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AUTOMATIC POWER FACTOR CORRECTION USING ARDUINO UNO

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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 PFC. 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/off the capacitors in proportion to variation of load within an installation. This drawback is overcome by using an APFC panel. In this paper measuring of power factor from load is done by using Atmega328 microcontroller and trigger required capacitors in order to compensate reactive power andbring power factor near to unity.

Keywords: Automatic power factor correction, embedded technology, Efficiency of the system increases, Improve the power system performance**.**

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.

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 capacitorbanks 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. PROPOSED SYSTEM

Microcontroller base automatic controlling of power factor with load monitoring is shown in fig.1. The principal element in the circuit is PIC microcontroller. The current and voltage single are acquired from the main AC line by using Current Transformer and Potential Transformer. These acquired signals are then pass on the zero crossing detectors. Bridge rectifier for both current and voltage signals transpose the analog signals to the digital signal.

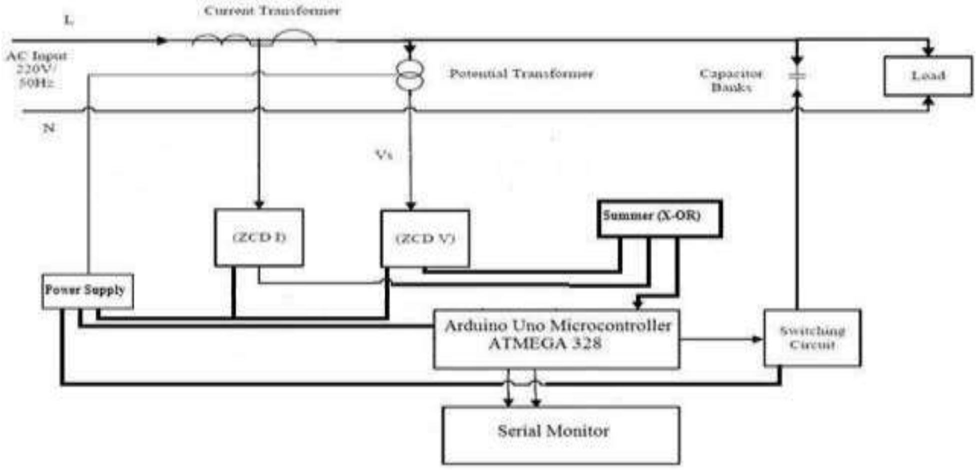

Fig.1 Block of PFC using ATMEGA 328

Microcontroller read the RMS value for voltage and current used in its algorithm to select the value of in demand capacitor for the load to correct the power factor and monitors the behavior of the enduring load on the basis of current depleted by the load. In case of low power factor Microcontroller send out the signal to switching unit that will switch on the in-demand value of capacitor. The tasks executed by the microcontroller for correcting the low power factor by selecting the in demand value of capacitor and load monitoring are shown in LCD.

System Design

Principle:

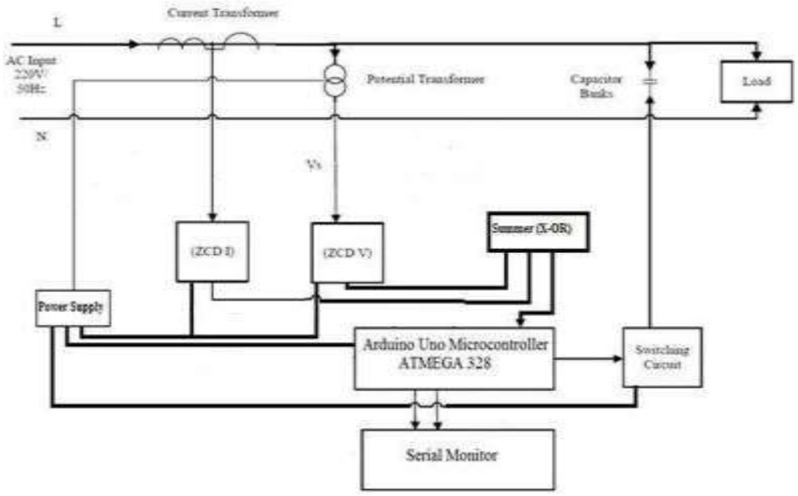

Fig 2: Block Diagram of Automatic Power Factor Correction Circuit.

The above given circuit for Automatic Power Factor detection and correction operates on the principal of constantly monitoring the power factor of the system and to initiate the required correction in

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case the power factor is less than the set value of power factor. The current and voltage signals are sampled by employing instrument transformers connected in the circuit. The instrument transformers give stepped down values of current and voltage, whose magnitude is directly proportional to the circuit current and voltage. The sampled analog signals are converted to suitable digital signals by the zero crossing detectors, which changes state at each zero crossing of the current and voltage signals. The ZCD signals are then added in order to obtain pulses which represent the time difference between the zero crossing of the current and voltage signals.

The time period of these signals is measured by the internal timer circuit of the Arduino by using the function pulse In(), which gives the time period in micro seconds. The time period obtained is used to calculate the power factor of the circuit. Now if the calculated power factor is less than the minimum power factor limit set at about 0.96-0.98, then the microcontroller switches on the require number of capacitors until the power factor isgreater than or equal to the set value.

Circuit Description

Automatic Power Factor Correction system is based on the AVR microcontroller AT mega 328. The voltage and current in the circuit are stepped down using a potential transformer and a current transformer respectively. These transformed a.c signals are next fed to a Zero Crossing Detector (ZCD) circuit. The output of the Zero Crossing Detector (ZCD) is a square wave, in which each change of state represents a zero crossing of the a.c waveform. The signal goes high on the first zero crossing of the current or voltage waveform and then goes low on the next zero crossing of the signal, thereby generating a square wave. Two separate Zero Crossing Detector (ZCD) circuits are used for voltage and current waveform. The two square waves are then summed using an Exclusive OR (X-OR) gate. The output of the summer gives the phase angle difference which is given to the Arduino microcontroller on one of its digital I/O pins (pin 3).

The value on the pin is read using the function pulse In (pin, value, timeout), where the parameters pin depicts the number of the pin on which you want to read the pulse. (int), value depicts the type of pulse to read i.e., either HIGH or LOW. (int) and timeout (optional) depicts the number of microseconds to wait for the pulse to start, default is one second (unsigned long). The function reads a pulse (either HIGH or LOW) on a pin. For example, if value is HIGH, pulse In() waits for the pin to go HIGH, starts timing, then waits for the pin to go LOW and stops timing. It finally returns the length of the pulse in microseconds or gives up and returns 0 if no pulse starts within a specified time out.

The timing of this function has been determined empirically and will probably show errors in longer pulses. Hence, it works efficiently on pulses from 10 microseconds to 3 minutes in length. The difference is measured with high accuracy by using internal timer. This time value obtained is in microseconds (μs). It is converted in milliseconds (ms) and is then calibrated as phase angle φ using the relation.

$$\varphi = \frac{t}{T} * 360$$

φ = difference in phase angle

t = time difference in milliseconds (ms);

T = the time period of one AC cycle (i.e., 20ms);

The corresponding power factor is calculated by taking cosine of the phase angle obtained above (i.e., cosφ). The values are displayed in the serial monitor which in this case is the computer screen. The display can also be obtained on a separate display by using the serial transmission pins: Serial Transmission (Tx) and Serial Reception (Rx) of the Arduino but that would require appropriate interfacing circuitry. The microcontroller then based on the algorithm then switches on the required number of capacitors from the capacitor bank by operating the electromagnetic relays until the power factor is normalized to the set limit.

Working

The voltage or current waveform has a sinusoidal waveform with a wave cycle of 360 degrees which when converted into time seconds it is 20 milliseconds (Frequency = 50Hz, T=1/F = 1/50). When the load is applied the current waveforms changes its every zero-crossing position depending on the characteristics of the load. Irrespective of load the time period is similar but every zero crossing of the current waveform changes whereas' the voltage waveform remains in the same position. But the zero crossing remains the same at 10milliseconds. So when load is applied there is a difference between the zero crossing of voltage and current waveforms. The difference in their time of zero crossing is noted and converted into degrees. This value is known as phase angle difference power factor is the cosine of the phase. The angle difference of the voltage and current waveforms. So, the obtained phase angle value of power factor. difference gives us the power for the Arduino and other components is supplied by a 5V DC supply. The two OpAmps converts the sinusoidal signal into square signal. The square waves from the output of the OpAmps is fed to OR(XOR) gate. The output of Xthe Exclusive OR gate is phase angle difference which is given to Arduino. The cosine of the phase angle difference gives the power factor value. If the power factor is less than 0.9 then the capacitor is switched on.

Aurdino UNO: The Arduino Uno is a microcontroller board based on the Microchip ATmega328P microcontroller. It consists of digital and analogy pins that may be interfaced to various boards and circuits. The board has 14 digital and 6 analogy pins, and is programmable with Arduino IDE The Arduino board can be powered by the external 9 volts battery or by USB cable. The inputs to the Arduino are power supply, XOR. It collects the data from input and accordingly gives commands to Relay and LCD display.

Fig 3. Aurdino Uno

Relay: A Relay is an electrically operated switching device as it works to isolate or change the state of electric circuit from one state to another. It consists of set of input terminals and operating contact terminals.

Capacitor bank: The Capacitor bank is a grouping of several identical capacitors interconnected in parallel or in series with one other. These banks are typically used to counteract undesirable characteristics such as power factor lag.

Fig4. Capacitor Bank

Current Transformer: Current transformer (CT) is a type of t ransformer that is used to reduce or multiply an alternating current (AC). It produces a current in its secondary which is proportional to the current in its primary. Current transformers,along with voltage or potential transformers, transformers.

Potential Transformer: are instrument The potential transformer is a device used to transform voltage of higher value to a lower value. The voltage stepped down by the potential transformer to a safe limit value which can be measured by an ordinary voltage instruments like voltmeter, wattmeter, etc.

Zero Crossing Detector: The zero crossing detector is device which converts sinusoidal signal into square signal. The output of the Op Amp is zero whenever the sinusoidal signal has a value greater than zero and the output becomes zero whenever the value becomes less than zero. Thus, the zero-crossing detector converts the signals.

Liquid Crystal Display (LCD): Liquid Crystal Display LCD is very basic module and is used very commonly in various circuits for display purpose. LCD display is preferred over LED display and seven segment display. LCD s are easily programmable, economical and can easily display characters, animations. A 16× 2 LCD display is used to display power factor value.

IV. RESULT

Inductive Load:

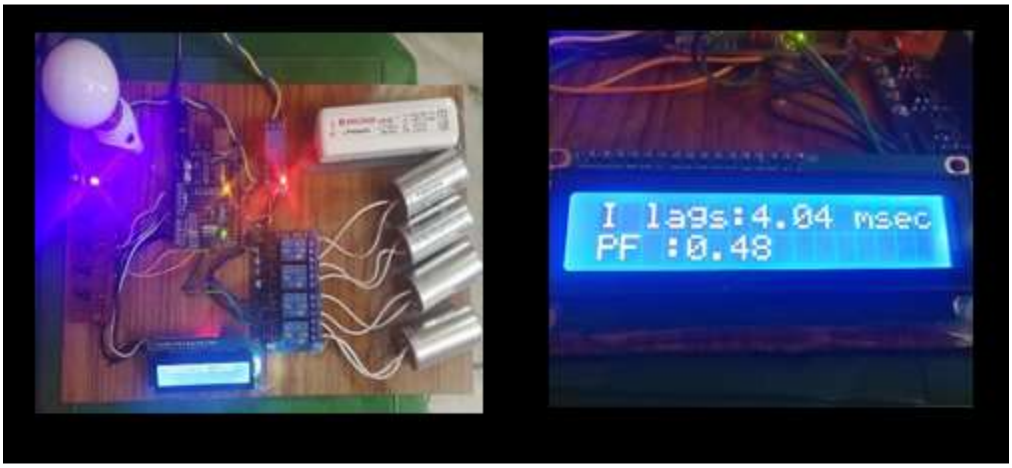

Fig 5. Before PFC

Capacitive Load:

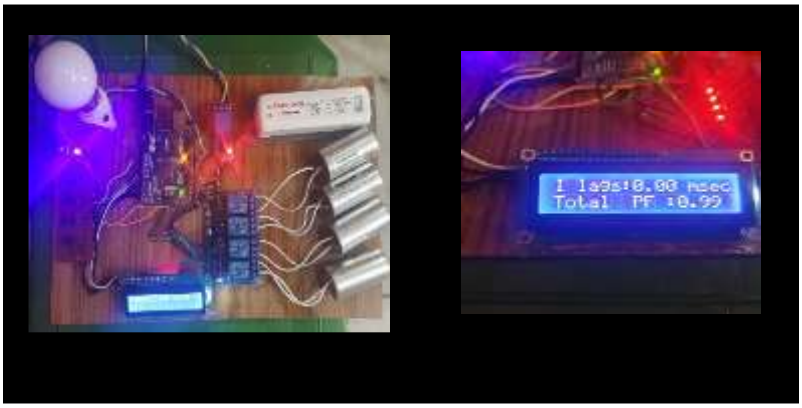

Fig 6. After P.F.C.

Resistive load:

Fig 7. Resistive Load

V. CONCLUSION & FUTURE SCOPE

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. This system with static capacitor can improve the power factor of any distribution line from load side. As, if this static capacitor will apply in the high voltage transmission line, then its rating will be unexpectedly large which will be uneconomical & inefficient. So a variable speed synchronous condenser can be used in any high voltage transmission line to improve powerfactor & the speed of synchronous condenser can be controlled by microcontroller.

In case of automatic PF correction, if the load is changing frequently, the numerous switching of capacitor bank may cause harmonic problem. Suitable filter design as well as an optimum algorithm design can be done based on the frequent load change pattern to avoid regular switching of capacitor bank. A comparative study on the location of correction equipment may be employed in the field to find out the optimum location referring to maximum utilization and savings as it operates automatically, manpower operator is not, required and this Automated Power Factor Correction using capacitive load banks can be used for the industries purpose at large scale in the future to urge benefit to the system efficiency and saving energy which can be contribution in conservation of energy.

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