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A Review on Methodologies of Automatic Power Factor Improvement Using Arduino

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Abstract – *This paper provides a comprehensive review of the recent and past development of the Automatic power factor improvement is designed to automatically improve the power factor whenever the power factor falls below a certain level. As we know, the demand for electric power is increasing day by day. Nowadays, many inductive loads are used in industry and small-scale applications. These inductive loads cause the power factor to drop and are one of the main reasons for power factor reduction in industrial applications. There is therefore a need to increase the degraded power factor. The automatic power improvement provides a solution to this problem. Due to the low power factor, there is a load on the power system and transmission lines which is unnecessary. By correcting the power factor of the power system, the efficiency of the power system can be improved. In this methodology, a power factor improvement prototype is developed using a peak microcontroller, relays, a potential transformer, a current transformer, and a zero-crossing circuit.*

Key Words: Correction, Microcontroller, Power Factor (PF), Inductive Load, Capacitor, Inductor, Automatic

1. INTRODUCTION

In the current scenario of technological revolution, power is very valuable. Industrialization mainly increases the inductive load, inductive loads affect the power factor, so the power system loses its efficiency. Some organizations develop products and carry out Research and development work in this area to improve or compensate for the power factor. Nowadays, the size of the design is getting smaller and to make this possible and make it into a product, a programmable device can be used. Whenever we think of programmable devices, embedded technology comes to the fore. Despite its ease of reliability and relatively lower cost, it has some drawbacks. The relays to be used are quite bulky and require regular maintenance. Multifunctionality is out of the question. Power factor correction is a very useful tool to improve the active power transmitted to the industrial installation. If an inductive load is connected anywhere in industrial applications, the power factor lags, when the power factor drops below a certain low level (0.97 offset), the power company charges a penalty to the respective consumer. So it becomes very essential to regulate the power factor with a limit. The automatic power factor improvement device is designed in such a way that it reads the power factor from the line voltage and current, calculates the adjustment required to achieve the desired power factor, switching the batteries of capacitors connected across the load.

2. LITERATURE SURVEY

The article "Power factor correction unit using 89C52" published in 2014 contains the use of the 89C52 to measure and correct the power factor. The advantage of this research was that it showed the best method to measure the power factor of the systems but the disadvantage was the increase in the response time of the microcontroller [1].

The article "Power factor correction unit using an active series of filters" contains the use of active filters for the purpose of power factor correction, which is a unique method of power factor correction. The advantage of this method was the use of active filters to improve the power factor, but the disadvantage was the use of active filters because the filters do not have sharp cutoff frequencies and there were no either using controller, the circuit was not automatic [2].

The article "Automatic Induction Motor Power Factor Correction Using Arduino" contains the practical realization and power factor correction through the induction motor. The advantage of this article was that it solved the problem of low power factor practically at the level of the induction motor by using it as an inductive load. The downside was that using the Arduino UNO board increased the cost of the circuit because it had to be more connected to the controller [3].

The article "Automatic power factor correction unit" published in 2016 contains the use of a precision rectifier, an EXOR gate and the use of an Arduino board as well as inductive and capacitive loads for d improvement and power factor correction. The advantage of this item is that it measures the voltage and current value and solves the power factor problem and displays the corrected value, but its disadvantage is the measurement of voltage and current

value using a rectified sine wave and also the use of a precision rectifier which increases the size and complexity of the circuit [4].

3. BLOCK DIAGRAM

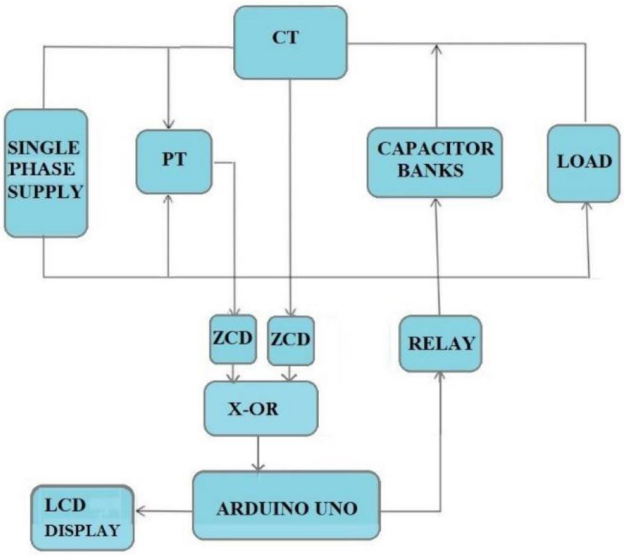

Fig -1: Block Diagram of Automatic Power Factor Improvement Using Arduino

The basic target of this system is following:

- Increased Efficiency of System

  The installation of PFI equipment makes it possible to increase efficiency of the system and device.

- Increased Available Power

  The installation of PFI equipment on the low voltage side increases the power available at the secondary of an MV/LV transformer. A high power factor optimizes an electrical installation by allowing better utilization of components.

- Reduced Voltage Drops

  Installing capacitors reduces voltage drops upstream of the connection point of the PFC device, thus avoiding network overload and reducing harmonics.

- Reduced Installation Size

  The installation of PFI equipment makes it possible to reduce the section of the conductors, since less current is absorbed by the compensated installation for the same active power.

- Savings on The Electricity Bill

  Power factor improvements eliminates reactive energy penalties, decreases kVA demand, and reduces power losses generated in plant transformers and conductors.

Proposed Improvement Scheme for Power Factor

The voltage or current waveform has a sinusoidal shape waveform with a 360 degree wave cycle which when converted to seconds of time it is 20 milliseconds (Frequency = 50Hz, T=1/F = 1/50).When the load is applied by the current waveforms changes each zero crossing position according to on the characteristics of the load. Regardless charge the time period is similar but the every zero crossing of the current waveform changes as the voltage waveforms remain in the same position. Thus, the voltage is used as the reference waveform for determines the time variation or time at which current waveform starts. The difference in the each zero crossing of voltage and current waveforms is known as phase angle difference. This phase angles difference is used to calculate the power factor because the power factor value is cosine of the phase angle difference between voltage and current.

As mentioned above, one cycle of the waveform is 20 milliseconds. The sine waveform contains a positive and negative half cycle. The waveform hits zero and goes into a negative cycle or a positive cycle for every half cycle i.e. 180 degrees which when converted to seconds is 10 milliseconds this process is known as zero crossing. But the zero crossing remains the same at 10 milliseconds. Thus, when the load is applied, there is a difference between the zero crossing of the voltage and current waveforms. The difference in their zero crossing time is noted and converted to degrees. This value is known as the phase angle difference. The power factor is the cosine of the phase angle difference of the voltage and current waveforms. Thus, the phase angle difference obtained gives us the value of the power factor. Power for the Arduino Microcontroller and other components is provided by a 5V DC power supply.

The two operational amplifiers convert the sinusoidal signal into a square signal. The square waves from the op amps output are fed to the exclusive OR (X-OR) gate. The output of the X-OR gate is the phase angle difference which is given to Arduino. The cosine of the phase angle difference gives the value of the power factor. If the power factor is less than 0.9, the capacitor is on.

CONCLUSION

Thus, by using the concept of automatic power factor improvement, the problem of low power factor can be eliminated and can be very useful for industries using inductive load. As the power factor is directly related to the power consumption, it should be as high as possible and

ideally 1 to reduce the power consumption and avoid the Maharashtra state penalty of electrical panel which is caused when the industries use a large power then the nominal due to the low power factor. Therefore, by using a capacitor load in parallel with an inductive load, the power factor can be increased. Moreover, power factor correction techniques can be applied to industries, power systems and also households to make them stable and through this the system becomes stable and the efficiency of the system increases. Using PIC microcontroller reduces cost and response time. Care should be taken for overcorrection, otherwise the voltage and current become larger, which makes the power system or machine unstable and shortens the life of capacitor banks.

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