National Exams May 2019

16-Elec-B8, Power Electronics and Drives

Open Book examination

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 220 points. A score of 150 points is a full mark (100%)
5. Please make sure to clearly indicate the steps followed to arrive at each solution (result.) Failure to do so, will result in a null mark for the part answered.
6. It is the candidate's responsibility to write his/her name on the bottom of each examination sheet and answer the qualitative questions clearly. It is also mandatory to submit the examination sheets inside the examination answer booklets.

CANDIDATE NAME: _____

Part 1-A (50 points)

5	a-	Define the term "harmonics" in electric power applications.	[5 Points]
	b-	A transformer designed for operating off a 50 Hz supply is to be operated off a 60 Hz supply. Explain the effect on core losses.	[5 Points]
	c-	Explain briefly the Pulse Width Modulation technique.	[5 Points]
	d-	Explain the principle of operation of a DC link converter.	[5 Points]
	e-	Explain the principle of operation of Multilevel Inverters.	[5 Points]
10	f-	Describe the function of a snubber in a power electronic circuit.	[5 Points]
	g-	Explain why Power MOSFETS are preferred devices in low voltage, low power and high frequency applications.	[5 Points]
	h-	Explain how modern static VAR compensators (SVC, SVG or STATCOM), based on power electronics, help improving system power factor and bus voltage control.	[5 Points]
	i-	Loads such as induction motors, heating furnaces, pumps, and blowers require variable ac supply. The conversion of fixed AC supply to variable AC can be done by autotransformers. Explain the disadvantages of his approach.	[5 Points]
	j-	Explain the principle of operation of a bidirectional AC voltage controller.	[5 Points]

Part 1-B (50 points)

Multiple Choice Questions

Question 1		
In a three-phase half wave rectifier the primary side of the transformer is delta connected because:		[5 Points]
a-	it has no neutral connection	
b-	we can get greater output voltage	
c-	it provides a path for the triplen harmonics	
d-	it provides better temperature stability	
Answer		
Explanation		

Question 2		
Which device can be used in a chopper circuit?		[5 Points}
a-	BJT	
b-	MOSFET	
c-	GTO	
d-	All the above	
Answer		
Explanation		

CANDIDATE NAME: _____

Question 3		
The chopper is a		[5 Points}
a-	Time ratio controller	
b-	AC to DC converter	
c-	DC transformer	
d-	High speed semiconductor switch	
Answer		
Explanation		

Question 4		
Static UPS requires		[5 Points}
a-	only rectifier	
b-	only inverter	
c-	both inverter and rectifier	
d-	none of the above	
Answer		
Explanation		

Question 5		
AC voltage controllers convert		[5 Points}
a-	fixed ac to fixed dc	
b-	variable ac to variable dc	
c-	fixed ac to variable ac	
d-	variable ac to fixed ac	
Answer		
Explanation		

CANDIDATE NAME: _____

Question 6		
In the principle of phase control		[5 Points]
a-	the load is on for some cycles and off for some cycles	
b-	control is achieved by adjusting the firing angle of the devices	
c-	control is achieved by adjusting the number of on off cycles	
d-	control cannot be achieved	
Answer		
Explanation		

Question 7		
HVDC transmission lines are _____ as compared to HVAC lines.		[5 Points]
a-	difficult to erect	
b-	more expensive for long distances	
c-	more expensive for short distances	
d-	less expensive for short distances	
Answer		
Explanation		

Question 8		
A TRIAC is used in		[5 Points]
a-	chopper	
b-	speed control of induction machine	
c-	speed control of universal motor	
d-	none of the above	
Answer		
Explanation		

Question 9

CANDIDATE NAME: _____

AC voltage controllers convert		[5 Points}
a-	fixed ac to fixed dc	
b-	variable ac to variable dc	
c-	fixed ac to variable ac	
d-	variable ac to fixed ac	
Answer		
Explanation		

Question 10		
In inverters, to make the supply voltage constant		[5 Points}
a-	an inductor is placed in series with the load	
b-	capacitor is connected in parallel to the load side	
c-	capacitor is connected in parallel to the supply side	
d-	none of the abovementioned	
Answer		
Explanation		

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Part 2 (120 Points)

Attempt all 4 problems.

PROBLEM 1 (30 Points) Rectifier

The ac supply voltage to a controlled half-wave rectifier is 220 V. The load circuit consists of a resistance R in series with an inductance L, with a power factor of 0.8. Complete the table shown below.

	Delay angle α	Conduction angle γ	Average value of dc output current I (A)	Load resistance R (Ω)	
A	?	150^o	27.5	?	[15 Points]
B	?	147.5^o	?	1.3	[15 Points]

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PROBLEM 2 (30 Points) ac voltage controller

A 120-V, 60-Hz single phase source supplies a single-phase, full-wave ac voltage controller operating with a conduction angle $\gamma = 138^o$.

a- The controller supplies an ac motor whose power factor 0.8 at full load. Determine the corresponding value of the delay angle α and the ratio of the output voltage to input voltage [15 points]

b- Assume now that $\gamma = 135^o$ and that the power factor of the load is 0.85, determine the corresponding value of the delay angle α and the ratio of the output voltage to input voltage [15 points]

PROBLEM 3 (30 Points) chopper

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	2.40	1.8	1.5	?	[10 Points]
2	?	2.40	1.45	1.25	[10 Points]
3	1.80	?	1.5	0.9	[10 Points]

PROBLEM 4 (30 Points) DC Motor Control

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 150 A all the time.

a- Find the armature voltage when the firing angle of the rectifier circuit is 45° and speed is 1750 rpm [15 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. [15 points]

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