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Power Factor Correction and Alert using GSM Module

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ABSTRACT: In an electrical power systems, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. In this 21st century, power quality has become one of the greatest concerns due to the rapidly increased number of industries and consumers who primarily depend on inductive loads and distortion inducing electronic equipment etc. Ultimatum of all these industries and consumers are lesser transmission efficiency and increase in line losses in transmission lines. In order to reduce line losses and improve the transmission efficiency, power factor correction has been suggested as one of the effective measures. This marked the development of many control methods for the Power Factor Correction (PFC). In this thesis we describe the design and development of microcontroller based automatic single-phase power factor correction along with a protective circuit to activate the relays when the power factor cannot be compensated. Also a message is sent to the user via GSM in case the required power factor is not attained. This thesis revolves around measurement of power factor using PIC (Peripheral Interface Controller) microcontroller and then using proper algorithm to switch on and off the capacitor bank in order to attain nominal power factor specified by the utilities.

KEYWORDS: Power Factor, Capacitor Bank, Power Factor Correction, GSM Module, PIC Microcontroller

I. INTRODUCTION

Power factor for the sake of simple definition is the ratio between the real power and the apparent power drawn by an electrical load and this ratio can vary between 0 and 1. The ratio which we have defined above is not a mere theoretical quantity which can be confined to books. It is a quantity that has got wide range of significance in real world day to day phenomena. It is a measure of how effectively the current is being converted into useful work output and more particularly is a good indicator of the effect of the load current on the efficiency of the supply system. Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power. In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor. Linear loads with low power factor (such as induction motors) can be corrected with a passive network of capacitors or inductors. Non-linear loads, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor correction may be used to counteract the distortion and raise the power factor. The devices for correction of the power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment. When an electric load has a PF lower than 1, the apparent power delivered to the load is greater than the real power that the load consumes voltage. All currents will cause losses in the supply and distribution system. A load with a power factor of 1.0 provides most efficient loading of the supply and a load with a power factor of 0.5 will result in much higher losses in the supply system as power required for the operation of an appliance is constant and supply voltage is a constant. So a low power factor causes high current flow through the transmission lines thereby increasing the losses through the transmission lines as losses are proportional to the square of the current owing through the lines. As the current owing through a line increases due to low power factor, ratio of power output to MVA generated decreases. A poor power factor can be the result of a significant phase difference between the voltage and current at the load terminals. Poor load current phase angle is generally the result of an inductive load such as an induction motor, power transformer, lighting ballasts, welding machine or induction furnace etc, which serve as backbone to many industries. A mechanism to automate power factor correction is the primary objective of this thesis. This project focuses on the design and implementation of microcontroller based automatic power factor correction using PIC Micro-controller chip.

There were many previous works carried out to improve the power factor. A brief description about the literatures that have been carried is given below.

Md. Raju et al. [1] proposed a new method which improves the power factor automatically of varying lagging loads to unity, using one single large shunt capacitor instead of using a bank of switching capacitors. Basically, this control scheme is a static power factor correction method by continuous voltage or current control of a capacitor. In this work the voltage across the capacitor is being changed by a bi-directional switch to control the magnitude of compensating capacitor current and thereby attaining unity power factor. This system incorporates high-speed insulated gate bipolar transistor switching technology. The gate signal of the switching devices is generated by using a compact and commercially available IC chip SG1524B.The scheme is simple in this sense that it uses only one static bi-directional switch controlled by an electronic control circuit that uses only analog ICs and some discrete digital components. T. W. Kim et al. [2] suggested a high-performance line conditioner with excellent efficiency and power factor. In this paper they proposed a fast output voltage controller by utilizing a fast input voltage detection method and a feed forward controller with current-limiting capability for various impulsive loads. This paper proposes a technique that is characterized by successful impulsive loading and quick recovery of the output voltage. They proposed a high-efficient line conditioner with excellent performance. The line conditioner comprises of a three-leg rectifier-inverter, which functioned as a boost converter and a buck converter. The proposed line conditioner combines low cost with excellent performance. The experimental results confirm that the proposed current limit technique has good current-limiting characteristics for impulsive loads and quick recovery of output voltage. Mr. Anant Kumar Tiwari et al. [3] proposed an automated project which involves measuring the power factor value from the load using microcontroller. Design of this auto-adjustable power factor correction is to ensure that the entire power system always preserves unity power factor. In this paper they explains a method in which both the waveforms are fed to zero crossing detectors, which give square waves in digital format. These digital waveforms are used by microcontroller to calculate power factor. Microcontroller takes decision to switch appropriate capacitor bank to compensate for power factor. The software and hardware required to implement the Power Factor Correction and Alert Using GSM Module suggested automatic power factor correction scheme are explained and its operation is described in this paper. APFC helps to decrease the time taken to correct the power factor which helps to increase the efficiency. Abhinav Sharma et al. [4] presented the design and development of a single phase TRIAC based Static VAR Compensator for reactive power compensation and power factor correction using PIC (Programmable Interface Circuit) micro-controlling chip. The PIC microcontroller determines the firing pulses for the TRIAC to compensate excessive reactive components, thus withdraw PF near to unity. The system is able to adjust the power factor from its low initial value to an almost unity power factor. It is also shown that the PIC microcontroller based switching did not introduce any distortions in the output waveform. P N Enjeti et al. [5] suggested a high-performance single-phase AC-to-DC rectifier with input power factor correction. The proposed approach has many advantages, including fewer semiconductor components, simplified control, and high-performance features, and satisfies IEC 555 harmonic current standards. Simulation and experimental results obtained on a laboratory prototype are discussed.

By going through all these papers we decided to do a project on power factor correction using capacitor bank. We use apparent power and active power for calculating the power factor and PIC16F877A as microcontroller. An alert circuit using GSM module is also added in this project.

II. SYSTEM DESCRIPTION

The circuit mainly consists of two sections namely power factor calculation and power factor correction. The former section includes the circuitry for the calculation of the power factor of the load connected whereas the later section

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improves the power factor near to the unity. The loads that we used are exhaust fan, tubular fluorescent lamp, incandescent lamp and glow type zero bulb. The 230 V, 50 Hz is stepped down using voltage transformer. The power factor is calculated using apparent power and active power. The instantaneous value of current is obtained using a current transformer. This value when passed through filter circuit will give an average value of power which corresponds to apparent power of the circuit. These outputs are fed to the PIC which does the further power factor calculations. PIC 16F877A microcontroller is the heart of this Automatic Power Factor Controller, it finds, displays and controls the power factor. To correct power factor, first we need to find the current power factor. It can be find by taking ratio of active power to apparent power. Then it displays the calculated power factor in the 14*2 LCD Display and switches ON the capacitors if required. When load is connected the power factor is calculated by the PIC microcontroller. If the calculated power factor is less than 0.95 then the relay switches on the capacitor accordingly. The relays are switched using ULN2003 which is basically a driver IC. The current lead in capacitor compensates the corresponding current lag which is usually present in loads. Hence the phase difference between the current and voltage will be reduced.

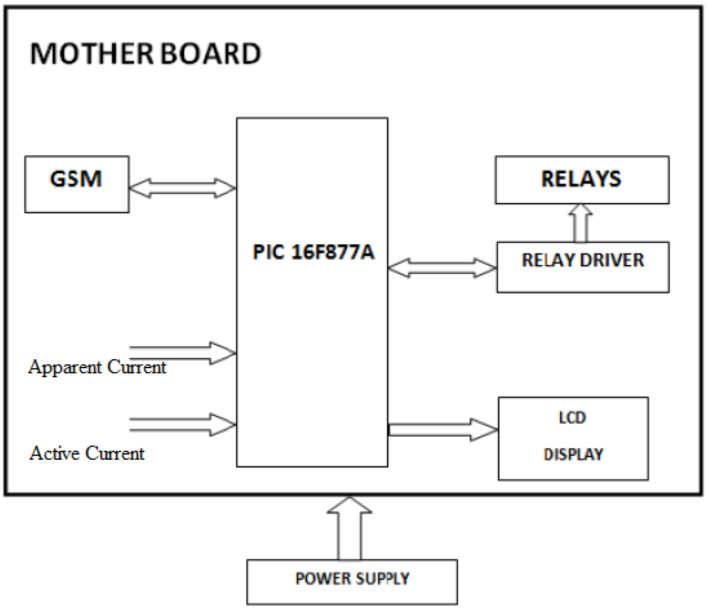

Fig. 1 Block Diagram of the system

The value of capacitors used were 12.5 microfarad and 20 microfarad. If the required compensation is not obtained after adding all the capacitors, an alert is sent to the users mobile via GSM. Also the device is disconnected from the circuit in case further compensation is not done. The device can be turned ON when needed by sending message via GSM. The capacitors are switched in such a way that small capacitor is added to the circuit when the power factor is between 0.80 and 0.92. The large capacitor is added when the power factor lies between 0.65 and 0.77. Both the capacitors are included in the circuit when the power factor becomes 0.50 to 0.62. When the power factor goes below 0.47 both the capacitors are added and also message is send to the users mobile that the device is to be turned OFF. Then the load can be disconnected by sending message ‘ OFF ‘ via GSM. The same can be turned ON by sending message ‘ ON ’.

III. RESULT AND DISCUSSION

The power factor detection side consists of a current transformer which gives a measure of current through the load. From the instantaneous value of current and the average value of current over a duration of time, the apparent and active currents are obtained. From the active and apparent power obtained the power factor of the system with a particular load is calculated. Now the calculated power factor is checked for improvement and required compensation is given in each case. This is controlled via PIC micro-controller. Here we are using two capacitors of 12.5 microfarad

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and 20 microfarad for providing compensation. However, if required compensation is not achieved even after adding all capacitors of the capacitor bank, there is a provision for sending message to the users mobile (via GSM) requesting the user to turn OFF the device thereby reducing power losses in the system.

The loads that we used are exhaust fan (60W) , tubular fluorescent lamp (80W) , incandescent lamp (100W) and glow type zero bulb (10W). The circuit was checked connecting all these loads. The power factor of these loads were obtained from the LCD and were noted. The values of power factor for these different loads are tabulated.

Table 1. Power Factor Obtained for different Loads

Sl. No.	Load	Power factor displayed
1	Exhaust fan 60W	0.71-0.75
2	Tubular Fluorescent Lamp 80W	0.75-0.77
3	Incandescent Lamp 100W	0.77-0.80
4	Glow type zero bulb 10W	0.45-0.47

When the circuit was checked connecting exhaust fan, the capacitor of 20 microfarad was added. The large capacitor of 20 microfarad was switched on when we connected the tubular fluorescent lamp. Similarly when 100W incandescent lamp was connected 12.5 microfarad capacitor was switched on. The power factor for glow type zero bulb is very low and both the capacitors are added to the circuit. Also message is received in the users mobile warning that the power factor is low. The device is disconnected by sending message ‘ OFF ‘ to the SIM inserted in the GSM module. The device can be turned on by sending ‘ OFF ‘ to the same number.

IV. CONCLUSION

It can be concluded that power factor correction techniques can be applied to the industries, power systems and also households to make them stable so that the system becomes stable and efficiency of the system increases. The use of microcontroller reduces the costs. Due to use of microcontroller multiple parameters can be controlled at a time and the use of extra hardwares such as timer, RAM, ROM and input output ports reduces. Care should be taken for overcorrection otherwise the voltage and current becomes more due to which the power system or machine become unstable and the life of capacitor banks reduces. The loads with different inductances are added and accordingly the capacitors are added from the capacitor bank to obtain the desired compensation. Thus the power factor of the circuit is improved. It will also let the user know if the power of the circuit is very low and the compensation cannot be achieved further using the capacitor bank. The device can then turned OFF by sending message to the GSM module and also it can be turned ON later sending message.

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