Major Project Report

On

"DESIGN OF RASPBERRY PI WEB BASED ENERGY MONITORING SYSTEM FOR RESIDENTIAL ELECTRICAL CONSUMPTION"

Submitted in Partial Fulfillment of the Academic Requirement for the Award of Degree of

BACHELOR OF TECHNOLOGY

in

Electronics & Communication Engineering (ECE)

Submitted By:

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CMR INSTITUTE OF TECHNOLOGY

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Approved by AICTE, Permanent Affiliation to JNTUH, Accredited by NBA and NAAC

Kandlakoya(V), Medchal Dist - 501 401

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CERTIFICATE

This is to certify that a Major Project entitled with **"DESIGN OS RASPBERRY PI WEB BASED ENERGY MONITORING SYSTEM FOR RESIDENTIAL ELECTRICAL CONSUMPTION"** is being submitted by:

JILLA SOWJANYA **20R01A0426**

to JNTUH, Hyderabad, in partial fulfillment of the requirement for award of the degree of B.Tech in ECE and is a record of a bonafide work carried out under our guidance and supervision. The results in this project have been verified and are found to be satisfactory. The results embodied in this work have not been submitted to have any other University for award of any other degree or diploma.

Signature of Guide	Project Coordinator	Signature of HOD
Mr. B. Ravi Kumar	Mr. P.Pavan Kumar	Dr. K. Niranjan Reddy

EXTERNAL EXAMINER

ACKNOWLEDGEMENT

I am extremely grateful to **Dr. M. Janga Reddy**, Director, **Dr. B. Satyanarayana**, Principal and **Dr. K. Niranjan Reddy** Head of Department, Dept of Electronics & Communication Engineering (ECE), CMR Institute of Technology for their inspiration and valuable guidance during entireduration.

I am extremely thankful to **Mr. P.Pavan Kumar,** Major Project Coordinatorand Project Supervisor **Mr. B. Ravi Kumar**, Dept of Electronics & Communication Engineering (ECE), CMR Institute of Technology for their constant guidance, encouragement and moral support throughout the project.

I will be failing in duty if we do not acknowledge with grateful thanks to the authors of the references and other literatures referred in this Project.

I express our thanks to all staff members and friends for all the help and coordination extended in bringing out this Project successfully in time.

Finally, I am very much thankful to our parents and relatives who guided directly or indirectly for every step towards success.

JILLA SOWJANYA **20R01A0426**

Declaration

I **JILLA SOWJANYA (20R01A0426),** of the Major-Project entitled as **"DESIGN OS RASPBERRY PI WEB BASED ENERGY MONITORING SYSTEM FOR RESIDENTIAL ELECTRICAL CONSUMPTION"** hereby declared that the matter embodied in this project is the genuine work done by me only and has not been submitted either to the university or to any university/institute for the fulfillment of the requirement of any course of study.

JILLA SOWJANYA **20R01A0426**

ABSTRACT

The goal of this project is to develop and deploy a web-based energy monitoring system for residential electricity consumption using Internet of Things (IoT) technology and various hardware elements, including a Raspberry Pi Pico, LCD display, current coil, relay energy meter PZEM004T, ESP8226, and RFID. The planned system will enable households to track their energy usage in real-time via a web-based interface, giving them insights into their energy usage habits and assisting them in finding ways to lower their electricity bills. The device will also compute the electricity rate depending on energy consumption and display it on the LCD screen. The hardware elements will cooperate to track and measure energy use, with the current coil identifying the power theft and give alert to the user via web server or via mobile application. An RFID tag and reader will be used for the purpose of prepaying option, that will display the amount which has been paid by the user. This web-based energy monitoring system will give households an affordable and practical tool to track their energy usage, prepaid amount, lower their electricity bills, and contribute to a more sustainable future.

However, the translation of these algorithmic accuracies into real-world deployments necessitates a nuanced consideration of the trade-off between computational speed and detection accuracy. While both SSD and Faster R-CNN exhibit proficient performance in controlled experimental settings, their efficacy in dynamic, real-world scenarios may hinge upon the optimization of parameters to strike an optimal balance between rapid response times and precise detection capabilities. Factors such as hardware specifications, environmental conditions, and deployment constraints profoundly influence the practical applicability of these algorithms in diverse security contexts.

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1. INTRODUCTION

Over time, residential households' use of electricity has increased, resulting in rising electricity costs and environmental issues. Energy monitoring devices that enable households to track their energy usage in real-time and find solutions to lower their electricity bills are becoming more and more necessary to address these challenges. In this project, we suggest an Internet of Things (IoT)-based web-based energy monitoring system that makes use of a variety of hardware elements, including Raspberry Pi Pico, LCD display, current coil, relay 3.3, relay energy meter PZEM004T, ESP8226, and RFID, to measure and monitor energy consumption in residential homes. With a web-based interface, the system will enable homeowners to track their energy usage in real-time, giving them insights into their usage patterns and assisting them in finding ways to lower their electricity bills. Also, based on energy consumption, the system will determine the electricity rate and display it on the LCD panel. With the current coil monitoring the current flowing through the circuit and the energy metre PZEM004T measuring the voltage and power consumption, the hardware components will work together to measure and monitor the energy usage. The Raspberry Pi Pico will process and store the data after receiving it wirelessly from the ESP8226 module. Relay 3.3 will manage the power supply to the relay and the energy metre, ensuring that only the essential parts are turned on when required. An RFID card reader will be used to authenticate the user and guarantee that only permitted users can access the system. Users can check their energy use and tariff information on the LCD panel after swiping their RFID card to gain access to the system. Homeowners will be able to monitor their energy usage, lower their electricity costs, and contribute to a more sustainable future with the help of this web-based energy monitoring system.

2. LITERATURE SURVEY

This paper presents design and development of a GSM based energy monitoring, profiling and control system. Our system integrates digital energy meters installed at consumer unit with an electric supply company's energy monitoring system. Single phase or three phase digital electric meter can be used with indigenously developed add on transmission module, which takes the meter reading and utilizes the GSM network to transmit the energy usage reading using Short Message Service (SMS) back to the energy supplier. At the supplier end, an energy monitoring system is used to manage all received meter readings, compute the billing cost, update the database and maintain an energy consumption profile for each user. Various alerts and control can also be generated by the supplier. A simple, cost effective and reliable working prototype of complete system has been developed using digital energy meter manufactured by MicroTech Limited, Pakistan to demonstrate an efficient and transparent means of automatic meter reading, billing and notification through the use of GSM network. The conventional metering system requires the supplier company to send personnel who manually read and record the energy consumption, so billing can be done accordingly. The manual reading system suffers from a wide variety of disadvantages, which tenders it inefficient. It requires a large number of meter readers to collect reading from all consumers, hence the frequency of meter reading acquirement is low, that is, usually once a month. Moreover, with human involvement, it is prone to human errors as well as tampering of records. This leads to non-transparency in the metering system. To devise an efficient metering system, the concept of Automatic Meter Reading (AMR) and Energy Profiling System (EPS) [1-2] originated, which provide an effective means of energy consumption information collection, and its analysis, for accurate billing. A plethora of technologies can be utilized for the implementation of such a system, each having its own pros and cons. Radio frequency based EPS can make use of Handheld, Mobile, and Fixed network. In handheld and touch based EPS, a handheld computer equipped with a transceiver is used (radio frequency or touch) to collect readings, but it does not make optimum use of the AMR capable meters, as meter reading personnel are required. Mobile or Drive-by meter reading is another approach where a reading device is installed in a vehicle. Due to the short range of mobility, it again requires a team for collection of meter readings. AMR can also be implemented by making use of Power Line Communication (PLC) [3-4], but it has an inherent disadvantage of interference and noise, which deems it unreliable. Wi-Fi, ZigBee and 3G technologies [5-6] have also been used for transmission

of metering information, but have not being widespread as they require installation of facility/ access points to cover the designated areas and thus do not provide a cost effective solution in existing environments. Our indigenously developed GSM transmission module induce transparency in the current meter reading system, by facilitating low cost real time monitoring of consumer energy consumption. Automation would lead to an efficient energy metering system by removing human errors. Our system also allows the energy supplier company to remotely control the consumer energy meter. A major feature is the inclusion of a user consumption profiling system, accessible to users and the energy supply company. By incorporating control coupled with profiling, the project aims at creating some degree of awareness among users, encouraging them towards conservation of energy. An additional feature explored is the traffic profiling using Global Positioning System (GPS) to indicating the location of consumers which is extremely beneficial if used in collaboration with sensor circuits to indicate meter theft. Most of these features were not available with system developed.

Dr. D. S. Jangamshetti, and Dr. S. H. Jangamshetti, "Design, Implementation and Testing of Theft and Maintenance Monitoring of Batteries of Stand-alone SPV systems," IEEE, 2015

Battery management system (BMS) is used in Electric Vehicles (EV) and Energy Storage Systems to monitor and control the charging and discharging of rechargeable batteries. BMS keeps the battery safe and reliable and increases the stability without going into damaging state. The state of the battery is maintained by monitoring voltage, current, and the ambient temperature. For monitoring purpose, data is obtained from various analog/digital sensors and processed through the microcontroller. In the imminent future, Electric Vehicles will be the leading form of transportation. Lithium-based rechargeable batteries will be widely used. These battery packs will need to be constantly monitored and managed in order to maintain the safety, efficiency and reliability of the whole electric vehicle. A battery management system consists of: (1) a battery level monitoring system (2) optimal charging algorithm and (3) a cell/thermal balancing circuitry. The voltage, current and temperature measurements are used to estimate all crucial states and parameters of the battery system, such as the battery impedance and capacity, state of health, state of charge, and the remaining useful life. the stability of the electrodes depend on the temperature within the cell and its effects on the volatile organic solvents that make up the electrolyte. Selected solvents have a boiling point at 90°C and any increase above 90°C would boil off the solvent. Hence, increasing the cell's internal pressure, and forcing the solvent to vent.

Thus preventing such excessive rise in temperature helps preserve the integrity of the cells. s. It is also affected by the discharge rate and temperature. At the end of the cell's life the actual capacity will be approaching only 80% of its rated capacity. In this case, even if the cell is fully charged, its SOC would only be 80%. For an accurate estimate the ageing and environmental factors have to be taken into account. If the SOC reference is also defined as the current fully charged capacity of the cell, then, the adjustment factors would have to be applied to the rated capacity to determine a new reference capacity .

Khadijah Alsafwan, Fatimah Alshaer, Lolah Hakami, Khawlah Aseeri, Masoumah AlJishi, Dilek Dustegor, "iTrack: A Residential Energy Monitoring System Tailored to Meet Local Needs," IC, 2015.

t—Saudi Arabia has encountered a great economic growth in oil and gas resources in the past decades, and if domestic consumption rates continue in their current pathways, it is expected that there will be a contraction in oil exports, which will negatively affect Saudi Arabia's ability in the future to maintain the current high levels of spending in both investment and consumption. Residential consumption in Saudi Arabia accounts for 51% of total electricity sold in 2012. Therefore, targeting private residencies will reduce both the amount of fuel needed to generate electricity and the amount of greenhouse gases. This project aims to build a smart home system. This system will monitor and analyze the energy consumption, utilize lights when needed, program the temperature by keeping your house warmer than normal when you are away and setting the temperature as high as comfortable if needed. Then display the information to improve customer awareness by using colored LEDs to alert customers to different parameters, and turn their loads on and off based on the cost of electricity use as well as enable consumers to control some of their home appliances usage through a mobile application to reduce electricity usage and minimize energy waste

Savita, Sumit Shrivastava, Abhishek Arora, Vikas Varshney, "Overvoltage and Undervoltage Protection of Load using GSM modem SMS Alert," IEEE, 2018.

The on-time delay circuit not only protects the load from switching surges but also from quick changeover (off and on) effect of over/ Here is an inexpensive auto cut-off circuit, which is fabricated using transistor and other discrete components. It can be used to protect loads such as refrigerator, T.V., and VCR from undesirable over and under line voltages, as well as surges caused due to sudden failure/resumption of main power supply. This circuit can be used directly as a standalone circuit between the mains supply and the load, or it may be inserted between an existing automatic/manual stabilizer and the load. The over/under

voltage cut-off with ON-Time delay provides various types of protection. Over-voltage protection. Under-voltage protection. Protection against transients. Protection to load from frequent turning ON & OFF by providing time delay . Here is an inexpensive auto cutoff circuit, which is fabricated using transistors and other discrete components. It can be used to protect loads such as refrigerator, TV, and VCR from undesirable over and under line voltages, as well as surges caused due to sudden failure/resumption of mains power supply. This circuit can be used directly as a standalone circuit between the mains supply and the load, or it may be inserted between an existing automatic/manual stabilizer and the load. The on-time delay circuit not only protects the load from switching surges but also from quick changeover (off and on) effect of over-/under-voltage relay, in case the mains voltage starts fluctuating in the vicinity of under- or over-voltage preset points. When the mains supply goes out of preset (over- or under-voltage) limits, the relay/load is turned _off‘ immediately, and it is turned _on‘ only when AC mains voltage settles within the preset limits for a period equal to the _on‘ time delay period. The on-time delay period is pre-settable for 5 seconds to 2 minutes duration. Using presets VR3 and VR4. For electronic loads such as TV and VCR, the on time delay may be set for 10 seconds to 20 seconds. For refrigerators, the delay should be preset for about 2 minute‘s duration, to protect the compressor motor from frequently turning _on‘ and _off‘ The under/over voltage protection circuit with time delay presented here is a low cost and reliable circuit for protecting such equipments from damages. Whenever the power line is switched on it gets connected to the appliance only after a delay of a fixed time. If there is hi/low fluctuations beyond sets limits the appliance get disconnected. The system tries to connect the power back after the specific time delay, the delay being counted from the time of disconnection. If the power down time (time for which the voltage is beyond limits) is less than the delay time, the power resumes after the delay: If it is equal or more, then the power resumes directly. This circuit has been designed, built and evaluated by me to use as a protector for my home refrigerator. This is designed around readily available semi-conductor devices such as standard bipolar medium power NPN transistor (D313/SL100/C1061), and NE555 timer IC. Its salient feature is that no relay hunting is employed. This drawback is commonly found in the proctors available in the market. The complete circuit is consisting of various stages. They are: - Dual rail power supply, Reference voltage source, Time delay stage and Relay driver stage.

3. SYSTEM PROPOSAL

3.1 Existing system

In current residential settings, energy consumption monitoring relies predominantly on traditional electricity meters integrated within the household's electrical infrastructure. These meters serve as the primary means of measuring and recording the total amount of energy consumed over specific intervals. They operate by measuring the flow of electricity passing through the household's circuits, providing periodic readings that are often utilized by utility companies for billing purposes.

However, while traditional meters effectively serve their fundamental purpose of measuring energy consumption, they possess inherent limitations. These limitations primarily revolve around the lack of granularity and accessibility in the data they provide. Traditional meters typically offer only basic metrics, such as total energy consumption readings, and may not provide insights into more nuanced aspects of energy usage, such as peak consumption periods or appliance-specific usage patterns.

Moreover, accessibility to the data collected by traditional meters is often limited. Users may have minimal access to real-time energy consumption data, and the periodic readings provided may not be easily interpretable or actionable. As a result, opportunities for proactive energy management and optimization within residential settings may be limited, potentially hindering efforts to promote energy efficiency and sustainability.

In summary, while traditional electricity meters effectively measure total energy consumption, they lack granularity and accessibility in the data they provide. This limitation underscores the need for more advanced and user-friendly energy monitoring solutions that can offer real-time insights into energy usage patterns and facilitate proactive energy management and optimization.

3.2Proposed system

The proposed solution introduces a Raspberry Pi-based web-enabled energy monitoring system designed specifically for residential electricity consumption. At the core of this system lies a Raspberry Pi, renowned for its flexibility and extensive community support.

Complementing the Raspberry Pi are additional hardware components, including non-intrusive current sensors, which augment data collection capabilities beyond those offered by traditional meters. These sensors enable continuous measurement of energy consumption at finer intervals, providing real-time insights into usage patterns and trends previously inaccessible with conventional meters alone.

The proposed system addresses the limitations of the existing setup by enhancing data granularity and accessibility. Through a web-based interface hosted on the Raspberry Pi, users gain easy access to real-time energy consumption data, allowing for immediate visualization and interpretation from any internet-enabled device. This accessibility empowers users to make informed decisions regarding energy usage optimization and promotes proactive energy management efforts. Furthermore, the system's flexibility and scalability facilitate future expansion and customization to meet evolving needs and technological advancements in energy monitoring. Overall, the proposed Raspberry Pi-based energy monitoring system represents a significant advancement over traditional approaches, offering enhanced functionality, accessibility, and potential for promoting energy efficiency and sustainability in residential settings

BLOCK DIAGRAM

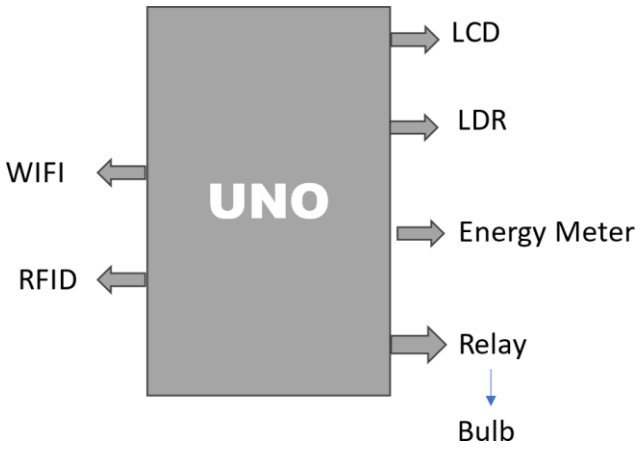


Fig 1.1: Block Diagram

4.RASPBERRY PI

4.1 RASPBERRY PI PICO BASED ENERGY MONITORING

The electrical system's voltage, current, and power are all monitored by the energy monitoring system. The PZEM-004T energy usage metre, a Raspberry Pi 4 acting as a web server for data storage and user interface are used in this study. Due to the PZEM-004T and Raspberry Pi's incompatible communication formats, the Raspberry pi was utilised as a repeater to send data from the PZEM-004T to the Raspberry Pi Pico. As seen in Figure 1, the Raspberry Pi Pico, Esp8266, and PZEM004T are connected. On the Raspberry Pi web-based energy monitoring system, there are three key subsystems: energy measurement, data transmission, and the website. Initially, PZEM-004T measures the voltage and current flowing through the load. PZEM004T then uses this voltage and current to estimate energy. Then, PZEM-004T receives a request byte from Raspberry Pico. The PZEM-004T then uses serial communication to transfer data about voltage, current, power, and energy to microcontroller. Then it transmits its data to Raspberry Pi 4. The Raspberry Pi stores its data in a database on the final subsystem Furthermore, a web-based user interface displays the database's data. Figure 2 depicts the schematic for the Raspberry Pi Pico's web-based energy monitoring system. First, the PZEM-004T is connected to the AC power supply and the CT sensor for voltage and current detection, which is utilised to determine power and energy. The RX and TX pins of the PZEM004T are then connected to the digital pins of the Raspberry Pi Pico. Data is transformed , so that the communication protocol used by the Raspberry Pi Pico is compatible. Finally, a USB connection between Esp8266 and Raspberry Pi Pico is required so that it can transmit data to Raspberry Pi Pico.

4.2 EXPERIMENTAL SETUP

I. Raspberry Pi Pico

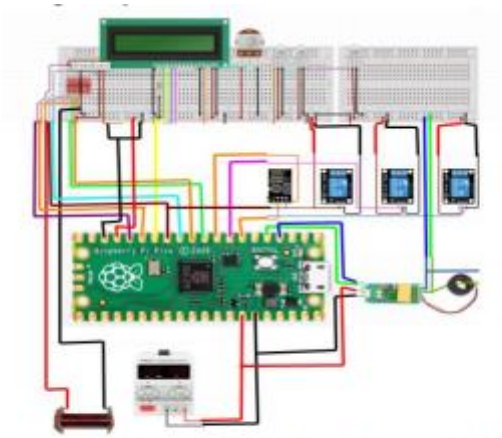


Figure 2: Schematic of Raspberry Pi Pico Web-Based Energy Monitoring System

Via a web-based interface, the proposed system will allow homes to monitor their energy use in real-time, providing them with insights into their usage patterns and helping them identify methods to reduce their electricity costs. On the LCD panel, the device will also compute the electricity rate based on energy consumption. The hardware components will work together to monitor and quantify energy use, with the current coil detecting the passage of current. With the help of this web-based energy monitoring system, households will have an affordable and useful tool to monitor their energy use, cut their electricity costs, and help create a more sustainable future.

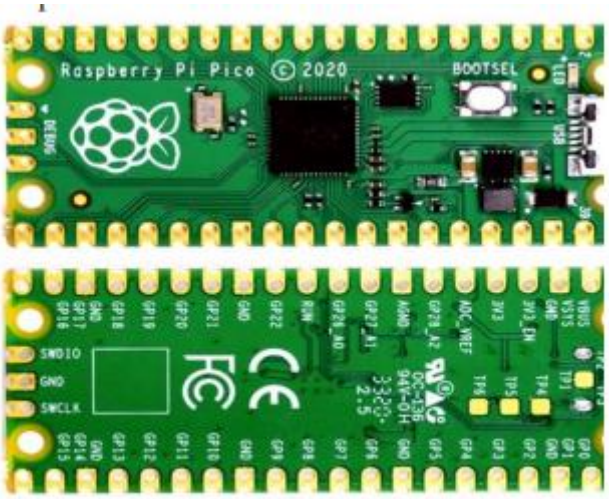


Figure 3: Raspberry pi Pico

Raspberry Pi Pico is a microcontroller board mainly developed for robotics and embedded applications. Unlike other Raspberry Pi modules, this board is not a full computer. Pico is the most economical board among other Raspberry Pi modules. This tiny board incorporates 26 GPIO pins that you can configure either as an input or as output. Moreover, RP2040 is added to the board that is considered as the first in-house microcontroller introduced by

Raspberry Pi. Mostly the RP2040 microcontroller pins are taken to the user IO pins on the right and left edge of the module.

PIN DESCRIPTION

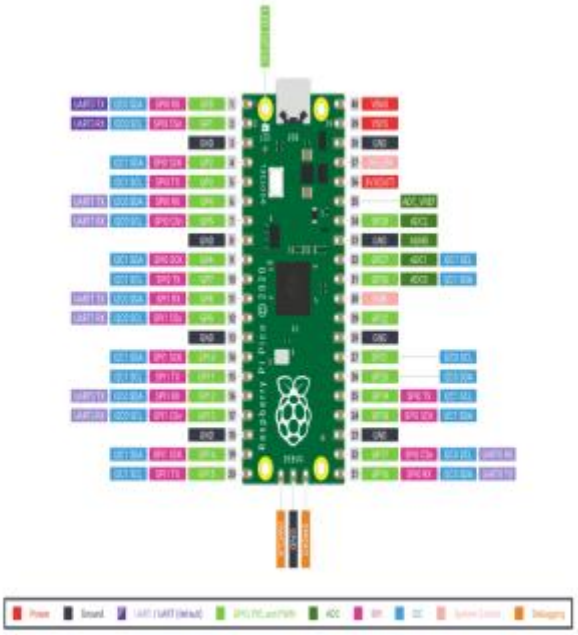


Figure 4: Raspberry Pi Pico Pin Description

II. EM-18 Reader Module

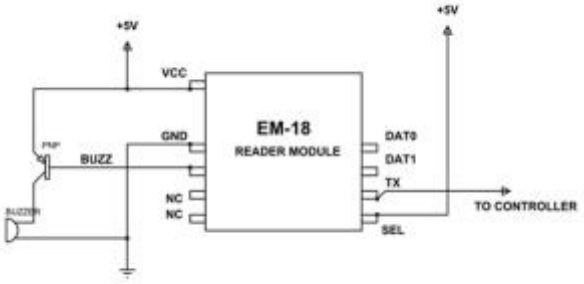


Figure 5: Block Diagram of EM-18 module

EM-18 is used like any other sensor module. First we choose the mode of communication between module and controller. Next we will program the controller to receive data from module to display. Next power the system. When a tag is brought near the MODULE it reads the ID and sends the information to controller. The controller receives the information and performs action programmed by us.

III. PZEM-004T

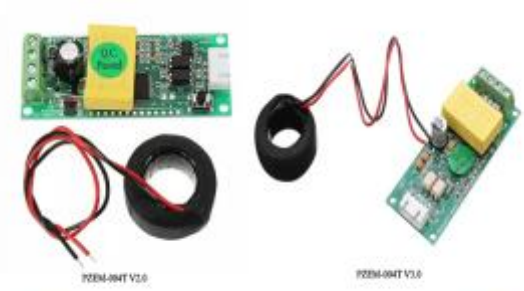


Figure 6: Hardware of PZEM-004T

PZEM-004T is an electronic module that functions to measure: Voltage, Current, Power, Frequency, Energy and Power Factors. With the completeness of these functions / features, the PZEM-004T module is ideal for use as a project or experiment for measuring power on an electrical network such as a house or building. The PZEM-004T module is produced by a company called Peacefair, there are 10 Ampere and 100 Ampere models. Please be careful because the wiring between the 10 Ampere models with 100 Amperes is different, if a short circuit or a short circuit can occur in the electrical network.

IV. ESP8266

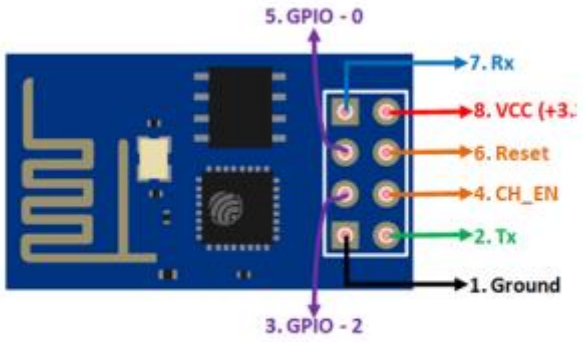


Figure 7: Block Diagram of Esp8266

ESP8266 is Wi-Fi enabled system on chip (SoC) module developed by Espressif system. It is mostly used for the development of the Internet of Things (IoT) embedded applications. The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturing company Espressif Systems. The ESP8266 is capable of either hosting an application or offloading all the Wi-Fi networking functions from another application processor. Each ESP8266 Wi-Fi module comes pre-programmed with an AT command set firmware, now you can simply hook this up to your Arduino device and get as much Wi-Fi ability as a Wi-Fi Shield offers.

4. RESULTS AND DISCUSSION

A. User Interface of Raspberry Pi Pico Webbased Energy Monitoring System The user interface of Raspberry Pi Pico webbased energy monitoring system is shown in Fig 8. This system designed for access to a local network. On this research, this monitoring system can be accessed from a desktop or mobile phone.

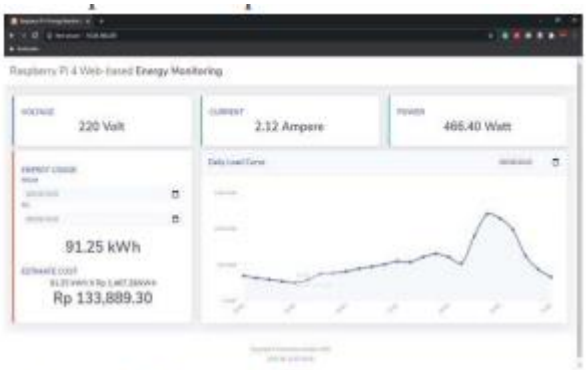


Figure 8: User interface of ubidots server

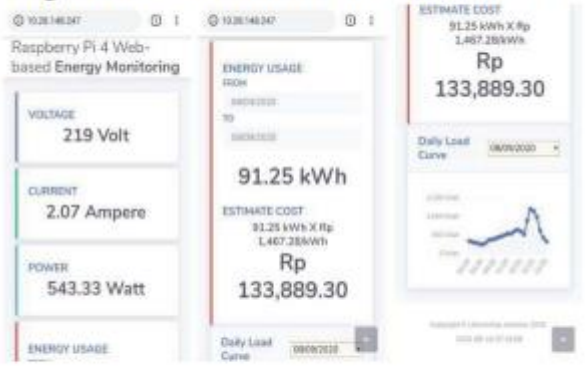


Figure 9: Output of Web-Based Energy Monitoring System

4.3 RASPBERRY PI INTRODUCTION

Raspberry Pi is a small single board computer. By connecting peripherals like Keyboard, mouse, display to the Raspberry Pi, it will act as a mini personal computer.

Raspberry Pi is popularly used for real time Image/Video Processing, IoT based applications and Robotics applications.

Raspberry Pi is slower than laptop or desktop but is still a computer which can provide all the expected features or abilities, at a low power consumption.

Raspberry Pi Foundation officially provides Debian based Raspbian OS. Also, they provide NOOBS OS for Raspberry Pi. We can install several Third-Party versions of OS like Ubuntu, Archlinux, RISC OS, Windows 10 IOT Core, etc.

Raspbian OS is official Operating System available for free to use. This OS is efficiently optimized to use with Raspberry Pi. Raspbian have GUI which includes tools for Browsing, Python programming, office, games, etc.

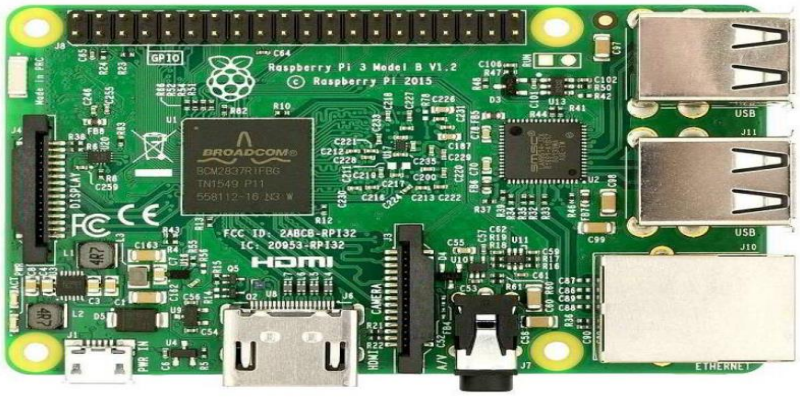
We should use SD card (minimum 8 GB recommended) to store the OS (operating System).

Raspberry Pi is more than computer as it provides access to the on-chip hardware i.e. GPIOs for developing an application. By accessing GPIO, we can connect devices like LED, motors, sensors, etc and can control them too.

It has ARM based Broadcom Processor SoC along with on-chip GPU (Graphics Processing Unit).

The CPU speed of Raspberry Pi varies from 700 MHz to 1.2 GHz. Also, it has on-board SDRAM that ranges from 256 MB to 1 GB.

Raspberry Pi also provides on-chip SPI, I2C, I2S and UART modules.



Raspberry Pi 3 Board

There are different versions of raspberry pi available as listed below:

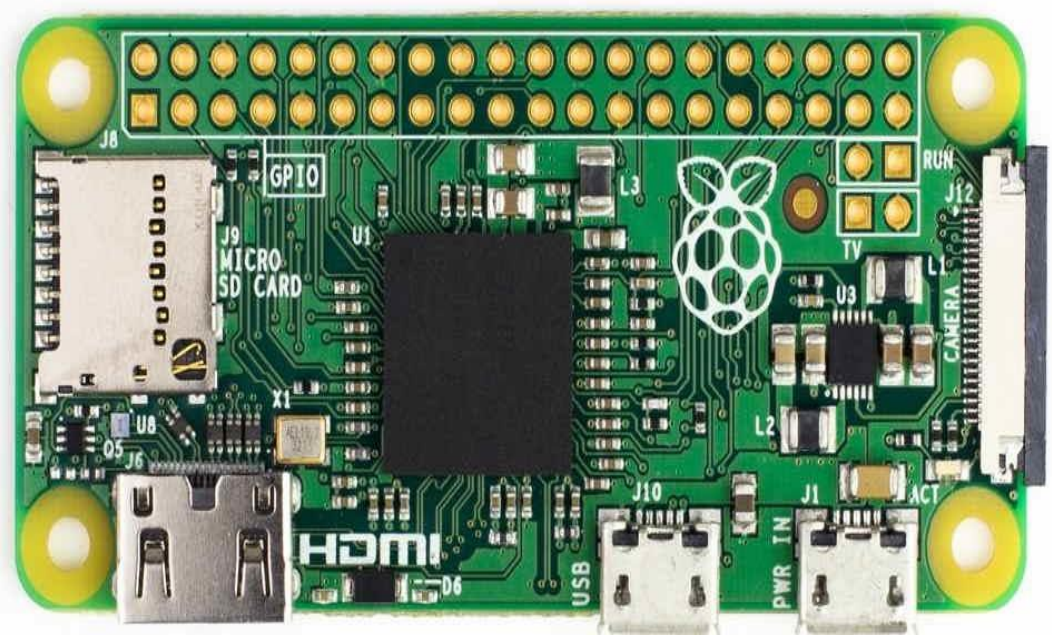
1. **Raspberry Pi 1 Model A**
2. **Raspberry Pi 1 Model A+**
3. **Raspberry Pi 1 Model B**
4. **Raspberry Pi 1 Model B+**
5. **Raspberry Pi 2 Model B**
6. **Raspberry Pi 3 Model B**
7. **Raspberry Pi Zero**

Out of the above versions of Raspberry Pi, more prominently use Raspberry Pi and their features are as follows:

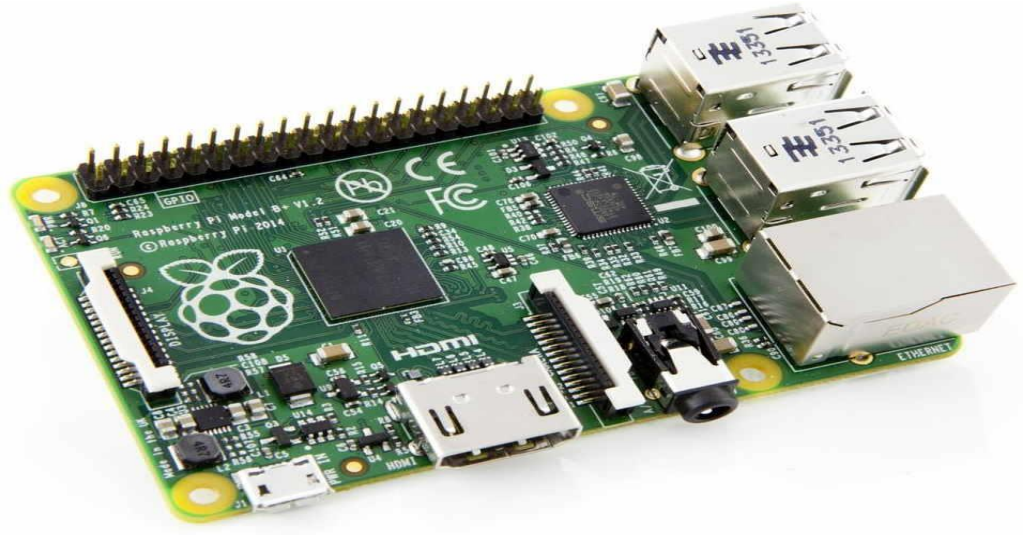
4.3.1 raspberry pi features

Features	Raspberry Pi Model B+	Raspberry Pi 2 Model B	Raspberry Pi 3 Model B	Raspberry Pi zero
SoC	BCM2835	BCM2836	BCM2837	BCM2835
CPU	ARM11	Quad Cortex A7	Quad Cortex A53	ARM11
Operating Freq.	700 MHz	900 MHz	1.2 GHz	1 GHz
RAM	512 MB SDRAM	1 GB SDRAM	1 GB SDRAM	512 MB SDRAM
GPU	250 MHz Videocore IV	250MHz Videocore IV	400 MHz Videocore IV	250MHz Videocore IV
Storage	micro-SD	Micro-SD	micro-SD	micro-SD
Ethernet	Yes	Yes	Yes	No
Wireless	WiFi and Bluetooth	No	No	No

Raspberry Pi zero and Raspberry Pi are shown below



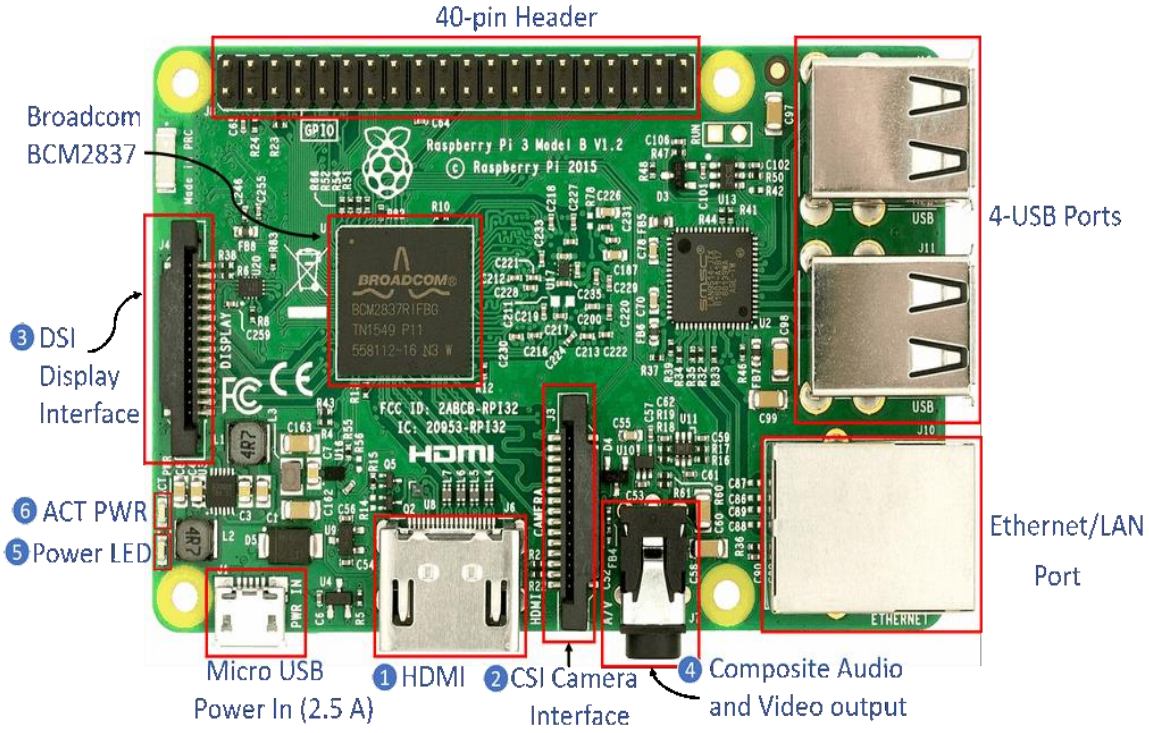
Raspberry Pi Zero



Raspberry Pi Board

Raspberry Pi 3 On-chip Hardware

The On-chip hardware of Raspberry Pi 3 (here) is as shown in below figure,



Raspberry Pi 3 Model B Hardware

Some Hardware Components shown above are mention below:

1. **HDMI (High-Definition Multimedia Interface):** It is used for transmitting uncompressed video or digital audio data to the Computer Monitor, Digital TV, etc. Generally, this HDMI port helps to connect Raspberry Pi to the Digital television.
2. **CSI Camera Interface:** CSI (Camera Serial Interface) interface provides a connection in between Broadcom Processor and Pi camera. This interface provides electrical connections between two devices.
3. **DSI Display Interface:** DSI (Display Serial Interface) Display Interface is used for connecting LCD to the Raspberry Pi using 15-pin ribbon cable. DSI provides fast High-resolution display interface specifically used for sending video data directly from GPU to the LCD display.
4. **Composite Video and Audio Output:** The composite Video and Audio output port carries video along with audio signal to the Audio/Video systems.
5. **Power LED:** It is a RED colored LED which is used for Power indication. This LED will turn ON when Power is connected to the Raspberry Pi. It is connected to 5V directly and will start blinking whenever the supply voltage drops below 4.63V.
6. **ACT PWR:** ACT PWR is Green LED which shows the SD card activity.

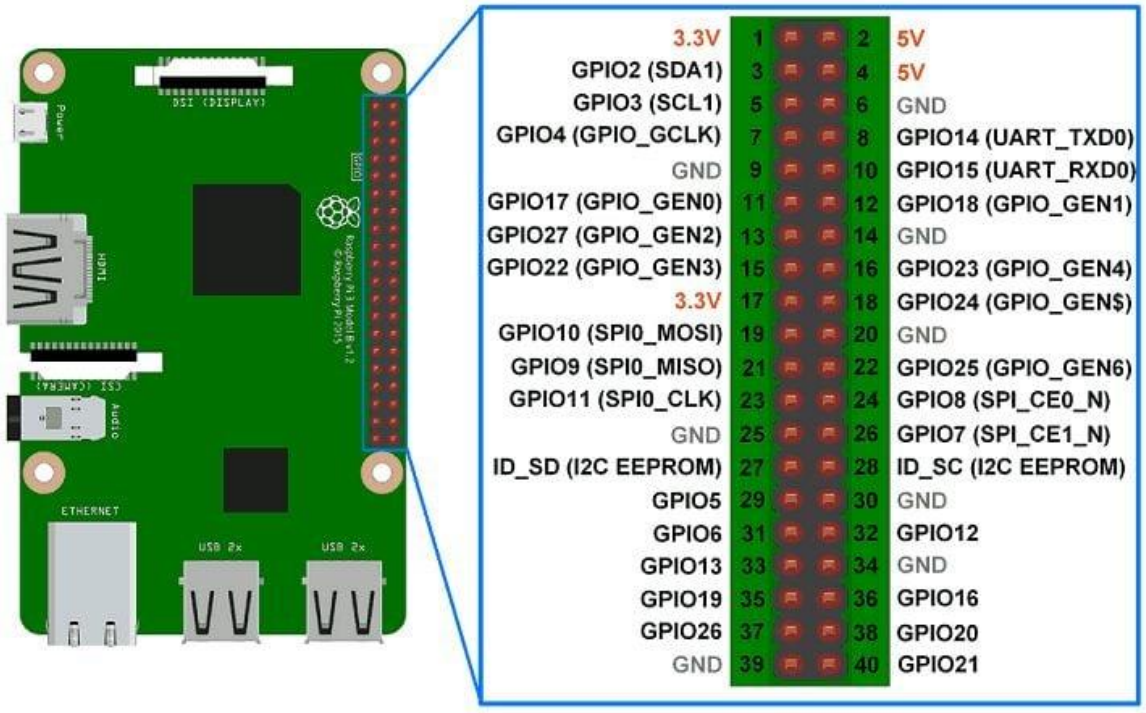
4.4 RASPBERRY PI GPIO ACCCES

INTRODUCTION

GPIO (General Purpose Input Output) pins can be used as input or output and allows raspberry pi to connect with general purpose I/O devices.

- Raspberry pi 3 model B took out 26 GPIO pins on board.
- Raspberry pi can control many external I/O devices using these GPIO's.
- These pins are a physical interface between the Pi and the outside world.
- We can program these pins according to our needs to interact with external devices. For example, if we want to read the state of a physical switch, we can configure any of the available GPIO pins as input and read the switch status to make decisions. We can also configure any GPIO pin as an output to control LED ON/OFF.
- Raspberry Pi can connect to the Internet using on-board Wi-Fi or Wi-Fi USB adapter. Once the Raspberry Pi is connected to the Internet then we can control devices, which are connected to the Raspberry Pi, remotely.

GPIO Pins of Raspberry Pi 3 are shown in below figure:



Raspberry Pi 3 Model B GPIO Pins

Some of the GPIO pins are multiplexed with alternate functions like I2C, SPI, UART etc.

We can use any of the GPIO pins for our application.

Pin Numbering

We should define GPIO pin which we want to use as an output or input. But Raspberry Pi has two ways of defining pin number which are as follows:

- **GPIO Numbering**
- **Physical Numbering**

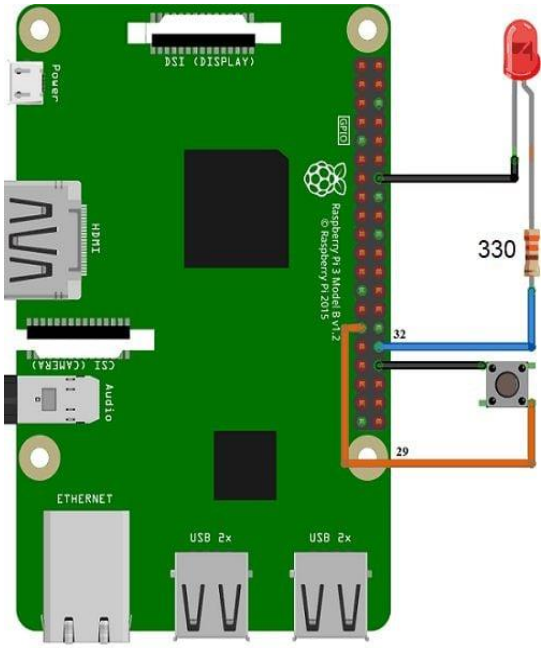
In **GPIO Numbering**, pin number refers to number on Broadcom SoC (System on Chip). So, we should always consider the pin mapping for using GPIO pin.

While in **Physical Numbering**, pin number refers to the pin of 40-pin P1 header on

Raspberry Pi Board. The above physical numbering is simple as we can count pin number on P1 header and assign it as GPIO.

But, still we should consider the pin configuration diagram shown above to know which are GPIO pins and which are VCC and GND.

Interfacing Diagram



5.HARDWARE COMPONENTS

5.1 LDR SENSOR

LDR (Light Dependent Resistor) as the name states is a special type of resistor that works on the photoconductivity principle means that resistance changes according to the intensity of light. Its resistance decreases with an increase in the intensity of light.

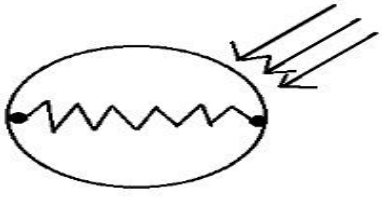
It is often used as a light sensor, light meter, Automatic street light, and in areas where we need to have light sensitivity. LDR is also known as a Light Sensor. LDR are usually available in 5mm, 8mm, 12mm, and 25mm dimensions.

How are LDRs Made?

The Light-dependent resistors made with photosensitive semiconductor materials like Cadmium Sulphides (CdS), lead sulfide, lead selenide, indium antimonide, or cadmium selenide and they are placed in a Zig-Zag shape as you can see in the pic below.

Two metal contacts are placed on both ends of the Zig-Zag shape these metal contacts help in creating a connection with the LDRs.

Now, a transparent coating is applied on the top so that the zig-zag-shaped photosensitive material gets protected and as the coating is transparent the LDR will be able to capture light from the outer environment for its working.



LDR Symbol

It works on the principle of photoconductivity whenever the light falls on its photoconductive material, it absorbs its energy and the electrons of that photoconductive material in the valence band get excited and go to the conduction band and thus increasing the conductivity as per the increase in light intensity.

Also, the energy in incident light should be greater than the bandgap gap energy so that the electrons from the valence band got excited and go to the conduction band.

The LDR has the highest resistance in dark around 1012 Ohm and this resistance decreases with the increase in Light.

Light Intensity V/S Resistance

As per the property of LDRs, the amount of light entering the LDR the inversely proportional to the resistance of the sensor, and the graph is hyperbolic in nature.

Light Dependent Resistor

Difference Between Photodiode and LDR

Photodiodes give quick responses and are used where needed to detect quick responses on and off like in optical communication, and optoisolators. The photodiodes are semiconductor devices and work on PN junctions.

Whereas the LDR, Photocell, a photoelectric, photovoltaic effect, or photoconductivity is used to generate a current or a voltage when exposed to light or other electromagnetic radiation. They are generally used in burglar alarms.

5.1.1 Types of LDR or Photoresistors

1. Intrinsic Photoresistor

This type of photoresistor is made with pure semiconductors without any doping. This kind of photoresistor uses pure semiconductors like silicon and germanium. when the incident light with an adequate amount of energy falls on this, electrons gain that energy and get excited, and a few of them go to the conduction band.

2. Extrinsic Photoresistor

This type of photoresistor uses a doped semiconductor; this means some impurities are mixed with the semiconductor such as phosphorus to make this photoresistor.

Extrinsic light-dependent resistors are generally designed for longer wavelengths of light, with a tendency towards infrared (IR).

How to Test LDRs?

1. Take a multimeter and set it up in Ohms mode.
2. Now connect the positive terminal and negative terminal wires to the two sections of the LDR
3. Place a glowing torch light or any medium of light onto the surface of the LDR and check the reading.
4. Now place a hand over the LDR or place the LDR in the dark and check the multimeter reading.
5. You can see that in 1st case the value of Ω would be lower than in the 2nd case. In the dark, LDR's resistance is high as several megaohms, while in the light, it can get reduced to 100Ω also

5.1.2 LDR Applications

- The photoresistor is generally used in detecting the presence and intensity of light
- Used in automatic lights that switch on and off according to light
- Simple Smoke Detector Alarm, Clock with automatic light
- Optical circuit design
- Photo proximity switch
- Laser-based security systems
- Solar Street Lamps
- Camera light meters
- Clock radios
- Can be used in Dynamic Compressors, some compressors use LDR and LED connected to the signal source to create changes in signal gain.

Limitation:

- LDRs require a few milliseconds or more to respond fully to the changes in light intensity, i.e. they require a few seconds to return to their normal resistance once the light source is removed.
- The sensitivity of a Light-dependent resistor varies with the light wavelength. If the wavelength is outside a certain range, it will not affect the resistance at all.
- Light-dependent resistors have lower sensitivity than photodiodes and phototransistors.

5.2 RELAY MODULE

Relay modules are simply circuit boards that house one or more relays. They come in a variety of shapes and sizes, but are most commonly rectangular with 2, 4, or 8 relays mounted on them, sometimes even up to a 16 relays.

Relay modules contain other components than the relay unit. These include indicator LEDs, protection diodes, transistors, resistors, and other parts

But what is the module relay, which makes the bulk of the device? You may ask. Here are facts to note about it:

- A relay is an electrical switch that can be used to control devices and systems that use higher voltages. In the case of module relay, the mechanism is typically an electromagnet.
- The relay module input voltage is usually DC. However, the electrical load that a relay will control can be either AC or DC, but essentially within the limit levels that the relay is designed for.
- A relay module is available in an array of input voltage ratings: It can be a 3.2V or 5V relay module for low power switching, or it can be a 12 or 24V relay module for heavy-duty systems.
- The relay module information is normally printed on the surface of the device for ready reference. This includes the input voltage rating, switch voltage, and current limit.

5.2.1 Relay Module Function

What does a relay module do? The relay module function is mainly to switch electrical devices and systems on or off. It also serves to isolate the control circuit from the device or system being controlled.

This is important because it allows you the use a microcontroller or other low-power device to control devices with much higher voltages and currents.

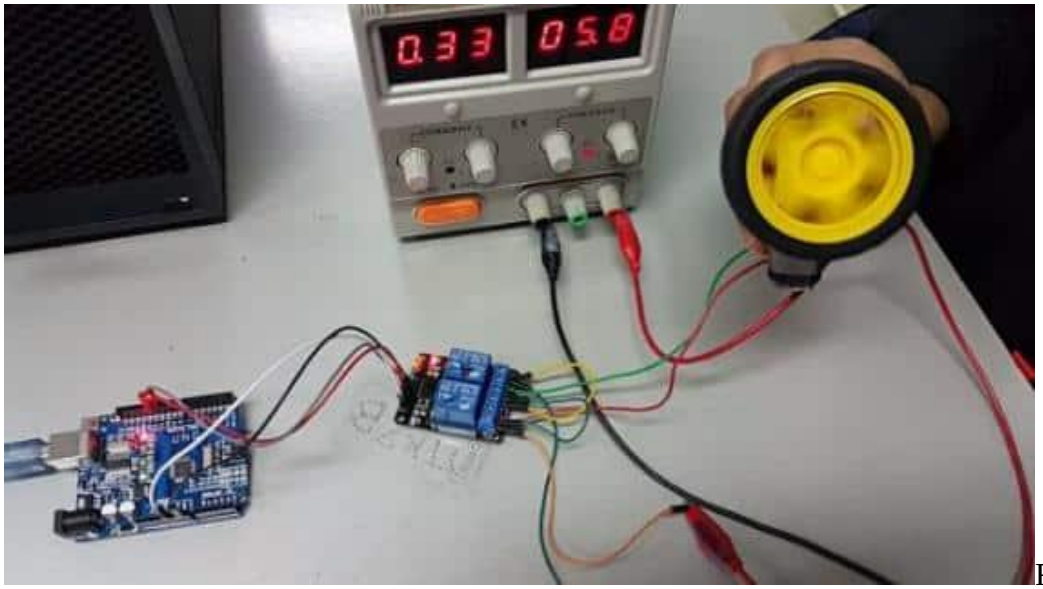
Another relay module purpose is to amplify the control signal so that it can switch the higher currents using only a small out of power from a microcontroller.

Relay Module vs. Relay

It is also important to note the difference between a relay vs. relay module. A relay is a single device that has an electromagnet and a switch, or it can be the solid-state type.

A relay module, on the other hand, is a board that has one or multiple relays on it and several other components to provide isolation and protection.

Because of its modular construction, this type of switching and control device can be many different configurations. It can be a single-channel relay module for a single load or it can be a multi-channel device with multiple relays to control several circuits.



Relay motor working demonstrated

Resource: https://www.youtube.com/watch?v=OzlJ9E2_aSo

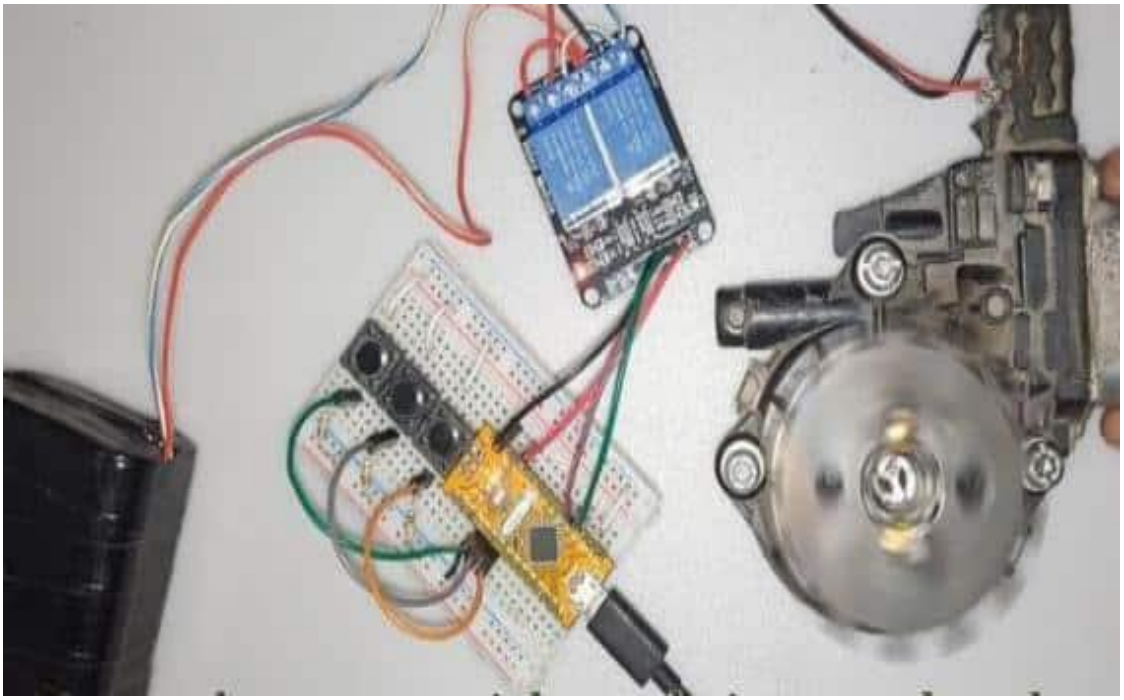
Relay Module Working

How does a relay module work? The relay module working principle is actually quite simple. It uses an electromagnet to open and close a set of electrical contacts. Here is the sequential working of relay module devices for easier understanding:

- The typical relay module connection points include an input side that consists of 3 or 4 jumper pins, and an output side that has 3 screw terminals.
- When the control signal is applied to the input side of the relay, it activates the electromagnet, which attracts an armature.
- This in turn closes the switch contacts on the output (high voltage) side, allowing electricity to flow and power the device or system that is connected to it.
- To prevent flyback voltage from damaging the relay module circuit and the input device, a diode is often placed in parallel with the electromagnet coil. This diode is known as a flyback diode. It allows current to flow in only one direction.

- When a higher level of isolation is required, an optocoupler is used. An opto-isolated relay module has the photoelectric device on the input side, which is used to control the electromagnet's switching action.

Relay modules are available with either normally open (NO) or normally closed (NC) switch configurations.

- A NO switch is open when the electromagnet is not activated, and closed when it is activated.
- An NC relay switch, on the other hand, remains closed by default, and only opens when the relay is activated.
- 

  How to use a relay module for motor control Resource: https://www.youtube.com/watch?v=NzRGxhTZ0NM

- Relay Module Uses

- Relay modules are used in all sorts of applications, from controlling lights and motors to more complex systems such as automation processes and safety or security systems. Here are just a few examples of the relay module uses in different applications.

- Relay modules are also used in home automation systems to control lights, appliances, and other devices. The home automation relay module is often used with mains electricity. So it's mostly rated for 10A or less for maximum current, and up to 250V AC.

- Industrial Relay Module

- In industrial applications, the industrial relay module is used to control machinery, process controls, and other industrial equipment. Other relay module uses in industrial settings include lighting control and the control of alarm or security systems.

- Automotive Relay Module

- Relay modules are widely used in automotive applications. The automotive relay module controls things like headlights, turn signals, and even the starter motor. A car relay module is also found in many other automotive circuits such as those that operate remote starters or theft alarms.

- Arduino Relay Module

- Hobbyists often use a relay module with Arduino in their projects. An Arduino is a microcontroller board that is widely popular in DIY electronics projects. The relay module, when paired with an Arduino, can control various appliances and devices.

5.3 ESP8266

The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability, produced by Espressif Systems[1] in Shanghai, China. The chip first came to the attention of Western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at first there was almost no English-language documentation on the chip and the commands it accepted.[2] The very low price and the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, the chip, and

the software on it, as well as to translate the Chinese documentation.[3] The ESP8285 is an ESP8266 with 1 MiB of built-in flash, allowing the building of single-chip devices capable of connecting to Wi-Fi.[4] The successors to these microcontroller chips is the ESP32 family of chips, including the pin-compatible ESP32-C3.

FEATURES:

- Processor: L106 32-bit RISC microprocessor core based on the Tensilica Xtensa Diamond Standard 106Micro running at 80 MHz[5]
- Memory:
    - 32 KiB instruction RAM
    - 32 KiB instruction cache RAM
    - 80 KiB user-data RAM
    - 16 KiB ETS system-data RAM
- External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included)
- IEEE 802.11 b/g/n Wi-Fi
    - Integrated TR switch, balun, LNA, power amplifier and matching network
    - WEP or WPA/WPA2 authentication, or open networks
- 16 GPIO pins
- SPI
- I²C (software implementation)[6]
- I²S interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 10-bit ADC (successive approximation ADC)

ESP8266 comes with capabilities of

- 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2),
- general-purpose input/output (16 GPIO),
- Inter-Integrated Circuit (I²C) serial communication protocol
- analog-to-digital conversion (10-bit ADC)
- Serial Peripheral Interface (SPI) serial communication protocol,
- I²S (Inter-IC Sound) interfaces with DMA(Direct Memory Access) (sharing pins with GPIO),

- UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and
- pulse-width modulation (PWM).

It employs a 32-bit RISC CPU based on the Tensilica Xtensa L106 running at 80 MHz (or overclocked to 160 MHz). It has a 64 KB boot ROM, 64 KB instruction RAM and 96 KB data RAM. External flash memory can be accessed through SPI.

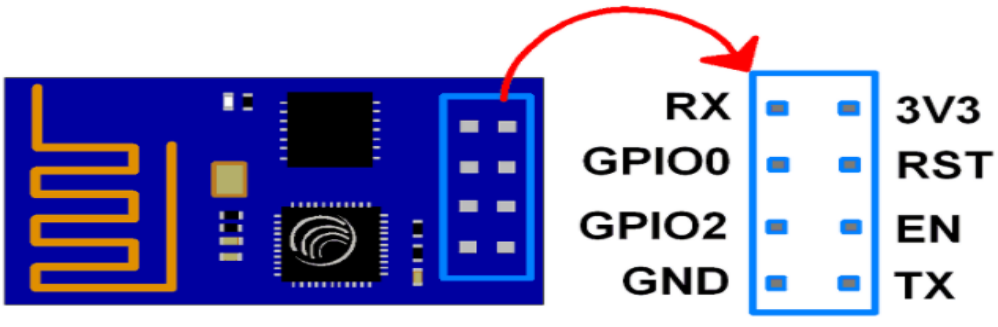
ESP8266 module is low cost standalone wireless transceiver that can be used for end-point IoT developments.

To communicate with the ESP8266 module, microcontroller needs to use set of AT commands. Microcontroller communicates with ESP8266-01 module using UART having specified Baud rate.

There are many third-party manufacturers that produce different modules based on this chip. So, the module comes with different pin availability options like,

- ESP-01 comes with 8 pins (2 GPIO pins) – PCB trace antenna. (shown in above figure)
- ESP-02 comes with 8 pins, (3 GPIO pins) – U-FL antenna connector.
- ESP-03 comes with 14 pins, (7 GPIO pins) – Ceramic antenna.
- ESP-04 comes with 14 pins, (7 GPIO pins) – No ant.

5.3.1 ESP8266-01 PIN DESCRIPTION:



ESP8266-01 Module Pins

3V3: - 3.3 V Power Pin.

GND: - Ground Pin.

RST: - Active Low Reset Pin.

EN: - Active High Enable Pin.

TX: - Serial Transmit Pin of UART.

RX: - Serial Receive Pin of UART.

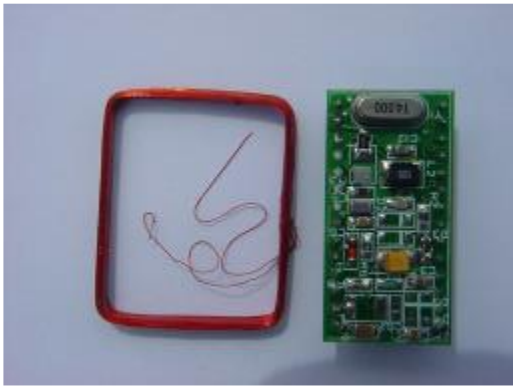
GPIO0 & GPIO2: - General Purpose I/O Pins. These pins decide what mode (boot or normal) the module starts up in. It also decides whether the TX/RX pins are used for Programming the module or for serial I/O purpose.

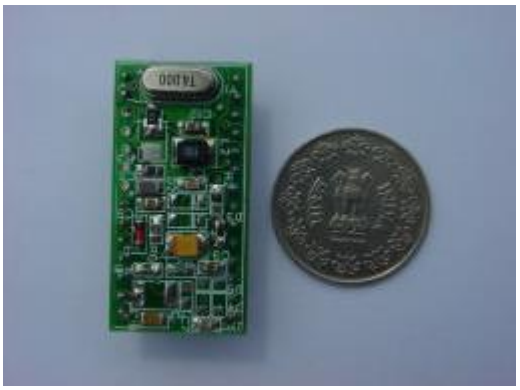
To program the module using UART, Connect GPIO0 to ground and GPIO2 to VCC or leave it open. To use UART for normal Serial I/O leave both the pins open (neither VCC nor Ground).

5.4 RFID READER

Active RFID and Passive RFID technologies, while often considered and evaluated together, are fundamentally distinct technologies with substantially different capabilities. In most cases, neither technology provides a complete solution for supply chain asset management applications. Rather, the most effective and complete supply chain solutions leverage the advantages of each technology and combine their use in complementary ways. This need for both technologies must be considered by RFID standards initiatives to effectively meet the requirements of the user community.

RFID Reader Module, are also called as interrogators. They convert radio waves Returned from the RFID tag into a form that can be passed on to Controllers, which can Make use of it. RFID tags and readers have to be tuned to the same frequency in order to Communicate. RFID systems use many different frequencies, but the most common and Widely used & supported by our Reader is 125 KHz.





Functions

1. Supports reading of 64 Bit Manchester Encoded cards
2. Pins for External Antenna connection
3. Serial Interface (TTL)
4. Wiegand Interface also available

Technical Data:

- Frequency: 125 kHz
- Read Range: up to 8 cm
- Power supply: 5V DC (± 5 %)
- Current consumption max. : 60 mA
- Operating temperature: -20 ... +65° C
- Storing temperature: -40 ... +75° C
- Interface: RS232 (TTL), Wiegand and others (on Demand)
- Dimensions (l x w x h) : 36 x 18 x 10 mm
- Serial Interface Format: 9600Baud, No Parity, 8 Data bits, 1 Stop bit

Note: The TTL RS-232 Interface can not be connected directly to a PC COM port. Therefore the signal must be converted to RS 232 level for PC connection.

This Firmware has the following Functions:

Read Tag-ID

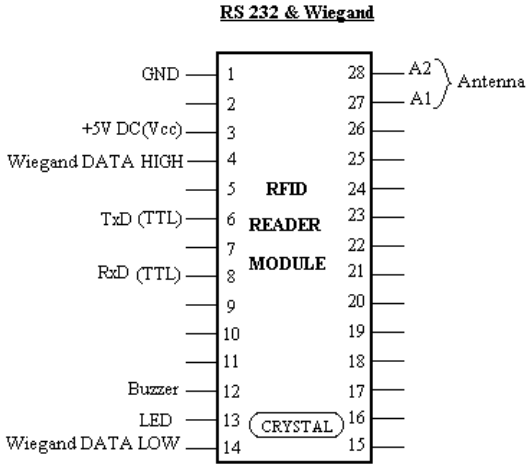
Send Tag-ID in ASCII Format through the Serial/ Wiegand Interface.

Sequence starts with Tag ID follows from Carriage-Return/Line-Feed (0Dh 0Ah), Example: '041201938C<CR><LF>'

Applications:

Our readers can be used for Access control, Time & Attendance, Vending machines, Industrial and other applications where Reading the data from the Card only is required

RFID 125 Reader Module Pin Diagram & Description



6.SOFTWARE DESCRIPTION

6.1 ACCESS RASPBERRY PI ON LAPTOP USING WI-FI

- Raspberry Pi is a small computer which needs a display to access Raspberry Pi Home (CLI or GUI). So, we need external display to access Raspberry Pi.
- If we have display/TV then we can connect Raspberry Pi to the display using HDMI or VGA cable. But, if we don't have a display, then we can access Raspberry Pi using Laptop's Screen. This can be done by using Raspberry Pi Wi-Fi.
- To access Raspberry Pi, we need to connect Raspberry Pi to a wifi network after boot so that we can access it on Laptop using wi-fi network.
- When Raspberry Pi is connected to the wifi network, we can access it on Laptop by finding its IP address. This method is suitable when we don't have display for logging into Raspberry Pi.

How to Connect Raspberry Pi to the wifi without using display?

After downloading Raspbian on SD card, open SD card in laptop and then open directory given below:

```
sudo nano /etc/wpa_supplicant/wpa_supplicant.conf
```

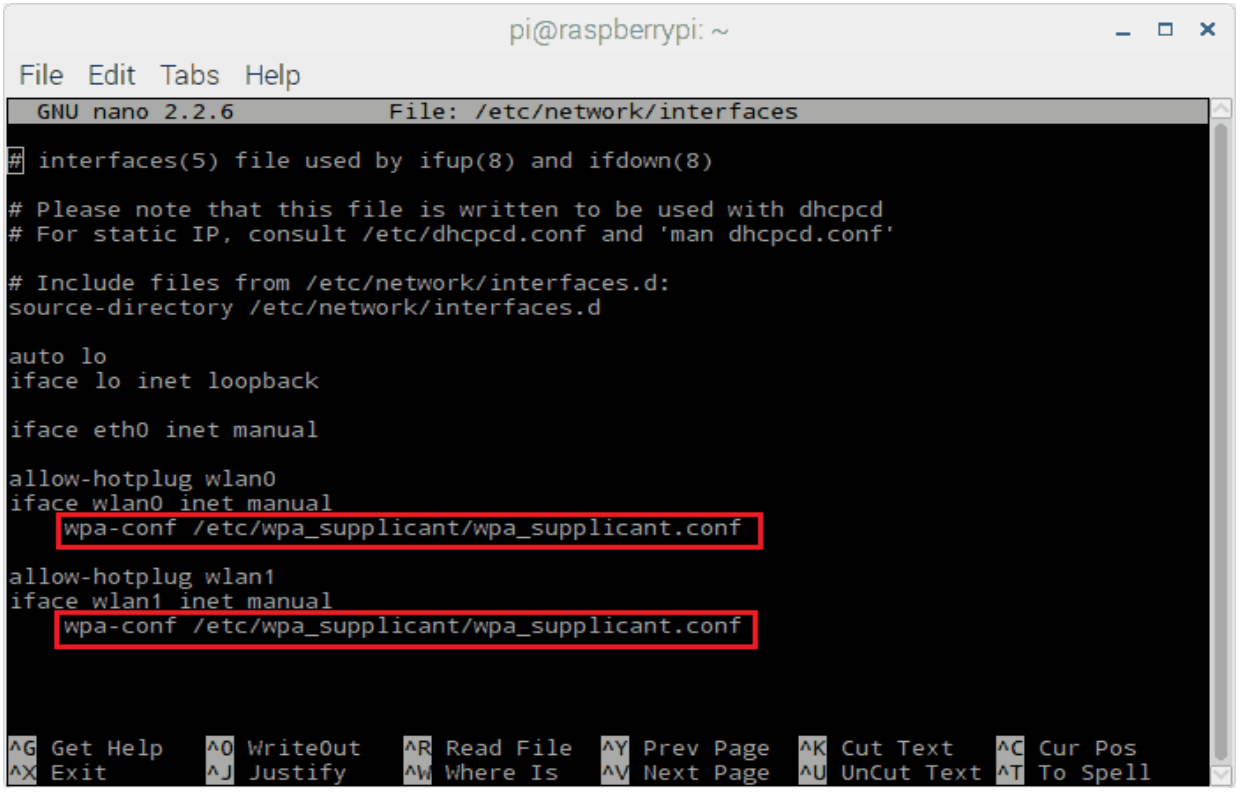
Add following details in the opened file,

```
ctrl_interface=DIR=/var/run/wpa_supplicant Group=netdev
update_config=1
country=US
network {
        ssid="Enter your SSID"
        psk="Enter your password"
        key_mgmt=WPA-PSK
}
```

Then, save above file using Ctrl+X.

Now, open following directory and add highlighted line shown in below image,

sudo nano /etc/network/interfaces



Save the above file.

SSH remotet login

Now, we have to login to Raspberry Pi using SSH.

Also for remote login into raspberry using SSH, we need to enable SSH on Raspberry Pi.

To enable SSH, just add a file named ssh with no extension onto the boot partition of SD card. We don't need to write anything in ssh file.

Now, eject the SD card and insert it into Raspberry Pi Board and power-on Raspberry Pi.

Raspberry Pi will now connect to WiFi network automatically after booting. Now, we can find the IP address of Raspberry Pi using **Advance IP scanner**. Advance IP scanner scans the network and provides list of connected device. In that we will get IP address of

After getting IP address of Raspberry Pi, use Putty (SSH) for logging into the raspberry Pi given in below demo,

Now, we can access Raspberry Pi CLI (Command Line Interface). If we have to access Raspberry Pi GUI then we can access it using VNC viewer. Before using VNC viewer, we need to enable it using command.

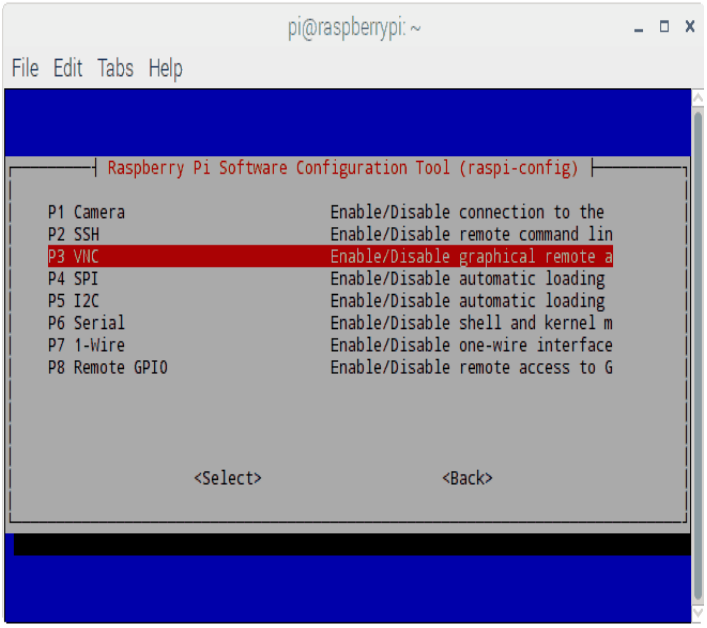
6.2 VNC (Virtual Network Computing) ViewerEnabling

To access Raspberry Pi's Graphical user interface, we can use VNC viewer which allows us to control the Raspberry Pi home remotely using Mobile, Laptop, etc. With VNC server, we can see Raspberry Pi home on our computer or mobile.

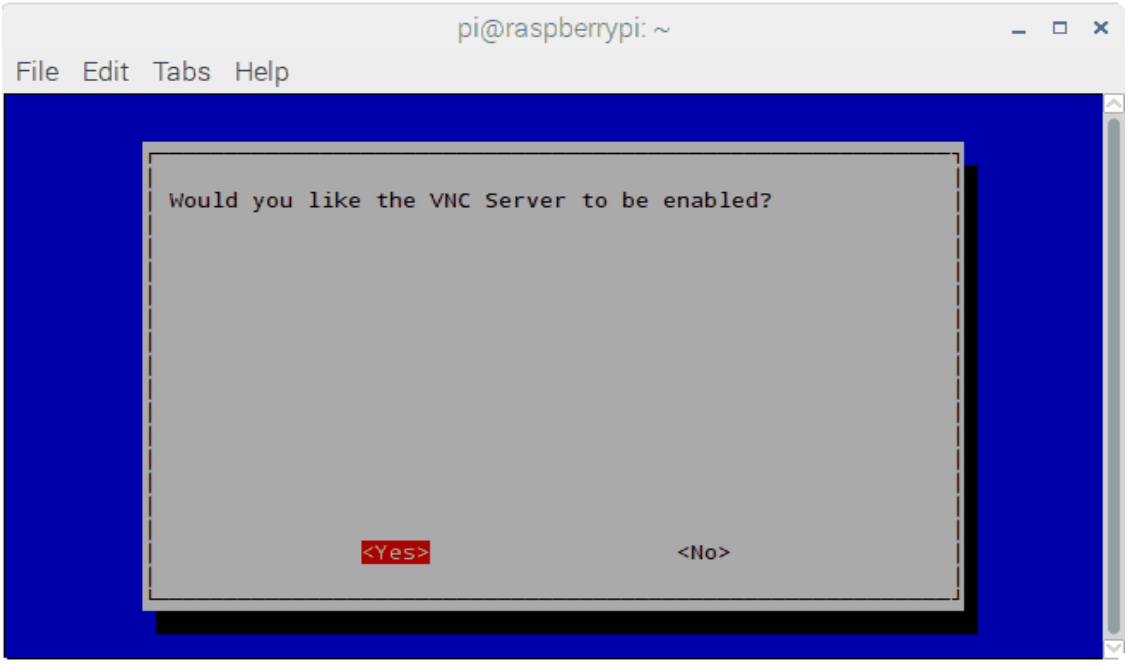
To enable VNC viewer on Raspberry Pi use CLI (command line interface) and following few steps given below,

```
sudo raspi-config
```

Now, select **Interfacing option** for enabling VNC.



Then enable VNC as shown in below image,

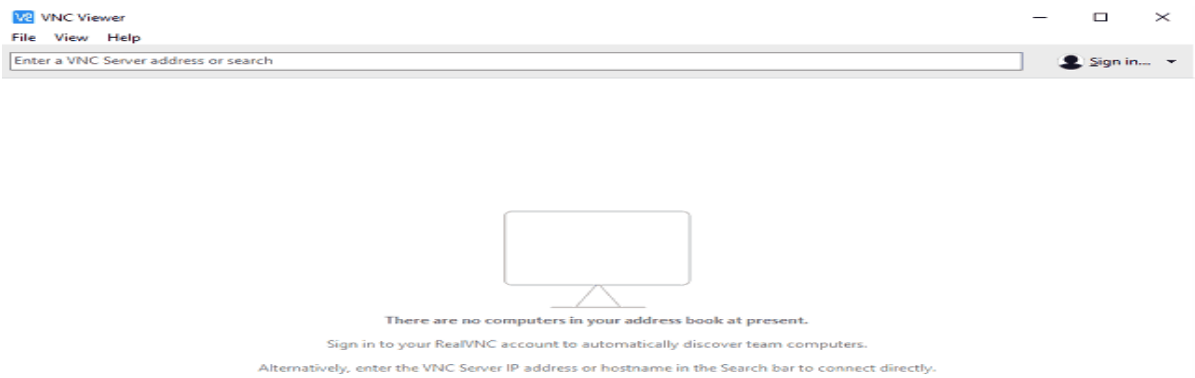


Now, reboot raspberry pi to apply changes.

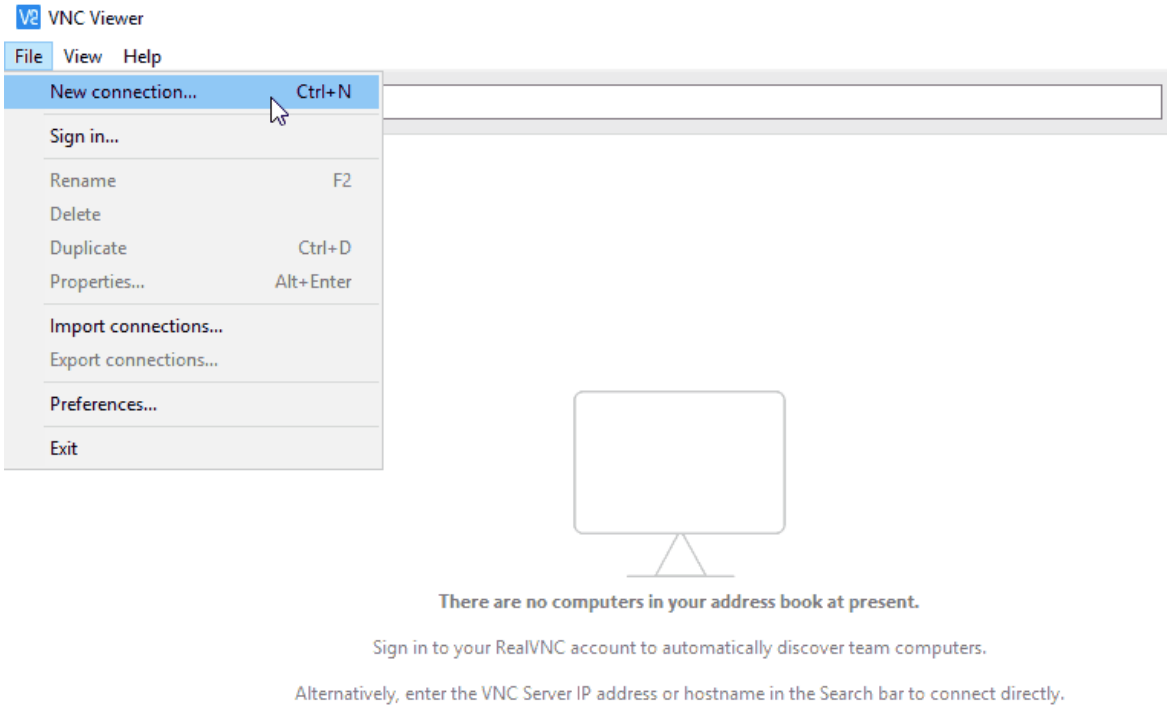
6.3 Connecting to Raspberry Pi with VNC Viewer

Now, we can connect to Raspberry Pi using VNC Server. For login to Raspberry Pi using VNC, Download and Install VNC viewer application on laptop.

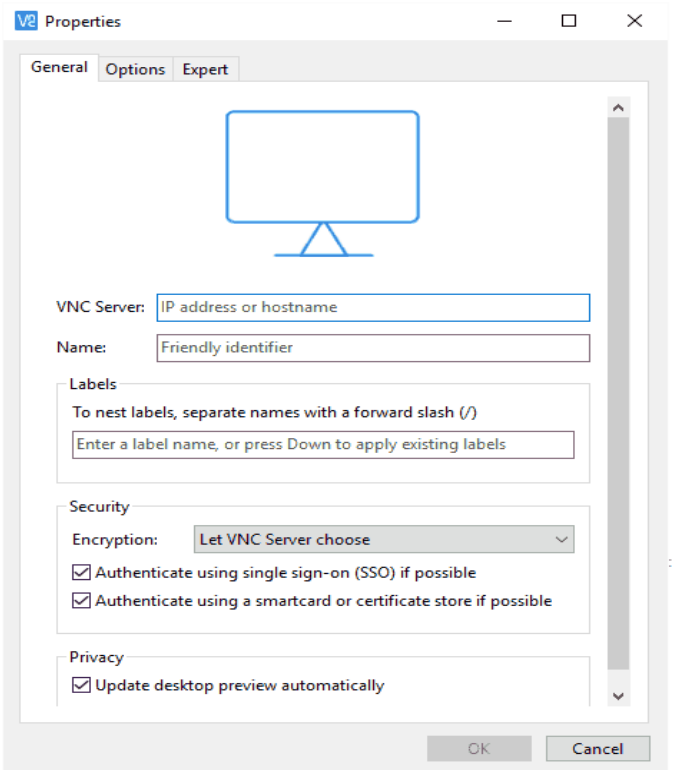
After installing VNC viewer application, the application window will appear as shown below,



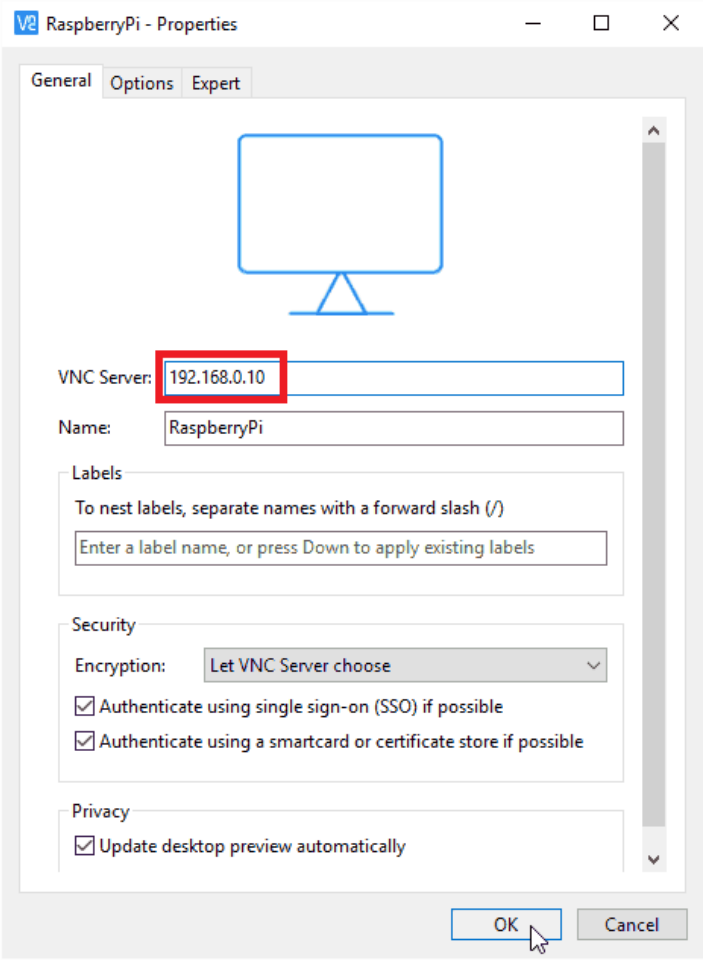
Now, select **File** option and in that select **new connection** as shown below,



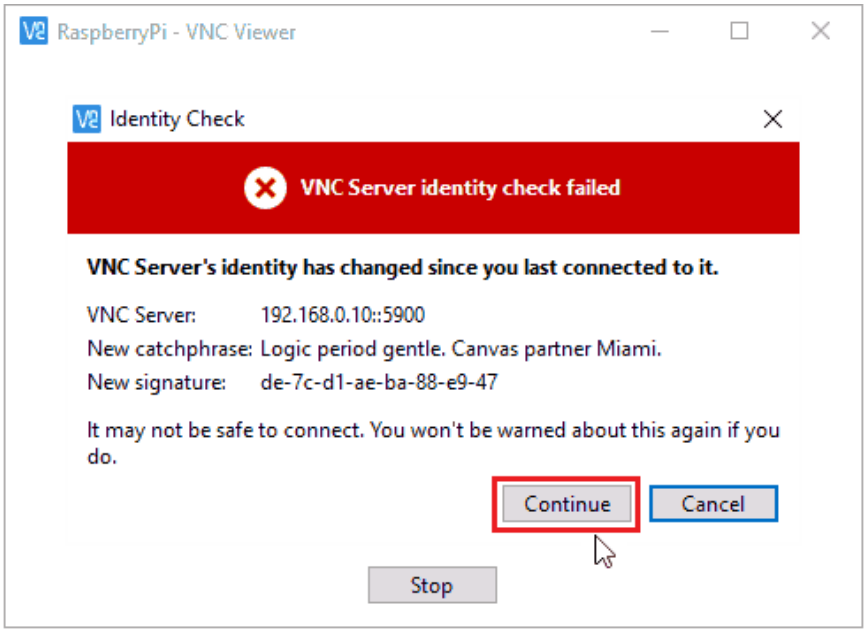
Then, following window will pop-up



Enter IP of your Raspberry Pi which was found by Advance IP scanner and provide any name as shown below,

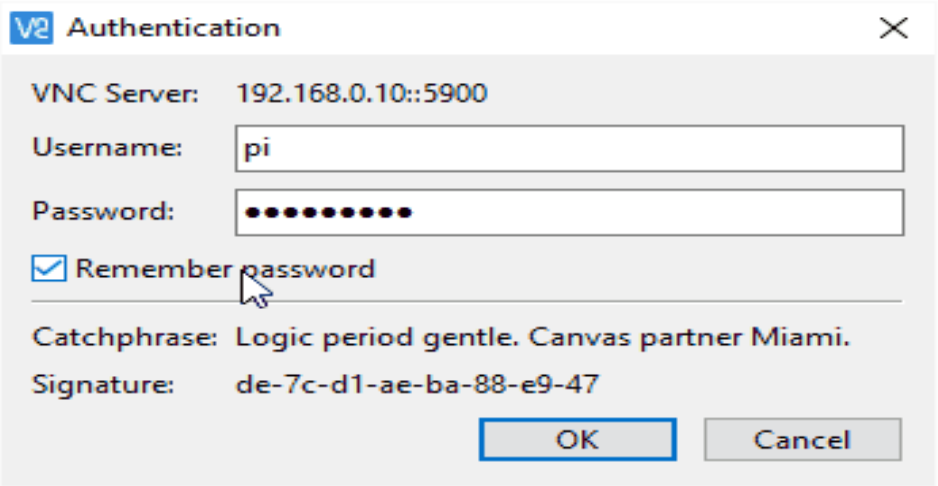


Then a small window will pop-up whi



And select continue.

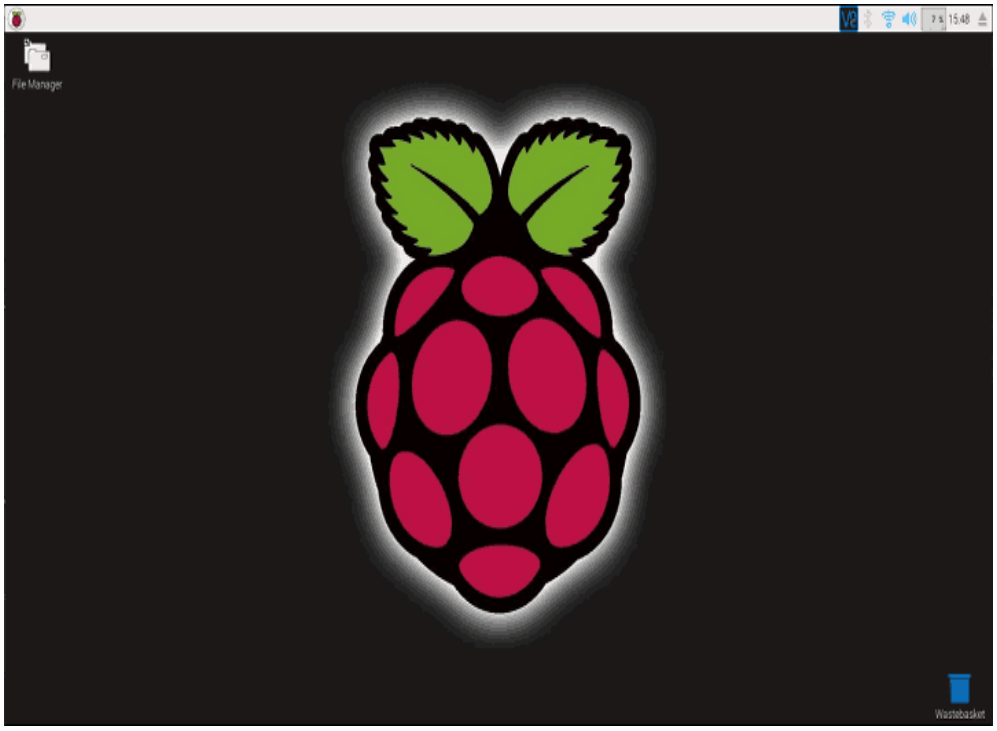
Then, add login details as shown below,



Now, we successfully logged into the Raspberry Pi.

We can see the CLI (Command Line Interface) of raspberry Pi. To access Raspberry Pi in GUI mode, enter following command

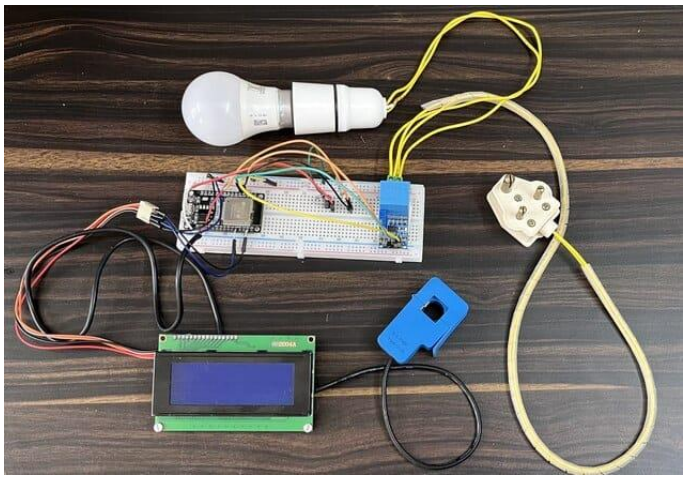
and we will get GUI home screen of Raspberry Pi as shown below.



Now, we can access Raspberry Pi home screen on Laptop's display.

7.RESULT

The result is the identification of limitations in the existing residential energy monitoring system, primarily relying on traditional electricity meters. These meters, while effective at measuring total energy consumption, lack granularity and accessibility in the data they provide. This limitation hampers efforts towards proactive energy management and optimization within residential settings, potentially hindering initiatives aimed at promoting energy efficiency and sustainability.



By recognizing these limitations, there arises a need for a more advanced and user-friendly energy monitoring solution. The proposed Raspberry Pi-based web-enabled energy monitoring system seeks to address these challenges by offering enhanced functionality, accessibility, and real-time insights into energy usage patterns. With its ability to provide detailed data granularity and user-friendly accessibility through a web-based interface, the proposed system empowers users to make informed decisions regarding energy usage optimization and promotes proactive energy management efforts.

In essence, the result of recognizing the limitations of the existing system is the proposal of an innovative solution that has the potential to revolutionize residential energy monitoring, paving the way for increased energy efficiency and sustainability. This solution is visualized through a system architecture diagram, illustrating the integration of Raspberry Pi, non-intrusive current sensors, web-based interface, and database to create a comprehensive energy monitoring system.

8.CONCLUSION

In conclusion, the existing residential energy monitoring system, predominantly relying on traditional electricity meters, demonstrates notable limitations, primarily regarding data granularity and accessibility. While these meters effectively measure total energy consumption, they lack the capability to provide detailed insights into energy usage patterns. This deficiency poses challenges for proactive energy management and optimization within residential settings, potentially impeding efforts to promote energy efficiency and sustainability.

By acknowledging these limitations, there emerges a pressing need for a more sophisticated and user-friendly energy monitoring solution. The proposed Raspberry Pi-based web-enabled energy monitoring system offers a promising response to these challenges. By integrating non-intrusive current sensors with Raspberry Pi technology and a web-based interface, this system introduces an innovative approach to energy monitoring.

The proposed system empowers users with real-time insights into their energy usage patterns, enabling informed decision-making and proactive energy management efforts. With enhanced data granularity and user-friendly accessibility through the web-based interface, users can easily visualize and interpret their energy consumption data. This fosters a deeper understanding of energy usage patterns, facilitating the implementation of effective energy-saving strategies and promoting sustainable practices.

Furthermore, the proposed system's scalability and flexibility allow for future enhancements and customization to meet evolving needs and technological advancements in energy monitoring. Through continuous monitoring and analysis of energy consumption data, users can identify trends, optimize usage patterns, and contribute to overall energy efficiency and sustainability goals.

In summary, the proposed Raspberry Pi-based web-enabled energy monitoring system represents a significant step forward in residential energy monitoring. By addressing the limitations of the existing system and offering enhanced functionality, accessibility, and real-time insights, this system has the potential to revolutionize energy management practices in residential settings, ultimately leading to increased energy efficiency and sustainability.

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