

MATLAB EXPO

Electrification, AI and the Future of Engineering Education



Carlos Sanchis
Senior Academic CSE
@carsanbo

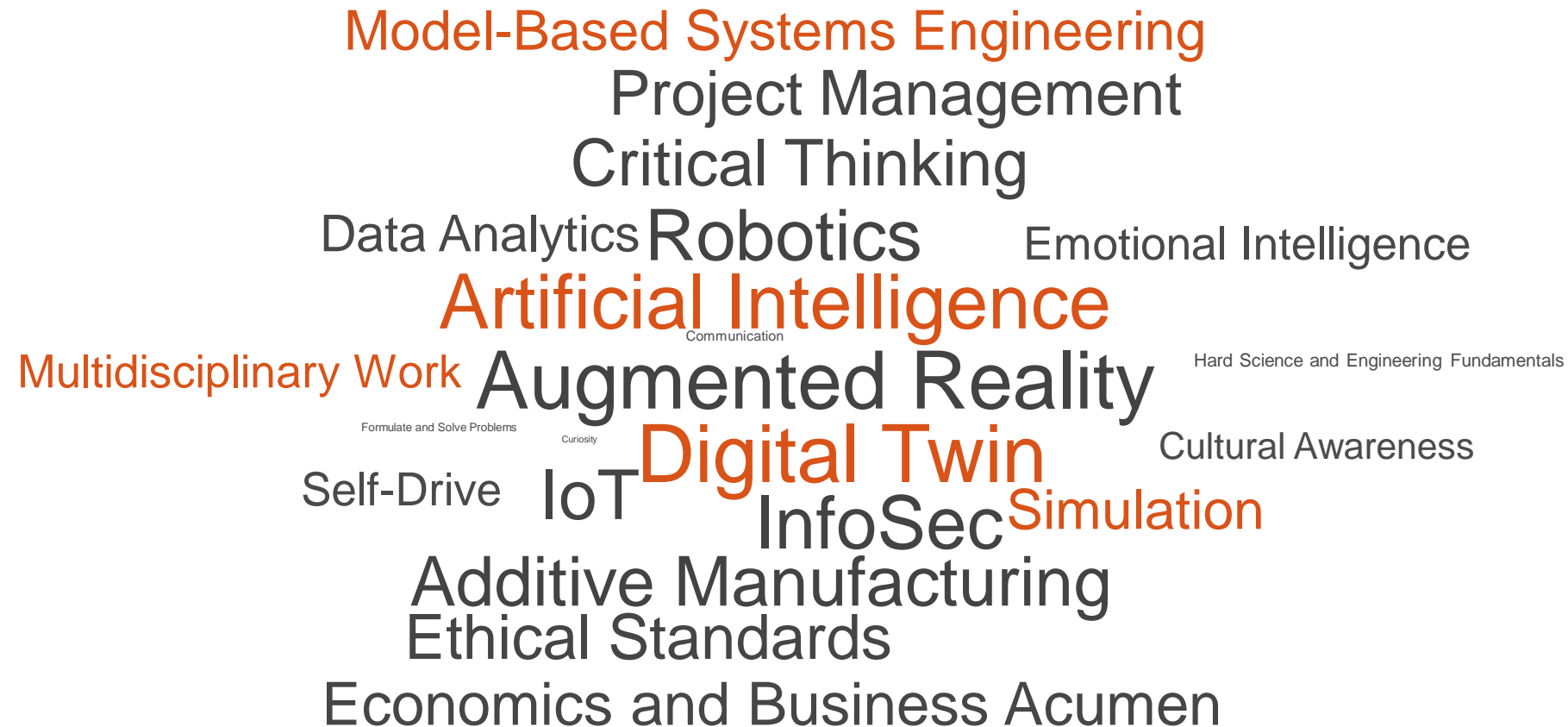


Sumit Tandon
Academic CSE Manager
@sumit77tandon



2020 ASEE Survey for Skills Gaps in Recent Engineering Graduates

Systems Thinking (80%)



**Electrification
of Everything**

**Autonomous
Systems**

**Systems Thinking
in the Classroom**

Electrification of Everything

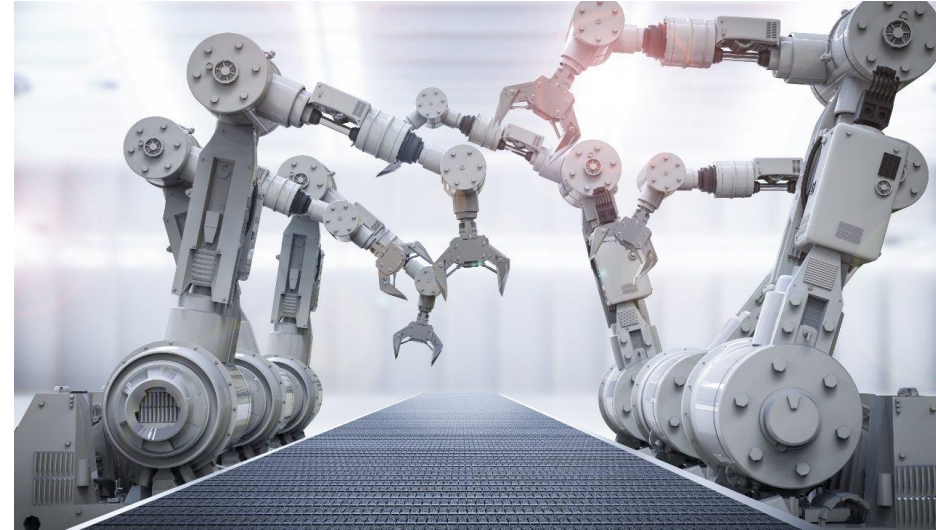
Renewable Energies



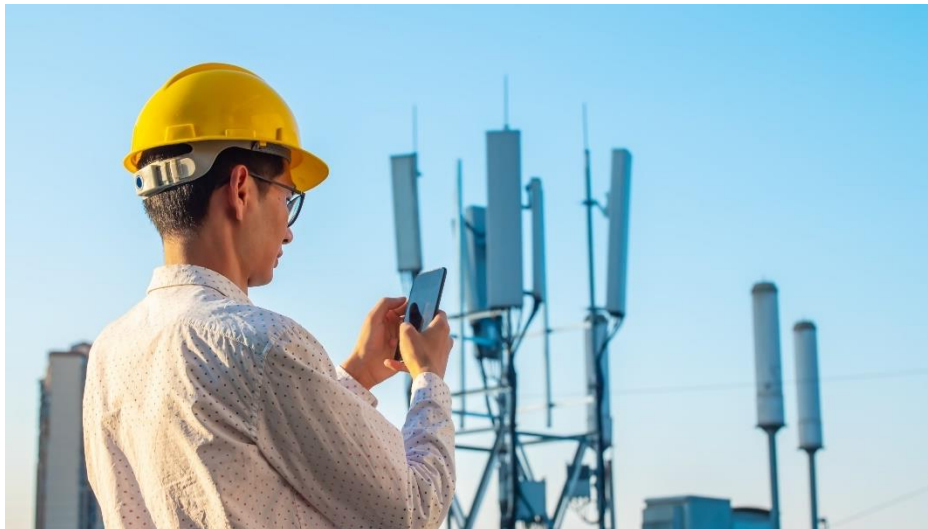
Electric Vehicles



Electric Motors



Electronics Everywhere



Electrification of Everything

➤ Why is it happening?

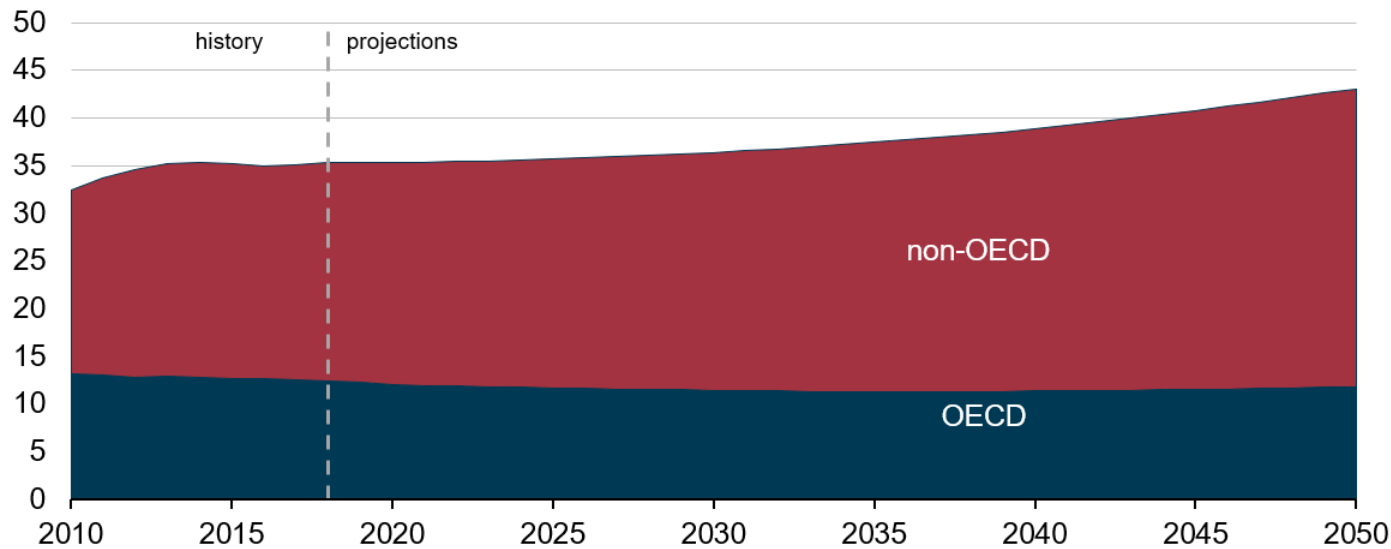
What challenges is Industry facing?

How are engineers overcoming them?

Climate Change

Energy-related carbon dioxide emissions

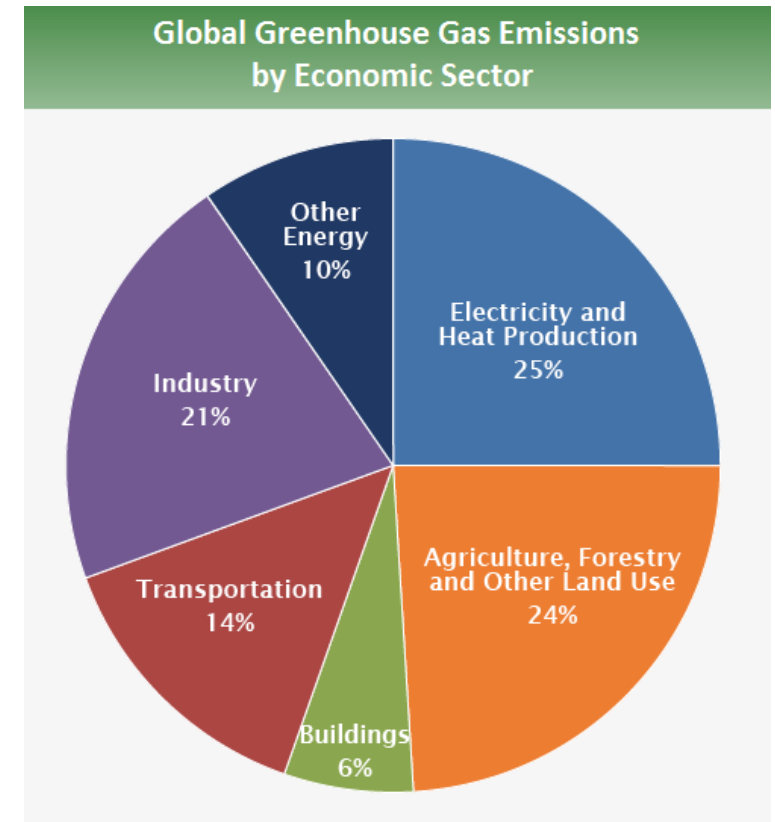
billion metric tons



OECD: [Organization for Economic Cooperation and Development](https://www.oecd.org/)

International Energy Outlook 2019

<https://www.eia.gov/outlooks/ieo/pdf/ieo2019.pdf>

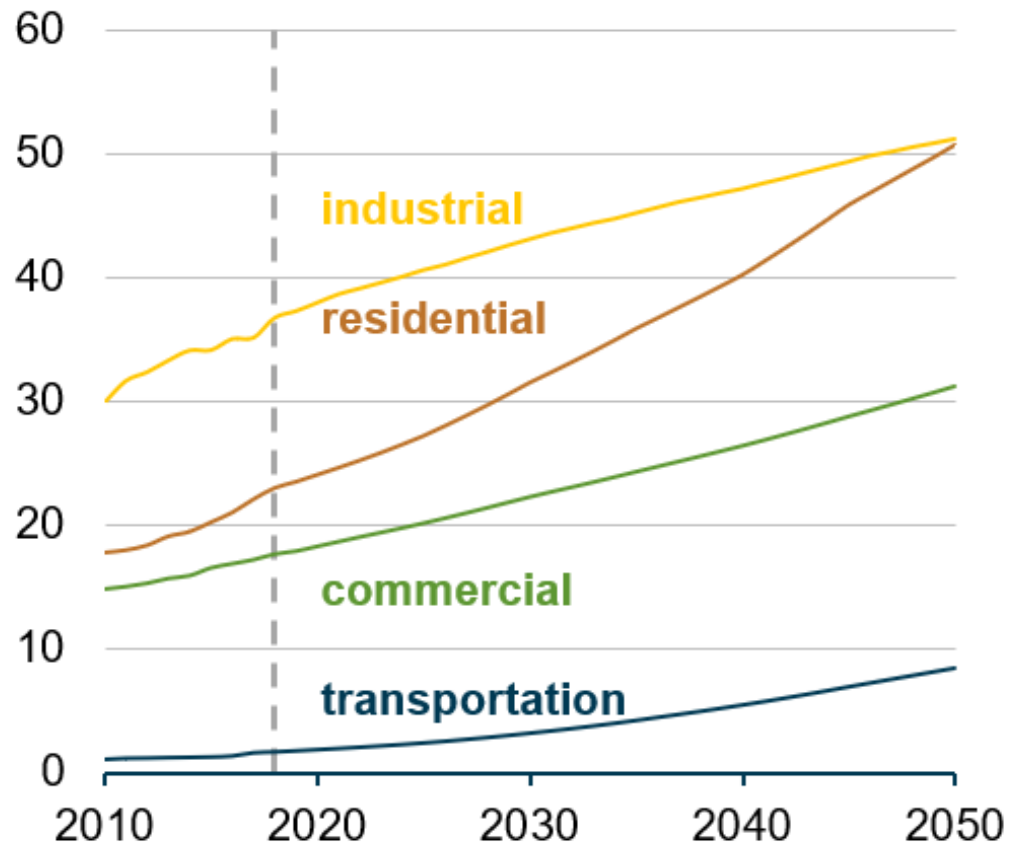


United States Environmental Protection Agency

<https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Sector>

Need for Smarter, More Efficient Systems

Electricity use by sector, world
quadrillion British thermal units



Electricity use in the **residential** and **commercial** sectors is predicted to grow fastest in China, India, and other countries with growing middle classes.

International Energy Outlook 2019

<https://www.eia.gov/outlooks/ieo/pdf/ieo2019.pdf>

Electrification of Everything

Why is it happening?

➤ What challenges is Industry facing?

How are engineers overcoming them?

Key Challenges in Electrification

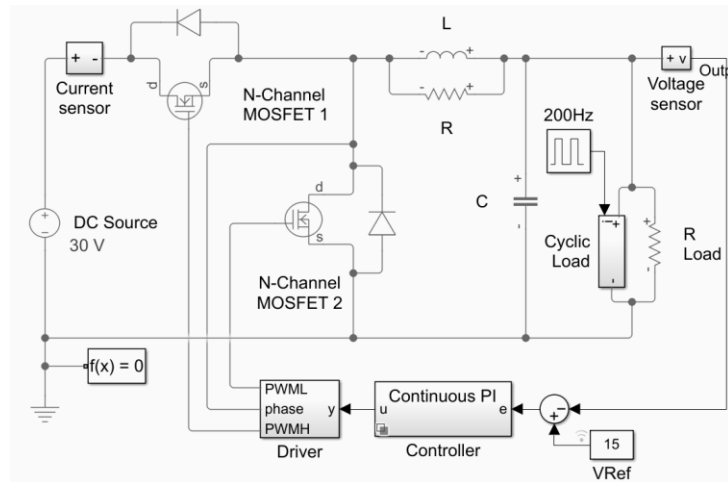
Batteries

- Battery Modeling
- Safe Operation
- Aging Optimization
- BMS Development



Power Electronics

- Dynamic Simulation
- Digital Control
- Supervisory Logic
- Rapid Prototyping



Motor Control

- Sensor Calibration
- Parameter Estimation
- Efficient Algorithms
- Controller Tuning



Electrification of Everything

Why is it happening?

What challenges is Industry facing?

➤ How are engineers overcoming them?

Lightyear One

World's First Solar-Powered Car

450 Miles on a Single Charge.

From Student Competition to Startup.



Key Challenges in Electrification

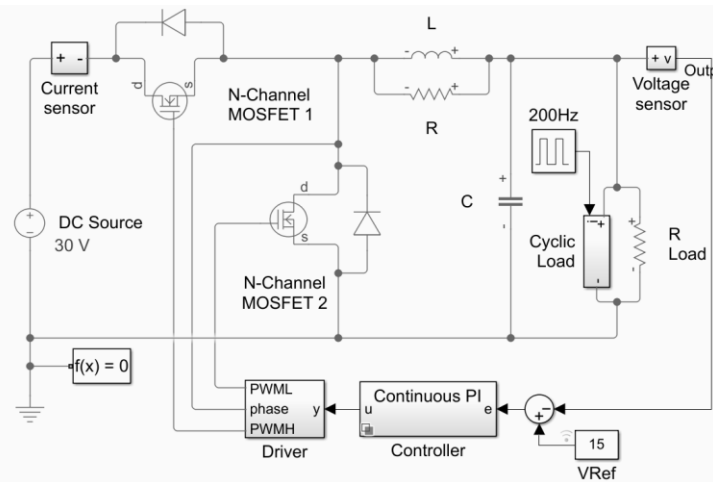
Batteries

- Battery Modeling
- Safe Operation
- Aging Optimization
- BMS Development



Power Electronics

- Dynamic Simulation
- Digital Control
- Supervisory Logic
- Rapid Prototyping

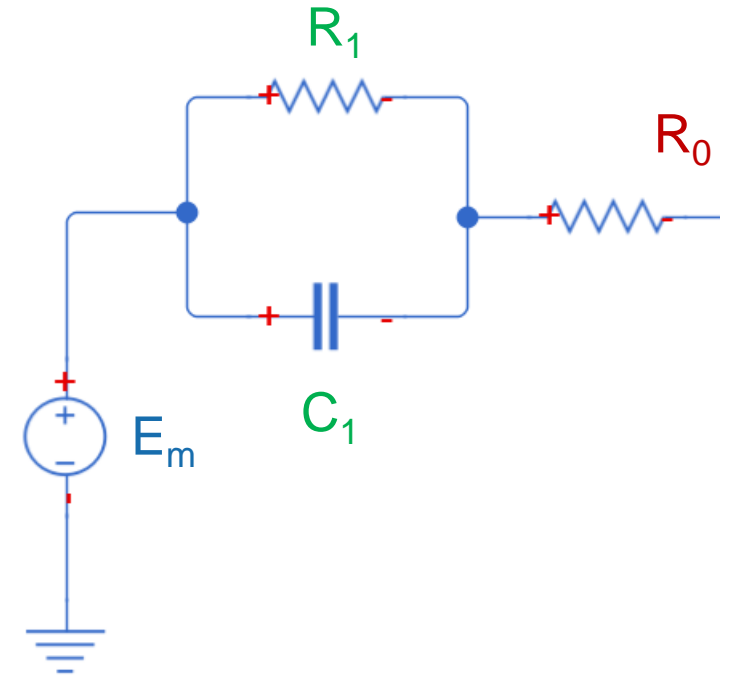
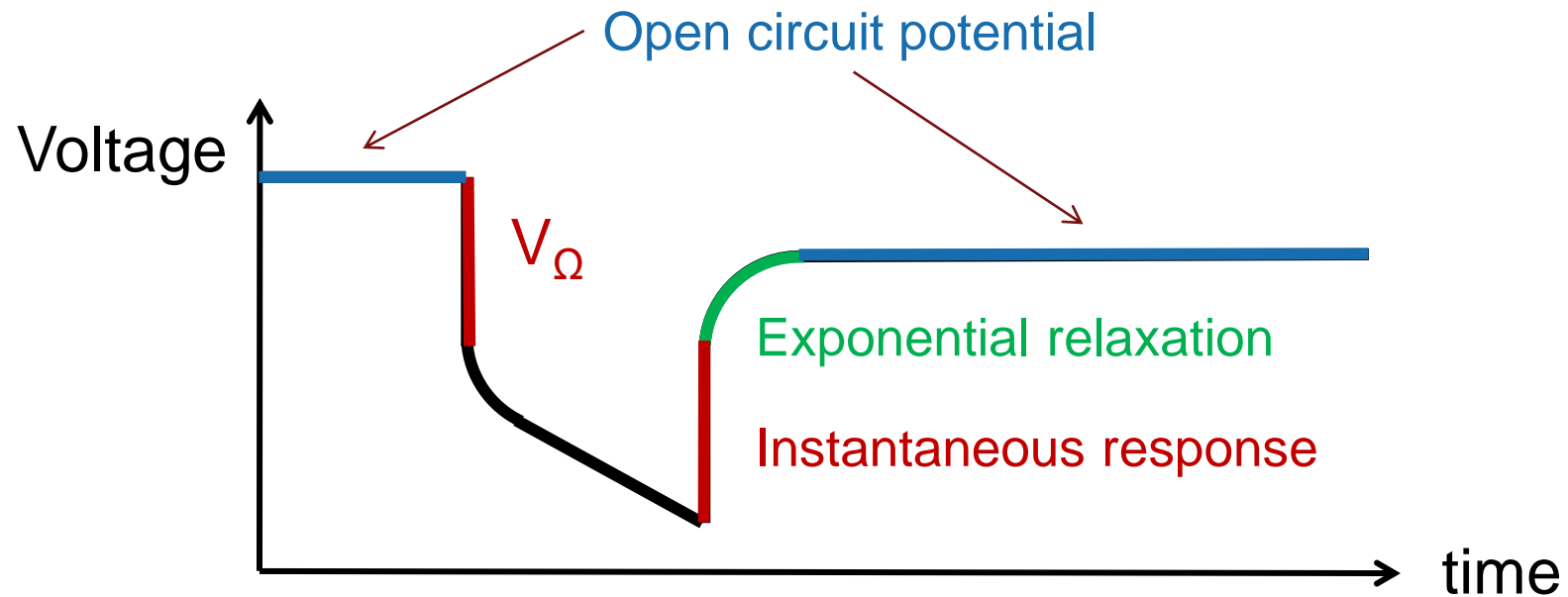
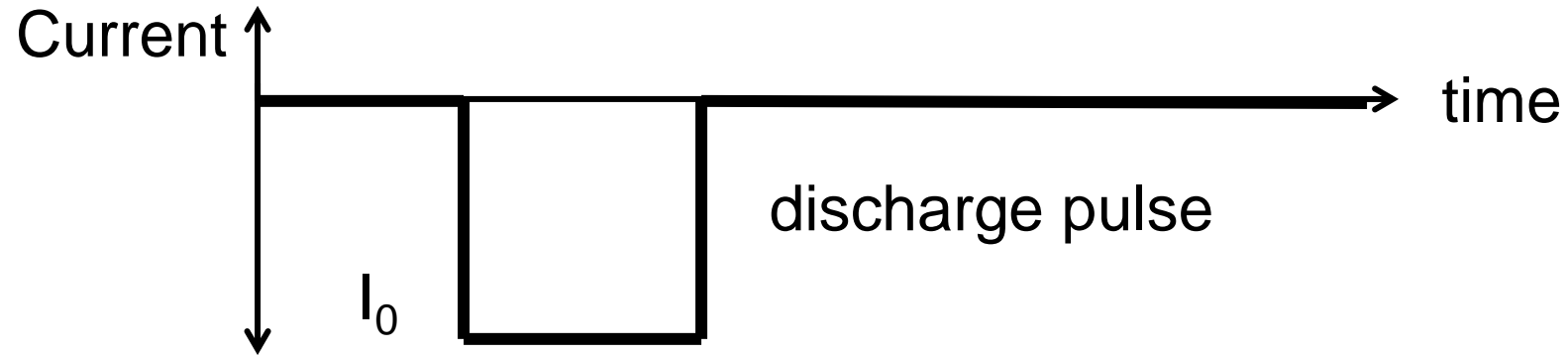


Motor Control

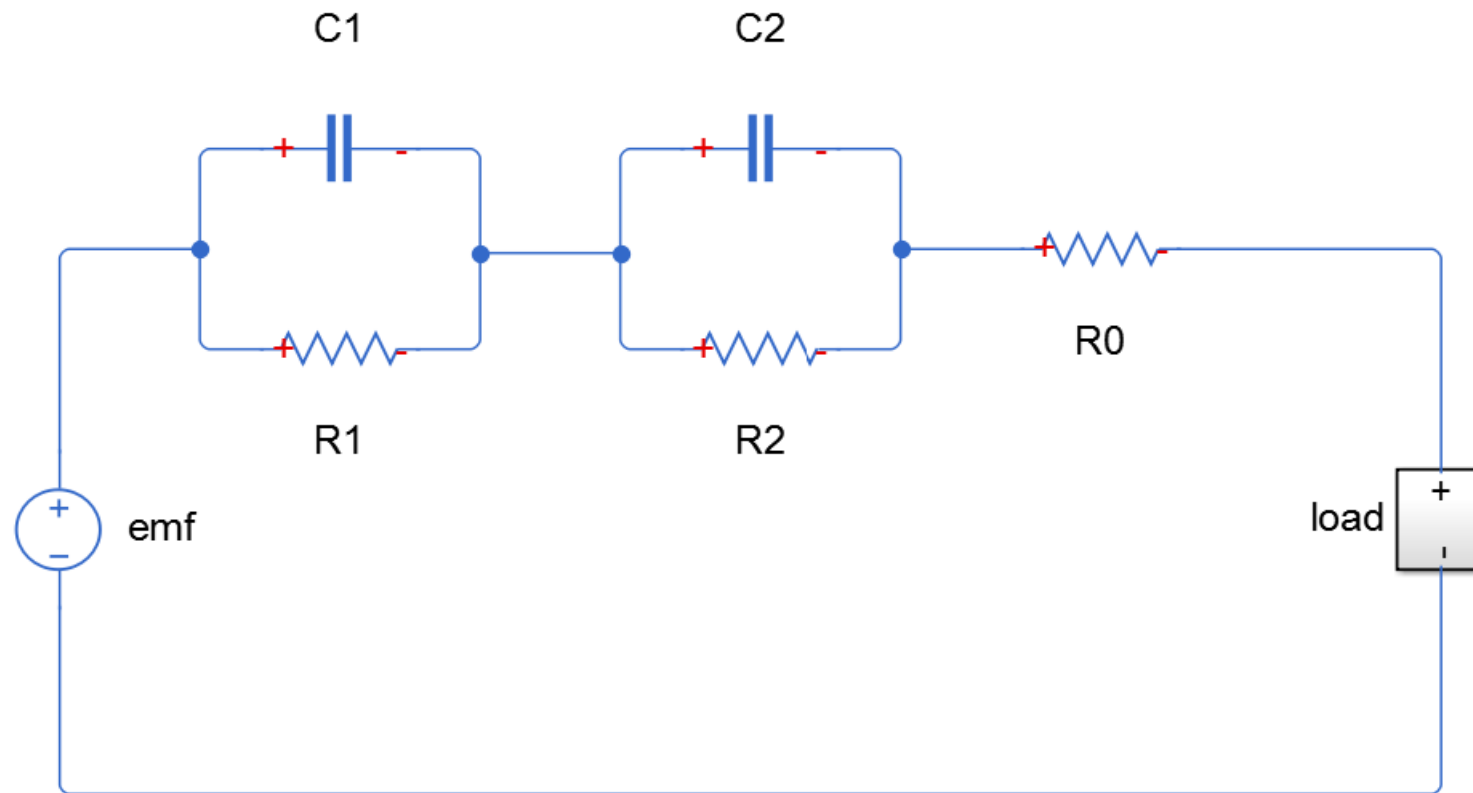
- Sensor Calibration
- Parameter Estimation
- Efficient Algorithms
- Controller Tuning



Modeling Li-ion Battery Cells



Equivalent Circuit



BatteryCellEquivalentCircuit - Simulink

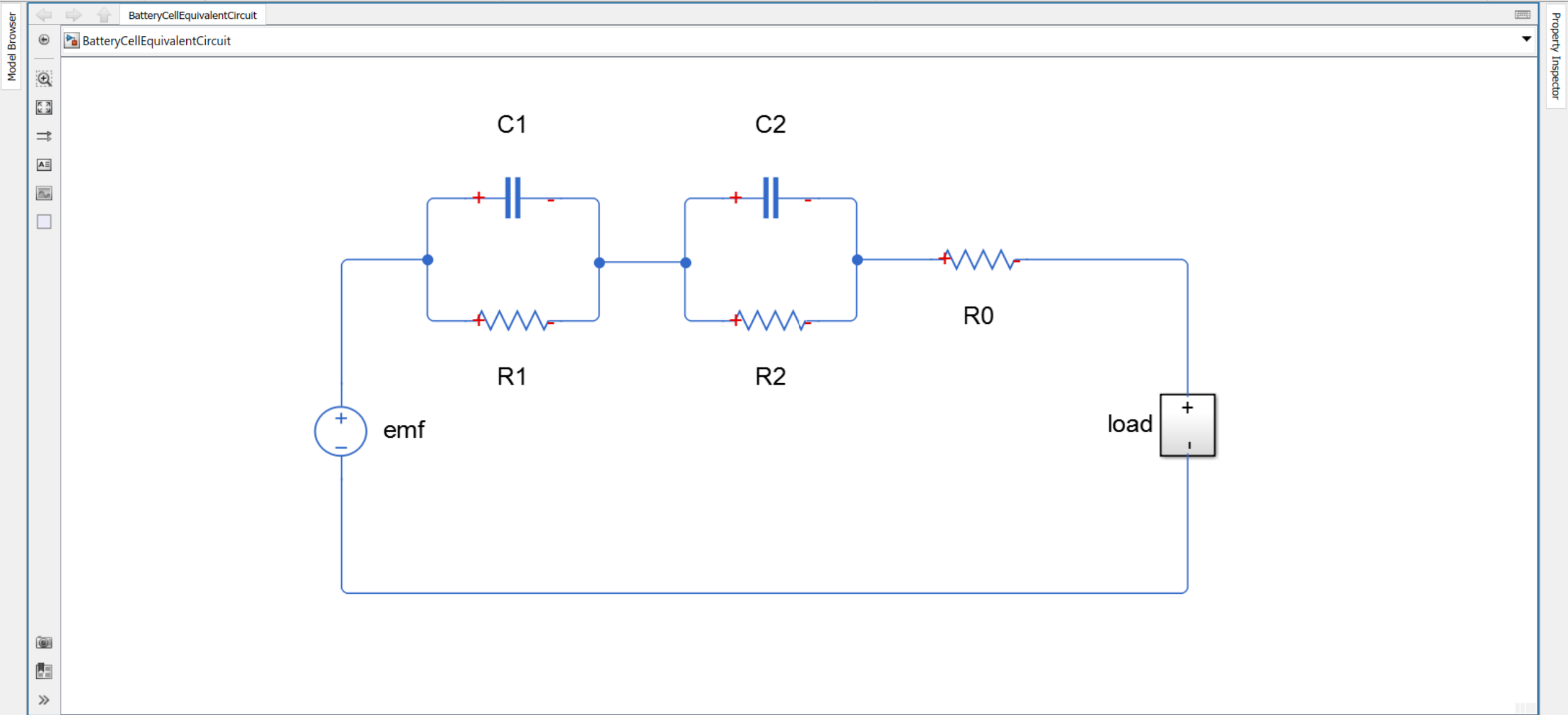
SIMULATION DEBUG MODELING FORMAT APPS

FILE LIBRARY PREPARE SIMULATE REVIEW RESULTS

Stop Time: 10.0
Normal
Fast Restart

Step Back Run Step Forward Stop

Data Inspector Logic Analyzer Bird's-Eye Scope Simulation Manager



Model Browser


















BatteryCellEquivalentCircuit

Simulink Library Browser

Enter search term

Simscape/Foundation Library/Electrical/Electrical Elements

- SerDes Toolbox
- SimEvents
- Simscape
 - Foundation Library
 - Electrical
 - Electrical Elements**
 - Electrical Sensors
 - Electrical Sources
 - Gas
 - Hydraulic
 - Isothermal Liquid
 - Magnetic
 - Mechanical
 - Moist Air
 - Physical Signals
 - Thermal
 - Thermal Liquid
 - Two-Phase Fluid
 - Utilities
 - Driveline
 - Electrical
 - Connectors & References
 - Control
 - Electromechanical
 - Integrated Circuits
 - Passive
 - Semiconductors & Converters
 - Converters
 - Sensors & Transducers
 - Sources
 - Switches & Breakers

 Capacitor	 Diode	 Electrical Reference	 Gyator	 Ideal Transformer	 Inductor	 Infinite Resistance
 Memristor	 Mutual Inductor	 Op-Amp	 Open Circuit	 Resistor	 Rotational Electromechanical Converter	 Switch
 Thermal Resistor	 Translational Electromechanical Converter	 Variable Resistor				

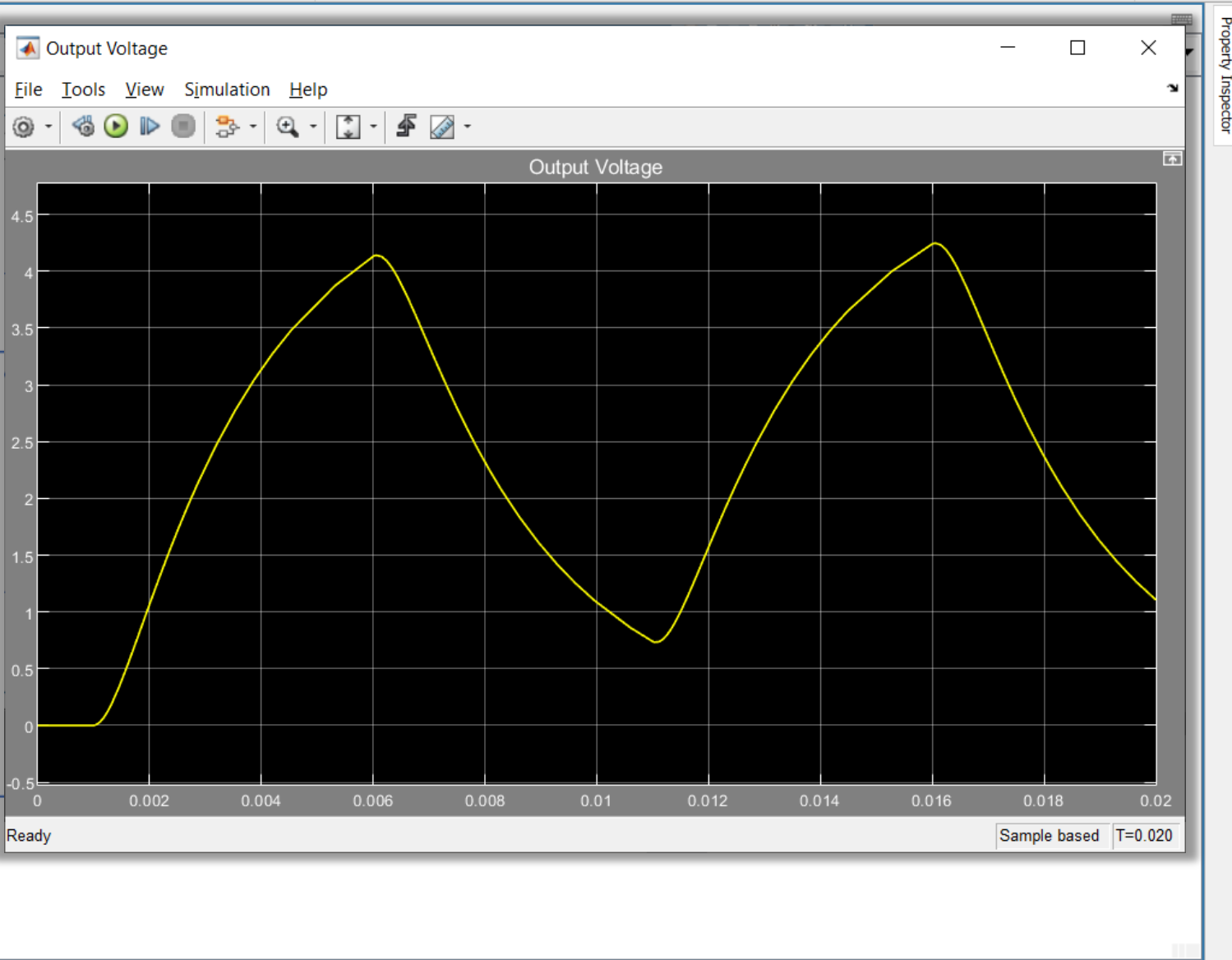
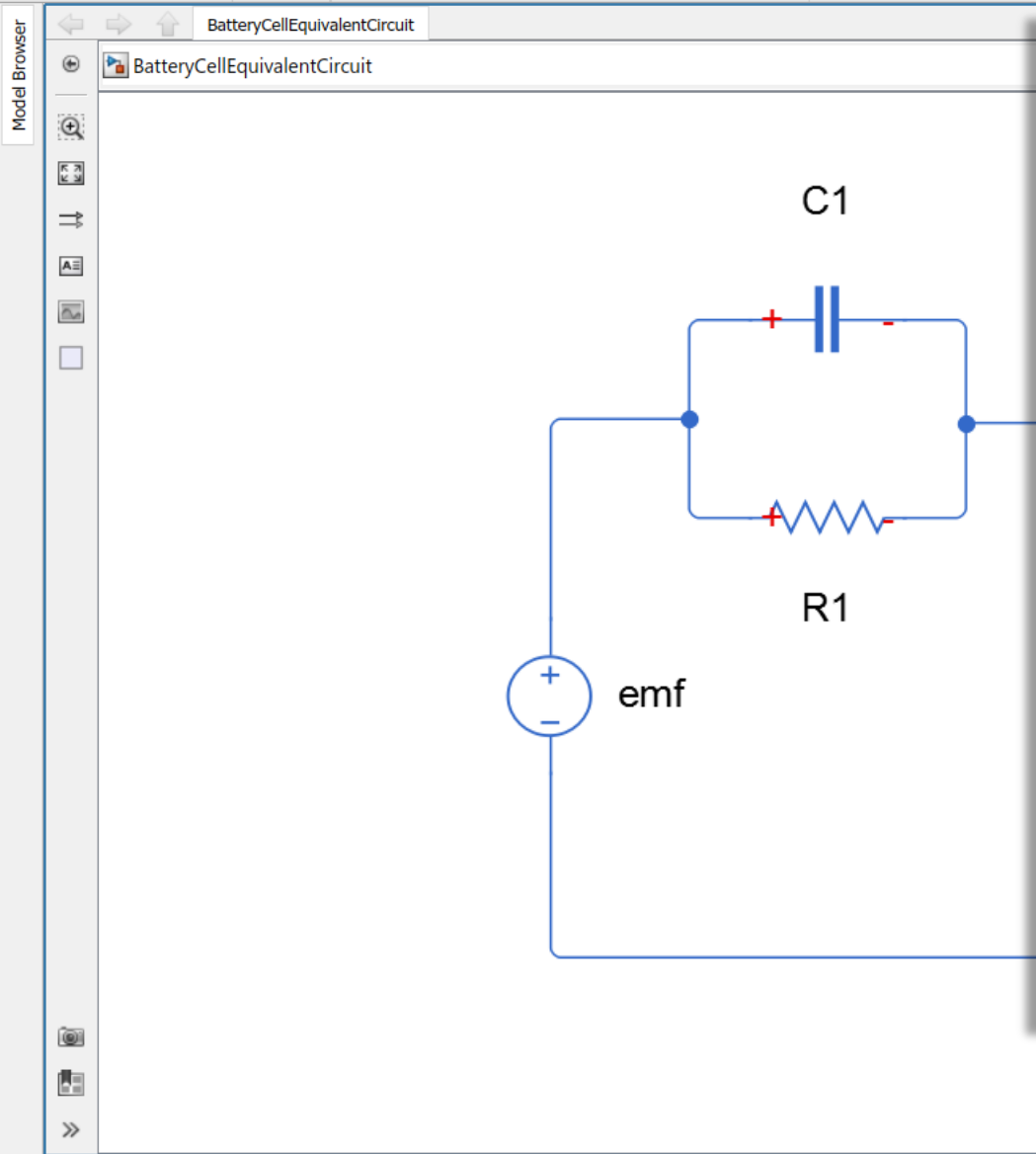
Property Inspector

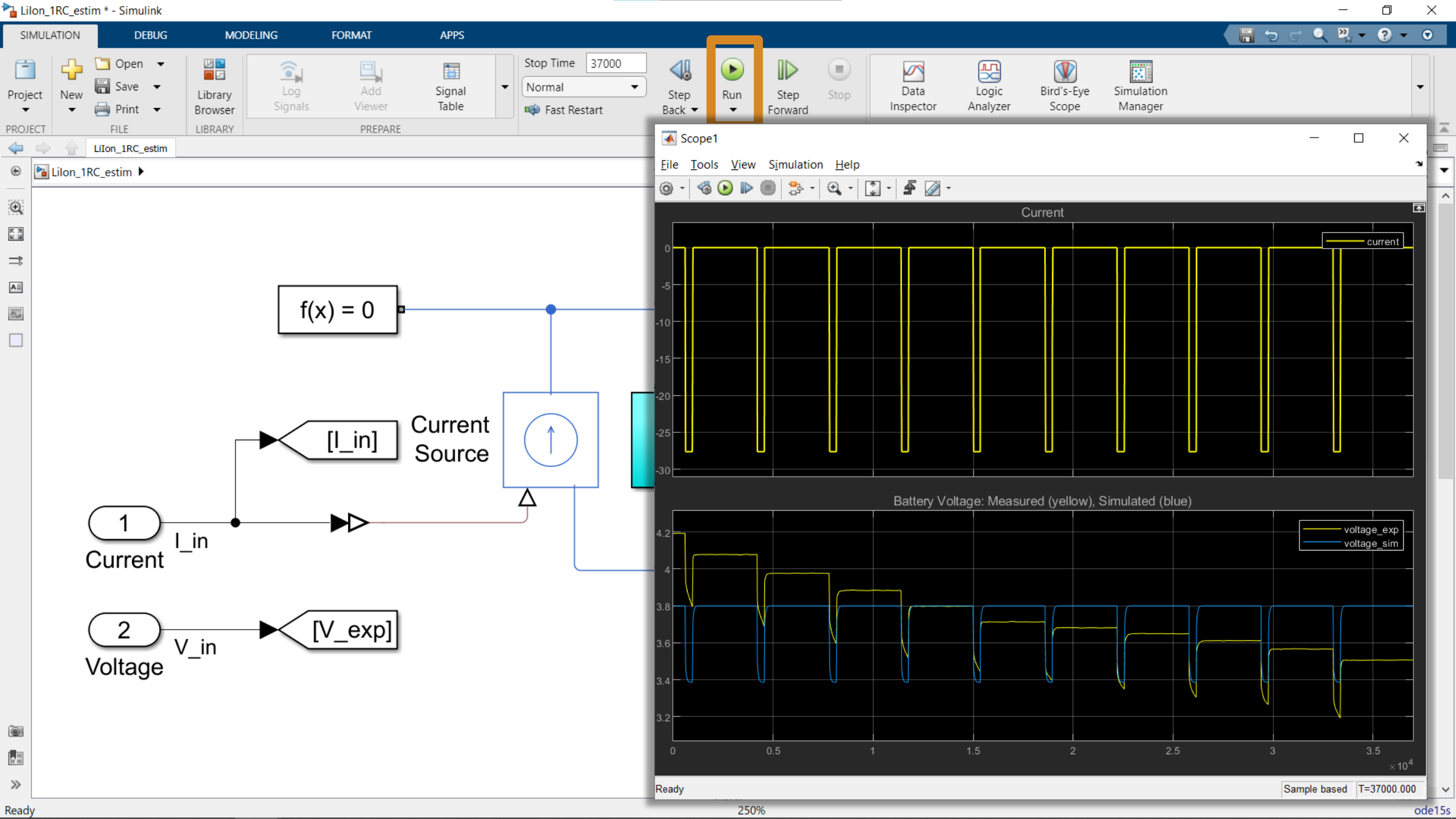
BatteryCellEquivalentCircuit - Simulink

SIMULATION DEBUG MODELING FORMAT APPS

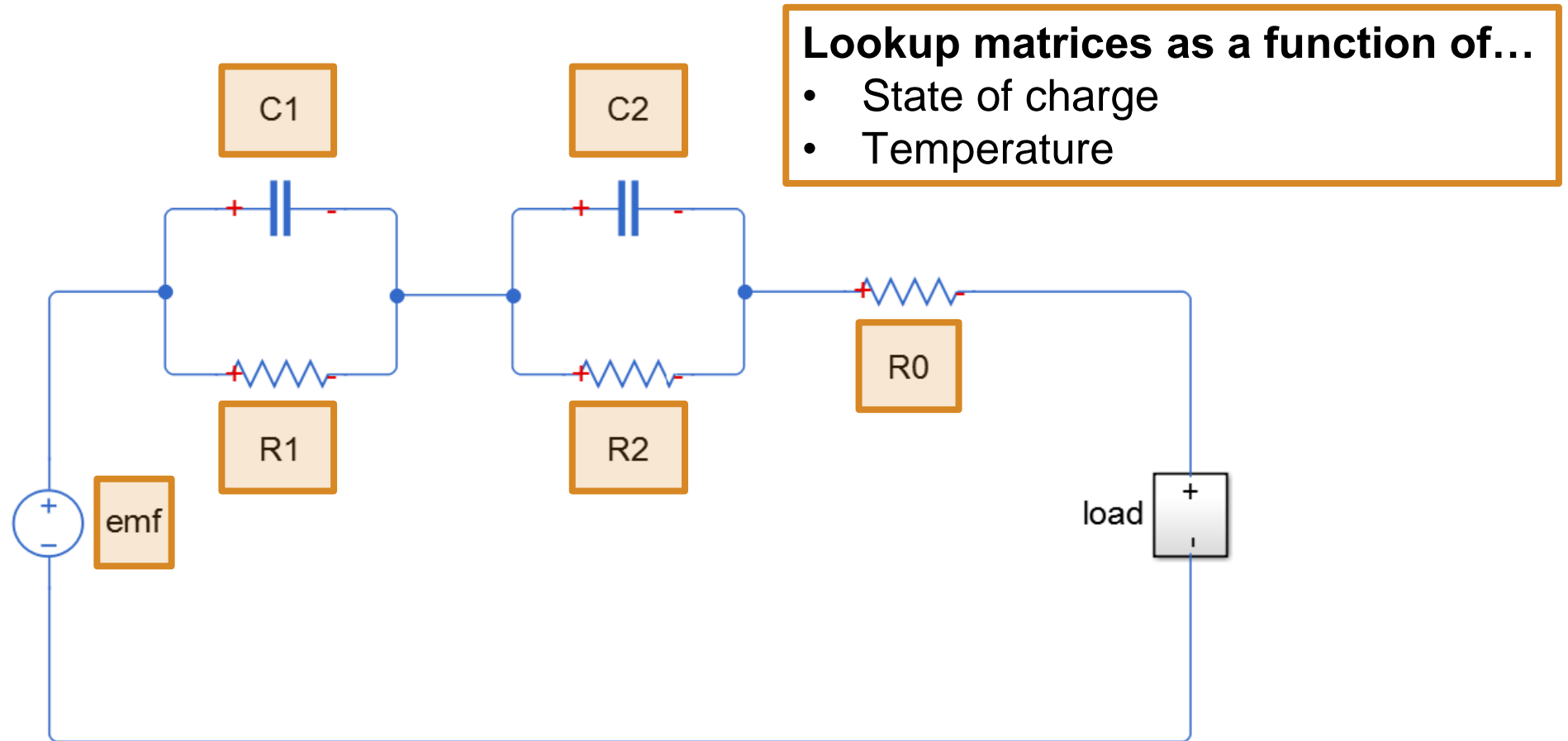
FILE LIBRARY PREPARE SIMULATE REVIEW RESULTS

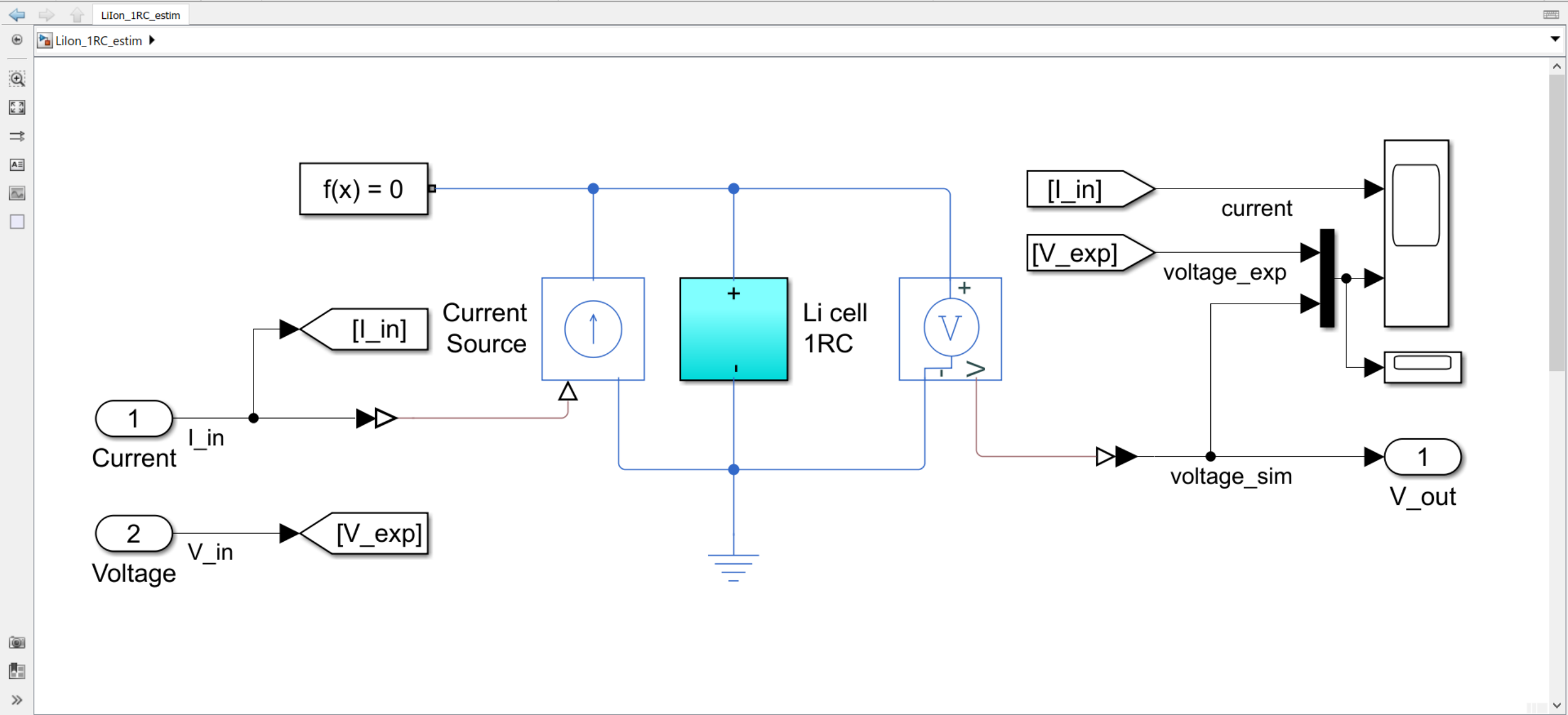
Open, Save, Print, Library Browser, Log Signals, Add Viewer, Signal Table, Stop Time: 10.0, Normal, Fast Restart, Step Back, Run, Step Forward, Stop, Data Inspector, Logic Analyzer, Bird's-Eye Scope, Simulation Manager





Equivalent Circuit Parameters





Search

Get Add-Ons

ENVIRONMENT

Lilon_

FAVORITES

- Linearization Manager
- Model Linearizer
- Control System Designer
- Parameter Estimator
- Response Optimizer
- Robot Operating System (ROS)
- Embedded Coder
- Fixed-Point Tool
- Requirements Manager
- Coverage Analyzer
- Simulink Test

SIMScape

- Load-Flow Analyzer

CONTROL SYSTEMS

- Steady State Manager
- Linearization Manager
- Model Linearizer
- Frequency Response ...
- Control System Designer
- Control System Tuner
- Model Discretizer
- Parameter Estimator**
- Response Optimizer
- Sensitivity Analyzer
- Robot Operating System (ROS)

SIGNAL PROCESSING AND WIRELESS COMMUNICATIONS

- Logic Analyzer
- Bird's-Eye Scope
- Video Viewer
- RF Budget Analyzer
- SerDes Designer

CODE GENERATION

- Embedded Coder
- Simulink Coder
- AUTOSAR Component ...
- DDS Application ...
- HDL Coder
- PLC Coder
- Fixed-Point Tool
- Single Precision Converter
- Lookup Table Optimizer
- DO Qualification Kit
- IEC Certification Kit

REAL-TIME SIMULATION AND TESTING

- Simulink Real-Time
- Desktop Real-Time

MODEL VERIFICATION, VALIDATION, AND TEST

- Requirements Manager
- Requirements Editor
- Requirements Viewer
- Model Advisor
- Clone Detector
- Model Transformer
- Metrics Dashboard
- Model Slicer
- Coverage Analyzer
- Design Verifier
- Simulink Test

CODE VERIFICATION, VALIDATION, AND TEST

- SIL/PIL Manager
- Code Inspector
- HDL Verifier
- FIL Wizard

Ready

ode15s

1

V_out

Parameter Estimator - Estimate model parameters and initial states from data and calibrate models

PARAMETER ESTIMATION | VALIDATION | ITERATION PLOT | VIEW

Open Session Save New Experiment Select Experiments Select Parameters Sensitivity Analysis Add Plot Plot Model Response Cost Function: Sum Squared Error Stop Estimation

FILE EXPERIMENTS PARAMETERS PLOTS OPTIONS ESTIMATE

Data Browser

▼ Parameters

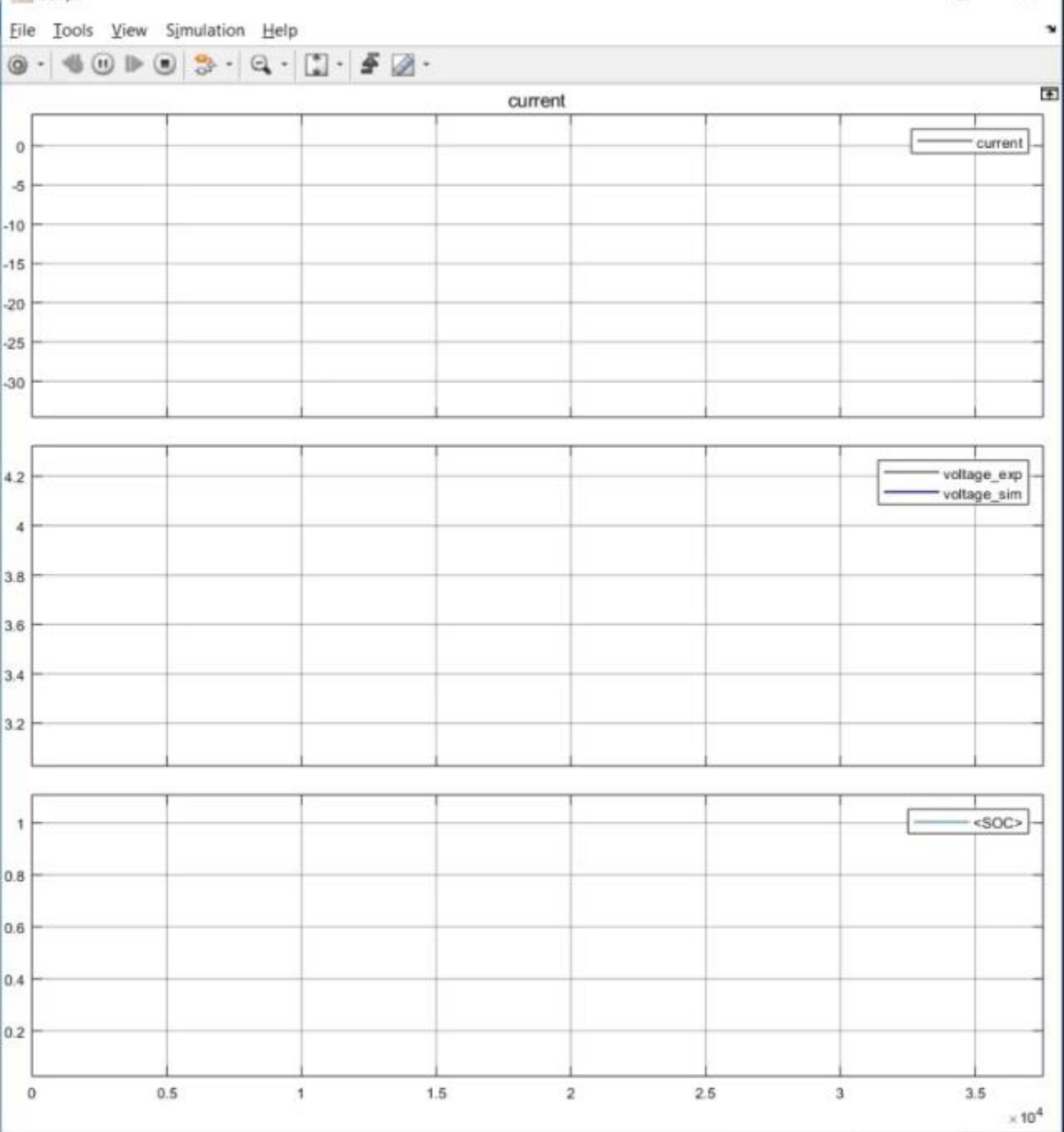
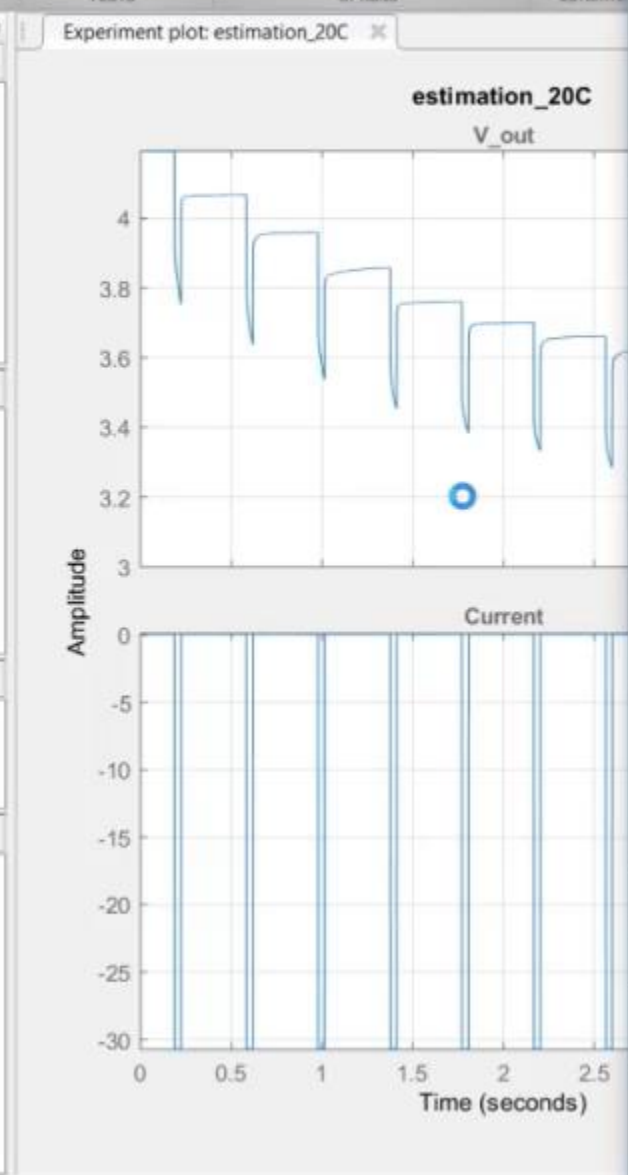
- C1
- Em
- R0
- R1

▼ Experiments

- estimation_20C
- estimation_40C
- estimation_5C
- validation_20C

▼ Results

▼ Preview



Data Browser

▼ Parameters

C1
Em
R0
R1

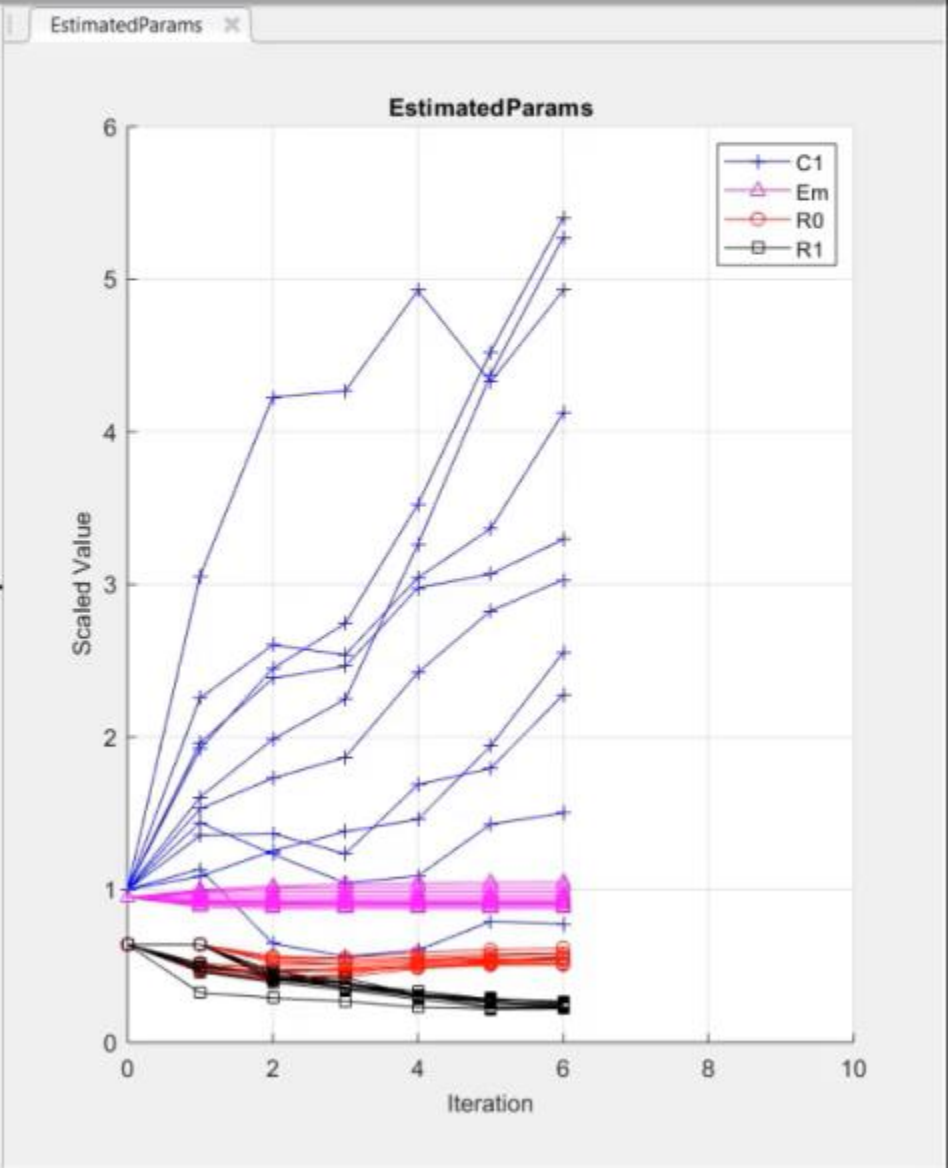
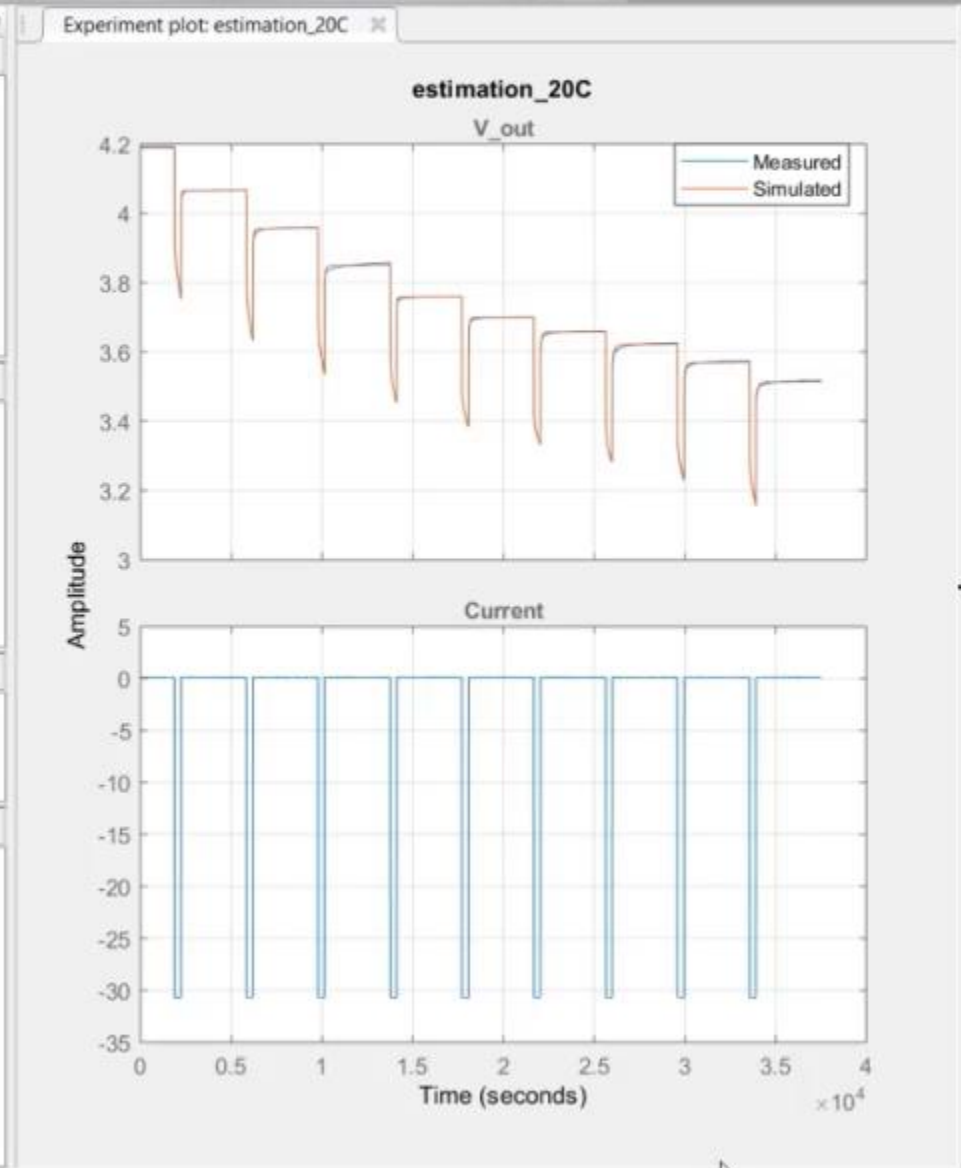
▼ Experiments

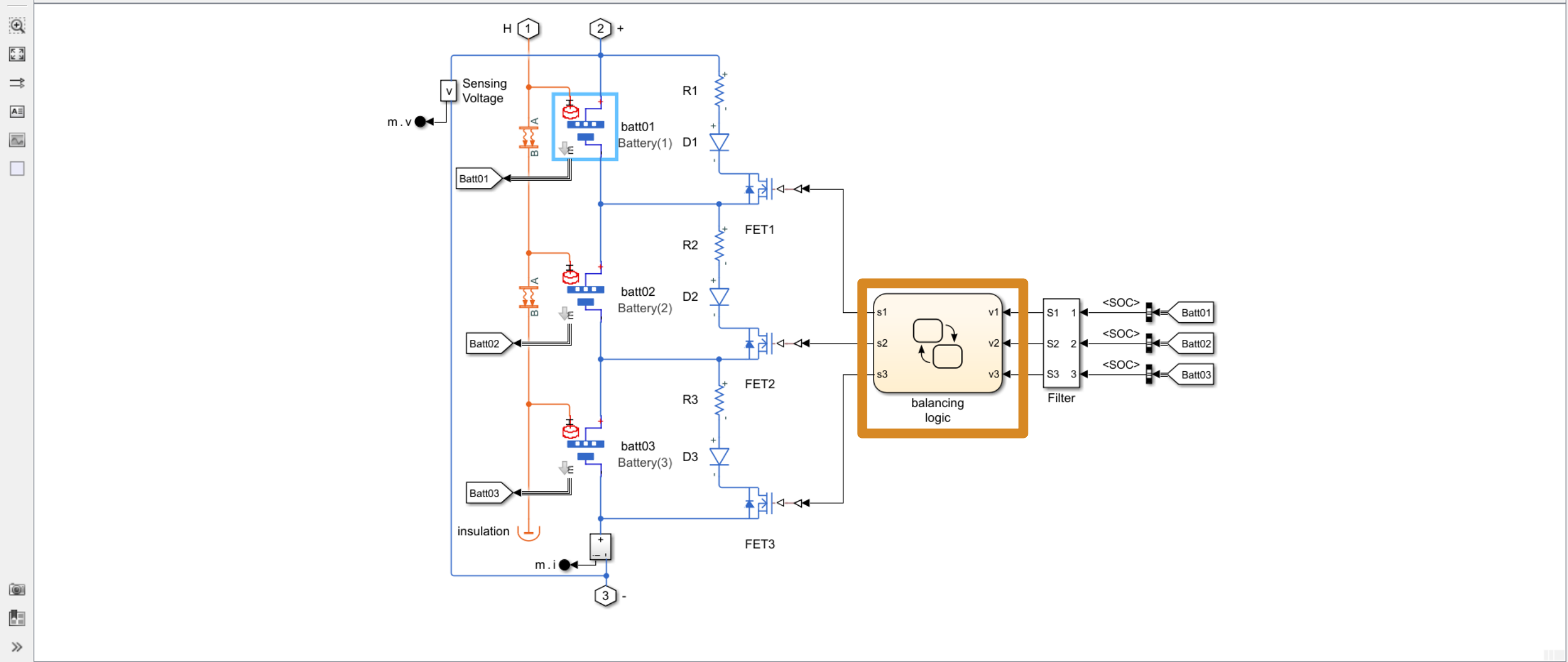
estimation_20C
estimation_40C
estimation_5C
validation_20C

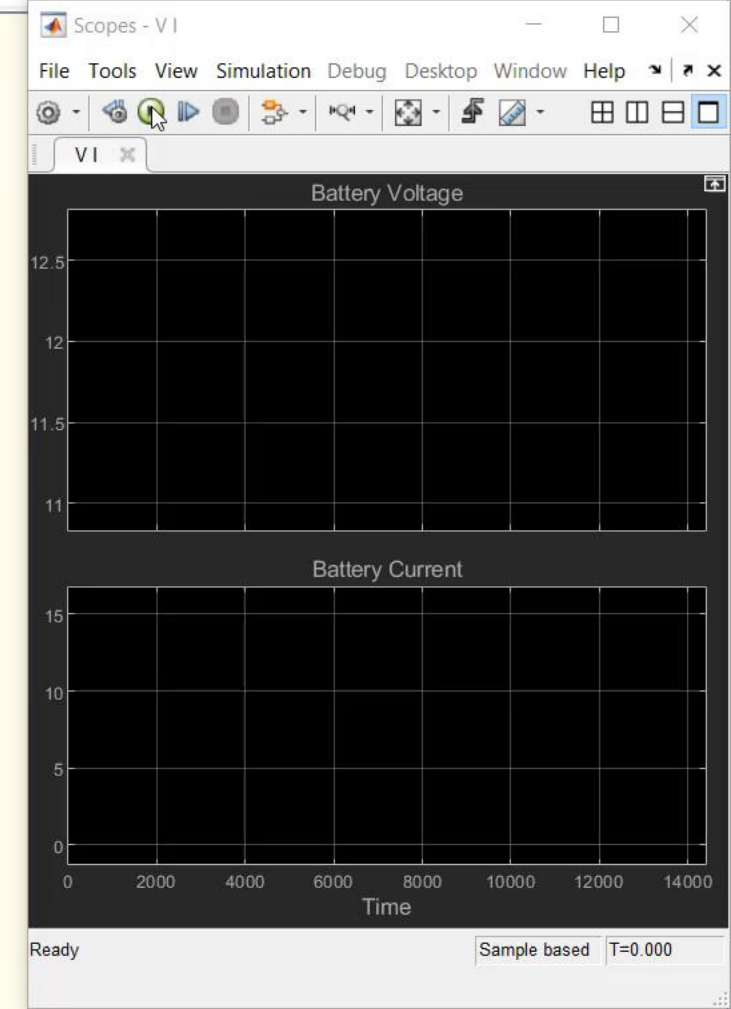
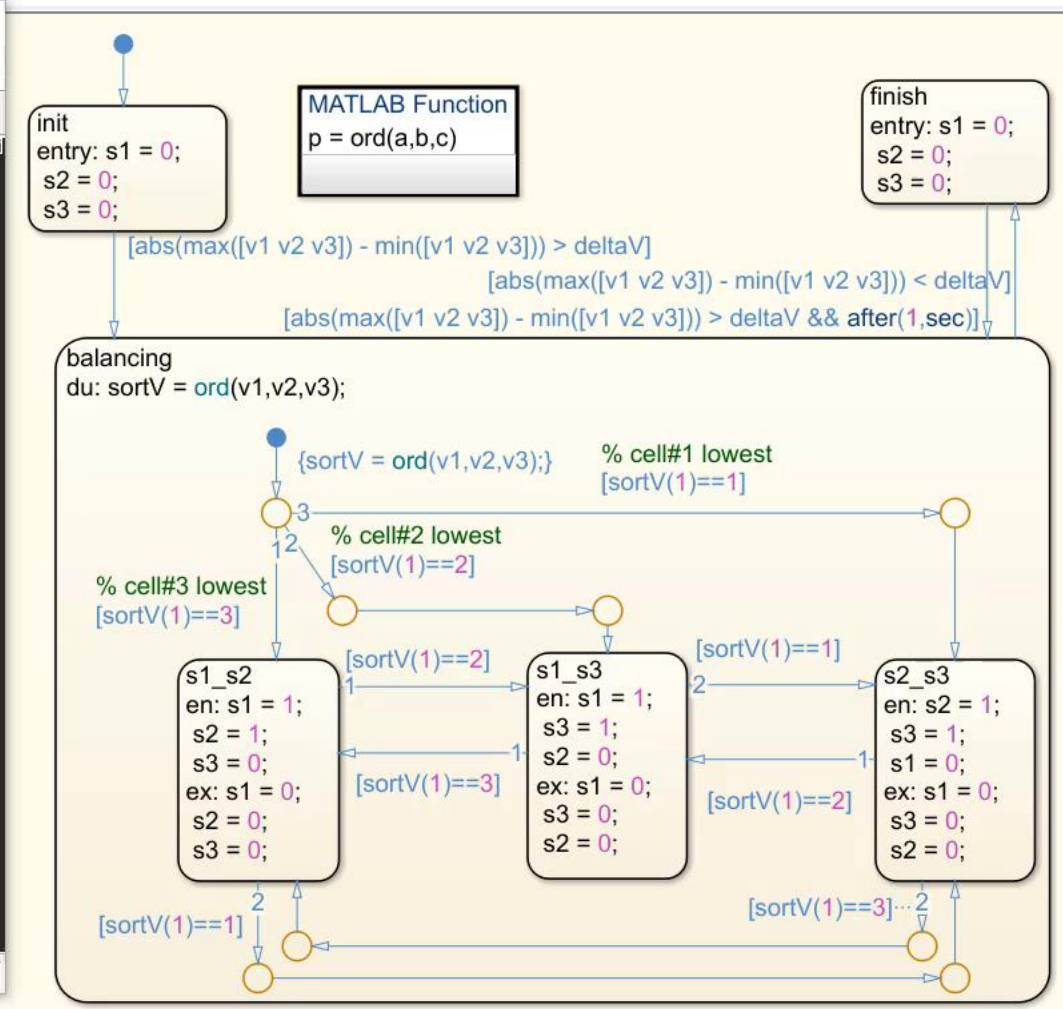
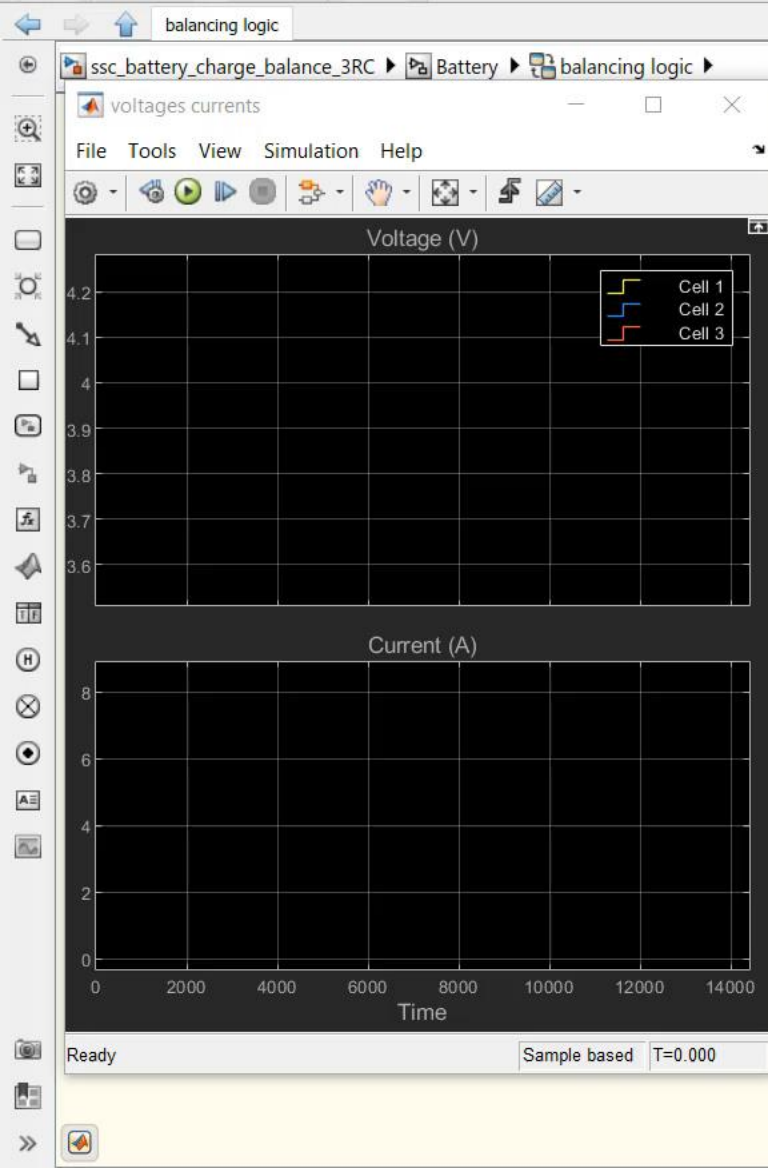
▼ Results

EstimatedParams

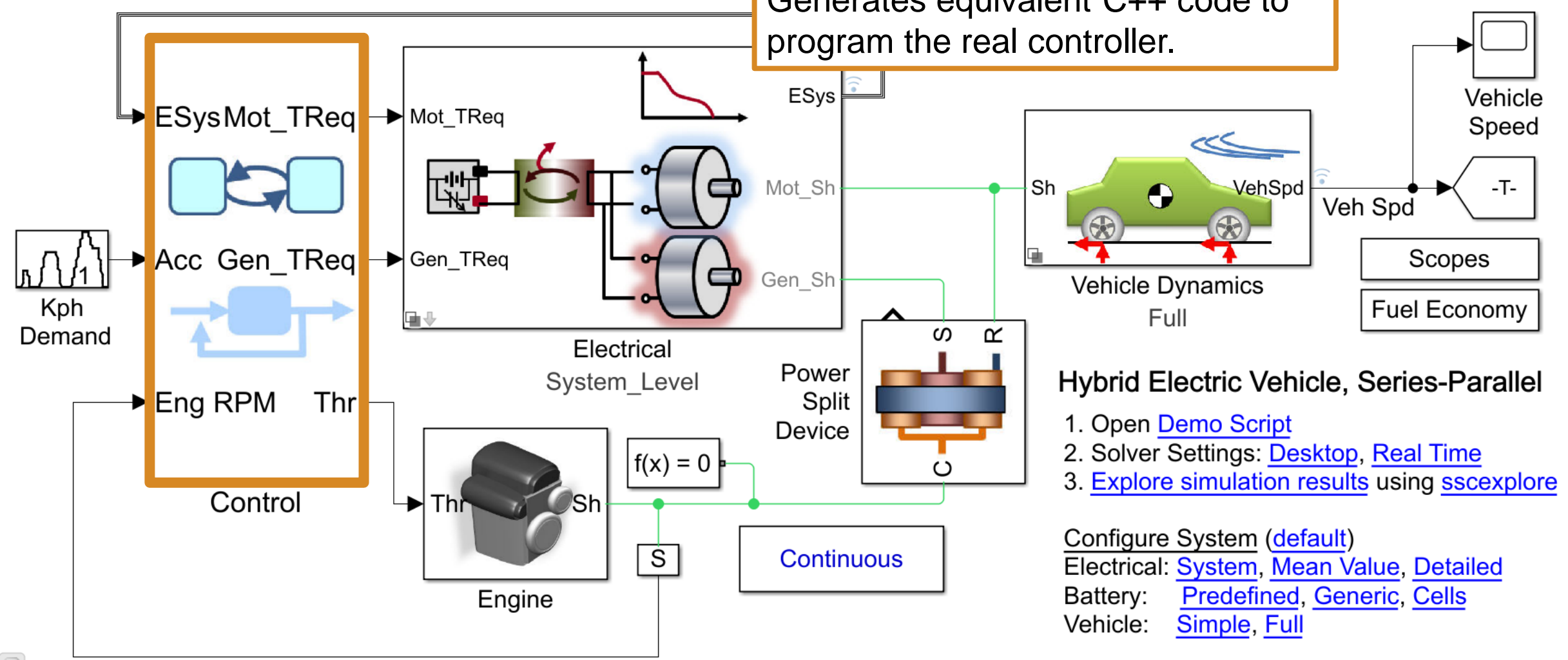
▼ Preview







Automatic C++ Code Generation
 Generates equivalent C++ code to program the real controller.

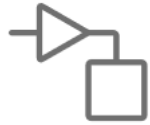


Hybrid Electric Vehicle, Series-Parallel

1. Open [Demo Script](#)
2. Solver Settings: [Desktop](#), [Real Time](#)
3. [Explore simulation results](#) using [sscxplore](#)

Configure System ([default](#))
 Electrical: [System](#), [Mean Value](#), [Detailed](#)
 Battery: [Predefined](#), [Generic](#), [Cells](#)
 Vehicle: [Simple](#), [Full](#)

Model-Based Design: From Concept to Code



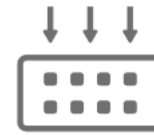
Model and Simulate Your System

Explore a wide design space by modeling the system under test and the physical plant. Your entire team can use one multi-domain environment to simulate how all parts of the system behave.



Test Early and Often

Reduce expensive prototypes by testing your system under conditions that are otherwise too risky or time-consuming to consider. Validate your design with hardware-in-the-loop testing and rapid prototyping. Maintain traceability from requirements to design to code.

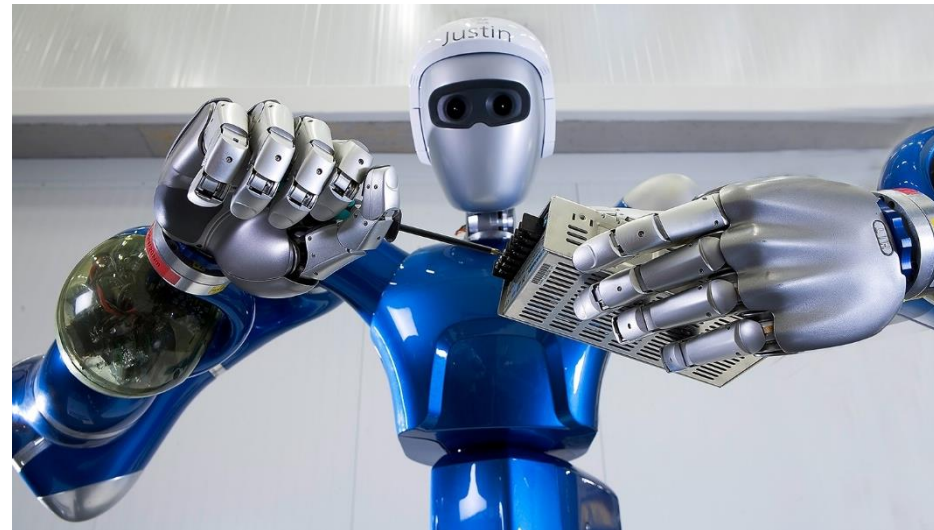


Automatically Generate Code

Instead of writing thousands of lines of code by hand, automatically generate production-quality C and HDL code that behaves the same way as the model you created in Simulink. Then deploy it directly onto your MCU, DSP, or FPGA.

Autonomous Systems

Autonomous Systems



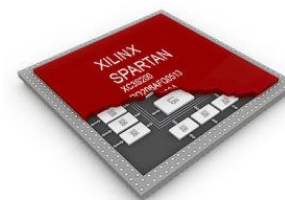
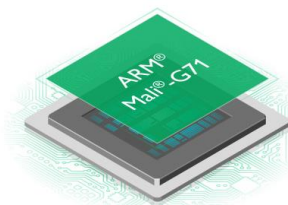
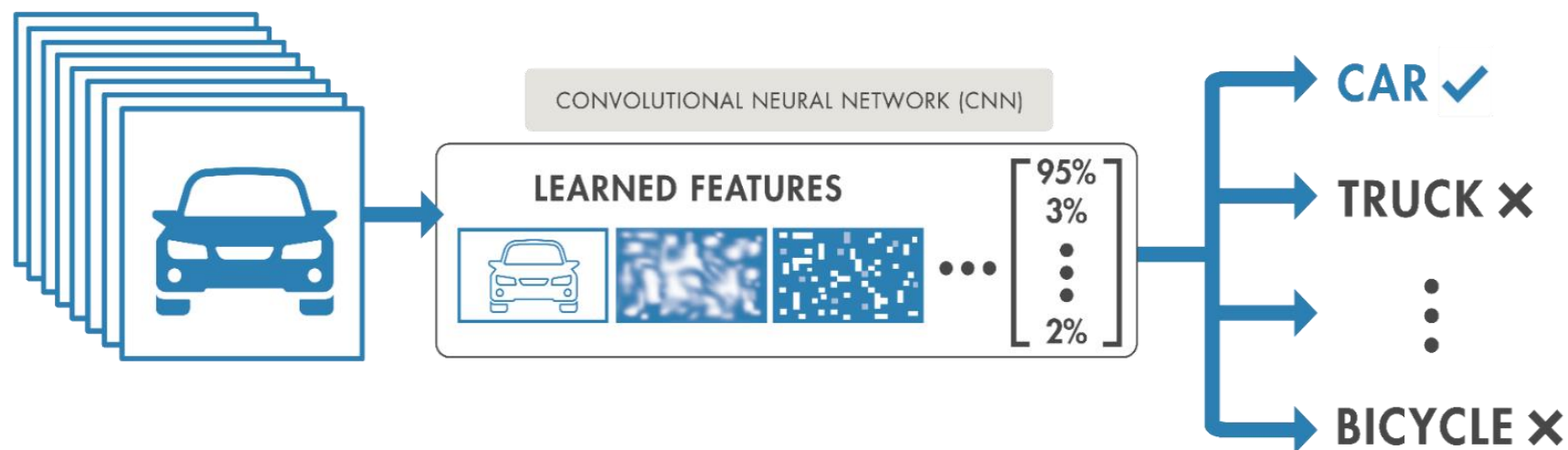
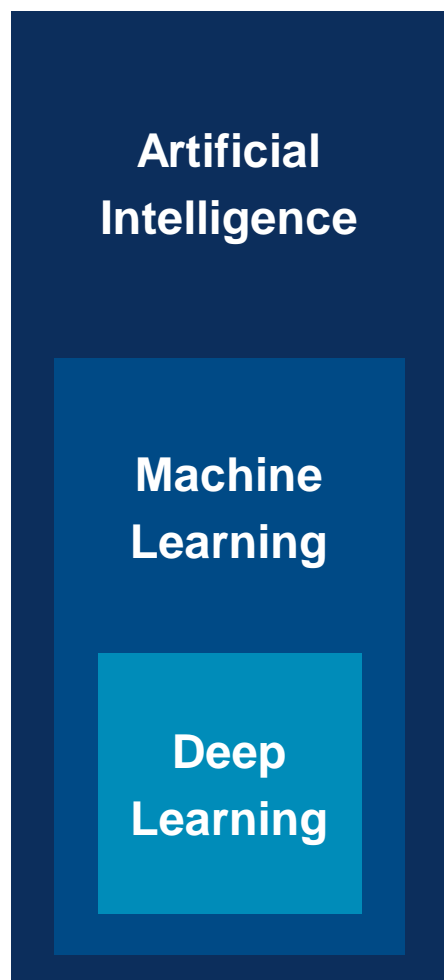
Autonomous Systems

➤ Why is it happening now?

What challenges is Industry facing?

How are engineers overcoming them?

Why Now?



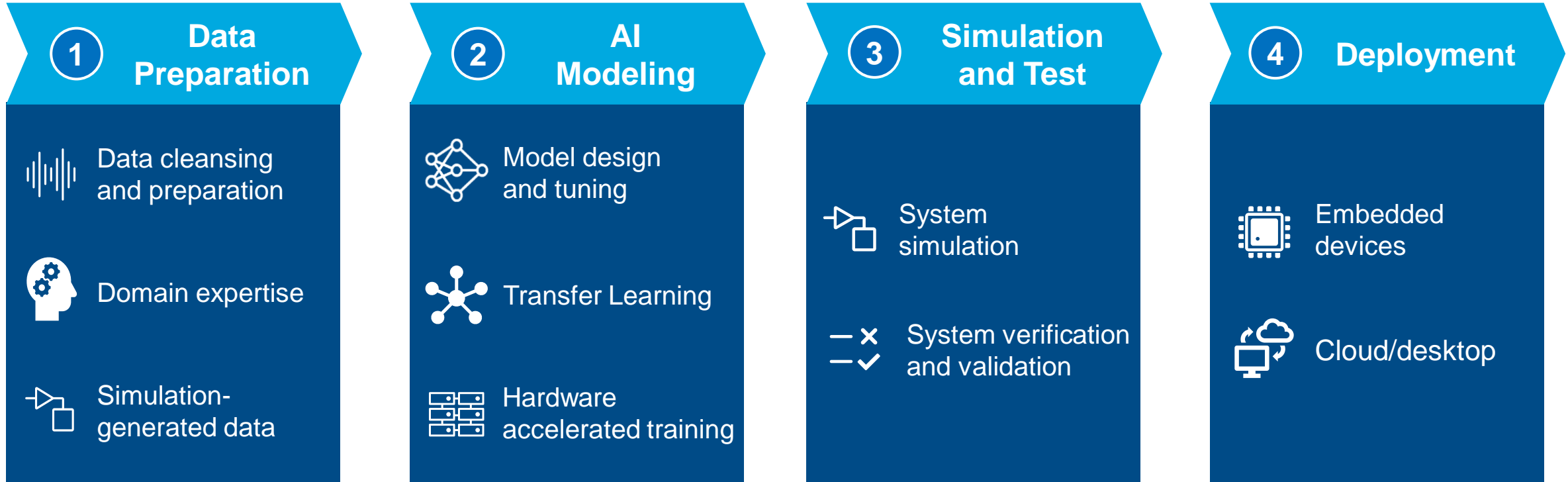
Autonomous Systems

Why is it happening now?

➤ What challenges is Industry facing?

How are engineers overcoming them?

Key Challenges in AI



Autonomous Systems

Why is it happening now?

What challenges is Industry facing?

➤ How are engineers overcoming them?

Subaru EyeSight

Detects obstacles, applies brakes, adjusts cruise control, and stays in lane.



Automated Labeling Apps

1 Data Preparation

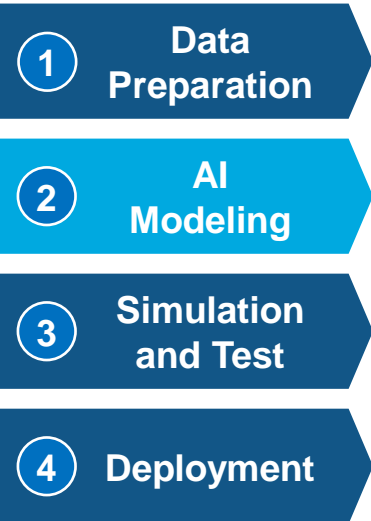
2 AI Modeling

3 Simulation and Test

4 Deployment

The screenshot displays the MATLAB Ground Truth Labeler application interface. The window title is "Ground Truth Labeler". The interface is divided into several sections:

- Top Bar:** Contains tabs for "LABEL" and "LIDAR".
- Toolbars:** Includes "GROUND" (Hide Ground, Ground Settings), "CUBOID" (Shrink to Fit, Snap to Cluster, Cluster Settings), "COLORMAP" (Colormap: Red to..., Colormap Value: Z Height), and "CAMERA VIEW" (Restore Default View, Bird's Eye View, Chase View, Ego View, Ego Direction: +x).
- Left Panel:** Features "ROI Labels" and "Scene Labels" tabs. Under "Scene Labels", there is a "Vehicle" category with a "car" sub-label (checked) and a "TailLight" sub-label (unchecked). Buttons for "Label", "Sublabel", and "Attribute" are also present.
- Main View:** Shows two side-by-side views. The left view is a camera perspective of a street scene with a car highlighted by a green bounding box. The right view is a "lidarSequence" showing a 3D point cloud with a yellow bounding box around the car.
- Bottom Panel:** Contains a timeline with "Start Time" (00.00000), "Current" (07.50000), "End Time" (10.20001), and "Max Time" (10.20001). It also includes playback controls and a "Zoom In Time Interval" button.



Algorithms

Machine learning

Trees, Naïve Bayes, SVM...

Deep learning

CNNs, GANs, LSTM, MIMO...

Reinforcement learning

DQN, A2C, DDPG...

Regression

Linear, nonlinear, trees...

Unsupervised learning

K-means, PCA, GMM...

Predictive maintenance

RUL models, condition indicators...

Bayesian optimization

Pre-built models

Image classification models

AlexNet, GoogLeNet, VGG,
SqueezeNet, ShuffleNet, ResNet,
DenseNet, Inception...

Reference examples

Object detection

Vehicles, pedestrians, faces...

Semantic segmentation

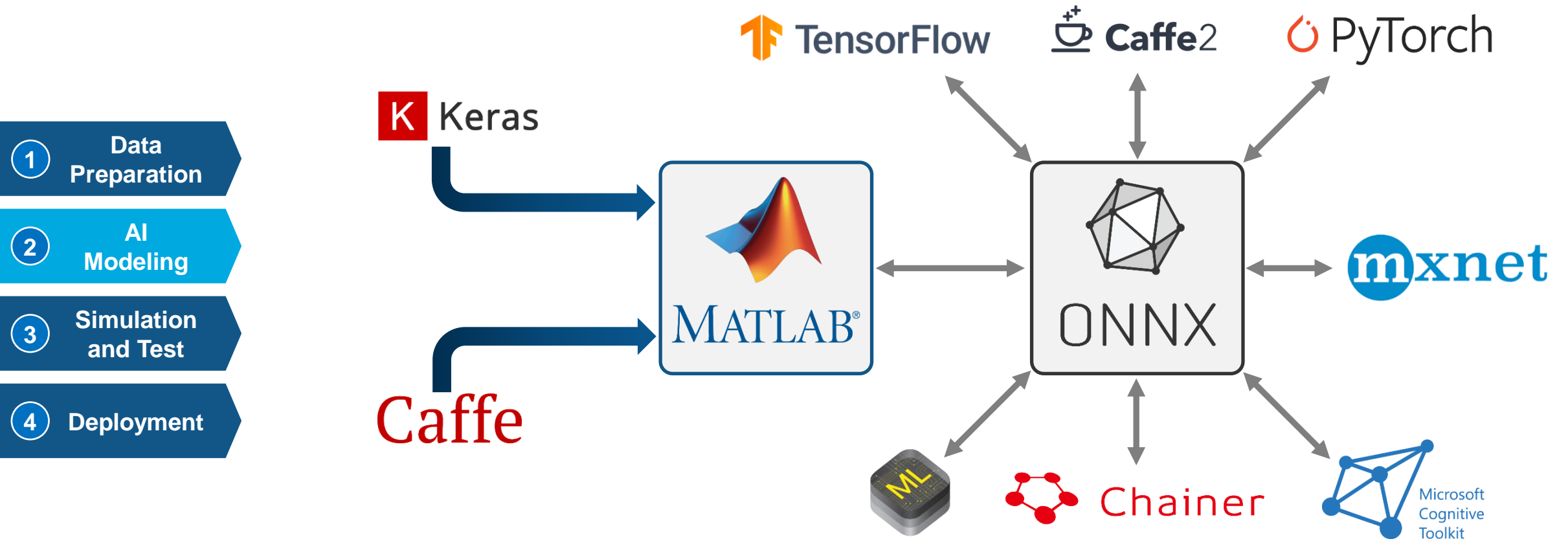
Roadway detection, land cover
classification, tumor detection...

Signal and speech processing

Denoising, music genre recognition,
keyword spotting, radar waveform
classification...

...and more...

Leveraging the Larger AI Community



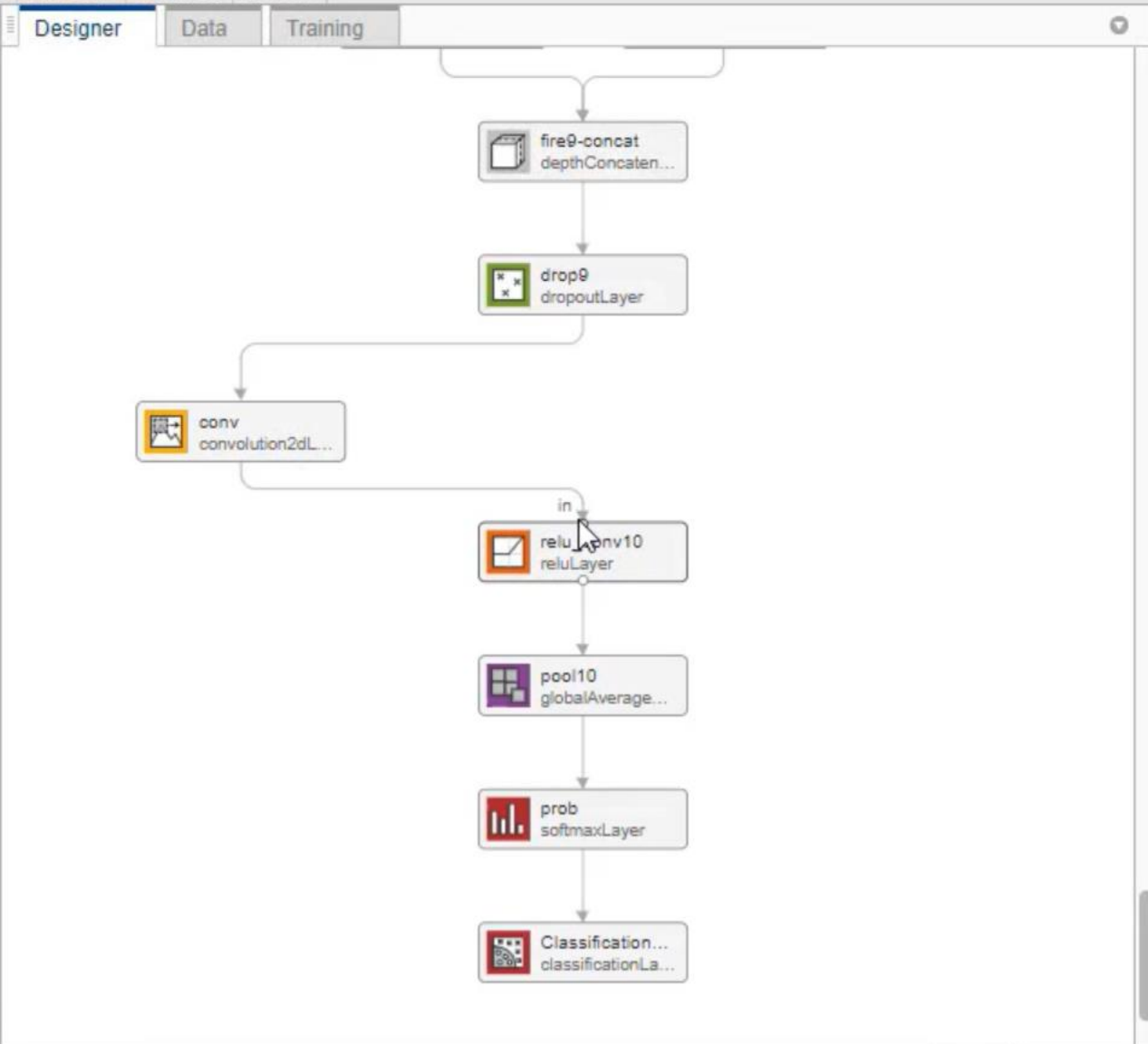
New Duplicate Cut Copy Paste Fit to View Zoom In Zoom Out Auto Arrange Analyze Export

NETWORK BUILD NAVIGATE LAYOUT ANALYSIS EXPORT

Layer Library

Filter layers...

- INPUT
 - imageInputLayer
 - image3dInputLayer
 - sequenceInputLayer
 - featureInputLayer
 - roiInputLayer
- CONVOLUTION AND FULLY CONNECTED
 - convolution2dLayer
 - convolution3dLayer
 - groupedConvolution2dLayer
 - transposedConv2dLayer
 - transposedConv3dLayer
 - fullyConnectedLayer
- SEQUENCE
 - lstmLayer



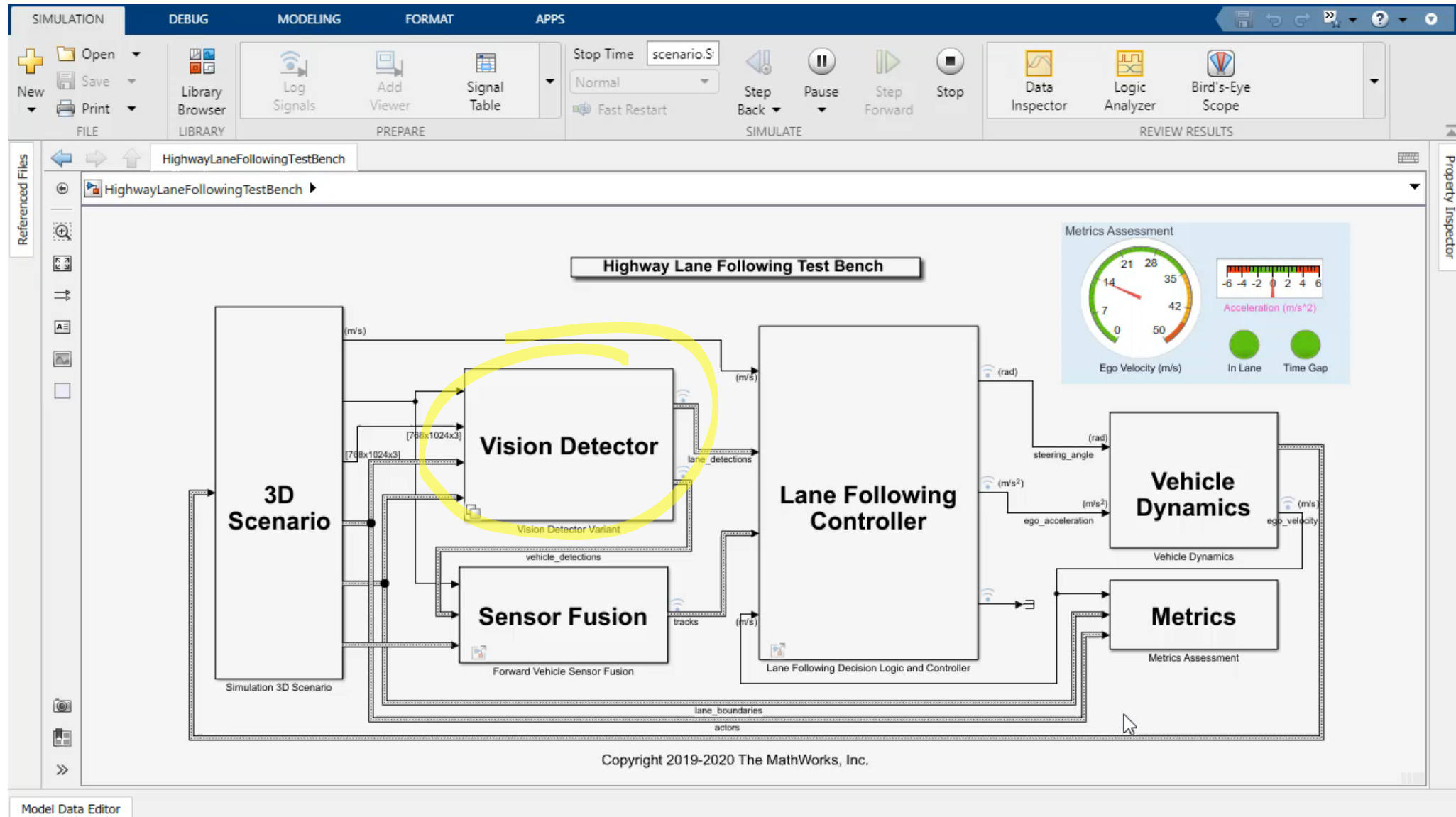
Properties

Input type	Image
Output type	Classification
Number of layers	68
Number of connections	74

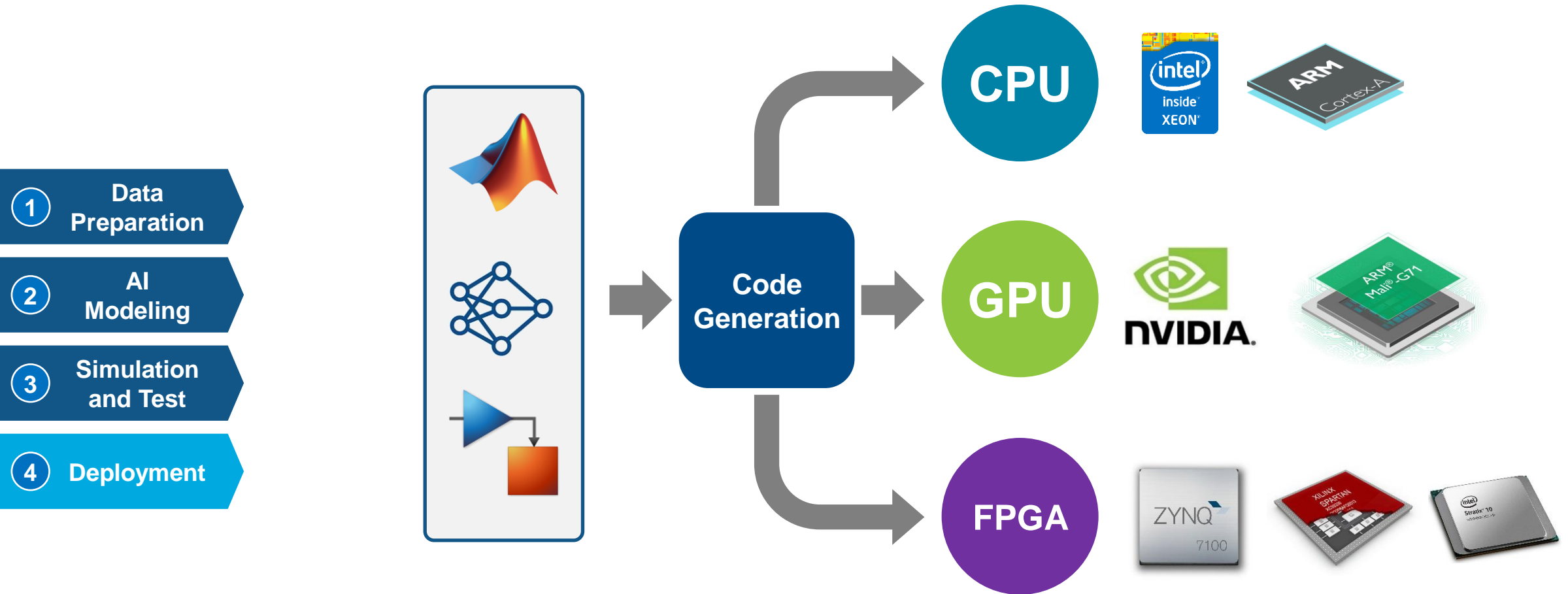
Overview

System Simulation

- 1 Data Preparation
- 2 AI Modeling
- 3 Simulation and Test
- 4 Deployment



Deploy to Any Device with Zero Coding Errors



Model-Based Design: From Concept to Code



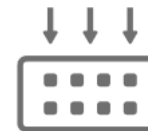
Model and Simulate Your System

Explore a wide design space by modeling the system under test and the physical plant. Your entire team can use one multi-domain environment to simulate how all parts of the system behave.



Test Early and Often

Reduce expensive prototypes by testing your system under conditions that are otherwise too risky or time-consuming to consider. Validate your design with hardware-in-the-loop testing and rapid prototyping. Maintain traceability from requirements to design to code.



Automatically Generate Code

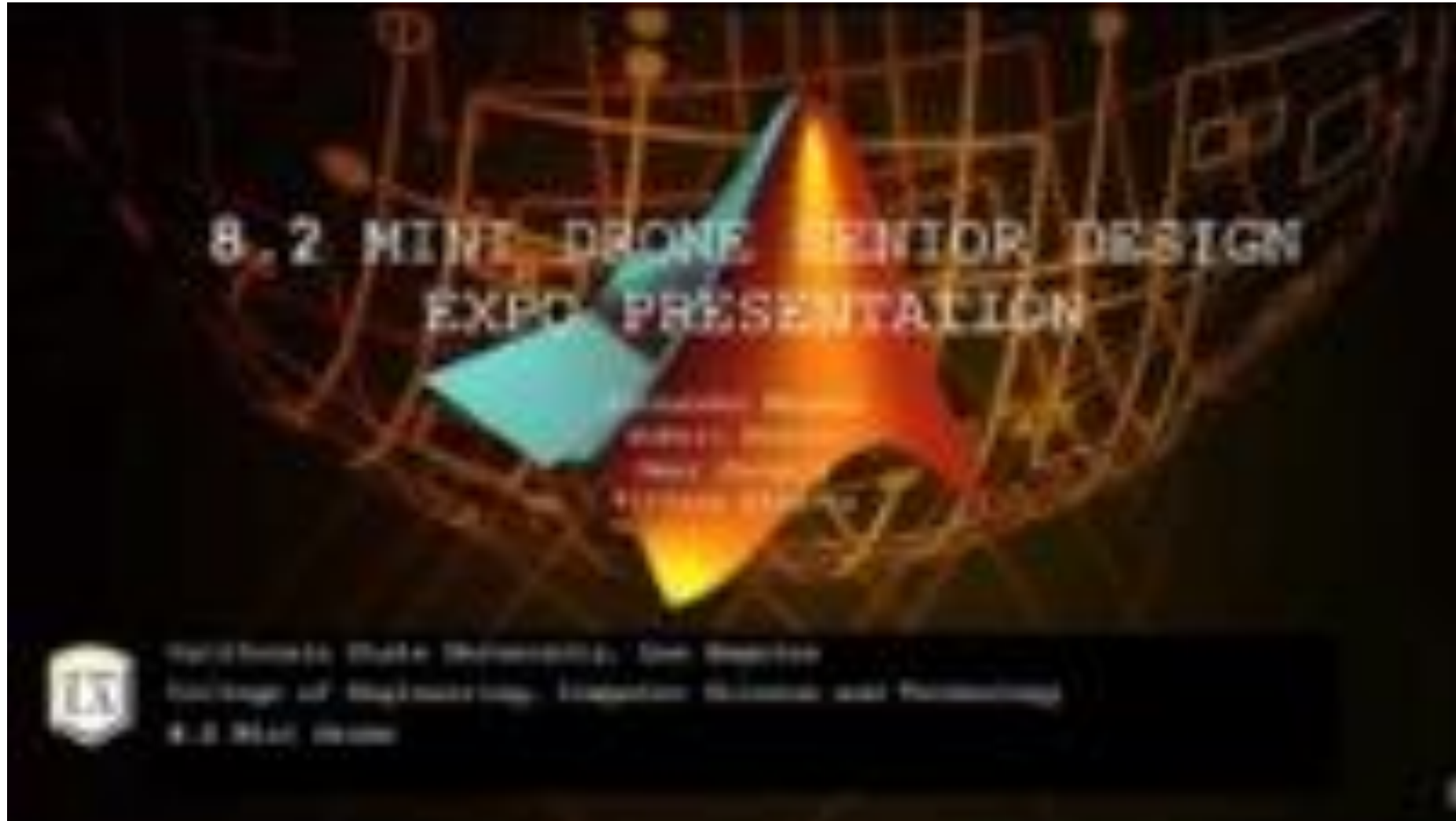
Instead of writing thousands of lines of code by hand, automatically generate production-quality C and HDL code that behaves the same way as the model you created in Simulink. Then deploy it directly onto your MCU, DSP, or FPGA.

Systems Thinking in the Classroom

Systems Thinking in the Classroom

- How can Systems Thinking be incorporated?
How can Students be prepared?
What if you have questions?

Cal State Los Angeles – Minidrone Project



<https://tinyurl.com/3ws24bc7>

Incorporating Systems Thinking: The technical aspects

IMAGE PROCESSING

Left
• Fir
Ima
• Cre
and

CONTROL SYSTEM

POSSIBLE DESIGN CONFIGURATIONS

• Ob
ul
ca
• Ou
co
re
en
• Th
bo
pl

SUB
STA
Peak St
• 1.803

Peak de
• .057

• Calcu
• FoS c

Pros
• Symr
desl
sim
flic
adju



Incorporating Systems Thinking: The non-technical aspects

The collage illustrates various project management tools used in a systems thinking context. It includes:

- AGENCY TESTING**: A Gantt chart showing task progress over time.
- RISK ASSESSMENT**: Two matrices comparing requirements (e.g., Hover, Line Follow, Landing) against sources and testing methods.
- PROJECT TIMELINE**: A detailed Gantt chart for 'Team 8.2: Mini Drone Project Timeline' from Sep 2020 to Oct 2021, showing phases like CoDR, PDR, and CDR.

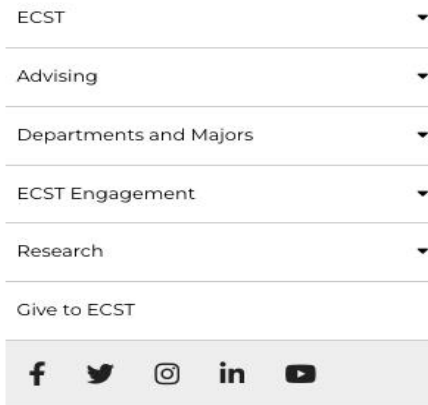
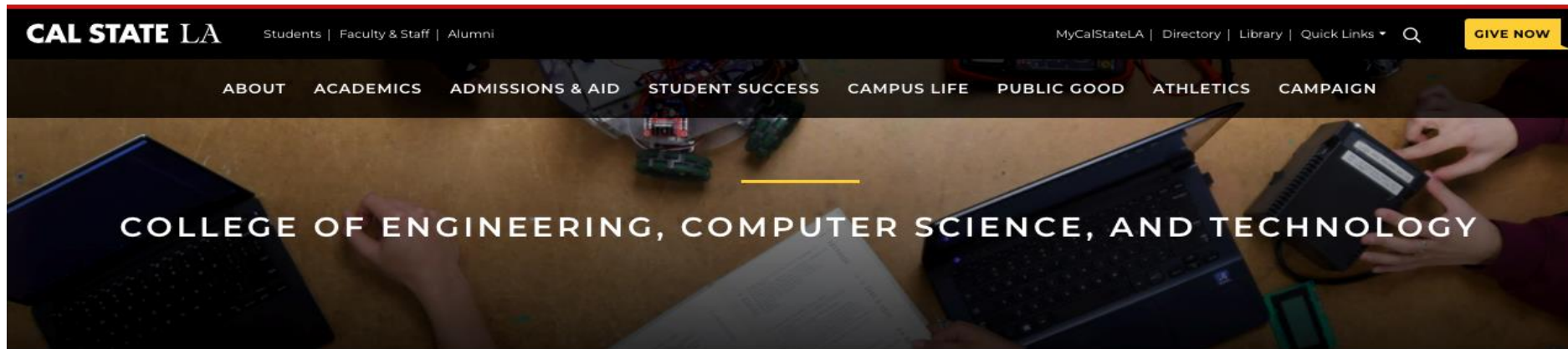
Requirement	Source	Testing	Verification
Hover			
Line Follow			
Landing			
Disturbance			
Claw Design			
Augmented Reality			
Time			

Requirement	Source	Testing	Verification
Hover All			
Line Follow			
Landing			
Disturbance			
Claw Design			
Augmented Reality			
Time			

PROJECT TIMELINE



Observations of student, faculty and the university



CAL STATE LA SUPPORTS USING THE TOOLS PROFESSIONALS USE IN ENGINEERING EDUCATION



Photo: Jocylene Arevalo

USING THE TOOLS PROFESSIONALS USE
GIVES ECST STUDENTS A LEG UP

Systems Thinking in the Classroom

How can Systems Thinking be incorporated?

➤ How can Students be prepared?

What if you have questions?

Resources to consider:

MathWorks Excellence in Innovation Projects



Contribute to the progress of engineering and science by solving key industry challenges!

Are you looking based on industry trends you learn about technical components for your problem?

Projects by technology trends

- 5G
- Artificial Intelligence
- Autonomous Vehicles
- Big Data
- Computer Vision
- Drones
- Industry 4.0
- Neuroscience
- Robotics
- Sustainability and Renewable Energy



Flight Controller Design and Hardware Deployment

Build a mini drone and use the PX4 Hardware Support package to design the flight controller using Simulink.



Portable Charging System for Electric Vehicles

Design a portable charger for Electric Vehicles

Self-Paced Online Training



**MATLAB
Onramp**



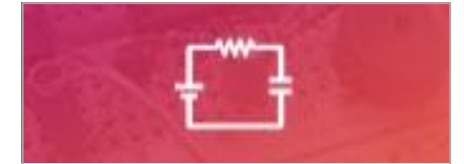
**Simulink
Onramp**



**Stateflow
Onramp**



**Control Design
Onramp**



**Circuit Simulation
Onramp**



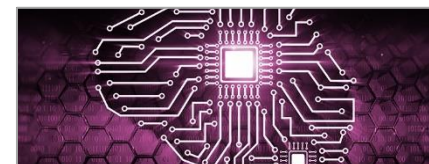
**Machine Learning
Onramp**



**Deep Learning
Onramp**



**MATLAB for Data
Processing and
Visualization**



**Machine Learning
with MATLAB**



**Deep Learning
with MATLAB**

Freely Reusable Courseware



Teaching Calculus with MATLAB

- » Integrate MATLAB into your Calculus curriculum



Teaching Physics with MATLAB

- » Integrate MATLAB into your Physics curriculum



Teaching Chemistry with MATLAB

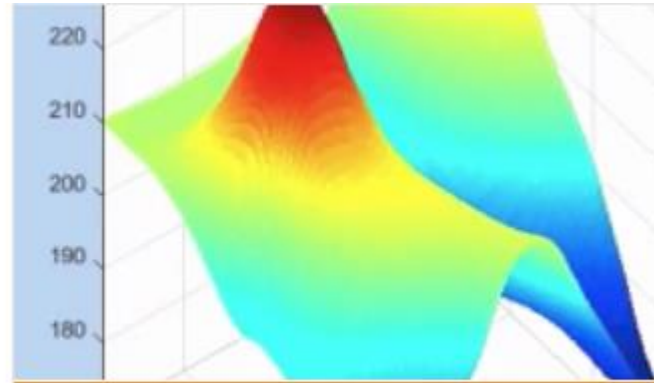
- » Integrate MATLAB into your Chemistry curriculum

Freely Reusable Courseware



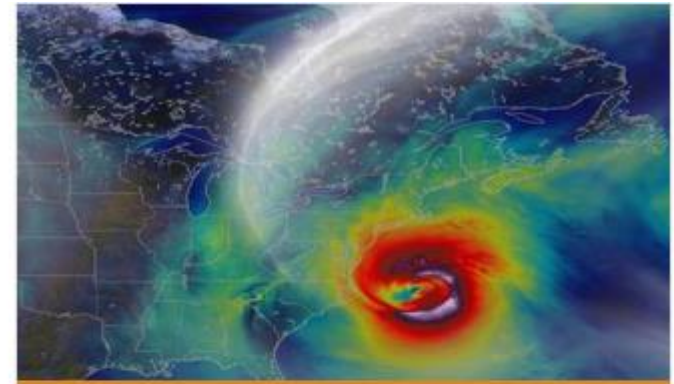
Teaching Biology with MATLAB

- » Integrate MATLAB into your Biology curriculum



Teaching Geoscience with MATLAB

- » Integrate MATLAB into your Geoscience curriculum



Teaching Computational Science Using MATLAB

- » Integrate MATLAB into your robust data analysis, data visualization and exploration curriculum

Freely Reusable Courseware



Teaching Psychology and Neuroscience with MATLAB

- » Integrate MATLAB into your Psychology and Neuroscience curriculum



Teaching Econometrics with MATLAB

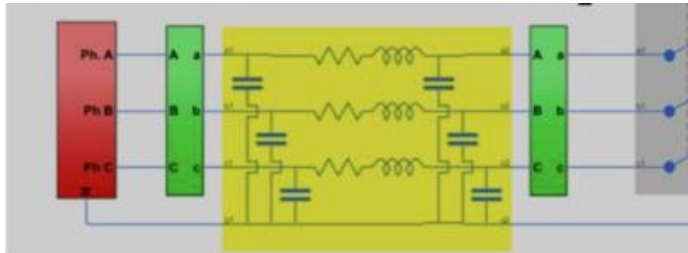
- » Integrate MATLAB into your Econometrics curriculum



Teaching Quantitative Finance and Risk Management with MATLAB

- » Integrate MATLAB into your Quantitative Finance and Risk Management curriculum

Self-Paced Virtual Labs



ELECTRICAL ENGINEERING

Electric Machine and Power Labs

Douglas Jussaume, University of Tulsa

Eight power labs and assignments that mimic hardware lab operation; the typical lab requires students to connect the power circuit, run and record data, and submit a lab report

Includes: Models, Assignments



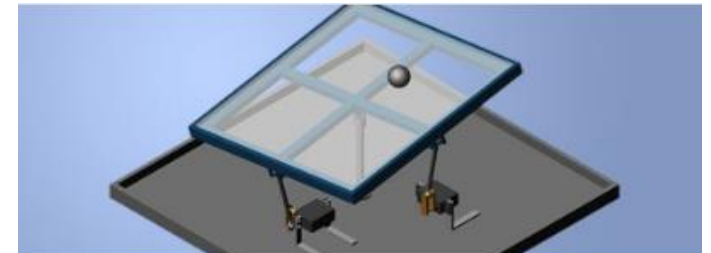
ELECTRICAL ENGINEERING

Digital Communication Laboratory

Lee C. Potter and Yang Yang, The Ohio State University

Laboratory course providing hands-on exploration of physical layer communication

Includes: Code, Assignments



MECHANICAL AND ELECTRICAL ENGINEERING

Virtual Hardware and Labs for Controls

MathWorks

Four introductory labs with virtual models; designed to give an intuitive introduction to basic controls concepts, such as feedback control

Includes: Code, Models, Assignments

Systems Thinking in the Classroom

How can Systems Thinking be incorporated?

How can Students be prepared?

➤ What if I have questions?

What if I have questions?

- Explore product pages and documentation
- Leverage the MATLAB user community
- Contact
 - Technical Support
 - Account Manager
 - Customer Success Engineer

MATLAB EXPO

Thank you



© 2022 The MathWorks, Inc. MATLAB and Simulink are registered trademarks of The MathWorks, Inc. See [mathworks.com/trademarks](https://www.mathworks.com/trademarks) for a list of additional trademarks. Other product or brand names may be trademarks or registered trademarks of their respective holders.