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Automated Power Factor Correction And Monitoring System

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Abstract: This paper is mainly proposed for reducing the power loss in industries by using power factor compensation through a number of shunt capacitors. Power factor is defined as the ratio of real power to apparent power. So, the increase in reactive power (real power) increases the apparent power, so the power factor also decreases. By having low power factor, the industry needs more energy to meet its demand, so the efficiency decreases. In this system we proposed the time lag between zero voltage pulse and zero current pulse delay generated by suitable op-amp circuits in comparator mode and fed into two interrupt pins in microcontroller. Microcontroller displays the power loss due to inductive load on the LCD. This process is continuously actuate until the power loss would be zero by using relays which is used to bring the shunt capacitors into load circuit. 8-bit microcontroller is used in this project which belongs to 8051 family.

Keywords: VZCD, IZCD, PFC, LCD, Shunt Capacitors, Inductive Load.

I. INTRODUCTION

In the present technological revolution, power is very precious and the power system is becoming more and more complex with each passing day. As such it becomes necessary to transmit each unit of power generated over increasing distances with minimum loss of power. However, with increasing number of inductive loads, large variation in load etc. the losses have also increased manifold. Hence, it has become prudent to find out the causes of power loss and improve the power system. Due to increasing use of inductive loads, the load power factor decreases considerably which increases the losses in the system and hence power system losses its efficiency. Power factor is defined as the ratio of real power to apparent power. This definition is often mathematically represented as KW/KVA, where the numerator is the active (real) power and the denominator is the (active + reactive) or apparent power. It is a measure of how effectively the current is being converted into useful work output. A load with a power factor of 1.0 result in the 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 either a significant phase difference between the voltage and current at the load terminals, or it can be due to a high harmonic content or distorted/discontinuous current waveform. 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.

A distorted current waveform can be the result of a rectifier, variable speed drive, switched mode power supply, discharge lighting or other electronic load. Automatic power factor correction techniques can be applied to industrial units, power systems and also households to make them stable. As a result, the system becomes stable and efficiency of the system as well as of the apparatus increases. Therefore, the use of microcontroller based power factor corrector results in reduced overall costs for both the consumers and the suppliers of electrical energy. Power factor correction using capacitor banks reduces reactive power consumption which will lead to minimization of losses and at the same time increases the electrical system 's efficiency. Power saving issues and reactive power management has led to the development of single phase capacitor banks for domestic and industrial applications. The development of this project is to enhance and upgrade the operation of single phase capacitor banks by developing a micro-processor based control system. The control unit will be able to control capacitor bank operating steps based on the varying load current. Current transformer is used to measure the load current for sampling purposes. Intelligent control using this micro-processor control unit ensures even utilization of capacitor steps, minimizes number of switching operations and optimizes power factor correction.

II. LITERATURE SURVEY

$$P_{avg} = VI\cos\varphi$$

Where, φ is the phase angle between the voltage and current. The term cosφ is called the power factor. Power factor is the ration 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.

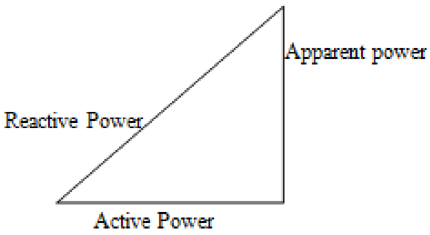

Fig1. Power Triangle.

A load with a power factor of 1.0 result in the 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 either a significant phase difference between the voltage and current at the load terminals or it can be due to a high harmonic content or distorted/discontinuous current waveform. 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. A distorted current waveform can be the result of a rectifier, variable speed drive, switched mode power supply, discharge lighting or other electronic load.

III. POWER FACTOR CORRECTION

Capacitive Power Factor correction is applied to circuits which include induction motors as a means of reducing the inductive component of the current and thereby reduce the losses in the supply. There should be no effect on the operation of the motor itself. An induction motor draws current from the supply that is made up of resistive components and inductive components.

1. The resistive components are:
   - Load current
   - Loss current

2. The inductive components are
   - Leakage reactance
   - Magnetizing current

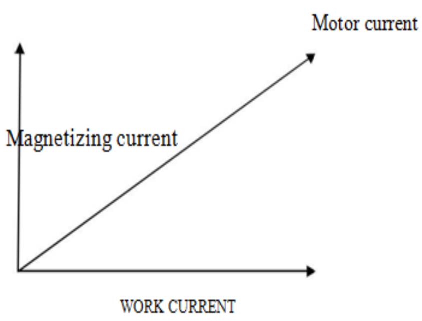

Fig2. Current Triangle.

The current due to the leakage reactance is dependent on the total current drawn by the motor but the magnetizing current is independent of the load on the motor. The magnetizing current will typically be between 20% and 60% of the rated full load current of the motor. The magnetizing current is the current that establishes the flux in the iron and is very necessary if the motor is going to operate. The magnetizing current does not actually contribute to the actual work output of the motor. It is the catalyst that allows the motor to work properly. The magnetizing current and the leakage reactance can be considered passenger components of current that will not affect the power drawn by the motor, but will contribute to the power dissipated in the supply and distribution system.

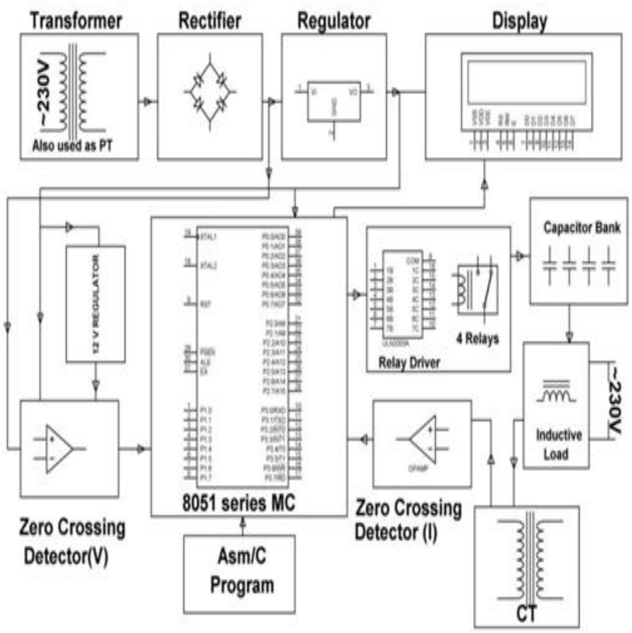

Fig3. Block diagram.

IV. HARDWARE DESCRIPTION

A. Potential Transformer

A potential transformer, a voltage transformer or a laminated core transformer is the most common type of transformer widely used in electrical power transmission and appliances to convert mains voltage to low voltage in order to power low power electronic devices. They are available in power ratings ranging from mW to MW. The potential transformer here is being used for voltage sensing in the line. They are designed to present negligible load to the supply being measured and have an accurate voltage ratio and phase relationship to enable accurate secondary connected metering. The potential transformer is used to supply a voltage of about 12V to the Zero Crossing Detectors for zero crossing detection. The outputs of the potential transformer are taken from one of the peripheral terminals and the central terminal as only a voltage of about 12V is sufficient for the operation of Zero crossing detector circuit.

B. Current Transformer

The current transformer is an instrument transformer used to step-down the current in the circuit to measurable values and is thus used for measuring alternating currents. When the current in a circuit is too high to apply directly to a measuring instrument, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can in turn be conveniently connected to measuring and recording instruments. A current Transformer isolates the measuring instrument from what may be a very high voltage in the monitored circuit. Current transformers are commonly used in metering and protective relays. Like any other transformer, a current transformer has a single turn wire of a very large cross-section as its primary winding and the secondary winding has a large number of turns, thereby reducing the current in the secondary to a fraction of that in the primary. Thus, it has a primary winding, a magnetic core and a secondary winding. The alternating current in the primary produces an alternating magnetic field in the magnetic core, which then induces an alternating current in the secondary winding circuit.

C. Capacitor Bank

Capacitor banks may also be used in direct current power supplies to increase stored energy and improve the ripple current capacity of the power supply. The capacitor bank consists of a group of four ac capacitors, all rated at 400V, 50 Hz i.e., the supply voltage and frequency. The value of capacitors is different and it consists of four capacitors of 2.5□ farad. All the capacitors are connected in parallel to one another and the load. The capacitor bank is controlled by the relay module and is connected across the line. The operation of a relay connects the associated capacitor across the line in parallel with the load and other capacitors.

D. Relay

The relays used in the control circuit are high-quality Single Pole-Double Throw (SPDT), sealed 6V Sugar Cube Relays. These relays operate by virtue of an electromagnetic field generated in a solenoid as current is made to flow in its winding. The control circuit of the relay is usually low power (here, a 6V supply is used) and the controlled circuit is a power circuit with voltage around 230Vac. The relays are individually driven by the relay driver through a 6V power supply. Initially the relay contacts are in the Normally Open ‘state. When a relay operates, the electromagnetic field forces the solenoid to move up and thus the contacts of the external power circuit are made. As the contact is made, the associated capacitor is connected in parallel with the load and across the line. The relay coil is rated up to 8V, with a minimum switching voltage of 5V. The contacts of the relay are rated up to 7A @ 270C AC and 7A @ 24V DC.

E. Liquid crystal display

LCD panel consist of two patterned glass panels in which crystal is filled under vacuum. The thickness of glass varies according to end use. Most of the LCD modules have glass thickness in the range of 0.70 to 1.1mm Normally these liquid crystal molecules are placed between glass plates to form a spiral stair case to twist the light. These LCD cannot display any information directly. These act as an interface between electronics and electronics circuit to give a visual output. The values are displayed in the 2x16 LCD modules after converting suitably. The liquid crystal display (LCD), as the name suggests is a technology based on the use of liquid crystal. It is a transparent material but after applying voltage it becomes opaque. This property is the fundamental operating principle of LCDs.

F. Microcontroller

Micro-controller unit is constructed with ATMEL 89C51 Micro-controller chip. The ATMEL AT89C51 is a low power, higher performance CMOS 8-bit microcomputer with 4K bytes of flash programmable and erasable read only memory (PEROM). Its high-density non-volatile memory compatible with standard MCS-51 instruction set makes it a powerful controller that provides highly flexible and cost effective solution to control applications.Micro-controller works according to the program written in it. The program is written in such a way, so that the output from the ADC will be converted into its equivalent voltage and based on the magnitude of the voltage, it calculates the parameter value. Now this magnitude is again digitalized and fed to 7-segment display unit through the latch.Micro-controllers are "embedded" inside some other device so that they can control the features or actions of the product. Another name for a micro-controller, therefore, is "embedded controller". Micro-controllers are dedicated to one task and run one specific program. The program is stored in ROM (read-only memory) and generally does not change. Micro-controllers are often low-power devices. A battery-operated Microcontroller might consume 50 milli watts. A micro-controller has a dedicated input device and often (but not always) has a small LED or LCD display for output. A micro-controller also takes input from the device it is controlling and controls the device by sending signals to different components in the device.

V. METHODOLOGY

The voltage signal obtained is converted into the digital by comparator circuit since micro controller accepts the digitized format only. This is given to the microcontroller as one input. Similarly, for current signal, from the current transformer is converted into voltage signal by rectification. As previously digitized the voltage signal, this current signal in the form of voltage is also digitized by the comparator circuit. These two digitized signals i.e. voltage and currents are sent to the microcontroller as the inputs. According to the program written microcontroller calculates the time difference between the zero crossings of these two signals. This time difference is indirectly proportional to the system power factor. The information about this power factor and the power loss is displayed on the LCD display. And according to the range calculated by the microcontroller program; this drives the relays which switches the shunt capacitors across the load. While increasing of the inductive load by connecting the other loads like motors to this circuit results in reduced power factor. This will make the microcontroller to drive the more number of relays resulting in more shunt capacitors to be connected. In this project simple method of capacitor requirement calculation used based on the time delay between the voltage and current to bring the power factor near to unity. But in real time applications it will not be so. It requires the calculations like load current magnitude and KVAR requirement etc. Number of capacitors requirements depends on the load on the particular system. These parameters must be considered while dealing with the commercial power factor improvement or compensating products.

Zero crossing detector: A zero crossing is a point where the sign of a mathematical function changes (e.g. from positive to negative), represented by the crossing of the axis (zero value) in the graph of the function. It is a commonly used term in electronics, mathematics, sound and image processing. In alternating current, the zero-crossing is the instantaneous point at which there is no voltage present. Ina a sine wave this condition normally occurs twice in a cycle.A zero crossing detector is an important application of op-amp comparator circuit. It can also be referred to as a sine to square wave converter. Anyone of the inverting or the non-inverting comparators can be used as a zero crossing detector. The reference voltage in this case is set to zero. The output voltage waveform shows when and in what direction an input signal crosses zero volts. If input voltage is a low frequency signal, then output voltage will be less quick to switch from one saturation point to another.

VI. RESULT ANALYSIS

The expected outcome of this paper is to measuring the power factor value displaying it in the LCD and to improve power factor using capacitor bank and reduce current draw by the load using microcontroller and proper algorithm to turn on capacitor automatically, determine and trigger sufficient switching of capacitor in order to compensate excessive reactive components, thus bringing power factor near to unity, thereby improving the efficiency of the system and reducing the electricity bill.

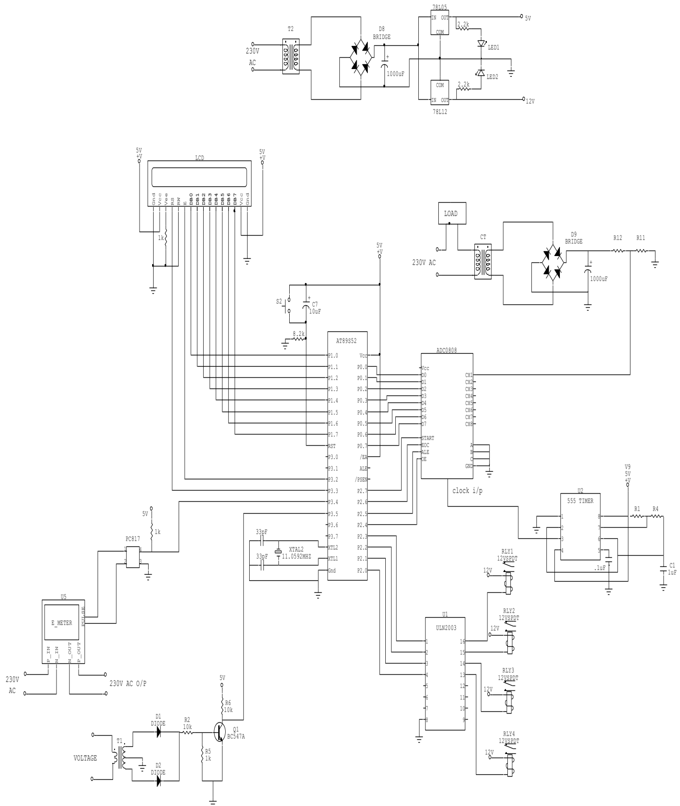

Fig4. Circuit diagram.

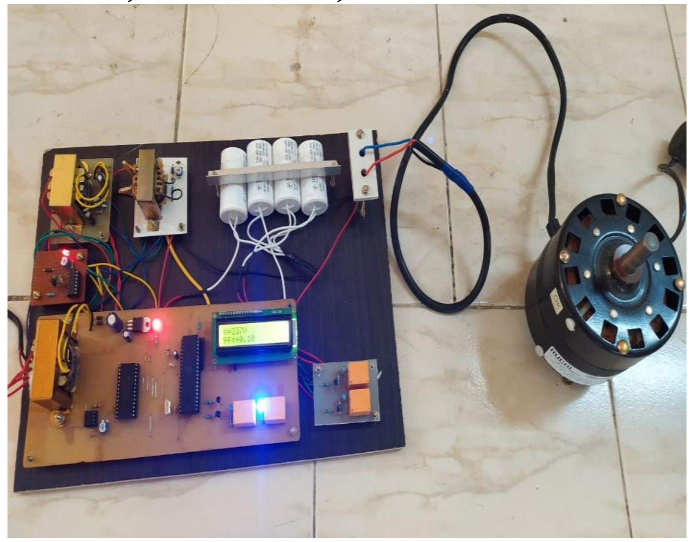

Fig5. Hardware Model.

VII. CONCLUSION

The Automatic Power Factor Detection and Correction provides an efficient technique to improve the power factor of a power system by an economical way. Static capacitors are invariably used for power factor improvement in factories or distribution line. However, this system makes use of capacitors only when power factor is low otherwise they are cut off from line. Thus, it not only improves the power factor but also increases the life time of static capacitors. The power factor of any distribution line can also be improved easily by low cost small rating capacitor.It can be concluded that power factor correction techniques can 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 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's such as timer, RAM, ROM and input output ports reduces.

VIII. REFERENCES

[1] P. N. Enjeti and R Martinez, ―A high performance single phase rectifier with input power factor correction, IEEE Trans. Power Electron.vol.11, No. 2, Mar.2003.pp 311-317.

[2] J.G. Cho, J.W. Won, H.S. Lee, ―Reduced conduction loss zero-voltage-transition power factor correction converter with low cost, IEEE Trans. Industrial Electron. vol.45, no 3, Jun. 2000, pp395-400.

[3] V.K Mehta and Rohit Mehta, ―Principles of power system‖, S. Chand & Company Ltd, International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue 4, October 2013 272 Power Factor Correction Using PIC Microcontroller, www.arduino.cc

[4] Design and Implementation of Microcontroller-Based Controlling of Power Factor Using Capacitor Banks with Load Monitoring, Global Journal of Researches in Engineering Electrical and Electronics Engineering, Volume 13, Issue 2, Version1.0 Year 2013 Type: Double Blind Peer Reviewed International Research Journal Publisher: Global

Journals Inc. (USA) Online ISSN: 2249-4596 & Print ISSN: 0975-5861
[5] Electric power industry reconstructing in India, Present scenario and future prospects, S.N. Singh, senior member, IEEE and S.C. Srivastava, Senior Member, IEEE.