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Automatic Power Factor Compensation (APFC) For Industrial Power Use to Minimize Penalty

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ABSTRACT

In this proposed system, two zero crossing detectors are used to detect the zero-crossing of voltage and current. The project is designed to minimize fines for industrial units using automatic power factor regulators. The microcontroller used in this project belongs to the 8051 0. family the time delay between the 0-voltage pulse and the 0 current pulses is duly generated by the appropriate amplifier circuits operating in the comparator mode. The comparator is supplied to the two interrupt pins of the microcontroller. The program takes over to operate the appropriate number of relays from its output to introduce shunt capacitors into the load circuit to gain power factor until it is almost uniform. The capacitors and relays are interfaced with the microcontroller using a relay driver. It displays the time delay between current and voltage on the LCD. In addition, the design can be improved by using a thyristor control switch instead of a relay control to avoid the contact pitting common when switching torsion capacitors due to the high rush current.

Keywords : Active Power, Reactive Power, Power Factor, AT89C52 Microcontroller, Penalty, Capacitor Banks, Current Transformer, Voltage or Potential Transformer.

I. INTRODUCTION

The power factor is the ratio between real power and the apparent power of the equipment. In the present trend, the Automatic Power Factor Controller design can be achieved by using a programmable device. As we think about programmable device embedded system comes forefront. Embedded system nowadays is very popular and microcontroller proves to be advantageous with the reduction of cost, extra hardware use such as timer, RAM, and ADC are avoided. Only the relays used are disadvantageous as they are too bulky and need regular maintenance. Now embedded technology has become cheaper with the help of the technical revolution to apply it in all the fields. The automatic Power Factor Correction device is very useful to improve the transmission of active power efficiently. The power factor must be

maintained within a limit. As inductive load is connected, the Power factor lags and when the Power factor goes below the lagging Power factor, then a penalty is charged by the supplying company. Therefore, it is necessary to maintain the Power factor within a limit. APFC techniques can be applied to industries, power systems, and also to households to make them stable and also help in improving the efficiency of the system. Poor Power factor can be improved by the addition of Power factor correction, but a poor Power factor that is caused due to distortion in the current waveform needs to have a change in the design of the equipment APFC is to be developed based on microcontroller(AT89S52\C51) Poor Power factor can be improved by the addition of Power factor correction, but a poor Power factor which is caused due to distortion in current waveform needs to have a change in the design of the equipment APFC is to be developed based on microcontroller (AT89S52\C51). Lesser reactive power flows from the line. They decrease the phase difference in the voltage and current. When capacitors are used Losses are low and also require very less maintenance. Installation of capacitors is easy because of their lighter weight and does not require a foundation.

1.1 Power Factor Improvement

Alternating current circuits

Unlike Director Current Circuits, where only resistance restricts the current flow, in Alternating Current Circuits, other circuits aspects determine the current flow through these are the same as resistance, they do not consume power, but load the system with reactive currents; like D.C. circuits where the current multiplied by voltage gives watts, here the same gives only VA.

Like resistance, these are called "Reactance". Reactance is caused by the inductance or by the capacitance. The current drawn by inductance lags the voltage while the one by capacitance leads the voltage. Almost all industrial loads are inductive and hence draw lagging wattles current, which unnecessarily loads the system, performing no work. Since the capacitive currents are leading in nature, loading the system with capacitors wipes out them.

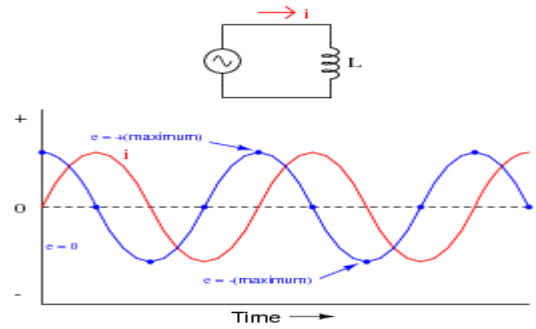


Fig: Waveforms For Inductive Load

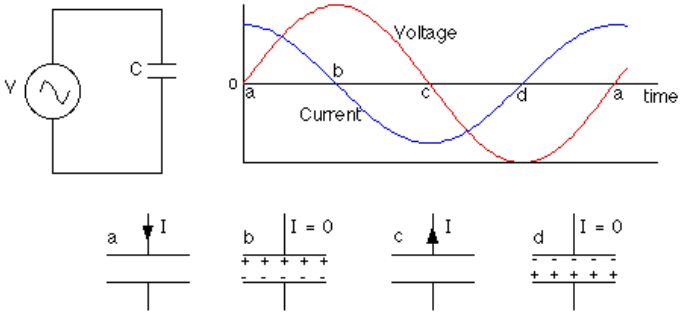


Fig: Waveforms For Capacitive Load

Capacitors for power-factor improvement

Whatever the power factor is, however, the generating authority must install machines capable of delivering a particular voltage and current even though, in a particular case, not all the voltage and current products are being put to good use. The generators must be able to resist the rated voltage and current regardless of the power delivered. For example, if an alternator is rated to deliver 1000A at 11000 volts, the machine coils must be capable of carrying the rated current. The apparent power of such a machine is 11 M V A and if the load power factor is unit this 11 MVA will be delivered and used as 11 MW of active power i.e. the alternator is being used to the best of its ability. If the load power factor is say, 0.8 lagging, then only 8.8 MW are taken and provide revenue, even though the generator still has to be rated at 1000A at 11 kV. The lower the power factor, the worse the situation becomes from the supply authorities' viewpoint. Accordingly, the

consumers are encouraged to improve their load power factor and in many cases are penalized if they do not. Improving the power factor means reducing the angle of lag between the supply voltage and supply current.

1.2 Power Factor Correction

The energy issue of an AC electric powered energy machine is described because the ratio of the actual energy flowing to the burden to the plain energy withinside the circuit and is a dimensionless wide variety among zero and 1 (regularly expressed as a percentage, e.g. zero. five pf = 50% pf). Real energy is the capability of the circuit for appearing paintings at a selected time. Apparent energy is manufactured from the cutting-edge voltage of the circuit. Due to power saved in the load and lower back to the source, or because of a non-linear load that distorts the waveform of the cutting-edge drawn from the source, the plain energy could be extra than the actual energy.

Linear hundreds with a low energy issue (including induction motors) may be corrected with a passive community of capacitors or inductors. Non-linear hundreds, including rectifiers, distort the cutting-edge drawn from the machine. In such cases, energetic or passive energy issue correction can be used to counteract the distortion and lift the energy issue. The gadgets for correction of the energy issue can be at a significant substation, unfold out over a distribution machine, or constructed into the energy-ingesting gadget.

Power factor correction of linear loads

It is regularly suited to modify the strength element of a gadget to close to 1.0. This strength element correction (PFC) is done with the aid of using switching in or out banks of inductors or capacitors. For example, the inductive impact of motor hundreds can be offset with the aid of using domestically linked capacitors. When reactive factors deliver or soak up reactive strength close to the load, the plain strength is reduced.

Power element correction can be carried out with the aid of using an electrical strength transmission application to enhance the steadiness and performance of the transmission community. A correction device can be set up with the aid of using personal electric clients to lessen the fees charged to them with the aid of using their power supplier. An excessive strength element is typically suited in a transmission gadget to lessen transmission losses and enhance voltage law on the load.

Power element correction brings the strength element of an AC strength circuit in the direction of 1 with the aid of using providing reactive strength of the alternative sign, including capacitors or inductors which act to cancel the inductive or capacitive results of the load respectively. For example, the inductive impact of motor hundreds can be offset with the aid of using domestically linked capacitors. If a load had a capacitive value, inductors (additionally referred to as reactors on this context) are linked to accurate the strength element. In the power industry, inductors are stated to devour reactive strength, and capacitors are stated to deliver it, even though the reactive strength is simply shifting backward and forward on every AC cycle.

The reactive factors can create voltage fluctuations and harmonic noise whilst switching on or off. They will deliver or sink reactive strength no matter whether or not there's a corresponding load working nearby, growing the gadget's no-load losses. In the worst case, reactive factors can engage with the gadget and with every different to create resonant conditions, ensuing in gadget instability and extreme overvoltage fluctuations. As such, reactive factors can not honestly be carried out at will, and strength element correction is usually a concern to engineering analysis. an computerized strength element correction unit is used to enhance the strength element. A strength element correction unit normally includes numerous capacitors which might be switched thru contactors. These contractors are managed with the aid of using a regulator that measures the strength element in an electrical community. To be capable of degree the strength element, the regulator makes use of a present

day transformer to degree the present day in a single phase.

Depending on the load and strength element of the community, the strength element controller will transfer the important blocks of capacitors in steps to make certain the strength element remains above a specific value (normally demanded with the aid of using the electricity supplier), say 0.9.

Instead of the usage of a hard and fast of switched capacitors, an unloaded synchronous motor can deliver reactive strength. The reactive strength drawn with the aid of using the synchronous motor is a characteristic of its subject excitation. This is called a synchronous condenser. It is commenced and linked to the electric community. It operates at the main strength element and places VARS onto the community as required to assist a gadget's voltage or to hold the gadget strength element at a certain level. The condenser's set up and operation are the same to massive electric-powered motors. Its main gain is the convenience with which the quantity of correction may be adjusted; it behaves like an electrically variable capacitor. Unlike capacitors, the quantity of reactive strength furnished is proportional to voltage, now no longer the rectangular of voltage; this improves voltage balance on massive networks. Synchronous condensers are regularly utilized about excessive voltage direct present day transmission initiatives or massive commercial vegetation which includes metallic mills.

Distortion Power Factor

The distortion power factor describes how the harmonic distortion of a load current decreases the average power transferred to the load.

$$\text{distortion power factor} = \frac{1}{\sqrt{1 + \text{THD}_i^2}} = \frac{I_{1,\text{rms}}}{I_{\text{rms}}}$$

This is the total harmonic distortion of the load current. This definition concerning total harmonic distortion assumes that the voltage stays undistorted (sinusoidal, without harmonics). This simplification is often a good approximation in practice. I1, RMS is the fundamental component of the current and Irms is the total current both are same to (RMS)root mean square values.

The result when multiplied by the displacement power factor (DPF) is the overall, true power factor or just power factor (PF).

II. LITERATURE REVIEW

From the literature survey, we've got determined that because of contemporary-day-day improvement withinside the commercial quarter the call for the strength has been multiplied extremely. There is a greater strength call for arises because of the masses in industries. An electric load may be categorized into 3 sorts and they're resistive load like filament lamp, capacitive load like motor starter

Keith Harker (1998):

Power machine reliability and protection are enormously dependent on the practices hired in each commissioning and preservation process. Both ought to be to an excessive fashionable to make sure that the system does now no longer input carrier with latent deficiencies. This needs engineers who recognize the vital control worried in addition to the technical processes. There could be very little literature

Anant Kumar Tiwari, International Journal of Engineering Research and Applications, Volume 4, issued February 2014:

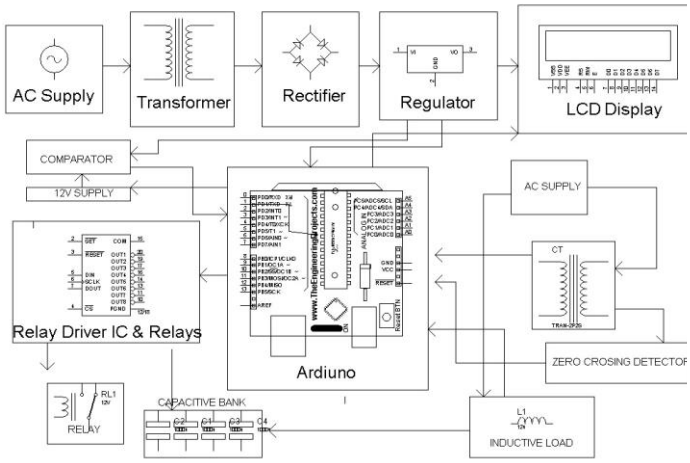
The majority of the masses withinside the industries are enormously inductive in nature consisting of induction motors, AC/DC drives, welding machines, arc furnaces, fluorescent Lighting, digital controls, and computers. There can be some resistive masses for warmers and incandescent bulbs. Very hardly ever industries might also additionally have capacitive masses consisting of synchronous motors [2]. Net commercial load is enormously inductive inflicting a negative lagging strength aspect. If this negative strength aspect is left uncorrected, the enterprise would require an excessive call from Electricity Board and will also go through a penalty for the negative

strength aspect. Standard exercise is to attach strength capacitors withinside the strength machine at suitable locations to atone for the inductive nature of the weight

Barsoum, Nader (2007) "Programming of PIC Micro-Controller for Power Factor Correction":

In latest years, the strength pleasant of the AC machine has ended up an awesome difficulty because of the unexpectedly multiplied numbers of a digital system, strength electronics, and excessive voltage strength machines. To lessen harmonic infection in strength traces and enhance transmission performance, strength aspect correction studies have become a warm topic. Many manipulate strategies for the strength aspect correction (PFC) had been proposed. This paper describes the layout and improvement of a 3-section strength aspect corrector the usage of a PIC (programmable interface circuit) micro-controlling chip. This entails sensing and measuring the strength aspect fee from the weight of the usage of PIC and sensors, then the usage of the right set of rules to decide and cause enough switching capacitors to atone for immoderate reactive components, as a consequence retreating PF close to unity; as a result, acquires better performance and higher pleasant AC output. Various strength aspect correction strategies can also be mentioned in their programs in a selected sections.

III. PROJECT BLOCK DIAGRAM



Model of Project

IV. HARDWARE REQUIREMENTS

Hardware Components:

- ✓ TRANSFORMER (230 – 12 V AC)
- ✓ VOLTAGE REGULATOR
- ✓ RECTIFIER
- ✓ FILTER
- ✓ MICROCONTROLLER (AT89S52/AT89C51)
- ✓ RELAY
- ✓ RELAY DRIVER
- ✓ PUSHBUTTONS
- ✓ LCD
- ✓ LM339
- ✓ CURRENT TRANSFORMER
- ✓ INDUCTIVE LOAD
- ✓ SHUNT CAPACITOR
- ✓ LED
- ✓ 1N4007 / 1N4148
- ✓ RESISTOR
- ✓ CAPACITOR

4.1 Software Requirements

- Keil Compiler
- Languages: Embedded C or Assembly

V. ADVANTAGE

- ✓ Reactive strength decreases
- ✓ The performance of the delivery device and equipment increases.
- ✓ The electric intake price lists depend upon the strength factor. Avoid bad voltage regulation
- ✓ Overloading is avoided
- ✓ Copper loss decreases
- ✓ Transmission loss decreases
- ✓ Improved voltage control

VI. DISADVANTAGES

- ✓ Large line losses: Line losses are proportional to the square of the current. Therefore, the larger the current then the greater the line losses.
- ✓ Greater conductor size and cost: At a low power factor, the current will be increased. To transmit this high current conductor's size has been increased.
- ✓ Effect on transformers: For decreased power factor, the KW capacity of the transformer is decreased and voltage is increased.
- ✓ Effect on switchgear and busbars: The cross-sectional area of the bus bar, and the contact surface of the switchgear must be enlarged for the same power to be delivered at low power factors.

VII. CONCLUSION

It can be concluded that power factor correction techniques can be applied the industries, power systems and It can be concluded that power factor correction techniques can be applied to the industries, power systems, and also households to make them stable, and due to that the system becomes stable and the efficiency of the system, as well as the apparatus, increases. The use of a microcontroller reduces the costs. Due to the use of a microcontroller, multiple parameters can be controlled and the use of extra hard wares such as timer, RAM, ROM, and input-output ports reduces. Care should be taken for overcorrection otherwise the voltage and current become more due to which the power system or machine becomes unstable and the life of capacitor banks reduces.

VIII RESULT

The end result of the project is an Arduino-based Advanced Power Factor Control system designed to automatically correct power factor in industrial settings. By continuously monitoring voltage and current waveforms and processing the time lag between them, the system activates relays to connect shunt capacitors into the load circuit, bringing the power factor closer to unity. The project aims to minimize penalties incurred by industrial units due to lagging power factor, thereby enhancing energy efficiency and reducing operational expenses. Additionally, the system's real-time monitoring capability, facilitated by an LCD display, allows for effective assessment and control of the power factor correction process. Through the integration of hardware components like transformers, relays, and capacitors, along with software tools like Arduino IDE and Proteus for development and simulation, the project provides a comprehensive solution for improving power system efficiency and reducing electricity costs in industrial environments.

IX. FUTURE SCOPE

The automated strength component correction and the use of capacitive load banks could be very green because it reduces the fee via way of means of reducing the strength drawn from the supply. As it operates automatically, Manpower isn't always required and this Automated Power Factor Correction of the use of capacitive load banks may be used for the industry's cause withinside the future.

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