Chapter 7

MAGNETIC CIRCUIT CONCEPTS

AMPERE-TURNS AND FLUX

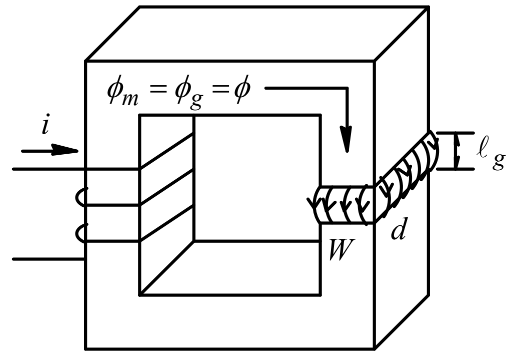


Figure 7-1 Magnetic structure with air gap.

$$H_m \ell_m + H_g \ell_g = Ni$$

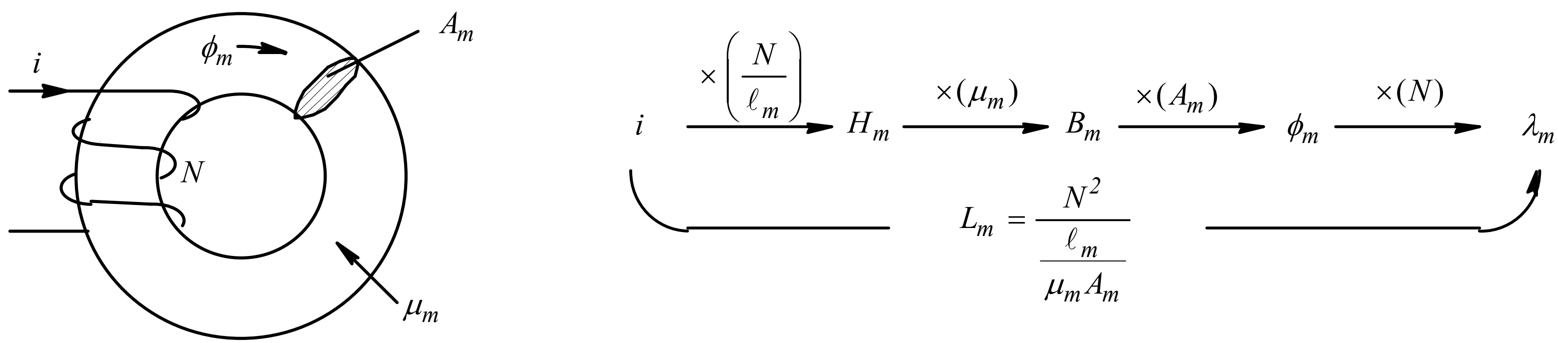
$$\phi(\underbrace{\frac{\ell_m}{A_m \mu_m}}_{\Re_m} + \underbrace{\frac{\ell_g}{A_g \mu_o}}_{\Re_g}) = Ni$$

$$\phi = \frac{Ni}{\Re}$$

$$\Re = \Re_m + \Re_g$$

INDUCTANCE

$$\lambda_m = N\phi_m = L_m i$$



(a) (b)

Figure 7-2 Coil Inductance.

Energy Storage due to Magnetic Fields

$$W = \frac{1}{2} L_m \, i^2 \;\; [J]$$

$$w = \frac{1}{2} \frac{B^2}{\mu} \;\; [J/m^3]$$

FARADAY'S LAW: INDUCED VOLTAGE IN A COIL DUE TO TIME-RATE OF CHANGE OF FLUX LINKAGE

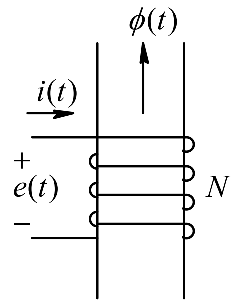
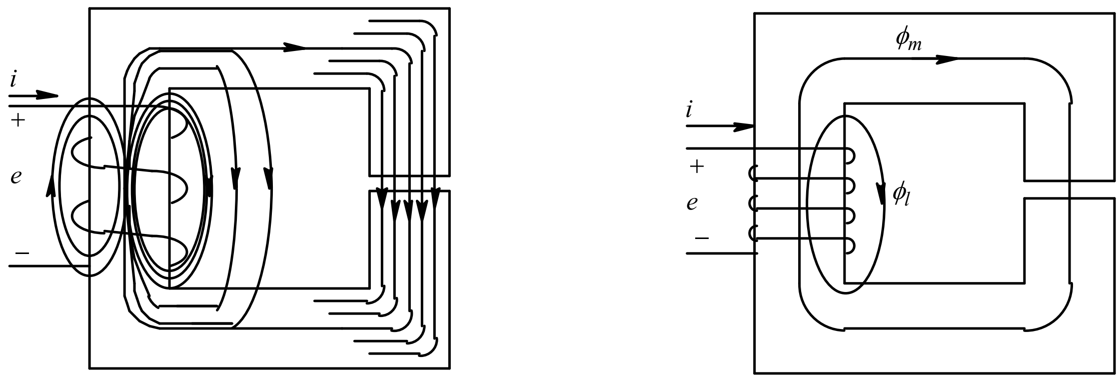


Figure 7-3 Voltage polarity and direction of flux and current.

$$e(t) = \frac{d}{dt}\lambda(t) = N\frac{d}{dt}\phi(t)$$

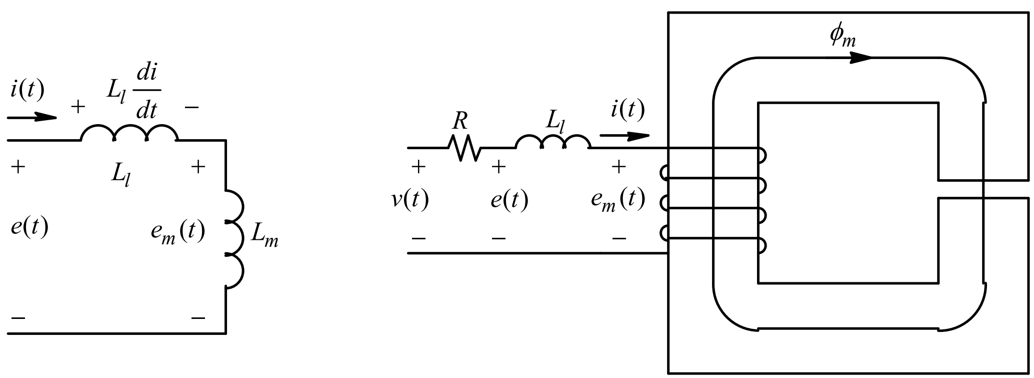
$$\phi(t) = \phi(0) + \frac{1}{N}\int_0^t e(\tau)\cdot d\tau$$

LEAKAGE AND MAGNETIZING INDUCTANCES



(a) (b)

Figure 7-4 (a) Magnetic and leakage fluxes; (b) equivalent representation of magnetic and leakage fluxes.



(a) (b)

Figure 7-5 (a) Circuit representation;
(b) leakage inductance separated from the core.

TRANSFORMERS

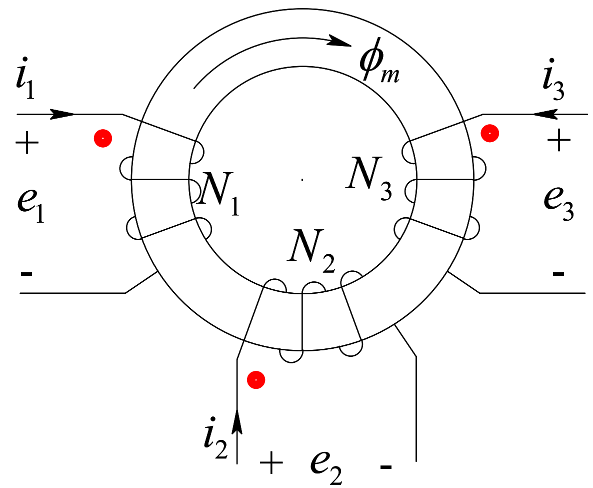


Figure 7-6 Transformer with three windings.

$$e_1 = N_1 \frac{d\phi_m}{dt}$$

$$e_2 = N_2 \frac{d\phi_m}{dt}$$

$$e_3 = N_3 \frac{d\phi_m}{dt}$$

$$\frac{d\phi_m}{dt} = \frac{e_1}{N_1} = \frac{e_2}{N_2} = \frac{e_3}{N_3} \quad \Rightarrow \quad \phi_m = \frac{1}{N_1}\int e_1 dt = \frac{1}{N_2}\int e_2 dt = \frac{1}{N_3}\int e_3 dt$$

$$\phi_m = \frac{N_1 i_1 + N_2 i_2 + N_3 i_3}{\Re_m}$$