Three-Phase Voltages

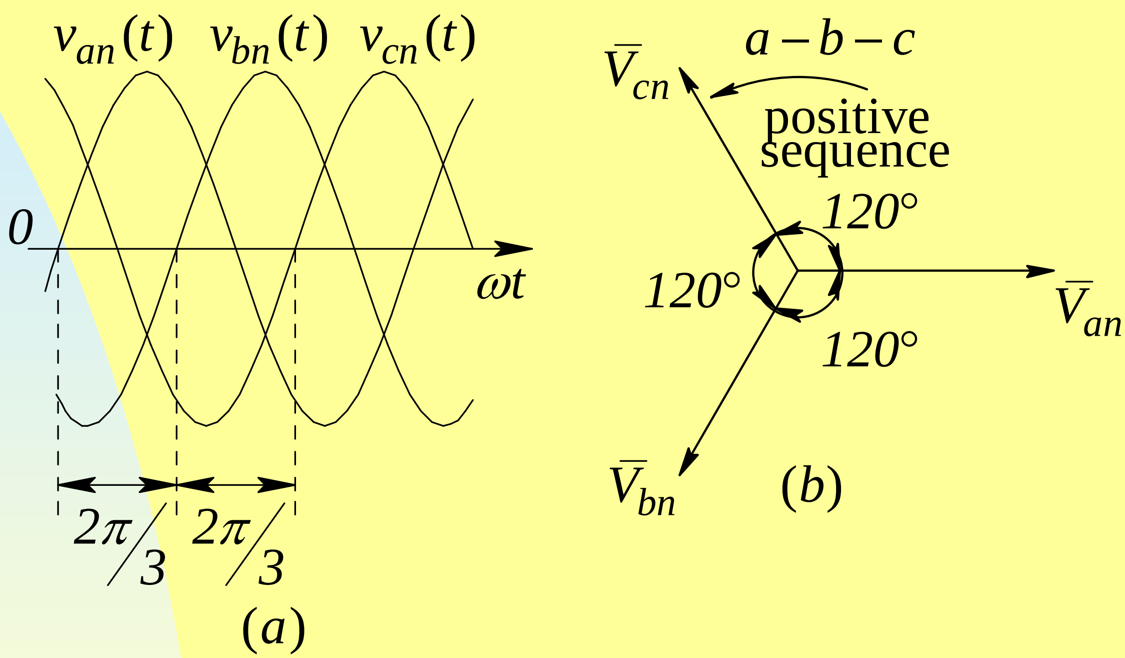
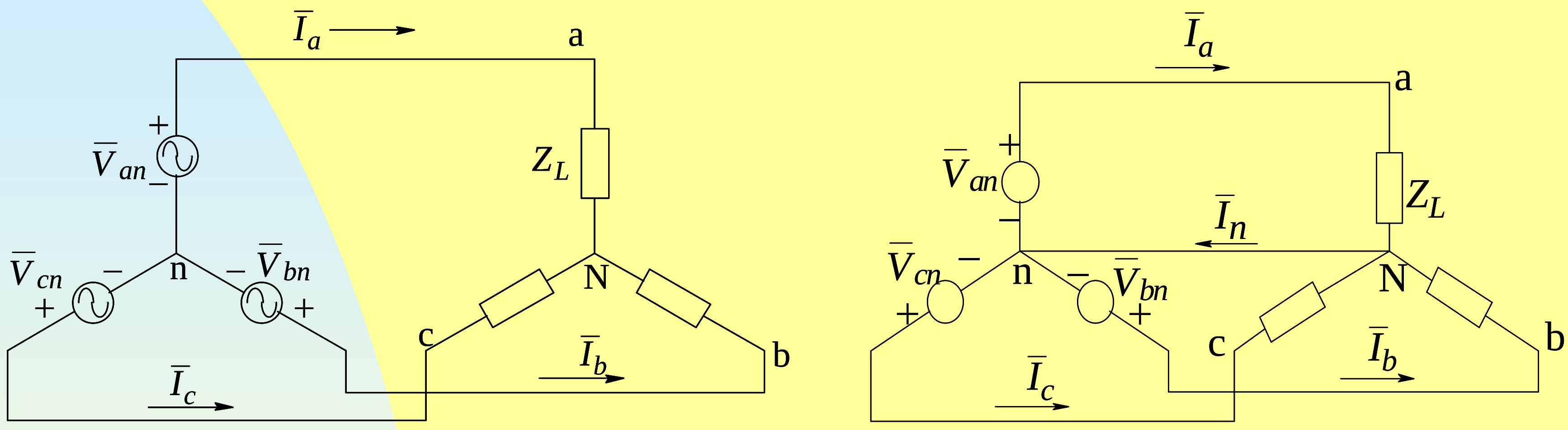


Fig. 2-11 Three-phase voltages in time and phasor domain.

Balanced Three-Phase Circuit Analysis



(a) (b)

Fig. 2-12 Balanced wye-connected, three-phase circuit.

Per-Phase Analysis

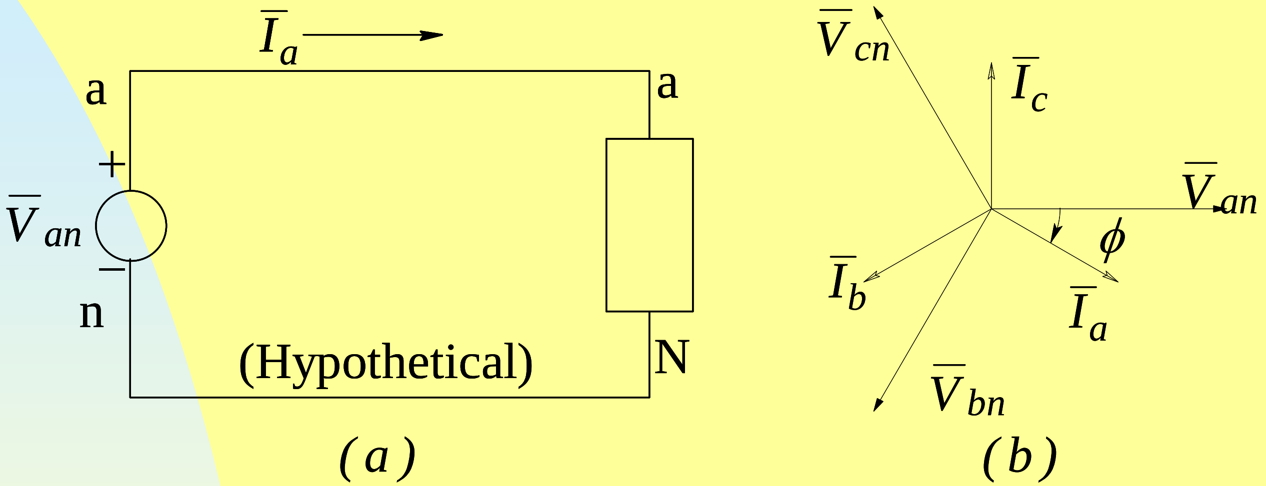


Fig. 2-13 Per-phase circuit and the corresponding phasor diagram.

Balanced Mutual Coupling

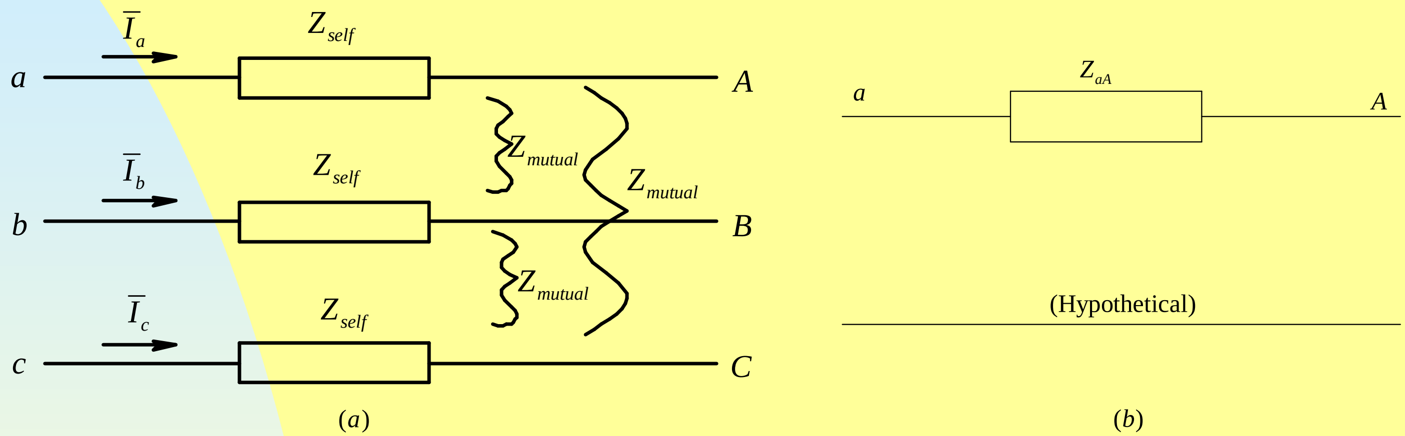


Fig. 2-14 Balanced three-phase network with mutual couplings.

$$Z_{aA} = Z_{self} - Z_{mutual}$$

Line-Line Voltages

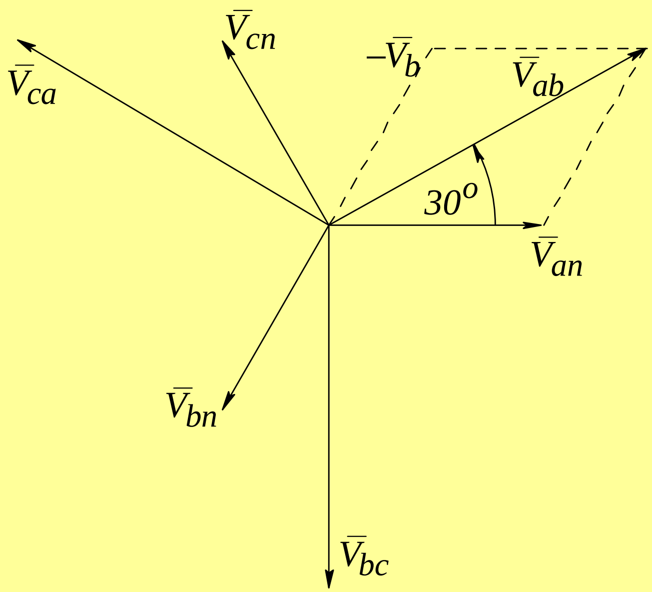


Fig. 2-15 Line-to-line voltages in a three-phase circuit.

Wye-Delta Transformation

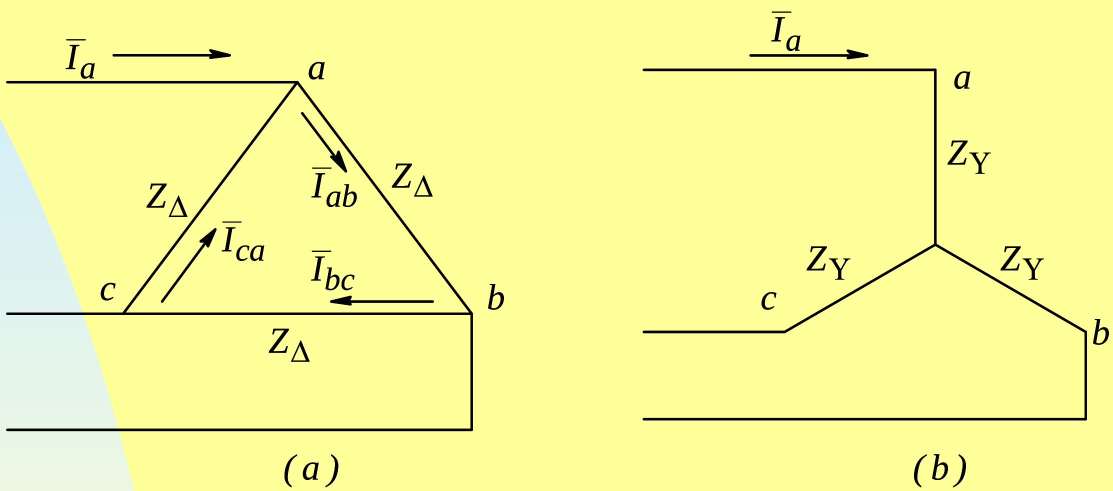


Fig. 2-16 Delta-wye transformation.

Power Flow in AC Systems

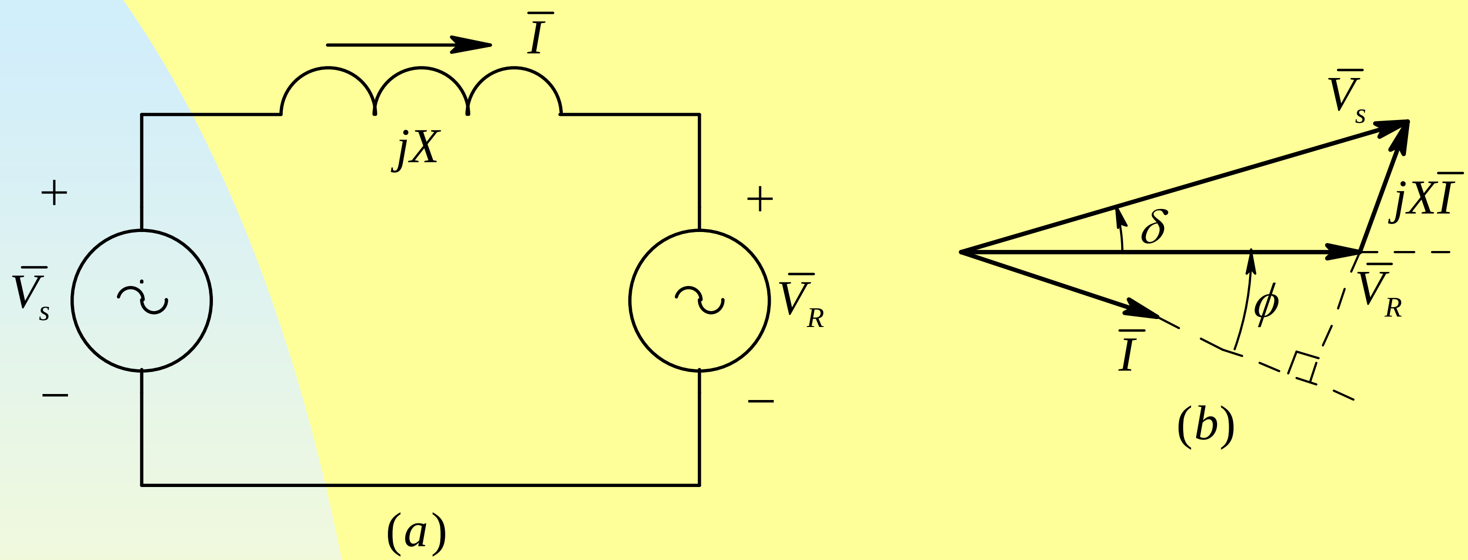


Fig. 2-17 Power transfer between two ac systems.

Power-Angle Diagram

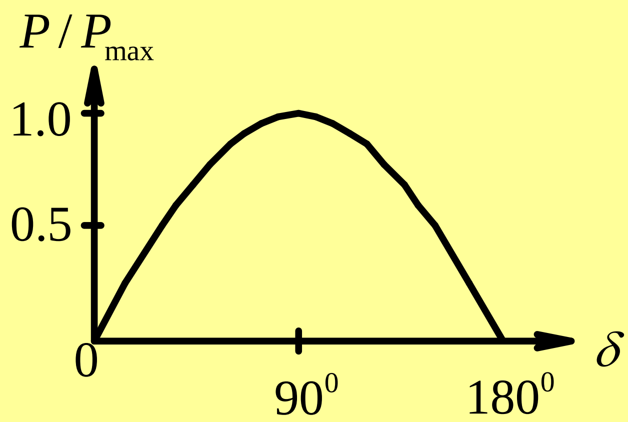


Fig. 2-18 Power as a function of δ.

$$P_R = \underbrace{\frac{V_S V_R}{X}}_{(= P_{\max})} \sin\delta$$

Reactive Power

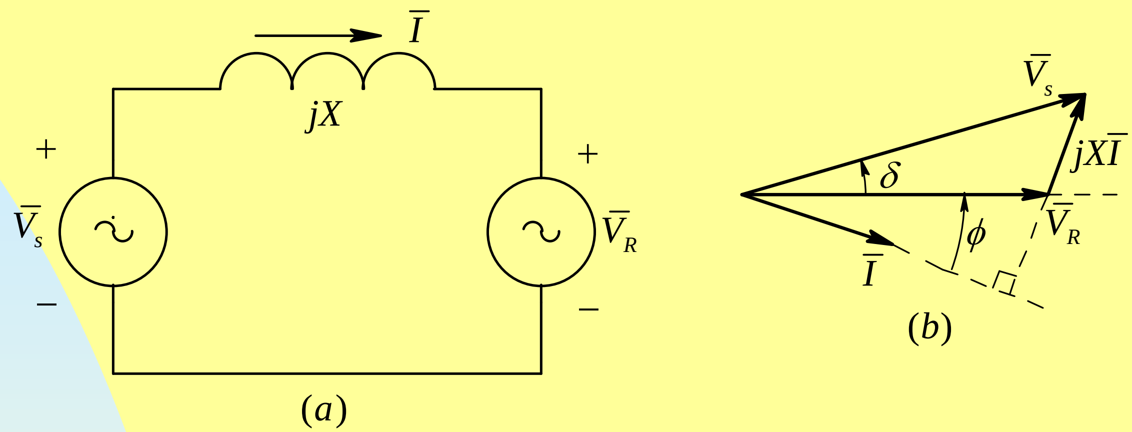


Fig. 2-17 Power transfer between two ac systems.

$$Q_R = \frac{V_S V_R \cos\delta}{X} - \frac{V_R^2}{X}$$

Per Unit Quantities

$$R_{base}, X_{base}, Z_{base} = \frac{V_{base}}{I_{base}} \qquad \text{(in } \Omega\text{)} \qquad (2\text{-}48)$$

$$G_{base}, B_{base}, Y_{base} = \frac{I_{base}}{V_{base}} \qquad \text{(in } \mho\text{)} \qquad (2\text{-}49)$$

$$P_{base}, Q_{base}, (VA)_{base} = V_{base} I_{base} \qquad \text{(in Watt, VAR, or VA)} \qquad (2\text{-}50)$$

In terms of these base quantities, the per-unit quantities can be specified as

$$\text{Per-Unit Value} = \frac{\text{actual value}}{\text{base value}} \qquad (2\text{-}51)$$

Energy Efficiency of Apparatus

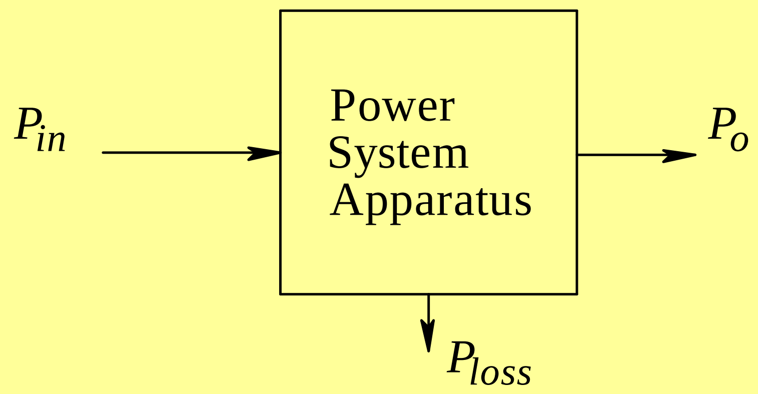


Fig. 2-19 Energy Efficiency $\eta = P_o / P_{in}$.

Electro-Magnetic Concepts: Ampere's Law

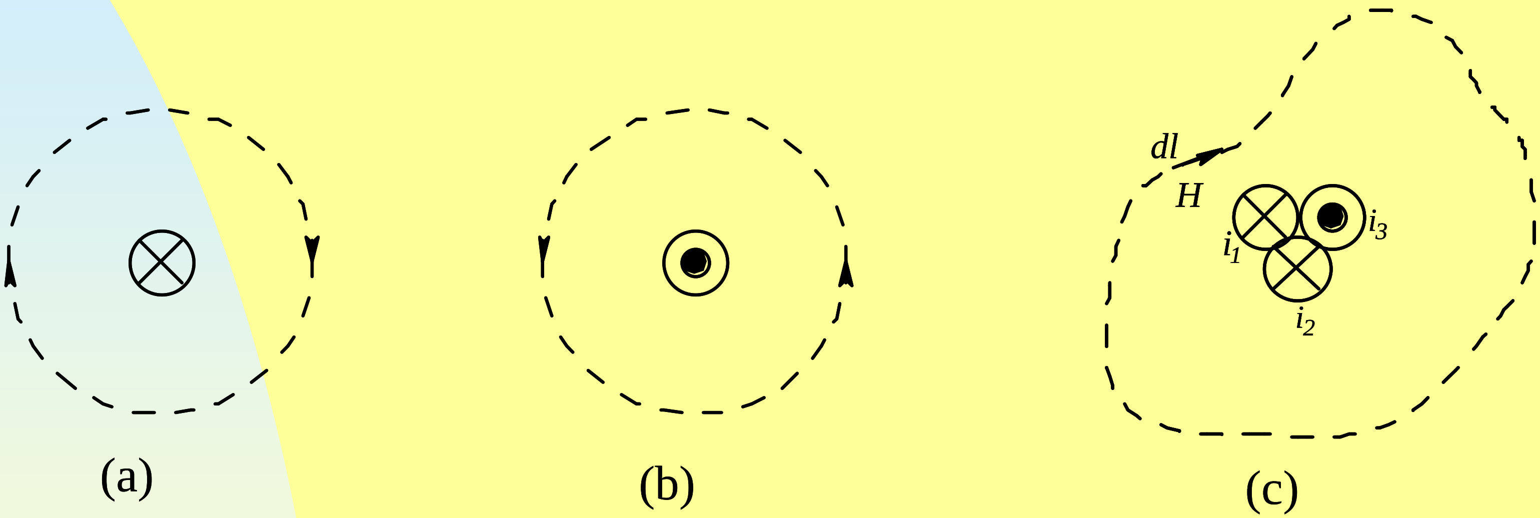


Fig. 2-20 Ampere's Law.

$$\oint H d\ell = \sum i$$

Example of a Toroid

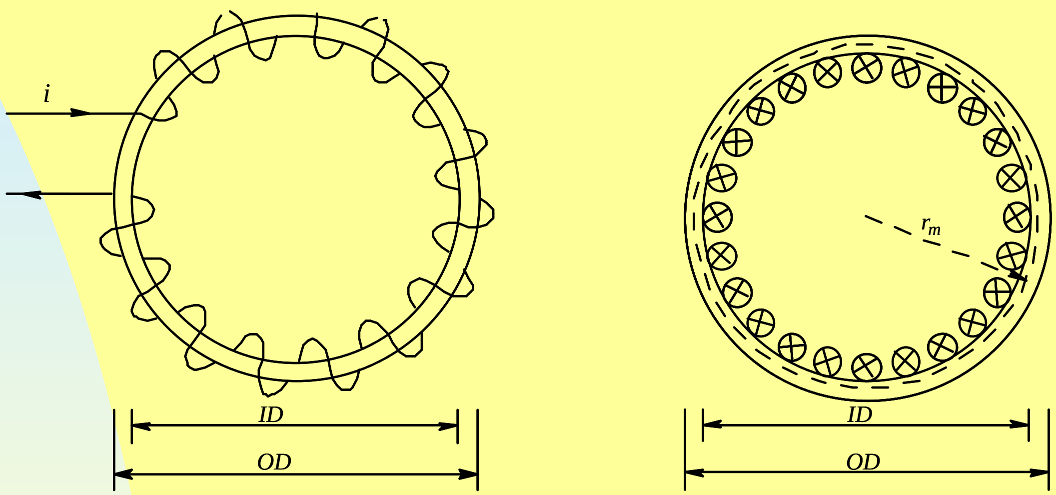


Fig. 2-21 Example 2-9.

B-H Curves in Ferromagnetic Materials

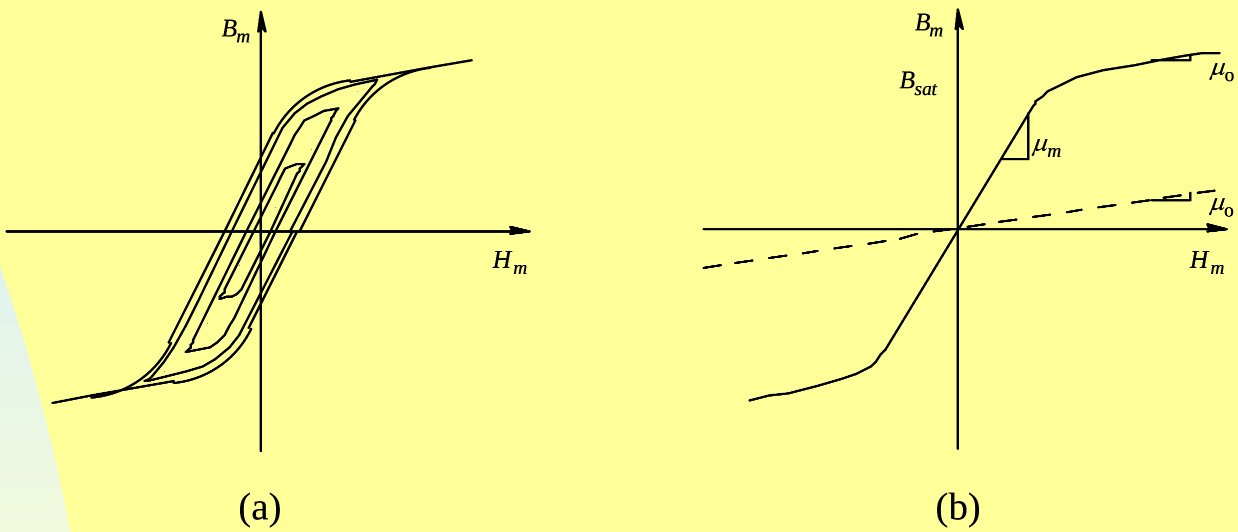


Fig. 2-22 B-H characteristic of ferromagnetic materials.

Flux and Flux-Density

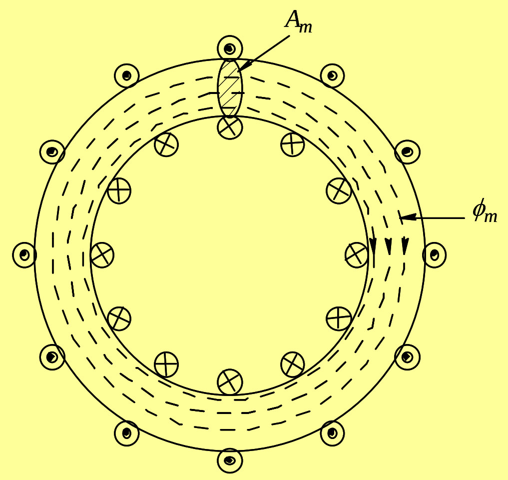
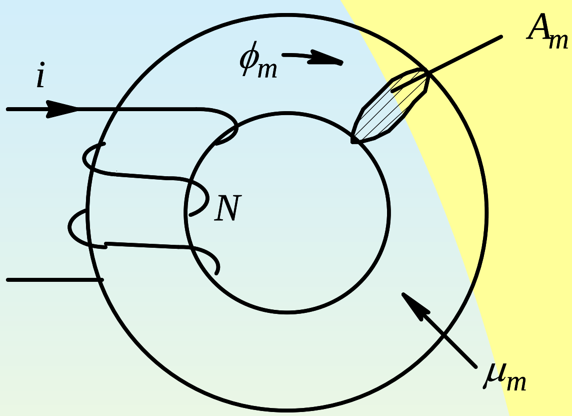
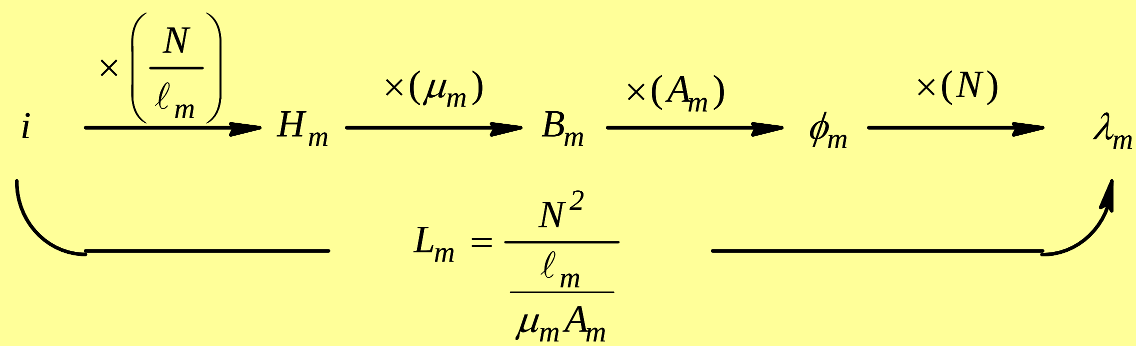


Fig. 2-23 Toroid with flux ϕ_m.

Inductance



(a)



(b)

Faraday's Law

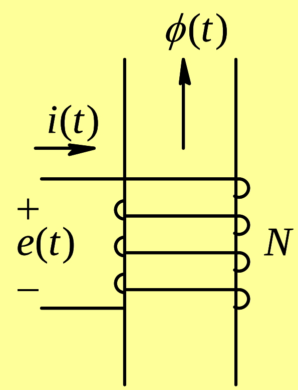


Fig. 2-26 Voltage polarity and direction of flux and current.

Leakage Flux

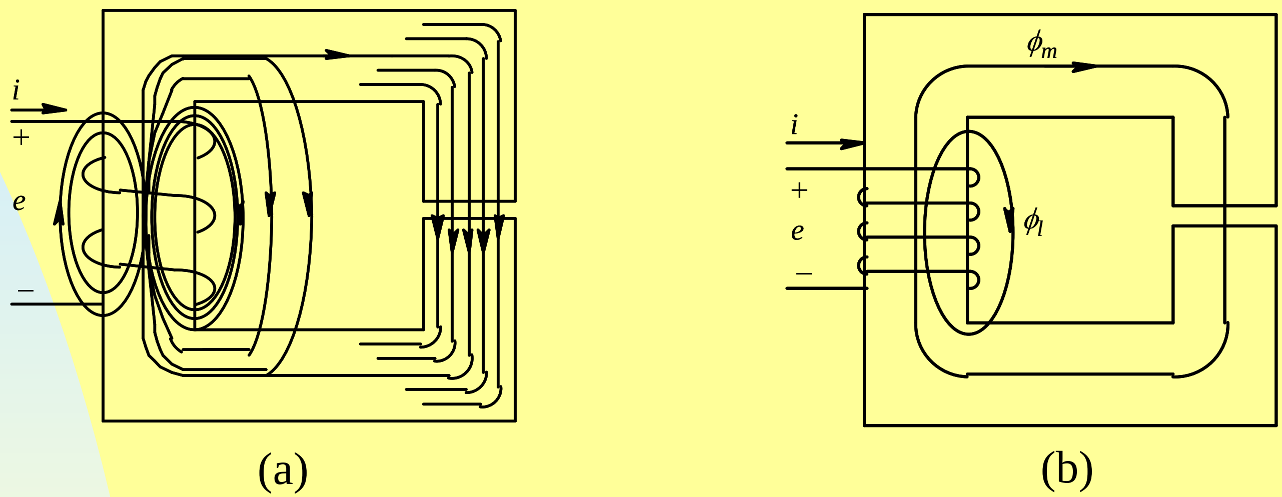


Fig. 2-28 Including leakage flux.

Representation of Leakage Flux by Leakage Inductance

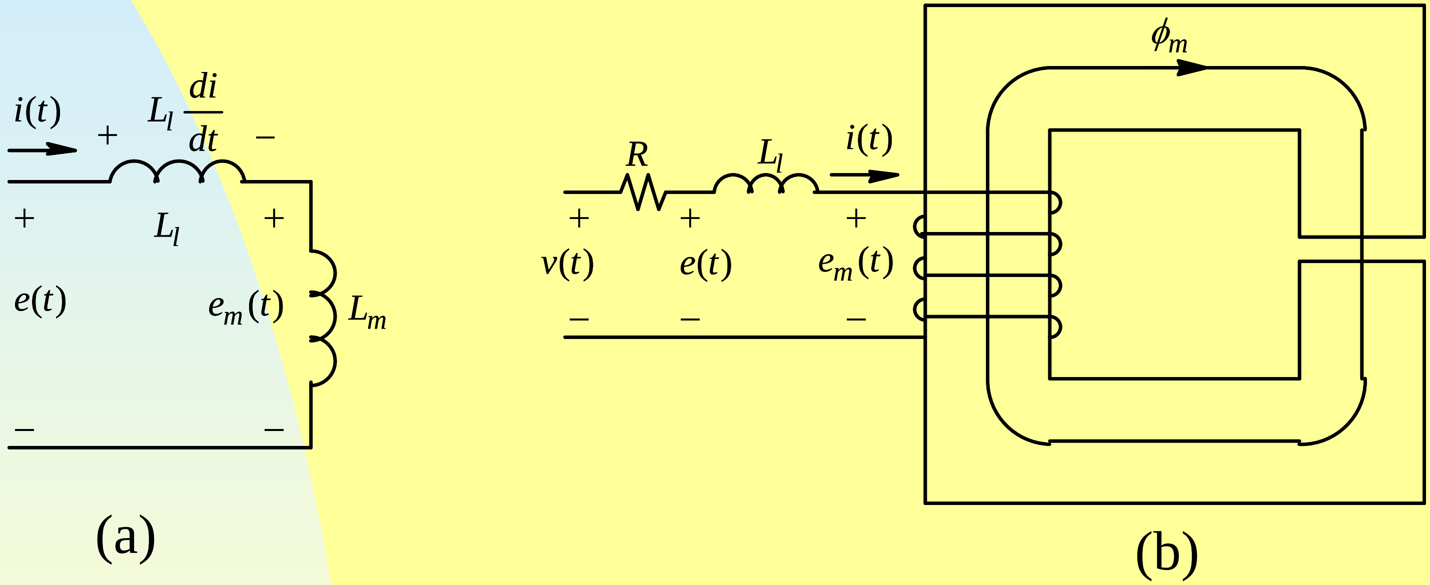


Fig. 2-29 Analysis including the leakage flux.

Summary

- Overview and Changing Landscape
- Review of Electric and Magnetic Circuit Concepts