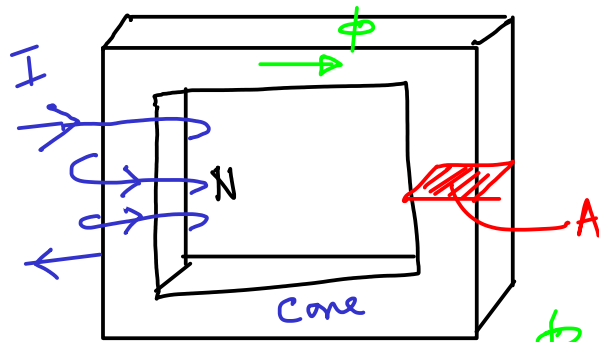
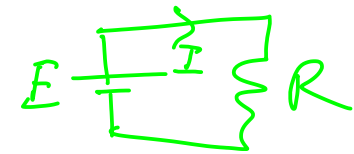
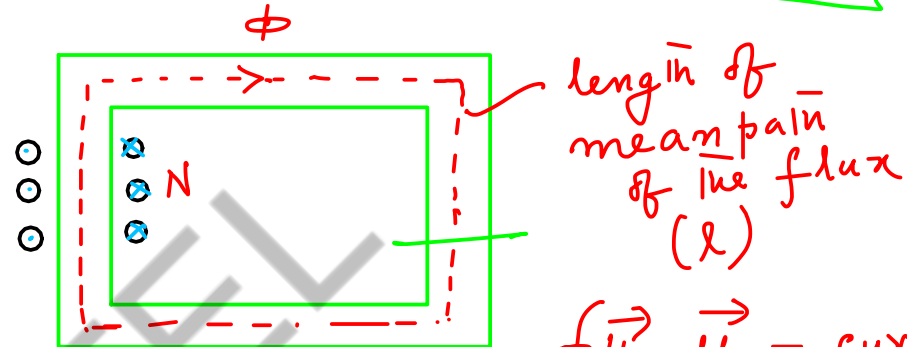
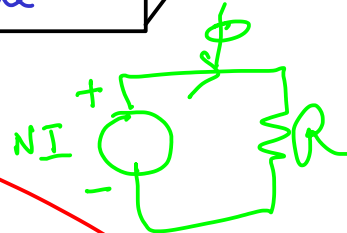


Magnetic Circuit



length of mean path of the flux (l)

$\oint \vec{H} \cdot d\vec{l} = \text{current enclosed}$



Cause

$$H l = N I$$

$$H = \frac{N I}{l} \quad \text{AT/m}$$

$$I = \frac{\text{EMF}(E)}{R}$$

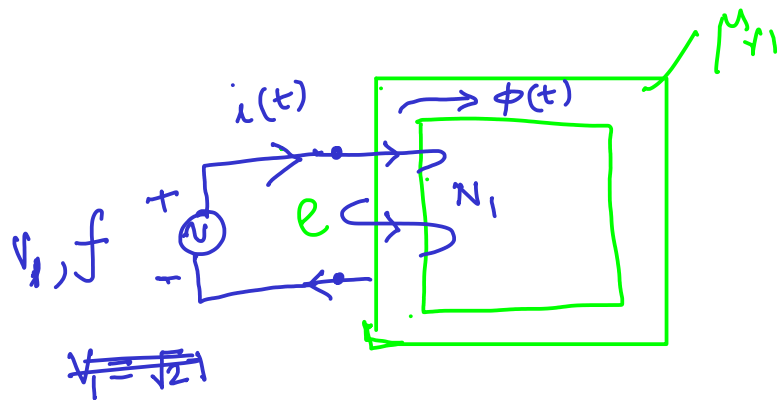
$$\Phi = B \times A$$

$$= \mu_0 \mu_r \frac{N I}{l} A$$

effect $\rightarrow \Phi$

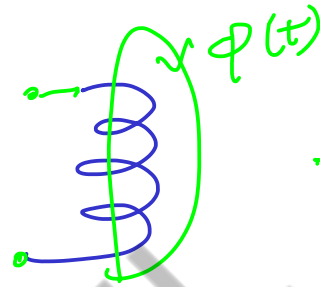
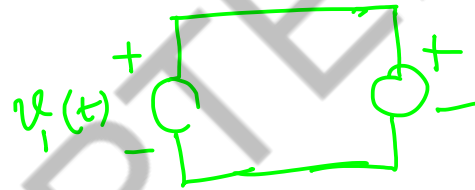
$$= \frac{N I}{\left(\frac{l}{\mu_0 \mu_r A} \right) \text{Reluctance } R}$$

$$B = \mu_0 \mu_r H = \mu_0 \mu_r \frac{N I}{l} = \frac{\text{EMF}}{\left(\frac{l}{\mu_r A} \right)}$$



$$V_1 = \frac{1}{\sqrt{2}} V_m$$

~~$$V_1(t) = \sqrt{2} V_1 \cos \omega t$$~~



induced
 $e_1(t)$ emf

$$\phi = \phi_{max} \sin \omega t$$

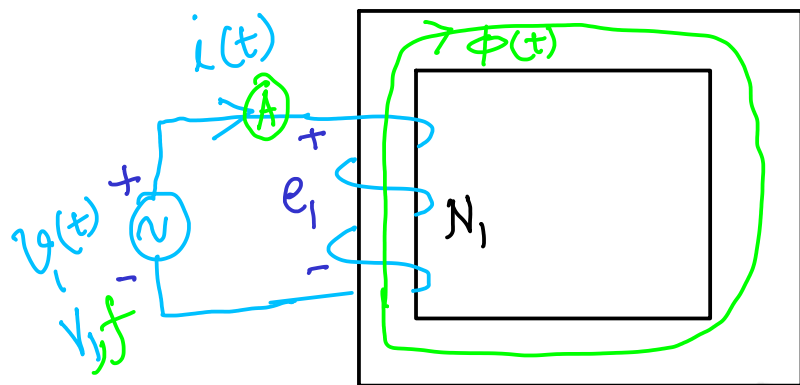
$$V_1 = \sqrt{2} \pi f \phi_{max} N_1$$

$$\phi_{max} = \frac{V_1}{\sqrt{2} \pi f N_1}$$

$$e_1 = N_1 \frac{d\phi_1}{dt} = N_1 \phi_{max} \omega \cos \omega t$$

$$E_1 = \frac{N_1 \phi_{max} \omega}{\sqrt{2}} = \underline{\underline{\sqrt{2} \pi f \phi_{max} N_1}}$$

Lec-2



- Neglect winding resistance
- All the flux created is confined to the core

$$N_1 \frac{d\Phi}{dt}$$

$$\rightarrow e, \bar{E}_1 \uparrow \bar{V}_1 = \bar{E}_1$$

$$= \sqrt{2} \pi f \Phi_{\max} N_1$$

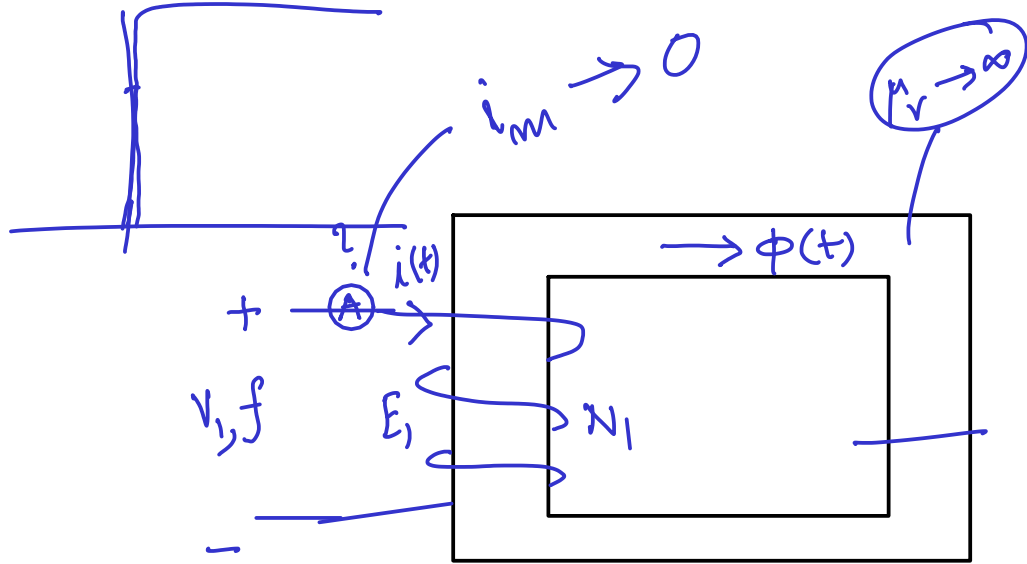
$$\uparrow V_1$$

$$\downarrow E_1$$

$i(t)$ is +ve & also $\frac{di}{dt}$ is +ve
 $\frac{d\Phi}{dt}$ is +ve

$$V_1 = \sqrt{2} \pi f \Phi_{\max} N_1$$

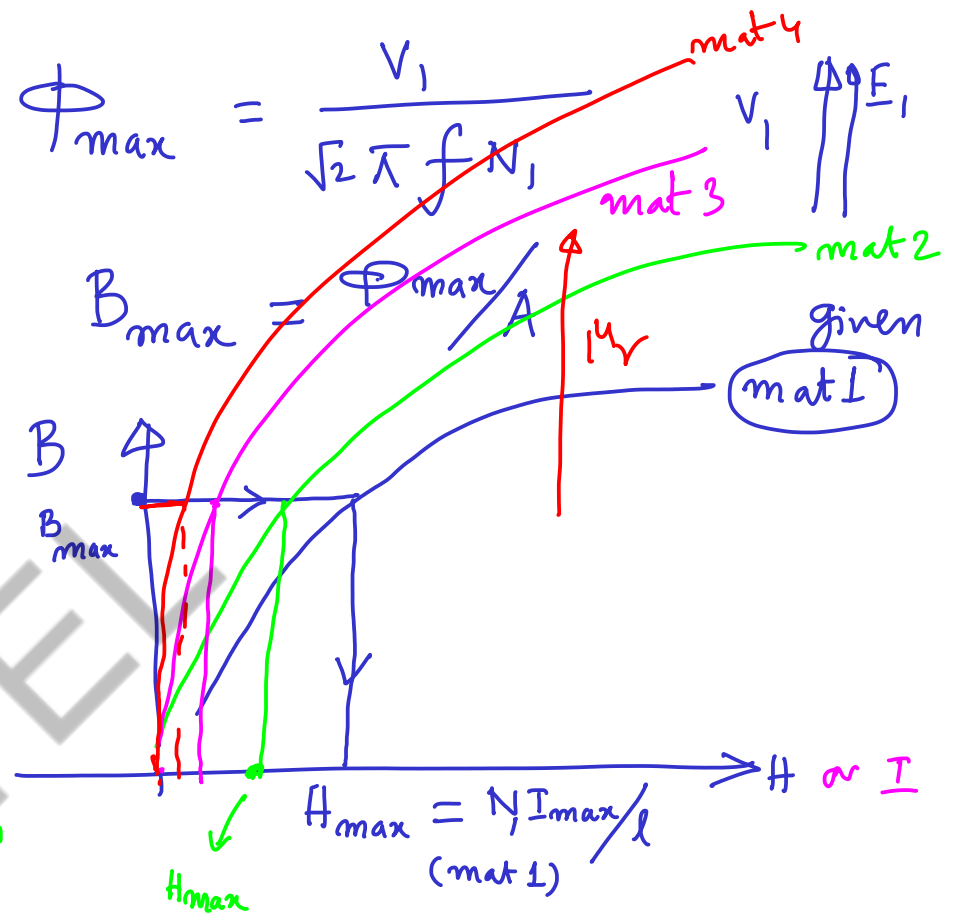
$$\Rightarrow \Phi_{\max} = \frac{V_1}{\sqrt{2} \pi f N_1}$$



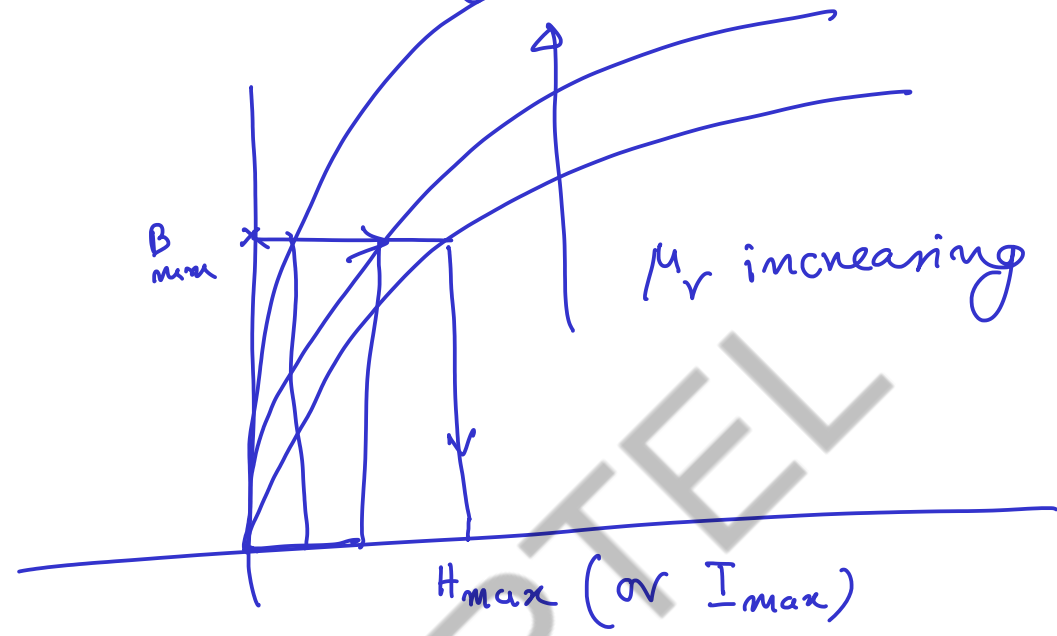
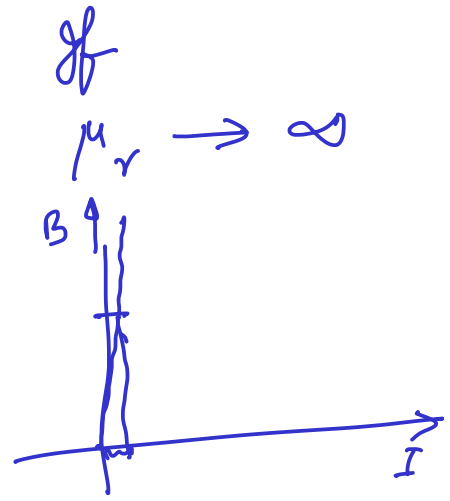
$$I_{max} = \frac{l H_{max}}{N_1}$$

$$I = I_{max} / \sqrt{2}$$

Magnetising
current i_m
or I_m

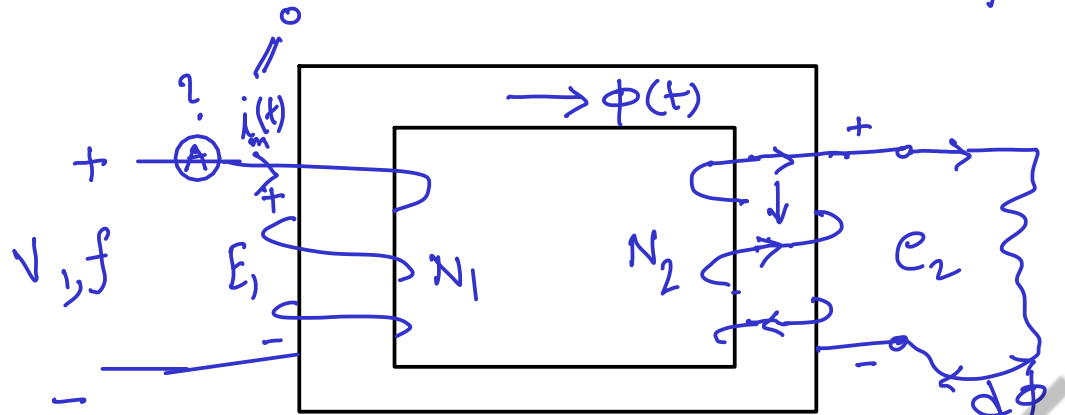


$$\phi_{\max} = \frac{V_1}{\sqrt{2} \pi f N_1} \therefore B_{\max}$$



Ideal transformer :-

$$\Phi_{\max} = \frac{V_1}{\sqrt{2} \pi f N_1}$$



$$e_1 = N_1 \frac{d\phi}{dt}$$

$$e_2 = N_2 \frac{d\phi}{dt}$$

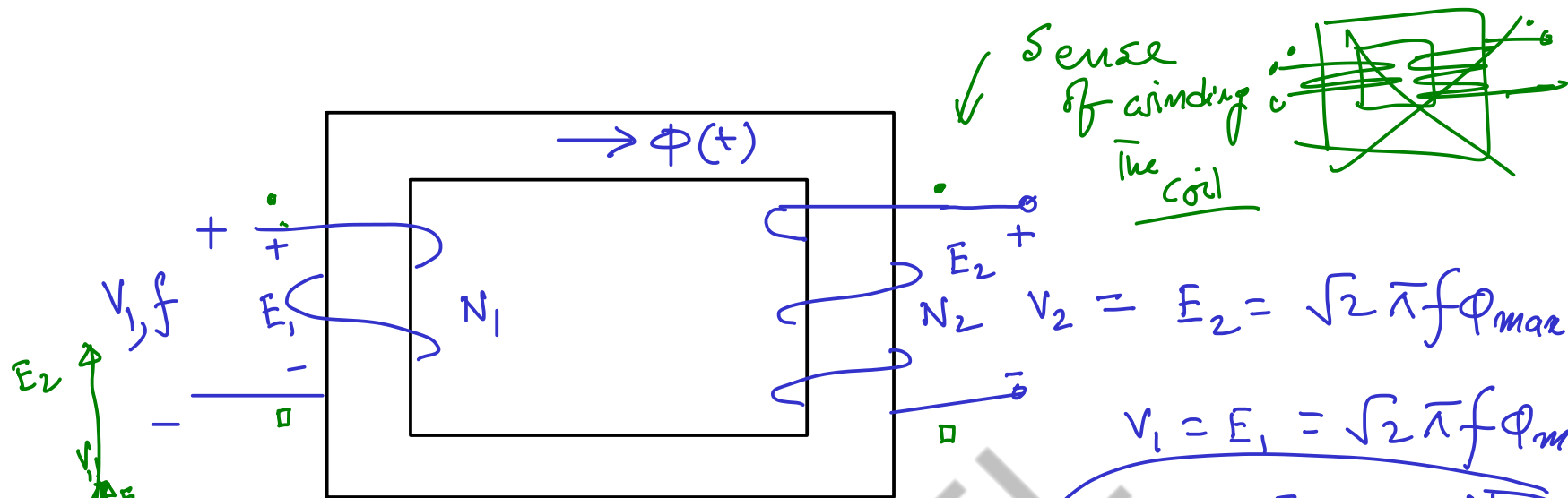
$$V_1 = E_1 = \sqrt{2} \pi f \Phi_{\max} N_1$$

$$E_2 = \sqrt{2} \pi f \Phi_{\max} N_2$$

① winding resistances = 0

② no leakage flux (all flux is confined to the core) or ~~the~~ all the flux is mutual flux

③ Magnetic core material is extremely good ($\mu_r \rightarrow \infty$!) so that magnetising current necessarily to create flux is $\approx$ zero



$$V_2 = E_2 = \sqrt{2} \pi f \Phi_{\max} N_2$$

$$V_1 = E_1 = \sqrt{2} \pi f \Phi_{\max} N_1$$

$$\therefore \frac{V_1}{V_2} = \frac{E_1}{E_2} = \frac{N_1}{N_2}$$

$$\therefore \mu_r \rightarrow \infty$$

$$\Phi_{\max} = \frac{V_1}{\sqrt{2} \pi f N_1}$$

→ Φ current necessary
 $\mu_m \approx 0$

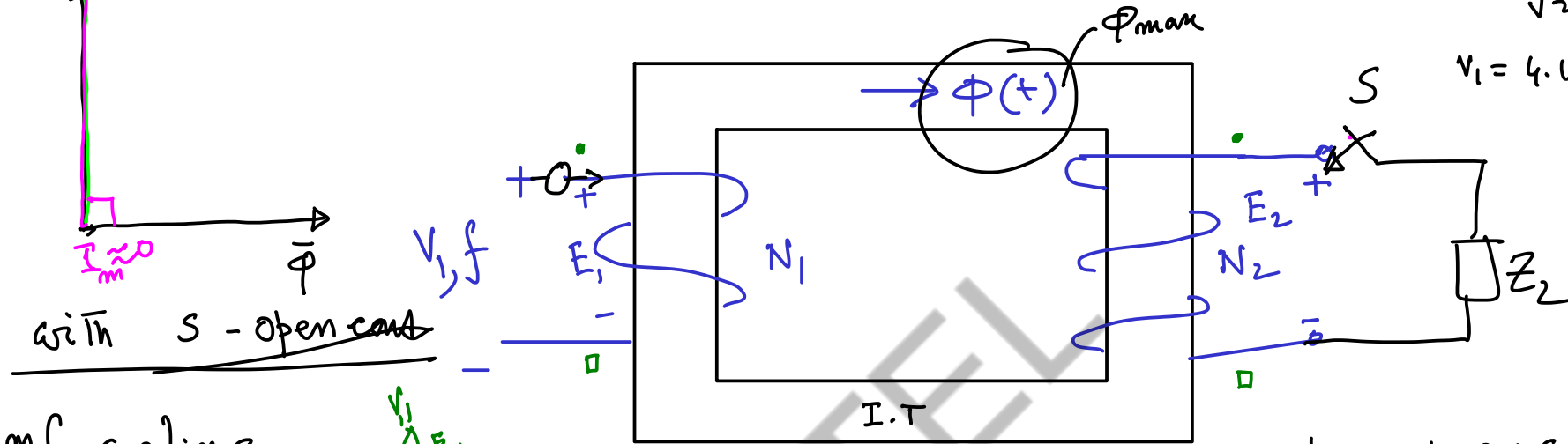
lec-4

Ideal transformer

$$\frac{E_2}{E_1} = \frac{V_2}{V_1} = \frac{N_2}{N_1}$$

$$\Phi_{max} = \frac{V_1}{\sqrt{2} \pi f N_1}$$

$$V_1 = 4.44 f \Phi_{max} N_1 = E_1$$



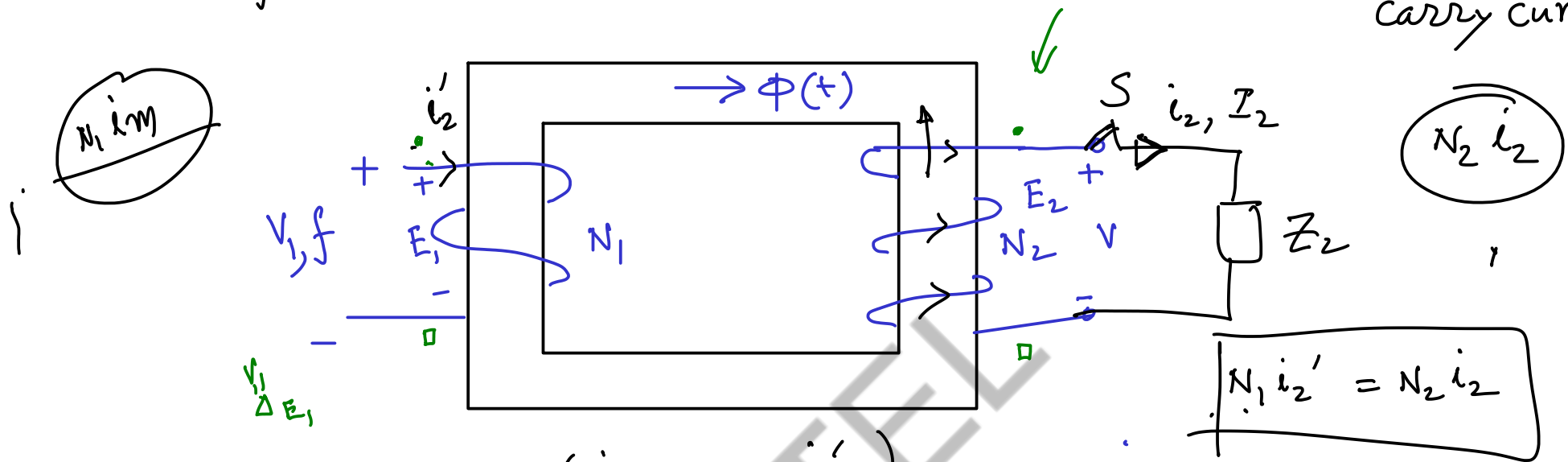
mmf acting

$$= N_1 I_m (\approx 0) \Rightarrow \Phi$$

with S closed (when both coils carry current) net mmf must be once again $N_1 I_m$

whether S is opened or closed Φ core flux can not change!

$N_1 I_m \rightarrow$ magnetising mmf with S opened
 net mmf with S closed must be also $N_1 I_m$ when both the coils carry current

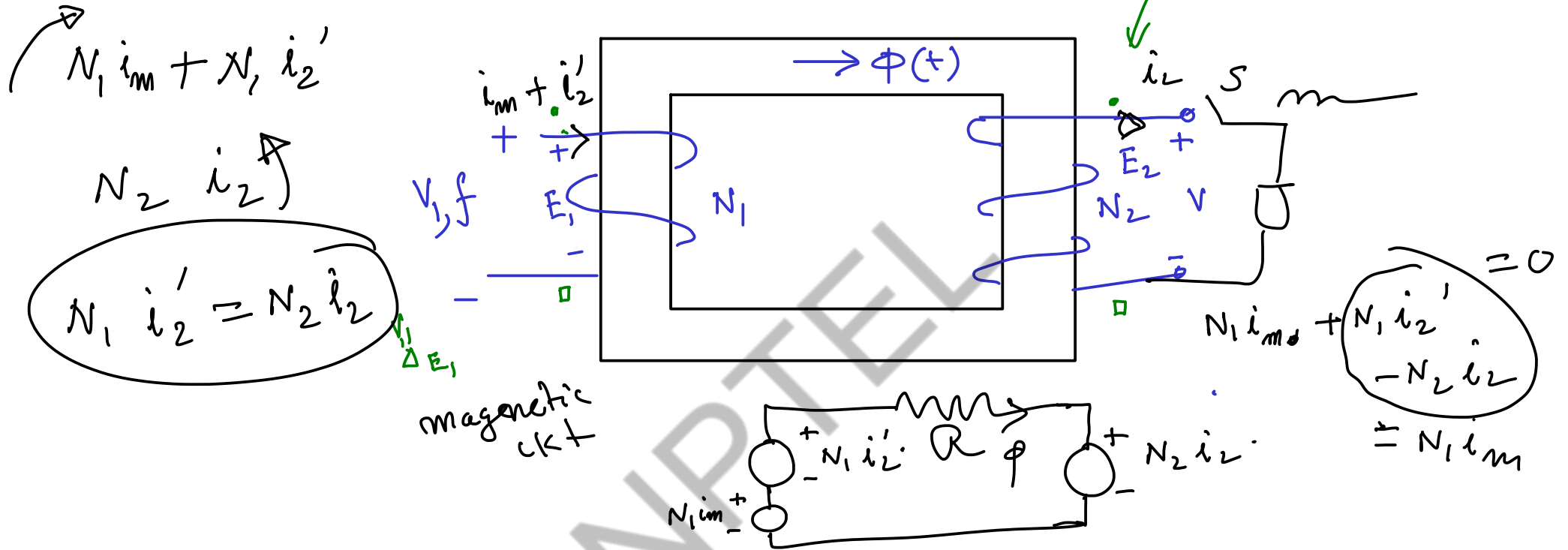


$$N_1 (i_m + i_2')$$

$$= \rightarrow N_1 i_m + \rightarrow N_1 i_2' + N_2 i_2$$

$S \rightarrow \text{opened} :- N_1 i_m \text{ (net mmf)}$

$S \rightarrow \text{closed } \cancel{\text{re}} N_1 i_m \text{ (net mmf)}$

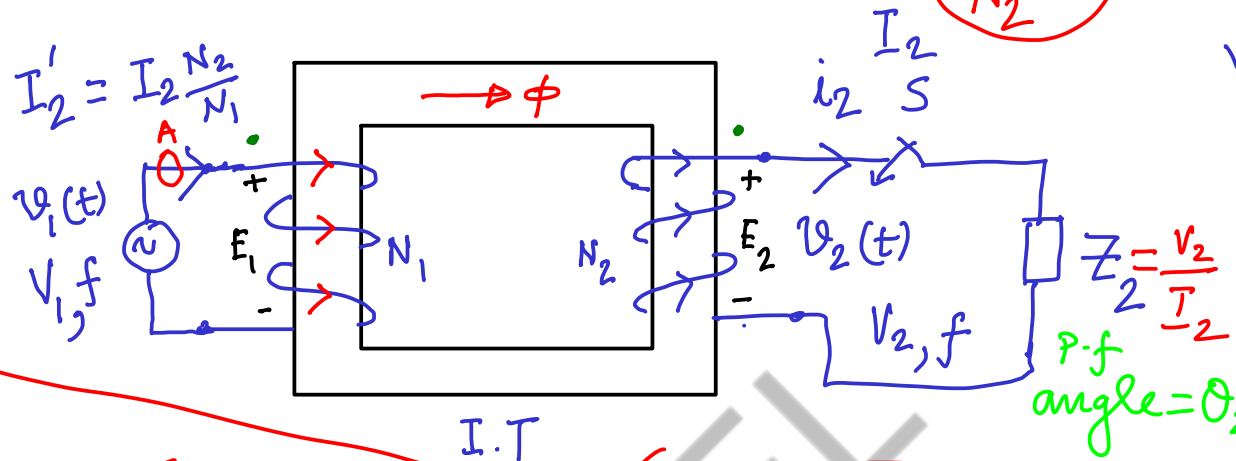
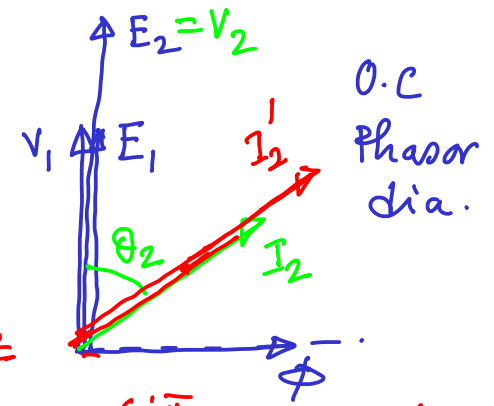


$\frac{V_1}{V_2} = \frac{N_1}{N_2} = a$ Ideal Transformer $\mu_r \rightarrow \infty$

$\frac{N_1}{N_2} = a$

$N_1 i_m (\approx 0) = I_1 = \frac{I_2}{a}$

$I_2' = I_2 \frac{N_2}{N_1}$



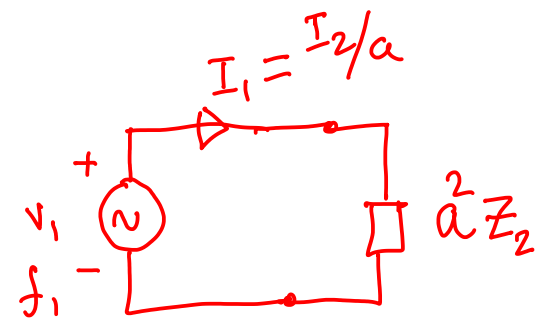
with S closed Phasor dia.

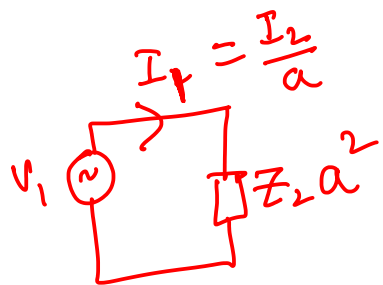
Equiv ckt. :-

- (1) ref. to the pr. or supply side
- (2) ref. to sec or load side.

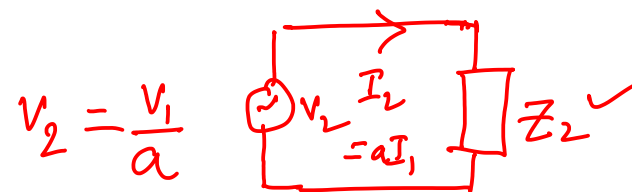
Imp. seen

by the supply $= \frac{V_1}{I_1} = \frac{a V_2}{I_2/a} = a^2 \frac{V_2}{I_2} = a^2 Z_2$

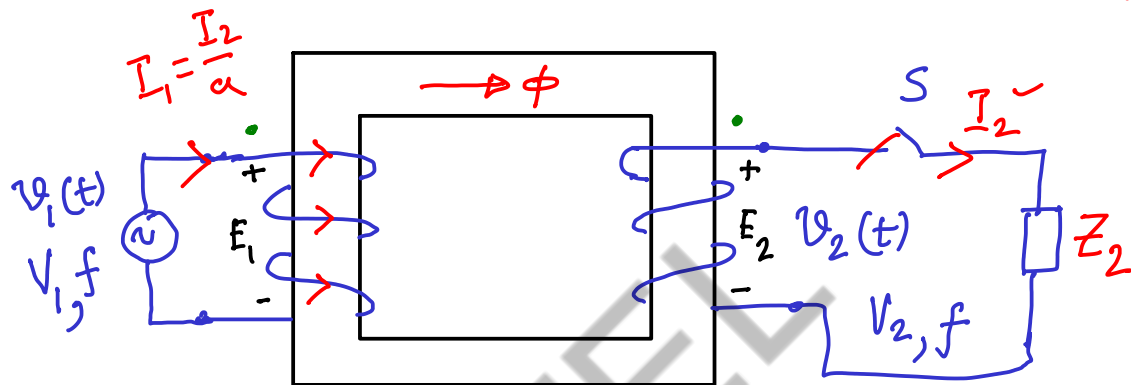




Ref. to pr. side
source side



Equiv.ckt.
ref. to
sec. side
or load side



$$V_1 I_1 = a V_2 \times \frac{I_2}{a} = V_2 I_2$$

$$V_1 = a V_2$$

$$I_1 = I_2 / a$$

$$a = \frac{N_1}{N_2}$$

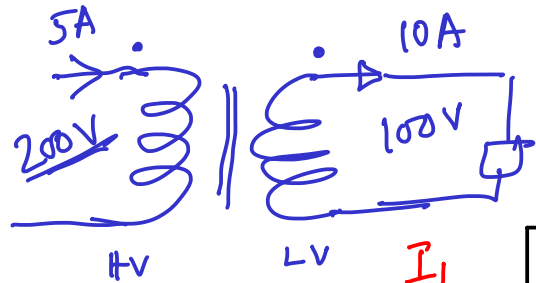
→ VA or
KVA remain
Same on both
sides.

Equiv ckt. :

Rating of transformer

200V/100V, 1 KVA, 50Hz

Dec-6

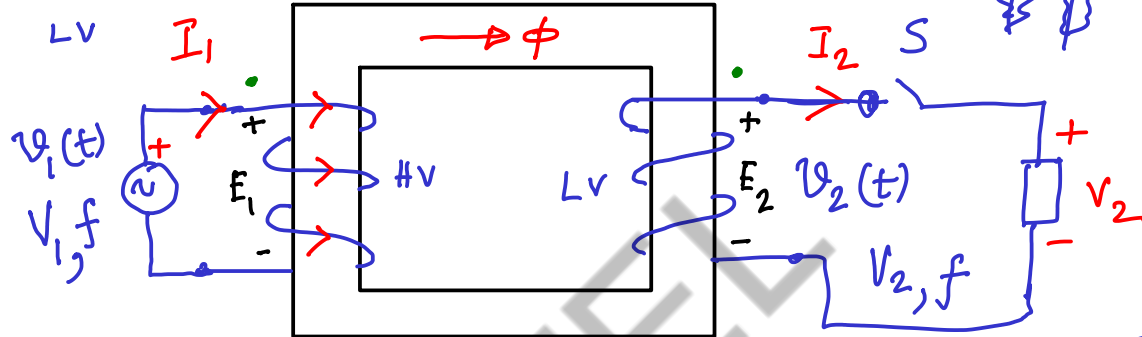
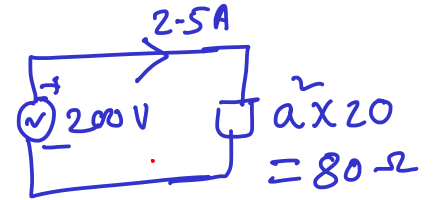


$$a = \frac{N_1}{N_2} = \frac{200}{100} = 2$$

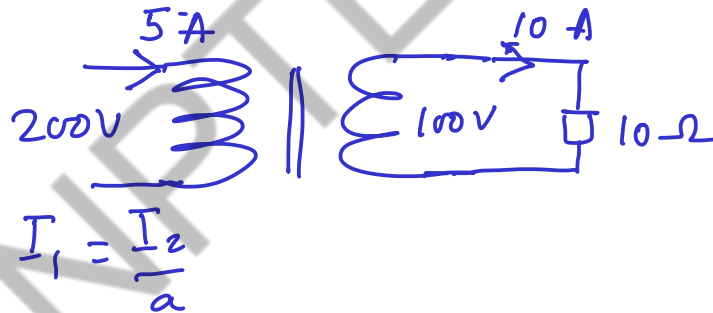
1- ϕ transformer

$$I_{HV} \text{ (rated)} = \frac{1000}{200} \text{ A} = 5 \text{ A}$$

$$I_{LV} \text{ (rated)} = \frac{1000}{100} \text{ A} = 10 \text{ A}$$

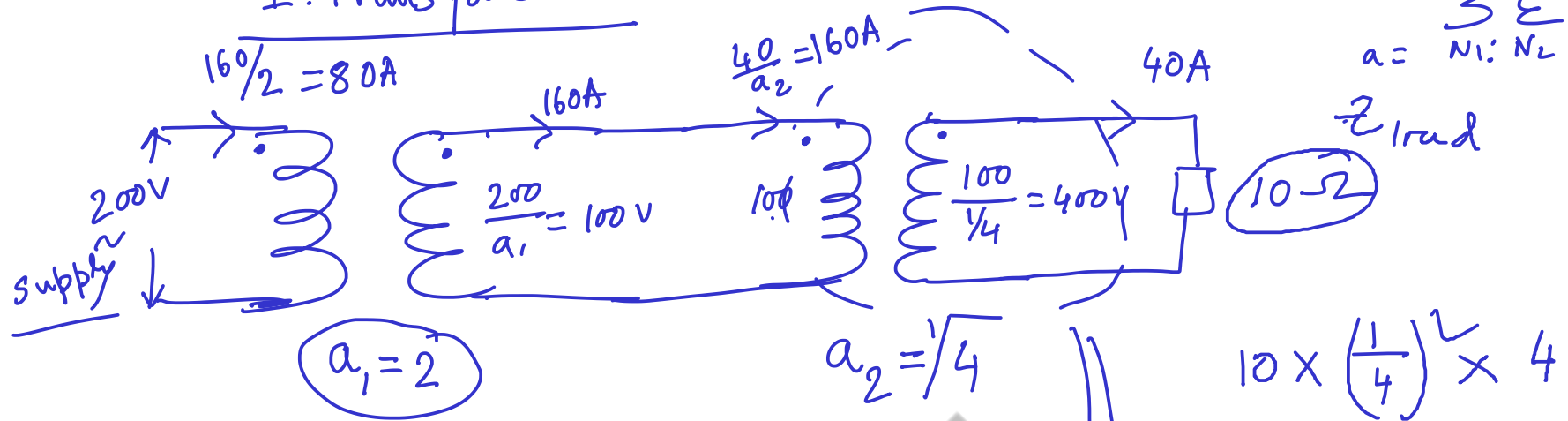


HV side $\odot$ Thinner section
LV side $\otimes$



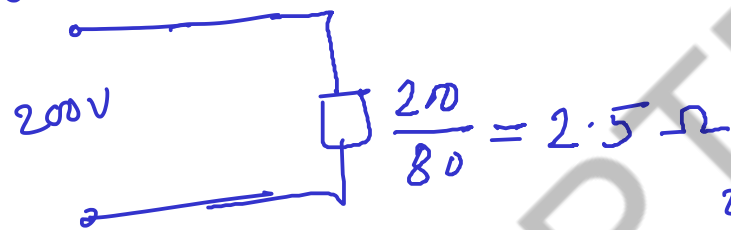
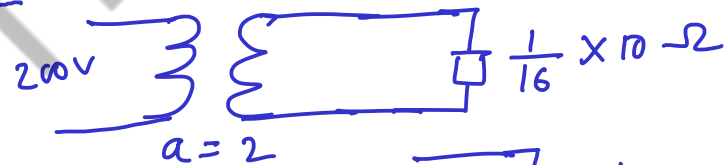
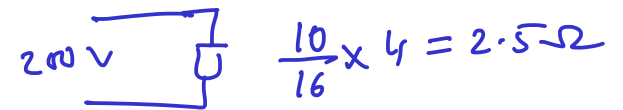
$a = \frac{200}{100} = 2$
at Rated current
tfo operates at
full load condition.

I. Transformer



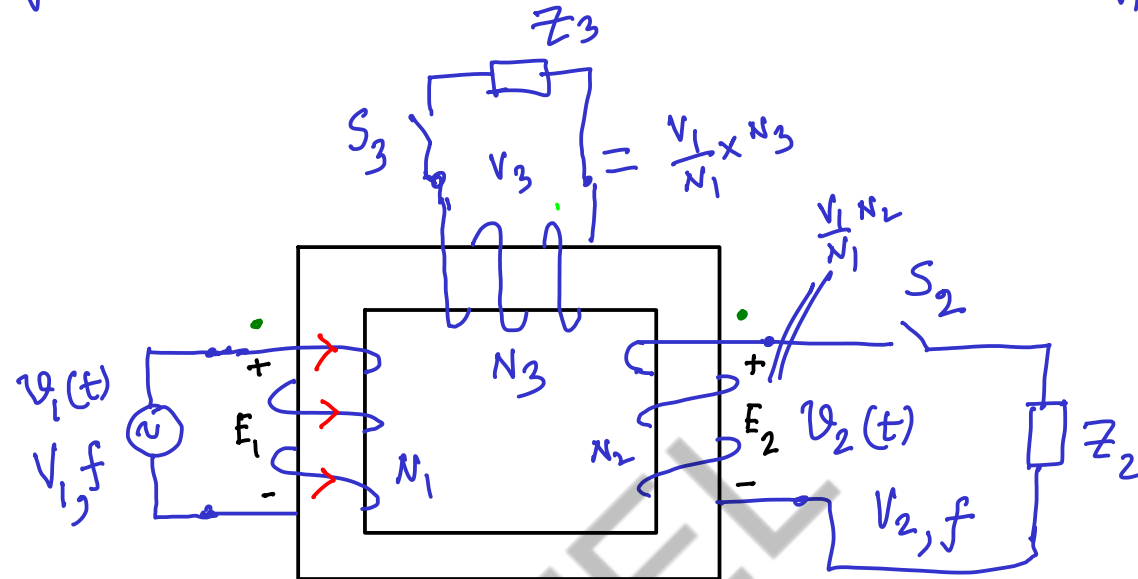
$$10 \times \left(\frac{1}{4}\right)^2 \times 4 = 2.5 \Omega$$

Equiv ckt.
ref. to source



Ideal transformer: Examples

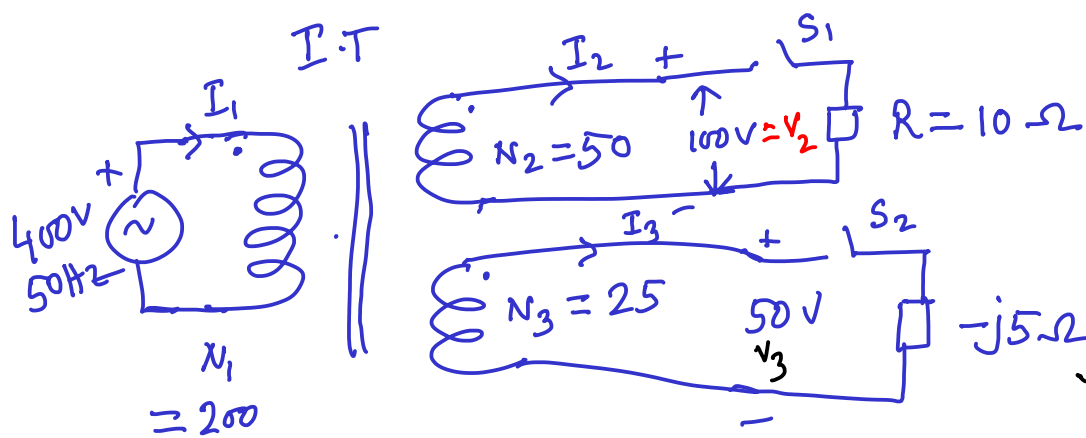
dec-7



$$\frac{V_1}{N_1} = \frac{V_2}{N_2}$$

$$\frac{V_1}{N_1} = \frac{V_2}{N_2}$$

= voltage per
turn
= constant



$$\text{Voltage/turn} = \frac{400}{200} = 2$$

(i) $V_2 = 100V$ & $I_2 = \frac{100}{10} = 10A$

(ii) $I_3 = 0$ & $I_1 = \frac{I_2}{(200/50)} = \frac{10}{4} = 2.5A$

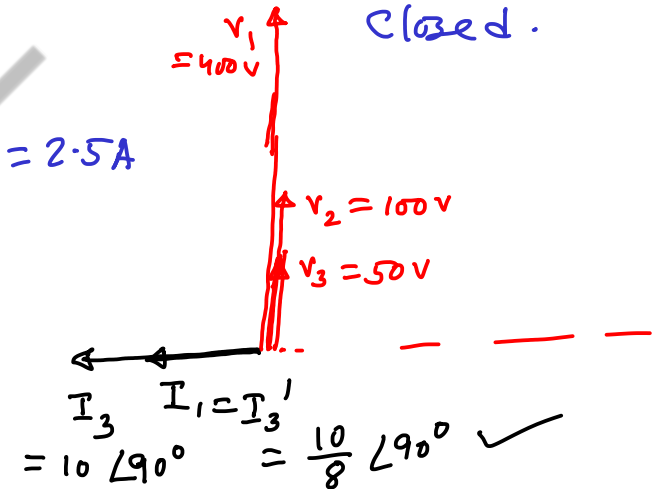
$$I_3 = \frac{50 \angle 0^\circ}{5 \angle -90^\circ} = 10 \angle 90^\circ$$

Calculate I_1 , I_2 & I_3

(i) when only S_1 is closed (S_2 opened)

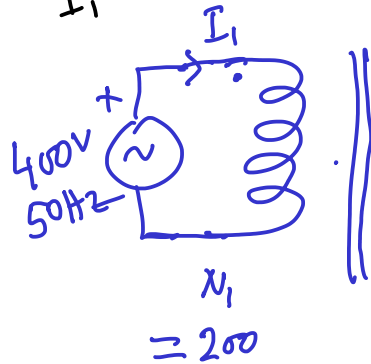
(ii) only S_2 closed & S_1 opened

(iii) both S_1 & S_2 are closed.



(iii)

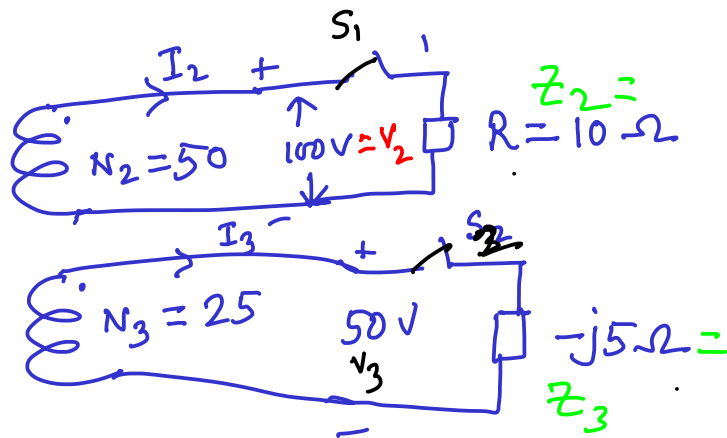
$$I_1 = I_2' + I_3'$$



$$V/\text{turns} = 2$$

$$I_1 = I_2' + I_3'$$

— ... —



$$I_2 = \frac{100 \angle 0^\circ}{10 \angle 0^\circ} = 10 \angle 0^\circ \text{ A} \quad \therefore I_2' = \frac{10}{4} \angle 0^\circ = 2.5 \text{ A}$$

$$I_3 = \frac{50 \angle 0^\circ}{5 \angle -90^\circ} = 10 \angle 90^\circ \text{ A}$$

$$I_3' = \frac{10 \angle 90^\circ}{8} = 1.25 \angle 90^\circ$$

both S_2 & S_3 are closed.

