



HOME AUTOMATION SYSTEM

Embedded System Project

Smart Home with Solar Tracking System

Based on AVR Microcontroller





Higher Institute Of Engineering And Modern Technology - Al-Marg

Graduation Project
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2	System Requirement Specification	7	Software Implementation
3	System Design	8	Maquette Implementation
4	Hardware Implementation	9	Mobile Application
5	Solar Tracking System	10	Security System





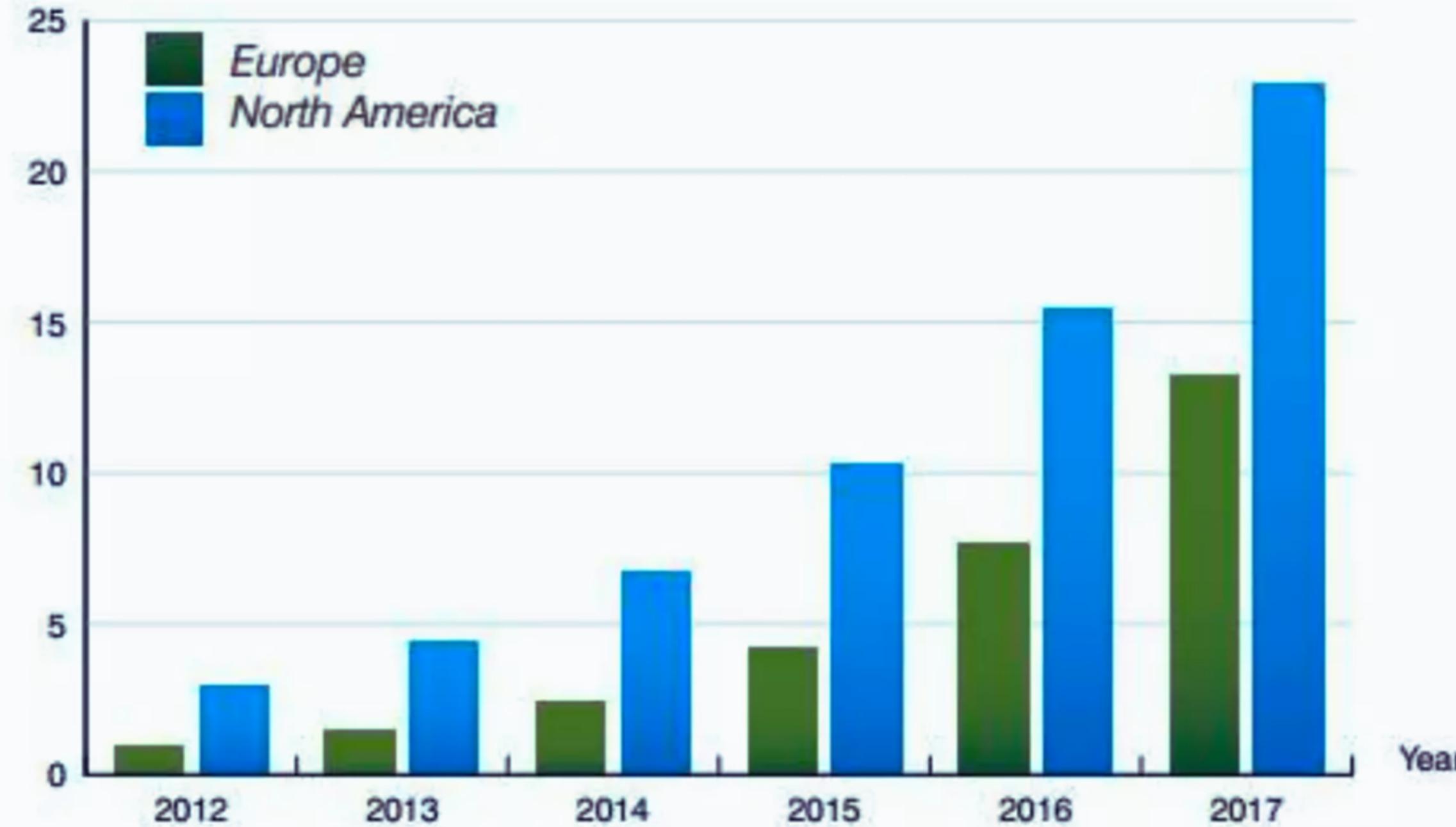
Introduction

Introduction

- Our seminar is about “Smart Home and Solar Tracking System by using AVR Microcontroller” .
- The user can control most of devices at home by using Mobile Application.
- “Home automation” refers to the automatic and electronic control of household features, activity, and appliances.



Million homes



*Total number of smart homes
(Europe and North America 2012–2017)*

Advantages

- Safety
- Comfort
- Secures Home Through Automated Door Locks
- Saves money (operating cost) & energy
- Save Time
- Great for the parents



Disadvantages

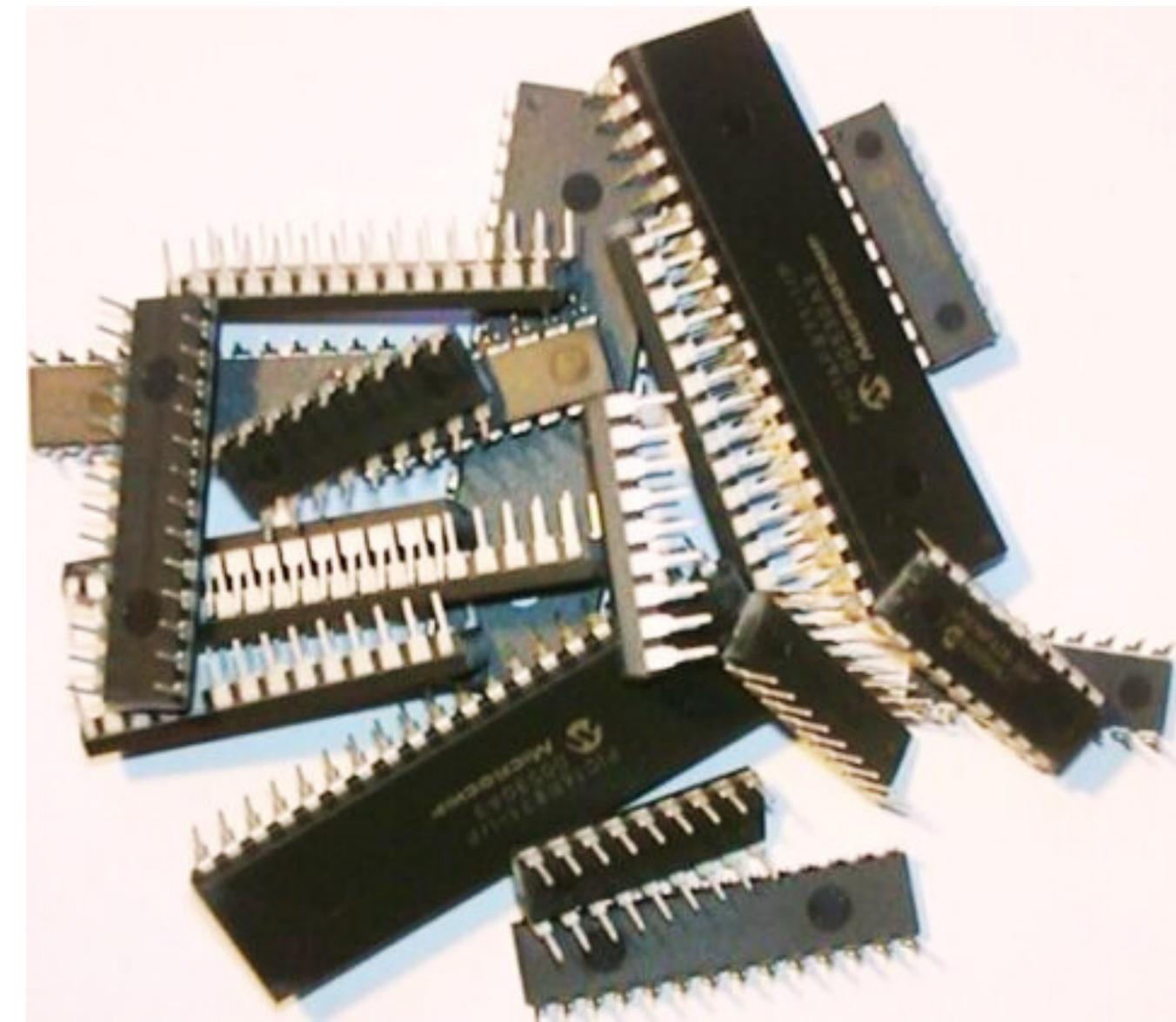
- Internet System vulnerable to hacking
- Crashing of system
- Human error
- Costly (installing cost)



Microcontrollers for embedded systems

An embedded system is controlled by its own internal microprocessor

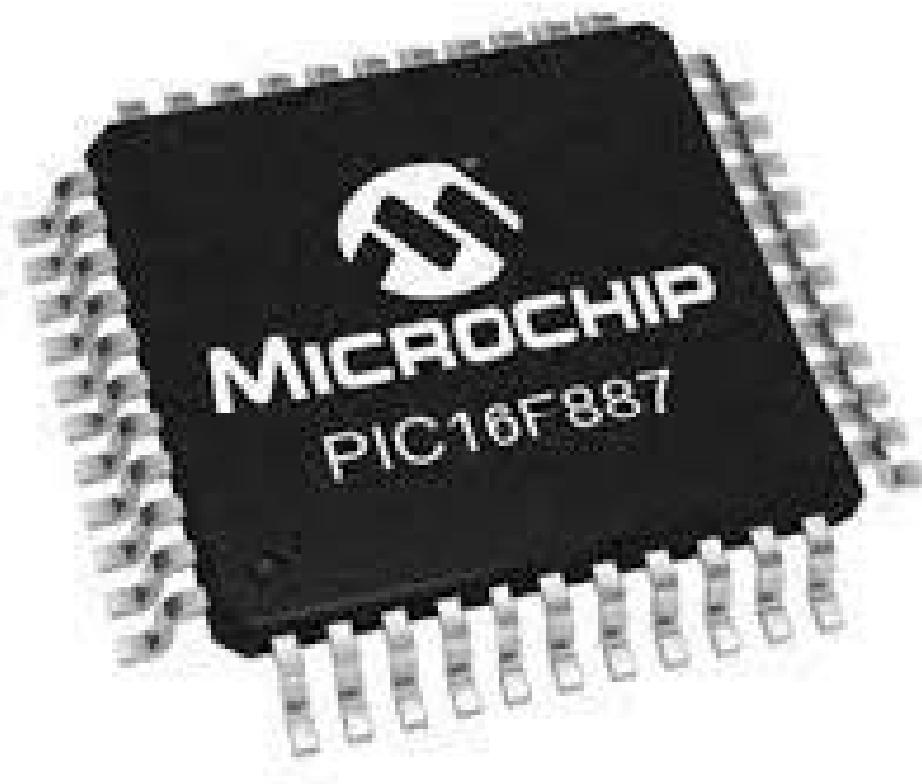
only one application software is burned into ROM to perform a specific task.



Choosing a Microcontroller

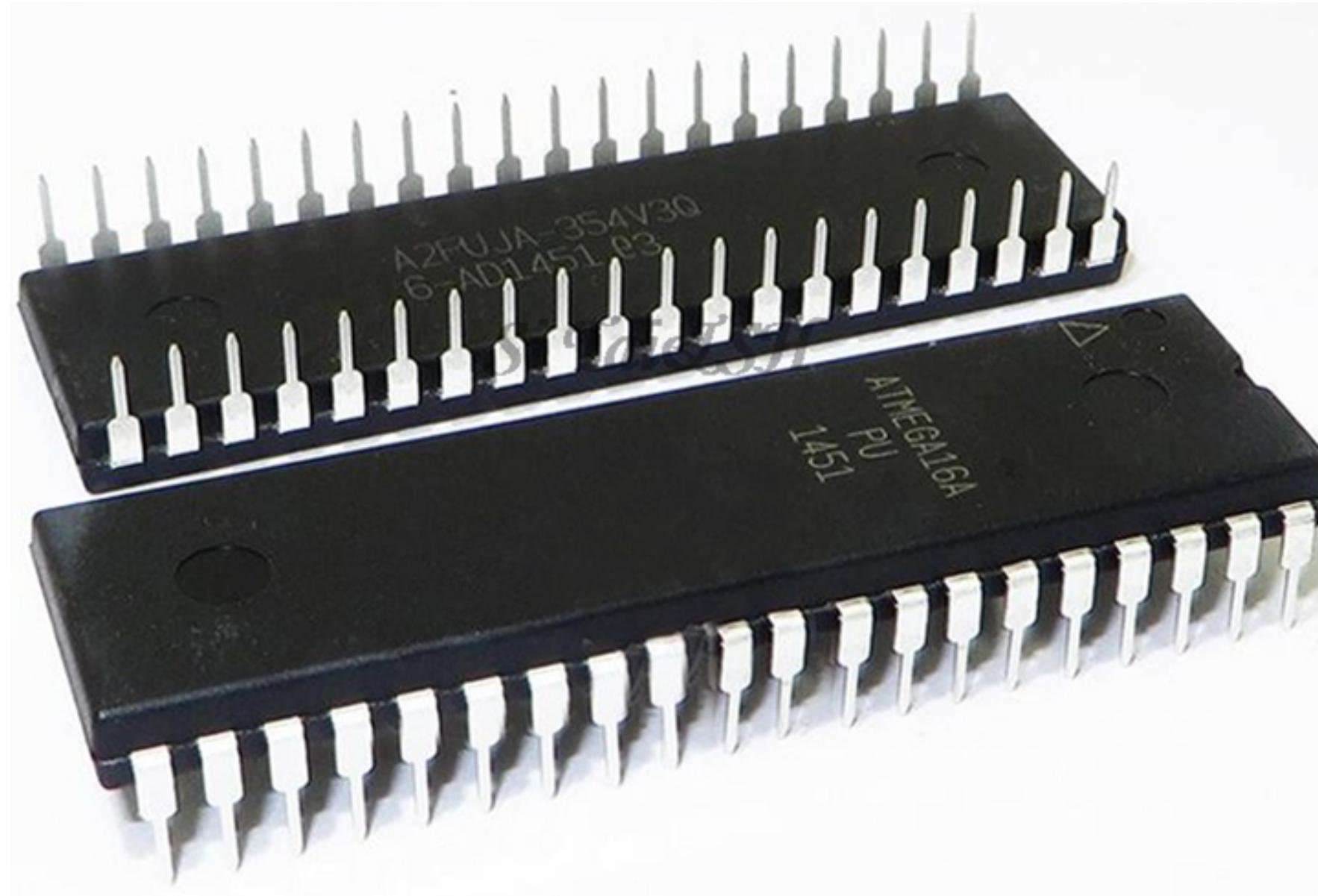
When choosing a microcontroller, some criteria must be taken into account:

1. Speed
2. Power consumption.
3. The amount of RAM and ROM on the chip.
4. The number of I/O pins.
5. The availability of an assembler, C language compiler and technical support.
6. The number of internal peripherals (Timers, ADCs, ...etc.).



Technology used

ATMEGA16A Microcontroller



Why to choose AVR Microcontroller ?

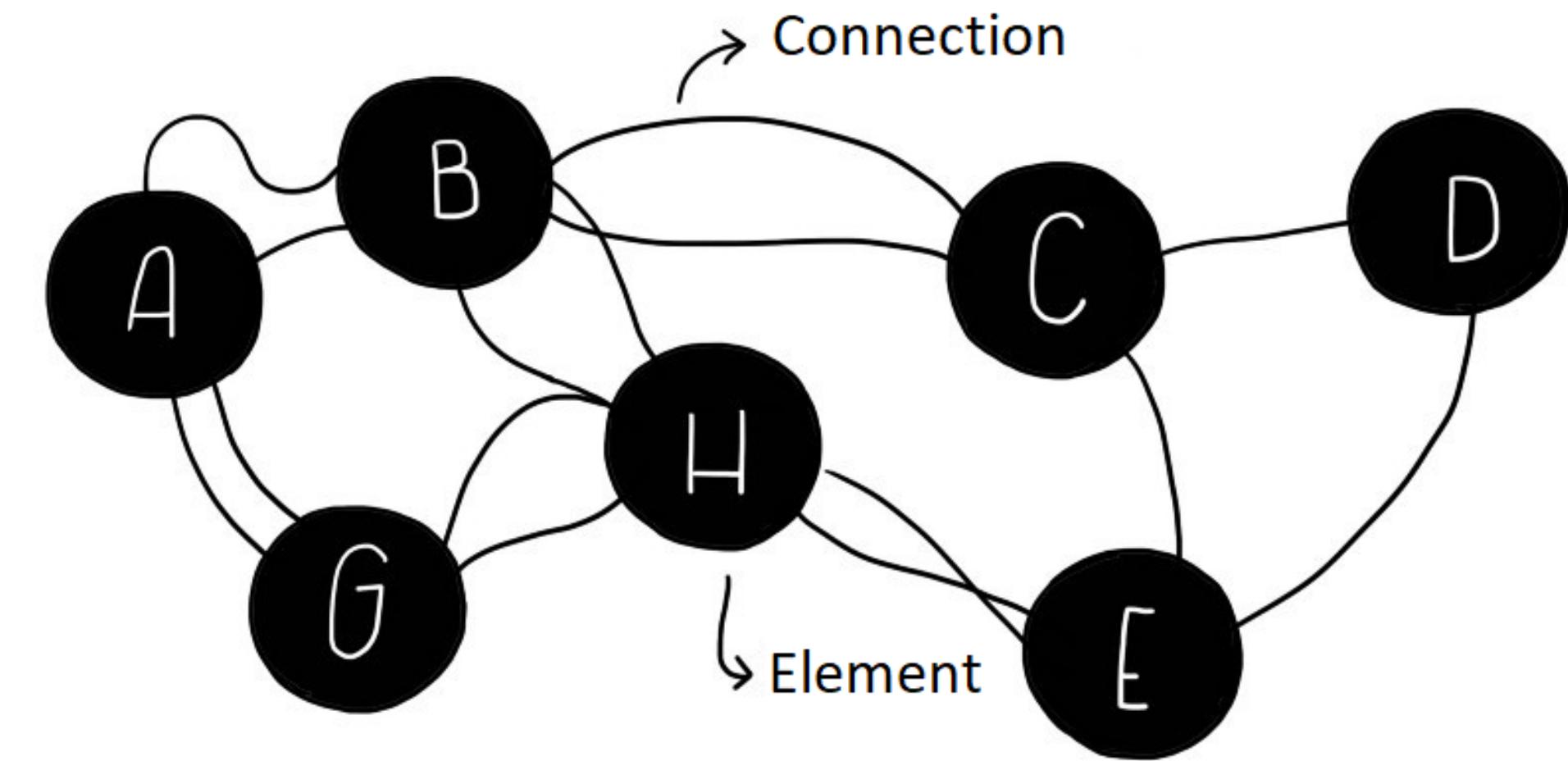
- Easy to Code
- Easy to Program
- Powerful and Inexpensive



Tasks

- Door Locker Security System
- Fire Alarm System
- Gas Alarm System
- Rain Indicator System
- Temperature sensing system
- Motion Detector system
- Wi-Fi Control System
- Automatic Light control system
- Soil Moisture control system
- Solar Tracking system

SYSTEM



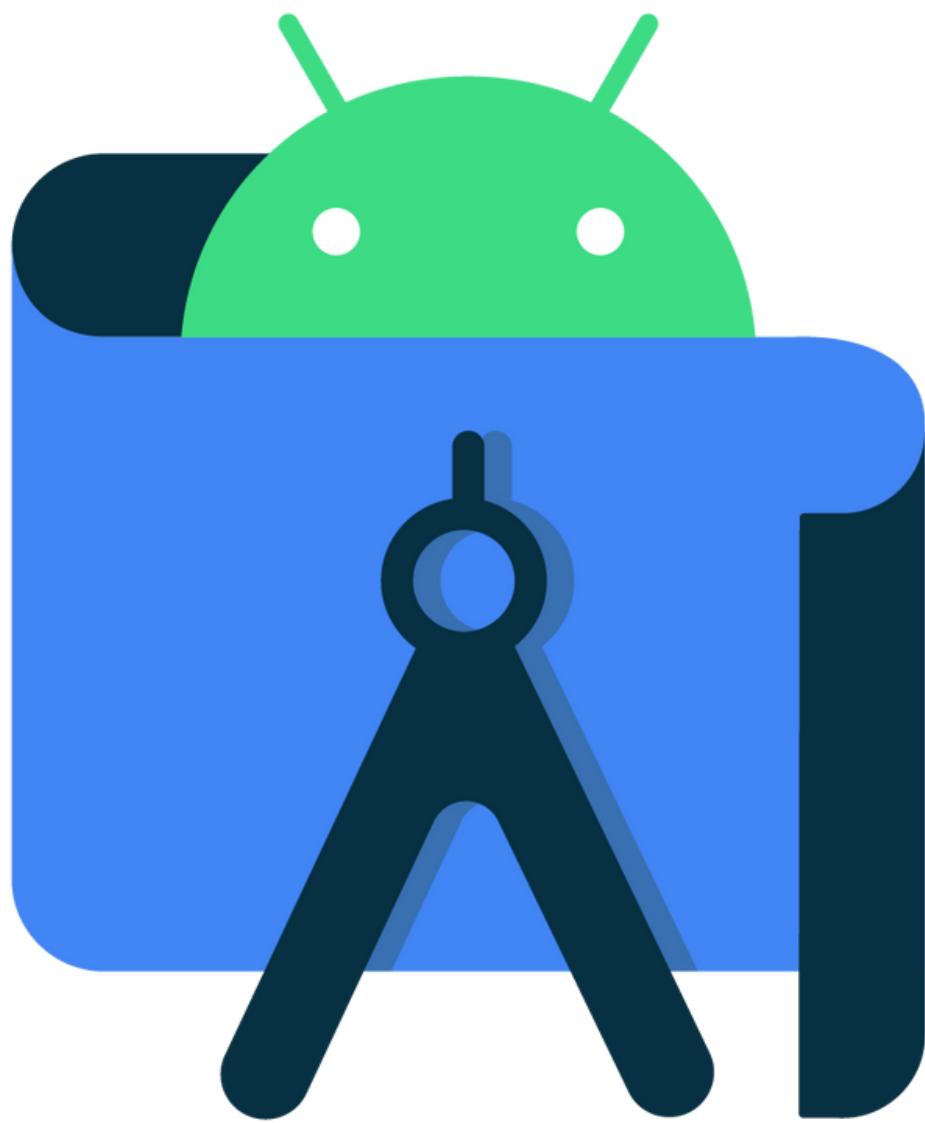
Software



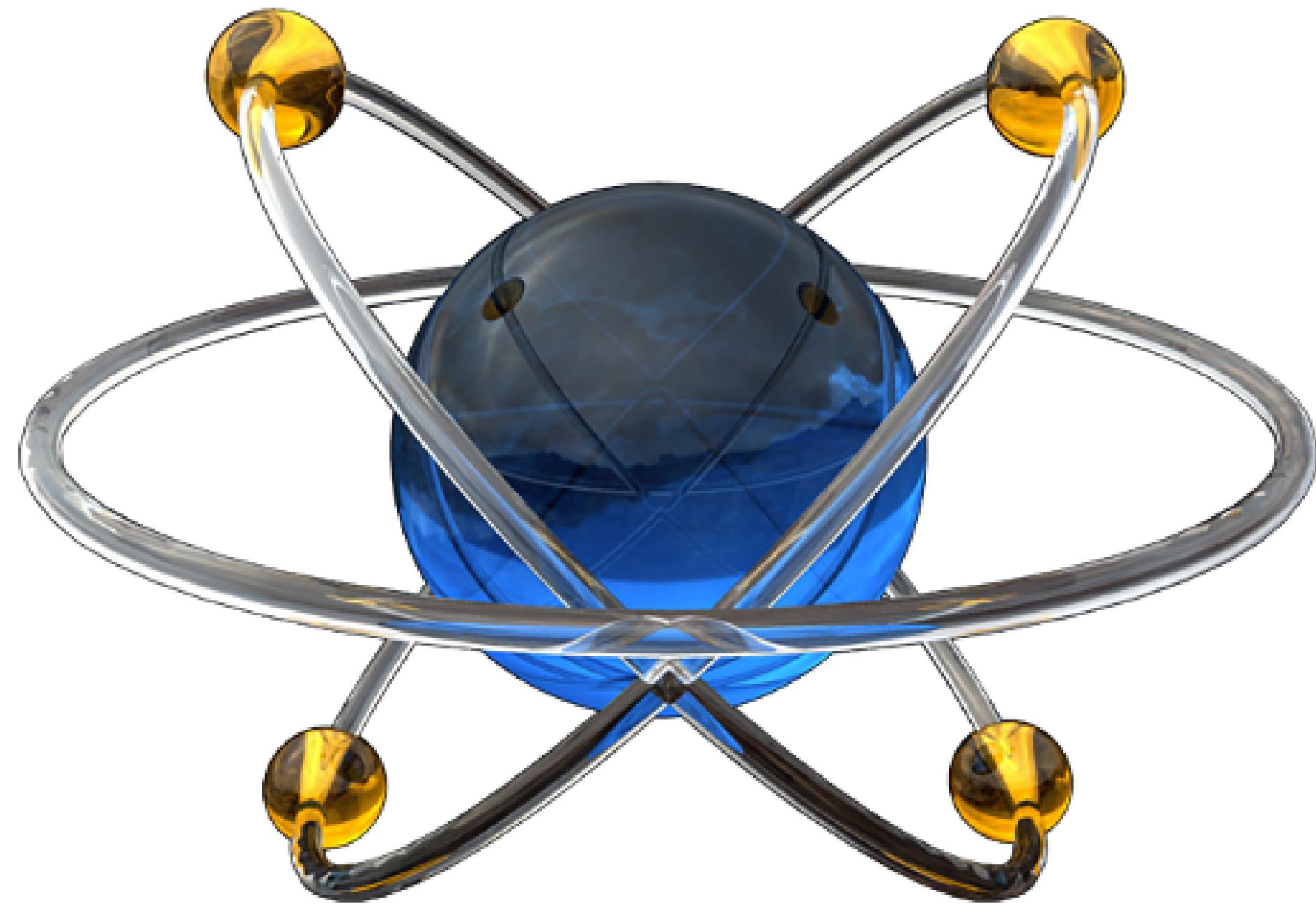
Software



Software



Software

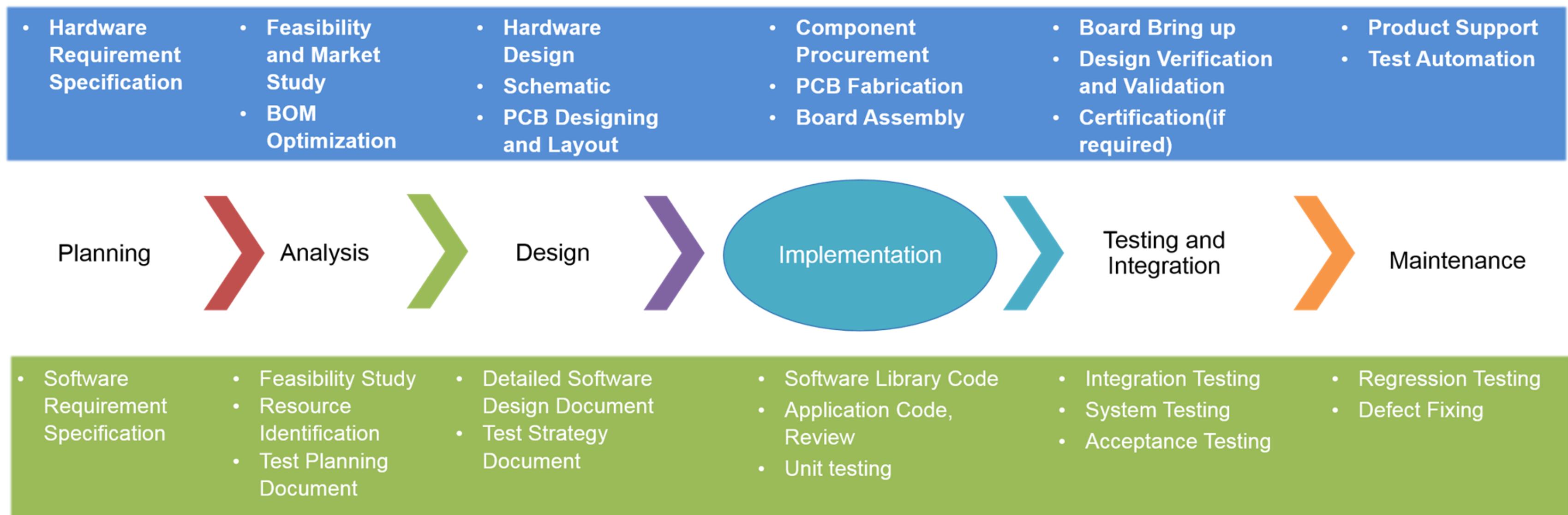


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Embedded Software Design

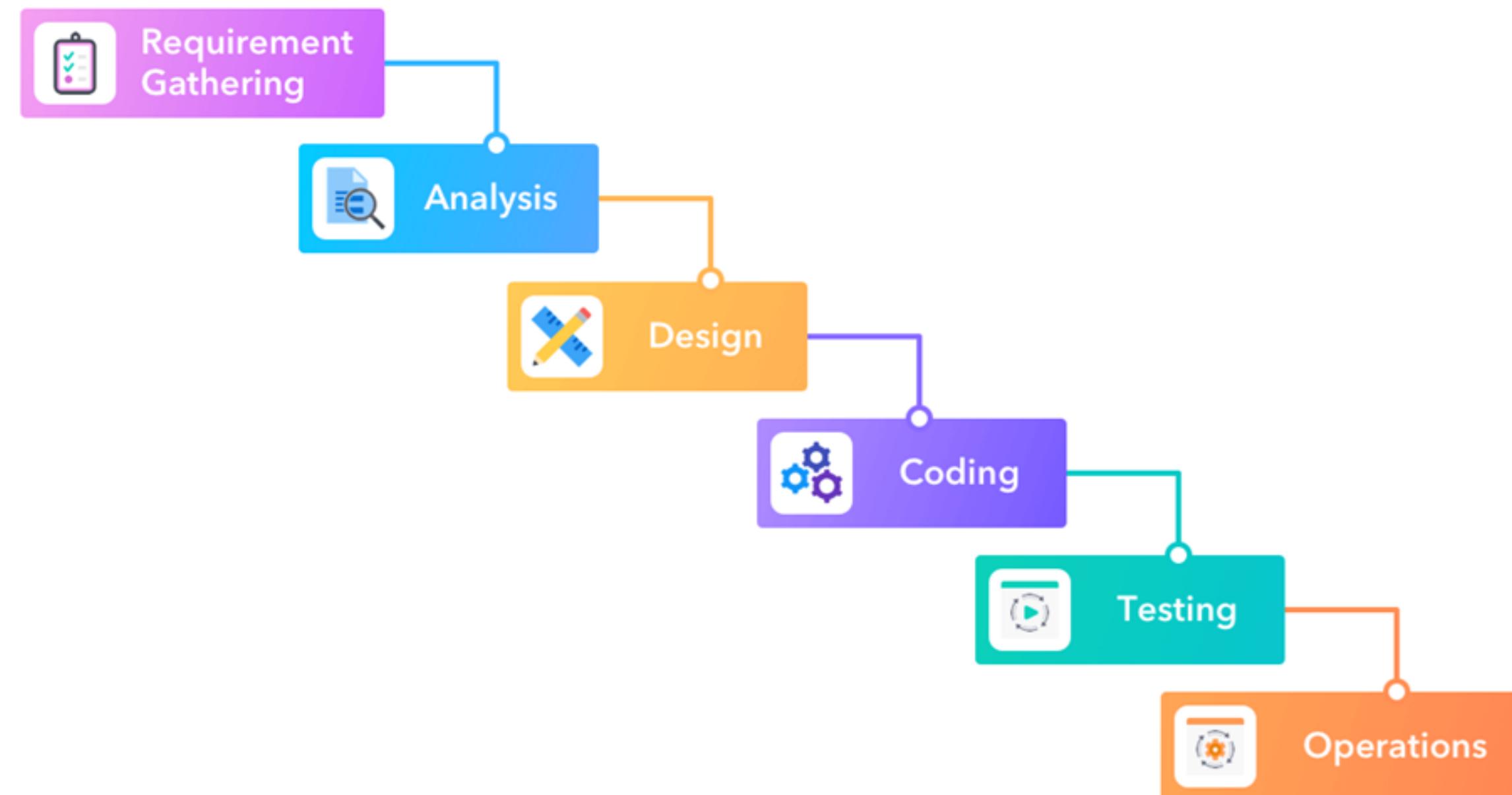
Embedded Software Design

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.



Software Development Life Cycle

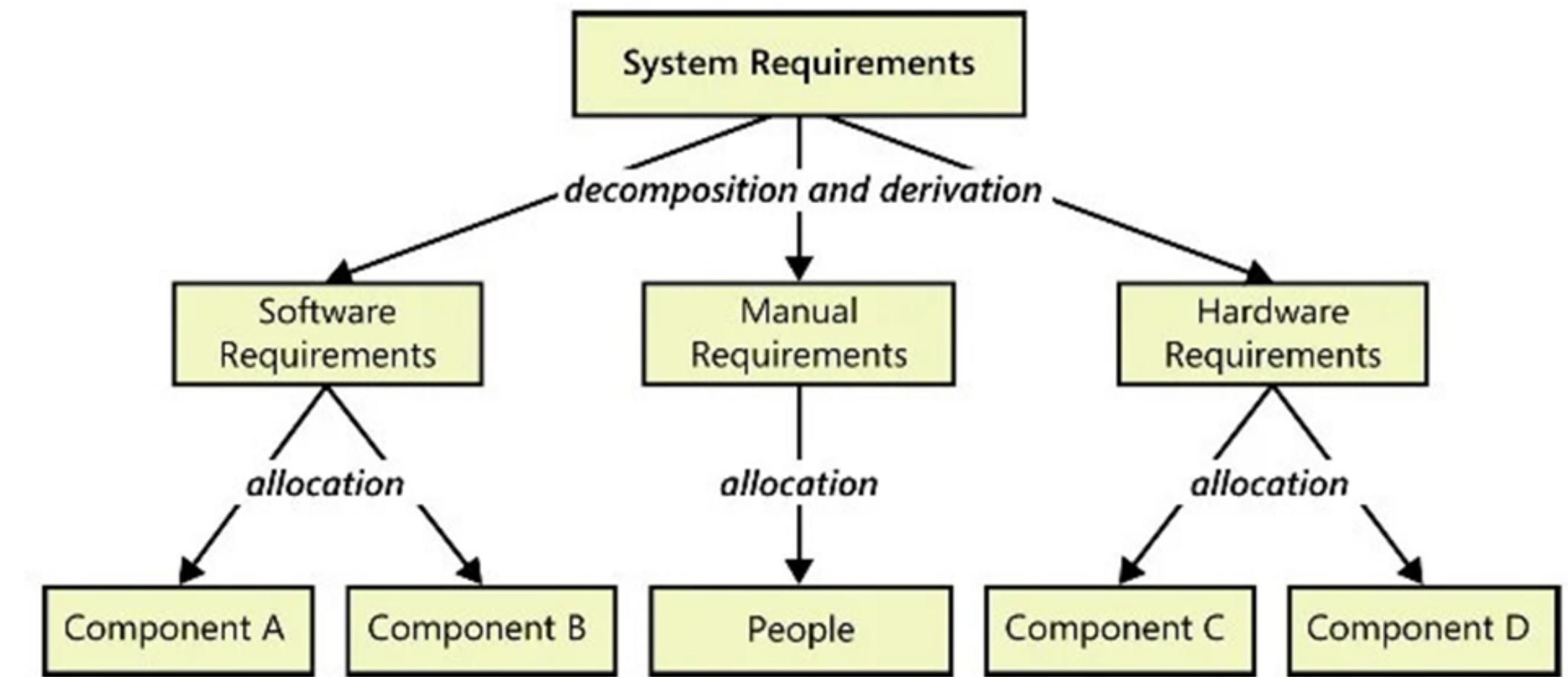
- Waterfall Model – Design



System Requirement Specification (SRS)

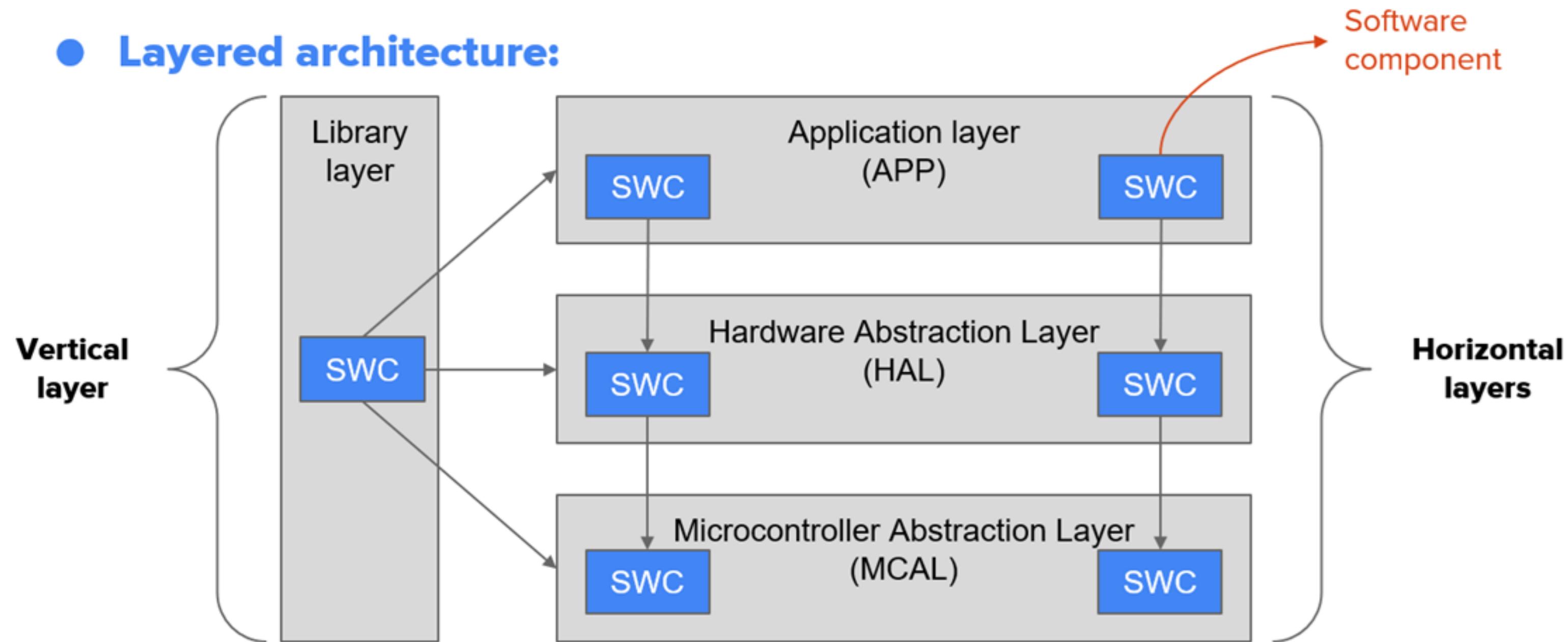
Creating a good system requirement specification (SRS) is important for the success of any project.

1. Define the purpose and Objectives
2. Identify the stakeholders
3. Specify the hardware requirements
4. Specify the functional requirements
5. Specify the non-functional requirements
6. Specify the security Requirements
7. Define the system architecture
8. User Scenarios
9. System Testing
10. Review and Validation

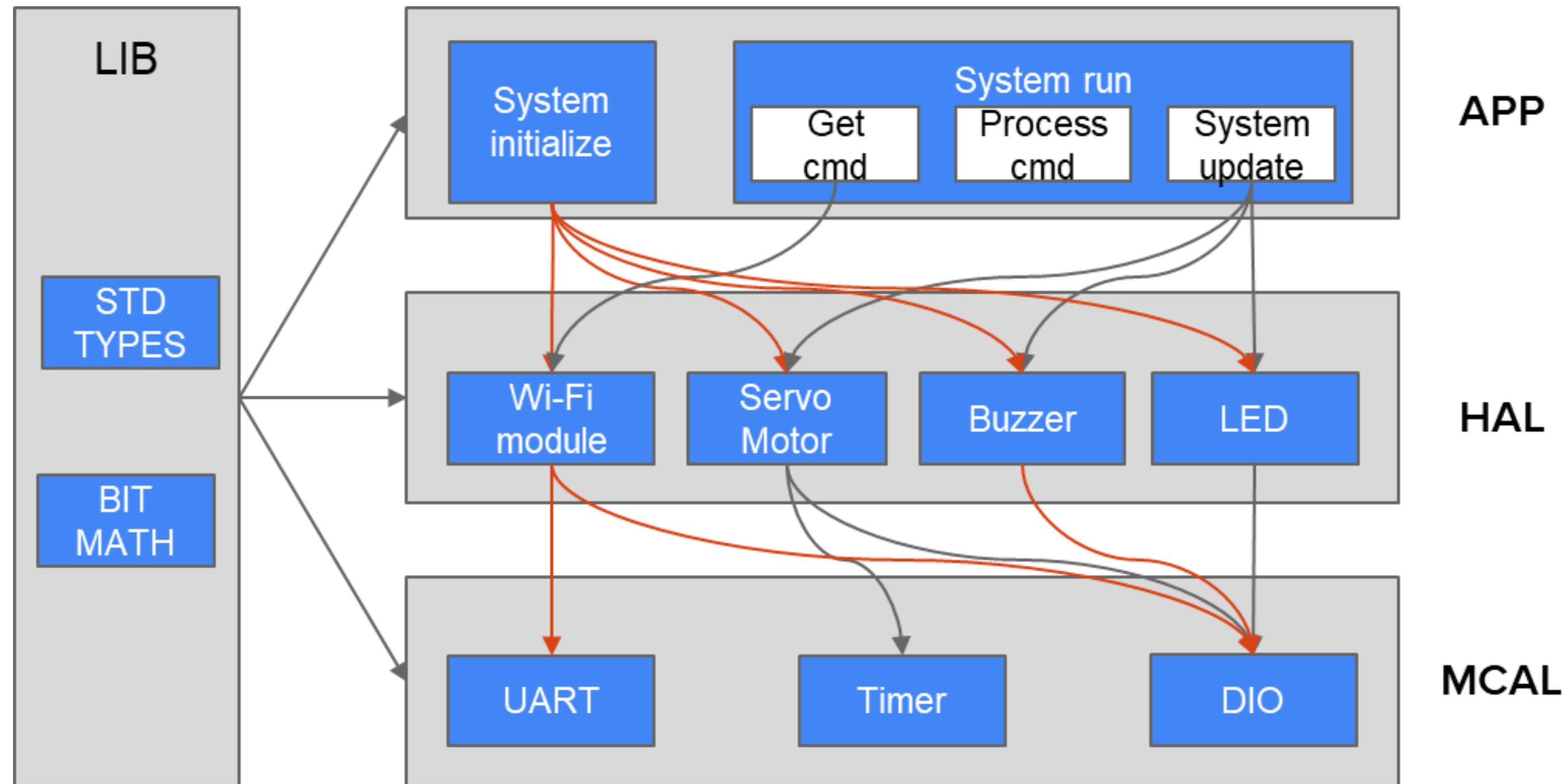


Layered Architecture in Embedded Systems

- **Layered architecture:**



Layered Architecture in Embedded Systems



Module Structure

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

Every module contains 6 files:

- 1- MODULE_interface.h**
- 2- MODULE_config.h**
- 3- MODULE_program.c**
- 4- MODULE_register.h**
- 5- MODULE_private.h**
- 6- MODULE_test.c**



System Design

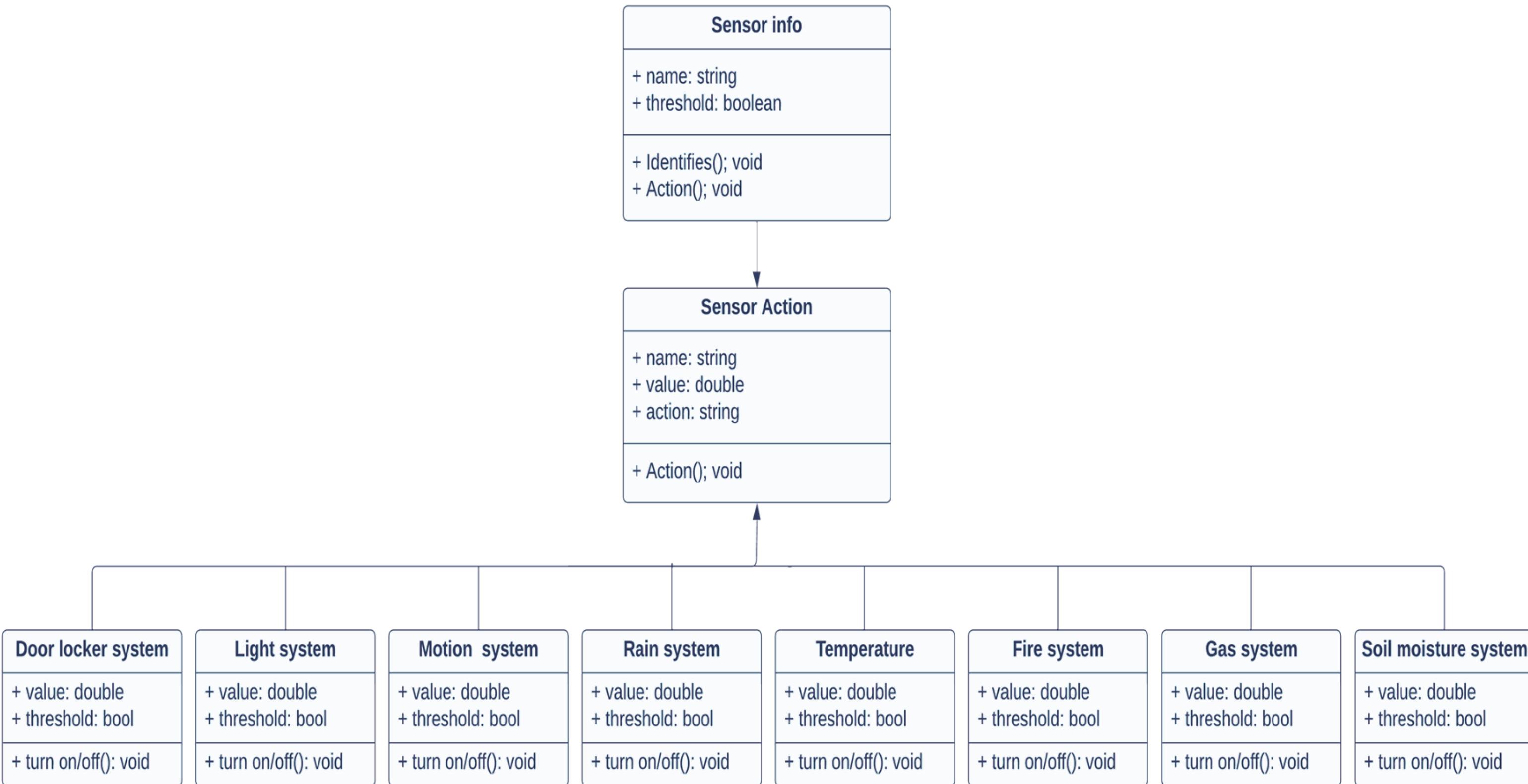
UML Diagrams

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

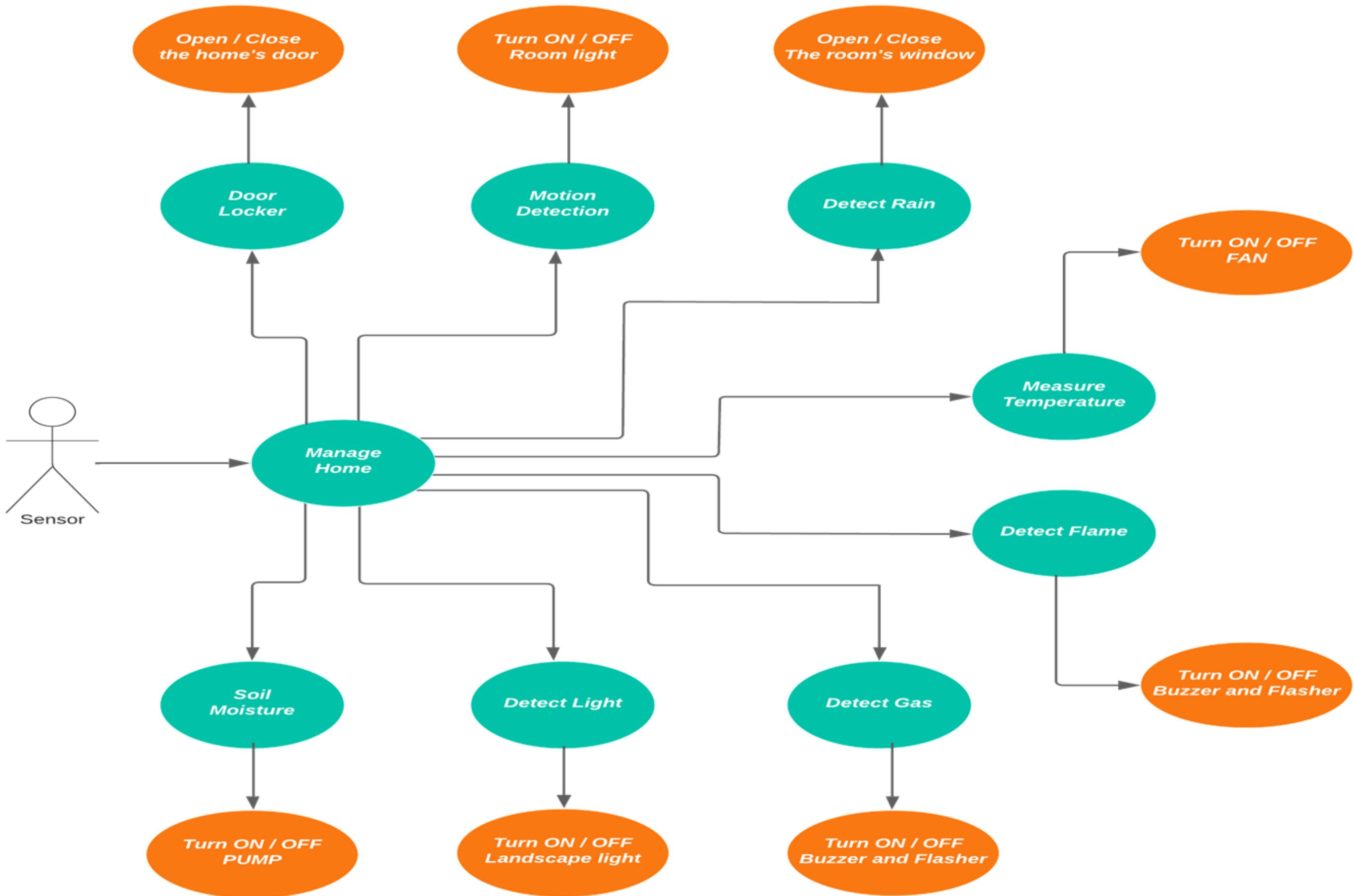
UNIFIED
MODELING
LANGUAGE™



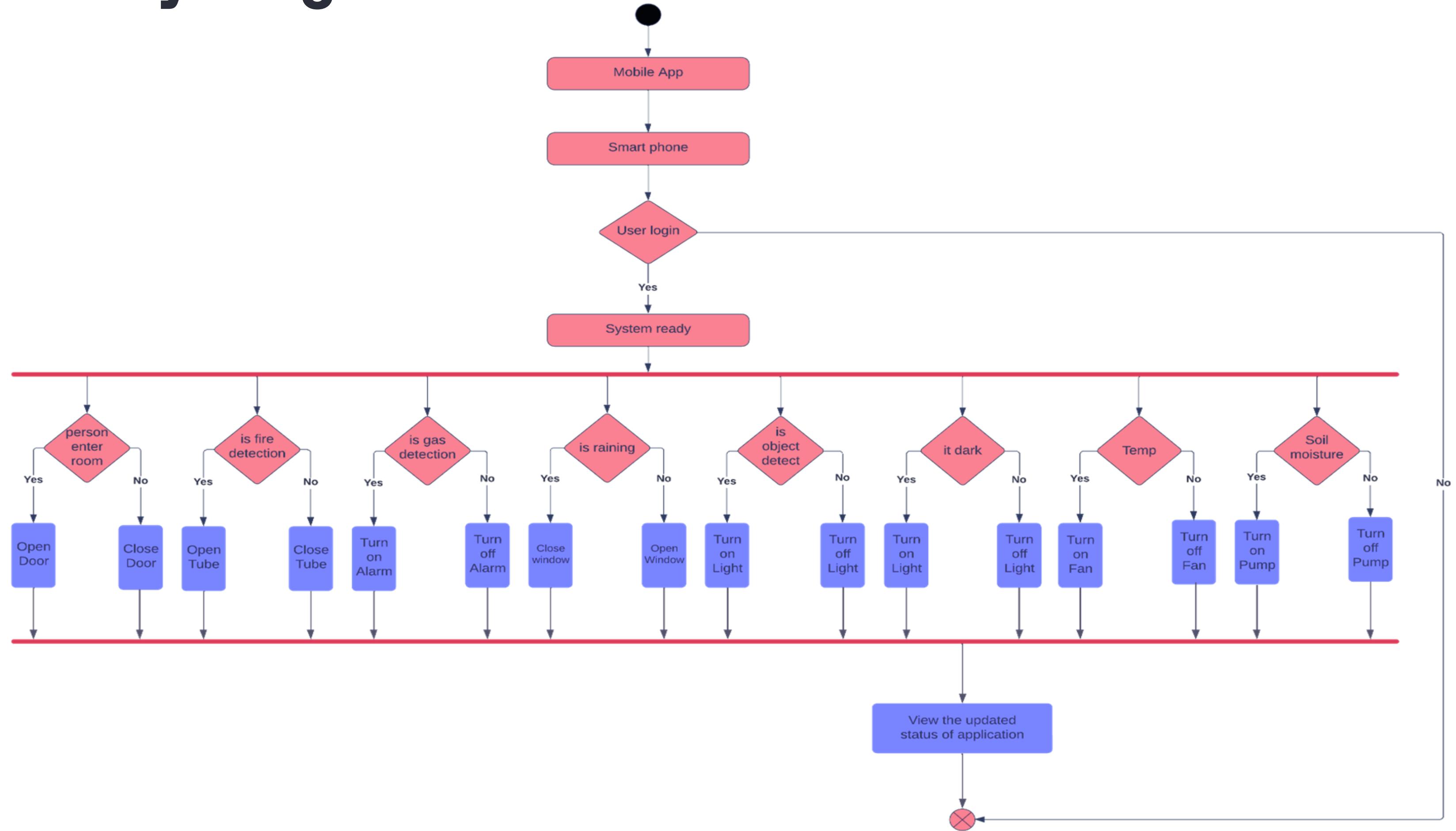
Class Diagram



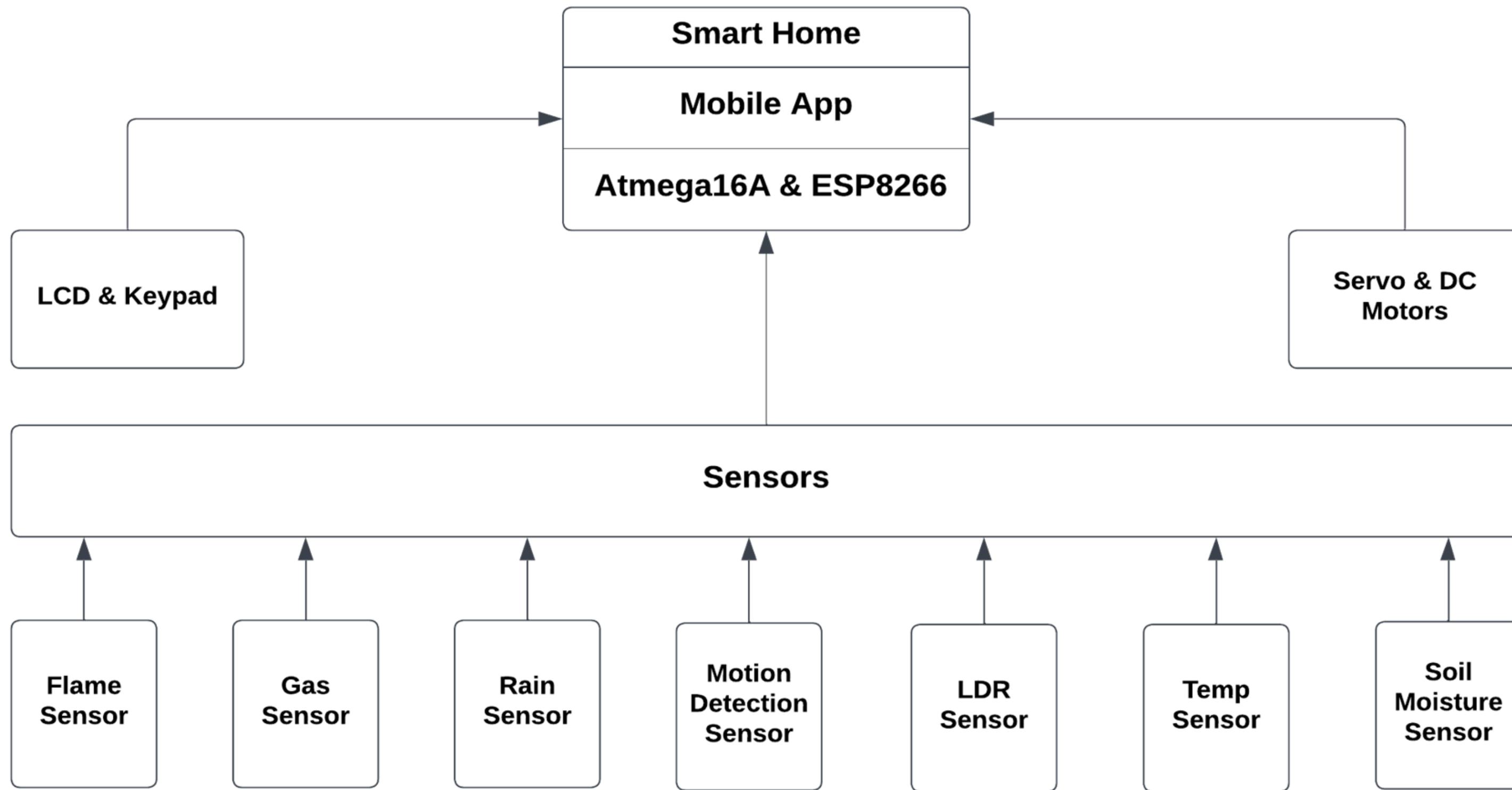
Use case Diagram



Activity Diagram



Block Diagram





Hardware Implementation

ATMEGA16

Prand: Atmel

Type: ATmega16-16PU

Data Bus Width: 8 bit

Maximum Clock Frequency: 16Mhz

Program Memory Size: 16KB

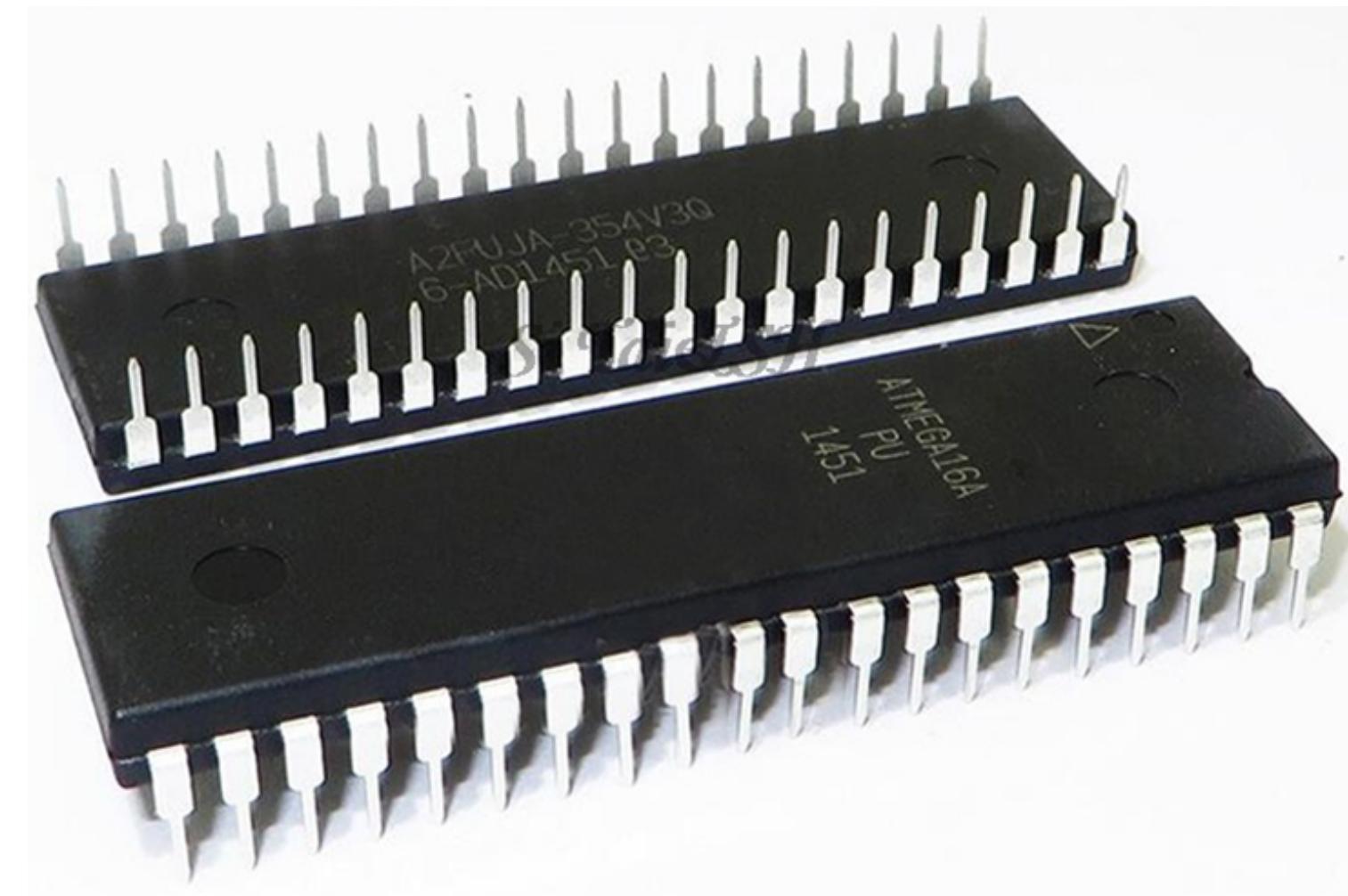
Data RAM Size: 1KB

Operating Supply Voltage: 4.5 to 5.5 v

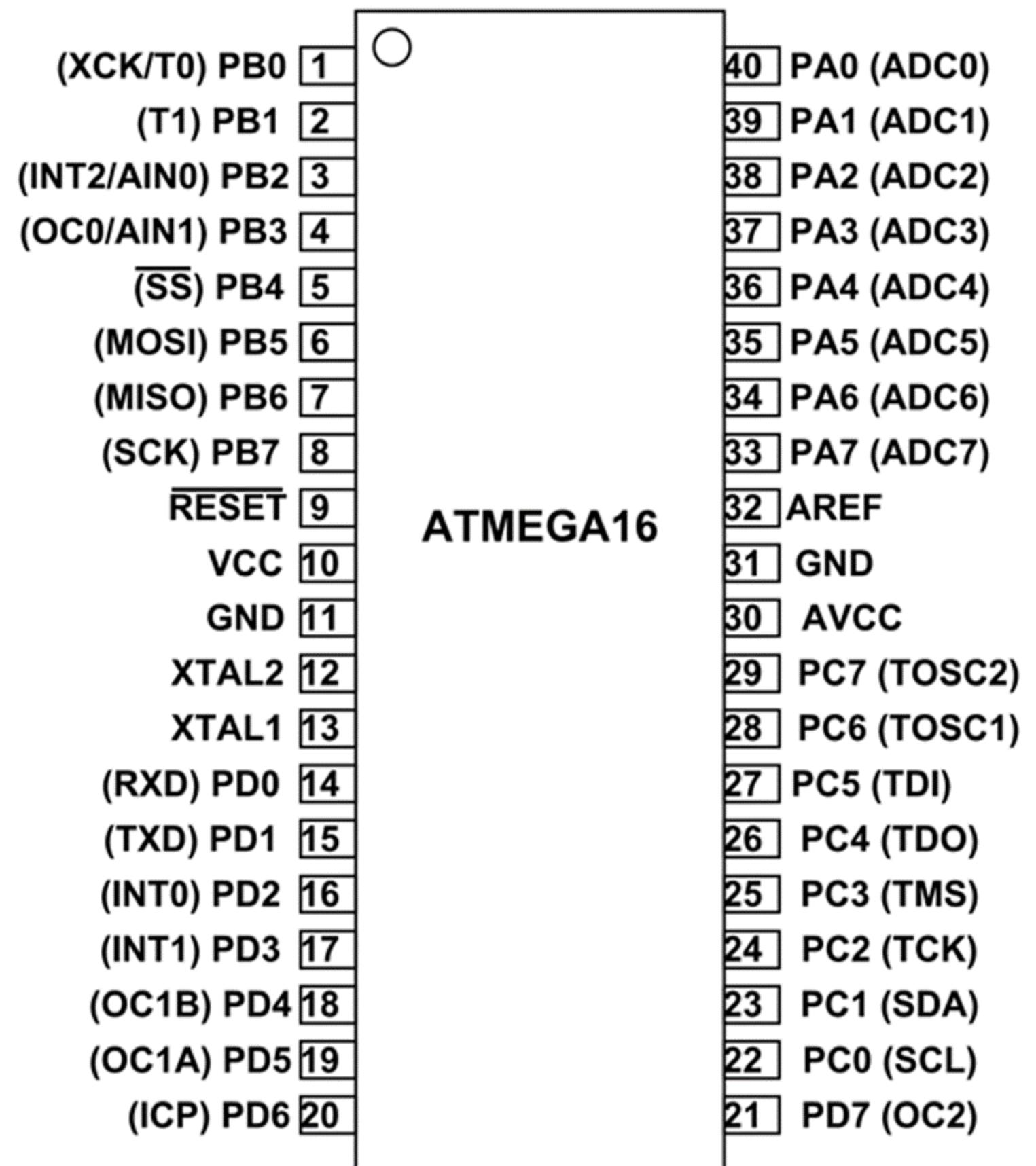
Number of Programmable I/Os: 32

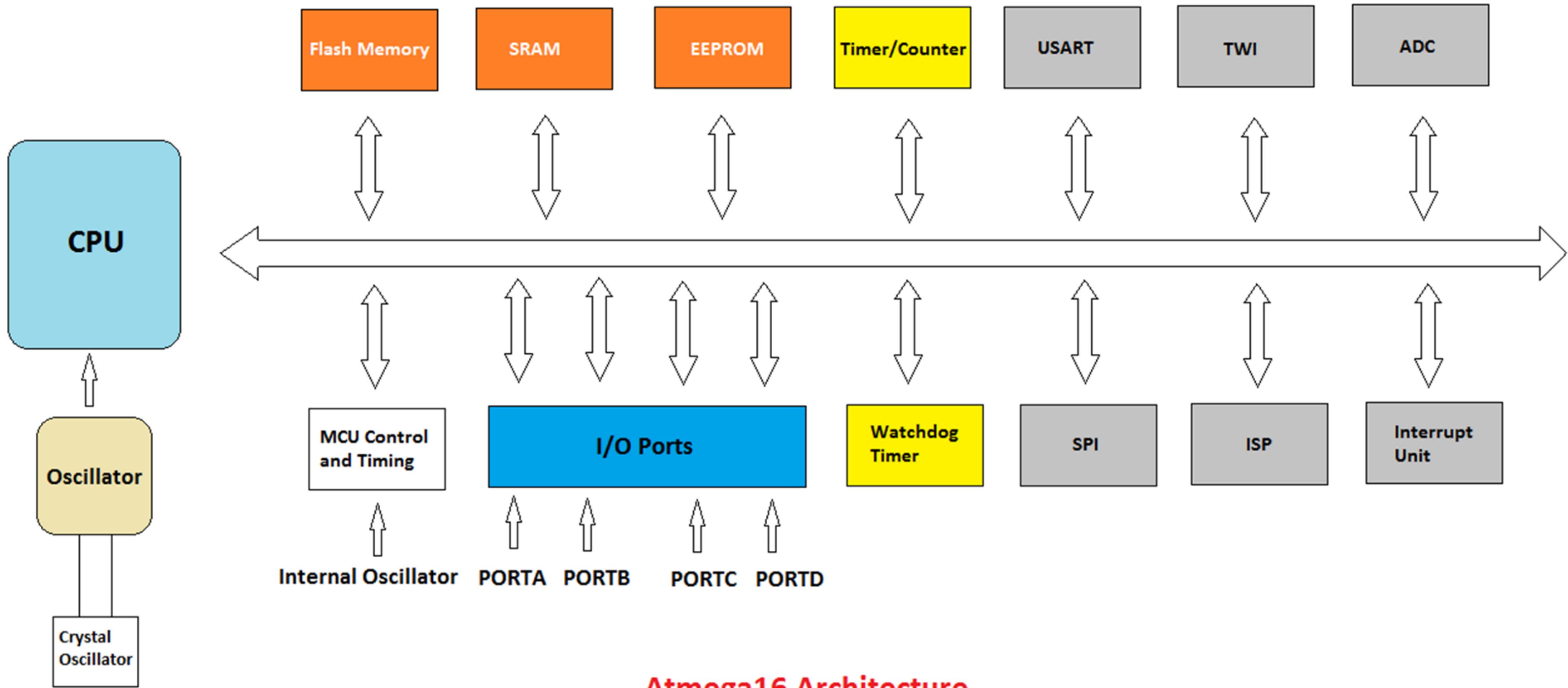
Number of Timers: 3

Peripherals :- GPIO, Interrupts, EEPROM, ADC, Timers/Counters, PWM, USART, SPI and I2C



Pin Diagram of ATmega16 Microcontroller





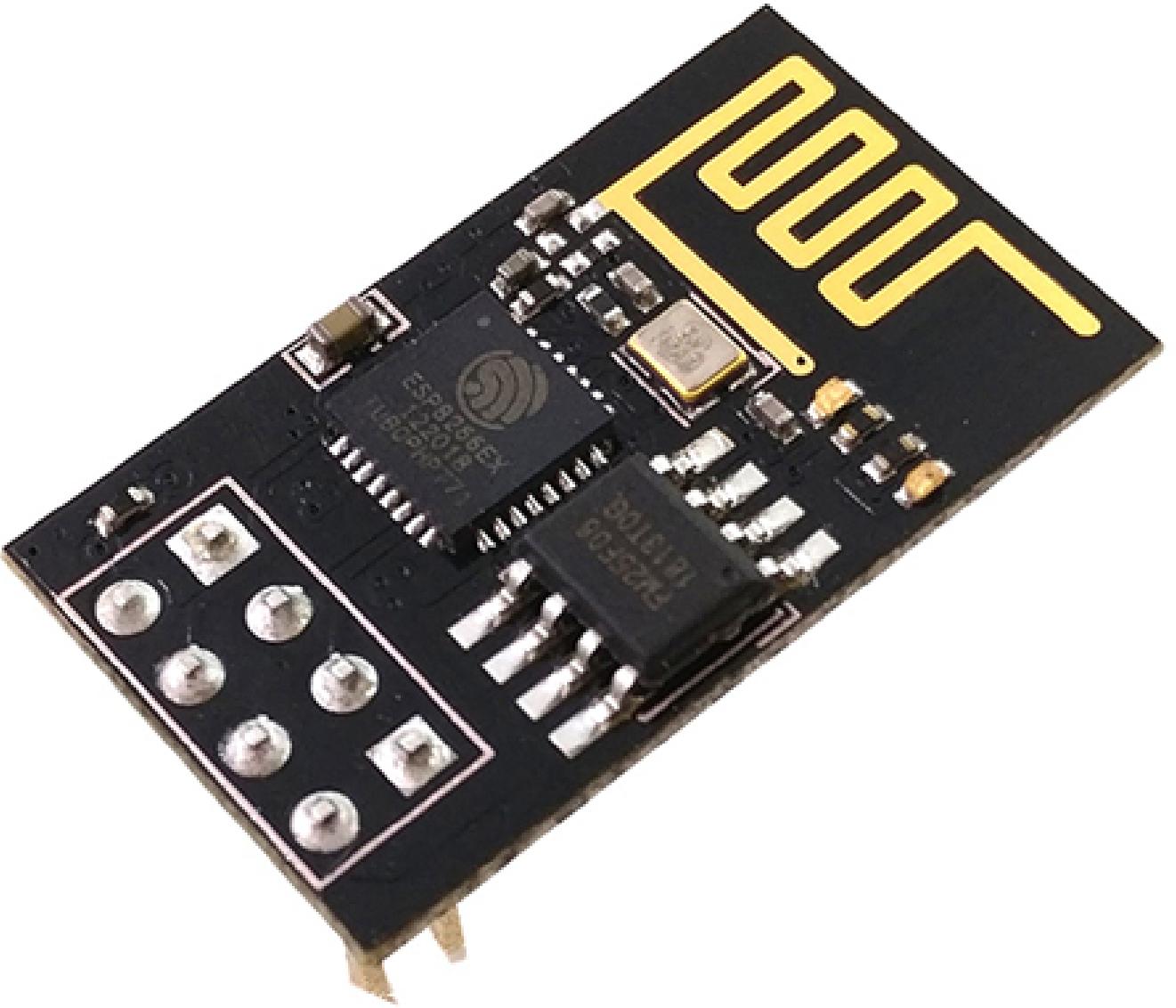
Atmega16 Architecture

ESP8266 Wi-Fi Module

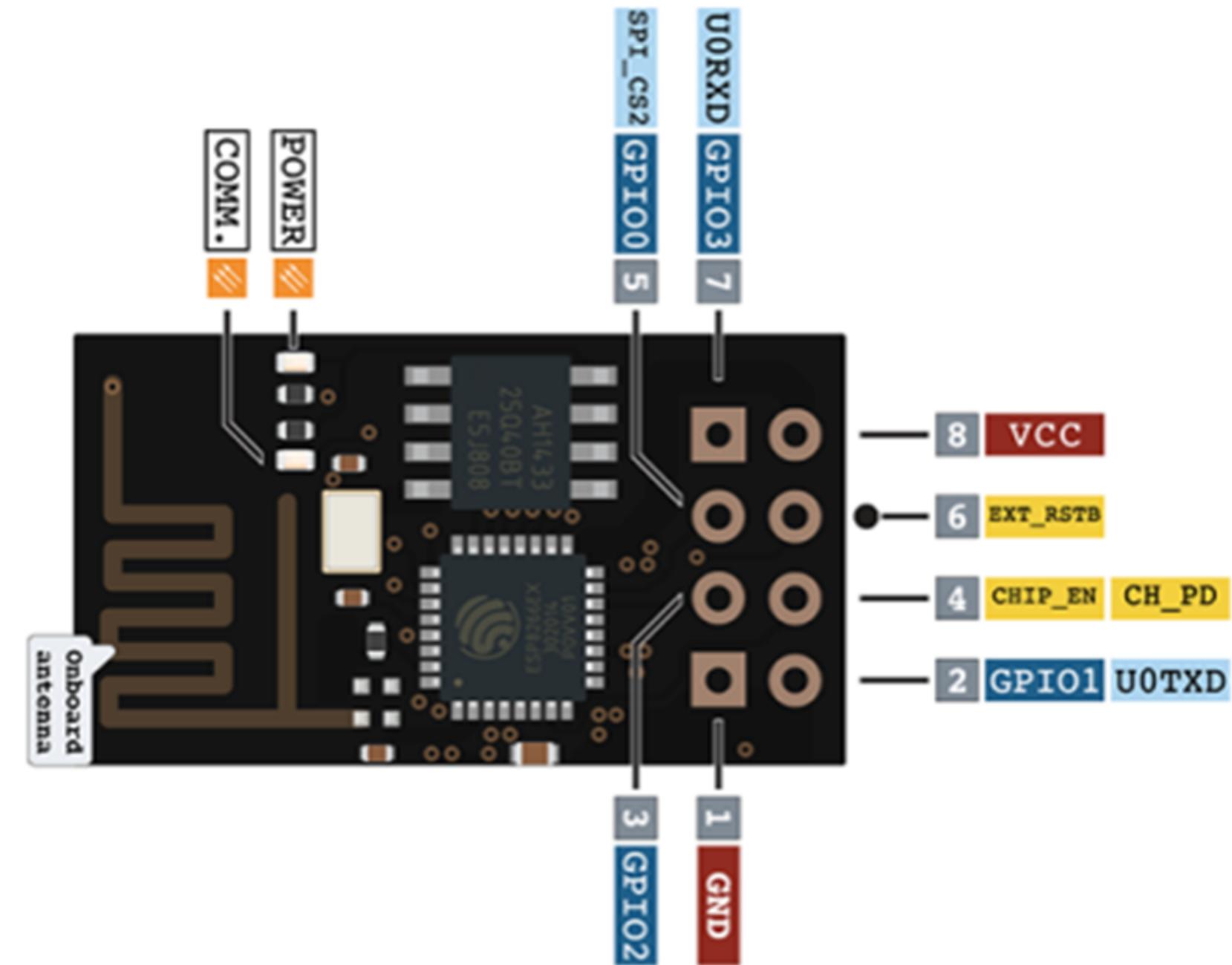
- ESP8266 is Wi-Fi enabled system on chip (SoC) module developed by Espressif system.

ESP8266 comes with capabilities of

- 2.4 GHz Wi-Fi
- general-purpose input/output (16 GPIO)
- Inter-Integrated Circuit (I^2C)
- analog-to-digital conversion
- Serial Peripheral Interface (SPI)
- I²S interfaces with DMA(Direct Memory Access)
- UART
- pulse-width modulation (PWM).

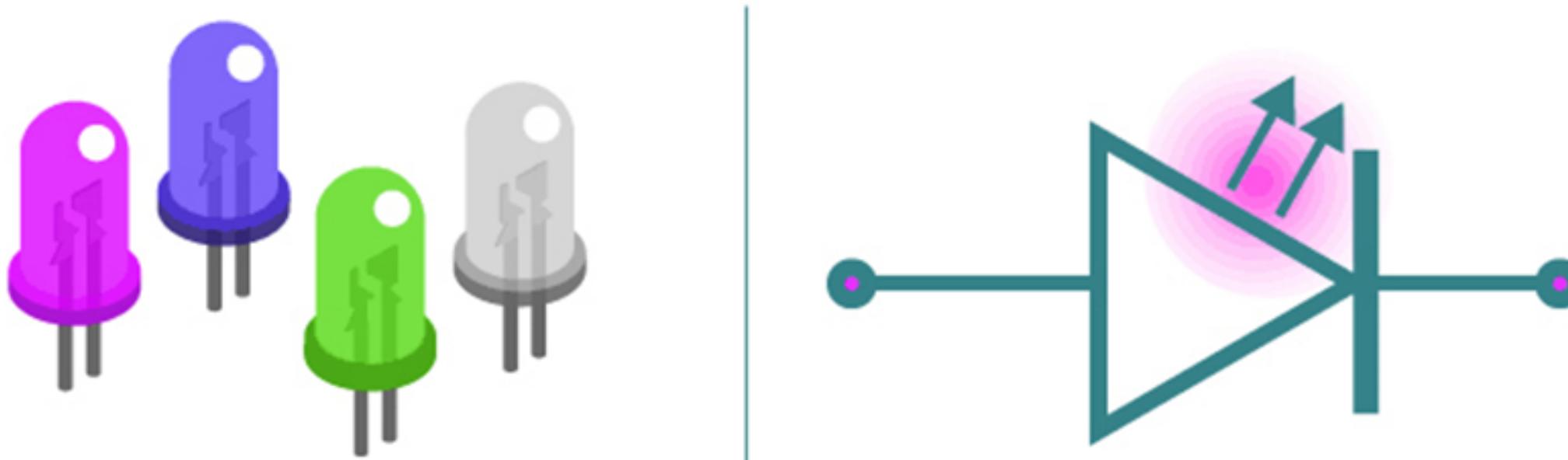


ESP8266 Interfacing



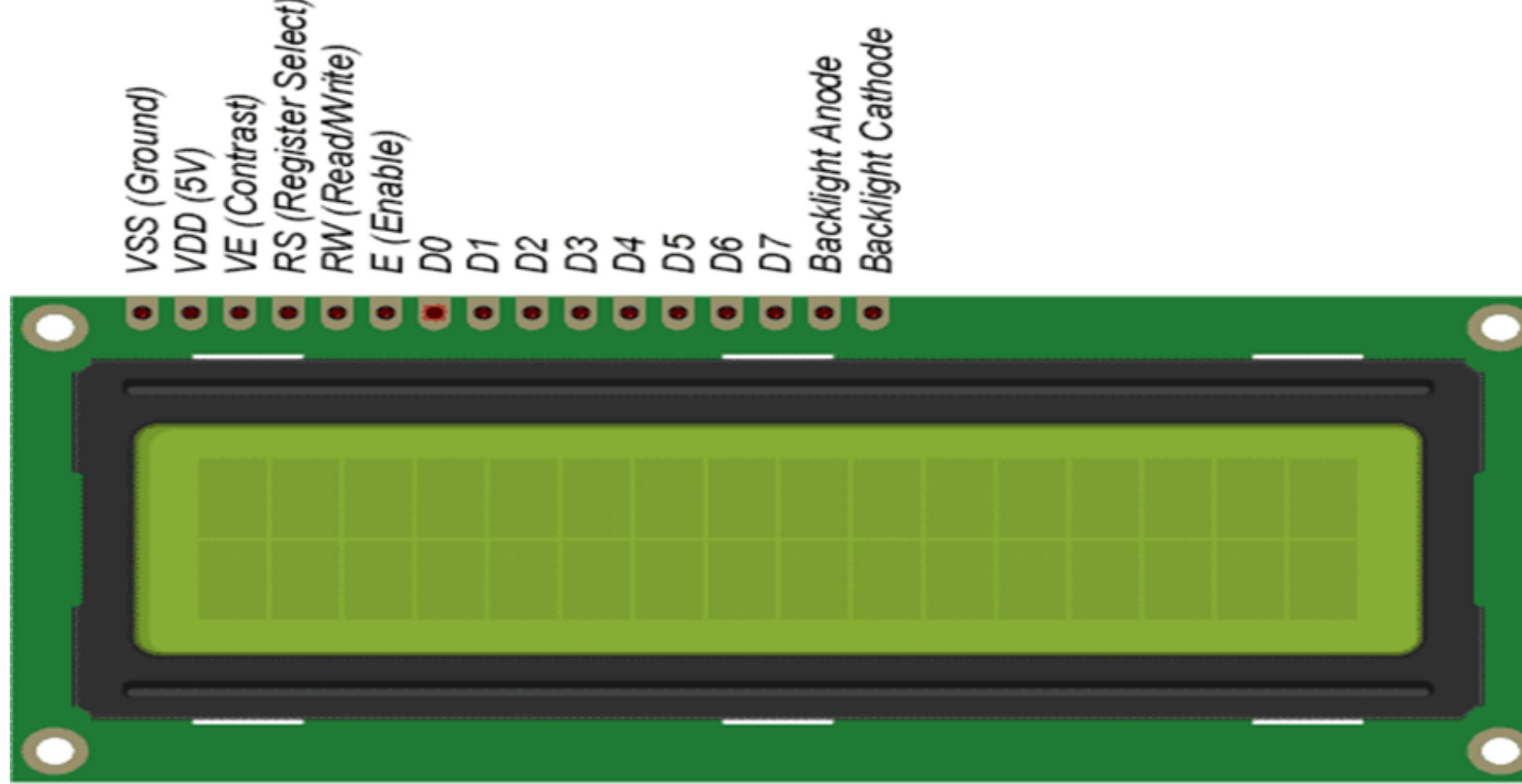
LED

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.

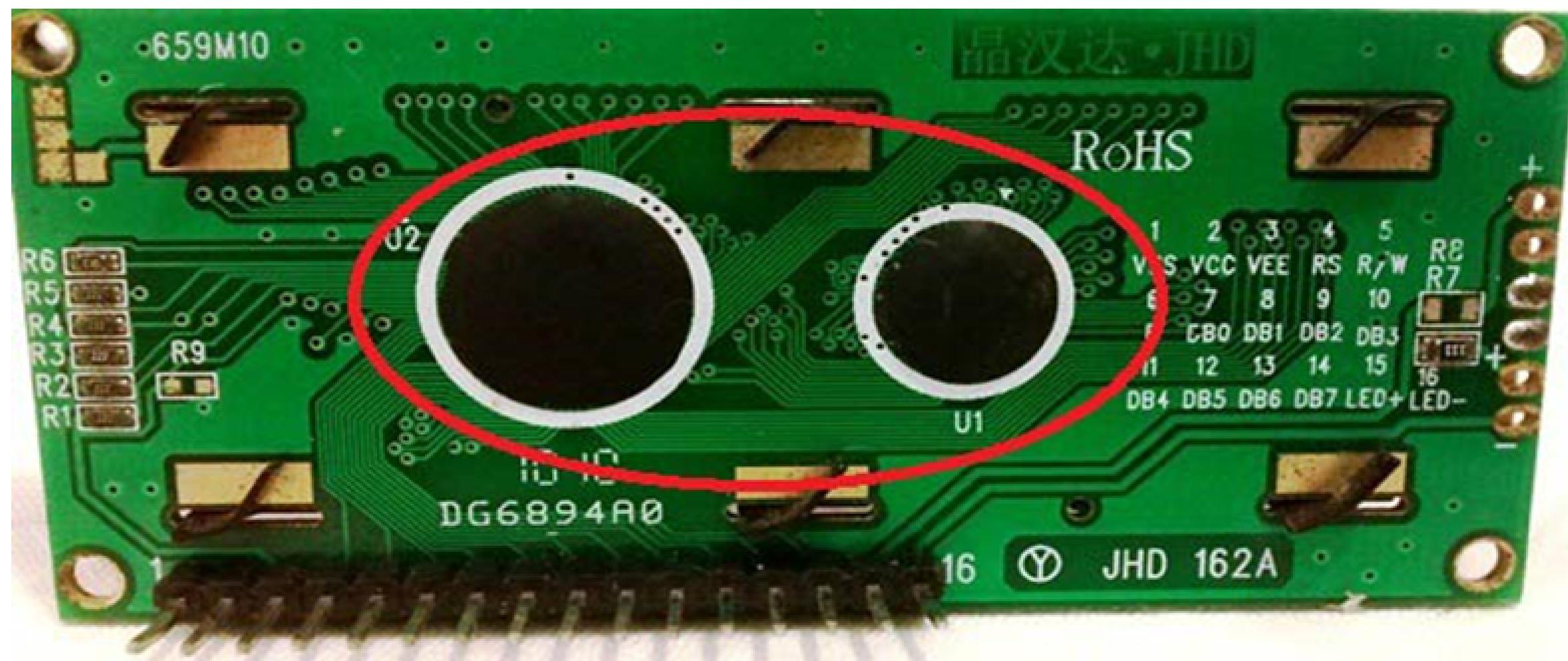


LCD 2*16

An LCD is an electronic display module which uses liquidcrystal to producea visible image. The 16x2 LCD displayis a very basic module commonly used in DIYs and circuits. The 16x2 translates a display 16 characters per line in 2 such lines.

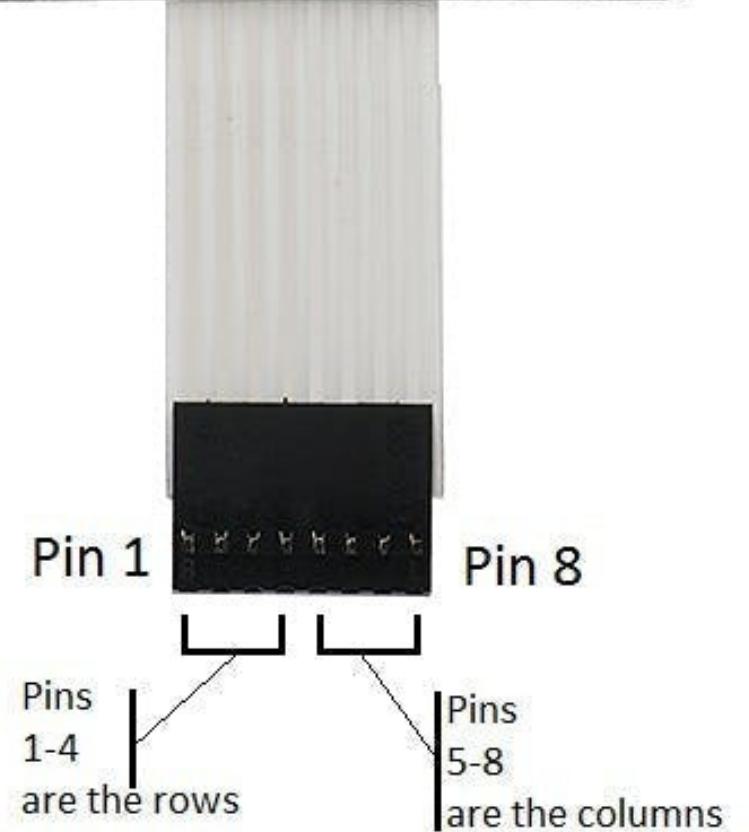


LCD 2*16

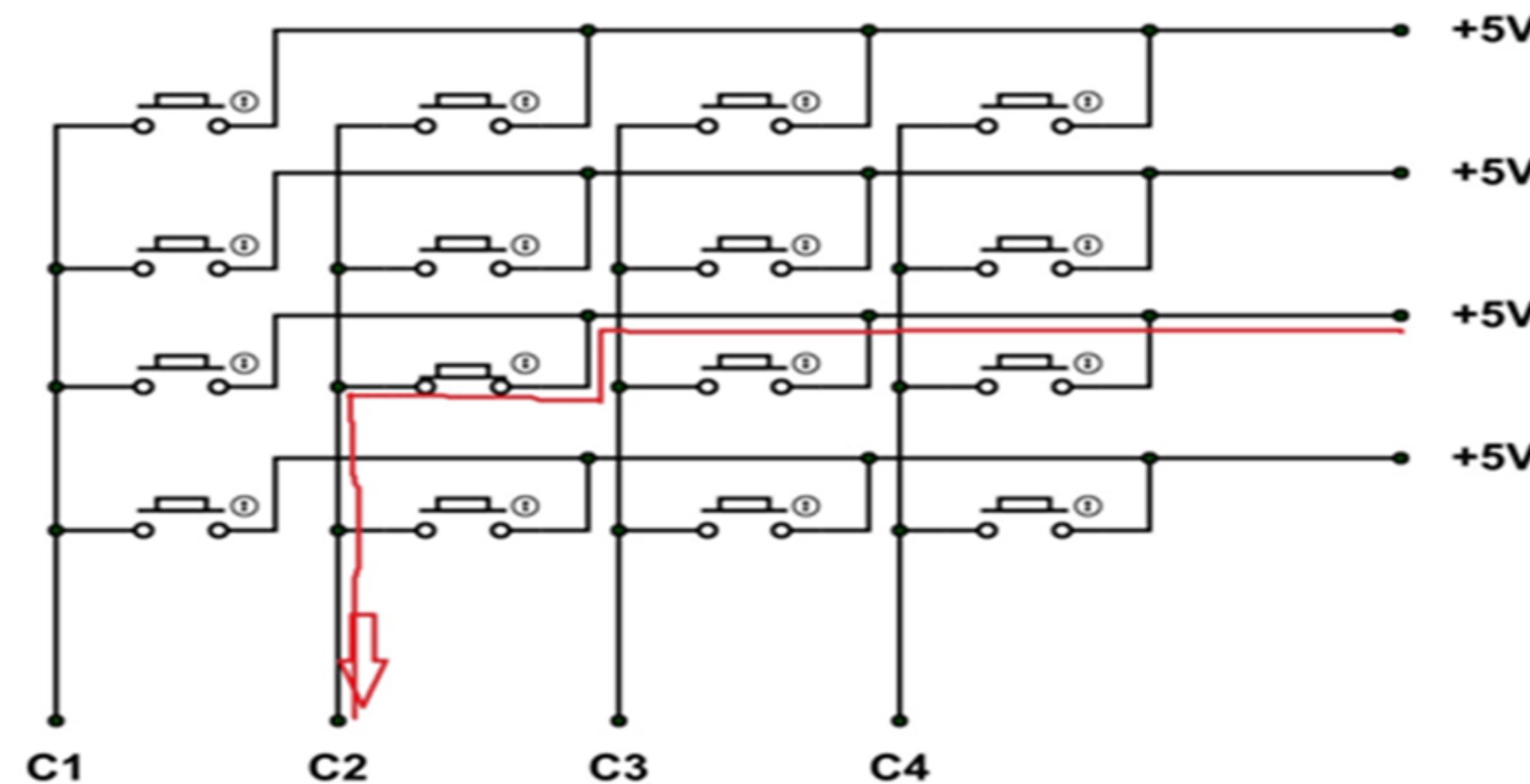


Keypad

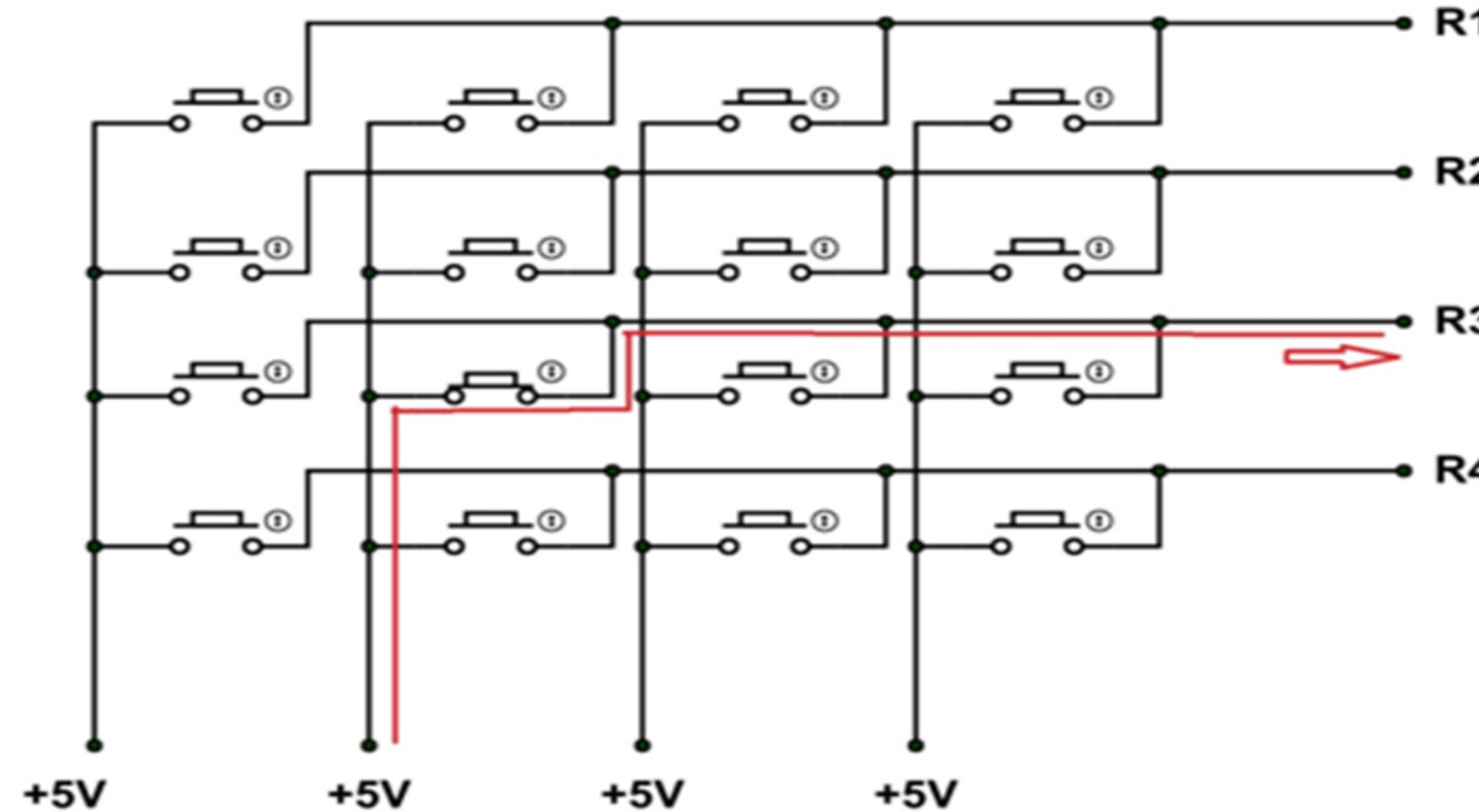
The keypad component contains a set of library routines that enable scan of 4*4 switch array and return the data associated with the switch pressed the component provide APIs



Keypad

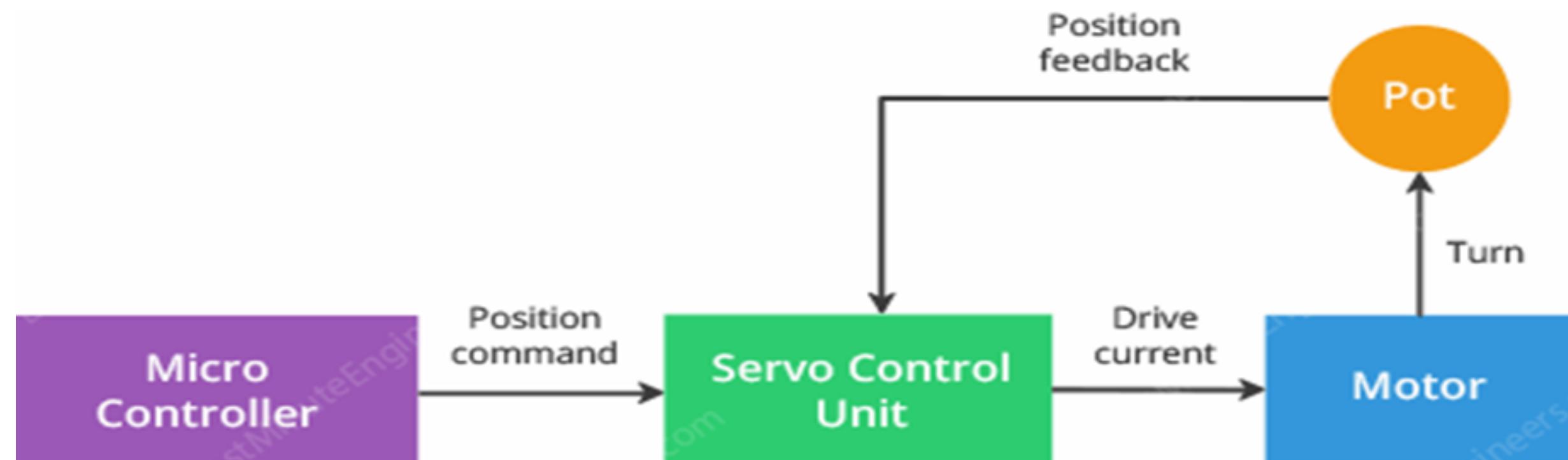


Keypad



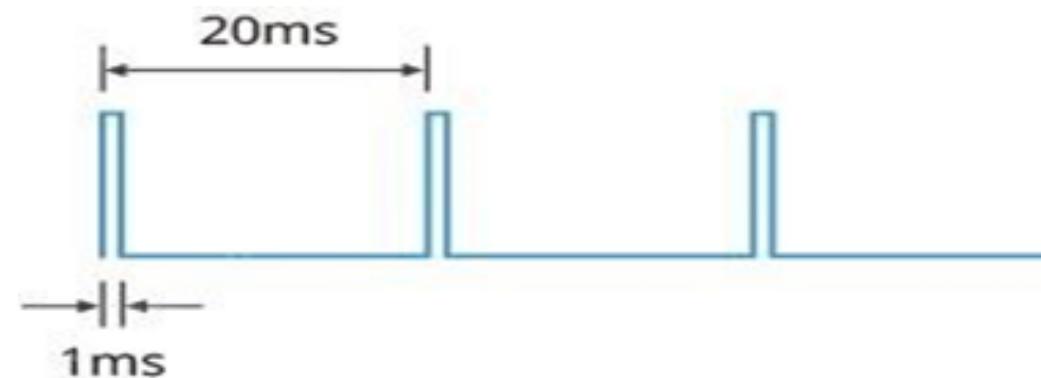
Servo Motor

A closed loop system uses the feedback signal to adjust the speed and direction of the motor to achieve the desired result.

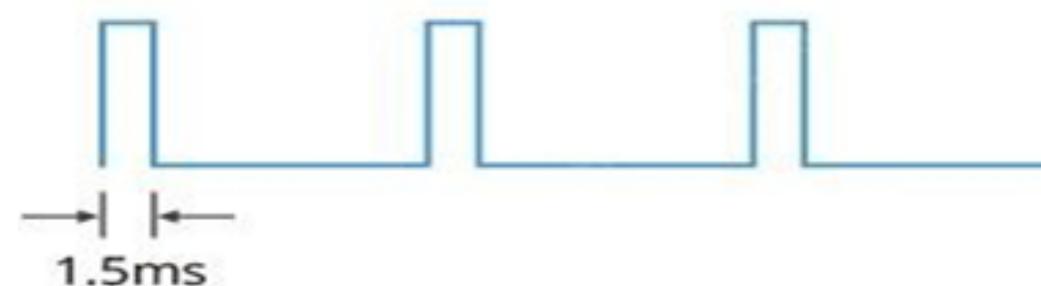


Pulse Shape for Servo Motor

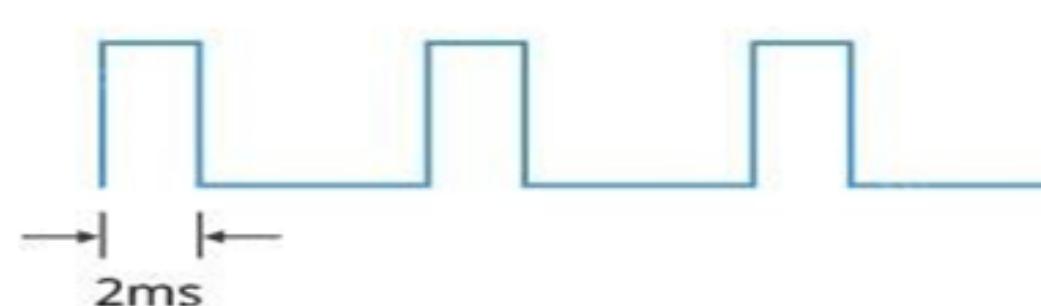
The length of the pulse determines the position of the servo motor.



0 Degrees



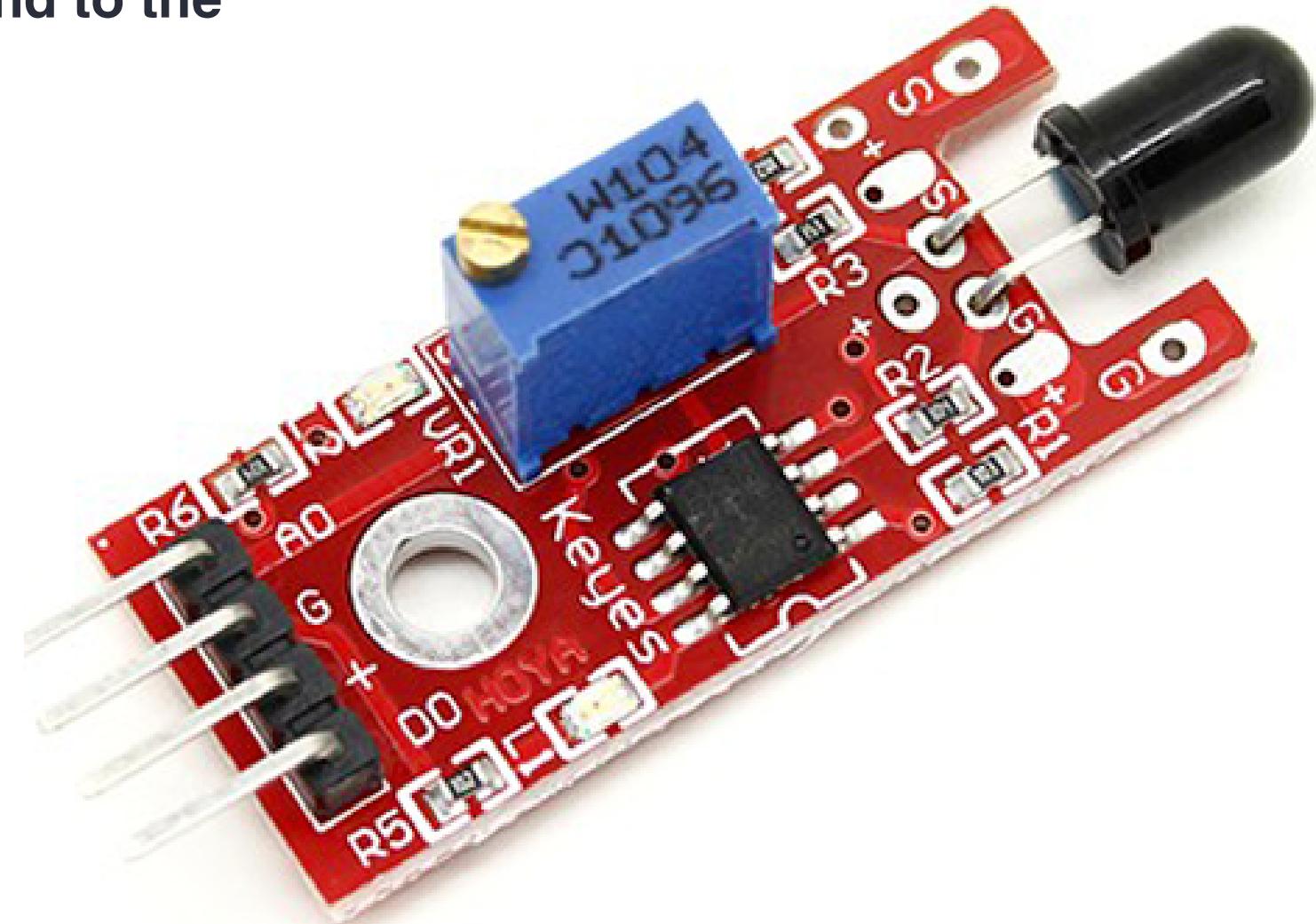
90 Degrees



180 Degrees

Flame Sensor

A flame detector is a sensor designed to detect and respond to the presence of a flame or fire, allowing flame detection.



Gas Sensor

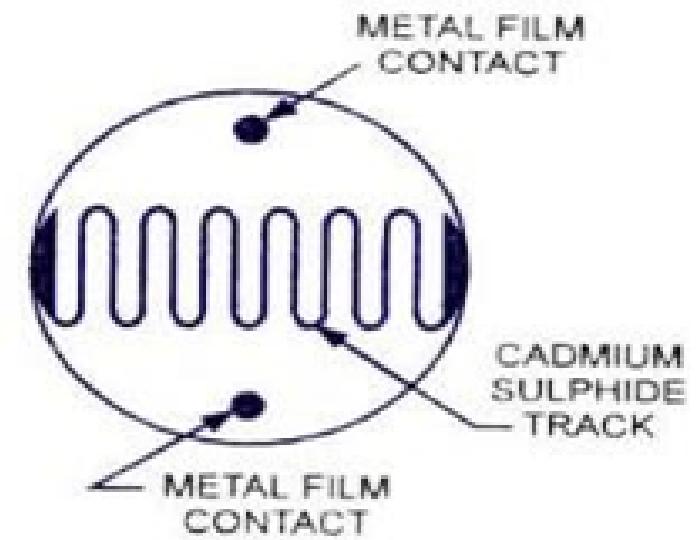
The sensors conductivity is more higher along with the gas concentration rising. The sensor convert change of conductivity to correspond output signal of gas concentration.

MQ-5 gas sensor has high sensitivity to Methane, Propane and Butane, ch4 and natural gas .

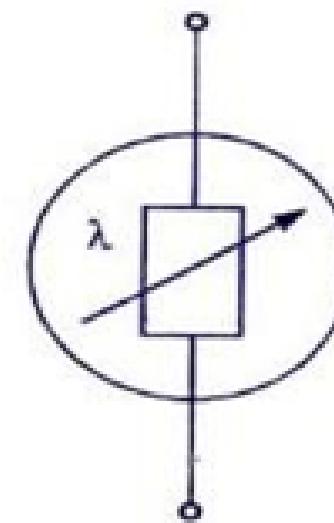


LDR

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation



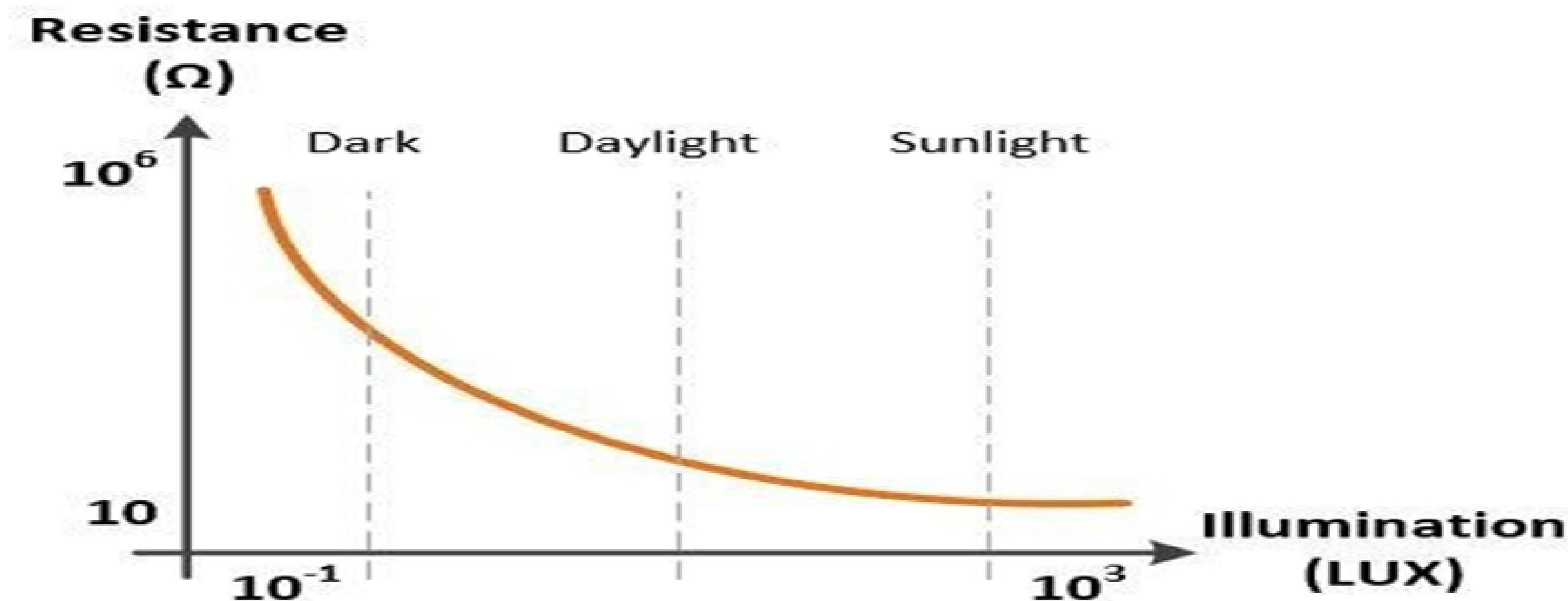
(a) Basic Structure



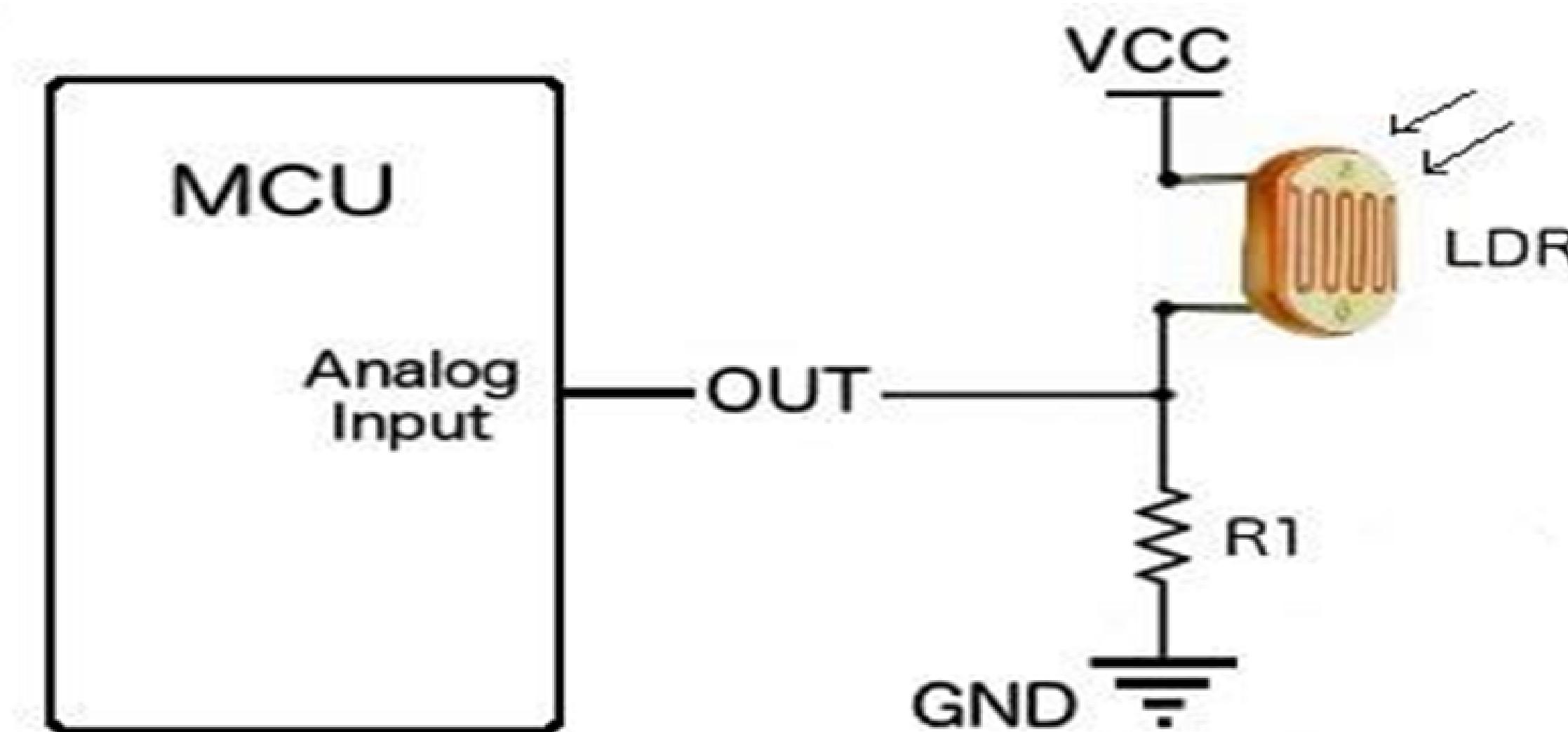
(b) Symbol

LDR

LDR Relation between Resistance and Illumination

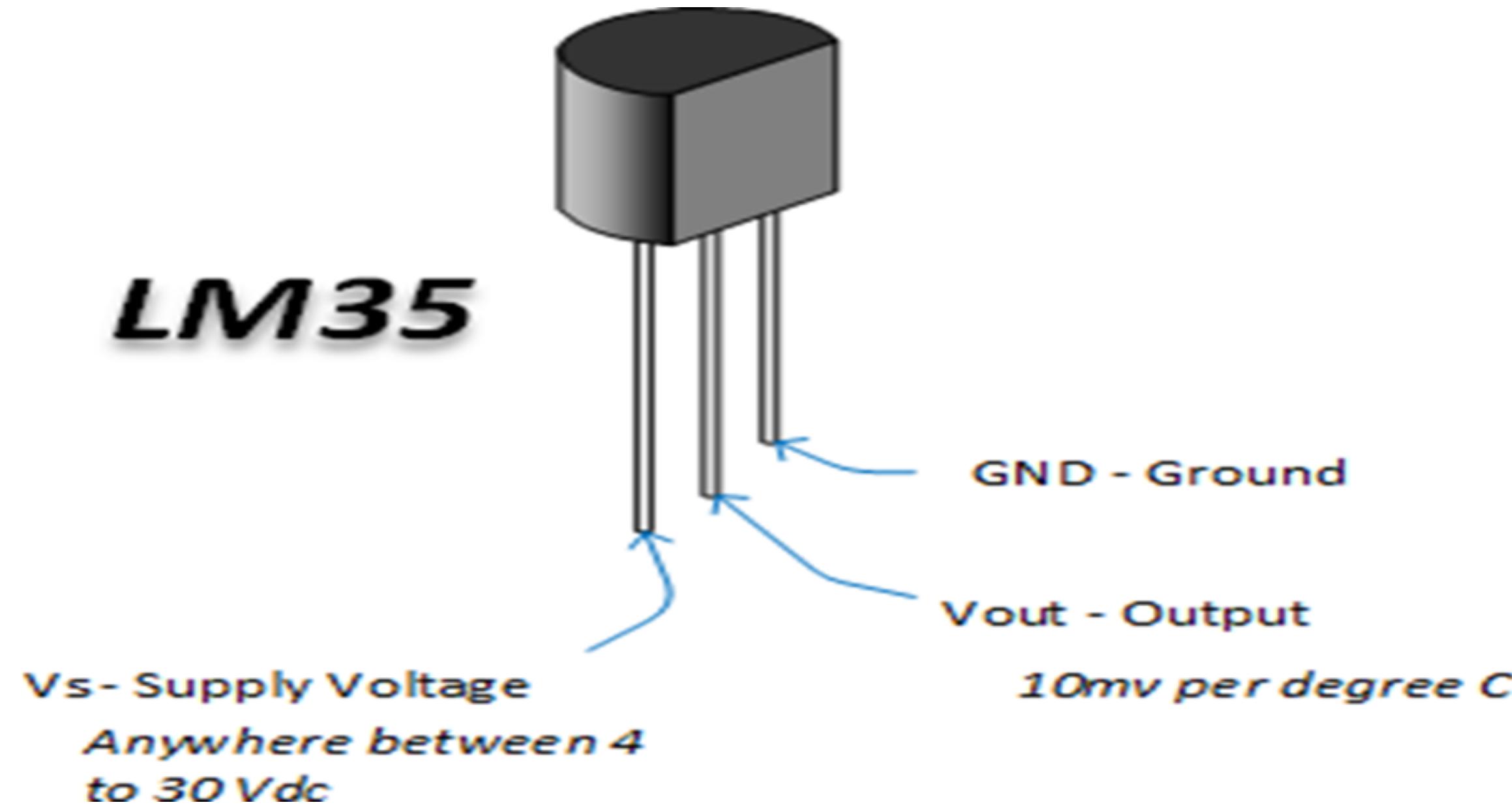


LDR with MCU



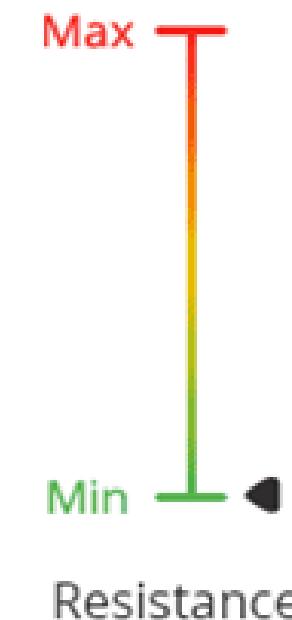
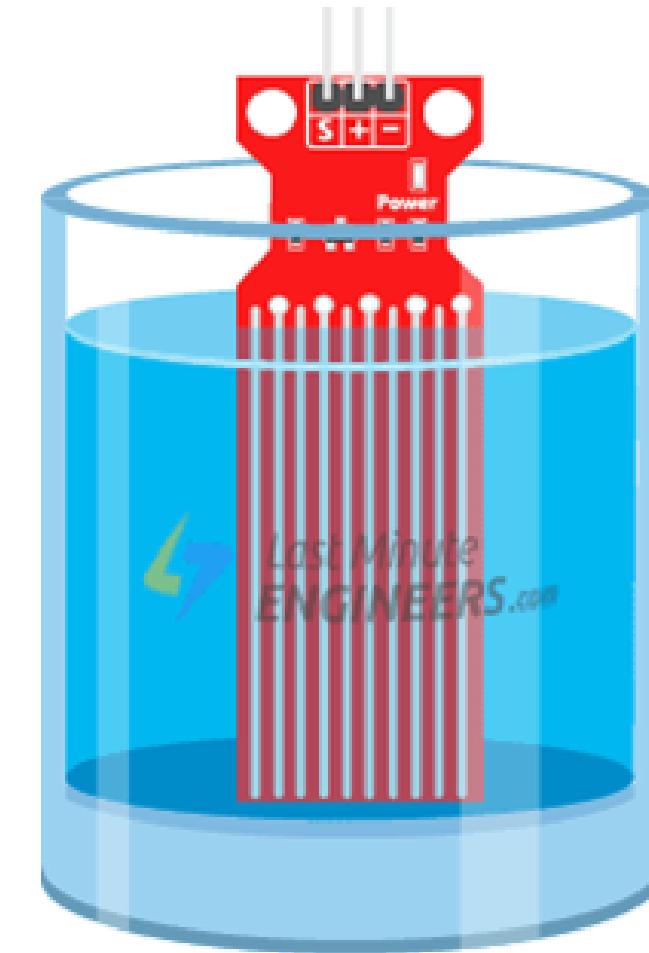
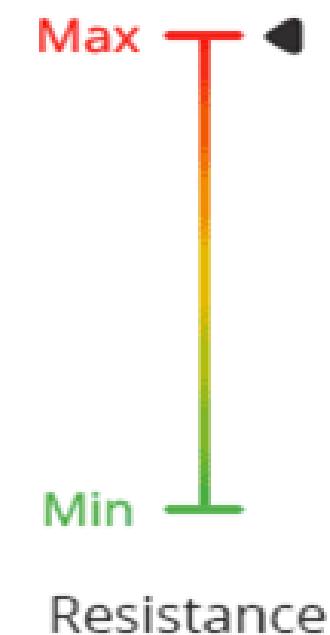
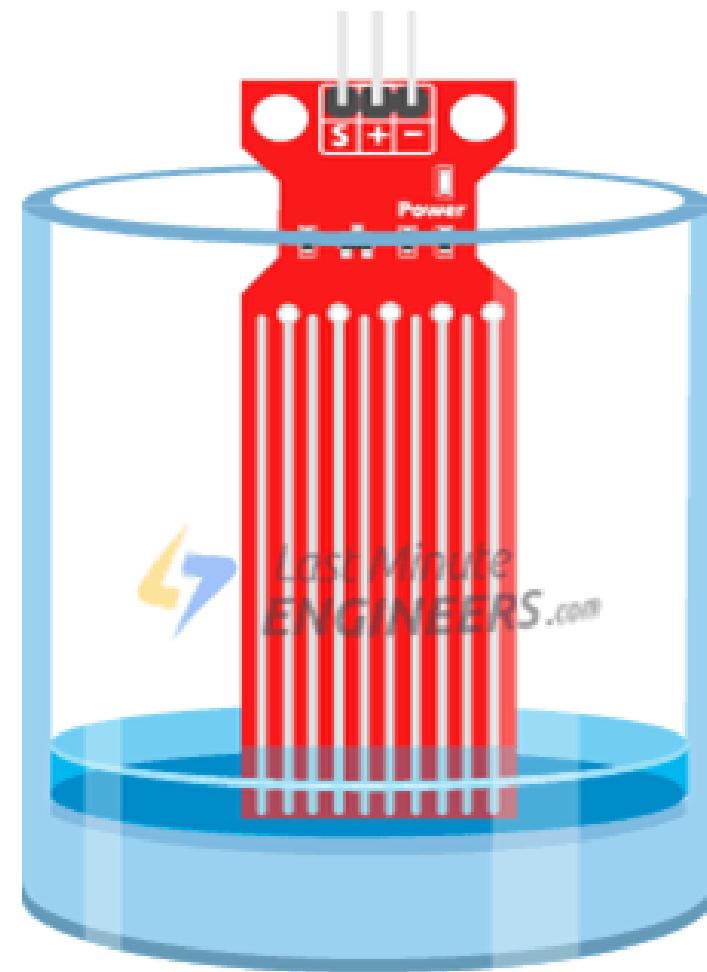
LM35

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature.



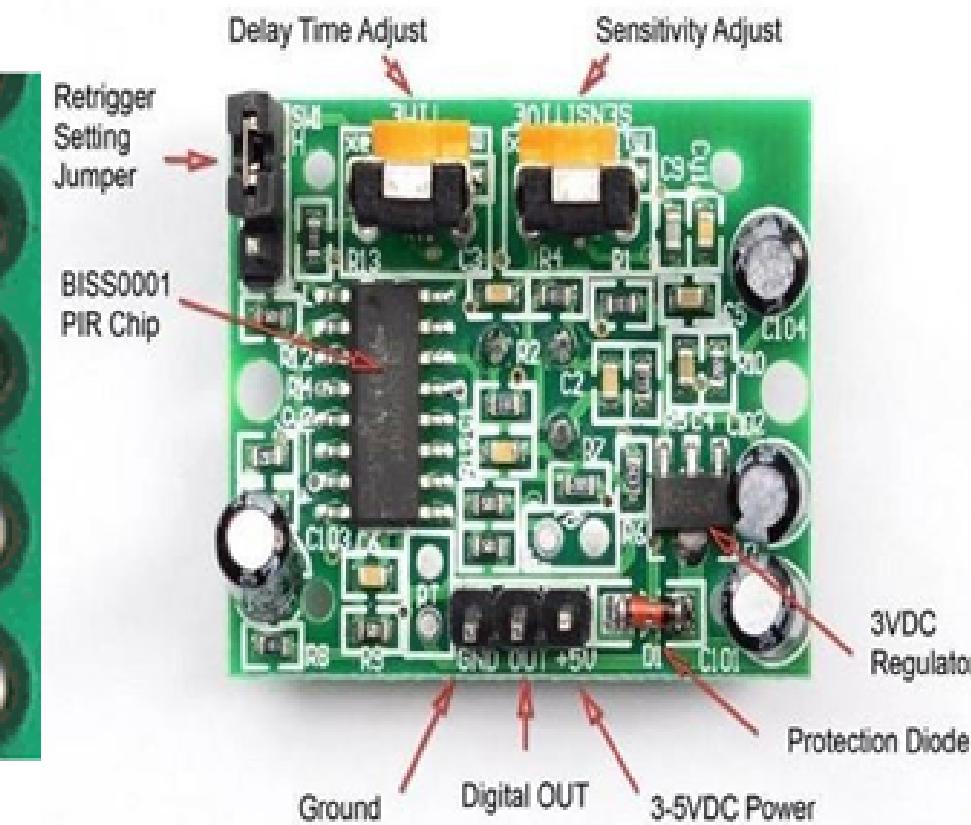
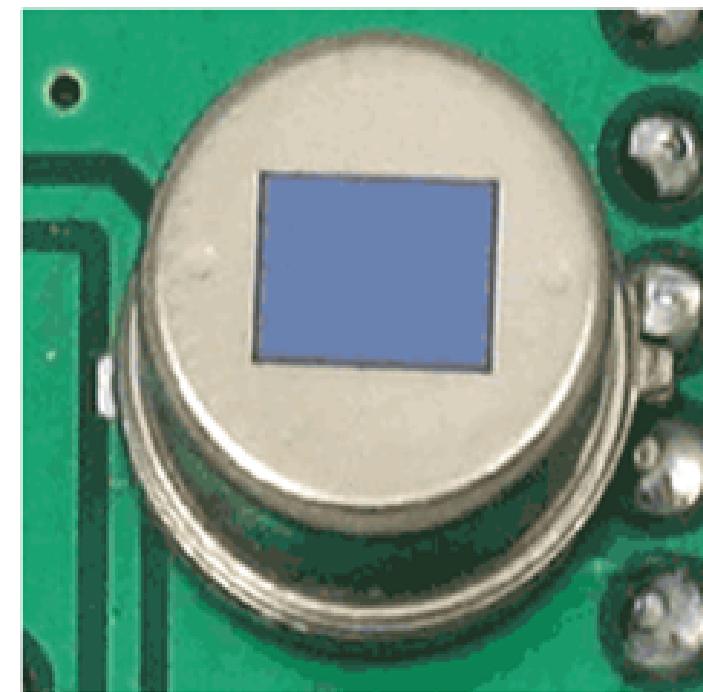
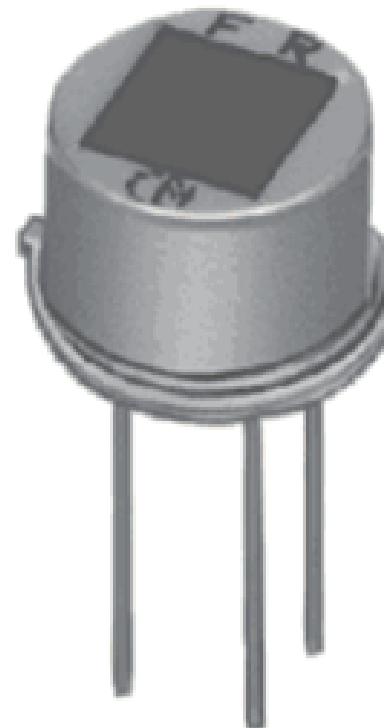
Rain Sensor

A water level indicator sensor, also known as a probe sensor, is what tells the control panel that corrective action is needed

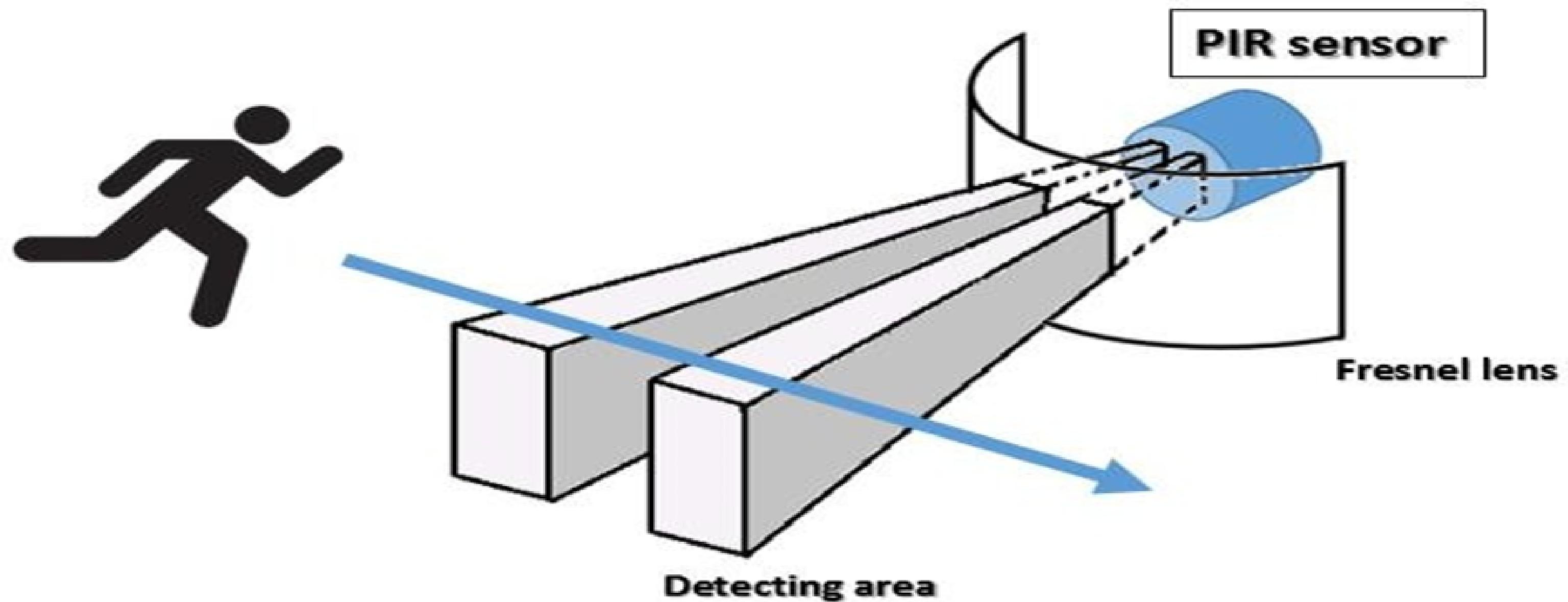


PIR Sensor

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view.



How does the PIR Sensor work?



Soil Moisture Sensor

A soil moisture sensor can read the amount of moisture present in the soil surrounding it. It is ideal for monitoring garden, or your plant's water level. This is a must have tool for a connected garden.



Buzzer

A buzzer or beeper is an audio signaling device, which may be electromechanical, or piezoelectric



FAN

Runs at lowest current on 5v DC voltage with high-speed rotation.



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.

Power Supply Terminals

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

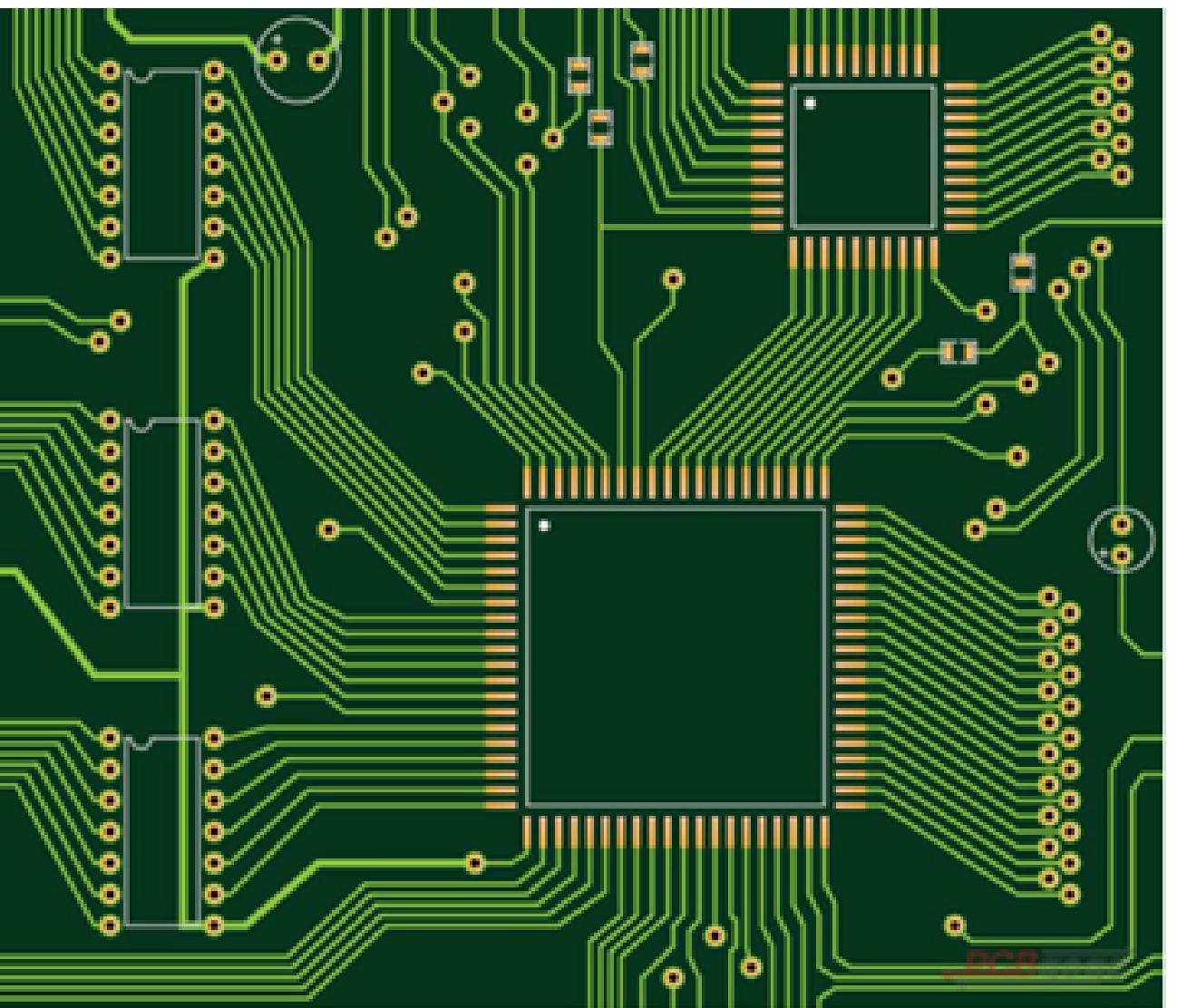


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PCB Implementation

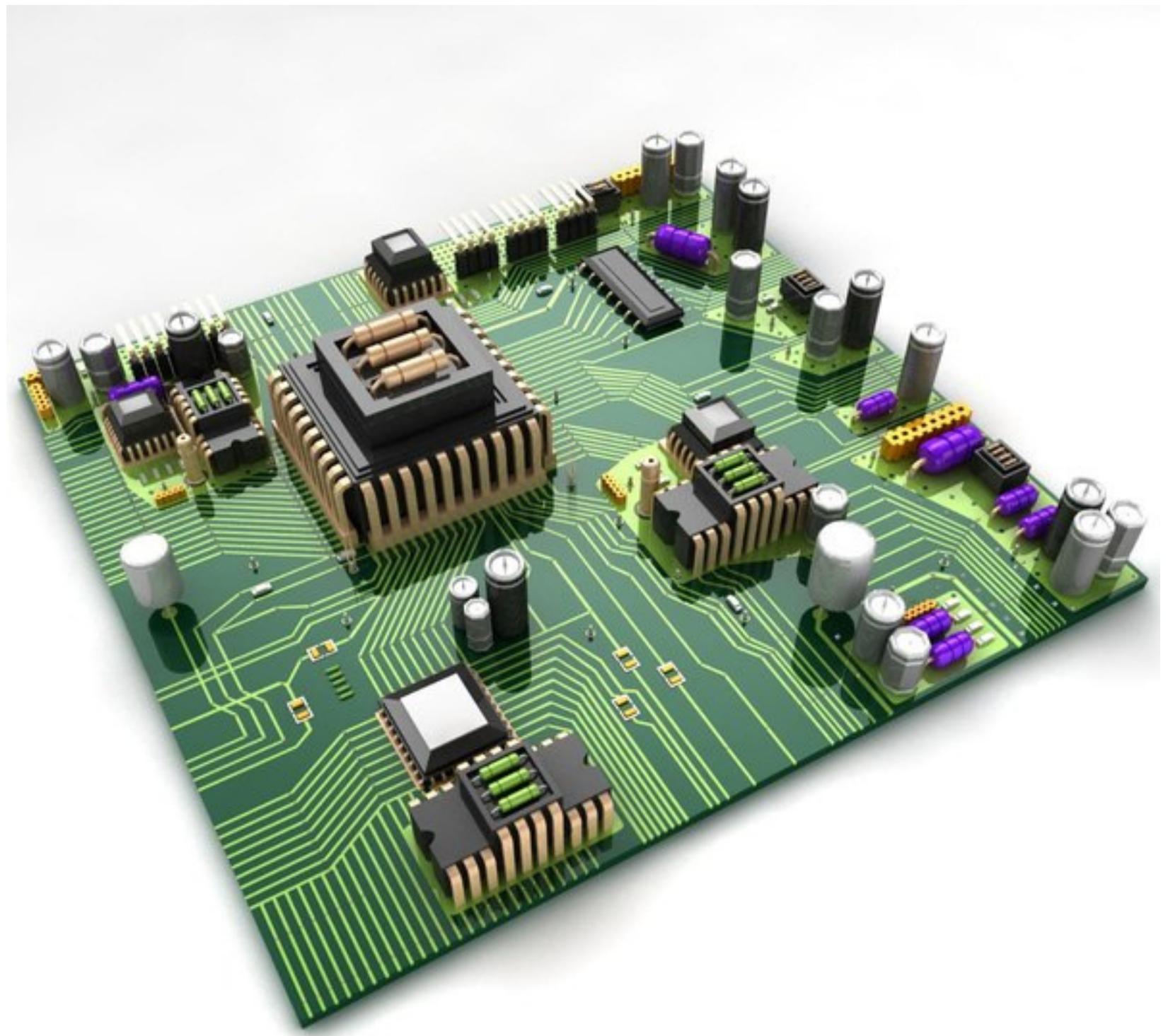
What is PCB ?

- A printed circuit board, or PC board, or PCB, is a non-conductive with conductive lines printed or etched.
- PCB is an electronic assembly that uses copper conductors to create electrical connections between components.



Why we use PCB ?

- To decrease the wiring problems
- Its easy to maintenance and find the problem
- Reduce the used space on the chip



Types of PCB

Single-Sided PCBs

Double-Sided PCBs

Multilayer PCBs

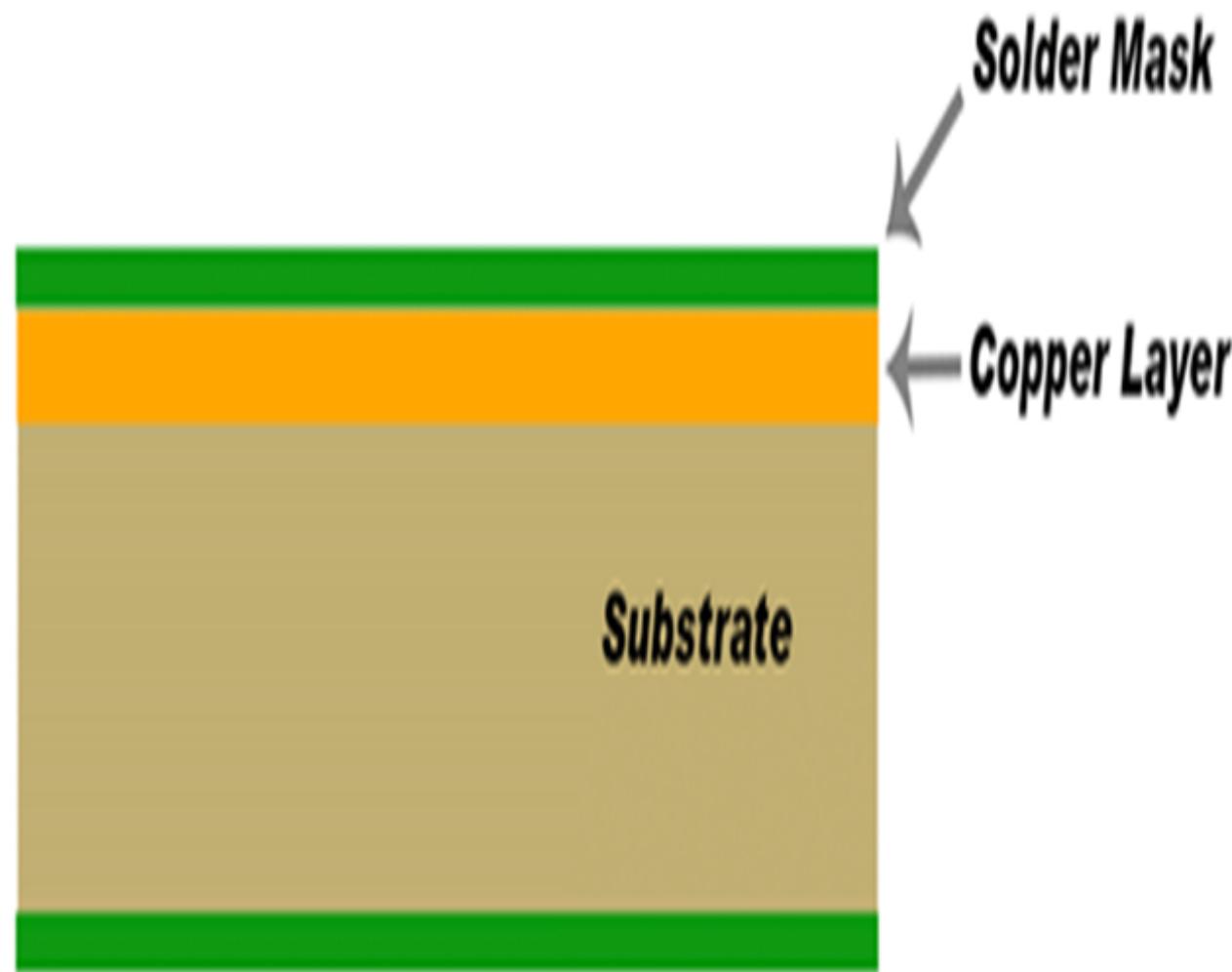
Rigid PCBs

Flex PCBs

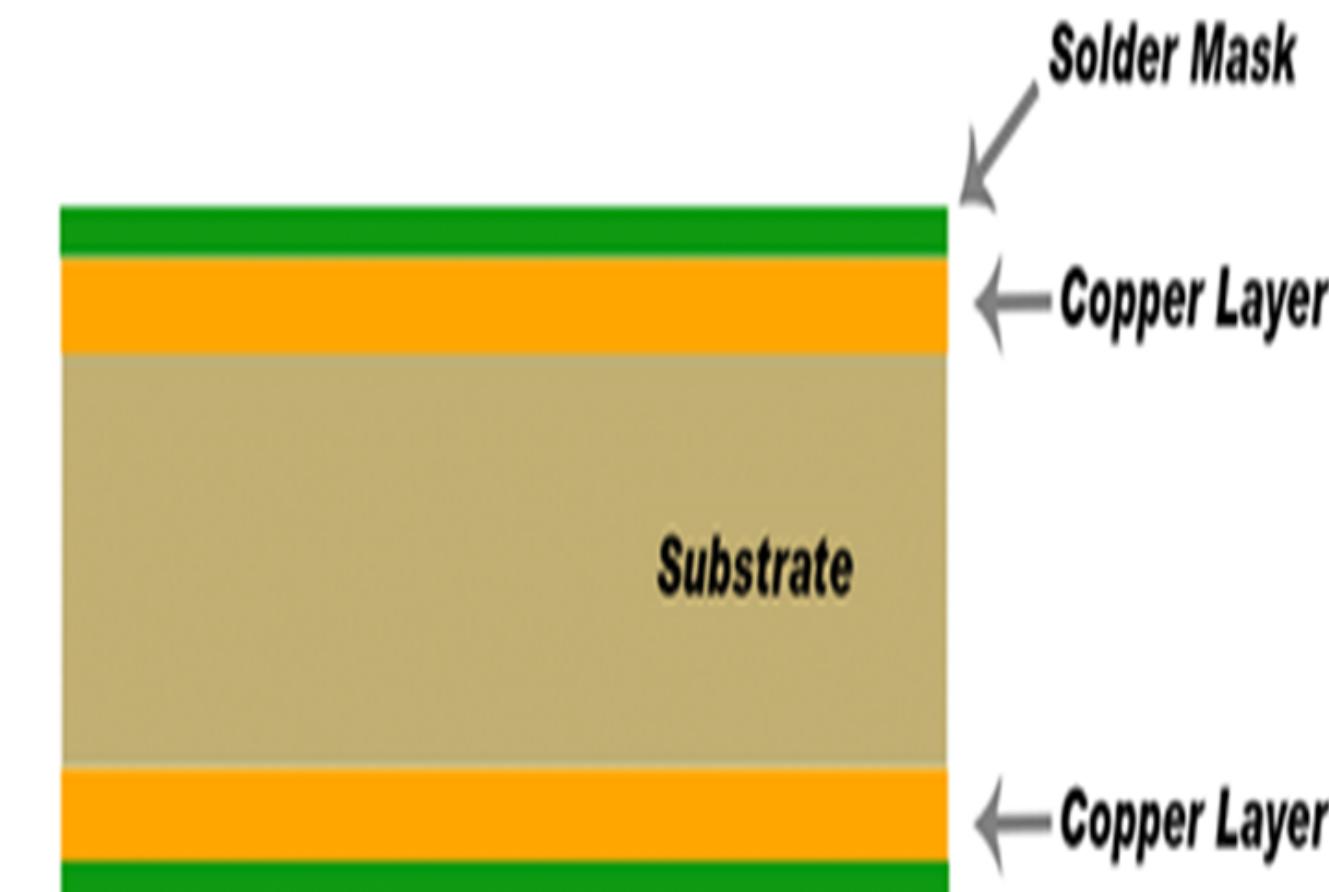
Rigid-Flex PCBs

PCB Types

Single-Sided PCBs

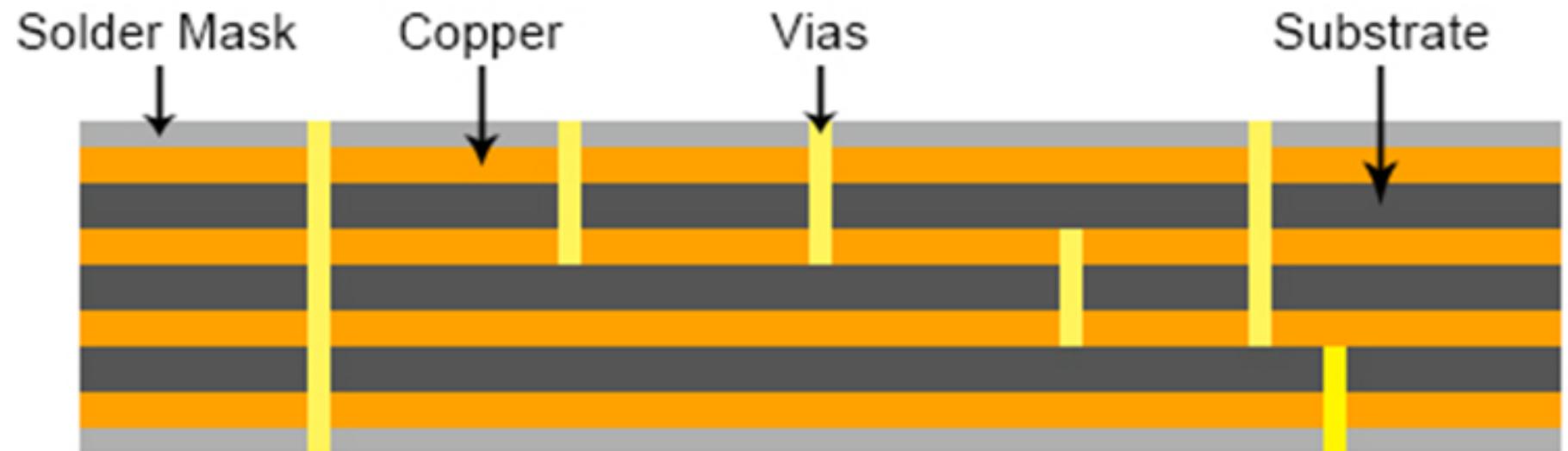


Double-Sided PCBs

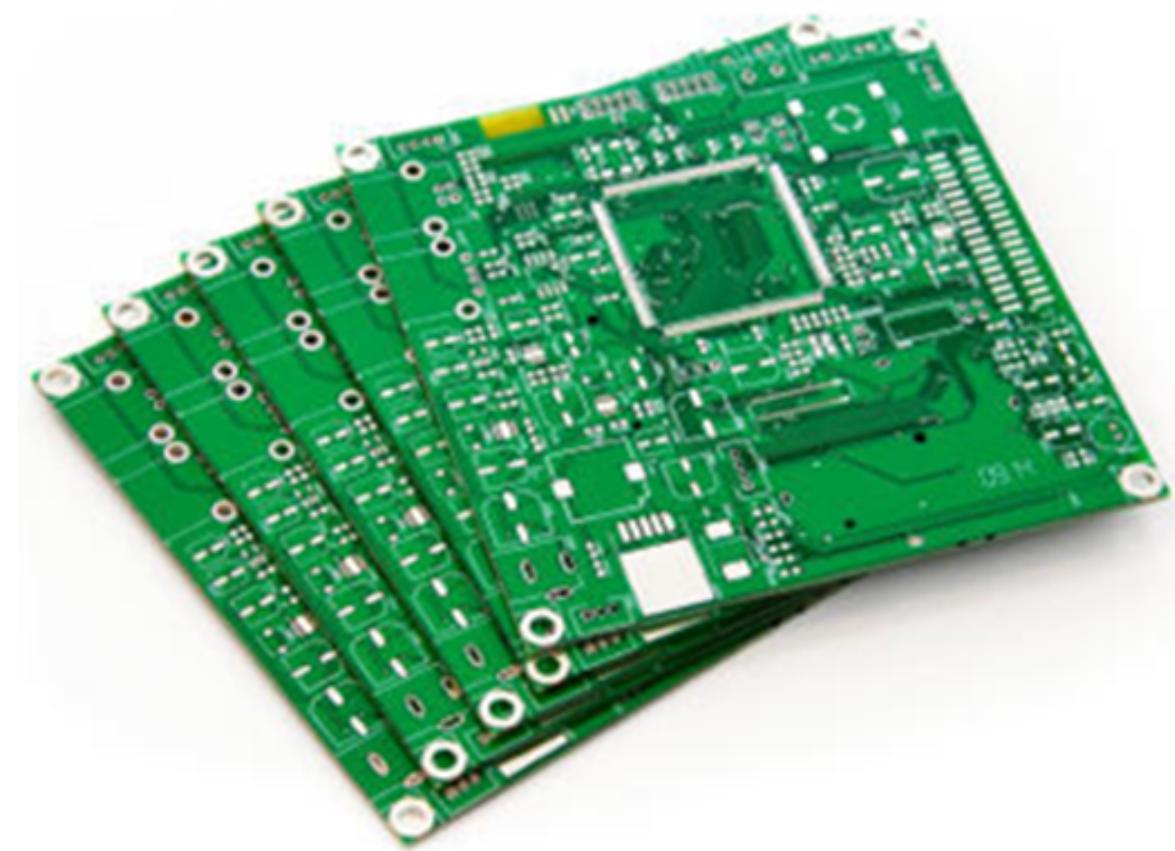


PCB Types

Multi-Layer PCBs

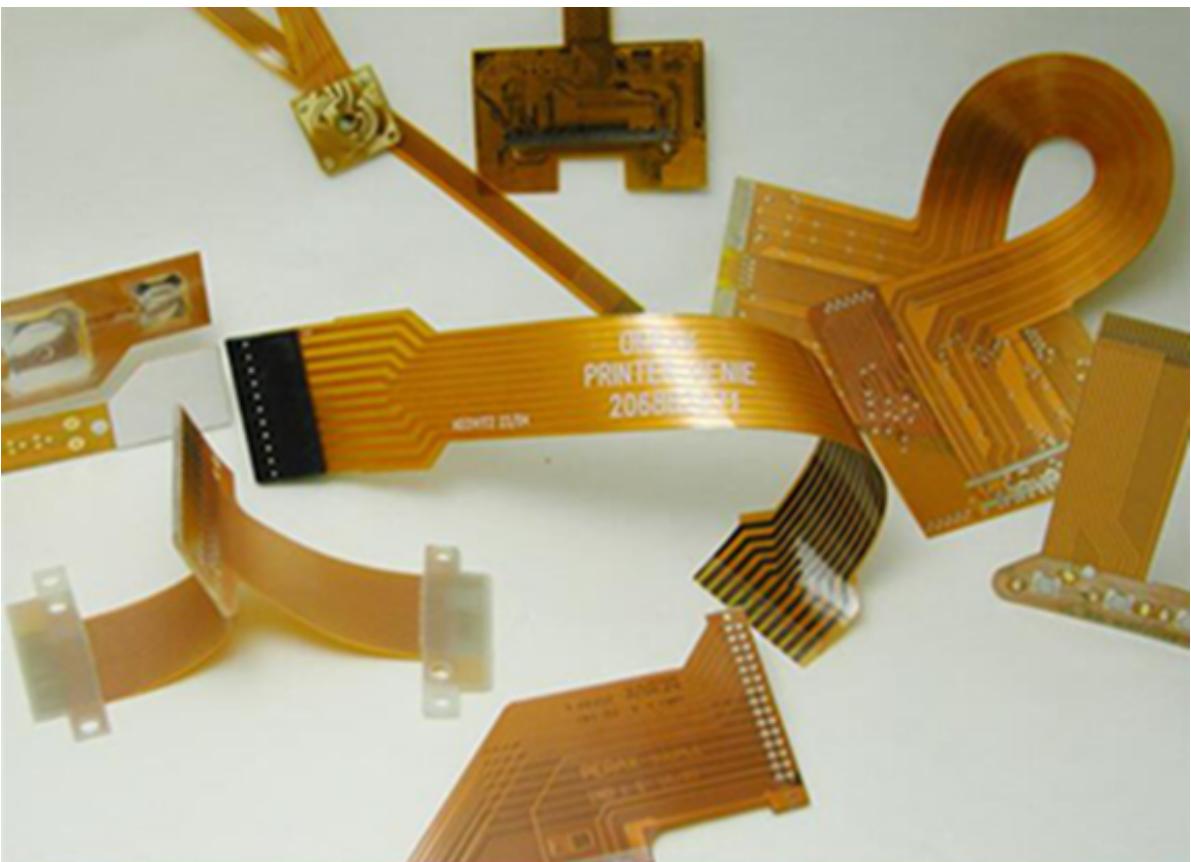


Rigid PCBs

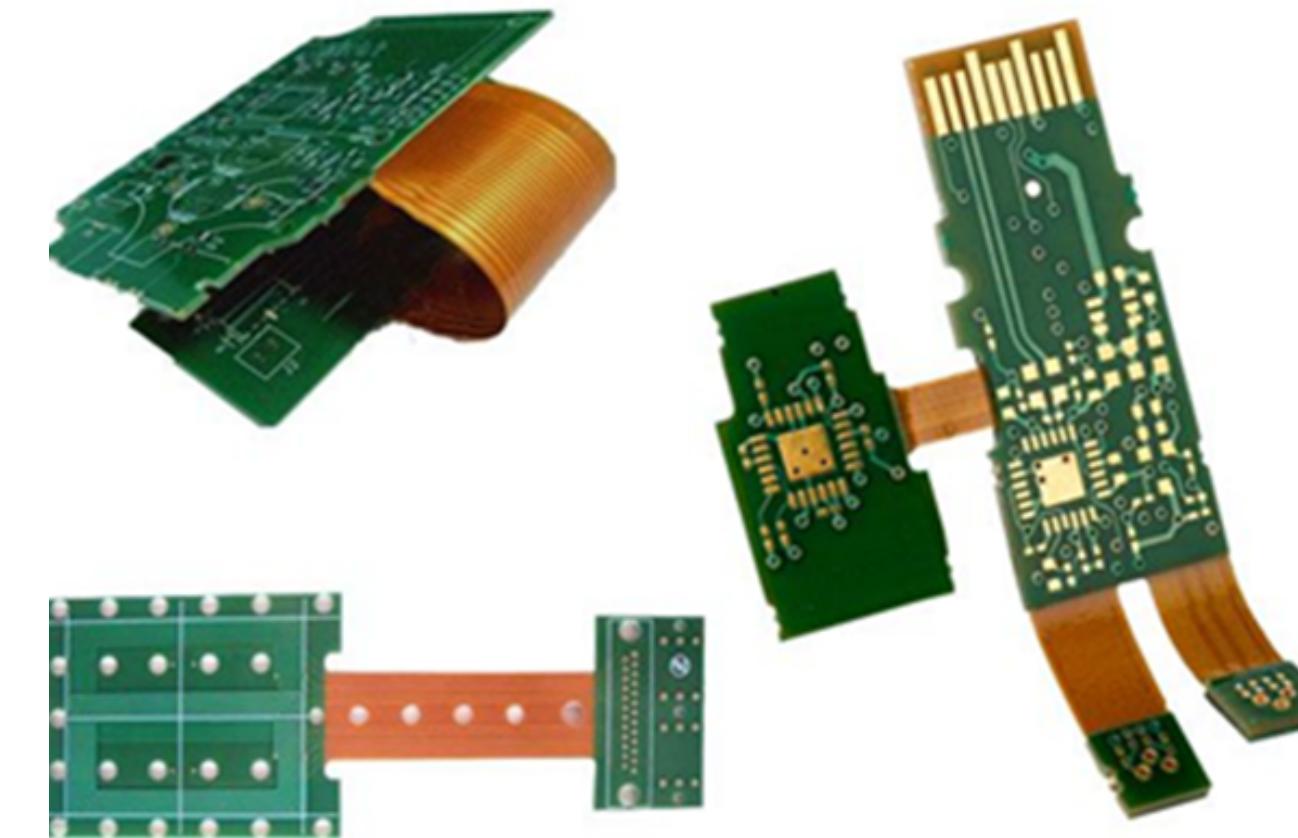


PCB Types

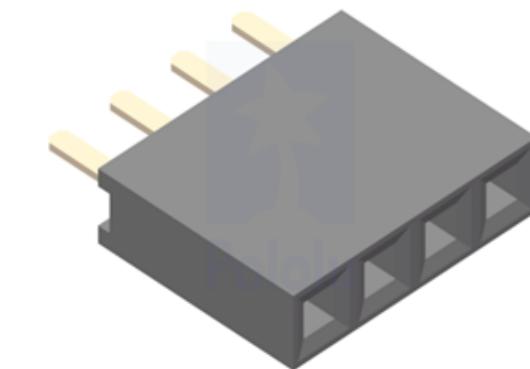
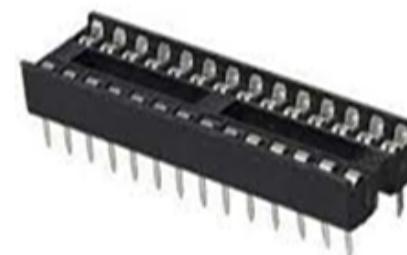
Flex PCBs



Rigid-Flex PCBs



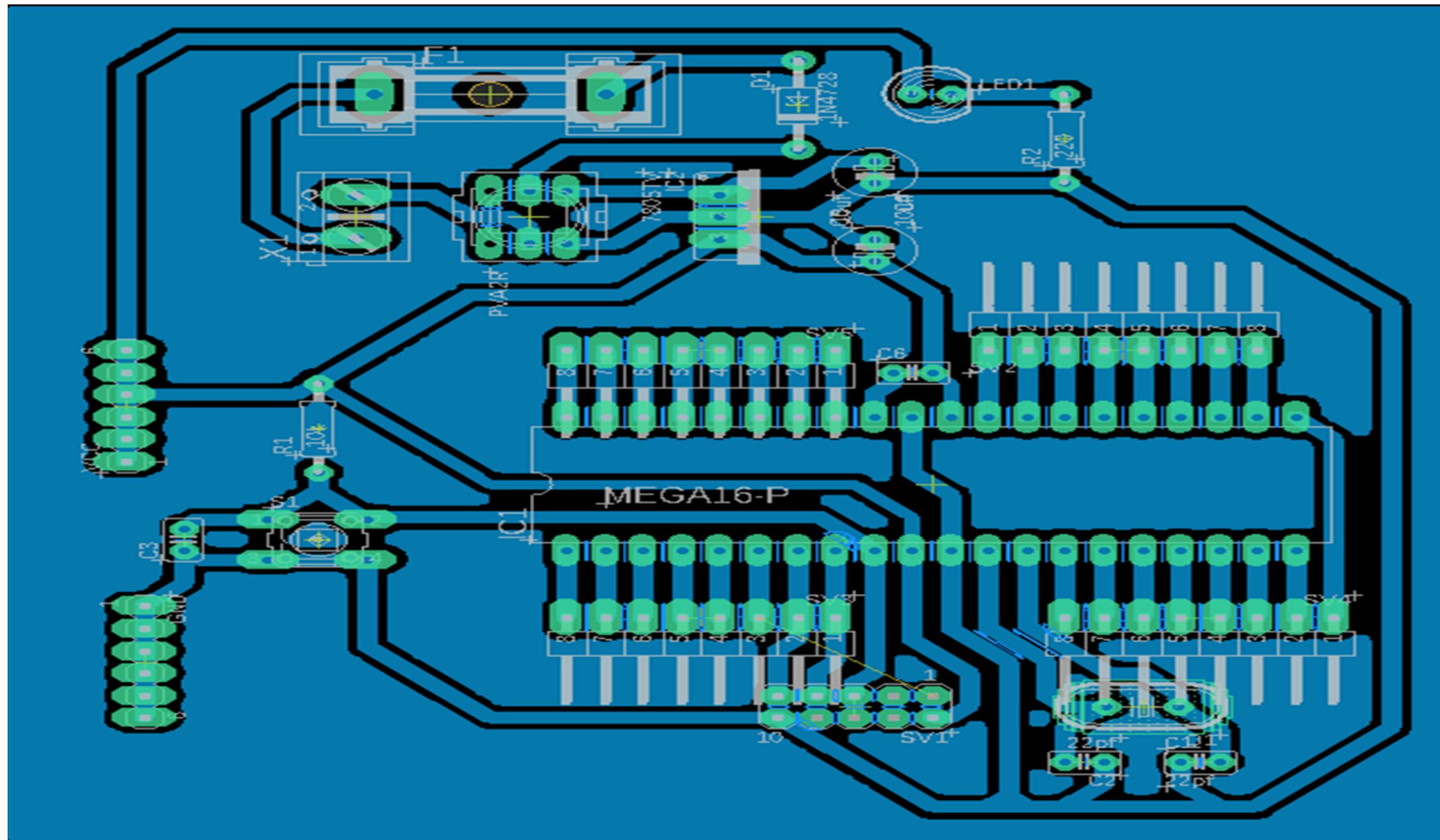
Components



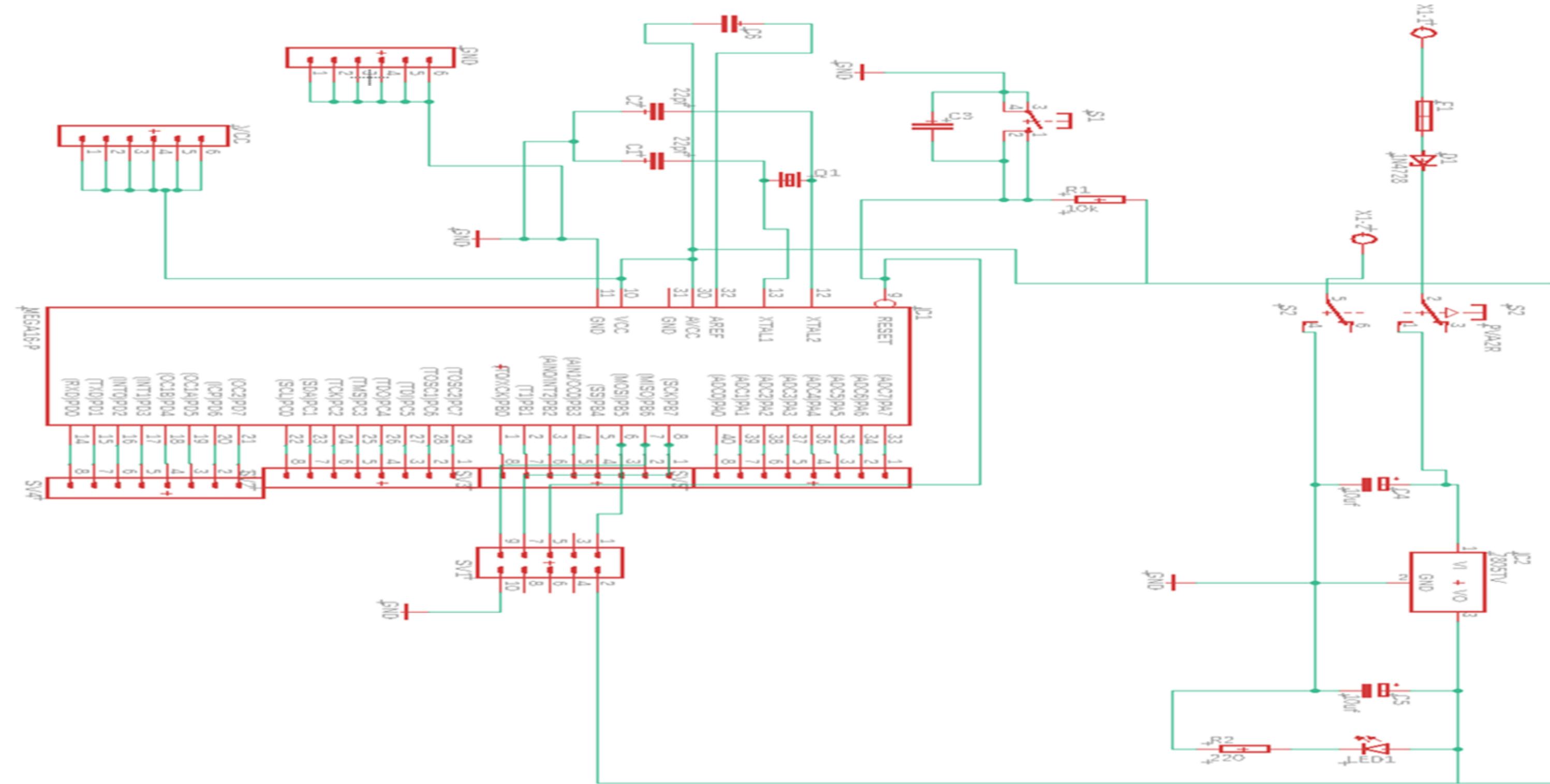


PCB Designs

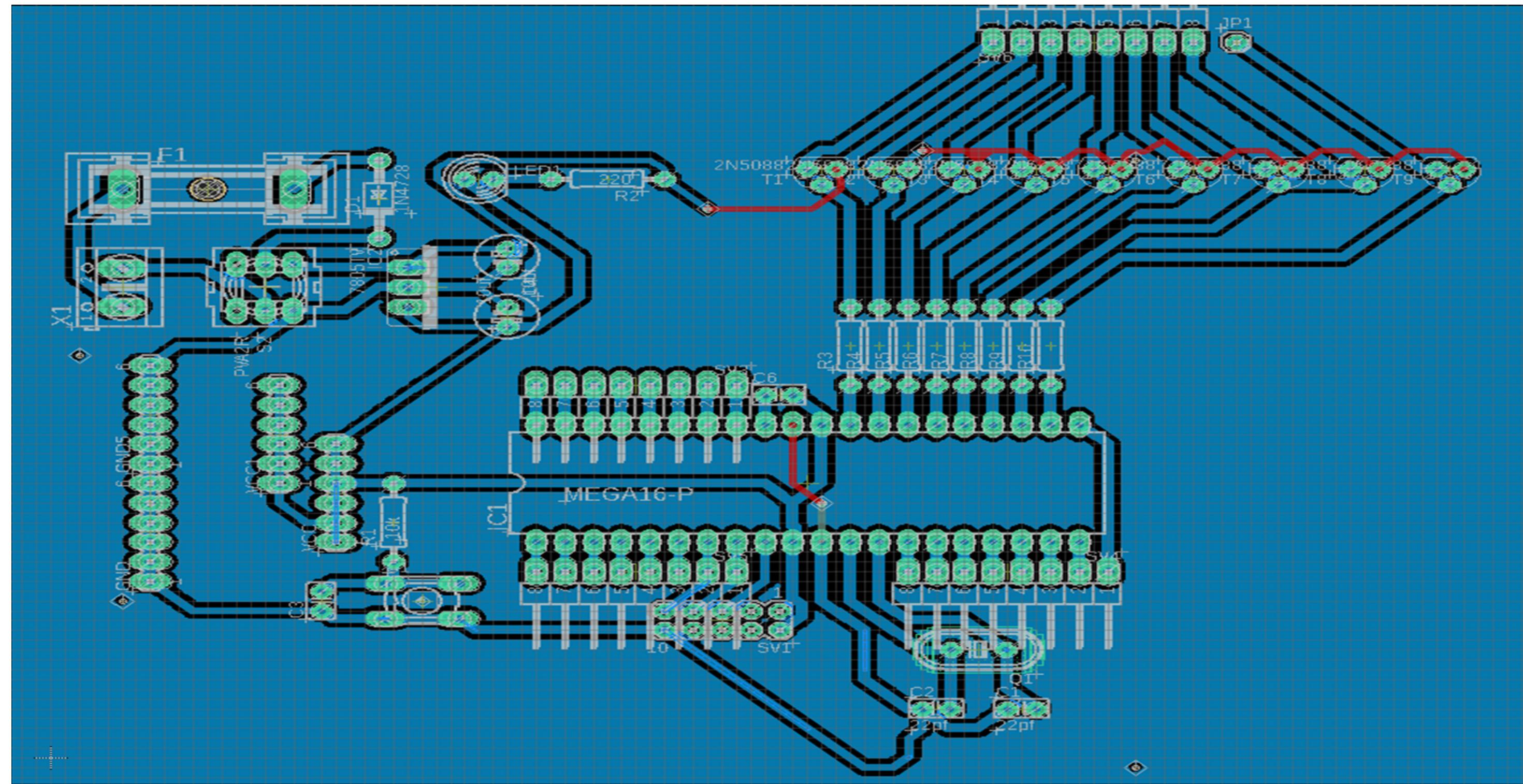
Slave Board PCB



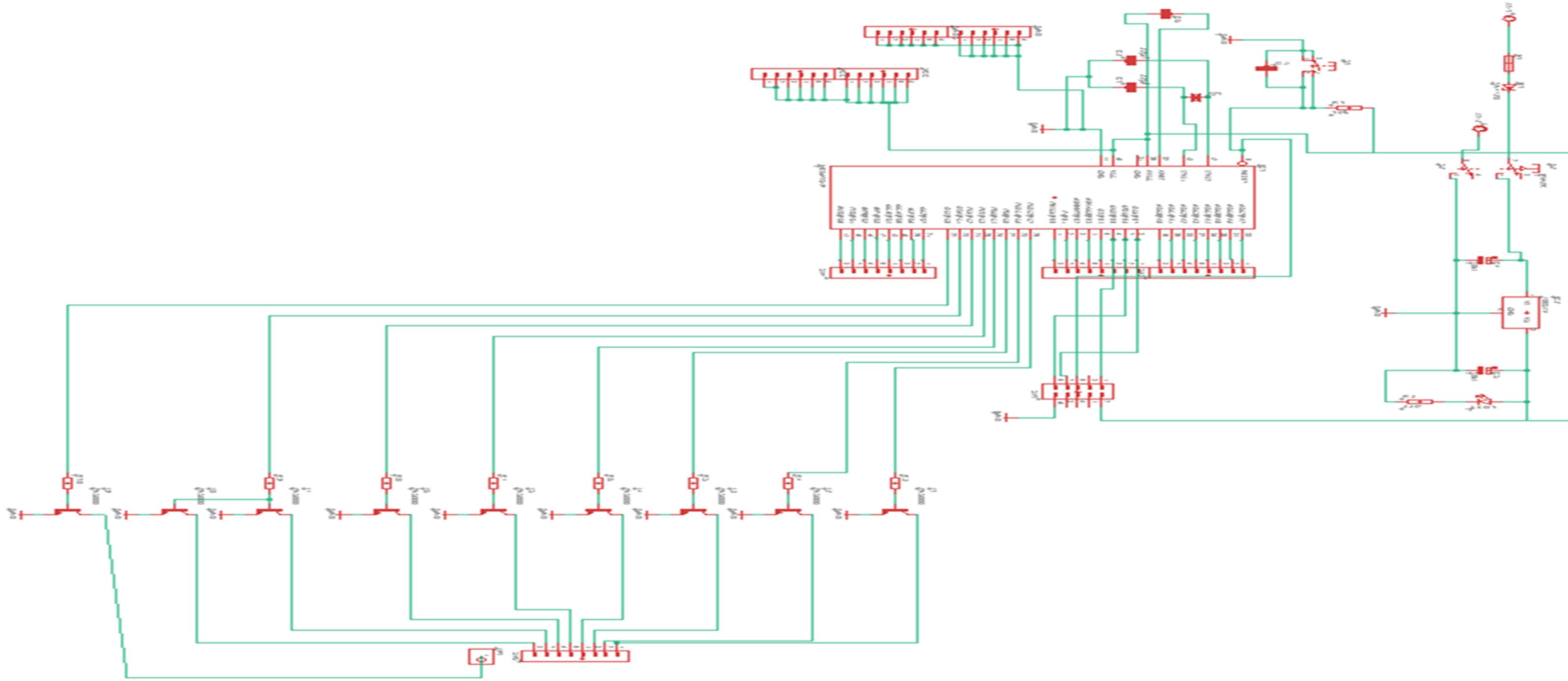
Slave Board Schematic Design



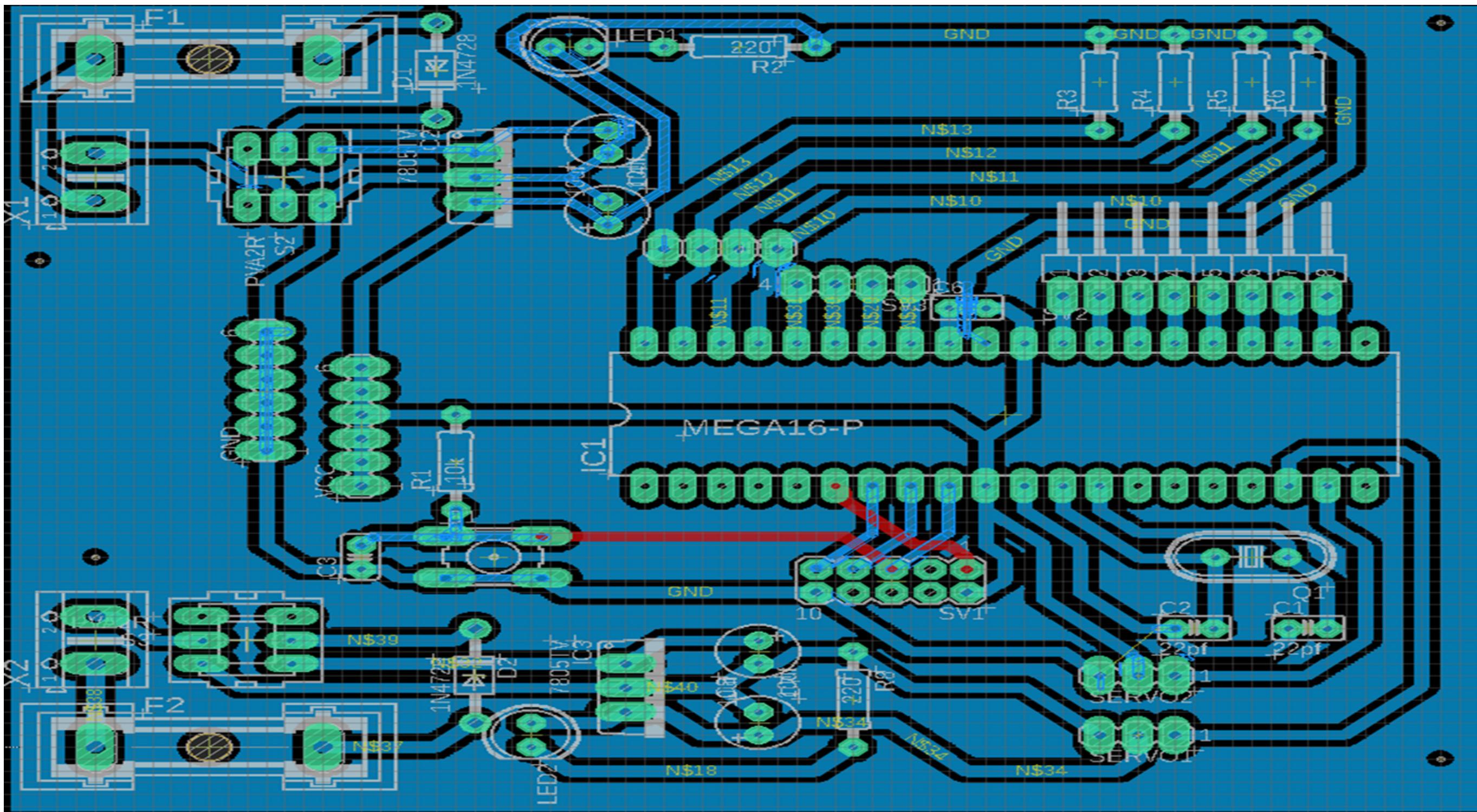
Master Board PCB



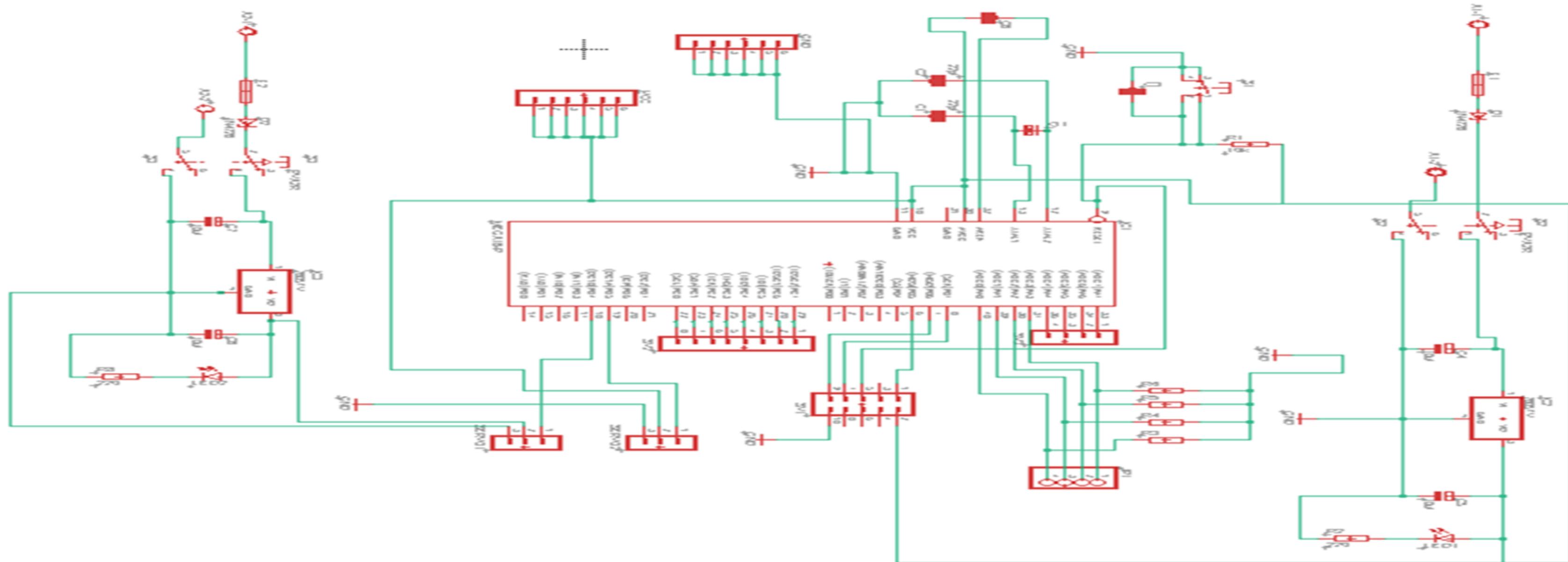
Master Board Schematic Design



Solar Tracking Board PCB



Solar Tracking Board Schematic Design



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Solar Tracking System

Introduction

Solar Energy:

It is considered a type of renewable energy, and it is one of the clean energies for the environment

Solar energy is the energy obtained by capturing heat and light from the Sun. Energy from the Sun is referred to as solar energy.

Technology has provided a number of ways to utilize this abundant resource. It is considered a green technology because it does not emit greenhouse gases. Solar energy is abundantly available and has been utilized since long both as electricity and as a source of heat.

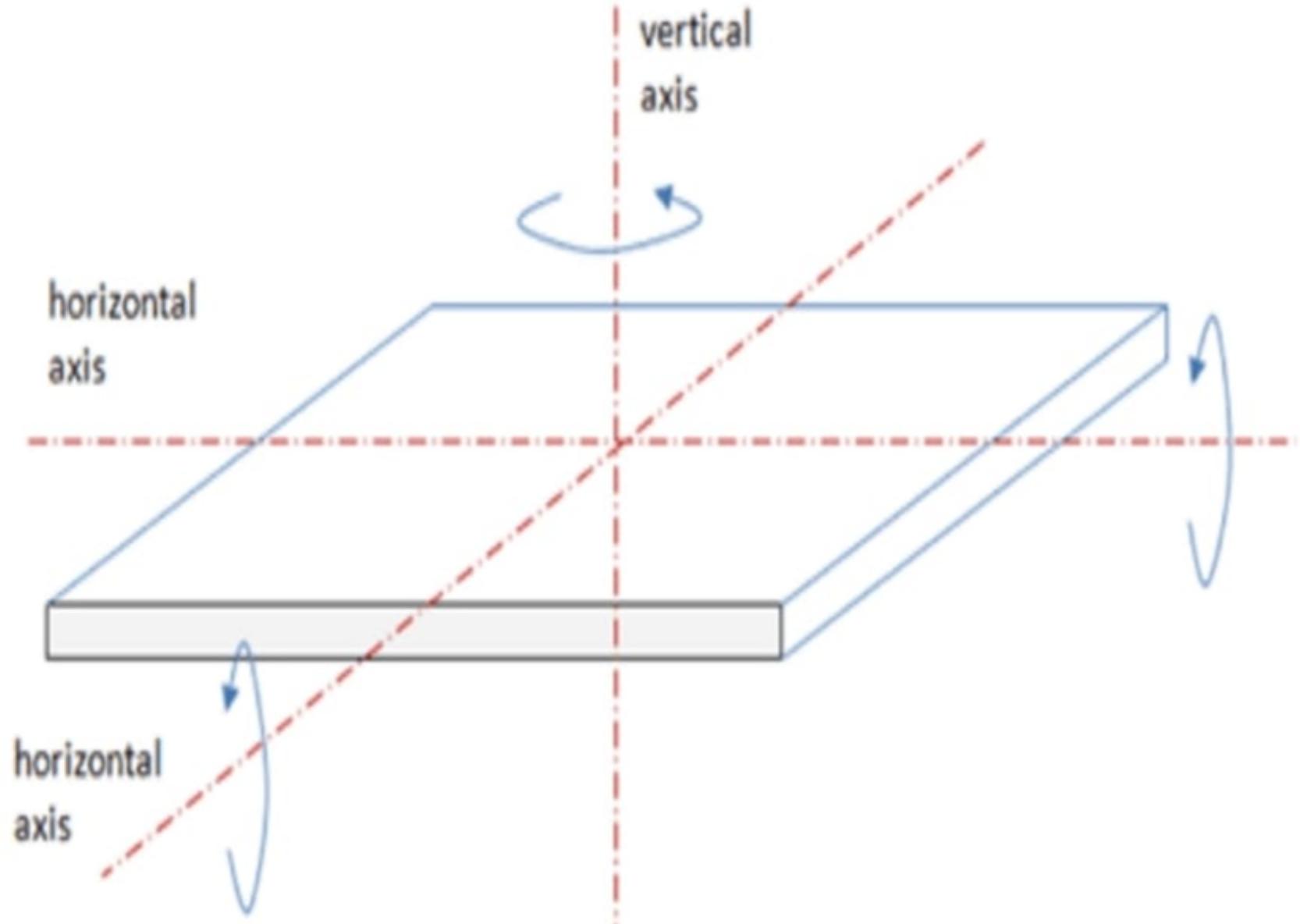
Objective of Solar Tracker

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.

Types of Solar Tracker

We can note all the axes that the photovoltaic solar panel can rotate around. When the panel rotates around only one axis, it is called “Single Axis Trackers” and it may rotate around one of the horizontal axes or the vertical axes. As for when the board rotates around two axes, the tracking system is called “Dual Axis Trackers”.



Single Axis Tracker

A single axis system moves the panels through one range of motion. The axis is typically oriented north-south, so the solar panels can tilt east through west as the sun rises and sets



Dual Axis Tracker

A dual axis system can tilt in two directions. One of the axes works as above, to maximize generation through the day

The other is oriented east west, allowing a tilt north through south to optimize output during

Double Axis Tracking



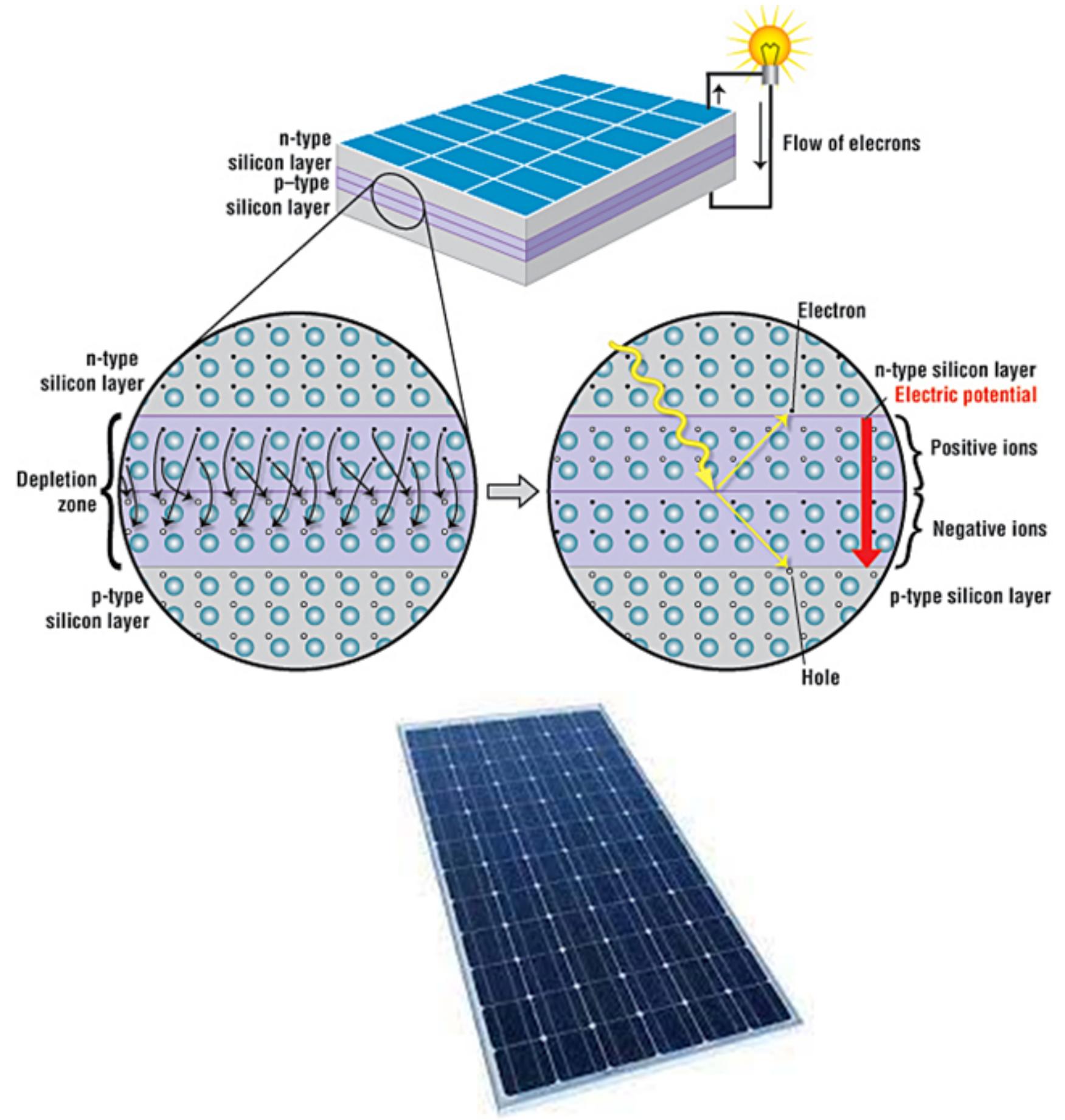
Components

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.

Maximum power: 5w

voltage at p max: 17.5V

current at p max: 0.29A



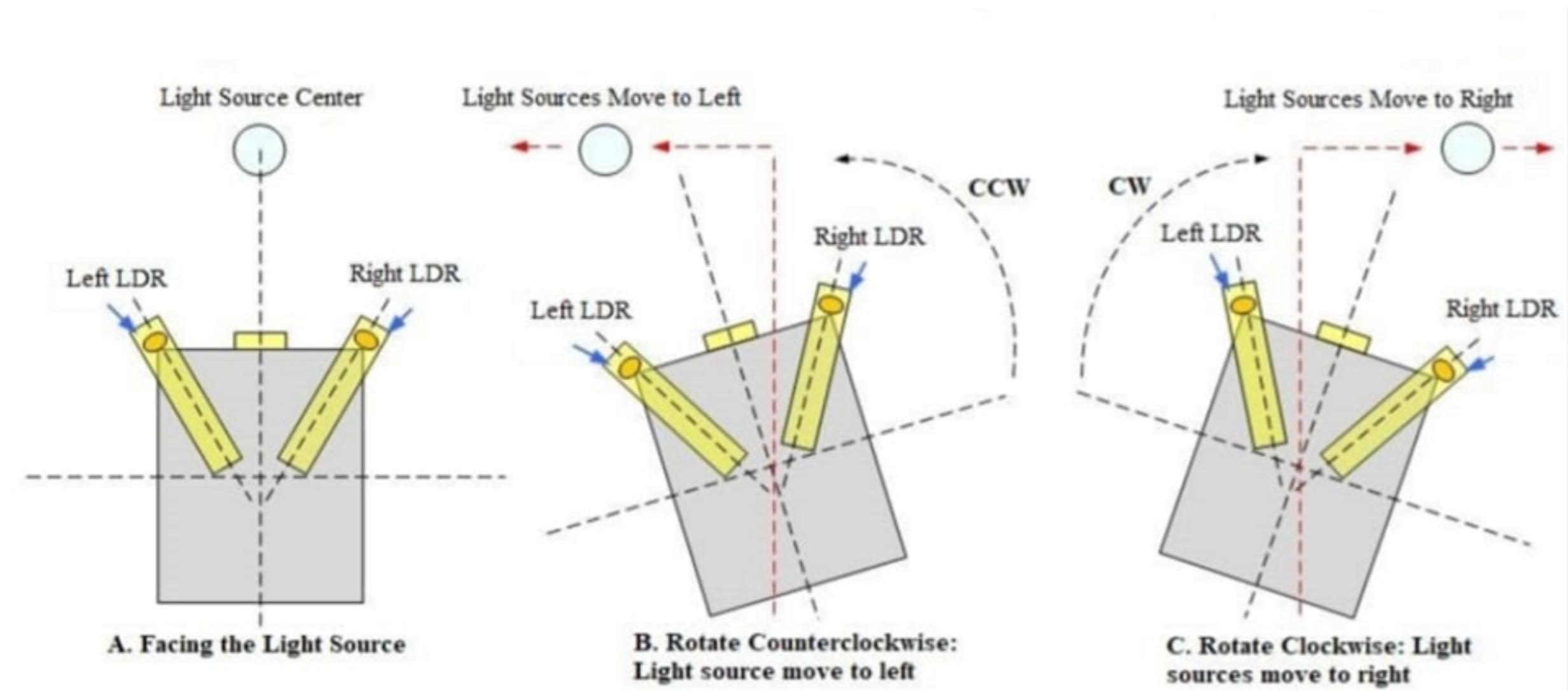
Light Dependent Resistor

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.



Lithium Batteries

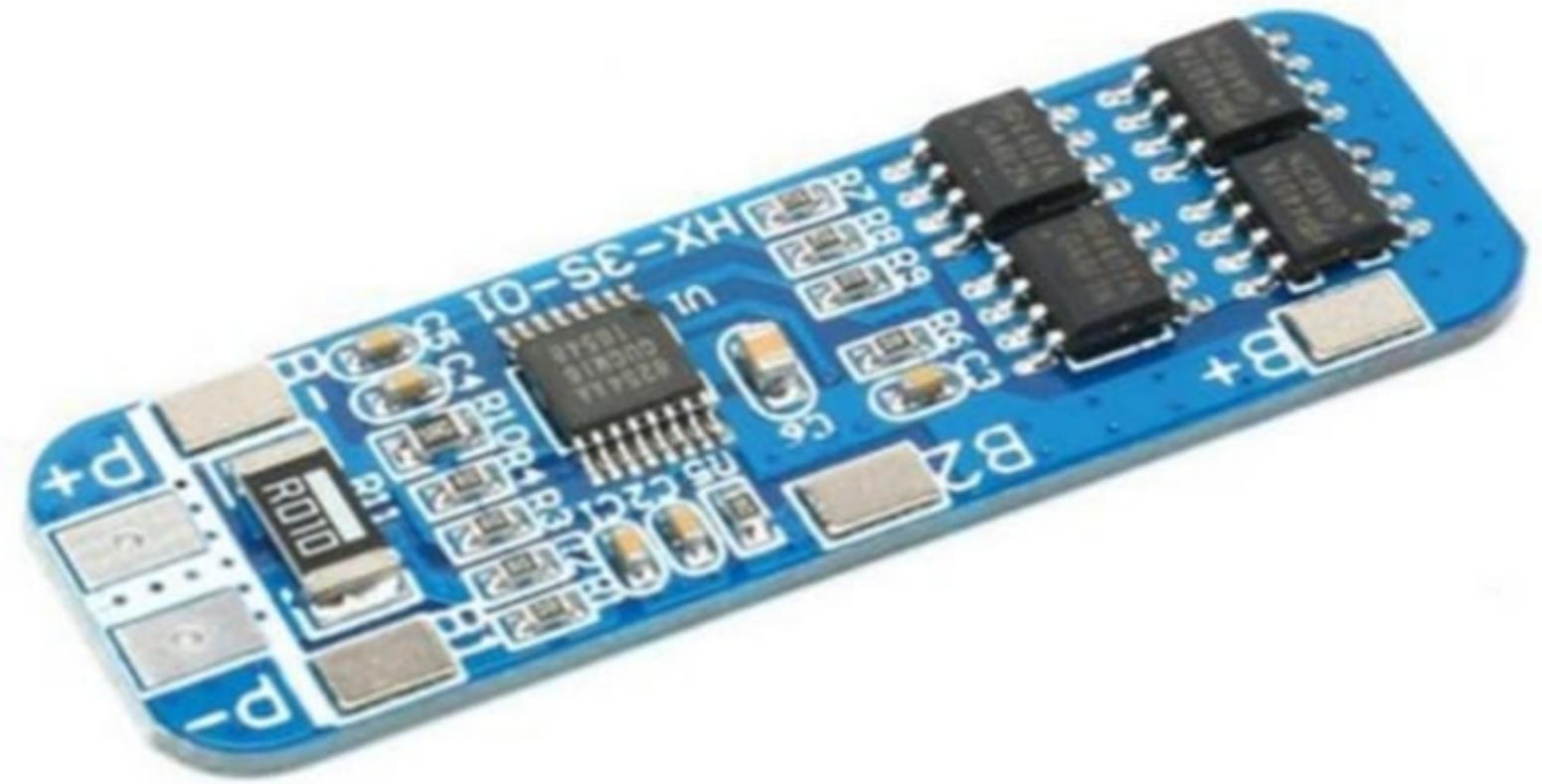
Lithium batteries are among the best solar energy batteries that have many advantages when compared to lead-liquid batteries, gel batteries, and AGM batteries.

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

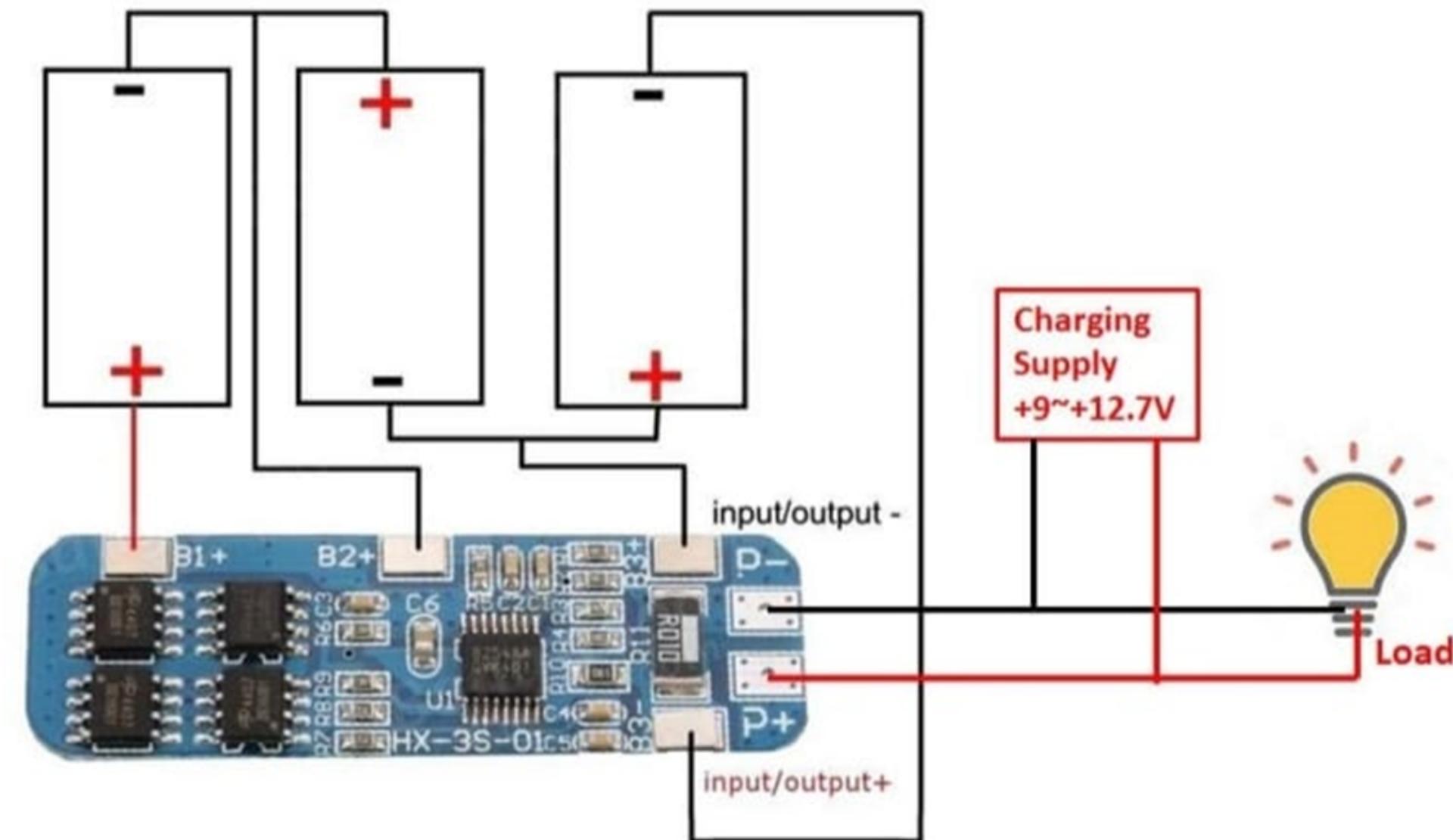


Battery management system (BMS)

is any electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its safe operating area[clarification needed], monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it. A battery pack built



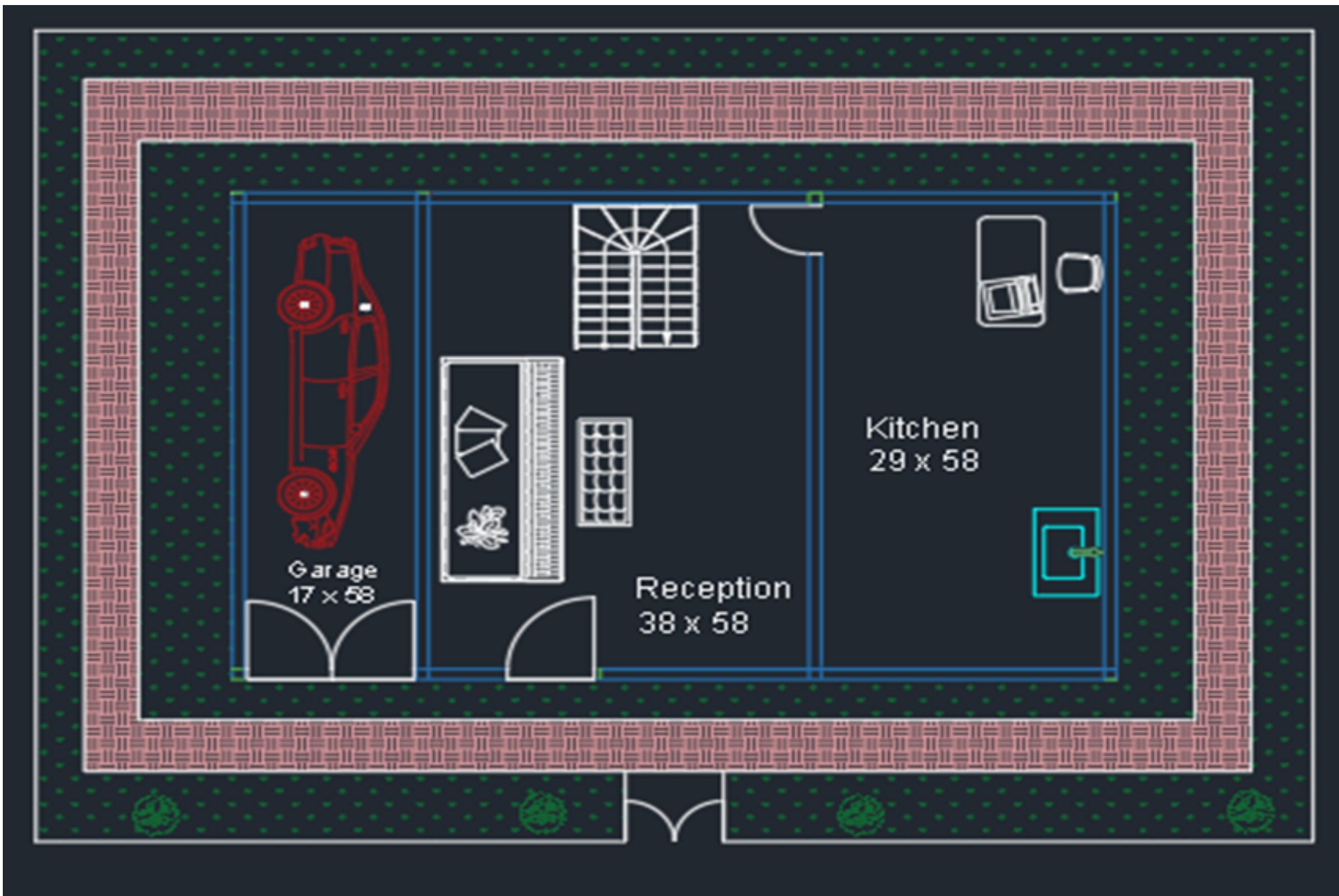
The Controlling Circuit



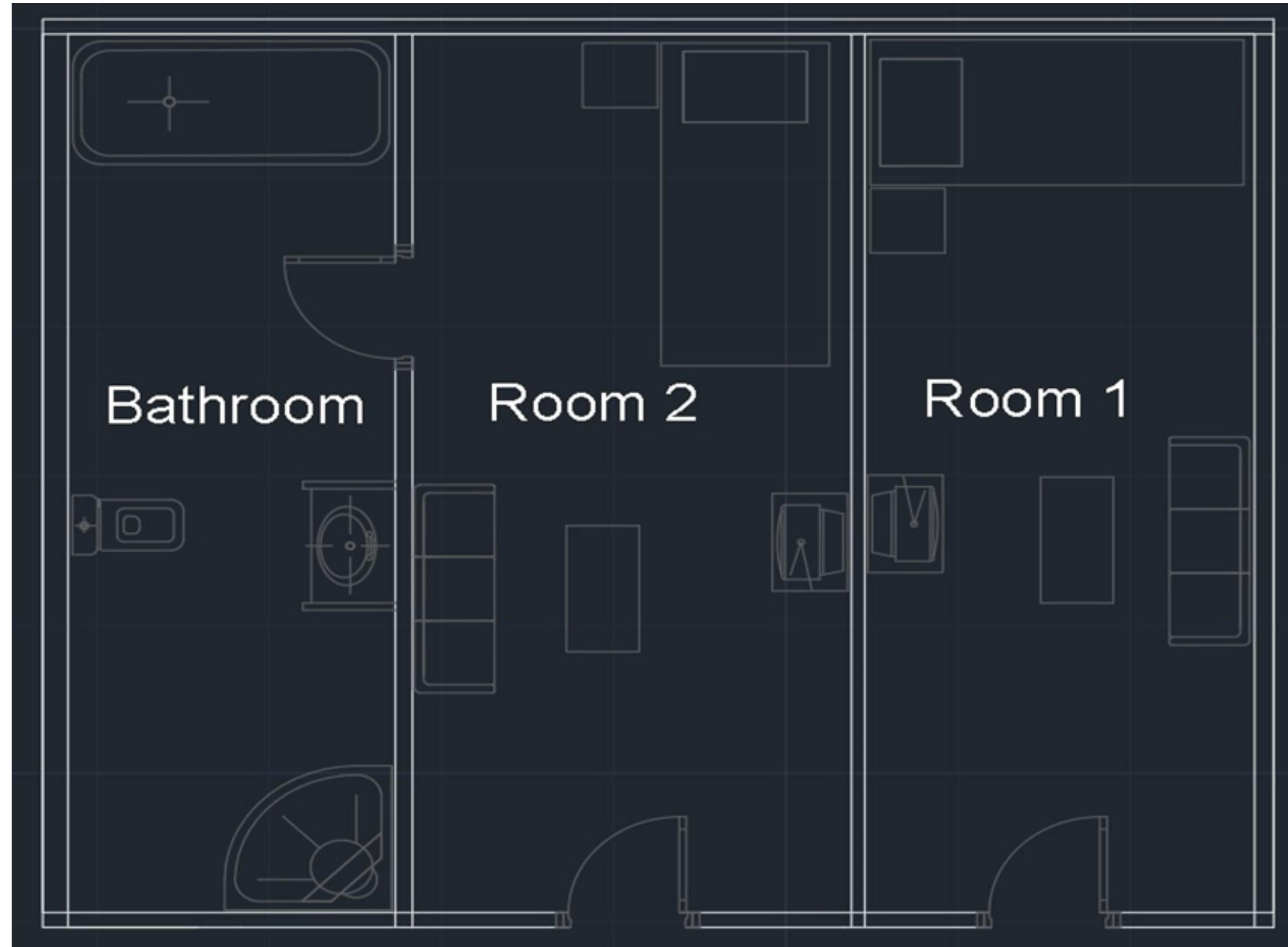
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Maquette Implementation

- The design of the ground floor



- The design of the second floor

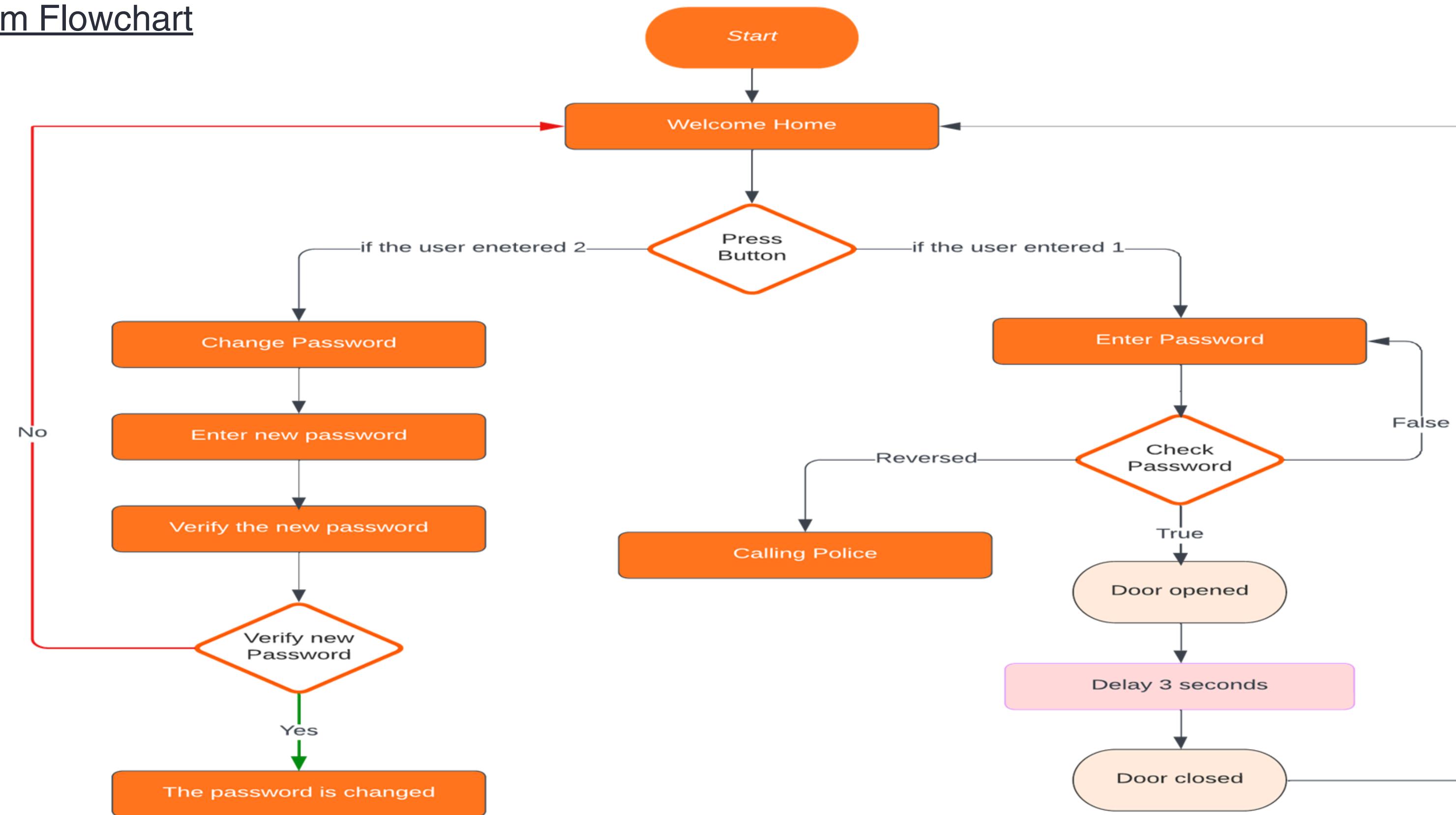


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Software Implementation

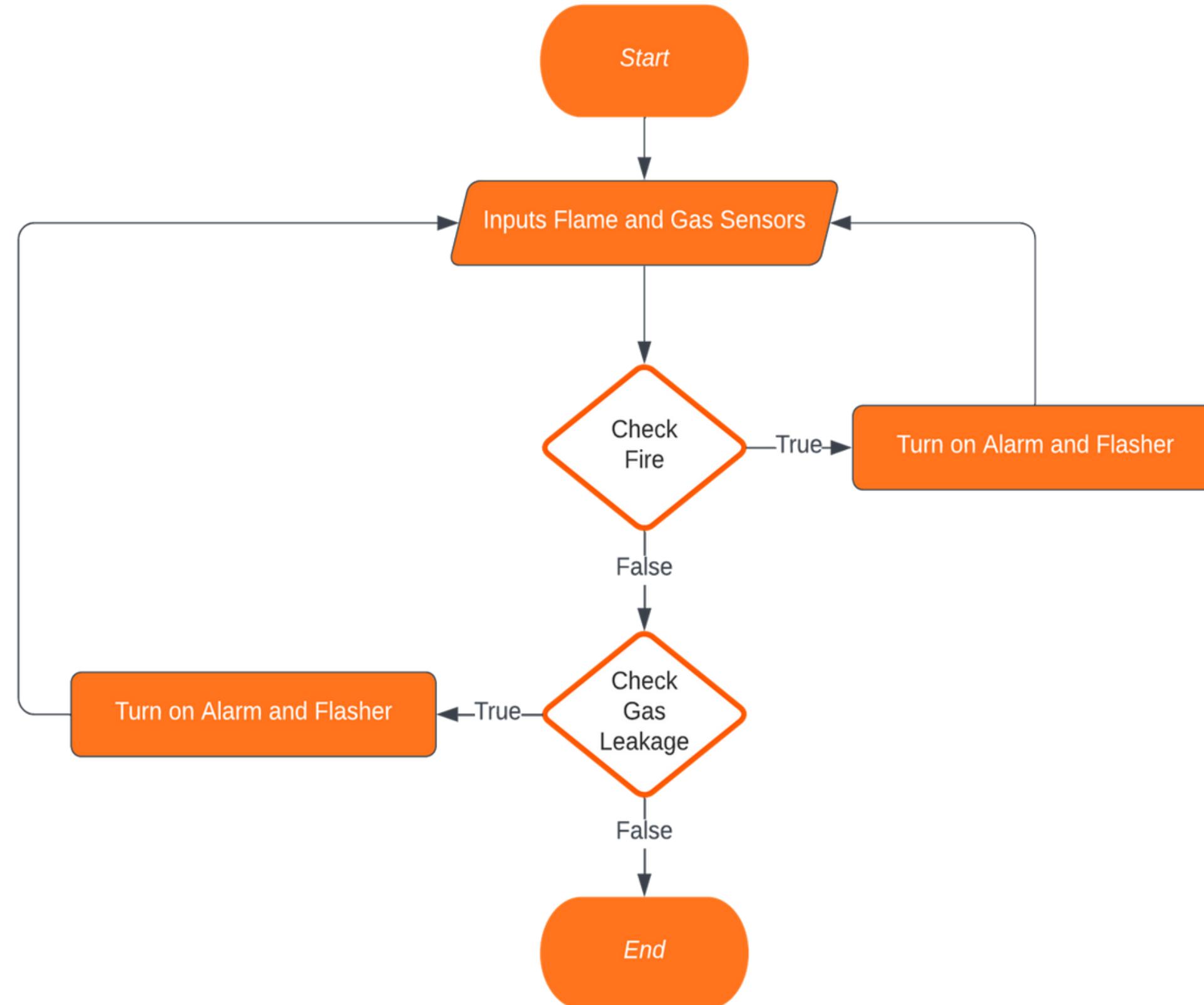
Door Locker Security System

System Flowchart



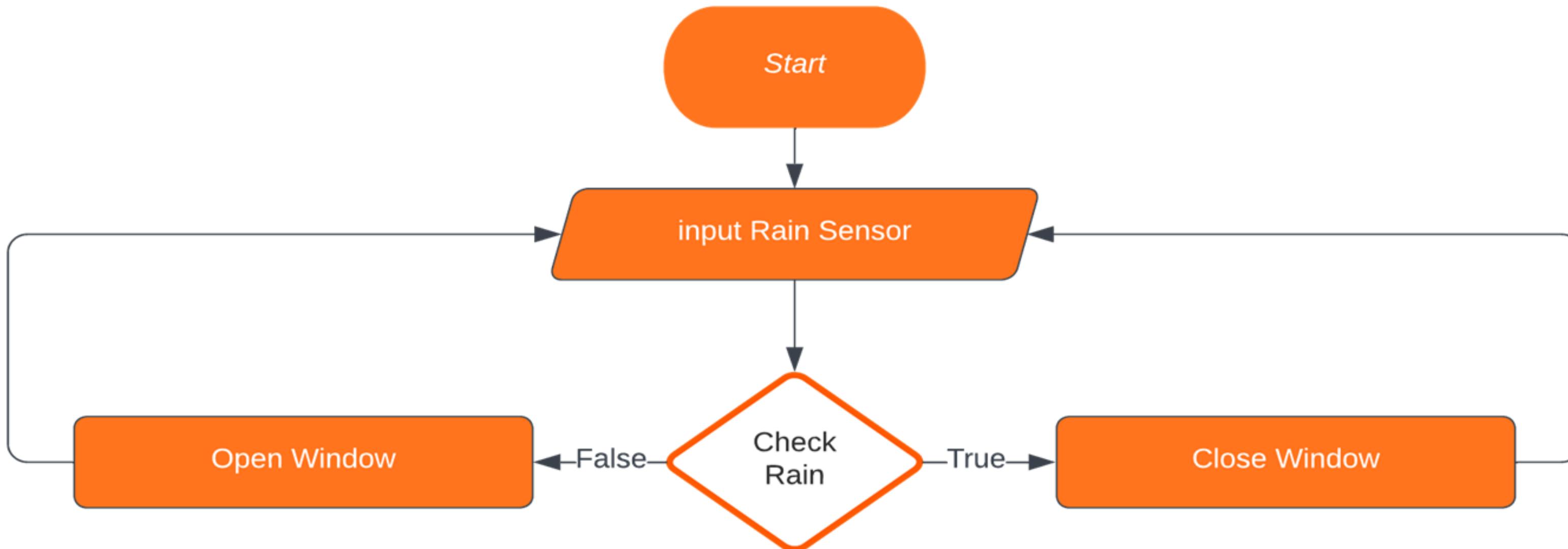
Home Security System

System Flowchart



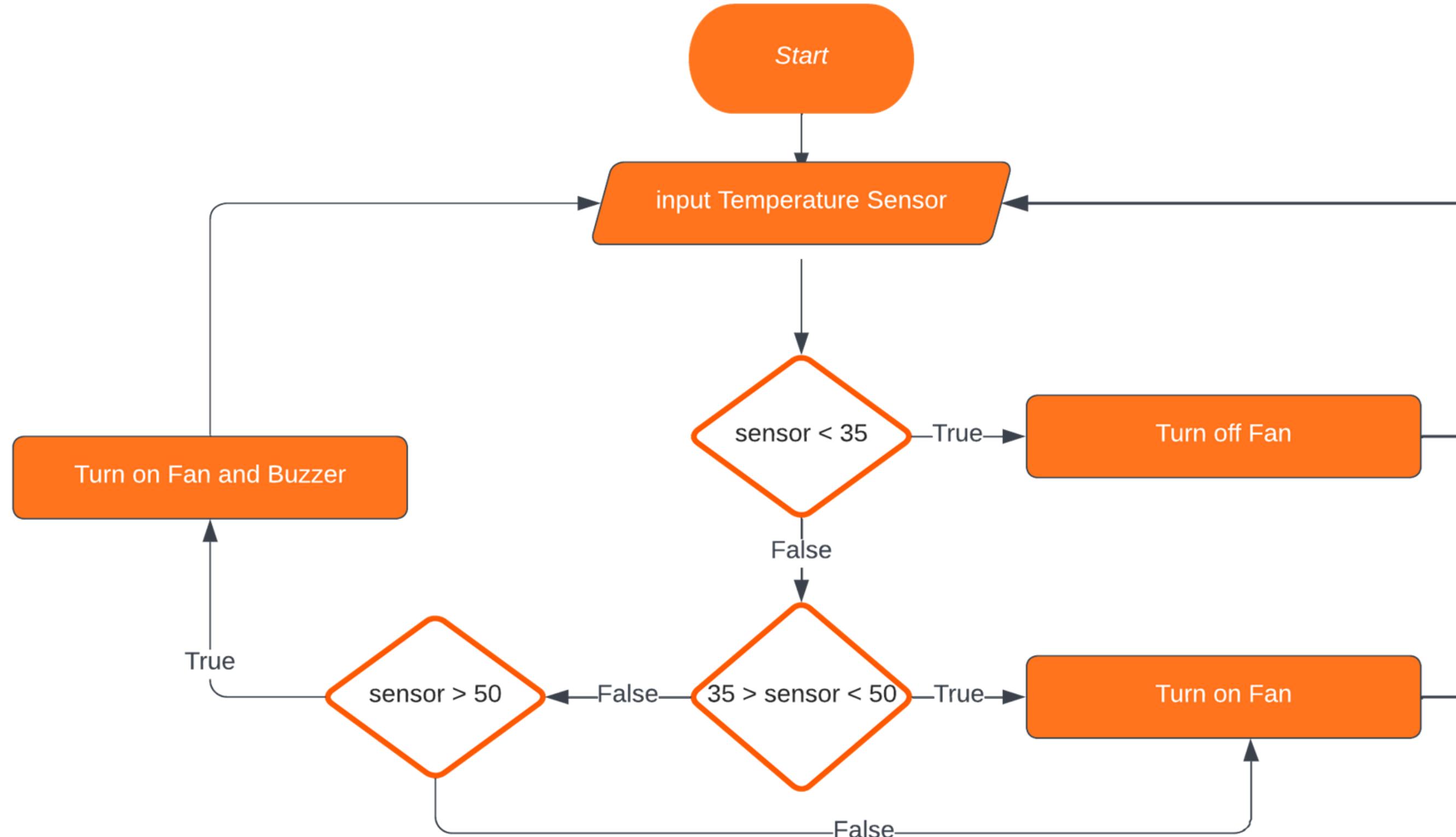
Rain Indicator System

System Flowchart



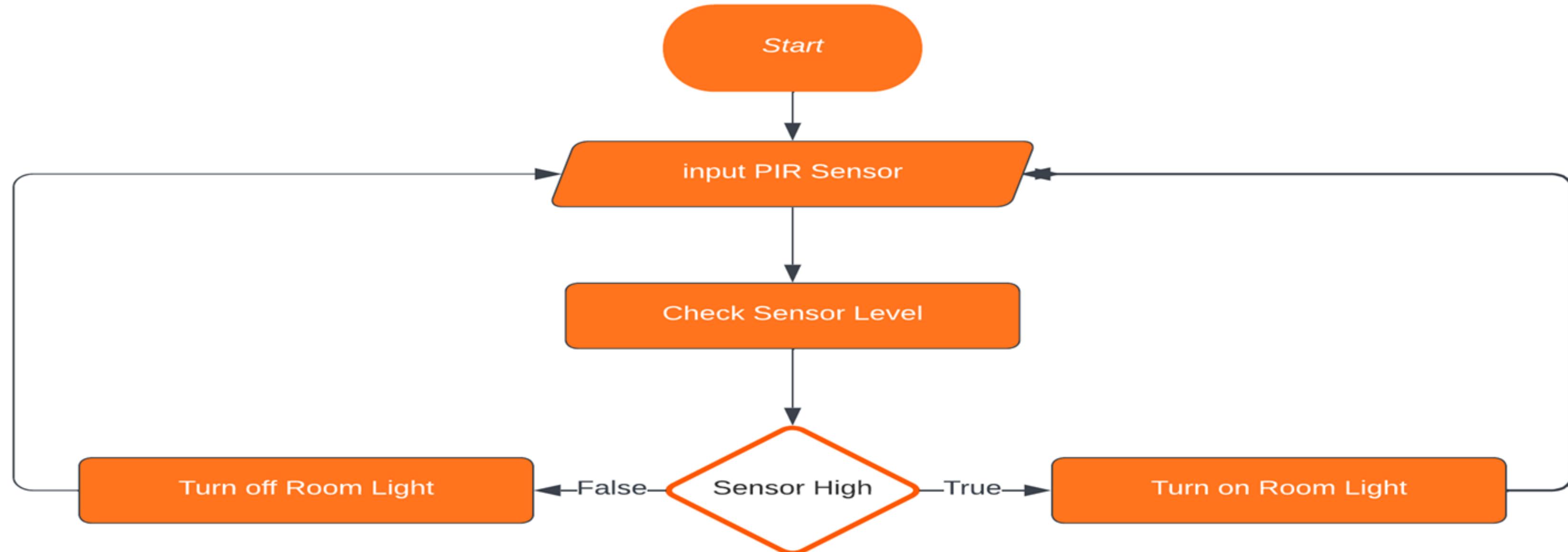
Temperature sensing system for Air Conditioner

System Flowchart



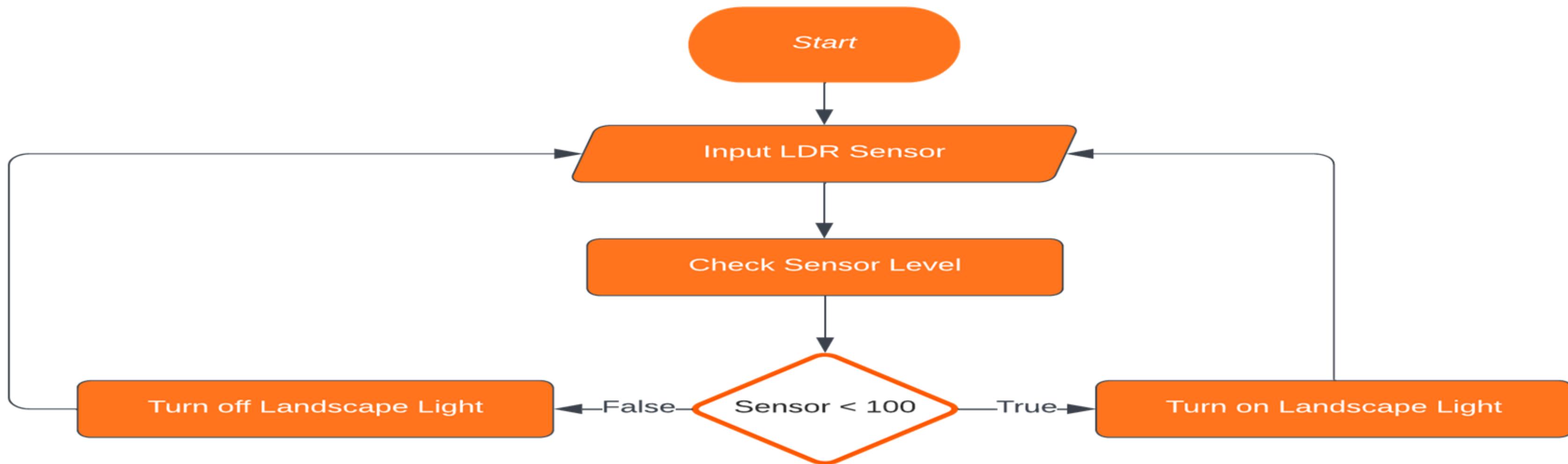
Motion Detection system

System Flowchart



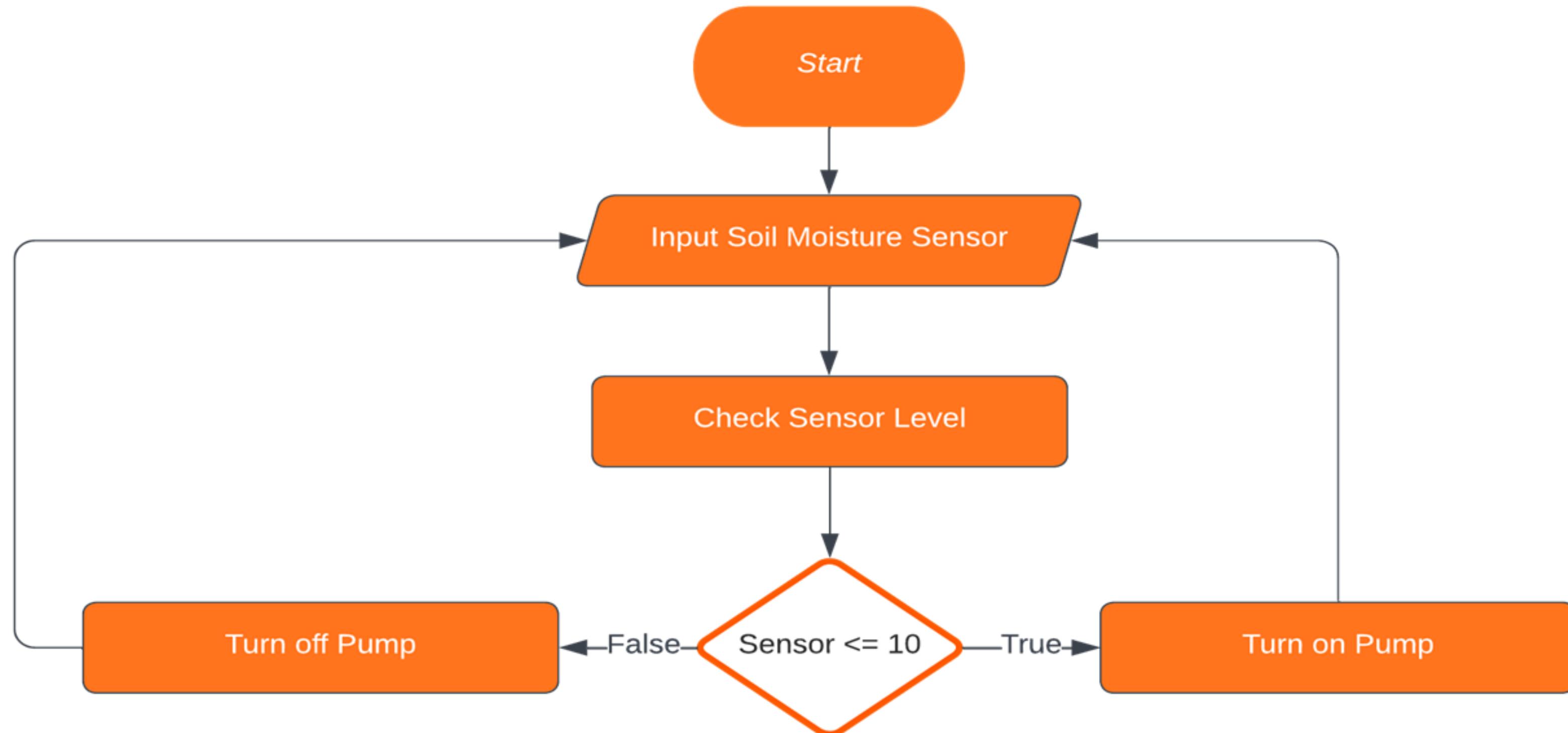
Automatic light control system

System Flowchart



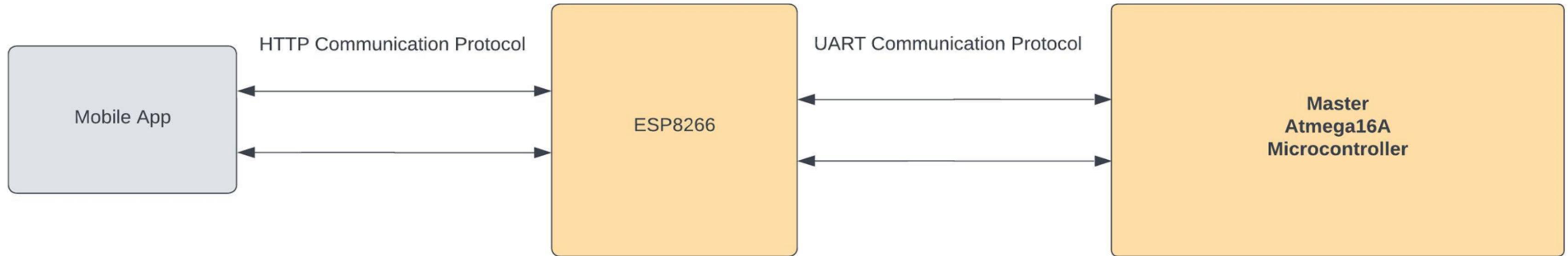
Soil moisture control system

System Flowchart



Wi-Fi control system

System Diagram

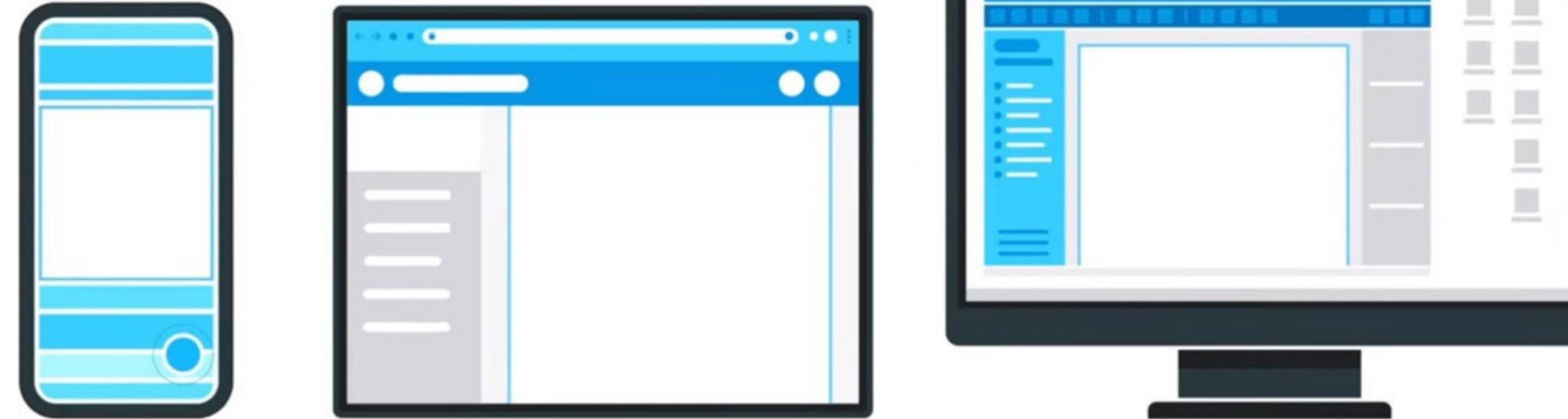


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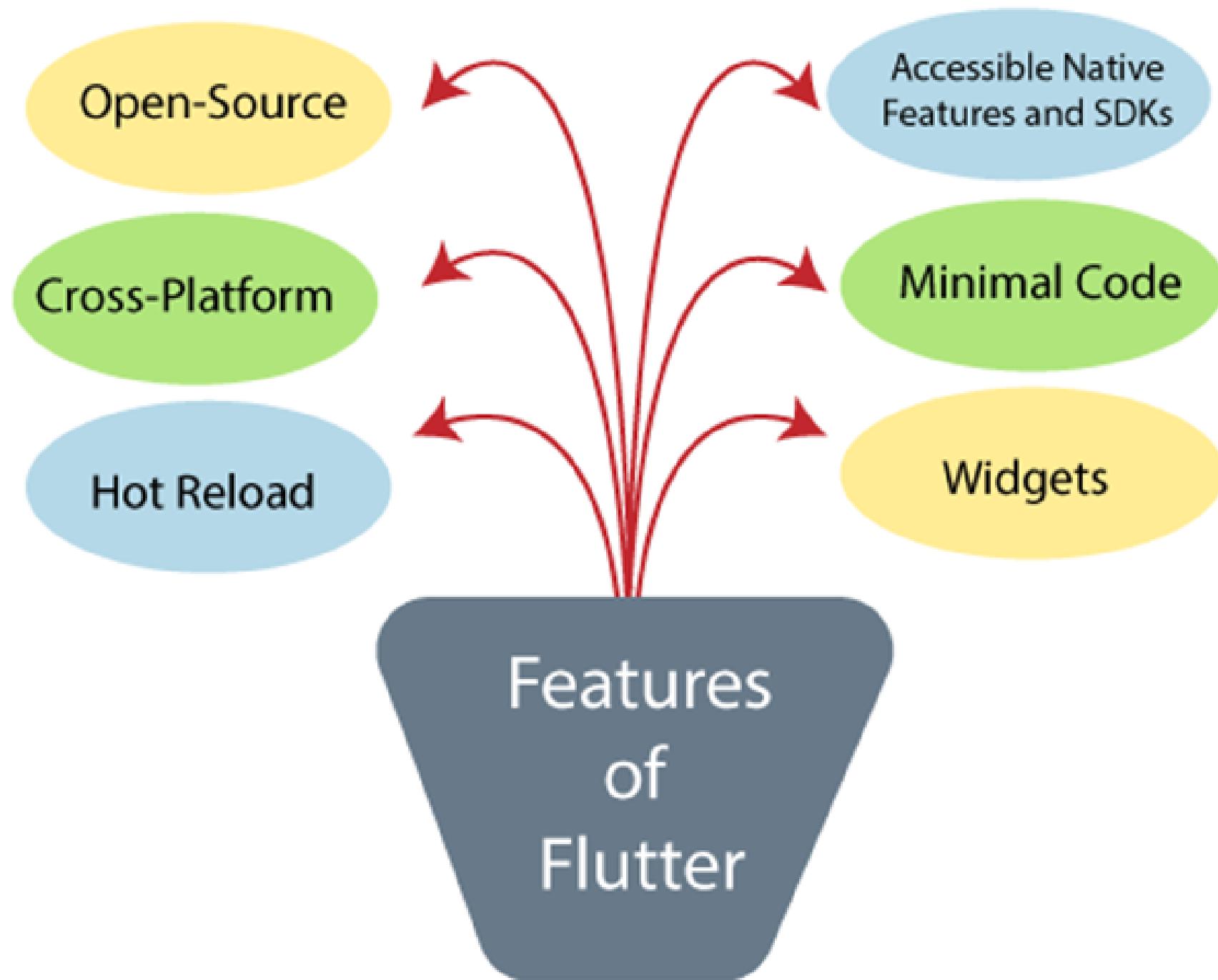
Mobile Application

What is flutter ?

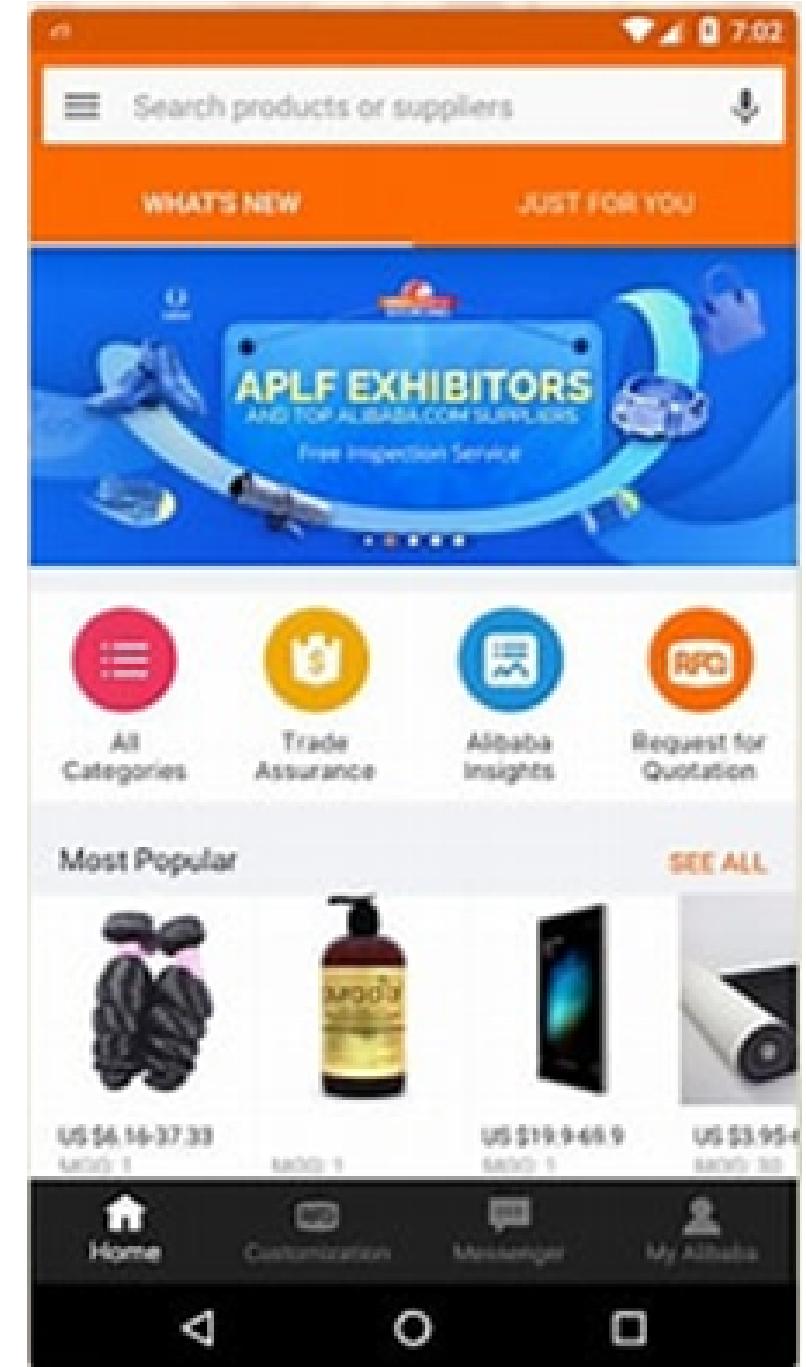
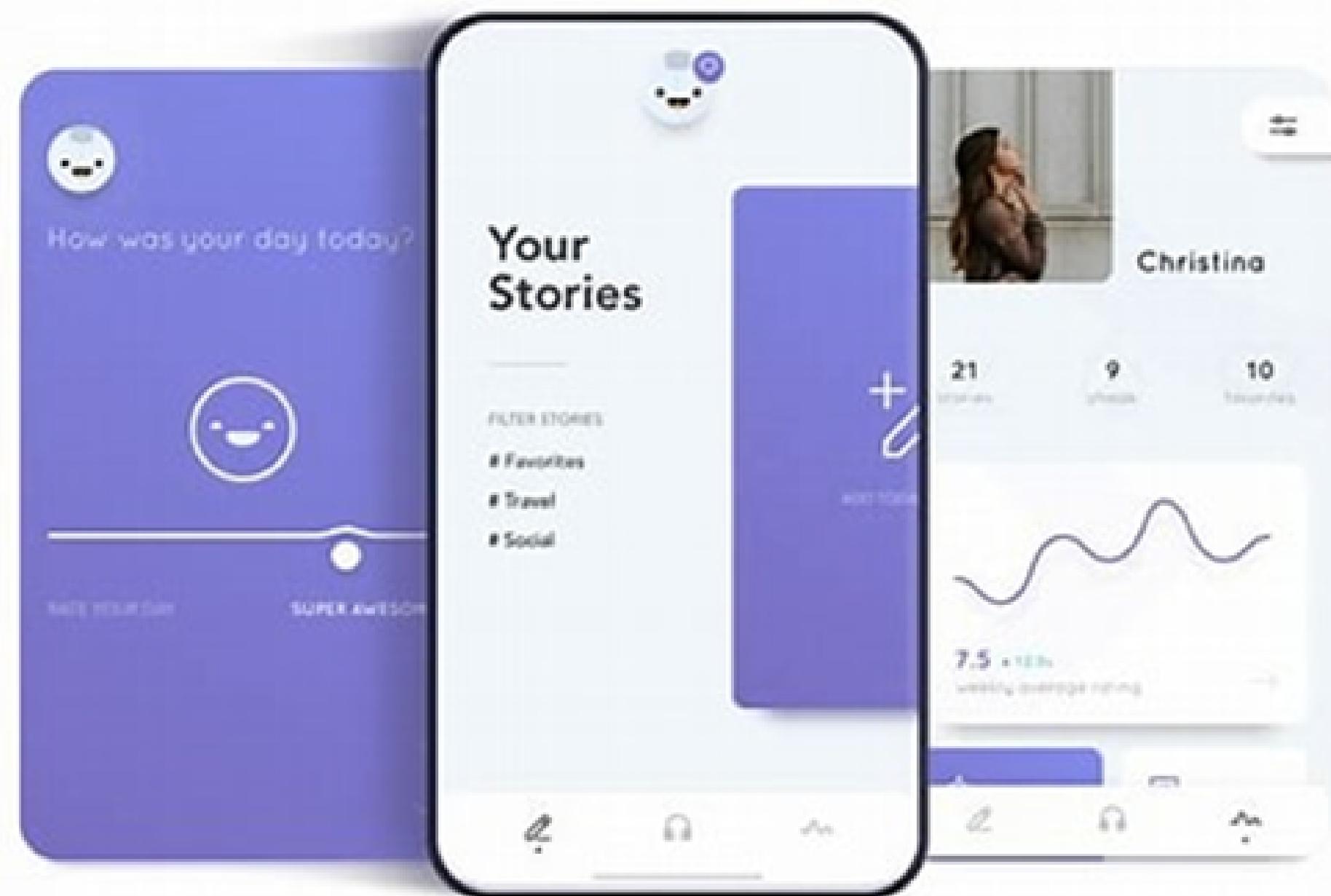
Flutter is an open source framework by Google for building beautiful, natively compiled, multi-platform applications from a single codebase.



Why using flutter ?



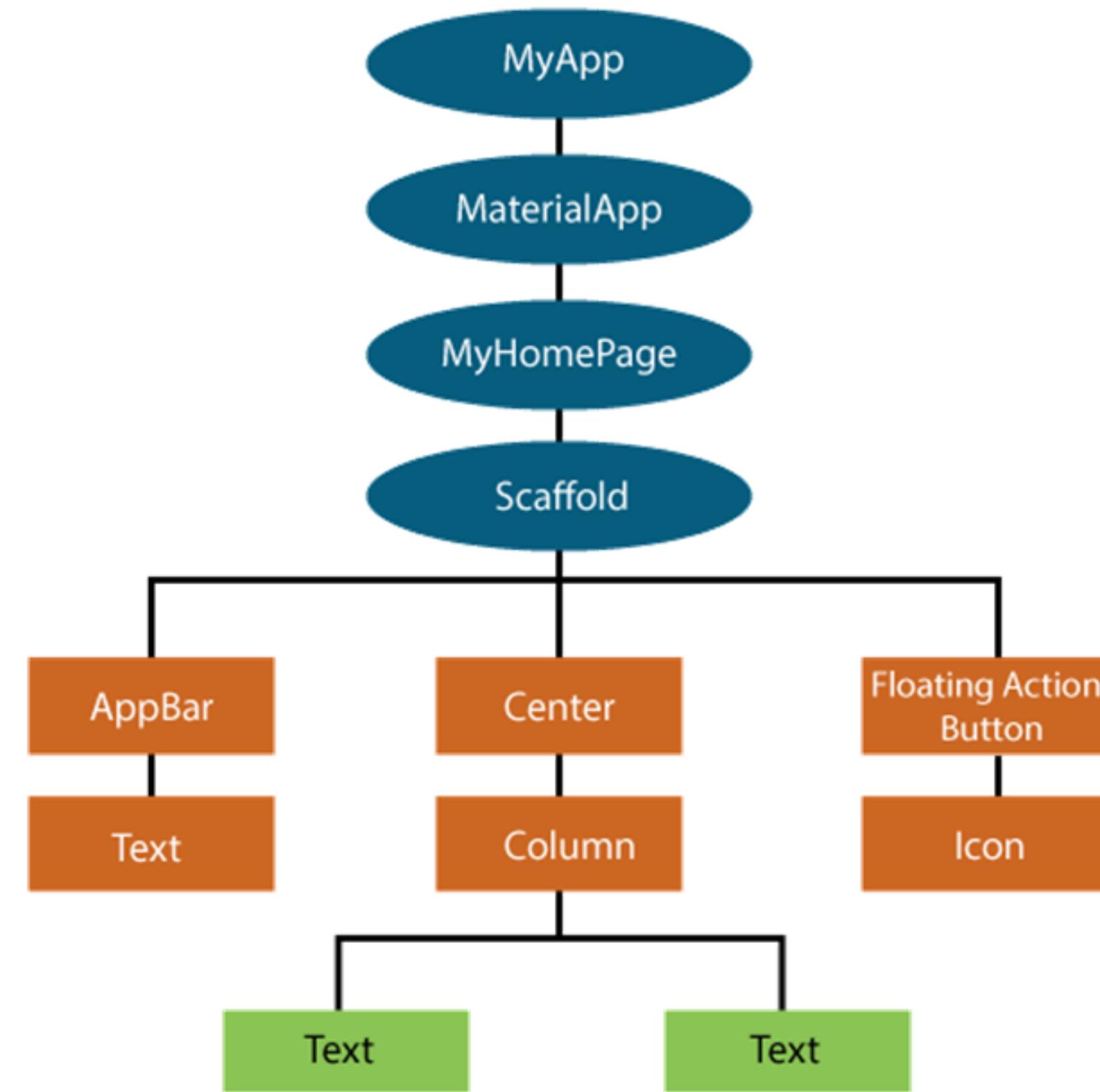
Apps built with flutter?





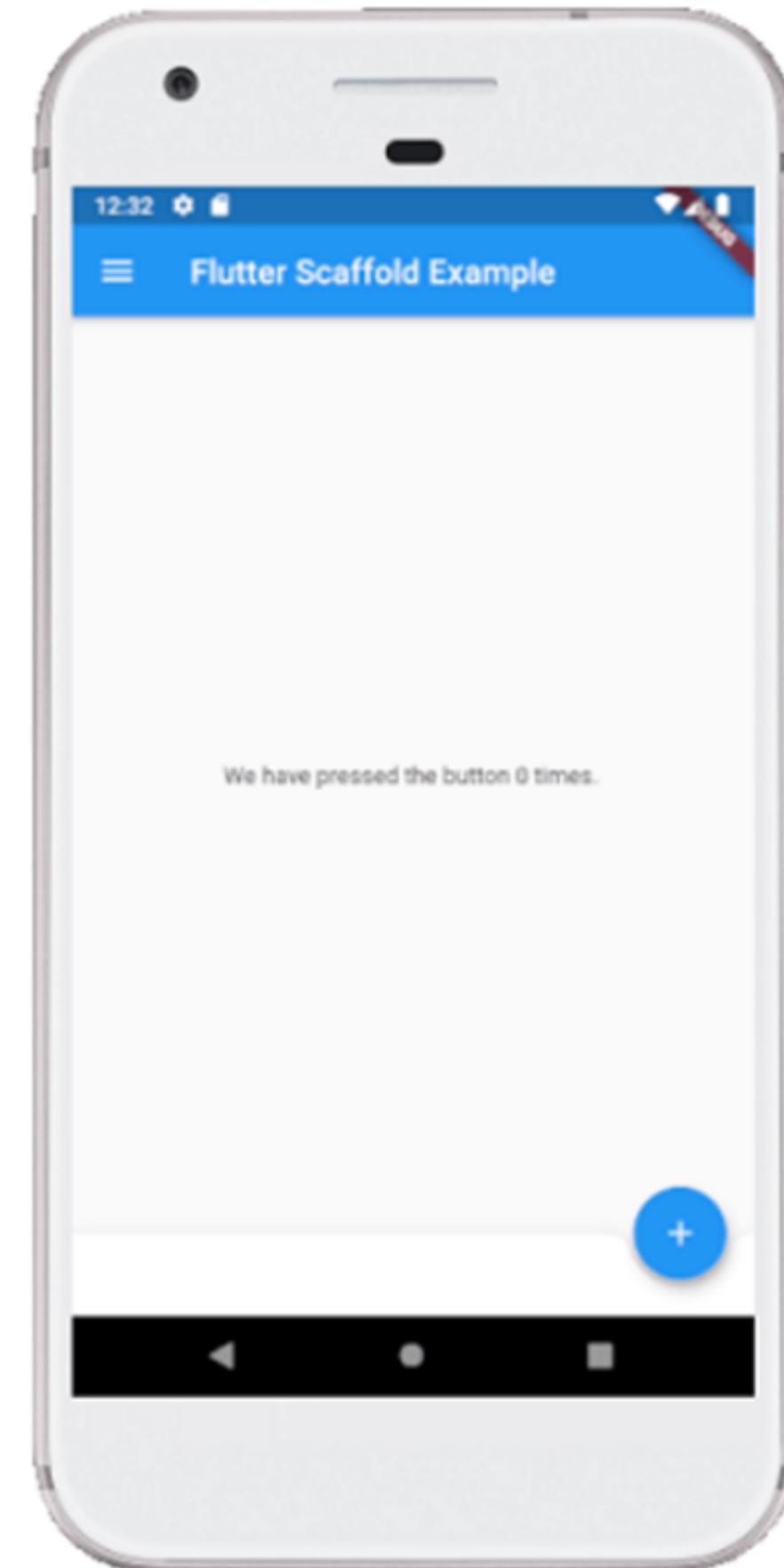
Flutter Platform

Flutter widgets



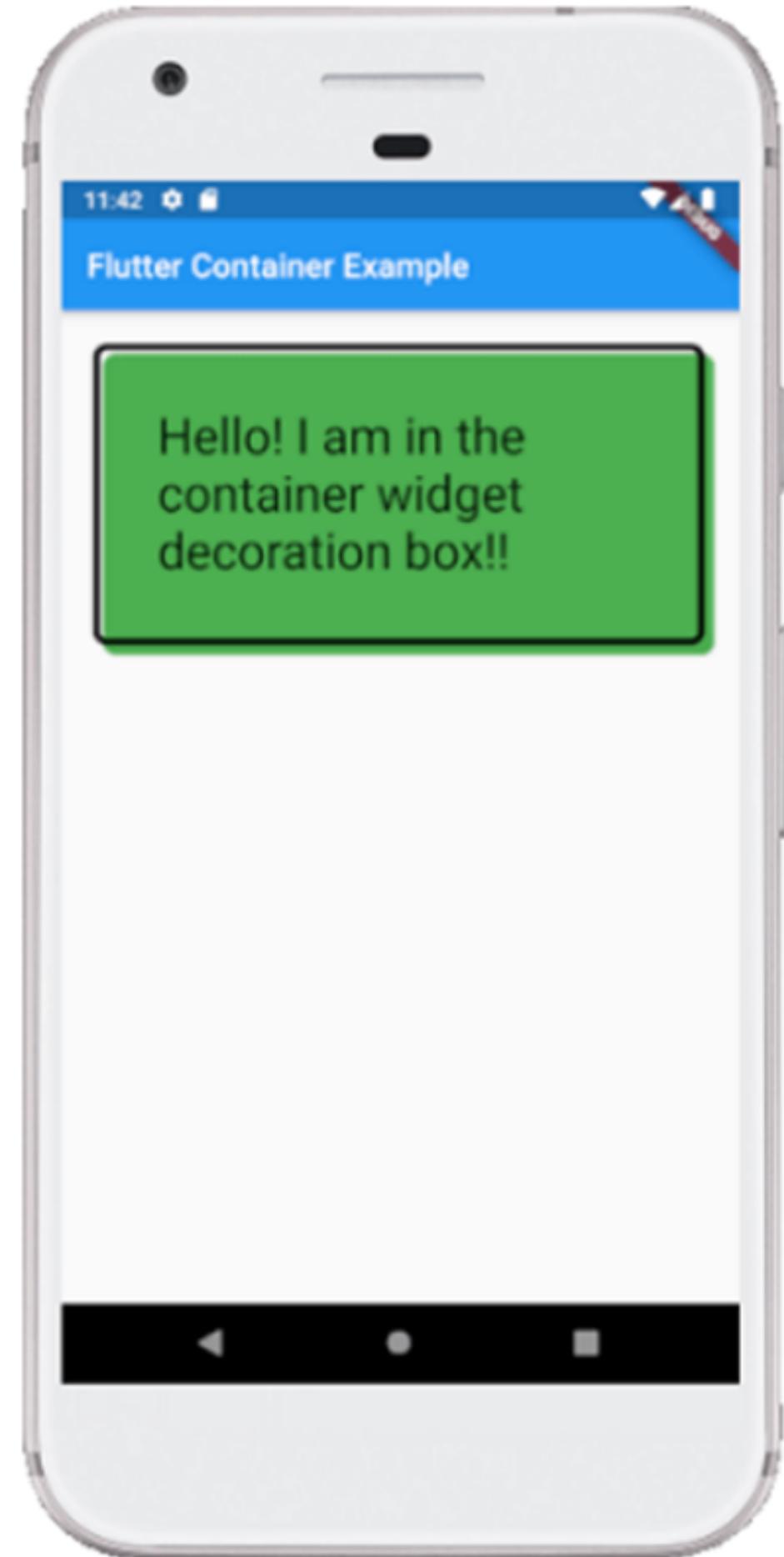
Scaffold Widget

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.



Container Widget

The container in Flutter is a parent widget that can contain multiple child widgets and manage them efficiently through width, height, padding, background color, etc.



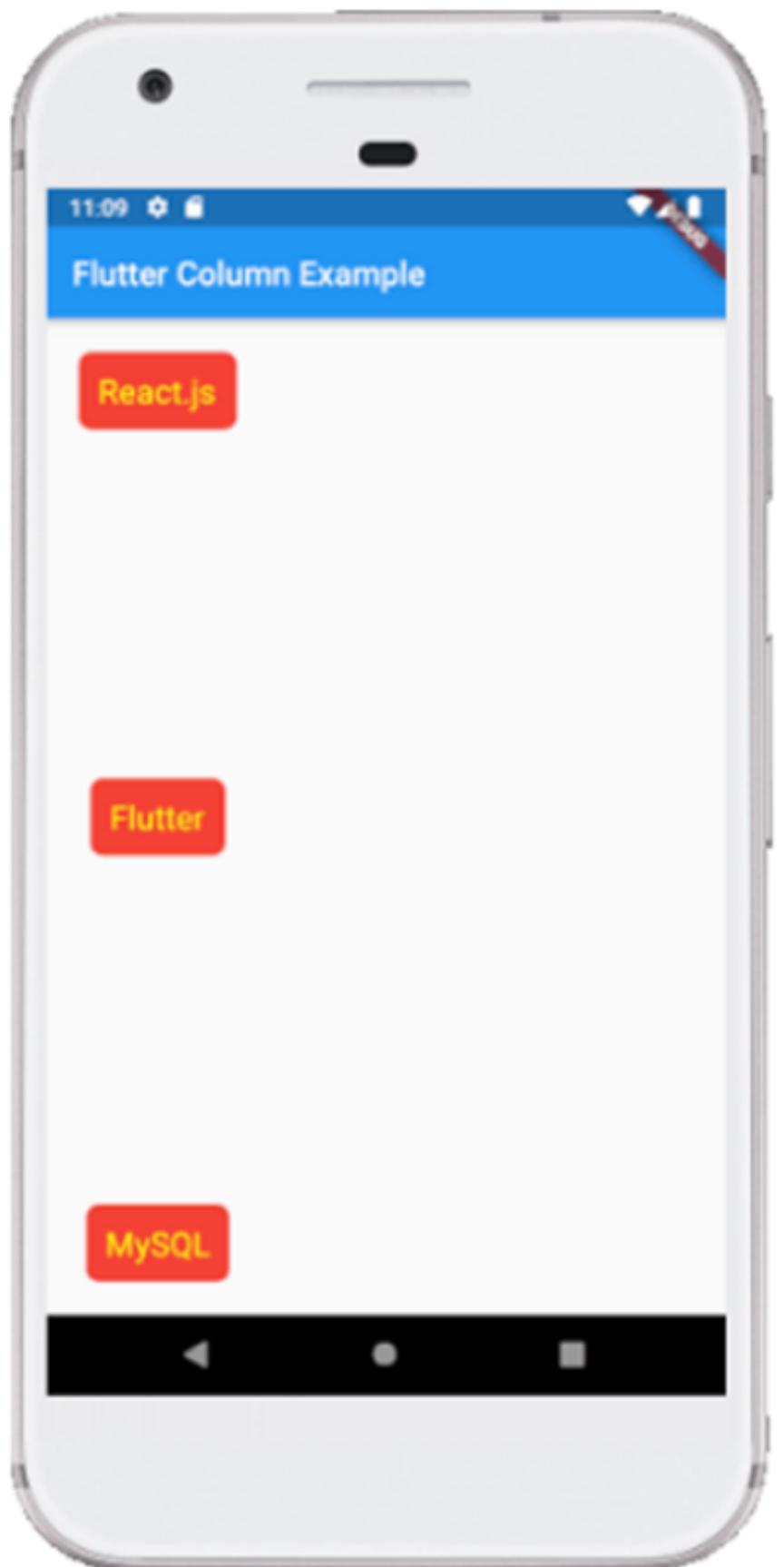
Row Widget

This widget arranges its children in a horizontal direction on the screen. It will expect child widgets in a horizontal array. If the child widgets need to fill the available horizontal space, we must wrap the children widgets in an Expanded widget.



Column Widget

A column widget does not appear scrollable because it displays the widgets within the visible view



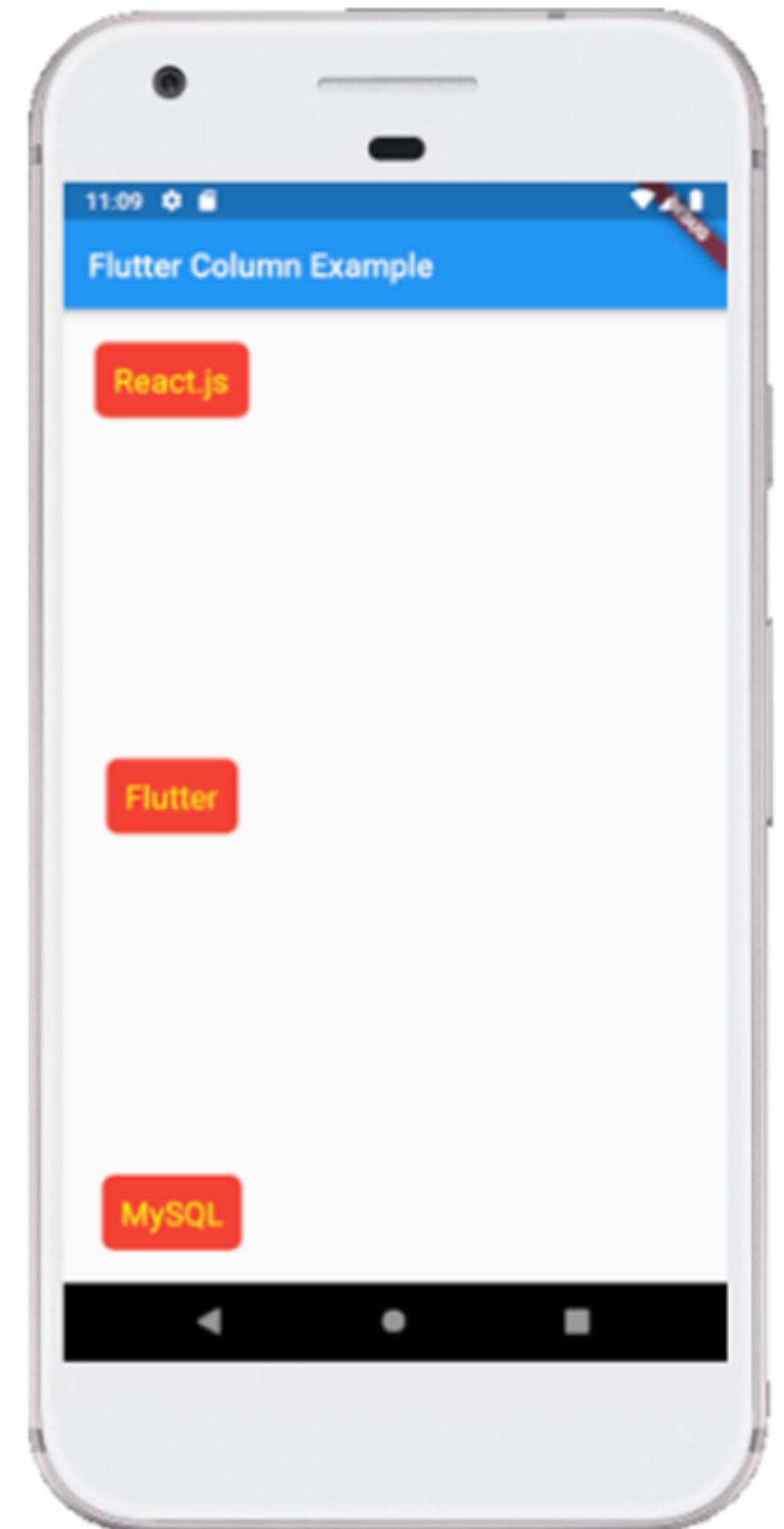
Raised button

It is a button, which is based on the material widget and has a rectangular body.

This button has two callback functions.

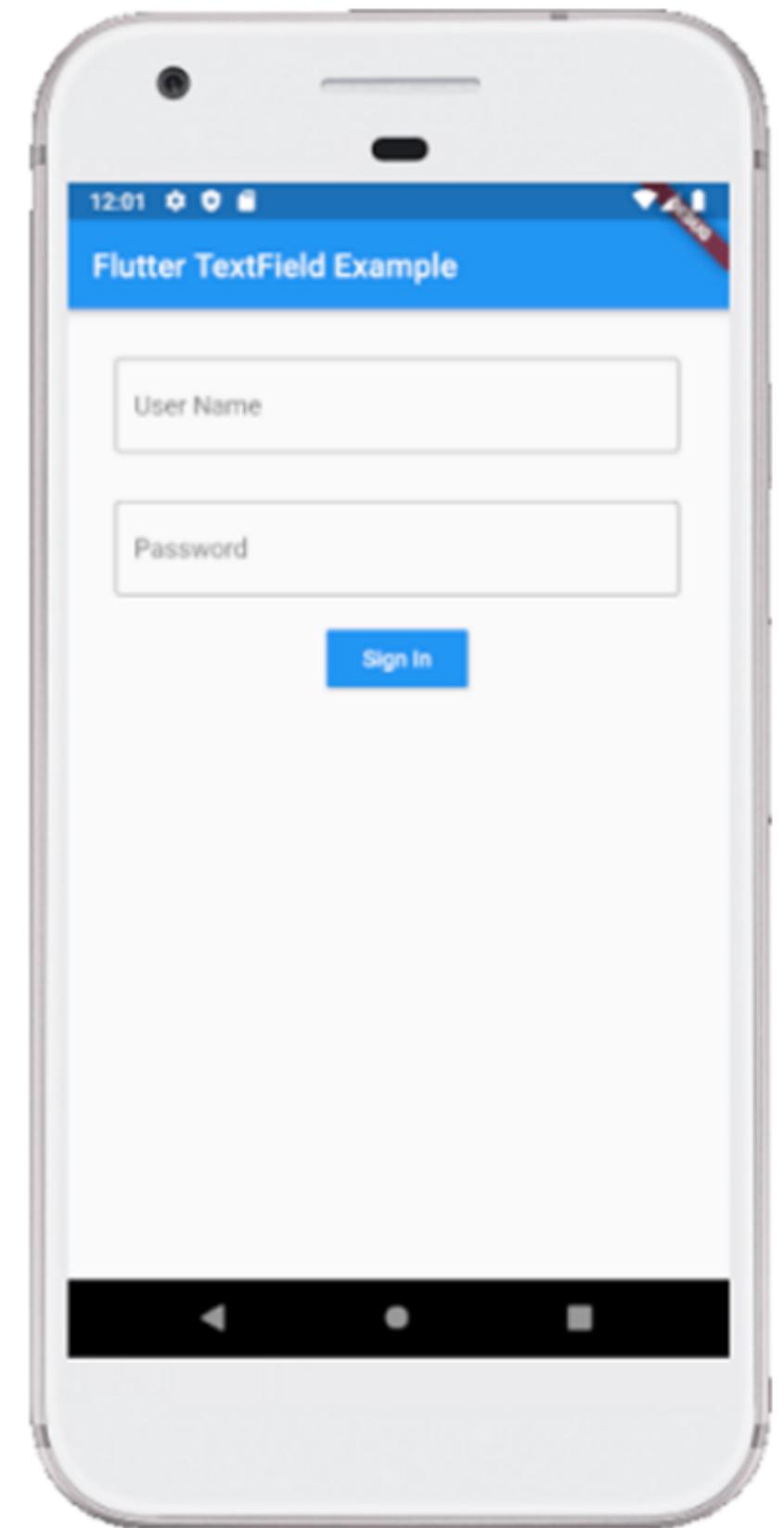
onPressed(): It is triggered when the button is pressed.

onLongPress(): It is triggered when the button is long pressed.



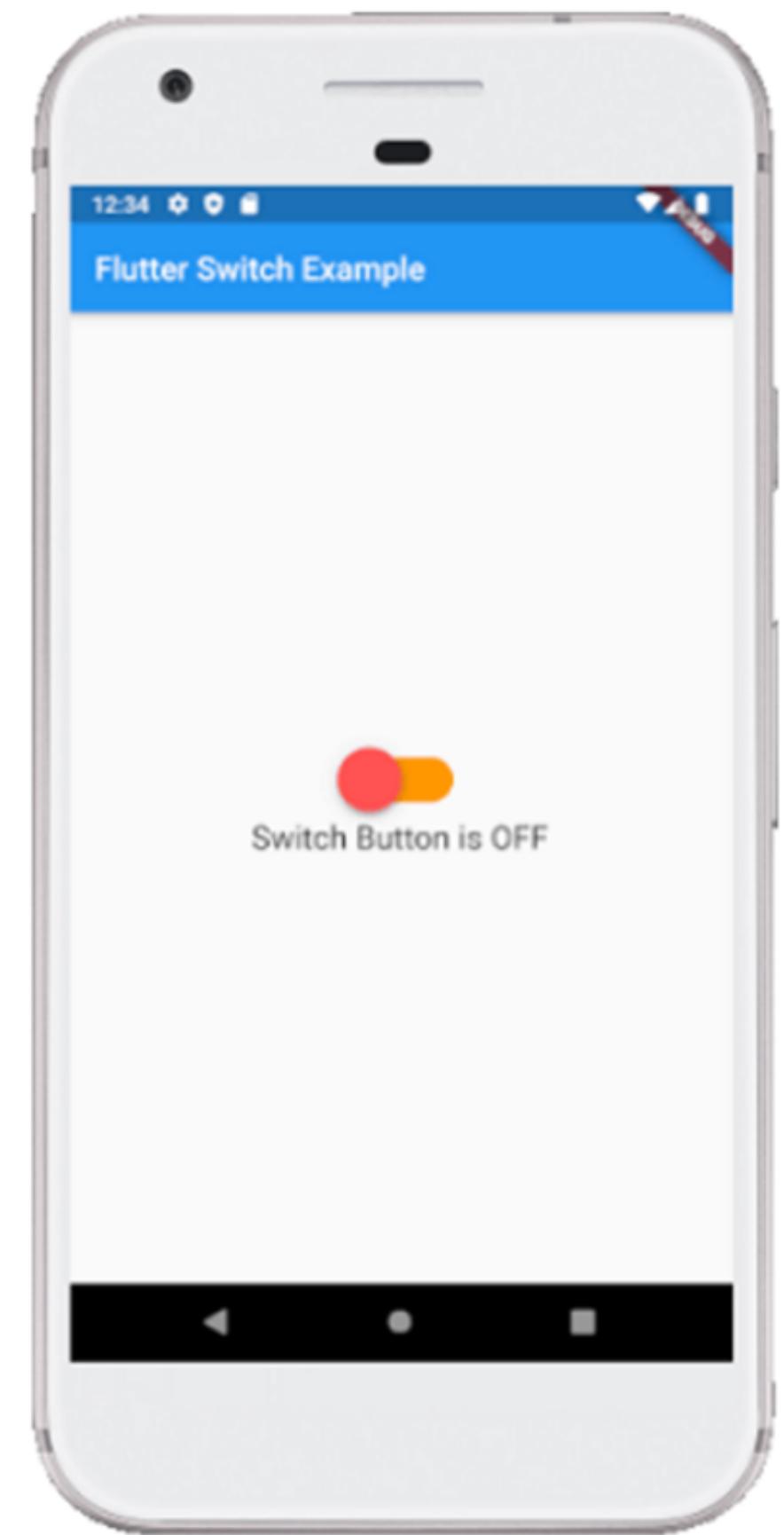
Text field

A Text Field is an input element which holds the alphanumeric data, such as name, password, address, etc. It is a GUI control element that enables the user to enter text information using a programmable code.



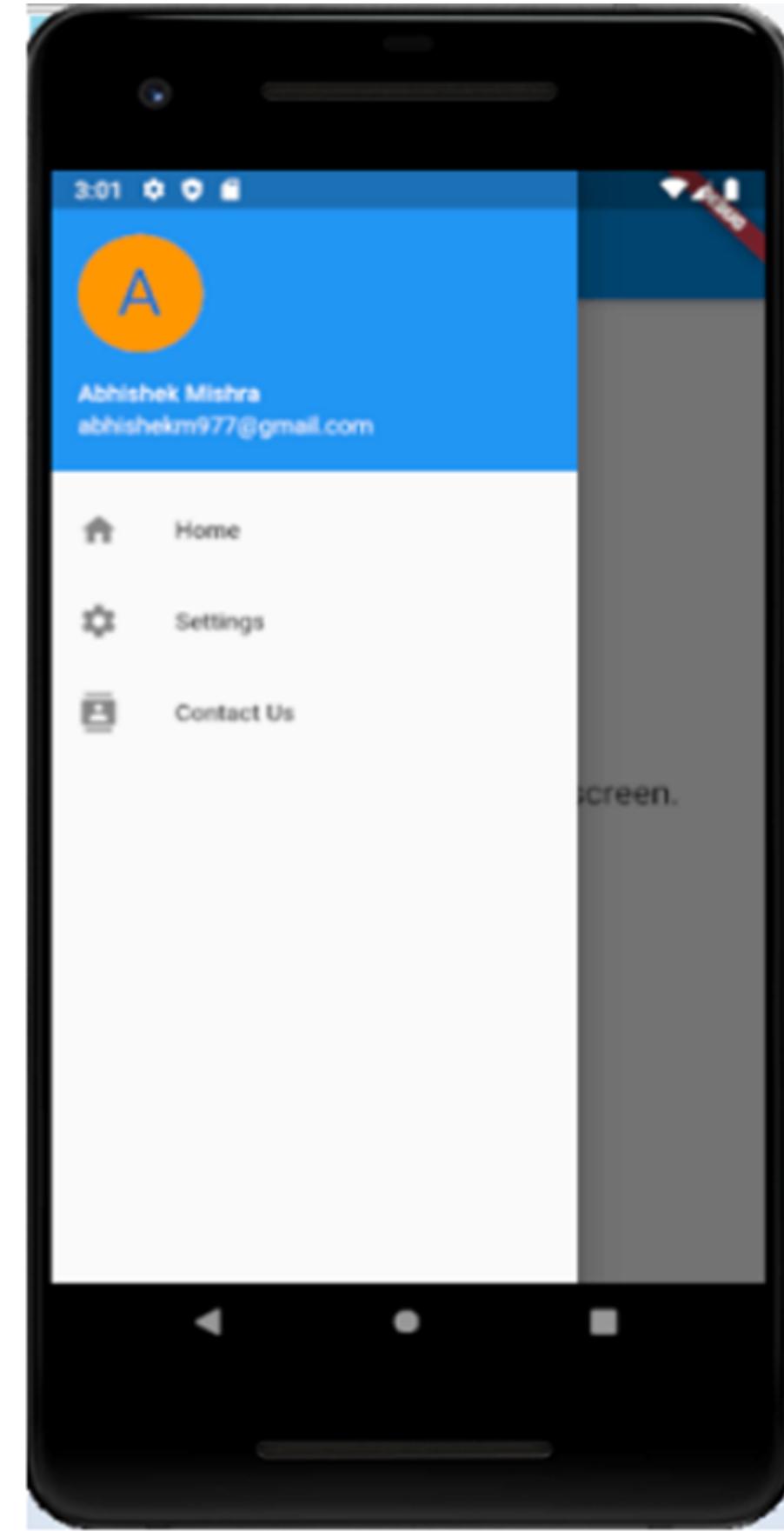
Switch List Tile Widget

A switch is a two-state user interface element used to toggle between ON (Checked) or OFF (Unchecked) states



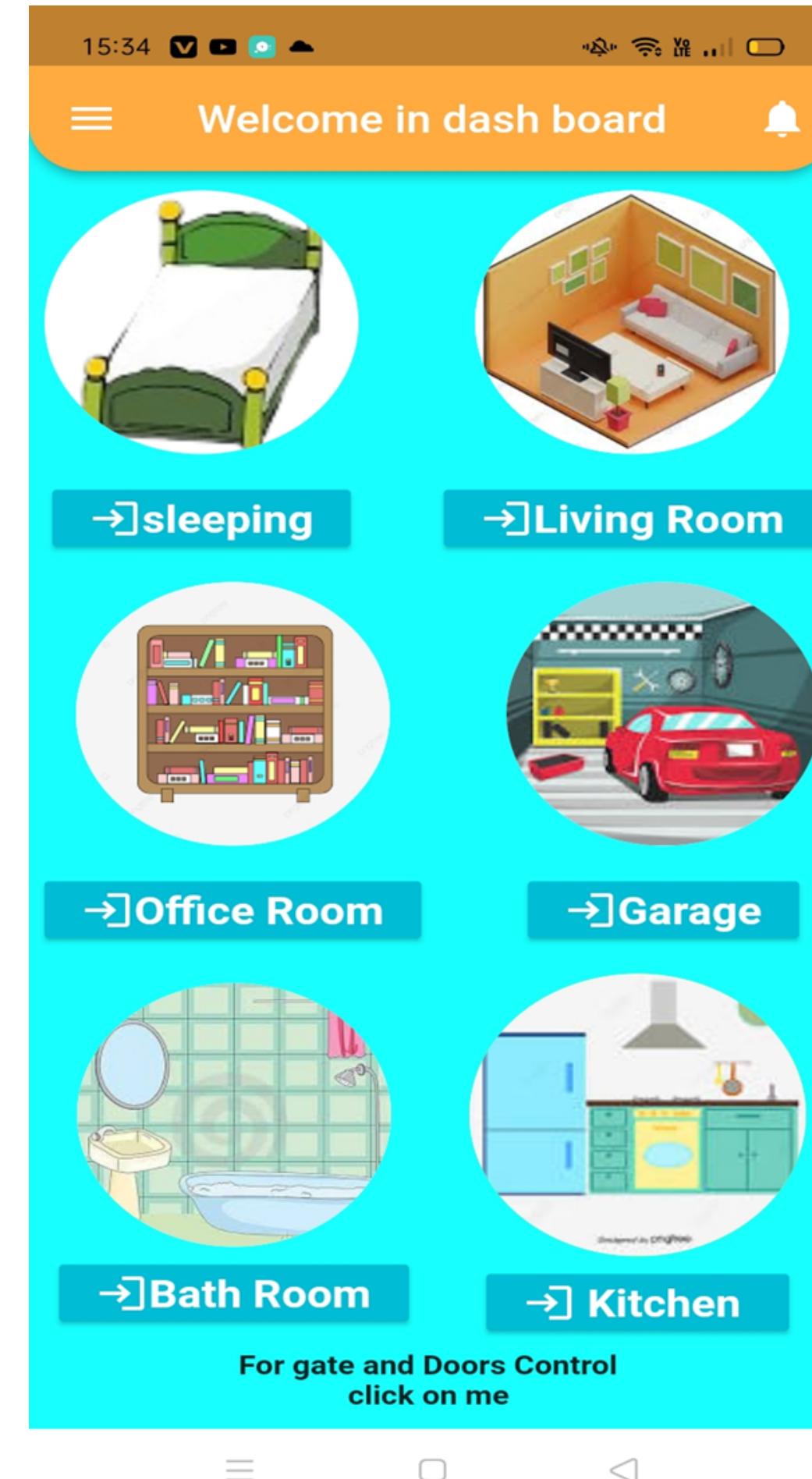
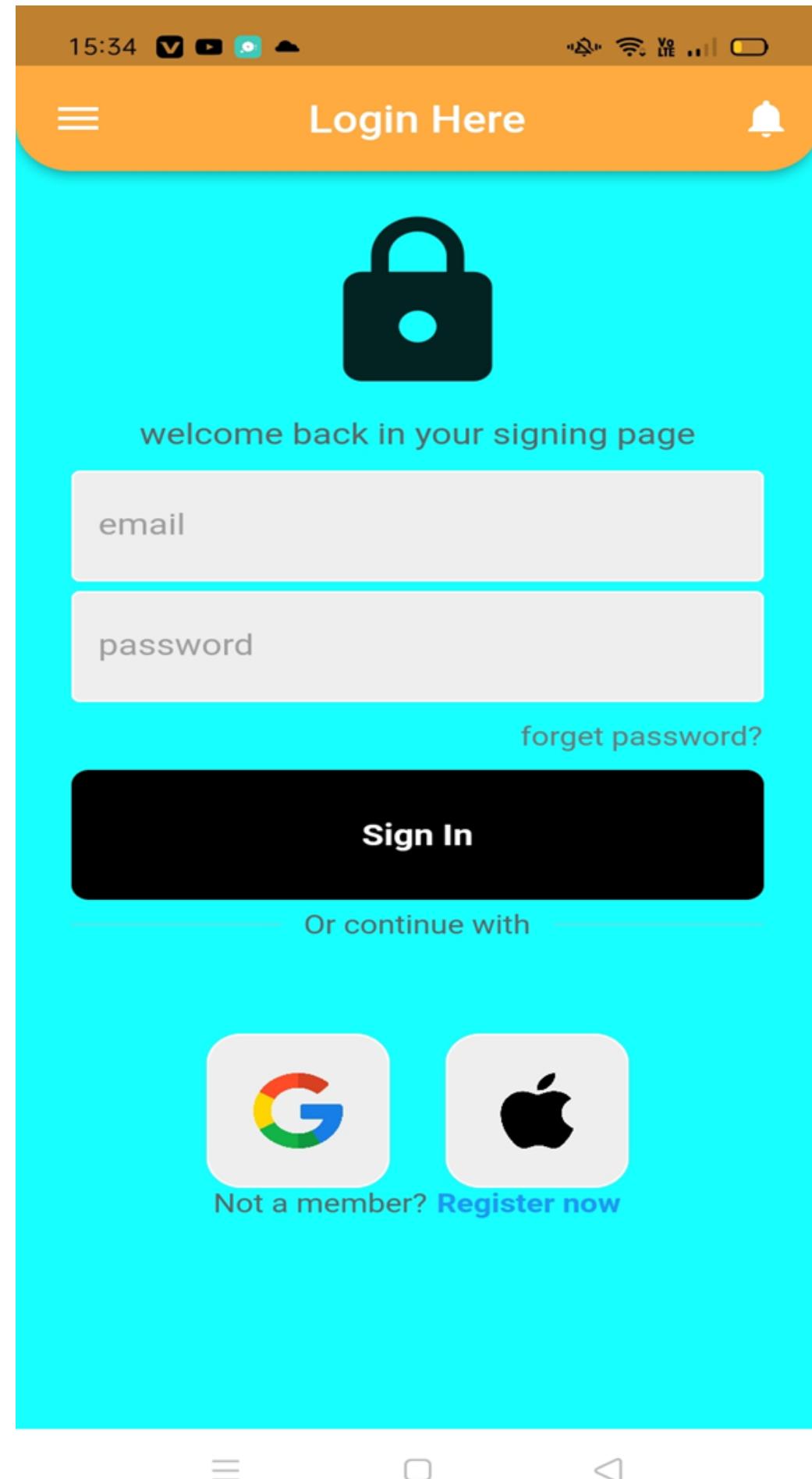
Drawer Widget

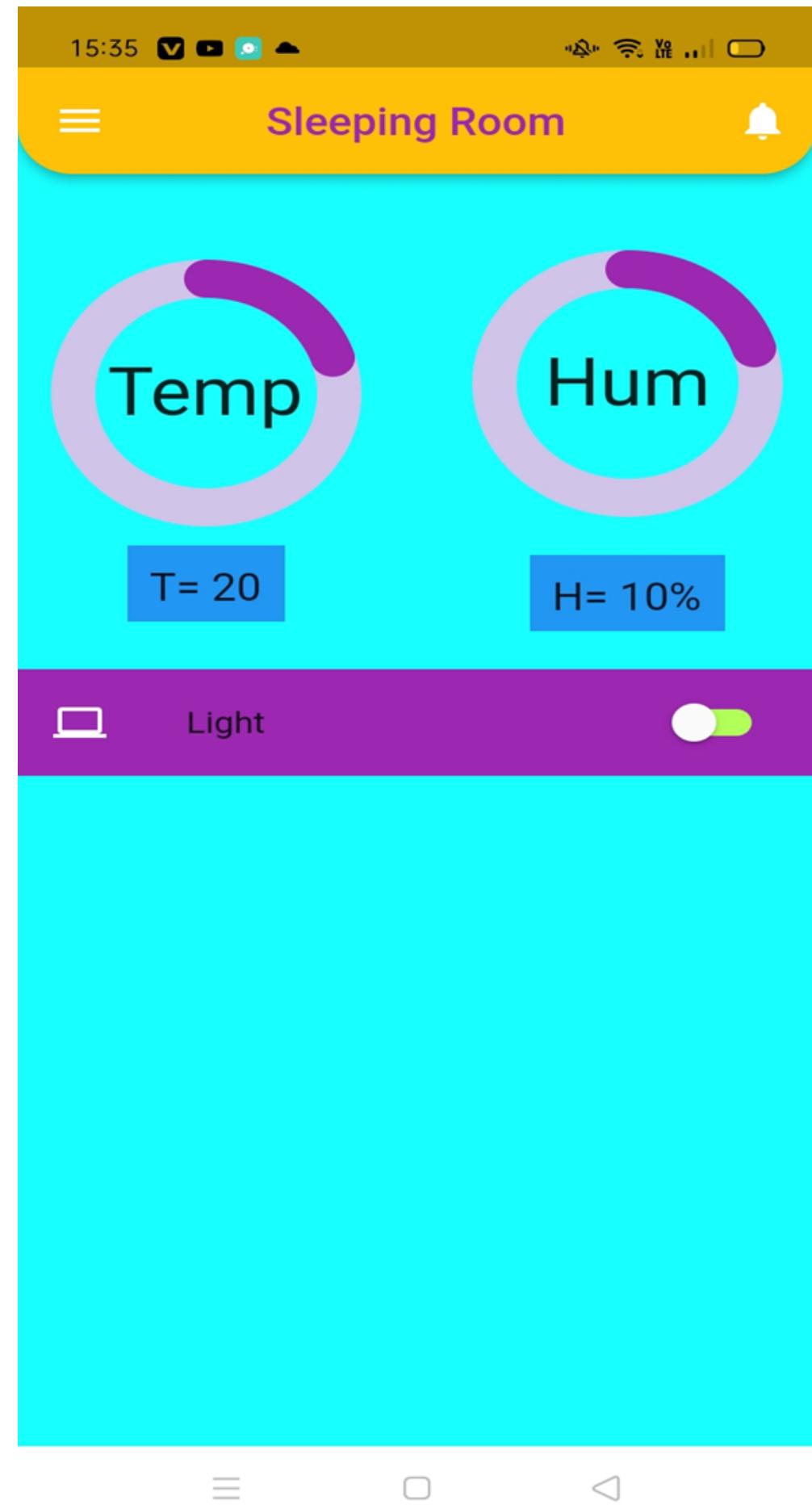
A drawer is an invisible side screen. It is a sliding left menu that generally contains important links in the application and occupies half of the screen when displayed.



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APP SCREEN





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System Security

Hacking Wireless Networks

Wireless Concepts

- **GSM:** universal system used for mobile transportation for wireless network worldwide
- **Bandwidth:** Describes amount of information that may be broadcasted over a connection
- **BSSID:** The MAC address of an access point that has set up a basic service set
- **ISM band:** a set of frequency for the international industrial, scientific, and medical communities
- **Access Point:** Used to connect wireless devices to a wireless network
- **Hotspot:** Places where wireless network is available for public use
- **WiFi refers to IEEE 802.11 Standard**

Example model :

Amendments	Frequency (GHz)	Modulation	Speed (Mbps)	Range (Meters)
802.11 (Wi-Fi)	2.4	DSSS, FHSS	1, 2	20 – 100
802.11a	5	OFDM	6, 9, 12, 18, 24, 36, 48, 54	35 – 100
	3.7			5000
802.11b	2.4	DSSS	1, 2, 5.5, 11	35 – 140
802.11d	It is an enhancement to 802.11a and 802.11b that enables global portability by allowing variations in frequencies, power levels, and bandwidth			
802.11e	It provides guidance for prioritization of data, voice, and video transmissions enabling QoS			
802.11g	2.4	OFDM	6, 9, 12, 18, 24, 36, 48, 54	38 – 140
802.11i	A standard for wireless local area networks (WLANs) that provides improved encryption for networks that use 802.11a, 802.11b, and 802.11g standards; defines WPA2-Enterprise/WPA2-Personal for Wi-Fi			
802.11n	2.4, 5	MIMO-OFDM	54 – 600	70 – 250
802.15.1 (Bluetooth)	2.4	GFSK, π/4-DPSK, 8DPSK	25 – 50	10 – 240
802.15.4 (ZigBee)	0.868, 0.915, 2.4	O-QPSK, GFSK, BPSK	0.02, 0.04, 0.25	1 – 100
802.16 (WiMAX)	2 – 11	SOFDMA	34 – 1000	1609.34 - 9656.06 (1-6 miles)

Wireless Encryption

- **WPA (WIFI Protected Access)**: Stronger encryption with TKIP
- **WPA2**: Stronger data protection with AES
- WPA-2 personal uses a pre-shared key to protect access
- WPA-2 Enterprise includes EAP or RADIUS for centralized authentication w/Kerberos etc.



Wireless Threats

- Access Control Attacks
- Availability Attacks
- Authentication Attacks
- Rogue Access Point Attack
- Client Mis-Association
- Honey spot Access Point Attack
- AP MAC Spoofing

Wireless Hacking Methodology

WIFI Discovery

Discovers the WIFI network

GPS Mapping

Attackers create a map of discovered Wi-Fi network and create a database

Wireless Traffic Analysis

identify vulnerabilities,
WIFI reconnaissance,
Tools for Packet Capture
& Analysis

Mobile Platform Attack Vectors

OWASP Mobile Top 10 Risks:

- Insecure Data Storage
- Assumption malware won't enter system. Jailbreaking bypasses encryption
- Unintended Data Leakage
- When a user places sensitive data in a location accessible to other apps
- Broken Cryptography
- Weak encryption algorithms. Users should use ARS or 3DES algorithms
- Security Decision via Untrusted Inputs
- Apps use protection mechanisms dependent on input values

Anatomy of a Mobile Attack

- The device -> the network -> the data center
- Clicking Jacking
- Framing
- Drive By Downloading
- Man in the Middle
- Data Caching



THANK YOU

