# GUJARAT TECHNOLOGICAL UNIVERSITY M. E. - SEMESTER – I • EXAMINATION – WINTER • 2013

Subject Code: 710709N

Date: 06-01-2014

Subject Name: Electrical Drives

Time: 10.30 am – 01.00 pm

### **Instructions:**

# **Total Marks: 70**

- 1. Attempt all questions.
- 2. Make suitable assumptions wherever necessary.
- 3. Figures to the right indicate full marks.
- Q.1 (a) Discuss the speed-torque characteristics of an Induction motor fed by a variable 07 voltage variable frequency source. With appropriate mathematical analysis, show the effect of variation of frequency on torque and power capability of the motor. Also, show the relative variation of slip speed, terminal voltage and the current drawn by the motor.
  - (b) Discuss the four quadrant operation of an electrical drive by considering an or example of an electrical vehicle. Clearly mention the conditions required to operate in respective quadrants.
- Q.2 (a) Explain various modes of operation of 1-phase fully-controlled rectifier-fed of separately excited motor for regenerative braking with the help of neat sketch indicating status of devices and parameters unambiguously.
  - (b) Derive an expression for the critical speed  $\omega_{mc}$  of a separately excited DC 07 motor fed from a single-phase half-controlled rectifier.

### OR

- (b) Draw and explain the speed-torque characteristics of a 3-phase fullycontrolled rectifier drive. Also find the expression for no-load speed. List the assumptions if any.
- Q.3 (a) Explain the non-simultaneous control mode operation of a dual converter. 07 Hence, discuss the four quadrant closed-loop control of a DC separately excited motor employing the dual converter.
  - (b) What is composite braking? Explain in detail with suitable example and plots. 07 OR
- Q.3 (a) Write a brief note on the various current control schemes used with DC motor. 07
  - (b) A 230V, 500 rpm, 90A separately excited DC motor has the armature resistance **07** and inductance 0f 0.115 $\Omega$  and 11mH respectively. The motor is controlled by a two quadrant (class C) chopper operating from a voltage source of 230V. If the switching frequency is 400 Hz, calculate (i) motor speed for a motoring operation at  $\delta = 0.5$  and half the rated torque (ii) motor speed for regenerating operation at  $\delta = 0.5$  and rated torque.
- Q.4 (a) What is the effect on the motor efficiency and the current drawn from the source, when speed control of an induction motor is achieved by varying the stator (terminal) voltage (with fixed frequency)? Discuss in brief the various AC voltage controller configurations that can be employed for the stator voltage control technique.
  - (b) For a doubly-fed wound rotor induction motor, discuss the principle of injecting a voltage in the rotor circuit to obtain sub-synchronous motoring and subsynchronous braking operation.

#### OR

Q.4 (a) Justify the following statement: "The voltage source fed induction motor can be operated with open-loop control while the current source fed induction motor is

usually operated in closed-loop control." Also, draw the speed torque characteristics of an induction motor (i) when fed by voltage source and (ii) when fed by current source. For these two cases, comment on the location of the operating points on these characteristics to achieve optimum performance.

- (b) With neat diagram explain closed-loop slip-speed control for controlling the 07 speed of a VSI fed induction motor. Clearly explain the function of each block used.
- Q.5 (a) Derive the performance equations of a wound field cylindrical rotor 07 synchronous motor operating from a source having constant voltage and constant frequency.
  - (b) A 460 V, 60 Hz, 6-pole, 1180 rpm, star-connected squirrel cage induction 07 motor has following parameters per phase referred to the stator:  $R_s=0.19\Omega$ ,  $R_r=0.07\Omega$ ,  $X_s=0.75\Omega$ ,  $X_r=0.67\Omega$  and  $X_m=20\Omega$ .

The motor is fed by a 6-step inverter, which in turn is fed by a 6-pulse fully controlled rectifier.

- (i) If the rectifier is fed by an ac source of 460V and 60Hz, what should the rectifier firing angle be to get the rated fundamental voltage across the motor?
- (ii) If the machine is operated at constant flux calculate the inverter frequency at 600rpm and rated torque.
- (iii) If the machine is operated at constant flux calculate the inverter frequency at 500rpm and half the rated torque.

#### OR

- Q.5 (a) Comment on the voltage, current and power ratings of the converters used in the Static Scherbius drive vis-à-vis that of the rating of the inverter used for VVVF control from the stator side.
  - (b) Which harmonics are dominant in the output voltage of a six-step inverter? 07 Discuss the effects of these harmonics on the performance of an induction machine fed from a six-step inverter.

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