Chapter 1

INTRODUCTION

1.1 OVERVIEW

Natural lakes and all kinds of artificial lakes make the living environment beautiful. However, with the increase of the activities of human beings, the pollution of the floating garbage on the surface of the lake is serious. Governing the pollution of the floating garbage on the surface of the lake is urgent. Water pollution with floating garbage is a serious issue in many countries. The process of cleaning the water surface is a routine task. Collecting large amounts of dry waste floating such as plastic bottles confront the tension on the water surface and small drag force causes the waste materials to float away. The aim of this project is to design a robot that will assist humans with collecting waste materials by scooping the waste off the water surface and investigate performance of the designed waste scoopers installed on the floating waste scooper robot.

Rapid increase in volume and types of solid and hazardous waste because of continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for national and local governments to ensure effective and sustainable management of waste. It is estimated that in 2006 the total amount of municipal solid waste generated globally reached 2.02 billion tones, representing a 7% annual increase since 2003 (Global Waste Management Market Report 2007). The segregation, handling, transport and disposal of waste are to be properly managed to minimize the risks to the health and safety of patients, the public, and the environment. The economic value of waste is best realized when it is segregated. Currently there is no such system of segregation of dry, wet and metallic wastes.

It is designed to sort the refuse into metallic waste, wet waste and dry waste. The AWS employs parallel resonant impedance sensing mechanism to identify metallic items, and capacitive sensors to distinguish between wet, dry and metallic waste. Experimental results show that the segregation of waste into metallic, wet and dry waste has been successfully implemented using the AWS.

Improper waste separation can lead to hazardous materials like batteries, chemicals, and e-waste ending up in landfills. These substances can seep into the soil, contaminating it. This contamination affects plant life, animals, and can potentially enter the food chain, posing risks to all organisms, including humans. When waste is not properly separated, harmful chemicals from various materials can leach into groundwater and surface water bodies. This includes heavy metals and pharmaceutical residues. Contaminated water sources harm aquatic life and make the water unsafe for human consumption and agricultural use. Burning waste materials that haven't been properly separated, such as organic waste and plastics, releases toxic gases into the atmosphere. These gases include dioxins, furans, and methane, which contribute to air pollution and climate change. The burning of plastics also releases carcinogenic substances that pose health risks. Organic waste that is not separated and composted often ends up in landfills, where it decomposes anaerobically (without oxygen). This process produces methane, a potent greenhouse gas that significantly contributes to global warming and climate change. Improperly disposed waste can be mistaken for food by wildlife or can entangle animals. This leads to injuries, illnesses, and even death among animals. Plastics are particularly harmful to both marine and terrestrial wildlife, causing severe ecological damage. Exposure to hazardous waste, contaminated soil, and polluted water poses serious health risks to humans. These risks include respiratory issues, skin problems, and diseases caused by toxic chemicals present in improperly managed waste.

Waste segregation and recycling are effective ways of reducing dumped trash. Unfortunately, these practices are not widely implemented in the country. People have been negligent when it comes to proper waste disposal, ignoring labels and throwing recyclables that can still be reused. Most of the people are unaware or ignore the fact the waste segregation and recycling can reduce cost, reduce drain in our resources, and lessen the waste being produced. Typical composition of garbage people throw in are 5.8% metals, 3.5% glass, 1.6% plastic,12.9% papers, 1.8% textiles and 53.7% biodegradables which means only the remaining 20.7% of the wastes should really be going to our landfills. In our country, recycling centers do manual process of sorting wastes, so it increases human interface. For this we implement a system which minimizes human interference in the waste collecting and segregation process. Materials such as paper, glass and metals are the wastes that need to be segregated in this project.

1.2 MOTIVATION

Waste segregation and recycling are effective ways of reducing dumped trash. Unfortunately, these practices are not widely implemented in the country. People have been negligent when it comes to proper waste disposal, ignoring labels and throwing recyclables that can still be reused. Most of the people are unaware or ignore the fact the waste segregation and recycling can reduce cost, reduce drain in our resources, and lessen the waste being produced. Typical composition of garbage people throw in are 5.8% metals, 3.5% glass, 1.6% plastic,12.9% papers, 1.8% textiles and 53.7% biodegradables which means only the remaining 20.7% of the wastes should really be going to our landfills. In our country, recycling centers do manual process of sorting wastes, so it increases human interface. For this we implement a system which minimizes human interference in the waste collecting and segregation process. Materials such as paper, glass and metals are the wastes that need to be segregated in this project. One of the most pervasive and problematic waste materials is plastic bottles, which, if not properly managed, contribute to environmental pollution and resource wastage. To address this issue, the installation of bottle separation machines in public places presents a practical and impactful solution. Installing bottle separation machines in public places serves as a constant reminder of the importance of recycling and waste segregation. These machines can be designed with user-friendly interfaces and informative displays that educate the public about the benefits of recycling. By engaging individuals in the recycling process, we can foster a culture of environmental responsibility and encourage sustainable practices in everyday life. Public places such as parks, transit stations, shopping centers, and sports venues are ideal locations for bottle separation machines due to the high volume of foot traffic and beverage consumption. Providing convenient and accessible recycling options encourages people to participate in recycling programs. When individuals can easily dispose of their plastic bottles in designated machines, the likelihood of proper waste segregation and recycling increases significantly. Composting organic waste instead of sending it to landfills helps reduce methane emissions. Methane is a potent greenhouse gas that contributes to climate change. By composting, you’re helping to slow down global warming. Recycling materials like paper, glass, and plastic means we need to extract fewer raw materials from the Earth. This conserves natural resources and reduces the

energy needed to produce new products, ultimately helping to preserve our planet for future generations.

1.2 OBJECTIVES

- Design and implement a robust system that can accurately identify and sort different types of waste (e.g., plastics, metals, organic waste) using sensors and embedded technology.
- Automate the waste separation process to reduce human intervention and increase efficiency.
- Design the system to be scalable so that it can be easily adapted for different capacities, from small-scale household setups to large industrial applications.
- Optimize the design to ensure that the system is cost-effective to build, maintain, and operate. This includes selecting affordable components and maximizing energy efficiency.
- Create an intuitive user interface to allow easy monitoring, control, and maintenance of the system.
- Integrate data collection capabilities to monitor system performance, waste separation efficiency, and other relevant metrics.

1.4 BACKGROUND

Waste management is a critical issue faced by cities and communities worldwide. With increasing urbanization and industrialization, the volume of waste generated has skyrocketed, leading to severe environmental and health problems. Traditional waste disposal methods, such as landfilling and incineration, have significant drawbacks, including pollution, greenhouse gas emissions, and resource wastage. Technological advancements in embedded systems, sensors, and automation have opened new avenues for improving waste management. An embedded system integrates hardware and software designed to perform a specific task within a larger system. In this case, the task is to identify, sort, and manage different types of waste efficiently. The primary objective of this project is to create a system that can automatically separate waste into categories such as recyclables, organic waste, and hazardous materials. This would help

streamline the recycling process, reduce contamination, and minimize the environmental impact of waste disposal.

The system would typically consist of various sensors (like optical sensors, weight sensors, and chemical sensors) to identify different types of waste. It would use actuators (such as motors and robotic arms) to physically sort the waste. The embedded system would be the brain of the operation, processing sensor data and making decisions about how to handle each piece of waste. The rapid growth in technology, particularly in embedded systems and automation, has opened new possibilities for tackling environmental challenges. Advances in sensors, microcontrollers, and actuators make it feasible to create sophisticated systems that can identify and sort waste efficiently. By leveraging these technologies, the project aims to enhance waste management processes, making them more effective and less labor-intensive.

Traditional waste sorting often relies on manual labor, which can be hazardous, inefficient, and costly. Workers are exposed to harmful substances and unsanitary conditions, leading to health risks. Manual sorting is also prone to errors, resulting in contamination of recyclable materials. An embedded system automates the sorting process, reducing the dependence on human intervention and minimizing errors. By separating waste at the source, less material ends up in landfills. Landfills are reaching capacity in many regions and expanding them is not always feasible due to land scarcity and environmental concerns. Reducing landfill usage lowers the environmental impact, decreases greenhouse gas emissions from decomposing waste, and mitigates soil and water contamination.

1.5 PROBLEM STATEMENT

The rapid surge in global waste production, driven by population growth and industrialization, is overwhelming traditional waste management systems. Manual sorting is inefficient and error-prone, leading to improper segregation. This mismanagement results in serious environmental issues: pollution of land, air, and water resources; increased greenhouse gas emissions; and the loss of recyclable materials that could be reintroduced into the production cycle. There's an urgent need for an efficient, automated solution that can accurately identify and separate different types of waste—plastics, metals, glass, organic matter, and hazardous

materials—with high speed and precision. Existing solutions are often too costly, lack scalability, or fail to achieve the necessary accuracy. Additionally, a versatile system that can be implemented across various scales, from households to large industrial facilities, is lacking. This project proposes the development of an embedded system for automated waste separation. By integrating advanced sensors, image processing, and machine learning algorithms within a compact platform, the system will detect and classify waste materials in real-time. Mechanical components will then sort the waste accordingly. Aiming to be cost-effective, energy-efficient, and adaptable, this solution seeks to revolutionize waste management practices. By tackling current inefficiencies, this project will contribute to reducing environmental pollution, conserving natural resources through enhanced recycling, minimizing health hazards associated with waste handling, and driving progress toward a sustainable, circular economy.

1.6 LITERATURE SURVEY

Automated Waste Segregation System using Machine Learning: A Comprehensive Analysis by Myra G. Flores, Jose B. Tan Jr.

The basic Idea behind this project is to implement a smart way of handling the garbage which is done by using the IOT protocol for transmitting the dustbin status wirelessly, through e- mail to notify to the concerned person that system is filled with garbage and need to be replaced. This system is based on IOT protocol. The working is based on Arduino platform. This microcontroller

controls the movement of Dustbin on specific path defined by a line, or the path can be pre-programmed in the device. The LCD display, Ultrasonic Sensor, Proximity Sensor, Wi-Fi module (ESP8266) and Motor Driver (L293D) are interfaced with Arduino UNO board. If someone wants to put the garbage in it, then the person can stop the dustbin by keeping hand in front of it. Notification is displayed on LCD and transfers the message through the Wi-Fi module–ESP8266. This module transmits and receives data to web server. It collects information from proximity sensor, ultrasonic sensor and controls movement of dustbin.

A Waste Separation System Based on Sensor Technology and Deep Learning: A Simple Approach Applied to a Case Study of Plastic Packaging Waste by Rok Pucnik, Monika Dokl, Yee Van Fan, Annamaria Vujanovic, Zorka Novak Pintaric.

Plastic waste pollution is an escalating global concern. The efficient segregation of plastic waste is crucial for promoting recycling and reducing environmental impact. The article introduces a smart waste separation system that leverages sensor technology and deep learning (DL) to address this issue. The authors present a simplified conceptual model for a waste segregation system tailored for plastic packaging. The model integrates advanced sensors to detect various plastic types and deep learning algorithms to classify and sort waste with high precision. The core of the system is its innovative use of sensor technology and DL. Sensors accurately identify different plastic waste based on their physical and chemical properties. Concurrently, deep learning models are trained to classify the waste, improving the system’s efficiency over time through continuous learning and adaptation. To validate the effectiveness of the proposed system, a case study is conducted. The case study focuses on separating plastic packaging waste, demonstrating the system's practical application and its potential to significantly enhance the efficiency of plastic waste segregation. The proposed waste separation system is versatile and can be implemented at the source, such as in smart waste bins, or at centralized sorting facilities. This flexibility ensures that the system can be adapted to different waste management scenarios and infrastructure setups. The article concludes with suggestions for future research and development. These include improving the scalability of the system, integrating more advanced sensor technologies, and expanding the deep learning models to cover a wider range of waste types. The authors emphasize the importance of continuous innovation to further enhance the system's performance and adaptability.

Automatic Waste Management and Segregation System using IoT by Namratha A M, Nandini S, Nanditha K, Meghashree C, and Dr. Manjula G.

The article addresses the challenges of waste management in urban areas, particularly in India. It highlights the importance of proper waste segregation and management to maintain a healthy environment and reduce pollution. The authors identify the inefficiencies in the current waste management systems, such as improper waste collection, treatment, and disposal. They

emphasize the need for a more efficient and automated system to handle waste effectively. The proposed solution is an automatic waste management and segregation system that utilizes Internet of Things (IoT) technology. The system includes smart bins equipped with sensors to detect and segregate waste into different categories, such as dry and wet waste. The system comprises various components, including IR sensors, MQ sensors, dry-wet sensors, Arduino Uno, Node MCU, and servo motors. These components work together to monitor the level of waste in the bins and segregate it accordingly. The system can be implemented across cities by placing smart bins at strategic locations. The data collected by the sensors is transmitted to a central server, where it is analyzed to optimize waste collection routes and schedules. The article concludes by highlighting the potential of IoT-based waste management systems to improve waste management practices and contribute to a cleaner and healthier environment. The authors suggest further research and development to enhance the system's efficiency and scalability.

IoT based Waste Management for Smart Cities by Padmakshi Venkateshwara Rao and Pathan Mahammed Abdul Azeez.

The article addresses the significant challenges posed by waste management in urban areas, particularly in India. It highlights the environmental and public health issues caused by inadequate waste collection, transport, treatment, and disposal. The authors identify the inefficiencies in the current waste management systems, such as improper waste collection and disposal, leading to unhygienic conditions and environmental pollution. They emphasize the need for a more efficient and automated system to handle waste effectively. The proposed solution is an IoT-based waste management system designed for smart cities. The system includes smart bins equipped with ultrasonic sensors, NodeMCU, servo motors, and the Blynk app to track and manage waste levels in real-time. The system operates by continuously monitoring the fill levels of waste bins using ultrasonic sensors. When a bin reaches its maximum capacity, the system sends an SMS notification to the municipal authorities via the Blynk app, prompting immediate action for waste collection.

CHAPTER 2

EXISTING METEHODOLOGY

Traditional recycling bins are designed to be easily identifiable, often color-coded and labeled with icons or text indicating the type of recyclable material they are meant to collect (e.g., plastic, paper, glass). Bins are strategically placed in high-traffic areas such as parks, transit stations, shopping centers, and office buildings to maximize accessibility and convenience for the public. At the recycling facility, an initial manual or mechanical sorting process separates contaminants and non-recyclable materials from the collected recyclables. Recycling bins are emptied on a regular schedule by waste management personnel to ensure they do not overflow and to maintain a clean environment. Collected recyclables are transported to sorting and processing facilities. This is typically done using specialized recycling trucks that keep different types of recyclables separated to prevent contamination. Recyclable materials are further separated by type (e.g., plastics, metals, paper, glass) using a combination of manual sorting and automated technologies such as conveyor belts, magnets, optical sorters, and air classifiers.

Smart recycling bins are advanced versions of traditional recycling bins equipped with sensors and digital displays to guide users in correctly sorting their waste. Improved accuracy in waste sorting; can provide real-time data on recycling rates; can incentivize users through rewards. Throughout the sorting and processing stages, quality control measures are in place to ensure that contaminants are removed and that the recycled materials meet industry standards. Waste management agencies collect data on recycling rates, contamination levels, and bin usage patterns to assess the effectiveness of the recycling program. The methodology behind smart recycling bins combines advanced technology, strategic placement, user engagement, and data-driven management to enhance the efficiency and effectiveness of recycling programs. By providing real-time feedback, optimizing collection processes, and reducing contamination, smart bins represent a significant advancement over traditional recycling methods, contributing to more sustainable waste management practices.

CHAPTER 3

PROPOSED METHODOLGY

The proposed system is designed to automatically separate metallic waste from other types of waste using an embedded system. Waste materials are deposited into the system through an input section, such as a conveyor belt or chute. The system is capable of handling mixed waste, including metallic and non-metallic materials, ensuring a smooth and efficient sorting process. An inductive proximity sensor or metal detector is placed in the system to detect metallic components. When metal is detected, a signal is sent to the microcontroller for further processing. The microcontroller, such as an Arduino or Raspberry Pi, then analyzes the sensor’s data and determines the appropriate sorting action. If metallic waste is identified, the system activates a mechanism, such as a servo motor or pneumatic actuator, to direct it into a designated metallic waste bin. If no metal is detected, the waste is classified as general waste and directed to a separate bin. A motorized diverter or robotic arm is used to guide the waste into the correct bin based on the microcontroller's decision. This ensures real-time waste segregation with minimal human intervention. The system can also be equipped with an LCD display or IoT connectivity for monitoring waste segregation efficiency. Alerts or logs can be maintained to track waste types and volumes, allowing for further optimization and data analysis. The entire system operates on a regulated power supply with an energy-efficient design. Safety measures, such as emergency stop buttons, are incorporated to prevent malfunctions and ensure smooth operation. The proposed methodology ensures an automated, efficient, and reliable approach to waste segregation, significantly improving recycling processes. The embedded system enhances precision and reduces human effort in waste management, making it a viable solution for smart cities, industries, and public waste disposal systems.

3.1 BLOCK DIAGRAM

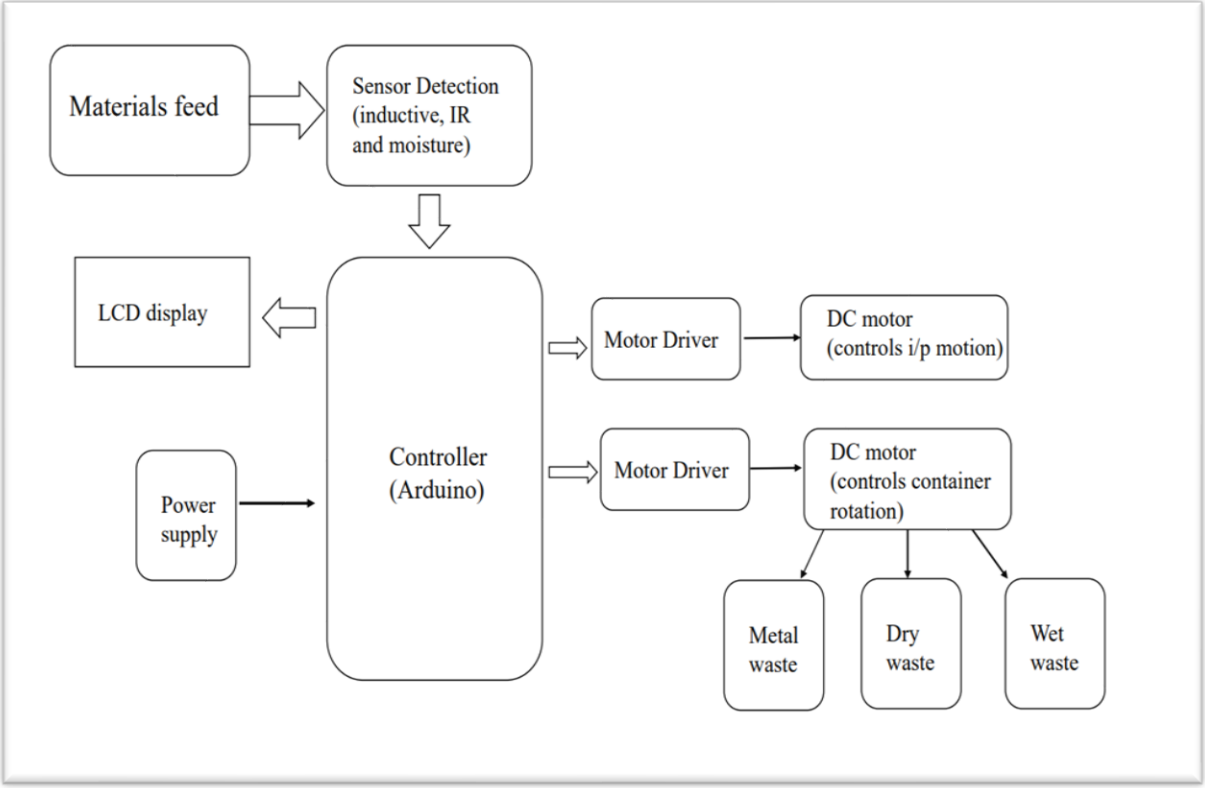


Fig 3.1.1: Block diagram of waste segregation machine

This block diagram represents a waste segregation system based on embedded system. It consists of different slots in dustbin for collecting different wastes like plastic, and metallic separately.

Waste materials are given as input to the machine, the sensors in the input port senses the waste material and the bin is adjusted to the specific materials by rotating the storage bin which is connected to the motor and then the input port is opened through the motor. The number waste materials of specific type are displayed on the LCD display. Then the storage bin position comes to initial position.

3.2 FLOW CHART

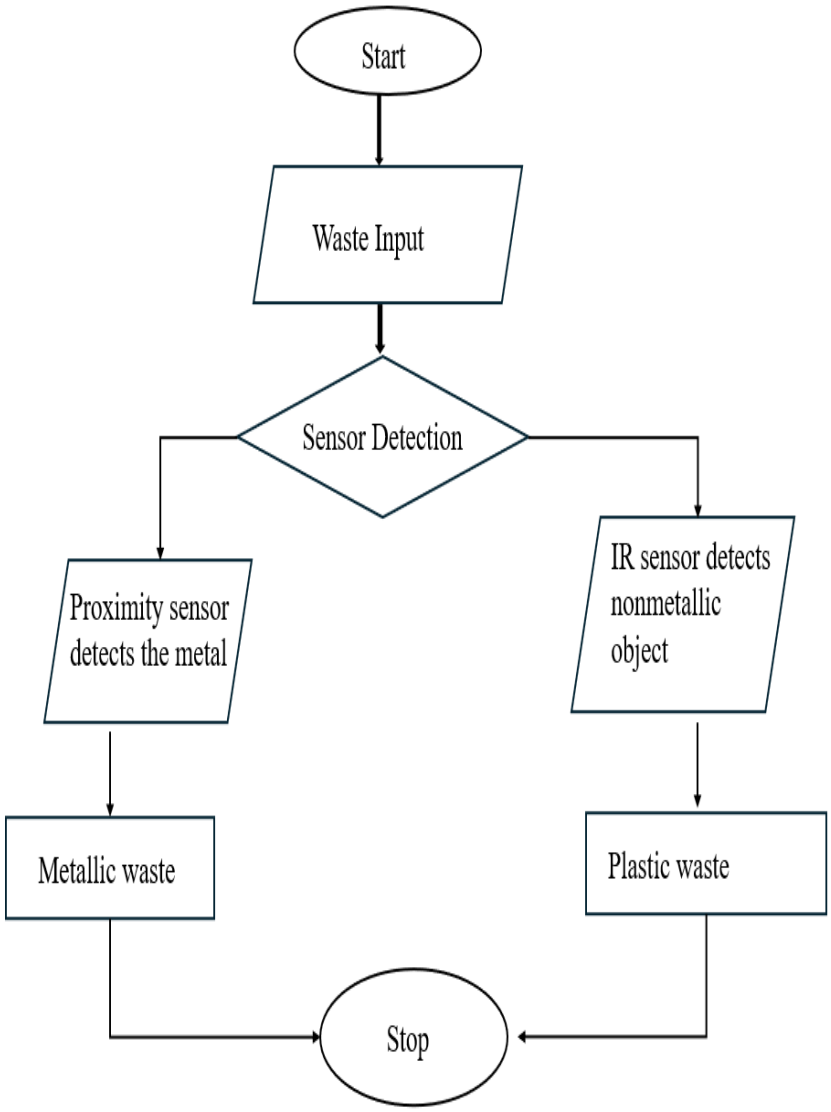


Fig 3.2.1: Flow chart of waste segregation machine using embedded system

The given flowchart represents an automated waste sorting process. It starts with the input of waste, which is then analyzed using a sensor detection system. If the sensor detects a specific type of waste, it is sorted into different categories such as metal, plastic, paper, and organic waste. If no specific type is detected, the waste is classified as general waste. The

process then concludes after sorting the waste into the appropriate category. This system helps in efficient waste management by automating the segregation process, improving recycling efforts, and reducing landfill waste.

3.3 SYSTEM REQUIREMENTS

HARDWARE REQUIREMENTS

- Arduino uno Atmeg328
- LCD
- IR sensor
- DC motors
- Proximity sensor
- Motor driver
- Power adapter
- Storage bin
- Mechanical parts

SOFTWARE REQUIREMENTS

- Embedded C
- Arduino IDE software

1. Arduino UNO (ATMEGA 328P)

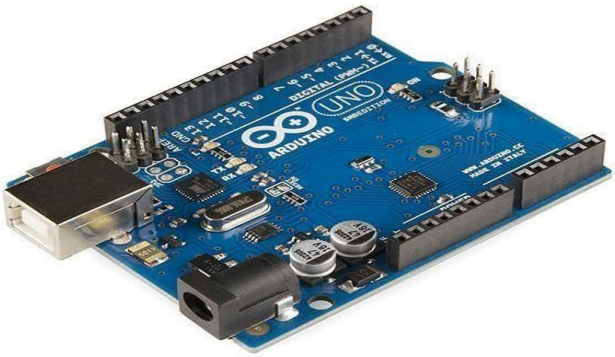


Fig. 3.3.1: Arduino UNO

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also like the Arduino Nano and Leonardo. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform. The ATmega328 on the Arduino Uno comes pre- programmed with a bootloader that allows uploading new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. The Uno also differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 programmed as a USB-to-serial converter.

- Microcontroller: Arduino UNO is one type of microcontroller board, and it is designed by Arduino.cc. It can be built with a microcontroller like Atmega328. It is a small size board and flexible with a wide variety of applications. Other Arduino boards mainly include Arduino Mega, Arduino Pro Mini, Arduino Nano, Arduino YUN, Arduino Lilypad, Arduino Leonardo, and Arduino Due.

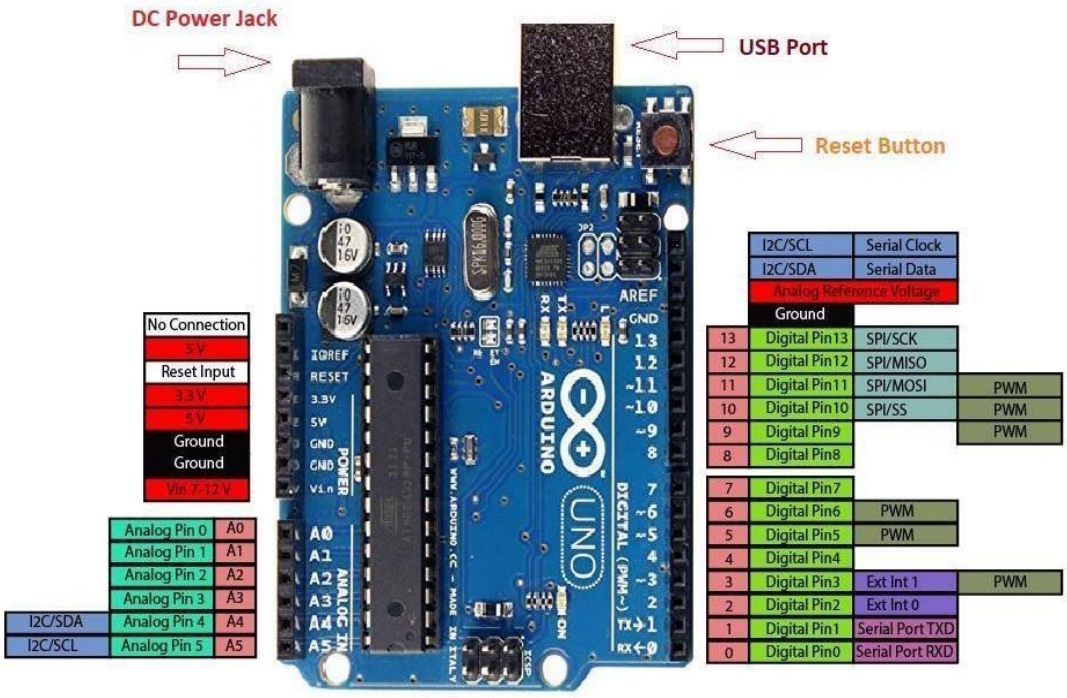


Fig. 3.3.2: Arduino pin configuration

LED- Arduino Uno comes with built-in LED which is connected through pin 13. Providing HIGH value to the pin will turn it ON and LOW will turn it OFF.

Vin- It is the input voltage provided to the Arduino Board. It is different than 5 V supplied through a USB port. This pin is used to supply voltage. If a voltage is provided through power jack, it can be accessed through this pin.

5V- This board comes with the ability to provide voltage regulation. 5V pin is used to provide output regulated voltage. The board is powered up using three ways i.e. USB, Vin pin of the board or DC power jack.

USB supports voltage around 5V while Vin and Power Jack support a voltage range between 7V to 20V. It is recommended to operate the board on 5V. It is important to note that, if a voltage is supplied through 5V or 3.3V pins, they result in bypassing the voltage regulation that can damage the board if voltage surpasses its limit.

GND-These are ground pins. More than one ground pins are provided on the board which can be used as per requirement.

Rese- This pin is incorporated on the board which resets the program running on the board. Instead of physical reset on the board, IDE comes with a feature of resetting the board through programming.

IOREF-This pin is very useful for providing voltage reference to the board. A shield is used to read the voltage across this pin which then selects the proper power source.

PWM- PWM is provided by 3,5,6,9,10, 11pins. These pins are configured to provided 8-bit output PWM.

SP- It is known as Serial Peripheral Interface. Four pins 10(SS), 11(MOSI), 12(MISO), 13(SCK) provide SPI communication with the help of SPI library.

AREF- It is called Analog Reference. This pin is used for providing a reference voltage to the analog inputs.

TW- It is called Two-wire Interface. TWI communication is accessed through Wire Library. A4 and A5 pins are used for this purpose.

Serial Communication- Serial communication is carried out through two pins called Pin 0 (Rx) and Pin 1 (Tx). Rx pin is used to receive data while Tx pin is used to transmit data.

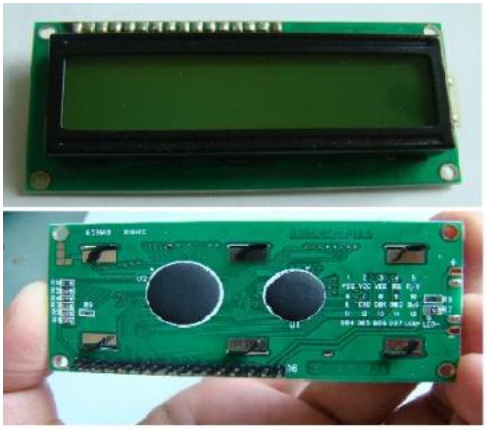
External Interrupts- Pins 2 and 3 are used for providing external interrupts. An interrupt is called by providing LOW or changing value.

There are several I/O digital and analog pins placed on the board which operate at 5V. These pins come with standard operating ratings ranging between 20mA to 40mA. Internal pullup resistors are used in the board that limits the current exceeding from the given operating conditions. However, too much increase in current makes these resisters useless and damages the device.

2. LCD

Fig. 3.3.3: LCD

- LCD (Liquid Crystal Display) is a type of flat panel display which uses liquid crystals in its primary form of operation. LEDs have a large and varying set of use cases for consumers and businesses, as they can be commonly found in smartphones, televisions, computer monitors and instrument panels. Key Features:
- Display Size: A 16x2 LCD display refers to a type of character-based liquid crystal display (LCD) that can display 16 characters on each of its 2 rows.
- Character Matrix: The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates a display of 16 characters per line in 2 such lines. In this LCD, each character is displayed in a 5×7pixel matrix.
- Interface: 16x2 LCDs are compact displays that show 16 characters on 2 lines. Each character is formed by a 5x7 pixel matrix. They are widely used for text-based information in electronics, robotics, and embedded systems. Operated at 4.7-5.3V, they interface with microcontrollers.
- Backlight: A liquid crystal display (LCD) backlight is a light source placed behind a pixel panel to illuminate the pixel panel. LCDs rely on an underlying electrical current to properly display contrast. A backlight allows viewers to see the display more clearly in low-light conditions.



16-pin LCD, Pin 15 Led+ and Pin 16 is LED-

Pin No.	Name	Function
1	V_{ss}	Ground
2	V_{dd}	+ve supply
3	V_{ee}	Contrast
4	RS	Register Select
5	R/W	Read/Write
6	E	Enable
7	D0	Data bit 0
8	D1	Data bit 1
9	D2	Data bit 2
10	D3	Data bit 3
11	D4	Data bit 4
12	D5	Data bit 5
13	D6	Data bit 6
14	D7	Data bit 7

Source: Everyday Practical Electronics, 1997

Fig 3.3.4: PIN Configuration of 16x2 LCD Display

The 16×2 LCD pinout is shown below:

- Pin1 (Ground/Source Pin): This is a GND pin of display, used to connect the GND terminal of the microcontroller unit or power source.
- Pin2 (VCC/Source Pin): This is the voltage supply pin of the display, used to connect the supply pin of the power source.
- Pin3 (V0/VEE/Control Pin): This pin regulates the difference of the display, used to connect a changeable POT that can supply 0 to 5V.
- Pin4 (Register Select/Control Pin): This pin toggles among command or data register, used to connect a microcontroller unit pin and obtains either 0 or 1(0 = data mode, and 1 = command mode).
- Pin5 (Read/Write/Control Pin): This pin toggles the display among the read or writes operation, and it is connected to a microcontroller unit pin to get either 0 or 1 (0 = Write Operation, and 1 = Read Operation).
- Pin 6 (Enable/Control Pin): This pin should be held high to execute Read/Write process, and it is connected to the microcontroller unit & constantly held high.
- Pins 7-14 (Data Pins): These pins are used to send data to the display. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only

four pins are connected to the microcontroller unit like 0 to 3, whereas in 8-wire mode, 8-pins are connected to microcontroller unit like 0 to 7.

- Pin15 (+ve pin of the LED): This pin is connected to +5V.
- Pin 16 (-ve pin of the LED): This pin is connected to GND.

3. IR sensor

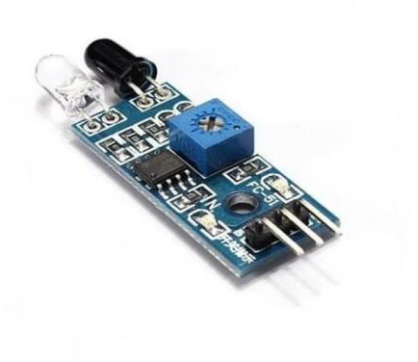


Fig 3.3.5: IR sensor

An Infrared (IR) sensor is an electronic device that detects and measures infrared radiation in its environment. Essentially, all objects emit some form of thermal radiation, and IR sensors can capture this. They are widely used in various applications because of their ability to sense heat and motion.

- **Emission:** The IR LED emits infrared light, which travels through the air.
- **Reflection/Absorption:** This emitted light either gets reflected to the sensor by an object or gets absorbed by it. Different materials and surfaces reflect or absorb IR light to varying degrees.
- **Detection:** The detector (typically a photodiode or phototransistor) senses the reflected infrared light. It converts this light into an electrical signal proportional to the intensity of the infrared light it receives.
- **Processing:** The electrical signal is processed to determine specific characteristics like distance, motion, or temperature.

- **Sensitivity:** The sensitivity of an IR sensor is crucial for its accuracy and reliability. It depends on factors like the quality of the emitter and detector, the wavelength of the infrared light, and the distance between the sensor and the object.
- **Range:** The effective range of an IR sensor can vary widely depending on its design. Some sensors can detect objects a few centimeters away, while others can detect objects several meters away.

4. Proximity sensor

Fig. 3.3.6: Metal detector

This Tube Type Inductive Proximity Sensor Detection Switch NPN DC6-36V 4mm Normally Open switch LJ12A3-4-Z/BX is a component widely used in automatic control industry for detecting, controlling, and non-contact switching. When the proximity switch is close to some target object, it will send out control signal. When the metal approaches near proximity switch sensing area, an Eddy Current is induced in metal. Which in turn disturbs the magnetic field produced by the Inductive Proximity Sensor. This change is sensed by the sensor. This inductive proximity switches can be non-contact, no pressure, no spark, quickly issued the electrical command. Accurately reflect the position and the stroke movement mechanism. Positioning accuracy, operating frequency, service life. Easy to install and suitable for harsh environments.

This 4mm proximity sensor can detect a variety of metals, miniature size, long life, low price, shielded type installation, anti-interference ability, 1mm detection distance, using for precise positioning of molds, precision machine tools, and robots.

Features

- Red LED checks the state of the proximity sensor.
- High repeated positioning accuracy.
- High switching frequency.
- Wide voltage range.
- Anti-vibration, dust, water and oil prevention.
- Outer (thread) Diameter: M12.
- Reverse power protection, short circuit protection, directly connecting with PLC.
- Can replace small switches and limit switches.

5. DC motor

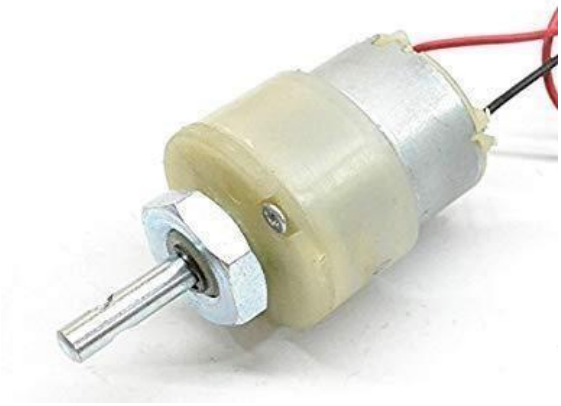


Fig. 3.3.7: DC motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic

fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

DC motors were the first form of motor widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills.

6. Motor driver

Fig 3.3.8: Motor driver

L293D IC is a typical Motor Driver IC which allows the DC motor to drive on any direction. This IC consists of 16-pins which are used to control a set of two DC motors instantaneously in any direction. It means by using a L293D IC we can control two DC motors. As well, this IC can drive small and quiet big motors. This L293D IC works on the basic principle of H-bridge, this motor control circuit allows the voltage to be flowing in any direction. As we know that the voltage must be change the direction of being able to rotate the DC motor in both the directions. Hence, H-bridge circuit using L293D ICs are perfect for driving a motor. Single L293D IC consists of two H-bridge circuits regarding privacy and security concerns related to these devices and their intention of pervasive presence.

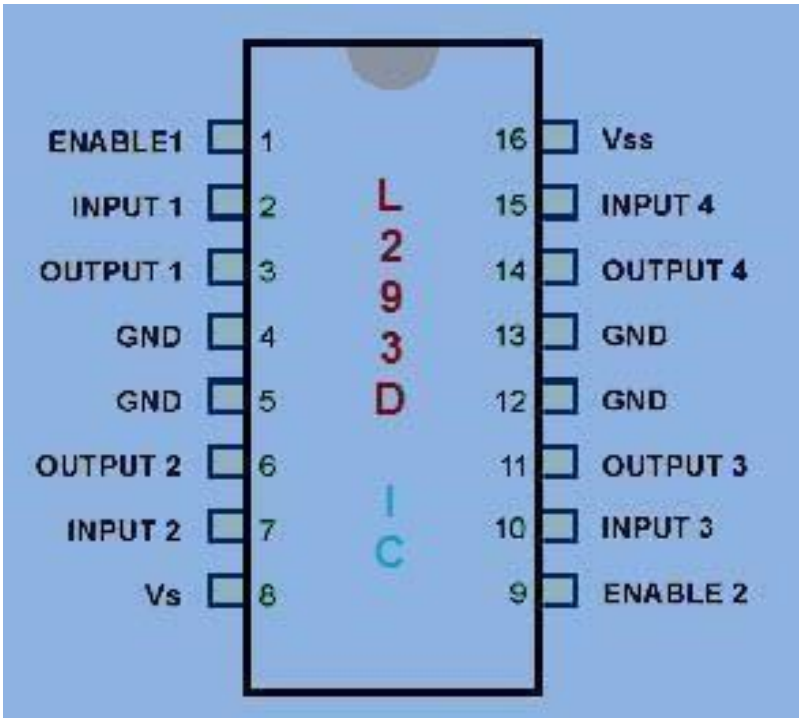


Fig 3.3.9: Pin configuration of motor driver

- Pin-1 (Enable 1-2): When the enable pin is high, then the left part of the IC will work otherwise it won ‘t work. This pin is also called as a master control pin.
- Pin-2 (Input-1): When the input pin is high, then the flow of current will be through output1
- Pin-3 (Output-1): This output-1 pin must be connected to one of the terminals of the motor
- Pin4 &5: These pins are ground pins
- Pin-6 (Output-2): This pin must be connected to one of the terminals of the motor.
- Pin-7 (Input-2): When this pin is HIGH then the flow of current will be though output 2
- Pin-8 (Vcc2): This is the voltage pin which is used to supply the voltage to the motor.
- Pin-16 (VSS): This pin is the power source to the integrated circuit.

- Pin-15 (Input-4): When this pin is high, then the flow of current will be through output-4.
- Pin-14 (Output-4): This pin must be connected to one of the terminals of the motor
- Pin-12 & 13: These pins are ground pins
- Pin-11 (Output-3): This pin must be connected to one of the terminals of the motor.
- Pin-10 (Input-3): When this pin is high, then the flow of current will through output-3
- Pin-9 (Enable3-4): When this pin is high, then the right part of the IC will work & when it is low the right part of the IC won ‘t work. This pin is also called as a master control pin for the right part of the IC.

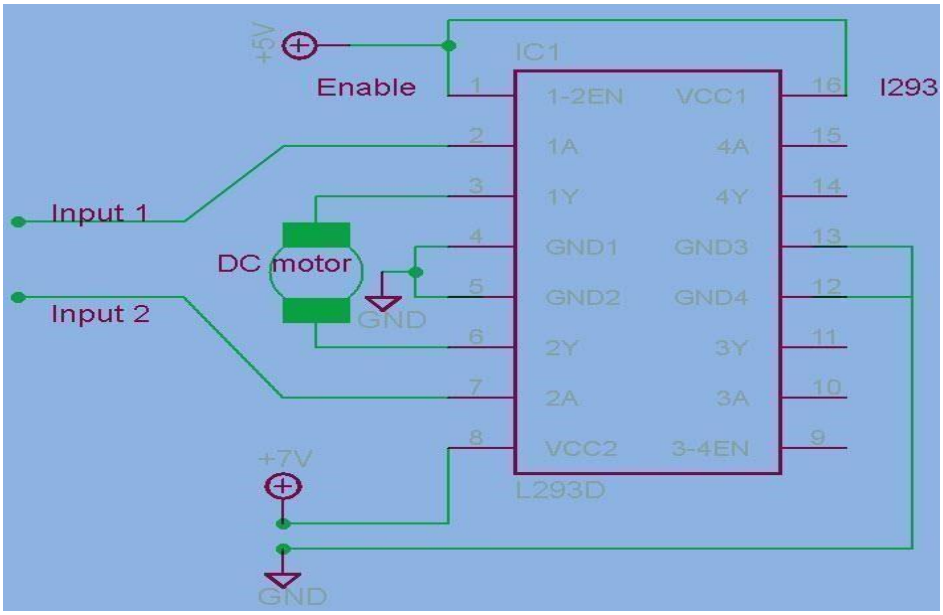


Fig.3.3.10: Pin connection with motor

The IC LM293D consists of 4-i/p pins where, pin2 and 7 on the left side of the IC and Pin 10 and 15 on the right side of the IC. Left input pins on the IC will control the rotation of a motor. Here, the motor is connected across side and right i/p for the motor on the right-hand side. This motor rotates based on the IPS we provided across the input pins as Logic 0 and Logic 1.

Let ‘s consider, when a motor is connected to the o/p pins 3 and 6 on the left side of the IC. For rotating of the motor in clockwise direction, then the i/p pins must be provided with Logic 0 and

Logic 1. When Pin-2= logic 1 & pin-7 = logic 0, then it rotates in clockwise direction. Pin-2=logic 0 & Pin7=logic1, then it rotates in anti-clock direction Pin2= logic0 & Pin7=logic 0, then it is idle (high impedance state) Pin-2= logic 1 & Pin7=logic 1, then it is idle In a similar way the motor can also operate across input pin15 and pin-10 for the motor on the right hand side. The L4293D motor driver IC deals with huge currents, due to this reason, this circuit uses a heat sink to decrease the heat. Therefore, there are 4ground pins on L293D IC. When we solder these pins on the PCB (printed circuit board), then we can get a huge metallic area between the ground pins where the heat can be produced.

7. Arduino IDE

Fig 3.3.11: Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cornerstone in the realm of microcontroller programming, renowned for its simplicity, accessibility, and versatility, making it a preferred choice for hobbyists, educators, and professionals alike. This open-source software provides an intuitive and user-friendly platform for writing, editing, compiling, and uploading code to Arduino boards, such as the popular Arduino Uno, Mega, Nano, and more specialized variants like the MKR series or Arduino Pro boards. Designed with simplicity in mind, the Arduino IDE supports the C and C++ programming languages and offers a beginner friendly interface with features like syntax highlighting, automatic indentation, and error highlighting. These features are essential for reducing the learning curve for newcomers while still catering to the needs of advanced developers working on complex projects.

A standout aspect of the Arduino IDE is its seamless integration with an extensive ecosystem of sensors, actuators, and communication modules, enabling the rapid prototyping and deployment of a wide range of projects. These include robotics, IoT systems, smart home automation, environmental monitoring, wearable devices, and even artistic installations. The IDE simplifies the inclusion of external components through its library management system, which allows developers to import and manage libraries for various hardware and software functionalities. Whether you're working with Wi-Fi modules like the ESP8266 or ESP32, Bluetooth modules like HC-05, GPS receivers, motor controllers, or advanced sensors such as LiDAR, the Arduino IDE makes it easy to configure, control, and retrieve data from these peripherals.

The IDE's built-in serial monitor is another powerful feature, enabling real-time data visualization and debugging. This tool is indispensable for monitoring sensor outputs, testing communication protocols, or understanding the behavior of connected hardware. For educators, the Arduino IDE serves as an invaluable teaching aid, allowing students to engage in hands-on learning by experimenting with electronics and coding. Its simplicity ensures that even young learners or those with no prior programming experience can create functional projects, fostering creativity and innovation.

Despite its simplicity, the Arduino IDE is also capable of handling more complex tasks through its support for advanced features such as custom libraries, external toolchains, and integration with other software platforms. Developers can enhance their workflows by linking the IDE with external version control systems like Git, or by using the IDE's command-line interface for automation and scripting. For those seeking even greater flexibility, the IDE's open-source nature allows for customization and extension, making it possible to tailor the development environment to specific needs. Furthermore, the Arduino IDE is cross-platform, running seamlessly on Windows, macOS, and Linux, ensuring accessibility for users regardless of their operating system.

Overall, the Arduino IDE is far more than just a programming tool; it is an enabler of creativity, innovation, and education in the field of electronics and embedded systems. By providing a simple yet powerful environment for coding and hardware integration, it has empowered millions of users worldwide to turn their ideas into reality, making it an

indispensable resource in the maker movement, academic institutions, and professional development labs. From blinking an LED to building complex IoT networks, the Arduino IDE serves as a gateway to exploring the infinite possibilities of technology and design.

8. C Language

Arduino is an open-source electronics platform based on easy-to-use hardware and software. The programming language used in the Arduino IDE (Integrated Development Environment) is a subset of C and C++. The Arduino language simplifies many complexities of C and C++ to make it more accessible to beginners, providing a straightforward environment to write, compile, and upload code to the microcontroller. Arduino libraries offer predefined functions and constants that streamline common tasks, such as `digitalWrite()`, `digitalRead()`, `analogWrite()`, and `analogRead()`.

In Arduino, programs are called "sketches." Sketches are written in the Arduino programming language and consist of two primary functions: `setup()` and `loop()`. The `setup()` function runs once when the microcontroller starts and is used to initialize variables, pin modes, and libraries. The `loop()` function runs continuously, allowing the microcontroller to execute commands in a repetitive cycle.

Using C in Arduino allows for direct manipulation of hardware, making it suitable for low-level programming. This control enables precise management of microcontroller features like I/O pins, timers, and communication protocols. C's efficiency is crucial in resource-constrained environments like microcontrollers, as programs written in C run faster and consume less memory.

The Arduino community is vast, with many resources, tutorials, and forums available to assist users. The use of C in Arduino allows for easy integration with other C libraries and codebases, enhancing its functionality. Arduino is widely used for rapid prototyping of electronic projects, making it an excellent tool for learning programming and electronics.

Arduino boards are commonly used in Internet of Things (IoT) projects for connecting sensors and actuators to the internet. They are also employed in home automation, robotics, and other control systems. The use of C in the Arduino IDE makes it a powerful and versatile platform for developing a wide range of applications, from simple LED blinkers to complex automation systems.

One of the key advantages of Arduino is its accessibility to both beginners and experienced developers. The platform abstracts many technical details, allowing users to focus on their projects without getting bogged down by complex programming concepts. The predefined functions and libraries make it easy to interact with hardware components, such as sensors, motors, and displays.

Arduino sketches can be easily shared and modified, fostering a collaborative environment where users can learn from each other and build upon existing projects. The Arduino ecosystem includes a wide range of compatible hardware and shields, which are add-on boards that expand the functionality of an Arduino board.

The combination of C and C++ in Arduino provides a balance between simplicity and power. While the language is easy to learn, it retains the capabilities of C and C++ for more advanced projects. This makes Arduino a versatile platform for hobbyists, educators, and professionals alike.

In summary, Arduino leverages the strengths of the C programming language to provide an accessible, efficient, and powerful platform for a wide range of electronic projects. Its ease of use, combined with a robust community and extensive resources, makes it an ideal choice for both beginners and experienced developers. Whether you're prototyping a new idea, learning about electronics, or building an IoT solution, Arduino offers the tools and flexibility to bring your projects to life.

CHAPTER 4

RESULTS AND DISCUSSIONS

The results of implementing a waste segregating machine using embedded system for waste separation purposes are multifaceted and yield several benefits.

1.Automated Waste Segregation

- The system efficiently separates metallic waste from other waste types without human intervention, reducing manual labor and errors.

2.Improved Recycling Efficiency

- Proper segregation at the source enhances the recycling process by ensuring that metals are directed to recycling facilities, reducing contamination of recyclable materials.

3.Environmental Sustainability

- By promoting better waste management, the project reduces landfill waste, minimizes pollution, and supports sustainable waste disposal practices.

4.Cost-Effective Solution

- Automation reduces the need for labor-intensive sorting processes, leading to cost savings for municipalities, industries, and waste management companies.

5.Faster and More Accurate Sorting

- The embedded system provides real-time waste detection and segregation, improving sorting speed and accuracy compared to manual methods.

4.1 WORKING MODULE

Fig 4.1.1: Working model

In a system designed to separate to waste using Arduino Uno, the process begins with the sensors sensing the material of bottles inserted to the port to the separator. When a sensor detects the bottles it sends the signal to the Arduino board and the board sends the signal to motor controller, it supplies the voltage to the motor which is placed to rotate the container which stores the different bottle material like plastic, metal in a correct angle. After container rotates the motor controller supplies the voltage to the motor used to block the port will open the way to the bottles. The Arduino board sends the signal to LCD display the counted bottles separately. The motor controller controls the motor to rotate the container back to normal position, the motor connected to block the way the port also closes the port by rotating. The system can be integrated into smart waste management solutions, making it suitable for urban areas, industries, public spaces, and waste processing plants.

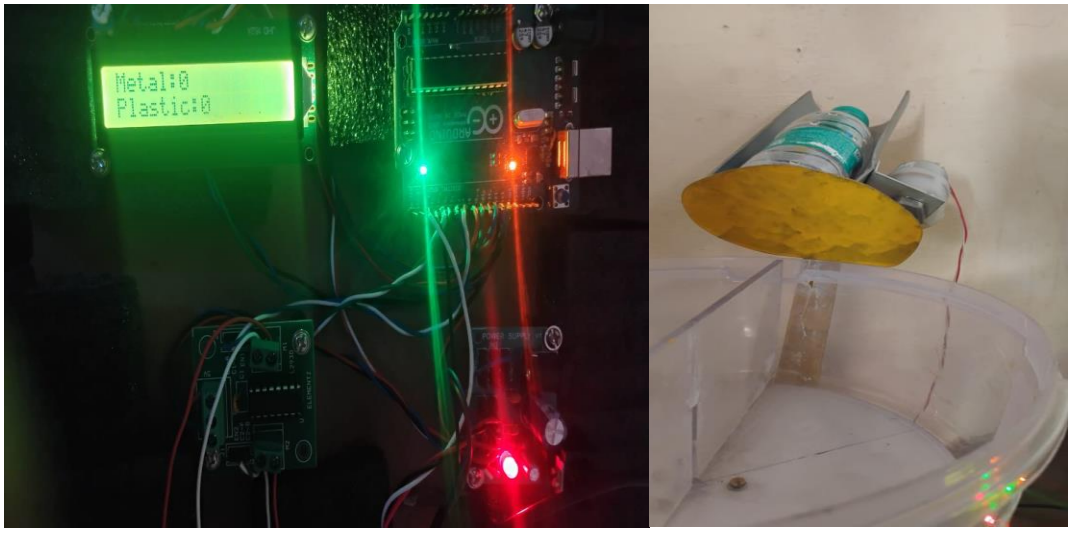


Fig 4.1.2: Meter reading before the waste is sensed

The meter reading in the above figure is before the waste material is sensed, when the material is placed in the input port the sensor such as proximity sensor, IR sensor detect the object and then the counting on the LCD is shown. It displays the number of components of different materials.

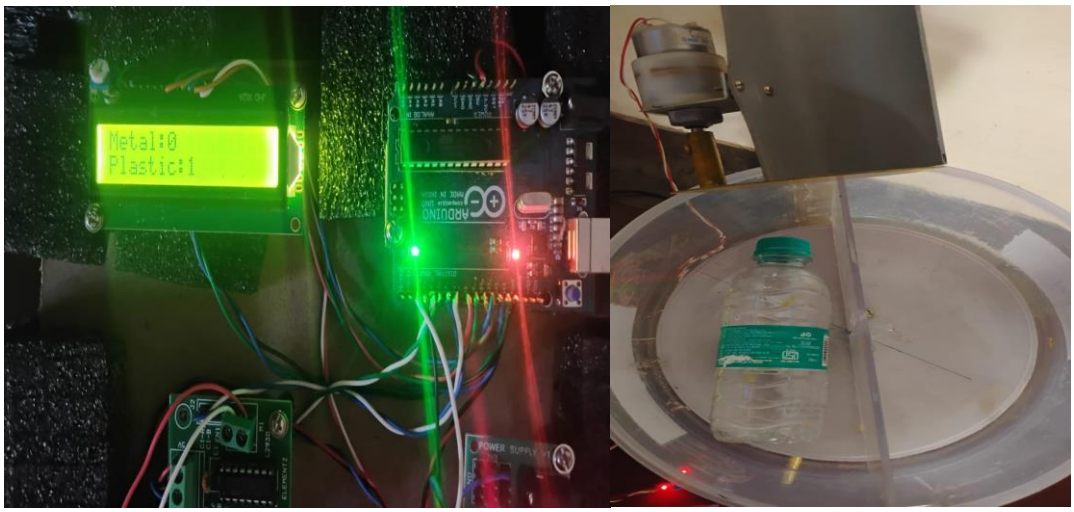


Fig 4.1.3: Meter reading after the waste is sensed

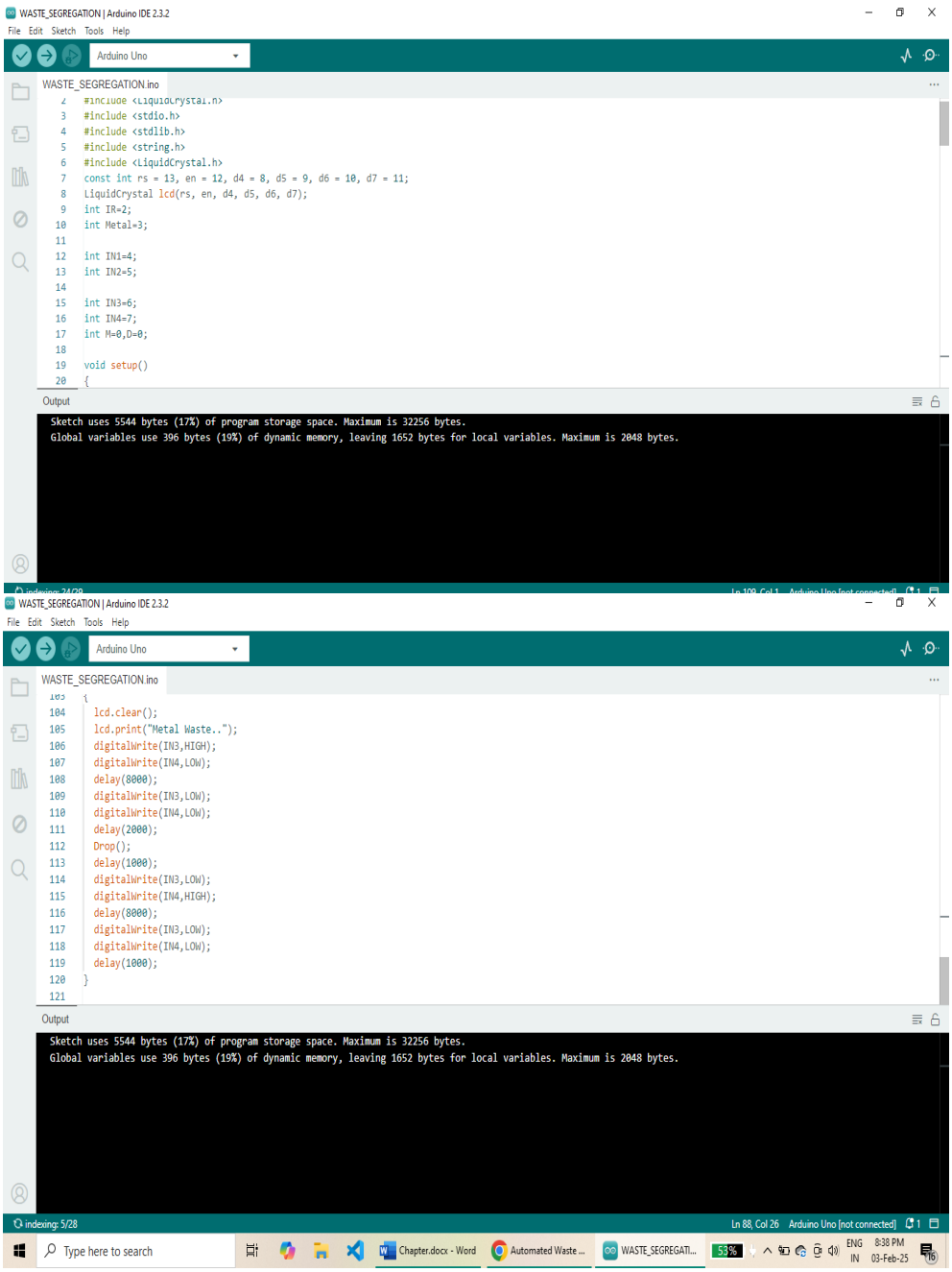


Fig 4.1.4 Arduino software code

The Arduino IDE platform is used to verify and upload the code to microcontroller the input pins and output pins can be used in various method which can be changed from the program code. The delays can also be added to the working model to increase the efficiency of prototype.

4.2 Applications

- Public Parks and Recreation Areas**:** Encourage visitors to recycle their bottles, reducing litter and promoting a clean environment.
- City Streets and Sidewalks**:** Positioned alongside regular trash bins to make recycling convenient for pedestrians.
- Airports: Helps manage the large volume of waste generated by travelers, promoting sustainability.
- Train and Bus Stations**:** Encourages commuters to recycle, improving waste management in high-traffic areas.
- Subway Stations: Provides an easy way for passengers to dispose of bottles responsibly.
- Shopping malls**:** Placed near food courts and retail stores to manage the high volume of bottles from beverages.
- Markets and Street Vendors**:** Assists in managing waste from beverages consumed on-the-go.
- Sports Stadiums**:** Helps manage waste from large crowds during events, promoting recycling.
- Encourages concertgoers to recycle bottles, reducing litter and waste.
- Schools and Universities**:** Educates students about recycling while providing practical recycling solutions on campus.
- Libraries and Community Centers**:** Supports sustainability initiatives and educates the public on the importance of recycling.
- Apartment Complexes**:** Provides a centralized location for residents to recycle bottles, improving community waste management.
- Residential Streets**:** Positioned alongside regular waste bins to encourage household recycling.

- Museums and Cultural Sites**:** Helps manage waste from visitors, promoting a clean and sustainable environment.
- Beaches and Parks**:** Ensures that recyclable waste is properly sorted and collected, reducing litter in natural areas.
- Government Buildings: Supports governmental sustainability initiatives and promotes recycling among employees and visitors.
- Corporate Campuses**:** Encourages employees to recycle, contributing to corporate social responsibility goals.
- Reduces the volume of waste sent to landfills.
- Conserves natural resources by promoting the recycling of materials.
- Lowers waste management costs.
- Generates revenue from the sale of recyclable materials.
- Raises public awareness about the importance of recycling.
- Provides educational opportunities on waste management and sustainability.
- Keeps public areas cleaner and more attractive.
- Reduces the risk of pests and odors associated with waste.
- Makes it easy for people to recycle, encouraging higher participation rates.

4.3 Advantages

- Recycling Efficiency: Facilitates the recycling process by pre-sorting materials, making it easier and more cost-effective for recycling facilities.
- Waste Reduction: Helps reduce the amount of waste sent to landfills by ensuring that bottles are properly recycled.

- Resource Conservation: Contributes to the conservation of natural resources by promoting the reuse of materials.
- Environmental Awareness: Encourages the public to be more conscious of their waste disposal habits and the importance of recycling.
- Educational Tool: Acts as a visual and practical reminder of the need to separate recyclables, which can help educate people about waste management.
- Cleanliness: Helps keep public spaces cleaner by providing designated places for bottle disposal, reducing litter.
- Hygiene: Reduces the risk of pests and odors associated with improperly disposed bottles, particularly those containing liquids.
- Cost Savings: Reduces the cost of waste management by lowering the amount of waste that needs to be processed or sent to landfills.
- Revenue Generation: Recycled materials can be sold to recycling companies, generating revenue for municipalities or organizations

.

4.4 Disadvantage

- Initial Costs: The installation of bottle separators involves upfront costs for purchasing and placing the containers.
- Maintenance: Requires regular maintenance, including emptying the containers and ensuring they are not contaminated with non-recyclable waste.
- Misuse: There is a risk that people may not use the separators correctly, leading to contamination of recyclable materials.
- Awareness Gap: Not everyone is aware of or motivated to follow proper recycling practices, which can reduce the effectiveness of the separators.

- Space Consumption: Bottle separators take up space, which might be a constraint in areas with limited room.
- Clutter: If not well-designed or maintained, they can contribute to visual clutter in public spaces.
- Logistics: Coordinating the collection and transport of separated bottles to recycling facilities can be complex and require additional resources.
- Consistency: Ensuring that bottle separators are available and used consistently across different public areas can be challenging.

Overall, while bottle separators in public places offer significant environmental and social benefits, they also come with practical and logistical challenges that need to be addressed to maximize their effectiveness.

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

Conclusion

Waste segregation machine in public places significantly improve the efficiency of recycling programs by ensuring that wastes are correctly sorted and collected. This reduces contamination and increases the volume of materials that can be recycled. The widespread use of waste segregation machine contributes to substantial environmental benefits, including reduced landfill waste, conservation of natural resources, and lower greenhouse gas emissions associated with the production of new materials. Placing waste segregator in public places raises public awareness about the importance of recycling and encourages responsible waste disposal behavior. It serves as a practical educational tool, promoting sustainable practices among the community. By providing a designated place for waste disposal, waste separators help maintain cleaner and more hygienic public spaces, reducing litter and the associated health risks. Implementing waste separators can lead to cost savings in waste management and generate revenue from the sale of recyclable materials. It also reduces the expenses associated with waste disposal and landfill management.

Future Scope

Future bottle separators can integrate advanced technologies such as AI and IoT for better sorting accuracy, real-time monitoring, and efficient collection schedules. Smart separators can alert maintenance teams when they are full or need attention. Developing separators that can handle a wider range of materials, including metals, paper, and various types of plastics, would further enhance recycling rates and resource recovery. Improved integration with broader waste management and recycling systems can streamline operations, ensuring that collected bottles are efficiently transported and processed at recycling facilities. Expanding the deployment of bottle separators to more public areas, including rural and underserved regions, can increase recycling participation and reduce environmental impact on a larger scale. Encouraging partnerships

between municipalities, private companies, and non-profit organizations can foster innovation, funding, and shared responsibility in promoting and managing waste separators in public spaces. Ongoing public education campaigns can complement the presence of bottle separators, emphasizing the importance of recycling and proper waste disposal. Schools, community centers, and social media can be effective platforms for these campaigns.

Future designs of bottle separators should focus on sustainability, using recycled and eco-friendly materials. Additionally, ensuring that the separators themselves can be recycled or repurposed at the end of their life cycle is crucial. Implementing incentive programs, such as deposit return schemes or rewards for recycling, can motivate more people to use bottle separators and adopt sustainable behaviors. Continuous research into new materials, better sorting techniques, and user behavior can lead to improvements in the design and functionality of bottle separators. Collaboration with academic institutions and industry experts can drive innovation.

In conclusion, while waste separators in public places have already shown significant benefits in promoting recycling and reducing waste, there is considerable potential for future advancements. By leveraging technology, expanding coverage, fostering partnerships, and enhancing public education, waste separators can play an even more crucial role in creating sustainable and clean urban environments.

REFERENCES

1. Chinmay Kolhatkar, Prachi Choudhari, Bhavesh Joshi, Dhruvin Bhuva‖ Smart E-dustbin

―2018 International Conference on Smart city and emerging technology (ICSCET).

2. Saurabh Dugdhe, Pooja Shelar, Sajuli Jire and Anuja Apte.‖ Efficient Waste Collection System‖, 2016 International Conference on Internet of Things and Applications (IOTA).

3. Chandradeep Tiwari, Smt. Nagarathna. K ―Waste Management using Solar Smart Bin‖ 2017 International Conference on Energy, communication, data analytics and soft computing (ICECDS).

4. G Sai Rohit, M Bharat Chandra, Shaurabh Saha, Debanjan Das‖ Smart Dual Dustbin Model for Waste Management in Smart Cities‖ 2018 3rd International Conference for Convergence in Technology (I2CT).

5. A.S. Furtatova, O.V. Novikova‖ Professional Requalification Program for the Specialists in the Field of Waste Management‖ 2018 International Conference‖ Management of Municipal Waste as an Important Factor of Sustainable Urban Development‖(waste).

6. S. Vinoth Kumar, T. Senthil Kumaran, A., Krishna Kumar and Mahantesh Mathapati

―Smart Garbage Monitoring and Clearance System using Internet of things‖ 2017 IEEE

International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM).

7. Krishna Nirde , Prashant S. Mulay, Uttam M.Chaskar ―IoT based solid waste management system for smart city‖ 2017 International Conference on Intelligent Computing and Control Systems (ICICCS) .

8. Murugaanandam. S, Ganapathy. V and Balaji. R ―Efficient IOT Based Smart Bin for Clean Environment ‖ 2018 International Conference on Communication and Signal Processing.

9. Santhosh Kumar B R, Varalakshmi N , Soundarya S Lokeshwari , Rohit K, Manjunath, Sahana D N ―Eco-Friendly IoT Based Waste Segregation and Management‘‘2017 International

Conference on Electrical, Electronics, Communication, Computer and Optimization Techniques (ICEECCOT).

https://github.com/topics/waste-management-system

https://projecthub.arduino.cc/thekhurapaatimind/waste-segregator

https://github.com/topics/waste-management-system

arduino-based-automated-waste-segregator-final-year-project.htm