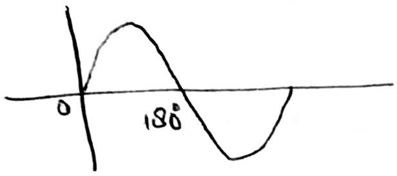
Chapter #12

Three Phase Circuits :-

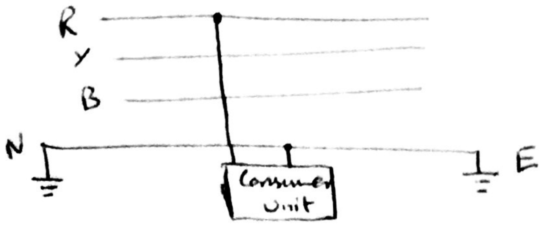
→ The Power Supply System
- → Single Phase (used where less Power is required) e.g houses, small loads
- → Three Phase (use in industries, factories where power requirement is more.

Single Phase (Split Phase)

* Power supply is through one conductor

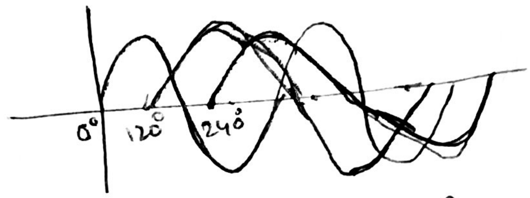


* Two wires for completing the circuit
* Voltage they carry is 230V
* Min. power transfer capability.
* Simple circuit/network
* Power failure may occure
* Lower efficiency
* Less economical
* used in houses, for small loads

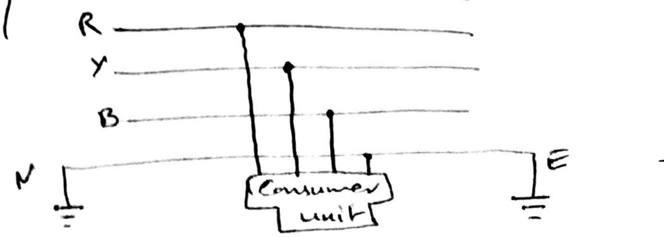


Three Phase.

* The power supply is through three conductors.

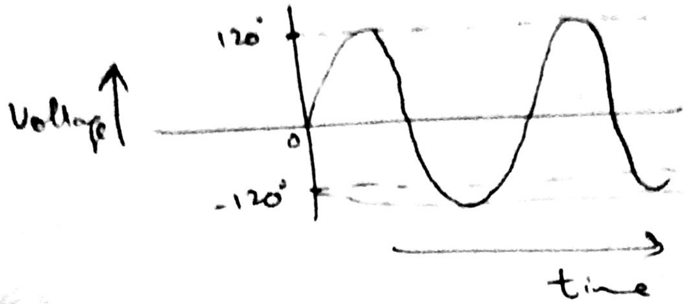


* Requires four wires for completing the circuit.
* Voltage carry is 415V
* Max. power transfer capability
* Complicated circuit/network
* No chance of power failure
* highly efficient.
* more economical.
* in industry, factories and for heavy loads.



* Single Phase:

- requires two wires for completing circuit i.e the conductor and neutral
- The conductor : carries current
  neutral : return path of current.
- supply voltage : 230V
- used for small loads (appliances)



Single Phase supply

* Three Phase:

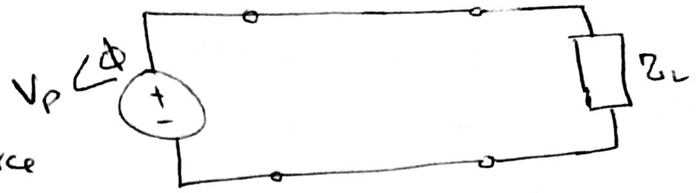
- Consist of 4 wires : 3 conductors and 1 neutral.
- conductors are out of phase and space apart 120°
- is continuous supply and never drop to zero.
- Can be drawn to Star or Delta configuration.
  - Star is used for long distance transmission.

" The star connection of the three-phase allows the use of two different voltages (i.e 230 volts and 415 volts). The 230V is supplied by using the one phase and one neutral wire, and the three phase is supply b/w any two phases "

→ Single Phase Systems:

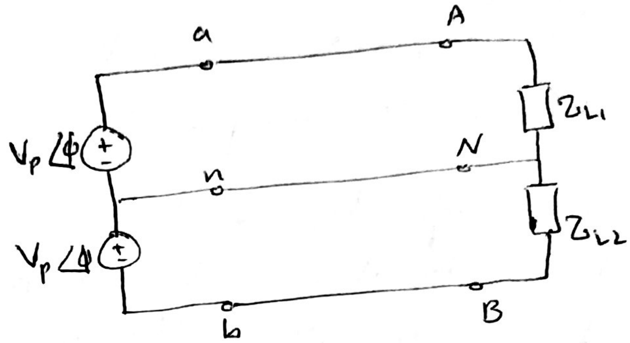
→ Two wire type

- V_p is rms magnitude of source



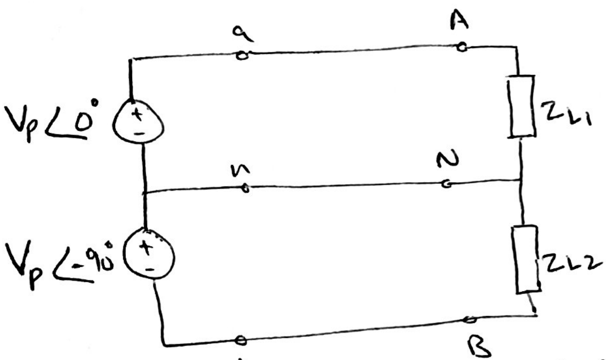
→ Three wire type.

- two indentical sources connected to two loads by two outer wires and a neutral.



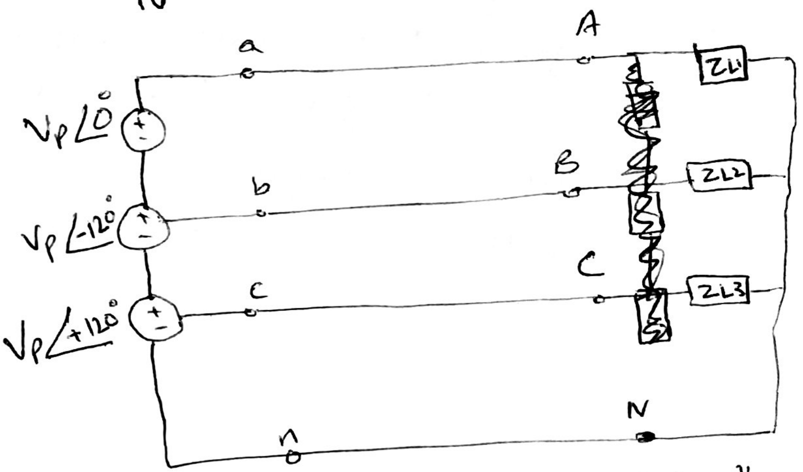
→ Poly Phase System:

* "Circuits or systems in which the ac sources operate at the same frequency but different phases are called *Polyphase Systems*".



"Two phase Three wire System"

- A two phase system is produced by a generator consisting of two coils placed perpendicular to each other so that the voltage generated by one lags the other by 90°.



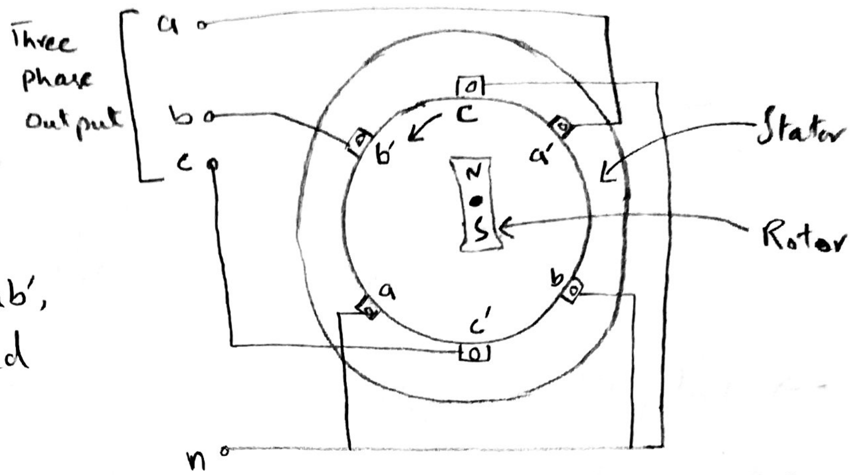
"Three-phase four Wire System"

- A three phase system is produced by a generator consisting of three sources having the same amplitude and frequency but out of phase with each other by 120°.

⟹ Balanced Three Phase Voltages :-

* Three phase voltages are often produced with a three-phase ac generator.

* Generator:
  - Rotor: rotating magnet
  - Stator: stationary winding.



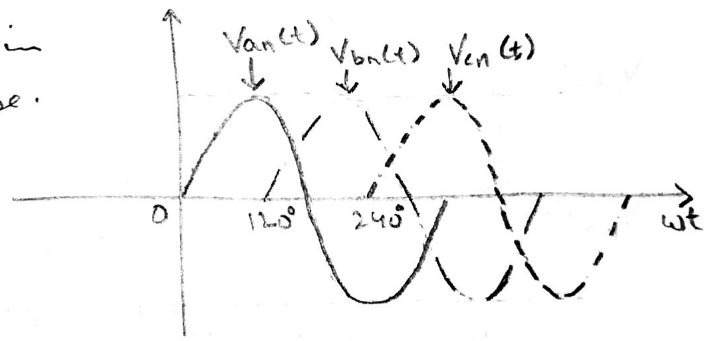
"A Three Phase Generator"

* Three separate winding or coils with terminals aa', bb', and cc' are physically placed 120° around the stator.

* As the rotor rotates, it's magnetic field "cuts" the flux from the three coils and induces voltages in the coils.

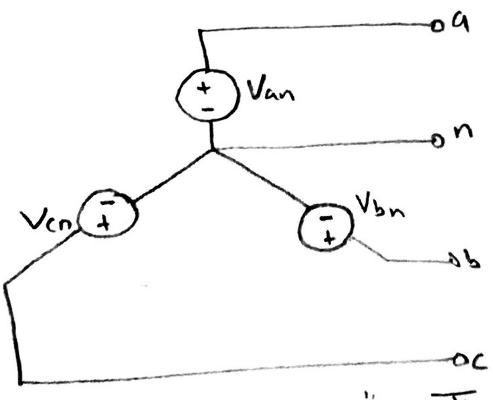
$$V_{induce} = -N\frac{d\phi}{dt}$$

* induce voltages are equal in magnitude but 120° out of phase.

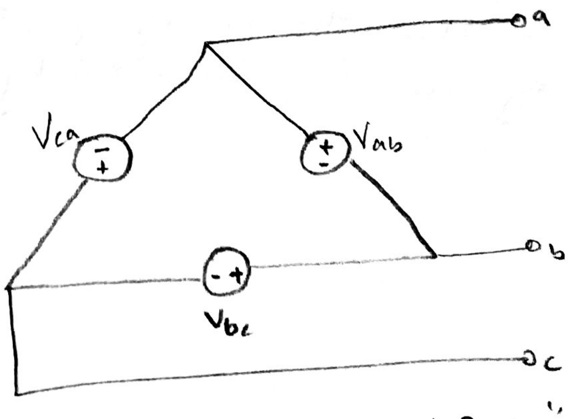


"Generated voltages are 120° apart from each other"

→ Three phase voltage sources can be either WYE-connected or DELTA-connected.



"Y-connected Sources"



"Δ-connected Sources"

Three Phase

* Y-connected voltages:

→ The voltages V_{an}, V_{bn} and V_{cn} are respectively b/w a, b, and c and neutral line 'n'.

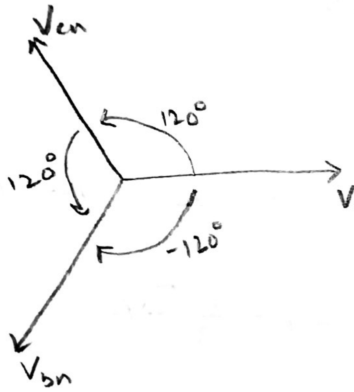
→ V_{an}, V_{bn}, V_{cn} : called phase voltages.

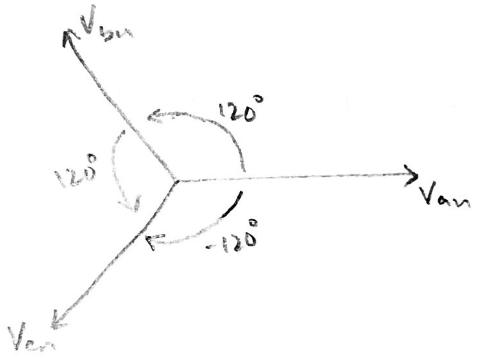
→ Balanced Voltages: if the voltage sources have the same magnitude (amplitude) and frequency 'ω' and are 120° out of phase with eachother, the voltages are said to be 'Balanced'.

This implies that:

$$V_{an} + V_{bn} + V_{cn} = 0$$

$$|V_{an}| = |V_{bn}| = |V_{cn}|$$





Phase Sequences
abc - positive sequence

$V_{an} = V_p \angle 0°$

$V_{bn} = V_p \angle -120°$

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

- V_p : is effective rms value of Phase voltage
- V_{an} leads V_{bn} which leads V_{cn}
- Rotor rotates counter clockwise

Phase Sequence
acb - negative sequence

$V_{an} = V_p \angle 0°$

$V_{cn} = V_p \angle -120°$

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

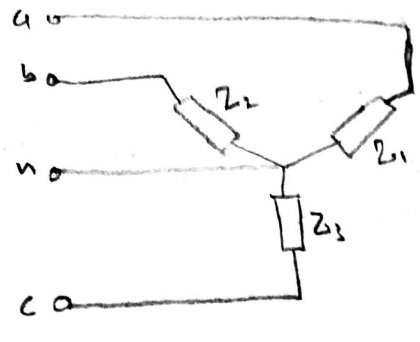
- V_{an} leads V_{cn} which leads V_{bn}
- Rotor rotates in clock wise direction.

$$V_{an} + V_{bn} + V_{cn} = V_p \angle 0° + V_p \angle -120° + V_p \angle +120°$$
$$= V_p (1.0 + 0.5 - j0.866 - 0.5 + j0.866)$$
$$= 0$$

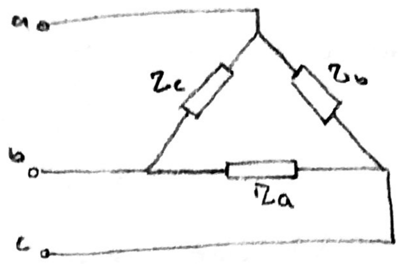
→ Three - Phase Load:-

* Three phase load [Y-connected / Δ-connected]

* Balanced load: "is on in which the phase impedances are equal in magnitude and phase"



"Y-conected load"



"Δ-connected load"

* For balanced Δ connected load,

$$Z_a = Z_b = Z_c = Z_\Delta$$

* For balanced Y-connected load,

$$Z_1 = Z_2 = Z_3 = Z_Y$$

* From our previous study in Δ→Y and Y→Δ conversion, we can write:

$$Z_\Delta = 3 Z_Y \quad \text{or} \quad Z_Y = \frac{1}{3} Z_\Delta$$

* Since both source and load have either Δ or Y connected we can have four possible cases.
  - → Y-Y connection (Y-connected source & Y connected load).
  - → Y-Δ " (" " " " Δ ")
  - → Δ-Δ " (Δ " " " " " ")
  - → Δ-Y " (Δ " " " Y ")

* Y connected sources are more common.

* Balanced Δ connected load is more common.

Exp 12.1 Determine phase sequence of the set of voltages:

$v_{an} = 200 \cos(\omega t + 10^\circ)$, $v_{bn} = 200 \cos(\omega t - 230^\circ)$

$v_{cn} = 200 \cos(\omega t - 110^\circ)$

Soln: voltages can be expressed in their respective phasor forms as:

$V_{an} = 200\angle 10^\circ$ V, $V_{bn} = 200 \angle -230^\circ$ V, $V_{cn} = 200 \angle -110^\circ$ V

We can see that V_{an} leads V_{cn} by 120° and V_{cn} in turns leads V_{bn} by 120°. So we have an acb sequence.