CLASS TEST - 2016

EE

Power Electronics

Date : 07/07/2016

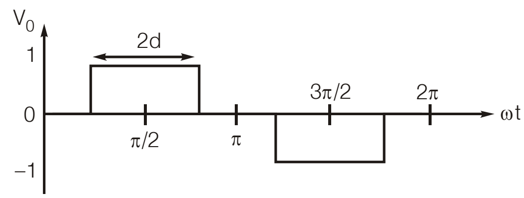
ANSWERS

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

Explanation

1. (d)

2. (a)



Output voltage $V_0 = \sum_{n=1,3,5}^{\infty} \left(\frac{4V_s}{n\pi}\right)(\sin nd)\,(\sin n\pi/2)\,(\sin n\omega t)$

∴ RMS value of fundamental component

$$V_{rms(fundamental)} = \frac{4V_s}{\sqrt{2}\,\pi} \sin d \times 1$$

$\alpha = 120°,\ 2d = 120° \Rightarrow d = 60°$

$$V_{rms(fundamental)} = \frac{4V_s}{\sqrt{2}\,\pi} \sin 60° = 0.78\ V_s = 0.78\ V$$

3. (d)
Ripple current is independent of E(back emf) so it remains same.

4. (c)

5. (c)
RMS output voltage for single-phase half-bridge inverter

$$\left(V_{0rms}\right)_{HB} = \frac{V_{dc}}{2}$$

Output power
$$P_{0\,HB} = \frac{\left(V_{0rms}^2\right)_{HB}}{R} = \frac{V_{dc}^2}{4R}$$

$$P_{0\,HB} = \frac{V_{dc}^2}{4R} \qquad ...(1)$$

RMS output voltage for single-phase full-bridge inverter

$$\left(V_{0rms}\right)_{FB} = V_{dc}$$

Output power
$$P_{0\,FB} = \frac{\left(V_{0rms}^2\right)_{FB}}{R} = \frac{V_{dc}^2}{R}$$

$$P_{0\,FB} = \frac{V_{dc}^2}{R} \qquad ...(2)$$

By dividing (1) with (2),

$$\frac{P_{0HB}}{P_{0FB}} = \frac{\dfrac{V_{dc}^2}{4R}}{\dfrac{V_{dc}^2}{R}}$$

$$4\,P_{0\,HB} = P_{0\,FB}$$

6. (a)

RMS value of fundamental component is

$$V_{1rms} = \frac{2V_{dc}}{\sqrt{2}\pi} = 10.8 \text{ V} \qquad V_{dc} = 24 \text{ V}$$

For a 1-ϕ half bridge inverter,

$$V_0 = \frac{V_{dc}}{2} = 12 \text{ V}$$

RMS harmonic voltage

$$\left|\sum_{n=3,5,7}^{\infty} V_{n_{rms}}^2\right|^{1/2} = \sqrt{V_0^2 - V_{1rms}^2} = \left[12^2 - (10.8)^2\right]^{1/2} = 5.23 \text{ V}$$

Total harmonic distortion (THD)

$$\text{THD} = \frac{1}{V_{1rms}}\left[\sum_{n=2,3}^{\infty} V_{n_{rms}}^2\right]^{1/2} = \frac{\sqrt{V_0^2 - V_{1rms}^2}}{V_{1rms}}$$

$$= \frac{5.23}{10.8} = 0.484 = 48.4\%$$

7. (b)

8. (d)

The advantages possessed by PWM technique are as under :–

(i) The output voltage control with this method can be obtained without any additional components.

(ii) With this method lower order harmonics can be eliminated or minimised along with its output voltage control. As higher order harmonics can be filtered easily, the filtering requirements are minimised.

9. (b)

The converter circuits which employ zero voltage and/or zero current switching are called resonant converters. These converters are basically used to reduce the switching losses.

10. (c)

A dual converter with circulating current mode is preferred if load current is to be reversed quite frequently and a fast response is desired in the four quadrant operation of the dual converter.

11. (a)

Approximately, the slip may be neglected, with the output inverter frequency related to synchronous speed.

$$N = \frac{120f}{P}$$

Also, at each condition, the voltage/frequency ratio = 220/50
hence the required inverter outputs are:

$$f = \frac{900 \times 4}{120} = 30 \text{ Hz}$$

$$\text{voltage} = \frac{220}{50} \times 30 = 132 \text{ V.}$$

12. (c)
We have, RMS value of fundamental component

$$V_{1rms} = \frac{2V_{dc}}{\sqrt{2}\pi} = 10.8\,\text{V}$$

The lowest harmonic is third harmonic.

$$\text{Third harmonic voltage is, } V_{3rms} = \frac{2V_{dc}}{3\pi\sqrt{2}} = 3.6\,\text{V}$$

$$V_{dc} = 24\text{ V}$$

HF for the third harmonic

$$HF_3 = \frac{V_{3rms}}{V_{1rms}} = \frac{3.6}{10.8} = 33.33\%$$

DF of the third harmonic

$$DF_3 = \frac{\left(V_{3rms}/3^2\right)}{V_{1rms}} = \frac{3.6/9}{10.8} = 0.037 = 3.7\%$$

13. (c)

Here $V_m = \sqrt{2} \times 230\,\text{V}$

Average output voltage

$$V_0 = \frac{3V_m}{\pi} = \frac{3\sqrt{2} \times 230}{\pi} = 310.60\text{ V}$$

Let the battery emf is E and average charging current is I_0 then,

$$V_0 = E + I_0R$$

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

14. (c)

The resistances $R_1 = R_2 = \frac{V_{dc}}{I} = \frac{120}{20} = 6\,\Omega$

Now, we have the relation for C for successful commutation as

$$C = 1.44\frac{t_{off}}{R_1} = 1.44 \times \frac{60 \times 10^{-6}}{6} = 14.4\,\mu\text{F}$$

15. (b)
For a three phase bridge inverter, rms value of output line voltage

$$V_{line(rms)} = \sqrt{\frac{2}{3}}V_{dc} \qquad V_{dc} = 500\text{ V}$$

$$= 0.816 \times 500 = 408\text{ V}$$

16. (c)

For a single-phase semiconverter feeding a separately excited motor.

$$V_0 = V_t = \frac{V_m}{\pi}(1+\cos\alpha) = E_a + I_a r_a$$

$$\frac{330}{\pi}(1+\cos 30°) = 80 + I_a \cdot 4$$

$$196.01 = 80 + I_a \cdot 4$$

∴ Average armature current,

$$I_a = \frac{196.01-80}{4} = 29\text{ A}$$

Motor torque,
$$T = \frac{E\,I_a}{2\pi \times \frac{N}{60}} = \frac{80 \times 29}{2\pi \times \frac{1400}{60}} = 15.82\text{ Nm}$$

17. (d)

KVL in the loop is,

$$-V + L\frac{di}{dt} = 0$$

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

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

Integrating on both sides,

$$\int dt = \int \frac{L}{V}di$$

$$t_{min} = \frac{0.1}{100} \times 4 \times 10^{-3}$$

$$t_{min} = 4\ \mu\text{s}$$

∴ The minimum width of the gating pulse required to properly turn on the SCR is 4 μs.

18. (d)

$$V_{03} = \frac{4\,V_s}{3\pi}\sin 3(\omega t) = \frac{4 \times 230}{3 \times \pi}\sin 3(\omega t)$$

$$= 97.6150 \sin(942.47t)$$

$$Z_3 = R + j\left(3\omega L - \frac{1}{3\omega C}\right)$$

$$= \quad 4 + j\left(3 \times 2\pi \times 50 \times 35 \times 10^{-3} - \frac{1}{3 \times 2\pi \times 50 \times 155 \times 10^{-6}}\right)$$

$$= \quad 4 + j(32.986 - 6.8453)$$

$$= \quad \sqrt{4^2 + (26.1407)^2}$$

$$Z_3 = 26.44\ \Omega$$

$$I_0 = \frac{97.6150}{\sqrt{2}} \times \frac{1}{26.44} = 2.61\text{ A}$$

19. (b)

In a single-phase semiconverter

$$\text{Input displacement factor (IDF)} = \cos\theta_1 = \cos\left(-\frac{\alpha}{2}\right)$$

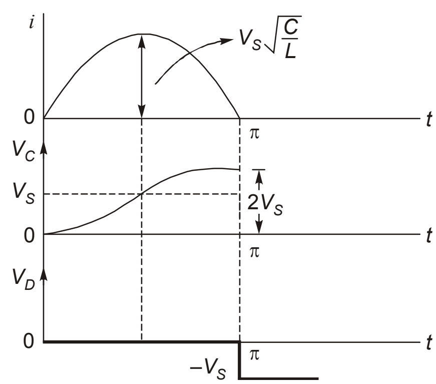
$$= \cos\left(\frac{\alpha}{2}\right) = \cos 30°$$

$$\text{IDF} = 0.866$$

$$\text{Current distortion factor (CDF)} = \frac{I_{s_1}}{I_s} = \frac{2\sqrt{2}\cos\frac{\alpha}{2}}{\sqrt{\pi(\pi - \alpha)}} = \frac{2\sqrt{2} \times 0.866}{\sqrt{\pi\left(\pi - \frac{60 \times \pi}{180}\right)}} = 0.955$$

20. (c)

The output voltage waveforms of the circuit is



according to the waveforms

voltage across inductor is zero, since inductor is short circuited for dc.

voltage $V_1 = -V_s = -100$ V

voltage $V_3 = 2V_s = 200$ V

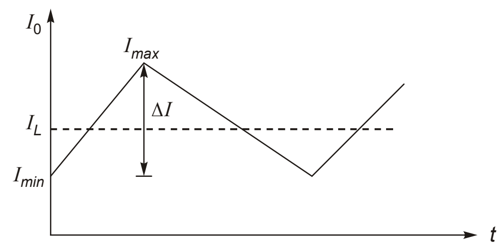
hence, the three voltages are – 100 V, 0, 200 V

21. (c)

IGBT and MCT are bipolar devices so the statements 2 and 4 are not correct.

22. (a)

Given chopper is a buck chopper so, $V_0 = \alpha V_s$



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

$$\Delta I = I_L = 2I_0$$

This is applicable only at boundary of continuous and discontinuous condition

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

23. (a)

24. (b)

Here in this case line commutated inverter means the battery is supplying power to source.

$$I_0 = \frac{5000}{450} = 11.11 \text{ A}$$

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

$$-E + I_0 R = \frac{3(400)\sqrt{2}}{\pi}\cos\alpha$$

$$-312.236 = 540.189\cos\alpha$$

$$\alpha = \cos^{-1}\left(\frac{-312.236}{540.189}\right)$$

$$\alpha = 125.31°$$

25. (c)

The diode will start conducting at an angle θ_1, where

$$\theta_1 = \sin^{-1}\frac{150}{\sqrt{2}\times 230} = 27.46°$$

Arrange value of charging current,

$$I_0 = \frac{1}{2\pi R}\left[\int_{\theta_1}^{\pi-\theta_1}(V_m \sin\omega t - E)\, d(\omega t)\right]$$

$$= \frac{1}{2\pi\times 8}\left[2\sqrt{2}\times 230\cos 27.46° - 150\left(\pi - \frac{2\times 27.46\times\pi}{180}\right)\right]$$

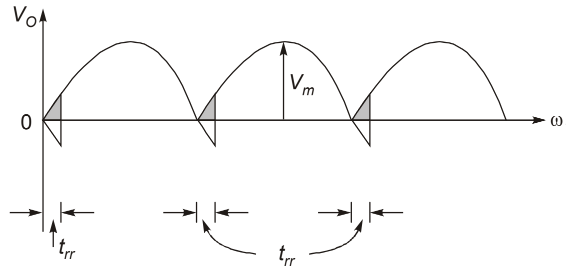
$$I_0 = 4.97 \text{ A}$$

power delivered to battery is,

$$P = E\times I_0 = 150\times 4.97$$

$$P = 745.5 \text{ W}$$

26. (a)



If reverse recovery time is taken into consideration, the diodes D_1 and D_2 will not be off at $\omega t = \pi$, but will continue to conduct until

$$t = \frac{\pi}{\omega} + t_{rr}$$

the reduction in output voltage is given by cross hatched area.
Average value of this reduction in output voltage is given by

$$V_r = \frac{1}{\pi}\int_0^{t_{rr}} V_m \sin\omega t \, d(\omega t)$$

$$V_r = \frac{V_m}{\pi}(1-\cos\omega\, t_{rr})$$

with zero reverse recovery time, average output voltage

$$V_0 = \frac{2V_m}{\pi} = \frac{2\sqrt{2}\times 230}{\pi} = 207.07 \text{ V}$$

for $f = 2500$ Hz, the reduction in the average output voltage,

$$V_r = \frac{V_m}{\pi}(1-\cos\omega t_{rr})$$

$$= \frac{\sqrt{2}\times 230}{\pi}\left(1-\cos 2\pi\times 2500\times 40\times 10^{-6}\times\frac{180}{\pi}\right)$$

$$= 19.77 \text{ V}$$

percentage reduction in average output voltage $= \frac{19.77}{207.07}\times 100$

$$= 9.55\%$$

27. (b)

If number of pulses increases, output waveform becomes more uniform dc. The harmonic content will be decreased.

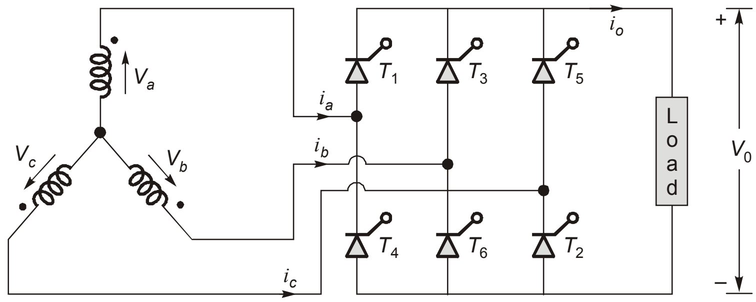
28. (a)

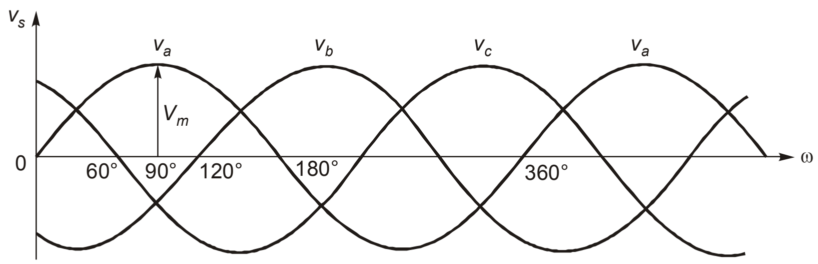
When zero of the triangular wave coincides with zero of the reference sinusoid, there are $(m-1)$ pulses per half cycle.

i.e., $\left(\frac{f_c}{2f}-1\right)$

$\therefore$ $(m-1)$

29. (a)





$$V_A = V_m \sin\omega t$$

Phase A will get maximum voltage at $\omega t = 90°$. At this instant

$$V_0 = V_A - V_B$$

$$V_0 = V_m \sin\omega t - V_m \sin(\omega t - 120°)$$

$$= V_m - V_m \sin(-30°) \qquad [\because \omega t = 90°]$$

$$V_0 = 1.5\, V_m$$

30. (c)

Even harmonics are always zero for a halfwave symmetry waveform.

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