The Power Triangle

- Objectives
- Description
- Example with a single load (use your calculator)
  - Find P, S, Q
  - Draw the power triangle
- Multiple loads/branches
  - Approach
  - **In Class Problem**
    - (A) Find P_T (W), Q_T (VARS), S_T (VA)
    - (B) Draw the power triangle
    - (C) Determine Fp
    - (D) Find **Is**

The Power Triangle – Objectives

- Become familiar with the differences between average, apparent, and reactive power and how to calculate each for any combination of resistive and reactive elements.
- Become aware of how the real, apparent, and reactive power are related in an ac network and how to find the total value of each for any configuration.
- Understand the concept of power-factor correction and how to apply it to improve the terminal characteristics of a load.

The Power Triangle – Description

- The discussion of power in Chapter 14 included only the average or real power delivered to an ac network.
- We now examine the total power equation in a slightly different form and introduce two additional types of power: apparent and reactive.

AVERAGE POWER → $P = V_{RMS} I_{RMS} \cos(\theta)$, (W)

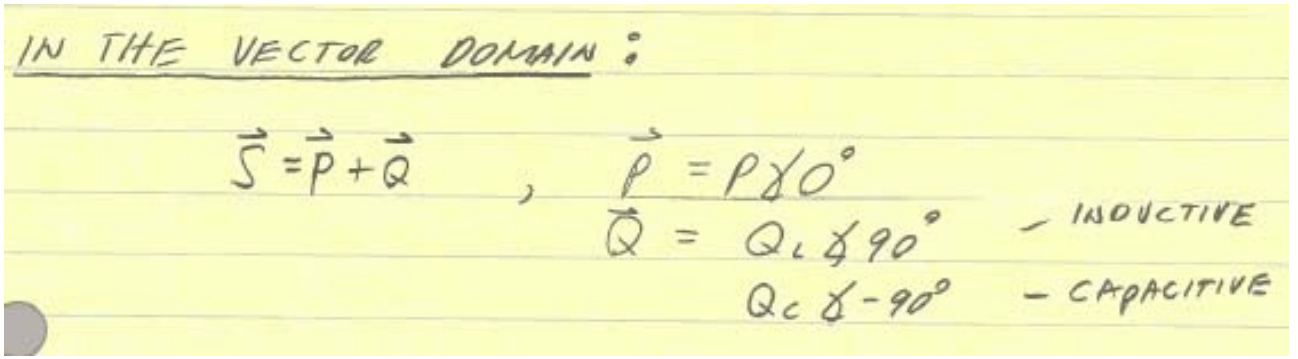
DISSIPATED POWER

APPARENT POWER → $S = V_{RMS} I_{RMS}$, (V·A)

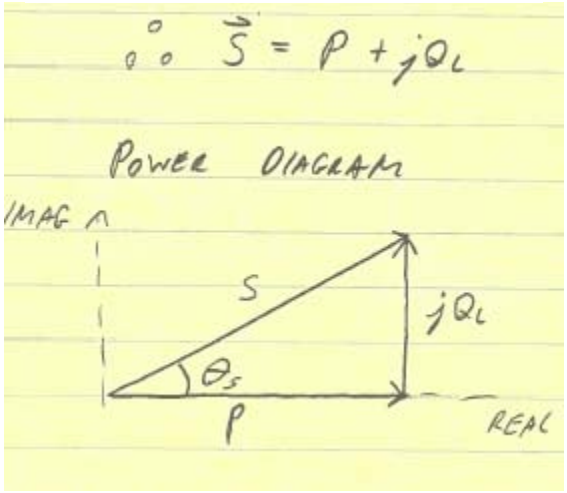
REACTIVE POWER → $Q = V_{RMS} I_{RMS} \sin(\theta)$, (VAR)

RECALL: $\theta = |\theta_V - \theta_I|$

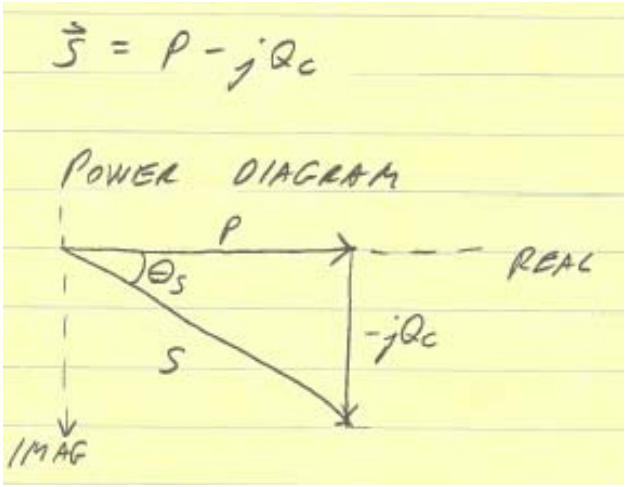
The Power Triangle – Description



For **inductive** circuits

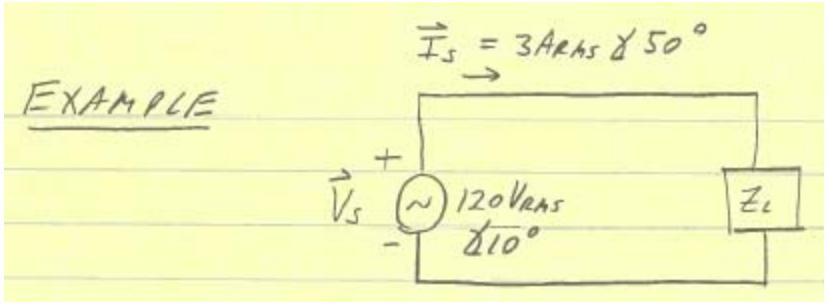


For **capacitive** circuits



The Power Triangle

The Power Triangle – Example (verify the numbers)



FIND: P, THE AVERAGE POWER DELIVERED
S, " APPARENT POWER
Q, " REACTIVE POWER
DRAW THE POWER TRIANGLE

$P = V_{RMS} I_{RMS} \cos(\theta)$

$= (120V)(3A)\cos(10° - 50°)$

$P = (120V)(3A)(0.766) = \boxed{275.8\,W}$

$S = V_{RMS} I_{RMS}$

$= (120V)(3A) = \boxed{360\,VA}$

$Q = V_{RMS} I_{RMS} \sin(\theta)$

$= (120V)(3A)\sin(10° - 50°)$

$Q = 231.4\,VAR$

Is this (C) or (L)? Why?

I leads **V** therefore, capacitive

$\boxed{231.4\,VAR\ (C)}$

The Power Triangle – Example (verify the numbers)

$P = (120V)(3A)(0.766) = \boxed{275.8\ W}$

$S = V_{RMS} I_{RMS} = (120V)(3A) = \boxed{360\ VA}$

$Q = 231.4\ VAR \Rightarrow \boxed{231.4\ VAR\ (C)}$

Finding **S**:

RECALL: $\vec{S} = \vec{P} + \vec{Q}$

$\vec{S} = 275.8\ W \angle 0^\circ + 231.4\ VAR \angle -90^\circ$

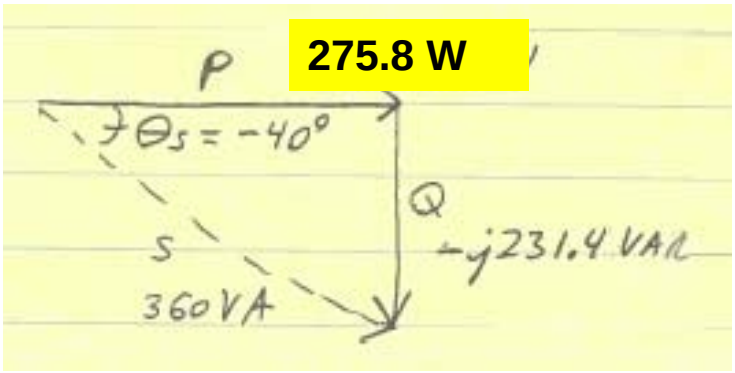
$\vec{P}$ $\quad$ $\vec{Q} = Q_c \angle -90^\circ$

$\boxed{360.02\ VA \angle -40^\circ \quad \text{OR} \quad 275.8 - j231.4}$

REAL (W) $\quad$ REACTIVE (VAR)

APPARENT (VA)

Drawing the Power Triangle



The Power Triangle – Approach for multiple loads/branches

1) FIND P, Q FOR EACH CIRCUIT BRANCH

2) $P_T = P_1 + P_2 + \ldots$

3) $Q_T = Q_{CT} - Q_{LT}$

OR

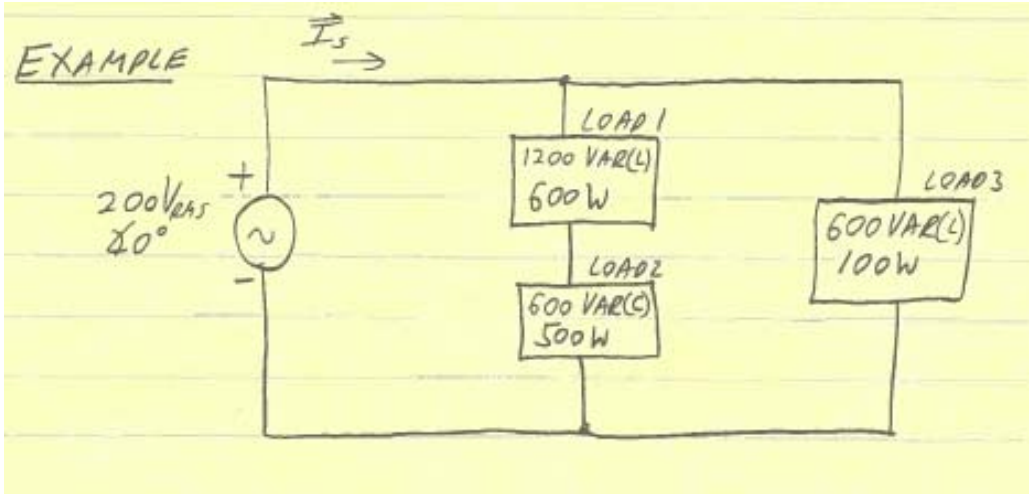
$Q_{LT} - Q_{CT}$

4) $S_T = \sqrt{P_T^2 + Q_T^2}$

OR ADD "$\vec{S}$" IN EACH BRANCH TO FIND $\vec{S}_T$ (VECTOR FORM)

5) $F_p = P_T / S_T$, OR $F_p = \cos(\theta_Z) = \cos(\theta_S)$

In Class Problem



(**A**) Find P_T (W), Q_T (VARS), S_T (VA)
(**B**) Draw the power triangle
(**C**) Determine Fp
(**D**) Find **Is**

Approach:

1) FIND P, Q FOR EACH CIRCUIT BRANCH

2) $P_T = P_1 + P_2 + \ldots$

3) $Q_T = Q_{CT} - Q_{LT}$ OR $Q_{LT} - Q_{CT}$

4) $S_T = \sqrt{P_T^2 + Q_T^2}$

OR ADD "$\vec{S}$" IN EACH BRANCH TO FIND $\vec{S}_T$ (VECTOR FORM)

5) $F_p = P_T / S_T$, OR $F_p = \cos(\theta_Z) = \cos(\theta_S)$