SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title: ELECTRONIC CIRCUIT DESIGN

Code No.: ELR 310-6

Program: ELECTRICAL TECHNOLOGY

Semester: SIX

Date: JANUARY 1986

Author: R. Palo

New: _____ **Revision:** X

APPROVED: L P Viaggetti — Chairperson — 85-12-09 — Date

ELECTRONIC CIRCUIT DESIGN — Course Name

ELR 310-6 — Course Number

PHILOSOPHY/GOALS:

This course is intended to introduce the electrical student to electric power systems design. Assignments related to load flow, short circuit computations, system grounding and power system projection will be given.

GRADING:

Written tests conducted at regular intervals and are assigned equal weight. Missed tests are graded zero percent provided a legitimate excuse such as illness can be supported by a doctor's certificate. Comprehensive make up tests will be conducted at the end of the semester for people with missed tests and legitimate excuses.

A	---	80 - 100%
B	---	66 - 79%
C	---	55 - 65%
R	---	REPEAT

70% for Tests
30% for Assignments

TEXTBOOK(S):

IEEE Recommended Practice for Electric Power Distribution For Industrial Plants

REFERENCE TEXT(S):

Handbook of Electric Power Calculations by Seidman & Mahrous, McGraw-Hill

COURSE OUTLINES

BLOCK	TOPIC	HOURS
1	Review Network Analysis	12
2	Review Transformers	6
3	Review Synchronous Machines	6
4	Transmission Lines	12
5	Electric Power Networks	12
6	Load Flow Studies	12
7	Short Circuit Computations	12
8	System Grounding	6
9	Power System Protection	12
		90 HOURS

SPECIFIC OBJECTIVES

BLOCK 1 - REVIEW NETWORK ANALYSIS

1. The student shall be able to compute voltage and current in DC & AC Networks using:

   a) Mesh analysis
   b) Nodal analysis
   c) Thevenin & Norton theorems
   d) Superposition

2. The student shall be able to compute:

   a) Real
   b) Reactive
   c) Apparent

   Power in 1 & 3 phase AC circuits.

3. The student should be able to compute power factor, power factor correction, line voltage & currents for 1 & 3 phase loads.

BLOCK 2 - REVIEW TRANSFORMERS

1. The student shall be able to compute the following:

   a) Transformation ratio
   b) Voltage, current and turns ratio
   c) Impedance matching
   d) KVA rating

   For 1 & 3 phase transformers.

2. The student shall be able to draw phasor diagrams of voltage and current for lagging, unity and leading P.F. loads.

3. The student shall be able to calculate:

   a) Voltage regulation
   b) Efficiency
   c) Proper rating given cyclic load
   d) Short circuit current or duration given squared rating.

BLOCK 3 - REVIEW SYNCHRONOUS MACHINES

1. The student shall be able to calculate per unit base quantities from name plate data.

2. The student shall be able to calculate:

   a) Per unit direct axis reactance
   b) Per unit quadrature axis reactance
   c) Per unit open circuit time constant
   d) Per unit short circuit time constant

BLOCK 3 - CONTINUED

3. The student shall be able to determine the steady state phasor diagram for a synchronous generator connected to an infinite BUS for over and under excitation.

4. The student shall be able to calculate power output (real and reactive), power factor and efficiency.

5. The student shall be able to size grounding transformer and resistor required for short circuit protection.

6. The student shall be able to calculate motor current and power factor improvement when replacing induction motors by synchronous motors.

BLOCK 4 - TRANSMISSION LINES

1. The student shall be able to calculate the following for single and three phase transmission lines:

   a) Resistance
   b) Inductance
   c) Inductive reactance
   d) Per phase inductive reactance
   e) Capacitance
   f) Capacitive reactance
   g) Charging current
   h) Reactive power
   i) Short, medium and long transmission line models
   j) Complex power at both ends

BLOCK 5 - ELECTRIC POWER NETWORKS

1. The student shall be able to draw a 1 line diagram of a power system using appropriate graphical symbols.

2. The student shall be able to use the per-unit method of solving 3-phase problems.

3. The student shall be able to select the per unit base for short circuit calculations and change the base of per unit quantities.

4. The student shall be able to perform Wye-Delta and Delta-Wye conversions.

5. The student shall be able to calculate the per unit reactance of three-winding transformers.

6. The student shall be able to calculate complex power for a balance 3-phase system.

7. The student shall be able to check phase sequence using lamps.

BLOCK 5 - CONTINUED

8. The student shall be able to calculate the division of load between transformers in parallel.

9. The student shall be able to calculate real, reactive and apparent power and power factor for generators in load sharing arrangements.

10. The student shall be able to size capacitors used to improve power factor.

11. The student shall be able to size a 2-winding transformer connected as an auto transformer.

12. The student shall be able to draw a 2-wattmeter connection for measuring 3-phase power.

13. The student shall be able to compute the KUA rating of open delta connected transformers.

14. The student shall be able to compute the real and reactive power to parallel wye and delta connected loads.

BLOCK 6 - LOAD - FLOW STUDIES

1. The student shall be able to conduct a single transmission line study by:
   a) Converting actual values to per unit values
   b) Draw a circuit model
   c) Derive model equations
   d) Obtain a solution for real and reactive power, line voltage and current thru each line.

2. The student shall be able to write Nodal equation for a power system.

3. The student shall be able to apply a digital program for the solution of a multi-bus system.

BLOCK 7 - SHORT CIRCUIT CALCULATIONS

1. The student shall be able to:

   a) Determine transformer regulation from short circuit tests
   b) Calculate trerminal voltage of single phase transformer at full load
   c) Calculate voltage and current in balanced 3-phase circuits
   d) Calculate 3-phase short circuit current, subtransient, transient and synchronous
   e) Power in unbalanced 3-phase circuits
   f) Determine phase sequence components (positive, negative and zero) of current and complex power, impedance and reactance.
   g) Calculate line currents under line to line short circuit conditions
   h) Calculate line currents under line to ground short circuit conditions
   i) Select circuit breakers based on subtransient current contribution from motors
   j) Calculate induction motor inrush current
   k) Calculate induction motor short circuit current
   l) Calculate BUS voltages using matrix equation and inversion.

BLOCK 8 - SYSTEM GROUNDING

1. The student shall be able to:

   a) List the recommended ground resistance for a solidly grounded system (residential - commercial, light industrial, substation lighting protection)
   b) Calculate ground resistance based on groud resistivity and design of driven grounds
   c) Determine resistance for ground grids
   d) Determine the effect of ground fault distance from ground point
   e) Run a test to measure ground resistance and ground resistivity.

BLOCK 9 - POWER SYSTEM PROTECTION

1. The student shall be able to:

   a) Determine the setting of the trip device on a circuit breaker
   b) Set time over current relays for 400 HP and 7000 HP motors
   c) Set a thermal breaker
   d) Select and set a differential relay for 5500 HP motor protection
   e) Select directional control units for overcurrent relays
   f) Determine in-feed effect on ground-distance relay setting
   g) Select ground relay for generator stator