

CLIMATIC DATA ACQUISITION USING SENSOR INTERFACED RASPBERRY PI SYSTEM

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in

Electronics and Communication Engineering

By

THUMMA AYYAPPA REDDY (Reg.No. 39130479)
VULLI SATYA VEERA MANIKANTA (Reg.No. 39130516)



DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

**JEPPIAAR NAGAR, RAJIV GANDHISALAI,
CHENNAI - 600119**

APRIL 2023



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with 'A' grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai - 600 119

www.sathyabama.ac.in



DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Final Year Project Report is the bonafide work of **THUMMA AYYAPPA REDDY (REG NO: 39130479) AND VULLI SATYA VEERA MANIKANTA (REG NO: 39130516)** who have done the project work as an individual who carried out the project entitled "CLIMATIC DATA ACQUISITION USING SENSOR INTERFACED RASPBERRY PI SYSTEM" under my supervision from January 2023 to April 2023.

Dr. D. Anbarasi Jebasevi
15/04/23

Internal Guide

Dr. G.D. ANBARASI JEBASELVI M.E., Ph.D.

Dr. G.D. Anbarasi Jebasevi
15/4/2023

Head of the Department

Dr. T. RAVI, M.E., Ph.D.

Submitted for Viva voce Examination held on _____

Dr. T. Ravi
19/4/23
Internal Examiner

Dr. T. Ravi
19/4/23
External Examiner

DECLARATION

We, **THUMMA AYYAPPA REDDY** (REG NO: 39130479) and **VULLI SATYA VEERA MANIKANTA** (REG NO:39130516), hereby declare that the Project Report on “**CLIMATIC DATA ACQUISITION USING SENSOR INTERFACED RASPBERRY PI SYSTEM**” done by us under the guidance of **Dr.G.D.ANBARASI JEBASELVI M.E.Ph.D.**, at Sathyabama Institute of Science and technology is submitted in partial fulfilment of the requirements of the award of Bachelor of Engineering degree in **Electronics and Communication Engineering**.

DATE:

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATES

1. 
2. 

ACKNOWLEDGEMENT

I am pleased to acknowledge our sincere thanks to **Board of Management of SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr.N.M. NANDHITHA M.E., Ph.D., Dean**, School of Electronics, **Dr.T.RAVI M.E., Ph.D.**, Head of the Department of Electronics and Communication Engineering for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to our Project Guide **Dr.G.D.ANBARASI JEBASALVI M.E., Ph.D.**, for her valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.

I wish to express our thanks to all Teaching and Non-teaching staff members of the **Department of Electronics and Communication Engineering** who were helpful in many ways for the completion of the project.

ABSTRACT

Weather is an important factor in daily life and plays an important part in many activities like farming, industry etc. So sometimes, it may be an absolute need to know about immediate weather conditions. However, the current ways to access weather report are through television or using bulk systems, both of which are not all time available or convenient. This proposed work is an advanced solution for monitoring the weather conditions at a particular place and make the information visible anywhere in the world. The technology behind this is Internet of Things (IoT), which is an advanced and efficient solution for connecting the things to the internet and to connect the entire world of things in a network. Here things might be whatever like electronic gadgets, sensors and automotive electronic equipment. The system deals with monitoring and controlling the environmental conditions like temperature, relative humidity, light intensity and CO level with sensors and sends the information to the web page and then plot the sensor data as graphical statistics. The data updated from the implemented system can be accessible in the internet from anywhere in the world.

Table of Contents

Chapter No	TITLE	Page No.
	ABSTRACT	v
	LIST OF FIGURES	viii
1	INTRODUCTION	1
2	LITERATURE SURVEY	2
	2.1 Inferences from Literature Survey	
3	AIM AND OBJECTIVE	
	3.1 Aim of the Project	6
	3.2 Objective of the Project	6
	3.3 Working	7
4	DESCRIPTION OF PROPOSED SYSTEM	
	4.1 Methodology	9
	4.2 Existing System	9
	4.3 Description of Proposed Model/System	9
	4.4 System Work Flow	10
	4.5 Safety Consideration	10
	4.6 Financial report on estimated costing	11
5	IMPLEMENTATION DETAILS	
	5.1 Hardware Required	13
	5.2 Software Requirements	32
6	RESULTS AND DISCUSSION	33
7	CONCLUSION	34
	7.1 Conclusion	36
	7.2 Future work	37
	7.4 Implementation Issues	38
	REFERENCES	39
	APPENDIX	

LIST OF FIGURES

FIG.NO	TITLE	PAGE NO
3.1	Block Diagram of Prototype	8
5.1	Raspberry Pi	14
5.2	Raspberry Pi Pin Discription	15
5.3	Raspberry Pi pin Reference	16
5.4	DHT11 Sensor	17
5.5	DHT11 Signal	18
5.6	Light Dependent Resistor	19
5.7	Construction of LDR	20
5.8	LDR Working Principle	21
5.9	Light Dependent Resistor	22
5.10	BMP180 Pressure Sensor	23
5.11	I2c Protocol	24
5.12	Timing diagram for starting	26
5.13	MQ2 Sensor	26
5.14	MQ2 Sensor Cofiguaration	27
5.15	Typical Sensitivity Character	29
5.16	MQ2 Part Description	29
5.17	Single Channel Relay	30
5.18	Relay Working	30
5.19	Relay Module Pins	31
5.20	LED	31

CHAPTER 1

INTRODUCTION

Nowadays, the application of Internet of Things (IoT) affects all habitual domains. The invented IoT systems are attempted to control, manage, and monitor human usual actions, environmental parameters, or animal movements. So, all these innovations are developed to facilitate human work and make the life easier than before. In this stage, the environmental monitoring systems are invented to measure and control the environment parameters. For many years, humans try to understand their environment. So, humans have invented many objects to measure various parameters. For example, humans have created thermometer, barometer, and pyrometer for measuring temperature, atmospheric pressure, and solar system radiation, respectively. However, those traditional tools must be used locally. On the other hand, with the invention of IoT, humans can measure all environment parameters remotely. Thus, the procedure of quantifying and measuring environmental parameters has become simple than in previous days.

Currently, as stated above there aren't many cost effective systems which can be deployed in numbers across the city to relay instantaneous and localized weather from within the city. This project describes a weather observation system for the Raspberry Pi, utilizing a set of pi boards. There are two sets of boards- central processor and sensor boards. Each sensor board is in turn interfaced to the DHT-11 humidity sensor and also the DS18B20 temperature sensor. A single pi acts as a centralized weather station and all other sensor pi boards relay their data to this centralized board, which organizes the data and logs them into tables or graphs based on user requirements. The data logged is also uploaded to a cloud server so that it can be accessed anywhere at any time.

In weather monitoring, factors such as temperature, humidity and pressure are to be measured for this project, thus sensors have always been given the task for doing so. Main focus of project is to develop compact and powerful weather station. Data acquisition systems are very popular for consumer and industrial applications. Raspberry Pi, acting as data logger process the converted output of sensors from analog to digital. The logged data can then be transferred to a desktop. So by using easily obtained components and less complicated circuitry powerful weather station can be build Now a day's various weather factors like wind and many other cause great impact on humans day to day life.

The Motivation of Project is in recent developments in wireless and micro sensor technologies have provided foundation platforms for considering the development of effective modular systems. They offer the prospect of flexibility in use, and network scalability. The Raspberry Pi has proved to be ideal as the core of such a system. There are many other practical uses for the environment monitor including monitoring of temperature and humidity in a home, outbuilding, greenhouse, or even a museum. Although this has been designed for passive monitoring it would be possible to have this used for actively notifying someone of a temperature change.

CHAPTER 2

2.1 LITERATURE SURVEY

- **A F Pauzi and M Z Hasan** et al. in [1] presents Weather forecast these days is unpredictable too be exact because of the climate changes drastically over weather. In cause of that, Weather Reporting System is mostly used to monitor the continuously changing climatic and weather conditions over controlled areas likes house, industry, agriculture and etc. in real time monitoring. Internet of Things (IoT) platform use is Thing Speak it's should be able displaying the weather parameters and the information will visible wherever in the world and it's also displaying on the OLED with two-way microcontroller communication via Wi-Fi hotspots.
- **Puja Sharma and Shiva Prakash** et al. in [1] describes live environmental condition is one of the biggest issues because there is an IoT of hurdles arrives when live environmental condition is measured. The proposed system will remove this problem since it monitors real- time weather conditions. In this proposed work we will monitor the live weather's parameter of the Gorakhpur Region. The proposed system will work on the client- server architecture model using IoT. The system is organized in Two-tier Architecture. Our proposed system contains a various sensor which will monitor the temperature of the region, humidity, Rain value and pressure of the system.
- **Jamal Mabrouki, Mourade Azrour, Driss Dhiba, Yousef Farhaoui, and Souad El Hajjaji** proposed that In recent years, the monitoring systems play significant roles in our life. So, in this paper, we propose an automatic weather monitoring system that allows having dynamic and real-time climate data of a given area. The proposed system is based on the internet of things technology and embedded system. The system also includes electronic devices, sensors, and wireless technology. The main objective of this system is sensing the climate parameters, such as temperature, humidity, and existence of some gases, based on the sensors. The captured values can then be sent to remote applications or databases. Afterwards, the stored data can be visualized in graph and tables form.

- **Girija C, Harshalatha H, Andreanna Grace Shires, Pushpalatha H P** presents that By keeping the embedded devices in the environment for monitoring enables self-protection (i.e., smart environment) to the environment. To implement this need to deploy the sensor devices in the environment for collecting the data and analysis. By deploying sensor devices in the environment, we can bring the environment into real life i.e., it can interact with other objects through the network. Then the collected data and analysis results will be available to the end user through the Wi-Fi.
- **Ruchi Mittal and Bhatia** propose a system in which they detect irregular patterns of sensory data with respect to time and space. They design a system which continuously queries and monitors sensor data to detect any deviations from the norm. This is essential in detecting a faulty sensor node and ensuring it can be quickly replaced. This system is especially helpful when detecting environmental activity like forest. In order to achieve desired results, Data preprocessing and sensor data clustering is used. In data preprocessing, the sensor data is cleaned by putting in missing values and removing any unwanted data.
- **Ms. Padwal S. C.** et al. have proposed the system to implement a WSN platform that can be used for a range of longterm environmental monitoring for IoT applications. This paper presents functional design of WSN for IoT application.
- **Tamilarasi B.** et al. have proposed the system that deals with the functional design and implementation of WSN platform, which can be used for long-term environmental monitoring in IoT application.
- **Nikhil Ugale** et al. have proposed the system based on IoT for environmental condition monitoring in homes. The proposed system use different sensors light, temperature, level and humidity to collect the data to monitor the environmental conditions and also to detect any fault in devices. PIC microcontroller is used to control and monitor all the sensors connected to it. Different sensors are placed against different devices to check the functionality of the devices. Once device turn on sensor will sense the functionality of the device if it is not working properly then automatically e-mail or SMS will send to the service provider as well as user. Also one more functionality is added that device can turn on and off through cell phone as well as to get full functionality details of device through SMS. This system has successfully demonstrated a new IoT architecture that lets existing embedded systems be

integrated into the IoT network. “Internet of Things” is very effective for home automation and effective utilization of home appliances. Using this Low-cost system device can be connected easily and corresponding information can be globally accessible.

- **Kondamudi Siva Sai Ram** et al. have proposed the system is an advanced solution for monitoring the weather conditions at a particular place and make the information visible anywhere in the world. Internet of Things (IoT) technology is used for this. This system is designed for monitoring and controlling the environmental conditions like temperature, relative humidity, light intensity and CO2 level with sensors and sends the information to the web page and then sensor data is plot in graphical form. Output from the system can be accessible in the internet from anywhere in the world. In this system microcontroller (LPC2148) is used as a main processing unit for the entire system and all the sensor and devices can be connected with the microcontroller. Data from the sensors can be retrieved by the microcontroller and this sensor data is sent to the internet through ESP8266 Wi-Fi module having TCP/IP protocol stack integrated on chip connected to it.

CHAPTER 3

AIM AND WORKING

3.1 AIM AND OBJECTIVE

To increase the efficiency of the System we are upgrading from Arduino Uno board to Raspberry pi board its Special designed for IoT applications and also upgrading Arduino IoT cloud platform its reliable and secure for tracking our own weather data. Provide a remote monitoring and controlling application for analysis of a particular sensor data.

Allow the user to manipulate the data and take some necessary actions. To provide very user-friendly interface for interacting with given data by sensors. The monitoring framework incorporates sensors like fire sensor, smoke sensor, ultrasonic sensor, moisture and temperature sensor, current and voltage with Wi-Fi module for control operations. With the benefits of unusual exercises, reasonable activities will be activated.

3.2 OBJECTIVE

The Primary motivation behind taking up this project is the large utility of remote weather monitoring in various areas ranging from house hold applications to industrial applications. The weather conditions at a particular location can be monitored from a distant place by remote user and eliminates the physical presence in order to know the climatic conditions at the location by using wireless technology. Person's physical presence may be dangerous in certain conditions like leakage of poisonous gases. The objective of this project is to design a real time weather monitoring system to measure weather parameters from remote location in which Raspberry Pi is main part of the system.

3.3 WORKING

The implemented system consists of a Raspberry pi as a main processing unit for the entire system and all the sensor and devices can be connected with the Raspberry pi. The sensors can be operated by the Pi to retrieve the data from them and it processes the analysis with the sensor data and updates it to the internet through Wi-Fi module connected to it. The gas sensor used to monitor the gas level in atmosphere, the DHT11 used to measures the temperature as well as humidity in the environment. The sensor used to monitor temperature level and Humidity level sensor is used to monitor the air moisture level. The smoke sensor (CO₂) is used to measure the poisons gases. LDR is used to identify the sun light, when the sun light below the threshold level then turn on the light. If any critical condition automatically sends the alert message. The pressure sensor working was so fascinating it will calculate the pressure in hector Pascal with this calculation we know the day is sunny or cloudy when the pressure less than normal day the chances will be high for rain fall else the its greater than threshold the chances of sunny.

3.3.1 APPLICATIONS

- It is used for Weather Monitoring
- This model helps in Atmosphere Changes detection

3.3.2 ADVANTAGES

- This Project is Easy to Operate the System
- It has Low-Cost Maintenances

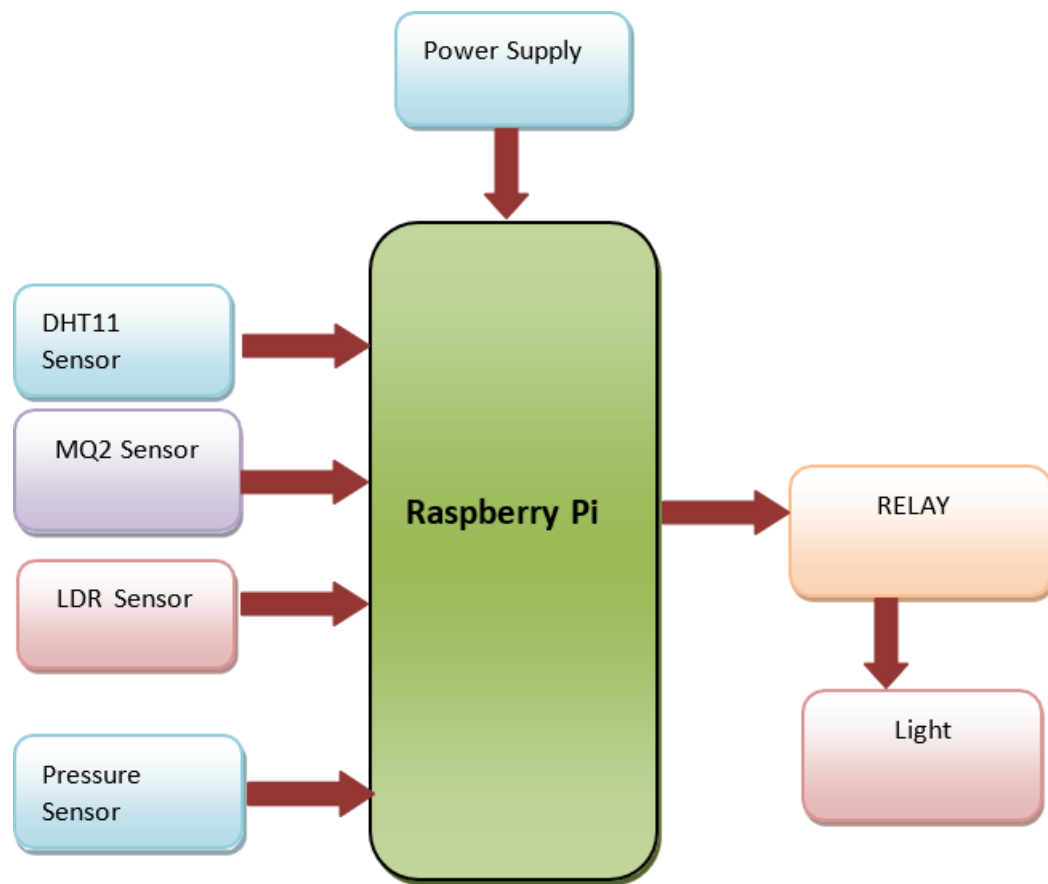


Fig 3.1: Block Diagram of Prototype

CHAPTER 4

METHODOLOGY

4.1 METHODOLOGY

In this chapter, the procedure for design and development of Raspberry Pi Based Weather Reporting Over IOT is explained. The block diagram of the system is shown. The schematic of embedded control hardware circuit is shown in diagram. The hardware and software description of the data acquisition system for monitoring physical parameter are described below.

4.2 EXISTING SYSTEM:

Existing system model is presented in uses ZigBee based wireless sensor networks to monitor physical and environmental conditions with thousands of application in different fields.

4.2.1 Demerits:

- Short distance communication
- Lot of hardware requirements

4.3 PROPOSED SYSTEM:

The implemented system consists of a raspberry pi as a main processing unit for the entire system and all the sensor and devices can be connected with the microcontroller. The sensors can be operated by the microcontroller to retrieve the data from them and it processes the analysis with the sensor data and updates it to the internet through Wi-Fi module connected to it.

- The pressure sensor used to monitor the pressure level sensor
- The temperature sensor used to monitor temperature level.
- The water level sensor is used to monitor the rain fall.
- Humidity level sensor is used to monitor the air moisture level.

- The smoke sensor is used to measure the poisons gases and rain fall sensor is used to measures the content.
- The LDR is used to identify the sun light, when the sun light below the threshold level then turn on the light.
- If any critical condition automatically send the alert message.

4.4 SYSTEM WORKFLOW:

Connect the sensors to the appropriate GPIO pins or I2C pins on the Raspberry Pi, following the manufacturer's instructions and using suitable interface circuitry if required. Install the necessary software components on the Raspberry Pi, including the operating system, Python libraries, and data logging and analysis tools. Write Python scripts to interface with the sensors and read the climatic data. Store the acquired data in a file or a database for further analysis. Set up a data logging interval based on your requirements, such as every minute or every hour, to continuously acquire data from the sensors. Analyze the acquired data using Python data analysis libraries to generate visualizations or insights about the climate data. Optionally, you can implement additional features such as data alerts, data transmission to a remote server, or data visualization on a web dashboard.

4.5 SAFETY CONSIDERATIONS:

- Follow appropriate safety precautions when working with electronic components, such as wearing anti-static wristbands and avoiding short circuits.
- Be mindful of the power requirements of the sensors and the Raspberry Pi, and use suitable power sources and voltage regulators to prevent damage to the components.
- Take into account environmental factors, such as temperature and humidity, when placing the sensors to ensure accurate readings.
- Follow local laws and regulations regarding data acquisition, especially if you are collecting data from public spaces or private properties.

Overall, a climatic data acquisition system using a Raspberry Pi and sensor interfacing can be an exciting project that allows you to collect, analyze, and visualize climate data in a DIY setup. Remember to plan and implement appropriate safety measures and follow best practices for data acquisition and analysis.

4.6 FINANCIAL REPORT ON ESTIMATED COSTING

Raspberry Pi hardware: The cost of the Raspberry Pi board itself can vary depending on the model and specifications chosen. Raspberry Pi boards are available in different versions with varying capabilities and price points. As of September 2021, the cost of a Raspberry Pi board can range from \$10 to \$75, depending on the model.

Sensors: The cost of sensors can vary greatly depending on the type, accuracy, and functionality of the sensors chosen for climate data acquisition. Sensors for measuring temperature, humidity, pressure, wind speed, etc., are commonly used in climatic data acquisition systems. The cost of sensors can range from \$5 to \$100 or more per sensor, depending on the brand, type, and quality.

Interface hardware: Depending on the type of sensors chosen, additional interface hardware may be required to connect the sensors to the Raspberry Pi board. This can include analog-to-digital converters (ADCs), digital-to-analog converters (DACs), or other interface components. The cost of interface hardware can vary depending on the specific requirements and complexity of the system.

Power supply: Raspberry Pi systems typically require an external power supply for operation. The cost of a suitable power supply unit (PSU) will depend on the power requirements of the Raspberry Pi board and other components in the system.

Storage: Depending on the amount of data to be collected and stored, additional storage may be required. This can include microSD cards or external storage devices such as USB drives or hard drives. The cost of storage will depend on the storage capacity needed and the type of storage media chosen.

Enclosure and peripherals: Depending on the setup and requirements, an enclosure for the Raspberry Pi board and sensors may be needed to protect them from environmental factors. The cost of an enclosure will depend on the type and quality chosen. Additionally, peripherals such as a keyboard, mouse, monitor, and cables may be required for initial setup and configuration, which will add to the overall cost.

Software: Raspberry Pi systems typically run on open-source software such as Raspbian, which is a free operating system based on Linux. However, depending on the specific requirements of your project, additional software or tools for data acquisition, processing, and analysis may be needed. The cost of software will depend on the specific applications and licenses chosen.

Labor and setup costs: Labor and setup costs associated with assembling and configuring the Raspberry Pi system, interfacing sensors, installing software, and conducting testing and calibration may also need to be considered. These costs will depend on the expertise and labor rates of the personnel involved.

CHAPTER 5

HARDWARE AND SOFTWARE IMPLEMENTATION

5.1 HARDWARE REQUIRED

- Raspberry Pi
- DHT11 Sensor
- LDR Sensor
- BMP180 Pressure Sensor
- MQ2 Sensor
- Relay
- LED
- Battery
- Power Supply

5.1.1 Raspberry Pi

Raspberry Pi 3 Model B was released in February 2016 with a 1.2 GHz 64-bit quad core ARM Cortex-A53 processor, *on-board* 802.11n Wi-Fi, Bluetooth and USB boot capabilities. On PI DAY 2018, the Raspberry Pi 3 Model B+ was launched with a faster 1.4 GHz processor, a three-times faster gigabit Ethernet (throughput limited to ca. 300 Mbit/s by the internal USB 2.0 connection), and 2.4 / 5 GHz dual-band 802.11ac Wi-Fi (100 Mbit/s).[26] Other features are Power over Ethernet (PoE) (with the add-on PoE HAT), USB boot and network boot (an SD card is no longer required).

The Broadcom BCM2835 SoC used in the first generation Raspberry includes a 700 MHz ARM1176JZF-S processor, VideoCore IV graphics processing unit (GPU), and RAM. It has a level 1 (L1) cache of 16 KB and a level 2 (L2) cache of 128 KB. The level 2 cache is used primarily by the GPU. The SoC is stacked underneath the RAM chip, so only its edge is visible. The ARM1176JZ(F)-S is the same CPU used in the original iPhone,[53] although at a higher clock rate, and mated with a much faster GPU



Fig 5.1 Raspberry Pi

The earlier V1.1 model of the Raspberry Pi 2 used a Broadcom BCM2836 SoC with a 900MHz 32-bit, quad-core ARM Cortex-A7 processor, with 256 KB shared L2 cache.[54] The Raspberry Pi 2 V1.2 was upgraded to a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor,[24] the same one which is used on the Raspberry Pi 3, but underclocked (by default) to the same 900 MHz CPU clock speed as the V1.1. The BCM2836 SoC is no longer in production as of late 2016. The Raspberry Pi 3 Model B uses a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor, with 512 KB shared L2 cache. The Model A+ and B+ are 1.4 GHz

The Raspberry Pi 4 uses a Broadcom BCM2711 SoC with a 1.5 GHz (later models: 1.8 GHz) 64-bit quad-core ARM Cortex-A72 processor, with 1 MB shared L2 cache. Unlike previous models, which all used a custom interrupt controller poorly suited for virtualization, the interrupt controller on this SoC is compatible with the ARM Generic Interrupt Controller (GIC) architecture 2.0, providing hardware support for interrupt distribution when using ARM virtualization capabilities.

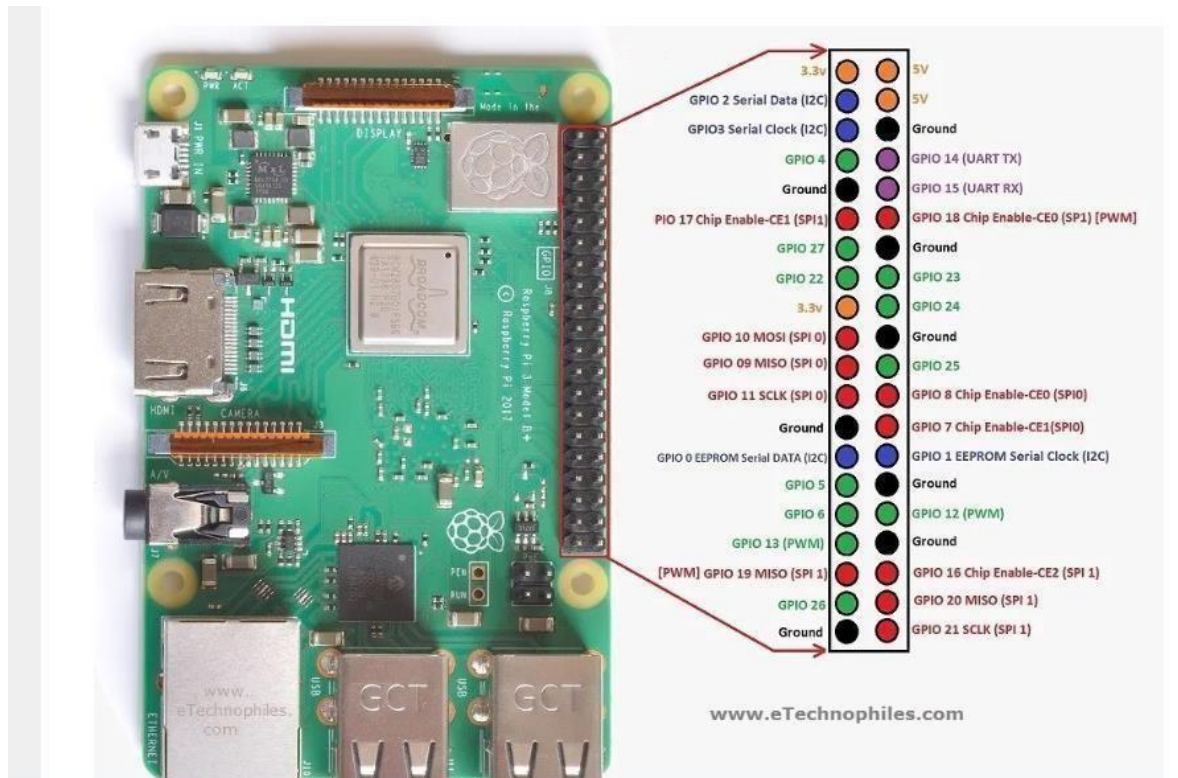


Fig:5.2 : Raspberry Pi Pin Description

Table 5.1 Technical specifications

Raspberry Pi	Raspberry Pi 3
Operating Voltage	3V
Input Voltage (recommended)	5V,2A Power source
Input Voltage (limit)	3-5V

Digital I/O Pins	17
PWM Digital I/O Pins	4
Analog Input Pins	0
DC Current per I/O Pin	16 mA
DC Current for 3.3V Pin	50mA
Flash Memory	8GB eMMC
DRAM	1GB
Clock Speed	700MHz to 1.4GHz
Length	68.6 mm
Width	53.4 mm
Weight	42 g

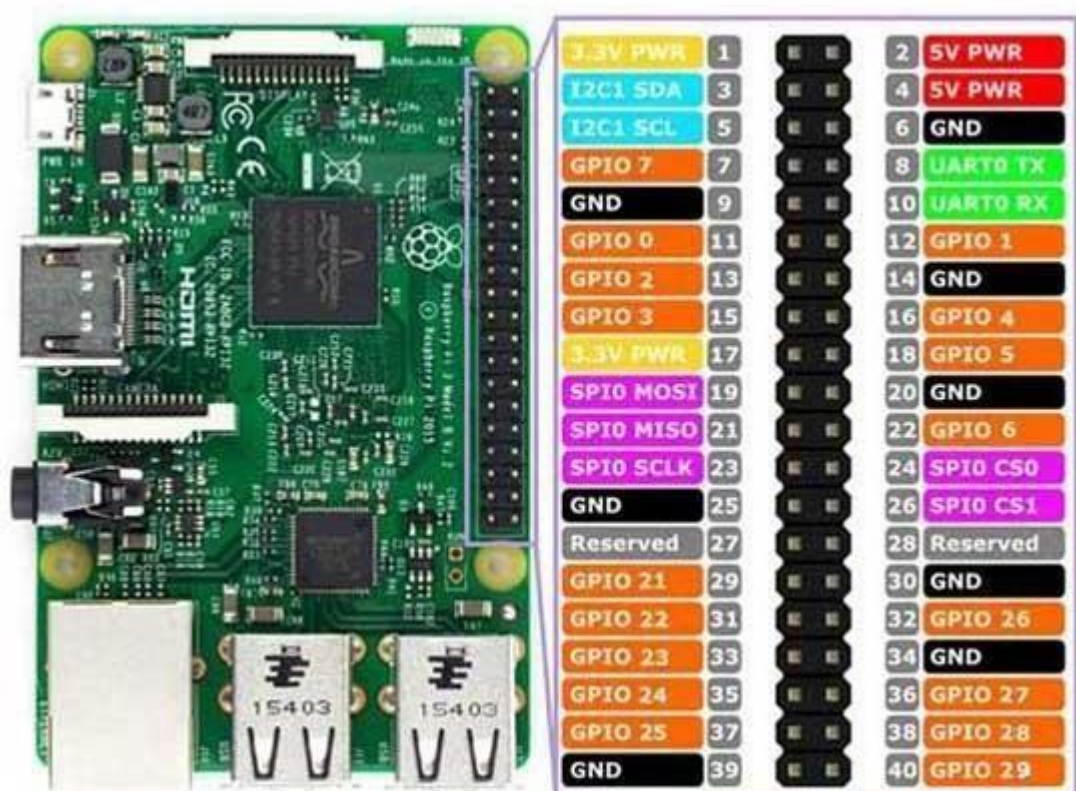


Fig: 5.3: Raspberry PI pin Reference

5.1.2 DHT11 Sensor:

Measurement and control of temperature and relative humidity finds applications in numerous areas. These days devices are available which have both temperature and humidity sensors with signal conditioning, ADC, calibration and communication interface all built inside them. The use of such smart sensors greatly simplifies the design and reduces the overall cost. Humidity and temperature measurements with Sensation's SHT1x/SHT7x sensors. These sensors are capable of measuring both temperature and relative humidity and provide fully calibrated digital outputs. While SHT1x/SHT7x are very accurate sensors, they are still expensive for hobbyists use. This article discusses the DHT11 sensor which also provides calibrated digital outputs for temperature and humidity but is relatively lot cheaper than the Sensirion sensors. The DHT11 sensor uses a proprietary 1-wire protocol which we will be exploring here and implementing with the Raspberry Pi that will receive the temperature and humidity values from the sensor and display them on cloud.

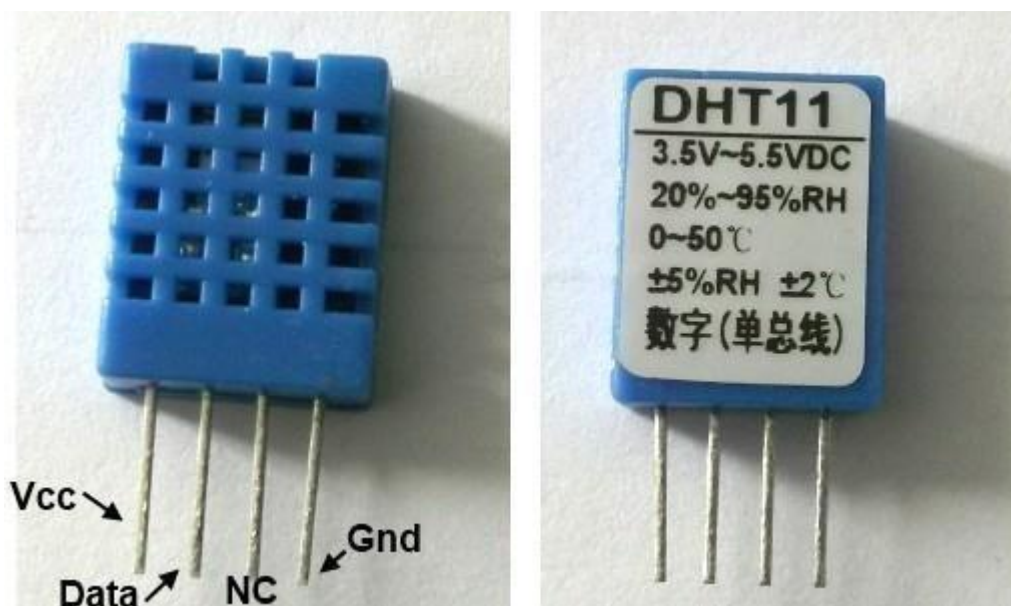


Fig:5.4 :DHT11 Sensor

5.1.2.1 Introduction to DHT11 Sensor

The DHT11 sensor comes in a single row 4-pin package and operates from 3.5 to 5.5V power supply. It can measure temperature from 0-50 °C with an accuracy of $\pm 2^{\circ}\text{C}$ and relative humidity ranging from 20-95% with an accuracy of $\pm 5\%$. The sensor provides fully calibrated digital outputs for the two measurements. It has got its own proprietary 1-wire protocol, and therefore, the communication between the sensor and a microcontroller is not possible through a direct interface with any of its peripherals. The protocol must be implemented in the firmware of the MCU with precise timing required by the sensor.

5.1.2.2 DHT11 signal description

The following timing diagrams describe the data transfer protocol between a MCU and the DHT11 sensor. The MCU initiates data transmission by issuing a “Start” signal. The MCU pin must be configured as output for this purpose. The MCU first pulls the data line low for at least 18 ms and then pulls it high for next 20-40 μs before it releases it. Next, the sensor responds to the MCU “Start” signal by pulling the line low for 80 μs followed by a logic high signal that also lasts for 80 μs . Remember that the MCU pin must be configured to input after finishing the “**Start**” signal. Once detecting the response signal from the sensor, the MCU should be ready to receive data from the sensor. The sensor then sends 40 bits (5 bytes) of data continuously in the data line. Note that while transmitting bytes, the sensor sends the most significant bit first.

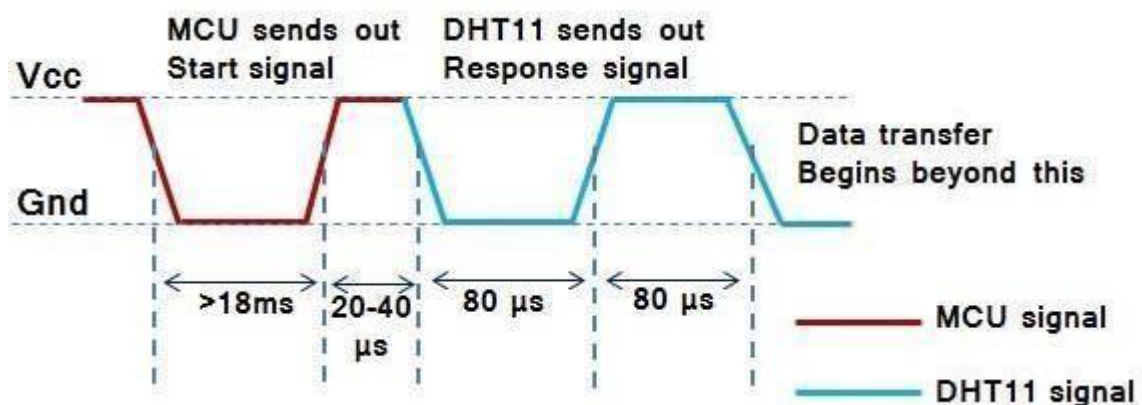


Fig 5.5:DHT11 Signal

The 40-bit data from the sensor has the following structure. Data (40-bit) = Integer Byte of RH + Decimal Byte of RH + Integer Byte of Temp. + Decimal Byte of Temp. + Checksum Byte For DHT11 sensor, the decimal bytes of temperature and humidity measurements are always zero. Therefore, the first and third bytes of received data actually give the numeric values of the measured relative humidity (%) and temperature (°C). The last byte is the checksum byte which is used to make sure that the data transfer has happened without any error. If all the five bytes are transferred successfully then the checksum byte must be equal to the last 8 bits of the sum of the first four bytes, i.e., **Checksum = Last 8 bits of (Integer Byte of RH + Decimal Byte of RH + Integer Byte of Temp. + Decimal Byte of Temp.)**

Now let's talk about the most important thing, which is signaling for transmitting "0" and "1". In order to send a bit of data, the sensor first pulls the line low for 50 μs. Then it raises the line too high for 26-28 μs if it has to send "0", or for 70 μs if the bit to be transmitted is "1". So, it is the width of the positive pulse that carries information about 1 and 0.

5.1.3 LDR Sensor

The controlling of lights and home appliances is generally operated and maintained manually on several occasions. But the process of appliances controlling may cause wastage of power due to the carelessness of human beings or unusual circumstances.

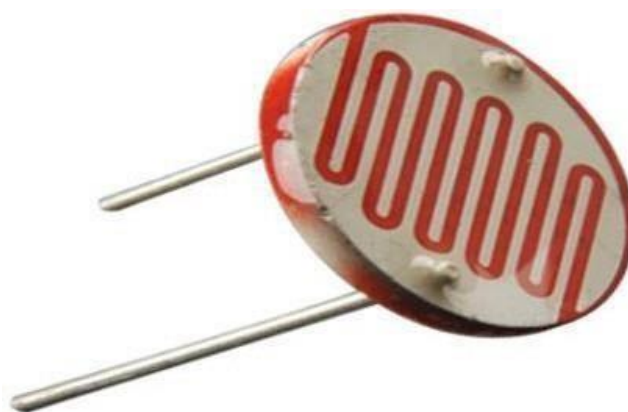


Fig 5.6. Light Dependent Resistor

To overcome this problem, we can use the light-dependent resistor circuit for controlling the loads based on the intensity of light. An LDR or a photo resistor is a device that is made up of high resistance semiconductor material. This article gives an overview of what is LDR, light-dependent resistor circuit and its working

5.1.3.1. Construction of an LDR

The construction of an LDR includes a light-sensitive material that is placed on an insulating substrate like as ceramic. The material is placed in a zigzag shape in order to get the required power rating and resistance. The area of zigzag separates the metal placed.

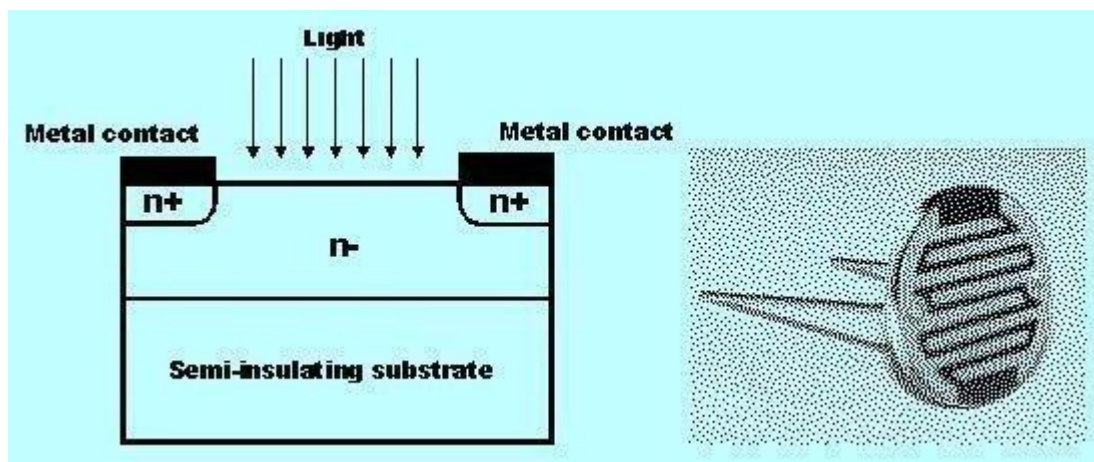


Fig:5.7: Construction of LDR

Where the Ohmic contacts are made either on the sides of the area. The resistances of the contacts must be as less as possible to make sure that the resistance, mainly varies due to the light effect only. The use of lead & cadmium materials is avoided they are injurious to the environment

5.1.3.2. Working Principle of Light Dependent Resistor

The working principle of an LDR is photo conductivity that is nothing but an optical phenomenon. When the light is absorbed by the material then the conductivity of the material reduces. When the light falls on the LDR, then the electrons in the valence band of the material are eager to the conduction band. But, the photons in the incident light must have energy superior than the band gap of the material to make the electrons jump from one band to another band (valance to conduction).

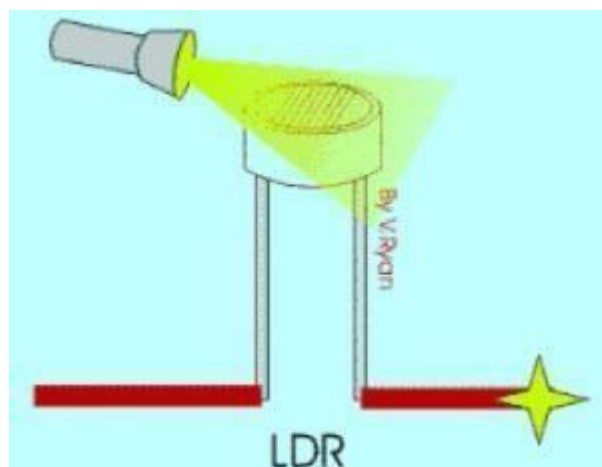


Fig 5.8:LDR Working Principle

5.1.3.3. Light Dependent Resistor Circuit

The circuit of LDR is an electronic circuit built with LDR, relay, Darlington pair, diode, & resistors shown in the below circuit diagram. A voltage supply is given to the load. The required DC voltage of the LDR circuit is supplied from a bridge rectifier circuit or a battery. This circuit changes the AC supply into a DC. The bridge rectifier circuit uses a step-down transformer to step-down the voltage from 230v into 12v. The diodes are connected in the form of a bridge used to alter the AC voltage into DC. The voltage regulator is used to change the 12v DC-6v DC, and then, this DC voltage is supplied to the entire circuit. A 230v AC supply for both the bridge rectifier and the load

is to be kept continuously for continuous operation of the light sensor circuit.

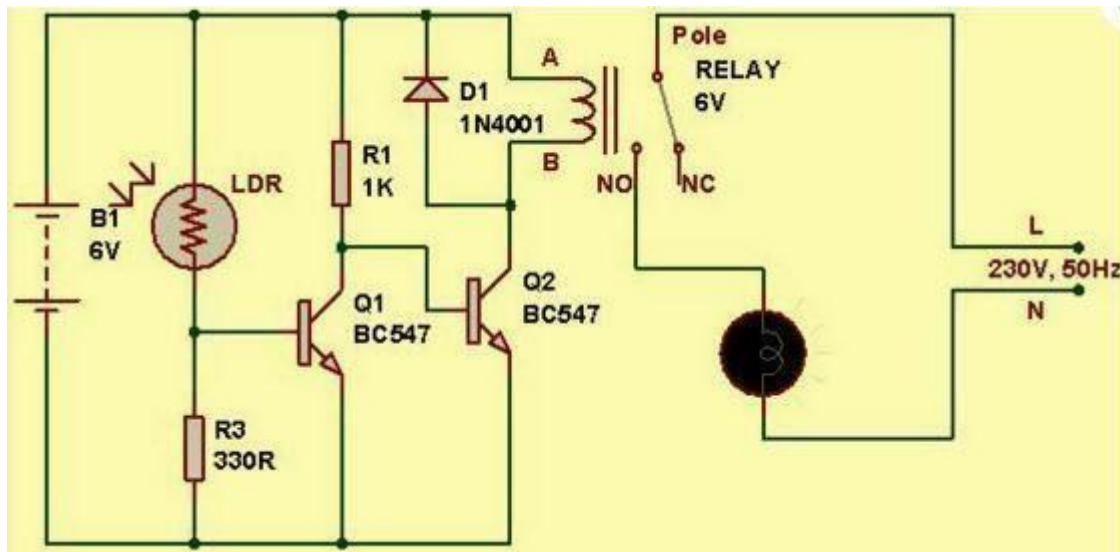


Fig 5.9 Light Dependent Resistor Circuit

In the morning time, this sensor has a low resistance around 100Ω . Thus, the power supply flows through the LDR & ground through the variable resistor and resistor as shown in the above light sensor circuit. This is due to the resistance offered by the light- dependent resistor in the daytime or when the light falls on the LDR, then it is less compared to the resistance of the remaining part of the sensor circuit. We are alert of the principle of current, that the flow of current always flows in the path of low resistance.

Therefore, the relay coil does not get sufficient supplies to get strengthened. Hence, the light is switched off in the daylight. In the same way, during the night time, the resistance of the LDR increases to a high value ($20M\Omega$). Thus, due to the high resistance of the resistor, the flow of current is low or almost zero. Now, the flow of current through the low-resistance lane such that it increases the base voltage of the Darlington pair to reach more than $1.4v$. As the Darlington pair transistor is triggered, the relay coil acquires enough supply to get energized, and hence, the light switches in the night time.

5.1.3.4 Applications of LDR

Light-dependent resistors are simple and low-cost devices. These devices are used where there is a need to sense the presence and absence of light is necessary. These resistors are used as light sensors and the applications of LDR mainly include alarm clocks, street lights, light intensity meters, burglar alarm circuits For a better understanding of this concept, here we have explained one project namely; power conserving of intensity controlled street lights using LDR.

5.1.4 BMP180 SENSOR

The BMP180 is the function compatible successor of the BMP085, a new generation of high precision digital pressure sensors for consumer applications. The ultra-low power, low voltage electronics of the BMP180 is optimized for use in mobile phones, PDAs, GPSnavigation devices and outdoor equipment. With a low altitude noise of merely 0.25m at fast conversion time, the BMP180 offers superior performance. The I2C interface allows for easy system integration with a microcontroller. The BMP180 is based on piezo- resistive technology for EMC robustness, high accuracy and linearity as well as long termstability.

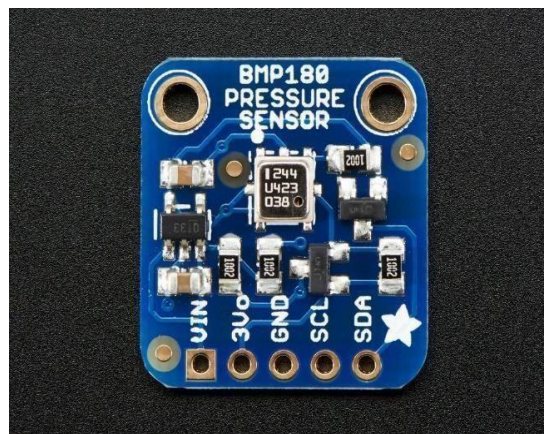


Fig:5.10: BMP180 Pressure Sensor

5.1.4.1 General description

The BMP180 is designed to be connected directly to a microcontroller of a mobile device via the I2C bus. The pressure and temperature data has to be compensated by the calibration data of the E 2PROM of the BMP180.

5.1.4.2 General function and application schematics

The BMP180 consists of a piezo-resistive sensor, an analog to digital converter and a control unit with E2PROM and a serial I2C interface. The BMP180 delivers the uncompensated value of pressure and temperature. The E2PROM has stored 176 bit of individual calibration data. This is used to compensate offset, temperature dependence and other parameters of the sensor. · UP = pressure data (16 to 19 bit) · UT = temperature data (16 bit).

5.1.4.3 Measurement of Pressure and Temperature

The Raspberry Pi sends a start sequence to start a pressure or temperature measurement. After converting time, the result value (UP or UT, respectively) can be read via the I²C interface. For calculating temperature in °C and pressure in hPa, the calibration data has to be used. These constants can be read out from the BMP180 E2PROM via the I²C interface at software initialization. The sampling rate can be increased up to 128 samples per second (standard mode) for dynamic measurement. In this case, it is sufficient to measure the temperature only once per second and to use this value for all pressure measurements during the same period.

5.1.4.4 Global Memory Map

The memory map below shows all externally accessible data registers which are needed to operate BMP180. The left columns show the memory addresses. The columns in the middle depict the content of each register bit. The colors of the bits indicate whether they are read-only, write-only or read- and writable. The memory is volatile so that the writable content has to be re-written after each power-on. Not all register addresses are shown. These registers are reserved for further Bosch factory testing and timing.

- **Oss (register F4h <7:6>):** controls the oversampling ratio of the pressure measurement (00b: single, 01b: 2 times, 10b: 4 times, 11b: 8 times).

- **Soft reset (register E0h):** Write only register. If set to 0xB6, will perform the same sequence as power on reset.
- **Chip-id (register D0h):** This value is fixed to 0x55 and can be used to check whether communication is functioning.

After conversion, data registers can be read out in any sequence (i.e., MSB first or LSB first). Using a burst read is not mandatory.

4.2.4.7 I2C protocol The I²C interface protocol has special bus signal conditions. Start (S), stop (P) and binary data conditions are shown below. At start condition, SCL is high and SDA has a falling edge. Then the slave address is sent. After the 7 address bits, the direction control bit R/W selects the read or write operation. When a slave device recognizes that it is being addressed, it should acknowledge by pulling SDA low in the ninth SCL (ACK) cycle.

At stop condition, SCL is also high, but SDA has a rising edge. Data must be held stable at SDA when SCL is high. Data can change value at SDA only when SCL is low. Even though VDDIO can be powered on before VDD, there is a chance of excessive power consumption (a few mA) if this sequence is used, and the state of the output pins is undefined so that the bus can be locked. Therefore, VDD *must* be powered before VDDIO unless the limitations above are understood and not critical.

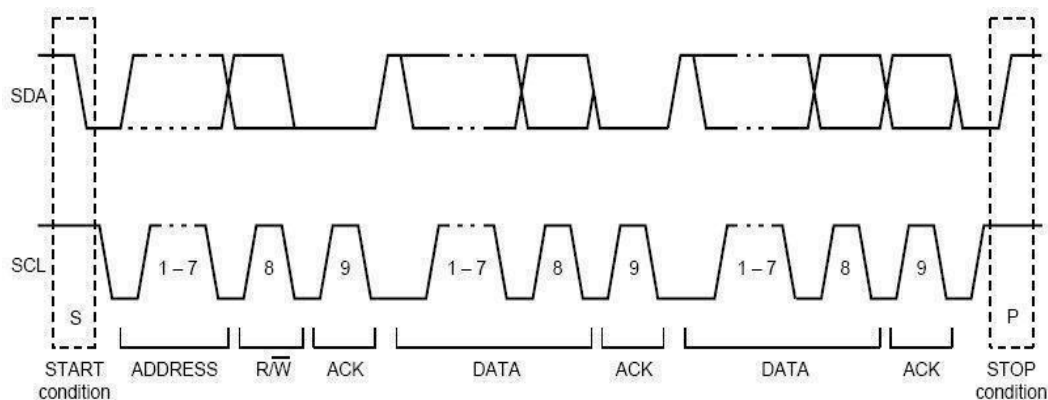


Fig:5.11: I2c Protocol

5.1.4.5 Start temperature and pressure measurement

The timing diagrams to start the measurement of the temperature value UT and pressure value UP are shown below. After start condition the master sends the device address write, the register address and the control register data. The BMP180 sends an acknowledgement (ACKS) every 8 data bits when data is received. The master sends a stop condition after the last ACKS.

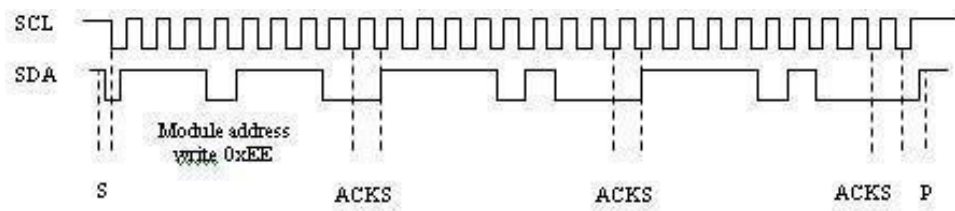


Fig 5.12: Timing diagram for starting pressure measurement

5.1.5 MQ2 Sensor

Sensitive material of MQ-2 gas sensor is SnO_2 , which with lower conductivity in clean air. When the target combustible gas exists, the sensor's conductivity is higher along with the gas concentration rising. Please use simple electro circuit, convert change of conductivity to correspond output signal of gas concentration.



Fig 5.13: MQ2 Sensor

MQ-2 gas sensor has high sensitivity to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam, it is with low cost and suitable for different application.

5.1.5.1 Character and Configuration

- Good sensitivity to Combustible gas in wide range
- High sensitivity to LPG, Propane and Hydrogen
- Long life and low cost

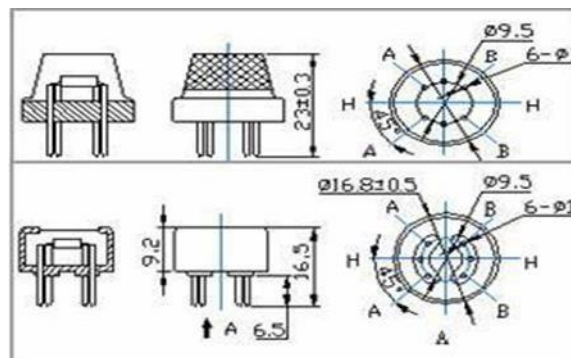


Fig 5.14:MQ2 Sensor configuration

5.1.5.2 Application

- Domestic gas leakage detector
- Industrial Combustible gas detector
- Portable gas detector

5.1.5.3 Basic test tool

The above is basic test circuit of the sensor. The sensor needs to be put 2 voltage, heater voltage (VH) and test voltage. VH used to supply certified working temperature to the sensor, while VC used to detect voltage (VRL) on load resistance RL, whom is in series with sensor. The sensor has light polarity, Vc need DC power. VC and VH could use same power circuit with precondition to assure performance of sensor. In order to make the sensor with better performance, suitable RL value is needed.

5.1.5.4 Sensitivity Characteristics

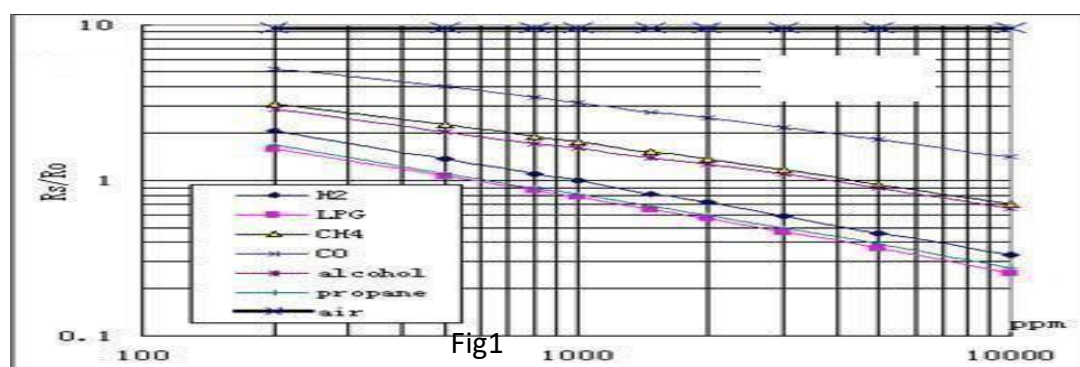


Fig 5.15: Typical sensitivity characters

The MQ-2, ordinate means resistance ratio of the sensor (R_s/R_o), abscissa is concentration of gases. R_s means resistance in different gases, R_o means resistance of sensor in 1000ppm Hydrogen. All test is under standard test conditions.

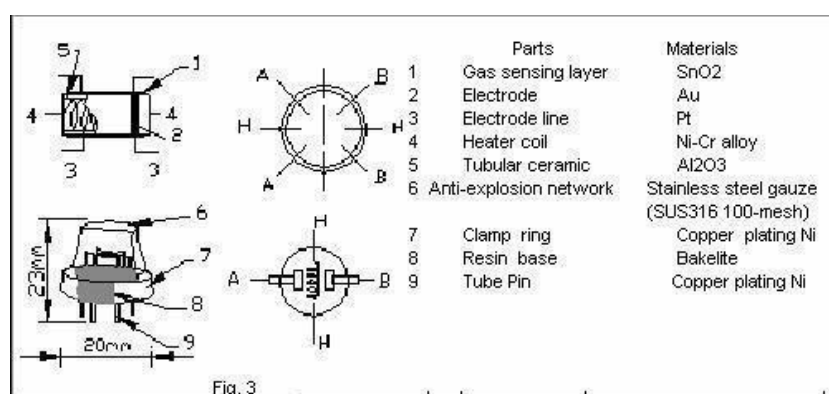


Fig 5.16: MQ2 Parts Description

Structure and configuration of MQ-2 gas sensor is shown as Fig. 3, sensor composed by micro AL₂O₃ ceramic tube, Tin Dioxide (SnO₂) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless-steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-2 have 6 pin, 4 of them are used to fetch signals, and other 2 are used for providing heating current.

5.1.6 SINGLE CHANNEL RELAY

The Single Pole Double Throw relay is quite useful in certain applications because of its internal configuration. It has one common terminal and 2 contacts in 2 different configurations: one can be Normally Closed and the other one is opened or it can be Normally Open and the other one closed. So basically you can see the SPDT relay as a way of switching between 2 circuits: when there is no voltage applied to the coil one circuit “receives” current, the other one doesn’t and when the coil gets energised the opposite is happening.



Fig:5.17:Single channel relay

Relays consist of three pins normally open pin , normally closed pin, common pin and coil. When coil power on magnetic field is generated the contacts connected to each other. features: Contact current 10A and 250V AC or 30V DC. Each channel has indication LED. Coil voltage 12V per channel. Kit operating voltage 5-12 V , Input signal 3-5 V for each channel. Three pins for normally open and closed for each channel. How to connect relay module with Arduino.

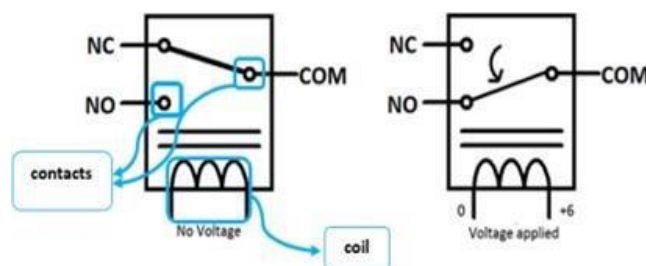


Fig:5.18: Relay Working

As shown in relay working idea it depends on magnetic field generated from the coil so there is power isolation between the coil and the switching pins so coils can be easily powered from Arduino by connecting VCC and GND pins from Arduino kit to the relay module kit after that we choose Arduino output pins depending on the number of relays needed in project designed and set these pins to output and make it out high (5 V) to control the coil that allow controlling of switching process.

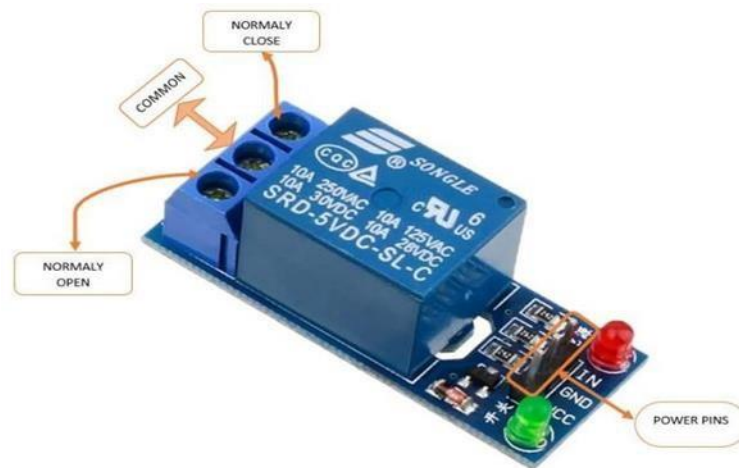


Fig: 5.20 Relay module pins

5.1.7 LED

Light-emitting diode (LED) is a widely used standard source of light in electrical equipment. It has a wide range of applications ranging from your mobile phone to large advertising billboards. They mostly find applications in devices that show the time and display different types of data.



Fig 5.21 LED

5.1.8 BATTERY

9 Volts HW BATTERY and Connector, HI-WATT 100% Original 6F22 9V Long Life Carbon Zinc Batter Electronic Toys, Clocks, Walkie-Talkies, Smoke Alarms, Handheld Test Equipment, Digital Instruments, Transistor Radios'



Fig 5.22 HW Battery

5.1.9 POWER SUPPLY:

In our project I used 9 volts transformer for continuous power supply. Why I am using this means to continuous power will come. Otherwise, If I use a battery sometimes the total currents will loss so that's way, I am using A.C Transformer. A.C transformer is giving the input to Bridge Rectifier. Bridge Rectifier converts A.C to D.C. After that we are using one filter capacitor 1000uf/25v electrolytic capacitor. We connecting this capacitor in parallel section. The main purpose of this capacitor is if there is any alternate peaks, we need to reduce that peaks. Nothing but a filtering that redpolls. After that we are using LM7805 Regulator Most digital logic circuits and processors need a 5-volt power supply. To use these parts, we need to build a regulated 5-volt source. We make a 5-volt power supply, The LM7805 is simple to use. First connect the positive lead of our unregulated DC power supply Input pin, connect the negative lead to the Common pin and then when we turn on the power, we get a 5-volt supply from the Output pin. Here we are using one red color led to indicate the power.

We are using General purpose PCB. To mount or place the components on the PCB. After that The LM7805 is simple to use. You simply connect the positive lead of your unregulated DC power supply (anything from 9VDC to 24VDC) to the Input pin, connect the negative lead to the Common pin and then when you turn on the power, you get a 5-volt supply from the Output pin.

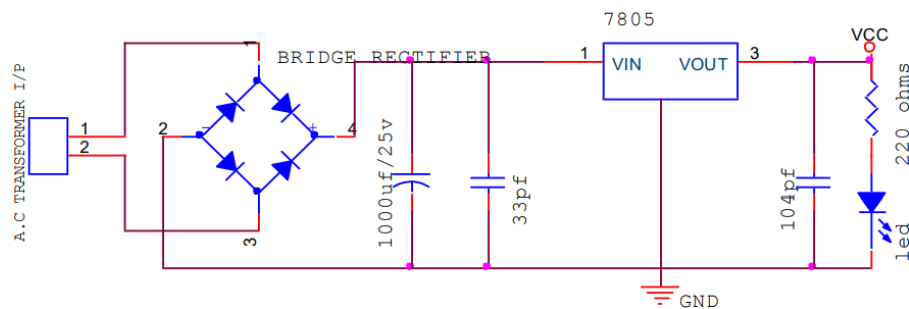


Fig:5.23:Circuit diagram of Power Supply

5.2 SOFTWARE REQUIREMENTS

These are some of the software requirements you may need to acquire climatic data using a sensor interfaced Raspberry Pi system. The specific libraries and tools required may vary depending on the type of sensor you are using and the data processing and storage requirements of your project.

Raspberry Pi Operating System: An operating system (OS) compatible with Raspberry Pi, such as Raspbian, which is a popular OS for Raspberry Pi is needed. You can download and install the OS on your Raspberry Pi device.

Python Libraries: You will need various Python libraries to interface with the sensor and acquire climatic data. Some commonly used libraries for sensor interfacing include RPi.GPIO for controlling GPIO pins, smbus for I2C communication, and Adafruit libraries for specific sensors such as Adafruit_DHT for DHT temperature and humidity sensor, Adafruit_BMP for BMP180/BMP280 barometric pressure sensors, etc.

Sensor-specific Libraries: Depending on the type of sensor you are using for climatic data acquisition, you may need sensor-specific libraries or APIs provided by the sensor manufacturer. These libraries will allow you to interact with the sensor and retrieve data from it.

Data Logging Libraries: If you want to log the climatic data acquired from the sensor over time, you will need data logging libraries such as CSV, SQLite, or a database library like MySQL or MongoDB to store the data in a structured manner for further analysis or visualization.

Visualization Libraries: If you want to visualize the climatic data in the form of graphs or charts, you will need visualization libraries such as Matplotlib or Plotly. These libraries allow you to create visual representations of the data for better analysis and interpretation.

Networking Libraries: If you want to send the climatic data to a remote server or cloud for storage or analysis, you may need networking libraries such as Requests or Paramiko for communication with web APIs, FTP, or SSH protocols.

Cron Job Configuration: If you want to automate the data acquisition process at specific intervals, you can configure cron jobs on the Raspberry Pi. Cron is a time-based job scheduler in Linux-based systems that allows you to automate tasks, including running your Python script to acquire climatic data at predefined intervals.

Security Libraries: If you want to implement security measures, such as data encryption or authentication, you may need security libraries such as OpenSSL or PyCrypto to ensure the confidentiality and integrity of the acquired climatic data.

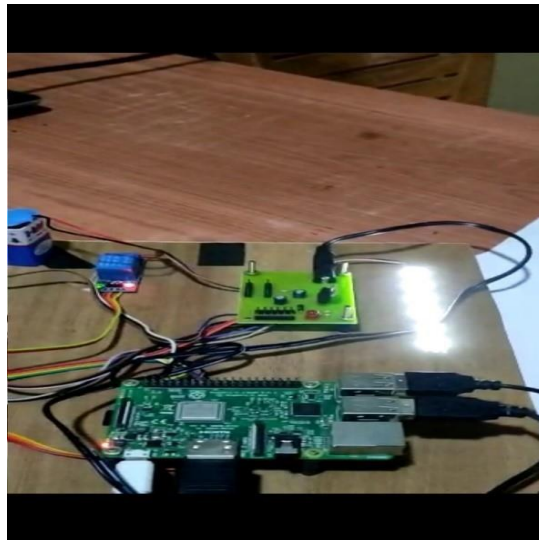
Error Handling Libraries: To handle errors and exceptions that may occur during data acquisition or processing, you may need error handling libraries such as logging or traceback to log errors and troubleshoot issues.

CHAPTER 6

RESULTS AND DISCUSSION

6.1 Results

The system for climatic data acquisition using sensor interfaced Raspberry Pi is designed to collect and process environmental data using sensors connected to a Raspberry Pi microcontroller. The Raspberry Pi acts as a central hub that interfaces with various sensors to collect data related to temperature, humidity, pressure, and other environmental parameters. The collected data can then be processed, analyzed, and stored for further use. The Weather Monitoring with Raspberry Pi has the special sensor detecting the carbon monoxide which is used to know the CO level at our surrounding. To live in quality air, it will perform sensing of gases, pressure, etc. It works on 5V power supply and Raspberry Pi has the fastest among other WiFi modules and is less cost efficient also. When any one of the sensors is not working, it gives an error. When the power went off and came back, it will automatically boot the sensor and resume working without operator. This system starts recording the values from the sensor and stores and analyzes in the cloud.



6.1 Experimental set up

Day	Temperature	Humidity	Pressure(hpa)	C02(ppm)
Morning	29*c	82%	1009	405
Afternoon	33*c	85%	1007	405
Evening	31*c	53%	1006	405
Night	26*c	43%	1009	405

Table 6.1 Wheather Report for 24 Hours

Overall, the system for climatic data acquisition using sensor interfaced Raspberry Pi provides a flexible and cost-effective solution for collecting and processing environmental data for various applications, such as weather monitoring, agriculture, smart homes, and industrial automation.

6.2 Discussion

This weather monitoring arrangement is placed on top of roof which is located on the building, it has portable and adjustable. According to the weather monitoring system which senses the physical and chemical characteristics. In- between if there any disturbance in the system automatically stops and starts indications.

After connecting, it starts giving required power supply to sensors based on operation defined by program. Humidity is continuously taken by the sensor and given to the Raspberry Pi and then it will show the value given by the sensor with some mathematical manipulations like this all sensors working.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 Conclusion

The design and development weather monitoring system is very challenging this system has been tested successfully in different areas with various terrain, in various conditions. The performance and efficiency of weather monitoring is increased by the help of this Raspberry Pi. This Raspberry Pi has a good capturing capability, so that the Big number values are easily manipulated, because of this the quality of values increased. This can be used throughout day and night which reduces the laborcost. Since it was designed to be user friendly, the operator can control the Weather monitoring system easily .

In this paper, a comparative analysis on various systems developed for the controlling and monitoring system for the industry is proposed. Design and implementation of the existing system is also discussed. After reviewing the existing studies, a cost efficient system has been proposed for industrial monitoring and controlling based on IoT framework. In our system various parameters are continuously monitored remotely that to without any human interference. The system ensures a safety work environment for the worker. Facial recognition based logging system is designed to prevent the network intrusion.

The system enables real-time data collection, allowing for immediate analysis and decision-making. The sensors can be customized to measure various environmental parameters such as temperature, humidity, pressure, air quality, and more, providing a comprehensive picture of the climatic conditions in a specific location. Additionally, the Raspberry Pi's ability to connect to the internet allows for remote monitoring and data access, making it possible to collect data from multiple locations and share it across different platforms. The system can also be configured to send alerts or notifications based on predefined thresholds, enabling timely responses to changing climatic conditions or environmental events.

7.2 Future Scope

The future scope of climatic data acquisition using a sensor-interfaced Raspberry Pi system is promising, with several potential advancements and applications on the horizon. Some of the future possibilities for this technology include:

Enhanced Sensor Technology: As sensor technology continues to advance, we can expect more sophisticated and accurate sensors to become available for environmental monitoring. This could include sensors with higher resolutions, wider measurement ranges, and improved sensitivity, allowing for more precise and comprehensive data collection.

Internet of Things (IoT) Integration: The integration of the Raspberry Pi system with IoT technologies could enable seamless connectivity and communication among different sensor nodes, allowing for more extensive data collection from various locations. This could lead to the development of large-scale sensor networks for monitoring climate conditions across regions or even globally.

Artificial Intelligence and Machine Learning: The use of AI and machine learning algorithms for data analysis could enable more advanced and automated data processing, pattern recognition, and predictive analytics. This could facilitate the identification of complex climate patterns, early warning systems for extreme weather events, and better understanding of climate change impacts.

Decision Support Systems: The data collected from the Raspberry Pi system could be integrated into decision support systems for various industries such as agriculture, energy, water management, and urban planning. This could provide valuable insights for making informed decisions related to crop management, energy consumption, water allocation, and infrastructure planning, contributing to more sustainable practices.

Citizen Science and Community Engagement: The Raspberry Pi system could be used to engage citizens in climate monitoring and research, allowing for participatory data collection and community-driven initiatives. This could foster public awareness and engagement in climate issues and enable collaborative efforts to address local environmental challenges.

Climate Modeling and Prediction: The data acquired from the Raspberry Pi system could be utilized in climate modeling and prediction models to improve our understanding of climate dynamics, forecast future climate scenarios.

7.3 Implementation Issues

Implementing climatic data acquisition using a sensor-interfaced Raspberry Pi system may involve some challenges or issues that need to be addressed. Some of the common implementation issues in this context may include:

Sensor Selection and Calibration: Choosing appropriate sensors for accurate and reliable data acquisition is crucial. However, sensor selection can be challenging due to factors such as sensor availability, compatibility with Raspberry Pi, accuracy, and cost. Additionally, sensors may require calibration to ensure accurate measurements, which can be time-consuming and complex.

Hardware and Software Integration: Integrating sensors with Raspberry Pi hardware and software may require technical expertise in electronics and programming. Configuring the sensor interfaces, connecting sensors to Raspberry Pi, and setting up appropriate drivers or libraries can be challenging, especially for users with limited technical knowledge.

Power Management: Sensors may require continuous power supply for continuous data acquisition, which can be challenging in remote or outdoor environments. Managing power consumption, battery life, and charging can be critical to ensure uninterrupted data acquisition and reliable operation of the Raspberry Pi system.

Data Transmission and Storage: Collecting and storing data from sensors may require efficient data transmission and storage methods. Issues such as data loss, data corruption, and data storage capacity need to be considered to ensure reliable data acquisition and storage for further analysis.

Environmental Conditions: Environmental conditions, such as extreme temperatures, humidity, and dust, may affect the performance and longevity of sensors and Raspberry Pi hardware. Ensuring proper environmental protection for sensors and Raspberry Pi system is important to maintain accurate and reliable data acquisition.

Data Quality and Validation: Ensuring data quality and validity is critical in climatic data acquisition. Issues such as sensor drift, noise, and data outliers may affect the accuracy and reliability of collected data. Implementing appropriate data validation techniques, data filtering, and data quality checks are important to ensure reliable data for analysis.

REFERENCES

- [1] Muck PY, Homam MJ, mariyam@uthmedumy (2021) lot Based Weather Station Using Raspberry Pi 3. International Journal of Engineering & Technology 7(4.30):1–4
2. U. Hariharan and K. Rajkumar, “Prolong Network Lifetime Using Dynamic Routing for Wireless Sensor Networks,” INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH, vol. 9, no. 3, pp. 7166–7169, Mar. 2020.
3. A. Zanella, N. Bui, A. Castellani, L. Vangelista, and M. Zorzi, “Internet of things for smart cities,” IEEE Internet of Things journal, vol. 1, no. 1, pp. 22–32, 2020.
4. L. Atzori, A. Iera, and G. Morabito, “The internet of things: A survey,” Computer networks, vol. 54, no. 15, pp. 2787–2805, 2019.
5. Joseph FJJ (2019) IoT Based Weather Monitoring System for Effective Analytics. International Journal of Engineering and Advanced Technology (IJEAT) 8(4):1–5
6. Bhagat AM, Thakare AG, 1 KAM, Muneshwar NS, Choudhary PV (2019) IOT Based Weather Monitoring and Reporting System Project. International Journal of Trend in Scientific Research and Development (IJTSRD) 3(3):1– 3
7. D. Gaurav, D. Mittal, B. Vaidya, and J. Mathew, “A gsm based low cost weather monitoring system for solar and wind energy generation,” in The Fifth International Conference on the Applications of Digital Information and Web Technologies (ICADIWT 2018). IEEE, 2017, pp. 1–7.
8. Pogorzelski, S., Pogorzelska, M., & Wójcik, G. (2018). Raspberry Pi-Based Wireless Sensor Network for Environmental Monitoring. Sensors, 18(12), 4282.
9. Nykänen, A., & Röning, J. (2017). An Internet of Things-based Environmental Monitoring System: From Sensor to Cloud. Future Internet, 9(4), 73.
10. Aldairi, A. M., Mhd Ali, K. M., Abdul-Salaam, G., & Abdullahi, M. (2020). Raspberry Pi-based Wireless Sensor Networks for Environmental Monitoring: A Review. IEEE Access, 8, 154434-154447.
11. Bell, B., & Ghafoor, A. (2016). A Raspberry Pi-Based Wireless Sensor Network for Environmental Monitoring. IEEE Sensors Journal, 16(11), 4286-4293.
12. Kasemsuwan, V., Kasemsuwan, P., & Haddawy, P. (2016). Raspberry Pi-Based Wireless Sensor Networks for Environmental Monitoring. Procedia Computer Science, 86, 107-110.

