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Minimizing Penalty in Industry by Automatic Power Factor Correction (APFC)

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***Abstract*: In the present technological revolution power is very precious so we need to find out the cause of power loss and improve the power system. Because of industrialization the use of inductive load is increased now a days and hence power system losses its efficiency. Hence we need to make some improvement and achieve the high power factor with a suitable method of Automatic power factor corrector. Whenever we are thinking about any programmable device then the embedded technology comes into forefront.**

The embedded is nowadays very much popular and most of the product are developed with microcontroller based embedded technology.

The project is planned to reduce penalty for industrial units by adding automatic power factor correction unit. Power factor is termed as ratio of real power to apparent power. It can be mathematically represented as kW/kVA, where the numerator consists of active (real) power and the denominator have (active + reactive) or apparent power. Reactive power is nothing but non-working power produced by the magnetic and inductive loads, to create magnetic flux. If the reactive power increases the apparent power also increases, so the power factor is reduced. In such case if the power factor is low, but the industry needs more energy to meet its demand, so the industries demand will raise and load will be increased more time by time this results in decrease in efficiency.

In this proposed system the time lag between the zero current pulse and zero voltage pulse is produced or generated by purpose of operational amplifier circuits in comparator mode are fed to couple of interrupt pins of the microcontroller. It exhibits the time lag between the current and voltage on LCD. The program takes over to actuate appropriate number of relays from its output to bring shunt capacitors into the load circuit to get the power factor till it reaches near unity. The Arduino uno microcontroller AT Mega 328 used in the project.

***Keywords*: Power Factor (PF), Active power, Apparent power, Reactive power, Current transformer (CT), Potential transformer(PT), capacitor bank, Liquid crystal Display (LCD).**

1. Introduction

A. Power Factor theory

In any AC system the current, and therefore the power, is made up of a number of components based on the nature of the load consuming the power. These are resistive, inductive and capacitive components. In the case of a purely resistive load, for example, electrical resistance heating, incandescent lighting, etc., the current and the voltage are in phase that is the current follows the voltage. Whereas, in case of inductive loads, it lags behind the voltage because the current is out of phase with the voltage. Other than for a few purely resistive loads and synchronous motors, now a days many of the equipment and appliances for consumer installation are inductive in nature, i.e., inductive motors of all types, transformers and regulators, welding machines and electric arc and induction furnaces, choke coils and magnetic systems, etc. In that instance of a capacitive load the voltage and current together are again out of phase but now current leads voltage. Maximumly and commonly capacitive loads are the capacitors installed in system for correction of power factor of the load.

The inductive or the capacitive loads are generally termed as the reactive loads. The significance of these different types of loads is that the active (or true or useful) power can only be consumed in the resistive portion of the load, where the current and the voltage are in phase.

(Watt less or) Reactive power which is essential for energizing or activating the magnetic circuit of the equipment (and due to which not obtainable for any capable work). Inductive loads needs two forms of power - Working/Active power (measured in kw) to deal the actual work of producing heat, light, motion, outputs of motors etc., and Reactive power (measured in kVAr) to sustain the electromagnetic field. The current known as watt-less current is required to produce the magnetic field around an electric motor. If there was no watt-less current then an electric motor would not turn. The fault is arised due to the factuality that we can occasionally have excessive watt-less current, in such type of cases we need to remove some of it.

The vector composition of these two power components active and reactive is termed as Apparent Power (measured in kVA), the value of this varies broadly for the same active power depending upon the reactive power drawn by the equipment. The ratio of the active power (kW) of the load to the apparent power (kVA) of the load is known as the power factor of the load.

It is a measured that how much effectively the current is being transformed into useful work output and more specifically is a good detector of effect of the load current on the efficiency of the supply system of circuit.

A load with a power factor of unit (1.0) result in the most effective loading of the supply and a load with a power factor of (50% of unity) 0.5 has outcome of much higher losses in the supply system.

Low power factor results to large copper losses, poor voltage regulation and handling capacity will also be reduced of the system. The increase in the load current, increase in power loss, and decrease in efficiency of the overall system Net industrial load is highly inductive causing a very poor lagging power factor. If this poor power factor is not corrected, the industry will have to demand a high maximum demand from Electricity Board and also will have to undergo through a penalty for poor power factor quality. Basically we have option to connect power capacitors in the power system at recognized places to recompence the inductive nature of the load.

Disadvantage of low power factor can be easily interpret by an example:

Supplied Voltage = 240 Volts Single phase.
Input given to motor = 10000 KW
Power Factor = 0.63
Current (I1)
= Power(kW)/Volts (V)xP.F = 10000/240x0.63=66.13 Amp.

If the power factor of the motor is increased to 0.9 the current Drawn by the motor shall be,
Current (I2)
= Power (kW)/Volts (V)xP.F = 10000/240*0.9 = 46.3 Amp.

Thus as shown above power factor reduces the current required for the same value of active or useful power. The outcome is that sizes of the equipment and apparatus like the switchgear, cables, transformers, etc., will have to be get larger to provide the higher current in the circuit. All this adds to the cost.

Further, the over current leads to increased power loss or I^2R losses in the circuits. Also due to over current, the conductor temperature raises and so the life of the insulation gets degraded as per over use and over current flow through it.

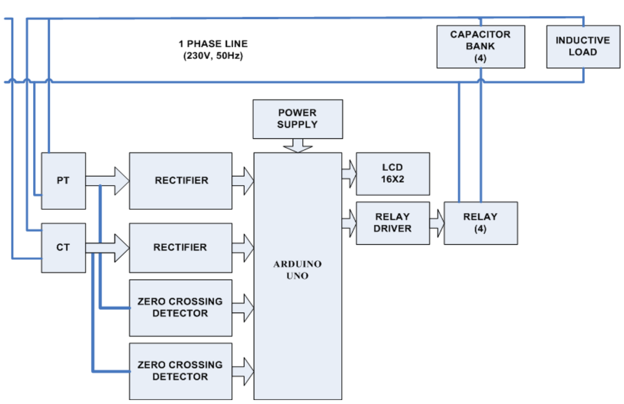

Fig. 1. Block diagram

So it is evident to improve the power factor by applying certain methods and application doing so will lead to improve the system quality and will be cost effective. Poor power factor due to an inductive load can be upgraded by adding power factor correction.

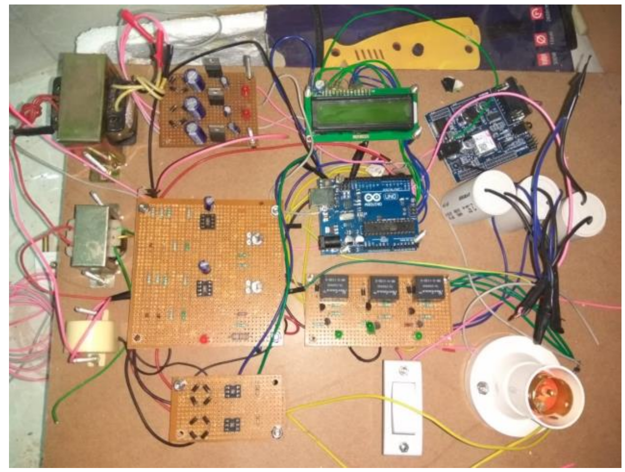

Fig. 2. Hardware setup

2. Power Supply

The 230V AC supply is firstly step down to 12V AC with the help of a step down transformer. This is then converted to DC using bridge rectifier. The AC ripples is filtered out by using a capacitor and given to the input pin of voltage regulator 7805, 7812. At output pin of this regulator we get a constant 5V, 12V DC which is used for Microcontroller and other ICs in this project.

3. Transformer

A. Rating: (230V,0-15V A.C,1A)

Transformers convert AC electricity from one voltage to another with a little loss of power. Step-up transformers increase voltage, step-down transformers reduce voltage. Most of the power supplies use a step-down transformer to lessen the dangerous unsafe high voltage to a safer level of low voltage.
The input coil is said as the primary and so the output coil is said as the secondary. No electrical connection between the two coils; in place of they are linked by an alternating magnetic field generated in the soft-iron core of the transformer. The couple of lines in the center of the circuit symbol represent the core. Transformers waste very small amount of power so the power output is (almost) equal to the given power input. Note that here voltage is stepped down and current is stepped up.
The ratio of the number of turns on each coil, called the turn's ratio, determines the ratio of the voltages. A step-down transformer has a many no's of turns on its primary (input) coil which is attached to the high voltage mains supply, and a small number of turns on its secondary (output) coil to give a desired low output voltage.

Turns Ratio = (Vp / Vs) = (Np / Ns) Where,
Vp = primary (input) voltage.

Vs = secondary (output) voltage
Np = number of turns on primarycoil
Ns = number of turns on secondary coil
Ip = primary (input) current Is = secondary (output) current.

4. CT & PT

A CT is connected in series with supply line, and potential transformer is connected in parallel with supply line. CT and PT are used to step down and also measure the current and voltage respectively.

5. Zero Crossing Detector

Zero crossing detector use to generate synchronous pulse of AC voltage Phase angle also used in power control circuits. The relationship of simulation is to convert pulse into sine wave. It measures time difference between current and voltage waveform which is used to measure power factor using Arduino Uno microcontroller.

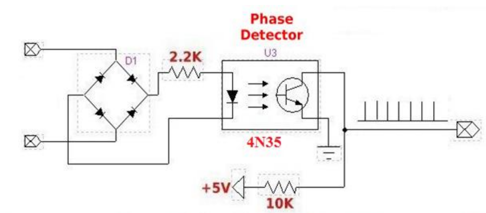

Fig. 3. Zero crossing detector

6. Arduino uno microcontroller

It has 14 digital i/o pins of which 6 can be used as PWM outputs. It has 6 analog inputs and USB connection. It has a stronger RESET circuit.
Operating voltage: 5V
Clock speed: 16MHz
EEPROM: 1KB
It is an open source electronics platform plate based on easy to use hardware and software.
Arduino programming is used in this system because it is adapted with particular needs as easy tool for fast prototyping it is flexible for user.

7. Relay (SPDT)

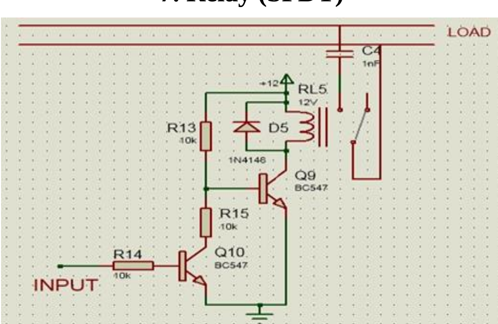

Fig. 4. Relay

Here, we have used relay as electromagnetic switch to control the circuit. The relay switch connections are usually named as COM, NC, NO.

A. Relay driver circuit

Transistor (BC547) is used as switch.
(0 = OFF, 1= ON)
Diode (1N4007) is used as Freewheeling Diode.

8. Capacitor Bank

Capacitor bank is a group of number of capacitors connected in parallel. When low power factor is experienced by the system then capacitor bank is added in the circuit to improve power factor and reducing the phase difference between voltage and current.

9. LCD

The most common device attached to microcontroller is a LCD. Here we use 16x2 display. As a result, the corrected power factor shown on LCD.

10. Advantages of improved power factor

- Reactive is power decreased
- Poor voltage regulation can be avoided
- Over loading can be avoided
- Reduction in Copper losses
- Transmission loss decreased
- Improved voltage regulation
- Efficiency of supply system and apparatus increases.

11. Result

The variations in supply line are observed and supply line parameters like current, voltage, power, power factor, phase angle are recorded. These observations are recorded before and after application of APFC and it is displayed on LCD. LCD displays as per programming and calls of ARDUINO UNO microcontroller.

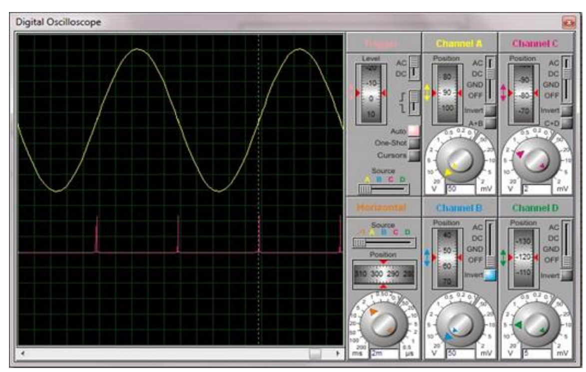

Fig. 5. Simulation of zero crossing detector

Here Zero crossing detector and relay driver circuit are the components working for specific objective such as pulse wave simulation and switching operation along with microcontroller. Whenever supply line experiences the low power factor problem it is detected through the process with the help of CT, PT for current and voltage parameters and further time difference is recorded and power factor is measured by using

Zero crossing detector. Further according to the programming Arduino will transmit signals to relay driver circuit for actuation of systems power factor.

We can achieve power factor up to 0.96-0.97 by using microcontroller and capacitor.

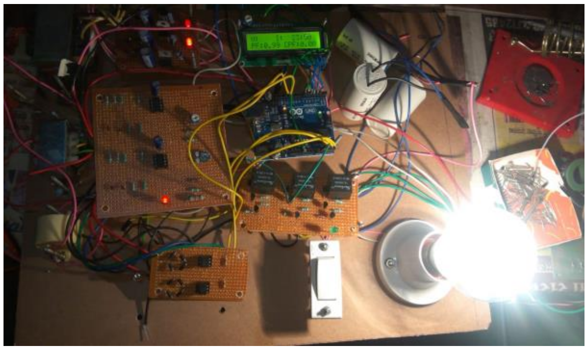

Fig. 6. Experimental result

12. Conclusion

This project has proposed the advanced method of the power factor correction by using the microcontroller which has the many advantages over the various conventional methods of the power factor compensation. The switching of capacitors is done automatically by using the relay and thus the power factor correction is more accurate. Thus we have presented the possible advanced method for the correction of the power factor. Installation capacitor bank for power factor correction will obtain profitable both sides consumer and electric flow. Installation of capacitor bank can help in deduction of reactive current use further minimizing the losses. By considering all characteristics of the power factor it is obvious that power factor is the most important part for the utility at company level as well as for the consumer position. Utility companies get relieve from the power losses while the consumers are also free from low power factor featured penalty charges.

The automotive power factor correction using capacitive load banks is very capable and can accomplish the circuit as it reduces the cost by decreasing the power drawn from the supply. 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.

References

[1] Sapna Khanchi & Vijay Kumar Garg, "Power Factor Improvement of Induction Motor by using Capacitors", International Journal of Engineering Trends & Technology (IJETT), Volume 4, no. 7, July 2016.

[2] Jain Sandesh, Thakur Shivendra Singh and Phulambrikar S.P., "Improve Power Factor and Reduce the Harmonic Distortion of the System", International Journal of Advanced Research in Computer Science and Software Engineeriong. Volume 1, no. 5, November 2012.

[3] J. B. V Subrahmanyam, S. Radha Krishna Reddy, P. K. Sahoo, N. Madhukar Reddy, C. Sashidhar, "A Novel Method for Improvement of Power Factor in Wind Mill Power station," International Journal of Engineering Technology and Advanced Engineering", Volume 2, no. 2 February 2012.

[4] Abhinav Sharma, Shavet Sharma, Parveen Lehana and Saleem Khan, "To Analysis the Effect of Combination Load on the Power Factor", International Journal of Advanced Research in Computer Science and Software Engineering, volume 3, no. 8, August 2013.

[5] Anant Kumar Tiwari, "Automatic Power Factor Correction Using Capacitive Bank", International Journal of Engineering Research and Applications, Volume 4, February 2014.