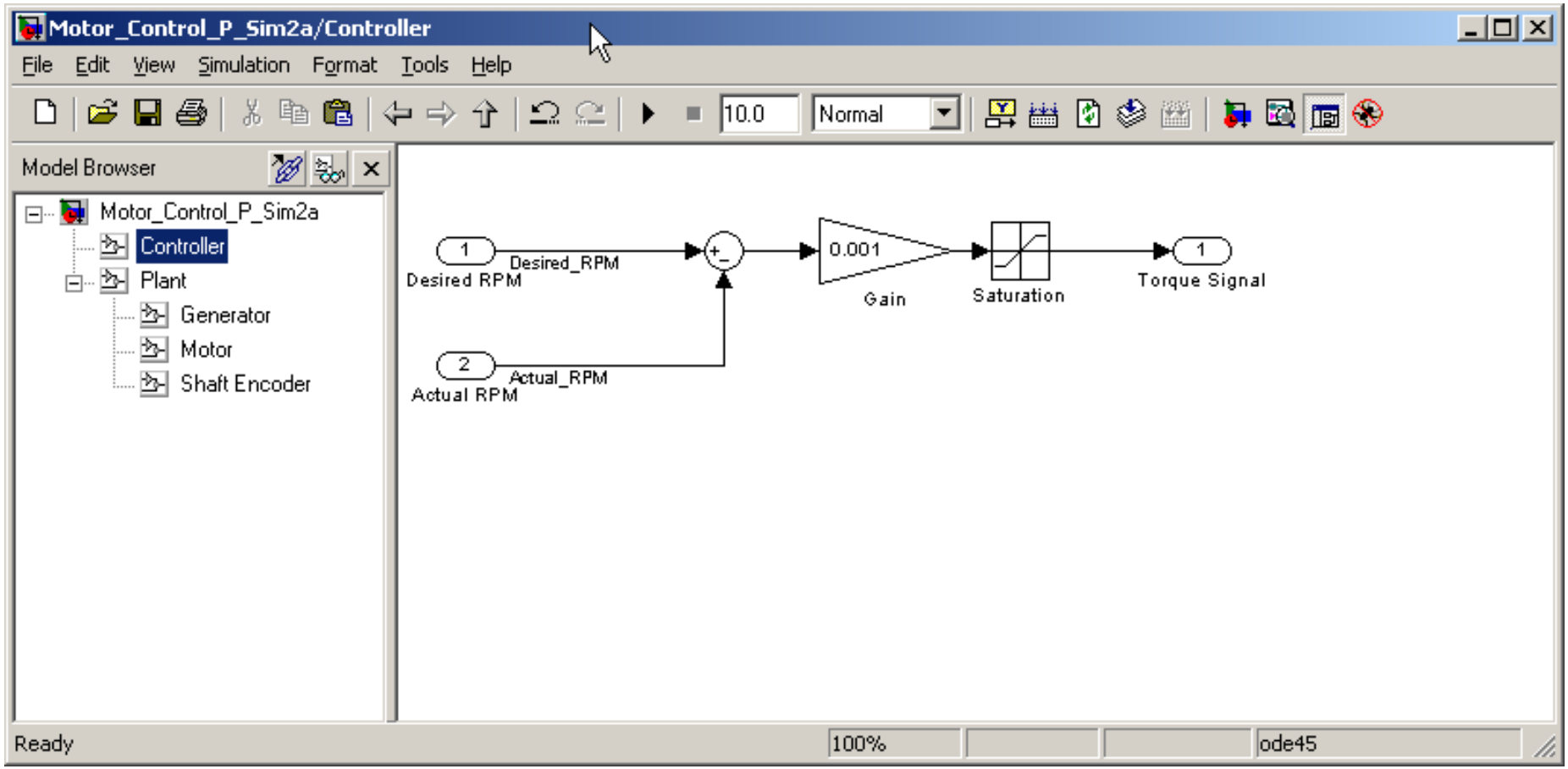
- Develop simple, first order component models



- Assemble into a system

Introductory Course

- Develop a proportional controller



Introductory Course

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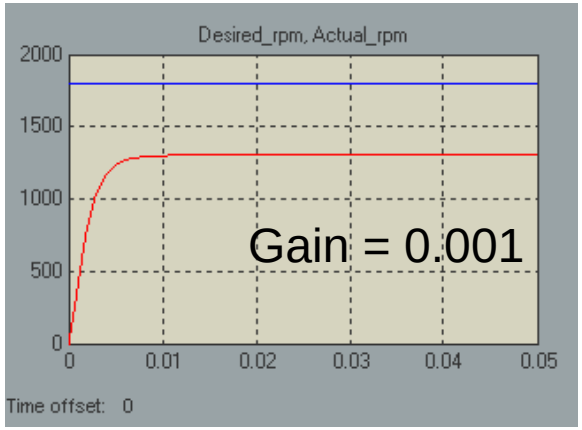
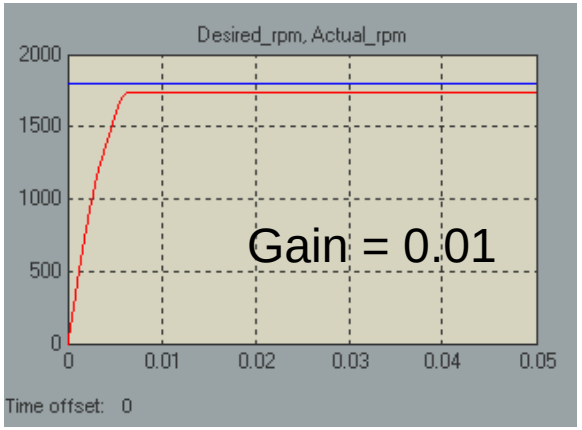
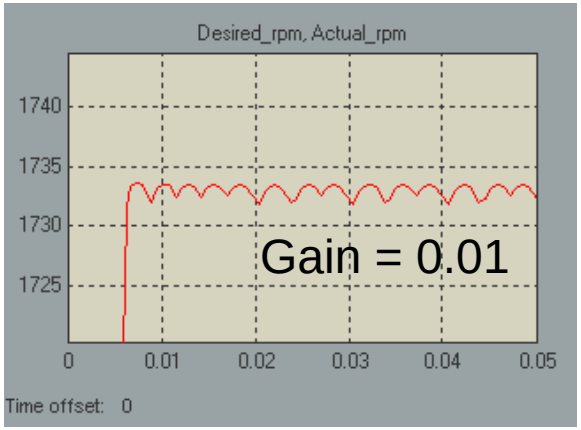
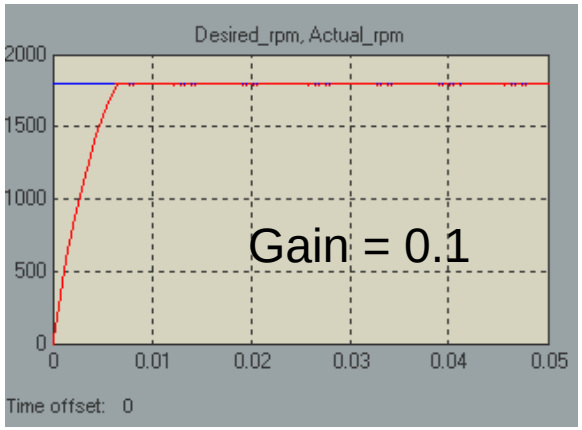
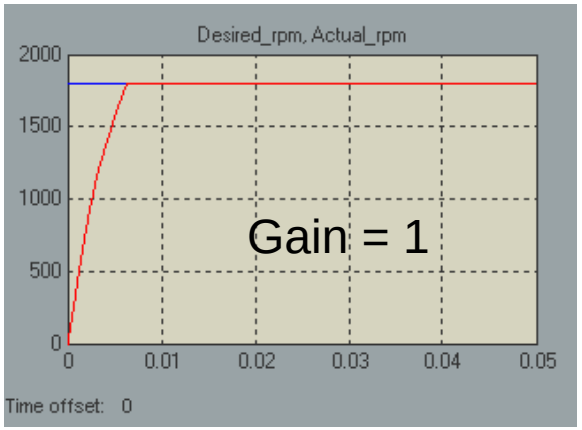
- Investigate in software

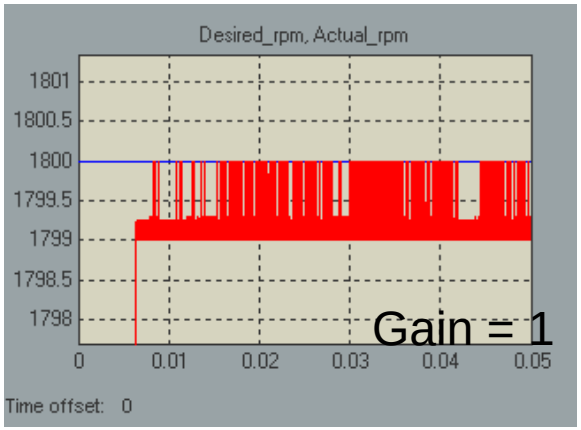






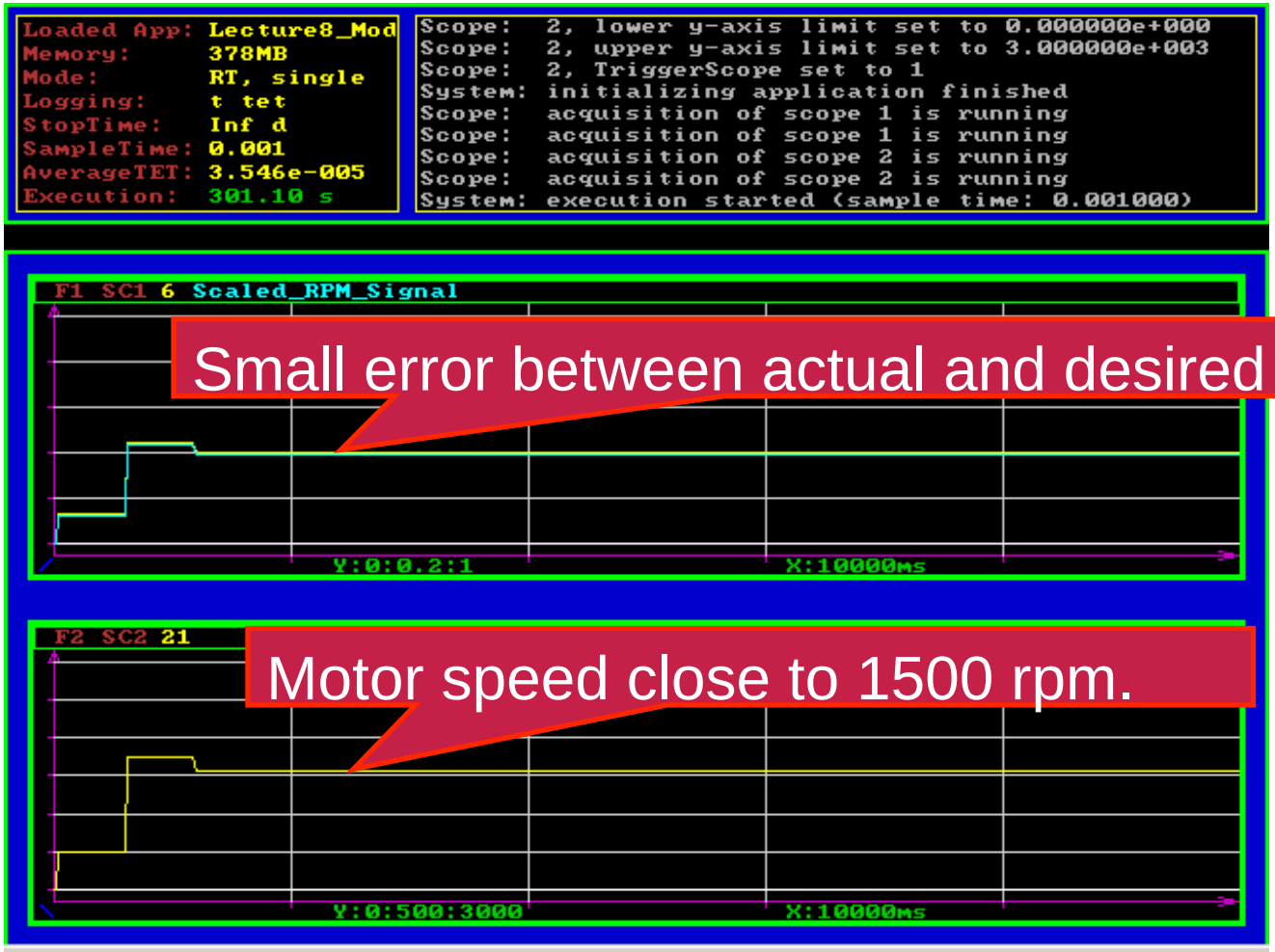






Introductory Course

- Real Time Target via XPC



Introductory Course

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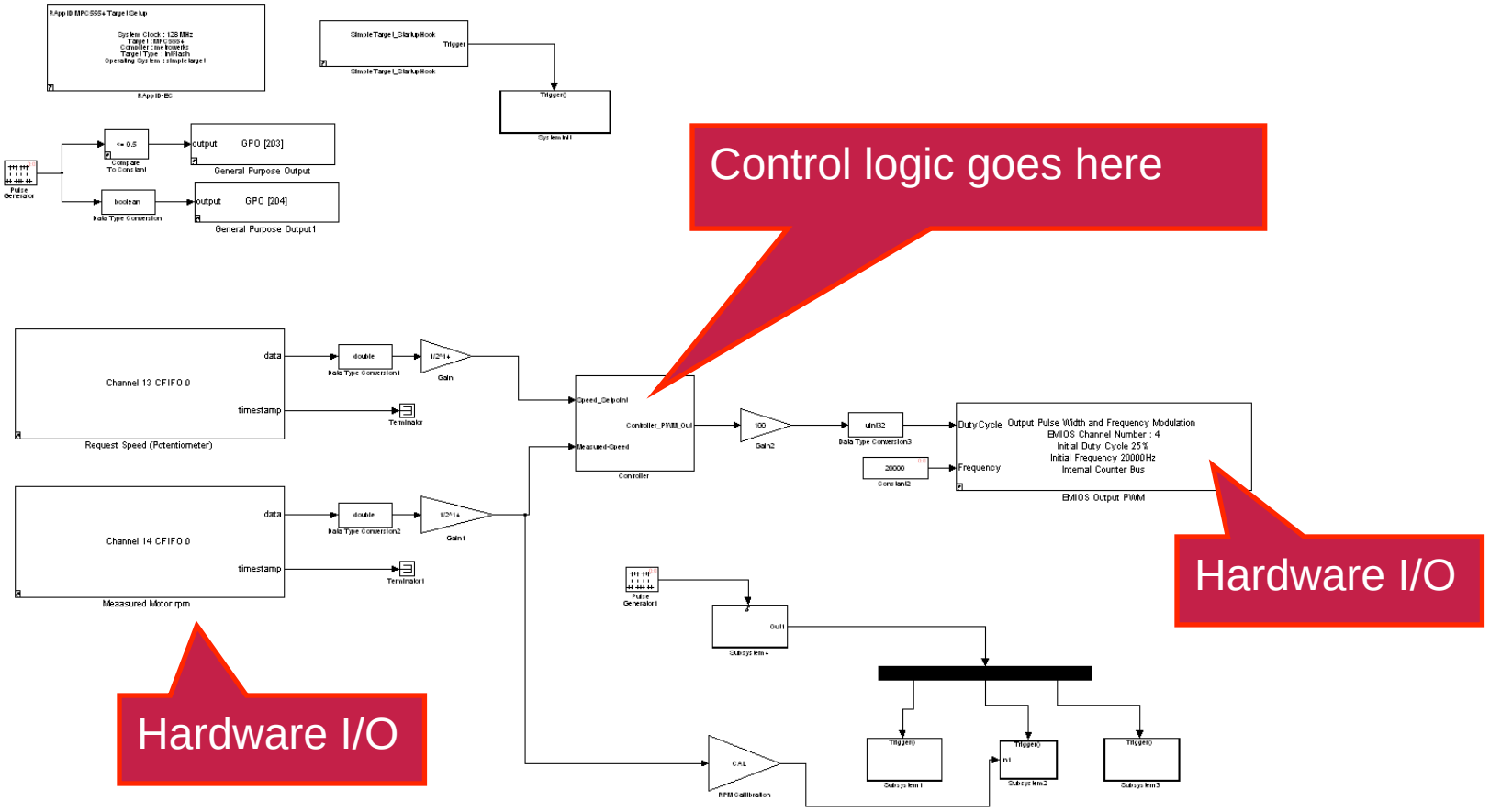
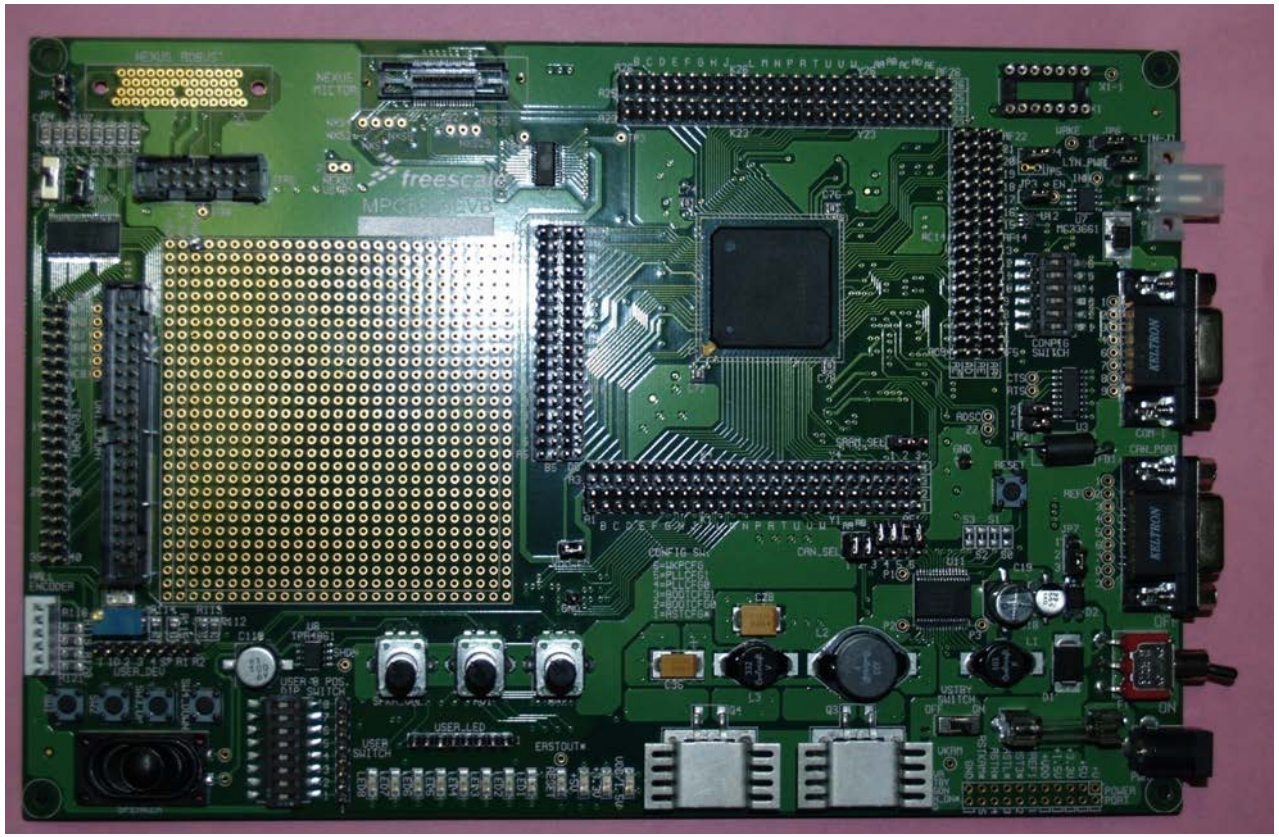
- Embed the control code in a wrapper



Introductory Course

- Download to the MPC5554 EVB



- Auto Code Generation!

Introductory Course

- Investigate the physical system
- Perform verification and validation
- Generate data corrected models

Contact presenter for access

Advanced Course

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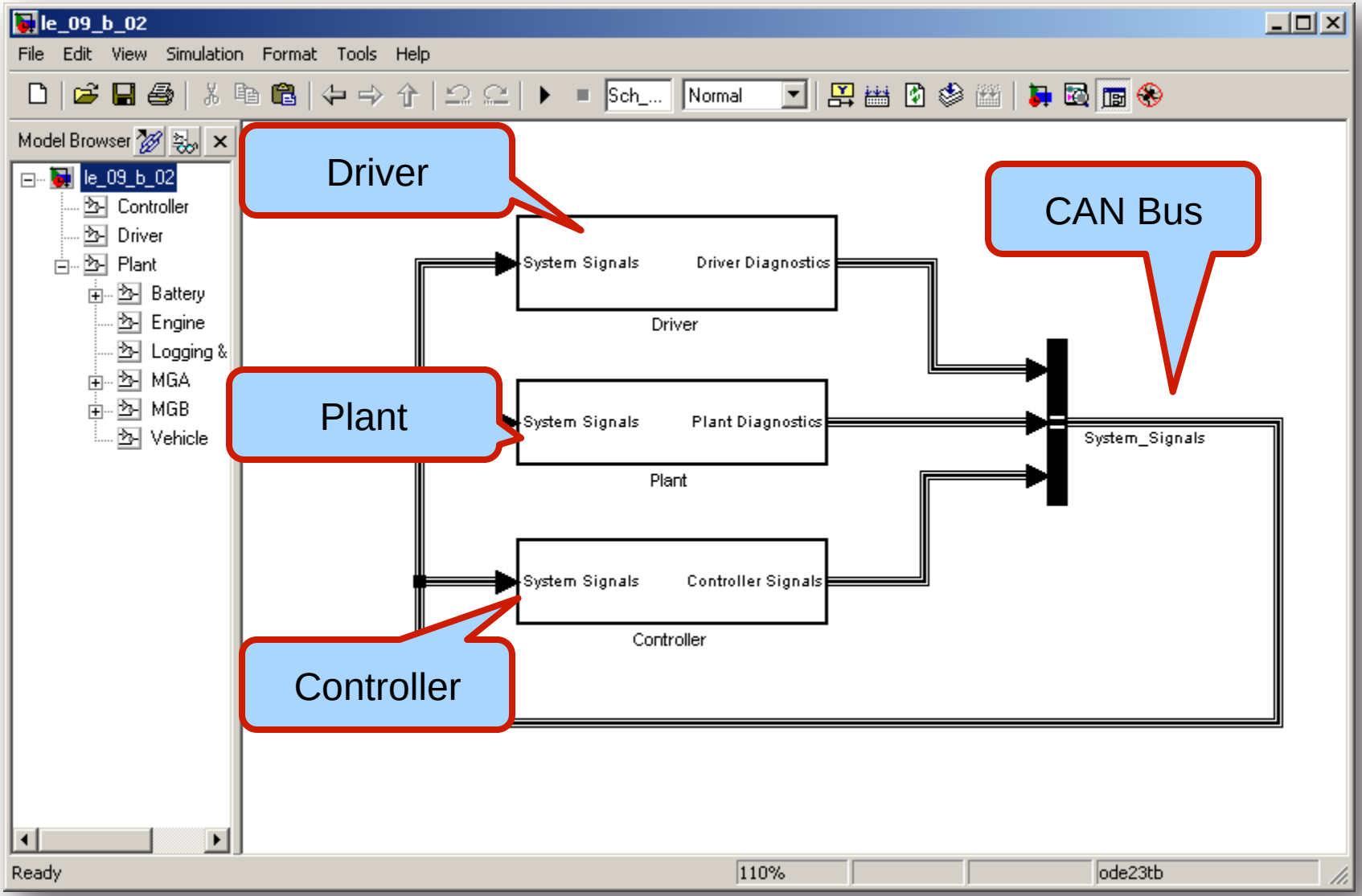
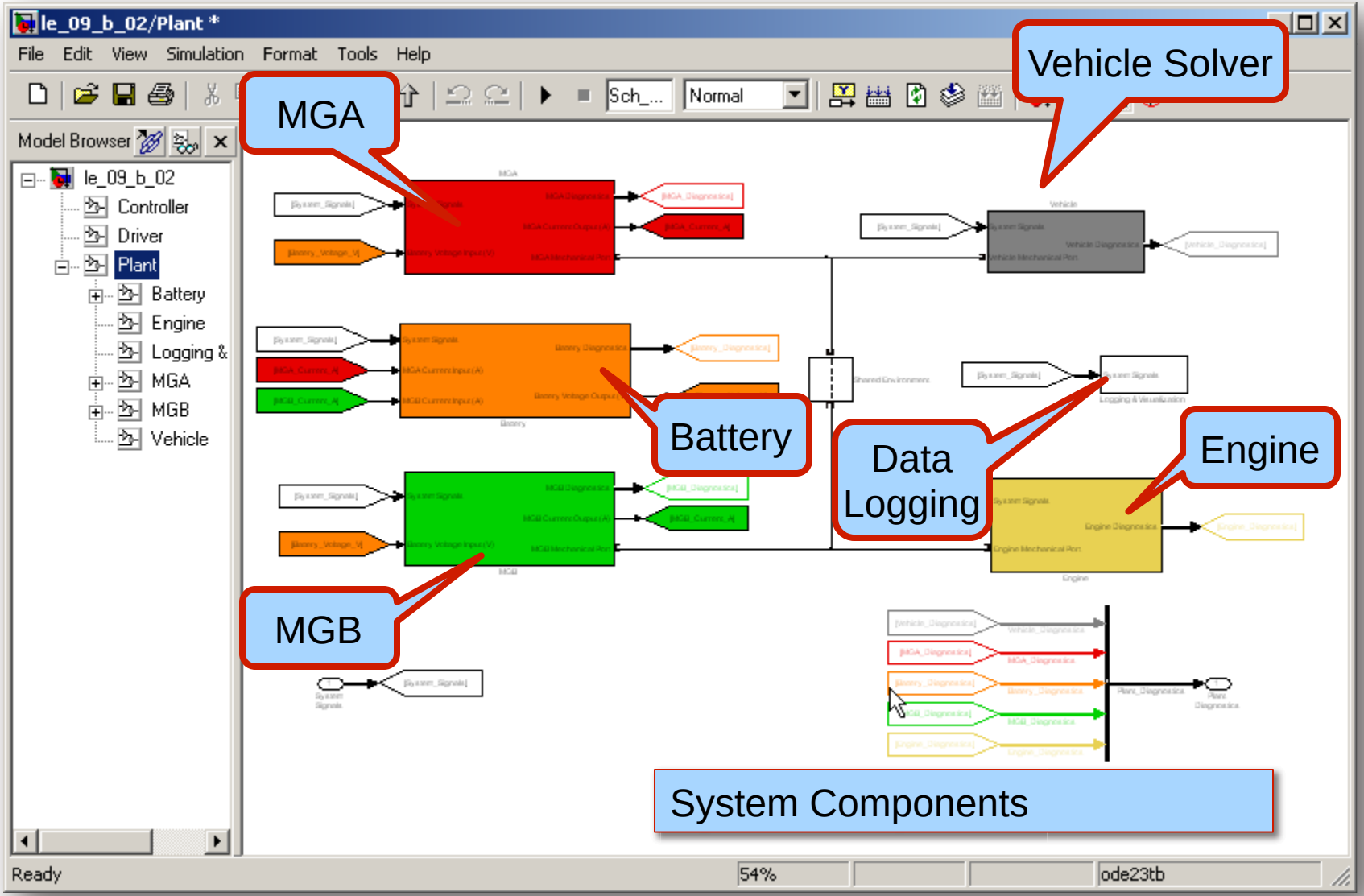
- MBSD of a Series Electric Vehicle
  - Uses a complicated system
    - Lots of components
    - Complex control strategy
  - Focuses on model development
    - Apply MBSD approach to develop medium fidelity models
    - Incrementally build the controller
  - Introduces CAN communication between controller and plant.

Advanced Course



Advanced Course



Advanced Course

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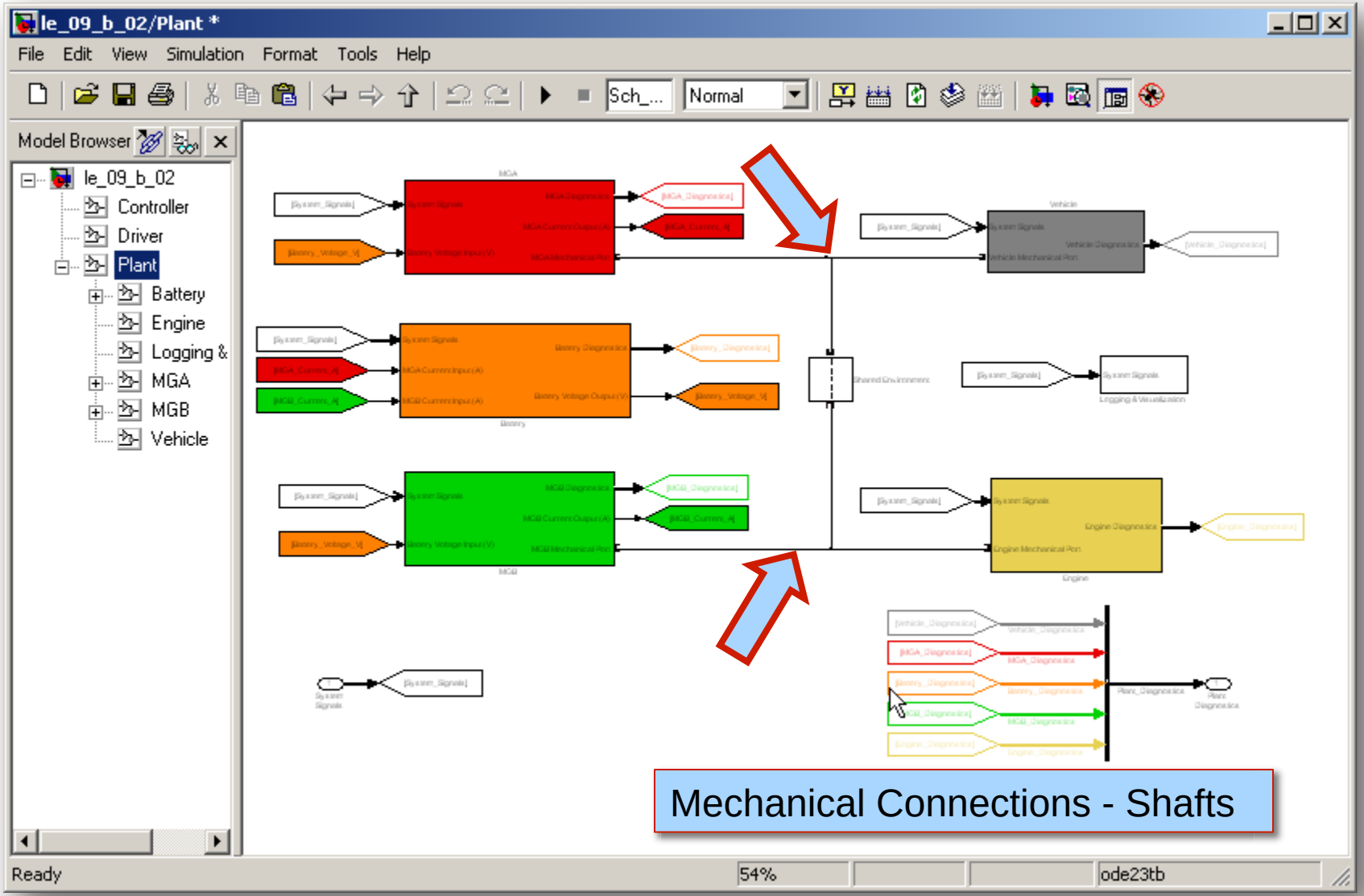
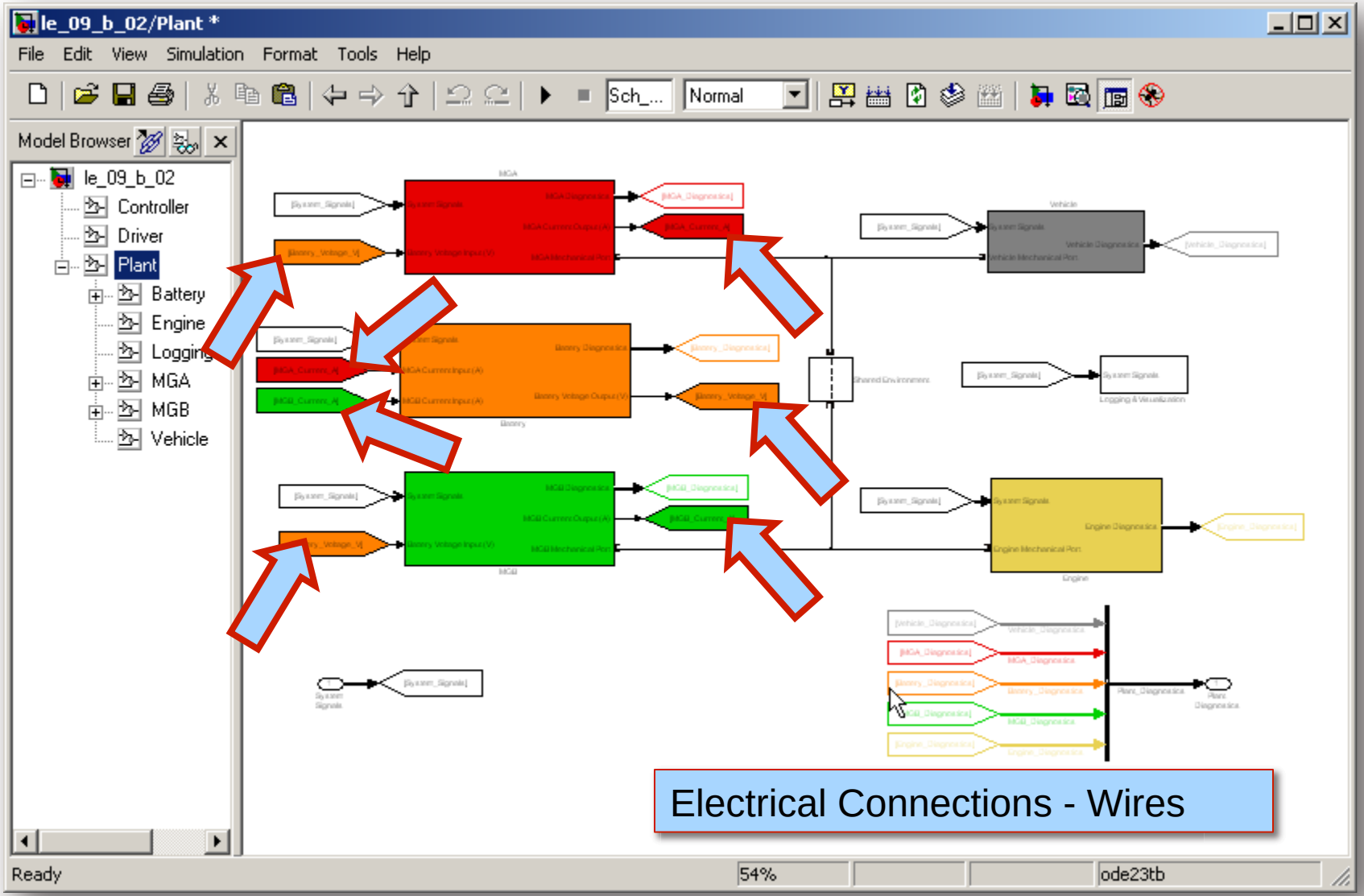
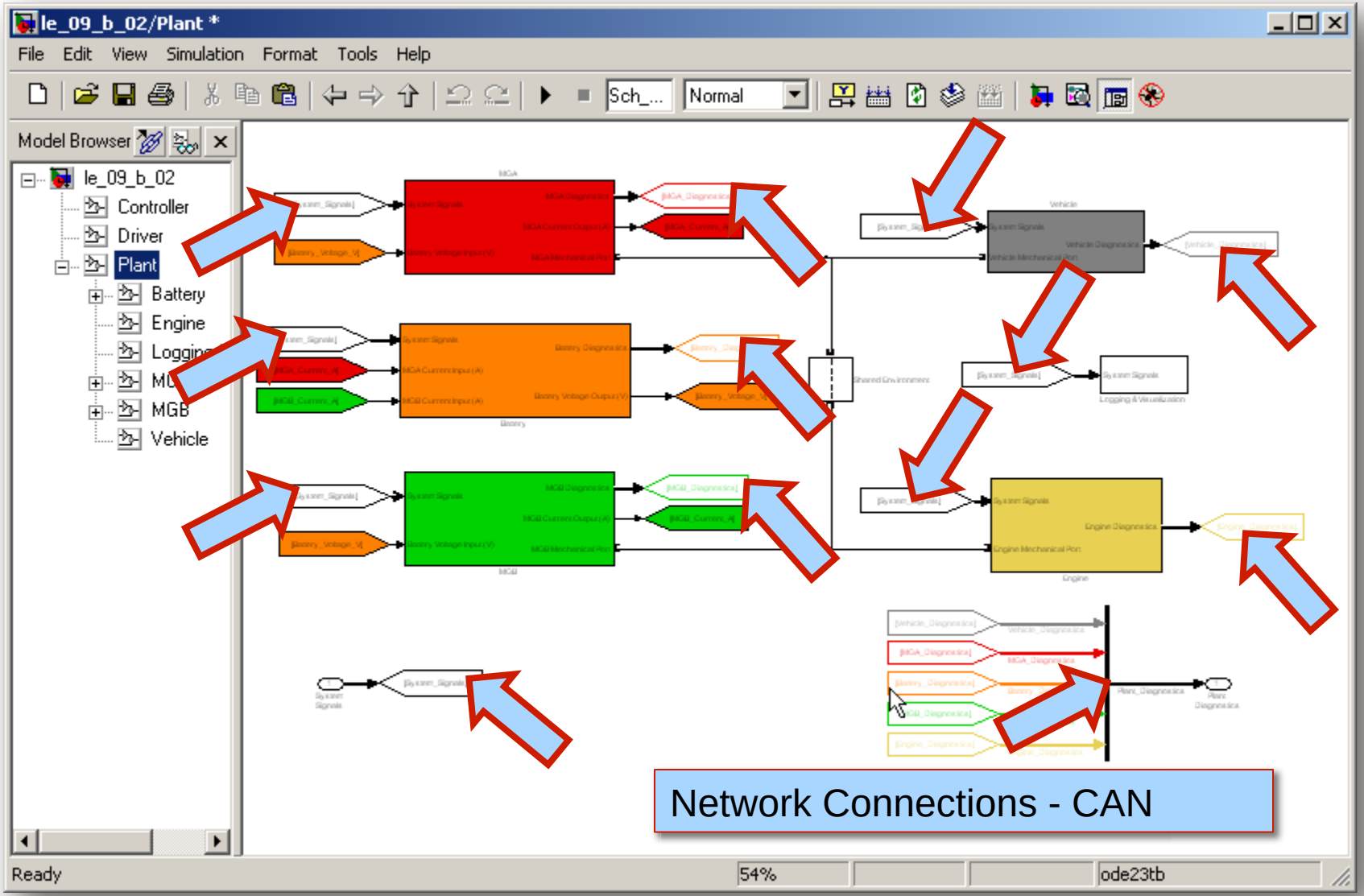


Advanced Course



Advanced Course



Advanced Course

- Develop and refine component models
  - Constants
  - Steady state experimental data
- Develop and refine battery charging logic
  - Bang Bang controller
  - Maintain SOC between preset limits
    - Constant engine RPM (single FB loop)
    - Constant charging current (Dual FB loop)
- Implement shifting logic
  - PRD

Advanced Course

- Woodward controller
  - Plant runs on a National Instruments target
  - Controller runs on a Woodward MotoHawk tagret
  - Communicate via CAN
- Students build a board with
  - “gas” pot
  - “brake” pot
  - PRD buttons
- HIL testing commences

Advanced Course

- Development procedure used in
  - ChallengeX
  - EcoCAR
  - EcoCAR2
- Nearly all logic/CAN errors can be eliminated
- Limitations of controller are exposed
- Controller goes directly into vehicle

Contact presenter for access

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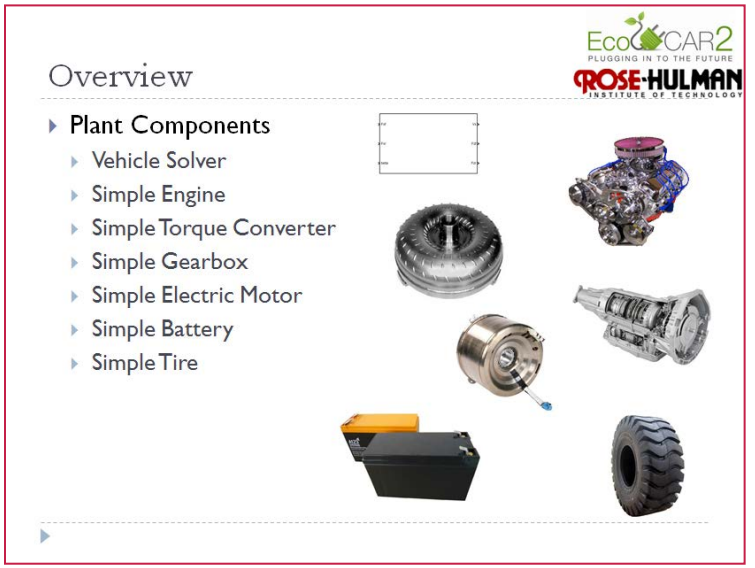
Future Plans

Vehicle System Modeling

- Develop multiple fidelity component models
  - Engine
  - Torque convertor
  - Gearbox
  - Motor
  - Battery
  - Tire



- Utilize a systems engineering approach

Vehicle System Modeling

- "Simple" vehicle modeling
  - Electric vehicle
  - Traditional Automobile
- "Complex" vehicle modeling
  - Series Electric Vehicle
  - Parallel Hybrid Vehicle
  - Powersplit Hybrid Vehicle

Vehicle System Modeling

- Over various drive cycles, estimate
  - Energy consumption (WtW)
  - Emissions production (WtW)
  - Vehicle range
- Investigate control strategies to improve performance
- Compare architectures

Embedded Control

- Traditional microcontroller courses have been heavy on C programming
- Why not leverage MBSD and autocode generation to open microcontrollers to the masses?
- 10 labs will be developed to use an industry standard microcontroller target in these simple and fun MBSD exercises

Strategic Partners

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Allison Transmission

ALCOA

Remy

U.S. DEPARTMENT OF ENERGY

Duke Energy

Clean Cities
U.S. Department of Energy

WOODWARD
MotoTron Control Solutions
Production Controls in a Flash

GM

ArcelorMittal

SIEMENS

ON Semiconductor

freescale semiconductor

MathWorks

ENERDEL

dSPACE

Argonne NATIONAL LABORATORY

NATIONAL SCIENCE FOUNDATION

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