IMPLEMENTING SELF-SUSTAINABLE WIRELESS SENSOR NETWORK USING PV PANEL.

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***Abstract*——Environmental monitoring is an important part of environmental protection and is also the most important source of information. Using a solar panel, a self -sustainable wireless sensor network is implemented for environmental monitoring. A system is developed for cloud based remote environment monitoring using LoRa Technology. WSN node senses the temperature and humidity and transmits data to the IoT cloud. The user can view measured data from any location via the internet by utilizing the web application, which is also available for mobile devices.**

Keywords—WSN, LoRa, Environment monitoring, IoT cloud

I. INTRODUCTION

Environmental issues such as climate change have received much attention in recent years, and environmental monitoring, modeling, and management enable us to gain a deeper understanding of natural environmental processes. Environmental monitoring is a broad area focusing on using scientific and engineering principles to improve environmental conditions.A WSN can be described as a network of sensor nodes that detects the environmental parameters and transmits the data wirelessly.WSNs are a critical component of the Internet of Things (IoT) and are essential for enabling smart cities, industrial automation, environmental monitoring, and healthcare applications. The nodes in a WSN communicate wirelessly with each other and with a base station, which serves as a gateway to the wider network.WSN technology is currently a crucial component of every developing nation because it is employed as the main monitoring system in a variety of applications. Data measurement and monitoring are significantly simplified and made more cost-effective by WSN, which also eliminates the risks associated with wiring systems.

The design and implementation of a WSN requires careful consideration of several factors such as the size of the network, the type of sensors used, the communication protocols, the power consumption, and the data processing and analysis methods. In addition, WSNs face numerous challenges such as limited power, limited bandwidth, communication interference, and security threats.

One of the most important components of a WSN is the sensor node. Sensor nodes in the network are transmitters, the hardware of the sensor nodes in this paper includes the following parts: solar panel,boost converter with lithium-ion batteries, micro-controller NodeMCU including wifi module ESP32 and the sensor DHT11. After the creation of sensor nodes and the uploading of the code on the development board, voltage from the solar panel is boosted using the converter and is used to charge the battery, sensor nodes collects the data and transmits it through LoRa module which is then received in the receiver side and temperature and humidity uploaded and displayed in the Arduino IoT cloud .

A.Wireless Sensor Network Topology

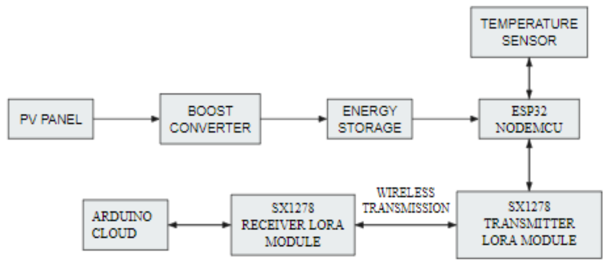
Different types of WSN exist based on their scale and application.These are point-to-point,star and mesh.
Mesh wireless sensor networks (WSNs) are a type of WSN in which each node can communicate with multiple other nodes in the network, creating a mesh-like structure. The nodes in a mesh WSN can act as both transmitters and receivers, allowing for multiple communication paths between nodes.
A star wireless sensor network (WSN) is a type of WSN in which all the nodes communicate with a central coordinator or base station, forming a star-like structure. In a star WSN, each node sends its data to the base station, which then processes the data or sends it further to other nodes in the network. This type of network topology is simple and easy to implement, and it requires less power and communication overhead compared to mesh WSNs.
Point-to-point wireless sensor networks (WSNs) are a type of WSN in which two nodes communicate directly with each other without the need for a central coordinator or base station. This type of network is also known as a peer-to-peer network. In a point-to-point WSN, one node acts as a transmitter and the other node acts as a receiver. The transmitter node sends data to the receiver node, which then processes the data or sends it further to other nodes in the network.
In this paper point-to-point topology is utilized as there is only a single sensor node is deployed. Point-to-point WSNs typically require less power than other types of WSNs because they do not require the additional overhead of routing and maintaining multiple paths between nodes. This enables it to integrate into other wireless nodes. Because of their simple implementation and low power requirements, point-to-point WSNs can be less expensive to deploy than other types of WSNs.

C. Method of Implementation

To implement a self-sustainable Wireless Sensor Network, a photovoltaic (PV) panel is used to power the wireless sensor network.This solution enables the continuous operation of the WSN while utilizing renewable energy from the sun.The PV panel collects solar energy and converts it into electrical energy. However, the output voltage of the PV panel may not be sufficient to power the sensor nodes directly. Therefore, a boost converter is used to increase the voltage to the required level. The boost converter steps up the voltage to a higher level and regulates the output voltage to ensure that it remains stable.The output voltage from the boost converter is then stored in a rechargeable battery. The battery acts as an energy storage system and provides power to the sensor nodes when the solar energy is not available or insufficient. The battery can be recharged during daylight hours when the PV panel is generating energy.

In summary, using a PV panel, boost converter, and rechargeable battery can enable the continuous operation of a WSN while utilizing renewable energy from the sun. This solution is sustainable, cost-effective, and reduces the maintenance cost associated with battery replacements.

III. BLOCK DIAGRAM.



Block diagram illustrates the basic idea about the objective of the paper. A self sustaining wireless sensor network is implemented which is powered using a PV panel. A boost converter is employed to attain the necessary voltage from the PV panel which is then stored in a Li-ion Battery which powers ESP32 and LoRa transmitter module and transmits the sensor data (DHT11) to the receiver side.
The receiver side has both ESP32 and LoRa module which in turn projects the data received to an Arduino cloud.

IV. BOOST CONVERTER DESIGN

To power the WSN, a PV panel of 3V, 250mA is used which is then increased to 4V using a boost converter and stored in a Li-ion battery.

A. Boost converter design

1.Duty Ratio $= 1 - \frac{V_{in}}{V_{out}} = 0.25$ (1)

2.Ripple current is taken as 30% of load current.

a.Load current = 0.33A

b.Ripple current = $0.33\times 0.3 = 0.09A$

3.Induction Selection

$$L = \frac{V_{in}\times D}{f_s\times \Delta I_l} = 0.378\text{mH} \approx 0.5\text{mH} \quad (2)$$

4.Voltage Ripple is taken to be 1% of output voltage

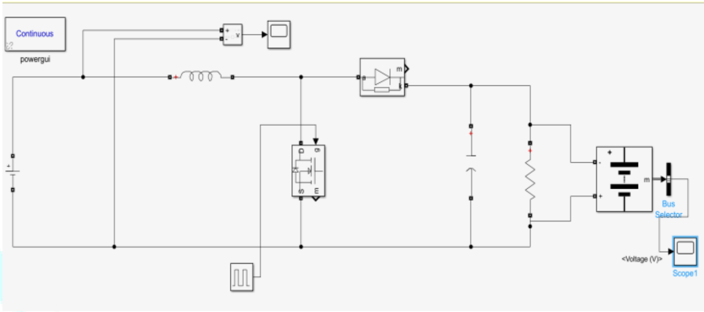
a.Output voltage = 4V

b.Voltage ripple = 4× 0.01 = 0.04V

5.Output capacitor

$$C = \frac{I_{o(MAX)}\times D}{f_s\times \Delta V} \approx 100\mu F \quad (3)$$

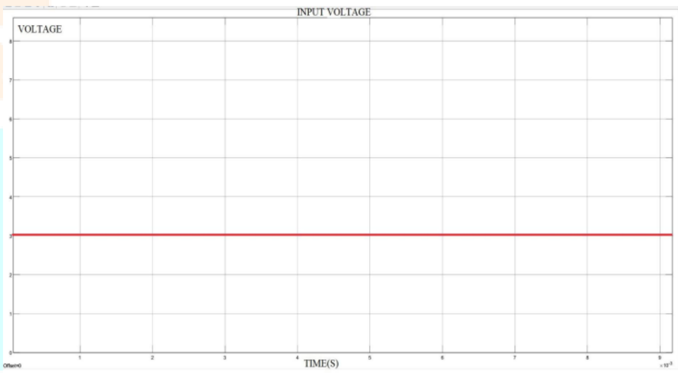
A. Boost Converter Simulation



MATLAB/Simulink is software used, 3V open circuit voltage from the PV panel is the input given to the boost converter circuit,4V is the output obtained from the battery output.

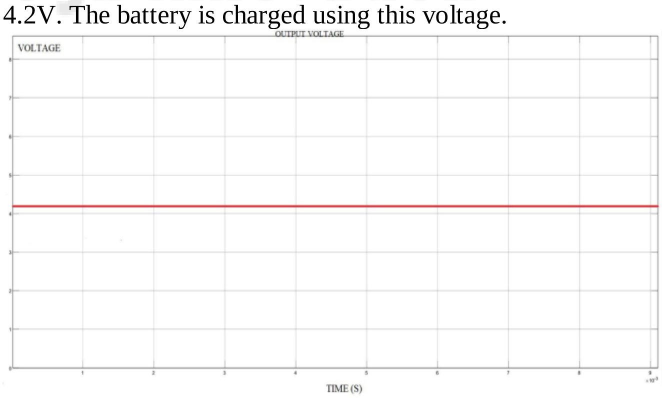
C.Simulation result

In simulation, the input voltage observed was around 3V. This voltage is given as the input to the boost converter.



Input Voltage v/s Time

Output voltage from the boost converter is observed upto 4.2V. The battery is charged using this voltage.



Output Voltage v/s Time

IV. HARDWARE

A.BOOST CONVERTER SCHEMATICS

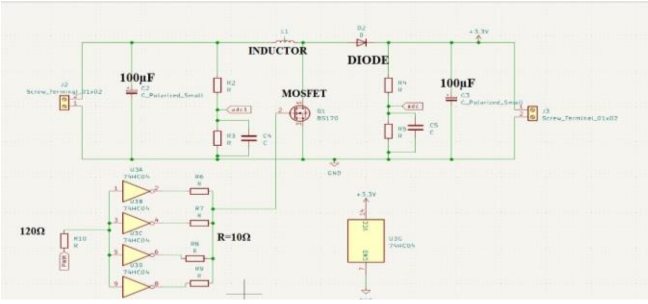
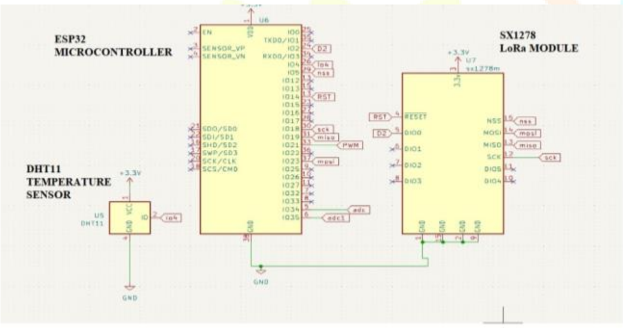


Figure consists of the boost converter circuit. Solar panel is connected to terminal 1 and the battery is connected in terminal 2. Gate signal is given from the microcontroller to the MOSFET.

B.TRANSMITTER CIRCUIT



Consists of the transmitting circuit in the WSN.
It includes a DHT 11 sensor, ESP32 microcontroller and SX1278 LoRa module. Temperature and humidity values are obtained from the DHT 11 sensor. The data is transmitted wirelessly using the LoRa module.

C.RECEIVER CIRCUIT

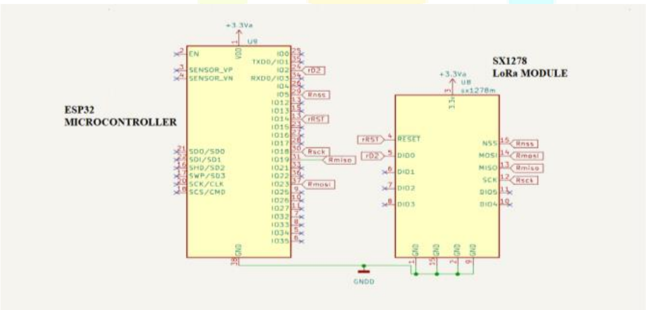
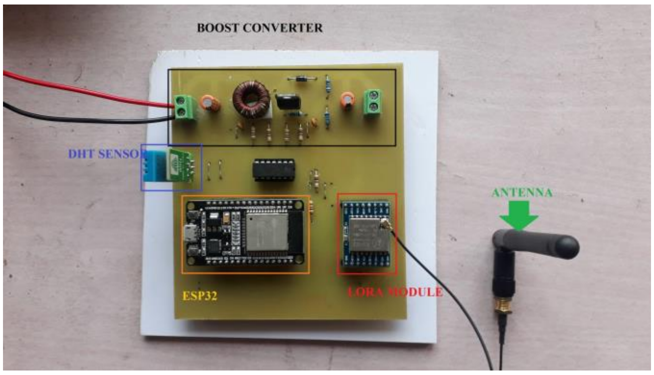
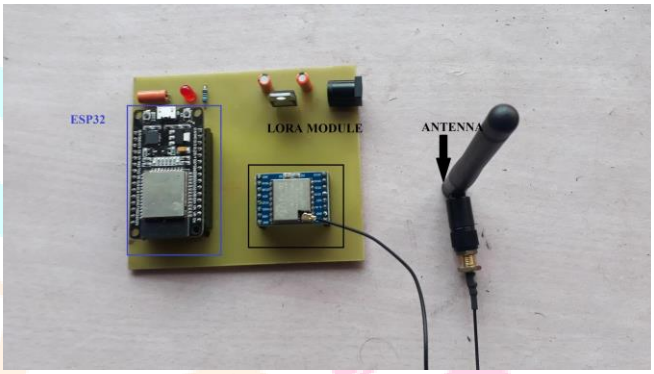


Figure consists of the receiving circuit in the WSN.
It includes ESP32 microcontroller and SX1278 LoRa module. Temperature and humidity values transmitted are received at an antenna connected to the LoRa module. The data is then uploaded to the IoT cloud using ESP32.

B. HARDWARE SETUP



Transmitter Circuit

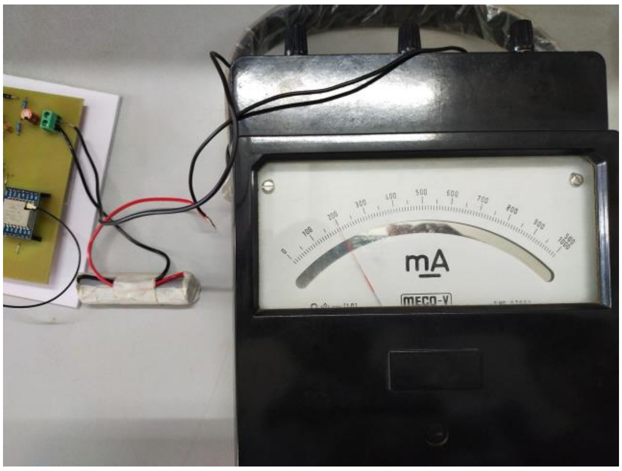


Receiver Circuit

E.HARDWARE RESULT

Input Voltage to the Boost converter = 3.12V
Output Voltage from the Boost converter = 4.16V

The battery connected to the boost converter takes around 0.1A current for charging.



V. CONCLUSION

This paper introduces a self-sustainable environmental monitoring system using PV panel, which can be installed in remote locations and environmental parameters can be observed. The implementation of an environmental monitoring system is crucial for ensuring the sustainability of our planet. This system provides a means of measuring and tracking key environmental indicators, such as climate conditions. Furthermore, an environmental monitoring system provides valuable data that can be used to inform policy decisions and ensure that our actions are aligned with the goal of environmental sustainability. The benefits of an environmental monitoring system are far-reaching and can positively impact not only the natural environment but also human health and wellbeing. The provides temperature and humidity values continuously which is observed by the user in computer or mobile phones.

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