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SMART BINS FOR SMART LIFESTYLE

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Abstract: A smart city is incomplete without a smart waste management system, as they play an important role in keeping the environment clean and hygienic. This paper reviews about smart ways and methods to monitor, collect the waste and send alerts to authorities like corporation or local waste disposal team which results in saving the fuel, money and work hours. In order to provide an energy efficient system, solar panel is used to power-up the batteries. In bad weather, the battery is used as a power backup which has been developed for both rural and urban areas in order to give better solution for the issues in disposing the waste.

Index Terms – Arduino UNO, Raspberry Pi, AVR Microcontroller, Blynk App, Rain sensor, Ultrasonic Sensor, ESP8266,etc

I. INTRODUCTION

The first smart bin was invented in 2013 in France. Since then smart waste management has become the biggest and most influential in some of the smart cities. The smart bins powered by technology and AI have emerged across various big cities. Before the invent of smart bins, traditional dust bins had a lots of drawbacks. Few of them are: collection of waste from bins which are less than 50% full, improper disposal of waste which are scattered around the bins breed bacteria, flies that hatch offspring in eatables causing food poisoning and various other diseases, besides flies the animals like stray dogs and rats can spread diseases, unpleasant odors that leads to suffocation, littering of waste in open space that cause unhygienic environment etc. Even the garbage collector's work becomes inefficient by emptying not so full bins and by not so necessary trips. Waste disposal by hospitals that are biomedical, untreated, industrial waste etc., are harmful to all living beings i.e., it causes infectious and deadly diseases. In order to overcome all those hazardous impacts, smart bins are being used. Smart bins supports the development of safer and hygienic community with the applications of sensors or manually operated foot pedals that helps to dispose the waste without even touching them with hands. Wastage of resources is minimized with the help of smart bins and the waste management system becomes efficient. Smart bins are indeed a boon to every stakeholders of waste management i.e., smart bins not only enhance operational efficiency but also reduce managerial cost, exploitation of resources and road –side pollutions. The smart bins are ideally suitable for busy places like parks, theatres, campuses, hypermarkets, theme parks, airports, railways etc. in this paper, the effective and efficient application of sensors and various hardware and software components in smart bins are overlooked.

II. HARDWARE AND SOFTWARE DESCRIPTION

HARDWARE COMPONENTS-SENSORS

a) **Ultrasonic Sensor**

HC-SR04 is an ultrasonic sensor used for measuring the distance by ultrasonic waves and the range of detecting objects from 2cm to 400cm. Distance can be measured by equation. The targeted distance can be calculated by measuring the time between an ultrasonic wave is received and transmitted. When the sensor detects the person, it sends signals to the Arduino, which activates the Servomotor to automatically open the lid of Smart bin.

Fig.1: Ultrasonic Sensor

b) **PIR Sensor**

A Passive InfraRed sensor is an electronic sensor that is often used in PIR-based motion detection. In smart bin, it sends signals to the controller when the motion is detected within the sensor's range based on the human body temperature. The detection range is within 10m(adjustable)

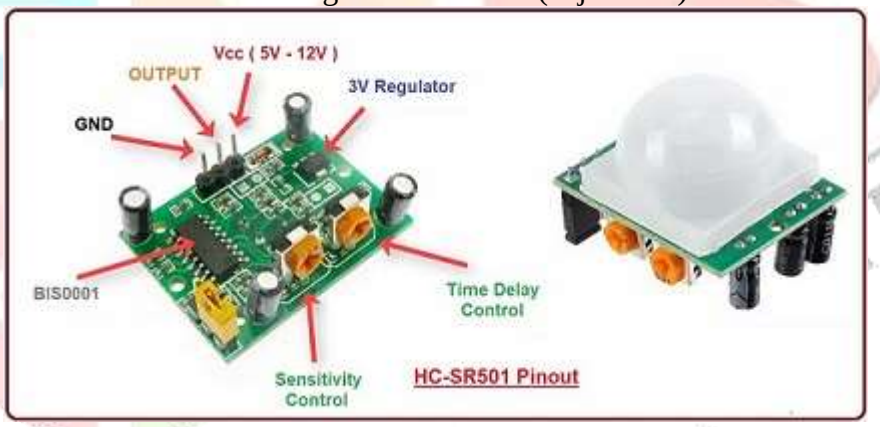


Fig.2: PIR Sensor

c) **IR Sensor**

IR sensor can be used for the detection of level of waste in the smart bin and it gives information to the microcontroller. AVR microcontroller gives information to the WiFi IOT module and displays the weight and level of the garbage present in the garbage bins

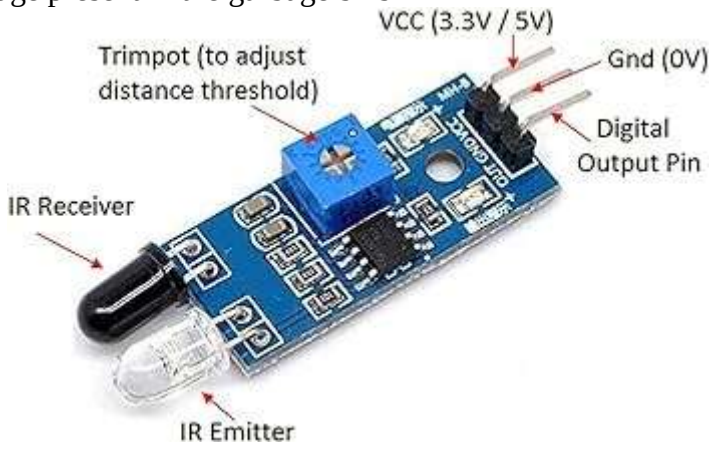


Fig.3: IR Sensor

d) **Proximity Sensor**

The proximity sensors such as inductive, and capacitive sensors along with the help of motors, the machine can automatically segregate the papers, plastics, and metals into their correct bins. The proximity capacitive sensor detects objects with a distance of 4 mm to 60 mm from the sensor head. The dielectric value of the waste in the bin and the output will be processed by a proximity sensor which is then connected to the microcontroller and then the servo motor will work in the process of sorting waste. The inductive proximity sensor functions as a detector whether the incoming waste is metal waste or not. While the capacitive proximity sensor functions as a detector for incoming waste in the form of plastic bottles or not. The plastic sensor segregates biodegradable and non- biodegradable waste and vegetable peel as well.

Fig.4: Proximity Sensor

e) **RFID Sensor**

Placing RFID tags on smart bins enhances efficiency by automating and optimizing waste collection processes. These tags help track and manage individual waste containers, enabling route optimization based on fill levels, reducing vehicle fuel consumption and ensuring timely collections.

Fig.5: RFID Sensor

f) **GSM Module**

A GSM module is an electronic device that allows communication between the devices and the GSM mobile network usually consists of a SIM card slot, an antenna and a set of electronics that allows communication with the mobile network. The GSM module enables remote communication using AT commands via UART. When the smart bin gets filled, alert messages will be sent to the respective authorities.

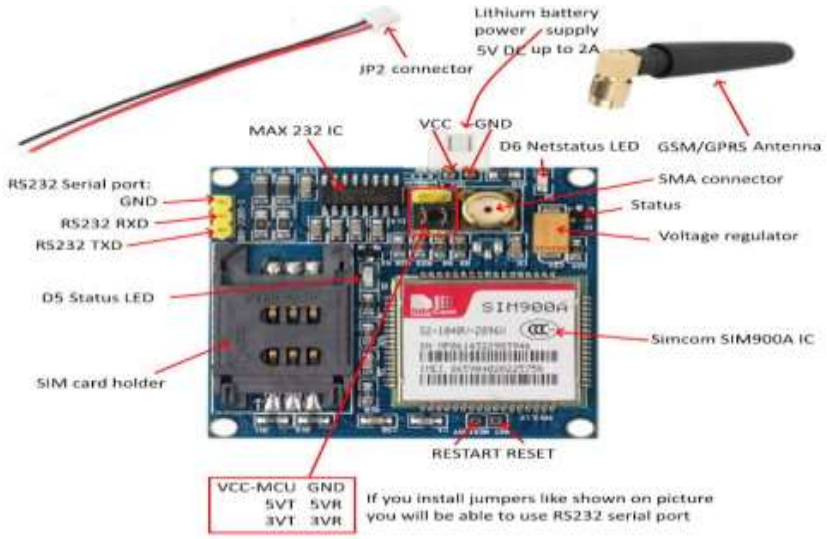


Fig.6: GSM Module

g) **GPS Module**

GPS (Global Positioning System) is a tracking device that is used to track the precise location of the smart bin. With the help of the satellite, the smart bin location can be found which gives exact latitude and longitude of the bin location. Once the location of the smart bin is found, the information will be sent to the truck driver for collecting the waste.

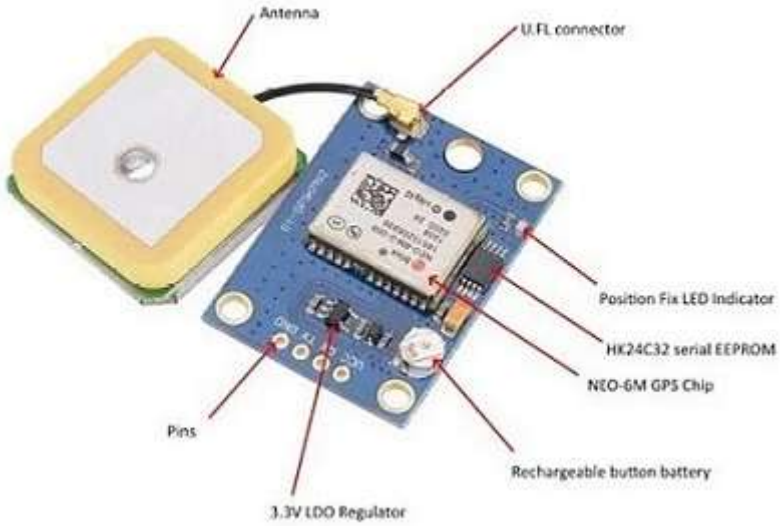


Fig.7: GPS Module

h) **NodeMCU ESP8266**

NodeMCU ESP8266 is a cost-effective and versatile WiFi development board, which is specifically designed for IoT products. It is powered by the ESP8266 chip, which integrates a microcontroller, Wi-Fi module, and necessary peripherals onto a single board for powering and retrieving values from other components such as the GPS module and the Ultrasonic Sensor. It also features multiple input and output interfaces like UART, I2C, SPI, and GPIO which makes it easier to interface with other hardware modules. Many features of the ESP8266 can be accessed with the help of ESP-12 module. The module supports the 802.11b/g/n protocol and has a range of up to 100 meters.

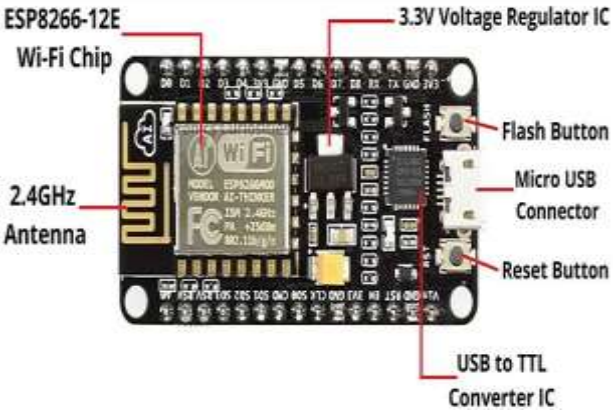


FIG. 8: ESP8266 NODEMCU

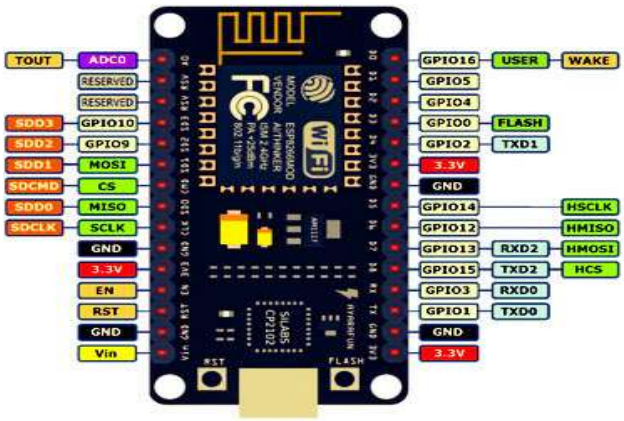


FIG.9: ESP8266 PINOUT

i) **Temperature and Humidity Sensor**

The DHT11 is a high precision digital humidity and temperature sensor used to distinguish between dry and wet waste. Depending upon the output temperature, dry and wet waste would be segregated. It uses a capacitive humidity sensor and a thermistor to measure the air in the surrounding, and recognize a digital signal on the data pin. At every 2 seconds, new data will be received the sensors. The level of dryness of waste can be detected with the help of humidity sensor and will provide information related to the presence of wet waste in the dry waste contents inside the compartment when it is not under usage for a long duration of time, and hence the collection of waste can be triggered when wet fragments are detected in order to avoid discharges from the bin.

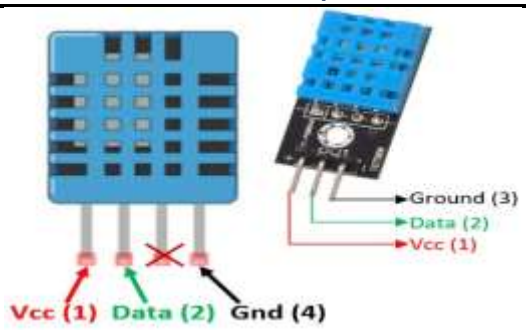


Fig.10. DHT11Sensor Pinout

j) **Weight Sensor**

Weight sensors are fixed below the garbage bins. The level weight with respect to the fill of garbage bins are indicated by the system with the help of internet. It is advantageous for the authorities to know about the lifting weight of the garbage bins. Eventhough the garbage bin is not filled up, but still the weight of fill has reached the threshold of what the garbage lifting vehicles can pick up, then the vehicles can be immediately driven to empty the bins. The status of the level and weight of garbage collected in the bins are displayed in the LCD screen.

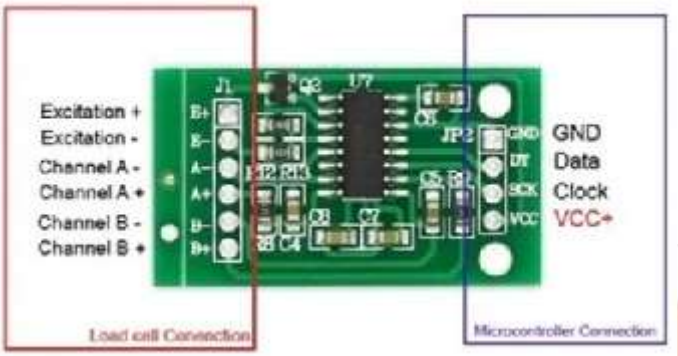


Fig.11:HX711 Pinout

k) **Level Sensor**

The level sensor is used to indicate the level of dustbin filled and will provide the information continuously. Once the threshold is reached, an alert will be sent to the authorities for collecting the garbage.

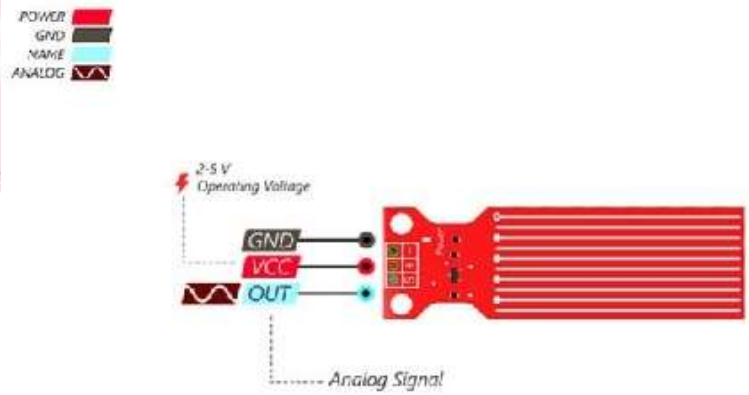


Fig.12: Level Sensor

l) **Rain Sensor**

On rainy season, the situation gets aggravated when rain water enters the dustbin, releasing bad odour. To avoid such harmful effects, a rain sensor is used to sense rain and automatically closed the lid of the bin when it senses rain. Rain sensors are a group of water sensors with clustering AND gate. So, a rain sensor detects rain by placing water sensors on the various sides, and by using the data on all the water sensors, a rain is detected**.**

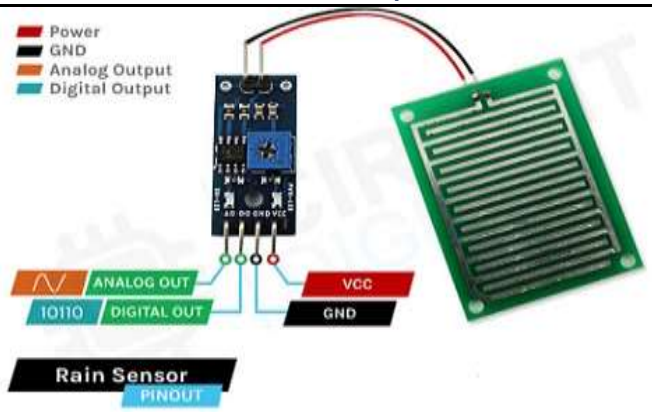
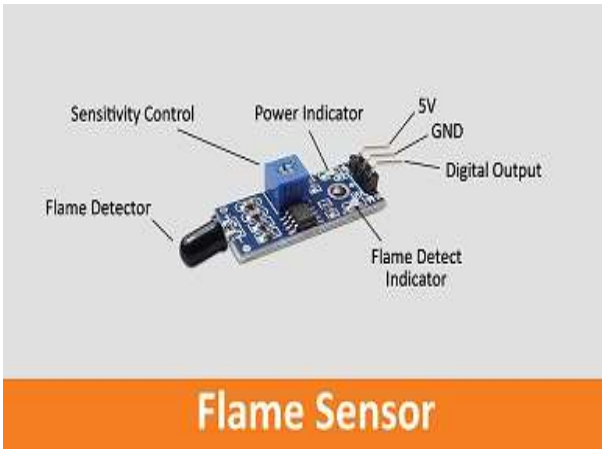


Fig.13: Rain Sensor

m) **Flame Sensor**

Flame sensor is used to detect flame inside the smart bin. The Flame sensor is being interfaced with Arduino and buzzer to give emergency alerts. And the sensing is based on smoke, humidity, temperature etc. once the sensor detects flame of fire in the bin, the buzzer starts ringing.



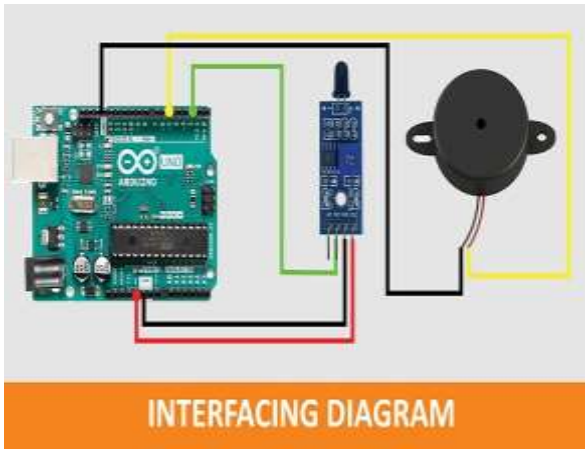
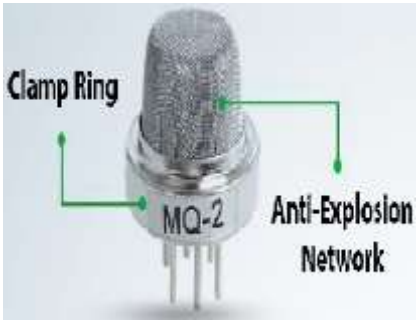


Fig.14: Flame Sensor **Fig.15: Flame Sensor Interfacing with Arduino**

n) **Gas/Smoke Sensor**

The MQ2 gas sensor is a widely used gas detection module that is capable of detecting a variety of gases such as smoke, propane, butane, methane, and carbon monoxide. The sensor module consists of a sensing element and an integrated circuit, and works on the principle of gas conductivity. When the gas comes into contact with the sensing element, it changes the resistance of the element, which is measured by the integrated circuit. The sensor requires a 5V power supply and has four pins: Vcc (power), GND (ground), Dout (digital output), and Aout (analog output). The sensor's output signal can be read as either a digital signal (high or low) or an analog signal (varying voltage level). The MQ2 gas sensor is often used in gas leakage detection systems, air quality monitoring, and safety applications. However, it should be noted that the sensor has limitations and can give false readings in certain conditions, and thus should not be relied upon as the sole means of detecting dangerous gases.



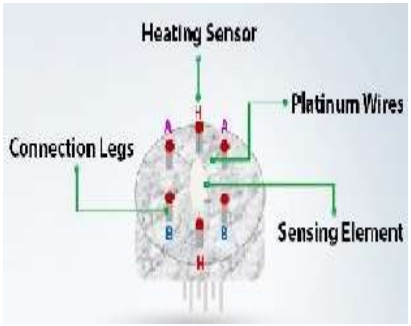


Fig.16: MQ2 Sensor **Fig.17: MQ2 Working** **Fig.18: MQ2 Pinout**

o) **Solar Panel**

The solar panel connection for the Smart Bin can make use of the power of renewable energy to ensure uninterrupted operation and sustainability. Integrated with precision, the solar panels efficiently capture sunlight, converting it into electricity to power up the bin's monitoring systems and communication modules.

Fig.19: Solar Panel installed Smart Bin

p) **LCD Display**

The LCD 16x2 is a display module that can show up to 16 characters per row with a total of 32 characters across the entire display. It uses liquid crystal display (LCD) technology for low power consumption and high contrast. The display is typically controlled by an integrated circuit (IC) driver, such as the HD44780, which communicates with a microcontroller or other digital device. The LCD 16x2 module typically requires 16 pins to be connected to a microcontroller or other digital device, which are used for power, ground, and data communication. The data communication is typically done using a parallel interface, where eight data pins are used to transmit the character data, along with other control pins for selecting the display row and column. The LCD 16x2 display can be programmed to display text, symbols, and even simple graphics, and the backlight can be turned on or off to improve visibility in different lighting conditions.

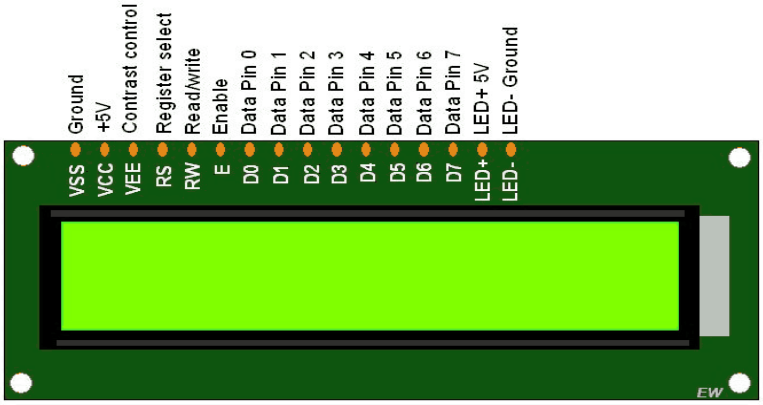


Fig.20: LCD Display

q) **Servomotor**

Servomotor is an electrical device having lifting or rotating efficiency. If you want to rotate an object at some specific angles or distance, then we can use a servo motor. A servo motor can be DC or AC based on the type of power it uses. It is used here to open the lid of the trash bin if user if present in front of the trash bin

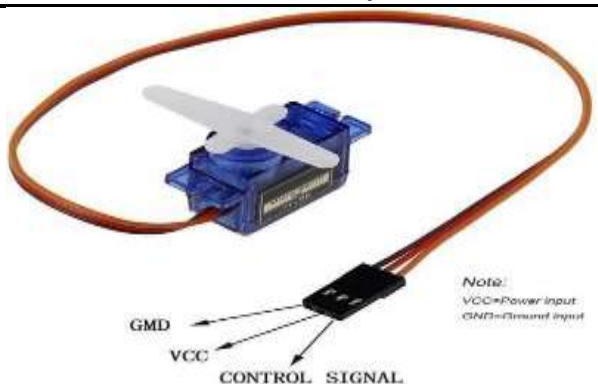


Fig.21:Servomotor

r) **LED (Light Emitting Diode)**

The LEDs are Green LED; which indicates that the waste level inside the bin is very low, and more wastes can be added, Yellow LED; which indicates that the half filled waste level inside the smart bin and more wastes can be added, Red LED; which indicates that the smart bin is full and it needs to be emptied

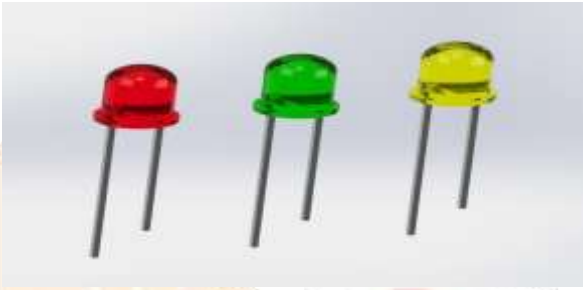


Fig.22: LED

s) **Buzzer**

Buzzer is used to alert the authorities when the bin gets overflowed and also send alert notifications if any abnormal activities are happening in and around the smart bins. When detecting the wastes around the bins, the buzzer alerts the people who are disposing the wastes outside

Fig.23:Buzzer

t) **Breadboard and Jump Wires**

A breadboard is a solderless assembly base for mock-up of electronic circuits. It is an internally connected pin to pin with metal strips. It is very easy to use and it has various sizes depending on the number of individual circuit points in the circuit. A typical breadboard includes top and bottom power distribution rails. Jump wires are also called jumper wires. Jump wires are an electronic wires used for connection of various electronic components. Based on the connecting ends, the jumper wires are categorized into male to male and male to female connectors. Jump wires are generally used to make connections with bread board.

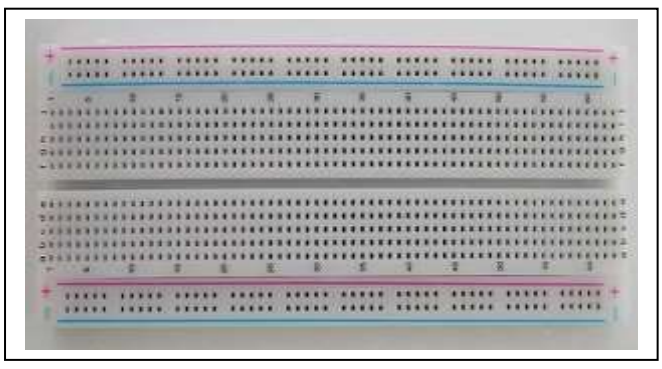


Fig.24: Breadboard

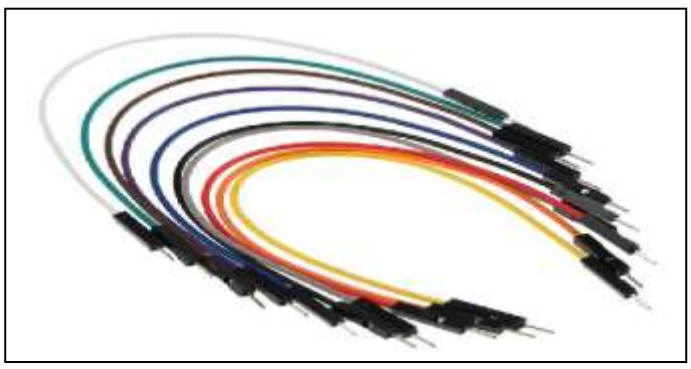


Fig.25: Jump Wires

HARDWARE COMPONENTS-CONTROLLER BOARD

i) Arduino UNO

The Arduino UNO R3 Compatible Board is a microcontroller board which is dependent on the ATmega328. It can be interfaced with other Arduino boards, it can also can control relays, LEDs, servos, and motors as an output. The purpose of Arduino UNO in smart bins is to manage the circuit and enable the waste segregation system for different types of waste such as metals, glass, dry and wet waste.

Fig.26:Arduino UNO Board

ii) Raspberry Pi

It is a single boad computer developed by the Raspberry Pi Foundation, founded in 2009, in the UK with the aim of promoting basic computer education in schools and developing countries which is low-cost and just the size of credit card and able to work on low 5V power supply. Raspbian operating systems is Debian-based OS, its features and prefereneces are specially designed for Raspberry Pi. It also supports most Linux OS such as Windows 10 IOT Core, Ubuntu MATE, Ubuntu Core, PiNET. Raspberry Pi is a System-on-Chip(SoC) based on Broadcom BCM2837 containing Broadcom Arm Processor and a Videocore.

Raspberry Pi 3 is a single board computer which is as small as debit card/credit card. Raspberry Pi 3 board contains ARM Processor in addition with inbuilt Bluetooth and WiFi. Raspberry Pi boards does not contain on-chip ADC. Raspberry Pi board has on-chip camera slot and picamera is also available in the market. Because of on-chip camera Raspberry Pi board is also used for desinging Image and Video processing based applications.

Fig.27: Raspberry Pi Board

iii) AVR Microcontroller

AVR microcontroller belongs to Atmel's AVR series microcontroller family. AVR microcontroller is also known as ATmega32 microcontroller. Arduino UNO is used for connecting all the sensors through pins. ATMEGA328P is an 8-bit microcontroller which is a high performance, low power controller from Microchip. Since its being used in Arduino boards, it becomes the popular from all AVR controllers. AVR microcontroller gives information to the WiFi IOT module and displays the weight and level of the garbage present in the garbage bins. Transmit the information wirelessly to concerned dustbins may not be full. AVR microcontroller will give information to the municipality department through IOT webpage using Wi-Fi IOT module. IOT module is interfaced to the AVR microcontroller through which the information is out there within the internet.

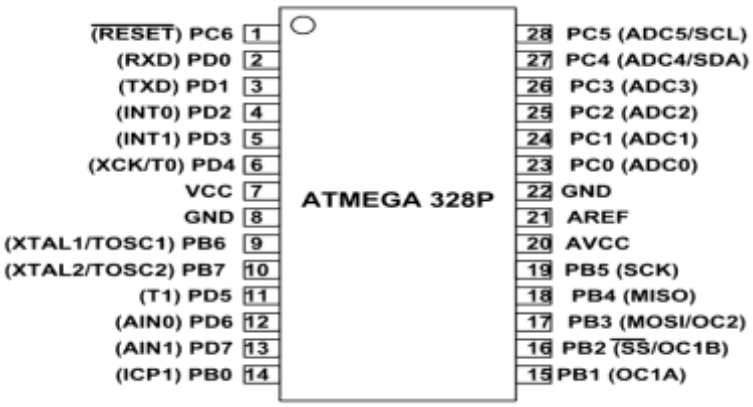


Fig.28:AVR Microcontroller

SOFTWARE REQUIREMENTS

i) Blynk App

Blynk is a framework for controlling Raspberry Pi, Arduino as well as other gadgets via iOS and Android apps via using the internet browser. This is a virtual monitor in which you might track your progress may to make a visual frontend for our application, drag & drop widgets. The Blynk is not being bound to any shield or particular board. Instead, this works with whatever gear you want. Blynk will get you online and ready for if it's the web of your goods you're Raspberry Pi or Arduino are connected via web by this modern ESP8266 microchip or Wi-fi Ethernet. The internet of things was in mind when Blynk was built. It has the ability to operate hardware remotes, shows, save data, sensor data visualise it, as well as a range of other jobs. The framework is made up of three key components:

(a) **App Blynk**

Using the many widgets provided by the Blynk app, you can design beautiful interfaces for the projects.

(b) **Server Blynk**

Blynk server is the in charge of any and any correspondence between phones as well as the hardware. You may either utilise our Blynk Cloud or create your own the server of Blynk is on our own computers. This is capable of supporting thousands of devices, open source and even can runs upon software of Raspberry Pi.

(c) **Blynk Libraries**

Blynk libraries enables connectivity and with the server handle every outgoing and incoming command on every platforms of popular software.

ii) Python

Python programming language is used for the major part of the processing as well as for collecting data from sensors.

iii) Arduino Compiler

It is an open-source Arduino Software (IDE) which is simple to understand, write code and upload it to the board. It gives a user friendly and understanding platform for the coders to write code. It supports java language. We have written the code for garbage collection in the Arduino IDE software

iv) Arduino C

Arduino C is the derived programming language from C/C++ which contains in built hardware based libraries.

v) Python

Python programming language is used for the major part of the processing as well as for collecting data from sensors.

vi) Embedded C

Embedded C is used to program a wide range of microcontrollers and microprocessors which allows us to work with hardware devices like sensors and input-output devices. .Embedded C compilers are used to compile the Embedded C program such as Keil, SPJ,etc.

vii) GUI(Graphical User Interface)

GUI is used to display different parameters and information regarding the smart bin and waste collection viz. location and status of bin, date & time of waste collection. GUI will be used in the interface and these widgets tracking the level of smart bin filled will be put in the location exactly the way smart bins are placed every part of the city. This will help the garbage monitoring to keep a track of smart bin filled in exact location. Thus our application will help the garbage monitoring to keep a check or track on every

smart bin throughout city. It will help him taking accurate decision and avoid the overflow of bins and use the resources more efficiently.

viii) MQTT Protocol

The MQTT protocol makes the work easier and fast for communication between IOT connected devices. MQTT is commonly used for IoT applications to connect to and communicate with low-power devices such as sensors, actuators, and home appliances. Garbage collection system becomes more autonomous with quick transmission of data by using MQTT protocol. The main advantage in MQTT protocol is that, eventhough the clients are not available in the node network, data will be sent. Whenever the client is connected to that node, they will be able to see the data which was sent. So that they can able to monitor the waste collection accordingly.

ix) IOT Gecko

IOT Gecko is a free IOT systems development platform for students, researchers as well as developers. IOT Gecko provides the tools required. It is a supportive software to design your IOT based systems with ease.

x)Django

Django framework is used for backend and frontend purposes

III. BLOCK DIAGRAM

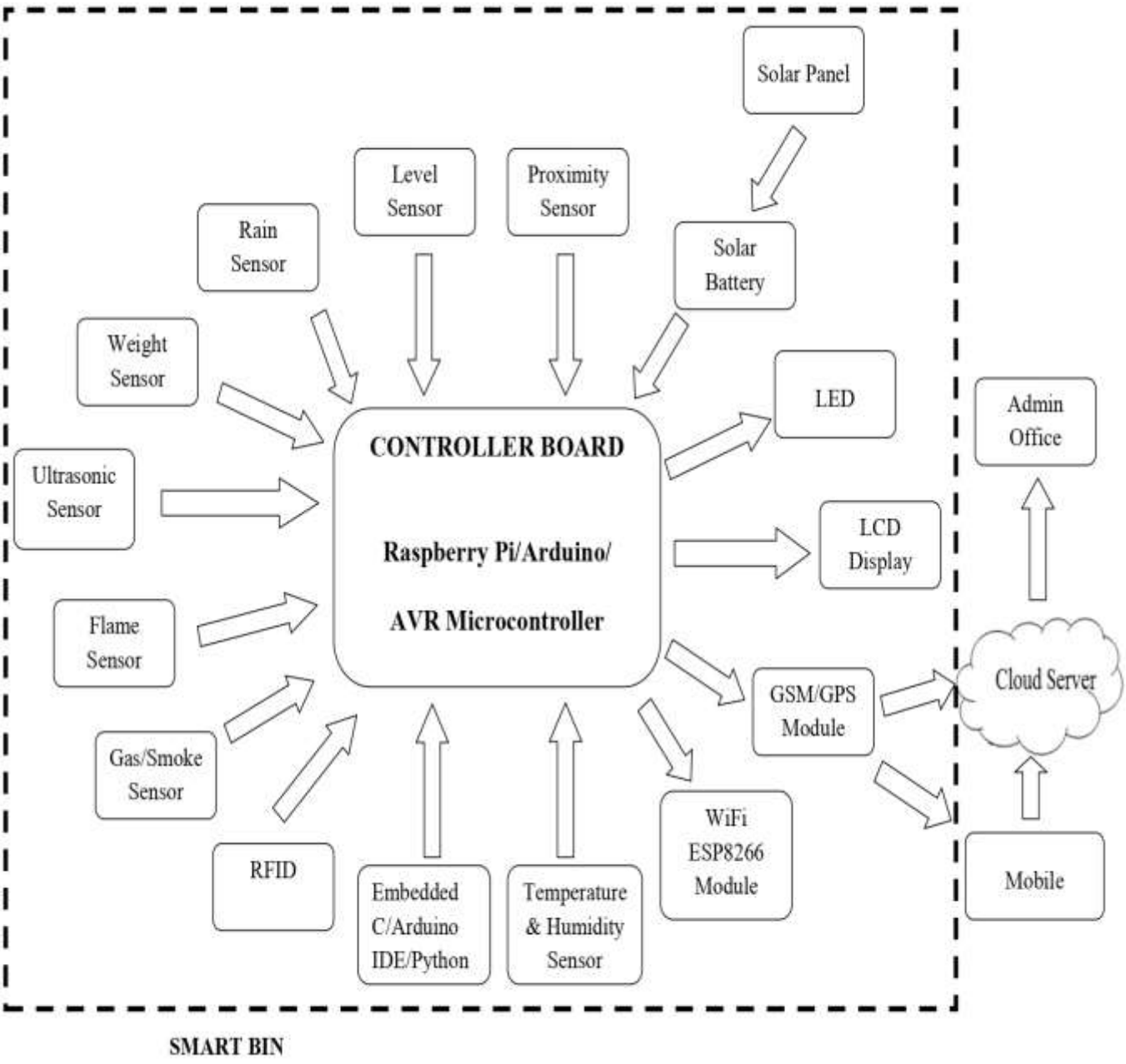


Fig.29: Smart Bin Block Diagram

IV CONCLUSION

This paper throws light on various sensors, controllers and the software used in the Smart Bins that supports to have a smart lifestyle. The time and effort of human are well administered with the help of this smart technology. Smart Bins implemented cities have the benefit of maintaining healthy and waste-ridden environment. At present Smart Bins are mostly used in some of the smart cities. When it proves its integrity and efficiency, it can be used in many more places. In future, these Smart Bins can be evolved into Robotic Bins without human intervention.

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