Smart Home

Graduation Project

Smart Home with Solar Tracking System Project

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(2022-2023)

Acknowledgement

It has been such a great opportunity to achieve our goal and with every day spent on this project, we gained lots of experience and saw what an ambitious team can do, followed by the knowledge of how to actually design and analyze our project. For that we have to thank all the individuals who made it possible for students like us to complete the project.

We would like to express our deepest gratitude to our graduation project supervisors **Dr. Mohamed Mahmoud Abdelwahab** and **Dr. Sabah Ibrahim**.

We would like to thank them for their patience and guidance along the semester and without their encouragement and believing in our team, we wouldn't have achieved our target.

At last, we would like to thank all the people who helped, supported and encouraged us to successfully finish the graduation project whether they were in the university or not.

Abstract

Due to the rapid development in the field of the Automation industry, human life is becoming more advanced and better in all aspects. In the present scenario, automated systems are being preferred over the non-automated system. With the rapid growth in the number of consumers using the internet over the past years, the Internet has become an important part of life, and IoT is the newest and emerging internet technology. Internet of things plays an important role in human life as well as in the educational field because they are able to provide information and complete the given tasks while we are busy doing some other work. In this project, a prototype and implementation of Smart Home Automation with Wi-Fi technology are demonstrated. ESP8266 is used as a Wi-Fi technology. The proposed system consists of a hardware interface and software interface.

Smart homes are no longer design concepts of the future, they are being built now and they are having a direct impact on the lifestyles of people living in them. The aim of smart home systems is to create an environment that is aware of the activities taking place within it.

Smart-home technology encompasses a wide range of everyday household devices that can connect to one another and to the Web. This connectivity allows owners to program simple daily tasks and, in some cases, to control device operation from a distance. Designed for convenience, smart homes also hold the promise of improved independent living for elderly people and those with disabilities.

The focus of this project is on how to save power by using solar cells and how to ensure security of our houses.

In the hardware interface, the integration of ESP8266 Wi-Fi technology for controlling home appliances and sensors is manifested, and an application is provided for controlling to multiple users of home, with smart phones, tablets, and laptops. This system is one of the best methods for controlling home devices with ease with multiple users and one of the best method for an energy management system.

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Chapter 1

INTRODUCTION TO SMART HOME

1.1 What is Smart Home Technology or Home Automation?

Home automation system is getting popular and widely used in a lot of homes worldwide. It has tons of advantages to users even more to the handicapped and/or elderly users in which it will make it easier for them to control their home appliances. Home automation systems can be labeled to two media in which how it is connected and they are either wired or wireless connected. The main difference between these two kinds is that home appliances are linked .wirelessly to a central controller if it is a wireless home automation system

On the other hand, the appliances are connected to a central controller if the medium use wired communication method. Wireless system had been introduced in order to dispose of wired communication among home appliances, AVR Microcontroller (Atmega16A) based, .WIFI based home automation will be applied

Home automation systems can be operated by electricity or a computer chip using a range of different types of switches. Home automation is the residential extension of building automation. It is the automation of the home, housework or household activity. Home Automation is a central system that can control and create communication between nearly all .aspects of your home

Home automation systems, or smart home technologies, are systems and devices that can control elements of your home environment lighting, appliances, telephones, as well as home security, mechanical, entry and safety systems. They can be used to improve safety, expand .usability and make life easier for people of all abilities

One of my earliest memories of home automation was when the Mr. Coffee automatic drip coffee machine came out in the early 1970s. They were so pleased to know that when they .woke up in the morning a freshly brewed pot of coffee would be waiting for them

Now that we're in the twenty-first century, rudimentary coffee makers are getting a makeover by tinkerers bolting network adapters, temperature sensors, and microcontrollers to make the brew at the right time and temperature and to send a text message alerting that the beverage is ready for consumption.

Smart homes include:

- Lighting
- Heating and Air Conditioning
- Television
- Saving power by using solar cells.
- Gas & Electric Fireplaces
- Security System
- Irrigation Systems
- Watering Systems
- Doors
- Appliances
- Internet

1.2 What can Home Automation Do?

Home automation can:

- Increase your independence and give you greater control of your home environment.
- Make it easier to communicate with your family.
- Save you time and effort.
- Improve your personal safety
- Reduce your heating and cooling costs.
- Increase your home's energy efficiency.
- Alert you audibly and visually to emergency situations.
- Allow you to monitor your home while you are away. For more information on home.

1.3 System Elements

Elements of a home automation system include sensors (such as temperature, daylight, or motion detection), controllers (such as a general-purpose personal computer or a dedicated automation controller) and actuators, such as motorized valves, light switches, motors, others.

One or more human-machine interface devices are required, so that residents of the home can interact with the system for monitoring and control; This may be a specialized terminal or, increasingly, it may be an application running on a smart phone or tablet computer.

Devices may communicate over dedicated wiring, over a wired network, or wirelessly using one or more protocols.

Building automation networks developed for institutional or commercial buildings may be adapted to control in individual residences.

A centralized controller can be used, or multiple intelligent devices can be distributed around the home.

Figure 1: Control everything by Mobile Phone

1.4 Objectives

- Develop a Home Automation Remote System.
- Control Home Doors by "Mobile App, piezo, keypad."...
- Improve comfort: Control home lights by "Mobile App."
- Use devices that are easy to install.
- Use low-price materials and devices.
- Manage multiple control points.
- Setting up a sound alarm system.
- Fire sensor and alarm.
- Gas and Smoke sensors and alarms.
- Ensure security by: Using motion sensors and motion cameras.

1.5 How does the Project Smart Home process work?

The hardware that will be implemented will enable the remote controlling (switching on or off) of electric appliances in the house, it will have a fire alarm and sound alarm systems.

By Some Controllers Hardware:

- Motors.
- Interface board.
- Solar Cells.
- Mobile phone.
- Atmega16A.
- ESP-01.
- Sensors.

1.5.1 How Microcontroller Works?

Microcontroller is nothing but the CPU (Central Processing Unit) with supporting components like memory and I/O peripherals. If a computer matches a majority of these characteristics, then you called it as "microcomputer". Basically, this microcontroller takes an instruction (in the form of programming and execute them one by one in less than a millionth of a second. This way through art of programming we instruct microcontroller and use its

1.5.2 How to choose Microcontroller?

- Make a list of required hardware interfaces
- Examine software architecture
- Figure out memory needs
- Cost and power constraints
- Market availability of microcontroller chip
- Find out supported compilers and tools.

1.5.3 Embedded Processors

- The microprocessor chip (such as the Pentium) cannot work alone because it doesn't contain RAM, ROM and I/O ports on the microprocessor chip itself.
- To use the general-purpose microprocessor, we must add RAM, ROM, I/O ports externally to make them functional.
- Although the addition of external RAM, ROM, and I/O ports makes these systems much more expensive, they have the advantage of flexibility enabling the designer to decide on the amount of RAM, ROM, and I/0 ports needed to fit the task at hand.
- Such processors cannot be used in small size applications such as TV remote control, air

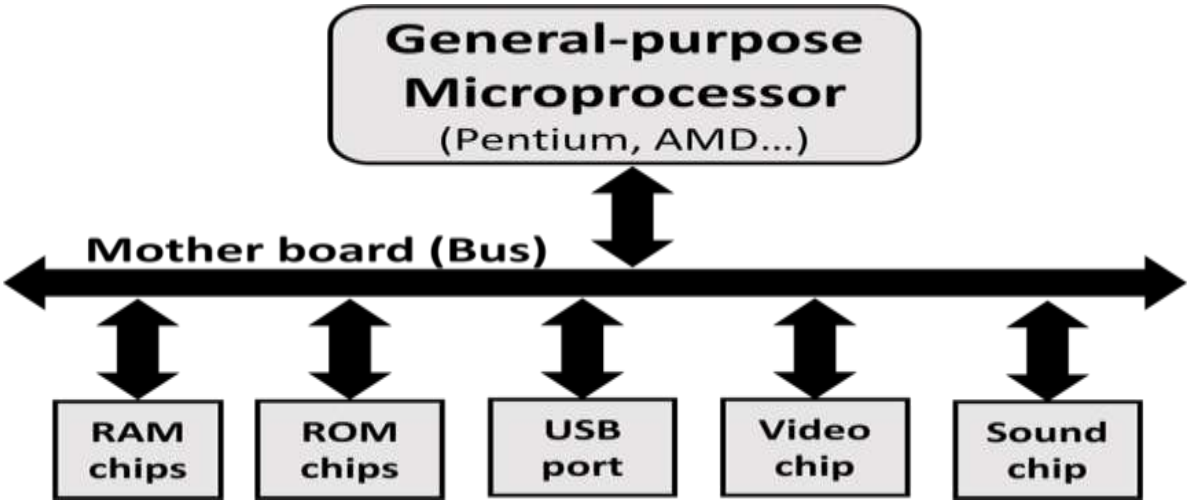


Figure 2: General-purpose Microprocessor

1.6 The Microcontroller

The microcontroller is simply a computer in a single chip, which contains:

- ✓ Microprocessor (CPU)
- ✓ Fixed amount of memory (RAM and ROM).
- ✓ Input/output ports.
- ✓ Other peripherals (such as timers, Analog-to-digital ...)
- ✓ In other words, all of the previous components are embedded together in a single chip. Therefore, the designer cannot add any external memory, I/O or timers to it.
- ✓ The fixed amount of on-chip ROM, RAM, and number of I/0 ports in microcontrollers makes them ideal for many applications for example a TV remote control or small size robotics.

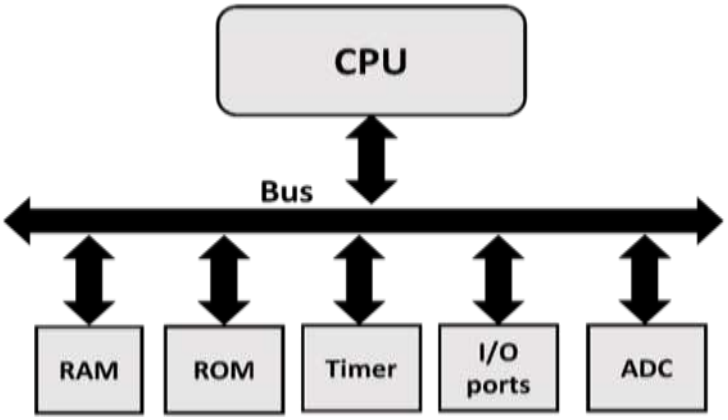


Figure 3: The Microcontroller

1.6.1 Microcontrollers for Embedded Systems

What's embedded systems?

- An embedded system is controlled by its own internal microprocessor (or microcontroller).
- In an embedded system, the microcontroller's ROM is loaded with a program for specific functions needed for the system.
- A printer is an example of an embedded system because the processor inside it performs one task only (getting the data and printing it).
- In contrast, a general-purpose computer (such as PC) can be used for any number of applications such as word processor, video game player, network server, or Internet terminal.
- The reason a PC can perform many tasks is that it has an operating system that can be used to execute many applications
- In an embedded system, only one application software is burned into ROM to perform a specific task.

1.7 Choosing a Microcontroller

- When buying a microcontroller, some criteria must be taken into account:
- Speed, what is the highest speed the microcontroller support?
- Packaging, does it come in a 40-pin DIP (dual inline package) or a QFP (quad flat package)?
- Power consumption.
- The amount of RAM and ROM on the chip.
- The number of I/O pins.
- The availability of an assembler, C language compiler and technical support.
- The number of internal peripherals (Timers, ADCs, …etc.).

1.7.1 Why to choose AVR Microcontroller?

Easy to Code: AVR was designed from ground up to allow efficient programming in high level languages with a particular focus on C language.

Easy to Program: The combination of on chip reprogrammable flash memory and In-System programming interface keeps the process of transferring software into microcontroller chip simple and easy.
Powerful and Inexpensive: AVR chips are powerful by performance (1 MIPS/MHz and clock up to 16MHz and space up to 128K of flash program memory and 4K EEPROM and SRAM at low prices. Most AVR additionally includes in-built peripherals such as UART and ADC (Analog to Digital Converter).

Hobbyist Friendly: Most of AVR chips come in easy to use 8-20, 28 or 40 pin dual in-line package (DIP) which makes them bread board friendly.

1.8 Used Software

1. C Programming
2. Embedded C
3. Dart programming
4. Mobile Application by Flutter
5. Eagle software
6. AutoCAD

1.9 Application Logo

Figure 4: Application Logo

CHAPTER 2

EMBEDDED SOFTWARE DESIGN

2.1 Software Development Life Cycle

Creating a well-tested reliable embedded software is important, especially in safety-critical applications. A great design starts with a well thought system design. Following the system design, embedded hardware design and software design will take place with high clarity .

Embedded system design is based on software development processes and life cycle, using any of the popular models such as the waterfall model, the V-Model and nowadays most of the software houses use the agile methodologies.

- **Waterfall Model – Design**

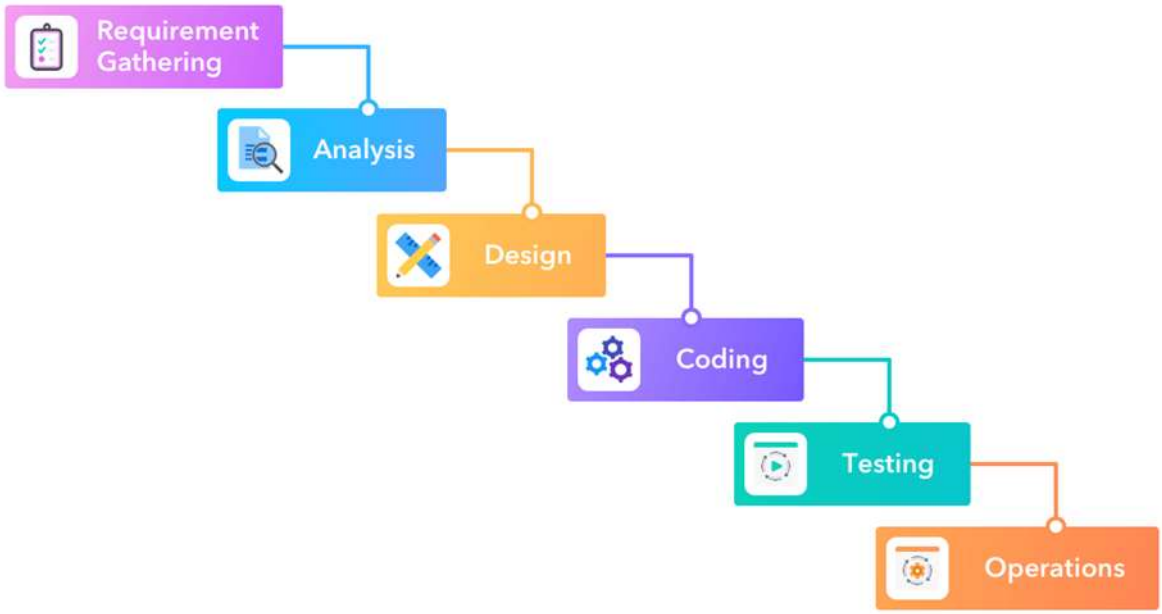


Figure 5: Waterfall Model-Design

The waterfall model is a sequential software development model that follows a linear, sequential approach to software development. It is one of the earliest software development models.

The waterfall model consists of several phases, each of which must be completed before moving on to the next phase. The phases are as follows:

Requirements gathering and analysis: In this phase, the requirements for the software are gathered and analyzed to determine the functionality and features that the software must have.

Design: In this phase, the software architecture is designed, including the software modules, data structures, and algorithms that will be used.

Implementation: In this phase, the software is actually developed, and the code is written and tested.

Testing: In this phase, the software is tested to ensure that it meets the requirements and functions correctly.

Deployment: In this phase, the software is deployed and installed on the target system.

Maintenance: In this phase, the software is maintained and updated to ensure that it continues to meet the requirements and functions correctly.

One of the advantages of the waterfall model is that it is easy to understand and follow, since each phase must be completed before moving on to the next. It also allows for a clear separation of responsibilities, since different team members can be responsible for different phases of the development process.

2.2 System Requirements

Creating a good system requirement specification (SRS) is important for the success of any project.

Here are steps to create an SRS for this project:

1. **Define the purpose and Objectives:** The purpose of this project is to design and develop a smart home system that allows users to control and monitor various devices and appliances in their homes. .

2. **Identify the stakeholders:** The stakeholders in this project include homeowners, home builders, system integrators, and the development team.

3. **Specify the hardware requirements:** To set a particular software application or system, it is used to ensure that the hardware components of a system are capable of running the software effectively and efficiently.

4. **Specify the functional requirements:** The system shall allow users to control lights, doors, and other devices in their homes through a mobile app.

5. **Specify the non-functional requirements:** The system shall have a response time of less than 2 seconds for user commands and notifications and be highly secure.

6. **Specify the security Requirements:** The SRS should include security requirements that ensure that the smart home system is secure and protected from unauthorized access or malicious attacks. These requirements should include authentication, access control, data protection, and encryption, as well as any other relevant security.

7. **Define the system architecture:** provides a high-level view of the system's components, their interrelationships, and how they interact with each other to support the system's objectives. It defines the system's overall behavior, including the processing of data, the flow of information, and the user interface.

8. **User Scenarios:** The SRS should include user scenarios that describe how the system will be used in real-world situations. These scenarios should provide a clear understanding of the user's goals and objectives, as well as any constraints or limitations that may impact the design and development of the system.

9. **System Testing:** The smart home system shall be tested extensively to ensure that it meets all the requirements listed in the SRS. Testing shall include unit testing, integration testing, system testing, and user acceptance testing. The testing shall be done using both manual and automated methods.

10. **Review and Validation:** The SRS will be reviewed and validated with all stakeholders to ensure that it meets their needs and expectations. Any changes or revisions will be documented and communicated to all stakeholders.

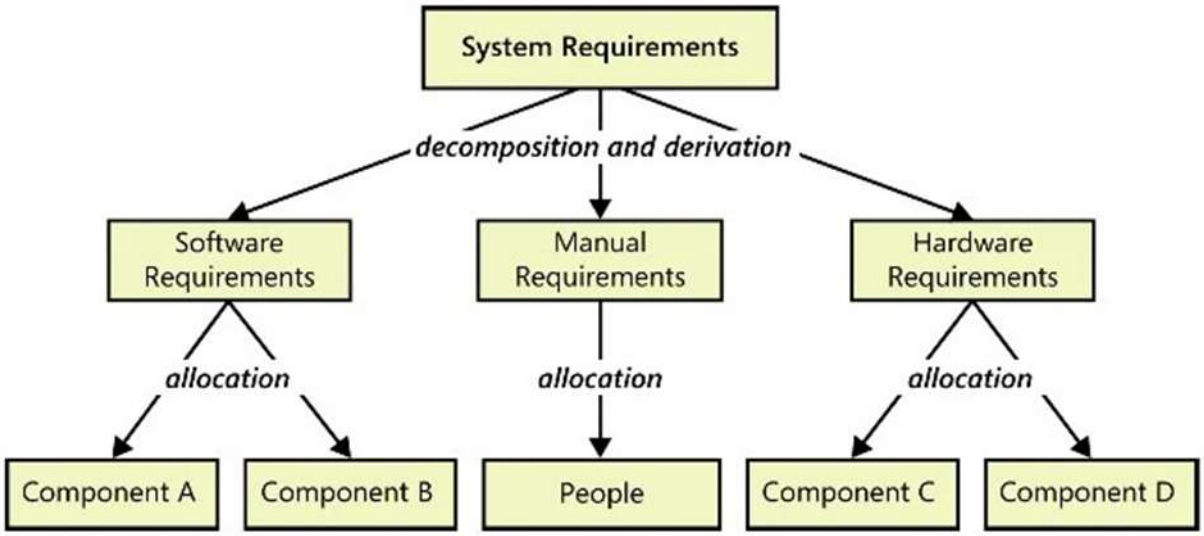


Figure 6: System Requirements

CRITERIA	MEETS SPECIFICATIONS
System Requirements	**1- Hardware Requirements** 1. Two ATmega16 microcontrollers for smart home. 2. ATmega16 microcontroller for solar tracking system. 3. Fire Sensor connected to Master PA0 pin. 4. Gas Sensor connected to Master PA1 pin. 5. Rain Sensor connected to Master PA2 pin. 6. PIR Sensor connected to Master PA3 pin. 7. LDR Sensor connected to Master PA4 pin. 8. Temperature Sensor connected to Master PA5 pin. 9. Soil Moisture Sensor connected to Master PA6 pin. 10. LCD1 Data pins (D4, D5, D6 and D7) connected on Master port B, pins 0, 1, 2, and 3. 11. Connect Master port B, pins 4, 5, 6, and 7 to slave port B, pins 4, 5, 6, and 7 (SPI). 12. White LEDS For Lightening connected on Master port C, pins 0, 1, 2, 3, 4, 5, and 6. 13. DC Motor (Fan) connected to Master PC7 pin. 14. WIFI Module RX pin connect to Master PD0 pin (TX). 15. WIFI Module TX pin connect to Master PD1 pin (RX). 16. LCD1 Control pins (RS, RW, and E) connected on Master port D, pins 2, 3, and 7. 17. Two Servo Motors (Window) connected to Master PD4 pin (OC1B). 18. Servo Motor (Garage door) connected to Master PD5 pin (OC1A). 19. Buzzer 5v connected to Master PD6 pin. 20. Keypad 8 Pins connected on port A pins. 21. LCD2 Data pins (D4, D5, D6 and D7) connected on Slave port B, pins 0, 1, 2, and 3. 22. LCD Control pins (RS, RW, and E) connected on Slave port C, pins 5, 6, and 7. 23. One RGB LED connected to PB0, PB1 and PB2, use it as Indicator LED for door state. 24. Buzzer 5v connected to Slave PD3 pin. 25. Two servo Motors (Home door) connected to Slave PD4 (OC1B) and PD5 pins (OC1A). 10. Blue LED connected to PB0, use it as Indicator LED by detection the soil moisture. 11. Red LED connected to PB1, use it as Indicator LED by detection the fire and gas. 28. Reset Push Button connect to Master Reset pin. 29. Reset Push Button connect to Slave Reset pin. 30. Reset Push Button connect to Solar MCU Reset pin. 31. Connect AREF pin to AVCC pin in three MCUs. 32. Install automatic solar cell. 33. Four LDR Sensors connect to Solar ECU port A, pins 0, 1, 2, and 3 pins. 34. Two servo Motor for X-axis and Y-axis connected to Solar MCU PD5 and PD6 pins. 35. ESP-01 WIFI Module 36. Design the 3 layout of PCB system boards (Master, Slave and Solar MCUs). 37. Design a PCB For WIFI Module.

CRITERIA	MEETS SPECIFICATIONS
System Requirements	**2- Software Requirements** **Functional Requirements:** 1. Device Control: The smart home system should allow users to control their smart devices, such as lights, and door lock, by using a central interface. 2. Automation: The smart home system should support automation of devices, such as turning off lights or adjusting the temperature when the user leaves the house. 3. Scene Creation: The smart home system should support the creation of scenes, allowing users to set multiple devices to specific settings with a single command. 4. Energy Management: The smart home system should provide users with the ability to monitor and manage energy usage of devices, providing insights into energy consumption patterns and allowing users to optimize energy consumption. 5. User Management: The smart home system should support multiple user profiles, allowing for customized device control and access levels. **Non-Functional Requirements:** 1. Performance: The smart home system should operate with minimal latency, providing near-instantaneous device control and automation. 2. Security: The smart home system should be designed to protect user privacy and data, including secure storage of user data and compliance with industry security standards. 3. Usability: The smart home system should have a user-friendly interface, allowing users to easily control their devices and access system features. 4. Compatibility: The smart home system should be compatible with a wide range of smart devices available in the market. 5. Reliability: The smart home system should be designed to operate reliably and with minimal downtime.
Make full static architecture for the system	1. Define system layers 2. Define system drivers 3. Place each driver into the appropriate layer in the appropriate order 4. Define APIs that will be used for each driver, with its documentation, description, input arguments, output arguments, and return. 5. Define the new data types you will use in these drivers 6. Define the bit math macro file you will use in these drivers

CRITERIA	MEETS SPECIFICATIONS
Apply your layered architecture into Project's folder structure	1. Create a folder for each layer 2. In each layer folder, create a folder for each driver related to this layer 3. In each driver folder, create .c and .h files 4. Create a manic file that will call your application"
Prepare all les for development	1. Add header file guard to all header files 2. Write all typedefs related to each driver in its header file 3. Write all prototypes for all drivers' APIs in their header files 4. Include lower layer drivers into the .h files of the upper layer/calling drivers 5. Include each driver's .h file into its related .c file 6. Include app.h into main .c
Implement your drivers	1. Write a skeleton for each function using comments. 2. Convert each step into the appropriate code 3. Each function should return error state to indicate that everything is ok or not"
Test your drivers	"Implement a test module for each driver" 1. This test module is simply a main function that call driver's APIs and validate its output. 2. These test modules can be manually test or automated test.
User story 1	Developing a system to unlock a door using a password. 1- The system asks the user to enter a password or change the password. 2- If the user chooses to enter a password, then he must enter the password, and verify the password entered. 3- If the user chooses to change password then he is capable of changing the password and then is redirected to phase 1. 4- If the user chooses to enter a password, he has 3 chances to enter the password correctly, If the password is entered correctly within the 3 chances the door will open and stay opened for an extra 3 seconds and then close. Else the whole system is locked. 5- If the user entered the reversed password, the system will call the police.
User story 2	Developing a system to detect the fire. - When the system is detected a fire, the fire alarm system will immediately sound an alarm to alert and the led will flash light.
User story 3	Developing a system to detect the Gas. - When the system is detected a Gas (Propane), the smoke alarm system will immediately sound an alarm to alert and The led will flash light.
User story 4	Developing a system to detect the Rain. 1- When the system is detected the rain, The rain indicator system will immediately close the windows and the windows will not open during the rain. 2- when the rain stops, the user can open the windows

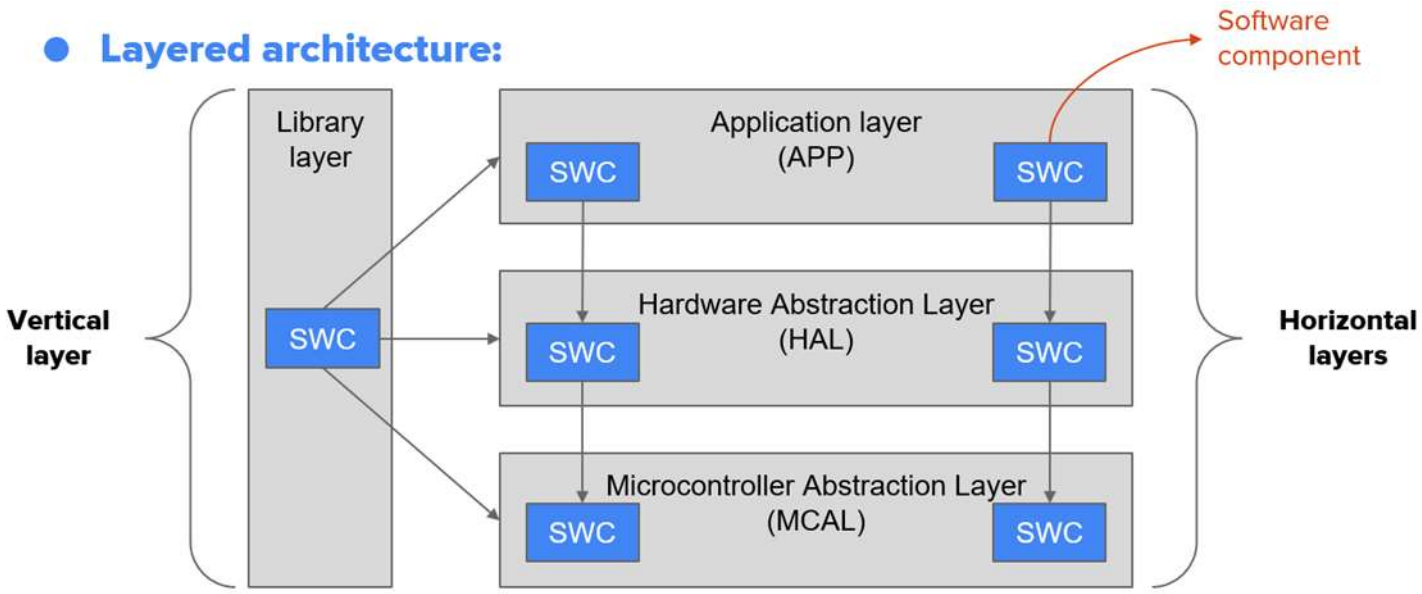
CRITERIA	MEETS SPECIFICATIONS
User story 5	Developing a system to detect the motion. 1- when the system is detected the motion of the user (when the user enter the room), The light room is automatically turn on.
User story 6	Developing a system to detect the rise and fall in the temperature and take action upon it. 1- Whenever the temperature measured by the LM35 Temperature goes below 30 degree Celsius the Air conditioner gets turned off. 2- whenever the temperature goes beyond 30 degree Celsius (threshold) the Air conditioner gets turned on.
User story 7	Install solar cells to provide electricity and is a clean and green source of energy that produces no emissions or pollutants, it a much more environmentally friendly option compared to traditional forms of energy generation that rely on fossil fuels.
User story 8	Developing a system to increase the efficiency of solar panels by following the movement of the sun throughout the day. 1- The sensors detect the position of the sun in the sky and provide feedback to the control system. 2- The control system calculates the optimal position of the solar panel and sends signals to the motors. 3- The motors rotate the solar panel along the horizontal and vertical axes to track the sun's position. As the sun moves across the sky throughout the day, the solar panel continuously adjusts its position to ensure maximum exposure to sunlight.
User story 9	Developing a system control a landscape light by LDR. 1- When the night comes, the landscape light will turn on. 2- When the sun light comes, the landscape light will turn off.
User story 10	Developing a remote control system by mobile application via WIFI module. 1- The user can control multiple devices from a single mobile application. 2- The user can remotely control devices such as rooms lights, home door, window
User story 11	Develop a system to measure soil moisture to preserve garden soil moisture saturation and reduce plant withering. 1- When the soil is dry, the system will indicate the user (blue LED) to open the pumps.

Table 1: System Requirement Specifications

2.3 Layered Architecture in Embedded Systems

Layered architecture is a common design pattern used in embedded systems to organize software components into distinct layers or levels. This approach can help to improve system reliability, scalability, and maintainability by separating different concerns and providing clear interfaces between layers.

In a layered architecture, each layer is responsible for a specific set of functions, and communicates with the layers above and below it using well-defined interfaces or APIs. Typically, the layers are organized in a hierarchical fashion, with lower-level layers providing services to higher-level layers.



Common layers in embedded system architecture include:

Microcontroller Abstraction Layer (MCAL) is a software layer that abstracts the hardware details of a microcontroller, making it easier for developers to write portable and efficient code. The MCAL provides a standardized interface to access the hardware resources of the microcontroller, such as input/output (I/O) pins, timers, interrupts, and analog-to-digital converters (ADCs).

Hardware Abstraction Layer (HAL): is a software layer that provides an abstraction of the hardware platform, making it easier to write software that is portable across different hardware platforms. The HAL provides a standardized interface to access the hardware resources of the platform, such as input/output (I/O) ports, timers, interrupts, and other peripherals.

Application Layer: includes software that is designed to meet the specific needs of the users, and provides a user-friendly interface for users to interact with the system. The software in the application layer interacts with the lower layers of the software stack, such as the operating system layer, device driver layer, and HAL, to access the hardware resources and provide the desired functionality.

Library (LIB): provide a standardized interface to access common functionality, making it easier for developers to write applications without having to write everything from scratch. Library layers typically include functions and data structures that provide an abstraction of the underlying functionality, allowing developers to use the libraries without having to understand the underlying implementation details.

2.4 Module Structure

Every folder in the MCAL or HAL folders is considered as a module.

Every module contains 5 files:

MODULE_interface.h: Contains the interface of the module like functions prototypes and structure types.

MODULE_program.c: Contains the implementations and details of the module.

MODULE_register.h: A register definition file that contains registers names and their map either in the microcontroller or in an external device.

MODULE_config.h: Contains the pre-build configurations of the module.

MODULE_private.h: Contains definitions private to the module.

MODULE_test.c: Contains tests for the module only.

2.5 System Design

2.5.1 UML Diagrams

UML stands for Unified Modeling Language. UML is a Way of visualizing a software program using a collection of diagrams

2.5.1.1 Class Diagram

Class diagram are the backbone of almost every object-oriented method, including UML. They describe the static structure of a system. It shows relationships between classes, objects attributes, and operations

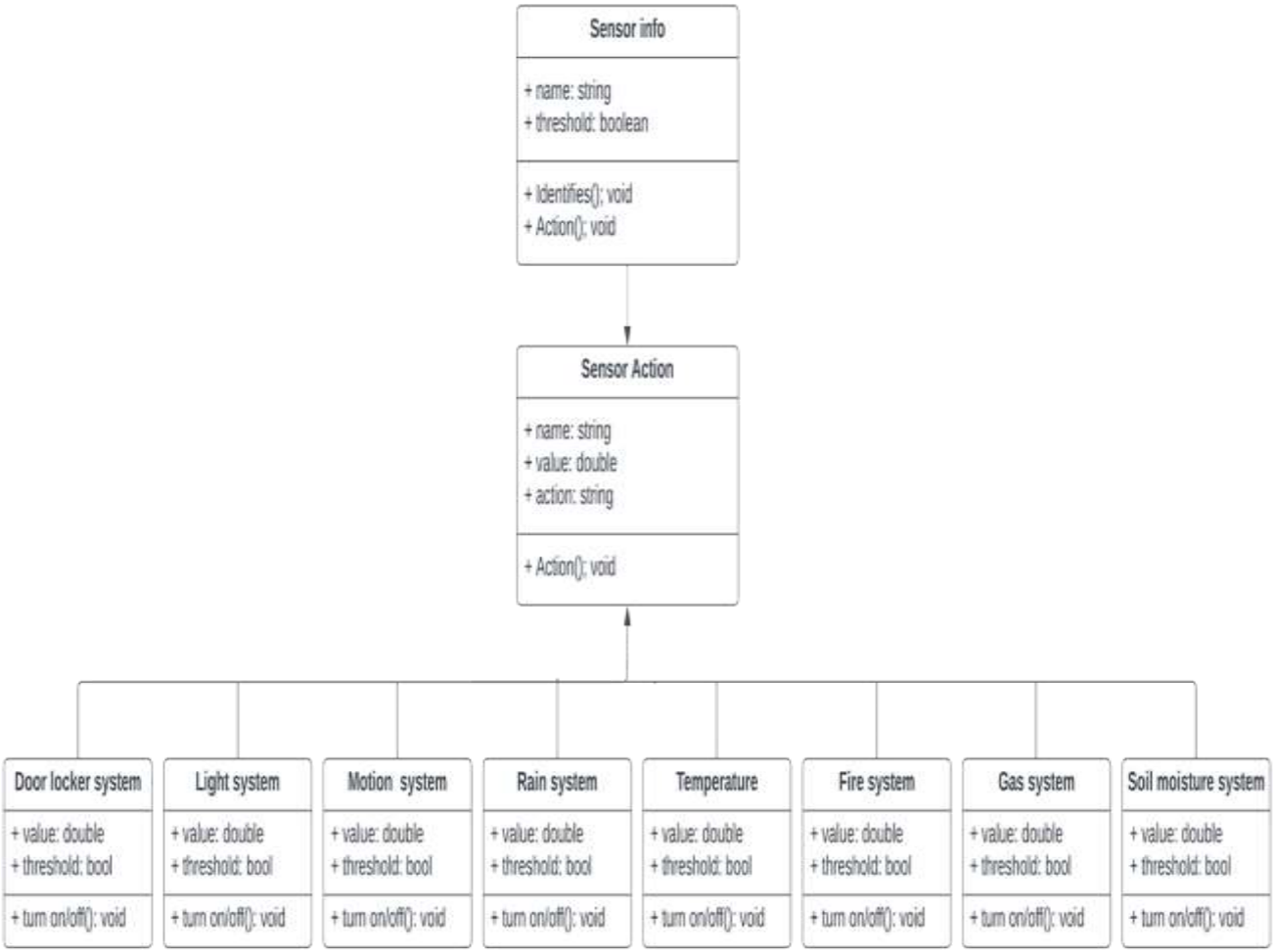


Figure 7: Class Diagram

2.5.1.2 Use Case Diagram

Use case diagram is a dynamic or behavior diagram in UML model the functionality of a system using actors and use cases. Use cases are a set of actions, services, and functions that the system needs to perform.

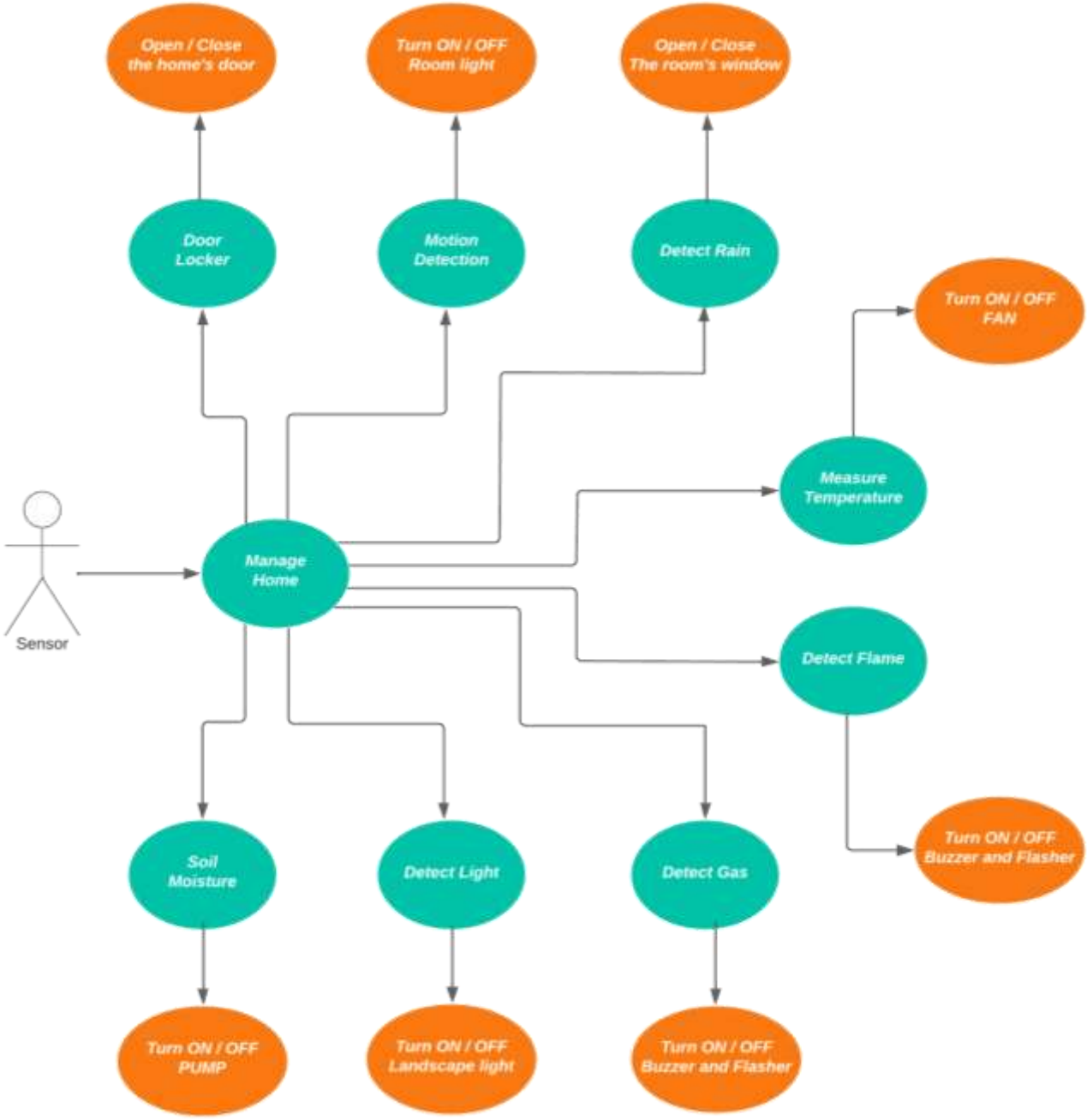


Figure 8: Use Case Diagram

2.5.1.3 Activity Diagram

An activity diagram visually presents a series of actions or flow of control in operation on some classes in the system results in change in the state of the system.

Activities modeled can be sequential and concurrent.

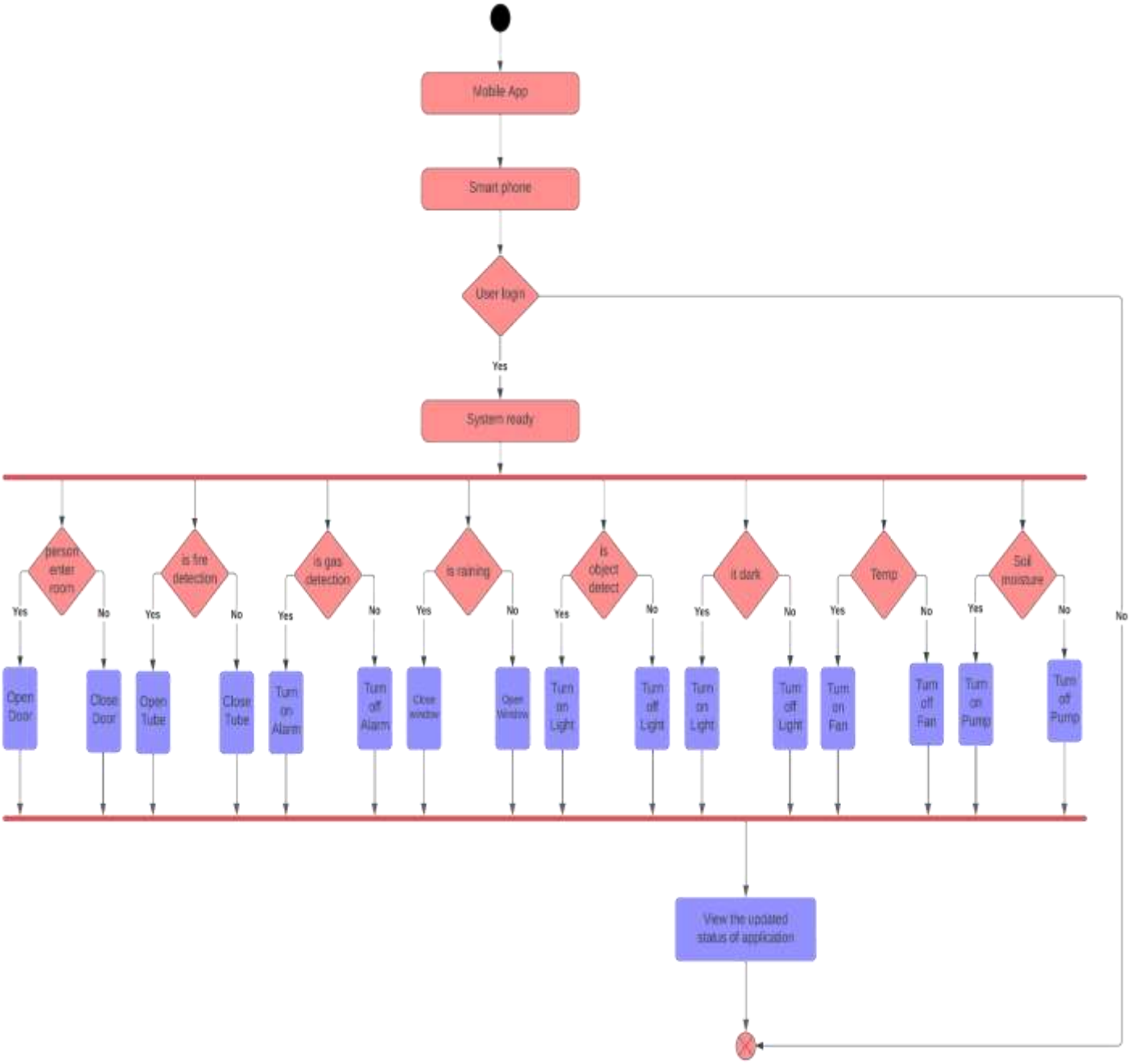


Figure 9: Activity Diagram

2.5.1.4 Block Diagram

A block diagram is a diagram of a system in which the principal parts or functions are represented by blocks connected by lines that show the relationships of the blocks. Block diagrams are typically used for higher level, less detailed descriptions that are intended to clarify overall concepts without concern for the details of implementation.

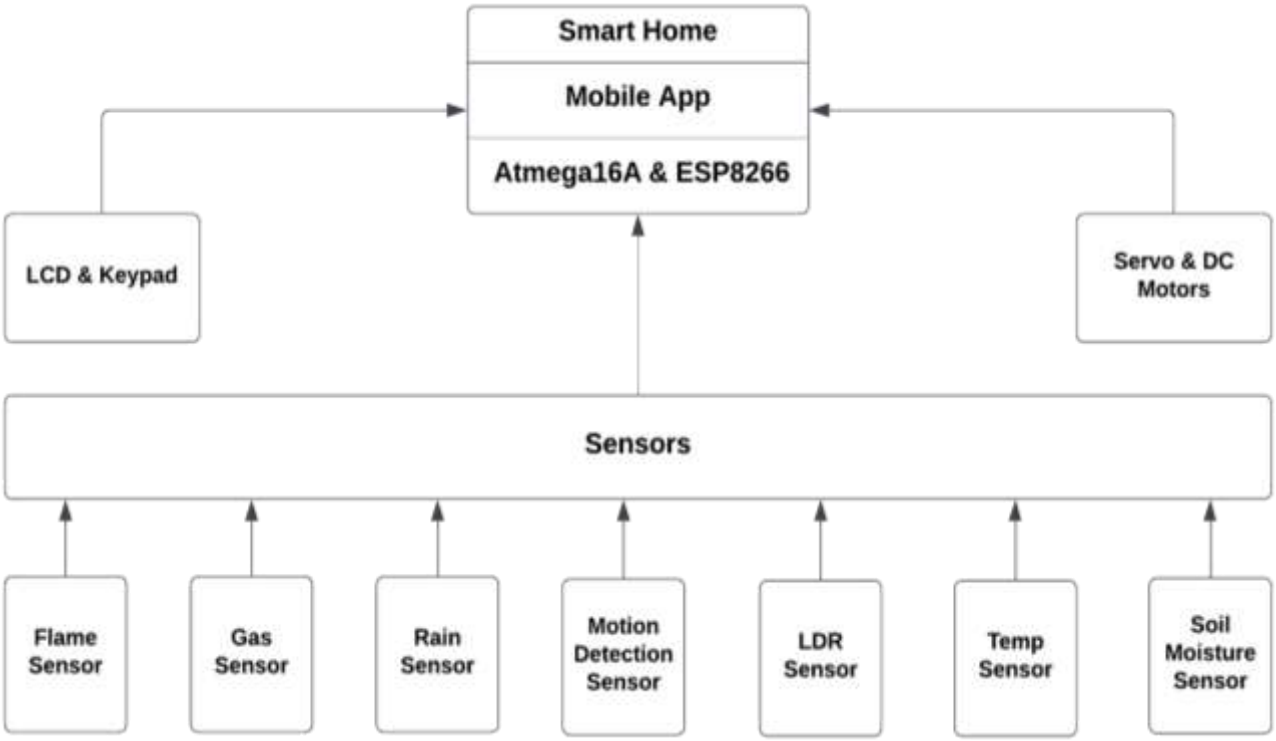


Figure 10: Block Diagram

Chapter 3

SYSTEM IMPLEMENTATION

3.1 Hardware Implementation

3.1.1 ATMEGA16 Microcontroller

Figure 11: ATmega16

The ATmega16 is an 8-bit microcontroller from the Atmel AVR family. It is widely used in embedded systems and is known for its versatility, performance, and ease of use. Here are some key features of the ATmega16:

Architecture: The ATmega16 is based on the Harvard architecture and incorporates a powerful RISC core with a rich set of instructions.

CPU and Memory: It operates at a clock frequency of up to 16 MHz and has 16KB of in-system programmable Flash memory for storing program code. It also has 1KB of EEPROM for non-volatile data storage and 1KB of SRAM for volatile data storage.

I/O Ports: The microcontroller has 32 general-purpose I/O pins divided into four 8-bit ports (Port A, B, C, and D). These ports can be used for various input and output operations.

Timers/Counters: The ATmega16 has three 16-bit timers/counters: Timer/Counter0, Timer/Counter1, and Timer/Counter2. These timers can be used for tasks such as generating precise time delays, measuring external events, or generating PWM signals.

Serial Communication: It supports multiple serial communication protocols including USART (Universal Synchronous/Asynchronous Receiver/Transmitter), SPI (Serial Peripheral Interface), and I2C (Inter-Integrated Circuit).

Analog-to-Digital Converter (ADC): The ATmega16 features a 10-bit ADC with eight multiplexed input channels. This allows the microcontroller to convert analog signals into digital values for processing.

Interrupts: The microcontroller has both external and internal interrupt capabilities, which allow it to respond to external events or specific conditions within the microcontroller.

Development Tools: Atmel provides a comprehensive set of development tools, including an Integrated Development Environment (IDE) called Atmel Studio, which offers a complete software development environment for writing, compiling, and debugging code for the ATmega16.

PWM Output: The ATmega16 has multiple PWM (Pulse Width Modulation) channels that can generate analog-like signals with varying duty cycles. This feature is useful for applications such as motor control, LED dimming, and audio generation.

Watchdog Timer: The microcontroller includes a built-in watchdog timer that can be configured to reset the system if a software or hardware malfunction occurs. It provides an additional level of reliability by ensuring that the system can recover from unexpected errors.

Power-Saving Modes: The ATmega16 offers different power-saving modes, including Idle, Power-down, and Standby modes. These modes help conserve power by reducing the microcontroller's overall power consumption when it is not actively processing tasks.

Bootloader Support: The ATmega16 can be used with a bootloader, which is a small program that allows firmware updates to be loaded into the microcontroller's memory using a serial interface. Bootloaders provide a convenient way to update firmware without requiring a dedicated programmer.

Operating Voltage Range: The ATmega16 operates within a voltage range of 2.7V to 5.5V, making it compatible with a wide range of power supply options. This flexibility allows the microcontroller to be used in battery-powered applications as well as systems powered by regulated power supplies.

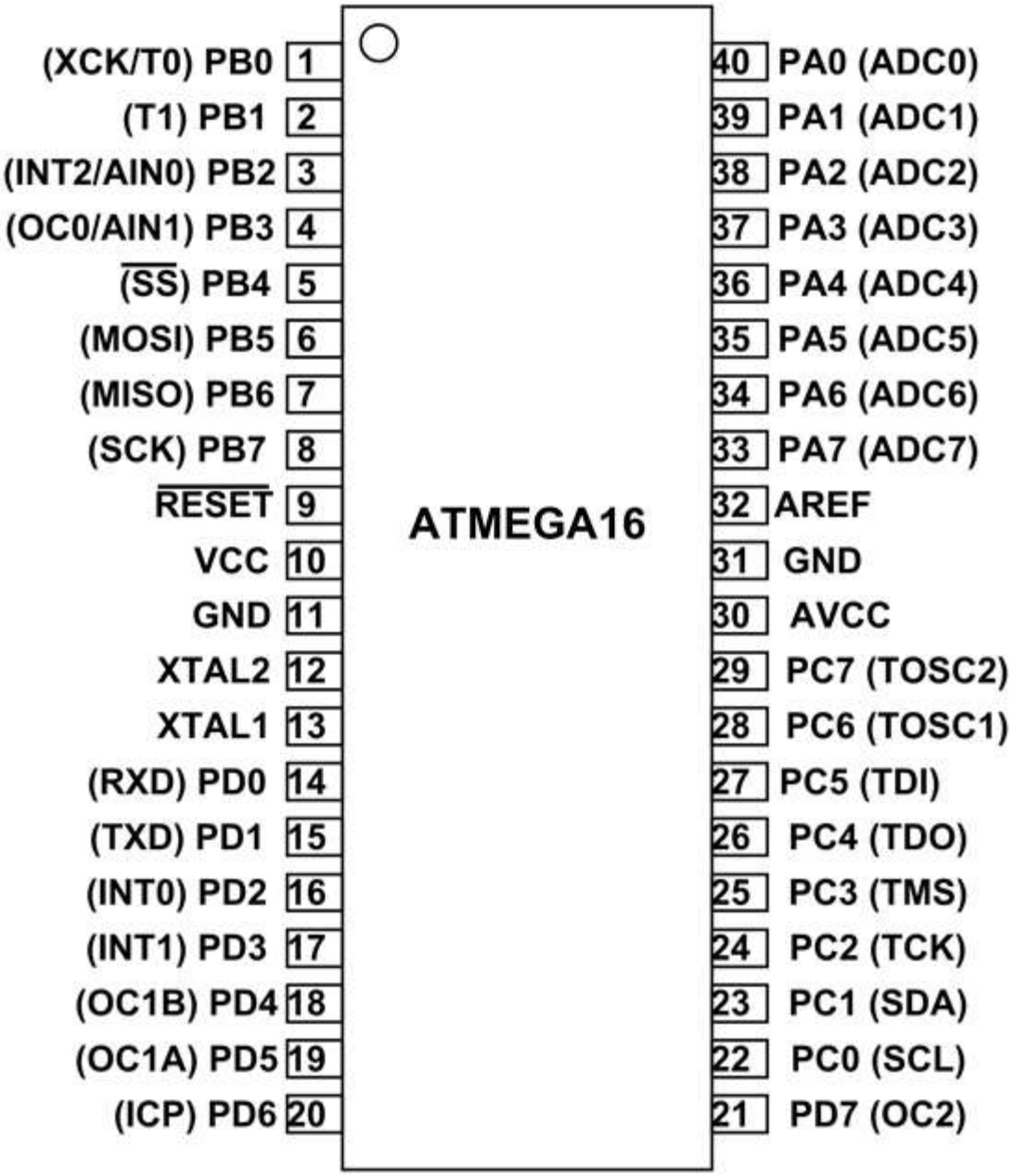


Figure 12: Pin Diagram of ATmega16 Microcontroller

3.1.2 ESP8266 Wi-Fi Module

3.1.2.1 ESP8266 Wi-Fi Module Description

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.

Figure 13: ESP8266

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts. There is an almost limitless fountain of information available for the ESP8266, all of which has been provided by amazing community support. In the Documents section below you will find many resources to aid you in using the ESP8266, even instructions on how to transforming this module into an IoT (Internet of Things) solution!

3.1.2.2 Features

- 802.11 b/g/n
- Wi-Fi Direct (P2P), soft-AP
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLLs, regulators, DCXO and power management units
- +19.5dBm output power in 802.11b mode
- Power down leakage current of < 2ms
- Standby power consumption of < 1.0mW (DTIM3)

3.1.2.3 Specification of ESP8266

- Wi-Fi Direct (P2P), soft-AP
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLLs, regulators, DCXO and power management units
- 19.5dBm output power in 802.11b mode
- Power down leakage current of < 1.0mW (DTIM3)

3.1.2.4 ESP8266 Wi-Fi Module Description

The module has a 2×4-pin header on the assembly. See pic for layout as the boards may not have the pins labeled.

2 x 4 Header:

- **GND =** Ground. Connect to ground on MCU
- **GPIO2** = General Purpose Digital I/O
- **GPIO0** = General Purpose Digital I/O
- **RX =** Receive Data. Connects to RX on MCU
- **TX** = Transmit Data. Connects to TX on MCU
- **CH_PD =** Enable / Power Down. Must be pulled to 3.3V directly or via pull-up resistor to enable
- **RST =** Reset. Active low, must be pulled to 3.3V directly or via pull-up resistor
- **VCC =** 3.3V. Can draw up to 200mA worse case.

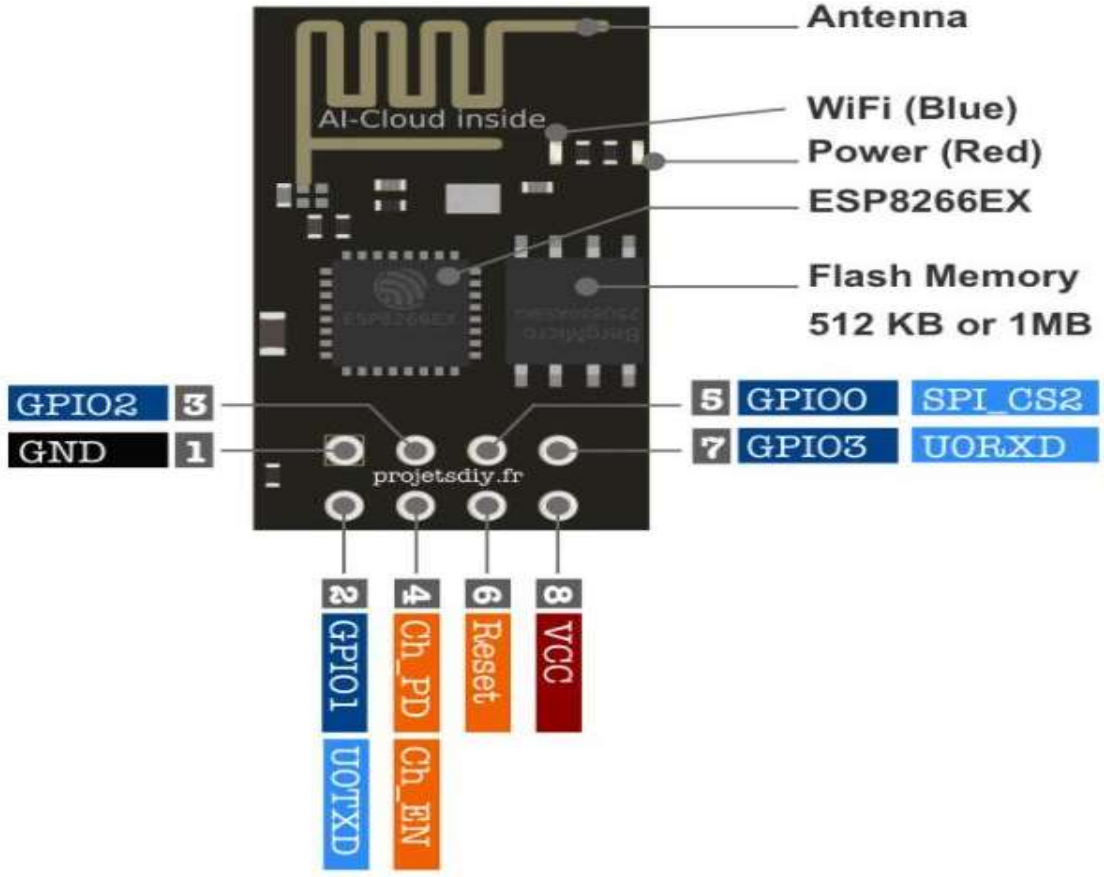


Figure 14: ESP Specification

3.1.3 Light Emitting Diode (LED)

3.1.3.1 What is LED?

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current flows through it. When current passes through an LED, the electrons recombine with holes emitting light in the process. LEDs allow the current to flow in the forward direction

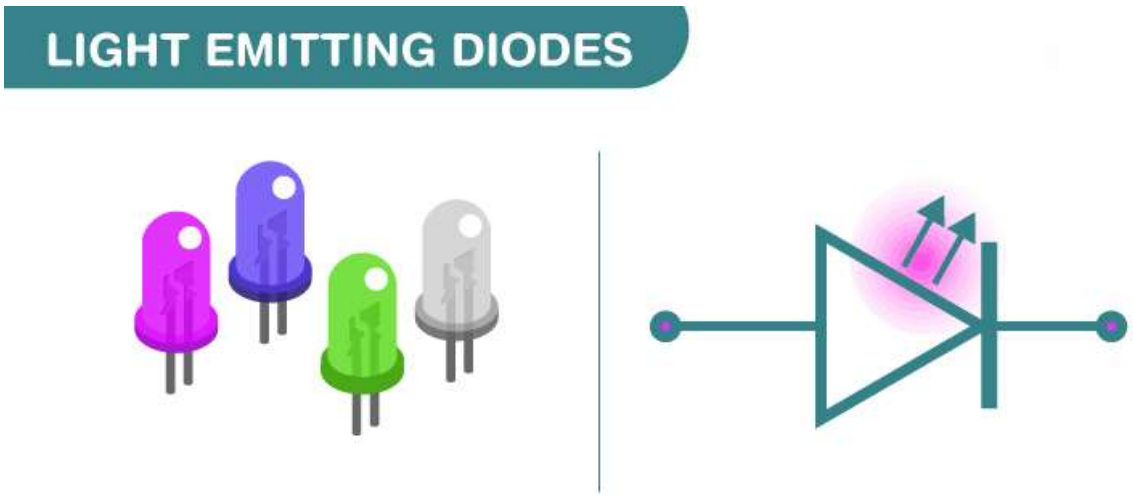


Figure 15: Light Emitting Diodes

and blocks the current in the reverse direction.

Light-emitting diodes are heavily doped p-n junctions. Based on the semiconductor material used and the amount of doping, an LED will emit colored light at a particular spectral wavelength when forward biased. As shown in the figure, an LED is encapsulated with a transparent cover so that emitted light can come out.

3.1.3.2 LED Symbol

The LED symbol is the standard symbol for a diode, with the addition of two small arrows denoting the emission of light.

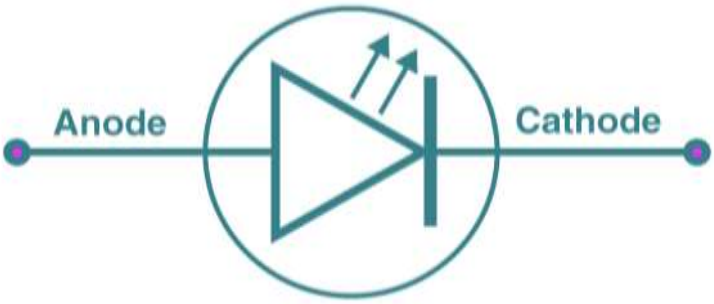


Figure 16: LED Symbol

3.1.3.3 Simple LED Circuit

The circuit consists of an LED, a voltage supply and a resistor to regulate the current and voltage

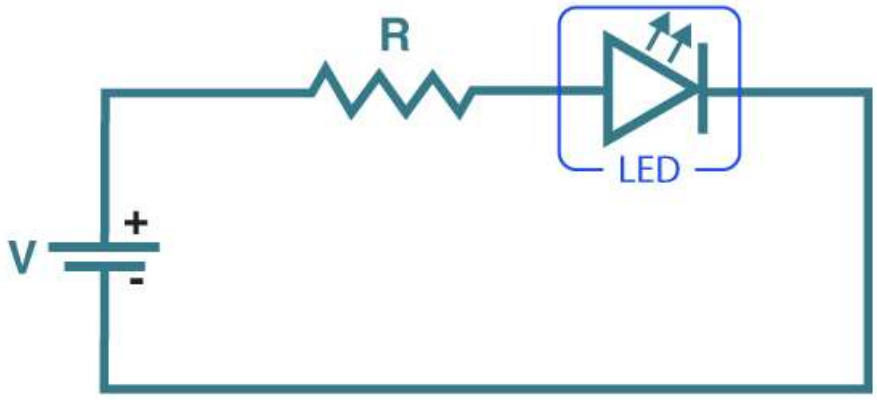


Figure 17: LED Circuit

3.1.3.4 How does an LED work?

When the diode is forward biased, the minority electrons are sent from p → n while the minority holes are sent from n → p. At the junction boundary, the concentration of minority carriers increases. The excess minority carriers at the junction recombine with the majority charges carriers.

The energy is released in the form of photons on recombination. In standard diodes, the energy is released in the form of heat. But in light-emitting diodes, the energy is released in the form of photons. We call this phenomenon electroluminescence. Electroluminescence is an optical phenomenon, and electrical phenomenon where a material emits light in response to an electric current passed through it. As the forward voltage increases, the intensity of the light increases and reaches a maximum.

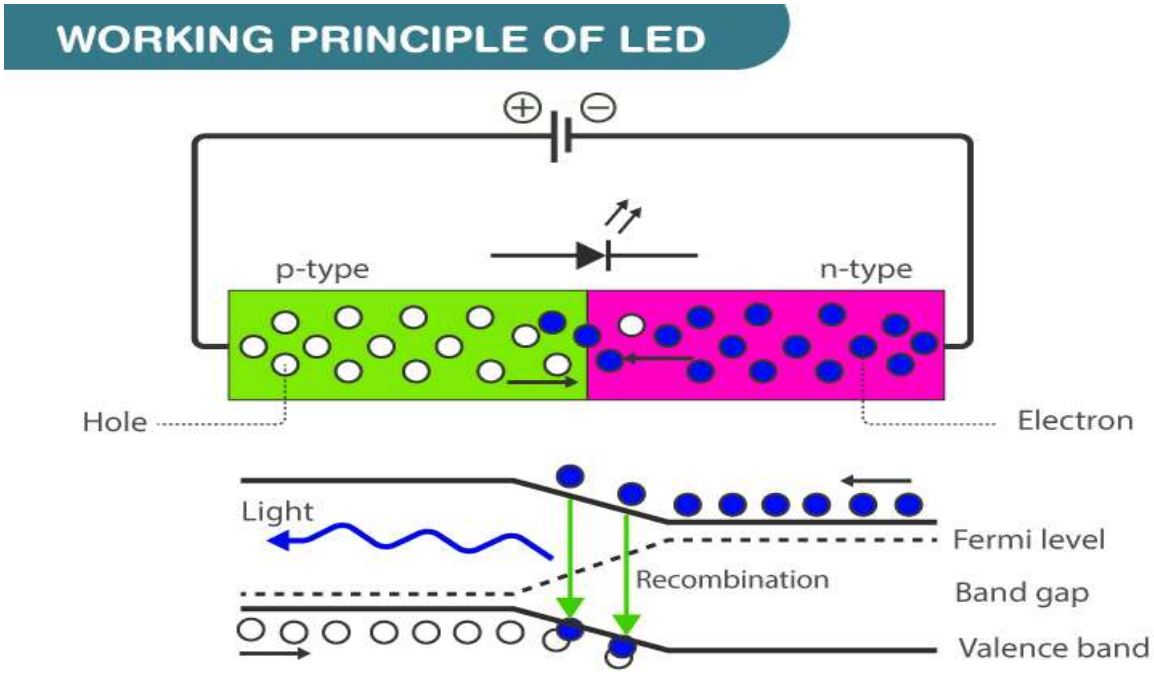


Figure 18: Working Principle of LED

3.1.3.5 What determines the color of an LED?

The color of an LED is determined by the material used in the semiconducting element. The two primary materials used in LEDs are aluminum gallium indium phosphide alloys and indium gallium nitride alloys. Aluminum alloys are used to obtain red, orange and yellow light, and indium alloys are used to get green, blue and white light. Slight changes in the composition of these alloys change the color of the emitted light.

3.1.3.6 Uses of LED

LEDs find applications in various fields, including optical communication, alarm and security systems, remote-controlled operations, robotics, etc. It finds usage in many areas because of its long-lasting capability, low power requirements, swift response time, and fast switching capabilities. Below are a few standards LED uses:

- Used for TV back-lighting
- Used in displays
- Used in Automotive
- LEDs used in the dimming of lights

3.1.3.7 Advantages of LEDs over Incandescent Power Lamps

Some advantages of LEDs over Incandescent Power Lamps are:

- LEDs consume less power, and they require low operational voltage.
- No warm-up time is needed for LEDs.
- The emitted light is monochromatic.
- They exhibit long life and ruggedness.

3.1.4 Liquid Crystal Displays (LCD)

An **LCD** is an electronic display module which uses liquid crystal to produce a visible image. The 16×2 LCD display is a verybasic module commonly used in DIYs and circuits. The 16×2 translates a display 16 characters per line in 2 such lines. In this **LCD** each character is displayed in a 5×7-pixel matrix.

3.1.4.1 Features

- Operating Voltage is 4.7V to 5.3V.
- Current consumption is 1mA without backlight.
- Alphanumeric LCD display module, meaning can displayalphabets and numbers.
- Consists of two rows and each row can print 16 characters.
- Each character is built by a 5×8-pixel box.
- Can work on both 8-bit and 4-bit mode.
- It can also display any custom generated characters.
- Available in Green and Blue Backlight.

3.1.4.2 Pin Description

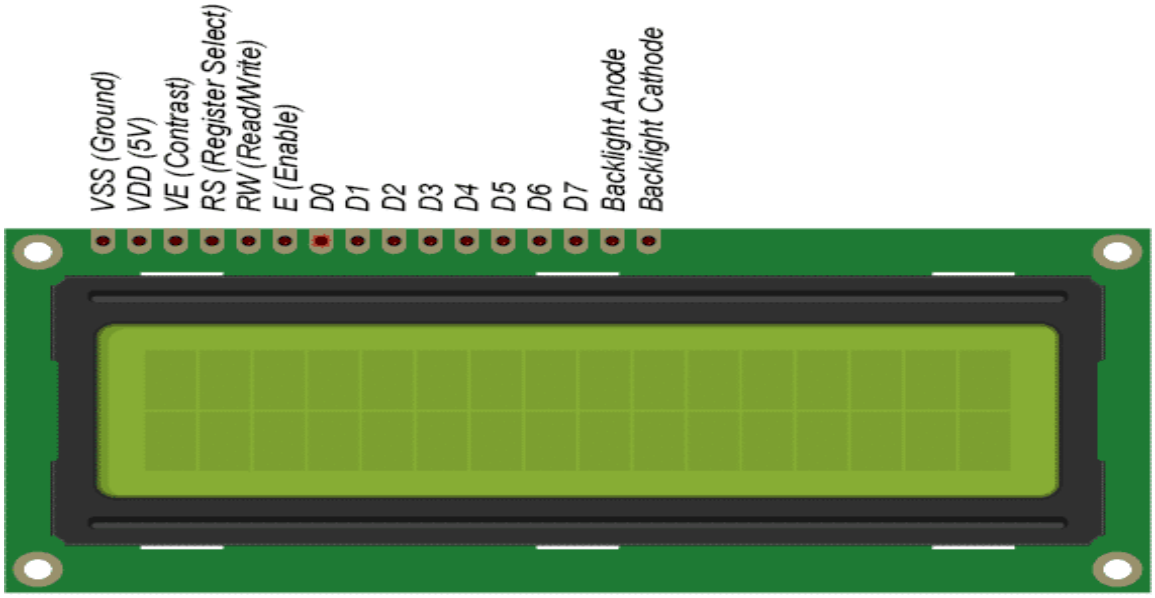


Figure 19: LCD 16x2 Pin Description

3.1.4.3 Registers of LCD

A 16×2 LCD has two registers like data register and command register. The RS (register select) is mainly used to change from one register to another. When the register set is '0', then it is known as command register. Similarly, when the register set is '1', then it is known as data register.

Command Register

The main function of the command register is to store the instructions of command which are given to the display. So that predefined tasks can be performed such as clearing the display, initializing, set the cursor place, and display control. Here commands processing can occur within the register.

Data Register

The main function of the data register is to store the information which is to be exhibited on the LCD screen. Here, the ASCII value of the character is the information which is to be exhibited on the screen of LCD. Whenever we send the information to LCD, it transmits to the data register, and then the process will be starting there. When register set =1, then the data register will be selected.

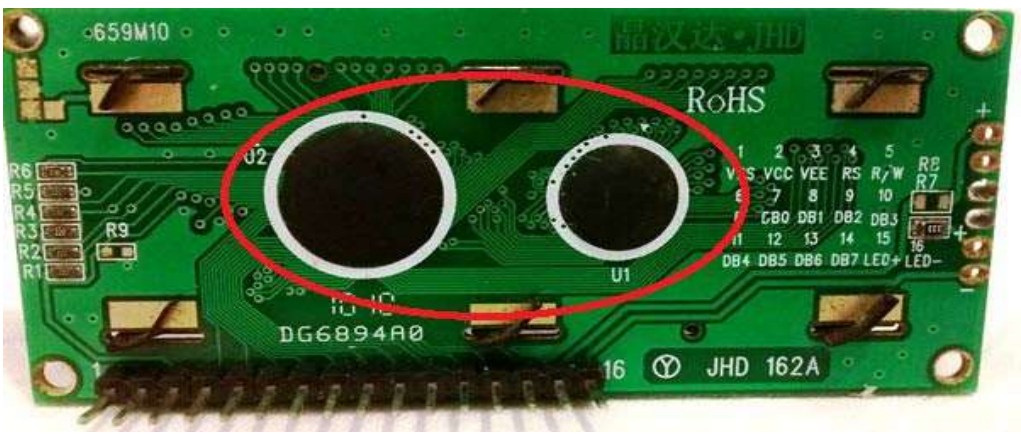


Figure 20: Two Black Circles (LCD Board)

3.1.4.4 What is this two black circle like things on the back of our LCD?

These black circles consist of an interface IC and its associated components to help us use this LCD with the MCU. Because our LCD is a 16*2 Dot matrix LCD and so it will have (16*2=32) 32 characters in total and each character will be made of 5*8 Pixel Dots. A Single character with all its Pixels enabled.

3.1.5 Keypad

The keypad component contains a set of library routines that enable scan of 4*4 switch array and return the data associated with the switch pressed the component provide APIs (application programming interface routines allow you to configure the component using software) to implement user defined character data for each Switch.

3.1.5.1 Features

• Implements the 4*4 switch keypad matrix protocol.
• Require only 8 I/O pins.
• Pins don't have to be sequential or to be on the same port.
• Pull up resistor is not required.
• VCC is not required.

3.1.5.2 Pin Description

Keypad Pins Description	
Pin. No	**Pin Description**
1	Controls all the buttons of 1st row
2	Controls all the buttons of 2nd row
3	Controls all the buttons of 3rd row
4	Controls all the buttons of 4th row
5	Controls all the buttons of 1st column
6	Controls all the buttons of 2nd column
7	Controls all the buttons of 3rd column
8	Controls all the buttons of 4th column

Table 2: keypad Pins Description

3.1.5.3 How to use 4x4 Keypad Modules

Using **KEYPAD MODULE** is little tricky. As 16 keys are connected in matrix formation the module is a little complex to use. The module gives only 8 pins as a way for interacting with 16 buttons.
We are going to explain **how to use the KEYPAD MODULE** in a simple way step by step:
Consider we have connected the **KEYPAD MODULE to a microcontroller.**

STEP 1: First set all ROWS to OUTPUT and set them at +5V. Next set all COLUMNS as INPUT to sense the HIGH logic. Now consider a button is pressed on keypad. And that key is at 2ND COLUMN and 3rd ROW.

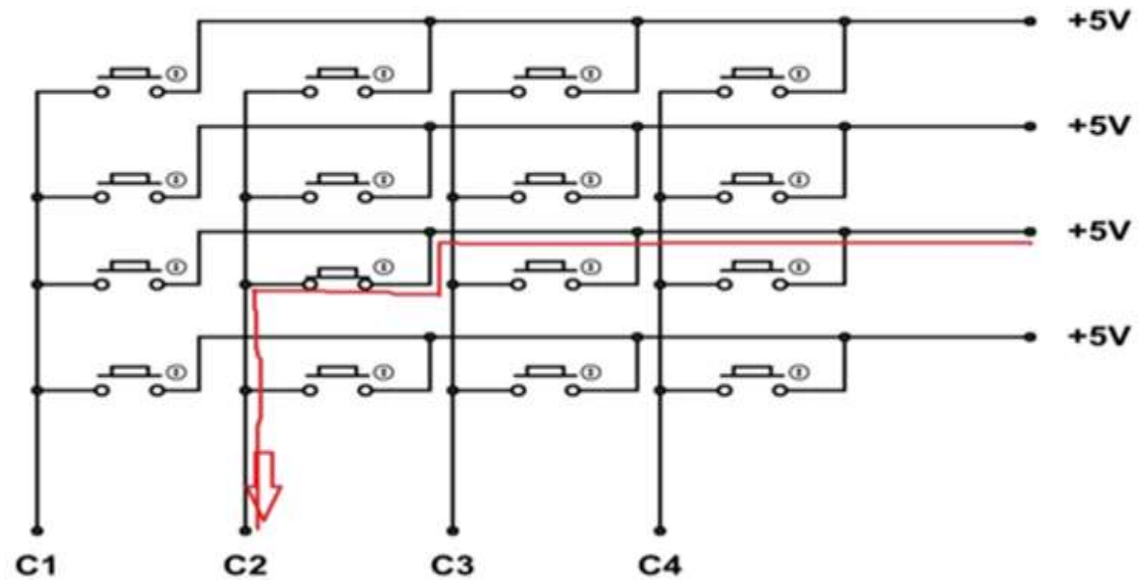


Figure 21: All Rows as Input in keypad

With the button being pressed the current flows as shown in figure. With that a voltage of +5V appears at terminal C2. Since the COLUMN pins are set as INPUTS, the controller can sense C2 going high. The controller can be programmed to remember that C2 going high and the button pressed is in C2 COLUMN.

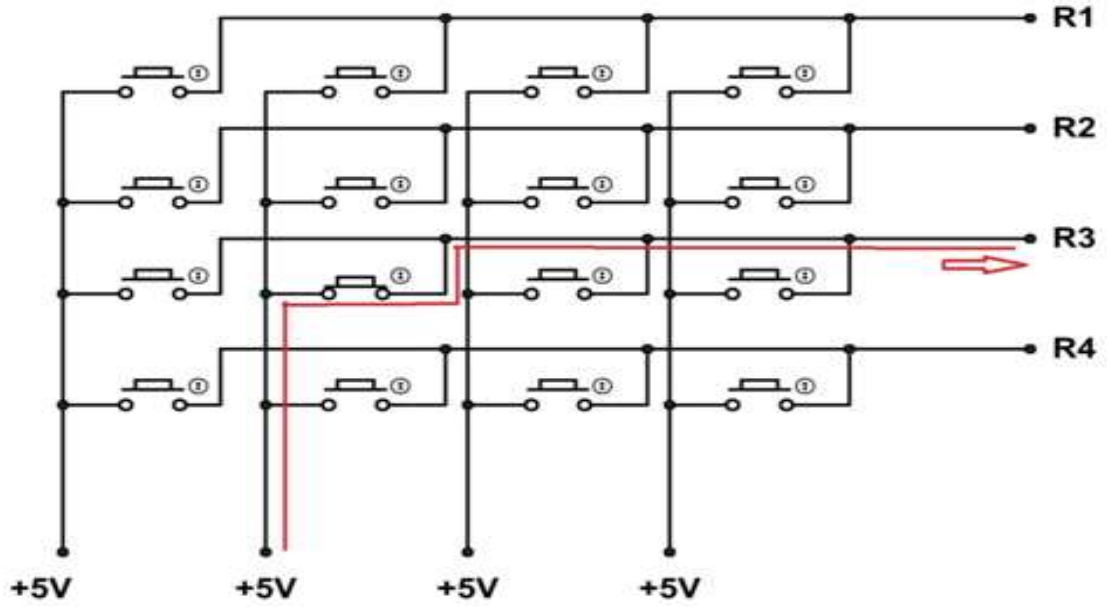


Figure 22: All Columns as Input in keypad

STEP 2: Next set all COLUMNS to OUTPUT and set them at +5V. Next set all ROWS as INPUT to sense the HIGH logic. Since the key pressed is at 2ND COLUMN and 3rd ROW. The current flows as shown below.

With that current flow a positive voltage of +5V appears at R3 pin. Since all ROWS are set as INPUTS, the controller can sense +5V at R3 pin. The controller can be programmed to remember the key being pressed at third ROW of KEYPAD MATRIX.

From previous step, we have known the COLUMN number of key pressed and now we know ROW number. With that we can match the key being pressed. We can take the key INPUT provided by this way for **4X4 KEYPAD MODULE**.

3.1.6 Servo Motor

Servo is a general term for a closed loop control system.
A closed loop system uses the feedback signal to adjust the speed and direction of the motor to achieve the desired result.

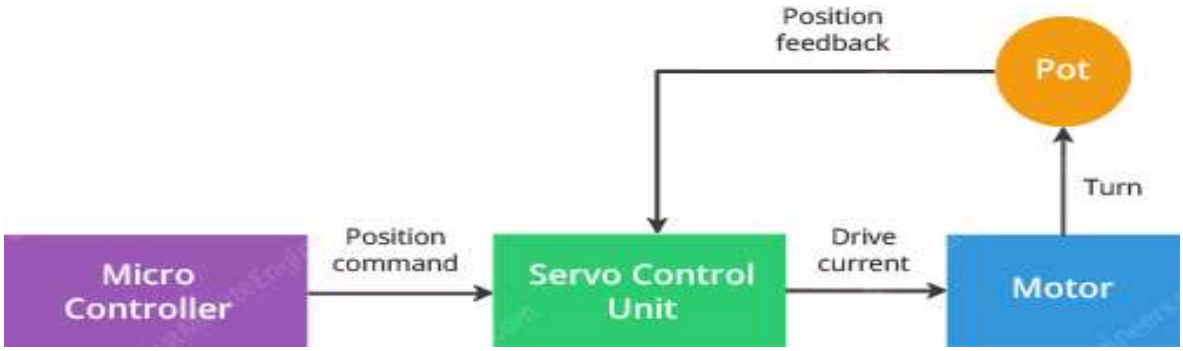


Figure 23: Servo Motor Diagram

RC servo motor works on the same principal. It contains a small DC motorconnected to the output shaft through the gears. The output shaft drives a servo arm and is also connected to a potentiometer (pot).

The potentiometer provides position feedback to the servo control unit wherethe current position of the motor is compared to the target position.
According to the error, the control unit corrects the actual position of the motorso that it matches the target position.

3.1.6.1 How Servo Motors Work?

You can control the servo motor by sending a series of pulses to the signal line.A conventional analog servo motor expects to receive a pulse roughly every 20milliseconds (i.e. signal should be 50Hz).

The length of the pulse determines the position of the servo motor.

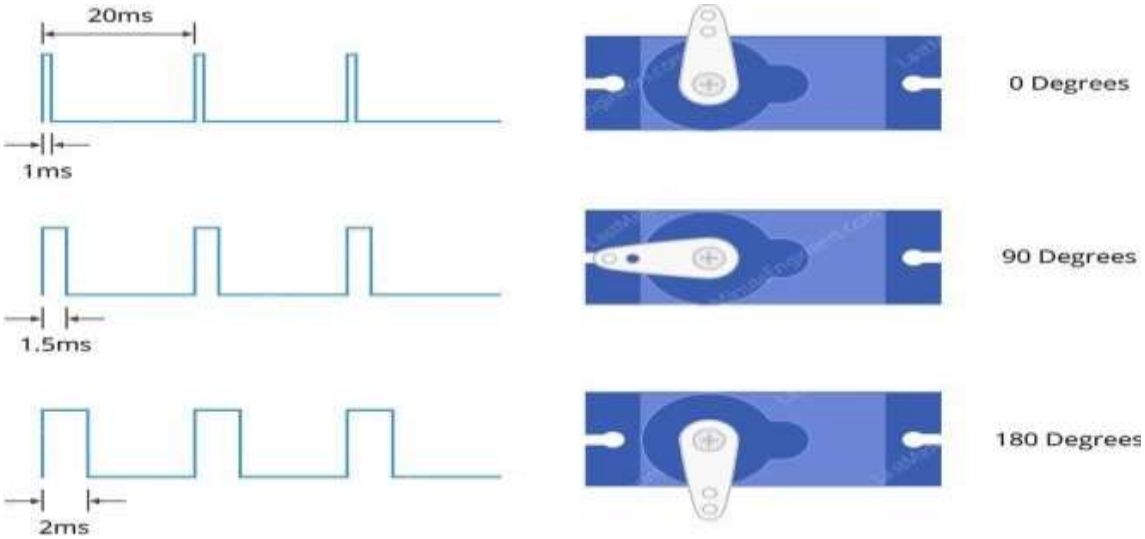


Figure 24: Pulse Shape for Servo Motor

- If the pulse is high for 1ms, then the servo angle will be zero.
- If the pulse is high for 1.5ms, then the servo will be at its center position.
- If the pulse is high for 2ms, then the servo will at 180 degrees.
- Pulses ranging between 1ms and 2ms will move the servo shaft throughthe full 180 degrees of its travel.

The duration of the pulses may sometimes vary with different brands andthey can be 0.5ms for 0 degrees and 2.5ms for 180 degrees.

3.1.4.2 Servo Motor Pinout

Servo motors typically have three connections and are as follows:

GND is a common ground for both the motor and logic.
5v is a positive voltage that powers the servo.
Control is input for the control system.

3.1.7 Flame Sensor

3.1.7.1 What is a Flame Sensor?

A flame detector is a sensor designed to detect and respond to the presence of a flame or fire, allowing flame detection. Responses to a detected flame depend on the installation, but can include sounding an alarm, deactivating a fuel line (such as a propane or a natural gas line), and activating a fire suppression system. When used in applications such as industrial furnaces, their role is to provide confirmation that the furnace is working properly; in these cases they take no direct action beyond notifying the operator or control system. A flame detector can often respond faster and more accurately than a smoke or heat detector due to the mechanisms it uses to detect the flame.

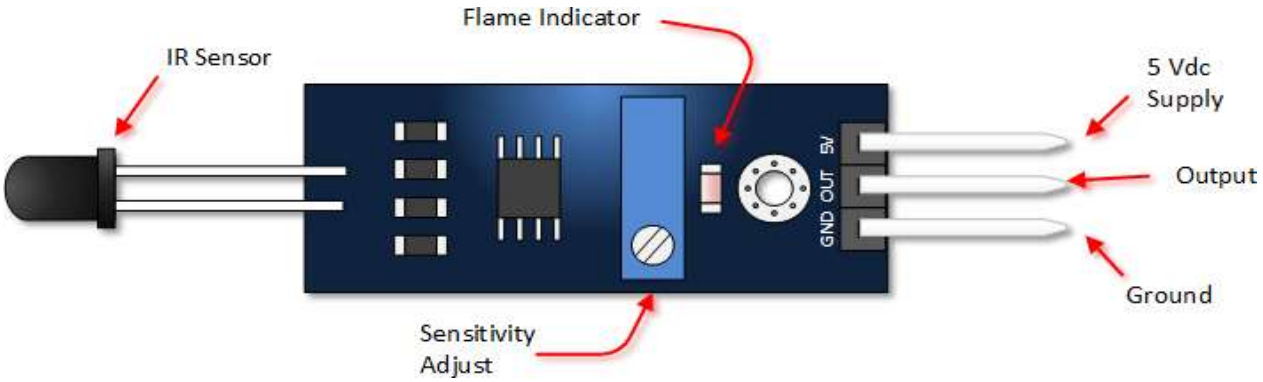


Figure 25: Flame Sensor

3.1.7.2 Specification

• Detects a flame or a light source of a wavelength in the range of 760nm-1100 nm.
• Detection range: up to 50 cm.
• Adjustable detection range.
• Detection angle about 60 degrees, it is sensitive to the flame spectrum.
• Comparator chip LM393 makes module readings stable.
• Operating voltage 3.3V-5V.
• Digital and Analog Output.
• Power indicator and digital switch output indicator.

3.1.7.3 Features

• Effective Range: 2:30 cm (Adjustable by potentiometer)
• Voltage Supply: 3.3: 5Vcc
• Detection Angle: 35°
• The comparator uses the LM393 LED indicator (red---> power on, Green---> detection)
Digital output. 4.1.6.4 Advantages: The advantages of Infrared Sensor are:
• Their low power requirements make them suitable for most electronic devices such as laptops, telephones, PDAs.
• They are capable of detecting motion in presence/ absence of light almost with same reliability
• They do not require contact with object to for detection

Figure 26: Flame Sensor Pins

3.1.8 Gas sensor

They are used in gas leakage detecting equipment's in family and industry, are suitable for detecting of LPG, natural gas, town gas, avoid the noise of alcohol and cooking fumes and cigarette smoke.

3.1.8.1 How Does the MQ-5 Sensor Module Work?

To effectively detect combustible Gas, the MQ-5 Sensor requires a heating element. Putting a heating source close to combustible Gas, on the other hand, may be harmful. As a result, the Sensor has an anti-explosion network made up of two thin layers of stainless-steel mesh, as seen in the illustration below. A heating element is included in this stainless-steel mesh.

Figure 27: Gas Sensor

Figure 28: Gaseous Components

Only gaseous components from the environment travel through this mesh structure, which protects against dust and other suspended particles. We can see that the Sensor comprises two main components when we disassemble it. The heating element is composed of nichrome wire, while the detecting element is platinum wire with a tin dioxide covering. The mesh decapper from the real Sensor is shown below.

This is what the Sensor looks like when the mesh is removed. As you can see in the above image, we cut the stainless-steel mesh and positioned it on the side of the Sensor. The previously mentioned sensing feature is now evident as well. The star-shaped pins on the Sensor are made by attaching the actual detecting and heating element to the Sensor's six legs. The black Bakelite base of the Sensor, which promotes heat conductivity, can also be observed.

3.1.8.2 How to use MQ-5 Sensor to Detect Combustible Gas?

In the above animation, we have a bottle holding LPG, and as it is sprayed, the gas concentration in the surroundings increases. The gas content grows as we pour it a second and third time. As the gas content grows, the Sensor's output voltage rises, as visible on the multimeter. When the module's green LED reaches a certain threshold, it glows (which may be controlled using the potentiometer). The backside shot of the module that we've supplied for demonstrative reasons demonstrates this.

3.1.8.3 How to Measure Gas Concentration in PPM using the MQ-5 Sensor?

This is a very accurate sensor that is calibrated to detect the PPM of combustible gas present in the environment; but, in order to do so, you must first understand the MQ-5 Sensor's sensitivity characteristics, which can be found in the MQ-5 Sensor datasheet and look like the image below.

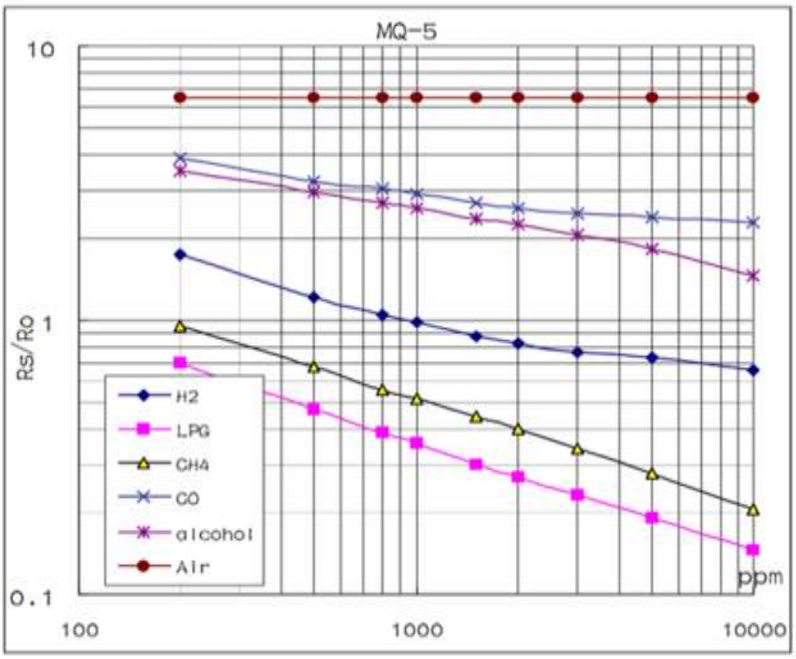


Fig. shows the typical sensitivity characteristics of the MQ-5 for several gases.
in their: Temp: 20℃、
Humidity: 65%、
O_2 concentration 21%
RL=20kΩ
Ro: sensor resistance at 1000ppm of H_2 in the clean air.
Rs:sensor resistance at various concentrations of gases.

3.1.9 Light Dependent Resistor (LDR)

3.1.9.1 What is a Light Dependent Resistor?

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate an LDR, one of the most commonly used symbol is shown in the figure below.

3.1.9.2 Characteristics of LDR

LDR‘s are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When a light dependent Resistor is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as 1012 Ω and if the device is allowed to absorb light its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular LDR.

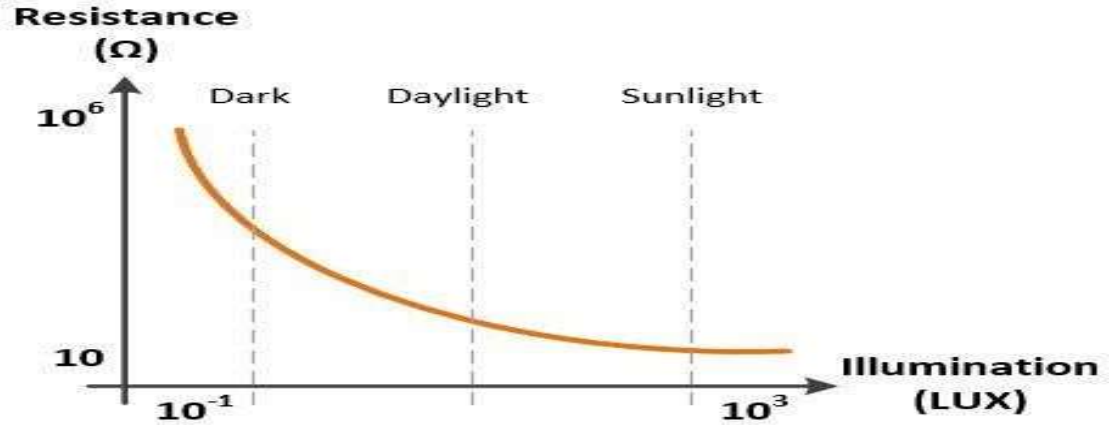


Figure 29: LDR Relation between Resistance and Illumination

3.1.9.3 Working Principle of LDR

• A light dependent resistor works on the principle of photo conductivity.
• Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material.
• Automatic light control is used to control the landscape lights (Turn on and off based on the light).
• Here we make use of LDR (Light Dependent Resistor) and LED (Light Emitting diode) and MCU

3.1.9.4 Hardware Connection

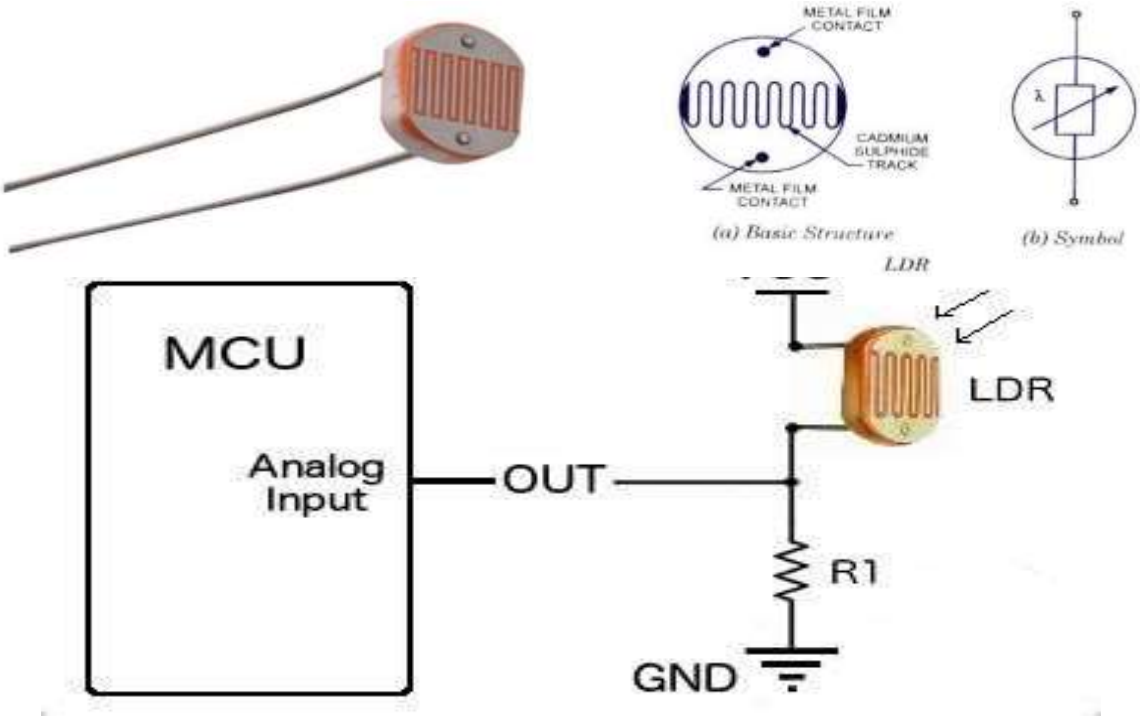


Figure 30: LDR with MCU

3.1.10 LM35 Temperature Sensor

The LM35 is a low voltage, precision centigrade temperature sensor manufactured by Texas Instruments. It is a chip that provides a voltage output that is linearly proportional to the temperature in °C and is, therefore, very easy to use with a MCU.

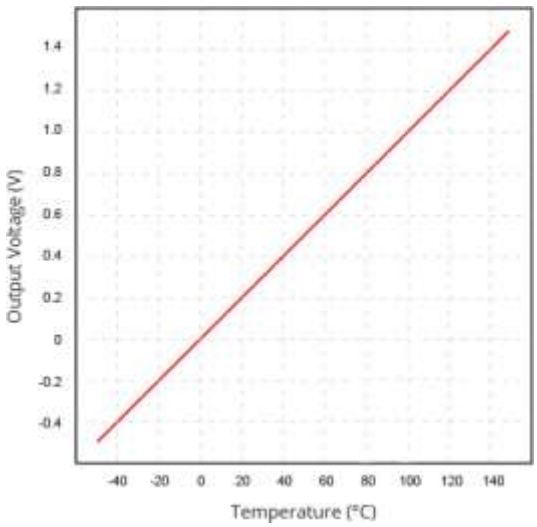
Figure 31: LM35 Sensor

The LM35 temperature sensor is fairly precise, never wears out, works under many environmental conditions and requires no external components to work. In addition, the LM35 sensor does not require calibration and provides a typical accuracy of ±0.5°C at room temperature and ±1°C over a full −55°C to +155°C temperature range.

The sensor can be powered with a 4V to 30V power supply and consumes less than 60µA during active temperature conversions, providing very low self-heating (less than 0.08°C in still air).

3.1.10.1 How to Measure Temperature

The LM35 is easy to use; just connect the left pin to power (4V to 30V) and the right pin to ground (assuming the flat side of the sensor is facing you). Then the middle pin will have an analog voltage that is directly proportional (linear) to the temperature in °C. This can be easily seen in the output voltage vs temperature characteristic. Note that the analog output voltage is independent of the power supply.



To convert the voltage to temperature, simply use the basic formula:

Temperature (°C) = Vout * 100

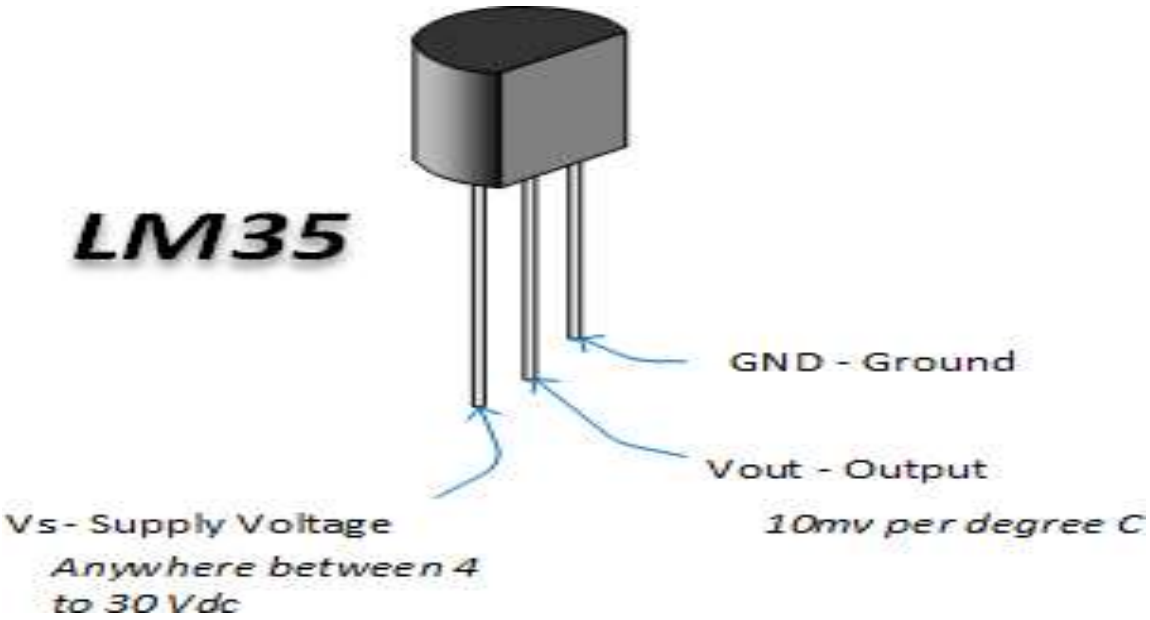
For example, if the voltage out is 0.5V that means that the temperature is 0.5 * 100 = 50 °C

3.1.10.2 LM35 Sensor Features

- Minimum and Maximum Input Voltage is 35V and -2V respectively. Typically 5V.
- Can measure temperature ranging from -55°C to 150°C
- Output voltage is directly proportional (Linear) to temperature (i.e.) there will be a rise of 10mV (0.01V) for every 1°C rise in temperature.
- ±0.5°C Accuracy
- Drain current is less than 60uA
- Low-cost temperature sensor
- Small and hence suitable for remote applications

3.1.10.3 LM35 Sensor Pinout

The LM35 comes in three different form factors, but the most common type is the 3-pin TO-92 package, which looks just like a transistor. Let's take a look at its pinout.



+Vs is the power supply for the sensor which can be anywhere between 4V to 30V.

Vout pin produces an analog voltage that is directly proportional (linear) to the temperature. It should be connected to an Analog (ADC) input.

GND is a ground pin.

3.1.11 Rain Sensor

3.1.11.1 What Is Water Level Sensor?

A water level indicator is a system that relays information back to a control panel to indicate whether a body of water has a high or low water level. Some water level indicators use a combination of probe sensors or float switches to sense water levels. “The Water Level Indicator employs a simple mechanism to detect and indicate the water level in an overhead tank or any other water container”.

Purpose of Water Level Indicator: The purpose of a water level indicator is to gauge and manage water levels in a water tank. The control panel can also be programmed to automatically turn on a water pump once levels get too low and refill the water back to the adequate level.

3.1.11.2 Water Level Indicator Sensor?

a water level indicator sensor, also known as a probe sensor, is what tells the control panel that corrective action is needed. A combination of high and low sensors is used to tell the control panel when water levels are too high or too low. The control panel will then automatically turn the pump on or off depending on the corrective action needed.

3.1.11.3 Water Level Sensor Pinout

The water level sensor is super easy to use and only has 3 pinsto connect.

S (Signal) pin is an analog output that will be connected to oneof the analog inputs on your MC.

+ (VCC) pin supplies power for the sensor. It is recommended to power the sensor with between 3.3V – 5V.

– (GND) is a ground connection.

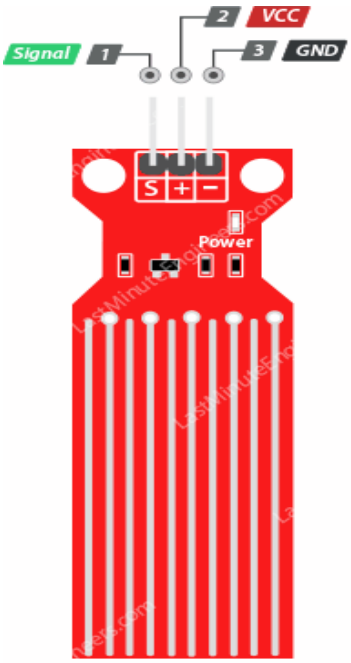


Figure 32: Rain Sensor

3.1.11.4 How Water Level Sensor Works?

The water detection sensor has basically three parts. It has a reference probe, a fill start probe, and a fill stop probe. You can place these probes at any height inside your water container. If the water ever sinks below the level of the fill start probe, then the water level will automatically increase to fill up the tank. If the water level reaches up to the fill stop probe, then it will send a command to stop the flow of water.

Some water level sensor systems have even more probes than that. Some have five, and in certain cases, systems have even been made with seven probes or more.
All these different probes will be placed at different heights inside the water container. As the water level reaches each probe, it will command the flow of water to increase or decrease by a certain amount.

By having more probes, the system can make more nuanced adjustments to water flow. Instead of simply flowing at 100% or at 0%, a system with extra probes can decide to have partial flow at various levels. This can make water flow systems more efficient.
The working of the water level sensor is straightforward.

The series of exposed parallel conductors, together acts as a variable resistor (just like a potentiometer) whose resistance varies according to the water level.
The change in resistance corresponds to the distance from the top of the sensor to the surface of the water.

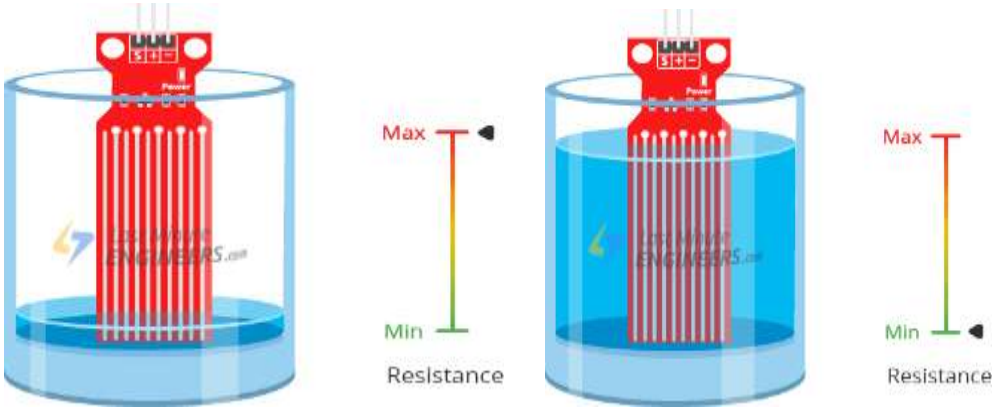


Figure 33: How Water Level Sensor Works

The resistance is inversely proportional to the height of the water:

- The more water the sensor is immersed in, results in better conductivity and will result in a lower resistance.
- The less water the sensor is immersed in, results in poor conductivity and will result in a higher resistance.

The sensor produces an output voltage according to the resistance, which by measuring we can determine the water level.

3.1.12 Motion Sensor PIR

This is a simple to use motion sensor. Power it up and wait 1-2 seconds for the sensor to get a works great from 5 to 12V (datasheet shows 12V). Youcan also install a jumper wire past the 5V regulator on board to make this unit work at 3.3V. Sensor uses l.6mA&3.3V. Sensor uses l.6mA&3.3V.

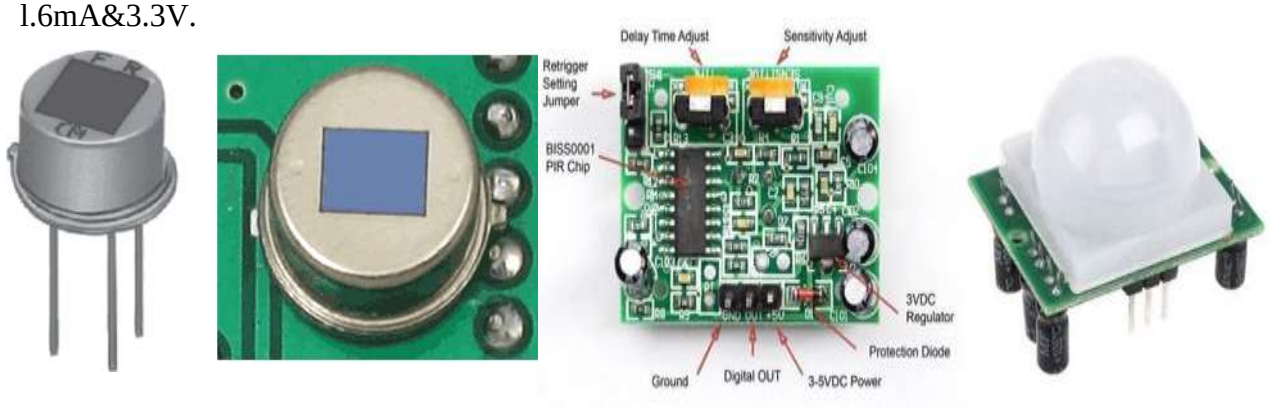


Figure 34: PIR Sensor

3.1.12.1 Specification

Input Voltage: DC 3-5V
Output signal: 3.3V (motion detected-output high)
Detection Angle: 110 degrees
Detection Length: max 7 m

3.1.12.2 Types of Motion Sensors

- Passive Infrared (PIR) Detects body heat (infrared energy).
- Microwaves (MW).
- Dual Technology Motion Sensors.
- Area Reflective Type.
- Ultrasonic.
- Vibration

3.1.12.3 How does the PIR Sensor work?

The **PIR** sensor itself has two slots each one of them is made of a special material that is sensitive to infrared. And when a warm body like a human or animal passes by, it first intercepts one halfof the PIR sensor. This causes a positive differential change between the two halves. These change pulses are what is detected.

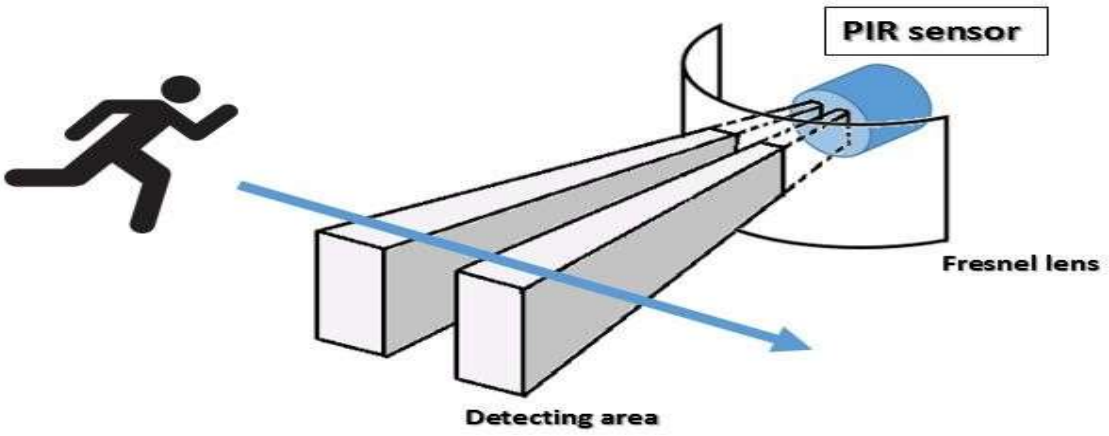


Figure 35: PIR Detecting Area

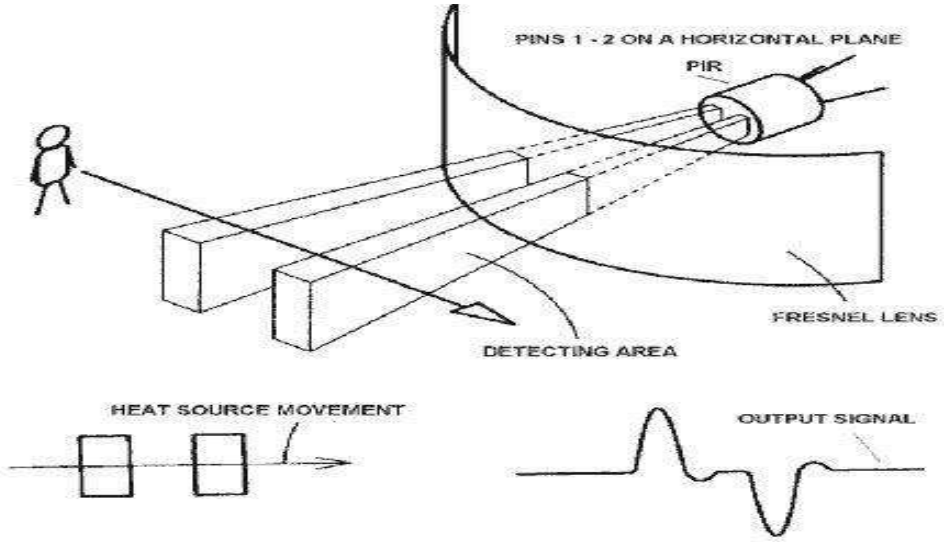


Figure 36: PIR Functionality

3.1.13 Soil Moisture Sensor

The moisture of the soil plays an essential role in the irrigation field as well as in gardens for plants. As nutrients in the soil provide the food to the plants for their growth.

3.1.13.1 What is a Soil Moisture Sensor?

The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content not directly with the help of some other rules of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content.

The relation among the calculated property as well as moisture of soil should be adjusted & may change based on ecological factors like temperature, type of soil, otherwise electric conductivity. The microwave emission which is reflected can be influenced by the moisture of soil as well as mainly used in agriculture and remote sensing within hydrology.

These sensors normally used to check volumetric water content, and another group of sensors calculates a new property of moisture within soils named water potential. Generally, these sensors are named as soil water potential sensors which include gypsum blocks and tensiometer.

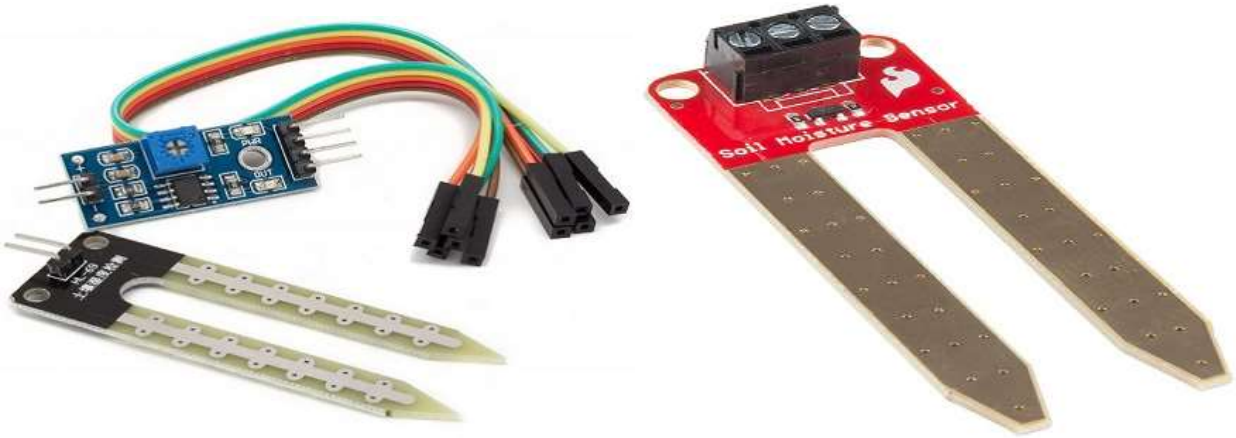


Figure 37: Soil Moisture Sensor

3.1.13.2 Soil Moisture Sensor Pin Configuration

The FC-28 soil moisture sensor includes 4-pins

VCC pin is used for power

A0 pin is an analog output

D0 pin is a digital output

GND pin is a Ground

3.1.13.3 Working Principle

This sensor mainly utilizes capacitance to gauge the water content of the soil (dielectric permittivity). The working of this sensor can be done by inserting this sensor into the earth and the status of the water content in the soil can be reported in the form of a percent.

This sensor makes it perfect to execute experiments within science courses like environmental science, agricultural science, biology, soil science, botany, and horticulture.

3.1.13.4 Specifications

The specification of this sensor includes the following.

The required voltage for working is 5V

The required current for working is <20mA

Type of interface is analog

The required working temperature of this sensor is 10°C~30°C

3.1.14 Buzzer

A buzzer or beeper is an audio signaling device, which may be electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke.

Active buzzer 5V Rated power can be directly connected to a continuous sound, this section dedicated sensor expansion module and the board in combination, can complete a simple circuit design, to "plug and play.

It generates consistent single tone sound just by applying D.C voltage. Using a suitably designed resonant system, this type can be used where large sound volumes are needed.

Figure 38: Buzzer

3.1.15 2N2222A Transistor

3.1.15.1 What is a 2N2222A Transistor?

The 2N2222A transistor is a common NPN BJT & it is mainly used in the applications of switching & amplifying with less power. This transistor is mainly designed for low power, low to medium current, medium voltage & works at fairly high speeds.

In the 2N2222 NPN transistor, a single P-doped layer is embedded among two N-doped layers. This transistor includes three terminals like Base, Emitter & Collector. 2N2222A transistor symbol is shown below.

2N2222A transistor offers constant DC collector current like 800mA, so it is necessary to use where low to medium current is necessary. It functions on the value of high transition frequency like 250MHz through 10ns delay time, 225ms storage time, 60ms fall time & 25ms rise time. It is available in the TO-92 package.

3.1.15.2 2N2222A Transistor Pin Configuration

The **pin configuration of the 2N2222A transistor** is shown below. This transistor includes three pins & its each pin functionality is discussed below.

Pin1 (Collector): This is the first pin of the transistor & it is an o/p pin. The main function of this pin is to provide transistor current toward the o/p load.

Pin2 (Base): The base pin is a control pin & it is a second pin of the transistor. The main function of this pin is to control the current from emitter to base.

Pin3 (Emitter): The emitter pin is the third pin of the transistor & it is used to drain out the complete current of the transistor.

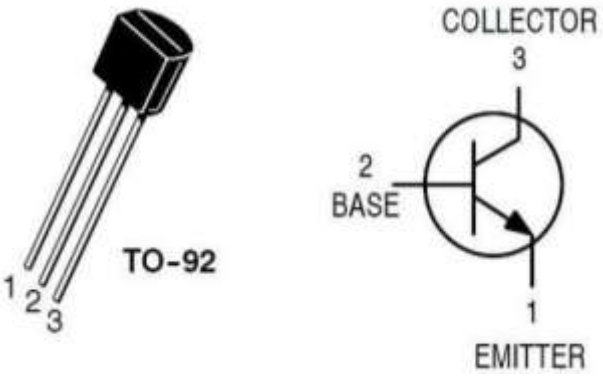


Figure 39: 2N2222A Transistor

3.1.15.3 Features & Specifications

- The polarity of Transistor – NPN
- Type of termination –Through Hole
- The voltage from the emitter to the base terminal is 6V once the collector terminal is open
- DC collector current is 800mA
- The maximum base current is 5mA
- Fall time is 60ns
- Turn-on time is 25ns

Figure 40: Real shape for 2N222 NPN

3.1.16 FAN

Generally used in system, panel box etc to keep the system cool. very effective and tiny/small size fan, can be used in various application. Runs at lowest current on 5v DC voltage with high-speed rotation.

3.1.16.1 Specifications

- Dimensions: 40 x 40 x 10mm
- Noise: 18DB
- Voltage: 5V
- Speed: ~4000RPM
- Airflow: ~20CFM
- Current: 0.10A

Figure 41: FAN

3.1.17 Power Supply

A power supply is an electrical device that supplies electric power to an electrical load.

The main purpose of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load.

3.1.17.1 How Power Supply works?

The main job of an AC/DC power supply is to transform the alternating current (AC) into a stable direct current (DC) voltage, which can then be used to power different electrical devices. Alternating current is used to transport electric power all across the electric grid, from generators to end users.

3.1.17.2 Advantages of Power Supply

Low cost. If your device requires a power output of less than 10W, then the component and manufacturing costs are much lower when compared to switching power supplies.
Low noise/ripple. Linear regulators have a very low output voltage ripple and high bandwidth.

3.1.17.3 Power Supply Terminals

- L phase
- N neutral
- Earth
- + V terminal source +12v
- – V terminal source 0v

Figure 42: Power Supply

3.2 PCB Implementation

A printed circuit board (PCB; also printed wiring board or PWB) is a medium used in electrical and electronic engineering to connect electronic components to one another in a controlled manner. It takes the form of a laminated sandwich structure of conductive and insulating layers: each of the conductive layers is designed with an artwork pattern of traces, planes and other features (similar to wires on a flat surface) etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate.

3.2.1 Common substrates

Often encountered materials:

FR-2, phenolic paper or phenolic cotton paper, paper impregnated with a phenol formaldehyde resin. Common in consumer electronics with single-sided boards. Electrical properties inferior to FR-4. Poor arc resistance. Generally rated to 105 °C.

FR-4, a woven fiberglass cloth impregnated with an epoxy resin. Low water absorption (up to about 0.15%), good insulation properties, good arc resistance. Very common. Several grades with somewhat different properties are available. Typically rated to 130 °C.

2 Pin PCB Mount Screw Terminals Block Pitch 5mm	
Glass Fuse 1A-250V (Size T5x20mm)	
ATMEGA16A-PU (8-bit AVR with 16K Bytes of ISP Flash)	
L7805CV "+5V Regulator"	
1N4007 "1A Silicon Diode General Purpose"	

6 pin switches	
Male pin header	
Female pin header	
10k resistor	
IC base	
Ceramic Capacitor 22pF 50v (PF22)	
Electrolytic Capacitor 10uF 50v	
220 ohm 1/4w 5% carbon film resistor	

Table 3: PCB Components

3.2.2 Common substrates

Often encountered materials:

FR-2, phenolic paper or phenolic cotton paper, paper impregnated with a phenol formaldehyde resin. Common in consumer electronics with single-sided boards. Electrical properties inferior to FR-4. Poor arc resistance. Generally rated to 105 °C.

FR-4, a woven fiberglass cloth impregnated with an epoxy resin. Low water absorption (up to about 0.15%), good insulation properties, good arc resistance. Very common. Several grades with somewhat different properties are available. Typically rated to 130 °C.

Aluminum, or *metal core board* or insulated metal substrate (IMS), clad with thermally conductive thin dielectric - used for parts requiring significant cooling - power switches, LEDs. Consists of usually single, sometimes double layer thin circuit board based on e.g. FR-4, laminated on aluminum sheet metal, commonly 0.8, 1, 1.5, 2 or 3 mm thick. The thicker laminates sometimes also come with thicker copper metallization.

Flexible substrates - can be a standalone copper-clad foil or can be laminated to a thin stiffener, e.g., 50-130 µm

Kapton or UPILEX, a polyimide foil. Used for flexible printed circuits, in this form common in small form-factor consumer electronics or for flexible interconnects. Resistant to high temperatures.

Petalux, a polyimide-fluoropolymer composite foil.[23] Copper layer can delaminate during soldering.

3.2.3 Less-often encountered materials:

- FR-1, like FR-2, typically specified to 105 °C, some grades rated to 130 °C. Room-temperature pinchable. Similar to cardboard. Poor moisture resistance. Low arc resistance.
- FR-3, cotton paper impregnated with epoxy. Typically rated to 105 °C.
- FR-5, woven fiberglass and epoxy, high strength at higher temperatures, typically specified to 170 °C.
- FR-6, matte glass and polyester
- G-10, woven glass and epoxy - high insulation resistance, low moisture absorption, very high bond strength. Typically rated to 130 °C.
- G-11, woven glass and epoxy - high resistance to solvents, high flexural strength retention at high temperatures.[24] Typically rated to 170 °C.
- CEM-1, cotton paper and epoxy
- CEM-2, cotton paper and epoxy
- CEM-3, non-woven glass and epoxy

- CEM-4, woven glass and epoxy
- CEM-5, woven glass and polyester
- PTFE, ("Teflon") - expensive, low dielectric loss, for high frequency applications, very low moisture absorption (0.01%), mechanically soft. Difficult to laminate, rarely used in multilayer applications.
- PTFE, ceramic filled - expensive, low dielectric loss, for high frequency applications. Varying ceramics/PTFE ratio allows adjusting dielectric constant and thermal expansion.
- RF-35, fiberglass-reinforced ceramics-filled PTFE. Relatively less expensive, good mechanical properties, good high-frequency properties.
- Alumina, a ceramic. Hard, brittle, very expensive, very high performance, good thermal conductivity.
- Polyimide, a high-temperature polymer. Expensive, high-performance. Higher water absorption (0.4%). Can be used from cryogenic temperatures to over 260 °C.

3.2.4 Copper thickness

Copper thickness of PCBs can be specified directly or as the weight of copper per area (in ounce per square foot) which is easier to measure. One ounce per square foot is 1.344 mils or 34 micrometers thickness. Heavy copper is a layer exceeding three ounces of copper per ft^2, or approximately 0.0042 inches (4.2 mils, 105 µm) thick. Heavy copper layers are used for high current or to help dissipate heat.

On the common FR-4 substrates, 1 oz copper per ft^2 (35 µm) is the most common thickness; 2 oz (70 µm) and 0.5 oz (17.5 µm) thickness is often an option. Less common are 12 and 105 µm, 9 µm is sometimes available on some substrates. Flexible substrates typically have thinner metallization. Metal-core boards for high power devices commonly use thicker copper; 35 µm is usual but also 140 and 400 µm can be encountered.

In the USA, copper foil thickness is specified in units of ounces per square foot (oz/ft^2), commonly referred to simply as ounce. Common thicknesses are 1/2 oz/ft^2 (150 g/m^2), 1 oz/ft^2 (300 g/m^2), 2 oz/ft^2 (600 g/m^2), and 3 oz/ft^2 (900 g/m^2). These work out to thicknesses of 17.05 µm (0.67 thou), 34.1 µm (1.34 thou), 68.2 µm (2.68 thou), and 102.3 µm (4.02 thou), respectively.

oz/ft²	g/m²	µm	thou
1/2 oz/ft²	150 g/m²	17.05 µm	0.67 thou
1 oz/ft²	300 g/m²	34.1 µm	1.34 thou
2 oz/ft²	600 g/m²	68.2 µm	2.68 thou
3 oz/ft²	900 g/m²	102.3 µm	4.02 thou

Table 4: Copper Thickness

1/2 oz/ft^2 foil is not widely used as a finished copper weight, but is used for outer layers when plating for through holes will increase the finished copper weight Some PCB manufacturers refer to 1 oz/ft^2 copper foil as having a thickness of 35 µm (may also be referred to as 35 µ, 35 micron, or 35 mic).

- 1/0 – denotes 1 oz/ft^2 copper one side, with no copper on the other side.
- 1/1 – denotes 1 oz/ft^2 copper on both sides.
- H/0 or H/H – denotes 0.5 oz/ft^2 copper on one or both sides, respectively.
- 2/0 or 2/2 – denotes 2 oz/ft^2 copper on one or both sides, respectively.

3.2.5 Electrical properties

Each trace consists of a flat, narrow part of the copper foil that remains after etching. Its resistance, determined by its width, thickness, and length, must be sufficiently low for the current the conductor will carry. Power and ground traces may need to be wider than signal traces. In a multi-layer board one entire layer may be mostly solid copper to act as a ground plane for shielding and power return. For microwave circuits, transmission lines can be laid out in a planar form such as strapline or microstrip with carefully controlled dimensions to assure a consistent impedance. In radio-frequency and fast switching circuits the inductance and capacitance of the printed circuit board conductors become significant circuit elements, usually undesired; conversely, they can be used as a deliberate part of the circuit design, as in distributed-element filters, antennae, and fuses, obviating the need for additional discrete components. High density interconnects (HDI) PCBs have tracks and/or vias with a width or diameter of under 152 micrometers.

3.2.6 Penalization

Several small printed circuit boards can be grouped together for processing as a panel. A panel consisting of a design duplicated n-times is also called an n-panel, whereas a multi-panel combines several different designs onto a single panel. The outer tooling strip often includes tooling holes, a set of panel fiducials, a test coupon, and may include hatched copper pour or similar patterns for even copper distribution over the whole panel in order to avoid bending. The assemblers often mount components on panels rather than single PCBs because this is efficient. Penalization may also be necessary for boards with components placed near an edge of the board because otherwise the board could not be mounted during assembly.

3.2.7 MASTER PCB

3.2.7.1 SCHEMATIC DESIGN FOR MASTER BOARD

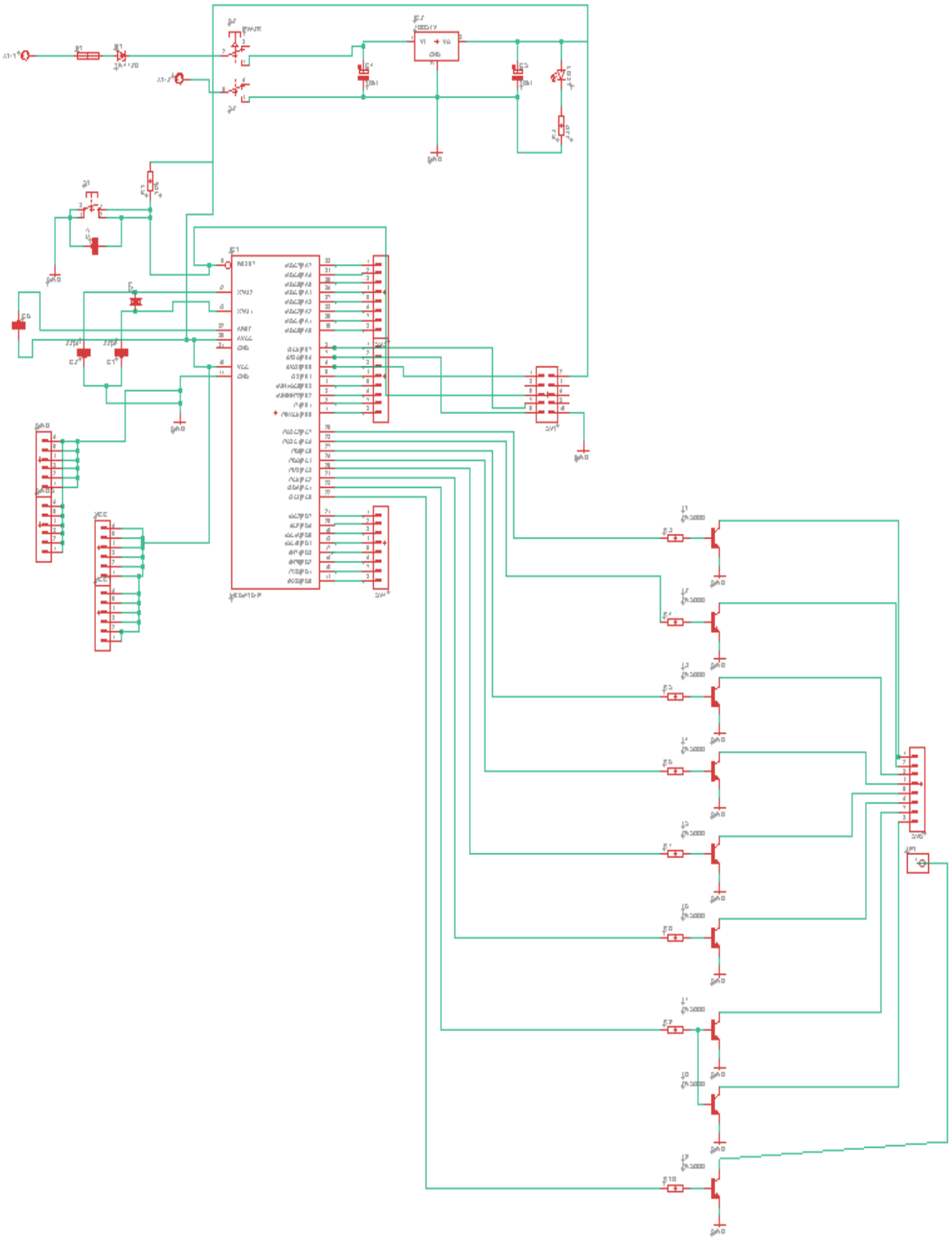


Figure 43: Schematic Design for Master Board

3.2.7.2 PCB DESIGN FOR MASTER BOARD

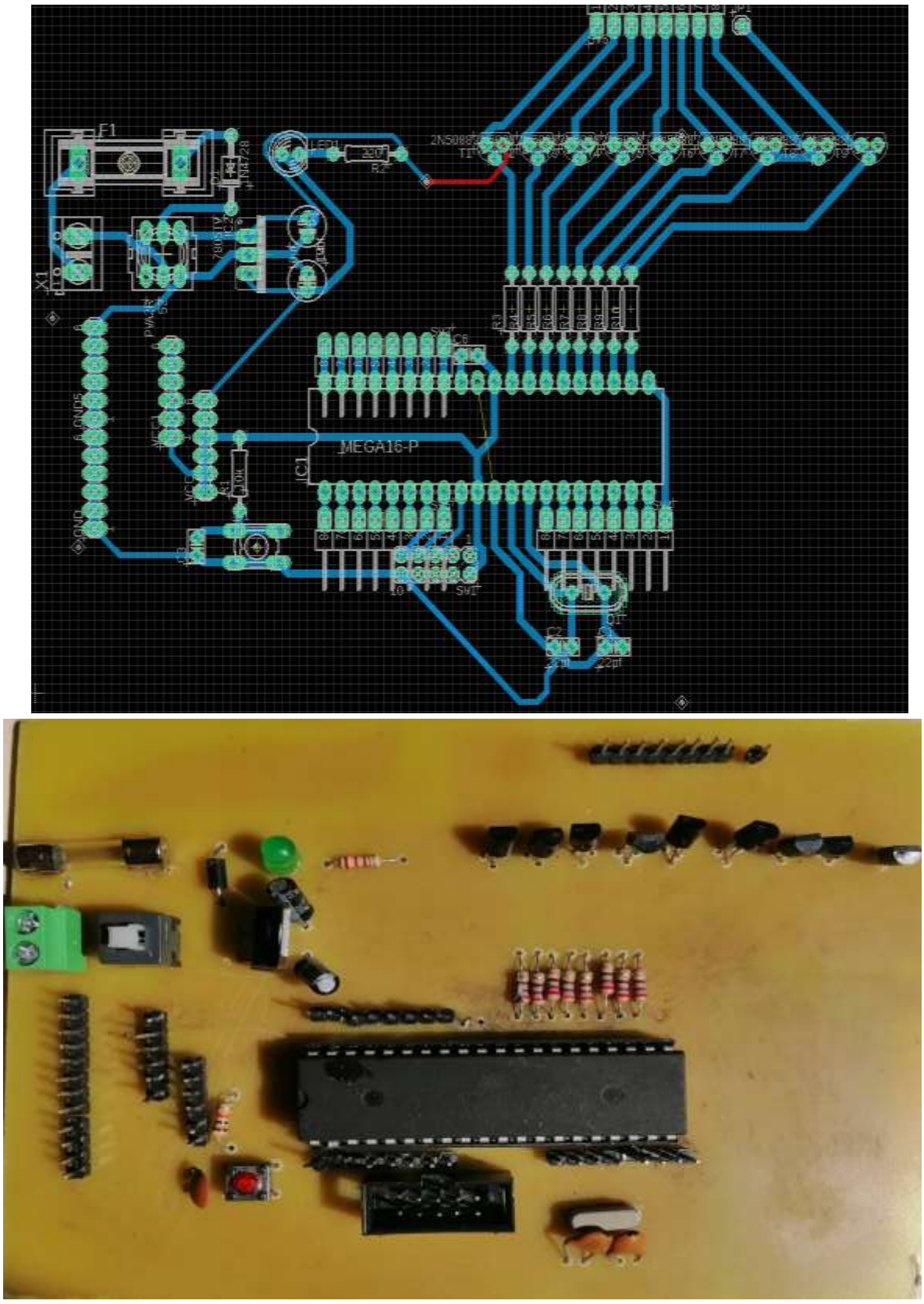


Figure 44: PCB Design for Master Board

3.2.8 SLAVE PCB

3.2.8.1 SCHEMATIC DESIGN FOR SLAVE BOARD

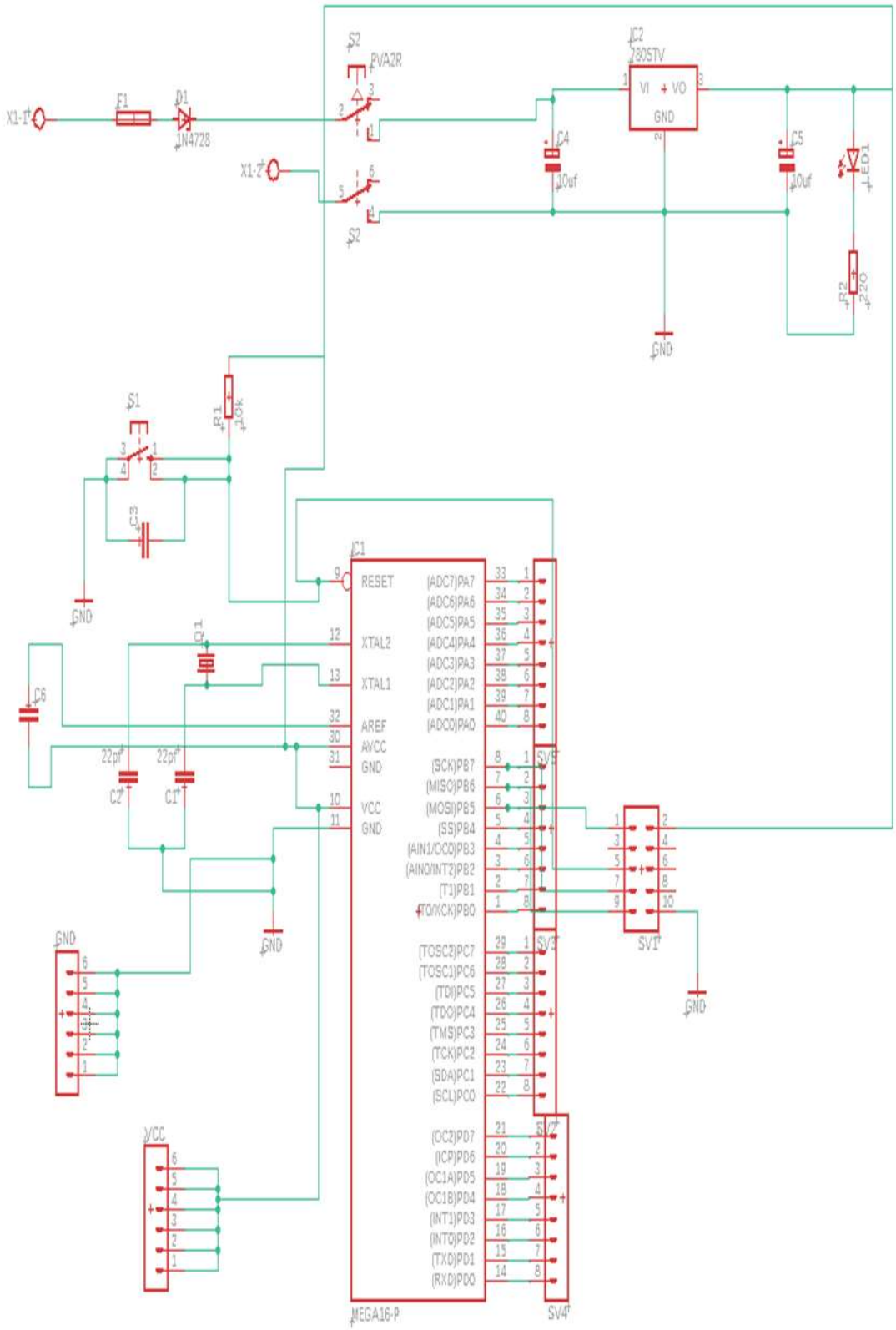


Figure 45: Schematic Design for Slave Board

3.2.8.2 PCB Design for slave board

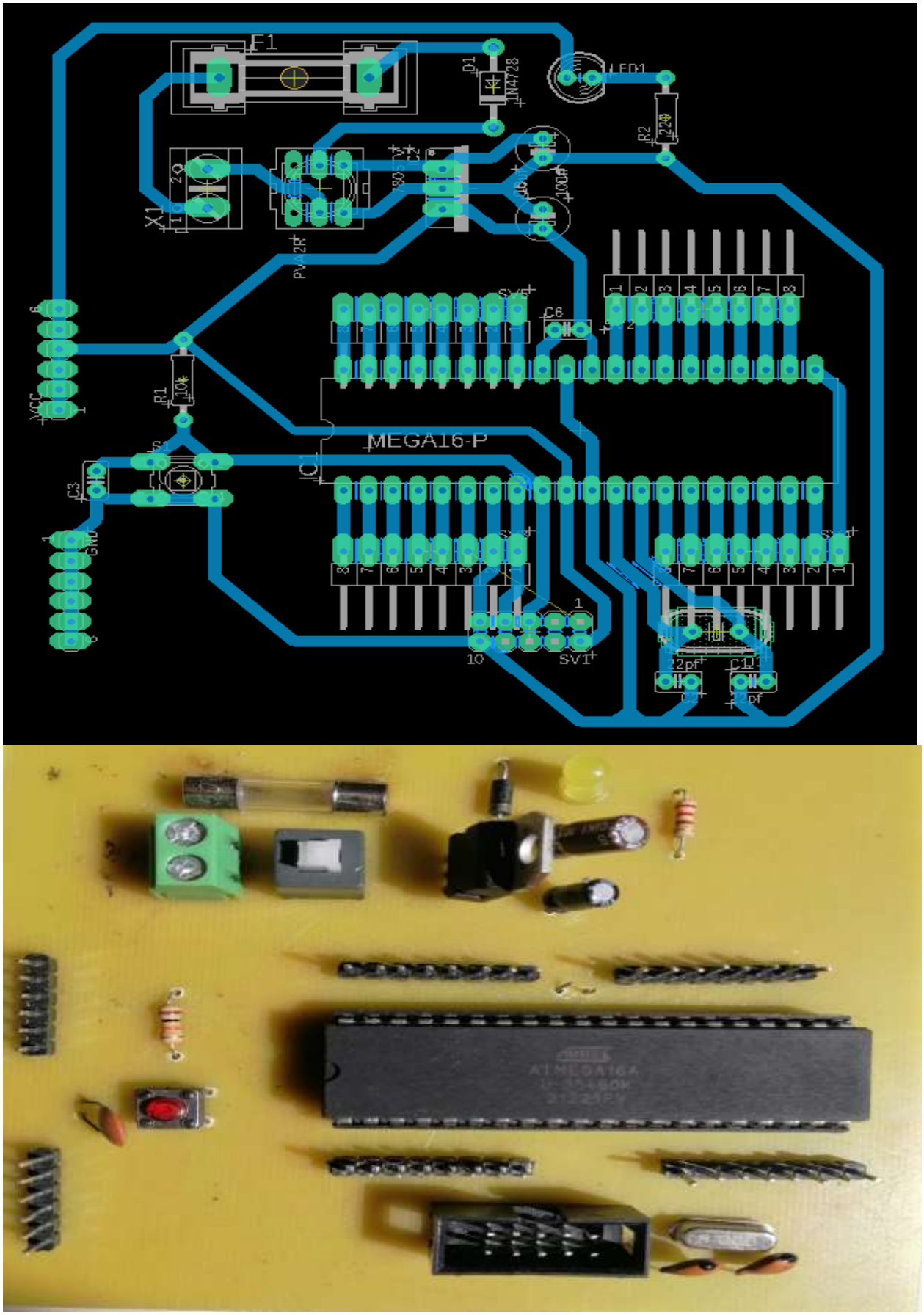


Figure 46: PCB Design for Slave Board

3.2.9 Solar PCB

3.2.9.1 Schematic design for solar board

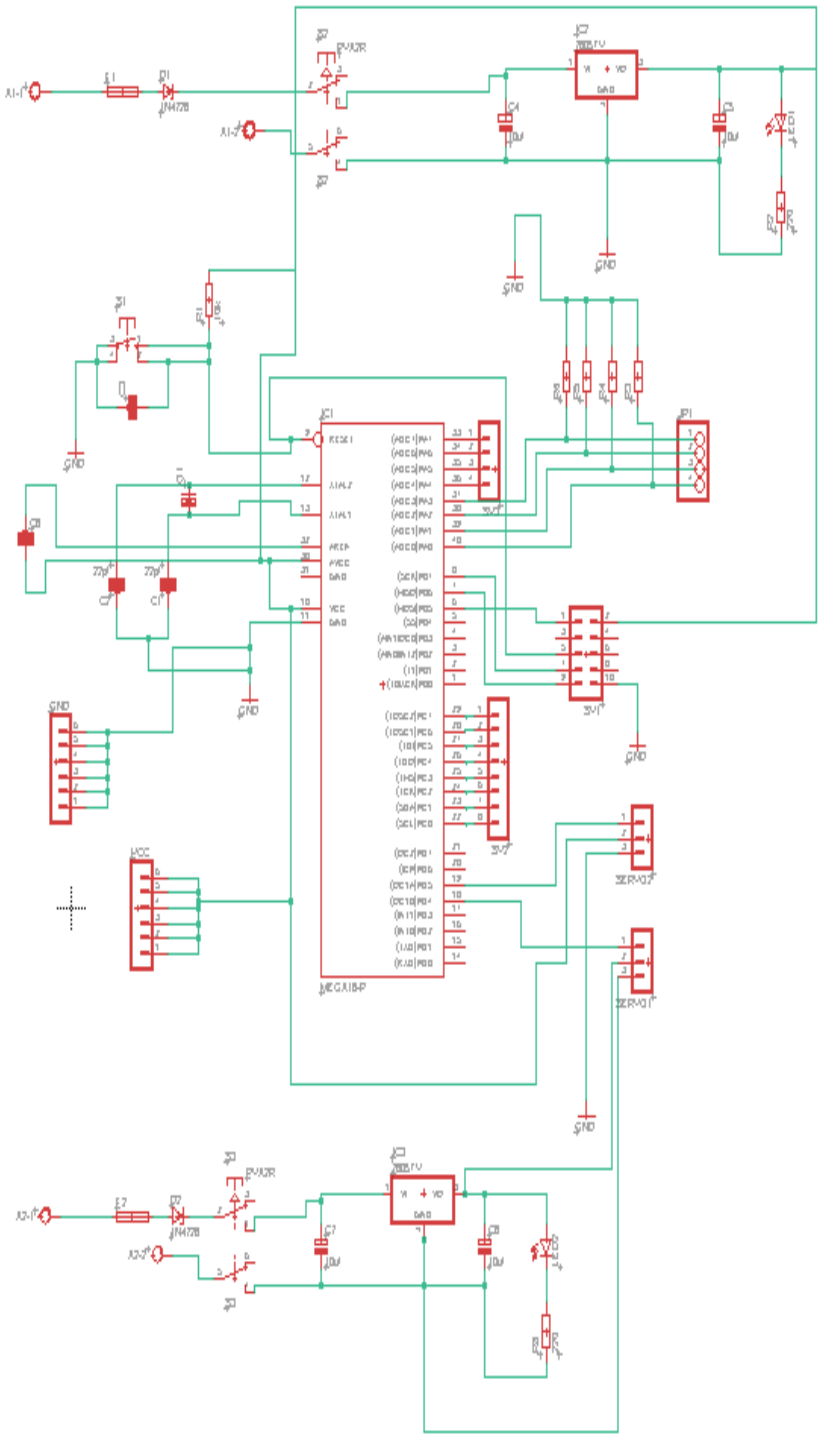


Figure 47: Schematic Design for Solar Board

3.2.9.2 PCB DESIGN FOR SOLAR BOARD

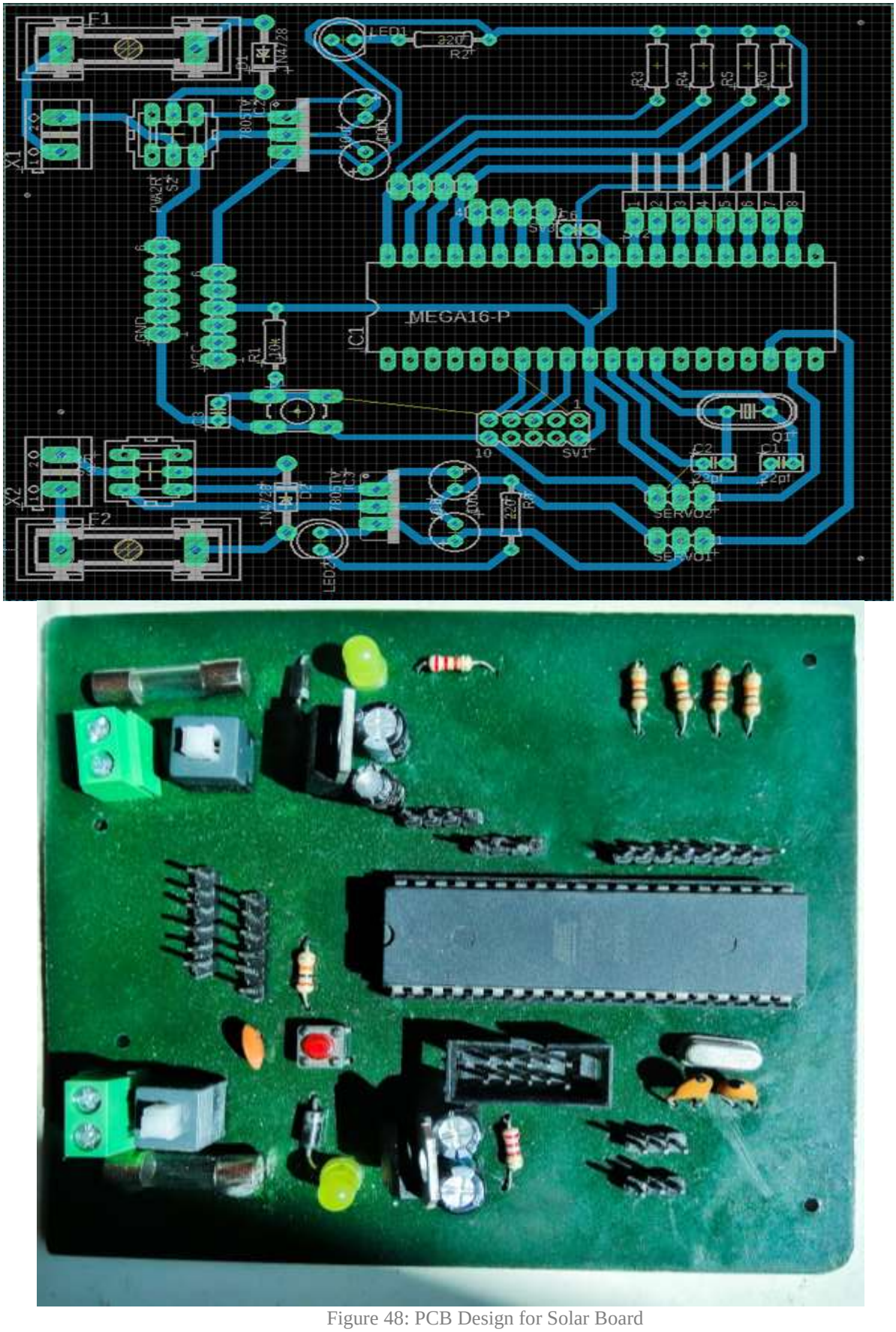


Figure 48: PCB Design for Solar Board

3.3 Software Implementation

3.3.1 Door Locker System

Implemented via AVR Atmega16 MCU based on AVR Architecture using layered architecture model, it is an 8-bit Atmel AVR series microcontroller with 8 MHz internal clock frequency.
Implemented drivers for DIO, Timer, SPI, Keypad, LCD, Buzzer, Led and Servo Motor.

Main Components

- ATmege16A
- 16*2 LCD
- 4*4 Keypad
- Indicator RGB LED
- Buzzer
- Servo Motor

System Flowchart

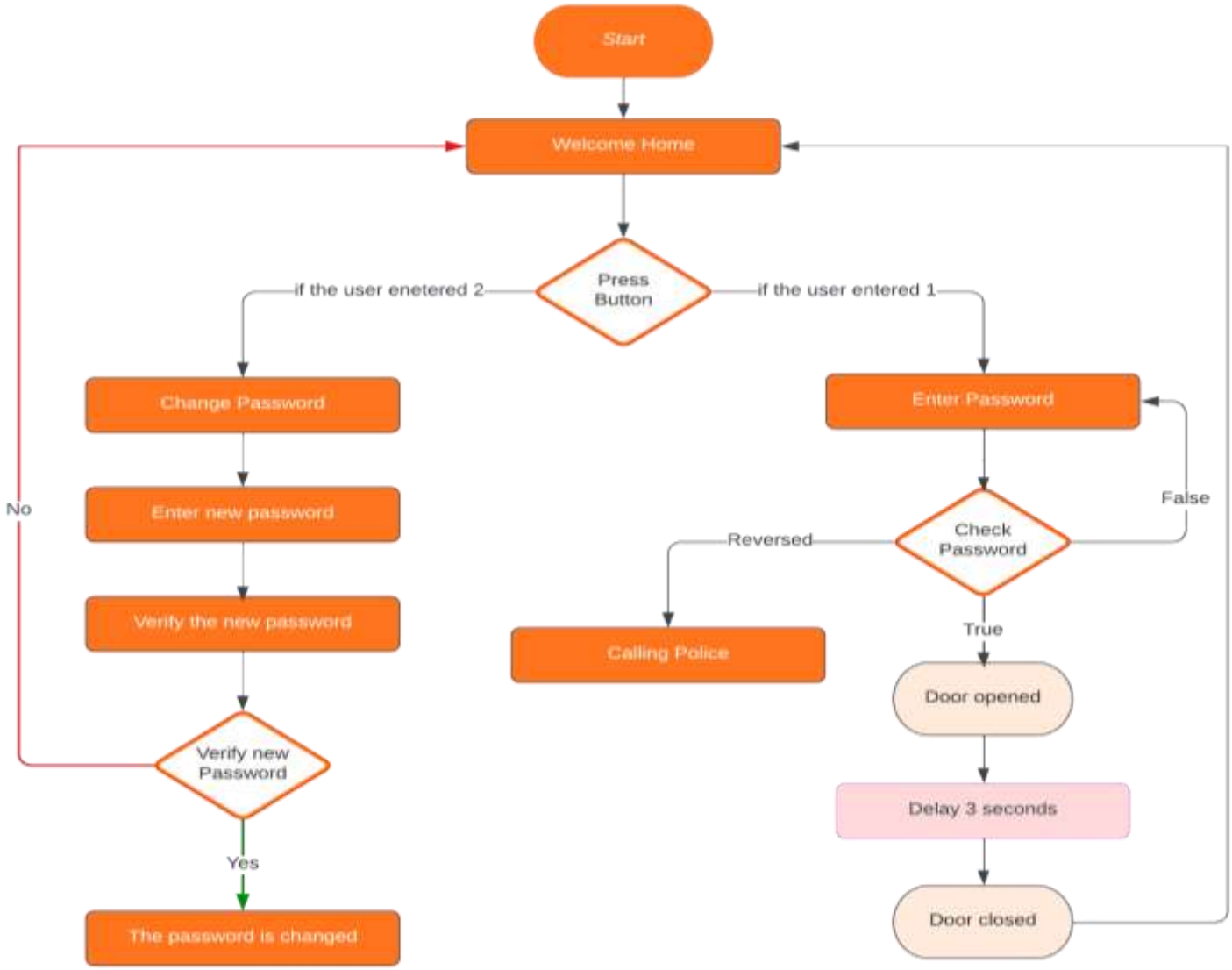


Figure 49: Door Locker System Flowchart

Project Description

- The door is unlocked using a password entered via a keypad:

  i. The door opens by move the servo motor to 90 degrees
  ii. It is then held open for 3 seconds.
  iii. Then it is closed by move the servo motor to 0 degrees

- If the user entered a wrong password 3 consecutive times:
  i. The keypad accepts no input and the system blocked.
  ii. A buzzer and a red LED are triggered.

- If the user entered a reversed password:
  i. It will call the police automatically and report a thief's threat to the owner of the house to open the door by force.

-The user can change the password at any time he wants

Project Specifications

- Responsible for interaction with the user.
- System initialization: It prompts the user to enter a new password and confirm it.
- It sends the password input to the CONTROL ECU to be confirmed.
- No input is accepted from keypad if the password is entered 3 consecutive times.

Tools

eclipse IDE

3.3.2 Home Security System

Home alarm systems are quite popular, they usually include a cluster of sensors that continually monitor any building flame, gas, smoke, or fire and cause an alarm if they detect them. One of the easiest ways to detect fire, gas, and smoke is by utilizing a Flame sensor and MQ-5 Gas Sensor.

Components

- Atmega16A
- Flame Sensor
- MQ-5 Sensor
- Buzzer
- Indicator LED

Project Specifications

- Sense Smoke/Fire/Flame - (to detect fire in house)
- Detect Gas leak
- Turn on the alarm and the flasher when fire or gas leak occurs.

System Flowchart

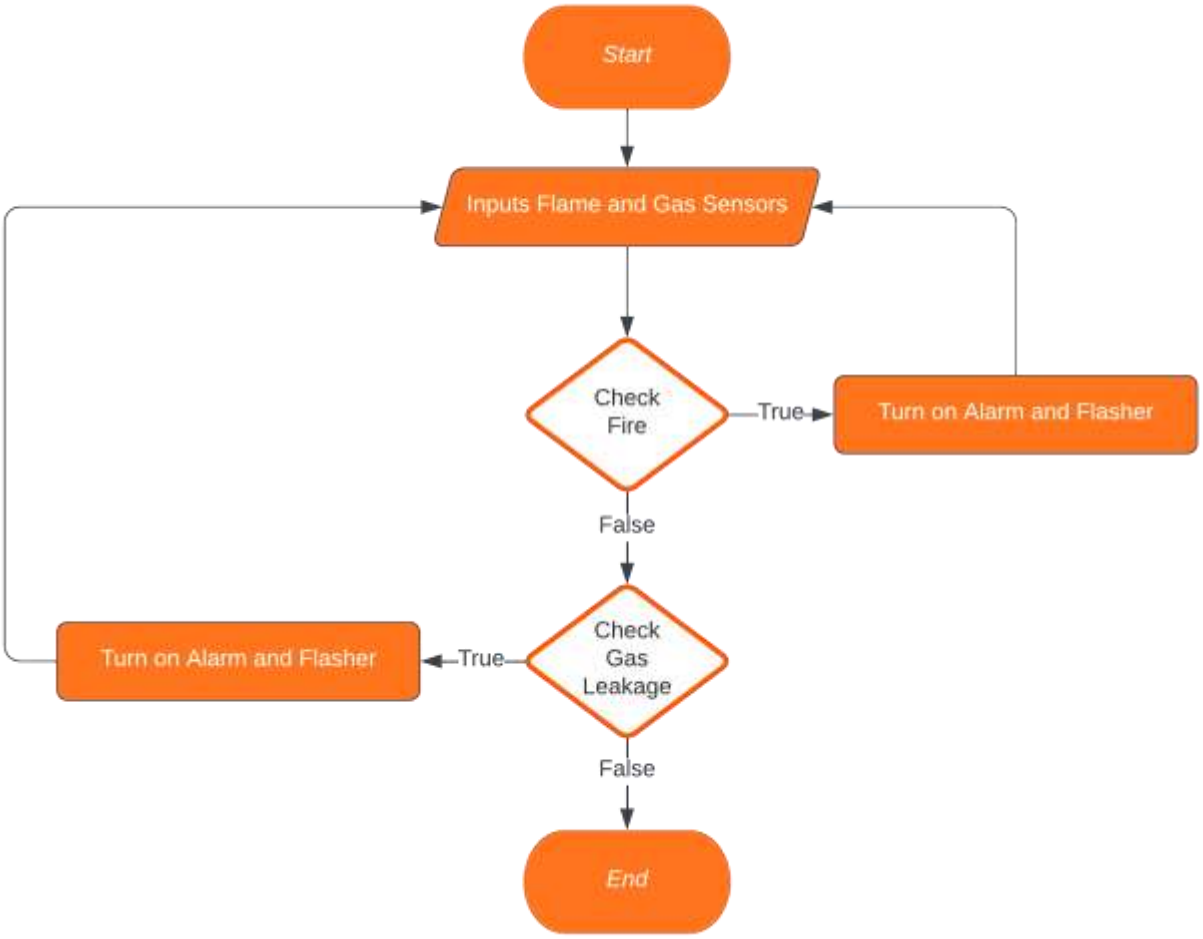


Figure 50: Home Security System Flowchart

Project Description

The flame sensor detects the presence of fire or flame based on the Infrared (IR) wavelength emitted by the flame. It gives logic 1 as output if a flame is detected, otherwise, it gives logic 0 as output. MCU checks the logic level on the output pin of the sensor and performs further tasks such as activating the buzzer and LED.

The MQ-5 Sensor senses the smoke in the air and reads and displays the level of Smoke in the Air in PPM (parts per million). When the smoke sensor detects a gas leakage, The MCU triggers the Buzzer and lights the LED

Result

You should see your LED and Buzzer turn on when the sensor detects a fire, flammable gas, or smoke.

Tools

eclipse IDE

3.3.3 Rain Indicator System

Rain Indicator System is a simple but very useful system which detects the rain and automatically close the windows in the home. The sensor acts like a simple switch where the switch closes when it rains and is normally open when the rain stops.

Main Components

- Atmega16A
- Rain Sensor
- Servo Motor

System Flowchart

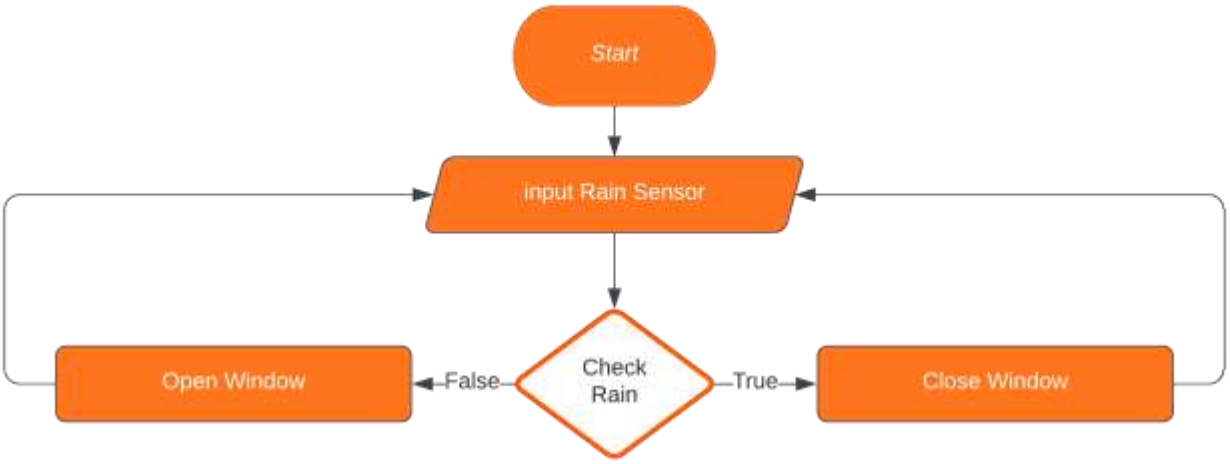


Figure 51: Rain Indicator System Flowchart

Project Description

- when it rains, the windows in the home will be closed automatically
- when the rain stops, the windows in the home will be opened automatically

Project Specifications

- prevent rain from entering homes and offices.
- save the user from damaging possessions that were being sundried.

Tools

eclipse IDE

3.3.4 Temperature sensing system for air conditioner

The goal of this project is to design a temperature monitoring system that controls and regulates the temperature of a particular environment.

Components

- Atmega16A
- LM35 Temperature sensor
- DC Motor (Fan)

System Flowchart

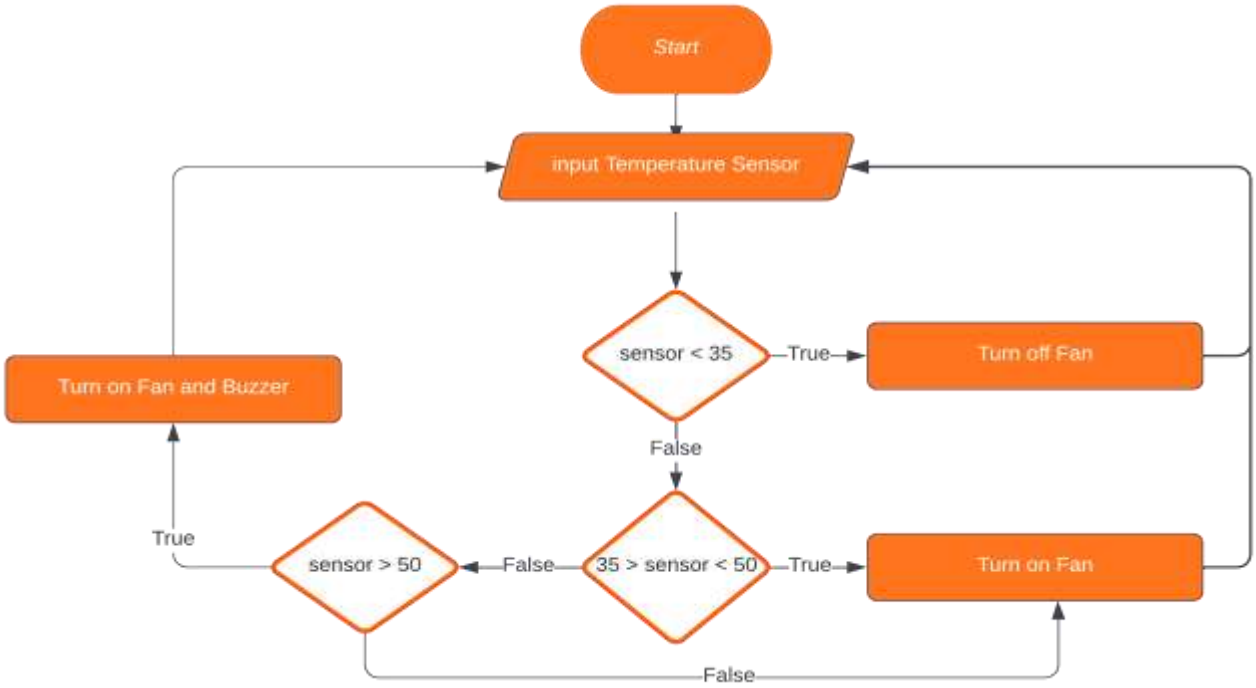


Figure 52: Temperature Sensing System for Air Conditioner

Project Specifications

- Uses LM35 Temperature Sensor for measurement of temperature.
- It controls temperature by turning on and off the air conditioner.

Project Description

This is a software based project in which LM35 sensor is used to detect temperature and take action upon it.
Automatically detects the rise and fall in the temperature with the help of LM35 Temperature sensor and accordingly turns on/off the Air Conditioner with the help of AVR Microcontroller.
Whenever the temperature measured by the LM35 Temperature goes below 30 degree Celsius the Air conditioner gets turned off. And whenever the temperature goes beyond 30 degree Celsius (threshold) the Air conditioner gets turned on.

Tools

Eclipse

3.3.5 Wi-Fi control system

A Wi-Fi control system via a mobile app is a popular feature of a smart home that enables users to remotely control their home appliances and devices using their mobile device. With this type of system, the user's mobile device communicates with the home appliances or devices through Wi-Fi.

Components

- Atmega16A
- Wi-Fi Module ESP-01
- Smart Home LEDs
- Mobile App

Project Diagram

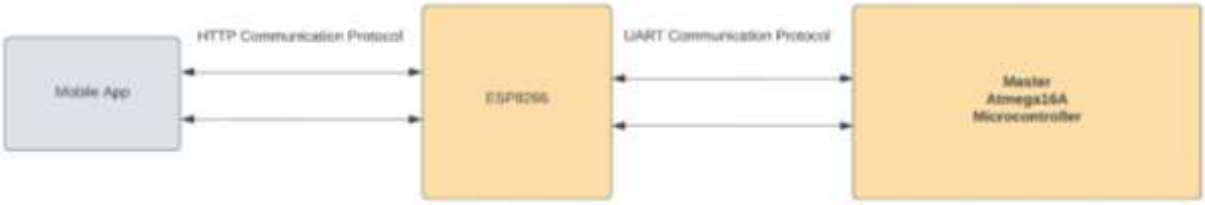


Figure 53: Wi-Fi Control System Diagram

Project Specifications

The ability to remotely control appliances and devices can help to reduce energy usage and save money on utility bills.

The mobile app can provide enhanced security features, such as authentication and encryption, to ensure that the user's data is protected.

Project Description

A Wi-Fi control system via a mobile app in a smart home is a solution that enables homeowners to control their home appliances and devices from a mobile device using Wi-Fi connectivity. With this system, homeowners can use their mobile device to remotely turn on and off lights, adjust the thermostat, lock or unlock doors, and control other home appliances and devices.

One of the main benefits of a Wi-Fi control system via a mobile app is convenience. With this system, users can control their home devices from anywhere, at any time, as long as they have an internet connection. This means that they can turn off lights or adjust the thermostat even when they are away from home, which can help to save energy and reduce costs.

Tools

eclipse IDE

3.3.6 Automatic light control system

An **automatic light control system** is a system of lights that turn on and off automatically based on various conditions, such as time of day, presence of people, or ambient light levels. Such systems can be used to conserve energy and improve safety and convenience in buildings, outdoor spaces, and other areas.

Components

- Atmega16A
- LDR
- Landscape LEDs

System Flowchart

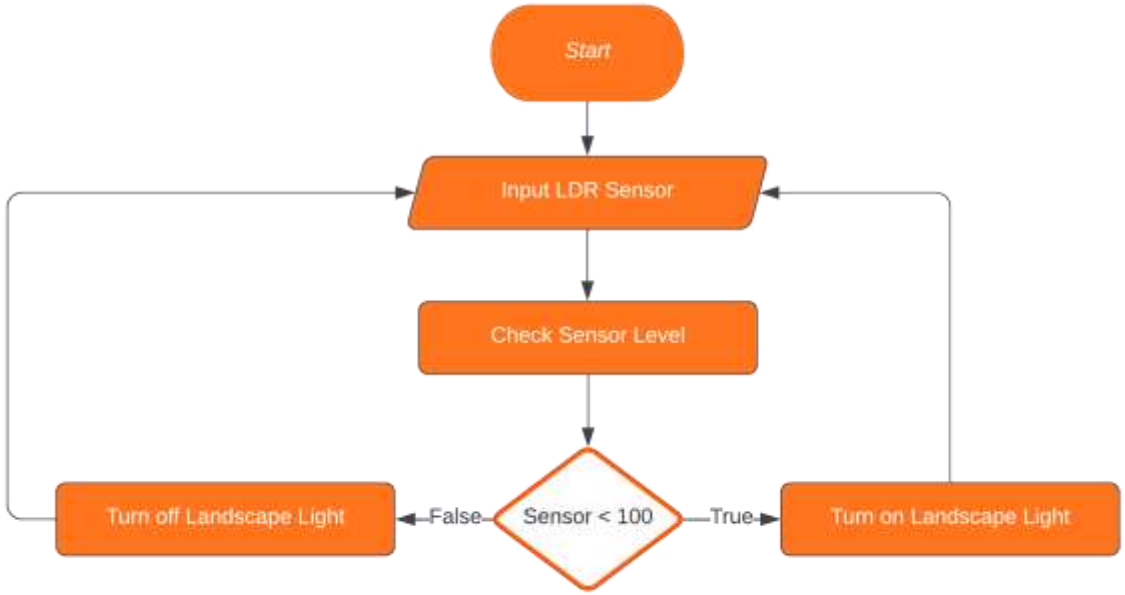


Figure 54: Automatic Light Control System Flowchart

Project Specifications

Prevent loss of current unnecessarily during day time and make the system more efficient than before.

Project Description

A photoresistor (or light-dependent resistor, LDR, or photo-conductive cell) is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity a photoresistor is made of a high resistance semiconductor. In the dark, a photoresistor can have a resistance as high as several mega ohms (MΩ), while in the light a photoresistor can have a resistance as low as a few hundred ohms.

Tools

Eclipse IDE

3.3.7 Soil moisture control system

When you hear the term “smart garden,” one of the first things that comes to mind is a system that monitors them moisture level of the soil and automatically supplies the necessary amount of water to the plants.

Components

- Atmega16A
- Soil Moisture Sensor
- Water Pump

System Flowchart

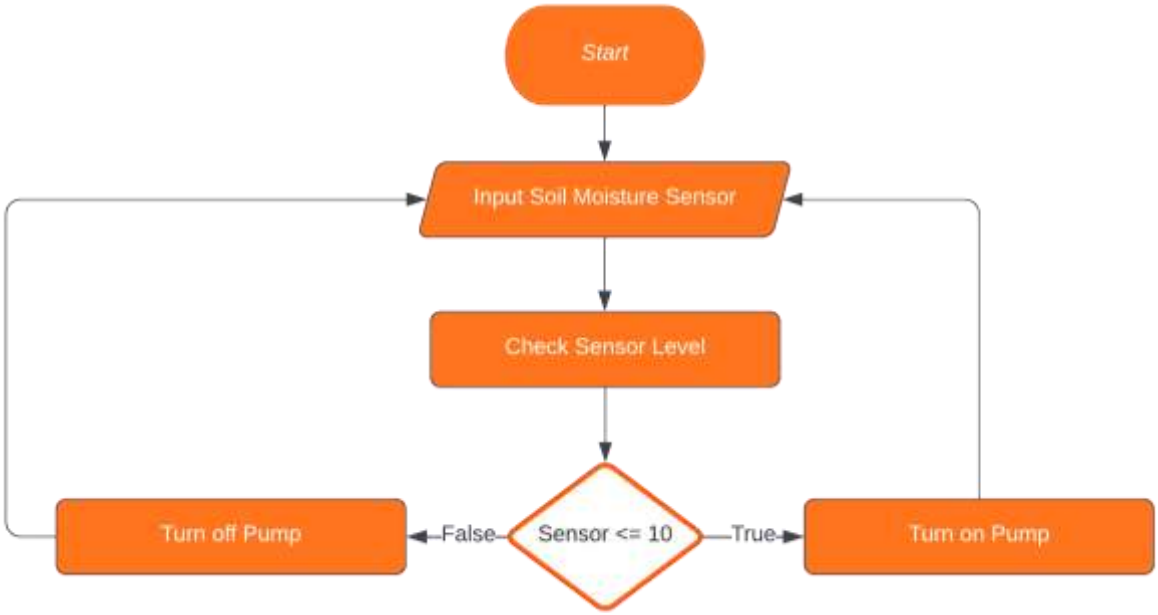


Figure 55: Soil Moisture Control System Flowchart

Project Specifications

Optimize irrigation, improve crop yields, and prevent waterlogging or drought stress.

Project Description

The soil moisture sensor consists of two probes that are used to measure the volumetric content of water. The two probes allow the current to pass through the soil, which gives the resistance value to measure the moisture value.

When there is water, the soil will conduct more electricity, which means that there will be less resistance. Dry soil conducts electricity poorly, so when there is less water, then the soil will conduct less electricity, which means that there will be more resistance.

Tools

Eclipse IDE

3.3.8 Project Summary Diagrams

- The connection of the microcontrollers and the peripherals are used in this project.

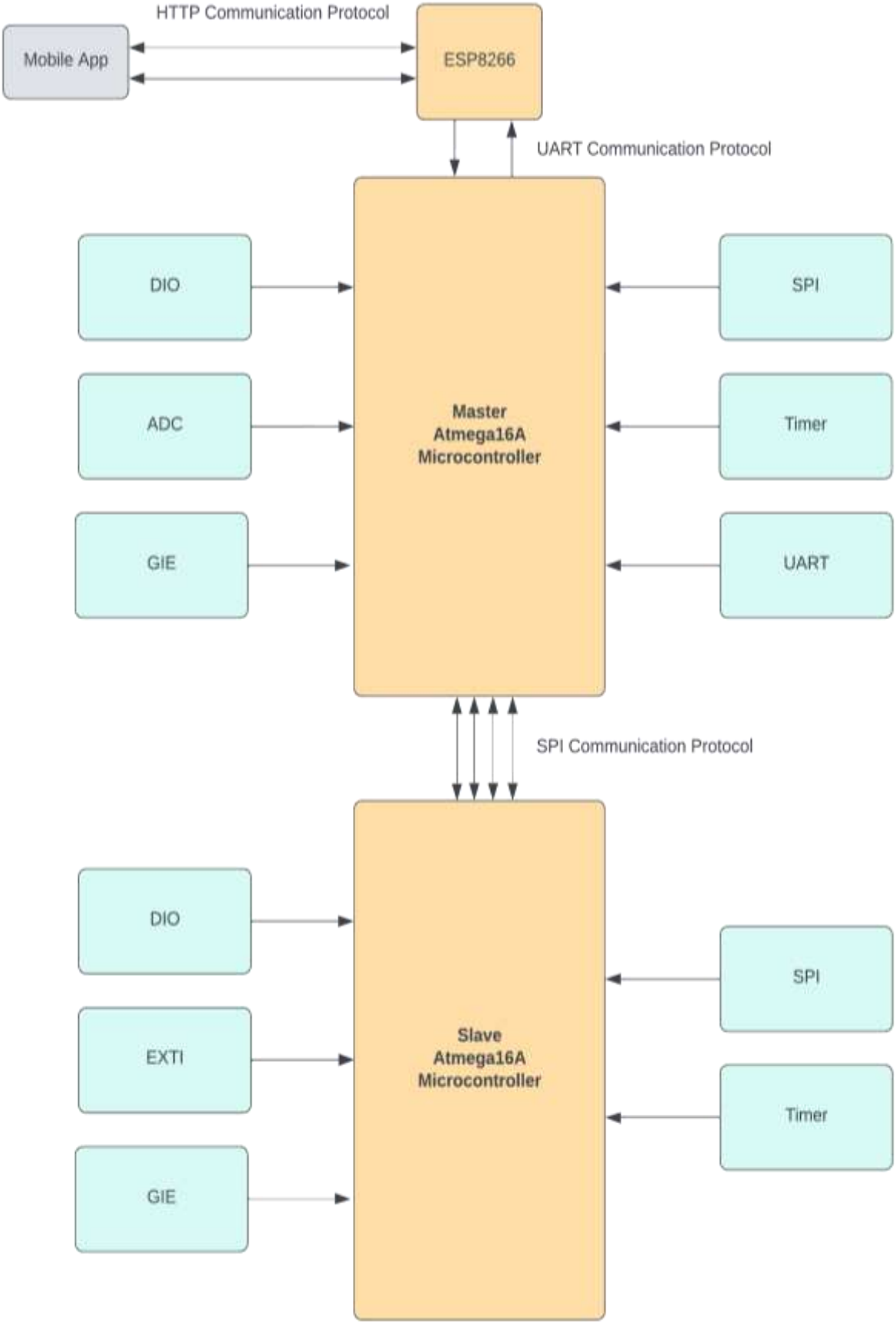


Figure 56: The connection of the Microcontrollers and the Peripherals

- The hardware components connection with the microcontrollers.

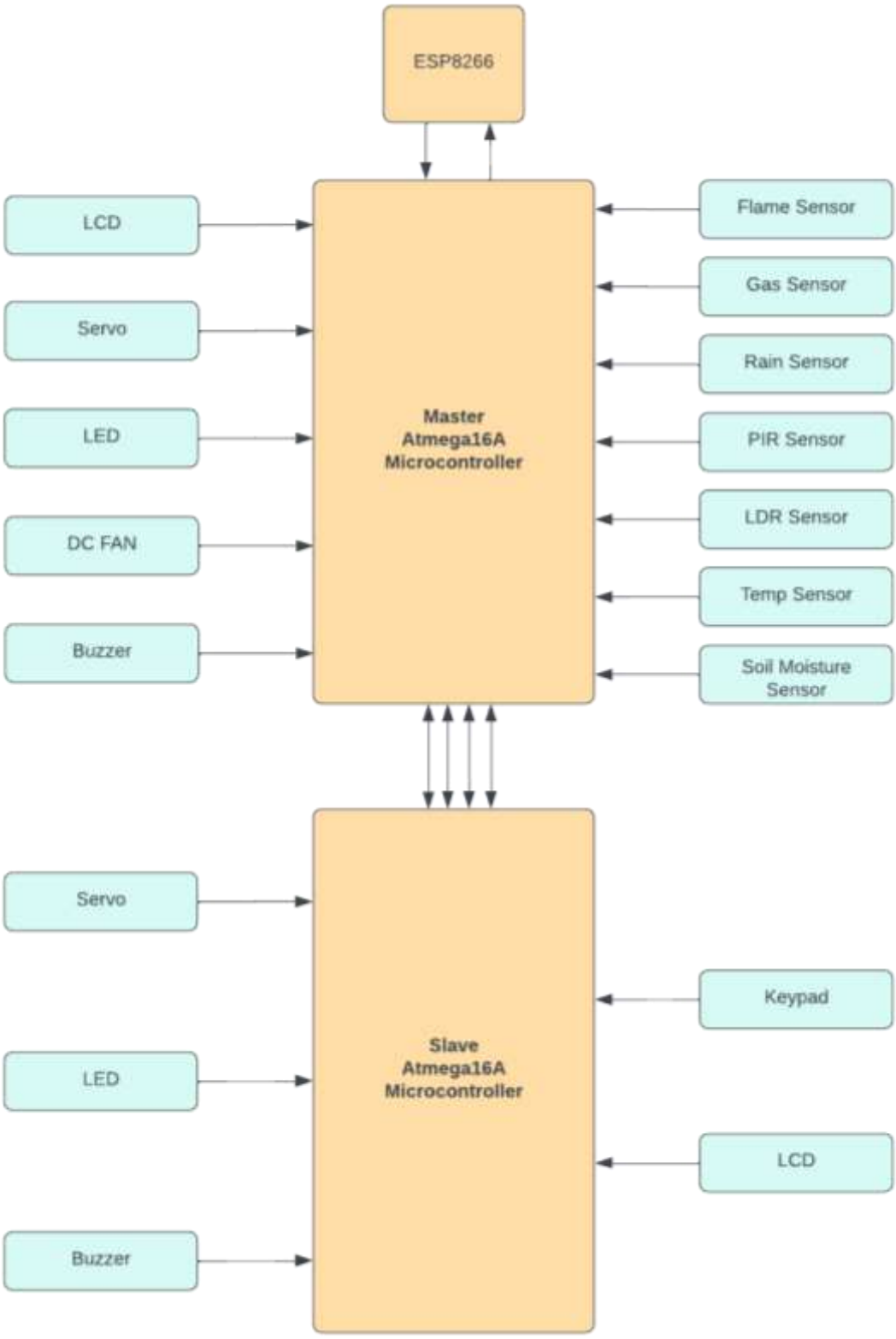


Figure 57: The Hardware Components Connection

3.4 Maquette Implementation

- **The Design of the ground floor of the smart home**

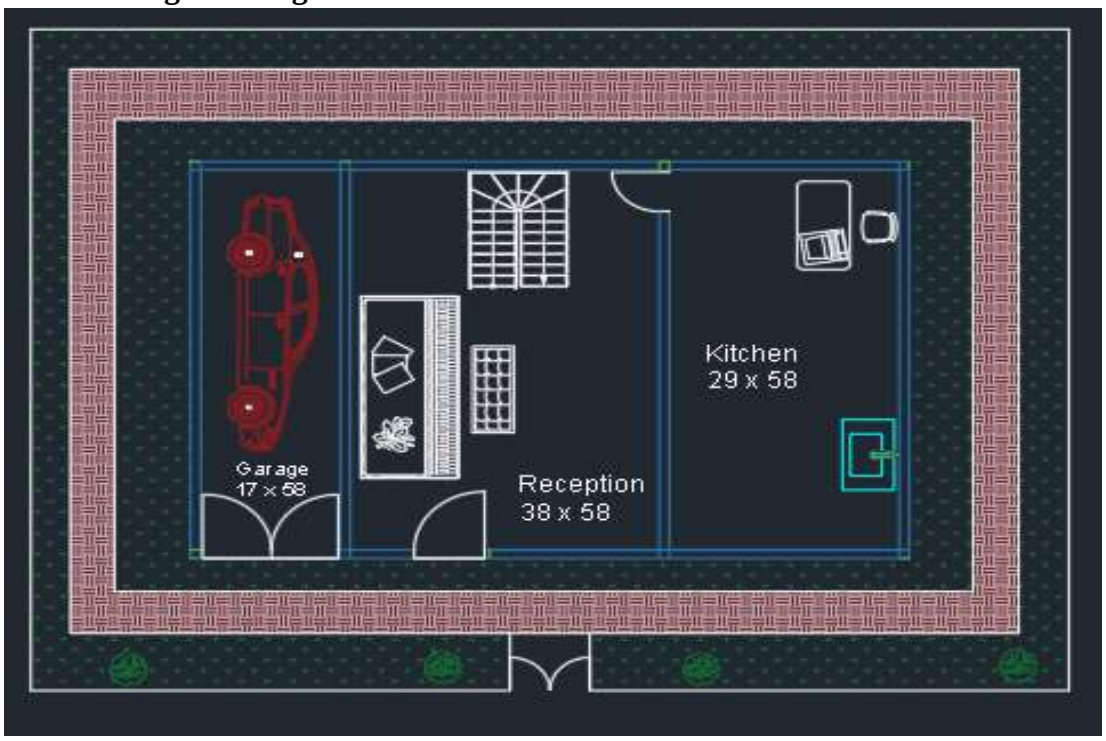


Figure 58: Ground Flour with Garden and Garage

- **The Design of the second floor of the smart house**

Figure 59: Second Flour

CHAPTER 4

SOLAR TRACKING SYSTEM

Automatic Solar Tracking System

4.1 Solar panels

Solar panels are a cumulative orientation of photovoltaic cells. The PV cells are arranged in a solar panel or a PV array such that is serves the purpose of exciting the electron of the material consisting inside the solar cells using photons The average amount of sunlight received by solar panels particular depends on the position of the sun Being a repository of energies, Sun witnessed to be the eminent and ever continuing source of A part of this source of natural energy is received by the solar panel.

Certain ways have been developed to utilize this energy source as an alternative to other nonrenewable sources. Considering its multitudinous flourishing ways in which it can be applied to bring about the change in conserving other resources, the manipulation of the energy source is encouraged.

Solar panels are hence used to utilize solar power in electrical means. They are aligned different arenas to collect maximum solar power. Though, solar panels can be used to absorb or collect solar power, there work is bounded to certain hours of the day and the sunlight pouring directly on them, i.e., the angle between the sunrays and the panel is orthogonal.

While at other hours of the day, the angle of the sunrays is different, hence the amount of the solar power captured is very less.

To overcome such pitfalls, and encapsulate the maximum available of solar energy the solar tracking systems were introduced.

A solar tracking system is designed with the intention of keeping the angle between the sunrays and the solar array 90°.

4.2 Principles of solar cell operation

A solar cell consists of two types of semiconductors, called p- and n-type silicon. p-type silicon is produced by adding atoms - such as boron or gallium - that have one electron in their outermost energy level lower than silicon. Because boron has one fewer electron than is needed to form bonds with surrounding silicon atoms, an electron voids or "hole" is created.

n-type silicon is made by including atoms that have one more electron in their outermost shell than silicon, such as phosphorous. Phosphorus has five electrons in its outermost energy level, not four. It bonds with its neighboring silicon atoms, but one electron is not involved in the bonding. Instead, it can move around inside the silicone structure for free.

A solar cell consists of a layer of p-type silicon placed next to a layer of n-type silicon. In the n-type layer, there is an excess of electrons, and in the p-type layer, there is an excess of positively charged holes (which are vacancies due to a lack of valid electrons). Near the junction of the two layers, the electrons on one side of the junction (n-type layer) move into the holes on the other side of the junction (p-type layer). This creates a region around the junction, called the depletion region, where electrons fill holes.

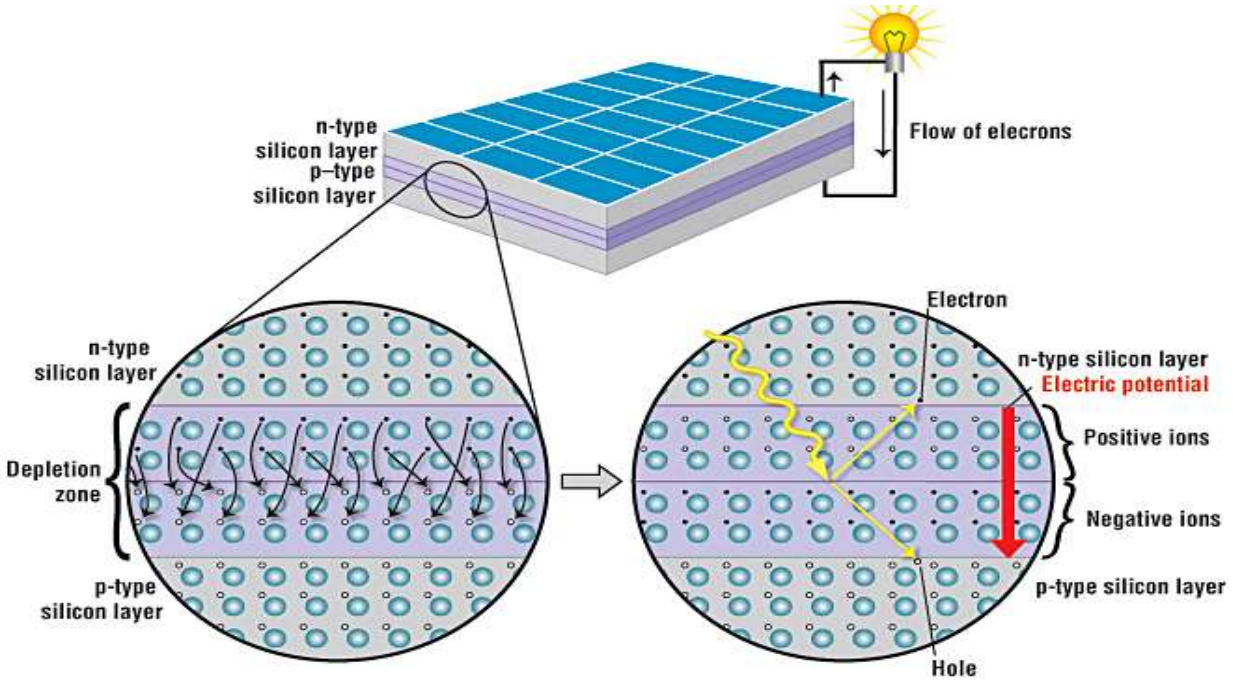


Figure 60: 2 Principles of solar cell operation

When all holes are filled with electrons in the depletion region, the p-type side of the depletion region (where the holes were located initially) now contains negatively charged ions, and the n-type side of the depletion region (where the electrons were located) now contains ions positive charge. The presence of these oppositely charged ions creates an internal electric field that prevents electrons in the n-type layer from filling holes in the p-type layer.

When sunlight hits a solar cell, electrons in the silicon pop off, creating "holes "the spaces left by escaping electrons. If this happens in the electric field, the field will transfer electrons to the n-type layer and holes to the p-type layer. If you connect the n-type and p-type layers with a metal wire, the electrons will move from the n-type layer to the p-type layer by crossing the depletion region and then travel through the outer wire to the back of the n-type layer, creating a flow of electricity.

4.3 Types of photovoltaic solar cells

1. Monocrystalline Silicon Cell.
2. Polycrystalline Silicon Cell.
3. Thin Film Cells.
4. High Efficiency Cells.

4.4 The efficiency of solar panel

The efficiency is one of the most significant criteria which defines the quality of the output of a certain device There are many factors which alter the efficiency of a solar panel Efficiency can be described as the ration of the input energy through the solar cell to the energy of the sun the efficiency of the solar panel is monitored by the light intensity, material of the solar cell, temperature etc.

4.5 Effect of light intensity

Variation in the intensities of light plays a significant role in depicting the amount of power output This change in intensities monitors all the technical criterions such as voltage, circuit current, efficiency, shunt resistance etc. As a result, higher the intensities of light, greater is the power output.

4.6 Theory of using two LDR

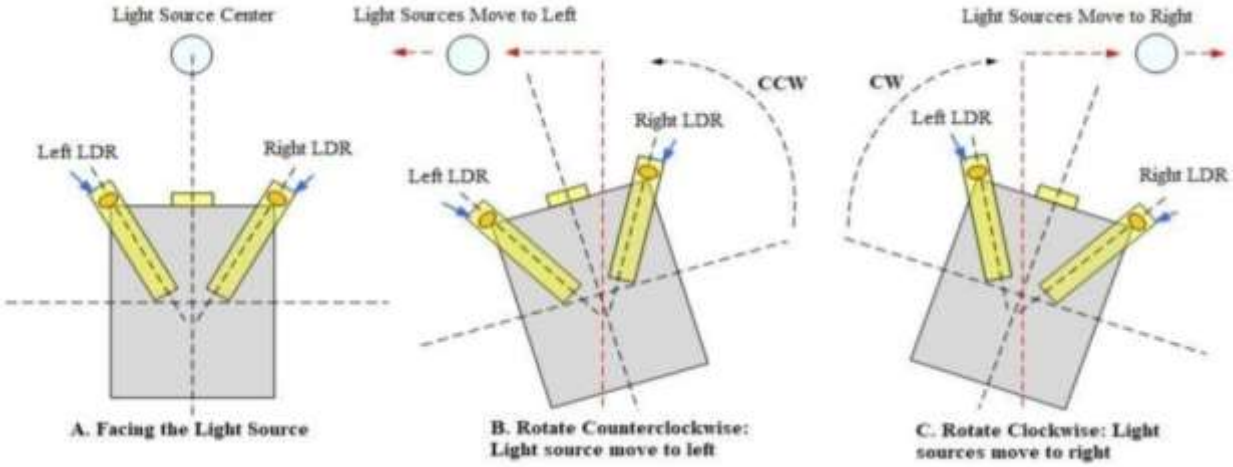


Figure 61: Theory of using two LDR

The figure depicts the notion for the instalment of the light dependent resistors (LDR).

A secure state is attained when the light intensities of the two LDR become the same. The principal source of light energy, the Sun, moves from east to west. This movement of the Sun causes the variation in the level of light intensities falling on the two LDRs. The designed algorithm compares the variation in the light intensities inside the microcontroller and the motor then is operated to rotate the solar panel, so it moves aligned with the trail of the light source

4.7 Advantages and disadvantages of solar panels

Advantages:

- The process of attaining solar energy is unsoiled.
- It is a renewable source of energy.
- The investment is done only during the installation of solar panels, the expenses of
- Acquired solar energy after installation is little.
- Solar energy is a perennial source of energy.
- There is no adulteration is the process of acquiring solar energy.
- The yield rate is very high, using solar panels.
- It requires the least maintenance, once the setup is installed.
- Solar energy is very useful and can be easily drawn into applications in rural areas
- where the extraction of electricity is difficult.
- Solar energy does not create noises compared to the noises created by the machinery in
- the extraction of other natural resources

Disadvantages:

- The installations of the solar panel could be pretty expensive, which would require huge
- Investments and years of saving.
- Production of electricity is directly dependent on the energy captivated which is
- Interlinked with the path sun covers. This factor could bring many countries to
- Disadvantage.
- The power station of solar energy lags in the production of the latter as compared to the
- Traditional power stations. Moreover, the costs of building such solar power stations
- Could be exorbitant.

4.8 Solar Tracker

Solar tracker, a system that positions an object at an angle relative to the Sun. The most-common applications for solar trackers are positioning photovoltaic (PV) panels (solar panels) so that they remain perpendicular to the Sun's rays and positioning space telescopes so that they can determine the Sun's direction. PV solar trackers adjust the direction that a solar panel is facing according to the position of the Sun in the sky. By keeping the panel perpendicular to the Sun, more sunlight strikes the solar panel, less light is reflected, and more energy is absorbed.

That energy can be converted into power. Solar tracking uses complex instruments to determine the location of the Sun relative to the object being aligned. These instruments typically include computers, which can process complicated algorithms that enable the system to track the Sun, and sensors, which provide information to a computer about the Sun's location or, when attached to a solar panel with a simple circuit board, can track the Sun without the need for a computer. Studies have shown that the angle of light affects a solar panel's power output.

A solar panel that is exactly perpendicular to the Sun produces more power than a solar panel that is not perpendicular. Small angles from perpendicular have a smaller effect on power output than larger angles. In addition, Sun angle changes north to south seasonally and east to west daily. As a result, although tracking east to west is important, north to south tracking has a less-significant impact.

4.9 Principle of Sun Tracking Solar Panel

The Sun tracking solar panel consists of two LDRs, solar panel and a servo motor and ATmega16A Micro controller.

Two light dependent resistors are arranged on the edges of the solar panel. Light dependent resistors produce low resistance when light falls on them. The servomotor connected to the panel rotates the panel in the direction of Sun. Panel is arranged in such a way that light on two LDRs is compared and panel is rotated towards LDR which have high intensity i.e., low resistance compared to other.

Servo motor rotates the panel at certain angle.

When the intensity of the light falling on right LDR is more, panel slowly moves towards right and if intensity on the left LDR is more, panel slowly moves towards left. In the noon time, Sun is ahead and intensity of light on both the panels is same.

In such cases, panel is constant and there is no rotation Servo motor is used to rotate the panel. To drive the servo motor, a PWM Signal must be provided to its control pin and hence Pin 17 (which has PWM) is connected to the control pin of the servo motor.

By connecting a battery to the solar panel, you can store the energy generated by the solar cells and this energy can be used when required. There is separate charge controller circuits dedicated to efficiently control the charge acquired from solar panels and charge the batteries.

4.10 Types of Solar Tracker

4.10.1 Active Solar Tracker

- It uses motors and gear trains or direct drive actuators, to follow the
- Movement of the sun.
- Directed by a controller.
- Deactivates during darkness based on the design of the system.
- It uses a light sensor to locate the angle at which maximum sunlight
- Can be absorbed.
- The MCU directs the solar panel to change the angle

4.10.2 Passive Solar Tracker

- It uses a liquid, easily compressible and boiled.
- It is driven by the solar heat.
- The fluid moves when heated, like a teeter-totter and hence the solar panel moves

4.10.3 Chronological Solar Tracker

- Works with the rotation of the earth.
- Have no sensors.
- Depends on the geographical location.
- Uses a controller to calculate the moment and position of the earth
- with respect to the sun at a given time and location.

4.10.4 Single Axis Tracker

- Tracks in a single cardinal direction.
- It has a single row tracking configuration.
- More reliable.

4.10.5 The common categories in which single axis trackers can be classified holds

- Horizontal single axis trackers (HSAT).
- Horizontal single axis tracker with tilted modules (HTSAT).
- Vertical single axis tracker (VSAT).
- Tilted single axis tracker (TSAT).
- Polar aligned single axis tracker (PSAT).

4.10.6 Horizontal Single-Axis Solar Tracker (HSAT)

HSAT rotates from east to west throughout the day on fixed axis, which is parallel to the ground, and it is considered as the most cost-effective tracker configuration in many PV applications. HSAT structure is placed on many supports along the rotating axis, requires less

material for construction and its horizontal configuration is most preferred compared to other tracking geometries.

4.10.7 Vertical Single-Axis Solar Tracker (VSAT)

These systems can be mounted in north/south or east/west orientation to follow more "up-and-down" movement of the sun in the sky. These are most often seen in high-altitude/mountainous locations or those at more extreme latitudes.

4.10.8 Dual-axis Solar Trackers

A dual-axis tracker enables your panels to rotate on two axes simultaneously. It is aligned horizontally as well as vertically, i.e., it can adjust in all directions – North, South, East, And West. These trackers may be appropriate for some commercial properties. A dual-axis solar tracking system is designed to maximize solar energy generation across the year. It uses algorithms and sensors, which can track the changes corresponding to seasons and changes in the height of the sun, alongside the general daily motion.

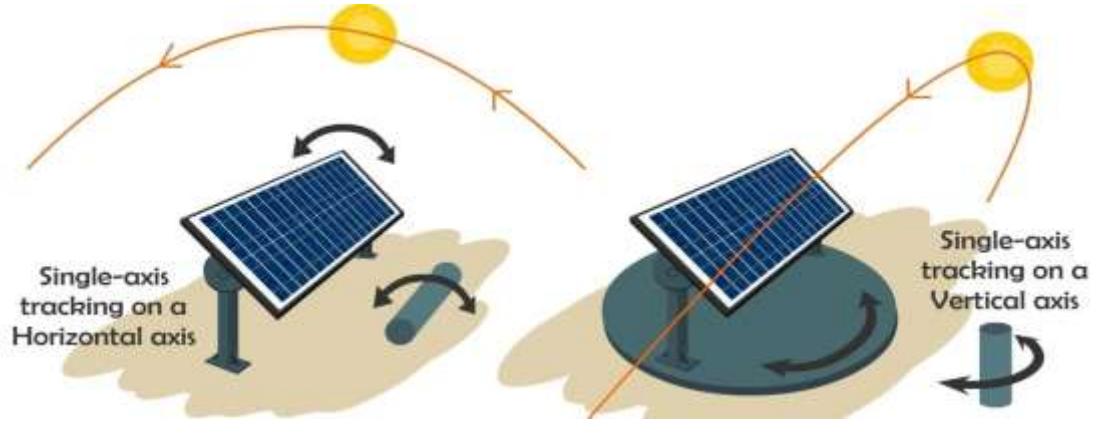


Figure 62: Description of the types of tracker movement

4.11 Advantages of a solar tracker

1. **More productivity:** Solar energy trackers enhance the productivity of solar panels. It is due to the elevated level of direct exposure to sunlight. The productivity depends on the geographic location of the installation
2. **Simple & Easy:** Solar energy trackers are convenient devices to track the sun for better energy output. The increased output offers a sustainable power source for our requirements.
3. **Land Optimization:** Solar trackers are significant land optimization tools. They can generate more electricity than the installations devoid of tracking systems and occupy the same amount of land.
4. **Easy Monitoring:** You can easily monitor the working of your solar tracking system from your PC right away.

4.12 The downsides of a solar tracker

1. **High Cost**: Solar tracking devices are a bit more expensive. They have a high initial cost as they have moving parts.
2. **More Maintenance:** Solar tracking systems demand more maintenance. Though, the requirements of maintenance depend on the type & quality of the tracking system.
3. **Site Preparation Requirements**: All types of solar energy tracking systems require significant preparation at the site of installation. It includes additional trenching for wiring and grading, etc.
4. **Weather Constraints**: A solar tracking system is not favorable in snowy weather. Such tracking systems are only beneficial in hot climates.

4.13 The Hardware Prototype

The hardware prototype is assembled of different electronic devices, and elementary materials used for the mechanical support. The electronic devices/circuit that are utilized in the prototype are again subdued under three basic titles.

- The Solar input
- The controlling circuit

4.14 The Solar input

The solar input comprises of the solar panel and two modules of photo sensors, each of which is joined to the solar panel along its length on either side of the panel. The solar panel is supported to the wooden base by the mechanical structure. The photo sensors are hence, connected to the controlling circuit.

The photo sensors used in the prototype are Light Dependent Resistors.

4.15 Light Dependent Resistor

The conundrum of light dependent resistor and photoresistor is used in a supplementary and in a complementary manner inter alia in a synonymous form. By being the light-sensitive devices, it's an embodiment of resistivity which is the function of incident electromagnetic radiation. Photoconductors and photoconductive cells or simple photocells are some of the names by which such devices are also designated. Constituted out of semiconductor materials, these devices are substantiated with high resistance. Symbolic balkanization is the means

to indicate the LDR, one of the most commonly used symbols is shown in the figure

below. The arrow indicates light falling on it.

Figure 63: Light Dependent Resistor

4.16 Lithium batteries

are among the best solar energy batteries that have many advantages when compared to lead-liquid batteries, gel batteries, and AGM batteries.

It is the most important part of the solar system, and developments continue in the production of batteries, and companies compete to find the best battery with the highest efficiency, and the last battery reached is the lithium battery, lithium batteries are the most common and most demanded of the types of solar batteries, because they have many advantages

It is noteworthy that these batteries were manufactured with the latest technology, as they used chemical compounds with lithium iron phosphate (LiFePO4) technologies, which are widely found in solar energy batteries, in addition to lithium-ion technology (Li-ion).

Lithium batteries for solar energy, electric batteries are one of the basic components of solar systems, with the exception of the on-grid system.

Electric batteries are used only to store electrical energy in order to use it when the solar panels are out of service and in the event that the public or main electricity network is not available.

The lithium battery also has a high depth of discharge, that is, a high cycle rate when discharging 80% of the total capacity, in addition to a low self-discharge rate of 1.5% to 2% per month, so it can be stored for a longer period than lead and gel batteries.

Advantages:

- It has a high number of discharge cycles.
- You don't need any maintenance.
- Its internal resistance is low.
- Its specific capacity is high with high loading capacities.
- Small size and lighter weight than lead-acid batteries.
- Support fast charging.

Figure 64: Lithium Batteries

4.17 The Controlling Circuit

The control circuit consists of: a BMS charger and 3 lithium batteries in a series connection, the voltage of each battery is 3.7 volts, and the BMS circuit is used to connect the three batteries in series for safety and to reduce the risk of charging the batteries in a series BMS is the best way to charge lithium batteries

Battery management system (BMS) is technology dedicated to the oversight of a battery pack, which is an assembly of battery cells, electrically organized in a row x column matrix configuration to enable delivery of targeted range of voltage and current for a duration of time against expected load scenarios.

The oversight that a BMS provides usually includes

- Monitoring the battery
- Providing battery protection
- Estimating the battery's operational state
- Continually optimizing battery performance
- Reporting operational status to external devices

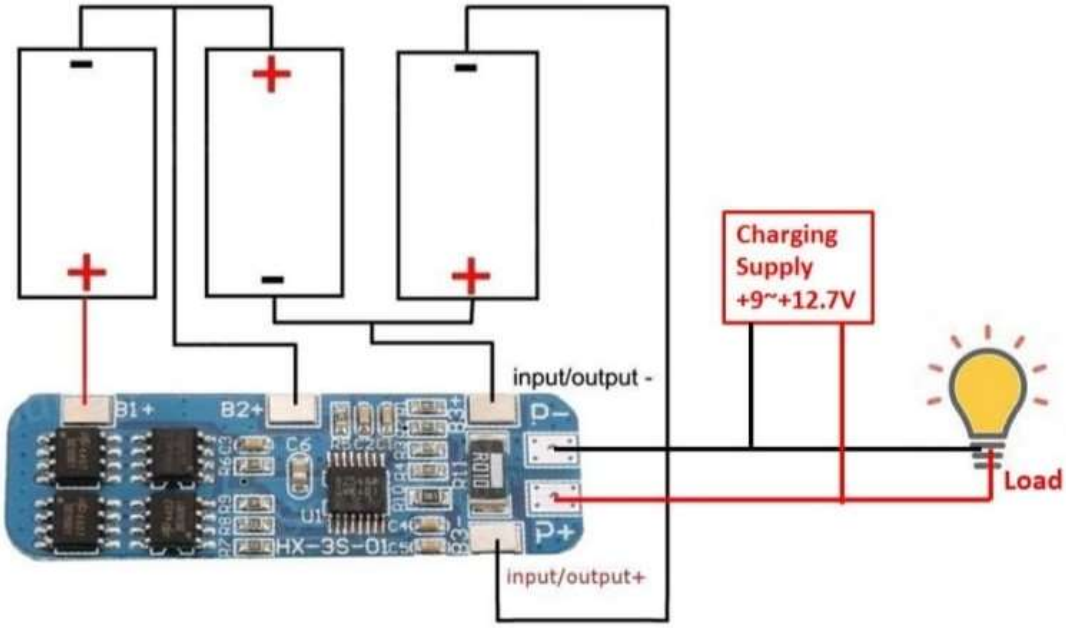


Figure 65: Battery management systems (BMS)

Battery management systems do not have a fixed or unique set of criteria that must be adopted. The technology design scope and implemented features generally correlate with: The costs, complexity, and size of the battery pack Application of the battery and any safety, lifespan, and warranty concerns

Certification requirements from various government regulations where costs and penalties are paramount if inadequate functional safety measures are in place.

Chapter 5

Mobile Application

5.1 App summary graph: (algorithms)

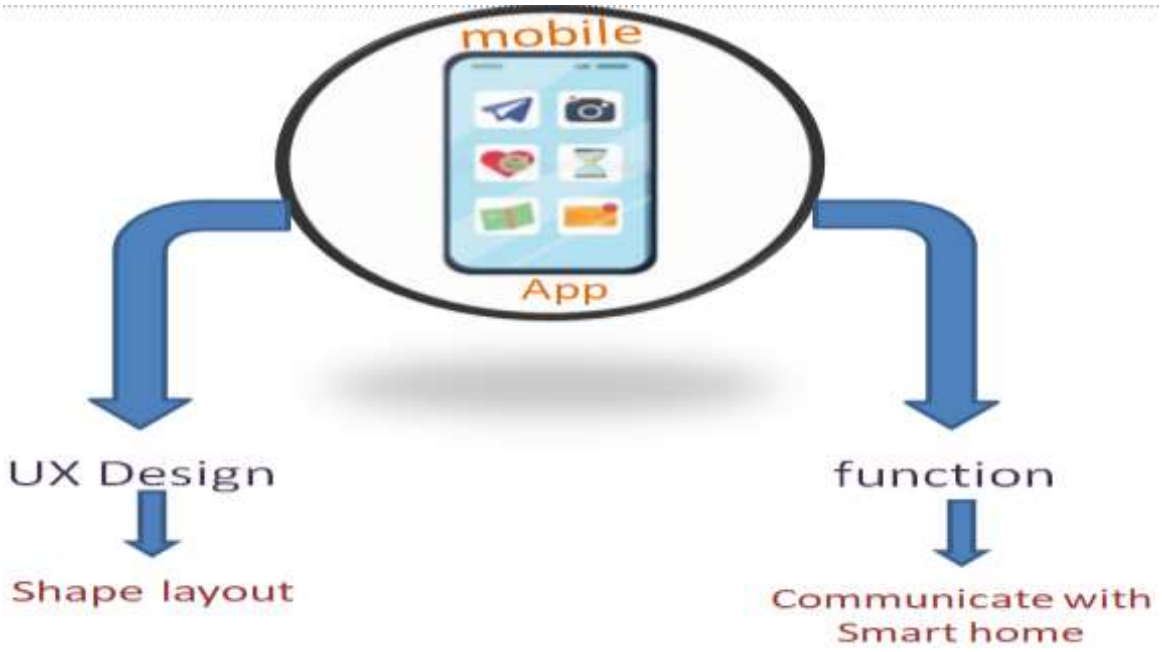


Figure 66: App Summary Graph

5.2 UI Design: Basic widgets

5.2.1 Text

The Text widget lets you create a run of styled text within your application.

5.2.2 Row, Column

These flex widgets let you create flexible layouts in both the horizontal (Row) and vertical (Column) directions. The design of these objects is based on the web's flexbox layout model.

5.2.3 Stack

Instead of being linearly oriented (either horizontally or vertically), a Stack widget lets you place widgets on top of each other in paint order. You can then use the Positioned widget on children of a Stack to position them relative to the top, right, bottom, or left edge of the stack. Stacks are based on the web's absolute positioning layout model.

5.2.4 Container

The Container widget lets you create a rectangular visual element. A container can be decorated with a Box Decoration, such as a background, a border, or a shadow. A Container can also have margins, padding, and constraints applied to its size. In addition, a Container can be transformed in three-dimensional space using a matrix.

5.2.5 Scaffold

The Scaffold is a widget in Flutter used to implements the basic material design **visual layout structure**. It is quick enough to create a general-purpose mobile application and contains almost everything we need to create a functional and responsive Flutter apps. This widget is able to occupy the whole device screen. In other words, we can say that it is mainly responsible for creating a base to the app screen on which the child widgets hold on and render on the screen. It provides many widgets or APIs for showing Drawer, Snack Bar, Bottom Navigation Bar, App Bar, Floating Action Button, and many more.

The Scaffold class is a shortcut to set up the look and design of our app that allows us not to build the individual visual elements manually. It saves our time to write more code for the look and feel of the app. The following are the constructor and properties of the Scaffold widget class.

```
const Scaffold({
  Key key,
  this.appBar,
  this.body,
  this.floatingActionButton,
  this.floatingActionButtonLocation,
  this.persistentFooterButtons,
  this.drawer,
  this.endDrawer,
  this.bottomNavigationBar,
  this.bottomSheet,
  this.floatingActionButtonAnimator,
  this.backgroundColor,
  this.resizeToAvoidBottomPadding = true,
  this.primary = true,
})
```

1. **App Bar**: It is a horizontal bar that is mainly displayed at the top of the Scaffold widget. It is the main part of the Scaffold widget and displays at the top of the screen. Without this property, the Scaffold widget is incomplete. It uses the app Bar widget that itself contains various properties like elevation, title, brightness, etc. See the below example:

2. **Body:** It is the other primary and required property of this widget, which will display the main content in the Scaffold. It signifies the place below the app Bar and behind the floating Action Button & drawer. The widgets inside the body are positioned at the top-left of the available space by default. See the below code:

3. **Drawer:** It is a slider panel that is displayed at the side of the body. Usually, it is hidden on the mobile devices, but the user can swipe it left to right or right to left to access the drawer menu. It uses the Drawer widget properties slides in a horizontal direction from the Scaffold edge to show navigation links in the application. An appropriate **icon** for the drawer is set automatically in an app Bar property. The gesture is also set automatically to open the drawer. See the following code.

4. **Floating Action Button:** It is a button displayed at the bottom right corner and floating above the body. It is a circular icon button that floats over the content of a screen at a fixed place to promote a primary action in the application. While scrolling the page, its position cannot be changed. It uses the Floating Action Button widget properties using Scaffold. Floating Action Button. See the below code:

5. **Background Color:** This property is used to set the background color of the whole Scaffold widget.

6. **Primary:** It is used to tell whether the Scaffold will be displayed at the top of the screen or not. Its default value is **true** that means the height of the app Bar extended by the height of the screen's status bar

7. **Persistent Footer Button:** It is a list of buttons that are displayed at the bottom of the Scaffold widget. These property items are always visible; even we have scroll the body of the Scaffold. It is always wrapped in a **Button Bar widget**. They are rendered below the body but above the bottom Navigation Bar

8. **Bottom Navigation Bar:** This property is like **a** menu that displays a navigation bar at the bottom of the Scaffold. It can be seen in most of the mobile applications. This property allows the developer to add multiple icons or texts in the bar as items. It should be rendered below the body and persistent Footer Button. See the below code

9. **End Drawer:** It is similar to a drawer property, but they are displayed at the right side of the screen by default. It can be swiped right to left or left to right.

10. **Resize To Avoid Bottom Inset:** If it is true, the body and the Scaffold's floating widgets should adjust their size themselves to avoid the onscreen keyboard. The bottom property defines the onscreen keyboard height.

11. **Floating Action Button Location:** By default, it is positioned at the bottom right corner of the screen. It is used to determine the position of the floating Action Button. It contains many predefined constants, such as center Docked, center Float, end Docked, end Float, etc.

5.3 Flutter Switch:

A switch is a two-state user interface element used to toggle between ON (Checked) or OFF (Unchecked) states. Typically, it is a button with a thumb slider where the user can drag back and forth to choose an option in the form of ON or OFF. Its working is similar to the house electricity switches.

In Flutter, the switch is a widget used to select between two options, either ON or OFF. It does not maintain the state itself. To maintain the states, it will call the on Changed property. If the value return by this property is true, then the switch is ON and false when it is OFF. When this property is null, the switch widget is disabled. In this article, we are going to understand how to use a switch widget in the Flutter application.

5.4 Properties of Switch Widget

value	It contains a Boolean value true or false to control whether the switch functionality is ON or OFF.
active Color	It is used to specify the color of the switch round ball when it is ON
Active Track Color	It specifies the switch track bar color.
Inactive Track Color	It specifies the switch track bar color when it is OFF.
Drag Start Behavior	It handled the drag start behavior. If we set it as Drag Start Behavior. Start, the drag moves the switch from on to off.
on Changed	It will be called whenever the user taps on the switch.

Table 5: Properties of Switch Widget

5.5 Flutter Buttons:

- ✓ Flat Button
- ✓ Raised Button
- ✓ Floating Button
- ✓ Drop Down Button

5.5.1. Flat Button

It is a text label button that does not have much decoration and displayed without any elevation. The flat button has two required properties that are: child and on Pressed (). It is mostly used in toolbars, dialogs, or in line with other content. By default, the flat button has no color, and its text is black. But, we can use color to the button and text using color and text Color attributes, respectively.

5.5.2. Raised Button

It is a button, which is based on the material widget and has a rectangular body. It is similar to a flat button, but it has an elevation that will increases when the button is pressed. It adds dimension to the UI along Z-axis. It has several properties like text color, shape, padding, button color, the color of a button when disabled, animation time, elevation, etc.

This button has two callback functions. On Pressed (): It is triggered when the button is pressed. Uncompressed (): It is triggered when the button is long pressed.

It is to note that this button is in a disabled state if OnPressed () and OnLongPressed () callbacks are not specified.

5.5.3 Floating Action Button

A FAB button is a circular icon button that triggers the primary action in our application. It is the most used button in today's applications. We can use this button for adding, refreshing, or sharing the content. Flutter suggests using at most one FAB button per screen. There are two types of Floating Action Button:

5.5.4 Dropdown Button

A drop-down button is used to create a nice overlay on the screen that allows the user to select any item from multiple options. Flutter allows a simple way to implement a drop-down box or drop-down button. This button shows the currently selected item and an arrow that opens a menu to select an item from multiple options.

5.6 Flutter Progress Bar:

A progress bar is a graphical control element used to show the progress of a task such as downloading, uploading, installation, file transfer, etc. In this section, we are going to understand how to show a progress bar in a flutter application.

Flutter can display the progress bar with the help of two widgets, which are given below:

1. Linear Progress Indicator
2. Circular Progress Indicator

5.7 Linear Progress Indicator

The linear progress bar is used to show the progress of the task in a horizontal line.

Flutter provides mainly two types of linear progress indicators:

Determinate: Determinate progress bar indicates the actual amount of progress at each point in making the task. Its value will increase monotonically from 0.0 to 1.0 to show the amount of task completed at that time. We need to use a non-null value from 0.0 to 1.0 for creating a determinate progress indicator.

Indeterminate: Indeterminate progress bar does not indicate the amount of progress in completing the task. It means we do not know when the task is finished. It makes progress without indicating how much progress remains. We can make an indeterminate progress indicator by using a null value.

It is a widget, which spins to indicate the waiting process in your application. It shows the progress of a task in a circular shape. It also displays the progress bar in two ways: Determinate and Indeterminate.

A determinate progress bar is used when we want to show the progress of ongoing tasks such as the percentage of downloading or uploading files, etc. We can show the progress by specifying the value between 0.0 and 1.0.

An indeterminate progress bar is used when we do not want to know the percentage of an ongoing process. By default, Circular Progress Indicator shows the indeterminate progress bar.

5.8 Flutter Icons:

An icon is a graphic image representing an application or any specific entity containing meaning for the user. It can be selectable and non-selectable. For example, the company's logo is non-selectable. Sometimes it also contains a hyperlink to go to another page. It also acts as a sign in place of a detailed explanation of the actual entity.

Flutter provides an Icon Widget to create icons in our applications. We can create icons in Flutter, either using inbuilt icons or with the custom icons. Flutter provides the list of all icons in the Icons class. In this article, we are going to learn how to use Flutter icons in the application.

Property	Descriptions
icon	It is used to specify the icon name to display in the application. Generally, Flutter uses material design icons that are symbols for common actions and items.
color	It is used to specify the color of the icon.
size	It is used to specify the size of the icon in pixels. Usually, icons have equal height and width.
text Direction	It is used to specify direction of the icon

Table 6: Flutter Icons

5.9 Flutter REST API

In this section, we are going to learn how we can access the REST API in the Flutter app. Today, most of the apps use remote data using APIs. So, this section will be the important part for those developers who want to make their carrier in Flutter.

Flutter provides http package to use http resources. The http package
uses await and Async features and provides many high-level methods such as read, get, post, put, head, and delete methods for sending and receiving data from remote locations. These methods simplify the development of REST-based mobile applications.

The detail explanation of the core methods of the http package are as follows:

Read: This method is used to read or retrieve the representation of resources. It requests the specified URL by using the get method and returns the response as Future<String>.

Get: This method requests the specified URL from the get method and returns a response as Future<response>. Here, the response is a class, which holds the response information.

Post: This method is used to submit the data to the specified resources. It requests the specified URL by posting the

Given data and return a response as Future<response>.

Put: This method is utilized for update capabilities. It updates all the current representation of the target resource with the request payloads. This method requests the specified url and returns a response as Future<response>.

Head: It is similar to the Get method, but without the response body.

Delete: This method is used to remove all the specified resources.

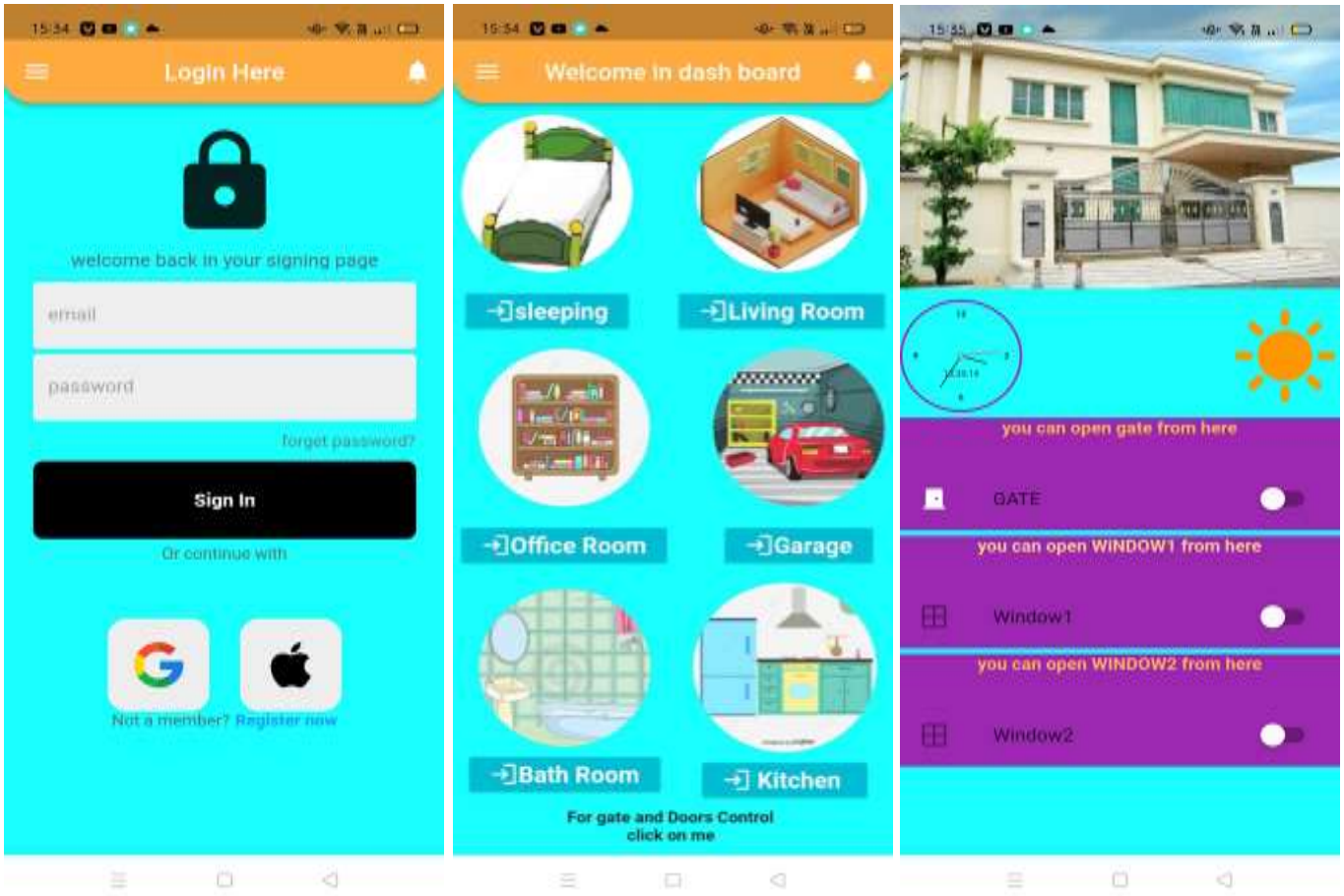


Figure 67: Mobile Application Pages

Chapter 6

SECURITY SYSTEM

From the apps and websites, we use every day to the numerous connected devices we continue to add to our homes, there are more ways than ever cybercriminals can hack your data. As we enter a more connected reality, we need to be increasingly aware that smart home.

6.1 Why is Cyber Security a Smart Home Issue?

Smart Home and IoT devices are increasingly being targeted by hackers as the weak point of any home or enterprise security network. Imagine what would happen if someone hacks a single device and obtains all your Wi-Fi credentials. Perhaps worse, what if a cybercriminal gains access to your smart thermostat and learns when you'll be away? They may use that information to determine the best time to burgle your home. If someone compromises your connected home, your data could easily be leaked.

6.2 Top Five Smart Devices That Made an Impact on Cyber Security

1. **Smart TVs:** With a click of a button or by the sound of our voice, our favorite shows will play, pause, rewind ten seconds, and more – all thanks to smart TVs and streaming devices. Although a great way to enjoy entertainment, it's also a breeding ground for cyber-attacks; but how do they do it? By infecting a computer or mobile device with malware, a cybercriminal could gain control of your smart TV if your devices are using the same Wi-Fi.
2. **Voice Controlled Assistants:** Voice-controlled assistants and smart speakers are always listening and, if hacked, could gain a wealth of information about you. Often used as a central command hub, connecting other devices to them (ie. smart speakers, smart lights, security cameras, refrigerator or smart locks). Some people even opt to connect accounts such as food delivery, driver services, and shopping lists that use credit cards. If hacked, someone could gain access to your financial information or even access to your home.
3. **Connected Cars:** Today, cars are essentially computers on wheels. Between backup cameras, video screens, GPS systems, and Wi-Fi networks, they have more electronics stacked in them than ever. Despite the advancements in technology, these remain access points for an attacker. In fact, an attacker can take control of your car a couple of ways; either by physically implanting a tiny device that grants access to your car through phone or by leveraging a black box tool and your car's diagnostic port completely remotely. Hacks can range anywhere from cranking the radio up, to cutting the transmission or disabling the breaks.
4. **Connected Baby Monitors:** When you have a child, security and safety fuels most of your thoughts. While smart baby monitors are helpful, they are also an easy target for cybercriminals.
5. **Cell Phones:** In any given day, we access financial accounts, check work emails and communicate with family and friends. That's why it's shocking to know how surprisingly easy it is for cybercriminals to access personal data on your cell phone. Phones can be compromised in a variety of ways, here are a few: accessing your personal information by way of public Wi-Fi (say, while you're at a coffee shop using free Wi-Fi), implanting a bug, leveraging a flaw in the operating system, or by infecting your device with malware by way of a bad link while surfing the web or browsing email.

6.3 Stay Smart Home/IoT Safe

Here are ten things you can do to stay smart home/IoT safe:

1. Change the default username and password. Always remember to change your passwords regularly.
2. Stick with protected devices only.
3. Set up a guest Wi-Fi network.
4. Set up two-factor authentication.
5. Stay on-top of software updates.
6. Never manage your smart devices from public Wi-Fi networks.
7. Disable unnecessary features.
8. Use biometric authentication.
9. Secure your network fully and make sure you have a firewall.
10. Rename and reboot your router regularly.

Security for smart home devices is as critical as security on laptops and smartphones – and because many are less user-friendly when it comes to customizing settings, it can take far more effort to get right. While there's absolutely no doubt that smart home/IoT devices make life easier, our everyday items are extremely hackable.

6.4 Smart Home: Threats and Countermeasures

An estimated 80% of IoT devices are vulnerable to a wide range of attacks. Clearly, connecting traditionally 'stand-alone' smart devices such as lights, appliances and locks introduces numerous cyber security risks. Even connected baby monitors are vulnerable to digital intruders, as a number of horrified parents belatedly discovered when hackers spoke to their young children via compromised devices. Common cyber security threats and attacks against smart home devices include:

Man-in-the-middle: An attacker breaches, interrupts or spoofs communications between two systems. For example, fake temperature data 'generated' by an environmental monitoring device can be spoofed and forwarded to the cloud. Similarly, an attacker can disable vulnerable HVAC systems during a heat wave, creating a disastrous scenario for service providers with affected models.

Data and identity theft: Data generated by unprotected wearables and smart appliances provide cyber attackers with an ample amount of targeted personal information that can potentially be exploited for fraudulent transactions and identify theft.

Device hijacking: The attacker hijacks and effectively assumes control of a device. These attacks are quite difficult to detect because the attacker does not change the basic functionality of the device. Moreover, it only takes one device to potentially re-infect all smart devices in the home. For example, an attacker who initially compromises a thermostat can theoretically gain access to an entire network and remotely unlock a door or change the keypad PIN code to restrict entry.

Distributed Denial of Service (DDoS): A denial-of-service attack (DoS attack) attempts to render a machine or network resource unavailable to its intended users by temporarily or indefinitely disrupting services of a host connected to the Internet. In the case of a distributed denial-of-service attack (DDoS), incoming traffic flooding a target originates from multiple sources, making it difficult to stop the cyber offensive by simply blocking a single source. In fact, DDoS attacks are rising rapidly, primarily due to the lack of security in IoT Devices. The Mirai botnet attack was a massive distributed DDoS attack that left much of the internet inaccessible on the US east coast.

Permanent Denial of Service (PDoS): Permanent denial-of-service attacks (PDoS), also known as plashing, is an attack that damages the device so badly that it requires replacement or reinstallation of hardware. Bricker Bot, coded to exploit hard-coded passwords in IoT devices and cause permanent denial of service, is one such example. Another example could see fake data fed to thermostats in an attempt to cause irreparable damage via extreme overheating

Securing Smart Homes

Connected smart home devices should be protected by a comprehensive IoT security solution (device to cloud) that does not disrupt a Service provider or OEMs profitability or time to market. A comprehensive IoT security solution should include the following capabilities:

Figure 68: Security System

Secure boot

Secure boot utilizes cryptographic code signing techniques, ensuring that a device only executes code generated by the device OEM or another trusted party. Use of secure boot technology prevents hackers from replacing firmware with malicious versions, thereby preventing attacks.

Mutual authentication

Every time a smart home device connects to the network it should be authenticated prior to receiving or transmitting data. This ensures that the data originates from a legitimate device and not a fraudulent source. Cryptographic algorithms involving symmetric keys or asymmetric keys can be utilized for two-way authentication. This ensures that the data originates from a legitimate device and not a fraudulent source. Cryptographic algorithms involving symmetric keys or asymmetric keys can be utilized for two-way authentication. For example, the Secure Hash Algorithm (SHA-x) can be used for symmetric keys and the Elliptic Curve Digital Signature Algorithm (ECDSA) for asymmetric keys.

Secure communication (Encryption)

Protecting data in transit between a device and its service infrastructure (the cloud). Encryption ensures that only those with a secret decryption key can access transmitted data. For example, a smart thermostat that sends usage data to the service operator must be able to protect information from digital eavesdropping.

Figure 69: Secure Communication

Security monitoring and analysis

Captures data on the overall state of the system, including endpoint devices and connectivity traffic. This data is then analyzed to detect possible security violations or potential system threats. Once detected, a broad range of actions formulated in the context of an overall system security policy should be executed, such as quarantining devices based on anomalous behavior. This monitor-analyze-act cycle may execute in real time or at a later date to identify usage patterns and detect potential attack scenarios. It is critical to ensure that endpoints devices are secured from possible tampering and data manipulation, which could result in the incorrect reporting of events.

6.5 Web server Concepts:

A web server is a program that hosts websites, attackers usually

target software vulnerabilities and config errors to compromise the servers Nowadays, network and OS level attacks can be well defended using proper network security measures such as firewalls, IDS, etc. Web servers are more vulnerable to attack since they are available on the web

6.5.1 Webserver Attacks

- DoS/DDoS Attacks: Attackers may send numerous fake requests to the web server which results in the web server crash or become unavailable
- May target high-profile web servers
- DNS Server Hijacking: Attacker compromises DNS server and changes the DNS settings so that all requests coming towards the target web server is redirected to another malicious server
- DNS Amplification Attack: Attacker takes advantage of DNS recursive method of DNS redirection to perform DNS amplification attack
- Attacker uses compromised PCs with spoofed IPs to amplify the DDoS attack by exploiting the DNS recursive method
- Directory Traversal Attack: Attackers use to sequence to access restricted directories outside of the web server root directory (trial and error)
- Man-in-the middle Sniffing Attack: MITM attacks allow an attacker to access sensitive info by intercepting and altering communications
- Phishing Attacks: Attacker tricks user to submit login details for website that looks legit but it's not. Attempts to steal credentials.

- Website Defacement: intruder maliciously alters visual appearance of a web page by inserting offending data. Variety of methods such as MYSQL injection
- Web Server Configuration: Refers configuration weaknesses in infrastructure such as directory traversal
- HTTP Responses Splitting Attack: involves adding header data into the input field so that the server split the response into two responses. The attack can control the second response to redirect user to malicious website whereas the other response will be discarded by browser
- Web Cache Poisoning: An attacker forces the web server's cache to flush its actual cache content and sends a specially crafted requests, which will be stored in cache

6.5.2 Webserver Attack Tools

- Metasploit: Encapsulates an exploit.
- Payload module: carries a backpack into the system to unload
- Meta sploit Aux Module: Performing arbitrary, one-off actions such as port scanning, DoS, and fuzzing
- NOPS module: generate a no-operation instructions used for blocking out buffers
- Password Cracking: THC Hydra, Cain & Abe
- An ideal web hosting network should be designed with at least three segments namely: The internet segment, secure
- server security segment (DMZ), internal network
- Placed the web server in DMZ of the network isolated from the public network as well as internal network
- Firewalls should be placed for internal network as well as internet traffic going towards DMZ
- Patches and Updates: Ensure service packs, hotfixes, and security patch levels are consistent on all domain controllers
- Protocols: block all unnecessary ports, ICMPs, and unnecessary protocols such as NetBIOS and SMB. Disable WebDAV if not used
- Files and Directories: delete unnecessary files, disable serving of directory listings, disable serving certain file types , avoid virtual directories
- Detecting Hacking Attempts: Run scripts on the server that detects any changes made in the existing executable file.
- Compare hash values of files on server to detect changes in codebase. Alert user upon any change in detection
- Secure the SAM (stand-alone servers only)
- Defending against DNS hijacking: choose ICANN accredited registrar. Install anti-virus

6.5.3 Patch Management

- Hotfixes are an update to fix a specific customer issue
- A patch is a small piece of software designed to fix problems
- Hotfixes and Patches are sometimes combined for server packs
- Patch Management is a process used to ensure that the appropriate patches are installed on a system to help fix known vulnerabilities
- Before installing a patch, verify the source.

6.6 Webserver Security Tools

Helps automate web app security testing and guards. N Stalker is a scanner to search vulnerabilities

6.6.1 Wireless Encryption

- WEP (wired equivalent privacy): weakest encryption. Uses 24-bit initialization vector. A 64-bit WEP uses a 40-bit key etc.
- Can use Cain & Abel to crack
- WPA (WIFI Protected Access): Stronger encryption with TKIP.
- You can brute force the keys offline
- You can defend by using stronger passphrases
- WPA2: Stronger data protection with AES
- WPA-2 personal uses a pre-shared key to protect access

6.6.2 Wireless Threats

- Access Control Attacks: Aims to penetrate a network by evading WLAN access control measures, such as AP MAC filters
- and Wi-Fi port access controls
- Integrity Attacks: Sending forged control management or data frames over a wireless network
- Confidentiality Attacks: attempt to intercept confidential information sent over wireless associations
- Availability Attacks: DoS
- Authentication Attacks: Steal the identity of Wi-Fi clients, their PI, logins, etc. to unauthorized access of network resources
- Rogue Access Point Attack: Hijacking connections and acting as a middle man sniffing
- Client Mis-Association: Attacker sets up a rogue access point outside of the corporate perimeter and lures the employees
- of the organization to connect with it
- Misconfigured Access Point Attack: Accidents for configurations that you can exploit
- AP MAC Spoofing: Hacker spoofs the MAC address of the WLAN client equipment to mask an authorized client

6.6.3 Crack Wi-Fi encryption

- Crack WEP using Air crack
- Crack WPA-PSK using air crack
- WEP cracking using Cain & Abel
- Compromise the Wi-Fi Network

Chapter 7

Conclusion and Future Works

7.1 Conclusion

In this project, an efficient and secured approach for smart homes was proposed and implemented. C programming language and AVR ATEMGA16A (Microcontroller) had been used to connect the sensors circuit to the home.

A series of experiments had been carried out on the proposed smart home. These experiments shew how to make the home more secure by Door Locker Security System.

This project showed the idea of cooling system by the temperature sensor which sense the temperature in the home then the role of Fan become to make the temperature inside home endurable.

Also, we monitored motion inside home by PIR (passive Infra-Red) motion sensor it used to detect if a human has moved in or out of the sensor range

We tried to prevent fire and gas leakage to happen and those by a flame sensor and gas sensor. And Turn on the alarm and the flasher when fire or gas leak occurs, the water level sensor was used to prevent rain from entering homes and offices by detecting the rain and automatically close the windows in the home.

We created an application that used to control the lights and the doors of home by smart phone

7.2 Current Problem

The problems that made us think about the smart homes:

1. Energy Consumption: Traditional homes waste a lot of energy, with appliances and lights left on even when no one is using them.
2. Home Security: Traditional homes are vulnerable to break-ins and theft.
3. Aging Population: As the population ages, there is a growing need for homes that are designed to be more accessible and user-friendly for people with mobility issues or disabilities.
4. Lifestyle Changes: With the increasing pace of modern life, many people are looking for ways to make their lives more convenient and efficient.

7.3 Benefits

1. Smart homes are a popular trend in real estate, and having a smart home can increase the value of our homes if we decide to sell them in the future.
2. Smart homes can be controlled remotely using a smartphone or tablet, allowing us to monitor and control our homes from anywhere in the world.
3. Smart homes can help prevent accidents by alerting us to potential hazards, such as a gas leak or a fire.
4. Smart homes can monitor our health and wellness by tracking our activity levels, vital signs, and other health metrics, helping us to lead a healthier lifestyle.

7.4 Future Work

1. Improved Energy Efficiency: Smart homes can already help reduce energy consumption by automatically turning off lights and appliances when not in use.
2. Enhanced Security: Future systems could incorporate more advanced technologies like facial recognition and biometric authentication to further enhance security.
3. Personalization: Smart homes could become even smarter by personalizing their behavior based on individual preferences.
4. Integration with Smart Cities: smart homes could automatically adjust their behavior based on traffic patterns or air quality readings.
5. Better Interoperability: Future systems could incorporate more standardized protocols to make it easier for devices to work together seamlessly.
6. Health and Wellness Monitoring: they could monitor vital signs or track activity levels to help identify potential health issues early on.
7. Virtual Assistants: Future virtual assistants like Siri and Alexa could be even more intelligent and could help automate even more aspects of our lives.

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