Basic Electrical Engineering (TEE 101)

Lecture 43: Practical Transformer on Load – Part 2

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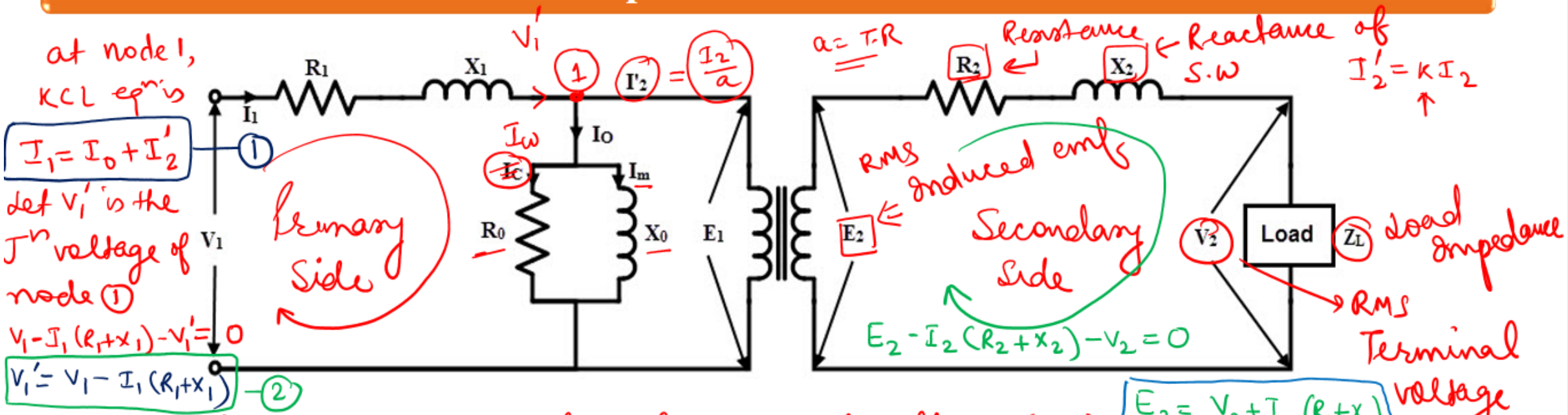
Content

This lecture covers:

- **Phasor Diagram of Practical Transformer for Inductive Load (i.e. Lagging Power Factor)**
- **Phasor Diagram of Practical Transformer for Resistive Load (i.e. Unity Power Factor)**
- **Phasor Diagram of Practical Transformer for Capacitive Load (i.e. Leading Power Factor)**

Important Parameters



at node 1, KCL eqn is

$I_1 = I_0 + I_2'$ — (1)

def V_1' is the 1^{st} voltage of node (1)

$V_1 - I_1(R_1+X_1) - V_1' = 0$

$V_1' = V_1 - I_1(R_1+X_1)$ — (2)

I_w = RMS value of real component of I_0

I_m = RMS value of the magnetising component of I_0

V_1 = RMS value of the input voltage (V_1)

I_1 = RMS value of the full load primary current

I_0 = RMS value of the NO-load primary current

I_2' = RMS value of the ~~full~~ primary counter current

E_1 = " " " " Induced emf in the primary winding

R_1 & X_1 ⇒ winding Resistance and Reactance of the Primary "

R_0 & X_0 ⇒ Core parameters (under NO-load condition)

$E_2 = V_2 + I_2(R_2+X_2)$ — (3)

Phasor Diagram of Practical Transformer for Inductive Load

$Z_L \in$ Inductive

NOT Pure Inductor

In an R-L load the current lags the voltage by ϕ

from the emf eqn concept

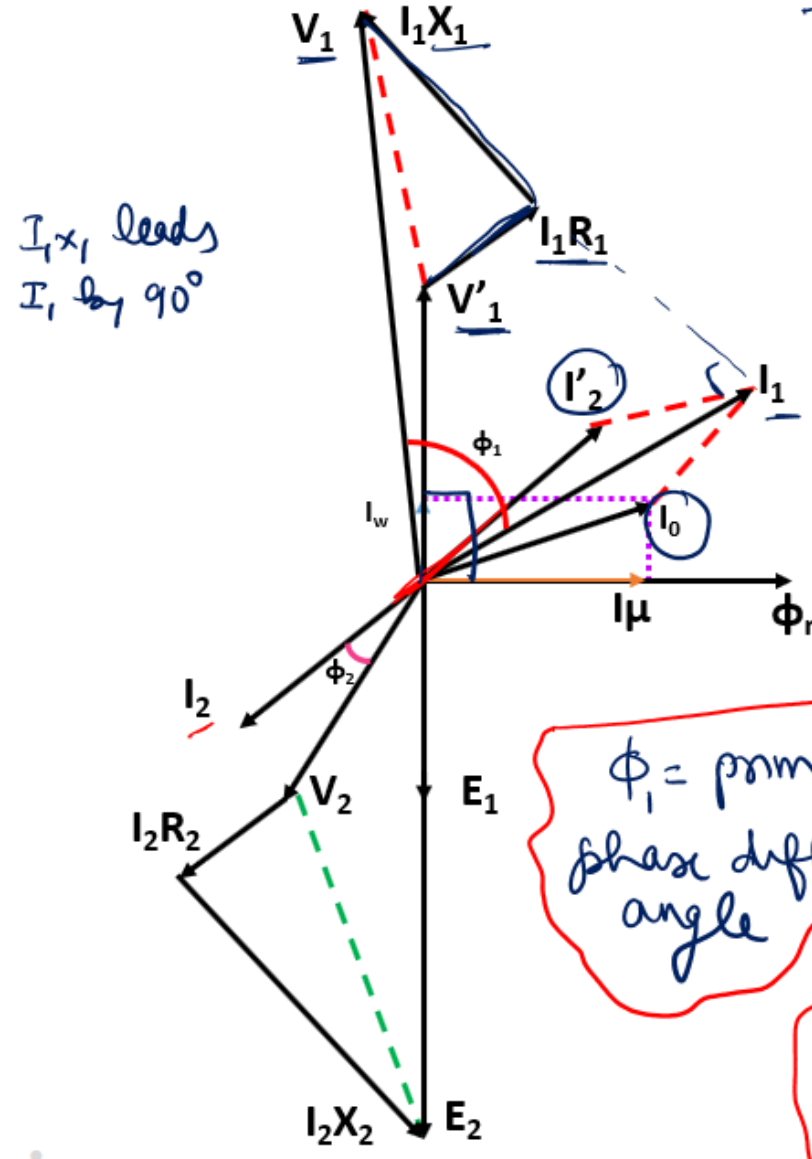
$\phi = \phi_m \sin\theta$

$e_1 = E_{m_1} \sin(\theta - 90^\circ)$

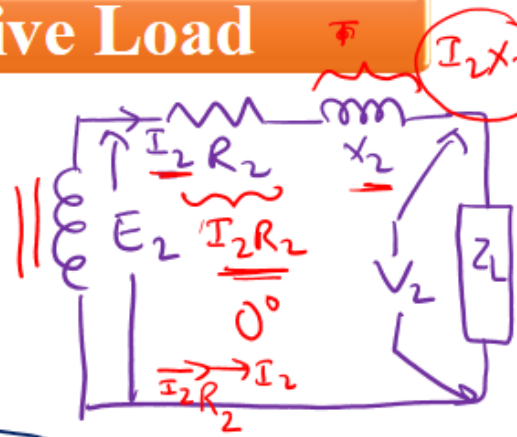
$e_2 = E_{m_2} \sin(\theta - 90^\circ)$

$\because Z_L$ = Inductive

hence, I_2 lags V_2 by ϕ_2



I_1x_1 leads I_1 by 90°



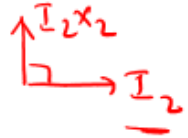
SW

$V_1 = I_1R_1 - I_1x_1 - V_1' = 0$

$V_1' = V_1 - I_1(R_1 + X_1)$

cause of

$V_1 = V_1' + I_1R_1 + I_1x_1$



E_1 vs V_1'

as per Lenz's law, E_1 opposes V_1'

ϕ_1 = primary phase difference angle

I_0 = NO load current

$I_0 = I_w + I_\mu$

voltage across R_0 & x_0 is V_1'

I_w & V_1' are in phase

I_μ lags V_1' by $\pi/2$ rad

$E_2 = V_2 + I_2R_2 + I_2X_2$

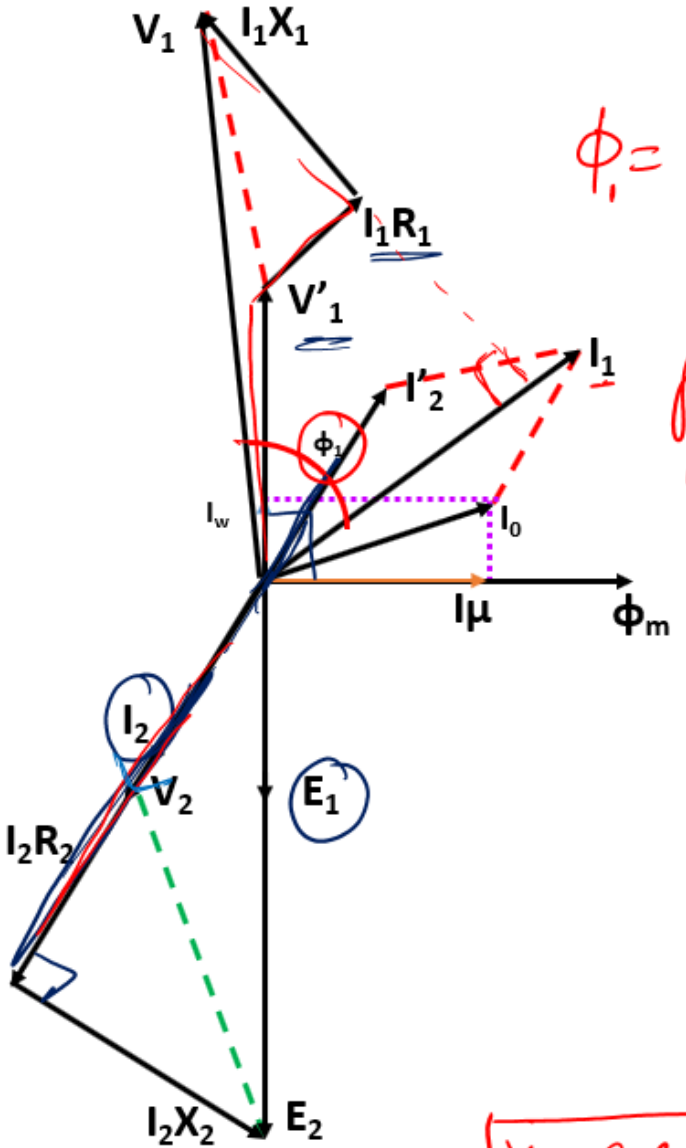
$= V_2 + I_2(R_2 + X_2)$

Phasor Diagram of Practical Transformer for Resistive Load

This is for the unity P.f

$Z_L = R$

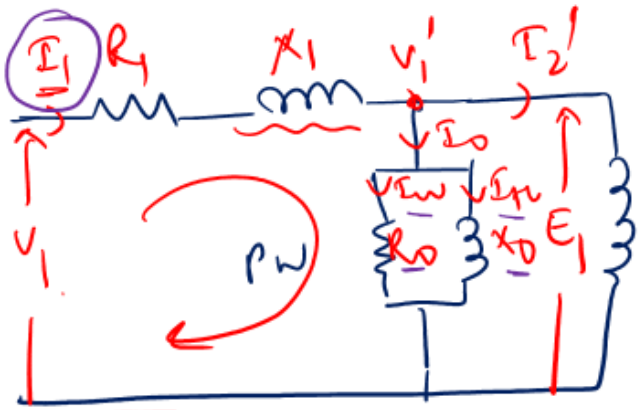
In a resistance the voltage & current are in same phase.



ϕ_1 = primary winding phase diff. b/w V_1 & I_1

I_2R_2 & I_2 are in phase

I_2X_2 leads I_2 by 90°



$V_1 = -E_1 + I_1R_1 + I_1X_1 + V_1'$

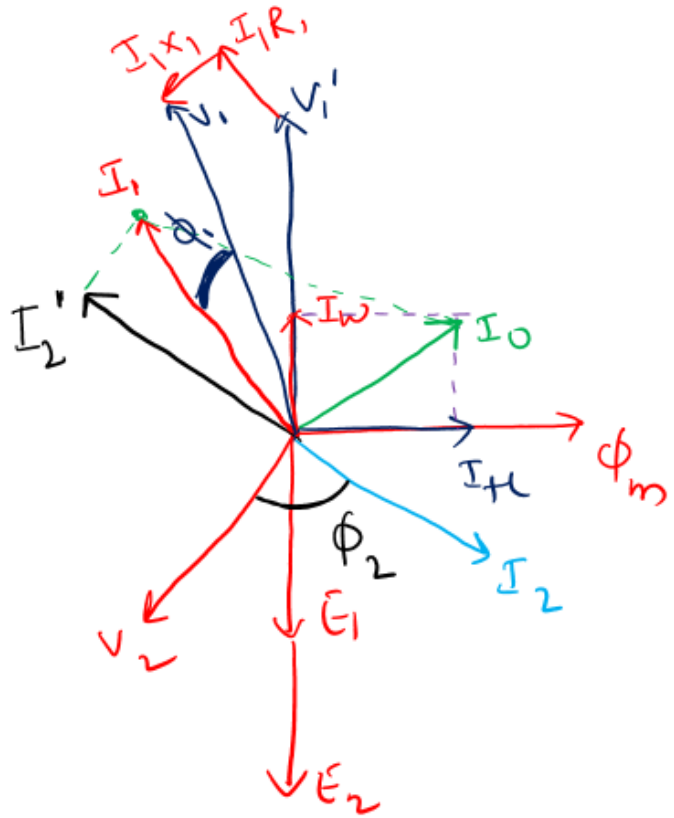
I_1X_1 leads I_1 by 90°

Phasor Diagram of Practical Transformer for Capacitive Load

Z_L = R-C (i.e capacitive)

In this case,

I_2 (full load secondary current) leads V_2 (full load terminal voltage of secondary) by angle ϕ_2



Phasor diagram of transformer for a capacitive load i.e for leading p.f (power factor)

ϕ_2 = phase difference angle between V_2 and I_2 for capacitive load

Thank You