Power Electronics
- Lecture 3

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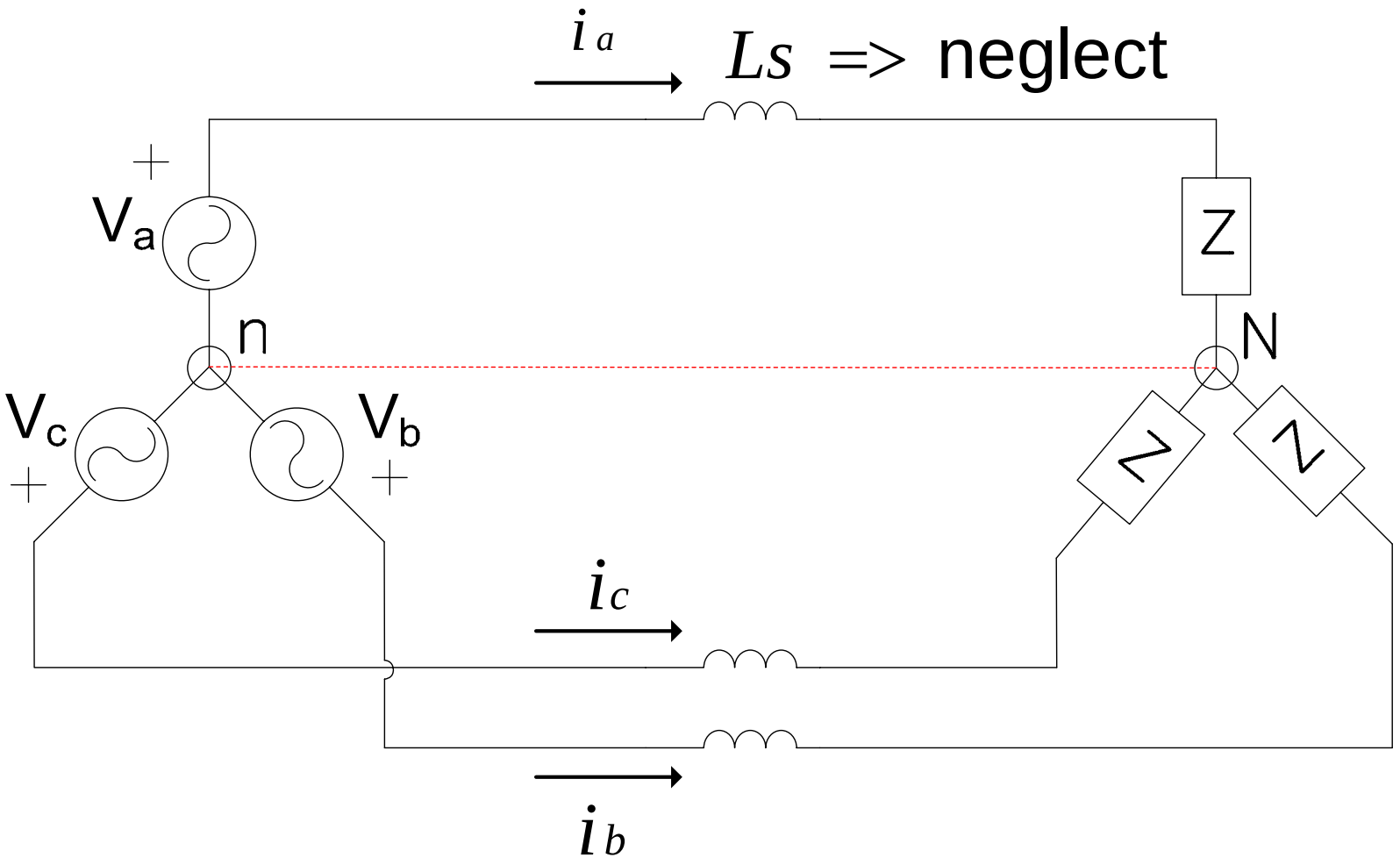
Lecture 3 – Three-phase Systems

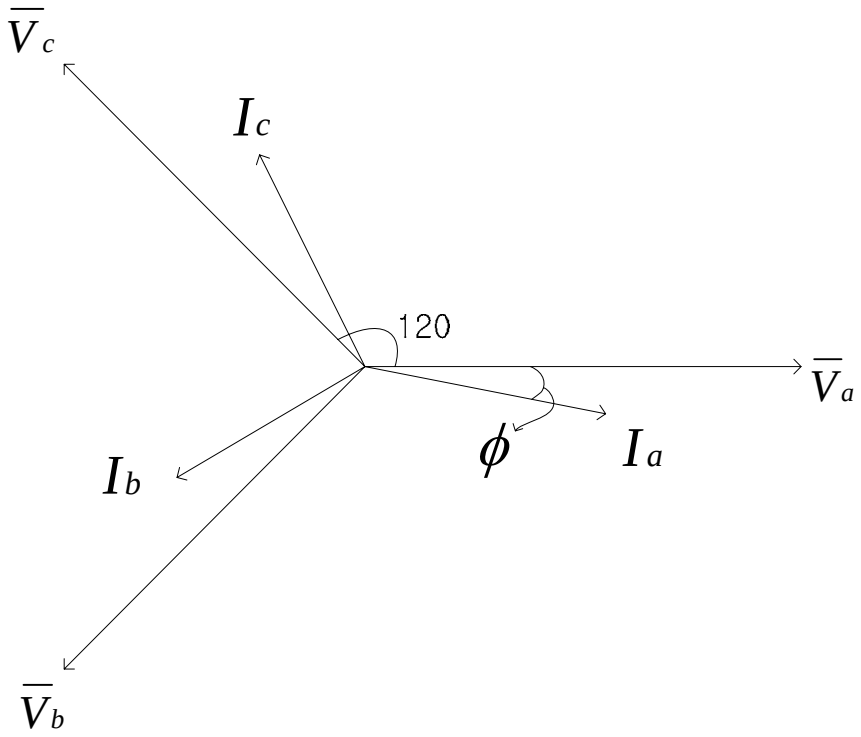
- Contents
  - Phasor representation in three-phase system
  - Power definitions in three-phase system
  - Advantages of three-phase system

Three-Phase System
– Wye connection



※ V_{nN}=0 under balanced system

Three-Phase System
– Phasor representation of balanced system



$$v_a = \sqrt{2}V\cos\omega t$$

$$v_b = \sqrt{2}V\cos(\omega t - 120°)$$

$$v_c = \sqrt{2}V\cos(\omega t + 120°)$$

$$i_a = \sqrt{2}I\cos(\omega t - \phi)$$

$$i_b = \sqrt{2}I\cos(\omega t - \phi - 120°)$$

$$i_c = \sqrt{2}I\cos(\omega t - \phi + 120°)$$

- Phasor representation

$$\mathbf{V}_a = Ve^{j0},\ \mathbf{V}_b = Ve^{j(-120°)},\ \mathbf{V}_c = Ve^{j(120°)}$$

$$\mathbf{I}_a = Ie^{-j\phi},\ \mathbf{I}_b = Ie^{-j(\phi+120°)},\ \mathbf{I}_c = ve^{-j(\phi-120°)}$$

Power Definitions for Three-phase System

- Instantaneous active power $\triangleq p(t) = v_a i_a + v_b i_b + v_c i_c$
- Instantaneous reactive power $\triangleq q(t) = v_a' i_a + v_b' ib + v_c' ic$
- Complex power $\triangleq \mathbf{S} = \mathbf{V}_a \mathbf{I}_a^* + \mathbf{V}_b \mathbf{I}_b^* + \mathbf{V}c \mathbf{I}_c^*$
- Apparent power $\triangleq |\mathbf{S}| = 3VI$

$90°$**phase delayed of** v_a

$= \sqrt{2}V \cos(wt - 90°)$

- Average of instantaneous active power, P_{av}

$$\triangleq \frac{1}{T}\int_T p(t)dt = \mathrm{Re}[\mathbf{S}] = 3VI\cos\phi$$

- Average of instantaneous reactive power, Q_{av}

$$\triangleq \frac{1}{T}\int_T q(t)dt = \mathrm{Im}[\mathbf{S}] = 3VI\sin\phi$$

Advantages of Three-phase System

- $\mathbf{S} = P_{av} + jQ_{av}$
  $p(t) = P_{av}$
  "Instantaneous active power, p(t) is constant having the same value as the average real power(P_{av}) under balanced system"
- Advantages of three-phase system
  - $p(t) = P_{av}$; no ripple component under balanced condition
  - $\mathbf{Number\ of\ wires = 3}$; $\mathbf{1\text{-}\phi -> 2\ wires}$
    $\mathbf{2\text{-}\phi -> 3\ wires}$
  - Three-phase system may require additional wire to carry small-sized common-mode neutral current

MISSION

The Laboratory performs the research and educational activity in the area of electrical system that can be applied in environmental-friendly & sustainable energy conversion process.