04.01.2019

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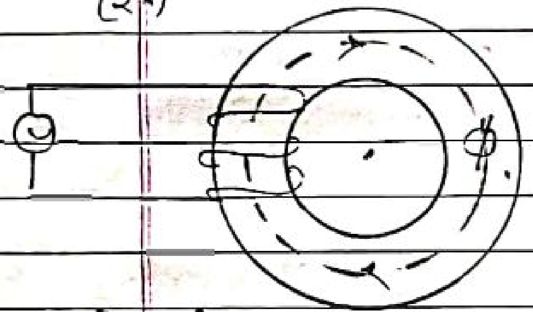
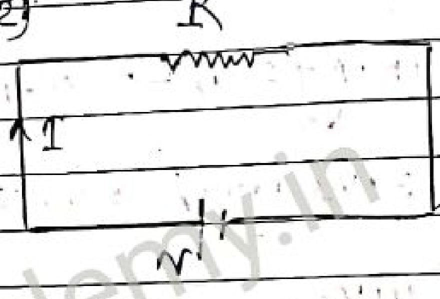
UNIT → 03

Transformer :- Magnetic circuit.

Magnetic circuit	Electric circuit
(i) It is a closed path followed by magnetic flux in the magnetic material	It is the closed path followed by electric current in the electric conductor
(2) 	(2) 
Excitation :- MMF (magneto ~~magneto~~ motive force)	Excitation :- EMF (Electric motive force)
unit :- MMF = NI, Ampere turns (AT)	V = IR, unit :- volt
Response : flux $\phi = \frac{mmf}{S\,(\text{Reluctance})}$	Response : current $I = V/R$
unit ϕ = Weber (wb)	unit : Ampere
Reluctance :- It opposes the flow of magnetic flux in the magnetic circuit. $S = \frac{mmf}{\phi}$, unit : AT/wb	Resistance : It opposes the flow of electric current. $R = V/I$, unit : Ω (ohm)

series combination in Magnetic circuit :-	series combination in Electric circuit :-
$S_{eq} = S_1 + S_2 + S_3 + \cdots + S_n$	$R_{eq} = R_1 + R_2 + R_3 + \cdots + R_n$
Parallel combination	Parallel combination :-
$\frac{1}{S_{eq}} = \frac{1}{S_1} + \frac{1}{S_2} + \frac{1}{S_3} \cdots + \frac{1}{S_n}$	$\frac{1}{R_{eq}} = \frac{1}{R_1} + R_2^{-1} + \frac{1}{R_3} + \cdots + \frac{1}{R_n}$
Permiance :- $P = \frac{1}{S}$ unit : wb/AT Def:- it is the easyness to flow of magnetic flux in magnetic circuit, it is the inverse of Reluctance	conductance :- $G = \frac{1}{R}$ unit = Ω^{-1} it is the easyness to flow of electric current in the electric circuit and inverse of Resistance
Reluctivity $S = \frac{1}{\mu} \times \frac{L}{A}$. $1/\mu$ = reluctivity μ = Permeability	Resistivity :- $R = \rho l / A$. $\rho = RA/l$ ↳ Resistivity
Magnetic field intensity. $H = \frac{mmf}{length}$ unit = AT/m	Electric field intensity (E) :- $E = V/l$ unit = volt/metre

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(Q·02:) Difference b/w Electric circuit and magnetic circuit.

Ans:-	Magnetic circuit.	Electric circuit
01)	Flux is assumed to flow in magnetic circuit. It is an imaginary qty.	01) Electric current actually flows in the circuit. It is a real quantity.
(2.)	There is no insulator available in case of magnetic circ	2) various types of insulator available in case of Electric circuit.
(3.)	Flux can pass through the air.	(3.) Electric current can not pass through the air.
(4.)	MMF is required only to generate magnetic flux in the magnetic circuit. It is not required to maintain magnetic flux.	(4.) EMF is required for both generating and maintaining Electric current in the electric circuit.

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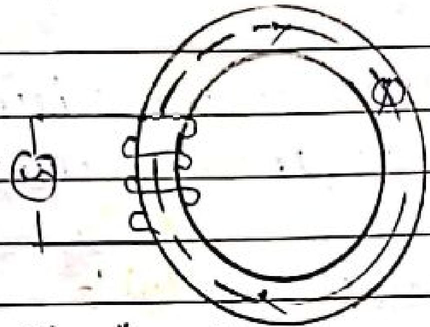
05/02/2019-

Basic Defination:-

(i) Magnetic circuit:-

It is the close path followed by magnetic flux in a magnetic material



Magnetic flux:-

It is the magnetic lines of forces acting in a direction in which magnetic force acts.

$\phi = \frac{MMF}{S\,(\text{Reluctance})}$

unit ϕ = Weber (Wb).

MMF:- (Magneto motive forces):

MMF. is a force that drives the magnetic flux in a magnetic circuit.

- mmf = NI
  where N = no. of Turns
  I = current.
  unit(mmf) = AT i.e Ampere Turns.

- mmf = ϕS
  ϕ = Magnetic flux.
  S = Reluctance

- mmf = $H \times l$
  $H \rightarrow$ Field intensity i.e magnetic field In.
  $l \rightarrow$ length of magnetic circuit.

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Permeability :- (μ) :-
It is the property of material which measures how much material can conduct magnetic flux.
- $\mu = \mu_0 \mu_r$

where, $\mu_0 \rightarrow$ freespace permeability
$\mu_r \rightarrow$ Relative permeability
value of $\mu_0 = 4\pi \times 10^{-7}$

Magnetic flux density :- (B) :-
It is magnetic flux per unit area.
- $B = \phi/A = wb/m^2$.
- $B = \mu H$

where μ - Permeability.
$H \rightarrow$ magnetic flux intensity

Reluctance :- (S) :
It is the property of material which opposes the flow of flux in a magnetic circuit.
- $S = \frac{mmf}{\phi} = \frac{AT}{wb}$
- $S = \frac{1 \times l}{\mu A}$

where $1/\mu \rightarrow$ Reluctivity

Magnetic field intensity :(H)
It is the ratio of magneto motive force (MMF) to the length of magnetic circuit.
- $H = \frac{MMF}{l} = AT/m$ - unit

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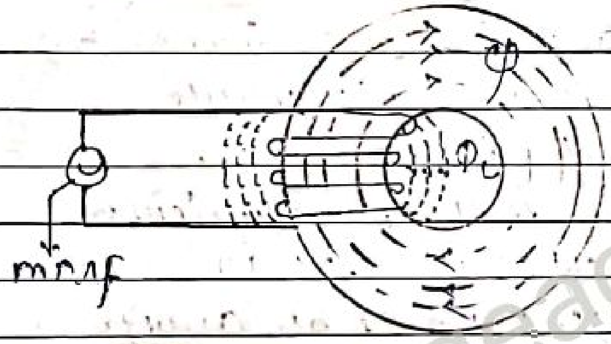
Permiance (P) :-

It is the inverse of Reluctance. It can be defined as the easyness provided by the circuit to flow the magnetic flux.

$P = 1/S$

unit : $\frac{Wb}{AT}$

Leakage flux fringing :-



Leakage flux (ϕ_L) :-
It is the flux which is not linking with the magnetic core and is surrounded near the coil.

Useful flux (ϕ) :-
It is the flux which is perfectly linking with the magnetic core.

Total flux (ϕ_T) :-
It is the combination of leakage flux and useful flux.

$\phi_T = \phi_L + \phi$

The ratio of total flux (flux in the iron path i.e magnetic flux) to the useful flux is known as leakage factor. $\frac{\text{Total flux}}{\text{useful flux}}$

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06/02/2019 -.

1 ϕ Transformer:-

Faraday's Law of Electromagnetic induction-.

(i) whenever magnetic flux linking in a closed circuit changes w.r.t the time and emf is induced. e

(ii) The magnitude of induced emf is given by -ve of rate of change of magnetic flux linked with the closed circuit

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

N = No. of Turns

- -ve sign is due to Lenz's law; which states that the direction of induced emf is such that it opposes the cause that produced it.

Transformer:-

It is a ac static device which transforms low voltage, high current to high voltage low current and vice-versa without changing its frequency.

Principle:-

The working principle of transformer is based on mutual induction.

The Phenomena of generation of induced emf in the secondary coil by changing the current in primary coil known as mutual induction.

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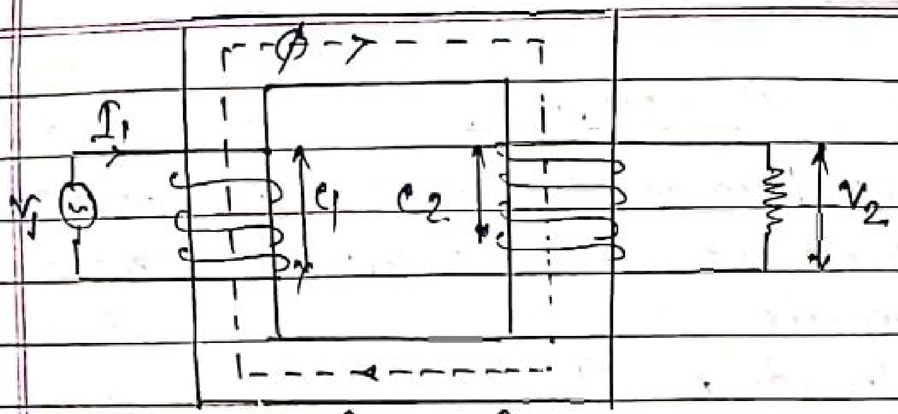

e_1 → self induction.
e_2 → Mutual induction

operation of Transformer is based on Faraday's law of electromagnetic induction.

(1) An alternating voltage V_1 is applied across the primary winding of the transformer which will result alternating current I_1 flowing through primary winding.

(2.) Flux (ϕ) is produced across the primary winding due to primary current I_1. This flux is also alternating in nature.

(3.) A/c to Faraday's law of emi whenever magnetic flux links with closed circuit is changing w.r.t time and emf is ind. Hence emf e_1 is induced across primary winding due to self induction.

(4.) Since both windings (primary and s) are mounted on the same magnetic core, the same flux ϕ will also link with the secondary winding. Hence emf E_2 will be induced across secondary winding due to

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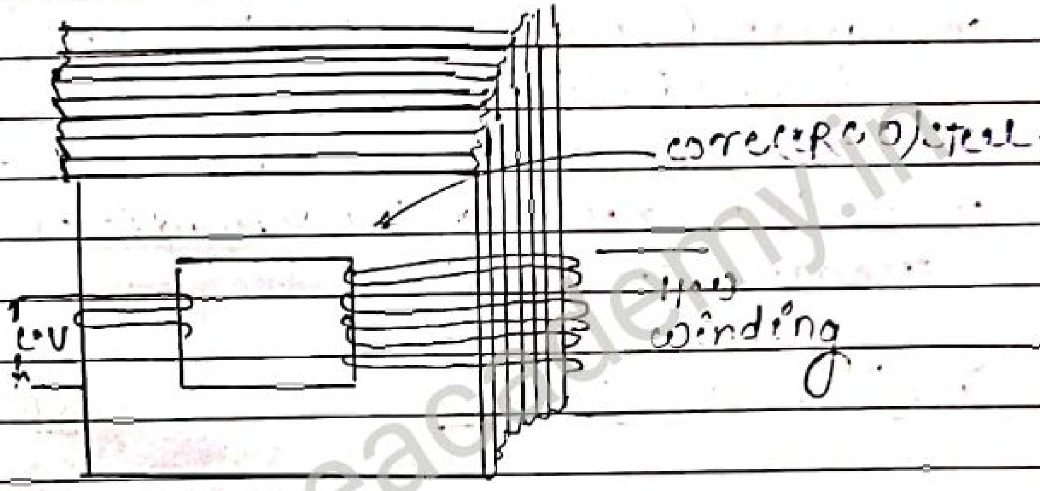
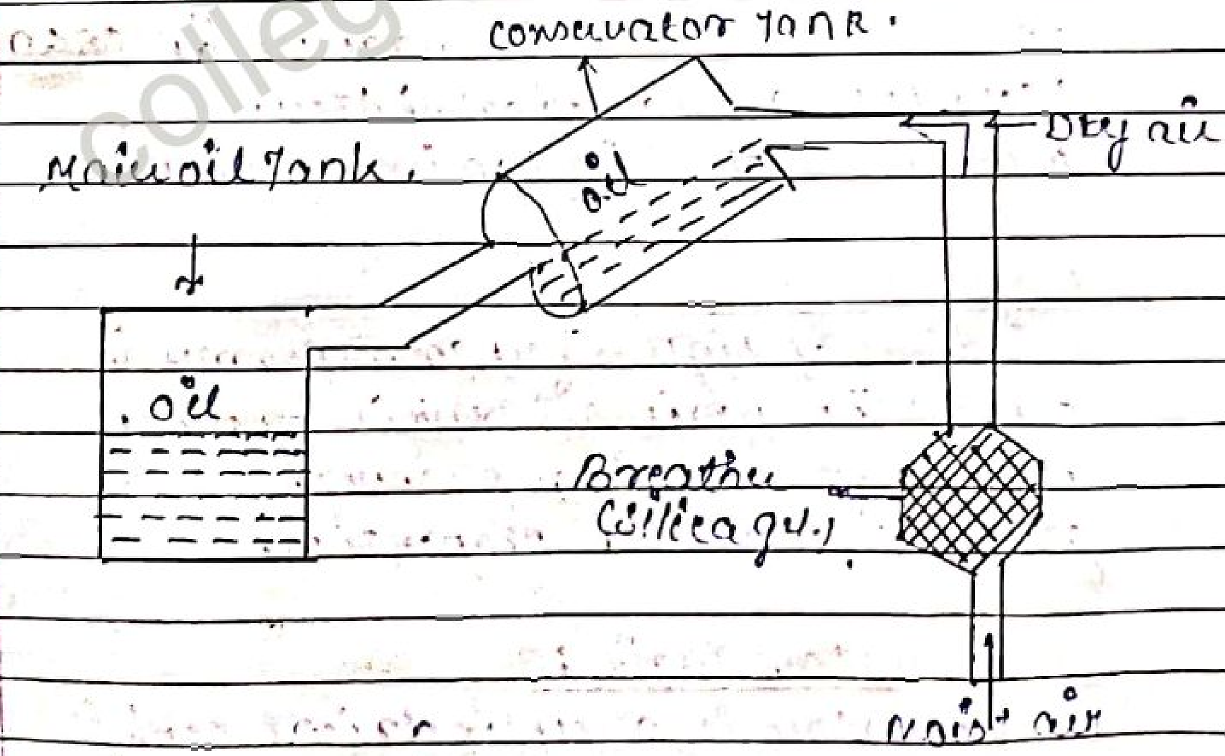
mutual induction.

(5.) Current I_2 is produced in the secondary winding due to E_2 which is known as secondary current.

07/02/18

CRGO → (cold rolled grain oriented)





Shivalal

Transformer winding :-
(X-mer)

It forms the electrical circuit for the xmer generally made up of copper coils, Transformer windings are of two types:-

(1) High voltage winding
(2) Low voltage winding

→ H.V winding have large no. of turns as compare to low voltage windings.
→ winding which is connected to the source is known as primary winding and the one which is connected to the load is called secondary winding.

Transformer core :-

It forms the magnetic circuit for the transformer, it is made up of CRGO (Cold Rolled Grained oriented steel. In the form of thin laminated sheet.

Main oil tank :-
windings of high rated Transformer is kept in the main oil tank in order to ensure good cooling properties & good insulation properties.

conservator Tank :-
conservator is a cylindrical tank attached to the main oil tank and it is used to prevent direct contact of moist air with oil in the main oil tank.

During high load operations winding of transformer gets heated up and oil from main oil tank evaporates to the conservator tank.

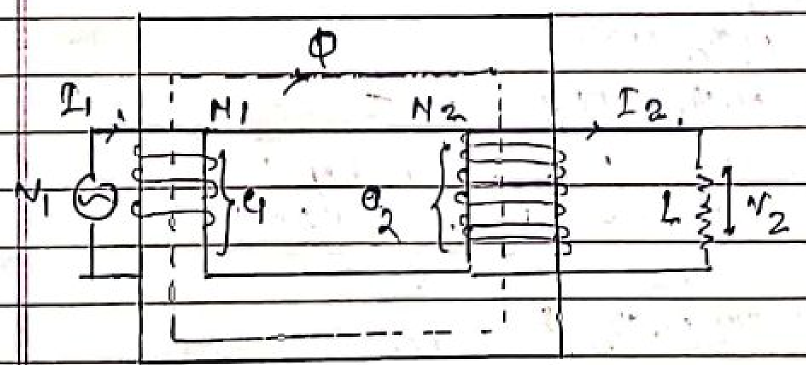
→ During low load operation windings of transformer gets cooled out then oil from conservator tank return back to the main oil tank.

Breather :-

Breather is attached to conservator tank and it is made up of silica gel. It ensures only dry air goes into the conservator tank during low load operation of transformer.

08/02/19 -

EMF Equation :- of Transfer,



where N_1 - no. of turns in primary winding
N_2 - " in secondary winding
V_1 - Primary/ source voltage
V_2 - secondary/ load voltage
I_1 - Primary current
I_2 - secondary current
Φ - flux.
f = frequency

e_1 = induced emf in Primary winding
e_2 = induced emf in secondary winding

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The Instaneous equation of flux is given by
$\phi = \phi_m \sin\omega t$ —— (1)

The induced emf in the primary winding is given by $e_1 = -N_1 \frac{d\phi}{dt}$ —— (ii)

By putting the value of ϕ in eqn (2):-

$e_1 = -N_1 \frac{d(\phi_m \sin\omega t)}{dt}$

$e_1 = -N_1 \phi_m \omega \cos\omega t$

$e_1 = -N_1 \phi_m \omega \sin(\omega t - \pi/2)$ —— (iii)

$[\because -\cos\omega t = \sin(\omega t - \pi/2)]$

By comparing equations (1) & (3) it is clear that emf lags the flux by $\pi/2$.
now comparing equation 3 with instanteneous equation of emf..

$e = E_{max} \sin\omega t$

$E_{max} = N_1 \phi_m \omega$

$E_{max} = N_1 \phi_m 2\pi f$

Rms value of emf is given by:

$E_{rms} = \frac{E_{max}}{\sqrt{2}} = \frac{N_1 \phi_m 2\pi f}{\sqrt{2}}$

$E_{rms} = e_1 = 4.44 N_1 \phi_m f$ —— (4)

Similarly,
for secondary winding rms value of emf is given by
$e_2 = 4.44 N_2 \phi_m f$ —— (5)

Transformation Ratio (K):-
Dividing eq 5 by 4:-

$\frac{e_2}{e_1} = \frac{N_2}{N_1} = k$ for Practical Transformer

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conditions for Ideal Transformer

- Resistance of Primary & Secondary winding becomes negligible.
- There should be no leakage flux
- There should be no losses in Transformer

I/P Power = O/P Power

$E_1 I_1 \cos\phi = E_2 I_2 \cos\phi$.

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

, for Ideal Transformer.

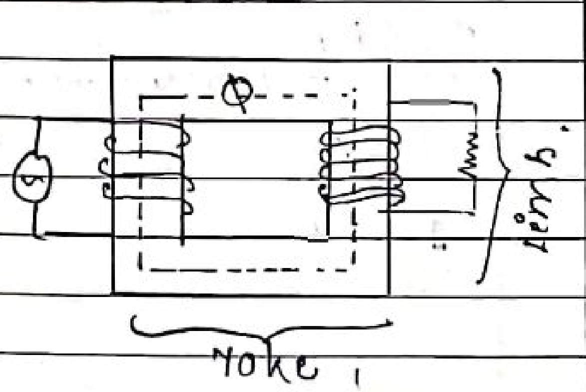
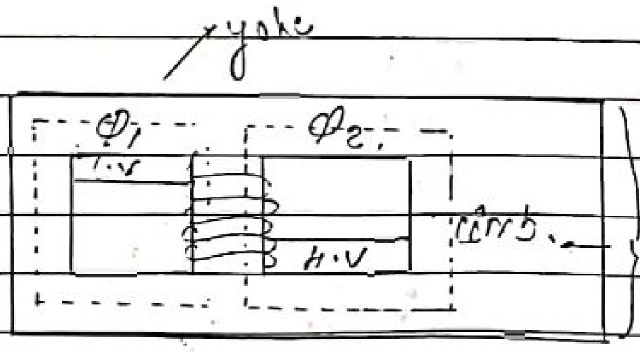
$$\frac{e_2}{e_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2} = k$$

also $e_1 \simeq V_1$ and $e_2 \simeq V_2$.

$$\frac{e_2}{e_1} = \frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2} = k$$

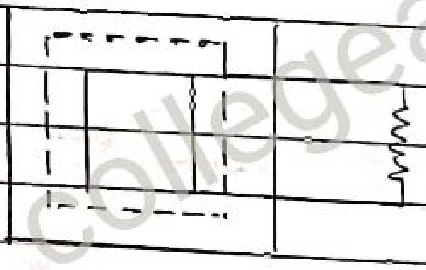
11/02/19 :- Classification of X-mer :-

① Based on Position of windings :-

core type	shell type
	

core type	shell type
(1) In core type transform core is surrounded by the windings.	In the shell type transformer winding is surrounded by core.
(2.) • no. of limbs = 02 • no. of yokes = 02	• no. of limbs = 03. • no. of yokes = 02
(3.) no. of magnetic path = 1	no. of magnetic path = 02

• **Based on the operation:-**

step-up	step-down.
	
It transforms low voltage, high current to high voltage low current.	It transforms high voltage, low current to low voltage high current.
• $N_p < N_s$. ↳ primary winding N_s → secondary winding ∴ $V_p < V_s$. also $I_p > I_s$	• $N_s < N_p$. N_s → primary winding N_p secondary winding $V_s < V_p$ $I_s > I_p$

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③ • Based on the location of Transformer.

Distribution Xmer.	Power transformer.
• output ratting = 5 KVA	~~It transforms high voltage to~~ • output rating = 500 KVA
• Efficiency i.e η = 50%	η = 80%
• Distribution transformer remains energized for 24 hours.	• It remains energized for high load operation and it is used as power stations.
• It transforms transmission line voltage to the distribution voltage (230V) that the use of Household supply	• It transform transmission voltage to to the Transmission voltage.

Losses in Transformer:-

- Core loss:
  - Eddy current loss
  - Hysteresis loss
- Winding loss: (I^2R)

• Core loss:-

These loses takes place in the core material (magnetic part of Transformer) These are of Two Types → Eddy current loss and Hysteresis loss.

Eddy current loss –

Because of the alternating field emf is infused in core which causes induced current known as Eddy current. The Eddy current loss in watts can be given as –

$$W_e = k_e B_m^2 f^2 t^2 v$$

B_m maximum flux density

$f \rightarrow$ frequency

t = thickness of lamination

v = volume of core

k_e = eddy current coefficient

These losses can be minimised by providing laminated core.

Hysteresis loss –

These losses depends on the quality of core material can be minimised by using good quality material such as. (silicon steel, nickel iron, CRGO steel)

$$W_h = k_h B_m^{1.6} f v.$$

Total core losses.

$$P_c = W_e + W_h.$$

NOTE:–

The core losses are fixed loses. They donot depends on the load.

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Shivalal

Copper loss (ohmic loss:) -

These loses takes place in the conducting material windings) of the Transformer and they are given by

$P_{oh} = I^2 R$ watts

r = resistance of winding, P_{oh} = ohmic power loss

since, there are two windings in normal transformer i.e. $P_{oh} = I_1^2 r_1 + I_2^2 r_2$

These loses are normally calculate at 75°C. These are variable loses since they depends on the load current.

Stray load loss:-

occurrence of these loses is due to presence of leakage field. Percentage of these loss is very small as compare to copper loses and core losses. so can be neglect for calculation of efficiency

Dielectric loss -

This loss occurs in insulating material or oil. This loss is also negligible and it is not taken into account for calculation of efficiency

Efficiency :-

since there are no rotational loses (frictional and windage), so the Transformer has very high efficiency which is defined as a ratio of output power to the input power.

$$\eta = \frac{\text{O/P Power in watts}}{\text{I/P Power in watts}}$$

OR

$$\eta = \frac{\text{output}}{\text{output} + \text{losses}}$$

$$= \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_c + P_{cu}}$$

where V_2 = voltage across the load
I_2 = current through the load
P_c = core loss (iron loss)
P_{cu} = copper loss (ohmic losses)
$\cos\phi_2$ = load power factor

In percentage $\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_c + P_{cu}} \times 100\%$

Efficiency can be also written in terms of input and losses.

$$\eta = \frac{\text{Input} - \text{losses}}{\text{Input}}$$

All Day Efficiency (Energy efficiency):
The primary of distribution transformer is always energised whereas the load is continuously change throughout the all day. So, the efficiency is normally expressed in energy (load × time).

$$\%\eta = \frac{\text{output in kWh}}{\text{input in kWh}} \times 100$$

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Voltage regulation of X-mer :- .

It is defined as a change in magnitude of secondary terminal voltage when load at a given power factor is removed with with primary supply voltage is kept constant.

It is defined as a percentage of p.u of secondary rated voltage, no load voltage.

Voltage Regulation $= \frac{E_2 - V_2}{E_2}$ in P.U

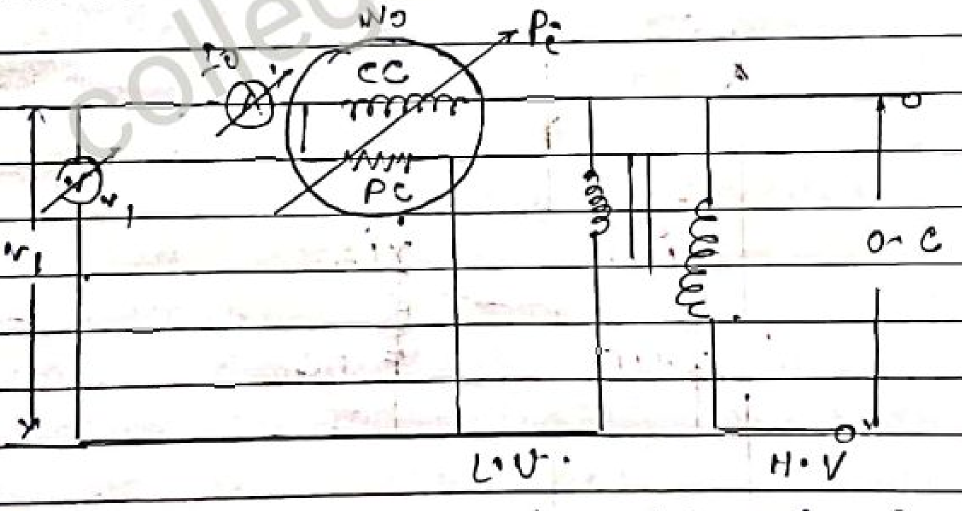
% V.R $= \frac{E_2 - V_2}{E_2} \times 100$ (in %)

E_2 = secondary rated voltage (no load voltage)

V_2 = secondary terminal voltage at full load.

13/02/2019 —

Open circuit Test :-



- open circuit test is performed to determine iron loses (core loses)
- open circuit test determines parameter of parallel branch of equivalent circuit of Transformer i.e. Rc. Xm
- High voltage winding is kept open during open circuit test.
- Test is carried out at low voltage side that means

all the instruments (voltmeter, ammeter) are connected at low voltage side.

Since there is no load connected at the secondary side. Hence the value of no load current i.e I_0 is very small (2-5% of full rated current)

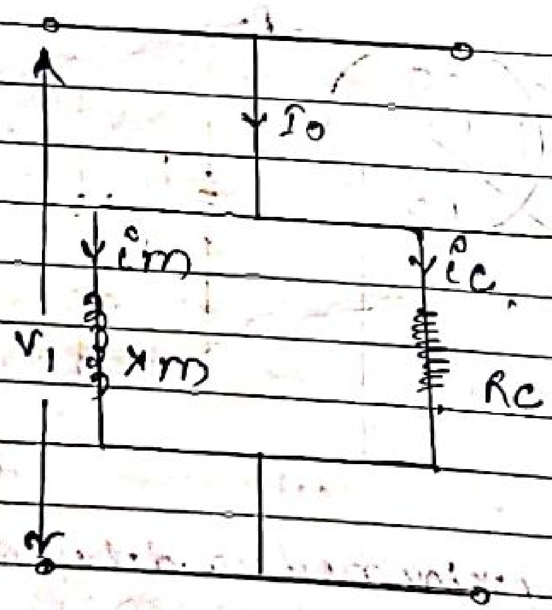
Readings of different instruments are as follows:

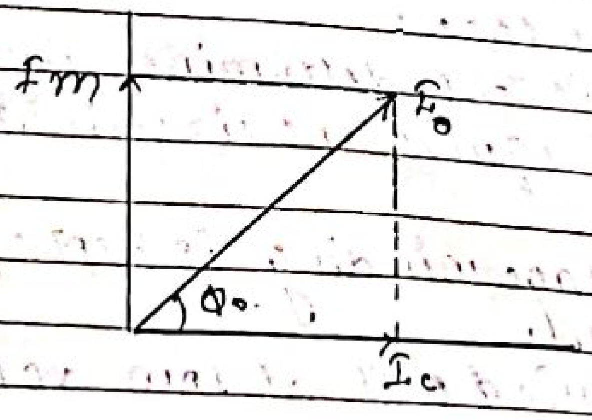
Ammeter = I_0 = no load current

voltmeter = V_1 = primary voltage

wattmeter = P_i = iron loss

iron loss is given by $\boxed{W_0 = V_1 I_0 \cos\phi_0}$





O.C → I_0 ... X_m ...

S.C → I ... (V ...)

$I_c = I_0 \cos\phi_0$

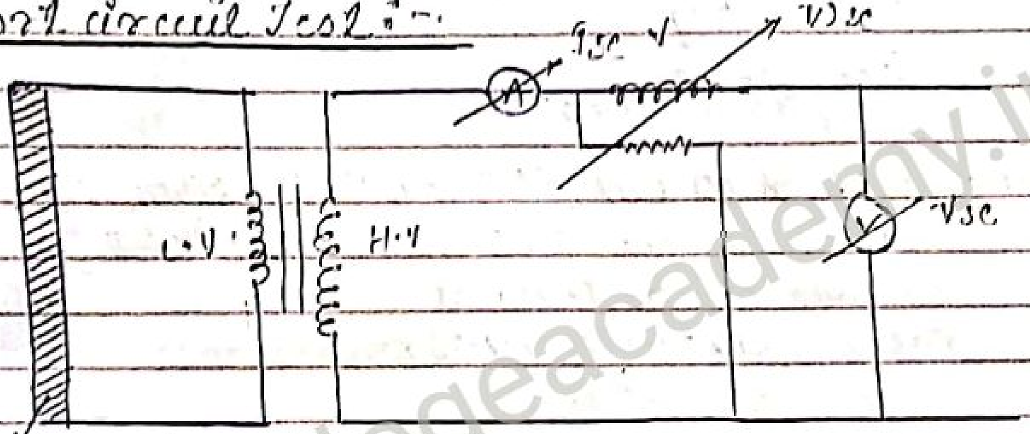
$I_m = I_0 \sin\phi_0$

$R_c = \dfrac{V_1}{I_c}$

$X_m = \dfrac{V_1}{I_m}$

14/02/2019 + 15/02/19 —

Short circuit Test :-



Shorted by copper wire.

(1) Short circuit Test determines copper loses (P_c).

(2) Short circuit Test determines parameter of series branch of equivalent circuit of Transformer i.e. $R_1 X_1$ and $R_2 X_2$,

(3) Low voltage side is shorted by thick copper wire during short circuit test. Test is carried out at high voltage side that means all instruments are connect at high voltage side.

(4) The Readings of different instruments are as follows.

Ammeter: Isc = short circuit current.

Voltmeter: Vsc = short circuit voltage

Wattmeter = Wsc = Pc = copper losses.

The Cu loss is given by: $W_{sc} = I^2_{sc} R_{eq}$.

↳ Req equivalent.

$$R_{eq} = \frac{W_{sc}}{I^2_{sc}}$$

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(5.) The equivalent impedence is given by

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

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

(6.) The equivalent leakage reactance is given by.

$$Z_{sc} = \sqrt{R_{eq}^2 + X_{sc}^2}$$

$$X_{sc} = \sqrt{Z_{sc}^2 - R_{eq}^2}$$

Numerical: A 10 KVA, 200/400 volt, 50 Hz, 1ϕ xmer using for open & short circuit test results are as follows

O.C.T 120 W, 20 V, 1.25 A

$P_f = W_0 = 120$ W

$V_1 = 20$ V

$I_0 = 1.25$ A.

S.C.T 200 W, 20 V, 25 A.

$P_c = W_{sc} = 200$ W

$V_{sc} = 20$ V

$I_{sc} = 25$ A.

① calculate Magnetising current / working current at normal voltage & current.

② Efficiency of Transformer when transformer is supplying rated load at 0.8 power factor lagging.

$V_2 I_2 = 10$ KVA.

$V_2 I_2 = 10000$ VA

$V_1 = 200$ V

$V_2 = 400$ V

$f = 50$ HZ.

$W_0 = I_0 V_1 \cos\phi_0$

$\cos\phi_0 = \frac{W_0}{V_1 I_0} = \frac{120}{200 \times 1.25} = 0.48$

$I_m = I_0 \sin\phi_0 \Rightarrow 1.25 \times \sqrt{1-(0.48)^2}$

$I_m = 1.096\ A$

$I_c = I_0 \cos\phi_0$
$= 1.25 \times 0.48$

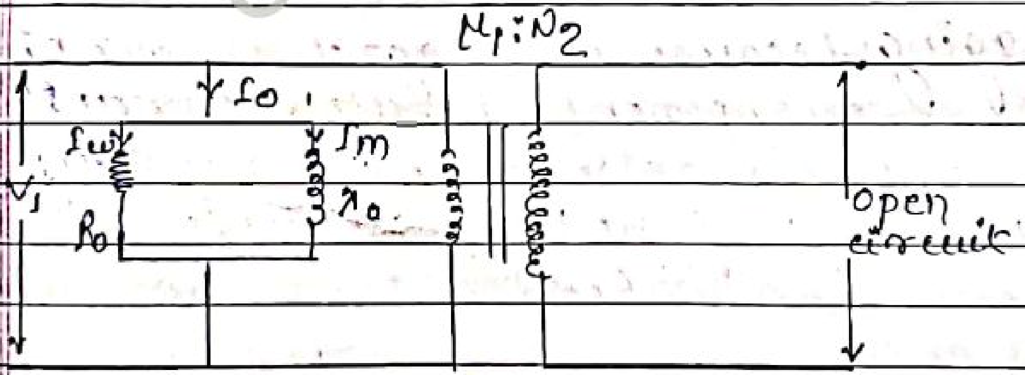
$\boxed{I_c = 0.6\ A}$

$R_c = V_1/I_c = 200/0.60 = 333.3\ \Omega$.
$X_m = V_1/I_m = 200/1.096 = 1182.46\ \Omega$

$\eta = \frac{V_2 I \cos\phi \times 100}{V_2 I_2 \cos\phi + P_i + P_c}$
$= \frac{10000 \times 0.8}{(10000 \times 0.8) + 120 + 200} = 96\%$

21/02/2018 :-

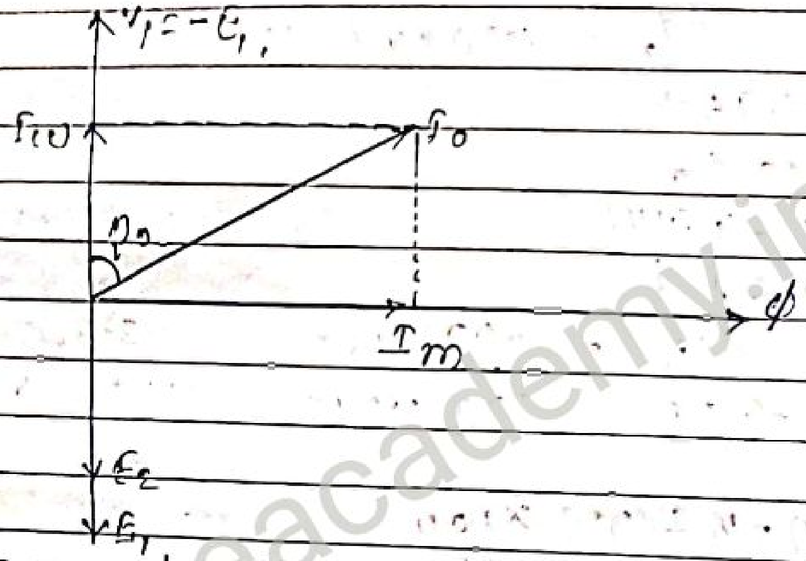
Equivalent circuit of x-mer under no load :-



$R_0 = \frac{V_1}{I_w}$, $X_0 = \frac{V_1}{I_m}$.

R_0 and X_0 should be in parallel and should be in Primary circuit. This parallel branch called as no load branch and shunt branch.

Phasor Diagram of x-mer under no-load Condition—



- ϕ_0 = no load Phase angle of Transformer and its range is 70° to 75°
- $\cos\phi_0$ = no load power factor of transformer and the range is 0·2 to 0·25 lagging.

∴ Transformer has poor no load Power factor of the order of 0·2 – 0·25 lagging. because its magnetising current commponent of no load current is very high as compare to the working current of no no load current.
($I_m >>> I_{cw}$).

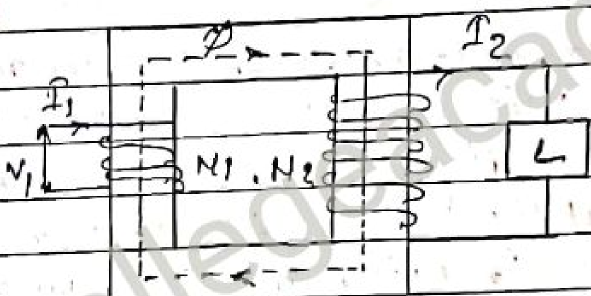
TRANSFORMER on LOAD :-

When the secondary circuit of a x-mer is complete through an impedence or load. The transformer is said to be loaded and current flows through the secondary winding and load.

(ii) The magnitude and phase of secondary current (I_2) w.r.t the secondary terminal voltage V_2 will depends upon the characteristic of load i.e I_2 will be in same phase with V_2 for non-inductive load (Resistive).

I_2 lags V_2 for inductive load, I_2 leads V_2 for capacitive load

(3.)



when the Transformer is on no load, ~~as shown in figure~~ it draws no load current I_0 from the supply mains. The no load current I_0 sets up an mmf → $N_1 I_0$ which produces flux ϕ in the core.

(4.) when an impedence is connected across the secondary terminal, current I_2 flows through the secondary winding. Now the secondary current I_2 sets up its own mmf → $I_2 N_2$ and hence creates a secondary flux ϕ_2 which opposes the main flux ϕ setup by exciting current I_0 A/c to Lenz law.

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(5.) The ~~fer~~ opposing secondary flux ϕ_2 weakens the main flux momentarily, so primary back emf E_1 tends to reduce, so difference of applied voltage V_1 and back emf E_1 increases. Therefore more current is drawn from the source of supply flowing through the primary winding until the orignal

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value of flux ϕ is obtained. It again causes increase in back EMF E_1 and it adjusted itself as such that there is a balance between applied voltage V_1 and back emf E_1.

(6.) Let the additional primary current be I_1'. The current I_1'. The current I_1' is in phase opposition with secondary current I_2 and is called as counter balancing current.

(7.) The additional current I_1' sets up an mmf $N_1 I_1'$ producing the flux ϕ_1' in the same direction as that of main flux ϕ and cancel out the flux ϕ_2 produced by secondary mmf $-N_2 I_2$ being equal in magnitude.

$$N_1 I_1' = N_2 I_2$$

$$I_1' = \frac{N_2 I_2}{N_1}$$

(8.) The total primary current I_1 is therefore phasor sum of counter balancing current I_1' and no load current I_0, which will approx. equal to the I_1' as I_0 is usually very small as compare to I_1'.

(9.) Since the secondary flux ϕ_2 produced by secondary mmf $N_2 I_2$ is neutralised by the flux ϕ_1' produced by mmf $N_1 I_1'$ set up by counterbalancing primary current I_1', the flux in the transformer core terminals almost constant forms no load to full load.

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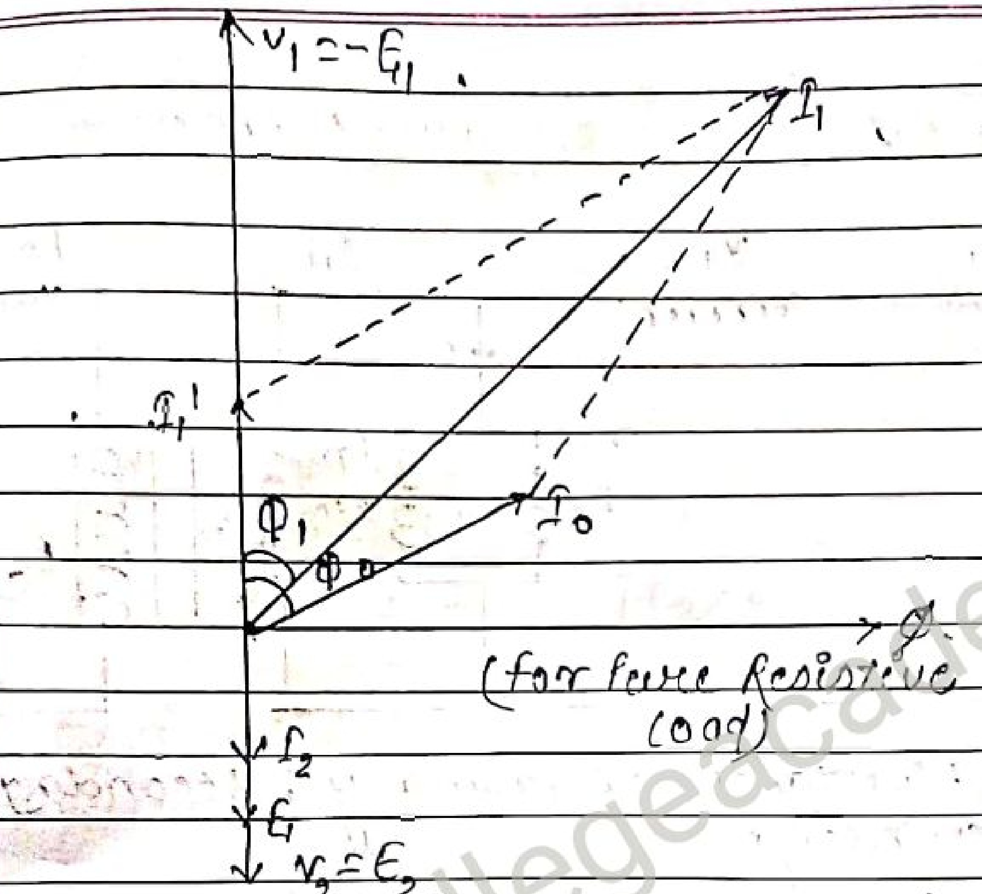
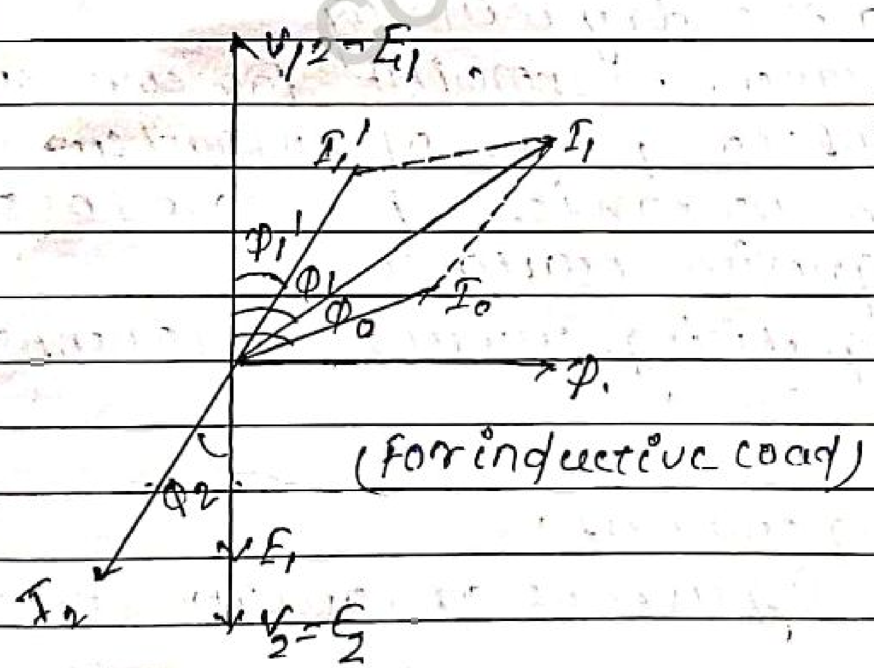
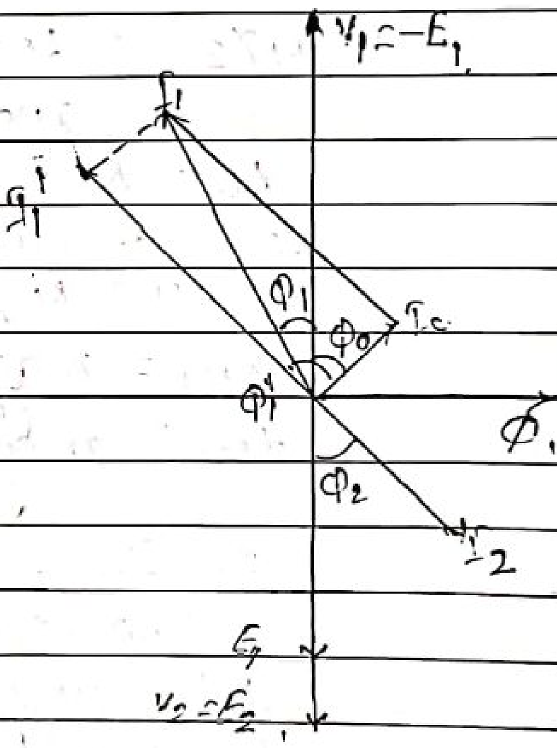


(for pure Resistive load)



(for inductive load)



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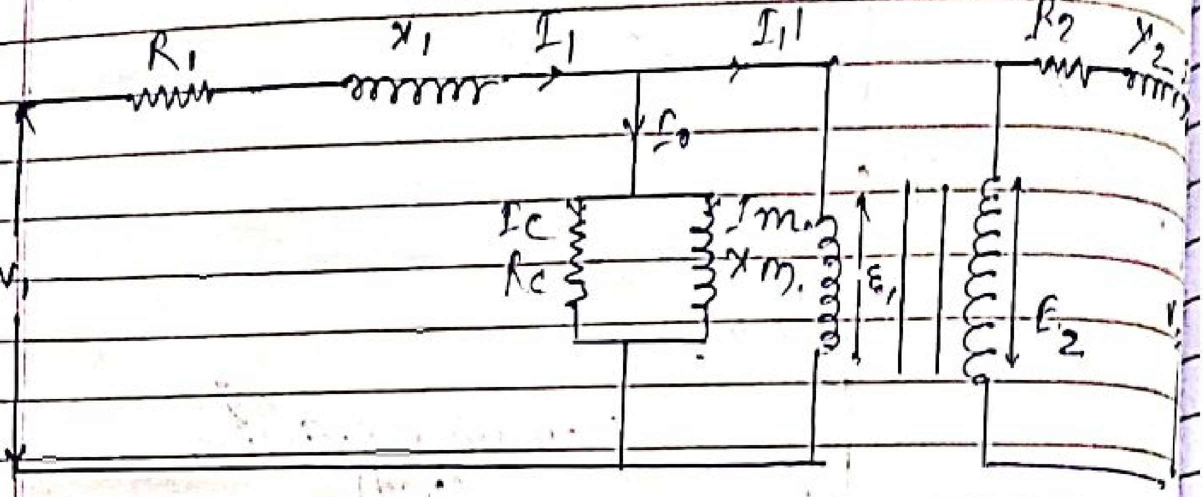
Equivalent circuit of Transformer :-



$R_1 R_2$ = Resistances of Primary & Secondry winding.

$x_1 x_2$ = Leakage reactance of Primary and secondry winding

R_c = Resistance responsible for core losses

I_c = current component of no load current working responsible for core loss.

X_m = magnetism Reactance.

I_m = magnetising current component of I_0

$I_0 = I_m + I_c$
= no load current.

I_1' = Balancing current or counter current

$I_1 = I_0 + I_1'$
= Primary current.

I_2 = secondary current

For simplification of circuit ignore I_0 i.e. Parallel branch can be removed from the equivalent circuit.

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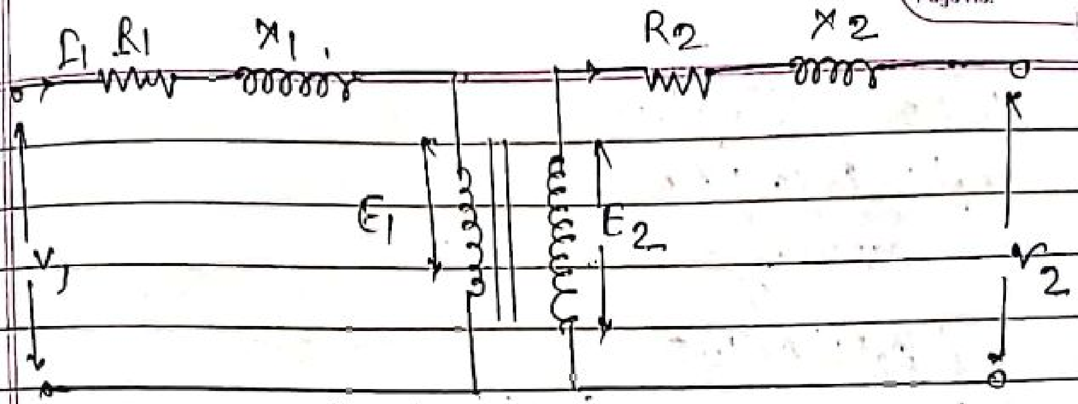
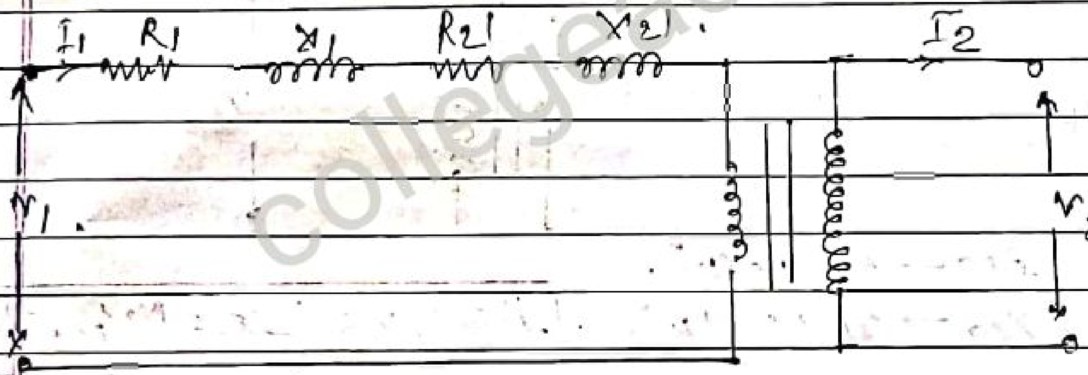


By applying KVL :-

$$V_1 = E_1 + I_1 R_1 + j I_1 X_1$$
$$E_2 = V_2 + I_2 R_2 + j I_2 X_2$$

Equivalent circuit :-

Equivalent circuit refered to Primary side :-



where R_2' = secondary resistance Refery to Primary side.
X_2' = secondary leakage reactance refered to Primary side.

condition :-
we can move the resistance and leakage from secondary side to primary side, only when they can consume same amt. of Power in Primary side as they were consuming in secondary side.

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$I_2^2 R_2 = I_1^2 R_2'$.

$R_2' = (I_2/I_1)^2 R_2$.

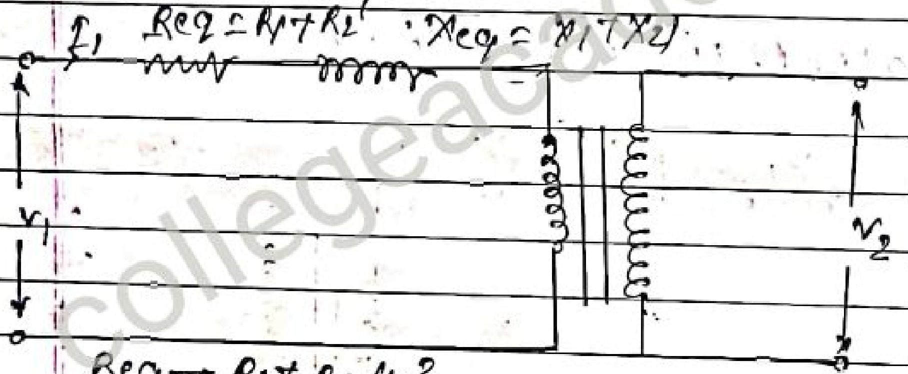
$[\because V_2/V_1 = I_1/I_2 = K]$

$\boxed{R_2' = R_2/K^2}$

similarly, $I_2^2 X_2 = I_1^2 X_2'$

$X_2' = (I_2/I_1)^2 X_2$

$$\boxed{X_2' = \frac{X_2}{K^2}}$$



$R_{eq} \to R_1 + R_2/K^2$.

$X_{eq} \to X_1 + X_2/K^2$. $\boxed{K = V_2/V_1 = E_2/E_1 = N_2/N_1 = I_1/I_2}$

R_{eq} = equivalent Resistance referred to primary side

X_{eq} = equivalent leakage Reactance referred to primary side

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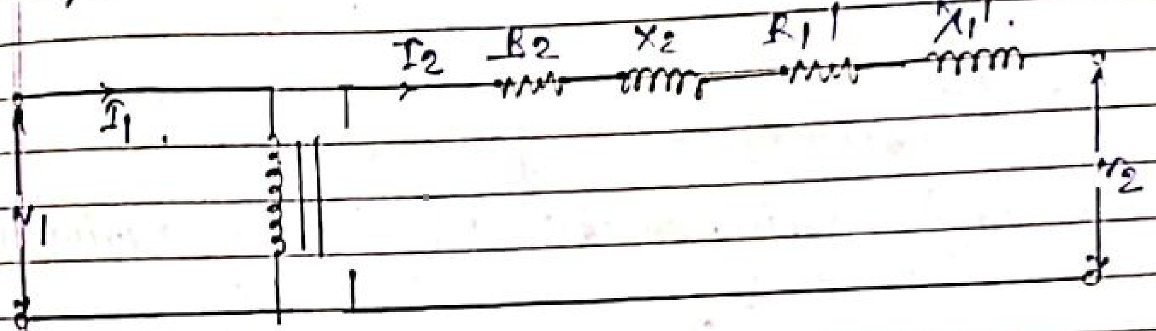
Equivalent circuit referred to SECONDARY SIDE:-



R_1' - primary resistance referred to secondary side

x_1' = Primary leakage resistance refers to secondary side

we can move the resistance and leakage reactance from primary side to the secondary side only when they will consume same amt. of power in secondary side as they were consuming in Primary.

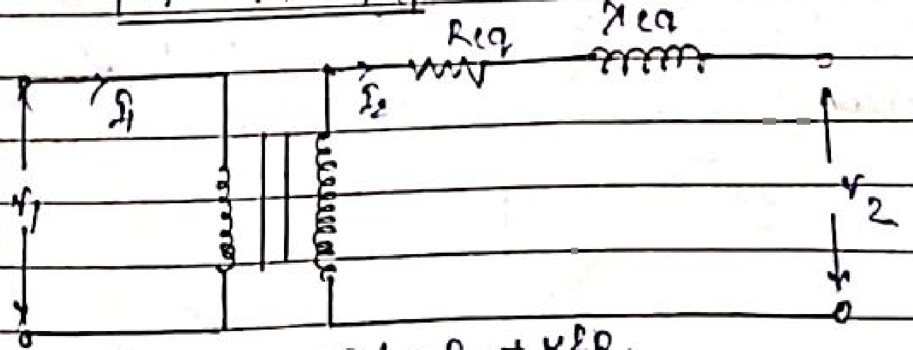
$$I_1^2 R_1 = I_2^2 R_1'$$

$$R_1' = (I_1/I_2)^2 R_1$$

$$[\because V_2/V_1 = I_1/I_2 = K].$$

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

$$\boxed{x_1' = K^2 x_1.}$$



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

$$X_{eq} = X_2 + X_1' = X_2 + K^2 X_1^2.$$

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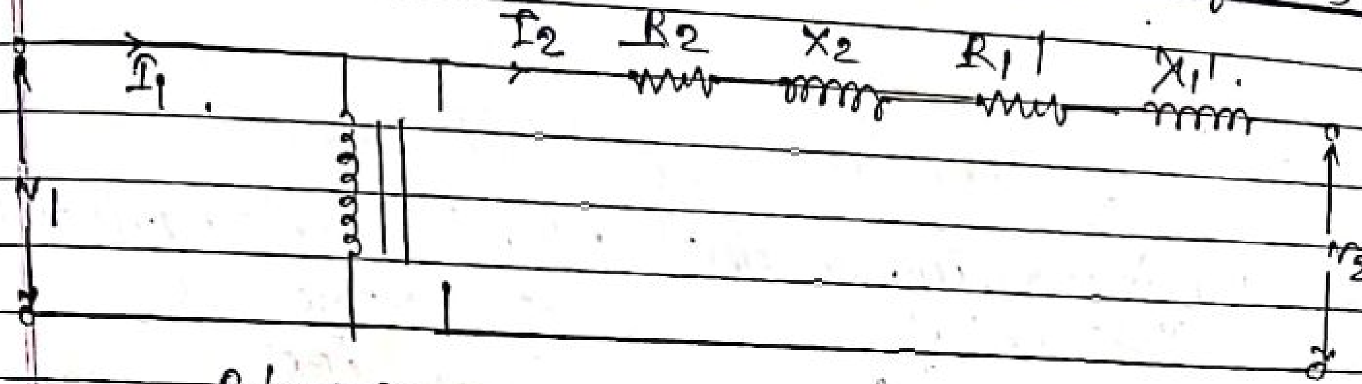
Equivalent circuit refer to SECONDARY SIDE:-



R_1' = Primary resistance refer to secondary side

X_1' = Primary leakage resistance refers to secondary side

We can move the resistance and leakage reactance from primary side to the secondary side only when they will consume same amt. of Power in secondary side as they were consuming in Primary.

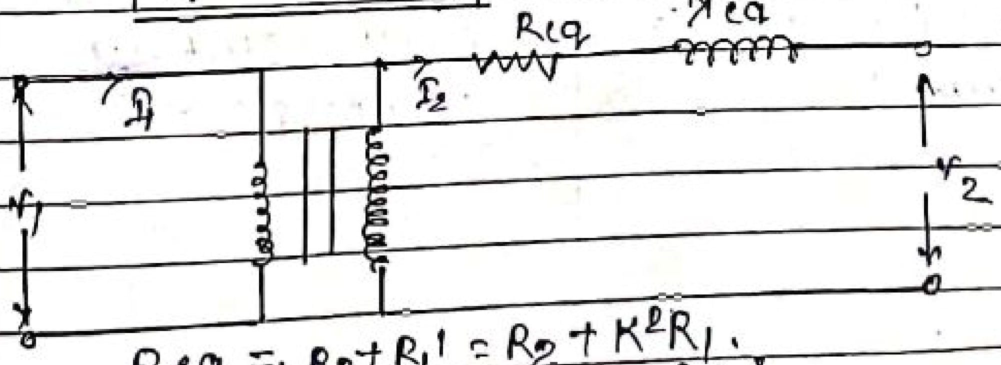
$I_1^2 R_1 = I_2^2 R_1'$

$R_1' = (I_1/I_2)^2 R_1$

$[\because V_2/V_1 = I_1/I_2 = K]$

$R_1' = K^2 R_1$

$\boxed{X_1' = K^2 X_1}$



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

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

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