

Disadvantages of Low Power Factor:

The power factor plays an importance role in a.c. circuits since power consumed depends upon this factor.

$$P = V_L I_L \cos \phi \quad (\text{For single phase supply})$$

$$\therefore I_L = \frac{P}{V_L \cos \phi} \quad \dots(i)$$

$$P = \sqrt{3} V_L I_L \cos \phi \quad (\text{For 3 phase supply})$$

$$\therefore I_L = \frac{P}{\sqrt{3} V_L \cos \phi} \quad \dots(ii)$$

It is clear from above that for fixed power and voltage, the load current is inversely proportional to the power factor. Lower the power factor, higher is the load current and *vice-versa*. A power factor less than unity results in the following disadvantages :

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1. Since the voltages and power are constant [$P = \sqrt{3} V I \cos\phi$], the current is inversely proportional to the power factor.
2. Increasing the current means increasingly apparent power (kVA).
3. Increasing the current means increasing the wiring sizes of the generators and increasing the cost.
4. Increase the voltage drop.
5. Poor voltage regulator.
6. Less efficiency.
7. Increasing the load on the generating plants causes an increase in demand for the current.

Advantages of improving the Power Factor:

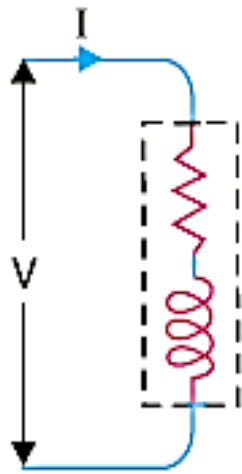
- 1.** Increasing the efficiency of the network and the equipment used.
- 2.** Reduce the voltage drop.
- 3.** Reduce the area of the wire and thus reduce the cost.
- 4.** Increase the power transmitted by the same wires.
- 5.** Reduce the copper losses (I^2R).
- 6.** Reduce the sizes of transformers and generators.
- 7.** Reduce the kWh withdrawn from the network.
- 8.** Reduce load on the network.
- 9.** Optimal use of network and generators.
- 10.** Maintain the average of energy generated and reduce the cost of equipment and equipment.

Methods to improve the Power Factor:

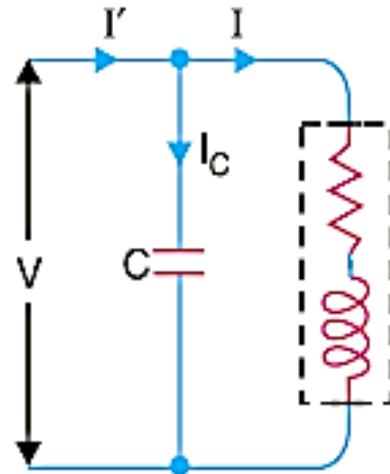
- 1.** Connect capacitors with the load.
- 2.** Use of synchronous motors.
- 3.** Use of synchronous condensers.

Power Factor Correction:

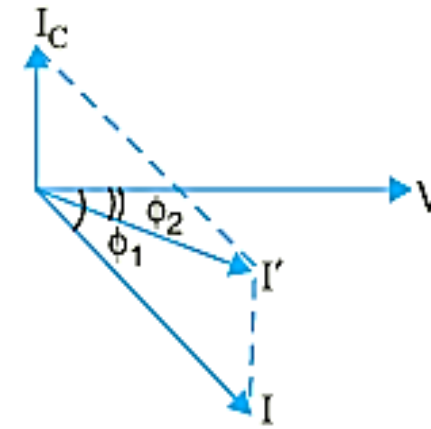
The low power factor is mainly due to the fact that most of the power loads are inductive and, therefore, take lagging currents. In order to improve the power factor, some device taking leading power should be connected in parallel with the load. One of such devices can be a capacitor. The capacitor draws a leading current and partly or completely neutralises the lagging reactive component of load current. This raises the power factor of the load.



(i)



(ii)



(iii)

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From the phasor diagram, it is clear that after p.f. correction, the lagging reactive component of the load is reduced to $I' \sin \phi_2$.

Obviously,
$$I' \sin \phi_2 = I \sin \phi_1 - I_C$$

or
$$I_C = I \sin \phi_1 - I' \sin \phi_2$$

$\therefore$ Capacitance of capacitor to improve p.f. from $\cos \phi_1$ to $\cos \phi_2$

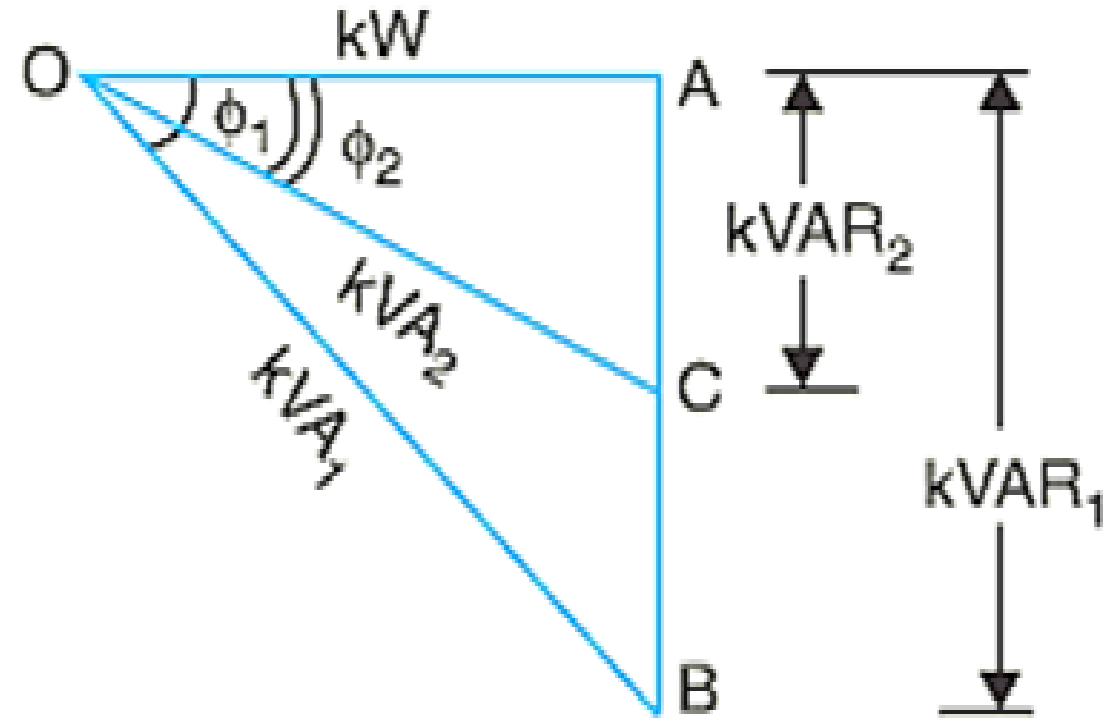
$$= \frac{I_C}{\omega V}$$

$$\left(\because X_C = \frac{V}{I_C} = \frac{1}{\omega C} \right)$$

Power Triangle:

Leading kVAR supplied by p.f. correction equipment

$$\begin{aligned} &= BC = AB - AC \\ &= \text{kVAR}_1 - \text{kVAR}_2 \\ &= OA (\tan \phi_1 - \tan \phi_2) \\ &= \text{kW} (\tan \phi_1 - \tan \phi_2) \end{aligned}$$



Knowing the leading kVAR supplied by the p.f. correction equipment, the desired results can be obtained.

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Example *An alternator is supplying a load of 300 kW at a p.f. of 0.6 lagging. If the power factor is raised to unity, how many more kilowatts can alternator supply for the same kVA loading ?*

Solution :

$$\text{kVA} = \frac{\text{kW}}{\cos \phi} = \frac{300}{0.6} = 500 \text{ kVA}$$

$$\text{kW at 0.6 p.f.} = 300 \text{ kW}$$

$$\text{kW at 1 p.f.} = 500 \times 1 = 500 \text{ kW}$$

$$\begin{aligned} \therefore \text{Increased power supplied by the alternator} \\ = 500 - 300 = \mathbf{200 \text{ kW}} \end{aligned}$$

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Example A single phase motor connected to 400 V, 50 Hz supply takes 31.7A at a power factor of 0.7 lagging. Calculate the capacitance required in parallel with the motor to raise the power factor to 0.9 lagging.

$$\text{Active component of } I_M = I_M \cos \phi_M = 31.7 \times 0.7 = 22.19 \text{ A}$$

$$\text{Active component of } I = I \cos \phi = I \times 0.9$$

These components are represented by OA in Fig. 6.9.

$$\therefore I = \frac{22.19}{0.9} = 24.65 \text{ A}$$

$$\text{Reactive component of } I_M = I_M \sin \phi_M = 31.7 \times 0.714^* = 22.6 \text{ A}$$

$$\begin{aligned} \text{Reactive component of } I &= I \sin \phi = 24.65 \sqrt{1 - (0.9)^2} \\ &= 24.65 \times 0.436 = 10.75 \text{ A} \end{aligned}$$

It is clear from Fig. 6.9 that :

$$\begin{aligned} I_C &= \text{Reactive component of } I_M - \text{Reactive component of } I \\ &= 22.6 - 10.75 = 11.85 \text{ A} \end{aligned}$$

$$\text{But } I_C = \frac{V}{X_C} = V \times 2\pi f C$$

$$\text{or } 11.85 = 400 \times 2\pi \times 50 \times C$$

$$\therefore C = 94.3 \times 10^{-6} \text{ F} = \mathbf{94.3 \mu F}$$

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$$\text{Average load} = \frac{\text{Area (in kWh) under daily load curve}}{24 \text{ hours}}$$

$$\text{Load factor} = \frac{\text{Average load}}{\text{Max. demand}}$$

$$\text{Demand factor} = \frac{\text{Maximum demand}}{\text{Connected load}}$$

$$\text{Diversity factor} = \frac{\text{Sum of individual max. demands}}{\text{Max. demand on power station}}$$

$$\text{Plant use factor} = \frac{\text{Station output in kWh}}{\text{Plant capacity} \times \text{Hours of use}}$$

$$\text{Reserve capacity} = \text{Plant capacity} - \text{Max. demand}$$

$$\text{Plant capacity factor} = \frac{\text{Average demand}}{\text{Plant capacity}}$$

Thanks