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# LoRa Based Photovoltaic Solar Energy Monitoring System

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***Abstract:-*** **The use of renewable energy plants is on greater demand around the world. The main reasons for increase in installation of renewable energy power plant includes reducing air pollution and produces no greenhouse gas emissions from fossil fuels, creating economic development, and protection of environment. Monitoring of these power plants requires human effort if monitored manually. As humans are prone to make mistakes and would be difficult to monitor several power plants, electronic devices such as sensors and microcontrollers are used to collect data and helps in remote monitoring. This paper proposes a smart and efficient remote monitoring system for photovoltaic solar power plant that includes low-cost LoRa network of IOT technology at the communication layer having an advantage of long distance coverage and low power consumption. The sensor modules are used to measure and collect the parameters such as current and voltage from the solar panel. The data is given to Arduino which is interfaced with LoRa module acts as transmitter, is sent to another LoRa receiver. The system makes use of Blynk application in which the user can view and monitor the parameters. Additionally, solar tracker is also implemented in order to increase the working efficiency.**

***Keywords: Photovoltaic solar panel, LoRa (long range), remote monitoring, solar tracker***

## I. INTRODUCTION

In modern life electricity has become most essential part of life. In day to day life, consumption of electricity has been drastically increased. To meet the requirements it is necessary to produce more electricity to supply to the end users. The use of fossil fuels eventually led damaging and affecting the environmental factors. In contrast, the usage of renewable energy sources has been increased in recent years overcomes the disadvantages of fossil fuels by being eco-friendly. However, its installation cost is still high. From the different renewable energy sources, the photovoltaic solar energy is considered as one of the mature technologies, which has a significant effect on the current power system. To ensure that the system is operating correctly as much as predicted monitoring is much needed. Many industries follow the conventional methods of monitoring the installed systems manually. The readings were noted down manually for several parameters like current, voltage, power and temperature by visiting the installation place once in a week or month to check the system performance. This requires lot of human power and it is difficult to visit the installation place every time. Hence remote monitoring is much needed. But most of the agencies don't employ remote monitoring of solar installations. One of the main reasons is, because of lack of cellular service at remote locations. In this paper, the LoRa (long range) technology is used for remote monitoring of photovoltaic solar power plant. LoRa is an alternative wireless network solution emerged in the field of IoT. It is low power and wide area network with low power consumption and long transmission range. Solar tracking is also implemented in this project. The energy extracted from the photovoltaic solar panel depends upon solar irradiance. The solar panel should be normal to the incident radiation from the sun in order to extract maximum energy from sun. Solar tracking system improves the system efficiency by approximately 36% compared to normal stationary panels implemented in the industries [1]. In this proposed system, the data from the photovoltaic solar panel is sensed and collected from sensors and transmitted using LoRa modules. Further the data is uploaded to webserver using Blynk application which helps in monitoring and analyzing the system performance by the user.

## II. LITERATURE SURVEY

Many authors have proposed solutions in regarding to remote monitoring of PV solar power plants. A low cost Iot based solar monitoring system is proposed. In this system the GPRS module and low cost microcontroller is used to collect and send the data to the server over internet which can be accessed anywhere around world [2]. Another Iot based system has been proposed, in which Node MCU is used as microcontroller. Various parameters of solar panel are monitored using graphical user interface and the received data is uploaded to cloud using internet [3]. PV power plant monitoring using ZigBee technology has also been proposed. In which system uses the ZigBee technology to upload the incoming data to cloud via 4G communication network. [4]. An Iot solution based on

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Arduino with 3G connectivity technology has also been proposed [5]. All these current existing systems have limited coverage area. The method based on zigbee technology is not much efficient since it cannot cover up the large distances in huge scale. The methods based on cellular internet also have limited coverage area with low battery life and cannot be implemented in remote areas having no or less network coverage. Hence the wireless solution low cost LoRa network of Iot is considered to remote monitoring of PV power plants. LoRa is a wireless Radio frequency technology which is used to transmit the information to long distances without consuming much power. It operates in the physical layer of the stack. It is based on chirp spread spectrum technique, in which chirp pulses are used as carrier signal to encode information [6]. The advantage of LoRa is its capability of transmitting the data to long distances without using cellular internet or Wi-Fi. It has low power consumption and high battery life and it is efficient than other wireless technologies. It is said that the data can be transmitted up-to 10 kilometers and more [7]. Most of the photovoltaic solar panels are stationary that means it is fixed on a rooftop of house or fixed to the ground. As the sun moves across the sky during the day it is necessary for the solar panels to face the sun to increase its working efficiency. This can be achieved by solar tracking. The importance and methods of the solar tracking system is discussed in[1].

## III. PROPOSED SYSTEM

The main objective of our proposed work is to monitor the current and voltage parameters of PV solar power plant by Lora technology. To increase the efficiency of the solar panel dual-axis solar tracking system is also implemented. In this section we present LoRa based photovoltaic solar power monitoring system.

In our proposed method, the solar panel is mounted on the microcontroller based dual-axis solar tracking system which moves according to the position of the sun. The functionality of this tracking system is that it can track the sun in all the four directions i.e. both east-west and north-south directions which helps to increase efficiency. The tracking system consists of servomotors, LDRs, resistors and Arduino nano as the microcontroller. LDRs are used to sense the amount of light falling on them. Four LDRs and resistors are connected in voltage divider fashion and the output is connected to Arduino. In order to track the east-west direction the analog values from top two LDRs and bottom two LDRs are compared and servomotors are moved according to the greater values. For north-west tracking, the analog values from left two LDRs and right two LDRs are compared and the servomotors are moved accordingly.

The overall system is able to measure and monitor the PV solar panel current and voltage continuously. The voltage is sensed by voltage sensor and current is sensed by Hall-effect current sensor. The obtained data is processed and sent by Lora transmitter in which Arduino nano is interfaced with LoRa module. The data is received by LoRa receiver in which Node mcu Esp8266-integrated wifi module is interfaced with LoRa module. Further the data is processed and uploaded to web server by Esp8266 microcontroller via internet. The data is displayed using Blynk application and the data can be accessed anywhere by the user for monitoring purpose.

The system block diagram for transmitter and receiver sections is shown in Fig 1.

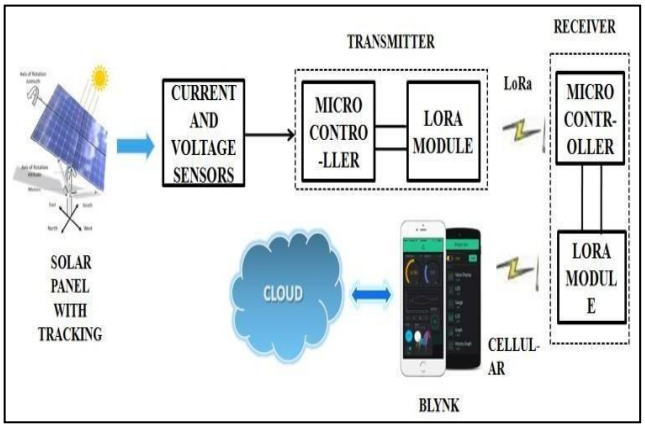


Fig.1. System block diagram

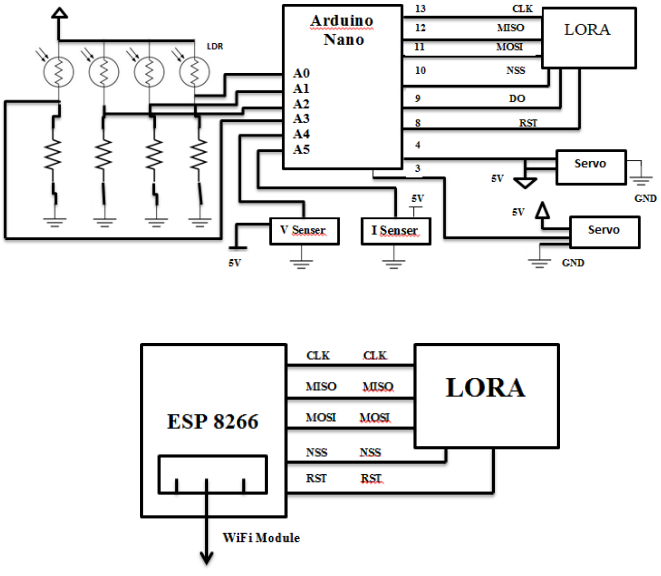


Fig.2. Circuit Diagram of proposed system

## IV. HARDWARE COMPONENTS USEDFOR IMPLEMENTATION

**Current sensor**

We are using ACS712 current sensor which is also known as Hall-effect sensor. We use this device to measure current generated from the solar panel. It is capable of measuring up to 20A. The operating voltage is 5V. It consists of a Hall-effect sensor in its IC which detects the incoming current through its magnetic field generation. The amount of current is measured by generating the voltage proportional to its magnetic field.

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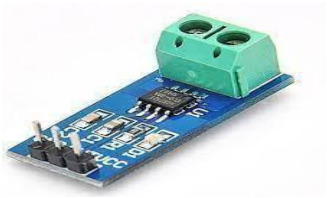

Fig.3. ACS712 Current Sensor

**Voltage sensor**

Voltage sensor module (25V) is a device which is used to measure voltage of the solar panel. It can measure AC or DC voltage level. It works on the principle of Resistive Voltage divider design in which two resistors connected in the circuit measures the voltage and lowers it to the level which can be read by the arduino.

Fig.4. Voltage Sensor

**LDR**

Light dependent resistor (LDR) is the sensor module which is used to measure the intensity of light. It mainly works on the principle of photoconductivity. LDR is constructed using cadmium sulphide film. When the photons or light falls on the resistor all the electrons of the semiconductor present in the valence band excites to the conduction band. In our project LDR is used to measure the light intensity of the solar panel. Using LDRs dual axis solar tracking is designed. By comparing the values of LDRs the solar tracking is done accordingly.

Fig.5. LDR

**Servomotors**

A servomotor is an electronic device consists of built in motor, a feedback circuit and a motor driver. It uses position feedback for which the motor is coupled with sensor to control its motion. The objective of it is to provide an exact movement as per the external control [8]. It is used to control the position of objects, rotate objects, move legs, arms or hands of robot and also to move sensors with high precision. We are using two servomotors in the tracking system on which the solar panel is mounted. The microcontroller is programmed in such a way that depending on the amount of light falling on the LDRs the servomotor moves in horizontal or vertical directions.

**LoRa module**

LoRa Ra-02 module is used for LoRa communication. It is designed by the AI-THINKER which is based on the chip SX1278 transceiver having frequency range of 433MHz. This module is mainly used for long range spread spectrum communication. It basically works with serial peripheral interface communication protocol which supports larger data rates and high speeds. This module can be interfaced with any microcontroller through SPI communication protocol. It is mandatory to operate the LoRa module with an antenna in order to prevent the damage of module. The operating voltage is 3.3V. It supports FSK, GFSK, MSK, GMSK and LoRa modulation techniques [9]. The Fig 6 shows the pin diagram of the module. The ground pins are denoted by 1, 2, 9 and 16. The pin number 3 represents input supply voltage and 4 is the reset pin. To read and write data, the module consists of five digital input and output pins. MISO represents master in slave out, in which the data is transmitted from slave to master.

MOSI represents master out slave in; data is transmitted from master to slave.

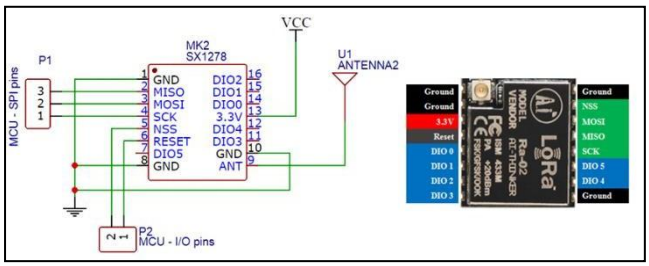


Fig.6.LoRa Ra 02 Module

**Arduino Nano**

Arduino Nano is a microcontroller based on ATmega328 which is small and breadboard friendly. It has 14 digital input/output pins and 8 analog pins. Its operating voltage is 5V. It is coded using Arduino IDE software using C language and uploaded directly to board. In our proposed system, the Arduino Nano processes the incoming data from the LDRs and controls the motion of the servomotors. It is interfaced with the LoRa module via serial interface protocol which acts as transmitter. It processes and transmits the incoming data obtained from current and voltage sensors to receiver system.

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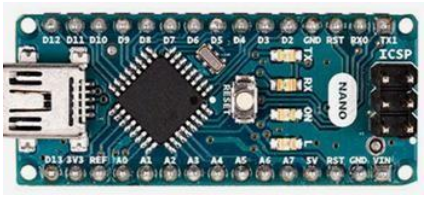

Fig.7. Arduino Nano

### ESP8266

ESP8266 is a microcontroller developed by Espressif Systems. It is a low-cost Wi-Fi microchip integrated with TCP/IP protocol stack that can give any microcontroller access to Wi-Fi network. The module is cost-effective board and is designed to occupy minimal PCB area. It is preprogrammed with an AT command and it can be integrated with sensors or other application specific devices through its GPIO pins. It can be programmed using Arduino IDE using C/C++ language. In our project, it is interfaced with LoRa module with SPI communication protocol which acts as receiver by detecting and processing the received packets and helps in uploading the data to server.

Fig.8. ESP8266

## V. SOFTWARE USED FOR IMPLEMENTATION

### Arduino IDE

It is open source integrated development environment software that enables code to be written and uploaded to boards. The languages supported for programming is C/C++. It can be installed on various operating systems including windows, MAC and Linux. It consists of a text editor in which the code can be written. The compiler is present to compile and check the errors if there any and also debugger. The output can be viewed in the serial monitor.

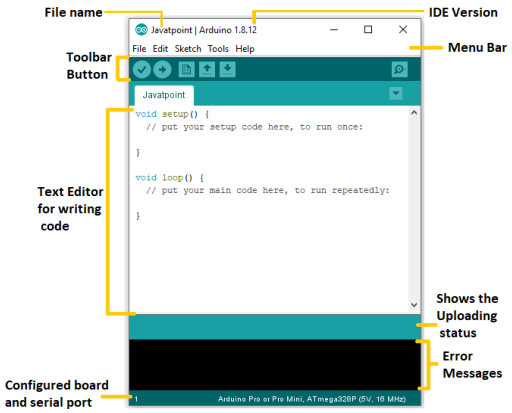


Fig.9. Arduino IDE

### Blynk

Blynk is a software platform with an android application which allows creating interfaces for projects using various widgets. It was designed for internet of things to remotely control the hardware, display and store the sensor data to visualize. It is a digital dashboard in which by simply dragging and dropping widgets the required graphic interface can be built. In our system, the Esp32 is connected to blynk over internet which uploads data to the server. Further the current and voltage data is viewed and monitored using Blynk.

## VI. FLOW CHART REPRESENTATION

The solar panel is mounted on the tracking system which is designed according to the circuit diagram. Initially the values from the LDRs are collected. The top two LDRs and bottom two LDRs values are compared. If the values of top set of LDRs are greater then, vertical servomotor will move in that direction. It the values of bottom set of LDRs are greater then, the servomotor will move in that direction. This is for east-west tracking. For angular deflection, the values from the left and right LDRs are compared, whichever is greater the servomotor moves in that direction. The voltage and current values of the solar panel is read and sent to the microcontroller. LoRa module is initialized. It checks if the band is free to transmit the data. If not then the message will be popped in the serial monitor stating starting LoRa failed. If band is available then it

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makes a string for sending of data. It reads the data from the sensors and it concatenates the packet with values and transmits the data to the receiver LoRa module. If the packet was successfully sent it returns 1;0 if there was an error and the process continues. The flow chart representation for the transmitter circuit is show in fig.10.

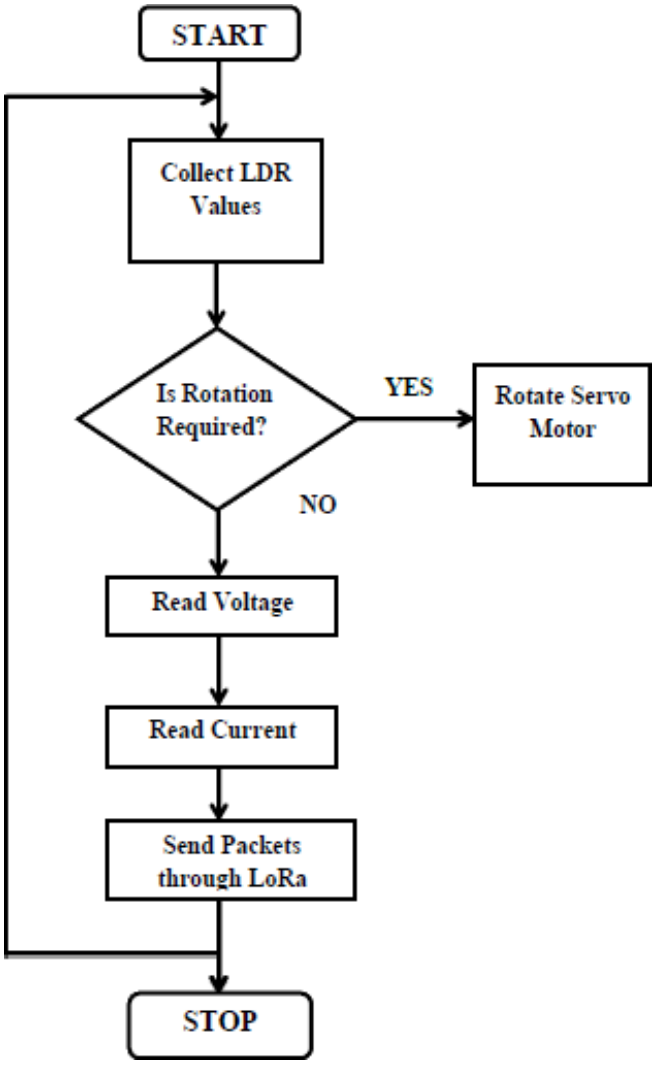


Fig.10. Flow chart representation of transmitter circuit

At the receiver side, the receiver circuit is powered up and connected to Wi-Fi. Then the serial monitor is initialized. It checks for the data packets sent from the transmitter module. The received data packets are decrypted and the contents in the packets are read and displayed on the serial monitor. An Esp8266 microcontroller is used to upload the data to the web server. Further the Blynk application is installed in mobile phone and by setting up it and connecting to the Esp8266 microcontroller the user can view and store the data. Hence it is accessed and easily monitored by the user. The flow chart representation for the receiver circuit is shown in fig.11.

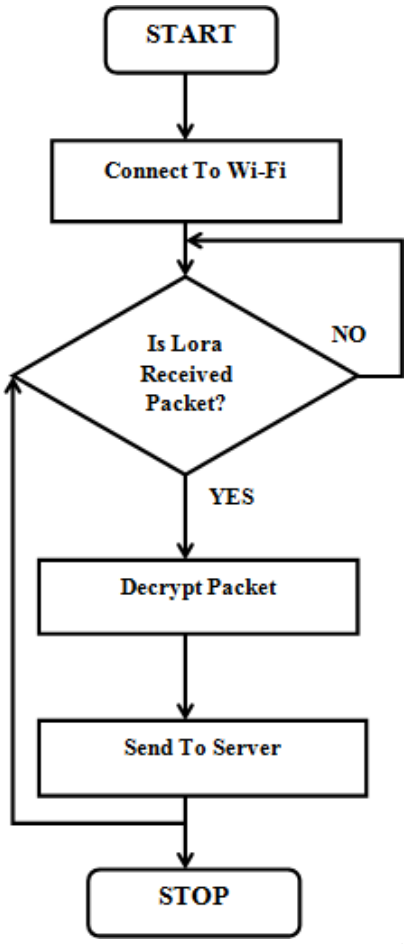


Fig.11. Flow chart representation of receiver circuit

## VII. RESULTS AND CONCLUSION

This project is carried out using a small prototype of solar panel and sensors. It is designed to get the readings of current and voltage generated by solar panel. The results of this proposed system is displayed on the serial monitor of the Arduino IDE software. The result in the serial monitor is shown in fig.13. The Blynk mobile application is also used to view the data which can be analyzed by the user to monitor. The current in amperes and voltage in volts is displayed on the webpage of the blynk which can be accessed by the user from anywhere.


Fig.12 Results displayed on Blynk webpage

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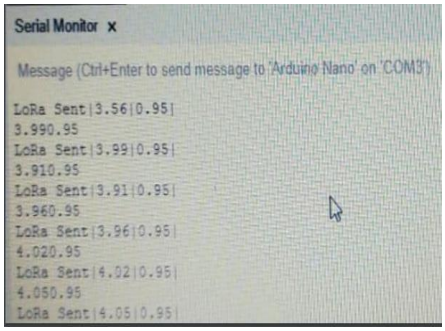


Fig.13. Serial Monitor data

In this paper, LoRa, the low power wide area network technology of IOT based approach for monitoring photovoltaic solar power system is presented and prototype is developed. This system records the solar panel parameters like current and voltage. The data is transmitted using LoRa technology which remotely monitors the solar panel and providing long distance transmission. The system can be implemented in remote areas where no network coverage is available. The designed system can transmit data within 1km range as we are in urban with obstructed links. But by using good antenna and in open field maximum 10km range can be achieved. Further the data is transferred to web server using Node mcu Esp8266 microcontroller. The results are displayed in the serial monitor and also on the Blynk webpage which can be accessed by the user virtually to monitor the system performance byanalyzing the parameters. This reduces the man power of taking the readings of the parameters by visiting the installation place every now and then. Automatic solar tracking mechanism is very important in improving the efficiency of the solar systems. The proposed system implements the dual-axis solar tracking mechanism to improve the efficiency of the system performance than compared to fixed solar panels. Hence this system monitors the solar panels remotely which is efficient, cost effective and ensures best system performance.

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