



# International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

## Power Factor Compensation Using PIC

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**ABSTRACT:** In recent years, the power quality of the ac system has become great concern due to the rapidly increased numbers of electronic equipment, power electronics and high voltage power system. Most of the commercial and industrial installation in the country has large electrical loads which are severally inductive in nature causing lagging power factor which gives heavy penalties to consumer by electricity board. This situation is taken care by Power factor correction device. Power factor correction is the capacity of absorbing the reactive power produced by a load. In case of fixed loads, this can be done manually by switching of capacitors, however in case of rapidly varying and scattered loads it becomes difficult to maintain a high power factor by manually switching on and off the capacitors in proportion to variation of load within an installation. The objective of this project is to measure the power factor from using PIC controller and trigger the capacitor bank by using a triac circuit in order to compensate reactive power and the power factor is improved.

**KEYWORDS:** Power Factor, Apparent power, Reactive power, Inductive load, PIC, Triac Circuit, Comparator, Current Transformer, Potential Transformer.

### I. INTRODUCTION

Power factor is the ratio between the KW and the KVA drawn by an electrical load where the KW is the actual load power and the KVA is the apparent load power. 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. When an electric load has a power factor lower than one, the apparent power delivered to the load is greater than the real power that the load consumes. 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. 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, welder or induction furnace. An improved power factor AC output is the main target of this project. This project focuses on the design and implementation of power factor correction using PIC microcontroller chip to determine the power factor of the loaded power system and generate proper action to add a variable capacitor.

### II. BLOCK DIAGRAM

The block diagram of the project is shown in figure 1. The voltage and current from the line are measured using potential and current transformers respectively and are given to zero crossing detectors. The zero crossing detector is an operational amplifier which is used as a comparator with reference grounded. The analog signals are converted to rectangular pulses by the zero crossing detectors which are fed to the microcontroller. These pulses are given to two interrupt pin that is INT0 and INT1 of microcontroller. Microcontroller have internal timer circuit which calculate time in milliseconds which then convert into phase angle. By using the phase angle power factor is calculated and it is displayed on LCD. If the power factor is not within the desired limits it switches the capacitor by firing the triac circuit. A variable capacitance is obtained by varying the duty cycle of the triac.

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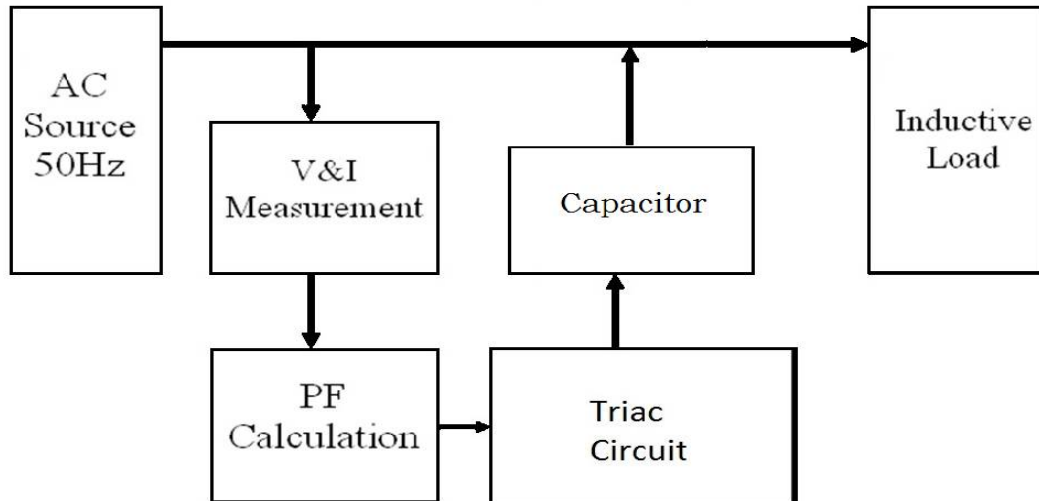


Fig.1 Block diagram of the system

### III. CIRCUIT DESIGN

The design aims 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 the capacitors using triac.

- A. Potential and Current Transformer: The potential transformer is used to read the voltage of the line. It steps down the voltage and is fed to the ZCD (V). The current transformer is used to read the current and it converts the current to equivalent voltage and is given the ZCD (C).
- B. Zero Crossing Detector: As the name indicates the zero crossing detector is a device for detecting the point where the voltage crosses zero. The zero crossing detector is shown in fig 2.

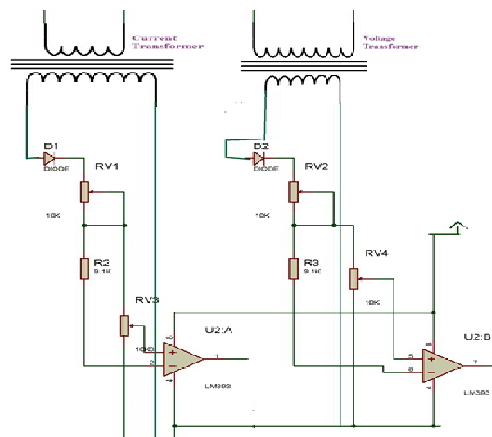


Fig.2 Zero Crossing Detector

The zero crossing detector circuit is an important application of the op-amp comparator circuit. It can also be called as the sine to square wave converter. Anyone of the inverting or non-inverting comparators can be used as a zero-crossing detector. The only change to be brought in is the reference voltage with which the input voltage is to be compared, must be made zero ( $V_{ref} = 0V$ ). An input sine wave is given as  $V_{in}$ .

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- C. Capacitor Bank: Capacitors are commonly used within a lot of power system, especially electronic constructed circuitry. In three phase power system, capacitors are normally installed within an isolating non-conductor metal box which is called capacitor bank, they are fixed or switched or variable. Fixed banks are connected permanently to the primary conductors through fused switches. Switched capacitor banks are tied to primary system through automated switch, allowing them to be put on line and taken off line as needed. Distribution power system usually connects capacitors in parallel rather connecting in series. The function of shunt capacitors is to provide leading KVAR to an electrical system when required.
- D. Triac Circuit: Triac is a power electronic component that conducts in both directions when triggered through gate. The basic triac circuit is shown in fig 3.

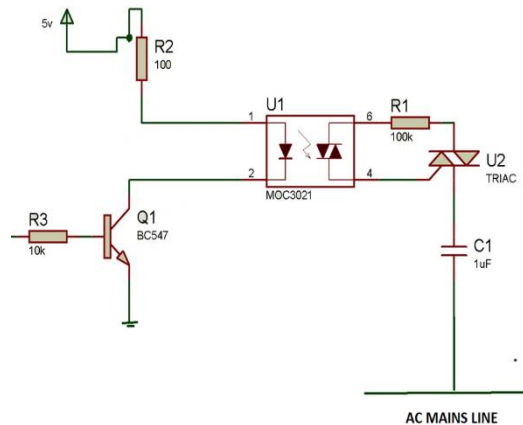


Fig.3 Triac Circuit

MOC3021 is an opto triac that is used for isolation between power and driving circuitry. When the base of BC547 is applied with a voltage  $>0.7V$ , opto triac gets triggered. As the triac gets triggered now, the positive or negative voltage (whatever maybe) get pass through the gate of BT136 (triac) and hence triggered it. It should be noted here that by using above arrangement we can control the RMS voltage in both directions. What needs to be taken care of, is the triggering time or firing angle. By using the triac circuit a variable capacitor is obtained. Here actually we are varying the rms voltage of the capacitor by varying the firing angle of the triac.

- E. PIC 16F877A Features:
- 2 PWM 10-bit
  - 256 Bytes EEPROM data memory
  - ICD
  - 25mA sink/source per I/O
  - Self Programming
  - 2 x 8-bit, 1 x 16-bit timers
  - 8 ch, 10-bit ADC

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Pin Diagram:

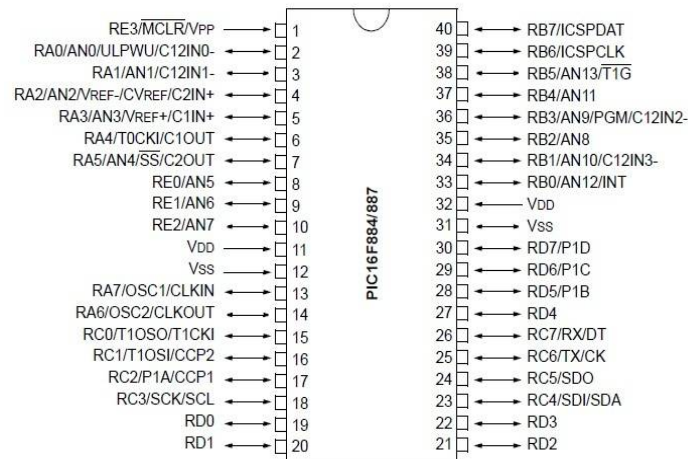


Fig.4 Pin Diagram of PIC16F877A

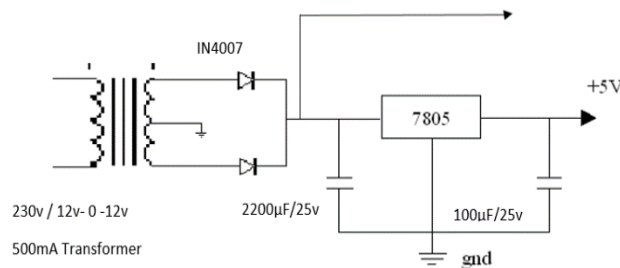


Fig.5 Auxiliary Power Supply

- F. Auxiliary Power Supply: A full wave rectifier is connected across main line to convert AC signal to DC. A capacitor is connected at output of rectifier to get pure DC. The output of full wave rectifier is 12V but the controller works on 5V. Hence output of this full wave rectifier is further given to IC 7805 (Voltage regulator IC) which gives fixed output voltage 5V. A capacitor is connected at the output of IC 7805 in order to get pure DC voltage. Fig 5 shows the circuit of the auxiliary power supply.

## IV. WORKING

Whenever we switch on the circuit the P.T and C.T measure the voltage and current respectively and they are passed through zero crossing detector. The zero crossing detector detects when the voltage and current signals cross the zero reference and these results are sent to the controller. The controller compares the two values and the power factor is measured. If the value is less than the 0.85 the capacitor bank is switched on automatically. The duty cycle of the triac is incremented step by step until the power factor is in between 0.85 to 0.95. If the power factor is greater than 0.95 the duty cycle of the triac is decremented. If the power factor is initially greater than 0.85 there is no action of triac circuit.

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## V. CIRCUIT DIAGRAM

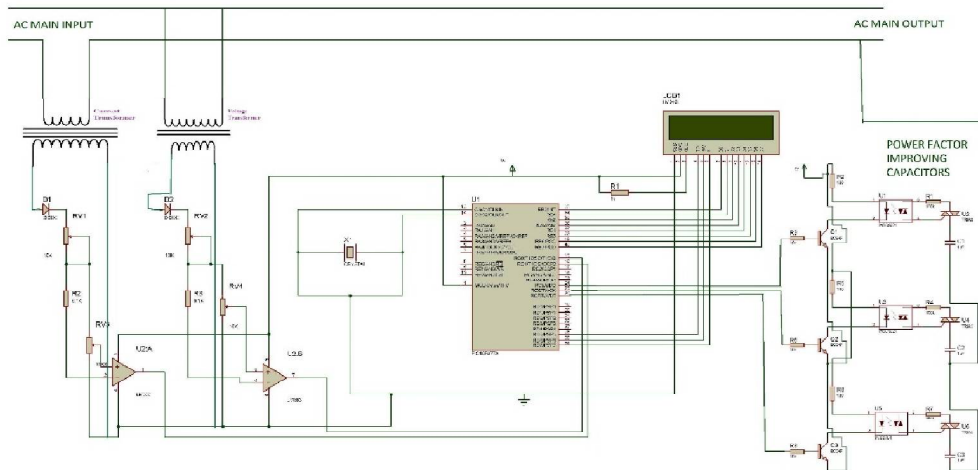
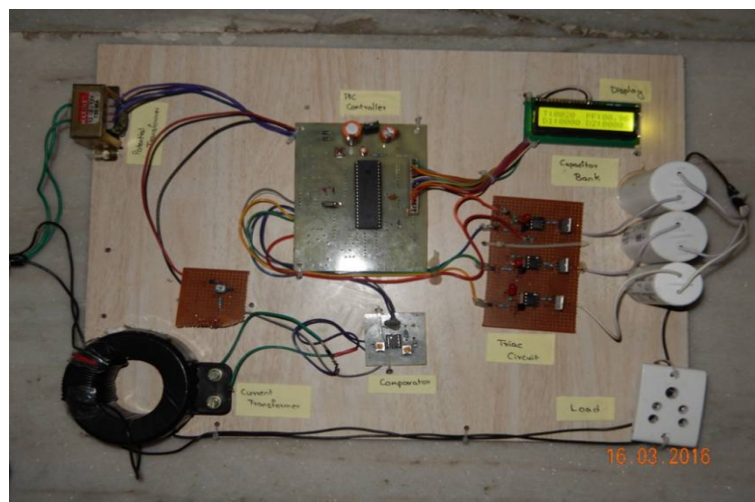


Fig.6 Circuit Diagram

## VI.HARDWARE



## VII. EXPERIMENTAL RESULTS

Load	Power Factor before correction	Power Factor after correction
750W Mixer	0.62	0.86
400W Driller	0.74	0.92
300W Cutter	0.68	0.88
200W Bulb	0.89	0.89



ISSN (Print) : 2320 – 3765  
ISSN (Online): 2278 – 8875

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## **VIII. CONCLUSION**

The automotive power factor correction using capacitive load banks is very efficient as it reduces the cost by decreasing the power drawn from the supply. It can be concluded that power factor correction techniques can be applied to the industries, power systems and also house holds which reduces the power factor penalty and lower energy consumption. The use of microcontroller reduces the costs. Due to use of microcontroller multiple parameters can be controlled and the use of extra hard wares such as timer, RAM, ROM and input output ports reduces. Switching through triac circuit results in addition of variable capacitor instead of fixed value of capacitor which maintains the power factor values within the limits.

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