POWER FACTOR CORRECTION USING PIC MICROCONTROLLER18F4520

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ABSTRACT *The power factor correction of electrical loads is a common problem to all industries. Earlier the power factor correction was done by adjusting the capacitive bank manually. The automated power factor corrector (APFC) using capacitive load bank is helpful in providing the power factor correction up to required power factor. Proposed automated project involves measuring the power factor from the load using microcontroller. The design of this auto-adjustable power factor correction is to ensure the entire power system always preserving unity power factor. The software and hardware required to implement the suggested automatic power factor correction scheme are explained and its operation is described. APFC helps us to decrease the time taken to correct the power factor which helps to increase the efficiency. Further with the PIC architectures advantages obtained i.e. small instruction set to learn, RISCarchitecture, built in oscillator with selected speed, inexpensive microcontrollers, wide range of interfaces including PC, SPI, USB, USART, PWM, A/D, Ethernet eManually power factor correction has many methods. Those methods are having high maintenance and they are much costlier as compared to this method.*

INTRODUCTION

An electrical load that operates on alternating current requires apparent power, which consists of real power plus reactive power. Real power is the power actually consumed by the load. Reactive power is repeatedly demanded by the load and returned to the power source, and it is the cyclical effect that occurs when alternating current passes through a load that contains a reactive component. Power in an electric circuit is the rate of flow of energy passes at a given point of the circuit. In power circuit energy storage elements such as inductors and capacitors may result in periodic reversals of the direction of energy flow. The portion of power that averaged over a complete cycle of the AC waveform, results in net transfer of energy in one direction is known as real or active power. The portion of power due to stored energy, which returns to the source in each cycle, is known as reactive power. Power factor is the ratio of active power to apparent power.

Majority of the loads in the industries are highly inductive in nature such as induction motors,

AC/DC drives, welding machines, arc furnaces, fluorescent lightings, electronic controls and computers. There may be a few resistive loads for heaters and incandescent bulbs. Very few industries may have capacitive loads such as synchronous motors. Net industrial load is highly inductive and they cause very poor lagging power factor. If this poor power factor is left uncorrected, the industry will require a high maximum demand from Electricity Company and also will suffer a penalty for poor power factor. Disadvantages of poor power factor are large kVA rating of equipment, greater conductor size, Large copper losses, Poor voltage regulation, Reduced handling capacity of system etc. Poor power factor can be the result of significant phase angle is generally the result of an inductive load such as an induction motor, power transformer or induction furnace. [1]

This paper focuses on the design and implementation of power factor correction using PIC microcontroller chip, determine the power factor of the loaded power system, and generate proper action to calculate and to add sufficient capacitor so every time power factor becomes unity.

PROPOSED SYSTEM
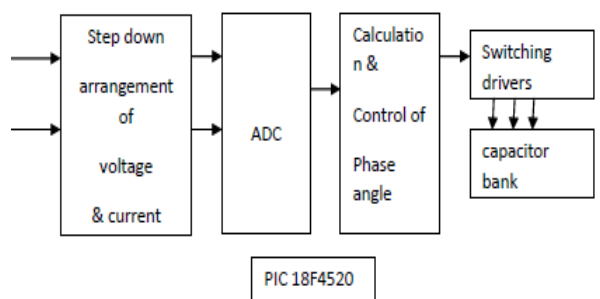
Figure 1: block diagram of Automatic Power Factor

The block diagram of automatic power factor corrector using PIC microcontroller18F4520 is shown in figure1.The AC input i.e. 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is pulsating DC voltage. So in order to get a pure DC voltage the output voltage from the rectifier is fed to a filter to remove any AC components present even after rectification. The ADC is used to convert analog signal into digital signal.The two sinusoidal waveforms are being changed to square waves through two zero-crossing detectors. These digital square waves are used by microcontroller to calculate phase difference and thus power factor. A capacitive load bank is used which develops an electric load applied to an electrical power source and converts or dissipates the resultant power output of the source. In this way we can improve power factor.

CIRCUIT DESIGN
The aim is to monitor phase angle continuously and the event of phase angle deviation a correction action is initialized to compensate for this difference by continuous changing variable capacitors value via switching process.

SENSORS
The alternative voltage and current signals are both sensed and scared down using sensors, while the current is converted into

an equivalent voltage representation. The voltage transducer is able to read both DC and AC signal by converting the captured signal into smaller scale. The current transducer scares down input signal. This device can only be used if ±12…15V is supplied.

ZERO CROSSING DETECTORS

It is a device for detecting the point where the voltage crosses zero in either direction. It can be detected using a specific design circuit. A Sample of a zero crossing detector is shown in figure. When input is too low this design cannot be applied as output pulses tends to be distorted. The actual output being tested and discovered that output waveform was even distorted. As far as PIC chip is within 1W power dissipation, high alternating input voltage are acceptable by the chip input points. A high resistor must be placed externally before the pin in order to ensure very low current supply into it. A typical input AC voltage, Hz, sinusoidal wave will definitely cross from 0 to 2V; therefore a threshold around 1V will allow zero crossing detector accuracy around 32µs.

CAPACITOR BANK

Capacitors are commonly used within a lot of power system especially electronic constructed circuitry. It is most beneficial component for power system as it has many advantages. i.e. release of system capacity, reduction of   kVAr generation requirements, reduction of system loss, improve voltage regulation etc. These benefits require only small amount of investment and maintenance compare to a lot of power system components. In three phase power system, capacitors normally installed within an isolating non conducting metal box, which is called capacitor bank; they are either fixed or switched. The actual capacitor in farads of a capacitor bank can be calculated using following equation. :[3]

$$C = (VAr/2\pi f * VR^2)$$

Where, VAr = capacitor unit VAr rating
$\quad$ C = capacitor in farad
$\quad$ F = frequency in Hz
$\quad$ VR = capacitor unit rated voltage

Standard capacitors sizes are 50,100,150,200,300 and 400 KVAR. Since capacitors can be connected more than one per phase in order to increase the bank size, it is recommended to select two or at most three capacitor unit sizes to avoid stocking the sizes. [7].

CAPACITOR SIZE

(1) First measure present (old) KVA and PF

(2) Calculate active power,   Active Power (kW)   =PF(old)* kVA (old)

(3) Calculate system kVAr, System kVAr=[kVA(old) – kW]$^{1/2}$

(4) Identify a target PF (new) which is unity in our case.

(5) Calculate the new kVA using target PF (new) kVAnew = kW/PF(new)

(6) Calculate new kVAr, kVAr(new) = [kVA(new)- kW]$^{1/2}$

(7) kVAr(new) is the difference between kVAr(sys) and added capacitor's kVAr: kVAr(new) = kVAR(sys) – kVAr(cap)

(8) So kVAR of the capacitors to be installed is _ kVAr(cap) = kVAR(sys) – kVAR(new)

HARDWARE AND CONFIGURARTION

The system may be divided into three stages. In first stage the incoming voltage and current signals are step down to the PIC voltage level (e.g.5V). Here we have used the step down arrangement of the transformer. Second stage is concerned with zero crossing level detection by using an IC (LM324) for voltage and current, the incoming signals. Voltage signal can be acquired by using opto-coupler at the output of Potential. The main part of the circuit is Microcontroller(18F4520 with crystal. After acquiring voltage and current signals they are then passed through the zero cross detector block (ZCD I and ZCD II), that converts both voltage and current waveforms in square-wave that are further provided to microcontroller to detect the delay between both the signals at the same time instant. Two bridge rectifier circuits are utilized to convert both AC voltage and current signal into pulsating DC signal that is further provided to ADC pin of Microcontroller for its conversion   into digital signal, so that the microcontroller performs its further necessary task after this the checking of RMS value for voltage and current is performed, these values are used in the algorithm of Microcontroller to select the capacitor of desired value to counteract the effect of low power factor of the load and monitor continuously which load is operated on the basis of current consumed by the load. Results of corrected power factor, needed capacitor value to correct the
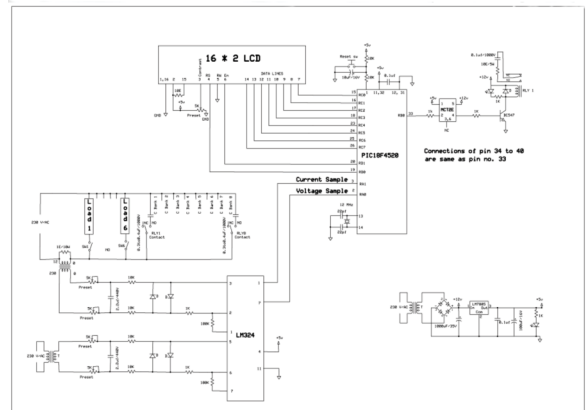

Figure 2: hardware configuration [9]

low power factor to desired value are shown on LCD.

ALGORITHM

The algorithm for this method is shown below
Step-1: Start the program.

Step-2: Initialization the variables and control.

Step-3: Take voltage sample and current sample.

Step-4: Find out time in millisecond between voltage transition and current transition.

Step-5: P.F on LCD display.

Step-6: If P.F is lagging the relay will operate and add capacitor to make P.F unity.

Step-7: If P.F is leading the relay will release and disconnect the capacitor from capacitor bank to make P.F unity.

Step-8: Stop the program.

RESULTS & DISCUSSION

Sr. No.	Load	Supply Voltage in Volt	Supply Current In Amp.	Present P.F. of load lagging	Leading kVAr supplied by cap. bank for targeted P.F.
1	x'mer1	220V	0.1	0.97	5.392
2	x'mer1 &2	220V	0.11	0.89	11.031
3	x'mer1, 2&3	220V	0.17	0.65	28.413
4	x'mer1, 2,3&4	220V	0.24	0.87	26.045

For observation no.1 Required leading kVAr needed to make targeted P.F.(Unity in our case) when present P.F. on load is 0.97 and supply voltage and current are 220V & 0.1 Amp. is supplied by capacitor bank using PIC microcontroller.

CONCLUSION

This paper is an attempt to design and implement the power factor controller using PIC microcontroller. It first measures the power factor and calculates the kVAr and decided how many capacitors are required to improve power factor to unity. At that instant controller stops the capacitors connecting across the load through relay. This paper also facilitates to monitor the power factor changes on LCD in real time.

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