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# Solar powered IOT Based Remote Patient Monitoring System to Measure Vital Body Signs

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***Abstract*— The IoT patient health monitoring system powered by solar panels is an innovative idea that uses the Internet of Things (IoT) and renewable energy to electronically monitor patient health. The system is comprised of various sensors that are coupled to an ESP8266 microcontroller, which sends the collected data to a central server (Thing Speak) via a Wi-Fi module. The computer processes and analyses the data, and healthcare practitioners can access the patient's health information via an online dashboard or mobile app. The usage of solar panels as a power source is unique to this project. The system is ecologically benign and self-sufficient because it is not connected to the mains. The system's solar panels make it ideal for deployment in rural areas where power is in short supply. It will help people become more aware of their health situation and take proper action.**

***Keywords*— Renewable, Thing Speak, Self-sufficient, Remote, conscious, Solar-panel.**

## I. Introduction

Changes in physiological indicators in the human body, such as heart rate, oxygen saturation, body temperature, and blood pressure, are frequently linked to diseases. The diagnosis of these diseases includes performing several hospital tests to discover differences in physiological function measures from normal rates and then determining the presence or absence of such problems. Several attempts have been made, using current advancements in IoT and wireless sensor networks, to deliver patient data remotely without requiring patients to attend the hospital [1]. This allows doctors/specialists to determine the best course of action or to summon specialized medical aid. The transmission of critical medical data in an emergency can have a significant impact on the patient's life [2]. This approach has been designed to solve problems for patients so that patients and those who care for them can be aware of their health status and effectively treat them. There has been a lot of effort put into this. Recent improvements are included in the literature on health monitoring systems.

These breakthroughs span a wide range of technological and functional domains. Mobi Health and Mobi Care systems, for example, convey vital signs to healthcare institutions via mobile cellular networks (GPRS and UMTS). Gupta et al. monitored the patient's vital signs using IoT and a microcontroller. They only looked at the ECG signal from one direction [3]. A Raspberry Pi was used to collect data from wearable sensors, which was then delivered to a MySQL database. The authors also used the GSM cellular network to send emergency alert messages to hospitals. The authors used IoT and cloud computing to create an ECG smartphone app. A microcontroller board was used to record ECG data from a patient and wirelessly send it through Bluetooth to a mobile device. The authors detected numerous vital indications (ECG, body temperature, patient location) using an IoT sensor module [4]. This module can send measurements to the cloud and is linked to a local website through COM for local monitoring. However, these systems were inefficient. Our proposed technology is relatively inexpensive, user-friendly, and allows for speedier data transmission. To display data, a web server will be used (Fig.1). It will benefit both rural patients and the health-related commercial industries [5].


Fig. 1. IoT based Patient Health Monitoring System

Reliable power is a major issue for IoT-based health monitoring devices. These devices can be powered by solar panels, which create electricity from sunshine. It will display the two sensors' data on the LCD. Between 2019 and 2023, several journals published on this topic. In 2021, Sensors released an article about a solar-powered IoT-based geriatric patient health monitoring device [6].

The system included sensors to monitor heart rate, blood pressure, and other vital signs, as well as a solar-powered gateway to send data to healthcare specialists. The data is collected from the patient's body by one temperature sensor and one pulse sensor. It will transmit data to the Arduino UNO, but it will not send data to the server. To transfer data, NodeMCU is used. Data will be refreshed every 15 seconds. This system is advantageous to more than just the sufferer [7]. It will allow doctors to simply monitor their patients, eliminating the need for them to visit each patient and spend a significant amount of time checking them. They will save time by using this website. This approach also maintains security because not everyone has access to patients' data.

## II. Proposed System Topology

The suggested solar-powered IoT-based health monitoring system monitors the health of solar panels using Internet of Things (IoT) technology. As illustrated in Fig. 2, the system uses multiple sensors to collect data from the solar panels and transfers it to a big server over the internet. The data is then controlled and analyzed to ensure the solar panels' health.

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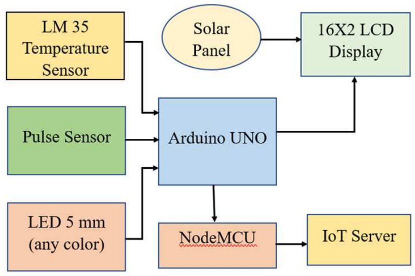


Fig. 2. Block diagram of the Proposed System

It is made up of coloured sensor that detect heartbeat, temperature, and humidity. These sensors are properly interfaced with the microcontrollers, which are designed to pick up the various parameters intended to measure from the casing and send the obtained results for interpretation and analysis. The suggested system is made up of two major regulators: the Arduino UNO and the ESP8266-01 Wi-Fi Module. The ESP8266-01 Wi-Fi Node MCU with Pulse Sensor is directly connected to the LM35 Temperature Sensor temperature and humidity detector [8]. Because temperature and humidity conditions rarely endanger patients' lives in hospitals, and because the LM35 Temperature Sensor isn't directly connected to the patient for data collection, it's best to use the ESP8266-01 Wi-Fi Module, which allows the doctor to monitor the temperature of the patient's body from anywhere if his phone is connected to the Internet. The ESP8266-01 Wi-Fi Module Node MCU has some impressive features, which we shall discuss further in the following chapters. The IoT technology is used to send the message to the doctor from the outside world via a cloud server. Data will also be shown on a 16x2 LCD display. This is how the system can be used in a professional setting. This type of system is built using only a few algorithms. In our project, we can employ the AES Algorithm. Hierarchical Clustering, Decision Tree Classifier, and Blowfish Algorithm are some other algorithms [9].

Artificial Neural Networks (ANNs) can be used to forecast solar power. ANNs can analyze historical data to learn how different elements such as cloud cover, humidity, temperature, and wind speed affect the output of solar panels. ANNs can anticipate future energy generation from solar panels by using these insights [10]. This data can be used to manage the delivery of electricity to various devices and to monitor the health of solar panels. Forest at Random: The Random Forest algorithm can detect faults in solar panels. This technique can use a variety of input characteristics such as voltage, current, temperature, and other data to determine whether or not a solar panel is operating normally. By analyzing data from various sensors such as temperature and humidity sensors, this system can also pinpoint the root cause of the failure. K-Means Clustering is an unsupervised learning process that can be used to categorize data based on similarities. This algorithm can be used to group solar panels depending on their performance in the context of a solar power IoT-based health monitoring system project. It is feasible to detect common problems impacting the panels by recognizing groups of panels with comparable output. This can assist enhance solar panel efficiency by detecting problems before they cause substantial damage.

## III. Proposed System Design and Simulation

As shown in Fig. 3, virtual circuit design is one of the finest techniques to evaluate a design before designing it physically. By simulating, we learn about the output and what kind of output to expect, and it displays waves to help us grasp the result better. To begin, we selected Microcontroller from the component bar. The microcontroller is in charge of managing the system and analysing sensor data. The pulse sensor is used to determine the patient's heart rate. VCC, GND, and SIG are the three pins of the pulse sensor module. The VCC pin is connected to the +5V power supply, the GND pin is connected to the ground, and the SIG pin is connected to the microcontroller's analogue input pin A0. The LM35 temperature sensor is used to measure the patient's body temperature [11]. The LM35 temperature sensor is a precision integrated circuit temperature sensor with three pins: VCC, GND, and OUT. The VCC pin is connected to the +5V power supply, the GND pin is connected to the ground, and the OUT pin is connected to the microcontroller's analogue input port A1.

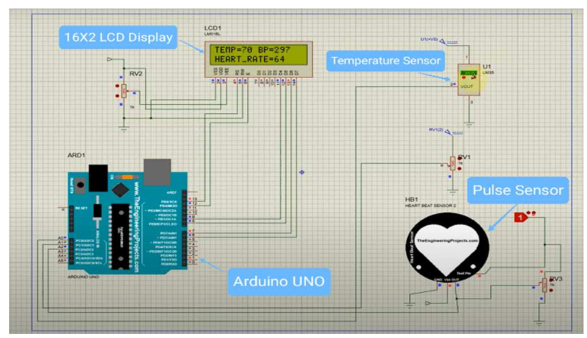


Fig. 3. Circuit Diagram of Proposed System (Proteus)

A 16x2 LCD display is used to display the BPM and body temperature of the patient. The LCD display has 16 pins, which are connected with the Arduino as Table I.

TABLE I. Pins and its Connections Specification of the LCD

| ***Pin Numbers*** | ***Specifications*** |
|---|---|
| Pin 1 (VSS) | Connected to ground. |
| Pin 2 (VDD) | Connected to +5V power supply. |
| Pin 3 (VEE) | Connected to a variable resistor to adjust the contrast of the display. |
| Pin 4 (RS) | Connected to pin 13 of the Arduino. |
| Pin 5 (RW) | Connected to ground. |
| Pin 6 (E) | Connected to 12 no. pin of Arduino. |
| Pins 7-10 (DB0-DB3) | Not used and left unconnected. |
| Pins 11-14 (DB4-DB7) | Connected to pin 9 to 6 of Arduino. |
| Pin 15 (LED+) | Connected to +5V power supply through a resistor. |
| Pin 16 (LED-) | Connected to ground. |

We have used multiple components to design this circuit. In our case, we have seen the data on LCD Display in Proteus. The temperature was all right and it's realistic, but the BPM was quite high than possible [12]. There was no form of wave. Some equations are used in different Health Monitoring Systems which are given below:

*Heart Rate: The equation is HR = 60 / RR interval* (1)

where the RR interval is the time between two consecutive R waves in an ECG waveform.

*Blood Pressure: BP = CO x SVR* (2)

where CO is cardiac output and SVR is systemic vascular resistance.

$$\textit{Oxygen Saturation: } SpO2 = (SaO2 / P50) \times 100 \tag{3}$$

where SaO2 is the arterial oxygen saturation and P50 is the partial pressure of oxygen at which hemoglobin is 50% saturated.

$$\textit{Respiratory Equation: } RR = 60 / (T2 - T1) \tag{4}$$

where T2 is the time of the second breath and T1 is the time of the first breath.

$$\textit{Glucose Monitoring Equation: } G = (S - 3.5) / 0.175 \tag{5}$$

where S is the signal output from a glucose monitoring device.

Solar power calculation: The solar power generated by a photovoltaic (PV) panel can be calculated using the following equation:

$$P = V \times I \tag{6}$$

Solar Panel Energy Equation: the energy generated by a solar panel can be calculated as:

$$E = A \times \eta \times G \times V \times t \tag{7}$$

## IV. HARDWARE DEVELOPMENT AND TESTING

After successful design and simulation by using Proteus Design Suite, the hardware of sensing and monitoring site was developed (Fig. 4). Our Solar powered IoT-based remote patient monitoring system is an innovative solution that enables healthcare providers to remotely monitor the vital signs of patients from anywhere in the world. By leveraging the power of IoT, our system can capture and transmit important patient data in real time.

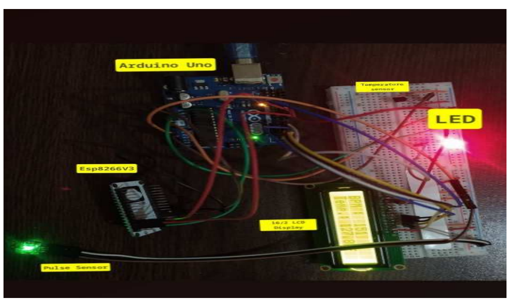


Fig. 4. Fully integrated IoT Based Health Monitoring System

The system includes a breadboard, connecting wires, an ESP8266-01 Wi-Fi Module, an Arduino UNO Board, an LED (5mm any color), a pulse sensor, an LM35 temperature sensor, a 16x2 LCD Display, resistors (1k ohm), a solar panel with charger. The patient's heart rate and body temperature are each measured using the LM35 Temperature Sensor and Pulse Sensor, respectively.

TABLE II. SPECIFICATIONS OF THE SYSTEM COMPONENTS

| *Components* | *Quantity* | *Functionality* |
|---|---|---|
| ESP8266-01 Wi-Fi Module | 1 | Enables communication with the internet via Wi-Fi. |
| Arduino UNO Board | 1 | Microcontroller board that controls the system |
| Pulse Sensor | 1 | Measure pulse rate and heart rate variability |
| LM35 Temperature Sensor | 1 | Measure body temperature |
| 16x2 LCD Display | 1 | Displays vital signs and system status. |
| Solar Panel with Charger | 1 | Provides power to the system and charges the battery |

The data is then wirelessly transmitted to the cloud for archival and review. Table II lists the specifications of the system's primary components.

The ESP8266-01 Wi-Fi Module connects our system to the internet, allowing us to communicate vital signs data obtained by the pulse and temperature sensors to a remote server. It accomplishes this by wirelessly interacting with a Wi-Fi network and transmitting data packets to a specific IP address. The Arduino UNO Board serves as the system's central processing unit. It takes input from the pulse and temperature sensors and performs calculations to turn raw data into usable numbers. It also manages the LED and LCD displays by providing output signals to them. The LED (5mm, any color) is a simple visual indicator that shows whether the system is on or off. The Arduino UNO Board controls it, sending a signal to the LED to turn it on or off dependent on the system's status.

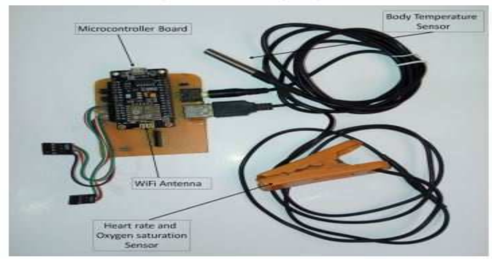


Fig. 5. Sensors used in the proposed Patient Health Monitoring System

The Pulse Sensor is used to assess a patient's pulse rate (Fig. 5). It accomplishes this by sensing the heart's pulse wave and converts it into a digital signal that the Arduino UNO Board can read. The LM35 Temperature Sensor is used to determine the body temperature of the patient. It accomplishes this by measuring the ambient temperature in the environment and converts it into a digital signal that the Arduino UNO Board can read. The 16x2 LCD Display is used to display vital signs data in an easy-to-understand format. The Arduino UNO controls it, sending output signals to the display to display the required data.

## V. EXPERIMENTAL RESULT ANALYSIS OF THE SYSTEM

The setup is installed shown in Fig. 6 and is connected to the Battery to be independently working. The performance was measured through experimentations and validated.

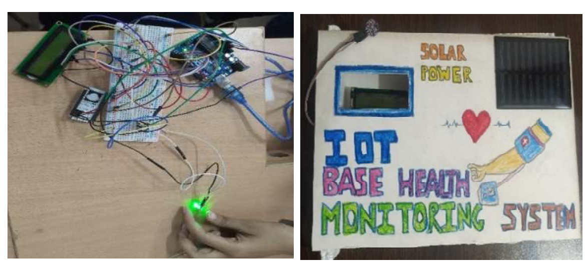


Fig. 6. Implemented Circuit of the proposed System

The experiment outcome includes a thorough report on the experiment's findings. The monitoring system can collect and analyze enormous volumes of data, giving healthcare providers insights into patient trends and allowing them to make informed patient care decisions. Overall, a solar-powered IoT-based remote patient monitoring system can assist improve patient outcomes, lower healthcare costs, increase reliability and data security, and improve the quality of treatment for patients with chronic illnesses or who require continuous monitoring.

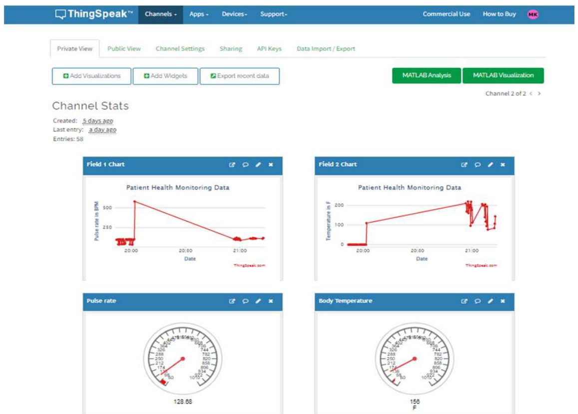


Fig. 7. System pushed Sensor data to “ThingSpeak” Server

### A. *Continuous monitoring of vital signs*

The system can continuously monitor vital signs such as heart rate, blood pressure, temperature, and oxygen saturation levels, providing real-time data to healthcare providers. Fig. 7 shows the continuous data monitored by ThingSpeak.

### B. *Remote monitoring*

The system can enable remote monitoring of patients, allowing healthcare providers to keep track of patients' vital signs and health status without the need for frequent in-person visits (Fig.8).

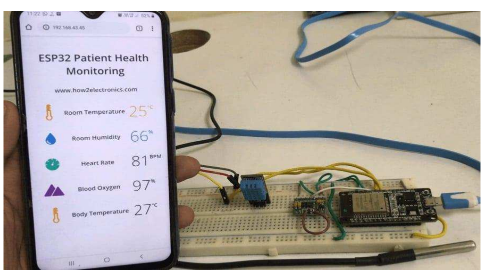


Fig. 8. Vital Body Signs in IoT (body temperature, heart rate, the ambience)

### C. *Improved patient outcomes*

Continuous monitoring can help detect subtle changes in a patient's condition, enabling healthcare providers to take proactive measures to prevent complications and improve patient outcomes.

### D. *Lower healthcare costs*

Remote monitoring can reduce the need for hospitalization or frequent visits to healthcare providers, potentially lowering healthcare costs for patients and healthcare providers.

### E. *Renewable energy source*

The use of solar power as a renewable energy source can help reduce the environmental impact of the monitoring system and ensure uninterrupted monitoring even in areas with unreliable electricity supply.

## VI. Conclusion

This paper describes an IoT-based health monitoring system. We monitor patient health via temperature and heartbeat sensing. IOT-based patient health tracking saves lives by monitoring patient health numbers online. The upgraded IoT patient health monitoring system monitors patient health remotely over the internet utilising sensors and microcontroller circuit. Daily monitoring, recording, and database storage make the suggested patient health monitoring system useful in emergencies. This paper describes an IoT-based health monitoring system. This IoT device lets users track their health statistics, which may help them stay healthy. If needed, sufferers could seek medical attention. Due to technical and software issues, the IOT device can be integrated with cloud computing to share the database among hospitals for intense care and treatment. The goal is affordability for average people. Patients will have access to individualised healthcare and financial sustainability. This study describes an IoT-based solution that simplifies medical device use at home at a low cost. Additional sensors can measure numerous health metrics and improve the system's sensors. New algorithms can be integrated for system security.

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