Bismillah Hir Rahmanir Rahim.

[Alfi Emon 7/7]

Chapter 1

Introduction of Machinery Principles.

It can convert.

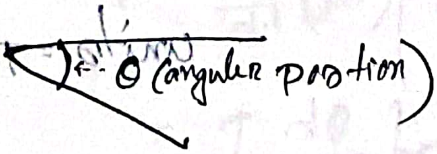
Electric Machines → Mechanical energy to electric energy.
or electric energy to mechanical energy.

Mechanical energy → Electric energy ⇒ GENERATOR.

Electric energy → Mechanical energy ⇒ Motor.

• Almost all the motors and generators convert energy from one from another through the magnetic field.

Angular position, θ: It is an object is the angle at which it is oriented (অবস্থান), measured from some willingly (স্বেচ্ছায়) reference point.



[measured in radians or degree].

Angular velocity, ω : It is the rate of change in angular position with respect to time.

(+) ধন চিহ্ন Counterclockwise

(−) " " clockwise ঋণ

Linear velocity defined as the rate of change of the displacement along line (r) with respect of time.

$$V = \frac{dr}{dt} \begin{matrix} \leftarrow \text{distance} \\ \leftarrow \text{taken time} \end{matrix}$$

Angular velocity ω is units are rad/s.

angular velocity $\Rightarrow \omega = \frac{d\theta}{dt} \begin{matrix} \leftarrow \text{angular position.} \\ \leftarrow \text{time.} \end{matrix}$

Angular Accleration : (α), It is defined as the rate change in angular velocity (ω) with respect of time

$$\alpha = \left(\frac{d\omega}{dt} \right) \leftarrow \text{angular velocity} \qquad \text{units} = rad/s^2.$$

Torque : τ : Torque is known as a rotational force applied on a rotating body giving angular acceleration called rotating force.

τ = force × perpendicular distance (অনুভূমিক ও চাপযোগ্য হয়)

$= F \times r\sin\theta$

Work, W : Work is defined as the application of force through a distance.

$$W = \int F\,dr.$$ [বক্র কোনো বিন্দু হিসাবে Line upper lower দিয়ে দিলে done).

$$W = Fr.$$

$$W = \int \tau\, d\theta$$ [for rotating bodies].

if τ is constant then $W = \tau\theta$.

Power, P : It is defined as rate of doing work.

$$P = \frac{dW}{dt}\ \text{(watts)}.$$

if apply it rotating bodies

$$P = \frac{d}{dt}(\tau\theta)$$

$$= \tau\frac{d\theta}{dt}$$ for $\omega = \frac{d\theta}{dt}$ ← angular velocity হয়।

$$= \tau\omega$$

Newton's Law of Rotation: Newton's Law for objects moving in a straight line gives a relationship between the force applied to the object and the accelaration experience by the object as the result of force applied to it..

त्वरण

$$F = ma$$

mass of object

accelaration.

applying it on rotating bodies.

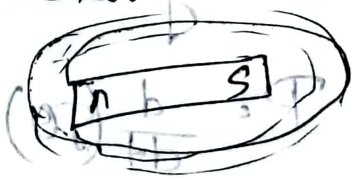
$$T = J\alpha \,(Nm)$$

angular accelaration.

moment of inertia

The magnetic field: It is the fundamental mechanism by which energy is converted from one from to another in motors, generators and transformers.

basic principle: 1) current carrying wire produces a magnatic filded in area around it.



Production of a magnetic field :

Ampere's Law : the basic Law governing the production of a magnetic field by a current.

$$\underset{\text{integration}}{\text{line of}} \oint H\,dL \xleftarrow{\text{Length}} = I_{net} \leftarrow \text{net current.}$$

ampere turns per meter

if Ampere Law is the mean path Length then I used then current Passing path integration Inet is then Ni

যত সংখ্যক বৃত্তাকার, বরাবর (N turns)

$$\Rightarrow H l_e = N i \text{ current} \text{ প্রবাহিত হচ্ছে বিদ্যুৎ।}$$

H defined magnetic field intensity প্রাবল্য

$$\boxed{H = \frac{Ni}{l_e}}$$

If megnetic field flux density (ঘনত্ব) হলে

$$B = \mu H \rightarrow \text{intensity.}$$

B → megnatic field flux; μ → constant, Permeability of meterial.

Faradays Law:

induced voltage from a time changing magnetic field.

<u>2nd law</u>

Directly proportional to the rate of changes in the flux with respect time.

induced voltage → $e_{ind} = \dfrac{d\phi}{dt}$ ← flux passing through coil.

dt ← time

If N number of turns in the coil তাহলে

$$\boxed{e_{ind} = -N\frac{d\phi}{dt}}$$

[এখানে (-) use হবে না Math এ (-) দিয়ে দিক বুঝায়
Lenz এর Law এ (-) use হবে]

Lenz Law: Lenz' Law states that the direction of the lectric current induced in a conductor by changing magnetic field is such that the magnetic field reated by the induced current opposes changes in e initial magnetic field.

$$E_b = -N\left(\frac{\Delta\phi}{\Delta t}\right)$$

$\boxed{S \quad N}$ (N) এখানে N clock wise হওয়ায় N হয়েছে but বিপরীত অবস্থান হলে S Cole আসবে So that বিপরীত অবস্থান হলে অতিক্রম দিবে না Same অবস্থান হলে আসতে দিবে না।

Math

$\phi = 0.05 \sin 377t$ Wb If there are 100-turn on core what voltage is produced at the terminal of the coil.

here $\theta = 0.5 \sin 377t$ wb, $N = 100$ turn.

we know

$$e_{ind} = N \frac{d}{dt} \theta$$

$$= 100 \cdot \frac{d}{dt} (0.05 \sin 377t)$$

$$= 100 \cdot 0.05 \frac{d}{dt} (\sin 377t)$$

$$= 5 \cdot \cos 377t$$

$$= (5 \cdot 377) \cos 377t \cdot \frac{d}{dt}(377t)$$

করে দাও

$$= 1885 \cos 377t \ V$$

(2) A coil that 700 turn develops an average induced voltage of 50V what must be the change in the magnetic flux occour to produce such voltage if the time interval of this chang 0.7s

here, $N = 700$.

$e_{ind} = 50V$.

$dT = 0.7s$.

Here we know

$$e_{ind} = N \frac{d\theta}{dt}$$

$$d\theta = \frac{e_{ind} \cdot dt}{N}$$

$$= \frac{50 \times 0.7}{700}$$

$$= 0.05\ wb.$$

$$\boxed{\begin{array}{c}\text{Short note} \\ d\theta \text{ unit} \Rightarrow wb \\ e_{ind} \text{ "} \Rightarrow V\end{array}}$$

(3) The magnetic flux linked with a coil having 250 turns is changed from 1.4 wb to 2.0 wb in 0.4 S calculate induced emf (eind) the coil.

here

$N = 250$

$d\theta = (2 - 1.4)\ wb$

$= 0.6\ wb.$

$dt = 0.4S$

We know that

$$e_{ind} = N \frac{d\phi}{dt}$$

$$= 250 \times \frac{0.6}{0.4}$$

$$= 375\ V.$$ (Ans).

Production of Induced Force on ~~Fire~~ wire.

here $F = i\,(L \times B)$

i — current flow

L — direction of current flow, length of conductor.

B — magnatic field density.

If the current conductor is position at an angle to the magnatic field then

$$\boxed{F = iLb\sin\theta}$$

Math

• If magnatic filux density is 0.25 T, directed into this page If the wire is 1.0 m long and carries 0.5 A of current in the direction from the top of the pages to the botom of the page what are the magnitude and direction of the force ~~of the~~ indiced on the wire.

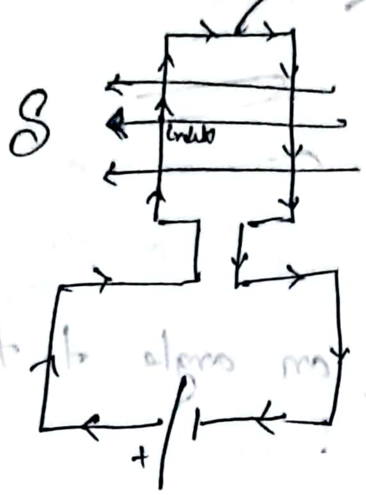
we know $F = iLb\sin\theta$

$= 0.05 \times 1 \times 0.25 \sin 90^\circ$

$= 0.125\,N$ (directed to right)

How to Motor works / Construction

Some way (ে generator উৎপন্ন হয়।



Motor → Fleming L. Hand Rule

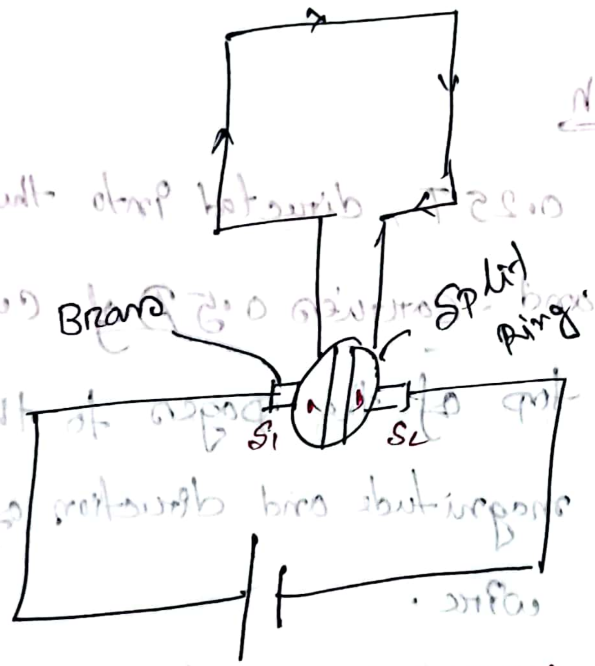
Generator → " Right " "

F – Force

B – flux density

I = Current

- Left hand ব্যবহার করলে দিয়েছেন fleming ratio স্বভাবই হয় Ir flow



① একই দিকে ঘুরবে use করলে সবসময় দিকে 180° পর motor current এর change হবে

② যেমন flow বাড়ে flow এর দিকে

· Continuous rotation কে দেয়া যা করে

- Split ring Ir যদি S_1 এ flow করে a দিয়ে then split ring ঘুরলে b Ir S_1 আবারে থেকে same current flow হবে।

[আবার fan always same flow এ ঘুরে]

Linear DC Machine:

- $f = i(l \times B)\sin\theta$ — magnitude wire, flux density, lenght of wire
- $e_{ind} = VBl\cos\theta$ [ভ্যাসপ perpendicular describe]
- $V_B - Ri - e_{ind} = 0$ ← $V_B - e_{ind} = Ri$ ← force 0 হলে তবে
- $F = ma$ — Newton law for bar across

$i = \frac{V_B - e_{ind}}{R}$

$i = \frac{V_B}{R}$

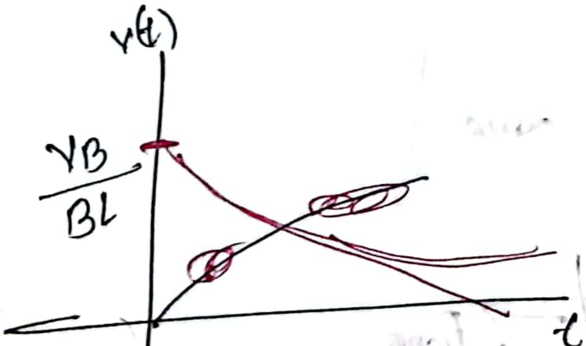
Kirchhoff's Voltage law

force থাকলে eind বাড়ে (movement বাড়ে)

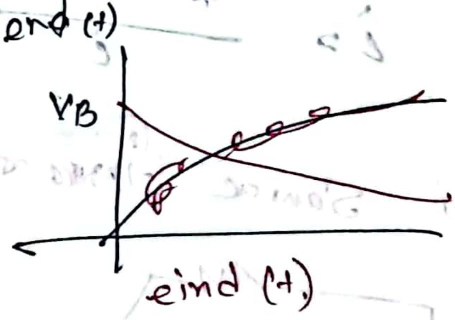
Statistic condition: $e_{ind} = V_B = V_{ss}BL$.

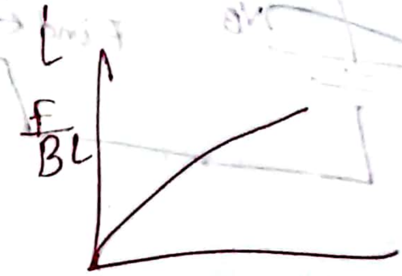
$F = ilb$ $\quad i = \frac{V_B}{R}$ $\quad e_{ind} = VBL$

$i = \frac{V_B}{R}$ → the current flow starting হয়.



velocity v(t) as function time





(i) current.

$e_{ind} > V_B$ - Generator

$e_{ind} < V_B$ - motor

Linear DC machine as a motor

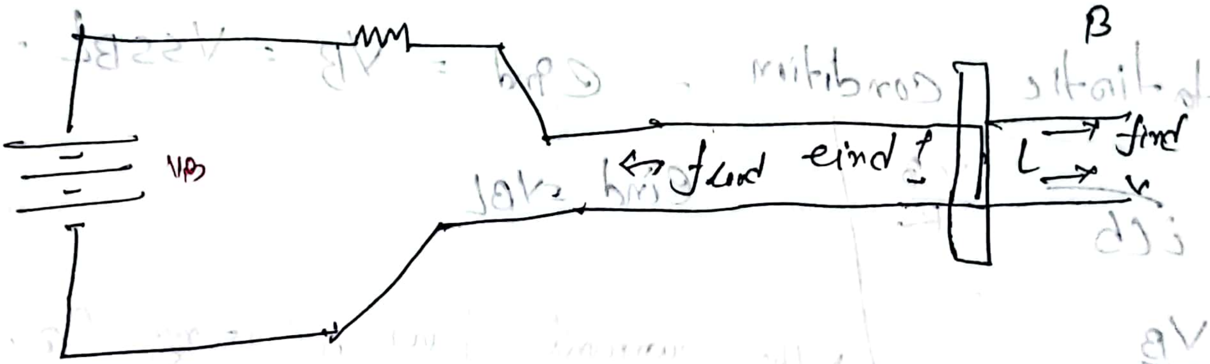
- $F_{net} = F_{Load} - F_{ind}$ direction

  সমান হবে / বাড়লে

- $e_{ind} = VBL$

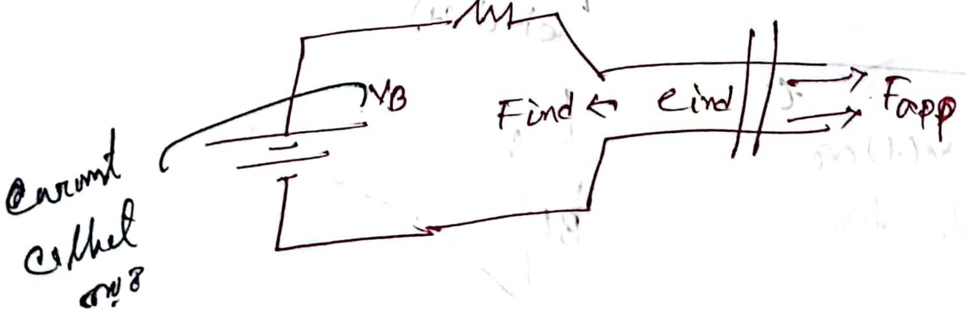
- $i = \dfrac{V_B - e_{ind}}{R}$ i কমবে / বাড়বে

- $F_{ind} = ilB$



Generator হলে $i = \dfrac{e_{ind} - V_B}{R}$ হবে বাকি same

- e_{ind} source হিসেবে কাজ করে



Induced voltage on a conductor moving in magnetic field.

• The voltage induced in the wire given by.

$$e_{id} = (v \times B) \cdot L$$

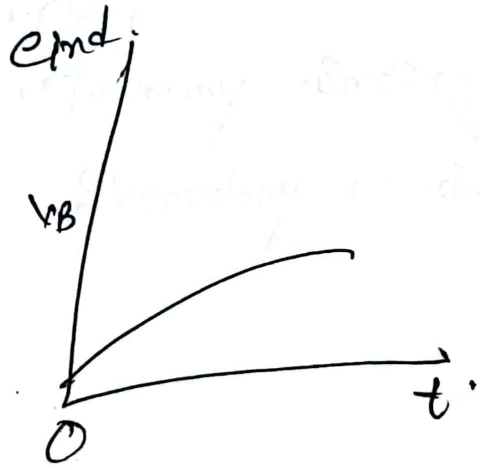
Induced voltage — velocity — mag flux density — length of conductor

—x—

বেগের (V) মান বাড়লে e_{ind} মান বাড়ে

$$C_2 \quad e_{ind} = v(BL)$$

constant



Transformer

· The transformer is a static device which change the voltage level and current level without changing the frequency.

work:

(i). Used to increase or decrease the current level.

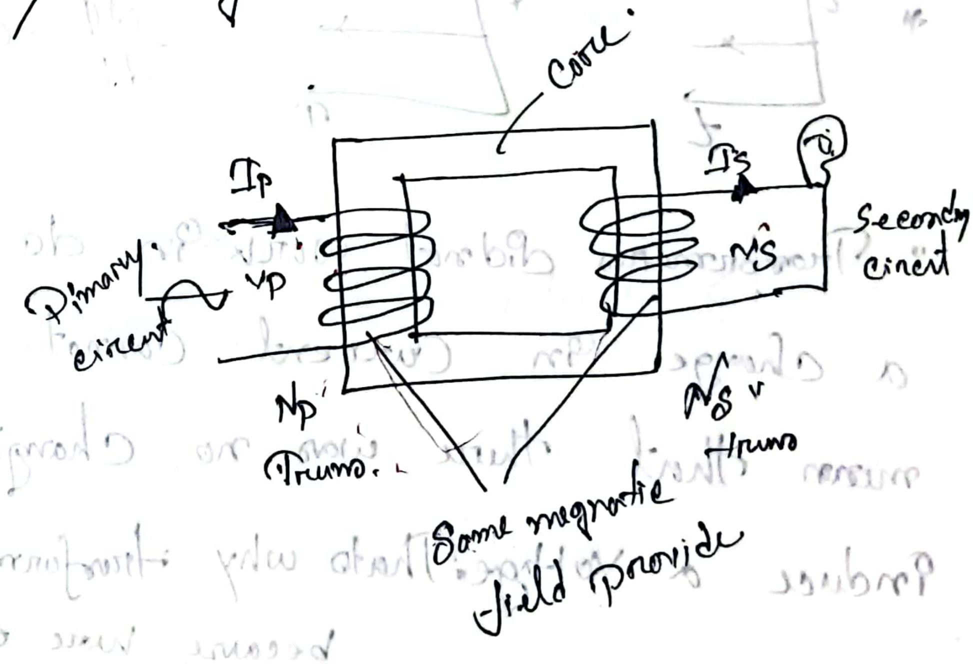
(ii) Adjust the voltage into proper level.

(iii) It is static device, i.e. It has no moving parts (voltage up down করে)

Construction:

Transformers are mainly three parts.

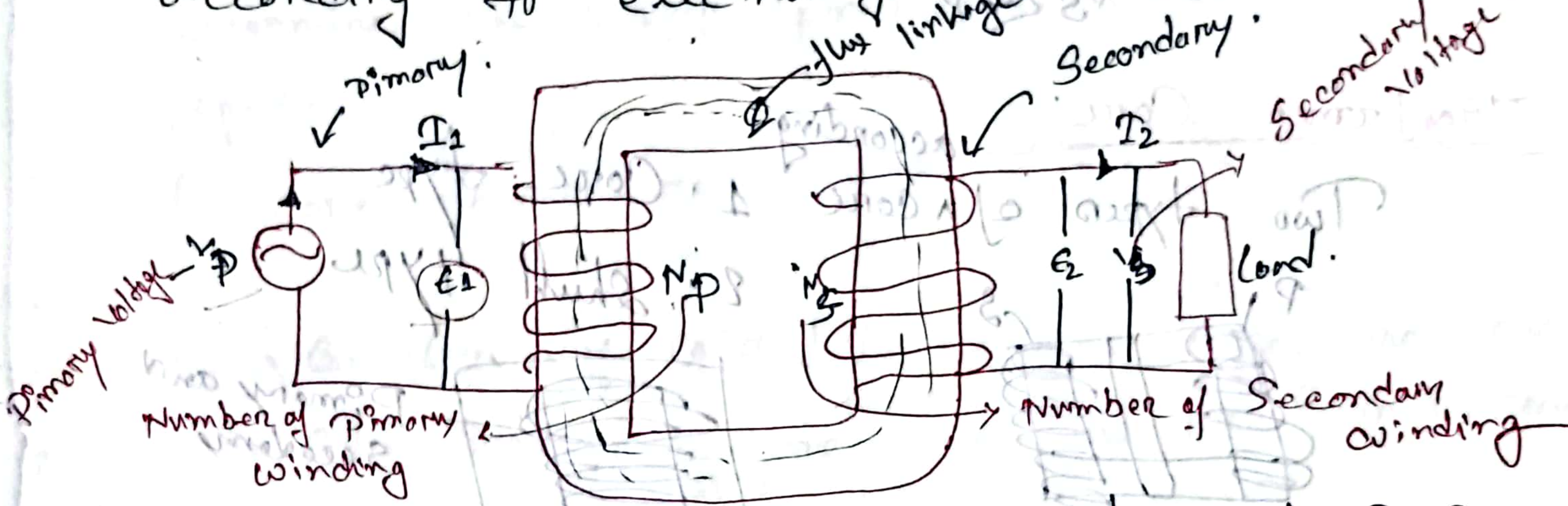
- Core
- Primary winding
- Secondary winding → not connected থাকে



[illegible]

Working Principle of Transformer

- The basic of a transformer is mutual induction between two circuits linked by a common magnetic flux. পারস্পরিক আবেশ
- It follows Faraday's electromagnetic induction.
- If one coil of transformer is connected to a source of voltage an flux is set up in the core. most of the flux is linked with other coil. according to electromagnetic induction.



when V_p is applied to the Pimary and e.m.f E_1 is induced known as primary E.m.f.

$$E_1 = -N_1 \frac{d\phi}{dt}$$

- The $E.m.f_2$ is termed as secondary E.m.f.

$$E_2 = -N_2 \frac{d\phi}{dt}$$

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

Transformer type:

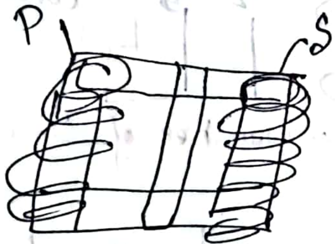
up → Send coil (Secondary)
down ← Primary coil

- Step-up transformer.
  - if $N_S > N_P$
    then $E_S > E_P$ ← Secondary coil set up
    or $V_S > V_P$
- Step Down
  - if $N_S < N_P$
    then $E_S < E_P$ ← Primary coil step down
    or $V_S < V_P$

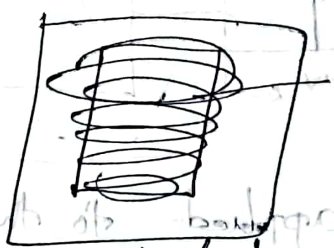
Transformer Core

Two types of core according

1. Core type
2. Shell type

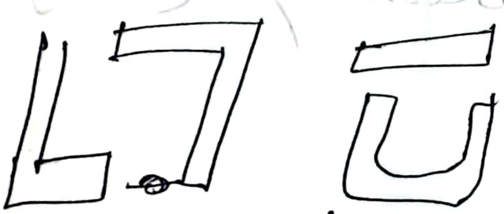


Core type



Shell type

magnetic core is made L/U shapes



for reducing leakage flux. Voltage winding one after one.

it is made E and I shapes

it surrounds a considerable part of winding.

Losses of Practical Transformer

- Copper loss — depends on the Current
- Core loss / Iron loss → depends on the Voltage of transformer
- leakage loss.

Copper Losses: The resistive (রোধজনিত) heating losses in Primary and Secondary winding in the transformer.

This loss is proportional to the square of the Current in the windings.

To determine the Copper losses short circuit test is Performed.

Total coper losses are $= I_1^2 R_1 + I_2^2 R_2$.

Iron loss: Core loss also called, The power losses that take palace in its iron core are known as the iron losses.

- ALternating flux set up ~~accouted~~ এর জন্য তৈরি হয়।
- open circuit test করলে determin করা যায়

Iron losses.

- Eddy Current
- hysteresis current

Eddy Current loss: Because of time variation of flux in magnatic material, Current is induced in the magnatic material it is called eddy Current losses.

[Core এ যদি কিছু voltage induced হয় Magnetic flux এর কারণে, তাকে eddy Current loss).
for heat produce হয়

They are proportional to the square of the voltage.
সমানুপাতিক

Hysteresis losses: It is ~~associated~~ connected with rearrangement of magnatic domins.

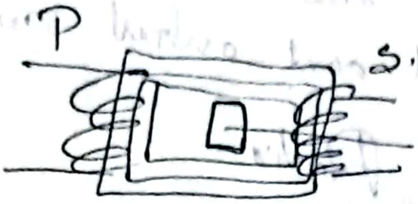
- This power is disappear in the form of heat is hysteresis.
[illegible]

- To reduce loss we need to select such type of material which has small hysteresis area.

- The eddy current and hysteresis current losses are both occours in the core of the transformer.

- We can reduce eddy ~~and~~ current losses making the core by med thin sheets together and reduce the hysteresis loss that the less area of the hysteresis loop

Leakage flux: The fluxes which escape the core and pass through only one transformer winding are leakage fluxes.



leakage current (current flow হচ্ছে না লিক leage).

- These escaped fluxes produce a self covering in primary and secondary coils.

The ideal Transformer:

- An ideal transformer is a loss-less device that has.
  - No winding resistance (রেজিস্ট্যান্স)
  - No leakage flux
  - No iron losses in the core

- why transformer Rating in KVA (volt ampere)?

⇒ we know copper losses depends on current, core iron loss are depends on the voltage. Also we dont know the value or nature of load. So we don't know the power factor. That's why transformer rating given in KVA not KW.

Turn Ratio: The relation between.

⇒ input voltage and output voltage.

⇒ input current and output current.

Are Called Turn Ratio.

Transformation Ratio ⇒ $\frac{E_2}{E_1} = \frac{N_2}{N_1} = K$.

Turns Ratio. ⇒ $\alpha = \frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{I_S}{I_P}$

Power in ideal Transformer:

Power input at primary

$$P_{in} \Rightarrow V_P I_P \cos \theta_P$$

Power output from Secondary.

$$P_{out} \Rightarrow V_S I_S \cos \theta_S.$$

Apply turn ratio $a = \frac{n_P}{n_S}$

$$V_S = V_P / a \quad I_S = a I_P.$$

$$P_{out} = \frac{V_P}{a} (a I_P) \cos \theta.$$

$$P_{out} = V_P I_P \cos \theta = P_{in}$$

for ideal transformer

⇒ $\frac{I_2}{I_1} = \frac{V_1}{V_2} = \frac{1}{K_1}$

$V_1 I_1 = V_2 I_2$

Impedance Transformation.

$\frac{V_P}{V_S} = a$

Primary Voltage $V_P = aV_S$. $V_P = BS a$

" Current $I_P = \frac{I_S}{a}$ — a and k same mean

$I_S / I_P = a$

$I_P = \frac{I_S}{a}$

The apparent impedance of primary is

$$Z_L' = \frac{V_P}{I_P} = \frac{a\,V_S}{I_S/a} = a^2 \frac{V_S}{I_S}$$

$$Z_L' = \cancel{a^2 Z_P} \cdot a^2 Z_L$$

a^2 and k^2 same mean.

Shifting impedance by transformation Ratio.

$$\frac{V_2}{V_1} = E_2/E_1 = \frac{N_2}{N_1} = K.$$

for primary Equivalent of the sec induced voltage $E_2' = \frac{E_2}{K} = E_1$

Similarly $V_2' = V_2/K$.

Secondary current $I_2' = K I_2$

for transfering sec impedance to primary K^2 used.

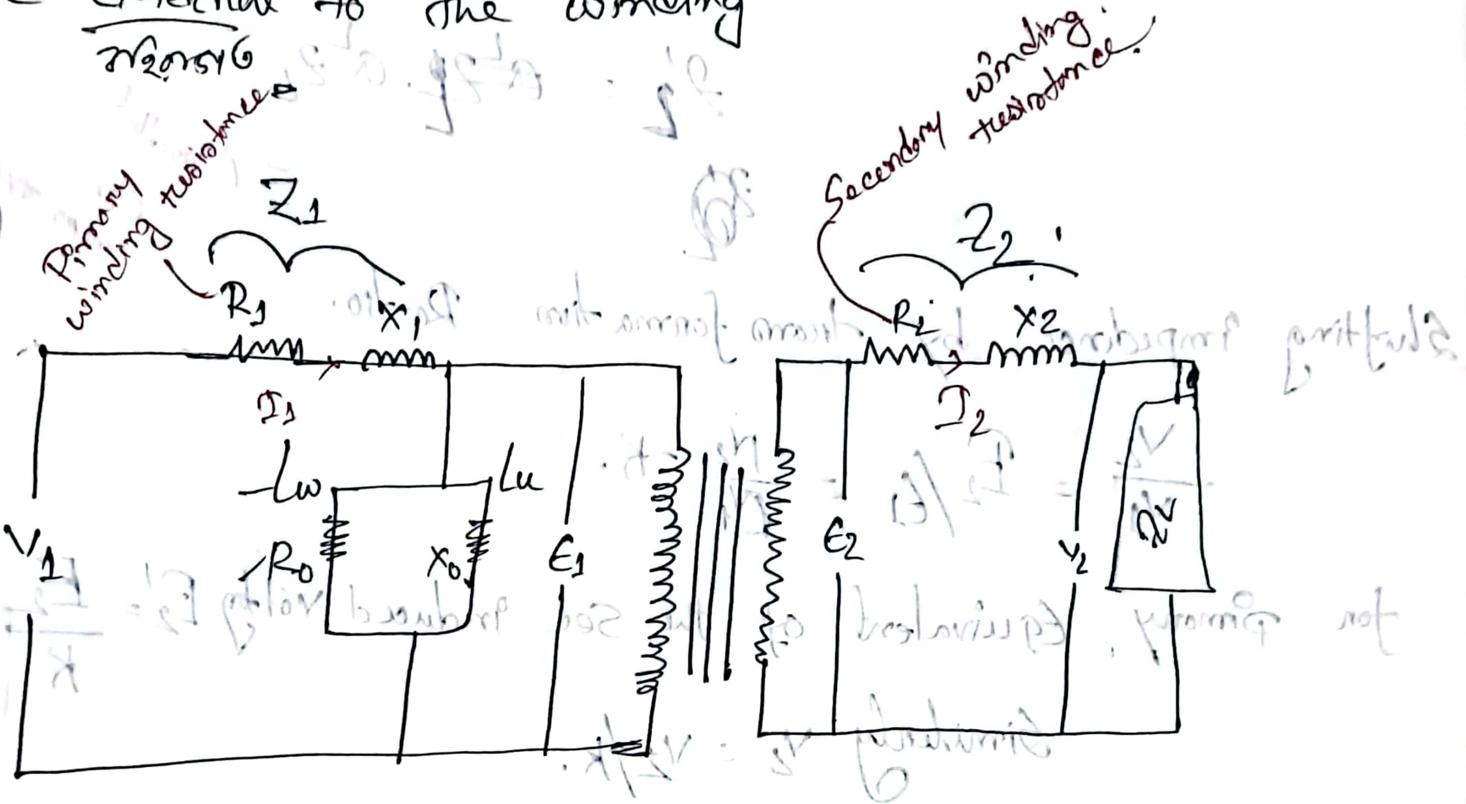
$R_2' = R_2 / K^2$

$X_2' = X_2 / K^2$

$Z_2' = Z_2 / K^2$

Equivalent transformer Circuit for

• Equivalent circuit transformer is basically an equivalent circuit in which the resistance (রোধকত্ব) and leakage reactance (প্রতিরোধ্য) of the transformer are imagined to be external (বহিঃস্থ) to the winding



R_1 = Primary winding (Copper loss)

R_2 = Secondary " (")

X_1 = leakage

X_2 = "

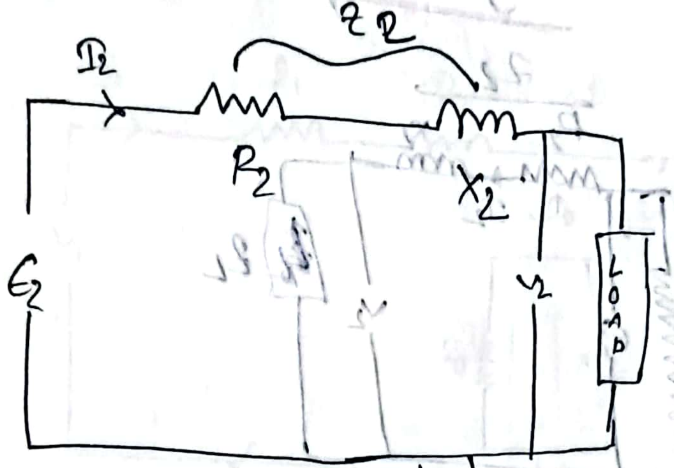
X_0 = inductor

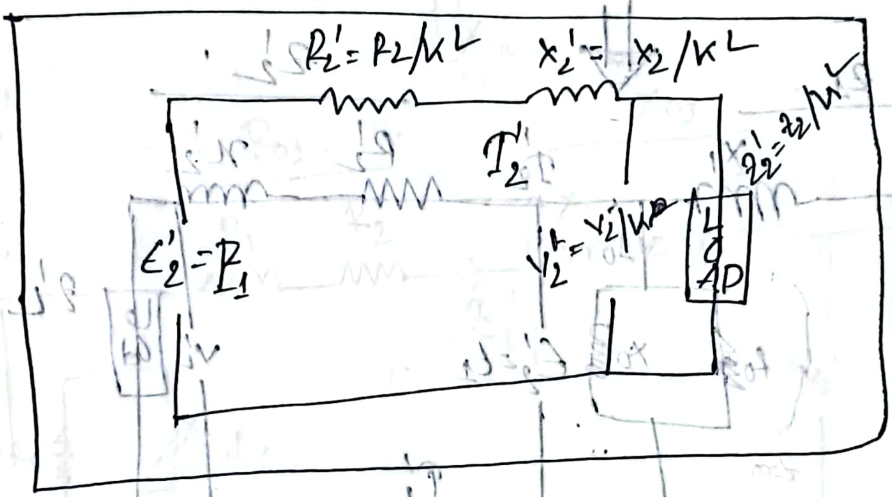
R_0 = iron loss (Eddy and histeresis)

I_μ = Magnetizing component

I_w = working component (iron loss)

Secondary Impedance referred to Primary





$R_2' = R_2/K^2$

$X_2' = X_2/K^2$

$Z_2' = Z_2/K^2$

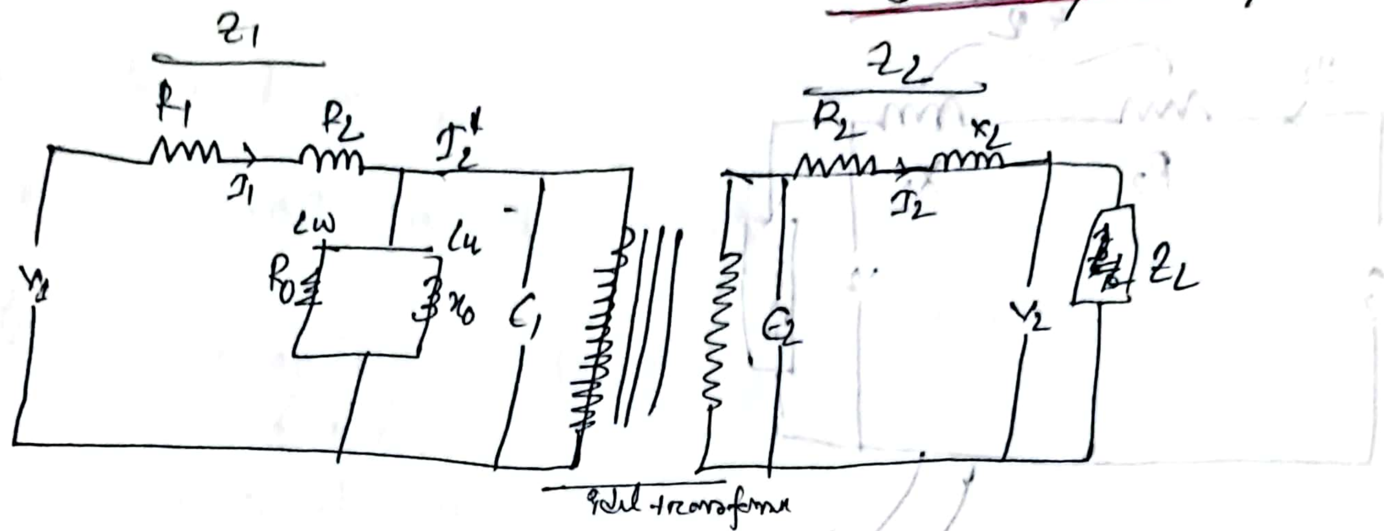
Shortcut:

Primary ⇒ Secondary ↷ K गुण हुआ

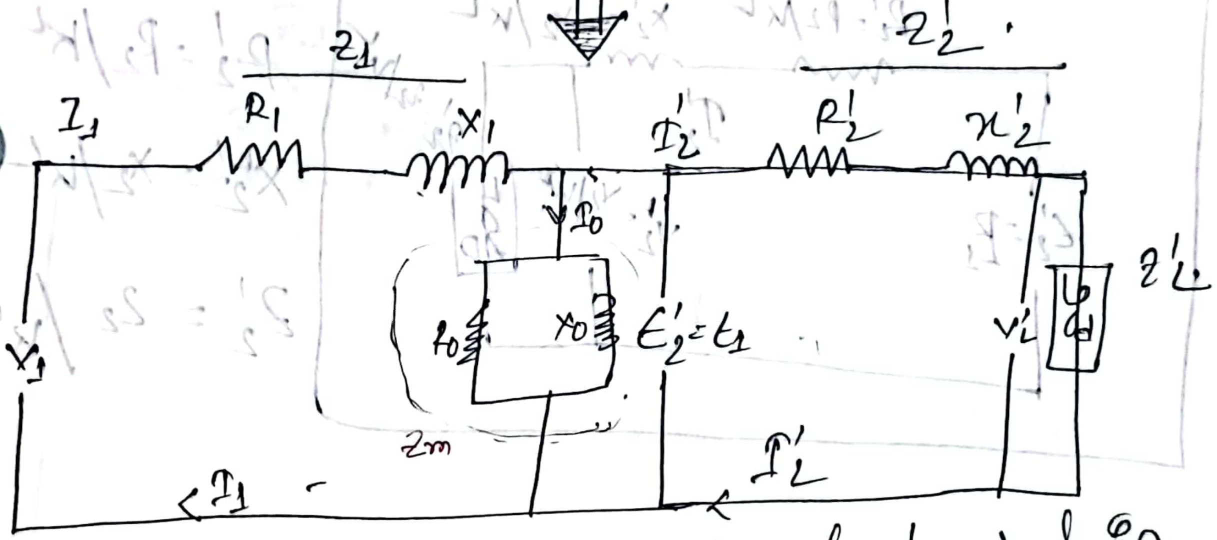
Secondary ⇒ Primary ↷ $\frac{1}{K^2}$ भाग हुआ

high voltage side → Primary side

Equivalent Circuit
- Referred to Primary.



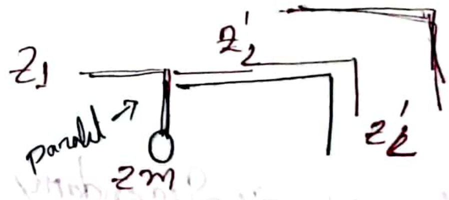
Equivalent circuit diagram.



total impedance between the input terminal in.

$$Z = Z_1 + Z_m \,||\, (Z_2' + Z_L')$$

$$= Z_1 + \frac{Z_m(Z_2' + Z_L')}{Z_m + (Z_2' + Z_L')}$$



or

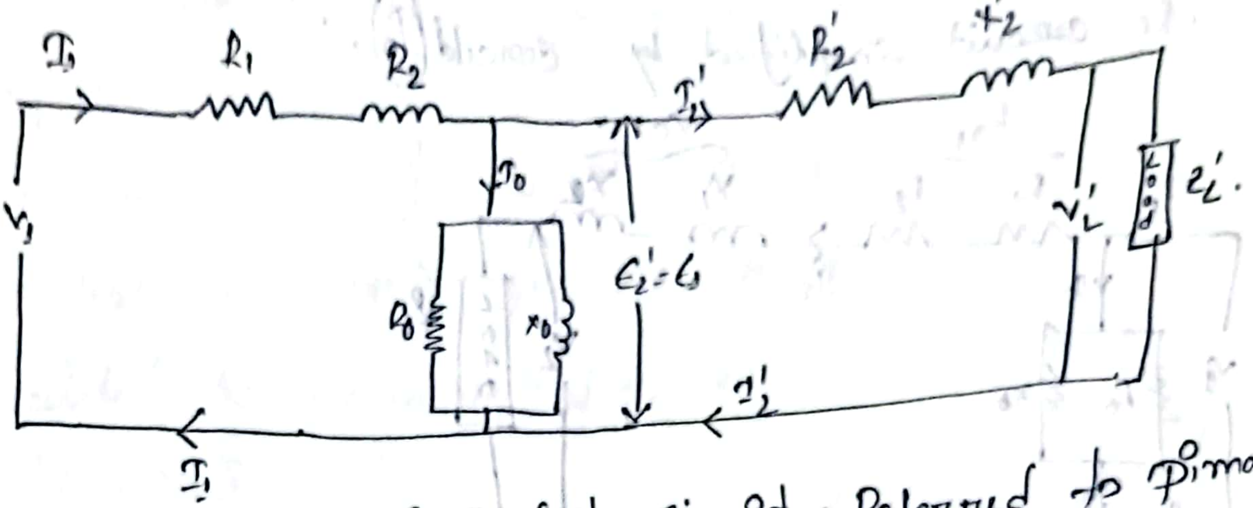
$Z_m || Z_2' + Z_L'$

parallel element $A||B = \frac{AB}{A+B}$

$$V_1 = I_1 \cdot Z_1$$

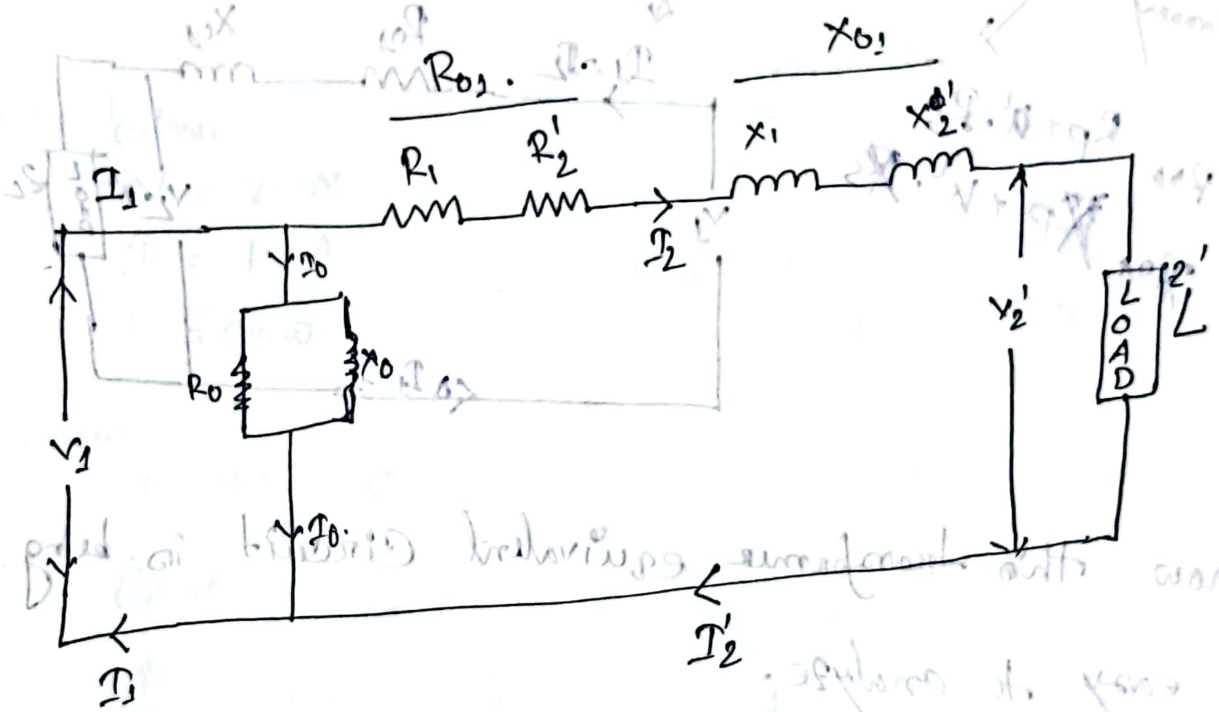
$$= I_1 \left[Z_1 + \frac{Z_m(Z_2' + Z_L')}{Z_m(Z_2' + Z_L')} \right.$$

Exact Equivalent Circuit:



Equivalent circuit - Referred to primary

$\Downarrow$



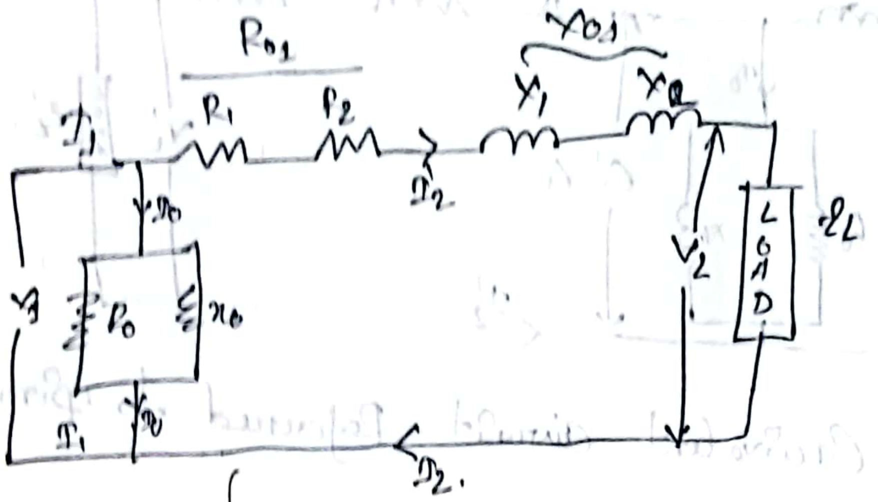
Side note

\# For well designed transformer

$\phi_m >> \phi_{LP}$ → অর্থাৎ Mutual flux এর মান large there remain

Approximate Equivalent Circuit

Now the circuit simplified by cancel I_0.

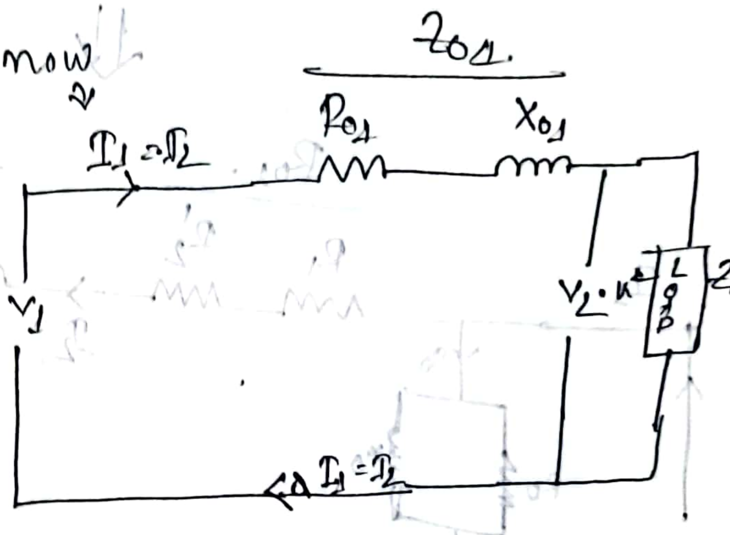


ref to primary

R_{01} $R_p + k^2 \cdot R_s$

X_{01} $X_p + k^2 \cdot X_s$

now



now this transformer equivalent circuit is being So easy to analyze.

h.v থাকে Secondary

L.V " Primary.

Transformer Math C213067

① 5 KVA 200/1000 V, 50Hz, Single-phase transformer gave the following test results.

O.C test (L.V Side): 200 V, 1.2A, 90W

S.C test (H.V Side): 50V, 5A, 110W.

a. Calculate the parameters of the equivalent circuit referred to the L.V Side.

b. Calculate the parameters of the equivalent circuit referred to the H.V Side.

Ans A

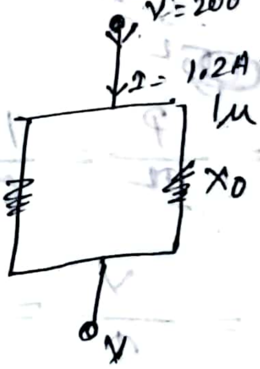
Given

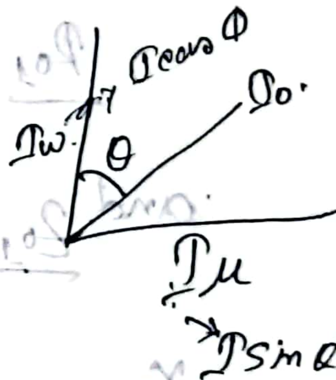
$V = 200V$

$I = 1.2A$

$P = 90W$.

O.C Circuit (L.V Side)





We know

$$P = VI \cos\phi$$

$$\cos\phi = \frac{P}{VI}$$

$$\phi = \cos^{-1}\left(\frac{P}{VI}\right)$$

$$= \cos^{-1} \frac{90}{(200 \times 1.2)}$$

$$= 67.98$$

now

$$I_w = I\cos\phi$$

$$= 1.2 \cos 67.98$$

$$= 0.45A$$

$$I_\mu = I\sin\theta$$

$$= 1.2 \cdot \sin 67.98$$

$$= 1.11A.$$

Now $R_0 = \frac{V}{I_w}$ $\qquad X_0 = \frac{V}{I_\mu}$

$= \frac{200}{0.45}$ $\qquad = \frac{200}{1.11}$

$= 444.44\,\Omega$ $\qquad = 180.180\,\Omega$

Ans B

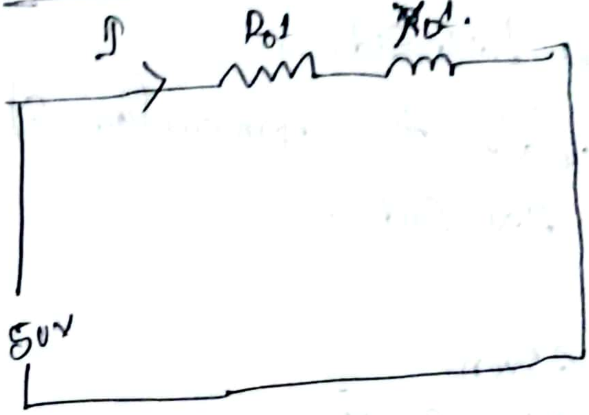
Given.

$V = 50V$

$I = 5A$

$P = 110W$

Short circuit (H.V side)



we know that,

$P = I^2 R_{01}$

$R_{01} = \frac{P}{I^2} = \frac{110}{5^2} = 4.4\,\Omega$

and $Z_{01} = \frac{V}{I} = \frac{50}{5} = 10\,\Omega.$

$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$

$= \sqrt{10^2 - (4.4)^2}$

$= 8.98\,\Omega.$

① referred to the L.V man primary side

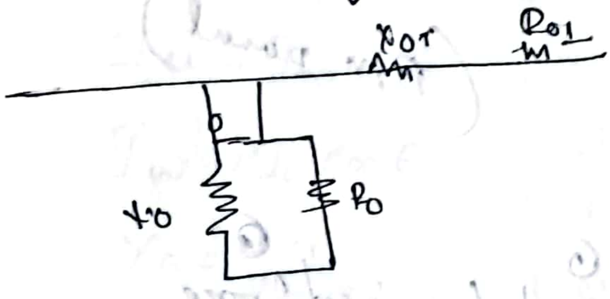
$k = \frac{1000}{200} = 5$

$Z_{01} = \frac{Z_{02}}{k^2}$

$= \frac{10}{25} = 0.4\,\Omega$

$X_{01} = \frac{X_{02}}{k^2} = \frac{8.98}{25} = 0.9592\,\Omega$

$R_{01} = \frac{R_{02}}{k^2} = \frac{4.4}{25} = 0.176\,\Omega$



H.V seconder referred

$X_0 = 179.79 \times k^2$

$R_0 = \times W$

$R_0' = \times W$

W^2

$R_t \cdot =$

Open Circuit test

No load test

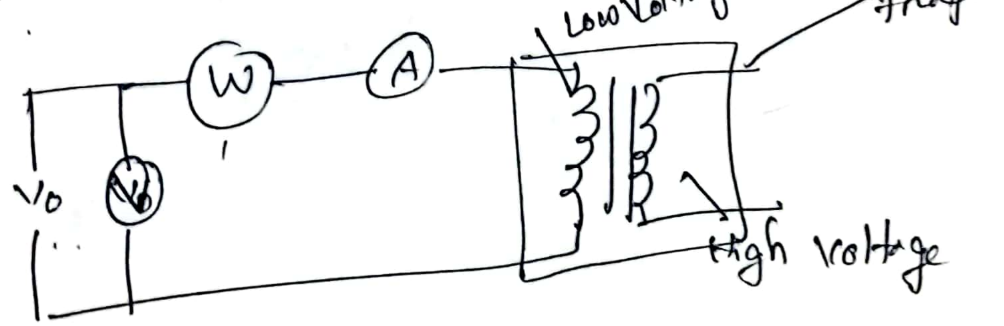
why transformer tests is needed.

- The performance of a transformer can be calculated on the basis of its equivalent circuit which contains 4 main parameters.
- These parameters can be easily determined by two steps
  - ⇒ open circuit test / no load test (R, x pannel)
  - ⇒ Short circuit test / impedance test.

Open circuit test

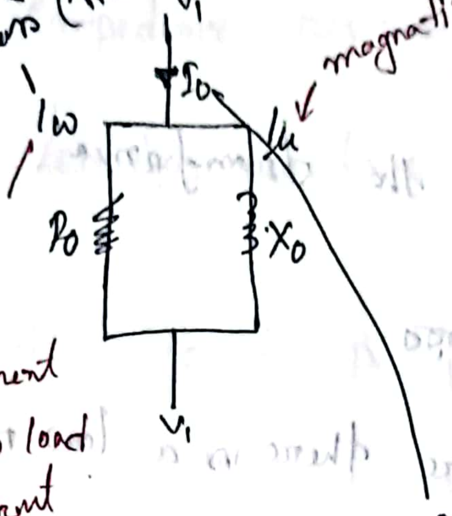
- Core losses determined করে
- open circuit in low voltage.
  - wattmeter ⇒ power মাপে — iron losses measures করে
  - Amp meter ⇒ Current মাপে (I_0)
  - volt meter ⇒ voltage মাপে — Low voltage

- open circuit থাকবে open করে



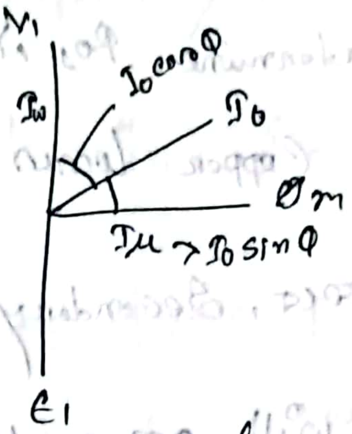
(*) working current
core loss (iron loss)

magnetizing component of no load current



Core loss component of no load current

no load current



I_W = Iron loss
I_μ = magnetizing current.
I_0 = no load current

here $I_\mu = I_0 \sin\theta$

$I_W = I_0 \cos\theta$

$X_0 = \dfrac{V_1}{I_\mu}$

$R_0 = \dfrac{V_1}{I_W}$

no load power $P = V_1 I_0 \cos\theta$

$Z_0 = \sqrt{R_0^2 + X_0^2}$

$W = V_1 \cos\phi$
P

$\cos\theta = \dfrac{W}{V_1 I_0}$

$I_0^2 = I_\mu^2 + I_W^2$

$= \sqrt{I_\mu^2 + I_W^2}$

No load power = Core loss + Cu loss
iron: $I_0^2 R$; $I_0^2 R$

Sort note:

Cu loss using individual two winding $\Rightarrow I_1^2 R_1 + I_2^2 R_2$

Cu " " equivalent resistance each side

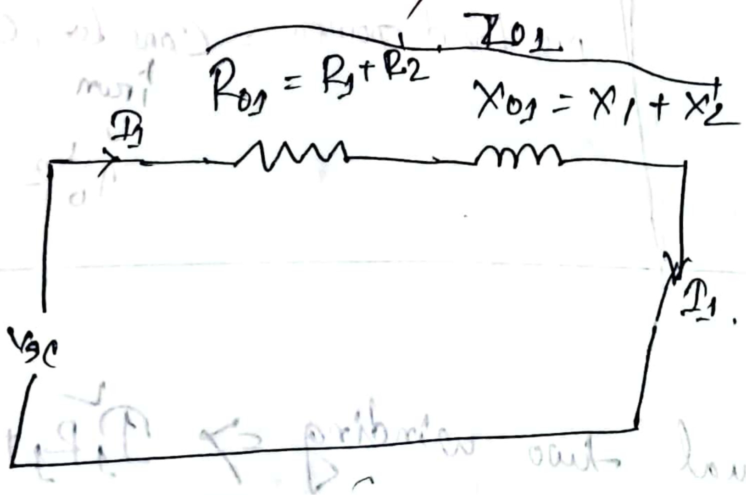
$\Rightarrow I_1^2 R_{01}$

$\Rightarrow I_2^2 R_{02}$

Short circuit Test.

- Conducted to determine R_{01}, X_{01}.
- Its full load Copper losses of the transformer
- Primary তে থাকবে, Secondary বন্ধ
- Short circuit will occur where there is a low resistance.. [Low voltage হয়) (R, X series)

- Full load Cu loss P_c = wattmeter reading = W_s.
- Voltage = Voltmeter reading = V_{sc}
- Full load primary current = Ammeter reading = I_1.



$$P_c = I_1^2 R_1 + I_1^2 R_2' = I_1^2 R_{01}.$$

$$P_c = I_1^2 R_{01}.$$ → total resistance referred to primary.

$$R_{01} = \frac{P_c}{I_1^2}.$$

- Total impedence referred to primary $Z_{01} = \dfrac{V_{sc}}{I_1}$
- " leakage reactance " " " $X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$

Sort circuit P.f.| Power factor $P = VI\cos\theta$

$\cos\theta = \dfrac{P}{VI}$

Marth open test & and Sort circuit test

- equivalent ~~resistance~~ or referred Pimary resistance তাকে $\underline{R_{01}}$ $= \cancel{R_2 + R_1 \cdot K^2}$ $= R_1 + \dfrac{R_2}{K^2}$
- " " " " Secondury $R_{02} = R_1 \times K^2 + R_2$.
- " reactance তাকে $\underline{X_{01}}$ হলো X_{01}.

Primary $= X_{01} = R_1 + \dfrac{R_2}{K^2}$

Secondury $= X_{02} = R_1 \times K^2 + R_2$

- equivilent impedence তাকে

Pimary $Z_{01} = \sqrt{R_{01}^2 + X_{01}^2}$

Secondry $Z_{02} = \sqrt{R_{02}^2 + X_{02}^2}$

Math Ceo3067

(2) A 100 KVA. 2000/440 V transformer has $R_1 = 5\ \Omega$. $R_2 = 0.08\ \Omega$.

The values of reactances $X_1 = 6\ \Omega$, $X_2 = 0.05\ \Omega$.

A. Calculate equivalent Impedance referred to primary.

B. Calculate equivalent impedance referred to secondary.

(A)

here $K = \frac{V_2}{V_1} = \frac{440}{2000} = 0.22$.

$R_1 = 5\ \Omega$, $R_2 = 0.08\ \Omega$, $X_1 = 6\ \Omega$, $X_2 = 0.05\ \Omega$.

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

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

$= 5 + \frac{0.08}{(0.22)^2} = 6.65\ \Omega$.

$X_{01} = X_1 + X_2'$

$= X_1 + \frac{X_2}{K^2}$

$= 6 + \frac{0.05}{(0.22)^2}$

$= 7.03\ \Omega$.

Impedence of Pimary Side $Z_{01} = \sqrt{R_{01}^2 + X_{01}^2}$

$= \sqrt{(6.65)^2 + (7.03)^2}$

$= 9.68\ \Omega$.

Ans B.

$K = 0.22$, $R_1 = 5\ \Omega$, $R_2 = 0.08\ \Omega$, $X_1 = 6\ \Omega$, $X_2 = 0.065\ \Omega$

Now $R_{02} = R_1' + R_2$

$= R_1 \times K^2 + R_2$

$= \cancel{0.08}\ 5 \times (0.22)^2 + 0.08 = 0.322\ \Omega$.

$X_{02} = X_1' + X_2$

$= X_1 \times K^2 + X_2$

$= 6 \times (0.22)^2 + 0.065 = 0.2954\ \Omega$.

Impedence on Secondary Side $Z_{02} = \sqrt{R_{02}^2 + X_{02}^2}$

$= \sqrt{(0.322)^2 + (0.2954)^2}$

$= 0.44\ \Omega$.

③ A 50-KVA 4400/220 V transformer has $R_1 = 3.45\,\Omega$, $R_2 = 0.009\,\Omega$. The values of reactances are $X_1 = 5.2\,\Omega$ and $X_2 = 0.015\,\Omega$. Calculate for the transformer.

(i) equivalent resistance as referred to primary.

Ans

$$K = \frac{220}{4400} = 0.05$$

$R_1 = 3.45$

$R_2 = 0.009$

$X_1 = 5.2$

$X_2 = 0.015$

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

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

$$= 3.45 + \frac{0.009}{(0.05)^2}$$

$$= 7.05\,\Omega$$

(ii) Equivalent resistance as referred to secondary.

$$R_{02} = R_1' + R_2$$

$$= R_1 \times K^2 + R_2$$

$$= 3.45 \times (0.05)^2 + 0.009$$

$$= 0.176\,\Omega.$$

(iii) equivalent ~~resistance~~ reactance both primary and secondary

$X_{01} = X_1 + \frac{X_2}{K^2} = 5.2 + \frac{0.015}{(0.05)^2} = 11.2\ \Omega.$

$X_{02} = X_2 + X_1 \cdot K^2 = 0.015 + 5.2 \times (0.05)^2 = 0.028\ \Omega$

(iv) Equivalent impedance as referred to both primary and secondary.

find value in (3) (4)

Impedence as primary $Z_{01} = \sqrt{R_{01}^2 + X_{01}^2}$

$= \sqrt{(7.05)^2 + (11.2)^2}$

$= 13.23\ \Omega$

Impedence as secondary $Z_{02} = \sqrt{R_{02}^2 + X_{02}^2}$

$= \sqrt{(0.176)^2 + (0.028)^2}$

$= 0.03311\ \Omega.$

(v) Total Cu loss first using individual resistance of the two winding and secondly, using equivalent resistance as reffered to each side.

Ans 5

Cu loss using individual resistance of two winding

$$Cu\ loss = I_1^2 R_1 + I_2^2 \cdot R_2$$

$$= (11.36)^2 \cdot 3.45 + (227.27)^2 \cdot 0.009$$

$$= 910\ W.$$

$I_1 = \frac{50k}{4400}$

$= 11.36$

$I_2 = \frac{50k}{220}$

$= 227.27$

$R_{01} = 7.05$

$R_{02} = 0.0176$

Cu loss using equivalent resistance as referred to each side:

$$Cu\ loss = I_1^2 R_{01}$$

$$= (11.36)^2 \cdot 7.05$$

$$= 910\ W.$$

$$Cu\ loss = I_2^2 R_{02}$$

$$= (227.27)^2 \times 0.0176$$

$$= 910\ W.$$

CamScanner

Motor Sizing

Motor : It converts electrical energy into mechanical energy.

• mechanical power of the motor (P) measured in Watts.

$1 HP = 746 W$.

Speed (N) : The number of revolutions per minute of the motor

$n = \frac{N}{60}$, $\omega = 2\pi N/60$

revs per sec , radians per second.

Torque : The force with which a motor turns is called.

Torque · measured in Nm.

Relation betn Power, Speed and Torque :

$$P = \frac{2 \cdot \pi \cdot T \cdot N}{60}$$

Rms power : $= \sqrt{\frac{P_1^2 t_1 + P_2^2 t_2 + P_3^2 t_3 + \cdots P_n^2 t_n}{t_1 + t_2 + t_3 + \cdots t_n}}$

Efficiency : $\eta = \dfrac{\text{output}}{\text{input}} \times 100\%$.

$$\eta = \frac{P_{mecanical}}{P_{electrical}} \times 100\%.$$

* Motor Sizing refers to the process of picking the correct motor for a given load.

* যদি motor বেশি ছোট হয়, অর্থাৎ প্রয়োজনমত torque না থাকে, Start হওয়ার জন্য প্রতিত Spped এ. তখন ঐ motor will overheat and burnout হবে।

* If motor বেশি বড় for an application. Money has been wasted.

তাই Motor প্রয়োজনমত Size এ হবে.

Choosing Right motor

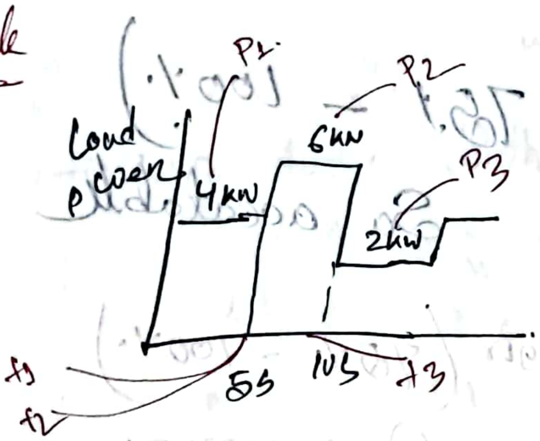
For Load torque is constant) then Choosing a motor wh- ose rated torque is slightly above the torque required by the load.

The load torque should be btn 75% – 100% of the rated motor torque 95% is Ideal choice

right motor area

Also Loading torque = $T_{motor} - T_{load}$

Example



(Service factor 20%)

100+20
= 120%

$\boxed{SF = 1.2}$

⇒ Load max are 6 kW → Load (max)

Load power (max) < Pmotor × Service factor

Pmotor ⩾ 6/1.2

= 5 kW

$$\text{Rms load power} = \sqrt{\frac{P_1^2 t_1 + P_2^2 t_2 + P_3^2 t_3 \cdots P_n^2 t_n}{t_1 + t_2 + t_3 + \cdots + t_n}}$$

$$= \frac{4^2 \cdot 5 + 6^2 \cdot 5 + 2^2 \cdot 10}{5 + 5 + 10}$$

$$= 4.16 \text{ KW}$$

· If $P_{motor} = 5 \text{ kW}$

$$\text{Rms load power} = \frac{4.16}{5} \times 100\%$$

$$= 83\% \; (75\% - 100\%)$$

— So accatable

Chose 5 KW motor bcz এটা (75% - 100%) ভিতরে আছে Rms load power.

· Starting perpormance

~~mape~~ দরকার নাই এর math ও।

Motor duty class

Motor run করে কিছু time ব্যবহারের হতে পারে।

(Some motors run all the time Some Motor Run Sorter rest period).

Motor duty Class 8 categories.

1. Continious duty = mail industry = running long
2. Sort time duty = home hold, crane — time operation Low
3. Intermittent periodic duty - some time and rest (Press unit etc)
4. " " " with strating and braking - billed mail
5. " " " Starting = cutting metel
6. Continious duty with intermittent periodic loading.
   ∟ no load running period
7. " " " Starting and braking.
   ∟ no resting period
8. " " " periodic speed changes.
   ∟ different running periods.
   load, speed

Contonius duty

Sort time "

Intermittent percodic duty

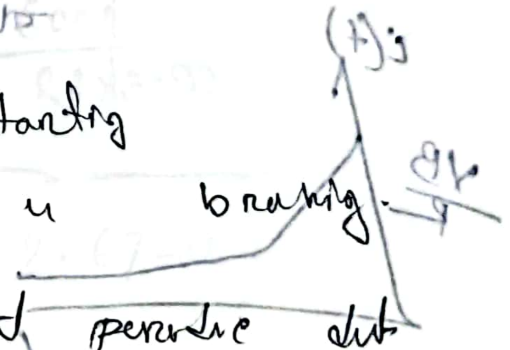
" " starting

" " braking

" " "

Continuous duty with intermittent periodic duty

" " " Standing and



...nym ratio $K = \frac{V_p}{V_s}$ ... current 0.5A.

$= \frac{110}{220}$ $V_p/V_s = \frac{220}{110} = 2$

Transformer EMF eq

N_p = No of primary turns.

N_s = No of Secondary turns.

ϕ_m = Max^m flux in the core in wb

$B_m \times A$ — area.

B_m — flux density

f = Supply frequency.

Avg rate of change flux $= \frac{\phi_m}{T/4}$ wb/s

Avg Emf / turn $= 4 f \phi_m$ Volt

For Ac wave.

$$\text{from factor} = \frac{\text{RMS}}{\text{Avg}} = 1.11$$

$$\text{Emf / turns (rms)} = 4.44 f \phi_m \text{ Volt.}$$

So induced Emf for primary (rms value)

$$= 4.4\, N_p f \phi_m \text{ Volt} \quad \text{আবার হবে}$$

$$= \boxed{4.44\, N_p f\, B_m \cdot A \text{ volt}}$$

2nd part

$$\text{Secondary} = 4.44\, N_s f \phi_m \text{ Volt}$$

$$= \boxed{4.44\, N_m f\, B_m A \text{ Volt}}$$

2nd part

$$\text{Hesterersis loss } P_h = K_h f B_m^{1.6}$$

$$\text{Eddy Current loss } P_e = K_e f^2 B_m^2.$$

here

$$E = 4.44\, N f \phi_m.$$

$$\phi_m = \frac{E}{4.44\, N f} \quad \therefore B_m A = \frac{E}{4.44\, N f}.$$

$$B_m = \frac{A}{4.44NA} \times \frac{E}{f}$$

$$B_m = \frac{E}{f}$$

$$= K \cdot \frac{E}{f}$$

Total core loss $(P_c) = P_h + P_e$

$$= K_h f \times k^{1.6} \frac{E^{1.6}}{f^{1.6}} + K_e f^2 \times \frac{k^2 E^2}{f^2}$$

$$= K_1 \cdot \frac{E^{1.6}}{f^{0.6}} + K_2 E^2$$

hysteresis depend on supply voltage current

eddy " only voltage

Short cut hysteresis and eddy

$$\boxed{\begin{aligned} W_{hysteresis} &= Af \\ W_{eddy} &= Bf^2 \end{aligned}}$$

Area of core = $E_2 = -4.44 f N_2 B_m A$

$\therefore A =$ বাই বাদ (৩.২০)

[illegible] Core Example

$$\boxed{\begin{aligned} W_h &= AF \\ W_e &= Bf^2 \end{aligned}}$$

[illegible]

$W_h = AF$ [illegible]

$W_e = Bf^2$ [illegible]

[illegible]

$W_h = AF$

= [illegible]

= 1300 W

$W_e = Bf^2$

= [illegible]

= 1400 W

Total (1300 + 1400) = 2700 Core loss

32.1

here emf turn 8 v

flux density 250/3000 v
E_1 E_2

we know

E_1 = N_1
em

(i) $E_1 = N_1 \times$ Emf induced per turn

$\therefore N_1 = \frac{E_1}{\text{Emf induced per turn}}$

$= \frac{250}{8} = 32$

$\frac{E_1}{N_1}$ = Emf in

Same $N_2 = \frac{3000}{8} = 375$

(ii) area of the core

$E_2 = 4.44 f N_2 B_m A$.

$3000 = 4.44 \times 50 \times 375 \times 1.2 \times A$.

$\therefore A = 0.03 m^2$.

32.8

(i) The peak value of flux density in the core.

$V = 520$, f

$$\frac{E_2}{E_1} = K \quad \therefore E_2 = K E_1 \quad \left[K = \frac{N_2}{N_1} = \frac{1000}{400} = 2.5 \right]$$

$$= 2.5 \times 520$$

(ii) the voltage induced in the secondary winding

$$E_1 = 4.44 f N_1 B_m A$$

$$520 = 4.44 \cdot 50 \times 500 \times B_m (60 \times 10^{-4})$$

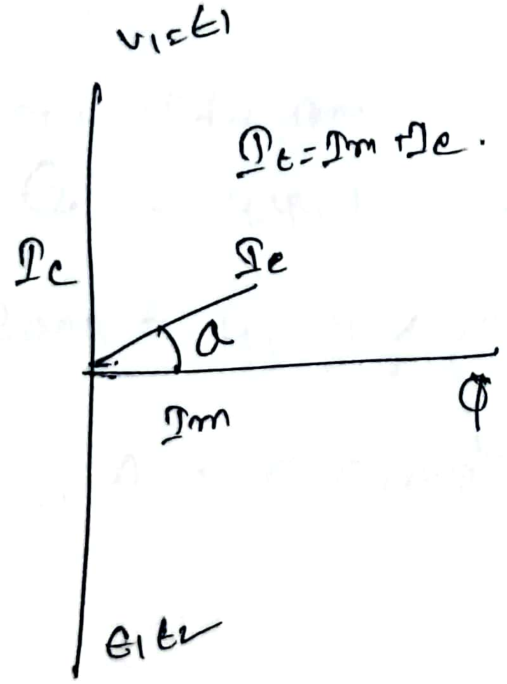
$$\therefore B_m = 0.976 \text{ Wb/m}^2$$

20 | 36

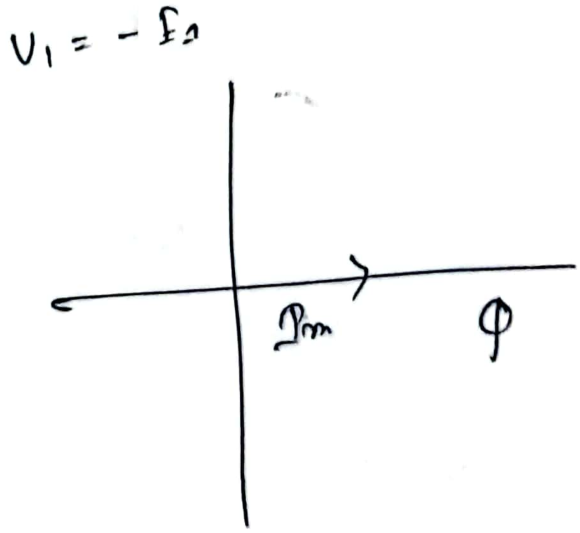
~~transformer machine~~

Practical vs Ideal Transformer

Practical	Ideal
• which has some energy losses ~~inside~~ inside the transformer.	• ~~which~~ is ~~has~~ imaginary transformer • which has no energy losses
• Inhale core losses.	• Core losses, are zero.
• Inhale coper losses.	• Copper loss are zero.
• Efficency less than 100	• Efecency is equal 100.

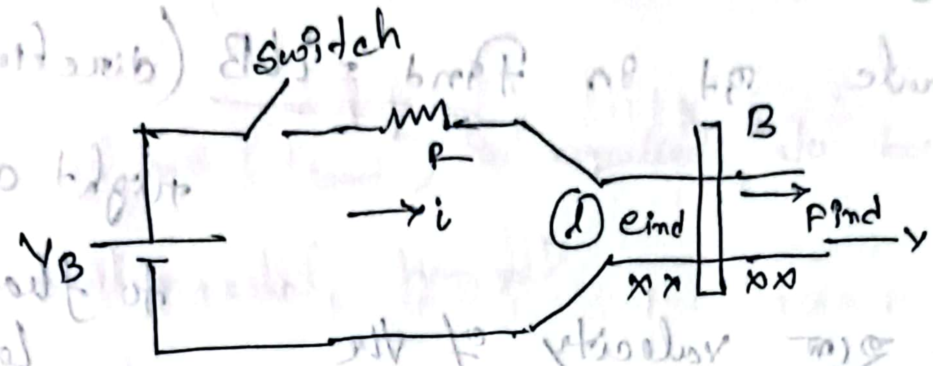


pharsar diagram (no load).



pharsar diagram (no load)

Linear DC machine



(i) $F = ilB$ — Magnetic flux density. — Current following through conductor.

(2) $e_{ind} = VBL$

(3) $V_B - iR - e_{ind} = 0$ — (V) maximum velocity of the moving conductor.

$\therefore i = \frac{V_B - e_{ind}}{R}$

Supply voltage.

(4) $F_{net} = ma$ → Accelaration of the moving.

~~no load~~

(Starting) ⇒ Let DC machine turning

Initial condition $e_{ind} = 0$.

here no movement of the Bar.

So

$i = \frac{V_B - 0}{R}$

$i = \frac{V_B}{R}$.

this current flow through the bar, and induced force is generate i.e. is $F_{ind} = iLB$ (direction right due to fleming law)

Forced increase ... velocity of the bar is increased. and e(ind) appear on the bar.

$$e_{ind} = VBL$$

increase e_ind (i) current decrease

$$i = \frac{V_B - e_{ind}}{R}$$

$e_{ind} = V_B$ $i = 0$ when net force on the bar is zero

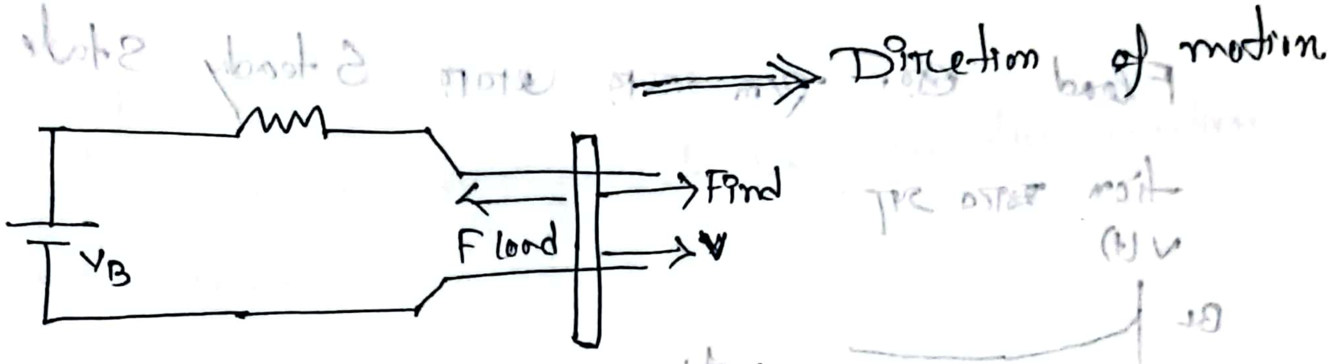
$$V_B = e_{ind} = V_{ss} BL$$

$$V_{ss} = \frac{V_B}{Bl}$$

Dc motor

• If a load (F_{Load}) is applied to bar opposite direction of motion, what happend?

(i)



Initially bar steady state থাকে, Fload use করলে
① opposite direction.. Net (force) হবে opposite direction

$$F_{net} = F_{load} - F_{ind}.$$

② Fnet create করে bar slow হবে velocity is decrease
velocity decrease হলে e (ind) decrease হবে.

$$e_{ind} \downarrow = V \downarrow BL$$

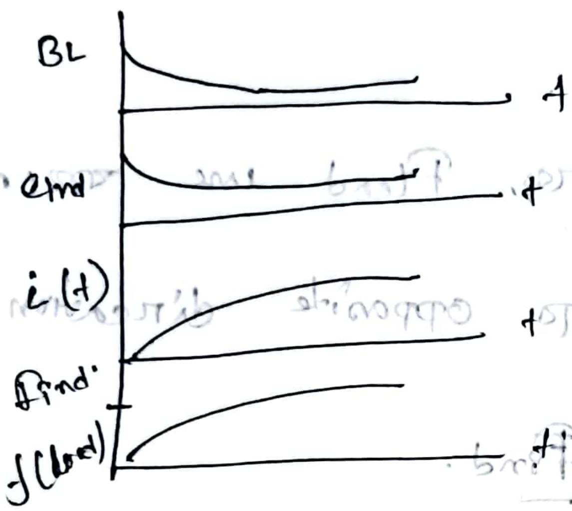
③ when e_{ind} decrease হলে current flow increase

$$i \uparrow = \frac{V_B - e_{ind} \downarrow}{R}$$

(4) তেমন Find increase (i বাড়লে Find বাড়বে)

$$F_{ind}\uparrow = i\uparrow LB$$

(5) Find বাড়বে যতক্ষণ এটি equal বা opposite হবে না Fload এর। হলে বার আবার Steady state condition হবে না।



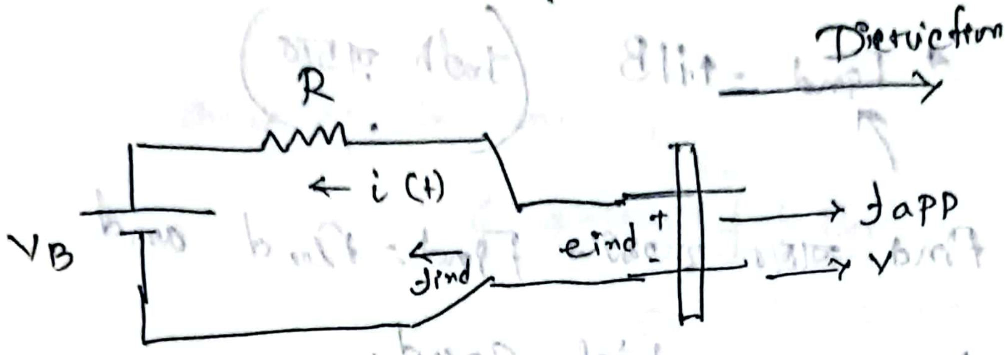
(6) Find is the direction or motion. So power converted electrical to mechanical to keep the bar moving.

$$P_{conv} = e_{ind}\, i = f_{ind}$$

$$P = (vi)$$

So it's working as a Motor

DC generator



If a load f_{app} applied to the direction motion. then what happend.

① F_{APP} এর জন্য F_{ind} Increase

$$F_{ind} = ma.$$

$$\uparrow a = \frac{F_{ind}\uparrow}{m}.$$

as a result (V) increased.

② when ($V\uparrow$) বাড়বে $e_{ind}\uparrow$ বাড়বে

$\uparrow e_{ind} = V\uparrow BL$ then (i) also increased.

$$\uparrow i = \frac{\uparrow e_{ind} - V_B}{R} \quad \left(\text{Apply KVL}\right)$$

③ (i) যদি increased হয়

$\uparrow F_{ind} = \uparrow i l B$ (both বাড়বে)

Find বাড়লে বাড়বে Find > Fload and

bar move high speed.

Now the Battery is charging Due to $e_{ind} > V_B$

So this convert mecanical power ($F_{ind} v$)

into electrical power [$e_{ind}\, i$]

∴ This generator

$e_{ind} > V_B$ ← Generator

$e_{ind} < V_B$ ← motor