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Impact of Power Factor on the Advancement of Equipment and Technology

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ABSTRACT
Power electronics equipment and high-voltage systems have become increasingly common, introducing additional harmonics into the grid. Harmonic contamination must be reduced, and transmission performance must be improved, which necessitates power factor adjustment. A number of methods have been proposed for power factor adjustment. The technique of utilizing a Programmable Interface Circuit chip to build the power factor corrector of a 3-phase power system was described and planned in this article. Sensors and a programmable interface circuit detect and measure the load's power factor value. The information is moved to an algorithm, which subsequently triggers capacitors based on the algorithm's performance. The capacitor also turns on the lag and lead power factors, which are shown on an oscilloscope LCD panel. This will assist to compensate for voltage regulation and contributes to a power factor that is closer to unity, thus enhancing the performance of the power system.

Keywords
Capacitor Banks, Oscilloscope, PIC Microcontroller, Power Factor, Pulse Width Modulation, Real Power, Reactive Power.

1. INTRODUCTION
The power factor is defined as the ratio of real power used by an electrical load to reactive power delivered to the load. It is an indicator of the efficiency with which current is converted into usable work or actual power and is an indicator of the impact of load current on the device supply[1]. A lesser energy factor indicates that the perceived power provided to the load is higher than the real power used by the load, resulting in supply and distribution system losses. A capacity with a unit power factor is extremely effective and has comparable losses when compared to a load with a voltage level of half. A large phase difference between current and voltage could lead to a poorer power factor due to various factors, such as power transformers, lighting ballasts, induction or welder furnaces.The paper will focus on designing and implementation of correction of power factor by using a microcontroller chip of PIC, determination of the system's power factor, generating proper action for calculating the capacitor to get back the power lost during the designing of the project. The problems arising due to lower power factor as discussed[2].The main source of getting capacitive reactance is capacitor and it supplies negative power. The relationship between real power and reactive power is given in figure 1 in the form of a power triangle[3].

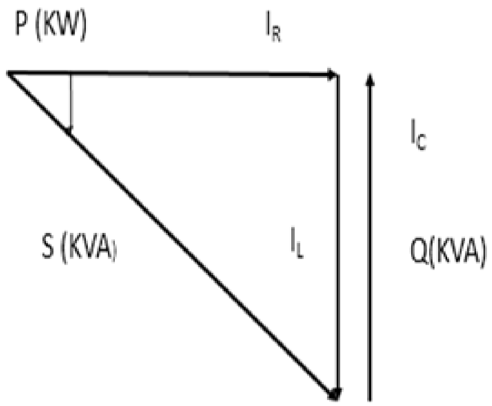

Figure 1: Form of a Power Triangle

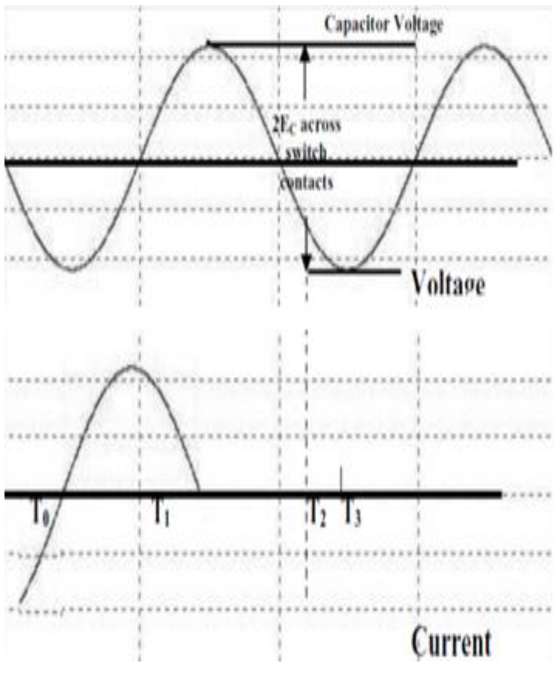

Figure 2: Graph of voltage and current at the contacts of switch

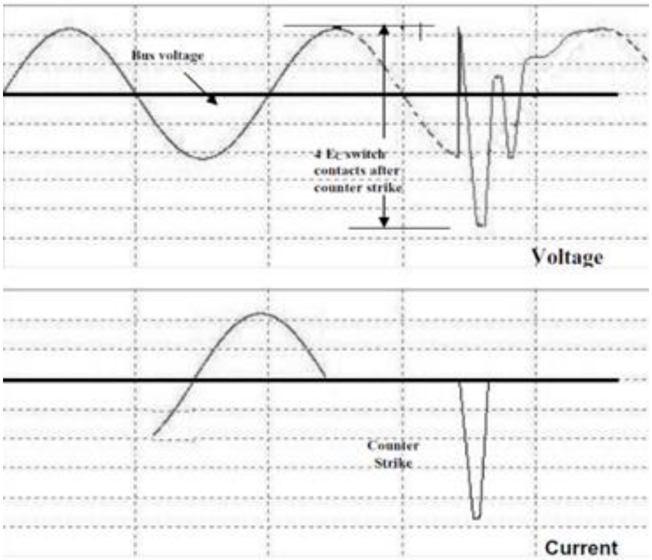

Figure 3: Difference between line and capacitor voltage causes strike

Power systems have shunt-connected capacitors and provide the device with leading VARs as needed. Because most inductive loads are inductive in nature, the impact of lagging loads needs to be eliminated by a leading power factor. The first step in installing fixed capacitors is to decide the power factor before the capacitor banks are designed, but only 94 percent of the efficiency is limited. To increase the efficiency up to 96%, switched capacitor banks are used. Whenever the switched capacitor is being used the control of switching capacitor is assigned to close bank connection as soon as the power reaches to two-thirds of the power supply. The three phase system has capacitors installed in an isolated insulating metal box called a capacitor bank[4]. The capacitor on load side has the same voltage as on the supply voltage, thus initial voltage is zero practically in the three phase bank of capacitors connected in the delta having its neutral grounded. The capacitor current will lead voltage by 90 degrees. In Figure 2, the relationship between the current peak and the capacitor voltage at the initial time is given. The voltage across the capacitor will overshoot and increase by three times across the switch gap if there is a voltage shift. The same behavior could be found in the first current zero as this will cause an interruption and normal maximum voltage will increase to three times around the capacitor.Here, T0 is the start of the switch, T1 is the first zero current, T2 is the half cycle after T3 is the first zero current when the switch is fully opened. Switch touch will appear four times after half a cycle, as seen in figure 3. The time span of the overshoot is counter striking for the circuit.

1.1. Solar Power Systems

A photovoltaic system is a device that transforms sunlight into electricity. Semi-conductive materials are utilized in the production of solar cells in this system, which convert photons' self-contained power into electricity whenever exposed to sunlight. The cells are arranged in a fixed or moving array to follow the sun and produce the greatest amount of energy. They generate no pollutants and need very little upkeep. They may, however, be very expensive. To remove the economic obstacles that are now preventing widespread adoption of PV systems, less cost components and improvements in the production process are needed. Photovoltaics are presently being utilized to produce green electricity in distant areas without access to the grid[5]. Photovoltaic panels, often known as solar panels, are readily accessible for both commercial and residential usage. Panels start at less than 5 kW and may be joined to create any size system. These systems are environmentally benign, emitting no pollutants, are simple to use, and utilize only solar light as a source of energy. They do, however, need vast areas and a hefty initial investment.

1.2. Turbines (Wind)

Wind turbines convert the energy from the wind into electricity. Because the wind is a very changeable source that cannot be stored, it must be treated as such. They are a reasonably cheap (in comparison to other renewable) method to generate energy, but they are inadequate for continuous power requirements since they depend on the changeable and sometimes unpredictable wind.

1.3. Fuel Cells (FC)

Fuel cells are mostly not very efficient, but they also emit relatively little pollution. A fuel cell works similarly to a battery. The functioning of a fuel cell is analogous to that of a battery that is constantly charged with a high-hydrogen-content fuel gas; this is the charge of the fuel cell combined with air, which provides the necessary oxygen for the chemical reaction.

1.4. Micro Turbines are Small Wind Turbines that Produce Electricity

Micro turbines are a novel and developing technology that is presently only available from a few manufacturers. A micro-turbine is a device that converts thermal energy into mechanical energy by using the flow of a gas. The combustible (typically gas) is combined with air pushed by the compressor in the combustor chamber. This product causes the turbine to spin, triggering the generator and compressor at the same time[6]. The compressor and turbine are placed atop the same spindle as the electric engine in the most typical configuration.

1.5. Synchronous Generators and Induction

Induction and synchronous generators are electrical devices that transform mechanical energy into electrical energy, which is subsequently sent to the network or to loads. Because when shaft of an induction generator rotates faster than the synchronous frequency produced by a prime mover, it generates electrical power (turbine, engine). The rotor flux direction, and even the orientation of the active currents, are adjusted, enabling the machine to power the load or network to something that is attached. The induction generator's power factor is load dependent, and its speed may be permitted to change with the wind speed using an electronic controller.

1.6. The Effect of DG on the System's Behavior

The effect of distributed generation on the voltage profile, system losses, and system dependability will be shown in this part of the.

1.7. Characteristics of Voltage

Tap changes at substation transformers and the usage of voltage regulators and capacitors on feeders are typically used to control distribution networks. Power flows from the substation to the loads are assumed in this kind of voltage control. Meshed power flows introduced by DG may conflict with conventional regulatory methods. The voltage profile is improved by increasing the size of the distributed generator, however this sizing must be controlled by rigorous system analysis or by the generator regulating itself, since large generators may cause over voltages.

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1.8. Losses

Because of its closeness to load centers, DG has a major effect on electric losses. DG units should be placed in locations where they can reduce losses the most. The DG allocation method is comparable to the capacitor allocation approach in terms of minimizing losses. The key distinction is that DG units have an effect on both active and reactive power, while capacitor banks only have an effect on reactive power flow.

1.9. Sustainability

A power system's aim is to provide energy to its consumers in a cost-effective and dependable way. Because the expense of disruptions and power outages may have a significant economic effect on the utility and its consumers, it is essential to design and maintain dependable power systems. Because distribution failures are more confined and less expensive than generation or relation to access outages, reliability research and assessment methods at the distribution level have traditionally lagged behind those at the generating level[7]. However, a study of utility customer outage data has shown that distribution system failure is the single greatest contributor to supply unavailability.

1.10. Applications of the DG

Part consumers are now using distributed generation to meet some or all of their energy requirements. DG technologies have a wide range of possible uses. Some clients, for example, utilize DG to decrease their electric utility's demand costs, whereas other use it to supply primary power or minimize environmental pollutants. Electric utilities may also utilize DG to improve their distribution networks[8]. There are many more uses for DG solutions.A list of those that may be of interest to electricity companies and their consumers is provided below

- Constant Power
- Cogeneration (combined heat and power)
- Maximum Power
- Revocation of Distribution networks
- Power of Ancillary Service
- Green Energy
- Backup Power System

2. LITERATURE REVIEW

The writers Anant Kumar Tiwari, Durga Sharma, Vijay Kumar Sharma have developed a self-adjustable power-factor corrector that always tries to make the system's power factor equal to unity. The automatic power factor corrector is used to provide the unity power factor using capacitive banks. Authors Nagarajan M and Kandasamy have designed a correction unit for power factor correction from 0 to 1 having frequency of 0.1 and operable Upto 500 Hz of frequency. The PIC measures the power factor through sensors and then data is sent over the algorithm as input to and then capacitors were used for supplying the requisite vars as per the output from the algorithm[9]. In paper the power quality has been improved by tracking load power factor continuously. When the power factor is reduced, capacitances of required value are inserted and for this purpose a microcontroller is used.

In paper AhsanShahid has designed a programmable interface controller chip to get the efficiency with lowest cost. The language being used is C and the compiler is MicroC[10]. Authors in have demonstrated work in which ZCD, opto-couplers and EX-OR gates along with an arduino microcontroller have been used to calculate the phase difference between voltage and current.Authors Ravi and et. al. has proposed a technique for design and development of one phase power factor correction using a mico-controller chip which is an Arduino Uno and ATmega328 as The microcontroller and the use of reactive power injection capacitors. A variety of power factor correction techniques were suggested in by using a PIC chip and some algorithm to cause the switching capacitors to compensate the reactive VARs to bring the power factor to 1. In Writers, Md. ShahriaRifat et al.[11] has described a cost effective and simple scheme of power factor measurement and correction by using PIC microcontroller and by using algorithms several capacitors are used to supply the reactive power. The lag-lead power factor is displayed on an LCD along with the number of capacitors.

3. DISCUSSION

Current electrical networks, particularly distribution and transmission systems, are radial distribution systems with centralized generation as that of the power source to serve the demand. Given the increasing development and installation of distributed energy resources in the power system network, it is essential to make the grid smarter and more accurately improve the quality of existing so that it can be used properly and power quality and reliability deterioration may be prevented. Electric energy is transferred from the source of generating to the consumer through transmission and distribution networks, which results in losses. The distribution system accounts for the bulk of these losses. The installation of distributed generators upon that distribution system may reduce power losses.

4. CONCLUSION

One of the most important elements of utilities is power factor, which is engaged in reducing losses owing to decreased power factor, which may rise due to many other factors in the system, such as harmonics. As a result, a microcontroller-based PIC chip with a software algorithm for single as well as three-phase systems was utilized. In a 500 Hz service range, this device tried to bring the load-side power factor closer to unity. The phase angle between both the voltage and current phasors has been constantly monitored and tracked for comparison, allowing for increased accuracy and flexibility in reactive power adjustment. This technique is extremely efficient since it may operate without any human involvement. The suggested method may be utilized on systems that rely on inverters or synchronous motors since they demand a lot of space. Financing for future usage is also required in order to expand its use in a variety of different power plants.

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