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*(University of Choice)*

**MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY**
**(MMUST)**

**MAIN CAMPUS**

**UNIVERSITY SPECIAL/SUPPLEMENTARY EXAMINATIONS**
**2021/2022 ACADEMIC YEAR**

**FIFTH YEAR EXAMINATIONS**

**FOR THE DEGREE**
**OF**
**BACHELOR OF SCIENCE IN ELECTRICAL AND COMMUNICATION ENGINEERING**

**COURSE CODE: ECE 513E**

**COURSE TITLE: ELECTRICAL MACHINE DRIVES & INDUSTRIAL APPLICATIONS**

**DATE: 5th October, 2022** **TIME:12.00 noon-02.00 p.m.**

**INSTRUCTIONS TO CANDIDATES**

Question ONE (1) is compulsory
Answer Any Other TWO (2) questions

TIME: 2 Hours

## Question 1 (30 Marks)

(a) Describe an electrical drive and give the main reasons of using drives in electric motor control. (4 marks)

(b) With aid of a well-illustrated diagram, explain the different components of an electronic drive system. (6 marks)

(c) Derive the voltage equation of a d.c motor and explain the significance of back e.m.f. (6 marks)

(d) With the aid of a simple sketch (torque/speed characteristic), define the following as applied to three phase induction motors.

i.. Sketch a typical torque/speed characteristic of a three phase induction motor, define the following and indicate them on the sketch

ii.. Pull -up torque. (1 mark)

iii.. Nominal torque. (1 mark)

iv.. breakdown torque. (1 mark)

(e) With the aid of well-illustrated diagrams, explain the Four-quadrant operation of an Induction Motor. (7 marks)

(f) A separately excited d.c. motor turns at 1200 r.p.m when the armature is connected to a 115 V source. Calculate the armature voltage required so that the motor runs at 100 r.p.m. (4 marks)

## Question 2 (20 Marks)

(a) calculate the full load current of a 75 kW, 4000 V, 3-phase, 900 r.p.m 50 Hz induction motor.. (7 marks)

(b) Explain the 'plugging' method used to slow a 3 -phase induction motor, list one disadvantage of the method (4 marks)

(c) Explain the key differences between induction machines and synchronous machines with regard to construction, operation (viz slip and synchronous speeds). (4 marks)

(d) (e) A 3-phase 10 kW, 415 V, 50 Hz 6 pole, wound rotor induction motor drives a variable-speed centrifugal pump. When the motor is connected to a 415 V line, the open-circuit rotor line voltage is 300 V. A 3-phase 415 V/240 V transformer is connected between the inverter and the line. If the motor has to develop 8 kW at a speed of 2000 rpm, calculate the following

(a) the power output of the rotor. (2 marks).

(b) rotor voltage and line voltage . (3 marks).

**Question 3 (20 Marks)**

(a) Explain the working principle of a thyristor. (4 marks).

(b) A Y-connected three-phase, 415V, 200kW, 50Hz, 8-pole wound-rotor induction motor controls the speed of a pump. Its speed is controlled with variable rotor resistance. The torque required by the pump varies as the square of its speed. At full load, the motor operates with slip s = 0.03 with the slip rings short circuited. The slip-torque relationship of the motor can be assumed to be linear from no-load to full-load. The resistance R0 2 of each phase of the rotor is 0.02. Find the value of the additional rotor resistance that must added to the rotor per-phase so that the motor runs at 600 rev/min. (9 marks)

(c) Explain regenerative braking in the context of induction motors. (3 marks)

(d) Explain the working principle of an IGBT. (4 marks)

**Question 4**

(a) Derive the e.m.f equation of a d.c motor and explain the significance of back e.m.f. (8 marks)

(b) A 30MVA, 15 kV, 60 Hz ac generator has a synchronous reactance of 1.2 pu and a resistance of 0.02 pu. Calculate

i. The base voltage, base power and base impedance of the generator. (3 marks)

ii. The actual value of the synchronous reactance. (2 marks)

iii. The actual winding resistance, per phase. (2 marks)

(c) Explain how the theory of a separately excited d.c machine is exploited to simplify control of a.c machines. (5 marks)

**Question 5**

(a) With the aid of typical torque -speed characteristic curve of a three phase squirrel cage induction motor operating at fixed voltage and frequency, explain the Four Quadrant operation of a three phase induction motor. (8 marks)

(b) A machine is turning clockwise in quadrant 3. Does it develop a clockwise or counter-clockwise torque? Explain. (3 marks)

(c) A 560 kW, 1200 r/min dc motor is connected to a 208 V, 3-phase, 60 Hz line using a 3-phase bridge converter (Fig. 1). The full-load armature current is 2500 A and the armature resistance is 4 m$\Omega$. The firing angle of the converter is $\alpha = 27°$ under rated full load conditions. Calculate

i. Converter voltage $E_d$. (3 marks)

ii. Armature $IR$ drop at rated current. (2 marks)

iii. Counter-emf ($E_0$) at 1200 r/min. (2 marks)

(d) Explain the basic difference between a line-commutated and a self-commutated inverter. (2 marks)

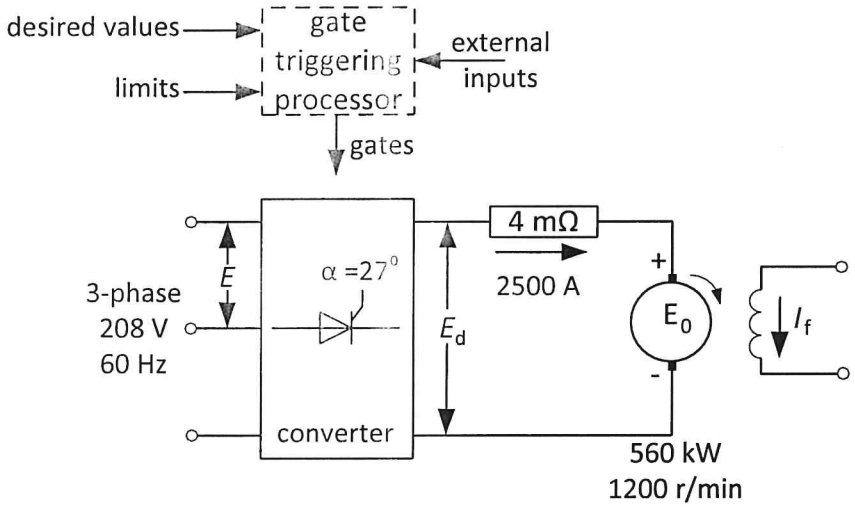


Figure 1: Dc motor with 3 phase bridge converter