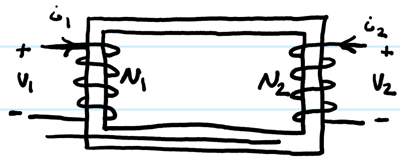
2018-09-24-1

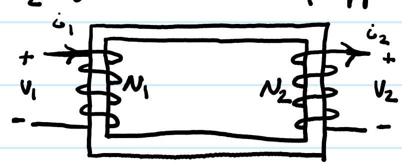
Last time: Mutually coupled coils



$\lambda_1 = L_1 i_1 + M i_2$

$\lambda_2 = M i_1 + L_2 i_2$

if i_2 direction is flipped



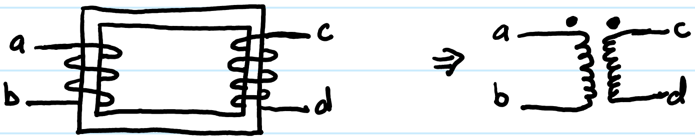
$\lambda_1 = L_1 i_1 + M i_2$

$\lambda_2 = M i_1 - L_2 i_2$

Today: 1) Dot convention

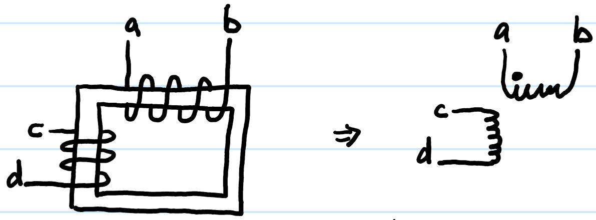
2) Circuits with Mutually Coupled coils

* Very tedious to keep track of details of coupled windings
* To simplify use dot convention



* Dots are assigned so that current entering a dotted terminal on one winding produces a voltage with positive polarity on the dotted terminal of the second winding.

Ex



* where to put second dot?

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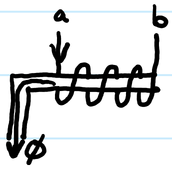
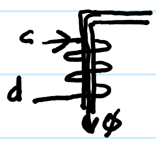
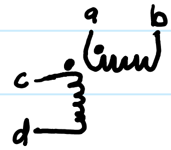
Steps: 1) Inject current into first dot and use RHR to find flux direction in iron

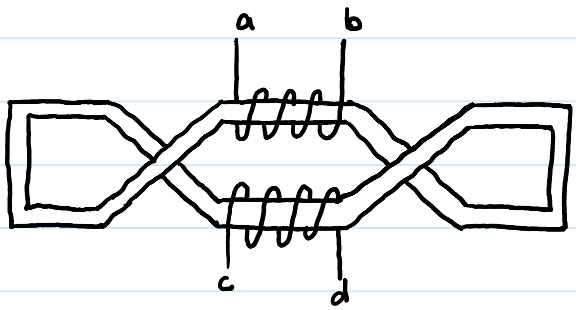


2) Put second dot on terminal of second coil to give same flux direction



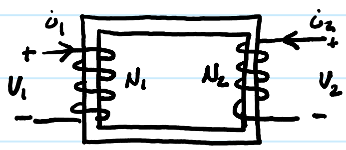


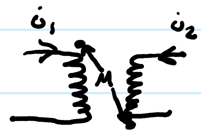
Ex|



1) Dot goes on a
2) Flux goes ← through top coil
3) Flux goes → through bottom coil
4) Dot goes on d

Circuit Models for mutually coupled coils





$\lambda_1 = L_1 i_1 - M i_2$

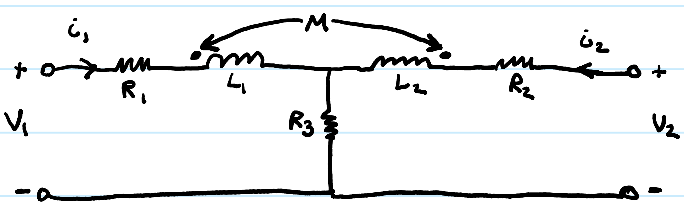
$\lambda_2 = -M i_1 + L_2 i_2$

* Current entering dotted terminal is $-i_2$
* Voltage induced has negative sign

$$V_1 = i_1 R_1 + L_1 \frac{di_1}{dt} - M \frac{di_2}{dt}$$

$$V_2 = \underbrace{i_2 R_2 + L_2 \frac{di_2}{dt}}_{\text{Independent of the dots}} - M \frac{di_1}{dt}$$

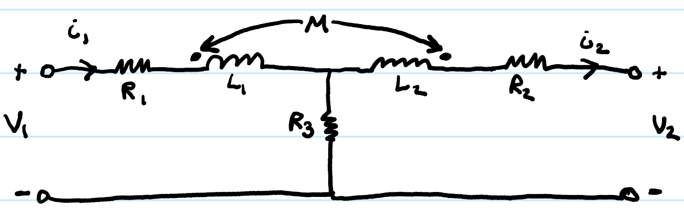
Ex



$$V_1 = i_1 R_1 + L_1 \frac{di_1}{dt} + R_3(i_1 + i_2) + M \frac{di_2}{dt}$$

$$V_2 = i_2 R_2 + L_2 \frac{di_2}{dt} + R_3(i_1 + i_2) + M \frac{di_1}{dt}$$

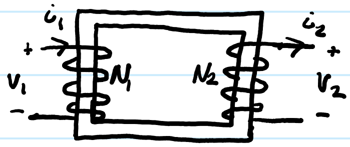
* i_2 direction reversed

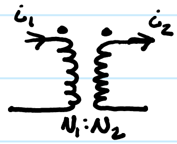


$$V_1 = i_1 R_1 + L_1 \frac{di_1}{dt} + R_3(i_1 - i_2) - M \frac{di_2}{dt}$$

$$V_2 = -i_2 R_2 - L_2 \frac{di_2}{dt} + R_3(i_1 - i_2) + M \frac{di_1}{dt}$$

Ideal transformers:





Assume: 1) $\mu = \infty$
2) Lossless coils
3) No leakage flux ($\phi_1 = \phi_2$)

$V_1 = N_1 \frac{d\phi}{dt}$ $\qquad$ $V_2 = N_2 \frac{d\phi}{dt}$

$\frac{V_1}{N_1} = \frac{d\phi}{dt}$ $\qquad$ $\frac{V_2}{N_2} = \frac{d\phi}{dt}$

$\frac{V_1}{N_1} = \frac{V_2}{N_2} \Rightarrow \boxed{\frac{V_1}{V_2} = \frac{N_1}{N_2} = a}$ $\qquad$ a is the turn ratio

$N_1 i_1 - N_2 i_2 = R\phi$ $\qquad$ $\mu = \infty,\ R = 0$

$N_1 i_1 = N_2 i_2$

$\boxed{\frac{i_1}{i_2} = \frac{N_2}{N_1} = \frac{1}{a}}$

* if direction of i changed, change sign of i
* if polarity of v changed, change sign of V
* if the dots are changed, change sign of v and i

Power for ideal transformer: $\frac{i_1}{i_2} = \frac{N_2}{N_1} = \frac{V_2}{V_1}$

$V_1 i_1 = V_2 i_2$

$\boxed{P_1 = P_2}$

*No power stored in an ideal transformer