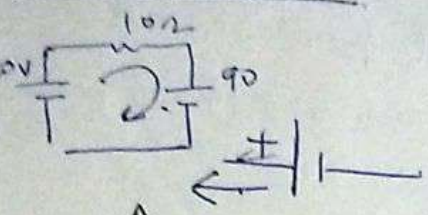
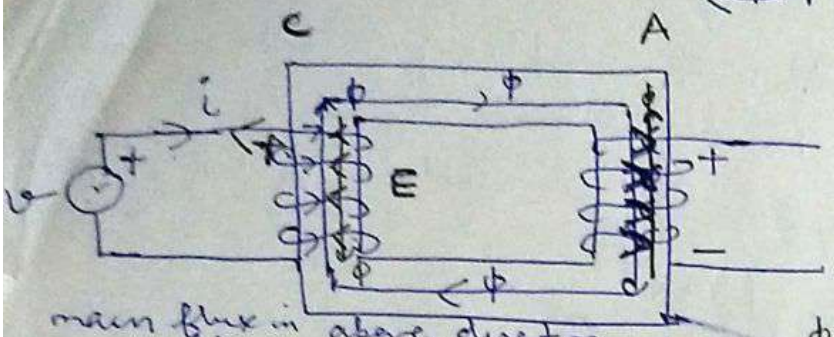
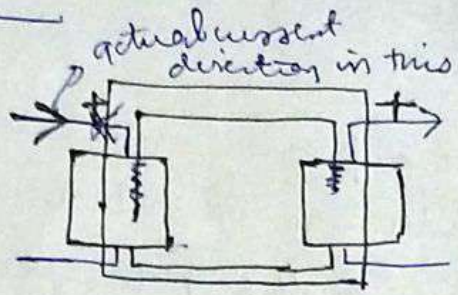
Transformer

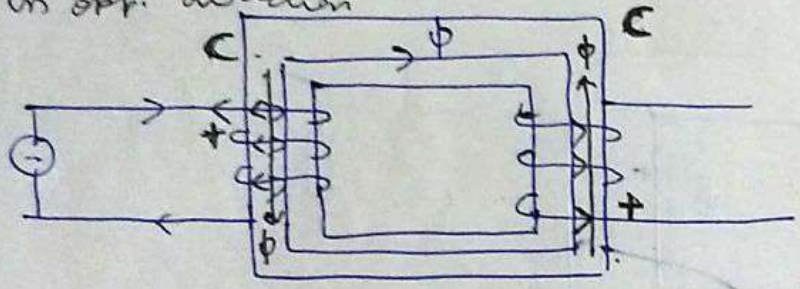
1-ϕ Transformer

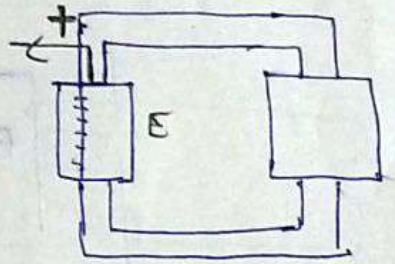


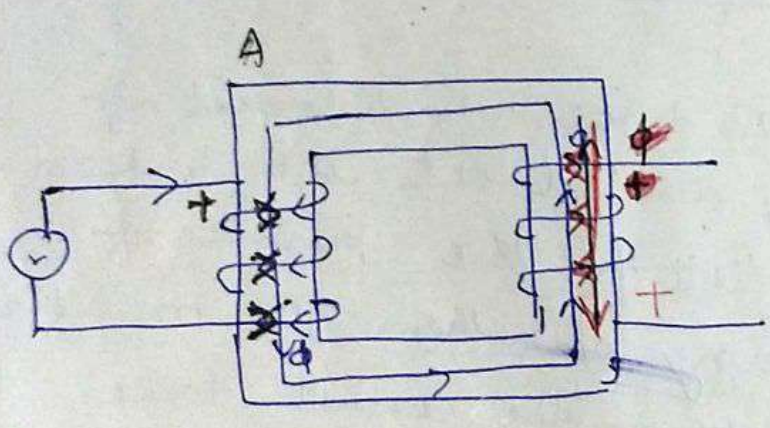




main flux in above direction
↳ flux due to induced emf ϕ will be in downward direction. If this emf is allowed to flow current it is in opp. direction





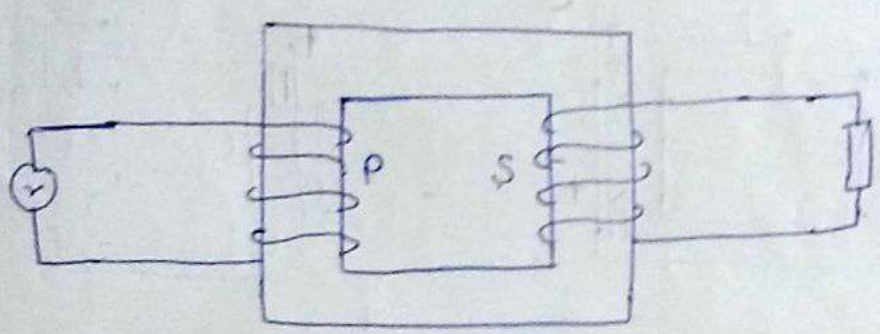


Induced EMF polarity depends on the direction of the winding wound on the core

Core के नीचे का wire नहीं दिखेगा।

Transformer is a static device which transfers electrical power at the same frequency usually from one voltage level to another.

Transformer works on the principle of electromagnetic induction b/w two coupled circuits or coils. Acc. to this principle, an emf is induced in a coil if it links a changing flux.



A transformer is a static device which consist of two or more stationary electrical ckts interlinked by a common magnetic ckt for the purpose of transfering electrical energy b/w them. The transfer of energy from one ckt to another circuit takes place without change in frequency.

Consider two coils 1 & 2 wound on a simple magnetic ckt. These two coils are insulated from each other and there is no electrical connection b/w them.

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Let N_1 & N_2 be the number of turns in coils 1 & 2 respectively

The Primary winding P is connected to an alternating voltage source, therefore an alternating current I_e starts flowing through N_1 turns.

The alternating mmf $N_1 I_e$ sets up alternating flux ϕ which is confined to the high permeability iron path

The alternating flux induces voltage E_1 in the primary winding P ~~and E_2 in the~~ s by self-induction

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

$$e = -N_1 \frac{d\phi}{dt}$$

$$= -N_1 \frac{d}{dt}(\phi_{max} \sin \omega t)$$

$$e = -N_1 \phi_{max} \omega \cos \omega t$$

$$= -N_1 \phi_{max} \omega \sin(90 - \omega t)$$

$$\boxed{e = N_1 \phi_{max} \omega \sin(\omega t - 90^\circ)}$$

$$\boxed{e = E_{max} \sin(\omega t - 90^\circ)}$$

$$\boxed{E_{max} = 2\pi f N_1 \phi_{max}} \quad \text{—(1)}$$

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

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The EMF e_1 induced in N_1 turns must be in such a direction so as to oppose the cause i.e I_e as per lenz law. Therefore the direction of e_1 as shown by the arrows in primary N_1 turns and it is seen to oppose V_1

$$v_1 = e_1 = -N_1 \frac{d\phi_1}{dt} \quad \text{--- (1)}$$

$$\boxed{V_1 = -e_1}$$

The EMF induced in the secondary winding

$$e_2 = -N_2 \frac{d\phi}{dt} = -N_2 \frac{d}{dt}(\phi_{max} \sin \omega t)$$

$$e_2 = -N_2 \phi_{max} \omega \cos \omega t$$

$$= -N_2 \phi_{max} \omega \sin(90 - \omega t)$$

$$e_2 = N_2 \phi_{max} \omega \sin(\omega t - 90)$$

$$\boxed{e_2 = E_{2max} \sin\left(\omega t - \frac{\pi}{2}\right)}$$

$$E_{2rms} = \frac{E_{2max}}{\sqrt{2}} = \sqrt{2}\pi f N_2 \phi_{max} \quad \text{--- (2)}$$

$$\boxed{\frac{E_1}{E_2} = \frac{N_1}{N_2} = \sqrt{2}\pi f \phi_{max} =} \; a.$$

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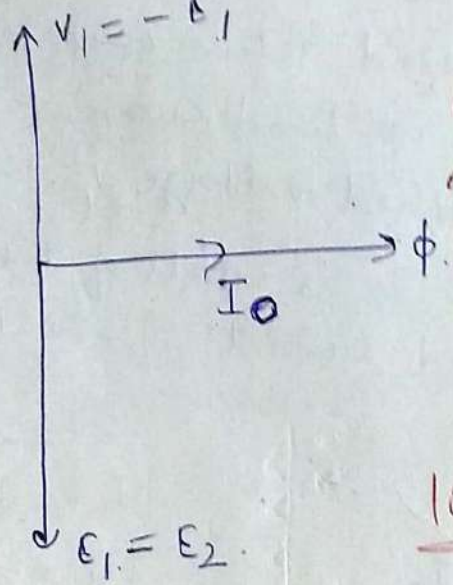
$$\boxed{\frac{E_2}{E_1} = \frac{N_2}{N_1} = K}$$

A transformer in which the o/p voltage is greater than the input voltage is called

Step up transformer.

A transformer in which the output voltage is less than its i/p voltage is called step down transformer.



Ideal transformer

1. No losses
2. No leakage flux
3. $\mu = \infty$

lossless Core transformer

Transformer on no load

A transformer is said to be on no load when the secondary wdg is open-ckted. The secondary current is zero.

When the alternating voltage is applied to the primary, a small current I_0 flows in the primary. The current I_0 is called no-load current of the transformer.

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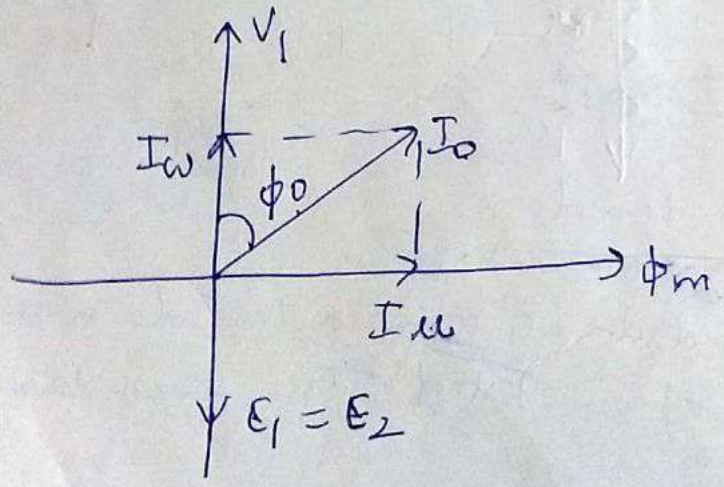
It is made up of two components I_μ & I_w.
The component I_μ is called the magnetising component. It magnetises the core. In other words, it sets up a flux in the core and therefore I_μ is in phase with ϕ_m.
The current I_μ is called the <u>reactive or wattless component of load current</u>

The component I_w supplies the hysteresis & eddy current losses in the core and the negligible ~~for~~ I^2R loss in the primary winding.
The current I_w is called active component or wattful component of no-load current. It is in phase with the applied voltage V_1.
The no load current I_0 is small of the order of 3 to 5% of the rated current of the primary.



$$I_w = I_0 \cos\phi_0$$
$$I_\mu = I_0 \sin\phi_0$$
$$I_0 = \sqrt{I_w^2 + I_\mu^2}$$
$$\cos\phi_0 = \frac{I_w}{I_0}$$

<u>Lossy Core transformer on no load</u>

Ideal Transformer

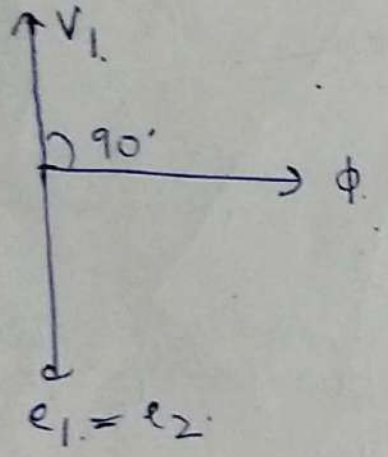
$\phi = \phi_{max} \sin \omega t$

$$e_1 = -N \frac{d\phi}{dt}$$

$$= -N \frac{d}{dt}(\phi_{max} \sin \omega t)$$

$$= -N \phi_{max} \omega \cos \omega t$$

$$e_1 = N_1 \phi_{max} \omega \sin\left(\omega t - \frac{\pi}{2}\right)$$



Ideal transformer

no losses

$$e_1 = N \phi_{max} 2\pi f =$$

$$\frac{e_1}{\sqrt{2}} = \frac{2\pi f N \phi_{max} \omega}{\sqrt{2}} = \boxed{\sqrt{2}\pi f N \phi_{max}}$$

$$\boxed{E_{rms} = \sqrt{2}\pi f N \phi_{max}} = 4.44 N_1 f \phi_{max}$$

$$e_2 = -N_2 \frac{d\phi}{dt} = = N_2 \phi_m \omega \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$= 4.44 N_2 . \phi_m . f$$

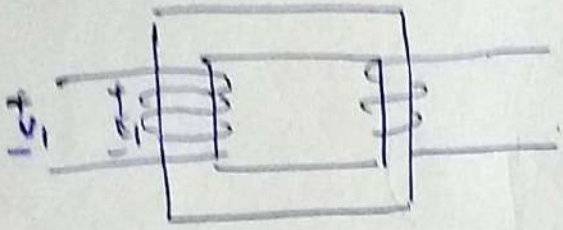
EMF induced in the secondary wdg is also lagging behind the flux vector by 90° & is in

phase with the Primary induced EMF.

$E_{2max} = N_2 \phi_m \omega$

$E_2 = 4.44 N_2 \phi_m f$

$$\boxed{E_2 = 4.44 N_2 B_m A_m f}$$



$V_1 = E_1 = -N_1 \frac{d\phi_1}{dt}$

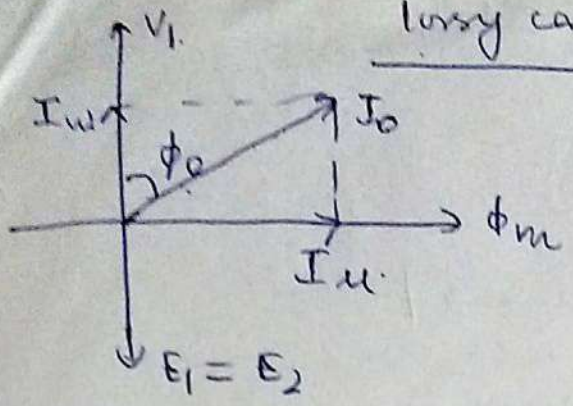
$$\boxed{V_1 = -E_1}$$

Features of Ideal Transformer.

1. No losses as Primary & secondary wdg Resistances are negligible
2. $\mu = \infty$ (Core has ∞ permeability)
3. Its leakage flux & leakage inductances are zero. The entire flux is confined to the core & links both the wdgs.
4. There are no losses due to resistance, hysteresis & eddy current. η is 100%.

Transformer with Iron losses

lossy core transformer on no load



$I_\mu = I_0 \sin\phi_0$

$I_w = I_0 \cos\phi_0$

$I_0 = \sqrt{I_\mu^2 + I_w^2}$

$$\boxed{I_0 = I_\mu + I_w}$$

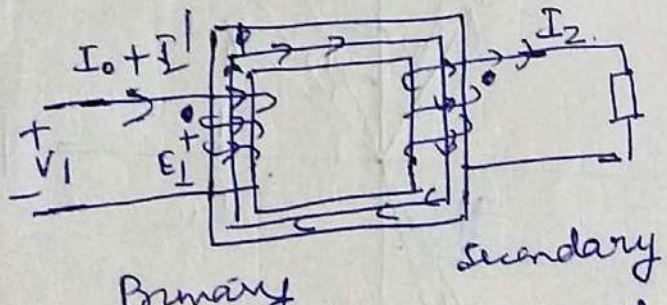
$$\boxed{\cos\phi_0 = \frac{I_w}{I_0}}$$

I_μ = To create a flux in the core ie It magnetises the core. It is reactive component of current

I_w = supplies the hysteresis & eddy current losses in the core and the negligible I^2R losses

→ called the active power component.

lossy transformer goes on load



This alternating flux link the wdg and induces an EMF. The EMF induced will oppose the cause responsible for its production.

$E_1 = 4.44 N_2 B_m A_m f$

$E_1 = 4.44 N_2 \phi_m f$

$$\boxed{\frac{E_1}{f} = \phi_{max}} = \text{const} \quad \boxed{\phi = \phi_{max} \sin\omega t}$$

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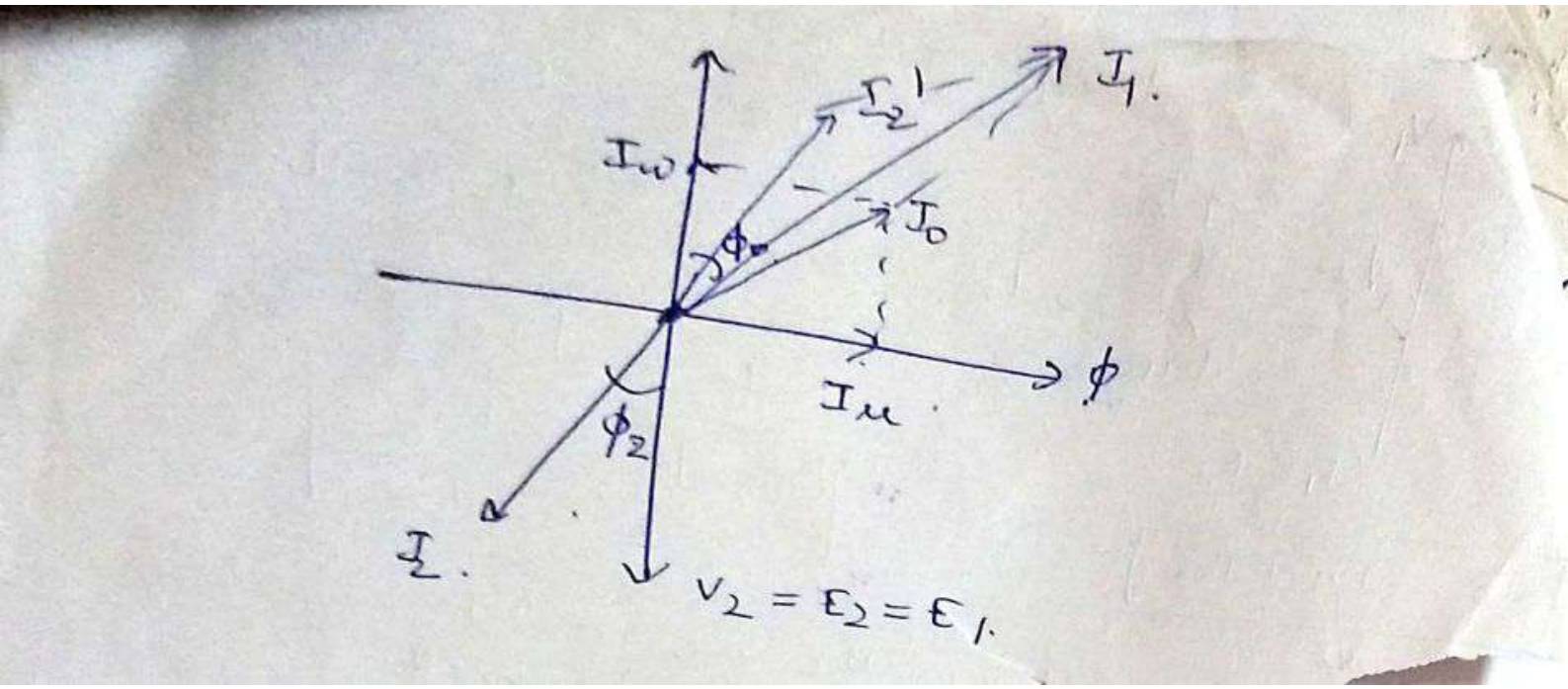

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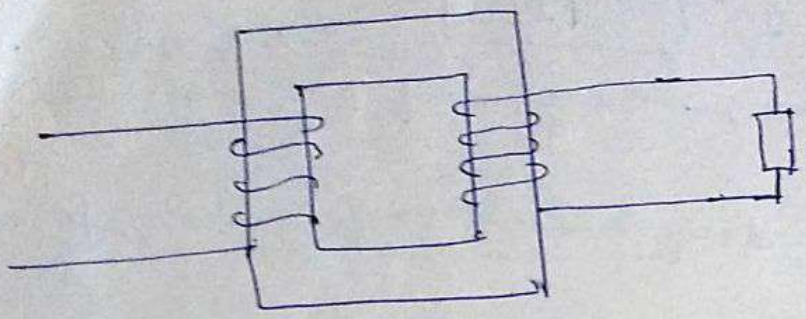


Primary Secondary

If the switch S is closed, a load impedance Z_L gets connected across the secondary terminals. Since the secondary winding resistance is zero $V_2 = E_2$ & According to lenz law, the direction of secondary current I_2 should be such that the secondary mmf ($= I_2 N_2$) is opposite to mutual flux ϕ in the core.

The secondary mmf being opposite to mutual flux ϕ, tends to reduce the alternating mutual flux ϕ. Any reduction in ϕ would reduce E_1 ~~and therefore~~

but $\boxed{V_1 = -E_1}$

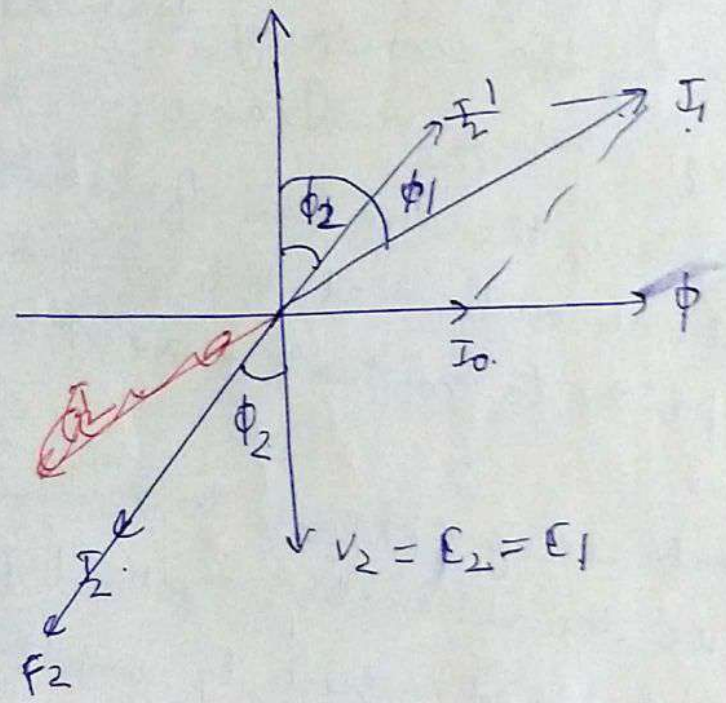
If the applied voltage V_1 is constant, E_1 and therefore, mutual flux ϕ in the core must remain constant. This can happen only if the primary draws more current I_1' from the source, in order to neutralise the demagnetising effect of F_2. In this manner, I_2 causes the primary to take more current, I_2'

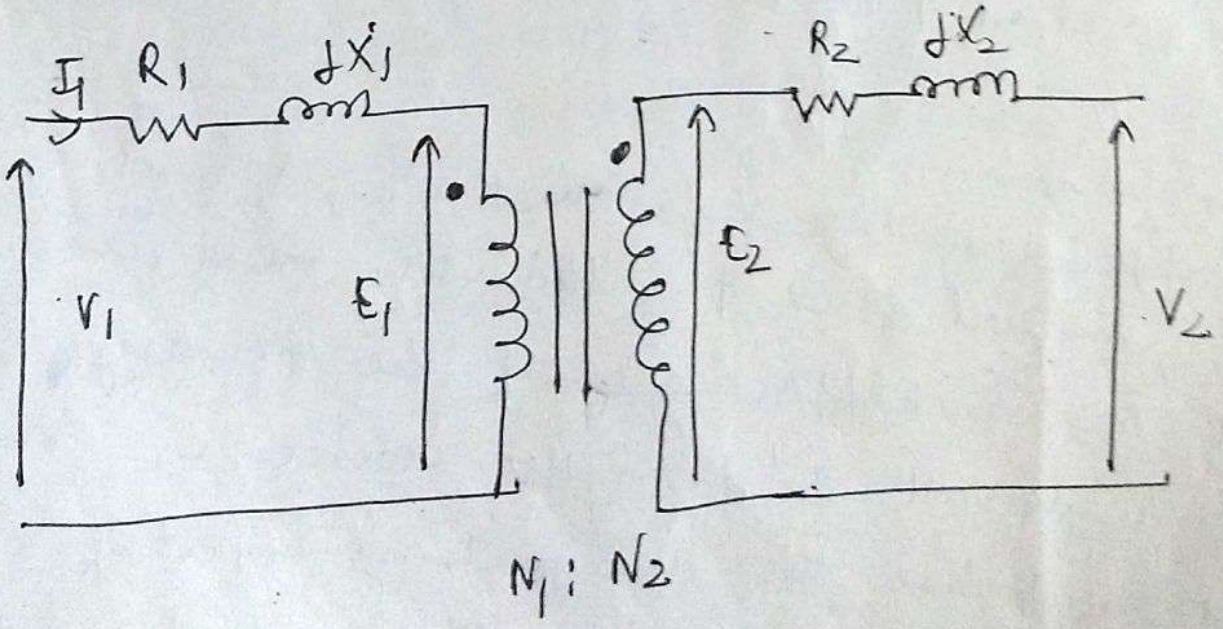
$$I_2' N_1 = I_2 N_2$$

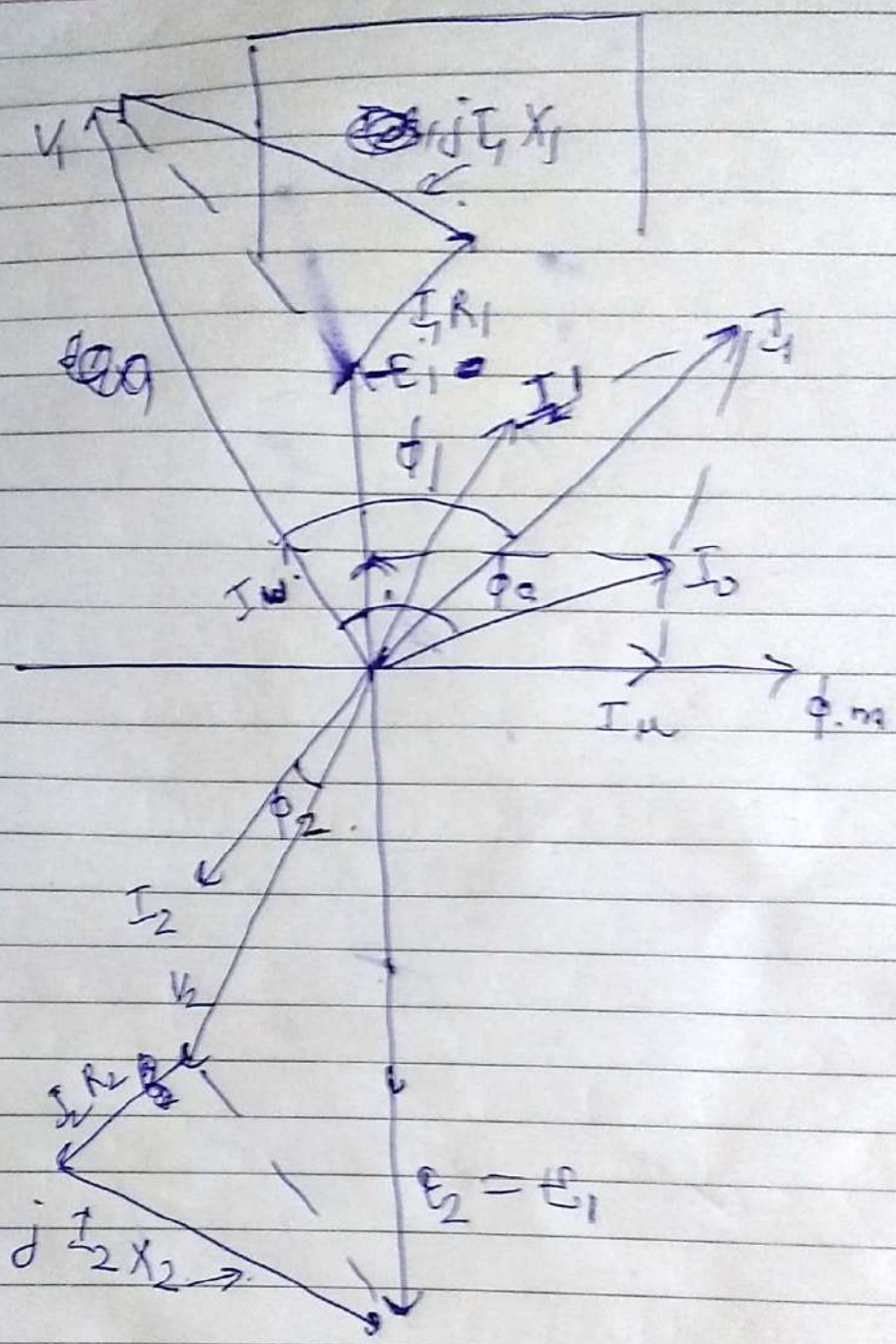
or compensating primary mmf F_1 = Secondary mmf F_2

I_2' = Secondary current referred to primary.

$$I_1 = I_2' + I_0$$







$$V_1 = -E_1 + I_1R_1 + jI_1X_1$$

$$V_1 = -E_1 + I_1(R_1 + jX_1)$$

$$\boxed{V_1 = -E_1 + I_1(Z_1)}$$

$$V_1 = |E_1| + I_1Z_1$$

$$V_1 = |E_1| + I_1R_1 + jI_1X_1$$

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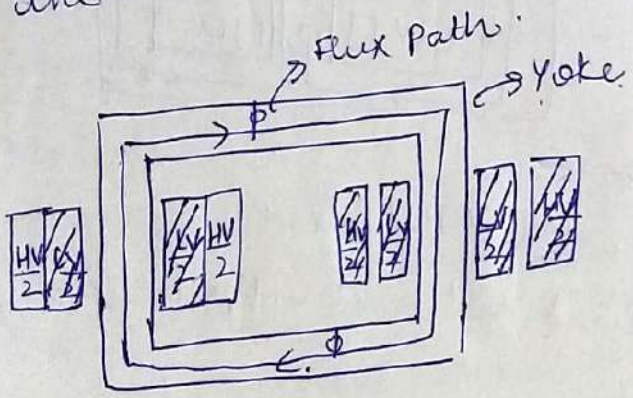
Construction of Transformer.

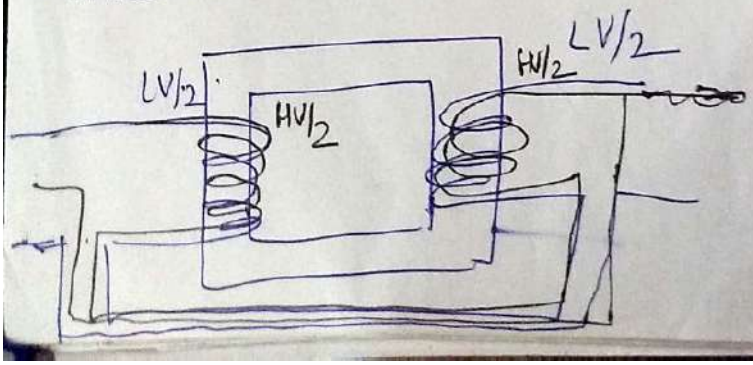
- Core type
- Shell type

A single phase transformer consists of primary & secondary winding put on a magnetic core. magnetic core is used to confine flux to a definite path.

Transformer core are made up of thin sheets (called laminations) of high grade silicon steel. The laminations reduce eddy current losses & the silicon ~~steel~~ steel reduces hysteresis losses.



In the core type transformer, the magnetic ckt consists of two vertical legs or limbs with two horizontal sections, called yokes.



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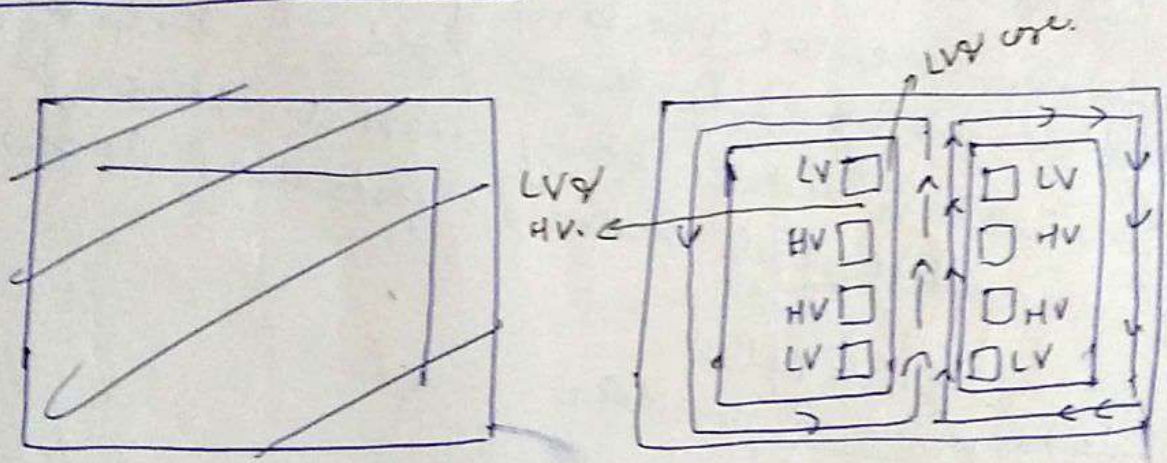
To keep the leakage flux to a minimum, half of each winding is placed on each leg of the core. The low voltage winding is placed next to the core and the high voltage winding is placed around the low-voltage winding.

Thus, two windings are arranged as concentric coils. Such a winding is called concentric winding or cylindrical winding.

Shell type Transformer



In Shell type transformer LV & HV windings are wound on the central limb and are interleaved or sandwiched.

In Shell type transformer, flux in the central limb divides equally and returns through the outer two legs.

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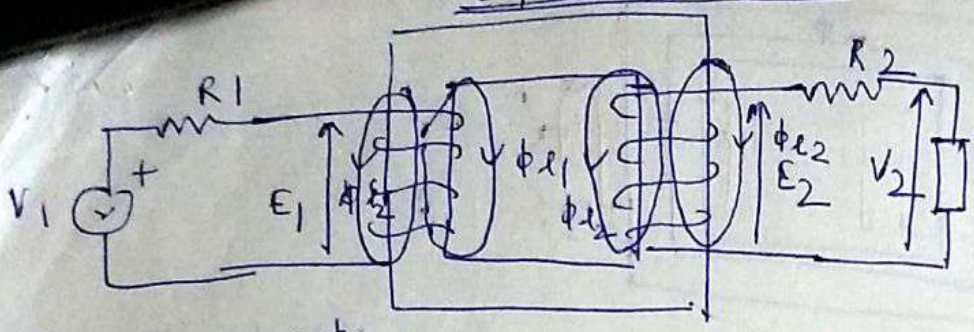
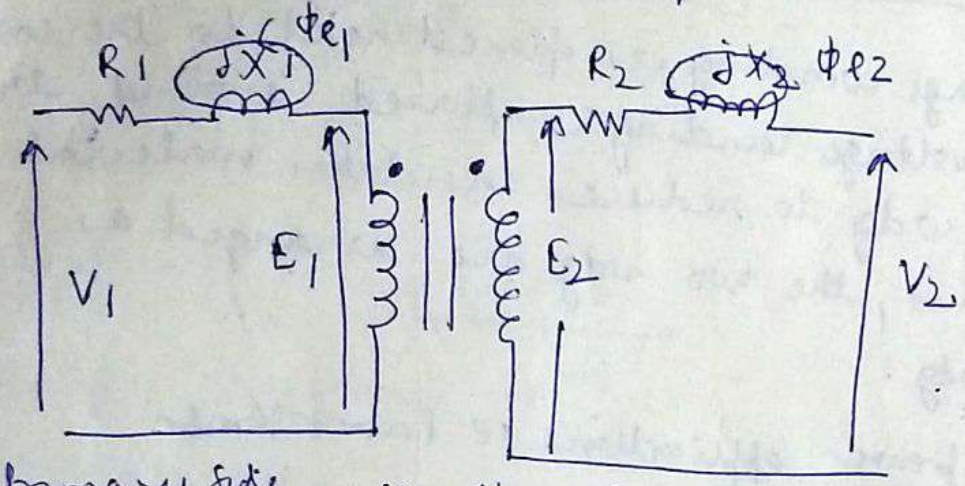
Equivalent ckt :





Primary side $N_1 : N_2$ Secondary side

$$E_2 = V_2 + I_2 R_2 + j I_2 X_2$$

$$\frac{E_2}{E_1} = K \qquad \frac{I_1}{I_2} = K$$

$$I_1^2 R_1 = I_2^2 R_2$$

$$R_1 = \left(\frac{I_2}{I_1}\right)^2 R_2$$

$$R_1 = \frac{R_2}{K^2}$$

$E_2' = \frac{E_2}{K} = E_1$ = Secondary voltage referred to primary.

$R_2' = \frac{R_2}{K^2} = R_1$ = Secondary Resistance referred to primary

$X_2' = \frac{X_2}{K^2} = X_1$ = Secondary Reactance referred to primary

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$I_1 = I_2 K = I_2'$

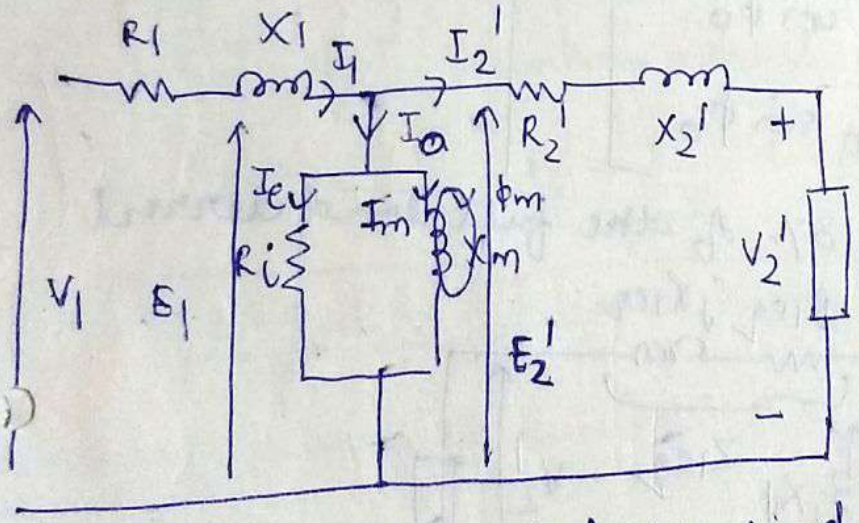
↳ Secondary current Referred to Primary

$$E_2 = V_2 + I_2 R_2 + j I_2 X_2$$

$$\frac{E_2}{K} = \frac{V_2}{K} + K I_2 \frac{R_2}{K^2} + j K I_2 \frac{X_2}{K^2} \quad (5)$$

$$E_2' = V_2' + I_2' R_2' + j I_2' X_2'$$

$$\boxed{E_2' = V_2' + I_2'(R_2' + j X_2')}$$



Exact Equivalent ckt.

Eddy current losses and Hysteresis losses

↳ $\boxed{P_h + P_e} \rightarrow R_i$

Mutual ~~current~~ Inductors flux $\phi_m \rightarrow X_m$

~~$I_0 = I_e + I_m$~~

~~no load current.~~

$$I_1 = I_0 + I_2'$$

$$I_2' = 0 \ (\text{load} = 0)$$

(6) $$I_1 = I_0$$

$$\boxed{I_1 = I_0 = I_e + I_m}$$

I_e = core loss component

I_m = magnetising "

$$I_e = I_0 \cos\phi_0$$

$$I_m = I_0 \sin\phi_0$$

As leakage Impedance $R_1, X_1 \simeq 0$

$$E_1 \simeq V_1$$

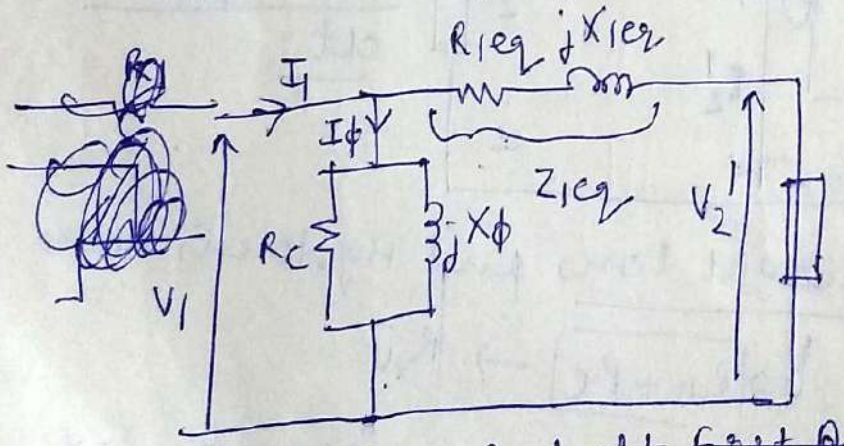
$$E_1 = V_1 - \underbrace{I_1(R_1 + jX_1)}_{\text{leakage impedance drop in primary}}$$

$R_1, X_1 \simeq 0$

$$E_1 = V_1$$

$$I_0 = \frac{V_1}{Z_0}$$

$I_0 \simeq$ 2 to 3% of the full load current



Approximate Equivalent ckt ~~First Approximation~~

$$R_{1eq} = R_1 + R_2' = R_1 + R_2/K^2$$

~~R_{2eq}~~ $$X_{1eq} = X_1 + X_2' = X_1 + \frac{X_2}{K^2}$$

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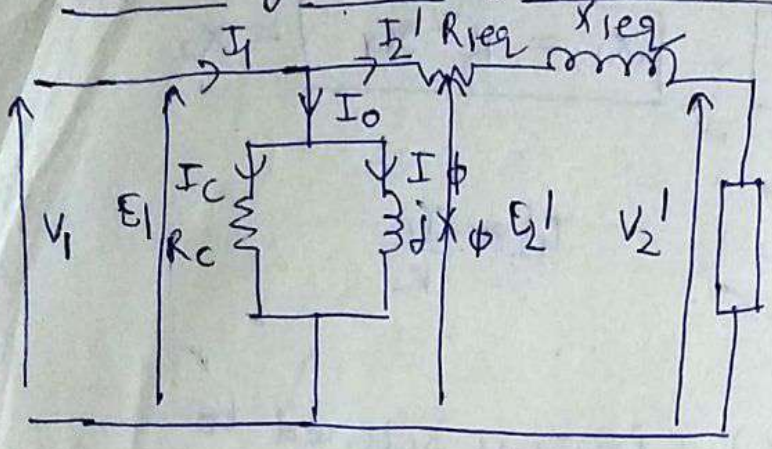
Conclusion

Secondary Ckt referred to primary



$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = K = \frac{I_1}{I_2}$$

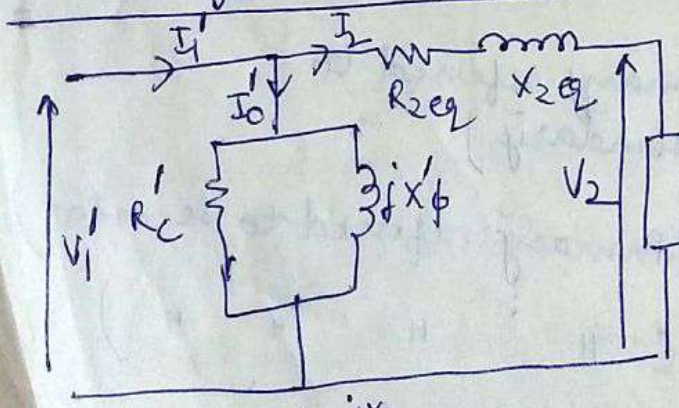
$$E_1 = \frac{E_2}{K} = E_2' \quad \text{(Secondary voltage referred to primary)}$$

$$I_1 = K I_2 = I_2' \quad \text{(Secondary current referred to primary)}$$

$$R_2' = \frac{R_2}{K^2}, \quad X_2' = \frac{X_2}{K^2} \quad \text{[Resistance \& Reactance referred to primary]}$$

$$\boxed{R_{1eq} = R_1 + R_2'}, \quad \boxed{X_{1eq} = X_1 + X_2'}$$

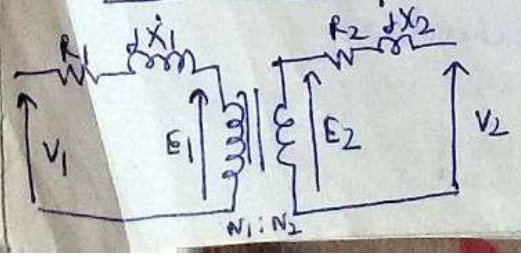
Primary referred to Secondary



$$\cancel{E_2 = V_2 + I_2 R_2 + jI_2 X_2}$$

$$K E_2 =$$

$$V_1 = E_1 + I_1 R_1 + jI_1 X_1$$



$$K V_1 = K E_1 + K I_1 (R_1) + j K I_1 X_1$$

$$K V_1 = K E_1 + \frac{I_1}{K}(K^2 R_1) + j(K^2 X_1)\frac{I_1}{K}$$

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Equivalent ckt

~~$V_1' = E_1' + K^2 I_1' R_1 + j K^2 I_1' X_1$~~

$$V_1' = E_1' + I_1'(R_1') + j I_1' X_1'$$

$$R_2 = \boxed{R_1' = K^2 R_1} \qquad \boxed{X_1' = K^2 X_1} = X_2$$

~~$V_1' = V_2 = K V_1$~~

10

$$I_1' = \frac{I_1}{K}$$

$$\frac{V_2}{V_1} = K$$

$$V_1' = V_2 = V_1(K) \quad \text{(Primary referred to Secondary)}$$

$$\frac{E_2}{E_1} = K$$

$$\boxed{E_1' = E_2 = E_1(K)} \quad \text{(Primary referred to Secondary)}$$

$$\left.\begin{aligned} R_{2eq} &= R_2 + R_1' = R_2 + K^2 R_1 \\ X_{2eq} &= X_2 + X_1' = X_2 + K^2 X_1 \end{aligned}\right\} \text{(Primary referred to Secondary)}$$

Primary ckt. referred to Secondary

$$\frac{E_2}{E_1} = K \Rightarrow \boxed{E_2 = K E_1 = E_1'}$$

$$\boxed{I_1' = I_2 = \frac{I_1}{K}} \quad \text{(Primary referred to Secondary)}$$

$$R_1' = K^2 R_1 \quad \text{(Primary referred to Secondary)}$$

$$X_1' = K^2 X_1 \quad \text{(" " " ")}$$

Total Resistance referred to Secondary

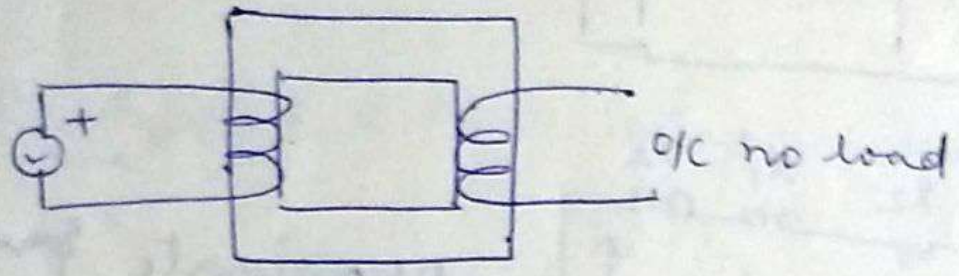
$$R_{2eq} = R_2 + R_1'$$

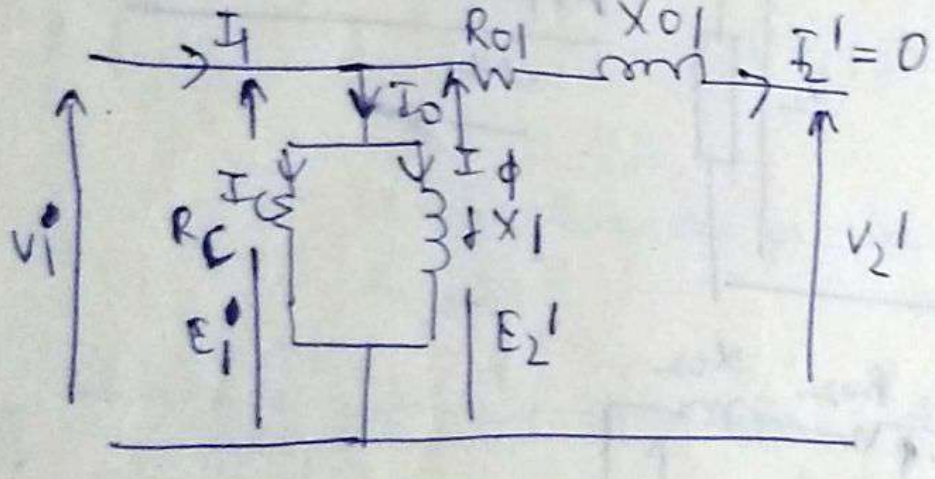
$$X_{2eq} = X_2 + X_1'$$

Scanned with CamScanner

~~Transformer Efficiency~~

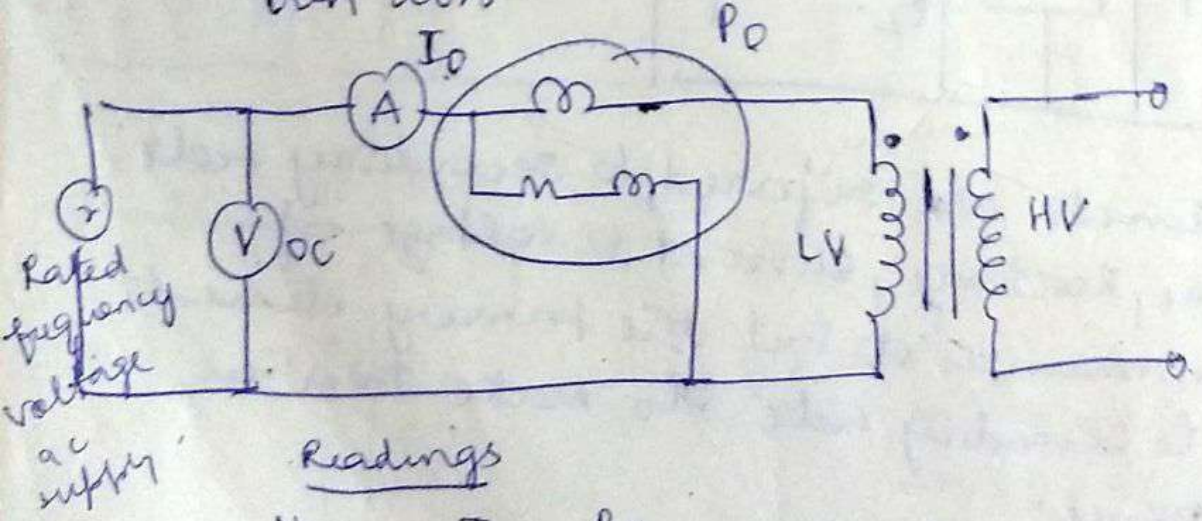
Open ckt Test.





Cu loss = 0

Power taken from the supply is equal to iron loss.



Readings

V_{OC}, I_0, P_0

V_{OC} → Rated voltage

I_0 → No load current

P_0 → Iron loss

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As iron loss depend on the applied voltage ∴ O/C test performed on Rated voltage

$$P_c = I_c^2 R_c = \frac{V_{oc}^2}{R_c}$$

(Iron loss remains constant wrt load current i.e constant loss)

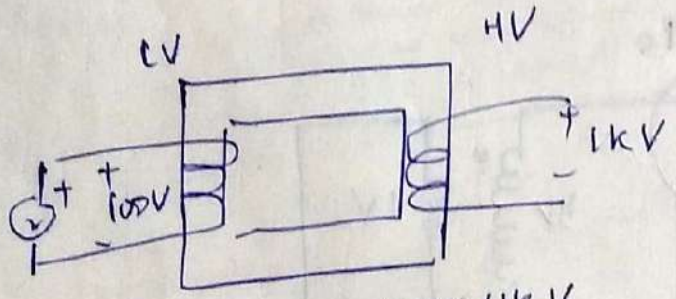
$$I_0 = \sqrt{I_c^2 + I_\phi^2}$$

$$I_c = I_0 \cos\phi$$

$$I_\phi = I_0 \sin\phi$$

$$\phi_0 = \cos^{-1}\left(\frac{P_0}{V_{oc} I_0}\right)$$

$$R_c = \frac{V_{oc}}{I_c} \quad \& \quad X_\phi = \frac{V_{oc}}{I_\phi}$$

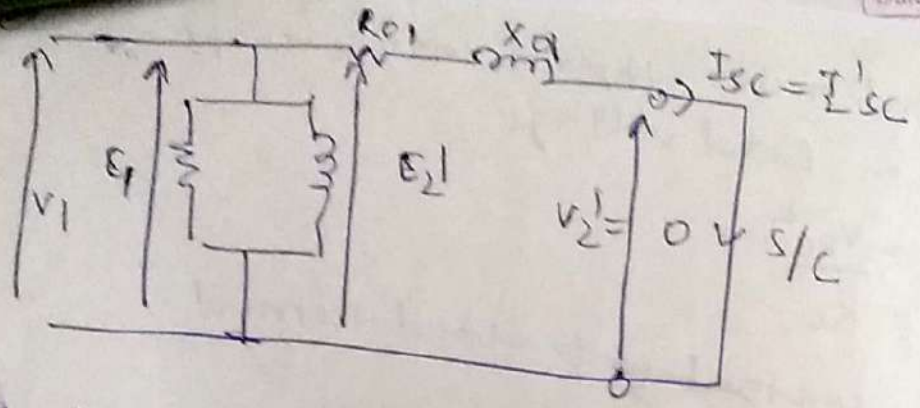


Rated voltage 100V / 1KV

Rated " 10A / 1A

Short ckt Test (for determination of Cu loss)

As Cu loss depend on the load current so it is performed at rated current or full load current

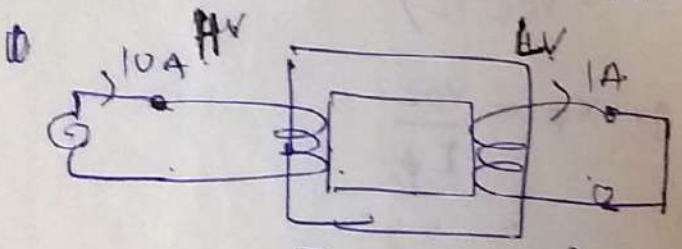


Cu loss = $I_{sc}^2 R$.

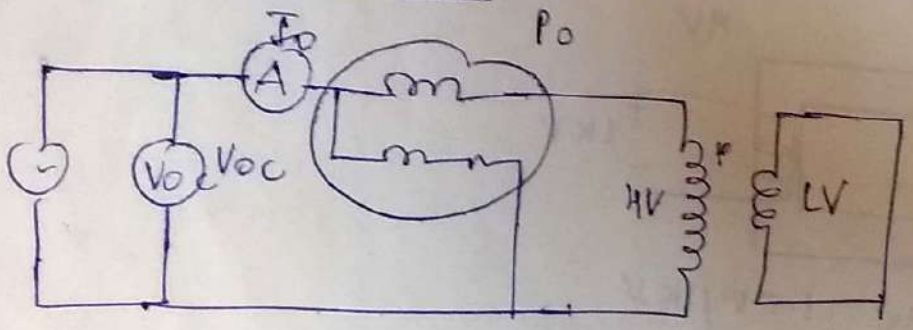
8-

1 KVA

	LV	HV
Rated voltage	100 V	1 KV
Rated current	10 A	1 A
	HC	LC



(It is performed on HV side)



Reading

V_{sc}, I_{sc}, P_{sc} [full load Cu loss]

V_{sc} → Input voltage

I_{sc} → full load current

$P_{sc} = I_{sc}^2 R$

$Z_{sc} = \frac{V_{sc}}{I_{sc}}$

$Z_{sc} = R + jX = \sqrt{R^2 + X^2}$

$X = \sqrt{Z_{sc}^2 - R^2} = ?$

Scanned with CamScanner

A 1-ϕ, 250/500V transformer gave the following results:

Open ckt Test – 250V, 1A, 80W (80W) on LV side

Short Ckt Test – 20V, 12A, 100W on HV side

Calculate the Circuit Constants & show them on an equivalent ckt.

Soln:

$V_1 = 250V, \; I_0 = 1A, \; P_i = 80W$

$P_i = V_1 I_0 \cos\phi_0$

$\cos\phi_0 = \frac{P_i}{V_1 I_0} = \frac{80}{250 \times 1} = 0.32$

$I_w = I_0 \cos\phi_0 = 1 \times 0.32 = 0.32A$

$I_\mu = I_0 \sin\phi_0 = \sqrt{I_0^2 - I_w^2} = \sqrt{1^2 - (0.32)^2}$

$= 0.947 \; A$

$R_0 = \frac{V_1}{I_w} = \frac{250}{0.32} = 781.25 \Omega$

$X_0 = \frac{V_1}{I_\mu} = \frac{250}{0.947} = 264 \Omega$

Short Ckt Test – As the primary is short ckted, therefore all the values refer to the secondary wdg. The results obtained in S.C. Test should be converted in terms of L.V side (Primary side)

Scanned with CamScanner

$V_{2sc} = 20V$, $P_{cfl} = 100W$, $I_{2sc} = 12A$

$$\cancel{\frac{N_1}{N_2}} = \frac{N_2}{N_1} = \frac{E_2}{E_1} = \frac{500}{250} = 2$$

Voltage applied on low voltage side

(short ckt voltage referred to primary)

$$E_2' = \frac{E_2}{K} = \frac{20}{2} = 10V$$

Primary (l.V) full load current

$$I_2' = 12 \times K = 12 \times 2 = 24A$$

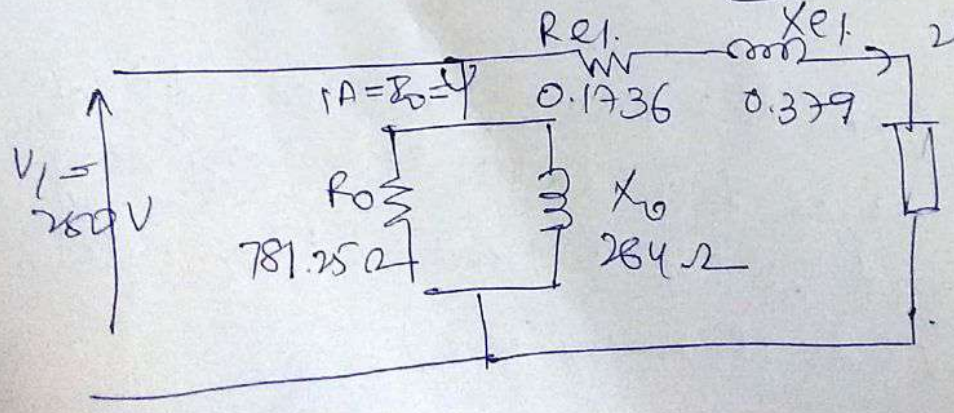
$$P_{cfl} = I_{sc}^2 R_{e1}$$

$$R_{e1} = \frac{P_{cfl}}{I_{sc}^2} = \frac{100}{(24)^2} = \underline{0.1736\,\Omega}$$

$$Z_{e1} = \frac{V_{1sc}}{I_{1sc}} = \frac{10}{24} = \underline{0.417\,\Omega}$$

$$X_{e1} = \sqrt{Z_{e1}^2 - R_{e1}^2} = \sqrt{(0.417)^2 - (0.1736)^2}$$

$$= \underline{0.379\,\Omega}$$



~~Equivalent~~ Equivalent ckt

Date: / /

Q The following results were obtained on a 50KVA, 2400/120V transformer

Open ckt test, Instruments on L.V

O.C.T = 120V, 9.65A, 396W

S.C.T = 92V, 20.8A, 816W

(a) O.C.T

$P_L = 396W$, $I_0 = 9.65A$, $V_1 = 120V$

$P_L = V_1 I_0 \cos\phi_0 = V_1 I_w$

$396 = 120 I_w \Rightarrow I_w = \frac{396}{120} = 3.3A$

$\frac{396}{120 \times 9.65} = \cos\phi$

$\boxed{I_w = I_0 \cos\phi = 3.3A}$

$I_\mu = I_0 \sin\phi_0 = 9.06A$

$R_0 = \frac{V_1}{I_w} = \frac{120}{3.3} = 36.3\Omega$

$I_\mu X_0 = 120$

$X_0 = \frac{120}{9.06} = 13.2\Omega$

Scanned with CamScanner

S.C.T $P_{cuFL} = 810W$, $I_{fl} = 20.8A$ $V_{sc} = 92V$

$$P_{cuFL} = (20.8)^2 R_{e1}$$

$$R_{e1} = \frac{810}{(20.8)^2} = \underline{1.87\Omega}$$

$$V_{sc} = I_{fl} Z_{e1}$$

$$92 = 20.8 Z_{e1}, \quad Z_{e1} = \frac{92}{20.8} = \underline{4.42\Omega}$$

$$X_{e1} = \sqrt{Z_{e1}^2 - R_{e1}^2} = \underline{4\Omega}$$

$$R_{e2} = R_{e1}\left(\frac{N_2}{N_1}\right)^2 = 1.87\left(\frac{120}{2400}\right)^2 =$$

$$= 0.0047\Omega$$

$$X_{e2} = 4\left(\frac{120}{2400}\right)^2 = \underline{0.01\Omega}$$

(b) $$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_c + P_{cuFL}} = \frac{50 \times 1000 \times 0.8}{50 \times 1000 \times 0.8 + 396 + 810}$$

$$= 0.9707 \text{ pu} = \underline{97.07\%}$$

(c) <u>Voltage Regulation</u>

$$\frac{I_1 R_{e1}}{V_1}\cos\phi + \frac{I_1 X_{e1}}{V_1}\sin\phi_2$$

$$= \frac{20.8 \times 1.87}{2400} \times 0.8 + \frac{20.8 \times 4}{2400} \times 0.6$$

$$= 3.376\%$$

Scanned with CamScanner

A 30KVA, 2000/200V, 1-ϕ, 50Hz transformer has primary resistance of 3.5 Ω & Reactance of 4.5 Ω. The secondary resistance & reactance are 0.015 Ω & 0.02 Ω respectively. Find (i) Equivalent resistance, reactance & impedance referred to the primary side (ii) total cu loss in the transformer.

(11)

Soln $K = \frac{V_2}{V_1} = \frac{200}{2000} = 0.1$

$S = V I_1$

$30 \times 10^3 = 2000 \times I_1$

$\frac{30 \times 10^3}{2000} = I_1 = 15 A$

$R_{1eq} = R_1 + \frac{R_2}{K^2} = 3.5 + \frac{0.015}{(0.1)^2} = 5 \Omega$

$X_{1eq} = X_1 + \frac{X_2}{K^2} = 4.5 + \frac{0.02}{(0.1)^2} = 6.5 \Omega$

$Z_{1eq} = \sqrt{R_{1eq}^2 + X_{1eq}^2} = \sqrt{5^2 + (6.5)^2} = 8.2 \Omega$

Total Cu loss $= I_1^2 R_1 = (15)^2 \times 5 = \underline{1,125 W}$

Q A 5 KVA, 240/120V, 1-ϕ transformer supplies rated current to a load at 120V. Determine the magnitude of load impedance as seen from input terminals of transformer. The load impedance is $(5 + j15) \Omega$

Scanned with CamScanner

Soln

Transformation Ratio $= k = \frac{V_2}{V_1} = \frac{120}{240} = 1/2$

$Z_L = (5 + j15)$

$Z_L' = \frac{Z_L}{k^2} = \frac{5 + j15}{(1/2)^2} = (20 + j60)\ \Omega$

Scanned with CamScanner

A 3300/250 V, 50 Hz, 1-ϕ transformer is built on a core having an effective cross sectional area of 125 cm^2 and 70 turns on the low voltage wdg. Calculate (a) the value of the max^m flux density (b) the no. of turns on the high voltage wdg.

$E_1 = 3300\,V$, $E_2 = 250\,V$, $f = 50\,Hz$

$A = 125\,cm^2 = 125 \times 10^{-4}\,m^2$

$E_2 = 4.44\, B_m f T_2$

$$B_m = \frac{E_2}{4.44\, A f T_2} = \frac{250}{4.44 \times 125 \times 10^{-4} \times 50 \times 70}$$

$$= \underline{1.289 \text{ Teslas (T)}}$$

$$\frac{E_1}{E_2} = \frac{T_1}{T_2}$$

$$T_1 = \frac{E_1}{E_2} \times T_2 = \frac{3300}{250} \times 70 = \underline{924}$$

<u>B</u>. A 125 KVA transformer having primary voltage of 2000 V at 50 Hz has 182 primary & 40 secondary turns. Neglecting losses, calculate (a) the full load primary & secondary currents (b) the no-load secondary induced emf and (c) the max^m flux in the core.

Scanned with CamScanner

(a) $KVA = \frac{V_1 I_1}{1000} = \frac{V_2 I_2}{1000}$

$$I_1 = \frac{1000 \times KVA}{V_1} = \frac{1000 \times 125}{2000} = \underline{62.5\ A}$$

$$I_2 N_2 = I_1 N_1$$

$$I_2 = \frac{I_1 N_1}{N_2} = \frac{62.5 \times 182}{40} = \underline{284.4\ A}$$

(b) $\frac{E_2}{N_2} = \frac{E_1}{N_1}$

$$E_2 = E_1 \left(\frac{N_2}{N_1}\right)$$

$$= \frac{2000 \times 40}{182} = \underline{439.6\ V}$$

(c) $V_1 = 4.44\, \phi_m f\, T_1$

$$\frac{2000}{4.44 \times 50 \times 182} = \phi_m$$

$$\boxed{0.0495\ Wb = \phi_m}$$

Scanned with CamScanner

Q A 1-ϕ transformer has 180 & 90 turns respectively in its secondary & primary wdg. The Respective resistances are 0.233Ω (secondary) & 0.067Ω (primary). Calculate the effective resistance of (a) the primary in terms of secondary winding, (b) the secondary in terms of the primary wdg & (c) the total Resistance of the transformer, in terms of primary

Ans (a) Resistance Referred to secondary.

$$R_1' = R_1 . K^2$$

$$K = \cancel{\frac{90}{180} = \frac{1}{2}} \quad \frac{N_2}{N_1} = \frac{180}{90} = 2$$

$$R_1' = (\cancel{0.233}\ 0.067)\cancel{\left(\frac{1}{2}\right)^2} (2)^2$$

$$= 0.268\,\Omega$$

(b) Resistance Referred to primary

$$R_2' = \frac{R_2}{K^2} = \frac{0.233}{K^2} = \frac{0.233}{4}$$

$$= 0.058\,\Omega$$

(c) the total Resistance of the transformer in terms of primary.

$$R_{01} = R_1 + R_2'$$

$$= 0.067 + \frac{R_2}{K^2} = 0.067 + 0.058$$

$$= 0.125\,\Omega$$

Scanned with CamScanner

A 230V/110V 1-φ transformer takes an i/p of 350 VA at no load and at rated voltage. The core loss is 110 W. Find (i) the iron loss component of no load current (ii) magnetising component of no load current (iii) no load pf.

Soln $V_1 I_0 = 350$

$$I_0 = \frac{350}{230} = \underline{1.52\,A}$$

(i) No load pf.

$$\text{Core loss} = V_1 I_0 \cos\phi_0$$

$$110 = 350 \cos\phi_0$$

$$\cos\phi_0 = \frac{110}{350} = 0.314$$

(ii) Core loss component of no load current

$$I_w = I_0 \cos\phi_0 = \frac{110}{230} = \underline{0.478}$$

(iii) Magnetizing component of no load current

$$I_\mu = \sqrt{I_0^2 - I_w^2} = \sqrt{(1.52)^2 - (0.478)^2}$$

$$= \underline{1.44\,A}$$

Scanned with CamScanner