CLASS TEST

SL. : 01JPEE_PE_14102023

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ELECTRICAL ENGINEERING

Power Electronics

Duration : 1:00 hr. **Maximum Marks : 50**

Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 A power electronic configuration has 30 SCRs connected in parallel combination for a circuit to bear a load current of 960 A. If the rating of each SCR is 400 V, 40 A then how many SCR's should be excluded from parallel path such that derating factor decreases by 50%.
(a) 5 (b) 6
(c) 3 (d) 2

Q.2 A single phase fully controlled bridge is supplied with 120 V, rms sinusoidal supply of 50 Hz. If the load current is continous and individual thyristor voltage drop is 1.5 V. The value of peak voltage across each thyristor and mean load voltage for a firing angle of 45° will be respectively.
(a) 169.71 V, 42.66 V
(b) 169.71, 73.39 V
(c) 196.42 V, 73.39 V
(d) 196.42 V, 42.66 V

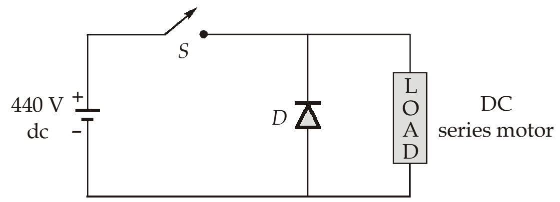
Q.3 A single phase full wave bridge converter has input voltage given by $V_{in} = 200 \sin 100\,t$. If the load connected on dc side of converter is R=40 Ω, L = 10 mH and E = 100V, then thyristor in the converter can be fired when condition which hold true is
(a) $100t > 10°$
(b) $100t > 30°$
(c) $100t > 23.58°$
(d) $100t > 5.71°$

Q.4 Consider the snubber configuration across a thyristor operating at 400 V (peak) supply such that the repetitive peak current, I_p is 250 A. If the value of $\left(\frac{di}{dt}\right)_{max}$ = 60 A/μsec and $\left(\frac{dV}{dt}\right)_{max}$ = 200 V/μsec as shown below, then value R_s will be considering safety factor 2 will be
(a) 6.67 Ω (b) 1.5 Ω
(c) 4.5 Ω (d) 3.33 Ω

Q.5 In a three phase diode bridge rectifier when working on resistive load, the peak inverse voltage appearing on a diode is
(a) $\sqrt{3}V_{ml}$ (b) $\sqrt{3}V_{mp}$
(c) 1.5 V_{ml} (d) 1.5 V_{mp}

Q.6 In a 3-ϕ, 180° mode of operation of a bridge inverter, the lowest order harmonics in output phase voltage will be (fundamental frequency of output is 50 Hz)
(a) 120 Hz (b) 300 Hz
(c) 180 Hz (d) 250 Hz

Q.7 A dc series motor is controlled by the circuit shown below.



The armature and field resistance are 0.06 Ω and 0.04 Ω respectively. The average armature current is 200 A and chopper frequency is 500 Hz. If the back emf is 200 V, then the pulse width would be equal to
(a) 0.5 ms (b) 1 ms
(c) 1.5 ms (d) 2 ms

Q.8 A type A chopper has input dc voltage of 200 V and a load of R = 10 Ω in series with L = 80 mH. If the load current varies linearly between 12 A and 16 A, the time ratio T_{on}/T_{off} for this chopper is
(a) 1.50 (b) 1.66
(c) 2.50 (d) 2.33

Q.9 In a single pulse modulation of PWM inverters the pulse width is 60°. For an input voltage of 300 V, the rms value of output voltage will be
(a) 173.20 V (b) 141.20 V
(c) 57.70 V (d) 231.40 V

Q.10 In a single phase VSI bridge inverter the load current $I_0 = 50 \sin(\omega t - 30°)$ A. If the supply voltage is 200 V, then the power drawn from the supply is
(a) 11.02 kW (b) 5.51 kW
(c) 12.24 kW (d) 17.30 kW

Q. No. 11 to Q. No. 30 carry 2 marks each

Q.11 A three phase, 440 V, 50 Hz supply is feeding a 440 V, 15 kW, 1500 rpm seperately excited dc motor with ripple free continous current through a thyristor bridge. Neglecting all the losses, the power factor of the ac mains at half the rated speed is

(a) 0.353 (b) 0.372
(c) 0.90 (d) 0.955

Q.12 A three phase fully controlled bridge converter with 415 V supply, 0.04 Ω resistance per phase and 0.25 Ω reactance per phase is operating in the inverting mode at a firing advance angle of 35°. The mean generator voltage when the current is level at 80 A is
(Thyristor voltage drop is 1.5 V)

(a) 481.2 V (b) 487.6 V
(c) 459.02 V (d) 462.1 V

Q.13 A single phase full converter supplies power to a highly inductive load. The load consists of R = 10 Ω and L = 10 mH, if the supply is 230 V, 50 Hz, average output voltage is 146.42 V and the reactive power drawn by load is 2.143 kVAR then firing angle of converter will be

(a) 30° (b) 40°
(c) 45° (d) 60°

Q.14 The forward characteristics of a power diode can be represented by $V_f = 0.80 + 0.015\, i_f$. The average power loss and rms current for a constant current of 50 A for $\frac{2}{3}$ of a cycle is

(a) 50.22 W, 20.12 A
(b) 51.67 W, 40.82 A
(c) 50.22 W, 18.26 A
(d) 51.67 W, 26.21 A

Q.15 A Buck-boost converter has the following parameters:

$V_S = 24$ V $D = 0.4$ $R = 5\ \Omega$
$L = 20\ \mu$H $C = 80\ \mu$F $f = 100$ kHz

The ratio of maximum inductor current, $I_{L,\,max}$ to minimum inductor current $I_{L,\,min}$ for above converter considering continous inductor current will be

(a) 1.50 (b) 2.63
(c) 1.24 (d) 3.50

Q.16 In a current commutated chopper, peak commutating current is twice the maximum possible load current. The source voltage is 230 V dc and main SCR turn off time is 30 µs. If maximum load current is 200 A, then the peak capacitor voltage is

(a) 230 V (b) 274 V
(c) 345 V (d) 180 V

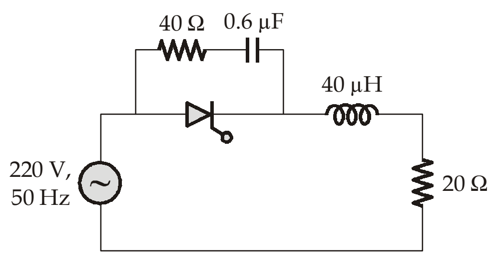
Q.17 A buck regulator has an input voltage of V_s = 12 V. The required average output voltage is V_0 = 5 V at R = 500 Ω and the peak to peak output ripple voltage is 20 mV and the switching frequency is 25 kHz. The peak to peak ripple current of inductor is limited to 0.8 A. The value of filter capacitor is

(a) 50.13 µF (b) 148.60 µF
(c) 201.06 µF (d) 127.66 µF

Q.18 The output of a buck-boost converter is 80 V with input 100 V. If the frequency of switch is 10 kHz, then the turn off time of the switch will be

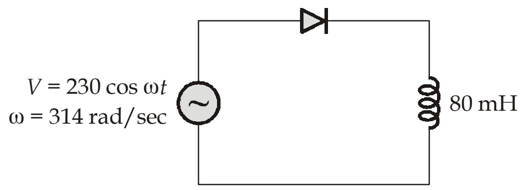
(a) 90 µsec (b) 112 µsec
(c) 45 µsec (d) 56 µsec

Q.19 For the Snubber configuration shown below the maximum rate of change of current with respect to time through the SCR will be



(a) 16.26 A/µsec (b) 5.28 A/µsec
(c) 7.78 A/µsec (d) 12.26 A/µsec

Q.20 In the circuit shown below, the maximum value of current which passes through inductor will be

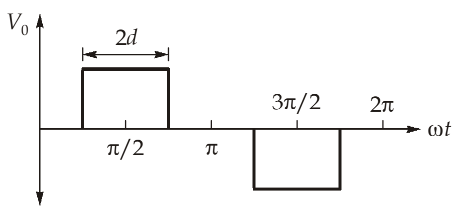


(a) 3.20 A (b) 5.42 A
(c) 12.40 A (d) 18.31 A

Q.21 In class B commutation (resonant pulse commutation) with L = 5 μH and C = 20 μF are used. If the initital voltage across the capacitor is V_S = 230 V, then the value of conduction time for auxiliary thyristor used and peak current, I_P will be
(a) 2 π μsec, 320 A (b) 10 π μsec, 460 A
(c) 6 π μsec, 240 A (d) 5 π μsec, 150 A

Q.22 A boost converter feeds an average current of 10 A to a load. The value of duty cycle and chopping frequency were 0.40 and 50 kHz respectively. Filter inductance and capacitance are of 10 mH and 120 μF. The peak to peak ripple voltage will be
(a) 0.33 V (b) 0.75 V
(c) 0.66 V (d) 1.82 V

Q.23 A single phase inverter is operated in PWM mode generating a single pulse of width '2d' in the centre of each half cycle as given below,



If the pulse width is 140° then the ratio of maximum value of third harmonic output voltage to maximum value of fundamental output voltage will be
(a) 0.10 (b) 0.18
(c) 0.24 (d) 0.36

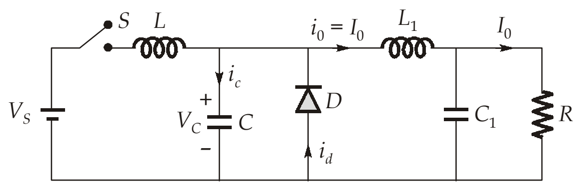
Q.24 A single phase diode bridge rectifier is connected by a transformer to ac supply of 230 V, 50 Hz and it feeds a R-L load of I_0 = 10 A. Average power delivered to load will be ______ .
(Take transformer turn ratio = 1)
(a) 2070.72 W (b) 1035.36 W
(c) 1542.36 W (d) 1170.50 W

Q.25 If V_s is the input dc voltage in single PWM inverter, then the pulse width required for eliminating third harmonic and corresponding rms value of fundamental component of output voltage are

(a) $120°, \frac{2\sqrt{2}}{\pi}V_s$ (b) $60°, \frac{\sqrt{6}}{\pi}V_s$

(c) $60°, \frac{2\sqrt{2}}{\pi}V_s$ (d) $120°, \frac{\sqrt{6}}{\pi}V_s$

Q.26 A ZCS resonant converter is shown in figure has peak current of $I_0 + V_s\sqrt{\frac{C}{L}}$ in the switch S. For natural turn off which of the following is true?



(a) $V_s\sqrt{\frac{C}{L}} > 0$ (b) $V_s\sqrt{\frac{C}{L}} > I_0$

(c) $V_s\sqrt{\frac{C}{L}} < I_0$ (d) $V_s\sqrt{\frac{C}{L}} \leq I_0$

Q.27 In a step down chopper, duty ratio is 1/3 and the input voltage is V_s. What is the maximum value of fundamental output voltage?

(a) $\frac{2\sqrt{3}V_s}{\pi}$ V (b) $\frac{2V_s}{\pi}$ V

(c) $\frac{\sqrt{3}V_s}{\pi}$ V (d) 0

Q.28 The full bridge inverter is used to produce a 60-Hz voltage across a series RL load using bipolar PWM. The dc input is 100 V, amplitude modulation ratio m_a is 0.8 and the frequency modulation ratio m_f is 21. What is the amplitude of the 60 Hz component of the output voltage?

(a) 1680 V
(b) $1680\sqrt{2}$ V
(c) $80\sqrt{2}$ V
(d) 80 V

Q.29 A 3-ϕ bridge rectifier charges a 240 V battery using 3-ϕ, 230 V, 50 Hz input supply. Current limiting resistance in series with battery is 8 Ω is used and inductor is kept to make current ripple free. The current distortion factor will be

(a) 0.866
(b) 0.955
(c) 0.500
(d) 0.414

Q.30 A full bridge inverter has bi-directional switches employed in a manner that their switching sequence produces a square wave voltage across a series *R*-*L* load. If the switching frequency is 50 Hz, dc supply voltage, V_{dc} = 100 V, R = 10 Ω and L = 25 mH, then power absorbed by the load and rms value of current will be respectively

(a) 543.62 W, 5.41 A
(b) 337.97 W, 4.23 A
(c) 516.96 W, 7.19 A
(d) 243.62 W, 3.43 A

■■■■

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POWER ELECTRONICS

ELECTRICAL ENGINEERING

Date of Test : 14/10/2023

ANSWER KEY

1.	(c)	7.	(b)	13.	(c)	19.	(c)	25.	(d)
2.	(b)	8.	(d)	14.	(b)	20.	(d)	26.	(b)
3.	(b)	9.	(a)	15.	(b)	21.	(b)	27.	(c)
4.	(d)	10.	(b)	16.	(c)	22.	(c)	28.	(d)
5.	(b)	11.	(a)	17.	(c)	23.	(b)	29.	(b)
6.	(d)	12.	(b)	18.	(d)	24.	(a)	30.	(c)

DETAILED EXPLANATIONS

1. (c)

We know,

$$\text{String efficiency, } \eta = \frac{\text{Current rating of configuration}}{\text{Current rating of 1 SCR} \times \text{Number of SCR's in string}} \quad \ldots\text{(i)}$$

$$\eta = \frac{960}{40 \times 30} = \frac{24}{30} = 0.80$$

$$\text{Derating factor} = 1 - \text{string efficiency}$$
$$= 1 - 0.8 = 0.2$$

For 50% decrease in rating factor

$$\text{New derating factor} = \frac{0.2 \times 50}{100} = 0.1$$

$\therefore$ New efficiency = 0.9

Using equation (i), we get

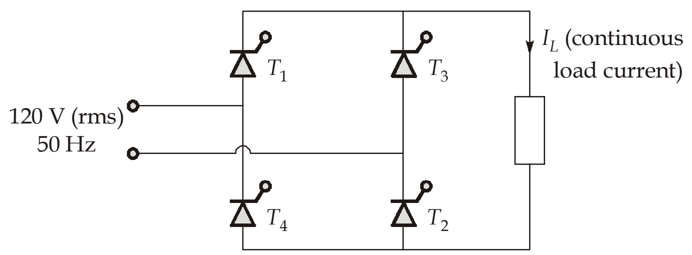
$$0.9 = \frac{960}{40 \times n}$$

$$\Rightarrow \quad n = \frac{960}{40 \times 0.9} = 26.66 \approx 27$$

Decrease in no. of parallel SCR = 30 – 27 = 3

2. (b)

For a single phase fully controlled bridge circuit



$$V_{\text{mean}} = \frac{2}{\pi} \times V_m \cos\alpha - 2V_T$$

Where, V_m is peak sinusoidal value, α is firing angle and V_T is thyristor voltage drop

For $V_m = 120\sqrt{2}$ V,

$$\alpha = 45°$$

$$V_{\text{mean}} = \frac{2}{\pi} \times 120\sqrt{2} \cos 45° - 2 \times (1.5)$$

$$= \frac{2}{\pi} \times 120\sqrt{2} \times \frac{1}{\sqrt{2}} - 3 = 73.39 \text{ V}$$

Peak value of voltage across each thyristor = $V_{\max}$

$$= 120\sqrt{2} = 169.71 \text{ V}$$

3. **(b)**

For 1-ϕ full bridge converter, boundary condition

$$V_m \sin \omega t = E$$

$$\sin \omega t = \frac{E}{V_m}$$

or $$\omega t = \sin^{-1}\left(\frac{E}{V_m}\right) = \sin^{-1}\left(\frac{100}{200}\right) = 30°$$

In above case ωt is given as $100t$

∴ When $100t > 30°$ then thyristors are forward biased and can be triggered.

4. **(d)**

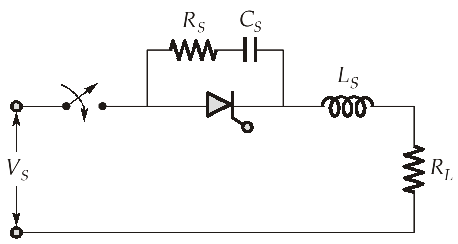
If factor of safety = 2

Allowable values:

$$I_p = \frac{250}{2} = 125 \text{ A}$$

$$\left(\frac{di}{dt}\right)_{max} = \frac{60}{2} = 30 \text{ A/}\mu\text{s}$$

$$\left(\frac{dv}{dt}\right)_{max} = \frac{200}{2} = 100 \text{ V/}\mu\text{s}$$



Also know, $$V_S = L_S\left(\frac{di}{dt}\right)$$

$$400 = L_S\left(\frac{60}{2}\right)$$

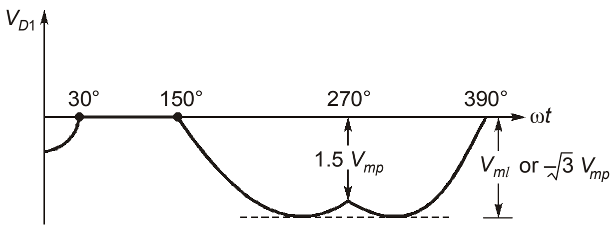
$$L_S = \frac{800}{60} = 13.33 \text{ μH}$$

We know, $$V_S = \frac{L_S}{R_S}\left(\frac{dV}{dt}\right)$$

So, $$R_S = \frac{800}{60 \times 400} \times \frac{200}{2} = 3.33 \text{ Ω}$$

5. **(b)**

PIV of a diode in 3-phase bridge rectifier is V_{ml} or $\sqrt{3}V_{mp}$.



6. **(d)**

In the output phase voltage the even, third and multiples of 3rd harmonics are absent. So, lowest order harmonics are 5th harmonics,

$$\text{Fourier series, } V_R = \sum_{n=6k\pm1} \frac{2V_s}{n\pi} \sin n\omega t$$

So, frequency of 5th harmonis = 5 × fundamental frequency = 5 × 50 = 250 Hz

7. **(b)**

The given chopper is a step down chopper,

$$V_0 = \alpha V_s$$

$$V_0 = I_0 (R_a + R_{se}) + E_b = \alpha V_s$$

$$= 200\,(0.06 + 0.04) + 200 = \alpha \cdot 440$$

$$\alpha = \frac{220}{440}$$

$$\alpha = 0.5$$

$$T_{on} = \alpha \cdot T$$

$$= 0.5 \times \frac{1}{500} = 1 \text{ ms}$$

8. **(d)**

$$\text{Average load current} = \frac{12+16}{2} = 14 \text{ A}$$

$$\text{Average load voltage} = V_0 = I_0 R = 14 \times 10 = 140 \text{ V}$$

$$V_0 = \alpha V_s$$

Since the chopper is step down or type-A,

$$140 = \alpha\, 200$$

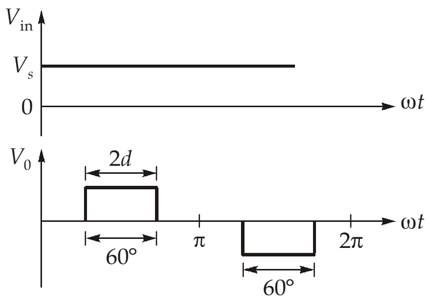
$$\alpha = \frac{140}{200} = 0.7$$

$$\frac{T_{on}}{T_{on} + T_{off}} = 0.7$$

$$0.3\, T_{on} = 0.7\, T_{off}$$

$$\frac{T_{on}}{T_{off}} = 2.33$$

9. **(a)**



$$V_{or} = V_s \sqrt{\frac{2d}{\pi}}$$

$$V_{0\text{ rms}} = 300\sqrt{\frac{60°}{180°}} = 173.20 \text{ V}$$

10. (b)

$$I_0 = 50 \sin(\omega t - 30°) \text{ A}$$

The given current have only fundamental component so only fundamental voltage component will be responsible for power.

$$V_{01} = \frac{4V_s}{\sqrt{2}\pi} = \frac{4 \times 200}{\sqrt{2}\pi}$$

$$= 180.06 \text{ V}$$

Taking voltage as reference,

$$\phi = 30°$$

$$\text{Active power, } P = V_{01} I_{01} \cos\phi$$

$$= \frac{180.06 \times 50}{\sqrt{2}} \times \cos 30° = 5513.19 \text{ W} \approx 5.51 \text{ kW}$$

$$P = 5.51 \text{ kW}$$

11. (a)

Hence it is mentioned in the given data that there is no losses.

$$V_0 = \frac{3V_{mL}}{\pi}\cos\alpha = E$$

Since, back emf $E \propto N$

$$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$

$$E_1 = 2E_2 \qquad \left(\therefore N_2 = \frac{1}{2}N_1\right)$$

So, $E_2 = \frac{E_1}{2} = \frac{V_0}{2} = 220 \text{ V}$

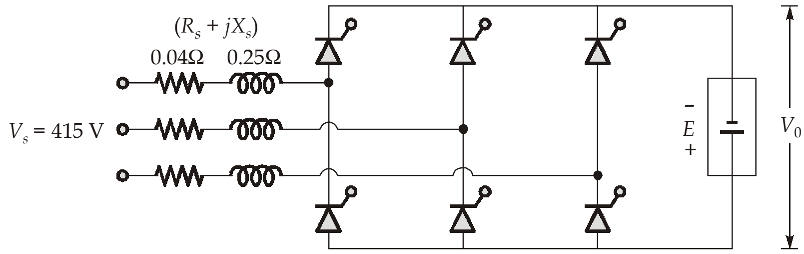
$$\frac{3 \times \sqrt{2} \times 440}{\pi}\cos\alpha = 220$$

$$\cos\alpha = \frac{220 \times \pi}{3 \times \sqrt{2} \times 440} = 0.3702$$

Input power factor of the supply

$$= \frac{3}{\pi}\cos\alpha = \frac{3}{\pi} \times 0.3702 = 0.353$$

12. (b)



$$V_{0x} = \frac{3V_{mL}}{\pi}\cos\alpha - 2I_0R_s - 2V_T - \frac{3\omega L_s I_0}{\pi}$$

$$= \frac{3\times\sqrt{2}\times 415}{\pi}\cos 145° - (2\times 80\times 0.04) - (2\times 1.5) - \left(\frac{3\times 0.25\times 80}{\pi}\right)$$

$$= -487.5898 = -E$$

$\therefore$ $$E = 487.5898 \approx 487.6 \text{ V}$$

13. (c)

Given, for single phase full converter,

$$V_0 = 146.42 \text{ V}$$

$$I_0 = \frac{V_0}{R} = \frac{146.42}{10} = 14.64\,\text{A}$$

Reactive power $Q = V_0\, I_0 \tan\alpha$

$$2.143\times 10^3 = 146.42\times 14.64 \tan\alpha$$

$$\tan\alpha = 0.9997$$

$$\alpha = 45°$$

14. (b)

With T as the time of a cycle,

The average power loss $= \dfrac{1}{T}\displaystyle\int_0^{2T/3} V_f \cdot I_f\, dt$

$$P = \frac{2}{3}\cdot V_f \cdot I_f$$

and $$V_f = 0.80 + (0.015\times 50)$$

$$V_f = 1.55 \text{ V}$$

$\therefore$ $$P = \frac{2}{3}\times 1.55\times 50 = 51.67 \text{ W}$$

$$I_{rms} = \sqrt{\frac{1}{T}\int_0^{\frac{2T}{3}} (50)^2\, dt}$$

$$I_{rms} = 50\sqrt{\frac{2}{3}} = 40.82 \text{ A}$$

15. (b)

Output voltage Buck-boost converter,

$$V_0 = -\frac{D}{1-D}V_S$$

$$V_0 = \frac{-0.4}{1-0.4}\times 24 = -16 \text{ V}$$

Average current through inductor,

$$I_L = \frac{V_S D}{R(1-D)^2} = \frac{24\times 0.4}{5(1-0.4)^2}$$

$$I_L = 5.33 \text{ A}$$

$$\Delta i_L = \frac{V_S DT}{L} = \frac{24\times 0.4}{20\times 10^{-6}\times 100\times 10^3} = 4.8 \text{ A}$$

$$I_{L,\,max} = I_L + \frac{\Delta i_L}{2} = 5.33 + \frac{4.8}{2} = 7.73 \text{ A}$$

$$I_{L,\,min} = I_L - \frac{\Delta i_L}{2} = 5.33 - \frac{4.8}{2} = 2.93 \text{ A}$$

The ratio of inductor currents,

$$\frac{I_{L,max}}{I_{L,min}} = \frac{7.73}{2.93} = 2.63$$

16. (c)

Given, source voltage, $V_s = 230$ V

Peak current, $I_p = 2\, I_0$ (load current)

$= 2(200) = 400$ A

and $I_p = V_s\sqrt{\frac{C}{L}}$

$$\sqrt{\frac{C}{L}} = \frac{I_p}{V_s} = \frac{400}{230}$$

or, $\sqrt{\frac{L}{C}} = \frac{230}{400}$ ...(i)

Peak capacitor voltage, $V_{cp} = V_s + I_0\sqrt{\frac{L}{C}}$

From equation (i), we get

Peak capacitor voltage, $V_{cp} = V_s + I_0\sqrt{\frac{L}{C}}$

$$V_{cp} = 230 + 200\left(\frac{230}{400}\right)$$

$= 230 + 115 = 345$ V

17. **(c)**

Output voltage, $V_0 = DV_s$

$5 = D \times 12$

$D = 0.416$

Peak to peak ripple current, $\Delta I = \dfrac{V_s D(1-D)}{Lf}$

$$0.8 = \frac{12 \times 0.416(1-0.416)}{25 \times 10^3 \times L}$$

$L = 0.145 \times 10^{-3}$ H

We know that

Peak to peak ripple voltage, $\Delta V = \dfrac{V_s D(1-D)}{8LCf^2}$

$$C = \frac{V_s D(1-D)}{8Lf^2 \times \Delta V}$$

$$= \frac{12 \times 0.416(1-0.416)}{0.145 \times 10^{-3} \times (25 \times 10^3)^2 \times 20 \times 10^{-3} \times 8} = 201.06\ \mu\text{F}$$

18. **(d)**

$V_0 = 80$ V

$V_{in} = 100$ V

for buck boost converter,

$$V_0 = \frac{V_{in} D}{1-D}$$

or $80 = \dfrac{100D}{1-D}$

or $D = 0.44$

$$\frac{T_{on}}{T} = 0.44$$

$$T = \frac{1}{f} = \frac{1}{10 \times 10^3} = 100\,\mu\text{s}$$

$T_{on} = 0.44 \times 100 = 44\ \mu$s

$T_{off} = T - T_{on}$

$T_{off} = 100 - 44 = 56\ \mu$s

19. **(c)**

We know in case of Snubber circuit,

$$\left(\frac{di}{dt}\right)_{max} = \frac{V_m}{L} \qquad \text{Where, } V_m = 220\sqrt{2}\text{ V}$$

$$\therefore \left(\frac{di}{dt}\right)_{max} = \frac{220\sqrt{2}}{40 \times 10^{-6}} = 7.78\ \text{A}/\mu\text{sec}$$

20. (d)

Diode → ON at, $\omega t = \frac{-\pi}{2}$

By applying KVL in circuit,

$$230 \cos \omega t = L\frac{di(t)}{dt}$$

$$\frac{di(t)}{dt} = \frac{230}{L}\cos\omega t$$

$$di(t) = \frac{230}{L}\cos\omega t\, dt$$

$$\int di(t) = \int\frac{230}{L}\cos\omega t\, dt$$

$$i(t) = \frac{230}{\omega L}\sin\omega t + K$$

at $\omega t = \frac{-\pi}{2}$, $i(t) = 0$,

$$0 = \frac{V_m}{\omega L}\sin\left(\frac{-\pi}{2}\right) + K$$

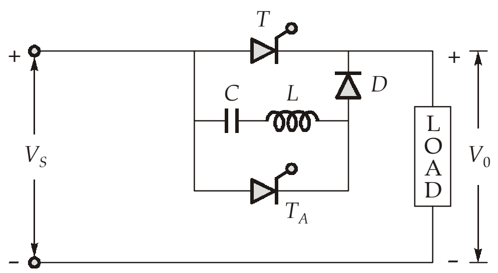
$$K = \frac{V_m}{\omega L}$$

$$i = \frac{V_m}{\omega L}\sin\omega t + \frac{V_m}{\omega L}$$

$$\therefore \quad i_{peak} \text{ at } \frac{\pi}{2} = \frac{2V_m}{\omega L} = \frac{2\times 230}{314\times 80\times 10^{-3}} = 18.31 \text{ A}$$

21. (b)

In class *B* commutation



Peak current through capacitor,

$$I_P = V_S\sqrt{\frac{C}{L}} = 230\sqrt{\frac{20}{5}} = 460 \text{ A}$$

The conduction time of auxiliary thyristor,

$$T_A = \frac{t}{\omega_r}$$

The resonant frequency,

$$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5\times10^{-6}\times20\times10^{-6}}}$$

$$= \frac{1}{10\times10^{-6}} = 0.1 \times 10^6 \text{ rad/s}$$

$$\therefore \quad T_A = \frac{\pi}{\omega} = \frac{\pi}{0.1\times10^6} = 10\,\pi\ \mu\text{sec}$$

22. (c)

For boost converter peak to peak ripple voltage,

$$\Delta V_0 = \frac{\alpha I_0}{fC} = \frac{0.40\times10}{50\times10^3\times120\times10^{-6}} = 0.66 \text{ V}$$

23. (b)

For single phase PWM inverter pulse width,

$$2d = 140°$$

$$d = 70°$$

$$\text{Ratio} = \frac{\text{Maximum value of third harmonics output voltage}}{\text{Maximum value of fundamental output voltage}}$$

$$= \frac{\frac{4V_s}{3\pi}\sin(3\times70°)\sin\left(\frac{3\pi}{2}\right)}{\frac{4V_s}{\pi}\sin\left(\frac{\pi}{2}\right)\sin(70°)} = \frac{1}{3}\frac{(-0.5)\times(-1)}{1\times0.9397} = 0.177 \approx 0.18$$

$$\text{Ratio} = 0.18$$

24. (a)

Input voltage is sinusoidal voltage,

Output load current, $I_0 = 10$ A

Average output voltage,

$$V_0 = \frac{2V_m}{\pi} = \frac{2\sqrt{2}\times230}{\pi} = 207.072 \text{ V}$$

$$\text{Power delivered to load} = V_0 I_0 = 2070.72 \text{ W}$$

25. (d)

$$V_{0n,\text{ rms}} = \frac{4V_s}{n\pi\sqrt{2}}\sin nd\cdot\sin\frac{n\pi}{2}$$

$$nd = \pi$$

For eliminating third harmonic

$$3d = \pi$$

$$d = \frac{\pi}{3} = 60°$$

$\therefore$ pulse width $\quad 2d = 120°$

$$V_{01,\text{ rms}} = \frac{2\sqrt{2}V_s}{\pi}\times\sin60° = \frac{\sqrt{6}V_s}{\pi}\text{ V}$$

26. (b)

For natural turn-off, peak resonant current $\left(\frac{V_s}{Z_0} \text{ or } V_s\sqrt{\frac{C}{L}}\right)$ must be greater than load current I_0.

27. (c)

Peak value of output voltage is :

$$V_{0n} = \frac{2V_s}{n\pi}\sin n\pi\alpha$$

$$\text{Fundamental, } V_{01} = \frac{2V_s}{\pi}\sin\frac{\pi}{3}$$

$$V_{01} = \frac{\sqrt{3}V_s}{\pi} \text{ V}$$

28. (d)

Amplitude of the 60 Hz fundamental frequency component of the output voltage is

$$V_1 = m_a V_{dc} = 0.8 \times 100 = 80 \text{ V}$$

29. (b)

Maximum value of line voltage,

$$V_{ml} = \sqrt{2}V_l = 230\sqrt{2} \text{ V}$$

Average output voltage,

$$V_0 = \frac{3V_{ml}}{\pi} = 310.60 \text{ V}$$

$$V_0 = E + I_0 R$$

$$\frac{V_0 - E}{R} = I_0 = \frac{310.60 - 240}{8} = 8.82 \text{ A}$$

As current is ripple free,

$$I_{0r} = I_0 = 8.82 \text{ A}$$

RMS value of fundamental component of source current,

$$I_{s1} = \frac{2\sqrt{3}}{\pi} \times \frac{I_0}{\sqrt{2}}$$

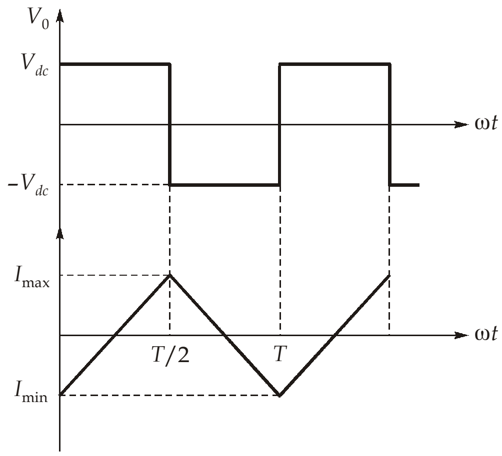
RMS value of source current,

$$I_s = \left[\frac{I_0^2 \times 2\pi}{\pi \times 3}\right]^{1/2} = \sqrt{\frac{2}{3}}I_0$$

Current distortion factor,

$$CDF = \frac{I_{s1}}{I_s} = \frac{2\sqrt{3}I_0}{\sqrt{2}\pi} \times \frac{\sqrt{3}}{\sqrt{2}I_0} = \frac{3}{\pi} = 0.955$$

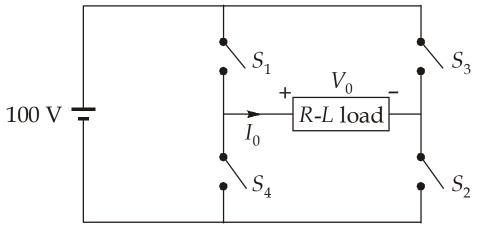
30. **(c)**



At t = 0,

S_1, S_2 : switches are closed

S_3, S_4 : switches are open



Output power,

$$P = I_{or}^2 R$$

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

$$V_{\text{on-rms}} = \frac{2\sqrt{2}}{n\pi} V_s$$

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

$$I_{\text{on-rms}} = \frac{V_{on}}{|Z_n|}$$

n	$V_{\text{on-rms}}$	$\|Z_n\|$	$I_{\text{on-rms}}$
$n = 1$	$V_{o1} = 90\,V$	$\|Z_1\| = 12.71\Omega$	$I_{o1} = 7.08A$
$n = 3$	$V_{o3} = 30\,V$	$\|Z_3\| = 25.59\Omega$	$I_{o3} = 1.17A$
$n = 5$	$V_{o5} = 18V$	$\|Z_5\| = 40.5\Omega$	$I_{o1} = 0.44A$
$n = 7$	V_{o7}		$I_{o1} = 0.23A$

$$I_{0r} = \sqrt{I_{o1}^2 + I_{o3}^2 + I_{o5}^2 + I_{o7}^2} = 7.19 \text{ A}$$

$$P = (7.19)^2 \times 10 = 516.96 \text{ W}$$

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