**M.E. (Electrical) 1st Semester Examination, December 2011**

Subject: Generalised Machine Theory

Code No. **EE 903**
Branch: EE
Full Marks : 70

Time: 3 hours

(i) The questions are of equal value.
(ii) Answer any **5** questions taking **3 *from Group A and 2 from Group B***.
(iii)Use graph paper(s) if required.

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## Group A

1.(a) Utilize tenets of generalized theory and small perturbation theory to obtain in details the transients that may be induced in the line and field currents when an alternator on no-load is suddenly subjected to a 3-phase symmetric short-circuit fault. You may neglect presence of damper windings and all winding resistances. The inverse Heaviside transform for $\{\omega^2/(p^2+\omega^2)\}$ is $(1-\cos\omega t)$. Draw the waveforms for $i_d$, $i_q$ and $i_a$.
(b) Justify why speed has been assumed to be constant in the analysis in part(a) above.
(c) Justify why the absence of damper windings leads to the conclusion that the above analysis is related to the transient period. (10+2+2)

2.(a) Starting from 'abc'-reference frame model, obtain the d-q axis model for a 3-phase synchronous motor and derive the voltage and torque equations. Particularly highlight the transformation of $Z_{abc}$ to $Z_{dq\gamma}$.
(b) What would be the values of currents and voltages in the 's' and 't' coils at steady state? (12+2)

3.(a) On the d-q space-time phasor plane identify the operation of the synchronous machine as motor or generator and its excitation status in the different quadrants. Justify through clear logic.
(b) The parameters of a 1 MVA, 11 kV, 3-phase, 6-pole, 50 Hz synchronous motor operating at 0.866 leading p.f. are:

| | |
|---|---|
| Direct axis synchronous reactance | 17 Ω/phase |
| Quadrature axis synchronous reactance | 10 Ω/phase |
| Resistance | 0.8 Ω/phase |

For rated current flowing in the armature determine (i) the excitation voltage and rotor angle and (ii) the cylindrical, reluctance and total torque under steady state. Draw the phasor diagram.(4+10)

4.(a) Derive a Kron's primitive machine type d-q model for a 3-phase induction machine. Outline methods of relating the d-q model with the actual 3-phase machine. Hence, derive the steady state equivalent circuit for the same.
(b) Which transformation matrices are affected by a change of winding phase sequence? (12+2)

5.(a) A balanced set of 3-phase slip-ring based coils, mounted on a machine rotor are carrying balanced 3-phase 50 Hz currents of 10 A. The machine is 6-pole machine. The rotor rotates a motor at a speed of N rpm. Evaluate using results of appropriate transformations (need not derive)

(i) $[i]_{\alpha\beta\gamma}$ and $[i]_{dq\gamma}$ if N = 500 rpm. What is the frequency of the rotor currents as seen by a stator based observer?

(ii) Plot the waveforms of $i_a$, $i_\alpha$, $i_\beta$, $i_d$ and $i_q$ in case (ii) above

(b) A 4-pole, 3-phase, 50 Hz induction motor with a star connected rotor winding has a standstill slip-ring voltage of 180 V. The rotor resistance and reactance per phase are 0.25Ω and 1.5Ω respectively. Determine,

(i) The torque and rotor phase current at starting,

(ii) The maximum torque, corresponding slip and rotor phase current. Neglect stator series impedance.

(iii) Draw the phasor diagram. (2+4+8)

## Group B

6.(a) A d.c. shunt generator is running steadily and develops a constant voltage on no-load. The armature terminals of the shunt generator are suddenly short-circuited. Find the expression to show the nature of variation of both the field current and the armature current with time, taking the instant of short-circuit at t=0. Draw the curves.

(b) Determine the time of building up of voltage in a saturated exciter at no-load with the help of Froelich's equation. (7+7)

7. (a) A d.c. separately excited generator with series field connected to a constant voltage supply is suddenly short-circuited. Determine the expression for transient armature current.

(b) Disscuss the methods to show how the effect of saturation can be taken into account in the analysis of d.c. machine. (8+6)

8. (a) From the expression of torque and power, find the equations for small changes of a separately excited d.c. motor. Hence find out the condition to check the stability of the system.

(b) Find the transfer function of a Ward-Leonard system considering load torque to vary linearly with speed. Hence find the expression for motor speed as a function of time when a d.c. supply is suddenly applied across the generator field winding, taking the instant of application of d.c. supply at t = 0. Develop the block diagram of the system. (7+7)