Power Factor Improvement of the System

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***Abstract*— This paper deals with the design of power factor improvement of the power system using single phase loads. Since nearly all the loads are inductive in nature and hence provides low power factor (lagging in nature). Power factor is one of the important attribute for any AC system. The power consumed is directly proportional to the power factor. Hence for low power factor large current is required, results in voltage drop, copper loss, and increase in economic cost. To encounter such problems in a power system implementing new and better devices to improve power factor is very important. Here in this paper we are using microcontroller controlled device to improve the power factor and compensate reactive power.**

***Index Terms*— Microcontroller, Zero crossing detector, Transformer.**

I. INTRODUCTION

Power Quality Improvement is one of the most important attribute in an electrical power system. Due to the use of inductive loads such as lamps, induction motors, rectifier and inverter circuits, adjustable speed drives etc. results in poor power factor. Mostly all the loads are inductive in nature. A large number of electrical machines and devices consumes reactive power and uses of such machines are increasing day by day so it is necessary to match the load requirement with the power factor so as to improve the power factor. Due to low power factor a large amount of power is lost. Also limited reactive power compensation facilities are available.

Low power factor affects the power companies and consumers bothin terms of efficiency and cost. So power companies ask their consumers to increase their power factor beyond a certain level or else they have to pay penalty. Thus power companies measures reactive power and charge extra penalties as per the power factor. Thus consumers having large load at low power factor employs power factor correction schemes to avoid giving penalties.

There are various methods to improve the power factor. The simplest method is switching in and out of the capacitor banks. The switching here is mechanical type hence it is unreliable, sluggish and is not fast enough to matchup with the fast reactive changes. Also in this method introduces switching transient currents which interrupts other processes. Also we can use synchronous motor connected across the supply when over exited. It draws lagging current from the supply and provides the reactive power. However, it has a major drawback as it is not fast enough to compensate volt-ampere reactance for fast load changes and have high losses.

To overcome the problems in the methods stated above we are using variable compensator along with a microcontroller.

Power factor and reactive power of the load is calculated. Based on the load and frequency of the system the relays are controlled.This device will draw a leading current and will partly or completely remove the lagging reactive component of load current due to which the power factor of the load improves.This project deals with the power factor correction to make it closer to unity, so that losses in the electrical circuits can be minimized and efficiency of the system can be increased, thus making the system economical

II. POWER FACTOR

First we need to understand the concept of power factor in order to improve it. In DC circuits inductors and capacitors both acts as a short circuit and open circuit respectively. Hence entire circuit acts as a resistive. While in AC circuits both inductor and capacitor offers some impedance given by The inductor and capacitor stores energy in form of magnetic and electrostatic energy respectively and there is a phase shift between the input voltage and input current. The cosine of this phase difference is known as power factor.

$$X_L = 2\pi f L \; and \; X_C = \frac{1}{2\pi f C}$$

The range of the power factor is given as -1< cos$\emptyset$<1 and represent the total amount of power used to do the work.

Total electrical power = Voltage× current. This is known as apparent power and its unit is Volt Amp VA and denoted by the symbol 'S'.

A fraction of this total electrical power which is responsible for the actual work is called as active power. It is denoted as 'P'. $P = VI\cos\phi$ *an*d its unit is watt.

The remaining fraction of power is known as reactive power. It does not perform any useful work. The controller regulates voltage at the terminal by controlling the flow of reactive power injected into or absorbed from the system. When system voltage is low, reactive power is generated. When system voltage is high, it absorbs reactive power, required for the active work to be done. It is denoted by *'Q'* $Q = VI\sin\phi$ and its unit is VAR (Volt Amp Reactive).

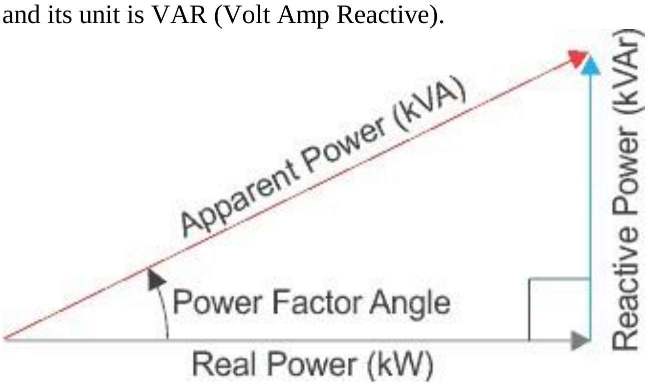

Figure1. Power Triangle Diagram

III. MICROCONTROLLER

ATmega 328 microcontroller performs following steps:

- Detect rising edge of Voltage and start the timer 0.
- Detect rising edge of Current and start the timer 0.
- Calculate
- If Δt ≤ 90 then where Δt is the time difference
- Convert Δt into degrees and save positive sign.

Else

- Convert Δt into degrees and savenegative sign.

- Store V sample.
- Store I sample.
- Store Φ phase angle sample.
- The ARM controller stores each and every samples of V, I and Φ; and it display the value of V, I, phase angle (Φ), power factor, active power (VIcosΦ), reactive power (VIsinΦ).

IV. WORKING

In this kit, current transformer and potential transformer reduce current and voltage levels respectively for zero crossing detectors. The zero crossing detectors are a device for detecting the point where the voltage crosses zero in either direction.
The reduced voltage and current signal are given to microcontroller. Microcontroller converts the analog output of the zero crossing detectors into digital signal and Microcontroller calculate the power factor of measured values, depends upon error it will send signal to relay. When relay energized by microcontroller, it connects capacitor parallel with load one by one, when relay de energized it disconnect the capacitor from the line. LCD display is used to display power factor value of the line continuously.

Algorithm :

- Measure voltage, current and frequency for connected load which may be resistive or reactive.
- Measure phase shift of I and V from Zero Current Detector and then calculate PF.
- On LCD display power factor, active power and reactive power without compensation.
- For compensation, we have to add equal and opposite reactance in parallel with load.
- By controlling the switching circuit connecting capacitor we can compensate pf as much as near to unity.
- No of capacitor may be as per requirement.

After compensation, display the pf, we may observe PF which will be improved.
One of the important aspects for the power factor improvement is Phase Shift Measurement for that several components are used to achieve the above which are explained as follows:

V. POTENTIAL TRANSFORMER (PT) & CURRENT TRANSFORMER (CT)

The values given to it are input to the system and represents the power consumed by the load. It is difficult to process these high values of current and voltage. Therefore, these values are reduced to small signals. 0230 V range is dropped to 0-6V by potential transformer and 0-5 A current is dropped to 0-50 mA current.

VI. SIGNAL CONDITIONING BLOCK

It consists of precision rectifier. The supply provided is 50Hz AC. SO to operate the microcontroller we need DC. After dropping the values to low the actual processing can be attained by transforming this ac signal to an equivalent dc signals. General Purpose
Op-amp is used along with the diodes, resistor and capicators.

VII. ZERO CROSSING DETECTORS (ZCD)

With the help of Comparator Zero Crossing Detectors convert sine wave signal into square wave signal . Diode will act as clamper which convert bipolar signal to unipolar. The square wave signals for voltage & current will be given to interrupt of microcontroller.

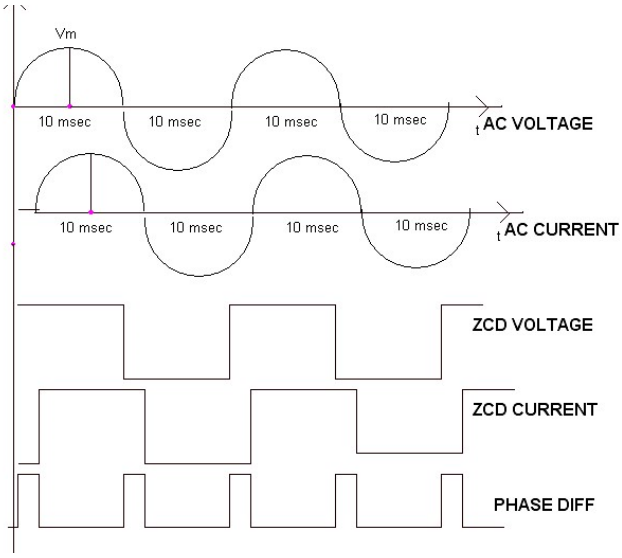

Fig.2 Waveform of zero crossing detector

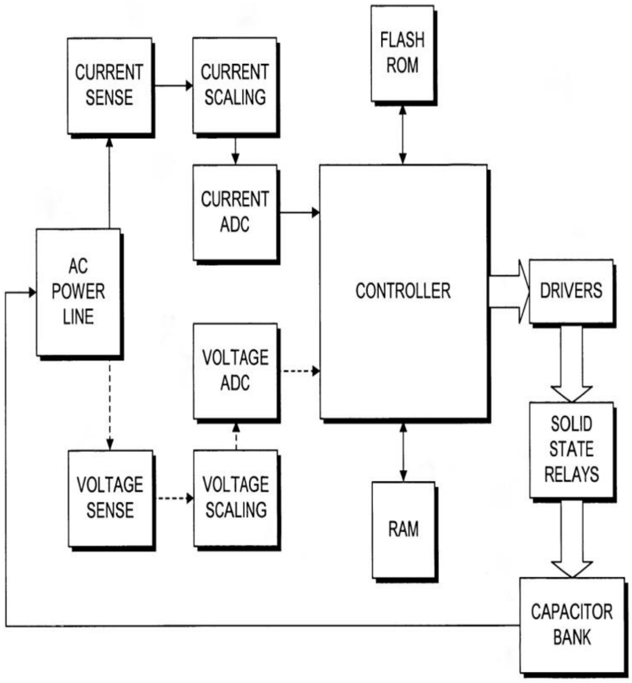

Fig.3 Block Diagram.

When INT0 interrupt will occur then internal timer will start and it will stop at INT1 interrupt. Time measurement by timer will give the respective phase shift in terms of Θ.

VIII. RESULT & CONCLUSION

It is known that power factor correction techniques needed be applied to the industries, power systems and also households to make them stable and due to that the system becomes stable and efficiency of the system increases. The main advantage of use of microcontroller is that it 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 are eliminated.

The main advantages of the designed Power Factor Correction system are as follows:

The electrical load on the source is reduced, thereby allowing the sourceto supplythe surplus power to other, without increasing its generation capacity.

Most of the Utilities impose low power factor penalties. By correcting the power factor, this penalty can be avoided.

High power factor reduces the current consumed by load, hence the power ratings of the equipment can be minimized.

Due to above advantages the system can be used in large number of industrial processes for the purpose of power quality improvement and voltage balancing by commercial and residential consumers, power utility companies and manufacturers of applications that generate reactive power.

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