Lecture 11

Wednesday, 14 February 2024 9:42 AM

EE114 - Power Engineering 1

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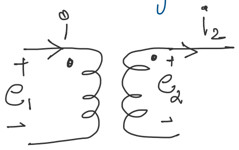
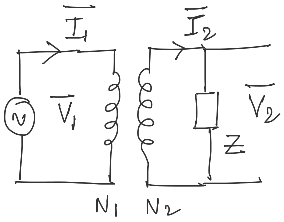
Consider an ideal transformer :-



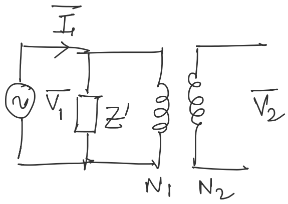
We now know $\frac{e_2}{e_1} = \frac{N_2}{N_1}$ & $i_2 N_2 = i_1 N_1$

Now let's connect a load to secondary side



Circuit 1

Consider another circuit



Circuit 2

Circuit 1 & circuit 2 are equivalent if

$\bar{I}_1$ in both circuits are same $\Rightarrow$ same source current

& $\bar{V}_2$ in both circuits are same

Same i/p & o/p characteristics

& Z is said to be referred to the primary side

$\Rightarrow$ $Z' \rightarrow$ Z referred to primary side

In circuit 1 $\rightarrow$ $\bar{I}_2 = \frac{\bar{V}_2}{Z}$ & $\bar{I}_1 = \frac{\bar{V}_2}{Z}\frac{N_2}{N_1}$

& $\bar{I}_1 = \frac{N_2^2}{N_1^2}\frac{\bar{V}_1}{Z}$

In circuit 2 $\rightarrow$ $\bar{I}_1 = \frac{\bar{V}_1}{Z'}$

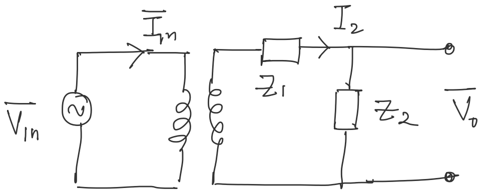
If in both circuits source current is same

$$\frac{\bar{V}_1}{Z'} = \frac{N_2^2}{N_1^2}\frac{\bar{V}_1}{Z}$$

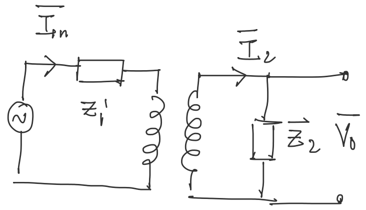
$$\boxed{Z' = \left(\frac{N_1}{N_2}\right)^2 Z}$$

Now consider another circuit

a)



b)



In figure (a)

$$\boxed{\overline{V_0} = \overline{I_2} Z_2}$$

$$\overline{V_0} = \overline{V_{in}} \times \frac{N_2}{N_1} - \overline{I_2} Z_1$$

$$\overline{V_0} = \overline{V_{in}} \frac{N_2}{N_1} - \overline{I_2} Z_1 \quad \text{—(i)}$$

both have same secondary current

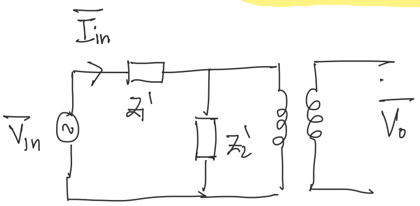
If figure (b) $\boxed{\overline{V_0} = \overline{I_2} Z_2}$

$$\overline{V_0} \frac{N_1}{N_2} = \overline{V_{in}} - \overline{I_{in}} Z_1'$$

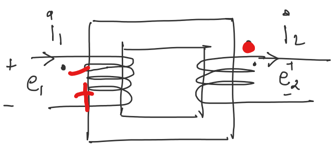
$$\Rightarrow \overline{V_0} = \overline{V_{in}} \frac{N_2}{N_1} - \frac{N_2^2}{N_1^2} Z_1' \overline{I_2} \quad \text{—(ii)}$$

From (i) & (ii) $\boxed{Z_1' = \frac{N_1^2}{N_2^2} Z_1}$

c)



* Actual transformer :-



* Let us μ is not infinite

$$e_1 = L_1 \frac{di_1}{dt} - M \frac{di_2}{dt}$$

$$\int e_1 dt = L_1 i_1 - M i_2$$

$$M = \frac{N_1 N_2}{R}$$

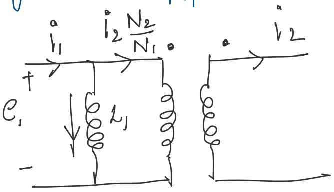
$$L_1 = \frac{N_1^2}{R}$$

$$i_1 = \frac{1}{L_1}\int e_1\,dt + \frac{M}{L_1} i_2$$

$$\frac{M}{L_1} = \frac{N_2 N_1}{N_1^2}$$

$$i_1 = \frac{1}{L_1}\int e_1\,dt + \frac{N_2}{N_1} i_2$$

circuit equivalent



Circuit equivalent of transformer with finite μ.

$$L_m = L_1 = \frac{N_1^2}{R_1}$$

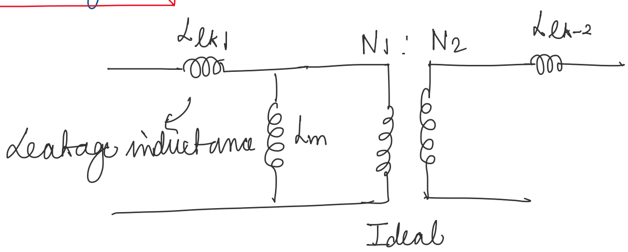
L_1 branch → magnetizing inductance

The current in magnetizing inductance is magnetizing current.

If μ is considered to be infinite $L_1 \rightarrow$ infinite then magnetizing current is zero. Its as if magnetizing branch is not at all there. We go back to ideal transformer.

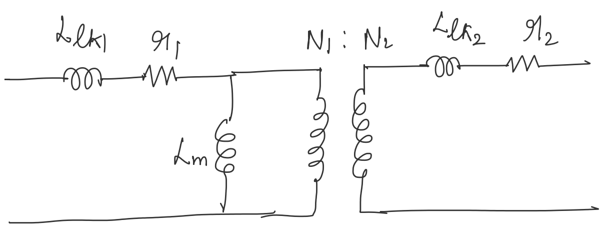
Primary current has 2 components, magnetizing current & secondary side current referred to primary side.

** Leakage



*** Losses

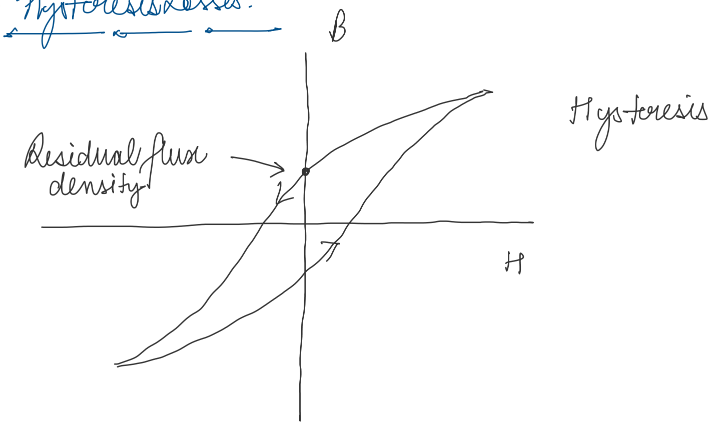
(i) Losses in winding → Copper loss or conduction losses



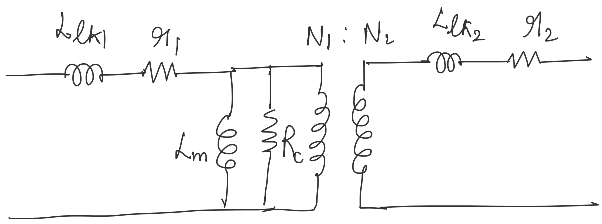
(ii) eddy current :— the flux the produces voltage in coil, also induces voltage in core. It leads to circulating current. The energy gets dissipated as heat.

We want to get rid of eddy current losses
→ we use laminated cores.

(iii) Hysteresis Losses :—



We take one path going up the B-H curve & another path while coming down. Energy is consumed in this process.



Coreloss → eddy current loss
→ hysteresis loss

Eddy loss = $K_e B_m^2 F^2 t^2 V$

Hysteresis loss = $\eta B_m^n F V$

It is represented as shunt because this is dependent on voltage induced in core. voltage induced is dependant on flux. which further depends upon applied voltage.

~~eddy current loss~~ $\cancel{\propto V^2 f}$

~~hysteresis loss~~ $\cancel{\propto V f (\oint BH)}$ → Area of BH loop

~~Volume~~ $\cancel{\propto V f B_m^n}$

$n \to 1$ to 2
typical 1.5
1.6