M.E. (Electrical)
1st Semester Final Examination, December 2012

Subject : Generalised Machine Theory

Code No. **EE 903**
Branch: EE
Time : 3 hours Full Marks : 70

(i) The questions are of equal value.
(ii) Answer any **6** questions taking ***3 from Group A and 2 from Group B***.
(iii)Use graph paper(s) if required.
(iv) All symbols have their usual significance.

Group A

1.(a) Utilise 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. Draw the waveforms for i_d, i_q and i_a. [You can use either Laplace or Heaviside transform: the inverse Heaviside transform for $\{\omega^2/(p^2+\omega^2)\}$ is $(1-\cos \omega t)$]
(b) Justify why speed has been assumed to be constant in the analysis in part(a) above.
(c) Justify why the neglecting of the presence of damper windings leads to the conclusion that the above analysis is related to the transient period.

(9+2+3)

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 $Z_{dq\gamma}$. Make appropriate replacements to obtain the steady state voltage equations of *dqγfst* coils.
(b) What are the values of currents and voltages in the '*s*' and '*t*' coils at steady state and why?

(10+4)

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 complete phasor diagram.

(5+2+3+4)

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 sequence and why?
(c) What is the frequency of currents fed to the rotor d-q coils in this case? Justify vis-à-vis the synchronous machine case. (8+3+3)

5.(a) Derive and draw simplified *d* and *q*-axes operational impedance circuits for a synchronous motor having damper windings. Redraw the *d*-axis circuit in case the mutual inductance between the *f* and *s* coils is separately considered.

(b) Derive the perturbed equations for the voltages in *dqfst* coils in a synchronous motor using small perturbation concept. Explain how these equations can be utilised by significantly interpreting each term for the study of electrical or mechanical transients in alternators and synchronous motors and how the different terms can be effectively defined/replaced/ neglected to represent the practical conditions.

(5+1+8)

Group B

6.(a) A separately excited d.c. generator is running steadily and develops a constant voltage on no-load. If the armature terminals are suddenly short-circuited, investigate the nature of variation of armature current with time.

(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) A cumulatively compound generator, with its shunt field separately excited has the following parameters :

$r_f = 100\Omega$ $\quad L_f = 50H$

$r_a = 0.6\ \Omega$ $\quad L_a = 0.03H$

$r_s = 0.4\ \Omega$ $\quad L_s = 0.02H$

M_d = Mutual inductance between series and shunt field = 1H

Generated e.m.f. / shunt field ampere = 100 at 100 rad /sec.

Generated e.m.f. / series field ampere = 0.5 at 100 rad / sec.

(i) The generator is running at constant speed of 100 radians per sec and is open circuited. The shunt field is suddenly switched across 200 volts supply. Find the rise of armature voltage with time.

(ii) After steady state has reached in part (i), the armature is suddenly short-circuited. Find an expression for the armature short-circuit current.

(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)