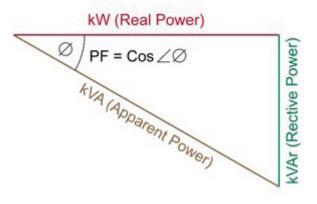# Power factor correction
Application notes

Power Factor Correction

Power Factor (PF) is the ratio of real power to the apparent power flowing to the load from the source. It is measured between 0 and 1.0 (unity) and is usually deemed as either leading or lagging, depending on the position of the current waveform with respect to the voltage.

$$\text{Power Factor (pf)} = \frac{kW \text{ (Real Power)}}{kVA \text{ (Total Power)}}$$

$$PF = \text{Cos} \angle \varnothing$$

kW (Real Power)

kVA (Apparent Power)

kVAr (Rective Power)

The advantage of the Acksen products over most others is that our data loggers constantly sample information (recording the Min, Max and Average) over the set period, many other products only take 'snap shots' of what is going on and can miss 99.9% of the data that is critical to your overall analysis.

In an electric power system, a load with a low power factor (tending towards zero) draws more current than a load with a high power factor (tending towards one) for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor.

Linear loads with low power factor (such as induction motors) can be corrected with a passive network of capacitors or inductors. Non-linear loads, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor correction may be used to counteract the distortion and raise the power factor. The devices for correction of the power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment.

A high power factor is generally desirable in a transmission system to reduce transmission losses and improve voltage regulation at the load. It is often desirable to adjust the power factor of a system to near 1.0. When reactive elements supply or absorb reactive power near the load, the apparent power is reduced. Power factor correction may be applied by an electrical power transmission utility to improve the stability and efficiency of the transmission network. Individual electrical customers who are charged by their utility for low power factor may install correction equipment to reduce those costs.

Motors driven by Variable Speed Drives will use the same power as before, but may draw more current, it should be noted that with reduced stored energy in the DC Bus capacitors, they may be more vulnerable to power dips.

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Power factor correction brings the power factor of an AC power circuit closer to 1 by supplying reactive power of opposite sign, adding capacitors or inductors that act to cancel the inductive or capacitive effects of the load, respectively. For example, the inductive effect of motor loads may be offset by locally connected capacitors. If a load had a capacitive value, inductors (also known as reactors in this context) are connected to correct the power factor. In the electricity industry, inductors are said to consume reactive power and capacitors are said to supply it, even though the energy is just moving back and forth on each AC cycle.

The reactive elements can create voltage fluctuations and harmonic noise when switched on or off. They will supply or sink reactive power regardless of whether there is a corresponding load operating nearby, increasing the system's no-load losses. In the worst case, reactive elements can interact with the system and with each other to create resonant conditions, resulting in system instability and severe overvoltage fluctuations. As such, reactive elements cannot simply be applied without engineering analysis.

An automatic power factor correction unit consists of a number of capacitors that are switched by means of contactors. These contactors are controlled by a regulator that measures power factor in an electrical network. Depending on the load and power factor of the network, the power factor controller will switch the necessary blocks of capacitors in steps to make sure the power factor stays above a selected value.
Instead of using a set of switched capacitors, an unloaded synchronous motor can supply reactive power. The reactive power drawn by the synchronous motor is a function of its field excitation. This is referred to as a synchronous condenser. It is started and connected to the electrical network. It operates at a leading power factor and puts vars onto the network as required to support a system's voltage or to maintain the system power factor at a specified level.

For power factor correction of high-voltage power systems or large, fluctuating industrial loads, power electronic devices such as the Static VAR compensator or STATCOM are increasingly used. These systems are able to compensate sudden changes of power factor much more rapidly than contactor-switched capacitor banks, and being solid-state require less maintenance than synchronous condensers.

Benefits of Power Factor Correction

1. REDUCING ELECTRICITY CHARGES: this can range from £100's to £10,000's per annum, depending on the size of the premises.
2. UTILITY REACTIVE POWER PENALTIES : utility companies levy this charge to consumers with poor power factor. Such surcharges can result in electricity bills increasing by up to 20%, depending on which company is supplying your electricity.
3. REDUCING CARBON EMISSIONS: utilising power factor correction can lower the amount of carbon emissions released into the atmosphere. Please use the calculator to find out how much you can save.
4. REDUCTION IN I2R LOSSES of transformers and electrical distribution equipment.
5. HEAT REDUCTION in cables, switchgear, transformers and alternators which, in turn, will prolong the lifespan of such equipment.
6. REDUCED VOLTAGE DROP in cables, allowing the same cable to supply a larger motor and improve the starting of motors at the end of long cable runs.

The EC-7VAR measures power factor between L1 (voltage) and A1 (current) and thus can be used to carry out a study of the PF on that part of the three phase system.