

课程大纲

COURSE SYLLABUS

1.	课程代码/名称 Course Code/Title	功率器件和开关电源设计/Power Electronics and Switching Power Supply
2.	课程性质 Compulsory/Elective	选修课/Elective
3.	课程学分/学时 Course Credit/Hours	3 学分/48 学时 3 Credit/48 Hours
4.	授课语言 Teaching Language	中英 CN/EG
5.	授课教师 Instructor(s)	化梦媛/Mengyuan HUA
6.	先修要求 Pre-requisites	EE201, 和 EE203/EE204
7.	教学目标 Course Objectives	
	<p>本课程通过对功率半导体器件的学习，使学生在理解并掌握硅基功率电子器件双极性晶体管，晶闸管，绝缘栅双极晶体管和场效应三极管的器件物理，工作原理和设计准则的基础上，进一步深入了解最新功率器件进展和仍存的挑战，从而对功率器件的发展建立较为完整的理解。在此基础上，通过对开关电源设计的学习，使学生理解开关电源的基本原理，电源拓扑结构和导通/开关损耗，重点掌握直流传输函数，反激变换器和正激变换器设计与磁学技术。对于反馈环路分析及稳定性，EMI 基础和滤波器设计，开关电源噪声以及 DM/CM 滤波器设计亦有较深刻理解。通过本课程的学习，使学生具备根据不同应用场景对开关电源的需求，选择合适拓扑，设计电路结构和应用功率器件的能力。</p> <p>This course is based on the study of power semiconductor devices, enabling students to understand and master the device physics, working principles and design criteria of silicon-based power electronics, including bipolar transistors, thyristors, insulated gate bipolar transistors and field effect transistors. Further understanding of the latest power device developments and the remaining challenges will lead to a more complete understanding of the development of power devices. On this basis, through the learning of switching power supply design, students will understand the basic principles of switching power supply, power supply topology and conduction / switching loss, focus on the DC transfer function, flyback converter and forward converter design and magnetic management technology. Feedback loop analysis and stability, EMI fundamentals and filter design, switching power supply noise, and DM/CM filter design will also be well understood by students. Through the study of this course, according to different application requirements for switching power supply, students will be able to choose the appropriate topology, design circuit structure and has the ability to apply power devices to achieve high-efficiency.</p>	
8.	教学方法 Teaching Methods	
	讲课/报告/项目 Lecture/Report/Project	
9.	教学内容 Course Contents	
	Section 1	介绍功率半导体器件和开关电源拓扑的发展历程 Introduction to the development of power semiconductor devices and topology
	Section 2	半导体器件固体物理，能带理论，输运特性和硅基功率器件（双极性晶体管，晶闸管，绝缘栅双极晶体管和场效应三极管）基本结构 Review of material properties, solid physics, transport physics, and the basic structures of Si-

	based devices (bipolar transistors, thyristors, insulated gate bipolar transistors and field effect transistors)
Section 3	硅基功率器件工作原理，设计准则和新型结构 Operation principle, design principle and advanced structures proposed in recent years of Si-based devices
Section 4	先进硅基功率器件制备工艺技术的发展 Development in the advanced Si-based power devices fabrication technology
Section 5	高压高频电路应用中硅基功率器件面临的挑战：反向导通，耗尽电容，少子寿命调制 Challenges in Si-power devices (slow reverse-recovery, body diode, reverse conduction, reverse blocking et.. al.) when applied at higher voltage and higher frequency.
Section 6	宽禁带半导体材料 (SiC, GaN, Diamond, Ga ₂ O ₃ , AlN)特性和优势 (如 FOM, 击穿电场, 迁移率) 及相关器件结构 Prosperities and advantages of wide band-gap materials (SiC, GaN, Diamond, Ga ₂ O ₃ , AlN) (e.g. E-field strength, FOM, mobility), and the related device
Section 7	宽禁带半导体功率器件中的特殊挑战 (外延生长, MOS-沟道迁移率, 电流崩塌, 缺陷相关的不稳定和可靠性问题等等) 和目前已有的解决方案 Special issues for wide band-gap semiconductor based devices (e.g. the epi-layer growth, low MOS-channel mobility, current collapse, trap-induced instability and reliability issues, and so on) and the most advanced techniques to address the challenges.
Section 8	Mid-term report 课程中期报告
Section 9	开关电源原理和拓扑；直流传递函数和纹波率的影响 Principles of switching power supply and topology; DC transfer function and ripple rate effects
Section 10	离线式变换器 (反激变换器和正激变换器) 设计与磁学基础 Off-line converter (fly-back converter and forward converter) design and magnetic basis
Section 11	导通损耗和开关损耗；印刷电路板布线分析和散热问题 Conduction losses and switching losses; printed circuit board wiring analysis and thermal issues
Section 12	反馈环路分析及稳定性：传递函数，LC 滤波器，环路稳定性判断和控制补偿设计 Feedback loop analysis and stability: transfer function, LC filter, loop stability judgment and control compensation design
Section 13	EMI 基础 (从麦克斯韦方程到 CISPR)；传导 EMI 设计和测量；实际电流输入 EMI 滤波器 EMI basics (from Maxwell's equation to CISPR); conducted EMI design and measurement; actual current input EMI filter
Section 14	开关电源的 DM/CM 噪声；电路板 EMI 解决方案；EMI 滤波器的输入电容和稳定性 DM/CM noise for switching power supplies; board EMI solutions; input capacitance and stability of EMI filters

Section 15	<p>基于宽禁带半导体功率器件的开关电源拓扑结构演变和创新</p> <p>Evolution and innovation of switching power supply topology for wide bandgap semiconductor power devices</p>
Section 16	Final report 课程期末结题报告
10. 课程考核 Course Assessment	
课程报告+项目 Report+project	
11. 教材及其它参考资料 Textbook and Supplementary Readings	
<p>Main Textbook</p> <p>J. Lutz, H. Schlangenotto, U. Scheuermann, and R. D. Doncker, <i>Semiconductor Power Devices: Physics, Characteristics, Reliability</i>, Springer, 2018</p> <p>A. I. Pressman, K. Billings, and T. Morey, <i>Switching Power Supply Design</i>, 2013, ISBN-13: 978-0071482721</p> <p>Supplemental Textbooks</p> <p>J. Baliga, <i>Fundamentals of Power Semiconductor Devices</i>, Springer, 2008, ISBN: 780387473147.</p> <p>D. Schroder, <i>Semiconductor Material and Device Characterization</i>, 2014, ISBN: 0-471-73906-5 978-0-471-73906-7</p>	