Magnetic Coupled Circuits

By

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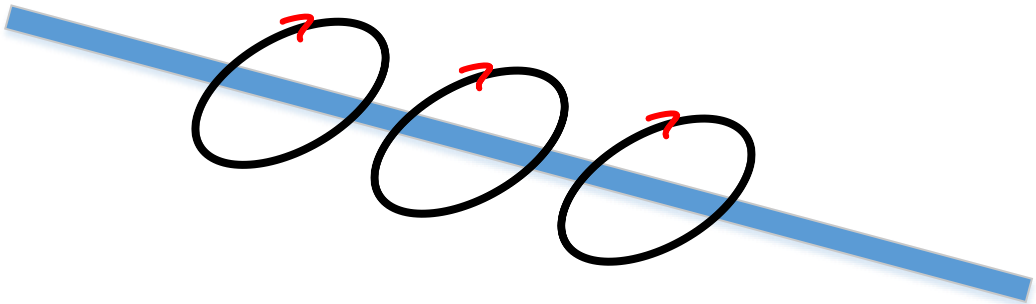
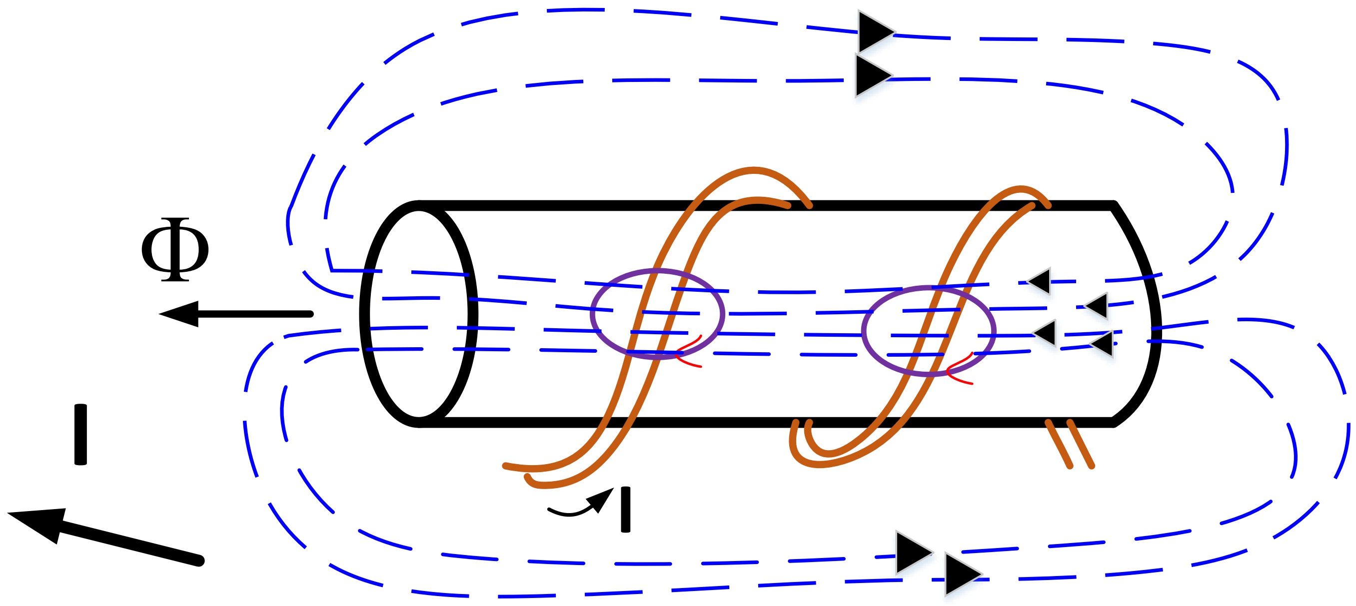
Introduction

- Magnetic flux produced around a conductor carrying AC and DC currents.
- The direction of the flux can be determined by the “Fleming’s” right hand rule.





Flux produced by a current carrying conductor

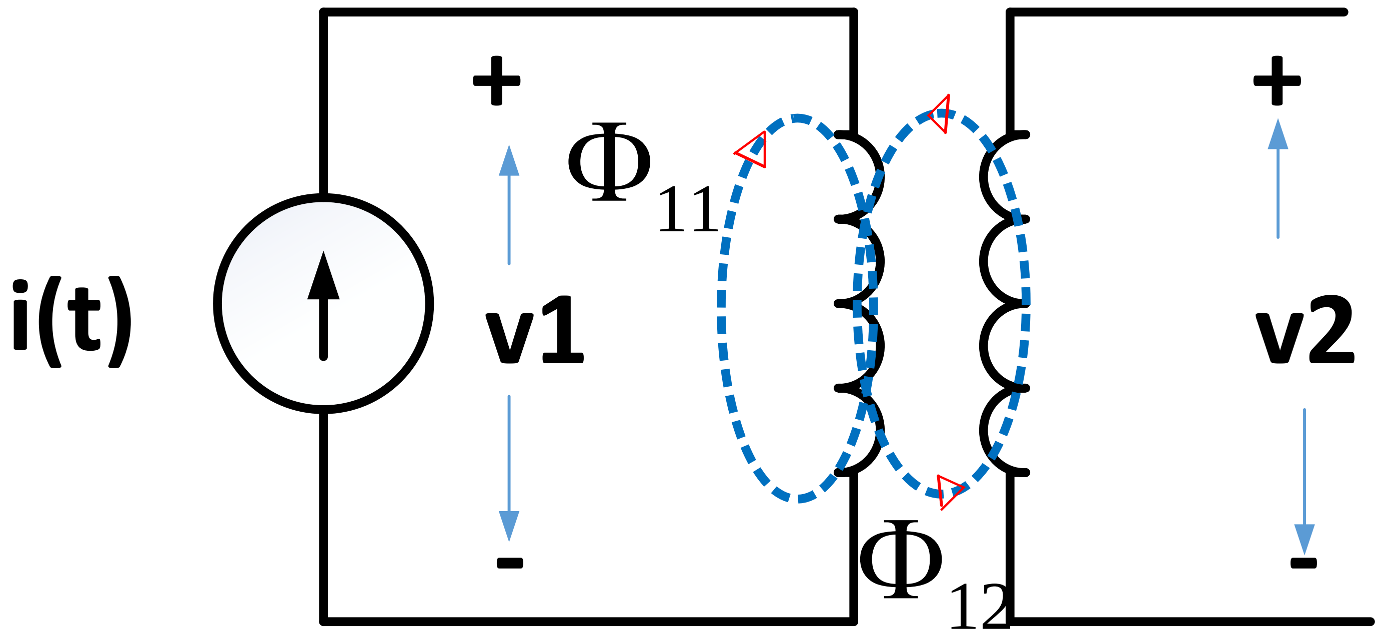
Mutual Inductance

- Let i is the current flowing through the conductor and Φ is the average flux produced in the direction normal to the cross-section of the coil.
- Assume N is the numbers turns in the coil.
- The flux linkage is defined as, $\lambda = N\Phi$
- The inductance of the coil is defined as, $L = \frac{\lambda}{i} = \frac{N\Phi}{i}$
- The relation between the terminal of the voltage and current for an inductor is given as,

$$v = \frac{d\lambda}{dt} = N\frac{d\Phi}{dt} = L\frac{di}{dt}$$

Mutual Inductance (Contd..)

- The inductance presented above equation is the “ self-inductance” of the coil.
- Let us consider another coil in the vicinity of the inductor.



Mutual Inductance (Contd..)

- Let two coils of self-inductance L_1 and L_2 placed in the close proximity of each other.
- Coil-1 has N_1 number of turns and coil-2 has N_2 turns.
- The total flux,

$$\Phi_1 = \Phi_{11} + \Phi_{12}$$

- The total flux links with coil-1. Hence,

$$v_1 = N_1 \frac{d\Phi_1}{dt} = \frac{d}{dt}\left(N_1 \Phi_1\right)$$
$$= \frac{d}{dt}\left(L_1 i_1\right) = L_1 \frac{di_1}{dt}$$

Mutual Inductance (Contd..)

- The flux Φ_{12} is only links with coil-2. Hence,

$$v_2 = N_2 \frac{d\Phi_{12}}{dt} = N_2 \frac{d\Phi_{12}}{di_1} . \frac{di_1}{dt}$$

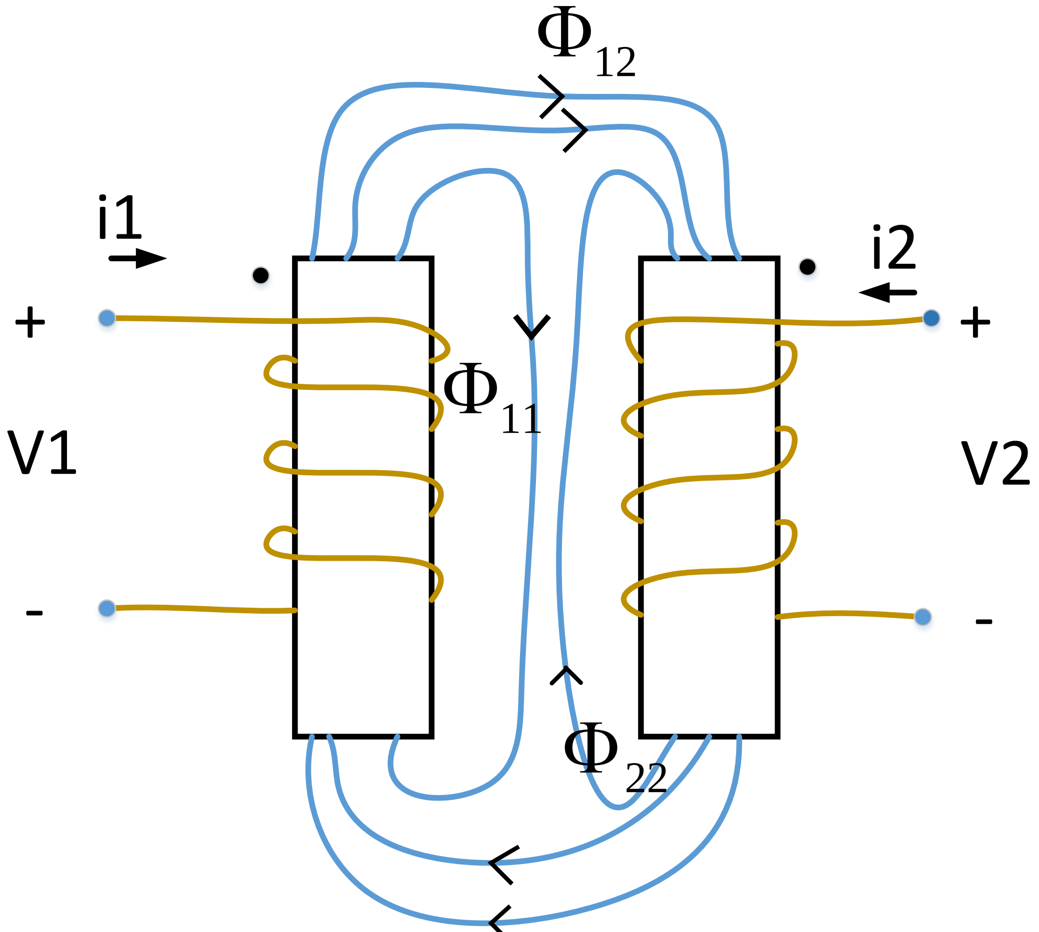
$$= M_{21} \frac{di_1}{dt}$$

- Where $M_{21} = N_2 \frac{d\Phi_{12}}{di_1}$

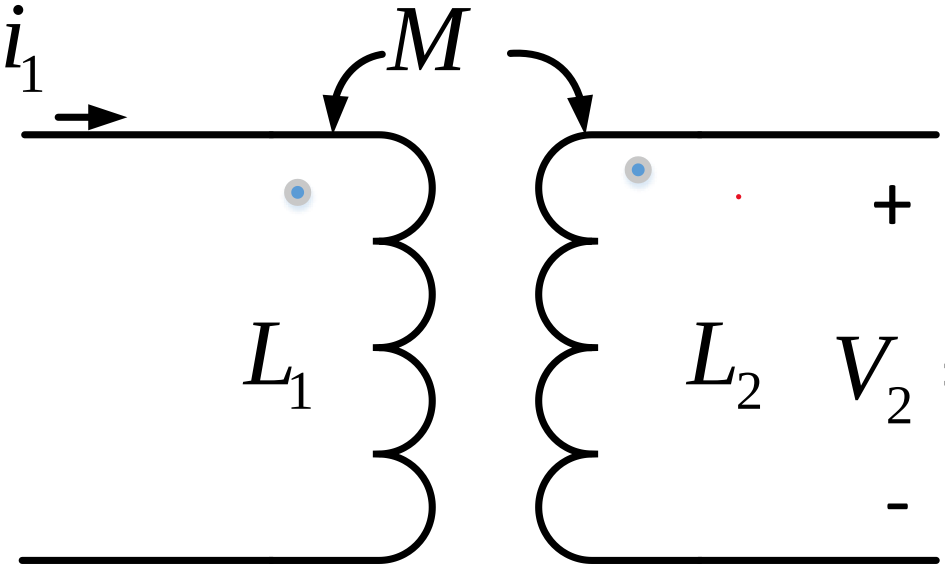
- M_{21} is called the mutual inductance of coil-2 with respect to coil-1

Dot Convention

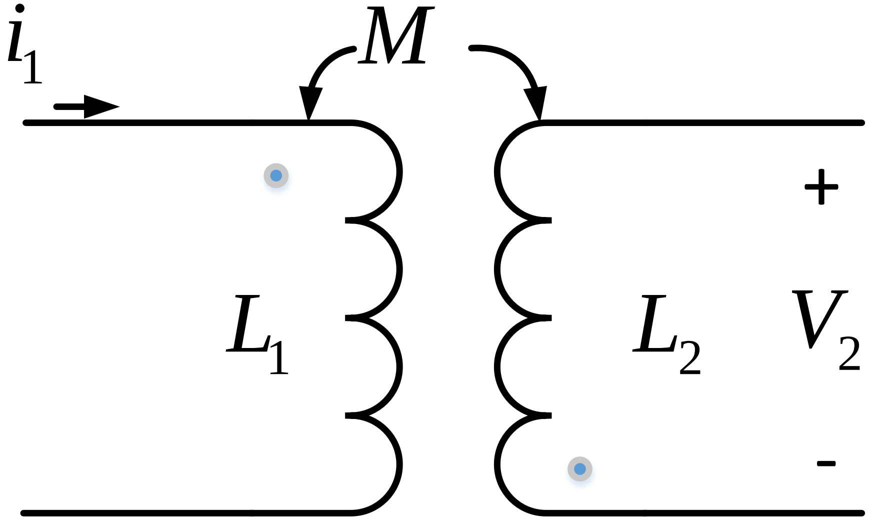
- Dots are used to mark the polarities of voltages



Dot Convention (Contd..)

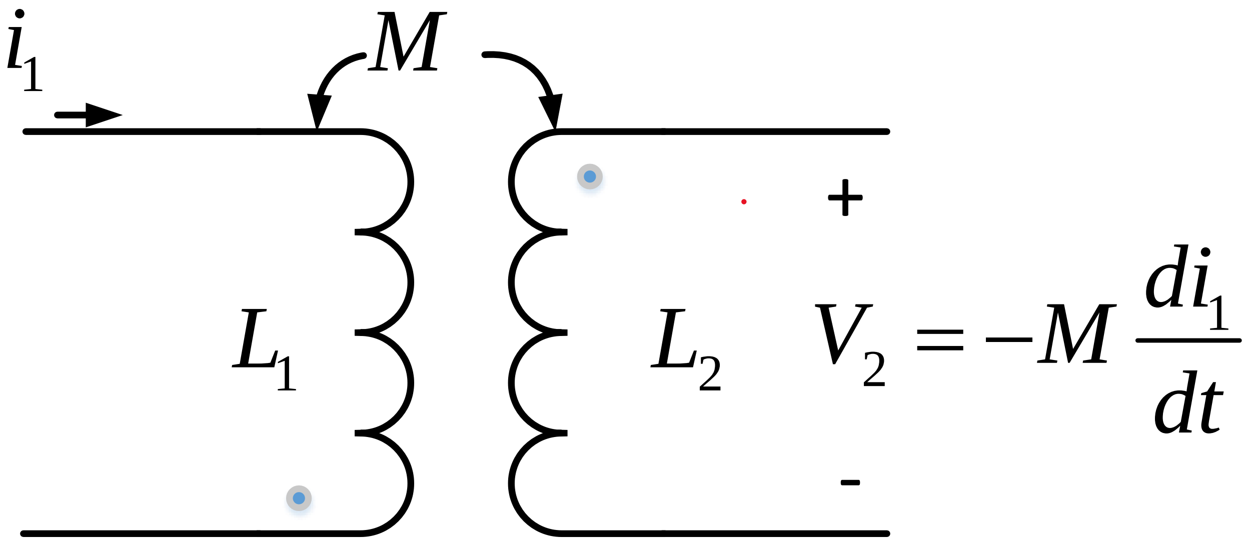


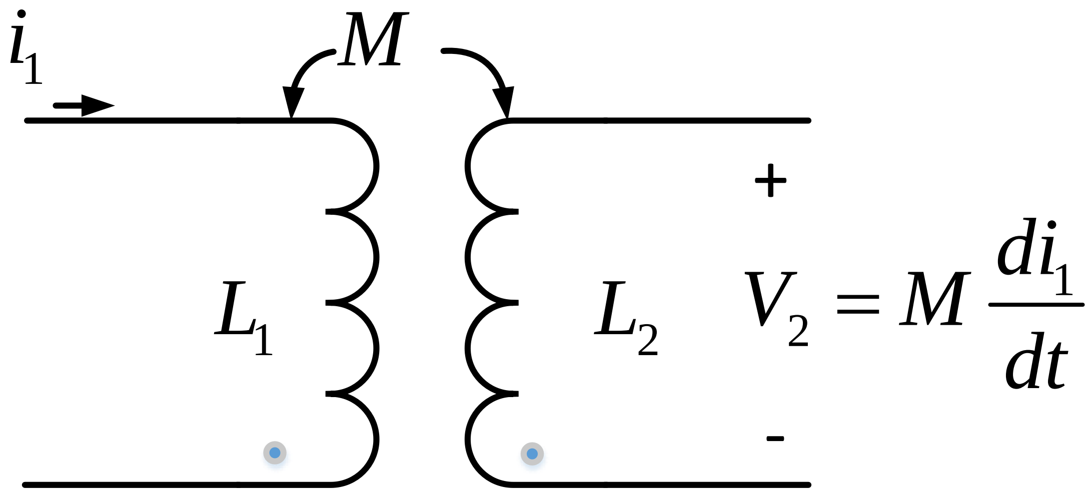
$$V_2 = M\frac{di_1}{dt}$$



$$V_2 = -M\frac{di_1}{dt}$$

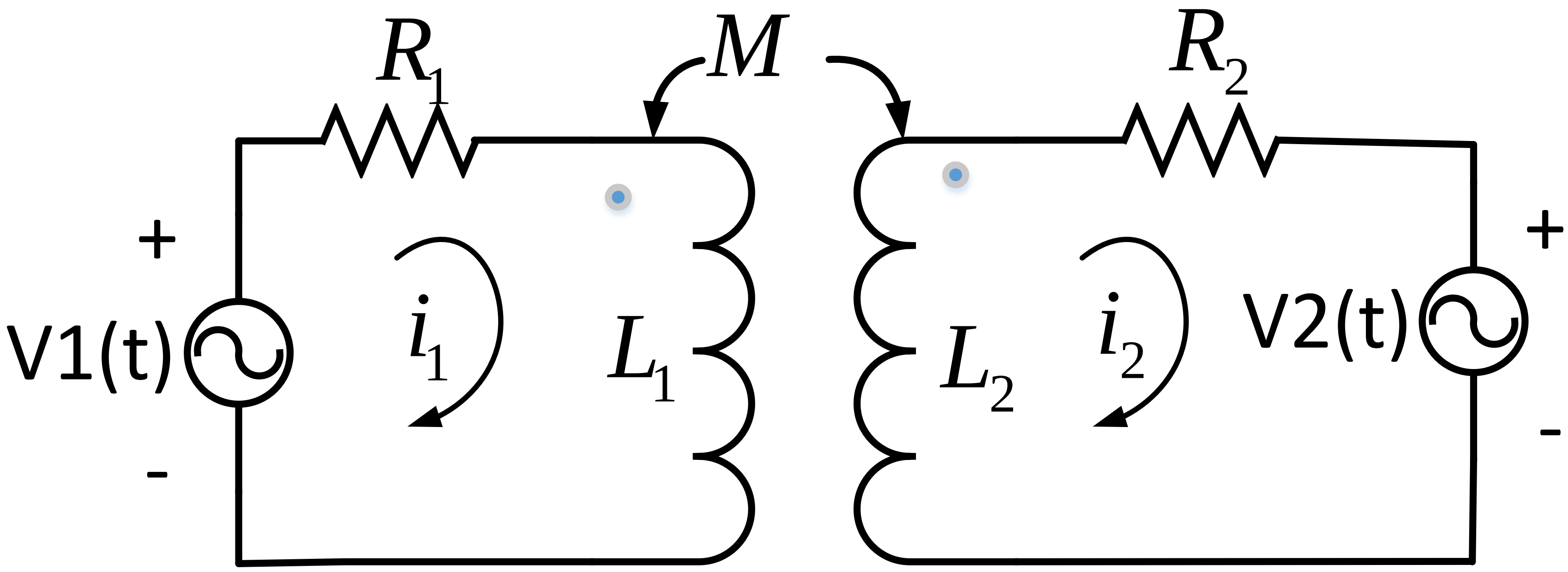
Dot Convention (Contd..)





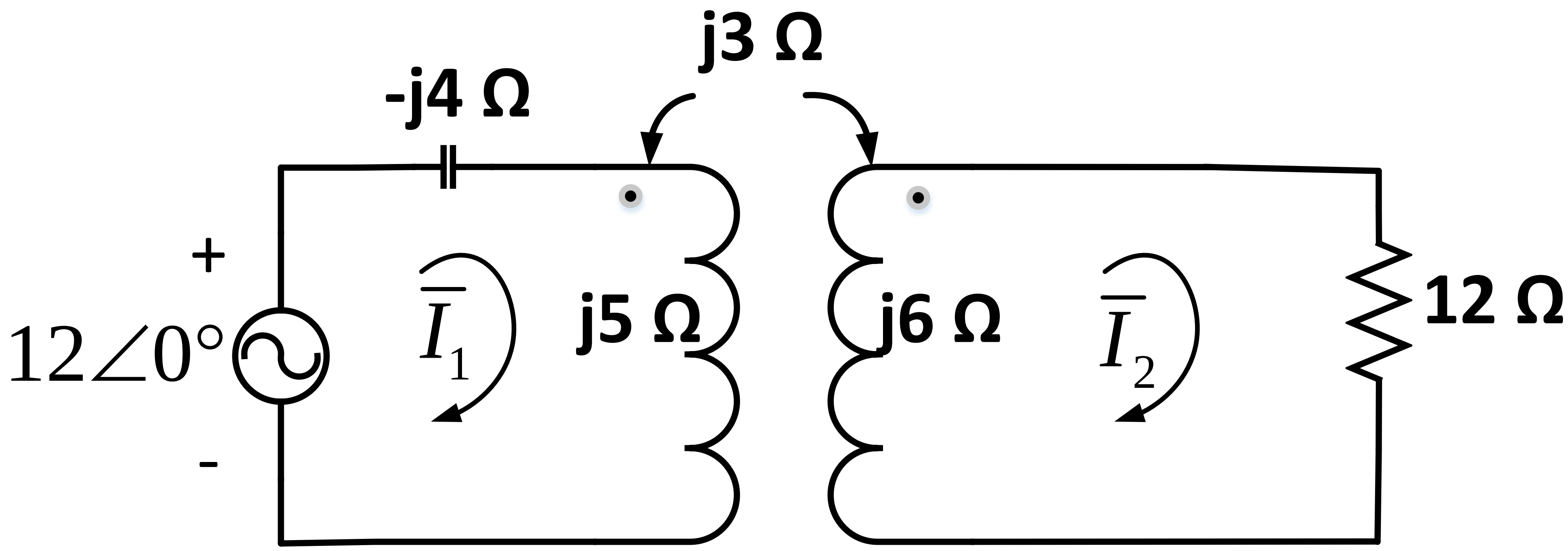
Example 1

- Write the KVL equations for the coupling circuit.



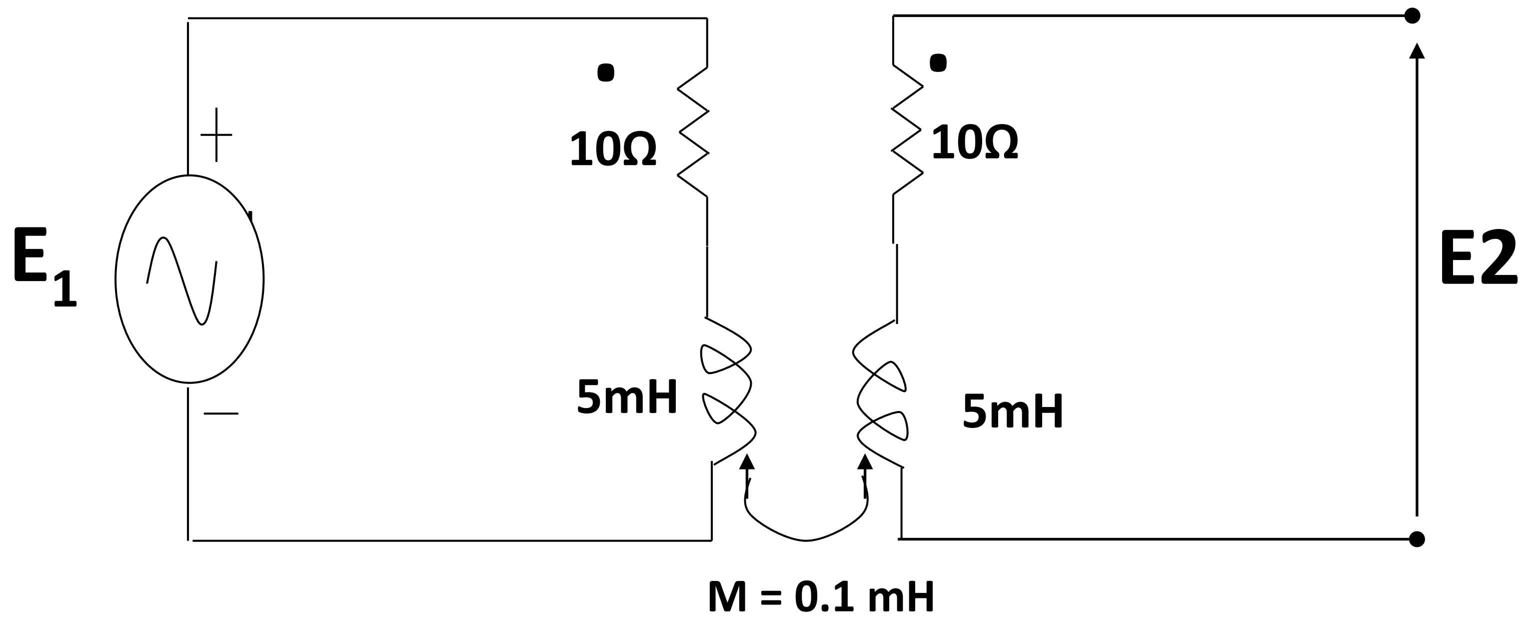
Example 2

Calculate the phasor currents $\overline{I}_1$ and $\overline{I}_2$ in the following circuit.



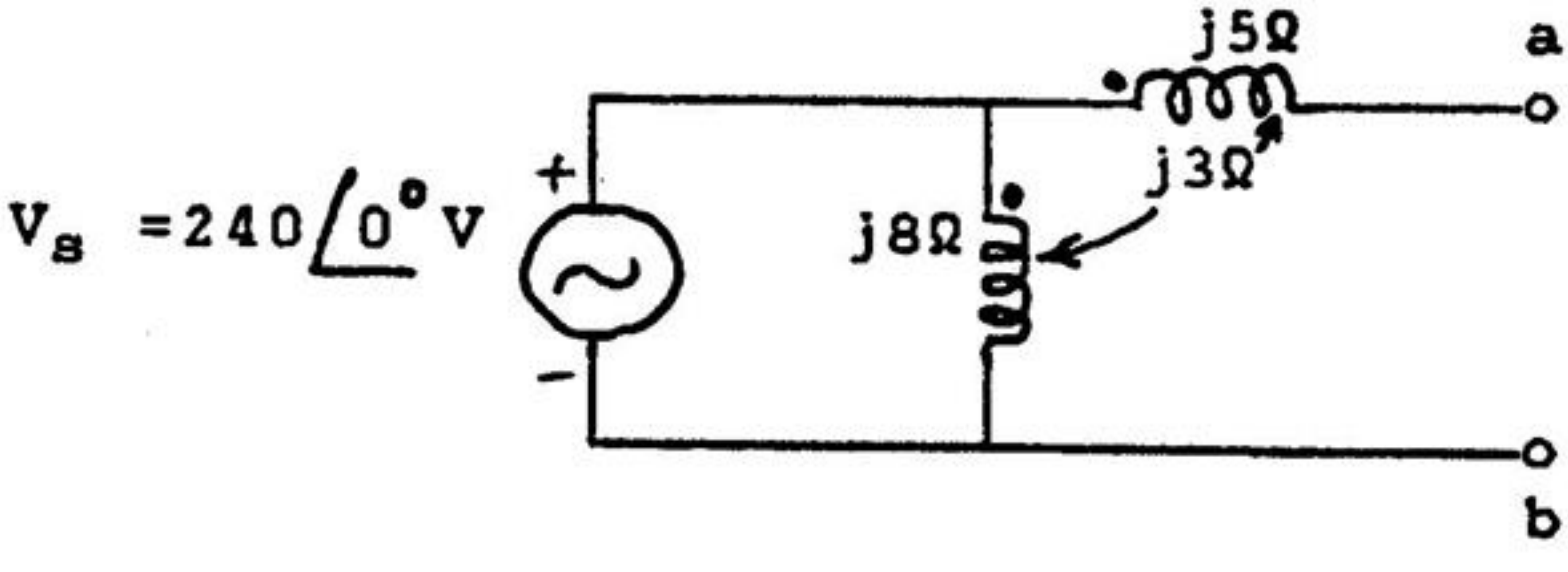
Example 3

For the circuit shown below, determine the p.d. E_2 which appears across the open-circuited secondary winding, given that $E_1 = 8\sin 1500t$ volts



Example 4

Find the Thevenin's equivalent between terminal a-b of the network shown in Fig. 1. Determine the current through a load of 5-*j*20 ohms connected between terminal a-b



Coefficient of Coupling

- It is shown that the upper limit of mutual inductance is given by,

$$M \leq \sqrt{L_1 L_2}$$

- The extent to which M approaches its maximum forcible value is given by,

$$K = \frac{M}{\sqrt{L_1 L_2}}$$

- Where K is called the coefficient of coupling