ENERGE

Power Factor - What does it mean?

Where open electricity markets have been introduced, the supply of electrical energy becomes competitive between the supply utilities. Although private distribution companies are obligated to run a profitable and successful business, they are also committed to maintain the quality of supply at a high level. Competition in an open electricity market creates new opportunities for even better quality of supply of electricity.

One very important aspect of improving the quality of supply is the control of power factor. Low power factor means poor electrical efficiency. The lower the power factor, the higher the apparent power drawn from the distribution network. This means that the supply company must install larger generation capacity, larger size transmission lines and cables, transformers and other distribution system devices, which otherwise would not be necessary. This results in a much higher capital expenditures and operating costs for the Electricity Supply Company, which in many cases is passed on to the consumer in the form of higher tariff rates.

This is the main reason behind why the Electricity Supply Companies in modern economies demand reduction of the reactive load in their networks via improvement of the power factor. In most cases, special reactive current tariffs penalize consumers for poor power factors.

Electrical load types

Loads on an electrical distribution system can be categorized as resistive, inductive and capacitive. Under normal operating conditions certain electrical loads (e.g. transformers, induction motors, welding equipment, arc furnaces and fluorescent lighting) draw not only active power (kW) from the supply, but also inductive reactive power (kVAr).

All inductive loads require active power: kW to actually perform the work, and reactive power (kVAr) to maintain the electromagnetic field. This reactive power is necessary for the equipment to operate but it imposes an undesirable burden on the supply.
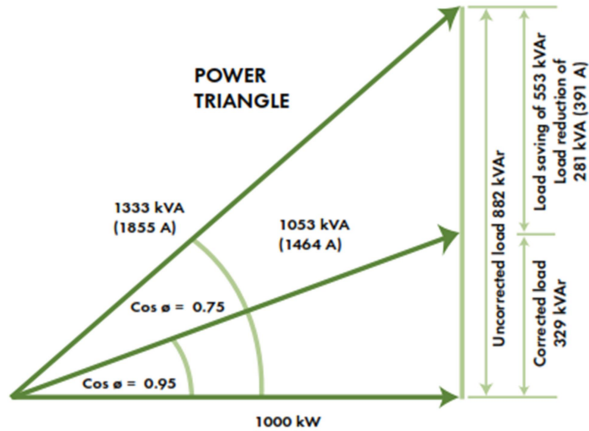
No Power Factor Correction

$\text{Cos} \, \varnothing = 0.75$
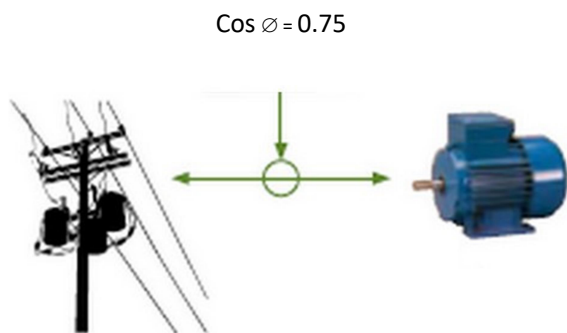
With Power Factor Correction

$\text{Cos} \, \varnothing = 0.99$
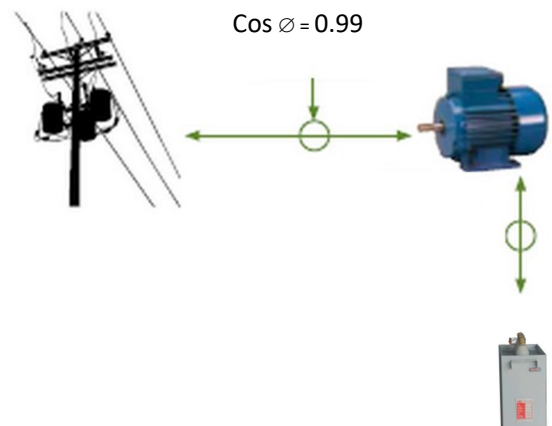
The power factor of a load is defined as the ratio of active power to apparent power, i.e. kW divided by kVA and in mathematical terms is referred to as cos Ø. The closer cos Ø is to unity, the less reactive power is drawn from the supply. Power Factor (cos Ø) = Active Power (kW) / Apparent Power (kVA).

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POWER TRIANGLE

1333 kVA
(1855 A)

1053 kVA
(1464 A)

Cos ø = 0.75

Cos ø = 0.95

1000 kW

Uncorrected load 882 kVAr

Corrected load 329 kVAr

Load saving of 553 kVAr
Load reduction of
281 kVA (391 A)

Please refer to the Cost Savings of a Power Factor Correction Unit to see how the above example works in with a practical situation.

Factors that could degrade electricity supply quality

Harmonics
The presence of harmonics in the waveform of the network voltage can be attributed to various causes such as rectifiers, variable speed drives, thyristors, saturated transformer, arc furnaces, etc.

The main problems caused by harmonics are:
- Interferences in telecommunications systems and equipment.
- Distortion of the Electricity Supply Voltage
- Erratic operation of control and protection relays
- Failures in transformers and motors due to overheating caused by core losses.

If the harmonic power is significant, i.e. THVD greater than 7%, THID greater than 40 %, this may result in overvoltages and overloads, which may lead to failure of the capacitors, circuit breakers, contactors etc.

Resonance
Amplification of both voltage and current at the same time will occur if the resonant frequency is close or equal to one of the harmonic frequencies present in the distribution system.

The power feeder (overhead line or underground cable) have an inductive impedance. By putting a capacitor in parallel with the load (for Power factor correction) it is possible for the combined system to have a resonance condition.

Cable Losses
As the power factor of a three phase system decreases, the current rises. The heat dissipation in the system rises proportionately by a factor equivalent to the square of the current rise.

Solutions

Power factor correction capacitors

A poor power factor can be improved by adding power factor correction capacitors to the plant's distribution system. Correction capacitors provide needed reactive power (kVAr) to the load. Therefore, the Electricity Supply Company is freed from having to supply it.

Power factor correction capacitors reduce the total current supplied by the Electricity Supply Company to the load and as a result the distribution system capacity is increased.

Capacitor ratings

Power factor correction capacitors are rated in electrical units called "VAr". One VAr is equivalent to one volt-ampere of reactive power VAr is the unit of measurement for indicating just how much reactive power the capacitor will supply.

Filter reactors

In most cases it is necessary to reduce the effects of the harmonic currents. One way of reducing harmonic currents is to install an inductance (filter reactor) in series with the capacitor.

The filter reactors protect the electrical installations and equipment but it does not eliminate the harmonics.

The reactor value should be calculated and designed in order to reduce the resonant frequency of the circuit to a value lower than that of the lowest harmonic in the system.

A capacitor equipped with a filter reactor is protected from harmonics regardless of the layout of the network to which it is connected. Except in some cases when switching in steps the inductance and capacitance values could add up to equal one of the harmonic frequencies in the system causing resonance.

Power loss reduction

Distribution system losses are also reduced through power factor correction by reducing the total load current in the system.

Voltage improvement

Power factor capacitors decrease distribution system voltage drops and fluctuations during the start of large inductive loads.

Where should the power factor correction equipment be installed

After determining the required size capacitor in kVAr, the next step is to decide on the location for installation of the capacitor bank.

It is difficult to set definite guidelines for location of capacitor installation.