Automated Waste Segregator using Renesas Microcontroller

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***Abstract*- Rapid increase in volume and types of solid and hazardous waste as a result of continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for national and local governments to ensure effective and sustainable management of waste. It is estimated that in 2006 the total amount of municipal solid waste generated globally reached 2.02 billion tones, representing a 7% annual increase since 2003 (Global Waste Management Market Report 2007). The segregation, handling, transport and disposal of waste are to be properly managed so as to minimize the risks to the health and safety of patients, the public, and the environment. The economic value of waste is best realized when it is segregated. Currently there is no such system of segregation of dry, wet and metallic wastes at a household level. This paper proposes an Automated Waste Segregator (AWS) which is a cheap, easy to use solution for a segregation system at households, so that it can be sent directly for processing. It is designed to sort the refuse into metallic waste, wet waste and dry waste. The AWS employs parallel resonant impedance sensing mechanism to identify metallic items, and capacitive sensors to distinguish between wet and dry waste. Experimental results show that the segregation of waste into metallic, wet and dry waste has been successfully implemented using the AWS.**

***Index Terms*-Automation, Economic Waste Segregation, sensor, Renasas Microcontroller, DC Servo Motor.**

I. INTRODUCTION

Modern world meets lots of challenges that include Smart waste management system. It is become matter of big concern if proper disposal system is not managed. Managing waste effectively and recycling efficiently, a nation can ahead one step forward. In this project, an automatic sorter machine is developed which can sort out the wastes in various categories to make waste management easier and efficient. It can be possible to sort out metal, paper, plastics and glass by developing an electromechanical system using microcontroller and operational amplifier. Moisture sensor is used to detect the placed material is wet or dry and proximity sensor are used to detect the metal content in the waste.

By using the proper recycling system, the curse of waste will turn into blessings for the civilization. The sorting procedure will make recycling more efficient. By means of this waste sorter, the conventional waste management system will be transformed into SMART system. This SMART system will help to make our environment more suitable for living, reducing global warming and making the world healthier. From the beginning of the human civilization, people used various methods of waste disposal to get rid of unwanted material. Sometimes it was buried in the land, thrown in the sea, fed to the animal or burnt. Getting rid of unwanted material is always a major concern for the modern society. Trash has played a tremendous role in history. The Bubonic Plague, cholera and typhoid fever, to mention a few, were diseases that altered the populations of Europe and influenced monarchies. They were perpetuated by filth that harboured rats, and contaminated water supply. When wastes are not properly managed then it may cause serious hazard, as seen in 1350. "Black plague" erupted and more than 25 million people from all over Europe fall victim to it in just five years .There is an increasing rate of waste generation in Bangladesh and it is projected to reach 47,064 tons per day by 2025. The Waste Generation Rate (kg/cap/day) is expected to increase to 0.6 in 2025.

A significant percentage of the population has zero access to proper waste disposal services, which will in effect lead to the problem of waste mismanagement .The total waste collection rate in major cities of Bangladesh such as Dhaka is only 37%. When waste is not properly collected, it will be

illegally disposed of and this will pose serious environmental and health hazards to the people of Bangladesh. This is not the only problem of Dhaka city but also for other big cities around the world. With so much concern recently about being greener and economically friendly, waste management has become a very important topic. People and companies are starting to realize that the things they use and the way they dispose of them can make a big impact on our world. Proper management of waste plays a vital role in global environment. That is why a waste sorting system is designed which can be used in houses, offices, industries as a part of smart waste management system.In this project, the IR detects some sorts of material is being put on the system tray. Then at first the weight sensor activates and find out the weight of the trash, then the metal sensor and glass sensor starts their actions. If metal sensor detects the material as metal, then a servo motor will put that trash in the bin (which is dedicated for metals). Moisture sensor is used to detect the placed material is wet or dry and proximity sensor are used to detect the metal content in the waste.

II. IMPLEMENTATION

The main goal of the project is to design and develop a sorting system that sorts the waste automatically into three categories namely metal waste, wet waste, and dry waste. Figure 1 shows the block diagram of AWS. The system mainly consists of Renesas Microcontroller, inductive proximity sensor, resistive plates, IR sensors and servo motors.

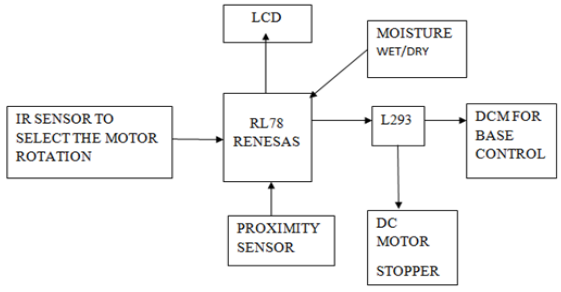


Fig. 1 Block diagram of AWS

The system starts when the waste material is put into the system. Waste is pushed through a flap into the inclined plane having the inductive proximity sensor. An upper enclosure ensures waste does not fall out of the sensing area. When the waste is dumped, the object slides over the incline to roll over the inductance coil which is used to sense any metal object. If the object is metallic a change in parallel resonant impedance of the metal detection system is observed. The object again continues and drops into the resistive sensing module. An IR and photodiode combination is placed here to check the presence of waste. As and when waste falls between resistive plates, a change in IR value is detected. That change is used as the threshold to start the calibrations. Here, a decision is made if the waste is wet or dry based on its relative permittivity. After the identification of waste, a circular base which holds containers for dry, wet and metallic waste is rotated. The collapsible flap is lowered once the container corresponding to the type of garbage is positioned under it. The waste falls into the container and the flap is raised. The waste in the containers now can be collected separately and sent for further processing.

A. Sensors

IR Sensor

The IR transmitters are connected to supply, so that they will transmit high signal all the time. The IR receivers are connected to the comparator circuit, to get digital signals. A low power operational amplifier LM324 IC has been used to develop a comparator circuit. Two set of LM324 IC has been used in this project. The circuit diagram of the comparator is shown below. Here, IR Sensors are used to detect the presence of obstacle. When the object is sensed by Sensor the Microcontroller gets turned on.

Fig.2 IR Sensor

Moisture Sensor/Parallel Plate Capacitive Sensor

$C=\varepsilon\varepsilon' A/D$

where, ε= absolute permittivity ;

A= Area of a Parallel Plate

ε'= relative permittivity ;

D= Distance between the plates.

The above formula is used to calculate Capacitance of the object. Wet waste has high Dielectric constant compared to dry waste. Hence, Capacitance of wet waste is more compared to dry waste. As the

capacitance changes the resistance also changes. This change in resistance above the threshold value is used to differentiate between wet waste and dry waste.

Fig.3. Moisture Sensor/Parallel Plate Capacitive Sensor

Proximity Sensor/Metal Detection Sensor

Proximity Sensors are used to detect the presence of metal. Alternating current is made to flow through a coil. When the external metal comes closer to Sensor, the flux path changes. So, current passing through the coil changes which is used to detect the presence of metal.

B. Actuators Used

DC Servo Motors

DC servo motor is a machine that converts electrical energy to mechanical energy. Two motors are used in AWS, one to control the flap movement and another to control the rotation of bins. 12V DC is used to run the motor, which is controlled by L298N Motor Driver circuit.

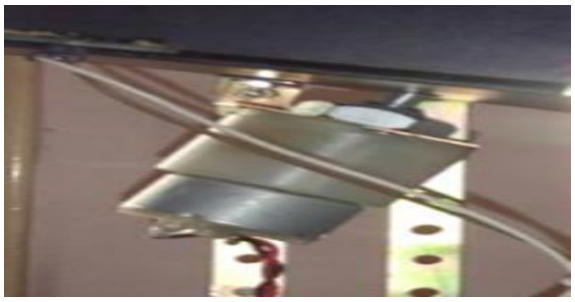


Fig.5. DC Servo Motor

L293N Motor Driver

The L298N is an integrated monolithic circuit in a 15 lead Multi watt Vertical packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

C. Functional Description

Power Output Stage

The L298N integrates two power output stages (A, B). The power output stage is a bridge configuration and its outputs can drive an inductive load in common or differential mode, depending on the state of the inputs. The current that flows through the load, comes out from the bridge at the sense output: an external resistor (RSA ; RSB), allows to detect the intensity of this current.

Input Stage

Each bridge is driven by means of four gates, the input of which are In1; In2; EnA and In3; In4; EnB. The inputs (In), sets the bridge state when En input is high; a low state of the En input inhibits the bridge. All the inputs are TTL compatible.

A non-inductive capacitor, usually of 100 nF, should be connected between both Vs and Vss, to ground. When the large capacitor of the power supply is too far from the IC, a second smaller one should be connected near the L298N.The sense resistor, not of a wire wound type, should be grounded near the negative pole of Vs that must be near the GND pin of the IC. Each input must be connected to the source of the driving signals by means of a very short path. It is used to control the rotation of flap and DC Motor holding bin.

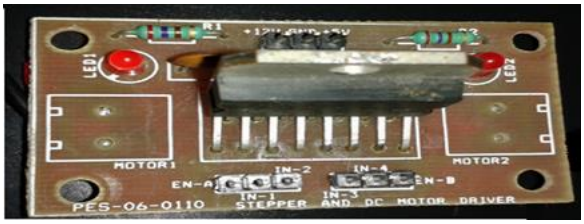


Fig.6. L298 Motor Driver

D. Working

Entry System And Initialization

The waste is dumped into the Automatic Waste Segregator which marks the entry of the waste and starts the system. It then initializes the sensor modules. The initialization of all modules ensures that any dynamic changes in the environment do not affect the sensing.

Metal Detection System

The object moves over the incline and falls on the inductive proximity sensor which contain an inductive coil. The inductive coil is a part of a

parallel inductance and capacitance (LC) circuit. This measures the parallel resonance impedance of a parallel LC circuit and returns data as a proximity value. This data changes whenever another metallic object is introduced in the vicinity of the coil.

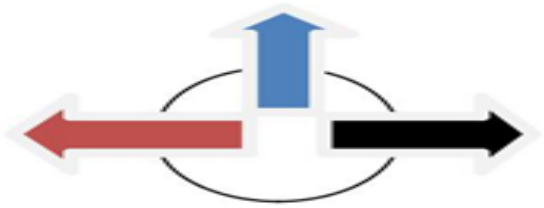
When an alternating current is passed through a coil it generates a magnetic field. When a metallic object is introduced in the vicinity of the coil, eddy current is induced on its surface. The eddy current is a function of the distance, size, surface area and composition of the target. This generates a magnetic field which opposes the original magnetic field which is generated by the coil. The inductive coupling between the coil and the object creates a mutual inductance effect on the coil which decreases the parallel resonant impedance of the circuit which in turn is reflected by an increase in the proximity count value. Magnetic fields do not affect the metal detection system. It can detect any conducting material irrespective of its magnetic properties. The waste continues down the incline towards the resistive sensing module.

Resistive Sensing Module

Two pairs of copper cladded plates of size 10*7 cm are placed along the walls of the structure which are inclined to each other at an angle of 60°. This arrangement is made to ensure that waste of all sizes can be sensed. The area between each pair of plates increases as it moves away from the apex of the structure. The sensitivity of the plate decreases with its increase in area, hence smaller plates would accurately sense objects of smaller size. Even though the sensitivity of the larger plate is decreased, it is designed to detect larger objects which will yield a change sufficient to be identified.

The property used for segregation of waste is the relative dielectric constant. Once a dielectric is introduced between the plates the resistance value between the plate's changes and subsequently a voltage change is detected. Wet waste has a higher relative dielectric constant than that of dry waste because of the moisture, oil and fat, content present in kitchen waste. If the change in the voltage is greater than threshold then the type of garbage is inferred as dry waste, else it is wet waste. Thus, the type of waste is identified as either wet or dry.

Segregation module



b)Servo motor rotates clockwise, when Wet is detected.

c)Servo motor rotates anticlockwise, when Metal is detected.

Wet Dry metal

Fig. 7. Rotation of DC Motor holding bins.

To achieve the segregation, two servo motors [5] are used. The containers are placed on a circular base which is mounted on the axle of a servo motor. The circular base rotates as the axle of the servo motor rotates. If the container corresponding to the type of garbage is not under the flap then the motor is rotated clockwise or anticlockwise. The servo motor is given three different positions or angles for the three types of wastes detected. The motor thus always comes to the required position according to the signal obtained. The default bin at the circular base is the dry bin. To avoid overshooting of the container due to the momentum of the base, the servo motor is rotated at lower speeds by using pulse width modulation (PWM) which is generated from the microcontroller's timer . Once the required container is positioned under the flap, a second servo motor lowers the collapsible flap by rotating the motor clockwise by 180° it then wai ts for 2 seconds to ensure that the waste falls down and finally raises the flap back to the initial position by rotating the motor anti clockwise by going back to 50°. PWM is used to

rotate the motor. Thus the segregation is completed. Rotation of circular base is as shown in figure 7.
a)Servo motor at rest. i.e.., When Dry is detected.
The flow of the software implementation is as shown in figure 8

III. RESULTS

The project has been tested for different categories of waste namely wet, dry and metal. Wet waste means organic wastes such as vegetable peel, garden wastes etc, dry waste include paper wastes, plastic bottles etc, and metallic waste include safety pins, foil paper etc.

Table 1. Voltage and resistance values across resistive plates for different wastes

Wastes	Voltage across resistive plates in volts	Resistance value of resistive plates in mega ohm
Metal	0	0
Plastic	4.84	0
Banana peel	4.37	7.8
Wet leaves	4.74	1.56
Aluminum foil	0	0
Potato peel	4.37	0.58
Dry cloth	4.26	0

The segregation of metals is done by inductive proximity sensor. Hence if a metal is detected the resistive sensing module will be inactive. Table 1 describes the value of voltage and resistance for different type of waste.

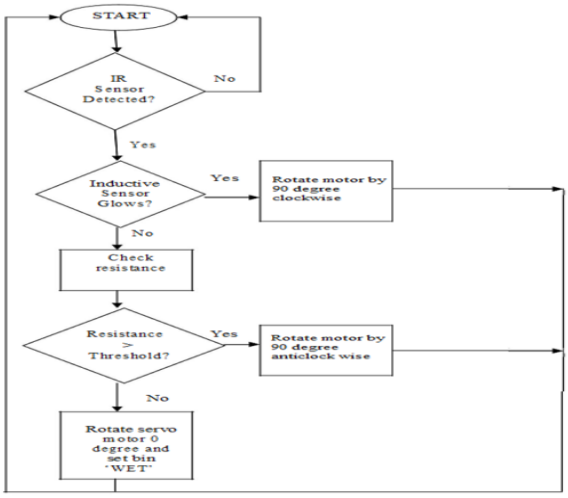


Fig. 8. Flow chart for software implementation

The system uses two type of sensing mechanism to segregate waste into three different categories. An inductive proximity sensor is used to detect the metallic garbage and resistive plates segregate the waste into wet and dry category. This system can be made more efficient by using different sensors for different type of waste. More bins can be added to this project as per the demand of user. Since the system is cheap and approachable everyone can buy it and use it.

Table 2 represents the result of waste segregation which shows whether the tested waste belongs to metal, dry or wet. Table 3 represents the rotation of circular base according to the waste detected. For metal waste, the motor connected to circular base rotates in anticlockwise direction. If detected waste is dry then no rotation is there and if it is wet waste motor rotates in the clockwise direction.

Table 2. The result of waste segregation

Wastes	Type of waste detected
Foil paper	Metallic waste
Banana peel	Wet waste
Lemon	Wet waste
Potato	Wet waste
Poly bag	Dry waste
Paper	Dry waste
Keys	Metallic waste

Table 3. Rotation of circular base according to detected waste

Wastes	Angle (in degrees)	Movement of bin
Foil paper	0	Anticlockwise
Banana peel	180	Clockwise
Lemon	180	Clockwise
Potato	180	Clockwise
Poly bag	90	No rotation
Paper	90	No rotation
Keys	90	Anticlockwise

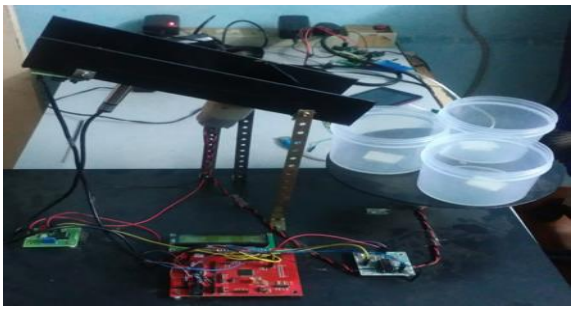


Fig. 9 Automatic Waste Segregator Prototype Set-up

IV. CONCLUSION

Automatic Waste Segregator has been successfully implemented for the segregation of waste into metallic, dry and wet waste at a domestic level. The system can segregate only one type of waste at a time with an assigned priority for metal, wet and dry waste. The experiment has been conducted for wet, dry and metallic wastes. It is found that the change of resistive count value is greater for wet waste and very less for dry waste. Other objects like glass and wood have intermediate relative dielectric constant and thus are detected as dry waste. Experimental result shows that the waste has been successfully segregated into metallic, wet and dry using the Automatic Waste segregator.

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