ELEMENTS OF ELECTRICAL ENGINEERING

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POWER FACTOR IMPROVEMENT

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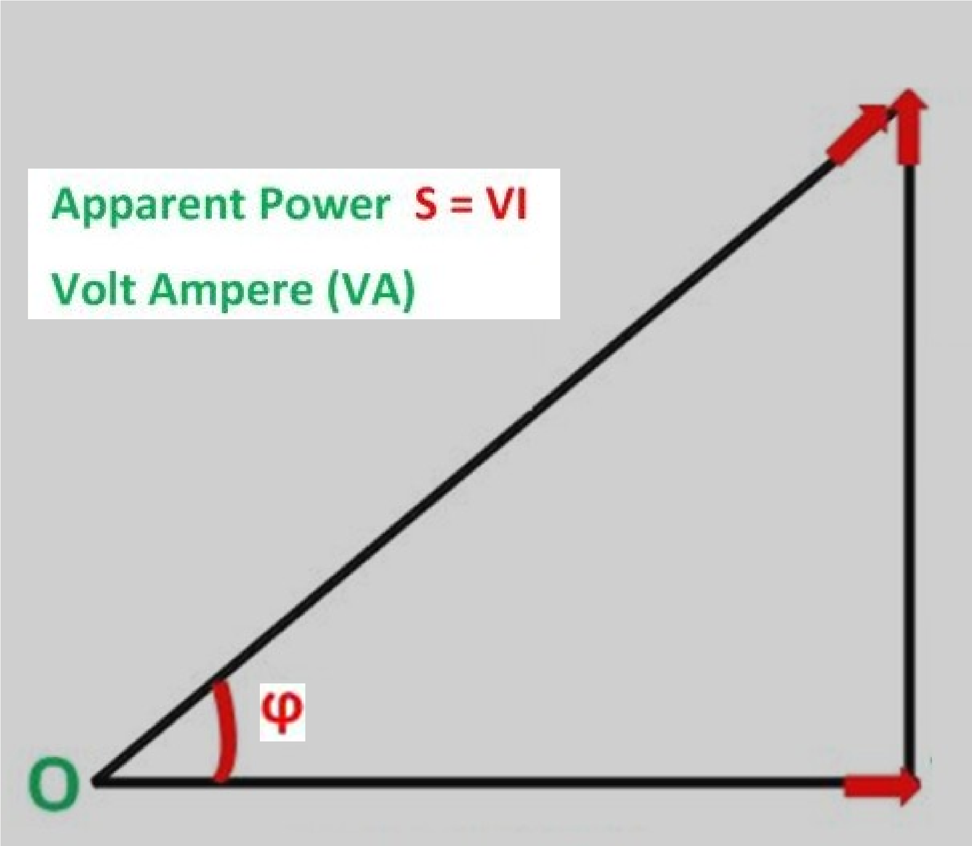
Power Factor



Reactive Power $Q = VI\sin\varphi$

Volt Ampere Reactive (VAR)

True Power $P = VI\cos\varphi$

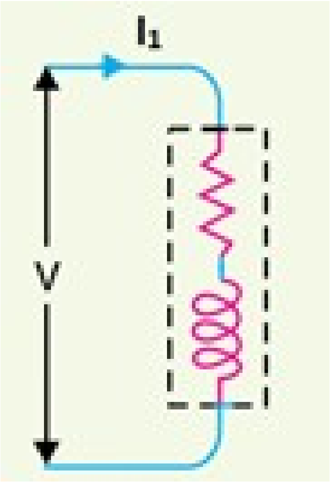
Kilo watt(kW)

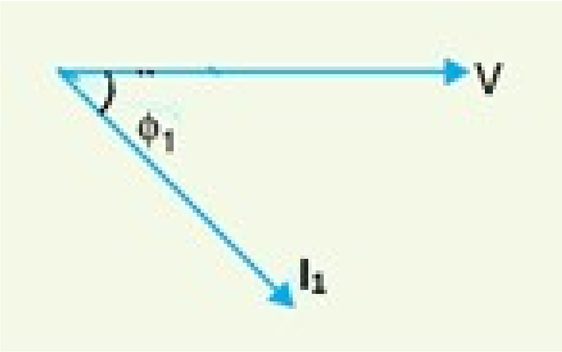
Power factor =

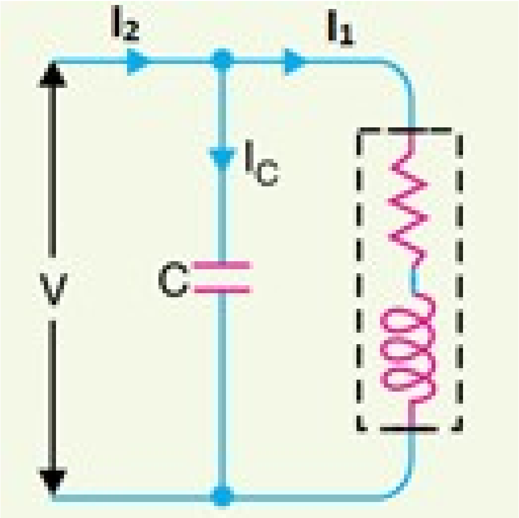
Disadvantages of Poor Power Factor operation

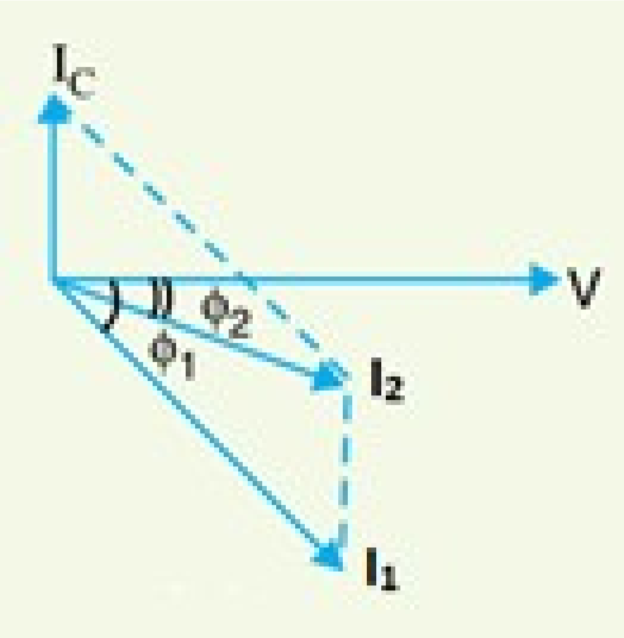
- Higher Reactive power flow in the system.
- I^2R Losses will be increased & hence lower efficiency.
- A Low Power Factor will lead to under utilisation of the installed capacity of the electrical systems.
- Leads to increase in the overall cost of the power system equipment.
- Inferior voltage profile at the load end.

Power Factor Improvement









Numerical Example 1

Question:

The power consumed in the inductive load is 2.5 kW at 0.71 lagging power factor. The input voltage is 230 V, 50 Hz. Find the value of the capacitor C which must be placed in parallel, such that the resultant power factor of the input current is 0.866 lagging.

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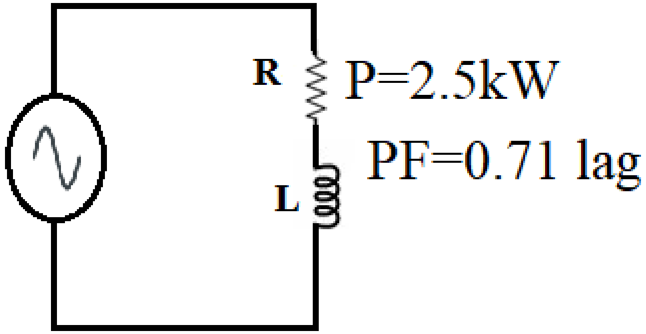

Numerical Example 1 (Solution contd..)

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Numerical Example 1 (Alternative Solution)

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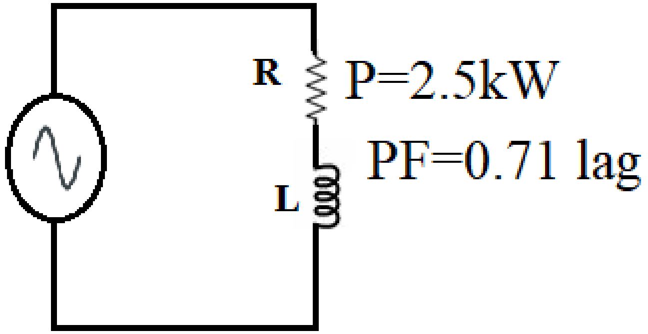
Solution:

$$P = VI\cos\phi$$

$$I = 15.309\ A$$

$$\phi = \cos^{-1} 0.71 = 44.76$$

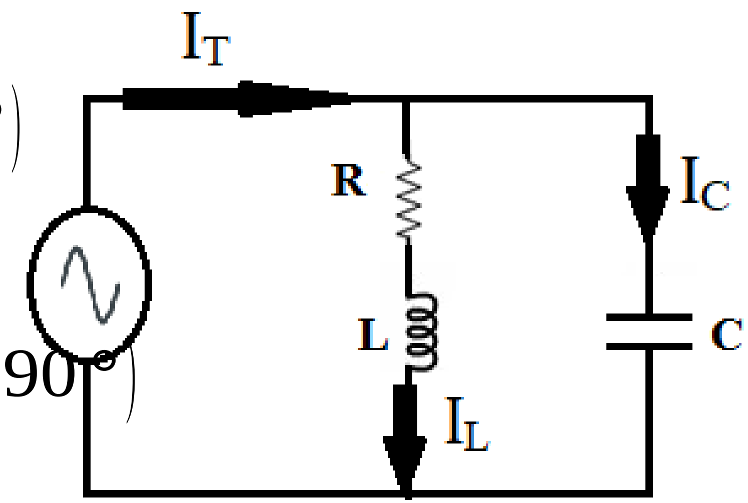
$$\therefore I = 15.309\angle -44.76°\ A$$



Numerical Example 1 (Alternative Solution)

$$By\,KCL$$

$$I_T\angle -30^\circ = (15.309\angle -44.76^\circ) + (I_C\angle 90^\circ)$$



By equating real parts.

$$I_T\cos 30^\circ = (15.309\cos 44.76^\circ) + (I_C\cos 90^\circ)$$

$$I_T = 12.55\,A$$

$$I_C = I_T - I_L$$

$$I_C = (12.55\angle -30^\circ) - (15.309\angle -44.76^\circ)$$

$$\therefore I_C = 4.504\angle 90^\circ$$

$$\therefore X_C = \frac{V_C}{I_C} = \frac{230}{4.504} = 51.065\,\Omega \quad C = \frac{1}{2\pi f X_c} = 62.33\,\mu f$$

Numerical Example 2

Question:

The load connected across an AC supply consists of a heating load of 15KW, a motor load of 40KVA at 0.6 lag and a load of 20KW at 0.8 lag. Calculate the total power drawn from the supply in (KW and KVA) and its power factor. What would be the KVAR rating of a capacitor to bring the power factor to unity and how must the capacitor be connected?

Solution: Load 1: Heating Load

$$- Q_1 = 0$$

$$so, S_1 = \sqrt{P_1^2 + Q_1^2} = 15\,kVA$$

Numerical Example 2

Load 2: Motor Load

$$P_2 = S_2 \cos\phi_2 = 24\,kW$$

$$Q_2 = S_2 \sin\phi_2 = 32\,kVAR$$

Load 3: Inductive Load

$$S_3 = 25\,kVA$$

$$Q_3 = S_3 \sin\phi_3 = 15\,kVAR$$

Numerical Example 2

$$P_T = P_1 + P_2 + P_3$$
$$\therefore P_T = 59\,kW$$

$$Q_T = Q_1 + Q_2 + Q_3$$

VAR

$$S_T = \sqrt{P_T^2 + Q_T^2}$$
$$¿ \sqrt{(59\,k)^2 + (47\,k)^2}$$
$$S_T = 75.43\,kVA$$

Numerical Example 2

Overall Power Factor is

To bring the power Factor to Unity, must be 0.
Hence we need to connect a capacitor of 47kVAR rating in parallel with the circuit.