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Solar Energy Monitoring and Controlling using BLYNK

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ABSTRACT: In the world of automation, we need everything to be done automatically to reduce the work and to save the time. So the project aims at automation, monitoring, and wireless controlling of home appliances that are operated by solar power, a renewable energy resource. In this project we are using sensors like PIR sensors, LDR sensors, and voltage sensors for monitoring the photovoltaic (PV) panel and also the environmental conditions. The use of a PIR sensor here is to detect the movement (motion) of the moving object, by which we can automate the home applications like switching off and switching on lights, fans, air conditioners, etc. The LDR sensor is used to maintain the solar panel efficiency by monitoring the intensity of light. The BLYNK app is used for analyzing the data in a graphical format and to control the appliance remotely through the mobile phones. The mode of communication that takes place between the microcontroller and the IoT platform (BLYNK app) is Wi-Fi. The use of photovoltaic (PV) panels here is to generate electricity by the electron's excitation due to sunlight. The energy gets stored in a battery like a lithium-ion battery.

KEYWORDS: ESP8266, SOLAR MONITORING, LDR SENSOR, PIR SENSOR, TEMPERATURE SENSOR, BLYNK APP

I. INTRODUCTION

We know that the world we are living in is going to be fully automated in the future, so the automation of everything that we are using in our day-to-day life is necessary. We also know that there is only a limited amount of non-renewable energy available on the earth, so there is a need to change to renewable energy like solar. The project that we have proposed here is concentrating on both home automation and solar monitoring with the use of microcontrollers, sensors, and IoT platforms. The microcontroller we have chosen is the ESP8266, and that has a Wi-Fi module in it. Some specific sensors are used to monitor the environmental conditions for automation and monitoring the solar. The IoT platform used here is the BLYNK APP.

In the conventional method, we are using the grid electricity for home automation, which may increase the energy consumption as well as the electricity bill, so we are choosing solar energy for our project, which decreases the power bill, but manual monitoring of the solar panel is required. This disadvantage can be avoided by using voltage sensors, temperature sensors, and LDR sensors. The voltage sensor monitors the voltage that is generated due to the PV (solar) panel, and the temperature is monitored by the (DHT11) temperature sensor in that location. The solar power gets stored (saved) in the lithium-ion (rocking chair) battery for the devices with the use of a charge controller. Then the inverter, BMS module, and grid exchanger are used to convert the direct current from the lithium-ion (rocking chair) battery into an alternating current for all the devices in the home. The charge controller ensures that the proper charging of the swing (rocking chair) battery is done and there is no problem like overcharging of the swing (rocking chair) battery, which reduces the efficiency and lifespan of the battery.

In our project, we are using the LDR sensor for monitoring the light's intensity. When the intensity of sunlight is more than the place's brightness, there is no need to switch on the lights. If the light is glowing, it gets turned off automatically. When the intensity of the light is low, then it denotes it is nighttime. If any motion is detected, then the lights get turned on; otherwise, the light will be in the off condition. For detecting the (movement) motion of a moving object PIR sensor is useful. If any motion gets detected, then the light gets turned on automatically if the lights were in the off condition. We can also monitor it remotely through the BLYNK app.

The microcontroller we are using here is the ESP8266, as it has 17 GPIO pins. The sensors, like LDR, get interfaced with the help of GPIO pins. It has a 32-bit RISC processor and a Wi-Fi module that supports the IoT platform. It also supports SPI, I2C, I2S, and URAD types of communication. In this microcontroller, we have written a code that is going to connect the BLYNK IoT platform and monitor the home appliances based on the sensor reading value. For example, if the temperature ($^{\circ}\text{C}$) is very high, then the AC gets on automatically (if it is connected to the microcontroller and properly coded); otherwise, if the temperature ($^{\circ}\text{C}$) is very low, then the AC gets off automatically. The mode of communication or interaction between the microcontroller and the IoT platform (BLYNK app) is Wi-Fi. The relay used here is acting as a switch, which helps the ESP8266 to control the high-voltage appliance. Usually these relays are of 5 volts.

Here we are using the BLYNK app, as it is a free IoT platform. It allows us to analyse and store the sensor value from the microcontroller to the cloud platform for real-time monitoring. It allows us to monitor the solar panel and home appliances through the Android mobile phone that we are using nowadays. We can also virtualize data by using the graph generated by the BLYNK app's graphical web-based interface for sensor reading. It also provides widgets like buttons and sliders for an easy user interface.

II. LITERATURE SURVEY

Nazmul Hassan [et al.](#) [1] design a method that uses the Node MCU as the microcontroller, sensors like current sensors, temperature sensors, a battery charge controller, and a ThingSpeak IoT cloud platform for monitoring the solar panel. It was an alternate solution for maintaining the solar panel manually, which was a time-consuming job. This project has used the NodeMCU as the microcontroller. The LDR sensors and temperature sensors (DHT11) are connected to the ESP8266 microcontroller, and that is used to find the climate condition, like hot or cold. The charge controller module is also used here, which helps in protecting the battery from overcharge and helps in the efficient use of the battery. The voltage sensor monitors the voltage that is generated due to the PV (solar) panel. This project uses the ThingSpeak IoT platform for Analysing the data, such as the intensity of the sunlight, temperature in that location, and solar current generation in a graphical format by graphical user interface. It is one of the open-source, free IoT cloud platforms that use the internet for connecting a Wi-Fi to send data between the ESP8266 and the IoT cloud platform. It gives the graphical image based on the data through which we can analyse how much current is generated in the daytime and nighttime or for a particular month or for a particular season. It allows us real-time monitoring. If there is any fault in the solar panel, we can identify it easily. There is no need to monitor the solar panel manually. But this project does not concentrate on controlling the applications connected to the solar panel, but it monitors only the solar panel.

K.G. Srinivasan [et al.](#) [2] project uses ThingSpeak as the IoT platform. The sensors, like a voltage divider and current sensor, are used here for calculating the power usage. They are using Arduino and Raspberry Pi as the microcontrollers for updating the sensor value in the cloud and to calculate the power consumed by the house daily. The Arduino (microcontroller) is connected to the voltage divider and current sensor, through which the total power usage can be calculated. The data from the Arduino (microcontroller) is sent to the Raspberry Pi (microcontroller) with the use of a USB cable, as it acts as the central monitoring system. Flask is the lightweight framework used here by using the Python language. The HTTP protocol is used here for storing and retrieving data in the IoT platform ThingSpeak.

Arvind [Sakhare et al.](#) [3] proposed a design by using ATMEGA328 and ESP8266 as the microcontrollers due to their high functionality, familiarity, and simplicity. Here we are using the current and voltage sensor for calculating the power consumption, which is connected to the ATMEGA328. The ATMEGA328 is connected to the microcontroller ESP8266. ATMEGA328 data is processed by ESP8266 and gets stored in the cloud IoT platform (ThingSpeak) and displays the value through the LCD display. The fault can be easily detected by the inconsistency in the data of the solar panel.

Kabalci [et al.](#) [4] proposed a design used for all kinds of renewable energy sources. The output AC voltage of the wind turbine is converted to DC voltage by the rectifier for the battery. The renewable energy source parameters, like voltage (volts) and current (amps), are being monitored by developing the sensing circuit. The data of the sensing circuit is then passed to the 18F4450 microcontroller. Then the processed parameters are sent to the PC (personal computer) through the USB cable and get saved in the database. The software is coded with the help of Microsoft Visual Studio, which allows for daily, weekly, and monthly monitoring of the data-generated energy by the wind turbine or solar panel.

Jiju [et al.](#) [6] developed a model that is used for online monitoring and controlling the renewable energy resource with the help of the Android platform for Bluetooth interface, which acts as a communication (for information) link for exchanging the information data within the power unit's digital hardware.

Goto [et al.](#) [7] design uses web technology, such as information technology or communication technology, as the user interface for the remote monitoring of power plants. This system is very useful in maintaining more than 200,000 power plants, and it also includes the inverters, rectifiers, UPSs, and plants installed in about 8,000 buildings.

Nkoloma [et al.](#) [9] proposes a system for Malawi's power plant real-time energy monitoring and controlling of renewable energy plants like solar (PV). The objective of this system is to develop a data acquisition system. This system gives direct access to monitor and control electricity in real-time in rural areas through SMS over the cellular network.

Wang [et al.](#) [10] propose a design used for real-time monitoring, controlling, and data acquisition of a solar wind battery, a renewable energy system that integrates with a digital power meter and programmable logic controller, which acts as a switch that helps in controlling the output parameters, such as power and voltage, of two wind induction generators. This system transfers the real-time information (electric data) through the internet to a remote monitoring center. Real-time data acquisition, monitoring, and control of various renewable energy systems.

Soham Adhya [et al.](#) [11] proposed a cost-effective design for monitoring and performance evaluation of the massive scale of a solar plant remotely using a web-based interface. This helps in historic analysis of the solar plant, fault detection, and maintaining the solar plant.

III. PROPOSED SYSTEM

3.1 Solar panel

The solar panel plays an essential role as it generates the renewable energy for the home appliances, which are automated. We can use the solar panel ranging from 10W to 100W for generating the energy. It reduces the electricity bill by generating the electricity from the renewable resource (sunlight). It needs manual monitoring and periodic maintenance, which is the limitation of using the solar panel. To overcome this limitation, we are moving to the wireless monitoring of the solar panel (PV) with the use of a microcontroller (ESP8266) and the sensors (temperature sensors and voltage sensors). The energy for the solar panel (PV) gets stored in the rocking chair battery (lithium-ion battery), which is used for the home appliance like a light. An inverter and the grid exchange are used here, which convert the DC (direct current) current to AC (alternating current) current, as most of the household equipment uses the alternating current. A charge controller and BMS module are used here for protecting the lithium-ion battery from overcharging, which may damage the battery's efficiency.

3.2 BMS module

A BMS module is used here, which protects the battery from overcharging. If the battery reaches the maximum voltage level or threshold current level, it turns off charging of the battery. It ensures each cell in the battery pack gets charged and discharged equally. If it is not charging or discharging equally, it turns off charging or discharging the battery. It also monitors the battery's temperature and takes the action of cutting off the charging process. The battery is protected from damage due to heat generation, which causes fire or explosions.

3.3 BLYNK IoT platform for controlling appliances

Home automation was done with the help of the BLYNK IoT platform. It is an open-source, free IoT platform that provides a cloud-based dashboard. The value of temperature in degrees Celsius and the value of voltage in volts are calculated in the microcontroller and sent to the IoT platform (BLYNK app) through the Wi-Fi. The BLYNK app also allows us to remotely monitor the home appliance through the widgets available in it. The graphical interface or the web interface available in the Blynk app is used to visualize the data, like temperature in that location, as a graph, chart, or tabulation. This app allows us remote control of the appliances by using the slider and button widgets. It allows us home automation and also real-time monitoring of home appliances and the solar panel.

3.4 Sensors used to monitor the solar panel

The passive infrared sensor detects moving things. It utilizes infrared wavelengths, which are emitted as thermal energy in the form of electromagnetic radiation, to detect the movement of humans. It detects item motion based on changes in thermal energy. If motion is detected, the data is sent to the microcontroller, which determines whether the appliance connected to it is turned on or turned off based on the sensor reading data values. When motion is detected, the data value is saved in the BLYNK IoT platform cloud dashboard. The LDR sensor detects the brightness of sunlight. If the intensity of sunlight is high, the lights that are currently on are turned off automatically. The voltage sensor monitors the voltage that is generated due to the PV (solar) panel. The DHT11 (temperature sensor) is used to monitor the temperature (°C) in the area. These sensors eliminate the need for manual solar panel monitoring, and any changes in the recorded value signal a problem with the solar panel. The values derived from sensor readings are delivered to the BLYNK IoT platform's cloud dashboard. We can remotely operate the appliance using the widgets.

3.5 ESP8266 microcontroller

In this project we are using the ESP8266 microcontroller because of its adverse benefits in IoT projects. It has many features. It has an integrated built-in Wi-Fi capability. It supports interfaces like SPI, I2C, and UART. It is provided with a 32-bit RISC processor, and it has 17 GPIO pins. With the help of these pins, we can connect the sensors like the LDR sensor, PIR motion sensor, temperature sensor, and voltage sensor. It is also a 10-bit ADC (analog to digital converter). This microcontroller is cost-efficient and uses less power. This microcontroller's code makes use of libraries such as the ESP8266WiFi Library and the Blynk Library. The DHT11 is connected to the D7 (GPIO13) digital pin, the PIR motion sensor is connected to the D5 (GPIO14) digital pin, the voltage sensor is connected to the A1 analog pin, first relay is connected to the D6 (GPIO12) digital pin for remote control via the BLYNK, and second relay is connected to the D8 (GPIO15) digital pin for LDR-based light control.

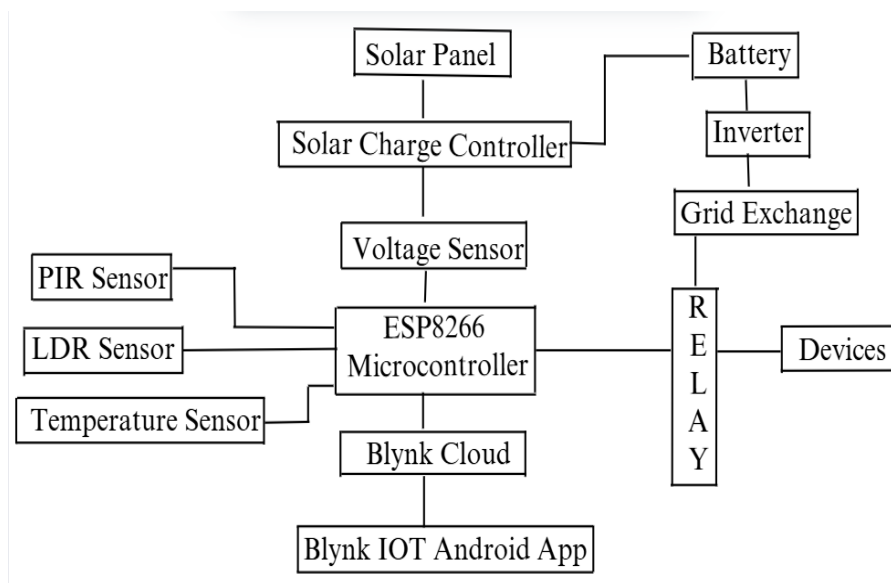


FIGURE 3.1: Block diagram of solar monitoring and controlling using Blynk

IV. Hardware Development

Here, first the solar panel (PV) is connected to the rocking chair (lithium-ion) battery through the charge controller. The battery is connected to the BMS module, which protects the battery from overcharging. If the battery reaches the maximum voltage level or threshold current level, it turns off charging of the battery. It ensures each cell in the battery pack gets charged and discharged equally. If it is not charging or discharging equally, it turns off charging or discharging the battery. It also monitors the battery's temperature and takes the action of cutting off the charging process. The battery is protected from damage due to heat generation, which causes fire or explosions. The BMS module protects the battery's efficiency and its lifetime.

Now the battery is connected through the relay, inverter, and the grid exchange to the devices so that the direct current is converted to alternating current, as most of the home appliances use the alternating current. Relays are used as a switch to turn on and turn off the appliances. In our project we are using three relays. One relay is used for remote monitoring of the light used here, a second relay is used for connecting the light with solar energy, and a third relay is used for connecting the light with normal grid electricity.

An inverter is used here to convert the direct current from the lithium-ion battery to alternating current, as most of the home appliances used in the household use the alternating current. For this inverter circuit, we are using the 12-0-12V, 2-amp transformer and IRFZ44N MOSFET.

The PIR sensor, LDR sensor, voltage sensor, and DHT11 (temperature sensor) are connected to the ESP8266 microcontroller. If any movement (motion) gets detected, then the PIR motion sensor sends the signal to the microcontroller. Based on the signal received from the sensor to the microcontroller, it turns on or turns off the light. The intensity of light in the location is found by the LDR sensor. The voltage sensor and DHT11 (temperature sensor) are connected to the microcontroller's analog pin, and with the help of the ADC, the signals from these sensors are converted to digital values. These sensor values are sent to the IoT platform (BLYNK app) through the Wi-Fi and get displayed in the app. The button widget, which is used in the BLYNK app, is used to control the appliances that are connected to it. Thus, the remote controlling of the appliance is possible.

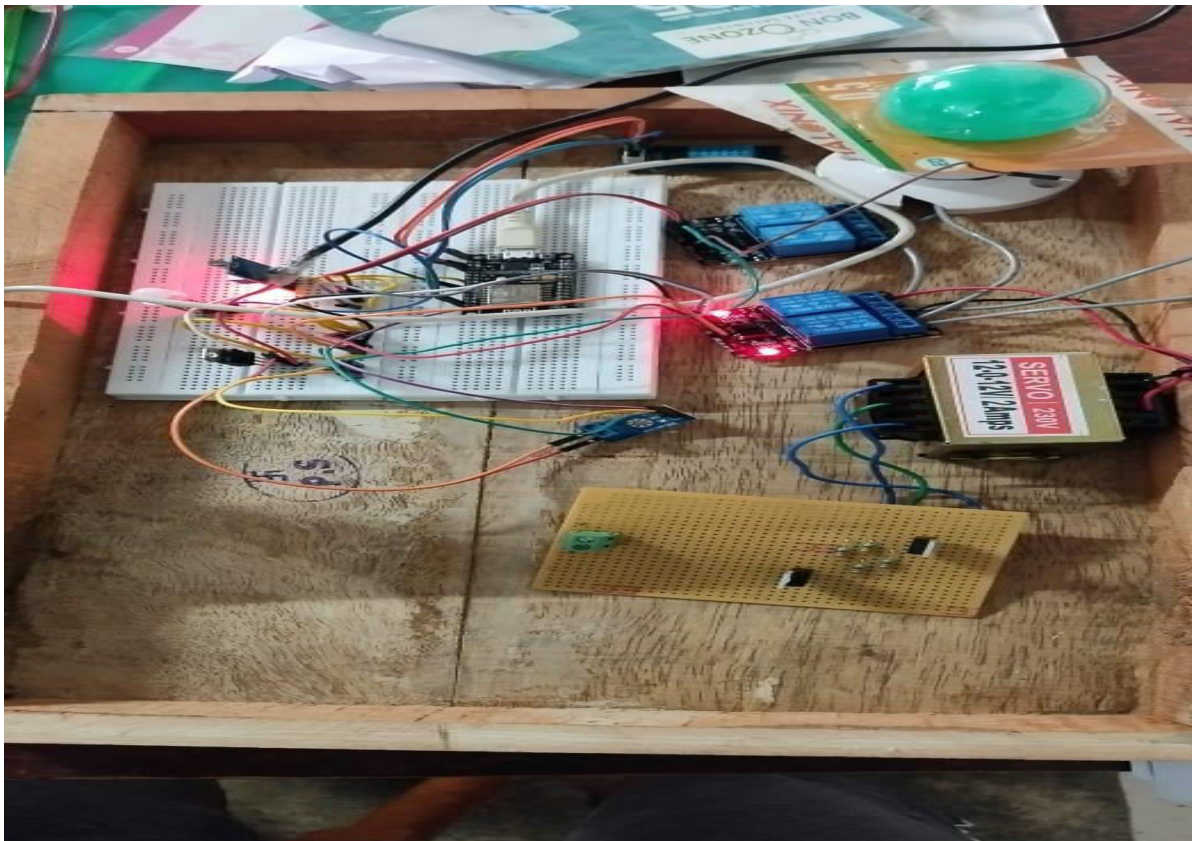


FIGURE 4.1 Hardware circuit of the proposed system

V. RESULT AND DISCUSSION

The proposed system works properly, which monitors the solar panel and automates the home appliance. The project works based on the value calculated by the sensor reading. The BLYNK app uses the value sent by the microcontroller through the Wi-Fi connection and shows the values with the help of widgets. A button widget is there to make the home

appliances controlled remotely. It allows for real-time solar monitoring, and there is no need for manual monitoring of the solar panel. It displays the intensity, temperature in degrees Celsius, and voltage in volts by using the gauge widget. It uses the button widget for remote control of the appliances. If any motion gets detected by the PIR sensor, then automatically home appliances like lights get turned on. If there is any fault in the solar panel, then there will be a drastic change in the voltage value, through which we can monitor the solar panel.

In FIGURE 3 it was clear that the PIR sensor doesn't detect any motion, and the light can be turned on and turned off remotely through the button widget.

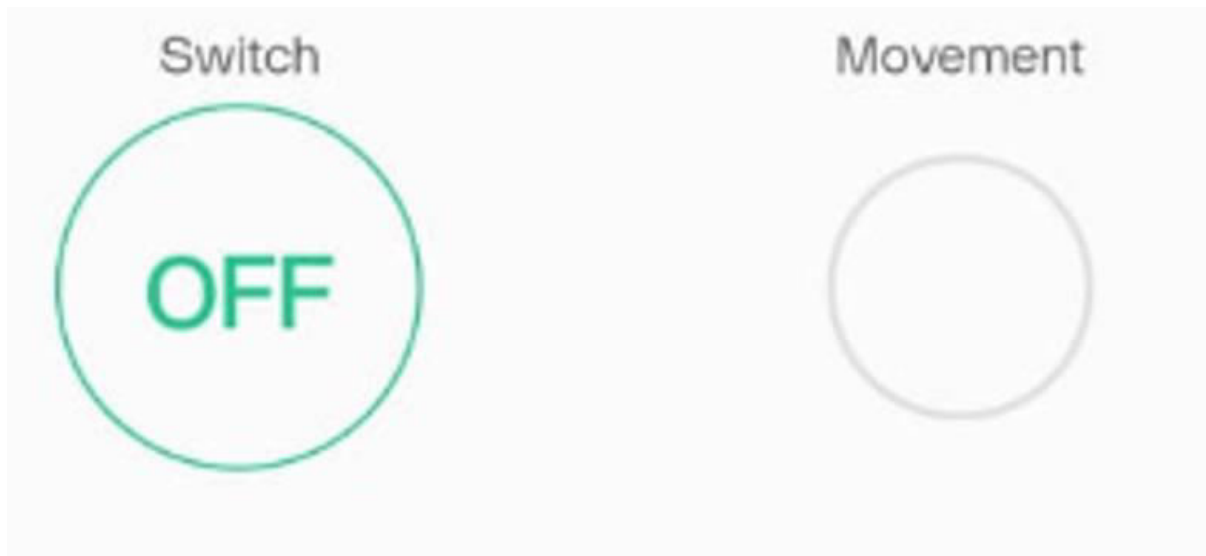


FIGURE 3: Blynk app interface (movement detection, remote control of light)

FIGURE 4 also shows the voltage as 15V and the temperature in the location as 39 degrees Celsius. If we make the switch in the BLYNK app as an on condition, then the light turns on. If we make the switch in the BLYNK app as an off condition, then the light turns off. Thus, we can remotely monitor and control the household appliances as well as the solar panel.

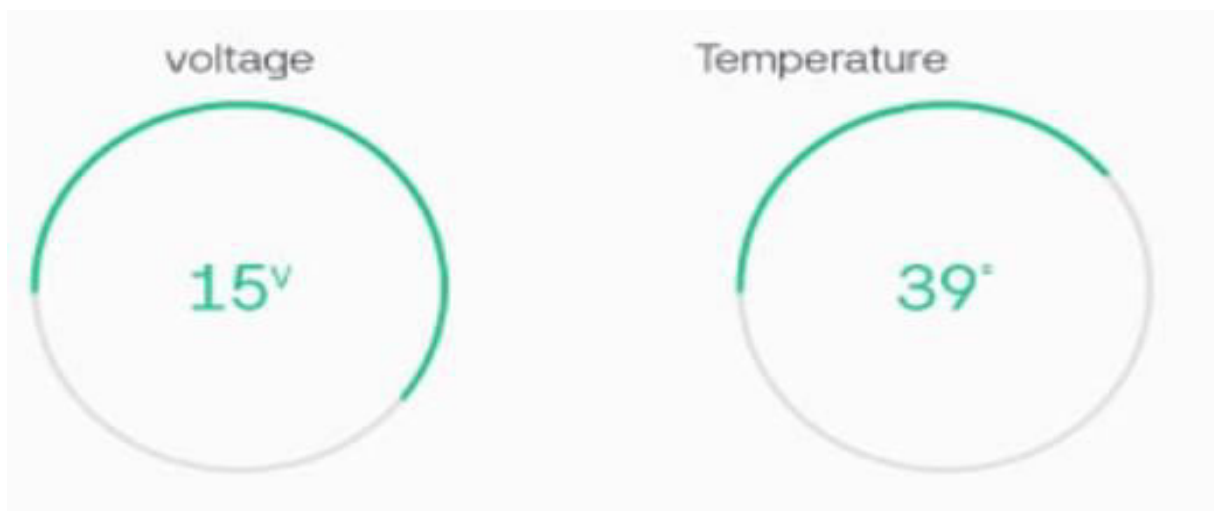


FIGURE 4: Blynk app interface (temperature, voltage)

FIGURE 5 shows zero for intensity, which means that there is less brightness in the room (maybe nighttime). If this widget shows one, then there is more brightness in the place (maybe it's morning time).



FIGURE 5: Blynk app interface (intensity of light)

VI. CONCLUSION AND FUTURE WORK

As this project works well in monitoring the solar panel and controlling the home appliance. It shows the temperature value, intensity of light, and the solar panel's voltage usage. It allows for the remote monitoring of the appliances connected to it through the button widget available on the BLYNK app. This project results in making the data analysis easier and eliminates the need for manual monitoring and maintaining. It is a cost-efficient and energy-efficient method. In the future we can also integrate this system with machine learning and digital signal processing for gesture as well as voice recognition and controlling appliances through gestures and voice. In the future we may also use Bluetooth instead of Wi-Fi. This project can be implemented for other renewable resources like wind turbines.

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