INTRODUCTION TO THREE PHASE SYSTEM

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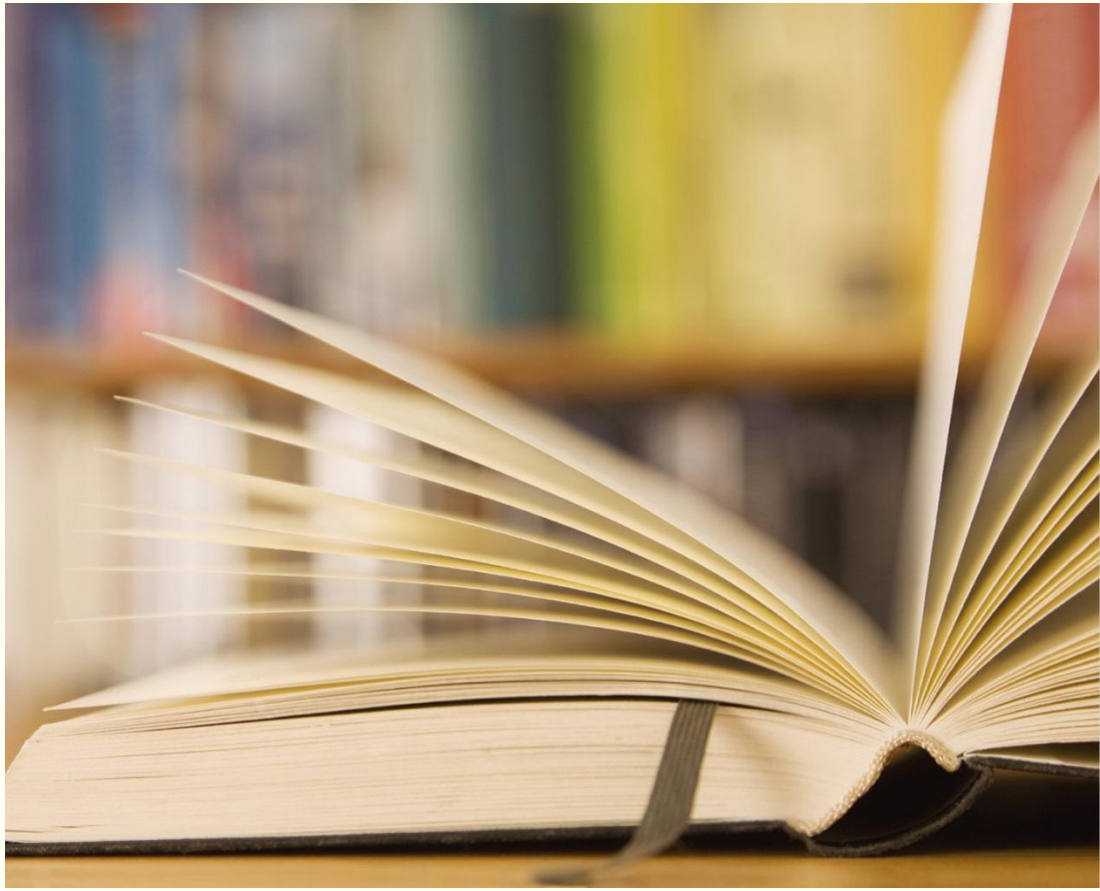


Learning Outcomes:

After the ending of the lesson, students will be able to know,

- About ***Single phase***, ***Two phase*** and ***polyphase system***.
- The difference between ***single phase***, ***two phase*** and ***three phase systems***
- The ***characteristics*** of three phase system
- The ***advantages*** of ***three phase system*** over ***single phase system***
- About ***balance*** and ***unbalance system***
- About the procedure of determining ***phase sequences*** of a system

Single Phase Vs Two Phase

Single Phase System

- **System has only one phase angle**
- **The magnitude of the sources are same or different**
- **The phase difference between each sources are zero**

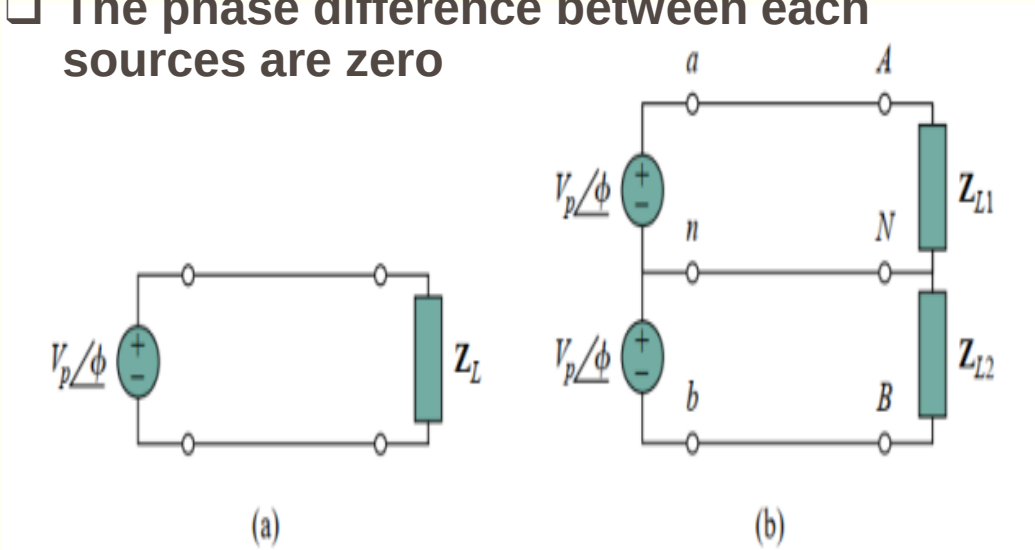


Fig. 1. Single-phase systems: (a) two-wire type, (b) three-wire type

Two Phase System

- System has two phase angles
- The magnitude of the sources are same or different
- The phase difference between each sources are 90 degrees

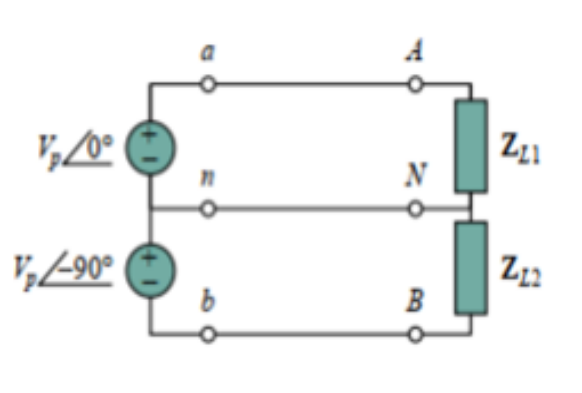


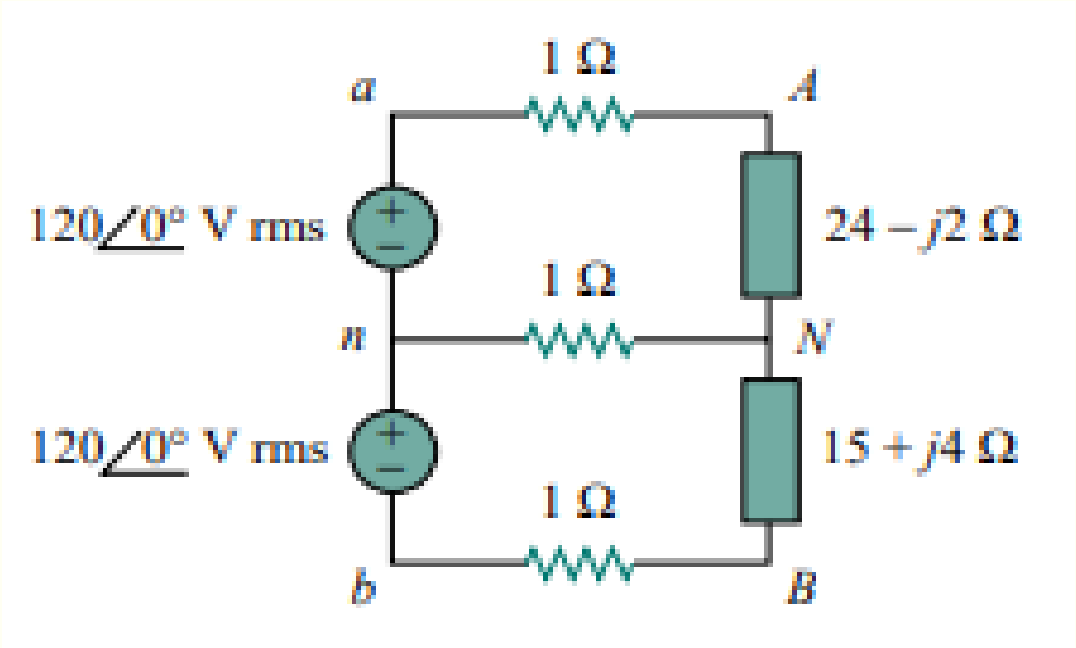
Fig. 2. Two-phase systems three-wire type

QUESTION SESSION_1

Only for Three Students

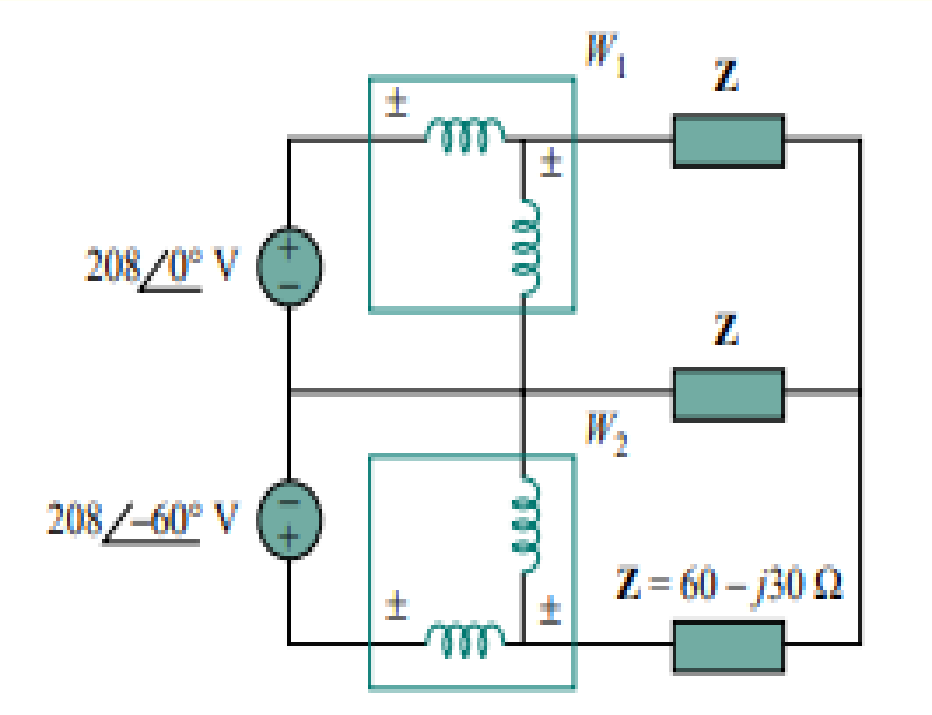
Question Session

Which kind of system has shown in the following figure?



Question Session

Which kind of system has shown in the following figure?



Three Phase System

- It has ***same or different amplitude*** but ***same frequency***
- out of phase with each other by ***120◦***

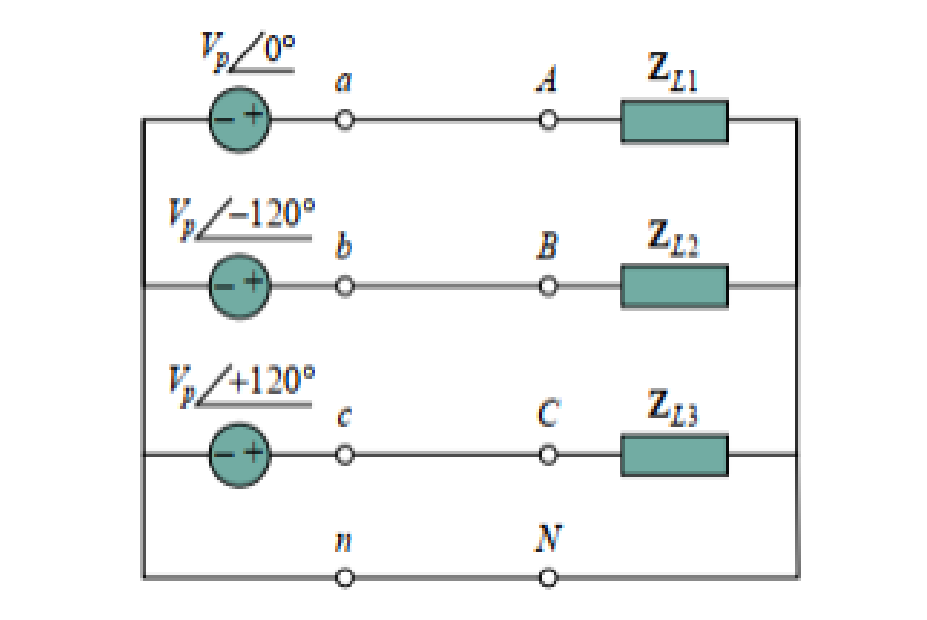
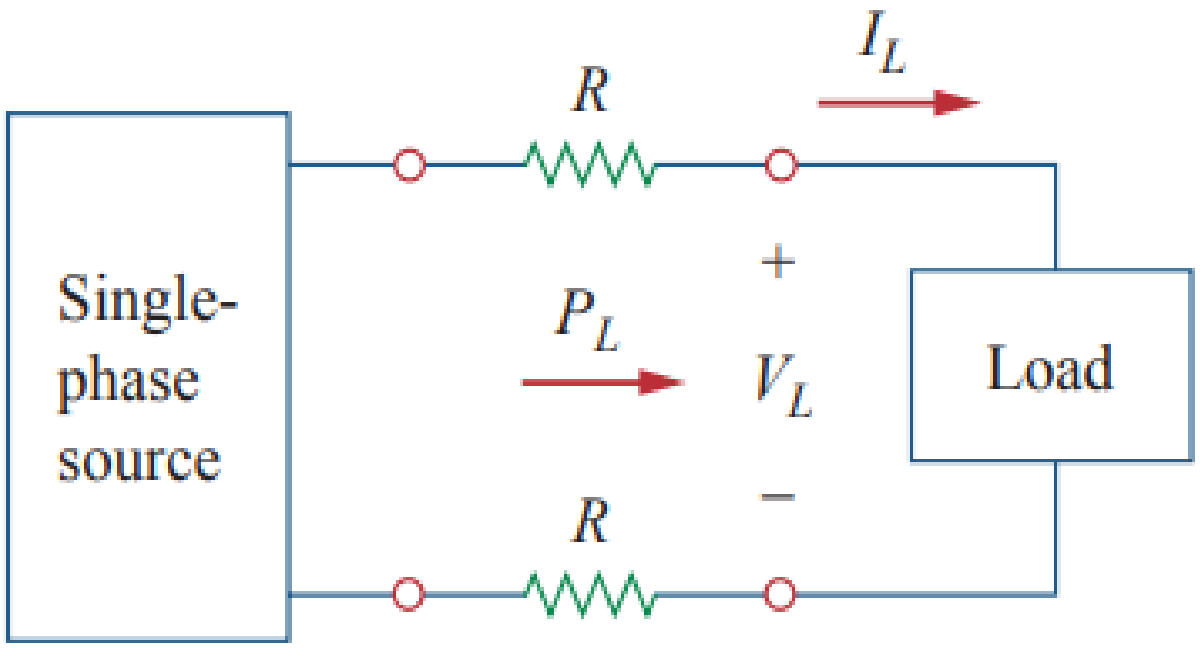


Fig. 3 Three phase four wire system

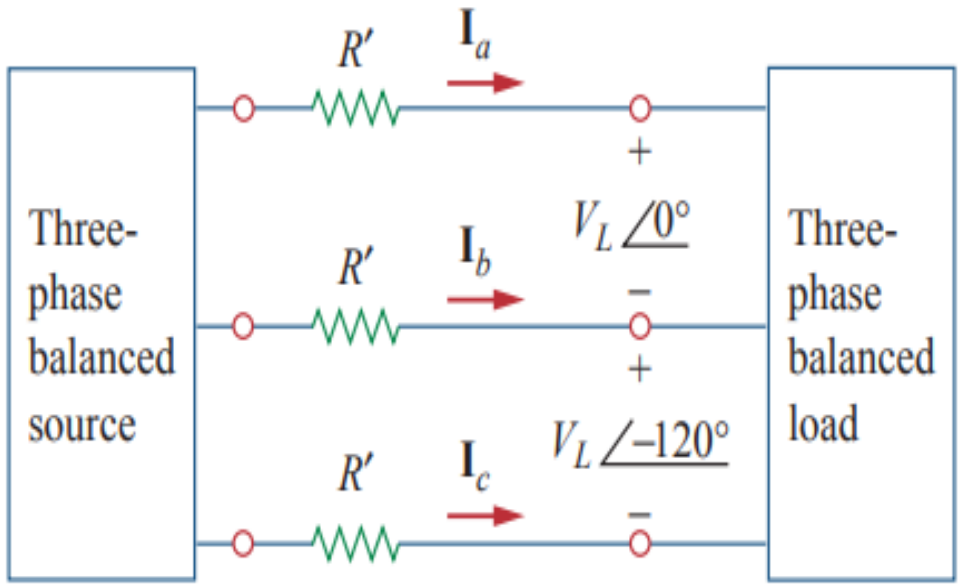
Why 3 phase system instead of single phase?

Let’s look into a 2-wire single phase system



$$P_{\text{loss}} = 2I_L^2R = 2R\frac{P_L^2}{V_L^2}$$

For a three phase system with:
Same power delivered and same line voltage



Transmission lines

$$P'_{\text{loss}} = 3(I'_L)^2 R' = 3R' \frac{P_L^2}{3V_L^2} = R' \frac{P_L^2}{V_L^2}$$

$$\frac{P_{\text{loss}}}{P'_{\text{loss}}} = \frac{2R}{R'}$$

$$R = \rho \ell / \pi r^2 \text{ and } R' = \rho \ell / \pi r'^2,$$

$$\frac{P_{\text{loss}}}{P'_{\text{loss}}} = \frac{2r'^2}{r^2}$$

If same power is tolerated in both systems,

$$r^2 = 2r'^2$$

$$\frac{\text{Material for single-phase}}{\text{Material for three-phase}} = \frac{2(\pi r^2 \ell)}{3(\pi r'^2 \ell)} = \frac{2r^2}{3r'^2}$$

$$= \frac{2}{3}(2) = 1.333$$

Conclusion

- Single phase systems use 33% more material than a 3-phase system to deliver the same power
- So, considerably less material is required to deliver power with a three-phase system than is required for a single phase system

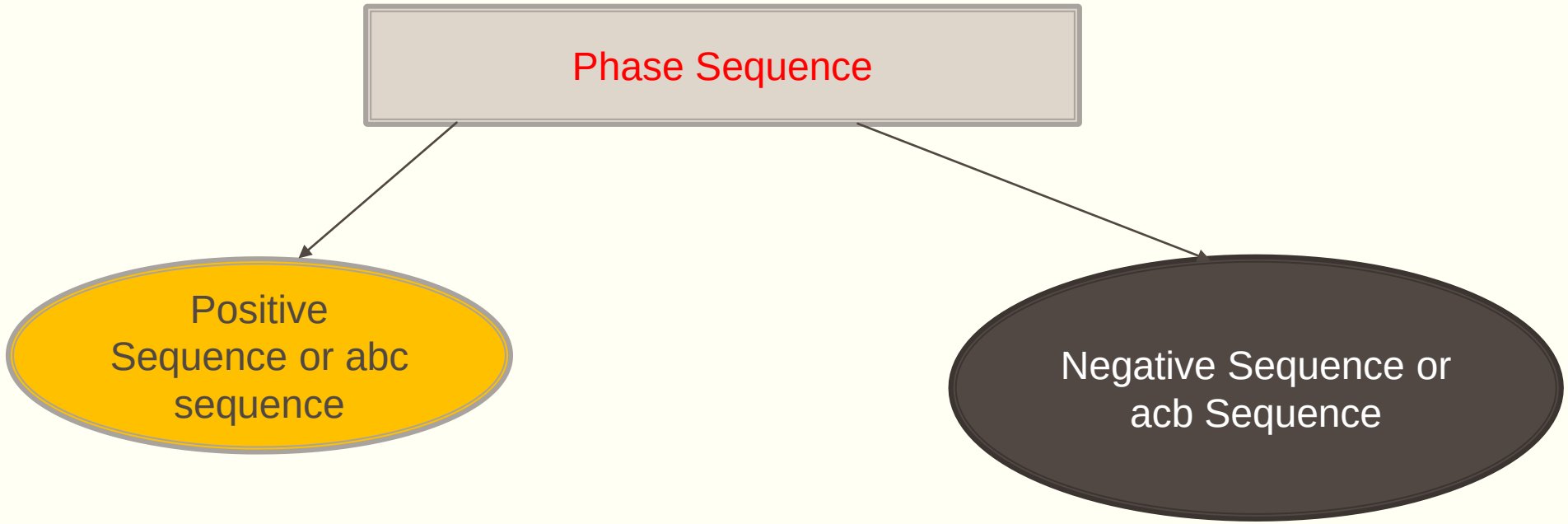
Advantages of Three Phase System

- First, nearly all electric power is generated and distributed in three-phase, at the operating frequency of 60 Hz (or ω = 377 rad/s) in the United States or 50 Hz (or ω = 314 rad/s) in some other parts of the world.
- When one phase or two-phase inputs are required, they are taken from the three phase system rather than generated independently.
- The instantaneous power in a three-phase system can be constant (not pulsating). This results in uniform power transmission and less vibration of three-phase machines.
- for the same amount of power, the three-phase system is more economical than the single-phase. Amount of wire required for a three-phase system is less than that required for an equivalent single-phase system.

Assignment 1

Compare the advantages and disadvantages of three phase and polyphase systems

Phase Sequence Calculation



Mathematical Expression for Positive Sequecnce

$$V_{an} = V_p \angle 0^\circ$$

$$V_{bn} = V_p \angle -120^\circ$$

$$V_{cn} = V_p \angle -240^\circ = V_p \angle +120^\circ$$

where Vp is the effective or rms value

Mathematical Expression for Negative Sequence

$$V_{an} = V_p \angle 0^\circ$$

$$V_{cn} = V_p \angle -120^\circ$$

$$V_{bn} = V_p \angle -240^\circ = V_p \angle +120^\circ$$

where Vp is the effective or rms value

Procedure for determining Phase Sequence

Step 1

We have to draw the vector diagram at first

Step 2

First we have to take Van as reference then rotate in clockwise direction to find the phase sequence

MATHEMATICAL PROBLEM

Problem 1

Given that $\mathbf{V}_{bn} = 110\angle 30°$, find $\mathbf{V}_{an}$ and $\mathbf{V}_{cn}$, assuming a positive (abc) sequence.

Answer: $110\angle 150°$, $110\angle -90°$.

What is the phase sequence of a balanced three-phase circuit for which $\mathbf{V}_{an} = 160\angle 30°$ V and $\mathbf{V}_{cn} = 160\angle -90°$ V? Find $\mathbf{V}_{bn}$.

Determine the phase sequence of the set of voltages

$$v_{an} = 200\cos(\omega t + 10°)$$

$$v_{bn} = 200\cos(\omega t - 230°), \qquad v_{cn} = 200\cos(\omega t - 110°)$$

Problem_2

Determine the phase sequence of a balanced three-phase circuit in which $\mathbf{V}_{bn} = 208\angle 130^\circ$ V and $\mathbf{V}_{cn} = 208\angle 10^\circ$ V. Obtain $\mathbf{V}_{an}$.

QUESTION SESSION_2

Only for Two Students

MCQ questions

What is the phase sequence of a three-phase motor for which $\mathbf{V}_{AN} = 220\angle -100^\circ$ V and $\mathbf{V}_{BN} = 220\angle 140^\circ$ V?

(a) *abc* (b) *acb*

If in an *acb* phase sequence, $\mathbf{V}_{an} = 100\angle -20^\circ$, then $\mathbf{V}_{cn}$ is:

(a) $100\angle -140^\circ$ (b) $100\angle 100^\circ$

(c) $100\angle -50^\circ$ (d) $100\angle 10^\circ$

READY FOR GROUP STUDY

If it is possible, please turn on your camera