Design and Implementation of Smart Waste Bin with Monitoring System

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Abstract— **Waste disposal are a part of our everyday life and mostly its condition are improper managed due to improper waste dumping, collection and management, which leads in foul smell and unhygienic condition, thus inherently results in pollution of the environment. Therefore, in this research, design and implementation of Smart Waste Bin with monitoring system is proposed utilizing the ongoing innovation of automation and GSM. The ultrasonic sensor in the bin persistently screens the level of the waste in the bin and communicates to the waste administration organization when the bin filled and the Ultrasonic sensor is also used to open and close the cover of the bin whenever persons are nearby the bin. Thus the research has better level of smartness compared to existing ones in metropolitan cities in a centralized manner.**

Keywords- **Microcontroller, Internet of Things (IOT), Smart Waste Bin, Solid waste management, Ultrasonic Sensor**

I. INTRODUCTION

One of the principle worries with our environment has been waste administration which impacts the wellbeing and condition of our general public. The detection, monitoring and management of wastes are one of the essential issues of the current time. The conventional method of manually checking the wastes in waste canister is a difficult process and takes more human exertion, time and cost which can easily be dodged with this current technology. This is the solution, a technique where waste management is automated. In this system, innovative ways that will help to keep the cities clean of waste and healthy.

Generation of waste is everyday by households and also by local factories, artisans and traders, as the way of life increments because of development and technological advancement. So as to oblige the developing populace and the way of life in the urban area, government and individuals has built domestic, industrial or commercial establishment to provide shelter and employment. This necessitates the need for waste bins with lids to contain unpleasant sights and odors and to minimize contamination. Efficient waste management and disposal is required to maintain safe and green environment. One major issue faced by the inhabitants of the low cost housing, market places, industries and flats is the issue of solid waste disposal, which causes pollutions, litters the environment and promotes certain diseases. Unlike commercial establishment, domestic waste disposal bins are shared among all residents which live in the same building, and thus, the bins tend to be filled very quickly. Thus, an unsystematic and inefficient disposal waste management may cause the bins to be always filled with garbage. And further littering from the residents will cause the garbage piles to be scattered outside the bins. Therefore, there will be a question of sanitary as those garbage piles may become the root cause of illness and diseases like dengue, diarrhea, and cholera.

The waste disposal can be managed more properly and efficiently by constantly monitoring the bin status and the garbage level.

This project presents an alternative in managing domestic waste especially in residential areas via a smart garbage monitoring system, which is developed based on Arduino Uno. This system will automatically monitor the garbage level at each bin and will alert the waste collation management in the case where the bins are almost full.

A. Problem Statement

Piles of trash are one of the major problems faced by most people in urban and rural areas of Nigeria. Bioenergy consult (2014), Nigeria with population exceeding 200 million, is one of the largest producers of solid waste in Africa. Despite a host of policies and regulations, solid waste management in the country is assuming alarming proportions with each passing day. Nigeria generates more than 32 million tons of solid waste annually, out of which only 20% - 30% is collected. Reckless disposal of solid waste has led to blockage of sewers and drainage networks. Improper collection and disposal of municipal wastes is leading to an environmental catastrophe.

This journal tackles the problem and presents the development of a smart garbage monitoring system in order to measure waste level in the garbage bin in real-time and to alert the appropriate authorities via SMS.

B. Aims this of the Study

The aim of this study is to design a smart waste bin that enables waste collation management to know when to come exactly to collect waste bins.

C. The Scope of the Study

The project focuses on designing a waste bin system capable of measuring the level of garbage in the bin, detecting the presence of human when they are close to enable the bin to fully open for disposal purpose and sending SMS notifications to the waste collation management, when the bin is full or almost full.

II. METHODOLOGY

The method that will be employing in the implementation of automatic control of the smart waste bin is using the top to bottom approach method. The various units that will be considered are listed below:

- A sensing unit for monitoring trash level in the bin,
- A controlling unit which acts as the brain for the control system and is responsible for doing the core work in the control of the system,
- An indicating unit which shows the level of trash and act as a visual aid to user in the trash bin,
- A switching unit that simply triggers the servo motor ON and OFF, depending on the signal received from the microcontroller to OPEN or CLOSE the bin,
- A GSM modem to send and receive SMS to/from the appropriate waste disposal body,
- A PIR sensor unit to detect the presence of coming human close to the bin for waste disposal.

III. SYSTEM DESIGN AND IMPLEMENTATION

The system design and implementation was carried out according to the system's block diagram below:

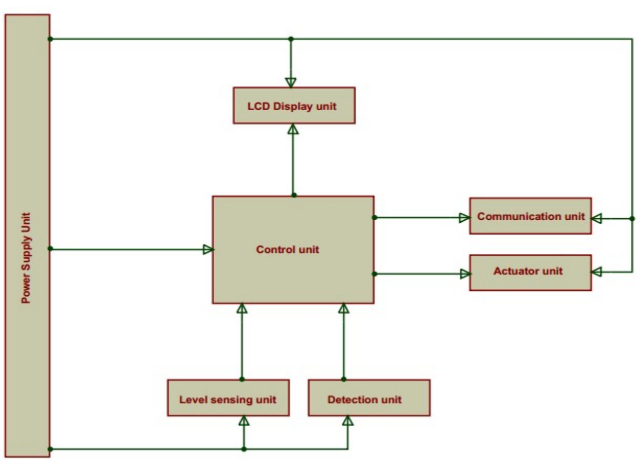


Fig. 1: Block Diagram of the system

A. *The Power Supply Unit:*

Fig 2 shows the diagram of the power supply unit which provides the desired 12 VDC and 5 VDC to run the circuit. The voltage obtained from the mains line is 220 VAC but the components require 12 VDC and 5 VDC, hence a step-down transformer is used to step the voltage down from 220 VAC to 12VAC. This 12 VAC is rectified to 12 VDC using a bridge rectifier circuit, and a filter capacitor is connected across the output of the bridge rectifier to remove ripples present in the output voltage. Then, the voltage regulator is used to supply the required voltage to the various components.

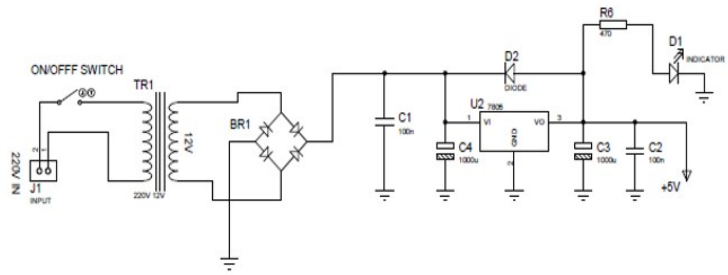


Fig. 2: Power supply circuit t

B. *Microcontroller Unit*

The control unit is the backbone of the system. It consist of a microcontroller which is responsible for monitoring and integrating the system to perform as desired, display the status on the LCD, sense the level of trash in the bin, detect the presence of human being and sends an SMS to the appropriate authority when bin is filled.

The microcontroller chosen for this project was the PIC16F887. It is an 8 bit microcontroller with low power consumption, digital input/output and in built ADC. The PIC16F887 comes in a single chip which consists of Microprocessor. 14 channel analog pins, 13 digital pins, 32KB flash memory with read-while-write capabilities, 256bytes EEPROM memory, 368 bytes RAM memory, 8K ROM memory in flash technology, 35 general purpose input/output lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 12C mode, 14-channel 10-bit Analog to Digital converter (ADC), programmable timer with internal oscillator, and 8MHz to 31KHz software selectable frequency, power saving sleep mode. It operates between voltages of 2.0V – 5.5V and operating frequency of 0 – 20MHz.

Power supply

From the manufacturer datasheet, PIC16F887 can operate at different supply voltages starting from $2.0V_{DC}$, a 5.5V dc power supply is the most suitable. As shown in figure 3.2 in the power supply circuit, a cheap integrated three terminal positive regulator LM7805 as specified in fig 3. 4, is used to provide high-quality voltage stability and quite enough current to enable the microcontroller and peripheral electronics to operate normally.

Reset signal

In order that the microcontroller can operate properly, a logic one (VCC) must be applied on the reset pin, because it enables the microcontroller to return safely to normal operating conditions if something goes wrong.

Clock signal

Even though the microcontroller has a built-in oscillator, it cannot operate without external components which stabilize its operation and determine its frequency (operating speed of the microcontroller). Depending on elements in use as well as their frequencies, the oscillator can be run in four different modes as shown below. However, the oscillator was used in the HS (High speed crystal oscillator) mode in this project.

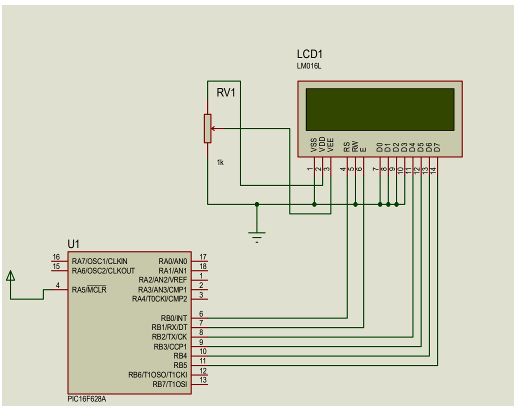


Fig. 3: PIC16F887 Microcontroller Unit

C. Level Sensing Unit

The level sensing unit is composed of an ultrasonic sensor and is used for monitoring the level of trash in the bin. The output from the ultrasonic sensor is fed into the digital input pin of the microcontroller for processing as shown in fig 4.7. Its capability to sense object within a range of 2cm – 400cm makes it quite suitable for the project.

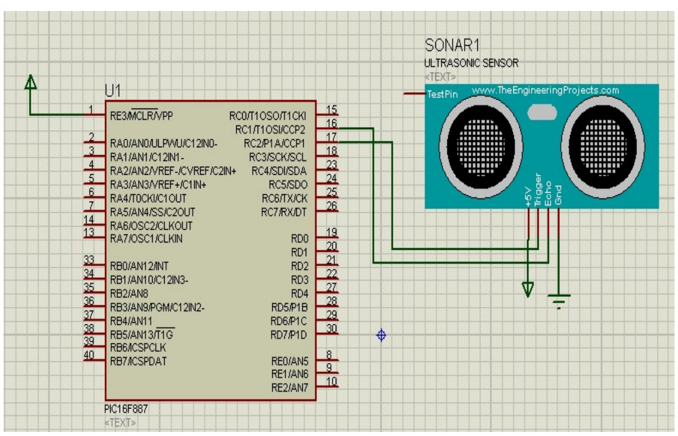


Figure 4: Level sensing circuit

D. Choice of Ultrasonic Sensor

The sensor features a stable performance, accurate distance measurement, high-density SMD and even close-range measurements. It finds uses in robotics barrier, object distance measurement, level detection, security systems, and vehicle detection/avoidance.

Table 1: Electrical specifications of the HC-SR04 ultrasonic sensor

Working Voltage	**DC 5 V**
Working Current	**15mA**
Working Frequency	**40Hz**
Max Range	**4m**
Min Range	**2cm**
MeasuringAngle	**15 degree**
Trigger Input Signal	**10uS TTL pulse**
Echo Output Signal	**Input TTL lever signal and the range in proportion**
Dimension	**45*20*15mm**

E. LCD Display Unit

The LCD display unit displays the state of the resultant phase voltage switching and digital selection of the system. It comprises of a Liquid Crystal Display unit [LCD], 16 x 4 module which is interfaced with the microcontroller used to display the selected healthiest available phase to feed the load as it is processed. This indicates the various outputs of the microcontroller in a digital form that can easily be comprehended by the observer. It displays the set point, process variable and the current status of the entire system.

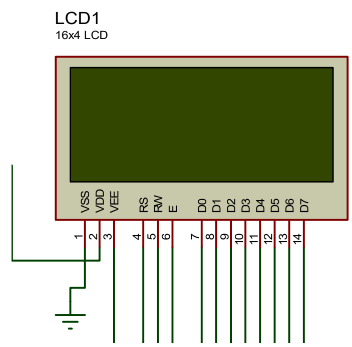


Fig: 5: Display Unit

F. Choice of Detection Unit

The detection unit is composed of a PIR sensor, which is chosen because it has a typical supply voltage of 5V – 12V, current consumption is minimum, within the range of 100uA – 1mA and has a sensitivity range of up to 20 feet (6 meter), which is used to obtain the desired range of values. The output of the PIR sensor can be easily fed into the digital input pin of the PIC microcontroller as shown in fig. 6.

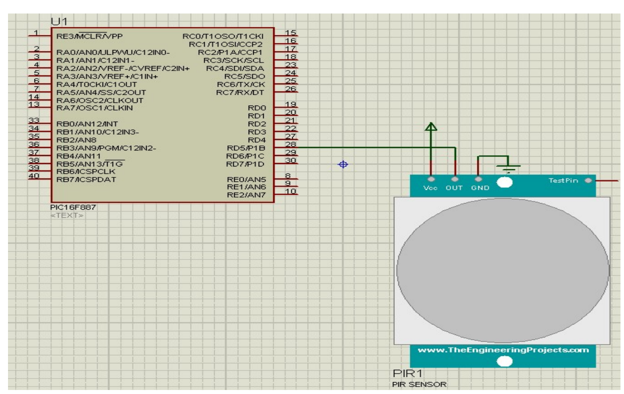


Fig.6: Detection circuit

G. Switching Unit:

Electromechanical relays are electrically operated switches that complete or interrupt a circuit by physically moving electrical contacts to make or break a circuit. Relays are extremely useful controlling a large amount of current and/or voltage with a small electrical signal. A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, a movable iron armature and one or more sets of contacts. When an electric current is passed through the coil, it generates a magnetic field that activates the armature, and the consequent movement of the movable contacts either makes or breaks the circuit depending on the circuit design and relay construction.

The electromagnetic relay will be used to serve two purposes;

i. To rotate the motor in the clockwise direction
ii. To rotate the motor in the anti-clockwise direction

The JQX-30F (T91) relay is used in this design. It has the following specifications;

Coil voltage = 12 VDC

Coil resistance = 155 ohm

Switching capability = 30 A

Power consumption = 0.9 W

The coil current is calculated from equation below.

$$I_c = \frac{V_c}{R}$$

Where Vc is the coil voltage and R is the resistance of the coil.

$$I_c = \frac{12}{155} = 0.077 \text{ A}$$

This is also the collector current of the transistor used to drive the relay.

H. Circuit Mode of Operation

Figure 3.11 is a complete circuit diagram of the smart waste bin. The system monitors the level of trash in the bin, open the bin lid automatically when it detects the presence of human in a close range and sends an SMS alert whenever the bin filled and ensures the bin remains close until it has been disposed.

The system is connected to AC mains which has a voltage of 220VAC, which was then stepped down by a step down transformer, passed through a rectifier to produce a DC voltage and then passed through the filtering circuit to remove ripples, and finally, passed to a voltage regulator to produce a constant DC voltage of 5 volts. This 5V DC is then fed to power up the LCD, Ultrasonic sensor, PIR sensor, GSM modem and to the microcontroller, while 12V is directly fed to the motor driver circuit.

LCD is connected to RB2 – RB7, GSM modem is connected to RC6 – RC7, PIR motion sensor is connected to RD5, Ultrasonic sensor is connected to RC0 – RC1 and the H-bridge motor door mechanism circuit, which is made up of complementary pair of NPN transistor is connected to RD6 – RD7 of microcontroller, consists of RL1, RL2, R1, R2, Q1 and Q2.

The system design is such a way that when power is supplied to the unit, the PIR sensor connected to RD5 sends an infrared wave around the system. When the PIR sensor sense the presence of human close to the bin, it send a command to the control unit, which triggers the ultrasonic sensor connected to RC0 and RC1 to check the level of the bin. If the bin is not filled the control system processes this signal and triggers the motor (M1) to rotate in a clockwise direction by sending a logic 0V to the H-bridge circuit through R1, which makes Q1 to conduct and after about 5secs the microcontroller sends 5V logic to the H-bridge circuit through R2 making Q2 to conduct indicating a polarity reversal to rotate the motor in an anticlockwise direction and the bin closes. If the bin is filled up and a user tries to access the bin, a visual warning will display on the liquid crystal display (LCD) informing the user that the bin is not accessible and the bin will remain lock, while an SMS alert notification will be sent to the appropriate authority for disposal of the bin via SIM 900 module connected to RC6 and RC7 of microcontroller.

Fig: 7: Waste Canister

IV. SOFTWARE IMPLEMENTATION

The program written for the microcontroller functions by executing instructions in a specified order, thus the program instructions must be organized in the desired order to avoid improper co-ordination of events during operation. The flowchart given in figure 3.10 shows the core instructions in the program and the order it will be executed by the microcontroller.

Simulation Stage

The program for the PIC16F887 was written in C language and compiled with the MikroC Pro for PIC compiler**.** After which it was simulated on Proteus 8.0 electronics work bench being programmed into the microcontroller. Proteus is a virtual system modeling and circuit simulation application and the simulations gave me an idea of how the code would function in the hardware. Proteus is an advanced workbench which contains digital input/output and components required for circuit design.

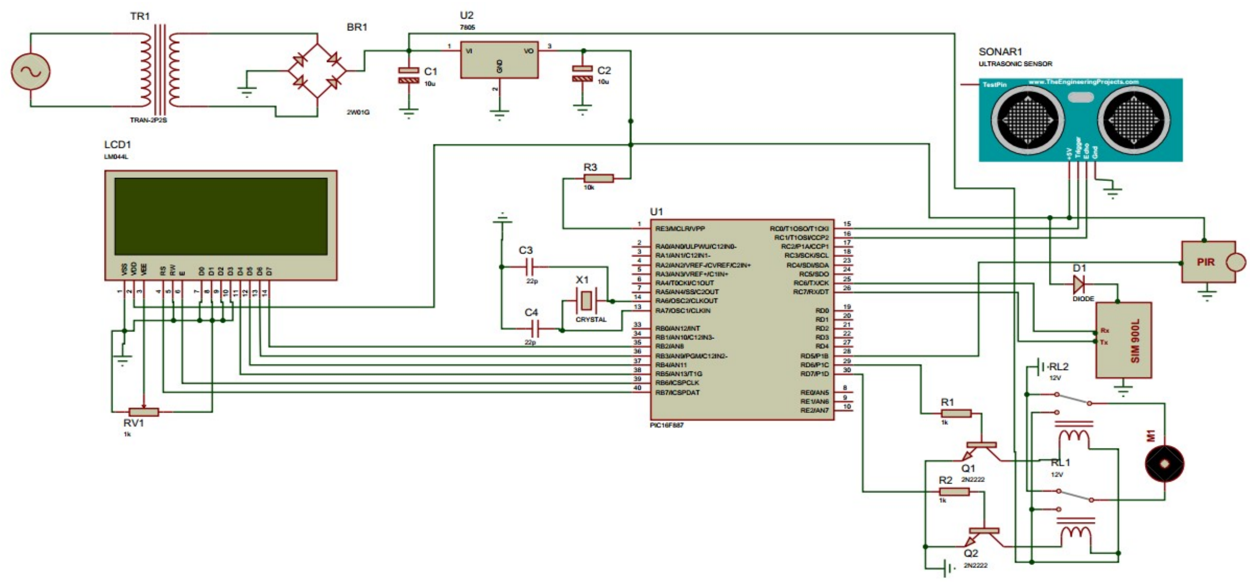
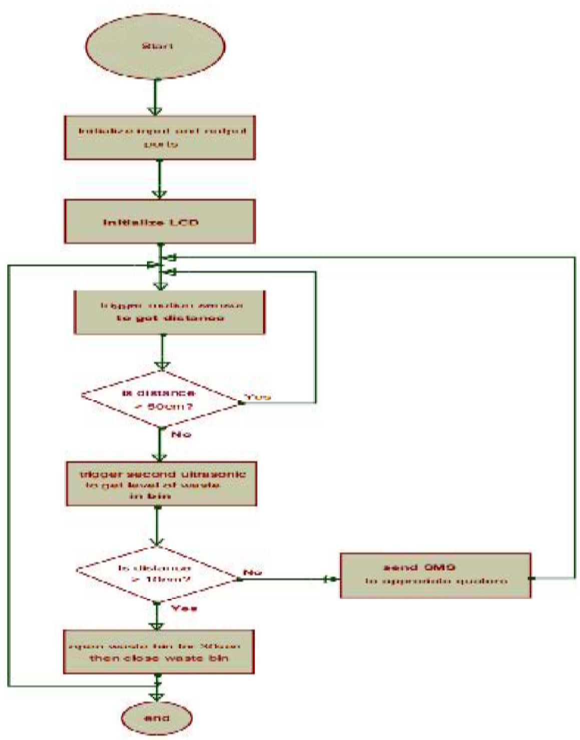


Fig: 8: Circuit diagram of Smart Waste Bin



V. RESULT

Design and implementation of smart waste bin with monitoring system was presented and discussed. Series of experiments were carried out to measure the performance of the system. The various units which make up the entire system were separately tested before they were integrated to the final system. The Experiments are conducted using plastic waste bin and paper as trash. The Ultrasonic sensor which constantly check the level of waste to determine the opening and closing of the bin was tested to open when the waste is up to set point and found to be closed when the waste is above the set point. The status of the bin is monitored via sms to the waste management agency and also the indicators indicate red when the bin is filled and green indicates less than 50% level and yellow indicate 70%

It could be observed that whenever a motion is detected near to the bin, the bin lid opens automatically and the level of the bin is detected, communicated to the waste management agency when the bin is filled.

VI. CONCLUSION

This study presents the design of a smart waste bin implemented on a PIC Microcontroller, which is responsible for monitoring and integrating the system to perform as desired, display the status on the LCD, sense the level of trash in the bin, detect the presence of human being and sends an SMS to the appropriate authority when bin is filled.

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REFERENCES

[1]. Mohan, Manju & Ramanathan, Kuppan Chetty & Sriram, Vijayram & Azeem, Mohd & Vishal, P & Pranav, G. (2019). IOT Enabled Smart Waste Bin with Real Time Monitoring for efficient waste management in Metropolitan Cities. 10.22662/IJASC.2019.1.3.013.

[2]. Prakash, Prabhu,"IoT based management system for smart cities", International Journal of Innovative Research in Science, Engineering and Technology, vol 4, Issue 2, February 2016.

[3]. Ferronato, N.; Torretta, V. Waste Mismanagement in Developing Countries: A Review of Global Issues. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1060.