

“Review on power factor correction by using Microcontroller”

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Abstract-In the industrial sector the various motoring loads are continuously running and increasing the inductive load. So the power factor in this system get reduces due to the inductive reactive power. But the electricity board has a standard limit regarding the power factor values and if the power factor goes below the specified limit the electricity company charges the penalty to the industrial consumers. APFC device reads power factor from line voltage and line current by determining the delay in the arrival of the current signal with respect to voltage signal. Capacitor bank added in circuit using relay driver IC .This time values are the calibrated as phase angle and corresponding power factor. If the power factor below 0.8 then capacitor add in circuit. The values of current, power, voltage and power factor are displayed in Liquid crystal display modules. Then the controller calculates the compensation requirement and capacitors are on through relay driver IC accordingly power factor. This is developed by using ATMEGA328controller.

Keywords: APFC, Reactive Power, Power Factor

1. INTRODUCTION

The low power factor leads to the increase in the load current, increase in power loss, and decrease in efficiency of the overall system. Majority of the loads in the industries are highly inductive in nature such as induction motors, AC/DC drives, welding machines, arc furnaces, fluorescent Lightings, electronic controls and computers. There may be a few resistive loads for heaters and incandescent bulbs. Very rarely industries may have capacitive loads such as synchronous motors. Net industrial load is highly inductive causing a very poor lagging power factor. If this poor power factor is left uncorrected, the industry will require a high maximum demand from Electricity Board and also will suffer a penalty for poor power factor. Standard practice is to connect power capacitors in the power system at appropriate places to compensate the inductive nature of the load. In this paper we are using a method of the reactive power compensation by capacitor switching with automatic control using ATMEGA328.

2. LITERATURE REVIEW

2.1 Overview of Previous Research Work:-

A limited number of studies have been attempted on the effect of poor power factor in mines and the corrective measures to mitigate the problem.

Oommen and Kohler (1988) explored the advantages that can be accomplished by proper implementation of power factor compensation. Different compensators along with the sizing and strategic

Location was also considered. A brief study on the economic analysis was carried out to show the economic viability of compensation

Jiang et al. (1993) proposed a novel single-phase power factor correction scheme based on parallel power factor correction concept which was described to be more efficient than convention two-cascade stage scheme.

Qureshi and Aslam (1995) outlined the different methods for power factor correction and carried out an experimental case study to explore the areas which will be suitable for compensation. After a practical demonstration to have a significant improvement in power factor was completed, they found that it would release the capacity of distribution transformer and the problem of over voltage under condition of low load was avoided.

Novak and Kohler (1998) pointed out the importance of power factor improvement for technological innovation and advancement in deep coal mine power systems. Different protection equipment to check the inherent electrical faults in the mining system were argued. The power factor correction near loads for improved voltage regulation was emphasized within the constraints of high voltage distribution in underground coal mines. **Shwehdi and Sultan (2000)** suggested some mathematical calculations for power factor and reactive power requirement of the system along with the capacitor size estimation methods. Different problems associated accompanied by essentials and cautions for capacitor used for correction purpose were discussed in details.

Celtekligil (2008) discussed the application of a method for dynamic power factor correction and voltage regulation in light rail transportation system. Main reactors have been switched on through thyristors using automatic power controllers by sensing the power factor and constantly monitoring the current and voltage, calculating the power factor and switching inductance banks as required. The system proposed connects inductive loads in parallel with the capacitive system to improve the power factor.

Choudhury (2008) gave a design and implementation of a low cost power factor improvement device for small signal low power loads. The design involved designing of a small signal model load, selecting appropriate capacitors, and designing appropriate switching circuits to select proper combination of capacitors.

Shahid and Anwar (2013) offered the design of a power factor improvement circuit using PIC (Programmable Interface Controller) chip with reduced parts count to achieve desired efficiency and low cost. The solution involves ensuring the power factor value from the load and uses an algorithm to determine and trigger switching capacitors in order to compensate for excessive reactive components to increase power factor value.

Sharma and Haque (2014) carried out a simulation and analysis study for power factor correction for metal halide high intensity discharge lamps. A modified boost converter using active devices was proposed along with PI controller to stabilize the control loops. The capacitor and inductor with voltage and current ripple with minimum ripple values was designed and to absorb

sinusoidal input current to reduce total harmonic distortion (THD) in the input current with output voltage regulation.

Allah (2016) suggested an automatic power factor correction based on Alienation technique. An alienation technique was developed for calculations of original power factor on-line, active and compensation reactive powers and determination of the required number of capacitor banks to get the desired power factor. Alienation coefficients were calculated between phase voltage and current signals of power supply.

2.2 Background of research work:-

In the present scenario of technological revolution it has been observed that the power is very precious. The industrialization is primarily increasing the inductive loading, the Inductive loads affect the power factor so the power system losses its efficiency. There are certain organizations developing products and caring R&D work on this field to improve or compensate the power factor. In the present trend the designs are also moving forwards the miniature architecture; this can be achieved in a product by using programmable device. Whenever we are thinking about any programmable devices then the embedded technology comes into force front. The embedded is now a day very much popular and most the product are developed with Microcontroller based embedded technology. The advantages of using the microcontroller is the reduction of the cost and also the use of extra hardware such as the use of timer RAM and ROM can be avoided. This technology is very fast so controlling of multiple parameters is possible; also the parameters are field programmable by the user. The electrical engineering and its applications are the oldest streams of Engineering. Though these systems are quite reliable and cheaper, it has certain disadvantages. The electro mechanical protection relays are too bulky and needs regular maintenance. The multifunctional is out of question. Recently, the technical revolution made embedded technology cheaper, so that it can be applied to all the fields. The pioneer manufactures of Power system and protection system such as SIMENS, LARSON & TUBRO, and CUTLER HAMPER etc. manufacturing power factor improvement devices on embedded technology. The Automatic Power factor Correction device is a very useful

device for improving efficient transmission of active power. If the consumer connect inductive load, then the power factor lags, when the power factor goes below 0.97(lag) then the Electric supply company charge penalty to the consumer. So it is essential to maintain the Power factor below with in a limit. Automatic Power factor correction device reads the power factor from line voltage and line current, calculating the compensation requirement switch on different capacitor banks.

3. POWER FACTOR THEORY

A poor power factor due to an inductive load can be improved by the addition capacitor of bank, so power factor is also defined as the cosine of the phase difference between current and voltage. It can be mathematically expressed as $\cos\phi$, where ϕ is the phase difference between current and voltage. Basically AC power circuits, have resistive loads (like heaters) or inductive loads (like motors) or capacitive loads (like power supplies). Depending upon the loads the current phasor can be in-phase with voltage, lagging the voltage or leading the voltage. For purely resistive load current is in phase with the voltage. Therefore phase difference $\phi=0^\circ$. Thus giving power factor, $\cos\phi=1$. Hence the power factor for purely resistive load is unity. In a purely inductive circuit, the current lags the voltage. Therefore the phase difference between current and voltage $\phi=90^\circ$. Hence power factor is lagging. In a purely capacitive circuit, the current leads the voltage therefore the phase difference between current and voltage $\phi=90^\circ$. thus the power factor is said to be leading.

3.1 Causes of Low Power Factor

Low Power factor is caused by inductive loads. Inductive loads require the current to create a magnetic field that produces the desired work. The result is an increase in reactive and apparent power and a decrease in the power factor, or efficiency, of a system. Since the power factor is defined as the ratio of KW to KVA, we see that low power factor results when KW is small in relation to KVA. An inductive load includes transformers, induction motors, and induction generators, high intensity discharge lighting. These inductive loads constitute your distribution system. This increase in reactive

Power factor is the ratio between the active power (kW) to the total apparent power (kVA) consumed by an A.C electrical equipment or a complete electrical installation. It is a measure of how efficiently electrical power is converted into useful work output. The ideal power factor is unity, or one. Anything less than one means that extra power is required to achieve the actual task at hand. A poor power factor can be the result of either a significant phase difference between the voltage and current at the load terminals, or it can be due to a high harmonic content or distorted current waveform.

power results in large angle between KW and KVA. This large angle decreases the power factor. The efficiency of inductive equipment and system power factor will vary depending on its manufacturer, design, size and age. Most inductive equipment has a nameplate with operating data, including its power factor at rated load.

3.2 Disadvantages of Low Power Factor

- Large Line Losses (Copper Losses): Line Losses is directly proportional to the square of current „ I^2 “ therefore, larger the current, the greater the line losses.
- Large kVA rating and size of electrical equipment's: Power factor is inversely proportional to the kVA i.e. $\cos\phi = kW / kVA$ Therefore, lower the power factor, the larger the kVA rating of machines also, the larger the kVA rating of machines, the larger the size of machines, the larger the cost of machines.
- Greater conductor size and cost: In case of low power factor, current will be increased, thus to transmit this high current, we need the larger size of conductor also cost of conductor increase.
- Poor voltage regulation and large voltage drop: Voltage drop = $V = IZ$. With low power factor, current will be increased. So the larger the current, the larger the voltage drop. In case of low power factor there would be large voltage drop which cause low voltage regulation.
- Low efficiency: In case of low power factor, there would be large voltage drop and large line losses and this will cause the system or equipment efficiency too low. Due to low power factor, there would be large line losses;

therefore, alternator needs high excitation, thus, generation efficiency would be low.

- Electrical power supply company imposes a penalty of power factor below 0.9 lagging in electric power bill. So industries must improve power factor above 0.9.

3.3 Benefits of Power Factor Correction

- The advantages that can be achieved by applying the power factor correction are
- Environmental benefit-reduction of power consumption due to improved energy efficiency
- Reduced power consumption means less greenhouse gas emissions.
- Reduction of electricity bills.
- Extra KVA available from the existing supply.
- In transformers and distribution equipment I²R losses decrease.
- In long cables reduction of voltage drop.
- Extended equipment life- reduced electrical burden on cables and electrical component.

Table No:3.4 Comparison between 8051 microcontroller and Atmega328:

Atmega328	8051
Atmega328 is more faster than 8051	8051 is less faster
It uses lesser number of clock cycle for instruction execution	It uses more clock cycle for instruction execution
It can use internal oscillator, saving additional circuitry	In 8051 to add external crystal Oscillator.
If you have to make small project which needs to store only few bytes in EPROM, you can use internal EEPROM in atmega328	In 8051 you have to add an external EEPROM even to store 1 byte. in addition you have to add more function in 8051
It much easier to use PWM in atmega328	It not easier to use PWM in 8051
Speed of atmega328 is 1 clock/ instruction cycle	Speed of 8051 is 12 clock / instruction cycle
Atmega328 is consume low power	8051 consume in average power.
It used modified architecture	It use Neumann architecture
It Bus width of 8/32 bit	It bus width is 8 bit for standard core

4. WORKING PRICIPLE

Capacitive power factor correction is applied to circuits which include induction motors as a means of reducing the inductive component of the current and thereby reduce the losses in the supply. There should be no effect on the operation of the motor itself. An induction motor draws current from the supply that is made up of resistive components and inductive components. The current due to the leakage reactance is dependent on the total current drawn by the motor, but the magnetizing current is independent of the load on the motor. The magnetizing current will typically be between 20% and 60% of the rated full load current of the motor. The magnetizing current is the current that establishes the flux in the iron and is very necessary if the motor is going to operate. The magnetizing current does not actually contribute to the actual work output of the motor. It is a catalyst that allows the motor to work properly. The magnetizing current and the leakage reactance can be considered as the passenger components of current that will not affect that the power drawn by the motor, but contribute to the power dissipated in the supply and distribution system.

Step down transformer use to power circuits, The output voltage from the step down transformer is 4 volt give to controller from the controller four wire drawn for connecting four relay through relay driver IC .we give 5 volt input to relay driver IC and take ground output and by default 12 volt given to relay each terminal .we use four capacitor each common terminal connected to relay and other terminal connected to neutral of supply Current transformer use for measurement of current .when system power factor goes on decreasing below 0.96 adding capacitor in circuit for compensate reactive power in circuits. If this power factor value is above 0.9 then the controller doesn't send any command signals to the relay driver switch to the capacitors on. But, if it is less than 0.9, then the controller sends command signals to the relay driver so that the capacitor bank on. Therefore, these capacitors reduce the lagging nature of the load by giving leading currents to it. The number of capacitors' switching depends on the value of the power factor – very low power factor needs all the capacitor, whereas high power factor needs none of those.

Voltage & Current Measurement Unit-Current transformer (CT) is connected series with line, and Potential transformer (PT) is connected parallel with supply line. CT & PT are used to step down the voltage and current for resistor divider network.

Controller -The ATmega328 is a single-chip microcontroller created by Atmel in the mega AVR family. The ATmega328 is commonly used in many projects and autonomous systems where a simple, low-powered, low-cost micro-controller is needed.

LCD-A microcontroller program must interact with the outside world using input and output devices that Communicate directly with a human being. One of the most common devices attached to a microcontroller is a Liquid crystal display. Some of the most common LCDs connected to the microcontroller are 16x2 and 20x2 displays.

Relay -Relay outputs are provided which operate to connect or disconnect the capacitor banks depending upon of the power factor conditions.

Capacitor Bank-Capacitor bank is an assembly of number of capacitors which are used to contribute KVA in the electrical system and finally improve the power factor. Shunt capacitors bank are arrangements of series/paralleled connected units.

Relay-A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal or where several circuits must be controlled by one signal. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw switch.

Relay Driver Relay-Driver is interfaced with the microcontroller output. It is used to drives the multiple relays as per the compensation required. Relay driver IC

5. SOFTWARE REQUIREMENT

Arduino sketch software.

6. CONCLUSION

In our project "Minimizing Penalty in Industrial Power Consumption by Engaging APFC Unit" in which the advanced method of the power factor correction by using Automatic power factor correction unit which has the many advantages over the various methods of the power factor correction. The switching of capacitors is done automatically by using the relay and thus the power factor correction is more accurate. Thus in this paper presented the possible advanced method for the correction of the power factor.

7. FUTURE SCOPE

There are several avenues for future research the application of complex valued? Neural network approach is implemented for contingency analysis using the offline data for training purpose. This method can be extended for online applications of realistic power system. For larger power system having thousands of variable input features selection for the neutral network plays an important role. As the size of the system increases the numbers of neurons increases there by increases the training time. A method of mutual information between the input and output variables is to be investigated. In this research voltage constrained transfer capability is compared the future work implement the other constraints like thermal and economic considerations. A well-coordinated power system planning, control and operation is required for the future electric utilities as they will find themselves in an increasingly competitive environment. There is an urgent need for the development of methods, procedure and software tools to deal with various contingencies, wide range of operating conditions. This would help in further research on accurate transfer capability computations

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