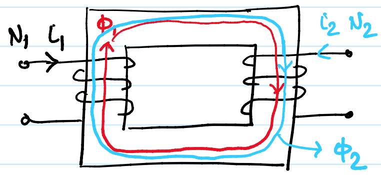
Lecture 18

Tuesday, May 11, 2021 1:52 PM

coupling factors
leakage inductance
dot marking.



All flux produced by coil 1
links coil -2
ie we have perfect coupling

$k = 1$

$$\phi_{1T} = \phi_1 + \phi_2$$

$$\phi_{2T} = \phi_1 + \phi_2$$

$$N_1 \phi_{1T} = \lambda_1 = N_1 \phi_1 + N_2 \phi_2$$

$$N_1 i_1 = \phi_1 R = \phi_1 \frac{l_c}{\mu A_c}$$

$$\phi_1 = \frac{\mu N_1 A_c}{l_c} i_1 \qquad \phi_2 = \frac{\mu N_2 A_c}{l_c} i_2$$

$$\lambda_1 = \underbrace{\frac{\mu N_1^2 A_c}{l_c}}_{\text{self inductance}} i_1 + \underbrace{\frac{\mu N_1 N_2 A_c}{l_c}}_{\text{mutual inductance (M)}} i_2$$

$$M = \frac{\mu N_1 N_2 A_c}{l_c}$$

$$= \frac{\mu A_c}{l_c} \cdot N_1 \cdot \left(\frac{N_1}{N_1}\right) \cdot \left(\frac{N_2}{N_2}\right) N_2 \cdot \left(\frac{\mu A_c}{l_c}\right)\left(\frac{l_c}{\mu A_c}\right)$$

$$= \underbrace{\left(\frac{\mu N_1^2 A_c}{l_c}\right)}_{L_{11}(L_1)} \cdot \underbrace{\left(\frac{l_c}{\mu N_1 N_2 A_c}\right)}_{1/M} \cdot \underbrace{\left(\frac{\mu N_2^2 A_c}{l_c}\right)}_{L_{22}(L_2)}$$

$$M = \frac{L_{11} L_{22}}{M} = L_1 L_2$$

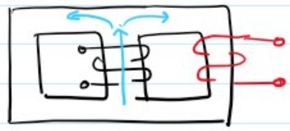
$$M^2 = L_{11} L_{22} = L_1 L_2$$

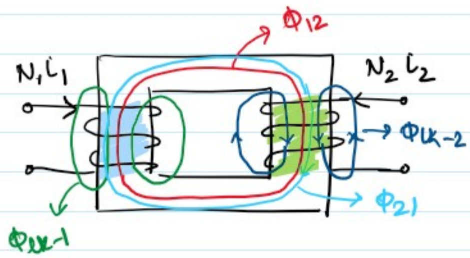
$$\boxed{M = \sqrt{L_{11} L_{22}}}$$

$$M = k \sqrt{L_{11} L_{22}}$$

$M = k\sqrt{L_{11}L_{22}}$

k = coupling factor. so far $k = 1$





$\Phi_{1T} = \Phi_{lk-1} + \Phi_{12}$

$\Phi_{2T} = \Phi_{lk-2} + \Phi_{21}$

$k = \dfrac{\Phi_{12}}{\Phi_{1T}}$ or $k = \dfrac{\Phi_{21}}{\Phi_{2T}}$

one can endup with positive or negative coupling

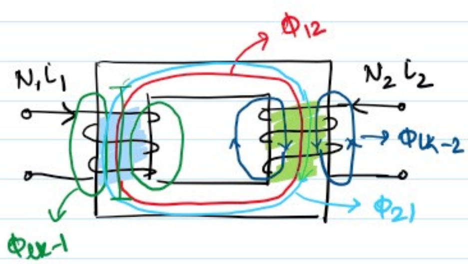
$\Phi_1^{Total} = \Phi_{1T} + \Phi_{21}$

$\Phi_2^{Total} = \Phi_{2T} + \Phi_{12}$

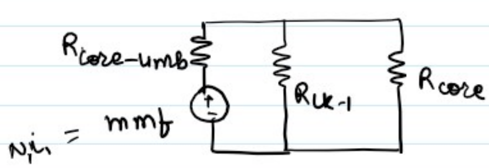
$\Phi_1^{Total} = \Phi_{lk-1} + \Phi_{12} + \Phi_{21}$

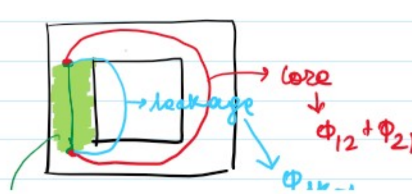
$\Phi_2^{Total} = \Phi_{lk-2} + \Phi_{21} + \Phi_{12}$

$N_1 \Phi_1^{Total} = \lambda_1 = N_1\Phi_{lk-1} + N_1\Phi_{12} + N_1\Phi_{21}$

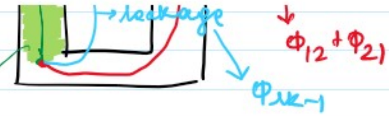


$mmf = N_1 i_1$





$N_1 i_1 =$ mmf 



air gap ⇒ majority of mmf was consumed by the airgap even when it is very small

core-limb → $\Phi_{lk-1} + \Phi_{12} + \Phi_{21}$

$$R_{core\text{-}limb} << R_{lk-1} \rightarrow N_1 i_1$$

$$\Phi_{lk-1} \approx \frac{N_1 i_1}{R_{lk}}$$

$$\Phi_{12} \approx \frac{N_1 i_1}{R_{core}}$$

$$\Phi_{21} \approx \frac{N_2 i_2}{R_{core}}$$

$$\lambda_1 = N_1 \Phi_{lk-1} + N_1 \Phi_{12} + N_1 \Phi_{21}$$

$$\lambda_1 = N_1 \cdot \frac{N_1 i_1}{R_{lk}} + N_1 \frac{N_1 i_1}{R_{core}} + N_1 \frac{N_2 i_2}{R_{core}}$$

$$= \frac{N_1^2}{R_{lk}} i_1 + \frac{N_1^2}{R_{core}} i_1 + \frac{N_1 N_2}{R_{core}} i_2$$

$$\lambda_1 = N_1^2 \left(\frac{1}{R_{lk-1}} + \frac{1}{R_{core}} \right) i_1 + \frac{N_1 N_2}{R_{core}} i_2$$

$$\lambda_1 = \frac{\mu N_1^2 A_c}{l_c} i_1 + \frac{\mu N_1 N_2 A_c}{l_c} i_2$$

self inductance

mutual inductance (M)

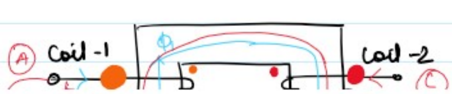
$$\text{self inductance} = \frac{N_1^2}{R_{lk-1}} + \frac{N_1^2}{R_{core}}$$

$$L_{11} = L_{lk-1} + L_M$$

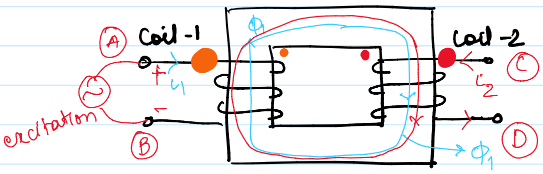
$$M = \frac{N_1 N_2}{R_{core}}$$

$$\left.\begin{aligned} \lambda_1 &= L_{lk-1} i_1 + L_M i_1 + M i_2 \\ \lambda_2 &= L_{lk-2} i_2 + L_M i_2 + M i_1 \end{aligned}\right\}$$ try and represent in the form of circuit

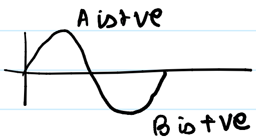
dot marking for coupled coils → Also indicates direct of voltage drop that should be considered



These are put up to let us identify which terminals of the two coils



These are put up to let us identify which terminals of the two coils have the same **polarity** through out as the exciting coil.



Simplified Dot Marking Procedure

Use this process instead of the detailed discussion done in the class.

- Arbitrarily select a terminal of one of the coils and mark it with a dot.
- Define current entering into the terminal and find direction of the flux using right hand rule.
- Arbitrarily pick one terminal of the second coil and define current entering in the coil.
- Find the direction of the flux produced by current in the second coil.
- Compare the directions of the two fluxes. If the fluxes have the same reference direction, place a dot on the terminal of the second coil where the test current enters. If the fluxes have different reference direction place a dot on the terminal of the second coil where the test current leaves.