(90) $\frac{100(10)}{9} = (6+R)^2 + (8+X_c)^2 \longrightarrow (1)$

$\frac{100}{9} = (R)^2 + X_c^2 \longrightarrow (2)$

$\Rightarrow \frac{100}{9} = \ldots$

$\Rightarrow \cancel{\frac{100}{9}(9)} = 64 + 16X_c + 12R$

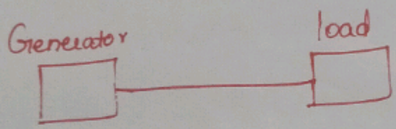
$\cancel{\frac{36}{16} = X_c = \frac{9}{4} = 2.25}$

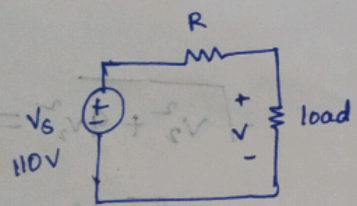
$\Rightarrow 36 = 16X_c + 12R$

$\Rightarrow \boxed{9 = 4X_c + 3R}$ and use this in eq^n (2) we get

X_c & R

* Generator — load

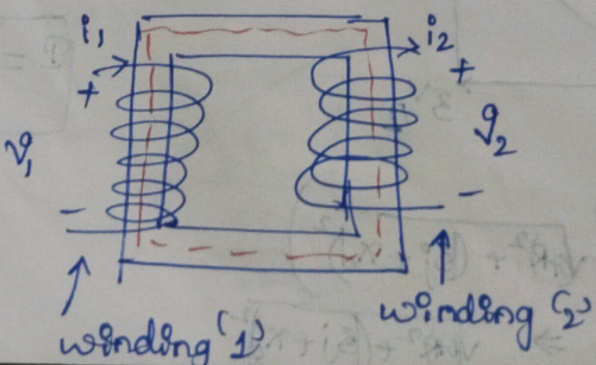




$V = V_s - iR$

* Transformer:-

* Ideal transformer:-



v_1 and v_2 are sinusoidal voltages.

(91) N_1: No. of turn…
N_2: No. of tu…

Assumptions:-
(1) Winding…
(2) Recipro…

Magnetic f…
Let ϕ be…

Ampere'…

$\oint \bar{H}$…

Now

R_1
R_2

N_1: No. of turns in winding '1'

N_2: No. of turns in winding '2'.

Assumptions:-

(1) Winding resistance are zero

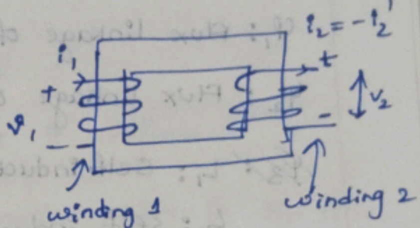
(2) Reciprocal of permeability of the core = 0

Magnetic flux is restricted to the core.

Let ϕ be this magnetic flux.

$$v_1 = N_1 \frac{d\phi}{dt} \quad , \quad v_2 = N_2 \frac{d\phi}{dt}$$

$$\boxed{\frac{v_1}{v_2} = \frac{N_1}{N_2}}$$



Ampere's law:

$\oint \bar{H} \cdot d\bar{L}$ = current enclosed (in red path)

$\bar{H}$ = magnetic field intensity.

$$0 = N_1 i_1 - N_2 i_2 \Rightarrow \boxed{\frac{i_1}{i_2} = \frac{N_2}{N_1}}$$

Now deviating from ideality.

R_1: Resistance of winding '1'.

R_2: Resistance of winding '2'.

⇒ Permeability of core is finite.

⇒ This results in leakage flux.

⇒ Leakage flux link few or all turns of only one winding.

⇒ Represented by leakage inductance

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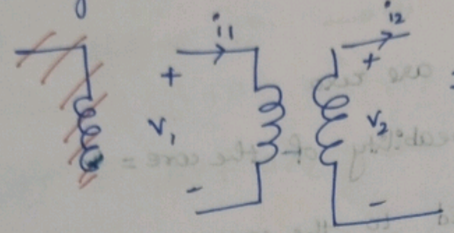
L_{1l} : leakage inductance of winding 1

L_{2l} : leakage inductance of winding 2



$$\frac{v_1}{v_2} = \frac{i_2}{i_1}$$

(Ideal transformer)

ψ_1 : Flux linkage of winding 1

ψ_2 : Flux linkage of winding 2

L_1 : self inductance of winding 1

L_2 : self inductance of winding 2

ψ_1 = Flux linkage of winding 1

ψ_2 = flux linkage of winding 2

$$\psi_1 = L_1 i_1 + M_{12} i_2'$$

$$\psi_2 = L_2 i_2' + M_{21} i_1$$

L_{1l} : leakage inductance of winding 1

L_{2l} : leakage inductance of winding 2

L_1 : self inductance of winding 1

L_2 : self inductance of winding 2

M_{12} & M_{21} are mutual inductances.

ϕ_1 : Flux in the core due to i_1.

ϕ_2 : Flux in the core due to i_2'.

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$L_1 = L_{1l} + \frac{N_1\phi_1}{i_1}$

$L_2 = L_{2l} + \frac{N_2}{i_2'}$

$M_{12} = \frac{N_1\phi_2}{i_2'}$

$M_{21} = \frac{N_2\phi_1}{i_1}$

Assumptions.

1. Area of cro

2. Magnetic

3. Let 'l' be

Magnetic

Magnetic

Let 'A' b

$\phi_1 =$

$L_1 =$

$L_2 =$

M_{12}

Let M

(28) $L_1 = L_{1l} + \frac{N_1 \phi_1}{i_1}$

$L_2 = L_{2l} + \frac{N_2 \phi_2}{i_2'}$

$M_{12} = \frac{N_1 \phi_2}{i_2'}$

$M_{21} = \frac{N_2 \phi_1}{i_1}$

Assumptions:

1. Area of cross section of core is small.
2. Magnetic field intensity in the core is uniform.
3. Let 'l' be the length of the magnetic path in the core.

Magnetic field intensity in the core due to $i_1 = \frac{N_1 i_1}{l}$

Magnetic field intensity in the core due to $i_2' = \frac{N_2 i_2'}{l}$

Let 'A' be the area of cross section of core,

$$\phi_1 = \frac{\mu A N_1 i_1}{l}, \quad \phi_2 = \frac{\mu A N_2 i_2'}{l}$$

$$L_1 = L_{1l} + \frac{\mu A N_1^2}{l}$$

$$L_2 = L_{2l} + \frac{\mu A N_2^2}{l}$$

$$M_{12} = \frac{\mu A N_1 N_2}{l} = M_{21}$$

Let $M = M_{12} = M_{21}$,

$$\boxed{L_1 = L_{1l} + \frac{N_1}{N_2} M}, \quad \boxed{L_2 = L_{2l} + \frac{N_2}{N_1} M}$$

$$v_1 = R_1 i_1 + \frac{d\varphi_1}{dt}$$

$$v_1 = R_1 i_1 + \frac{d}{dt}\left(L_1 i_1 + M i_2'\right)$$

$$v_1 = R_1 i_1 + \left(L_{1l} + \left(\frac{N_1}{N_2}\right) M\right)\frac{di_1}{dt} + M\frac{di_2'}{dt}$$

$$v_1 = R_1 i_1 + L_{1l}\frac{di_1}{dt} + \frac{N_1}{N_2} M \frac{di_1}{dt} - \frac{M di_2}{dt}$$

let $i_1' = \frac{N_2}{N_1} i_2$

$$\boxed{v_1 = R_1 i_1 + L_{1l}\frac{di_1}{dt} + \frac{N_1}{N_2} M\left(\frac{di_1}{dt} - \frac{di_1'}{dt}\right)} \rightarrow (1)$$

$$v_2 = R_2 i_2' + \frac{d\psi_2}{dt}$$

$$v_2 = R_2 i_2' + \frac{d}{dt}\left(L_2 i_2' + M_{21} i_1\right)$$

$$= R_2 i_2' + \frac{d}{dt}(M i_1) - L_2 \frac{di_2}{dt}$$

$$= -R_2 i_2 + M \frac{d}{dt} i_1 - L_2 \frac{N_1}{N_2}\frac{di_1'}{dt}$$

$$v_2 = -R_2\left(\frac{N_1}{N_2}\right) i_1' + M\frac{di_1}{dt} - \frac{N_1 L_2}{N_2}\frac{di_1'}{dt}$$

and $L_2 = L_{2l} + \frac{N_2}{N_1} M$

$$v_2 = -R_2\left(\frac{N_1}{N_2}\right) i_1' + M\frac{di_1'}{dt} - \frac{N_1}{N_2}\left(L_{2l} + \frac{N_2 M}{N_1}\right)\frac{di_1'}{dt}$$

$$\boxed{v_2 = -R_2 i_2 - L_{2l}\frac{di_2}{dt} + M\left(\frac{di_1}{dt} - \frac{di_1'}{dt}\right)} \rightarrow (2)$$

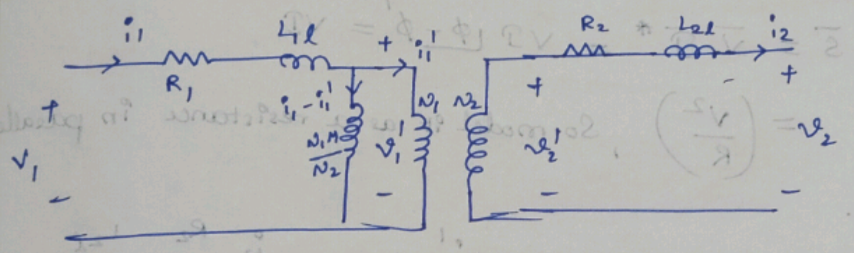
Let $v_1' = \frac{N_1}{N_2} M\left(\frac{di_1}{dt} - \frac{di_1'}{dt}\right)$

$$v_2' = M\left(\frac{di_1}{dt} - \frac{di_1'}{dt}\right)$$

$(1) \Longrightarrow \quad v_1 = R_1 i_1 + L_{1l}\frac{di_1}{dt} + v_1'$

$(2) \Longrightarrow \quad v_2 = -R_2 i_2 - L_{2l}\frac{di_2}{dt} + v_2'$

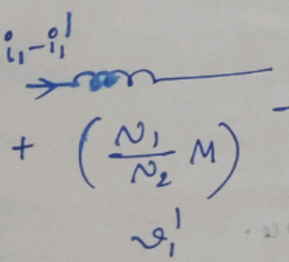
So,



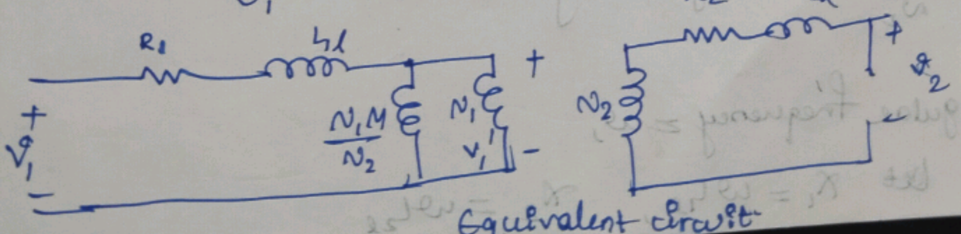
and, $\frac{v_1'}{v_2'} = \frac{N_1}{N_2} = \frac{i_2}{i_1'}$

Now

$$v_1' = \frac{N_1}{N_2} M\left(\frac{d}{dt}(i_1 - i_1')\right)$$



Model it as a self inductance.



Equivalent circuit

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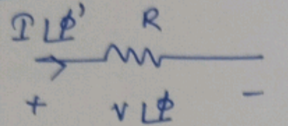
Coreloss:

1.) Eddy current loss

2. Hysterisis loss

$\boxed{\text{Avg core loss is approximately proportional to the RMS value } v_1' \text{ or } v_2'}$

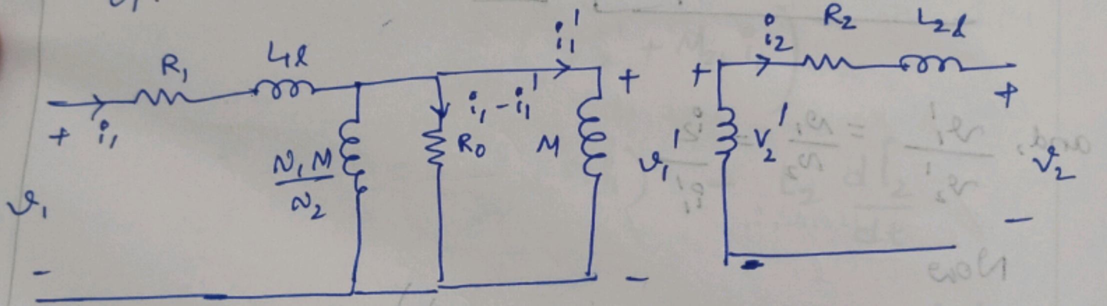
NOTE:



$$\bar{Z} = \frac{\bar{V}}{\bar{I}} = R = \frac{V\angle\phi}{I\angle\phi'} \Rightarrow \boxed{\phi = \phi'}$$

$$\bar{S} = \bar{V}\,\bar{I}^* = VI\angle\phi - \phi' = VI$$

$= \left(\frac{V^2}{R}\right)$, So model it as a resistance in parallel to v_1'.



R_1, R_2 represent loss in the conductor.

L_{1l}, L_{2l}: leakage inductances.

R_0 : Represents core loss

$\frac{N_1 M}{N_2}$: Magnetizing inductance.

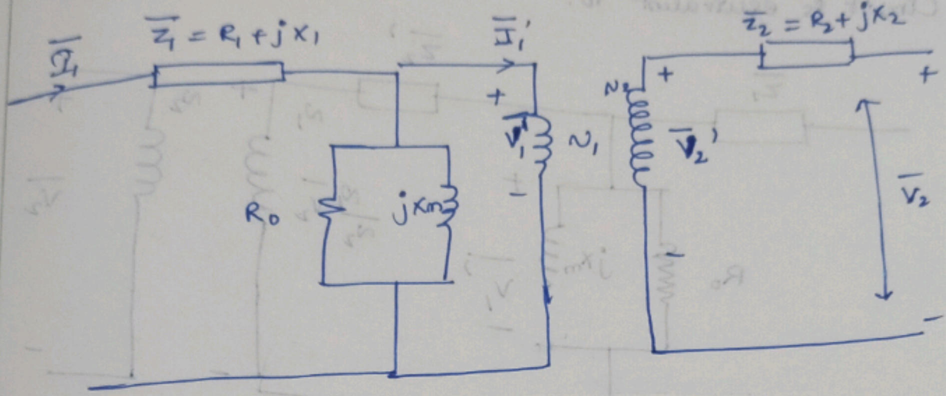
Angular frequency $= \omega$,

let $x_1 = \omega L_{1l}$, $x_2 = \omega L_{2l}$

$X_m = \frac{\omega N_1}{N_2} M$

X_1, X_2 : leakage reactance

X_m : Magnetizing reactance



$$\frac{\overline{V_1}'}{\overline{V_2}'} = \frac{N_1}{N_2} = \frac{\overline{I_2}}{\overline{I_1}'}$$

Suppose $v_1' = \sqrt{2}\, V_1' \sin(\omega t + \phi_1)$

$v_2' = \sqrt{2}\, V_2' \sin(\omega t + \phi_2)$

for $\frac{v_1'}{v_2'} = \frac{V_1'}{V_2'} \frac{\sin(\omega t + \phi_1)}{\sin(\omega t + \phi_2)} = \frac{N_1}{N_2}$

Hence $(\phi_1 = \phi_2)$ && $\frac{v_1'}{v_2'} = \frac{N_1}{N_2}$

$$\boxed{\overline{V_1}' = \frac{N_1}{N_2} \overline{V_2}'}$$

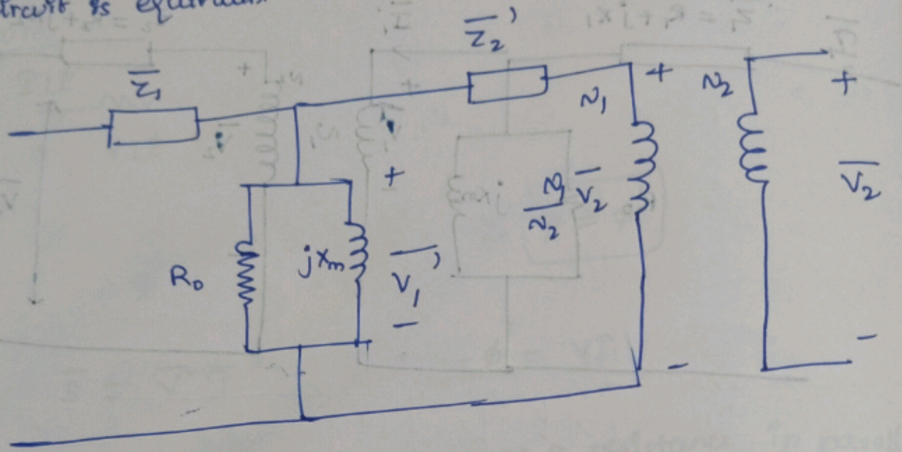
By KVL, $\overline{V_2}' = \overline{V_2} + \overline{I_2}\,\overline{Z_2}$

$\Rightarrow \overline{V_1}' = \frac{N_1}{N_2}(\overline{V_2}) + \left(\frac{N_1}{N_2}\right)^2 \overline{I_1}'\, \overline{Z_2}$

$$= \frac{N_1}{N_2}\bar{V_2} + \bar{I_1}'\bar{Z_2}'$$

where $\bar{Z_2}' = \left(\frac{N_1}{N_2}\right)^2 \bar{Z_2}$

Circuit is equivalent to:



$$\bar{Z_2}' = \left(\frac{N_1}{N_2}\right)^2 \bar{Z_2}, \quad \bar{Z_2} = R_2 + jX_2$$

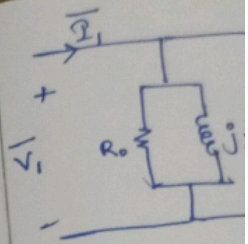
$$\Rightarrow \bar{Z_2}' = R_2' + jX_2'$$

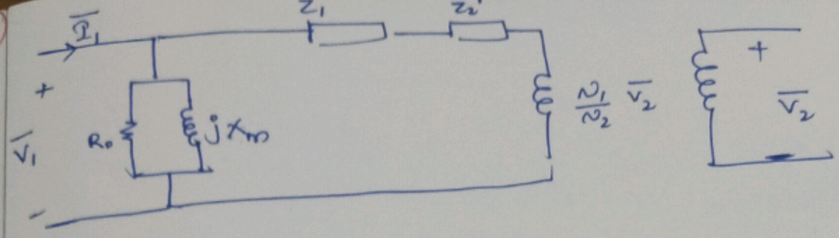
where, $R_2' = R_2\left(\frac{N_1^2}{N_2^2}\right)$

$$X_2' = \frac{N_1^2}{N_2^2}X_2$$

Note: R_1, R_1', X_1, X_2' are very small when compared with R_0 and X_m.

$\Rightarrow$ So, shifting R_0, X_m, we get an approximate equivalent.




I̅1
Z̅1
Z̅2'
+
V̅1
Ro
jXm
N1/N2 V̅2
+
V̅2