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Automatic Power Factor Correction Unit Using Arduino Uno and PZEM-004T

Aditya Mulik[1], Aditya Hon[2], Gauri Mate[3], Prof. S. V. Tathe[4]
Department of Electronics and Telecommunication Engineering[1-4]
Sinhgad College of Engineering, Pune, India

Abstract: *In India the energy consumption is in large amount and enough energy is not generated . To reduce energy losses we have to make up the losses which are wasted by means of reactive power generation.The reactive power can be compensated using capacitor banks and this can be termed as power factor correction. Power factor correction is a major problem in large scale industries .Power factor can be corrected according to load by using capacitor bank.*

Keywords: Arduino,Capacitor Bank, Power Factor

I. INTRODUCTION

In India, the electricity market is very critical and not enough to power people for generations. Large industries consume large amounts of electricity in kilowatts licensed by the department of Energy.

Power factor can be defined as the ratio of losses to the total amount of power generated compared to the power received. Maintaining a proper power factor can reduce energy loss. For this purpose, capacitors are used to compensate for the generated reactive power. The power factor depends on the type of load. If the load is an inductive load, the power factor will be low. If the load is resistive, the power factor is unity.

If we switch on the capacitors according to the load variations at correct time then the powerfactorcanbemaintained at constantby using micro controller.

Ideal value of power factor is unity.All resistive loadhave near unity power factor and inductive load have less power factor.

$$Power\ factor = \frac{Real\ power}{Total\ power} \times 100$$

Real power or true power, P is the power that is used to do work on the load.Power is measured in watts (W) and in the electricity billing, it is in kilowatt hours (kWH). It is the power used by the electrical resistance of a system doing useful work. Reactive power is the power not used to do work on the load. Power factor is called as the cosine of angle between the voltage and current. In an AC circuits there is generally a phase difference between voltage and current. If the circuit is inductive, the current is lags behind the voltage and the power factor is called lagging power factor and if the circuit is capacities then current leads to voltage and power factor is said to be leading power factor.

Electrical consumers operating on alternating current require apparent power resulting from the product of active power and reactive power. The reason that the power factor of an electrical load is less than one is that the apparent power is higher than the real power due to reactive power. Reactive power increases current from sources and loads. When this happens, power losses increase in both distribution and transmission lines. If the current and voltage are in phase, there is no power loss and the power factor value can be improved to near or even unity. This process is done by connecting capacitor banks. Power factor correction can be applied by power suppliers to improve grid stability and efficiency, or it can be installed by power consumers to reduce costs charged by power suppliers.

II. BLOCK DIAGRAM OF PROPOSED SYSTEM

In this method we first detect the power factor using PZEM004T module this module calculate the Voltag, Power, Current, Power Factor etc. This reading are stored in a variable in Arduino ,it compares the value with the predefined values and the activates the respective relays. Relays are used for switching of capacitors .After every capacitor is

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activated the power factor is recalculated by the module and the new value is compared with correct values if the power factor is in correct range then the system does not activate the next capacitor if the value is less than the predefined value then next capacitor is activated. For current sensing there is a current transformer connected to PZEM004T module.

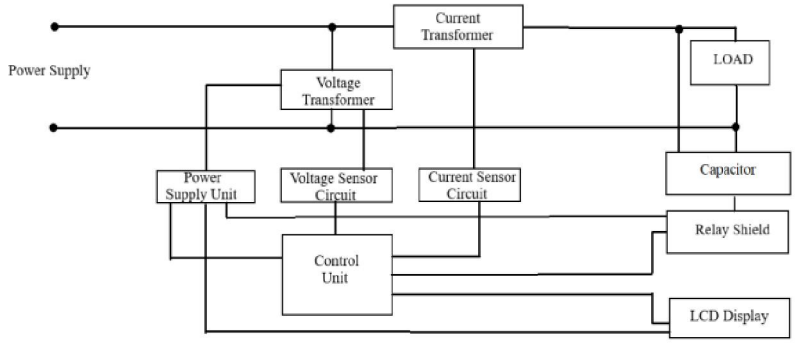

Fig. 1. Proposed System

V. HARDWARE DESCRIPTION

Different components used for power factor correction unit are as follow

3.1 Arduino

The Arduino Uno is a micro controller board which is based on the data sheet like ATmega328. This micro controller has up to 14 digital I/O pins from which 6 can be used as PWM (pulse width modulation) pin for outputs also six analog inputs. Arduino features a 16 MHz quartz oscillator with a USB (universal serial bus) connection and having an influence jack, an ICSP header, and one push button. It holds everything which required supporting the micro-controller, it just connect to a PC (personal computer) through a USB(universal serial bus) port. The Arduino made from both a programmable circuit card (i.e. micro-controller) and some software, Integrated Development Environment that runs on our PC and upload computer code to the physical board. The Arduino platform has become quite fashionable people just starting out with electronics, and permanently reason. To load new code the Arduino doesn't require a separate hardware. It can simply connect through USB port. The Arduino IDE can also uses C++ platform for more effectiveness. The new popular board is introduced i.e. Uno best for beginning Analog Energy Meter: It is used for monitoring the energy usage.

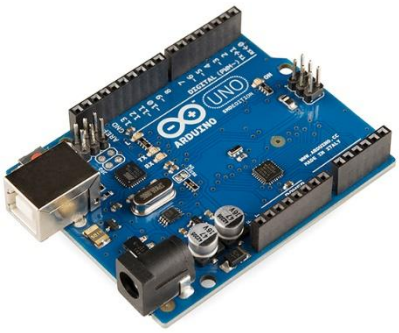

Fig. 2 Arduino Uno

3.2 Electrolytic Non-Polarized Capacitor bank

A capacitor bank is a group of several capacitors connected in the series or parallel combinations. Capacitors are electrical and electronic components that store electrical energy. Thus, capacitor banks (cap bank) stores the reactive

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energy (leading) and it compensate for reactive energy (lagging), and improves the power factor. As a result, the grid gets more stable and higher transmission capacity and suffers fewer transmission losses.

Fig. 3 Capacitor Bank

3.3 PZEM-004T

PZEM-004T is an electronic module that functions to measure: Voltage, Current, Power, Frequency, Energy and Power Factors. With the completeness of these functions / features, the PZEM-004T module is ideal for use as a project or experiment for measuring power on an electrical network such as a house or building

Fig. 4 PZEM-004T

3.4 Relay

A relay is an electrically operated switch. Relays circuits use an electromagnet to mechanical switch, some other principles can be also used, like solid-state relays. This relay circuit is operated over electrically switch which allows switching on or off a circuit using voltage or current which is higher than a microcontroller handling capacity. The function of the relay is to protect each circuit from each other. There are three connections for each channel in the module and these are NO COM and NC.

Fig. 5 Relay

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3.5 SOFTWARE DESCRIPTION

All the data coming from the sensors is fetched and processed using Arduino IDE.

IV. CALCULATIONS

Resistive Load :

Power rating: 40W,Current Rating : 0.17A ,Voltage Rating : 230V

Using formula for Apparent Power (S)

$$S = V \times I = 230 \times 0.17 \text{ VA}$$

$$S = 39.7 \text{ kVA}$$

$$Power\ factor = \frac{Real\ power}{Total\ power} \times 100$$

$$P.F = \frac{39.7}{40}$$

$$P.F = 0.99$$

Therefore, Resistive Load used has a Power Factor of 0.99 and no correction is required.

Inductive Load:-

Power rating: 3kW , Current Rating : 15 A, Voltage Rating : 220V

Using formula for Apparent Power (S) ,

$$S = V \times I = 15 \times 220$$

$$S = 3.3 \text{ kVA}$$

$$Power\ factor = \frac{Real\ power}{Total\ power} \times 100$$

$$P.F = \frac{3}{3.3}$$

$$P.F = 0.9$$

Therefore, Inductive Load used has a Power Factor of 0.90.This power factor is below the recommended value.To correct this power factor ,Reactive Power (Q) needs to be reduced

Calculating Reactive Power

$$\text{Reactive Power} = Q = (S^2 - P^2)^{\frac{1}{2}}$$

$$Q = 1.374 \text{ kVAr}$$

To reduce this reactive power , 2 capacitors of 0.440 kVAr Rating are added to circuit

A new reactive power (Q'),

$$Q' = Q - C = 1.374 - 0.440 - 0.440 = 0.494$$

Calculating new Apparent Power ,

$$S' = (P^2 + Q^2)^{\frac{1}{2}}$$

$$S' = 3.049 \text{ kVA}$$

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Corrected Power Factor ,

$$\text{P. F'} = \frac{P}{S'} = \frac{3}{3.049}$$

$$\text{P. F'} = 0.98$$

Therefore, after compensating a Inductive Load which produced reactive power of 1.374 kVA and had P.F of 0.90 with two Capacitors of 0.440 kVA rating, a Corrected P.F of 0.98 is achieved.

V. RESULT

In the proposed system, Power Factor Correction Unit is used to continuously detect and monitor power factor and auto correct power factor using capacitor bank.

VI. CONCLUSION

The proposed system is implemented to automatically correct power factor.Arduinodetects Power Factor by analyzing the load of the system, and according to the lagging P;Fit will perform the control action by switching capacitor bank through different relays and improves the Power Factor of the load. By improving Power Factor electricity bill can be reduced.

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