INDIAN INSTITUTE OF TECHNOLOGY, DELHI
Department of Electrical Engineering
EEL 749/845: SPECIAL ELECTROMECHANICAL SYSTEMS
Major Test, Session 2006-07, II Sem. Duration – 2 Hr, Max. Marks: 80

1. Identify suitable Electric Machines and controllers (if required) for following applications.
   a) Grid fed Wind Energy System
   b) Stand alone Small Hydro Energy System
   c) Food Mixer
   d) Robots
   e) Machine tools
   f) Air Conditioner
   g) Battery Driven Vehicles
   h) CD Drives (8)
2. Derive the Equivalent circuit of a 1-phase Induction Motor using 3- phase Symmetrical Component Theory. Derive the Expression for developed Torque. (8)
3. Draw the Schematic of a Doubly fed Induction Machine employing Convertors in rotor circuit. Identify the direction of Airgap power, rotor power and shaft power under
   a) Sub synchronous motoring
   b) Super synchronous motoring
   c) Sub synchronous generating
   d) Super synchronous generating (8)

4. a) Prove that the minimum capacitance to cause self excitation in a 3- phase Induction machine is inversely proportional to square of speed using an approximate analysis. Mention the assumptions made. (4)

b) A 3.7 kW , 3- phase, 4-pole, 50 Hz, 415-V, 7.6A, Delta connected Induction Motor has the following p.u. parameters taking rated phase voltage and current as base values.

R_s=0.061, R_r=0.053, x_{ls}=x_{lr}=0.087, x_m=2.80 (unsaturated)

This motor has to be operated as a Self Excited Induction Generator (SEIG) driven at synchronous speed.

(i) Calculate the minimum capacitor/ phase to be connected to cause self excitation based on the derivations of [4(a)] above. (3)

(ii) Draw a steady state equivalent circuit to analyze the system and label all parameters with numerical values in ohms. (3)

(iii) In the above equivalent circuit assume the p.u. generated frequency (F) to be equal to p.u. speed (υ) except in the terms containing their difference i.e. (F- υ) . Use the magnetizing curve of Fig.1. and calculate the capacitance to be connected to cause 1.0 p.u. airgap voltage Vg. on no load. Why this value differs from that of (i) above. Calculate the terminal voltage. (10)

5.A 4 kW, 1500 rpm, switched reluctance motor (Fig.2) has 8 stator poles and 6 rotor poles. Stator is wound with 4-phase windings. (Windings of opposite poles connected in series to form a phase) . Its man dimensions are as follows.

Stator bore dia.: 92.2 mm
Stator core outer dia.: 180 mm
Stator back Iron Width: 10mm.
Stator Pole arc: 21°
Rotor inside (Bottom of poles) dia: 44.7 mm
Airgap length: 0.35mm
Stack length: 150 mm.
Rotor Pole tip dia: 95.5 mm
Rotor Pole Arc : 20°

ii) Assume core material to be infinitely permeable and calculate aligned and unaligned inductance in terms of turns per pole. (6)

iii) Assume the above variation to be linear and plot the variation of inductance with rotor position. (4)

iv) Plot the ideal current to be injected in each phase and plot the resultant torque in terms of inductance and current. (6)

6. a) List the differences between the following three types of Permanent magnet motors- (i) PMDC (Brushless), (ii) PMDC (with brushes), (iii) PMSM (5)

b) Draw the phasor diagram under no load and load of a Permanent Magnet Synchronous motor. Show how the loading of motor causes demagnetization of main flux. Using this phasor diagram determine how the developed torque will be altered if both supply voltage and frequency to the motor are halved. (10)

7. A 3- phase 4- pole, 50 Hz wound rotor Induction motor is running at 1350 rpm. What are the frequencies of stator and rotor currents if,

v) supply is balanced, rotor shorted

vi) supply is unbalanced, rotor shorted

vii) One line of supply is disconnected, rotor shorted

viii) Supply balanced and one rotor phase is open with others shorted

ix) Supply unbalanced and one rotor phase is open with others shorted

(Note: Speed is same in all cases) (5)

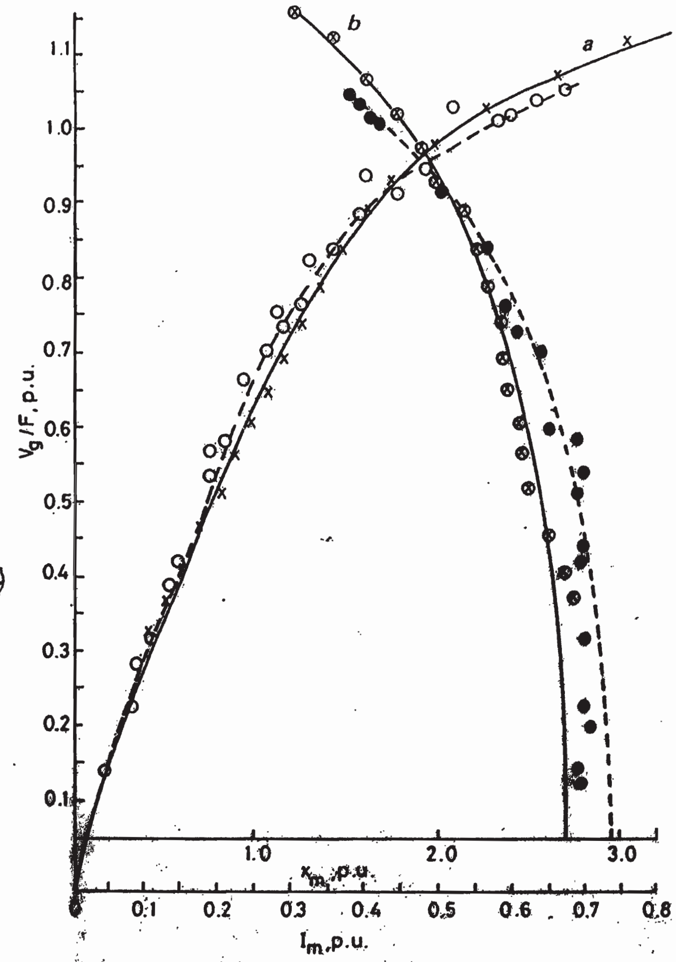

Fig. 1 *Magnetisation curve for 3.7 kW, 4 pole, 50 Hz induction machine*

a Φ/F, V_g, I_m
× × × design points
—— fitted curve (design points)
⊙⊙⊙ expt. points
- - - fitted curve (expt. points)
b V_g/F, V_g, x_m
—— from fitted curve
⊗⊗⊗ design points
● ● ● from expt. points
- - - fitted curve (expt. points)

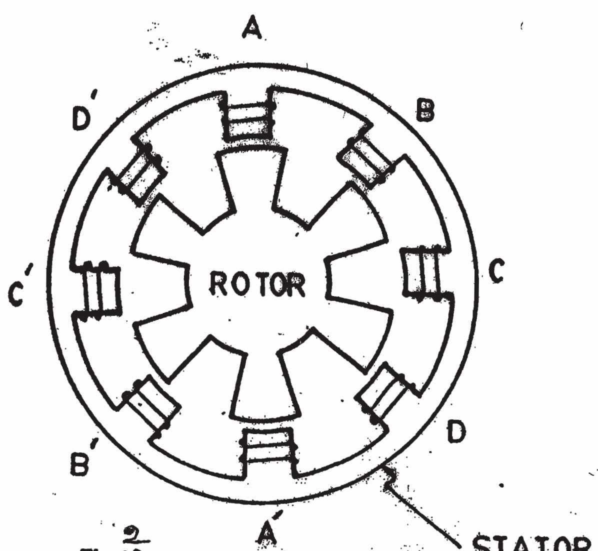

Fig. 2 Cross section of four phase SRM