($\mathcal{L}$) inductor Design

STEP 1: Obtain the value 'L' of the inductor

$$v_L = \underline{\underline{\mathcal{L}}} \frac{di_L}{dt}$$

Step 2: $A_p = A_c A_w = \dfrac{2\mathcal{E}}{K_w \cdot K_c \cdot J \cdot B_m}$

$A_{c_{select}}$

$A_{w_{select}}$

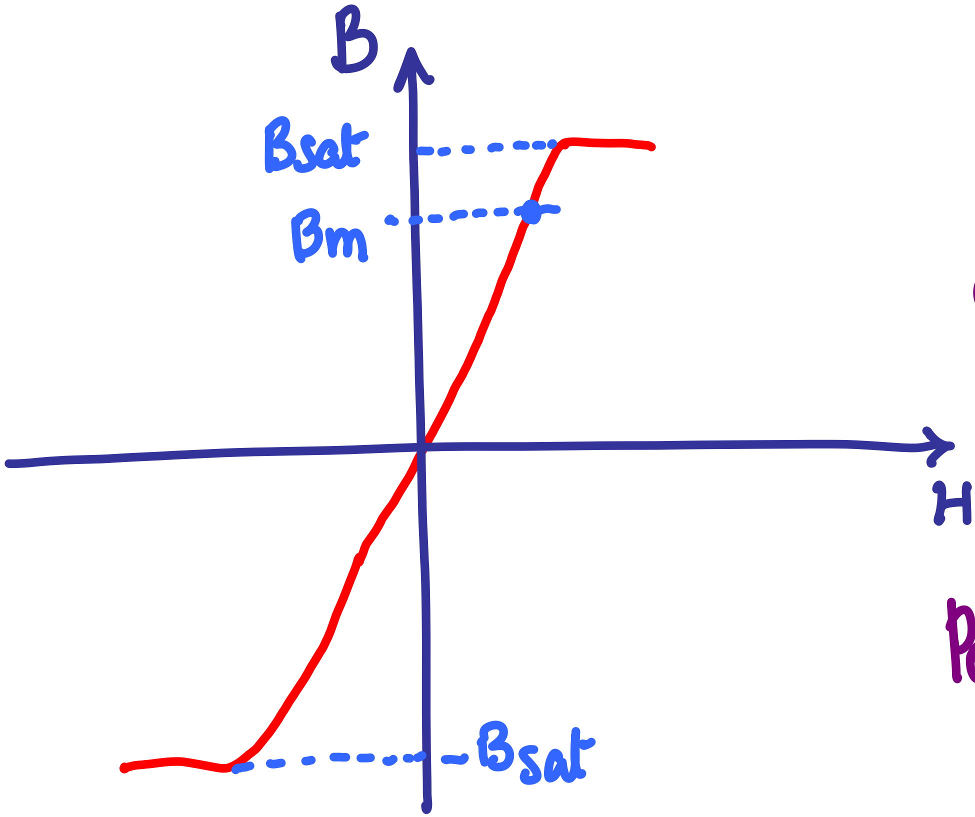
$\mathcal{E}$: energy, Joules

K_w = window factor, 0.6
like flyback transformer
0.3 - 0.4

$K_c \simeq 1$

$J = 3 \times 10^6\ A/m^2 \quad \{(2 - 5)\ A/mm^2\}$

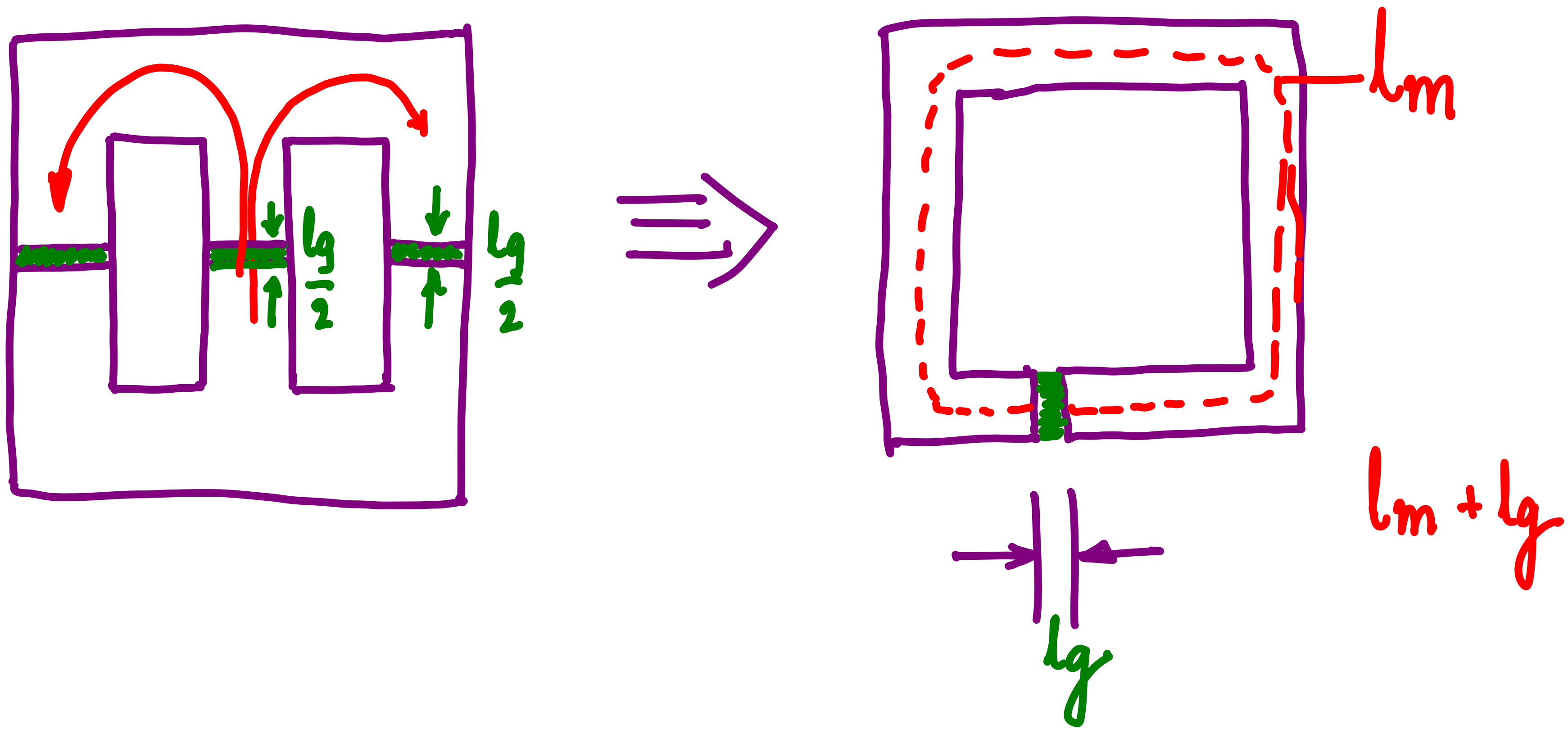
$B_m = 0.25\ T$



	Bsat	Bm
Ferrite -	0.3T	0.25T
CRGO -	1.2 to 1.4T	1.1T
CRNGO -	1.1 - 1.2 T	1T
Powdered Iron -	1.5T	1.3T
Amorphous Glass -	1.6T	1.4T

Step 3: Permeance, Λ

$\hookrightarrow A_L$ factor $\Rightarrow$ nH/turn^2



$$\mathcal{R} = \frac{l_m}{\mu_0 \mu_r A_c} + \frac{l_g}{\mu_0 A_c} = \frac{1}{\mu_0 A_c}\left\{ \frac{l_m}{\mu_r} + l_g \right\}$$

$$\Lambda = \frac{1}{\mathcal{R}} = \frac{\mu_0 A_c}{\left\{ \frac{l_m}{\mu_r} + l_g \right\}}$$

$$\frac{l_m}{\mu_r} << l_g$$

$$\Lambda = \frac{\mu_0 A_c}{l_g}$$

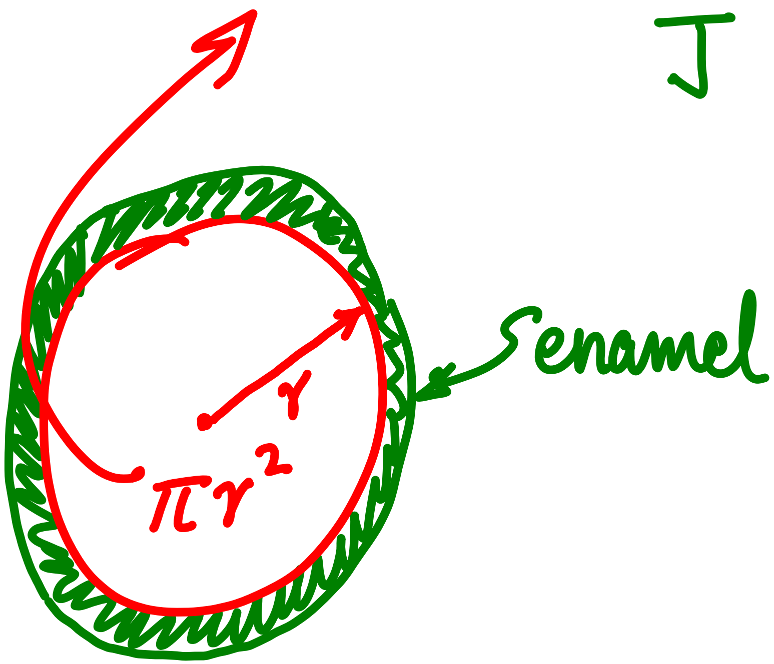
Step 4: Number of turns

$$\Lambda = \frac{L}{N^2}$$

$$N = \sqrt{\frac{L}{\Lambda}} = \sqrt{\frac{L}{A_L}}$$

Step 5: Gauge of the Wire

$$a_{wire} = \frac{I_{rms}}{J} \quad , m^2$$



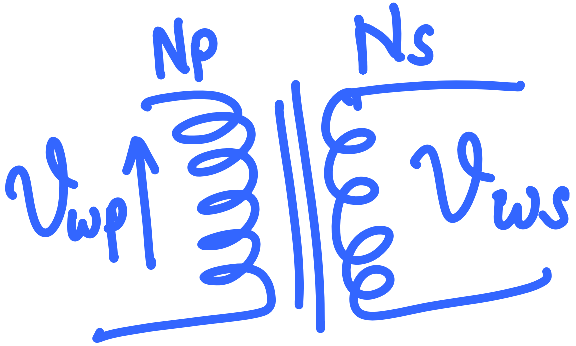
$a_{wire_{select}}$

Step 6: Window area cross check

$$K_w A_w > a_{wire_{select}} \cdot N$$

Design of Transformer

μ : permeability & Λ are <u>HIGH</u>



$$A_p = A_c \cdot A_w =$$

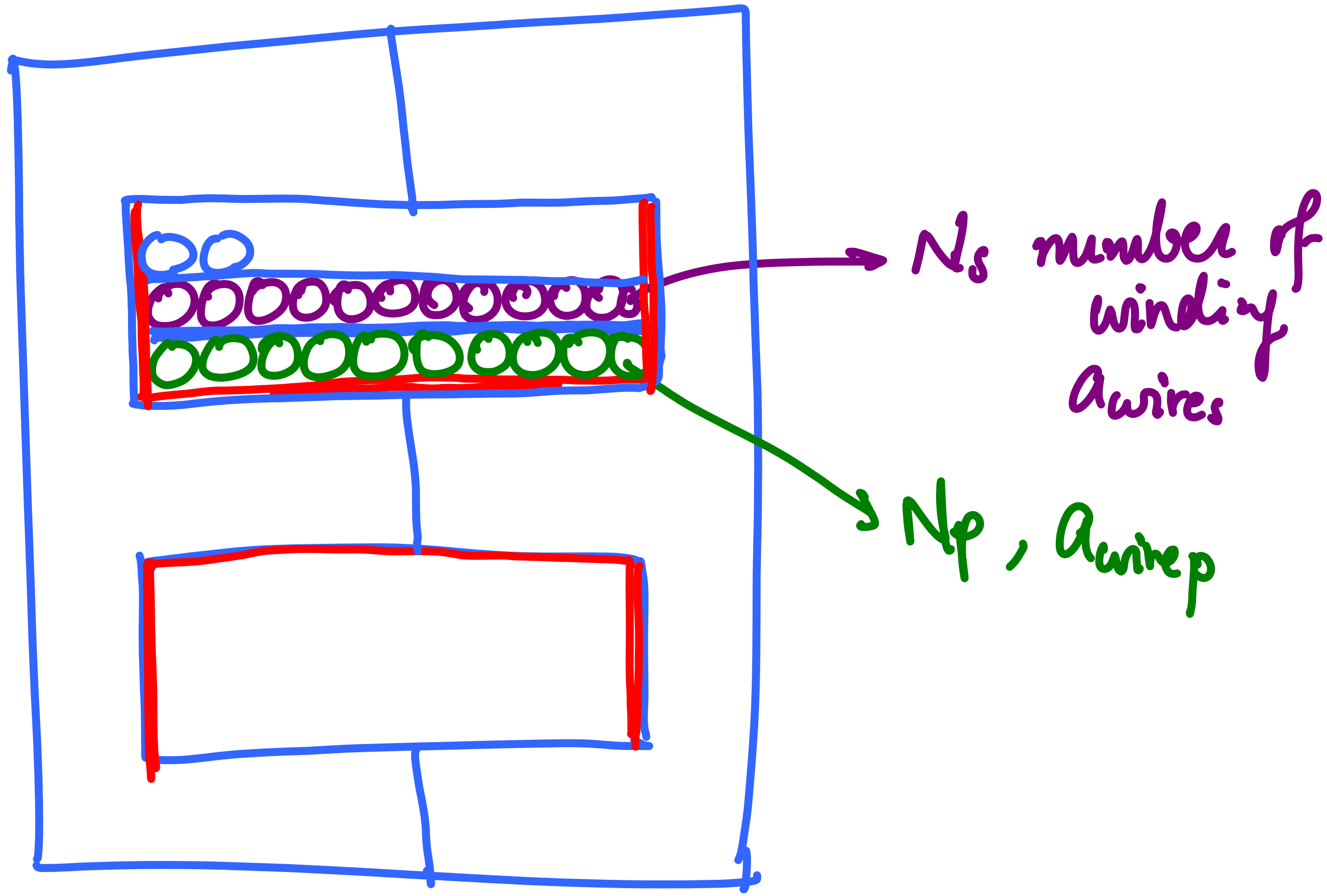
$$f(v \cdot i_{rms})$$

$$f(P_o)$$

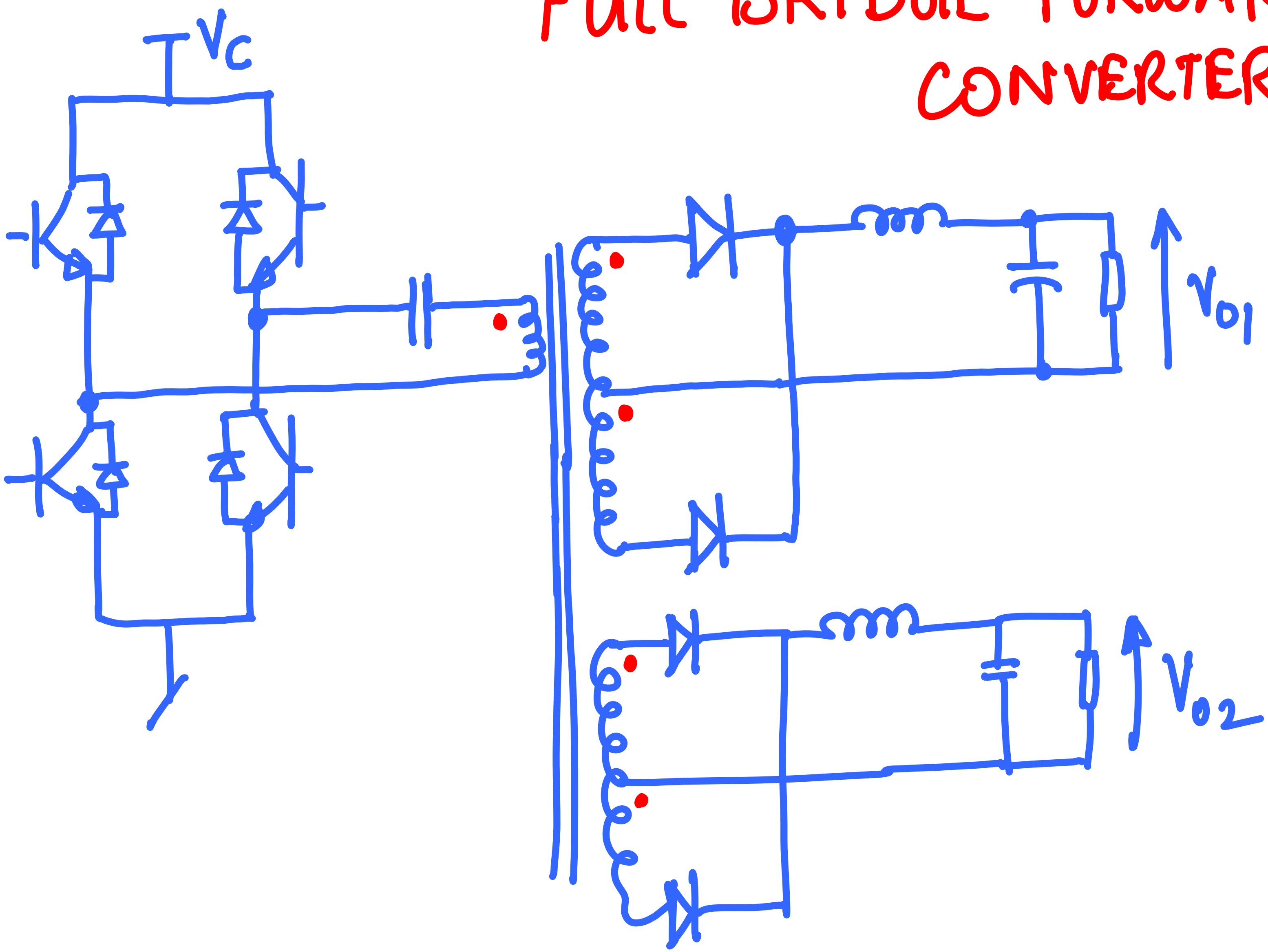
$$v_{wp} = N_p \frac{d\phi}{dt} = N_p \cdot A_c \cdot \frac{dB}{dt}$$

$$= N_p A_c \frac{\Delta B}{\Delta T}$$

$$K_w A_w > \underbrace{\overbrace{a_{wire_p}}^{\frac{I_{rmsp}}{J}} \cdot N_p} + \underbrace{\overbrace{a_{wire_s}}^{\frac{I_{rms}}{J}} \cdot N_s}$$


N_s number of winding
a_{wires}
N_p , a_{wirep}

FULL BRIDGE FORWARD CONVERTER.



Step 1: Specifications (USER)

$V_C = 325\,V$ dc ; # nominal dc link voltage

$V_{Cmin} = 200\,V$ dc ;

$V_{Cmax} = 380\,V$ dc ;

$V_o = [15V, 5V]$; vector

$I_o = [0.5A, 1A]$;

Step 2: Specs (DESIGNER)

Δi_L : $\underline{\underline{10\%}}$ of I_0

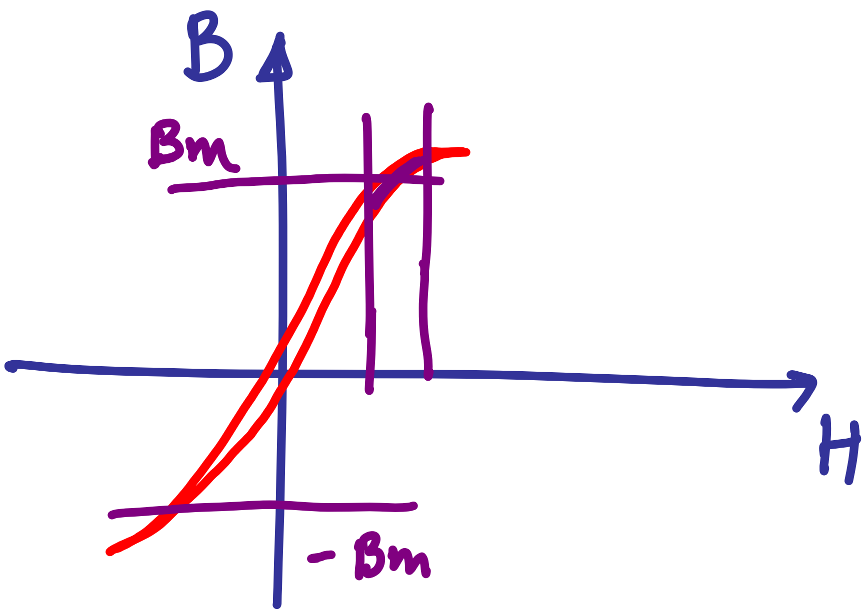
$\left(\frac{2L}{R_D T_s}\right) \Rightarrow$ conduction

f_s : $\underline{\underline{20\text{ kHz}}}$

B_m = 0·2 T

B_{mL} = 0·25 T

η = 0·8 (80%)



$D_{max} = 0.45$

$J = 3 \times 10^6 \ A/m^2$

$K_w = 0.4$

$K_{wL} = 0.6$

$V_d = 0.7$ to $1 \ V$

$\mu_0 = 4\pi \times 10^{-7} \ H/m$

Step 3: Power calculations

$$P_s = \sum_{\text{all sec}} 1.1(V_o + V_d) \cdot I_o$$

secondary power just at the xfm sec.

Step 4: Turns ratio

$$n = \frac{1.1(V_o+V_d)}{2 \cdot D_{max}(V_{cmin} - 0.1 V_{cmax})}$$

$$D_{min} = (D_{max} \cdot V_{cmin}) / V_{cmax}$$

Step. 5: Transformer

$$A_p = f(P_o)$$

$A_{c_{select}}$, $A_{w_{select}}$

$$N_p = \frac{V_{cmax}}{4 B_m \cdot A_{c_{select}} \cdot f_s}$$

$$N_s = n \cdot N_p$$

$$a_{wirep} : \frac{nI_o}{J}$$

$$a_{wires} : \frac{I_o\sqrt{D_{max}}}{J}$$

$a_{wirp_{select}}$, $a_{wires_{select}}$

$$K_W A_W > \sum a_w \cdot N$$

Step 6 : Inductor

- L
- $A_p : f(\mathcal{E})$
- Λ
- N
- a_{wire}
- $K_w A_w > a_{wire_{select}} \cdot N$

Step: 7 Flux walking capacitance

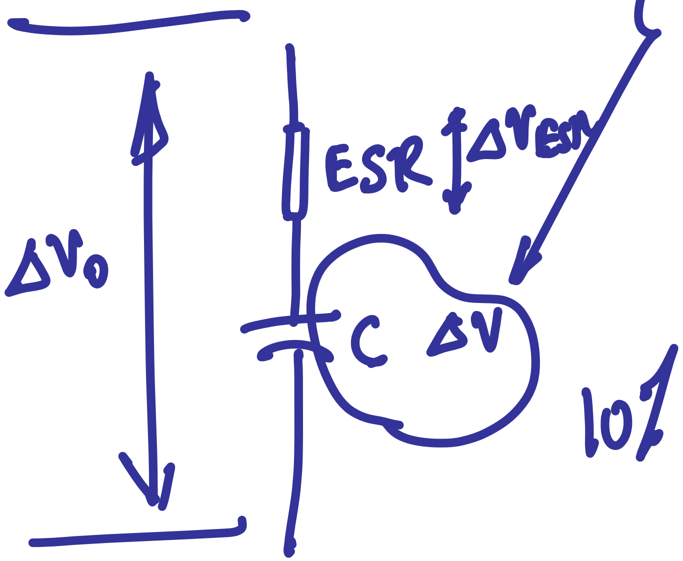
$$C_w = \frac{n I_o \cdot D_{max}}{0.1\, V_{cmax} \cdot f_s}$$

Σ of all sec reflected currents.

Step: 8 Filter capacitor at output

$$C = \frac{\Delta i_L}{\Delta V_c \cdot 8 \cdot f_s}$$

ripple that needs to be allowed

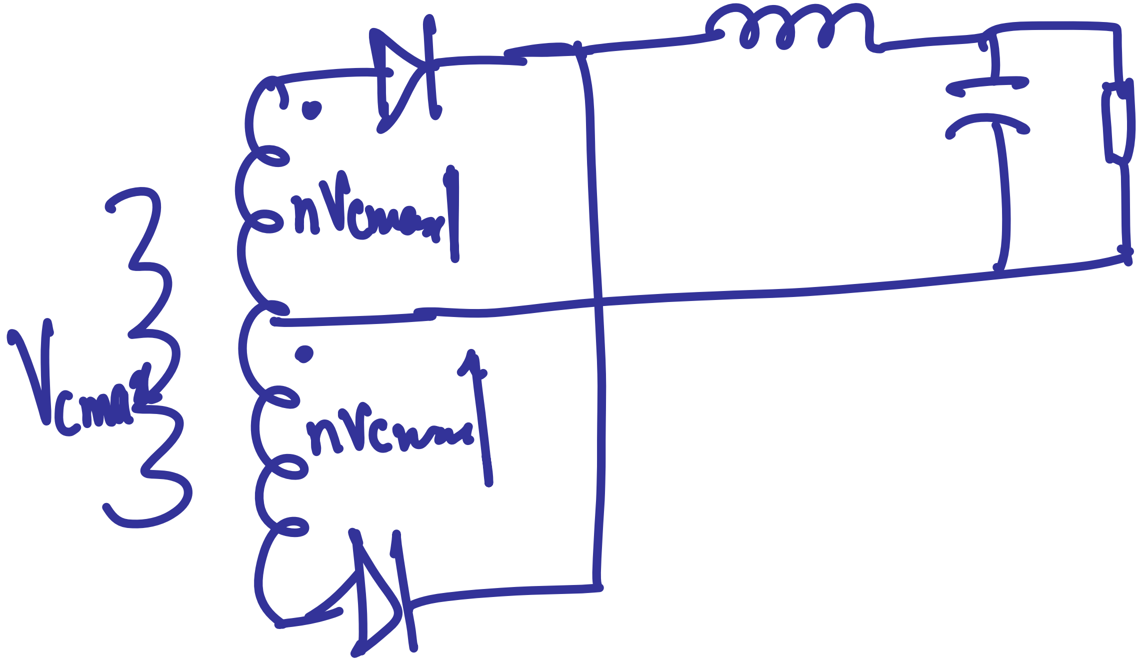


$$ESR < 0.8 \frac{\Delta V_o}{\Delta i_L}$$

Step 9 : DIODE

$\underline{\underline{PIV}} > \underline{2n\, V_{cmax}}$

$\underline{I_{dm} > \left(I_o + \frac{\Delta i_L}{2}\right)}$



$\underline{I_{dav} > I_{dm} \times D_{max}}$

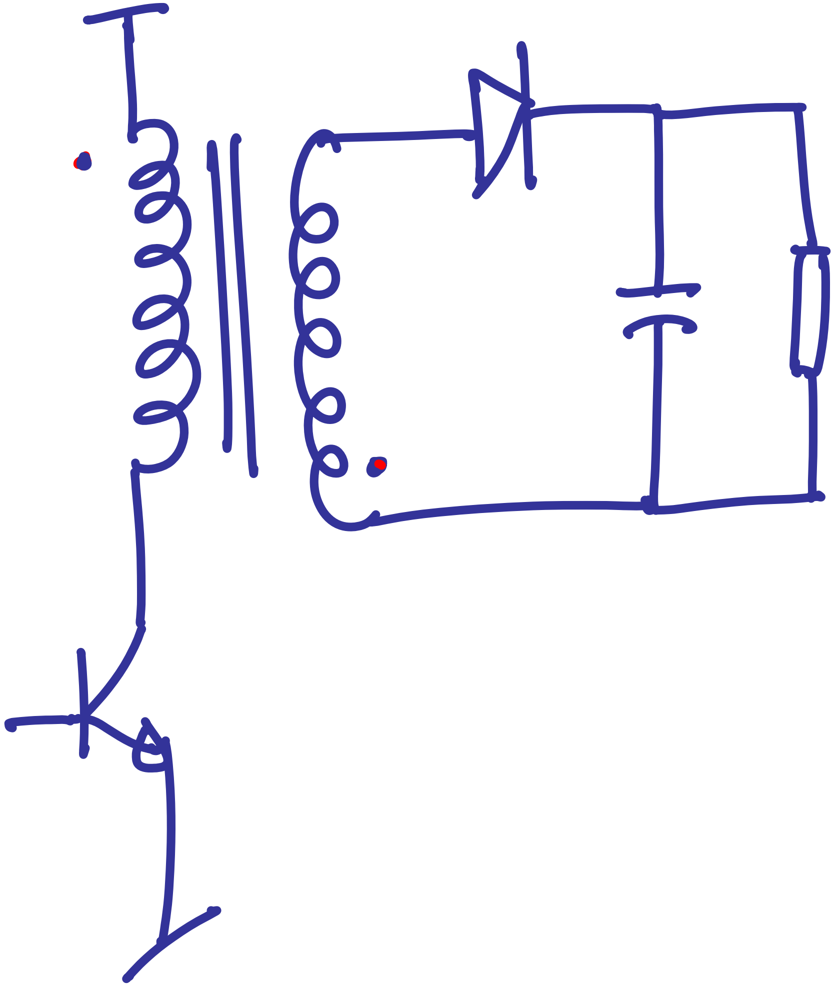
Step 10: Switches

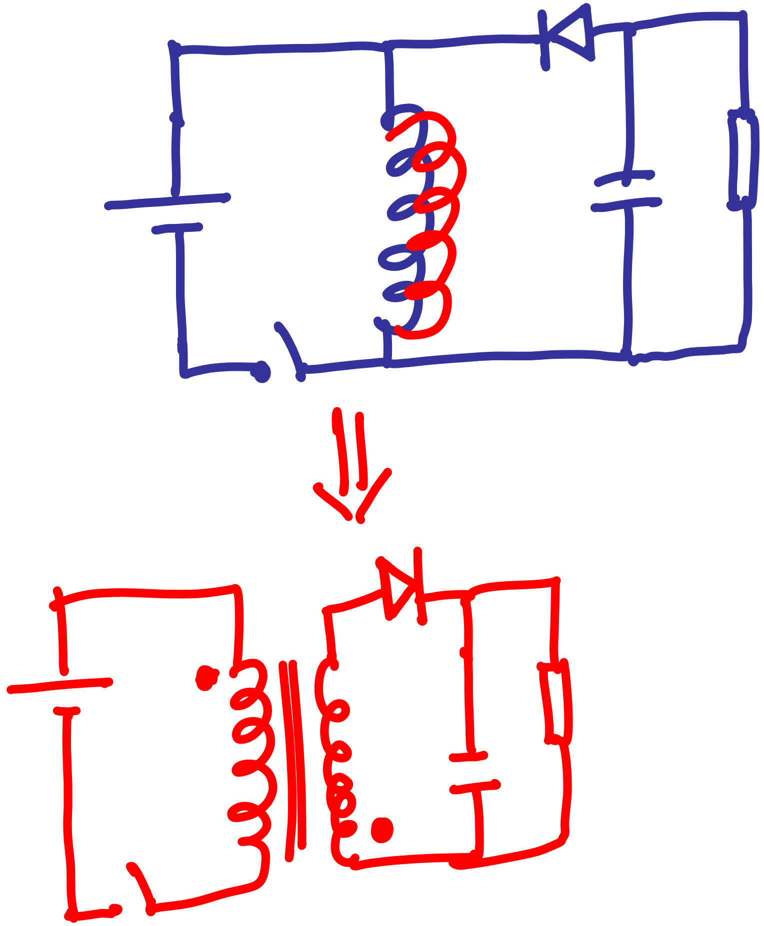
$$V_{CEO} > V_{cmax}$$

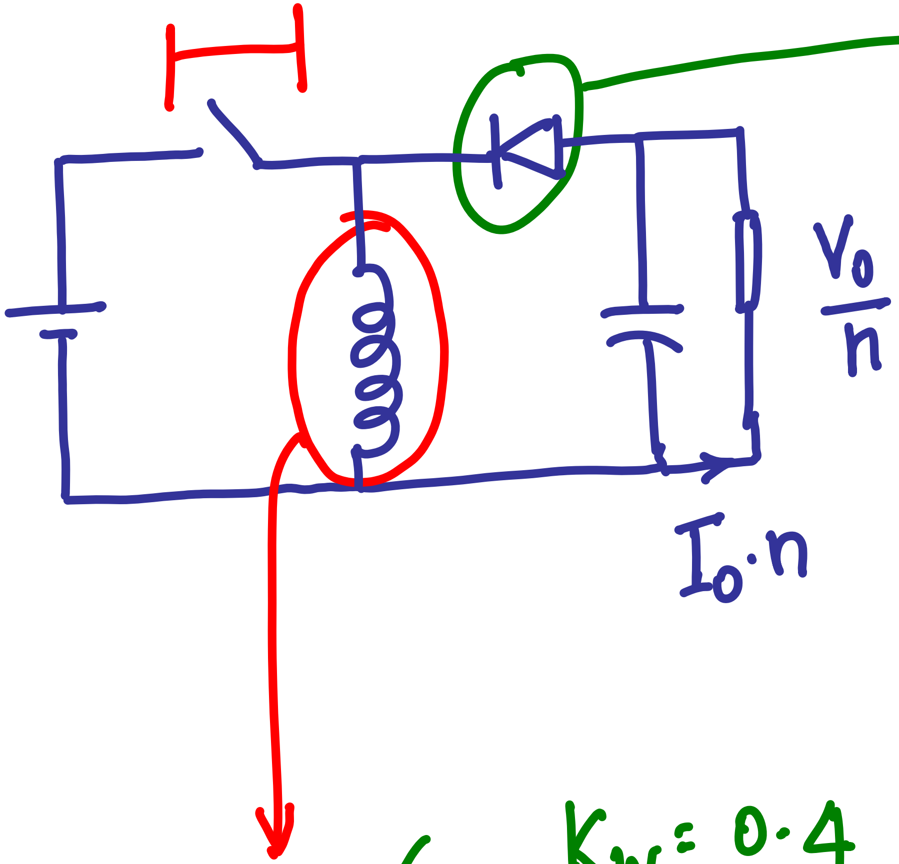
$$I_{cm} \geq \sum n\left(I_o + \frac{\Delta i_L}{2}\right) + I_{mag}$$

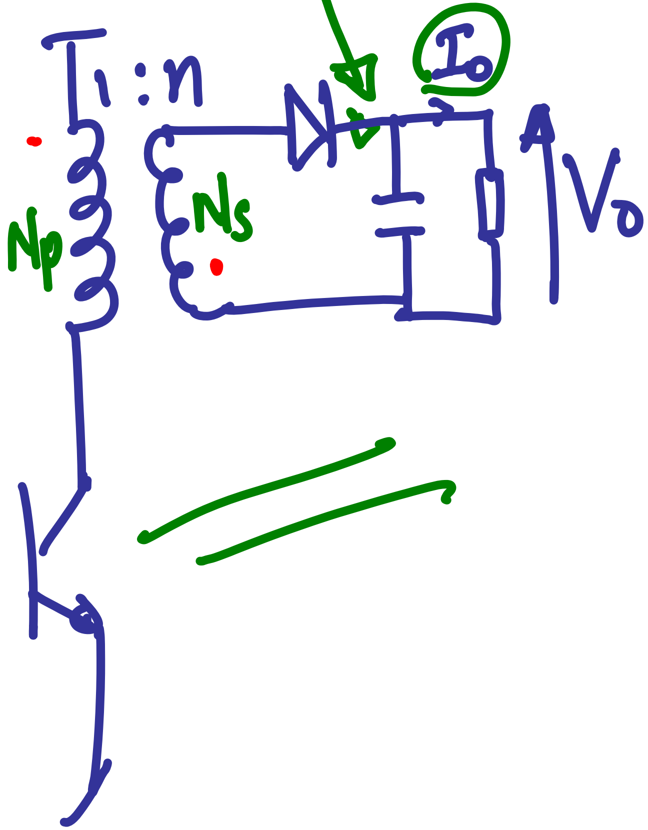
I_{mag}: 10% of I_o

FLYBACK CONVERTER









$\cancel{K_w = 0.6}$

$K_w = 0.4$

$= 0.3$

$$K_w A_w > a_{wire_p} \cdot N_p + a_{wire_s} \cdot N_s$$