Microcontroller-Based Automatic Power Factor Correction

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Abstract— As technology develops quickly, electricity efficiency becomes critical.This study tackles the important problem of power loss in industrialized environments brought on by a rise in inductive load usage, which lowers power system efficiency. To improve the power factor is a suggested programmable gadget that makes use of embedded technology. An 8051 Microcontroller is used by the embedded system to precisely measure the delay between line voltage and current signals in order to read power factor data. These numbers are shown on 2X16 LCD modules after being calibrated into phase angles and matching power factors. The motherboard of the system determines the necessary compensation and turns on particular capacitor banks in accordance. This innovative method ensures stability and increased efficiency for a variety of applications, including residences, power systems, and industries. Additionally, the incorporation of microcontrollers lowers costs.

Keywords—*Power Factor Correction, Embedded Technology, Inductive Load, Microcontroller, Efficiency Improvement, Phase Angle Calibration, LCD Modules.*

I. INTRODUCTION

When it comes to electrical systems, power factor is essential. Numerous issues arise from the electrical system's low power factor. When the load's active power remains constant, the reduction in load power factor will impact voltage stability in two ways: first, it will cause the reactive power to rise and change the load's voltage characteristics; second, it will cause the reactive power to fall and change the power grid's voltage characteristics. Consequently, the distribution substation's voltage stability will decrease as a result of the combined effect. Power factor correction can result in significant cost reductions for electrical installations with low power factors.

The way electrical utilities charge their consumers is primarily to blame for these reductions. Enhancing power factor can lower power expenses, increase voltage, free up the distribution system's electrical capacity, and lower system losses. Our inductive load is one of the primary causes of the low power factor. The majority of industrial facilities use inductive loads in their motors and transformer infrastructure. Among them, the network provides a significant quantity of reactive power to the massive industrial motors so they can operate as intended. Power factor enhancement is therefore crucial for all sectors and household electrical equipment alike. One extremely well-known method for power factor correction (PFC) is to use shunt capacitor banks. Reactive component losses can be effectively decreased using capacitors. Diminished Values are inversely proportional to the square of the power factor because they are directly correlated with the current squared, which is decreased in response to an increase in power factor. Although the capacitors have losses, they are negligible—just 0.3 percent of the KVAR rating.

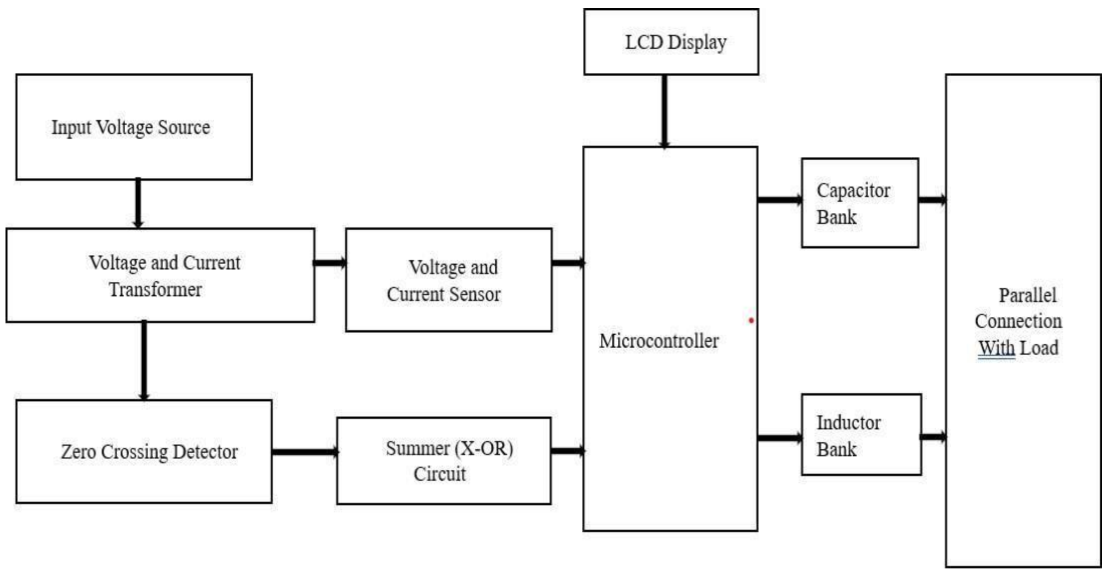
Line current rises as the load power factor drops below a specific point, increasing line loss and voltage drop. Therefore, when the power factor drops below the designated value, the goal is to inject capacitances of the necessary values. First and foremost, a signal with a pulse width corresponding to the phase difference is produced. The power factor can be calculated from each pulse's ON period. Next, using fundamental formulae linking the capacitance and the reactive power, the precise value of the capacitance to be injected is found.

In the end, the generated capacitance value was close to the values that the system could switch. The microcontroller does mathematical calculations and is configured to automatically execute power factor adjustment. It will switch all the capacitors together, which when taken collectively are very close to the precise value of the capacitance.

II. METHODOLOGY

It is suggested to improve the PF for both leading and lagging loads. In order to get the load PF as close to unity as possible (0.98 lagging), the microcontroller is configured to determine how many capacitors or inductor banks should be automatically linked to a single-phase load through relays. In this work, three types of loads—resistive, inductive, and capacitive—with two distinct sizes are taken into consideration. The resistive load is used to confirm that the ZCD circuits are operating as intended. Initially, a voltage transformer (PT) and a current transformer (CT) sense the voltage and current of the load connected to the single-phase voltage source, respectively. Next, the sinusoidal voltage and current waveforms are converted to square waveforms by sending the voltage and current waveforms to the ZCD circuits. Then, a summer circuit consisting of an XOR logic gate sums the two square waves that are synchronized to the voltage and current waveforms. To convey the phase angle difference, the XOR gate's output is connected to one of the microcontroller's I/O pins.
It computes the PF. The microcontroller determines the value and quantity of capacitors or inductor banks to be connected in parallel with the load based on these computations. A LCD monitor is also included in the design to display the measurements.

BLOCK DIAGRAM



Block Diagram of Microcontroller Based Automatic Power Factor Correction

III. LITERATURE SURVEY

Modern electrical systems require power factor correction (PFC), and the incorporation of microcontrollerbased solutions has attracted a lot of interest. The effectiveness of using microcontrollers for automatic power factor correction has been investigated in a number of studies and projects with the goals of improving power efficiency, lowering losses, and guaranteeing stable electrical systems.

Improvements in Microcontroller Technology: The literature emphasizes how the development of complex power factor correction systems has been fuelled by the ongoing improvements in microcontroller technology. The development of microcontroller architectures that accept open-source bootloaders, such the Atmel328, has made programming easier and more productive.

Importance of Power Factor adjustment: Power factor adjustment is crucial for electrical systems, according to researchers. Research shows that efficient power factor correction can result in lower system losses, higher voltage levels, more electrical capacity, and cost savings. These advantages have spurred academics to investigate novel strategies for automated PFC.

Utilization of Capacitor Banks: Shunt capacitor banks are a proven method for adjusting power factor. The literature sheds light on how well capacitors work to reduce losses brought on by reactive components. Microcontrollers, when used strategically, can regulate capacitors to provide a dynamic solution for accurate correction.

Challenges with Inductive Loads: The literature frequently acknowledges that inductive loads play a significant role in poor power factor. Industries that mostly use inductive loads—such as transformers and motors—have difficulty keeping their power factors at optimal levels. Microcontroller-based solutions have therefore been put out to deal with these particular problems.

A number of research examine the methods that microcontrollers use to automatically adjust the power factor. The creation of pulse width signals proportionate to phase discrepancies is explored in the literature, allowing for the real-time evaluation of power factors. Equations in mathematics are also used to calculate the precise capacitance needed for correction.

Case Studies and Implementations: A number of case studies and real-world applications of microcontroller-based automatic power factor correction projects are found in the literature review. These studies offer insightful information about the practical uses, difficulties faced, and general effectiveness of such systems in many contexts.

To sum up, research on microcontroller-based automatic power factor correction projects emphasizes the need of utilizing cutting edge technologies to create effective and flexible correction plans. These research set the stage for upcoming developments and breakthroughs in the discipline by adding to the continuing conversation about maximizing power efficiency and stability in electrical systems.

IV. FUTURE SCOPE

When automatic PF correction is used, harmonic issues may arise from the capacitor bank's repeated switching when the load is changing regularly. To prevent frequent switching of the capacitor bank, an optimal algorithm and a suitable filter design can be created based on the pattern of frequent load changes. To determine the best position for maximum utilization and cost savings, a comparative research on the placement of correctional equipment may be used in the field. Zigbee technology, which improves working wireless distance, can be used to extend this project. GSM technology, which alerts the authorities via SMS of power factor correction, can also be used to expand the system.

V. CONCLUSION

It is determined that power factor correction techniques can be used to stabilize power systems, households, and industries. As a result, the system becomes more stable and apparatus and system efficiency both rise. Utilizing microcontrollers lowers expenses. Multiple parameters can be managed thanks to the usage of microcontrollers, which also minimizes the need for additional hardware like input/output ports, RAM,
ROM, and timers. Avoid overcorrecting to prevent increased voltage and current, which can cause instability in the power system or machine and shorten the lifespan of capacitor banks.

It is also confirmed that by connecting capacitors or inductors in parallel to the load, the developed hardware can bring the PF of various load sizes closer to unity.

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