CHAPTER 9

POWER ELECTRONICS

YEAR 2012 **ONE MARK**

MCQ 9.1 A half-controlled single-phase bridge rectifier is supplying an R-L load. It is operated at a firing angle α and the load current is continuous. The fraction of cycle that the freewheeling diode conducts is

(A) $1/2$ (B) $(1-\alpha/\pi)$

(C) $\alpha/2\pi$ (D) α/π

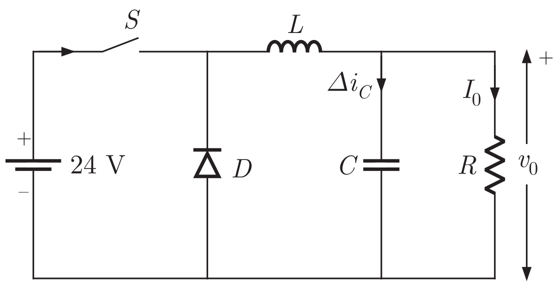
MCQ 9.2 The typical ratio of latching current to holding current in a 20 A thyristor is

(A) 5.0 (B) 2.0

(C) 1.0 (D) 0.5

YEAR 2012 **TWO MARKS**

MCQ 9.3 In the circuit shown, an ideal switch S is operated at 100 kHz with a duty ratio of 50%. Given that Δi_c is 1.6 A peak-to-peak and I_0 is 5 A dc, the peak current in S, is

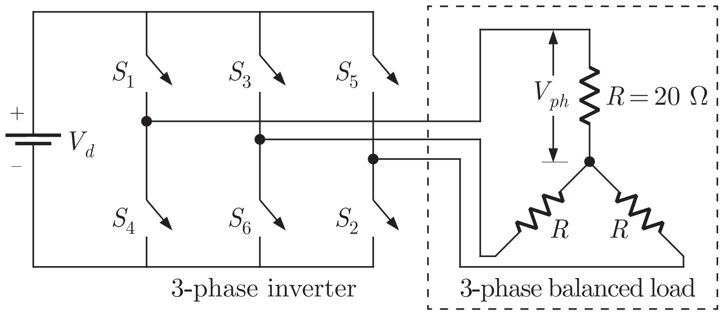


(A) 6.6 A (B) 5.0 A

(C) 5.8 A (D) 4.2 A

Common Data for Questions 4 and 5

In the 3-phase inverter circuit shown, the load is balanced and the gating scheme is 180° conduction mode. All the switching devices are ideal.



MCQ 9.4 The rms value of load phase voltage is

(A) 106.1 V (B) 141.4 V

(C) 212.2 V (D) 282.8 V

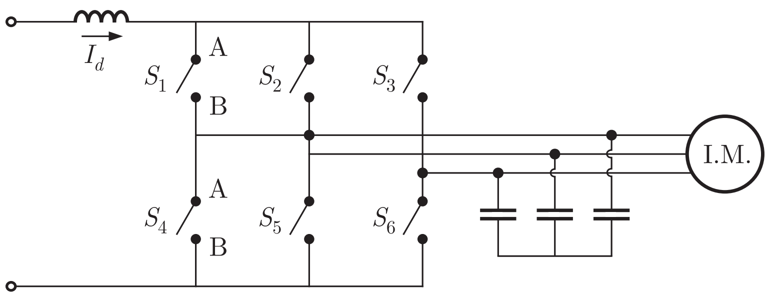
MCQ 9.5 If the dc bus voltage $V_d = 300$ V, the power consumed by 3-phase load is

(A) 1.5 kW (B) 2.0 kW

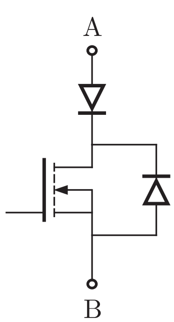
(C) 2.5 kW (D) 3.0 kW

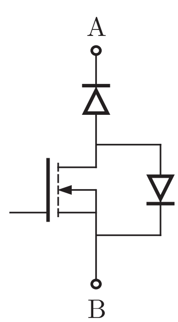
YEAR 2011 ONE MARK

MCQ 9.6 A three phase current source inverter used for the speed control of an induction motor is to be realized using MOSFET switches as shown below. Switches S_1 to S_6 are identical switches.



The proper configuration for realizing switches S_1 to S_6 is

(A)


(B)


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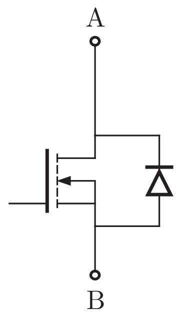
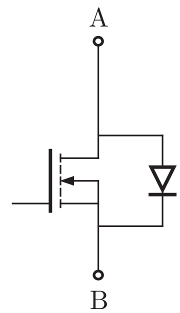
(C) 

(D) 

MCQ 9.7 Circuit turn-off time of an SCR is defined as the time

(A) taken by the SCR turn to be off

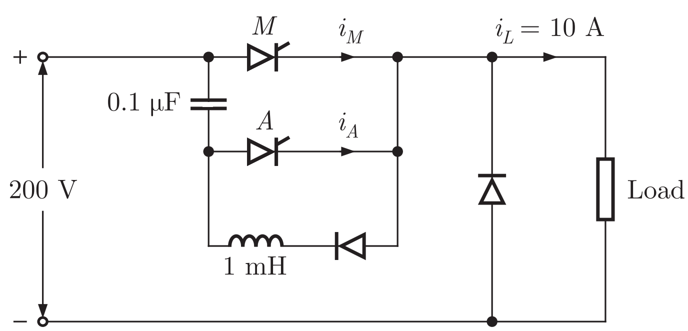
(B) required for the SCR current to become zero

(C) for which the SCR is reverse biased by the commutation circuit

(D) for which the SCR is reverse biased to reduce its current below the holding current

YEAR 2011 TWO MARKS

MCQ 9.8 A voltage commutated chopper circuit, operated at 500 Hz, is shown below.



If the maximum value of load current is 10 A, then the maximum current through the main (M) and auxiliary (A) thyristors will be

(A) $i_{M\max} = 12$ A and $i_{A\max} = 10$ A

(B) $i_{M\max} = 12$ A and $i_{A\max} = 2$ A

(C) $i_{M\max} = 10$ A and $i_{A\max} = 12$ A

(D) $i_{M\max} = 10$ A and $i_{A\max} = 8$ A

Statement for Linked Answer Questions: 9 & 10

A solar energy installation utilize a three – phase bridge converter to feed energy into power system through a transformer of 400 V/400 V, as shown below.

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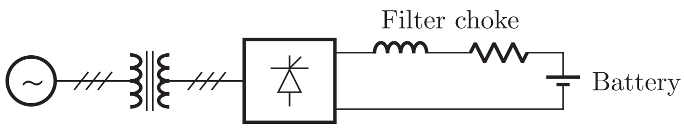


The energy is collected in a bank of 400 V battery and is connected to converter through a large filter choke of resistance $10\,\Omega$.

MCQ 9.9 The maximum current through the battery will be

(A) 14 A (B) 40 A

(C) 80 A (D) 94 A

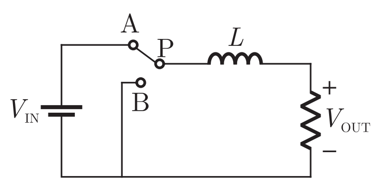
MCQ 9.10 The kVA rating of the input transformer is

(A) 53.2 kVA (B) 46.0 kVA

(C) 22.6 kVA (D) 7.5 kVA

YEAR 2010 ONE MARK

MCQ 9.11 The power electronic converter shown in the figure has a single-pole double-throw switch. The pole P of the switch is connected alternately to throws A and B. The converter shown is a



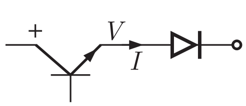
(A) step down chopper (buck converter)

(B) half-wave rectifier

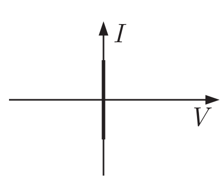
(C) step-up chopper (boost converter)

(D) full-wave rectifier

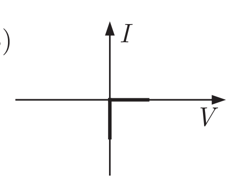
MCQ 9.12 Figure shows a composite switch consisting of a power transistor (BJT) in series with a diode. Assuming that the transistor switch and the diode are ideal, the I-V characteristic of the composite switch is



(A)



(B)



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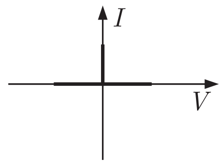
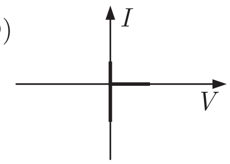
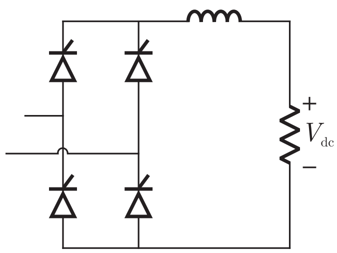
(C)


(D)


MCQ 9.13 The fully controlled thyristor converter in the figure is fed from a single-phase source. When the firing angle is 0°, the dc output voltage of the converter is 300 V. What will be the output voltage for a firing angle of 60°, assuming continuous conduction



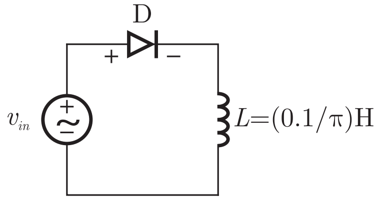
(A) 150 V (B) 210 V
(C) 300 V (D) 100π V

YEAR 2009 ONE MARK

MCQ 9.14 An SCR is considered to be a semi-controlled device because
(A) It can be turned OFF but not ON with a gate pulse.
(B) It conducts only during one half-cycle of an alternating current wave.
(C) It can be turned ON but not OFF with a gate pulse.
(D) It can be turned ON only during one half-cycle of an alternating voltage wave.

YEAR 2009 TWO MARKS

MCQ 9.15 The circuit shows an ideal diode connected to a pure inductor and is connected to a purely sinusoidal 50 Hz voltage source. Under ideal conditions the current waveform through the inductor will look like.



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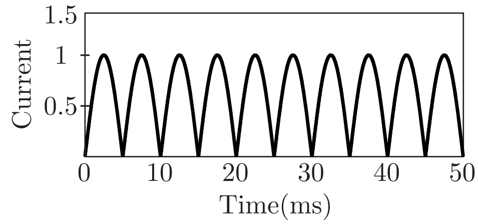
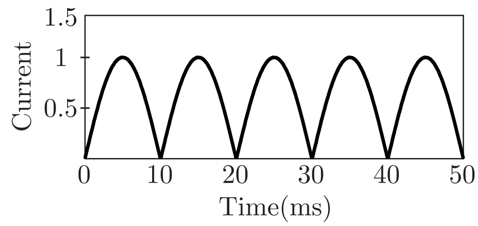
(A)



(B)



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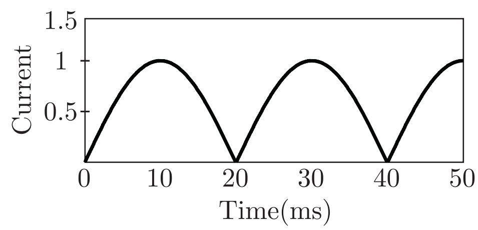

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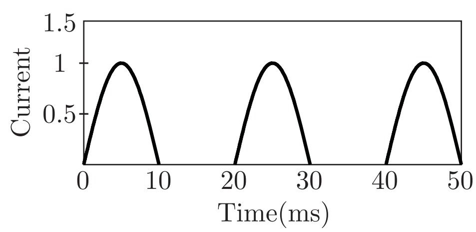
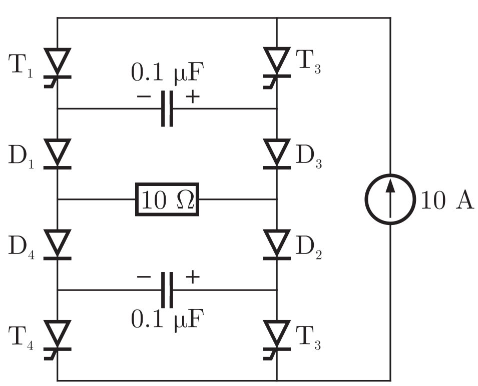


MCQ 9.16 The Current Source Inverter shown in figure is operated by alternately turning on thyristor pairs (T_1, T_2) and (T_3, T_4). If the load is purely resistive, the theoretical maximum output frequency obtainable will be



(A) 125 kHz (B) 250 kHz

(C) 500 kHz (D) 50 kHz

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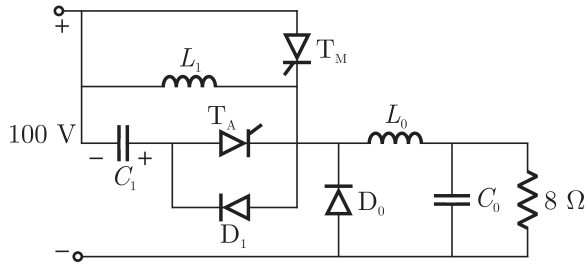
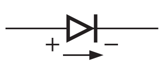
MCQ 9.17 In the chopper circuit shown, the main thyristor (T_M) is operated at a duty ratio of 0.8 which is much larger the commutation interval. If the maximum allowable reapplied dv/dt on T_M is 50 V/μs, what should be the theoretical minimum value of C_1 ? Assume current ripple through L_0 to be negligible.



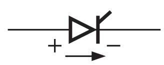
(A) 0.2 μF (B) 0.02 μF

(C) 2 μF (D) 20 μF

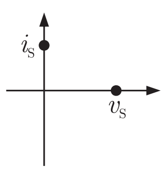
MCQ 9.18 Match the switch arrangements on the top row to the steady-state V-I characteristics on the lower row. The steady state operating points are shown by large black dots.



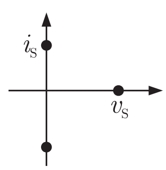
(P)



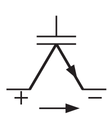
(Q)



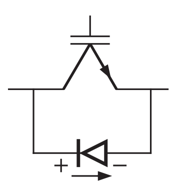
(i)



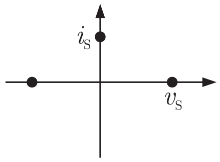
(ii)



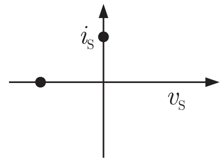
(R)



(S)



(iii)



(iv)

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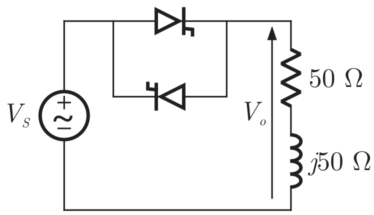
(A) P-I, Q-II, R-III, S-IV
(B) P-II, Q-IV, R-I, S-III
(C) P-IV, Q-III, R-I, S-II
(D) P-IV, Q-III, R-II, S-I

YEAR 2008 **ONE MARK**

MCQ 9.19 In the single phase voltage controller circuit shown in the figure, for what range of triggering angle (α), the input voltage (V_0) is not controllable ?



(A) $0° < \alpha < 45°$
(B) $45° < \alpha < 135°$
(C) $90° < \alpha < 180°$
(D) $135° < \alpha < 180°$

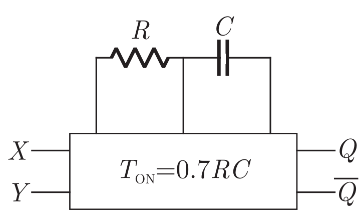
MCQ 9.20 A 3-phase voltage source inverter is operated in 180° conduction mode. Which one of the following statements is true ?

(A) Both pole-voltage and line-voltage will have 3rd harmonic components
(B) Pole-voltage will have 3rd harmonic component but line-voltage will be free from 3rd harmonic
(C) Line-voltage will have 3rd harmonic component but pole-voltage will be free from 3rd harmonic
(D) Both pole-voltage and line-voltage will be free from 3rd harmonic components

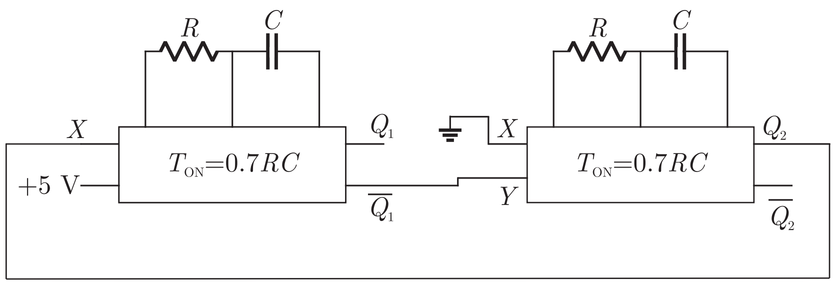
YEAR 2008 **TWO MARKS**

MCQ 9.21 The truth table of monoshot shown in the figure is given in the table below :

X	Y	Q	$\overline{Q}$
0	↑	⊓	⊔
↓	1	⊓	⊔



Two monoshots, one positive edge triggered and other negative edge triggered, are connected shown in the figure, The pulse widths of the two monoshot outputs Q_1 and Q_2 are T_{ON_1} and T_{ON_2} respectively.



The frequency and the duty cycle of the signal at Q_1 will respectively be

(A) $f = \frac{1}{T_{ON_1} + T_{ON_2}}$, $D = \frac{1}{5}$

(B) $f = \frac{1}{T_{ON_1} + T_{ON_2}}$, $D = \frac{T_{ON_2}}{T_{ON_1} + T_{ON_2}}$

(C) $f = \frac{1}{T_{ON_1}}$, $D = \frac{T_{ON_1}}{T_{ON_1} + T_{ON_2}}$

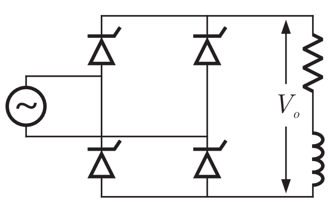
(D) $f = \frac{1}{T_{ON_2}}$, $D = \frac{T_{ON_1}}{T_{ON_1} + T_{ON_2}}$

MCQ 9.22 A single phase fully controlled bridge converter supplies a load drawing constant and ripple free load current, if the triggering angle is 30°, the input power factor will be

(A) 0.65 (B) 0.78

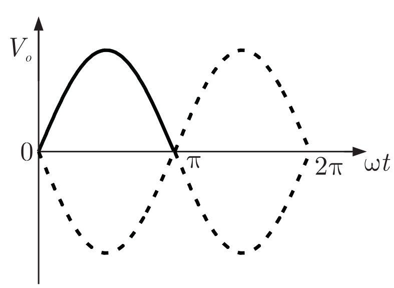
(C) 0.85 (D) 0.866

MCQ 9.23 A single-phase half controlled converter shown in the figure feeding power to highly inductive load. The converter is operating at a firing angle of 60°.

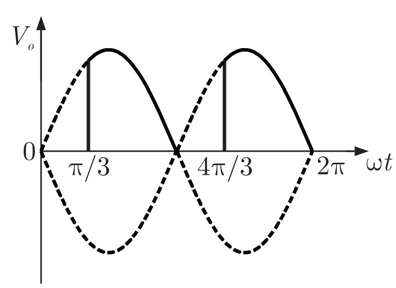


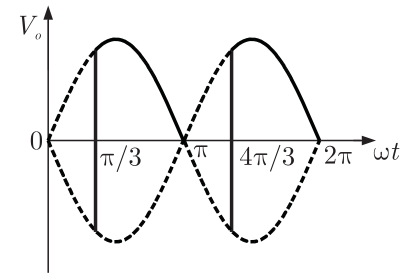
If the firing pulses are suddenly removed, the steady state voltage (V_0) waveform of the converter will become

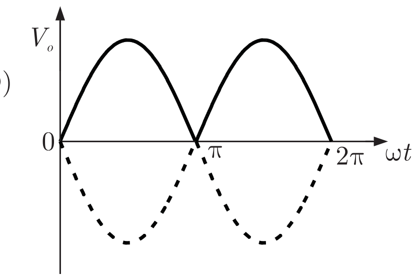
(A)



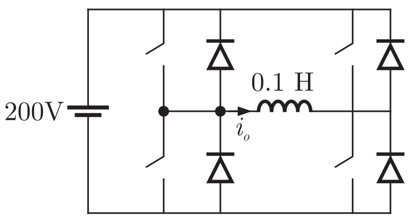
(B)



(C)


(D)


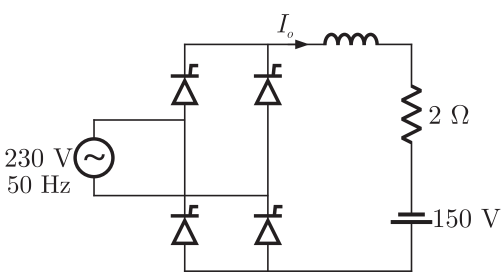
MCQ 9.24 A single phase source inverter is feeding a purely inductive load as shown in the figure. The inverter is operated at 50 Hz in 180° square wave mode. Assume that the load current does not have any dc component. The peak value of the inductor current i_0 will be



(A) 6.37 A (B) 10 A

(C) 20 A (D) 40 A

MCQ 9.25 A single phase fully controlled converter bridge is used for electrical braking of a separately excited dc motor. The dc motor load is represented by an equivalent circuit as shown in the figure.



Assume that the load inductance is sufficient to ensure continuous and ripple free load current. The firing angle of the bridge for a load current of $I_0 = 10$ A will be

(A) 44° (B) 51°

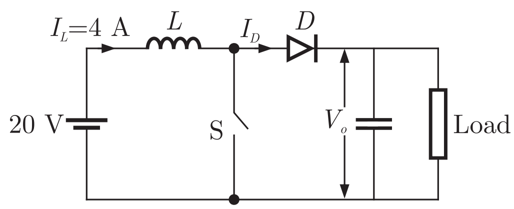
(C) 129° (D) 136°

MCQ 9.26 A three phase fully controlled bridge converter is feeding a load drawing a constant and ripple free load current of 10 A at a firing angle of 30°. The approximate Total harmonic Distortion (%THD) and the rms value of fundamental component of input current will respectively be

(A) 31% and 6.8 A (B) 31% and 7.8 A

(C) 66% and 6.8 A
(D) 66% and 7.8 A

MCQ 9.27 In the circuit shown in the figure, the switch is operated at a duty cycle of 0.5. A large capacitor is connected across the load. The inductor current is assumed to be continuous.



The average voltage across the load and the average current through the diode will respectively be

(A) 10 V, 2 A
(B) 10 V, 8 A
(C) 40 V 2 A
(D) 40 V, 8 A

YEAR 2007 ONE MARK

MCQ 9.28 A single-phase fully controlled thyristor bridge ac-dc converter is operating at a firing angle of 25° and an overlap angle of 10° with constant dc output current of 20 A. The fundamental power factor (displacement factor) at input ac mains is

(A) 0.78
(B) 0.827
(C) 0.866
(D) 0.9

MCQ 9.29 A three-phase, fully controlled thyristor bridge converter is used as line commutated inverter to feed 50 kW power 420 V dc to a three-phase, 415 V(line), 50 Hz ac mains. Consider dc link current to be constant. The rms current of the thyristor is

(A) 119.05 A
(B) 79.37 A
(C) 68.73 A
(D) 39.68 A

MCQ 9.30 A single phase full-wave half-controlled bridge converter feeds an inductive load. The two SCRs in the converter are connected to a common DC bus. The converter has to have a freewheeling diode.

(A) because the converter inherently does not provide for free-wheeling
(B) because the converter does not provide for free-wheeling for high values of triggering angles
(C) or else the free-wheeling action of the converter will cause shorting of the AC supply
(D) or else if a gate pulse to one of the SCRs is missed, it will subsequently cause a high load current in the other SCR.

MCQ 9.31 "Six MOSFETs connected in a bridge configuration (having no other power device) must be operated as a Voltage Source Inverter (VSI)". This statement is

(A) True, because being majority carrier devices MOSFETs are voltage driven.

(B) True, because MOSFETs hav inherently anti-parallel diodes

(C) False, because it can be operated both as Current Source Inverter (CSI) or a VSI

(D) False, because MOSFETs can be operated as excellent constant current sources in the saturation region.

YEAR 2007 TWO MARKS

MCQ 9.32 A single-phase voltages source inverter is controlled in a single pulse-width modulated mode with a pulse width of 150° in each half cycle. Total harmonic distortion is defined as

$$\text{THD} = \frac{\sqrt{V_{rms}^2 - V_1^2}}{V_1} \times 100$$

where V_1 is the rms value of the fundamental component of the output voltage. The THD of output ac voltage waveform is

(A) 65.65% (B) 48.42%

(C) 31.83% (D) 30.49%

MCQ 9.33 A three-phase, 440 V, 50 Hz ac mains fed thyristor bridge is feeding a 440 V dc, 15 kW, 1500 rpm separately excited dc motor with a ripple free continuos current in the dc link under all operating conditions, Neglecting the losses, the power factor of the ac mains at half the rated speed is

(A) 0.354 (B) 0.372

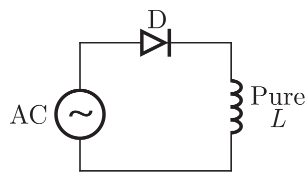
(C) 0.90 (D) 0.955

MCQ 9.34 A single-phase, 230 V, 50 Hz ac mains fed step down transformer (4:1) is supplying power to a half-wave uncontrolled ac-dc converter used for charging a battery (12 V dc) with the series current limiting resistor being 19.04 Ω. The charging current is

(A) 2.43 A (B) 1.65 A

(C) 1.22 A (D) 1.0 A

MCQ 9.35 In the circuit of adjacent figure the diode connects the ac source to a pure inductance L.

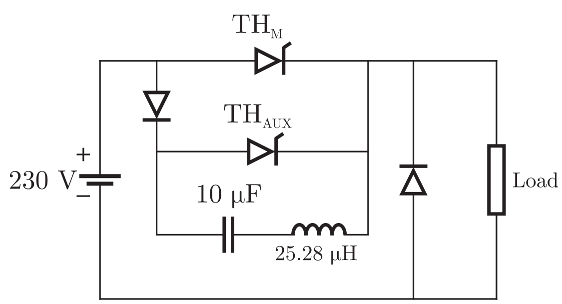


The diode conducts for

(A) 90° (B) 180°

(C) 270° (D) 360°

MCQ 9.36 The circuit in the figure is a current commutated dc-dc chopper where, Th_M is the main SCR and Th_{AUX} is the auxiliary SCR. The load current is constant at 10 A. Th_M is ON. Th_{AUX} is trigged at $t = 0$. Th_M is turned OFF between.

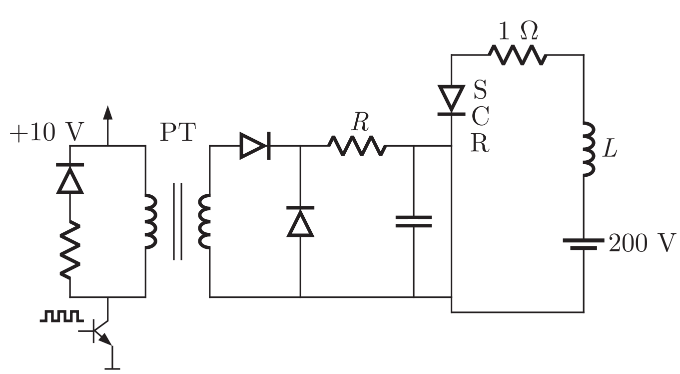


(A) $0\ \mu s < t \le 25\ \mu s$ (B) $25\ \mu s < t \le 50\ \mu s$

(C) $50\ \mu s < t \le 75\ \mu s$ (D) $75\ \mu s < t \le 100\ \mu s$

Common Data for Question 37 and 38.

A 1:1 Pulse Transformer (PT) is used to trigger the SCR in the adjacent figure. The SCR is rated at 1.5 kV, 250 A with $I_L = 250$ mA, $I_H = 150$ mA, and $I_{G\max} = 150$ mA, $I_{G\min} = 100$ mA. The SCR is connected to an inductive load, where $L = 150$ mH in series with a small resistance and the supply voltage is 200 V dc. The forward drops of all transistors/diodes and gate-cathode junction during ON state are 1.0 V



MCQ 9.37 The resistance R should be

(A) 4.7 kΩ (B) 470 kΩ

(C) 47 Ω (D) 4.7 Ω

MCQ 9.38 The minimum approximate volt-second rating of pulse transformer suitable for triggering the SCR should be : (volt-second rating is the maximum of product of the voltage and the width of the pulse that may applied)

(A) 2000 μV-s (B) 200 μV-s

(C) 20 μV-s (D) 2 μV-s

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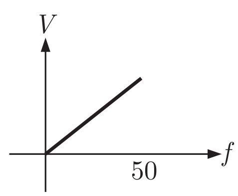
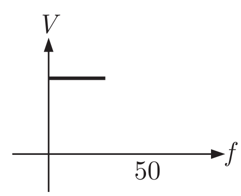
MCQ 9.39 The speed of a 3-phase, 440 V, 50 Hz induction motor is to be controlled over a wide range from zero speed to 1.5 time the rated speed using a 3-phase voltage source inverter. It is desired to keep the flux in the machine constant in the constant torque region by controlling the terminal voltage as the frequency changes. The inverter output voltage vs frequency characteristic should be

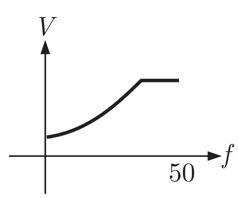
(A)



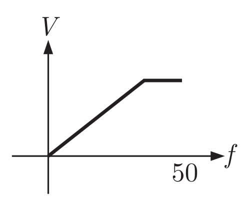
(B)



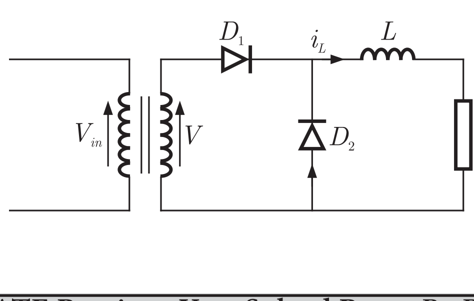
(C)



(D)



MCQ 9.40 A single-phase half wave uncontrolled converter circuit is shown in figure. A 2-winding transformer is used at the input for isolation. Assuming the load current to be constant and $V = V_m \sin \omega t$, the current waveform through diode D_2 will be



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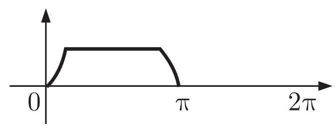
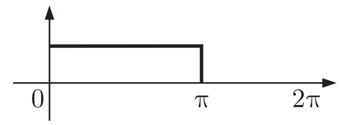
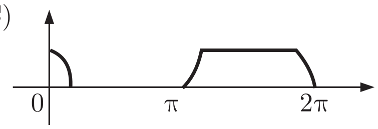
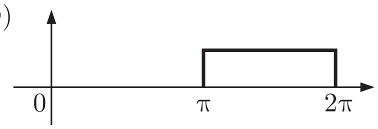
(A) 

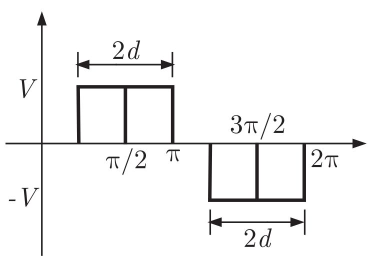
(B) 

(C) 

(D) 

YEAR 2006 TWO MARKS

MCQ 9.41 A single-phase inverter is operated in PWM mode generating a single-pulse of width $2d$ in the centre of each half cycle as shown in figure. It is found that the output voltage is free from 5th harmonic for pulse width 144°. What will be percentage of 3rd harmonic present in the output voltage $(V_{o3}/V_{o1\,max})$?



(A) 0.0% (B) 19.6%
(C) 31.7% (D) 53.9%

MCQ 9.42 A 3-phase fully controlled bridge converter with free wheeling diode is fed from 400 V, 50 Hz AC source and is operating at a firing angle of 60°. The load current is assumed constant at 10 A due to high load inductance. The input displacement factor (IDF) and the input power factor (IPF) of the converter will be

(A) IDF $= 0.867$; IPF $= 0.828$

(B) IDF $= 0.867$; IPF $= 0.552$

(C) IDF $= 0.5$; IPF $= 0.478$

(D) IDF $= 0.5$; IPF $= 0.318$

MCQ 9.43 A voltage commutation circuit is shown in figure. If the turn-off time of the SCR is 50 μsec and a safety margin of 2 is considered, then what will be the approximate minimum value of capacitor required for proper commutation ?

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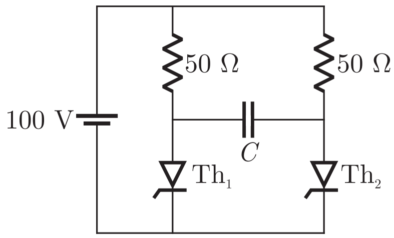


(A) 2.88 μF (B) 1.44 μF

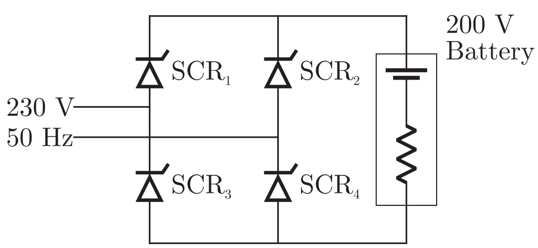
(C) 0.91 μF (D) 0.72 μF

MCQ 9.44 A solar cell of 350 V is feeding power to an ac supply of 440 V, 50 Hz through a 3-phase fully controlled bridge converter. A large inductance is connected in the dc circuit to maintain the dc current at 20 A. If the solar cell resistance is 0.5 Ω,then each thyristor will be reverse biased for a period of

(A) 125° (B) 120°

(C) 60° (D) 55°

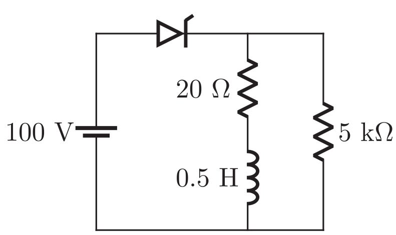
MCQ 9.45 A single-phase bridge converter is used to charge a battery of 200 V having an internal resistance of 0.2 Ω as shown in figure. The SCRs are triggered by a constant dc signal. If SCR_2 gets open circuited, what will be the average charging current ?



(A) 23.8 A (B) 15 A

(C) 11.9 A (D) 3.54 A

MCQ 9.46 An SCR having a turn ON times of 5 μsec, latching current of 50 A and holding current of 40 mA is triggered by a short duration pulse and is used in the circuit shown in figure. The minimum pulse width required to turn the SCR ON will be

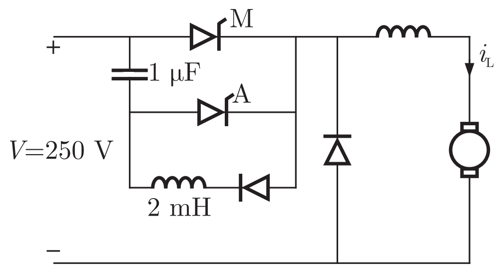


(A) 251 μsec (B) 150 μsec

(C) 100 μsec (D) 5 μsec

Data for Q. 47 and Q. 48 are given below. Solve the problems and choose the correct answers.

A voltage commutated chopper operating at 1 kHz is used to control the speed of dc as shown in figure. The load current is assumed to be constant at 10 A



MCQ 9.47 The minimum time in μsec for which the SCR M should be ON is.

(A) 280 (B) 140

(C) 70 (D) 0

MCQ 9.48 The average output voltage of the chopper will be

(A) 70 V (B) 47.5 V

(C) 35 V (D) 0 V

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MCQ 9.49 The conduction loss versus device current characteristic of a power MOSFET is best approximated by

(A) a parabola

(B) a straight line

(C) a rectangular hyperbola

(D) an exponentially decaying function

MCQ 9.50 A three-phase diode bridge rectifier is fed from a 400 V RMS, 50 Hz, three-phase AC source. If the load is purely resistive, then peak instantaneous output voltage is equal to

(A) 400 V (B) $400\sqrt{2}$ V

(C) $400\sqrt{\frac{2}{3}}$ V (D) $\frac{400}{\sqrt{3}}$ V

MCQ 9.51 The output voltage waveform of a three-phase square-wave inverter contains

(A) only even harmonics

(B) both odd and even harmonic

(C) only odd harmonics

(D) only triple harmonics

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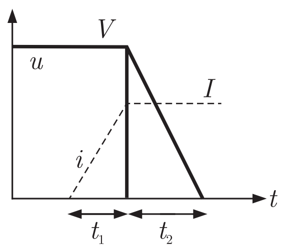
MCQ 9.52 The figure shows the voltage across a power semiconductor device and the current through the device during a switching transitions. If the transition a turn ON transition or a turn OFF transition ? What is the energy lost during the transition?



(A) Turn ON, $\frac{VI}{2}(t_1 + t_2)$ (B) Turn OFF, $VI(t_1 + t_2)$

(C) Turn ON, $VI(t_1 + t_2)$ (D) Turn OFF, $\frac{VI}{2}(t_1 + t_2)$

MCQ 9.53 An electronics switch S is required to block voltage of either polarity during its OFF state as shown in the figure (a). This switch is required to conduct in only one direction its ON state as shown in the figure (b)

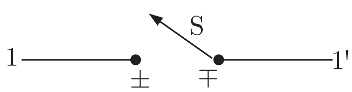


fig (a)

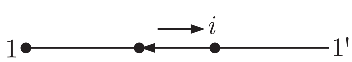
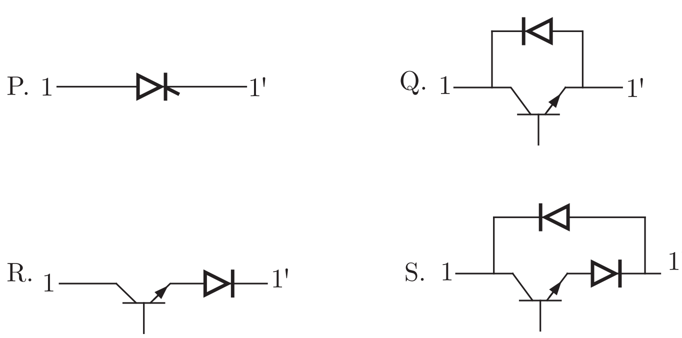


fig (b)

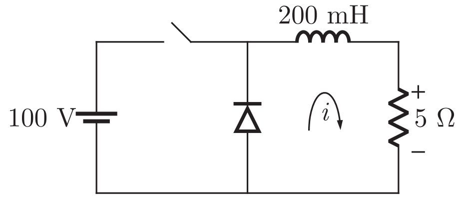
Which of the following are valid realizations of the switch S?



(A) Only P (B) P and Q

(C) P and R (D) R and S

MCQ 9.54 The given figure shows a step-down chopper switched at 1 kHz with a duty ratio $D = 0.5$. The peak-peak ripple in the load current is close to



(A) 10 A (B) 0.5 A

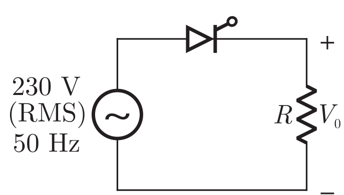
(C) 0.125 A (D) 0.25 A

MCQ 9.55 An electric motor, developing a starting torque of 15 Nm, starts with a load torque of 7 Nm on its shaft. If the acceleration at start is 2 rad/sec^2, the moment of inertia of the system must be (neglecting viscous and coulomb friction)

(A) 0.25 kg-m^2 (B) 0.25 Nm^2

(C) 4 kg-m^2 (D) 4 Nm^2

MCQ 9.56 Consider a phase-controlled converter shown in the figure. The thyristor is fired at an angle α in every positive half cycle of the input voltage. If the peak value of the instantaneous output voltage equals 230 V, the firing angle α is close to



(A) 45° (B) 135°

(C) 90° (D) 83.6°

YEAR 2004 ONE MARK

MCQ 9.57 A bipolar junction transistor (BJT) is used as a power control switch by biasing it in the cut-off region (OFF state) or in the saturation region (ON state). In the ON state, for the BJT

(A) both the base-emitter and base-collector junctions are reverse biased

(B) the base-emitter junction is reverse biased, and the base-collector junction is forward biased

(C) the base-emitter junction is forward biased, and the base-collector junction is reverse biased

(D) both the base-emitter and base-collector junctions are forward biased

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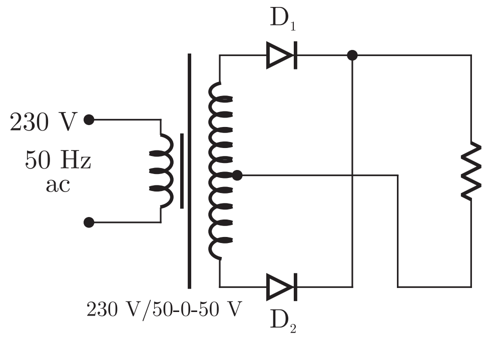
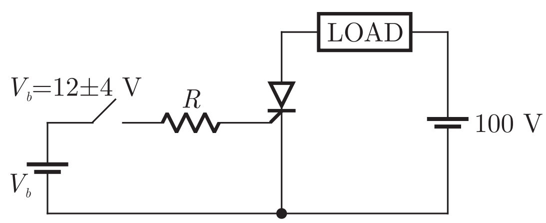
MCQ 9.58 The circuit in figure shows a full-wave rectifier. The input voltage is 230 V (rms) single-phase ac. The peak reverse voltage across the diodes D_1 and D_2 is



(A) $100\sqrt{2}$ V (B) 100 V

(C) $50\sqrt{2}$ V (D) 50 V

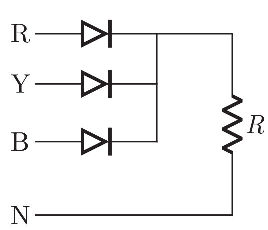
MCQ 9.59 The triggering circuit of a thyristor is shown in figure. The thyristor requires a gate current of 10 mA, for guaranteed turn-on. The value of R required for the thyristor to turn on reliably under all conditions of V_b variation is



(A) 10000 Ω (B) 1600 Ω

(C) 1200 Ω (D) 800 Ω

MCQ 9.60 The circuit in figure shows a 3-phase half-wave rectifier. The source is a symmetrical, 3-phase four-wire system. The line-to-line voltage of the source is 100 V. The supply frequency is 400 Hz. The ripple frequency at the output is



(A) 400 Hz (B) 800 Hz

(C) 1200 Hz (D) 2400 Hz

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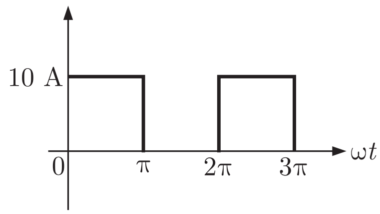
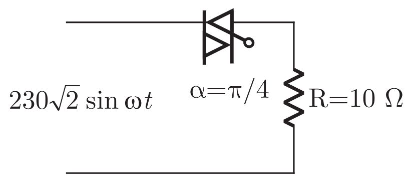
MCQ 9.61 A MOSFET rated for 15 A, carries a periodic current as shown in figure. The ON state resistance of the MOSFET is 0.15 Ω. The average ON state loss in the MOSFET is



(A) 33.8 W (B) 15.0 W

(C) 7.5 W (D) 3.8 W

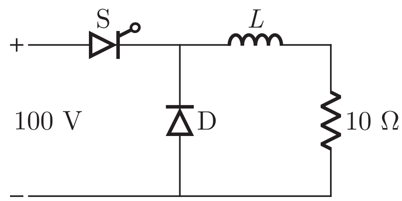
MCQ 9.62 The triac circuit shown in figure controls the ac output power to the resistive load. The peak power dissipation in the load is



(A) 3968 W (B) 5290 W

(C) 7935 W (D) 10580 W

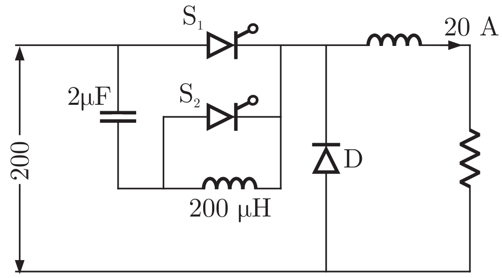
MCQ 9.63 Figure shows a chopper operating from a 100 V dc input. The duty ratio of the main switch S is 0.8. The load is sufficiently inductive so that the load current is ripple free. The average current through the diode D under steady state is



(A) 1.6 A (B) 6.4 A

(B) 8.0 A (D) 10.0 A

MCQ 9.64 Figure shows a chopper. The device S_1 is the main switching device. S_2 is the auxiliary commutation device. S_1 is rated for 400 V, 60 A. S_2 is rated for 400 V, 30 A. The load current is 20 A. The main device operates with a duty ratio of 0.5. The peak current through S_1 is



(A) 10 A (B) 20 A

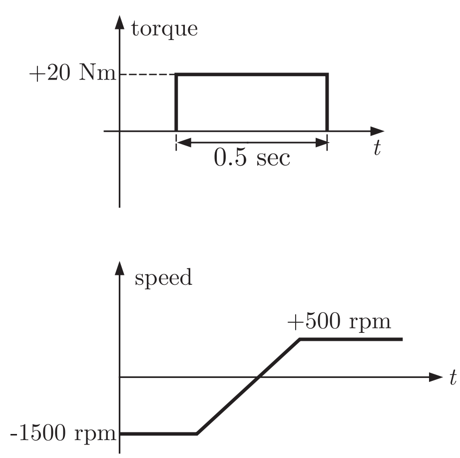
(C) 30 A (D) 40 A

MCQ 9.65 A single-phase half-controlled rectifier is driving a separately excited dc motor. The dc motor has a back emf constant of 0.5 V/rpm. The armature current is 5 A without any ripple. The armature resistance is 2 Ω. The converter is working from a 230 V, single-phase ac source with a firing angle of 30°. Under this operating condition, the speed of the motor will be

(A) 339 rpm (B) 359 rpm

(C) 366 rpm (D) 386 rpm

MCQ 9.66 A variable speed drive rated for 1500 rpm, 40 Nm is reversing under no load. Figure shows the reversing torque and the speed during the transient. The moment of inertia of the drive is

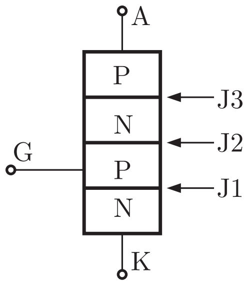


(A) 0.048 kg-m^2 (B) 0.064 km-m^2

(C) 0.096 kg-m^2 (D) 0.128 kg-m^2

YEAR 2003 ONE MARK

MCQ 9.67 Figure shows a thyristor with the standard terminations of anode (A), cathode (K), gate (G) and the different junctions named J1, J2 and J3. When the thyristor is turned on and conducting



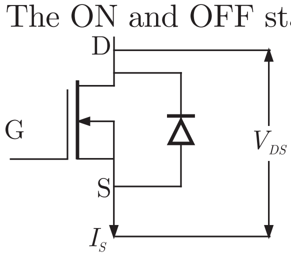
(A) J1 and J2 are forward biased and J3 is reverse biased

(B) J1 and J3 are forward biased and J2 is reverse biased

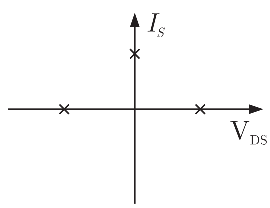
(C) J1 is forward biased and J2 and J3 are reverse biased

(D) J1, J2 and J3 are all forward biased

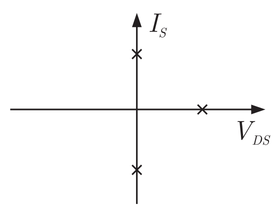
MCQ 9.68 Figure shows a MOSFET with an integral body diode. It is employed as a power switching device in the ON and OFF states through appropriate control. The ON and OFF states of the switch are given on the $V_{DS} - I_S$ plane by



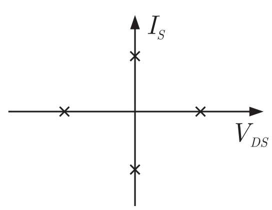
(A)



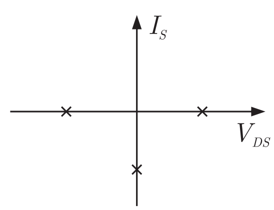
(B)



(C)



(D)



MCQ 9.69 The speed/torque regimes in a dc motor and the control methods suitable for the same are given respectively in List-II and List-I

	List-I		List-II
P.	Field Control	**1.**	Below base speed
Q.	Armature Control	**2.**	Above base speed
		3.	Above base torque
		4.	Below base torque

Codes:

(A) P-1, Q-3 (B) P-2, Q-1

(C) P-2, Q-3 (D) P-1, Q-4

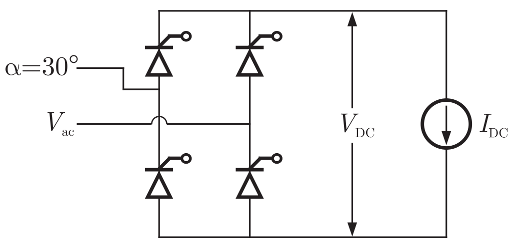
MCQ 9.70 A fully controlled natural commutated 3-phase bridge rectifier is operating with a firing angle $\alpha = 30°$, The peak to peak voltage ripple expressed as a ratio of the peak output dc voltage at the output of the converter bridge is

(A) 0.5 (B) $\sqrt{3}/2$

(C) $\left(1 - \frac{\sqrt{3}}{2}\right)$ (D) $\sqrt{3} - 1$

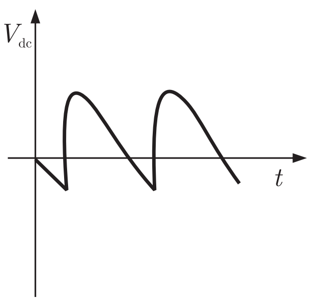
YEAR 2003 TWO MARKS

MCQ 9.71 A phase-controlled half-controlled single-phase converter is shown in figure. The control angle $\alpha = 30°$

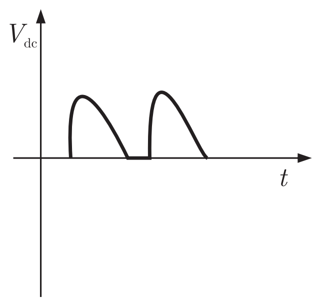


The output dc voltage wave shape will be as shown in

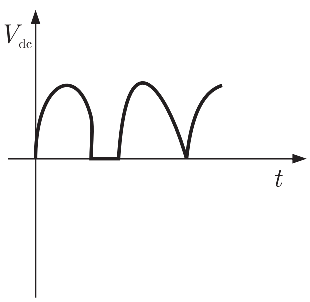
(A)



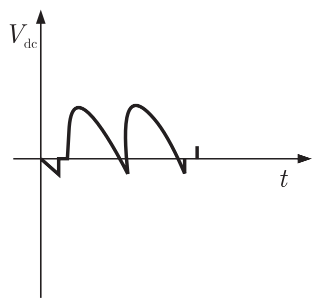
(B)



(C)



(D)



MCQ 9.72 A chopper is employed to charge a battery as shown in figure. The charging current is 5 A. The duty ratio is 0.2. The chopper output voltage is also shown in the figure. The peak to peak ripple current in the charging current is

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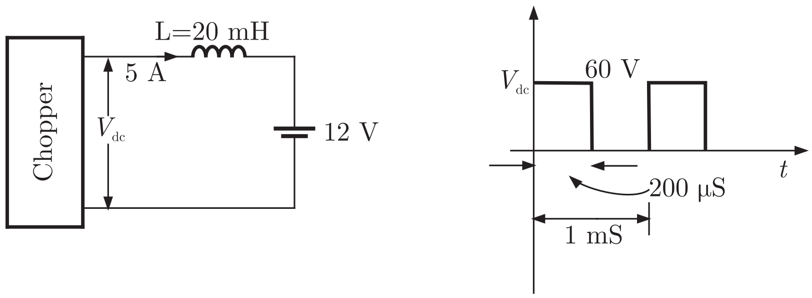
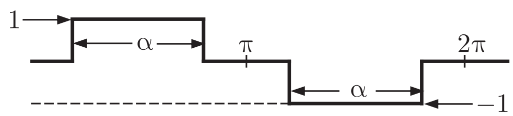


(A) 0.48 A (B) 1.2 A

(C) 2.4 A (D) 1 A

MCQ 9.73 An inverter has a periodic output voltage with the output wave form as shown in figure



When the conduction angle $\alpha = 120°$, the rms fundamental component of the output voltage is

(A) 0.78 V (B) 1.10 V

(C) 0.90 V (D) 1.27 V

MCQ 9.74 With reference to the output wave form given in above figure , the output of the converter will be free from 5^{th} harmonic when

(A) $\alpha = 72°$ (B) $\alpha = 36°$

(C) $\alpha = 150°$ (D) $\alpha = 120°$

MCQ 9.75 An ac induction motor is used for a speed control application. It is driven from an inverter with a constant V/f control. The motor name-plate details are as follows (no. of poles = 2)

V: 415 V V_{Ph}: 3 V f: 50 Hz N: 2850 rpm

The motor runs with the inverter output frequency set at 40 Hz, and with half the rated slip. The running speed of the motor is

(A) 2400 rpm (B) 2280 rpm

(C) 2340 rpm (D) 2790 rpm

YEAR 2002 ONE MARK

MCQ 9.76 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 frequency harmonic component in the ac source line current is

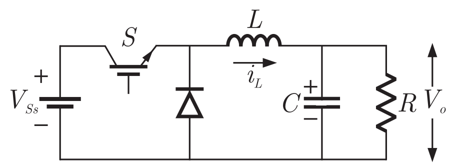
(A) 100 Hz (B) 150 Hz
(C) 250 Hz (D) 300 Hz

MCQ 9.77 A step-down chopper is operated in the continuous conduction mode is 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 the dc input voltage, the ratio V_0/V_s is given by

(A) D (B) $1-D$
(C) $\frac{1}{1-D}$ (D) $\frac{D}{1-D}$

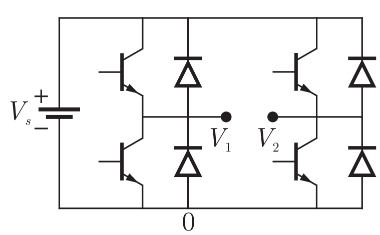
YEAR 2002 TWO MARKS

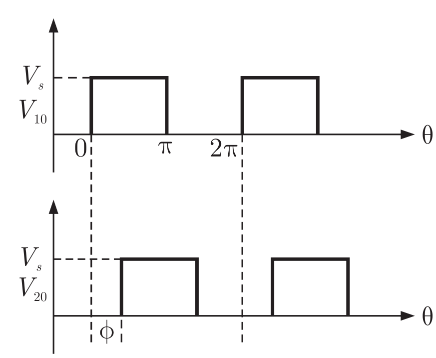
MCQ 9.78 In the chopper circuit shown in figure, the input dc voltage has a constant value V_s. The output voltage V_0 is assumed ripple-free. The switch S is operated with a switching time period T and a duty ratio D. What is the value of D at the boundary of continuous and discontinuous conduction of the inductor current i_L?



(A) $D=1-\frac{V_s}{V_0}$ (B) $D=\frac{2L}{RT}$
(C) $D=1-\frac{2L}{RT}$ (D) $D=\frac{RT}{L}$

MCQ 9.79 Figure(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 voltage V_{10} and V_{20} are as shown in figure(b). What is the rms value of the pole-to-pole voltage V_{12}?

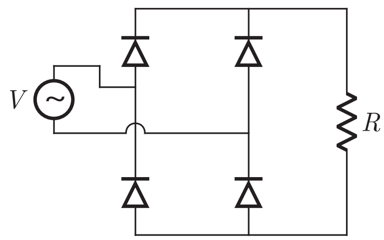




(A) $\frac{V_s\phi}{\pi\sqrt{2}}$ (B) $V_s\sqrt{\frac{\phi}{\pi}}$

(C) $V_s\sqrt{\frac{\phi}{2\pi}}$ (D) $\frac{V_s}{\pi}$

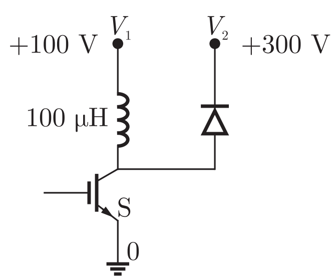
MCQ 9.80 In the single phase diode bridge rectifier shown in figure, the load resistor is $R = 50\,\Omega$. The source voltage is $V = 200\sin(\omega t)$, where $\omega = 2\pi \times 50$ radians per second. The power dissipated in the load resistor R is



(A) $\frac{3200}{\pi}$ W (B) $\frac{400}{\pi}$ W

(C) 400 W (D) 800 W

MCQ 9.81 *The semiconductor switch S in the circuit of figure is operated at a frequency of 20 kHz and a duty ratio $D = 0.5$. The circuit operates in the steady state. Calculate the power transferred from the dc voltage source V_2.



YEAR 2001 ONE MARK

MCQ 9.82 The main reason for connecting a pulse transformer at the output stage of thyristor triggering circuit is to

(A) amplify the power of the triggering pulse

(B) provide electrical isolation

(C) reduce the turn on time of thyristor

(D) avoid spurious triggering of the thyristor due to noise

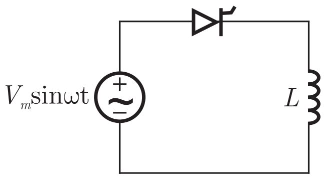
MCQ 9.83 AC-to-DC circulating current dual converters are operated with the following relationship between their triggering angles(α_1 and α_2)

(A) $\alpha_1 + \alpha_2 = 180^\circ$ (B) $\alpha_1 + \alpha_2 = 360^\circ$

(C) $\alpha_1 - \alpha_2 = 180^\circ$ (D) $\alpha_1 + \alpha_2 = 90^\circ$

YEAR 2001 **TWO MARKS**

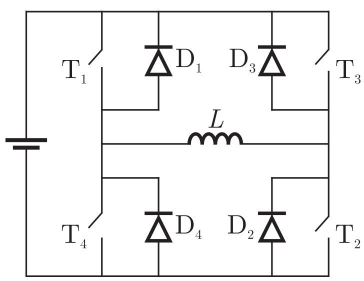
MCQ 9.84 A half-wave thyristor converter supplies a purely inductive load as shown in figure. If the triggering angle of the thyristor is 120°, the extinction angle will be



(A) 240° (B) 180°

(C) 200° (D) 120°

MCQ 9.85 A single-phase full bridge voltage source inverter feeds a purely inductive load as shown in figure, 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

MCQ 9.86 *A voltage commutated thyristor chopper circuit is shown in figure. The chopper is operated at 500 Hz with 50% duty ratio. The load takes a constant current of 20 A.

(a) Evaluate the circuit turn off time for the main thyristor Th_1.

(b) Calculate the value of inductor L, if the peak current through the main thyristor Th_1 is limited to 180% of the load current.

(c) Calculate the maximum instantaneous output voltage of chopper.

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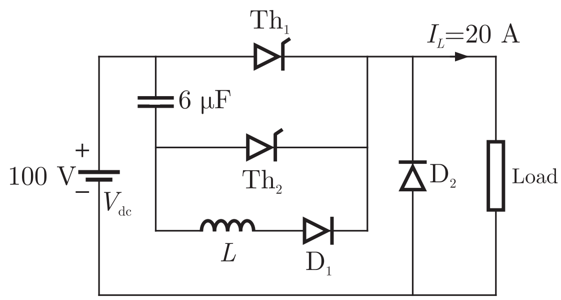
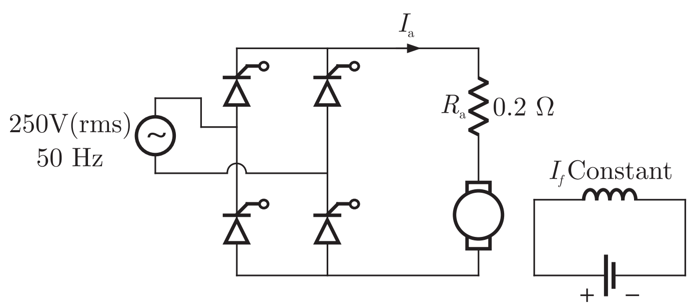


MCQ 9.87 *A separately excited dc motor is controlled by varying its armature voltage using a single-phase full-converter bridge as shown in figure. The field current is kept constant at the rated value. The motor has an armature resistance of 0.2 Ω, and the motor voltage constant is 2.5 V/(rad/sec). The motor is driving a mechanical load having a constant torque of 140 Nm. The triggering angle of converter is 60°. The armature current can be assumed to be continuous and ripple free.



(a) Calculate the motor armature constant.

(b) Evaluate the motor speed in rad/sec.

(c) Calculate the rms value of the fundamental component of the input current to the bridge.

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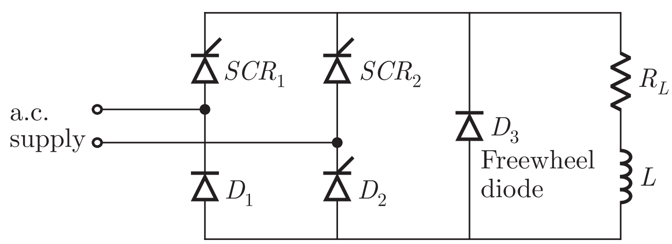
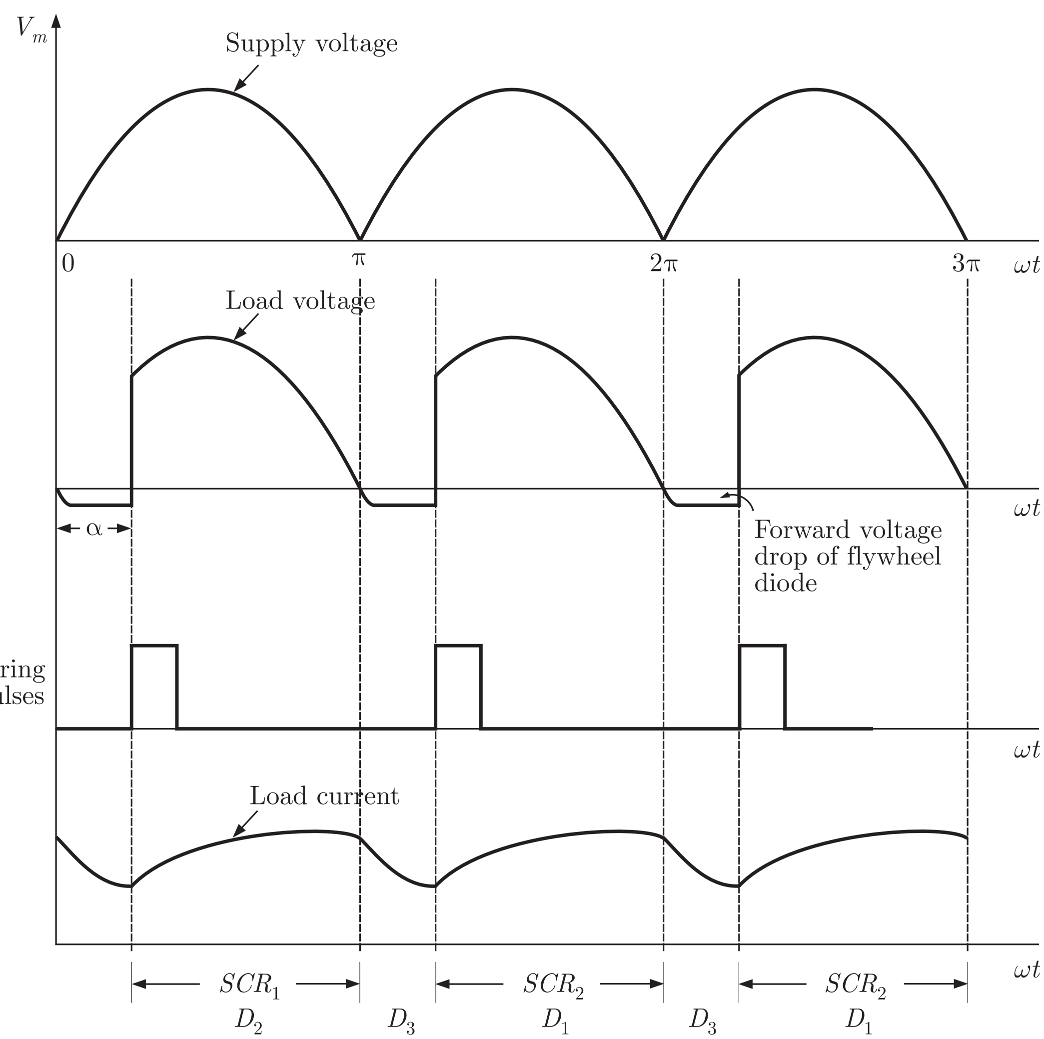
SOLUTION

SOL 9.1 Option (D) is correct.

The circuit of a single-phase half controlled bridge rectifier with RL load and free wheel diode is shown as below.



The voltage current wave forms are shown in figure below.



We note that, for continuous load current, the flywheel diode conducts from

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π to $\pi+\alpha$ in a cycle. Thus, fraction of cycle that freewheel diode conducts is α/π.
Thus fraction of cycle that freewheel diode conducts is α/π.

SOL 9.2 Option (B) is correct.
The latching current is higher than the holding current. Usually, latching current is taken two to three times the holding currents.

SOL 9.3 Option (C) is correct.

$$I_S = I_0 + \frac{\Delta i_c}{2} = 5 + 0.8 = 5.8\text{ A}$$

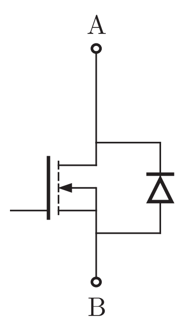
SOL 9.4 Option (B) is correct.
For a three-phase bridge inverter, rms value of output line voltage is

$$V_L = \frac{\sqrt{2}}{3} V_{dc} = \frac{\sqrt{2}}{3} \times 300 \qquad V_{dc} = 300\text{ V}$$
$$= 141.4\text{ V}$$

SOL 9.5 Option (D) is correct.

$$P = 3 \times \frac{V_L^2}{R} = 3 \times \frac{(141.4)^2}{20} \simeq 3\text{ kW}$$

SOL 9.6 Option (C) is correct.
Only option C allow bi direction power flow from source to the drive



SOL 9.7 Option (C) is correct.
Once the SCR start conducting by an forward current, the gate has no control on it and the device can be brought back to the blocking state only by reducing the forward current to a level below that of holding current. This process of turn-off is called commutation. This time is known as the circuit turn-off time of an SCR.

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SOL 9.8 Option (A) is correct.

Maximum current through main thyristor

$$I_M(\max) = I_0 + V_s\sqrt{\frac{C}{L}} = 10 + 200\sqrt{\frac{0.1 \times 10^{-6}}{1 \times 10^{3}}} = 12 \text{ A}$$

Maximum current through auxiliary thyristor

$$I_A(\max) = I_0 = 10 \text{ A}$$

SOL 9.9 Option (A) is correct.

Output voltage of 3-phase bridge converter

$$V_0 = \frac{3\sqrt{3}}{\pi} V_{ph} \cos\alpha$$

Maximum output

$$(V_0)_{\max} = \frac{3\sqrt{3}}{\pi} V_{ph} \quad \cos\alpha = 1$$

$$= \frac{3\sqrt{3}}{\pi} \times \frac{400 \times \sqrt{2}}{\sqrt{3}}$$

$$= 540.6 \text{ V}$$

Resistance of filter choke is $10\,\Omega$, So

$$(V_0)_{\max} = E + IR_{\text{chock}}$$

$$540.6 = 400 + I(10)$$

$$I \simeq 14 \text{ A}$$

SOL 9.10 Option (D) is correct.

$$\text{kVA rating} = \sqrt{3}\, V_L I_L = \sqrt{3} \times 400 \times \frac{\sqrt{6}}{\pi} \times 14$$

$$= 7.5 \text{ kVA}$$

SOL 9.11 Option (A) is correct.

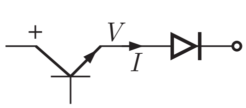
The figure shows a step down chopper circuit.

$\because$ $$V_{\text{out}} = DV_{\text{in}}$$

where, $D =$ Duty cycle and $D < 1$

SOL 9.12 Option (C) is correct.

Given figure as



The I-V characteristic are as

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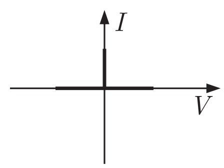


Since diode connected in series so I can never be negative.
When current flows voltage across switch is zero and when current is zero than there may be any voltage across switch.

SOL 9.13 Option (A) is correct.

Given fully-controlled thyristor converter, when firing angle $\alpha = 0$, dc output voltage $V_{dc_0} = 300$ V

If $\alpha = 60^\circ$, then $V_{dc} = ?$

For fully-controlled converter

$$V_{dc_0} = \frac{2\sqrt{2}\,V_{dc_1}}{\pi}\cos\alpha$$

$\because$ $\alpha = 0$, $V_{dc_0} = 300$ V

$$300 = \frac{2\sqrt{2}\,V_{dc_1}}{\pi}\cos 0^\circ$$

$$V_{dc_1} = \frac{300\pi}{2\sqrt{2}}$$

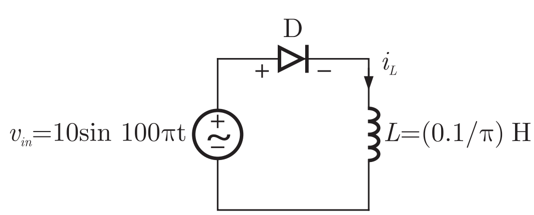
At $\alpha = 60^\circ$, $V_{dc_2} = ?$

$$V_{dc_2} = \frac{2\sqrt{2}}{\pi} \times \frac{300\pi}{2\sqrt{2}}\cos 60^\circ = 300 \times \frac{1}{2} = 150 \text{ V}$$

SOL 9.14 Option (C) is correct.

SCR has the property that it can be turned ON but not OFF with a gate pulse, So SCR is being considered to be a semi-controlled device.

SOL 9.15 Option (D) is correct.



Current wave form for i_L

$$v_L = \frac{Ldi_L}{dt}$$

$$i_L = \frac{1}{2}\int v_L\,dt$$

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for $0 < \omega_t \angle \pi$, $\quad v_L = v_{in} = 10\sin\omega t = \frac{di_L}{dt}$

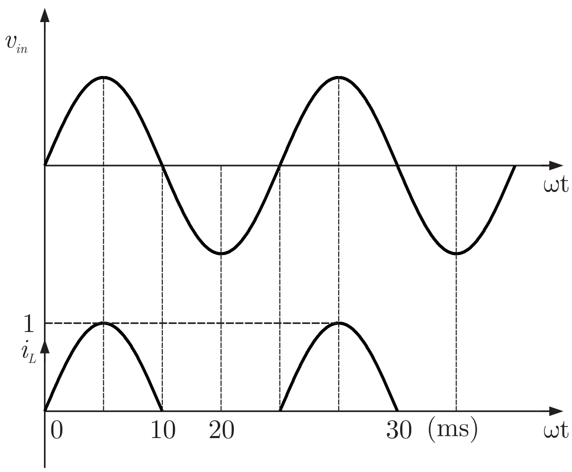
$$i_L = \frac{1}{2}\int v_L\,dt = -\cos 100\pi t + C$$

at $100\pi t = \pi/2$, $\quad i_L = 0,\ C = 0$

$$i_L = -100\cos\pi t$$

$$i_{L(\text{peak})} = 1 \text{ Amp}$$

for $\pi < \omega t\ \ v_L = v_{in} = 0$

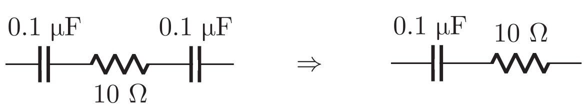


SOL 9.16 Option (C) is correct.

In CSI let T_3 and T_4 already conducting at $t = 0$

At triggering T_1 and T_2, T_3 and T_4 are force cumulated.

Again at $t = \frac{T}{2}$, T_1 and T_2 are force cumulated. This completes a cycle.



$$\text{Time constant } \tau = RC = 4 \times 0.5 = 2\ \mu\text{sec}$$

$$\text{Frequency } f = \frac{1}{\tau} = \frac{1}{2 \times 10^{-6}} = 500 \text{ kHz}$$

SOL 9.17 Option (A) is correct.

duty ratio $T_M = 0.8$

Maximum $\frac{dv}{dt}$ on $T_M = 50$ V/μsec

Minimum value of C_1 $= ?$

Given that current ripple through L_0 is negligible.

Current through $T_M = I_m =$ duty ratio $\times$ current

$= 0.8 \times 12.5 = 10$ A

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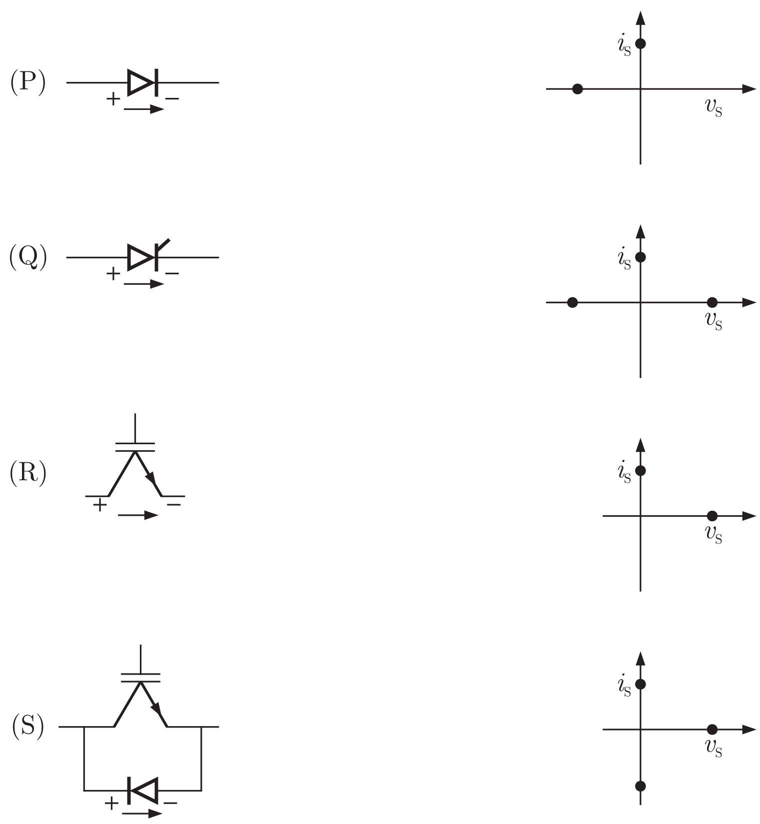
$$\because \qquad I_m = C_1 \frac{dv}{dt}$$

$$10 = C_1 \times \frac{50}{10^{-6}}$$

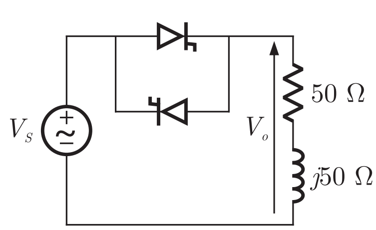
$$C_1 = \frac{50}{10} \times 10^{-6} = 0.2\ \mu\text{F}$$

SOL 9.18 Option (C) is correct.

Characteristics are as



SOL 9.19 Option (A) is correct.



$$R + jXL = 50 + 50j$$

$$\therefore \qquad \tan\phi = \frac{\omega L}{R} = \frac{50}{50} = 1$$

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$$\phi = 45^\circ$$

so, firing angle 'α' must be higher the 45°, Thus for $0 < \alpha < 45^\circ$, V_0 is uncontrollable.

SOL 9.20 Option (D) is correct.
A 3-ϕ voltage source inverter is operated in 180° mode in that case third harmonics are absent in pole voltage and line voltage due to the factor $\cos(n\pi/6)$. so both are free from 3rd harmonic components.

SOL 9.21 Option (B) is correct.

In this case $$f = \frac{1}{T_{\text{ON}_1} + T_{\text{ON}_2}}$$

and, $$D = \frac{T_{\text{ON}_2}}{T_{\text{ON}_1} + T_{\text{ON}_2}}$$

SOL 9.22 Option (B) is correct.
Given $\alpha = 30^\circ$, in a 1-ϕ fully bridge converter
we know that,

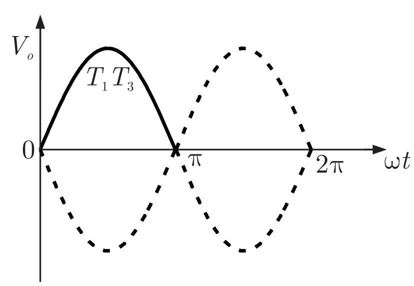
$$\text{Power factor} = \text{Distortion factor} \times \cos\alpha$$

$$\text{D.f. (Distortion factor)} = I_{s(\text{fundamental})}/I_s = 0.9$$

$$\text{power factor} = 0.9 \times \cos 30^\circ$$

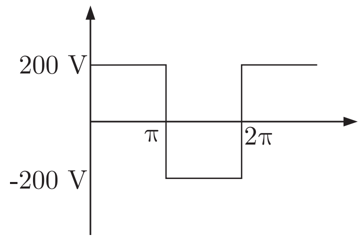
$$= 0.78$$

SOL 9.23 Option (A) is correct.
Output of this



Here the inductor makes T_1 and T_3 in ON because current passing through T_1 and T_3 is more than the holding current.

SOL 9.24 Option (C) is correct.
Input is given as



Here load current does not have any dc component

$\therefore$ Peak current occur at (π/ω)

$$\therefore \quad V_s = L\frac{di}{dt}$$

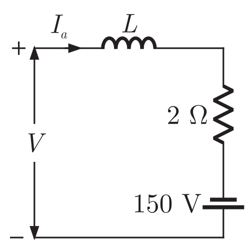
$$200 = 0.1 \times \frac{di}{dt}$$

Here $$di = \left(\frac{\pi}{2\pi}\right)\left(\frac{1}{50}\right) = \frac{1}{100}$$

So $$di_{(\max)} = 200 \times \frac{1}{100} \times \frac{1}{0.1} = 20 \text{ A}$$

SOL 9.25 Option (C) is correct.

Here for continuous conduction mode, by Kirchoff's voltage law, average load current



$$V - 2I_a + 150 = 0$$

$$I_a = \frac{V+150}{2}$$

$\therefore I_1 = 10$ A, So

$$V = -130 \text{ V}$$

$$\frac{2V_m}{\pi}\cos\alpha = -130$$

$$\frac{2\times\sqrt{2}\times 230}{\pi}\cos\alpha = -130^\circ$$

$$\alpha = 129^\circ$$

SOL 9.26 Option (B) is correct.

$$\text{Total rms current } I_a = \sqrt{\frac{2}{3}} \times 10 = 8.16 \text{ A}$$

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Fundamental current $I_{a1} = 0.78 \times 10 = 7.8$ A

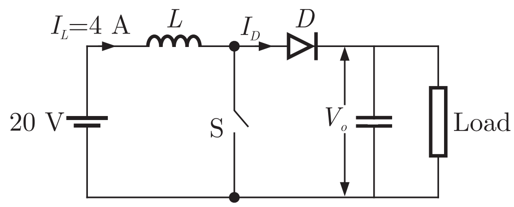
$$\text{THD} = \sqrt{\frac{1}{\text{DF}^2} - 1}$$

where

$$\text{DF} = \frac{I_{a1}}{I_a} = \frac{0.78 \times 10}{0.816 \times 10} = 0.955$$

$\therefore$
$$\text{THD} = \sqrt{\left(\frac{1}{0.955}\right)^2 - 1} = 31\%$$

SOL 9.27 Option (C) is correct.



In the given diagram
when switch S is open $I_0 = I_L = 4$ A, $V_s = 20$ V
when switch S is closed $I_D = 0$, $V_0 = 0$ V
Duty cycle $= 0.5$ so average voltage is $\frac{V_s}{1-\delta}$

$$\text{Average current} = \frac{0+4}{2} = 2 \text{ amp}$$

$$\text{Average voltage} = \frac{20}{1-0.5} = 40 \text{ V}$$

SOL 9.28 Option (A) is correct.

Firing angle $\alpha = 25^\circ$

Overlap angle $\mu = 10^\circ$

so, $I_0 = \frac{V_m}{\omega Ls}[\cos\alpha - \cos(\alpha+\mu)]$

$\therefore$ $20 = \frac{230\sqrt{2}}{2\pi \times 50Ls}[\cos 25^\circ - \cos(25^\circ + 10^\circ)]$

$\therefore$ $Ls = 0.0045$ H

$$V_0 = \frac{2V_m\cos\alpha}{\pi} - \frac{\omega LsI_0}{\pi}$$

$$= \frac{2 \times 230\sqrt{2}\cos 25^\circ}{3.14} - \frac{2 \times 3.14 \times 50 \times 4.5 \times 10^{-3} \times 20}{3.14}$$

$$= 187.73 - 9 = 178.74^\circ$$

$$\text{Displacement factor} = \frac{V_0I_0}{V_sI_s} = \frac{178.25 \times 20}{230 \times 20} = 0.78$$

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SOL 9.29 Option (C) is correct.

Given that

$$P = 50 \times 1000 \text{ W}$$

$$V_d = 420$$

So $$P = V_d \times I_d$$

$$I_d = \frac{50 \times 1000}{420} = 119.05$$

RMS value of thyristor current $= \dfrac{119.05}{\sqrt{3}} = 68.73$

SOL 9.30 Option (B) is correct.

Single phase full wave half controlled bridge converter feeds an Inductive load. The two SCRs in the converter are connected to a common dc bus. The converter has to have free wheeling diode because the converter does not provide for free wheeling for high values of triggering angles.

SOL 9.31 Option (D) is correct.

If we connect the MOSFET with the VSI, but the six MOSFETs are connected in bridge configuration, in that case they also operated as constant current sources in the saturation region so this statement is false.

SOL 9.32 Option (C) is correct.

Given that, total harmonic distortion

$$\text{THD} = \frac{\sqrt{V_{rms^2} - V_1^2}}{V_1} \times 100$$

Pulse width is 150°

Here $$V_{\text{rms}} = \left(\sqrt{\frac{150}{180}}\right) V_s = 0.91\, V_s$$

$$V_1 = V_{\text{rms(fundamental)}} = \frac{0.4\, V_s}{\pi \times \sqrt{2}} \sin 75° = 0.8696\, V_s$$

$$\text{THD} = \sqrt{\frac{(0.91\, V_s)^2 - (0.87\, V_s)^2}{(0.87\, V_s)^2}} = 31.9\%$$

SOL 9.33 Option (A) is correct.

When losses are neglected,

$$\frac{3 \times \sqrt{2} \times 440}{\pi} \cos\alpha = K_m \times \frac{750 \times 2\pi}{60}$$

Here back emf ε with ϕ is constant

$$\varepsilon = V_0 = K_m \omega_m$$

$$440 = K_m \times \frac{1500 \times 2\pi}{60}$$

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$$K_m = 2.8$$
$$\cos\alpha = 0.37$$

at this firing angle

$$V_t = \frac{3\sqrt{2}\times 440}{\pi}\times(0.37) = 219.85\text{ V}$$
$$I_a = \frac{1500}{440} = 34.090$$
$$I_{sr} = I_a\sqrt{2/3} = 27.83$$
$$\text{p.f.} = \frac{V_t I_s}{\sqrt{3}\,V_s I_{sr}} = 0.354$$

SOL 9.34 Option (D) is correct.

$$V_s = \frac{230}{4} = 57.5$$

Here charging current $= I$

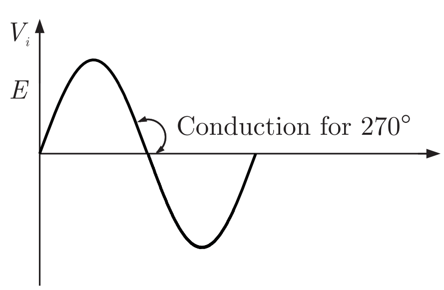
$$V_m\sin\theta = 12$$
$$\theta_1 = 8.486 = 0.148\text{ radian}$$
$$V_m = 81.317\text{ V}$$
$$\varepsilon = 12\text{ V}$$

There is no power consumption in battery due to ac current, so average value of charging current.

$$I_{av(\text{charging})} = \frac{1}{2\pi\times 19.04}[2V_m\cos\theta_1 - \varepsilon(\pi-2\theta_1)]$$
$$= \frac{1}{2\pi\times 19.04}[2\times V_m\times\cos\theta_1 - 12(\pi-2\theta_1)]$$
$$= 1.059\ \Omega/\text{A}$$

SOL 9.35 Option (C) is correct.

Conduction angle for diode is 270° as shown in fig.



SOL 9.36 Option ( ) is correct.

SOL 9.37 Option (C) is correct.

Here, V_m = maximum pulse voltage that can be applied

so $= 10 - 1 - 1 - 1 = 7$ V

Here 1 V drop is in primary transistor side, so that we get 9V pulse on the secondary side. Again there are 1 V drop in diode and in gate cathode junction each.

$$I_{g\,max} = 150 \text{ mA}$$

So $$R = \frac{V_m}{I_{g\,max}} = \frac{7}{150 \text{ mA}} = 46.67\ \Omega$$

SOL 9.38 Option (A) is correct.

We know that the pulse width required is equal to the time taken by i_a to rise upto i_L

so, $$V_s = L\frac{di}{dt} + R_i(V_T \approx 0)$$

$$i_a = \frac{200}{1}[1 - e^{-t/0.15}]$$

Here also $t = T$, $i_a = i_L = 0.25$

$$0.25 = 200[1 - e^{-T/0.5}]$$

$$T = 1.876 \times 10^{-4} = 187.6\ \mu\text{s}$$

Width of pulse $= 187.6\ \mu$s

Magnitude of voltage$= 10$ V

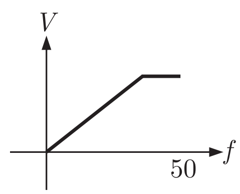
V_{sec} rating of P.T. $= 10 \times 187.6\ \mu$s

$= 1867\ \mu$V-s is approx to $2000\ \mu$V-s

SOL 9.39 Option (D) is correct.

If we varying the frequency for speed control, V/f should be kept as constant so that, minimum flux density (B_m) also remains constant

So, $$V = 4.44 N B_m A f$$



SOL 9.40 Option (D) is correct.

In first half cycle D_1 will conduct and D_2 will not and at $\theta = 0$ there is zero voltage. So current wave form is as following

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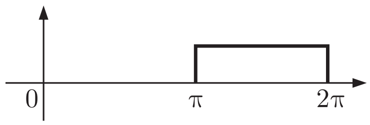

SOL 9.41 Option (B) is correct.

In the PWM inverter

$$V_0 = \text{output voltage of inverter}$$

$$V_0 = \sum_{n=1}^{\infty} \frac{4V_s}{n\pi} \sin nd \, \sin n\omega t \, \sin n\pi/2$$

So the pulse width $= 2d = 144°$

$$V_{01} = \frac{4V_s}{\pi} \sin 72° \sin \omega t$$

$$V_{03} = \frac{4V_s}{3\pi} \sin(3 \times 72°) \sin 3\omega t$$

so, $$\left(\frac{V_{03}}{V_{01\max}}\right) = \frac{\frac{4V_s}{3\pi} \times \sin(3 \times 72°)}{\frac{4V_s}{\pi} \sin 72°} = 19.61\%$$

SOL 9.42 Option (C) is correct.

Given that

400 V, 50 Hz AC source, $\alpha = 60°$, $I_L = 10$ A

so,

Input displacement factor $= \cos\alpha = 0.5$

and, input power factor $=$ D.F. $\times \cos\alpha$

$$\text{distortion factor} = \frac{I_{s(\text{fundamental})}}{I_s} = \frac{\frac{4 \times 10}{\pi \times \sqrt{2}} \sin 60°}{10 \times \sqrt{2/3}}$$

$$= 0.955$$

so, input power factor $= 0.955 \times 0.5 = 0.478$

SOL 9.43 Option (A) is correct.

We know that

$$T = RC \ln 2$$

So $$C = \frac{T}{R \times 0.693} = \frac{100}{50 \times 0.693} = 2.88 \ \mu\text{F}$$

SOL 9.44 Option (A) is correct.

Let we have

$$R_{\text{solar}} = 0.5\,\Omega, \ I_0 = 20 \text{ A}$$

so $$V_s = 350 - 20 \times 0.5 = 340 \text{ V}$$

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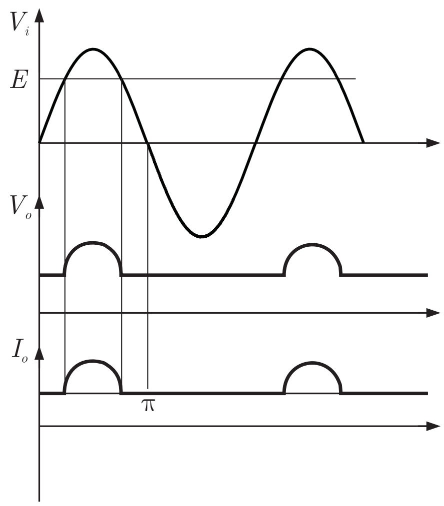
$$\therefore \qquad 340 = \frac{3 \times 440 \times \sqrt{2}}{\pi} \cos\alpha$$

$$\cos\alpha = 55^\circ$$

So each thyristor will reverse biased for $180^\circ - 55^\circ = 125^\circ$.

SOL 9.45 Option (C) is correct.

In this circuitry if SCR gets open circuited, than circuit behaves like a half wave rectifier.



So

$$I_{avg} = \text{Average value of current}$$

$$= \frac{1}{2\pi R}\int_{\theta_1}^{\pi-\theta_1} (V_m \sin\omega t - E)\, d\theta$$

$$\because \qquad I_{0(avg)} = \frac{1}{2\pi R}[2V_m \cos\theta - E(\pi - 2\theta_1)]$$

$$= \frac{1}{2\pi \times 2}[2 \times (230 \times \sqrt{2})\cos\theta - 200(\pi - 2\theta_1)]$$

$$\theta_1 = \sin^{-1}\left(\frac{E}{V_m}\right) = \sin^{-1}\left(\frac{200}{230 \times \sqrt{2}}\right) = 38^\circ = 0.66 \text{ Rad}$$

$$\therefore \qquad I_{0(avg)} = \frac{1}{2\pi \times 2}[2\sqrt{2} \times 230\cos 38^\circ - 200(\pi - 2 \times 0.66)]$$

$$= 11.9 \text{ A}$$

SOL 9.46 Option (B) is correct.

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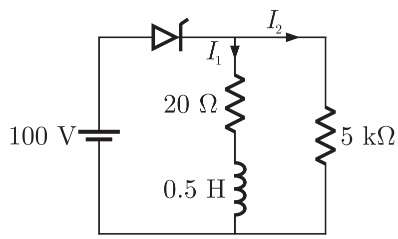


In this given circuit minimum gate pulse width time= Time required by i_a rise up to i_L

$$i_2 = \frac{100}{5 \times 10^3} = 20 \text{ mA}$$

$$i_1 = \frac{100}{20}[1 - e^{-40t}]$$

$\therefore$ anode current $I = I_1 + I_2 = 0.02 + 5[1 - e^{-40t}]$

$$0.05 = 0.05 + 5[1 - e^{-40t}]$$

$$1 - e^{-40t} = \frac{0.03}{5}$$

$$T = 150 \text{ μs}$$

SOL 9.47 Option (B) is correct.

Given $I_L = 10$ A. So in the +ve half cycle, it will charge the capacitor, minimum time will be half the time for one cycle.

so min time required for charging

$$= \frac{\pi}{\omega_0} = \pi\sqrt{LC}$$

$$= 3.14 \times \sqrt{2 \times 10^{-3} \times 10^{-6}} = 140 \text{ μsec}$$

SOL 9.48 Option (C) is correct.

Given $T_{on} = 140$ μsec

$$\text{Average output} = \frac{T_{on}}{T_{total}} \times V$$

$$T_{total} = 1/f = \frac{1}{103} = 1 \text{ msec}$$

$$\text{so average output} = \frac{140 \times 10^{-6}}{1 \times 10^{-3}} \times 250 = 35 \text{ V}$$

SOL 9.49 Option (A) is correct.

The conduction loss v/s MOSFET current characteristics of a power MOSFET is best approximated by a parabola.

SOL 9.50 Option (B) is correct.

In a 3-ϕ bridge rectifier

$$V_{rms} = 400 \text{ V},\ f = 50 \text{ Hz}$$

This is purely resistive then

instantaneous voltage $\quad V_0 = \sqrt{2}\, V_{rms} = 400\sqrt{2}\ \text{V}$

SOL 9.51 Option (C) is correct.

A 3-ϕ square wave (symmetrical) inverter contains only odd harmonics.

SOL 9.52 Option (A) is correct.

In Ideal condition we take voltage across the device is zero.

average power loss during switching $= \dfrac{VI}{2}(t_1 + t_2)$ (turn ON)

SOL 9.53 Option (C) is correct.

So in P thyristor blocks voltage in both polarities until gate is triggered and also in R transistor along with diode can do same process.

SOL 9.54 Option (C) is correct.

$$\text{Duty ratio } \alpha = 0.5$$

here
$$T = \frac{1}{1 \times 10^{-3}} = 10^{-3} \text{ sec}$$

$$T_a = \frac{L}{R} = \frac{200 \text{ mH}}{5} = 40 \text{ msec}$$

$$\text{Ripple} = \frac{V_s}{R}\left[\frac{(1 - e^{-\alpha T/T_s})(1 - e^{-(1-\alpha)T/T_a})}{1 - e^{-T/T_s}}\right]$$

$$(\Delta I)_{max} = \frac{V_s}{4fL} = \frac{100}{4 \times 10^3 \times 200 \times 10^{-3}}$$

$$= 0.125 \text{ A}$$

SOL 9.55 Option (C) is correct.

$$T_{st} = 15 \text{ Nm}$$

$$T_L = 7 \text{ Nm}$$

$$\alpha = 2 \text{ rad/sec}^2$$

$$T = I\alpha$$

so
$$T = T_{st} - T_L = 8 \text{ Nm}$$

$$I = \frac{8}{2} = 4 \text{ kgm}^2$$

SOL 9.56 Option (B) is correct.

We know that $\quad V_{rms} = 230$ V

so, $\quad V_m = 230 \times \sqrt{2}$ V

If whether $\alpha < 90^\circ$

Then $V_{\text{peak}} = V_m \sin\alpha = 230$

$$230\sqrt{2}\sin\alpha = 230$$

$$\sin\alpha = \frac{1}{\sqrt{2}}$$

$$\text{angle } \alpha = 135^\circ$$

SOL 9.57 Option (D) is correct.

When we use BJT as a power control switch by biasing it in cut-off region or in the saturation region. In the on state both the base emitter and base-collector junction are forward biased.

SOL 9.58 Option (A) is correct.

Peak Inverse Voltage (PIV) across full wave rectifier is $2V_m$

$$V_m = 50\sqrt{2}\ \text{V}$$

so, $\text{PIV} = 100\sqrt{2}\ \text{V}$

SOL 9.59 Option (D) is correct.

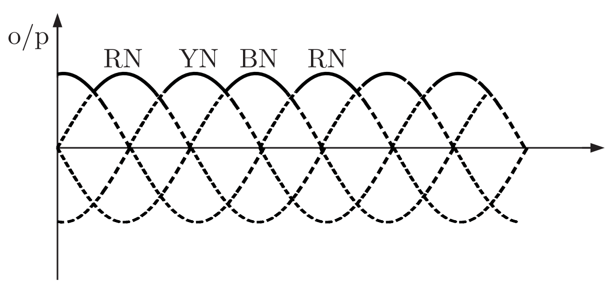
$$V_b = 12 \pm 4\ \text{V}$$

$$V_{b\max} = 16\ \text{V}$$

$$V_{b\min} = 8\ \text{V}$$

$$\text{Required value of } R = \frac{V_b(\min)}{I_g} = \frac{8}{10\times 10^{-3}} = 800\ \Omega$$

SOL 9.60 Option (C) is correct.



Ripple frequency $= 3f = 3\times 400 = 1200$ Hz

So from V_0 ripple frequency $= 1200$ Hz

SOL 9.61 Option (C) is correct.

Given that $R = 0.15\ \Omega$

$$I = 15\ \text{A}$$

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So average power losses $= \frac{1}{(2\pi/\omega)}\int_0^{\pi/\omega} I^2 R dt$

$= \frac{\omega}{2\pi} \times 10^2 \times 0.15 \times \pi/\omega$

$= 7.5$ W

SOL 9.62 Option (D) is correct.

Output dc voltage across load is given as following

$$V_{dc} = \sqrt{2}\, V\left[\frac{1}{\alpha\pi}\left\{(2\pi - \alpha) + \frac{\sin 2\alpha}{2}\right\}\right]^{\frac{1}{2}}$$

$$= \sqrt{2} \times 230\sqrt{2}\left[\frac{1}{\frac{\pi}{4}\times\pi}\left\{\left(2\pi - \frac{\pi}{4}\right) + \left(\frac{\sin \pi/2}{2}\right)\right\}\right]^{\frac{1}{2}}$$

$$= 317.8 \text{ V}$$

$$\text{losses} = \frac{V_{dc}^2}{R} = \frac{(317.8)^2}{100} = 10100 \text{ W}$$

SOL 9.63 Option (C) is correct.

$V_s = 100$ V, duty ratio$= 0.8$, $R = 10\ \Omega$

So average current through diode $= \frac{\alpha V_s}{R}$

$= \frac{0.8 \times 100}{10} = 8$ A

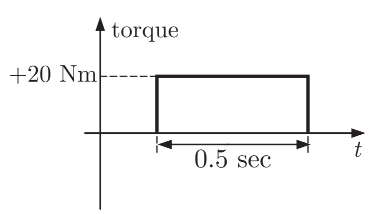
SOL 9.64 Option (D) is correct.

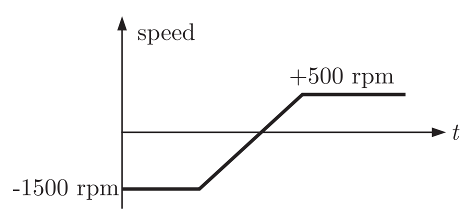
Peak current through S_1

$$I = I_0 + V_S\sqrt{C/L} = 20 + 200\sqrt{\frac{2\times10^{-6}}{200\times10^{-6}}} = 40 \text{ A}$$

SOL 9.65 Option ( ) is correct.

SOL 9.66 Option (C) is correct.





so

$$\alpha = \left[\frac{500 - (-1500)}{0.5}\right] \times \frac{2\pi}{60} = 418.67 \text{ rad/sec}^2$$

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and $\qquad T = 40 \text{ Nm}$

$$T = I\alpha$$

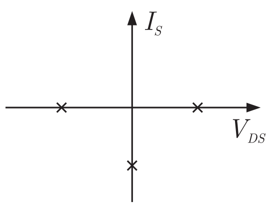
$$I = \frac{T}{\alpha} \times \frac{40}{418.67} = 0.096 \text{ kgm}^2$$

SOL 9.67 Option (D) is correct.

When thyristor turned on at that time J2 junction will break. So J1, J2, J3 all are in forward bias.

SOL 9.68 Option (D) is correct.

The ON-OFF state of switch is given on $V_{DS} - I_S$ plane as following



When $V_{DS} = +$ ve, diode conducts and $I_S = 0$

$V_{DS} = -$ ve, diode opens, but $I_S = 0$, D $\rightarrow -$ ve potential.

SOL 9.69 Option (B) is correct.

P. Field control-Above base speed

Q. Armature control-below base torque

SOL 9.70 Option (A) is correct.

As we know in fully controlled rectifier.

$$V_{PP} = V_m - V_m \cos(\pi/6 + \alpha) \qquad \because \alpha = 30^\circ$$

or $\qquad V_{PP} = V_m[1 - \cos(\pi/6 + 30^\circ)]$

or $\qquad \dfrac{V_{PP}}{V_m} = 0.5$

SOL 9.71 Option ( ) is correct.

SOL 9.72 Option (A) is correct.

In the chopper during turn on of chopper V-t area across L is,

$$\int_0^{T_{on}} V_L\, dt = \int_0^{T_{on}} L\left(\frac{di}{dt}\right) dt = \int_{i_{min}}^{i_{max}} L di$$

$$= L(i_{max} - i_{min}) = L(\Delta I)$$

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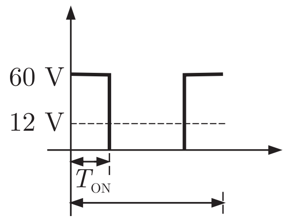
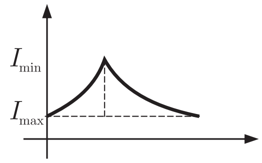


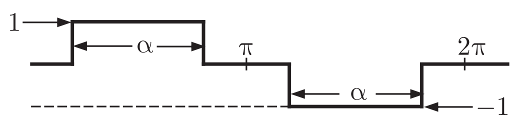


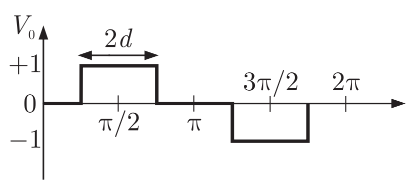
$$V\text{-}t \text{ are applied to `}L\text{' is} = (60 - 12)\,T_{on}$$
$$= 48\,T_{on}$$

So now volt area

$$\Delta I = \frac{48\,T_{on}}{L} = \frac{48 \times 0.2 \times 10^{-3}}{20 \times 10^{-3}} = 0.48 \text{ A}$$

SOL 9.73 Option (A) is correct.





$$\text{Output voltage } V_0 = \sum_{n=1,3,5}^{\infty}\left(\frac{4V_S}{n\pi}\right)(\sin nd)(\sin n\omega t)(\sin n\pi/2)$$

$\therefore$ RMS value of fundamental component

$$V_{rms(\text{fundamental})} = \frac{4V_S}{\sqrt{2}\,\pi}\sin d \times 1$$

$\alpha = 120^\circ$, $2d = 120^\circ \Rightarrow d = 60^\circ$

$$V_{rms(\text{fundamental})} = \frac{4V_S}{\sqrt{2}\,\pi} \times \sin 60^\circ$$
$$= 0.78\,V_S = 0.78 \text{ V}$$

SOL 9.74 Option (A) is correct.

After removing 5^{th} harmonic

$$5d = 0, \pi, 2\pi$$

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$$\therefore \qquad \text{Pulse width} = 2d = \alpha = 0, \frac{2\pi}{5}, \frac{4\pi}{5}$$
$$= 0^\circ, 72^\circ, 144^\circ$$

SOL 9.75 Option (C) is correct.

$$N_{Sa} = 3000 \text{ rpm}$$
$$N_a = 2850 \text{ rpm}$$
$$S_{FL} = \frac{3000 - 2850}{3000} = 0.05$$

where by (V/f) control

$$N_{sb} = 3000\left(\frac{40}{50}\right) = 2400 \text{ rpm}$$
$$\therefore \qquad N_2 = \text{new running speed of motor}$$
$$= 2400\left(1 - \frac{0.05}{2}\right) = 2340 \text{ rpm}$$

SOL 9.76 Option (C) is correct.
For six pulse thyristor rectifier bridge the lowest frequency component in AC source line current is of 250 Hz.

SOL 9.77 Option (A) is correct.
Given a step down chopper is operated in continuous conduction mode in steady state with a constant duty Ratio D.

$$V_0 \rightarrow \text{dc output voltage.}$$
$$V_s \rightarrow \text{dc input voltage}$$
$$\frac{V_0}{V_s} = D = \text{duty ratio}$$

SOL 9.78 Option ( ) is correct.

SOL 9.79 Option (B) is correct.
From figure

$$(V_{12})_{\text{rms}} = \left[\frac{1}{\pi}\int_0^{\phi} V_s^2 \, d\omega\right]^{1/2}$$
$$= \frac{V_s}{\sqrt{\pi}} \times \sqrt{\phi} = V_s\sqrt{\frac{\phi}{\pi}}$$

SOL 9.80 Option (C) is correct.

Given that, $V = 200 \sin \omega t$

$$f = 50 \text{ Hz}$$

Power dispatched in the load resistor $R = ?$

First we have to calculate output of rectifier.

$$(V_0)_{\text{rms}} = \left[\frac{1}{\pi}\int_0^{\pi}(200\sin\omega t)^2 d\omega t\right]^{1/2}$$

$$= \frac{200}{\sqrt{\pi}}\left[\int_0^{\pi}\left(\frac{1-\cos 2\omega t}{2}\right)d\omega t\right]^{1/2}$$

$$= \frac{200}{\sqrt{\pi}}\left[\frac{1}{2}\left(\omega t - \frac{\sin 2\omega t}{2}\right)_0^{\pi}\right]^{1/2}$$

$$= \frac{200}{\sqrt{\pi}}\left[\frac{1}{2}\times\pi\right]^{1/2} = \frac{200}{\sqrt{2}}$$

Power dissipiated to resistor

$$P_R = \frac{(V_0)^2_{\text{rms}}}{R} = \left(\frac{200/\sqrt{2}}{50}\right)^2 = 400 \text{ W}$$

SOL 9.81 *

Given $f = 20$ kHz

$D = 0.5$

Power transferred from source V_1 to $V_2 = ?$

$$\text{Time period } t = \frac{1}{f} = \frac{1}{20\times 10^{-3}} = 50\ \mu\text{sec}$$

$$D = 0.5$$

$$t_{\text{ON}} = 25\ \mu\text{sec},\ t_{\text{off}} = 25\ \mu\text{sec}$$

at t_{ON}, energy will stored in inductor circuit

$$v = L\frac{di}{dt}$$

$$100 = 100\times 10^{-6}\frac{di}{dt}$$

$$\frac{di}{dt} = 10^6$$

$$i = 10^6 t + i(0) \qquad \because i(0) = 0$$

$$i = 10^6 t \qquad ...(1)$$

$$E = \frac{1}{2}Li^2$$

$$E = \frac{1}{2}\times 100\times 10^{-6}\times 10^{12}\times 25\times 25\times 10^{-12}$$

$$E = 3.1250\times 10^{-2} \text{ J}$$

Now power transferred during t_{off}

$$P_t = \frac{3.1250\times 10^{-2}}{25\times 10^{-6}} = 12.5\times 10^2 \text{ W}$$

SOL 9.82 Option (B) is correct.

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For providing electrical isolation it is necessary to connect a pulse transformer at the output stage of a thyristor triggering circuit.

SOL 9.83 Option (A) is correct.

In ac to dc circulating current dual converters if triggering angles are α_1 and α_2, than it is necessary that

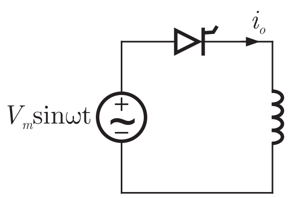
$$\alpha_1 + \alpha_2 = 180^\circ$$

SOL 9.84 Option (D) is correct.

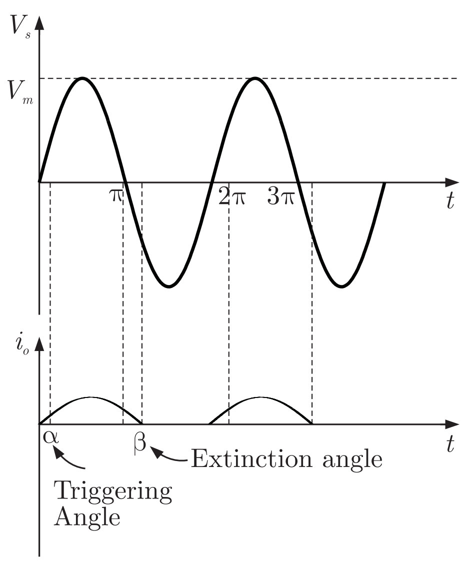
Given a half wave Thyristor converter supplies a purely inductive load

$$\text{Triggering angle } \alpha = 120^\circ$$

$$\text{than extinction angle } \beta = ?$$



First we have to draw its output characteristics as shown below



output is given by

$$i_0 = \frac{V_m}{Z}\sin(\omega t - \phi) - \frac{V_m}{Z}\sin(\alpha - \phi)\exp\left(\frac{-R}{\omega L} - \alpha\right) \qquad ...(1)$$

We know at extinction angle i.e. $\omega t = \beta$, $i_0 = 0$

from equation (1), at $(\omega t = \beta)$

$$0 = \frac{V_m}{Z}\sin(\beta - \phi) - \frac{V_m}{Z}\sin(\alpha - \phi)\, e^\circ$$

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or $\sin(\beta - \phi) = \sin(\alpha - \phi)$

or $\beta - \phi = \alpha - \phi$

or $\beta = \alpha = 120^\circ$

SOL 9.85 Option (D) is correct.

$\because \quad f = 50 \text{ Hz}$

So total time $= \dfrac{1}{f} = \dfrac{1}{50} = 20 \text{ msec}$

Conduction time for each feedback diode in a cycle is being given by

$$t_{\text{conduction}} = \frac{20}{8} = 2.5 \text{ msec}$$

SOL 9.86 *

Given a voltage commulated thyristor chopper circuit in figure which is operated at 500 Hz, with 50% duty ratio.

$$I_L = 20 \text{ A(constant)}$$

We have to evaluate

(a) T_{off} for thyristor Th_1

(b) $L = ?$ if peak current through Th_1 is 180% limited

(c) Maximum instantaneous output voltage

Turn off time $T_{\text{off}} = \dfrac{CV_s}{I_L} = \dfrac{6 \times 10^{-6} \times 100}{20} = 30 \,\mu\text{sec}$

Peak current through Th_1

$$i_{\text{Th}_1} = I_0 + V_{dc}\sqrt{\frac{C}{L}}$$

$\because \quad i_{\text{Th}_1} = 1.8 I_L = 1.8 \times 20 = 36 \text{ A}$

$$36 = 20 + 100\sqrt{\frac{6 \times 10^{-6}}{L}}$$

or $0.16 = \sqrt{\dfrac{6 \times 10^{-6}}{L}}$

$$L = \frac{6 \times 10^{-6}}{(0.16)^2} = 2.34 \times 10^{-4} \text{ H}$$

Maximum instantaneous output voltage

$$V_m = 2V_{dc} = 200 \text{ V}$$

SOL 9.87 *

Given in figure separately excited dc motor is controlled by varying its armature voltage using 1-ϕ full converter bridge.

Motor voltage constant $K_v = 2.5$ V/rad/sec

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$$\text{Motor Torque } T = 140 \text{ Nm}, \alpha = 60^\circ$$

armature current continuous and ripple free.

(a) $I_a = ?$

(b) $N_m = ?$

(c) rms of fundamental component of input current.

(a) $\because$ Motor Torque $\quad T = E_b I_a \quad$ and $E_b = K_v \omega$

Than
$$K_v \omega I_a = T\omega$$

$$I_a = \frac{T}{K_v} = \frac{140}{25} = 50 \text{ Amp}$$

(b) In dc motor we know

$$I_a = \frac{V_0 - E_b}{R_a}$$

$$V_0 = \frac{2V_m \cos\alpha}{\pi}$$

$$= \frac{2 \times 250\sqrt{2}}{\pi} \cos 60^\circ$$

$$E_b = V_0 - I_a R_a$$

$$E_b = \frac{500\sqrt{2}}{\pi} \times 2 - 20(0.2)$$

$$E_b = 215.2 \text{ V}$$

$$\omega = \frac{E_a I_a}{T} = \frac{215.2 \times 20}{140} = 30.74 \text{ rad/sec}$$

(c) Rms value of fundamental component of input current

$$I_{sr} = \frac{I_{or}}{\sqrt{2}\left[\frac{1}{\pi}\left((\pi - \alpha) + \frac{1}{2}\sin 2\alpha\right)\right]^{1/2}}$$

$$I_{or} = 56 \text{ Amp}, \alpha = 60^\circ$$

$$I_{sr} = \frac{56}{\sqrt{2}\left[\frac{1}{\pi}\left(\pi - \frac{\pi}{3}\right) + \frac{1}{2}\sin 120^\circ\right]^{1/2}}$$

$$I_{sr} = \frac{39.6}{\left(\frac{2}{3} - \frac{1}{4}\right)^{1/2}} = 61.34 \text{ Amp}$$

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