FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
HARMATTAN SEMESTER EXAMINATION FOR 2012/2013 ACADEMIC SESSION
COURSE TITLE: ELECTRICAL MACHINES COURSE CODE: PSE 411
INSTRUCTION: ANSWER FIVE QUESTIONS ONLY DATE: 18TH MARCH, 2013. TIME: 3HOUR

Q1(a). With the aid of useful sketches, outline any three classes of DC motors, their equivalent circuits and show when their speed/torque characteristics attain equilibrium.

(b). Briefly explain the step-by-step operation of a simple DC machine.

(c). A DC shunt-wound motor is supplied with 300V. The armature resistance is 10Ω and the field winding has a resistance of 500Ω. When running with a torque of 100Nm, the motor takes 30A.

i). Determine the speed of the motor

ii). If the torque is increased to 120Nm, without any change in field current, find the new speed.

Q2(a). Using simple waveforms, explain the interactions between current, voltage and flux in the ideal transformer, (hint: V_1, I_μ, E_1, E_2 and ϕ).

Also derive the emf equations of the ideal transformer for E_1 and E_2.

(b). A single phase transformer has 400 turns in the primary and 1600 turns in the secondary. The cross-sectional area of the core is $90cm^2$ and the primary winding is connected to a 50Hz supply at 300V. Find the maximum flux density and the induced voltage in the secondary.

Q3(a). With the aid of sketches, explain the interaction of the parameters in 2(a) for a transformer with losses, but no magnetic leakage.

(b). A transformer has a primary winding of 100 turns and a secondary winding of 200 turns. When the load current on the secondary is 60A at 0.85p.f lagging, the primary current is 20A at 0.707p.f lagging. Determine graphically or otherwise the no-load current of the transformer and its phase angle with respect to the voltage.

(c). Briefly explain any two tests that can be carried out on DC machines

Q4. A Star-connected asynchronous motor rated 415V(line voltage), 25HP, 50Hz, four poles, has the following machine parameters in ohms/phase refered to the stator: $R_1 = 0.64, R_2' = 0.33, X_1 = 1.10, X_2' = 0.46, X_m = 26$. Assuming the operating slip of 2.2% at rated voltage and frequency, and a constant losses of 1100W comprising core losses and rotational losses, Calculate: (i) Motor's speed in rad/sec and in rev/min. (ii) Stator current (iii) Power factor (iv) Mechanical Power, P_{mech} and Output power, P_{out} (v) Induced torque, T_{ind} and Load torque, T_{load} (Nm).

Q5. Draw the equivalent circuits and phasor diagrams of: (a) Cylindrical-rotor Synchronous generator (b) Cylindrical-rotor Synchronous motor. Assume negligible armature resistance in both cases. (c) Derive the expressions for maximum electrical output Power, $P_{o(max)}$ for (a) and maximum gross output Power, $P_{g(\max)}$ for (b). Give the expression for load angle δ at which (c) is attained. (d) Draw the phasors showing the generator's operation at (i) 0.8 P.F lagging (ii) 0.8 P.F leading and (iii) 1.0 P.F

Q6. (a) Draw the equivalent circuit model of a Salient pole Synchronous generator, and (b) use the phasor diagram of the machine in (a) with armature resistance neglected to derive the expression for active power and the machine's developed torque respectively. (c) Draw the torque-speed characteristic of the machine and show that there is a torque even in the absence of excitation. (d) State the advantages of Salient pole generator over cylindrical rotor type.