

FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
RAIN SEMESTER 2013/2014 EXAMINATION
PSE 506: ELECTRIC DRIVE SYSTEMS
INSTRUCTIONS: : ANSWER FIVE QUESTIONS ONLY Time: 3 Hrs.

1 a. Explain the statement that “an induction motor cannot run at synchronous speed” **b.** Define the term “slip” as it applies to induction motors. **c.** A 3-phase induction motor runs at almost 1,000 rpm at no load and 950 rpm at full load when supplied with power from a 50Hz 3-phase line. **(i)** How many poles has the motor? **(ii)** What is the percentage slip at full load? **(iii)** What is the corresponding frequency of rotor voltage? **(iv)** What is the corresponding speed of the rotor field with respect to the rotor? **(v)** What is the corresponding speed of the rotor with respect to the stator? **(vi)** What is the corresponding speed of the rotor field with respect to the stator field? **(vii)** What is the rotor frequency at a slip of 10%?

2a. Enumerate the different methods by which the torque-speed characteristics of a three-phase induction motor can be modified. **b.** A 460-V, 25hp, 60Hz, four-pole, 3-phase wound-rotor induction motor has the following impedances in ohms per phase referred to the stator circuit; $R_1=0.641 \Omega$, $R_2=0.330 \Omega$, $X_1=1.106 \Omega$, $X_2=0.464 \Omega$. **(i)** What is the maximum torque of this motor? At what speed and slip does it occur? **(ii)** What is the starting torque of this motor? **(iii)** When the rotor resistance is doubled, what is the speed at which the maximum torque now occurs? What is the new starting torque of the motor?

3a. State three non-linear effects in a.c Machine modelling. **b.** Starting from the first principle, derive an expression for the energy consumption during starting of a d.c motor. **c.** What are the methods used in reducing energy loss during starting of motors.

4a. From the equivalent circuit of the rotor of an induction motor, show that the expression for the rotor current is given by:

$$I_2 = \frac{E_2}{\sqrt{\left(\frac{R_2}{s}\right)^2 + X_2^2}}$$

all variables have their usual meanings.

(b) An 1.100V, 50Hz delta connected induction motor has a star connected slip-ring rotor with a phase transformation ratio of 3.8 the rotor resistance and standstill leakage reactive are 0.012Ω and 0.25Ω per phase respectively. Neglecting stator impedance and magnetizing current, determine: **(i)** the rotor current at start with slip rings shorted. **(ii)** the rotor power factor at start with slip rings shorted. **(iii)** the rotor current at 4% slip with slip-rings shorted. **(iv)** the external rotor resistance per phase required to obtain a starting current of 100A in the stator supply lines.

5a. Write the voltage equations of the three reference frames in which the modelling of electric machines are based. State the meaning of each symbol. **b.** Explain how skin effect affects the selection of motor for industrial drives. **c.** Compute the eddy current skin-depth for aluminium slot having the following parameters: Bar size = 0.3 Cm wide and 2.00 cm deep, Slot width = 0.315 cm, Frequency = 60Hz, Resistivity = $3.47 \times 10^{-8} \Omega\text{m}$.

6a. The stator voltage equation of an induction machine is given by: $V_s^{abc} = P\lambda_s^{abc} + r_s^{abc} I_s^{abc}$. Write the equations in full. **b.** Transform only the voltage equation in (b) above to its equivalent **qd0** frame.

