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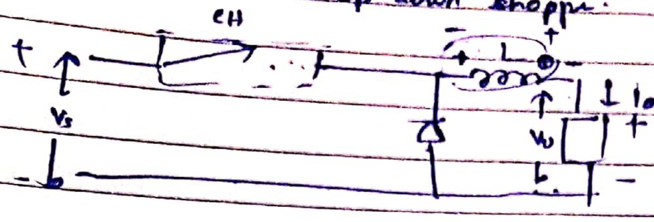
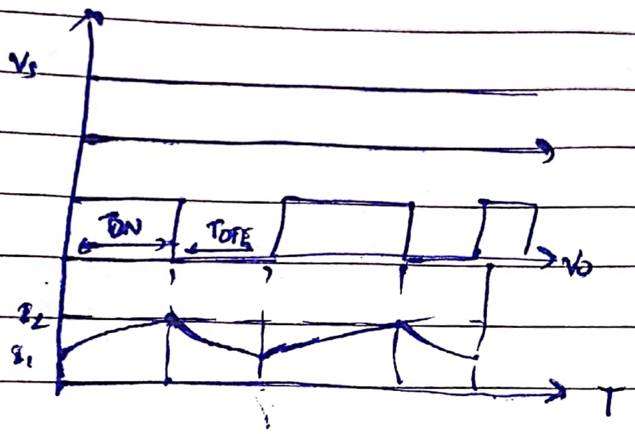
Step down chopper.



CH OFF $V_0 = 0$

CH ON $V_0 = V_s$



energy concept

$V_s + L = V_0$

$L = V_0 - V_s$

$(V_0 - V_s) \times \frac{I_1 + I_2}{2} \times T_{ON} = \left(\frac{I_1+I_2}{2}\right) V_0 \times T_{OFF}$

$L - V_0 = 0$

$V_s + L = V_0$

$V_s - L = V_0$

$L = V_s - V_0$

$V_0 \times T_{ON} = V_0 \times T$

$V_0 = V_s \times \frac{T}{T_{ON}}$

$(V_s - V_0) \times \frac{I_1 + I_2}{2} \times T_{ON} = (V_0) \times \frac{I_1 + I_2}{2} \times T_{OFF}$

$V_s \times T_{ON} = V_0 \times T$

$V_0 = V_s \times \frac{T_{ON}}{T}$

Conserving energy in the inductor at both time during T_{ON} and T_{OFF}

$$(V_s - V_0) \times \cancel{\left(\frac{I_1 + I_2}{2}\right)} \times T_{ON} = V_0 \times \cancel{\left(\frac{I_1 + I_2}{2}\right)} \times T_{OFF}$$

$$T_{ON} \times V_s = V_0 \times T$$

$$V_0 = V_s \times \frac{T_{ON}}{T}$$

$$V_0 = V_s \times D$$

duty cycle can be varied to get the necessary voltage

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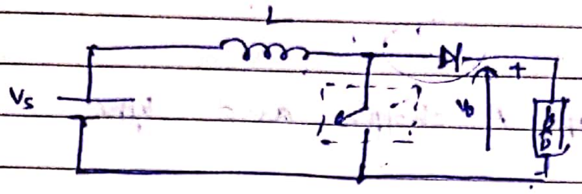
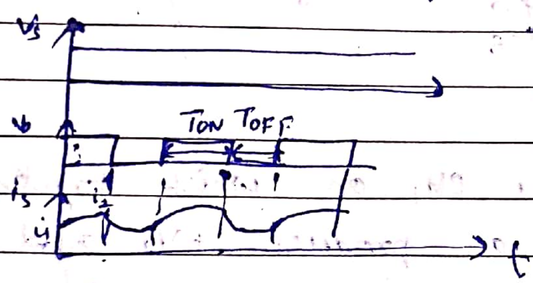
Step up choppe :

The avg. V_0 in a step up choppe > (V_s). The figure below shows a configuration of a step up choppe.



current and voltage waveforms.

V_0 is +ve when choppe is switched on and -ve when chopper is off.



where: T_{ON} - time interval when choppe is on;
T_{OFF} - time interval when choppe is off.
V_L - Load Voltage.

Assuming that the energy in the conductor will not change during on and off state so:

$E_{ON} = V_L I_L t$ $\qquad I_L = \frac{i_1 + i_2}{2}$ ⇒ average current across L

$= V_L \frac{(i_1 + i_2)}{2} \times t$

$E_{ON} = V_s \times T_{on} \frac{(i_1 + i_2)}{2}$ $\qquad V_L = V_s$ during on state

$E_{OFF} = (V_0 - V_s) \times T_{OFF} \times \frac{(i_1 + i_2)}{2}$

$\alpha = \frac{T_{ON}}{T_{OFF}}$ $\qquad \alpha$ = duty

$V_s \times T_{ON} = (V_0 - V_s) \times T_{OFF}$

$V_s (T_{ON} + T_{OFF}) = V_0 \times T_{off}$

$\boxed{V_0 = V_s (1 + \alpha)}$

$\alpha = 0$

$V_0 = V_s$

$\alpha = 1$

Good Write

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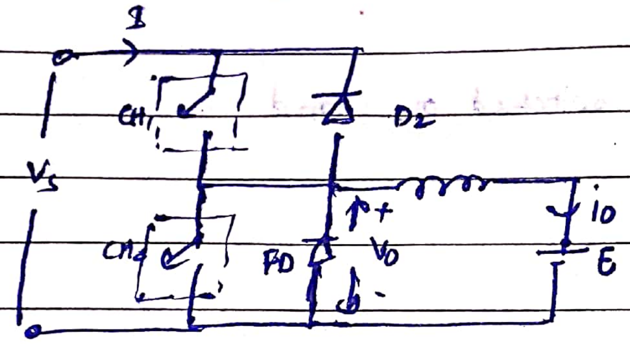
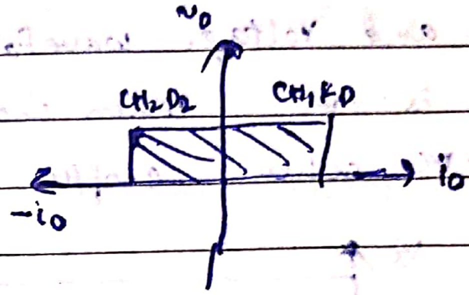
Two Quadrant chopper:

In a 2 quadrant chopper 2 different types of chopper are connected in parallel.

For eg. Type - C chopper:

It is made by connecting type A chopper and type B chopper in parallel.

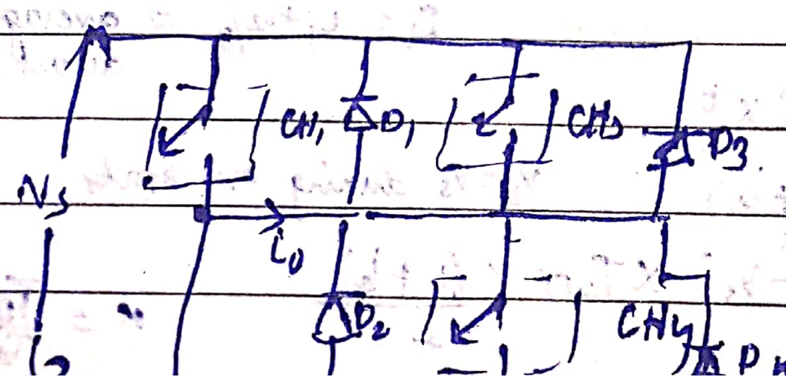




First when ~~map~~ make the CH_1 on which together with FD produce a produce $+V_0$ and $+i_0$

Next when we make the CH_1 off and CH_2 on it acts like a type - B chopper and produce a $+V_0$ and $-i_0$. which gives us the 2 quadrant chopper.

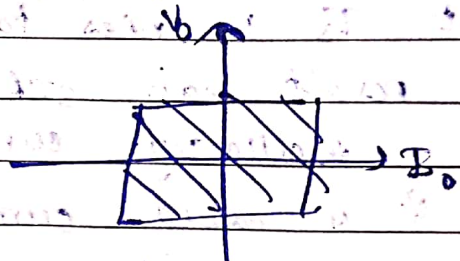
Four Quadrant chopper



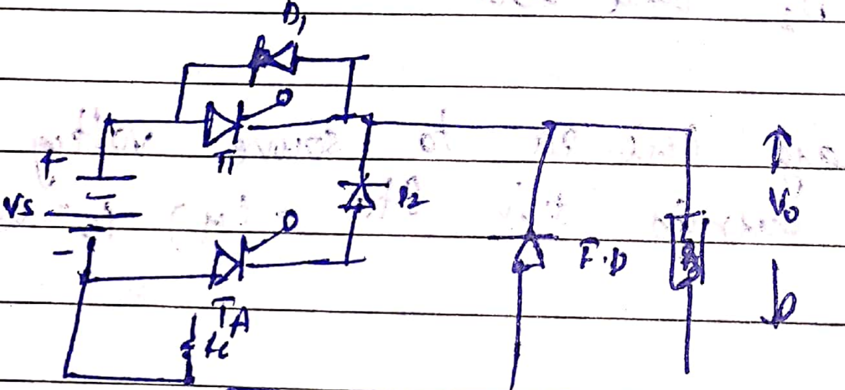
• First Quadrant: During the first Quadrant operation the chopper CH_4 will be on. Chopper CH_3 will be off and CH_1 will be operated. As the CH_1 and CH_4 is on the load voltage V_0 will be equal to source voltage V_s and $I_L = i_0$ will begin to flow. V_0 is +ve and i_0 is +ve.

• Second Quadrant: In this case CH_2 will be operating and other 3 are kept off. As CH_2 is on negative current will start flowing through the inductor L. When ch_2 is off the current will be fed back to source through the Diodes D_1 and D_4. Here $E + L\frac{di}{dt}$ will be more than source voltage V_s

Similarly 3rd and 4th Quadrant will function out to give the following graph



Que 6) Explain the working of current commutated chopper. Also draw its associate waveform



Capacitor is charged to V_s, main thyristor T_1 is fired at $t = 0°$, so the load voltage $V_0 = V_s$

At $t = t_1$ auxillary thyristor is turned on comutate main thyristor.

within turning or a TA, an oscillator current i_c is set up in the ckt.

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

At t_2, $V_c = -V_s$ & i_c tends to reverse in the auxilary thyristor TA, it gets naturally commutate

As TA is reverse biased & turnes off at t_2 oscillatory current i_c begin 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 oscillatory current through T_1 turns it off. it is called current commutate copn.

After t_4, a constant current equal to I_0 flows throug V_s, C, L, D_2 and Load

Capacitor C is charge line ea to source voltag V_s at t_5, so during tie $(t_5 - t_4)$ $i_c = I_0$.

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Numerical Que: 09

Q9)
Sol^n : $E_0 = 5V$

a) E_d max $= 13.5$, E_{dl} min $= 10V$

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

$$T_{ON} = \frac{E_0}{E_{dmin} \cdot F} = \frac{5}{10 \times 50 \times 10^3}$$

max period $= 10 \mu sec$.

b) $I_0 = 10A$
the o/p pow || I_s
$$E_{dc} \cdot I_s = E_0 \cdot I_0$$
$$12 \times I_s = 5 \times 10$$
$$\boxed{I_s = 4.16}$$

c) $\Delta I = 500mA$
$$A = \frac{5(10-5)}{5 \times 10^3 \times 10 \times 500 \times 10^{-3}} = 100 \mu H.$$

Q10) $E_{dc} = 200V$, Load an $= I_0 = 50A$ & $t_q = 200 \mu s$.

① $$C \geq \frac{\pi}{2} \frac{t_q}{E_{dc}} I_0 \geq \frac{\pi}{2} \frac{200 \times 10^{-6}}{200} \times 50 \geq 78.54 \mu F.$$

capacitor voltage rating = safety factor × Eac
$= 1.5 \times 200 = 300V$.

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(ii) selection of induction L_1

$$t_q = \sqrt{L_1 C}$$

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

$L_1 = L_2 = 0.51\,mH$

(iii) selection of SCR T_1

V_{BO} = safety factor × E_{dc} = 1.5×200 = 300 V.

I_T = " " × I_0 = $1.5 \times 50 = 750$

(iv) Selection of auxilary scr T_2

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

$t_q \cong 250\,\mu s$.

(v) selection of Diode D_1

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

$I_D = I_T = 75A$

(vi) SCR dynamic characdes

Main SCR T_1 $\frac{dv}{dt} = \frac{I_{0max}}{C}$

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

$= 0.64\,V/\mu s$.

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

= $\frac{\text{safety factor} \times E_{dc}}{L}$ = $0.59\,A/\mu s$

$T_2 = \frac{dv}{dt} = \frac{E_{peak}}{\sqrt{L_1 C}}$ $\frac{di}{dt}$ = -B.O

$= 1.49\ \mu s$

$\frac{di}{dt} = \frac{E_{peak}}{L} = 1.5 \frac{\times 400}{2\mu H} = 150 A/\mu s$.

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