NIXON POWER SERVICES

KOHLER
IN POWER. SINCE 1920.

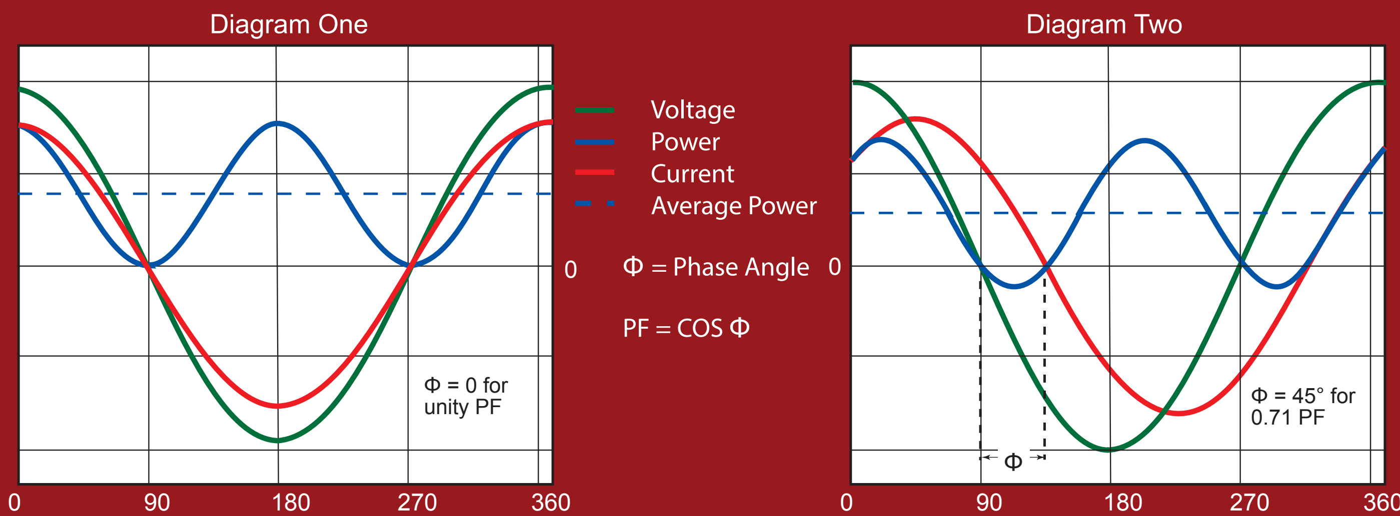
The Effect of Power Factor On An Electrical System

Information Sheet # 55

1.0 Introduction:

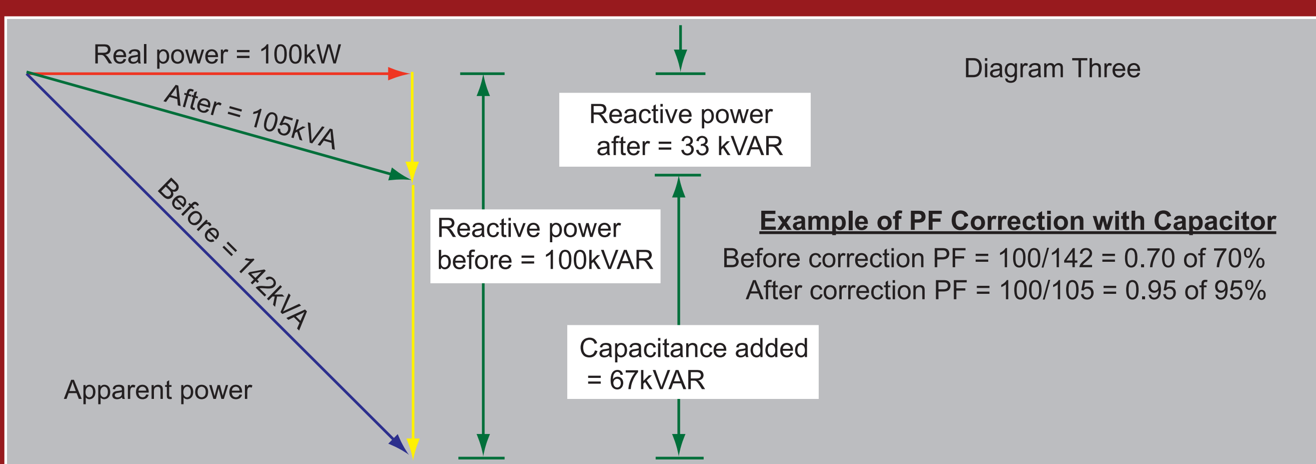
Power factor in electrical systems is often referred to but frequently not fully understood.

This information sheet discusses power factor as regards its explanation and how it relates to generator systems.



Purely resistive load connected with volts and amps in step for an unity (1) power factor when all the source energy is transfered and available to the load. Good power factors are normally greater than 0.9 to 0.95.

Inductive load connected with current waveform lagging volts. Below unity PF only a percentage of the power is available at the load. i.e 0.8 PF has real power 80% of apparent power. Reactive loads have a percentage of power returned to the source.



To fulfill our commitment to be the leading supplier and preferred service provider in the Power Generation Industry, the Nixon Power Services team maintains up-to-date technology and information standards on Power Industry changes, regulations and trends. As a service, our Information Sheets are circulated on a regular basis, to existing and potential Power Customers to maintain awareness of changes and developments in engineering standards, electrical codes, and technology impacting the Power Generation Industry.

NIXON POWER SERVICES

Corporate Office
155 Franklin Road
Suite 255
Brentwood, TN 37027
Phone: 888-826-4966

Birmingham, AL
2512 Cone Dr.
Birmingham, AL 35217
Phone: 205-739-2255

Atlanta, GA
1440 Lakes Parkway
Suite 600
Lawrenceville, GA 30043
Phone: 770-448-6687

Louisville, KY
11910 Carrier Court
Louisville, KY 40299
Phone: 502-267-0474

Charlotte, NC
3101 Yorkmont Road
Suite 100
Charlotte, NC 28208
Phone: 704-588-1043

Raleigh, NC
3821 Commerce Park Dr.
Raleigh, NC 27610
Phone: 919-279-9191

Nashville, TN
1515 JP Hennessy Drive
La Vergne, TN 37086
Phone: 615-244-0650

Blountville, TN
1612 Highway 75
Blountville, TN 37617
Phone: 423-279-0357

2.0 Definition of Power Factor:

In a purely resistive AC circuit, the voltage and current waveforms are in step (or in phase), changing polarity at the same instant in each cycle (*see diagram one*). Where reactive loads are present, such as with capacitors or inductors (like electric motors, strip heaters, (Continued Over) cooking stoves, lamp ballasts, etc.), the energy stored in the loads results in a time difference between the current and voltage waveforms, as the stored energy is not available to do work at the load it is termed apparent power. This is known as a lagging power factor (which is less than 1.0).

Power factor, as shown in vector diagram (*see diagram two*) is the ratio of true power (shown as watts (W) amps x volts) to the apparent power (shown as VA amps x volts) flowing to the load in an alternating current (AC) system. Watts and VA are more commonly quoted in thousands as kW and kVA. kW and kVA in an AC system are only the same when power factor has a value of one (unity). More frequently equipment is designed to have a power factor equal to 0.8.

3.0 Difference Between True Power - kW and Apparent Power - kVA and Reactive Power:

In an AC system, such as inductive motors, transformers and solenoids, internal electrical energy is required for magnetization of items such as a motor's field coils. This internal power stored and discharged within an inductive piece of equipment is referred to as reactive power and measured as volts x amps reactive (VAR). Without internal magnetization the AC equipment would not function.

The more reactive power required for magnetization of the internal inductive load, the greater the unusable power and increase in apparent power (kVA) requirements within the electrical system. As shown in diagram one, the greater the value of apparent power (kVA) the lower the power factor and by ratio the lower the real power available, given in kWs.

In layman's terms, power factor has as more to do with the internal inductive loads of AC electrical equipment and the resultant true power kW available. A system designer endeavors to select equipment and design a system that reduces the drop in power factor. A system with a low power factor increases the energy lost in the system and requires a much greater input than can be used effectively to power equipment. Generator sets are normally rated for power factors between 0.8 and unity.

In summary, apparent power kVA is the power required to serve the equipment's internal reactive load power requirements and true power kW is the power available after reactive power has been satisfied.

4.0 Adverse Effects and Why to Avoid Low Power Factor:

A system load with a low power factor will draw more current than a system with a higher power factor A system designer considers the following:

- A Low power factor draws a higher internal current and the excessive heat generated will damage and/or shorten equipment life
- Increased reactive loads can reduce output voltage and damage equipment sensitive to reduced voltage
- Low power factor requires equipment to be constructed heavier to absorb internal energy requirements
- Low power factor will result in a more expensive system with equipment able to absorb internal loads and larger load requirements
- A system designer looks to increase power factor to lower system costs, increase reliability and increase the system's life cycle
- Utilities will charge a higher cost to industrial and commercial clients having a low power factor.

5.0 Methods to Increase Power Factor and Load Types:

Electrical system designers endeavor to increase the power factor to as near as 1.0 as possible by incorporating power factor 'corrector' devices within the system. Power factor correction methods adopted depend on whether the load is termed linear or non-linear.

Linear Load - These are loads such as induction motors and transformers that can be corrected with the addition of a passive network of capacitors or inductors. Capacitors store electrical power that can be used to excite the internal magnetic fields and reduce the required apparent power kVA. (*see diagram three*)

Non- Linear Load - These loads include equipment that has components such as rectifiers, some form of arc discharge such as fluorescent lamps, electric welders, arc furnaces, etc. This type of load will distort the current drawn into a system. The current in non-linear loads is interrupted by switching devices within the equipment. Switching causes the current to contain frequency components that have multiple power factor frequencies.

For non-linear loads, captive or passive power factor correction can be incorporated to counter the distortion and elevate the power factor.

Power factor correction devices can be installed either at a central substation, spread throughout the distribution system, or built into the power-consuming equipment

Non Reactive Loads - These loads are purely resistive such as heater elements and incandescent lights and do not effect power factor.