Smart Power Factor Correction with Integrated Energy Monitoring System

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1. Introduction

In modern electrical systems, maintaining an optimal power factor is crucial for energy efficiency and cost reduction. A low power factor leads to increased energy losses, higher electricity bills, and potential penalties from utility companies. This project proposes a Smart Power Factor Correction (PFC) System integrated with real-time energy metering, implemented using an embedded system programmed in assembly language. The system aims to monitor and correct the power factor automatically while providing real-time energy consumption data, making it suitable for industrial, commercial, and household applications.

2. Problem Identification

In electrical systems, a low power factor poses significant challenges, such as increased energy losses, higher electricity bills, and inefficiencies in power transmission. This occurs due to the presence of reactive power, which does not perform any useful work but places additional burden on the system. Many existing power factor correction solutions rely on manual intervention, making them prone to errors, inefficient, and unsuitable for dynamic electrical loads that fluctuate over time. Furthermore, most systems lack integrated real-time energy monitoring, depriving users of actionable insights into energy usage and system performance. With rising energy costs and potential penalties from Ceylon Electricity Board, there is an urgent need for automated solutions that optimize energy consumption while providing real-time data on energy parameters, making the system more efficient and user-friendly.

3. Proposed Solution

This offers an automated solution to address the challenges associated with low power factor and energy inefficiency. This system combines real-time monitoring and intelligent algorithms for dynamic power factor correction, ensuring optimal performance in industrial, commercial, and household applications. The system continuously monitors the power factor of the electrical load and calculates the required capacitance to correct it. Capacitor banks are dynamically switched using MOSFETs or relays to achieve the desired correction. By adjusting to fluctuating loads in real time, the system maintains a power factor close to unity, minimizing reactive power and reducing energy losses. This optimization helps avoid penalties from utility providers and enhances overall energy efficiency. Additionally, the system incorporates real-time energy monitoring features. It tracks the highest current demand to identify peak usage and prevent overloading, while continuously calculating the active power consumed by the load. Essential energy parameters such as real power, reactive power, apparent power, and power factor are monitored to provide a comprehensive overview of system performance.

The system includes an intuitive interface, such as an LCD or OLED display, to present critical data including corrected power factor values, active power usage, and maximum demand current. This real-time data display provides immediate feedback, allowing users to assess the system's performance and make informed decisions to optimize energy usage.

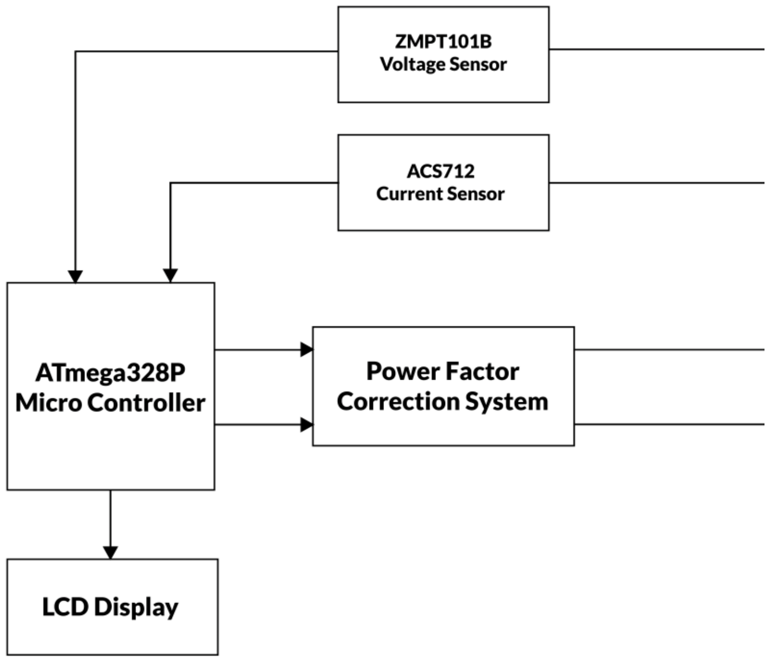
By integrating automated power factor correction and real-time energy monitoring, this solution addresses the inefficiencies of traditional systems, offering an efficient, user-friendly approach to optimizing electrical system performance.

4. Market Analysis

In Sri Lanka, rising electricity tariffs and the need for energy efficiency have created a growing demand for advanced power management solutions. Industries, commercial establishments, and households frequently experience financial losses and inefficiencies due to poor power factor performance, which leads to higher energy consumption and increased costs. While existing power factor correction systems are available, they are often expensive, designed for large-scale applications, or rely on outdated manual methods, making them unsuitable for many small and medium-sized enterprises and households.

The proposed Smart Power Factor Correction System fills this gap by offering an affordable and automated solution that integrates power factor correction with real-time energy monitoring. This dual functionality ensures not only the optimization of energy usage but also provides valuable insights into consumption patterns. Additionally, its scalable design allows for future enhancements, such as IoT connectivity, making it adaptable to evolving technological trends. By addressing a critical market need with an innovative and cost-effective approach, the system supports Sri Lanka's energy efficiency goals. It offers significant financial and operational benefits, helping users reduce energy costs and improve overall sustainability, while aligning with the country's broader objectives for sustainable development.

5. Implementation Design



6. Timeline

Task	Duration	Completion Date
Planning the project	2 weeks	Week 2
Learning Assembly Language	3 weeks	Week 5
Designing the circuit modules	3 weeks	Week 8
Physical implementation	2 weeks	Week 10
Testing	2 weeks	Week 12
Finalizing and preparing the reports	2 weeks	Week 14
Final Demonstration preparation	1 weeks	Week 15

7. Budget

Component	**Cost (Rs.)**
Arduino Uno R3 Board	3000
ZMPT101B Voltage Sensor	550
ACS712 30A Current Sensor Module	380
1602 16x2 Yellow Backlight LCD Display	470
Capacitors	500
Other Items	1500
Total	**Rs.4900**