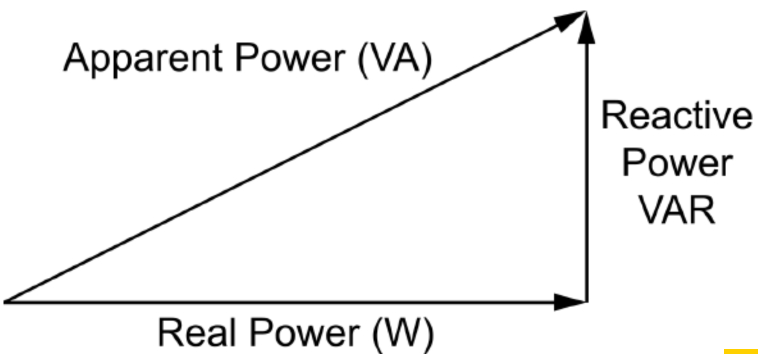
Power Quality Issues - Part 5 - Reactive Power and Power Factor

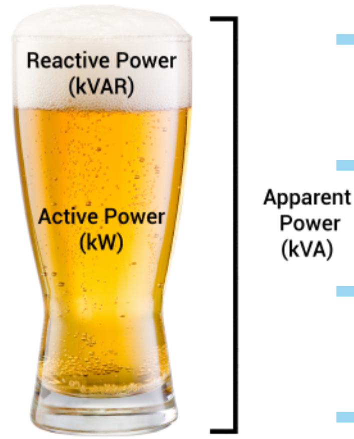
As with voltage imbalance, covered in the previous article, reactive power and power factor are not power quality issues in the same sense as harmonics and transients, but are of critical importance, particularly with regards to a facilities electrical energy consumption and efficiency. **Julian Grant - General Manager at Chauvin Arnoux UK**, looks at the causes and effects of high reactive power and poor power factor, along with solutions to improving them.

In a purely resistive AC circuit, voltage and current waveforms are in phase with each other, changing polarity at the same instant in each cycle and all the power entering the load is consumed by the load. Reactive power exists in an AC circuit when the current and voltage are not in phase. Some electrical equipment used in industrial and commercial buildings requires an amount of reactive power in addition to real power in order to work effectively. These tend to be items with copper windings in them; especially transformers, motors, induction heaters, arc welders and compressors, etc., even fluorescent and LED lighting. In the case of inductive loads, the current lags behind the voltage, however, nowadays various capacitive loads may be encountered which cause the opposite effect, that is for the current to lead the voltage.



Reactive power (kVAr) is the vector difference between real power (kW), and the total power consumed, which is called apparent power and is measured in kVA. Power factor is a ratio of the real power that is used to do work and the apparent power that is supplied to the circuit.

It's quite easy to understand if you consider a pint of beer, where the whole glass that you pay for is the apparent power, the bit you want most (the beer) is the real power (active power), and the bit you want as little of as possible (the head) is the reactive power.



A full pint with no head would represent a power factor of 1, or unity power factor, and in that situation, there would be no reactive power. In reality a power factor greater than 0.95 is generally aimed for, 0.98 if you can get it. A pint with a nice small head on it!

Poor power factor, and the associated high reactive currents, can cause a variety of issues within an electrical installation. Many network operators apply penalties in the form of a reactive power charge when power factor falls below 0.95, and this is recorded as a parameter on a half hourly meter. Aside of the costs there are related environmental issues in that reactive power adds to the burden on the national grid and causes unnecessary increased levels of CO2 emissions at a time when we are aiming to reduce them.

Power factor also impacts on the reliability of the network itself and can cause a variety of electrical issues that may result in the early failure of capital equipment. This equipment often gets replaced at great expense without the root cause ever being observed or identified.

Poor power factor can also impact heavily on authorised supply capacity and associated charges which are based on the maximum demand required from the network. This is often imposed to pay for the supply network infrastructure required to deliver the maximum declared energy requirement. It follows therefore that an unnecessarily high level of reactive power not only pushes the price up, but it also limits the available headroom for expansion, and may cause excursions above the authorised supply capacity which will result in penalty charges.

According to The Carbon Trust it is not uncommon for industrial installations to be operating at power factors between 0.7 and 0.8, which is surprising since measuring power factor is not at all difficult. It can be routinely measured using portable test instruments, or alternatively, can be permanenly monitored in real-time with constantly displayed values, while also showing a multitude of other useful parameters including voltage, current and energy consumption.

While specification of a power factor correction (PFC) system requires knowledge of several factors including the voltage level and typical usage of the reactive loads on-site, the usage profile across the site, the degree of harmonic distortion present, and the power quality required by the on-site loads, all of this is easily measured and calculated. PFC systems are a fraction of the cost of the potential savings they can bring.

The simplest form of PFC involves fitting capacitors, and it is worth shopping around and taking expert advice on the system that will suit you. If a single machine has a poor power factor, capacitors can be connected in parallel with the device, so that they compensate for the poor power factor whenever the machine is switched on.

If the power factor of a site is permanently poor and no single item of equipment is solely responsible, fixed PFC can be connected across the main power supply to the premises.

Where many machines are switching on and off at various times, the power factor may be subject to frequent change. In this case the amount of PFC needs to be controlled automatically. In other words, the banks of capacitors need to be selectively switched in and out of the power circuit appropriately. There are various solutions on the market for performing this capacitor bank switching automatically.

Selection of the correct design of power factor correction is critical to ensure long term reliable operation of a facility. With the increasing use of non-linear loads in industry, such as variable speed drives, LED lighting, large quantities of IT equipment, etc. and their associated harmonics, it may be the case that none of the traditional methods discussed so far for power factor correction will be suitable.

The simple connection of PFC capacitors to an installation with a significant number of harmonic generating non-linear loads, or where loads are expected to contain in excess of 25% of non-linear loads, could create more problems than it solves. The impedance of capacitors reduces as frequency increases and so harmonic currents which are at higher frequencies are more likely to flow in capacitors that are connected in circuit. The increased currents cause higher voltages across the dielectric of the capacitor which can lead to stress and premature failure. It is also possible to inadvertently create harmonic resonance. This is generally caused by parallel resonance between the power factor correction capacitors connected to a load and the transformer supplying the load.

When a number of harmonic current sources are injecting currents into the supply and the frequency of one of the harmonics coincides with the resonant frequency of the supply transformer and power factor correction capacitor combination, the system resonates and a large circulating harmonic current is excited between these components. The result of this is that a large current flow in the supply transformer, resulting in a large harmonic voltage distortion possibly causing equipment malfunction, loss of transformer output due to increased heating, interference with communication systems, premature failure of motors and power factor capacitors.

In these situations, professional advice and the potential use of detuned power factor correction, thyristor switched power factor correction or active power factor correction may well be required.

Power factor is one of the simplest things to measure in an electrical installation, can be responsible for unnecessary power consumption and charges, and yet can be relatively simple and very cost effective to fix. Contact **Chauvin Arnoux** directly for any questions you may have about this subject or any of the other power quality issues – we're happy to help!

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