Electric vehicles and charging stations

Renewable energy

Rail

Lighting
Power Electronic Systems
Our Project Today

DC/DC LED Developer's Kit

Fig 1: TMDSDCDCLEDKIT

Fig 4: DC/DC LED Lighting Board Block diagram with F28035

MATLAB EXPO 2019
Challenges for Power Electronics Engineer

- Understand the impact of the power source and load
- Testing for a complete range of operating and fault conditions
- Designing and implementing digital controls using only SPICE simulator tools
- Catching errors during software-hardware integration testing
- Compliance to industry standards
- Development Time
Power Converter Control Design Workflow Tasks

1. Size inductor, capacitor and understand the behaviour in continuous and discontinuous mode

2. Determine non linear switching and the thermal behavior of the converter

3. Design control algorithm based on time/frequency domain specification

4. Implement power electronic controls on an embedded processor
Let’s get to it!
Power Converter Control Design Workflow Tasks

- Size inductor, capacitor and understand the behaviour in continuous and discontinuous mode
  - Determine non linear switching and the thermal behavior of the converter
  - Design control algorithm based on time/frequency domain specification
  - Implement power electronic controls on an embedded processor
Simscape model for DC-DC Sepic Converter
Simscape model for DC-DC Sepic Converter
Simscape model for DC-DC Sepic Converter
DC/DC Sepic Converter
Open Loop Duty
DC/DC Sepic Converter
Open Loop Duty

470uH
12V
950uF
0.5

13
DC/DC Sepic Converter
Open Loop Duty

Asynchronous PWM Generator
Recap: Size Inductor, Capacitor and Understand the Behaviour in Continuous and Discontinuous mode.

What we did:
- Use simulation to design DC to DC converters
- Optimize component sizing using simulation driven analysis
Power Converter Control Design Workflow Tasks

- Size inductor, capacitor and understand the behaviour in continuous and discontinuous mode

- **Determine non linear switching and the thermal behaviour of the converter**

- Design control algorithm based on time/frequency domain specification

- Implement power electronic controls on an embedded processor
DC-DC Sepic converter with Non-Linear Switching Dynamics
Comparison of N-Channel MOSFET Characteristics With Datasheet
Comparison of N-Channel MOSFET Characteristics With Datasheet
Recap: Determine Power Losses and Simulate Thermal Behaviour of the Converter.

What we did

- Use semiconductor blocks from Simscape Electrical to model the non-linear switching behavior of SEPIC converter
- Leverage the multi-domain simulation capability of Simscape in understanding the thermal dynamics
Power Converter Control Design Workflow Tasks

- Size inductor, capacitor and understand the behaviour in continuous and discontinuous mode
- Determine non linear switching and the thermal behavior of the converter
- Design control algorithm based on time/frequency domain specification
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DC/DC Sepic Converter Voltage Mode Control (VMC)
DC/DC Sepic Converter
Voltage Mode Control (VMC)
DC/DC Sepic Converter
Voltage Mode Control (VMC)
Step Plot: Reference tracking

- Tuned response
- Block response

Identified Plant Structure: One Pole

Plant Parameters: $K = 3.4373$, $T_1 = 0.04$
Controlling PID parameters
Controller was re-tuned using the new plant "Plant1"
Block Parameters: Discrete PID Controller

- **Continuous-time**
- **Discrete-time**

Sample time (-1 for inherited): -1
Integrator and Filter methods:

**Compensator formula**

\[ P + I \cdot T_s \cdot \frac{1}{z-1} \]

### Controller parameters

**Source:** Internal

- **Proportional (P):** 0.2987551672997
- **Integral (I):** 37.8468024852967

### Automated tuning

- **Select tuning method:** Transfer Function Based (PID Tuner App)

- **Enable zero-crossing detection**

- **TBPRD1**
- **double**
- **1**
- **CMP**
Recap: Design Control Algorithm Based on Time/Frequency Domain Specifications

What we did
• Identify plant model from input output simulation data
• Use auto tuning algorithms to tune the control gains
Power Converter Control Design Workflow Tasks

- Size inductor, capacitor and understand the behaviour in continuous and discontinuous mode
- Determine non linear switching and the thermal behavior of the converter
- Design control algorithm based on time/frequency domain specification
- **Implement power electronic controls on an embedded processor**
Implementing Control for Power Converters on TI DC-DC LED Developer Kit
Fast Code Generation Using Embedded Coder Quick Start

SIMULINK MODEL

QUICK START – 7 Simple Steps

GENERATED CODE
# Code Generation Report for 'DC_DC_LED_External_2'

## Model Information

<table>
<thead>
<tr>
<th>Author</th>
<th>vivekr</th>
</tr>
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<tbody>
<tr>
<td>Last Modified By</td>
<td>vivekr</td>
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<tr>
<td>Model Version</td>
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### Configuration settings at time of code generation

## Code Information

<table>
<thead>
<tr>
<th>System Target File</th>
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<tbody>
<tr>
<td>Hardware Device Type</td>
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<tr>
<td>Simulink Coder Version</td>
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<tr>
<td>Timestamp of Generated Source Code</td>
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<td>C:\Users\vivekr\Desktop\DC_DC_LED_External_2_ert_rtw\</td>
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<td>Type of Build</td>
<td>Model</td>
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<tr>
<td>Objectives Specified</td>
<td>Execution efficiency, RAM efficiency, ROM efficiency</td>
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</table>
Control Algorithm deployment to TI controller and Parameter Tuning using External Mode
Implementation Of Power Electronics Control On Embedded Processor
Recap: Implement Power Electronics Control on an Embedded Processor

What we did:
• Verify the controller for various test cases
• Generate code from MATLAB and Simulink models optimized for embedded controllers
How We Addressed The Challenges

- Understand the impact of the power source and load
- Testing for a complete range of operating and fault conditions
- Designing and implementing digital controls using *only* SPICE simulator tools
- Catching errors during software-hardware integration testing
- Compliance to industry standards
- Development Time

- Size inductor, capacitor and understand the behaviour in continuous and discontinuous mode
- Determine non linear switching and the thermal behavior of the converter
- Design control algorithm based on time/frequency domain specification
- Implement power electronic controls on an embedded processor
Call To Action

- Get **power electronics control design trial package** with necessary tools for desktop modeling, simulation, control design

- Visit the demo booth on: **Motor Control and Power Conversion with TI MCUs**

- Read White Paper
  
  **10 Ways to Speed up Power Conversion Control Design with Simulink**
Motor Control Modeling and Simulation Using MATLAB and Simulink

**Topics Covered:**
- Simulink as a Platform for System and Plant Modeling
- Modeling and Simulation Electrical Systems Using Simscape
- System Analysis and Controller Design
- Control Algorithm Development for Three-Phase Motors
Please provide feedback for this block of sessions

- Scan this QR Code or log onto link below (link also sent to your phone and email)
- Enter the registration id number displayed on your badge
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