Basic Electrical Technology

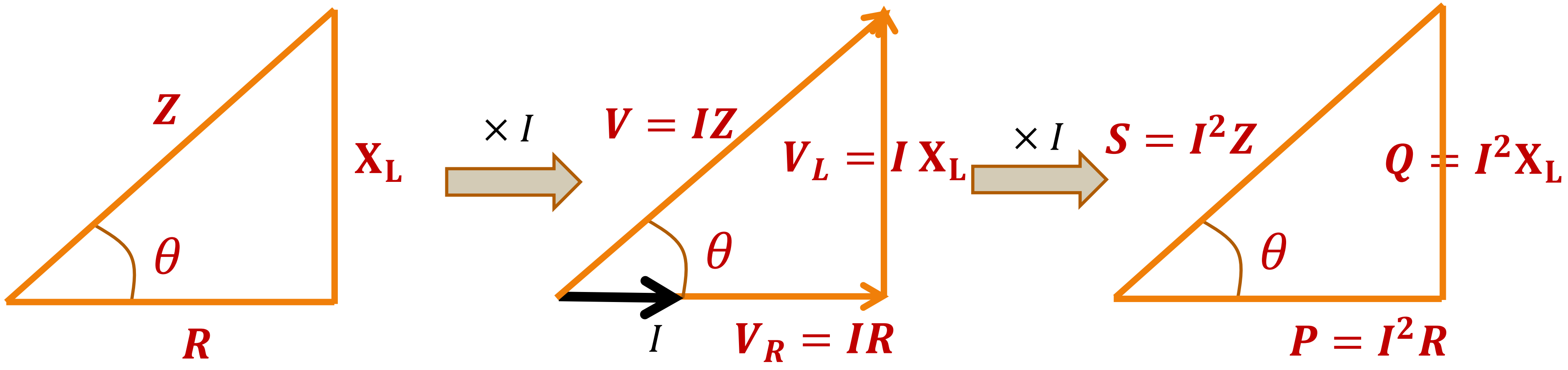
[ELE 1051]

CHAPTER 3 - SINGLE PHASE AC CIRCUITS

(3.5)

Power associated in RL load

For RL load:



Impedance diagram | Phasor diagram | Power diagram

$$S = P + jQ$$

where,
S = Apparent Power (VA)
P = Active Power (W)
Q = Reactive Power (var)

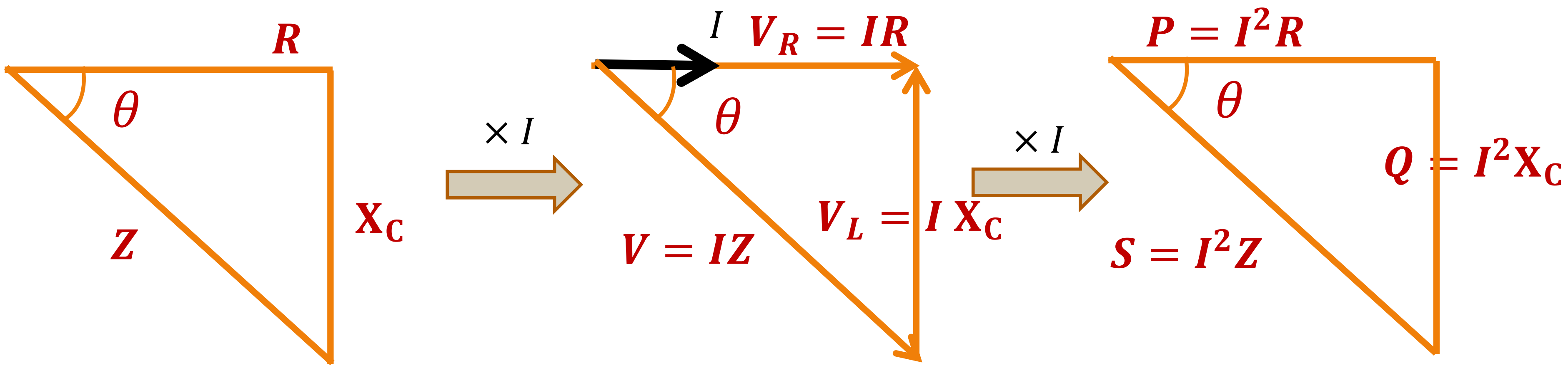
$$S = |V||I\,|$$

$$P = VI\cos\emptyset$$

$$Q = VI\sin\emptyset$$

Power associated in RC load

For RC load:



Impedance diagram

Phasor diagram

Power diagram

$$S = P - jQ$$

Where,
S = Apparent Power (VA)
P = Active Power (W)
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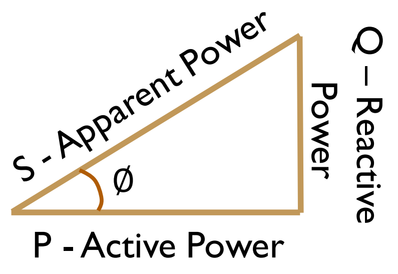
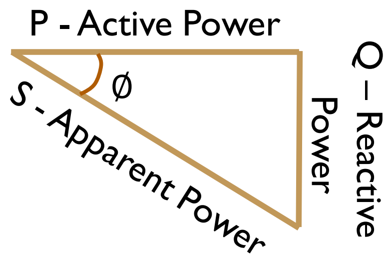
$$S = |V||I\,|$$
$$P = VI\cos\emptyset$$
$$Q = VI\sin\emptyset$$

Power in AC circuits

Power in AC circuit can be written as,

$$S = (\bar{V})(\bar{I}^*)$$

For RL Load	$Z = \lvert Z\rvert\angle\emptyset$ $if\ \bar{V} = \lvert V\rvert\angle 0°$ $\bar{I} = \lvert I\rvert\angle -\emptyset$ $I^* = \lvert I\rvert\angle\emptyset$	$S = VI(\cos\emptyset + j\sin\emptyset)$ $\boldsymbol{S = P + jQ}$ $P = V_{rms}I_{rms}\cos\emptyset$ $Q = V_{rms}I_{rms}\sin\emptyset$	
For RC Load	$Z = \lvert Z\rvert\angle -\emptyset$ $if\ \bar{V} = \lvert V\rvert\angle 0°$ $\bar{I} = \lvert I\rvert\angle\emptyset$ $I^* = \lvert I\rvert\angle -\emptyset$	$S = VI(\cos\emptyset - j\sin\emptyset)$ $\boldsymbol{S = P - jQ}$ $P = V_{rms}I_{rms}\cos\emptyset$ $Q = V_{rms}I_{rms}\sin\emptyset$	

$\underline{Units:}$ $Apparent\ Power(S)$ $\boldsymbol{VA}$ $Active\ Power(P)$ $\boldsymbol{W}$ $Reactive\ Power(Q)$ $\boldsymbol{var}$

Power Factor

$$\boldsymbol{Power\ Factor = \frac{Active\ Power\ P\ in\ watts}{Apparent\ Power\ S\ in\ voltamperes}}$$

$$\cos\theta = \frac{P}{S} = \frac{P}{VI}$$

- For an impedance Z,

$$\cos\theta = \frac{IR}{V} = \frac{IR}{IZ} = \frac{resistance}{impedance}$$

- Power factor is *lagging* when the *current lags the supply voltage*
- Power factor is *leading* when the *current leads the supply voltage*
- For a resistive load, power factor is Unity

Disadvantages of Low Power Factor

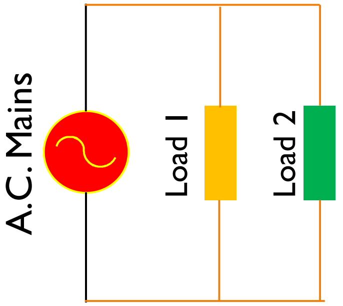
- Under utilisation of power system network
- Increased transmission losses
- Hence bulk consumers are advised to maintain the power factor close to unity by power utilities

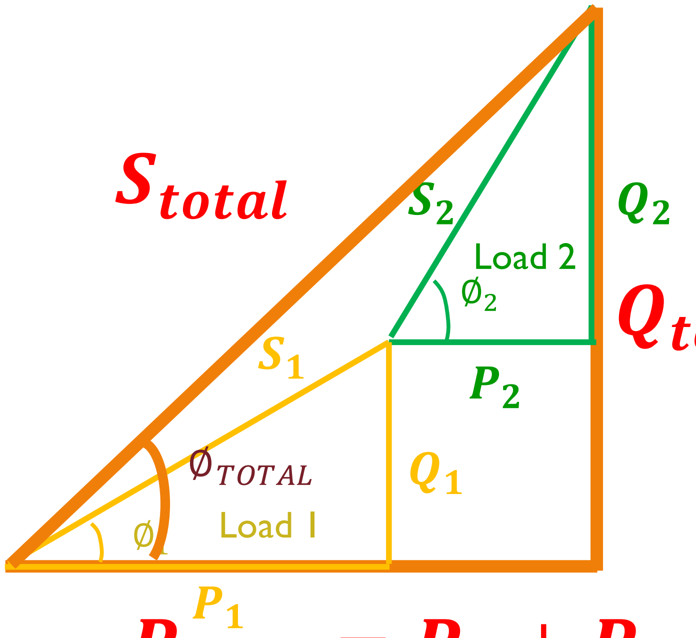
Remedial Measures

- Reactive power demand of Inductive loads can be compensated with capacitive loads
- It is possible to localise reactive power requirement by connecting parallel capacitors across the load

Power Triangle

- Practically, loads are in connected parallel
- Majority of the loads are inductive in nature





$$Q_{total} = Q_1 + Q_2$$

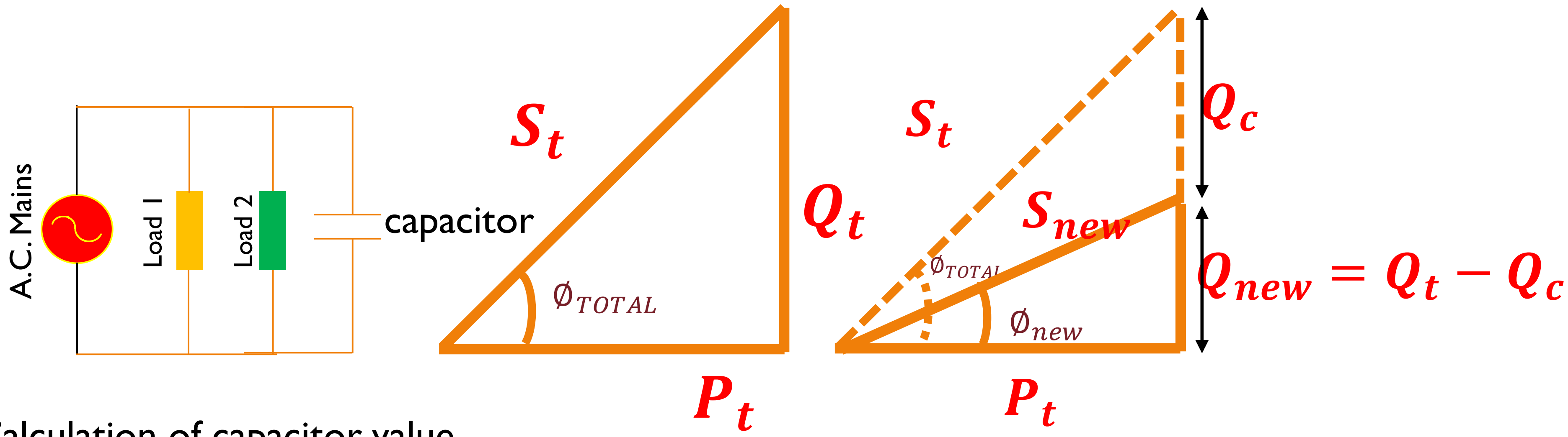
$$S_{total} = P_{total} + jQ_{total}$$

$$P_{total} = P_1 + P_2$$

http://www.kptcl.com/save.htm

Power Factor Improvement

- Connect capacitor parallel to the load
- Energy stored by the capacitor provides the required reactive power by the load



Calculation of capacitor value

- Calculate Q_c needed to improve power factor to $cos\emptyset_{new}$
- Calculate $X_c = \frac{V^2}{Q_C}$ & $C = \frac{1}{2\pi f X_c}$

Illustration 1

A single-phase motor takes 8.3 A at a power factor of 0.866 lagging when connected to a 230 V, 50 Hz supply. Capacitance bank is now connected in parallel with the motor to raise the power factor to unity. Determine the capacitance value

$$\boldsymbol{C = 57.43\mu F}$$

Illustration 2

A single-phase load of 5 kW operates at a power factor of 0.6 lagging. It is proposed to improve this power factor to 0.95 lagging by connecting a capacitor across the load. Calculate the kvar rating of the capacitor

$$Q_C = 5.023kVAR$$

Illustration 3

Obtain the complete power triangle for three parallel-connected loads:

(a) 250VA, 0.5 p.f lagging

(b) 180W ,0.8 p.f leading

(c) 300VA, 100 var (inductive)

Ans

P_{TOTAL}=587.8W

Q_{TOTAL}= 181.5var (inductive)

S_{TOTAL} = 615.2VA

0:955 lagging

Thank You!