Power Electronics Test 3

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

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

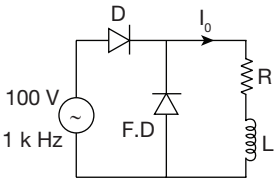
1. In a electronic device having *THD* = 12% and out put wave form *V*, *I* lag by 30°. Then the power factor of system should be

(A) 0.8598 (B) 0.1039
(C) 0.866 (D) 0.8722

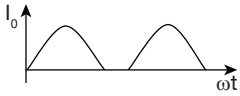
2. Which one of the following suited for current controlled device

(A) MOSFET (B) BJT
(C) TRIAC (D) SCR

3.

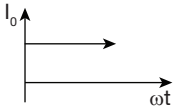


highly inductive load and operated at high frequency follow the wave form.

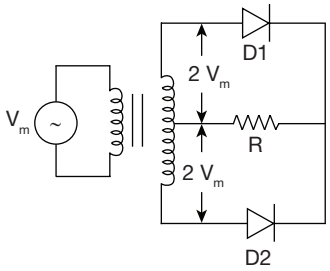
(A) 

(B) 

(C) 

(D) 

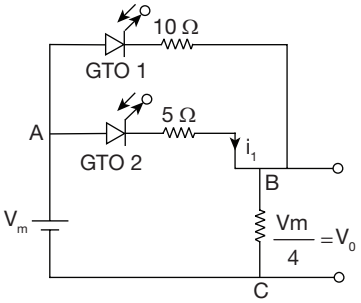
4.

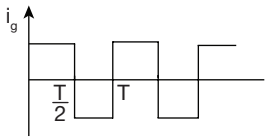


PIV across D_1 & D_2 are

(A) $4V_m, 4V_m$ (B) $2V_m, 4V_m$
(C) $4V_m, 2V_m$ (D) $2V_m, 2V_m$

5.

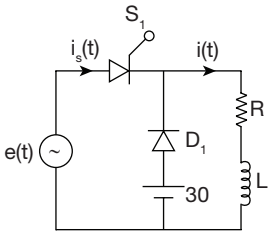




A fully current controlled GTOs are triggered using the gate signal pulse. What will be the value i_1; $V_0 = V_{\text{average}}$

(A) $\frac{V_m}{10}$ (B) $\frac{V_m}{20}$
(C) $\frac{V_m}{5}$ (D) $\frac{V_m}{15}$

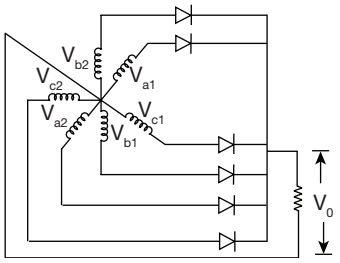
6.



Select most suited condition

(A) $i\,(t)$ always present
(B) $i_s\,(t)$ flows continuously
(C) $i_s\,(t)$ flow when S_1 ON at $e(t) > 30$ V
(D) (A) and (C) both potions.

7.



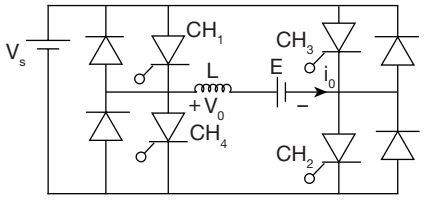
Two set of supply having *a*, *b*, *c* sequence 50 Hz and electrical Angle of 60° phase difference. Then the output signal frequency should be

(A) 50 Hz
(B) 150 Hz
(C) 300 Hz
(D) 0

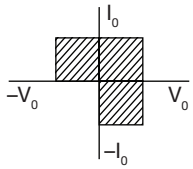
8. A single phase diode bridge rectifier is fed from a 230 V, 50 Hz AC source, Then load is purely resistive. Then the output RMS value equal to

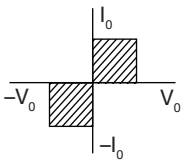
(A) 162.6 V
(B) 325.3 V
(C) 230 V
(D) 115 V

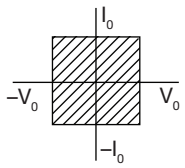
9.

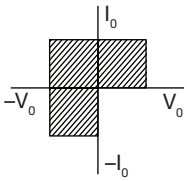


A multi quadrant chopper satisfy one of the following condition

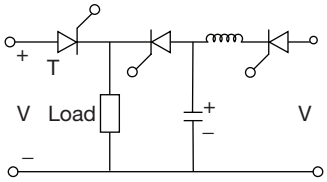
(A) 

(B) 

(C) 

(D) 

10. For external pulse commutation circuit as shown.



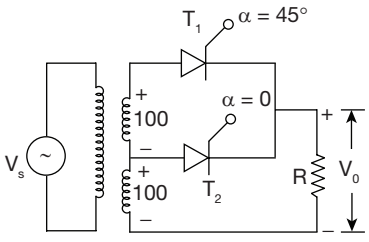
Vs = 100 V DC. What will be the minimum value of V_1 to commutate T_1 thyristor

(A) 100 (B) 50
(C) 70.7 (D) 150

11. A thyristor switch has voltage rating of 700 V for each and 7 SCRs are connected in series for handling a voltage of 3800 V. The derating factor for this set of arrangement is

(A) 77.5%
(B) 45.78%
(C) 22.45%
(D) 23.12%

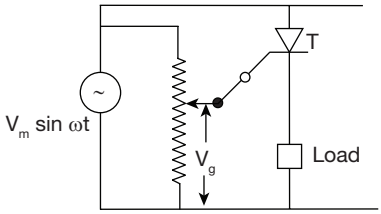
12. A multi voltage regulator circuit shown in figure.



The average out put voltage will be

(A) 166.87 V (B) 83.43 V
(C) 127.3 V (D) 180 V

13.



The triggering circuit as shown in figure the triggering angle can

(A) $0 - 180°$ (B) $0 - 2\pi$
(C) $0 - \frac{\pi}{2}$ (D) $\frac{\pi}{4} - \frac{5\pi}{6}$

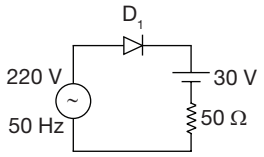
14. Which one of the following condition is exact for thyristor for continuous conduction mode

(A) $V_{Cathode} > V_{anode}; I_{Anode} > I_{latch}$
(B) $V_{Cathode} > V_{anode}; I_{Anode} > I_{Holding}$
(C) $V_{anode} > V_{Cathode}; I_{Anode} > I_{Holding}$
(D) $V_{Cathode} < V_{anode}; I_{Anode} > I_{Latch}$

15. Generally inductor connected at the cathode end of SCR for _____ protection

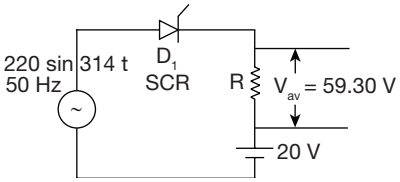
(A) $\frac{dV}{dt}$
(B) $\frac{di}{dt}$
(C) over current
(D) over voltage

16. An uncontrolled switch connected as shown in figure. With standard 50H_z frequency what will be the time taken by the switch to turn ON.



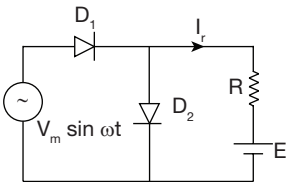
(A) 17 ms (B) 24 ms
(C) 35 ms (D) 5 ms

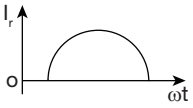
17. The circuit shown in figure produces an average output voltage of 59.30 V across the resistor. What will be the conduction Angle for SCR

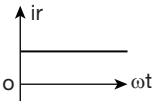


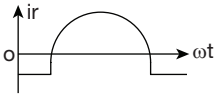
(A) 5° to 175° (B) 5.21° to 174.79°
(C) 15° to 165° (D) 0 to 180°

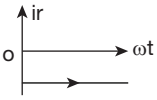
18. Which among the following wave forms indicates the circuit current i_r when $V_m > E$



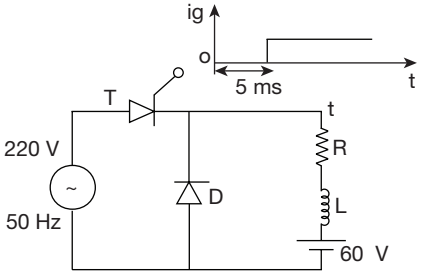
(A) 

(B) 

(C) 

(D) 

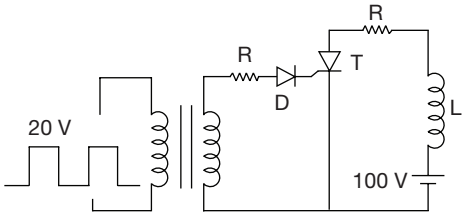
19. The circuit shown in figure is triggered using an external pulse. When will the SCR start conduction



(A) 11.11° (B) 15.82°
(C) 90° (D) 0°

20. A 12 pulse rectifier output generated with minimum and maximum value of _____
(A) 0, V_m (B) 0.96 V_m, V_m
(C) 0.5 V_m, V_m (D) 0.916 V_m, V_m

21.

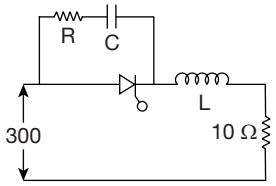


A 2 : 1 pulse transformer is used to trigger the SCR rated at 1.6 KV, 200 A. with I_h = 150 mA, I_L = 200 mA and $I_{g\,max}$ = 200 mA, $I_{g\,min}$ = 100 mA. The SCR connected to an inductive load where L = 100 mH in series with small resistance and the supply voltage is 100 V. Forward drops of diode and gate junction during ON state 1 volt each. Then the Resistance R for perfect ON would be
(A) 90 Ω (B) 40Ω
(C) 50Ω (D) 80Ω

22. A thyristor protection circuit as shown with supply voltage of 300 V dc

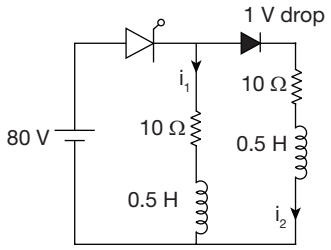
$\left(\frac{di}{dt}\right)_{max}$ = 80 A/ μs

$\left(\frac{dv}{dt}\right)_{max}$ = 300 V/μs for better protection the values of R, L respectively are



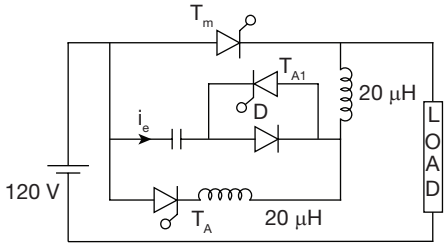
(A) 3.75, 3.75 (B) 3.75, 0.26
(C) 0.3, 0.3 (D) 0.3, 3.75

23. An SCR having turn on time of 5 μs, latching current of 100 mA and holding current of 38 mA is triggered by a short duration pulse. What will be the minimum width, triggering pulse would require for successful turn ON of SCR



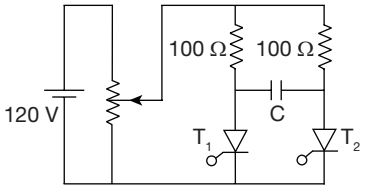
(A) 4×10^{-4} s (B) 3.15 μs
(C) 3.15×10^{-4} s (D) 5 μs

24. A commutation circuit shown in figure.



What will be the maximum possible value of current through auxiliary thyristor
T_A when C = 0.3 μF L = 20 μH
(A) 15 A (B) 46.47 A
(C) 309 A (D) 14.69 A

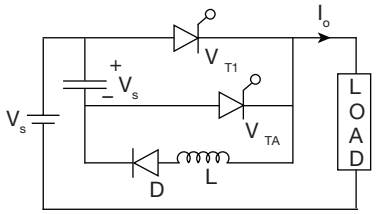
25.



A voltage commutation circuit shown in figure. If turn off time of SCR is 10 μs and safety margin of 1.5. What will be the minimum value of capacitor required for commutation.

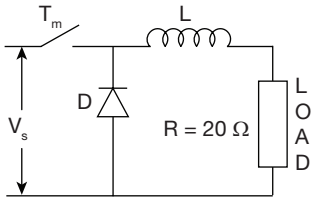
(A) 0.14 μF (B) 0.2166 μF
(C) 0.15 μF (D) 0.10 μF

26. In a class *D* commutation as, shown in figure. $L = 1$ μH & $C = 2$ μF. For a constant load current of 100 A, calculate circuit turn off time for auxiliary thyristor



(A) 2 μs (B) 1.11 μs
(C) 2.2 μs (D) 4.4 μs

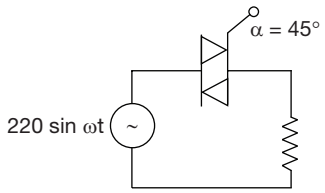
27. A step down chopper as shown in figure with 150 dc input. The duty ratio of main thyristor T_m is 0.6 and $L >> 20\ \Omega$ then the average current through 20 Ω resistance.



(A) 4.5 A (B) 7.5 A
(C) 2.5 A (D) 1.66 A

28. A ideal chopper feeds to a load as shown in figure. Switch S_1 operated at 100 KHz with duty ratio of 0.3 the peak to peak source ripple current in amps is
(A) 40 A (B) 4 A
(C) 1.2 A (D) 2.4 A

29. A triac based voltage converter connected as shown in the figure

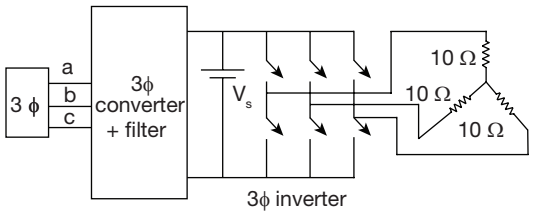


Operated at α = 45° what will be the mean power across the load per cycle $\left(\frac{V_{av}^{\ 2}}{R}\right)$

(A) 1429.1 W (B) $\frac{1429.1}{R}$ W

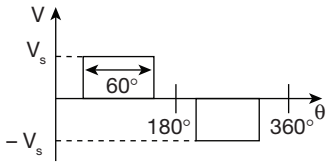
(C) $\frac{57.6}{R}$ KW (D) 57.6 KW

30. In a 3ϕ converter and inverter circuit as shown in figure $V_s = 400$ V



If all the devices are ideal; power taken from the source at 180° conduction mode. Then the power drawn from the supply will be
(A) 3.56 KW (B) 5.33 KW
(C) 10.67 KW (D) 16 KW

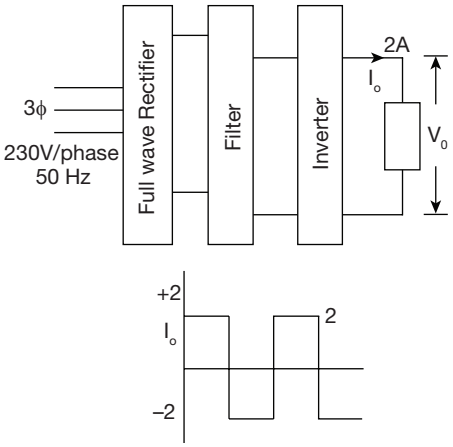
31. In a single pulse modulation as shown what will be the maximum value of dominant harmonic signal



(A) $\frac{8V_s}{\pi}$ (B) $\frac{4V_s}{\pi}$

(C) $\frac{4V_s}{3\pi}$ (D) $8\frac{V_s}{\pi}$

Linked Answer Questions 32 and 33:



32. The output average voltage delivered by 3ϕ full wave rectifier of 230 $V_{phase,}$ 50 Hz in a converter inverter system of power supply will be
(A) 180 V (B) 269 V
(C) 538 V (D) 380 V

33. What will be the load power
(A) 761 W (B) 1076 W
(C) 360 W (D) 538 W

Common data Question 34 and 35:

A inverter has output equation

$$\sum_{n=1,3,5}^{\infty} \frac{100}{n\pi} \sin\frac{n\pi}{2} \sin nd \sin n\omega t$$

at $d = 60°$, single pulse modulation

34. What will be the rms out put voltage _____
(A) 20.4 V (B) 40.8 V
(C) 81 V (D) 25 V

35. Find which frequency eliminated by pulse width modulation _____
(A) 3rd (B) 5th
(C) 7th (D) 9th

Answer Keys

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

Hints and Explanations

1. Power factor $= \dfrac{\cos\theta}{\sqrt{1+THD^2}} = \dfrac{\cos\ 30°}{\sqrt{1+0.12^2}} = 0.8598.$

Choice (A)

2. BJTcan easily turn on and turn off using base current.

Choice (B)

3. When $L >> R$ and operated at high frequency the inductor output wave form will be ripple free because inductor makes current continuous.

$$\int_{I_{min}}^{I_{max}} di = \int_0^{\frac{T}{2}} \frac{V}{L} dt$$

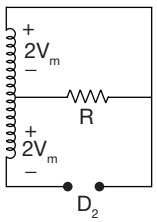
$$I_{max} - I_{min} = \frac{V}{L} \times \frac{T}{2}$$

$$T = \frac{1}{1\times10^3} = 1\times10^{-3}$$

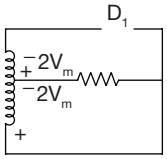
$$I_{max} - I_{min} = \left(\frac{V}{L}\right) \times 0.5\times10^{-3} \cong 0.$$

No ripple - means pure dc *o/p* Choice (D)

4.



In first half cycle D_1 closed D_2 opened
voltage across D_2 is $2\ V_m + 2V_m$
PIV $= 4V_m$
another half cycle



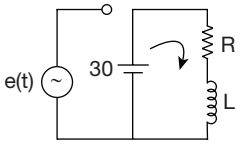
voltage across $D_1 = 2V_m + 2V_m$
PIV $= 4\ V_m$. Choice (A)

5. i.e. $V_{AC} = \dfrac{V_m}{2}$ (∵ GTO n on position).

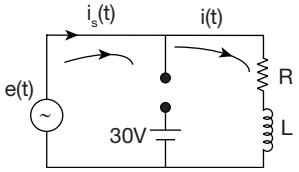
$$V_{AB} = \frac{V_m}{2} - \frac{V_m}{4} = \frac{V_m}{4}$$

$$i_1 = \frac{\left(\frac{V_m}{4}\right)}{5} = \frac{V_m}{20}\text{A}.$$ Choice (B)

6. When $e(t) < 30V$ S_1 OFF D_1 ON

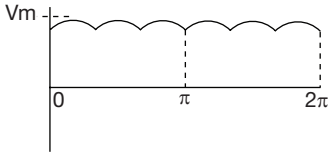


when $e(t) > 30V$ D_1 OFF S_1 ON



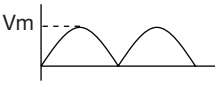
Choice (D)

7. The output wave form will be like



every 2π having 6 pulses
i.e., output frequency = 6 × 50 Hz = 300 Hz.
Choice (C)

8.



$$V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} V_m^{\ 2} \sin^2 \omega t\ d\omega t}$$

$$= \frac{V_m}{\sqrt{2}} = \frac{230\times\sqrt{2}}{\sqrt{2}} = 230\text{V}.$$ Choice (C)

9. This can be operate in all the 4 quadrants. Choice (C)

10. For commutate T_1 thyristor voltage across the capacitor will be same as supply voltage
i.e, $V_s = V_c$
The maximum value of V_c can
$V_c = V_1(1 - \cos \omega_0 t)$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$V_{C_{max}} = 2V_1$$

$$V_s = 2V_1 = 100$$

$$V_1 = \frac{100}{2} = 50\text{V}.$$ Choice (B)

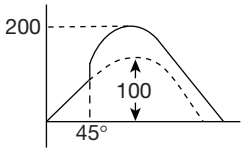
11. String efficiency $= \dfrac{\text{Voltage rating of string}}{\text{Voltage rating of SCR} \times \text{N}}$

$N = 7$ $V_{string} = 3800$
$V_{SCR} = 700$

$$\eta = \frac{3800}{7 \times 700} = 0.775$$

Derating factor $DRF = 1 - \eta$
$= 1 - 0.775 = 22.45\%$. Choice (C)

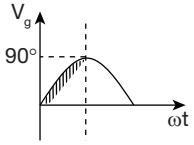
12.



$$V_{av} = \frac{\sqrt{2}}{2\pi}\left[100\int_0^{\frac{\pi}{4}} \sin \omega t + \int_{\frac{\pi}{4}}^{\pi} 200 \sin \omega t\right] d\omega t$$

$$= \frac{1}{\sqrt{2}\pi}(29.28 + 341.4) = 83.34\text{V}$$ Choice (B)

13. Supply source is ac



Firing angle can be achieved only from 0 - 90°.
Choice (C)

14. Choice (C)

15. Choice (B)

16. $V_{rms} = 220\text{V}$
$f = 50$
Diode ON, when $\sqrt{2} \times 220 \sin \omega t > 30$

$$\omega t > \sin^{-1}\left(\frac{30}{220 \times \sqrt{2}}\right)$$

$$t = \frac{5.53}{2\pi \times 50} = 17\text{ms}.$$ Choice (A)

17. The SCR ON at $220 \sin \omega t > 20$

$$\omega t = \sin^{-1}\left(\frac{20}{220}\right) = 5.2159$$

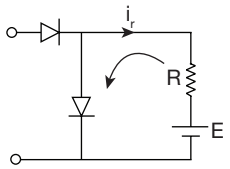
So SCR trigger only after 5.2159° → (5.2159° to 180°) triggering angle take as α.

i.e., $$V_{av} = \frac{1}{2\pi}\int_{\alpha}^{\pi-\alpha} (220 \sin \omega t - 20)\, d\omega t$$

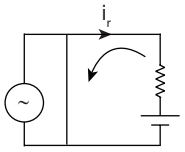
$$\frac{1}{2\pi}[220 \times 2 \cos \alpha - 20][\pi - 2\alpha] = 59.3$$

by solving
α = 0.2625 radian = 15°.04
α to (180 – α) i.e., 15° to 165° Choice (C)

18. **Mode I (0 -180°)**
$V_m \sin \omega t < E$



Mode II (0 – 180°)
$V_m \sin \omega t > E$ then D_1 & D_2 short circuited



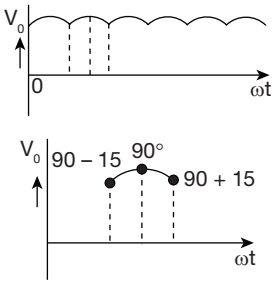
Mode III (180 - 360°)
D_1 reverse bias as Mode 1 Choice (D)

19. Condition for SCR ON. Forward bias and triggering should apply
SCR forward bias at

$$\omega t = \sin^{-1}\left(\frac{60}{220 \times \sqrt{2}}\right) = 11.11°$$

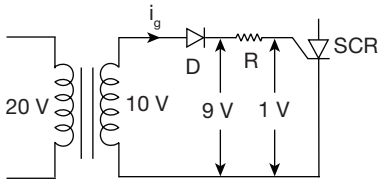
Here triggering pulse given at $t = 5$ ms
i.e., $\omega t = \theta = 2\pi \times 50 \times 5 \times 10^{-3}$
$= 1.5707$ rad
$= 90°$. So SCR ON at 90° Choice (C)

20.



$V_{min} = V_m \sin(90 - 15) = 0.9659\ V_m$
$V_{max} = V_m \sin 90 = V_m$. Choice (B)

21.



For perfect ON selected $I_{g\max}$ 200 mA
voltage across the resistance V_R = 8V
= 10 – diode drop – junction drop

$$R_{\min} = \frac{V_R}{i_{g\max}} = \frac{8}{200\text{mA}} = 40\ \Omega$$

$$R_{\max} = \frac{V_R}{i_{g\min}} = \frac{8}{100\text{mA}}\ 80\Omega. \qquad \text{Choice (B)}$$

22. $\left(\frac{di}{dt}\right)_{\max} = \frac{V}{L}$

$$\left(\frac{300}{80}\right) = L = 3.75 \text{ Henry}$$

$$R = \frac{L}{V}\left(\frac{dV}{dt}\right)_{\max} = \frac{L}{V}\left(\frac{dV}{dt}\right)_{\max}$$

$$= \frac{3.75}{300} \times 300 = 3.75\ \Omega \qquad \text{Choice (A)}$$

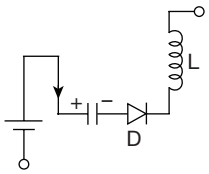
23. For successful turn ON $i_1 + i_2 \geq 100$ mA

$$i_1 = \frac{80}{10}\left(1 - e^{\frac{-10t}{0.5}}\right)$$

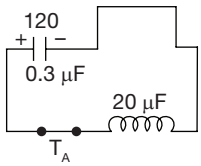
$$i_2 = \frac{80-1}{10}\left(1 - e^{\frac{-10t}{0.5}}\right)$$

$I = i_1 + i_2 = (8 + 7.9)\ (1 - e^{-20t}) = 100$ mA
$1 - e^{-20t} = 6.30\mu$
$t = 3.15 \times 10^{-4}$ s. Choice (C)

24.



The maximum value of capacitor voltage is V_c = 120 V after long time when T_A, T_{A1} is ON



Then the maximum value of current $I_{c\max}$

$$I_c = V\sqrt{\frac{C}{L}}\sin\omega t$$

$$I_{c\max} = V\sqrt{\frac{C}{L}} = 120\sqrt{\frac{0.3}{20}}$$

$$= 14.69 \text{ A.} \qquad \text{Choice (D)}$$

25. The circuit turn off time for thyristors are
$t_{c1} = R_1 C \ln 2$
$t_{c2} = R_2 C \ln 2$
$t_{c1} = t_{c2}$
$R_1 = R_2$
safety margin = 1.5
for safe turn off
$R_1 c \ln 2 = 1.5\ t_{c1}$
$t_{c1} = 10\ \mu$ sec

$$c = \frac{(1.5\ t_{c1})}{(R_1 \ln 2)} = 2.16 \times 10^{-7}\text{F} \qquad \text{Choice (B)}$$

26. In class D commutation turn off time for auxillary thyristor is $t_{c1} = \frac{\pi}{2\omega_0}$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$t_{c1} = 2.221\ \mu$s Choice (C)

27. For step down chopper
output average voltage, $V_0 = \alpha\ V_{\text{Supply}}$
$V_0 = 0.6 \times 150 = 90$

current, $I_0 = \frac{90}{20} = 4.5\text{A}$. Choice (A)

28. The source ripple depend on inductance. The voltage across the inductor is due to ripple.

When S_1 closed and open $V_s = L\frac{di}{dt}$

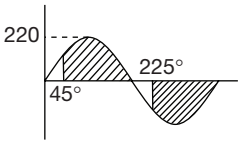
$$\int_{\min}^{\max} di = \frac{V_s}{L}\int_0^{T_{ON}} dt$$

$$I_{\max} - I_{\min} = \frac{V_s}{L}T_{ON}$$

$$= \frac{20}{50\mu} \times \frac{0.3}{100K}$$

$$= 1.2A \qquad \text{Choice (C)}$$

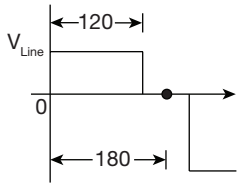
29. The output wave form of converter starts from 45°



$$V_{av} = \frac{2}{2\pi}\int_{\frac{\pi}{4}}^{\pi} 220\sin\omega t\ = 119.54$$

$$P_{av} = \frac{V_{av}^{\ 2}}{R} = \frac{1429.1}{R} \text{ watts.} \qquad \text{Choice (B)}$$

30.



$$V_{phase} = \frac{V_{Line}}{\sqrt{3}}$$

$$V_{phase_{rms}} = \frac{1}{\sqrt{3}}\left[\frac{1}{\pi}\int_0^{\frac{2\pi}{3}} V_s^2\, d\omega t\right]^{\frac{1}{2}}$$

$$= \frac{1}{\sqrt{3}}\left[400^2 \times \frac{2\pi}{3} \times \frac{1}{\pi}\right]^{\frac{1}{2}} = 188.561\text{V}$$

$$\text{per phase power} = \frac{V^2}{R} = \frac{188.561^2}{10}$$

$$= 3555.55\text{ W}$$

Total power = 3 × 3555.55

= 10.67 KW Choice (C)

31. Output voltage signal

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

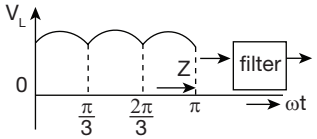
$2d = 60°$

$$d = \frac{60°}{2} = 30°$$

$$V_0 = \frac{4V_s}{\pi}\left[\sin 30° \sin\omega t - \frac{\sin 3\omega t}{3} + \frac{4}{2}\frac{\sin 5\omega t}{5} + \ldots.\right]$$

The 3rd harmonic content is dominant having maximum value $V_0 = \frac{4V_s}{3\pi}$. Choice (C)

32. full wave rectifier output will be



and then goes through filter which gives DC value equal to average value of

$$\Rightarrow \frac{3}{\pi}\int_{\frac{\pi}{3}}^{\frac{2\pi}{3}} \sqrt{3} \times 230 \times \sqrt{2} \sin\omega t\, d\omega t$$

$V_0 = 537.99$ Volt. Choice (C)

33. Consider lossless convertion,

Power = $V_0 I_0$

$P_{average} = 538 \times 2 = 1076$ Watts. Choice (B)

34. (a) $V_{rms} = \left[\frac{V_s^2 \times 2d}{\pi}\right]^{\frac{1}{2}}$

$$\frac{100}{n\pi} = \frac{4V_s}{n\pi};\ V_s = 25\text{ V}$$

$V_{rms} = 20.41$. Choice (A)

35. $\sin nd = 0$

at $nd = \pi$

$$n = \frac{\pi}{d} = \frac{180°}{60} = 3$$

3rd harmonic is eliminated. Choice (A)