

ELECTIVE II: ADVANCED TOPICS IN ELECTRICAL MACHINES

Time: Three hours

Full Marks: 100

Answer any five questions
All questions carry equal marks

1. Derive the expressions for speedemf, transformer emfs and electrical torque of Kron's primitive machine.
A three-phase induction motor has following per phase parameters referred to stator.
 $r_1=0.3 \Omega$, $r_2=0.4\Omega$, $x_1=3.5 \Omega$, $x_2=3.5 \Omega$, $x_0=48 \Omega$.
Find the parameters of an equivalent two-phase motor if it's per phase turns are (i) $\frac{3}{2}$ times and (ii) $\sqrt{\frac{3}{2}}$ times that of three-phase induction motor? 6+8+6
2. (a) What is meant by 'invariance of power' as applied to the electrical machines? 5
(b) Show that the transpose of the transformation matrix should be equal to its inverse. 7
(c) A 2-pole synchronous machine has 3-phase armature currents as:
 $i_a = I_m \cos \omega t$, $i_b = I_m \cos (\omega t - 120^\circ)$, $i_c = I_m \cos (\omega t - 240^\circ)$.
At time $t=0$, the rotor phase 'a' axis is aligned with the field winding axis. Find d and q axes currents. 8
3. A 250 V separately excited DC generator is initially unexcited but running at rated speed and connected to a load. A 240 V DC supply is suddenly applied to the field winding. Neglecting magnetic non-linearity and any speed change, find out the variation of armature current as a function of time. Drive the necessary expression. The constants of the generator are $R_f=50\Omega$, $L_f=25$ H, $R_a=0.04 \Omega$, $L_a=0.03$ H, $R_L=2 \Omega$ and $L_L=1.25$ H. Slope of the air-gap line is 36 V/field ampere at rated speed. 20
4. (a) Develop the generalized model of polyphase synchronous machine. From the torque matrix of a 3-phase salient pole alternator and phasor diagram, obtain an expression for synchronous power in terms of load angle. 2+6
(b) For salient pole synchronous machines, P_1 and P_2 are the maximum values of electromagnetic power and reluctance power respectively. Show that the load angle δ , at which resultant power is maximum, can be obtained from the relation, 6
$$\cos \delta = \frac{-P_1 \pm \sqrt{P_1^2 + 32P_2^2}}{8P_2}$$
- (c) A salient pole synchronous motor delivers rated power output at rated voltage and takes 0.8 pf leading current. Compute the motor excitation voltage if $X_d=1.25$ pu and $X_q=1.00$ pu. 6
5. Draw the generalized mathematical model of a polyphase induction machine. Write down the voltage equations for this model and obtain the equivalent circuit for the poly phase induction motor. 20
6. What are the major sources of energy loss in power transformer? Describe different types of cooling systems used for power transformers? 15
A 200 KVA transformer has heating time constant of 2.0 hour. The ratio of iron loss to full load copper loss is 1:8. The temperature rise on full load is 58° C. Calculate the overload (in %) for which a temperature rise of 65°C will be observed after 4.5 hours. 5

7. Why impulse testing of power transformer is necessary? Discuss, how surge voltage is generated from an impulse generator? Describe the general arrangement of equipments for an impulse test. 20

8. Write short notes on any two of the followings:

- i. Park's transformation 2×10
- ii. Routine tests of synchronous generators and motors
- iii. Expression of electromagnetic torque of DC series motor using generalized theory electrical machines