

TRASH COMPACTOR WITH LEVEL MONITORING SYSTEM

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechatronics Engineering

by

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**DEPARTMENT OF MECHATRONICS ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of S. Karthick Raja, J. Sabeer Khan who carried out the project entitled “Trash Compactor with Level Monitoring System” under my supervision from 01.11.2021 to 10.05.2022.

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ABSTRACT

One of the major necessities to be addressed in our environment is waste management which in addition to disturbing the environment also has a huge effect on the health of society. Chennai alone generates 5600 tons of waste every day. One of the most pressing issues of our day is the identification, monitoring, and management of trash. The conventional method of manually monitoring garbage in waste bins is a complex, time-consuming procedure that requires more human effort, time, and money, and is in no way compatible with current technology. This is a cutting-edge approach to trash management that is fully automated. This project is an automated Garbage Monitoring Device, a cutting-edge system that will aid in the clean-up of cities.

This system monitors the garbage bins and provides information about the amount of garbage collected via a web page. This website also sends all information to the relevant city or municipality corporation. This system is a garbage compactor that detects the waste level within the trash containment unit using integrated infrared and ultrasonic sensors. Unlike other systems, these use linear actuators to compress and compact the rubbish collected, resulting in an exact level of garbage, which reduces the amount of disinformation given by other systems and increases energy efficiency owing to less labor. The system's database management is handled by MongoDB, which will be used to show data on a web page for the municipality's next steps.

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LIST OF ABBRIVIATIONS

GCV - Garbage Collecting Vehicle

GMS	-	Garbage Monitoring System
GO	-	Government Organization
NGO	-	Non-Government Organization
SAARC	-	South Asian Association for Regional Cooperation
MSW	-	Municipal Solid Waste
CAD	-	Computer Aided Design
CPU	-	Central Processing Unit
ADC	-	Analog to Digital Converter
DAC	-	Digital to Analog Converter
UN	-	United Nation
IDE	-	Integrated Development Environment
OS	-	Operating System
RAM	-	Random Access Memory
ROM	-	Read Only Memory
AC	-	Alternating Current
DC	-	Direct Current
GND	-	Ground End
IR	-	Infra-Red
V	-	Voltage
HZ	-	Hertz
L	-	Liters

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW OF GARBAGE DISPOSAL

In the modern era, the urbanization of cities has come with a cost. One of them is an increase in population in urban areas. Not only in urban areas, according to the UN the world population increases by 2% every year. Which is responsible for the increase in consumerism in common people and industrialism in businessmen. Whatever may be the growth, both consumerism and industrialism have a drawback of resulting in a major issue of improper waste disposal and management.

Waste generation rates around the world are rising and 5.7 lakh metric tons per day in India. The statistics estimated that the volume of solid waste generated a mark of 0.74 kilograms per person per day. This leads to overflowing dumpsites, because of improper garbage compacting. Resulting in a lack of hygiene and increasing the harm to society day by day that is destroying mankind. Domestic waste generation increases by 10 to 15 percent during festivals and special occasions, which is more in the case of India. But there are only approximately 1500 buckets of 750 liters volume for a local urban area of 700 sq km. More than two thousand garbage collectors are working to cover nearly one million houses' domestic garbage. Many GOs and NGOs are working under this process to ensure the proper disposal of garbage (Swachh Bharath Mission, Swachh Bharat Abhiyan, Swachh Seva Sahakari Sanstha Maryadit in Pune, Shuddhi, Environmentalist Foundation of India, Project Mumbai, Aahwahan).

1.2 ANALYSIS OF TYPE OF GARBAGE IN INDIA

After analyzing lots of resources, it is clear that the few major types of waste are spread all over the garbage yards. They are municipal waste from residents, plastic waste from hotels and other commercials, E-waste from tech parks and

manufacturing industries, medical waste from hospitals and clinics, and finally construction waste from construction sites.



Fig. 1.1: Major Types of Waste in Garbage in India

1.2.1 Municipal wastes

Municipal wastes are also called domestic wastes. These wastes are produced as a result of common people day to day routine. Some may be caused due to grocery stores, vegetable shops, hotels and restaurants, and other sectors. The before mentioned producers of municipal waste are considered the indirect cause of common people. In simple these wastes are produced by our lifestyle. It requires a huge revolution to limit these kinds of waste. The actual problem arises when the municipal waste is not properly disposed of. The major risk arises when these municipal wastes are disposed of in water bodies. Since India has a huge population, yearly India alone generates over 6.2 crore tons of municipal waste. Improper disposal of these kinds of waste causes several health issues in the surroundings and is the major cause of vector-borne diseases. This waste can be considered as waste

that is only generated by human beings for their living and non-other lives on this earth.

1.2.2 Plastic Wastes

Plastic is a man-made material that serves multiple purposes. Different kinds and percentages of plastics are used in various applications. Plastic is one of the most used materials in all industries and houses. In several places, this plastic has replaced many other materials in the recent decade. The actual problem arises when this plastic is not handled and properly disposed of after the usage. This plastic waste is an actually non-biodegradable waste. Which takes decades to decay when disposed of inland and or water bodies. The major part of the plastic waste is plastic used for packing. Since plastic is a durable material that does not allow moisture and water drops to pass through them, plastics are used. Most of the use and throw materials like straw, plastic bags, bottles, packing cushions, and bubble covers for packing are made of plastic. These use and throw materials are considered to be waste after a single use. People do not take interest in recycling these kinds of plastics. The plastic that is being disposed of inland and water causes environmental pollution. This also affects the food chain of the animals in that locality. Waste disposal used in the water bodies nearly kills one million marine creatures every year, because of indigestion from the plastic waste they accidentally eat.

1.2.3 E - Wastes

Electronic waste is a waste generated when an electrical or electronic device has become useless due to aging, low performance, and non-recoverable repairs. The electronics abandoned by a user are e-waste. India secures the fifth position in the production of this E-Waste. According to statistics, India generates 20 lakhs tons of E-waste. Electronics like computers, calculators, mobiles, audio equipment, video devices, and other peripheral devices when disposed of become E-waste. It majorly carries elements like silicon, lead, chromium, etc. which are considered to be toxic substances. Improper disposal of these kinds of wastes causes harm to the environment. Accidently burning these kinds of waste along with other garbage

causes a toxic gas to spread along with the air. The above situation may lead to severe health issues. For instance, these electronics use lead for their internal connections, burning of this lead in the presence of air releases lead oxide (PbO_2). Respiration of this gas may cause harm to the neurological and reproductive system, as well as may damage organs like kidneys and brain. Like the above instance, other elements also cause harm to flora and fauna in that area of E-waste disposal. This waste is the major cause of lung cancer which cause respiratory problems.

1.2.4 Biomedical Waste

Waste generated by the medical industries is called Biomedical waste. India alone roughly generates over seven hundred tons of Biomedical waste every year. This waste is generated in hospitals, clinics, and bio laboratories. Biomedical wastes are generated during the treatment of both human beings and animals. The main biomedical wastes are expired drugs, expired medicines, used bandages, syringes, fluid bottles, diseased human tissues and etc. The aging of these wastes without proper disposal gives rise to harmful bacteria and toxins. Sometimes the illegal act of disposing of medical waste in the sea and other water bodies causes huge harm to the marine ecosystem.

1.2.5 Construction and Demolition (C&D) Waste

The waste generated while demolishing a building or a particular area is considered to be Construction and Demolition waste. On average India alone produces nearly 170 million tons of construction waste per year. Construction or reconstruction of both public and private properties like buildings, houses, parks, roads, flyovers, and other structures are major generators of these kinds of wastes. In modern construction methodology, the waste generated is mostly tried to be used for laying the foundation for those constructions. In some cases, the demolition waste volume will be more when compared to the volume of scrabs required for the reuse process. In that case, the remaining construction wastes are thrown out. The demolishment wastes like timber woods, steel rods, iron rods, broken bricks, solid concrete and etc. are the major contents of construction wastes.

1.2.6 Hazardous Waste

Any waste that causes disastrous damage to the environment is considered hazardous waste. India alone yearly generates 7.36 metric tons of hazardous waste. Some hazardous wastes are volatile in nature and evaporate easily at high temperatures. Some hazardous wastes are highly explosive and risky substances, causing a high danger to life. This waste has a high risk of toxic gas emissions and other chemical emissions. Most of the hazardous air pollution is caused by the burning and improper disposal of these wastes. Some of the hazardous are disposed of on the water bodies, which leads to marine murder of lives in that water body. This hazardous substance can cause blood cancer, lung cancer, neuro disorder, various skin diseases and etc.

1.2.7 Battery Waste

Exhausted and used batteries generate battery waste. Though the technology has grown to give long output from a small power source, the wastage due to these power sources remains the same. Nearly 2.8 billion dry battery cells are utilized each year in India. The batteries used in the electronics, electrical, and automobile industries are the major generators of this battery waste. The few kinds of batteries that are commonly used in this era are carbon batteries, lithium-ion, and lead-acid batteries. Since petrol products are price rising, the concept of e-vehicle is getting implemented in the automobile industry. These E-Vehicles contain these batteries as their energy source. Though it is not a huge kind of waste for the present decade, it will be the one in the future. Improper disposal of the batteries can end up disastrous. The heavy metals used in these batteries may be toxic and poisonous. According to the government rules each and every battery, irrespective of its size should be sent for recycling and proper disposal. Instead, nearly 90% of the total count of batteries produced in a year goes unnoted.

1.3 CHALLENGES IN WASTE MANAGEMENT:

In India due to the high population garbage generation is high, whereas the facility to manage that garbage is low, that is collecting the garbage, transporting to nearby municipality yards, waste treatment and finally disposing it to major garbage yard, where most of the garbage turns to dust. The waste generated in urban areas is far more than the waste generated in rural areas. Statistics state that urban areas of the Indian states hold at least 30% of each state's population. The current garbage management system of India is unable to match the garbage produced. The obstacles and challenges are more than it seems. According to a conference conducted in prospects SAARC nations, the best solution for waste management is keeping the reusable materials and substances within a good economical range. If so, the RRR (Reuse Reduce Recycle) methodology gets into progress, which reduces garbage production.

Another challenge in waste management is the segregation of different kinds of waste. The reusable materials should be renewed, the recyclable materials have to be sent for the recycling process, and the final segregation of the waste which cannot be used or recycled has to be sent to the reduction of volume process. Encouragement for the idea of engineered garbage yard to utilize it to the maximum are less. Projects proposing energy from wastes as their own un-rectifiable drawbacks. This leads to the exploitation of available material resources. The energy generation process from the extraction of methane from those wastes or from the thermal power of those wastes is an important project stumbling due to the lack of a corresponding engineering specialist. Expertise in environmental science is also needed to implement the above processes with the current waste management system efficiently.

1.3.1 Challenges in infrastructure development for public health

The improvement in the civil infrastructure plays a vital role in India to become a world leader in the economy. To achieve successful economic growth, it is critical to provide the extraordinary infrastructure that serves the environmental protection, quality, and security of the lives. Creating an infrastructure for waste management is not a cutting

the edge task. It is a very long-term process. India's industrial development and increase in population lead to natural resource exploitation. In this critical situation, waste processing is our only potential resource for human needs and proper waste management. Investment has to be done in Solid Waste Management to make the waste of resources that humans need the more. Particular steps have to be taken to recover the reusable and recyclable materials. This infrastructure must concentrate on reusable materials, energy generation, and nutrients recovery. India is practicing this recycling for a long time. Recovery of reusable and recyclable is common in this process. The recycling process is carried out for reusable wastes like glass, paper, wood, plastic, metals and etc. So, it will not take much time for India to implement the infrastructure required for the SWM process.



Fig. 1.2: Recycling Picture for various garbage
(Source: [www.constructionworld .in](http://www.constructionworld.in))

1.3.2 Statistics on waste generation

Effective waste management plans meet its barriers while finding the characteristics of the waste, volume growth of the waste generation, and predicting the type and volume as a future preparation. The amount of Municipality Solid waste (MSW) produced per day can be found by analysing the lifestyle of the people living in that

locality. The MSW also majorly depends on business activities happening in the locality.

Table 1.1: Waste Generation Statistics in each State of India
(Source: Sunil Kumar, Stephen R - Challenges and opportunities associated with waste management in India [20])

The major Garbage Generating States	Minimum Waste Generated per Day	Maximum Waste Generated per Day
Maharashtra	25603 tons	19204 tons
Uttar Pradesh	11825 tons	15639 tons
Tamil Nadu	11639 tons	15100 tons
West Bengal	11523 tons	15363 tons
Andhra Pradesh	9856 tons	14872 tons
Kerala	7683 tons	11542 tons
Madhya Pradesh	7216 tons	10205 tons
Rajasthan	6845 tons	10142 tons
Gujarat	5526 tons	8329 tons
Karnataka	4992 tons	6315 tons
Mizoram	3852 tons	7831 tons
Manipur	780 tons	3852 tons

Other major states like Goa, Delhi, Chhattisgarh, Orissa, Assam, Bihar, Meghalaya, Jammu & Kashmir, Tripura, and Nagaland generate less or more garbage than Manipur, that is nearly 3500 tons per day.

1.3.3 Predictions on future waste growth

By 2050, global garbage output is predicted to reach over 27 billion tons per year, with Asia accounting for one-third of the total, with China and India leading the way. In 2025, waste output in India's metropolitan regions would be 700 grams per person per day, around four to six times greater than in 2000. As the number of communities grows, the difficulties connected with trash become more acute, opening up the potential for self-help organizations and NGOs to centralize waste management.

The below graph represents the projectile of the waste generation quantity. The y-axis represents the land area of the garbage yard required in Square Kilometers. The x-axis represents the upcoming years with an interval of 10 years.

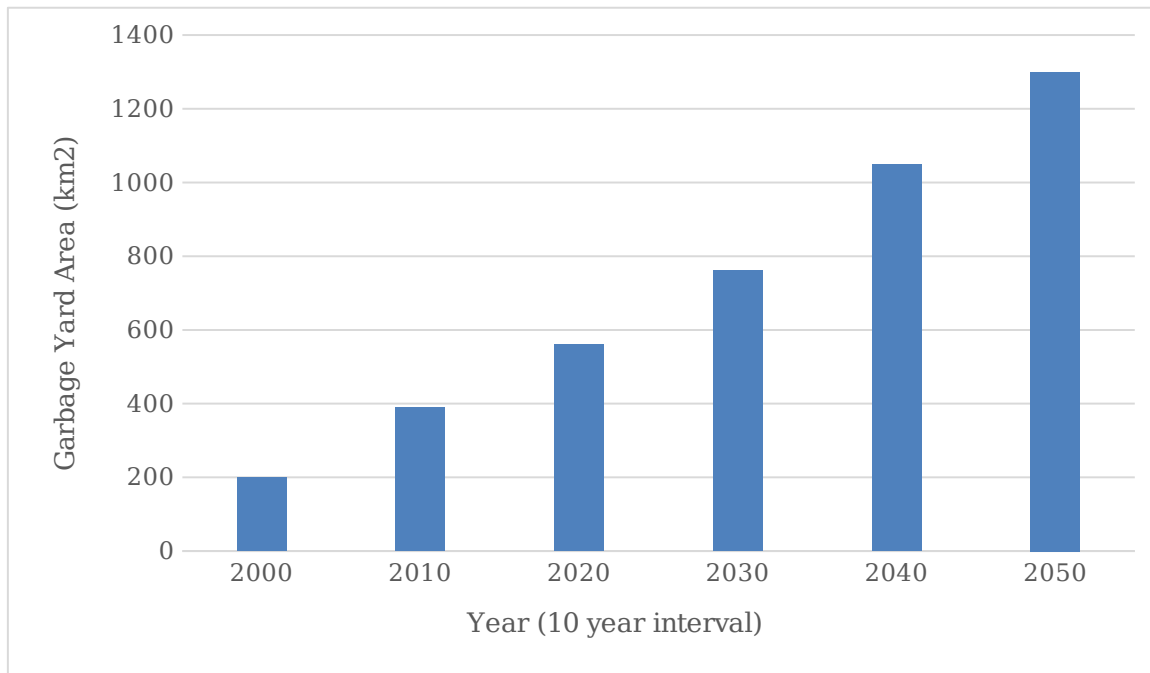


Fig. 1.3: Bar Chart of Future Waste Generation of every decade

(Source: Sunil Kumar, Stephen R - Challenges and opportunities associated with waste management in India [20])

The trash produced in India's metropolitan regions amounts to nearly 170,000 tons per day or 62 million tons per year, and this figure is predicted to rise by 5% per year due to population growth and changing lifestyles. In 2001, urban India created 31.6 million tons of trash, which has increased to 47.3 million tons now. Waste production is expected to reach 161 million tons by 2041, a projectile increase for a decade.

1.4 EXISTING SYSTEM OF GMS

The existing system consists of just an ordinary Iron or PVC bin with a capacity of 850 to 1100 liters. The volume of these bins is not used to its maximum capacity. So those dustbins usually overflow. This makes the work of local garbage collectors hard and time-consuming. Because these garbage collectors dump the waste in the street corner municipality bin in most of the localities. So, it takes time and energy for them

to compact the existing garbage in the bins. In the existing system, the garbage compacting is only done by the garbage collecting heavy vehicles. This also has the drawback of scheduling pickup based on the garbage-filled up. Because no system updates the garbage level appropriately concerning time. This overflow of garbage due to various reasons causes an unhygienic environment and affects human health. Most of these municipality bins are placed on the street corners and main junctions. So, it is hard to keep additional bins in the same place to avoid overflowing garbage. Which in turn causes traffic jams, accidents, and nuisance to the environment.



Fig. 1.4: Conventional Garbage Collection Process

The overflow of the garbage is caused due to non-compressed volume of the garbage. This state of situation makes the garbage disposal for both common people and local garbage collectors. The proposed system will monitor the garbage level regularly and compress the garbage to its temporary plastic state.

1.5 MERITS AND DEMERITS OF THE EXISTING SYSTEM

The merit of the existing system is that the compaction is carried out in the Garbage Collecting heavy-duty Vehicles (GCV). Which in turn reduces the garbage volume during transportation. The demerit is that the compaction is only done in the final stage of the garbage collection. And also, there is no level monitoring system for the garbage in the bin. This raises the number of trips required to collect the garbage or irregular garbage collection. Due to improper utilization of the volume of the bin, the local garbage collectors suffer a lot from the disposal of the garbage collected into the municipality bins.

1.6 ORGANISATION OF THE REPORT

The first chapter explains the general introduction and overall statistics that insist on the necessity of the proposed system. The second chapter explains the various systems that are previously implemented and published. The third chapter explains the design and control flow of the proposed system of garbage management. The fourth chapter explains in detail the working of the proposed system, with a brief explanation of the various hardware components and software modules used in this project. The fifth chapter explains the implementation and the results obtained from the experimental trial of the project prototype model. Finally, the sixth chapter provides the conclusion and future improvements that can be made to improve this project.

CHAPTER 2

LITERATURE SURVEY

The following research articles are studied as a part of a literature survey and the findings of this research are summarized in the following table. Some of the data and ideas of presenting formats are used for this project. The table below represents the Title of the resource, year of publication, author name, and the concept they have proposed, which was very helpful in developing this Garbage Monitoring system with its own novelty.

S.No	Title	Year	Author	Concept
1	Waste compacting bin	June 2020	Mallikarjuna ReddyG, Mounesh, Laxmanagouda Biradar, Vijay Kumar, Shanawaz Patil	This paper presents trash compaction with an ultrasonic sensor for level detection and uses DC motors and X frames for compaction.
2	Design And Analysis of 200W Solar Trash Compactor	Nov 2019	Ranjeet Kumar Jha, Durgesh Sharma	The paper states about trash compactor which is designed to compress the waste as effectively as 5 times using a solar photovoltaic system.
3	IoT based Smart Garbage System Powered with Solar Cell	Jan 2020	Karthick R , Vinothini C, Saranya, Sasikumar G, Tharini M, Ikash K	This paper explains a system that provides an ideology for managing the garbage collected data remotely in real-time using Wi-Fi. This system is proposed for Municipality Solid Waste.
4	Smart garbage	Aug	Vinoth Kumar S,	The paper details the

	monitoring and clearance system using the internet of things	2020	Mahantesh Mathapati, Senthil Kumaran T, Krishna Kumar A	process carried out by a working model of the level monitoring system. This system employs GSM or GPRS to transfer the message of indication to the concerned person. It is an IoT-based system.
5	IoT Based Dust bin Monitoring System Using Node MCU	Jan 2020	Lova Raju K, Naga Phanendhra V, Md. Abbas Hussain, Umesh Chandra, Naga Phanendhra V, Narendra D	The project is proposed to measure the trash level with help of ultrasonic and transfer data to the respective person in charge through Node MCU. The Flame sensor is used to detect the fire, which may be caused accidentally.
6	Smart garbage management system for a sustainable urban life	Aug 2020	Minhaz Uddin Sohag, Amit Kumer Podde	The paper explains an electronic system that measures and intimates the garbage level of a bin.
7	Design and Development of an Economical and Reliable Trash Compactor	Oct 2020	Abu Fazal, Ridhi Lakhotia, Ankur, Ajay Yadav, Bhattacharjee	In this paper, a reliable and economical solar-powered trash compactor increases the capacity of existing trash bins.
8	Development and Testing of a Breadboard Compactor for Advanced Waste Management Designs	Jan 2007	John W. Fisher, Gregory S. Pace, John A. Hogan, Kanapathipillai Wignarajah, and Eric J. Litwiller	The chapter explains the design of a prototype. This consists of a breadboard frame to compact the garbage. The experiment is conducted in various wastes and the result is obtained.
9	Automated Trash Compactor Bin	Jun 2021	Deepak Kumar Sinha, Rafa Shaikh, Hritik	The paper explains trash compacting, with a novel frame model. Which is used

	with Auto-Seal Mechanism		Mahajan, Ketan Patni	to exert force on the trash to reduce its volume and utilize the bin volume efficiently.
10	The Design and Implementation of Smart Trash Bin	Aug 2017	Fady E. F. Samann	The paper provides the ideology of Waste monitoring in small-scale cases. The design is considered cost-effective by the author. The ultrasonic sensor proximates the fullness of the garbage level of the bin. The intimation alert for the GMS is done by SMS.
11	A LoRaWAN IoT enabled Trash Bin Level Monitoring System	Mar 2021	Alfred Kirubaraj A, Theodoros Anagnostopoulos, S.R. Jino Ramson, S. Vishnu, Adnan M., and Abu Mahfouz, Senior Members, IEEE	According to the author, one of the main problems faced in urban areas is waste management. This improper maintenance may cause serious health issues if is not handled immediately. So, the author is proposing a trash level monitoring system, which communicates the result through the LoRaWAN. This system is an IoT-based level monitoring system.
12	Design and Implementation of a Smart Solid Waste Monitoring and Collection System Based on the Internet of Things	Aug 2017	Aaditya Jain, Ranu Bagherwal	The authors propose a system to monitor the completeness of the waste in the garbage bin. They use GSM/GPRS systems to communicate the level of the garbage. The hardware consists of sensors and a microcontroller as a control system for his proposed project. The data obtained through the above software is displayed in an android

				application.
13	Household Waste Management System Using IoT and Machine Learning	Dec 2020	Sonali Dubey, Pushpa Singh, Piyush Yadav	The author proposes a system that uses electronic sensors to sense household waste. The communication process is carried out by the IoT. Apart from the concept of automation in level monitoring, the system uses machine learning to create a new process to monitor waste generation to its high accuracy. The author concentrates on the green city approach and reducing the pollution caused due to improper waste management and improving the environment.
14	Theoretical modeling and fabrication of smart waste management system for the clean environment using WSN and IoT	Mar 2020	Kanimozhi P, Ramalingam S, Murugesan S	An approach that places undesirable approach that places undesirable managers, the computers. This framework is an IoT Based trash monitoring system, an extraordinary innovation to make the city areas a smart administration of waste.
15	Design and Analysis of a Hydraulic Trash Compactor	Feb 2020	Kamalakanta. Muduli, Kolawole David Somade, Narayan Biswal Peter Oyekola	The major aim of the design is monitoring and trash compacting using a hydraulic press. In his proposal, they try to use the basically available sources to construct this system. They carry the test drives required to ensure the reliability and efficiency of the system.

16	Space Mission Utility and Requirements for a Heat Melt Compactor	Aug 2016	Fisher, John Lee, Jeffrey	This system is proposed for outer space working. As per the name, this system uses a heat melt process for compacting in the system. This design is a technology approach for NASA. They also concentrate on the recycling process of compacted waste into useful materials.
17	Resources, Conservation and Recycling	May 2015	Biplob Nandy, Gaurav Sharma, Saryu Garg, Shweta Kumari, Tess George, Yengkhom Sunanda, Bärbel Sinha	This paper explains the various process of resource conservation. And also, about recycling of waste. Has done an analysis on quantity and type of material recovered at different stages.
18	Municipal solid waste management in Kolkata, India	Dec 2008	Subhasish Chattopadhyay, Amit Dutta, Subhabrata Ray.	The author explains his innovative plan to segregate the type of waste at the source. This ideal requires a considerably high investment. It proposes a pattern plan for waste collection and optimizes transport efficiency.
19	Smart Trash Monitoring System Design Using Node MCU-based IoT	Mar 2022	Riffa Haviani Laluma, Ade Geovania Azwar, Ronny Permana Halim, Gunawansyah, Gunawan, Nurwathi.	The authors create a planned strategy to design a tool that concentrates on trash monitoring. This is an integrated design that contains an application for communicating garbage filling status. This helps in arranging temporary waste collection which is always ready to transport to the final garbage yard, without queuing the request of transporting.

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CHAPTER 3

OVERVIEW OF NEW GARBAGE COMPACTING AND MONITORING SYSTEM

3.1 OBJECTIVE OF TRASH COMPACTING SYSTEM

The objective of the project is to develop an automated system for monitoring the garbage level and compacting the garbage to a level to utilize the maximum volume of the existing municipality bin efficiently. This automation will provide society with major benefits like avoiding accidents due to overflowing garbage on the road, reducing the manpower required to compact the garbage, and creating a clean and neat environment. Therefore, the proposed system can able:

- To automate the monitoring of the garbage level and intimate the same to a webpage available for the local municipality or corporation.
- To automate the compaction which ensures the maximum utilization of the volume of the bins and nullifies the human effort required for that.

3.2 AIM AND SCOPE OF GMS

Even Though the dustbin buckets are available at main street junctions, they are not used efficiently due to overflow of garbage and improper management. People in urban areas do not have the patience to properly dispose of the garbage. That is utilizing the maximum volume of the municipality bins while disposing of the garbage. This causes the need for the use of automated technologies which reduce the time and human effort of garbage collectors and common people. Automation is always recommendable in a place where the work involves unhygienic practice. The automation done here is a garbage compactor for local municipality garbage bins. Designed to utilize the maximum volume and monitor garbage level. The model is

designed and fabricated to compress the garbage to a reasonable volume (one-fourth at least) without any human effort.

3.3 PROPOSED SYSTEM OF GMS

The proposed system is a prototype model of an attachment that can be employed with the existing municipality bin. This prototype compacts the garbage according to the existing garbage level that is level before compaction. This system also measures the garbage level after every garbage disposal, which is detected by an Ultrasonic sensor. Also, the level is updated immediately on the webpage. Different indications are made to show the level increment and full status of the bin. This system can be assembled at a low cost which provides 3 to 4 times more efficiency than existing systems. Apart from reducing the garbage overflow, it also increases the environment's cleanliness and hygiene. This also has an effect on reducing the road accidents caused by the garbage spread on the roads. It also detects the smoke and toxic gas created accidentally to intimate in real-time on the webpage.

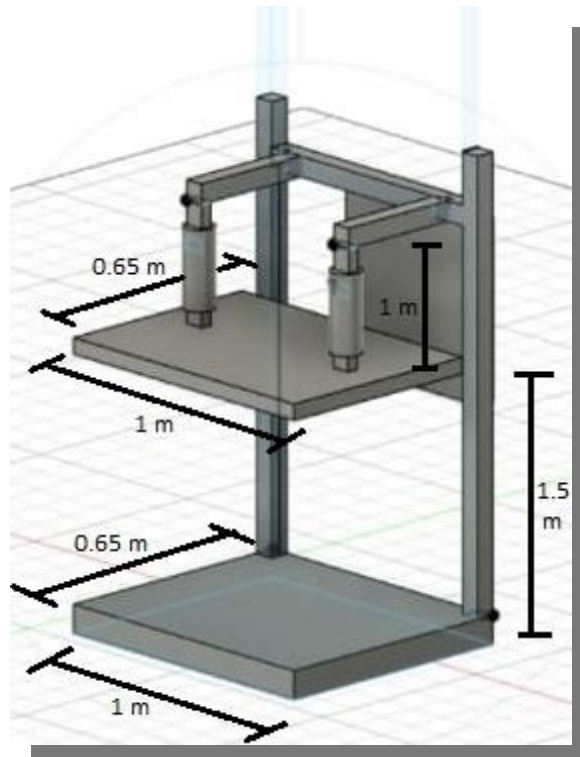


Fig. 3.1: CAD of Dual Actuator Trash Compactor for 660L Bin

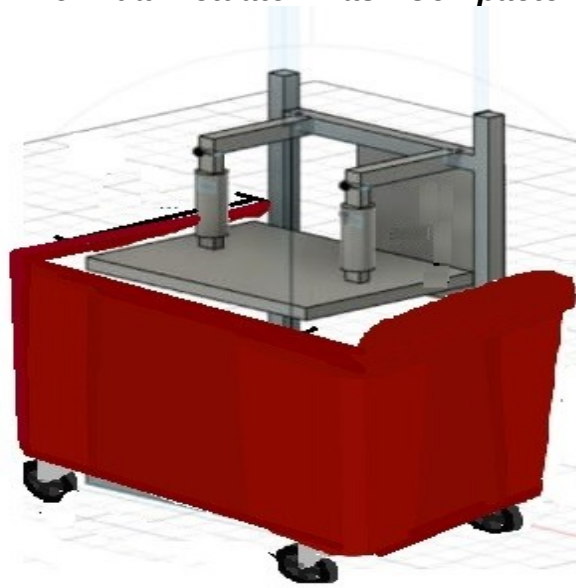


Fig. 3.2: Bin 660L with Compactor Attachment

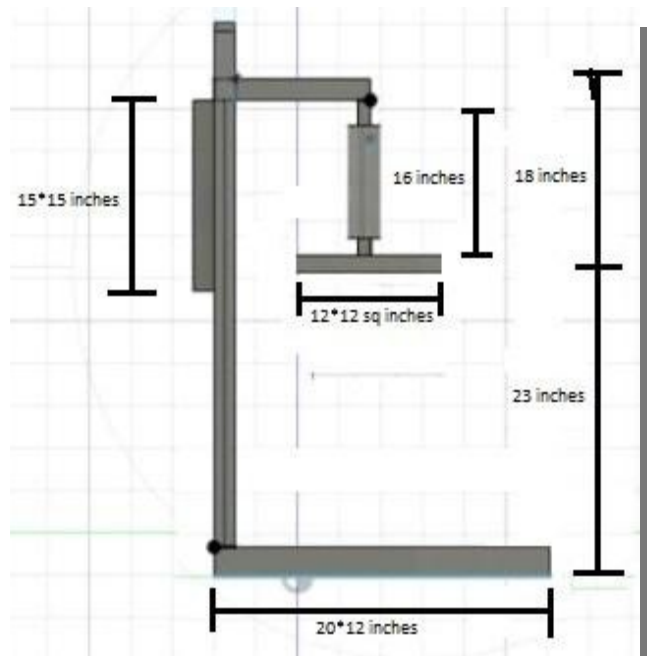


Fig. 3.3: CAD of Single Actuator Trash Compactor for 120L Bin



Fig. 3.4: Bin 120L with Compactor Attachment

CHAPTER 4

DETAILED DESIGN AND COMPONENTS OF GMS

In this chapter, the system design and working of the Trash compactor with a level monitoring system are explained in detail.

4.1 BLOCK DIAGRAM OF WORKING OF GMS

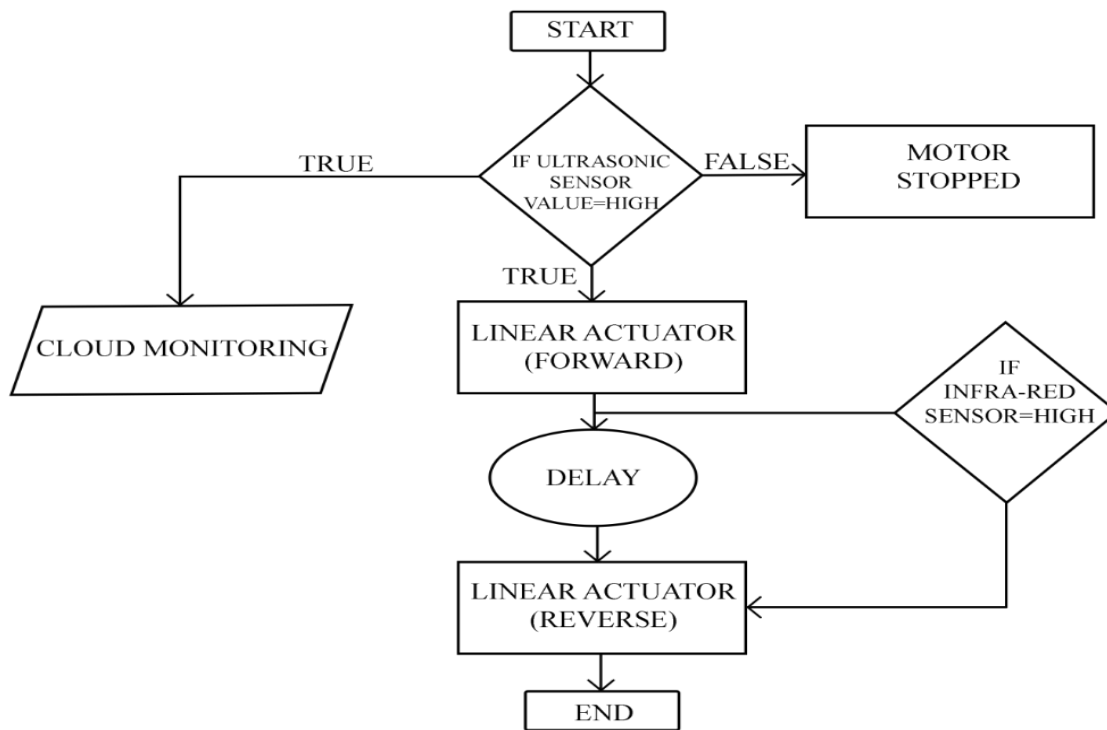


Fig. 4.1: Block Diagram of working of Garbage Monitoring System

In this system, each garbage compacting unit is connected to the central server page through the internet. These units can be identified by a unique ID number provided by the municipality. The bin is constantly monitored through IoT and displayed on a web page using 'UBIDOTS'. The level of garbage is sensed and measured using an Ultrasonic Sensor. The data is then processed using the controlling unit to obtain the information that is to be displayed on the webpage. Arduino UNO acts as the controlling unit in this process. This Arduino UNO is programmed to control all the sensors and output devices. This is also connected to an IoT device, that is ESP32. The ESP32 is an electronic chip module that acts as a Wi-Fi module to connect to the internet. This electronic chip takes care of data transferring through the internet. The municipality officer can view and act

according to data displayed on the webpage through the internet. Which intern can be accessed from any sort of smart device like PCs, Laptops, Mobile, Tablets, etc. In Addition to these features, this system also contains a gas sensor. A Gas sensor is used to detect the smoke and different gas levels exhausted due to accidental fire. The IR sensor is used to detect the person if he is going to throw the garbage. It helps the Arduino UNO to reverse actuate the actuator.

4.2 ARDUINO UNO

The Arduino Uno utilizes the ATmega328P microprocessor (datasheet), the ATMEGA328P-PN is a well-known microcontroller since it is used in many Arduino board products. There are 14 pins for digital input and output, which include an In-Circuit Serial Programming Header i.e., ICSPH, a USB connector, a power jack, 6 I/P analog pins, and 16 Megahertz ceramic resonators, and finally a reset button on the chipboard. Arduino UNO is considered to be a basic microcontroller, even very much suitable for a person to boot learning on the microcontroller. The board consists of a USB type B female port to connect the board to the computer and it can also power the Arduino UNO board with an input of 5 volts. The board secondly consists of an AC-to-DC adapter end female port to power the board with a range of 5V to 12V. The port can be powered both by a direct supply with an adapter or a battery with a voltage range of 5V to 12V.

4.2.1 Specifications of Arduino UNO

The reverse-engineered Arduino boards are also available in the market, which are way cheaper than genuine boards. This availability gives the confidence a learner to explore and learn about UNO. At first, the name "UNO" is derived from the Italian word "one", this name was suggested to commemorate the 1.0 version release of the Arduino Software (IDE). The first member of the Arduino family was Arduino UNO. This board is also known as a reference model board, with the first USB connectivity enhancing the programming bridge. Some of the Arduino boards like Arduino Mega stay genuine because of their unique specifications. The specification of Arduino UNO is given below.

Table 4.1: Specification of Arduino UNO

Name of Microcontroller	UNO
Operating Voltage	5V
No. of Digital I/O Pins	14 (count)
PWM Digital I/O Pins	6 (count)
Analog Input Pins	6 (count)
Recommended Input Voltage	7-12V
DC Current per I/O Pin	20 milli Ampere
DC Current for 3.3V Pin	50 milli Ampere
Limit of Input Voltage	6-20V
Clock Speed	16 Mega-Hertz
SRAM	2 Kilo-Bytes
EEPROM	1 Kilo-Bytes
Flash Memory	32 Kilo-Bytes (ATmega328P) of which 0.5 Kilo-Bytes is used by the bootloader)
LED_BUILTIN	13 (count)
Length	6.86 cm
Width	5.34 cm

4.2.2 Pinout Diagram of Arduino UNO

The Arduino UNO consists of a number of Input and Output pins as described in the below figure. These pins are different from the other input ports like type A USB and Circle centered 2.1mm External power supply port.

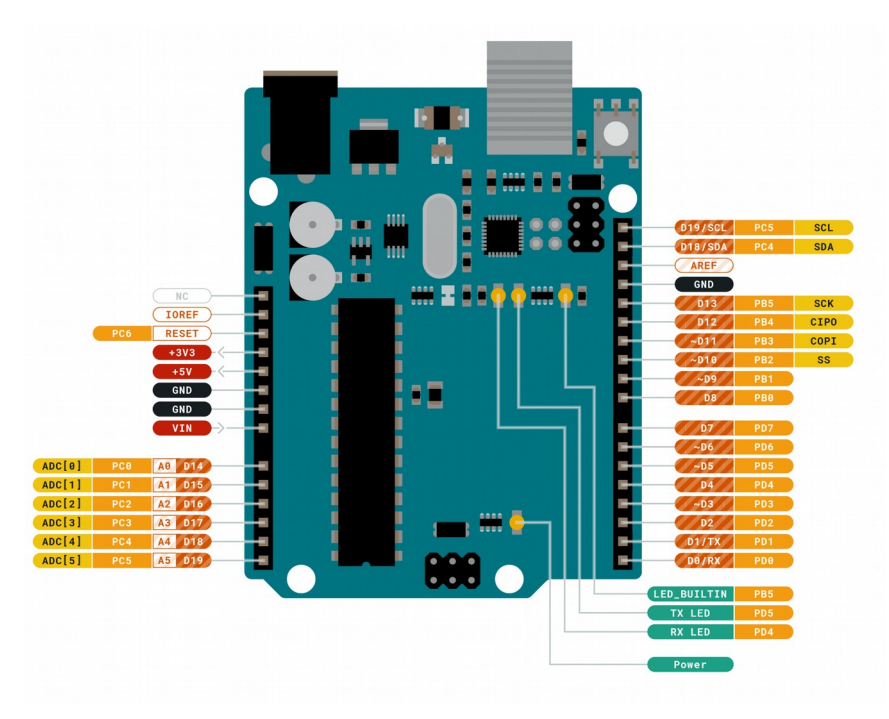


Fig. 4.2: Pinout Model of Arduino UNO

(Source: www.usa.arduino.cc/products/arduino-uno-rev3)

The important thing to study in an Arduino is the pin configuration of that Arduino board. The pin configuration and its purpose slightly vary for each type of Arduino Board. So before using any Arduino device, it is better to know about all the pins present in it. This helps in error reduction, reduces the possibility of short-circuiting, and reduces time consumption for programming and assembling.

4.2.3 Programming tool for Arduino

The programming tool used for programming different Arduino boards is known as Arduino Software. The type of the board which is going to be programmed is selected in the “Board” sub-menu, under the “Tools” main menu. Selecting Arduino or Other board types before programming will avoid the port and “Board not found” issues arising while uploading. The automatic booting of the microcontroller is programmed in Arduino. This booting feature is very useful after a power switching or after resetting the board. This enables the user to upload new code to the board after resetting it, this process does require any external program for booting the

new program that is going to be uploaded soon by the user. The bootloader uses an STK-500 protocol for calling the header file of the C language, which is being used for programming.

The source code for the firmware of the ATmega16U2 and Arduino repository is also accessible by the ATmega8U2 in the rev1 and rev2 boards. The DFU bootloader of ATmega16U2 or ATmega8U2 may be activated and triggered with the help of the following steps:

- Rev1 boards – The soldered jumper cables are connected to the back of the board. The next step is to reset the ATmega8U2.
- Rev2 or Later boards – In these boards, the resistor pulls the HWB line of the ATmega16U2 and ATmega8U2 to the ground (GND). This makes it easy to turn it to DFU mode.

After that, you can load fresh firmware using Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux). You can also utilize an external programmer with the ISP header for overwriting the DFU bootloader.

4.2.4 Warnings for using UNO

Usually, the USB ports are protected against shorts and overcurrent by a resettable poly fuse on the Arduino Uno. Most of the computers come with built-in security the fuse adds a layer of protection to the system and it also offers an extra degree of safety. If the USB port receives more than 500 milliamps or more than that is supplied to the USB port, the poly fuse protects the device from short-circuiting by instantly terminating the connection and the connection will remain terminated until the short or overload is addressed.

4.2.5 Unique Characteristics of Arduino UNO board

The Arduino UNO board differs from the other prior boards by some of the components present in it. This made the revolution over the previous board by not having the FTDI serial-to-USB driver chip in it. The component FTDI USB-to-

serial is avoided in this new UNO version. Instead of building and including a USB-to-serial driver into the ATmega16U2 microcontroller and converter, it was available in the ATmega8U2 up to version R2.

4.2.6 Powering of Arduino UNO

The Arduino UNO requires a real-time power supply for its performance of the specified task. The power source for this Arduino UNO can be provided in two ways, Powering through USB or external power sources like a battery. The external power supply gives more voltage than the USB. An AC to DC adapter or a battery can be used as a power source which comes under the external power source category. For this external power source purpose, a 2.1mm circle female port provision is attached to the UNO board. The voltage through the external power supply can be varied from 5V to 19V for a safe drive. The 2.1mm male port is connected to the AC to the DC adapter or directly to the battery in between the voltage range of 5V to 19V. If the input for the board is provided with less than 6V the output voltage of the board will be less than 5 Volts. So it is recommended to provide a voltage greater than or equal to 7 volts. The power pins of the Arduino UNO board are as follows,

- Vin is the Arduino board's input voltage when powered by an external power supply (instead of 5 volts it is opposed from a USB port or another regulated power source). If power is supplied via the power jack, this pin can be used to either supply or access voltage.
- 5V - The board's regulator provides a regulated 5V to this pin. The board may be powered via the DC power jack (7 - 12V), the USB connection (5V), or the VIN pin (7-12V). When power is supplied via the 5V or 3.3V pins, the regulator is bypassed because it contains high voltage, which might cause damage to your board. We do not advise you to do so.
- 3.3V - A 3.3-volt supply is provided via the onboard regulator. A maximum current of 50 milliamperes can be drawn.
- GND. Pins that have been ground.

- IOREF - The voltage reference that the microcontroller uses to operate and utilizes to function is provided by this pin on the Arduino board. The IOREF pin voltage may be read by a properly designed and correctly built shield, which can then select the right power supply, pick the appropriate power source or enable voltage translators on the outputs to function at 5V or 3.3V.

4.2.7 Input and Output of Arduino UNO

Each of the 14 digital pins on the Uno can be used as an input or output using the pinMode(), digitalWrite(), and digitalRead() utilized methods. 5 volts are used to power them. Each pin has an inbuilt 20-50k ohm pull-up resistor (by default unconnected) and may supply or receive 20 mA as a recommended operational condition.

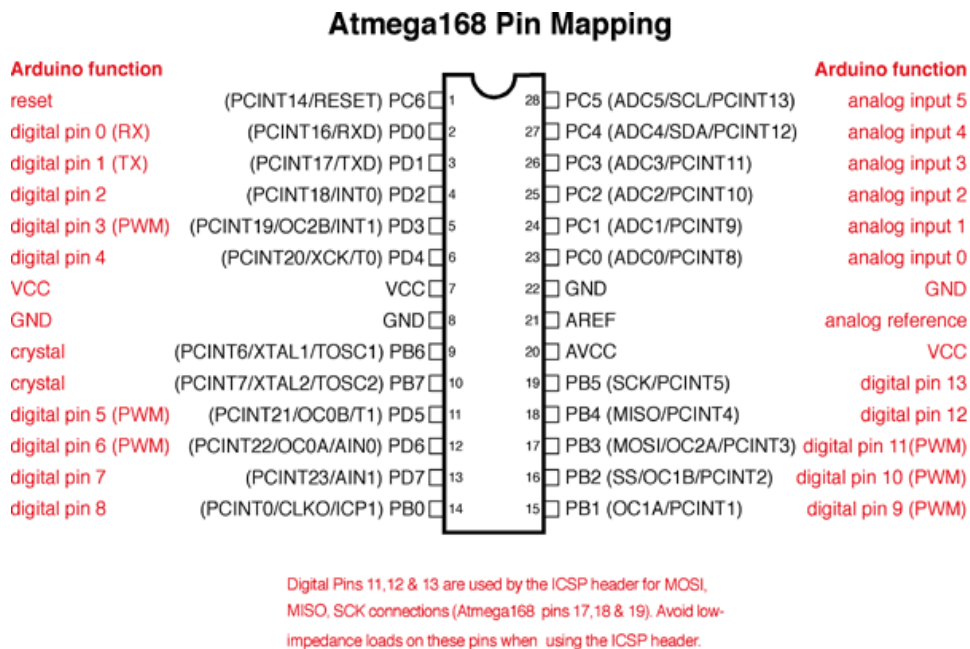


Fig. 4.3: Pinout of Arduino UNO

(Source: www.Arduino.cc/figure/Atmega-pin-mapping)

A limit of 40mA on any I/O pin must not be exceeded to risk permanent harm to the microcontroller. In addition, a number of pins have particular functions:

- The numerals 0 (RX) and 1 (TX) are serial numbers (TX). TTL serial data can be received (RX) and sent (TX) with this device. These pins are linked to the equivalent pins on the Atmega8U2 USB-to-TTL Serial chip.
- Interrupts from the outside (numbers 2 and 3). These pins can be set to trigger an interrupt based on a low value, a rising or falling edge, or a value change. The `attachInterrupt()` method provides further details.
- Three, five, six, nine, ten, and eleven are PWM. The `analogWrite()` function creates a PWM signal with an 8-bit resolution.
- 10 SPI (SS), 11 SPI (MOSI), 12 SPI (MISO), 13 SPI (MISO) (SCK). These pins are communicated with via the SPI library.
- LED 13 is a number that represents the number of times a light is turned on. Digital pin 13 is used to power an embedded LED. When the pin is HIGH, the LED illuminates; when the pin is LOW, the LED is switched off.
- TWI pins A4 (SDA) and A5 (SCL). Using the Wire library, you may support TWI communication.
- The Uno has six analog inputs labeled A0 through A5, each with a 10-bit resolution (i.e. 1024 different values). By default, they measure from zero to five volts, but the AREF pin and the `analogReference()` function may be used to modify the top limit of their range. A few additional pins may be found on the board.:
- AREF - A reference voltage is present on the analog inputs. When analog reference is used with it, the result is `analogReference()`.
- Reset - Set this line to LOW, to restart the microcontroller. Usually used to add a reset button to shields that block the reset button on the board.

4.2.8 Communication of Arduino UNO

The Arduino Uno can communicate with a computer, another Arduino board, and other electronic devices, it can also communicate with microcontrollers. Serial UART TTL (5V) communication is supported by the Atmega328 on digital pins 0 (RX) and 1 (TX) (TX). An Atmega16U2 on the board can easily transmit the serial data through the USB port in the board, which appears to software on the PC as a

virtual com port. The 16U2 firmware utilizes standard USB COM drivers, therefore no additional drivers are required. However, in Windows, an a.inf file is required. The Arduino Software (IDE) has a serial monitor that may be used to send and receive basic textual data. The RX and TX LEDs on the board will blink when data is sent over the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). The Software Serial library may be used to communicate serially on any of the Uno's digital pins. The Atmega328 also supports I2C (TWI) and SPI communications. To make utilizing the I2C bus easier, the Arduino Software (IDE) includes the Wire library; consult the documentation for more information. To communicate with SPI, use the SPI library.

4.2.9 Automatic Software Reset in UNO

The Arduino Uno board is designed in such a way that it may be reset by software running on a connected or it may be reset by software running on a linked computer rather than requiring a physical click of the reset button before an upload. A 100 nano farad capacitor connects the Atmega328's reset line to one of the Atmega8U2/16U2's hardware flow control lines (DTR) also it is connected to the reset line of the Atmega328 via a 100 nano farad capacitor. The reset line falls far enough to reset the chip when this line is asserted (taken low). The Arduino Software (IDE) makes advantage of this feature to allow you to upload code by hitting the upload button on the toolbar in the interface. The bootloader can have a shorter timeout since the decrease of DTR may be well coordinated with the commencement of the upload.

This setup has further ramifications. The UNO board can support to connect with Mac OS and Linux computers, but only one system can connect to the UNO board at a time. When the Uno is connected to a Mac OS X or Linux computer, when a software connection is created to it, it resets itself (via USB). For about a half-second after that, the bootloader on the Uno will be active. It is configured to delete incorrect data (that is, everything that isn't a brand-new code upload or uploaded fresh code), However, when a connection is created, it will intercept the

initial few bytes of data delivered or transmitted to the board. When a sketch on the board is first started, it may receive a one-time setup or other data, before sending this data, ensure that the program with which it interacts waits for a second after initiating the connection and also after the connection begins. A trace on the Uno board can be cut to deactivate the auto-reset. Solder the pads on each side of the trace together to reactivate it. It has the words "RESET-EN" inscribed on it.

4.3 ESP 32 – WIFI MODULE

ESP32 is a system on a chip (soc) type microcontroller. The ESP32 can efficiently work in a low power supply, also it is a cost-efficient wi-fi module in the market. ESP32 comes with a wide frequency range of wi-fi modules and it consists of dual-model Bluetooth. The microprocessors inside the ESP32 consist of three types that are Tensilica Xtensa LX6 dual-core microprocessor, Tensilica Xtensa LX7 dual-core microprocessors, and RISC-V single-core microprocessor which comes with built-in antenna switches, either one type of microprocessor can be used in an ESP32, the module also consists of parts like power amplifiers, RF baluns, filters, low-noise receive amplifiers, and power management modules are used in the ESP32 series. Espressif Systems designed and developed the ESP32 microcontroller, it is a shanghai-based Chinese company, and by using 40 nm technology the series was produced by TSMC.

4.3.1 Block diagram of the architecture of ESP32

The Block diagram of the architecture of the ESP32 displays in detail, the list of inbuilt sensors, Bluetooth module, Wi-Fi module, a Radio module, processor, cryptographic hardware, and types of memory. It consists of sensors like IR, temperature sensor, touch sensor, and converters like Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC). The Bluetooth module consists of two components one is a link controller and the other is a baseband. Similarly, the

Wi-Fi module consists of two components, a MAC configuration, and a Baseband configuration.

The radio module consists of a Radio Frequency (RF) receiver, a Radio Frequency (RF) transmitter, a clock generator, and a Switch. Two variants of the microprocessor can be used. They are single-core Xtensa or Dual-core Xtensa LX6.

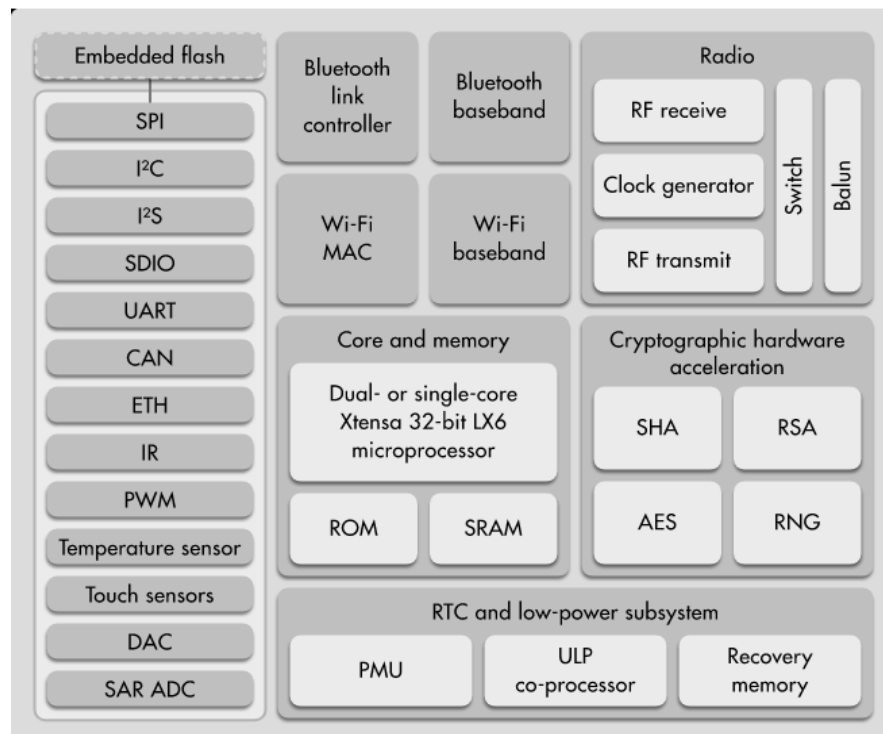


Fig. 4.4: Block Diagram of ESP32
(Source: www.esp32.net/)

4.3.2 Features and Specifications of ESP32

Processors used in ESP 32 and its specification,

- Ten silica Extensa 32-bit LX6 microprocessor as the main CPU
- 2 or 1 core (depending on variation)
- Except for the ESP32-S0WD, which is single-core, all ESP32 chips are dual-core.
- Up to 240 MHz clock frequency

- Up to 600 DMIPS performance
- ADC conversions, calculations, and level thresholds can all be done while you sleep thanks to the ultra-low-power co-processor.

Specifications of Connectivity module via wireless in ESP 32,

- 802.11 b/g/n/e/i (802.11n up to 150 Mbit/s @ 2.4 GHz) Wi-Fi: 802.11 b/g/n/e/i (802.11n up to 150 Mbit/s @ 2.4 GHz)
- Bluetooth Low Energy (BLE) with v4.2 BR/EDR (BLE)

The types of memory and its specification are,

- 448 KB ROM is used for booting and basic functionality.
- 520 KB SRAM if used for data and instructions.
- 8 KiB RTC quick SRAM
- During RTC, for data storage and the primary CPU Get out of deep-sleep mode.
- 8 KiB RTC sluggish SRAM
- During deep sleep mode, you can access the coprocessor.
- E-Fuse: Consists of 1 Kilobit i.e., 1024 bits out of which 256 bits are used for the Chip and MAC address configuration of the system, and the remaining 768 bits out of 1024 KB are used for customer applications like Chip Identity (ID) and Encryption of Flash.
- Embedded-Flash: Embedded-Flash is a feature that allows you to internally mount the flash on the D2WD and PICO-D4 of ESP32 through IO (16 or 17), SD (CMD, CLK), SD (DATA 0, DATA 1) on the D2WD and PICO-D4 of ESP32.
- 0 MiB (D0WDQ6, D0WD, and S0WD) ESP32 chips
- 2 MiB (D2WD) ESP32 chip
- 4 MiB (PICO-D4 SiP module) ESP32 chip

External Flash and SRAM specifications and working in ESP32 include safeguarding developers' programs and data, the ESP32 supports up to four 16 MiB external QSPI flashes and SRAMs to encrypted in hardware on the basis of

AES. In origin, the ESP32 is used to access the external QSPI flash through high-speed caches.

- Memory mapping onto the CPU code space allows for access to modes of 8, 16, and 32 bits i.e., with a max 16MB external flash. Code execution is a possibility.
- External flash/SRAM memory with a capacity of up to 8 MiB. This external flash/SRAM allows 8, 16, and 32, bit access through mapping to the CPU data area. Data read operation is performed from the flash and SRAM. Data-write is possible on the SRAM.

Peripheral input/output devices in ESP32 are a rich basic interface with capacitive touch, an Analog to Digital converter, a Digital to Analog converter, Inter Integrated Circuit, Universal Asynchronous receiver or transmitter, Controller Area Network, Serial Peripheral Interface, Inter-Integrated Sound, Reduced Media Independent Interface, and PWM. Security management is achieved by the following specifications,

- All security aspects of the 802.11 standards of Information Technology (IEEE) are supported, including WFA, WPA/WPA2, and WAPI.
- This provides a secured boot
- Flash encryption alone takes memory up to 768 bits out of 1024 bits for customers, using an OTP.
- RSA, SHA-2, AES, random number generator, and elliptic curve cryptography (ECC), are examples of cryptographic hardware acceleration (RNG)

4.3.3 Programming of ESP32

The following are examples of the environmental software and hardware components, frameworks used for ESP32, and the programming of ESP32.

- The officially supported software IDEs like Visual studio code with Express if extension in framework with integrated development source.

- ESP32 Arduino Core A microcontroller-friendly Python 3.1 implementation Micro Python Arduino (IDE).
- ESP-Uno is a JavaScript-based Software Development Kit with some firmware that closely resembles the Node JavaScript (Node.js) framework.
- IoT Toolkit or Lua Network for networking ESP32-Wrover
- Mongoose OS is a microcontroller-based operating system that may be programmed in JavaScript or C. Express if Systems recommends this platform. Amazon Web Services and Google Cloud are two of the most popular IoT platforms.
- For the ESP32, there's mruby.
- Lua Network-based firmware for Node MCU
- Including the ESP32 – Zerynth, Python 3.1 is used for IoT and microcontrollers.

4.3.4 Uses of ESP 32 in the various sector

Commercial applications of ESP32 are,

- Attendees at the Alibaba Group's annual meeting in 2017 wore an IoT LED bracelet designed by the company. Each wristband served as a "pixel," receiving signals for synchronized LED light control and allowed for the creation of a "live and wireless screen."
- The M1 is a biometric attendance-tracking system from DingTalk.
- LIFX Mini is a line of LED-based light bulbs that may be controlled remotely.
- Pium is an aromatherapy and scent device for the home.
- Odroid Go is an ESP32-based handheld gaming device kit created by HardKernel to mark Odroid's tenth anniversary.
- Panic Inc. and Teenage Engineering collaborated on Playdate, a handheld video gaming console.

Industrial applications of ESP32 are as follows:

- The ESP32-ROVER / ESP32-ROVER-B based Moduino X series X1 and X2 modules from TECHBASE are the devices used for industrial automation, along with the monitoring system that allows digital inputs and outputs. It also enables analog inputs with different networking mediators.
- NORVI Industrial Internet of Things Devices with ESP32-WROVER or WROVER-BSOC are used for getting the digital and analogue inputs, receiving the output from the relay, and many other communication processes. It works with LoRa and Nb-IoT as extension modules.

4.4 SENSORS AND ELECTRICAL COMPONENTS OF GMS

4.4.1 Ultrasonic Sensor

An ultrasonic sensor is a sensor that generates ultrasonic sound waves which are not audible to human ears, but travels as sound waves and reflects back when it strikes an object. After receiving the reflected sound wave the sensor sends the electric signals as output, which helps in calculating the distance of the object from the sensor. Transmitters, Receivers, and Transceivers are the three types of transceivers.

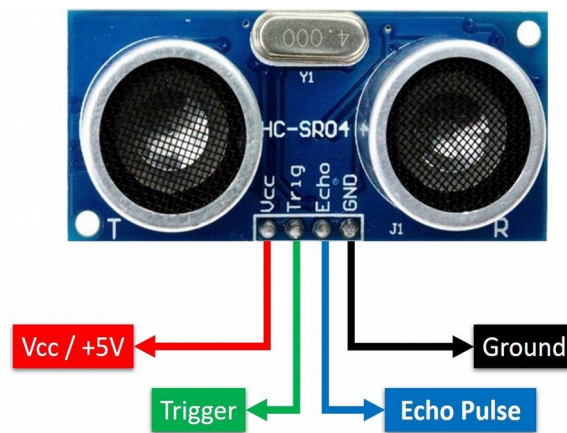


Fig. 4.5: Ultrasonic Sensor

(Source: www.microcontrollerslab.com/hc-sr04-ultrasonic-sensor)

Components of Ultrasonic Sensor are as follows,

- Transmitters – In ultrasonic sensors, the transmitters help to produce ultrasonic sound from electrical energy.
- Receivers – In ultrasonic sensors, the receivers help to receive the reflected ultrasonic sound and generate corresponding electric signals.
- Transceivers – In ultrasonic sensors, the transceivers can both transmit and receive ultrasound.

The principle used in ultrasonic sensors is based on the concept that the ultrasonic sound travels faster than the normal sound in the range of 20Hz to 20000Hz. The ultrasonic sensor has two components, a transmitter, and a receiver. The ultrasonic sound wave is created by a piezoelectric crystal available in the transmitter. The reflected sound wave is received by a microphone-like structure called the receiver. This ultrasonic sound is a high-frequency sound wave that reverberates from the surface of the target object and creates different echo patterns.

Ultrasonic Sensors Working – The working of the sensor is that it produces an ultrasonic sound wave that is not audible to the ears of humans and other living creatures. There is a transducer part in the sensor which enables the function of sending and receiving ultrasonic sound waves. A single transducer is used for both sending the pulse and receiving the echo pulse. By identifying the time taken for sending and receiving the ultrasonic pulse sound is determined and transferred as an output of the sensor. This duration output from the sensor is used to find the distance between the object and the sensor using the regular distance formula ($D=S \times T$), where D is the distance between the object and sensor, S is the speed of the sound wave, T is the duration between the triggering and echoing. The ultrasonic sensor module works on the following principle: the sensor transmits a 40kHz ultrasonic pulse through the air to a certain distance; if the ultrasonic pulses

identify any objects or barriers, they will return to the sensor. The distance can be estimated after the pulse returns by computing the speed of sound and the transit time between the object and the sensor. Ultrasonic sensors detect things regardless of their substance, color, or surface for presence detection. It can detect any object using ultrasonic pulses (unless the object is made of wool, which is incredibly soft and absorbs sound.) When it comes to identifying transparent and other materials, optical technologies may fail, however, ultrasonic sensors are a reliable solution. Ultrasonic proximity, level, and distance sensors are often utilized with microcontroller platforms such as ARM, PLC, Beagle board, Arduino, Raspberry Pi, and others.

4.4.2 IR Sensor

An Infra-Red sensor (IR sensor) is an electronic device that identifies and measures the IR radiations in the surrounding environment. This sensor is the optoelectronic component that is sensitive to radiation. With a spectral sensitivity of 0.7 μ m interval between 5 to 1000nm. The wavelength of the infrared light is longer than the other visible lights, it is why the IR is not visible to the human eye. IR radiation was discovered in the visible and microwave regions of the electromagnetic spectrum. Near-infrared, mid-infrared, and far-infrared are the three sections of the IR spectrum.

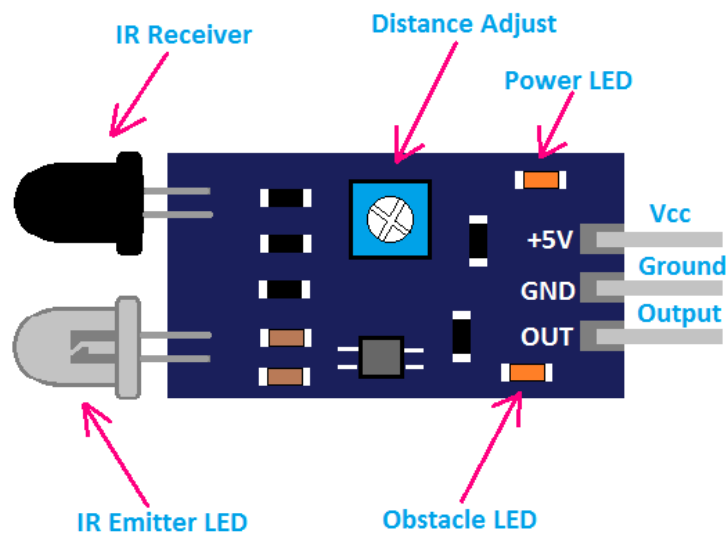


Fig. 4.6: InfraRed Sensor

(Source: www.etechnog.com/2021/06/ir-sensor-circuit)

Range of IR Sensor,

- The wavelength varies from 0.75 to 3 meters in the near-infrared area.
- The wavelength extends from 3 to 6 meters in the mid-infrared region.
- The wavelength of infrared light in the far IR zone is more than 6m.

IR Sensor Working Principle – These IR sensors can be classified based on the wavelengths, transmission time of radiation, output power range and response time of the radiation. When used together, an IR LED and an IR Photodiode forms a Photocoupler or Optocoupler, which is referred to as a Photo or Optocoupler.

IR LED or IR Transmitter – This part of the sensor produces the infrared required for the target hitting. This transmitter is a light-emitting diode that transmits infrared light. This component looks like a general Light-Emitting Diode (LED) used for indications using light color in the electronics. As discussed earlier this component of the sensor does not emit any visible light. Infrared radiations from this emitter are not visible to the human eye. The infrared radiation produced by this transmitter is detected or received by a receiver component in the IR sensor. The below figure shows the transmitter component of the IR sensor.



Fig. 4.7: Transmitter of IR

(Source: <https://rahimaelectronics.com/product/ir-photo-diode-transmitter>)

IR Receiver or Photodiode – The IR sensor that is discussed here can consists of two types of infrared receivers. One is a photodiode and the other is a

phototransistor, the receiver components of the IR sensor. The photodiode or phototransistor is used in the IR sensor, because of its unique characteristics to detect the infrared radiation, that is reflected from the target object of the transmitter of the IR sensor. The physical appearance of this photodiode (IR receiver) looks like a normal LED with a black-coated surface on it. This black layer, according to its absorbing property of the color receives the infrared light. The below figure shows the photograph of the receiver component of the IR sensor.



Fig. 4.8: Receiver of IR

(Source: <https://robu.in/ir-sensor-working/>)

These IR receivers can be classified based on their shape, size, wavelength required, voltage requirement, application, purpose and etc. The transmitter and receiver component pair of the IR sensor should be capable of producing and receiving the infrared radiation of the same wavelength respectively.

The IR sensor component emitter is an infrared radiation emitter and the receiver is an infrared photodiode, which detects the reflected IR radiation. As discussed earlier this light radiation emitted from the IR LED hits the object and gets reflected by the object's surface, which in turn is received or detected by the Photo Diode as shown in the below figure.

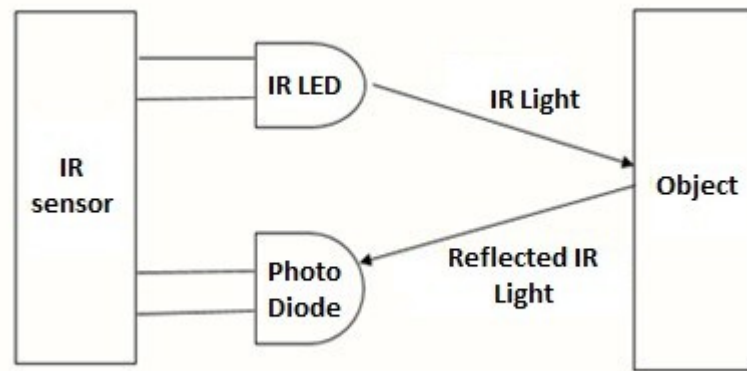


Fig. 4.9: Working of IR
(Source: <https://robu.in/ir-sensor-working/>)

The emitter component of the IR sensor varies from other radiation emitters since it uniquely emits only infrared radiation of a fixed wavelength for which it is manufactured. As light diodes are used for making the IR transmitter, the photodiode and phototransistors are used for manufacturing of IR receiver component of the sensor.

The infrared sensor is further classified into two types:

- Active infrared sensor – An IR sensor comes into this category of the Active infrared sensor when both the IR transmitter component and IR receiver component are present in the same chipboard of the IR sensor. The function of this sensor is that it can both produce and detect the radiation of infrared. The emitter component of the active IR sensor constantly emits radiations, when the object comes closer into the range of detection, the IR radiation hits the object and gets reflected from the surface of the object. The reflected radiation is then absorbed or received by the photodiode of the IR sensor. This active IR sensor is the perfect proximity sensor used for object detection. This active IR sensor is used in many applications like obstacle detection in robots, workpiece detection in rally belts, and obstacle detection in other applications.

- **Passive infrared sensor** – This kind of IR sensor is meant for the purpose of just detecting infrared light. This sensor does not consist of the infrared emitting component transmitter LED. In this scenario, the object that is being detected emits infrared. The passive IR sensor does not contain the emitter component but contains a signal processor to transmit the signal according to the obtained information. These passive sensors are used for motion detection for security purposes in ATMs and also for home surveillance. While an infrared emitting object is moving there will be a difference in the infrared level between the pyroelectric elements this helps in detecting the motion when it is happening in the detecting range.

4.4.3 Gas Sensor

A gas sensor is a piece of equipment that is used to detect the gaseous state substance in the surrounding. This device not only detects the presence of the gases but can also measure the concentration of that gas. Based on the concentration of the detected gas, a component inside the sensor changes its resistance, this change in resistance causes a change in potential difference given as output by the sensor. Based on the output value of the potential difference, the concentration of the gas is calculated and its identity is found. The determination of the type of gas present in the environment is carried out by the detecting module in the gas sensor. This gas sensor consists of a comparator circuit which is often used in the other sensors also to detect the gas type. When the concentration of the gas reaches the threshold, the comparator will get adjusted. The analog pin of the comparator may be used to figure out how much gas is in the air. The digital pin of the comparator swings high, as soon as the concentration of the gas reaches its threshold level.

Types of Gas Sensor – These gas sensors are generally classified based on the type of material used inside the sensor. Based on the elements present in the materials the gas sensors are used for various tasks:

- Gas sensor with metal oxide as an inner element.
- Optical gas sensor is a type of gas sensor that uses light to detect gas.
- Sensor for electrochemical gas.
- Gas sensor based on capacitance.
- Sensor for calorimetric gas.
- Gas sensor based on acoustics.

Gas Sensor Construction - The metal oxide semiconductor-based gas sensor is the most widely utilized of the above-mentioned varieties. All gas sensors will include a sensing element that includes the following components.

- Heater Coil
- Electrode Line
- Gas Sensing Layer
- Ceramic tubular electrode

The parts of a metal oxide gas sensor are shown in the diagram below.

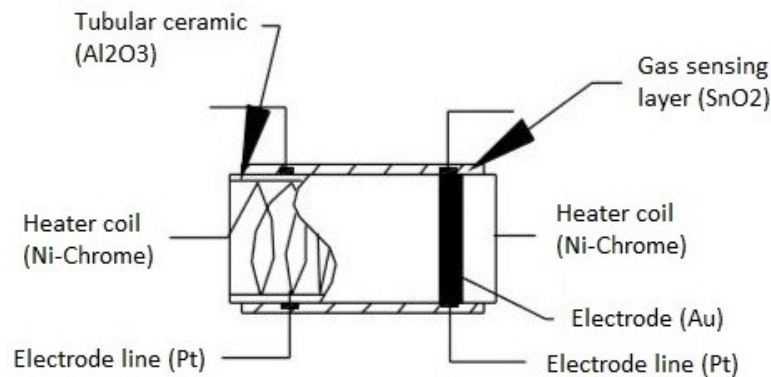


Fig. 4.10: Model Diagram of Gas Sensor
(Source: www.sensor.net)

Gas detecting layer - This is the major component of the sensor that may be used to detect changes in gas concentration and cause an electrical resistance change.

The gas detecting layer is essentially a chemoreceptor that alters its resistance value in response to the presence of gas. The quantity of a certain gas present in the atmosphere. Tin Dioxide (SnO_2) is the detecting element, and it has an excess of electrons in general (donor element). As a consequence, if dangerous gases are detected, the element's resistance and the current flowing through it vary, indicating a change in gas concentration.

Gas sensor Working – Total capacity of determination of the kind of gas by the gas sensor depends on the chemiresistor's current conducting ability. The most common chemiresistor is an n-type semiconductor with unbound electrons which is known as a donor, and the element none other than tin dioxide (SnO_2). In most circumstances, there is more oxygen in the atmosphere than there are incombustible gases. The unbound electrons in SnO_2 are driven to the surface by the oxygen particles, which attract them. If no free electrons are available in the module, then there will no output of current that is current is zero. The black-colored free electrons inside SnO_2 are attracted by the oxygen molecules which will be in blue color, preventing current flow. The orange-colored reducing gas interacts with the oxygen molecules that are in an absorbed state when the sensor is exposed to dangerous or combustible gases. The chemical bond between the free electrons and the oxygen breaks, which enables the free electrons the permission for escaping. The liberated electrons can now conduct current since they have returned to their natural place. The amount of current that can be conducted in SnO_2 is determined by the free electrons count available. When the gas is extremely toxic, a huge number of free electrons will be generated.

4.4.4 Two-Channel Relay Module

This Relay Module is a two-channel relay module with a specification 5v input. Since the input required for this relay is 5 voltages it can be directly controlled by Arduino, AVR, PIC, and ARM microcontrollers. A triggered low-level control signal operates the relay with 3.3V to 5V DC supply. The triggering of the relay will activate the normal-open and normal-closed contacts. It's a frequent component in

automated control systems. Simply explained, it's a low-current signal that operates a high-current circuit through an automated switch. The relay system is supplied by V_{CC} power from Arduino. The input voltage range for 5V relay signals is 0V-5V. The power supply consists of a JD- V_{CC} . It is feasible to use short V_{CC} and JD- V_{CC} .



Fig. 4.11: Two-Channel Relay

(Source: www.electronicsspecification.com/two-channel-relay-module)

The purpose of this module is that the Arduino alone can be used to switch the power between two high voltage devices. As specified in above figure 4.11, each channel can hold from 10A at 125VAC to 10A at 250VAC or 10A at 25VAC to 10A at 30VAC. The position of the relay is shown by two LEDs indicators available on the board. The respective LED will light up once a relay is engaged. The 2-Channel Relay module has the following features:

- Good for controlling higher-amperage circuits safely. The lower current in a power system can control the greater current.
- Dual channel control requires a 2-channel high voltage system output.
- This item is brand new and of excellent quality.
- [Arduino, 8051, AVR, PIC, DSP, ARM] Standard interface that can be controlled directly by a microcontroller.
- A wide range of voltages can be controlled.

- Having the ability to handle large load currents of up to 125V-15A or 250V-10A
- With four mounting holes all around the board, it's simple to install and fix.
- It has a beginning, a common end, and a closed-end.
- The contacts used are NO (Normally-Open) and NC (Normally-Closed).

2-Channel Relay Board Specification:

- Model: JQC-3FF-S-Z, 2 Channel Relay Module
- Operating voltage: 5V DC
- Blue is the predominant color. On a black PCB, there are relays.
- 10A at 250V AC or 15A at 125V

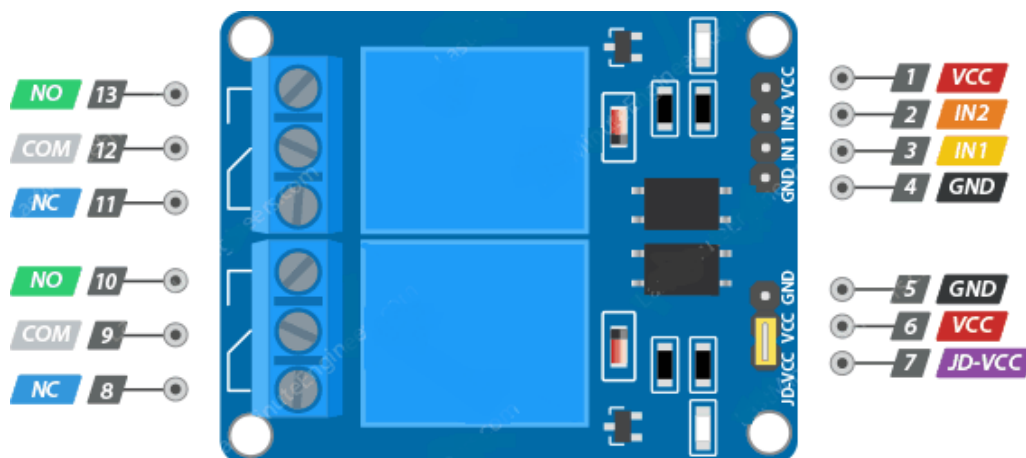


Fig. 4.12: Pinout Diagram of Relay
 (Source: www.electronics-digital.in/pinout/relay)

Control Pins of the Relay 2-Channel module are,

- V_{CC} - The built-in optocoupler and, if desired, the relay's electromagnet is both powered by the V_{CC} pin. This happens only if the jumper cables are placed.
- GND - The ground connection is referred to as GND.
- IN1 & IN2 - The relay is controlled via the IN1 and IN2 pins. The relay will be triggered only when the low pins are active because the above module

of the two-channel LOW pin is triggered. Vis versa the relay remains inactive if the pin is pulled at HIGH voltage.

Power Supply Section Pins of the Relay 2-Channel module are,

- For the relay's electromagnetic part, the required electricity is provided from JD-V_{CC}. The Arduino's 5V line is used to power the jumper while it is in place. You'll need to connect it to a separate power source if you don't have a jumper cable cap.
- VCC - When the jumper cap is on, the VCC pin is soldered to the JD-VCC pin. Keep this pin disconnected if you remove the jumper.
- GND - The ground connection is referred to as GND.

Output Terminals of the Relay 2-Channel module are,

- COM – This pin is used to switch the signal you would like to switch.
- NC – The COM pin is connected to the NC pin by default, this used to be in effect until the Arduino sends a signal to the relay module, instructing the module to disconnect.
- NO - NO pin remains open by default. This used to be in effect until Arduino provide a signal to the relay module. The signal instructs the module to establish the connectivity.

4.4.5 Electric Actuator

An electric actuator is an electro-mechanical device that transforms electrical energy into kinetic energy in a single linear or circular motion. It improves the efficiency and complexity of a process by automating a damper or valve. Electric actuators are available in a range of sizes and forms, depending on the specific tasks they perform inside the processes for which they were created. Electric actuators are being used more often these days as a result of the trend toward more decentralization in automation technologies. Last-generation electric actuators can now be integrated with new process controllers, making it easier to fulfill recently updated automation standards. Electric actuators are now safer than

ever before, thanks to failsafe features that keep human control over the operation even if the power goes out.

Main Components of an Electric Actuator - An electric actuator's motor may run on any voltage and is utilized in a variety of industries. In single-phase motors, the most frequent voltages are:

- 115 V Alternating Current
- 24 V Alternating Current
- 12 volts Direct current
- 24 Volts Direct Current
- 208 volts AC
- 230 Volts AC

Three-phase motors also employ 230 VAC and 460 VAC voltages in addition to these possibilities. On top of the motor is a brake for the actuator. When the motor rotor is locked in place when it is not in use, the media is prevented from forcing the valve open when it should be closed. An electric actuator with an AC motor's third key component is the motor start capacitor. It provides enough electricity to start the motor. A capacitor is not required for electric actuators with DC motors. An electric actuator's end-of-travel limit switches are made up of two single-pole, double-throw (SPDT) switches. The closed position is one, while the open posture is the other. In the immediate, closed, and open positions, these switches provide a suitable number of electrical contacts.

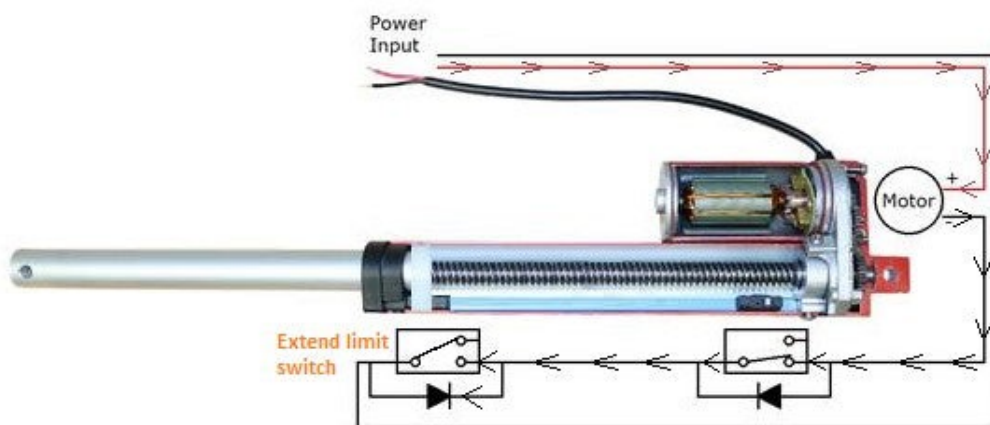


Fig. 4.13: Electric Actuator

(Source: www.progressiveautomations.com/inside-an-electric-linear-actuator)

An electric motor generates rotational motion by spinning the spindle, or rotor. The motor spindle is directly connected to a helical screw that rotates in a ball screw nut via the drive shaft. As the spindle rotates, the helical screw forces the ball screw nut forward or backward. As the motor turns clockwise or anti-clockwise, a hollow piston rod is coupled to the ball screw nut, creating linear motion out of or into the linear actuator. The motor is driven by an electric motor, which permits the rotation speed and hence the linear speed of the actuator to be changed. The linear actuator can be designed to move to a specific location, pause and then move on, or return to its rest state, thanks to a feedback system that provides positional information. The torque that can be created by the motor, and hence the force that can be turned into useful motion by the actuator, is determined by the motor's power.

There are various types of actuators, each with a slightly different function:

- Pneumatic motors are air-driven machines that transfer energy into linear or rotary motion using either vacuum or compressed air. Both speed and torque are determined by air pressure and flow. These are employed in applications where precise positioning is not required.
- Hydraulic motors use pressurized fluid to propel a piston through a tube. The torque produced is proportional to the fluid pressure. Linear, rotational, or oscillating motion is produced by hydraulic motors, although acceleration is limited. Hydraulic motors are inefficient, can cause fires, and require more maintenance than usual
- Clutch/brake motors work by attaching a constantly rotating shaft to a load and only halting when the load is released. While this motor is simple to use, affordable, and ideal for modest weights, it accelerates in an uncontrolled and incorrect manner.

- A digital pulse is translated into rotational movement or displacement by electromechanical stepper motors (DC motors). While stepper motors are wasteful and ineffectual for variable loads, they are great for steady loads and precise positioning.
- Connections, beginning, and/or overload protection for AC motors are all handled by electric starters (induction type). While induction motors are more commonly associated with fixed speeds, the introduction of microprocessor technology has made variable speed operation possible.
- Servo motors (direct current motors) are extremely efficient and have very few defects. Servos provide speed control and position precision thanks to their feedback device. They are small and are inexpensive.

4.5 SOFTWARE COMPONENTS EMPLOYED FOR GMS

4.5.1 Arduino IDE

The Arduino IDE is a software application that provides an integrated development environment for the editors. This software application has a text editor for reading and writing codes for the programming of Arduino devices, Wi-Fi modules, and other electronic devices. This IDE also has the feature of click and drag of the simple display user interface components like text are toolbar bar, a button, text terminal and etc. This IDE uploads the program created or imported to Arduino devices and also other devices.

The editor in Arduino software allows the user to create various codes that are to be uploaded to Arduino or other devices. The codes created in the code editor of the Arduino IDE are called Sketches. Like other file formats, this sketch also has an extension. The extension is in .ino file format. Most text editors are used for their basic actions like cutting and pasting or copying and pasting. This text editor also has the feature of cut/copy and paste. Same way as other general text

editors, it provides the “find and replaces” feature of text editing. This code editor also shows suggestions and feedback as messages after saving or exporting a code. It also indicates the fault in the code, irrespective of the language used. The console window in the IDE displays a detailed indication of the errors and other suggestions for improvement while compiling the file. This software provides a toolbar, enabling us most of the options like selecting the port, validating, and uploading programs. The toolbar can also enable a serial monitor.

- **Formatting by default** – This editor automatically indents every line of the code, when the enter key is pressed. This provides better readability. Also generates the closing braces automatically, when opening braces are generated by the user.
- **Archive Sketch** – This feature saves the archived and nonrecent files in a zip file, which also contains the copy of the most recent sketches.
- **Reload & Fix Feature** – This IDE enables the feature of fixing the difference between OS char map encoding and the char maps of the editor.
- **Serial Data Monitor** – This is a software window that immediately displays the ongoing data transfer to any compatible electronic board like Arduino UNO through the specified port. The resetting of the entire chipboard can be performed by the RESET feature in the monitor.
- **Any kind of Arduino board can be programmed using this IDE.** The chipboards of the WIFI module and Bluetooth module can also be programmed.
- **Port Option in Toolbar** - This sub-menu come under the main menu “Tools”. This Port menu displays all the ports available for devices if it is connected and also for some virtual boards.
- **While programming these electronic boards without using the inbuilt USB-serial connection, you'll need to use a hardware programmer.** You won't normally require this, but you will if you're burning a bootloader to a new microcontroller.

4.5.2 UBIDOTS Web Page

This software component of the project is a web service provided by UBIDOTS. It provides the drag and drops option for the user to display the output from the electronic components like Node MCU, ESP 32, and some other Bluetooth modules.

The final output, which is the garbage level, output, and intimation from sensors is displayed on this webpage. The same can be displayed in a private webpage of the Municipality using HTML, Javascript, and a Database.

API and SDKs - The hardware can be connected to Ubidots easily. This web service has more than 200 libraries, SDKs, and API that helps in integration over HTTP, MQTT, TCP, UDP, or by Parsing custom/industrial protocols. With Ubidots Device Types, it doesn't matter if you're onboarding one device or 1,000. Create the new device in Ubidots every time a new piece of hardware is identified, automatically defining variables, device attributes, and appearance.

4.6 FABRICATED PROTOTYPE MODEL OF GMS

4.6.1 Chassis of the Prototype model of GMS

The chassis part of this proposed GMS plays a major role in making the application of this system. As discussed earlier this garbage management and trash compacting system is an attachment to the existing municipality garbage bin. For fulfilling the purpose of trash compaction, the perfect chassis is the basement. The stability and life of the GMS depend on the chassis structure and quality of construction. Various iron components like 1-inch square pipe, 2mm plates, 6mm solid bars, redox mixture and etc. are employed in making this chassis frame. Also, various processes like cutting, grinding, drilling, welding and etc. are performed for making this complete chassis part.



Fig. 4.14: Photograph of the chassis of the Garbage Monitoring and Compacting system

4.6.2 Compressing Plate

This part of the chassis in the prototype is going to compress the trash in the vertical direction. The compressing plate is the only moving part in the chassis system of this GMS. The top view of this component will show a square shape. It is a 12 x 12 inches square plate with a 1-inch square pipe for its frame support. A 2mm plate with an area of 144 square inches is welded to a square frame made of a 1-inch square iron pipe. A hole drilled 3mm solid bars of length 2.5 inches and breadth of 1 inch is welded to the center pipe of the square frame.

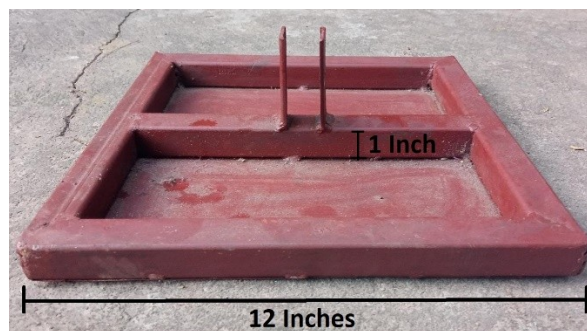


Fig. 4.15: Photograph of Compressing Plate

4.6.3 Rectangular Frame Base

The base frame for this prototype is designed in a rectangular shape for the particular purpose of stable support for the system and also should fit under space between the ground and the base of the bin. This frame is constructed with a 1-inch square. These pipes are joined using electric welding. The base frame is of a length of 24 inches and a breadth of 18 inches. The ends of the pipe were cut at a 45° slant to avoid a change in dimension after welding and increase the joint weld quality.

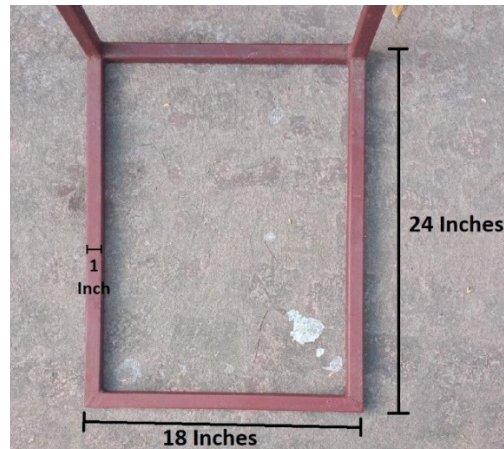


Fig. 4.16: Photograph of Rectangular Frame Base of the prototype

4.6.4 Cantilever Beam

This cantilever beam is attached for the purpose of holding the electrical actuator vertically. This part can be considered as the most tension experiencing part while trash compacting. The below cantilever part is made of a 6mm solid iron bar with a length of 12 inches and a breadth of 2.5 inches. A 10mm hole is drilled on the right bottom edge to hold the electrical actuator with bolt and nut. This cantilever beam is welded to a horizontal rectangular pipe which acts as one of the beams between the pillars of the chassis.

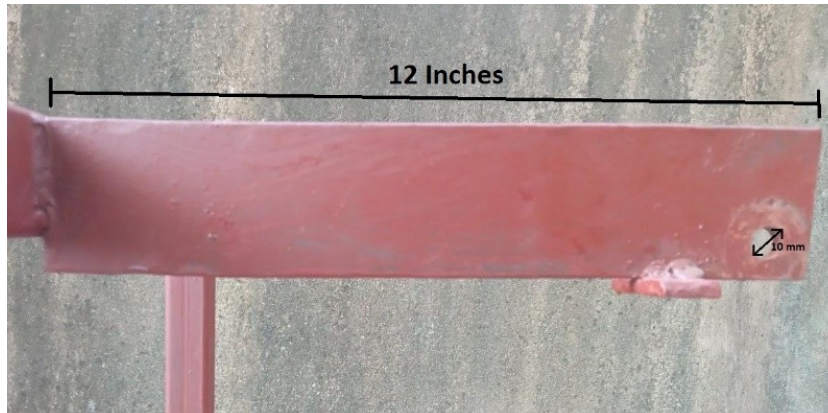


Fig. 4.17: Photograph of Cantilever beam for Holding Actuator

4.6.5 L-Shaped support plate

The “L” shaped plate is made for the purpose of holding some of the electrical components like battery, adapter, connecting wires, etc., and electronic components like the control system that is the Arduino UNO, ESP 32, jumper cables, etc. Failure of this part by holding the above electrical and electronic components is a not possible event. Because the bending moment caused due to the load applied by the mass of the battery and other components is very low. The plate consists of a vertical and a horizontal plate. The plate has a breadth of 5 inches while the horizontal plate has a breadth of 4 inches, but both the plates have the same length of 7 inches. This support plate is mounted on one of the horizontal beams of the pillars of the chassis.

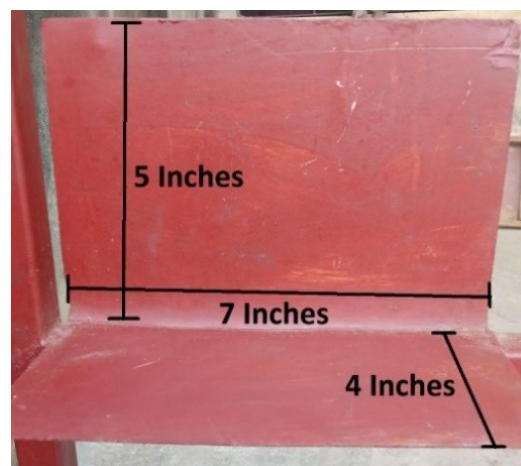


Fig. 4.18: Photograph of L-Shaped support plate for Battery and electronic devices mounting

4.6.6 Vertical Pillars

The same major material of iron 1-inch square pipe is used for these pillars. This chassis consists of two vertical pillars to hold the electrical actuator at a certain height. These pillars are of a height of 48 inches and cross-section of 1 square inch as mentioned above. These pillars are welded to the base rectangular frame. These pillars have two beams in between the for horizontal support. Though the pillar does not suffer much tension while compression, its end joints experience much tension.



Fig. 4.19: Photograph of vertical pillars of the prototype

4.6.7 Electronic Components of the GMS prototype

Arduino UNO is programmed to control all the sensors and output devices. This is also connected to an IoT device, that is ESP32. The ESP32 is an electronic chip module that acts as a WiFi module to connect to the internet. This electronic chip takes care of data transferring through the internet. The municipality officer can view and act according to data displayed on the webpage through the internet. A Gas sensor is used to detect the smoke and different gas levels exhausted due to

accidental fire. The IR sensor is used to detect the person if he is going to throw the garbage. It helps the Arduino UNO to reverse actuate the actuator.

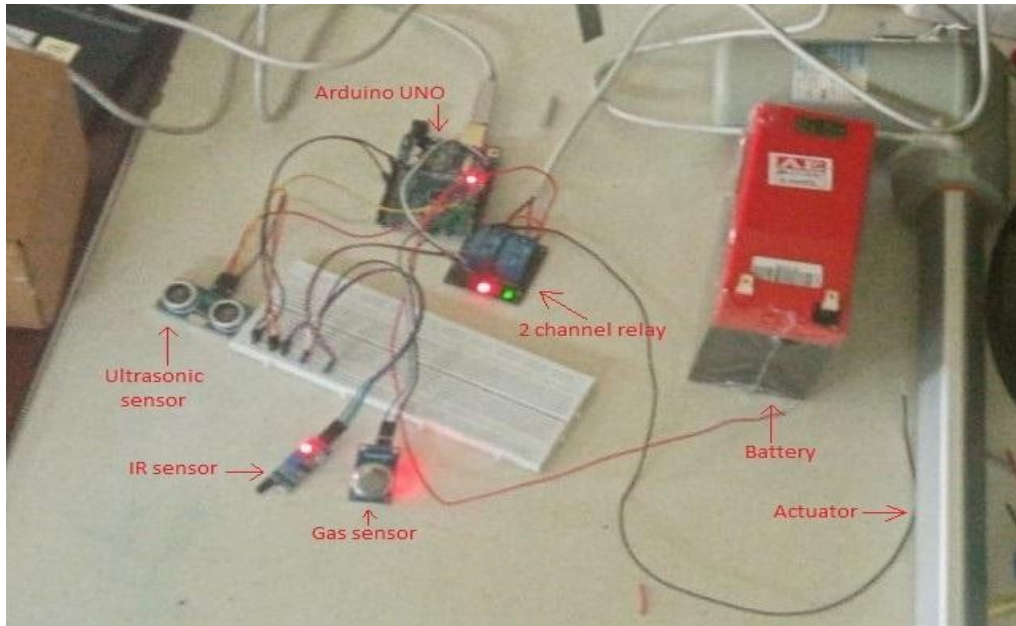


Fig. 4.20: Electronic part of Garbage Monitoring System (GMS)

As mentioned above the electronic components are connected to act as a prototype model for the Garbage Monitoring system (GMS). The power source for the actuator is provided by a 12V DC battery and for the control system i.e., the Arduino and sensors, it is provided by a 9V battery. This makes the system a standalone prototype.

CHAPTER 5

EXPERIMENTS AND RESULTS

5.1 EXPERIMENT OBSERVATION FROM THE TRASH COMPACTOR

The below table shows the data obtained from the prototype model of the trash compactor. The experiment is carried out for various types of garbage. Step by Step methodology is carried out to find each of the minimum compression ratios. The round value of an average of a minimum of 5 trials has been taken for each of the minimum compression. The spring back percentage was also noted in the very same trial. There is no variation in the load applied for the garbage compression since the electrical actuator is used in the prototype model.

- **Compression % = $(H_0 - H_1) \times 100 / H_0$**
 H_0 => Initial Height of the Garbage
 H_1 => Height after garbage Disposal
- **Spring Back % = $(H_{sb} - H_{comp}) \times 100 / H_{comp}$**
 H_{sb} => Garbage height after spring back
 H_{comp} => Garbage height under compression

By using the above common mathematical formula, the experiment is carried out and an average of the compression percent and spring percent of a variety of garbage materials have been obtained. The experiment is carried out by the prototype of a garbage compactor system, with a base of a steel table. The initial height garbage (H_0) is measured before compacting process. The sample of the specified variety of the waste whose level is measured is kept on the steel table for compaction. Then the Height after compaction (H_{comp}) is measured. After leaving the garbage sample undisturbed the volume spring back, that compacted garbage will expand to a small volume. Then the garbage height after spring back (H_{sb}) is measured.

Table 5.1: Experimental Results of the Prototype Garbage Compacting System

S. No .	Type of Waste	Constant Load Applied by the Electric Actuator	Minimum Compression %	Spring Back %
1.	Paper	150 kg	>80	<10
2.	Plastic	150 kg	>70	<1
3.	Glass	150 kg	>30	<1
4.	Cardboard	150 kg	>50	<15
5.	Textile Fiber	150 kg	>70	<30
6.	Wood Timber	150 kg	>20	<5
7.	Ash or Dust	150 kg	>10	<1

5.2 RESULT OF THE TRASH COMPACTOR ON UBIDOTS WEBPAGE

The output from the control system is displayed in the UBIDOTs and various indications are available for a better understanding. Apart from the presentation each of the data representations has a separate purpose.

Table 5.2: Types of representation in Webpage and Its Purpose

Representat ion Type	Purpose
Metric	This representation displays the garbage level up to a precision of two decimal places.
Trash Level Graph	Displays the change in Garbage Level with respect to time.
Gauge Widget	This data representation displays the frequency of the garbage increase.
Value Table	The frequent change in the level is displayed as a data table.
Map	Shows the Geo Location of the bin.

The below figures represent the data obtained from the prototype model of the Garbage Monitoring System (GMS). The different representations of the data like metric value, graphical representation to know the periodic update, trash level for visual representation, gauge widget to display the frequency of the garbage filling, data table for showing every change in the level, and Global position for mapping the location of the garbage bin.

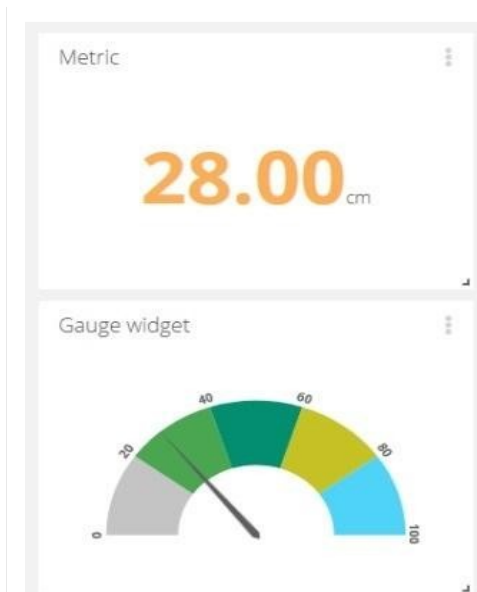


Fig. 5.1: Metric and Gauge widget Representation of trash level on Webpage

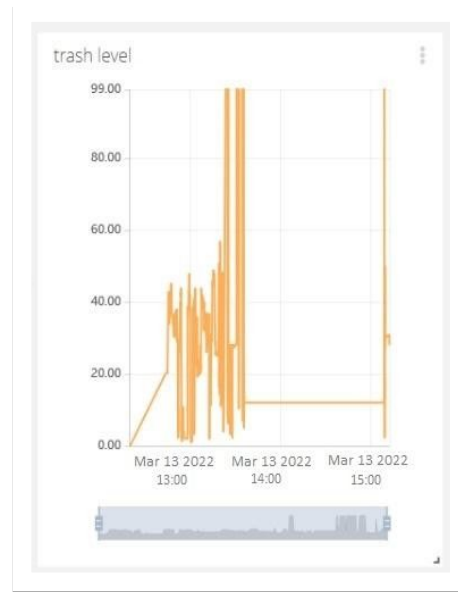


Fig. 5.2: Graphical Representation of trash level periodic filling on Webpage



Fig. 5.3: Virtual Representation of latest trash level with date and time on Webpage

Values Table	
DATE	DISTANCE (ESP-32) LAST VALUE
13-03-2022 15:12	28.00
13-03-2022 15:12	29.00
13-03-2022 15:12	29.00
13-03-2022 15:12	29.00
13-03-2022 15:12	31.00
13-03-2022 15:12	30.00

Fig. 5.4: Tabular Representation of every minor change in trash level on Webpage

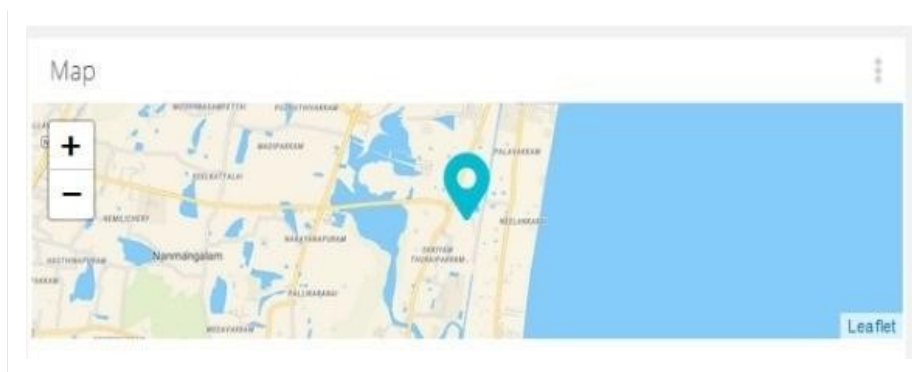


Fig. 5.5: Map Representation of geolocation of the bin on Webpage

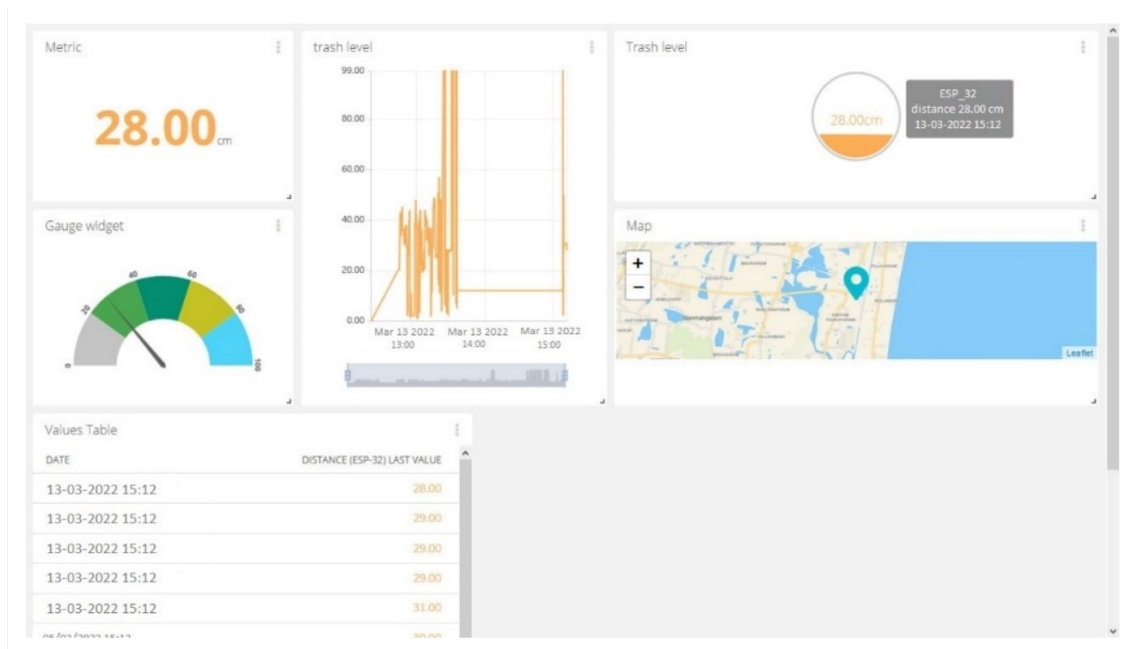


Fig. 5.6: Overall Screenshot of the UBIDOTS Webpage

The results are further monitored by the respective municipality and corporation members. They can arrange the trials of garbage picking based on the data.

CHAPTER 6

CONCLUSION

This paper explained how the proposed system is very useful and efficient for the waste management process. This system highly concentrates on the factor of efficiently using the available garbage bins to their maximum capacity. Apart from this feature, it also consists of a smart system that measures the garbage level after compacting the waste. This smart system will accurately measure the garbage level and update the same to the responsible persons. The responsible person refers to the Garbage collecting vehicle driver, local municipal officers, and other municipality higher officials. Since this system updates the data immediately through a wireless network, the further process can be immediately performed in real-time. With the help of this system, the effort of the local garbage collector and

the number of trips by the Garbage Collecting vehicle are reduced. As a result, the overflowing of the garbage can be avoided. The cleanliness of the road and surrounding increases, which will be a stepping stone for environmental development. Further development can be made to improve the compacting system, which purely depends on the type of actuator used. The data that is being collected can be used for developing this automated system into an AI-controlled system.

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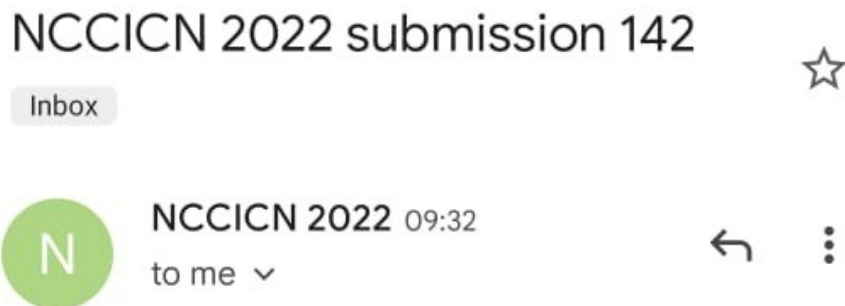
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- **Journal Paper First Page:**

GARBAGE COMPACTOR WITH LEVEL MONITORING SYSTEM

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ABSTRACT - Waste disposal management is an important process to be handled with caution. Chennai alone generates 5.6 tons of waste every day. One of the primary problems of the present era is the detection, monitoring, and management of waste. Manually monitoring garbage in waste bins is a complicated, time-consuming procedure that requires more human work, time, and money. This is a cutting-edge approach to trash management that is fully automated. This project is a garbage monitoring system that is automated. This technology, which is quite unique, monitors the waste bins and provides information on the amount of rubbish collected in the bins via a web page. All the info is sent to the appropriate city or municipality corporation via a website. This System is a Trash compactor that uses integrated infrared and ultrasonic sensors to detect the trash level inside the trash containment unit. Apart from other systems, this leverages linear actuators to compress and compact the collected garbage. Thereby yielding accurate levels of garbage, which in turn reduces the misinformation communicated by the other systems and energy efficiency due to reduction of the manpower.

Keywords: Garbage compactor, Level Monitoring, IoT Based, Municipality Bins

1. Introduction

In the modern era, the urbanization of cities has come with a cost. One of them is an increase in population towards urban areas. Not only in urban areas, according to the UN the world population increases 2% every year [6]. Which is responsible for the increase in consumerism in common people and industrialism in businessmen. Whatever may be the growth, both consumerism and industrialism have a drawback of resulting in a major issue of improper waste disposal and management. Waste generation rates around the world are rising and 5.7 lakh metric tons per day in India. The statistics estimated that the volume of solid waste generated a mark of 0.74 kilograms per person per day [9]. This leads to overflowing dumpsites, because of improper garbage compacting. But there are only approximately 1500 buckets of 750 liters volume for a local urban area of 700 sq km [10]. More than two thousand garbage collectors are working to cover nearly one million houses' domestic garbage. Many GOs and NGOs are working under this process to ensure the proper disposal of garbage (Swachh Bharath Mission, Swachh Bharat Abhiyan, Swachh Seva Sahakari Sanstha Maryadit in Pune, Shuddhi, Environmentalist Foundation of India, Project Mumbai, Aahwahan). People in urban areas do not have the patience to properly dispose of the garbage. That is utilizing the maximum volume of the municipality bins while disposing of the garbage. This causes the need for the use of automated technologies which reduce the time and human effort of garbage collectors and common people. Automation is always recommendable in a place where the work involves unhygienic practice. The automation done here is a garbage compactor for local municipality garbage bins. Designed to utilize the maximum volume and monitor garbage level. The model is designed and fabricated to compress the garbage to a reasonable volume (one-fourth at least) without any human effort.

2. Existing System of Garbage Collection in Municipality

The existing system consists of just an ordinary Iron or PVC bin with a capacity of 660L to 1100 liters[17]. The volume of these bins is not used to its maximum capacity. So those dustbins usually overflow. This makes the work of local garbage collectors hard and time-consuming. Because these garbage collectors dump the waste in the street corner municipality bin in most of the localities. So, it takes time and energy for them to compact the existing garbage in the bins. In the existing system, the garbage compacting is only done by the garbage collecting heavy vehicles. Which also has the drawback of scheduling pickup based on the garbage-filled up. Because there is no system that updates the garbage level appropriately with respect to time. This overflow of garbage due to various reasons causes an unhygienic environment and affects human health. Most of these municipality bins are placed in the street corners and main junctions. So it is hard to keep additional bins in the same place to avoid overflowing garbage. Which in turn causes traffic jams, accidents, and nuisance to the environment.

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