ITT Technical Institute

ET3380

Power Electronics

Onsite and Online Course

SYLLABUS

Credit hours: 4.5

Contact/Instructional hours: 56 (34 Theory Hours, 22 Lab Hours)

Prerequisite(s) and/or Corequisite(s):

Prerequisites: ET1410 Integrated Circuits or equivalent, ET3280 Electrical Machines and Energy Conversion or equivalent

Course Description:

This course introduces principles and applications of power electronics. Topics include electric power conversion, conditioning and control, power devices and switches, switching techniques, rectifiers, converters and inverters, and switching power supplies.

COURSE SUMMARY

COURSE DESCRIPTION

This course introduces principles and applications of power electronics. Topics include electric power conversion, conditioning and control, power devices and switches, switching techniques, rectifiers, converters and inverters, and switching power supplies.

MAJOR INSTRUCTIONAL AREAS

- Electrical Power Conversion
- Power Conditioning and Control
- Power Devices and Switches
- Switching Techniques
- Rectifiers
- Converters
- Inverters
- Switching Power Supplies

COURSE LEARNING OBJECTIVES

By the end of this course, you should be able to:

1. Demonstrate an understanding of the fundamental principles of electrical power conversion.
2. Describe the basic concepts and applications of power conditioning and control.
3. Describe the fundamental operating principles and characteristics of power devices and switches.
4. Demonstrate an understanding of thermal/fault protection of devices and circuits.
5. Explain the operating principles and characteristics of power converters and their applications.
6. Discuss the fundamental operating principles and characteristics of diode rectifiers and their applications.
7. Discuss the fundamental operating principles and characteristics of power inverters and their applications.
8. Discuss the fundamental operating principles and characteristics of controlled rectifiers and their applications.

9. Apply the fundamental operating principles and characteristics of dc and ac power supplies.
10. Design and analyze power electronics circuits.

COURSE OUTLINE

MODULE 1: BASIC PRINCIPLES OF ELECTRONIC POWER CONVERSION

COURSE LEARNING OBJECTIVES COVERED

- Demonstrate an understanding of the fundamental principles of electrical power conversion.
- Describe the basic concepts and applications of power conditioning and control.
- Describe the fundamental operating principles and characteristics of power devices and switches.
- Demonstrate an understanding of thermal/fault protection of devices and circuits.
- Design and analyze power electronics circuits.

TOPICS COVERED

- Introduction to Power Electronics
- Major Types of Power Converters and Power Electronic Equipment
- Characteristics of Practical Power Semiconductor Devices
- Electrical Analog Thermal Models and Methods for Cooling Power Devices
- Operation of Snubbers and Other Protective Circuit Devices
- Fast-Acting Fuses and Electromagnetic Interference (EMI)

MODULE LEARNING ACTIVITIES	GRADED	Out-Of-Class Time
Reading: Rashid, M. H., Chapters 1 and 17.	No	6 hrs
Lesson: Study the lesson for this module.	No	1 hr
Exercise: Submit the exercise titled "Power Switching Devices Characteristics and Circuit Protection."	Yes	1.5 hrs
Lab: Complete the lab titled "Power Switching Devices and Thermal and Current Protection."	Yes	N/A
Quiz: Prepare for Quiz 1.	No	2 hrs

Total Out-Of-Class Activities: 10.5 Hours

MODULE 2: POWER DIODES AND RECTIFIERS

COURSE LEARNING OBJECTIVES COVERED

- Describe the fundamental operating principles and characteristics of power devices and switches.
- Discuss the fundamental operating principles and characteristics of diode rectifiers and their applications.
- Design and analyze power electronics circuits.

TOPICS COVERED

- Diode Characteristics and Circuit Models
- Operation and Characteristics of Diode Rectifiers
- Reverse Recovery Current of Diodes
- Analysis and Design of Diode Rectifiers
- Effects of Load and Source Inductances on the Rectifier Output Voltage

MODULE LEARNING ACTIVITIES	GRADED	Out-Of-Class Time
Reading: Rashid, M. H., Chapters 2 and 3.	No	7.5 hrs
Lesson: Study the lesson for this module.	No	2 hrs
Discussion: Participate in the discussion titled "Effects of the Source and Load Inductance."	Yes	N/A
Quiz: Take Quiz 1.	Yes	N/A
Exercise: Submit the exercise titled "Power Diode Characteristics and Diode Rectifiers."	Yes	3 hrs
Lab: Complete the lab titled "RC-RL Diode Circuits and Diode Rectifier Circuits."	Yes	N/A
Quiz: Prepare for Quiz 2.	No	2 hrs

Total Out-Of-Class Activities: 14.5 Hours

MODULE 3: POWER TRANSISTORS AND DC-DC CONVERTERS

COURSE LEARNING OBJECTIVES COVERED

- Describe the basic concepts and applications of power conditioning and control.
- Describe the fundamental operating principles and characteristics of power devices and switches.
- Explain the operating principles and characteristics of power converters and their applications.
- Design and analyze power electronics circuits.

TOPICS COVERED

- Characteristics of an Ideal Transistor Switch
- Switching Characteristics of Different Power Switch Types
- Arrangements of Operating Transistors in Series and Parallel
- Switching Technique for DC-DC Conversion
- Principle of Operation of DC-DC Converters
- Effects of Load Inductance on the Total Current and the Conditions for Continuous Current

MODULE LEARNING ACTIVITIES	GRADED	Out-Of-Class Time
Reading: Rashid, M. H., Chapters 4 and 5.	No	11.5 hrs
Lesson: Study the lesson for this module.	No	2 hrs
Discussion: Participate in the discussion titled "Discontinuous Mode."	Yes	N/A
Quiz: Take Quiz 2.	Yes	N/A
Exercise: Submit the exercise titled "Power Transistors and DC-DC Converters."	Yes	3 hrs
Lab: Complete the lab titled "Power Transistors and DC-DC Converters."	Yes	N/A
Quiz: Prepare for Quiz 3.	No	2 hrs

Total Out-Of-Class Activities: 18.5 Hours

MODULE 4: INVERTERS

COURSE LEARNING OBJECTIVES COVERED

- Describe the basic concepts and applications of power conditioning and control.
- Describe the fundamental operating principles and characteristics of power devices and switches.
- Explain the operating principles and characteristics of power converters and their applications.
- Discuss the fundamental operating principles and characteristics of power inverters and their applications.
- Design and analyze power electronics circuits.

TOPICS COVERED

- Types of Inverters (DC-AC Converters)
- Operating Principles of the Inverters
- Modulation Techniques
- Design and Analysis of Inverters
- Switching Techniques and Operation of Resonant Pulse Inverters
- Zero-Voltage and Zero-Current Resonant Pulse Inverters
- Design and Analysis of Resonant Pulse Inverters

MODULE LEARNING ACTIVITIES	GRADED	Out-Of-Class Time
Reading: Rashid, M. H., Chapters 6 and 7.	No	10.5 hrs
Lesson: Study the lesson for this module.	No	2 hrs
Discussion: Participate in the discussion titled "Zero-Current and Zero-Voltage Inverters."	Yes	N/A
Quiz: Take Quiz 3.	Yes	N/A
Exercise: Submit the exercise titled "DC-AC Converters and Resonant Converters."	Yes	3 hrs
Lab: Complete the lab titled "DC-AC Converters and Resonant Converters."	Yes	N/A
Quiz: Prepare for Quiz 4.	No	2 hrs

Total Out-Of-Class Activities: 17.5 Hours

MODULE 5: THYRISTORS AND THYRISTORIZED CONVERTERS

COURSE LEARNING OBJECTIVES COVERED

- Describe the basic concepts and applications of power conditioning and control.
- Describe the fundamental operating principles and characteristics of power devices and switches.
- Discuss the fundamental operating principles and characteristics of controlled rectifiers and their applications.
- Design and analyze power electronics circuits.

TOPICS COVERED

- Characteristics of Thyristors
- Control Requirements of Different Types of Thyristors
- Operation and Performance of Controlled Rectifiers
- Pulse Width Modulation Control
- Operation and Characteristics of AC Voltage Controllers
- Effects of Load Inductance on the Load Current
- Design and Analysis of Controlled Rectifiers and AC Voltage Controllers

MODULE LEARNING ACTIVITIES	GRADED	Out-Of-Class Time
Reading: Rashid, M. H., Chapters 9-11.	No	12 hrs
Lesson: Study the lesson for this module.	No	2 hrs
Discussion: Participate in the discussion titled "Power Factor and Phase Angle Control."	Yes	N/A
Quiz: Take Quiz 4.	Yes	N/A
Exercise: Submit the exercise titled "Thyristors and Controlled Rectifiers and AC Voltage Controllers."	Yes	3 hrs
Lab: Complete the lab titled "Thyristors and Controlled Rectifiers and AC Voltage Controllers."	Yes	N/A
Final Exam: Prepare for the final exam.	No	5 hrs

Total Out-Of-Class Activities: 22 Hours

MODULE 6: POWER ELECTRONICS APPLICATIONS

COURSE LEARNING OBJECTIVES COVERED

- Demonstrate an understanding of the fundamental principles of electrical power conversion.
- Describe the basic concepts and applications of power conditioning and control.
- Describe the fundamental operating principles and characteristics of power devices and switches.
- Demonstrate an understanding of thermal/fault protection of devices and circuits.
- Explain the operating principles and characteristics of power converters and their applications.
- Discuss the fundamental operating principles and characteristics of diode rectifiers and their applications.
- Discuss the fundamental operating principles and characteristics of power inverters and their applications.
- Discuss the fundamental operating principles and characteristics of controlled rectifiers and their applications.
- Apply the fundamental operating principles and characteristics of dc and ac power supplies.
- Design and analyze power electronics circuits.

TOPICS COVERED

- Circuit Topology of Power Supplies
- Design and Analysis of Power Supplies

MODULE LEARNING ACTIVITIES	GRADED	Out-Of-Class Time
Reading: Rashid, M. H., Chapter 13.	No	3 hrs
Reading: ITT Tech Virtual Library> Basic Search> Switch-Mode Power Supplies> pp. 642-665	No	2 hrs
Lesson: Study the lesson for this module.	No	2 hrs
Discussion: Participate in the discussion titled "Resonant Power Supplies."	Yes	N/A
Lab: Complete the lab titled "Design a Power Supply with Power Electronics Principles."	Yes	N/A
Final Exam: Take the final exam.	Yes	N/A

Total Out-Of-Class Activities: 7 Hours

EVALUATION AND GRADING

EVALUATION CRITERIA

The graded assignments will be evaluated using the following weighted categories:

CATEGORY	WEIGHT
Exercise	25%
Lab	25%
Quiz	20%
Discussion	10%
Final Exam	20%
TOTAL	100%

GRADE CONVERSION

The final grades will be calculated from the percentages earned in the course, as follows:

GRADE	PERCENTAGE
A (4.0)	90–100%
B+ (3.5)	85–89%
B (3.0)	80–84%
C+ (2.5)	75–79%
C (2.0)	70–74%
D+ (1.5)	65–69%
D (1.0)	60–64%
F (0.0)	<60%

LEARNING MATERIALS AND REFERENCES

REQUIRED RESOURCES

COMPLETE TEXTBOOK PACKAGE

Rashid, M. H. (2014). *Power electronics: Circuits, devices, and applications (4th ed.). Upper Saddle River, NJ: Prentice Hall.*

OTHER ITEMS

Multisim software

RECOMMENDED RESOURCES

- Power Electronics Technology: http://www.powerelectronics.com

  A great site offering up the latest developments in power electronics circuits

- Books:
  - Mohan, N., Undeland, T.M., & Robbins, W. (2002). *Power electronics: Converters, applications, and design (3rd ed.). Chichester, West Sussex, UK: John Wiley & Sons,* Ltd.

    Highly regarded supplemental text covering the field of power electronics
  - Kazimierczuk, M.K. (2008). *Pulse-width modulated dc-dc power converters.* Chichester, West Sussex, UK: John Wiley & Sons, Ltd.

    Supplemental text with in-depth examination and detailed description of dc-dc conversion
  - Elgerd, O., & Van Der Puije, P. (1997). *Electric power engineering (2nd ed.). New York, NY: Springer.*

    Supplemental text with good treatment of high power concepts
  - Tarter, R.E. (1993). *Solid-state power conversion handbook (2nd ed.). Chichester, West Sussex, UK: John Wiley & Sons, Ltd.*

    Supplemental text including great description of practical hands-on device and circuit considerations

- Periodicals:
  - Power Electronics Technology Magazine, Penton Media

    A great resource, providing the latest industry news from the power electronics arena

- Professional Associations:
  - IEEE Power Electronics Society
    This pre-eminent group is tasked with advancing and documenting new developments and technological breakthroughs in the power electronics field.

- Professional Portals:
  - http://www.ieee-pels.org/
    Public portal for contacting and accessing the IEEE Power Electronics Society

- ITT Tech Virtual Library: (accessed via Student Portal |https://studentportal.itt-tech.edu)
  - Basic Search
    - Erickson, R., et al. (2000). *Fundamentals of power electronics (2nd ed.).* Secaucus, NJ: Kluwer Academic Publishers.
    - Pressman, A., et al. (2009). *Switching power supply design (3rd ed.). New* York, NY: McGraw Hill.
    - Basso, C. P. (2008). *Switch-mode power supplies : SPICE simulations and practical designs. New York: McGraw-Hill.*
  - Search using CRCnetbase
    - Rajashekara, K., & Skvarenina, T. (2004). *The power electronics handbook.* Boca Raton, FL: *CRC Press, LLC.*

Note: All links are subject to change without prior notice.

Information Search

Use the following keywords to search for additional online resources that may be used for supporting work on the course assignments:

- Total harmonic distortion
- Power conversion waveforms
- Pulse width modulation power control
- Semiconductor
- Power circuits
- Diode rectifier circuits
- PWM stages
- Chopper circuits

INSTRUCTIONAL METHODS AND TEACHING STRATEGIES

The curriculum employs a variety of instructional methods that support the course objectives while fostering higher cognitive skills. These methods are designed to encourage and engage you in the learning process in order to maximize learning opportunities. The instructional methods include but are not limited to lectures, collaborative learning options, use of technology, and hands-on activities.

To implement the above-mentioned instructional methods, this course uses several teaching strategies, such as group discussions, problem-solving exercises, and hands-on labs. Your progress will be regularly assessed through a variety of assessment tools including discussions, labs, exercises, quizzes, and final exam.

OUT-OF-CLASS WORK

For purposes of defining an academic credit hour for Title IV funding purposes, ITT Technical Institute considers a quarter credit hour to be the equivalent of: (a) at least 10 clock hours of classroom activities and at least 20 clock hours of outside preparation; (b) at least 20 clock hours of laboratory activities; or (c) at least 30 clock hours of externship, practicum or clinical activities. ITT Technical Institute utilizes a “time-based option” for establishing out-of-class activities which would equate to two hours of out-of-class activities for every one hour of classroom time. The procedure for determining credit hours for Title IV funding purposes is to divide the total number of classroom, laboratory, externship, practicum and clinical hours by the conversion ratios specified above. A clock hour is 50 minutes.

A credit hour is an artificial measurement of the amount of learning that can occur in a program course based on a specified amount of time spent on class activities and student preparation during the program course. In conformity with commonly accepted practice in higher education, ITT Technical Institute has institutionally established and determined that credit hours awarded for coursework in this program course (including out-of-class assignments and learning activities described in the “Course Outline” section of this syllabus) are in accordance with the time-based option for awarding academic credit described in the immediately preceding paragraph.

ACADEMIC INTEGRITY

All students must comply with the policies that regulate all forms of academic dishonesty or academic misconduct. For more information on the academic honesty policies, refer to the Student Handbook and the Course Catalog.

INSTRUCTOR DETAILS

Instructor Name	
Office Hours	
Contact Details	

(End of Syllabus)