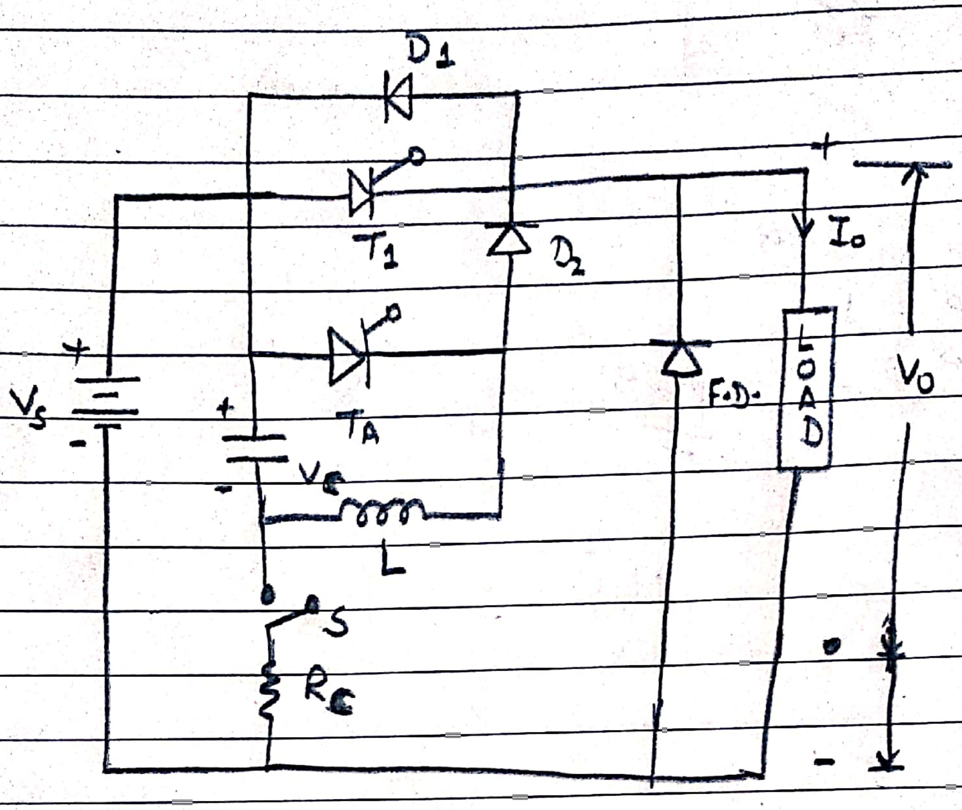
Date
Page

Que: 06 Explain the working of current commutated chopper. Also, draw the associated waveforms.

Ans:



- Capacitor is charged to V_s, main thyristor T_1 is fired at $t = 0$. So the load voltage $V_o = V_s$.

- At $t = t_1$, auxiliary thyristor is turned on commutate main thyristor.

- Within turning on a T_A, an oscillatory current i_c is set up in the circuit.

$$\boxed{i_c = \frac{V_s}{\omega_0 L}\sin\omega_0 t = V_s\sqrt{\frac{C}{L}}\sin\omega_0 t}$$

Date
Page

- At t_2, $V_C = -V_s$ & i_C tends to reverse in the auxiliary thyristor T_A, it gets naturally commutated.

- As T_A is reverse biased & turned off at t_2. oscillatory current i_C begins to flow through C, L, D_2 & T_1.

- At t_3. i_C rises to i_0 so that $i_{T_1} = 0$. As a result main SCR T_1 is turned off at t_3. Since oscillating current through T_1 turns it off it is called current commutated chopper.

- After t_3, i_C supplies load current I_0 & the excess current, $i_{D_1} = i_C - I_0$ is conducted through diode D_1.
- After t_4, a constant current equal to I_0 flows through V_s, C, L, D_2 and Load.

- Capacitor C is charged linearly to source voltage V_s at t_5, so during time $(t_5 - t_4)$. $i_C = I_0$.

- In this commutation an opposite current pulse will be injected through SCR. As a result currents decreases and finally comes to zero if both the currents would be equal & opposite.

- Anti parallel diode is useful to apply the reverse voltage after current through SCR becomes to zero. The value of reverse voltage is low. So:

1. Turn off time increases.
2. Turn off power loss increases.

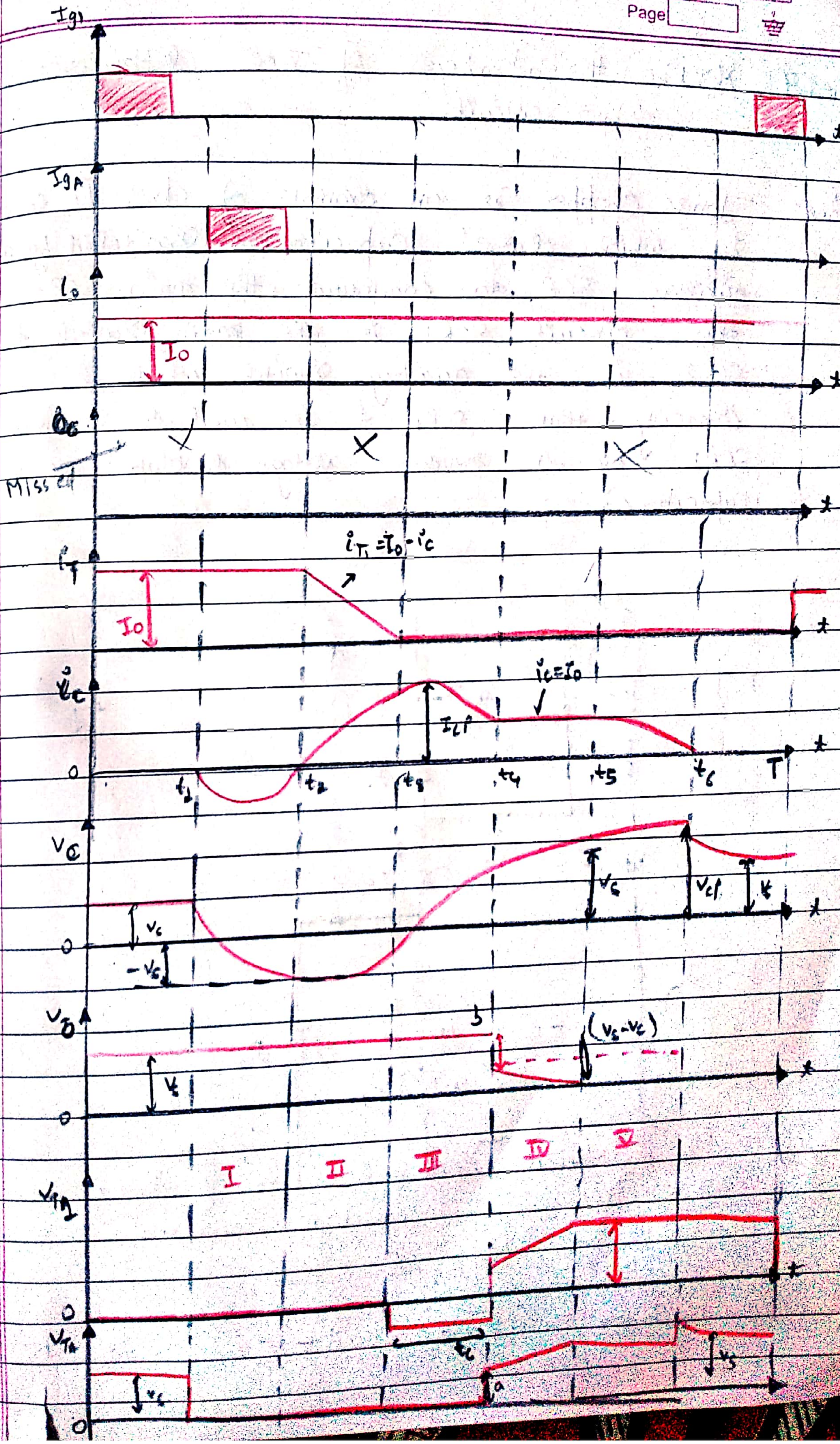
$$L = \frac{V_s \cdot t_c}{(x I_0)\left[\pi - 2\sin^{-1}\left(\frac{1}{x}\right)\right]}$$

$$x = \frac{I_{cp}}{I_0}$$

$$C = \frac{(x I_0)\, t_c}{V_s\left[\pi - 2\sin^{-1}\left(\frac{1}{x}\right)\right]}$$

I_{o}

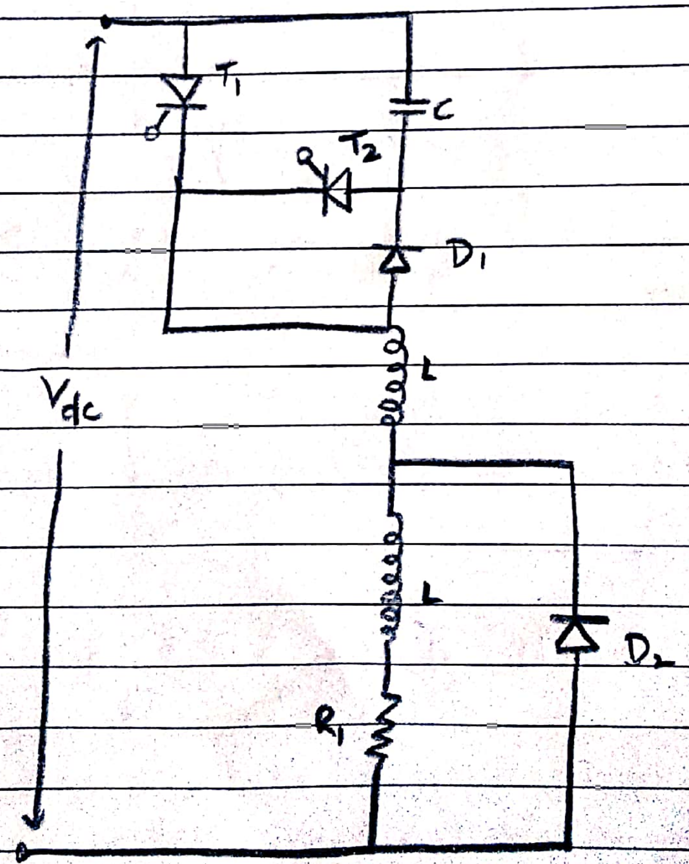
Waveform :



Date
Page

Que:07 Mention the advantages of Jones Chopper over other chopper circuits.

Ans: Jones Chopper is an example of class D commutation in which charged capacitor is switched by an auxilary SCR to commutate the main SCR. In this circuit SCR1 is the main switch & SCR2 is the auxilary switch which is lower capacity than SCR_1 & is used to commutate SCR1 by a reverse voltage developed across the capacitor C.



Advantages :

* It allows the use of higher voltage and lower microfarad commutating capacitors. This is because the trapped energy of inductor L_2 can be forced in to the commutating capacitor rather than simply charging the capacitor by supply voltage.

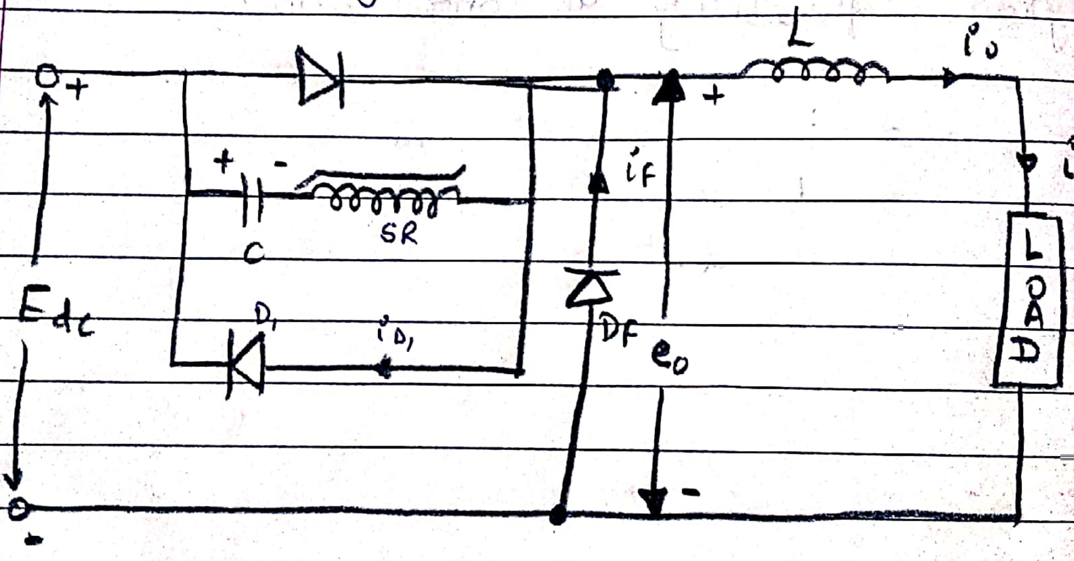
- In this circuit there is no starting problem & anyone of the SCR can be turned on initialy there is great flexibility in control aslo.

Date

Page

Que:08 Describe Morgan chopper with associated voltage & current waveforms.

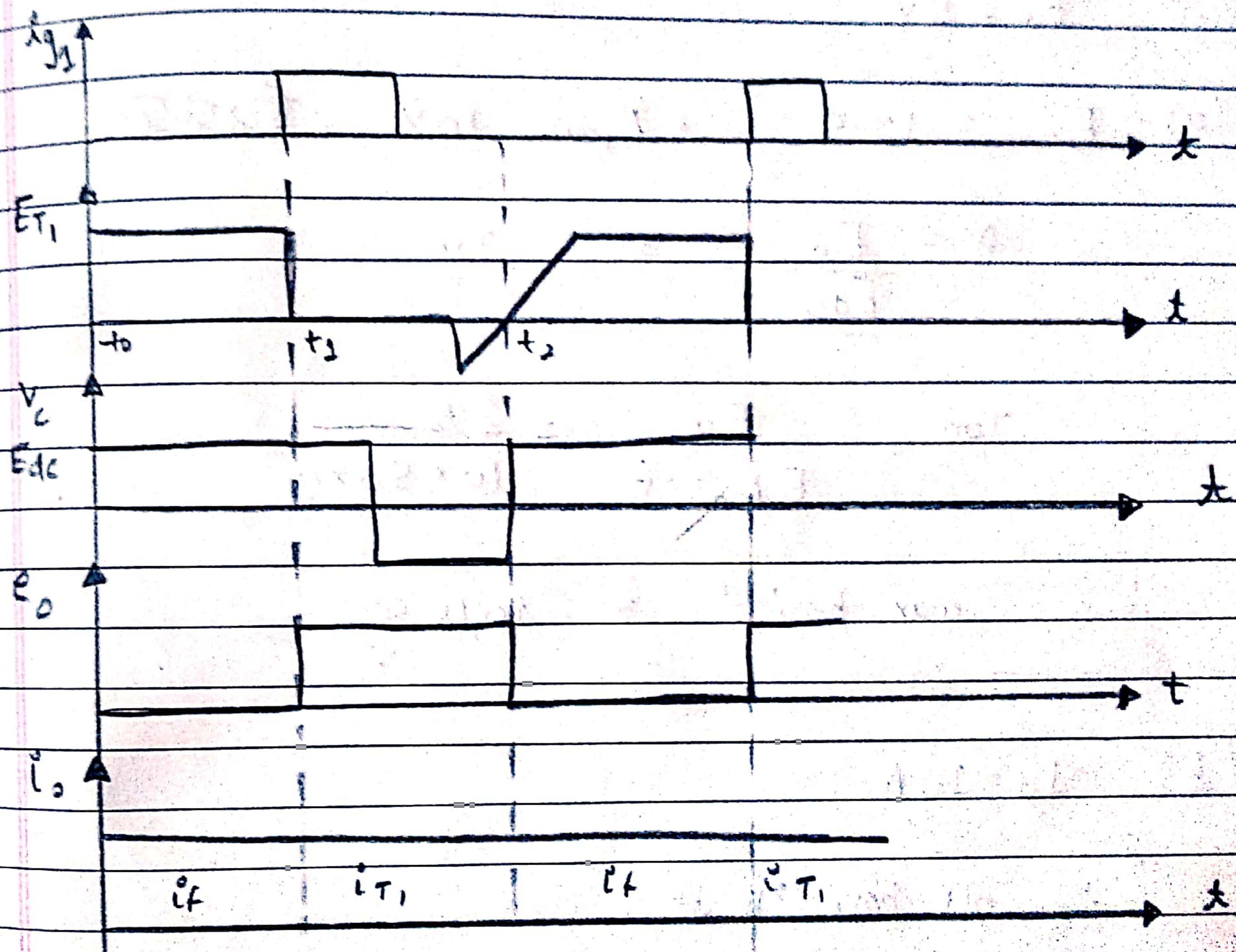
Ans: Figure shows the power - circuit of Morgan chopper. In this circuit, T_1 is the main thyristor, whereas capacitor C, saturable reactor SR and diode D_1 forms the commutating circuit. The exciting current of the saturable reactor is assumed to be negligible small. When the saturable reactor is saturated, it has very low inductance.



When the SCR T_1 is OFF, capacitor C will charge to the supply voltage E_{dc} with the polarity as shown in figure. And the saturable reactor is placed in the positive saturation condition. The capacitor charging path is

E_{dc+} - C - SR - Load - E_{dc}

Thyristor T_1 is triggered at time $t = t_1$. When thyristor T_1 is turned on, the capacitor voltage appears across the saturable reactor & the core flux is driven from the positive saturation towards negative saturation.



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Ques: A buck converter operating at 50kHz is fed from a 12V battery & supplies 5V to load. Neglecting switch & device losses determine:

Sol:ⁿ $E_0 = 5V$

(a) $E_{dc}max = 13.5$; $E_{dc}min = 10V$

$$\alpha = \frac{E_0}{E_{dc}} = \frac{T_{on}}{T}$$

$$T_{on} = \frac{E_0}{E_{dc\,min} \cdot f} = \frac{5}{10 \times 50 \times 10^3}$$

10

max period = 10μ sec

(b) $I_0 = 10A$

then o/p power'll be

$$E_{dc} \cdot I_s = E_0 \cdot I_0$$
$$12 \times I_s = 5 \times 10$$

$$\boxed{I_s = 4.16}$$

(c) $\Delta I = 500mA$

$$L = \frac{5(10-5)}{5 \times 10^3 \times 10 \times 500 \times 10^{-3}} = 100 \mu H$$

Date
Page

Que: 10 Design the Jones chopper circuit for optimum frequency considerations to meet the following specifications.

Soln: $E_{dc} = 200V$, Load current, $I_o = 50A$ & $t_q = 200\mu s$.

(i) $C \geq \frac{\pi}{2} \frac{t_q}{E_{dc}} I_o \geq \frac{\pi}{2} \frac{200 \times 10^{-6} \times 50}{200} \geq 78.54\mu F$

(ii) Capacitor voltage rating = safety factor × E_{dc}

$= 1.5 \times 200 = 300V$

(ii) Selection of induction L_1

$t_q = \sqrt{L_1 C}$

$L_1 = \frac{(t_q)^2}{C} = \frac{200 \times 200 \times 10^{-12}}{78.54 \times 10^{-6}} = 0.51$

$L_1 = L_2 = 0.51mH$

(iii) Selection of SCR T_1

V_{BO} = Saftey factor × $E_{dc} = 1.5 \times 200 = 300V$

I_T = " × $I_o = 1.5 \times 50 = 75A$.

(iv) Selection of auxiliary SCR T_2

Turn off time - $t_q \leq \frac{\pi}{2}\sqrt{L_1 C} \leq \frac{\pi}{2}\sqrt{0.51 \times 10^{-3} \times 78.54 \times 10^{-6}}$

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$t_q \simeq 250\,\mu s$

(V) Selection of diode D_1

PIV rating of diode = V_{BO} of SCR = 300V

$$I_D = I_T = 75A$$

(VI) SCR dynamic characteristics

(a) Main SCR T_1, $\frac{dv}{dt} = \frac{I_{o\,max}}{C}$

$$= \frac{50}{78.54 \times 10^{-6}}$$

$$= 0.64 \text{ volts per } \mu s$$

$$\frac{di}{dt} = \frac{E_{Rem}}{L_1}$$

$$= \frac{\text{safety factor} \times E_{dc}}{L_1} = \frac{1.5 \times 200}{0.51 \times 10^{-3}}$$

$$= 0.59\ A/\mu s$$

(b) $T_2 = \frac{dv}{dt} = \frac{E_{peak}}{\sqrt{L_1 C}}$

$$= \frac{1.5 \times 200}{\sqrt{0.51 \times 10^{-3} \times 78.54 \times 10^{-6}}} = 1.49\,V/\mu s$$

Date
Page

$$\frac{di}{dt} = \frac{E_{peak}}{L_s}$$

$$= \frac{1.5 \times 200}{2\,\mu H} = 150\,A/\mu s$$

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