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Research On Automatic Power Factor Correction with All Power Measurements Over Lora Wireless Communication

Pranali A. Asolkar
Department of Electrical Engineering, Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
Pranaliasolkar33@gmail.com

Sakshi G. Ghodke
Department of Electrical Engineering, Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
Sakshighodke9325@gmail.com

Revati V. Lulekar
Department of Electrical Engineering, Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
revatilulekar@gmail.com

Manthan M. Kathane
Department of Electrical Engineering, Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
manthankathane2020@gmail.com

Darshan P. Lajurkar
Department of Electrical Engineering, Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
Darshanlajurkar0@gmail.com

Dhruv D. Nishan
Department of Electrical Engineering, Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
dhrunishan2@gmail.com

Abstract**—** Automatic power factor corrector is designed to improve power factor automatically whenever power factor falls below a certain level. Efficient generation of power at present is crucial as wastage of power is a global concern. As we know, the demand for electrical energy is increasing day by day. Power factor measures a system's power efficiency and is an important aspect in improving the quality of supply. This paper presents an embedded system for automatic power factor correction with comprehensive power measurements via LoRa wireless communication. It comprises two Arduino Uno-based modules for both transmission and reception., In this system utilising PT and CT sensors for accurate power measurements. Data exchange is achieved through two LoRaWAN modules over a 100-metre range, with real-time power factor and correction data displayed on an LCD at the receiver end. The heart of the system is a capacitor bank equipped with relay switching, intelligently optimising the power factor. A half HP motor serves as the load, exemplifying the practical benefits of efficient power factor correction in electrical systems, ultimately enhancing energy efficiency and reducing costs.

Keywords- Power Factor, Automatic Correction, LoRa Wireless Communication.

I. INTRODUCTION

In today's world, efficient utilisation of electrical power resources is a critical concern. Electrical systems in industrial and commercial settings often grapple with the challenge of optimising power factor, a fundamental aspect of energy efficiency. This paper introduces an embedded system designed to tackle this issue, offering automatic power factor correction through precise power measurements, all facilitated by LoRa wireless communication.

At its core, this system relies on two Arduino Uno-based modules, one dedicated to transmitting data and the other to receiving and visualising it. The transmitter features an Automatic Power Factor Correction (APFC) module, making use of Potential Transformer (PT) and Current Transformer (CT) sensors to provide accurate power measurements. Data transmission occurs wirelessly over LoRaWAN, allowing for a range of up to 100 metres, while real-time power factor and correction information is displayed on an LCD screen at the receiver's end. The intelligent control of a capacitor bank, achieved through relay switching, ensures that the power factor is maintained at an optimal level. By incorporating a half HP motor as a representative load, this paper exemplifies how improved power factor correction can lead to enhanced energy efficiency, reduced operational costs, and a more sustainable electrical infrastructure.

II. LITERATURE REVIEW

1. Liang, Ruobing, et al. In this paper, the author, Starting with two vital indicators (network transmission delay and packet loss rate), this study explored the coverage and transmission performances of LoRa in buildings in detail. The author deployed three LoRa receiver nodes on the same floor and eight LoRa receiver nodes on different floors in a 16-story building, respectively, where the data acquisition terminal was located in the centre of the whole building. The communication performance of LoRa was evaluated by changing the send power, communication rate, payload length and position of the wireless module. In the current research, the metrics of LoRa were quantified to facilitate its practical application in smart buildings. To the best of our knowledge, this may be the first academic research evaluating RTT performance of LoRa via practical experiments.

2. Mr. Juned Mulani, et al. Through this paper's methodology, the author has developed a power factor correction prototype that is developed using pic microcontroller, relays, potential transformer, current transformer and zero crossing circuit. The author stated that Because of the low power factor there is a burden on the power system and transmission lines which is unnecessary. By correcting the power factor of the power system, efficiency of the power system can be improved.

3. Mr. Anant Kumar Tiwari, The paper “Power factor correction unit using 89C52" contains the use of 89C52 to measure and correct the power factor. The advantage of this research was that it shows the best method to measure power factor of systems but the drawback was the increase in response time of microcontrollers.

4. Zhiguo Pan and F. Z. The paper “Power factor correction unit using active series of filters” contains the use of active filters for the purpose of power factor correction which is a unique method for power factor correction. The advantage of this method was the use of active filters to improve power factor but the drawback was the use of active filters as the filters don’t have sharp cut off frequencies and also there was no use of controllers the circuit was not automatic.

5. Stephen, J. C., The paper “Automatic Power Factor Improvement of Induction Motor using Arduino” contains practical realisation and correction of power factor across the induction motor. The advantage of this paper was it solved the problem of low power factor practically at induction motor using it as inductive load. The drawback was that the use of Arduino UNO boards increased the cost of the circuitry as it should be further connected to the controller.

6. G.Premkumar, The paper “Automatic power factor correction unit” contains the use of precision rectifier a XOR gate and use of Arduino board along with inductive and capacitive loads for the purpose of power factor improvement and correction.The advantage of this paper is that it measures the value of voltage and current and solves the problem of power factor and displays the corrected value but its drawback is the measurement of voltage and current value by using rectified sine wave and also use of precision rectifier which increases the size and complexity of circuit.

7. Noreen, Umber, et al. In this paper, the author focuses on the emerging transmission technologies dedicated to IoT networks. Characteristics of LoRa are based on three basic parameters: Code Rate (CR), Spreading Factor (SF) and Bandwidth (BW). This paper provides in depth analysis of the impact of these three parameters on the data rate and time on air.

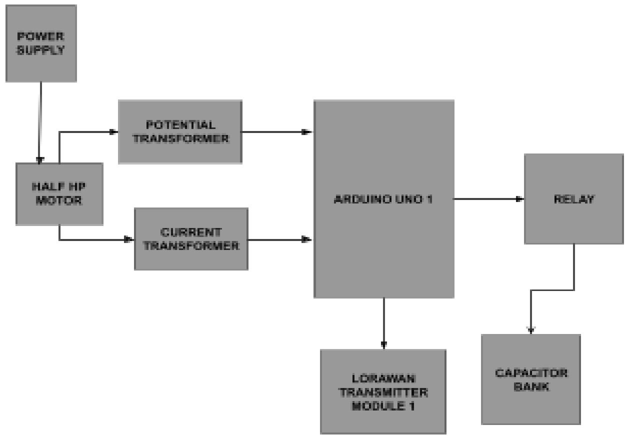
8. Kabir, Yasin, et al. The authors aim of this project is to build an Automatic Power Factor Correction (APFC) Unit, which is able to monitor the energy consumption of a system and automatically improve its power factor. An open source energy monitoring library was implemented in the design for accurate power calculation. The APFC device calculates the reactive power consumed by a system’s inductive load and compensates the lagging power factor using capacitance from a capacitor bank.

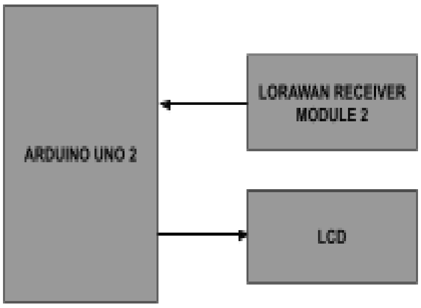
9. Ndukwe, Cherechi, et al. In this paper, the author proposes a LoRa-based wireless communication system for data transfer in microgrids. The proposed system allows connection of multiple sensors to the LoRa transceivers, and enables data collection from various units within a microgrid. The proposed system focuses on communications at the secondary communication level of the microgrid between local controllers of each distributed generation (DG) unit and the microgrid central controller due to the possibility of applying low-bandwidth communication systems at this level.

10. Kolobe, Lone, et al. In this paper, the author studied a systematic literature review of published refereed primary studies on LoRa applications was conducted using articles from 2010-2019. The author identified 21 relevant primary studies. These reported a range of different assessments of LoRa with 10 out of 21 reporting on novel use cases. The authors conclude that more work is needed in terms of field testing, as no articles could be found on performance/deployment in Botswana or South Africa despite the existence of LoRa networks in both countries.

BLOCK DIAGRAM

TRANSMITTER SYSTEM





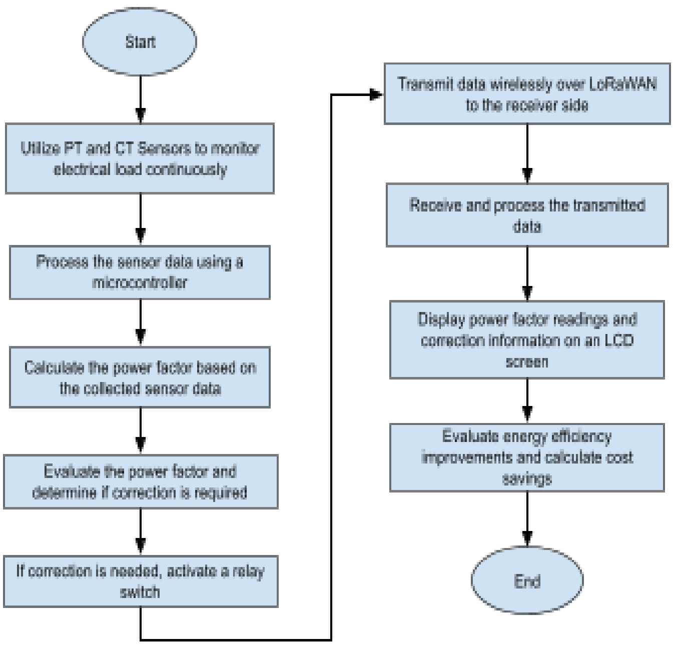
RECEIVER SYSTEM

DESCRIPTION

Block Diagram 1 – First Block Diagram shows the Transmitter system which shows that In this paper we used Arduino Uno as a microcontroller, potential transformer, current transformer and a half HP motor as an input device and we used a lorawan SX1278 module, relay, capacitor bank as an output device.

Block Diagram 2 - Second Block Diagram shows the receiver module which shows that we used Arduino Uno as a microcontroller, and we used a lorawan receiver module as an input device in it. And an LCD as an output device.

FLOW CHART



III. SYSTEM REQUIREMENT

HARDWARE REQUIREMENT

1. Arduino Uno
2. Half HP motor
3. LoRaWAN Sx1278 Module
4. Potential Transformer
5. Current Transformer
6. LCD
7. Capacitor bank
8. Relay
9. Step Down Transformer

SOFTWARE REQUIREMENT

1. Arduino IDE
2. Proteus

IMPLEMENTATION

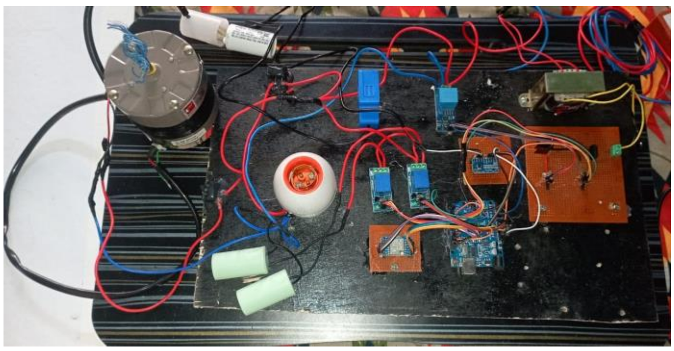


Fig. shows the experimental setup of the system

IV. RESULT

```
13:18:19.354 -> Voltage: 241.374 V
13:18:19.354 -> Irms: 0.602 A
13:18:19.354 -> Real Power: 155.170 W
13:18:19.354 -> Power Factor: 0.997
13:18:21.745 -> New Power Factor (Capacitor 1): 0.99
13:18:21.745 -> Voltage: 241.086 V
13:18:21.745 -> Irms: 0.654 A
13:18:21.745 -> Real Power: 160.686 W
13:18:21.745 -> Power Factor: 0.997
13:18:24.182 -> New Power Factor (Capacitor 1): 0.99
13:18:24.182 -> Voltage: 241.998 V
13:18:24.182 -> Irms: 0.667 A
13:18:24.182 -> Real Power: 161.125 W
13:18:24.182 -> Power Factor: 0.997
13:18:26.573 -> New Power Factor (Capacitor 1): 0.99
13:18:26.573 -> Voltage: 241.442 V
13:18:26.573 -> Irms: 0.667 A
13:18:26.573 -> Real Power: 160.933 W
13:18:26.573 -> Power Factor: 0.997
```

Case 1: No Load connected

```
13:02:59.505 -> Voltage: 244.718 V
13:02:59.505 -> Irms: 0.000 A
13:02:59.505 -> Real Power: 0.000 W
13:02:59.505 -> Power Factor: 1.000
13:03:00.723 -> Voltage: 243.816 V
13:03:00.723 -> Irms: 0.000 A
13:03:00.723 -> Real Power: 0.000 W
13:03:00.723 -> Power Factor: 1.000
13:03:01.942 -> Voltage: 243.461 V
13:03:01.942 -> Irms: 0.000 A
13:03:01.942 -> Real Power: 0.000 W
13:03:01.942 -> Power Factor: 1.000
13:03:03.114 -> Voltage: 243.446 V
13:03:03.114 -> Irms: 0.000 A
13:03:03.161 -> Real Power: 0.000 W
13:03:03.161 -> Power Factor: 1.000
```

In the first scenario, with no load connected, the power factor reaches an optimal value of 1, indicating efficient utilisation of electrical power as there is no reactive power consumption.

Case 2: Resistive Load Reading

In the second case, when a resistive load is introduced, the power factor is measured at 0.999, which is nearly equal to unity. Therefore, introducing the resistive load causes no significant change in the power factor.

Case 3 : After capacitive load Activate

In the third case, involving both resistive and inductive loads with an initially decreased power factor of 0.97, the activation of a capacitor results in an improved power factor of 0.99. This adjustment suggests that the capacitor compensates for reactive power, enhancing the overall efficiency of the electrical system.

V. CONCLUSION

In conclusion, this innovative embedded system for automatic power factor correction, empowered by LoRa wireless communication and comprehensive power measurements, offers a robust solution to enhance energy efficiency, reduce operational costs, and promote sustainable power usage in electrical systems. By continuously monitoring and optimising the power factor, this system exemplifies the benefits of real-time correction, ensuring that electrical infrastructure operates at its most efficient, cost-effective, and environmentally conscious capacity.

In addition to its significant contributions to energy conservation and cost reduction, this system also serves as an invaluable educational tool for understanding the principles and advantages of power factor correction. By implementing automated correction measures, it demonstrates the practical and far-reaching implications of efficient power management, further underlining the importance of adopting such technologies in modern electrical systems. As industries and businesses continue to prioritise sustainability and cost-efficiency, this system emerges as a vital step toward achieving these goals while simultaneously minimising the environmental impact of energy consumption.

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