Total No. of Questions: 6 *Total No. of Printed Pages:3*

Enrollment No......................................

Faculty of Engineering
End Sem Examination May-2024
EE3CO55 Power Electronics

Programme: B.Tech. Branch/Specialisation: EE

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d. Assume suitable data if necessary. Notations and symbols have their usual meaning.

Q.1 i. Which characteristic is crucial for understanding the switching speed of Power MOSFET and Power IGBT? **1**

(a) Static capacitance
(b) Dynamic resistance
(c) Gate threshold voltage
(d) Avalanche breakdown voltage

ii. Which analogy is commonly used to understand the operation of an SCR? **1**

(a) Thermionic emission (b) Two-transistor
(c) Operational amplifier (d) Zener diode

iii. What is the primary mode of operation of a dual converter? **1**

(a) AC to DC conversion (b) DC to AC conversion
(c) Bidirectional power flow (d) Unidirectional power flow

iv. A Single-phase Semi-Converter uses: **1**

(a) 2 SCRs and 2 diodes (b) 4 SCRs
(c) 4 SCRs and 2 diodes (d) 6 SCRs

v. In three-phase, fully controlled rectifier calculate the average output voltage if the supply is 400V and the firing angle is 45 degrees. **1**

(a) 381.97 V (b) 383.19 V (c) 384.25 V (d) 400 V

vi. In a three-phase semi-converter, firing angle is less than 60 degrees, as such each SCR and diode conduct respectively for ______ (in degrees). **1**

(a) 60, 60 (b) 90, 30
(c) 120, 120 (d) 180, 180

vii. Which of the converter is used for only stepping down the input voltage? **1**
(a) Buck converter (b) Boost converter
(c) Buck-boost converter (d) SEPIC converter

viii. In continuous conduction mode (CCM), the output voltage of a buck converter is determined by: **1**
(a) Duty cycle (b) Inductor current ripple
(c) Capacitor voltage ripple (d) Load resistance

ix. In a Voltage Source Inverter (VSI) output current depends on: **1**
(a) Load (b) Input voltage source
(c) Input current source (d) Filter

x. In a Current Source Inverter (CSI) device used are: **1**
(a) Unipolar and Bidirectional
(b) Bipolar and Unidirectional
(c) Unipolar and Unidirectional
(d) Bipolar and Bidirectional

Q.2 i. Draw and compare the static characteristics of power MOSFET and IGBT. **2**

ii. What is the significance of the static and dynamic characteristics of power semiconductor devices? **3**

iii. Discuss the importance of snubber circuits in power semiconductor devices and provide examples of situations where their implementation is beneficial. **5**

OR iv. How do different triggering methods, such as resistive triggering (R), resistive-capacitive triggering (RC), and unijunction transistor (UJT) triggering, influence the turn-on processes of SCR? **5**

Q.3 i. Explain the operating principle of a single-phase half-wave controlled rectifier. **2**

ii. Discuss the significance of freewheeling diodes in single-phase rectifiers with RL loads. How do they affect the performance of the rectification circuit? **8**

OR iii. Derive the expression for average output voltage in a single-phase fully controlled bridge rectifier. Explain the factors influencing the average output voltage. **8**

Q.4 i. Discuss the operating principle of a three-phase half-wave rectifier with an R load. How does it differ from a single-phase half-wave rectifier? **3**

ii. Compare the operation of single-phase step-down and step-up cycloconverters. How do they achieve frequency conversion and what are their respective applications? **7**

OR iii. How does varying the firing angle impact the output voltage waveform and output power of the three-phase fully controlled rectifier with R? **7**

Q.5 i. A buck DC-DC converter has the following parameters: **4**
Input voltage 50V, duty cycle 0.4, L = 400 μH, C = 100 μF, f = 20 kHz, R = 20 Ω assuming ideal components, calculate (a) the output voltage, and (b) the maximum and minimum inductor current.

ii. Investigate the impact of duty cycle (D) variations on the operation of buck, boost, and buck-boost converters in Continuous, Conduction Mode (CCM). How do changes in the duty cycle affect the converter's output voltage? **6**

OR iii. Discuss the continuous conduction mode (CCM) and discontinuous conduction mode (DCM) in buck converters. When would you choose one mode over the other? What factors influence this decision in practical applications? **6**

Q.6 Attempt any two:

i. Compare and contrast single-phase half-bridge and full-bridge inverters with resistive (R) loads. Discuss their advantages, limitations, and applications. **5**

ii. Discuss the operating principles and characteristics of the 120-degree conduction mode of three-phase square wave inverters. **5**

iii. How does the Current Source Inverter (CSI) differ from Voltage Source Inverters (VSI) in terms of operation and applications? Discuss the advantages and limitations of CSI systems. Explain why CSI technology is preferred over VSI. **5**

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Scheme of Marking

MEDI-CAPS UNIVERSITY Knowledge is Power	Faculty of Engineering End Sem Examination May-2024 Power System -I (T) - EE3CO56 (T) Programme: B.Tech. Branch/Specialisation:

Q.1	i)	Bundled conductors are mainly used in high voltage overhead transmission lines to c) Reduce corona	**1**
	ii)	The charging current in a transmission line increases due to corona effect because corona increases b) Effective conductor diameter	**1**
	iii)	What is the line to earth capacitance value of the short transmission line? d) Negligible	**1**
	iv)	Performance of short transmission lines depends on which of the following? b) Resistance and Inductance	**1**
	v)	String efficiency of overhead insulator approaches to 100%, when a) Shunt capacitance approaches zero and potential across each disc is the same.	**1**
	vi)	What is the number of suspension insulators required for 132 kV transmission? b) 8	**1**
	vii)	Sag is independent of b) Line voltage	**1**
	viii)	If supports are at equal levels and tension in an overhead line is increased to two times, then a) Sag decreases to half of the previous value	**1**
	ix)	The area under the load curve represents c) Number of units generated	**1**
	x)	Size and cost of installation depends upon b) Maximum demand	**1**
Q.2	i.	Each difference between GMD and GMR equal 1 Mark …. 2 difference 2 Marks .	**2**
	ii.	.The Inductance/phase/km = 1.274mH ….. 3 Marks	**3**
	iii.	Diagram with parameters of three phase transmission line for symmetrical spacing………….. 2 Marks Derivation………. 3 marks.	**5**

OR	iv.	Diagram with components of single phase transmission line for unsymmetrical spacing………….. 2 Marks Derivation……………. 3 marks.	**5**
Q.3	i.	Definition ……………. 2 marks Mathematical expression ……… 1 mark.	**3**
	ii.	Derivation……………..5 marks Phasor diagram ……….. 2 marks.	**7**
OR	iii.	Each calculation is equals to………. 2 marks, i.e., (a) sending end voltage = 33709 V …….. 2 Marks (b) transmission efficiency = 98.44 % ………. 2 Marks (c) sending end power factor = 0.79 ……… 2 Marks Phasor diagram …………… one mark	**7**
Q.4	i.	Definition ………… 1 mark, Diagram of pin type insulator ……… one mark Explanation ……….. two marks	**4**
	ii.	Construction ……… 2 mark Each advantage is equal to one mark (total 4 marks).	**6**
OR	iii.	Each calculation is equal to two marks, *i.e.,* (i) The ratio of capacitance between pin and earth to the self-capacitance of each unit = 0.375 …………..2 Marks (ii) The line voltage = 64.28kV…………2 Marks (iii) String efficiency = 68.28%.............2 Marks	**6**
Q.5	i.	Description of different methods ……….. four marks.	**4**
	ii.	(i) Definition ……………. 1 marks and (ii) Derivation…………….. five marks.	**6**
OR	iii.	(i) Definition ………….. 2 marks and (ii) Description of different types ……….. four marks.	**6**
Q.6			
	i.	(i) Schematic diagram ……….. 3 marks and (ii) Working ……………. 2 marks.	**5**
	ii.	(a) demand factor = 0.86956 ………(02 marks) (b) average demand = 7020.5 kW ……….(01 mark) (c) load factor = 0.351 or 35.1% ………….(02 marks)	**5**
	iii.	Average cost of electrical energy = 2.58/kWh…….. 5 Marks	**5**

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Power system - I

EE3CO56

solution

Q.2 (ii)

$D_{12} = 2m$, $D_{23} = 2.5m$, $D_{31} = 4.5m$

$D = 1.24\ cm \Rightarrow r = \frac{1.24}{2} = .62\ cm$

$L = 2\times10^{-7} \ln \frac{D_{eq}}{r'}$ H/m/p

$D_{eq} = \sqrt[3]{D_{12}D_{23}D_{31}} = \sqrt[3]{2\times2.5\times4.5} = \boxed{2.823\ m}$

$r' = 0.7788 r = 0.7788 \times 0.62 = 0.4828\ cm$

$= \boxed{0.48\cancel{2}8 \times 10^{-2}\ m}$

Now $L = 2\times10^{-7} \ln \frac{2.823}{0.4828\times10^{-2}}$ H/m

$= 2\times10^{-7} \ln(584.71)$ H/m $= 2\times10^{-7}\times 6.3711$

$= 12.742\times10^{-7}$ H/m $= 12.742\times10^{-4}$ H/Km

$= \boxed{1.2742\ mH/Km}$

Q.3 (ii)

$P_r = 1100KW = 1100\times10^3\ W$

$V_r = 33KV$, $\cos\phi = 0.8$ (lag)

$R = 10\Omega$, $X_L = 15\Omega$

$V_s = ?$ $\%\eta = ?$ $P_s = ?$

(a) $P_r = \sqrt{3} V_{rp} I_r \cos\phi$

$\Rightarrow I_r = \frac{P_r}{\sqrt{3} V_r \cos\phi} = \frac{1100\times\cancel{10^3}}{\sqrt{3}\times33\times\cancel{10^3}\times0.8}$

$= \boxed{24.05\ A}$

$V_{rp} = \frac{V_r}{\sqrt{3}} = \frac{\cancel{1100}\,33 \times 10^3}{\sqrt{3}} = \boxed{19052.55\ V}$ (2)

Now $V_{s_p} = V_{rp} + I_r R \cos\phi + I_r X \sin\phi$

$= 19052.55V + 24.05 \times 10 \times 0.8 + 24.05 \times 15 \times 0.6$

$= 19052.55 + 192.4 + 216.45$

$= \boxed{19461.4\ V}$

2

$\therefore V_s (\text{line}) = 33708.1\ V = \boxed{33.7\ KV}$

(b) I^2R Loss $= (24.05)^2 \times 10 = 5784.025\ W$

$= 5.784\ KW$

$\therefore$ sending end power

$P_s = P_r + I^2R$

$= 1100 KW + 5.784 KW$

$= 1105.\boxed{784\ KW}$

Transmission efficiency

$\% \eta = \frac{P_r}{P_s} \times 100$

2

$= \frac{1100}{1105.784} \times 100 = 99.47\%$

(c) sending end p.f

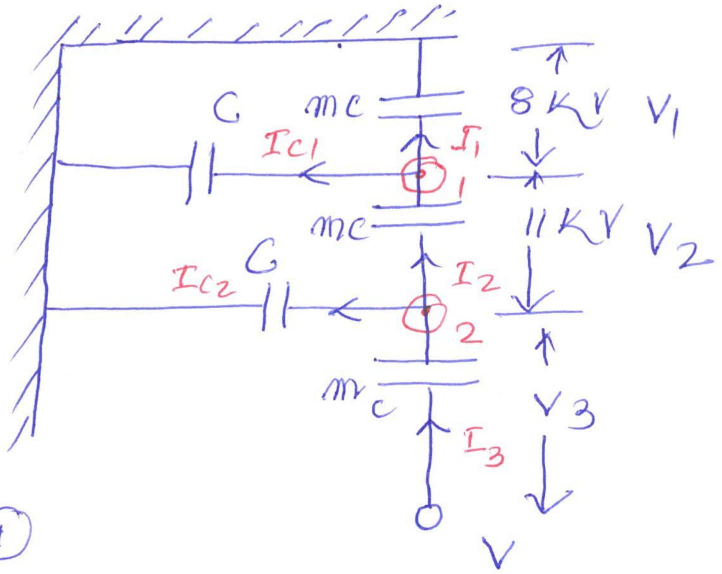
$P_s = \sqrt{3} V_s I_s \cos\phi_s$

$\Rightarrow \cos\phi_s = \frac{P_s}{\sqrt{3} \times V_s I_s} = \frac{1105.784 \times 10^3}{\sqrt{3} \times 33.7 \times 10^3 \times 24.05}$

$= \boxed{0.7877}$

2

Q.4 (iii) ③



At node ①

$$I_2 = I_1 + I_{C1} \quad \cdots \quad (1)$$

$$\Rightarrow \frac{V_2}{\frac{1}{\omega mC}} = \frac{V_1}{\frac{1}{\omega mC}} + \frac{V_1}{\frac{1}{\omega C}} \Rightarrow V_2 \omega mC = V_1 \omega mC + V_1 \omega C$$

$$\Rightarrow V_2 m = V_1 m + V_1 \Rightarrow V_2 m = V_1 (1+m)$$

$$\Rightarrow 11m = 8(1+m) = 8 + 8m$$

$$\Rightarrow 3m = 8 \Rightarrow m = \frac{8}{3} \Rightarrow \frac{1}{m} = \frac{3}{8} = \boxed{0.375}$$

2

At node-②

$$I_3 = I_2 + I_{C2}$$

$$\Rightarrow V_3 m\omega C = V_2 m\omega C + (V_1 + V_2)\omega C$$

$$\Rightarrow V_3 m = V_2 m + V_1 + V_2$$

$$\Rightarrow V_3 = V_2 + 0.375 (V_1 + V_2)$$

$$= 11 + 0.375 (11 + 8) = 18.125 \text{ KV}$$

$$\therefore V = V_1 + V_1 + V_3 = 8 + 11 + 18.125 = \boxed{37.125 \text{ KV}}$$

Line voltage $V_L = \sqrt{3} \times 37.125 = \boxed{64.3 \text{ KV}}$

2

% string efficiency $\eta = \frac{V}{n \times V_3}$

2

$$= 6 \; \frac{37.125}{3 \times 18.125} = \boxed{68.27\%}$$

Q 6 (i) connected Load = 23 MW (4)

Maximum demand = 20 MW

unit generated = 61.5×106 per annum

(1) Demand factor

$$= \frac{\text{Max. demand}}{\text{connected Load}} = \frac{20 MW}{23 MW} = \boxed{0.869}$$ 2

(ii) Average demand

$$= \frac{\text{unit generated/annum}}{\text{Hours in a year}}$$ 1

$$= \frac{61.5 \times 106}{8760} = \boxed{7020.5\ KW}$$

(iii) Load factor $= \frac{\text{Average demand}}{\text{Max. demand}}$ 2

$$= \frac{7020.5\ KW}{20{,}000\ KW} = \boxed{0.351}$$

(ii) (a) First 50KWh @ Rs 3.00/KWh

cost (a) = 50×3 = $\boxed{Rs\ 150}$

(b) Next 50 KWh @ Rs 2.80/KWh

cost (b) = $50 \times$ Rs 2.80 = $\boxed{Rs\ 140}$

(c) Next 40KWh @ Rs 2.50/KWh

cost (c) = 40×2.50 = $\boxed{Rs\ 100}$

(d) Next 30 KWh @ Rs 2.20/KWh 3

cost (d) = 30×2.20 = $\boxed{Rs\ 66}$

(e) Next 30KWh @ 2/KWh

∴ cos (d) = 30×2 = $\boxed{Rs\ 60}$

Total cost of 200 KWh

= Rs 150 + Rs 140 + Rs 100 + Rs 66 + Rs 60 = $\boxed{Rs\ 516}$ 1

Average unit cost = 516/200 = $\boxed{2.58}$ 1