SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title: ELECTRICAL MACHINES II

Code No.: ELR 232-6

Program: ELECTRICAL TECHNICIAN

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COURSE OBJECTIVES:

LEC	LAB	TOPIC
3		DC Machine Construction The function of the parts of a dc machine Windings Commutation, brush neutral Armature reaction Armature reactance
4	6	DC Generator Characteristics Magnetization curve Voltage Buildup Separate excitation Self excitation shunt, series, compound connections and characteristics Voltage regulation
4	6	DC Motors Torque developed Back emf Armature power Separately excited, shunt, series, and compound motor characteristics and connections Starting requirements Reversal techniques Performance tests
2	0	Efficiency of DC Machines Basic efficiency relationships Loss distribution
6	6	DC Motor Control Manual and automatic control Dynamic braking Regenerative braking Speed control
4		DC Motor Selection Speed rating and classifications Frame size Duty Cycle Temperature ratings Voltage and current ratings Enclosures
6	6	Synchronous Generators Construction Windings Pole, speed, frequency

ELECTRICAL MACHINES II

ELR 232-6

SPECIFIC OBJECTIVES

BLOCK I: DC Machine Construction

At the end of this block the student shall be able to:

1. Recall and apply:

   a) Faraday's Law of Induction
   b) Fleming's Relationships
   c) Lenz's Law
   d) The generated voltage equation: $E = \frac{\phi Z S P}{60a} \times 10^{-8}$ volts (E) or

   $$E = \frac{\phi Z w P}{2\pi a} \text{ volts (SI)}$$

   e) The force acting on a conductor is: $F = \frac{BIL}{1.13} \times 10^{-7}$ lbs. (E) or

   $$F = BI\ell \text{ newtons (SI)}$$

2. Recall and explain:

   a) the construction and function of the parts of a dc machine.

   b) the application and configurations of lap, wave and frog-log windings.

   c) the purpose of multielement and multiplex armature coils.

   d) commutation, brush neutral.

   e) armature reaction and reduction methods.

   f) armature reactance and reduction methods.

   g) the requirements of the magnetic circuit.

BLOCK II: DC Generator Characteristics

At the end of this block the student shall be able to:

1. Recall and explain with the aid of schematics and/or graphs:

   a) the open circuit magnetization curve of a generator.
   b) the factors affecting the build-up of voltage by a self excited generato
   c) the connections of a shunt generator, and recall and be able to apply:

$$I_a = I_f + I_\ell \quad \text{and} \quad V_a = V_f = V_t = E_g - I_a R_a$$

$$S = \frac{V_a - I_a R_a}{K\phi} \qquad (E)$$

or

$$\omega = \frac{V_a - I_a R_a}{k\phi}$$

g) the connections, speed and torque versus output characteristics of a shunt motor, and:

$$T = C\Phi I_a \qquad (E)$$

or

$$t = c\phi I_a \qquad (SI)$$

and percent speed regulation is:

$$\frac{S_{n\ell} - S_{f\ell}}{S_{f\ell}} \times 100 \qquad (E)$$

or

$$\frac{\omega_{n\ell} - \omega_{f\ell}}{w_{f\ell}} \times 100 \qquad (SI)$$

h) the connections, speed and torque versus output characteristics of a series motor, and:

$$S = \frac{V_a - I_a (R_a + R_{SE})}{KK^1 I_a} \qquad (E)$$

or

$$\omega = \frac{V_a - I_a (R_a + R_{SE})}{kk^1 I_a} \qquad (SI)$$

and

$$T = C\Phi I_a = CC^1 {I_a}^2 \qquad (E)$$

$$t = c\phi I_a = cc^1 {I_a}^2 \qquad (SI)$$

i) the connections, speed and torque versus output characteristics of cumulatively and differentially compounded motors, and:

$$S = \frac{V_a - I_a (R_a + R_{SE})}{K\phi_{sh} \pm KK^1 I_a} \qquad (E)$$

($\pm$ cumulative, $-$ differential)

or

$$\omega = \frac{V_a - I_a (R_a + R_{SE})}{k\phi_{sh} \pm kk^1 I_a} \qquad (SI)$$

f) reversing control, plugging reverse control.
g) retardation, dynamic and regenerative braking
h) stopping, electric brakes
i) jogging
j) the four methods of dc motor speed control:
   1) field control
   2) armature resistance control
   3) series and shunt armature resistance control
   4) armature voltage control

BLOCK VI: DC Machine Selection

At the end of this block the student shall be able to:

1. Recall and explain the following factors used in motor application:

   a) shaft power in or out in hp or kW
   b) driven load characteristics
   c) speed rating
   d) frame size
   e) speed classifications
   f) duty cycle and compute rms hp
   g) ambient temperature effects
   h) allowable temperature vise
   i) voltage and current ratings
   j) enclosure types
   k) maintenance factors

BLOCK VII: Synchronous Generators

At the end of this block the student shall be able to:

1. Recall and explain with the aid of sketches as appropriate:

   a) the reasons for and the physical construction of salient pole and cylindrical rotor alternators.

   b) alternator windings, chording, coil group connections and winding distributio

   c) the pole-speed-frequency relations:

$$f = \frac{PS}{120} \text{ Hz} \qquad \text{(E)}$$

$$f = \frac{Pw}{4\pi} \text{ Hz} \qquad \text{(SI)}$$

   d) the basic generated voltage is:

$$E_{AV/PP} = 4\Phi Nnf \times 10^{-8} \text{ volts} \qquad \text{(E)}$$

$$= 4\phi Nnf \text{ volts} \qquad \text{(SI)}$$

   e) the pitch factor is kp = sin (p/2) and the distribution factor is:

$$k_d = \frac{\sin(n\alpha/2)}{n \sin(\alpha/2)}$$

   and that the complete pole-phase group voltage is:

$$Egpp = 4.44\Phi Nnf \; kp \; kd \times 10^{-8} \text{volts} \qquad \text{(E)}$$
$$= 4.44\phi Nnf \; kp \; kd \text{ volts} \qquad \text{(SI)}$$

f) use reflected impedances and equivalent circuits to calculate performance under varying power factor load conditions.

g) the procedures for open and short circuit testing and use the observed data to determine losses, voltage drops, regulation and efficiency.

h) typical distribution transformer connections.

i) how to identify coils and carry out polarity and voltage tests.

j) the three principle types of autotransformers and that the power transferred is:

$$P_{tr} = P_1(1 - \frac{1}{\alpha})$$

and $$P_{con} = P_2 - P_{tr}$$

and the applications and disadvantages of autotransformers.

k) the function and precautions that must be exercised in using instrument transformers.

l) the requirements for parallel operation of transformers.

m) the relative advantages and requirements of using single-phase transformers in 3-phase applications.

n) the standard three-phase transformer connections, namely:
1) Wye-Wye
2) Delta-Delta
3) Wye-Delta
4) Delta-Wye
5) Open delta
6) Scott-Tee

BLOCK IX: Polyphase Induction Motors

At the end of this block the student shall be able to:

1. Recall, explain and utilize as appropriate:

a) the physical construction of the squirrel cage induction motor (SCIM) and the wound rotor induction motor (WRIM).

b) the production of a rotating magnetic field.

c) the production of torque and be able to apply:

$$S = \frac{120f}{P} \text{ rpm} \qquad \text{(E)}$$

or $$w = \frac{4\pi f}{P} \text{ rads/sec.} \qquad \text{(SI)}$$

$$S = \frac{\text{synchronous speed - rotor speed}}{\text{synchronous speed}}$$

$$= \frac{S - S_r}{S} \times 100\% \qquad \text{(E)}$$

or $$= \text{——} \times 100\% \qquad \text{(SI)}$$

and

$$S_r = S(1-s) = (\frac{120f}{P})(1-s) \qquad \text{(E)}$$

or $$r = (1-s) = (\frac{4\pi f}{P})(1-s) \qquad \text{(SI)}$$

and

a) reversing and non-reversing full voltage starters.
b) reversing and non-reversing reduced voltage starter types: 1) line resistan
2) line reactanc
3) auto transfor
4) Wye-Delta
5) wound rotor
c) the use of plugging, jogging, retarding and stopping techniques.
d) speed control methods: 1) consequent pole (constant torque, constant horse power and variable torque)
2) two winding stators
3) variable frequency
e) the factors affecting ac motor selection: 1) shaft power
2) speed rating
3) frame size
4) speed classification
5) duty cycle
6) temperature effects
7) voltage and current ratings
8) enclosures