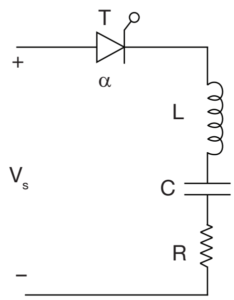
POWER ELECTRONICS AND DRIVES TEST I

Number of Questions: 35 **Section Marks: 90**

Directions for questions 1 to 35: Select the correct alternative from the given choices.

1.

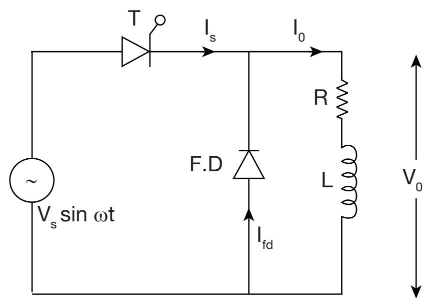


Conduction Angle only extent up to

(A) $0 - \frac{\pi}{2}$ (B) $0 - \pi$

(C) $\pi - 2\pi$ (D) $0 - 2\pi$

2. With small value of Inductance in load side



Which of the following statement is correct.

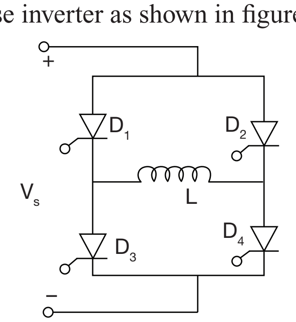
(A) i_s always present and a non-zero value.

(B) V_0 always equal to supply voltage

(C) I_0 always present and non zero value

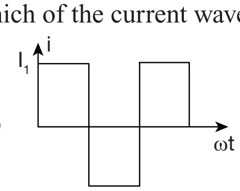
(D) free wheeling diode used for get use of trapped power in inductor, cut off the negative portion of voltage and smooth the current ripple

3. A single phase inverter as shown in figure below

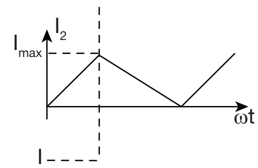


Which of the current wave form is true

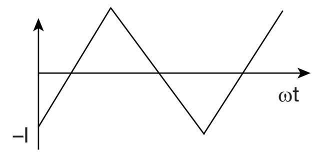
(A)



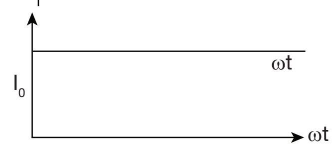
(B)



(C)



(D)



4. Negative triggering the gate of SCR protected by separate protection circuit because it will

(A) harm the thyristor life

(B) result in to turn off of SCR some time

(C) produce unpredictable operation

(D) produce higher loss

5. For very fast switch action at low power ________ switch is used

(A) SCR (B) BJT

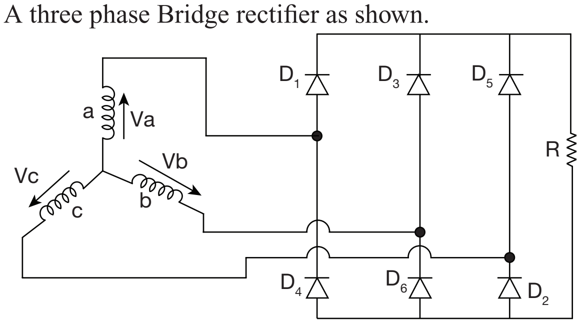
(C) MOSFET (D) GTO

6. A six pulse half wave rectifier converter convert two set three phase supply to a single out put. What will be the minimum current handling capacity of each diode. (Source voltage. V_s = 100 V) (R_{Load} = 20 W)

(A) 5 A (B) 12.24 A

(C) 21.21 A (D) 7.07 A

7. A three phase Bridge rectifier as shown.



Which is more suitable sequence of operation for maximum out put

(A) D_1D_6, D_6D_3, D_3D_4, D_4D_5, D_5D_6, D_6D_3

(B) D_1D_6, D_2D_1, D_2D_3, D_3D_4, D_5D_4, D_5D_6

(C) D_1D_6, D_6D_2, D_2D_3, D_3D_4, D_5D_4, D_5D_6

(D) D_1D_6, D_1D_2, D_2D_3, D_3D_4, D_5D_1

8. I_n Dual converter the reactors are connected to

(A) Limit the ripples in current

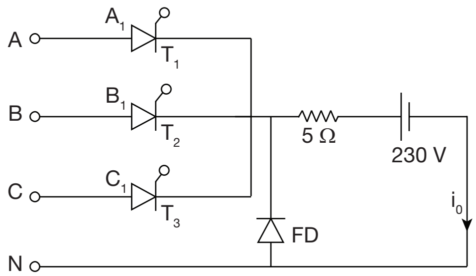
(B) Limit the circulating current

(C) Isolate dc component.
(D) Make continous circuit current

9. In a dual converter rectifier working with $\alpha_1 = 60°$ then the inverter firing angle α_2 =

(A) 60° (B) 300°
(C) 120° (D) 240°

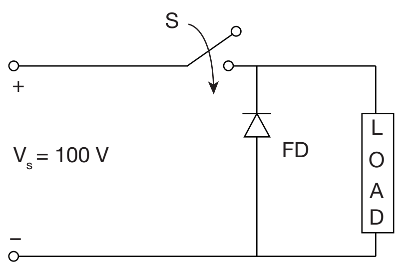
10.



Each thyristor triggered using common continuous triggering signal; neutral to line voltage is 230 V. Conduction angle for switch D_1 is

(A) 0° (B) 120°
(C) 180° (D) 90°

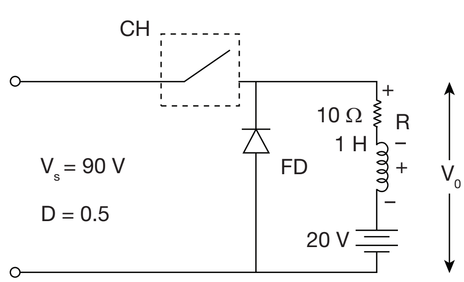
11.



The circuit as shown with duty cycle of switch, $D = 0.5$ will follow

(A) unity voltage ripple factor
(B) voltage ripple factor more than unity
(C) voltage ripple factor less than unity
(D) No ripples

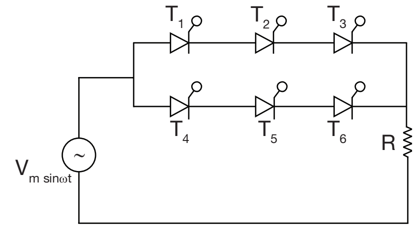
12.



The circuit having chopping frequency of 1500 Hz. What will be the maximum ripple current flow through the inductor

(A) 0.0116
(B) 7.5×10^{-3} A
(C) 0.0212 A
(D) 0.015 A

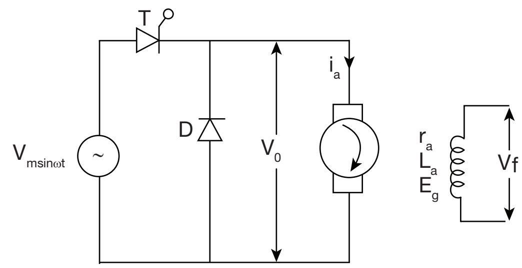
13.



6 identical switches of forward voltage handling capability of $V_{max} = 400_{rms}$
$i_{max} = 100\ A_{rms}$
The circuit has peak power handling capacity of

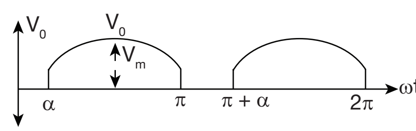
(A) 240 KW (B) 480 KW
(C) 169.7 KW (D) 80 KW

14.

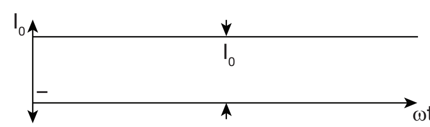


A single phase DC motor drive as shown which of the following is right for the circuit on the assumption of *La>>ra*.

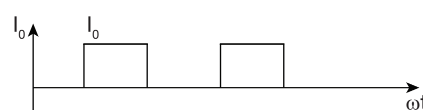
(A)



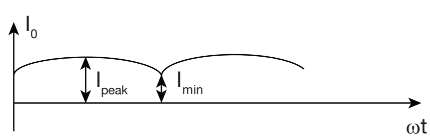
(B)



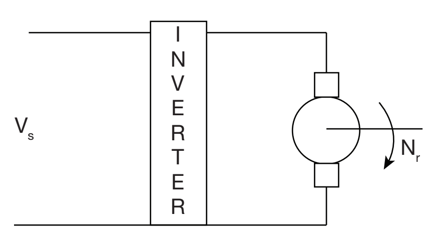
(C)



(D)



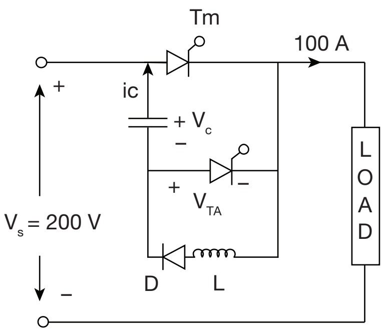
15. A thyristor controlled induction motor working at a slip of 0.02 fed from voltage controlled source inverter as shown



Operated at 50 Hz, 6 pole machine. The speed of rotor will be

(A) 1000 rpm (B) 2940 rpm
(C) 980 rpm (D) 3000 rpm

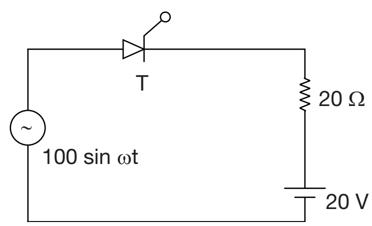
16. Commutation circuit as shown in figure.



Having $L = 20$ μH and $C = 50$ μF, $V_c = V_s$ for a constant load current of 100 A. What will be turn off time for main thyristor T_m

(A) 125μs (B) 10 ms
(C) 25 ms (D) 100μs

17. A simple load commutation circuit as shown in figure



works for a long time after 3 years the internal voltage of battery change by the function

$E_{Battery} = (20 - 1.2 \times \text{years})$ volt

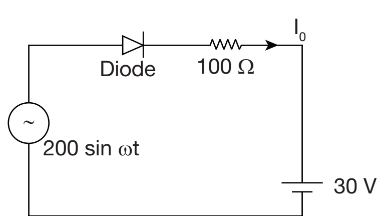
What will be the present triggering angle for continuous gate triggering mode.

(A) 9.44° (B) 11.54°
(C) 13.65° (D) 0°

18. Inverter controlled with pwm method with pulse width of 160° in each half cycle. What will be the total harmonic distortion (THD)

(A) 0.54 (B) 0.3617
(C) 0.72 (D) 0.35

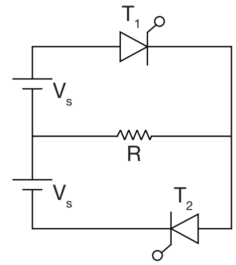
19.



What will be the value of power dissipated in the resistor

(A) 33 w (B) 66.2 w
(C) 40.5 w (D) 63.6 w

20.



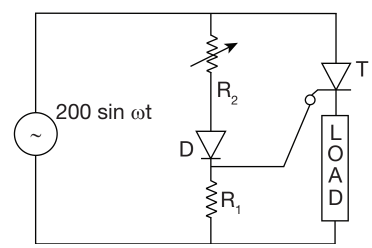
Inverter arrangement as shown in figure having V_s = 100 A and R = 10 W what will be the maximum value of 5th harmonic component.

(A) 2.54 A (B) 12.56 A
(C) 0 A (D) 20.12 A

21. A three phase 120 degree mode voltage source inverter connected to a resistive inductive load, $R = 10\ \Omega$, $L = 200$ μH. What will be the load power if inverter source voltage is 100 V dc.

(A) 166 W (B) 500 W
(C) 866 W (D) 288 W

22. A circuit as shown in figure triggered by resistance firing circuits



Thyristor rating of $I_L = 200$ mA

$I_H = 180$ mA $V_{g\,max} = 20$ V

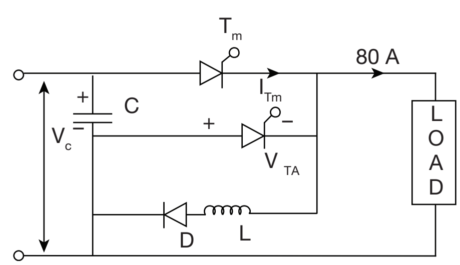
$V_{g\,min} = 15$ V $R_{2\,min} = 5$ K Ω

$R_{2\,max} = 5.666$ K Ω

What will be the value of R_1 for sure turn ON of SCR at $\omega t = 45°$

(A) 555.55 Ω (B) 823.57 Ω
(C) 1.1K Ω (D) 932.29 Ω

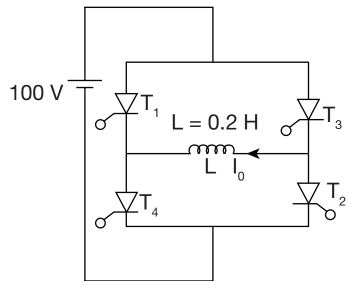
23.



Commutation circuit as shown in figure having $L = C$ = 1 m units and V_c = 120 V maximum voltage a capacitor can store. What will be the minimum current main thyristor can be handling.

(A) 120 A (B) 80 A
(C) 200 A (D) 240 A

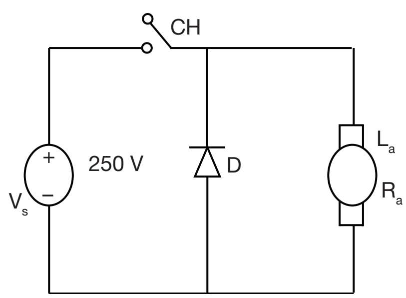
24. A voltage source inverter arrangement as shown figure.



Operated in 180° mode, 50 Hz the peak to peak value of I_0 will be

(A) 5 A (B) 2.5 A
(C) 10 A (D) 0 A

25. A separately excited dc motor has rated armature current of 25 A and rated armature voltage 180 V. The power supplied by a step down chopper at a switch frequency of 5 KHz used to control armature voltage. Neglecting all the losses L_a = 0.2 mH armature resistance Ra = 1 Ω Duty ratio of the chopper to obtain 60% rated torque at rated speed and the rated field current is ______________

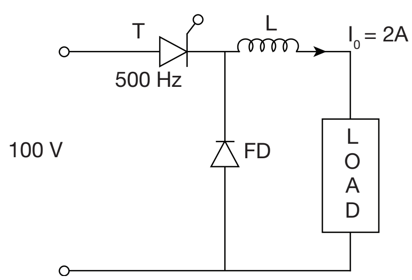


(A) 0.68 A (B) 0.6 A
(C) 0.82 A (D) 0.62 A

26. A single phase bridge inverter fed from 100 V dc connected to RL load of R = 5 Ω & L = 0.01 H determine the current of 5th harmonic content when inverter operated at 50 Hz two pulse PWM method of d = 45°

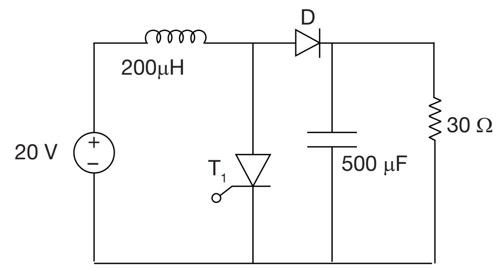
(A) 2.82 A (B) 2 A
(C) 1 A (D) 5.6 A

27. The chopper circuit as shown the thyristor T operated at a duty ratio of 0.8. What will be the value of critical inductance L for which the current falls to zero



(A) 4.96 mH (B) 8.66 mH
(C) 8 mH (D) 4.851 mH

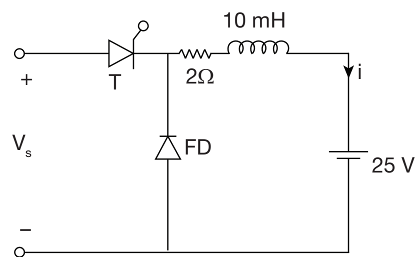
28. A boost converter feeds a resistive load from a battery source. Switch is operated at 5000 Hz with duty ratio of 0.4



What will be the average source current in steady state

(A) 4.16 A (B) 0.66 A
(C) 3 A (D) 1.851 A

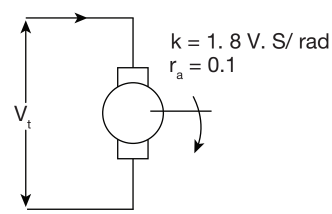
29. A type – A chopper circuit source voltage V_s = 200 V chopping frequency 500 Hz Duty cycle D = 0.3



The maximum current i is

(A) 21.799 A (B) 34.2 A
(C) 87.5 A (D) 26.25 A

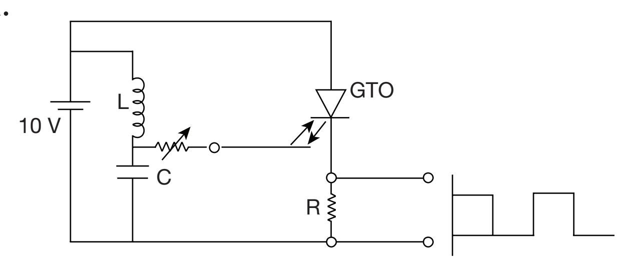
30. A 120 kW, 400 V, 1800 rpm separately excited dc motor is energized by 420 V_L, 50 Hz three phase source through three phase semi converter. The voltage drop in brushes and thyristor are 5V



At no load armature current of 25 A what will be the no load speed at firing angle of 45°.

(A) 2528.6 rpm (B) 3000 rpm
(C) 1777.4 rpm (D) 2590.1 rpm

31.



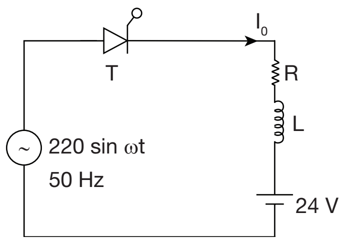
A 10 volt pulse generator made by using GTO L = 0.1H., C = 10 μF.

Consider all devices are ideal what will be the frequency of output pulses.

(A) 2214.5 Hz (B) 322.5 Hz
(C) 1121.3 Hz (D) 159.2 Hz

Common data Questions 32 and 33:

A single phase half wave converter with RLE load as shown



Conduction extent up to 200°

32. The average load voltage is (if continuous gate pulses given to SCR).

(A) 80.34 V (B) 78.79 V
(C) 68.52 V (D) 72.41 V

33. Circuit conduction time of the circuit

(A) 0.05 s (B) 0.02 s
(C) 0.01 s (D) 0.6 s

Linked Answer Questions for 34 and 35:

34. A single phase inverter operated at single pulse PWM method $2d = 72°$; $N = 1$. The 3rd and 5th frequency component voltages are

(A) 0.4 V_s; 0 V (B) 0.285 V_s; 0.4 V_s V
(C) 0.2854 V_s, 0 V (D) 0.3 V_s, 0 V

35. The inverter replaced with $N = 2$, two pulse width modulation.

The percentage change in third harmonics is

$$\frac{V_{03_{rms\ N=1}} - V_{03_{rms\ N=2}}}{V_{03_{rms\ N=1}}} \times 100$$

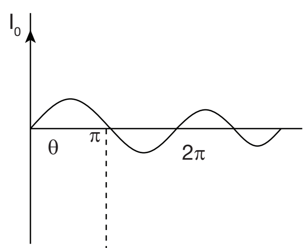
(A) 50% (B) 47.2%
(C) 60% (D) 62.5%

Answer Keys

1. B	**2.** D	**3.** C	**4.** B	**5.** C	**6.** D	**7.** B	**8.** B	**9.** C	**10.** D
11. A	**12.** D	**13.** B	**14.** B	**15.** C	**16.** D	**17.** A	**18.** B	**19.** B	**20.** A
21. B	**22.** B	**23.** C	**24.** A	**25.** A	**26.** B	**27.** C	**28.** D	**29.** A	**30.** A
31. D	**32.** B	**33.** C	**34.** C	**35.** B					

Hints and Explanations

1. The output current wave form of RLC circuit will be an AC



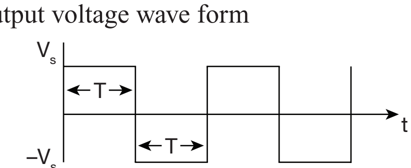
Conduction extent; when current was in forward direction ie, $0 - \pi$

$\pi - 2\pi$ direction was opposite

that is, diode only conducts $0 - \pi$. Choice (B)

2. More accurate answer is Choice (D)

3. The output voltage wave form



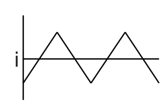
at $D_1 D_3$ Path

$$I = \frac{+V_s}{L} \times t + I_{initial}\ (-ve)$$

$$I_{\max} = \frac{V_s}{L} \times T + I_{\text{initial}}\ (-ve)$$

At $D_2\ D_4$ Path

$$I_{\max} = \frac{-V_s}{L} \times T + I_{initial} (+ve)$$



So Choice (C) is correct. Choice (C)

4. Choice (B)

5. Choice (C)

6. For 6 pulse operation at a time one switch is closed. The maximum output switch can give when it is closed.

At $\alpha \le 90 \pm \frac{180}{2n} \le \alpha$

$\le 90 \pm \frac{180}{12}$ $(\because n = 6)$

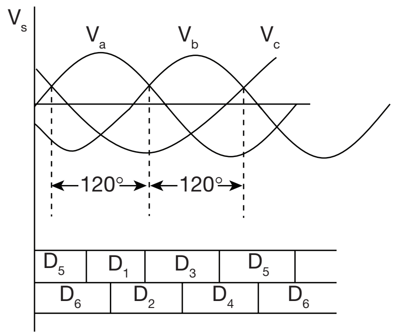
$75 \le \alpha \le 105$

i.e., The maximum current

$$= \frac{V_m}{R} = \frac{\sqrt{2} \times 100}{20} = 7.07 \text{ A}$$

For maximum current of 7.07 Ampere, the diode should have minimum current handling capacity of 7.071 Ampere Choice (D)

7. For maximum output at a time two phases conducts and each set conducts for $\frac{360}{6}$ and each diode $\frac{360}{3}$ degree



Choice (B)

8. Choice (B)

9. For a dual converter firing angle are related by

$\alpha_1 + \alpha_2 = 180° \mid \alpha_1 = 60°$

$\alpha_2 = 180 - \alpha_1 = 120°$. Choice (C)

10. We can remove Diode from this circuit. Diode has no role in conduction

V_a, V_b, V_c each are more positive 0 – 120°, 120 – 240°, 240 – 360° respectively

$V_A = \sqrt{2} \times 230 \sin \omega t$

$V_B = \sqrt{2} \times 230 \sin (\omega t - 120)$

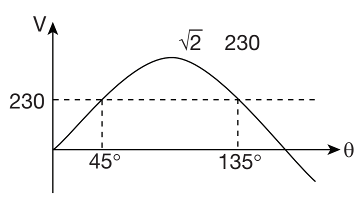
D_1 is forward bias

When $V_m \sin \theta > 230$

$\sqrt{2} \times 230 \sin \theta > 230$

$\theta > 45°$

i.e., D_1 forward bias from 45° to 135°



Conduction Angle will be

135° – 45° = 90°. Choice (D)

11. Voltage ripple factor = $\sqrt{\frac{V_{rms^2} - V_{av^2}}{V_{av^2}}}$

$V_{av} = \alpha V_s$; $V_{rms} = \sqrt{a} V_s$

$$V.R.F = \sqrt{\frac{aV_s^2 - a^2V_s^2}{a^2V_s^2}} = 1$$

$\alpha = D = 0.5$ Choice (A)

12. Ripple = ΔI

$$\Delta I_{max} = \frac{V_s}{R} \tan h\left(\frac{R}{4fL}\right) \text{ here } 4fL >> R$$

Then $\frac{R}{4fL} \to 0$

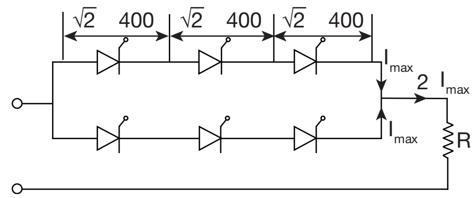
$$\Delta I_{max} = \frac{V_s}{R} \times \frac{R}{4fL}$$

$$\Delta I_{max} = \frac{V_s}{4fL}$$

$$\text{i.e., } \Delta I_{max} = \frac{V_s}{4fL} = \frac{90}{4 \times 1500 \times 1}$$

$= 0.015$ A. Choice (D)

13.



$V_{peak} = 3\, V_{max\ peak}$

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

$= 1697.056$ V

$I_{peak} = 2\, I_{max\ peak}$

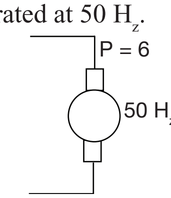
$= 2 \times 100 \times \sqrt{2} = 282.84$ A

Peak power = $V_{max}\, I_{peak}$

= 480 KW. Choice (B)

14. Option (b) right; every motor is working under the condition of $L_a >> r_a$ internal resistance of motor very less. High inductance oppose ripple. Choice (B)

15. The machine operated at 50 H_z.



Synchronous speed N_s

$$\text{i.e., } N_s = \frac{120 f}{8} = 1000 \text{ rpm}$$

A slip of $S = 0.02$

$N_r = (1 - S)\, N_s = 980$ rpm. Choice (C)

16. Circuit turn off time for main thyristor $I = c\frac{dV_c}{dt}$

at voltage commutation for constant current I_0;

$$\text{i.e., } I_0 = c\frac{V_c}{t}$$

When $V_c = V_s$; turn off the switch $I_0 = c\frac{V_s}{t}$

$t = c\frac{V_s}{I_0} = 50\mu \times \frac{200}{100} = 100\ \mu s.$ Choice (D)

17. The SCR is at a state of continuous triggering mode so SCR will ON at forward bias condition.
i.e., $100 \sin \omega t \geq E$
Battery voltage After 3 year
$E_{3year} = 20 - 1.2 \times 3 = 16.4$ Volt

$\omega t = \sin^{-1}\left(\frac{16.4}{100}\right) = 9.439°$

SCR ON after 9.439° to (180° – 9.439°)
triggering Angle = 9.439°. Choice (A)

18. $\text{THD} = \frac{\sqrt{V_{rms}^2 - V_1^2}}{V_1}$; $2d = 160°$

$d = 80°$
V_1 = rms fundamental frequency signal

$$V_0 = \sum_{n=1,3,5}^{\infty} \frac{4V_s}{n\pi} \sin\frac{n\pi}{2} \sin nd \sin n\omega t$$

$$V_1 = \frac{4V_s}{\pi} \sin 80° \sin n\omega t$$

$$(V_1)_{\text{rms}} = \frac{1.2538}{\sqrt{2}} V_s$$

$$(V_1)_{\text{rms}} = 0.8866\, V_s$$

$$V_{\text{rms}} = \sqrt{\frac{1}{\pi}\int_{\frac{\pi}{2}-d}^{\frac{\pi}{2}+d} V_s^2 d\omega t}$$

$$= V_s\sqrt{\frac{2d}{\pi}} = 0.9428\, V_s$$

$$\text{THD} = \frac{\sqrt{(0.9428V_s)^2 - (0.8866V_s)^2}}{0.8866V_s} = 0.3617.$$

Choice (B)

19. The switch forward bias when $200 \sin \omega t > 30$ V

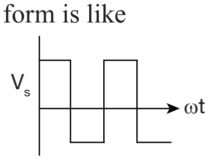
$\omega t = \sin^{-1}\left(\frac{30}{200}\right) = 0.1505\text{rad}$

$= \frac{200 \sin\omega t - 30}{100}$

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_{0.1505}^{\pi-0.1505}\left(\frac{200\sin\omega t - 30}{100}\right)^2 d\omega t} = 0.8133\ \text{A}$$

Power dissipated across resistance of 100 Ω
is $= I^2 R = 0.8133^2 \times 100 = 66.159$ W. Choice (B)

20. The output wave form is like



The fourier series representation of above output voltage.

$$V_0 = \sum_{n=1,3,5}^{\infty} \frac{4\ V_s}{n\pi} \sin\ n\omega t$$

$$I_{0n} = \frac{V_{0n}}{R} \quad I_5 = \frac{V_{05}}{R}$$

$$= \frac{4\ V_s}{5\pi \times 10} \sin 5\omega t \quad I_{5_{\max}} = \frac{4 \times 100}{5\pi \times 10} = 2.5464\ \text{A}.$$

Choice (A)

21. The average voltage across the inductor for a complete cycle is zero and also the power dissipated across inductor per cycle is zero So,

The load power only due to resistor $\frac{P}{phase} = \frac{\left[V_{phase}\right]^2}{R}$

$\frac{V_{rms}}{phase} = 0.4082\ V_s = \frac{V_s}{\sqrt{6}} = 40.82$ volt

$\frac{power}{phase} = \frac{(40.82)^2}{10} = 166.62$ Watt

for 3 phases = 166.62 × 3 ≅ 500 Watt. Choice (B)

22. For sure turn ON triggering I_g should be $I_{g\max}$ only when $V_g = V_{g\max} = 20$ V

i.e., $V_{R1} = 200 \sin \omega t \left[1 - \frac{R_2}{R_1 + R_2}\right]$

$\omega t = 45^\circ$

$20 = 200\ (\sin 45^\circ) \left[1 - \frac{5K}{5K + R_1}\right]$

$R_1 = 823.57\Omega.$ Choice (B)

23. $V_c = 120$ V

The current through the capacitor $I_c = V_c\sqrt{\frac{C}{L}} \sin \omega_0 t$

$= 120\sqrt{\frac{1\mu}{1\mu}} \sin\ \omega_0 t = 120 \sin\ \omega_0 t$

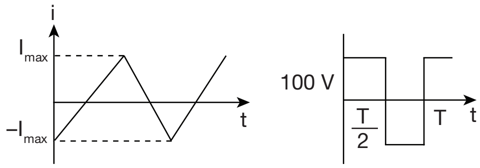
I_T max = 120 + 80
I_{Tm} = 200A Choice (C)

24. A voltage source inverter load current through inductor is $V = L\frac{di}{dt}$; $\int di = \int \frac{V}{L} dt$

for 50 Hz $\frac{T}{2}$ time current flow in one direction of slope

and another $\frac{T}{2}$ time other direction of slope

$T = \frac{1}{50} = .02$ sec $\frac{T}{2} = 0.01$ sec



$$100 = L\frac{di}{dt} = \frac{L[[I_{max}]-[-I_{max}]]}{0.01}$$

$$2I_{max} = \frac{100\times 0.01}{0.2}$$

$2I_{max} = 5\text{A}$ Choice (A)

25. $V_a = E_b + I_aR_a$
$180 = E_b + 25 \times 1$
$E_b = 155$ V
60% rated torque
$I = 0.6 \times 25 = 15\text{A}$
$V_a = 155 + 15 \times 1 = 170$ V

$D = \frac{V_0}{V_s}. = \frac{170}{250} = 0.68$ Choice (A)

26. For two pulse PWM method

$$V = \sum_{n-1,3,5....}^{\infty} \frac{8\,V_s}{n\pi}\sin\,n\gamma\,\sin\frac{nd}{2}\,\sin\,n\omega t$$

Here = $d = 45°$

i.e., $\gamma = \frac{\pi - 2d}{N+1} + \frac{2d}{2N}$

$N = 2$ pulse

$$\gamma = \frac{180-90}{3} + \frac{45}{2}$$

$\gamma = 52.5°$

$$V_5 = \frac{8\times 100}{5\times\pi}\left[\sin\left(\frac{5\times 45}{2}\right)\sin(5\times 52.5)\sin 5\omega t\right]$$

$$Z_n = \sqrt{R^2 + (nj\omega L)^2}$$

$$= \sqrt{5^2 + (5\times 2\times\pi\times 50\times 0.01)^2} = 16.484$$

$V_5 = -46.65 \sin \omega t$

$$i_5 = \frac{V_5}{Z_5} = \frac{-46.65\sin 5\omega t}{16.484}$$

$|i_{5\,rms}| = \frac{2.829}{\sqrt{2}}$ Amps $\cong$ 2A. Choice (B)

27. For *dc – dc* converter the critical inductance value.

$$L = \frac{(V_s - V_0)}{2f\,V_sP_0}V_0^2$$

$V_0 = \alpha\, V_s = 0.8 \times 100 = 80$ V
$I_0 = 2A$
Power $P_0 = V_0I_0 = 160$ Watt
$f = 500$

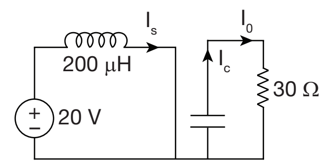
$$L = \frac{(100-80)}{2\times 500\times 100}\times\frac{80^2}{80\times 2}$$

$= 8 \times 10^{-3}\, H = 8$ mH. Choice (C)

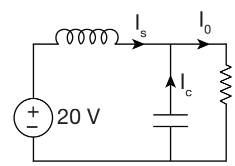
28. In a Boost converter the average current through capacitor is zero.

$$V_0 = \frac{V_s}{1-D} = 38.33\text{V}$$

When switch is closed then $|I_c| = |I_0|$



When switch is open



$I_s = I_c + I_0$
$I_c = I_s - I_0$
Average current through capacitor = 0
$(-I_0) \times DT + (I_s - I_0)\,(1 - D)\,T = 0$
$I_0 = (1 - D)\,I_s$

$$I_s = \frac{I_0}{1-D}$$

$$I_0 = \frac{V_0}{R}$$

$I_s = \frac{V_0}{(1-D)R} = \frac{V_s}{(1-D)^2\,R} = 1.851$ A. Choice (D)

29. $$I_{max} = \frac{V_s}{R}\left[\frac{1-e^{\frac{-T_{on}}{T_a}}}{1-e^{\frac{-T}{T_a}}}\right] - \frac{E}{R}$$

$$T_a = \frac{L}{R} = \frac{10\times 10^{-3}}{2} = 5\times 10^{-3}$$

$T_{on} = 0.3 \times T$

$$= 0.3 \times \frac{1}{500} = 6\times 10^{-4}\,s$$

$E = 25$
$R = 2$
$I_{max} = 21.799$ A. Choice (A)

30. Converter *O*/*P*: $K = 1.8$ Vs/rad
$Ra = 0.1\ \Omega$

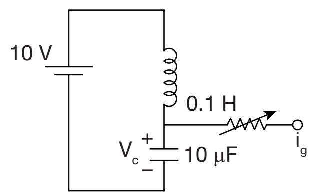
$$V_{av} = \frac{3\,V_{ml}}{2\pi}(1+\cos a);\ \alpha = 45° = 484.134\ \text{V}$$

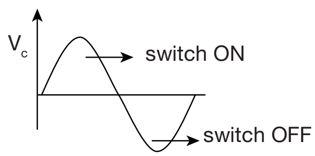
Converter motor equation.
$484.134 = E_a + I_a r_a + 5$
$= K\omega_m + 25 \times .1 + 5$

$$\omega_m = 264.79 = \frac{2\pi N_s}{60}$$

$N_s = 2528.6$ rpm Choice (A)

31. Here all devices are ideal GTO is the device closed when positive gate current applied on gate and off when negative gate current applied
i.e., Gate circuit





Voltage across the capacitor $V_c = \frac{1}{c}\int idt$

$$I_c(t) = V_s\sqrt{\frac{C}{L}}\ \sin\omega t$$

$$V_s = 10\text{ V}\ \omega = \frac{1}{\sqrt{LC}}$$

$$L = 0.1\ H f = \frac{1}{2\pi\sqrt{LC}} = 159.15\text{ Hz}$$

$C = 10$ μF ω = 1000
$i_{c\,\max}(t) = 0.1$ Amps
$i_c\,(t) = 0.1 \sin 1000\,t$

$$V_c = \frac{1}{c}\int i\ dt$$

$$= \frac{-1}{c}V_s \times \sqrt{\frac{C}{L}}.\cos\ \omega t \times \omega$$

$= -V_s \cos \omega t$
V_c is the voltage for gate triggering. The frequency of gate signal is the frequency of switch ON and OFF.
i.e., out put signal frequency is
$f = 159.15$, ≅ 159.2 Hz Choice (D)

32. $$V_0 = \frac{1}{2\pi}\begin{bmatrix} V_m(\cos a - \cos\beta) \\ +\ E(2\pi + a - \beta) \end{bmatrix}$$

$$a = \sin^{-1}\left(\frac{E}{V_m}\right)$$

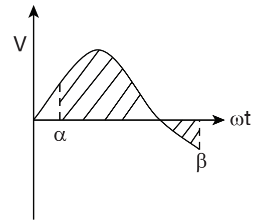
$$= \sin^{-1}\left(\frac{24}{220}\right) = 6.2629°$$

β = 200°
$V_0 = 78.791$ V. Choice (B)

33. The circuit on form α to β
α ≤ ωt ≤ β

$$t_{on} = \frac{\beta - a}{\omega}$$

ton = 0.01076 s



Choice (C)

34. $V_0 = \frac{4\ V_s}{\pi}\sum_{n=1,3,5}^{a}\frac{\sin\ n\omega t}{n}$ is the standard output signal when it is operated $N = 1$
Single PWM

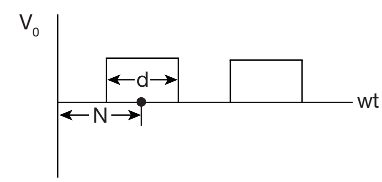
$$V_{on} = \frac{4\ V_s}{\pi}\sum_{n=1,3,5}^{\infty}\left(\sin\frac{n\pi}{2}\sin\ nd \sin\ n\omega t\right)\frac{1}{n}$$

$$V_{03_{rms}} = \frac{4V_s}{\sqrt{2}\times 3\pi}[-0.951056] = 0.2854\ \text{V}_s$$

$$V_{05} = \frac{4V_s}{\sqrt{2}\times 5\pi}[-1\times\sin 0] = 0\text{V}$$

Choice (C)

35. $N = 2$, $2d = 72°$
Multi pulse modulation $D = 36°$



$$V = \frac{2\times 4V_s}{\pi}\sum_{n=1,3,5}^{\infty}\left(\sin\ n\gamma \sin\frac{nd}{2}\sin n\omega t\right)\times\frac{1}{n}$$

$$\gamma = \frac{\pi - 2d}{N+1} + \frac{d}{N}$$

$$= \frac{180 - 72}{3} + \frac{36}{2} = 54°$$

$$V_{03_{rms}} = \frac{8V_s}{\sqrt{2}\times 3\pi}\left[\sin(3\times 54)\sin\frac{3\times 36}{2}\right]$$

$= 0.15005\ V_s$
Percentage change

$$= \frac{V_{\underset{N=1}{03_{rms}}} - V_{\underset{N=2}{03_{rms}}}}{V_{\underset{N=1}{03_{rms}}}}\times 100$$

$$= \frac{(0.2854 - 0.15)V_s}{0.2854\ V_s}\times 100\ = 47.42\%$$

Choice (B)