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SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title: ELECTRIC CIRCUIT DESIGN

Code No.: ELR 310-7

Program: ELECTRICAL TECHNOLOGY

Semester: SIX

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New: ______ Revision: X

APPROVED: L.P. Crozzetto
Chairperson ______ Date ______

ELECTRICAL CIRCUIT DESIGN	ELR 310
Course Name	Course Number

PHILOSOPHY/GOALS:

To provide a fundamental understanding of generation, transmission and distribution systems.

METHOD OF ASSESSMENT (GRADING METHOD):

Approximately four (4) written tests will be conducted. Quizzes may be given without prior notice.

A	80 - 100%
B	66 - 79%
C	55 - 65%
R	less than 50%

TEXTBOOK(S):

Electrical Power System Engineering - Turan Gonen

COURSE OUTLINE

BLOCK	TOPIC	LECTURE HOURS
1	The Overall System	16
2	Power Generation	20
3	Power Transmission	20
4	Substations and Distribution	20
5	Grounding, Fuses and Protective Relaying	20
		96

SPECIFIC OBJECTIVES

BLOCK 1 - THE OVERALL SYSTEM

The student shall be able to recall:

1. Basic requirements of a power system.
2. What various schematic symbols represent in a 1 Line diagram of a power system and rating data normally included.
3. Preferred nominal line to line voltages on 3 phase 60 Hz systems.
4. A measure of power system stability.
5. Why power systems are interconnected (3 reasons).
6. How load duration curves are obtained.
7. Characteristics of peak, intermediate and base power stations.
8. Definitions for demand and consumption and compute cost of power to an industrial user given the consumption and demand rate schedules.
9. Convert power, voltage, current and impedance to P.U. quantities to facilitate network solutions.

BLOCK 2 - POWER GENERATION

The student shall be able to:

1. Recall the principle sources of electric power in North America.

2. Recall the hydraulic power formula based on head and flow rates.

3. Describe 3 types of hydraulic turbines; Pelton, Francis and Kaplan.

4. Identify the principle components of a hydroelectric installation.

5. Calculate the thermal output of a power boiler given the fuel flow rate, composition by weight and boiler efficiency.

6. Identify the principle components of a thermal plant.

7. Define the fusion and fission reactions.

8. Describe the principle of operation of 2 types of fission reactors using light water and heavy water moderators.

9. Identify the principle components of a nuclear power station.

10. Describe the main characteristics of alternators with salient pole and cylindrical pole rotors.

11. Identify the principle components of a large 3-phase alternator.

12. Draw an electrical model for a balanced 3 phase alternator.

13. Compute the synchronous reactance.

14. Compute the nominal impedance and P.U. synchronous reactance based on machine ratings.

15. List 3 conditions required in order to synchronize an alternator to the bus.

16. Draw the phasor diagrams of an alternator supplying an infinite bus which is floating, overexcited and underexcited.

17. Calculate the per phase power output based on the L-N terminal voltage, rotor voltage, power angle and the synchronous reactance.

18. Describe transient reactance and compute 3-phase short circuit currents.

BLOCK 3 - POWER TRANSMISSION

The student shall be able to:

1. Calculate the nominal impedance of a transformer given its ratings.

2. Draw the per phase equivalent circuit of a transformer.

3. Compute the equivalent leakage reactance of a transformer referred to the primary or secondary side given the P.U. leakage reactance.

4. Compute the load sharing between paralleled transformers to determine overload conditions of any of the transformers.

5. Compute circulating current between paralleled transformers of unequal turns ratio.

6. Explain with the aid of sketches, the following types of circuit breakers, OCB's, Air Blast, SF6 and vacuum.

7. Draw and describe the function of various switches; air-break, fused disconnect and ground switches.

8. Describe the function and size current limiting reactors.

9. Draw the equivalent PI model of a transmission line based on distributed parameters.

10. Compute active and reactive power and voltage regulation of a transmission line.

11. Compute the maximum power transferred by a resistive-only line and a reactive only line.

12. Compute the required line compensation for a reactive only line.

13. Compute power flow between power systems on an inductive line given the sending and receiving end L-N voltage, inductive, reactance and phase angle between sending and receiving voltages.

14. Choose a nominal line voltage given the power to be transferred and the voltage regulation desired.

15. Define the meaning of surge impedance load.

16. Describe how a phase shift transformer is used to control the direction of power flow.

17. Use conductor tables to determine effective cross sectional area (In square inches, square millimeters and circular mils), ampacity and tensile strength.

18. Use conductor tables to determine per phase resistance and reactance and estimate line voltage drop.

19. Estimate line sag and length given line tension, span and weight per unit length.

20. Sketch the construction of pin type and suspension type insulators.

21. Define the basic impulse level rating and sketch the Std. impulse waveform.

22. Sketch single and double cct. HV and EHV transmission line towers.

23. Describe the purpose of shielding, grounding and transposition of lines.

24. Describe the characteristics and function of lightning arrestors.

25. Explain with the aid of sketches a typical HVDC transmission system.

BLOCK 4 - SUBSTATIONS AND DISTRIBUTION

The student shall be able to:

1. Draw a schematic of common types of distribution systems; simple radial, expanded radial, primary selective, primary loop, secondary selective and secondary spot networks.

2. Calculate the maximum and minimum values of primary service voltage, secondary service voltage and utilization voltage given the Standard voltage profile on a 120 Vac base.

3. List 4 and explain abnormal voltage conditions.

4. List 4 and explain common causes for overvoltage conditions and way to protect against it.

5. Describe how tap changing transformers are used to regulate line voltage.

6. Calculate steady state AC currents flowing into balanced and unbalanced 3 phase loads.

7. Calculate capacitance required for power factor improvement of motor loads.

8. Perform Fourier analysis of a periodic waveform using numerical techniques.

9. Set up the node voltage equations for an admittance network.

10. Be familiar with the Gauss-Seidel Iterative formula and its use in the solution of systems of linear equations.

11. Solve load flow problems numerically on a digital computer using the Gauss-Seidel Iterative formula.

12. List and explain the types of three-phase line faults.

13. Calculate the symmetrical fault current at a given point in the network knowing the L-N voltage and equivalent impedance of the network.

14. Calculate the asymmetric current given the load impedance and time after the switch has been closed.

15. Describe how sequence components may be used to represent unbalanced 3-phase voltage and current.

16. Show how the distributed model of a transmission line may be used to derive the wave equation for voltage and current surges on a loss-less infinite length line.

17. Calculate the voltage and current at any position of the loss less, infinite line at any time.

18. Calculate propagation velocity ( ) and characteristic impedance ( ) of a loss less transmission line.

19. Calculate reflected surge voltage and current of a transmission line terminated by a load impedance ( ).

20. Calculate the refracted surge voltage and current of a transmission line mismatch.

BLOCK 5 - GROUNDING FUSES AND PROTECTIVE RELAYING

The student shall be able to:

1. List and explain 4 classifications of power system grounding and main advantages and disadvantages of each.

2. Draw a schematic diagram of how a zig-zag grounding transformer is used to convert 3-phase Delta systems to 3-phase Grounded Wye systems.

3. List the recommended maximum grounding resistance for "solidly grounded" power systems; residential-commercial, industrial, substation and lightning arrestor.

4. Estimate the ground resistance knowing the physical dimensions, configurations and depth of the conductors and ground resistivity.

5. Derive the resistance between two concentric hemispheres.

6. Describe the procedures used to measure ground resistivity and ground resistance.

7. List 2 advantages each in favour of the use of fuses and thermal-magnetic circuit breakers for overcurrent protection.

8. List 5 categories of LV cartridge fuses.

9. Define the continuous current rating and interrupt rating as applied to fuses and circuit breakers.

10. Describe the principle of operation of a current limiting fuse.

11. Describe the principle of operation of a time delay fuse.

12. Sketch the time-current characteristics of 1-time, time delay and current limiting fuses.

13. Select correct fuse ratings for selective operation on overcurrent in motor and lighting loads.

14. Sketch and explain 5 basic types of electro-magnetic relays used in power system protection.

15. Draw the time-current characteristic for 4 types of relays used for overcurrent protection.

16. Determine whether selective action will occur when O.L. relaying is time graded in simple radial distribution systems.

17. Compute the relay tap settings for instantaneous and time overloads given the required percent O.L. and C.T. ratio.

18. Compute the relay time based on the fault current, the CT ratio and the relay time overcurrent curves.

19. Describe the principle of distance relays.

20. Describe the principle of operation of directional relays.

21. Compute the percent line coverage for overcurrent protection with and without directional relays.

22. Describe the principle of operation of differential relays.

23. Sketch 2 ways of implementing pilot wire differential protection of feeders.

24. List abnormal conditions in generators which must be protected against and the types of relays used.

25. List abnormal conditions in transformers which must be protected against.

26. Draw a schematic of a 3-phase transformer differential protection showing the proper CT ratios and configurations.