Power Electronics and Drives Test 3

Number of Questions:25 **Section Marks: 25**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

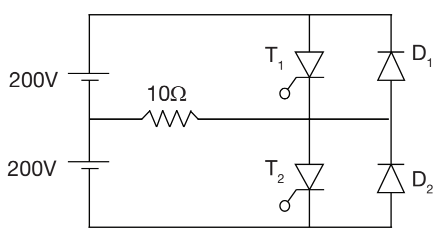
1. The operation of an inverter fed induction motor can be shifted from forward motoring to regenerative braking by
(A) increasing inverter frequency
(B) decreasing inverter frequency
(C) reducing inverter voltage
(D) reversing phase sequence

2. A single phase, half bridge inverter has input voltage of 120V dc. Inverter is feeding a load of 10 Ω. The rms output current at fundamental frequency is
(A) 2.7A
(B) 3.82A
(C) 5.4A
(D) 7.64A

3. The quality of output a.c. voltage of a cyclo converter is improved with
(A) increase in output voltage at reduced frequency
(B) decrease in output voltage at reduced frequency
(C) decrease in output voltage at increased frequency
(D) increase in output voltage at increased frequency

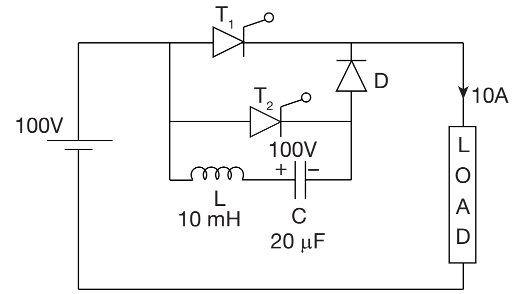
4. In a 3 – ϕ voltage source inverter operating in square wave mode, the output line voltage is free from
(A) 3rd harmonic
(B) 7th harmonic
(C) 11th harmonic
(D) 13th harmonic

5. A single phase half-bridge inverter is feeding power to a load of resistance 10 Ω, d.c. input to the converter is 400V. The power delivered by each source will be



(A) 2 kW
(B) 4 kW
(C) 8 kW
(D) 16 kW

6. A boost regulator circuit shown in below figure has an input voltage of 5V. The average output voltage is 15V and the average load current I_o = 0.5A. The switching frequency is 25kHz. If L = 150 μH and C = 220 μF, the ripple current of inductor ΔI will be?



(A) 0.63A (B) 0.89A
(C) 0.445A (D) 0.315A

7. In a sinusoidal PWM inverter, the harmonics are of the form $AZ + \ell$ (Z is the carrier ratio) where
(A) both A and ℓ are either even or both are odd
(B) A is always even and ℓ is always odd
(C) A is always odd and ℓ is always even
(D) A is odd and ℓ is even or A is even and l is odd

8. A 3 – ϕ, 180° mode, voltage source inverter is operated with pure resistive load of 20 Ω. The dc supply voltage is 400V. The instantaneous maximum load current will be
(A) 40A (B) 20A
(C) 6.66A (D) 13.33A

9. In ac applications with inverter, a different of harmonic is needed. The total harmonic distortion is given by

(A) $\sqrt{\dfrac{A_{rms}^2 - A_{1rms}^2}{A_{rms}}}$ (B) $\sqrt{\dfrac{A_{rms}^2 - A_{1rms}^2}{A_{1rms}^2}}$

(C) $\sqrt{\dfrac{A_{1rms}^2 - A_{rms}}{A_{rms}}}$ (D) $\sqrt{\dfrac{A_{1rms} - A_{rms}}{A_{1rms}}}$

10. A 250V separately excited dc motor has armature resistance of 2.5 Ω. When driving a load at 1000 rpm with constant torque, the armature takes 20A. The motor is controlled by a dc chopper operating with a frequency of 800Hz and input voltage of 250V dc. What should be the value of duty ratio at half rated torque, if it is desired to reduce the speed from 1000 rpm to 600 rpm?
(A) 0.31 (B) 0.43
(C) 0.58 (D) 0.79

11. A single phase current source inverter is operated with pure capacitive load, the n^{th} harmonic load voltage directly proportional to

(A) $\dfrac{1}{n}$ (B) $\dfrac{1}{n^2}$
(C) n (D) n^2

12. A single phase half bridge voltage source inverter is operating pure inductive load, the nature of the load current wave form is

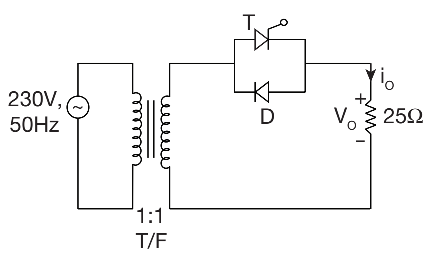
(A) sine wave
(B) square wave
(C) triangular wave
(D) impulse generation

13. A step up chopper has input voltage of 220V, and output voltage of 660V and the conducting time of thyristor-chopper is 200 µs. If the pulse width is halved, for constant frequency operation, the new output voltage will be?
(A) 110V (B) 220V
(C) 330V (D) 440V

14. A 3 – ϕ, 120° mode, voltage source inverter operated with a resistive load and supply voltage 250dc. The fundamental line rms voltage and total harmonic distortion of the line voltage respectively are?
(A) 168.8V, 31.08%
(B) 243.2V, 48.34%
(C) 74.31V, 48.34%
(D) 98.42V, 31.08%

15. In PWM, in inverters, the amplitude and frequency for triangular carrier and square reference signals are respectively 10V, 10kH and 1V, 1kHz. The number of pulses per half cycle and pulse width respectively _______?
(A) 4, 40.5° (B) 4, 20.25°
(C) 5, 64.8° (D) 5, 32.4°

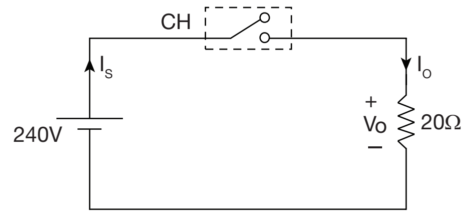
16. *A* 1 – ϕ, half controlled AC voltage regulator shown in figure, is operated with 230V, 50Hz supply voltage and pure load resistance of 25 Ω. For the triggering angle of 30°, the supply power factor will be_______?



(A) 0.9927 lag (B) 0.9927 lead
(C) 0.5877 lag (D) 0.5877 lead

17. An AC voltage regulator used for integral cycle control of high moment of inertia load. The supply voltage of the controller is 250V, 50 Hz and load rms voltage is 223.6V. The number of OFF cycles are 3, the number of ON cycles will be?
(A) 4 (B) 6
(C) 12 (D) 18

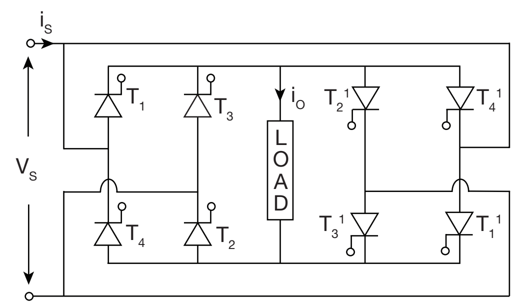
18. A step down dc chopper operating with supply voltage 240V dc and load resistance of 20 Ω. For the average output voltage of 60V, find the effective source resistance?



(A) 10 Ω (B) 20 Ω
(C) 40 Ω (D) 80 Ω

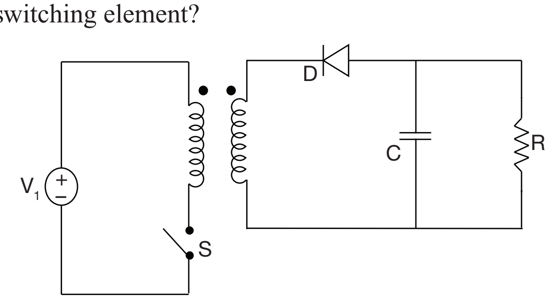
19. For a single pulse width modulation of a single phase inverter, what is the distortion factor for a pulse width of $\frac{\pi}{2}$?
(A) 0.9 (B) 0.95
(C) 0.866 (D) 0.5

20. The input voltage to the cyclo converter in figure shown below is 120V (rms), 50Hz. The load resistance is 5 Ω and the load inductance is 40 mH. The frequency of the output voltage is 20Hz. If the converters are operated as semi converters such that 0 ≤ α ≤ π and the delay angle is $\frac{2\pi}{3}$ rad, determine the rms value of the output voltage?



(A) 53V (B) 37.47V
(C) 75V (D) 18.73V

21. For the isolated buck boost converter as shown in the circuit below, the output voltage is to be 50V at a duty cycle of 40%. The dc input is obtained from a front end rectifier without voltage doubling fed from a 150V ac. What is the peak forward blocking voltage of the switching element?



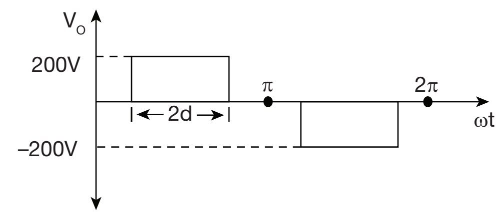
(A) 176.78V (B) 187.35V
(C) 353.6V (D) 374.7V

22. What is the wave form of the current flowing through the diode in buck-boost converter?
(A) Square wave
(B) Triangular wave
(C) Trapezoidal wave
(D) Sinusoidal wave

23. A step down d.c. chopper has load resistance of 10 Ω, input voltage is 250V (d.c). The chopper switch has the voltage drop of 1.5V when conducting. If the frequency is 5 kHz. The chopper efficiency at duty ratio 0.5 will be?
(A) 88.14% (B) 99.37%
(C) 92.57% (D) 97.37%

24. *A* 1 – ϕ circuit for temperature regulation uses ON-OFF control. The ac input is 400V, 1 – ϕ, 50 Hz supply. The circuit has a variable frequency, constant ON time. If the input voltage goes up by 15%, calculate the percentage change required in the triggering frequency of the chopper?
(A) 13.04% (B) –7.5%
(C) 7.5% (D) –13.04%

25. A pulse width modulated inverter output wave form shown in figure. Find the total pulse width in each half cycle $2d$ to eliminate the seventh harmonic from the output voltage and also find the 5[th] harmonic rms value of the output voltage?



(A) 51.42°, 28.15 V (B) 25.71°, 14.08 V
(C) 51.42°, 14.08 V (D) 25.71°, 28.15 V

Answer Keys

1. B	**2.** C	**3.** D	**4.** A	**5.** B	**6.** B	**7.** B	**8.** D	**9.** B	**10.** C
11. B	**12.** C	**13.** C	**14.** A	**15.** D	**16.** A	**17.** C	**18.** D	**19.** A	**20.** A
21. C	**22.** C	**23.** B	**24.** D	**25.** A					

Hints and Explanations

1. The regenerative braking for the inverter fed induction motor drive can be applied With f < 50Hz successfully but above 50 Hz a braking resistor is necessary.
Choice (B)

2. Fundamental output current $= \dfrac{2V_s}{\pi R}\sin\omega t$

RMS output current $= \dfrac{\sqrt{2}\,V_s}{\pi R}$

$= \dfrac{\sqrt{2}\times 120}{\pi\times 10} = 5.4\text{A}$ Choice (C)

3. Choice (D)

4. The output line voltage equation of 3 – Φ VSI

$$V_L = \sum_{n=1,3,5}^{\infty} \frac{4V_s}{n\pi}\cos\left(\frac{n\pi}{6}\right)\sin n\left(\omega t - \frac{\pi}{6}\right)$$

So, all tripplen harmonics are absent from the line voltage

If n = 3, $\cos\left(\dfrac{3\pi}{6}\right) = 0$ Choice (A)

5. Power delivered by each source $= \left(\dfrac{V_S}{2}\right)\left(\dfrac{V_S}{2R}\right)$

$= \left(\dfrac{400}{2}\right)\left(\dfrac{400}{2\times 10}\right) = 4\text{kW}$

Choice (B)

6. Expression for ripple current $\Delta I = \dfrac{V_s\left[V_o - V_s\right]}{f\,LV_o}$

$\Delta I = \dfrac{5\times(15-5)}{25\times 10^3\times 150\times 10^{-6}\times 15} = 0.89\text{A}$ Choice (B)

7. Choice (B)

8. The instantaneous maximum output voltage $= \dfrac{2V_s}{3}$

and maximum output current $= \dfrac{2V_s}{3R}$

$= \dfrac{2\times 400}{3\times 20} = 13.33\text{A}$ Choice (D)

9. Total harmonic distortion $= \dfrac{\text{useless harmonic}}{\text{fundamental component}}$

$= \dfrac{\sqrt{A_{rms}^2 - A_{1rms}^2}}{A_{1rms}} = \sqrt{\dfrac{A_{rms}^2 - A_{1rms}^2}{A_{1rms}^2}}$ Choice (B)

10. Motor equation: $V_o = E_b + I_o R_a$
at rated values: $E_b = V_o - I_o R_a$
$= 250 - 20 \times 2.5 = 200V$
$E_b \;\alpha\; \phi N$
$E_b = kN$
$K = \dfrac{E_b}{N} = \dfrac{200}{1000} = \dfrac{1}{5}$

Output of the chopper, $V_o = \delta V_s$

$$\left(\delta V_s - \frac{I_o R_a}{2}\right) = \text{kN}$$

$\delta\,(250) - 10 \times 2.5 = \frac{1}{5} \times 600 \Rightarrow \delta = 0.58$ Choice (C)

11. n^{th} harmonic load current, $I_{\text{on}} = \frac{4\,I_o}{n\pi} \sin n\omega t$

$$V_{on} = \frac{4 I_o (Z_n)}{n\pi} \sin(n\omega t + \Phi_n)$$

$$Z_n = R + j(n\omega L - \frac{1}{n\omega c})$$

$$Z = \frac{-j}{n\omega c} \;\{\because \text{Pure capacitive load}\}$$

$$|Z| = \frac{1}{n\omega c}$$

$$\varphi_n = \frac{-\pi}{2}$$

$$V_{on} = \frac{4 I_o}{n^2 \pi\omega c} \sin\left(n\omega t - \frac{\pi}{2}\right)$$

$V_{\text{on}} \;\alpha\; \frac{1}{n^2}$ Choice (B)

12. For voltage source inverter, $V = L\frac{di}{dt}$

$$i = \frac{1}{L}\int V.dt$$

$$i = \frac{V}{L} \times t$$

$$i(t) = \left(\frac{V}{L}\right)t$$

Hence which forms triangular wave Choice (C)

13. For step up chopper, $V_o = \frac{V_s}{1-\delta}$

$$660 = \frac{220}{1-\delta}$$

$$\delta = \frac{2}{3} = \frac{T_{ON}}{T}$$

$$T_{\text{ON}} = \frac{2}{3}T \text{ and } T_{\text{OFF}} = \frac{1}{3}T$$

$$\frac{1}{3}T = 200\mu\text{s}$$

$T = 600$ µs and $T_{\text{ON}} = \frac{2}{3} \times 600 = 400$ µs

If $P.W.$ is halved $T^1_{ON} = 200$ µs and $\delta = \frac{T^1_{ON}}{T} = \frac{200}{600} = \frac{1}{3}$

Output voltage $= \frac{V_S}{1-\delta} = 220.\frac{1}{1-\frac{1}{3}} = 330\text{V}$

Choice (C)

14. Line voltage $V_{R4} = \sum_{n=6k\pm1}^{\infty} \frac{3V_s}{n\pi} \sin\left(n\omega t + \frac{\pi}{3}\right)$

$$(V_{R4})_{\text{rms}} = \frac{3V_s}{\sqrt{2}\pi} = \frac{3\times 250}{\sqrt{2}\times\pi} = 168.8\text{V}$$

$$\text{Distortion Factor} = g = \frac{(V_{01})_{rms}}{V_{or}} = \frac{\frac{3V_s}{\sqrt{2}\pi}}{\frac{V_s}{\sqrt{2}}} = \frac{3}{\pi}$$

$THD = +\sqrt{\frac{1}{g^2} - 1} = 31.08\%$ Choice (A)

15. $A_r = 1\text{V}$ $A_C = 10\text{V}$
$f_r = 1$ kHz $f_c = 10$ kHz

$$N = \frac{f_c}{2f_r} = \frac{10}{2\times 1} = 5$$

$$\frac{2d}{N} = \left(1 - \frac{V_r}{V_c}\right)\frac{\pi}{N} = \left(1 - \frac{1}{10}\right)\frac{\pi}{5}$$

$\frac{2d}{N} = \frac{9\pi}{50}(\text{or})32.4^o$ Choice (D)

16. Source power factor

$$= \frac{V_{or}}{V_{sr}} = \left[\frac{V_m^2}{\pi}\left\{\frac{(2\pi - \alpha)}{2} + \frac{\sin 2\alpha}{4}\right\}\right]^{\frac{1}{2}}$$

$$P.f = \left\{\frac{1}{\pi}\left[\frac{2\pi - \frac{\pi}{6}}{2} + \frac{\sin\left(\frac{\pi}{3}\right)}{4}\right]\right\}^{\frac{1}{2}}$$

$= 0.9927$ lag Choice (A)

17. Output rms voltage, $V_{\text{or}} = \sqrt{k}\,V_{sr}$

$$k = \left(\frac{V_{or}}{V_{sr}}\right)^2 = \left(\frac{223.6}{250}\right)^2$$

$k = 0.8$

But $k = \frac{m}{m+n}$

$0.8 = \frac{m}{m+3} \Rightarrow m = 12$ Choice (C)

18. For step down chopper, $V_o = \delta V_s$
$60 = \delta\,(240)$

$$\delta = \frac{1}{4}$$

Source effective resistance $= \dfrac{V_s}{(I_s)_{avg}}$

$$= \frac{V_s}{\left(\frac{\delta V_s}{R}\right)} = \frac{R}{\delta} = \frac{20}{\left(\frac{1}{4}\right)} = 80\Omega$$ Choice (D)

19. For single PWM,

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

$$(V_{01})_{\text{peak}} = \frac{4V_s}{\pi}\sin\frac{\pi}{4}$$

$$(V_{01})_{\text{rms}} = \frac{2V_s}{\pi}$$

$$(V)_{s\text{rms}} = V_s\sqrt{\frac{\pi/2}{\pi}} = \frac{V_s}{\sqrt{2}}$$

Distortion factor $= \dfrac{\frac{2V_s}{\pi}}{V_s/\sqrt{2}} = \dfrac{2\sqrt{2}}{\pi} = 0.9$ Choice (A)

20. For $0 \le \alpha \le \pi$, the rms output voltage is

$$V_{or} = V_s\left[\frac{1}{\pi}\left(\pi - \alpha + \frac{\sin 2\alpha}{2}\right)\right]^{\frac{1}{2}}$$

$$= 120\left[\frac{1}{\pi}\left(\pi - \frac{2\pi}{3} + \frac{\sin\left(\frac{4\pi}{3}\right)}{2}\right)\right]^{\frac{1}{2}} = 53\text{V}$$ Choice (A)

21. $V_o = a\dfrac{\delta V_s}{1-\delta}$

$$50 = a.\frac{(0.4)\left(150\sqrt{2}\right)}{1-0.4}$$

$a = 0.3535$

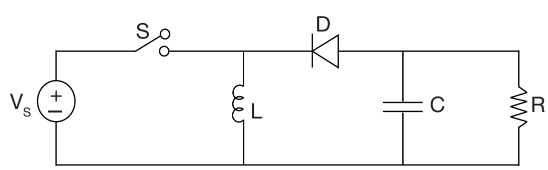
$\therefore$ Peak forward blocking current $= V_s + \dfrac{V_o}{a}$

$$= 150\ \sqrt{2} + \frac{50}{0.3535}$$

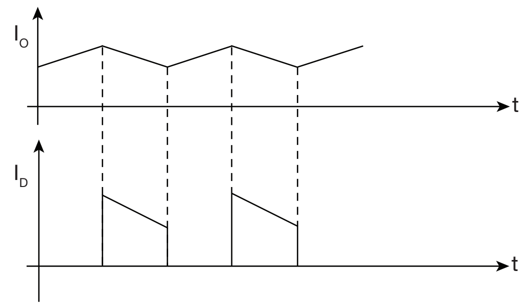
$$= 150\sqrt{2} + \frac{50}{0.3535} = 353.57\text{V}$$

Choice (C)

22.



Buck – Boost Converter



Current through diode is trapezoidal wave

Choice (C)

23. Average output voltage $V_o = (V_S - 1.5)\dfrac{T_{ON}}{T}$

$= (250 - 1.5) \times 0.5 = 124.25\text{V}$

Average current $I_o = \dfrac{V_o}{R} = \dfrac{124.25}{10} = 12.42\text{A}$

RMS output voltage $V_{\text{or}} = [(V_s - 1.5)^2 . \dfrac{T_{ON}}{T}]^{1/2}$

$= (250 - 1.5) \times \sqrt{0.5} = 175.71\text{V}$

Input power to chopper $= V_S \times I_o$

$= 250 \times 12.42 = 3107\text{W}$

Output power of the chopper $= \dfrac{V_{or}^2}{R} = \dfrac{(175.71)^2}{10}$

$= 3087.4\text{W}$

% chopper efficiency $= \dfrac{\text{output power}}{\text{input power}} \times 100$

$\dfrac{3087.4}{3107} \times 100 = 99.37\%$ Choice (B)

24. For supply voltage 400V, $V_o = \dfrac{T_{ON}}{T} \times 400 = T_{ON}\ f(400)$

When the supply voltage is increased by 15%

$V_{\text{rms}} = (1.15) \times 400 = 460\text{V}.$

$V_o = T_{\text{ON}} f^1 \times 460$

When input supply changes

$V_O = f^1\ T_{\text{ON}} \times 460 = f \times T_{\text{ON}} \times 400$

$\dfrac{f^1}{f} = \dfrac{400}{460}$;

$\dfrac{f^1 - f}{f} = \dfrac{400 - 400}{460} = -13.04\%$ Choice (D)

25. $V_{\text{on}} = \dfrac{4V_s}{n\pi}\sin\left(\dfrac{n\pi}{2}\right).\sin(nd).\ \sin(n\omega t)$

To eliminate 7th harmonic, $n = 7$

$\sin(nd) = \pi$; $7d = \pi$

$2d = \dfrac{2\pi}{7}\ rad$ (or) 51.42^o

N^{th} harmonic rms output voltage, $(V_{\text{on}})_{\text{rms}}$

$= \dfrac{2\sqrt{2}V_s}{5\pi} \times 1 \times \sin\left(\dfrac{5\pi}{7}\right) = 28.15\text{V}$ Choice (A)