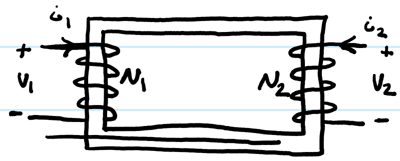
2018-09-24-1

Last time: Mutually coupled coils



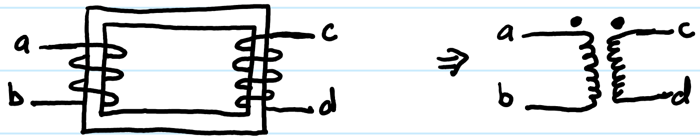
$\lambda_1 = L_1 i_1 + M i_2$

$\lambda_2 = M i_1 + L_2 i_2$

Today: 1) Dot convention

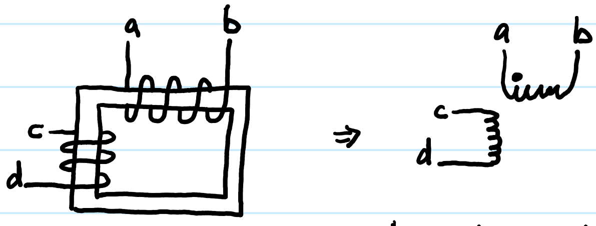
2) Circuits with Mutually coupled coils

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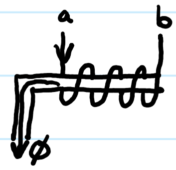
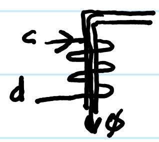
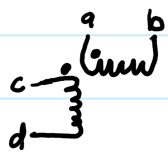
Steps: 1) Inject current into first dot and use RHR to find flux direction in iron

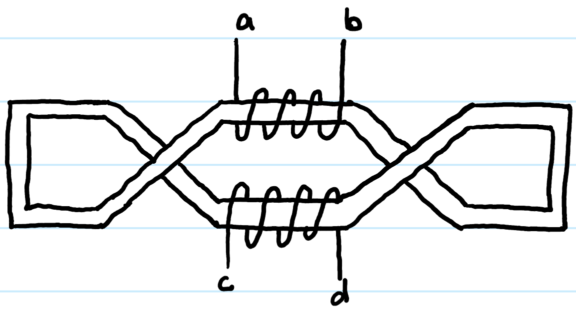


2) Put second dot on terminal of second coil to give same flux direction





Ex



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

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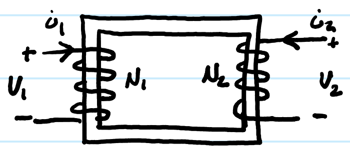
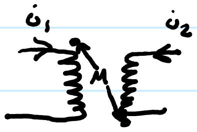
Circuit Models for mutually coupled coils





$\lambda_1 = L_1 i_1 - M i_2$

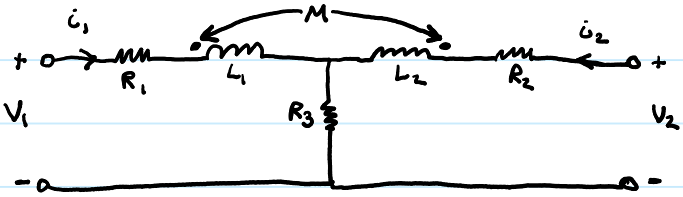
$\lambda_2 = -M i_1 + L_2 i_2$

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

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

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

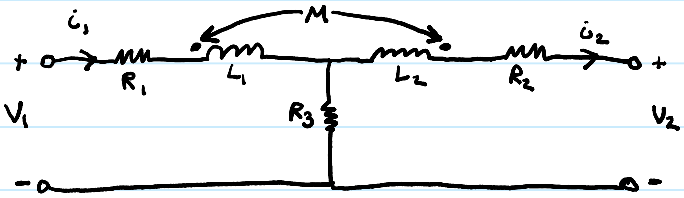
Ex



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

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

* i_2 direction reversed



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

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

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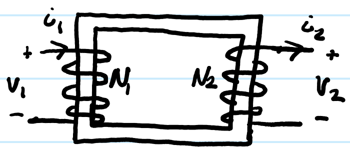
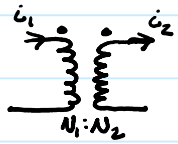
Ideal transformers:





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: $\frac{i_1}{i_2} = \frac{N_2}{N_1} = \frac{V_2}{V_1}$

$V_1 i_1 = V_2 i_2$

$P_1 = P_2$

*No power stored in an ideal transformer