A Review on Power Factor Improvement Using Induction Motor

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ABSTRACT: Capacitor banks are used to increase the power factor of a system. However, power factor adjustment is not required at all times since overcorrection may cause machine failure. The power factor enhancement of an induction motor utilizing a condenser controlled by a Programmable Logic Controller is described here (PLC). The energy savings measures are automatically accomplished by increasing the power factor of the induction motor. The value of a system that indicates how much power is borrowed from the power company for the system is known as the power factor. When the power factor falls below unity, an organization or business will need more current to provide the same quantity of power. Because of the voltage drop, line losses rise as the current increases, I2R. Because of their cheap cost, dependability, and robustness, induction motors are extensively utilized in industry. Induction motors have a relatively low power factor of approximately 0.33 with no load, however as the load increases, the power factor improves as we approach closer to full load. Low power factor is corrected using power factor correction, which reduces the phase mismatch between the voltage and current phasors. Controlling the power factor of a constantly changing load is challenging. Improved power factor is required to get as near to unity as possible without incurring penalties from electrical distributers. Because induction motors run with a trailing power factor, it is necessary to increase their power factor. Power factor is mostly operated closest to unity for systems to make them stable and the efficiency of the system as well as the apparatus capacity increases. Automatic power factor improvement techniques can be applied to industries, and power factor is mostly operated closest to unity for systems to make them stable and the efficiency of the system as well as the apparatus capacity increases. This is accomplished by reducing expenses via the usage of a microcontroller.

KEYWORDS: Induction Motor (IM), Programmable Logic Controller (PLC), microcontroller, Zero Crossing Detector (ZCD)

1. INTRODUCTION

One of the most significant and critical issues in today's generation is the power factor. Any motor that runs on an alternating current (AC) system necessitates apparent power, which is the sum of active and reactive power. Active power is used by the load. Because reactive power is the power required by the load and returned to the power source, it is also important for load. The ratio between the usable powers whose unit is Kilo Watt (KW) and the total power whose unit is Kilo Volt Ampere (KVA) consumed by an electrical device or motor is known as the power factor. The power factor is a measurement of how well electrical power is utilized to accomplish a meaningful task. Unity is the optimum power factor. If the power factor is less than one, it indicates that more energy is needed to complete the task. The fundamental concept for power factor correction of a motor is to connect a capacitor in parallel with the low power factor component. Static type compensation, in which static type capacitors are employed for power factor correction, is a classic technique for power factor correction. However, while using power factor adjustment star/delta type control in this situation, caution is advised. As a result, capacitors should not be subjected to frequent on-off cycles [1], [2].

The Automatic Power Factor Correction device is a highly helpful tool for increasing the efficiency of active power transmission. When a customer connects an inductive load, the power factor lags, and when the power factor falls below 0.97, the power factor lags (lag). The customer is then charged a penalty by the electric supply provider. As a result, it's critical to keep the Power Factor below a certain threshold. The automatic power factor correction device calculates the compensation required switch on various capacitor banks by reading the power factor from line voltage and line current [3], [4].

The following are some of the benefits that may be obtained by using a good power factor correction scheme:

- Induction motor efficiency improves when power consumption is reduced.
- There will be less greenhouse emissions as a result of lower electricity usage.
- Lowering electricity bills
- Additional KVA from the same existing supply

- I2R losses in transformers and distribution systems are reduced.

1.1.The Causes of Low Power Factor:

Inductive loads are the most common cause of poor power factor. In an inductive load, the current lags after the voltage. As a result, the power factor is behind [5], [6]. The following major inductive loads are to blame for the poor power factor:

- Inductive loads, such as transformers, induction motors, generators, and some lighting ballasts, produce low power factor. At maximum load, three phase induction motors have a power factor of approximately 0.8 lagging. This motor operates at a very low power factor of 0.2 to 0.3 lagging under mild loads. At a power factor of approximately 0.6, a single phase induction motor is used (lag)
- The magnetizing current is drawn from the source via a transformer. This current has little effect on the power factor under mild loads, although the main current power factor is poor.
- Low lagging power factor is present in arc lamps, electric discharge lamps, industrial heating furnaces, and welding equipment.

1.2.Components Used For Power Factor Correction

1.2.1. Block Diagram:

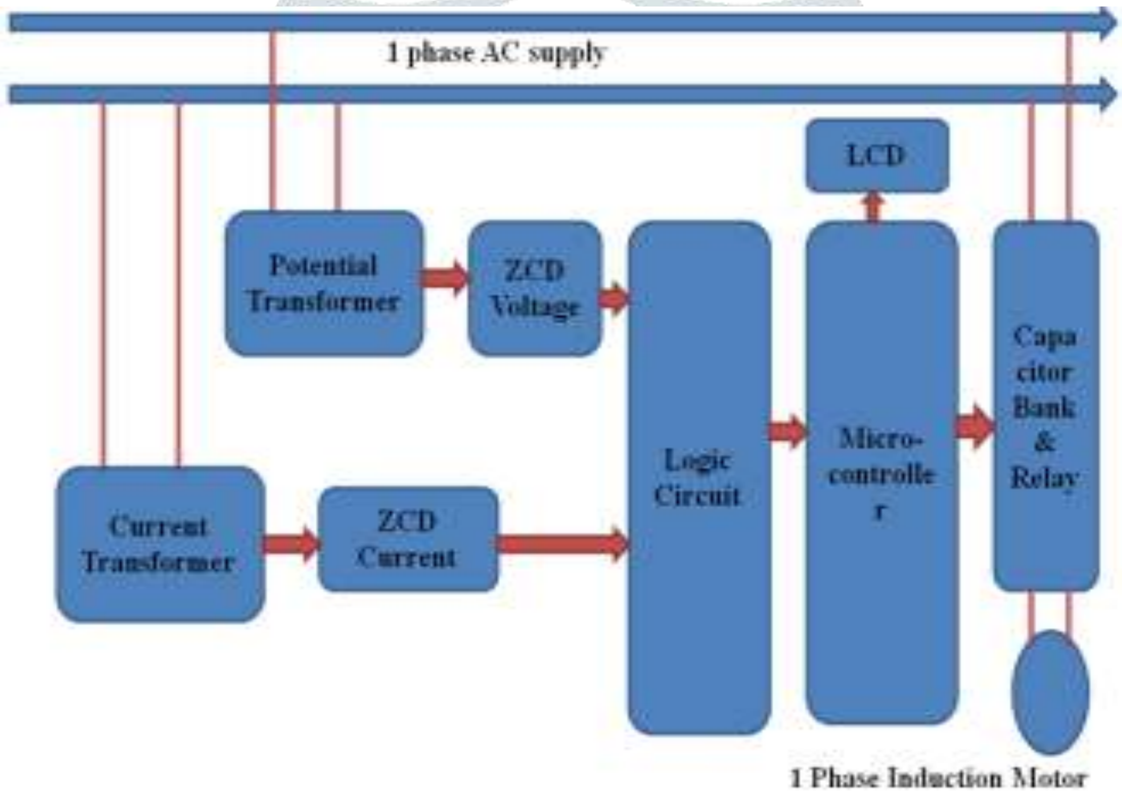

Figure 1: Illustrates the block diagram of the components used in power factor improvement.

1.2.2. Power Source:

We use a step-down transformer, Integrated Circuit (IC) regulators, diodes, capacitors, and resistors in this power supply. The primary of the transformer receives the input supply, which is 230V AC. The flux generated in the main coil is transferred to the secondary coil due to the magnetic action of the coil. The diodes receive the output of the secondary coil. The diodes are linked in a bridge configuration here. Rectification is accomplished with the use of diodes. The bridge circuit's output is not pure dc; there is some rippling ac present. To eliminate the ac, a capacitor is placed at the output of the diodes. Capacitors are also used for filtering. The diode's negative terminals (D2 & D3) are linked to the capacitor's positive terminal, and so to the IC Regulator's input (7805 & 7812). We're employing voltage regulators to obtain a fixed voltage that meets our needs. " A voltage regulator is a circuit that maintains a steady voltage despite load current fluctuations. These ICs are intended as fixed voltage regulators and can produce o/p currents in excess of 1A with proper heat sinking. Through resistors, the o/p of the IC regulator is supplied to the Light Emitting Diode LED. When the o/p of the IC, i.e. the voltage, is given to the LED, it creates its forward bias and therefore the LED becomes on state, resulting in a positive voltage. Figure 2 shows the power supply unit [7].

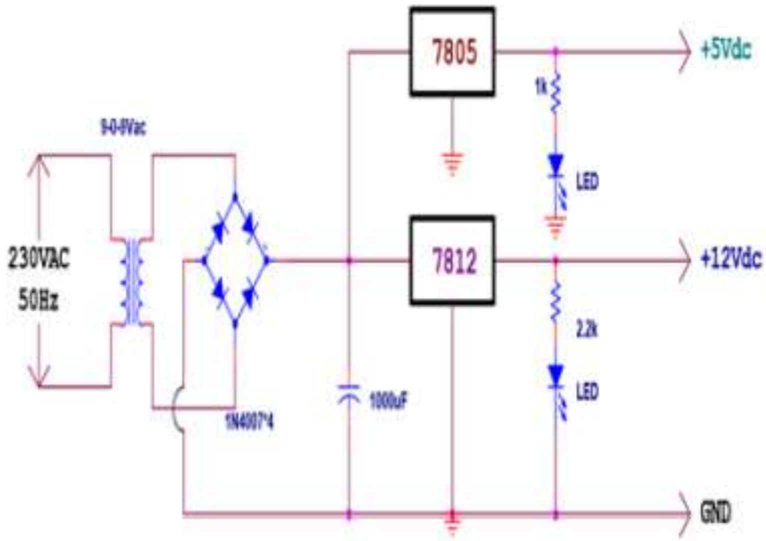

Figure 2: Illustrates the circuit diagram of power supply using 5v voltage regulator and 12v voltage regulator.

1.2.3. Detectors of Zero Crossing:

A sine-wave to square-wave converter is used in the zero crossing detectors. In this instance, the reference voltage is zero. When and in whatever direction an input signal passes 0 volts, the output voltage waveform displays it. If the input voltage is a low-frequency signal, the output voltage will transition from one saturation point to the next more slowly. If there is noise between the two input nodes, the output voltage may vary between positive and negative saturation voltage, Vsat. Figure 2 shows the zero-crossing detector [7].

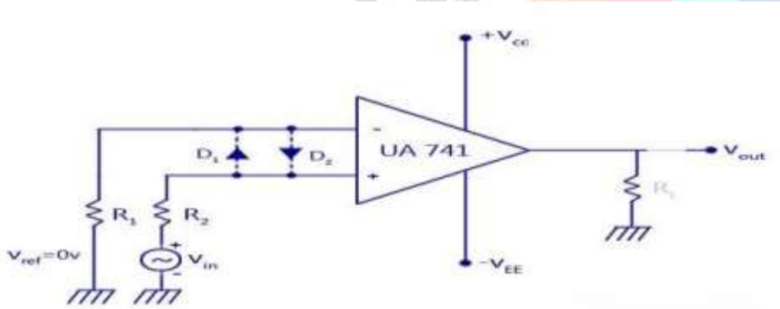

Figure 2: Represents the pin and circuit connection of operational amplifier UA741 used to convert sinusoidal waveform into square.

1.2.4. Microcontroller (Arduino):

The Arduino Uno is an ATmega328-based microcontroller board. There are 14 digital input/output pins (six of which may be used as PWM outputs), six analog inputs, a 16 MHz crystal oscillator, a USB connection, a power connector, an ICSP header, and a reset button on this board. It comes with everything you'll need to get started with the microcontroller; just plug it into a computer with a USB connection or power it with an AC-to-DC converter or battery. The Uno is unique in that it does not utilize the FTDI USB-to-serial driver chip seen on previous boards. Instead, it uses an Atmega8U2 that has been coded to act as a USB-to-serial converter. The name "Uno" comes from the Italian word "uno," which means "one." It was chosen to commemorate the impending release of Arduino 1.0. Moving forward, the Uno and version1.0 will be the reference versions of Arduino. For a comparison with earlier generations, the Uno is the newest in a series of USB Arduino boards and the standard model for the Arduino platform. To run the programs, we use the build software Adriano Uno, which downloads to the controller board via USB connection. The current, voltage, and power factor data are shown on an LCD display [8].

1.2.5. Electro Magnetic Relay:

These are a variety of very dependable gadgets that are frequently utilized in the field. These devices have a minimum operating frequency of 10-20ms. The frequency range is 50Hz to 100Hz. The relay employed here can handle continuous currents of 25mA. The electromagnetic relay works on the magnetism concept. When the base voltage is applied to the relay driver section, the driver transistor is pushed into saturation, allowing current to flow through the coil of the relay. This creates a magnetic field, which acts against the spring tension to shut the contact coil [9].

Because such contact points are separated from the low voltage source, electromagnetic relays may be used to switch high voltages. In most cases, electromagnetic relays have two contact sites. Known as usually closes (NC) and ordinarily open (NO), these are the two types of normally closes (NO). When the relay is turned off, normally closed locations will provide a short CKT route. When the relay is activated, normally open locations will provide a short CKT route.

1.2.6. Liquid Crystal Display:

The LCD panel is made up of two patterned glass panels that are filled with crystal under vacuum. Glass thickness varies depending on the intended application. The majority of LCD modules have a glass thickness of 0.70 to 1.1mm. To twist the light, these liquid crystal molecules are often arranged between glass plates to create a spiral stair case. Before accessing the bottom plate, light from the top plate twists 900 degrees. As a result, LCDs are also known as optical switches. These LCDs are unable to show any data immediately. These provide a visual output by acting as an interface between electronics and electronics circuits. After conversion, the values are shown on the 2x16 LCD modules.

1.2.7. Bank of Capacitors:

Because the magnetizing current of induction motors accounts for a significant part of the inductive or lagging current on the supply, it is simple to correct each individual motor by connecting the correction capacitors to the motor starters. It's critical for static correction that the capacitive current is smaller than the induction motor's inductive magnetizing current. The correction capacitors are connected directly in parallel with the motor windings in many systems that use static power factor correction. When the motor is turned off, the capacitors are turned off as well. The capacitors are linked to the supply when the motor is attached to the supply, giving correction at all times the motor is connected to the supply. This eliminates the need for costly power factor monitoring and control equipment. Figure 3 represents the delta connected capacitor bank [10].

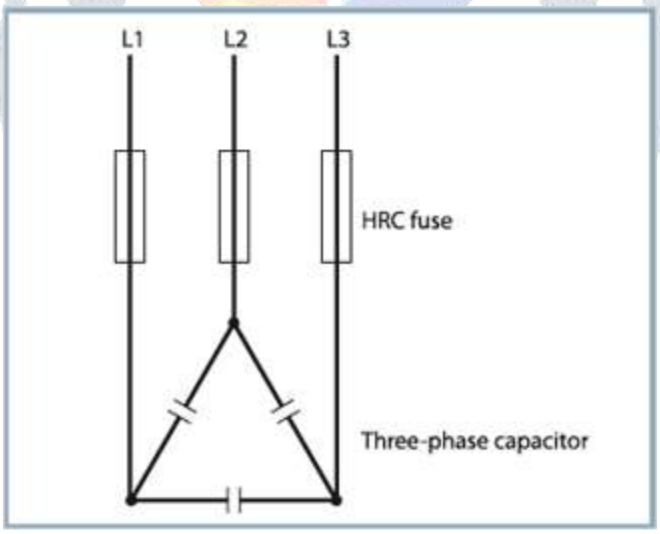

Figure 3: Illustrates the wiring diagram of three phase delta connected capacitor bank.

The capacitors stay connected to the motor terminals while the motor slows down in this scenario. While linked to the power source, an induction motor is powered by a spinning magnetic field in the stator that generates current in the rotor. There is a magnetic field associated with the rotor when the motor is removed from the supply for a length of time. As the motor slows down, voltage is generated at its terminals at a frequency that is proportional to its speed. With the motor inductance, the capacitors linked across the motor terminals create a resonant circuit. If the motor is severely misaligned. When static correction is used, it is essential that motors be never excessively corrected or severely corrected.

1.2.8. Software Used:

- Compiler for Atmel Studio 6.0 Atmel Studio 6 fulfills a lot of what AVR Studio 5 promised but didn't quite achieve. Studio 5, which was released in 2011 and was based on Microsoft Visual Studio, was a significant upgrade over AVR Studio 4, which was based on the tried-and-true

Eclipse IDE. Studio 4 is starting to show its age, so an update was much needed. However, version 5 arrived with a lengthy list of problems and failed to deliver on many of the promised features, leaving many users unsure if they should update. The new version seems to have fixed many of those issues, and we gave it a better rating in our first testing. The Atmel Software Framework (ASF), a huge collection of open source code containing 1,600 ARM and AVR project examples, is integrated with Atmel Studio 6. The ASF enhances the IDP by making ready-to-use code available in the same environment, reducing the amount of low-level design needed for projects. Use the IDP to program a wide range of AVR and ARM Cortex-M processor-based MCUs, including Atmel SAM3 ARM Cortex-M3 and M4 Flash devices.

- Embedded C Language C, BASIC, and assembly languages are the most popular programming languages for embedded systems. Programs for embedded systems are usually expected to monitor and control external devices, as well as directly manipulate and use the internal architecture of the processor, such as interrupt handling, timers, serial communications, and other available features. C used for embedded systems is slightly different from C used for general purpose (under a PC platform) - programs for embedded systems are usually expected to monitor and control external devices and directly manipulate and use the internal architecture of the processor, such as interrupt handling, timers, serial communications, and other available features. When choosing languages for embedded systems, there are many variables to consider.

2. DISCUSSION

As the world's energy consumption grows, so does the need for efficient and high-quality power in motors and motor systems. The motor and motor systems, for example, are one of the key areas where possible energy savings may be achieved, according to Eskom's (South African electrical public utility) demand management. In residential, commercial, and industrial applications, motors and associated systems are the most widely utilized. They are expected to use close to 60% of the power in South Africa, with a worldwide usage of approximately 40%. Many of the fractional motors with less than 1 horsepower are within the 60 percent. Due to their cheap manufacturing costs, fractional motors are mostly single phase induction motors that are utilized in household applications despite their poor efficiency and low power factor. Refrigerators, washing machines, and furnaces, as well as conveyors, pumps, winders, wind tunnels, and other industrial equipment, all use induction motors. The swimming pool is the largest energy user in home applications. In South Africa, there are an estimated 800 000 swimming pools, with 92 percent of them being in private households.

There are a variety of approaches that may be used to boost the power factor. PFCs are divided into two categories: passive and active. To increase the power factor, passive PFCs utilize reactive components such as capacitors and inductors that operate at line frequency.

The dependability, simplicity, and immunity to Electro Magnetic Interference are all benefits of passive PFCs (EMI). The major drawback of passive PFCs is their large reactive components, which are caused by their operating at line frequency, making them extremely costly to use in small systems and resulting in poor voltage control. One technique of PFCs that may be used is a synchronous machine (condenser). Because synchronous machines are very costly, they are only used in high-power applications.

Active PFCs are becoming increasingly popular as power electronics advances, allowing components like as IGBTs and MOSFETS to be utilized at higher frequencies for power factor enhancement. For example, DC/DC converters like Buck, Boost, Buckboost, and Cuk may be utilized in various kinds of PFCs. Active PFCs have the benefit of having minimal reactive components in the circuits, a near unity power factor, and low total harmonic distortion. The benefits listed above make it appropriate to invest in the development of a PFC for motor systems.

3. CONCLUSION

In commercial and industrial applications, power factor correction (PFC) is widespread. With decreasing natural resources utilized for power production and also surpassing energy demand, the necessity to expand its application has grown. As a result, more efficient motor systems and power consumption are needed at the forefront of a utility's demand side management system. It may be inferred that power factor correction methods can be used to industries, power systems, and even homes to stabilize them, resulting in the system becoming stable and the system's and equipment' efficiency increasing. The cost of using a microcontroller is reduced. Multiple parameters may be controlled with a microcontroller, and the need of additional hard work such as a timer, RAM, ROM, and input output ports is reduced.

Overcorrection should be avoided at all costs; otherwise, the voltage and current will increase, causing the power system or machine to become unstable, and the life of the capacitor banks will be shortened.

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