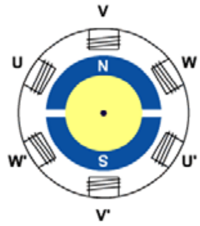
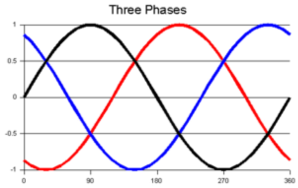


CH11: Balanced Three-Phase Circuits

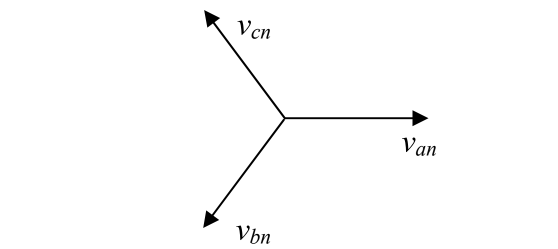
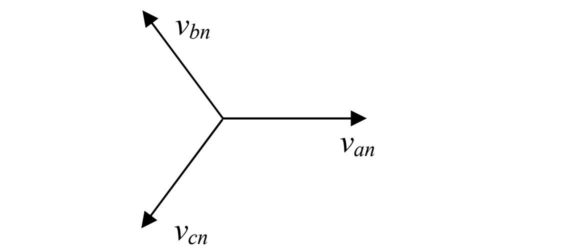
<u>-Summary- ver 2.1</u>

<u>Dr. Ali Muqaibel</u>

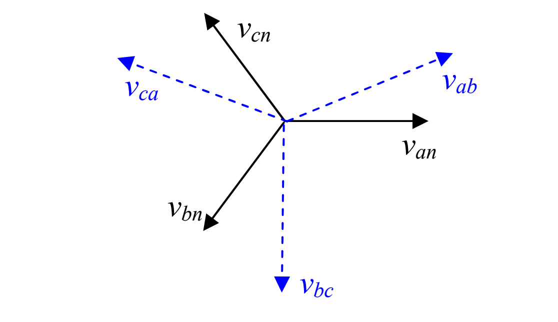
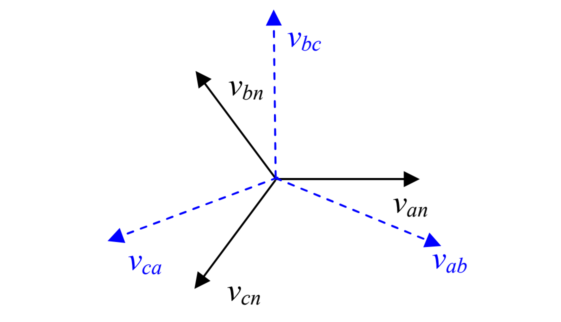
- 3Ø circuits are important in power generation, transmission & distribution



- Balanced three – phase voltages or currents must be
  →sinusoidal with same f
  →same amplitude
  →out of phase by 120^o

	
positive sequence (abc)	negative sequence (acb)

- circuits can operate (connected) in parallel only if they have the same sequence.
- Δ connection ==► $V_L = V_Ø$
- Y connection ==► $I_L=I_Ø$
- In balanced 3 Ø current in the neutral $I_Ø=I_{aA}+I_{bB}+I_{cC}=0$
- Transform any Δ→Y (if need be) $Z_Y=Z_Δ/3$.
- For Y-Y:
  - $|V_L| = \sqrt{3}\,|V_Ø|$
  - V_L leads $V_Ø$ by 30^o for + sequence & lags by 30^o for – sequence.

	
positive sequence (abc)	negative sequence (acb)

- For Y-Δ
  - Start by Δ →Y transformation (when needed)
  - $|I_L| = \sqrt{3}\,|I_Ø|$
  - I_L lags $I_Ø$ by 30^o for + sequence and leads by 30^o for – sequence
- For a sinusoidal waveform

$$v_{rms} = \frac{|V_{amp}|}{\sqrt{2}}$$

- for balanced 3 Ø circuit
  - Average Power (watts)

    $P_{\varnothing} = P_A = P_B = P_c = V_{\varnothing} I_{\varnothing} \cos\Theta_{\varnothing}$, $\boldsymbol{P_T = 3P_{\varnothing}}$

    $P_T = \sqrt{3}\, V_L I_L \cos\Theta_{\varnothing}$ ....for Y or Δ
  - Reactive Power (VARs)

    $Q_{\varnothing} = V_{\varnothing} I_{\varnothing} \sin\Theta_{\varnothing}$
  - Complex Power or apparent power (VA)

    $S_{\varnothing} = V_{\varnothing} I^*_{\varnothing} = P_{\varnothing} + jQ_{\varnothing}$

    $S_T = 3S_{\varnothing} = \sqrt{3} V_L I_L [\varnothing_{\varnothing}]$
- Instantaneous power

  $P_T = P_A + P_B + P_c = 1.5\, V_m I_m \cos\underline{\Theta_{\varnothing}} = 3V_{\varnothing} I_{\varnothing} \cos\Theta_{\varnothing}$
- Measuring Average Power with <u>Two</u> Wattmeters

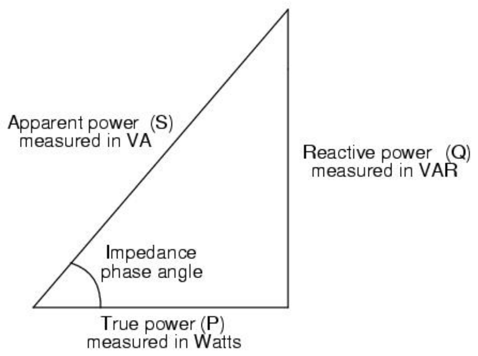
  $W_1 = V_L I_L \cos(\Theta_{\varnothing} + 30)$

  $W_2 = V_L I_L \cos(\Theta_{\varnothing} - 30)$

  $P_T = W_1 + W_2 = \sqrt{3} V_L I_L \cos\Theta_{\varnothing}$

  $Q_T = \sqrt{3}(W_2 - W_1) = \sqrt{3} V_L I_L \sin\Theta_{\varnothing}$
- Capacitor banks can be used to reduce losses and control the voltage level

The "Power Triangle"



<u>Note :</u>

- This summary is meant to give an overview and it does **<u>NOT</u>** replace the book
- It is a matter of practice not just knowing the formula.
- Some variables represent vectors and some represent scalar values.

If you have any comment or correction please send to muqaibel@kfupm.edu.sa

Prepared by
Dr. Ali Muqaibel