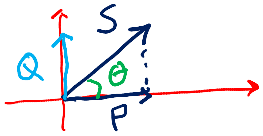
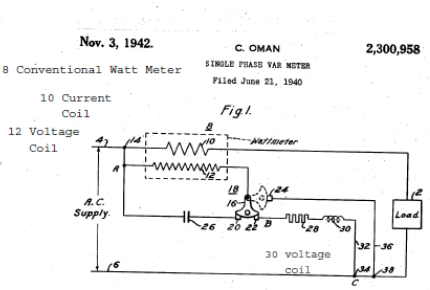
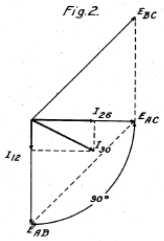
Lab 3 – Real Power & Reactive Power

- Real Power (P) [Watt] [W] $|V||I|\cos\theta$
- Reactive Power (Q) [Var] $|V||I|\sin\theta$
- Complex Power (S) = P + jQ
- Apparent Power (|S|) = SQRT (P^2 + Q^2)







3-phase power: P and Q

$V_{AB} = V_L$ ("Line-to-Line" Voltage)

$$P_{3\phi} = 3 V_p I_p \cos\theta_p$$

V_L: Line-to-Line Voltage magnitude on 1φ equiv

$V_p = \frac{V_L}{\sqrt{3}}$ and $I_p = I_L$ (Y-Load case)

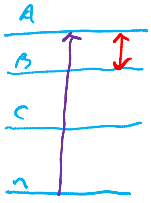
$I_L = I_p\sqrt{3}$ current over a line

Δ Load case

$$P_{3\phi} = 3 V_p I_p \cos\theta_p$$

$$= 3 \frac{V_L}{\sqrt{3}} I_L \cos\theta_p = \sqrt{3}\, V_L I_L \cos\theta_p$$

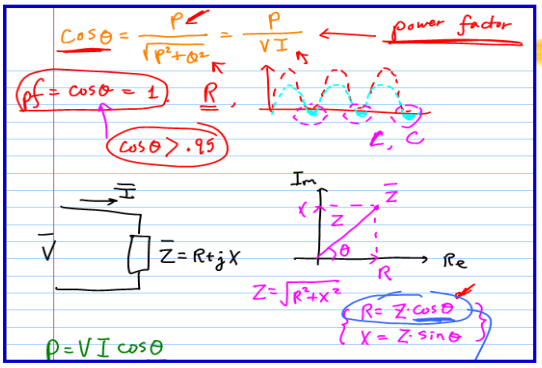
$$Q_{3\phi} = 3 V_p I_p \sin\theta_p = \sqrt{3}\, V_L I_L \sin\theta_p$$

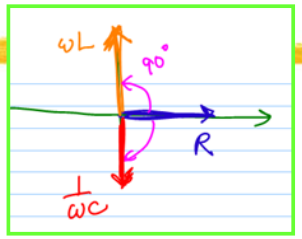


$V_{An} \rightarrow V_p$ "phase Voltage"

"line-to-neutral" Voltage

P and Q & R and X





$$Z = R + jX = R + j(X_L - X_C)$$

$$X_L = \omega L, \quad X_C = \frac{1}{\omega C}$$

$$\bar{V} = \bar{I}\bar{Z} \qquad \bar{I} = \frac{\bar{V}}{\bar{Z}} = \frac{V\angle 0^\circ}{Z\angle\theta} = \frac{V}{Z}\angle -\theta$$

$$P = VI\cos\theta = I^2 \cdot Z\cdot\cos\theta = I^2 \cdot R$$

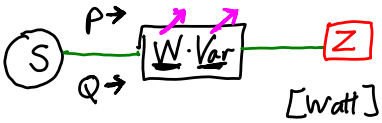
$$Q = VI\sin\theta = I^2 \cdot Z\cdot\sin\theta = I^2 \cdot X$$

$$\cos\theta = \frac{R}{Z} \leftarrow \text{power factor}$$

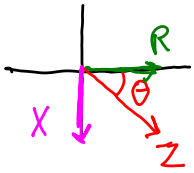
P and Q with Z

$P = VI\cos\theta$ $\quad Q = VI\sin\theta$ $\quad$ [Watt] [Var]

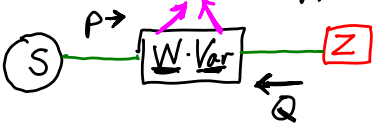
$R = 5 \quad X = 5 \quad \theta = 45^\circ \quad P > 0 \quad Q > 0$

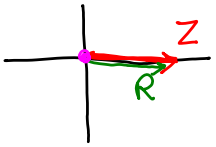


[Watt] [Var]

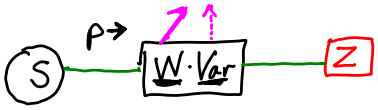


$R = 5 \quad X = -5 \quad \theta = -45^\circ \quad P > 0 \quad Q < 0$



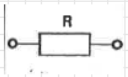


$R = 5 \quad X = 0 \quad \theta = 0 \quad P > 0 \quad Q = 0$



Example

LAB 3 -- EXAMPLE CALCULATION



$P_{3\phi} = 3 V_p I_p \cos\theta_p$

$= 3 \frac{V_L}{\sqrt{3}} I_L \cos\theta_p = \sqrt{3}\, V_L I_L \cos\theta_p$

$Q_{3\phi} = 3 V_p I_p \sin\theta_p = \sqrt{3}\, V_L I_L \sin\theta_p$

$VP := 120$

$VL := VP \cdot \sqrt{3} = 207.846097$

$R := 300$

$Z := R \qquad |Z| = 300$

$\theta := \arg(Z) = 0$

$IL := \frac{VP}{Z} = 0.4$ We measure this in the lab

$|IL| = 0.4$

$P := 3 \cdot |VP| \cdot |IL| \cdot \cos(\theta) = 144$

$P := \sqrt{3} \cdot |VL| \cdot |IL| \cdot \cos(\theta) = 144$ W

$Q := \sqrt{3} \cdot |VL| \cdot |IL| \cdot \sin(\theta) = 0$ Var

$\rightarrow P$

$Q = 0$

Example

$P_{3\phi} = 3 V_p I_p \cos\theta_p$

$= 3 \frac{V_L}{\sqrt{3}} I_L \cos\theta_p = \sqrt{3}\, V_L I_L \cos\theta_p$

$Q_{3\phi} = 3 V_p I_p \sin\theta_p = \sqrt{3}\, V_L I_L \sin\theta_p$

$VP := 120$

$VL := VP \cdot \sqrt{3} = 207.846097$

$R := 0 \qquad XL := 300$

$Z := R + i \cdot XL \qquad |Z| = 300$

$\theta := \arg(Z) = 1.570796$

$\theta deg := \theta \cdot \frac{180}{\pi} = 90$

$IL := \frac{VP}{Z} = -0.4 \cdot i$ We measure this in the lab

$|IL| = 0.4$

$P := \sqrt{3} \cdot |VL| \cdot |IL| \cdot \cos(\theta) = -5.027736 \cdot 10^{-13}$ W

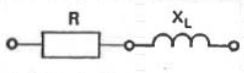
$Q := \sqrt{3} \cdot |VL| \cdot |IL| \cdot \sin(\theta) = 144$ Var

0

$P = 0$

$\rightarrow Q$

Example



$$P_{3\phi} = 3V_p I_p \cos\theta_p = 3\frac{V_L}{\sqrt{3}} I_L \cos\theta_p = \sqrt{3}\, V_L I_L \cos\theta_p$$

$$Q_{3\phi} = 3V_p I_p \sin\theta_p = \sqrt{3}\, V_L I_L \sin\theta_p$$

$VP := 120$

$VL := VP\cdot\sqrt{3} = 207.846097$

$R := 300$ $\quad XL := 300$

$Z := R + i\cdot XL$

$|Z| = 424.264069$

$\theta := \arg(Z) = 0.785398$ $\quad \theta deg := \theta\cdot\frac{180}{\pi} = 45$

$IL := \frac{VP}{Z} = 0.2 - 0.2\cdot i$ We measure this in the lab

$|IL| = 0.282843$

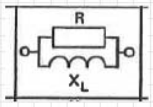
$P := \sqrt{3}\cdot|VL|\cdot|IL|\cdot\cos(\theta) = 72$ W

$Q := \sqrt{3}\cdot|VL|\cdot|IL|\cdot\sin(\theta) = 72$ Var

P →

Q →

Example



$$P_{3\phi} = 3V_p I_p \cos\theta_p = 3\frac{V_L}{\sqrt{3}} I_L \cos\theta_p = \sqrt{3}\, V_L I_L \cos\theta_p$$

$$Q_{3\phi} = 3V_p I_p \sin\theta_p = \sqrt{3}\, V_L I_L \sin\theta_p$$

$VP := 120$

$VL := VP\cdot\sqrt{3} = 207.846097$

$R := 300$ $\quad XL := 300$ $\quad X := i\cdot XL$

$Z := \frac{R\cdot X}{R + X} = 150 + 150\cdot i$ $\quad |Z| = 212.132034$

$\theta := \arg(Z) = 0.785398$ $\quad \theta deg := \theta\cdot\frac{180}{\pi} = 45$

$IL := \frac{VP}{Z} = 0.4 - 0.4\cdot i$ We measure this in the lab

$|IL| = 0.565685$

$P := 3\cdot|VP|\cdot|IL|\cdot\cos(\theta) = 144$

$P := \sqrt{3}\cdot|VL|\cdot|IL|\cdot\cos(\theta) = 144$ W

$Q := \sqrt{3}\cdot|VL|\cdot|IL|\cdot\sin(\theta) = 144$ Var

P →

Q →