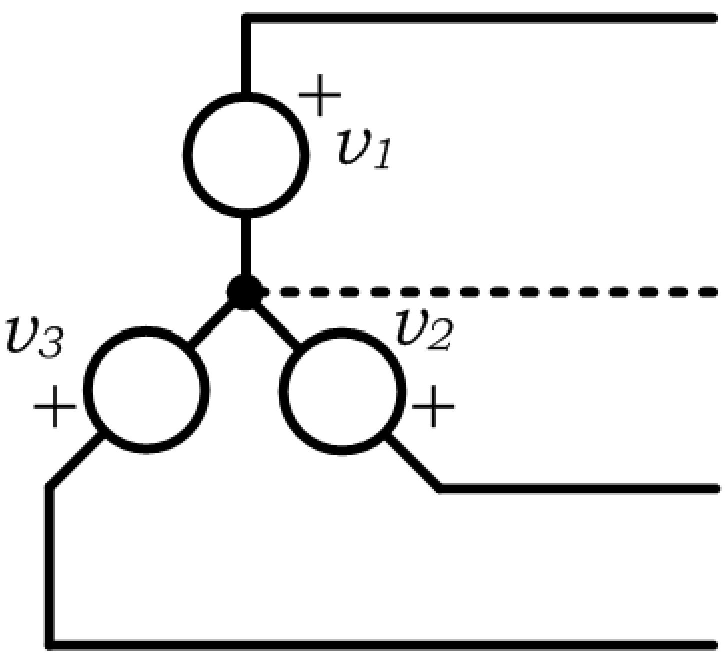
EE251
Lectures

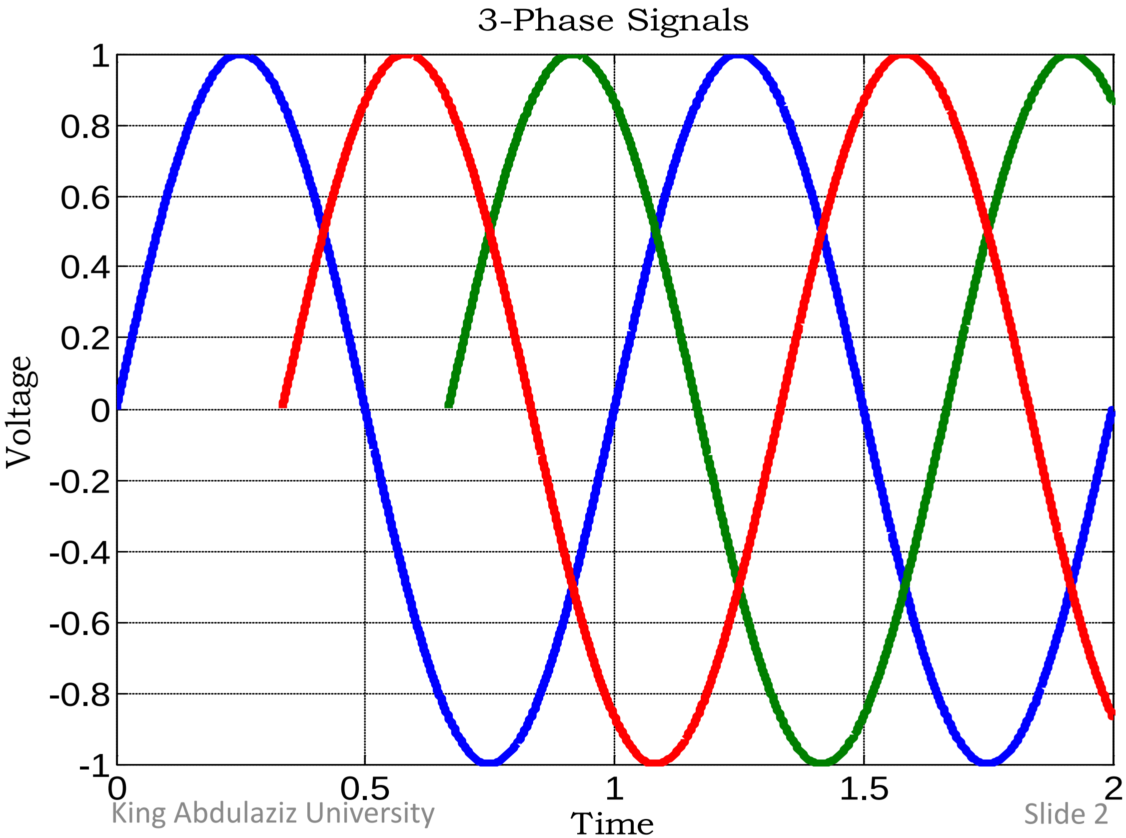
3-Phase Systems

Section 09

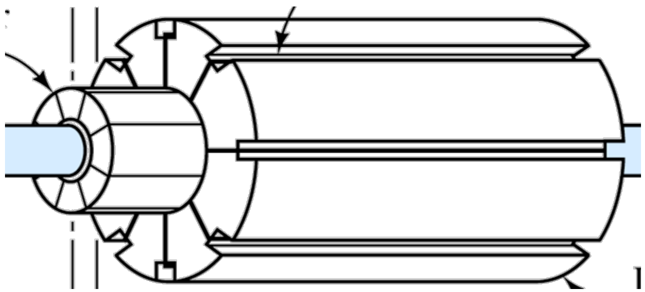
3-Phase Generators

- Method for transmitting alternating power
- Three conductors carrying three alternating currents with 360/3=120^{o} shift between them



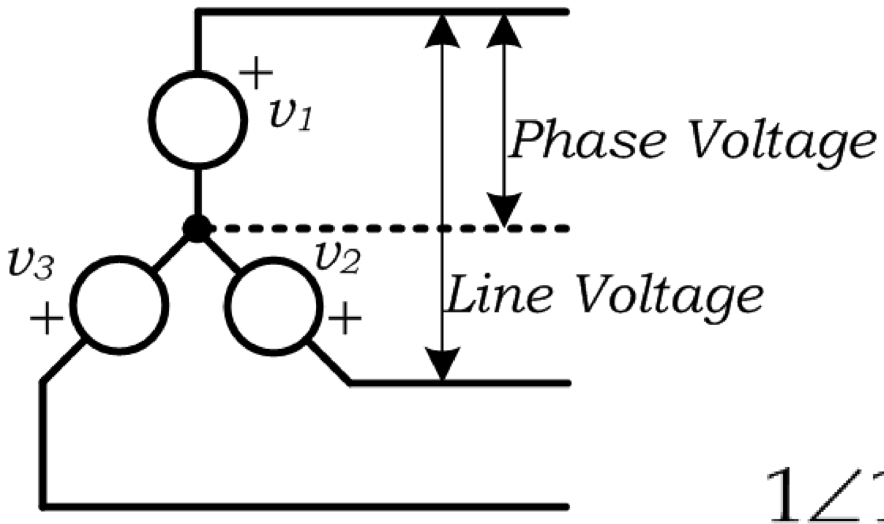


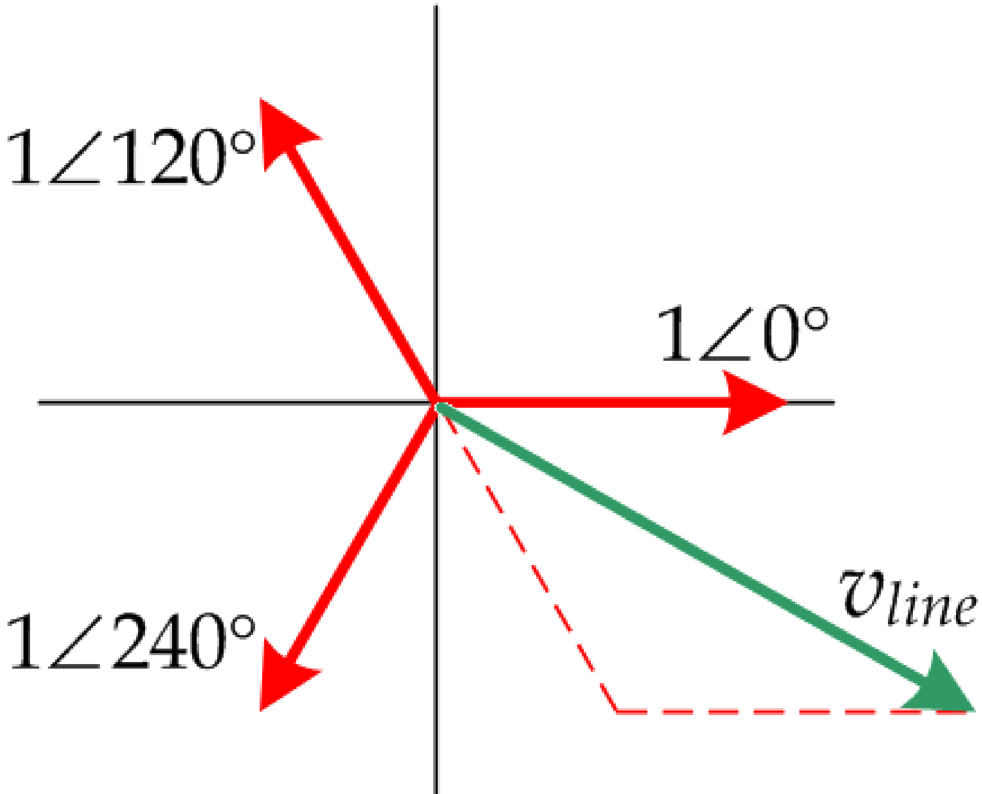
Why 3φ System?



- Single Phase Generation
  - push power
  - then stop
  - then drain power ➔ breaks down
- n-Phase Generation
  - constant power generation all the time
  - cost effective
- Usage
  - 1φ of each phase at homes
  - 3φ loads at industry

Vector Representation





Line Voltage

$$
\begin{aligned}
v_{12} &= v_1 - v_2 \\
&= 1\angle 0^\circ - 1\angle 120^\circ \\
&= 1 - \left(\cos 120 + j \sin 120\right) \\
&= \frac{3}{2} - j\frac{\sqrt{3}}{2}
\end{aligned}
$$

$$v_{12} = \sqrt{3}\angle -30^\circ$$

$$v_{23} = \sqrt{3}\angle +90^\circ$$

$$v_{31} = \sqrt{3}\angle -150^\circ$$

Examples

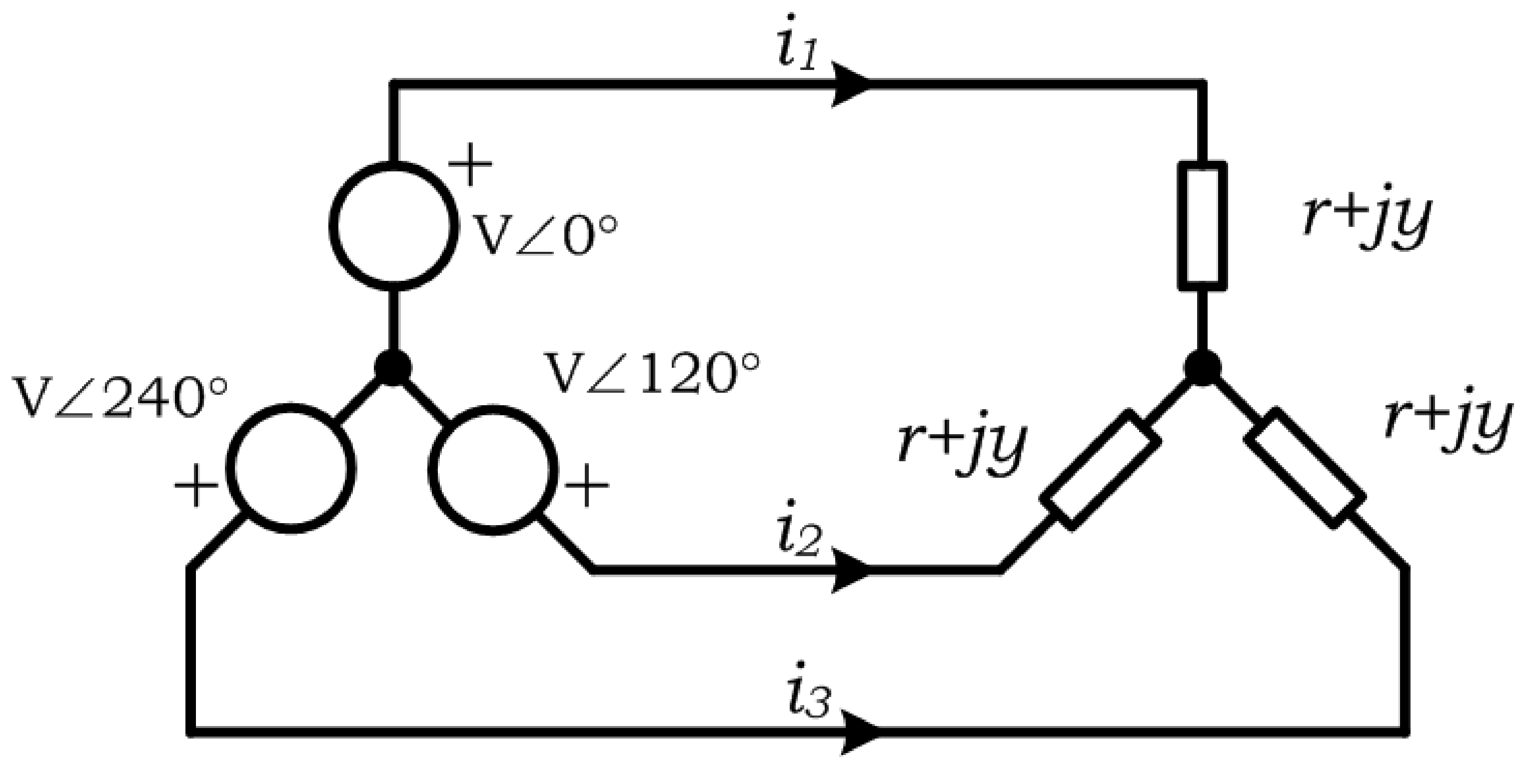
- If a phase voltage is $120\text{V}\sim$
  - Line Voltage = $120 \cdot \sqrt{3} = 208V \sim$
- If a line voltage is $220\text{V}\sim$
  - Phase Voltage = $220 / \sqrt{3} = 127V \sim$

More Advantages

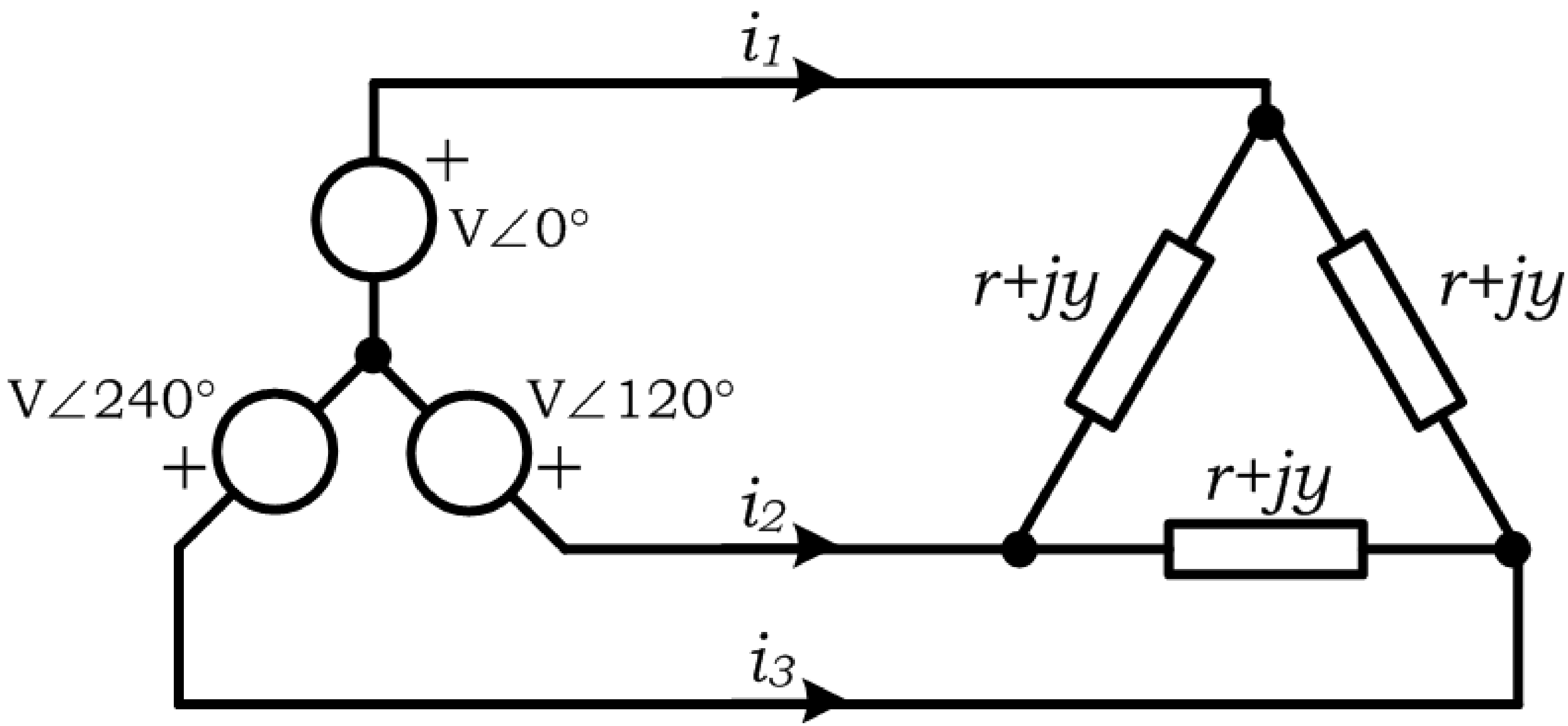
- Using Line Voltages
  - Higher voltage → Less Currents
  - Two different voltage ratings

- Single Phase
  - 6 wires instead of 4 (sometimes 3)
  - More line losses

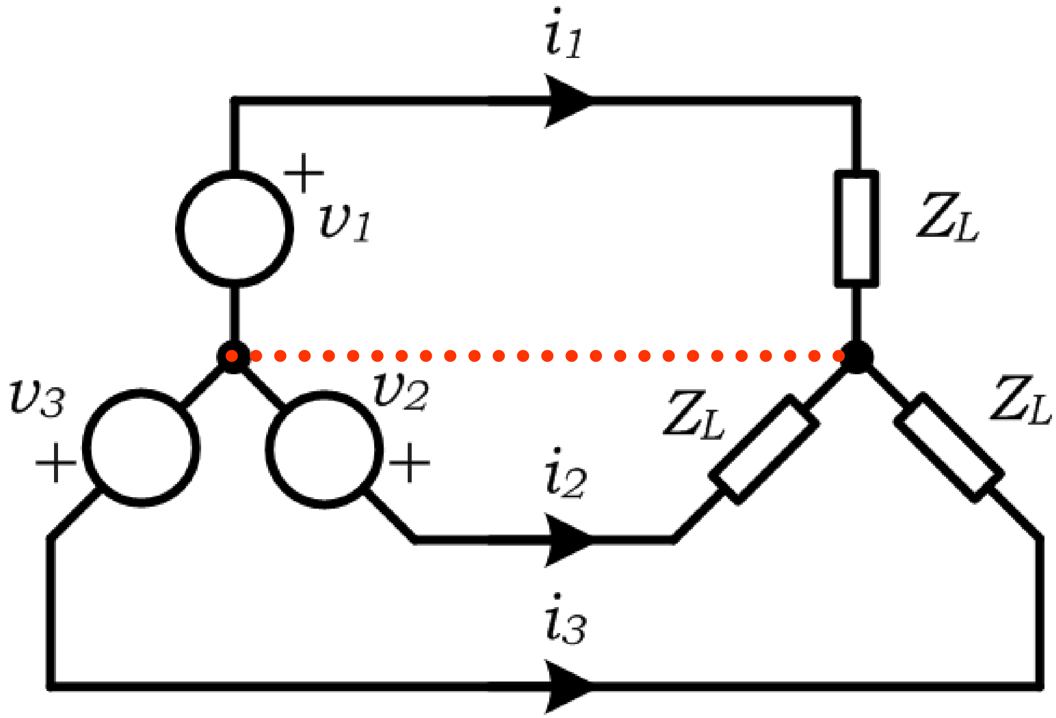
Star-Start Connection



Star-Delta Connection



Balanced Load



$$i_1 = I\angle 0°, i_2 = I\angle 120°, i_3 = I\angle 240°$$

$$I_n = 0$$

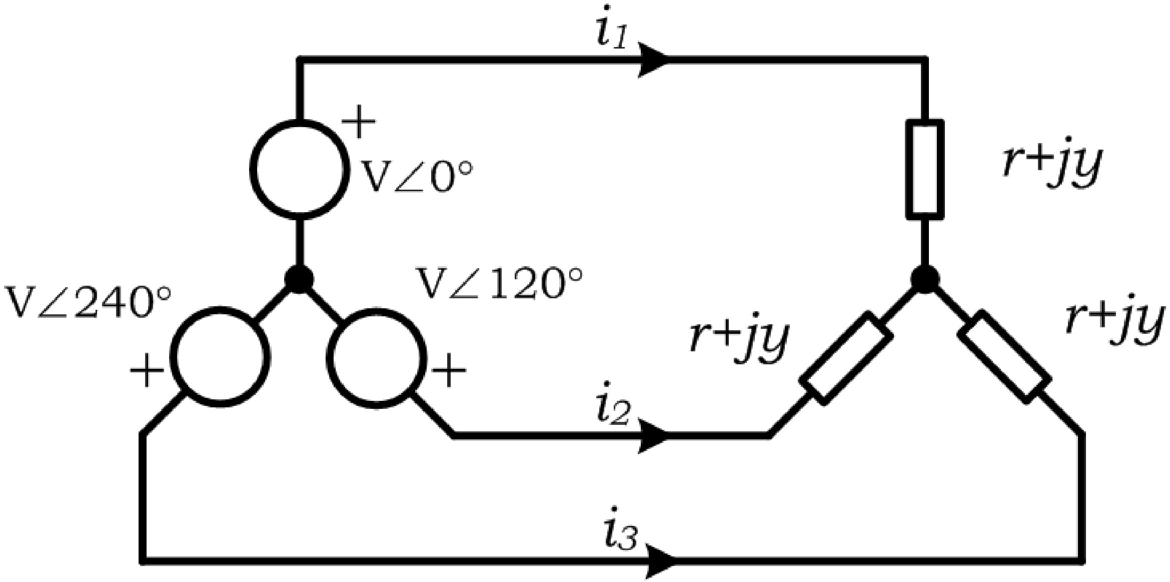
Power Factor (PF)

- Best Network when Q=0

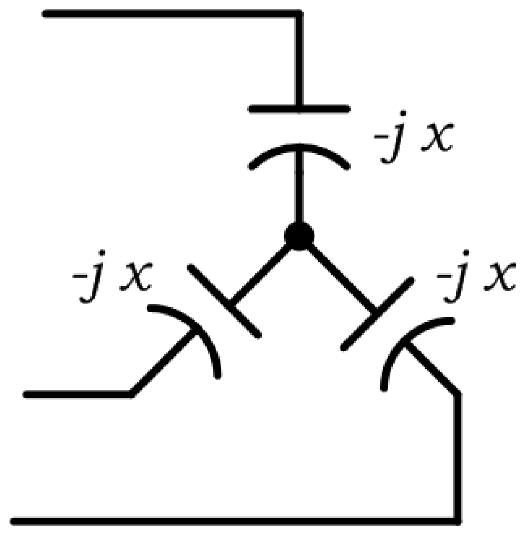
- Let the angle between Voltage and Current be θ

$$PF = \cos\theta = \begin{cases} 1 & \theta = 0^\circ \\ 0 & \theta = 90^\circ \end{cases}$$

Power Factor Correction (Y)

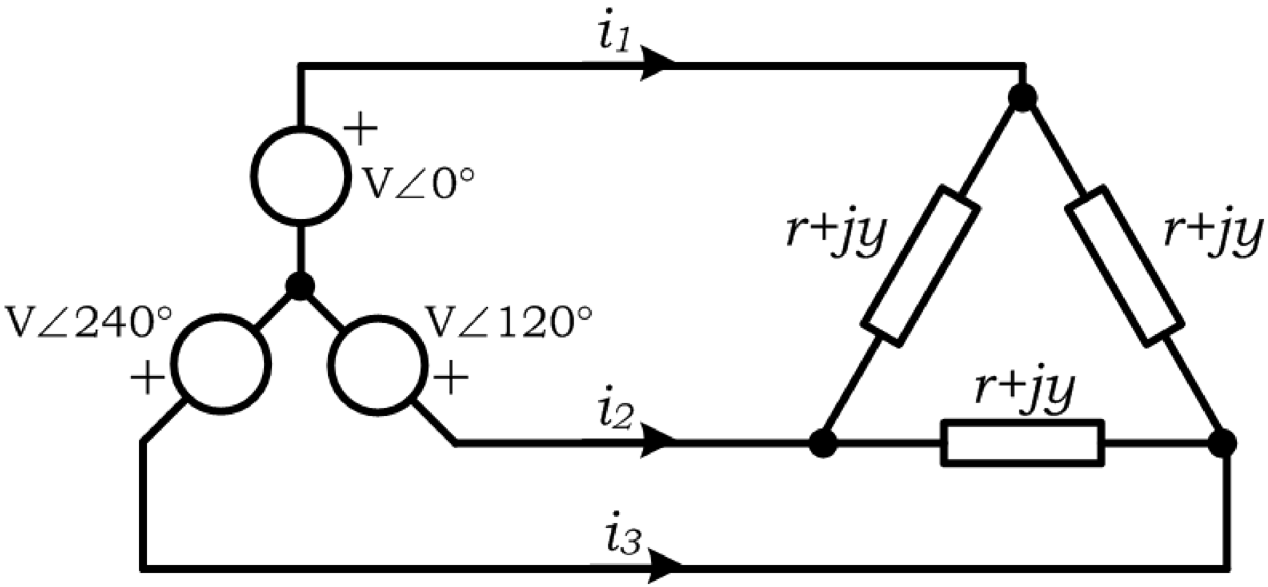


$$PF = \frac{r}{\sqrt{r^2 + y^2}}$$

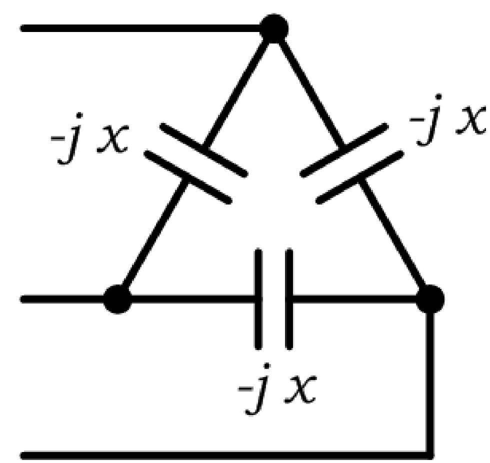


$$x = \frac{r^2 + y^2}{y} \rightarrow Z_{eq} = r + \frac{y^2}{r}$$

Power Factor Correction (Δ)

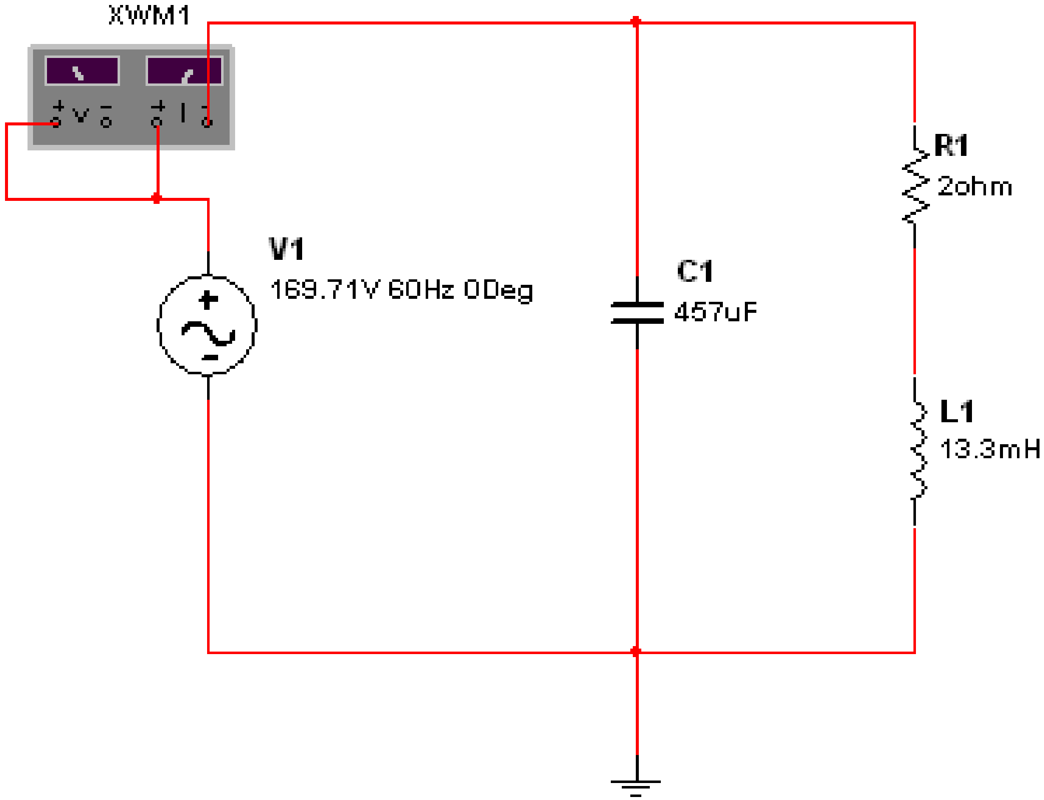


$$PF = \frac{r}{\sqrt{r^2 + y^2}}$$

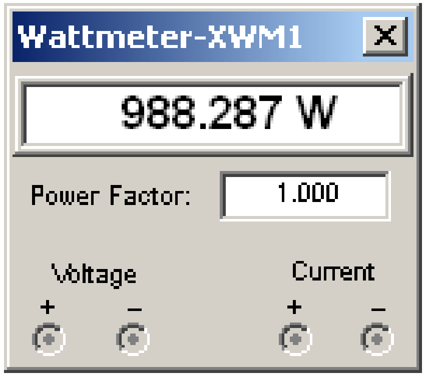


$$x = \frac{r^2 + y^2}{y} \rightarrow Z_{eq} = r + \frac{y^2}{r}$$

Example



XWM1
V1
169.71V 60Hz 0Deg
C1
457uF
R1
2ohm
L1
13.3mH



Wattmeter-XWM1
988.287 W
Power Factor:
1.000
Voltage
Current