iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: VI Month of publication: June 2017

DOI:

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

An IOT Enabled Smart Inverter

Ninganagouda Biradar[1], Dr. Baswaraj Gadgay[2], Veeresh Pujari[3]
[1] PG student Dept. of VLSI Design & Embedded Systems VTU PG Centre Kalaburagi.
[2]Research Guide & Professor VTU PG Centre Kalaburagi, Karnataka, India.
[3]Assistant Professor VTU PG Centre Kalaburagi, Karnataka, India

Abstract: Inverters and routers are commonly found in most households applications in today's life. However this work we discuss the implementation of a IOT enabled smart inverter i.e. a solar charged inverter that uses Wi-Fi technology to engage a two way communication with the user, and informing the user of both, the battery voltage of the inverter as well as utilization time of the loads which the user chooses to run. Moreover, the wireless control of loads is implemented to ease efficient utilization of energy also increase human comfort. This work uses the ARDUINO UNO microcontroller board based on the ATmega328P along with Node MCU which runs on theESP8266 Wi-Fi module to implement the aforementioned objectives.
Keywords— Smart Inverter, ARDUINO UNO, Node MCU ESP8266 Wi-Fi module, adafruit server, IoT

I. INTRODUCTION

The industrial revolution in power has become the most fundamental element required to fuel an economy. Every section of society like industries, homes and the government itself is heavily dependent on power for its smooth functioning. However, the population expansion has resulted in an increased demand for power. Pollution due to conventional energy sources is already at an all-time high. Hence, it is time we use renewable energy sources in order to reduce pressure on power grids. Therefore it is extremely important to focus on the concept of energy generation using renewable sources and energy storage in an efficient manner to reduce the pressure on power grids. Energy storage comes in handy during emergencies like floods, storms, equipment failure etc which result in long power cuts. The population explosion has also resulted in a power shortage and consequential power cuts. But with the ever rising technological advances the inverter is expected to be much smarter than it is now. One way of doing it is to let the consumer monitor its status remotely. In this paper we mainly focus on monitoring of inverter's battery, displaying the run-time utilization of the loads and controlling of loads wirelessly. Inverters found in most households and industries are powered by non-renewable energy resources and are primitive in their architecture and usage. Most consumers are caught off-guard when the inverter's battery dies out as the existing inverters lack the ability to alert the users about the power consumption and battery life remaining. A smart inverter must use renewable energy to charge its battery, it should be adaptive and able to send and receive messages quickly, as well as Share data with the owner. Hence there is scope for retrofitting the existing inverters to make them more user-friendly by displaying the battery voltage and also providing information on the run-time of his loads while using the battery, which will also promote judicious use of available energy by the consumer. Through this work, the said objectives are as follows:

A. To create an interactive IoT-enabled Smart Inverter which is charged by a solar PV panel and can display the existing battery voltage at any point in time.

B. To allow the user to then decide which crucial loads to run in the event of a power failure and key in his preferences onto the provided GUI such as a Web page/Mobile Application.

C. To allow the user to control the selected loads wirelessly, through a GUI such as a Web page/Mobile Application. To then display to the user as to how long he can run the chosen loads simultaneously or individually.

D. To then display to the user as to how long he can run the chosen loads simultaneously or individually.

II. RELATED WORK

The increasing energy demand and pollution caused by the rapidly depleting fossil fuels have now given way to the use of renewable sources to meet energy demands. Among the renewable energy sources, high interest is on the solar energy which generates electricity using PV (photo voltaic) modules [1]. The fact that there is a need for more efficient usage of renewable energy sources and solar energy happens to be one of them the smart inverters are need of the day. The solar energy can be used to charge the batteries during day time and the stored energy in the battery can be used when solar energy is not present.

Smart inverters are generally defined as inverters which are charged through solar energy and which can perform solar tracking [2].

The authors have used stepper motors to perform the solar tracking using the MQTT algorithm. However smart inverters can also be looked upon as inverters with bidirectional communication with the user and other stakeholders in the system. Our work explores this possibility by introducing interaction between the user and the inverter via IoT.

Residential houses were incorporated with a WSN system whose nodes aggregated the energy consumption data of different appliances in the house and presented it to the user for analysing. [3] In this work we consider a crucial situation where the user should be aware of his energy consumption i.e. in the event of a power failure, we acknowledge the fact the we have the inverter's limited resource in the form of its battery in order to meet our energy needs. Hence we display to the user how long he can run his loads with the existing battery voltage.

A circuit consisting of IC LM3914 and LEDs was used to indicate the battery voltage level of an inverter [4]. The battery voltage level was used to drive the LEDs via a regulator. Depending upon which of the 10 LEDs was glowing, the user could infer the amount of battery voltage left. This work improves upon the aforesaid idea by displaying the battery voltage by directly sensing it using a microcontroller, thus making it more accurate. The same voltage is displayed to the user via a mobile app along with the run-time of the loads.

III. PROPOSED METHOD

In this paper we use the Wi-Fi technology all over the place, to make the present inverters smarter and more user-friendly. The available options for wireless technologies are ZigBee, Wi-Fi, Bluetooth, GSM, etc. Wi-Fi uses radio waves (RF) to allow two devices to communicate with one another. The technology is most commonly used to connect Internet routers to devices like computers, tablets and phones; however, it can be used to connect together any two hardware components. Wi-Fi is a local wireless network that runs on the 802.11 standards set forth by the Institute of Electrical and Electronics Engineers (IEEE). Wi-Fi routers are already installed in everybody's homes and even Mobile devices can give out Wi-Fi signals using the mobile network's internet. This system doesn't need any other extra module to be installed; hence Wi-Fi is deemed to be a cheap and more adaptable solution for home automation.

The existing inverters inform the user about the voltage, current, power and other parameters using the display monitor on them. In this paper we propose an inverter with a wireless system with which a user can control household appliances wirelessly as well as monitor the battery health. This battery is charged using a solar panel, making it an eco-friendly power generator and reducing carbon footprint to a great extent. The run time of the loads is also calculated and is sent to the user in real time which makes the inverter smarter by letting the user know for how long he can run the loads on the battery voltage alone before the battery dies. Hence, this is a bidirectional system where commands are sent from the controller to the user and vice versa.

We use Arduino Uno board which is based on the ATmega328P microcontroller. It is interfaced with Node MCU which is a ESP8266 Wi-Fi module. ESP8266 is a cheap Wi-Fi module which is easily available and can be easily programmed to send and receive data. The ESP8266 can be programmed in both Access point mode and Server mode. In access point mode it connects to a local Wi-Fi in order to connect to the internet, after which it can interact with any module connected to the internet. The GUI was developed using adafruit IO IOT server, the user can access the data using the GUI and control the loads of the house as well.

IV. SYSTEM ARCHITECTURE

In this paper we use the Wi-Fi technology all over the place, to make the present inverters smarter and more user-friendly. The available options for wireless technologies are ZigBee, Wi-Fi, Bluetooth, GSM, etc.Wi-Fi uses radio waves (RF) to allow two devices to communicate with one another. The technology is most commonly used to connect Internet routers to devices like computers, tablets and phones; however, it can be used to connect together any two hardware components. Wi-Fi is a local wireless network that runs on the 802.11 standards set forth by the Institute of Electrical and Electronics Engineers (IEEE). Wi-Fi routers are already installed in everybody's homes and even Mobile devices can give out Wi-Fi signals using the mobile network's internet. This system doesn't need any other extra module to be installed; hence Wi-Fi is deemed to be a cheap and more adaptable solution for home automation.

The existing inverters inform the user about the voltage, current, power and other parameters using the display monitor on them. In this paper we propose an inverter with a wireless system with which a user can control household appliances wirelessly as well as monitor the battery health. This battery is charged using a solar panel, making it an eco-friendly power generator and reducing carbon footprint to a great extent. The run time of the loads is also calculated and is sent to the user in real time which makes the inverter smarter by letting the user know for how long he can run the loads on the battery voltage alone before the battery dies. Hence, this is a bidirectional system where commands are sent from the controller to the user and vice versa.

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

We use Arduino Uno board which is based on the ATmega328P microcontroller. It is interfaced with Node MCU which is a ESP8266 Wi-Fi module. ESP8266 is a cheap Wi-Fi module which is easily available and can be easily programmed to send and receive data.

The ESP8266 can be programmed in both Access point mode and Server mode. In access point mode it connects to a local Wi-Fi in order to connect to the internet, after which it can interact with any module connected to the internet.

he GUI was developed using adafruit IO IOT server, the user can access the data using the GUI and control the loads of the house as well.

A. Hardware set-up

In this section, we look at the hardware set-up of the system for wireless switching of loads and to monitor the status of the battery voltage along with the time for which the loads can be run during power cuts. This system is implemented using ARDUINO UNO board based on the ATmega328P microcontroller along with Node MCU which runs on the ESP8266 Wi-Fi module by Espressif

Voltage of the battery, after being reduced using a voltage divider circuit, is given to one of the ADC pins of the microcontroller. This digital value of the source voltage is then displayed on the LCD and same value is used to perform necessary calculations to display the time for which the loads can run. ESP8266 is connected to the microcontroller to transmit and receive messages using the Transmit and Receive pins of the controller. When a user sends a message to the Wi-Fi module ESP8266, it sends the same to the controller which is programmed to accept the message and compare it with a pre-defined string.

here are several feeds used in controlling the loads like Sw1 and Sw2 which in turn toggles the relay1 and relay2 to turn on and off the load1 and load2. Which in turn it sends binary values of 1 and 0 through adafruit server to enable or disable the respective load. One of the wires is the stepped up voltage of 230 volts and the other is a common ground. The stepped up voltage is given to the common terminal of each relay. Further, a connection is established from the NO (Normal Open) terminal of the relay to the load and another end of the load is connected to common ground. When the relay is enabled by the controller, the circuit gets completed and the load gets switched ON.

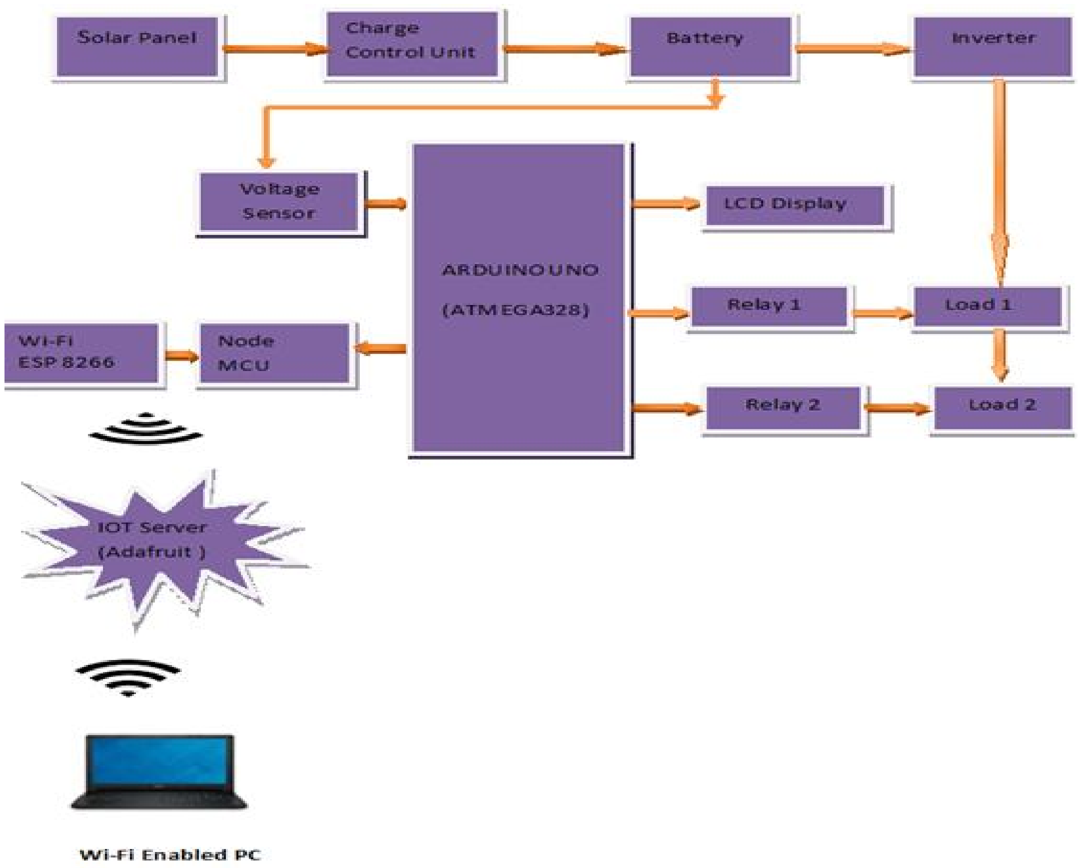


Fig. 1 Block Diagram of the hardware set-up

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

B. Switching of Loads

The controller is programmed to assist the Wi-Fi module ESP8266 to connect to the access point by using the SSID and password of the access point. The network uses the SSID (Service se Identifier or User name) and AIO key to connect to server

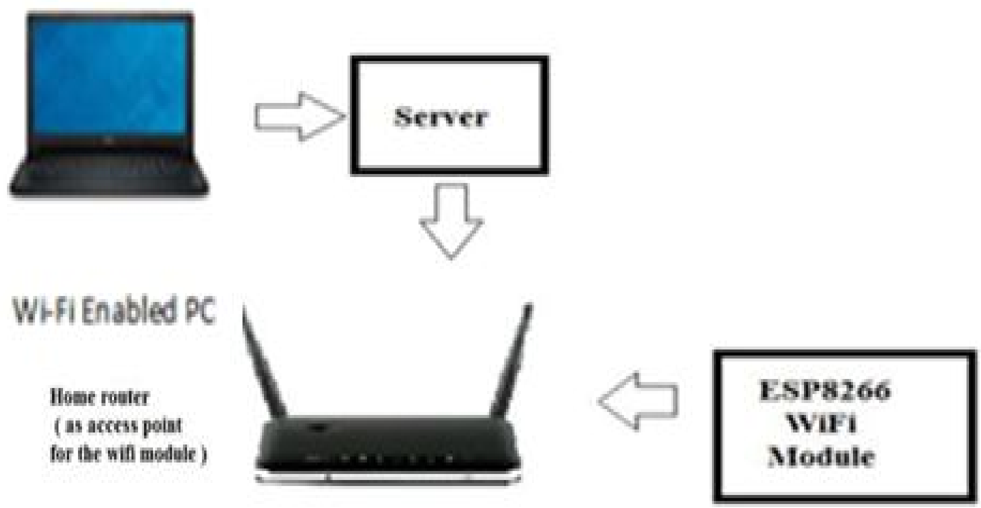


Fig. 2 Functional Block diagram of switching unit

The controller is programmed to assist the Wi-Fi module ESP8266 to connect to the access point by using the SSID and password of the access point

V. SOFTWARE IMPLEMENTATION

This section describes how various functionalities of the system are implemented. The software portion of the system mainly consists of two parts: Code to program the Arduino Uno microcontroller and to configure the ESP8266 Wi-Fi module to send data to server. Finally, the IOT adafruit IO server is accessed through user name and password.

Arduino embedded code is used to control ESP8266 into the C code and transmitted to ESP8266 using the UART serial communication. A MQTT protocol is used to publish the data and subscribing the data. MQTT is light weight machine to machine protocol that enables the cross platform devices to communicate with each other and it also enables client machine to communicate with mobile devices, mobile devices to IoT devices, IoT devices to severs etc. MQTT is used on top of the TCP/IP that is publish-subscribe model, and is an ISO standard. It is basically a communication gateway.

A. The code can be summarized as follows

1) The user can access the Adafruit IO server and configure through the User name and AIO key in config.h file.
2) The user then accesses the serial port to send and receive the data through the ESP 8266 through user name and password.
3) The user can select the feed "ON/1" to turn on the load and "OFF/0" to turn off the load. The server sends the commands via MQTT protocol to the ESP8266 which receives and transfers it to the Arduino Uno via UART.
4) The controller is programmed in such a way that when the user sends the command to turn on the load he also gets back information about the remaining battery voltage and run-time of the load on his web app.
5) Parallely the status of the loads, remaining battery voltage and run time of the loads is also displayed on the 16x2 LCD.

B. Battery life: The time left or battery backup is calculated as

Time left= (battery capacity *voltage of the battery)/ Wattage of loads

We have incorporated a solar charge controller which helps in charging the battery using solar power. A charge controller slows down the rate at which electric current enters the batteries. It prevents overcharging and protects against overvoltage which reduces the performance of the battery. A charge controller is placed between the solar PV and the battery. Even when the panel output varies a constant current flows into the battery and battery gets charged. This is important because the output of the panel is not uniform throughout the day and will reach peak during the afternoon and thus usage of charge controller ensures the battery charges uniformly. In the proposed solution, a rechargeable Sealed Lead-Acid Battery is used which has a standby voltage of 12 volts and 7.2Ah capacity. Its constant voltage charge is 15-35˚C. This battery output is given to the inverter module

C. Flowchart:

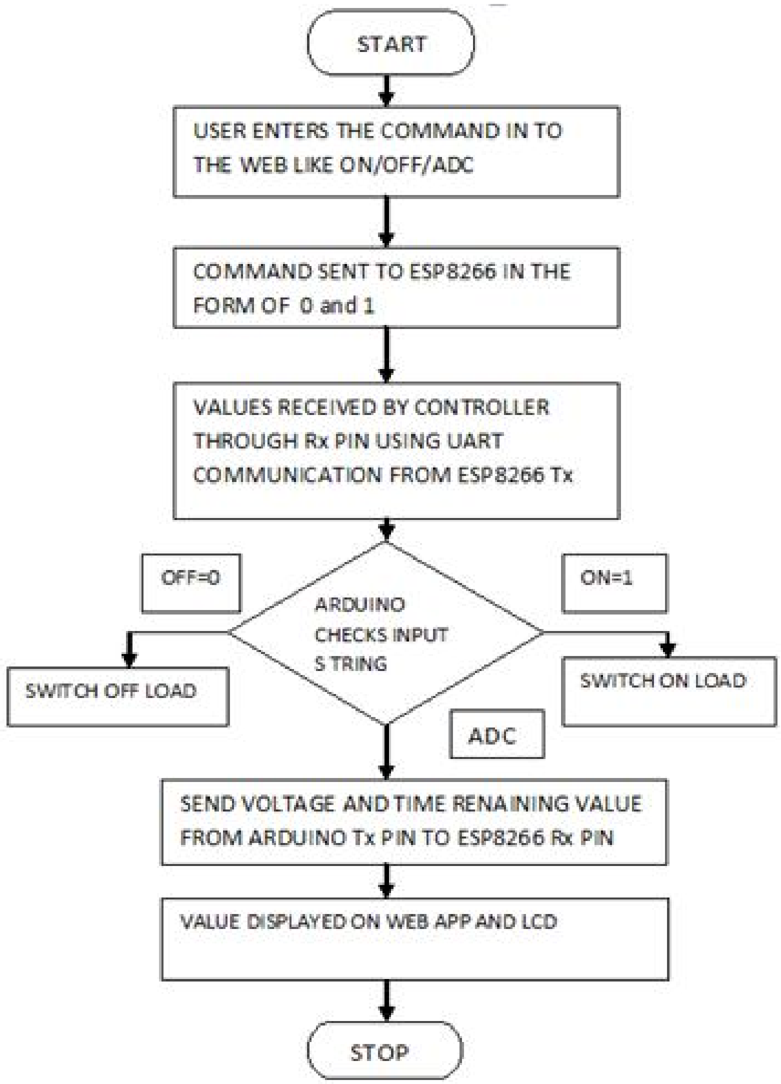


Fig. 3 Flowchart showcasing the sending and receiving data to control loads and monitor battery voltage and life

VI. RESULTS

In the proposed work, the inverter's battery is charged using a solar panel, making it an eco-friendly power generator. Since the definition of a smart inverter is that it is a new generation of inverter using renewable energy, the inverter is indeed a smart inverter having a wireless system with which a user can control household appliances wirelessly, monitor the battery health as well as inform the user the run time of the loads running on inverter battery alone. The battery voltage value and run time of the loads are known to the user which helps the user prioritize on choosing which loads to switch on. . The loads were successfully controlled wirelessly within a range of 150 meters. The app was used to control the loads wirelessly and monitor the battery voltage and run time of the loads.

Following message is displayed on the LCD screen when the ESP 8266 Wi-Fi module gets connected to the network by using the SSID and password mentioned in the Program.

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

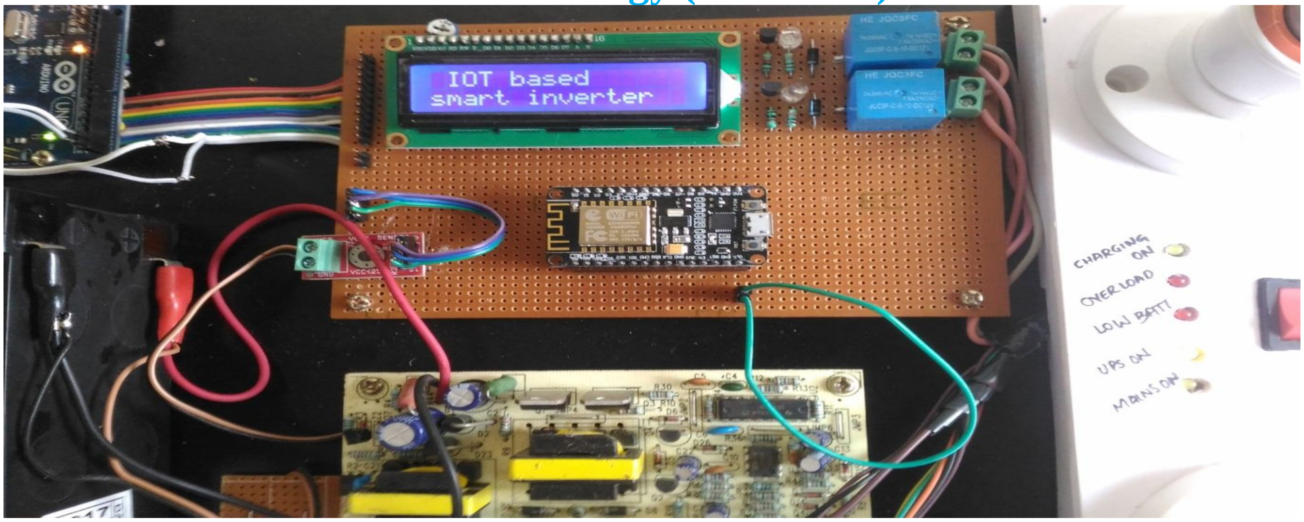


Fig. 4 LCD display with Wi-Fi connection

After displaying the welcome message "IOT based smart Inverter" some delay is introduced and then it displays battery voltage and the backup hours in the LCD as well as the web app.

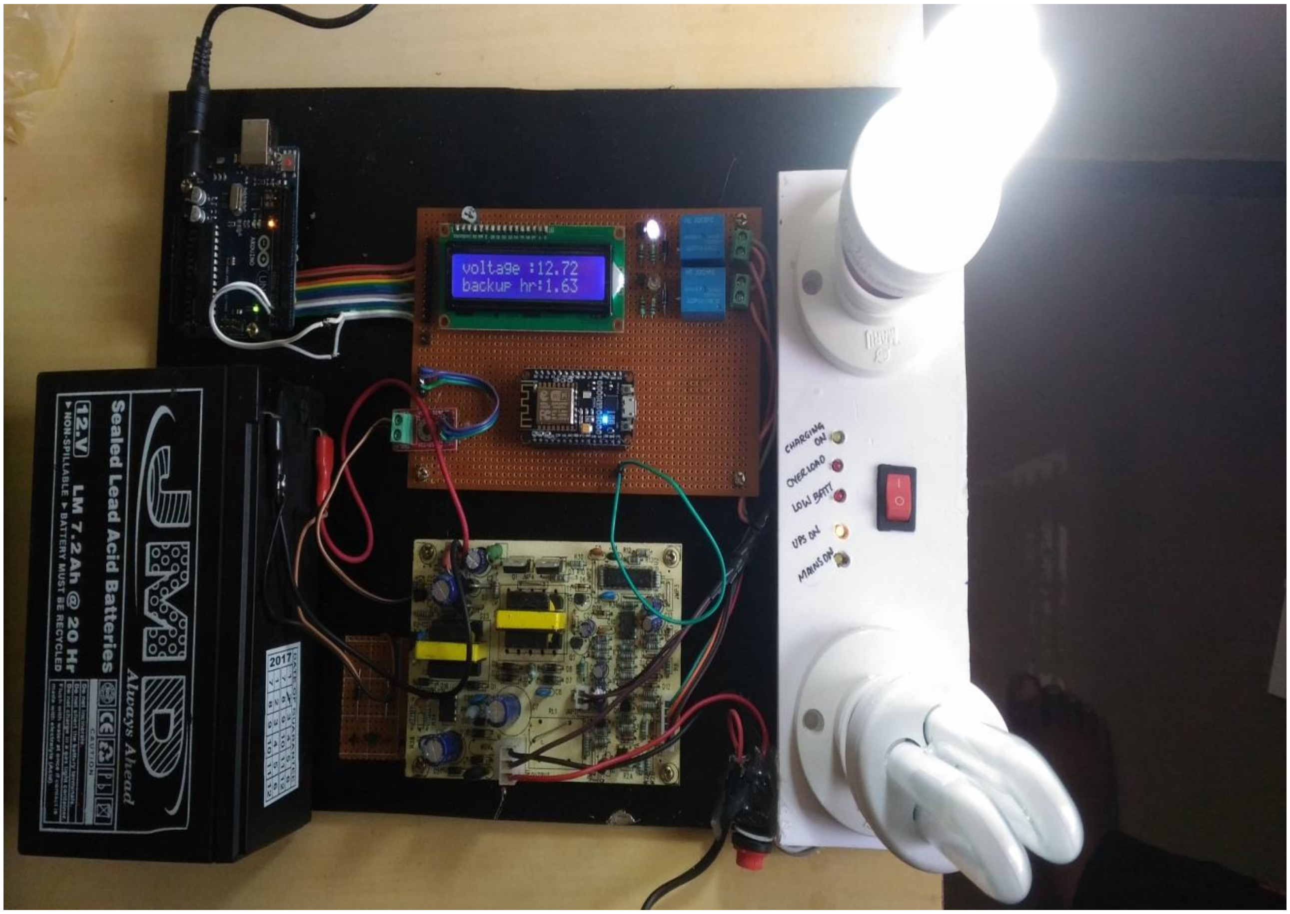


Fig. 5 when the load1 is turned on by using the web app then the status of load gets displayed on the LCD along with the battery voltage and the run time of the battery.

The adafruit server is accessed through the user name and the password and then controls the load remotely using server dashboard feeds.

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

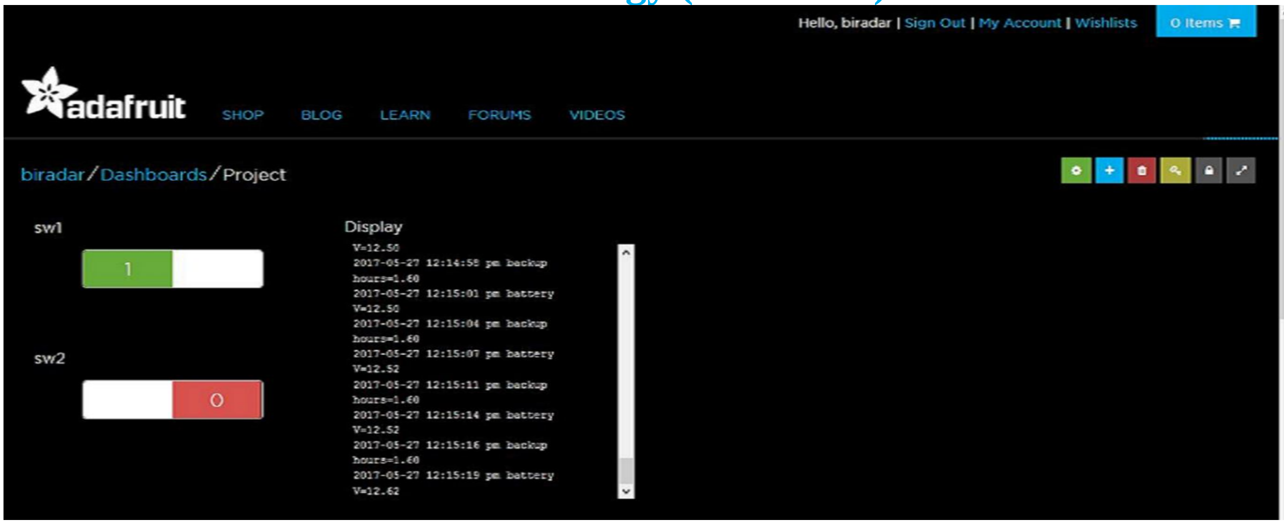


Fig. 6 App showing the switch Sw1 ON/1 and Sw2 OFF/0 and the value of battery after turning ON the load and the run time of the load with available battery voltage

TABLE 1: RUN TIME FOR VARIOUS COMBINATIONS OF LOADS (For Inverter =80watts)

Operating Loads(Bulbs) Bulb1=10 W Bulb2=5W	Run Time of the Loads(hours)
Bulb1	8 hours
Bulb2	16 hours
Bulb1+Bulb2	5 hours

VII. CONCLUSION AND FUTURE SCOPE

Through this work, we were able to successfully implement an IoT based Smart inverter by retrofitting an existing inverter with new functionalities such as bidirectional communication with the user. At the time of a power cut the user can wirelessly control loads based on his priorities. He can also check his battery voltage to avoid being caught off guard when the battery completely drains out with no indication. This prototype gives insight into working of a self sufficient and reliable system for home automation and monitoring power consumption of household appliances. This system requires only initial stage investment in solar panel and the smart inverter system is developed at low cost. A consumer generates enough energy for oneself and uses it accordingly with an environment friendly system. If extended to a community, this paper can be connected to grid, where users can "sell" or "buy" the power generated from others, making it even more diverse. This can be implemented using the concept of net metering. Also, since this work is confined to a LAN, port forwarding can be implemented to control the loads even when connected to a different network

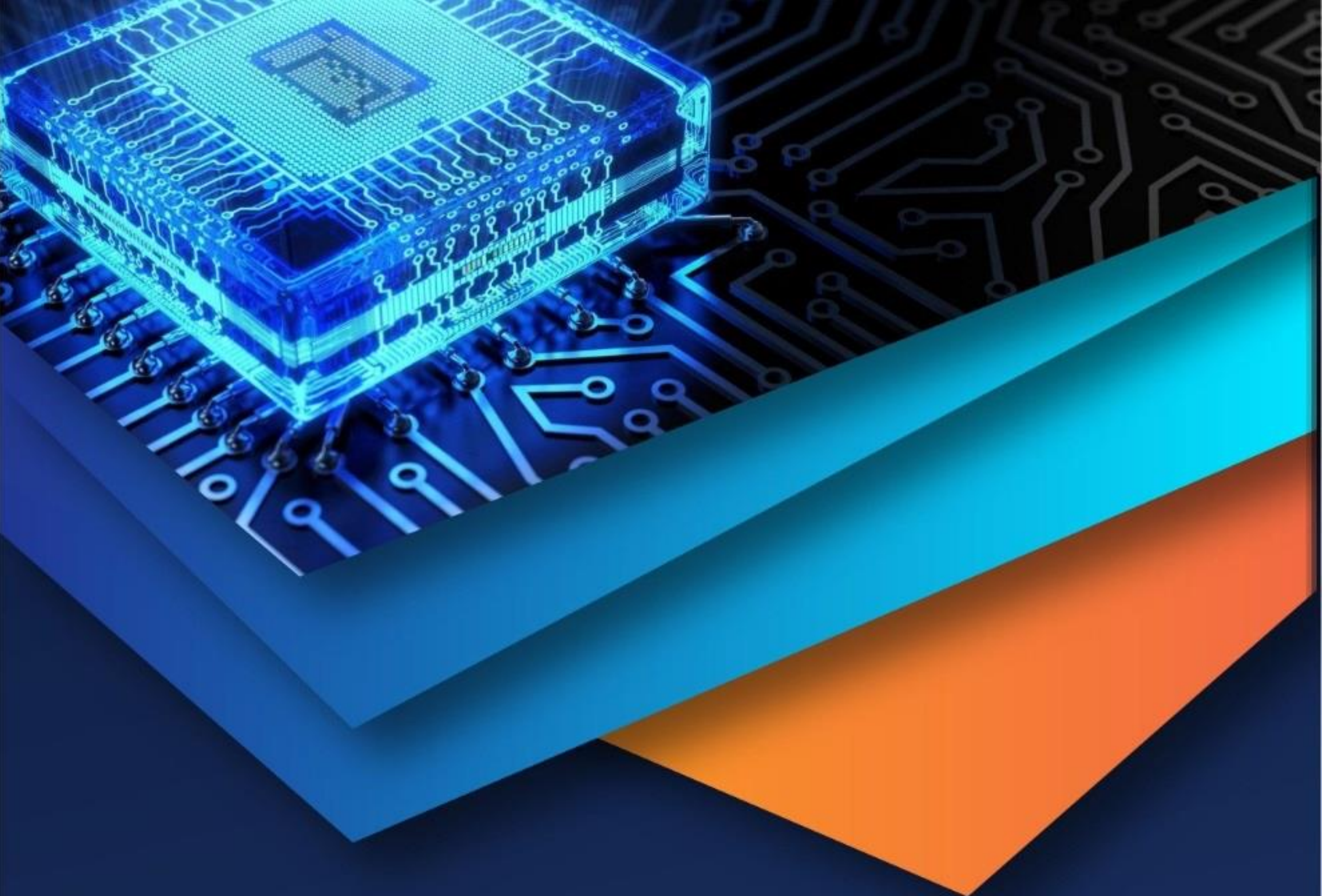
REFERENCES

[1] "Functionalities of smart inverter system for grid-connected applications." Authors : O. I. Adekola (Cape Peninsula Univ. of Technol., Cape Town, South Africa) , A. K. Raji

[2] "Solar smart inverter: A novel design using multi level topology and pulse width modulationwith load detection." Nithin Krishnan, PG Scholar, Dept.of Electronics & Communication, Divya H. Asst. Professor, Dept of Electronics & Communication, Mohandas College of Engineering, Kerala University Trivandrum-695541,Kerala,India.

[3] Aoi Hashizume, Tandanori Mizuno and Hiroshi Mineo, "Energy Monitoring System using Sensor Networks in Residential Houses," 26th IEEE International Conference on Advance Information Networking and Application Workshop, pp. 595-600, June 2012.

[4] Solar Panel using Inverter with level indicator", International Joural of Innovative and Emerging Research in Engineering ,Authors: Rajesh Singh Shekhawat,Ruchika Singh Rao,Kajal Kumari,Vinod Kumar



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY