Western Michigan University, Electrical and Computer Engineering Department

ECE 4200 – ECE 5200 - 100 Power Electronics I (3 - 0), Fall 2017 Course Information and Policies
41262/100 – ECE 4200    9:30 - 10:20 am MWF (Lecture: Asumadu)
42627/100 – ECE 5200    9:30 - 10:20 am MWF (Lecture: Asumadu)

ACADEMIC INTEGRITY POLICY, DIVERSITY, RELIGIOUS OBSERVANCES, DISABILITY

“Students are responsible for making themselves aware of and understanding the University policies and procedures that pertain to Academic Honesty. These policies include cheating, fabrication, falsification and forgery, multiple submission, plagiarism, complicity and computer misuse. The academic policies addressing Student Rights and Responsibilities can be found in the Undergraduate Catalog at http://catalog.wmich.edu/content.php?catoid=24&navoid=974. If there is reason to believe you have been involved in academic dishonesty, you will be referred to the Office of Student Conduct. You will be given the opportunity to review the charge(s) and if you believe you are not responsible, you will have the opportunity for a hearing. You should consult with your instructor if you are uncertain about an issue of academic honesty prior to the submission of an assignment or test.

Students and instructors are responsible for making themselves aware of and abiding by the “Western Michigan University Sexual and Gender-Based Harassment and Violence, Intimate Partner Violence, and Stalking Policy and Procedures” related to prohibited sexual misconduct under Title IX, the Clery Act and the Violence Against Women Act (VAWA) and Campus Safe. Under this policy, responsible employees (including instructors) are required to report claims of sexual misconduct to the Title IX Coordinator or designee (located in the Office of Institutional Equity). Responsible employees are not confidential resources. For a complete list of resources and more information about the policy see www.wmich.edu/sexualmisconduct.

In addition, students are encouraged to access the Code of Conduct, as well as resources and general academic policies on such issues as diversity, religious observance, and student disabilities:

- Office of Student Conduct www.wmich.edu/conduct
- Division of Student Affairs www.wmich.edu/students/diversity
- University Relations Office http://www.wmich.edu/policies/religious-observances-policy#
- Disability Services for Students www.wmich.edu/disabilityservices.”

OFFICIAL CONTACT PLACES/HOURS:

Name: Johnson Asumadu Email: johnson.asumadu@wmich.edu
Office: CEAS B-0224 Office Hours: 10:30 -11:30 a.m. MW or by appointment
Tel:  +1 (269) 276 – 3147 Fax: +1 (269) 276 – 3151
Classroom Assigned:CEAS D-0115 Class Hours: 9:30 - 10:20 AM
Lab: No Lab Lab Hours: No Lab
Web Site Address: URL for course: http://homepages.wmich.edu/~jasumadu/index.html

PREREQUISITES:

ECE 2500, ECE 3200, ECE 3300 (or Equivalent Courses)

KEY DATES:

1st Hour Mid Term Test - October 13, 2017 Normal Class Hour
2nd Hour Mid Term Test - November 17, 2017 Normal Class Hour
Final Examination - According to the University’s Exam Schedule

COURSE MATERIALS:

Text Books:
2. ECE 4200 Power Electronics Lecture Notes Revised Edition by Asumadu. (Required)
5. Schematic Capture with Cadence PSpice”, 3rd Edition, by Herniter. (Required)

Materials (Required):
1. SPICE Software (Free – it comes with required SPICE textbook).
2. Calculator: In this course I recommend that you use a scientific calculator that has at least the following features:
   (a) Performs operations for real numbers and complex numbers without requiring the user to perform the operations on the real part and the imaginary part, or magnitude and angle, separately,
   (b) solves linear algebra equations, including the case where the coefficients are complex,
(c) perform repetitive computations, and
(d) finds roots of polynomials.

**CATALOG DESCRIPTION:**
Analysis and design of power electronic systems, power sources, motor controls, tuning and sequencing circuits.

**COURSE OBJECTIVES:**
1. Provide seniors in electrical engineering the ability to analyze and design power semiconductor switching and control strategies for the control, conversion, and protection of electric power.
2. Integrate signal processing strategies into design concepts.

**PRE-ASSESSMENT:** *(Required skills at the start of the course)*
1. Sending and receiving EMAIL, including attachments.
2. Accessing information on a network using Web browsers and file utilities.
5. Electronics - ECE 3200: Semiconductor diodes, BJTs, FETs, PSPICE Models and Electronic Circuits.
6. ECE 3300: Electromagnetic devices, rotating machines and three-phase distribution systems.
7. Semiconductor diodes, BJTs, FETs including PSPICE models and electronic circuits.
9. Applying correct electrical engineering units (and symbols) to quantities using the English and SI systems: Ohms (Ω), Farads (F), Henries (H), Amperes (A), Volts (V), Volt-Amperes (VA), and Watts (W)
10. Applying correct engineering factors: kilo (k = 10^3), mega (M = 10^6), giga (G = 10^9), tera (T = 10^{12}), milli (m = 10^{-3}), Micro (µ = 10^{-6}), nano (n = 10^{-9}), pico (p = 10^{-12}), and femto (f = 10^{-15}).

**COURSE LONG-TERM BEHAVIOR:**
Behavior after 1 year:
1. Ability to create system models from individual components with known performance characteristics that can be used to predict system response to standard input.
2. Selecting appropriate tools and tests procedures to measure system response.
3. Compile design report that documents simulation results, component selection, prototype construction, laboratory investigation/testing, and conclusion.
4. Using manuals to select off-the-shelf components that are appropriate for use in a larger system.

**LEARNING OUTCOMES (The relevant ECE Department learning outcomes a-k, are included in parenthesis):**
1. Use electronics and solid-state power devices for the control, conversion, and protection of electrical energy. *(a, b, c, d, e, i, k)*
2. Ability to design switching using power semiconductor devices. *(a, b, c, e, i, k)*
3. Apply control techniques to meet desired switching objectives. *(b, c, e, i, k)*
4. Integrate signal processing strategies into the control concepts. *(a, b, c, d, e, i, k)*
5. Ability to specify design criteria (power, efficiency, ripple voltage and current, harmonic distortions, power factor). *(a, b, c, d, e, g, i, k)*
6. Ability to select components, interpret terminal characteristics of the components, model components, design circuit, and understanding operation of power electronics circuits. *(c, d, e, i, k)*
7. Use application software (PSPICE, MATLAB, MATHCAD) for simulating circuits with power semiconductor devices, motor drives, and different loading conditions. *(a, b, c, e, i, k)*

**COURSE ORGANIZATION:**
In power electronics, power semiconductor devices (diodes, transistors, etc.) are used as switches and these switches can be controlled by microelectronics for the conversion and protection of electrical energy. Therefore, the same power electronics circuit can have different forms (topologies) within a cycle depending on the time(s) the switches are turned on/off. Here are some of the things you will encounter in this course:

1. You will be expected to draw nodal voltage and branch current waveforms for varying topologies of power electronics circuits.
2. You will be expected to use PSpice to help you verify the waveforms of 1).
3. You will be expected to design converter circuits to control loads such as electric drives and R-L.

Students learn best if they understand how to learn, if they aware of all aspects of the process of learning, and if they take personal responsibility for their own learning; some of the principles of Process Education. The content of this course is classified into five categories and collectively called Knowledge Map.

Concept: Idea that represents a set of relationships.
Processes: Series of actions, steps, or changes that bring about a result.
Tools: Something that assists in carrying out a process.
Context: A well-defined situation in which concepts, processes, and tools may be applied.
Culture: "Way of being."

For example, consider the idea of a power semiconductor switch. A Power Semiconductor Switch is a concept that involves causing, say a transistor, to turn ON/OFF to convert electrical energy (example AC to DC) in order to control and protect a load. Solving the different circuit topologies for nodal voltages and branch currents, and troubleshooting are all processes of using a switch. Transistor, (P)SPICE simulation, etc. can be thought of as tools that are used to assist the Switch Building Process. Data sheets, safety precautions, etc. can be thought of as contexts (they allow us to apply concepts, processes, and tools)

**COURSE KNOWLEDGE MAP:**

**Key Concepts**
- Power Semiconductor Devices
- Switches
- Indicators
- Ohms Law
- Kirchoff’s Current Law
- Kirchoff’s Voltage Law
- Fourier Transformer
- Equivalent Circuits
  - Equivalent Resistor
  - Current Source
  - Voltage Source
- Waveform Behavior
  - DC, Sine wave, Square Wave
  - Triangular Wave, PWM Wave

**Processes**
- Circuit Diagrams
  - Nodes, Branches
  - Active Voltage Source
  - Active Current Source
  - Resistors, Capacitors
  - Inductors
  - Converters

**Contexts**
- Data Sheets
- Safety Precautions
- Norton’s Equivalent Circuit
- Thevenin’s Equivalent Circuits

**Tools**
- Diodes
- SBD, MPS
- Bipolar Transistors
- BJTs, IGBTs, SITs
- Metal oxide and Junction Field Effect Transistors
  - MOSFETs, JFETs, COOLMOS
- Thyristors
  - SCR, RCT, TRIAC, GTO, MTO, ETO, IGCT, SITH, MCT
- New Power – Element Technology
  - CSTBT, RC-IGBT, RB-IGBT, PT-IGBT, NPT-IGBT, LPT-CSTBT
- New Materials
  - SiC, GaN, AlGaN
- Simulation
  - PSPICE
  - Simulation Report
  - Results, Answers to questions, Conclusions
COURSE EVALUATION:
Individual Record Keeping (Maximum Points: 10%)
   Homework Assignments (Maximum Points: 10%)
   Reading Assignments
Examinations (Maximum Points: 70%)
   2 Mid Term Tests (20% of each)
   Final Examination (30%)
PSpice and Reports (Maximum Points: 20%)

Grading Scale
<table>
<thead>
<tr>
<th>Maximum Points (%)</th>
<th>GRADE</th>
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<tbody>
<tr>
<td>100 - 85</td>
<td>A</td>
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<tr>
<td>84 - 80</td>
<td>BA</td>
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<td>79 - 75</td>
<td>B</td>
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<td>74 - 70</td>
<td>CB</td>
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<tr>
<td>69 - 65</td>
<td>C</td>
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<tr>
<td>64 - 60</td>
<td>D</td>
</tr>
<tr>
<td>59 &amp; BELOW</td>
<td>E</td>
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Policy on Homework and SPICE:
Homework and PSPICE assignments are assigned during class periods and are due at the scheduled time. **Problems must be done neatly, submitted in numerical order on 8 1/2 X 11 inch paper, one side only. HOMEWORK AND SPICE TURNED IN LATE WILL RECEIVE NO CREDIT.** If you have questions about any homework, project, or do not understand any course materials, you must see me in B-0224 PARKVIEW CAMPUS as soon as possible. Solutions to all homework problems and projects will be made available.

Please do not skip doing homework and PSpice assignments. Do not rely on reading through the solutions as techniques for studying for the course. The practice of consulting the solution before working a problem is a bad habit to acquire. It is much better to spend the effort trying to do the solution on your own - even if you are not able to complete the solution. You will find that the homework, though not impossible, is usually harder than the exam questions. Solving other problems on your own is the best way to understand the course materials and to study for the exams. There is a strong correlation between homework scores and course grades. Furthermore, homework scores are important in deciding borderline cases when determining course grades.

Policy on Class Attendance:
I highly recommend that you attend classes. Please, make every effort to attend every class. Low attendance is almost always correlated with low grades. **You must be present to win**.

General Policy on use of Electronic Equipment During Tests/Examinations
1. Electronic calculators **CANNOT** be shared.
2. All cell phones/wifi equipment must be turned off and NOT be on sight (preferably in your backpack).
3. I will inspect and make sure that your ipad/surface/etc. can only be used for ebook or cText etc. and if necessary these must be loaded before coming for test and/or exam.
COURSE TENTATIVE SCHEDULE

September
5 – 18
Switching Semiconductor Devices
Diodes, Transistors, Thyristors
Power Considerations

September
20 – October 18
Diodes – Characteristics
AC-DC Rectifiers - Diodes Circuits
Single-phase and Three-phase
Harmonics

Transistor – Characteristics
DC-DC Switch-Mode Converters
Buck, Boost, Buck-Boost, Cuk. Forward, Flyback, Resonant

October 13
1ST HOURLY TEST: TEST I

October
16 – November 1
Buck, Boost, Buck-Boost, Cuk. Forward, Flyback, Resonant
DC-AC Inverters
Single-phase and Three-phase
PWM Inverters

November
3 – November 17
Thyristors – Characteristics
AC-DC Controlled Rectifiers
Single-phase and Three-phase

November 17
2ND HOURLY TEST: TEST II

20 – December 1
Natural and Forced Commutations
AC-AC Converters
Cycloconverters - Single-phase, Three-phase

December
4 – 8
Power Electronics Applications

FINAL EXAM USING THE UNIVERSITY SCHEDULE

NOTE: (i) AT THIS TIME I DO NOT INTEND TO GIVE MAKEUP HOMEWORK/TESTS/EXAM.

(ii) ALL THE INFORMATION PROVIDED ABOVE IS TENTATIVE AND SUBJECT TO CHANGE WITHOUT NOTICE

(iii) IF YOU ARE TAKING THIS COURSE AS ECE 5200, ADDITIONAL PROJECTS WILL BE ASSIGNED FOR THE COURSE.

OVERALL SCORE = 0.8*(TOTAL SCORE) + 0.2*(PROJECT SCORE)
# ACTIVITY | DUE DATE
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1 | Homework 1 | September 22, 2017
2 | Homework 2 | September 29, 2017
3 | Project 1 | October 02, 2017
4 | Homework 3 | October 09, 2017
5 | TEST 1 | October 13, 2017
6 | Project 2 | October 18, 2017
7 | Homework 4 | October 23, 2017
8 | Additional Project for ECE 5200 Starts | October 23, 2017
9 | Project 3 | November 03, 2017
10 | Homework 5 | November 06, 2017
11 | Homework 6 | November 13, 2017
12 | TEST II | November 17, 2017
13 | Project 4 | November 20, 2017
14 | Homework 7 | November 27, 2017
15 | Homework 8 | December 04, 2017
16 | Project 5 | December 04, 2017
17 | Additional Project for ECE 5200 Due | December 08, 2017