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Important Questions *for* GATE 2022

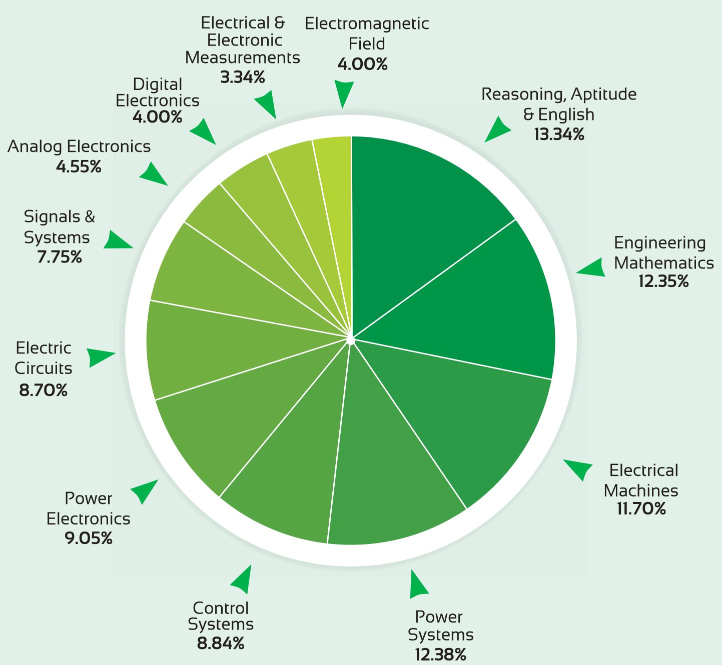
ELECTRICAL ENGINEERING

Day 8 of 8

Q.176 - Q.200 (Out of 200 Questions)

Power Electronics & Electromagnetic Fields

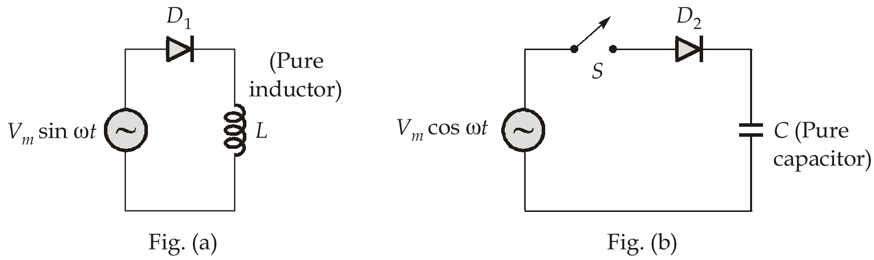
SUBJECT-WISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Reasoning, Aptitude & English	13.34%
Engineering Mathematics	12.35%
Electrical Machines	11.70%
Power Systems	12.38%
Control Systems	8.84%
Power Electronics	9.05%
Electric Circuits	8.70%
Signals & Systems	7.75%
Analog Electronics	4.55%
Digital Electronics	4.00%
Electrical & Electronic Measurements	3.34%
Electromagnetic Fields	4.00%
Total	**100%**

Power Electronics & Electromagnetic Fields

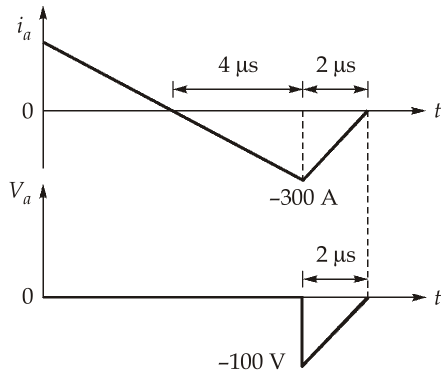
Q.176 In the circuits shown below :



If switch in figure (b) is closed at $t = 0$, then the diodes D_1 and D_2 conducts for

(a) 180° and 90°
(b) 90° and 180°
(c) 360° and 90°
(d) 360° and 0°

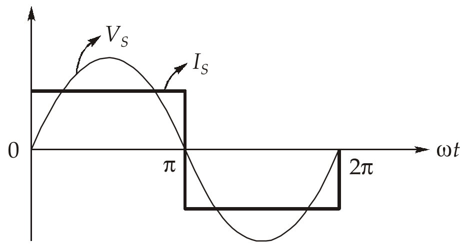
Q.177 During turn-off of a thyristor, idealized voltage and current waveforms are shown below :



For a triggering frequency of 50 Hz, the mean power loss due to turn off is

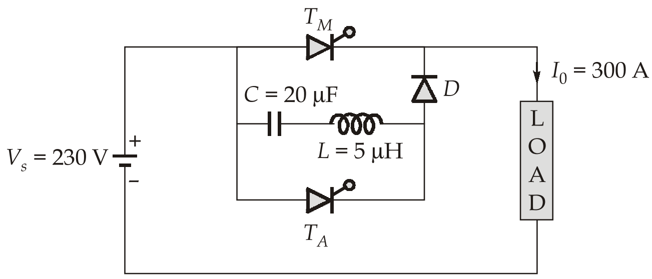
(a) 1 W
(b) 2 W
(c) 3 W
(d) 4 W

Q.178 The waveform shown below consists of source voltage (V_S) and source current (I_S) of a rectifier:



The input power factor is _________ lagging.

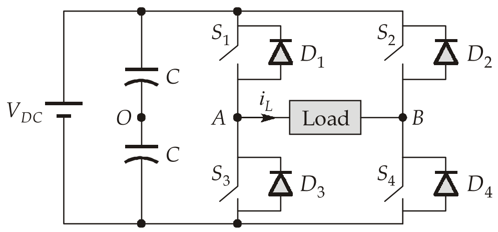
Q.179 In the circuit shown below



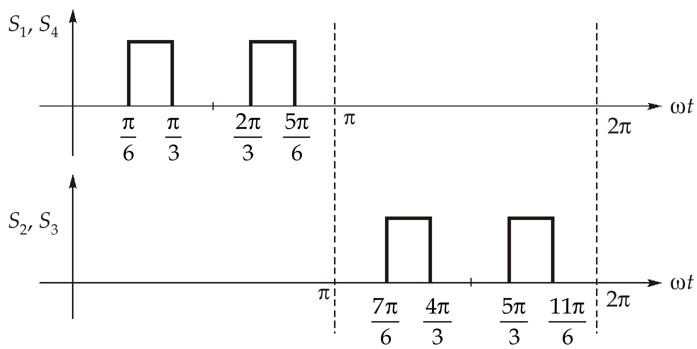
the voltage across main thyristor (T_M) when it gets turned off is ________

(a) 174 V
(b) 194 V
(c) 230 V
(d) $230\sqrt{2}$ V

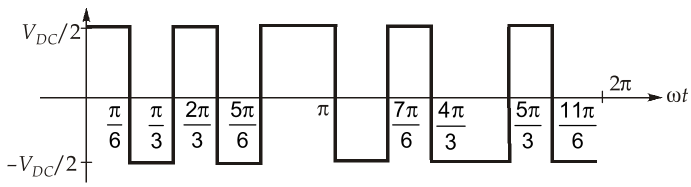
Q.180 A single-phase voltage source inverter shown in figure is feeding power to a load. The triggering pulses of the devices are also shown in the figure,



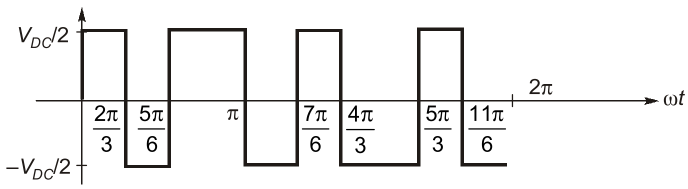
If the load current is sinusoidal and is zero at 0, π, 2π...., the node voltage V_{AO} has the waveform.



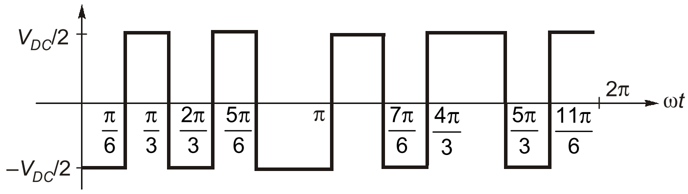
(a)



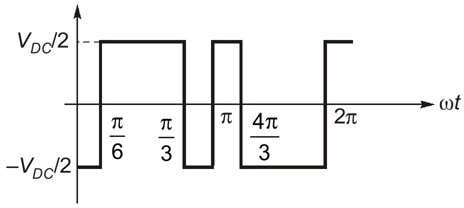
(b)



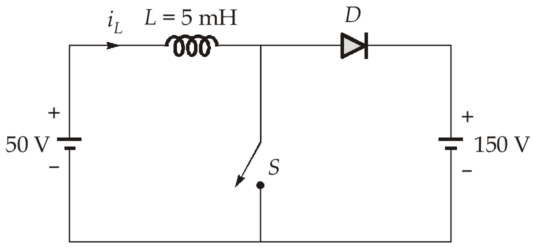
(c)



(d)



Q.181 In the circuit shown below :



If the switching frequency is 5 kHz, duty ratio is 0.4 and circuit reached to steady state then the average value of inductor current is ________ A.
(Assuming the switch and diode to be ideal and discontinuous mode of current conduction)

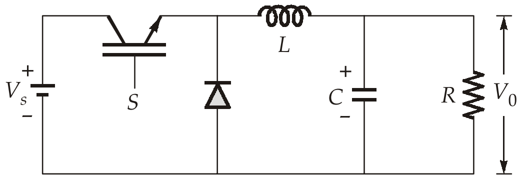
Q.182 A full bridge inverter has bi-directional switches employed in a manner that their switching sequence produces a square wave voltage across a series *R-L* load. If the switching frequency is 50 Hz, dc supply voltage, V_{dc} = 100 V, R = 10 Ω and L = 25 mH, then power absorbed by the load and rms 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

Q.183 For a power diode, the reverse recovery time is 4.2 μs and the rate of diode current decay is 40A/μs. For softness factor 0.25, the storage charge is

(a) 350 μC
(b) 282.24 μC
(c) 200 μC
(d) 210.6 μC

Q.184 In the chopper circuit shown in figure, the input 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 α. At the boundary condition of continuous and discontinuous condition of the inductor current i_L, the value of critical inductance L_C _____



(a) $L_C = \dfrac{\alpha V_s(1-\alpha)}{2I_0 f}$ (b) $L_C = \dfrac{V_s(2fI_0)}{(1-\alpha)I_0^2}$

(c) $L_C = \dfrac{V_0(1-f)}{2\alpha I_0}$ (d) $L_C = \dfrac{V_s(1-\alpha^2)}{2I_0 f}$

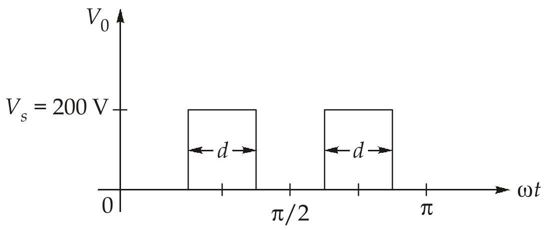
Q.185 A single phase full bridge inverter is operated at 60 Hz with MPM technique. A triangular carrier wave of 3 V, 1.2 kHz is compared to reference square wave of 1 V. The zero of the triangular wave coincides with zero of the reference square wave. The pulse width of each pulse is

(a) 10° (b) 12°
(c) 15° (d) 18°

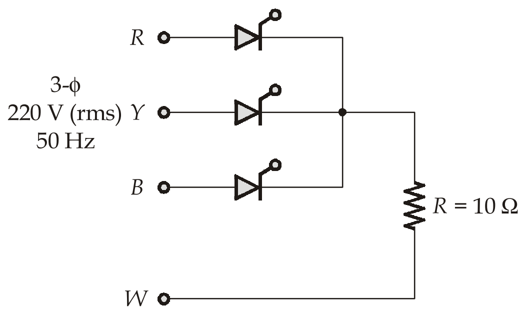
Q.186 The latching current of thyristors in the single-phase full converter is I_L = 500 mA and the delay time is t_d = 1.5 μs. The converter is supplied from a 120 V, 60 Hz supply and has a load at L = 10 mH and R = 10 Ω. The converter is operated with a delay angle of α = 30°. The minimum value of gate pulse width, t_G is ________

(a) 58.93 μs (b) 60.43 μs
(c) 57.43 μs (d) 61.93 μs

Q.187 In multiple-pulse modulation shown in figure. If d = 36° then the peak value of 7th harmonics is ________ V.



Q.188 In the 3-ϕ rectifier circuit shown below :



If firing angle of each thyristor is 45°, then the average power consumed by the load is _______ kW.

Q.189 A type-A chopper is fed from a 200 V dc source. This chopper is connected to load RLE with R = 0, L = 2.5 mH and constant E, for a duty cycle of 0.25. The chopping frequency to limit the amplitude of load current excursion to 8 A is ________ kHz.

Q.190 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

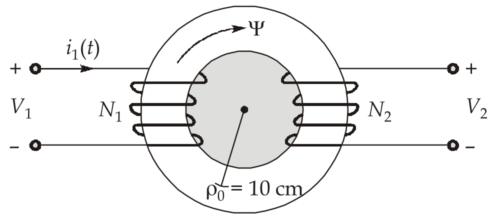
Q.191 A single phase semi converter, connected to 230 V, 50 Hz, source is feeding a load $R = 40\ \Omega$ in series with large inductor that makes the load current ripple free. If the value of firing angle is 45°, then the current distortion factor is

(a) 0.850 (b) 0.700
(c) 0.550 (d) 0.960

Q.192 Surface $x = 0$ separates two perfect dielectric with relative permittivities $\varepsilon_{r_1} = 2$ and $\varepsilon_{r_2} = 8$. If $\vec{E}_1 = (100\hat{a}_x + 200\hat{a}_y - 50\hat{a}_z)$ V/m for $x > 0$. Then $\vec{E}_2$ is

(a) $100\hat{a}_x + 50\hat{a}_y - 1.25\hat{a}_z$ (b) $400\hat{a}_x + 200\hat{a}_y - 50\hat{a}_z$
(c) $25\hat{a}_x + 200\hat{a}_y - 50\hat{a}_z$ (d) $100\hat{a}_x + 800\hat{a}_y - 200\hat{a}_z$

Q.193 The magnetic circuit shown below has a uniform cross-section of 10^{-3} m^2. If the circuit is energized by a current $i_1(t) = 3\sin 100\pi t$ A in the coil of $N_1 = 200$ turns, then the emf induced in the coil of $N_2 = 100$ turns is
(Assume $\mu = 500\ \mu_0$)



(a) $-6\pi \sin 100\pi t$ V (b) $-6\pi \sin 200\pi t$ V
(c) $-6\pi \cos 100\pi t$ V (d) $8\pi \cos 100\pi t$

Q.194 Two uniformly distributed line charges of $\lambda = 5$nc/m each are parallel to the X-axis, one at $z = 0$ and $y = -2$m and the other $z = 0$ and y = 4 m. The field E at (4, 1, 3) m is_______

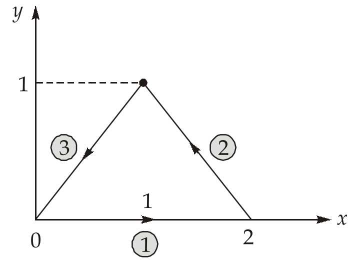
(a) 30 a_x (b) 30 a_y
(c) 6 a_z (d) 30 a_z

Q.195 The electric flux density vector of a certain charge distribution is given by

$$\vec{D} = 12xyz\hat{a}_x + (6x^2z + 6yz)\hat{a}_y + (6x^2y + 3y^2)\hat{a}_z \text{ C/m}^2.$$

The amount of charge enclosed in cube having a volume of 10^{-5} m^3 located at (x = 1 m, y = 1 m, z = 1 m) is _______μC.

Q.196 A triangular loop shown in below is made of conductor material and carries a current of 20 A. The magnitude of magnetic field $\vec{H}$ at point (0, 0, 5) due to side 1 of the loop is ______ mA/m.



Q.197 If $\mu_1 = 2\mu_0$ for region-1 $(0 < \phi < \pi)$ and $\mu_2 = 5\mu_0$ for region-2 $(\pi < \phi < 2\pi)$ and $B_2 = 10\hat{a}_\rho + 15\hat{a}_\phi - 20\hat{a}_z$ mWb/m^2, then the energy density in region-1 is

(a) 60.68 J/m^3
(b) 30.58 J/m^3
(c) 120.76 J/m^3
(d) 75.63 J/m^3

Q.198 Line $x = 0$, $y = 0$, $0 \le z \le 10$ carries current 2A along a_z. The magnetic field intensity $\vec{H}$ at point (5, 5, 0) is $|\vec{H}|(-\hat{a}_x + \hat{a}_y)\text{A/m}$, then the value of $|\vec{H}|$ is

(a) $\frac{1}{20\pi\sqrt{3}}$
(b) $\frac{1}{10\pi\sqrt{6}}$
(c) $\frac{1}{30\pi\sqrt{2}}$
(d) $\frac{1}{30\pi\sqrt{6}}$

Q.199 A stationary 10 turn square coil of 1 metre-side is situated with its lower left corner coincident with the origin and with sides x_1 and y_1 along x-axis and y-axis. If the field B is normal to the plane of coil and has its amplitude given by

$$B_0 = \sin\frac{\pi x}{x_1}\sin\frac{\pi y}{y_1}T$$

The rms value of emf induced in the coil if B varies harmonically at a frequency of 1 kHz

(a) 14 kV
(b) 18 kV
(c) 22 kV
(d) 28 kV

Multiple Select Question (MSQ)

Q.200 A single phase full converter is supplied from 230 V, 50 Hz source. The load consists of $R = 10\ \Omega$ and a large inductance so as to render the load current constant. For a firing angle of 30°. Which of the following is/are correct?

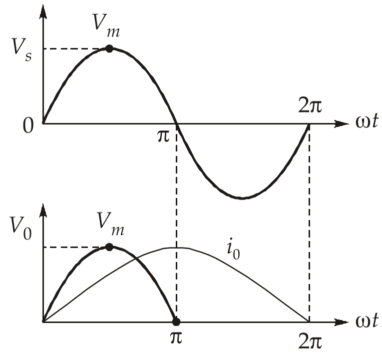
(a) Average value of thyristor current is 8.96 A.
(b) RMS value of thyristor current is 12.67 A.
(c) Average value of thyristor current is 4.48 A.
(d) RMS value of thyristor current is 9.36 A.

■■■■

Detailed Explanations

176. (d)

In figure (a),



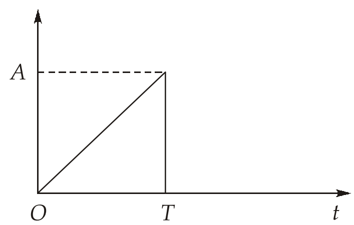
Inductor stores energy upto π radian and dissipates energy upto 2π radians.

So, diode conducts for 360° in figure (a).

In figure (b), the source is a 'cosine' function, so capacitor charges to its maximum value instantaneously as switch is closed at $t = 0$.

So, diode conducts for 0° in figure (b).

177. (a)



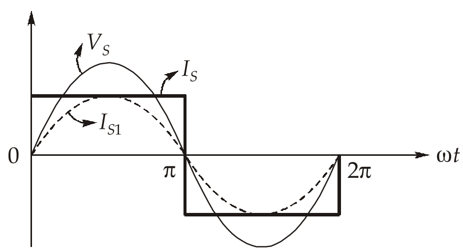
The rms value of the waveform is $\dfrac{A}{\sqrt{3}}$

$$\text{Power loss, } P = V_{rms}\, I_{rms}\, f \times t$$

$$= \frac{300}{\sqrt{3}} \times \frac{100}{\sqrt{3}} \times 50 \times 2 \times 10^{-6} = 1 \text{ W}$$

178. 0.90 (0.80 to 0.99)

The waveform of source current and fundamental component of source current (I_{s1}) is



$$\text{Input p.f.} = \frac{I_{s1}}{I_s}\cos\alpha = \frac{\frac{4I_s}{\sqrt{2}\pi}}{I_s}\cos 0°$$

$$\text{Input p.f.} = 0.9 \text{ lagging}$$

179. (a)

The main thyristor is turned off when i_c is,

$$i_c = I_p \sin \omega t = I_0$$

$$\omega t = \sin^{-1}\left(\frac{I_0}{I_P}\right)$$

Peak value of current through capacitor,

$$I_P = V_S\sqrt{\frac{C}{L}} = 230 \times \sqrt{\frac{20\times 10^{-6}}{5\times 10^{-6}}} = 460 \text{ A}$$

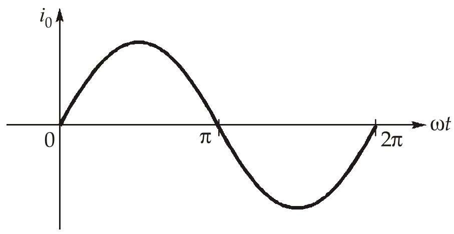
$$\omega t = \sin^{-1}\left(\frac{300}{460}\right) = 40.70°$$

Voltage across main thyristor is

$$= V_S \cos \omega t$$
$$= 230 \times \cos (40.70°) = 174.37 \text{ V}$$

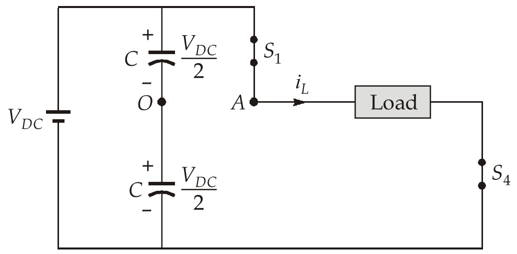
180. (c)

The load current waveform is



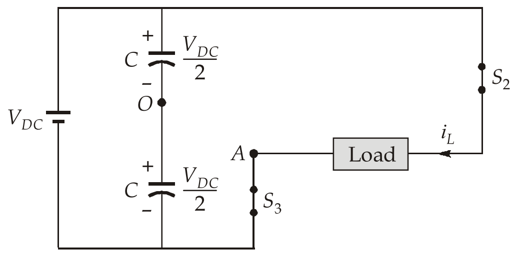
During the period switches are triggered the voltage across AO is

S_1 and S_4 ON

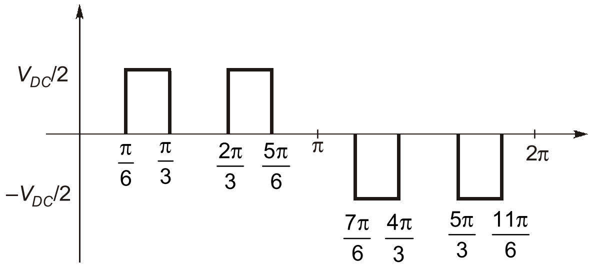


$$\text{Voltage } V_{AO} = \frac{V_{DC}}{2}$$

S_2 and S_3 ON



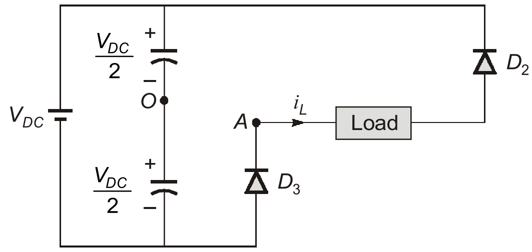
Voltage $V_{AO} = -\dfrac{V_{DC}}{2}$



When the switches are off.

The current direction from 0 to π is positive so it is in the direction given in the circuit.

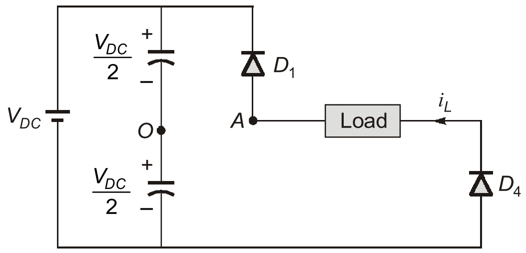
$0 \le \omega t \le \pi$



Voltage $V_{AO} = -\dfrac{V_{DC}}{2}$

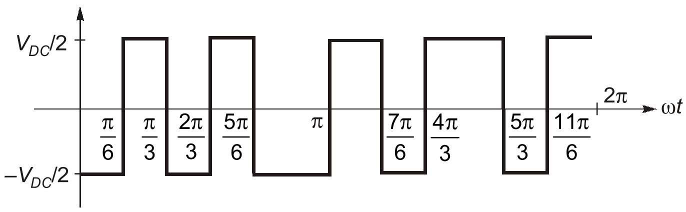
$\pi \le \omega t \le 2\pi$

The load current is negative so the current direction will be opposite to given direction.

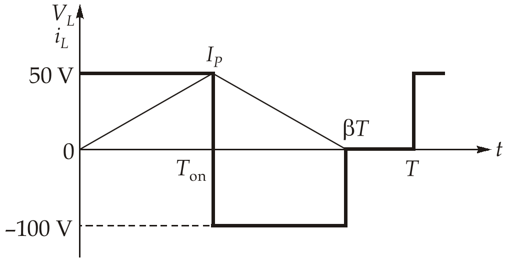


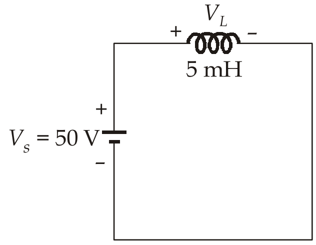
Voltage $V_{AO} = \dfrac{V_{DC}}{2}$

So, the complete voltage V_{AO} is



181. **0.24 (0.10 to 0.40)**





During T_{on} the circuit behaves as,

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

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

Integrating on both sides, we get

$$I_P = \frac{V_s}{L}T_{on}$$

$$T_{on} = \alpha T = \frac{\alpha}{f} = \frac{0.4}{5\times10^3} = 80\times10^{-6}\text{ s}$$

$$I_P = \frac{50}{5\times10^{-3}}\times(80\times10^{-6}) = 0.8\text{ A}$$

During T_{off}, it is $T_{on} \le t \le \beta T$

Apply KVL in the circuit,

$$V_L = V_s - V_0$$

$$(V_L)_{avg} = 0$$

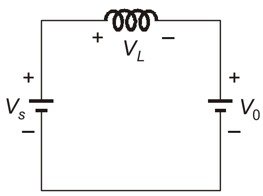
$$V_sT_{on} + (V_s - V_0)(\beta T - T_{on}) = 0$$

$$V_s\beta T = V_0(\beta T - T_{on})$$

$$\frac{V_0}{V_s} = \frac{\beta}{\beta-\alpha}$$

$$\beta = 0.6$$

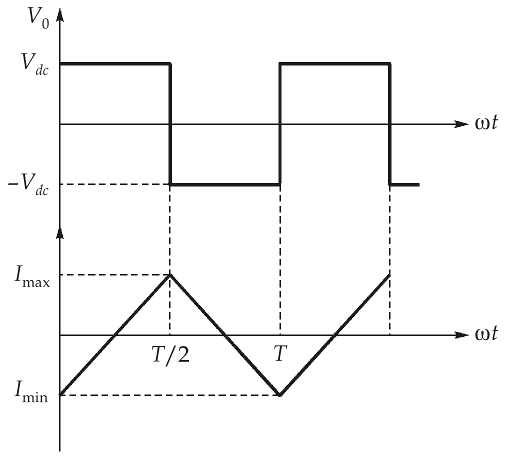
From the graph of I_L,



$$I_{L(avg)} = \frac{\frac{1}{2}\times b\times h}{T}$$

$$= \frac{\frac{1}{2}\times\beta T\times I_P}{T} = \frac{1}{2}\times0.6\times0.8 = 0.24\text{ A}$$

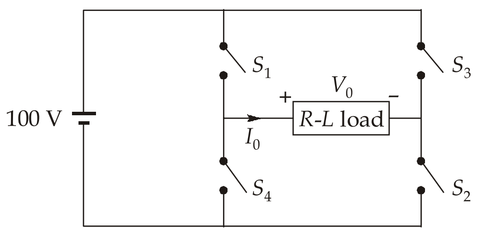
182. (c)



At $t = 0$,

S_1, S_2 : switches are closed

S_3, S_4 : switches are open



Output power, $P = I_{or}^2 R$

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

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

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

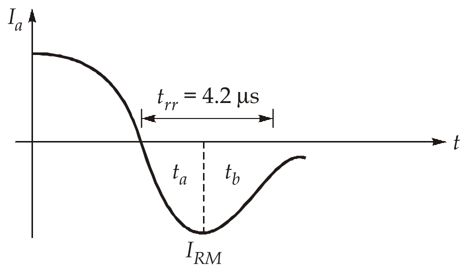
$$I_{\text{on-rms}} = \frac{V_{on}}{|Z_n|}$$

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

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

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

183. (b)



Given, softness factor $= \dfrac{t_b}{t_a} = 0.25$

$$t_b = 0.25\ t_a$$

$$t_{rr} = t_a + t_b = t_a + 0.25\ t_a = 1.25\ t_a$$

$\therefore$ $$t_a = \frac{4.2}{1.25} = 3.36\ \mu s$$

$$\text{Slope} = \frac{I_{RM}}{t_a} = 40\ A/\mu s$$

$$I_{RM} = 40 \times 3.36 = 134.4\ A$$

Total charge stored in the curve is,

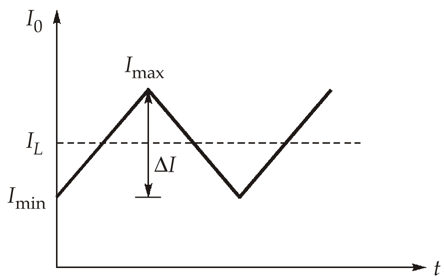
$$= \frac{1}{2} \times b \times h = \frac{1}{2} \times 4.2 \times 10^{-6} \times 134.4$$

$$= 282.24\ \mu C$$

184. (a)

Given chopper is a Buck chopper so,

Output voltage, $V_0 = \alpha V_s$



$$\Delta I = \frac{V_0 T_{off}}{L}$$

$$= 2I_L = 2I_0$$

This is applicable only at boundary of continuous and discontinuous condition.

$$L_C = \frac{\alpha V_s (1 - \alpha)}{2 I_0 f}$$

185. (b)

Reference wave

$\Rightarrow$ $V_r = 1$ V;

$f = 60$ Hz (Inverter output frequency)

Carrier wave

$\Rightarrow$ $V_c = 3$ V;

$f_c = 1.2$ kHz

Number of pulses per half cycle,

$$N = \frac{f_c}{2f} = \frac{1.2 \times 10^3}{2 \times 60} = 10$$

$$\text{Modulation index} = \frac{V_r}{V_c} = \frac{1}{3}$$

$$\text{Total pulse width} = \pi\left(1 - \frac{V_r}{V_c}\right)$$

$$= \pi\left(1 - \frac{1}{3}\right) = \frac{2\pi}{3} = 120°$$

$$\text{Each pulse width} = \frac{2d}{N} = \frac{120°}{10°} = 12°$$

186. (b)

Given, $I_L = 500$ mA $= 0.5$ A

$t_d = 1.5$ μs

$\alpha = 30°$,

$L = 10$ mH

and $R = 10\ \Omega$

Instantaneous value of the input voltage $V_s(t) = V_m \sin \omega t$

Where, $V_m = \sqrt{2} \times 120 = 169.7$ V

$V_1 = V_m \sin \omega t$

$$= 169.7 \times \sin\frac{\pi}{6} = 84.85 \text{ V}$$

The rate of rise of anode current $\frac{di}{dt}$ at the instant of triggering is approximately

$$\frac{di}{dt} = \frac{V_1}{L} = \frac{84.85}{10 \times 10^{-3}} = 8485 \text{ A/s}$$

If $\frac{di}{dt}$ is assumed constant for a short time after the gate triggering the time t_1 required for the anode current to rise to the level of latching current is calculated from

$$t_1 \times \left(\frac{di}{dt}\right) = I_L$$

or
$$t_1 \times 8485 = 0.5$$
$$t_1 = 58.93\ \mu s$$

Therefore, the minimum width of the gate pulse is

$$t_G = t_1 + t_d = 58.93 + 1.5$$
$$= 60.43\ \mu s$$

187. 18.18 (18.00 to 18.50)

We know that,
$$\gamma = \frac{\pi - 2d}{N+1} + \frac{d}{N}$$
$$= \frac{108}{3} + \frac{36}{2} = 54°$$
$$V_0 = \sum_{n=1,3,5}^{\infty} \frac{8V_s}{n\pi} \sin n\gamma \sin \frac{nd}{2} \sin n\omega t$$

Peak value of 7^{th} harmonics voltage

$$V_7 = \frac{8V_s}{n\pi} \sin n\gamma \sin \frac{nd}{2}$$
$$= \frac{8 \times 200}{7\pi} \times \sin(7 \times 54°) \times \sin\left(\frac{7 \times 36°}{2}\right)$$
$$= \frac{1600}{7\pi} \times 0.309 \times 0.809 = 18.188\ \text{V}$$

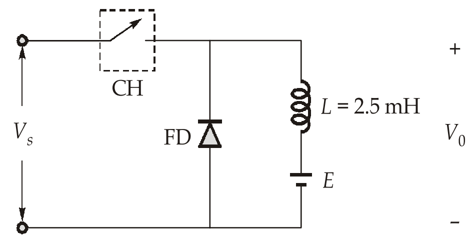
188. 1.60 (1.40 to 1.80)

$$V_{0\,\text{rms}} = \frac{V_{ml}}{2\sqrt{\pi}}\left[\left(\frac{5\pi}{6} - \alpha\right) + \frac{1}{2}\sin\left(2\alpha + \frac{\pi}{3}\right)\right]^{1/2}$$
$$V_{0\,\text{rms}} = \frac{220 \times \sqrt{2}}{2\sqrt{\pi}}\left[(2.618 - 0.785) + \frac{1}{2}\sin(90° + 60°)\right]^{1/2}$$
$$= \frac{220 \times \sqrt{2}}{2\sqrt{\pi}}[1.833 + 0.25]^{1/2} = 126.67\ \text{V}$$
$$I_{0\,\text{rms}} = \frac{V_{0\,\text{rms}}}{R} = \frac{126.67}{10} = 12.667$$

Power consumed by the load,

$$= (12.667)^2 \times 10$$
$$= 1604.55 \text{ W} = 1.604 \text{ kW}$$

189. 1.87 (1.60 to 1.99)



Average output voltage is given by,

$$V_0 = \alpha V_s$$
$$\alpha = \text{duty cycle} = 0.25$$
$$V_0 = 0.25 \times 200 = 50 \text{ V}$$

As the average value of voltage drop across L is zero

$$V_0 = E = \alpha V_s = 50 \text{ V}$$

During T_{ON}, the difference in source voltage V_s and load emf E appears across inductance L. Also during T_{ON}, the current through L rises from I_{min} to I_{max}

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

$$V_s - E = L\frac{\Delta I}{T_{ON}}$$

$$T_{ON} = \frac{L \cdot \Delta I}{V_s - E} = \frac{2.5 \times 8 \times 10^{-3}}{200 - 50}$$

$$= 1.33 \times 10^{-4} \text{ sec} = 133 \text{ µsec}$$

and, duty cycle, $\alpha = \dfrac{T_{ON}}{T}$

$$\frac{\alpha}{T_{ON}} = f$$

Chopping frequency, $f = \dfrac{\alpha}{T_{ON}} = \dfrac{0.25}{133 \times 10^{-6}} = 1.879 \text{ kHz}$

190. (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,

$$I_L = \frac{V_S D}{R(1-D)^2} = \frac{24\times0.4}{5(1-0.4)^2}$$

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

$$\Delta i_L = \frac{V_S DT}{L} = \frac{24\times0.4}{20\times10^{-6}\times100\times10^3} = 4.8 \text{ A}$$

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

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

The ratio of inductor currents,

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

191. (d)

Current distortion factor for single phase semi converter,

$$\text{CDF} = \frac{2\sqrt{2}\cos\left(\frac{\alpha}{2}\right)}{\sqrt{\pi(\pi-\alpha)}}$$

$$= \frac{2\sqrt{2}\cos\left(\frac{45}{2}\right)}{\sqrt{\pi\left(\pi-\frac{\pi}{4}\right)}} = \frac{2.613}{\sqrt{\frac{3\pi^2}{4}}} = \frac{2.613}{2.721} = 0.960$$

192. (c)

From boundary condition of dielectric-dielectric medium.

$$E_{t_1} = E_{t_2}$$

and $$D_{n_1} = D_{n_2}$$

$$\varepsilon_{r_1} E_{n_1} = \varepsilon_{r_2} E_{n_2}$$

or $$E_{n_2} = \frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} E_{n_1}$$

$$= \frac{2}{8}\times100 = 25$$

∴ $$\vec{E}_2 = 25\hat{a}_x + 200\hat{a}_y - 50\hat{a}_z$$

193. (c)

The flux in the circuit is,

$$\Psi = \frac{ö}{U} = \frac{N_i\, i_1}{l/\mu S} = \frac{N_1\, i_1\, \mu S}{2\pi\rho_0}$$

ö = magneto motive force

U = reluctance

l = mean length

S = cross-sectional area of magnetic core

According to Faraday's Law, the emf induced in the second coil is,

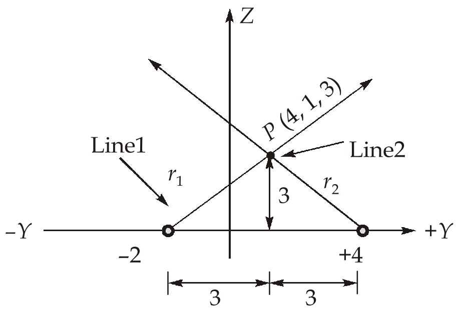
$$V_2 = -N_2 \frac{d\Psi}{dt} = -\frac{N_1\, N_2\, \mu S}{2\pi\rho_0} \frac{di_1}{dt}$$

$$V_2 = -\frac{100 \times 200 \times 500 \times (4\pi \times 10^{-7}) \times 10^{-3} \times 300\pi \cos 100\pi t}{2\pi(10 \times 10^{-2})}$$

$$= -6\pi \cos 100\pi t \text{ V}$$

194. (d)

Let r_1 and r_2 be the directed line segments from the lines 1 and 2 respectively to the point P(in Y-Z plane).



Then, $\quad r_1 = 3\hat{a}_y + 3\hat{a}_z$

and $\quad r_2 = -3\hat{a}_y + 3\hat{a}_z$

$$E_1 = \frac{\lambda}{2\pi\varepsilon_0 r_1}\left(\frac{3\hat{a}_y + 3\hat{a}_z}{r_1}\right) \quad \text{. . . (i)}$$

where, $\quad r_1^2 = 3^2 + 3^2 = r_2^2$ (in magnitude) $= 18 = r^2$

$$E_2 = \frac{\lambda}{2\pi\varepsilon_0 r_2}\left(\frac{-3\hat{a}_y + 3\hat{a}_z}{r_2}\right) \quad \text{. . . (ii)}$$

Adding (i) and (ii), we obtain the resultant field

$$E = E_1 + E_2 = \frac{\lambda}{2\pi\varepsilon_0 r^2}(2 \times 3\hat{a}_z)$$ (replacing r_1 and r_2 by r)

$$= \frac{5 \times 10^{-9}}{2\pi\varepsilon_0 (18)}(6\hat{a}_z) = 30\hat{a}_z \text{ V/m}$$

195. (180)

From Maxwell's equation,

$$\nabla.\vec{D} = \rho_v = \frac{\partial}{\partial x}(12xyz)\hat{a}_x + \frac{\partial}{\partial y}(6x^2z + 6yz)\hat{a}y + \frac{\partial}{\partial z}(6x^2y + 3y^2)\hat{a}_z$$

$$\nabla.\vec{D} = 12yz + 6z$$

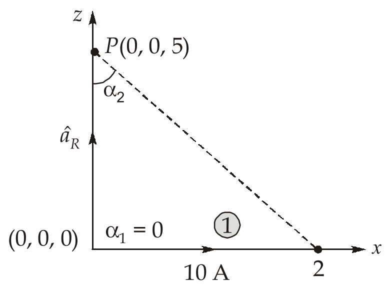
At point (1, 1, 1) $\nabla.\vec{D} = 12 + 6 = 18 \text{ C/m}^2$

$$Q = \int \rho_v dv$$

$$= 18 \times 10^{-5} = 180 \,\mu\text{C}$$

196. 118.21 (117.21 to 119.21)

Note here that the point of intrest is on z-axis and the side-1 of the triangular is on x-axis. So no need to consider other sides.



The perpendicular from point P on the current filament is at (0, 0, 0). The vector and unit vector in the direction of perpendicular towards point P is,

$$\bar{R} = 5\hat{a}_z$$

and $\hat{a}_R = \hat{a}_z$

The angles made by ends of the filament with the perpendicular are (dotted line),

$$\alpha_1 = 0;$$

$$\alpha_2 = \tan^{-1}\left(\frac{2}{5}\right) = 21.80°$$

The current filament along x-axis gives

$$\hat{a}_l = \hat{a}_x$$

Now the direction of H is,

$$\hat{a}_\phi = \hat{a}_l \times \hat{a}_R = \hat{a}_x \times \hat{a}_z = -\hat{a}_y$$

The field intensity due to finite filament is,

$$\bar{H} = \frac{I}{4\pi R}[\sin\alpha_2 - \sin\alpha_1]\hat{a}_\phi$$

$$= \frac{20}{4\pi \times (5)}[\sin(21.80°) - \sin(0)](-\hat{a}_y)$$

$$\bar{H} = -118.21\hat{a}_y \text{ (mA/m)}$$

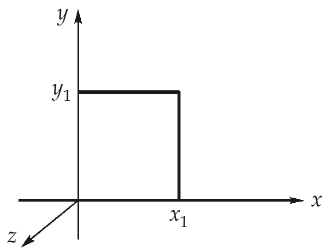
197. (a)

$$\mu_1 = 2\,\mu_0;$$
$$\mu_2 = 5\,\mu_0$$
$$B_2 = 10\hat{a}_\rho + 15\hat{a}_\phi - 20\hat{a}_z \text{ mWb/m}^2$$
$$B_{1n} = B_{2n} = 15\hat{a}_\phi$$
$$H_{1t} = H_{2t}$$
$$B_{1t} = \frac{\mu_1}{\mu_2}B_{2t} = \frac{2}{5}\left(10\hat{a}_\rho - 20\hat{a}_z\right)$$
$$B_{1t} = (4\hat{a}_\rho - 8\hat{a}_z)\text{mWb/m}^2$$
$$W_{m1} = \frac{1}{2}B_1 \cdot H_1 = \frac{B_1^2}{2\mu_1}$$
$$= \frac{(4^2 + 15^2 + 8^2)\times 10^{-6}}{2\times 2\times 4\pi\times 10^{-7}}$$
$$= \frac{305}{16\pi}\times 10 = 60.68 \text{ J/m}^3$$

198. (b)

$$H = \frac{I}{4\pi\rho}(\cos\alpha_2 - \cos\alpha_1)\hat{a}_\phi$$
$$\rho = \sqrt{5^2 + 5^2} = \sqrt{50}\text{ m}$$
$$= \frac{2}{4\pi\sqrt{5^2 + 5^2}}[\cos\alpha_2 - \cos\alpha_1]\hat{a}_\phi$$
$$\cos\alpha_2 = \frac{10}{\sqrt{50 + 100}} = \frac{10}{\sqrt{150}}$$
$$\cos\alpha_1 = \cos 90° = 0$$
$$\hat{a}_\phi = \hat{a}_l \times \hat{a}_\rho = \hat{a}_z \times \left(\frac{5\hat{a}_x + 5\hat{a}_y}{5\sqrt{2}}\right) = \left(\frac{-\hat{a}_x + \hat{a}_y}{\sqrt{2}}\right)$$
$$\vec{H} = \frac{2}{4\pi\times 5\sqrt{2}}\times\left(\frac{10}{\sqrt{150}} - 0\right)\times\left(\frac{-\hat{a}_x + \hat{a}_y}{\sqrt{2}}\right)$$
$$= \frac{1}{20\pi}\left(-\hat{a}_x + \hat{a}_y\right)\times\frac{10}{5\sqrt{6}}$$
$$= \frac{1}{10\pi\sqrt{6}}\left(-\hat{a}_x + \hat{a}_y\right)\text{A/m}$$

199. (b)

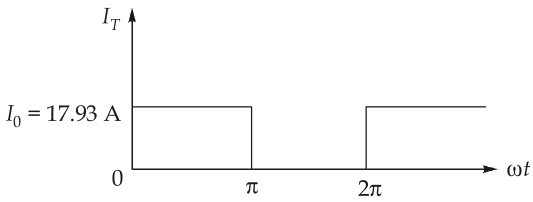


$$x_1 = y_1 = 1 \text{ m}$$
$$B_0 = \sin \pi x \sin \pi y \ T$$
$$B = B_0 \cos \omega_0 t$$
$$E(t) = \iint_s \frac{-dB}{dt} \cdot \hat{n}\, dS$$
$$= \iint_s \omega_0 B_0 \sin \omega t\, \hat{n}\, dS$$
$$E_{max} = \omega_0 \int_{y=0}^{1} \int_{x=0}^{1} \sin \pi x \sin \pi y\, dx\, dy$$
$$E_{max} = 1000 \times 2\pi \times \frac{4}{\pi^2} = \frac{8000}{\pi} \text{ V/turns}$$
$$E_{rms} = \frac{1}{\sqrt{2}} \times \frac{8000}{\pi} \times 10 = 18 \text{ kV}$$

200. (a, b)

Average output voltage of single phase full converter is,

$$V_0 = \frac{2V_m}{\pi} \cos\alpha$$
$$V_0 = \frac{2\sqrt{2} \times 230}{\pi} \cos 30° = 179.33 \text{ V}$$
$$I_0 = \frac{V_0}{R} = \frac{179.33}{10} = 17.93 \text{ A}$$



The average value of thyristor current,

$$I_{T\,avg} = 17.93 \times \frac{\pi}{2\pi} = 8.96 \text{ A}$$

The rms value of thyristor current,

$$I_{T\,rms} = 17.93 \times \sqrt{\frac{\pi}{2\pi}} = 12.67 \text{ A}$$

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