Investigation of Distoration Power Factor for Various Loads

R. Malathi and S. Swapna Priya

Abstract--- The power factor for various methods for improving the power factor and reduces the compatible deviation of the system. Poor power quality have caused our distortion to pay more for electricity, have an unnecessary impact on the system, and lower power quality. In a power station, a load draws energy from a network power (active) into a power source (for example, a personal computer, printer, etc.) or converts it into another form of energy (for example, a lamp or a stove) or a mechanical output (for example, electric power motor. To eliminate this negative impact, power factor correction was performed at the power station. Using the power factor correction obtained by the power factor correction switch panel, the reactive power required to transmit the effective power can be generated locally so that the power plant can be efficiently, reasonably, technically and economically managed. The system can adjust the power factor to the maximum or adjust it according to user needs. The proposed system does not create harmonics and reduces transmission losses. The simulation results were reported and proved to be in good agreement with the corresponding experimental results.

Keywords--- Power Factor, Investigation of Distoration, Lower Power Factors.

I. INTRODUTION

The power factor of an AC power system is defined as the ratio of the active force flowing to the load exerted on the circuit, and is a dimensionless number between 0 and 1. Active power is the ability of a circuit to do its work. At a certain time. The apparent force is the product of the circuit current and voltage. Because the load is stored and returned to the power source, or the waveform of the current received from the power source is distorted by non-linear loads, the apparent power is greater than the active force. In a power system, for the same amount of effective power transmission, a load with a lower power factor consumes more current than a load with a higher power factor. Higher currents increase energy loss in the power supply system and require larger wires and other equipment. Due to the cost of large appliances and the wasteful energy, power companies typically charge higher costs for industrial or commercial customers with lower power factors.

The increase in power factor causes a significant reduction in the apparent power received from the AC power source, thereby saving energy and reducing transmission losses. It usually follows the steps to control the reactive power in the power system network. This process is commonly referred to as reactive power compensation, which is a manufacturing technology used to improve the efficiency of electrical systems. In recent years, the need for controllable reactive power has been the key to making AC power systems more efficient and reliable. The static and dynamic power system must control the VAR compensator to provide rapid continuous reactive power support during operating conditions. Power quality issues are caused by non-standard voltage, current and frequency

Energy quality has serious economic impacts on customers, utilities and electrical equipment manufacturers. Advances in power electronics technology have allowed the development of a variety of controlled electronic reactive power compensation power system applications, but power factor correction switches have become more reliable. This is because they offer a high degree of flexibility in the design process and are reasonable in different scenarios. Power

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quality is also improved by incorporating a power factor correction switch.

II. Brief Background

The power factor of an AC power system is defined as the ratio of the actual force absorbed to the apparent force flowing through the load in the cycle, and is the dimensionless number of 1 in the closed space of -1. The power factor of less than one indicates that the voltage and current are different, reducing the average output of the grid. Real power is the immediate product of voltage and current, which refers to the ability of electricity to work. The average product of current and voltage is the apparent power. The apparent force may be greater than the actual force due to the non-linear load that is stored in the load and returned to the source or distorts the waveform of the current received from the source. A negative power factor occurs when the device generates (usually a load) power and then flows toward the source.

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Power factor correction can increase the power factor of loads, thereby improving the efficiency of the power supply system in which the load is connected. Low power factor linear loads such as induction motors can be adjusted by a network of passive capacitors or inductors. Non-linear loads such as rectifiers may distort the current received from the system. In this case, the active or inactive power factor can be used to offset the correction distortion and increase the power factor. The equipment used to fix the power factor may be located in the central substation, distributed in the power supply system, or built into the power consumption equipment.

III. Definition And Calculation

AC power flow has two components:

- Real power or active power (sometimes called average power), expressed in watts (W)
- Reactive power usually expressed in reactive volt-amperes (var)

These are combined with complex power to refer to the volt-ampere (VA). The magnitude of the complex energy is expressed in voltage-amperes and volt-amperes (VA).

VA and VAR are non-SI units that are mathematically equivalent to tile, but in engineering practice, the impact of the distoration does not reveal what size is used. This SI does not expressly authorize the use of a utility unit as the sole source of information for this purpose or body sizes.

The power factor is defined as the ratio of the apparent force to the actual force. Since the power is transmitted through the transmission line, it is not simply transmitted to the load at a time. It is made up of real energy, but is a combination of real and reactive power, called the apparent force. The power factor describes the actual force transmitted along a transmission line compared to the total apparent force flowing in the pipeline.

3.1. Power Triangle

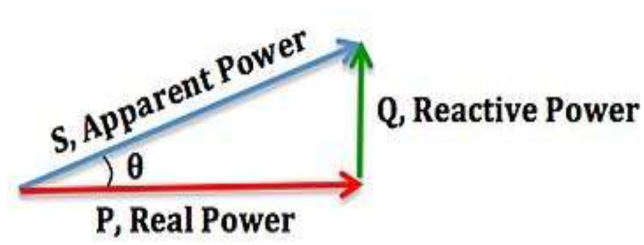

Figure 1: Model Power Traingle

One can specify the various components of AC power by applying power triangles in the vector space. The actual power is in the direction of I because it represents a completely real horizontal extension of the AC power source. The reactive power extends in the direction of j because it represents the pure imaginary components of the AC power source. Complex power (and its magnitude, apparent power) refers to the combination of real and reactive power, so it can be calculated using the vector sum of these two components. We can decide the mathematical relationship between these components is:

3.2. Increasing Power Factor

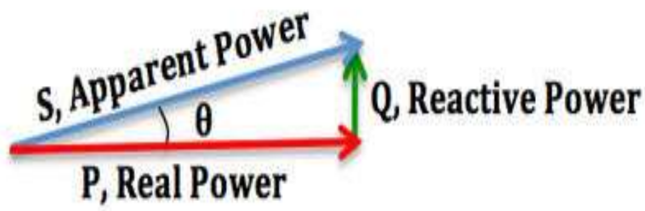

Figure 2: Increasing Power Factor

As the power factor (i.e. cos θ) increases, the ratio of real power to apparent power (which = cos θ), increases and approaches unity (1), while the angle θ decreases and the reactive power decreases. [As cos $\theta \rightarrow$ 1, its maximum possible value, $\theta \rightarrow 0$ and so Q $\rightarrow$ 0, as the load becomes less reactive and more purely resistive].

3.3. Decreasing Power Factor

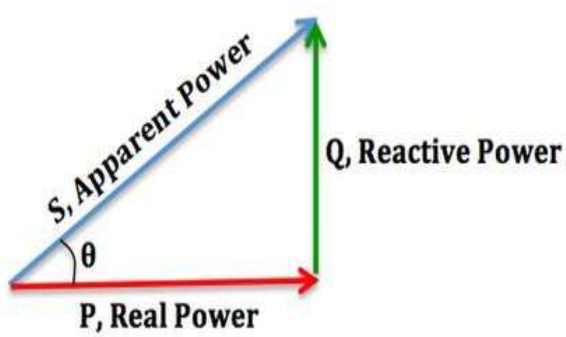

Figure 3: Decreasing Power Factor

As the power factor decreases, the ratio of real power to apparent power also decreases, as the angle θ increases and reactive power increases.

3.4. Lagging and Leading Power Factors

There is also a difference between backward and leading power factors. The phase of the current indicates whether the phase of the voltage is guiding or lagging. The backward power factor indicates that the load is inductive. When the load "consumes" the reaction force, the reacting force travels through the active component circuit and is "consumed" by the inductive load. The load "supply" refers to the reactive power, the leading power factor, as the load capacity, so that the reactive power is supplied to the reactive power circuit which is negative.

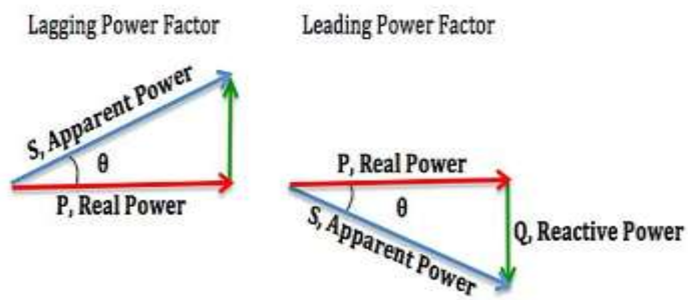

Figure 4: Lagging and Leading Power Factor

If θ is the phase angle between the current and voltage, then the power factor is equal to **the cosine of the angle : cos θ.**

Since the units are the same, the power factor is the dimensionless number between -1 and 1. When the power factor is equal to 0, the energy flow is completely reactive, and the energy stored in the load is returned to the power source in each cycle. When the power factor is 1, all the energy consumed by the electricity is consumed by the load. The power factor is usually expressed as "lead" or "lagging" to indicate the phase angle. Capacitive load leads (current leads voltage), inductive load regressions (current lag voltage).

If the total resistive load is connected to a power source, the current and voltage will gradually change the polarization, the power factor will be 1, and the energy will flow in the same direction through the energy network in each cycle. Inductive loads (induction motors (like any kind of wound coil)) use reactive power, and the current waveform reduces the voltage. Capacitive loads (such as capacitor banks or buried cables) generate reactive power, and the current phase leads to voltage. Both types of load absorb energy for a portion of the AC cycle, and this energy is stored in the magnetic or electric field of the device, but this energy is supplied during the rest of the cycle.

For example, to obtain 1 kWA of active power, you must transmit 1 kVA of apparent power (1 kW ÷ 1 = 1 kVA) if the power factor is 1. In the case of a low power factor, more apparent power must be transmitted to obtain the same active force. To obtain 1 kW of active power at a power factor of 0.2, 5 kVa of transmitted power must be transmitted (1 kW ÷ 0.2 = 5 kVa). This apparent power must be created and transmitted to the load, and it will suffer losses during production and transmission.

Electrical loads that consume AC power use active and reactive power. The vector sum of the active and reactive power is the apparent force. Balance of reactive power The active force is less than the apparent force, so the power factor of the electric load is less than one.

Returning electricity to electricity results in a negative power factor (0 to -1), for example, in a building with solar panels, when excess power is returned to the power source.

3.5. Distortion Power Factor

The deflection force factor is the deflection component associated with the harmonic voltages and currents in the system. The current is the fundamental wave component, and the total current both root mean square values (the deflection power factor can be used to describe each harmonic, using the relative current instead of the total current). This definition assumes that the voltage is not listed compared to the total harmonic distortion (sinusoidal, no harmonics). This simplification is usually a good approximation of a hard voltage source that undergoes downstream changes in the load distribution network. From the current distortion in the network to the 1–2% sequence of the total harmonic distortion of a typical generator, this can have a large impact, but may be a common practice when multiplying with the displacement force factor (TPF). The result is a total ignore, real power factor or power factor (PF)

3.6. Distortion in Three Phase Networks

In fact, the local impact of distortion current on devices in the three-phase distribution network depends on the degree of some harmonic distortion, rather than the total harmonic distortion, such as third-order or zero-order harmonics (3rd, 9th). When comparing wire to wire, they have the same phase properties. In a delta transformer, these harmonics can cause a rotating current in the delta windings and cause high resistance heat. In the star structure of the transformer, there is no third harmonic current, but non-zero currents are generated in the neutral. In some cases, this can lead to excessive overload and error in kilowatt-hour measurement and billing revenue. The presence of current harmonics waves in the transformer may cause large eddy currents in the magnetic center of the transformer. Eddy current losses generally increase with the square of the frequency, which reduces the efficiency of the transformer, dissipates the additional heat, and shortens its service life.

Negative Sequence Harmonics (5th, 11th, 17th, etc.), along with a phase differential of 120 degrees, are similar to basic harmonics, but in reverse order. In generators and motors, these currents create magnetic fields that resist the shaft rotation and sometimes cause damage to mechanical vibrations.

IV. CAUSES OF TRANSIENTS AND SPIKES

1) Non– linear loads
2) power electronic devices, IT and office equipments
3) arcing devices
4) load switching
5) large motor starting
6) Larger capacitor bank energies

An intermediate is a step caused by the sudden release of a very steep voltage from previously stored energy, which is a trigger or capacitor, created to cause high voltage instability or surge. The energy return circuit due to some switching action suddenly releases energy in the form of a sharp impulse, producing an unstable voltage spike that can be in an infinite value theory.

Such high TV / DT intermediate switching spikes may last for a short period of time (milliseconds or microseconds), or they may occur approximately two or three times per day, ie every short period of time.

4.1. Transient in Power System

Whenever there is a sudden change in the system (for example, due to failure, excessive loading or removal, or power outage), the sine wave differs from its normal shape. This short-term abrupt deviation from a normal sine wave is called an intermediate. They are transient transitions that cause energy bursts.

There are two types of transients: electromagnetic transients and electromagnetic transients. Although they are implemented with each other, they are slightly different.

Changes in voltage and current in electromagnetic transients are usually caused by shutting or opening circuit breakers, equipment malfunctions or malfunctions of power electronics, lightning strikes.

Electro-mechanical transients are caused by the mismatch between power generation and power consumption, which causes the generator to accelerate or slow down compared to its normal speed. The cause is usually interference in the system, i.e. interference in the nearest transmission line.

Thunderstorms can cause voltage spikes and raise hit wires to power your electronic components. Static electricity can cause spikes and surge. For example, if you touch an electronic device after a while on the carpet, you may feel or see sparks coming from your fingers through your gear. This spark is like a mini lightning, which causes spikes or voltage to the devices. Another source of voltage spikes and surge is the magnetosphere or any magnetic field that generates them. This magnetic field will increase the voltage near the wire and cause surge or spikes

4.2. Long Duration Voltage Variations

When the RMS (root mean square) difference exceeds the power frequency of one minute at the end, we say that they are long-term voltage changes. They may be high voltage (greater than 1.1) or low voltage (less than 0.9 pÚ). High voltage is usually the result of a switch load or an excited capacitor bank. Incorrect setting of the transformer plate converter can cause high voltage. Lower voltage is the reverse, which is the result of the event and causes a high voltage during the load switch or the switching of the capacitor bank.

4.3. Voltage Fluctuations and Flicker

Voltage fluctuations are continuous changes in a system with voltage amplifiers or randomly varying voltage amplitudes (which are in the range of 0.9 to 1.1 PU). Higher power loads. A large number of fluctuating currents, such as large motor drives and electric arc furnaces, cause low frequencies. Rotational voltage changes cause light sources (flashing and flashing), which can cause the body to have 3 significant physiological anemia or trigger flickers. The voltage flicker can ensure the operation of electrical and electronic devices such as motors and CRT devices. The typical spectrum of a voltage flicker is from 1 Hz to 30 Hz.

4.4. Waveform Distortion

It is defined as a standard sine wave steady state deviation from the power frequency. There are five types of waveform deflection: i. DC Offset, II. Harmonics, III. Interharmonics, IV. Bevelt corners, v. Noise. The presence of a DC voltage or current in an AC power system is called a DC offset. This could be due to geomagnetic interference or ground return mechanism in a single polar HVDC coupling. DC current in a transformer causes magnetic concentration, increased heat and transformer life. Non-linear loads and power electronics controllers are major sources of harmonics. Fourier analysis can be used to indicate the harmonic distortion. Total Harmonic Deviation (THD) is the most commonly used harmonic measurement system.

4.5. Major Problems that Arise from Harmonic Distortion Are:

1. Extra losses and heating in rotating machines and capacitors,
2. Over voltages due to resonance,
3. Interference with ripple control systems used in Demand Side Management (DSM),
4. Telephone interference caused by noise on telephone lines.

V. Linear Circuits

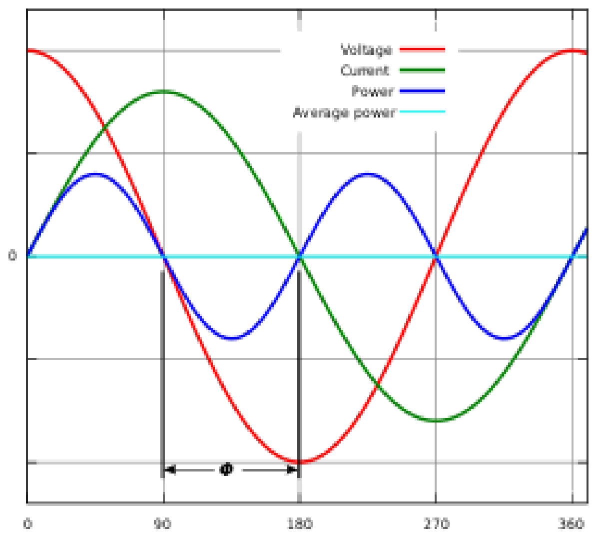

Figure 5: Wave from of Linear Circuits

Instantaneous and average power calculated from AC voltage and current with a zero power factor ($\phi = 90°$, $\cos(\phi) = 0$). The blue line shows all the power is stored temporarily in the load during the first quarter cycle and returned to the grid during the second quarter cycle, so no real power is consumed.

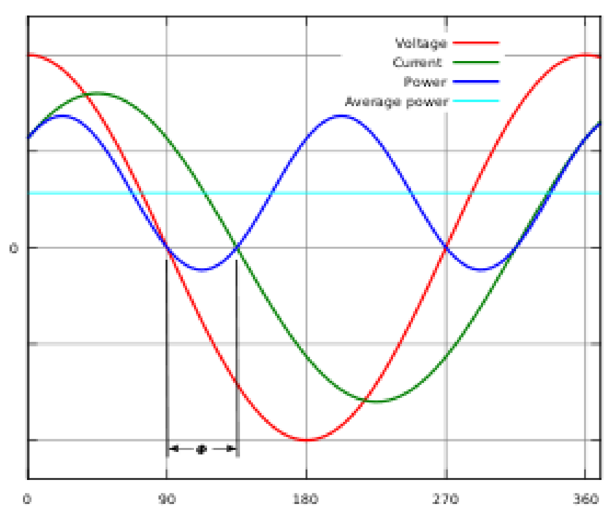

Figure 6: Wave form of Average Power

Instantaneous and average power calculated from AC voltage and current with a lagging power factor ($\phi = 45°$, $\cos(\phi) \approx 0.71$). The blue line shows some of the power is returned to the grid during the part of the cycle labeled ϕ.

In a completely opposed AC circuit, the voltage and current waveforms are in phase (or phase), and the polarity changes simultaneously with each cycle. All energy entering the load is consumed (or dispersed).

Where there are reactive loads, such as capacitors or inductors, the energy savings in the load can make a phase difference between the current and the voltage waveforms. In each cycle of AC voltage, in addition to any energy consumed in the load, the excess energy is temporarily stored in the electric or magnetic field loads, then returned to the grid after a period of time.

Therefore, in the electrical phase, the reactive load can lead to continuous "ups and downs" of the unproductive force. Compared to high power factor circuits, low power factor circuits use a higher current to transmit a certain amount of active power, increase losses due to anti-warming in power lines, and require higher rated conductors to be installed and transformer. A linear load does not change the shape of the current waveform, but it changes the relative time (phase) between the voltage and current.

The power factor of the circuits with the main resistance load (incandescent lamp, heating element) is approximately, but the power factor of the circuits with inductive or capacitive load (motor, solenoid valve, transformer, fluorescent ballast, etc.) is good.

VI. Non-Linear Loads

Examples of non-linear loads in electrical systems are rectifiers (such as the use of electricity), and arc discharge devices such as fluorescent lamps, electric welders or electric arc furnaces. Because the current in these systems is interrupted by the switching process, the frequency components that are now the amplitudes of the electrical system frequency are included. The deflection force factor is a measure of how much the average power is transferred to the high-order harmonic deflection load of the load current.

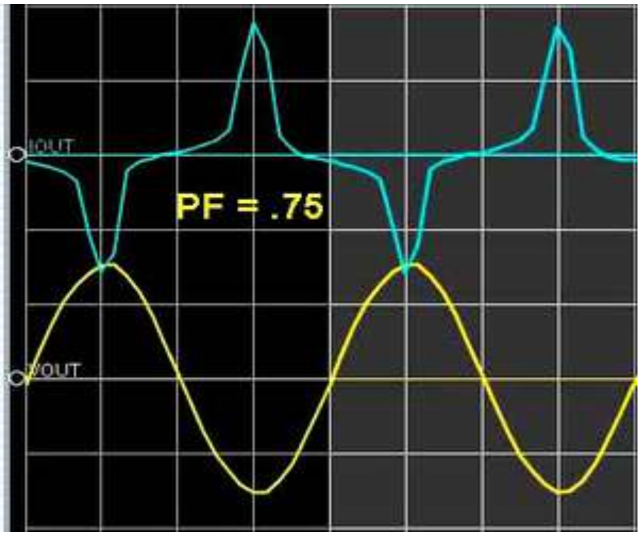

Figure 7: Sinusoidal Voltage and Non-sinusoidal

Sinusoidal voltage and non-sinusoidal current give a distortion power factor of 0.75 for this computer power supply load.

VII. Non Sinusoidal Components

In a linear circuit of voltage with a sinusoidal current and a frequency, the power factor is generated only from the phase difference between the current and the voltage. This is the "displacement power factor".

Non-linear loads change the shape of the current waveform from one sine wave to another. Non-linear loads produce harmonic currents in addition to the linear (fundamental frequency) AC current. This is particularly important in practical power systems with non-linear loads such as rectifiers, certain types of electric light sources, electric arc furnaces, welding equipment, switching power, variable speed drivers and other equipment. Free linear capacitors and inductors filters prevent excessive harmonic currents from entering the distribution system.

To measure actual or reactive power, a non-sinusoidal current must be used to design a wattmeter for normal operation.

VIII. Power Factor Correction Of Linear Loads

High power factors are often preferred in power distribution systems to reduce losses and improve voltage regulation at load. Compensation components adjacent to the power load will reduce the apparent power requirements of the power supply system. Power factor correction can be used by power transmission applications to improve network stability and performance. An electric customer charged by a utility company for a low power factor can install corrective equipment to increase its power factor, thus reducing costs.

Power factor correction provides or absorbs reactive power, and adds capacitors or inductors to eliminate the induction or capacitance effect of the load, thus approaching the power factor of the AC circuit. If the induction effect of the motor load is canceled, a capacitor can be connected locally. These capacitors help to generate reactive power to meet the requirements of inductive loads. This eliminates the need for reactive power on the way from the utility generator to the load. In the electric field, the inductors are said to consume reactive power, while the capacitors provide reactive power, although the reactive power is the energy that moves back and forth with each AC cycle.

Voltage fluctuations and compatible noise can be generated when turning on or off the reactive components in the power factor correction device. They provide reactive power quality with or without load operation, which increases the system's load loss. At worst, the reactive components can interact with the system and cause vibrational conditions to each other, resulting in system instability and severe high voltage fluctuations. Therefore, you cannot use unplanned analysis for reactive components.

8.1. An Automatic Power Factor Correction Unit

1. Reactive Power Control Relay; 2. Network connection points; 3. Slow-blow Fuses; 4. Inrush Limiting Contactors
2. Capacitors (single-phase or three-phase units, delta-connection); 6. Transformer (for controls and ventilation fans)

The automatic power factor correction unit contains several capacitors replaced by communication devices. These contacts are controlled by power factor regulators measured in the electrical network. Depending on the load and power factor of the network, the power factor controller will change the required volume of the capacitor at one point and ensure that the power factor is above the selected value.

Instead of a set of switch capacitors, a load-free coherent motor can provide reactive power. The reactive power drawn by a coherent motor is its field excitation function. This is called a synchronous capacitor. It is launched and connected to the grid. It is a leading power factor and acts as a support the voltage of the system or at a certain level to maintain the power factor network of the system.

The installation and operation of synchronous capacitors are identical to those of large electric motors. Its main advantage is that it is easy to adjust the size of the revision; It acts like a variable capacitor. Unlike capacitors, the amount of reactive power provided is proportional to the voltage, not the square of the voltage; This improves the stability of large network voltages. Cohesive capacitors are commonly used in large industrial plants such as HVDC transmission projects or steel mills.

Power electronics for high-voltage power systems or power electronics such as large, fluctuating industrial loads, static wire compensators or STATCOM are increasingly used. These systems can compensate for sudden power factor changes faster than contact-switch capacitor banks, and are solid-state requiring less maintenance than coherent capacitors.

IX. NON LINEAR LOADS

Switched Mode Power Supplies

One important type of non-linear load is millions, which are usually connected to switch-mode power supply (SMPS) on individual computers with an estimated output power of some watt to 1 kW. Historically, this low-cost power supply was incorporated into a simple full-wave rectifier and was performed only when the instantaneous voltage of the mains exceeds the voltage of the input capacitor. This results in a very high rate of peak-to-average input current, leading to a low distortion power factor and serious phase and neutral concerns.

A conventional switching power source is first converted from an AC power source into a DC bus with a bridge rectifier or similar circuit device. The output voltage is from that DC bus. The problem with this is that the rectifier is a non-linear device, so the input current is not very linear. This means that the input current has energy in the harmonics of the frequency of the voltage

This is a special problem for power companies because they cannot compensate for the reactive power and harmonic currents that can be drawn by the linear load because they can draw simple capacitors or inductors. Many jurisdictions have laws requiring power factor correction to a certain power level over all power supplies.

Regulators like the EU have compliance limits as a way to increase the power factor. Reducing component costs has accelerated the implementation of two different approaches. All switching power supplies with output power above 75 watts must have a minimum idle power factor correction in accordance with current standard EU EN61000-3-2. 80 plus power certificate requires a power factor of 0.9 or higher.

X. POWER FACTOR CORRECTION (PFC) IN NON LINEAR LOADS

10.1. Passive PFC

The easiest way to control high harmonic currents is to use the current passing through a filter at the line frequency (50Hz or 60Hz). A filter has a capacitor or inductor and the non-linear device looks like a linear load. An example of a passive PFC is a valley filling circuit.

The disadvantage of passive PFC is that it requires larger inductors or capacitors than equivalent power active PFC circuits. In addition, in practice, passive PFC is generally less effective in improving the power factor.

XI. MEASUREMENT TECHNIQUES

The power factor in a single-phase circuit (or a uniform three-phase circuit) can be measured using the watts ammeter, voltmeter system, where the power in watts is the product of the measured voltage and divided by the current. The power factor for a uniform polyphase circuit is the same at any stage. The power factor for the unbalanced polyphase circuit is not uniquely defined

TECHNICAL ADVANTAGES OF POWER FACTOR CORRECTION

By adjusting a power factor installed locally to provide the required reactive power at the same level of the required output power, the current value can be reduced so that the total power is absorbed on the load side; This means many advantages, one of which is the greater use of motors (generators and transformers) and power lines (transmission and distribution lines).

Better Utilization of Electrical Machines

According to the apparent power S of the generator and transformer, the small reactive power Q is supplied at the same level as the active power P, said the small apparent power. As a result, by increasing the power factor of the installation, these machines can be scaled to less obvious power, but still deliver the same active power.

Better Utilization of Electrical Lines

The advantage of allowing power factor correction is cable efficiency. In fact, at the same output power as mentioned earlier, the current becomes smaller by increasing the power factor. This reduction can be as simple as allowing the conductor and the lower cross section to be selected.

Reduction of Losses

The power loss of the electrical conductor depends on the resistance of the conductor and the square of current flowing through it; This is because, with the same value of the transmitted active force, the higher power factor reduces the current, which is: When the power factor increases, the loss of the power side conductor at a point where the power factor is corrected will be reduced.

ECONOMIC ADVANTAGES OF POWER FACTOR CORRECTION

The Electricity Supply Commission adopted a tariff system and fined energy consumption, with an average monthly power factor below 0.9. The contracts used vary by country and may vary depending on the type of customer: Therefore, the following description is intended to illustrate only the descriptive and descriptive information and the economic savings that can be obtained: power factor correction. Generally, when the power factor is in the range of 0.7 to 0.9, the absorbed reactive energy must be exerted for the terms of the power supply agreement, and if the power factor exceeds 0.9, there is no reason. For a power factor of less than 0.7, the power supply department can implement it.

Consumers make power factor correction. It should be noted that the average monthly power factor is greater than or equal to 0.9, meaning that the reactive energy requested from the network is less than or equal to 50% of the active energy: therefore, if the demand for reactive energy is not greater than 50% of the active population. Consumer's annual cost when consuming reactive power above a power factor equal to 0.9

GENERAL ADVANTAGES OF POWER FACTOR CORRECTION

- Decreased monthly energy costs.
- Efficient electrical system.
- Reduced loading on transformers.
- Reduced loading on distribution lines.
- Reduced voltage drops.
- Reduced wear and tear on electrical equipment.
- Increased load handling capability of the plants electrical system.

DISADVANTAGES OF LOW POWER FACTOR

- Increased energy costs.
- Overloaded transformers.
- Overloaded distribution lines.
- Resulting in voltage drops and needless wear and tear on electrical equipment.
- Reduced load handling capability of the plants electrical system.

XII. CONCLUSION

The proposed automatic power factor correction systems have some reactive current or reactive power ratings. When the reactive power detected by the absorption load is greater than the compensation level, the power factor will not be corrected for integration, but it will definitely be improved and the apparent power supplied by the AC power source will be reduced. These systems respond almost linearly in the area of pre-allocation throughout the activity. They achieve better power quality by reducing the apparent power received from AC power and reducing power transmission losses. In addition, the harmonic interference power system network is not released, so no filtering is required. The proposed system works better than traditional methods of reducing harmonics and improving the power factor.

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