Course Info

• Course focuses on design an modeling of “high frequency” power electronics
  • Course website: http://web.eecs.utk.edu/~dcostine/ECE581
  • Goal of course is understanding of motivations and issues with high frequency power electronics; analysis and design techniques; applications

• Prerequisites: undergraduate Circuits sequence, Microelectronics, ECE 481 – Power Electronics, or equivalent

Contact Info

Instructor: Daniel Costinett

• Office: MK504
• Office Hours: W 3-4pm, R 10-11am
• E-mail: Daniel.Costinett@utk.edu
• Email questions will be answered within 24 hours (excluding weekends)
• Please use [ECE 581] in the subject line
Course Structure

• Course meets MWF 9:15-10:05 am
• Plan to spend ~9 hours per week on course outside of lectures
• Grading:
  – Homework/Lab: 40%
    • One homework per week
    • Assignments due on Fridays unless otherwise noted on course website
  – Midterm: 25%
    • Tentatively scheduled for October 29th
  – Final: 35%

Assignments

• Assignments due at the start of lecture on the day indicated on the course schedule
• All assignments submitted through canvas
  – https://utk.instructure.com/courses/104569
• No late work will be accepted except in cases of documented medical emergencies
• Collaboration is encouraged on all assignments except exams; Turn in your own work
• All work to be turned in through canvas
Textbook and Materials

• The textbook
  will cover some of chapters 19-20 and reference materials from prior chapters. The textbook is available on-line from campus network. Purchase is not required for this course.

• MATLAB/Simulink, LTSpice will be used; All installed in the Tesla Lab

• Lecture slides and notes, additional course materials, homework, due dates , etc. posted on the course website

• Additional information on course website

Online Tools

• Zoom
  - [https://tennessee.zoom.us/j/94031104264](https://tennessee.zoom.us/j/94031104264)
  - All lectures will be livestreamed and recorded through the same zoom meeting

• Slack
  - [https://curenterc.slack.com/archives/G019PH31YP2](https://curenterc.slack.com/archives/G019PH31YP2)
  - Peer collaboration, and instructor-student communication

• Canvas
  - [https://utk.instructure.com/courses/104569](https://utk.instructure.com/courses/104569)
  - Submission of all assignments

• Slido
  - [https://app.sli.do/event/lhsyh9vk/live/questions](https://app.sli.do/event/lhsyh9vk/live/questions)
  - Anonymous feedback / Q&A during lectures
Office Hours

• In-person office hours not permitted
• Scheduled office hours are times of maximum availability
• Contact me by e-mail, slack to start a telecon
• Outside of office hours, I will respond within 24 hours to e-mail or slack messages

TiNY BOX CHALLENGE

• Design competition to build and test an “optimized” dc-dc converter
  – Fall ‘16 – 60-to-12V, 60W
  – Fall ‘18 – 48-to-1.2V, 12W
• Format and feasibility TBD due to labwork requirement
  – Usually ~October-November
  – Usually in groups of 2-3
Pandemic Planning

• Discussion
Introduction

• Why high frequency?
  – Power Density
  – Control Bandwidth

• Techniques
  – Devices
  – Control
  – Topologies
  – Passives

Motivating Example

12V/48V Electrical Architecture

- eBooster
- EPS / EMPS
- Roll Stabilization
- 48V High-Power Consumer
- 48V Boardnet
- 48V Starter/Generator
- 48V Battery System
- Classic 12V Boardnet
- DC/DC

- PTC Heater
- Electric Pumps
- El. AC Compressor

AVL UK Expo 2014 / Ulf Stenzel

Audi, “Electric biturbo and hybridization”, 2014
AVL, “48V Mild Hybrid Systems”
Baseline Design

- Use TI WebBench (webench.ti.com) to get a baseline design

### LTSpice Simulation

<table>
<thead>
<tr>
<th>Param</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>$V_g$</td>
<td>12 V</td>
</tr>
<tr>
<td>$V_{out}$</td>
<td>48 V</td>
</tr>
<tr>
<td>$R_{out}$</td>
<td>48 Ω</td>
</tr>
<tr>
<td>$\Delta V_{out}$</td>
<td>0.1 V</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>$L$</th>
<th>$C_{out}$</th>
<th>$f_s$</th>
<th>Diode</th>
<th>$\eta$ (Sim)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22uH</td>
<td>22uF</td>
<td>202k</td>
<td>Si (FR)</td>
<td>93.9%</td>
</tr>
</tbody>
</table>
Diode Reverse Recovery

Datasheet RR Characteristics

Fig. 10 - Typical Stored Charge vs. $dl_T/dt$

Fig. 9 - Typical Reverse Recovery Time vs. $dl_T/dt$
Charge Storage

IGBT Current Tailing

Example: buck converter with IGBT

transistor turn-off transition

\[ P_{sw} = \frac{1}{f_s} \int_{t_{sw}}^{t_{off}} p_A(t) \, dt = (W_{on} + W_{off}) f_s \]

Fundamentals of Power Electronics
Schottky Diode

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