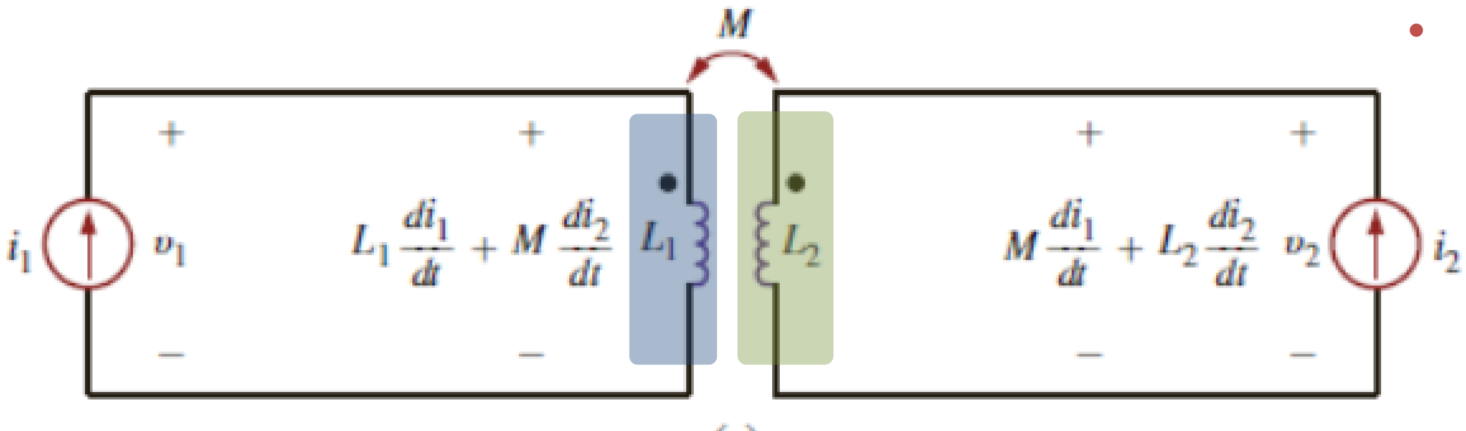
Last Lecture → Magnetically Coupled Coils

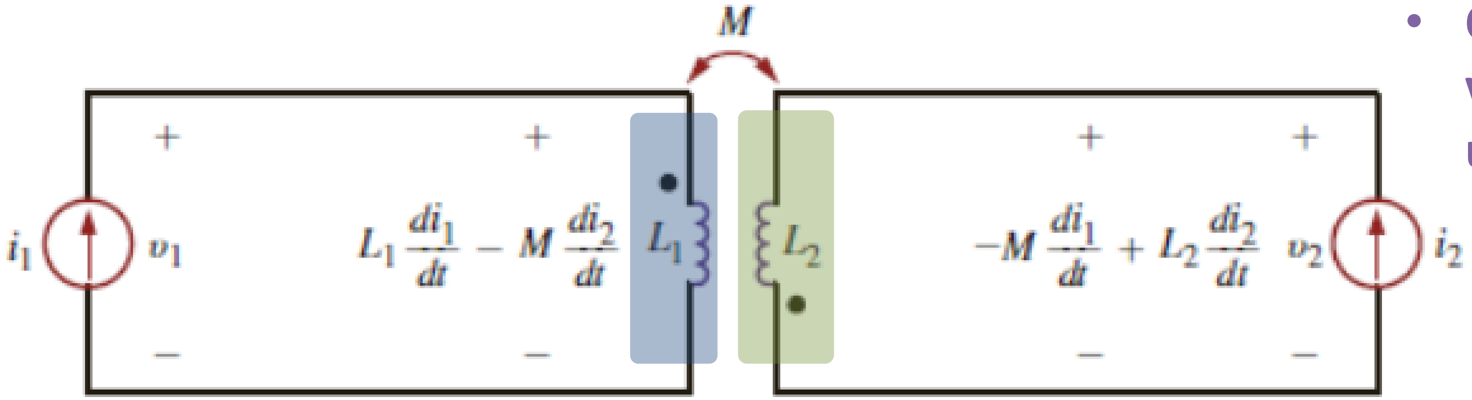


(a)

- Current enters the dotted terminal → voltage at coupled coil is positive at the dotted terminal

$$V_1 = jX_{L1}I_1 + jX_{LM}I_2$$

$$V_2 = jX_{L2}I_2 + jX_{LM}I_1$$



(b)

- Current enters the undotted terminal → voltage at coupled coil is positive at the undotted terminal

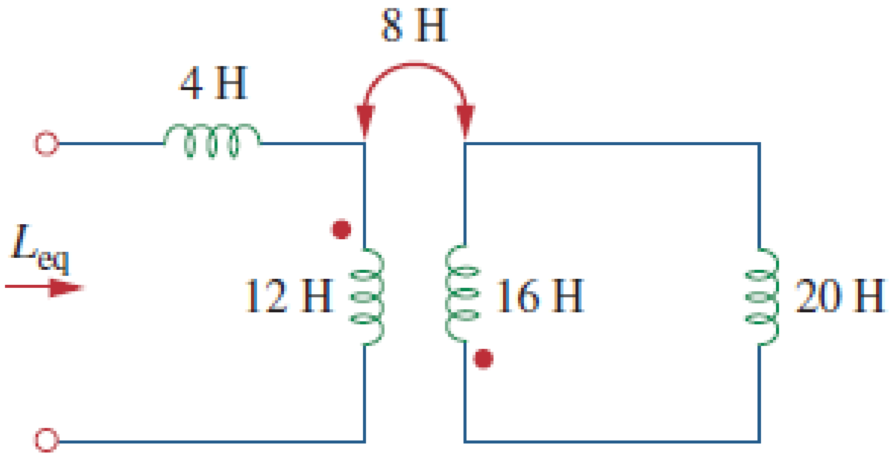
$$V_1 = jX_{L1}I_1 - jX_{LM}I_2$$

$$V_2 = jX_{L2}I_2 - jX_{LM}I_1$$

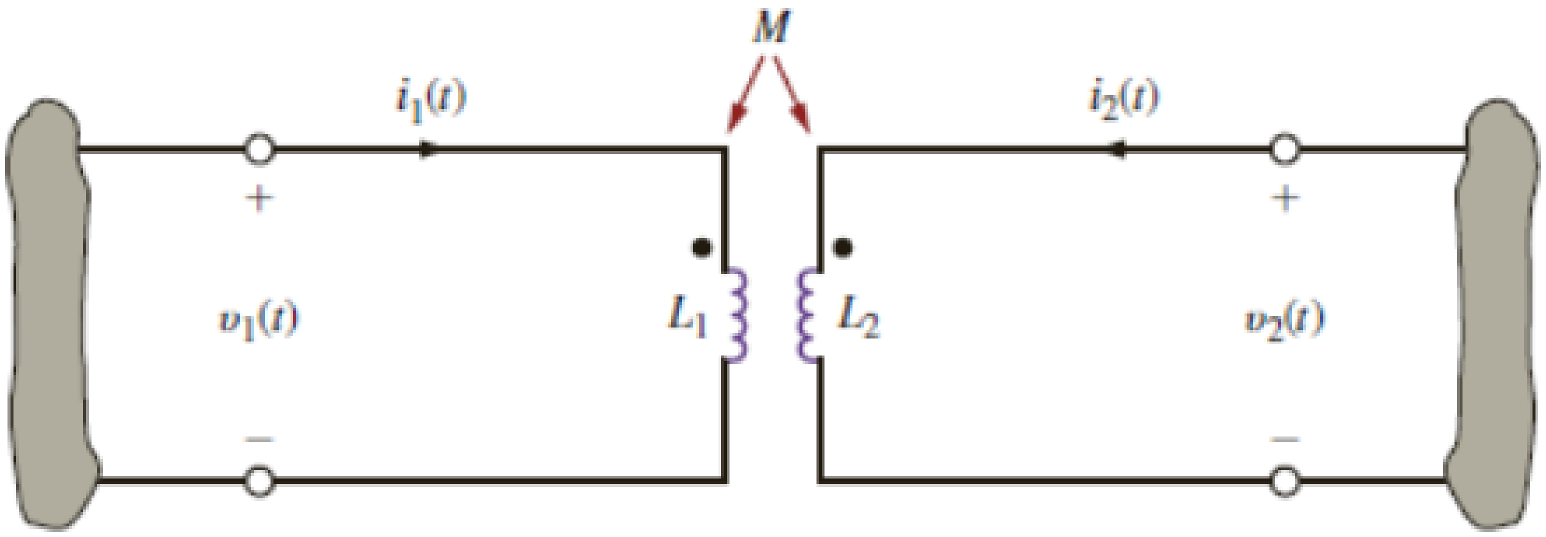
Circuits 1

Problem

Determine the equivalent inductance L_{eq} of the circuit.



Magnetically Coupled Coils → Energy

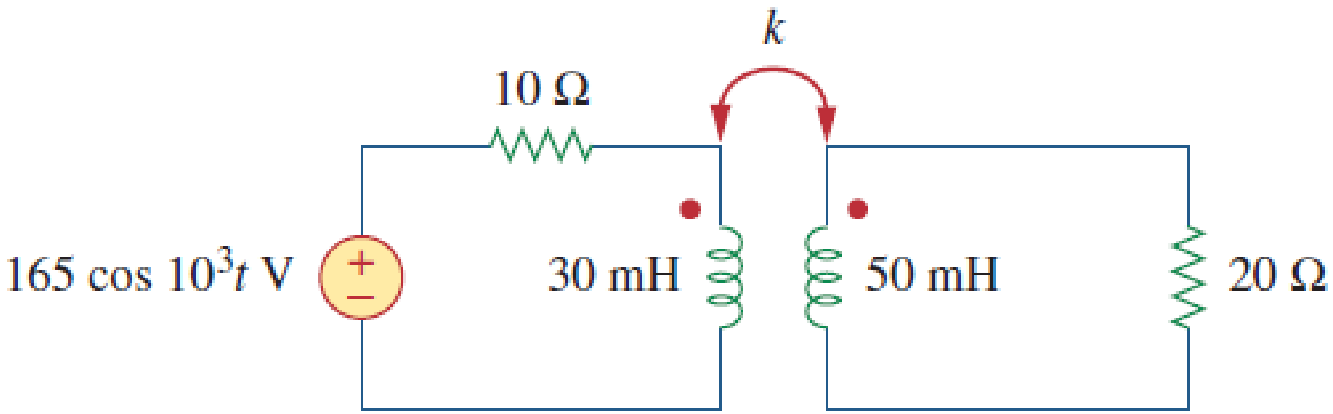


$$w(t) = \frac{1}{2}L_1[i_1(t)]^2 + \frac{1}{2}L_2[i_2(t)]^2 \pm M i_1(t) i_2(t)$$

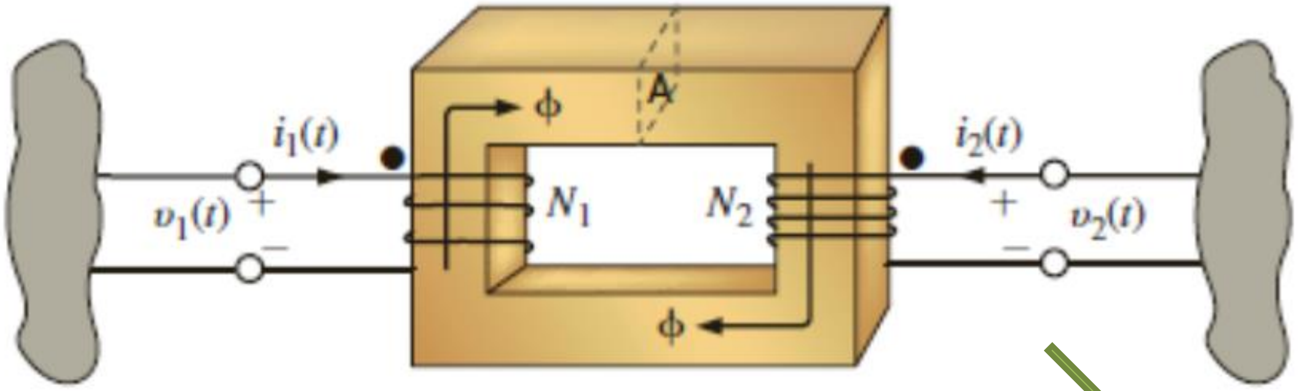
Coefficient of Coupling $k = \frac{M}{\sqrt{L_1 L_2}}$ $\quad 0 \le k \le 1$

Problem

Find the value of the coupling coefficient k that will make the 10 Ω resistor dissipate 320W. For this value of k, find the energy stored in the coupled coils at t = 1.5s.



The Ideal Transformer



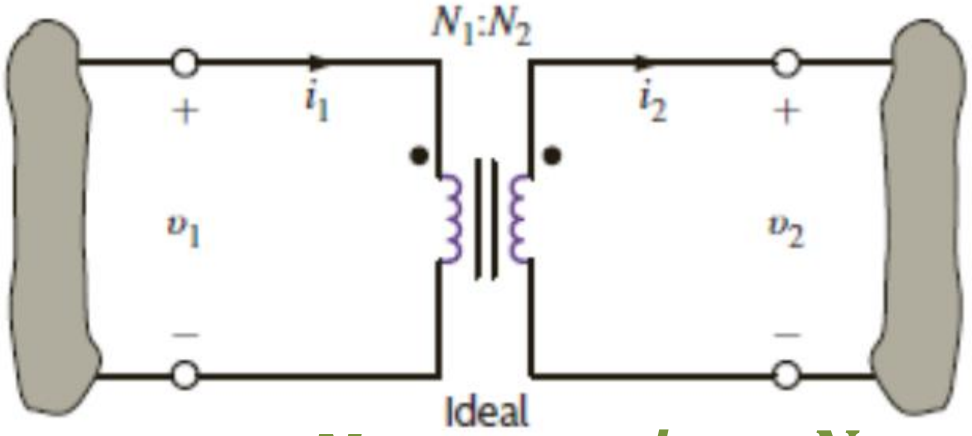
Assuming an ideal magnetic core with infinite permeability…

$$\left.\begin{aligned} P_1 + P_2 &= 0 \\ v_1 \cdot i_1 + v_1 \cdot \frac{N_2}{N_1} \cdot i_2 &= 0 \end{aligned}\right\} \therefore \frac{i_2}{i_1} = -\frac{N_1}{N_2}$$

$$\lambda_1 = N_1 \cdot \phi \qquad \lambda_2 = N_2 \cdot \phi$$

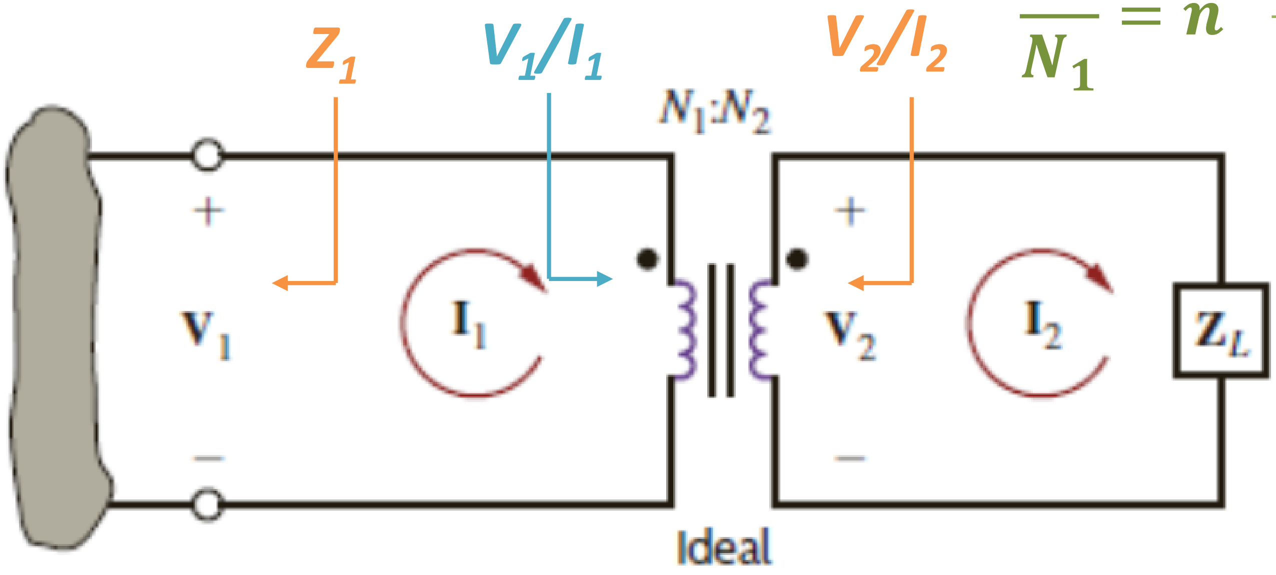
$$v_1 = \frac{d\lambda_1}{dt} = N_1 \frac{d\phi}{dt} \qquad v_2 = \frac{d\lambda_2}{dt} = N_2 \frac{d\phi}{dt}$$

$$\therefore \frac{v_2}{v_1} = \frac{N_2}{N_1}$$



$$\frac{v_2}{v_1} = \frac{N_2}{N_1} \qquad \frac{i_2}{i_1} = \frac{N_1}{N_2}$$

The Ideal Transformer



$$\frac{N_2}{N_1} = n$$

$$V_2 = \frac{N_2}{N_1} V_1 = n \cdot V_1$$

$$I_2 = \frac{N_1}{N_2} I_1 = \frac{1}{n} \cdot I_1$$

$$\frac{V_2}{I_2} = n^2 Z_1$$

$$\frac{V_1}{I_1} = \frac{1}{n^2} Z_L$$

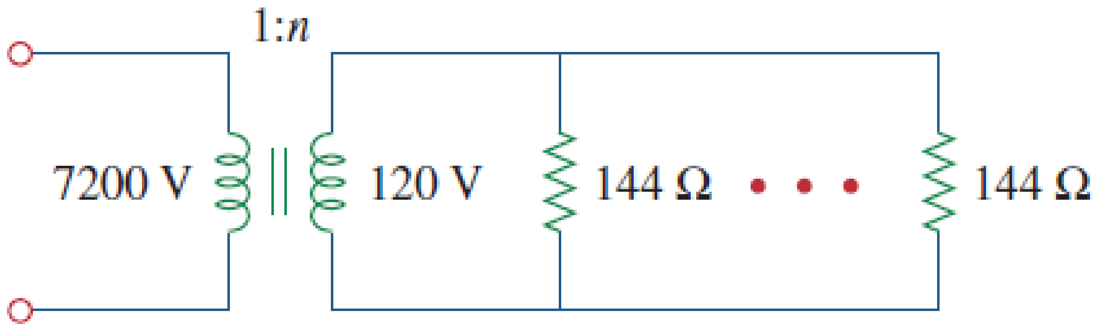
- *If both voltages are referenced positive at the dotted terminals or un-dotted terminals, then $V_2/V_1=N_2/N_1$. If this is not true, then $V_2/V_1=-N_2/N_1$.*
- *If both currents are defined as entering at dotted terminals or un-dotted terminals, then $I_2/I_1=-N_1/N_2$. If this is not true, then $I_2/I_1=N_1/N_2$.*

Problem

Ten bulbs in parallel are supplied by a 7,200/120 V transformer as shown, where the bulbs are modeled by the 144 Ω resistors. Find:

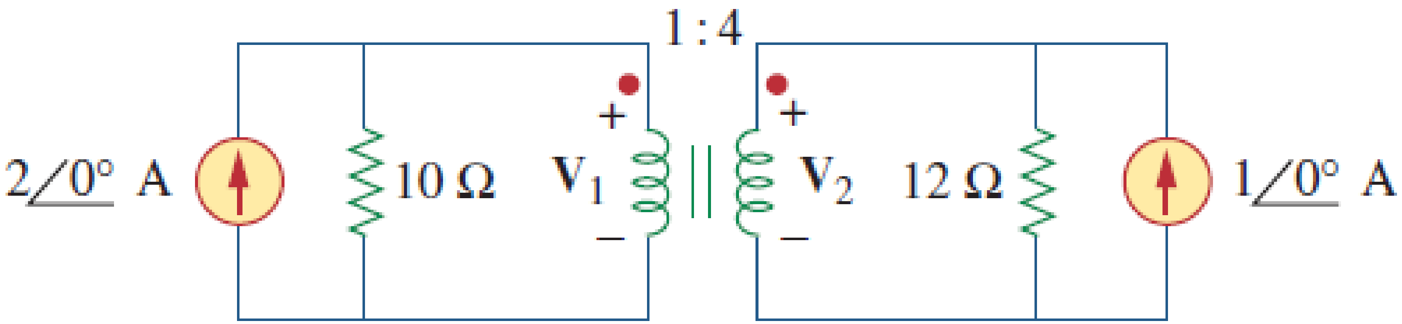
a) **the turns ratio n,**

b) **the current through the primary winding.**



Problem

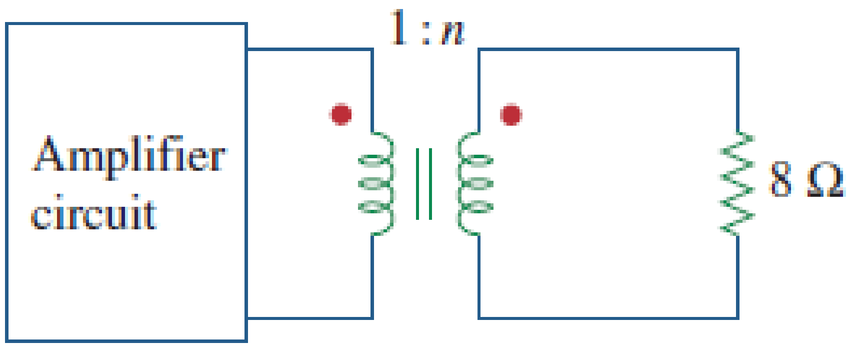
Obtain V_1 and V_2 in the ideal transformer circuit provided.



Problem

A transformer is used to match an amplifier with an 8Ω load as shown in the figure provided. The Thevenin equivalent of the amplifier is: V_{th} = 10V, Z_{th} = 128Ω.

a) Find the required turns ratio n for maximum energy power transfer
b) Determine the primary and secondary currents
c) Determine the primary and secondary voltages



Problem

Find the Thevenin equivalent for the circuit provided at terminals a-b.