Automatic Power Factor Correction using Arduino Atmega328p

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***Abstract*— Power is very valuable in the current scientific revolution. Therefore, we must find the cause of energy failure and develop the system to reduce them. Ever-demanding increase of power in use of the inductive load, the power factor in the network reduces. A lower power factor results in lofty energy costs.In power system the power factor is constantly altering due to increase/decrease in the size and number of devices connected. Thus it is difficult to continually maintain equilibrium of inductive and capacitive loads. The current commission has standard restrictive range on the magnitude of the power factor and if the power factor falls below the specified limit; the utility company raises the consumer penalty. This article describes a precise calculation technique to design a power factor correction system for a three-phase induction motor using Arduino Uno micro-controller chip. The hardware gear application was evolved with the help Arduino Uno, which houses the ATmega328p micro-controller. The offered sketch allows for the efficient detection of the power factor and, using the appropriate method, a sufficient number of capacitors to compensate the reactive power, thus the PF in the vicinity of the device gets higher efficiency and higher quality AC. [2]**

Keywords— APFC, Capacitors, Atmega 328p.

I. INTRODUCTION

In the current circumstances of the technological advancement, one can perceive throughout the survey that power is very much valuable and it is getting more and more compounded over the days. They are resistant, inductive and capacitive. In the matter of a completely resistive load, for example, the electrical resistance of the heaters, bulbs etc., the current and the voltage are both in same juncture(phase). While with inductive loads, the current is delayed in the voltage, that is to say, it is out of phase. Almost all existing equipment and devices are inductive (with the anomaly of some completely resistive loads and synchronous motors),such as induction machine of all types, electric arc, welding instruments, induction furnace heaters, choke-coils. With a capacitive load, the current and voltage are out of period, but now in this voltage lags the current. The most common type this loads are capacitors that correct power factor. "The power factor is the ratio of the actual power (KW) to the total (apparent) power(KVA).” The automatic power factor conversion project is sketched to automatically improve the power factor when this factor is less than unity. Additional problems are also associated when the power factor falls below the desired value. They are

- Feeder Cables Reactive losses
- Depletion in efficiency of cables
- Voltage fall at transformer secondary side
- Transformer Losses

The Automatic Power Factor is a very useful tool to improve the efficient transmission of power. When the load is connected to an inductive load, the power failure will be delayed when the power factor falls to 0.95 (lags), and the utility will charge to the consumer. Therefore, it is important to keep the power factor within the desired range. The automatic power factor tuning tool identifies the power factor from voltage and linear current, calculates the compensation requirement and encourages different capacitance banks to trigger.

The APFC is very popular for its excellent high and precise power factor measurement, quick active retaliation of low power factor and they are cheap. Digital APFC are used because of the digital control unit & has many dominating features over analog controllers; because of their programming ability, adaptability, temperature, aging and high voltage distortion.[5] By adjusting the power factor through the capacitor, the reactive energy consumption is reduced, which will result to minimisation of losses and greater efficiency of the electrical system.

II. CONCEPT

Power Factor- It is the ratio of active(true) power to the total (apparent) power. The unit of the active power is KW and that of the apparent power is KVA. In the circuit resistance{P=VIcosΦ (watts)} the power which is dissolved is true power & supplied to the equipments like machines, Bulbs, heaters etc. In the inductive reactance(X_L) of the circuit{Q=VIsinΦ (VAR)} the power which is dissipated is reactive power. The total power is the vector resultant of the true and reactive power. The magnetic field is supported by the Reactive Power(VAR). The power which is used for working of motors is the true power measured in watts and can be observed on a wattmeter.[2]At times Reactive power is required for proper functioning of the system as it circulates between generator and the load. Active power and reactive power together sum up for the apparent power. Thus the magnitude of reactive power consumed in load is understood as cosine of angle between apparent power and true power.

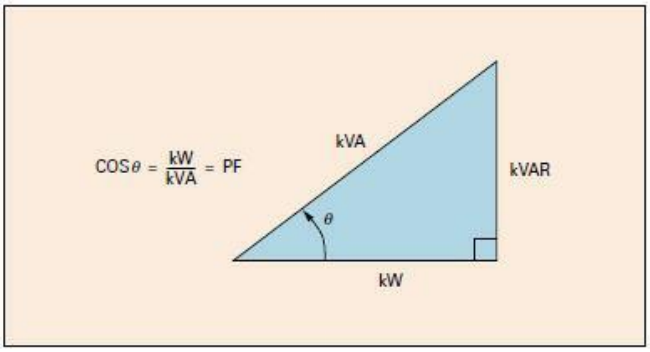

Fig-1 APFC Block Diagram

III. APFC

Automation process of Automatic Power Factor Converters results in power factor improvement. Power Factor is a key factor in measuring electrical consumption. Today the tariffs of Electrical Energy is increasing. Therefore, cost reduction is an important factor in reducing high energy consumption. APFC Panels are of great use where electrical installations have to supply a large load. Due to this power factor lag can entice operative power losses and penalty from Utility Board. Rapid alteration and scattering loads along with the retention of high power factor can be handled by these Panels.
This APFC is designed for the motor having following ratings- 3Φ Induction Motor, 5 H.P, 415V, Delta Connected, 7.3A, 1440 RPM.

IV. PRINCIPLE OF OPERATION

It works on the principle that, when the power factor falls below the set value; then APFC should notice and take necessary steps to compensate the required value of the power factor. The current and voltage signals are sensed by the current transformer and potential transformer connected in series and parallel respectively in the circuit. The Current transformer and Potential Transformer together they are also known as Instrument Transformer which give stepped down values of current and voltages whose quantity are directly proportional to the base values.[7] Zero Crossing Detectors are used to sample the analog signal and to convert them into required digital signals. These signals changes state at each current and voltage signals when they pass in Zero Crossing Detector. The pulses are obtained by ZCD which constitutes the difference in time between voltage and current signals from zero crossing of those signals. Arduino's function pulseIn() which is in the timer measures these signals of time difference, and result of these time period is in micro seconds. Power factor is calculated by these time periods signals. Once these time period signalled are found then value of power factor is known and if it is lower than 0.95 than Atmega328p triggers required number of Capacitors till the power factors becomes unity. The range set in these project is between 0.65-.0.85(No load- Full load)respectively.

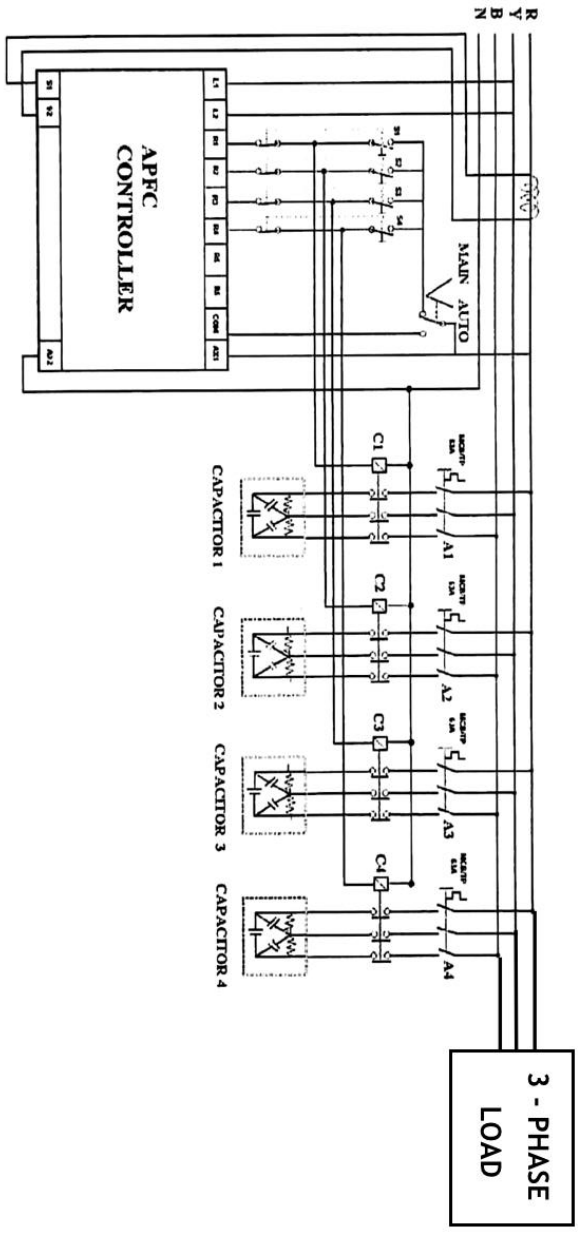

Fig-2 APFC Block Diagram

OBSERVATION TABLE

CALCULATIONS

Table-2

Comments	Φ	Cos Φ
No load	49.45°	0.65
Full load	31.76°	0.85

Vl	IL	W1*4	W2*4	N	V dc	I dc
415	1	20	60	1410	220	0
415	1.5	50	100	1460	220	1.4
415	2	80	160	1450	218	3
415	2.4	100	220	1440	218	4.5
415	3	100	240	1400	216	5.1
415	3.4	130	300	1395	218	8.2
415	6.8	630	180	1280	218	10

Table-1

The following readings were taken by using Two Wattmeter Method.

POWER FACTOR	CORRESPONDING TIME (ms)	CAPACITOR REQUIRED (microF)
0.98	0.57	0.58
0.93	1.12	1.16
0.866	1.67	1.75
0.766	2.22	2.33
0.65	2.77	2.94

Table-4

$\Phi = \frac{tan^{-}1(\sqrt{3}W1-W2)}{(W1+W2)}$

VAR required for compensation

VAR = W*(tanΦi – tanΦd)

Table-3

	Power (W)	VAR	VAR/Phase	Required Capacitance/
No Load	428.6	501	167	3.1μF
Full Load	261.7	162	54.07	0.1μF

Φi = initial angle

Φd = desired angle

No Load {VAR = W*1.169}

Full Load {VAR = W*0.619}

Required Capacitance

$C = \frac{VAR}{2\pi f V^2}$

Φ = t/T*360; where

- t = Timer of Arduino
- T= Cycle Time
- Φ = Phase angle

ALGORITHM FLOWCHART

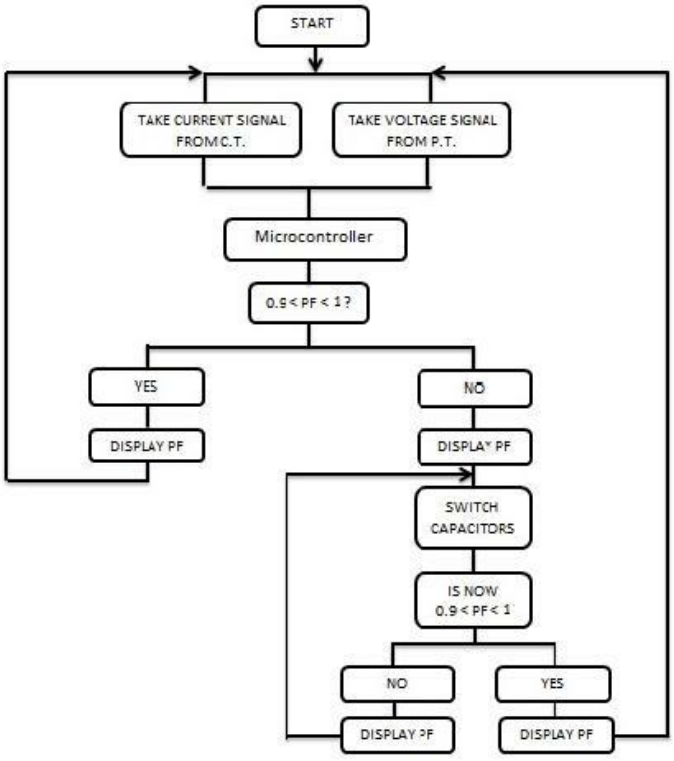

Fig-3 Flow Chart

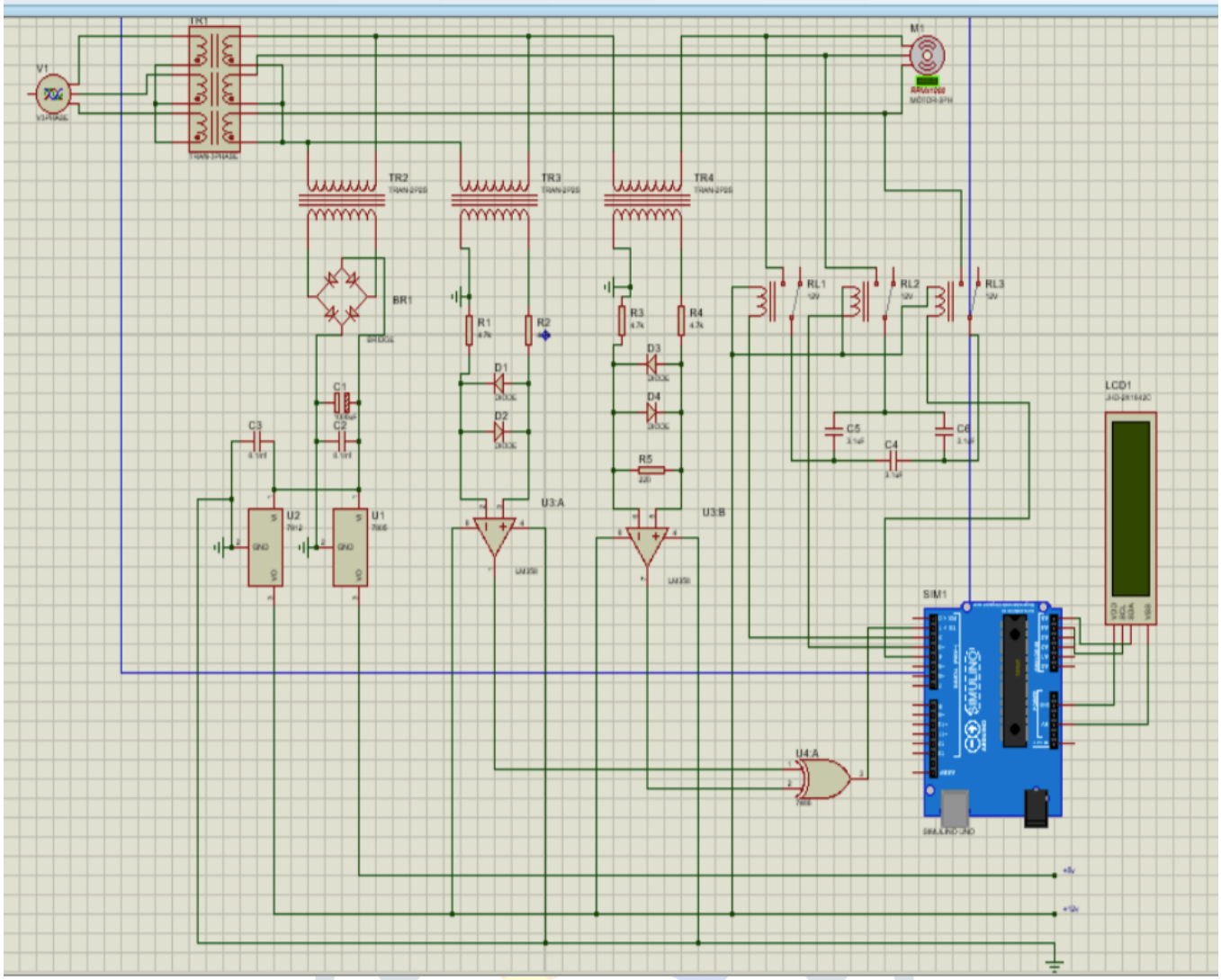

Fig-4 APFC Circuit Digram

CONCLUSION

The Automatic Power Factor Correction System is easy, fast, reliable and economical to improve power factor. These correction system can also with some modifications help to detect Harmonics in the system. These APFC are easy to build, require less power to operate and easily programmable. The whole system is compact and with housing it can obtain IP certification. These circuit can be easily made for the experimentation purpose in college laboratory with some small investment. Once the power factor is improved than capacitor gets switch OFF hence consuming less power.

ACKNOWLEDGMENT

I have been very fortunate to work for the Department's Machine Laboratory. And use the Motor for my projects testing.

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