

POWER FACTOR CORRECTION

(A BEGINNER'S GUIDE)

TECS

What is Power Factor Correction?

Power Factor affects every operation with a 3-phase AC electrical supply to some degree or other.

Quite simply, Power Factor is a measure of how efficiently electrical power is consumed. The ideal Power Factor is unity, or one. Anything less than one, (or 100% efficiency), means that extra power is required to achieve the actual task at hand. This extra power is known as Reactive Power, which unfortunately is necessary to provide a magnetising effect required by motors and other inductive loads to perform their desired functions. However, Reactive Power can also be interpreted as wattless, magnetising or wasted power and an extra burden on the electricity supply.

Power Factor Correction is the term given to a technology that has been used since the turn of the 20th century to restore Power Factor to as close to unity as is economically viable. This is normally achieved by the addition of capacitors to the electrical network which provide or compensate for the Reactive Power demand of the inductive load, and thus reduce the burden on the supply.

Benefits of Power Factor Correction

Below are just some of the benefits that can be achieved by applying the correct Power Factor Correction:

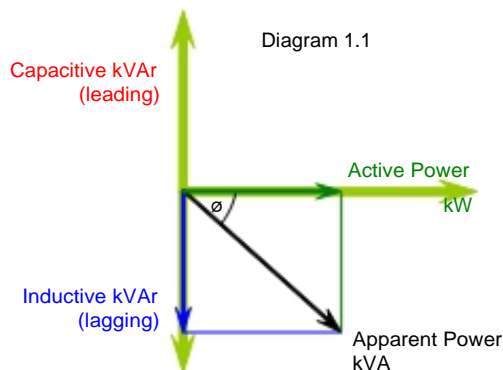
- Power consumption reduced
- Electricity bills reduced
- Electrical energy efficiency improved
- Extra kVA availability from the existing supply
- Transformer & distribution equipment I²R losses reduced
- Minimised voltage drop in long cables

How is Power Factor Caused?

Most electrical equipment such as motors, compressors, welding sets and even fluorescent lighting, create what's known as an inductive load on the supply. An inductive load requires a magnetic field to operate, and in creating such a magnetic field causes the current to "lag" the voltage (ie. the current is not in phase with the voltage)

Power Factor Correction is the process of compensating for the "lagging" current by applying a "leading" current in the form of capacitors. This way Power Factor is adjusted closer to unity and energy waste is minimised.

Power Factor Explained



AC power supplies comprise three main components:

Active Power: The real, usable power measured in kW (kilowatts). Reactive Power: The part of the supply that creates the inductive load, measured in kVAr (kilo-volt-amperes-reactive).

Apparent Power: The resultant of the other two components, measured in kVA (kilo-volt-amperes).

The Power Factor of a supply can be expressed in two ways:

1. Power Factor = $\frac{\text{Active Power (kW)}}{\text{Apparent Power (kVA)}}$
2. the cosine of the angle between Apparent Power and Active Power is expressed as the Power Factor ($\cos \phi$)

Diagram 1.1 shows the phasor relationship between active, reactive and apparent power:

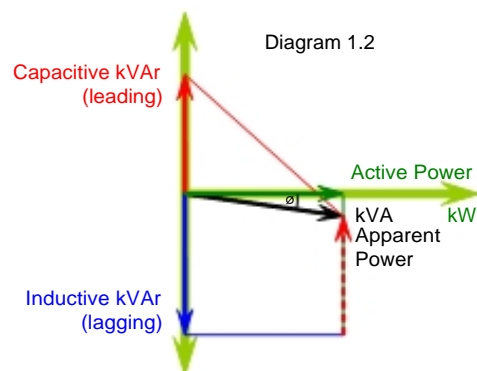
- Inductive kVAr 'lags' the kW by 90°
- Apparent power (kVA) is the phasor sum of kW + kVAr (lag)
- Power Factor is the cosine of angle ϕ

Diagram 1.2 shows the same power relationship with the addition of a capacitive load:

- Capacitive kVAr 'leads' the kW by 90°
- kVA is the phasor sum of kW + kVAr (lag) + kVAr (lead)

Power Factor is improved as angle ϕ is reduced and $\cos \phi$ therefore tends toward 1.00 (or unity power factor).

Both apparent power (kVA) and total reactive power (kVAr) from the supply are significantly reduced.



Understanding Power Factor

A good analogy to help appreciate the affect of Power Factor on an electrical network is to imagine a person running in the direction *A* to *B* as shown in diagram 2.1 below. The energy required certainly depends upon the load that the person is carrying (weight) and the distance covered, but the gradient of the running surface also influences the effort that's needed.

Diagram 2.1



When the running surface is flat, then angle ϕ is zero degrees (0°)

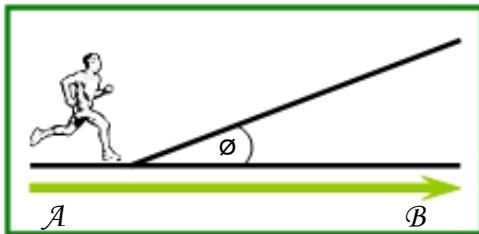
Cosine ϕ (0°) = 1.00

or Power Factor = 1.00

or Efficiency = 100%

In other words, 100% of the energy burned is being used to move the runner from *A* to *B*.

Diagram 2.2



But if the running surface is uphill as shown in diagram 2.2, say at 30° to the horizontal, then:

Cosine ϕ (30°) = 0.87

or Power Factor = 0.87

or Efficiency = 87%

In other words, only 87% of the energy burned is being used to move the runner in the horizontal direction of *B*, and so extra energy will be required to achieve the same objective.

In electrical terms, Power Factor Correction would be analogous to flattening the hill.

Example

A 100kW motor operates at a given Power Factor of 0.80 lagging. The total or apparent power required by the motor is actually $100\text{kW} / 0.80 = 125\text{kVA}$

By improving the power factor of the load to close to unity, say 0.95, then the total power drawn from the supply will be reduced to 105kVA ($100\text{kW} / 0.95$)

A total power reduction of 20kVA or an overall energy saving of 16%.

The Hidden Cost of Power Factor

Electrical networks with a poor Power Factor draw more power than is strictly required, forcing electricity generators to increase output.

This extra power means extra generating costs which are subsequently passed on to the industrial consumer in one form or another. However, due to the wide variation in the way that industrial/commercial electricity tariffs are presented, these extra costs or penalties for inefficient use of electricity are not always readily apparent and sometimes only a Power Factor survey at the main incoming electricity supply will determine the presence of a poor Power Factor.

Contact TECS

TECS specialise in power quality engineering and install Power Factor Correction equipment for all applications at low and high voltage. We may be able to help you to achieve significant energy savings and optimise your electrical power availability.

Please contact one of our technical sales engineers for assistance - We will be pleased to help, whatever your Power Factor Correction requirements.

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