Microcontroller Based Automatic Power Factor Improvement For Domestic System

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Abstract- *In this industrial age, wasting energy is a global concern the efficient production of electricity is crucial task. Today, many industries in the country face monetary losses and an electric charge which are inductive in nature and therefore cause relaxation power factor. The goal of this project is to present a simple and economical design of power factor improvement for single phase loads. This system uses a relay to switch the capacitor banks to correct the power lagging load factor. Arduino is programmed in such a way as to be able to control system and calculate the power factor of the loads by detecting the current transformer signals, Potential transformer and power factor maintenance greater than 0.9 by supplying the capacitors in parallel to the connected load by relay switching. When inductive loading is introduced in industry, it is known that the power factor will drop. The cost of electricity will be higher if the power factor is lowered. When the power factor drops in our system, the automated capacitor sets are activated and the power factor is restored to a predetermined level. As a programming device, an Arduino Uno microcontroller was used.*

Keywords- Microcontroller, Power Factor (PF), Zero Crossing Detector (ZCD), Liquid Crystal Display (LCD), Capacitor, Inductor.

I. INTRODUCTION

In the current scenario of technological revolution, from all of the observation, it can be said that power is very valuable and becoming more and more complex as the days go by. The increase in the use of inductive loads in industry will impact the power factor value of the system and hence due to this the efficiency of the power system decreases. Non-linear loads will lead to poor power factor which can disturb the AC voltage and give poor performance to other equipment connected to the same source. The main objective of this project is an improvement of the existing AC power supply output factor by adding capacitance. This project mainly aims attention to the arrangement and development of power factor improvement using Arduino Uno in which ATmega328 as a microcontroller. The power factor controller method and device are useful in improving efficiency active power transmission. This PF improvement is popular due to its advantages such as high power factor, fast dynamic response and low cost .PF improvement digital converters are more desirable because digital controllers have many advantages over analog controllers due to their programmability, flexibility, lack of temperature and aging effect, and higher input resistance voltage distortion. Power factor improvement using capacitor banks reduces reactive power consumption, which will cause minimization of losses and at the same time increases the efficiency of the electrical system. Power-saving and responsive issues energy management has led to the development of single-phase capacitor banks for domestic and industrial applications. The development of this project is to improve and upgrade the operation of single-phase capacitor banks by developing a microcontroller based control system. The output of this device which get from simulation result and hardware the implementation will be analyzed to see the effect of controlling and correcting the activity. This article proposed the control and power factor improvement.

II. NEED FOR IMPROVEMENT

Power factor improvement is desirable because the electrical power source must be able to supply real power as well as any reactive power demanded by the load. This may require domestic and power plant equipment, transmission lines, transformers, switches, etc. bulky and more expensive than would be needed for the actual power delivered alone. Additionally, resistive losses in transmission lines mean that some of the power generated is wasted because the extra current needed to provide reactive power is only used to heat the power lines. Electric utilities therefore limit the power factor of the loads they serve. The ideal figure for load power factor is unity (1) it is a pure resistive load, as it requires the smallest current to transmit a given amount of real power. Actual loads deviate from this ideal condition. Sometimes when the power factor is leading due to a capacitive load, inductors are used to correct the power factor. In the electrical industry, inductors are said to draw reactive power and capacitors supply it, even though the reactive power actually only goes back and forth between each AC cycle.

A. Advantages of Power Factor Improvement

The benefits that can be obtained by using an appropriate power factor correction scheme are:

a) The efficiency of the inductive load increases, due to the reduction in power consumption.
b) Due to the reduction in power consumption, there will be less greenhouse gases.
c) Reduction in electricity bills.
d) Additional KVA available from the same existing supply.
e) Reduction in I^2R losses in transformers and distribution.

B. The Cause of Low Power Factor

The usual reason of the low power factor is due to inductive loads. The current in an inductive load lags of the voltage. Therefore, the power factor lags. The significant inductive loads responsible for low power factor are as follows:

I. Low power factor is caused by inductive loads such as transformers, induction motors, generators and some lighting ballasts.
II. A transformer draws the magnetizing current from the supply. At low load, this current does not affect the power factor much, but at low load, the power factor of the primary current is low.
III. Arc lamps, electric discharge lamps, industrial heating furnaces, welding equipment operate at low inductive power factor.

III. BLOCK DIAGRAM

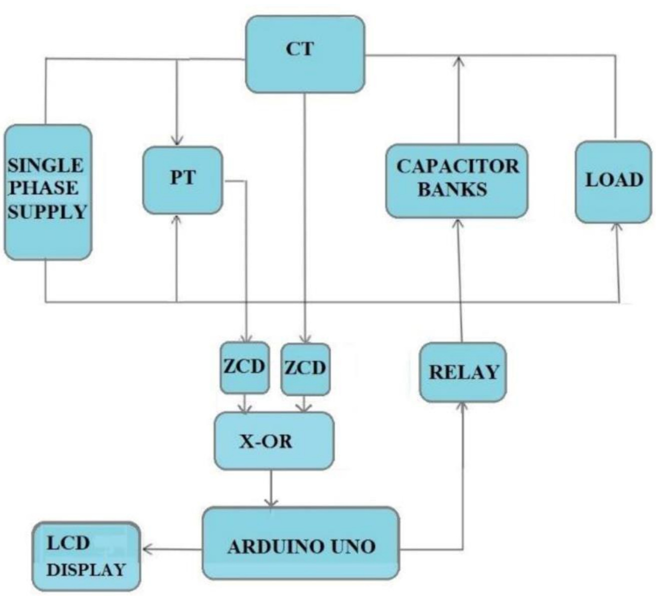

Fig .1.Block Diagram of Power Factor Improvement Using Arduino

A. Power Supply Section

In this power supply section, we use a step-down transformer, IC regulators, diodes, capacitors and resistors. The input power, i.e. 230 V AC, is supplied to the primary of the transformer. Due to the magnetic effect of the coil, the flux is induced in the primary is transferred to the secondary coil. Then the output of the secondary coil is given to the diodes. Here, the diodes are bridge-connected. Diodes are used for rectification purposes. The output of the bridge circuit is not pure direct current a somewhat rippled alternating current is also present. For the capacitor to be connected to the output of the diodes to remove AC current, the capacitor is also used for filtering purposes. The negative terminal of the diode (D2 and D3) is connected to the positive terminal of the capacitor and therefore to the input of the regulator IC (7805 and 7812). Here we use voltage regulators to get the fixed voltage for our needs. The voltage regulator is a CKT that provides a constant voltage regardless of variations in load currents. These ICs are designed as fixed voltage regulators and with adequate heat dissipation can supply o/p currents in excess of 1 A. The o/p of the regulator IC is given to the LED through resistors, when the o/p of the IC i.e. the voltage is given to the LED, it does its forward bias and hence the LED gloves are on and hence the positive voltage is obtained.

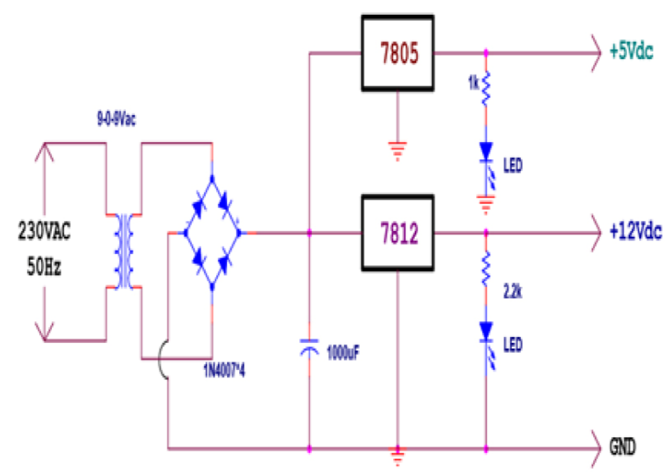

Fig.2. Power Supply Section

Similarly, for a negative voltage, here the two positive terminals of the diodes (D1 & D4) are connected to the negative terminals of the capacitor. The o/p of the regulator IC (7912) which is a negative voltage is given to the terminal of the LED, through a resistor, which makes it forward biased, drives the LED and hence the LED gloves to the state ON and thus the negative voltage is obtained. The mathematical relationship for AC input and DC output is

Vdc = Vm /3.141 (before capacitor)

Vd = Vm (after capacitor)

B. Zero Crossing Detectors

Zero crossing detectors are a sine to square converter. The reference voltage in this case is set to zero. The output voltage waveform indicates when and in which direction an input signal crosses zero volts. If the input voltage is a low frequency signal, the output voltage will pass less quickly from one saturation point to another. And if there is noise between the two input nodes, the output may fluctuate between positive and negative saturation voltage is Vsat.

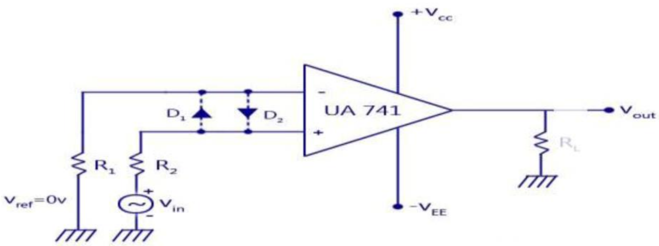

Fig.3 Zero Crossing Detectors

C. Arduino Uno (Microcontroller)

The Arduino Uno is a micro-controller board based on the Microchip ATmega328P microcontroller. This consists of digital and analog pins that can be interfaced to various boards and circuits. Table has 14 digital and 6 analog pins, and is programmable with Arduino IDE the Arduino the card can be powered by the external 9 volts battery or USB cable. Arduino Inputs are power, X-OR. It collects data from input and accordingly gives commands to the relay and LCD screen. The Uno is the latest in a series of Arduino USB boards, and the reference model of the Arduino platform for comparison with previous versions. We use the Arduino IDE compiler software to run the programs and upload the hex file to Arduino Uno and the LCD screen is used to display the current, voltage and power factor values.

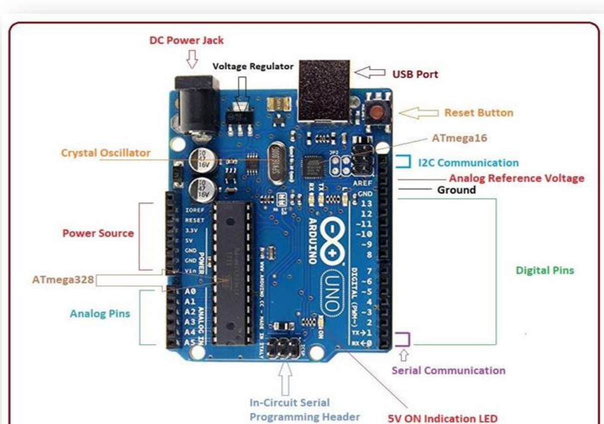

Fig.4. Arduino Uno

D. Electro Magnetic Relay

They are very reliable devices and widely used in the field. The operating frequency of such devices is at least 10-20 ms. That is, 50Hz to 100Hz. The relay used here can handle currents of 25mA continuously. The electromagnetic relay operates on the principle of magnetism. When the base voltage appears at the driver section of the relay, the driver transistor will be driven into saturation and allow current to flow through the coil of the relay, which in turn will create a magnetic field and the magnetic force produced in because of this will act against the spring tension and close the contact coil. These contact points are isolated from the low voltage supply, so that high voltage switching is possible using electromagnetic relays. Electromagnetic relays normally having 2 contact points. Named normally closed (NC), normally open (NO). Normally closed points will therefore have a short CKT path when the relay is off. Normally open points will therefore be a short CKT path, when the relay is energized.

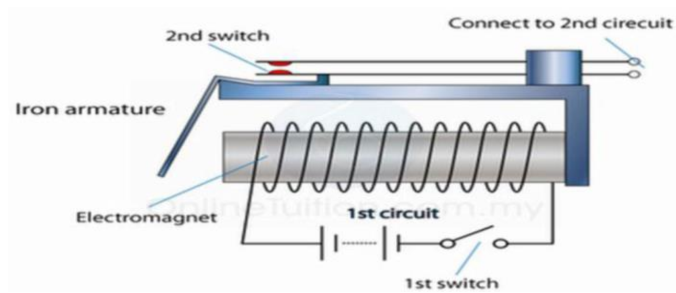

Fig.5. Electro Magnetic Relay

E. Liquid Crystal Display

Liquid Crystal Display - LCD is a very basic module and is very commonly used in various circuits for display purposes. LCD display is preferred over LED display and seven-segment display. LCD screens are easily programmable, economical and can easily display characters, animations. A 16×2 LCD display is used to display the power factor value. Therefore, LCDs are also called optical switches. These LCD screens cannot display any information directly. These act as an interface between the electronics and the electronic circuit to give a visual output.

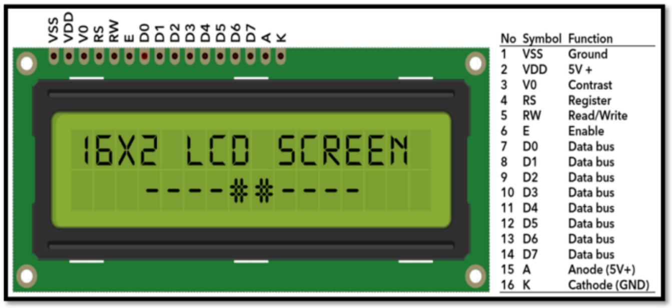

Fig.6. Liquid Crystal Display

F. *Capacitor Bank*

Shunt capacitor banks are used to improve the quality of power supply and the efficient operation of the electrical system. Flat voltage profile Show that a flat voltage profile on the system can significantly reduce line losses & shunt capacitor banks are relatively in-expensive and can be easily installed anywhere on the network. The capacitor bank consists of a number of shunt capacitors which are switched on or off depending on reactive power requirements. Capacitor switching can be done manually or automatically using relays. Shunt capacitors, either at the customer for power factor correction or at the distribution system for voltage control, dramatically change the variation of system impedance with frequency. Capacitors do not create harmonics, but severe harmonic distortion can sometimes be attributed to their presence.

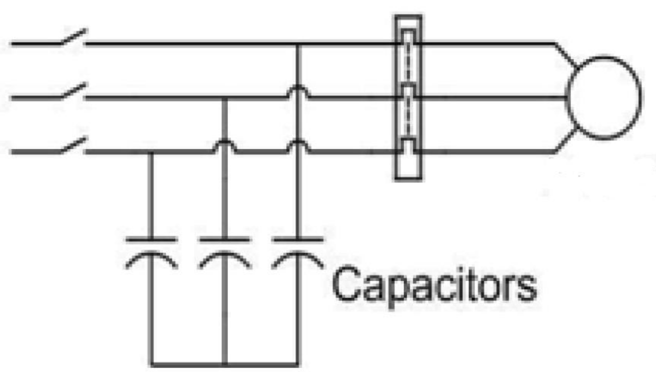

Fig.7. Capacitor Bank

G. Design

The power factor can be improved by installing specially designed Correction capacitors or reactive power generators in the electrical distribution system. These devices supplement the reactive power demand for the operation of all inductive loads and reduce the amount of KVA drawn from the main transformer, recorded on the meter as peak demand. The capacitor draws a leading current and partially or completely neutralizes the lagging reactive component of the load current. This increases the power factor of the connected load. A high power factor output is the main focus of this article which focuses on the design and implementation of power factor improvement using the Arduino Uno microcontroller, measures the power factor of the system loaded power supply, performs an appropriate action to supply sufficient capacity to recover the appropriate power loss using program, and finally simulates the design with the Arduino Uno controller chip. The program code was written in only C language.

IV. SOFTWARE ENVIRONMENTS

A. Arduino IDE

The Arduino IDE is open-source software, which is used to write and upload code to Arduino boards. The IDE application supports C and C++ programming languages. Here, IDE stands for Integrated Development Environment. The program or code written in the Arduino IDE is often referred to as a sketch. We need to connect the Genuino and Arduino board to the IDE to upload the sketch written in the Arduino IDE software. The sketch is saved with .ino extension and uploads the .hex file to Arduino.

B. Proteus Simulation

Proteus 8 Professional ISIS Design Suite was used to perform the simulation. The code helps display various power-related state vectors. Single phase voltages and currents are sensed using transducers potential transformer (PT) and current transformer (CT) respectively. These signals are applied to the controller to measure the values of currents and voltages, to measure the angle between voltage and current, and to measure sine and cosine values to determine active and reactive power. Using these values, we calculate the capacitor ratings. The magnetic relay is used to couple the 5V DC signal from the microcontroller to 220V AC to determine which particular capacitors should be turned on or off for optimum power factor. The turn's ratio of the potential transformer is selected at 230:5 to make the voltage on the secondary side compatible with the analog input of the microcontroller. Similarly, the current rating of the transformer is such that we get 5V on the secondary.

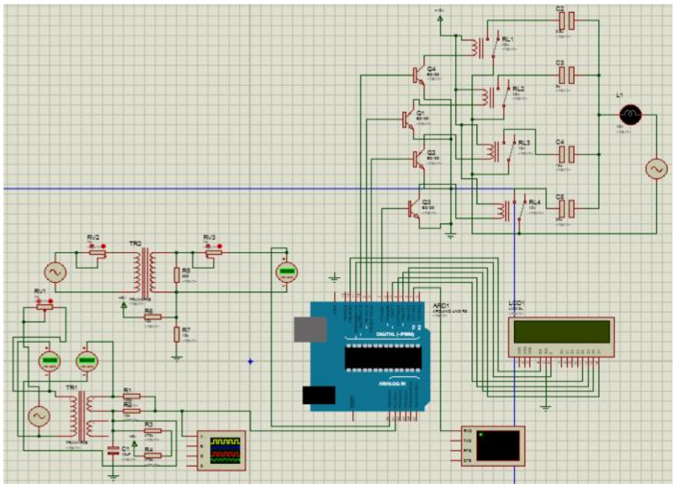

Fig.8. Power Factor Improvement Schematic in Proteus

V. RESULT

The expected result of this project is to measure the power factor value by displaying it on the Current voltage wave forms, LCD and improve the power factor by using a capacitor bank and reduce the current consumption by the load using a microcontroller and an appropriate algorithm to automatically turn on the capacitor, determine and initiate sufficient capacitor switching to compensate for excessive reactive components, thereby bringing the power factor closer to unity, there improving system efficiency and reducing electricity bills.

To verify the performance of automatic power factor correction using a microcontroller, a prototype is developed and tested. The figure shows the system configuration for automatic power correction using a microcontroller. The power supply is 12-6V using a step-down transformer. And it contains a microcontroller, an LCD module that displays the correct power factor, and relays that help include capacitor banks in the circuit as needed. The prototype is checked using an inductive load. This initially gives a lagging power factor, which subsequently gives an improved power factor close to unity by the proper operation of the Power factor improvement unit.

A. Analysis of Load without Correction

The analysis of the pure restive load (R-Load), series resistive-inductive loads (R-L Series Load) and parallel resistive-inductive loads (R-L Parallel Load) was performed without using the correction equipment. The designed loads were connected through the power guard PG08 and the readings of the different electrical parameters were recorded.

Analysis of Load without Correction

S. NO	LOAD TYPE	SUPPLY Volt	SUPPLY HZ	Load Current mA	Power Drawn W	Power factor	Remarks
1	Pure R	234	49.87	437	101.2	0.64	Correction Required
2	Series R-L	235	49.92	318	55.3	0.73	Correction Required
3	Parallel R-L	235	49.89	730	129.1	0.76	Correction Required

B. Analysis of Load with Correction

Since there is a need to improve the power factor for Series R-L load and Parallel R-L load, they were connected to the power supply along with correction equipment designed to verify the expected correction. The correction equipment is plugged into the power guard PG08 and the loads are connected to the output point of the equipment. The three designed loads were tested and the observed values were recorded.

TABLE II. Analysis of Load with Correction

S.NO	LOAD TYPE	SUPPLY Volt	SUPPLY HZ	Load Current mA	Power Drawn W	Power factor	Remarks
1	Pure R	230	49.12	424	96.6	0.99	35.0% Increase in PF
2	Series R-L	232	48.97	267	59.9	0.96	31.5% Increase in PF
3	Parallel R-L	234	49.19	602	134.2	0.97	29.3% Increase in PF

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