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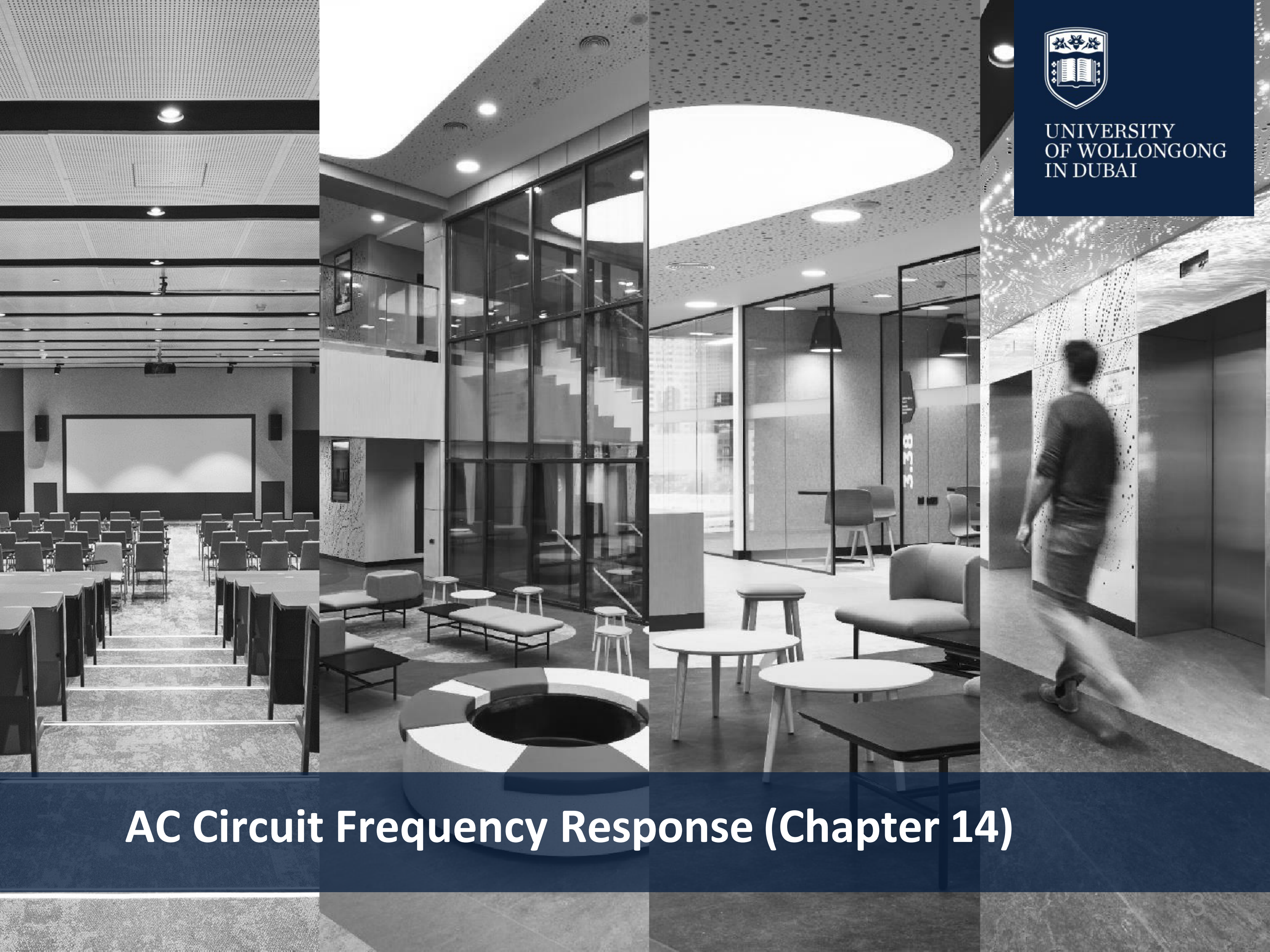
ECE202: CIRCUITS AND SYSTEMS
WEEK 7



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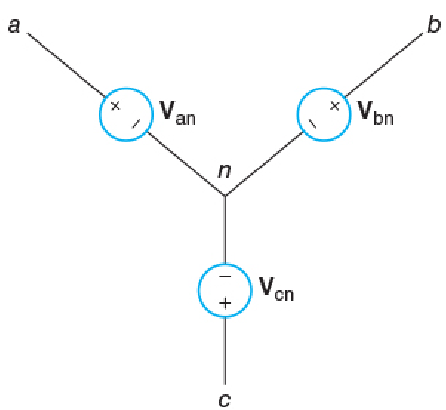
AC Circuit Frequency Response (Chapter 14)

Three Phase circuit

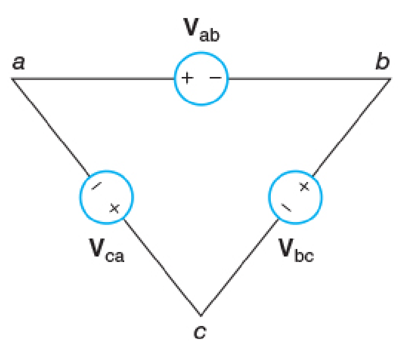
- In this chapter, circuits connecting balanced three-phase sources and balanced three-phase loads are analyzed.
- The balanced three-phase sources are three voltages with the same amplitude and frequency, but three different phases separated by 120^o. The sources can be arranged in a wye (Y) shape or a delta (Δ) shape.
- The balanced loads refer to three loads with identical impedances and also can be arranged in a Y or Δ shape.
- There are four combinations in connecting three-phase sources and three-phase loads.
- These are Y-Y connection, Y- Δ connection, Δ - Δ connection, and Δ -Y connection.
- The delta connected sources have equivalent wye connected sources, and vice versa.
- The delta connected loads have equivalent wye connected loads, and vice versa.

Three Phase

- The three voltage sources can be connected in Y shape (wye shape) or Δ shape (delta shape),
- The three voltages Van, Vbn, and Vcn in the Y-connected source are called phase voltages. Van + Vbn + Vcn = 0.
- The voltages between the lines, Vab, Vbc, and Vca, are called line voltages.



(a)



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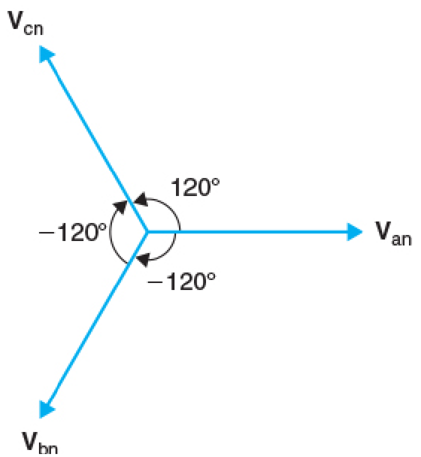
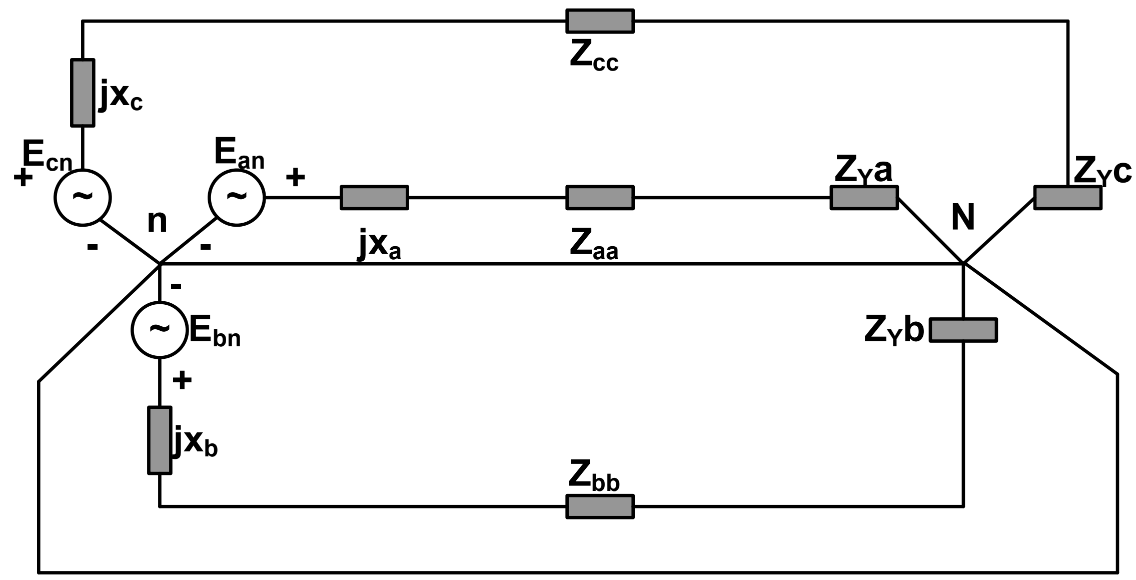


Three Phase

- The three voltage sources can be connected to three phase load impedance



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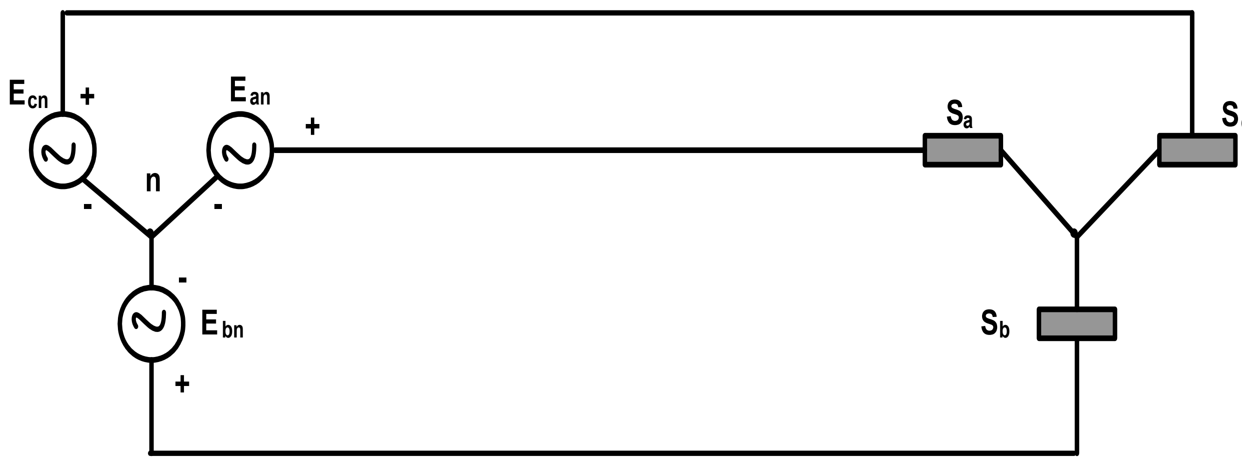
Three Phase

- If the 3-phase system is balanced
- The neutral wire doesn't carry any current and it can be omitted from the circuit



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Three Phase

- Note that there is the following relationship between phase voltages and line-line voltages:

$$E_{ab} = \sqrt{3}E_{an}\angle 30°$$

$$E_{bc} = \sqrt{3}E_{an}\angle(30\text{-}120)°$$

$$E_{ca} = \sqrt{3}E_{an}\angle(30+120)°$$

Assuming the phase ‘a’ as our reference angle.

Three Phase

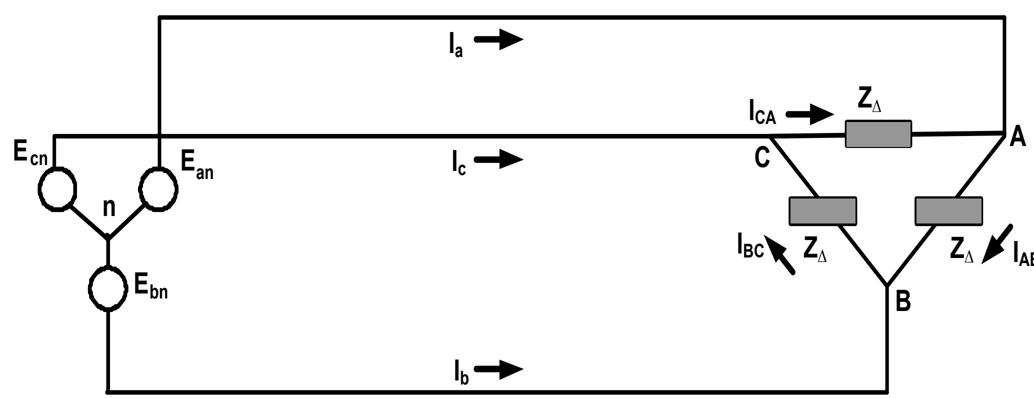
- Verify the relation between the line to line voltage and phase voltage

The Basic concepts of power grids: 3 phase systems

$$I_{AB} = \sqrt{3}E_{an}\angle 30^{o} / Z_{\Delta}$$

$$I_{BC} = \sqrt{3}E_{an}\angle (30-120)^{o} / Z_{\Delta}$$

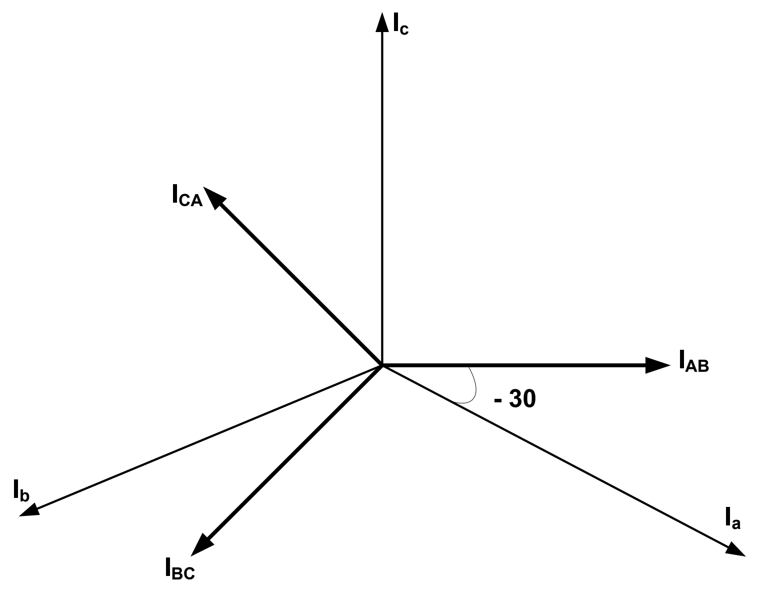
$$I_{CA} = \sqrt{3}E_{an}\angle (30+120)^{o} / Z_{\Delta}$$



The Basic concepts of power grids: 3 phase systems

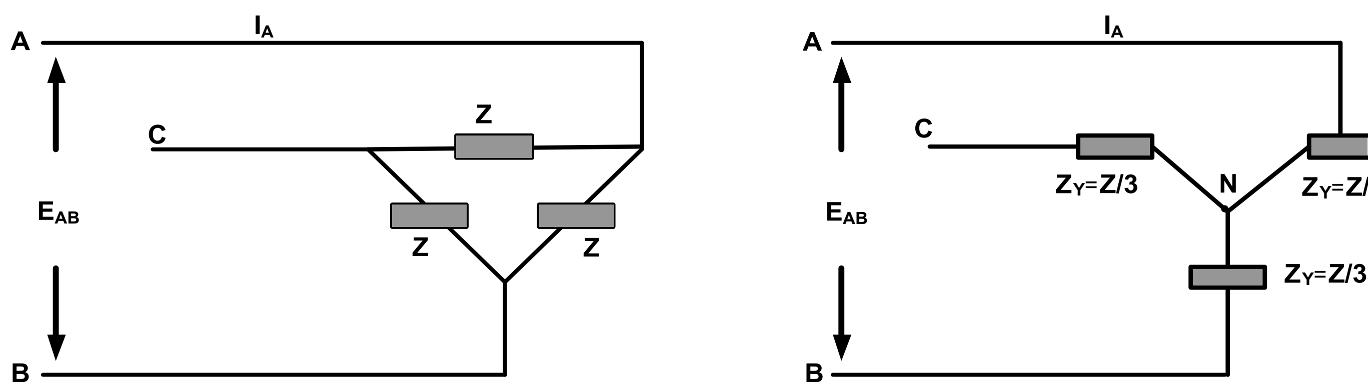
- We have the following relation between line-line current and phase currents:

$$I_a = \sqrt{3} I_{AB} \angle\text{-}30°$$
$$I_b = \sqrt{3} I_{BC} \angle\text{-}30°$$
$$I_c = \sqrt{3} I_{CA} \angle\text{-}30°$$



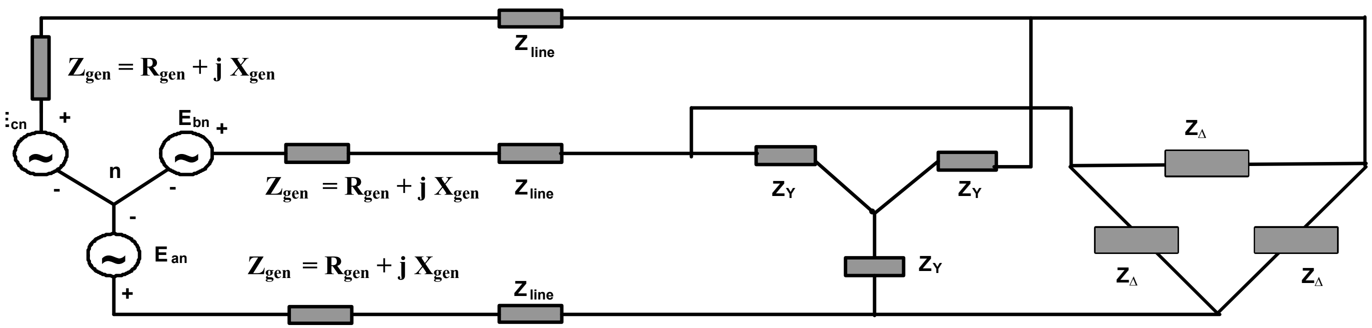
The Basic concepts of power grids: 3 phase systems

Delta connected load could be presented as Y connected load as shown in the figure below:



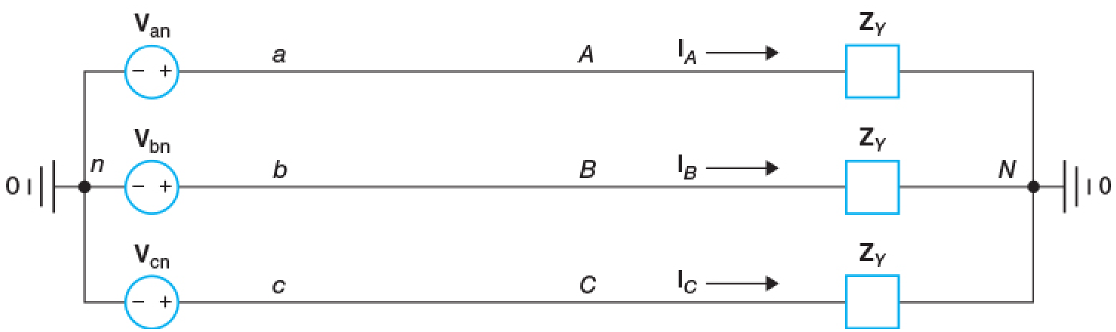
The Basic concepts of power grids: 3 phase systems

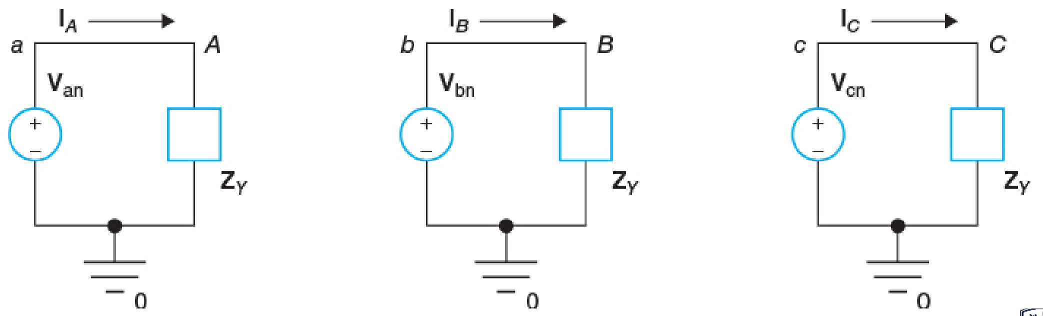
The 3-phase system can supply two loads, one is delta connected and one is wye connected



Three Phase: balanced Circuit

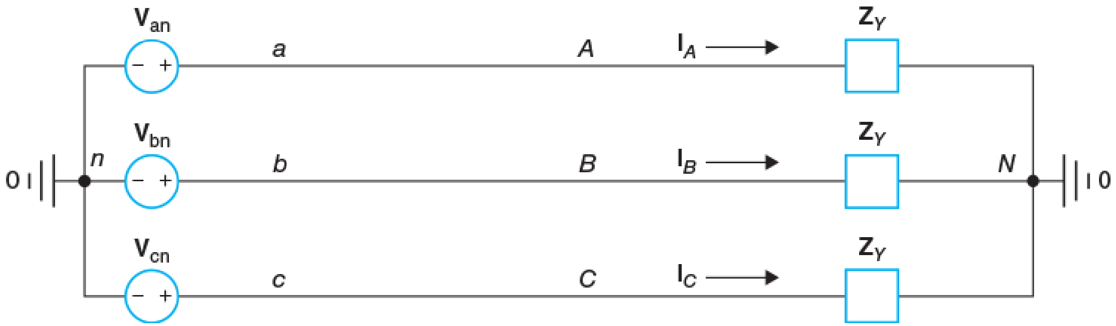
- A balanced Y-connected source connected to the balanced Y-connected load is shown





Three Phase: Example 1

- In the balanced Y-Y connection shown in Figure 12.6, let the magnitude of the line voltages be VL = 880 V (rms), the load impedance per phase be ZY = 50 + j25 Ohms, and the phase angle of Van be 0º. Find the phase voltages, the line currents, and the line voltages. Also, find the complex power, apparent power, average power, reactive power, and power factor of the load.



Three Phase: Example 1 Solution

Three Phase: Example 2

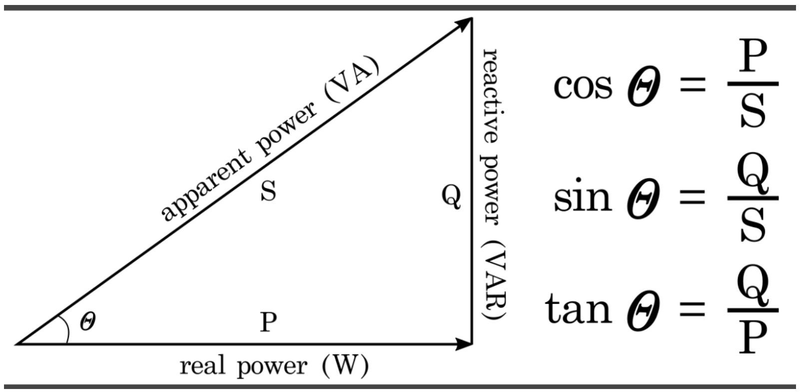
- A balanced three-phase Y-connected generator with a positive sequence has an impedance of 0.2 + j0.5 Ohms per phase and an internal voltage of 120 V/phase. The generator feeds a balanced three-phase Y-connected load having an impedance of 39 + j28 Ohm per phase. The impedance of the line connecting the generator to the load is 0.8 + j1.5 Ohm/phase. The a-phase internal voltage of the generator is specified as the reference phasor.
- A) construct the a-phase equivalent circuit of the system
- Calculate the three line currents
- Calculate the three-phase voltage at the load
- Calculate the line voltage at the terminal of the load
- Calculate the phase voltage at the terminal of the generator
- Calculate the line voltage at the terminal of the generator

Three Phase: Example 2 Solution

Three Phase: Complex Power

- In a three-phase system, the total power is the sun of the three-phase power.
- Under this section, the materials cover the followings
- A) Complex power S
- B) Real Power P
- C) Reactive Power Q

- $S = \sqrt{3} V_L I_L^*$
- $S = 3 V_\emptyset I_\emptyset^*$
- $P = S \times Pf$
- $Q = S \times \sin(\theta)$



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Three Phase: Example 3

- In a balanced three-phase system, the source has an abc sequence, is Y-connected, and Van = 120/20° V. The source feeds two loads, both of which are Y-connected. The impedance of load 1 is 8 + j6 Ohms/phase. The complex power for the a-phase of load 2 is 600/36° VA. Find the total complex power supplied by the source.

Three Phase: Example 3 Solution

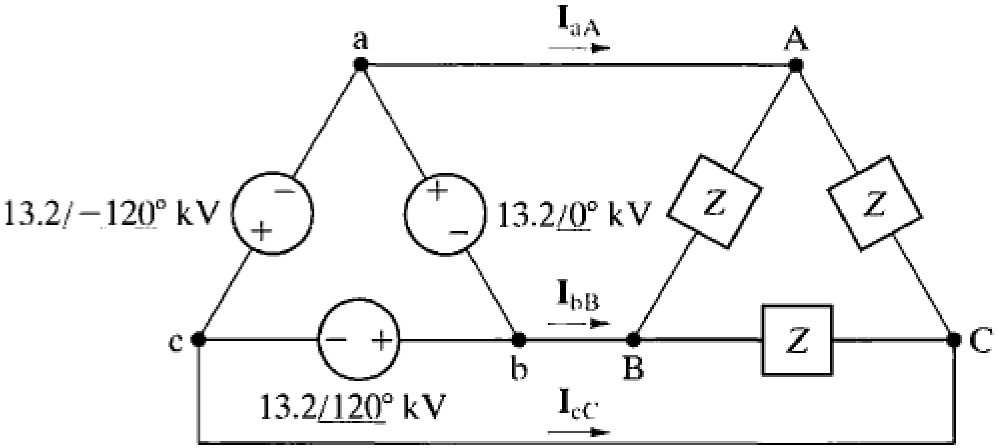
Three Phase: Example 4

- A balanced three-phase source is supplying 60 kVA at 0.6 lagging to two balanced Y-connected parallel loads. The distribution line connecting the source to the load has negligible impedance. Load 1 is purely resistive and absorbs 30 kW. Find the per-phase impedance of Load 2 if the line voltage is 120 V5 V and the impedance components are in series.

Three Phase: Example 4 Solution

Three Phase: Example 5

- The impedance Z has the following value: 100-J75 Ohm. Finds the line current I_{aA} , I_{AB} and I_{bc}.



Three Phase: Example 5 Solution

Three Phase: Example 6

- A balanced, three-phase circuit is characterized as follows:
- • Y-A connected;
- • Source voltage in the c-phase is 20 and - 9 0 ° V;
- • Source phase sequence is abc;
- • Line impedance is 1 + j3 Ohms/Phase
- • Load impedance is 117 —j99 Ohms/Phase.

a) Draw the single-phase equivalent for the a-phase.
b) Calculate the a-phase line current.
c) Calculate the a-phase line voltage for the three-phase load.

Three Phase: Example 6 Solution