M.E. POWER ENGINEERING FIRST YEAR FIRST SEMESTER EXAM 2018

ANALYSIS OF ELECTRICAL MACHINES

Full Marks : 100

Time: Three hours

(Use separate answer scripts for each part)

Part - I

Full Marks: 70

*Answer any **four** questions*
(Two marks for neatness)

1. What is generalized model of rotating electrical machines? 3
   Enumerate the conventions adopted for development of the generalized machine theory. 4
   Derive the voltage equations of a Kron's primitive machine in matrix form. 10

2. Show that transpose of the transformation matrix should be equal to its inverse in order to maintain power invariance in transforming one set of variables to another. 4
   Obtain identical transformations for currents and voltages from a rotating balanced 3-phase (a-b-c) winding to a rotating balanced 2-phase (α,β) winding. 8
   A 2-pole synchronous machine has 3-phase armature currents as follows:
   $$i_a = I_m \cos\omega t, i_b = I_m \cos(\omega t - 120°), i_c = I_m \cos(\omega t - 240°)$$
   At time t=0, axis of the rotor phase-A is aligned with the field winding axis. Find the direct and quadrature axes current components. 5

3. Derive the expressions for armature to field mutual inductances and armature self inductances of salient pole synchronous machine from consideration of its basic parameters. State the assumptions used. 10
   A cylindrical rotor synchronous machine has the following parameters:
   Self inductance for phase A = 3.15 mH
   Armature leakage inductance= .035 mH
   Calculate mutual inductance between its armature phases and its synchronous reactance. 7

4. Starting from the impedance matrix of a 3-phase salient pole synchronous machine without dampers, derive the phasor voltage equation under balanced steady-state operation. Draw phasor diagrams. 10
   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,
   $$\cos\delta = \frac{-P_1 \pm \sqrt{P_1^2 + 32P_2^2}}{8P_2}$$ 7

5. A 3-phase, 11 KV, 125 MVA, star connected turbo alternator has the following per unit (pu) constants.
   X_d=1.0, X_d'=0.3, T_d'=1.20 sec.
   The alternator is operating at no-load with its rated terminal voltage. Now a sudden short-circuit occurs across its terminals. Armature transformer voltages and its resistances are neglected for parts (i), (ii), (iii) and (iv), but not for part (v). Express currents in pu.
   (i) Find the current in phase *A* as a function of time. Assume that short circuit occurs when phase *A* is 90° away from field axis.
   (ii) Write an equation for the envelope of the short circuit current wave as a function of time.
   (iii) Find the *rms* value of the symmetrical short circuit current in phase *A*, just after the three-phase short circuit.
   (iv) Consider $X_d'' = 0.15, T_d'' = 0.3s$. Repeat part (i) and (ii)
   17

6. Write short notes on (any two) 17

(i) Park's transformation

(ii) Direct axis short circuit transient and sub-transient reactances and time constants of synchronous machine from equivalent circuit,

(iii) Electrical torque of Kron's primitive machine

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Master of Power Engineering 1st SEMESTER EXAMINATION 2018

Subject: Analysis of Electrical Machines

Use Separate Answersheet for each PART

Time: 3hrs **Full Marks: 100**

PART-II

Answer any three Questions **Marks 30**

Q1. What is rotor field oriented V-Type Control? Draw the block diagram and identify the blocks. 10

Q2. Derive the expression of torque from flux linkage and stator current in case of an universal field-oriented induction motor control. State your considerations. 10

Q3. Deduce the expression of short circuit armature current in case of a sudden three phase short circuit for an Induction Motor. State your assumptions. 10

Q4. Derive the expressions for d axis and q axis currents in case of Electromechanical Transients for an Induction Motor? 10

Q5. What tests were used for determination of operational impedences of solid rotor turbogenerators? Explain the tests. 10

Q6. Derive the Expression of Open Phase Transient Voltage and Torque in case of a Turbogenerator under single Line to Ground Faults. 10

Q7 Write short notes (Any Two) 5 X 2 = 10

1. Flux Weakening
2. Rotor field oriented I-Type Control
3. Constant airgap flux performance for field oriented control
4. Rotor Space Phasor Position Angle