The University of Jordan
School of Engineering
Department of Mechatronics Engineering
First Semester – 2019/2020

Course: Power Electronics for Mechatronics – 0908421 (3 Cr. – Core Course)

Instructor: Dr. Ahmad Malkawi
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Catalog Data: Principle of operation of: power semiconductor devices; single-phase and three-phase uncontrolled and controlled rectifiers feeding resistive and inductive loads; step-down (buck) and step-up (boost) DC-DC converters; AC voltage controllers; Applications: half-bridge and full-bridge single-phase and three-phase inverters feeding inductive loads; Applications: Power supplies, DC motor drives; AC motor drives.

Prerequisites by Course: Electronics + Electrical Actuater – 0908222 + 0908323

Prerequisites By Topic: The students are expected to have a good grounding in the principles of Electronics and Electrical circuits theory.

Textbook:

- Power Electronics Converters, Applications, and Design By Mohan, Undeland and Robbins, 3rd edition.
- Material is mainly contained on the webspace (see above).

References:

- Daniel W. Hart, “Power Electronics”, 2011, McGraw Hill International Edition.
- Power electronics”, Cyril W. Lander, Third Edition, McGraw Hill, 1993.
- Muhammad H. Rashid, “”Power Electronics: Circuits, Devices and Applications”, Third Edition, Pearson.

Schedule & Duration: 15 Weeks, 30 lectures (75 minutes each) plus exams.

Minimum StudentMaterial: Textbook, class handouts, scientific calculator, and an access to a personal computer.

Minimum College Facilities: Classroom with whiteboard and projection display facilities, library, computational facilities with MATLAB, Simulink and other engineering programs.

Course Objectives: The course aims to introduce the candidate to the concepts and principles of power electronics, the student is expected to know the different types of power electronic switching devices and their methods of operation, know how to carry out a Fourier series analysis on a periodic waveform, and know how to use Simulink and SimPowerSystems in simulating power electronic circuits.

Course Learning Outcomes and Relation to ABET Student Outcomes:

Upon successful completion of this course, a student should:

- Understand the operation and characteristics of power semiconductor devices.
- Understand the triggering and commutation techniques of the thyristor.
- Design uncontrolled and controlled rectifiers.
- Design chopping circuits.
- Design AC voltage controllers.
- Design single-phase and three-phase inverters.
- Understand the Pulse Width Modulation (PWM) techniques.
- Understand the power converter applications and impact on society.

Conduct a project in which a full power electronic system is designed to study the impact of engineering solutions in global, economic, environmental, and societal contexts. (4)

Course Topics:

Topic Description **Hrs**

1. **Introductory Basics Revision**:Revision of basic AC circuit concepts (single phase and three phase).Phasors and phasor diagrams; Real power, imaginary power and apparent power.Power factor: definition of power factor as real power divided by apparent power. Star and delta connected loads; line and phase voltages and currents; calculation of power in three phase load. **3**

2. **Components (Diodes and transistors)**; BJT, IGBT, FET, MOSFET. Thyristors, diacs and triacs. Samples of datasheets. **6**

3. **Harmonics**; Fourier series analysis of a periodic waveform Odd and even waveforms. Supply side and load side harmonics. Fourier series analysis of a square waveform. Proof that power can only be delivered to a load from a current having the sam frequency as the voltage source. **3**

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4. **AC to DC Converters (rectifiers):** Half wave and full wave single phase uncontrolled rectifiers; half wave and full wave single phase controller rectifiers; calculation of voltages and current, power delivered and power factors. Three phase rectifiers (controlled and uncontrolled). Pulse number in rectifiers and effect on supply side harmonics. Resistive and inductive loads Power factor calculations; distortion power factors. Crest factor, form factor and rectifier efficiency. **9**

5. **DC to DC Converters (choppers) DC to DC convertors (choppers);** the need for pulse width modulation (PWM) duty cycle; waveform calculations (average and root mean square of PWM output waveforms); resistive and inductive loads. DC motor armature control; four quadrant operation; H-bridges. Calculation of average and rms voltages and currents and delivered power; buck, boost and buck-boost converters.

6. **DC to AC Converters (inverters)**: Single phase step wave inverter. Single phase pulse width modulation (PWM) inverter. Triangulation and the generation of PWM pulses. Three phase step wave inverters (120 degree conduction, 2 transistors conducting at the same time); output line voltage in current waveforms; calculation of the rms line currrent. Three phase step wave inverters (180 degree conduction, 3 transistors conducting at the same time); output line voltage in current waveforms calculation of the rms line currrent. Three phase PWM inverters. **9**

7. **AC to AC converters (voltage phase controllers)** :Single phase AC voltage controllers; resistive loads; inductive loads. Snubber networks; the need for snubber networks. Thyristor firing circuits; interfacing. Calculation of root mean square of the voltage as a function of the firing angle (alpha). Natural commutation and forced commutation. Harmonic contents of the drawn current. Three phase AC voltage controllers with star-connected resistive loads. **6**

Ground Rules:

Attendance is required and strictly enforced. To that end, attendance will be taken every lecture; Absence of more than *7 hours* will result in the expulsion of the student from the course.

Assessments:

Exams and Projects.
Midterm exam on November 20.

Grading Structure:

Project	**20 %**
Midterm Exam	**30 %**
Final Exam	**50 %**
Total	**100%**

Last updated: Sep. 2019