IAT-3

7. $V_s = 5V$.
$V_a = 15V$.
$I = 0.5A$
$f = 25kHz$
$L = 220\mu H$.
$C = 220\mu F$

1. Duty cycle:-

$$V_a = \frac{V_s}{1-k}.$$

$$V_a - V_a k = V_s$$

~~$V_a - V_s$~~

$$15 = \frac{5}{1-k}$$

$$1-k = \frac{5}{15}.$$

$$1 - \frac{5}{15} = k.$$

$$\boxed{k = 0.6667}$$

(ii) The ripple current of inductor.

$$\Delta I = \frac{V_s(V_a - V_s)}{LfV_a} = \frac{5(15-5)}{220\times10^{-6} \times 25\times10^{3} \times 15}$$

$$= 0.60A$$

(iii) The ripple voltage of capacitor.

$$\Delta V = \frac{I_a(V_a - V_s)}{fCI_a} = \frac{0.606(15-5)}{220\times10^{-6} \times 25\times10^{3} \times 0.5}$$

$= 2.202V$

CMR

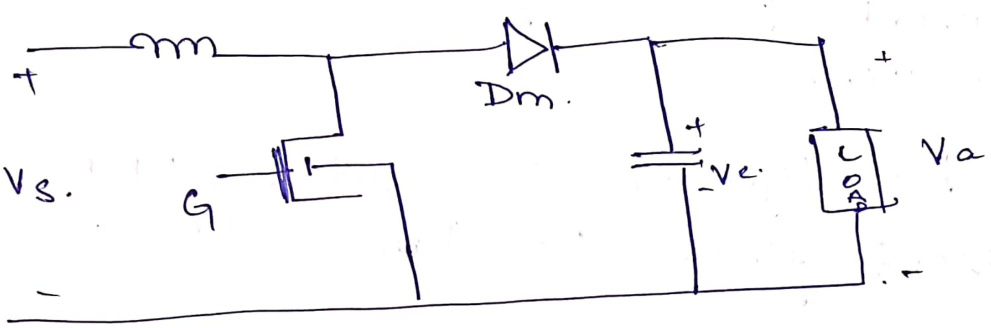
Critical values of L & C.

$$L = \frac{K(1-K)R}{2f} = \frac{0.667(1-0.667) \times 30}{2 \times 25 \times 10^3} = 133.266\,\mu H$$

$$C = \frac{K}{2fR} = \frac{0.667}{2 \times 25 \times 10^3 \times (30)} = 0.446\,\mu F$$

$$R = \frac{V_{avg}}{I_{avg}} = \frac{15}{0.5} = 30\,\Omega$$

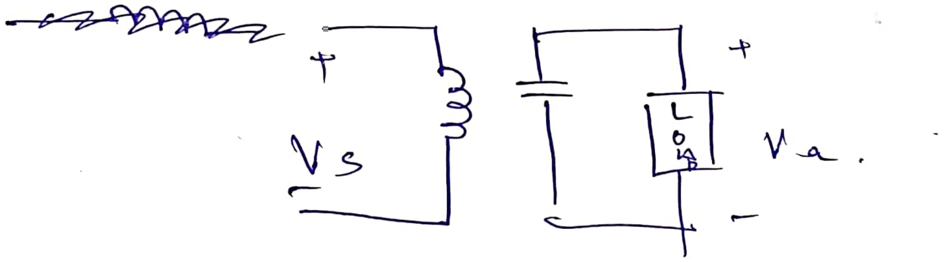
3. Boost Regulator



⇒ Boost Regulator, the output voltage is greater than the input voltage, hence called a boost Regulator.

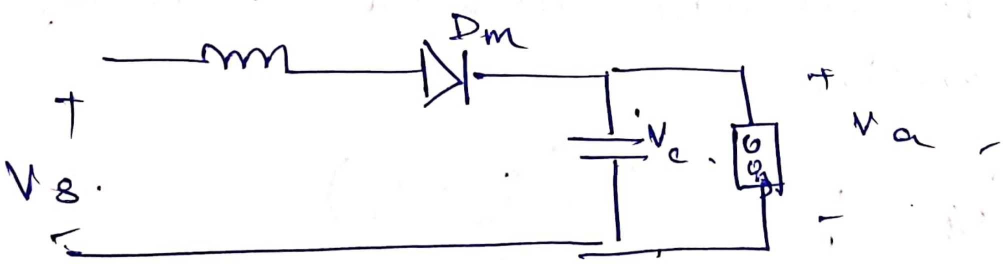
⇒ It has two modes of operation.

Mode 1



Mode 2

⇒



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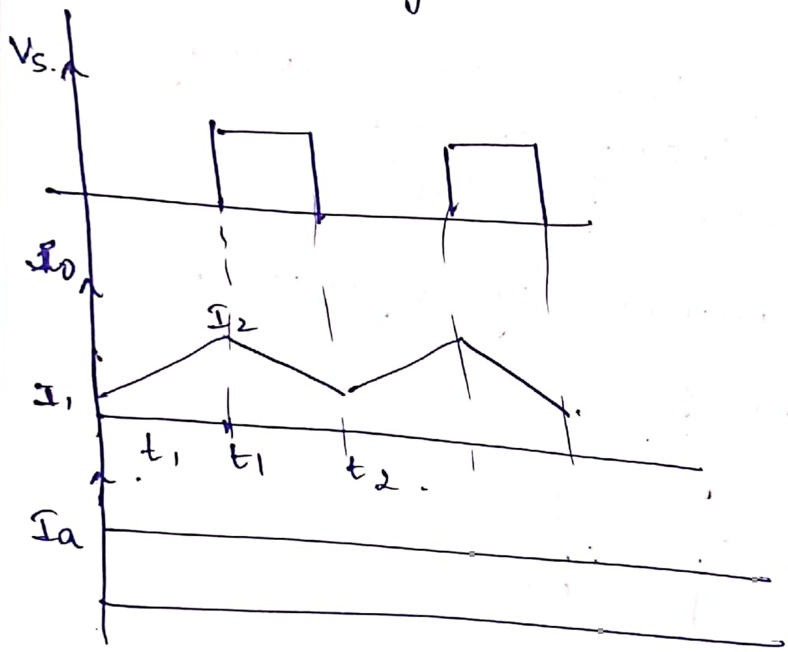
CMR

⇒ When the thyristor is switched on, it reverse biases the Dm diode, hence the current flows from source → ~~E~~ ~~Capa~~ inductor.

⇒ When the tyristor is switched OFF, The current flows L → Dm → Load.



Derivation

⇒ Consider current increases linearly in the inductor.

$$V_s = \frac{L(I_2 - I_1)}{t_1}$$

$$\boxed{V_s = \frac{L\Delta I}{t_1}} \rightarrow (1)$$

⇒ Consider current decreases linearly in the inductor.

$$V_s - V_a = -L\frac{(I_2 - I_1)}{t_2}.$$

$$\boxed{V_s - V_a = -L\frac{\Delta I}{t_2}} \rightarrow (2).$$

from (1) & (2).

~~$\frac{\Delta I}{t_1} = -L\frac{\Delta I}{t_2}$~~

$$\Delta I = \frac{V_s t_1}{L}. \qquad \Delta I = -\frac{(V_s - V_a)t_2}{L}$$

$$\frac{V_s t_1}{L} = \frac{(V_a - V_s)t_2}{L}$$

$$\boxed{V_s t_1 = (V_a - V_s)t_2.} \rightarrow (3)$$

$$V_s t_1 = V_a t_2 - V_s t_2.$$

$$V_s(t_1 + t_2) = V_a t_2. \Rightarrow \boxed{V_a = \frac{V_s T}{t_2}}$$

CMR

Subtitute $t_1 = KT$ & $t_2 = (1-k)T$. in ③.

$$V_s(k\cancel{T}) = (V_a - V_s)(1-k)\cancel{T}$$

$$V_s k = (V_a - V_s)(1-k)$$

$$= V_a - kV_a - V_s + V_s k.$$

$$\frac{V_a - V_s}{V_s} = \frac{1-k}{k}.$$

For Time period $T = t_1 + t_2$.

$$T = \frac{L\Delta I}{V_s} + \left(-\frac{\Delta I L}{V_s - V_a}\right)$$

$$= \frac{L\Delta I}{V_s} + \frac{\Delta I L}{V_a - V_s}.$$

$$T = \frac{L\Delta I V_a - L\Delta I V_s + \Delta I V_s}{V_s(V_a - V_s)}.$$

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$$T \times V_s (V_a - V_s) = \Delta I (LV_a - LV_s + LV_s)$$

$$\Delta I = \frac{V_s (V_a - V_s)}{L V_a f}$$ → Ripple Current

Ripple Voltage

$$\Delta V = \frac{I_s (V_a - V_s)}{I_a f C}$$

Critical Value of Inductor

$$L_c = \frac{k(1-k)R}{2f}$$

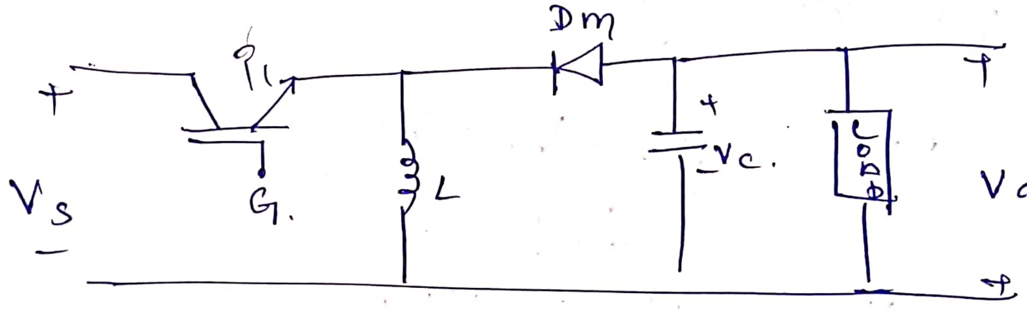
Critical Value of Capacitor.

$$C = \frac{k}{2fR}$$

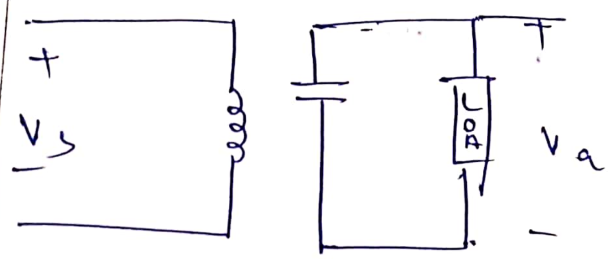
6. Buck- Boost regulator :-

⇒ The output voltage can be either more than or less that the input voltage.

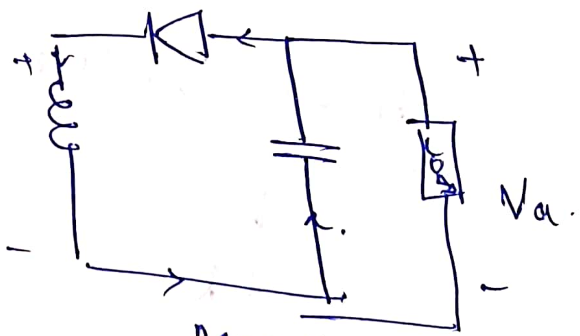
⇒ The output ~~vo~~ polarity is opposite to the input polarity, Hence it is also called as an Inverting chopper.



⇒ It has two modes of operation.



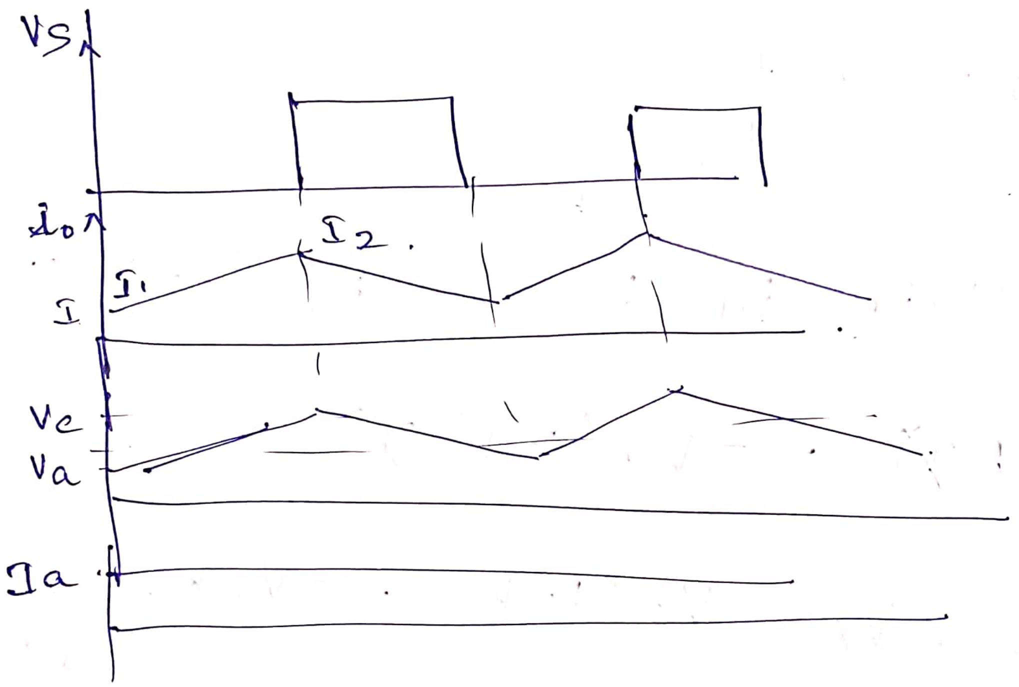
MODE1



MODE2.

⇒ In mode 1, The Thyristor T_1 is turned on. hence the ~~diode~~ freewheeling diode is reverse biased.

⇒ In mode 2, the thyristor ~~&~~ T_1 is turned off. The current starts flowing in the ~~diff~~ direction $C \rightarrow D_m \rightarrow L$. As energy is stored in L. Hence an output is generated



⇒ **Derivation**

Consider current increases linearly in inductor.

$$V_s = L \frac{\Delta I}{t_1} \rightarrow (1)$$

Consider current decreases linearly in the inductor.

$$V_a = -L \frac{\Delta I}{t_2} \rightarrow (2)$$

CMR

From ① & ② we get

$$\Delta I = \frac{V_s t_1}{L} = \frac{-V_a t_2}{L}$$

$$\boxed{V_a = -V_s \frac{t_1}{t_2}}$$

Substitute $t_1 = KT$ & $t_2 = (1-k)T$.

$$V_s (KT) = -V_a (1-k) T$$

~~$V_a = V_s$~~ $V_a (1-k) = -V_s k$. $= V_a = \frac{-V_s k}{1-k}$

$$V_a - V_a k = -V_s k.$$

$$V_a = (V_a - V_s) k.$$

$$\boxed{k = \frac{V_a}{V_a - V_s}}$$

Time period

$$T = t_1 + t_2$$

$$T = \frac{L\Delta I}{V_s} - \frac{L\Delta I}{V_a}$$

$$= \frac{L\Delta I}{V_s} + \frac{L\Delta I}{V_s \frac{k}{(1-k)}}$$

$$= \frac{L\Delta I}{V_s} + \frac{L\Delta I(1-k)}{V_s \cdot k}$$

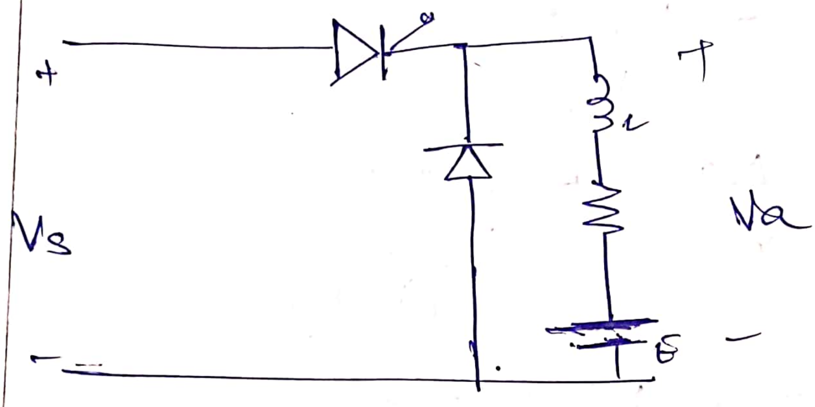
$$T = \frac{L\Delta I}{V_s}\left[1 + \frac{(1-k)}{k}\right]$$

$$T = \frac{L\Delta I}{V_s}\left[\frac{k+1-k}{k}\right]$$

$$\therefore \Delta I = \frac{V_s T}{L} k$$

$$\boxed{\Delta I = \frac{V_s k}{L f}}$$

2. Step down chopper having RL load.



⇒ ~~In Step down chopper;~~

⇒ Choppers are static devices that are used to convert DC into varying/pulsating DC

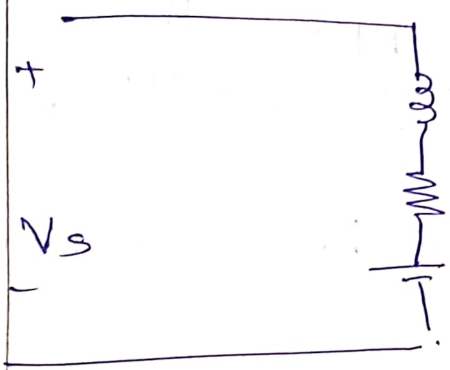
⇒ A step down chopper, the output voltage is less than the input voltage.

⇒ An alternating DC voltage can be obtained by either

- Varying T_{ON}
- Varying the chopper frequency keeping constant T_{ON} or T_{OFF}

⇒ The Thyristor acts as a switch.

⇒ When it is turned on, it acts as a short circuit and the output follows the input.



⇒ Current flows through the inductor L and it gets charged.

⇒ <u>Continuous</u> <u>load</u> <u>current</u>.

⇒ The chopper is switched ON, the load,
Current flows through the is reverse
the free wheeling diode increases
biased and the current time period t_1 to t_2
from i_1 to i_2 in the

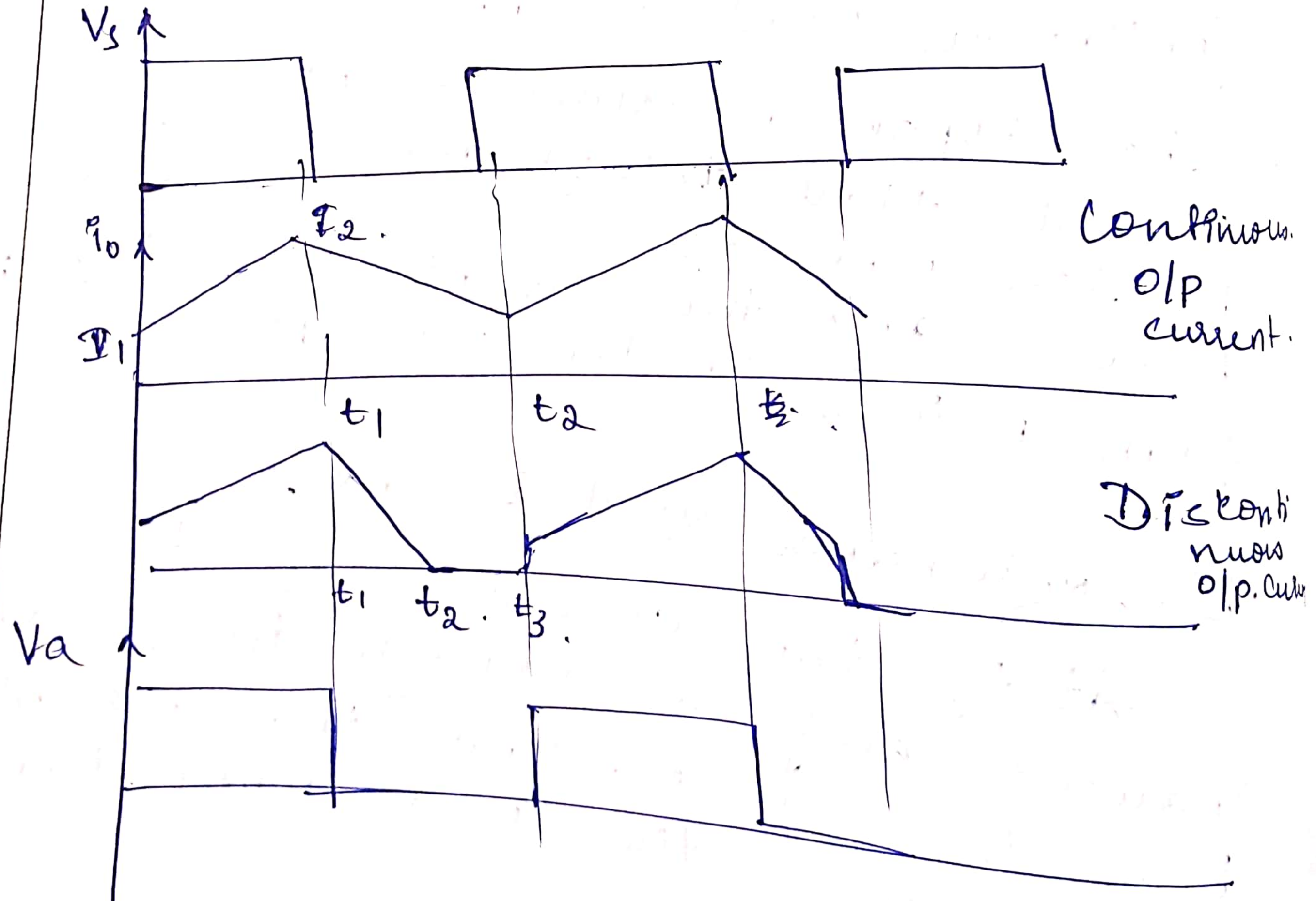
⇒ ~~Discontinuous load current~~.

At t_2 the current is i_2, the induced emf is enough to forward bias the diode. and the current flows through the load, until the emf becomes zero.

Discontinuous load current

⇒ If the Inductor has a very small value of Inductance, then during the OFF-period of the chopper, the induced emf will discharge faster. from (t_1 to t_2)

⇒ The output voltage will be zero for the time $t_2 - t_3$.



$$V_a = V_s \left(\frac{T_{ON}}{T_{ON} + T_{OFF}} \right).$$

$$V_{rms} = \sqrt{d}\, V_s.$$

$$I_{avg} = \frac{V_{avg}}{R}.$$

5. Classifications.

1. $V_s = 200V$.
$R = 8\,\Omega$.
thyristor − 2 V.
$f = 800 Hz$.
Duty cycle = 0.4.

i) Average output voltage :-

$$V_a = V_s\, d.$$

$$= V_s \left(\frac{t_{ON}}{\text{time period}} \right) = (V_s - 2)$$

$$= \frac{(200-2)}{\cancel{200}} \times 0.4$$

~~Va = 80V~~

$V_a = 79.2$.

ii) $V_{rms} = \sqrt{d}\,(V_s \div 2)$

$= \sqrt{0.4} \times (200 \times 2) = 125.22\,V.$

= ~~126.49 V~~.

iii) Chopper Efficiency $= \frac{V_a}{V_s} = \frac{79.2}{200}$

$= 39.6\,\%$

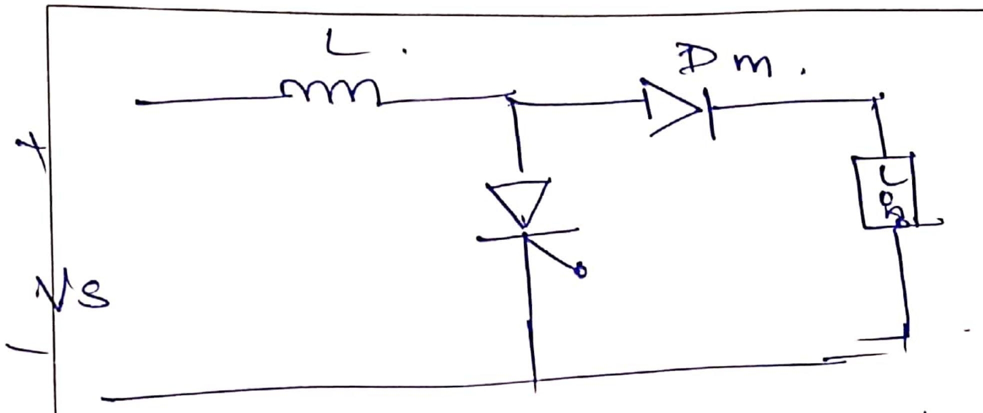
~~Irms~~ $I_{avg} = \frac{V_{avg}}{R}$

$= \frac{79.2}{8}.$

$= 9.9\,A.$

Step Up Chopper

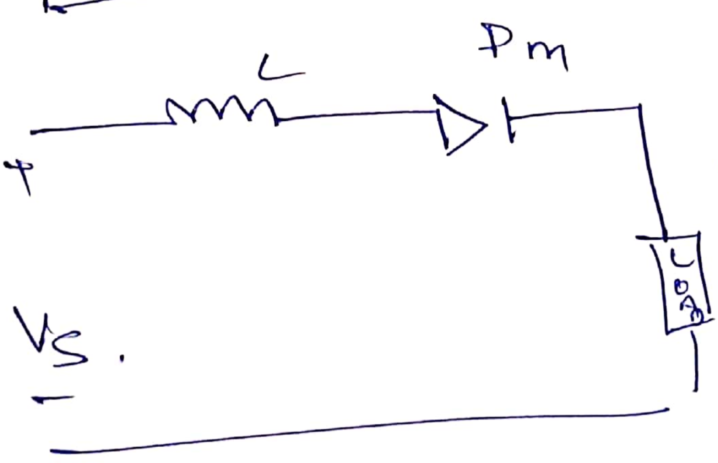
⇒ It is a device whose output voltage is greater than the input voltage.



⇒ When the Chopper is turned ON, and the inductor starts charging and stores energy.

⇒ When the chopper is turned OFF. The inductor is forced to discharge through the load. Dm is forward biased.

⇒ $V_o = V_s + L\frac{dI}{dt}$.



Vo.