

Curso Técnico em Eletrotécnica

Transformadores

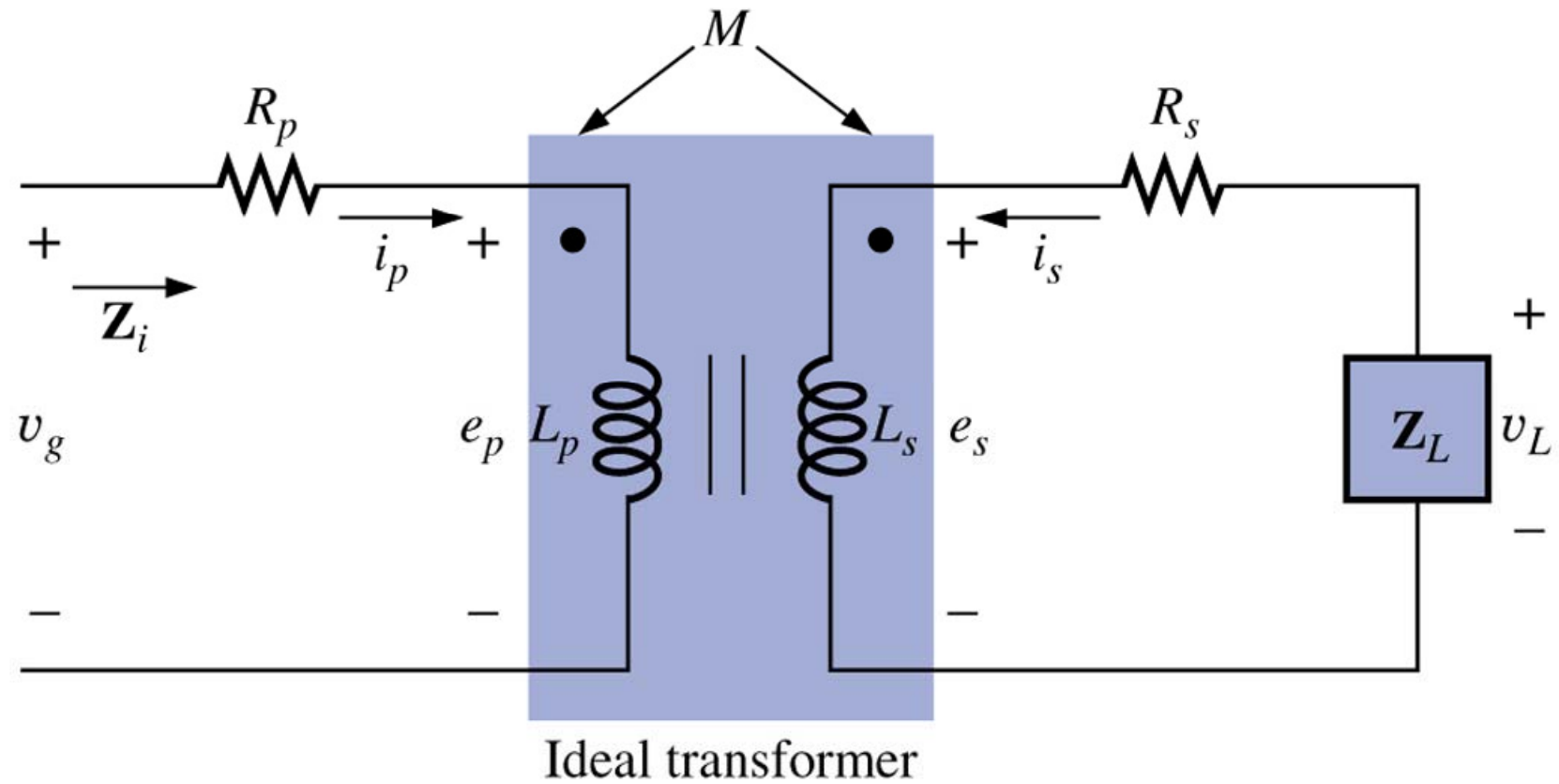
Parte 2

Transformadores

1. Transformador com núcleo de ar;
2. Circuitos equivalentes de transformadores.

Vitória-ES

Transformador com núcleo de ar



Transformador com núcleo de ar

Tensão induzida no primário:

$$e_p = L_p \frac{di_p}{dt} + M \frac{di_s}{dt}$$

No domínio fasorial:

$$v_1 = L \frac{di_1}{dt}$$

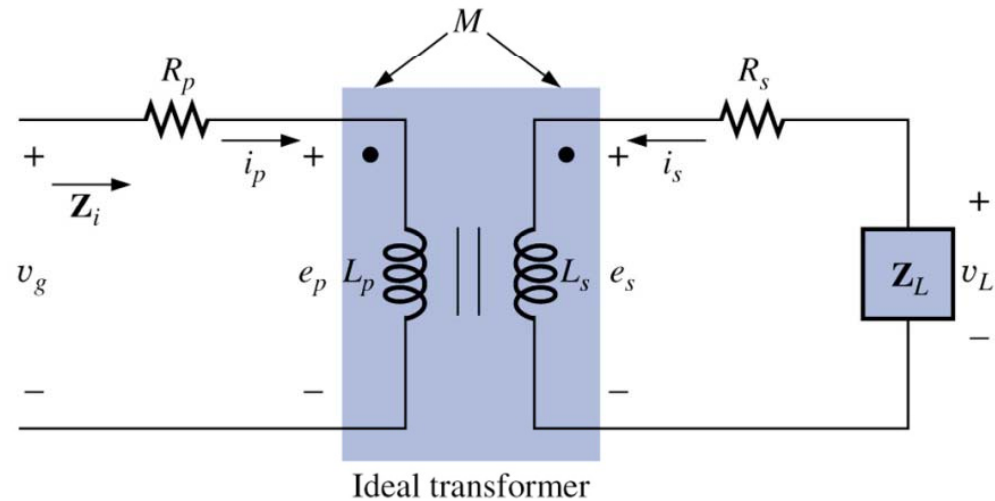
$$V_1 = I_1 \cdot X_L \cdot \underline{90^\circ}$$

$$X_L = \omega \cdot L$$

$$v_1 = M \frac{di_2}{dt}$$

$$V_1 = I_2 \cdot X_m \cdot \underline{90^\circ}$$

$$X_m = \omega \cdot M$$



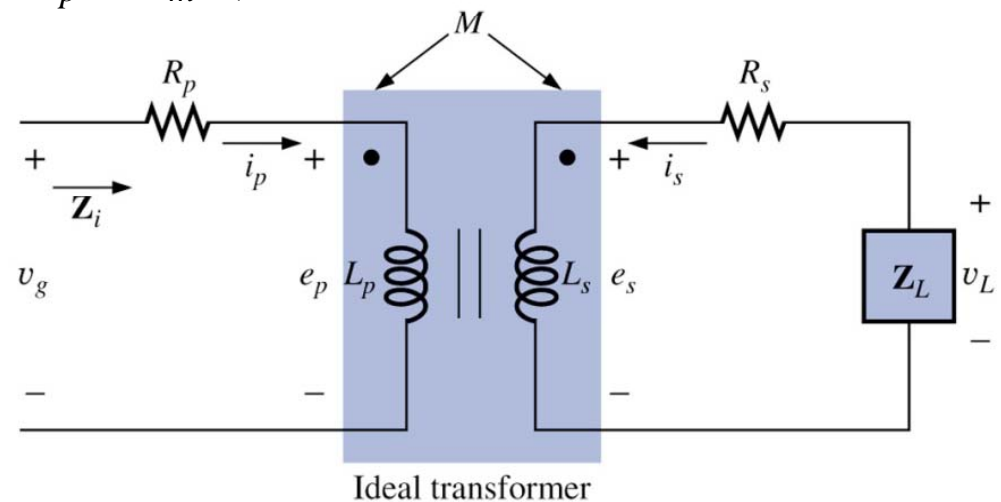
Transformador com núcleo de ar

$$E_p = I_p \cdot X_{Lp} \cdot \underline{|90^\circ} + I_s \cdot X_m \cdot \underline{|90^\circ}$$

$$V_g = I_p \cdot R_p \cdot \underline{|0^\circ} + I_p \cdot X_{Lp} \cdot \underline{|90^\circ} + I_s \cdot X_m \cdot \underline{|90^\circ}$$

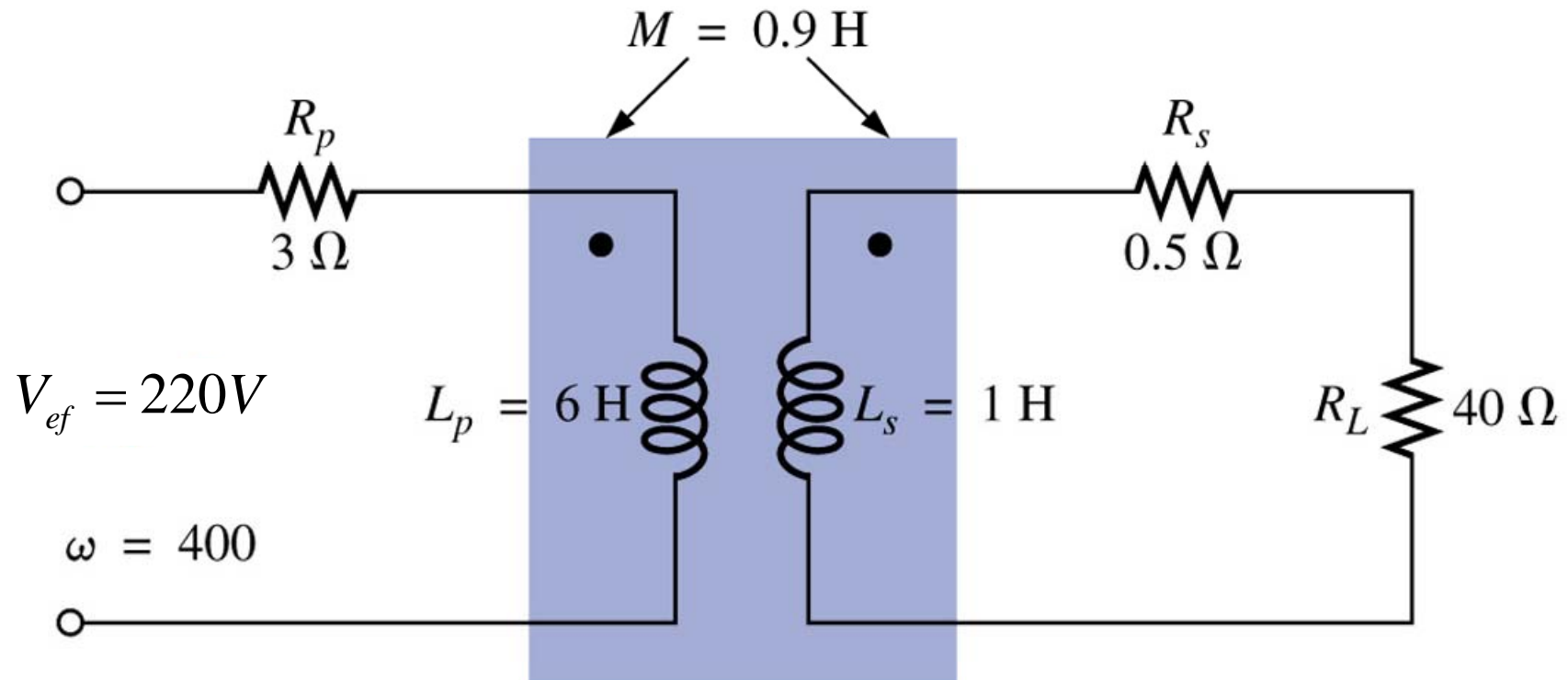
$$E_s = I_s \cdot X_{Ls} \cdot \underline{|90^\circ} + I_p \cdot X_m \cdot \underline{|90^\circ}$$

$$V_L = I_s \cdot R_s \cdot \underline{|0^\circ} + I_s \cdot X_{Ls} \cdot \underline{|90^\circ} + I_p \cdot X_m \cdot \underline{|90^\circ}$$

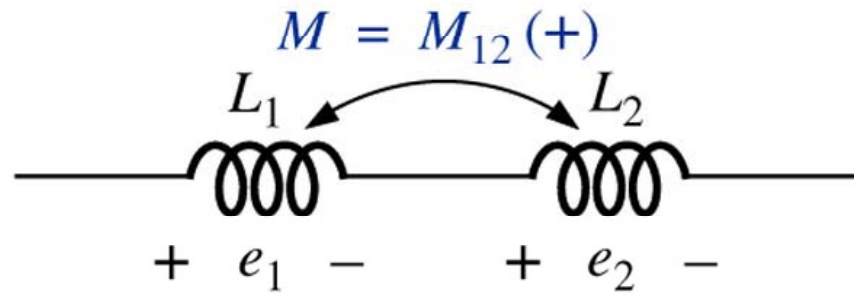


Transformador com núcleo de ar

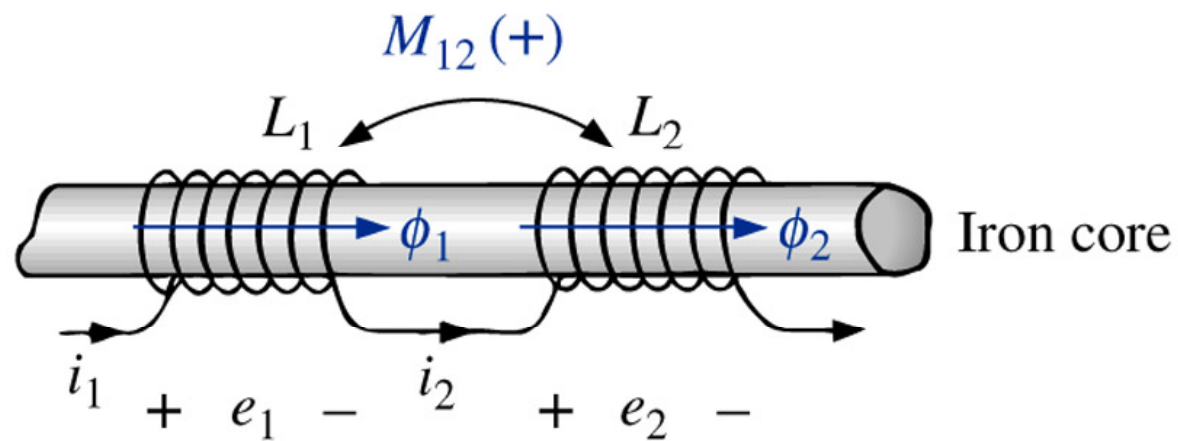
- Determine a tensão na saída do circuito a seguir;
- Determine a corrente na fonte do circuito abaixo.



Conexão de indutores acoplados

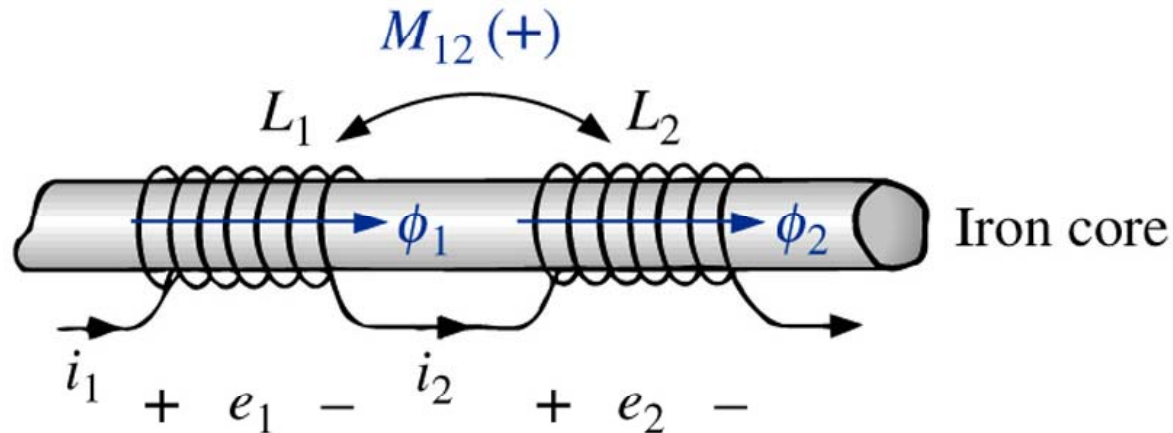


(a)



(b)

Conexão de indutores acoplados



$$e_1 = L_1 \frac{di_1}{dt} + M_{12} \frac{di_2}{dt}$$

$$e_2 = L_2 \frac{di}{dt} + M_{12} \frac{di}{dt} = (L_2 + M_{12}) \frac{di}{dt}$$

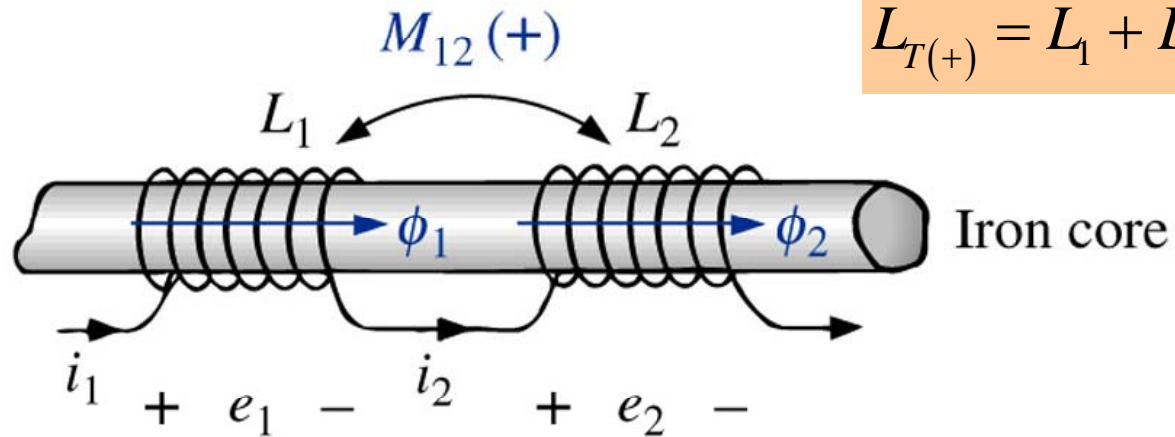
$$i_1 = i_2 = i$$

$$e_T = e_1 + e_2 = (L_1 + M_{12}) \frac{di}{dt} + (L_2 + M_{12}) \frac{di}{dt}$$

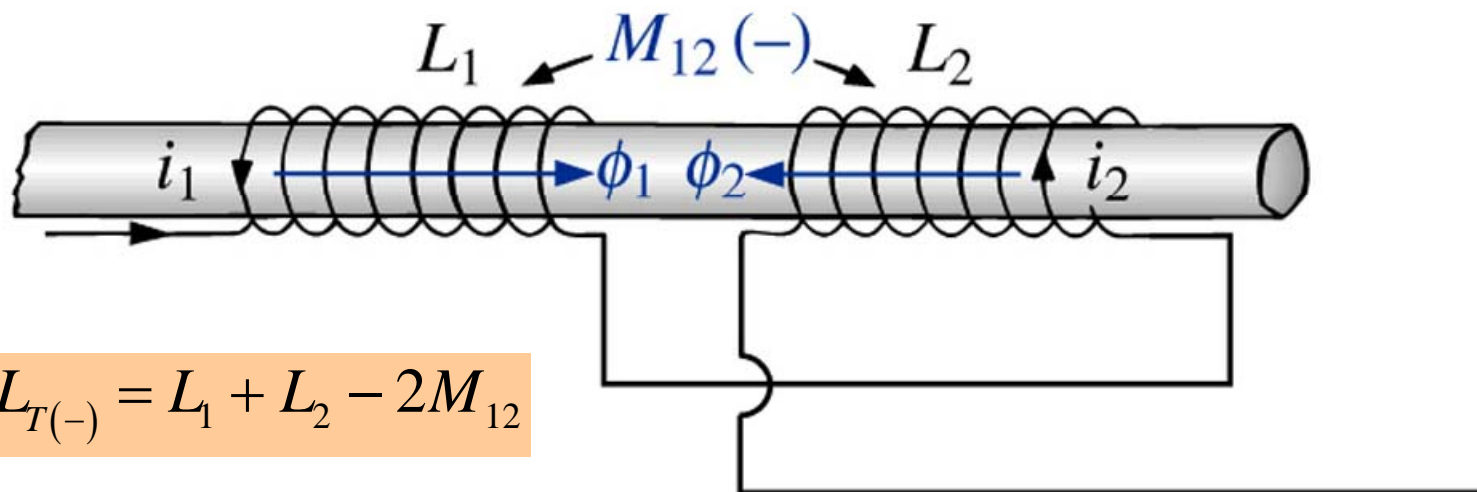
$$e_1 = L_1 \frac{di}{dt} + M_{12} \frac{di}{dt} = (L_1 + M_{12}) \frac{di}{dt}$$

$$L_{T(+)} = L_1 + L_2 + 2M_{12}$$

Conexão de indutores acoplados



$$L_{T(+)} = L_1 + L_2 + 2M_{12}$$



$$L_{T(-)} = L_1 + L_2 - 2M_{12}$$

Indutores acoplados – convenção do ponto

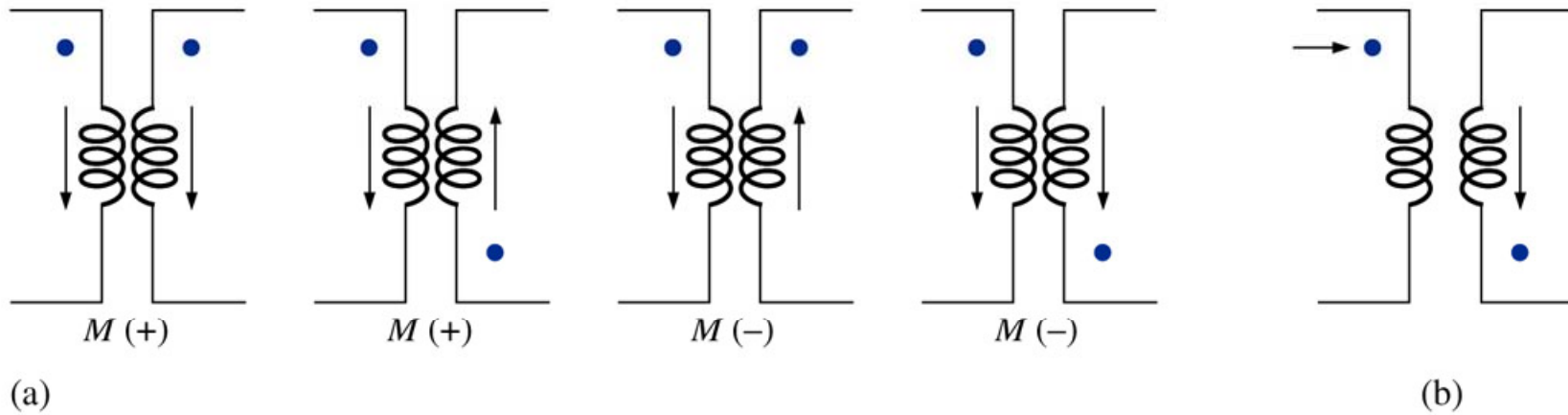


(a)



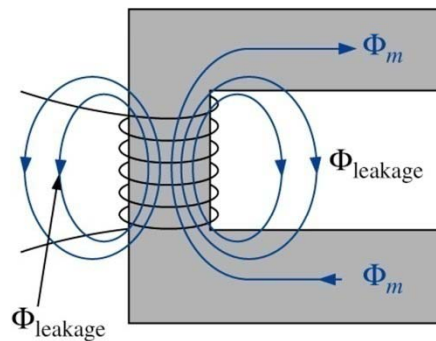
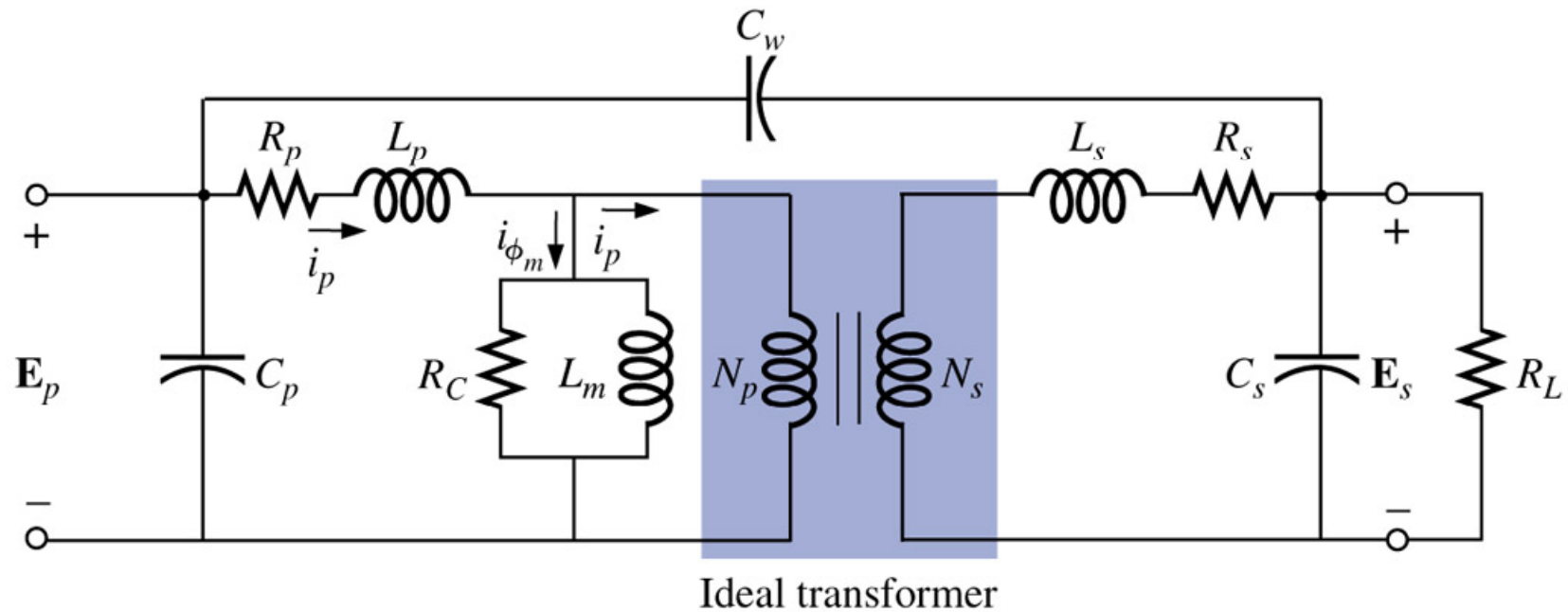
(b)

Enrolamentos acoplados – convenção do ponto



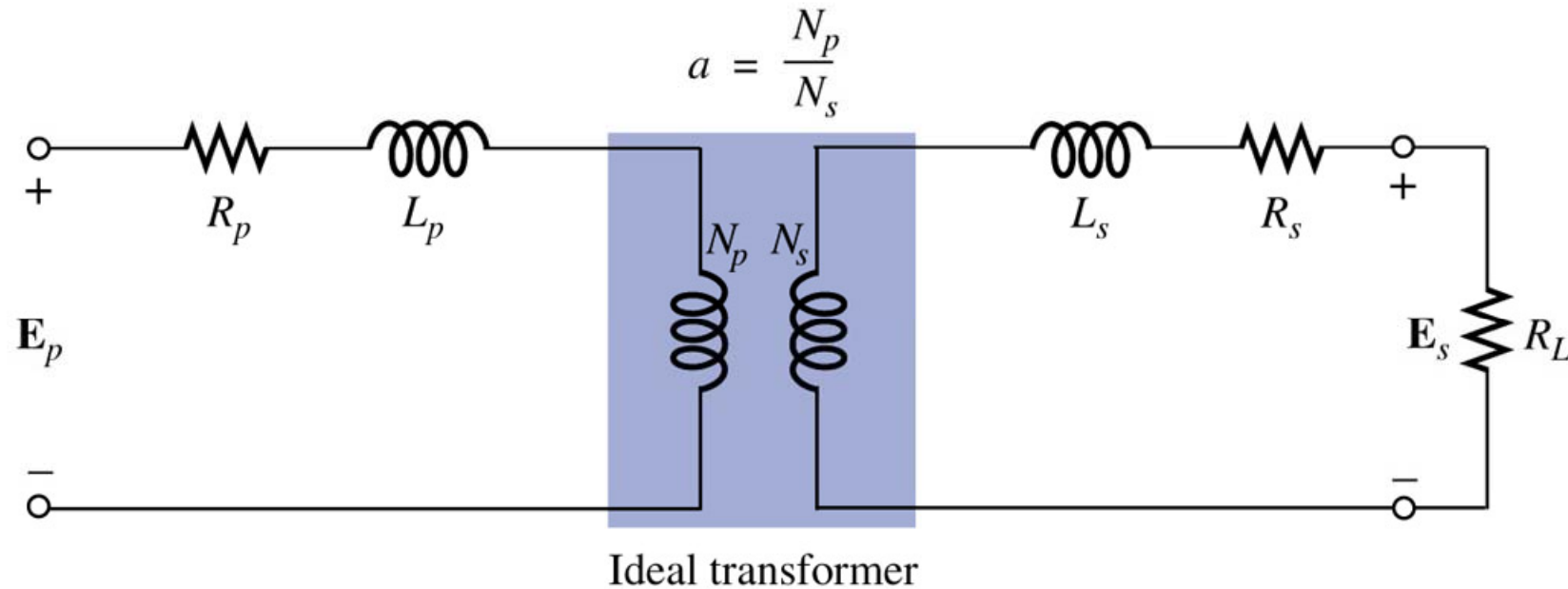
Circuito equivalente do transformador

Circuito equivalente completo de um transformador de núcleo de ferro real:



Circuito equivalente do transformador

Circuito equivalente reduzido do transformador de núcleo de ferro real:



$$R_{equivalente} = R_e = R_p + a^2 R_s$$

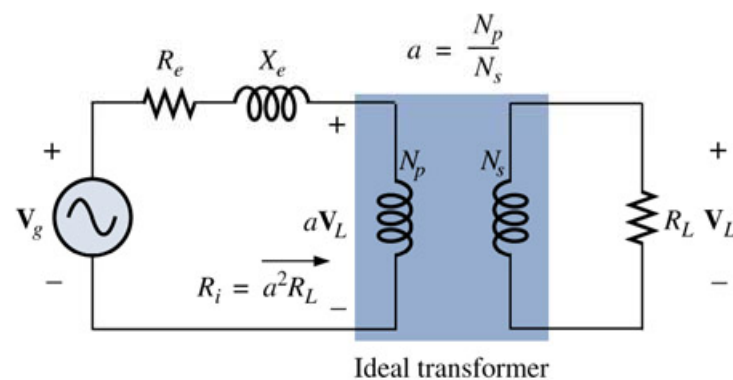
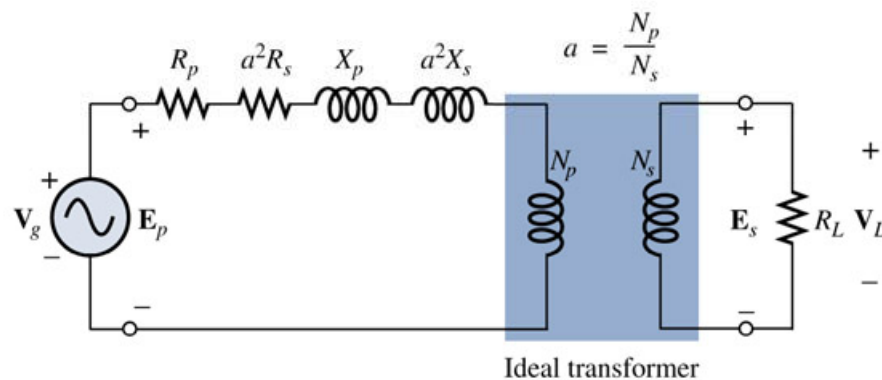
$$X_{equivalente} = X_e = X_p + a^2 X_s$$

Circuito equivalente do transformador

Circuito equivalente referido ao primário:

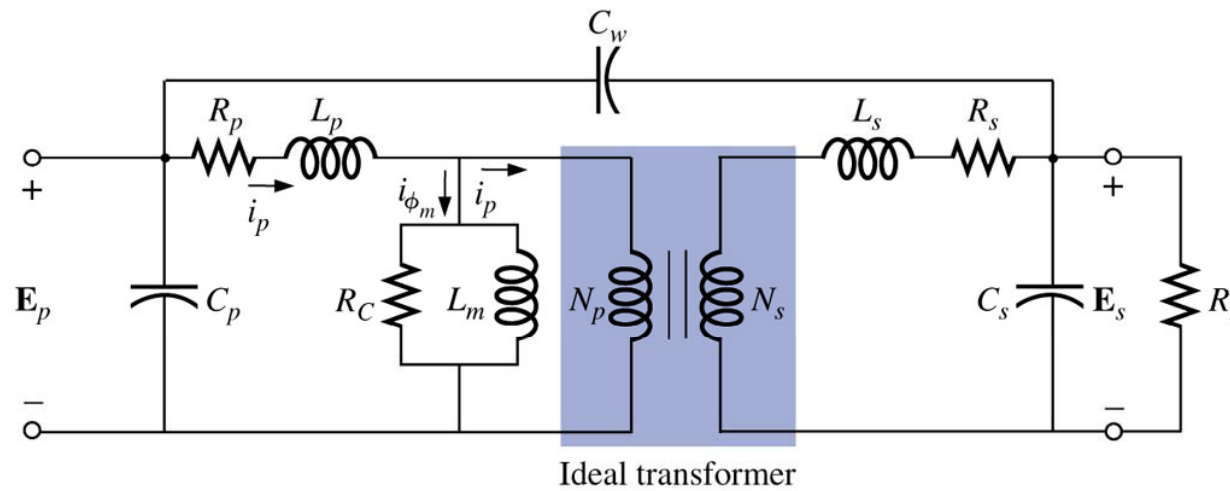
$$R_{equivalente} = R_e = R_p + a^2 R_s$$

$$X_{equivalente} = X_e = X_p + a^2 X_s$$

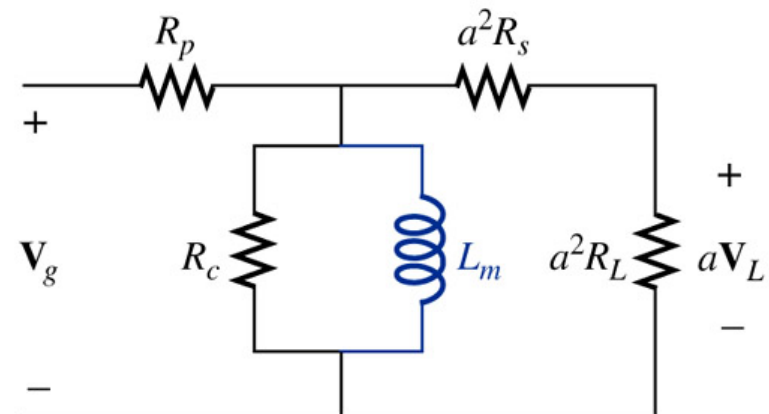


Circuito equivalente do transformador

Efeito da frequência:

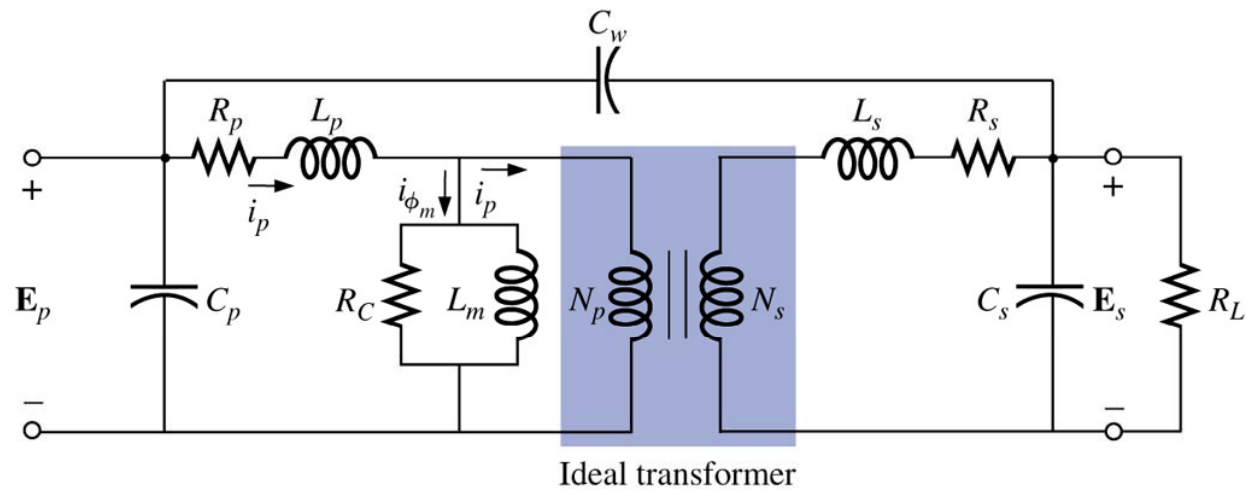


Circuito equivalente para baixas frequências



Circuito equivalente do transformador

Efeito da frequência:



Circuito equivalente para médias frequências

