SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY

SAULT STE. MARIE, ON

COURSE OUTLINE

COURSE TITLE: CIRCUIT ANALYSIS AND DESIGN

CODE NO.: ELN300 **SEMESTER:** 5TH

PROGRAM: ELECTRICAL/ELECTRONIC ENGINEERING TECHNOLOGY

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DATE: SEPTEMBER 1997 **PREVIOUS OUTLINE DATED:** N/A

APPROVED: K. DeRosario Sept 2/97
DEAN DATE

TOTAL CREDITS: 7

PREREQUISITE(S): N/A

LENGTH OF COURSE: 16 WEEKS @ 6 HOURS PER WEEK

TOTAL CREDIT HOURS: 96 HOURS

TOTAL CREDITS 7

PREREQUISITE: MTH 577 CALCULUS

I. PHILOSOPHY/GOALS: This project oriented course is intended to develop the students ability to apply design and analysis techniques and reporting skills to project oriented tasks.

II. STUDENT PERFORMANCE OUTCOMES:

Upon successful completion of the course, participants will be able to:

1) Understand the general purpose block diagram of a Power Electronic Converter and the principles and characteristics of state of the art solid state switches, such as the power MOSFET, IGBT, MCT, GTO, and Shottky diode.

2) Explain the principle, and the need for potential isolation in a Converter.

3) Explain the Firing, Control, and Auxiliary circuits of a Power Converter.

4) Design printed circuit board layouts for testability and manufacturability.

5) Import schematic diagrams and PCB layouts into a Word Perfect text document, and print PCB artwork and schematics on a laser printer, and on a pen plotter.

6) Design heat-sinks for power electronic components.

7) Analyze and design the auxiliary electronic circuits of a large Power Electronic Converter, such as pulse amplifiers, linear and switched mode power supplies, pulse distribution logic, signal isolation circuits and zero cross detectors.

8) Complete all phases of a Power Converter project, including design, manufacturing, testing, and documentation.

III. TOPICS TO BE COVERED:

Approximate time frame

		Theory/Laboratory hours
Block 1:	Review Power Electronic Converters and components	4/3
Block 2:	Heatsink design	3/3
Block 3:	Schematic capture and PCB design	2/3
Block 4:	Firing Circuits, Pulse Distribution and Synchronization	9/3
Block 5:	Linear Voltage and Current Regulator design	6/6
Block 6:	Switched Mode Power Supply design	15/6
Project 1	Design and build a Step-down Switched Mode Power Supply.	1/6
Project 2	Design and build a Flyback Converter	1/6
Project 3	Group project: Three phase Power Converter	1/6

IV. LEARNING ACTIVITIES/REQUIRED RESOURCES

Block 1: Review Power Electronic Converters and components.

Topic description:

- Introduction to Power Electronic Systems. Scope and applications.
- Classification of Power Converters.
- Power devices: Ideal switch, generic switch, Minority, Majority and Mixed carrier devices.
- Switching characteristics of power PN-junctions. Shottky diodes.
- Power BJT hybrid parameters: h_{11} , h_{12} , h_{21} ,h_{22} . How to read h parameters from the data book.
- Thyristors (GTO, TRIAC, MCT), Power MOSFET, IGBT.

Learning activities: Listen to lectures on power converters and semiconductor physics. Perform a laboratory test of the Reverse Recovery time of a switching diode.

Required resources: Study material and handouts are supplied by the teacher. Laboratory equipment is available in B102.

Block 2: Heat-sink design.

Topic description:

- Dissipated power in a semiconductor junction.
- The definition of the thermal resistance.
- Junction to case, case to heatsink and heatsink to air thermal resistance.
- Heat flow and the electrical equivalent to heat flow equations.
- Temperature rise versus dissipated power characteristics.
- Design examples.

Learning activities: Listen to lectures on heat-sink design. Solve assigned homework problems. Perform a heat-sink related laboratory experiment.

Required resources: Overheads, handouts, laboratory equipment.

Block 3: Schematic capture and PCB design.

Topic description:

- Printed circuit board layout concepts, for testability and manufacturability.
- Advanced Hiwire functions: Create graphics drivers for laser printers and pen plotters.
- Set up an hp7475 pen plotter for colour plotting.
- Create HPGL plot files (plot to a file from Hiwire) and import them into Word Perfect.
- Generate a Hiwire symbols library for power electronic components.

Learning activities: Follow a demonstration on the procedures of graphics file import, editing, printing and plotting. Use the principles learned in editing your project reports. Listen to a lecture on printed circuit board design. Design a PCB artwork for a buck converter.

Required resources: Hiwire, Smartwork, and Word Perfect software available in the laboratory. Buck converter schematic will be handed out. Pen plotter, special paper, IEEE driver card, desctop computers are available in the laboratory. Handouts will be provided.

Block 4: Firing Circuits, Pulse Distribution and Synchronization

Topic description:

- Isolation in a typical three-phase power converter.
- Isolation with individual line transformers and with off-line flyback converters.
- Isolation with multiple output off-line flyback converter.
- Isolation with DC to DC converters, off a common DC bus.
- Gate drivers for Thyristors, GTOs, IGBTs and power MOSFETs.

- Pulse distribution networks for power converters with more than two switches.
- Pulse distribution using the parallel port of a microprocessor. DDS.
- Zero cross detectors, and pulse-delay circuits. PLL sync circuits.
- Fiber optics in firing circuits.

Learning activities: Attend lectures on the topic of isolated firing circuits. Participate in a group project: design and build a complete three-phase power converter.

Required resources: Study material and handouts will be supplied by the teacher. Access to two digital storage oscilloscopes is available in B102.

Block 5: Linear Voltage and Current Regulator design

Topic description:

- Line and load regulation.
- Classes of voltage regulators.
- Linear shunt regulators.
- Linear series regulators.
- Overvoltage and short circuit protection.
- Monolithic integrated circuit voltage regulators.
- Programmable voltage regulators.
- Current source and current sink regulators.
- Design examples.

Learning activities: Listen to lectures on linear voltage and current regulators. Perform laboratory experiments with linear regulator chips.

Required resources: Study material and handouts are supplied by the teacher. Laboratory equipment is available in B102.

Block 6: Switched Mode Power Supply design

Topic description:

- Classes of Switched Mode voltage regulators.
- Buck, Boost, Buck-Boost and Boost-Buck Converters.
- BJT and MOSFET switches.
- Continuous Current Mode (CCM) and Discontinuous Current Mode (DCM) of operation.
- Voltage Mode and Current Mode topologies.
- Switched mode voltage regulators in a closed loop.
- Hysteretic control, variable frequency, variable pulse width, constant on-time, constant off-time.
- The DC to DC transformer concept.
- Isolated switched mode power supplies. The Forward Converter. The Flyback Converter.

Learning activities: Lectures will cover the classification, functioning and design of switched mode power supplies. Different model switchers will be built in the laboratory.

Required resources: Theory class and laboratory handouts will be supplied. A number of relevant reference books are available in the college library:

1. Rudolf P. Severns and Gordon Bloom, Modern DC-to-DC Switchmode Power Converter Circuits.
2. Eugene R. Hnatek, Design of Solid State Power Supplies.
3. Keith H. Billings, Switchmode Power Supply Handbook.
4. Abraham I. Pressman, Switching Power Supply Design.
5. George Chryssis, High Frequency Switching Power Supplies: Theory and design.
6. Motorola, Practical Switched Mode Power Supply design.

V. EVALUATION METHODS:

Four written tests will be conducted. Quizzes may be given without prior notice. Design assignments and hardware projects will carry the same weight as theory tests.

Grading is done using the following definitions:

- Consistently outstanding performance	A+ (91-100)%
- Outstanding performance	A (81- 90)%
- Above average performance	B (71- 80)%
- Satisfactory performance	C (55- 70)%
- Unsatisfactory performance	R (< 55)%

Upgrading:

a) If a test is missed for reasons whatsoever, the grade for that test is 0 unless a very good and credible reason can be given for the absence.

b) The method of upgrading is at the teachers discretion. It may consist of the rewriting of block tests, the writing of comprehensive examination, repeating laboratory experiments or repeating the course.

c) No upgrading tests will take place during the semester. All rewrites will be scheduled during the last week of the semester.

d) In the case of final marks less than 55% and greater than 50%, provided an 80% or better attendance record, consideration will be given to a supplemental examination covering the whole course. The grades that can be obtained on the supplemental are either a "C" grade or an "R" grade.

Attendance:

a) Attendance for laboratory classes is compulsory. Laboratory activities missed for reasons whatsoever must be completed during the students own time.

b) Attendance for all theory classes is highly recommended and recorded, but not mandatory.

c) Anyone with an accumulated attendance record of less then 80% at the end of the semester, and who is also in a failing condition, can expect to have to repeat the course, with no rights to write a make-up test.