

Power Factor Correction in Industry by using Microcontroller

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Abstract

Power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a power factor that is less than one. In this study, many small rating capacitors are connected in parallel and a reference power factor is set as standard value into the Microcontroller 16F877A IC. Suitable number of static capacitors is automatically connected according to the instruction of the Microcontroller 16F877A to improve the power factor close to unity. Many control methods for the Power Factor Correction (PFC) have been proposed. This work describes the design and development of a power factor corrector using PIC (Programmable Interface Controller) Microcontroller 16F877A chip. Measuring of power factor from load is achieved by using PIC Microcontroller 16F877A-based developed algorithm to determine and trigger sufficient switching of capacitors in order to compensate demand of excessive reactive power locally, thus bringing power factor near to unity.

Keywords: Power Factor Correction, Zero Cross Detection (ZCD), Microcontroller 16F877A, Relay, Inductive Load, Capacitor Bank

I. INTRODUCTION

Low power Factor in the power distribution system induces the energy crisis in the supply voltage. Most of industrial electric loads have a low power factor not transcending from 0.8 and thus imparts to the distribution losses. There are different methods of low power factor correction. One of the impendent is to use a fixed capacitor as a source of reactive power for compensating local reactive power demand. This approach is more reliable because it implies the count of lagging current in the power factor with very precise step setting in term of calculating the phase angle in power factor correction schemes. The project is to design and analyze the power factor correction in industry by using PIC Microcontroller 16F877A. In the industrial sector the various motoring loads are continuously running and generating the inductive load. Net industrial load is highly inductive causing a very poor lagging power factor. Measuring of power factor from load is achieved by using PIC Microcontroller 16F877A-based developed algorithm to determine and trigger sufficient switching of capacitors in order to compensate demand of excessive reactive power locally, thus bringing power factor near to unity.

However we have proposed an algorithm for automatic detection and controlling of Power Factor for an inductive load comprising of both induction motors as well as resistive load. Moreover detection and correction of power factor is very fast. Microcontroller 16F877A manipulates the developed algorithm to measure the needed reactive power (VAR) that will be supplied through automatic switching of capacitor banks for the improvement of power factor of the load.

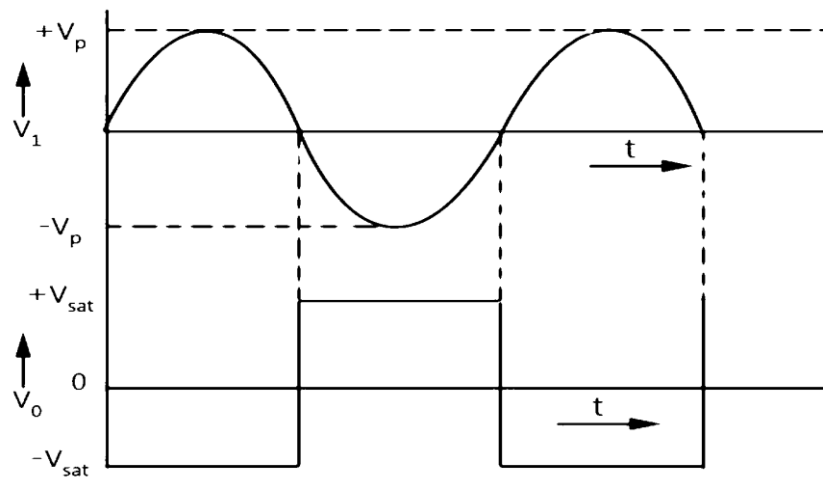


Fig. 1:

II. BLOCK DIAGRAM

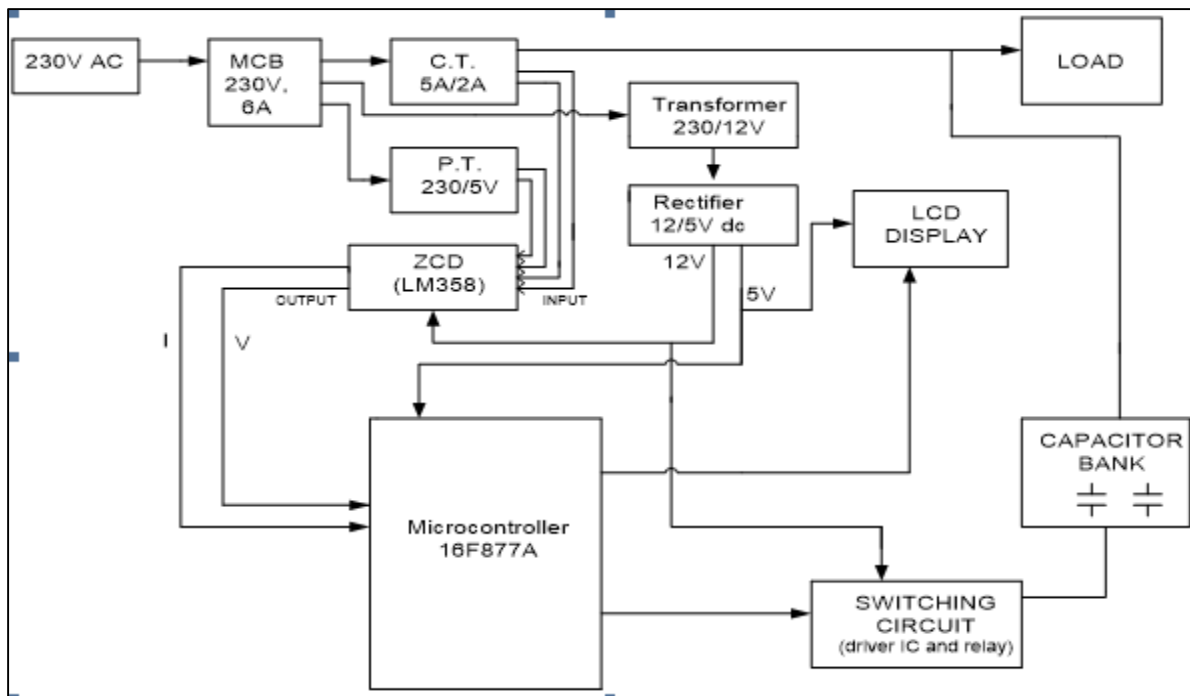


Fig. 2: Block Diagram of Controlling of Power Factor

III. POWER SUPPLY FOR CONTROL CIRCUIT

Circuit model of APFC is shown in Fig.2. This circuit consists of zero crossing detector, Microcontroller 16F877A, relay driver circuit, capacitor bank, and inductive load. The input power is single phase AC, 50Hz. The power is fed from 5V & 12V rectifier bridge circuit. Microcontroller 16F877A is used to calculate the lagging power factor and add the correct capacitance value. Relay driver circuit is controlled by Microcontroller 16F877A for switching the capacitance. Capacitor bank has variable ratings of capacitors in KVAR. These capacitors are parallel connected with source. CT and PT are used to sense the voltage and current waveforms in the circuit.

The 230V, 50 Hz is stepped down using voltage transformer and current transformer is used to extract the waveforms of the current. The output of the voltage transformer is proportional to the voltage across the load and output of current transformer is proportional to the current through the load. These waveforms are fed to the voltage comparators constructed using LM358 op-amp. The output changes during zero crossing of the current and voltage waveforms because of zero crossing detector. These outputs are fed to the PIC for further pf calculations.

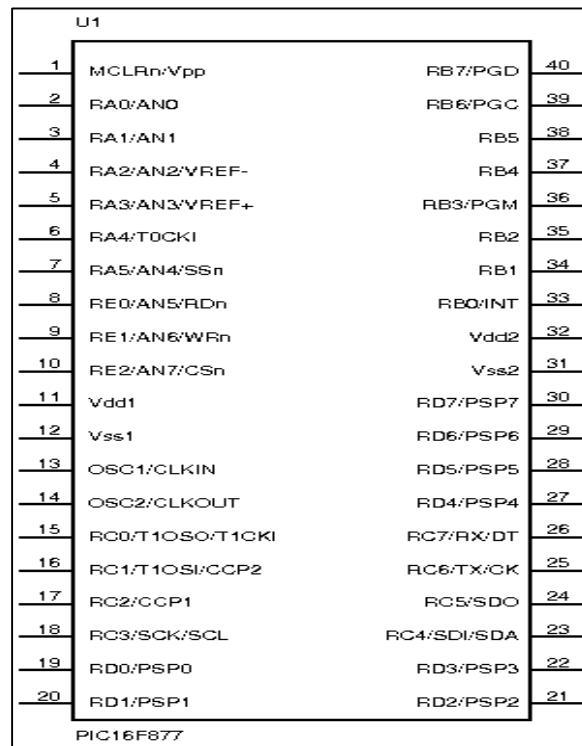


Fig. 5: Pin diagram of Microcontroller 16F877A

VI. CAPACITORS

Capacitors are used to increase the real power, it gives a leading power factor load .so we are adding the capacitors in inductive loads. Capacitor is a reactive current generator, so it is used for the power factor correction. It is rated in KVAR. Circuit model of APFC is shown in Fig.1. This circuit consists of zero crossing detector, Microcontroller 16F877A, relay driver circuit, capacitor bank, and inductive load. The input power is single phase AC, 50Hz. Microcontroller 16F877A is used to calculate the lagging power factor and add the correct capacitance value. Relay driver circuit is controlled by Microcontroller 16F877A for switching the capacitance. Capacitor bank has variable ratings of capacitors in KVAR. These capacitors are parallel connected with source. CT and PT are used to sense the voltage and current waveforms in the circuit

VII. POWER FACTOR CORRECTION

The input to the microcontroller is taken from the zero crossing detectors, whenever there is a positive signal from the potential transformer an counter gets starts in milliseconds and when there is positive signal from current transformer counter will stop. The time period is Δt ,

$$\text{Phase angle } \phi^\circ = 360^\circ * f * \Delta t$$

Where,

- 1) Δt - time delay between current and voltage waveform.
- 2) f -supply frequency

$$\text{Power factor} = \cos\phi$$

VIII. CALCULATION OF CAPACITOR SIZE IN FARADS AND KVAR FOR POWER FACTOR IMPROVEMENT:

Calculation method implies on both single phase and three phase circuits.

Consider motor input, P (kW)

Power factor before correction = $\cos\phi_1$

Desired power factor = $\cos\phi_2$

The required capacitor kVAR to improve the PF:

$$Q_c = P * (\tan\phi_1 - \tan\phi_2)$$

From this formula calculation of desired capacitor size can be found out for the purpose of power factor improvement.

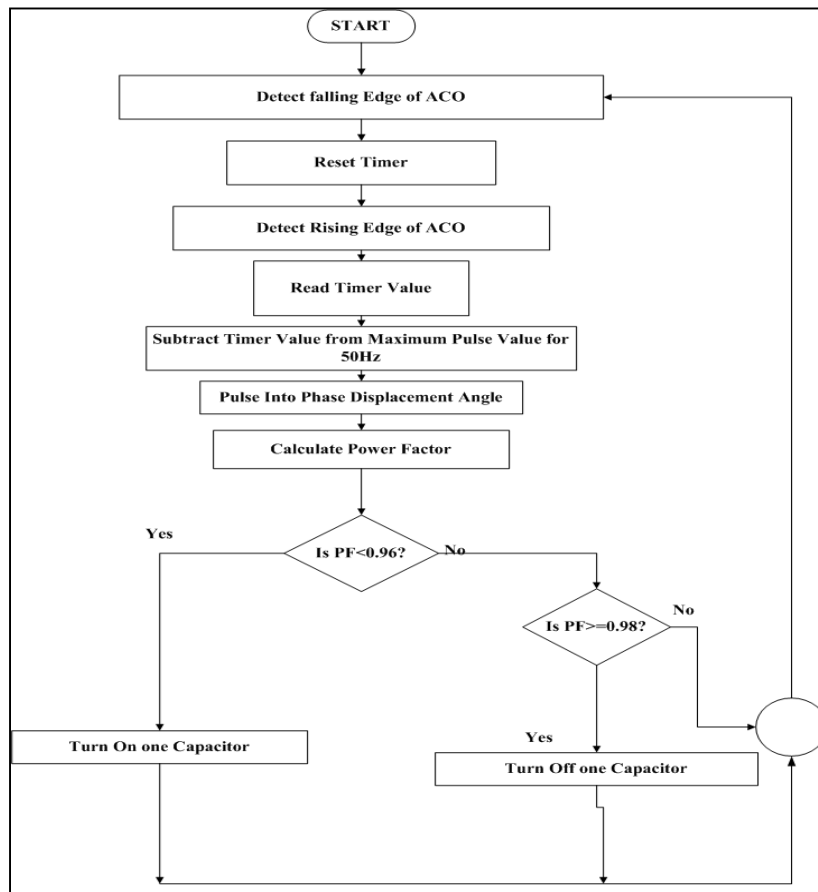


Fig. 6: Flow chart for the operation of microcontroller 16F877A

IX. HARDWARE ANALYSIS

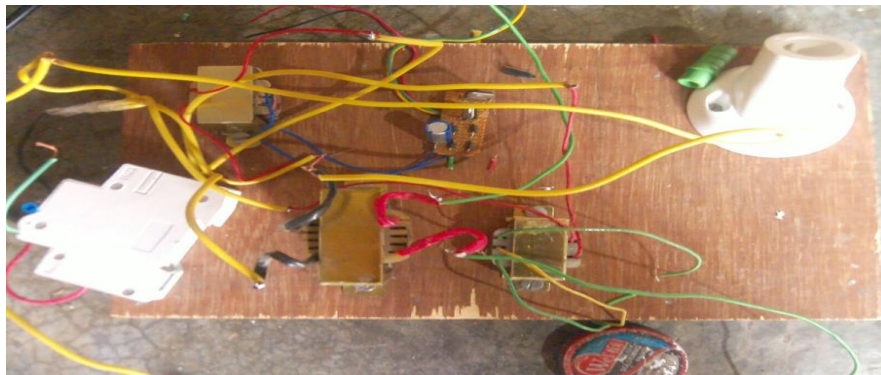


Fig. 7: Hardware model of the circuit

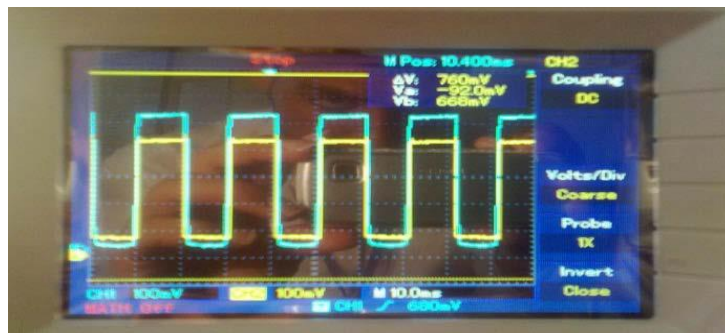


Fig. 8: Zero crossing detection for resistive load

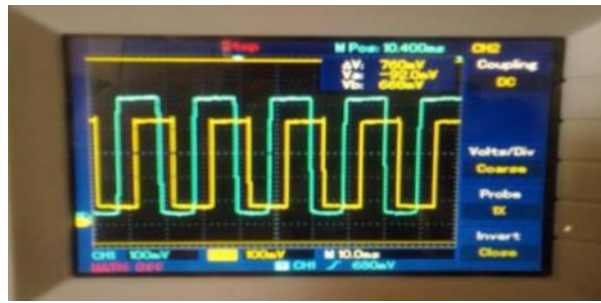


Fig. 9: Zero crossing detection before correction with inductive load

X. CONCLUSIONS AND FUTURE UP GRADATIONS

Form the hardware analysis fig.7 and fig.8 gives the waveforms of zero crossing detection for resistive load and zero crossing detection before correction with inductive load respectively. There are numerous benefits gained from power factor correction. Power factor correction increases load carrying capacity on existing circuits, improving voltage and reducing losses. It can be concluded that power factor correction techniques can be applied to the industries, power systems to make them stable and efficiency of the system as well as the apparatus increases. The use of microcontroller reduces the costs. Due to use of microcontroller multiple parameters can be controlled and the use of extra hardware such as timer, RAM, ROM and input output ports reduces. Care should be taken for overcorrection in case of situations where capacitor gets overcharged, this results in increase in the values of voltage and current due to which the power system or machine becomes unstable and the life of capacitor banks reduces.

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