National Exams December 2017

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. This is an Open Book examination.
3. Any non-communicating calculator is permitted. 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)

5	a-	Explain the reasons for using series smoothing reactors in inverter circuits	[2.5 Points]
	b-	Explain the functions of clamping capacitors and smoothing reactors in inverter circuits.	[2.5 Points]
	c-	Discuss three causes of harmonics in electric power distribution system.	[2.5 Points]
	d-	Explain the function of the free-wheeling diode in power electronic circuits.	[2.5 Points]
	e-	List and discuss five factors that influence the duration of the turn-off interval of an SCR.	[2.5 Points]
10	f-	Explain functions of clamping capacitors and smoothing reactors in inverter circuits.	[2.5 Points]
	g-	Explain functions of clamping capacitors and smoothing reactors in inverter circuits.	[2.5 Points]
	h-	Explain the principle of operation of a basic single-phase half wave controlled rectifier supplying a resistive load.	[2.5 Points]
	i-	Explain the principles of operation of basic chopper circuits and the effects of varying the on-time on operational modes of the chopper	[2.5 Points]
	j-	What are the types of dc drives based on the input supply? What are the variables to be controlled in a dc variable speed drive?	[2.5 Points]
15	k-	Explain the differences between current-fed inverters and voltage-fed inverters.	[2.5 Points]
	l-	Explain the principles of operation of a three-phase full wave bridge rectifier and how it is applied for speed control of a separately excited dc motor above and below rated speed	[2.5 Points]
	m-	Explain how the operation of a basic single-phase half wave controlled rectifier is affected if the load consists of resistance plus inductance in series with a dc voltage source.	[2.5 Points]
	n-	Explain the consequences of decreasing the supply frequency to an induction motor below the rated value while maintaining the value of the supply voltage constant at rated value.	[2.5 Points]
	o-	Explain the principle of operation of pulse width modulation (PWM) for inverter output voltage control. [5 points]	[2.5 Points]
20	p-	List at least three undesirable effects of using high frequency PWM drives.	[2.5 Points]
	q-	Explain why Silicon carbide (SiC), (also known as carborundum) is used in semiconductor electronics devices that operate at high temperatures or high voltages, or both.	[2.5 Points]
	r-	Explain in your own words the role of power electronic systems in renewable energy systems.	[2.5 Points]
	s-	Explain in your own words the role of power electronic systems in the smart grid.	[2.5 Points]
	t-	Explain in your own words the role of power electronic systems in the smart home.	[2.5 Points]

Part 2 (75 Points)

Attempt all 5 problems.

PROBLEM 1 (15 Points)

The ac supply voltage to a half-wave controlled rectifier is 120 V. The load circuit consists of a resistance R in series with an inductance L, with a power factor of 0.707. Complete the table shown below.

	Delay angle α	Conduction angle γ	Average value of dc output current I (A)	Load resistance R (Ω)	
A	?	145^o	25	?	[7.5 Points]
B	?	150^o	?	1.2	[7.5 Points]

PROBLEM 2 (15 Points)

A single-phase, 230 V (rms,) 60-Hz source supplies a full-wave a.c voltage controller. The controller powers a 100-hp motor, whose power factor is 0.85. The corresponding conduction angle is $\gamma = 165^o$.

b- Find the delay angle α . [5 Points]

c- Find the effective (rms) output voltage of the controller. [5 Points]

d- Assume that the efficiency of the motor is 0.95; find the average current through each of the thyristors of the controller. [5 Points]

PROBLEM 3 (15 Points)

The voltage input to a basic chopper circuit is V_i = 24 V, and the maximum allowed current is 20 A. The load consists of a series combination of R and an inductance with a time constant τ. Complete the entries of the table given below.

CASE	Chopper period (T) ms	On-Time (T_{on}) ms	Time Constant τ ms	Load Resistance R Ω	
1	2.50	2.00	1.25	?	[5 Points]
2	?	2.50	1.00	1.15	[5 Points]
3	1.2	?	1.5	0.9	[5 Points]

PROBLEM 4 (15 Points)

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

$R_s = 0.2\Omega$ $R_r = 0.3\Omega$

$X_s = 1.\Omega$ $X_r = 1.5\Omega$ $X_m = 10.42\Omega$

The motor is controlled by a current source inverter and the input current is kept constant at 12.5 A. The approximate equivalent circuit corresponding to this mode of operation is given in Fig. (1.)

a- Find the slip for a developed torque of 400 N.m, [10 Points]

b- Find the developed torque for a slip of 0.05 [5 Points]

Use the following torque formula for constant current operation:

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

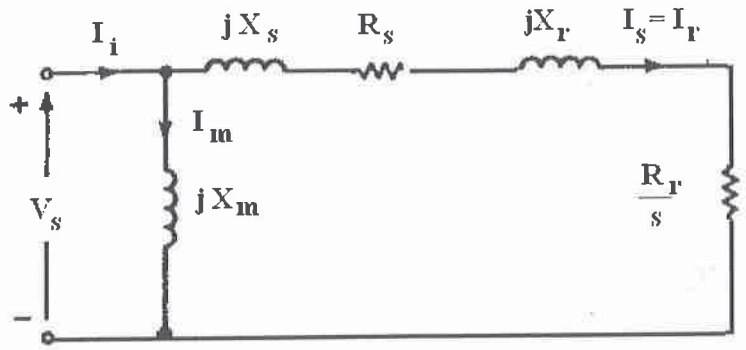

Figure (1) Approximate equivalent circuit for constant current operation of a three-phase induction motor

PROBLEM 5 (15 Points)

The armature of a separately excited dc motor is connected to a three-phase 230 V (line-to-line,) full wave, bridge-rectifier. Assume that the dc voltage drop in the armature circuit is constant at 20 V.

a- Find the firing angle of the rectifier circuit when the motor speed is 1750 rpm for a dc armature voltage of 220 V [5 points].

b- Find the firing angle of the rectifier circuit when the motor speed is reduced to 95% of its speed of part (b.) [5 points]

c- Find the speed of the motor for a firing angle of 55°. [5 points]