Converters: Buck,Boost,Buck-Boost

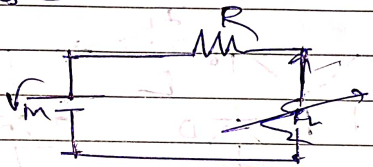
Convertors :–

① AC – AC convertor ⟶ transformer
② AC – DC ⟶ rectifier
③ DC – AC ⟶ Inverter
④ DC – DC ⟶ chopper 3

We will learn this

for dc – dc to conversion we want this as we want the voltages of different levels for different Applications from same sources. So we need these

For this if we use



we want RL should have V_o output so.

$V_{in} - IR - IR_L = 0$ $\quad I = \dfrac{V_{in}}{R+R_L}$

$IR_L = V_o$

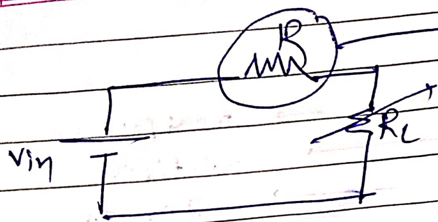
so, $I = \dfrac{V_o}{R_L}$ $\quad \dfrac{V_o}{R_L} = \dfrac{V_{in}}{R+R_L}$

$1 + \dfrac{R}{R_L} = \dfrac{V_{in}}{V_o}$

$\left(1 - \dfrac{V_{in}}{V_o}\right) = \dfrac{R}{R_L}$

& $\boxed{R = R_L\left(1 - \dfrac{V_{in}}{V_o}\right)}$ $\quad \boxed{R_L = \dfrac{R V_o}{V_o - V_{in}}}$

so, we can have this resistor in series & get desired output But here



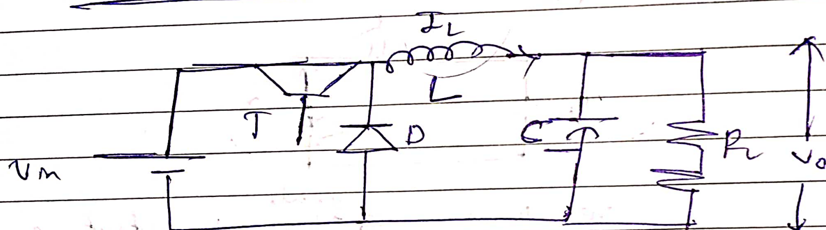
through this IR power is lost

But here If we increase current instead of trying to reduce voltage we can achieve same behaviour as load is constant.

So $V = IR$

$I \uparrow \; V \downarrow$

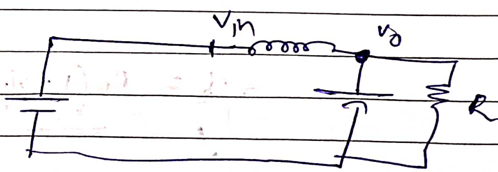
let's do it.



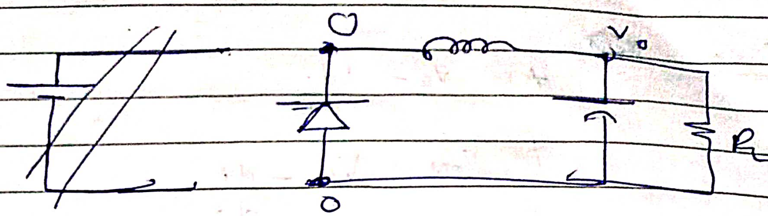
Now we want that the constant DC current through R_L & All Ripple through C

Why? Because of DPST.

So, Now for T_{ON}



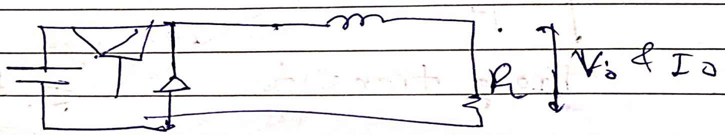
$\boxed{V_L = V_{in} - V_o}$ & for T_{OFF}



So, $V_L = -V_0$

Now
As we want that All Ripple should go through C
that means avg $I_C = 0$.

So, $I_0 = I_L$ → As direct series



Now Hly we want V_L avg $= 0$ so that $V_0 = V_C$

So, V_L avg $= 0V$

$$(V_{in} - V_0)\, d T_s + (-V_0)(1-d) T_s = 0$$

$$V_{in} d - \cancel{V_0 d} - V_0 + \cancel{V_0 d} = 0$$

$$\boxed{V_0 = V_{in} d}$$

By Vsec balance

let's

$$\frac{T_{ON}}{T_{ON} + T_{off}} = d$$

$T_{ON} = d T_s$ — $T_s = T_{ON} + T_{OFF}$

$T_{off} = (1-d) T_s$

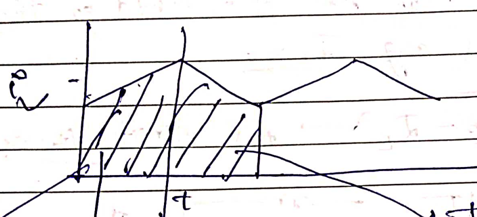
Now

As $V_L = L\frac{di}{dt}$

for T_{ON}: $\frac{V_L}{L} = \frac{di}{dt}$

so, $\frac{V_{in} - V_o}{L} = \frac{di}{dt}$

so $i\uparrow$ & for T_{off} $i\downarrow$



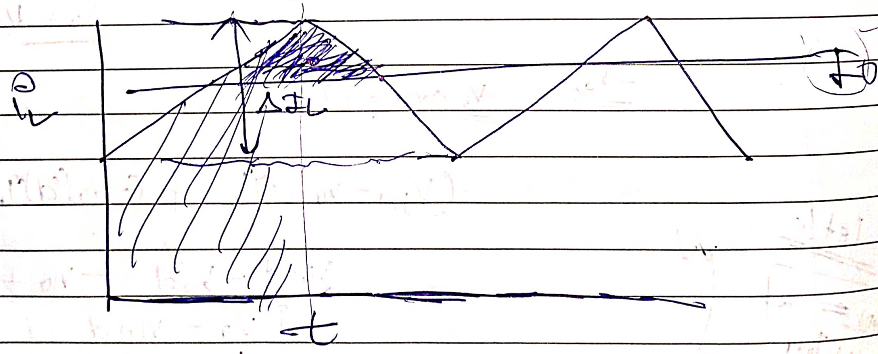
through diodes

$\frac{I_o \times dT_s}{T_s} = I_o d$ avg

through transistor

$\frac{I_o \times (1-d)T_s}{T_s} = I_o(1-d)$ avg

But $\boxed{Avg = I_o}$



So, now,

so, $\Delta Q = \frac{1}{2} \times \frac{\Delta I_L}{2} \times \frac{T_s}{2}$

these goes through $\Delta q = \frac{\Delta I_L T_s}{8}$

$$\Delta Q = C\Delta V$$

$$C\Delta V = \frac{\Delta I_L}{8f_s}$$

extra

$$\Delta V_c = \frac{d(1-d)}{8f^2LC}$$

$$\boxed{C = \frac{\Delta I_L}{8f_s \Delta V_c}}$$ w ΔV_c

Now,

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

For T_{off} $V_L = -V_o$

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

$$\cancel{\frac{dV_{in}}{L} = \frac{di}{dt}}$$

$$\cancel{L = \frac{d\, V_{in}\, \Delta t}{\Delta I_L}}$$ $\cancel{T_s}$

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

$$\frac{(1-d)T_s V_o}{L} = \Delta I_L$$

$$\boxed{L = \frac{(1-d)V_o T_s}{\Delta I_L}}$$

Always considered L to be minimum if two @ come

Buck

Conclusion :-

$$\boxed{V_o = V_{in} d}$$

$$\boxed{I_o = I_{L\,avg}}$$

$$L = \frac{(1-d) V_o T_s}{\Delta I_L} \qquad T_s = \frac{1}{f_s}$$

$$\boxed{L = \frac{(1-d) V_o}{f_s \Delta I_L}}$$

Always to be minimum

$$\boxed{C = \frac{\Delta I_L}{8 f_s \Delta V_c}}$$

PIV of D T Vin

$\boxed{I_{L\,avg} = I_o}$ $\boxed{V_{L\,avg} = 0}$

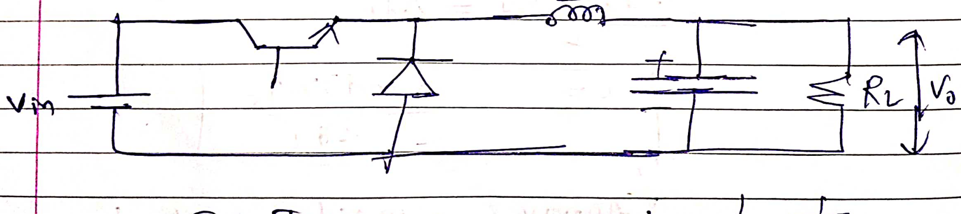
$\boxed{I_{c\,avg} = 0}$ $\boxed{V_{c\,avg} = V_o}$

$I_{diode\,avg} = I_L(1-d) = I_o(1-d)$

$I_{trans\,avg} = I_L d = I_o d$

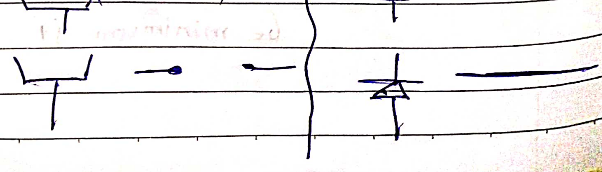
$$\boxed{V_o = V_{in} d}$$

At T_{ON} $V_L = V_{in} - V_o$ T_{off} $V_L = -V_o$

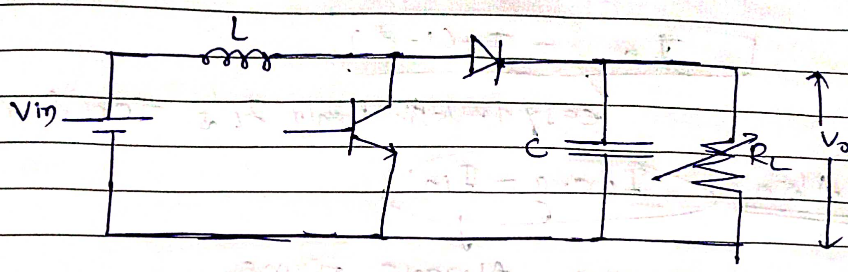


For T_{ON}

T_{off}



Boost converter :-



① V sec balance (across L) (To find relation Vin & Vo)

for T_{ON} $V_L = V_{in}$
for T_{off} $V_L = V_{in} - V_o$

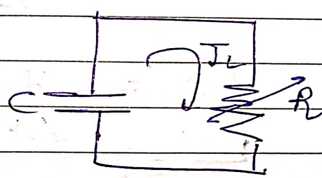
$\boxed{V_{L\,avg} = 0}$

$$V_{in} d T_s + (V_{in} - V_o)(1-d) T_s = 0$$
$$\cancel{V_{in} d} + V_{in} - V_o - \cancel{V_{in} d} + V_o d = 0$$
$$V_{in} - V_o(1-d) = 0$$
$$V_{in} = V_o(1-d)$$
$$\boxed{V_o = \frac{V_{in}}{1-d}}$$

② Current - sec balance (across C) (To find $I_{L\,avg}$)

$\boxed{V_c = V_o}$
$\boxed{I_{c\,avg} = 0}$

for T_{ON}



$\boxed{I_c = -I_o}$

for T_{off} $I_c = I_L - I_o$

$$-I_o d T_s + (I_L - I_o)(1-d) T_s = 0$$
$$\cancel{-I_o d} + I_L - I_o - I_L d + \cancel{I_o d} = 0$$
$$\boxed{I_L(1-d) = I_o}$$

$$\boxed{I_o = I_i(1-d)}$$

easy trick that only I_L's second will be I_o

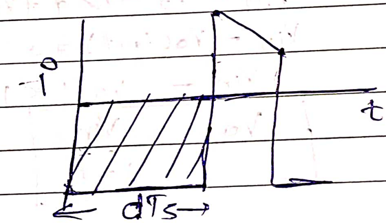
Also $I_{L\,avg} = I_{in}$

as Always same

(2) Current across Capacitor (for C)

Ton $\quad I_c = -I_o$

Toff $\quad I_c = I_i - I_o$



$$\Delta Q = I_o d T_s$$

$$C \Delta V_c = I_o d T_s$$

$$C = \frac{I_o d T_s}{\Delta V_c}$$

$$\boxed{C = \frac{I_o d}{\Delta V_c f_s}}$$

Page No.:
Date:
YOUVA

⊛ Current / Voltage across Inductor (for L)

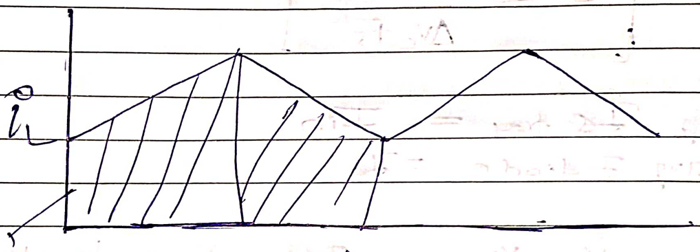
T_{ON} • $V_L = L\frac{di}{dt}$

$$\frac{V_L}{L} = \frac{di}{dt} \qquad V_L = V_{in}$$

$$\frac{di}{dt} = V_{in}$$

T_{off} $V_L = V_{in} - V_o$

$$\frac{V_{in} - V_o}{L} = \frac{di}{dt}$$



I_L avg I_{in}

$\frac{I_{in} dT_s}{T_s}$

$= I_{in}$

$$\frac{V_{in}}{L} = \frac{di}{dt}$$

$$\frac{dT_s V_{in}}{L} = di$$

$$L = \frac{d\,T_s\,V_{in}}{\Delta I_L}$$

$$\boxed{L = \frac{V_{in} d}{\Delta I_L f_s}}$$ → L to be maximum

for $\underset{\text{transistor}}{I_Q} = I_{in}$

$\underset{\text{avg}}{I_D} = I_o$

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Page No.:
Date:
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Summary

$$\boxed{V_o = \frac{V_{in}}{1-d}}$$

$$\boxed{I_o = I_L(1-d)}$$

$$\boxed{I_{L\,avg} = I_{in}}$$ $$\boxed{V_{L\,avg} = 0}$$

$$\boxed{V_{C\,avg} = V_o}$$ $$\boxed{I_{C\,avg} = 0}$$

$$\boxed{L = \frac{V_{in} d}{\Delta I_L f_s}}$$ → L to be minimum

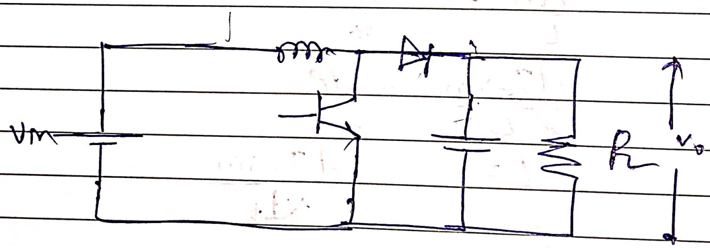
$$\boxed{C = \frac{I_o d}{\Delta V_c f_s}}$$

avg I_Q tran = I_{in}

avg I_{diode} = I_o

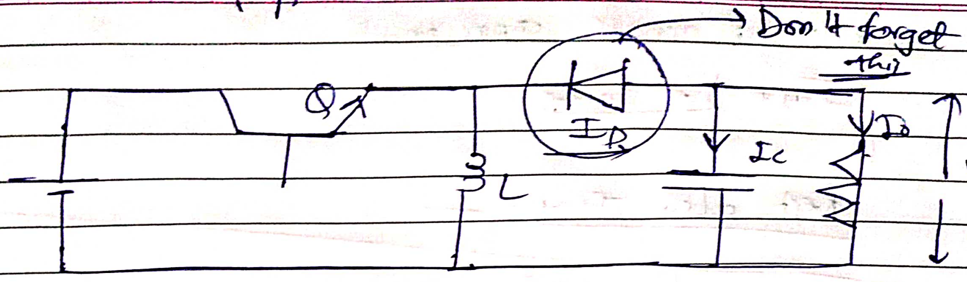
T_{ON} → $V_L = V_{in}$, $I_C = -I_o$

T_{off} → $V_L = V_{in} - V_o$, $I_C = I_L - I_o$



PIV of D = V_o

Buck - Boost



Volt second :→

Ton $\quad V_L = V_{in}$

Toff $\quad V_L = V_o$

$$V_{in}d + V_o(1-d) = 0$$

$$V_{in}d + V_o - V_od = 0$$

$$\boxed{V_o = -\frac{V_{in}\, d}{1-d}}$$

(−) for sign ✓

Current second :→

Ton $\quad I_c = -I_o$

Toff $\quad I_c = I_L - I_o$

$$-I_od + (I_L - I_o)(1-d) = 0$$

$$-\cancel{I_od} + I_L - I_o - I_Ld + \cancel{I_od} = 0$$

$$I_L(1-d) = I_o$$

$$\boxed{I_L = \frac{I_o}{1-d}}$$

$$\boxed{I_o = I_L(1-d)}$$

only Toff of I_L goes I_o

current across capacitor :-

Just the same

Rest also same :-

x

Summary

$$\boxed{V_0 = \frac{-V_{in} d}{1-d}}$$

$$\boxed{I_0 = I_L (1-d)}$$

$\boxed{I_{L\,avg} = I_{in}}$ $\boxed{V_{L\,avg} = 0}$ $\boxed{V_{C\,avg} = V_0}$ $\boxed{I_{C\,avg} = 0}$

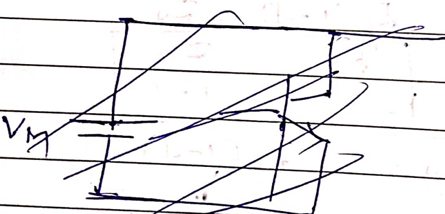
L for mini

$$\boxed{L = \frac{V_{in} d}{\Delta I_L f_s}} \qquad C = \frac{I_0 d}{\Delta V_C f_s}$$

avg $I_Q = I_{in}$ avg $I_d = I_0$

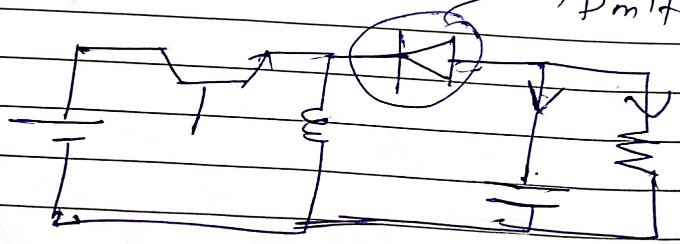
T_{on} $V_L = V_{in}$ T_{off} $V_L = V_0$

$I_C = -I_0$ $I_C = I_L - I_0$



PIV of D > $V_{in} + V_0$

Don't forget



Suppose 0.1 to 0.2 or 10% to 20%

% d Range → Range of d in %.

ΔI_L = ~~[illegible]~~ variation around to output

P = VI $V_o I_o = V_{in} I_{in}$ — use for I_{in}

consider d according V_{in} & Not V_{min} & d_{min} in L for min

Vout is same

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4 steps to derivation

Voltage second balance for V_{in} & w ~~I_L avg~~
Current second balance for I_L avg.

chr: Current across capacitor ΔQ.
Voltage across inductor $\frac{V_L}{L} = \frac{di}{dt}$

I_L avg	V_L avg		
I_C avg	V_C avg		
L	C	I_d avg	I_Q avg

Steps of question

find always L first for so that minimum L you get d

don't forgot V_{in} according d

IM   Pout = Pin $\eta = 100\%$