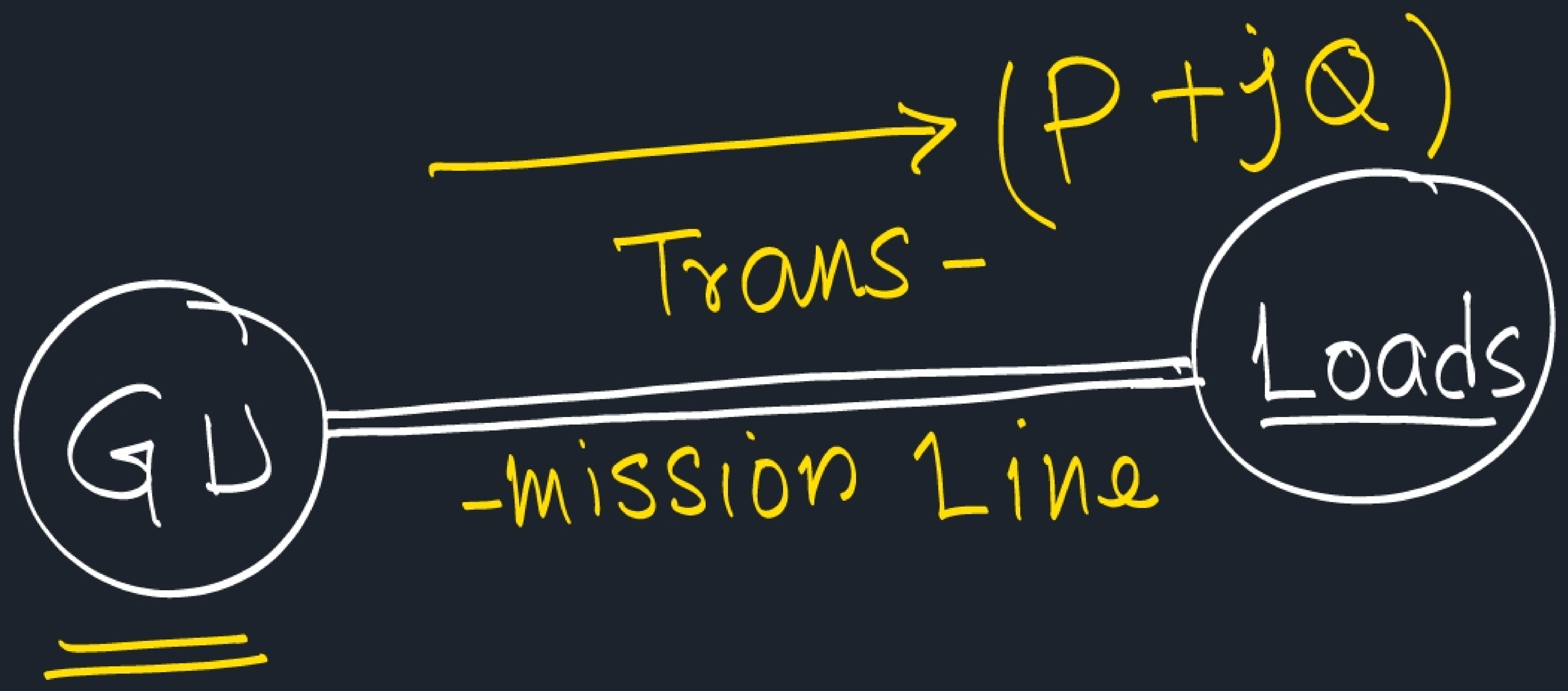
# Transformer :-



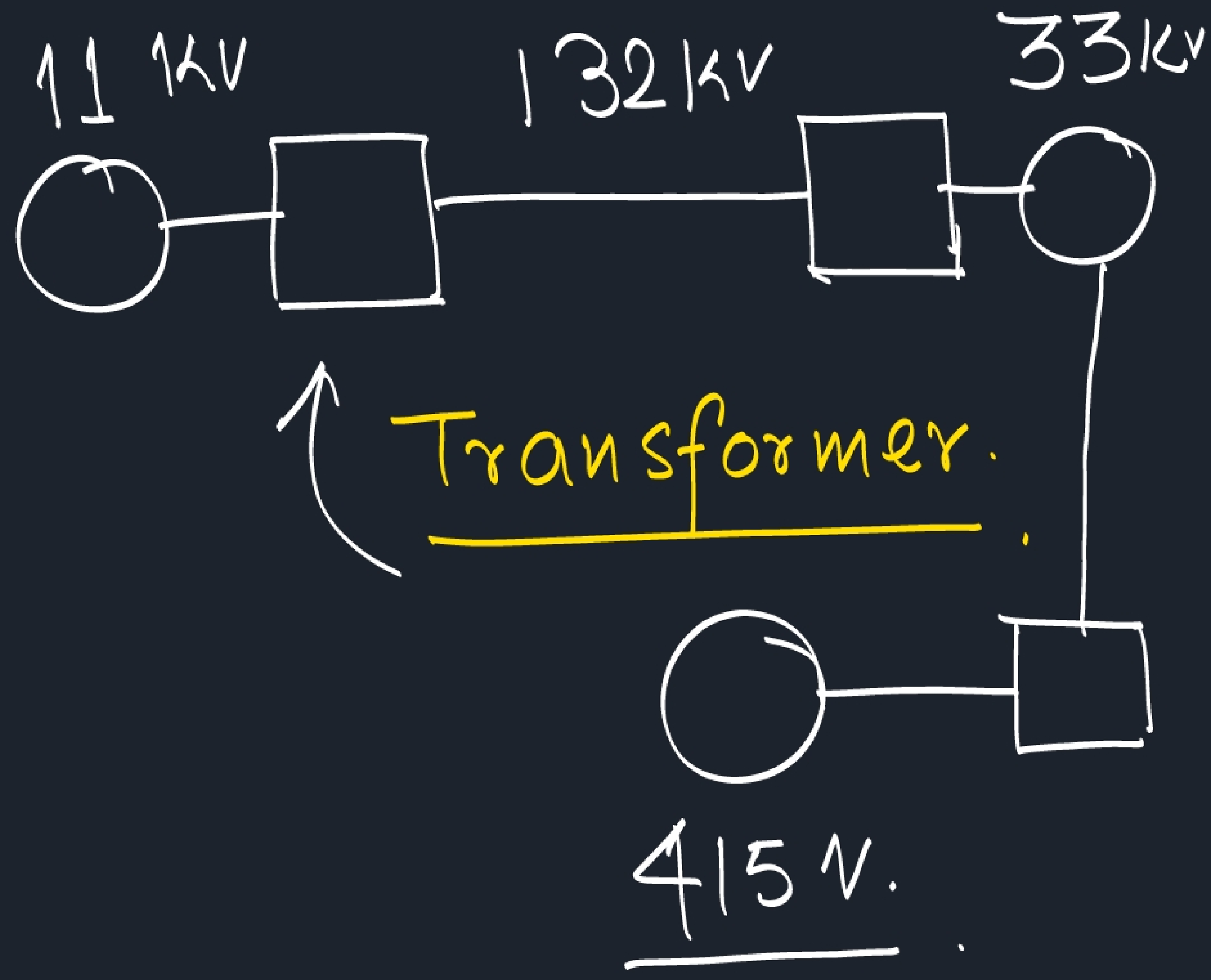

$$P_{3\phi} = 3 V_{ph} I_{ph} \cos\theta$$

$$I_{ph} = \frac{P_{3\phi}}{3 V_{ph} \cos\theta}.$$

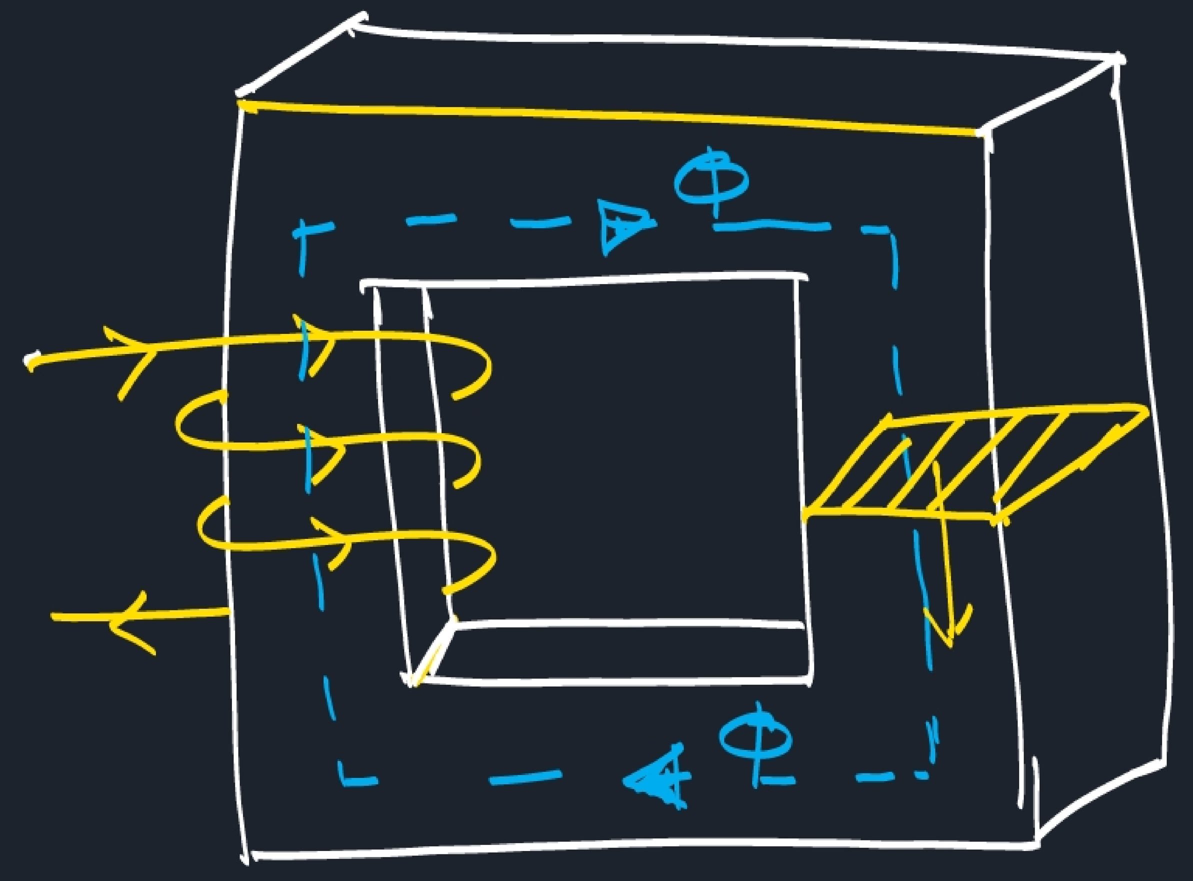
$$P_{loss} = 3 (I_{ph})^2 \cdot R_{ph}$$

$$= 3 \cdot \frac{P_{3\phi}^2}{9 V_{ph}^2 \cos^2\theta} \cdot R_{ph}$$

$$P_{loss} \propto \frac{1}{V_{ph}^2} \quad (\text{if } P_{3\phi}, \cos\theta \text{ Constant})$$




1. Step up
2. Step Down

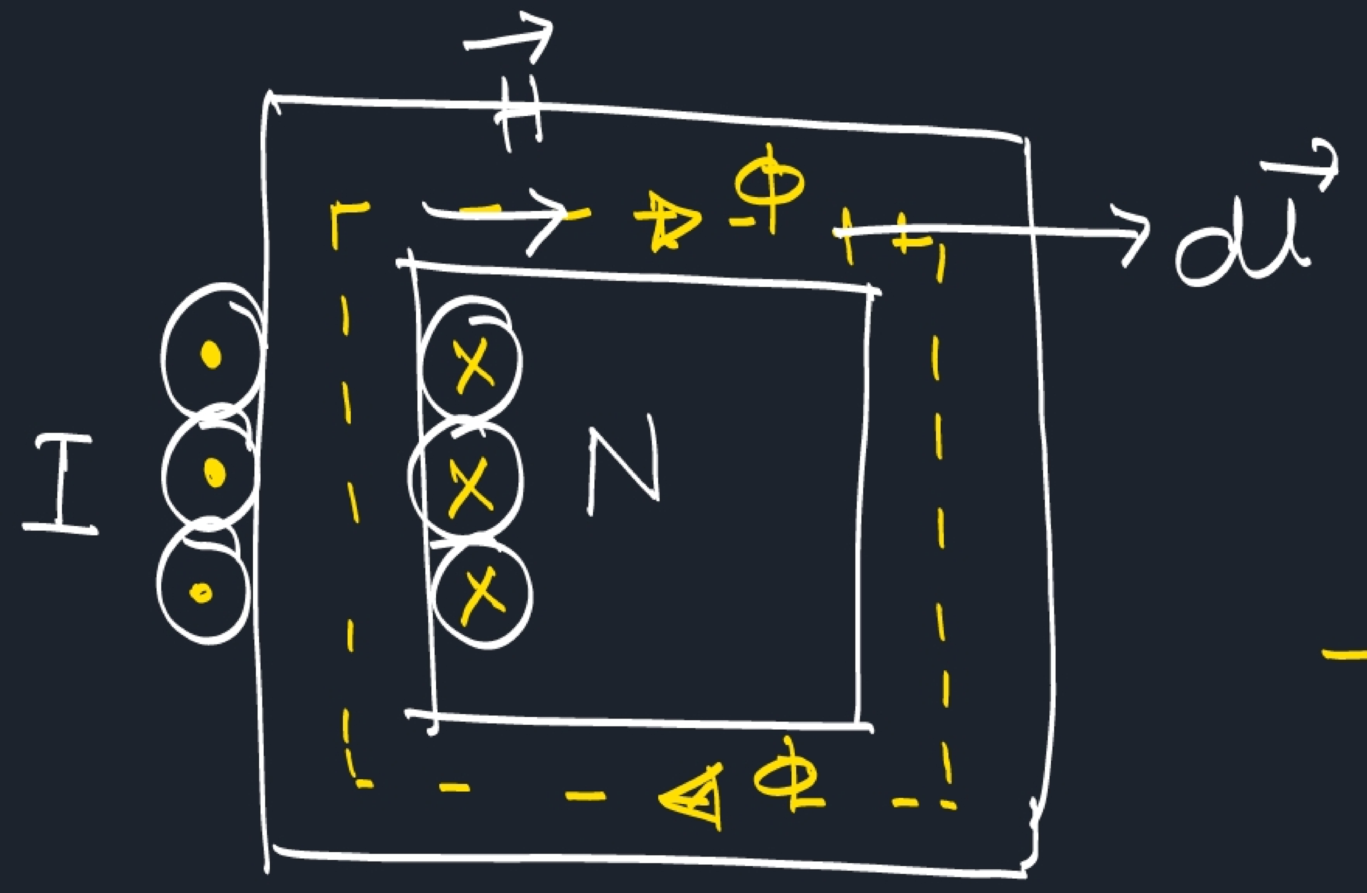



$\Phi = \vec{B}\cdot\vec{A} = BA\cos\theta$.

$\boxed{\Phi = BA}$ $\boxed{B = \mu H}$

$\boxed{\mu = \mu_0 \mu_r}$

$\mu_0 \rightarrow 4\pi\times10^{-7}$




unit of H is Amp-turn/m.

Ampere's Circuital Law.

$$\oint \vec{H}\cdot d\vec{l} = NI$$

$$H\cdot l = NI$$

$$\Rightarrow H = \frac{NI}{l}$$

$$\Rightarrow B = \frac{NI}{l/\mu}$$

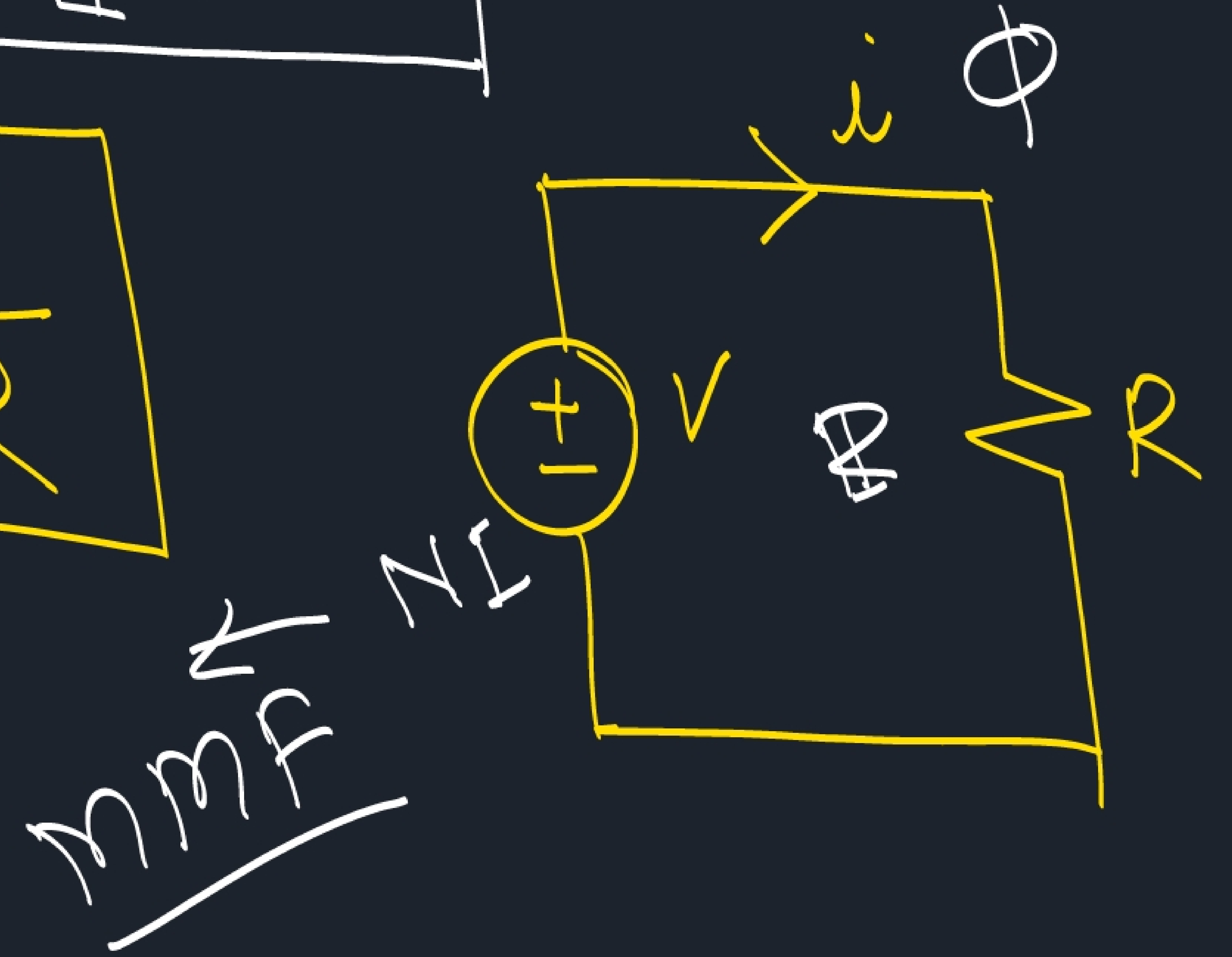
$$\boxed{\mathcal{R} = \frac{l}{A\mu_0\mu_r}}$$

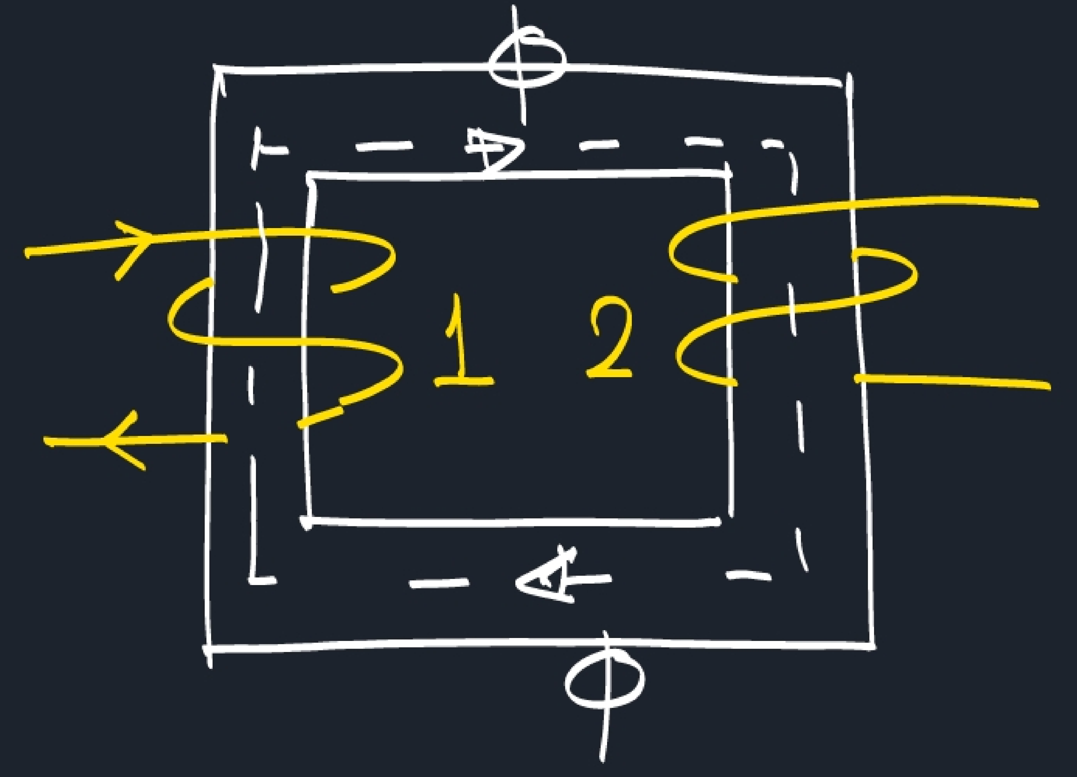
$$\Phi = BA = \frac{NI}{\frac{l}{\mu A}}$$

Reluctance $\mathcal{R}$

$$\boxed{\Phi = \frac{NI}{\mathcal{R}}}$$

$$\boxed{i = \frac{V}{R}}$$






$$e_1(t) = -N_1 \frac{d\phi}{dt}$$

$$e_2(t) = -N_2 \frac{d\phi}{dt}$$

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

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

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

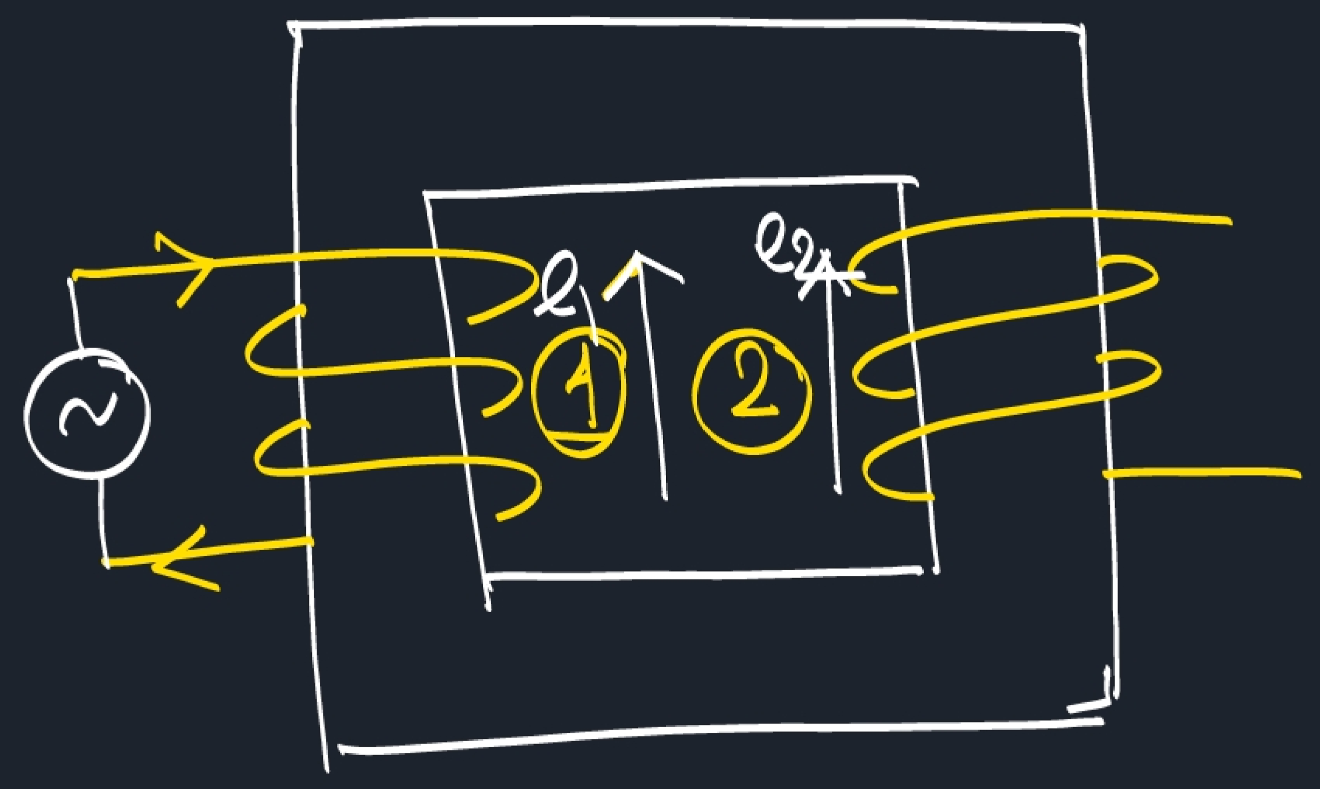
$$\boxed{\frac{e_1}{e_2} = \frac{N_1}{N_2}}$$

$N_1 < N_2$

$e_1 < e_2 \Rightarrow$ Step up T/F.

$N_1 > N_2$

$e_1 > e_2 \Rightarrow$ Step down T/F.




$e_1 = ?$ $e_2 = ?$

$$e_1(t) = -N_1 \frac{d\phi(t)}{dt}$$

$$\phi = BA.$$

$$= B_m \sin\omega t \cdot A$$

$$= \phi_m \sin\omega t$$

$$e_1(t) = N_1 \frac{d\phi(t)}{dt}$$

$$e_1(t) = N_1 \phi_m \omega \cos \omega t$$

$$= N_1 \phi_m \omega \sin(\omega t + \pi/2)$$

$$E_1 = \frac{N_1 \phi_m \omega}{\sqrt{2}}$$

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

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

1 → Primary

2 → Secondary

$$\boxed{E_1 = 4.44 f \phi_m N_1}$$

$$\boxed{E_2 = 4.44 f \phi_m N_2}$$

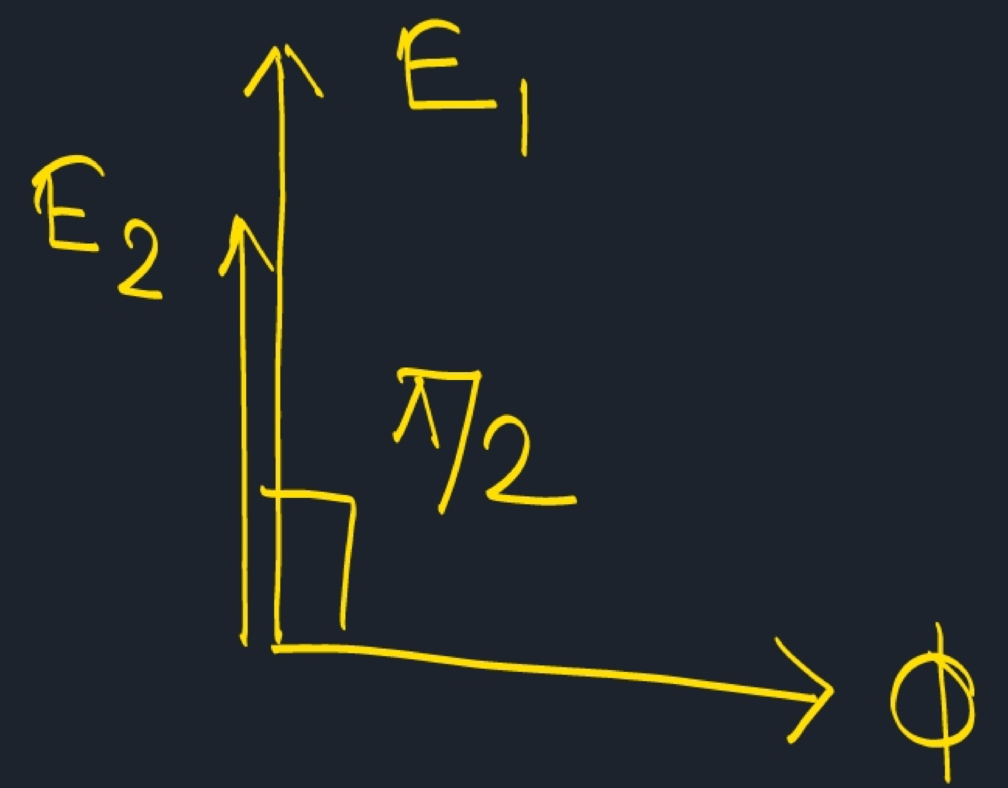
$f = 50\,Hz$

$\phi_m$ → Peak Flux.

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

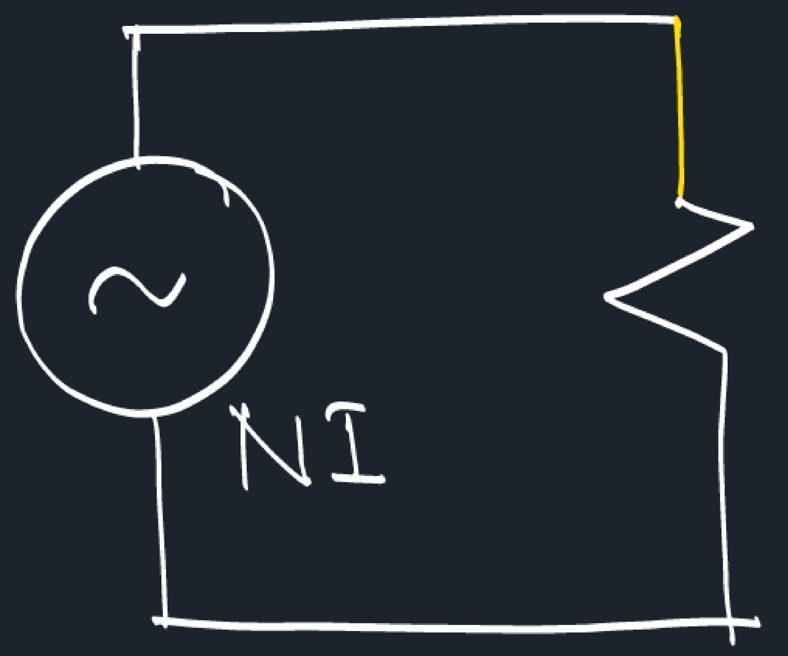
$$\phi_m \propto E_1$$

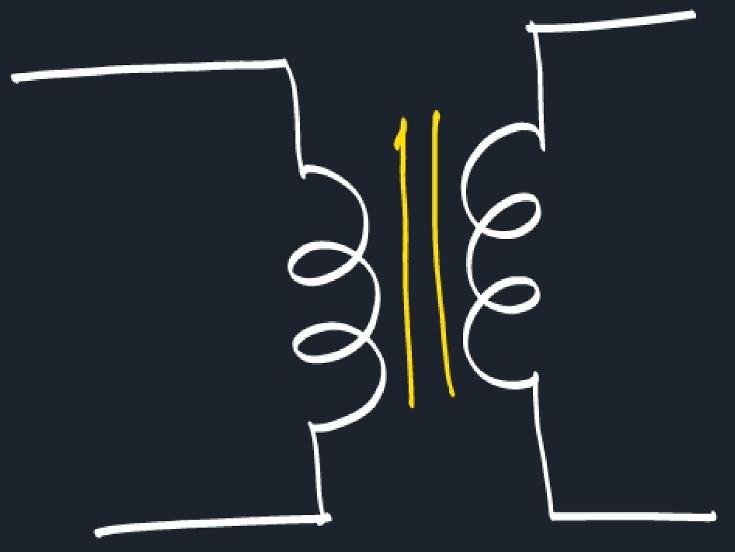
T/F → constant flux m/c.

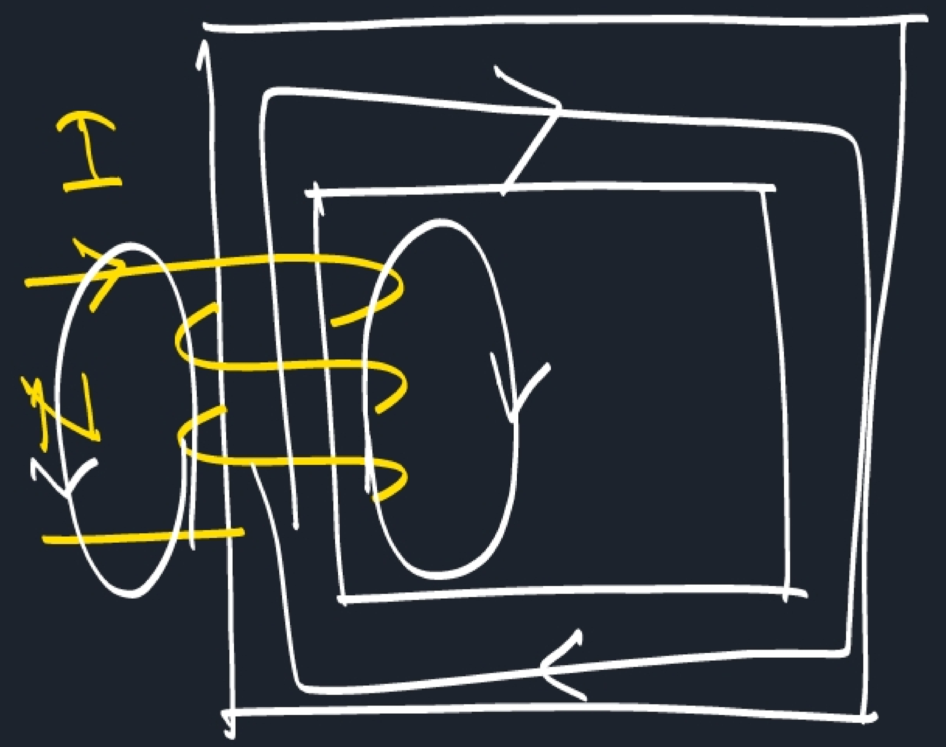


# 3003

$$\Phi = \frac{NI}{\mathcal{R}}$$






$$\boxed{\mathcal{R} = \frac{l}{A\mu_0\mu_r}}$$

$$\boxed{B = \mu_0\mu_r H.}$$

$$\boxed{H = \frac{NI}{l}}$$

$$\frac{V_1}{N_1} = \frac{V_2}{N_2} \quad \ldots (i)$$

$$I_1N_1 = I_2N_2 \quad --(ii)$$

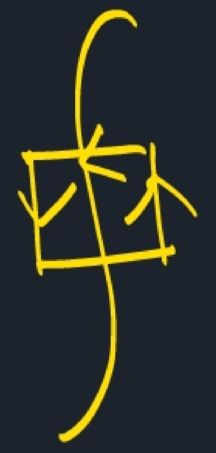
Ideal Case

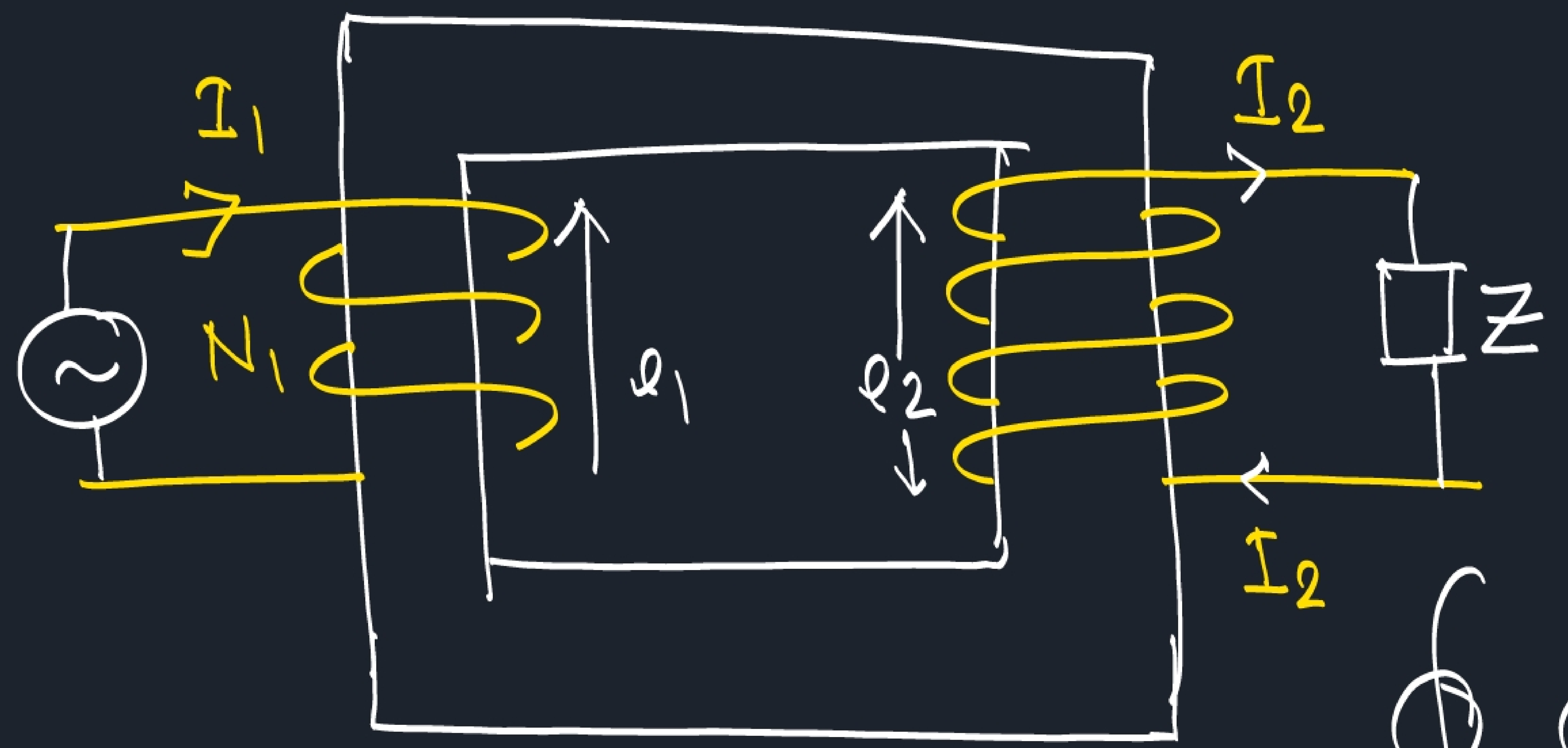
$\mathcal{R} \to 0$

$\mu_r \to \infty$

$\eta_{T/F} \to 100\%$

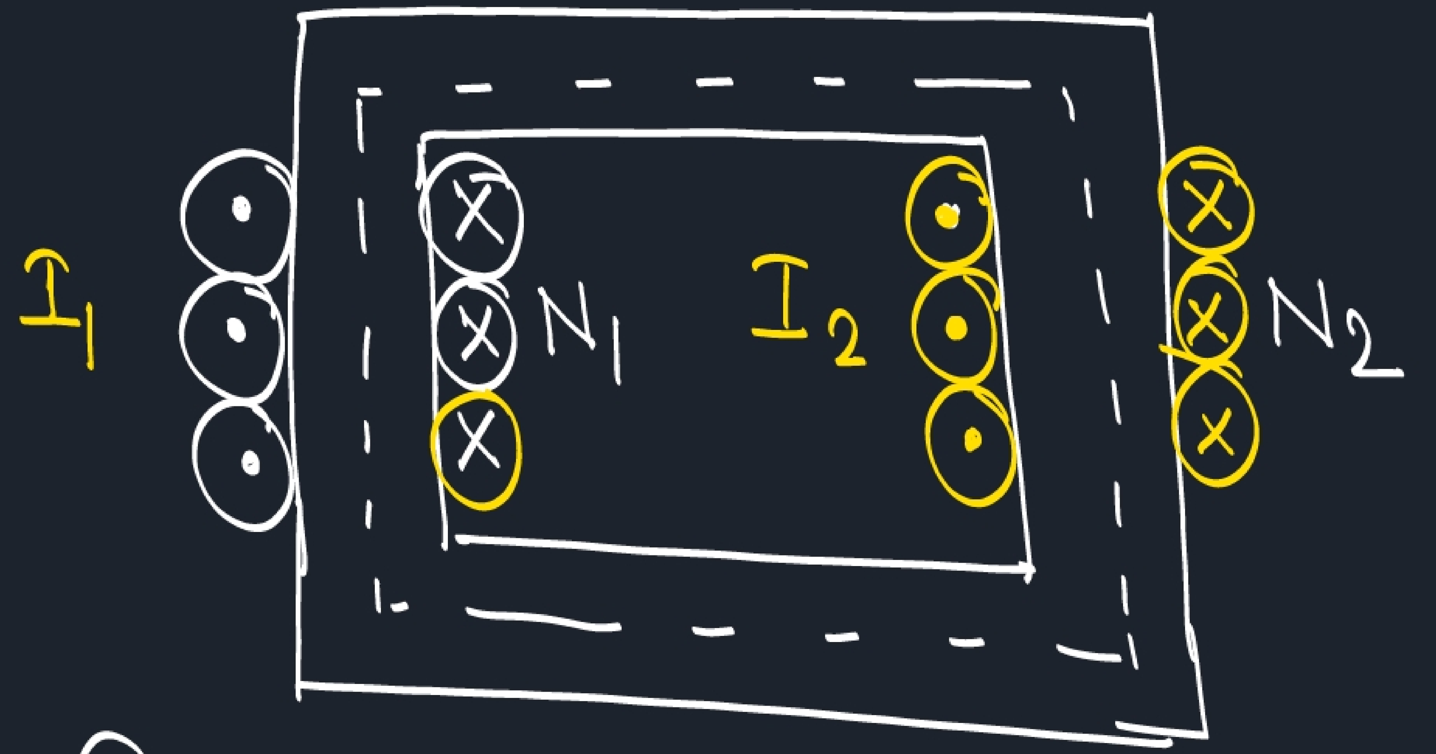
$\boxed{V_1I_1 = V_2I_2} \Rightarrow$ VA Rating





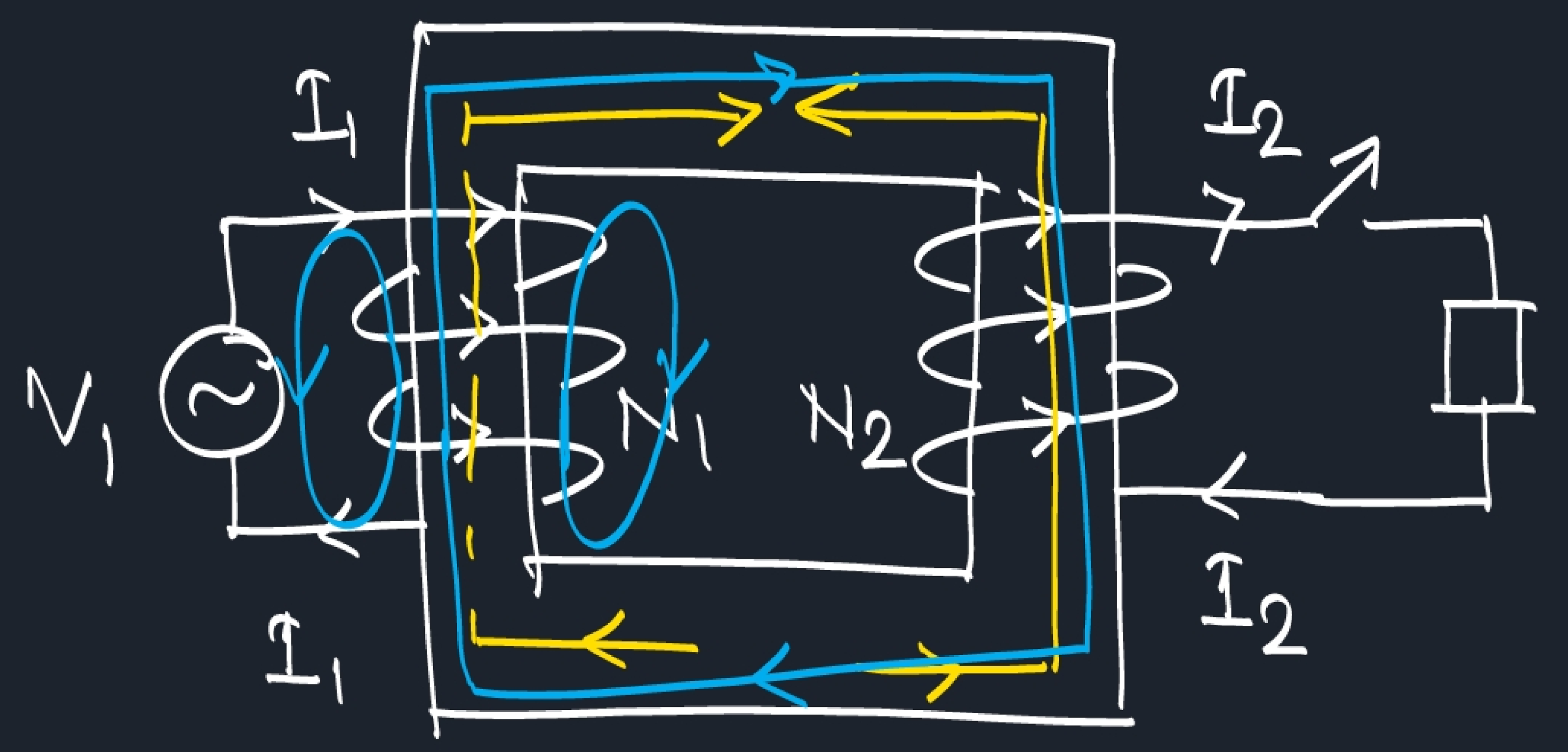

$$\boxed{I_2 = \frac{E_2}{Z.}}$$

$\oint \quad \oiint \quad \oiiint$




$$\oint \vec{H}\cdot d\vec{l} = N_1I_1 - N_2I_2 = 0$$

$\boxed{N_1I_1 = N_2I_2}$ mmf Balance.




$$\Phi_{total} = \Phi_m + \Phi_{\ell 1}$$

$$E_1^{total} = 4.44 f \Phi_{total} N_1$$

$$= 4.44 f (\Phi_m + \Phi_{\ell 1}) N_1$$

$$E_1^{total} = \underbrace{4.44 f \Phi_m N_1}_{} + \underbrace{4.44 f \Phi_{\ell 1} N_1}_{}$$

$$\Phi_m = \frac{N_1 I_m - N_2 I_2 + N_1 I_1'}{\mathcal{R}}$$

$$\Phi_m = \frac{N_1 I_m}{\mathcal{R}}$$

$$\Phi_m' = \frac{N_1 I_m - I_2 N_2}{\mathcal{R}}$$

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

$$\boxed{I_1 = I_m + I_1'}$$

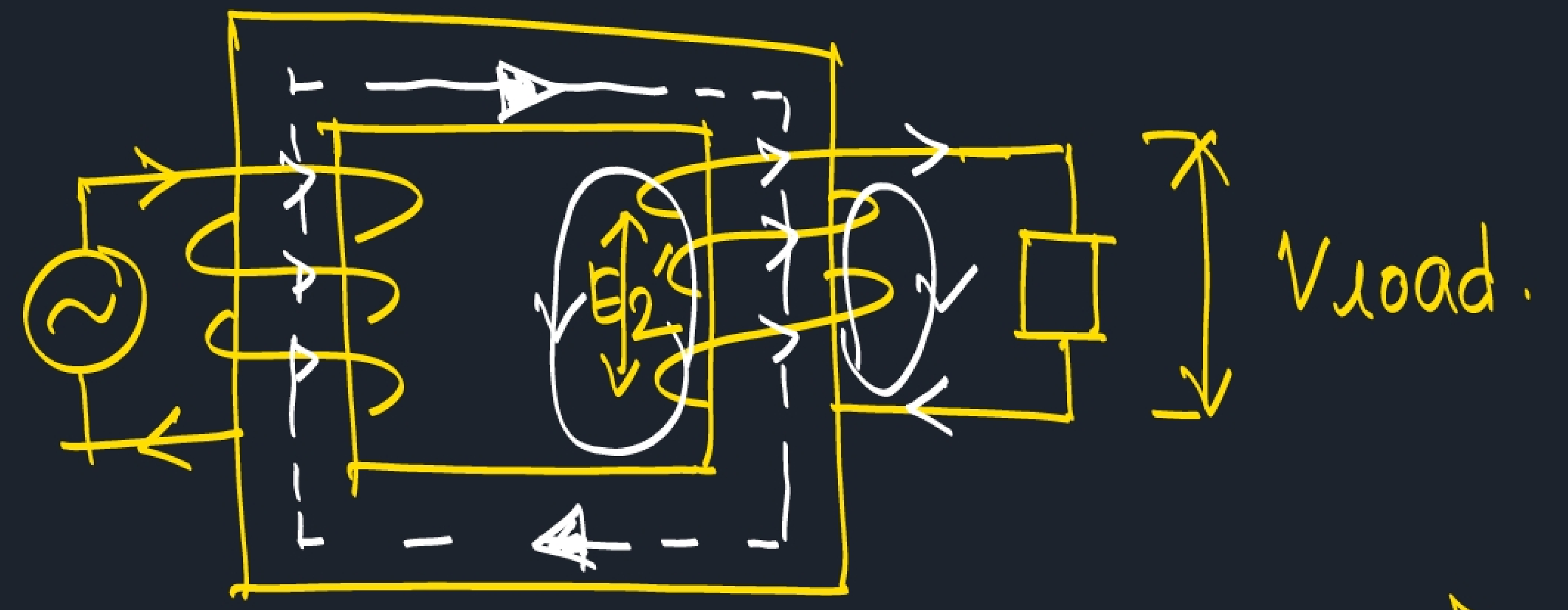
$$\boxed{V_1 = E_1 + I_1 R_1 + j I_1 X_{\ell 1}}$$

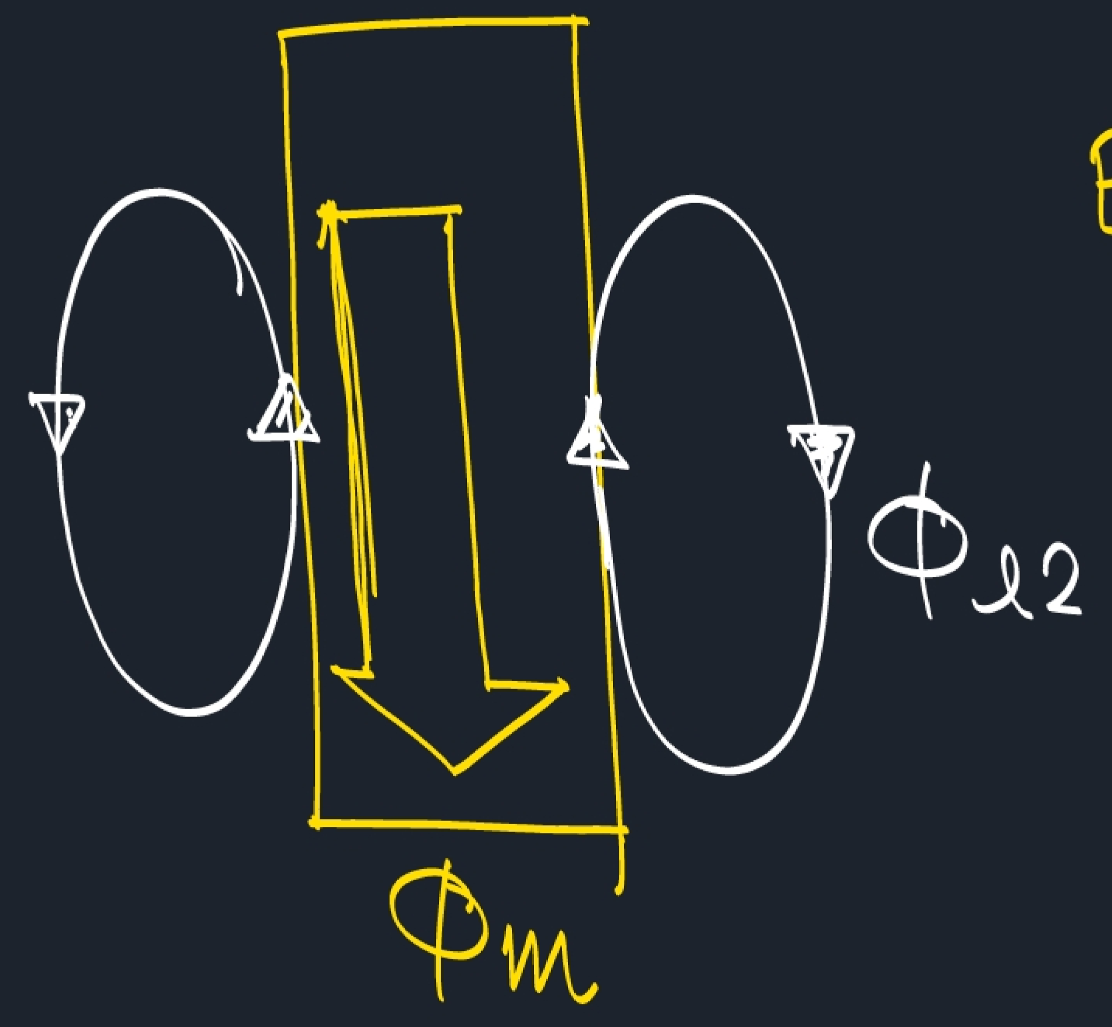
$$V_1 - I_1 R_1 = E_1^{total} = \underbrace{4.44 f \Phi_m N_1}_{} + E_{\ell 1}$$

$$= E_1 + E_{\ell 1}$$

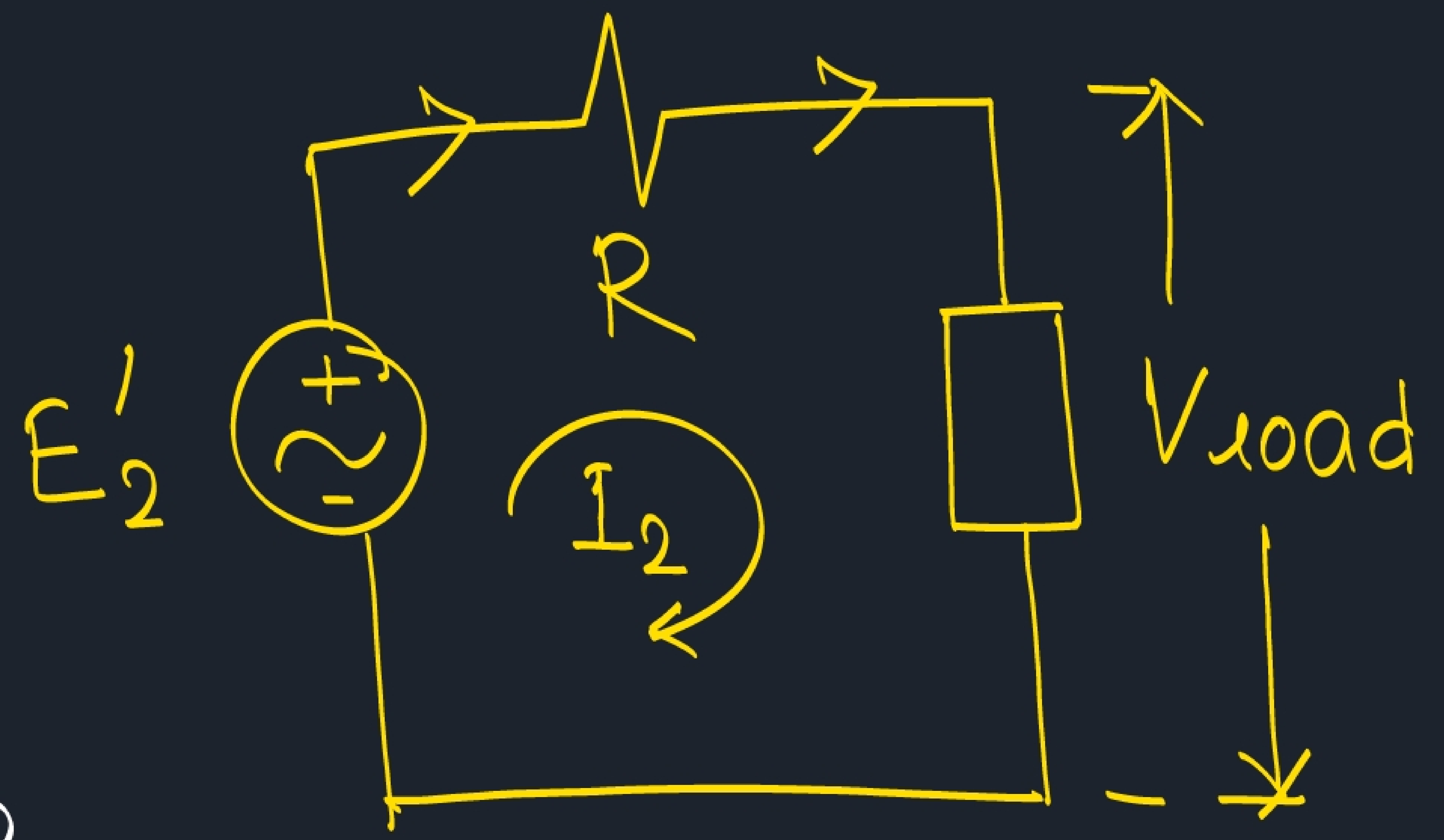
$$\boxed{V_1 - E_1 = I_1 R_1 + E_{\ell 1}}$$

$$= I_1 R_1 + j I_1 X_{\ell 1}$$




$\Phi_m \gg \Phi_{l2}$




$$E_2' = V_{load} + I_2 R_2 \Rightarrow E_2 - E_{l2} = V_{load} + I_2 R_2$$

$$E_2 = V_{load} + I_2 R_2 + E_{l2}$$

$$= V_{load} + I_2 R_2 + (I_2 \times j\omega L_2)$$

$$E_2' = 4.44 f \Phi N_2$$

$$= 4.44 f (\Phi_m - \Phi_{l2}) N_2$$

$$= \underbrace{4.44 f \Phi_m N_2}_{} - \underbrace{4.44 f \Phi_{l2} N_2}_{}$$

$$= E_2 - E_{l2}$$

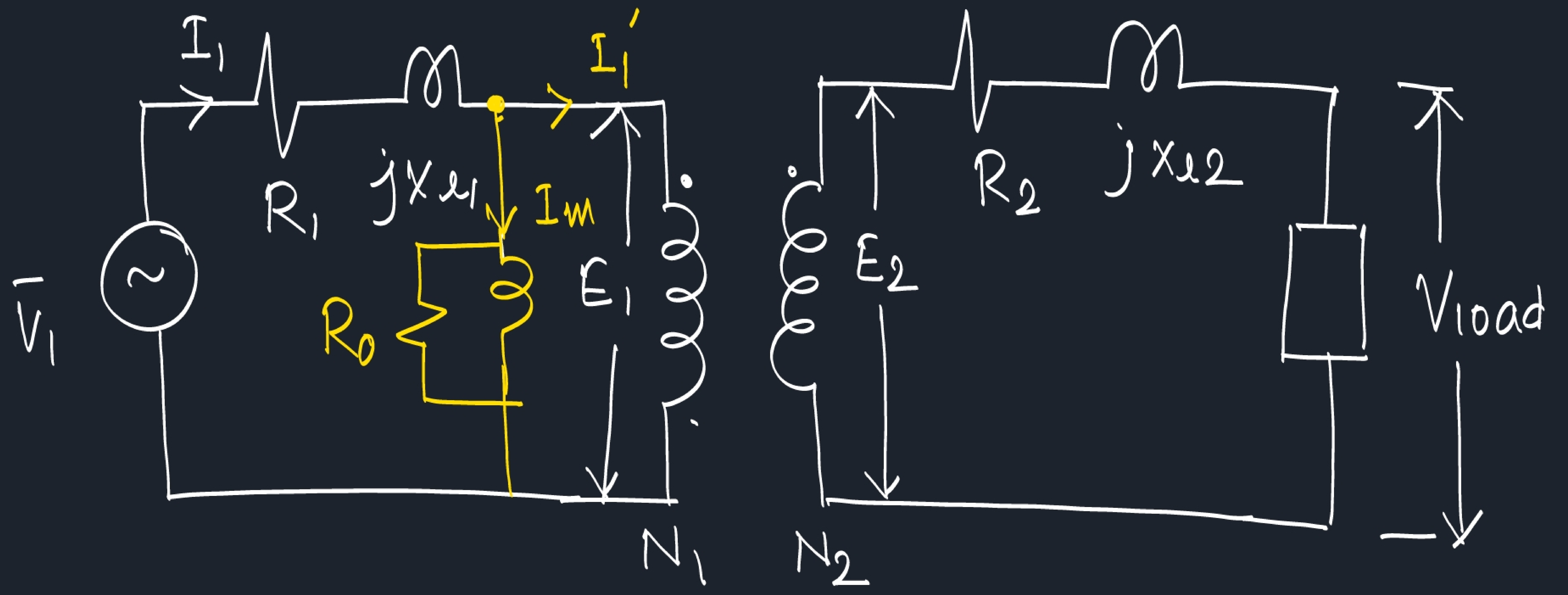
$$\boxed{E_2 = V_{load} + I_2 R_2 + j I_2 X_{l2}}$$

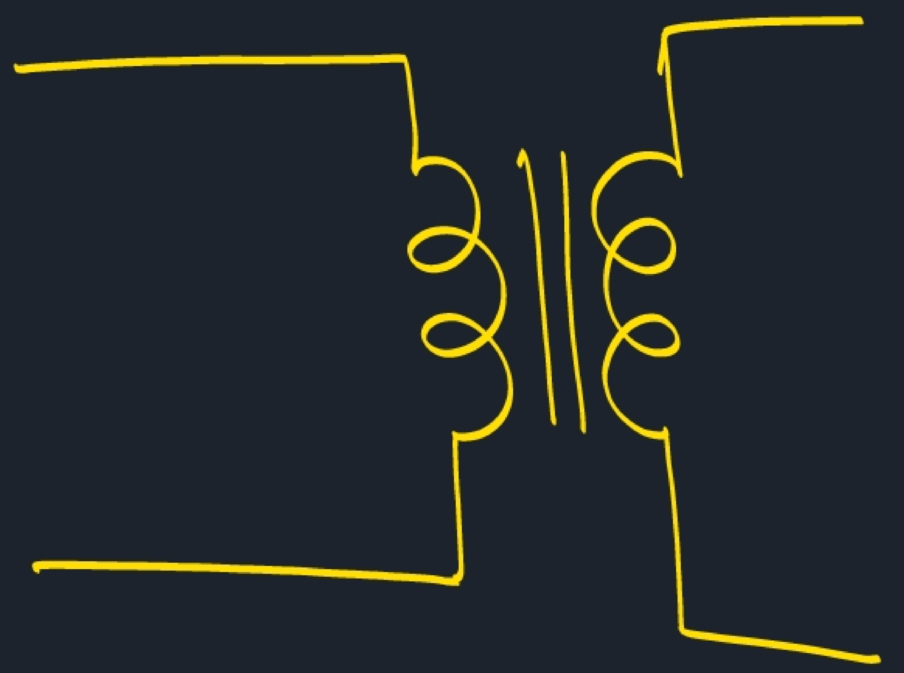
$$V_1 = E_1 + I_1 R_1 + jI_1 X_{l1} \quad \text{----(i)}$$

$$E_2 = V_{load} + I_2 R_2 + jI_2 X_{l2} \quad \text{---(ii)}$$

$$\hat{I}_1 = \hat{I}_m + \hat{I}_1' \quad \text{-------(iii)}$$

$$I_1' N_1 = I_2 N_2 \quad \text{-------(iv)}$$



$I_m$ Creates $\phi_m$.

i.e. an inductor should be associated to $\phi_m$.

$R_0 \Rightarrow$ represents inter loss of T/F.

↳ Hysteresis + Eddy Current.

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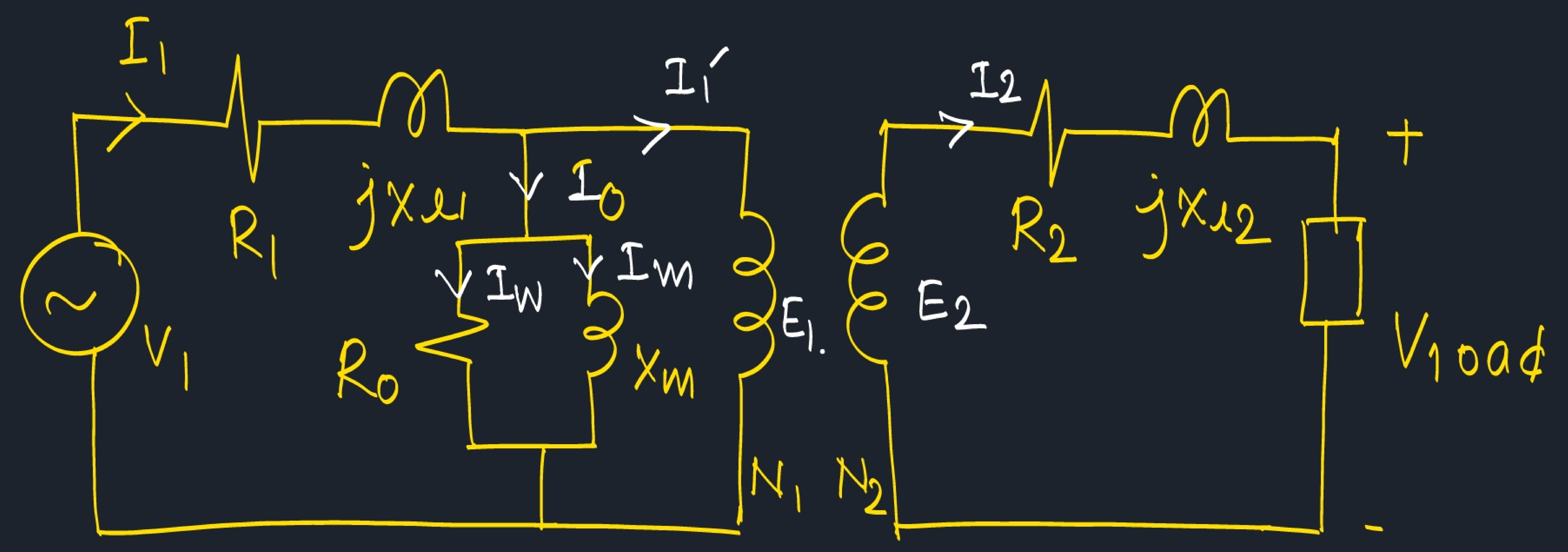
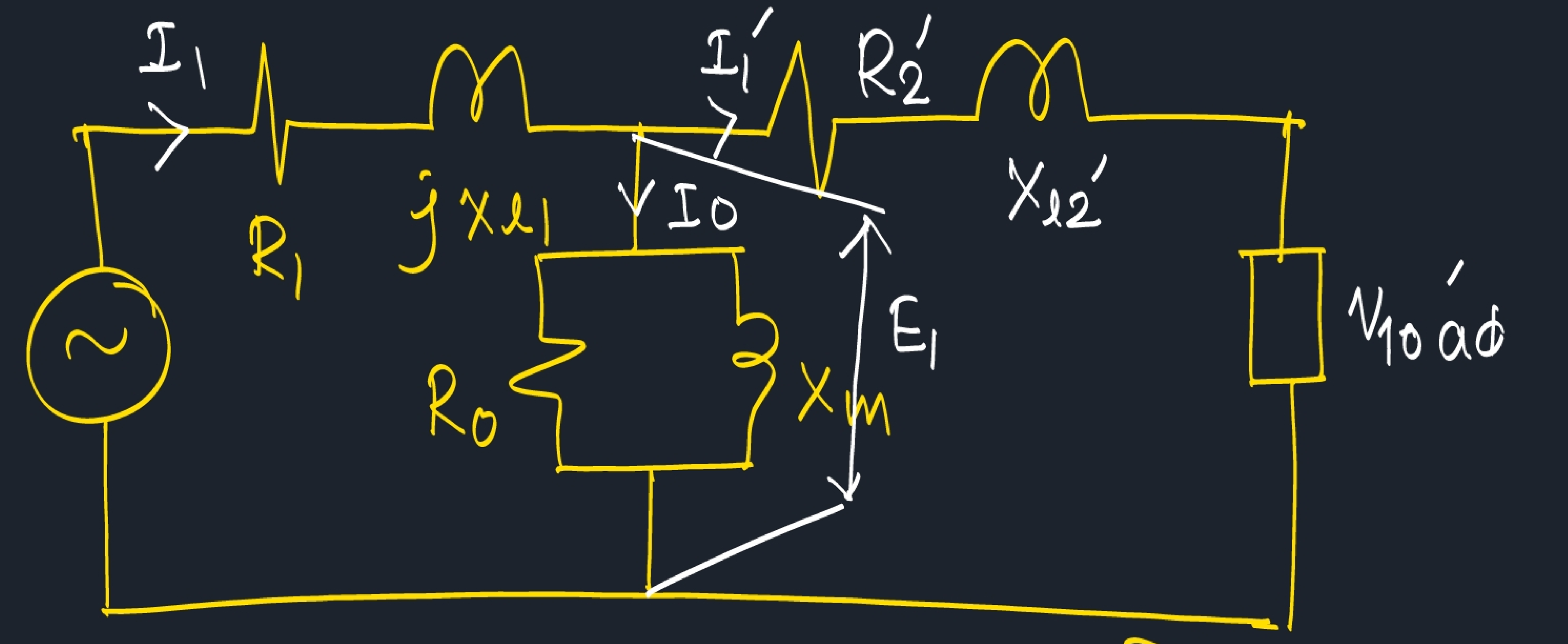



$\Rightarrow$




$$E_2 = V_{load} + I_2\left(R_2 + jX_{l2}\right)$$

$$\frac{E_1}{E_2} = \frac{N_1}{N_2} \qquad I_1' N_1 = I_2 N_2 \qquad I_2 = I_1'\left(\frac{N_1}{N_2}\right)$$

$$\Rightarrow \quad E_1 \cdot \frac{N_2}{N_1} = V_{load} + I_2\left(R_2 + jX_{l2}\right)$$

$$\Rightarrow \quad E_1 = \left(\frac{N_1}{N_2}\right) \cdot V_{load} + \left(\frac{N_1}{N_2}\right) I_2\left(R_2 + jX_{12}\right)$$

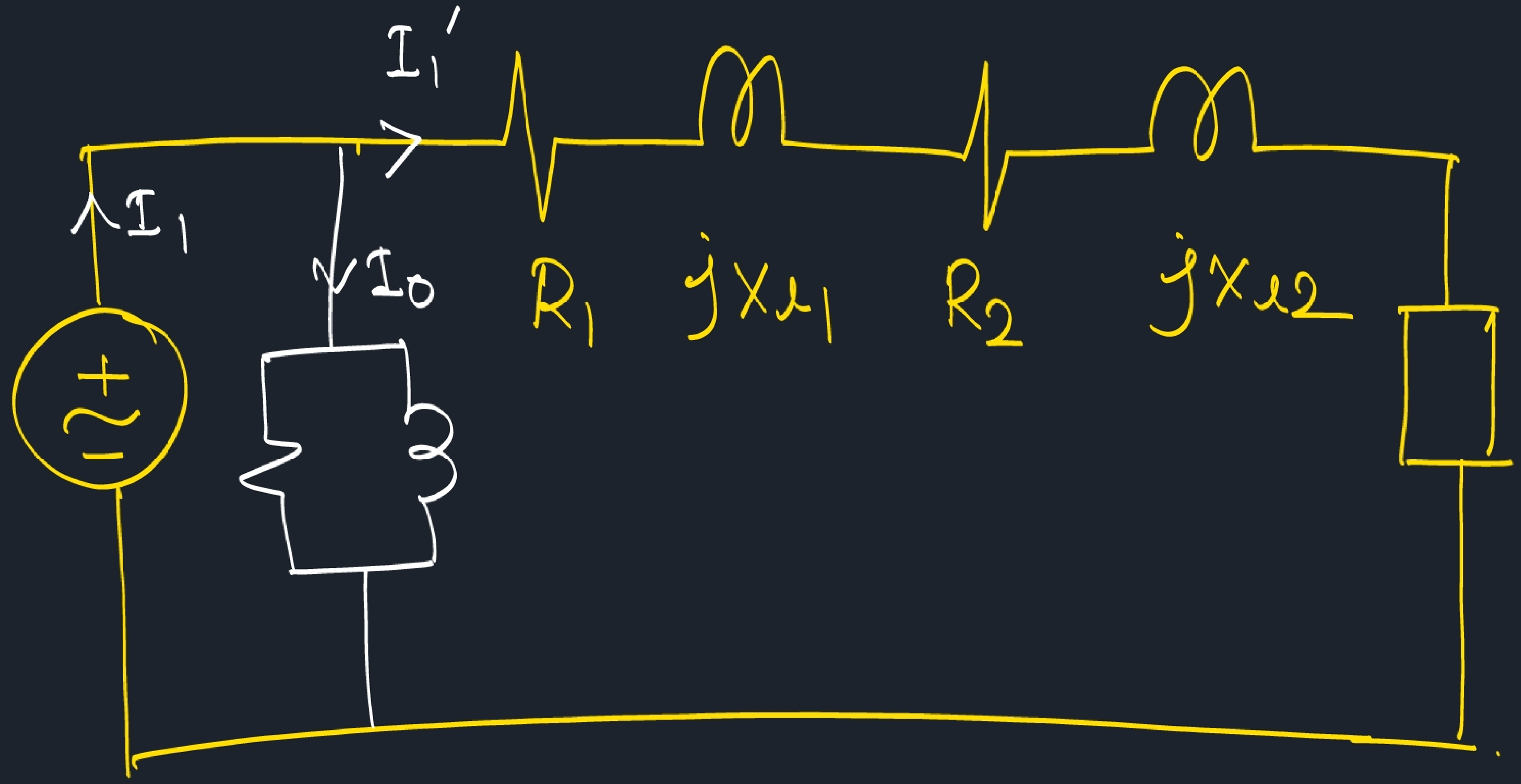
$$E_1 = \underbrace{\left(\frac{N_1}{N_2}\right) V_{load}} + \left(\frac{N_1}{N_2}\right)^2 \cdot I_1'\left(R_2 + jX_{l2}\right)$$

$$= V_{load}' + I_1'\left(R_2' + jX_{l2}'\right)$$

$$R_2' = \left(\frac{N_1}{N_2}\right)^2 R_2 \quad \Rightarrow \text{Secondary Referred to the Primary}$$

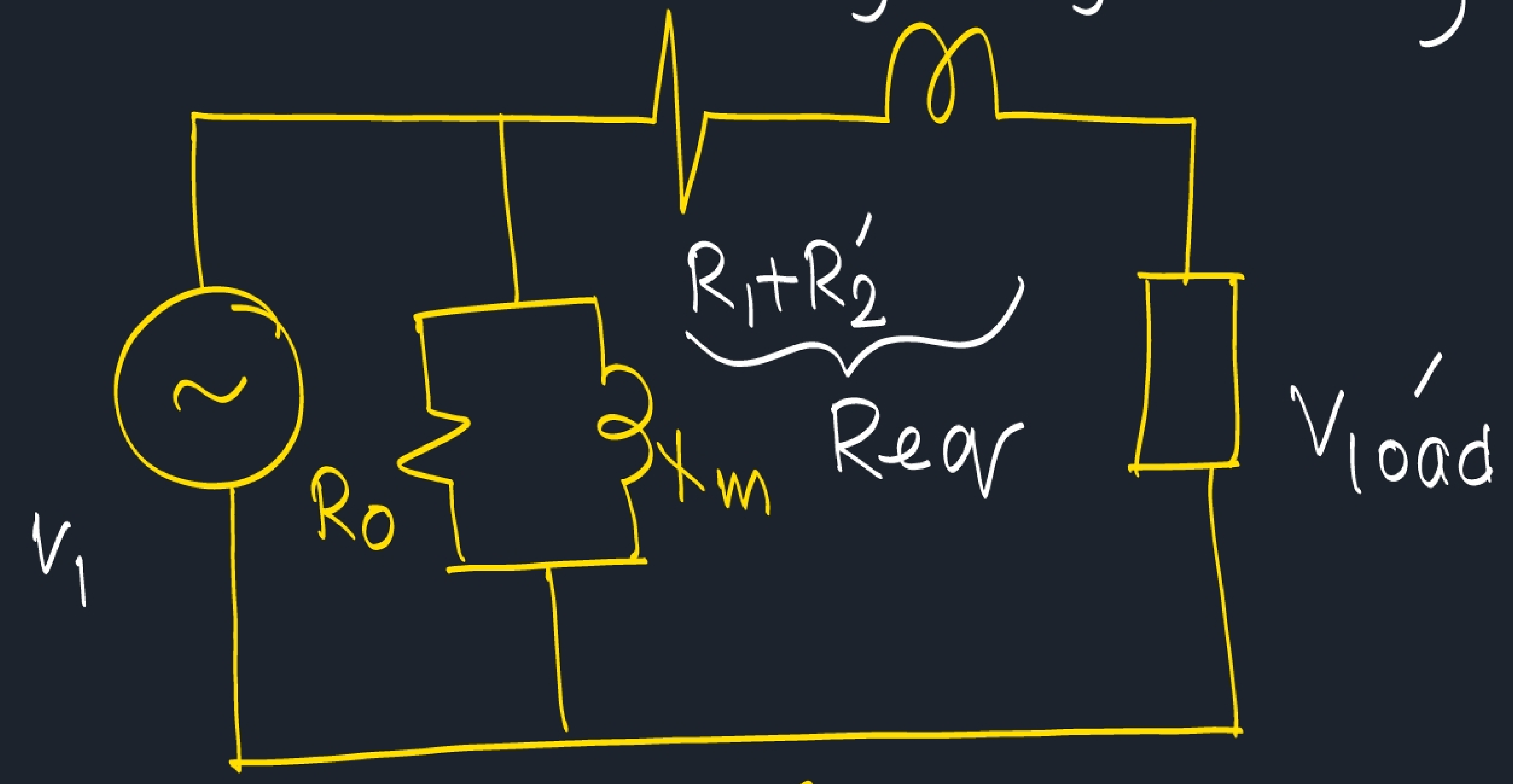
$$X_{l2}' = \left(\frac{N_1}{N_2}\right)^2 X_{l2}$$

EXACT Equivalent ckt of the T/F.




$\Rightarrow$

$jx_{l1} + jx_{l2}' = jx_{eq}$




$\hookrightarrow$ Approximated Equivalent ckt of the T/F.

$\tilde{I}_0 <<<< \tilde{I}_1 \; \& \; \tilde{I}_1'$

approx. (2-5%)

$R_0, X_m \Rightarrow$ Shunt Branch parameters

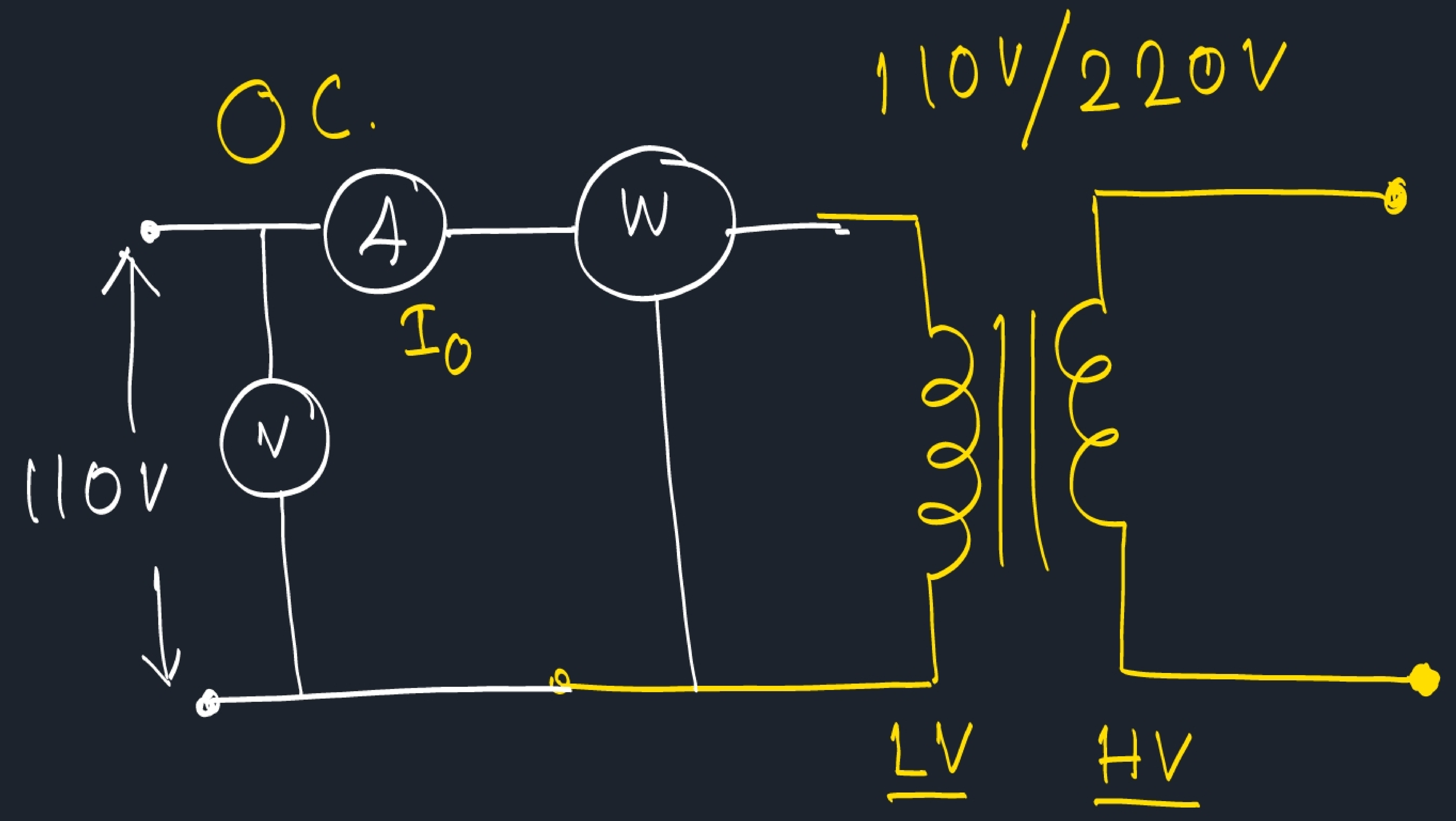
$R_{eq}, X_{eq} \Rightarrow$ Series Branch Parameters.

Two tests.

To find out the parameters of T/F.

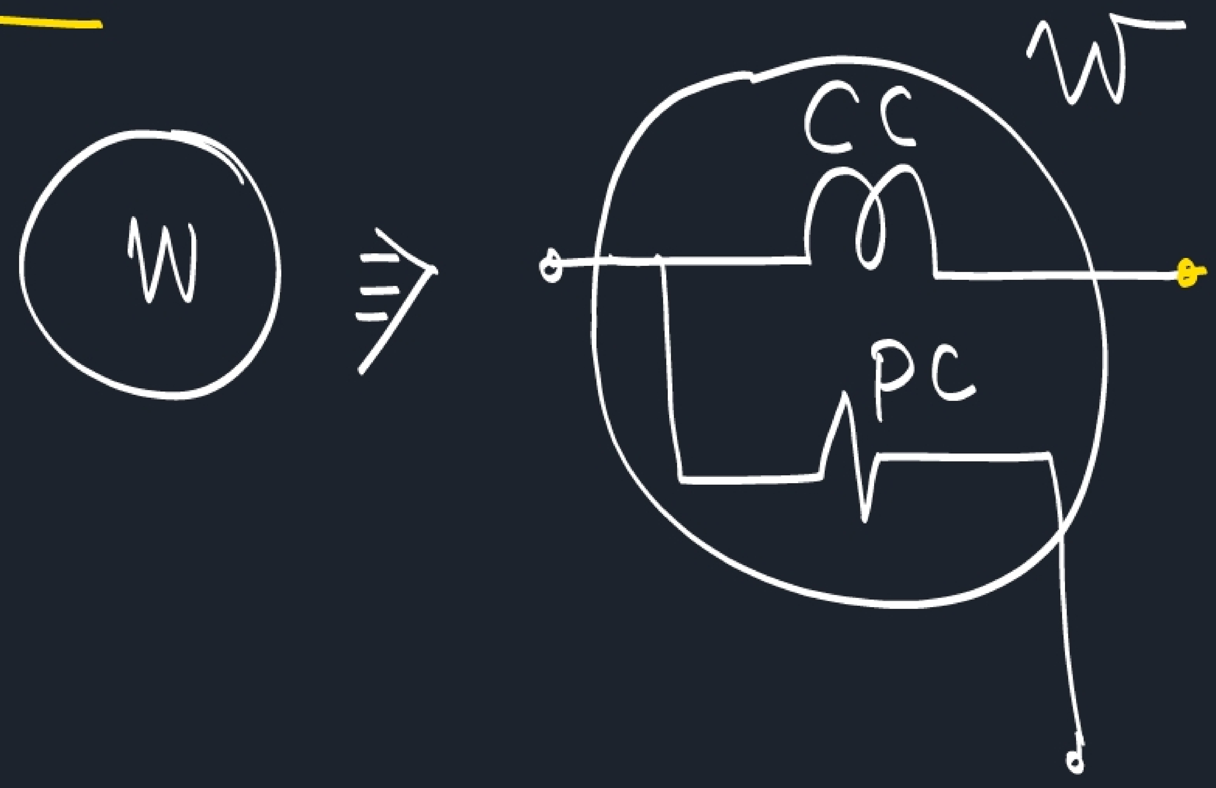
i) Open Circuit Test (OC Test)

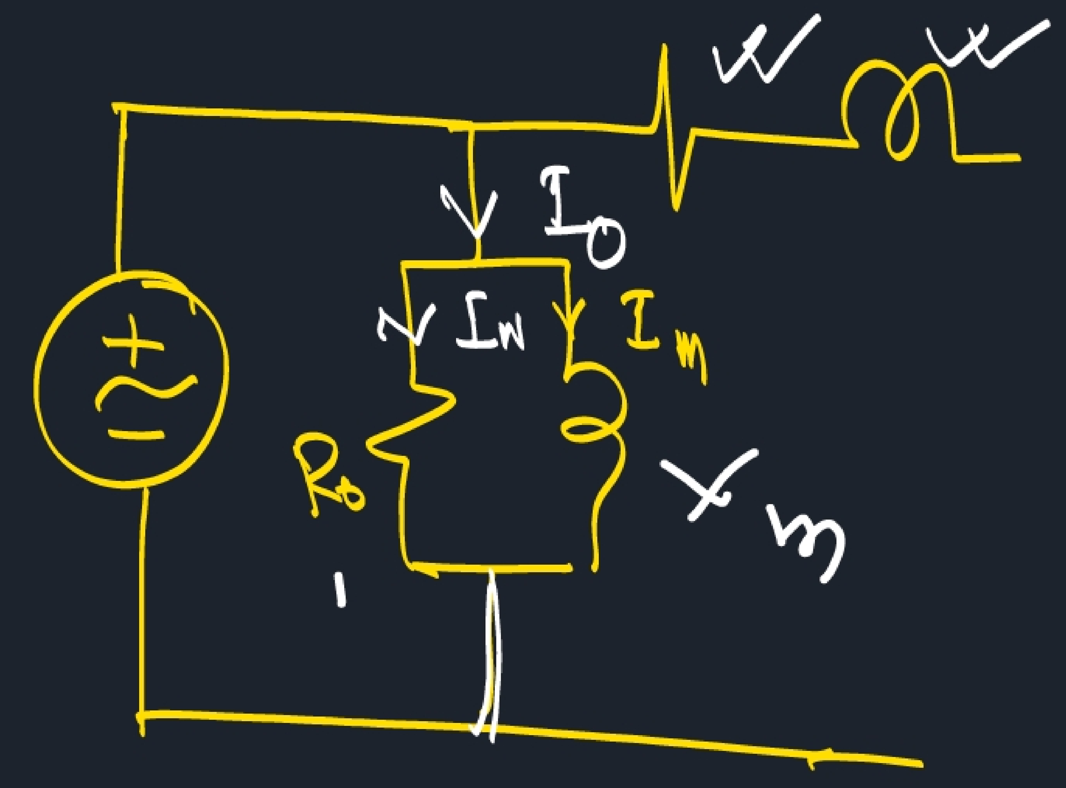
ii) Short Circuit Test (SC Test)




$V_0, I_0, W_0$

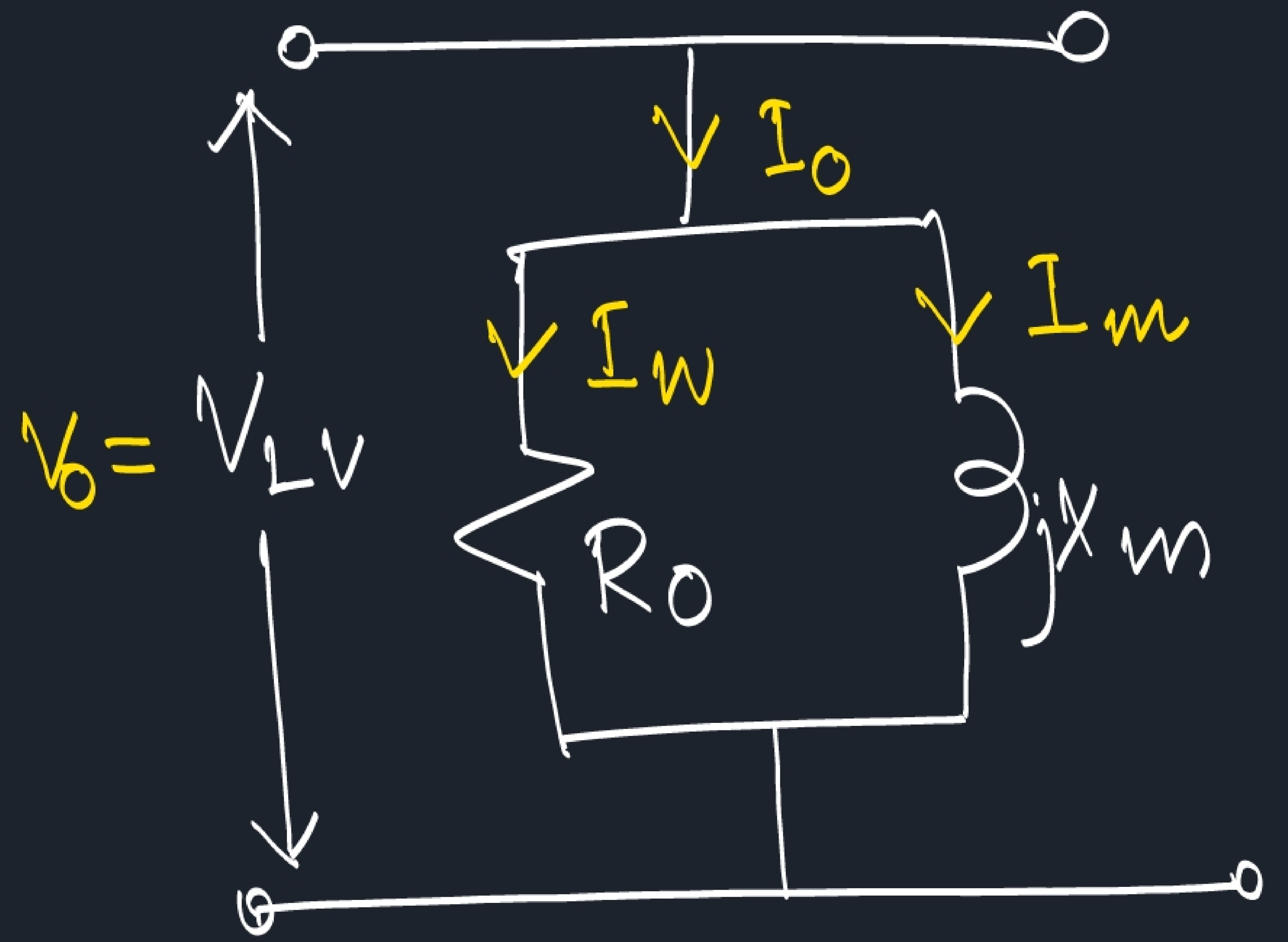
i) Voltmeter
ii) Ammeter
iii) Wattmeter.




$W = (I_W^2 \times R_0)$

V = Rated Voltage.



$$R_0 = \frac{V_0}{I_W}$$

$$jX_m = \frac{V_0}{I_m}$$

$$W_0 = I_W^2 R_0$$

$$W_0 = V I_W = V_0 I_0 \cos\theta_0$$

$$\underbrace{\theta_0 = \cos^{-1}\left(\frac{W_0}{V_0 I_0}\right)}$$

$$I_W = |I_0| \cos\theta_0$$

$$I_m = |I_0| \sin\theta_0$$

$V_0, W_0, I_0$

$$\underline{\underline{\tilde{I}_0 = |I_0|}} \angle \theta_0$$

Measured By Ammeter.

$$R_0 = \frac{V_0}{|I_0| \cos\theta_0} \qquad X_m = \frac{V_0}{|I_0| \sin\theta_0}$$

# SC Test :-

$1\phi$ T/F

$\underbrace{220\,V}_{HV} / \underbrace{110\,V}_{LV}$

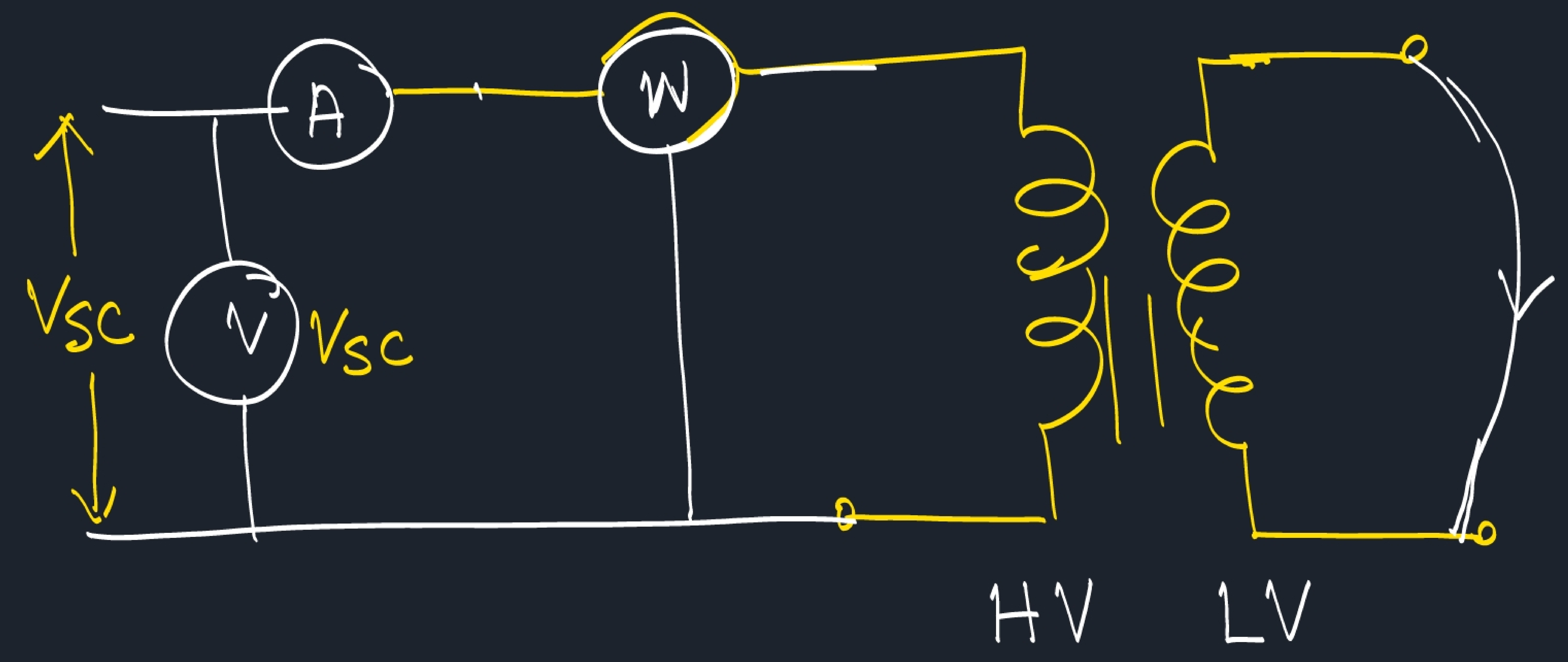
1 KVA Rating

$V_1 I_1 = V_2 I_2 = 1000$

$$\left.\begin{aligned} V_{LV} I_{LV} &= 1000 \\ V_{HV} I_{HV} &= 1000 \end{aligned}\right\}$$

$$\left.\begin{aligned} |I_{LV}| &= \frac{1000}{110} \text{ Amp} \\ |I_{HV}| &= \frac{1000}{220} \text{ Amp.} \end{aligned}\right\}$$

Q:




220/110 V.

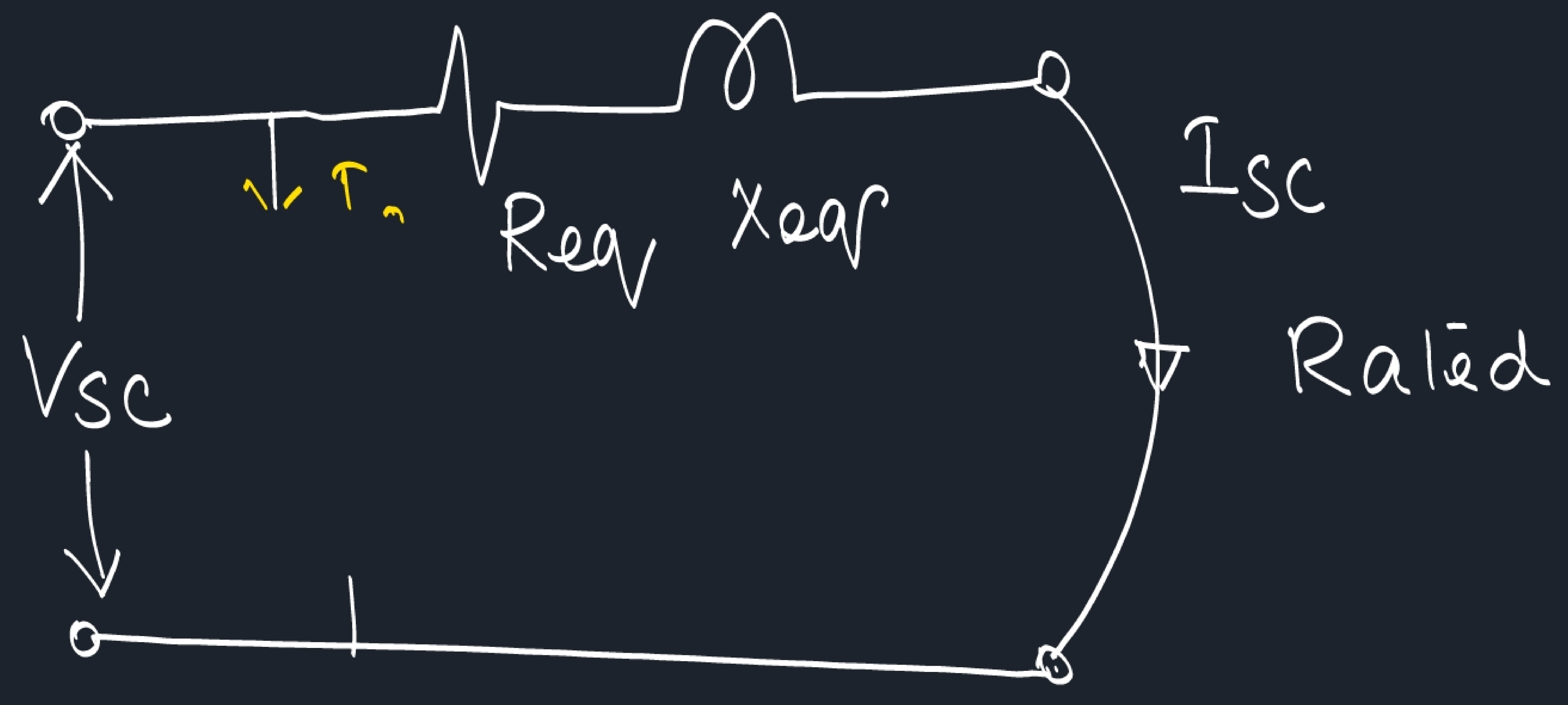
1000 VA.

$\frac{1000}{220}$ Amps.

Vsc, Isc, Wsc.

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

2509




$I_0 \lll I_{sc}$

$$W_{sc} = I_{sc}^2 R_{eq}$$

$$\boxed{R_{eq} = \frac{W_{sc}}{I_{sc}^2}}$$

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

Problem:-

$1\Phi$ T/F

$N_1 = 250$ (pri)

$N_2 = 500$ (Sec)

$A_{core} = 60 cm^2$

$f = 50 Hz$

$V = 230 V$ (Primary)

Peak flux density $B_m$

$$V_1 = E_1 = 4.44 f \Phi_m N_1$$

$$\Phi_m = \frac{230}{4.44 \times 50 \times 250} \text{ Wb.} = ?$$

$$B_m = \frac{\Phi_m}{A} = \frac{\Phi_m}{60 \times 10^{-4}} \text{ Wb/m}^2 = ?$$

## Problem:-

$$\boxed{\text{T/F : } 5\text{ KVA} \quad 200/1000\text{ V}} \text{ --- (i)}$$

$$\boxed{\text{OC Test : } 200\text{ V}, 1.2\text{ A}, 90\text{ W}} \text{ - (ii)}$$

$$\boxed{\text{SC Test : } 50\text{ V}, 5\text{ A}, 110\text{ W}} \text{ -- (iii)}$$

Estimate the transformer parameters.

(i) $\left.\begin{array}{l} V_{LV} = 200\text{ V} \\ V_{HV} = 1000\text{ V} \end{array}\right\}$ $V_{HV} I_{HV} = V_{LV} I_{LV} = 5000$

$I_{HV} = 5\text{ Amps}.$ $\quad I_{LV} = \dfrac{5000}{200} = 25\text{ Amps}$

(ii) LV Side is Choosen for OC Test

$V_0 = 200\text{ V}, \quad I_0 = 1.2\text{ A}, \quad W_0 = 90\text{ W}$

(iii) HV Side is Choosen for SC Test

$V_{SC} = 50\text{ V}, \quad I_{SC} = 5\text{A}, \quad W_{SC} = 110\text{ W}$

## OC Test:-

**Step-1**

$$\cos\theta_0 = \frac{W_0}{V_0 I_0}$$

$$= \frac{90}{200 \times 1.2}$$

$\theta_0 = ?$ $67.9756°$

**Step-2**

$$R_0^{LV} = \frac{V_0}{I_0 \cos\theta_0} = 444.44\,\Omega$$

**Step-3**

$$X_m^{LV} = \frac{V_0}{I_0 \sin\theta_0}$$

$$= 179.7866\,\Omega$$

## SC Test:-

**Step-1**

$$R_{eq}^{HV} = \frac{W_{sc}}{I_{sc}^2}$$

$$= \frac{110}{(5)^2} = 4.4\,\Omega$$

**Step-2**

$$|Z_{eq}|^{HV} = \frac{V_{sc}}{I_{sc}}$$

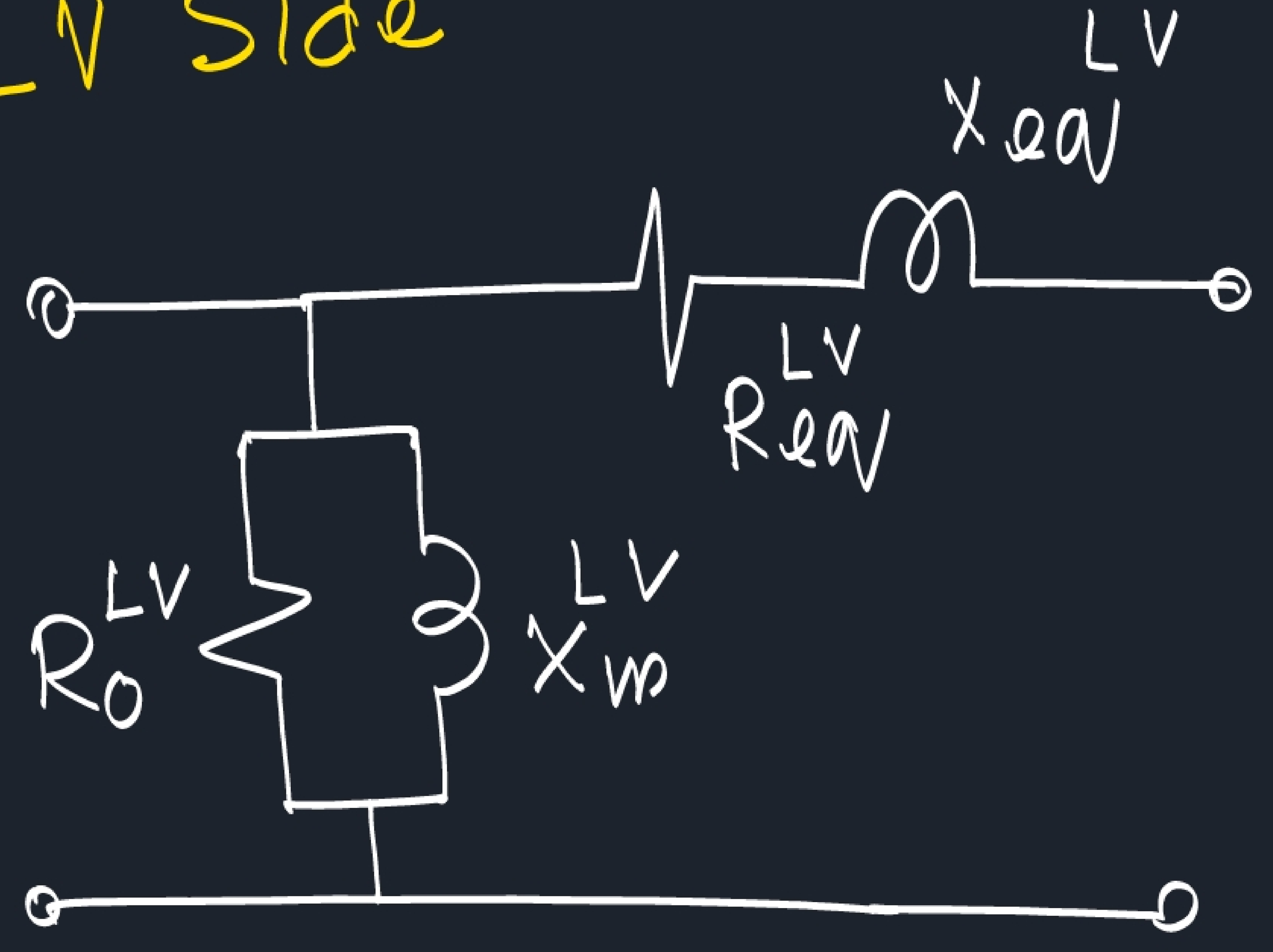
$$= \frac{50}{5} = 10\,\Omega$$

**Step-3**

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

$$= \sqrt{10^2 - (4.4)^2} = 8.97\,\Omega$$

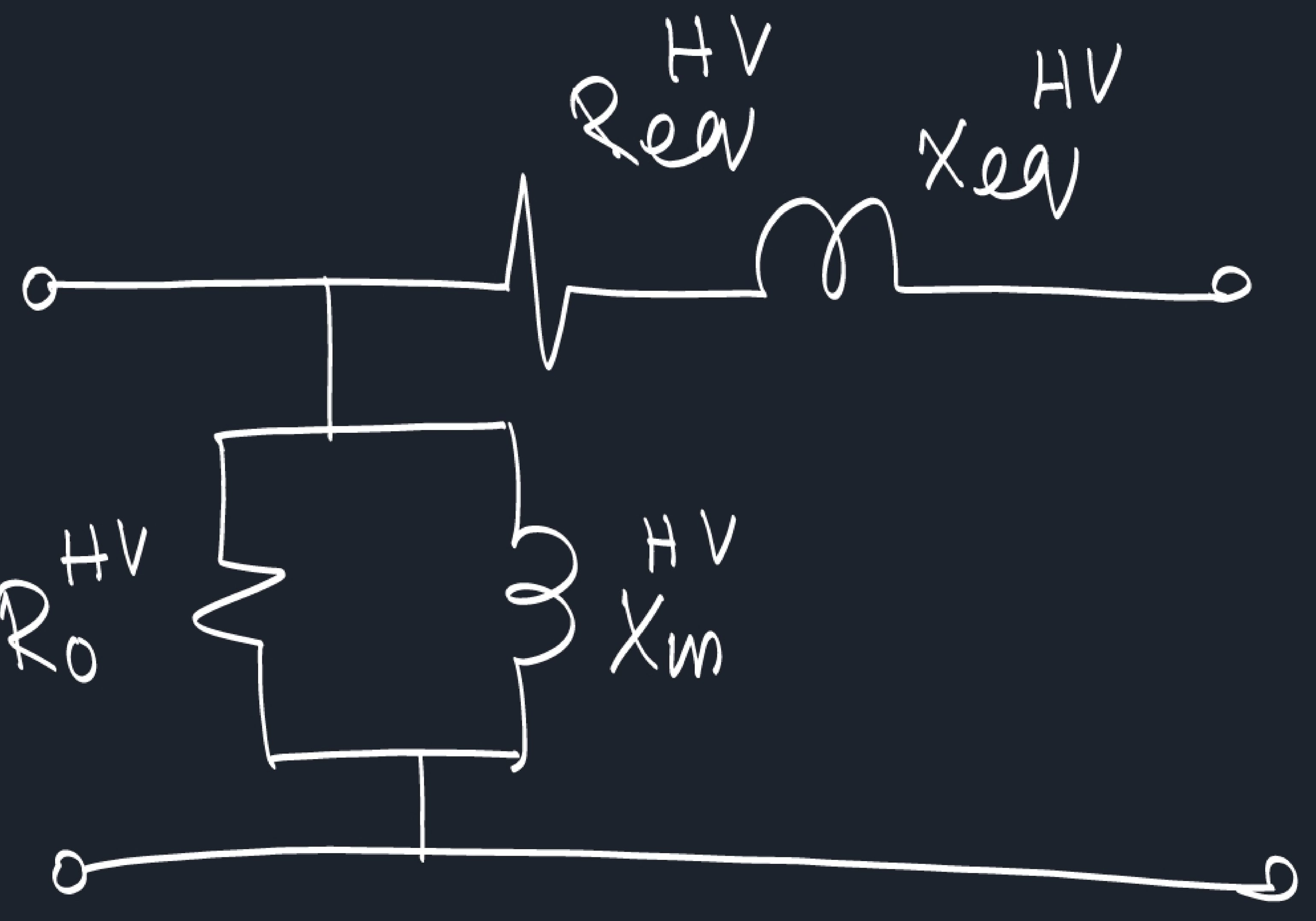
## LV Side

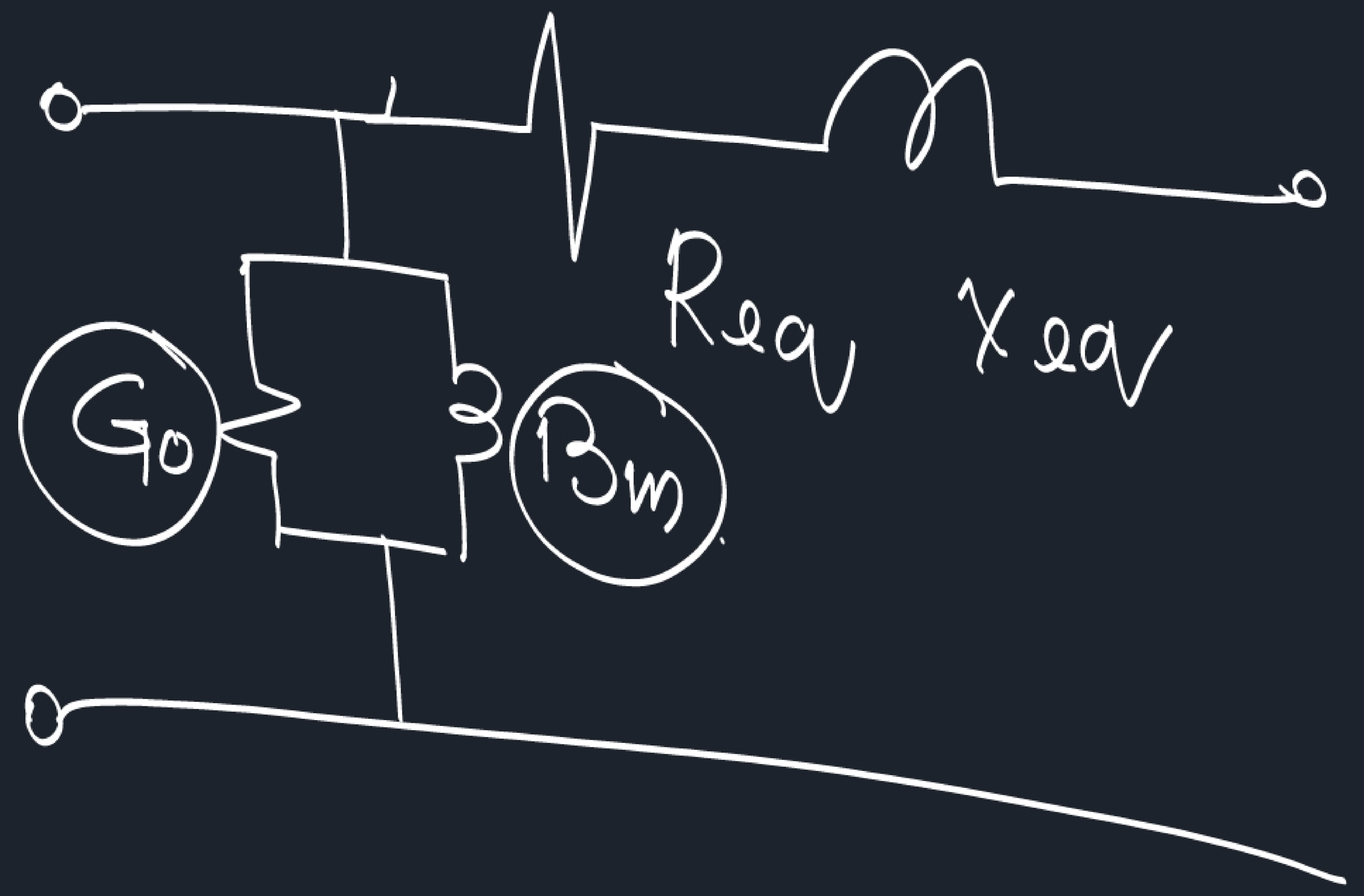



$$\frac{R_{eq}^{LV}}{R_{eq}^{HV}} = \left(\frac{N_{LV}}{N_{HV}}\right)^2 = \left(\frac{V_{LV}}{V_{HV}}\right)^2 = \left(\frac{200}{1000}\right)^2$$

$$\frac{X_{eq}^{LV}}{X_{eq}^{HV}} = \left(\frac{V_{LV}}{V_{HV}}\right)^2$$

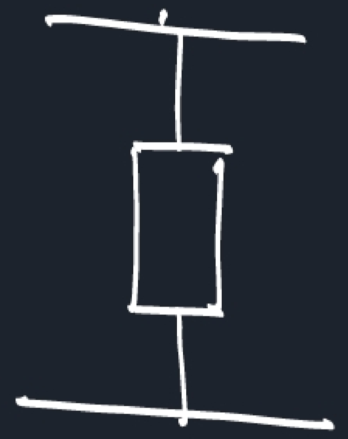
## HV



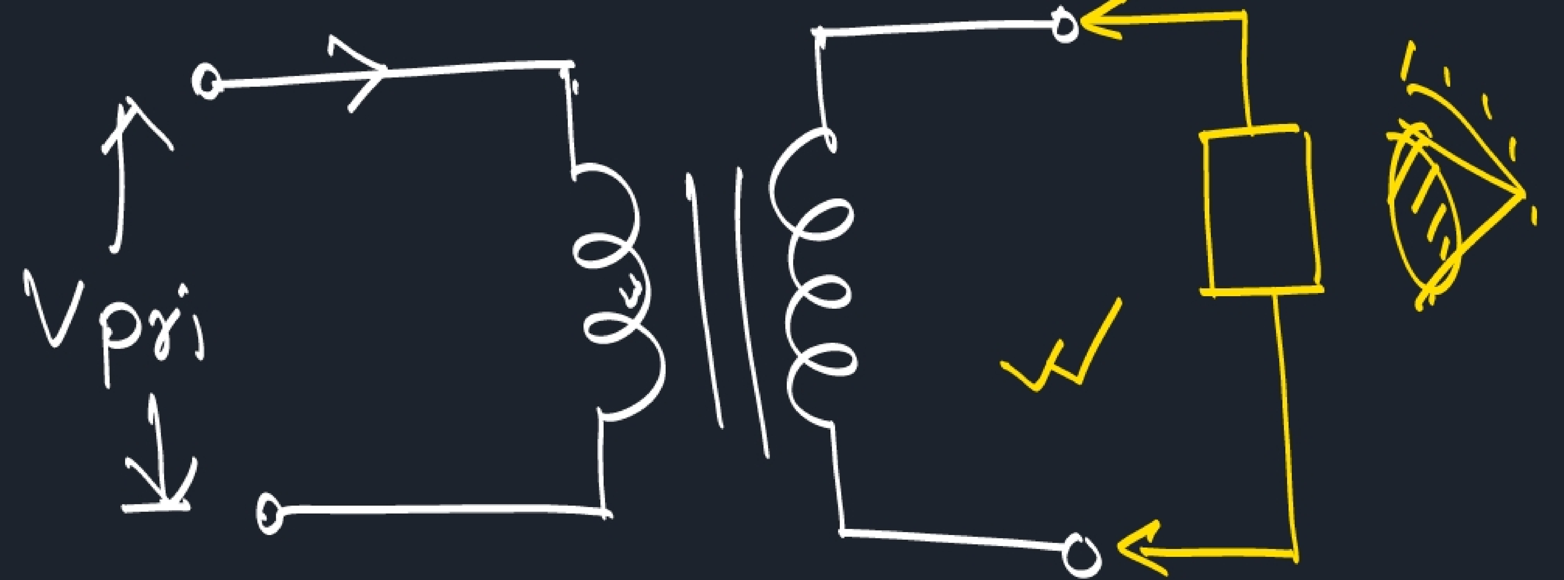

$Y = mx$

$I = G \cdot V$



$$\left.\begin{aligned} G_0 &= \frac{1}{R_0} \\ B_m &= \frac{1}{X_m} \end{aligned}\right\}$$

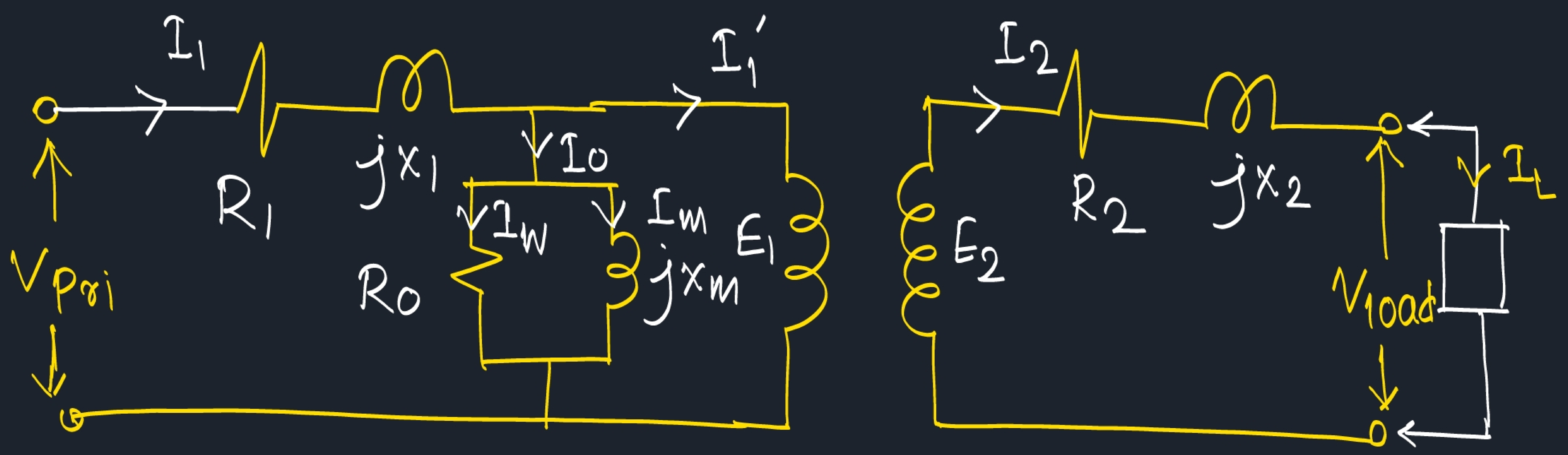
## (iii) Analyzing T/F with Load :-




220/110 V

$S = VI^*$

$S^* = V^* I$




$V_1/V_2$

$\frac{V_1}{V_2} = \frac{N_1}{N_2}$

Load $\rightarrow$ $P_L + jQ_L$ (R-L)

$P_L - jQ_L$ (R-C)

$\boxed{V_{load} = |V_{load}|\angle 0}$

$R_1, R_2 \Rightarrow \underbrace{\text{Winding Resistances}}$ $\hookrightarrow$ Cu loss

$R_o \Rightarrow \underbrace{\text{Shunt branch Resistance}}$ $\hookrightarrow$ Core loss

Let us assume the load is of R-L type. $S = P_L + jQ_L$

$S^* = V^* I$

$$I = \frac{(P+jQ)^*}{V^*} = \frac{P - jQ}{V_{load}\angle 0}$$

$$\boxed{\tilde{I} = \frac{P - jQ}{V_{load}\angle 0}}$$

$$\tilde{E}_2 = \tilde{V}_{load} + \tilde{I}\left(R_2 + jx_2\right)$$

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

$$\tilde{E}_1 = \tilde{E}_2 \cdot \left(\frac{N_1}{N_2}\right)$$

$$I_1 = I_1' + I_0$$

$$N_1 I_1' = N_2 I_2$$

$$I_2 = I$$

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

$$= \left(\frac{V_2}{V_1}\right) \cdot I$$

$$\underbrace{\tilde{I}_0 = \frac{E_1}{R_0} + \frac{E_1}{jX_m}}$$

$$\boxed{V_{pri} = \tilde{E}_1 + I_1\left(R_1 + jx_1\right)}$$

8929

## Problem :-

$1\Phi$ T/F.

150 KVA, 2400/240 V

$R_1 = 0.2\,\Omega$ $\quad R_2 = 2\,m\Omega$

$X_1 = 0.45\,\Omega$ $\quad X_2 = 4.5\,m\Omega$

$R_0 = 10\,k\Omega$ $\quad X_m = 1.55\,k$

The load :- Rated current @ rated Voltage at 0.8 pf (lag) at LV Side.

(Exact ckt)

## Soln :-

Rated current = ?

$$|I| = \frac{150 \times 10^3}{240} = 625\,A$$

$$\hat{I} = 625 \angle -\cos^{-1}(0.8)$$

$$\hat{E}_2 = 240\angle 0 + \hat{I} \times (2 + j4.5) \times 10^{-3}$$

$$= 242.692 \angle 0.354\ V$$

$$\frac{E_1}{E_2} = \frac{N_1}{N_2} = \frac{V_1}{V_2} = 10 \qquad \hat{E}_1 = 2426.92 \angle 0.354\ V.$$

$$I_1' N_1 = I_2 N_2$$

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

$$= \left(\frac{V_2}{V_1}\right) \cdot I_2$$

$$= \left(\frac{240}{2400}\right) \cdot 625 \angle -\cos^{-1}(0.8)$$

$$= 62.5 \angle -\cos^{-1}(0.8)$$

$$\tilde{I}_0 = \underbrace{\frac{E_1}{R_0}}_{I_w} + \underbrace{\frac{E_1}{jX_m}}_{I_m}$$

$$= 2426.92\angle 0.354 \left( \frac{1}{10\times10^3} + \frac{1}{j1.55\times10^3} \right)$$

$$= 1.5845\angle -80.835 \text{ Amp.}$$

$$\tilde{I}_1 = \tilde{I}_0' + \tilde{I}_1'$$

$$= 1.5845\angle -80.835 + 62.5\angle -36.869$$

$$= 63.649\angle -37.86$$

$$\text{Core loss} = |I_w|^2 \cdot R_0$$

$$I_w = 0.2427\angle 0.354$$

$$P_{core} = \left\{ (0.2427)^2 \times 10\times10^3 \right\} = 589 \text{ watt.}$$

$$V_{pri} = E_1 + I_1(R_1 + jX_1)$$

$$= 2426.92\angle 0.354 + (63.649\angle -37.86) \times (0.2 + j0.45)$$

$$= 2454.68\angle 0.695 \text{ Volt.}$$

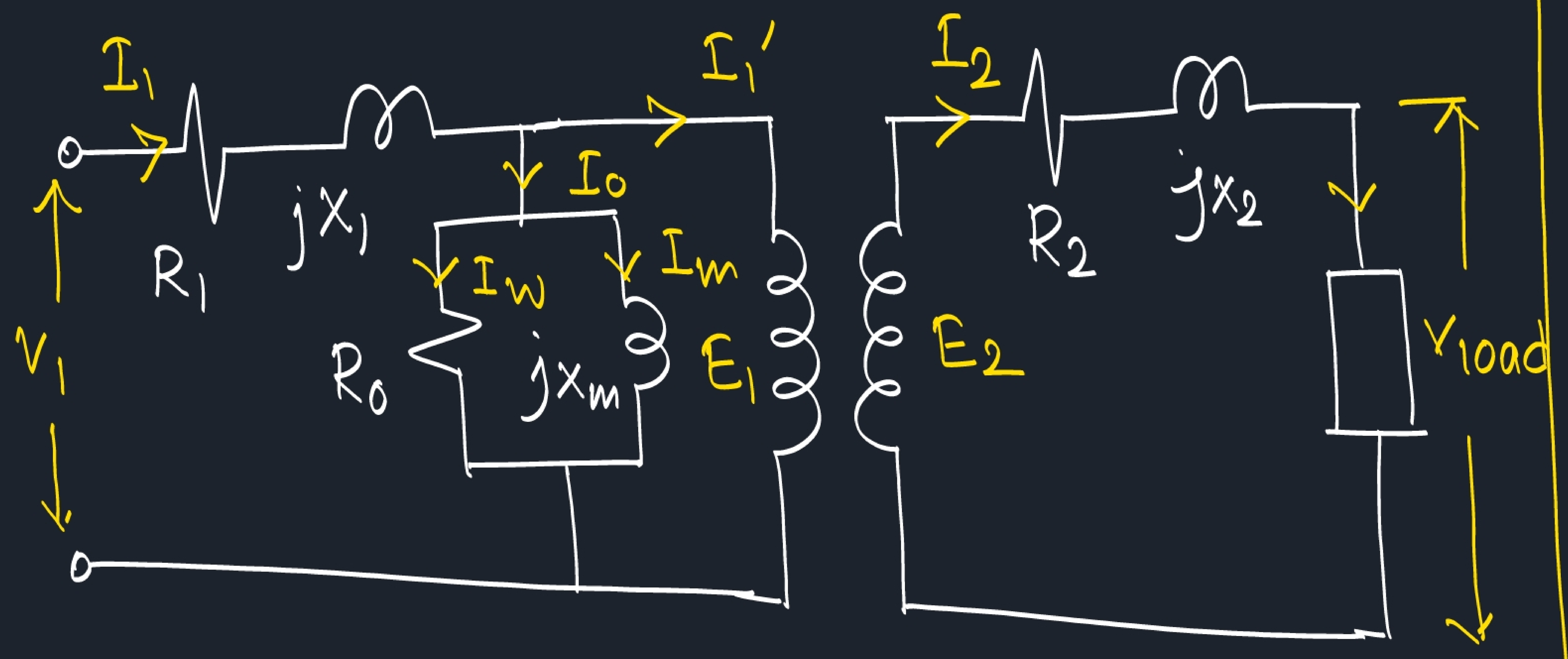
$$P_{cu} = |I_2|^2 R_2 + |I_1'|^2 R_1$$

$$= (625)^2 \times 2\times10^{-3} + (63.649)^2 \times 0.2 \text{ Watt.}$$

$$= 1591.489 \text{ W}$$

# Phasor Diagram:-

## Exact Equivalent Ckt.




$V_1 / V_2$

$\underline{\underline{V_1 > V_2}}$

Consider $\boxed{V_{load} = V_2 \angle 0}$ → Ref$^n$. Phasor.

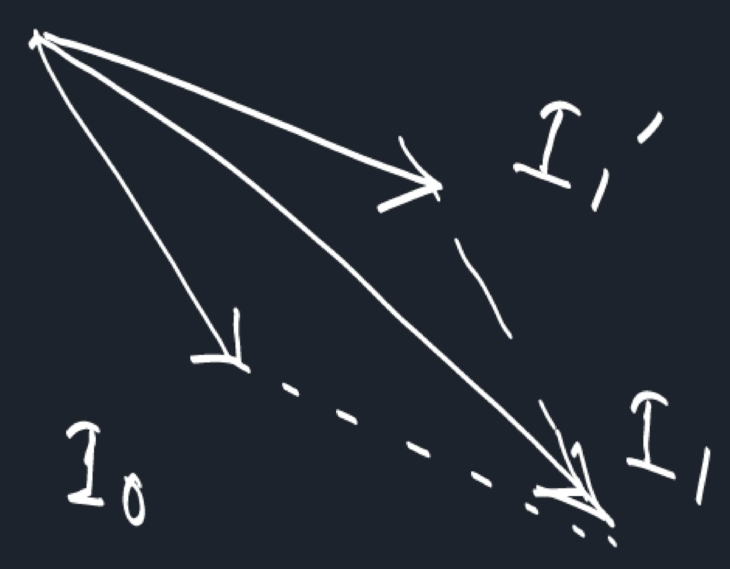
$\boxed{I_2 = I_{load}.}$

$\frac{E_1}{E_2} = \frac{N_1}{N_2} > 1$

$E_1 > E_2$ $\quad$ $I_1' < I_2$

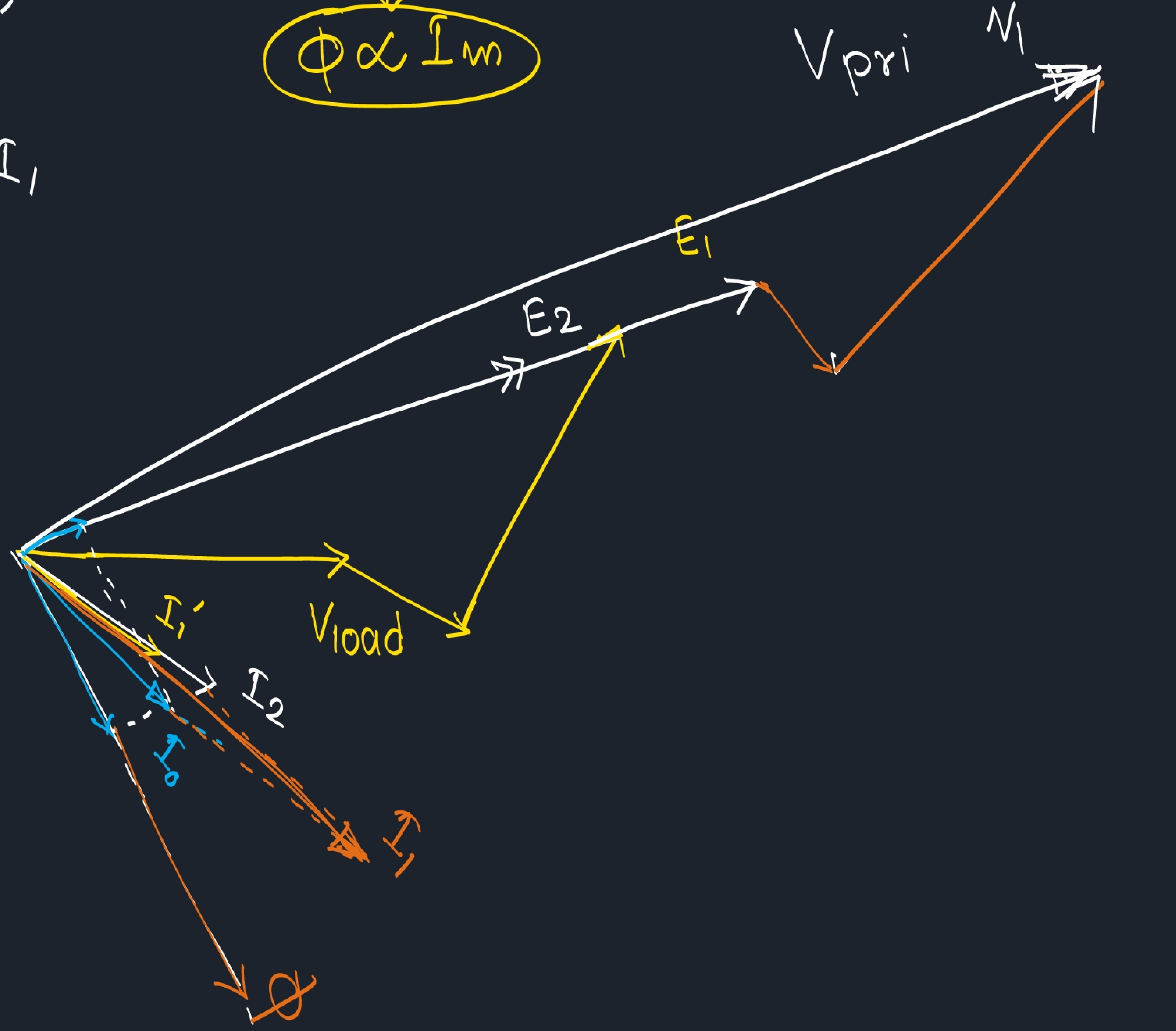
$I_0 = \frac{E_1}{R_0} + \frac{E_1}{jx_m} = \frac{E_1}{R_0} - j\frac{E_1}{x_m}$

$\hat{I}_1 = \hat{I}_1' + I_0$

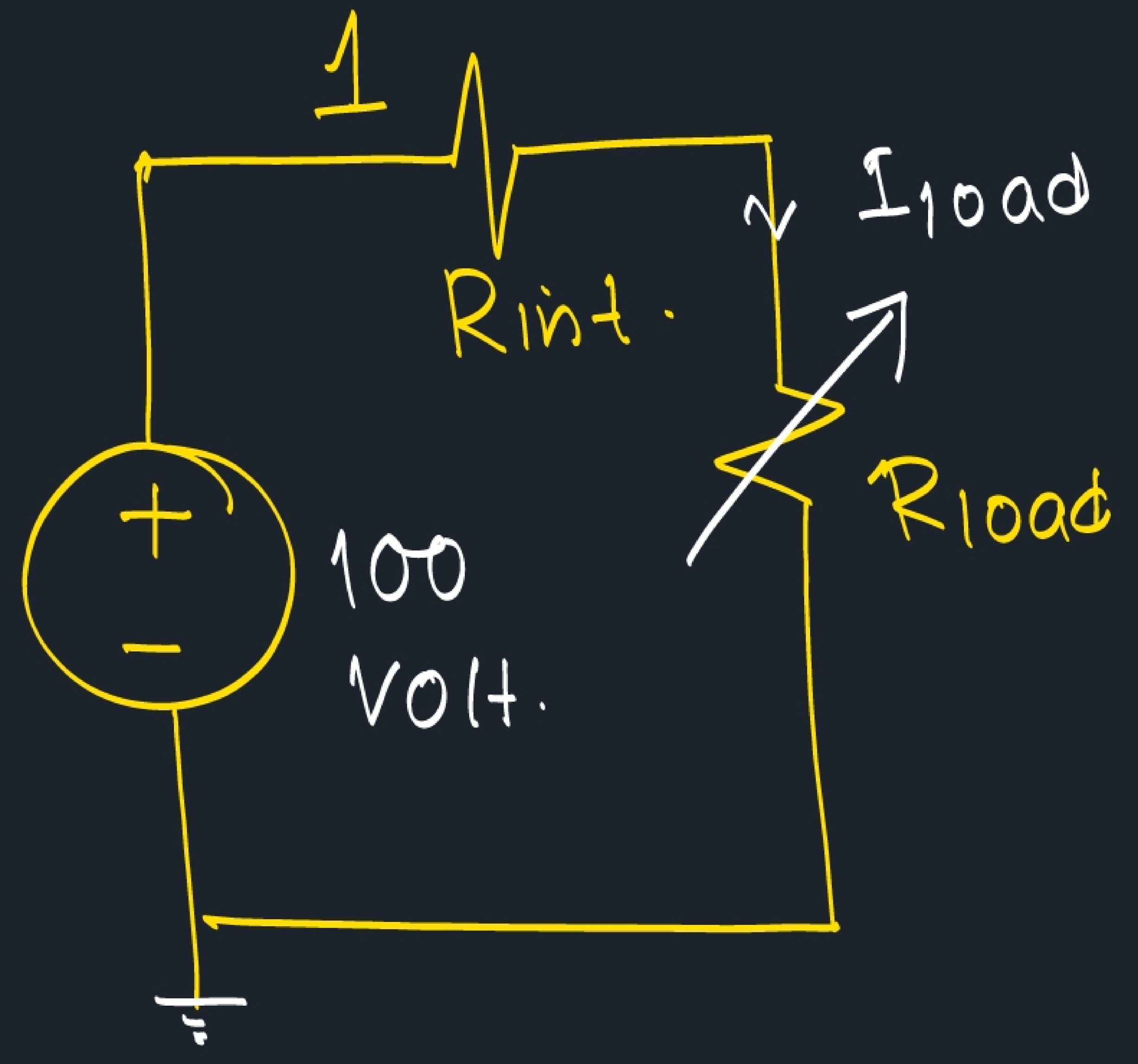


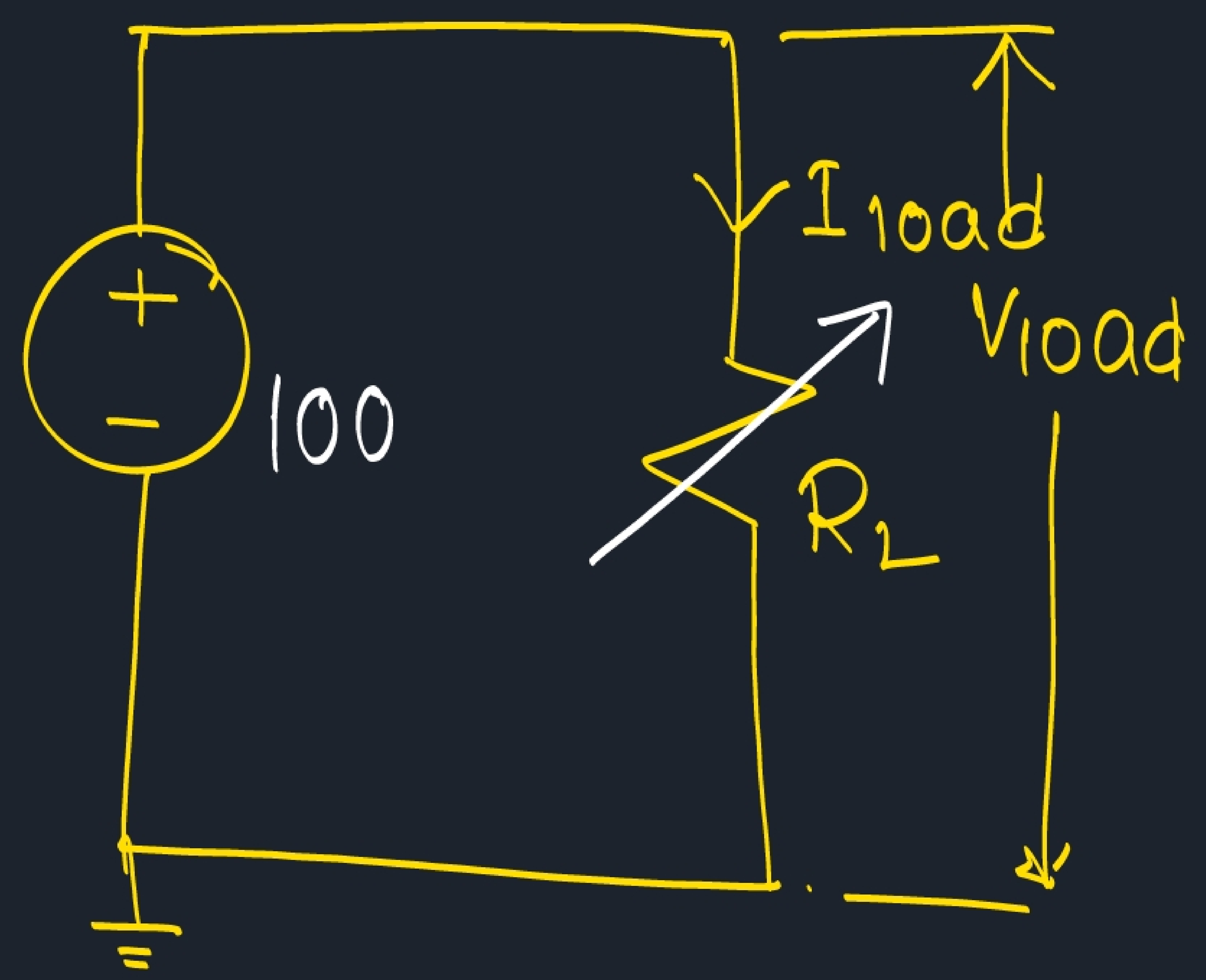

$N\phi \propto I_m$

$\phi \propto I_m$



# Voltage Regulation:-




$$V_{load} = 100 - R_{int} \cdot I_{load}$$

$$= 100 - R_{int} \cdot \frac{100}{R_{int} + R_{load}}$$

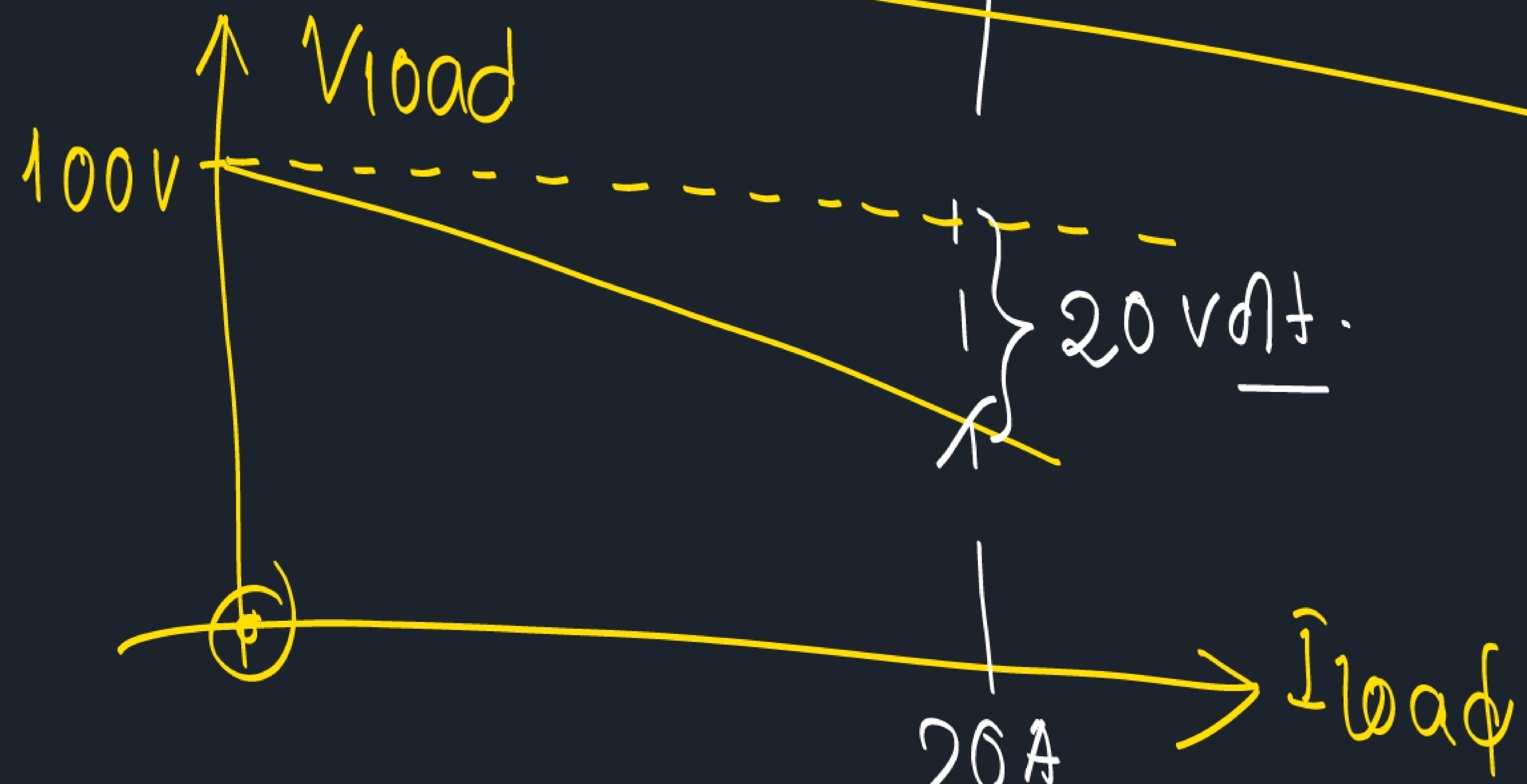
$$\% \text{Reg.} \ \frac{100-80}{80} \times 100$$

$$= \frac{20}{80} \times 100$$

$$= \underline{25\%}$$

| $R_{load}$ | $I_{load}$ | $V_{load}$. | |
|---|---|---|---|
| 4 | $\underline{\underline{20}}$ | 80 | |
| 19 | 5 | $19 \times 5$ = | |
| 49 | 2 | $49 \times 2$ = | |
| 99 | 1 | $99 \times 1$ = 99 | |

$$\underbrace{\left\{ \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100 \right\}}_{\text{\% Voltage Regulation}}$$



$\underline{2454.68\ V}$

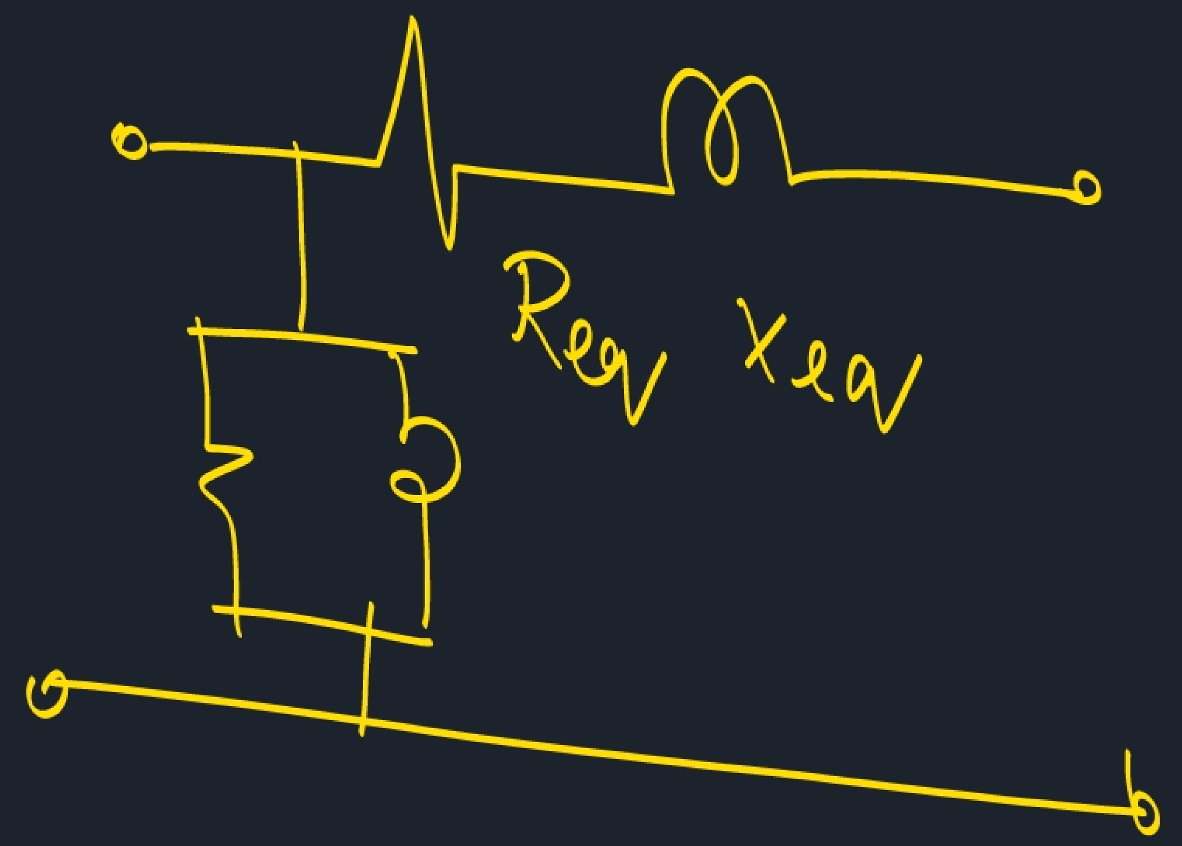
$$\% \text{Reg} = \underbrace{\frac{|V_{NL}| - |V_{FL}|}{|V_{FL}|} \times 100.}$$


Terminal/Load voltage $\rightarrow$ 240 V

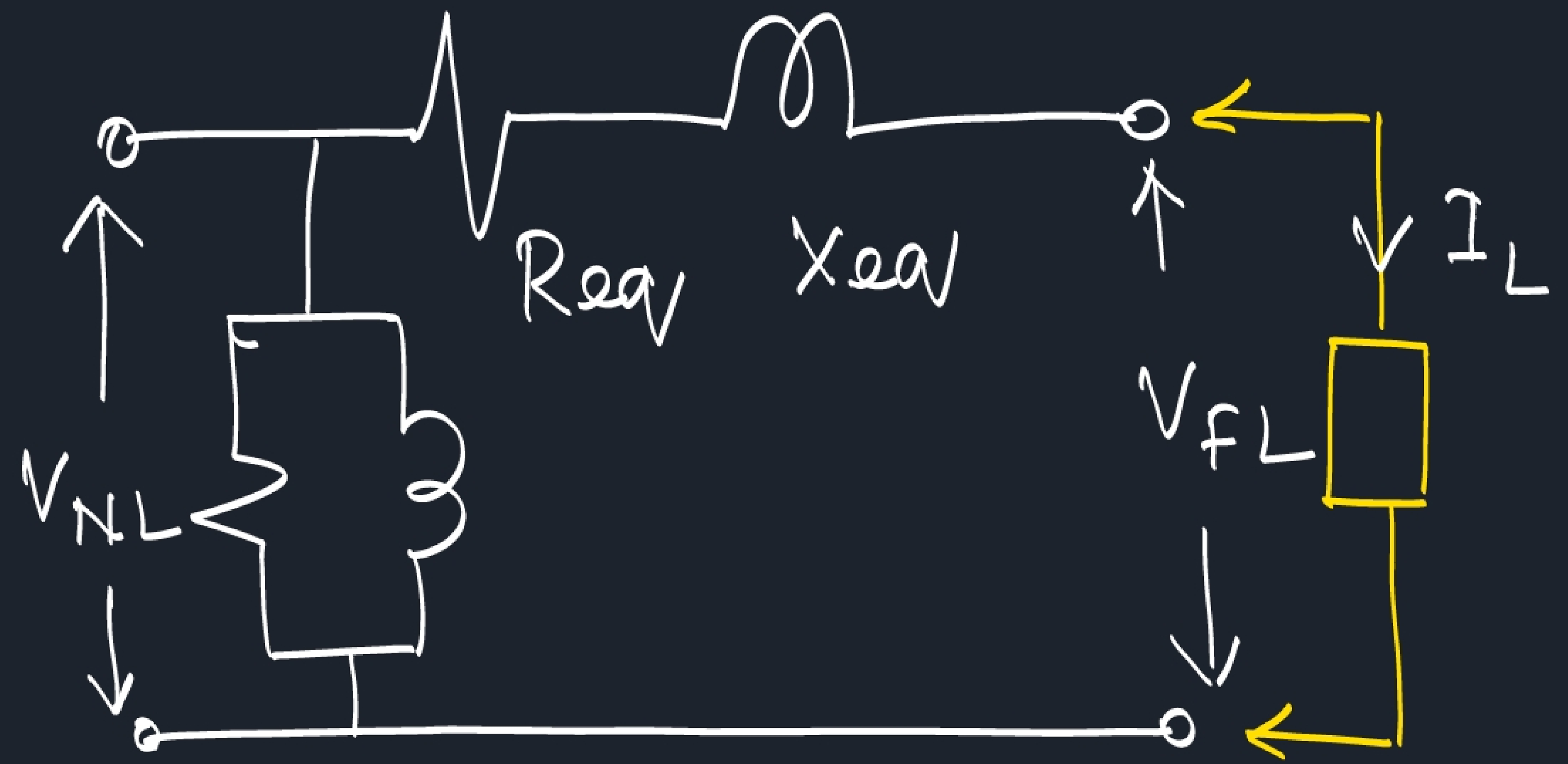
$$\% \text{Reg.} = \left\{ \frac{245.468 - 240}{240} \times 100 \right\}$$

No load rating 2400/240

$$\boxed{\frac{N_1}{N_2} = 10}$$




$$I_0 \ll I_1$$




$$\%\,Reg = \frac{|V_{NL}| - |V_{FL}|}{|V_{FL}|}$$

$$= \left\{ \frac{|I_L|(R_{eq}\cos\theta \pm X_{eq}\sin\theta)}{|V_{FL}|} \right\} \times 100$$

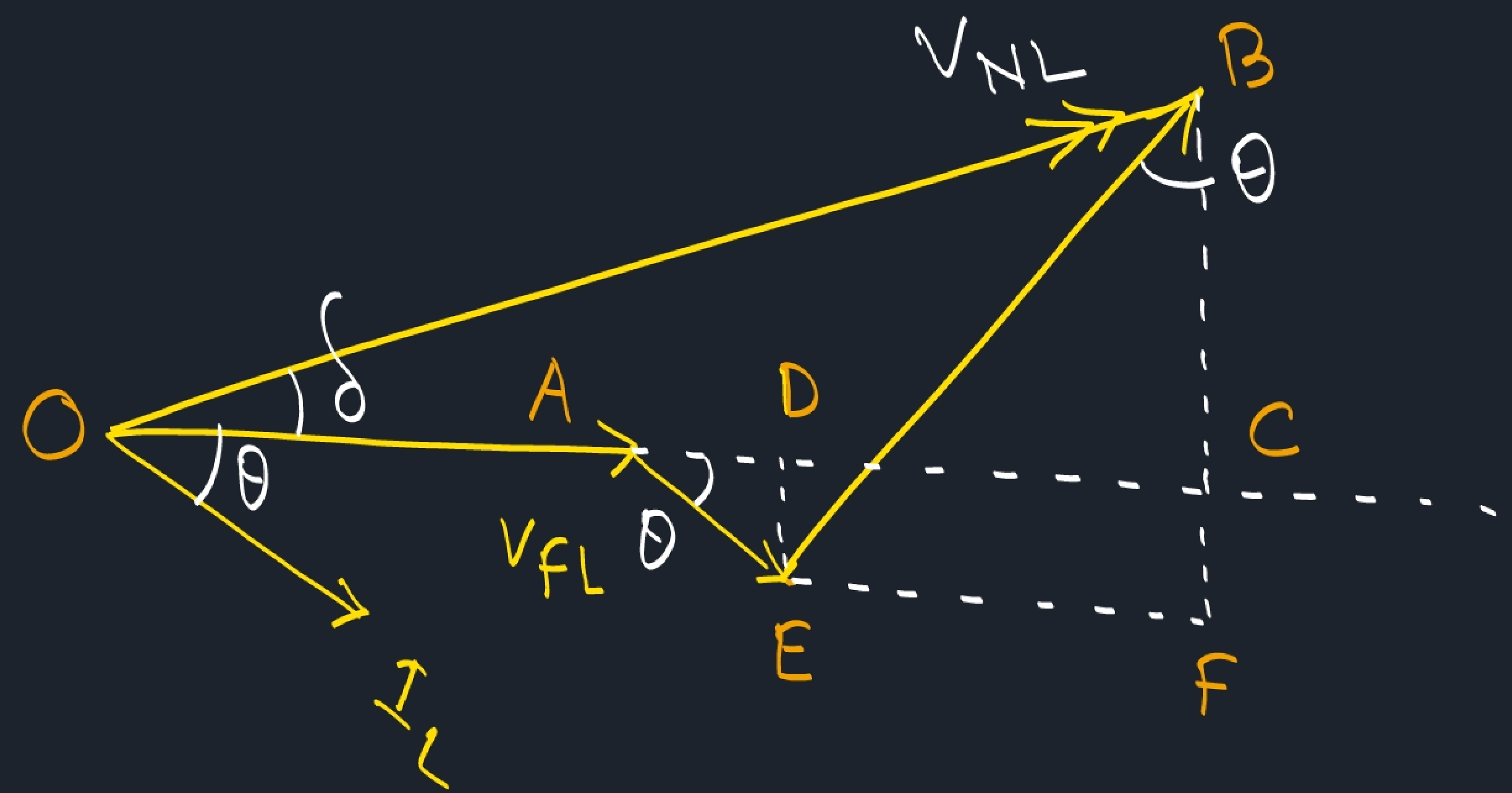
$$OC = OB\cos\delta$$

$$OC \approx OB.$$

$$V_{NL} = V_{FL} + I_L(R_{eq} + jX_{eq})$$

$\oplus \Rightarrow$ lagging pf

$\ominus \Rightarrow$ leading pf.

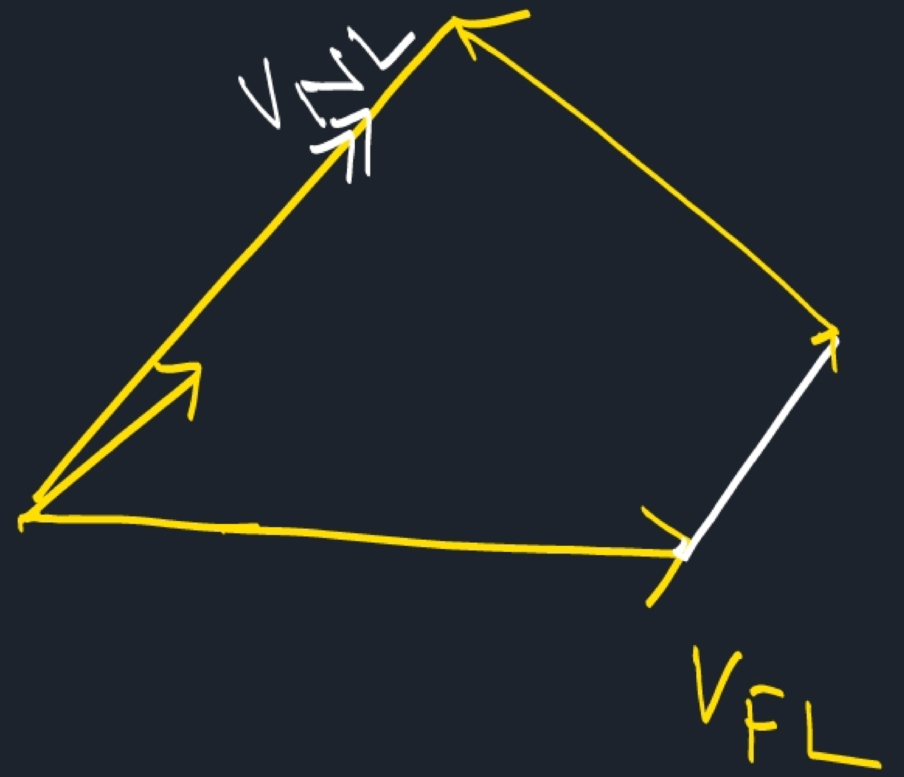



$$OC = OA + AD + DC$$

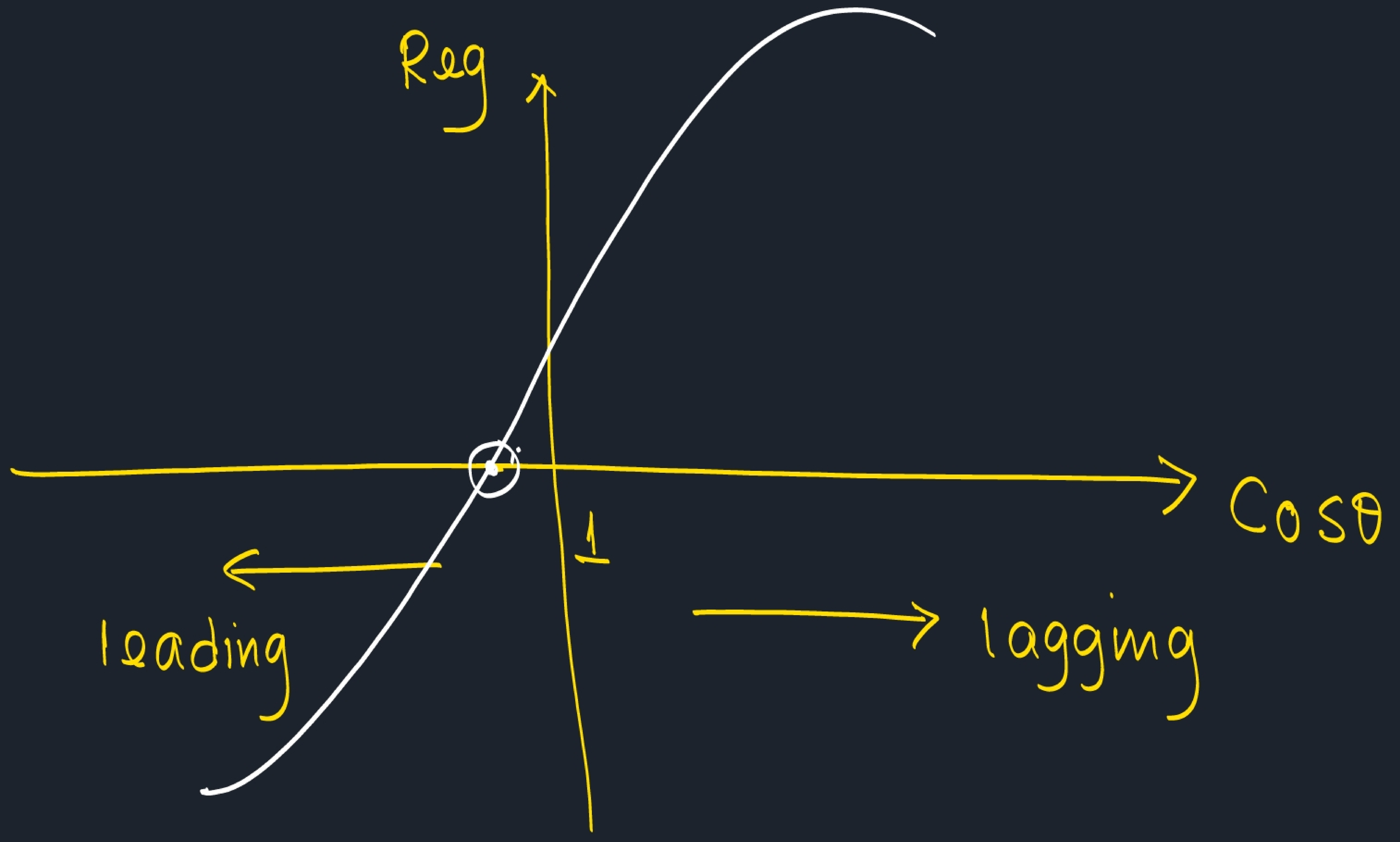
$$= OA + AD + EF$$

$$V_{NL} = V_{FL} + AE\cos\theta + EB\sin\theta$$

$$= V_{FL} + I_L R_{eq}\cos\theta + I_L X_{eq}\sin\theta$$




$$\%\,Reg = \frac{|I_L|\left(R_{eq}\cos\theta \pm X_{eq}\sin\theta\right)}{|V_{FL}|}$$




**Max VR**

$$R = K\left(R_{eq}\cos\theta + X_{eq}\sin\theta\right)$$

$$\frac{dR}{d\theta} = K\left(-R_{eq}\sin\theta + X_{eq}\cos\theta\right) = 0$$

$$R_{eq}\sin\theta = X_{eq}\cos\theta$$

$$\tan\theta = \frac{X_{eq}}{R_{eq}} \qquad \theta = \tan^{-1}\left(\frac{X_{eq}}{R_{eq}}\right)$$

**Zero VR**

$$R = K\left(R_{eq}\cos\theta - X_{eq}\sin\theta\right) = 0$$

$$\tan\theta = \frac{R_{eq}}{X_{eq}} \qquad \theta = \tan^{-1}\left(\frac{R_{eq}}{X_{eq}}\right)$$

## efficiency:-

$$\text{eff} = \frac{\text{o/p Power}}{\text{i/p Power}} \times 100.$$

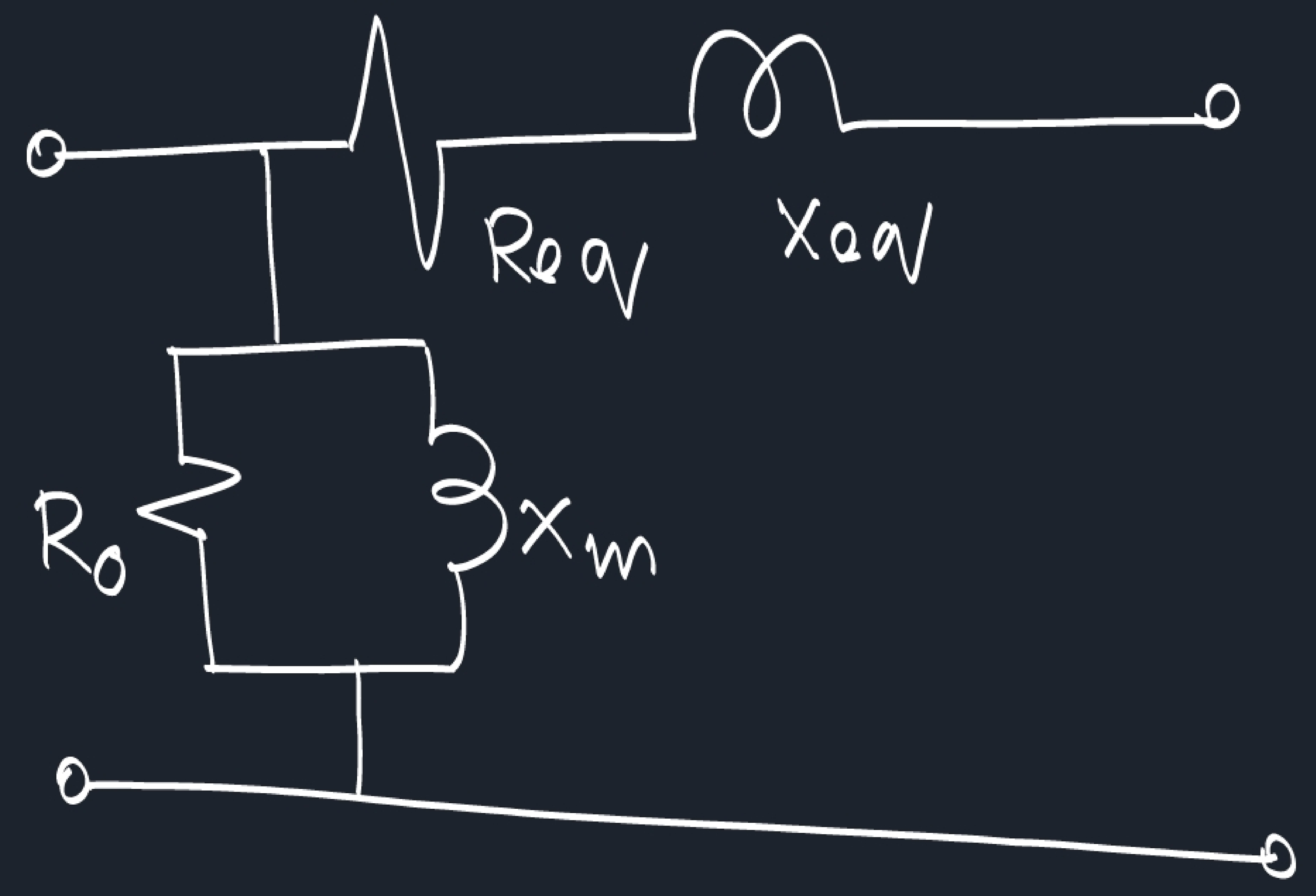
$$= \frac{\text{o/p Power}}{\text{o/p Power} + \text{losses}}$$

Core loss — $(P_{core})$ — Fixed loss

Cu loss. — $(P_{cu})$ — Variable loss.

Wattmeter Reading (OC Test) $\rightarrow$ Rated $P_{core}$

" " (SC Test) $\rightarrow$ Rated $P_{cu}$




$$\text{eff} = \frac{\text{o/p Power}}{\text{o/p Power} + P_{core} + P_{cu}}$$

$$K = \frac{\text{actual current}}{\text{Rated current}}$$

$$(P_{cu})_{\text{any load}} = K^2 \cdot (P_{cu})$$

$$\text{eff} = \frac{P_{out}}{P_{out} + P_{core} + k^2 P_{cu}} = \frac{K S \cos\theta}{K S \cos\theta + P_{core} + k^2 P_{cu}}$$

$$\frac{d(\text{eff})}{dk} = 0$$

find the value of k

For a T/F

I know the VA rating

$VI\cos\theta$

$= S\cos\theta$

VA rating of T/F

$$\text{eff} = f(k, \cos\theta)$$

Case-1 $\Rightarrow$ when k changes & $\cos\theta$ fixed.

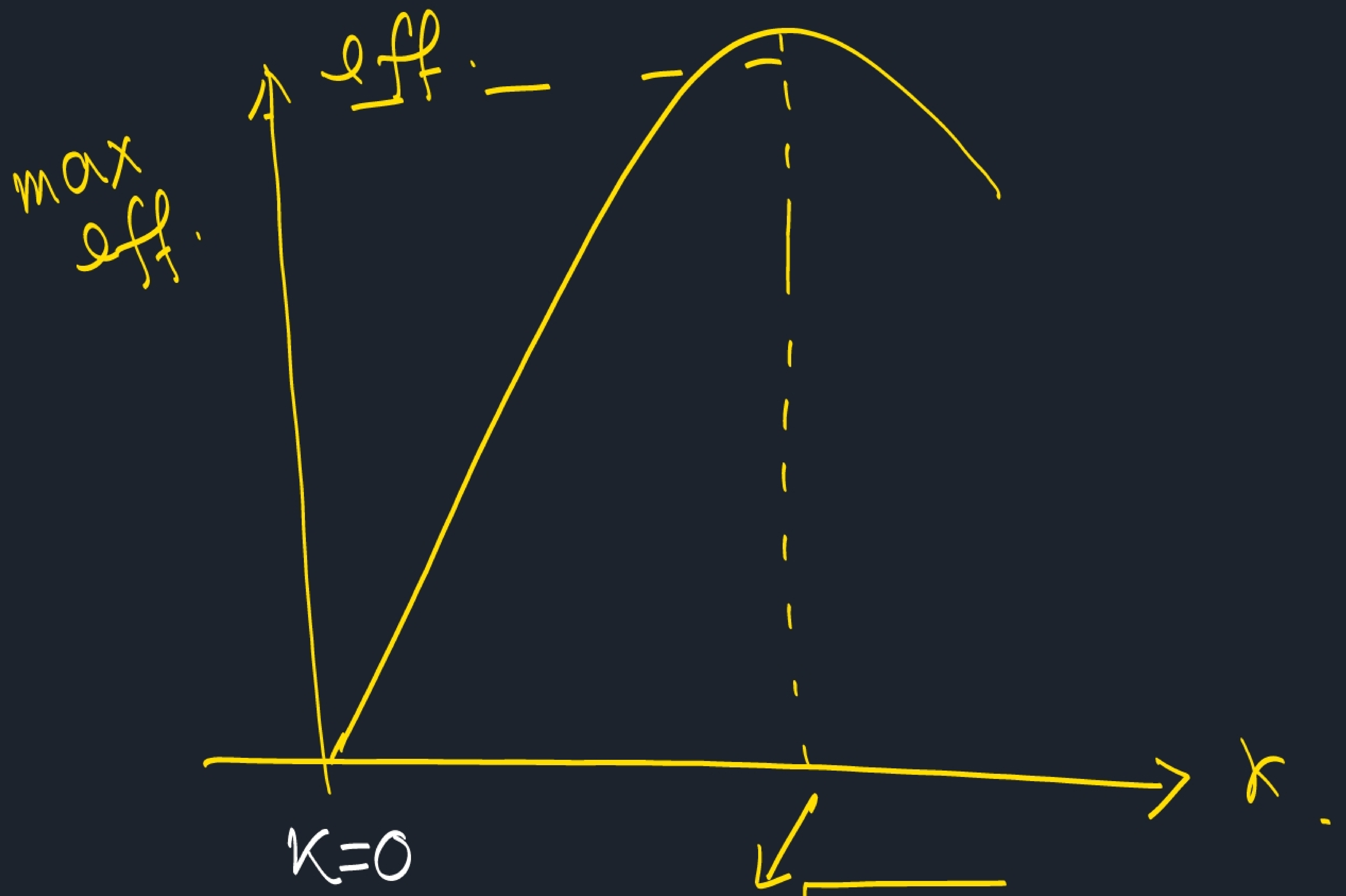
Case-2 $\Rightarrow$ when $\cos\theta$ changes & k is fixed.

$$= \frac{S\cos\theta}{S\cos\theta + \frac{P_{core}}{k} + k P_{cu}}$$

$$-\frac{P_{core}}{k^2} + P_{cu} = 0$$

$$k^2 = \frac{P_{core}}{P_{cu}}$$

$$\boxed{K = \sqrt{\frac{(P_{core})}{(P_{cu})}}}$$




$$k = \sqrt{\frac{P_{core}}{P_{cu}}}.$$