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Automatic Power Factor Correction Using ATmega328

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ABSTRACT: Power is precious. In the present scenario as the demand for power is increasing with time, transmission and distribution of power with minimum losses has become more important. Power factor plays a very important role in minimising of losses in power system. Hence it is required to maintain a power factor near to unity. It can be maintained near to unity by using power factor correction equipment. This paper presents information about automatic power factor correction using ATmega328. In the proposed paper Automatic power factor correction is done by using arduino controller ATmega328 and the controller is programmed using Emon library which is simple and efficient than other methods. Whenever the inductive load is operating at low power factor, shunt capacitor will connect across the load and improve the power factor automatically. This paper reviews the disadvantages of lagging power factor, advantages of power factor improvement, working methodology and its future scope.

KEYWORDS: Power factor, Active power, Reactive power ATmega328.

I. INTRODUCTION

An electric power system is a network of electrical components deployed to supply, transfer and use electrical power. Any inductive load that operates on alternating current requires apparent power. But apparent power is the addition of active power and reactive power. Active power performs useful work while reactive power does no useful work but is used for developing the magnetic field required by the device. The simplest way to specify power factor is the ratio of active power to the apparent power. Power factor basically states how far the energy provided has been utilized. The ideal power factor is unity. If the power factor is less than unity it means that excess power is required to perform the same amount of work. Hence it is required to maintain a power factor near to unity and it can be done by using power factor correction equipment. So this paper introduces a very simple, easy and low cost method to improve power factor automatically.

Disadvantages Of Low Power Factor

- At low power factor, the current drawn by the load is very high, which results in high copper losses, overheating and a shorter lifespan of the equipment.
- At low power factor, high current is required by the equipments, due to which the economic cost of the equipment increases.

Advantages Of Power Factor Improvement

- Reduced power losses.
- Increase system capacity
- Conserve energy
- Save on utility cost
- Increase lifespan of the equipment.
- Reduced current consumption by the load.

II. WORKING PRINCIPLE

230V AC is converted into 9V AC using step down transformer. Step down voltage then passed through the full wave rectifier and gets converted to 9V DC. Output of the rectifier that is pulsating DC is filtered by 1000µF capacitor. 9V DC is converted into +5V DC using 7805 regulator to power controller and LCD. The measurable current and voltage from CT and PT is given to the Atmega328 controller to process it. It calculates the power factor using **Emon library**. Whenever power factor falls below the specified value, Atmega328 actuates relay.

Relay switches capacitor to the load and improves the power factor. Output will be displayed on LCD automatically. It will display voltage, current and power factor values. This process will automatically switch on and off the capacitors by

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relay board and all the changing power factor values along with voltage and current will be displayed on LCD.

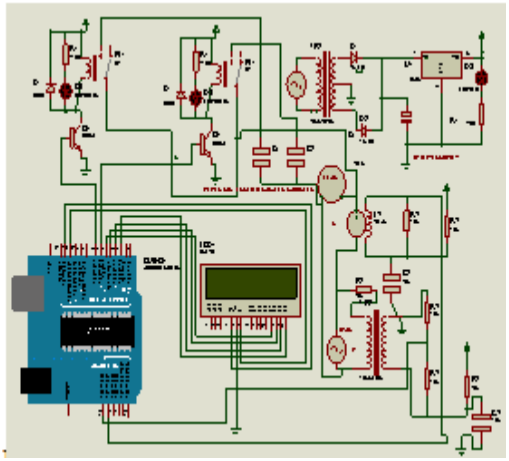

Fig-1. Circuit diagram of automatic power factor correction

ATMEGA328

ATmega328 is a very popular microcontroller chip produced by Atmel. It is an 8-bit microcontroller that has 32K of flash memory, 1K of EEPROM, and 2K of internal SRAM. This is the very popular controller used in Arduino boards. Because of its high performance with low power consumption it is best for power factor correction than the other controllers.

Fig-2. Pin description of ATmega328 microcontroller

EMON LIBRARY

Emon library indicates electricity or energy monitoring library. It can be used to measure how much electrical energy is used. It measures voltage with an AC to AC power adapter and current with a clip on CT sensor, by making the setup quite safe as no high voltage work is needed.

The energy monitor can calculate real power, apparent power, power factor, rms voltage, rms current. All the calculations are done in the digital domain on an Arduino.

By the following example we can understand the working of Emon library in the Arduino code.

```
#include "EmonLib.h"
// Include Emon Library
EnergyMonitor emon1;
// Create an instance
void setup()
{
  Serial.begin(9600);

  emon1.current(1, 111.1);            // Current: input pin, calibration.
}

void loop()
{
double Irms = emon1.calcIrms(1480);  // Calculate Irms only
Serial.print(Irms*230.0);            // Apparent power
  Serial.print(" ");
  Serial.println(Irms);              // Irms
}
```

Fig-3. Use of Emon library in the Arduino coding

ZMCT103D AND ZMPT107

ZMCT103 is a micro precision current transformer. It is popular for its low price, small size and easy PCB mounting, it is mainly used in electrical energy meter, household electrical equipment, in testing equipments and in relay protection also. This is very easy to use and makes the circuit very simple. It will sense and transform the load current to a measurable value to send it to a controller for further calculation. It's range is 5A/2.5mA.

ZMPT107 is a low cost, high precision micro voltage transformer. Because of its small size, high accuracy and good consistency, it will make a power factor correction process faster. It will

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transform the load voltage to a measurable value to send it to a micro controller for further calculations. This module makes it easy to measure AC voltage up to 1000 volts without any noise.

SHUNT CAPACITOR

Fig 3. Shunt capacitor

Power factor capacitors are the capacitors that are mainly used to improve the power factor. These capacitors have self healing property. That is during momentary faults, small areas of the capacitor electrodes evaporate to restore its function again. These PFCs can operate smoothly at a temperature as high as 70 degree. The PFCs have working voltage of 240 volt AC, 440 volt AC etc. Capacitance of PFC varies between 2uF to 100uF. The PFCs are also specified by its Reacting power (KVAr). Whenever there is a low power factor capacitor is connected to the load to neutralise a lagging power factor by supplying leading current.

III. RELAY WORKING

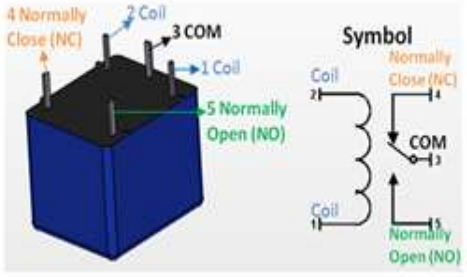

Fig 4. Relay pin configuration

A relay is an electrically operated switch in which, contacts can be made to operate in the pre arranged fashion. In short, a relay is a switch worked by an electromagnet. Above figure shows the construction features of a simple electromagnetic relay. It consists of a coil. A dc current passing through the coil produces a magnetic field. This magnetic field attracts an armature which in turn operates the contact, normally open contacts close and normally closed contacts open. As long as current flows, the two contacts remains closed. When the current is switched off, the attractive force on armature is no longer present and the contact is opened. Thus whenever there a signal from controller, relay operates and switches capacitor to the load to improve power factor.

IV. POWER FACTOR CORRECTION FORMULAS

Important formulas which is used for Power factor improvement calculation
Let, V=voltage, I=current,
P=real power/active power (kW)
S=apparent power (kVA)
Q=reactive power (kVAr)
X=reactance
Z=impedance
R= resistance

Basic formulas

1. $V=IR$
2. $V=P/I$
3. $P=i^2R$
4. $P=E^2/R$
5. $Q=i^2X$
6. $Q=E^2/X$
7. $S=i^2Z$
8. $S=E^{2/}Z$
9. $\text{Sin}\emptyset = \text{kVAr/kVA}$
10. $\text{Cos}\emptyset = \text{kW/kVA}$

Real power or active power

1. $\text{kW} = \text{kVA} * \text{COS}\emptyset$
2. $\text{kW} = \text{HP} * 0.746$ or $[\text{HP} * 0.746/\text{n}]$
3. $\text{kW} = \sqrt{(\text{kVA})^2 - (\text{kVAr})^2}$
4. $\text{kW} = \text{P} = \text{V} * \text{I} * \text{COS}\emptyset$ ….. for 1-Ph
5. $\text{kW} = \text{P} = \sqrt{3} * \text{V} * \text{I} * \text{COS}\emptyset$ …… for 3-Ph

Apparent power or total power- (s)

1. $\text{kVA} = \sqrt{(\text{kW})^2 + (\text{kVAr})^2}$
2. $\text{kVA} = \text{kW/COS}\emptyset$

Reactive power- (Q)

1. $\text{kVAr} = \text{C} * (2 * \pi * \text{V}^2)$
2. $\text{kVAr} = \sqrt{(\text{kVA})^2 - (\text{kW})^2}$

Power factor

1. $\text{COS}\emptyset = \text{P} / (\text{V} * \text{I})$ for 1-Ph
2. $\text{COS}\emptyset = \text{P} / (\sqrt{3} * \text{V} * \text{I})$ for 3-Ph
3. $\text{COS}\emptyset = \text{kW/kVA}$ (for both 1-Ph and 3-Ph)
4. $\text{COS}\emptyset = \text{R/Z}$

Required capacity of capacitor in microfarads

$\text{C} = \text{kVAr} / (2 * \pi * \text{f} * \text{V}^2)$

Required capacity of capacitor in kVAr

$\text{kVAr} = \text{C} * (2 * \pi * \text{f} * \text{V}^2)$

V. FUTURE SCOPE

The proposed system can be extended and implemented in industries and power systems. By using controllers which are most powerful, very fast acting and fast switching of capacitors can leads to a fast power factor correction. This can be done in future, which may leads to save a large amount of power to the power industries.

VI. CONCLUSION

The proposed project provides one of the simplest ways to improve the power factor automatically. This method eliminates the use of op-amp, zero crossing detectors and EXOR gates. Because of the Arduino IDE libraries, it became possible to get Emon library for measuring phase difference between voltage and current, and all other information (i.e. active power, reactive power, apparent power, power factor). Based on this analysis, a program is written to achieve a power factor close to unity. This program incorporates switching of capacitors automatically through relay board in order to compensate the lagging power factor. This method deals with modify method of automatic power factor correction using a popular arduino controller Atmega328.

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