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The Design & Implementation of an Environmentally-friendly Microcontroller Based Automatic Waste System Using Servo

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ABSTRACT

Clean bin is an idea for producing an excellent smart dustbin that can automatically open the lid when it detects people who want to throw out their trash. Beside this, it can also smartly detect the level of the trash that is inside the dustbin. To achieve the main objective, two element of engineering are combines: mechanical and electrical component. For electrical component, the ideas are to make the dustbin automatically open based on infrared technology. A simple control system involves PIC Microcontroller, infrared module sensor for distance sensing, mechanical arm with servo motor and (Light Emitting Device) LED indicator. Meanwhile for mechanical element, a simple arm is used to push the lid of the dustbin. The idea is to link the arm with the servo motor then the arm rotates as it follows the rotation of the servo motor. By combining this two main element, a smart clean bin is produced. The objective of the study was to determine the characterization of the waste and the current system of management activities.

Keywords: LED, Circuit, motor, Microcontroller, Sensor

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1. INTRODUCTION

Clean bin is an idea for producing an excellent smart dustbin that can automatically open the lid when it detects people who want to throw out their trash. Beside this also smartly detect the level of the trash that inside the dustbin. To achieve the main objective, two element of engineering are combines: mechanical and electrical component. For electrical component, the ideas are to make the dustbin automatically open based on infrared technology. A simple control system involves PIC Microcontroller, infrared module censor for distance sensing, mechanical arm with servo motor and (Light Emmiting Device) LED indicator. Meanwhile for mechanical element, a simple arm is used to push the lid of the dustbin. The idea is to link the arm with the servo motor then the arm rotates as it follows the rotation of the servo motor. By combining this two main element, a smart clean bin is produced. The proposed project presents a more hygiene way of disposing off waste and contaminated stuffs without having direct contact with the waste bin. Conventional waste-bin are either left opened, which allows flies and other insects, pest on these wastes and then fly into people's houses and cause them sickness. Other bins are closed requiring users to first get them opened, drop their waste before closing the bin, this allows proximity between several users with different contacts with germ to be easily spread and transmitted. This and more are what this proposed system intend to put an end to.

It presents, an electronic waste management system where the presence of an individual is sensed and at some very close degree of proximity, the system automatically opens the waste bin cover with the help of an attached servo motor producing an angular rotation on a fixed cover enabling opening and closing, and when a user has fully dropped off their waste, once he or she moves away from the bin, the proximity sensor sensing closure notices the distance between the bin and a user and automatically closes the bin, that way proving a user with a contactless approach to having the bin open and close while preventing rodents, flies and other insects from getting in and out enough to spread germs and diseases from homes and location where the waste bin are kept. Also available on this system is a more convenient way of informing users that the bin is full, an attached. To give a brief description of the project, the sensors are placed in the common garbage bins placed at the public places. When the garbage reaches the level of the sensor, then that indication will be given to ARM 7 Controller. The controller will give indication to the driver of garbage collection truck as to which garbage bin is completely filled and needs urgent attention. ARM 7 will give indication by sending SMS using GSM technology (M. Al-Maaded et al., 2012). It is important to understand the societal concerns over the increased rate of resource consumption and waste production and therefore the policy makers have encouraged recycling and reuse strategies to reduce the demand for raw materials and to decrease the quantity of waste going to landfill. (Hannan et al., 2012).

However, the knowledge of electronics and micro programming was applied to improve the previous work carried out by these experts to develop an automatic waste bin system. This automatic waste bin system, its operation is simply to sense human closure or proximity and open the bin cover, the cover stays open until the human presence been sensed is moved distances away enough to exceed 80 cm from the sensor before the cover closes back again, an attached servo motor helps makes the opening and closing possible (Raghumani Singh and C. Dey, 2011)..

2. LITERATURE REVIEW

The trend of making the manually controlled things automatic has become a common practice these days. The process of making the things automatic is being exploited in almost all the major fields of life. Making things automatic reduces burden on the humans. The cost and effort used in manually controlled products is much higher than the automated systems. Considering the fact, that the problem of efficient waste management is one of the major problems of the modern times, there is an utmost need to address this problem. The proper waste management system is must for the hygienic society in general and for world as a whole. Solid waste which is one of the sources and causes of environmental pollution has been defined under Resource Conservation and Recovery Act as any solid, semi-solid liquid or contained gaseous materials discarded from industrial, commercial, mining or agricultural operations and from community activities. Solid waste also includes garbage, construction debris, commercial refuse, and sludge from water or waste treatment plants or air pollution, control facilities and other discarded materials (Ajibade, L. T. *et al.,* 2005).

In order to protect human health and the environment from the potential hazards of delayed waste disposal and environmental pollution a systematically supervised and controlled handling of these wastes is must. The type of wastes which constitute environmental pollution and which this work emphasizes on is domestic refuse consisting of degradable food wastes, leaves, dead animals and non-degradable ones such as plastics, bottles, nylon, medical and hospital wastes, generated in households, hospitals, industries and commercial centers (Tchobanaglous *et al.,* 1997).The complexity of issues involved in municipal solid waste management necessitates development and application of new tools capable of processing data inputs of varying formats, numerical models and expert opinions in multi objective decision making scenario. Decision Support Systems (DSS) are among the most promising approaches to confront such situations. The Decision Support System models should idk2eally be integrated with geographical information system (GIS) to optimize collection, transportation, processing and disposal processes. An attempt to present an overview of Decision Support System in the area of solid waste management with specific reference to their development and applications in India. (A. Ohri and P.K. Singh, 2005).

Waste management is a continually growing problem at global and local levels. Solid wastes arise from human and animal activities that are normally discarded as useless or unwanted. In other words, solid wastes may be defined as the organic and inorganic waste materials produced by various activities of the society and which have lost their value to the first user (Opara, 2008). The domestic waste products are collected through waste bin at a common place at a particular spot for an area/street. A major difficult task is that checking process of waste bins for the collection of wastes. The usual method by which, a person has to wander through the different spots and check the places for waste collection. This is somewhat complex and time consuming process. The present day waste management system is not as efficient as it should have been taking into consideration the advancements in the technologies that arose in the recent years. There is no surety about the management/ clearing of wastes at all the places. To overcome this problem a new approach, *Automatic waste management system* is proposed. It is a step forward towards making the waste collection process automatic and efficient in nature. Whenever the waste bin gets filled this is acknowledged by placing a RF transmitter at the waste bin, which transmits it to the receiver at the desired place in the area or spot. The received signal indicates the waste bin status at the monitoring and controlling system.

In our daily life, we see the pictures of garbage bins being overfull and all the garbage spills out resulting in pollution. A big Challenge in the urban cities is Solid waste management (Hassan *et al.,* 2005). To give a brief description of the project, the sensors are placed in the common garbage bins placed at the public places. When the garbage reaches the level of the sensor, then that indication will be given to ARM 7 Controller. The controller will give indication to the driver of garbage collection truck as to which garbage bin is completely filled and needs urgent attention. ARM 7 will give indication by sending SMS using GSM technology (M. Al-Maaded *et al.,* 2012). It is important to understand the societal concerns over the increased rate of resource consumption and waste production and therefore the policy makers have encouraged recycling and reuse strategies to reduce the demand for raw materials and to decrease the quantity of waste going to landfill. (Hannan *et al.,* 2012). This automatic waste bin system, its operation is simply to sense human closure or proximity and open the bin cover, the cover stays open until the human presence been sensed is moved distances away enough to exceed 80 cm from the sensor before the cover closes back again, an attached servo motor helps makes the opening and closing possible.

2.1 Types of Automatic Waste System

There are several types of automatic waste management systms. These include:

- Microcontroller base automatic waste system using savor motor
- Microcontroller base automatic waste system using stepper motor
- Microcontroller base automatic waste system using driver motor

2.2 Advantages of Automatic Waste System

The main advantage of the automatic waste system is to provide a more hygiene way of disposing off waste and contaminated stuffs without having direct contact with the waste bin. Conventional waste-bin are either left opened, which allows flies and other insects, pest on these wastes and then fly into people's houses and cause them sickness. Other bins are closed requiring users to first get them opened, drop their waste before closing the bin, this allows proximity between several users with different contacts with germ to be easily spread and transmitted

3. METHODOLOGY

The system is an automatic waste bin system, its operation is simply to sense human closure or proximity and open the bin cover, the cover stays open until the human presence been sensed is moved distances away enough to exceed 80 cm from the sensor before the cover closes back again. An attached servo motor helps makes the opening and closing possible. The method of this system is based mainly on the mode of operation of the Servo Motors. The servo motorare ordinary geared down DC Motors equipped with servo mechanism for precise control of angular '8position. A servomechanism or servo refers to an error sensing negative feedback which is used to correct the performance of a device. Servo Motors do not rotate continuously; their rotation is limited between fixed angles. Usually these motors have rotation limit from 90° to 180° and some special have limit 360° or more.

3.1 Design Analysis

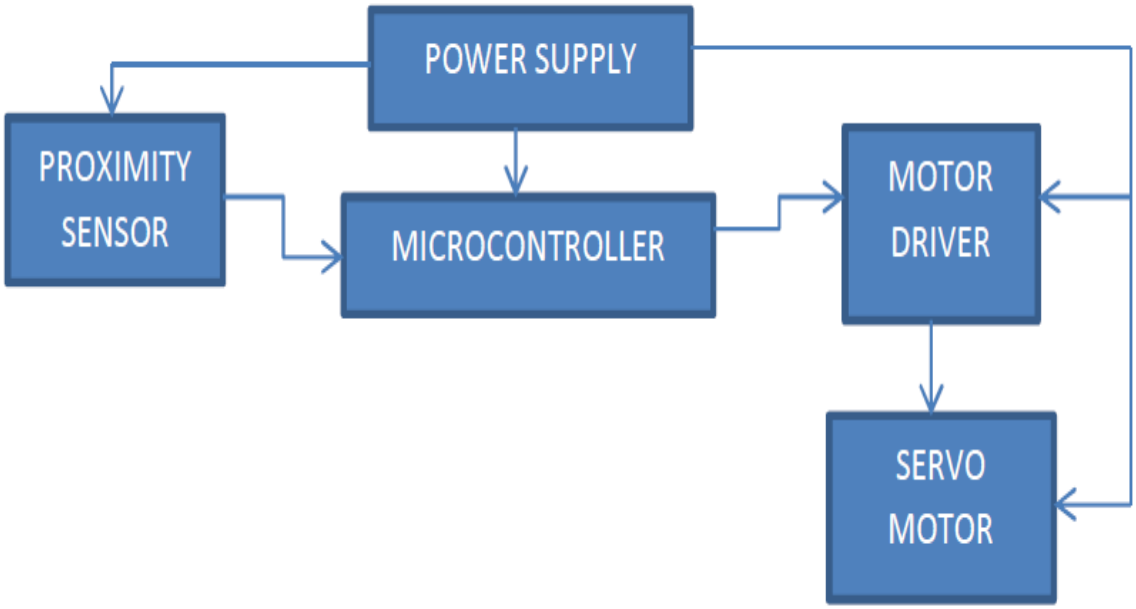


Fig. 1: Design Analysis Diagram

The block diagram above presents a microcontroller based automatic waste system using a servo motor, first on this block is the power supply, responsible for making power requirement of the proximity sensor, the microcontroller and the servo motor available. When we say power, we means, voltage and current specifications for every used components and module, determined by the manufacturers of these devices must be made available by the power supply unit. A proximity senor is attached to the bin construction which produces an infrared light when powered on, the light functions as directed by the microcontroller. The proximity sensor has two faces. One face of the proximity sensor sends out an infrared light has earlier stated while the second face receive the light deflected back by a object in form of a negative feedback and powers the servo motor to operate.

Unlike the conventional ones done before, the ability of this system to detect a close object as instructed by the microcontroller and open the bin lid automatically, make this unique. The system also has attached, a control button with which the bin can be powered off and empty when ever it is full or needs to be empty. The system makes use of a microcontroller with EEPROM feature so that the proximity sensor does not stop functioning in the case of power outage or system switch-off or reset. The servo motor has a driver that help the motor to open the bin lid based on the instruction given by the microcontroller the servo motor is attached to a gear in the lid.

The gear and the lid is aliened and properly fixed. The feedback mechanism is made available by the inbuilt infrared light in the proximity sensor present in the system. For the proximity sensor to be sensitive, the infrared light must be feedback to the second face of the proximity sensor and so temporarily interrupt the LDR planted inside the system. The LDR must be powered ON, the LDR serves as an indicator to the system. It is used to indicate weather the system is ON/OFF. Once that occurs, the system is either ready for use or not in use depending on the state of the LDR. LDR is a special kind of resistor whose action based on the intensity of light declining on it.

In the time of total darkness LDR resistance is approximately 1 mega ohm while at the time of bright light its resistance is 2-5 ohm. In this circuit the light source is adjusted with the LDR in such a way that the light will directly drop on the LDR so that when a voltage is supply it powers it. In the making of this system, several electronic components and modules were used, servo motor, proximity sensor, gear, microcontroller, Button, Switch, resistors, capacitors, voltage regulator, etc.

3.2 System Operation

It is a high performance device, which is low in energy consumption and will give a long service-life. Product Dimensions and Description of this design consist of numbers of Items. The design has been constructed in a way that it will add value to the environment and be of great benefit to the inhabitant due to its mode of operation. One of the construction purpose is the ordinary rectangular dustbin with lid to open and close itself until its fill up the rubbish, two(2) Servo Motor Tower Pro MG995 to lift up and lift down the dustbin lid three (3) Aluminum / PVC Board / Acrylic (2mm) Act as the arm which connected the dustbin lid with the servo motor four (4) Mounting Board (3mm) Casing for servo motor and PIC Micro controller circuit board battery as the power supply to control the servo motor, Infra-red censor, and LED indicator distance sensor to detect any motion that pass it LED indicator To show the level of rubbish (Red = full , Green = empty), once the system is powered ON, The LDR light comes on with a green light.

A proximity sensor was mounted close to the lid of the bin, this can also be called the sensor aspect of the system it is composed of l8two part one of which produces an infrared light and the other is a light dependent diode. The object passing through the sensor blocks the infrared light in turn causing a reflection that cast the light on the light dependent diode this receives the light and sends a signal to the microcontroller which power the driver of the motor that causes the bin lid to open automak8tically and with the aid of the gear the direction of the system opening is controllable.

The construction procedure is as follow, the system is an automatic waste bin system, its operation is simply to sense human closure or proximity and open the bin cover, the cover stays open until the human presence been sensed is moved distances away enough to exceed 80 cm from the sensor before the cover closes back again, an attached servo motor helps makes the opening and closing possible. For this completion of this system several blocks of the diagram working together makes this possible

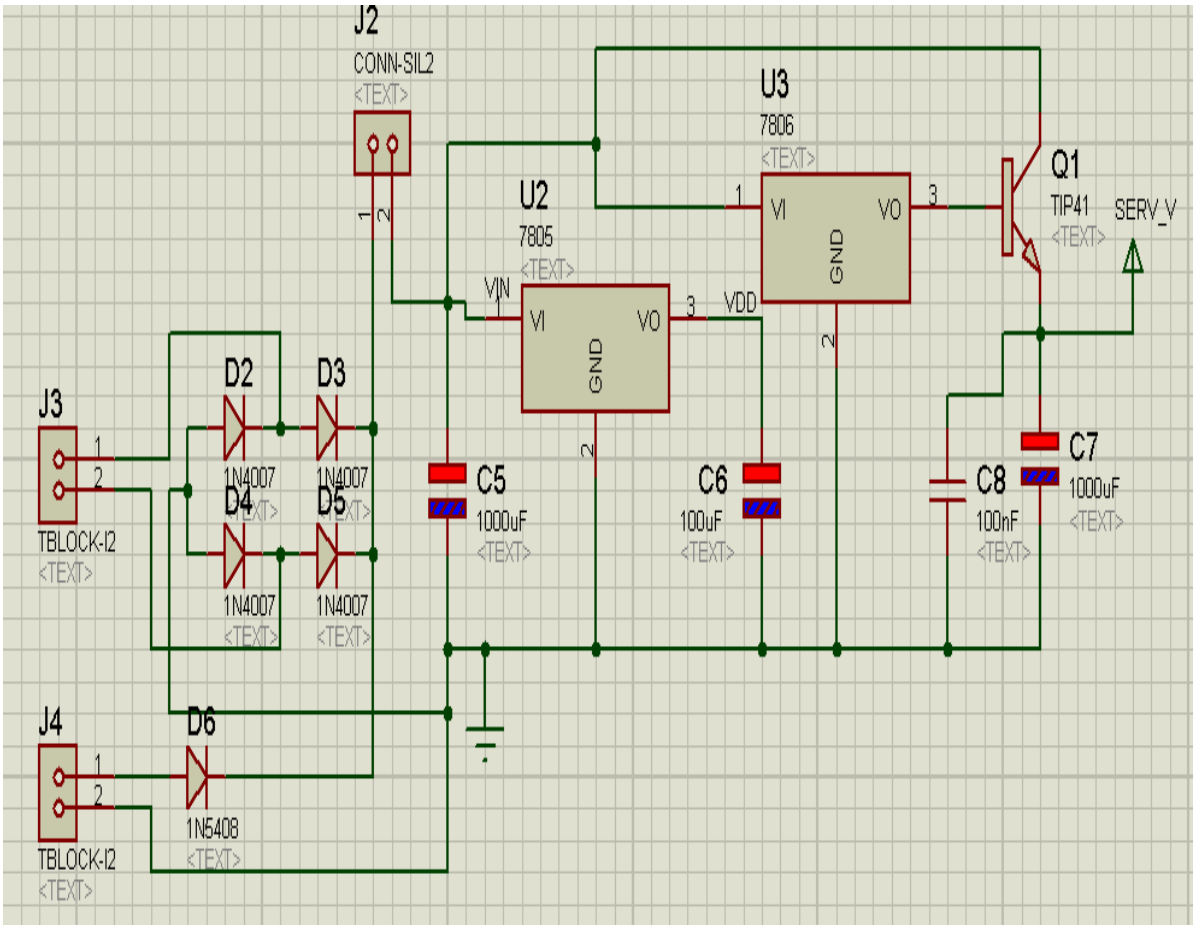
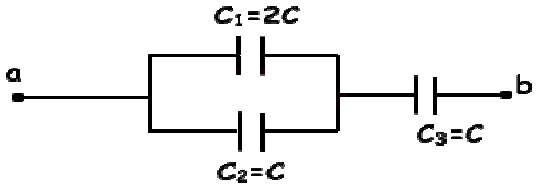


Fig. 2: Circuit Diagram of an Automatic Waste System

Calculating the total voltage supply from the A.C source: $V_s \times \sqrt{2}$--------= v_p

Where
V_s = Secondary voltage of the transformer
v_p = Calculated rectifier output voltage But V_s = 18v from the reading taken
$v_p = 18 \times \sqrt{2} = 25.4558$volt



$$\frac{Q}{C_{eq}} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3} = Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

Equivalent Capacitance becomes:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

C_1 and C_2 are in series

$$\frac{1}{C_{12}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_{12}} = \frac{1}{60} + \frac{1}{20} = \frac{4}{60} \qquad C_{12} = 15\,\mu F$$

C_3 and C_{12} are in parallel

$$C_{123} = C_{12} + C_3$$

$$C_{123} = C_{12} + C_3 = 15 + 9 = 24\,\mu F$$

C_{123} and C_4 are in series

$$\frac{1}{C_{eq}} = \frac{1}{C_{123}} + \frac{1}{C_4} = \frac{1}{24} + \frac{1}{12} = \frac{3}{24} \qquad C_{eq} = 8\,\mu F$$

Total charge of the system is:

$Q = C.V = 8\,\mu F . 120V = 960\,\mu F$

Potential difference between points B and C is:

$$V_{BC} = \frac{q}{C} = \frac{960}{12} = 80V$$

Potential difference between points A and B is:

$V_{AB} = V_{AC} - V_{BC} = 120V - 80V = 40V$

$Q_1 = Q_2 = C . V_{AB} = 15\,\mu F . 40V = 600\,\mu C$

4. RESULT AND DISCUSSION

4.1 Performance Test

In testing the designed and constructed system, four basic steps were taken. These steps are sequentially listed below as:

- Step 1: To ensure that all the components to be used are functionally operating, they were first tested with a digital multi meter and failed ones replaced before finally soldering them on the l2PCB.
- Step 2: The period of time for system to increment a count and send a message (delay) was specified using the program.
- Step 3: Using Circuit Maker 6 (Student Edition), the circuit was simulated. The result obtained from the simulation closely corresponds to the desired result, with only some slight variations.
- Step 4: To ensure that there was no breakage in the circuit path on the PCB, immediately after soldering on PCB, the circuit path was tested using the Digital Multi-meter. This was done to also ensure continuity of circuit on the PCB.

4.2 Presentation of Results

The components are properly tested with the aid of a multi-meter, the output of each component are stated below:
E. M. F. = 9v. DC and 220v step down to 12v. A.C Output voltage, Vo = 5volts D. C & 1.5A

Table 1: Components

Components used	Output voltage
Transformer	12v
Proximity sensor	3.5v
LED	2,20Ω
Servo motor	5v

4.3 Discussion of Results

The objective for testing all the components before they were finally soldered on the PCB is to avoid current linkage and wasted effort it will take to de-solder faulty components at the end of the day. From the continuity test carried out on the board to check the circuit path, it was discovered that the circuit was in a perfect working condition as continuity was ensured. Simulation of the circuit design was also done as mentioned earlier, with the sole objective of comparing the results obtained from design calculations to that obtained from simulation. The two results when compared closely correspond with only a very slight discrepancy in values.

4.4 Problem Encountered

It should be noted at this juncture, that the realization of the final system work was not without Problems. The various problems encountered during the design and implementation stage are
Stated below:

(1) Some measuring instruments that would have being used for detailed analysis of the circuit (i.e. Transistor Tester) were limited for use. Simulation software was instead used for the circuit analysis.
(2) Some basic components to be used for the system were not within reach as it was not available in town.
(3) The biggest problem encountered was at the implementation stage and writing the program as the system was sensing the closure of an object and will need to open by itself .The sensitivity of the circuit was reduced by putting distance into consideration and a limit.
(4) Locating the exact position to mount the sensor in the box to get a perfect sensing of the letter any time it is drop
(5) The aliment of the motor tooth to the gear was another problem faced. This was overcome by cutting one of the hook and replaced it by a suitable gear and firmly attach the motor to it.

5. CONCLUDING REMARKS

The progress in science & technology is a non-stop process. New things and new technology are being invented. "The Automatic Waste System was successfully built in this project work which was used to prevent the contamination of germs during the disposal of unwanted materials. Hence the Aim of this project work was achieved. As the technology grows day by day, we can imagine about the feature in which thing we may occupy every place. Hence the principle of the development of science is that "nothing is impossible." The projects that have been conducted have overcome some serious issue. It comes out with effective design and easy to use hoping that it will increase the quality of life. Main objective to conduct this project was achieved which is to design and build a prototype for automatic dustbin. During completing this project, we have gain a lot of knowledge about the electrical part, coding, and how to solve a problem. I repeat with the development of science and technology, "nothing is impossible".

6. RECOMMENDATION

It is a very cost effective circuits which can be produced on mass level and also very simple so it can be imbedded on a single chip that it may be installed in every home. The circuit can be improved by including a wide range 360 sensor which can sense any object from far distance. Also the mechanical aspect can be improved so that the user does not come directly in contact with the bin. The bin should be able to move some distance forward for the user to use and afterward it should go back to its original position. This will help to keep the environment more hygienic.

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