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등록 하기 matlabexpo.co.kr
Power Electronics Design and Simulation with Simscape Power Systems

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Electrical Power System

- **GENERATION**: Power Plant generates electricity.
- **TRANSMISSION**: Transmission lines carry electricity long distances. Transformer steps up voltage for transmission.
- **DISTRIBUTION**: Distribution lines carry electricity to houses. 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
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
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Demo: Small Microgrid System with Energy Storage

Battery

Grid

PV Converter

BMS Control

System Measurements

Continuous Ideal Switch

Insatance Data: County City

Microgrid Loads

Simulink Li-ion Model

Battery

Optimization Routine
Small Microgrid System with Energy Storage

1) heuristic algorithm to manage battery storage
2) grid pricing optimization model to minimize cost
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DC-DC Converter (Buck Converter)

High DC Voltage $\rightarrow$ Low DC Voltage

Error amp and switch control
Modeling Electrical Circuit – Buck Converter
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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

R2017a New Feature

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Discharge</th>
<th>Aging</th>
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</thead>
<tbody>
<tr>
<td>Initial battery age (Equivalent full cycles)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Aging model sampling time (s)</td>
<td>1e6</td>
<td></td>
</tr>
<tr>
<td>Aging characteristics at ambient temperature Ta1</td>
<td></td>
<td></td>
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<tr>
<td>Ambient temperature Ta1 (deg. C)</td>
<td>25</td>
<td></td>
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<tr>
<td>Capacity at EOL (End Of Life) (Ah)</td>
<td>5.4*0.9</td>
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<tr>
<td>Internal resistance at EOL (Ohms)</td>
<td>0.013333*1.2</td>
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<tr>
<td>Charge current (nominal, maximum) [Ic (A), Icmax (A)]</td>
<td>[2.3478, 3]</td>
<td></td>
</tr>
<tr>
<td>Discharge current (nominal, maximum) [Id (A), Idmax (A)]</td>
<td>[2.3478, 10]</td>
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<tr>
<td>Cycle life at 100 % DOD, Ic and Id (Cycles)</td>
<td>1500</td>
<td></td>
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<td>Cycle life at 25 % DOD, Ic and Id (Cycles)</td>
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<td>Cycle life at 100 % DOD, Icmax and Id (Cycles)</td>
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<tr>
<td>Cycle life at 100 % DOD, Icmax and Id (Cycles)</td>
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<tr>
<td>Aging characteristics at ambient temperature Ta2</td>
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<tr>
<td>Ambient temperature Ta2 (deg. C)</td>
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<tr>
<td>Cycle life at 100 % DOD, Ic and Id (Cycles)</td>
<td>950</td>
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</tbody>
</table>
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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
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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