$\boxed{\text{Lec-1}}$

Machine :- যে object একটা energy থেকে আরেকটা ~~energ~~ energy তে convert করে।

Classification

(1) Stationary → Mobile .

(2) Rotational → fan. (rotional energy তে convert করে)

→ Transformer :- (stational machine)

* power transformer :- power হয় যে system যেখানে ~~two~~ high power or low power এ convert করে।

Intro to Magnetic circuits

Motor or generator :- power generate নাই, ই

both are convertion of energy.

<u>Energy 1</u> | <u>Energy 2</u>

Electrical $\xrightarrow{\text{convert}}$ Machanical $\boxed{\text{Motor}}$

↑ input | ↓ output.

Machanical $\xrightarrow{\text{convert.}}$ electrical $\boxed{\text{Generator}}$

↑ input | ↓ output

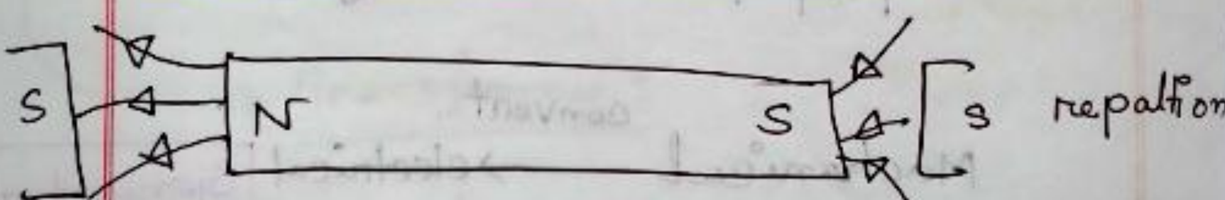
* Magnate => যেটার pole poles থাকে find in ~~nature~~ naturaly
parmanent & temporary.

Magnetic circuit: —

* electro magnate: — solinode.
(temporary magnate).

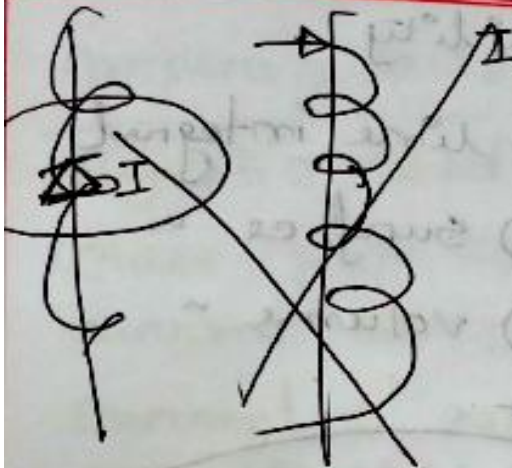
why do we need electromagnetic?:

properties of Magnate: —



- 2 poles.
- Magnetic lines.
  exit from North
  entry to south.
- opposite pole attraction.
- same " Repulsion.

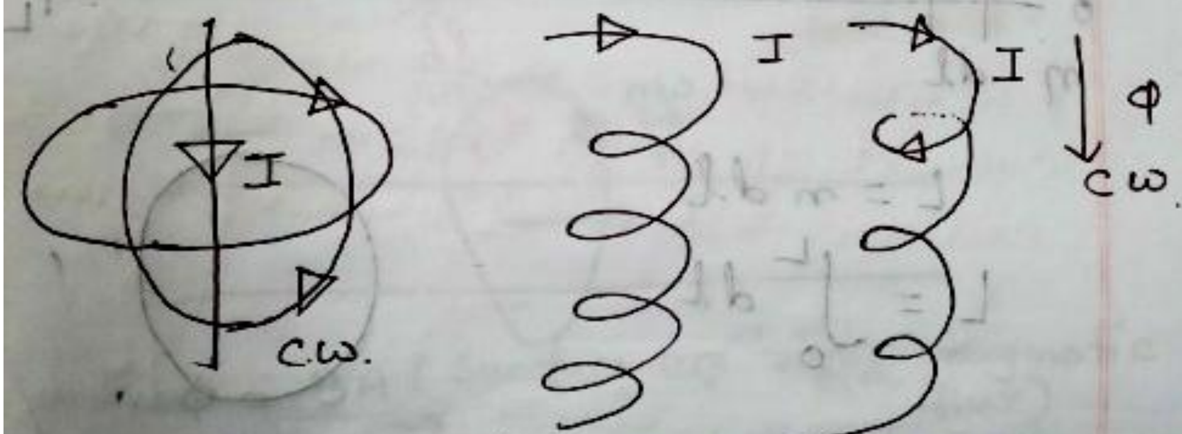
thumbs হল current এর direction.



* $\boxed{\text{Right hand rules}}$

google or youtube.

Fleming right hand rule.



$\Phi \longrightarrow$ Magnetic flux.

$B \longrightarrow$ Magnetic flux density

$= \Phi/A$

$H = \dfrac{B}{\mu} \rightarrow$ Magnetic field or Magnetic field Intensity.

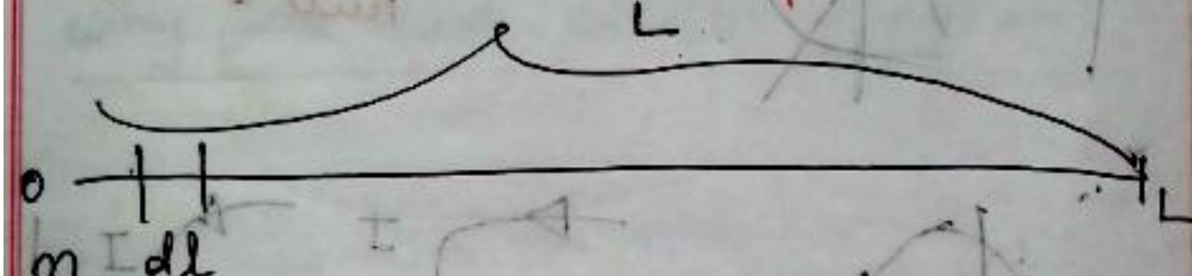
* electromegnatic thumb rule: .

μ = Mag permeability

* Integral → (1) line integral

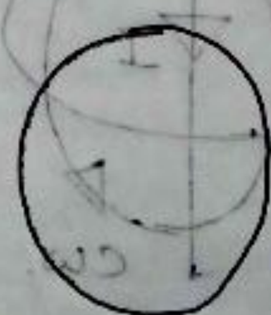
(2) surface "

(3) volume "



$L = n\,dl$

$L = \int_0^L dl$



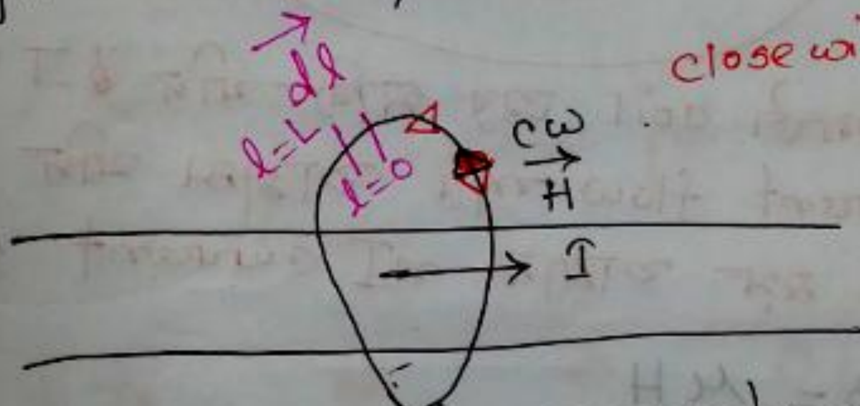
group:— EEE 363.3 SRD1 FALL 2018.

Lec :- 2

H. dl নিয়ম
alpo current
পাওয়া যায়,

Ampere's law :— Relation between magnatic field and electric current.
Close path এর ভিতরে কতগুলো electric current আছে;

Current ⇒ cause.
Magnatic field ⇒ effect.



ϕ = BA (surface এর কতটুকু magnatic flux).

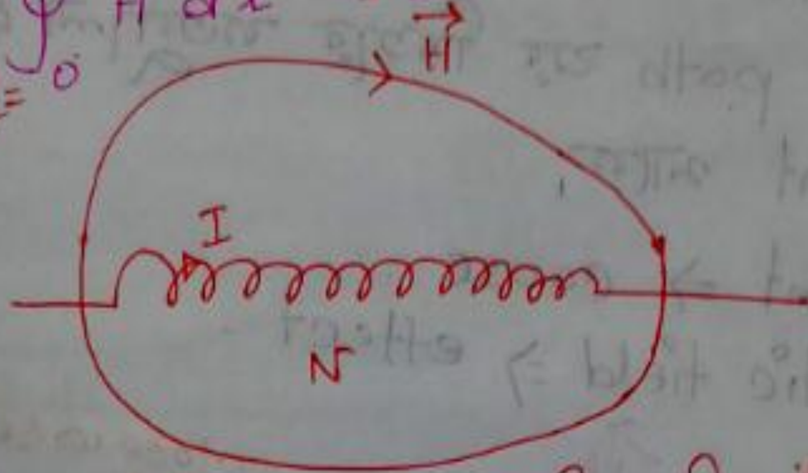
$\vec{B} = \mu\vec{H}$

$\vec{H}$ ⇒ vector quantity
⇒ Magnatic field intensity.

B = Magnatic flux density.

$\vec{H} \cdot \vec{dl}$

$$\oint_{l=0}^{l=L} \vec{H}\, \vec{dl} = NI$$



প্রত্যেকটা coil এর মধ্যে যদি I পরিমাণ current flow করে তাহলে যদি n সংখ্যক coil হয় তাহলে nI current flow হবে,

$B = \mu H$

μ = permeability of a medium/material.

* ferromagnatic material :- fe
(আরো খুব সহজে magnate হয়)

Flux density in free space:—
(air)

$B = \mu_0 H$

$\mu_0 \rightarrow 4\pi \times 10^{-7}$

M_i = Permeability of iron.

$= \mu_0 \mu_r$

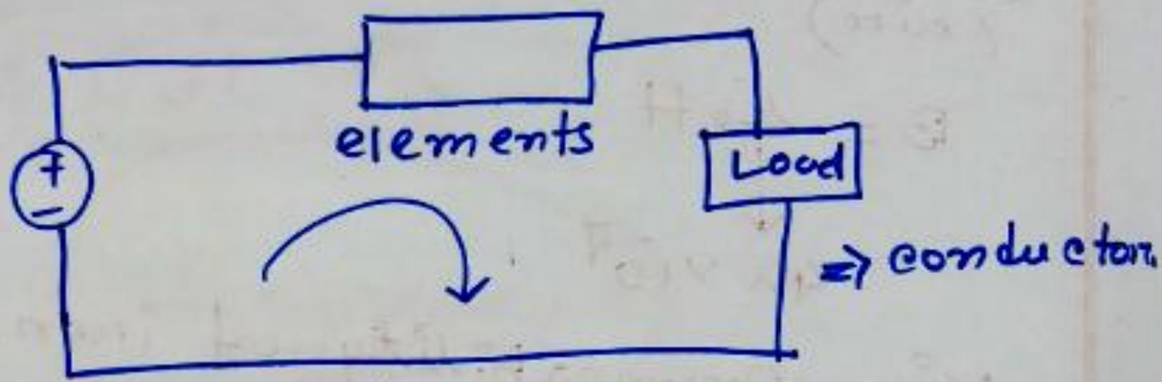
$\mu_r \rightarrow$ Relative permeability of iron.

$\Downarrow$

সমস্ত field এর under এ আছে।

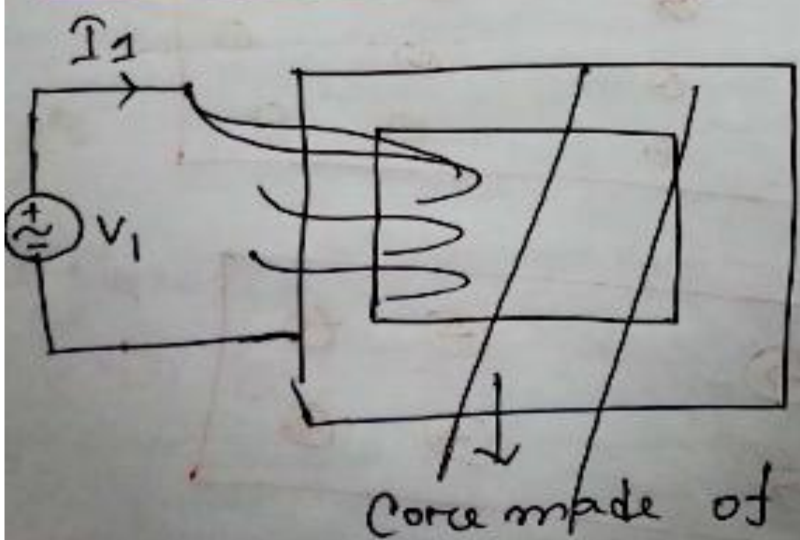
Magnatic circuit

electrical circuit :—



* close path.
* conductor দিয়ে close path বানানো হয়।

Magnatic Circuit :—

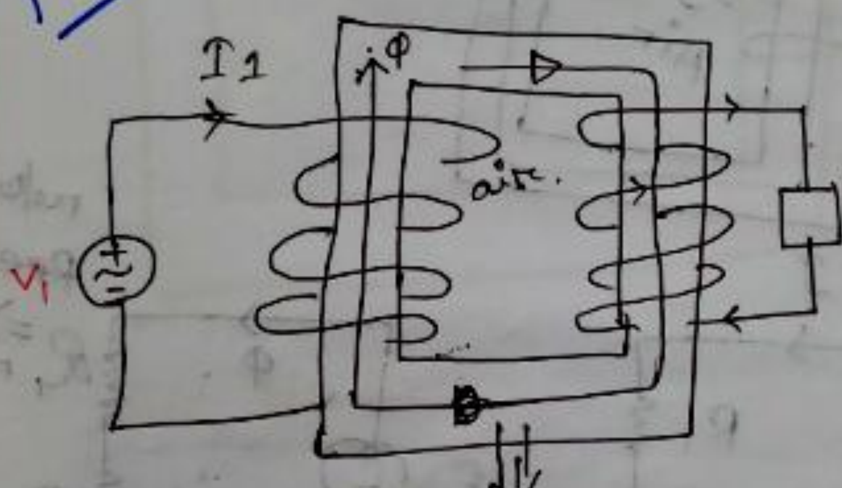


* reluctance :- কতটুকু বাধা দিয়ে flow করে,
* permeability :- কতটুকু help করে flow করে

$NI = MMF$

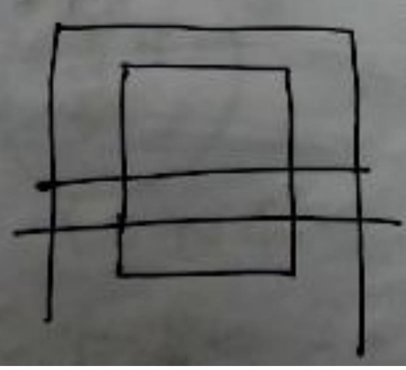
$= \mathcal{F}$

Problem

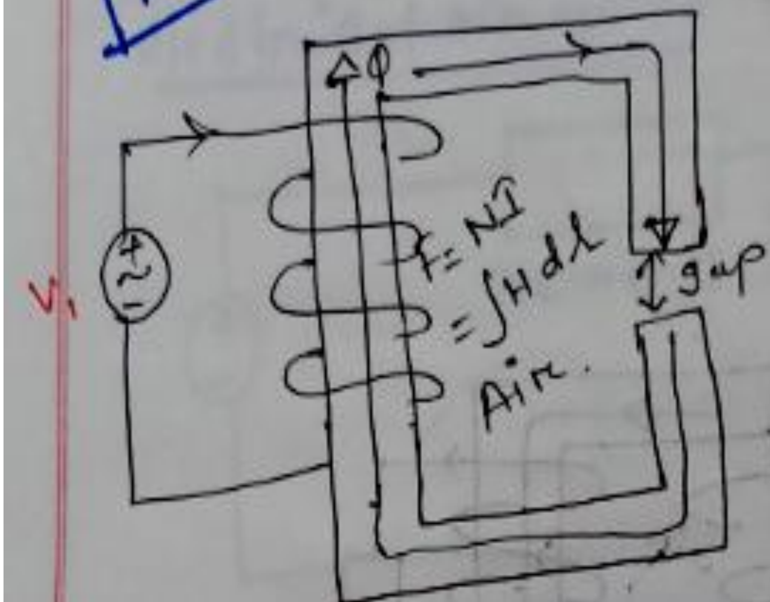


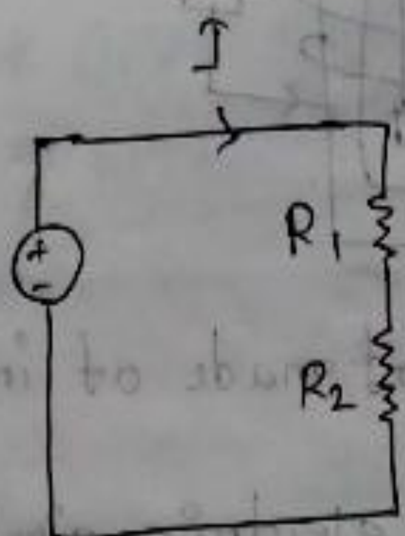
core ~~of~~ made of iron.

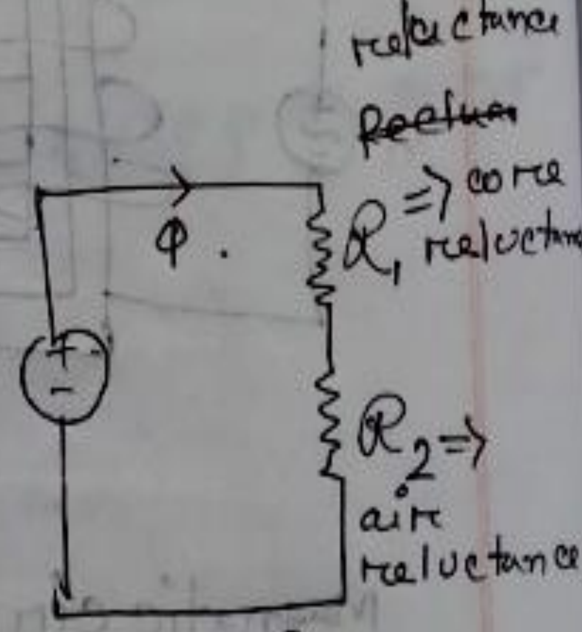
Magnatic circuit + electric circuit :-



Problem





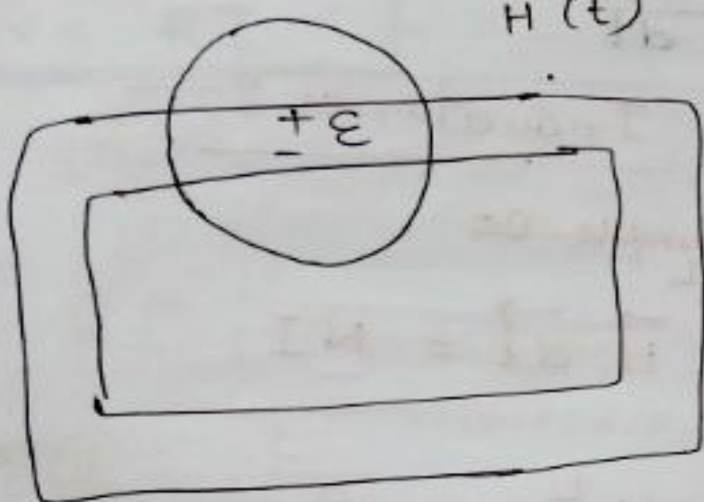


$$I = \frac{V}{R_1 + R_2}$$

$$\Phi = \frac{F}{\mathcal{R}_1 + \mathcal{R}_2}$$

Laws of electromagnatic induction

1st law:

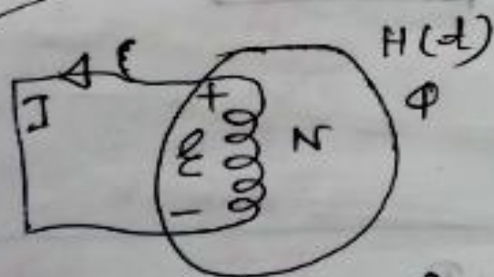


$$\varepsilon = \frac{d\lambda}{dt}$$

2nd law:

$$|\varepsilon| = \frac{d\cancel{\phi}\lambda}{dt}$$

$H(t)$
$B(t)$
$\phi(t)$
$\lambda(t)$ = Total flux linckage with the coil/conductor.



$$\lambda = N\phi$$

$$\boxed{|\varepsilon| = N\frac{d\phi}{dt}}$$

$$\frac{dN\phi}{dt} = N\frac{d\phi}{dt}.$$

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

Inductance :—

~~* for simple co~~

$$\oint_{l=0}^{l=L} \vec{H}\cdot\vec{dl} = NI$$

$$\Rightarrow H(l)_0^L = NI.$$

$$\Rightarrow \boxed{HL = NI} \quad NI = \mathcal{F}$$

$$\Rightarrow H = NI/L$$

$$\phi = BA \qquad \boxed{B = \mu H}$$

$$= \mu H A$$

$$= \mu \frac{NI}{L}\cdot A$$

$$\cancel{\phi = \frac{\mu A}{L}}\cdot NI$$

$$\Rightarrow \left(\frac{L}{\mu A}\right)\cdot\phi = NI = \mathcal{F}$$

$$\Rightarrow \boxed{\mathcal{R}\phi = NI = \mathcal{F}}$$

6 $\mathcal{F} = \mathcal{R}\phi$.
$V = RI$

$$R = \frac{\rho L}{A}$$

$$= \frac{L}{\sigma A}$$

$\sigma \rightarrow$ conductivity.

$$\mathcal{R} = \frac{L}{\mu A}.$$

Inductance :—

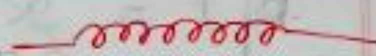
$$\mathcal{R}\phi = NI$$

$$\Rightarrow \phi = \frac{NI}{\mathcal{R}}$$

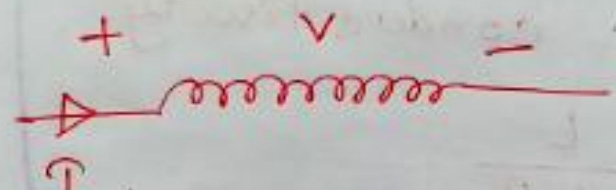
$$= \frac{NI}{\frac{L}{\mu A}}$$

$$\boxed{\phi = \frac{\mu A}{L} \cdot NI}.$$

Inductance :-



* Inductor change of current কে oppose করে, ~~so~~ that's why voltage produce করে.



$$V \propto \frac{di}{dt}$$

$$\Rightarrow V = L \frac{di}{dt}$$

L → particular conductor এর conductance

$$\Rightarrow L = \frac{V}{\frac{di}{dt}}$$

V → ~~cause~~ effect

$\frac{di}{dt}$ → ~~effect~~ cause

* Cause & effect :-

electromagnetism :- ~~current & field~~

~~এর মধ্যে~~ current flow করলে চারদিকে flux

L3 Inductance, $L = \dfrac{\lambda}{I}$

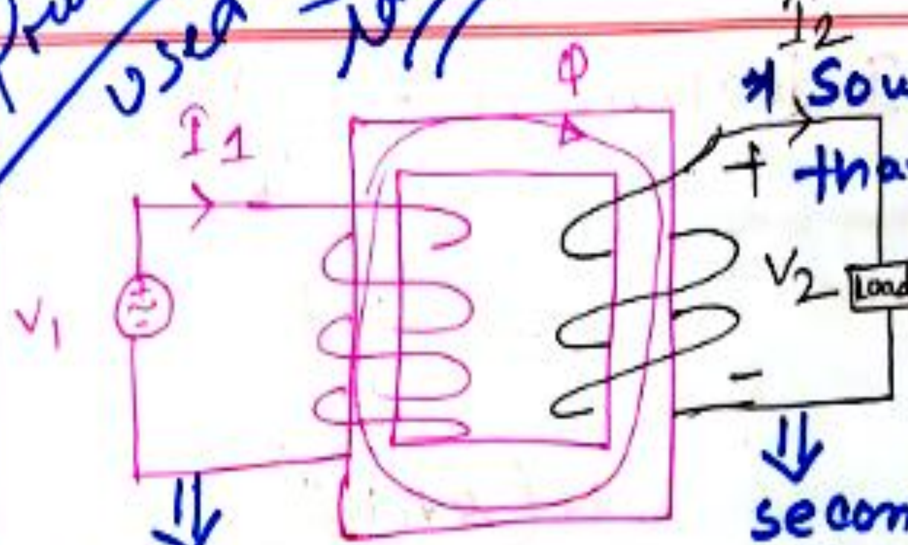
$$= \frac{N\phi}{I}$$

$$= \frac{N(\mu A N \cancel{I})}{l \cancel{I}}$$

$$\boxed{= \frac{N^2 \mu A}{l}}$$

Magnatic circuit এর basic :-
Core & Load, ~~magnatic~~ magnate.

Problem used by now



* Source AC that's why current & flux AC

⇓ primary circuit

⇓ secondary ~~circuit~~ circuit

Energy conversion Charles I Hubest

⇒ book.

Electric Machine

* Next 2টা ~~class~~ week class হবে না,
* 4টা class হবে না;

Lec:- 3

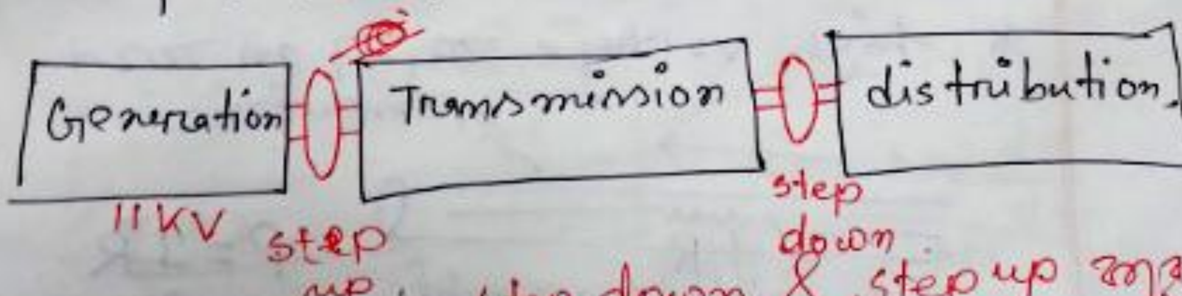
Transformer Lecture :-

electro magnetic induction follow করে।

Transformer :-

Make possible
power transformer, ~~instr~~ instrumental transformer.

~~Ag~~
* Transformer. নতুন power তৈরী ও-
করে না destroy করে, convert করে,
* voltage কে ~~conv~~
* voltage level change করে system.
* transformer power ~~section~~
এ ব্যবহার হয়
power system .

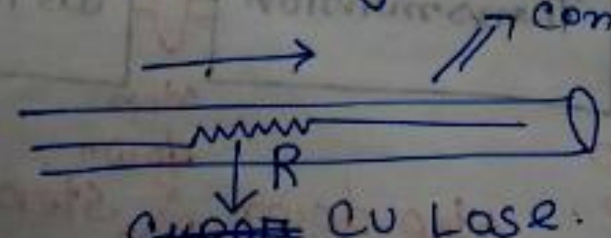


step down & step up করে
substitution এ

* electrical energy secondary energy.
* power plant power generate করায়।
* আশুগঞ্জ, কাপ্তাই, ঘোড়াশাল power plant আছে।
* ঘোড়াশালের Primary হিসাবে gas use করা হয়,
* 11KV voltage use করা হয়,

⇓

power generate করা হয়।
* Transmission এর voltage 230KV
* generation হয় 11KV
* that's why step ~~use~~ up transformer use করা হয়
* high voltage আনা হয় কারণ



$P = I^2R$

$P \propto I^2$

$V = IR$ ~~দুই~~ $\boxed{P = VI}$

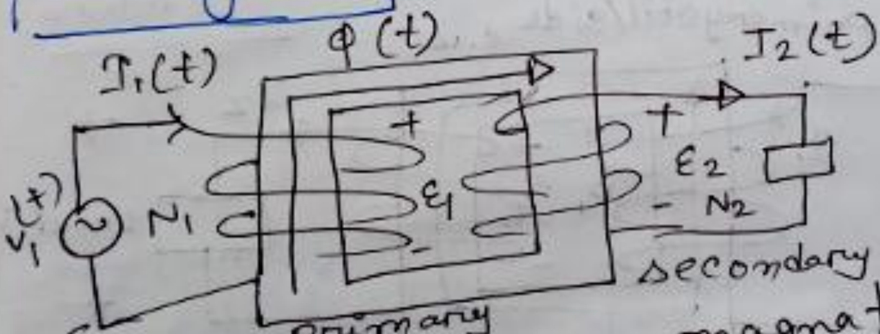
* current যত কম হবে power loss তত কম,

* current যদি কম করাতে চাই তাহলে voltage কে বাড়িয়ে দিতে হবে,

$P = \uparrow V \, I \downarrow$

History:—

principle:—



e_1 & ε_2 transformer voltage.

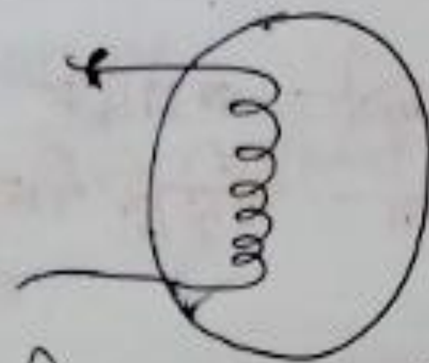
* দুইটা coil same magnatic field & same current এর under এ magnitically follow করে, couple coil.

$$\varepsilon_1 I_1 = \varepsilon_2 I_2 \qquad \varepsilon_1 = N_1 \frac{d\phi}{dt}$$

$$\Rightarrow \boxed{\frac{\varepsilon_1}{\varepsilon_2} = \frac{I_2}{I_1}} \qquad \varepsilon_2 = N_2 \frac{d\phi}{dt}$$

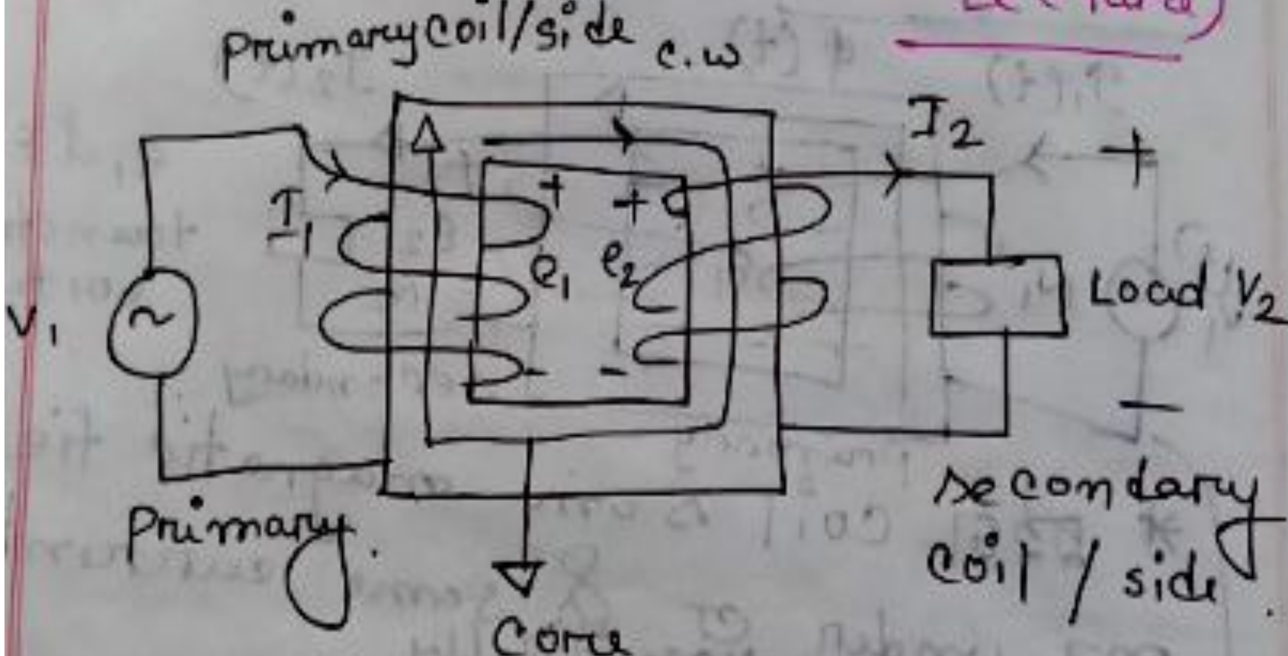
$$\frac{I_2}{I_1} = \boxed{\frac{|\varepsilon_1|}{|\varepsilon_2|} = \frac{N_1}{N_2}} = a.$$

turns ratio



* এটি rms value নিতেছি হয়,

Lec:- 4 (Transformer Lecture)



* loop টা close হয় that's why I & V produce হয়,

construction of single phase transformer ⇒ Utube.
construction of three phase transformer

single phase transformer :— ⇒ Utube,

Classification of Transformer :-

(1) Based on phase

→ Single - ϕ.

→ 3 - ϕ.

(2) Based on voltage level.

– step up

– step down.

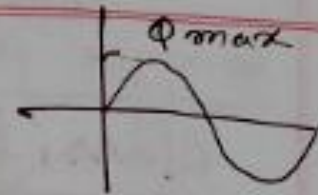
(3) Based on power Rating.

→ High voltage XFR / Transmission.

→ Distribution XFR.

* XFR 2નો ભેગ રહે Transformer દર્શાવ (like symbol).

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



$\omega = 2\pi f$

$\Downarrow$

Angular frequency.

$$e_1 = \frac{d\lambda}{dt}$$

where,

λ = Total flux Linckage with coil-1

$= N_1 \phi$.

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

[Primary)

$$e_1 = \boxed{N_1 \phi_{max} . \omega} \cos \omega t$$

$\Downarrow$

rms value of $\cos \omega t$.

$$\Rightarrow E_1 = \frac{N_1 \phi_{max} \omega}{\sqrt{2}}$$

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

[secondary]

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

$\Downarrow$

$$E_2 = \frac{N_2 \phi_{max} \omega}{\sqrt{2}}.$$

$$\frac{E_1}{E_2} = \frac{\frac{N_1 \phi_{max} \omega}{\sqrt{2}}}{\frac{N_2 \phi_{max} \omega}{\sqrt{2}}} = \boxed{\frac{N_1}{N_2}}$$

→ ~~turns~~ ~~Ra~~ turns ratio ~~or~~ a or K.

$$\mathcal{F}_1 = \mathcal{F}_2.$$

$$\boxed{\mathcal{F} = NI}$$

$$N_1 I_1 = N_2 I_2$$

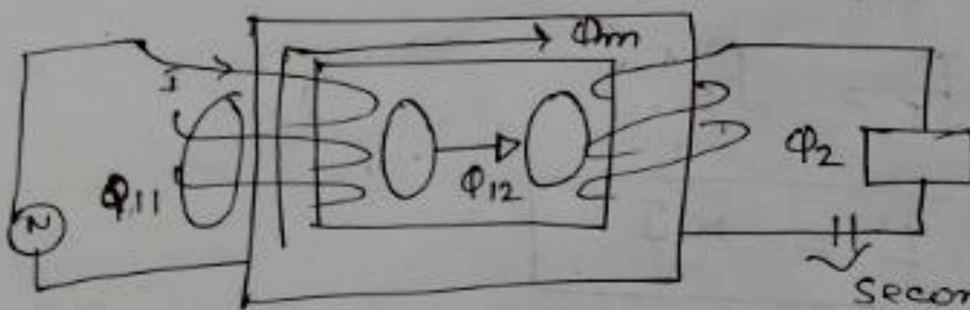
$$\Rightarrow \frac{I_1}{I_2} = \frac{N_2}{N_1} = E_1/E_2$$

$$\boxed{\Rightarrow \frac{E_1}{E_2} = \frac{I_2}{I_1} = \frac{N_1}{N_2} = \text{Turns Ratio}}$$

* Ideal transformar এ ~~fora~~ a ~~charge~~ flux loss নাই।

* leackage ~~charge~~ flux :

~~problem~~



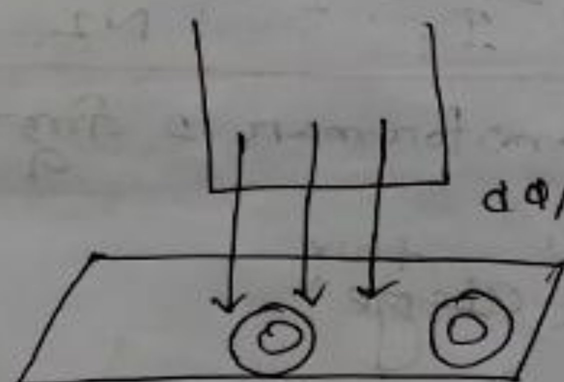
secondary flux

primary flux, $\Phi_1 = \Phi_{11} + \Phi m$.

$\Downarrow$

Leckage flux.

$\boxed{\Phi_2} = \Phi_{12} + \Phi m$.



$d\Phi/dt$.

[magnatic time এর সাপেক্ষে variable].

iron conductor

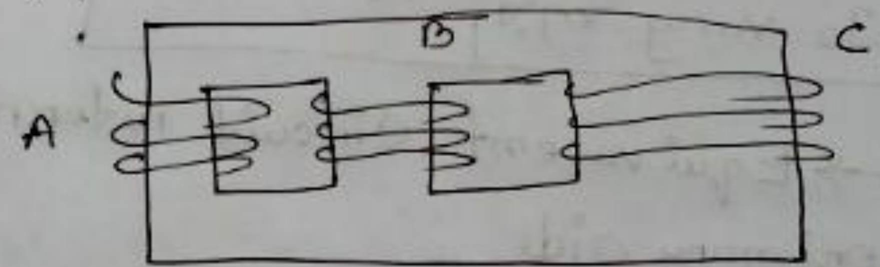
core এ current low.

(1) histrolisis loss

(2) Ed loss.

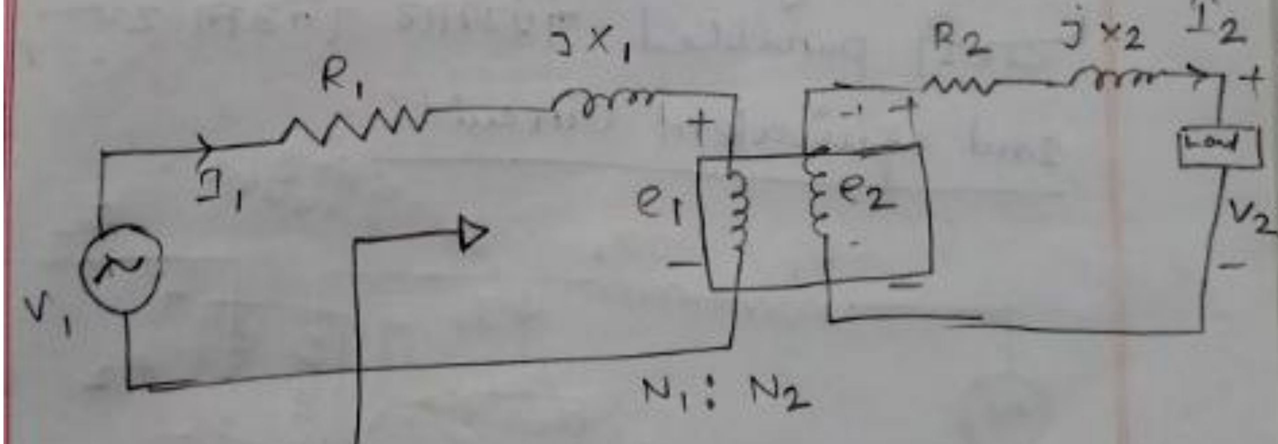
এই loss কমানোর জন্য - core এ ঝিঙ্ক layer এর sheet দেওয়া হয়,

Flash point : ~~th~~ liquid এর একটি temp. যখন ~~কে~~ নিচে air এর সাথে induce করে transformer এ 160° হয় flash point. এর নিচে হলে আগুন ধরে না, freezing point এ 15°C এর নিচে নিচে হয়।



Equivalent circuit of transformer:

Coil is nothing but inductor.
So, তার ভিতরে resistor থাকে,
transformer এ basic দুইটি part থাকে
(1) coil & (2) core.



$$X = j\omega L$$

$$X_C = \frac{1}{j\omega C}$$

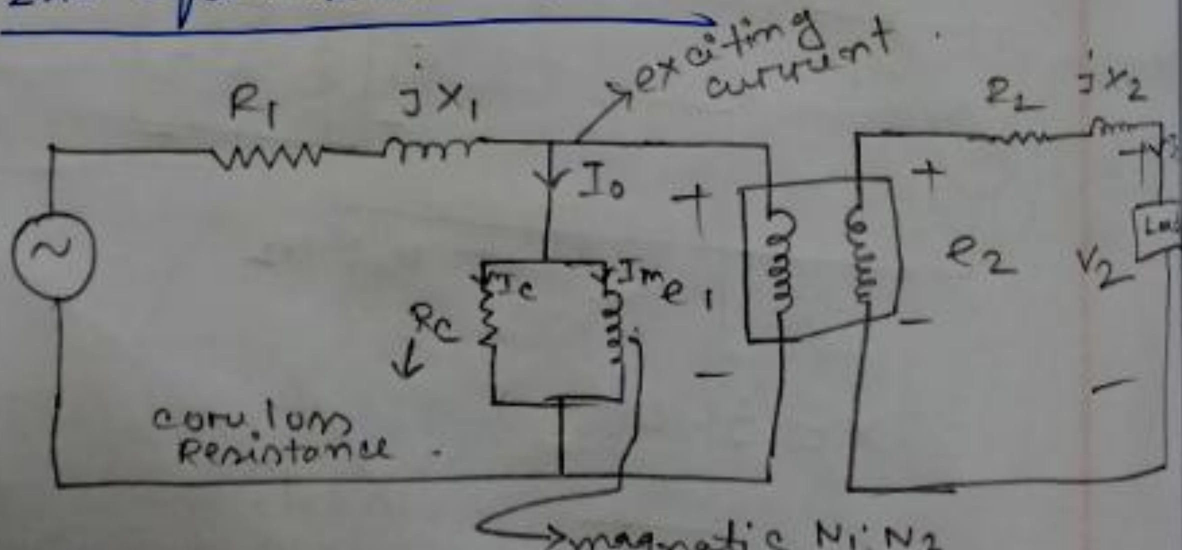
* V_2 fixed voltage থাকে,
* I_2 vary করে।

→ Equivalent circuit referred to primary side.

→ " " " secondary side.

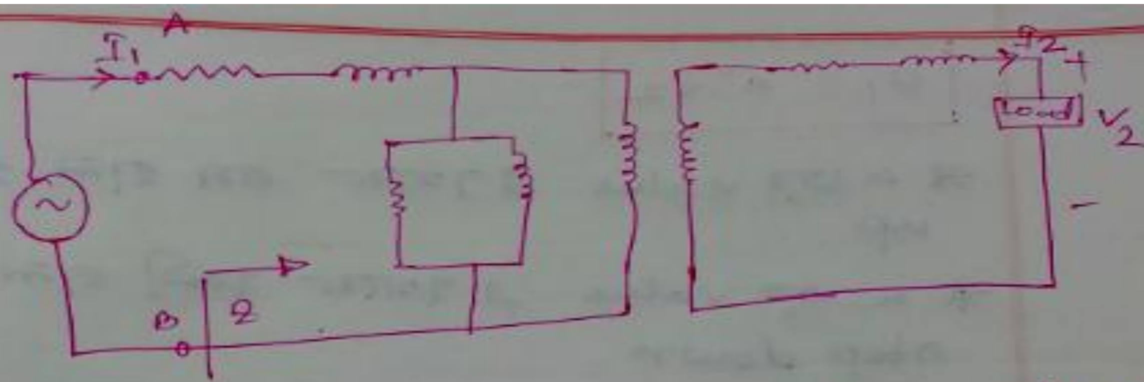
* Histelysis loss & Ed current loss উভয়ে parallel হিসাবে নেওয়া হয়।

<u>2nd equivalent circuit:</u>



→ magnatic reluctance $N_1 : N_2$

reluctance বাধা দেয়, basically current flow এর



Z_2 = Actual Impedence of secondary side.

Z_1 = Impedance ~~reflected~~ referred to primary side.

$$Z_1 = \frac{V_1}{I_1} \; ; \; Z_2 = \frac{V_2}{I_2}.$$

$$\frac{Z_1}{Z_2} = \frac{V_1}{I_1} \Big/ \frac{V_2}{I_2}.$$

$$\Rightarrow \frac{V_1}{V_2} \times \frac{I_2}{I_1} = a \times a$$
$$= a^2.$$

$$\boxed{Z_1 = a^2 Z_2}$$

* a এর value 1 থেকে কম হলে step up.
* a এর value 1 থেকে বেশি হলে step down.

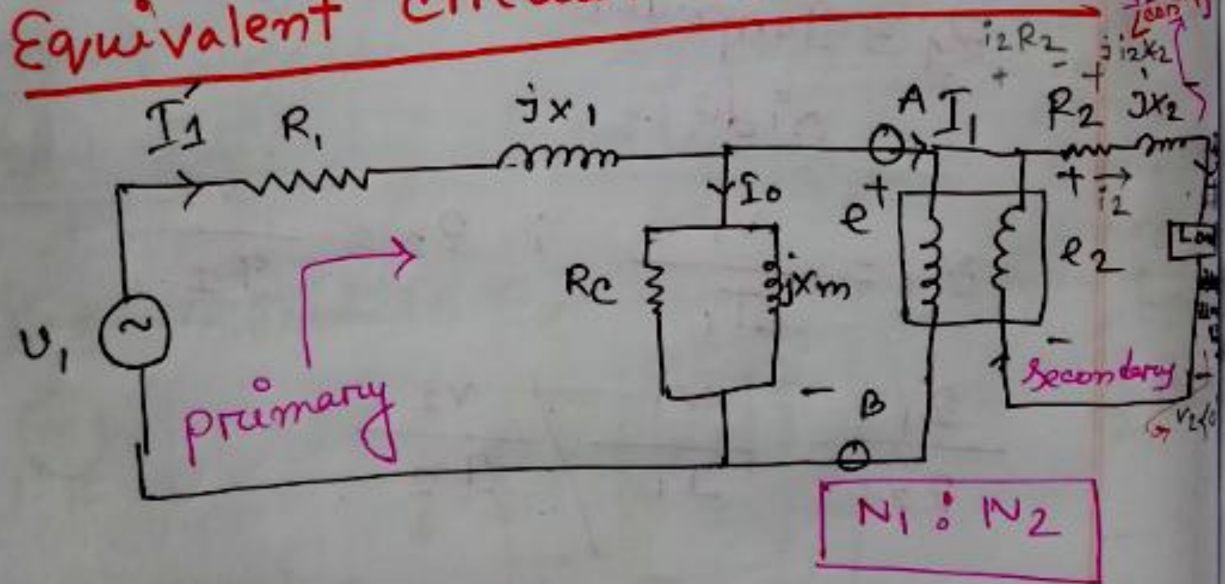
$\boxed{Z_1 = a^2 Z_2}$

* a এর value 1 থেকে কম হলে step up.
* a এর value 1 থেকে বেশি হলে step down.

Lec:- 5

$Z_1 = a^2 Z_2$

Equivalent circuit of a XFR:



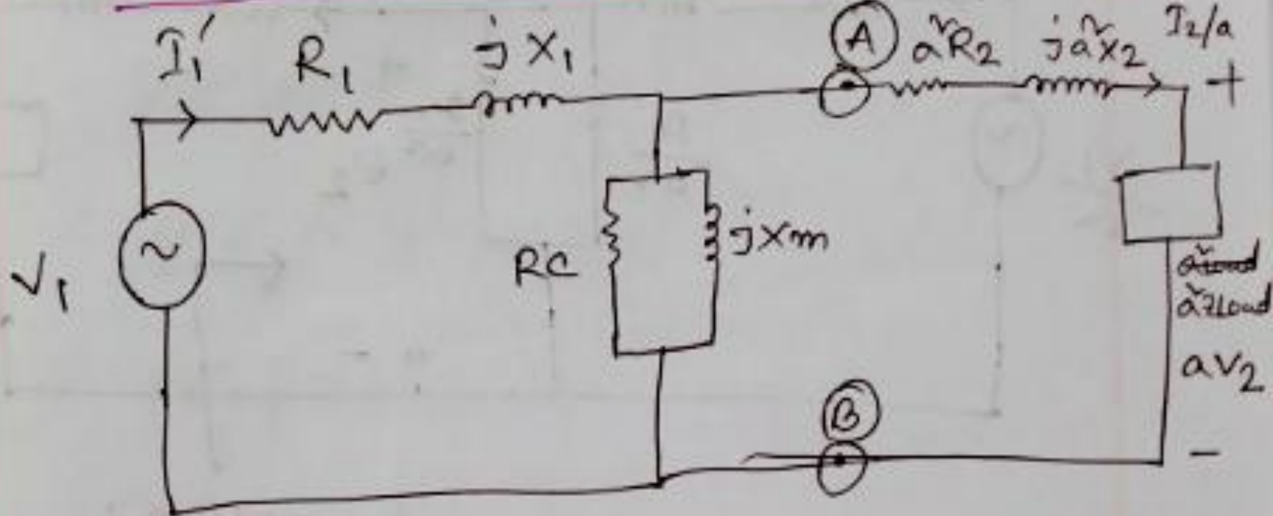
$Z_2 = \frac{1}{2} Z_1$

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

$I_1 \theta =$

$I_1' =$

① Eq circuit referred to primary side.



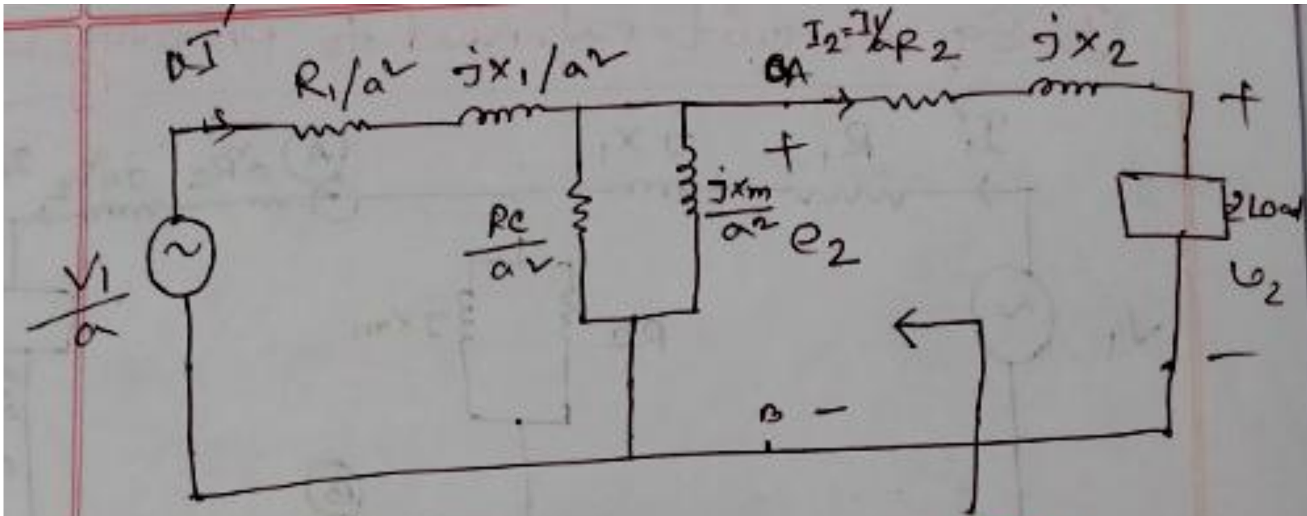
$$\boxed{\begin{aligned} e_1 &= a e_2 \\ V_1 &= a V_2 \end{aligned}}$$

$$\frac{v_1}{v_2} = a$$

$$v_1 = aV_2$$

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

② Eq. circuit referred to secondary side.



Phasor Diagram of a XFR:

~~$v = V\sin(\omega t + 0) \Rightarrow$ Triangular~~
~~$\rightarrow$ Triangular~~

$v = V\sin(\omega t + 0) \rightarrow$ Trigonometric form.

$v = V\angle 0^\circ \longrightarrow$ Phasor form.

$i = I\sin(\omega t - \theta) \rightarrow$ T.F

$i = I\angle -\theta$.

Rec $\longrightarrow$ polar :—

$Z = a + jb \rightarrow$ Rectangular.

$Z = r < \theta \rightarrow$ polar or phasor.

$r = |Z| = \sqrt{a^2 + b^2}$.

$\theta = \tan^{-1}\left(\frac{b}{a}\right)$.

polar $\longrightarrow$ Rec

$Z = r < \theta \longrightarrow$ polar.

$Z = \underbrace{r\cos\theta}_{\text{real}} + \underbrace{jr\sin\theta}_{\text{Imaginary}}$.

$V = A\cos\omega t$

$V = |V| < \theta$

$= A < 0^{\circ}$.

* phasor form Draw করার step:—

(1) Assume/ select a reference vector.

(2) Usually consumer's voltage are considered as refrence [reference means x অক্ষ বরাবর যত angle থাকে, ~~vector~~ হয় 0].

$\theta_2 < 0^\circ$

(3) power factor of consumer Load to assume/ known. $\theta = \cos^{-1} pf$

(4) Determine ~~all voltage drops and~~ ~~br~~ the load current.

(5) Determine all voltage drops and branch current.

(6) Apply KVL and KCL where appropriate.

most of the load is Inductive. Inductive lag current ~~lead~~ হয়, capacitor এ voltage lag ~~lead~~ হয়।

branch current

reference মানে angle 0 chaile kcl.

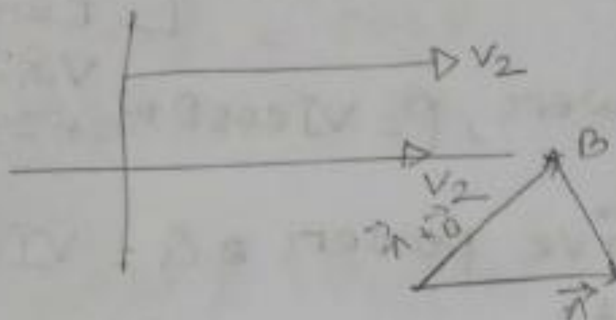
power factor. v, i

$p.f = \cos\theta$

$= \cos(\hat{v,i})$

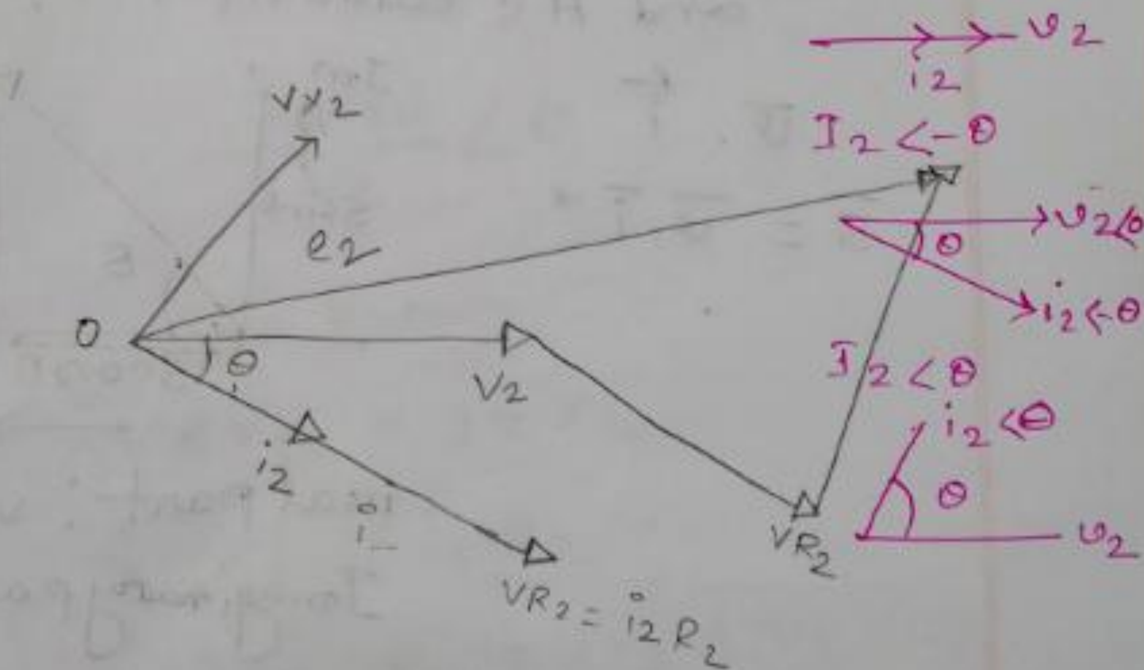
$\cos\theta = pf$

$\Rightarrow \theta = \cos^{-1} pf$.



$V_2 \angle 0°$

$I_2 \angle 0°$ inphase



magnitude

Apparent $S = VI$ kVA [যদি voltage v, current i হয়। V&I rms এ নিতে হয়]

Real Power, $P = VI\cos\theta$ W

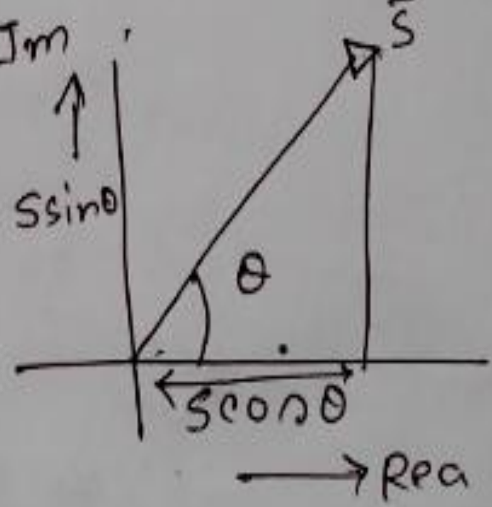
Reactive power $Q = VI\sin\theta$ var.

~~Apparent~~:

~~Real power~~: যদি AC voltage $\hat{v}$ and AC current $\hat{i}$ হয়।

$\bar{v} . \bar{i}$

$\bar{S} = \bar{v} . \bar{i}^*$



real part: $VI\cos\theta$.

Imaginary part: $VI\sin\theta$.

(4) Load $\longrightarrow$ S_{rated}

$pf = \cos\theta$

$V_{rated} = v_2$

lagging $\rightarrow$ cw

leading $\rightarrow$ c.cw.

given,

$S_{rated} = |v_2||i_2|$

$\Rightarrow |i_2| = \dfrac{S_{rated}}{|v_2|}$

$\Rightarrow i_2 = \dfrac{S_{rated}}{V_2} \angle\theta$.

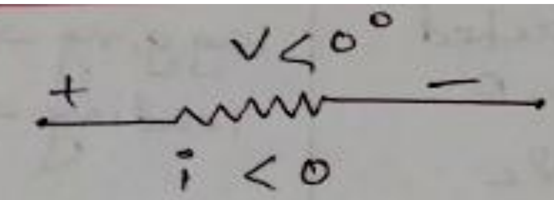
(5) (i) i_2 = Known.

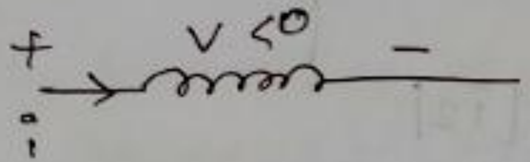
(ii) $V_{x_2} = j i_2 X_2$.

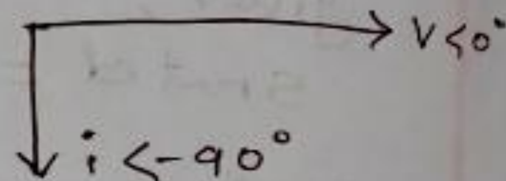
(iii) $V_{R_2} = i_2 R_2$

(iv) $-e_2 + V_{R_2} + V_{X_2} + V_2 = 0$

$e_2 = \overline{V_{R_2}} + \overline{V_{X_L}} + \overline{V_2}$





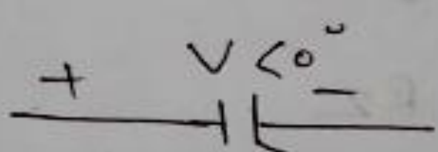


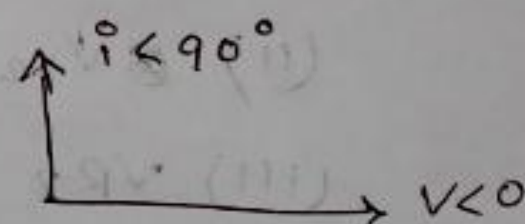
$$X_L = j\omega L$$

$$= \omega L \angle 90^\circ$$

$$i = \frac{V \angle 0}{\omega L \angle 90^\circ}$$

$$= \frac{V}{\omega L} \angle -90^\circ$$





$$e_2 = V_{R2} + V_{X2} + V_2$$

$$V_{R2} = i_2 R_2$$

$$V_{X2} = jX_2 R_2$$

Lec:-6

Phasor diagram of a XFR:-

(1) Step:—

(1) select/ Assume a ~~refre~~ reference voltage

(2) Usually consumer voltage is considered as reference.

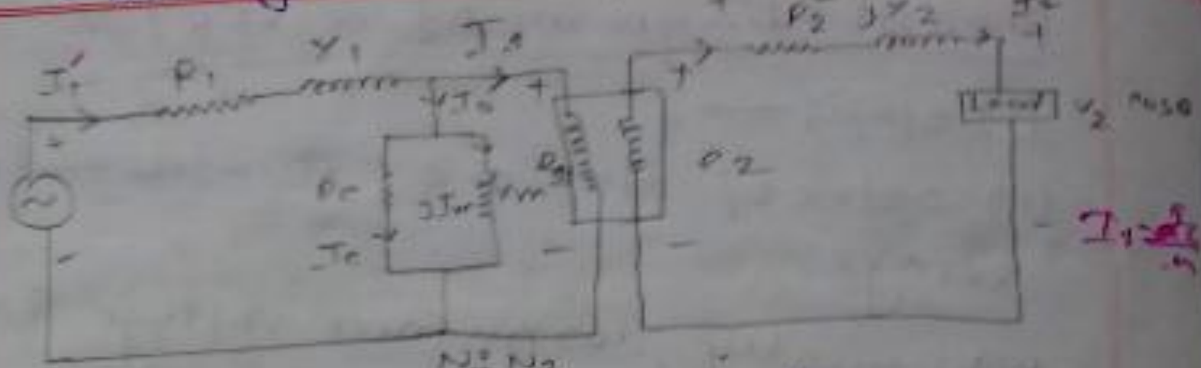
(3) power factor of consumer's lod to assume.

(4) Determine the load current.

(5) " all the voltage drops and branch current.

(6) Apply KVL/KCL where appropiate.

Always V_2 কে refrence হিসেবে নিতে হবে, তখন angle 0 থাকে,



$N_1 : N_2$

$a = N_1/N_2$

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

(1) $\longrightarrow$

(2) $\longrightarrow V_2 \angle 0^\circ$

(3) $\longrightarrow \cos\theta$ lagging .

(4) $\longrightarrow$ Load current $I_2 \angle -\theta$

(5) (6) $\longrightarrow$ KVL $\rightarrow e_2 = V_{R_2} + V_{X_2} + V_2$

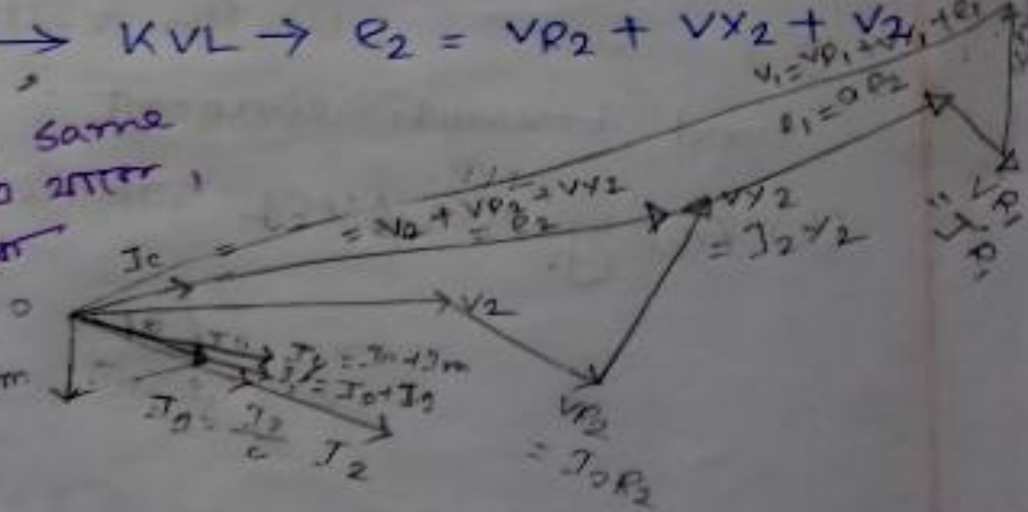
Lag → cw

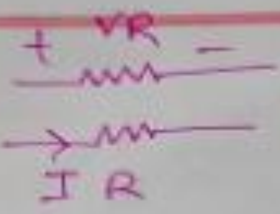
Lead → ccw .

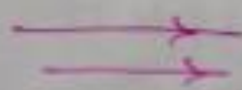
Note : KVL Always secondary circuit এ নিতে হবে.

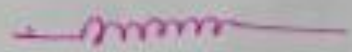
Ic & e1 same phase এ থাকে,

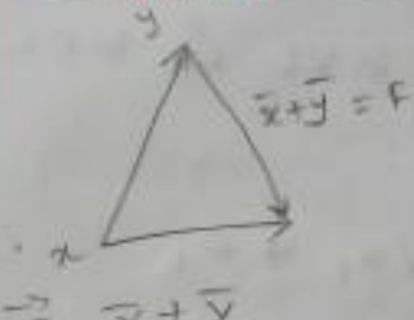
Im e1 এর 90° lag করে.

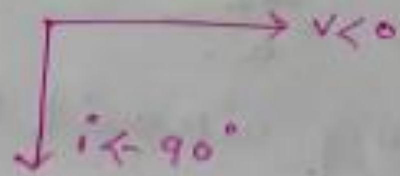




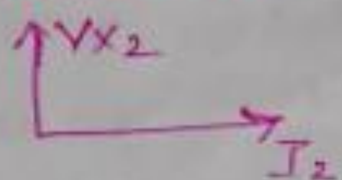








Inductor এ যদি I_2 কে refrence ধরি তাহলে V_2 lead করে.



From circuit:—

$$a = \frac{N_1}{N_2} = \frac{e_1}{e_2}$$

$$\Rightarrow \boxed{e_1 = a e_2}$$

[e_1 & e_2 Always in Phase এ থাকে তাদের শুধু magnitude different হয়.

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

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

primary circuit এ- KVL & KCL কে use করতে হবে।

$$KVL \rightarrow v_1 = V_{R_1} + V_{x_1} + e_1$$

$$KCL \rightarrow I_1' = I_0 + I_1$$

$$\Rightarrow V_{R_1} = I_1' R_1 \; ; \; V_{x_1} = I_1' x_1$$

$$I_0 = I_c + jI_m .$$

$$I_c = \frac{e_1}{R_c}$$

$$I_m = \frac{e_1}{X_m}$$

Approximate Equivalent circuit

$H = \frac{V}{R}$

* যখন Approximate equivalent circuit নিলে তখন X_c & R_c কে overlook করবো, তখন শুধু simple series circuit হবে।

Voltage Regulation:—

$$VR = \frac{V_{no\,load} - V_{full\,load}}{V_{fl}} \times 100\%$$

* যখন no load তখন Vin টাই থাকে।
* যখন full " " Vout " "

* Loading side এ voltage বেশী পেতে হলে no load এর voltage বেশী দিতে হয়।

* No load :

T.V 240V এর জায়গায় 200V.

$P = VI\cos\theta$.

* এই খানে $\cos\theta$ হল power factor.

* η higher হল Circuit ভাল

* transformer :- Core loss & copper loss.

Core loss :- Transformer এ core এ through এ হয় flux produce হয় ওই core loss.

copper loss : copper wire এর through এ হয় loss.

Lec:- 7

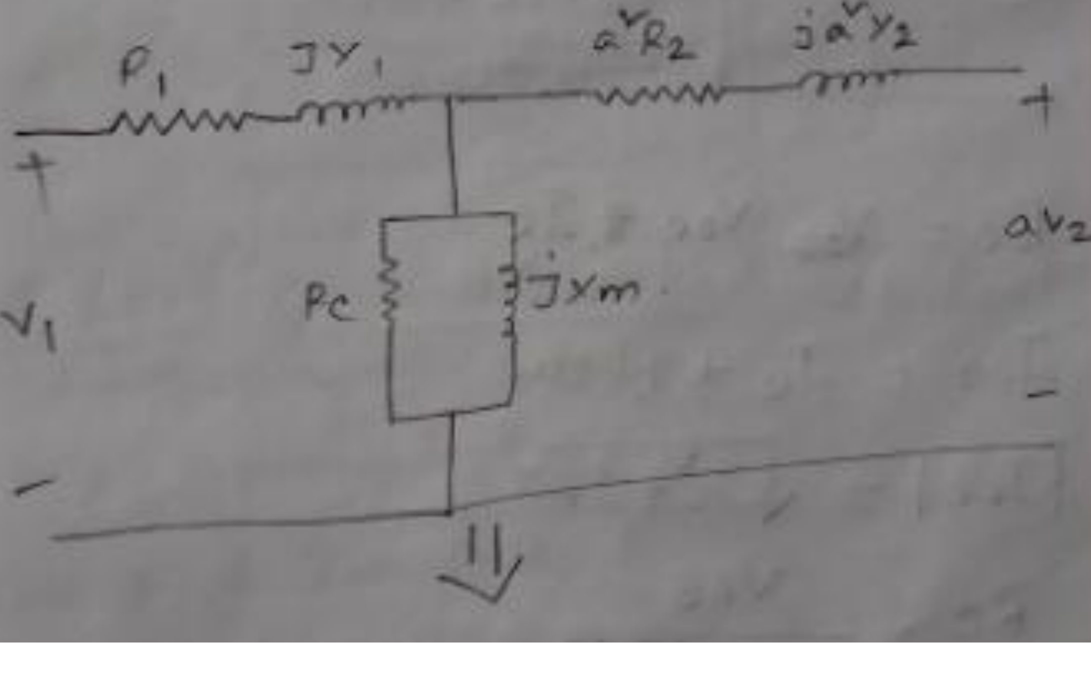
Transformer Tests:-

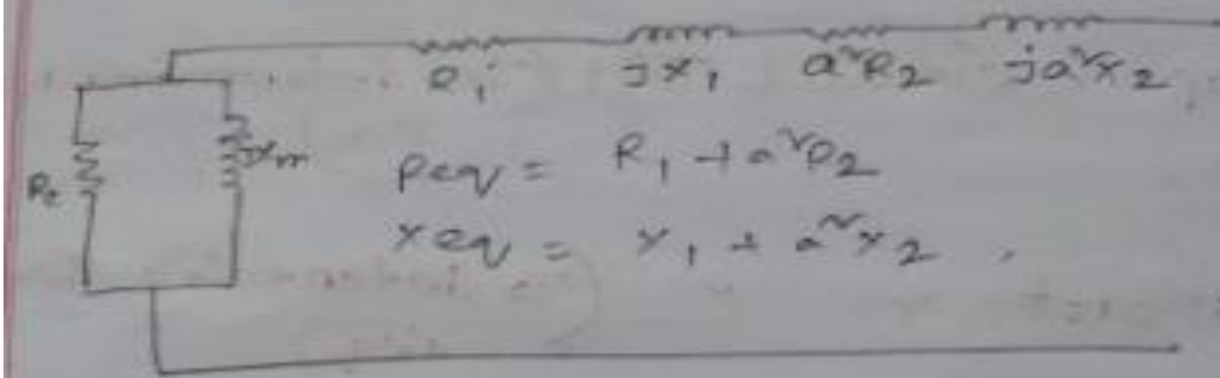
(1) open circuit Test (To determine R_c and X_m).

(2) short " " (To determine R_{eq} and X_{eq}).

R_c = core loss reactance.
X_m = Magnitizing " .

Ref. to primary side

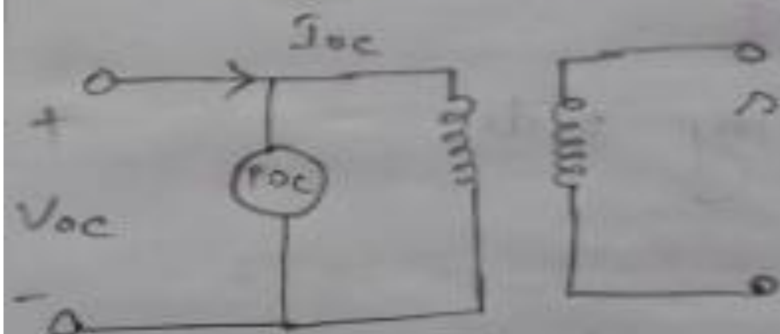




$R_{eq} = R_1 + a^2 R_2$

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

open circuit test



$$P_{oc} = \cancel{V_{oc}}\ V_{oc} \cdot I_c$$

$$I_{oc} = I_c + j I_m$$

$$|I_{oc}| = \sqrt{I_c^2 + I_m^2}$$

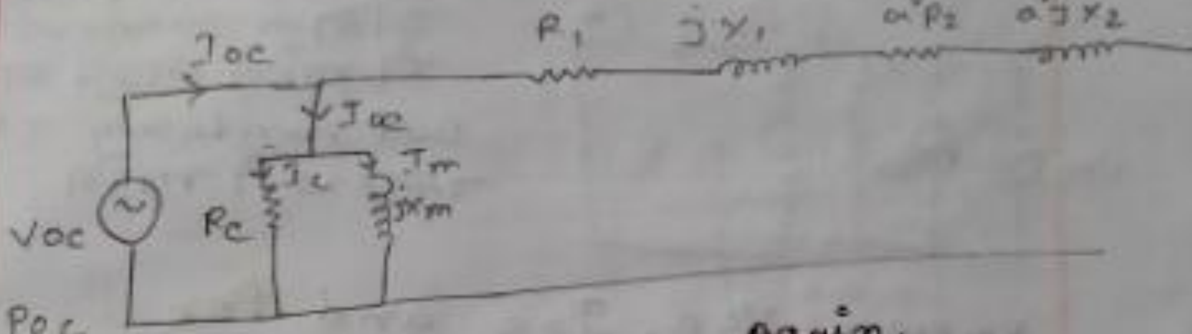
$$R_c = \frac{V_{oc}}{I_c}$$

$$X_m = \frac{V_{oc}}{I_m}$$

Rc হলো Real power, যেটা wattmeter দিয়ে measure করা যায়। Rated current means যে voltage apply করলে যে max output পাবো, But Rated voltage হবে।

Known V_{oc}, I_{oc}, and P_{oc}

App eq circuit.



$$I_{oc} = I_c + jI_m$$

$$P_{oc} = V_{oc} I_c$$

$$\Rightarrow I_c = \frac{P_{oc}}{V_{oc}}$$

$$I_{oc} = \sqrt{I_c^2 + I_m^2}$$

$$\Rightarrow I_m = \sqrt{\underbrace{I_{oc}^2}_{\text{known.}} - I_c^2}$$

Again,

$$V_{oc} = I_m X_m$$

$$\Rightarrow X_m = \frac{V_{oc}}{I_m}$$

I_c and I_m are determined.

$$V_{oc} = R_c I_c$$

$$\Rightarrow R_c = \frac{V_{oc}}{I_c}$$

Short Circuit test:-

→ Req, Xeq

* যেখানে, V কমিয়ে ওটিকে কে short করার থাকলে current কে min পাওয়া যায়, But randomly যেটা বললে ঠিক করার,

Known Vsc, Isc and Psc

$$I_{rated\,1} = \frac{10KVA}{400}$$

$$= \frac{10\times10^3}{400}$$

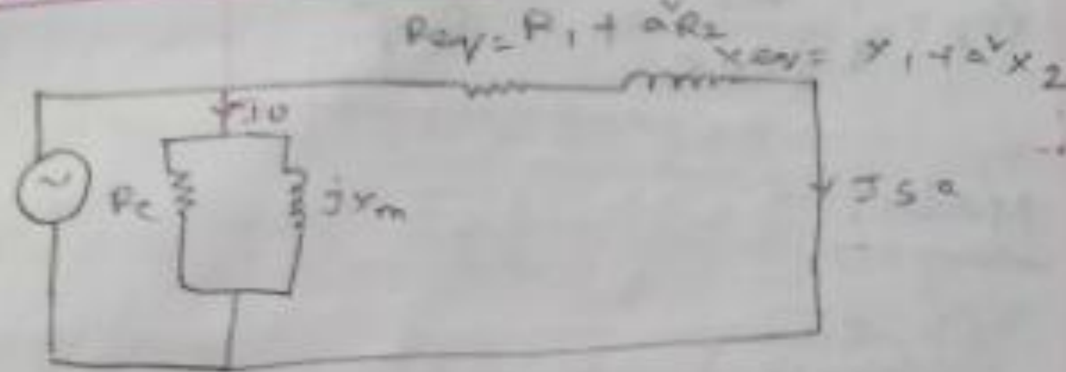
$$= 25A$$

$$I_{rated\,2} = \frac{10\,KVA}{120}$$

$$= \frac{10\times10^3}{120}$$

$$= 83A$$

equivalent circuit



$I_0 \longrightarrow$ Negligible.

$P_{sc} = I_{sc}^2 . R_{eq}$

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

$V_{sc} = I_{sc} Z_{eq}$

$\overline{Z_{eq}} = R_{eq} + jX_{eq}$

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

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

$$\Rightarrow \sqrt{R_{eq}^2 + X_{eq}^2} = \frac{V_{sc}}{I_{sc}}$$

Distribution transfor এর secondary
440V থাকে,
(3phase).

$$\boxed{X_{eq} = \sqrt{\frac{V_{sc}^2}{I_{sc}^2} - R_{eq}^2}}$$

Math:→

Siemens
75 KVA
4600 V
230 V

open circuit test:—

$V_{oc} = 230V$.

$I_{oc} = 13.04V$

$P_{oc} = 521\omega$.

$\Rightarrow P_{oc} = V_{oc} . I_c$

$\Rightarrow 521 = 230 . I_c$

$\Rightarrow I_c = 2.65 A$.

$R_{oc} = \frac{230}{2.65} =$

$$X_m = \frac{V_{oc}}{I_m}$$

$$\Rightarrow I_m = \sqrt{I_{oc}^2 - I_c^2}$$

$$P_{oc} = V_{oc} \cdot I_c$$

$$\Rightarrow I_c = \frac{P_{oc}}{V_{oc}}$$

$$R_c = \frac{V_{oc}}{I_c}$$

Per unit value:—

Base:—

Z_{base}

V_{base}

I_{base}

S_{base}(KVA) $\rightarrow$ যেটা দিয়ে দেওয়া হয়/ বলে দেওয়া থাকবে।

$$\frac{\text{Actual value}}{\text{Base value}}.$$

$$R_{pu} = \frac{R_{eq}}{Z_{base}}$$

$$X_{pu} = \frac{X_{eq}}{Z_{base}}.$$

$$V_{pu} = \frac{V}{V_{base}}$$

$$I_{pu} = \frac{I}{I_{base}}.$$

* rated current, voltage, power ওগুলোকে base ধরা হয়।

~~এরা~~ per system এ সাধারণত percentage এ দেওয়া থাকে.

Lec:-8

(b) per unit Resistance $R_{pu} = \dfrac{R_{eq_{HS}}}{Z_{base_{HS}}}$

$$= \frac{R_{eq_{LS}}}{Z_{base_{LS}}}$$

per unit Reactance, $X_{pu} = \dfrac{X_{eq_{HS}}}{Z_{base_{HS}}}$

$$= \frac{X_{eq_{LS}}}{Z_{base_{LS}}}$$

per unit Impedance, $Z_{pu} = \dfrac{\sqrt{R_{eq_{HS}}^2 + X_{eq_{HS}}^2}}{Z_{base_{HS}}}$

$$= \frac{\sqrt{R_{eq_{LS}}^2 + X_{eq_{LS}}^2}}{Z_{base_{LS}}}$$

HS $\longrightarrow$ primary

Referred to side $\rightarrow$

$\boxed{Req_{HS} = R_1 + a^2 R_2}$ $\Rightarrow$ Not given

$\boxed{Xeq_{HS} = x_1 + a^2 x_2}$ $\Rightarrow$ Not given.

$$Zeq_{HS} = \sqrt{Req_{HS}^2 + X^2eq_{LS}}$$

$$a = \frac{V_1}{V_S} = \frac{4600}{230} = 20.$$

(b) Using short circuit Test Data:

$V_{SC} = 160.8\,V$

$I_{SC} = 16.3\,V$

$P_{SC} = 1200\,\omega$

$$Req_{HS} = \frac{P_{SC}}{I_{SC}^2} = 4.51\,\Omega$$

$$Zeq_{HS} = \frac{V_{SC}}{I_{SC}} = 9.86\,\Omega$$

$$Xeq_{HS} = \sqrt{Zeq_{HS}^2 - Req_{HS}^2} = 8.77\,\Omega$$

* Transformer ও rated power all ~~ও~~ same. base ~~Vol~~ power হবে rated ~~ও~~ power.

$$Z_{base\,HS} = \frac{V_{base\,HS}}{I_{base\,HS}}$$

S_{base} = Apparent base power

$$= \frac{V_{base\,HS}}{\frac{S_{base}}{V_{base\,HS}}}$$

$$= \frac{V^2_{base\,HS}}{S_{base}} = \frac{(4600)^2}{(75 \times 10^3)}$$

$$= 282.13\,\Omega$$

$$R_{pu} = \frac{4.51}{282.13} = 0.0151$$

$$X_{pu} = \frac{8.77}{282.13} = 0.031$$

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

Per unit Impedence Z_{pu}

$$= \frac{9.86}{282.13} = 0.345$$

19 তারিখে Mid:- Syllabus - 12 তারিখ এর
আর class

(c) Voltage ~~Resistor~~ Regulator:-

$$VR = \frac{|V_{nl}| - |V_{fl}|}{|V_{fl}|} \times 100\%$$

$PF = \cos\theta$
$\Rightarrow \theta = \cos^{-1} 0.75$
41.40

$$VR = \left\{ \sqrt{(R_{pu} + \cos\theta)^2 + (X_{pu} + \sin\theta)^2} \right\} - 1$$

$Pf = \cos\theta = 0.75$

$\Rightarrow \theta = \cos^{-1}(0.75)$

$= \cancel{0.0}$

$Reg_{pu}^{VR} = 0.0319$

$Reg_{pu}^{VR} = 3.19\%$

BD = 50 Hz
USA = 60 Hz

2/15 Given,

Generate → current supply করে।
Load current নেয়।
R_{HS} [illegible]
R_{Δ}
Load এর voltage [illegible]
step up or step down

$S_{rated} = 100$ KVA

$f = 60$ Hz

$V_{1\,rated} = 7200$ V

$V_{2\,rated} = 480$ V

$R_{HS} = 3.06$, $X_{HS} = 6.05$,

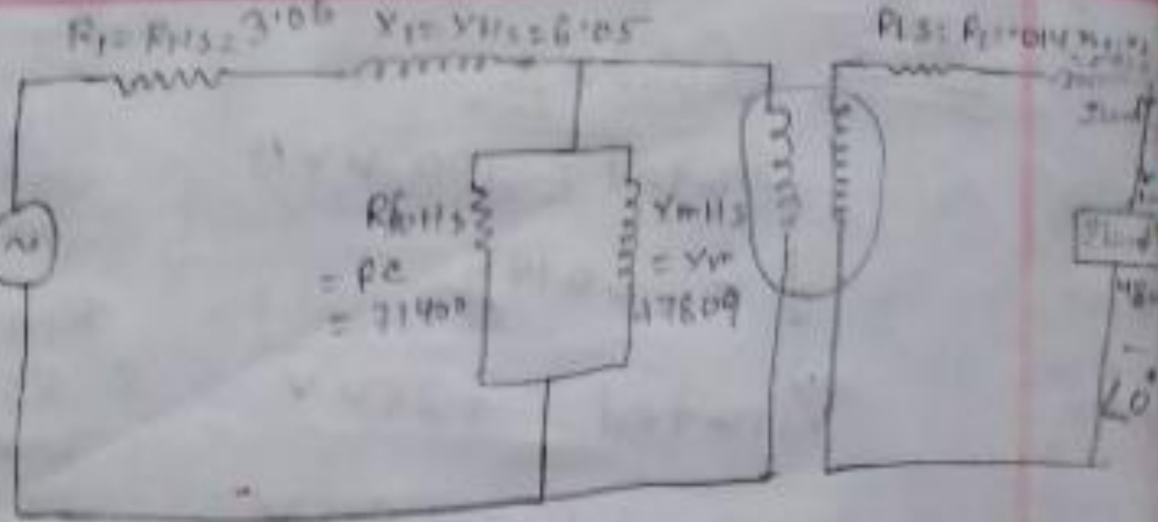
$X_{m\,HS} = 17809$

$R_{LS} = 0.014$, $X_{LS} = 0.27$

$R_{fc\,HS} = 71400$

$pf = 0.75$ lagging

যার power দেওয়া না থাকলে Rated power supply করে, I_{load} V_{load}



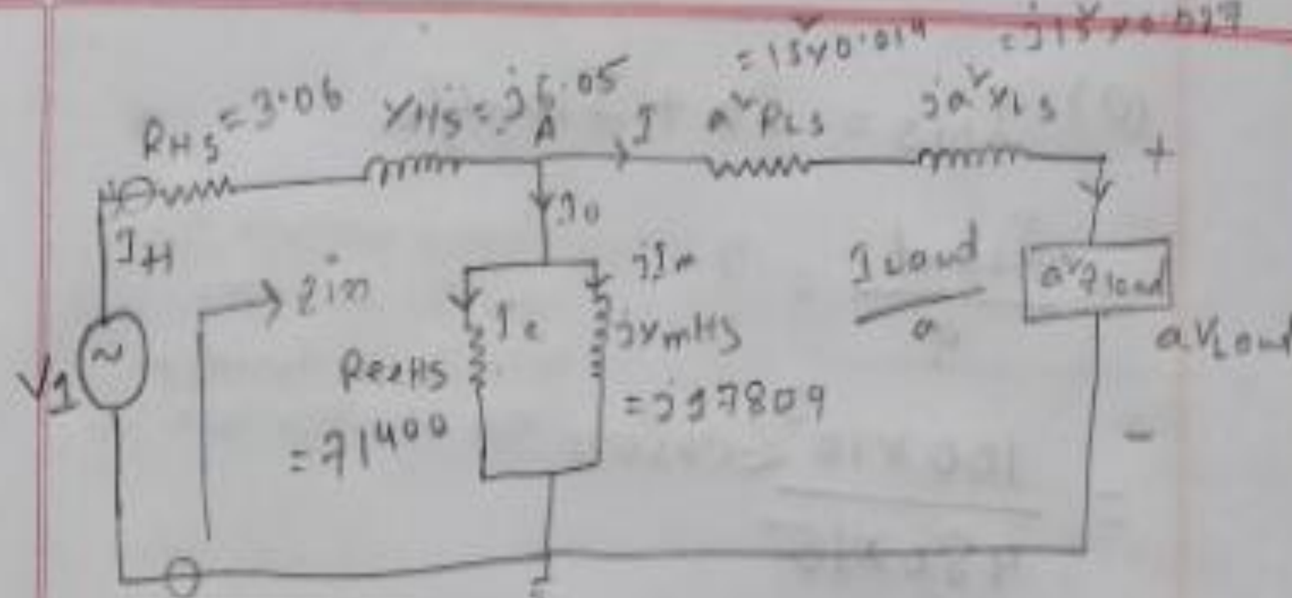
$Z_{Load} = ?$

Assume load is supplying rated 100kVA

$$Z_{Load} = \frac{V_{Load}}{I_{Load}} = \frac{480}{\frac{S_{rated}}{480}} = \frac{480}{\frac{100\times10^3 \angle -\cos^{-1} 0.75}{480}} =$$

$$I_{Load} = \frac{S_{rated}}{\text{voltage}}$$

$$= \frac{100\times10^3}{480} \angle -\cos^{-1} 0.75$$



appopriate eq. Circuit refrence to HS.

(a) $a = \frac{7200}{480} = 15$

$Req_{HS} = R_{HS} + a^2 R_{LS}$

$Xeq_{HS} = X_{HS} + a^2 X_{LS}$

(b) $Z_{in} = Req_{HS} + j\, Xeq_{HS} + a^2 Z_{Load}$

(c) $I_{HS} = I_o + I_{Load}/a$

$\Rightarrow \dfrac{I_{Load}}{a} = ?$

primary circuit এর current টা I_{HS} যেটা I_o & I_{Load}/a [illegible]

$= \dfrac{100 \times 10^3 \angle \cos^{-1} 0.75}{480 \times 15}$

(d) $\cancel{V_{in}} = V_1 = I_{HS} \times Z_{in}$

$= \left(I_o + \dfrac{I_{Load}}{a}\right) \times Z_{in}$

$\cancel{I_o =}$

$V_A = a V_{Load} + \dfrac{I_{Load}}{a}\left(a^2 R_{LS} + j a^2 X_{LS}\right)$

$I_o = I_c + j I_m = \dfrac{V_A}{R_{feHS}} + j \dfrac{V_A}{X_{mHS}}$

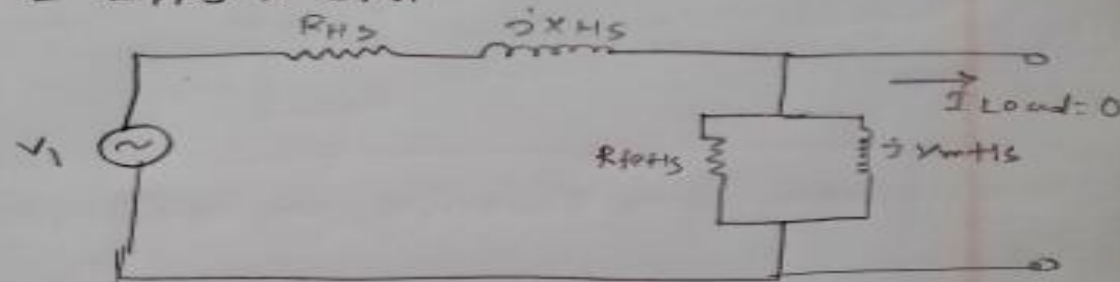
$I_c = \dfrac{V_A}{R_{feHS}}$

$I_m = \dfrac{V_A}{X_{mHS}}$

$I_{HS} = I_o + \dfrac{I_{Load}}{a}$

$V_1 = I_{HS} \times Z_{in}$

(f)



$Z_{in\,nl} = \left(R_{HS} + jX_{HS} + \left(R_{feHS} \parallel jX_{mHS}\right)\right)$

Lec:- 9

Induction Motor/ Machine:-

Machine
- stationary (Transformer)
- rotating
  - Motor
    - input elektric energy
    - output - machinical energy.
  - Generator
    - Input → Mechanical energy
    - output → electrical energy.

* Load এ output নেওয়া হয়।
* ডিজেল জেনারেটর:- base fuel থাকে, যেটা ডিজেল এ চলে।

Motor:- Electrical ⟶ Mechanical

Generator:→ Mechanical ⟶ electrical

Induction

3 phase ~~electrical~~ Motor

3 phase এর grid থাকে

Inductor Motor

- stator
- rotor

transformer :—

stationary part থাকে. তাই move ~~করতে~~ পারে না,

~~MMF = Magnetutive~~ Magnato Motive forces.

Stator:

Induction Motor এ primary side fixed থাকে, secondary side এ move করতে পারে.

Rotor :- ~~movab~~ moveable অংশ part.

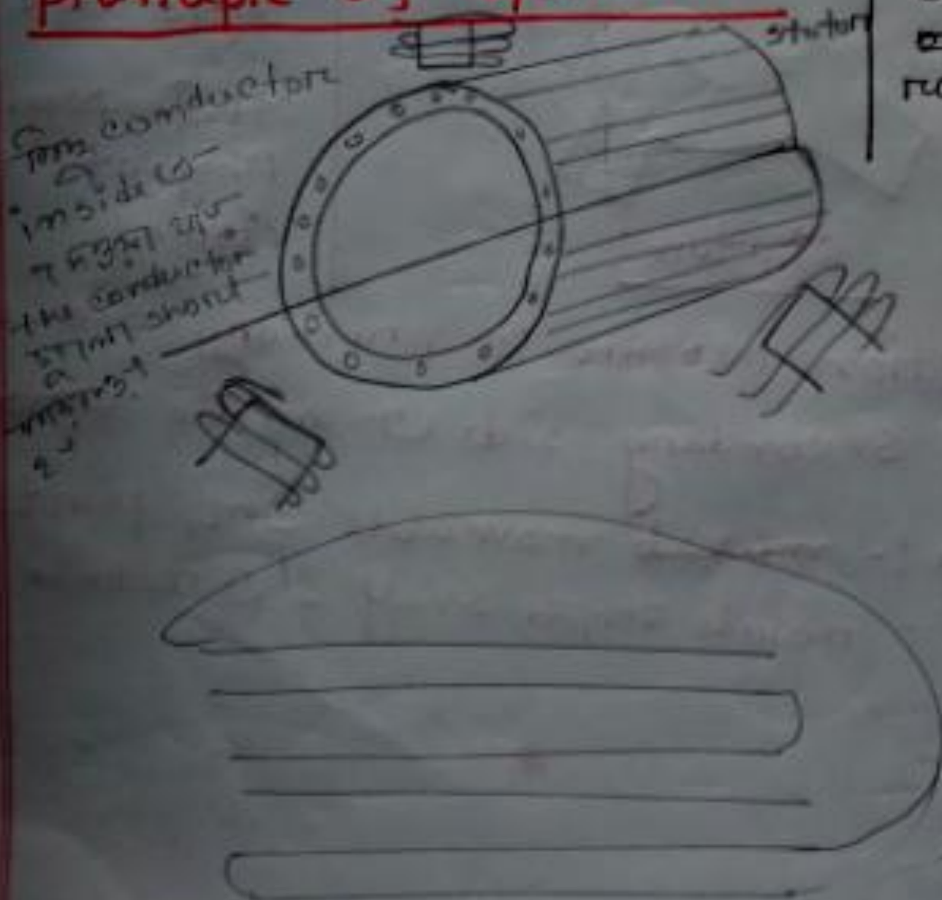
Rotor ; rotate করলে shelf 3 rotate করবে,

Motor এর গঠন base করে
Induction motor দুই প্রকার
(1) squirrel cage
(2) wound round

shaft এ অনেক গুলো ring লাগানো থাকে, slip ring লাগানো হয় output collect করার জন্য,

principle of operation:

primary হল stator ~~and~~ secondary rotor.

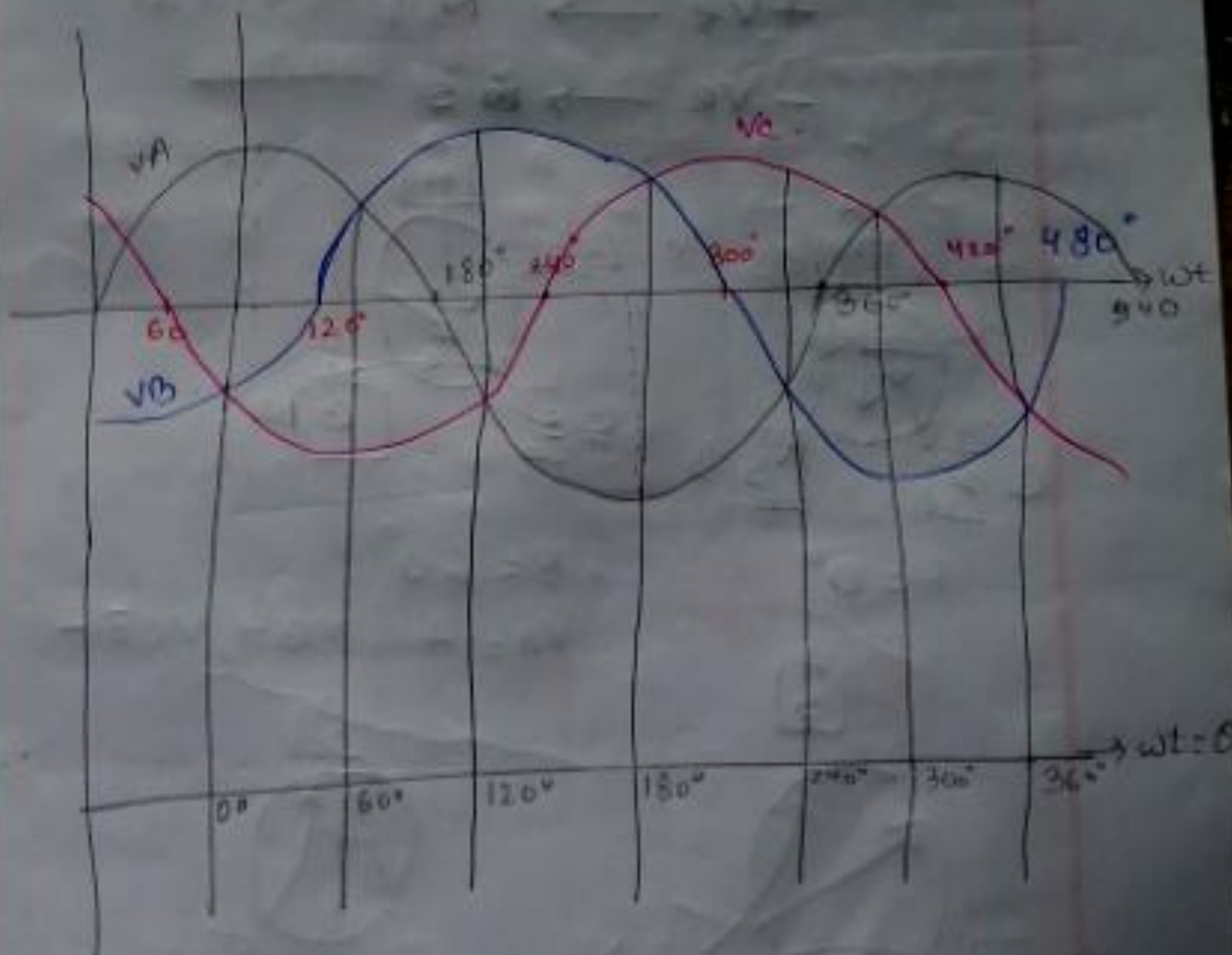


$$V_A = V_m \cancel{\sin}\, \cos \omega t$$

$$V_B = V_m \cancel{\sin}\, \cos(\omega t - 120^\circ)$$

$$V_C = V_m \cancel{\sin}\, \cos(\omega t - 240^\circ)$$

$$= V_m \cancel{\sin}\, \cos(\omega t + 120^\circ)$$

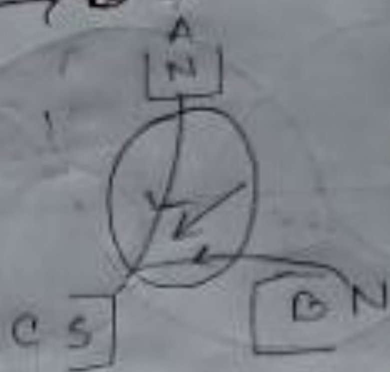


~~current~~ voltage current:

+ve → N

-ve → S

$\theta = 0°$



$\theta = 60°$

$V_A = +$, $V_B +$, $V_C = -$

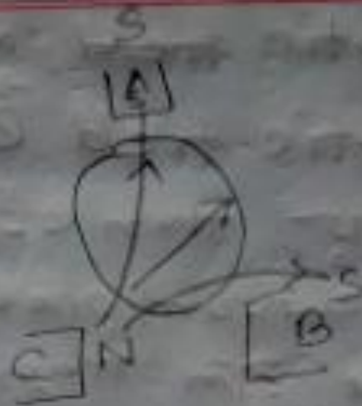
$\theta = 120°$

$V_A = -$ $V_B +$; $V_C -$

$\theta = 180°$

$V_A = -$ $V_B = +$

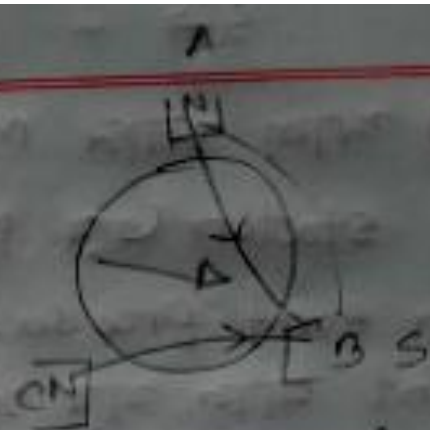
$V_C +$



$\theta = 240^\circ$

$V_A = -$ ~~$V_B = -$~~

$V_C = +$



$\theta = 300^\circ$

$V_A = +$

$V_B = -$

$V_C = +$

$\theta = 360^\circ$

$V_A = +$

$V_B = -$

$V_C = -$

$\vec{B_s}$

$\vec{B_R}$

$\vec{\tau} = K\,\vec{B_S} \times \vec{B_R}$.

যখনই τ apply হয়

তখনই Motor হয়।

N → current entry
S → " exit.

* Φ আমরা জানি magnatic ~~field~~ flux produce magnatic field $\vec{B}_s$ যা stator এর magnatic field then এটা then emf produce হয়, short থাকে, যার ফলে current produce হয়, current produce হলে magnitic flux produce হয়, যার ফলে magnatic field হয়, ~~which~~ which is $\vec{B}_R$

$\therefore \vec{\tau} = K\vec{B}_s \times \vec{B}_R$

~~τ pro~~

$\Phi = BA$

Φ = flux

τ produce হওয়া means rotor ঘুরে rotate করে,

Lec:- 12

* Problem base question :-
* Transformer
  - Equivalent ckT draw
  - short ckT test
  - open " "
  - & core loss.

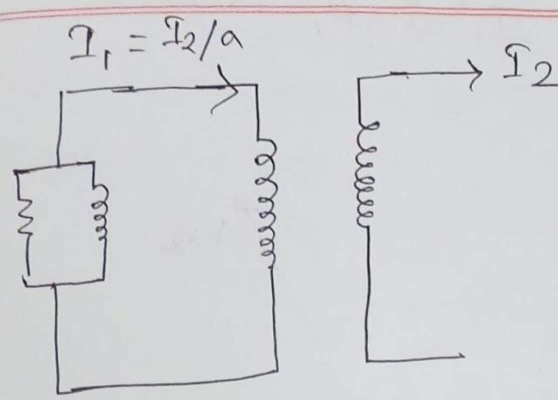
phasor diagram :-

Math এ phasor diagram বলা না থাকলে করার দরকার নাই,

(1) How a three phase inductor works

(2) How a rotating magnatic field from করে,

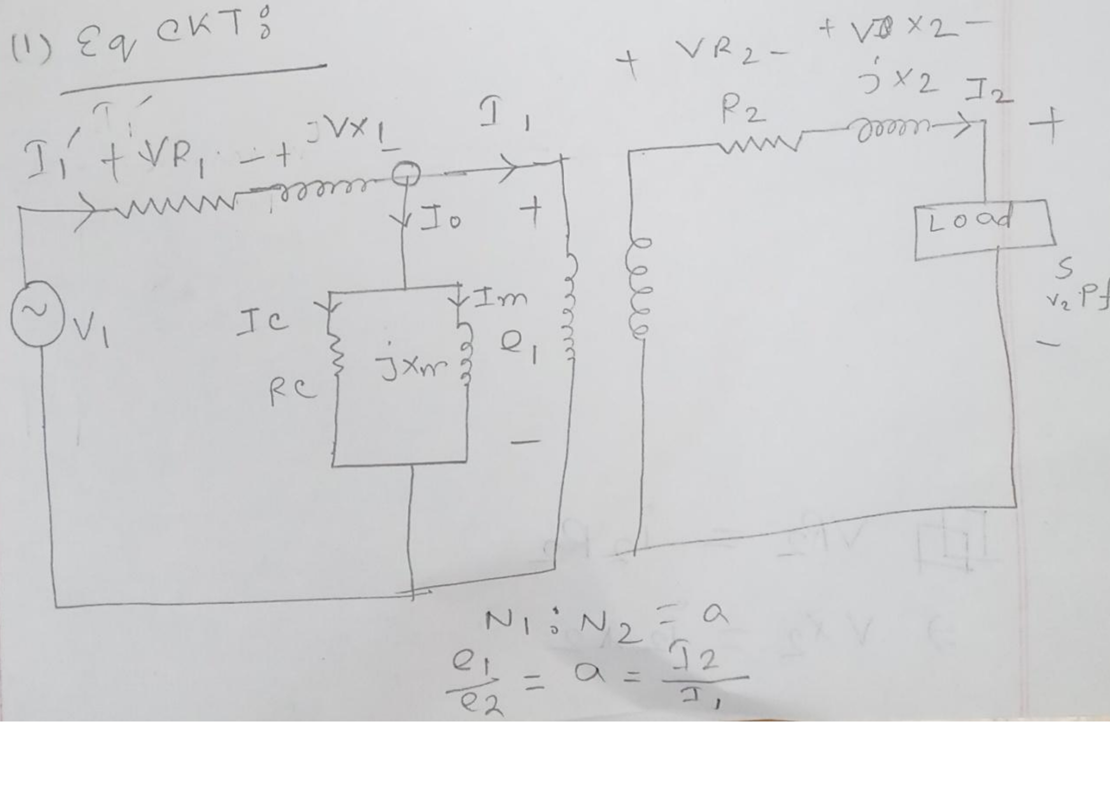
AC এর current flow করে,



$$I_1 = \frac{I_2}{a} \angle 180^\circ$$

(1) phasor Diagram of a 1-ϕ XFR

(1) Eq CKT:



$N_1 : N_2 = a$

$$\frac{e_1}{e_2} = a = \frac{I_2}{I_1}$$

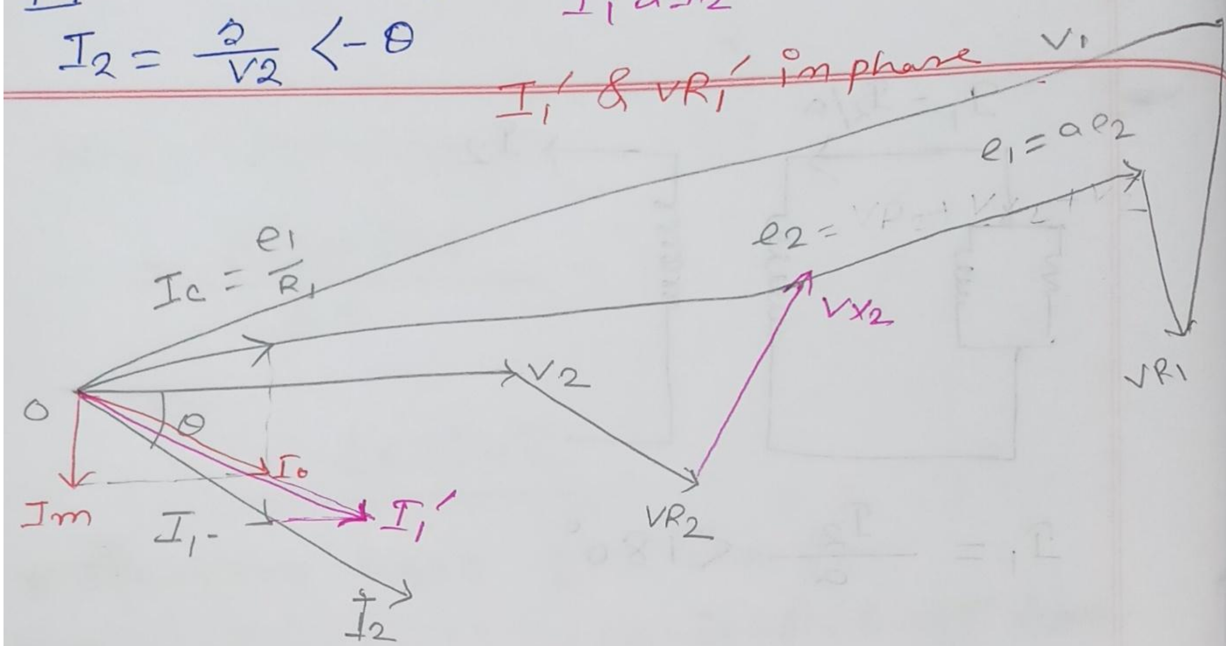
$\boxplus$ $\theta = \cos^{-1}(pf)$

$I_2 = \frac{S}{V_2} \angle -\theta$

e_1 & e_2 same phase

I_1 & I_2 " "

I_1' & VR_1' in phase



V_2 হল Inductor এর voltage.

$\boxplus$ $VR_2 = i_2 R_2$

$\Rightarrow VX_2 = i_2 X_2$

$e_2 = V_{R_2} + V_{X_2} + V_2$

$I_c = \dfrac{e_1}{R_c}$,

$I_m = \dfrac{e_1}{X_m}$

$\cancel{\bar{I}_0 = \bar{I}_c + \bar{I}_m}$

$I_c = \dfrac{e_1}{R_c}$, $I_m = \dfrac{e_1}{X_m}$

$\bar{I}_0 = \bar{I}_c + \bar{I}_m$

$= I_c + J X_m$

$I_1' = \bar{I}_0 + \bar{I}_1$

$V_{R_1} = I_1' R_1$

$V_{X_1} = I_1' X_1$

$V_1 = V_{R_1} + V_{X_1} + V_2$