EELE 250: Circuits, Devices, and Motors

Balanced three-phase circuits

Assignment Reminder

- Read 5.7 AND 15.1 - 15.2
- Lab notebooks due to TAs' office by 2:00PM today (628 Cobleigh)
- Quiz #8 due by class time on Monday.
- No lab next week.

Electrical Power Distribution

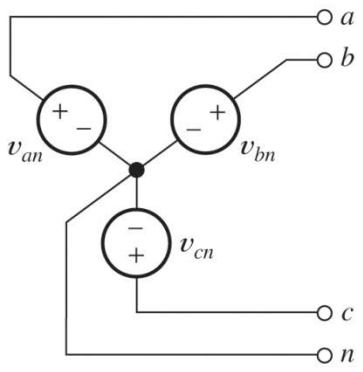
- In the United States and most of the world, electrical power is distributed as sinusoidal alternating voltage and current (AC), with three separate conductors and *phases*.
- The three sinusoidal phases are spaced by 120°

$$v_a(t) = V\cos(\omega t)$$
$$v_b(t) = V\cos(\omega t - 120°)$$
$$v_c(t) = V\cos(\omega t + 120°)$$

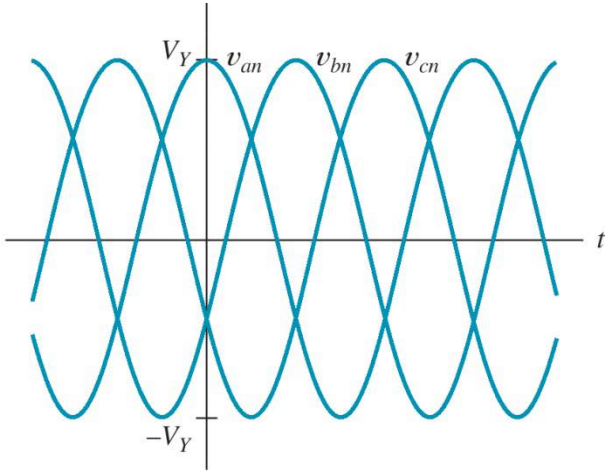
$$\mathbf{V}_a = V\angle 0°$$
$$\mathbf{V}_b = V\angle -120°$$
$$\mathbf{V}_c = V\angle 120°$$

Three-phase source

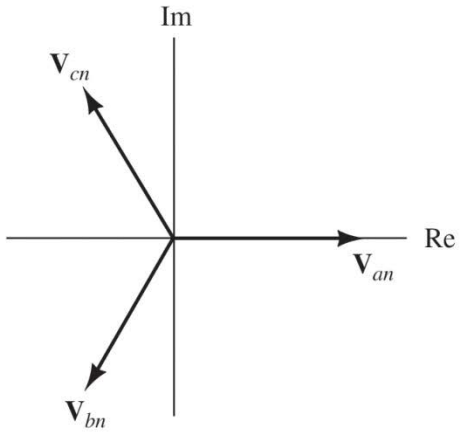
"Wye" configuration with neutral



(a) Three-phase source

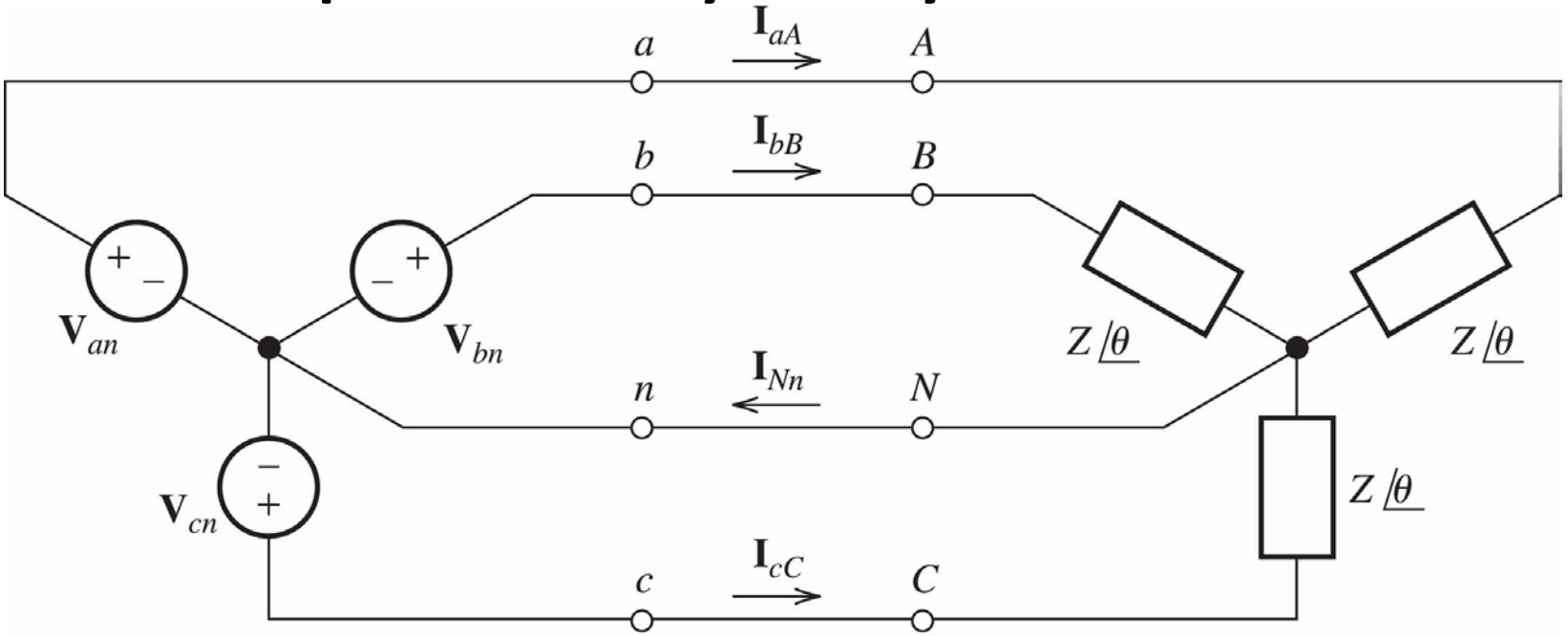


(b) Voltages versus time



(c) Phasor diagram

Three-phase wye-wye connection



$$I_{aA} = \frac{V_{an}}{Z\angle\theta} = \frac{V_Y\angle 0^\circ}{Z\angle\theta} = I_L\angle -\theta$$

$$\begin{aligned} I_{Nn} &= I_{aA} + I_{bB} + I_{cC} \\ &= \left(I_L\angle -\theta\right) + \left(I_L\angle -120^\circ - \theta\right) + \left(I_L\angle 120^\circ - \theta\right) \\ &= 0 \end{aligned}$$

Three-phase power

- With a single phase, the power fluctuates with time: $\cos^2(\omega t)$
- With three-phase connection, the power delivered by each phase is offset in time such that the total power is constant with time
- Three-phase motors receive constant power, and can therefore deliver constant torque
- Also, fewer conductors are needed to deliver three balanced phases compared to three separate phases.