



# Real Time Solar Panel Monitoring System Using LoRa Technology

Dr.S.Saravanan<sup>1</sup>, N.Sai Swapna<sup>2</sup>, M.Hareeshwar<sup>3</sup>, G.Haritha<sup>4</sup>, A.Divya<sup>5</sup>

<sup>1</sup>Associate Professor, Department of Electronics and Communication Engineering, N.B.K.R. Institute of Science and Technology, Vidyanaagar, Andhra Pradesh, India

<sup>2,3,4,5</sup>U.G. Students, Department of Electronics and Communication Engineering, N.B.K.R. Institute of Science and Technology, Vidyanaagar, Andhra Pradesh, India

**ABSTRACT**—Nowadays renewable resources have become important in human life. One of the renewable resources is solar energy, as it is vastly used to power up large industries, homes etc. To use solar energy efficiently a monitoring system is needed. But the analysis can be verified and the maintenance of the solar panels only done with the presence of technical human power near to the solar panel which is time-consuming and not reliable for long distances. This paper presents data transmission which uses LoRa technology to transfer the data provided by the sensors at the transmitter end (nearby the solar panel) and links or transfer to the receiver which can be used to avoid human interference.

**Keywords**— LoRa technology, NodeMCU, ThingSpeak

This paper introduces the advantages of LoRa (Long Range) technology which transmits the data over long distances in rural as well as urban areas. LoRa is a wireless technology which consumes low power and supports long distance transmission. By using this technology, it helps in monitoring the solar plants in real time. As to maintain the efficiency of the solar panel, LoRa technology can be used as it is more reliable in collecting and transmitting the data over longer distances without any interference. This system provides stable readings in real-time to ensure efficiency. The data transfer is done by the LoRa module and received data can also be visualized in IoT platform using ThingSpeak application which displays the values to ensure the performance of solar panel.

## I. INTRODUCTION

Solar energy is a renewable and alternative energy form. This energy can be harness using solar panel. The solar panel is an equipment which converts solar energy into electricity. The electricity helps by supporting residential homes, Industries and agricultural purposes etc,. By using solar panels, it helps to operate independent of power and also enables to improve quality of life. This system of provides reduced electricity and replaces traditional methods for providing electricity. As the usage of solar panels increased abruptly the monitoring and maintenance of these solar plants has to be increased correspondingly. To use the solar panels efficiently maintenance of the plants is necessary. The efficiency of the panel can be analysed by some parameters like temperature, voltage, intensity etc,. These values are calculated in presence of humans using multi-meter or sensors and ensure the efficiency of the panel traditionally.

After calculating the power by using sensors the networks like Wi-Fi or Bluetooth which are wireless networks used to note these readings. As the following networks cover a short range so for verifying the network parameters from the plant humans should be present near the solar panel. Hence it is a time-taking process and there is a chance of occurring errors manually and also frequent maintenance of the solar panel will be costlier.

## II. PROPOSED SYSTEM

In this project the monitoring of the solar panel is done in real time using lora technology. This monitoring system consists of various sensors like voltage sensor, LDR sensor, humidity and temperature sensor attached to the panel and provides required data of solar panel. This data is wirelessly communicated using LoRa technology. This monitoring system helps users to monitor solar panels perform in real-time. The following information provides brief details of the overview of the project.

A. TRANSMITTER END:

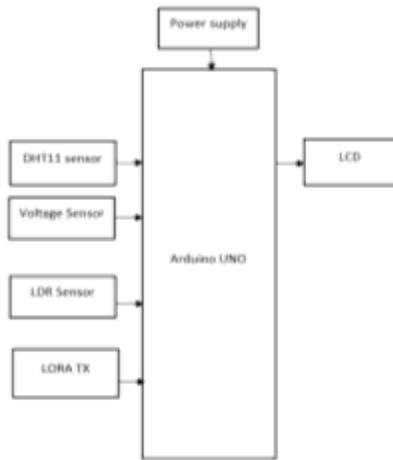


Fig.II.1 Block diagram of transmitter end of the project

To evaluate the performance of the solar panel using LoRa technology the solar panel is connected to the transmitter end system that contains various sensors for collecting the data like DHT11 sensor – for measuring temperature and humidity near the solar panel, Voltage sensor – for measuring how much light is converted into electricity, LDR sensor – for noting presence of light etc.,. These sensors are linked with Arduino and LCD display which displays these values and the LoRa transmitter transmits the data to the other LoRa receiver. A power supply will be there for providing power to all these components from solar panel.

B. RECEIVER END:

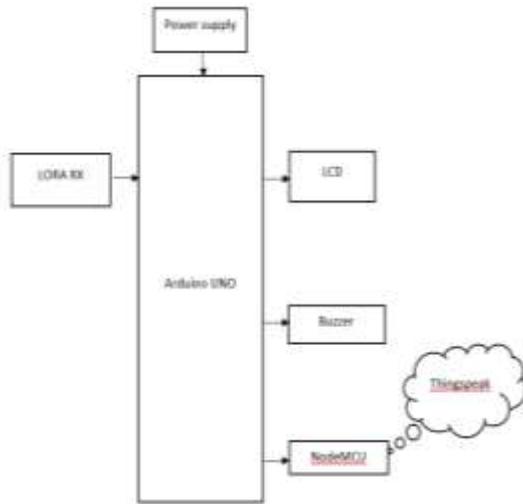


Fig.II.2 Block diagram of receiver end of the project

The receiver end will have a LoRa receiver which receives the data from the LoRa transmitter at transmitter end, gives these values to LCD display for tallying of the data received and certain alert messages with a buzzer sound will be given if in case any problem according to the considerations of code written to the Arduino UNO. In the receiver end we have another component, i.e., NodeMCU, which uploads the received data readings to the cloud platform- ThingSpeak using IoT that helps in analyzing the real time data incentives of solar panels from anywhere in the world.

III. METHODOLOGY

The implementation of the project involves in following steps:

ANALYSIS OF DATA:

The readings noted on the LCD display by the sensors will be transmitted through LoRa transceiver at the transmitter end to the receiver side LoRa transceiver. The same readings will be displayed on the receiver side LCD. As per the data fluctuations at the transmitter end, we can observe the appropriate alerts and buzzer sound at the receiver end and the same readings will be uploaded on ThingSpeak. Hence, we can visualize real time data on ThingSpeak platform.

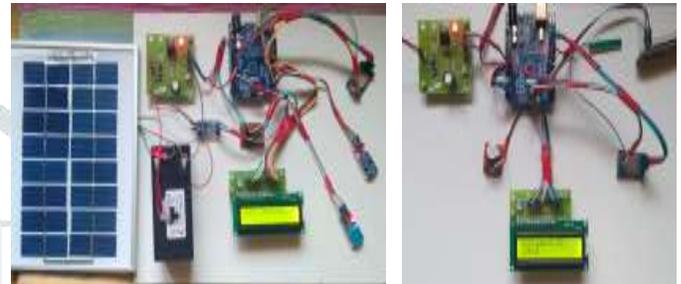


Fig.III.1 Implementation of the project

DATA TRANSMISSION IN LORA MODULE:

LoRa module uses a patented spread spectrum modulation known as Chirp Spread Spectrum Modulation (CSS). In this modulation technique the frequency increases or decreases over time intervals across the channel bandwidth. Due to this the signal can be recovered below the noise margin and provides long communication range with resilience. LoRa modulation can be used for raw data rate sensitivity, interference immunity and range.

LoRa module takes input data, encodes it through chirp spectrum modulation, and transmits a radio signal that travels long distances at low power levels. This radio signal gets demodulated by LoRa devices connected to the internet via Wi-Fi or Ethernet. The gateways then forward the data to the network server for processing and analysis.

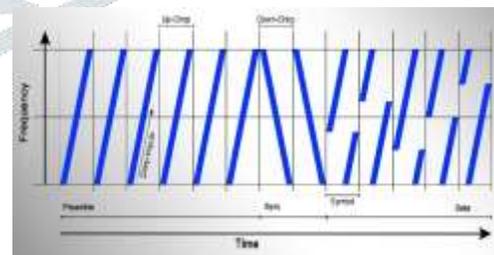


Fig.III.2 Chirp spectrum modulation of LoRa module

UPLOADING DATA TO IOT:

NodeMCU is used in this project to upload the readings from the receiver end LoRa to IoT platform-ThingSpeak. NodeMCU is a microcontroller that was specifically created for Internet of Things(IoT) with extremely low power requirements and an integrated ESP8266(Wi-Fi). It enables the connection of devices and the flow of data over the Wi-Fi protocol.

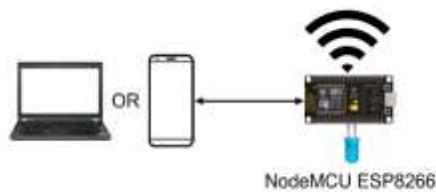


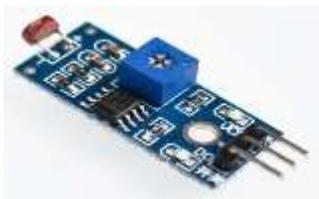
Fig.III.3 NodeMCU

**HARDWARE REQUIREMENTS:****A. ARDUINO UNO**

Arduino UNO is a widely used microcontroller due to its simplicity and ease of programming. This microcontroller is based on ATmega328P. It consists of a total of 20 pins which can be used for digital input/output, a USB port, power jack, reset button. Due to its simplicity, it functions as the central unit that collects data from sensors like LDR, Voltage sensors etc. When the UNO gets powered on it starts collecting data from the sensors at the transmitting side in real-time. The UNO analyses the data according to the program dumped in Arduino via Arduino IDE. Then the data gets transmitted from the transmitter side by using the LoRa module transmits the data to receiver as LoRa acts as a transceiver. At receiver, another UNO receives the data using LoRa module.

**B. VOLTAGE SENSOR**

The voltage sensor is connected to the solar panel verifies the voltage from the panel and provides it to the Arduino. This sensor can measure AC or Dc voltage level. It works on voltage divider principle. In this project, the voltage sensor is connected between voltage source and Arduino. The data calculated by the sensor will be received at Arduino. This sensor can sense up to 25V DC voltage.

**C. LIGHT DEPENDENT RESISTOR**

This LDR sensor detects the light near the solar panel and provides the output accordingly. If there is no presence of light the output goes high and if there is light, then the output goes low as it mainly depends on the light intensity. This sensor

provides output data to the Arduino so that it verifies the presence of light at the panel.

**D. DHT11 SENSOR**

This sensor monitors the humidity and temperature near the panel and provides the data to Arduino. It is a low-cost sensor that provides output based on real-time environmental data. In this project, the DHT11 sensor connected to the Arduino UNO. The Arduino UNO collects the data periodically from the sensor and the data provided by the sensor can be displayed using LCD display. Due to its simplicity, it is used in home automation and greenhouse monitoring systems.

**E. LORA MODULE**

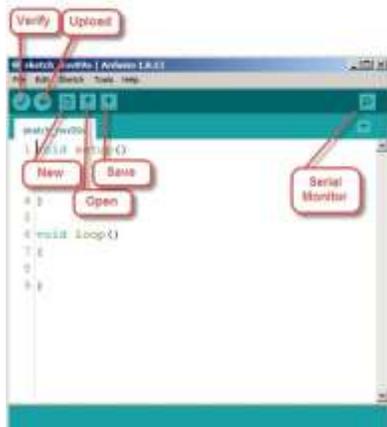
LoRa (Long Range) module is a low-power wireless communication system, and it also enables long-distance communication between devices. This device is used in IOT applications where data needs to be transmitted from various remote sensors without relying on traditional internet connectivity. In this project, the LoRa module acts as a transceiver which collects the data that needs to be transmitted from the Arduino at the transmitter side and it transmits the data using LoRa transmitter and at receiver side, the data will be received using LoRa receiver and the transmitted data can be verified by uploading it to the cloud using NodeMCU. As the LoRa module can cover several kilometers with low-power consumption it becomes ideal for real-time monitoring systems, remote sensing, agriculture activities etc. and it avoids human interference.

**F. NODEMCU**

NodeMCU is a microcontroller based on ESP8266 wi-fi chip which enables easy internet connectivity and control for IOT applications. It supports Arduino IDE which allows easily accessible to wide range of users. It acts as a connection between cloud and sensors. In this project, NodeMCU collects data from Arduino UNO at receiver end and transmits the data to the cloud. By using NodeMCU we can ensure real-time monitoring or cloud-based connectivity. Due to its USB interface, it became easy to upload so that made the NodeMCU popular for smart home applications.

**SOFTWARE USED:****G. ARDUINO IDE**

Arduino IDE plays a crucial role in IOT applications due to its simplicity and easy accessibility. It connects the computer with microcontrollers on the Arduino board which enables the control of electronic devices. It enables the user to edit the code, compile the code and upload the code. In this project, Arduino IDE is used to upload the code to the LoRa module as well as to the Arduino UNO and NodeMCU.

**H. THINGSPEAK**

ThingSpeak is an IOT analytics platform which allows the user to visualize and analyze the data in the cloud from the devices. This platform is free for small project analysis. This software is mostly used for weather analysis and monitoring systems due to its simplicity. ThingSpeak allows users to send data from different sources like electronic devices, sensors and other applications to cloud. In this project, ThingSpeak is used for reviewing data like voltage, temperature, humidity, light intensity collected from the NodeMCU.

**IV. RESULT**

The data given from the sensors are received at the Arduino at transmitter side by using LoRa transmitter. This data gets transmitted and at the receiver side the LoRa receiver receives the data and provides it the NodeMCU. The NodeMCU uploads it to cloud. By using ThingSpeak the data will be visualized from anywhere in the world. This following figures provide the data which is transmitted using LoRa technology.

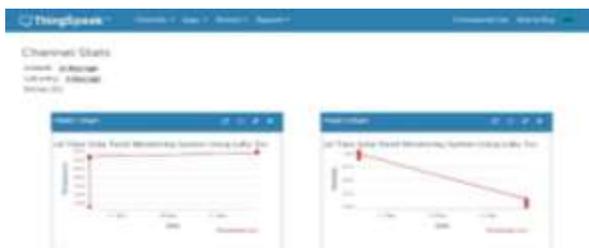


Fig.IV.1 Temperature and humidity analysis at solar panel



Fig.IV.2 Voltage and LDR readings at solar panel

**V. ADVANTAGES**

The advantages of this project given as follows:

1. It reduces the constant human supervision.
2. This system not only saves time but also avoids human error during manual readings.
3. Due to the presence of internet connectivity online surveillance enables real time monitoring.
4. Due its low cost maintenance and low power consumption made it suitable to adapt for harsh environments.

**VI. ACKNOWLEDGMENT**

The authors acknowledge the support of the Department of Electronics and Communication Engineering at N.B.K.R. Institute of Science and Technology for providing resources and necessary facilities for successful completion of this project. Special thanks are extended to Dr. S. Saravanan for his valuable mentorship and support throughout the research process.

**VII. CONCLUSION**

This project demonstrates an effective approach to monitor the solar panel and its efficiency using LoRa technology. By integrating various sensors like voltage sensor, DHT11 sensor and LDR sensor with Arduino and NodeMCU. As the Arduino collects data from this sensors and gets transmitted over longer distances using the LoRa module which also eliminates the need for human presence. This system enables continuous wireless real time monitoring of solar performance and also provide accurate data transmission in real time with minimum power consumption. LoRa ensures stable communication between transmitter to receiver and IOT enabling reliable data transmission and remote access through the ThingSpeak IOT platform. This system allows quick detection of issues and efficient maintenance for large scale solar power setups.

**VIII. REFERENCES**

- [1] John Doe, Jane Smith, "A LoRaWAN-Based IoT Solution for Solar Power Monitoring," IEEE Transactions on Smart Grid, 2023.
- [2] Alex Johnson, Emily Brown, "Performance Evaluation of LoRaWAN and Wi-Fi for Smart Grid Applications," International Journal of Energy Research, 2022.
- [3] Michael Green, Sophia Davis, "IoT-Based Monitoring of Renewable Energy Systems Using LoRa and WLAN," Renewable Energy Journal, 2021.
- [4] Robert White, Olivia Clark, "Implementation of a LoRaWAN Sensor Network for Environmental Monitoring in Smart Cities," Journal of Wireless Communications, 2023.
- [5] Daniel Lewis, Sarah Martinez, "Comparative Analysis of LPWAN Technologies for IoT Applications," IoT Journal, 2022.
- [6] LoRa Alliance, "LoRaWAN® Specification 1.0.4," LoRa Alliance Technical Paper, 2021. • ThingSpeak Documentation, "Cloud-Based IoT Data Analytics," MathWorks, 2024.