CLASS TEST

S.No.: 01SK_ABCDEFGHI_140725

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POWER ELECTRONICS

ELECTRICAL ENGINEERING

Date of Test : 14/07/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)

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

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

or $(m - 1)$ puses per half cycle.

2. (d)

Let, V_1 = Output of buck converter = Input of boost converter

$$V_1 = 10\,D_1$$

$$\text{Output of boost converter} = 30\text{ V} = \frac{V_1}{1 - D_2}$$

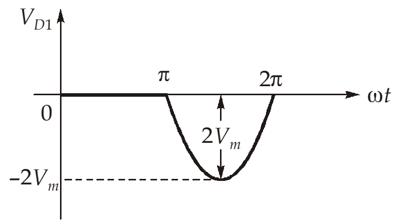
$$30 = \frac{10D_1}{1 - D_2}$$

or $$3 - 3\,D_2 = D_1$$

or $$D_1 + 3\,D_2 = 3$$

3. (b)

The waveform of voltage across diode,



$$V_m = V_{\text{rms}}\sqrt{2}$$

$$V_m = 280 \times \sqrt{2} = 395.97\text{ V}$$

Peak value of waveform shown above is

$$2\,V_m = 2 \times 395.97$$

$$2\,V_m = 791.94\text{ V}$$

The rms value of the wave form shown above is,

$$V_{D1,\,\text{rms}} = \left(\frac{\text{peak value}}{\sqrt{2}}\right) \times \sqrt{\frac{\pi}{2\pi}}$$

$$= \frac{791.94}{\sqrt{2} \times \sqrt{2}} = 395.97\text{ V}$$

4. (d)

For 1-ϕ semiconverter,

$$\text{Supply rms current, } I_{\text{rms}} = I_{dc}\left[\frac{\pi - \alpha}{\pi}\right]^{1/2} = I_{dc}\left[\frac{\pi - \pi/4}{\pi}\right]^{1/2} = 0.866\,I_{\text{dc}}$$

The rms value of the supply fundamental component of input current

$$I_{\text{rms},\,1} = \frac{2\sqrt{2}}{\pi} I_{dc} \cos\left(\frac{\alpha}{2}\right)$$

$$= \frac{2\sqrt{2}}{\pi} I_{dc} \cos\left(\frac{\pi}{4 \times 2}\right) = 0.83178\,I_{dc}$$

$$\text{Harmonic factor } (Hf) = \left[\left(\frac{I_{\text{rms}}}{I_{\text{rms},1}}\right)^2 - 1\right]^{1/2} = \left[\left(\frac{0.866 I_{dc}}{0.83178 I_{dc}}\right)^2 - 1\right]^{1/2} = 28.98\%$$

5. **(b)**

For Buck-converter

Average output voltage $= DV_s$

Where, D = Duty ratio, V_s = input voltage

V_s = 40 V, V_0 = 16 V

f = 20 kHz

$$16 = D \times 40$$

$$D = \frac{16}{40} = 0.4$$

Peak to peak ripple current,

$$\Delta I_L = \frac{V_s D(1-D)}{Lf}$$

$$0.8 = \frac{40 \times 0.4 \times 0.6}{L \times 20 \times 10^3}$$

$$L = 600\ \mu\text{H}$$

6. **(d)**

(a) Voltage drop in BJT is less as compare to MOSFET is correct statement.

(d) In MOSFET channel length is relatively small compare to channel width.

Other two statements are correct.

7. **(c)**

Due to absence of minority carrier reverse recover time of schottky diode is in nanosecond. It is used in SMPS.

8. **(a)**

For 1-ϕ full bridge inverter

V_{dc} = 60 V, R = 12 Ω

$$V_{01\ \text{rms}} = \frac{2\sqrt{2}\, V_{dc}}{\pi} = \frac{2\sqrt{2}}{\pi} \times 60 = 54.046\ \text{V}$$

$$\text{Power} = \frac{V_{01\text{rms}}^2}{R} = \frac{(54.046)^2}{12} = 243.41\ \text{W}$$

9. **(c)**

For 1-phase full-wave diode rectifier, rms value of output current

$$I_{0\ \text{rms}} = \frac{V_m}{\sqrt{2}R} = 120\sqrt{2}$$

$$\Rightarrow \quad V_m = 120 \times 2 \times R$$

$$= 240\ R$$

The charge is delivered by direct current

$$I_{dc} = \frac{2V_m}{\pi R} = \frac{2 \times 240R}{\pi R} = \frac{480}{\pi}\text{A}$$

Also, I_{dc} × time in hours = 500 Ah

∴ Time required to deliver this charge

$$= \frac{500 \times \pi}{480}\text{hrs} = 3.27\ \text{hrs}$$

10. (d)

Average output voltage,

$$V_0 = \frac{V_m}{\pi}(1 + \cos\alpha)$$

$$= \frac{230\sqrt{2}}{\pi}[1 + \cos 30°] = 193.20 \text{ V}$$

$$I_0 = \frac{V_0}{R} = \frac{193.20}{10} = 19.32 \text{ A}$$

$$\text{Reactive power} = V_0 I_0 \tan\left(\frac{\alpha}{2}\right) = 1 \text{ KVAR}$$

11. (d)

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

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

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

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

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

$$|Z_3| = \sqrt{4^2 + (26.1407)^2}\ \Omega$$

$$|Z_3| = 26.44\ \Omega$$

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

12. (a)

$$V_r = 4 \text{ V}$$

$$V_c = 6 \text{ V}$$

$$\text{Total pulse width} = 2d$$

$$\frac{2d}{N} = \left(1 - \frac{V_r}{V_c}\right)\frac{\pi}{N}$$ (Where N is number of pulses per half cycle)

$$2d = \left(1 - \frac{V_r}{V_C}\right)\pi$$

$$2d = \left(1 - \frac{4}{6}\right)180° = 60°$$

13. (a)

Average voltage with internal inductance (L_s)

$$V_{0\text{ avg}} = \frac{3V_{mL}}{\pi}\cos\alpha - \frac{3\omega L_s I_0}{\pi} \quad \text{...(i)}$$

$$V_{0\text{ avg}} = \frac{3V_{mL}}{\pi}\cos(\alpha+\mu) + \frac{3\omega L_s I_0}{\pi} \quad \text{...(ii)}$$

Where, $V_{mL} \rightarrow$ maximum line voltage

$\alpha \rightarrow$ firing angle
$\mu \rightarrow$ overlap angle
$L_s \rightarrow$ internal inductance
$I_0 \rightarrow$ load current

Subtract equation (i) from (ii),

$$\frac{3V_{mL}}{\pi}[\cos\alpha - \cos(\alpha+\mu)] = \frac{6\omega L_s I_0}{\pi}$$

$$\frac{3\times 400\times\sqrt{2}}{3.14}[\cos 36.86^\circ - \cos(36.86^\circ+\mu)] = \frac{6\times 2\pi\times 50\times 3.2\times 10^{-3}\times 20}{3.14}$$

$$\cos 36.86^\circ - 0.07105 = \cos(36.86^\circ + \mu)$$
$$36.86^\circ + \mu = \cos^{-1} 0.729$$
$$\mu = 43.192^\circ - 36.86^\circ$$
$$= 6.33^\circ$$

$$\text{Fundamental power factor} = \cos\left(\alpha+\frac{\mu}{2}\right) = \cos\left(36.86^\circ+\frac{6.33^\circ}{2}\right) = 0.7657$$

14. (c)

At rated condition,

$$P = 2.7 \text{ kW} = 2700 \text{ W}$$
$$V = 180 \text{ V}$$
$$I_{\text{rated}} = \frac{2700}{180} = 15 \text{ A}$$
$$\text{back emf} = E_b = 180 - 15\times 0.5 = 172.5 \text{ V}$$

Now, at duty ratio of 0.6

$$V = 200\times 0.6 = 120 \text{ V}$$

and at 70% of rated torque

$$\text{armature current} = 0.7\times 15 = 10.5 \text{ A}$$
$$\text{back emf } (E_b') = 120 - 10.5\times 0.5$$
$$= 114.75 \text{ V}$$

We know,

$$\text{back emf} \propto \text{speed}$$
$$\frac{E_b}{E_b'} = \frac{N_{\text{rated}}}{N}$$
$$\frac{172.5}{114.75} = \frac{1200}{N}$$
$$N = 798.26 \text{ rpm}$$

15. (d)

$$I_{L\text{ avg}} = \frac{I_{\max}+I_{\min}}{2} = \frac{25+15}{2}\text{A} = 20 \text{ A}$$

$$I_{L\text{ avg}} = \frac{I_0}{1-D}$$

Where, I_0 = output current, D = duty ratio

$$T_{ON} = 15\ \mu\text{sec},$$
$$T_{OFF} = 10\ \mu\text{sec}$$
$$D = \frac{T_{ON}}{T_{ON}+T_{OFF}} = \frac{15}{15+10} = \frac{15}{25} = \frac{3}{5} = 0.6$$
$$f = \frac{1}{T} = \frac{1}{T_{ON}+T_{OFF}} = \frac{1}{25}\times 10^6 = 40\text{ kHz}$$
$$I_{L\text{ avg}} = \frac{I_0}{1-D}$$
$$I_0 = 20\times\left(1-\frac{15}{25}\right) = 8\text{ A}$$

For boost converter, $\Delta V_0 = \Delta V_C = \dfrac{DI_0}{fC} = \dfrac{0.6\times 8}{40\times 10^3\times 150\times 10^{-6}} = 0.8\text{ V}$

16. (a)

For 3-ϕ half controlled instantaneous source current,

$$I_s = \frac{4I_0}{n\pi}\sin\left(\frac{n\pi}{3}\right)\cos\left(\frac{n\alpha}{2}\right)\sin(n\omega t - n\alpha)$$
$$(I_{s1})_{rms} = \frac{2\sqrt{2}I_0}{\pi}\cdot\frac{\sqrt{3}}{2}\cdot\cos\left(\frac{\alpha}{2}\right)$$
$$= \frac{\sqrt{6}}{\pi}I_0\cos\left(\frac{\alpha}{2}\right)$$

Also, $(I_s)_{rms} = I_0\sqrt{\dfrac{2}{3}}$, When $\alpha < 60°$

$= I_0\sqrt{\dfrac{\pi-\alpha}{\pi}}$, When $\alpha > 60°$

Distortion factor, $(\text{DF}) = \dfrac{(I_{s1})_{rms}}{(I_s)_{rms}} = \dfrac{\sqrt{6}}{\pi}\cdot\dfrac{I_0\cos\left(\frac{\alpha}{2}\right)}{I_0\sqrt{\frac{2}{3}}}$

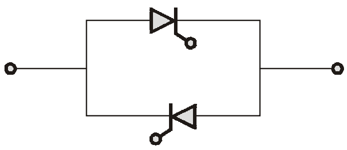
$$= \frac{3}{\pi}\cdot\cos\left(\frac{\alpha}{2}\right)$$

Power factor $= (DF)\cdot\cos\left(\dfrac{\alpha}{2}\right)$

$$= \frac{3}{\pi}\cos^2\left(\frac{\alpha}{2}\right) = \frac{3}{\pi}\cos^2\left(\frac{35}{2}\right)$$
$$= 0.869$$

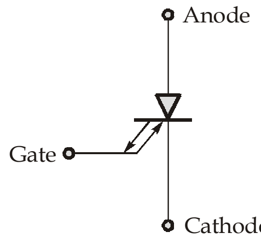
17. (a)

TRIAC



Bidirectional and Bipolar

GTO



It is also unidirectional and bipolar

18. (d)

This is buck converter circuit

The critical value of inductor L_C is,

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

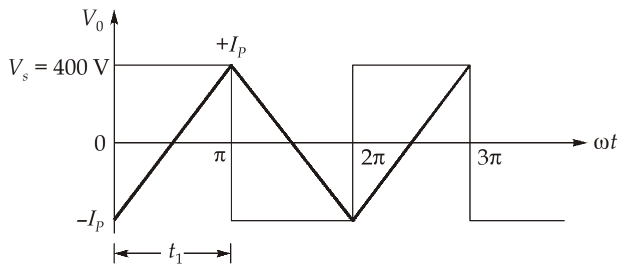
Where,
$$\alpha = \frac{V_0}{V_s} = \frac{5}{12} = 0.4166$$

$$L_C = \frac{(1-0.4166)500}{2\times 25\times 10^3} = 5.83 \text{ mH}$$

Critical value of capacitance,

$$C_c = \frac{1-\alpha}{16L_c f^2} = \frac{1-0.4166}{16\times 5.83\times 10^{-3}\times (25\times 10^3)^2} = 10 \text{ nF}$$

19. (a)



From $0 < \omega t < \pi$ the load current tends to peak value.

At t_1 peak value of output current is I_P.

$$t_1 = \frac{\pi}{\omega} = \frac{\pi}{2\pi\times 50} = \frac{1}{100} s$$

At $t = 0$,

$$i_0 = -I_P$$

$$V_0 = L\frac{di}{dt}$$

$$400 = 0.5\left(\frac{I_P-(-I_P)}{t_1-0}\right)$$

$$400 = 0.5\times\frac{2I_P}{t_1}$$

$$\frac{400}{0.5\times 2}\times\frac{1}{100} = I_P = 4 \text{ A}$$

20. (c)

The circuit is a oscillatory circuit,

$$i(t) = V_s\sqrt{\frac{L}{C}}\sin\omega t$$

$$i(t) = 250\sqrt{\frac{100}{25}}\sin\omega t$$

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

$$i(t) = 500 \sin \omega t \text{ A}$$

For maximum value of current

$$\sin \omega t = 1$$

$$\omega t = \frac{\pi}{2}$$

$$t = \frac{\pi}{2\omega} = \frac{\pi}{2\times\frac{1}{\sqrt{LC}}} = \frac{\pi\sqrt{LC}}{2} = \frac{\pi\sqrt{25\times10^{-6}\times100\times10^{-6}}}{2}$$

$$t = 78.5\ \mu\text{s}$$

$$V_c = \frac{1}{C}\int_0^{157\mu\text{sec}} 500\sin\omega t\, dt - 250$$

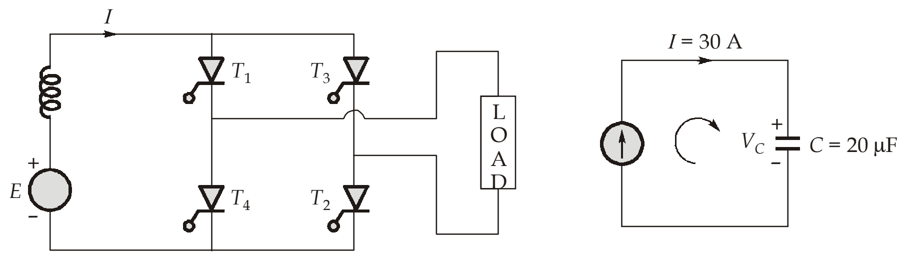
$$= \frac{500}{\omega C}\left(-\cos\omega t\Big|_0^{157\mu s}\right) - 250$$

$$= -250\ (1 - 1) - 250$$

$$V_C = -250 \text{ V}$$

21. (b)

During the on period of T_1 and T_2 the circuit behaves as

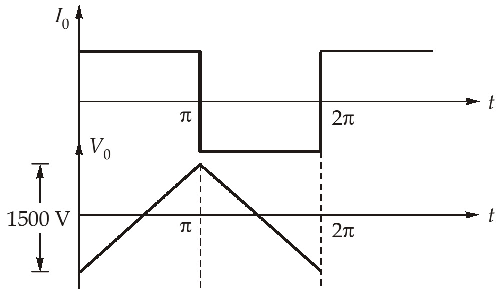


$$V_C = \frac{1}{C}\int_0^{t_{on}} i\,dt$$

$$V_C = \frac{30}{20\times10^{-6}}T_{on}$$

Where $$T_{on} = \frac{1}{2f} = \frac{1}{2\times500} = 1\times10^{-3}\text{ s}$$

$$V_C = \frac{30}{20\times10^{-6}}\times1\times10^{-3} = 1500 \text{ V}$$



Peak to peak of output voltage is 1500 V.
The reverse voltage that appears across thyristor is 750 V.

22. (b)

The line current of a 3-phase fully controlled converter is,

$$i_{sn} = \sum_{n=1,3,5...}^{\infty} \frac{4I_0}{n\pi} \sin\frac{n\pi}{3} \sin(n\omega t - n\alpha)$$

Rms value of 5th harmonic current,

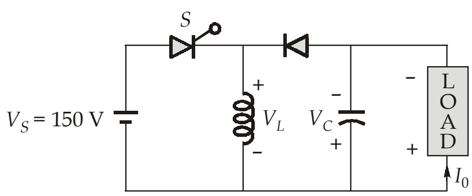
$$I_{s5} = \frac{4I_0}{\sqrt{2}\times 5\pi}\sin\left(\frac{5\pi}{3}\right) = -0.15593\ I_0$$

and,
$$I_{s1} = \frac{4I_0}{\sqrt{2}\,\pi}\sin\left(\frac{\pi}{3}\right) = 0.7796\ I_0$$

Percentage of 5th harmonic to fundamental

$$= \frac{I_{s5}}{I_{s1}}\times 100 = \frac{-0.15593}{0.7796}\times 100 = -20\%$$

23. (b)



The given chopper is Buck-Boost

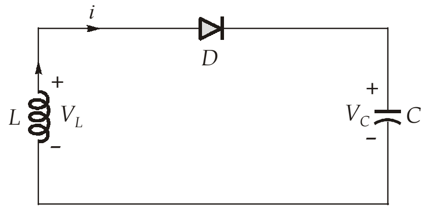
$$V_0 = \frac{V_S \times D}{1-D}$$

$$V_0 = \frac{150\times 0.4}{1-0.4} = \frac{150\times 4}{6} = 100\ \text{V}$$

but in question they asked opposite to the actual polarity

so, V_0 = – 100 V

24. (a)



$$V_L + V_C = 0$$

$$L\frac{di(t)}{dt} + \frac{1}{C}\int i(t)dt = 0$$

Applying Laplace transform

$$LsI(s) - LI(0^+) + \frac{1}{Cs}I(s) = 0$$

$$I(s)\left[Ls + \frac{1}{Cs}\right] = LI(0^+)$$

$$I(s) = \frac{LCs\,I(0^+)}{LCs^2 + 1}$$

$$I(s) = \frac{LCI(0^+)\cdot s}{LC\left(s^2 + \frac{1}{LC}\right)}$$

$$I(s) = I(0^+)\cdot\frac{s}{s^2 + \left(\frac{1}{\sqrt{LC}}\right)^2}$$

Applying inverse Laplace transform

$$i(t) = I(0^+)\cos\frac{1}{\sqrt{LC}}t = I(0^+)\cos\omega t$$

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

After $t = \frac{\pi}{2}$ currents gets reverse i.e. negative current diode will not allow, so conduction angle $= \frac{\pi}{2}$

$$\omega t = \frac{\pi}{2}$$

$$t = \frac{\pi}{2\omega} = \frac{\pi}{2\times\frac{1}{\sqrt{LC}}} = \frac{\pi\sqrt{LC}}{2} = 38.47\ \mu s$$

25. (a)

$$\%\ \text{THD} = \frac{\sqrt{V_{0,rms}^2 - V_1^2}}{V_1}\times 100$$

Rms value of output voltage $= V_s\sqrt{\frac{2d}{\pi}}$

Pulse width, $2d = 150°$(given)

$d = 75°$

$$V_{0,\,rms} = V_s\sqrt{\frac{2\times 75}{180}} = 0.9128\,V_s$$

$$V_{01,\ rms} = \frac{4V_s}{\sqrt{2}\pi}\sin\frac{\pi}{2}\sin 75° = 0.8696\ V_s$$

$$\%\ \text{THD} = \frac{\sqrt{(0.9128V_s)^2 - (0.8696V_s)^2}}{0.8696V_s} \times 100 = 31.92\%$$

26. (b)

Maximum value of line voltage,

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

Average output voltage,

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

$$V_0 = E + I_0R$$

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

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,

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

27. (b)

Due to source inductance,

Average reduction in output voltage,

$$\Delta V_{d0} = 4fL_sI_0$$

$$= 4 \times 50 \times (12 \times 10^{-3}) \times 16 = 38.4\ \text{V}$$

$$\Delta V_{d0} = \frac{V_m}{\pi}[\cos\alpha - \cos(\alpha + \mu)]$$

As $\alpha = 0°$ for diodes

$$38.4 = \frac{V_m}{\pi}[1 - \cos\mu]$$

$$38.4 = \frac{230\sqrt{2}}{\pi}[1 - \cos\mu]$$

$$\cos\mu = 1 - 0.37$$

$$\mu = \cos^{-1} 0.63$$

$$\mu = 50.95°$$

∴ Conduction angle of diode

$$= 180° + 50.95°$$

$$= 230.95°$$

28. (c)

Output voltage of Buck boost converter,

$$V_0 = \frac{-D}{1-D}V_S = \frac{-0.3\times 28}{1-0.3}$$

$$= \frac{-0.3}{0.7}\times 28 = -12\text{ V}$$

Average current through inductor,

$$I_L = \frac{V_S D}{R(1-D)^2} = \frac{28\times 0.3}{5(0.7)^2} = 3.42\text{ A}$$

29. (b)

$$m_i = \text{modulation index} < 1$$

$$V_{01\text{ (peak)}} = \frac{m_i V_{dc}}{2} = \frac{0.8\times 200}{2} = 80\text{ V}$$

$$I_{01\text{ (peak)}} = \frac{V_{01\text{peak}}}{\sqrt{R^2+(\omega L)^2}} = \frac{80}{\sqrt{8^2+(12)^2}}$$

$$= \frac{80}{14.422} = 5.547 \approx 5.55\text{ A}$$

30. (d)

Total energy loss, $E_{\text{total}} = E_{t1} + E_{t2}$

$$E_{t1} = \int_0^{t_1} Vi\cdot dt$$

As voltage across the switch is constant ie. 500 V

$$= 500\int_0^{t_1} i\cdot dt = 500\times\frac{1}{2}\times(0.4\times 10^{-6})\times 40 = 4\text{ mJ}$$

Similarly $E_{t2} = \int_0^{t_2} Vi\cdot dt$

As switch current is constant ie. 30 A

$$E_{t2} = 30\int_0^{t_2} V\cdot dt = 30\times\frac{1}{2}\times(0.4\times 10^{-6})\times 500 = 3\text{ mJ}$$

∴ total energy loss in process

$$= 4\text{ mJ} + 3\text{ mJ} = 7\text{ mJ}$$

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