Question Bank- EE 603
Type 2 & 3

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	POWER SEMI-CONDUCTOR DEVICES

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
Dr. Debabrata Roy	Assistant Professor	9432586471	debabrataroy1985@gmail.com

UNIT-I POWER SEMI-CONDUCTOR DEVICES

1. Why IGBT is very popular nowadays?
2. What are the different methods to turn on the thyristor?
3. What is the difference between power diode and signal diode?
4. IGBT is a voltage controlled device. Why?
5. Power MOSFET is a voltage controlled device. Why?
6. Power BJT is a current controlled device. Why?
7. What are the different types of power MOSFET?
8. How can a thyristor turned off?
9. Define latching current
10. Define holding current.
11. What is a snubber circuit?
12. What losses occur in a thyristor during working conditions?
13. Define hard-driving or over-driving.
14. Define circuit turn off time.
15. Why circuit turn off time should be greater than the thyristor turn-off time?
16. What is the turn-off time for converter grade SCRs and inverter grade SCRs?
17. What are the advantages of GTO over SCR?
18. What is meant by phase controlled rectifier?
19. Mention some of the applications of controlled rectifier.

Question Bank- EE 603
Type 2 & 3

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	CONTROLLED CONVERTERS

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
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UNIT-II PHASE-CONTROLLED CONVERTERS

1. What is the function of freewheeling diodes in controlled rectifier?
2. What are the advantages of freewheeling diodes in a controlled in a controlled rectifier?
3. What is meant by delay angle?
4. What are the advantages of single phase bridge converter over single phase midpoint converter?
5. What is commutation angle or overlap angle?
6. What are the different methods of firing circuits for line commutated converter?
7. Give an expression for average voltage of single phase semiconverters.
8. What is meant by input power factor in controlled rectifier?
9. What are the advantages of six pulse converter?
10. What is meant by commutation?
11. What are the types of commutation?
12. What is meant by natural commutation?
13. What is meant by forced commutation?
14. What is meant by dc chopper?
15. What are the applications of dc chopper?
16. What are the applications of dc chopper?
17. What is meant by step-up and step-down chopper?
18. Write down the expression for average output voltage for step down chopper.
19. Write down the expression for average output voltage for step up chopper.
20. What is meant by duty-cycle?

Question Bank- EE 603
Type 2 & 3

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	DC TO DC CONVERTER

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
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UNIT-III DC TO DC CONVERTER

1. What are the two types of control strategies?
2. What is meant by TRC?
3. What are the two types of TRC?
4. What is meant by FM control in a dc chopper?
5. What is meant by PWM control in dc chopper?
6. Write down the expression for the average output voltage for step down and step up chopper.
7. What are the different types of chopper with respect to commutation process?
8. What is meant by voltage commutation?
9. What is meant by current commutation?
10. What is meant by load commutation?
11. What are the advantages of current commutated chopper?
12. What are the advantages of load commutated chopper?
13. What are the disadvantages of load commutated chopper?
14. What is meant by inverter?
15. What are the applications of an inverter?
16. What are the main classification of inverter?
17. Why thyristors are not preferred for inverters?
18. How output frequency is varied in case of a thyristor?
19. Give two advantages of CSI.
20. What is the main drawback of a single phase half bridge inverter?

Question Bank- EE 603
Type 2 & 3

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	INVERTERS

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
Dr. Debabrata Roy	Assistant Professor	9432586471	debabrataroy1985@gmail.com

UNIT-IV INVERTERS

1. Why diodes should be connected in antiparallel with the thyristors in inverter circuits?
2. What types of inverters require feedback diodes?
3. What is meant a series inverter?
4. What is the condition to be satisfied in the selection of L and C in a series inverter?
5. What is meant a parallel inverter?
6. What are the applications of a series inverter?
7. How is the inverter circuit classified based on commutation circuitry?
8. What is meant by McMurray inverter?
9. What are the applications of a CSI?
10. What is meant by PWM control?
11. What are the advantages of PWM control?
12. What are the disadvantages of the harmonics present in the inverter system?
13. What are the methods of reduction of harmonic content?
14. Compare CSI and VSI.
15. What are the disadvantages of PWM control?
16. What does ac voltage controller mean?
17. What are the applications of ac voltage controllers?
18. What are the advantages of ac voltage controllers?
19. What are the disadvantages of ac voltage controllers?
20. What are the two methods of control in ac voltage controllers?

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	AC TO AC CONVERTERS

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
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UNIT-V AC TO AC CONVERTERS

1. What is the difference between ON-OFF control and phase control?
2. What is the advantage of ON-OFF control?
3. What is the disadvantage of ON-OFF control?
4. What is the duty cycle in ON-OFF control method?
5. What is meant by unidirectional or half-wave ac voltage controller?
6. What are the disadvantages of unidirectional or half-wave ac voltage controller?
7. What is meant by bidirectional or half-wave ac voltage controller?
8. What is the control range of firing angle in ac voltage controller with RL load?
9. What type of gating signal is used in single phase ac voltage controller with RL load?
10. What are the disadvantages of continuous gating signal?
11. What is meant by high frequency carrier gating?
12. What is meant by sequence control of ac voltage regulators?
13. What are the advantages of sequence control of ac voltage regulators?
14. What is meant by cyclo-converter?
15. What are the two types of cyclo-converters?
16. What is meant by step-up cyclo-converters?
17. What is meant by step-down cyclo-converters?
18. What are the applications of cyclo-converter?
19. What is meant by positive converter group in a cyclo converter?
20. What is meant by negative converter group in a cyclo converter?

Question Bank- EE 603
Type 4

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	POWER SEMI-CONDUCTOR DEVICES

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
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UNIT-I POWER SEMI-CONDUCTOR DEVICES

1. Explain the structure and operation of turn on and turn of characteristics of SCR
2.
    i. Describe the any two methods of turn-on mechanism of SCR.
    ii. Explain the turn off characteristics of SCR.
3. Discuss the transfer, output and switching characteristics of IGBT.
4. Explain the switching performance of BJT with relevant waveforms indicating clearly the turn on, turn off times and their components.
5.
    i. Draw and explain the forward characteristics of SCR using two transistor model of SCR.
    ii. Compare any six salient features of MOSFET with IGBT.
6.
    i. Compare the performance characteristics of MOSFET with BJT.
    ii. Briefly discuss the R-C triggering of SCR.
7. Discuss the operation of power MOSFET and explain the transfer, output and switching characteristics of power MOSFET.
8. Differentiate natural commutation and forced commutation.
9. Explain the operation of driver and snubber circuits for power MOSFET.
10. Explain with diagram the various modes of working of TRIAC.

Question Bank- EE 603
Type 4

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	CONTROLLED CONVERTERS

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
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UNIT-II PHASE-CONTROLLED CONVERTERS

1. Explain the operation of three phase half wave controlled converter with inductive load. Sketch the associated waveforms. (16)
2. With necessary circuit and waveforms, explain the principle of operation of three phase controlled bridge rectifier feeding R-L load and derive the expression for the average output dc voltage. (16)
3. Explain the operation of three phase semi converter with RLE load. Sketch the associated waveforms. (16)
4.
    i. Explain the effect of source inductance in the operation of single phase fully controlled converter, indicating clearly the conduction of various thyristors during one cycle. (8)
    ii. Explain the working of single phase dual converter with circuit diagram and waveforms. (8)
5. Explain the effect of source inductance in the operation of three phase fully controlled converter, indicating clearly the conduction of various thyristors during one cycle with relevant waveforms. (16)
6.
    i. Derive an expression for harmonic factor, displacement factor and power factor of a single phase semiconverter from the fundamental principle. (8)
    ii. Three phase fully controlled rectifier is connected to three phase ac supply of 230V, 60 Hz. load current is continuous and has a negligible ripple. If the average load current Idc =150 A and the commutating inductance Lc = 0.1mH. Determine the overlap angle when $\alpha = 10°$. (8)
7. A three phase half wave rectifier is operated from three phase star connected 208V, 60Hz supply. Load resistance =10 Ohm. If it is required to obtain an average output voltage 50 % of max possible output voltage. Calculate i)delay angle ii)rms value of output current iii)average value of output current iv) thyristor avg and rms current v) efficiency vi)TUF vii)supply power factor. (16)
8. Explain the operation of single phase dual converter with circulating and non circulating current type. (16)
9. Explain the operation of three phase dual converter with circulating and noncirculating current type. (16)

Question Bank- EE 603
Type 4

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	DC TO DC CONVERTER

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
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UNIT-III DC TO DC CONVERTER

1. Draw the circuit diagram of buck regulator and explain its working principle with necessary waveforms. Derive the expression for peak to peak ripple voltage of the capacitor that is present across the load. (16)
2. Describe the working principle of boost converter with necessary circuit and waveforms. (16)
3.
   i. Explain the various control strategies of chopper (10)
   ii. Design a filter component of a buck converter which has an input voltage of 12 V and output voltage of 5V. The peak to peak output ripple voltage is 20mV and peak to peak ripple current of inductor is limited to 0.8A. The switching frequency is 25KHz. (6)
4.
   i. A dc chopper has an input voltage of 200V and a load of 15ohm resistance. When the chopper is on, its voltage drop is 1.5V and the chopping frequency is 10KHz. If the duty cycle is 80%.Find
      a) average and rms output voltage
      b) chopper on time. (12)
   ii. Prove the output voltage of step down chopper is Vo = D Vs. (4)
5. Describe the working principle of buck-boost converter with necessary circuit and waveforms. (16)
6. What is SMPS? Mention the types of SMPS. Explain flyback SMPS in detail. (16)
7. Write short notes on Push pull SMPS, half bridge and full bridge SMPS(16)
8. Explain L type zero current switching resonant converters. (16)
9. Explain M type zero current switching resonant converters. (16) 10. Explain zero voltage switching resonant converters. (16)

Question Bank- EE 603
Type 4

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	INVERTERS

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
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UNIT-IV INVERTERS

1. Explain the principle of operation of 3 phase voltage source inverter with 180°conduction mode with necessary waveforms and circuits. Also obtain the expression for line to line voltage.
2. Discuss the functioning of three phase voltage source inverter in 120 degree operating mode with relevant waveforms and obtain the expression for voltages.
3. Explain the following PWM techniques used in inverter.
    - i. Sinusoidal PWM
    - ii. Multiple PWM
4. Explain the operation of single phase capacitor commutated CSI with R load.
5. Explain the harmonic reduction by transformer corner lines and stepped wave inverters.
6. Explain the different methods of voltage control adopted in an inverter with suitable waveforms.
7. Explain the working of series inverter with the help of circuit diagram and relevant waveforms.
8. Draw the circuit diagram of current source inverter and explain its operation with relevant waveforms.
9. Describe the working of a single phase full bridge inverter supplying R, RL loads with relevant circuit and waveforms.
10. What is the need for controlling the output voltage of inverters? Classify the various techniques adopted to vary the inverter gain and brief on sinusoidal PWM.

Question Bank- EE 603
Type 4

Question Paper Details					
Course	Stream	Semester	Subject	Paper Code	Chapter
B.Tech	Electrical Engg (EE)	6th	Power Electronics	EE 603	AC TO AC CONVERTERS

Paper Setter Details			
Name	Designation	Mobile No.	Email ID
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UNIT-V AC TO AC CONVERTERS

1. Draw the circuit diagram of three phase to single phase cycloconverter and explain its operation with waveforms
2. With the necessary circuit diagram and waveforms, explain the principle of operation of single phase ac voltage controller having only thyristor feeding resistive load by on-off control and phase control. Derive the expression for rms value of output voltages in both cases.
3. Describe the operation of single phase full wave AC voltage controller with the help of voltage and current waveform. Also derive the expression for average value of output voltage.
4. Explain sinusoidal and multiple PWM techniques used in inverter.
5. Explain the operation of the step down cycloconverter both bridge and midpoint configuration with necessary waveforms.
6. With aid of circuit diagram, explain the operation of three phase to three phase cycloconverter employing three phase half wave circuits and list few of its applications.
7. Explain the operation of single phase half wave phase controller and single phase full wave phase controller with circuit diagrams and waveforms.
8. Explain the principle of working of single phase to single phase step up cycloconverter. List the factors that affect the performance of cycloconverters.
9. Discuss the working of a single phase AC voltage controller with RL load when its firing angle is more than the load power factor angle. Illustrate with waveforms.
10. A single phase voltage controller feeds power to a resistive load of 3Ω from 230V, 50 Hz source. Calculate
    a. The maximum values of average and RMS thyristor currents for any firing angle .
    b. The minimum circuit turn off time for any firing angle .
    c. the ratio of third harmonic voltage to fundamental voltage for 60 °

MULTIPLE CHOICE QUESTIONS (MCQs)

Chapter 2: Thyristor: Principles and Characteristics

2.1 Which of the following conditions is necessary for triggering system for thyristors?
(a) It should be synchronised with the main supply
(b) It must use separate power supply
(c) It should provide a train of pulses
(d) None of these

2.2 For thyristors, pulse triggering is preferred to dc triggering because
(a) gate dissipation is low
(b) pulse system is simpler
(c) triggering system is required for a very short duration
(d) all of these

2.3 The SCR is turned-off when the anode current falls below
(a) forward current rating (b) breakover voltage
(c) holding current (d) latching current

2.4 In a SCR circuit, the angle of conduction can be changed by changing
(a) anode voltage (b) anode current
(c) forward current rating (d) gate current

2.5 The normal way to close a SCR is by approximate
(a) gate current (b) cathode current
(c) anode current (d) forward current

2.6 If gate current is increased, the anode-cathode voltage at which SCR closes is
(a) increased (b) decreased
(c) maximum (d) least

2.7 A conducting SCR can be opened by reducing __________ to zero.
(a) supply voltage (b) gate voltage
(c) gate current (d) anode current

2.8 With gate open, a SCR can be turned-on by making supply voltage
(a) minimum (b) reverse
(c) equal to cathode voltage (d) equal to break-over voltage

2.9 A SCR is a _________ switch.
(a) two directional (b) unidirectional
(c) three-directional (d) four-directional

2.10 The turn-off time of thyristor is 30 μ sec at 50°C. It's turn-off time at 100° is
(a) same (b) 15 μ sec
(c) 60 μ sec (d) 100 μ sec

2.11 Turn-off time of a thyristor effects its
(a) operating voltage (b) operating frequency
(c) overload capacity (d) thermal behaviour

2.12 The *di*/*dt* capability of a thyristor increases
(a) when the gate current is zero
(b) when the gate current increases
(c) when the gate current decreases
(d) when the anode to cathode voltage rating increases.

2.13 Thermal runaway of a thyristor occurs because
- (a) positive resistance coefficient of the junction
- (b) negative resistance coefficient of the junction
- (c) if the latching current is more
- (d) if the thyristor is loaded with wider current pulses.

2.14 A positive voltage is applied to the gate of a reverse biased SCR
- (a) This inject more electrons into junction J_1
- (b) This increases reverse leakage current into anode
- (c) Hesting of junction is unaffected
- (d) Failure of junction occurs due to thermal runaway.

2.15 At a room temperature of 30°C, minimum voltage and current required to fire a SCR is
- (a) 3 V, 40 mA
- (b) 0.6 V, 40 mA
- (c) no limit
- (d) 3 V, 100 mA

2.16 When the SCR conducts, the forward voltage drop
- (a) is 0.7 V
- (b) is 1 to 1.5 V
- (c) increases slightly with load current
- (d) remains constant with load current

2.17 The turn-on time of a SCR with inductive load is 20 μs. The pulse train frequency is 2.5 kHz with a mark/space ratio of 1/10, then
- (a) the SCR will turn-on
- (b) the SCR will not turn-on
- (c) the SCR will turn-on if inductance is removed
- (d) the SCR will turn-on if pulse frequency is increased to two times.

2.18 An SCR is rated at 75 A peak, 20 A average. The greatest possible delay in the trigger angle if the dc is a rated value is
- (a) 47.5°
- (b) 30° to 45°
- (c) 75.5°
- (d) 137°

2.19 In a SCR
- (a) gate current is directly proportional to forward breakover voltage.
- (b) as gate-current is raised, forward breakover voltage reduces.
- (c) gate-current has to be kept ON continuously for conduction.
- (d) forward-breakover voltage is low in the forward blocking state.

2.20 There are only silicon controlled rectifiers and not germanium because
- (a) Si is available as compared to Ge.
- (b) Only Si has stable off-state.
- (c) Ge is very temperature sensitive.
- (d) Si only has the characteristic $\alpha_1 + \alpha_2 < 1$ at low collector currents and reaches 1 at high currents.

2.21 For normal SCRs, turn-on time is
- (a) less than turn-off time *tq*,
- (b) more than *tq*
- (c) equal to *tq*
- (d) half of *tq*

2.22 The average on-state current for an SCR is 20 A for conduction angle of 120°. The average on-state current for 60° conduction angle will be
- (a) 20 A
- (b) 10 A
- (c) less than 20 A
- (d) 40 A

2.23 The average on-state current for an SCR is 20 A for a resistive load. If an inductance of 5 mH is included in the load, then average on-state current would be

(a) more than 20 A
(b) less than 20 A
(c) 15 A
(d) 20 A

2.24 In a thyristor, anode current is made up of

(a) electrons only
(b) electrons or holes
(c) electron and holes
(d) none of these

2.25 When a thyristor gets turned ON, the gate drive

(a) should not be removed as it will turn-off the SCR
(b) may or may not be removed
(c) should be removed
(d) should be removed in order to avoid increased losses and higher junction temperature

2.26 The forward voltage drop during SCR-on state is 1.5 V. This voltage drop

(a) remains constant and its independent of load current
(b) increases lightly with load current
(c) decreases slightly with load current
(d) varies linearly with load current

2.27 A thyristor can be termed as

(a) dc switch
(b) AC switch
(c) both A or B are correct
(d) square-wave switch

2.28 On-state voltage drop across a thyristor used in a 250 V supply system is of the order of

(a) 100-110 V
(b) 240-250 V
(c) 1-1.5 V
(d) None of these

2.29 In a thyristor, ratio of latching current to holding current is

(a) 0.4
(b) 1.0
(c) 2.5
(d) None of these

2.30 Gate characteristics of a thyristor

(a) is a straight line passing through the origin
(b) is of the type, $V_V = a + b. I_V$
(c) is a curve between V_g and I_g
(d) has a spread between two curves of $V_g = I_g$.

2.31 In an SCR, anode current flows over a narrow region near the gate during

(a) delay time *d*
(b) rise time *tr* and spread time *tp*
(c) *td* and *tp*
(d) *td* and *tr*

2.32 Turn-on time for an SCR is 10 μsec. If an inductance is inserted in the anode circuit, then the turn-on time will be

(a) 10 μsec
(b) less than 10 μsec
(c) more than 10 μsec
(d) about 10 μsec

2.33 Turn-off time of an SCR is measured from the instant

(a) anode current becomes zero
(b) anode voltage becomes zero
(c) anode current and anode voltage become zero at the same time
(d) gate current becomes zero.

2.34 A forward voltage can be applied to an SCR after its

(a) anode current reduces to zero
(b) gate recovery time
(c) reverse recovery time
(d) anode voltage reduces to zero

2.35 For an SCR, with turn-on time of 5 μsec, an ideal trigger pulse should have
- (a) short rise time with pulse width = 3 μsec.
- (b) long rise time with pulse width = 6 μsec.
- (c) short rise time with pulse width = 6 μsec.
- (d) long rise time with pulse-width = 3 μsec.

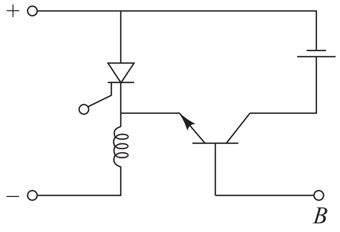
2.36 Turn-on time of an SCR in series with RL circuit can be reduced by
- (a) increasing circuit resistance R
- (b) decreasing R
- (c) increasing circuit inductance
- (d) decreasing L

2.37 Turn-on time of an SCR can be reduced by using a
- (a) rectangular pulse of high amplitude and narrow width
- (b) rectangular pulse of low amplitude and wide width
- (c) triangular pulse
- (d) trapezoidal pulse

2.38 Specification sheet for an SCR gives its maximum rms-on-state current as 35 A. This rms rating for a conduction angle of 120° would be
- (a) more than 35 A
- (b) less than 35 A
- (c) 35 A
- (d) None of these

2.39 Surge current rating of an SCR specifies the maximum
- (a) repetitive current with sine wave
- (b) non-repetitive current with rectangular wave
- (c) non-repetitive current with sine wave
- (d) repetitive current with rectangular wave

2.40 In the circuit given below, the function of the transistor is



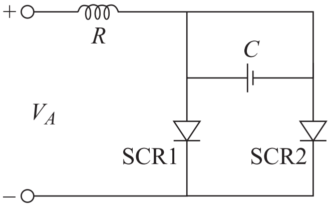
- (a) to provide control signal to trigger SCR
- (b) to make SCR-ON
- (c) to make SCR-OFF
- (d) to amplify anode-current

2.41 In a thyristor, the magnitude of the anode-current will
- (a) increase if gate-current is increased
- (b) decrease if gate current is decreased
- (c) increase if gate-current is decreased
- (d) not change with any variation in gate current

2.42 An SCR does not conduct for a certain value of load resistance. In order to make it ON, it is necessary to
- (a) decrease the load resistance
- (b) increase the resistance
- (c) increase the gate-pulse
- (d) none of these

2.43 Most SCRs can be turned-off by voltage reversal during negative half-cycle of the ac supply for
- (a) all frequencies
- (b) frequencies upto 300 Hz
- (c) frequencies upto 30 kHz
- (d) frequencies upto 300 kHz

2.44 In circuit given below, in order to make a conducting SCR off, it is necessary to
- (a) make other SCR-off
- (b) make other SCR-ON
- (c) reverse the polarity of the applied voltage
- (d) remove the gate-current of conducting SCR



2.45 If a diode is connected in antiparallel with a SCR, then
- (a) both turn-off power loss and turn-off time decrease
- (b) turn-off power loss decreases but turn-off time increases
- (c) turn-off power loss increases, but turn-off time decreases
- (d) none of the above

2.46 In a commutation circuit, employed to turn-off an SCR, satisfactory turn-off is obtained when
- (a) circuit turn-off time < device turn-off time
- (b) circuit turn-off time > device turn-off time
- (c) circuit time constant > device turn-off time
- (d) circuit time constant < device turn-off time

Chapter 3: Gate Triggering Circuits

3.1 UJT oscillators are used for gate-triggering of thyristors for
- (a) Better phase control
- (b) Snap action
- (c) Being cheap and simple
- (d) none of the above

3.2 It is recommended to use UJT oscillator for gate-triggering of the thyristors mainly because
- (a) it is fairly simple
- (b) it provides sharp firing pulses
- (c) it is less expensive
- (d) none of the above

3.3 A device that does not exhibit negative resistance characteristic is
- (a) FET
- (b) UJT
- (c) tunnel diode
- (d) SCR

3.4 A UJT has one base resistance of 5.2 k. Its intrinsic stand of ratio is 0.67. The inter-base voltage of 12 V is applied across the two passes. The value of base current will be
- (a) 1.16 mA
- (b) 1.28 mA
- (c) 1.34 mA
- (d) 1.41 mA

3.5 A PUT has $V_{BB} = 24$ V, & $R_{B1} = 3R_{B2}$. The value of η will be
- (a) 1/3
- (b) 2/3
- (c) 3/4
- (d) 4/3

3.6 In Q3.5, the value of VG will be
- (a) 12 V
- (b) 15 V
- (c) 18 V
- (d) 20 V

3.7 A PUT relaxation oscillator has values $V_{BB} = 15$ V, $R = 22$ kΩ, $R_2 = 6$ kΩ, $I_P = 100$ μA, $V_V = 1$ V, $I_V = 7$ mA, $C = 1$ μF, $R_K = 100$ kΩ, $R_3 = 12$ kΩ. The value of V_P will be
(a) 0.7 V (b) 10 V
(c) 10.7 V (d) 15 V

3.8 In Q.3.7, the value of $R_{\max}$ will be
(a) 2 kΩ (b) 2.2 kΩ
(c) 14 kΩ (d) 43 kΩ

3.9 In Q.3.7, the value of $R_{\min}$ will be
(a) 2 kΩ (b) 2.2 kΩ
(c) 14 kΩ (d) 43 kΩ

3.10 The frequency of oscillation in Q.3.7 will be
(a) 36.4 Hz (b) 40.7 Hz
(c) 50 Hz (c) 60 Hz

3.11 In a UJT, intrinsic stand off ratio η is typically
(a) 0.2 (b) 0.4
(c) 0.7 (d) 0.99

3.12 When a UJT is used for triggering of an SCR, the waveshape of the voltage is a
(a) Sine Wave (b) Saw-tooth wave
(c) Trapezoidal wave (d) Square wave

3.13 Optocouplers combine
(a) SITs and BJTs (b) IGBTs and MOSFETs
(c) Power transformer and silicon transistors
(d) Infrared light-emitting diode and silicon phototransistor

3.14 In a UJT, maximum value of charging resistance is associated with
(a) Peak Point (b) valley point
(c) any point between peak & valley point
(d) after the valley point

Chapter 4: Series and Parallel Operation of Thyristors

4.1 Equalising circuits are provided across each SCR in series operation to provide uniform
(a) current distribution (b) voltage distribution
(c) firing of SCRs (d) all of the above

4.2 In series connected thyristors
(a) L is used for tuning out junction capacitance
(b) L&C is used for filtering out the ripple
(c) R, C is called a snubber circuit
(d) L is intended to increase di/dt at switch on

4.3 Two identical SCRs are placed back-to-back in series with a load. If each is fired at 90°, a dc voltmeter across the load will read
(a) zero (b) $2/\pi \cdot$ peak voltage
(c) $1/\pi \cdot$ peak voltage (c) $4/\pi \times$ peak voltage

4.4 In order to obtain static voltage equalisation in series connected SCRs, connections are made of
(a) one reactor against the string
(b) resistors of different values across each SCR

(c) resistors of same value across each SCR
(d) one reactor in series with the string

4.5 Derating factors for parallel connection of thyristors are normally in the range
(a) 0.5 to 1% (b) 1 to 5%
(c) 8 to 20% (d) (d) 25 to 50%

4.6 To obtain the highest possible string efficiency, the SCRs connected in string must have
(a) different characteristics (b) same charactersitcs
(c) same voltage ratings only (d) same current ratings only

4.7 String efficiency is used for measuring the ________
(a) voltage rating of SCRs
(b) current rating of SCRs
(c) temperature rating of SCRs
(d) degree of utilization of SCRs

4.8 In series string, thyristor having the highest leakage resistance or low voltage current will share ________
(a) larger portion of the applied voltage
(b) smaller portion of the applied voltage
(c) larger portion of current
(d) smaller portion of current

4.9 Dynamic equalising networks are used to limit the ________
(a) rate of rise of current (b) rate of rise of voltage
(c) rate of rise of temperature (d) rate of rise of pressure

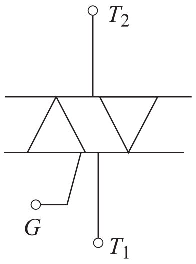
4.10 In optical triggering technique, LASCR is connected in ________
(a) gate circuit of each thyristor
(b) anode circuit of each thyristor
(c) gate circuit of only one thyristor
(d) anode circuit of only one thyristor.

Chapter 5: Power Semiconductor Devices

5.1 In a GTO, anode current begins to fall when gate current
(a) is negative peaks at time $t = 0$
(b) is negative peak at t = storage period t_s
(c) just begins to become negative and $t = 0$
(d) none of these

5.2 Thyristor A has rated gate current of 2 A and thyristor B is a rated gate current of 100 mA
(a) thyristor A is a GTO and B is a conventional SCR
(b) thyristor B is a GTO and A is a conventional SCR
(c) thyristor B may operate as a transistor
(d) none of these

5.3 Which of the following statements is true for firing a triac shown in figure below?
(a) Either T_1 or T_2 negative and there is current pulse into the gate.
(b) T_1 is negative and there is current pulse out of the gate.



(c) T_2 is negative and there is the current pulse out of the gate
(d) Either T_1 or T_2 is positive and there a current pulse out of the gate

5.4 As compared to UJT, SUS
(a) triggers only in one direction
(b) does not have negative resistance characteristics
(c) needs definate polarity of the applied voltage
(d) triggers only at one particular voltage

5.5 In its application, an SUS behaves in the same way as
(a) UJT (b) SCR
(c) tunnel diode (d) none of these

5.6 Which of the following *PNPN* devices has two gates?
(a) Triac (b) SCS
(c) SUS (d) Diac

5.7 Which of the following *PNPN* devices has a terminal for synchronising purpose?
(a) SCS (b) Triac
(c) Diac (d) SUS

5.8 Which of the following devices is a three layer device?
(a) SCS (b) SUS
(c) Triac (d) Diac

5.9 Which of the following methods will turn SCS off?
(a) Applying negative pulse to the anode
(b) Applying a positive pulse to the anode gate
(c) Applying negative pulse to the cathode gate
(d) All of these

5.10 Which of the following *PNPN* devices does not have a gate terminal?
(a) triac (b) SCS
(c) SUS (d) Complementary SCR

5.11 In a GTO, anode current begins to fall when gate current
(a) is negative peak at time $t = 0$
(b) is negative peak at time t = storage time t_s
(c) just begins to become negative at $t = 0$
(d) none of these

5.12 The device which cannot be triggered by voltage of either polarity is
(a) Diac (b) Triac
(c) Schottkey diode (d) SUS

5.13 A triac and SCR are compared
(a) Both are unidirectional devices
(b) Triac requires more current for turn-on than SCR at a particular voltage
(c) Triac has less time for turn-off than SCR
(d) Both are available with comparable voltage and current ratings

5.14 The uncontrolled electronic switch employed in power-electronic converters is
(a) thyristor (b) bipolar junction transistor
(c) diode (d) MOSFET

5.15 Which semiconductor power device out of the following is not a current triggered device?
(a) Thyristor (b) GTO
(c) Triac (d) MOSFET

5.16 The triac can be used only in
- (a) inverter
- (b) rectifier
- (c) multiquadrant chopper
- (d) cycloconverter

5.17 MOS controlled thyristors have
- (a) low forward voltage drop during conduction
- (b) fast turn-on and turn-off time
- (c) low-switching losses
- (d) high reverse voltage blocking capability
- (e) low gate input impedance

Of these statements

1. (a), (b) and (c) are correct
2. (c), (d) and (e) are correct
3. (b), (c) and (d) are correct
4. (a), (c) and (e) are correct

5.18 Power MOSFET is a
- (a) voltage controlled device
- (b) current controlled device
- (c) frequency controlled device
- (d) none of the above

5.19 When transistors are used in series or parallel, a snubber circuit is used to
- (a) control the current
- (b) control the voltage
- (c) limit d*i*/d*t*
- (d) all of these

5.20 Which of the following is preferred for VHF/UHF applications?
- (a) BJT
- (b) MOSFET
- (c) SIT
- (d) IGBT

5.21 Which of the following thyristors are gate turned off device?

I. Gate turned off thyristor
II. State Induction thyristor
III. MOS-controlled thyristor

- (a) I only
- (b) II only
- (c) I and II only
- (d) I, II and III

5.22 In a power-MOSFET, switching times are of the order of few
- (a) seconds
- (b) milliseconds
- (c) microseconds
- (d) nanoseconds

5.23 A switched-mode power-supply operation at 20 kHz to 100 kHz range uses as the main switching element:
- (a) Thyristor
- (b) MOSFET
- (c) Triac
- (d) UJT

5.24 The MOSFET switch in its on-state may be considered equivalent to
- (a) resistor
- (b) inductor
- (c) capacitor
- (d) battery

5.25 A triac is effectively
- (a) antiparallel connection of two thyristors
- (b) antiparallel connection of a thyristor and a diode
- (c) antiparallel connection of two diodes
- (d) two thyristor, in parallel to increase the current capacity of the device

5.26 Peak inverse rating of a triac
- (a) is the same as that of a thyristor
- (b) is greater than that of a thyristor
- (c) is inferior and very much less than that a thyristor
- (d) is not very significant due to the nature of its application

5.27 A reverse conducting thyristor is effectively
- (a) two thyristors in antiparallel
- (b) a diode connected antiparallel with a thyristor
- (c) two diodes in antiparallel
- (d) two thyristors connected in parallel

5.28 A Gate-turn-off thyristor
- (a) requires a special turn-off circuit like a thyristor
- (b) can be turned-off by removing the gate-pulse
- (c) can be turned-off by a negative current pulse at the gate
- (d) can be turned-off by a positive current pulse at the gate

5.29 A GTO like all the other power semiconductor devices requires protection against
- (a) rates of change of forward current and forward voltage
- (b) rate of change of current alone
- (c) rate of change of voltage alone
- (d) rates of change of forward current and forward voltage and overvoltages and currents

5.30 The inductance of snubber circuit and capacitance of snubber of a GTO
- (a) increase the rate of turn-off
- (b) make the turn-off very slow
- (c) cause overvoltages and spikes of voltage during turn-off
- (d) cause overvoltages and spikes of voltage during turn-on

5.31 An amplifying gate thyristor has
- (a) the advantages of high gate current at low level gate drive.
- (b) a poor di/dt rating even at high gate current
- (c) its di/dt improving only at high gate current
- (d) very slow spreading velocity

5.32 A BJT operates as a switch
- (a) under small signal conditions
- (b) with no signal condition
- (c) in the active region of transfer characteristic
- (d) under large signal conditions

5.33 The temperature coefficient of resistivity for power BJT is
- (a) positive
- (b) negative
- (c) zero

5.34 The main cause of the second breakdown in power BJT is
- (a) existence of the drift layer
- (b) low thickness of base
- (c) current crowding and negative temperature coefficient of resistivity

5.35 The turn-off snubber is connected in power BJT
- (a) to reduce the turn-on losses
- (b) to reduce the turn-off times
- (c) to divert the switching loss from the transistor to the snubber

5.36 The antisaturation arrangement ensure
- (a) high switching speed but high on state power loss
- (b) high switching speed and low on-state power loss
- (c) high switching speed and high breakdown voltage

5.37 The conductivity modulation in power BJT
- (a) reduces the turn-on time
- (b) reduces the on-state voltage drop
- (c) increase the on-state voltage drop

5.38 The SOA of a power device
- (a) gives the maximum operating temperature
- (b) specifies the maximum voltage and current
- (c) is an area in which the operating point of the device must be located for its safe operation.

5.39 A power BJT has a high interdigitated base emitter structure
- (a) to reduce current crowding during turn-on/off and hence avoid second breakdown
- (b) to increase gain of the transistor
- (c) to increase the switching frequency
- (d) to increase its voltage rating

5.40 The typical value of gain in a power BJT is

(a) 100 (b) 1 (c) 10 (d) 1000

5.41 A transistor cannot be protected by a fuse because
- (a) a fuse of that current rating is not available
- (b) its thermal time constant is very less
- (c) over temperature limit of power transistor is high
- (d) none of the above

5.42 The operating frequency of a power MOSFET is higher than a power BJT because

(a) it is a majority carrier device (b) it has an insulated gate

(c) drift layer is absent in it (d) its gain is infinite

5.43 The on-state voltage drop of a power MOSFET is higher than a power BJT because

(a) it has no drift layer (b) conductivity modulation is absent

(c) its current capacity is higher (d) none of the above

5.44 Paralleling of MOSFET is quite easier because
- (a) it has a positive temperature coefficient of resistivity
- (b) its on-state voltage drop is much lesser
- (c) its gate-drive circuits are simpler
- (d) conductivity modulation is absent

5.45 For a MOSFET, snubber circuits
- (a) are very much essential to give it a dv/dt protection.
- (b) are not essential due to large SOA, however are still recommended
- (c) are never used
- (d) none of the above

5.46 A device is said to have a symmetric blocking capability if
- (a) it blocks forward and reverse voltages of equal or comparable magnitudes
- (b) it blocks only reverse voltages
- (c) it blocks only forward voltages
- (d) none of the above

5.47 The turn-off gain of the GTO is of the order of

(a) 1–2 (b) 3–5

(c) 10–20 (d) >100

5.48 The body layer is connected to source terminal in a MOSFET in order to
- (a) reduce the on-state power dissipation
- (b) increase the speed of operation
- (c) avoid the latch-up in MOSFET

5.49 MOS devices should be handled by the package, not by leads to
- (a) avoid the damage due to handling
- (b) avoid damage due to static charge
- (c) avoid damage due to moisture
- (d) none of above

5.50 An IGBT structure is obtained by
- (a) adding an insulated gate to the BJT and adding a p^+ layer.
- (b) by combining a MOSFET and BJT
- (c) none of the above

5.51 The temperature coefficient of resistivity of an IGBT is
- (a) positive
- (b) negative
- (c) flat

5.52 The SOA of IGBT is better than that of a power transistor because
- (a) it is a majority carrier device
- (b) it is a minority carrier device
- (c) second breakdown is absent due to its flat temperature coefficient of temperature

5.53 The maximum operating frequency of an IGBT is approximately
- (a) 10 kHz
- (b) 50 kHz
- (c) 100 kHz

5.54 The on-state voltage drop across the IGBT is
- (a) less than that across the MOSFET
- (b) greater than that across the MOSFET
- (c) equal to that of MOSFET

5.55 The reduction in the on-state voltage drop in IGBT takes place due to
- (a) added p^+ layer in the IGBT structure
- (b) conductivity modulation
- (c) the n^- drift layer

5.56 The nonpunch through IGBT has a
- (a) symmetrical blocking capacity
- (b) asymmetrical blocking capacity
- (c) no blocking capacity at all

5.57 The blocking capacity of a punch-through IGBT is
- (a) symmetrical
- (b) asymmetrical
- (c) none of the above

5.58 A MOSFET controlled thyristor has a gate-turn-off capability because
- (a) The structure does not have a latching capability
- (b) There are separate MOSFET, for turn-on and turn-off
- (c) It is a minority carrier device
- (d) It is a majority carrier device

5.59 The turn-off time of an MCT is approximately
- (a) 0.1 μs
- (b) 1 μs
- (c) 2–3 μs
- (d) 10–20 μs

Chapter 6: Phase Controlled Converters

6.1 A single phase half-wave controlled rectifier has 400 sin 314 t volts as the input voltage and resistor R is the load. For firing angle of 60° for the SCR, the average output voltage in volts is
- (a) $400/\pi$
- (b) $300/\pi$
- (c) $240/\pi$
- (d) $360/\pi$

6.2 A single phase one-pulse controlled circuit has resistance and counter emf load and 400 sin 314 t volt as the source voltage. For a load counter emf of 200 V, the range of firing angle control is

(a) 30° to 150° (b) 60° to 180° (c) 60° to 120° (d) 30° to 180°

6.3 A single phase full-wave mid-point thyristor converter uses a 230/200 V transformer with centre tap on the secondary side. The P.I.V. per thyristor is

(a) 100 V (b) 141.4 V (c) 200 V (d) 282.8 V

6.4 In a single phase full converter bridge the output voltage is given by

(a) $\frac{1}{\pi}\int_{\alpha}^{\pi+\alpha} V_m \cos\theta \cdot d\theta$ (b) $\frac{1}{\pi}\int_{0}^{\pi+\alpha} V_m \cdot \cos\theta \cdot d\theta$

(c) $\frac{1}{\pi}\int_{\alpha-(\pi/2)}^{\alpha+(\pi/2)} V_m \cdot \cos\theta \cdot d\theta$ (d) $\frac{1}{2\pi}\int_{\alpha-(\pi/2)}^{\alpha+(\pi/2)} V_m \cos\theta \cdot d\theta$

6.5 In a single-phase semiconverter, the average output voltage is given by

(a) $\frac{1}{\pi}\int_{\alpha}^{\pi} V_m \cdot \cos\theta \cdot d\theta$ (b) $\frac{1}{\pi}\int_{(\pi/2)-\alpha}^{(\pi/2)+\alpha} V_m \cdot \cos\theta \cdot d\theta$

(c) $\frac{1}{\pi}\int_{\alpha-(\pi/2)}^{\alpha+(\pi/2)} V_m \cdot \cos\theta \, d\theta$ (d) $\frac{1}{\pi}\int_{\alpha-(\pi/2)}^{\pi} V_m \cos\theta \cdot d\theta$

6.6 For continuous conduction, in a single-phase full converter each pair of SCRs conducts for

(a) $(\pi - \alpha)$ radians (b) π-radians (c) α-radians (d) $(\pi + \alpha)$ radians

6.7 For discontinuous load current and extinction angle $\beta > \pi$ radians, in a single-phase full converter, each SCR conducts for

(a) α radians (b) $(\beta - \alpha)$ radians (c) β radians (d) $(\alpha + \beta)$ radians

6.8 In a single-phase full converter, if α and β are firing and extinction angles respectively, then the load current is discontinuous if

(a) $(\beta - \alpha) < \pi$ (b) $(\beta - \alpha) > \pi$ (c) $(\beta - \alpha) = \pi$ (d) $(\beta - \alpha) = 3\pi/2$

6.9 In a single phase converter with discontinuous conduction and extinction angle $\beta > \pi$, freewheeling diode conducts for

(a) α (b) $\beta - \pi$ (c) $\pi + \alpha$ (d) β

6.10 In a single-phase converter with discontinuous conduction and extinction angle $\beta < \pi$, the freewheeling diode conducts for

(a) α (b) $\pi - \beta$ (c) $\beta - \pi$ (d) zero degree

6.11 In a single-phase semiconverter, for discontinuous conduction and extinction angle $\beta < \pi$, each SCR conducts for

(a) α (b) β (c) $\pi - \alpha$ (d) $\beta - \alpha$

6.12 In a single-phase semiconverter, for discontinuous conduction and extinction angle $\beta > \pi$, each SCR conducts for

(a) $\pi - \alpha$ (b) $\beta - \pi$ (c) α (d) β

6.13 A freewheeling diode is placed across the dc load

(a) to prevent reversal of load voltage
(b) to permit transfer of load current away from the source
(c) both (a) and (b) above
(d) none of the above

6.14 In a single-phase full converter, if output voltage has peak and average values of 325 V and 133 V respectively, then the firing angle is
(a) 40° (b) 50° (c) 70° (d) 130°

6.15 A converter which can operate in both 3-phase and 6-phase modes is a
(a) 6-phase semiconverter (b) 6-phase full-converter
(c) 3-phase semiconverter (d) 3-phase full-converter

6.16 In a 3-phase semiconverter, for firing angle less than or equal to 60°, free-wheeling diode conducts for
(a) 30° (b) 60° (c) 90° (d) 0°

6.17 In a 3-phase semiconverter, for firing angle equal to 120° and extinction angle equal to 110°, freewheeling diode conducts for
(a) 10° (b) 30° (c) 50° (d) 70°

6.18 In a three-phase semiconverter, the three-SCRs are triggered at intervals of
(a) 60° (b) 90° (c) 120° (d) 150°

6.19 In a three-phase full converter, the six SCR's are fired at intervals of
(a) 30° (b) 60° (c) 90° (d) 120°

6.20 The frequency of the ripple in the output voltage of a 3-phase semiconverter depends upon
(a) firing angle and load resistance
(b) firing angle and supply frequency
(c) firing angle and load inductance
(d) only on load circuit parameters

6.21 In a 3-phase full-converter, if the load-current is I and ripple-free, then the average thyristor current is
(a) I/2 (b) I/3 (c) I/4 (d) I/5

6.22 In a single-phase full-converter, if the load current is I and ripple-free, then the average thyristor current is
(a) I/2 (b) I/3 (c) I/4 (d) I/5

6.23 In a single-phase full-converter, the number of SCRs conducting during overlap is
(a) 1 (b) 2 (c) 3 (d) 4

6.24 In a 3-phase full-converter, the output voltage is at a frequency equal to
(a) supply frequency f (b) 2f
(c) 3f (d) 6f

6.25 Which of the following 3-phase ac to dc converter requires neutral point connection?
(a) 3-phase semiconductor (b) 3-phase full-converter
(c) 3-phase halfwave converter (d) 3-phase converter with diodes

6.26 The frequency of ripple in the output voltage of a three-phase half controlled bridge rectifier depends on the
(a) firing angle (b) load inductance
(c) load resistance (d) supply frequency

6.27 A half-wave SCR controlled circuit with RL 50 Ω conducts for 90° for an applied voltage of 800 V sinusoidal rms. If the SCR voltage drop is negligible, the power dissipated by the load is
(a) 1800 W (b) 81 W (c) 52.36 W (d) 0 W

6.28 In a single-phase full-wave SCR circuit with R, L load
(a) power is delivered to the source for delay angles of less than 90°
(b) the SCR changes from inverter to converter at $\alpha = 90°$
(c) the negative dc voltage is maximum at $\alpha = 180°$
(d) to turn-off the thyristor, the maximum delay angle must be less than 180°.

6.29 The frequency of ripple in the output of a 3-phase semiconverter depends upon I. firing angle, II. load-resistance, III. supply frequency, IV. load inductance Combinations:
(a) I, II and IV (b) II, III and IV (c) I and II (d) I and III

6.30 In a three-phase-semiconverter
I. For firing angle less than or equal to 60°, freewheeling diode conducts for zero degree
II. For firing angle equal to 120°, and extinction angle equal to 110° freewheeling diode conducts for 50°.
III. The output SCRs are triggered at intervals of 60°.
Combinations:
(a) I and II (b) II and III (c) I and III (d) I, II and III

6.31 A single-phase, one pulse controlled circuit has resistance and counter emf load and 400 sin 314 t as the source voltage. For a load counter emf of 200 V, the range of firing angle control is
(a) 30° to 150° (b) 30° to 180° (c) 60° to 120° (d) 60° to 180°

6.32 In a 3-phase controlled bridge rectifier, with an increase of overlap angle, the output dc voltage
(a) decrease (b) increases
(c) does not change (d) depends upon load inductance

6.33 In a 3-phase, half wave rectifier, if per phase input voltage is 200 V, then the average output voltage is
(a) 233.91 V (b) 116.95 V (c) 202.56 V (d) 101.28 V

6.34 When a line commutated converter operates in the inverter mode (G 93)
(a) it draws both real and reactive power from the AC supply
(b) it delivers both real and reactive power to the AC supply
(c) it delivers both real and reactive power to ac supply
(d) it draws reactive power from AC supply

6.35 In a 3-phase controlled bridge rectifier, with an increase of an overlap angle, the output dc voltage
(a) decreases (b) increases
(c) does not change (d) depends upon load inductance

6.36 When the firing angle α of a single-phase fully controlled rectifier feeding constant dc current into a load is 30°, the displacement power factor of the rectifier is (G 98)
(a) 1 (b) 0.5 (c) $\frac{1}{\sqrt{3}}$ (d) $\frac{\sqrt{3}}{2}$

6.37 A 3-phase fully controlled, converter is feeding power into a d.c. load at a constant current of 150 A. The rms current through each thyristor of the converter is (G 98)
(a) 50 A (b) 100 A (c) $\frac{150\sqrt{2}}{\sqrt{3}}$ (d) $\frac{150}{\sqrt{3}}$

6.38 A six pulse thyristor rectifier bridge is connected to a balanced 50 Hz three-phase ac source. Assuming that the dc output current of the rectifier is constant, the lowest harmonic component in the ac source line current is (G 2002)

(a) 100 H (b) 150 Hz (c) 250 Hz (d) 300 Hz

6.39 A converter which can operate in both 3-pulse and 6-pulse modes is

(a) 1-phase full converter (b) 3-phase half wave converter
(c) 3-phase semiconverter (d) 3-phase full converter

6.40 In a three-phase full-converter, the output voltage during overlap is equal to

(a) zero (b) source voltage
(c) source voltage minus inductance drop
(d) average value of conducting phase voltages.

6.41 The effect of the source inductance on the performance of the single-phase and three-phase full-converters is to

(a) reduce the ripples in the load current
(b) make discontinuous current as continuous
(c) reduce the output voltage
(d) increase the load voltage

6.42 In the circuit shown in Fig. MCQ. 6.42, L is large and the average value of 'i' is 100 A. The thyristor is gated in the ______ half cycle of 'e' at a delay angle α equal to ______ (G 92)

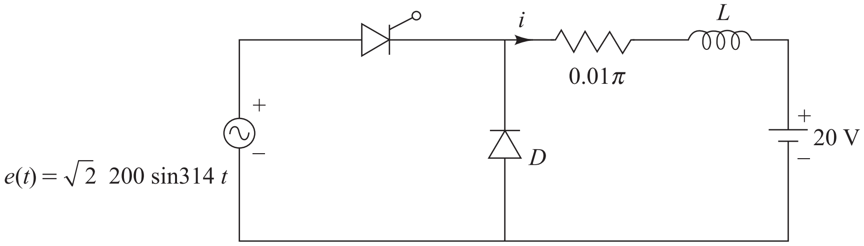


Fig. MCQ. 6.42

Explanation:

$$I_{av} = \frac{E_m}{2\pi R}\,[1 + \cos\alpha)]$$

$$100 = \frac{\sqrt{2}\cdot(200)}{2\times\pi\times(0.01)}\,[1 + \cos\alpha]$$

$\therefore \quad \alpha = 167.9°$

The maximum conduction angle is π since freewheeling diode is available. Therefore, SCR is gated in the positive half cycle of 'e' at a delay angle α equal to 168°.

6.43 Referring to the Fig. MCQ. 6.43, the type of the load is (a) inductive load (b) resistive load (c) dc motor (d) capacitive load. (G 94)

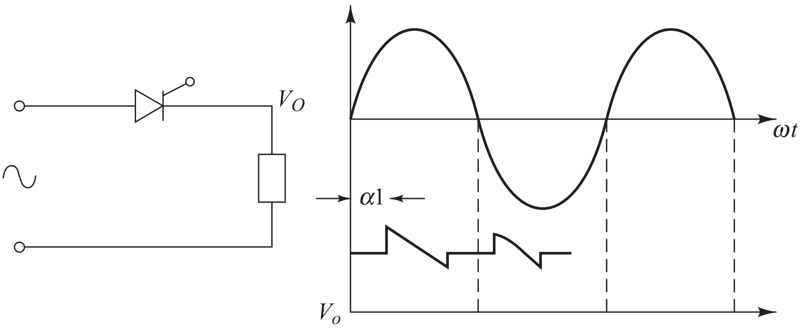


Fig. MCQ. 6.43

6.44 A half-wave thyristor converter supplies a purely inductive load, as shown in Fig. MCQ. 6.44. If the triggering angle of the SCR is 120°, the extinction angle will be

(a) 240° (b) 180°
(c) 200° (d) 120°

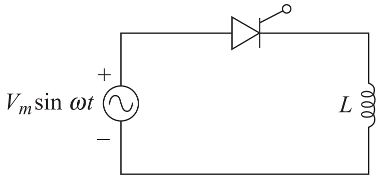


Fig. MCQ. 6.44

Chapter 8: Choppers

8.1 In dc choppers, if T_{on} is the on-period and f is the chopping frequency, then output voltage in terms of the input voltage V_s is given by

(a) $V_s \cdot T_{\text{on}/f}$ (b) $V_s \cdot f/T_{\text{on}}$ (c) $V_s/(f/T_{\text{on}})$ (d) $V_s \cdot f, T_{\text{on}}$

8.2 In dc choppers, the waveforms for input and output voltages are respectively

(a) discontinuous, continuous (b) continuous, discontinuous
(c) both continuous (d) both discontinuous

8.3 In dc choppers, per unit ripple is maximum when duty cycle α is

(a) 0.2 (b) 0.5 (c) 0.7 (d) 0.8

8.4 A step-up chopper has V_s as the source voltage and α as the duty cycle. The output voltage for this chopper is given by

(a) $V_s(1+\alpha)$ (b) $V_s/(1-\alpha)$ (c) $V_s(1-\alpha)$ (d) $V_s/(1+\alpha)$

8.5 In dc choppers, if T is the chopping period, then the output voltage can be controlled by PWM by varying

(a) T keeping T_{on} constant (b) T_{on}, keeping T constant
(c) T keeping T_{off} constant (d) T_{off} keeping T constant

8.6 In dc choppers, for periodic time T, the output voltage can be controlled by FM by varying

(a) T keeping T_{on} constant (b) T_{on} keeping T constant
(c) T_{off} keeping T constant (d) T keeping T_{off} constant

8.7 For type A chopper, V_s is the source voltage, R is the load resistance and α is the duty cycle. Average output voltage of this chopper is

(a) $\alpha \cdot V_s$ (b) $(1-\alpha)V_s$ (c) V_s/α (d) $V_s/(1-\alpha)$

8.8 If the chopper frequency is 200 Hz and t_{on} time is 2 ms, the duty cycle is

(a) 0.4 (b) 0.8 (c) 0.6 (d) none of these

8.9 Chopper control for DC motor provides variation in

(a) input voltage (b) frequency

(c) both (a) and (b) above (d) none of the above

8.10 In a thyristor dc chopper, which type of commutation results in best performance?

(a) voltage commutation (b) current commutation

(c) load commutation (d) supply commutation

8.11 A dc to dc transistor chopper supplied from a fixed voltage dc source feeds a fixed-resistive-inductive load and a free-wheeling diode. The chopper operates at 1 kHz and 50% duty cycle. Without changing the value of the average dc current through the load, if it is desired to reduce the ripple content of load current, the control action needed will

(a) increase the chopper frequency keeping the duty cycle constant

(b) increase the chopper frequency and duty cycle in equal ratio

(c) decrease only the chopper frequency

(d) decrease only the duty cycle

8.12 A voltage commutated chopper has the following parameters: $V_s = 200$ V, load circuit parameter 1 Ω, 2 mH, 5 V commutation circuit parameter: $L = 25\ \mu$H, $C = 50\ \mu$F. For constant load current at 100 A, the effective on-period and peak current through the main thyristor are respectively:

(a) 1000 μs, 200 A (b) 700 μs, 382.8 A

(c) 700 s, 282.8 A (d) 1000 μs, 382.8 A

8.13 In a type-A chopper, source voltage is 100 V, d.c. on-period = 100 μs, off-period = 150 μs and load RLE consists of $R = 2\ \Omega$, $L = 5$ mH, $E = 10$ V. For continuous conduction average output voltage and average output current for this chopper are respectively:

(a) 40 V, 15 A (b) 66.66 V, 28.33 A

(c) 60 V, 25 A (d) 40 V, 20 A

8.14 Refer the circuit shown in Fig. 8.53 the maximum current in the main SCR can be (given $I_o = 70.7$)

(a) 200 A (b) 170.7 A (c) 141.4 A (d) 70.7 A

8.15 A chopper operating at a fixed frequency is feeding an R–L load. As the duty ratio of this chopper is increased from 25% to 75%, the ripple in the load current

(a) remains constant

(b) decreases, reaches a minimum and 50% duty ratio and then increases

(c) increases, reaches a maximum at 50% duty ratio and then decreases

(d) keeps on increasing as duty ratio is increased.

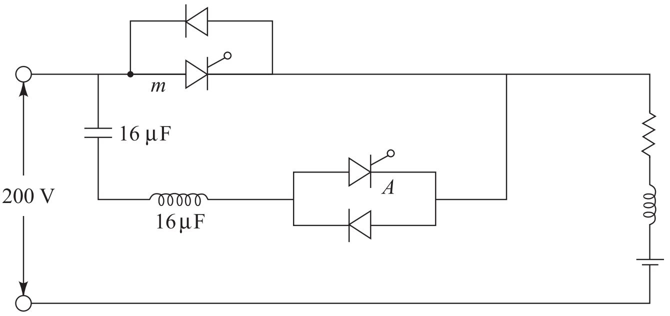


Fig. MCQ. 8.15

8.16 The efficiency of the chopper can be expected in the range

(a) 50 to 55 per cent
(b) 65 to 72 per cent
(c) 82 to 87 per cent
(d) 92 to 99 per cent

8.17 In dc choppers, the waveform for

(a) input voltage is continuous and output voltage is discontinuous
(b) input voltage is discontinuous and output voltage is continuous
(c) input voltage as well as output voltage both are continuous
(d) input voltage as well as output voltage both are discontinuous

8.18 In the chopper circuit shown, Fig. MCQ. 8.18 the input dc voltage has a constant value V_s. The output voltage V_0 is assumed ripple-free. The switch S is operated with a switching time period T and a duty ratio D. What is the value of D at the boundary of continuous and discontinuous conduction of the inductor current i_L?

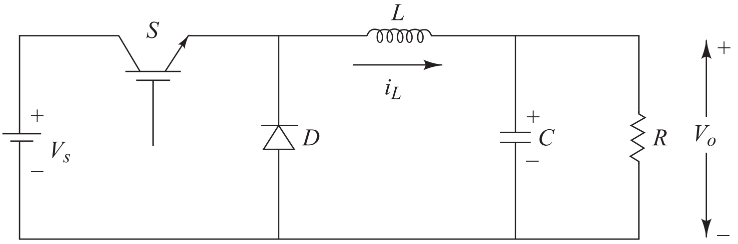


Fig. MCQ. 8.18

(a) $D = 1 - V_s/V_0$
(b) $D = 2L/RT$
(c) $D = 1 - \dfrac{2L}{RL}$
(d) $R = \dfrac{R - T}{L}$

8.19 In PWM method of controlling the average output voltage in a chopper the on-time is varied but the chopping frequency is

(a) varied
(b) kept constant
(c) either of these
(d) none of these

8.20 A load commutated chopper, fed from 200 V dc source, has a constant load current of 50 A. For a duty cycle of 0.4 and a chopping frequency of 2 kHz, the value of commutating capacitor and the turn-off time for one thyristor pair are respectively

(a) 25 μF, 50 μs
(b) 50 μF, 50 μs
(c) 25 μF, 25 μs
(d) 50 μF, 25 μs

8.21 A dc battery is charged from a constant dc source of 200 V through a chopper. The dc battery is to be charged from its internal emf of 90 to 120 V. The battery has internal resistance of 1 Ω. For constant charging current of 10 A, the range of duty cycle is

(a) 15 to 65
(b) 65 to 8
(c) 8 to 95
(d) None of these

8.22 A dc chopper is fed from 100 V dc. Its load voltage consists of rectangular pulses of duration 1 msec in an overall cycle time of 3 msec. The average output voltage and ripple factor for this chopper are respectively:

(a) 25 V, 1
(b) 50 V, 1
(c) 33.33, 1.5
(d) None of these

8.23 A step-down chopper is operated in the continuous conduction mode in steady state with a constant duty ratio D. If V_0 is the magnitude of the dc output voltage and if V_s is the magnitude of dc input voltage, the ratio V_o/V_s is given by

(a) D (b) $1 - D$ (c) $1/1 - D$ (d) $\frac{D}{1-D}$

8.24 When polyphase choppers are used, the output ripple

(a) decreases (b) increases
(c) remains the same (d) has low frequency

8.25 The features of chopper drives are

(a) smooth control but slow response
(b) smooth control but fast response
(c) fast response with smooth control but less efficient
(d) none of these

8.26 Choppers can be used in future electric automobiles

(a) for speed control only (b) for braking only
(c) for speed control and braking (d) none of these

8.27 Which of the following system is preferred for chopper drives?

(a) Constant frequency system (b) Variable frequency system
(c) Constant voltage system (d) None of these

8.28 Which of the following systems has a greater possibility of interference with signalling and telephone lines?

(a) constant frequency system (b) variable frequency system
(c) both are correct (d) none of these

8.29 Chopper controlled dc motor used in underground traction with regenerative braking, the power consumption will be reduced to

(a) 35–40% (b) 50–60% (c) 60–70% (d) None of these

8.30 In dc chopper, the load voltage is governed by

(a) number of thyristors used in the circuit
(b) duty cycle of the circuit
(c) dc voltage applied to circuit
(d) none of these

Chapter 9: Inverters

9.1 A single phase voltage-source-square wave inverter feeds pure inductive load. The waveform of the load current will be

(a) sinusoidal (b) rectangular (c) trapezoidal (d) triangular

9.2 Inverter gain is given by the ratio

(a) $\frac{\text{dc ouput voltage}}{\text{ac input voltage}}$ (b) $\frac{\text{ac o/p voltage}}{\text{ac input voltage}}$

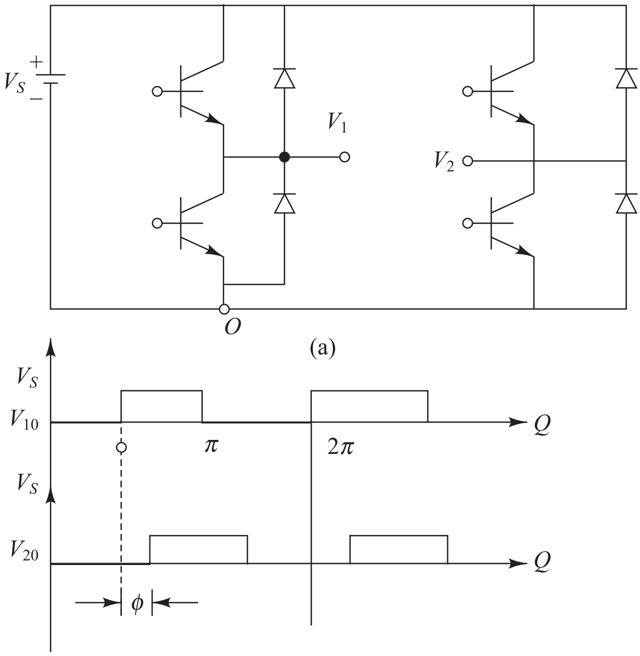
(c) $\frac{\text{dc o/p voltage}}{\text{ac I/P voltage}}$ (d) $\frac{\text{ac o/p voltage}}{\text{dc I/P voltage}}$

9.3 A PWM switching scheme is used with a three phase inverter to

(a) reduce the total harmonic distortion with modest filtering
(b) minimize the load on DC side
(c) increase the life of the batteries
(d) reduce low order harmonics and increase high order harmonics

9.4 Figure P.9.4(a) shows an inverter circuit with a dc source voltage V_s. The semiconductor switches of the inverter are operated in such a manner that the pole voltages V_{10} and V_{20} are shown in Fig. P.9.4(b). What is the rms value of the pole-to-pole voltage V_{12}?

(a) $\frac{V_s \cdot \phi}{\pi\sqrt{2}}$ (b) $Vs \cdot \sqrt{\frac{\phi}{\pi}}$ (c) $V_s \cdot \sqrt{\frac{\phi}{2\pi}}$ (d) $\frac{V_s}{\pi}$



(a)

(b)

Fig. P.9.4

9.5 A single-phase full-bridge voltage-source inverter feels a purely inductive load, as shown where T_1, T_2, T_3, T_4 are power transistors and D_1, D_2, D_3, D_4 are feedback diodes. The inverter is operated in square-wave mode with a frequency of 50 Hz. If the average load current is zero, what is the time duration of conduction of each feedback diode in a cycle?

(a) 5 msec (b) 10 msec (c) 20 msec (d) 2.5 msec

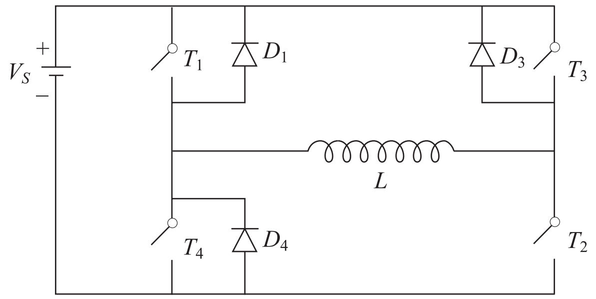


Fig. P.9.5

9.6 A three-phase voltage source inverter supplies a purely inductive three-phase-load. Upon fourier analysis, the output voltage waveform is found to have an h-th order harmonic of magnitude α_h times that of the fundamental frequency component ($\alpha_h < 1$). The load current then would have an h-th order harmonic of magnitude

(a) zero
(b) α_h times the fundamental frequency component
(c) $h \cdot \alpha_h$ times the fundamental frequency component
(d) $\alpha_{h/h}$ times the fundamental frequency component

9.7 Consider the following statements:

The diodes in a voltage source inverter (McMurray Inverter) should be able to:

1. Withstand a large voltage in the reverse direction
2. Carry the commutating current excess of load current
3. Provide the required reverse-bias to the outgoing thyristor
4. Feedback the reactive current to the source.

Of these statements:

(a) 1, 2 and 3 are correct (b) 1, 3 and 4 are correct
(c) 2, 3, and 4 are correct (d) 1, 2 and 4 are correct

9.8 In the inverter circuit shown in Fig. P 9.8, if the SCRs are fired at delayed angles, the frequency of the output waveform will

(a) increase (b) remain the same
(c) decrease
(d) depend upon which SCR is fired first

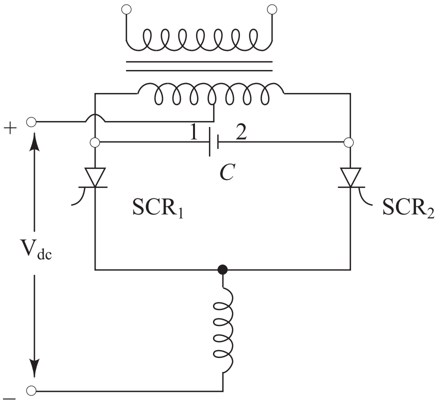


Fig. P.9.8

9.9 In the above circuit, if SCR_1 is ON and then SCR_1 is fired, the anode voltage of SCR_1 will become nearly equal to

(a) $+V_{dc}$ (b) $-V_{dc}$ (c) 1–2 V (d) zero

9.10 In the above circuit, if SCR_1 is ON the capacitor C will

(a) charge with terminal 2 as positive
(b) charge with terminal 1 as positive
(c) not charge at all unless SCR_2 is also turned –ON
(d) make SCR_2 ON.

9.11 In the SCR tap-switch inverter, when SCR_1 is fired
- (a) positive peak of the ac O/P is obtained
- (b) negative peak of the O/P is obtained
- (c) two-third to peak value is obtained
- (d) one-third of the peak value is obtained

9.12 In Fig. P.9.12, the function tap switching firing sequence of SCRs to obtain positive half-cycle is

(a) 1-2-3-4-5 (b) 5-3-1-3-5 (c) 6-4-2-4-6 (d) 6-5-4-3-2

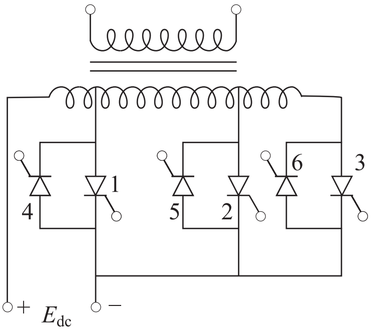


Fig. P.9.12

9.13 In Fig. P.9.12 the switching frequency of firing the six SCRs should be
- (a) same as the desired O/P frequency
- (b) three times the O/P frequency
- (c) five times the O/P frequency
- (d) ten times the O/P frequency

9.14 In Fig. P.9.12, the number of SCRs conducting at a time in one cycle is

(a) 1 (b) 2 (c) 3 (d) 5

9.15 If, for a single phase half-bridge inverter, the amplitude of output voltage is V_s and the output power is p, then their corresponding values for a single-phase full bridge inverter are

(a) $V_s \cdot p$ (b) $V_s/2, p/2$ (c) $2V_s, 2p$ (d) None of these

9.16 In voltage source inverters
- (a) load voltage waveform V_0 depends on load impedance Z, whereas load current waveform i_0 does not depend on Z
- (b) both V_0 and i_0 depend on Z
- (c) V_0 does not depend on Z whereas i_0 depends on Z
- (d) none of these

9.17 A single phase full-bridge inverter can operate in load commutation mode in case load consists of

(a) RLC overdamped (b) RLC underdamped

(c) RLC critically damped (d) None of these

9.18 A single phase bridge inverter delivers power to series connected RLC load with $R = 2$ ohm, $\omega L = 8$ ohm. For this inverter load combination, load commutation is possible in case the magnitude of 1/WC in ohms is

(a) 10 (b) 8 (c) 6 (d) zero

9.19 The single pulse modulation of PWM inverters, third harmonic can be eliminated if pulse width is equal to

(a) 30° (b) 60° (c) 120° (d) None of these

9.20 In single-pulse modulation of PWM inverters fifth harmonic can be eliminated if pulse-width is equal to

(a) 30° (b) 72° (c) 36° (d) 108°

9.21 In single-pulse modulation of PWM inverters, the pulse width is 120°. For an input voltage of 220 V_{dc}, the rms value of the output voltage is

(a) 179.63 V (b) 254.04 V (c) 127.02 V (d) None of these

9.22 A voltage source inverter is normally employed when

(a) source inductance is large and load inductance is small
(b) source inductance is small and load inductance is small
(c) both source and load inductance are small
(d) both source and load inductances are large

9.23 In resonant pulse inverters

(a) dc output voltage variation is wide
(b) the frequency is low
(c) output voltage is never sinusoidal
(d) dc saturation of transformer core is minimised

9.24 In multiple-pulse modulation used in PWM inverters, the amplitudes of reference square-wave and triangular carrier wave are respectively 1 V and 2 V. For generating 5 pulses per half-cycle, the pulse width should be

(a) 36° (b) 24° (c) 18° (d) 12°

9.25 In sinusoidal-pulse modulation, used in PWM inverters amplitude and frequency for triangular carrier and sinusoidal reference signals are respectively 5 V, 1 kHz and 1 V, 50 Hz. If zeros of the triangular carrier and reference sinusoid coincide, then the modulation index and order of significant harmonics are respectively

(a) 0.2, 9 and 11 (b) 0.4, 9 and 11
(c) 0.2, 17, and 19 (d) None of these

9.26 Which of the following statements is correct in connection with inverters

(a) voltage source inverter and current source inverter, both require feedback diode
(b) only current source inverter requires feedback diodes
(c) GTOs can be used in current source inverter
(d) only VSI requires feedback diodes

9.27 In a constant source inverter, if frequency of output voltage is f Hz, then frequency of voltage input to constant source inverter is

(a) f (b) $2f$ (c) $3f$ (d) $4f$

9.28 In an inverter with fundamental output frequency of 50 Hz, if third harmonic is eliminated, then frequencies of other components in the output voltage wave, in Hz, would be

(a) 250, 350, 500, high frequencies (b) 50, 250, 350, 500
(c) 50, 50, 350, 550 (d) None of these

9.29 A single-phase CSI has capacitor C as the load. For the constant source current, the voltage across the capacitor is

(a) square-wave (b) triangular wave
(c) step function (d) none of these

9.30 In sinusoidal PWM, there are '*m*' cycles of the triangular carrier wave in the half-cycle of the reference sinusoidal signal. If zero of the reference sinusoid coincides with zero/peak of the triangular carrier waves then number of pulses generated in each half-cycle are respectively

(a) $(m-1)/m$ (b) $(m-1)/(m-1)$ (c) m/m (d) none of these

9.31 Triangular PWM control when applied to three-phase, BJT based voltage source inverter, introduces

(a) low order harmonic voltages on dc side
(b) very high order harmonic voltages on dc side
(c) low order harmonic voltages on ac side
(d) very high order harmonic voltages on ac side

Chapter 10: Cycloconverters

10.1 Cycloconverter converts _________

(a) ac voltage to dc voltage
(b) dc voltage to dc voltage
(c) ac voltage to ac voltage at same frequency
(d) ac voltage at supply frequency to ac voltage at load frequency.

10.2 A six-pulse cycloconverter is fed from 415V three-phase supply with reactance of 0.3 Ω/phase. The output load voltage for firing angle of 45° and load current 40A is given by

(a) 272 V (b) 549 V
(c) 200 V (d) 180 V

10.3 A 3-pulse cycloconverter feeding a single-phase load of 200 V, 50 A at a power factor of 0.8 lagging. Power factor of the supply current is given by

(a) 0.48 (b) 0.9
(c) 0.1 (d) 0.38

10.4 A cycloconverters can be considered to be composed of two converters

(a) connected back to back (b) series connected
(c) parallel connected (d) series-parallel connected

10.5 For *p*-pulse cycloconverter, the peak value of the output voltage with maximum value of supply voltage ($V_{s_{\max}}$) is given by _________

(a) $V_{0_{(\max)}} = \frac{P}{\pi} \sin \frac{\pi}{P} V_{s(\max)}$ (b) $V_{0(\max)} = \frac{2P}{\pi} \sin \frac{\pi}{p} V_{s(\max)}$

(c) $V_{0(\max)} = \frac{p}{\pi} \cos \frac{\pi}{p} V_{s(\max)}$ (d) $V_{0(\max)} = \frac{3p}{\pi} \sin \frac{3\pi}{p} V_{s(\max)}$

10.6 For *P*-pulse cycloconverter, when the output voltage is reduced in magnitude by firing delay α, then

(a) $V_{0(\max)} = \frac{p}{\pi} \sin \frac{\pi}{p} V_{s(\max)} \cos \alpha$ (b) $V_{0(\max)} = \frac{p}{\pi} \cos \frac{\pi}{p} V_{s(\max)} \sin \alpha$

(c) $V_{0(\max)} = \frac{2p}{\pi} \sin \frac{2\pi}{p} V_{s(\max)} \cos \alpha$ (d) $V_{0(\max)} = \frac{2p}{\pi} \cos \frac{2\pi}{p} V_{s(\max)} \sin \alpha$

10.7 In a 3-pulse cycloconverter with intergroup reactor operating in circulating current mode, both P and N converter groups synthesize the
(a) same fundamental sinewave
(b) different fundamental sinewave
(c) same fundamental cosinewave
(d) different fundamental cosinewave

Chapter 11: A.C. Regulators

11.1 AC voltage regulators converters converts ________
(a) Fixed mains voltage to fixed ac voltage.
(b) Fixed mains voltage directly to variable ac voltage without change in frequency.
(c) Fixed mains voltage directly to variable ac voltage with change in frequency

11.2 Sequence control of AC regulators is employed for
(a) the improvement of power factor & reduction of harmonics
(b) the reduction of power factor only
(c) the reduction of harmonics only
(d) the improvement of power factor & increase in harmonics.

11.3 In a single phase full-wave ac regulator, varying the delay angle α from 0 to π can vary the rms output voltage from
(a) Vs to $Vs/4$ (b) Vs to $Vs/2$
(c) Vs to $3Vs/2$ (d) Vs to 0

11.4 The conduction angle (δ) of SCR T_1 in a single-phase full-wave controller is obtained from:
(a) $\delta = \beta - \alpha$ (b) $\delta = \beta + \alpha$
(c) $\delta = \alpha - \beta$ (d) $\delta = \beta + 0$

11.5 A single-phase half-wave ac voltage regulator using one SCR in antiparallel with a diode, feeds 1 kW, 230 V heater. For a firing angle of 180°, the load power is
(a) 5 W (b) 300 W
(c) 400 W (d) 500 W

Chapter 12: Resonant Converters

12.1 A series R-L-C circuit when excited by a 10 V sinusoidal voltage source of variable frequency, exhibits resonance at 100 Hz and has a 3-dB bandwidth of 5 Hz. The voltage across the inductor L at resonance is

(a) 10 V (b) $10\sqrt{2}$ V (c) $10/\sqrt{2}$ V (d) 200 V

12.2 Resonant converters are basically used to
(a) generate large peaky voltage
(b) reduce the switching losses
(c) eliminate harmonics
(d) convert a square-wave into a sine wave

12.3 In series resonant converters, the output is taken in
(a) parallel with C of tank circuit

(b) parallel with L of tank circuit
(c) parallel with C or L of tank circuit
(d) series with C or L of tank circuit

12.4 Class E resonant converters are used in
(a) low power, very high frequency applications
(b) low power low frequency applications
(c) high power, very high frequency applications
(d) high power, low frequency applications

12.5 Zero voltage and zero current switching helps in
(a) minimizing the switching losses
(b) increasing the switching losses
(c) minimizing the component sizes.
(d) increasing the component sizes.

12.6 As a filter, series RLC combination provides
(a) bandpass characteristics with a bandwidth directly proportional to the quality factor.
(b) bandpass characteristics with a bandwidth inversely proportional to the quality factor
(c) bandreject characteristics with a bandwidth directly proportional to the quality factor.
(d) bandreject characteristics with a bandwidth inversely proportional to quality factor.

12.7 Zero-current switching requires
(a) an upper limit on current flow
(b) lower limit on current flow
(c) an upper limit on voltage appearing across the switch
(d) lower limit on voltage appearing across the switch.

12.8 Resonant inverters are used in
(a) high-frequency applications requiring fixed output voltage
(b) high frequency applications requiring variable output voltage
(c) low-frequency applications requiring fixed output voltage
(d) low-frequency applications requiring variable output voltage

12.9 Parallel-resonant inverters are supplied from
(a) a constant dc source and give a sinusoidal output voltage
(b) a variable dc source and give a sinusoidal output voltage
(c) a constant dc source and gives a squarewave output voltage
(d) a variable dc source and gives a squarewave output voltage.

12.10 The half-bridge series resonant inverter is operated at an output frequency of 7 kHz. If $C_1 = C_2 = C = 3\ \mu\text{F}$, $L_1 = L_2 = L = 50\ \mu\text{H}$, $R = 2\ \Omega$ and $E_{\text{dc}} = 220$ V, the peak supply current becomes:
(a) 35.4 A (b) 55.4 A (c) 100 A (d) 200 A

12.11 The basic series resonant inverter with bidirectional switches has $C_r = 2\ \mu\text{F}$, $\text{L}_\text{r} = 20\ \mu\text{H}$, $R = 0$, $E_{\text{dc}} = 220$ V, $t_q = 12\ \mu\text{s}$ and $f_0 = 20$ kHz.
The peak-to-peak capacitor voltage becomes:
(a) 540 V (b) 100 V (c) 440 V (d) 200 V

12.12 Half-bridge series resonant inverter with bidirectional switches is operated with output frequency $f_0 = 3.5$ kHz, $C_1 = C_2 = 3\ \mu F$, $L_1 = L_2 = L_r = 50\ \mu\text{H}$, $R = 2\ \Omega$ and $E_{\text{dc}} = 220$ V

The rms load current becomes:

(a) 100 A (b) 44.1 A (c) 10 A (d) 120 A

12.13 Full-bridge series resonant inverter with bidirectional switches has $C_r = 6\ \mu F$, $Lr = 50\ \mu H$, $R = 2\ \Omega$, $f_0 = 3.5$ kHz and $E_{dc} = 220$ V. The average supply current is given by

(a) 10 A (b) 100 A (c) 70.71 A (d) 170.71 A

12.14 Class E resonant inverter operates at resonance and has $f_s = 25$ kHz, $E_{dc} = 12$ V and $R = 10\ \Omega$. The optimum value of L_r is given by

(a) 125 μH (b) 50 μH (c) 25.47 μH (d) 10 μH

12.15 The ZCS buck converter has $E_{dc} = 12$ V, $E_0 = 4$ V, $P_0 = 400$ mW and $f_{0\max} = 50$ kHz. The value of C_r is given by

(a) 60 nF (b) 40.7 nF (c) 20 nF (d) 100 nF

Chapter 13: Protection and Cooling of Power Switching Devices

13.1 The metal oxide varistor (MOV) is used for protecting

(a) gate circuit against overcurrents
(b) gate circuit against overvoltages
(c) anode circuit overcurrents
(d) anode circuit against overvoltage.

13.2 The anode current through a conducting SCR is 10 A. If its gate current is made one-fourth, the anode current will become

(a) 0 (b) 5 A (c) 2.5 (d) 10 A

13.3 Snubber circuit is used to limit the rate of

(a) rise of current (b) conduction period
(c) rise of voltage across SCR (d) none of these

13.4 The maximum di/dt in an SCR is _______

(a) directly proportional to V_m of supply voltage
(b) inversely proportional to V_m of supply voltage
(c) inversely proportional to L in the circuit
(d) directly proportional to L in the circuit

13.5 Which of the following does not cause permanent damage of an SCR?

(a) High current
(b) High rate of rise of current
(c) High temp. rise
(d) High rate of rise of voltage

13.6 For an SCR, di/dt protection is achieved through the use of

(a) R in series with SCR (b) L in series with SCR
(c) RL in series with SCR (d) RLC in series with SCR

13.7 For an SCR, dv/dt protection is achieved through the use of

(a) RL in series with SCR (b) RL across SCR
(c) L in series with SCR (d) none of these

13.8 If the voltage across a thyrite is increased, the current.

(a) decreases to a low value
(b) increases in proportion to voltage increase
(c) increases to a very high value
(d) is not affected

13.9 A thyrite resistor is used

(a) to provide temperature compensation
(b) to generate phase shift
(c) to rectify very high voltage
(d) to bypass voltage surges in equipment

13.10 Match the functions of the following protective elements in SCR applications:

SCR rating	*Protective element*
(A) di/dt limit	(P) snubber
(B) dv/dt limit	(Q) heat sink
(C) $i^2 t$ limit	(R) series reactor
(D) junction temp. limit	(S) to avoid runway speeds on no load

13.11 The thermal resistance between the body of a power semiconductor device and the ambient is expressed as

(a) voltage across the device divided by current through the device.
(b) average power dissipated in the device divided by the square of the rms current in the device.
(c) average power dissipated in the device divided by the temperature difference from body to ambient.
(d) temperature difference from body to ambient divided by average power dissipated in the device.

13.12 Device used for current protection is

(a) the fuse
(b) R-C network
(c) snubber network
(d) none of these

13.13 The scheme which can be implemented if two thyristor turn-on simultaneously, producing a short circuit on the supply, is known as

(a) protection by ringing
(b) gate-blocking
(c) electronic crowbar
(d) all the above

13.14 As soon as fault current is defected, it can be shunted away by turning on a parallel thyristor until the circuit breaker interrupts the fault current. This scheme is known as

(a) Electronic crowbar
(b) Protection by ringing
(c) Gate blocking
(d) none of these

13.15 Gates are protected against spurious (or noise) firing by using

(a) shield cables
(b) zener diode across the gate
(c) series resistance
(d) all the above

13.16 Gate can be protected against overcurrent by

(a) connecting a series resistance
(b) zener diode across the gate
(c) connecting a series inductor
(d) none of these

13.17 Gate can be protected against overvoltage by

(a) zener diode across the gate
(b) connecting a series resistance
(c) conntecting a series inductor
(d) heat sink

13.18 Suppressor is a device that responds to the rate of change of current or voltage to prevent

(a) a fall below a predetermined level
(b) rise above a predetermined level
(c) overloading
(d) none of these

13.19 Overvoltages may be generated by
(a) switching of inductive loads (b) variations in supply voltage
(c) bad commutation (d) none of these

13.20 Heat sink is a mass of metal that is added to a device for the purpose of
(a) absorbing heat (b) dissipating heat
(c) absorbing and dissipating heat (d) none of these

13.21 Surge current rating of thyristor specifies the maximum
(a) repetitive current with sine wave
(b) non-repetitive current with rectangular wave
(c) non-repetitive current with sine wave
(d) repetitive current with triangular wave

13.22 The object of connecting resistance and capacitance across gate circuit is to protect the thyristor gate against
(a) overvoltage (b) dv/dt
(c) noise signals (d) none of these

Chapter 14: Control of D.C. Drives

14.1 A motor armature supplied through phase controlled SCR receives a smoother voltage shape of
(a) high motor speed (b) low motor speed
(c) rated motor speed (d) very low motor speed

14.2 An SCR is used to control the speed of dc motor. At full speed, the motor is taking 1 A at 75 V. The maximum forward surge current rating and maximum forward breakover voltage rating respectively are of the order of
(a) 3 A, 225 V (b) 1 A, 300 V (c) 6 A, 150 V (d) 5 A, 200 V

14.3 In a dc motor, if the field coils get opened, the speed of the motor will
(a) decrease (b) come to a stop (c) increase (d) none of these

14.4 Chopper control for DC motor provides variation in
(a) input voltage (b) frequency
(c) both (a) and (b) above (d) none of the above

14.5 It is required to drive a d.c. shunt motor at different speeds in both the directions (forward and reverse) and also to break it in both the directions which one of the following would you use?
(a) a half-controlled thyristor-bridge (b) a full-controlled thyristor-bridge
(c) a dual converter (d) a diode bridge

14.6 A three-phase semiconverter feeds the armature of a separately excited dc motor, supplying a nonzero torque. For steady-state operation, the motor armature current is found to drop to zero at certain instances of time. At such instances, a voltage assumes a value that is
(a) equal to the instantaneous value of the ac phase voltage
(b) equal to the instantaneous value of the motor back emf
(c) arbitrary
(d) zero

14.7 A thyristorised three-phase, fully controlled converter feeds a dc load that draws a constant current. Then the input ac line current to the converter has
(a) an rms value equal to the dc load current
(b) an average value equal to the dc load current

(c) a peak value equal to the dc load current

(d) a fundamental frequency component, whose rms value is equal to the dc load current.

14.8 In case of armature controlled separately excited dc motor drive with close-loop control, an inner current loop is useful because it

(a) limits the speed of the motor to a safe valve

(b) helps in improving the drive energy efficiency

(c) limits the peak current of the motor to the permissible value

(d) reduces the steady-state speed error.

14.9 The advantage of the tachometer speed control method for d.c. motors is that it senses

(a) back emf (b) armature current

(c) armature voltage (d) speed

14.10 A step down chopper operates from a dc voltage source V_s, and feeds a dc motor armature with a back emf E_b. From oscilloscope traces, it is found that the current increases for time t_r, falls to zero over time t_1, and remains zero for time t_0, in every chopping cycle. Then the average dc voltage across the freewheeling diode is

(a) $\dfrac{V_s t_r}{(t_r + t_f + t_o)}$ (b) $\dfrac{(V_s t_r + E_b \cdot t_f)}{(t_r + t_f + t_o)}$

(c) $\dfrac{(V_s t_r + E_b \cdot t_o)}{(t_r + t_f + t_o)}$ (d) $\dfrac{(V_s t_r + E_b [t_f + t_o])}{(t_r + t_f + t_o)}$

14.11 Armature voltage of a dc motor can be controlled by means of

(a) cycloconverters (b) inverters

(c) AC–DC converters

(d) Bridge rectifier circuit with fixed input

14.12 The speed of a dc shunt motor above normal speed can be controlled by

(a) armature voltage control method

(b) flux control method

(c) both the methods

(d) none of these

14.13 For controlling the speed of dc motor of 150 hp rating, the following types of converters are normally used

(a) single-phase full converters

(b) single-phase dual converters

(c) three-phase full converters

(d) three-phase dual converters

14.14 A motor armature supplied through phase-controlled SCRs receives a smoother voltage shape at

(a) high motor speed (b) low motor speeds

(c) rated normal motor speeds (d) none of these

14.15 A dc chopper circuit controls the average voltage across the dc motor by

(a) controlling the input voltage

(b) controlling the field current

(c) controlling the line current

(d) continuously switching-ON and OFF the motor for fixed durations of t_{ON} and t_{OFF} respectively.

14.16 The advantage of tachometer speed control method for dc motors is that, it senses
- (a) back emf
- (b) armature current
- (c) armature voltage
- (d) speed

Chapter 15: Control of A.C. Drives

15.1 In an a.c. motor control, the ratio of voltage to frequency is maintained at constant value
- (a) to make maximum use of magnetic circuit.
- (b) to make minimum use of magnetic circuit.
- (c) to maximise the current from the supply to provide torque.
- (d) to minimize the current drawn from the supply to provide torque.

15.2 A single-phase voltage controller feeds an induction motor and a heater
- (a) In both the loads only fundamental and harmonics are useful.
- (b) In induction motor only fundamental and in heater only harmonics are useful.
- (c) In induction motor only fundamental and in heater harmonics as well as fundamental are useful.
- (d) In induction motor only harmonics and in heater only fundamental are useful.

15.3 Speed control of induction motor can be effected by varying
- (a) Flux
- (b) Voltage input to stator
- (c) Keeping rotor coil open
- (d) None of these

15.4 Voltage induced in the rotor of the induction motor when it runs at synchronous speed is
- (a) very near input voltage to stator
- (b) slip time the input voltage
- (c) zero
- (d) none of these

15.5 The speed and torque of induction motors can be varied by which of the following means?
- (a) Stator voltage control
- (b) Rotor voltage control
- (c) Frequency control
- (d) All of these

15.6 An inverter capable of supplying a balanced three-phase variable voltage/ variable frequency, its output is feeding a three-phase induction motor rated for 50 Hz and 440 V. The stator winding resistances of the motor are negligibly small. During the starting, the current inrush can be avoided without sacrificing the starting torque by suitably applying
- (a) low voltage at rated frequency
- (b) low voltage keeping V/F ratio constant
- (c) rated voltage at low frequency
- (d) rated voltage at rated frequency

15.7 For the large a.c. motor control shown below, if the firing angle of SCRs in the inverters circuit is delayed then

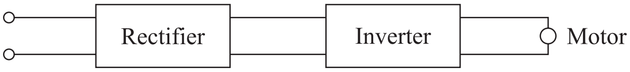


Fig. Q.15.7

(a) motor speed will increase
(b) motor speed will decrease
(c) the speed will not be effected
(d) frequency of inverter output will increase

15.8 In the above system, if the firing angle of the SCRs of the controlled rectifier is delayed, the motor speed will
(a) become high (b) become low
(c) remain same (d) depend upon firing of inverter

15.9 Thyristor switching circuits are used
(a) to reduce the stator voltage
(b) to increase the stator voltage
(c) to keep the stator voltage control
(d) none of these

15.10 Variable speed drives using stator voltage control are normally
(a) open-loop system (b) closed-loop system
(c) both are correct (d) none of these

15.11 For controlling the speed of three-phase induction motor, the method generally used is
(a) fixed voltage fixed frequency method
(b) variable voltage variable frequency method
(c) fixed voltage variable frequency method
(d) none of these

15.12 The slip power recovery method for the speed control of induction motor (slip-control)
(a) increase the efficiency (b) decrease the efficiency
(c) improves the power-factor (d) none of these.

15.13 In variable voltage variable frequency control, to achieve constant torque operation below base speed
(a) (V/F) has to be kept constant (b) flux has to be increased
(c) flux has to be decreased (d) none of these

15.14 Power factor of synchronous motor can be made leading by adjusting its
(a) speed (b) supply voltage
(c) excitation (d) supply frequency

Chapter 16: Power Electronic Applications

16.1 In induction heating depth of penetration is proportional to
(a) $\sqrt{\text{frequency}}$ (b) $\frac{1}{\sqrt{\text{frequency}}}$
(c) frequency (d) $(\text{frequency})^2$

16.2 Which of the following types of heating process is used for surface heating of steel?
(a) dielectric heating (b) Infra-red heating
(c) Induction heating (d) Resistance heating

16.3 Uninterruptible supply is used in
(a) Computers (b) Communication links
(c) Essential Instrumentation (d) all of the above

16.4 HVDC transmission is preferred to EHV – AC because
(a) HVDC terminal equipment are inexpensive.
(b) VAR compensation is not required in HVDC systems.
(c) System stability can be improved.
(d) Harmonics – problem is avoided.

16.5 A SMPS operating at 20 kHz to 100 kHz range uses as the main switching elements.
(a) SCR (b) MOSFET (c) Transistor (d) SIT

16.6 The use of high-speed circuit breakers
(a) reduces the short circuit current (b) improves system stability
(c) decreases system stability
(d) increases the short circuit current.

16.7 Bulk power transmission over long HVDC lines are preferred, on account of
(a) low cost of HVDC terminals (b) no harmonic problems
(c) minimum line power losses (d) simple protection

16.8 In a DC transmission line
(a) It is necessary for the sending end and receiving end to be operated in synchronism.
(b) The effect of inductive and capacitive reactances are greater than in an AC transmission line of the same rating.
(c) There are no effects due to inductive and capacitive reactances.
(d) Power transfer capability is limited by stability considerations.

16.9 Static VAR compensators are used to control
(a) Only magnitude of the ac line current from the utility.
(b) Only phase of the ac line current from the utility.
(c) Both magnitude and phase of the ac line current from the utility.
(d) None of the above.

16.10 A metal bar is heated electronically by
(a) Emission heating (b) Dielectric heating
(c) Induction heating (d) Conductive heating.

16.11 A rod of mild steel kept inside a coil carrying high frequency currents gets heated due to
(a) Dielectric heating (b) Induction heating
(c) Both a & b (d) None of these

16.12 If the frequency of current in copper is increased from 200 MHz to 800 MHz, the skin depth of penetration would become
(a) Four times (b) Equal to the radius of conductor
(c) Halved (d) Two fold

16.13 A freshly painted layer may be dried electronically by
(a) Conduction heating (b) Induction heating
(c) Dielectric heating (d) None of these

16.14 If the capacitor is loss-free in dielectric heating, the heat produced will be
(a) Zero (b) Infinity
(c) Proportional to value of capacitance
(d) Proportional to the frequency

16.15 Practically all the heating requirements can be met by an equipment of
(a) Coal (b) Gas (c) Oil (d) Electric

16.16 High frequency induction heating is used for
- (a) Ferrous metals only
- (b) Non-ferrous metals
- (c) Both ferrous and non-ferrous metals
- (d) None of these

16.17 Induction heating is used for
- (a) Insulating materials
- (b) Magnetic materials
- (c) Conducting materials
- (d) Both magnetic and non-magnetic material

16.18 For dielectric heating, the range of frequency normally is
- (a) 10 kHz – 100 kHz
- (b) 100 kHz – 1 MHz
- (c) 1 MHz – 10 MHz
- (d) 10 kHz – 40 MHz

16.19 In dielectric heating, non-uniform heating
- (a) Occurs for higher frequencies
- (b) Occurs for lower frequencies
- (c) is independent of frequency
- (d) Occurs for higher power factors

16.20 In dielectric heating, the rate of heating cannot be increased by increasing the potential gradient because
- (a) Coupling problems become highly pronounced
- (b) Very high voltages are not easily available
- (c) Heating becomes non-uniform
- (d) Corona takes place

ANSWERS TO MCQS

Chapter-2

2.1 (a) **2.2** (d) **2.3** (c) **2.4** (d)
2.5 (c) **2.6** (b) **2.7** (d) **2.8** (d)
2.9 (b)
2.10 (c) Hint: The turn-off time is temperature dependent and doubles between 25°C and 125°C.
2.11 (b) **2.12** (b) **2.13** (b) **2.14** (b, c)
2.15 (a) **2.16** (b, c) **2.17** (a)

[***Hint:*** Pulse Repetition Rate (PRR) = $\frac{1}{25\times10^3}$ = 0.4 ms = 400 ms

Mark/space ratio = 1/10, Pulse/width = $\frac{400}{11}$ = 36.4 µsec. SCR will turn-on if the pulse-width is more than SCR turn-on-time]

2.18 (b) ***Hint:*** Form factor = $\frac{\text{rms current}}{\text{average current}}$

2.19 (b) **2.20** (b, d) **2.21** (a)

2.22 (c) Explanation: I_{av} = Im/Form factor
Form factor for 120° = 1.878 and form factor for 60° = 2.7781
$\therefore$ I_{av} is less than 20 A.

2.23 (a) **2.24** (c) **2.25** (d) **2.26** (b)
2.27 (a) **2.28** (c) **2.29** (c) **2.30** (d)
2.31 (d) **2.32** (c) **2.33** (a) **2.34** (b)
2.35 (c) **2.36** (d) **2.37** (a) **2.38** (c)
2.39 (c) **2.40** (c) **2.41** (d) **2.42** (a)
2.43 (c) **2.44** (b) **2.45** (b) **2.46** (b)

Chapter-3

3.1 (a) **3.2** (b) **3.3** (a) **3.4** (a)
3.5 (c) **3.6** (c) **3.7** (c) **3.8** (d)
3.9 (a) **3.10** (a) **3.11** (c) **3.12** (b)
3.13 (d) **3.14** (a)

Chapter-4

4.1 (b) **4.2** (c) **4.3** (a) **4.4** (c)
4.5 (c) **4.6** (b) **4.7** (d) **4.8** (a)
4.9 (b) **4.10** (a)

Chapter-5

5.1 (b) **5.2** (a) **5.3** (c) **5.4** (d)
5.5 (a) **5.6** (b) **5.7** (d) **5.8** (d)
5.9 (d) **5.10** (c) **5.11** (b) **5.12** (d)
5.13 (b) **5.14** (c) **5.15** (d) **5.16** (c)
5.17 (a) **5.18** (a) **5.19** (c) **5.20** (c)
5.21 (c) **5.22** (d) **5.23** (b) **5.24** (c)
5.25 (a) **5.26** (c) **5.27** (b) **5.28** (c)
5.29 (d) **5.30** (c) **5.31** (a) **5.32** (d)
5.33 (b) **5.34** (c) **5.35** (c) **5.36** (a)
5.37 (b) **5.38** (c) **5.39** (a) **5.40** (c)
5.41 (b) **5.42** (a) **5.43** (b and a) **5.44** (b)
5.45 (b) **5.46** (a) **5.47** (b) **5.48** (c)
5.49 (b) **5.50** (a) **5.51** (c) **5.52** (c)
5.53 (a) **5.54** (a) **5.55** (b) **5.56** (a)
5.57 (b) **5.58** (b) **5.59** (b)

Chapter-6

6.1 (b) **6.2** (a) **6.3** (d) **6.4** (a)
6.5 (a) **6.6** (b) **6.7** (b) **6.8** (a)
6.9 (b) **6.10** (d) **6.11** (d) **6.12** (a)
6.13 (c) **6.14** (b) **6.15** (c) **6.16** (d)
6.17 (c) **6.18** (c) **6.19** (c) **6.20** (b)
6.21 (b) **6.22** (c) **6.23** (d) **6.24** (d)

6.25 (c) **6.26** (d) **6.27** (d) **6.28** (c)
6.29 (d) **6.30** (a) **6.31** (a) **6.32** (a)
6.33 (a)

Explanation: Since $V_t = 200$ V, therefore—

$$V_0 = \frac{3\sqrt{2}\,V_{\text{ph}}}{\pi} = \frac{3\sqrt{2}\times 200}{3.1414}$$
$$= 233.91\text{ V}$$

6.34 (c)
6.35 (a) **6.36** (b) **6.37** (d) **6.38** (c)
6.39 (c) **6.40** (d)
6.41 (c) **6.42** (positive, $\alpha = 167.9°$)
6.43 (c)

Explanation: The waveform V_0 is typical of R-L load and hence d.c. motor. For a pure inductive load, the energy stored in the inductor during off period may extend the waveform upto the next triggering point.

6.44 (d)

Chapter-8

8.1 (a) **8.2** (b) **8.3** (c) **8.4** (b)
8.5 (b) **8.6** (a) **8.7** (a) **8.8** (a)
8.9 (a) **8.10** (a) **8.11** (a) **8.12** (b)

Solution: Peak current $= I_o + V_s\sqrt{C/L} = 100 + 200\sqrt{\frac{50}{25}} = 382.8$ A

Effective-on period $= \pi\sqrt{L_C}$

$$= 3.14\sqrt{25\times 50\times 10^{-12}} = 700\ \mu\text{s}$$

8.13 (a)

Solution: Avg. output voltage $= V_o = \alpha \cdot V_s = \frac{T_{\text{on}}}{T} \cdot V_s$

$\therefore$ $T = 100\ \mu\text{s} + 150\ \mu\text{s} = 250\ \mu\text{s}$

$$V_o = \frac{100}{250}\times 100 = 40\text{ V}$$

$$I_o = \frac{V_o - E}{R} = \frac{40-30}{2} = 15\text{ A}$$

8.14 (b)

Solution: $I_{\text{peak}} = I_o + V_s\sqrt{C/L} = 70.7 + 200\sqrt{\frac{16}{64}} = 170.7$ A

8.15 (a)

Solution: Load voltage $E_o = \dfrac{E \cdot T_{\text{on}}}{T_{\text{on}} + T_{\text{off}}} = E \cdot \dfrac{T_{\text{on}}}{T} = E \cdot F \cdot T_{\text{on}}$

There are two ways to vary load voltage E_0, either by changing f or T_{on}. Here frequency is fixed and T_{on} is varied. As the frequency is kept constant, ripple remains constant

8.16 (d) **8.17** (a) **8.18** (c) **8.19** (a)
8.20 (a) **8.21** (a) **8.22** (c) **8.23** (a)
8.24 (a) **8.25** (b) **8.26** (c) **8.27** (a)
8.28 (b) **8.29** (a) **8.30** (b)

Chapter-9

9.1 (d) **9.2** (d) **9.3** (d) **9.4** (b)
9.5 (d) **9.6** (d) **9.7** (c) **9.8** (c)
9.9 (b) **9.10** (a) **9.11** (b) **9.12** (b)
9.13 (c) **9.14** (a) **9.15** (c) **9.16** (c)
9.17 (b) **9.18** (a) **9.19** (c) **9.20** (b)
9.21 (a) **9.22** (b) **9.23** (d) **9.24** (c)
9.25 (c) **9.26** (d) **9.27** (b) **9.28** (c)
9.29 (b) **9.30** (a) **9.31** (d)

Chapter-10

10.1 (d) **10.2** (a) **10.3** (d) **10.4** (a)
10.5 (a) **10.6** (a) **10.7** (a)

Chapter-11

11.1 (b) **11.2** (a) **11.3** (d) **11.4** (a)
11.5 (d)

Chapter-12

12.1 (d) **12.2** (b) **12.3** (d) **12.4** (a)
12.5 (a) **12.6** (b) **12.7** (a) **12.8** (a)
12.9 (a) **12.10** (a) **12.11** (c) **12.12** (b)
12.13 (c) **12.14** (c) **12.15** (b)

Chapter-13

13.1 (d) **13.2** (d) **13.3** (c)

13.4 (a, c) → Hint = $\left.\dfrac{di}{dt}\right|_{\max} = \dfrac{E_m}{L}$ A/sec

13.5 (a) **13.6** (b) **13.7** (b) **13.8** (c)
13.9 (c) **13.10** A–R, B–P, C–S, D–Q
13.11 (d)

Explanation: Temp. of device body = $T_D = P_D \cdot \theta_D + T_A$
where θ_D = thermal resistance

P_d = Power dissipated
T_A = ambient temp.

$$\therefore\ \theta_D = \frac{T_D - T_A}{P_d}$$, i.e. answer (d)

13.12	(d)	**13.13**	(a)	**13.14**	(a)	**13.15**	(a)
13.16	(a)	**13.17**	(a)	**13.18**	(b)	**13.19**	(d)
13.20	(c)	**13.21**	(c)	**13.22**	(c)		

Chapter-14

14.1	(a)	**14.2**	(a)	**14.3**	(c)	**14.4**	(c)
14.5	(c)	**14.6**	(b)	**14.7**	(c)	**14.8**	(c)
14.9	(d)	**14.10**	(c)	**14.11**	(c)	**14.12**	(b)
14.13	(c)	**14.14**	(a)	**14.15**	(d)	**14.16**	(d)

Chapter-15

15.1	(a)	**15.2**	(c)	**15.3**	(b)	**15.4**	(a)
15.5	(d)	**15.6**	(b)	**15.7**	(a)	**15.8**	(b)
15.9	(a)	**15.10**	(b)	**15.11**	(b)	**15.12**	(a)
15.13	(a)	**15.14**	(c)				

Chapter-16

16.1	(b)	**16.2**	(c)	**16.3**	(a)	**16.4**	(c)
16.5	(b)	**16.6**	(c)	**16.7**	(c)	**16.8**	(c)
16.9	(c)	**16.10**	(c)	**16.11**	(b)	**16.12**	(d)
16.13	(c)	**16.14**	(a)	**16.15**	(d)	**16.16**	(c)
16.17	(d)	**16.18**	(d)	**16.19**	(a)	**16.20**	(d)