Department of Electrical and Electronic Engineering, California State University, Sacramento

## EEE 146 Power Electronics, 3 units

Spring 2021, Section 1, Call No. 32441, Tu 2:00 P.M. - 3:15 P.M., Web Online Th Web Online – individual preparation

**Course Content:** Introduce solid state device applications in power control. PSpice modeling and review of thyristors, controlled rectifiers, DC-DC conversion and AC to DC inverters. Brief introduction to control of DC drives. Strong design emphasis. Microprocessor control of power electronics systems. UPS systems, power supplies, power quality monitoring.

Prerequisite:	EEE 108 – Electronics I. EEE 130 – Electromechanical Conversion		
Textbook:	<u>Power Electronics</u> , Daniel Hart, 2011, McGraw-Hill ISBN: 978-0-07-338067-4		
Instructor:	Russ Tatro email: <u>rtatro@csus.edu</u> Office Phone: 278-4878 Office Hours: see <u>http://w</u>	Office: Riverside 5030 Website: <u>www.csus.edu/indiv/t/tatror</u> Cell Phone: 530-386-3700 <u>ww.csus.edu/indiv/t/tatror/</u> or by appointment	
Grading:	Midterm I159Midterm II159Final Exam209Quizzes209Homework309	бо бо бо	

**Online Course**: This course will be offered entirely online. We will meet in a Canvas hosted Zoom lecture Tuesday. The Thursday class time will be dedicated to online materials, quizzes and the scheduled exams. The online material includes pre-recorded videos, online quizzes, outside class reading assignments and other online sessions.

All course materials will be available on ECS Moodle. See the end of the syllabus for the Moodle course site join instructions.

**Homework:** Homework assignments will be completed online. There is a homework assignment due every week. Problems shall either be from the textbook or created by the instructor. Problems will include SPICE based simulation. Most assignments are released Monday mornings at 6 am and typically available for three weeks prior to the due date. Start the homework early and bring your homework questions to lecture for clarification. Most assignments are due on Monday mornings at 5:00 am. Check the Moodle course site for homework assignments. All homework material is testable whether covered in class or only in the homework assignment. There is no time limit on completing the homework assignment as long as you complete the homework by the due date. You can "submit" the homework as many times as you wish until you get a perfect 100% on the assignment. You receive the exact same questions on every attempt on the homework so there is no reason not to attempt a less-than perfect homework score again and again.

**Quizzes:** There will be a 60 minute quiz each week (except for exam weeks). The quizzes are self-paced online between the hours of 6 am and midnight each Thursday in the ECS Moodle Quiz activity. The quiz must be completed in one session (no starting/stopping with a break) in a timed one continuous hour. The quizzes are "once and done" with only one submission allowed.

**Exams:** There will be two 75 minute midterm exams and a two hour final exam during the semester. The exams are timed online tests at the <u>scheduled lecture time</u> and completed using the ECS Moodle Quiz module. The instructor may alternately give a scheduled traditional in-class exam at his discretion. The student will use the online access of their choice and should make appropriate arrangements to take the exam online during the scheduled day/time. Exams are not self-paced and are taken ONLY during the scheduled class time. The exams are "once and done" with only one submission allowed.

Prior written permission is required for all make-up exams and then only with compelling reasons.

**Grading Policy:** Grades may be curved at the instructor's discretion. The class average will be in the B range. Typical grades ranges are:

"A" 94.5 and above	"A-" 89.5 to 94.49	
"B+" 87.5 to 89.49	"B" 83.5 to 87.49	"B-" 79.5 to 83.49
"C+" 77.5 to 79.49	"C" 73.5 to 77.49	"C-" 69.5 to 73.49
"D+" 67.5 to 69.49	"D" 63.5 to 67.49	"D-" 59.5 to 63.49

F Below 59.5

Week	Date	Chapter	Topics:	
1	01-26	1.1 – 1.3	Converter Classification, Power Electronics Overview	
	01-28	1.4 – 1.5	Electronic Switches and Switch Selection	
2	02-02	1.6 - 1.7	Simulating Switches	
	02-04	2.1 - 2.3	Power Computations, L and C	
3	02-09	2.4 - 2.6	Energy Recovery, RMS, Apparent Power	
	02-11	2.7 - 2.8	Sinusoidal and Nonsinusoidal Power Computations	
4	02-16	2.9	Power Computations in Simulation	
	02-18	3.1 - 3.2	Half-Wave Rectifier with Resistive Load	
	00.00	2.2.2.4		
5	02-23	3.3 - 3.4	Resistive-Inductive load and Simulation computations	
	02-25	Exam I	Chapters I and 2 Unline exam	
6	03-02	35 36	RL-Source Load Inductor-Source Load	
0	03-02	3.3 - 3.0 3.7 - 3.8	Freewheeling Diode HWR with Can Filter	
	03-04	5.7 - 5.8	The wheeling Diode, it will cap their	
7	03-09	3.9 - 3.10	Controlled HWR. Simulation	
	03-11	4.1 – 4.2	Single-Phase Full-Wave Rectifiers	
8	03-16	4.3 – 4.4	Controlled FWR, Three-Phase Rectifiers	
	03-18	4.5 - 4.6	Controlled TPR, DC Power Transmission	
9	03-23		Spring Break	
	03-25			
10	03-30	10.1 - 10.2	MOSFET and IGGBT Drive Circuits	
	0101	40.0.40.0.40.0		
	04-01	10.3, 10.5, 10.8	BJT Drivers, Transistor Snubbers, Heat Sinks	
11	04-01	10.3, 10.5, 10.8	BJT Drivers, Transistor Snubbers, Heat Sinks	
11	04-01	10.3, 10.5, 10.8 6.1 – 6.2	BJT Drivers, Transistor Snubbers, Heat Sinks DC-DC Converters Chapters 3, 4 and 10 Online aream	
11	04-01 04-06 04-08	10.3, 10.5, 10.8 6.1 – 6.2 Exam 2	BJT Drivers, Transistor Snubbers, Heat Sinks DC-DC Converters Chapters 3, 4 and 10 Online exam	
11	04-01 04-06 04-08 04-13	10.3, 10.5, 10.8 6.1 – 6.2 Exam 2 6.3 – 6.4	BJT Drivers, Transistor Snubbers, Heat Sinks DC-DC Converters <b>Chapters 3, 4 and 10 Online exam</b> The Buck (Step-Down) Converter	
11	04-01 04-06 04-08 04-13 04-15	10.3, 10.5, 10.8 6.1 - 6.2 Exam 2 6.3 - 6.4 6.5	BJT Drivers, Transistor Snubbers, Heat Sinks DC-DC Converters <b>Chapters 3, 4 and 10 Online exam</b> The Buck (Step-Down) Converter The Boost (Step-Up) Converter	
11	04-01 04-06 04-08 04-13 04-15	10.3, 10.5, 10.8 6.1 - 6.2 Exam 2 6.3 - 6.4 6.5	BJT Drivers, Transistor Snubbers, Heat Sinks DC-DC Converters <b>Chapters 3, 4 and 10 Online exam</b> The Buck (Step-Down) Converter The Boost (Step-Up) Converter	
11 12 13	04-01 04-06 04-08 04-13 04-15 04-20	10.3, 10.5, 10.8 6.1 - 6.2 <b>Exam 2</b> 6.3 - 6.4 6.5 6.6 - 6.7	BJT Drivers, Transistor Snubbers, Heat Sinks DC-DC Converters <b>Chapters 3, 4 and 10 Online exam</b> The Buck (Step-Down) Converter The Boost (Step-Up) Converter The Buck-Boost Converter, The Ćuk Converter	
11 12 13	04-01 04-06 04-08 04-13 04-15 04-20 04-22	10.3, 10.5, 10.8 6.1 - 6.2 <b>Exam 2</b> 6.3 - 6.4 6.5 6.6 - 6.7 7.1 - 7.2	BJT Drivers, Transistor Snubbers, Heat Sinks DC-DC Converters <b>Chapters 3, 4 and 10 Online exam</b> The Buck (Step-Down) Converter The Boost (Step-Up) Converter The Buck-Boost Converter, The Ćuk Converter DC Power Supplies, Transformer Models	
11 12 13	04-01 04-06 04-08 04-13 04-15 04-20 04-22	10.3, 10.5, 10.8 6.1 – 6.2 Exam 2 6.3 – 6.4 6.5 6.6 - 6.7 7.1 – 7.2	BJT Drivers, Transistor Snubbers, Heat Sinks         DC-DC Converters         Chapters 3, 4 and 10 Online exam         The Buck (Step-Down) Converter         The Boost (Step-Up) Converter         The Buck-Boost Converter, The Ćuk Converter         DC Power Supplies, Transformer Models	
11 12 13 14	04-01 04-06 04-08 04-13 04-15 04-20 04-22 04-22	10.3, 10.5, 10.8 6.1 - 6.2 <b>Exam 2</b> 6.3 - 6.4 6.5 6.6 - 6.7 7.1 - 7.2 7.3 - 7.4	BJT Drivers, Transistor Snubbers, Heat SinksDC-DC ConvertersChapters 3, 4 and 10 Online examThe Buck (Step-Down) ConverterThe Boost (Step-Up) ConverterThe Buck-Boost Converter, The Ćuk ConverterDC Power Supplies, Transformer ModelsFlyback Converter, Forward Converter	
11 12 13 14	04-01 04-06 04-08 04-13 04-15 04-20 04-22 04-22 04-27 04-29	10.3, 10.5, 10.8 6.1 - 6.2 <b>Exam 2</b> 6.3 - 6.4 6.5 6.6 - 6.7 7.1 - 7.2 7.3 - 7.4 8.1 - 8.3	BJT Drivers, Transistor Snubbers, Heat SinksDC-DC ConvertersChapters 3, 4 and 10 Online examThe Buck (Step-Down) ConverterThe Boost (Step-Up) ConverterThe Buck-Boost Converter, The Ćuk ConverterDC Power Supplies, Transformer ModelsFlyback Converter, Forward ConverterFull-bridge converter, Square-wave inverters	
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11 12 13 14 15	04-01 04-06 04-08 04-13 04-15 04-20 04-22 04-22 04-27 04-29 05-04	10.3, 10.5, 10.8 $6.1 - 6.2$ <b>Exam 2</b> $6.3 - 6.4$ $6.5$ $6.6 - 6.7$ $7.1 - 7.2$ $7.3 - 7.4$ $8.1 - 8.3$ $8.4 - 8.7$	BJT Drivers, Transistor Snubbers, Heat Sinks         DC-DC Converters         Chapters 3, 4 and 10 Online exam         The Buck (Step-Down) Converter         The Boost (Step-Up) Converter         The Buck-Boost Converter, The Ćuk Converter         DC Power Supplies, Transformer Models         Flyback Converter, Forward Converter         Full-bridge converter, Square-wave inverters         Fourier Series Analysis, Total Harmonic Distortion	
11 12 13 14 15	04-01 04-06 04-08 04-13 04-15 04-20 04-22 04-22 04-27 04-29 05-04 05-06	10.3, 10.5, 10.8 $6.1 - 6.2$ <b>Exam 2</b> $6.3 - 6.4$ $6.5$ $6.6 - 6.7$ $7.1 - 7.2$ $7.3 - 7.4$ $8.1 - 8.3$ $8.4 - 8.7$ $8.15 - 8.16$	BJT Drivers, Transistor Snubbers, Heat SinksDC-DC ConvertersChapters 3, 4 and 10 Online examThe Buck (Step-Down) ConverterThe Boost (Step-Up) ConverterThe Boost (Step-Up) ConverterThe Buck-Boost Converter, The Ćuk ConverterDC Power Supplies, Transformer ModelsFlyback Converter, Forward ConverterFull-bridge converter, Square-wave invertersFourier Series Analysis, Total Harmonic DistortionSimulation of Square-Wave Inverters	
11 12 13 14 15	04-01 04-06 04-08 04-13 04-15 04-20 04-22 04-22 04-27 04-29 05-04 05-06	10.3, 10.5, 10.8 $6.1 - 6.2$ <b>Exam 2</b> $6.3 - 6.4$ $6.5$ $6.6 - 6.7$ $7.1 - 7.2$ $7.3 - 7.4$ $8.1 - 8.3$ $8.4 - 8.7$ $8.15 - 8.16$	BJT Drivers, Transistor Snubbers, Heat Sinks         DC-DC Converters         Chapters 3, 4 and 10 Online exam         The Buck (Step-Down) Converter         The Boost (Step-Up) Converter         The Buck-Boost Converter, The Ćuk Converter         DC Power Supplies, Transformer Models         Flyback Converter, Forward Converter         Full-bridge converter, Square-wave inverters         Fourier Series Analysis, Total Harmonic Distortion         Simulation of Square-Wave Inverters	
11 12 13 14 15 16	04-01 04-06 04-08 04-13 04-15 04-20 04-22 04-22 04-22 04-29 05-04 05-06 05-11 05-12	10.3, 10.5, 10.8 $6.1 - 6.2$ <b>Exam 2</b> $6.3 - 6.4$ $6.5$ $6.6 - 6.7$ $7.1 - 7.2$ $7.3 - 7.4$ $8.1 - 8.3$ $8.4 - 8.7$ $8.15 - 8.16$	BJT Drivers, Transistor Snubbers, Heat Sinks         DC-DC Converters         Chapters 3, 4 and 10 Online exam         The Buck (Step-Down) Converter         The Boost (Step-Up) Converter         The Buck-Boost Converter, The Ćuk Converter         DC Power Supplies, Transformer Models         Flyback Converter, Forward Converter         Full-bridge converter, Square-wave inverters         Fourier Series Analysis, Total Harmonic Distortion         Simulation of Square-Wave Inverters         Course wrap-up	
11 12 13 14 15 16	04-01 04-06 04-08 04-13 04-15 04-20 04-22 04-22 04-22 04-27 04-29 05-04 05-06 05-11 05-13 05-20	10.3, 10.5, 10.8 $6.1 - 6.2$ <b>Exam 2</b> $6.3 - 6.4$ $6.5$ $6.6 - 6.7$ $7.1 - 7.2$ $7.3 - 7.4$ $8.1 - 8.3$ $8.4 - 8.7$ $8.15 - 8.16$	BJT Drivers, Transistor Snubbers, Heat Sinks         DC-DC Converters         Chapters 3, 4 and 10 Online exam         The Buck (Step-Down) Converter         The Boost (Step-Up) Converter         The Buck-Boost Converter, The Ćuk Converter         DC Power Supplies, Transformer Models         Flyback Converter, Forward Converter         Full-bridge converter, Square-wave inverters         Fourier Series Analysis, Total Harmonic Distortion         Simulation of Square-Wave Inverters         Course wrap-up         Chapters 6, 7 and 8, Online exam	

EEE 146 - Section 1 - Course Outline - Spring 2021

		EEE 146 – Q	Duiz, homework, and video assignme	ents
Due Date	es below are	only approximate – see the on	line schedule for actual deadlines	
Week	Date	Online Quiz	Online Homework	Online Videos
1	01-26			Section 1.1 to 1.3
	01-28			Section 1.4 to 1.5
2	02-02		Hmwk 01 - 1.1 to 1.5	Section 1.6 to 1.7
	02-04	Q1 - Ch 1		Section 2.1 to 2.3
3	02-09		Hmwk 02 – 1.6, 1.7, 2.1 to 2.3	Section 2.4 to 2.7
	02-11	Q2 - Ch 1		
4	02-16		Hmwk 03 – 2.4 to 2.7	Section 2.8 to 2.9
	02-18	Q3 - Ch 2		
5	02-23		Hmwk 04 – 2.8 to 2.9	Section 3.1 to 3.4
	02-25	Exam 1		
6	03-02		Hmwk $05 - 3.1$ to $3.4$	Section 3.5 to 3.8
	03-04	Q4 - Ch 3		
	00.00			
7	03-09		Hmwk $06 - 3.5$ to $3.8$	Section 3.9 to 3.10
	03-11	Q5 - Ch 3		Section 4.1 to 4.2
8	03-16		Hmwk $07 - 3.9$ to $3.10, 4.2$	Section 4.3 to 4.6
	03-18	Q6 - Ch 3		
0	02.22			
9	03-23	Surviva Ducals		
	03-23	Spring Break		
10	03 30		Hmult $08$ $43$ to $46$	Section 10.8
10	03-30	07 - Ch 4	$111100 \times 10^{-4.5} \times 10^{-4.5}$	Section 6.1 to 6.2
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04-06 04-08

Exam 2

12	04-13		Hmwk 10 –6.2 to 6.3	Section 6.3 to 6.5
	04-15	Q8 - Ch 10		
13	04-20		Hmwk 11 – 6.4 to 6.5 and 6.13	Section 6.6 to 6.7
	04-22	Q9 - Ch 6		Section 7.1 to 7.2
14	04-27		Hmwk 12 – 6.6 to 6.7, and 6.11	Section 7.3 to 7.4
	04-29	Q10 – Ch 6		Section 8.1 to 8.3
15	05-04		Hmwk 13 – 7.2 - 7.4, and 7.12	Section 8.4 to 8.5
	05-06	Q11 - Ch 6		Section 8.7 to 8.16
16	05-11		Hmwk 14 -8.2 - 8.5, 8.7, 8.15	
	05-13	Q12 - Ch 7	and 8.16	
17	05-20	Final's Week		

10.8

Hmwk 09 – 10.1, 10.3,10.5,

Hmwk 10 –6.2 to 6.3

## Material Covered by Chapter and Section

Chapter 1	Section 1.1 – Introduction	
Power Electronics Concepts	Section 1.2 – Converter Classification	
	Section 1.3 – Power Electronics Concepts	
	Section 1.4 – Electronic Switches	
	Section 1.5 – Switch Selection	
	Section 1.6 and 1.7 – Power Electronics Simulation	
Chapter 2	Section 2.1 - Introduction	
Power Computations	Section 2.2 – Power and Energy	
	Section 2.3 – Inductors and Capacitors	
	Section 2.4 – Energy Recovery	
	Section 2.5 – Effective Values: RMS	
	Section 2.6 – Apparent Power and Power Factor	
	Section 2.7 – Power Computations for Sinusoidal AC Circuits	
	Section 2.8 – Power Computations for NonSinusoidal Periodic	
	Waveforms	
	Section 2.9 – Power Computations Using Simulation	
Chapter 3	Section 3.1 - Introduction	
Half-Wave Rectifiers	Section 3.2 – Resistive Load	
	Section 3.3 – Resistive-Inductive Load	
	Section 3.4 – Simulation to Determine Numerical Computations	
	Section 3.5 – RL-Source Load	
	Section 3.6 – Inductor-Source Load	
	Section 3.7 – The Freewheeling Diode	
	Section 3.8 – Half-Wave Rectifier with a Capacitor Filter	
	Section 3.9 – The Controlled Half-Wave Rectifier	
	Section 3.10 – Simulation of Controlled Rectifiers	
	Section 3.11 – Commutation	
Chapter 4	Section 4.1 - Introduction	
Full-Wave Rectifiers	Section 4.2 – Single-Phase Full-Wave Rectifiers	
	Section 4.3 – Controlled Full-Wave Rectifiers	
	Section 4.4 – Three-Phase Rectifiers	
	Section 4.5 – Controlled Three-Phase Rectifiers	
	Section 4.6 – DC Power Transmission	
	Section 4.7 – Commutation: Effect of Source Inductance	
Chapter 6	Section 6.1 - Introduction	
DC-DC Converters	Section 6.2 – A Basic Switching Converter	
	Section 6.3 – The Buck (Step-Down) Converter	
	Section 6.4 – Buck Circuit Design Considerations	
	Section 6.5 – The Boost (Step-Up) Converter	
	Section 6.6 – The Buck-Boost Converter	
	Section 6.7 – The Cuk Converter	
	Section 6.11 – Discontinuous-Current Operation	
	Section 6.13 – Simulation of DC-DC Converters	

Chapter 7	Section 7.1 - Introduction	
DC Power Supplies	Section 7.2 – Transformer Models	
	Section 7.3 – The Flyback Converter	
	Section 7.4 – The Forward Converter	
	Section 7.12 – Simulation of DC Power Supplies	
Chapter 8	Section 8.1 - Introduction	
Inverters	Section 8.2 – The Full-Bridge Converter	
	Section 8.3 – The Square-Wave Inverter	
	Section 8.4 – Fourier Series Analysis	
	Section 8.5 – Total Harmonic Distortion	
	Section 8.6 – Simulation of Square-Wave Inverters	
	Section 8.7 – Amplitude and Harmonic Control	
	Section 8.15 – Three-Phase Inverters	
	Section 8.16 – Simulation of Three-Phase Inverters	
Chapter 10	Section 10.1 - Introduction	
Drive Circuits, Snubber Circuits,	Section 10.2 – MOSFET and IGBT Drive Circuits	
and Heat Sinks	Section 10.3 – Bipolar Transistor Drive Circuits	
	Section 10.5 – Transistor Snubber Circuits	
	Section 10.8 – Heat Sinks and Thermal Management	

## **ECS Moodle Tips and Hints**

- 1. The homework is available three weeks prior to the due date. You can "Submit" the homework as many times as you wish. I suggest you start the homework early and bring questions into class. You will NOT be able to see any assignment you did not complete (by submitting the assignment).
- 2. All quizzes are ONE submission only. During the quiz you will be able to "check" your answer. Wrong answers will receive a penalty of about 33% and you will be allowed up to three tries for each part of a problem. The computer will automatically submit your quiz at the end of the 60 minutes allowed for the quiz.
- 3. All exams are ONE submission only. During the exam you will be able to "check" your answer. Wrong answers will receive a penalty of about 33% and you will be allowed up to three tries for each part of a problem. The computer will automatically submit your exam at the end of the 60 minutes allowed for the exam. You must quickly send me your original work for my review if you feel a question was scored incorrectly or incompletely.
- 4. Periodically review your grade in the Moodle Gradebook. Bring to my attention any error or anomaly as soon as possible.

Entering questions answers into Moodle:

In most cases, you will be entering a number into Moodle as the answer to a calculation. The following table shows you acceptable and not acceptable forms of an answer.

Intended Answer	Acceptable alternatives	Non-Acceptable
0.5	.5, 0.5, 0.500, 5e-1, 5E-1	1/2, 50%, 10/20, 20/40,
10,000	10000, 10E3, 10e3	10,000 (no comma allowed)
-40	-40, -40.00, -4E1, -4e1	
π (pi)	3.14159 (as many digits as you care to use)	pi
Algebraic symbols	I will not ask you to enter equations symbolically into	Do not enter common math symbols
	Moodle.	such as +, -, X, /, ln, e, and so on as an
		equation.
		2+2 is not acceptable, enter "4"
		2-2 is not acceptable, enter "0"
		And so on.