National Exams May 2018

16-Elec-B8, Power Electronics and Drives

3 hours duration

NOTES

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit, with the answer paper, a clear statement of any assumptions made.

2. Any non-communicating calculator is permitted.

3. This is an **Open Book** examination. Note to the candidates: you must indicate the type of calculator being used, i.e. write the name and model designation of the calculator on the first inside left hand sheet of the exam work book.

4. Attempt all parts. The maximum total score is 125 points includes a bonus of 25 points.

Part 1 (50 points)

	a-	Define the delay angle of phase-controlled rectifier.	
	b-	What is the function of the freewheeling diode in a phase-controlled rectifier?	[2.5 Points]
	c-	What are the advantages of the free-wheeling diode in a rectifier circuit?	[2.5 Points]
	d-	what are the advantages of a GTO over a BJT	[2.5 Points]
5	e-	In power electronic circuits, what does the term commutation mean?	[2.5 Points]
	f-	Define the term natural commutation.	[2.5 Points]
	g-	What are the two types of AC voltage controllers? which one is preferred and why?	[2.5 Points]
	h-	Discuss the advantages of AC voltage controllers.	[2.5 Points]
	i-	What are the disadvantages of armature resistance control?	[2.5 Points]
10	j-	What do you understand by constant torque drive and constant power drive?	[2.5 Points]
	k-	List three methods for starting an induction motor.	[2.5 Points]
	l-	What are the disadvantages of the stator voltage control method?	[2.5 Points]
	m-	What are the advantages and disadvantages of rotor resistance control?	[2.5 Points]
	n-	Is it Possible to Use the same soft starter to start two MV induction motors?	[2.5 Points]
15	o-	Define electric drives.	
	p-	What is meant by slip power?	[2.5 Points]
	q-	What are the advantages of slip power recovery system?	[2.5 Points]
	r-	What is meant by V/Hz control?	[2.5 Points]
	s-	What are the advantages of V/Hz control?	[2.5 Points]
20	t-	What is the difference between a variable frequency drive (VFD) and a variable speed drive (VSD)?	[2.5 Points]

Part 2 (75 Points)

Attempt all 5 problems.

PROBLEM 1 (15 Points)

The ac supply voltage to a controlled half-wave rectifier is 220 V. The load circuit consists of a resistance R in series with a dc source E_c (the internal EMF of a dc motor.) When the average value of the dc output current is 32 A, the conduction angle is $\gamma = 145^o$, and $\alpha_{min} = 21^o$

a- Find the value of the dc source E_c, the delay angle α, and the load resistance R [7.5 points]

b- Assume that the delay angle is adjusted to $\alpha = 30^o$, find the average power absorbed by the dc source E_c. What is the motor's horsepower output value under these conditions [7.5 Points]

PROBLEM 2 (15 Points)

A 120-V, 60-Hz single phase source supplies a single-phase, full-wave ac voltage controller operating with a conduction angle $\gamma = 135^o$.

a- The controller supplies an ac motor whose power factor varies from 0.4 at starting to 0.8 at full load. Determine the corresponding values of the delay angle α. [7.5 points]

b- Determine the ratio of the output voltage to input voltage corresponding to the conditions of part (a.) [7.5 points]

PROBLEM 3 (15 Points)

The voltage input to a basic chopper circuit is V_i = 24 V. The period of the chopper is 2 ms. The load consists of a series combination of R = 1.8 Ω and an inductance $L=0.45 \times 10^{-3}$ H. The ratio of minimum to maximum values of the output current is 0.75. Determine the following:

a- The time constant of the load circuit, and the on-time. [5 Points]

b- The maximum and minimum values of the output current. [5 Points]

c- The time domain expressions of the chopper output currents, and the values of the output current at t= 1 ms and t=1.5 ms, respectively [5 Points]

PROBLEM 4 (15 Points)

A three-phase, eight-pole Y-connected induction motor with negligible no-load losses has the following parameters at 50 Hz:

$$R_s = 0.2\Omega \qquad R_r = 0.22\Omega$$

$$X_s = 1.1\Omega \qquad X_r = 1.5\Omega \qquad X_m = 10.417\Omega$$

The motor is controlled by a current source inverter and the input current is kept constant at 40 A. When the frequency is 50 Hz, the developed torque is 180 N.m. The approximate equivalent circuit corresponding to this mode of operation is given in Fig. (1.) Determine:

a- The slip and rotor speed. [7.5 points]

b- The terminal voltage per phase and the power factor. [7.5 points]

Use the following torque formula for constant current operation:

$$T = \frac{3\left[X_m I\right]^2 (R_r / s)}{s\omega_s \left[\left(R_s + \frac{R_r}{s}\right)^2 + (X_m + X_s + X_r)^2\right]}$$

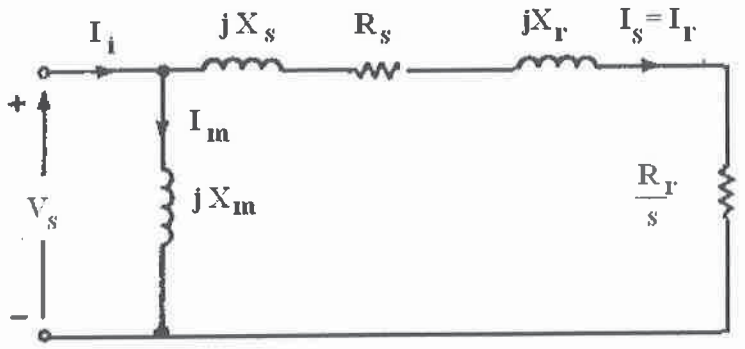

Figure (1) approximate equivalent circuit for Constant current operation of a three-phase induction motor

PROBLEM 5

A three-phase, full wave, bridge rectifier circuit feeds the armature terminals of a separately excited dc motor. The ac voltage source is 220 V (line-to-line). The motor draws an armature current of 155 A all the time.

a- Find the armature voltage when the firing angle of the rectifier circuit is 45° and speed is 1750 rpm [5 points]

b- To drive the motor at a speed of 1200 rpm, a firing angle of 55° is required. Find the resistance of the armature circuit, the output power and torque under these conditions. [5 points]

c- The firing angle is adjusted to 65°. Find the corresponding speed of the motor. [5 points]