



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

**Volume 9, Issue 10, October 2020**

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.512**

9940 572 462

6381 907 438

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# LoRa Network Based Solar Panel Power Monitoring System

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**ABSTRACT:** Solar power plants need to be monitored for optimum power output. This helps retrieve efficient power output from power plants while monitoring for faulty solar panels, connections, and dust accumulated on panels lowering output and other such issues affecting solar performance. So here we propose an automated IOT based solar power monitoring system that allows for automated solar power monitoring from anywhere over the internet. We use ARM-2148 based system to monitor, 12Watt solar panel parameters. Our system constantly monitors the solar panel and transmits the power output to IOT system over the internet. Here we use IOT transmit solar power parameters over the internet to IOT MQTT server. It now displays these parameters to the user using an effective FEED(GUI) and alerts user when the output falls below specific limits. These make remotely monitoring of solar plants very easy and ensure best power output. This paper proposes a wireless low-cost solution based on long-range (LoRa) technology able to communicate with remote PV power plants, covering long distances with minimum power consumption and maintenance. This solution includes a low-cost open-source technology at the sensor layer and a low-power wireless area network (LPWAN) at the communication layer, combining the advantages of long-range coverage and low power demand. Moreover, it offers an extensive monitoring system to exchange data in an Internet-of-Things (IoT) environment.

**KEYWORDS:** LoRa Technology, IOT, ARM, GUI, MQTT .

## I. INTRODUCTION

The Lora WAN specification provides seamless interoperability among smart things without the need of complex local installations, enabling the roll out of IOT applications, according to the association. In the Lora WAN network architecture, gateways are connected to the network server via standard IP connections while end-devices use single-hop wireless communication to one or many gateways. All end-point communication is generally bi-directional, but also supports operation such as multicast, enabling software upgrades over the air or other mass distribution messages to reduce the on-air communication time. There are many potential ways of monitoring solar panels. This paper which upload data continuously to a web portal which allows you to monitor your systems performance from anywhere in the world and there are simple methods like manually noting down the reading on your generation meter once a week in a log book. This concept can be implemented in large scale for n number of solar panels. This helps in detecting faulty solar panel easily through IOT MQTT server.

## II. RELATED WORK

The survey on this paper highlights the various benefits of LoRa network based solar panel power monitoring system. Earlier solar panel power monitoring concepts were using arduino ,NI( Texas ),GPS. When compared with other papers, this paper aims at transmitting the power to large distances detecting the faulty panel easily and reducing cost.

[1] Burak Inner, "Data monitoring system for solar panels with Bluetooth"; In photovoltaic (FV) systems, data collection units are used to monitor the system's stability and performance. Monitoring and analysing instantaneous changes of the electrical signals collected from the panel helps detection of the errors easily. This is accomplished by transferring data collected from panels by cables. There are some technical and cost limitations of this method. Moreover, considering the high temperature, humidity, rain, snow and harsh environmental conditions, wireless data transfer provides a big advantage over the wired transfer. In this study, an online software system has been developed for sending the data such as voltage, current, radiation, temperature, and humidity obtained from an installed 1000W PV system via the Bluetooth. A website has been designed for monitoring the data online. Software compatible with

both Bluetooth 2.1 and 4.0 standards, which runs on Raspberry Pi, collects the electrical measurement data of PV panels that was placed at various locations.

[2]Simon Siregar and Duddy Soegiarto,” Solar panel and battery streetlight monitoring system using GSM wireless communication system”; The use of single power solar system in generation of electricity for streetlights nowadays is widely used. Generally, many of this kind of streetlight is using one solar panel system to power its lamp. The problem that can arise for this kind of streetlight is how to control and guarantee the optimal system. The use of ACS712 current sensor and voltage sensor using voltage divider circuit with GSM communication system allows to monitor both the battery and the solar panel. The information from the current sensor and voltage sensor then processed by a microcontroller. This microcontroller then sends the data through a GSM communication system to a server, via short message service (SMS). This server then processed the data by passing the information from the SMS and sends the data to a web server database. This information then can be accessed by internet. The expected outcome of this monitoring system is a system that can be used in monitoring small solar power plants system as the streetlights.

[3] Haider-e-Karar, Aziz Altaf Khuwaja and Abdul Sattar,” Solar power remote monitoring and controlling using Arduino, LabVIEW and web browser”; This paper proposes an effective and efficient graphical user interface (GUI) to real time control and monitor the DC power generated by solar panels and DC power consumed by load locally and remotely. There are two GUIs provided server and client. Server computer needs to be installed near to solar panels for monitoring and controlling locally while client GUI can be accessed by using a web browser from any part of world, authorize person can monitor and control all operations. Server and client GUI are designed by using LabVIEW and LabVIEW UI builder while hardware is developed with Arduino Uno, current and voltage sensors, relays, and charge controller. Monitoring interface uses real time measurement results to prepare the power, current and voltage graphs, it is also possible to record and reach database file to analyse history of renewable energy source (RES) system. This will also help to increase performance of the existing solar system also other alternative resources of energy. In this system monitoring interface contains power production and consumption, voltage and current graphs and meters on a GUI. Controlling feature includes turn on/shutdown of solar system, increase, or decrease energy consumption, generation and switching to other available system.

### III. WIRELESS SENSOR NETWORK

LoRa Solution Wireless sensor network (WSN) is a mature field in technology to sense physical parameters and transmit them wirelessly out of the coverage range of the measurement. This is a potential area of interest for the scientific community, reinforcing some beliefs about the necessity for further research initiatives in a new wireless-network paradigm. In this context, the low-power wide-area network (LPWAN) is a recent WSN-based technology that emerged as an alternative wireless monitoring solution. Different applications and contributions can be found, mainly focused on the industrial environment. In particular, this technology is currently drawing much attention for managing assets over wide areas, such as the monitoring and control of PV power plants and the operation of distributed energy systems. The main characteristics are its excellent long-range, low-power consumption and reduced computation capacity (like a long-range WSN). In fact, the operation of a distributed energy system usually requires flexible and reliable communication systems. However, cable-based communications are, in many cases, an infeasible solution due to their complex installation and maintenance. In distributed energy systems with high penetration of renewable and small generation units connected at different voltage levels, this wireless technology can help to overcome the lack of information in the performance and generation of these installations. LPWAN is a generic term that encompasses a group of technologies, allowing wide area communications at lower cost points and reduced power consumption.

LPWAN technologies have arisen in both licensed and unlicensed markets, such as LTE-M, Sigfox, long range (LoRa), and narrow band (NB)-IoT. Among them, LoRa and NB-IoT are the most prominent, though they clearly present technical differences. Presently, LoRa is an LPWAN approach receiving relevant consideration in the literature, because it can operate efficiently in unlicensed bands. Unlike LoRa, an NB-IoT network must be set up within an existing cellular network. This makes LoRa a more flexible solution than NB-IoT to meet the requirements of outlying districts. It is worth noting that LoRa is arguably the main actor in the current LPWAN scene, used in an unlicensed spectrum below 1 GHz and supported by many worldwide technology leaders (Cisco, Microchip, IBM, HP, etc.). From a technological point of view, LoRa provides a proprietary chirp spread spectrum (CSS) modulation to achieve communication distances greater than 700 km. What makes LoRa stand out from other modulation methods is its unique spread spectrum technique, which provides robustness against interference and a very low minimum signal-to-noise ratio (SNR) for the receiver to be able to demodulate the signal. LoRa is thus a suitable solution for applications that require a very long battery lifetime and reduced cost. Moreover, as it strengthens, LoRa allows tuning of several

physical transmission properties: the bandwidth and central frequency of the communication, the coding rate (CR, the ratio between the length of the packet and the length of the error-correction code), the transmission power, and the spreading factor (SF, defined as the ratio between the symbol rate and chip rate). Higher SF values enhance the sensitivity and range of communication at the expense of increasing the over-the-air time of the packets, thus consuming more transmission duty cycles (TDCs). In the past few years, the interest of monitoring smart industries has increasingly become LoRa as one technology solution demanded by many researchers. Most of the contributions have been focused on analysing the advantages, disadvantages, capabilities, and limits of current developments/deployments in several scenarios: industrial environments, civil infrastructures such as bridges and public transport, line-of-sight and obstructed communications, and surveillance tasks to combat poachers in wildlife reserves in Africa. In addition, LoRa performance has been compared to other LPWAN solutions such as Sigfox and Weightless, as well as licensed options such as NB-IoT. Other studies have dealt with the real scalability of current LoRa networks, the performance of their different configurations or the download traffic analysis of these types of networks. LoRa defines the physical level and LoRaWAN encompasses the link layer of the protocol stack and the system architecture.

LoRaWAN uses long-range star architecture in which gateways are used to relay messages between the end nodes and a central core network. In a LoRaWAN scenario, nodes are not associated with a specific gateway. Instead, data transmitted by a node are typically received by multiple gateways. Furthermore, LoRaWAN uses the adaptive data rate (ADR) algorithm to estimate the CR and SF parameters under specific channel conditions. Subsequently, each gateway forwards the received packet from the end node to the cloud-based network server via standard IP connections. In this paper a small unit is built to show the operation.

#### IV.METHODOLOGY

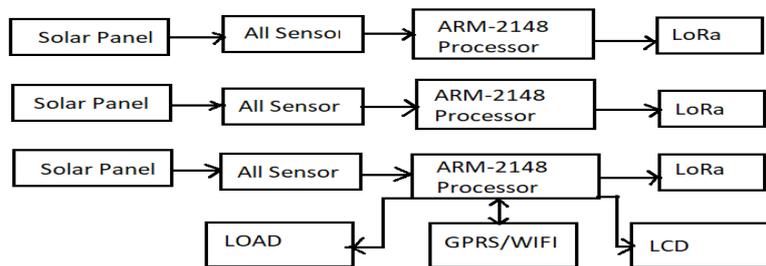


Fig.1: Transmitter Section

At transmitter side (Fig.1) we use three 12W solar panels which are connected to ARM LPC 2148. LM35 Temperature sensor is used to sense the surrounding temperature. Solar panel parameters are transmitted using RN2483 LoRa module which includes baseboard and antenna, which forms LoRaWAN communication. Temperature and Voltage of all three panels are displayed individually on 16x2 LCD screen. There is a 12V battery to store the voltage obtained and is then applied to load.



Fig.2: Receiver Section

At Receiver side (Fig.2) working condition of all three solar panels is displayed on 16x2 LCD screen. Temperature is displayed as (normal or abnormal), Solar Panel condition as (OK or NOK). We have nodeMCU, an open source IOT platform, consisting of wifi chip, for uploading result on an adafruit webpage continuously. User can view the working condition of entire system from anywhere in the world over the internet through this web portal RN2483( Low-Power Long Range LoRa Technology Transceiver Module) transceiver module features LoRa Technology RF modulation, which provides long range spread spectrum communication with high interference immunity.

Node MCU WIFI (Esp8266) Module: The Node MCU is an open-source firmware and development kit that helps to Prototype r IOT product.

**Node.js style network API** Event-driven API for network applications, which facilitates developers writing code running on a 5mm\*5mm sized MCU in Node.js style. Greatly speed up your IOT application developing process.

**Specification:**The Development Kit based on ESP8266, integrates GPIO, PWM, IIC, 1-Wire and ADC all in one board. Power your development in the fastest way combination with Node MCU Firmware.

**web server:**MQTT is a great protocol. It's extremely simple, and lightweight. Connecting to a server only takes about 80 bytes. We stay connected the entire time, every data 'publication' (push data from device to server) and data 'subscription' (push data from server to device) is about 20 bytes. MQTT can run on top of any kind of network, whether it is a mesh network, TCP/IP, Bluetooth, etc.

**adafruit io:**This is the web front end used to create and view dashboards of widgets (called blocks), as well as to illustrate data gathered from rigs and passed to the Adafruit cloud servers via the MQTT protocol.

**MQTT:**This is a low-bandwidth protocol for passing data back and forth between a server and hardware rig.

**MQTT library:**This additional code is needed to drive MQTT communication. Upon adding this library to your sketch, you can use abstractions of the code for additional functionality.

adafruit.io free beta account+aiio key: The code is only half the solution. This will help us to detect data and push the data to the cloud. With the account, we can connect to the cloud and create dashboards, which will receive our data as feeds. The key authenticates us.

### V. EXPERIMENTAL RESULTS



Fig.3.a: Transmitting View

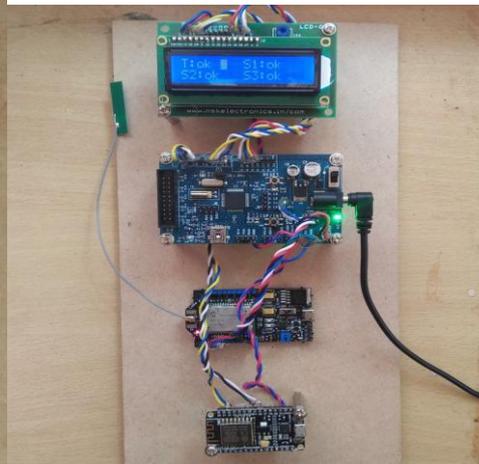


Fig.4.a: Receiving View



Fig.3.b: Transmitter side LCD display



Fig.4.b: Receiver side LCD display

The Transmitter view in Fig: 3.a and Receiver view in Fig: 4.a is as shown above. The Voltage value of all three solar panels and surrounding temperature is displayed on LCD screen. When all three solar panels are in proper working

condition and when the temperature is normal then the result is displayed on LCD screen as in above Fig: 3.b, i.e. Ok. When any one of the solar panels is not in working condition then the result is displayed on LCD screen as in the above Fig: 4.b. Here solar panel S1 is not in working condition so it is displayed as NOK (not ok).

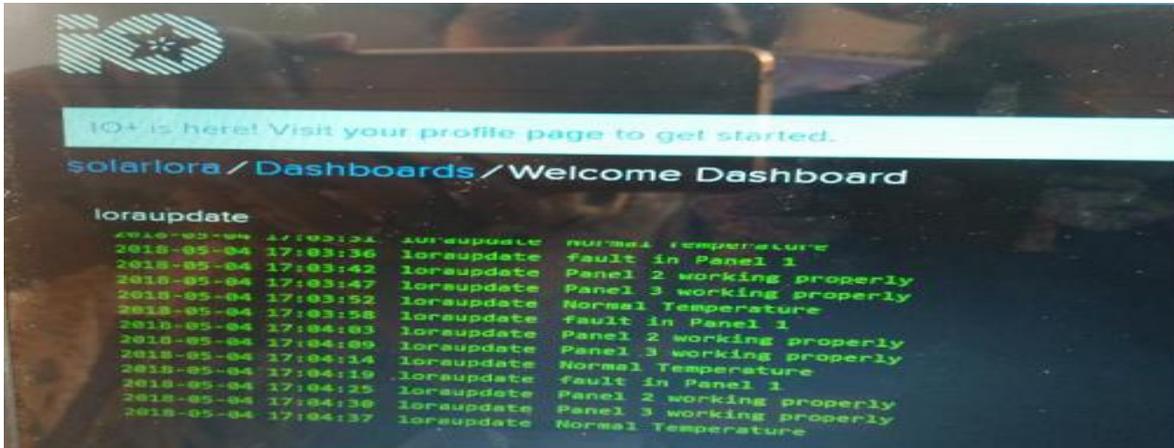


Fig.5: Loraupdate on adafruit io web portal

Temperature and all three panels working condition is updated on a adafruit io web portal continuously as shown in Fig.5, Here we have shown for three solar panels, this can be implemented for n number of solar panels on large scale for maximum amount of power output.

## VI. CONCLUSION

The paper highlights the various benefits of LoRa network based solar panel power monitoring system. Earlier solar panel power monitoring projects were using arduino, NI(Texas), GPS. When compared with other projects, This paper aims at transmitting the power to large distances detecting the faulty panel easily and reducing cost.

Using LoRa Technology modulation technique, RN2483 can achieve receiver sensitivity. LoRa Technology modulation also provides significant advantages in both blocking and selectivity compared to the conventional modulation techniques, solving the traditional design compromise between extended range, interference immunity, and low-power consumption. The RN2483 module delivers exceptional phase noise, selectivity, receiver linearity, and IIP3 for significantly lower power consumption.

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