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Power Factor Improvement Using Automatic Power Factor Compensation (APFC) Device

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ABSTRACT: This paper presents the project designed for improving power factor of industries automatically. Power factor measures a system's power efficiency and is an important aspect in improving the quality of supply. It is defined as the ratio of real power to the apparent power. Since most of the industrial loads are inductive in nature, they cause a low or poor power factor which can disrupts the AC voltage and reduce the performance of equipment connected on the same source or system. Moreover, these loads draw more currents due to their low power factor which in turn increases the cost of their power consumption. The main purpose is to overcome these unwanted problems and power factor needs to be improved by installing Automatic Power Factor Compensation (APFC) device. It enables the system to attain power factor values close to unity for efficient operation. The advantages of correcting power factor include reduced power system losses, increased load carrying capabilities, improved voltages and much more. The hardware required to implement the proposed APFC unit are explained in this paper.

KEYWORDS: Power Factor, Automatic Power Factor Compensation, Capacitor Bank, PF Penalty

I.INTRODUCTION

The efficient utilization of electrical power is a paramount concern in contemporary industrial and commercial settings. Central to this concern is the concept of power factor, a critical parameter representing the ratio of real power to apparent power in an electrical system. Real power is the power consumed by the load. Reactive power is repeatedly demanded by the load and returned to the power source, and it is the cyclical effect that occurs when alternating current passes through a load that contains a reactive component. The significance of power factor lies in its direct impact on energy consumption, utility costs, and overall system efficiency. The presence of reactive power causes the real power to be less than the apparent power, and so, the electric load has a power factor of less than 1 [2]. The reactive power increases the current flow between the power source and the load, which increases the power losses through transmission and distribution lines [2]. The significance of power factor in industrial and commercial applications cannot be overstated. A high-power factor signifies that the electrical system is operating efficiently, with a minimum of reactive power circulating in the network. Conversely, a low power factor is indicative of an imbalance between the real power (which performs useful work) and the reactive power (which does not contribute to useful work but circulates in the system). This imbalance results in higher energy losses and places additional stress on distribution infrastructure.

The power factor measures a system's power efficiency and is an important aspect of improving the quality of supply [1]. It is desirable to keep the PF above a specified amount (usually 0.90 or higher) or be subject to additional charges. Power factor correction attempts to adjust the power factor of an AC load or an AC power transmission system to unity (1.00) through various methods [11]. In most power systems, a poor power factor results from the increased usage of inductive loads is often unnoticed [3]. To address this issue and enhance power factor, engineers have developed various strategies, with one of the most prominent solutions being the utilization of power factor correction devices. This research embarks on a comprehensive exploration of automatic power factor improvement through the implementation of power factor correction devices. Simple methods include switching in or out banks of capacitors or inductors which act to cancel the inductive or capacitive effects of the load, respectively [4]. The advantages of correcting power factors include reduced power system losses, increased load carrying capabilities, improved voltages and much more [5]. The aim of this project is to build an automatic power factor compensation (APFC) unit, which can monitor the energy consumption of a system and automatically improve its power factor. The APFC unit calculates the reactive power consumed by a system's inductive load and compensates the lagging power factor using capacitance from a capacitor bank [11].

II. DESIGN AND METHODOLOGY

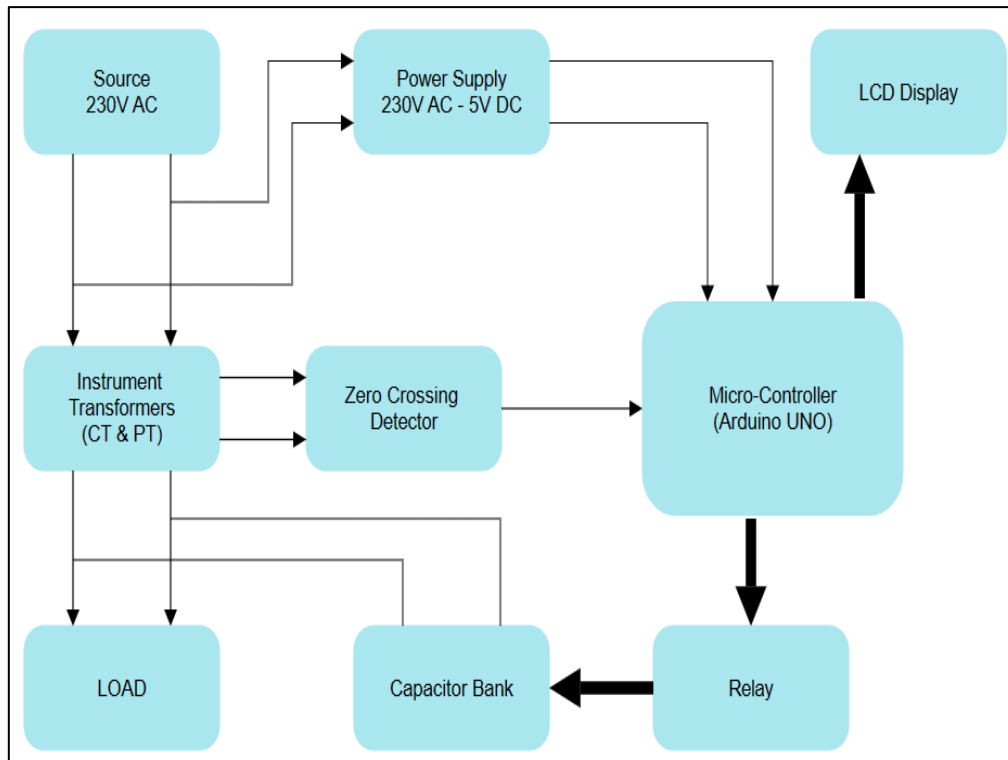


Figure-1 Block Diagram

2.1 Microcontroller

The microcontroller used in this project is Arduino Uno (ATmega328P). It is an open-source microcontroller which can be easily programmed, erased, and reprogrammed at any instant of time. Since Arduino is an open-source platform the software is not purchased and only the cost of buying the board or its parts is incurred, thus making it very cheap. The hardware designs are also available online for free from its official website [8]. The Arduino's microprocessor controls the switching of capacitor bank and adjust for reactive power while reducing the power factor almost to unity, which enhances the quality of the electricity. By detecting the signal from CT, PT and Zero Cross Detectors (ZCDs), the Arduino is programmed to continuously monitor and calculate the power factor of the attaching the load, and to maintain the power factor of the load well above reference value (0.9) by properly energizing the capacitors.

2.2 Potential Transformer

A voltage transformer, also known as a potential transformer, is an instrument transformer used in power systems for accurate voltage measurement and protection purposes. The PT used here steps-down the supply voltage of 230 Volts to 12 Volts as required by the circuit to operate. The output of a PT is used for all measurement and monitoring purposes in conjunction with relay operation [6]. It has a large number of turns on its primary (input) coil which is connected to the high voltage mains supply, and a small number of turns on its secondary (output) coil to give a low output voltage. PT is connected parallel with the supply line.

2.3 Current Transformer

A current transformer can be defined as an instrument transformer in which the secondary current, in normal conditions of use, is substantially proportional to the primary current. When current in a circuit is too high to directly apply to measuring instruments, CT produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. It also isolates the measuring instruments from what may be very high voltage in the monitored circuit. They are commonly used in metering and protective relays in the electrical power industry [6]. CT is connected series with line.

2.4 LCD

The term LCD stands for liquid crystal display. The main benefits of using this module includes, it is inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, animations, etc. LCD display can be considered as the most common device that is connected to the microcontroller for communication. Specifying the types of LCD displays, 16x2 and 20x4 are the most common ones connected to the microcontrollers. These digits indicate the numbers of the characters and the numbers of the lines. For example, a 16x2 LCD display contains 16 characters and 2 lines are made available to use. Similarly, 20x4 LCD display indicates 20 characters and 4 lines made accessible for use. In this project a 16x2 LCD is used for displaying the value of power factor before and after compensation [12].

2.5 Resistive load

Resistive loads are simple loads where the current and voltage waves are in phase with each other. They include non-motor loads that have a resistance, like incandescent lighting or heating loads. A 15 W bulb is used as a resistive load for this prototype.

2.6 Inductive Load

An inductive load, also known as lagging load, is that in which the alternating load current lags the alternating voltage of the load. Any device that has coils of wire in them can be classed as inductive loads. Examples of inductive loads includes motors, solenoids, and contactor coils. [13]. In this project, choke of a tube light is used as an inductive load.

2.7 Relay

A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), 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 [6]. In this project, electromagnetic relay module is used which trips the capacitor banks to switch ON/OFF according to reactive power requirement. Relay outputs are operated to connect or disconnect the capacitor banks depending upon of the power factor conditions.

2.8 Capacitor Bank

APFC Panel has the group of capacitors that's installed within it. This cluster of capacitors has a unique purpose, i.e. delivering the reactive power for the inductive loads per their requirement. This way, it improves the power factor and boosts the voltage as per the capacitor bank size & system's resilience. In three phase power system, capacitors normally installed within an isolating non-conductor metal box, which is called capacitor bank, they are fixed and switched. Fixed banks are connected permanently to the primary conductors through fused switches. Switch capacitors banks are tied to primary system through automated switch, allowing them to be put on line and taken off line as needed. It is usually connected in parallel to provide leading KVAR to an electrical system when and where needed. Capacitor bank represents an essential component in electrical systems, serving to enhance power factor and improve overall system efficiency.

III.HARDWARE IMPLEMENTATION

The proposed work can be explained in the form of flow chart as shown in Figure-2. It comprises of following blocks:

- Instrument Transformer (CT & PT)
- Bridge Rectifier
- Zero Crossing Detector (LM339 IC)
- Arduino UNO (ATmega328P)
- Resistive Load (15 W)
- Inductive Load (Choke)
- Electromagnetic Relay
- Capacitor Bank (4 x 2.5 uF)

PTs and CTs are interfaced with the Arduino UNO and it calculates phase shift (phase width) using **pulseIn** function. Then power factor is calculated using the cosine of the phase angle between voltage and current. The calculated value

of power factor is then compared with desired value and relays are given signals according to reactive power requirement.

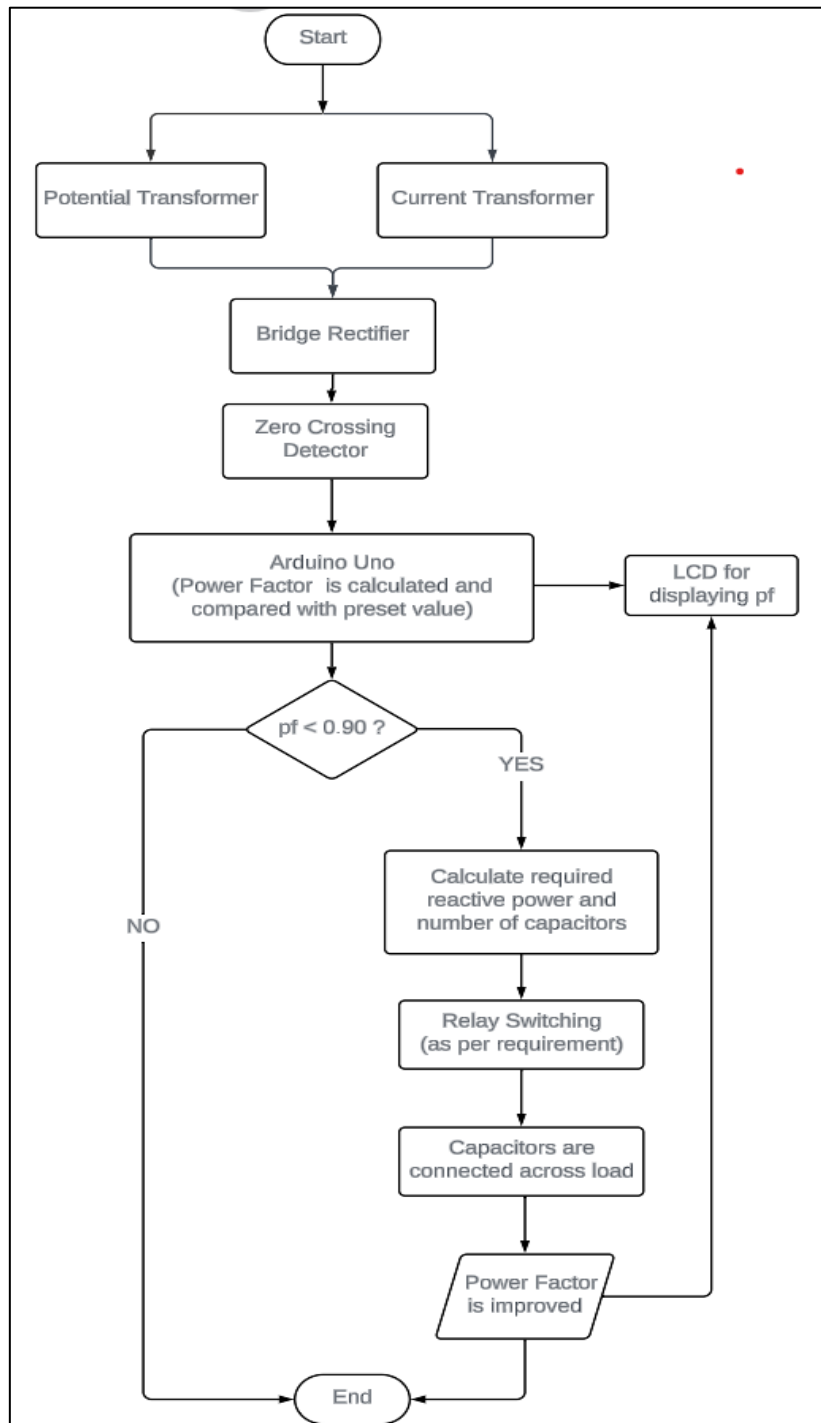


Figure-2 Flowchart of the Process

IV.RESULT AND DISCUSSION

The implementation of the automatic power factor compensation device resulted in noticeable improvement in the power factor of the system. This improvement indicates the effectiveness of the APFC device in mitigating reactive power losses and optimizing the power factor. By automatically adjusting the capacitors based on the real time reactive power demand, this device has successfully reduced the reactive power consumption of the system. This reduction not only improves the overall efficiency of the system but also helps in minimizing energy losses and reducing electricity bills. It led to reduction in reactive power charges and penalties imposed by utilities for low power factor operation.

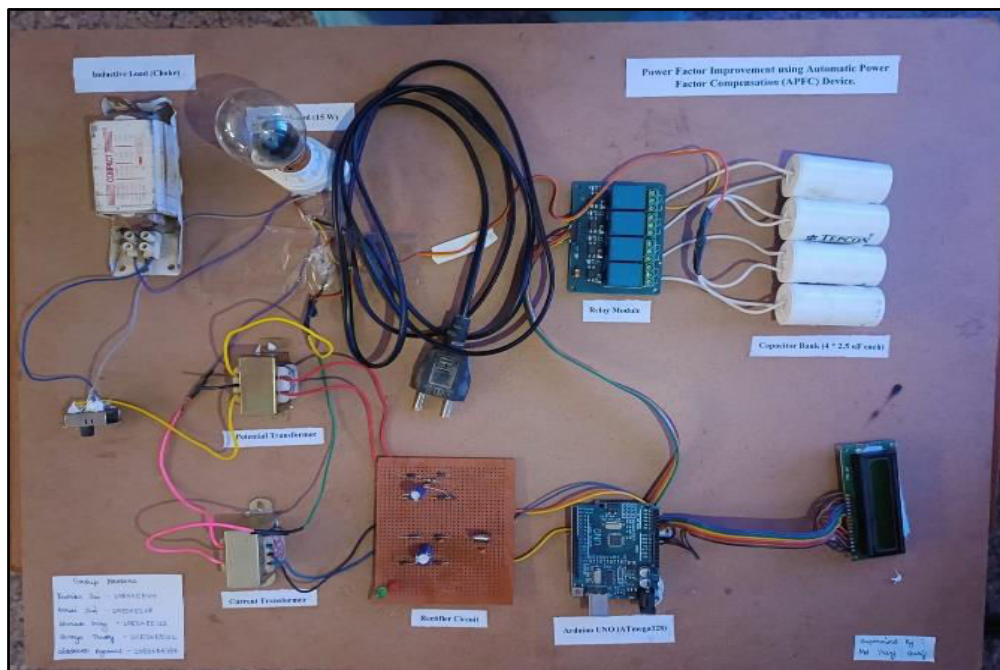


Figure-3 Prototype Snapshot

Table-1 gives us the reading of power factor with different loads, before and after APFC. Here, we can see that the maximum pf is achieved when the load is purely resistive with a power rating of 15W.

LOAD	PF (Before APFC)	PF (After APFC)
No load	0.98	-
R	0.95	0.99
L	0.49	0.97

Table-1

V. CONCLUSION

The automatic power factor compensation system represents a significant advancement in the field of electrical engineering offering a proactive solution to mitigate reactive power and optimize power factor in industrial and commercial applications. It has proven its ability to enhance the efficiency of electrical systems by actively monitoring and adjusting power factor in real time. By precisely regulating reactive power, the device ensures that electrical load operates at optimal levels, minimizing wastage and improving overall energy utilization. One of the most notable outcomes of this project is the substantial cost reduction achieved through improved power factor management. By mitigating penalties associated with poor power factor and optimizing energy consumption, this device translates into tangible financial savings for industrial and commercial users.

In conclusion, the paper presents a comprehensive exploration of automatic power factor improvement through the implementation of power factor correction devices. The aim is to address the issue of poor power factor in industries due to the increased usage of inductive loads. The proposed solution is the utilization of power factor correction devices, which include switching in or out banks of capacitors to cancel the inductive effect of the load. This correction leads to reduced power system losses, increased load carrying capabilities, improved voltages, and overall, more efficient operation.

REFERENCES

- [1] L. Wuidart, "Understanding Power Factor", Power, pp. 1-5, 2003.
- [2] N. Barsoum, "Programming of PIC Micro-Controller for Power Factor Correction", First Asia Int. Conf. Model. Simul. AMS07, pp. 19-25, 2007.
- [3] S. Saha, T. Tyagi, D. V. Gadre, "ARM (R) Microcontroller Based Automatic Power Factor Monitoring and Control System", Texas Instruments India Educ. Conf., pp. 165-170, 2013.
- [4] Ali, Murad. "Design and Implementation of Microcontroller Based Controlling of Power Factor Using Capacitor Banks with Load Monitoring." Global Journal of Researches in Engineering Electrical and Electronics Engineering Version 1.0 13.2 (2013): n. page. Web. Online ISSN: 2249-4596 & Print ISSN: 0975-5861.
- [5] A. Shahid, "Microchip-Based Embedded System Design for Achievement of High Power Factor in Electrical Power Systems", pp. 0-4, 2013.
- [6] Microcontroller based automatic power factor correction in mines, department of mining engineering, national institute of technology, Rourkela-769008, 2015.
- [7] Automatic power factor correction using capacitor banks and 8051 microcontroller, international journal of engineering and technical research, ISSN: 2321-0869, Volume-3, Issue-6, June 2015.
- [8] Working principle of Arduino and using it as a tool for study and research, international journal of control, automation, communication and systems, vol.1, no.2, April-2016, 1Department of Electronics and Communication Engineering, Gujarat Technological University, Ahmedabad, India.
- [9] Kulkarni Kaumudi, Kumbhar Pooja, Patil Priyanka, Prof. Madhuri International Namjoshi, "Automatic power factor correction using PIC microcontroller", Engineering Research Journal (IERJ) Volume 2 Issue 1 Page 13-16, ISSN 2395-1621, February 2016.
- [10] Power factor correction using SCR and microcontroller – International journal of innovative research in science, engineering and technology, vol.6, issue 4 April 2017.
- [11] Implementation and Analysis of Automated Power Factor Corrector Unit (APFC) for an Induction Motor March 2020 Journal of Information and Computational Science.
- [12] Automatic power factor correction using Arduino – a journal of engineering sciences, vol 13 ISSN NO:03779254, 6 June 2022, Mr. P. RAMA MOHAN REDDY, M. ANJALI, B. BHATARH, B. RAJESWARI, B. SATHEESH KUMAR, G.ABU TURAB, G. SRESTA.
- [13] Arduino uno based power factor corrector, international journal of research publication and reviews, vol 3, issue 6, pp4788-4807, June 2022 www.ijrpr.com ISSN 2582-7421.



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