POWER FACTOR IMPROVEMENT

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- CAUSES OF LOW POWER FACTOR
- POWER FACTOR CORRECTION
- ADVANTAGES OF POWER FACTOR CORRECTION
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DEFINITION:

Power factor (P.F) is the ratio between actual power to the apparent power.

Actual power/Apparent power.

P.F=Kw /Kva.

For a purely resistive load the power factor is unity. Active and reactive power are designated by P &Q respectively. The average power in a circuit is called active power and the power that supplies the stored energy in reactive elements is called reactive power.

Active Power:

Also known as “real power” or simply “power.” Active power is the rate of producing, transferring, or using electrical energy. It is measured in watts and often expressed in kilowatts (KW) or megawatts (MW). The terms “active” or “real” power are used in place of the term “power” alone to differentiate it from “reactive power.

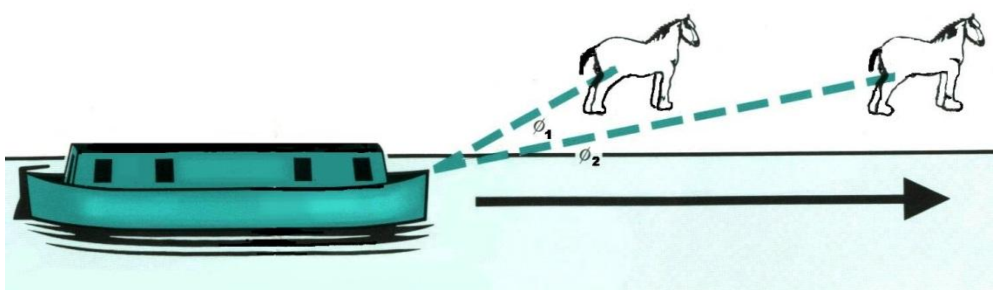
Apparent Power:

The product of the voltage (in volts) and the current (in amperes). It comprises both active and reactive power .

It is measured in “volt-amperes” and often expressed in “ kilovolt-amperes” (KVA) or “megavolt-amperes” (MVA).

POWER FACTOR DEFINITION

- Inductive loads cause the current to lag behind the voltage. The wave forms of voltage and current are then "out of phase" with each other. The more out of phase they become then the lower the Power Factor. Power Factor is usually expressed as Cos Phi. (Ø)



Consider a canal boat being pulled by a horse. If the horse could walk on water then the angle (Phi) Ø would be zero and COSINE Ø=1. Meaning all the horse power is being used to pull the load. However the relative position of the horse influences the power. As the horse gets closer to the barge, angle Ø1 increases and power is wasted, but, as the horse is positioned further away, then angle Ø2 gets closer to zero and less power is wasted.

CAUSES OF LOW POWER FACTOR

A poor power factor can be the result of either a significant phase difference between the voltage and current at the load terminals or it can be due to a high harmonic content or distorted/discontinuous current waveform. Poor load current phase angle is generally the result of Poor load current phase angle is generally the result of an inductive load such as an induction motor power transformer, lighting ballasts, welder or induction furnace, Induction generators Wind mill generators and high intensity discharge lightings.

CAUSES OF LOW POWER FACTOR

A distorted current waveform can be the result of a rectifier variable speed drive, switched mode power supply, discharge lighting or other electronic load.

POWER FACTOR CORRECTION

Power factor decreases with the installation of non resistive loads such as induction motors, Transformers.

Lighting ballasts and electronic equipments. Power factors can be corrected by using capacitors. These are rated in electrical units called VAR or KVAR.One VAR is equivalent to one volt of reactive power. VAR then are units of measurement for indicating just how much reactive power the capacitor will supply.

As reactive power is usually measured in thousands the letter K is used for thousand. the capacitor KVAR rating then shows how much reactive power the capacitor will supply. Each unit of the capacitor's KVAR will decrease the inductive reactive power demand.

POWER FACTOR CORRECTION

Most loads on an electrical distribution system fall into one of three categories; resistive, inductive or capacitive. In most plant, the most common is likely to be inductive. Typical examples of this include transformers, fluorescent lighting and AC induction motors. Most inductive loads use a conductive coil winding to produce an electromagnetic field, allowing the motor to function.

All inductive loads require two kinds of power to operate:

Active power (KW) - to produce the motive force

Reactive power (KVAR) - to energize the magnetic field

The operating power from the distribution system is composed of both active (working) and reactive (non-working) elements. The active power does useful work in driving the motor whereas the reactive power only provides the magnetic field.

POWER FACTOR CORRECTION

The amount of Power Capacitor KVAR required to correct

A system to a desired Power Factor level is the difference between the amount of KVAR in the uncorrected system and the amount of desired KVAR in the corrected system. The most efficient location for power factor capacitors is at the load. Capacitors work from the point of installation back to the generating source. Individual motor correction is not always practical, sometimes it is more practical to connect larger capacitors on the distribution bus or install an automatic system at the incoming service along with fixed capacitors at the load.

POWER FACTOR CORRECTION METHODS

- Static Var Compensator(SVC)
- Fixed Capcitors
- Switch Capacitors
- Synchronous Condensors
- Static Synchronous Compensator(STATCOM)
- Modulated power filter capacitor compensator

STATIC VAR COMPENSATOR (SVC)

The Static Var Compensator (SVC) is a shunt device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids [1]. The SVC regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the SVC generates reactive power (SVC capacitive). When system voltage is high, it absorbs reactive power (SVC inductive).

The variation of reactive power is performed by switching three-phase capacitor banks and inductor banks connected on the secondary side of a coupling transformer. Each capacitor bank is switched on and off by three thyristor switches (Thyristor Switched Capacitor or TSC). Reactors are either switched on-off (Thyristor Switched Reactor or TSR) or phase-controlled (Thyristor Controlled Reactor or TCR).

A rapidly operating Static Var Compensator (SVC) can continuously provide the reactive power required to control dynamic voltage swings under various system conditions and thereby improve the power system transmission and distribution performance.

Installing an SVC at one or more suitable points in the network will increase transfer capability through enhanced voltage stability, while maintaining a smooth voltage profile under different network conditions. In addition, an SVC can mitigate active power oscillations through voltage amplitude modulation

FIXED CAPACITOR

where the load does not change or where the capacitor is switched with the load, such as the load side of a Ideally suited for power factor correction in applications motor contactor. It is suitable for locations using induction motors, like food processing plants, or where small multiple loads require reactive power compensation.

Each Fixed Capacitor Bank is designed for high reliability and long life. These products are designed for applications that do not contain harmonic generating

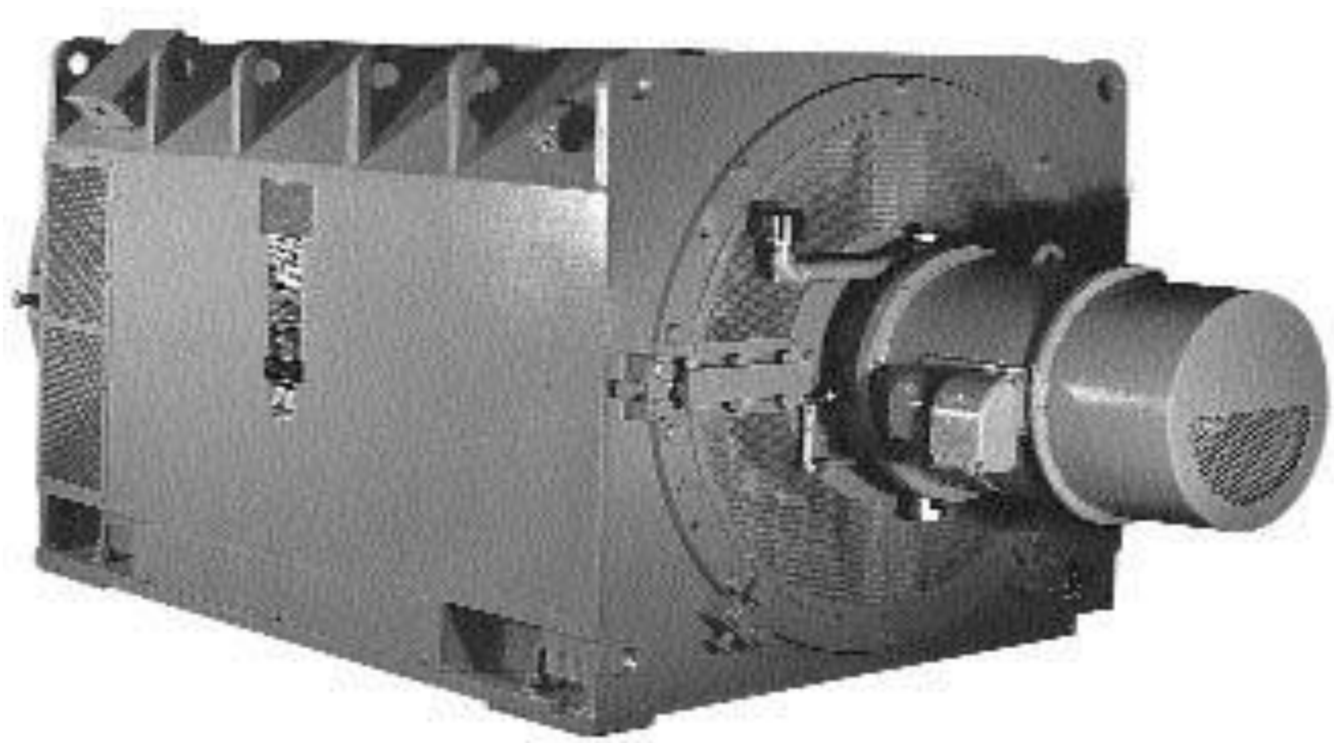
SWITCHED CAPACITOR

It is suited for centralized power factor correction in applications where plant loading is constantly changing, resulting in the need for varying amounts of reactive power. An advanced microprocessor-based reactive power controller measures plant power factor via a single remote current transformer (included), and switches capacitor modules in and out of service to maintain a user-selected target power factor. Typically applied at service entrance or near fluctuating loads.

SYNCHRONOUS CONDENSER

Synchronous condenser is a salient pole synchronous generator without prime mover. Synchronous condenser stabilizes power system voltage by supplying reactive power to the power system and Use for power factor correction. It is more economical than capacitors.

SYNCHRONOUS CONDENSER



STATIC SYNCHRONOUS COMPENSTOR (STATCOM)

The Static Synchronous Compensator (STATCOM) is a shunt device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids [1]. The STATCOM regulates voltage at its terminal by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the STATCOM generates reactive power (STATCOM capacitive).

When system voltage is high, it absorbs reactive power (STATCOM inductive).Similarly to the SVC the STATCOM can provide instantaneous and continuously variable reactive power in response to grid voltage transients enhancing the grid voltage stability

Installing a STATCOM at one or more suitable points in the network will increase the grid transfer capability through enhanced voltage stability, while maintaining a smooth voltage profile under different network conditions. The STATCOM provides additional versatility in terms of power quality improvement capabilities

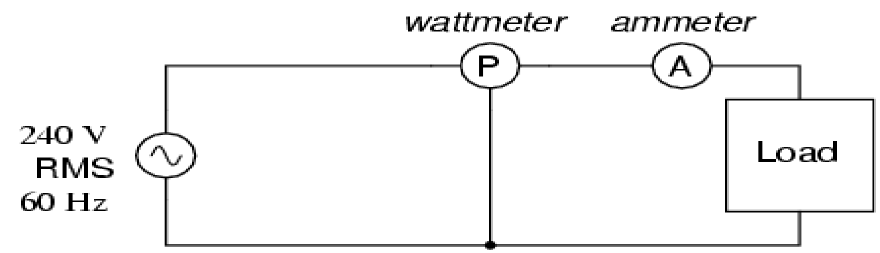
POWER FACTOR MEASUREMENT

Power factor can measure by using power factor meter
which is well known in power industry.

Power factor can also be calculated by installing watt meter along with the Ampere meter and volt meter by using the power factor basic formula.

Power factor=Actual Power/ Apparent power

POWER FACTOR MEASUREMENT



Wattmeter reading = 1.5 kW
Ammeter reading = 9.615 A RMS

$$S = IE$$

$$S = (9.615\ \text{A})(240\ \text{V})$$

$$S = 2.308\ \text{kVA}$$

$$\text{Power factor} = \frac{P}{S}$$

$$\text{Power factor} = \frac{1.5\ \text{kW}}{2.308\ \text{kVA}}$$

$$\text{Power factor} = 0.65$$

ADVANTAGES OF POWER FACTOR CORRECTION

- Eliminate Power Factor Penalties
- Increase System Capacity
- Reduce Line Losses in distribution systems
- Conserve Energy
- Improve voltage stability

- Less total plant KVA for the same KW working power
- Improved voltage regulation due to reduced line voltage drop
- Reduction in size of transformers, cables and switchgear in new installations

- Increase equipment life
- Save on utility cost
- Enhance equipment operation by improving voltage
- Improve energy efficiency

- Reduction in size of transformers, cables and switchgear in new installations.
- Delay costly upgrades.
- Less total plant KVA for the same KW working power.
- Improved voltage regulation due to reduced line voltage drop.

POWER COST REDUCTION

Utility companies in many areas include a penalty charge in the electrical rate for low power factor. The installation of power factor capacitors on the user's electrical distribution system eliminates the necessity of paying premium rates to the utility company for poor power factor.

The savings the utility company derives in reduced generation, transmission and distribution costs are passed on to the user in the form of lower electrical charges. Three of the more common ways a utility charges a user for poor power factor are based on

- KW demand with a trigger point typically between 85% and 95%
- KVA demand
- KVAR demand
- When the utility uses either KVA demand or KVAR demand as the basis for its penalty structure, all users pay a penalty, but those with high power factor pay a much lower penalty or none at all.

SYSTEM CAPACITY INCREASE

By adding capacitors to the system, the power factor is improved and the KW capacity of the system is increased. For example, a 1,000 KVA transformer with a 70% power factor provides 700 KW of power to the main bus. With the installation of capacitors so that the power factor is improved, say, to 90%, the KW capacity of the system is increased to 900 KW. When a system power factor is improved, the amount of reactive current flowing

Is lowered thus reducing transformer and distribution circuit loads, and releasing system capacity.

VOLTAGE IMPROVEMENT AND POWER LOSS REDUCTION

System losses are also reduced through power factor correction by reducing the total current and power in the system. A 20% reduction in current will yield a 36% reduction in distribution system losses. In this situation, an energy savings of as much as 50% will be realized with the installation of power factor capacitors.

In addition, power factor capacitors decrease the distribution system voltage drops and fluctuations.

DISADVANTAGES OF LOW POWER FACTOR

- Increases heating losses in the transformers and distribution equipments.
- Reduce plant life.
- Unstabilise voltage levels.
- Increase power losses.
- Upgrade costly equipments.
- Decrease energy efficiency.
- Increase electricity costs by paying power factor surcharges.

CONCLUSION

By observing all aspects of the power factor it is clear that power factor is the most significant part for the utility Company as well as for the consumer.   Utility company rid of from the power losses while the consumer free from low power factor penalty charges.

By installing suitably sized power capacitors into the circuit the Power Factor is improved and the value becomes nearer to 1 thus minimising line losses and improving the efficiency of a plant.