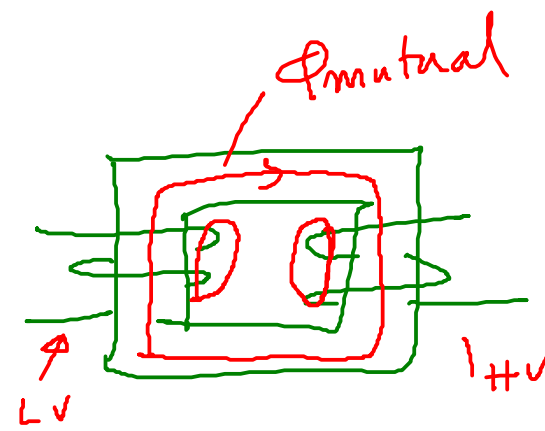
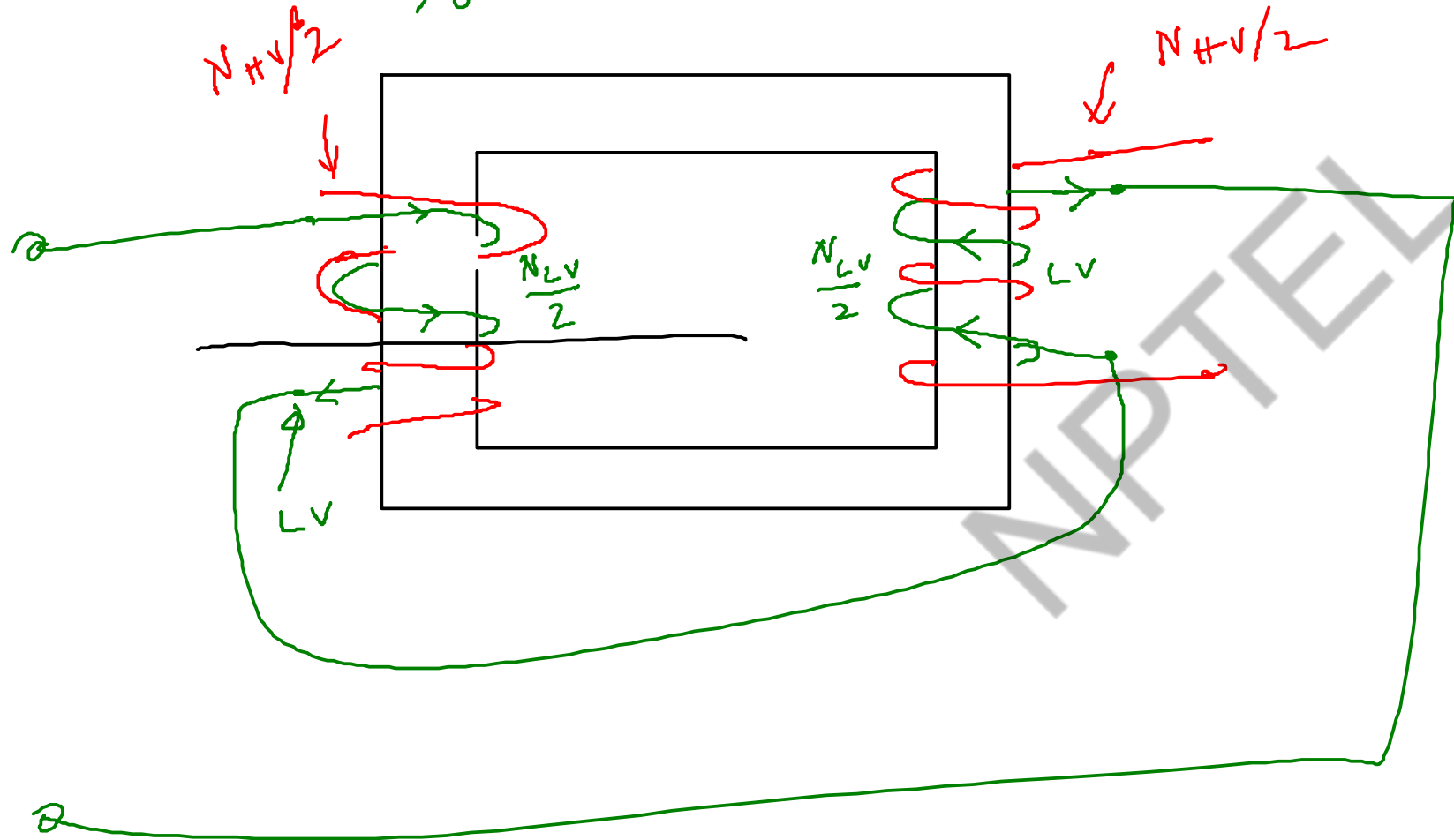
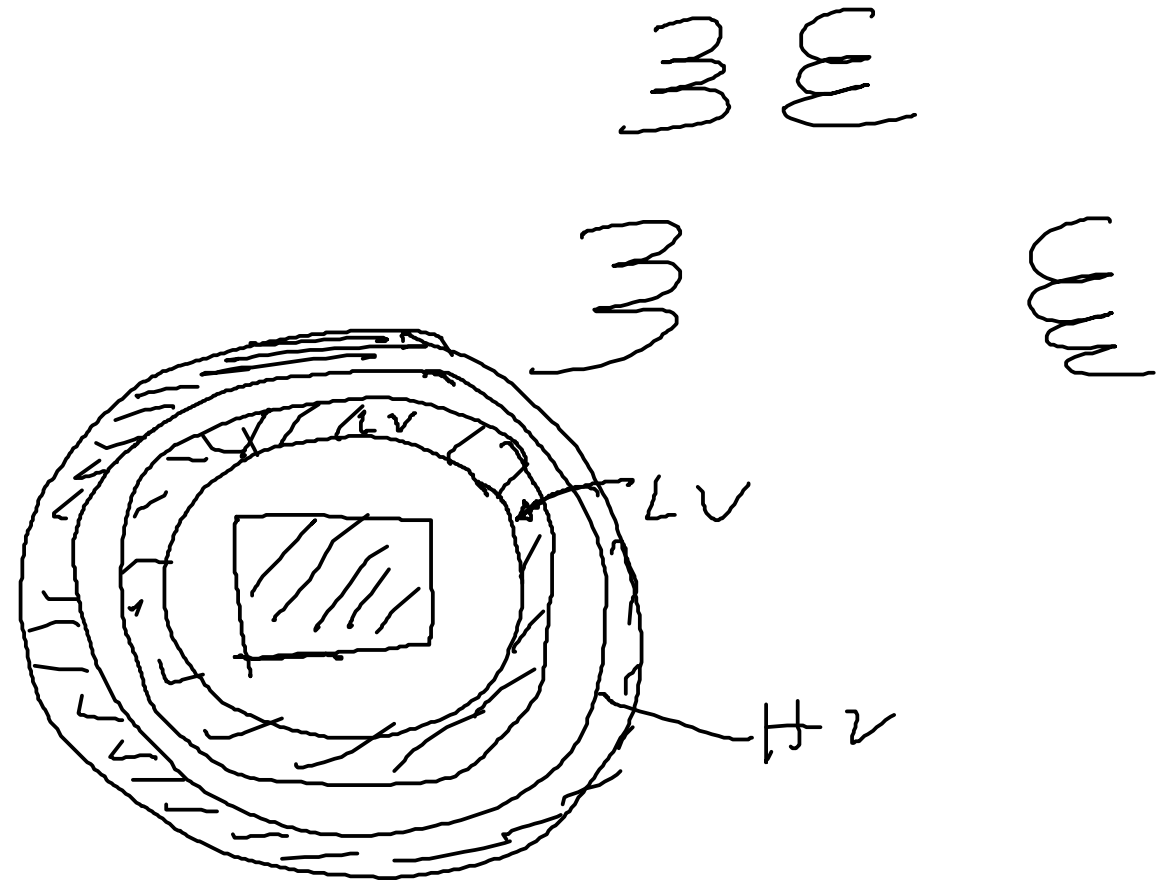
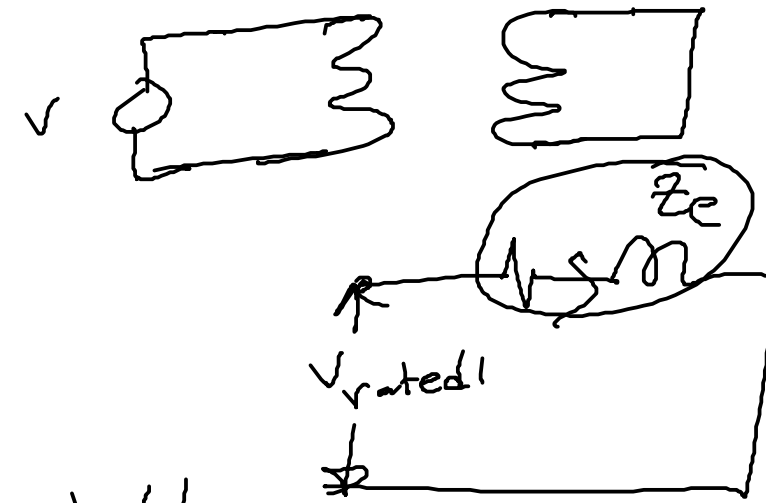




Q should be small

Dec-26





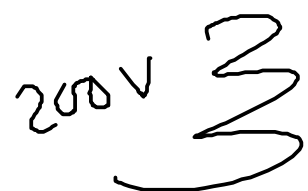
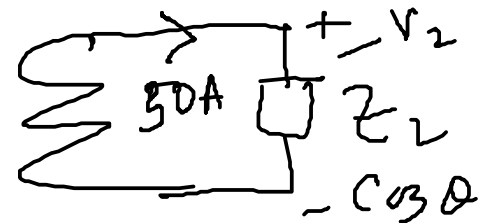
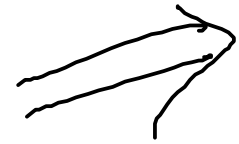
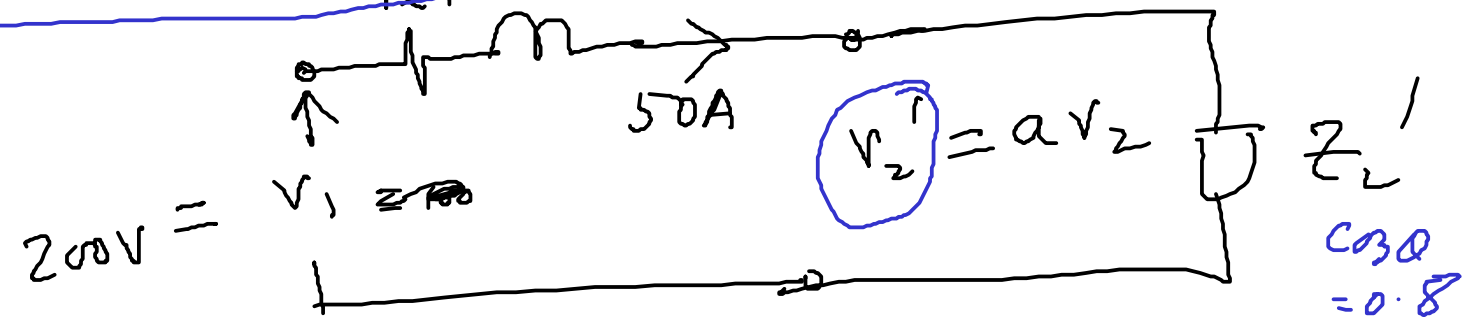
$$\cos \phi = \frac{I_1 r_e \cos \phi + I_1 x_e \sin \phi}{V_1} = \frac{|V_1| - |V_2'|}{|V_1|}$$

$$I_{sc} = \frac{V_{rated}}{z_e}$$

$$\Rightarrow |V_1| - |V_2'| = I_1 r_e \cos \phi + I_1 x_e \sin \phi \quad || \quad |V_2'| = |V_1| - (I_1 r_e \cos \phi + I_1 x_e \sin \phi) = 200$$

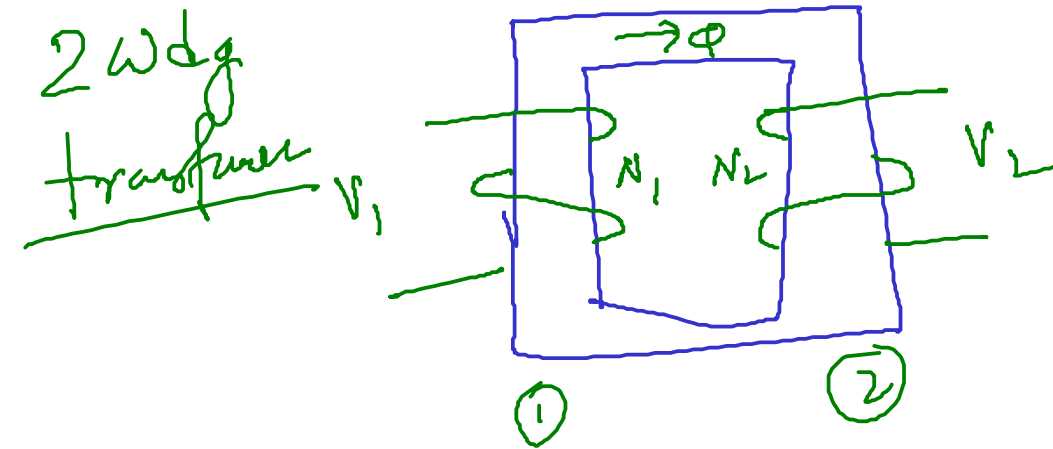
1 ph, 5 KVA, 200 V / 100 V, 50 Hz
 $I_1 = 25$ $I_2 = 50$ A

$$\frac{5000}{200}$$



$$|V_1| = |V_2'| + (I_1 r_e \cos \phi + I_1 x_e \sin \phi) = 200 + ($$

Auto-transformer :-



$$V_1 = E_{Ac} = E_1$$

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

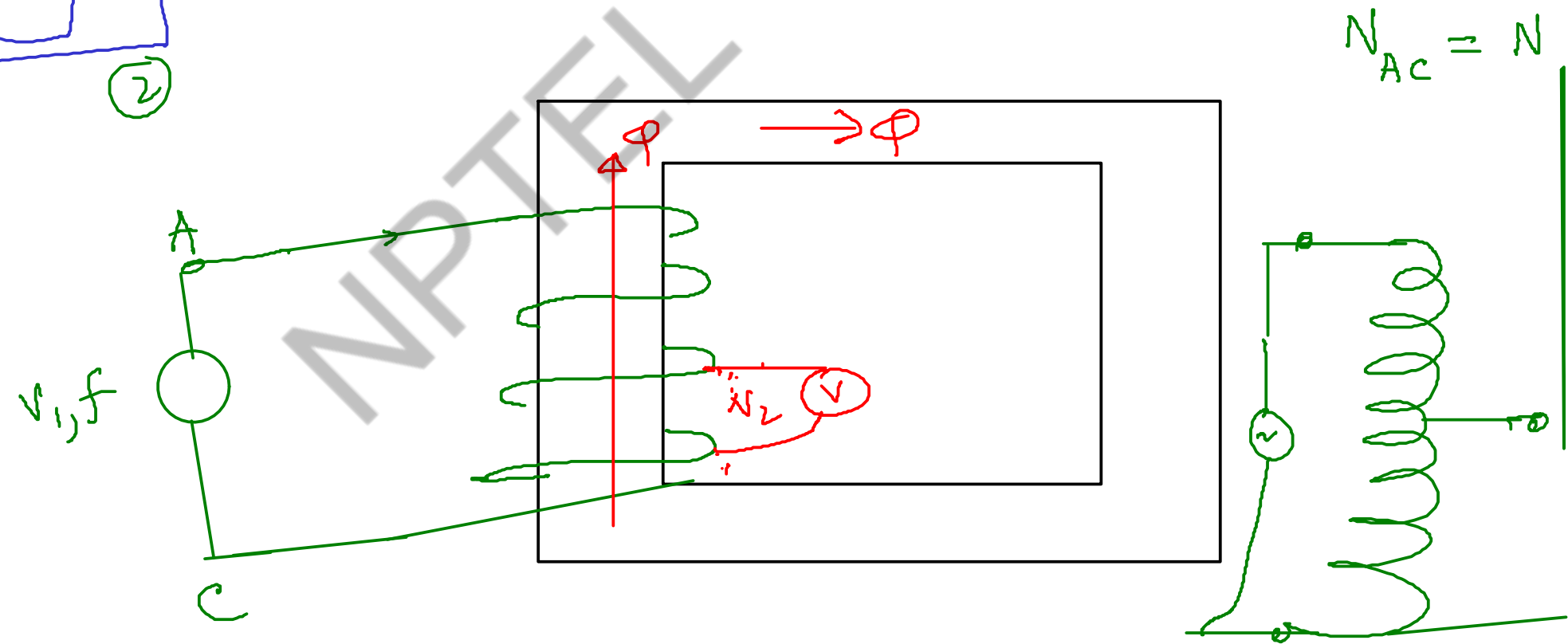
$$\frac{V_1}{N_1} \times N_2$$

voltage per turn $\frac{V_1}{N_1}$ $a = N_1/N_2$

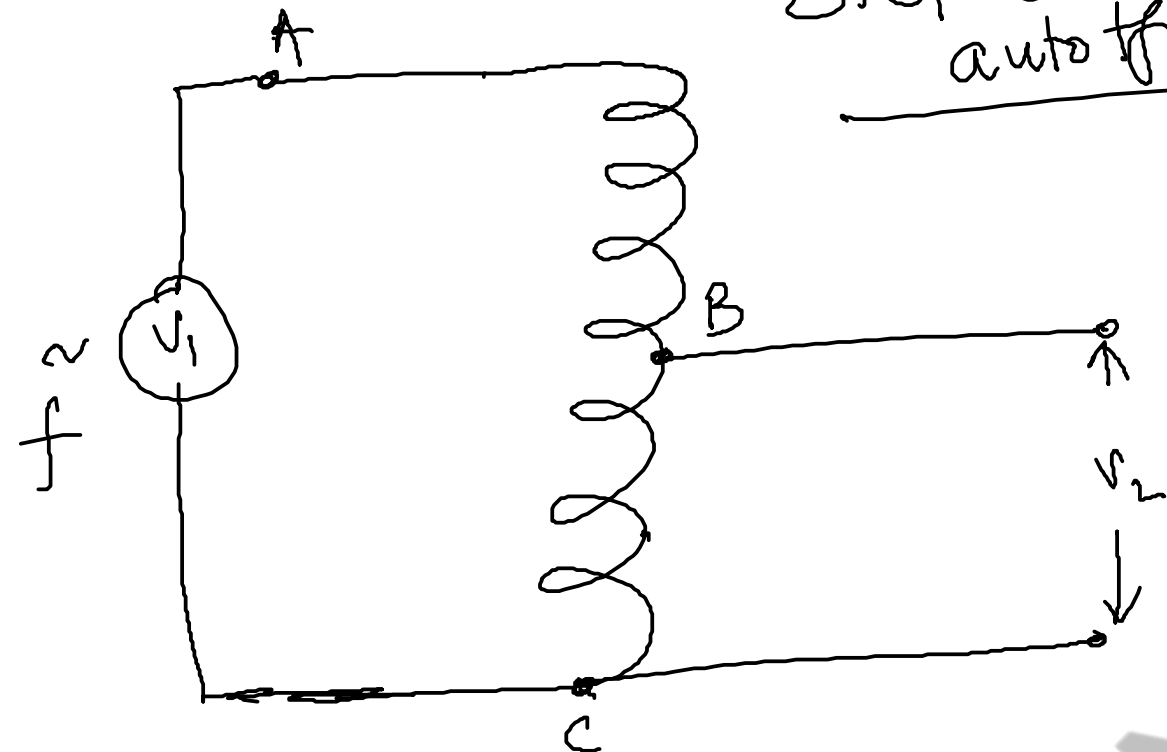
$$V_2 = \left(\frac{V_1}{N_1} \right) N_2 = \frac{V_1}{a}$$

$$= V_1 \left(\frac{N_2}{N_1} \right)$$

Ideal auto tfo

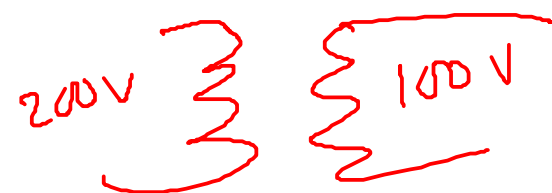


Autotransformer :-

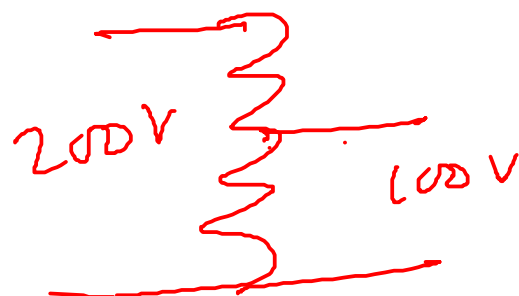


Step down
auto tfo

200V

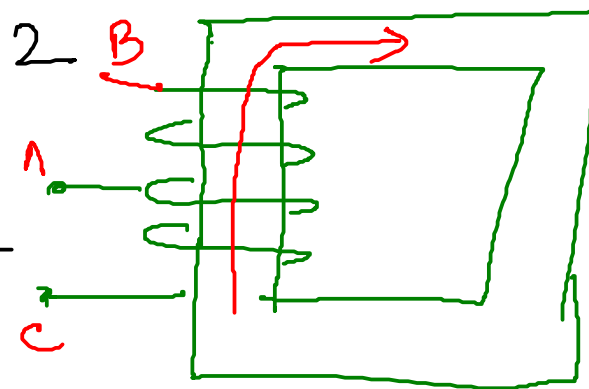
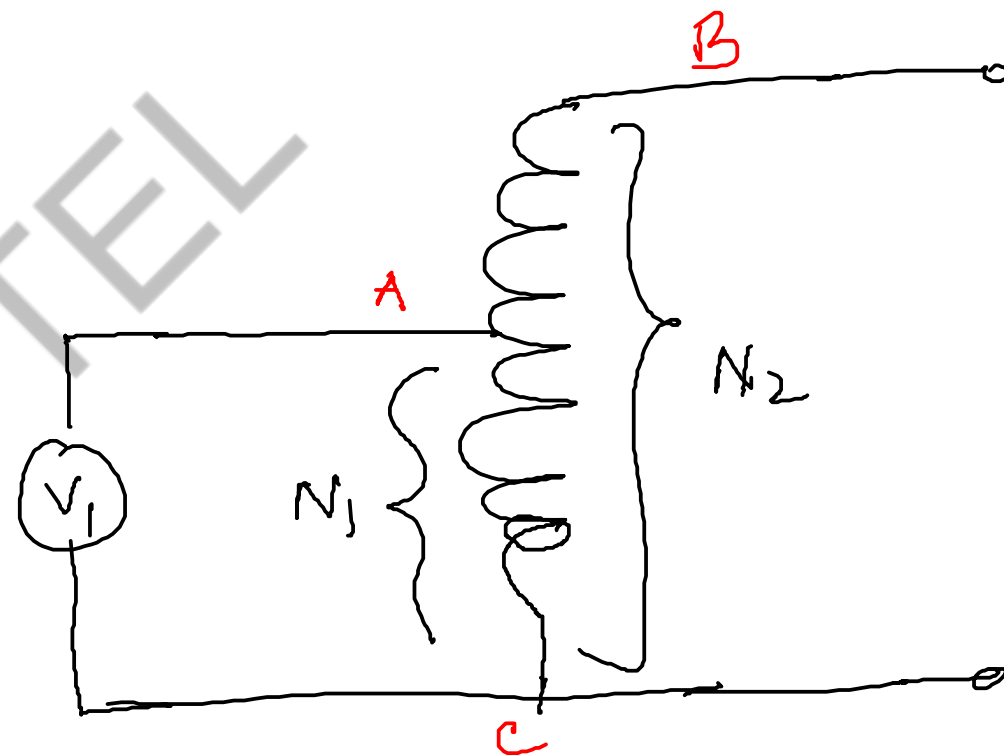


100V



$$N_{AC} = N_1 \quad || \quad N_{BC} = N_2$$

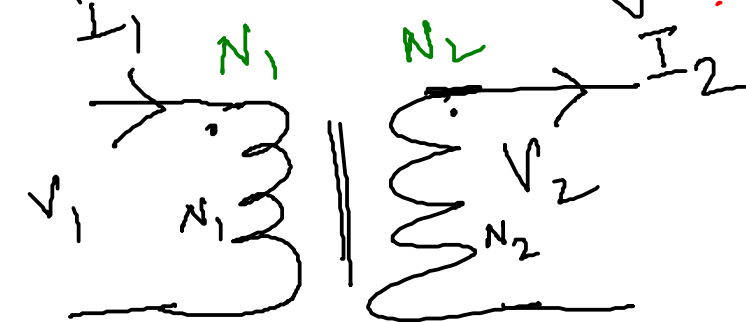
$$V_2 = \frac{V_1}{N_1} \times N_2$$



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

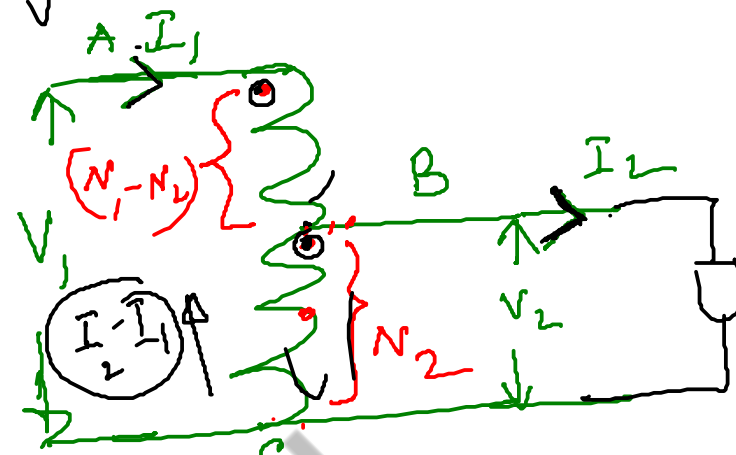
$N_2 > N_1$

ideal. Comparing a 2-wdg trf & an auto-transformer



$$V_1 I_1 = V_2 I_2$$

$$N_1 I_1 = N_2 I_2$$



$$N_{AC} = N_1$$

$$N_{BC} = N_2$$

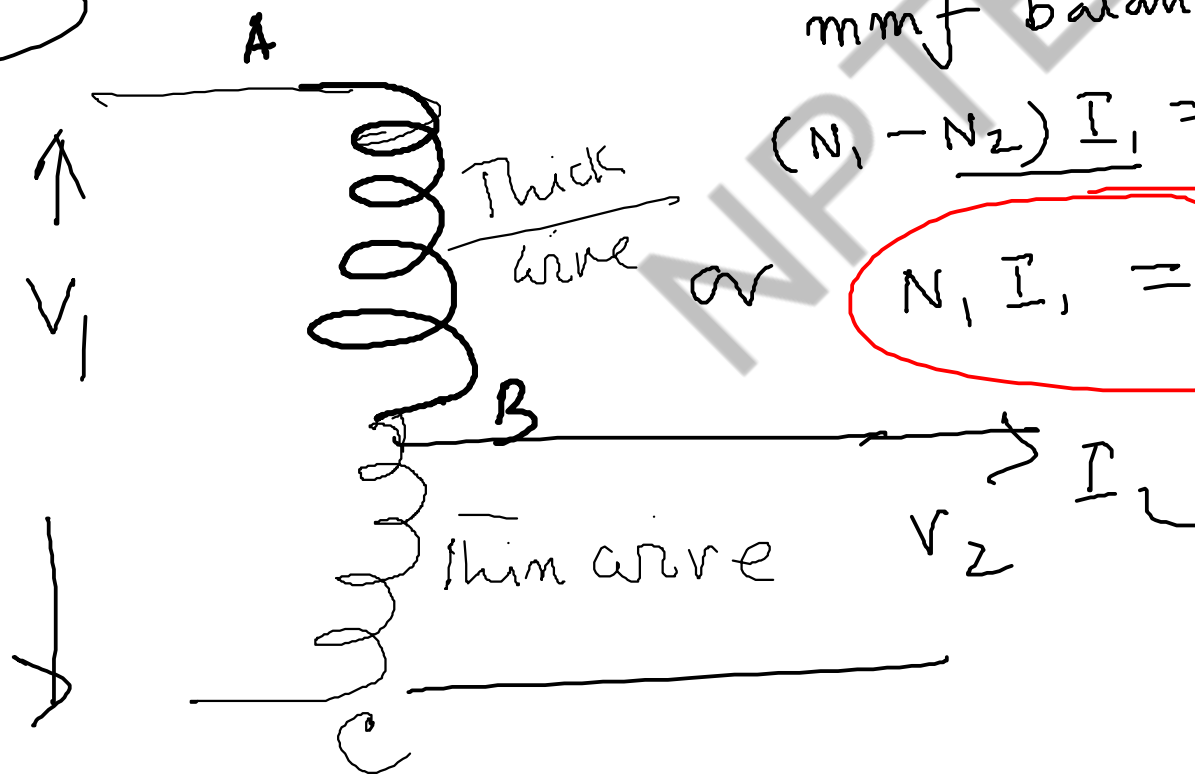
$$N_{AB} = N_1 - N_2$$

from
mmf balance

$$(N_1 - N_2) I_1 = N_2 (I_2 - I_1)$$

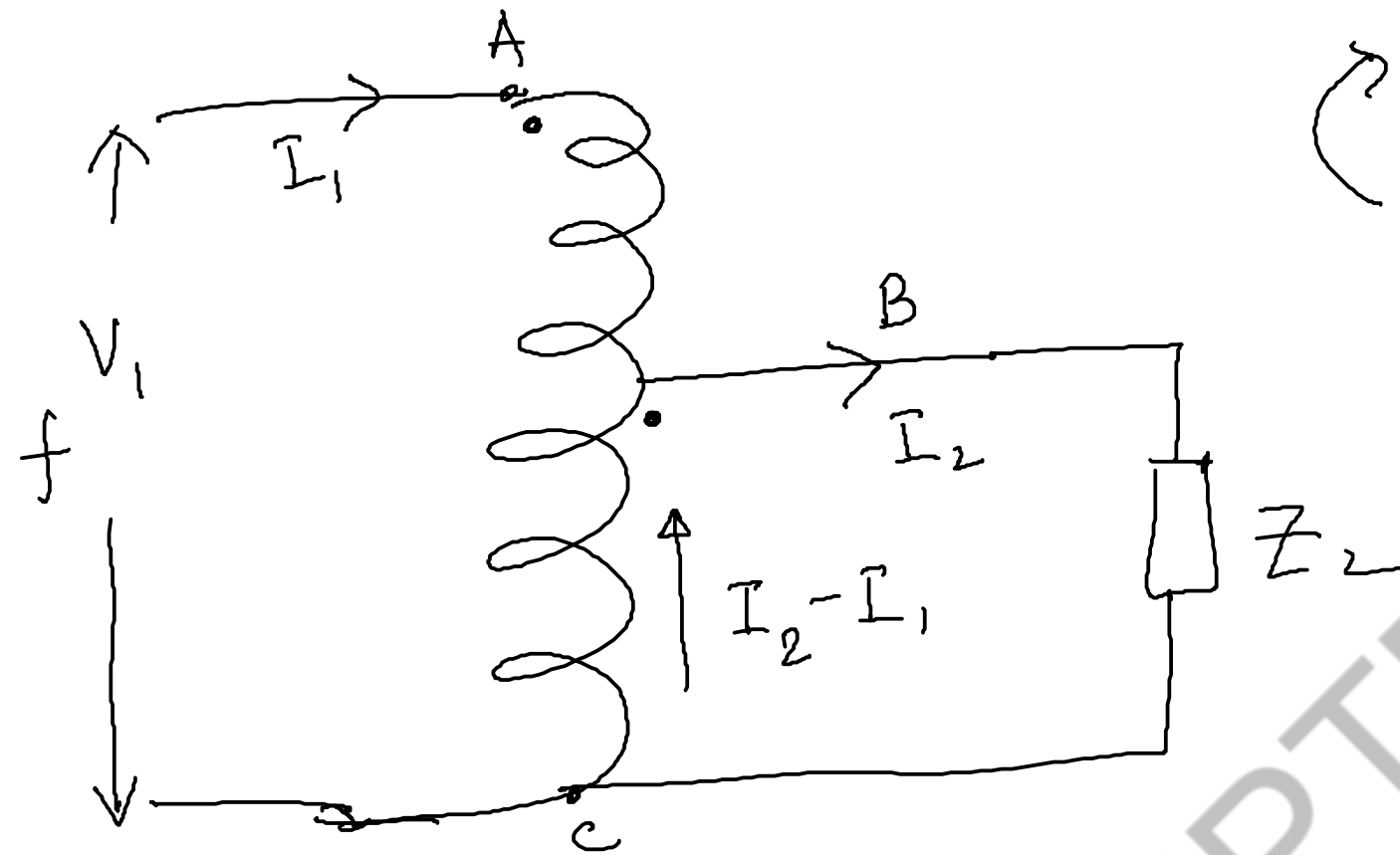
$$N_1 I_1 = N_2 I_2$$

Coil = AB
& coil BC
are two separate
coil.



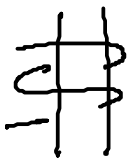
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NPTEL



$$N_{AB} = N_1 - N_2$$

$$N_{AC} = N_1 \quad N_{BC} = N_2$$



mmf balance:-

$$(N_1 - N_2) I_1 = N_2 (I_2 - I_1)$$

$$N_1 I_1 = N_2 I_2$$

vol. of cu reqd. for a coil

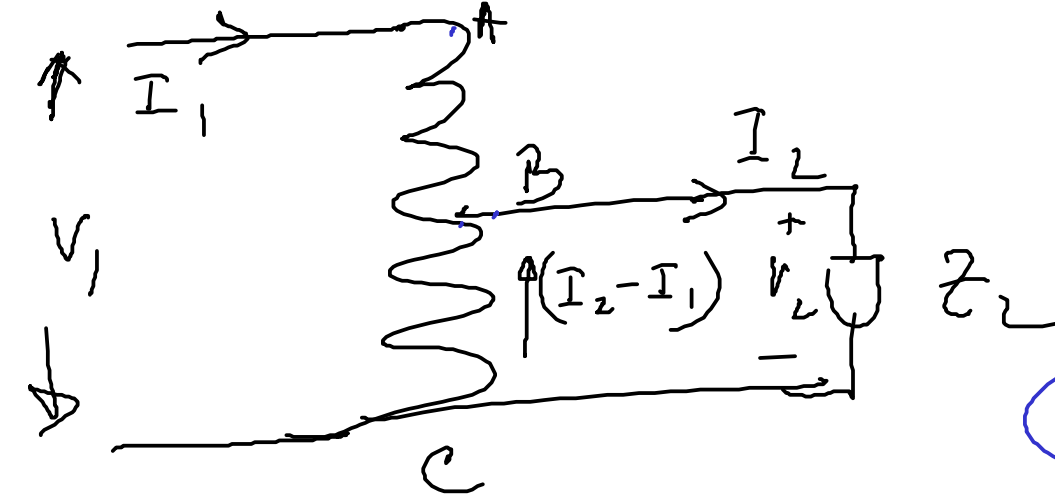
$$= \text{length of wire} \times \sqrt{\text{cross sec. area}}$$

length of wire $\propto$ no. of turns of the coil

Cross-sectional area of the wire $\propto$ current



$$N_1 I_1 = N_2 I_2 \quad \checkmark$$



$$N_{AC} = N_1$$

$$N_{BC} = N_2$$

$$N_{AB} = N_1 - N_2$$

$$N_1 I_1 = N_2 I_2 \quad \checkmark$$

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

vol. of Cu reqd. in Autotfo
 vol. of Cu reqd. in 2wdg tfo =

$$\frac{N_2 (I_2 - I_1) + (N_1 - N_2) I_1}{N_2 I_2 + N_1 I_1}$$

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

for step down case
 $N_1 > N_2$

$$a > 1$$

$$or \frac{1}{a} < 1$$

suppose

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

then

$$1 - \frac{3}{4} = 1 - 0.75 = 0.25$$

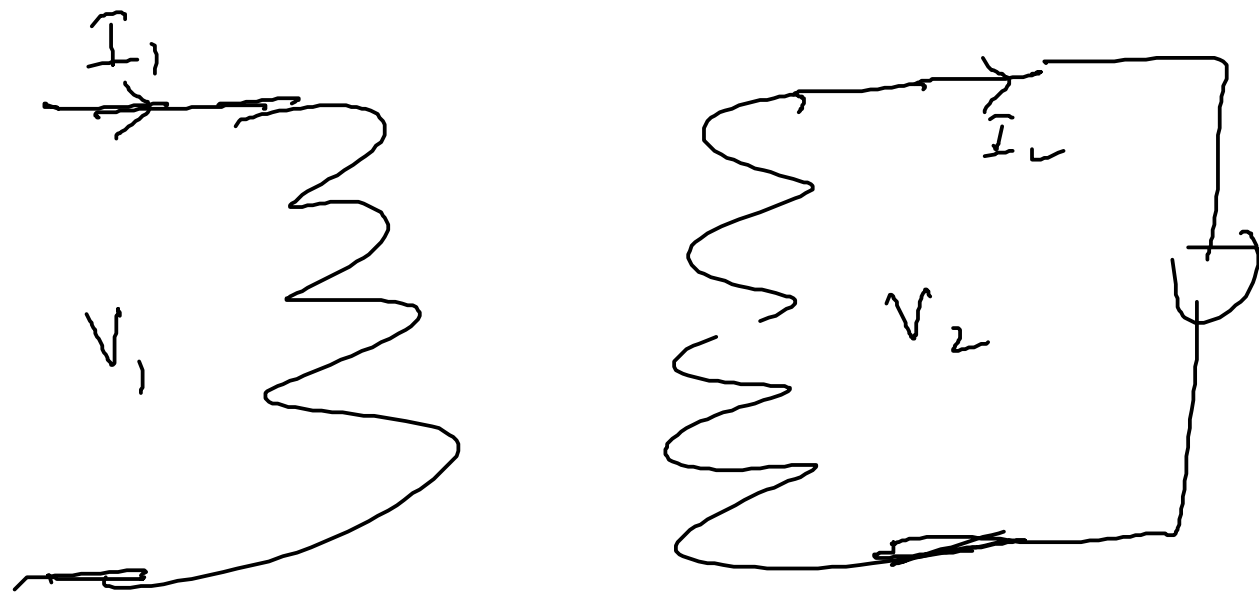
$$= \frac{N_2 I_2 - N_2 I_1 + N_1 I_1 - N_2 I_1}{N_1 I_1 + N_2 I_2} = \frac{2 N_1 I_1 - 2 N_2 I_1}{2 N_1 I_1}$$

$$= \frac{N_1 - N_2}{N_1} = 1 - \frac{N_2}{N_1} = \left(1 - \frac{1}{a}\right) \quad \checkmark$$

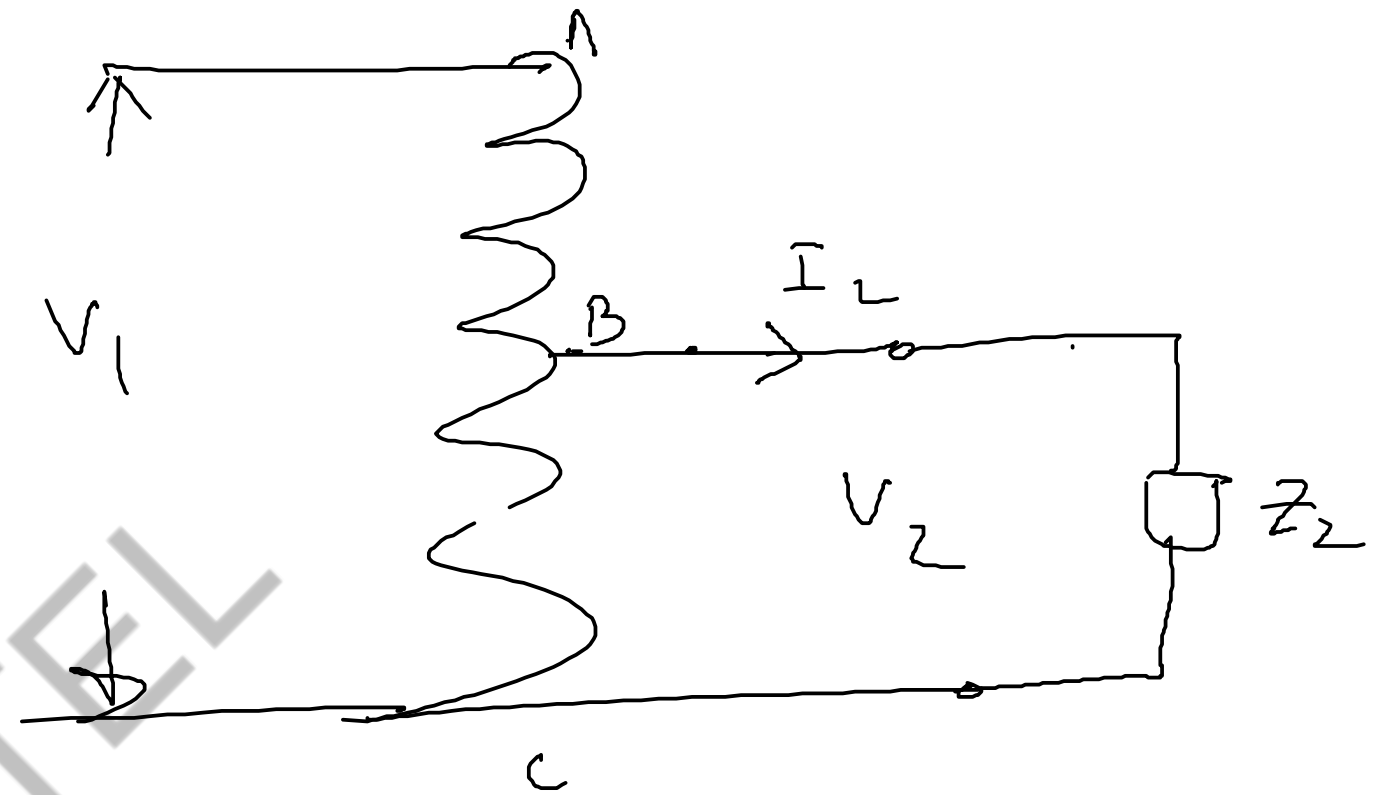
$$\text{Cu reqd. in auto} = \left(1 - \frac{1}{2}\right) \times \text{cu. reqd. in 2wdg tfo}$$

$$= 0.5 \times \text{cu reqd. in 2wdg tf.}$$

$$\rightarrow a = \frac{4}{3} \quad \checkmark$$



Open ckt. fault in
~~primary~~ secondary
 Two windg tfo
 provides isolation



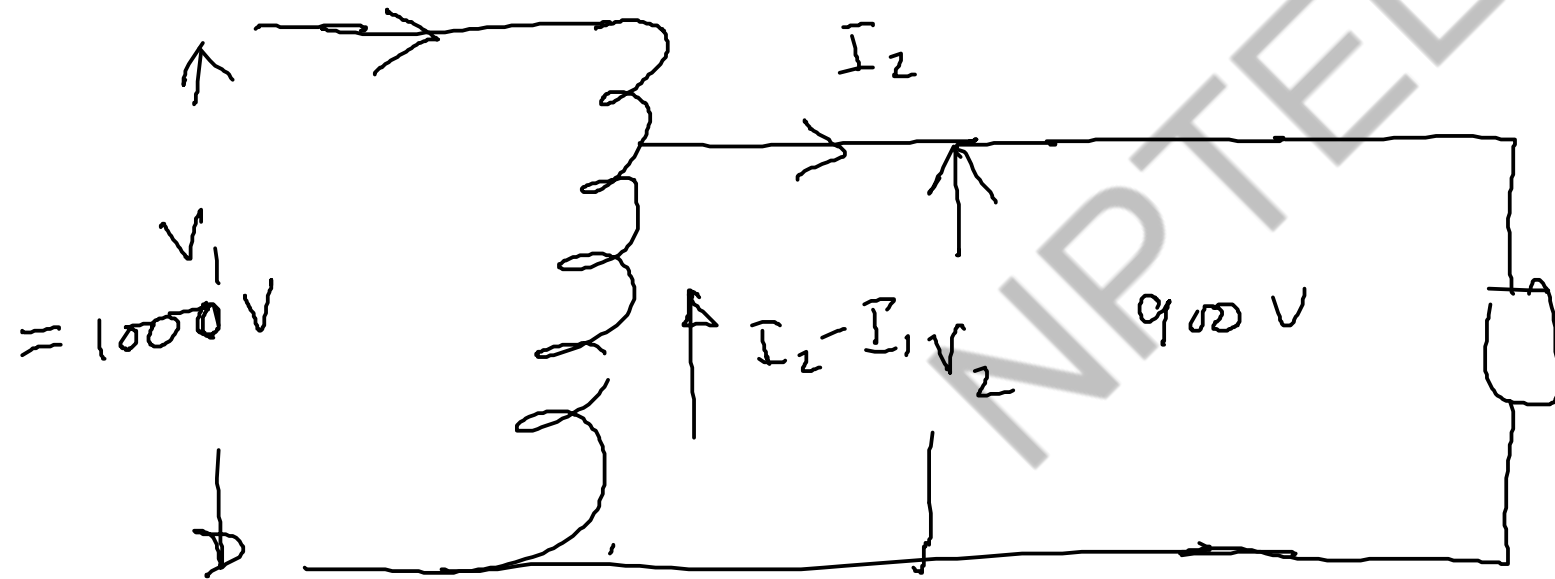
open ckt. fault in
 The common portion of the
 winding i.e., BC
 no isolation

Autotransformer Vs Two wdg tfo

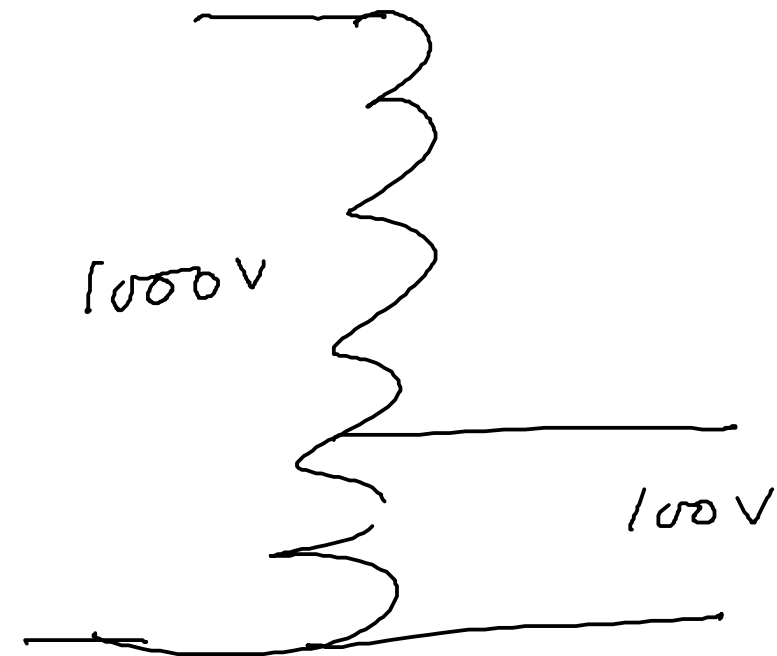
Dec-29

Cu. reqd. for Auto tfo = $(1 - \frac{1}{a}) \times$ Cu reqd. in 2wdg tfo

Savings of Cu will be more if $a \approx 1$ 1000V to 900V

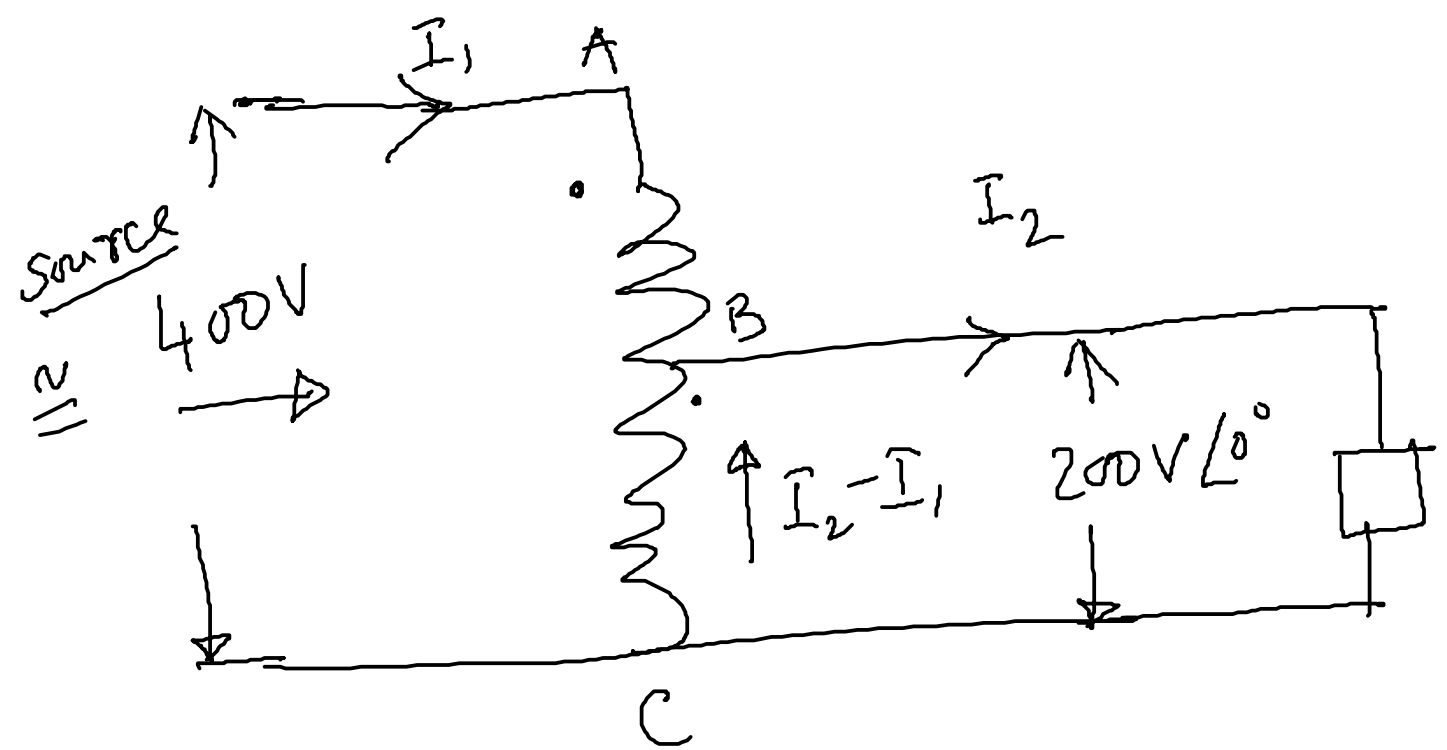


- $a \rightarrow 1$
- ① isolation is not that urgent
 - ② Savings of Cu substantial.



$$1 - \frac{1}{10} = 0.9$$

- ① isolation must be provided
- ② Savings of Cu is little



Ideal Autotrafo

numerical
example

$$V_2 = 200\angle 0^\circ \text{ V}$$

$$I_2 = \frac{200\angle 0^\circ}{10\angle 30^\circ} = 20\angle -30^\circ \text{ A}$$

output complex power

$$= V_2 I_2^* = 200\angle 0^\circ \times 20\angle +30^\circ = 4000\angle 30^\circ$$

$$\therefore I_2 - I_1 = 20\angle -30^\circ - 10\angle -30^\circ$$

$$= 10\angle -30^\circ$$

$$\therefore V_1 = 400\angle 0^\circ$$

$$\therefore V_1 I_1^* = V_2 I_2^*$$

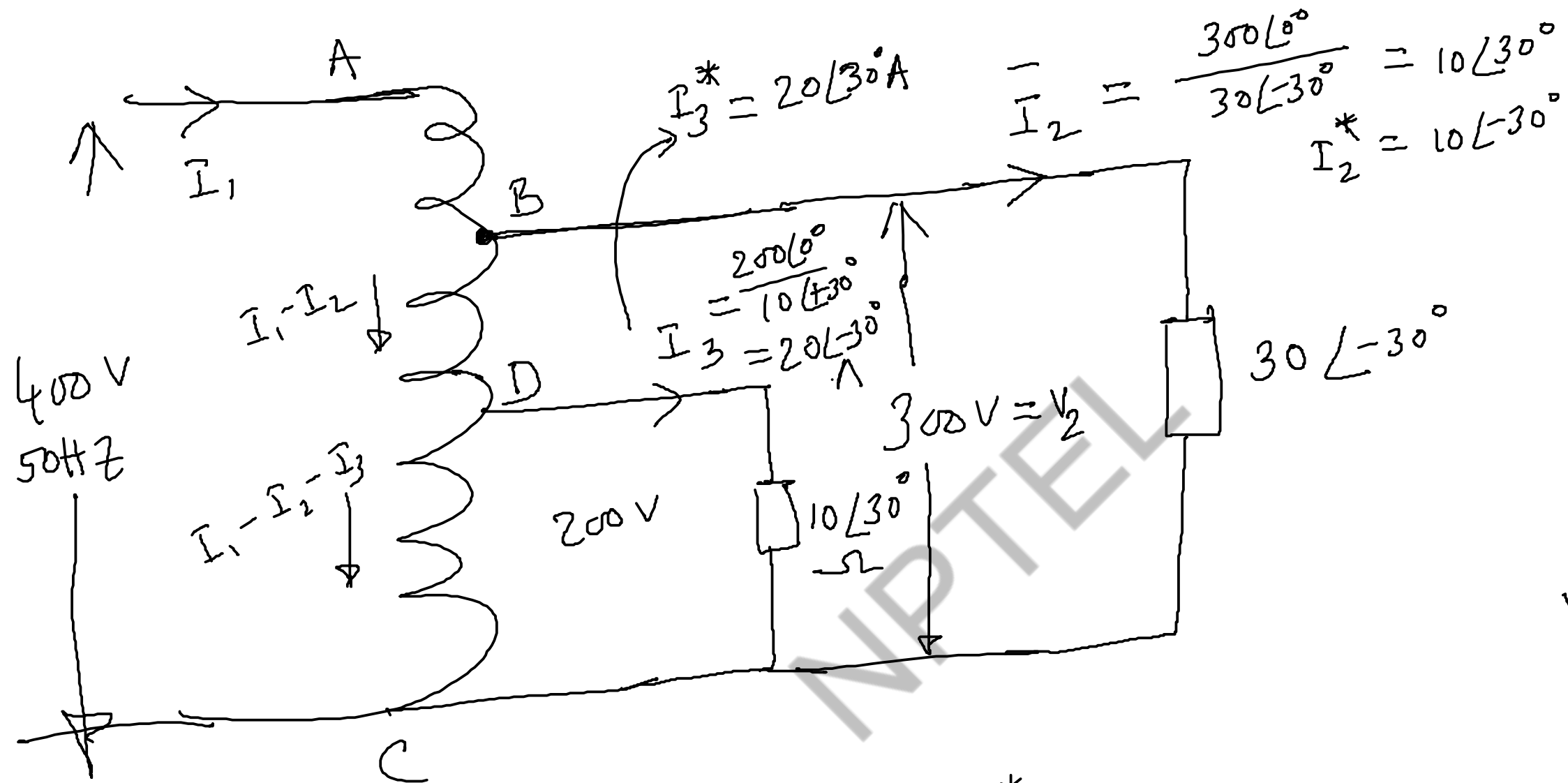
$$\therefore I_1^* = \frac{4000\angle 30^\circ}{400\angle 0^\circ} = 10\angle 30^\circ$$

$$\therefore I_1 = 10\angle -30^\circ$$

$$N_{AC} = 100$$

$$V_{\text{alt}} / \text{turns} = \frac{400}{100} = 4 \text{ V}$$

$$N_{BC} = 50 \quad V_{BC} = 4 \times 50 = 200 \text{ V}$$



$$N_{AC} = 100$$

$$\text{VAT/turn} = \frac{400}{100} = 4$$

$$N_{BC} = 75$$

$$V_2 = V_{BC} = 4 \times 75 = 300V \angle 0^\circ$$

$$N_{DC} = 50$$

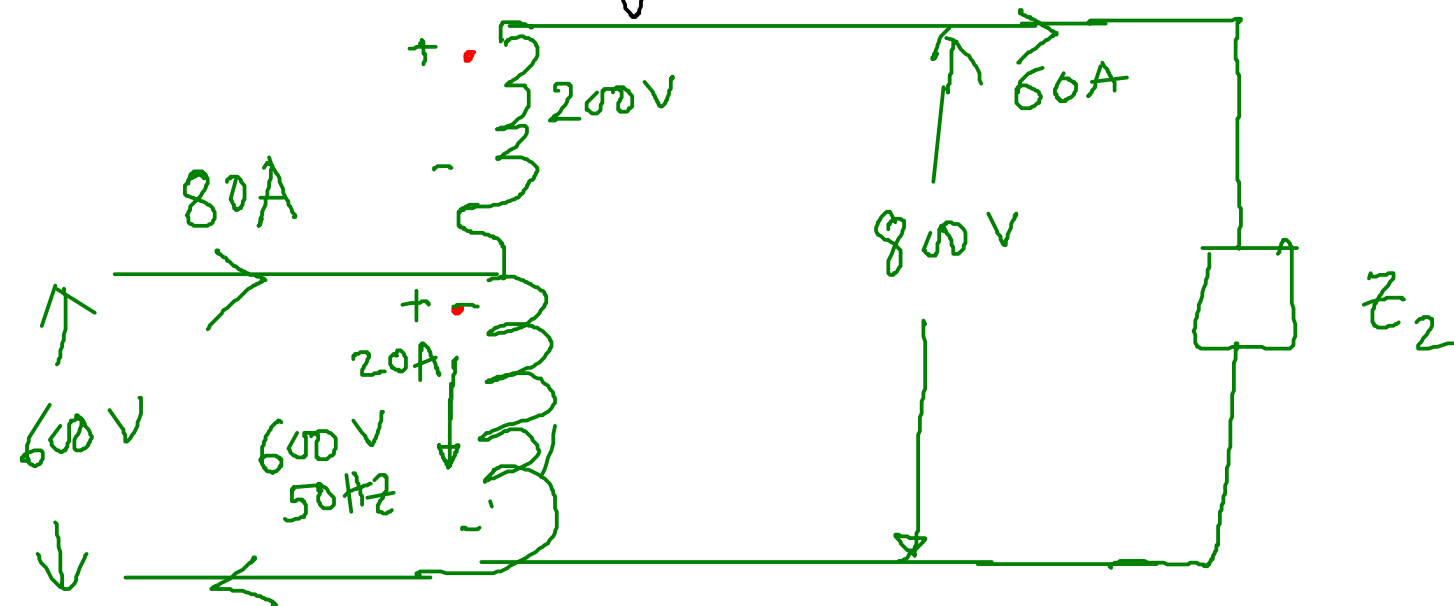
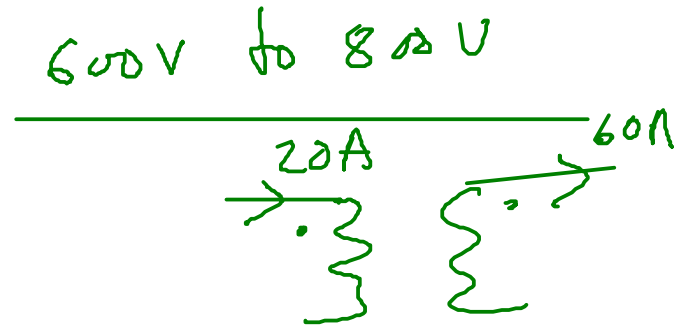
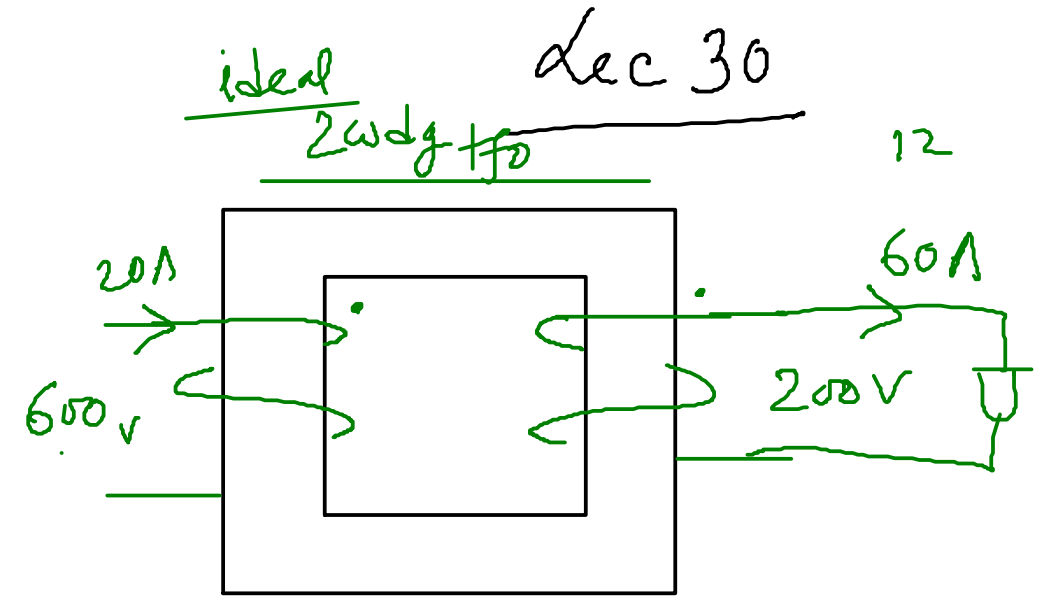
$$V_3 = V_{DC} = 50 \times 4 = 200V \angle 0^\circ$$

$$V_1 = V_{AC} = \text{Supply} = 400V \angle 0^\circ$$

$$V_1 I_1^* = V_2 I_2^* + V_3 I_3^*$$

$$I_1^* = \frac{V_2 I_2^* + V_3 I_3^*}{V_1} \rightarrow I_1 = (I_1^*)^*$$

Two wdg tfo as an autotransformer



12 KVA, $\frac{600V}{200V}$ 1 Ph

$$\frac{12000}{600} = 20A$$

$$\frac{12000}{200} = 60A$$

How much KVA The tfo is handling :-

$$800 \times 60 = 48000$$

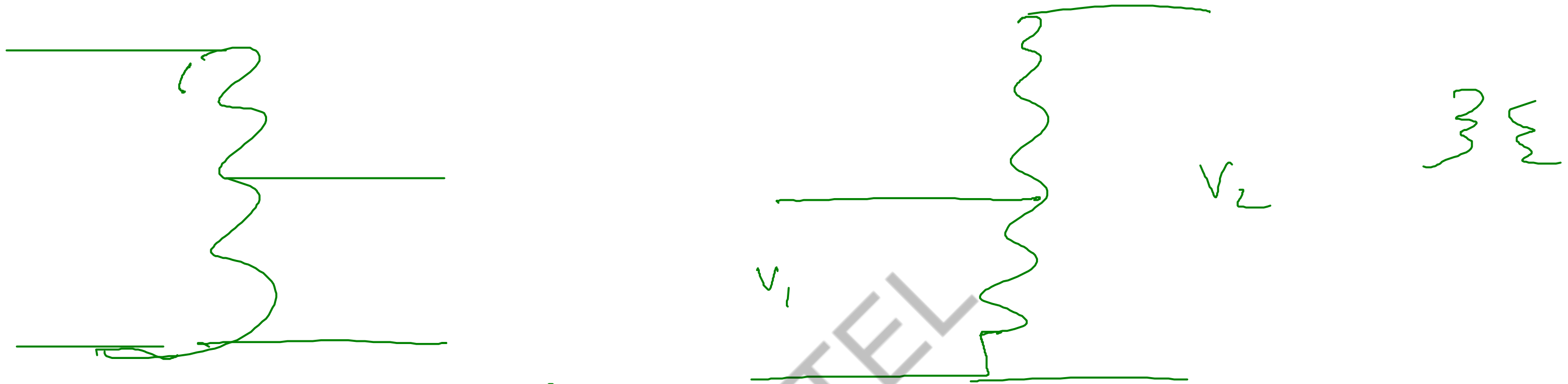
$$48 \text{ KVA}$$

KVA drawn from supply

$$= 600 \times 80 = 48 \text{ KVA}$$

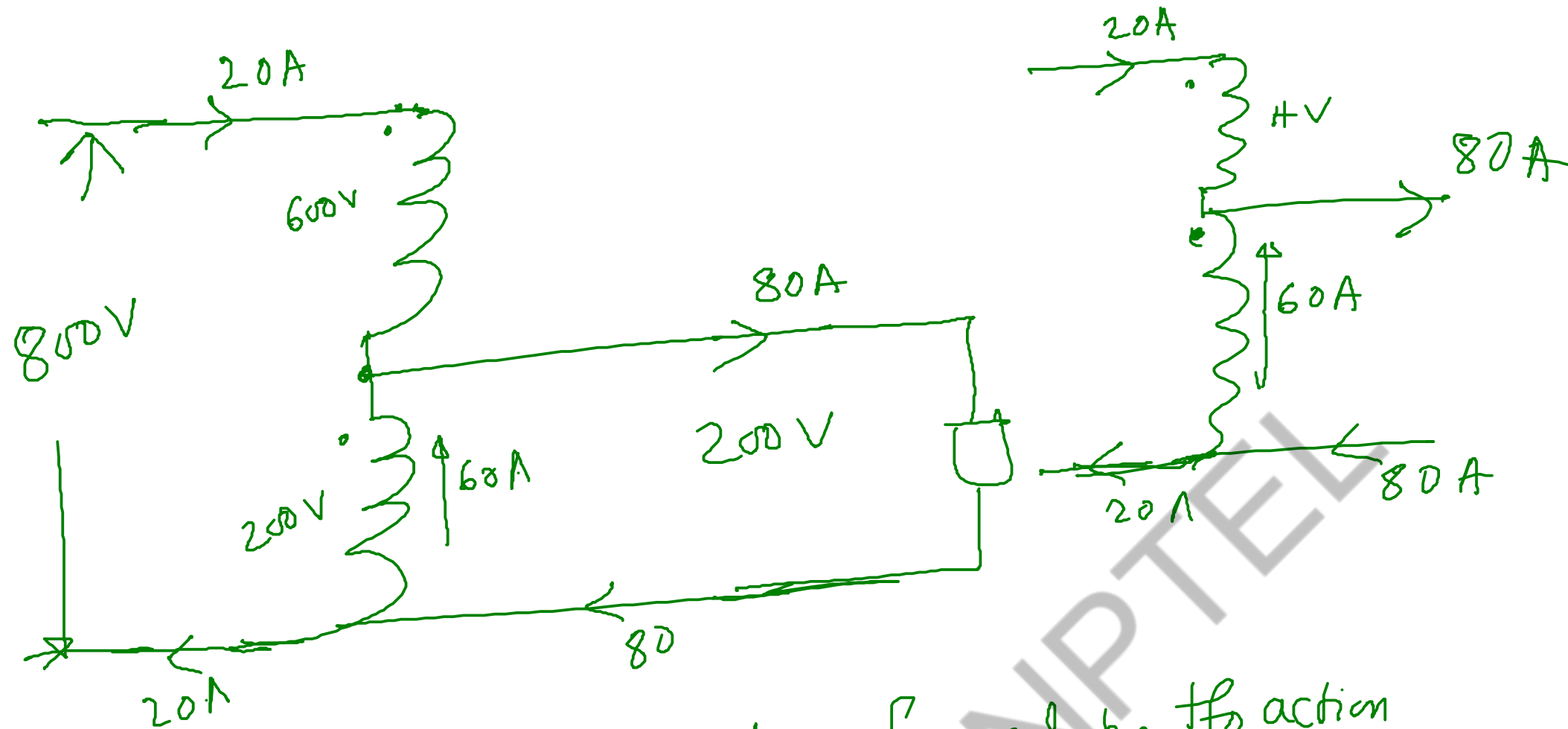
KVA handled now = 48 KVA without overloading
The tfo (or it coils)

by tfo action
KVA transmitted = 12 KVA
= 200×60
KVA transferred by electrical conduction
 $48 - 12 \text{ KVA} = 36 \text{ KVA}$



Power is transferred to the secondary side from primary side by two means

- (i) by transformer action
- (ii) by direct electrical connection



$$\begin{aligned}
 & \text{max. KVA of the load} \\
 &= \frac{800 \times 20}{200} = 80 \text{ A} \\
 &= \frac{16000}{200} = 80 \text{ A}
 \end{aligned}$$

KVA transferred by tfo action

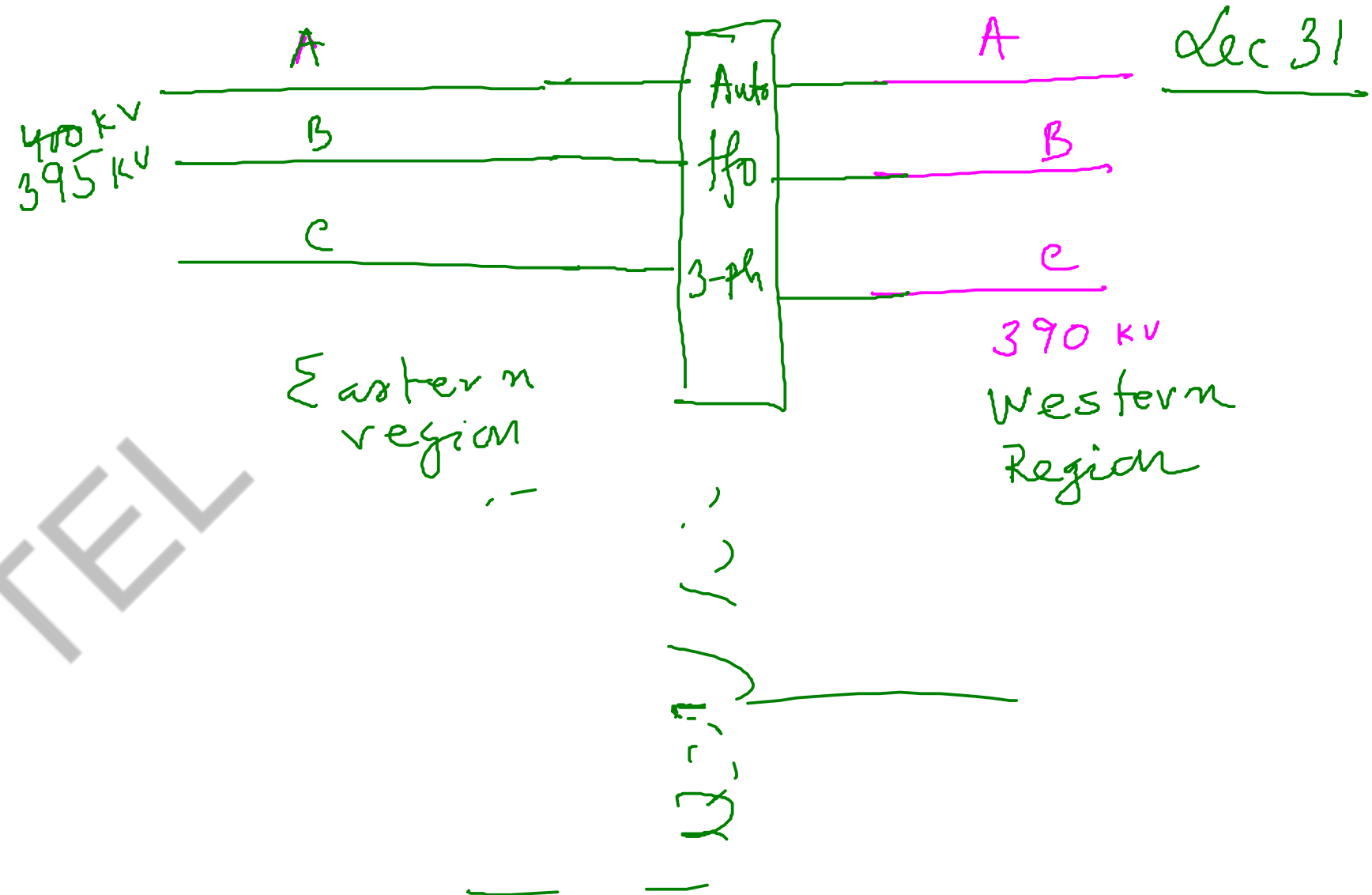
$$\begin{aligned}
 &= 20 \times 600 = 200 \times 60 \text{ VA} \\
 &= 12 \text{ KVA}
 \end{aligned}$$

KVA transferred through electrical conduction

$$= 16 - 12 = 4 \text{ KVA}$$

Auto transformer :-

Variaac



Practical Autotransformer

Neglect no load current (I_0)

$$\Rightarrow X_m \rightarrow \infty \text{ \& } R_{cl} \rightarrow \infty \text{ or } N_1 I_1 = N_2 I_2$$

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

$$E_2 = 4.44 f \Phi_{max} N_2$$

$$E_{AB} = 4.44 f \Phi_{max} (N_1 - N_2)$$

$$E_{AB} = E_1 - E_2$$

$$N_{AC} = N_1$$

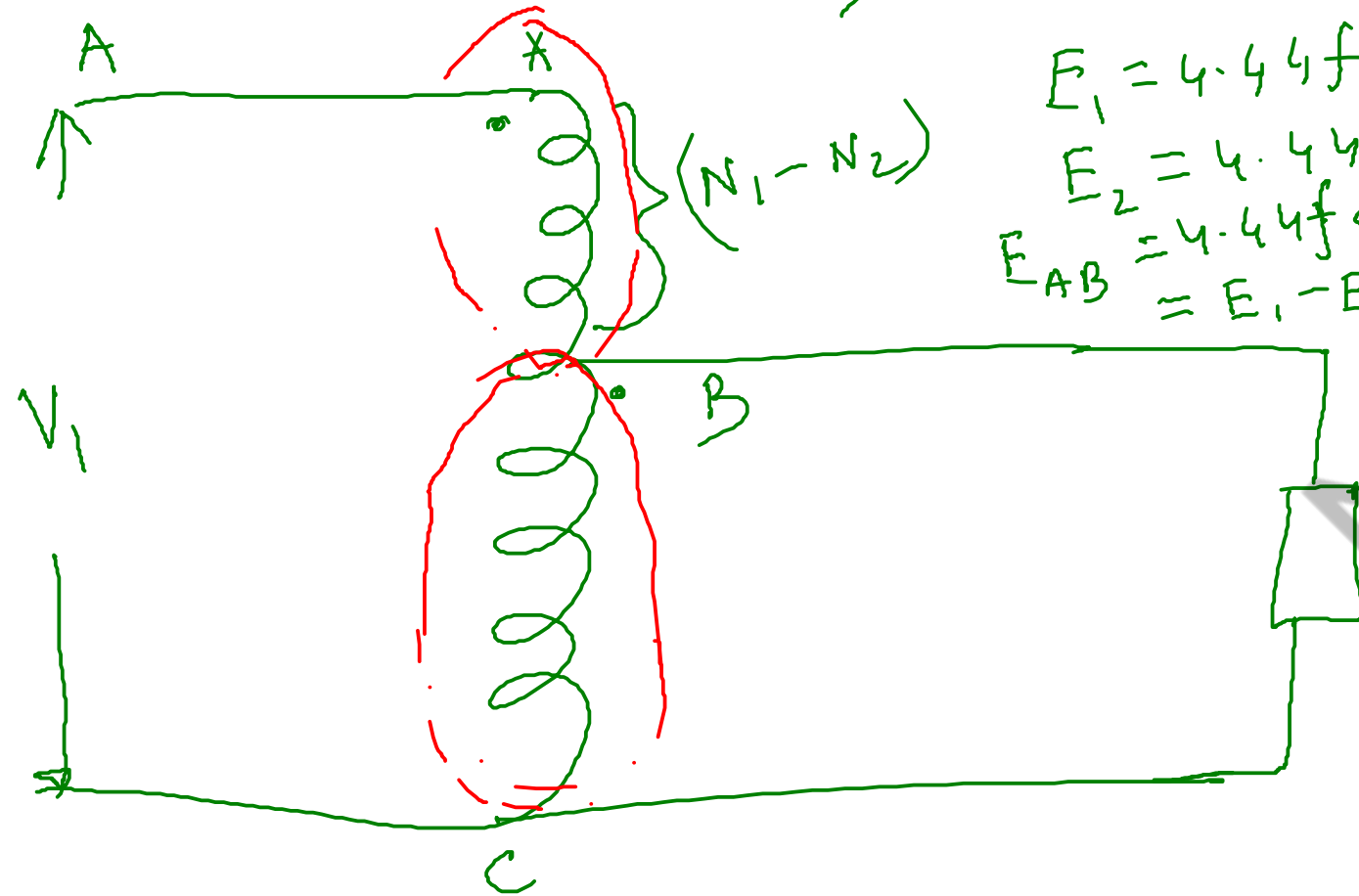
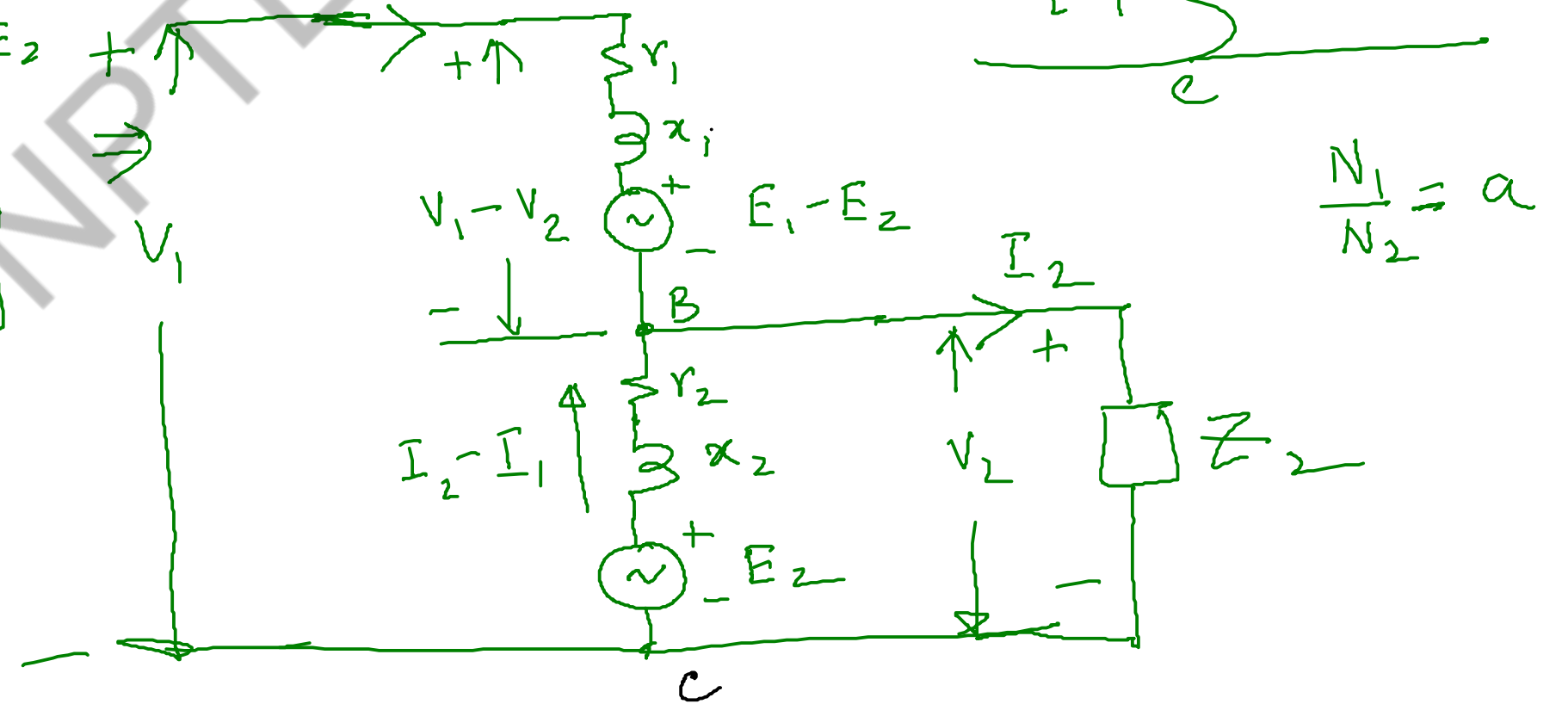
$$N_{BC} = N_2$$

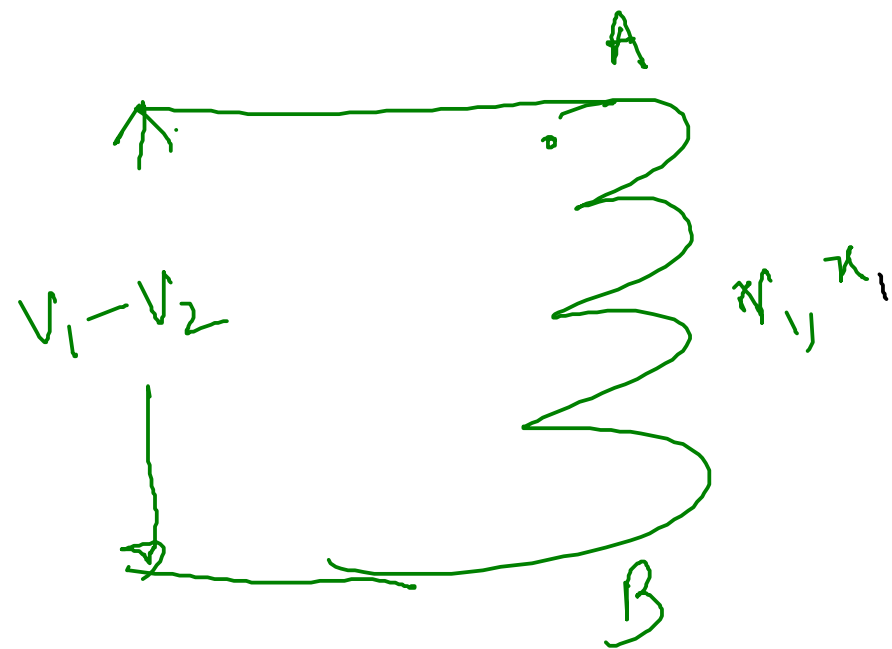
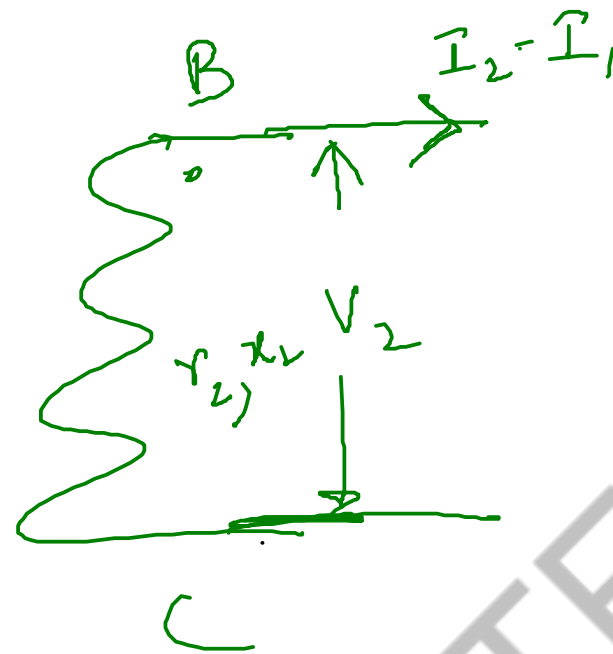
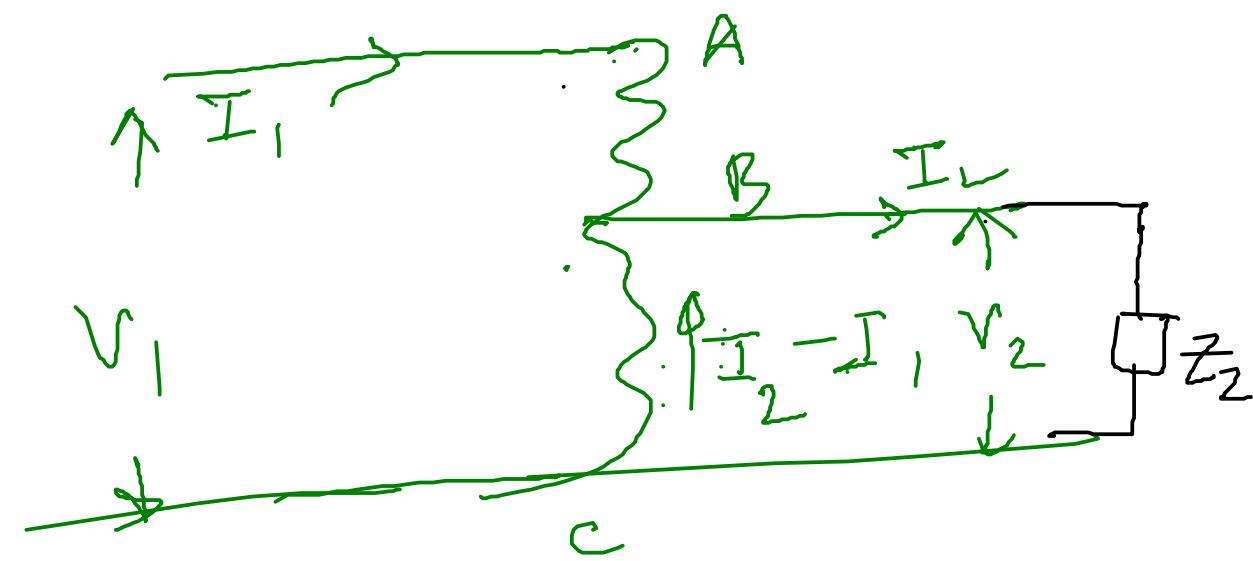
$$I_1 = I_2 / a$$

$$(N_1 - N_2) I_1 = N_2 (I_2 - I_1)$$

$$N_1 I_1 = N_2 I_2$$

$$I_1 = \frac{I_2}{a}$$

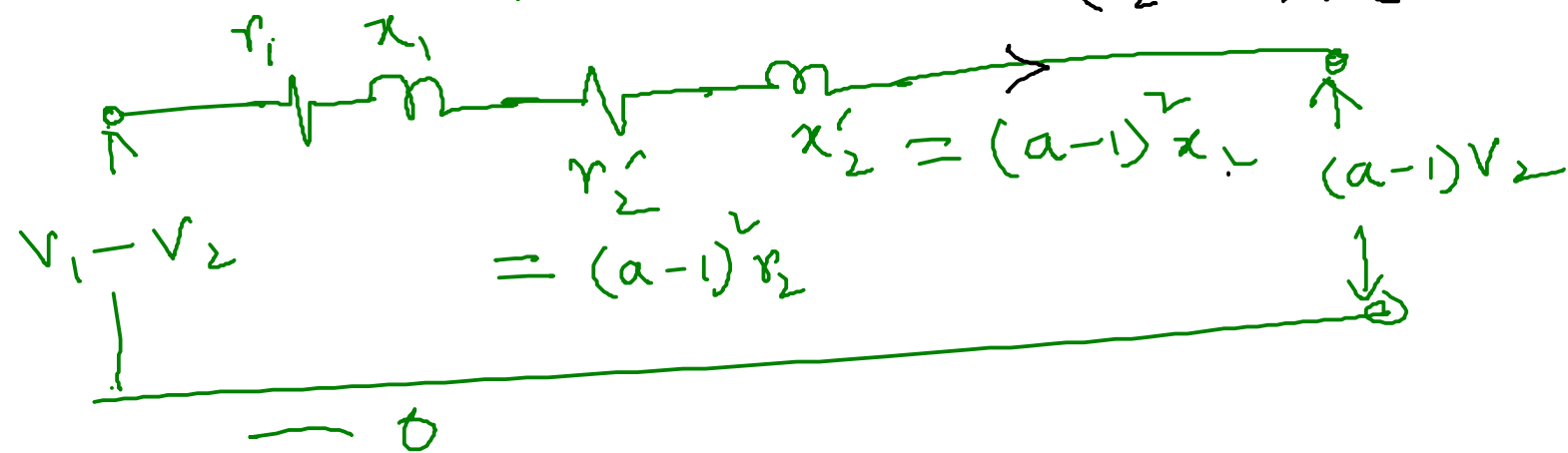




$$a = \frac{N_1}{N_2}$$

$$\frac{N_1 - N_2}{N_2} = a - 1$$

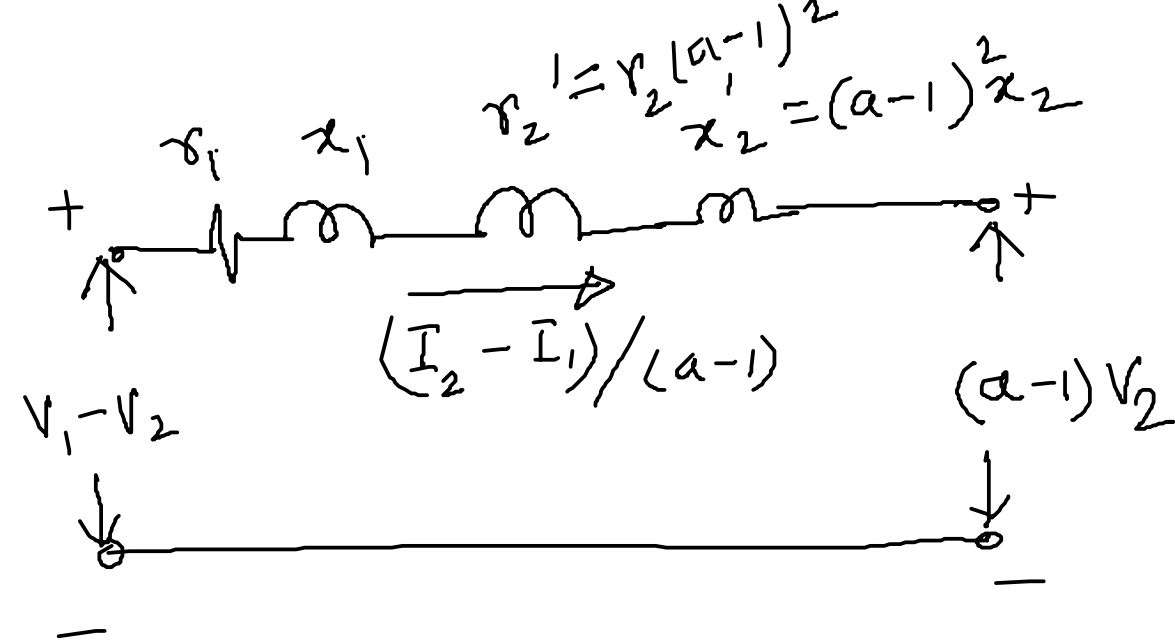
Draw the eqv ckt ref to
 $V_1 - V_2$ side $(I_2 - I_1)/(a - 1)$



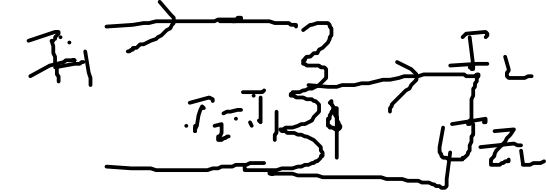
$$(N_1 - N_2) I_1 = N_2 (I_2 - I_1)$$

$$N_1 I_1 = N_2 I_2$$

$$\text{or } I_1 = I_2 / a$$



$$I_1 = \frac{I_2}{a}$$



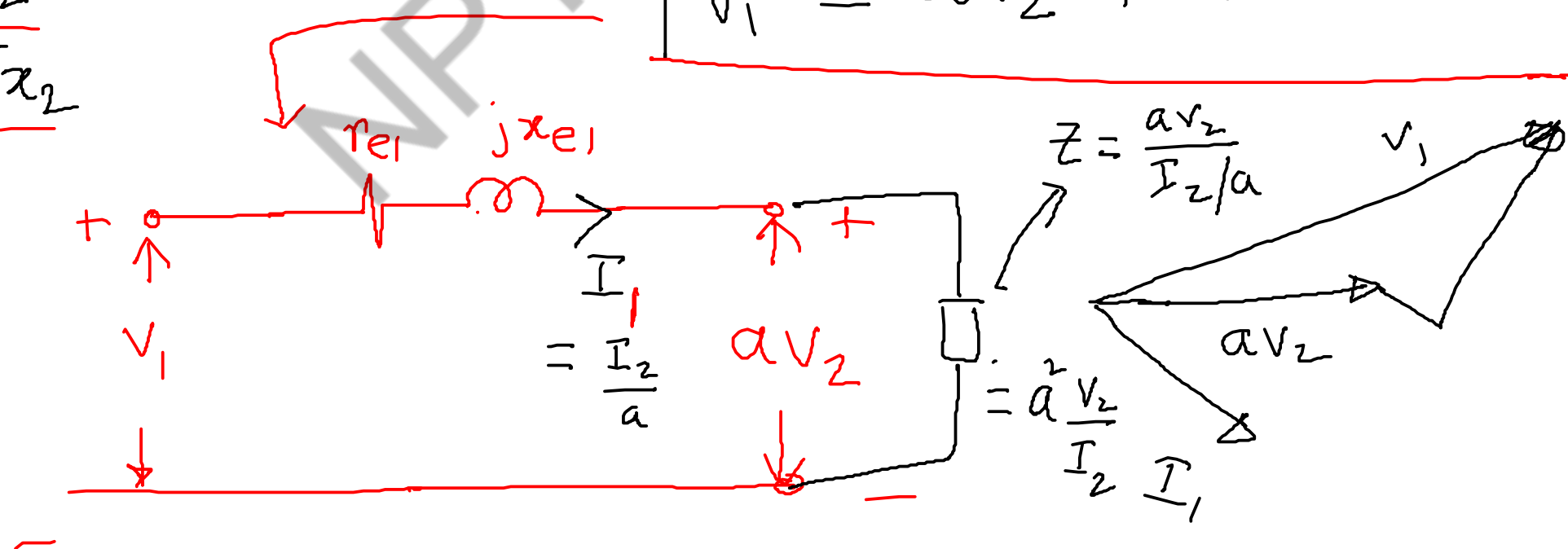
$$V_1 - V_2 = (a-1)V_2 + \frac{(I_2 - I_1)}{(a-1)}(r_{e1} + jx_{e1})$$

$$\text{or } V_1 = aV_2 + \frac{(a-1)I_1}{(a-1)}(r_{e1} + jx_{e1})$$

$$r_{e1} = r_1 + (a-1)^2 r_2$$

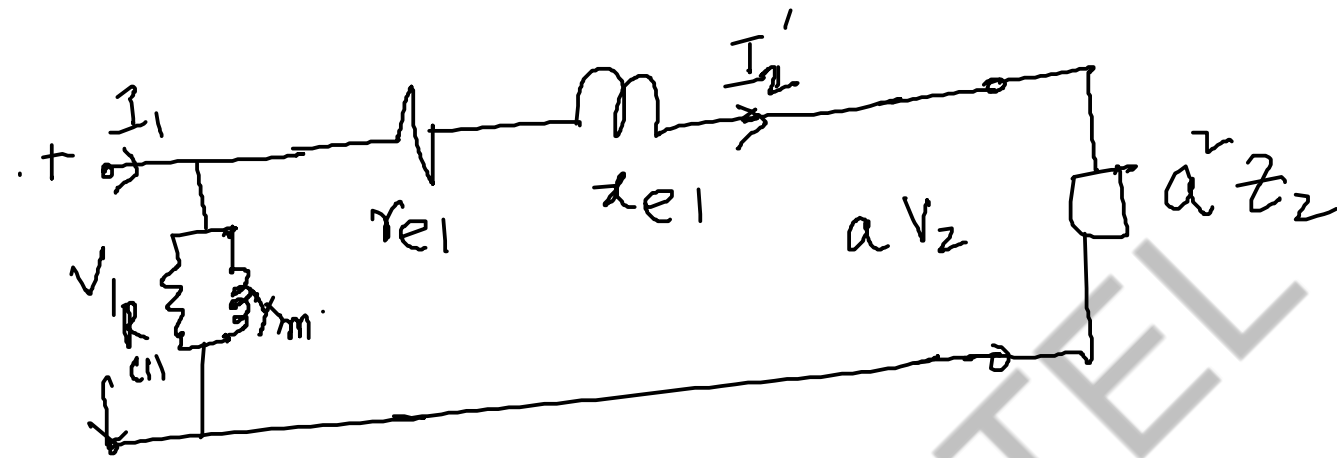
$$x_{e1} = x_1 + (a-1)^2 x_2$$

$$\text{or } V_1 = aV_2 + (r_{e1} + jx_{e1})I_1$$



Equivalent ckt. of a practical
Autotransformer

Lec. 32

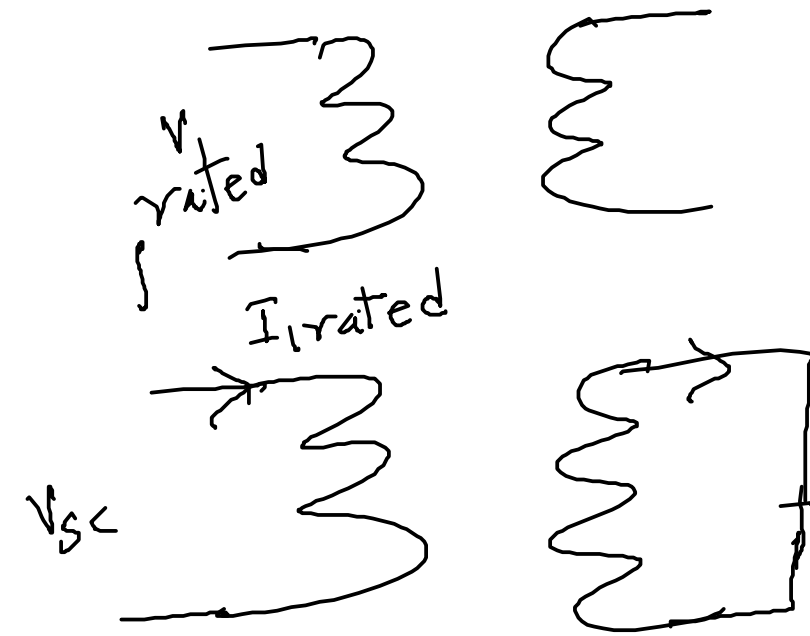


$$r_{e1} = r_1 + (a-1)^2 r_2$$

$$x_{e1} = x_1 + (a-1)^2 x_2$$

for 2wdg tfo : o.c test & s.c test to find
out equivalent ckt parameters

o.c



flux will be rated
there will be core loss only

practically core loss is absent
compared to Cu loss.

operation
at rated
condition



both core & Cu losses
are present.

Sumpner's Test (Back to Back test)

2 nos of 10 KVA,

200V/100V, 50 Hz

$$\frac{15000}{100} = 150A$$

