MATLAB EXPO 2017
KOREA
4월 27일, 서울
등록하기 matlabexpo.co.kr
Power Electronics Design and Simulation with Simscape Power Systems

강효석 과장 / Ph. D.
Application Engineer
MathWorks Korea
Electrical Power System

- **Generation**: Power plant generates electricity.
- **Transmission**: Transmission lines carry electricity long distances.
- **Distribution**: Distribution lines carry electricity to houses.
  - Transformer steps up voltage for transmission.
  - Neighborhood transformer steps down voltage.
  - Transformers on poles step down electricity before it enters houses.
Industry Needs of Power Electronics

- Technology for the control and conversion of electric power
- One of main technology to overcome energy problem
- Key factor is energy conservation through high efficiency
Diverse User in Power Electronics

OMRON

Power Electronics

ABB

Sandia National Laboratories

Alstom Grid
Introduction to Simscape Power Systems

- Enables physical modeling (acausal) of electrical power systems and electric drives

- Electrical system topology represented by schematic circuit

- Used by electrical, system and control engineers to develop plant models and test control systems
Working with Simscape Power Systems

Simscape Power Systems is a tool for modeling the generation, transmission, distribution, and consumption of electrical power

- With Simscape Power Systems you can:
  - Quickly build electrical power system models
  - Model synchronous and asynchronous electric drives
  - Perform common electrical system analysis tasks
  - Develop and test controls
  - Generate code for improved performance
MathWorks Investment in Simscape

- More than 15 years of acausal modeling
- Steady advances in breadth and depth of libraries and capabilities
Key Points

- Physical component models at various levels of fidelity are necessary for Power Electronics
- Modeling the plant and controller in a single environment enables system level optimization
- Deploy the model as C code to other simulation environments, or use it as a standalone executable
Agenda

- Modeling electrical and electronic components
  - Modeling Electrical Circuit: Buck Converter
  - Battery Modeling using Simscape Power Systems
- Designing control algorithms
- Simulating in Real Time
- Summary
Agenda

- Modeling electrical and electronic components
  - Modeling Electrical Circuit: Buck Converter
  - Battery Modeling using Simscape Power Systems
- Designing control algorithms
- Simulating in Real Time
- Summary
Demo: Small Microgrid System with Energy Storage

- PV Converter
- BMS Control
- Grid
- Battery
Small Microgrid System with Energy Storage

1. Heuristic algorithm to manage battery storage
2. Grid price optimization module to minimize cost
Agenda

- Modeling electrical and electronic components
  - Modeling Electrical Circuit: Buck Converter
  - Battery Modeling using Simscape Power Systems
- Designing control algorithms
- Simulating in Real Time
- Summary
DC-DC Converter (Buck Converter)

High DC Voltage → Low DC Voltage
Modeling Electrical Circuit – Buck Converter
Agenda

- Modeling electrical and electronic components
  - Modeling Electrical Circuit: Buck Converter
  - Battery Modeling using Simscape Power Systems
- Designing control algorithms
- Simulating in Real Time
- Summary
Battery Modeling using Simscape Power Systems

Li-ion Battery Models

1) SimPowerSystems Specialized Technology
2) Simscape Li-ion equivalent circuit
Simscape Power Systems ST
Lithium-Ion Battery Aging Model

- Model the lifetime performance of a battery storage system
  - generic aging model with parameters that can be obtained from manufacturer data sheets or simple experiments
Agenda

- Modeling electrical and electronic components
  - Modeling Electrical Circuit: Buck Converter
  - Battery Modeling using Simscape Power Systems
- Designing control algorithms
- Simulating in Real Time
- Summary
Simulating plant and controller in one environment allows you to optimize system-level performance

- Automate tuning using optimization algorithms
- Accelerate process using parallel computing
Defining Control Logic for Battery Management System
Defining Control Logic for Battery Management System

Adapted from: Smart Energy Systems Website
Peak Demand Shift using Energy Storage

Adapted from: Smart Energy Systems Website
Implementation of Energy Management Logic

Ref: Liu 2011 - A Hybrid AC/DC Microgrid and Its Coordination Control
Factoring in Variable Electricity Cost

Adapted from: Smart EnergySystems Website
Defining Control Logic for Battery Management System
Agenda

- Modeling electrical and electronic components
  - Modeling Electrical Circuit: Buck Converter
  - Battery Modeling using Simscape Power Systems
- Designing control algorithms
- Simulating in Real Time
- Summary
Detect Integration Issues Earlier

Controls engineers and domain specialists can work together to **detect integration issues in simulation**

- Convert models to C code for HIL tests
- Share with internal users with fewer licenses
- Share with external users while protecting IP
Process-in-the-Loop (PIL) & Hardware-in-the-Loop (HIL) Simulation
Integrate Your Models into Other Simulation Environments

- Model can be converted to C code
  - Run in real-time to test controller hardware (HIL)
  - Standalone executable (parameter sweeps)
  - Integration with other simulation tools

*Deploy the model as C code to other simulation environments, or use it as a standalone executable*
Summary

- Physical component models at various levels of fidelity are necessary for Power Electronics

- Modeling the plant and controller in a single environment enables system level optimization

- Deploy the model as C code to other simulation environments, or use it as a standalone executable
Q&A