ECE330: Power Circuits & Electromechanics

Review. Three-phase AC circuits

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Schedule

- Mon 2/24: Review
- Wed 2/26: Review
- **Thu 2/27: Exam 1**
- Fri 2/28: No class

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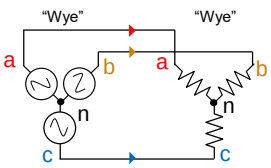
Important

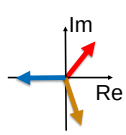
3ϕ models



Assumption 1 (Balanced)
- Same phase-neutral voltage
- Same phase current

Assumption 2 (Positive sequence)
- Phase b lags phase a by 120°
- Phase c leads phase a by 120°

$$\overline{V}_{an} = V\angle\theta_v \qquad \overline{I}_a = I\angle\theta_i$$
$$\overline{V}_{bn} = V\angle(\theta_v - 120^\circ) \qquad \overline{I}_b = I\angle(\theta_i - 120^\circ)$$
$$\overline{V}_{cn} = V\angle(\theta_v + 120^\circ) \qquad \overline{I}_c = I\angle(\theta_i + 120^\circ)$$



Implications (Assumption 1)
- Zero neutral current
- Identical load per phase
- Total power = 3x power per phase

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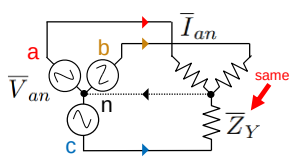
Important

Single phase Equivalence



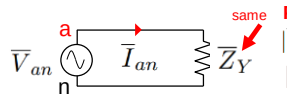
Three-phase circuit (Y-Y)

Line voltage / line current

$$V_L = |\overline{V}_{ab}| = \sqrt{3}|\overline{V}_{an}|$$
$$I_L = |\overline{I}_{an}|$$

Three-phase power

$$\overline{S}_{3\phi} = 3\overline{S}_\phi$$



Per-phase equivalent (one of three shown)

Phase-neutral quantities

$$|\overline{V}_{an}| = |\overline{V}_{ab}|/\sqrt{3} = V_L/\sqrt{3}$$
$$|\overline{I}_{an}| = I_L$$

One-phase power

$$\overline{S}_\phi = \overline{S}_{3\phi}/3$$

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2.22 A three-phase load of 15 kVA at 0.8 PF leading is connected in parallel with a three-phase 72 kW load at 0.8 PF lagging. The line-to-line voltage is 2000 V.

a) Find the line current and the PF of the combined total load.

b) Find the total kVAR needed to bring the PF to unity.

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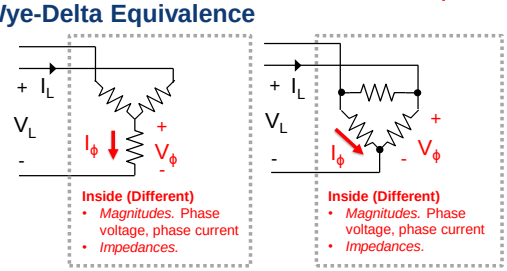
Important

Wye-Delta Equivalence



Outside (Same)
- *Magnitudes.* Line voltage (aka line-to-line voltage), line current
- *Phasors.* Phase-to-phase voltage, phase-to-neutral voltage, phase-to-phase voltage, phase-to-neutral voltage
- *Power.* Power factor, complex power, PF angle, P, Q.

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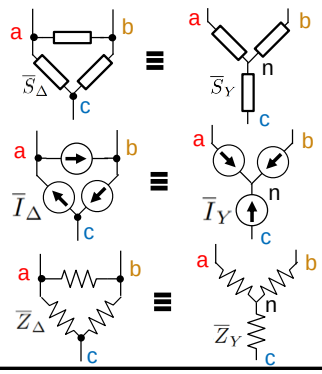
Important

Wye-Delta equivalence



Power

$$\overline{S}_\Delta = \overline{S}_Y$$

Current

$$\sqrt{3}|\overline{I}_\Delta| = |\overline{I}_Y|$$

$$\text{PowFac}_\Delta = \text{PowFac}_Y$$

Impedance

$$\overline{Z}_\Delta = 3\overline{Z}_Y$$

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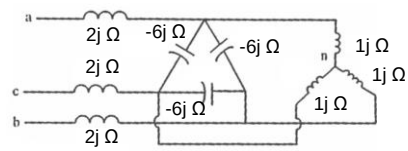
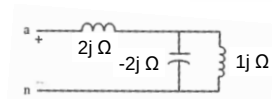
Warm-up

What is the equivalent per-phase Wye impedance?





$$2j + \left(\frac{1}{-2j} + \frac{1}{j}\right)^{-1} = 4j$$

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Warm-up

2.16 A 345 kV three-phase line supplies 750 MVA at 0.8 PF lagging to a three-phase load which is delta connected.

a) Find the complex impedance per phase. "equivalent Delta current"

b) Find the magnitudes of the line and phase currents.

c) Compute real and reactive power per phase.

d) Compute the total complex power.

1. Draw and label the 3-phase circuit diagram
2. Draw and label the equivalent wye-wye diagram
3. Draw and label the equivalent 1-phase diagram
4. Solve the 1-phase problem
5. Convert back to wye-wye, then back to orig 3-phase

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A three-phase wye-connected load draws 100 kW at a PF of 0.80 lagging from a 240 V (line-line) three-phase system. Three capacitors are delta-connected across the load. The total kVAR of the capacitors is 35 kVAR.

1. Find the line current before and after the capacitors are added.
2. Find the new power factor.

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A three-phase, 100 V (line-line) delta-connected generator delivers 625 VA at 0.8 PF leading to the following two loads in parallel:

- A purely capacitive three-phase wye-connected load that consumes 875 VAR
- A balanced delta-connected three-phase impedance

Find the impedance of each of the legs of the delta-connected load.

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