Development of a Smart Bin for Garbage Level Detection

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ABSTRACT

This paper is all about waste management system automation in a smart-city system to keep humans safe from environmental pollution and reduction of waste borne diseases. This is to assist the waste management authorities in the discharge of their duties via prompt response anytime the garbage level reaches its maximum using GSM telecommunication technology as an IT tool. This is achieved by designing an interactive microcontroller-GSM based garbage management system as a medium between the user, waste bin, and the waste management authorities.

This system therefore automatically controls waste level in the bin by avoiding waste overflow using an ultrasonic sensor to monitor the threshold level of the garbage by activating the LED and sending SMS alert notifications to the concerned authority. However, the system also sends feedback to the concerned authority/person after the garbage has been cleared when queried. All information about this cost effective and resource optimization smart dustbin system can be accessed from anywhere and anytime by the concern persons/authorities accordingly to take necessary action.

(Keywords: dustbin, garbage, dumpster, IoT, sensor, smart, solid waste management, residential waste).

INTRODUCTION

With increases in population, the scenario of cleanliness with respect to garbage and solid-waste management is degrading tremendously. The overflow of garbage in public areas creates unhygienic conditions in the nearby surroundings. Therefore, Smart dustbins are a new idea of implementation which makes a normal dustbin smart using sensors for garbage level detection and sending messages to the user updating the status of the bin. Whenever garbage dustbins are filled, information can be sent to the concerned authority/person to clean and offload the dustbin. GSM is now the backbone of the communication system based on its low cost, high performance devices, and easy implementation; GSM is used in sending this alert information in real time.

Generally, we see that the concerned authorities offloading garbage placed at strategic locations have regular schedules of picking up these garbage bins or dustbins. This schedule varies as per the population of that place. It can be once in a day or twice in a day, or in some cases once, in two days. Also, during festivals or functions in some areas, lots of garbage material is generated by people in that particular location. Then the garbage bins or dustbins placed at such places may be overflowing. This creates unhygienic conditions and may expose people in that environment to possible diseases. This paper however implemented a model to avoid such situations using telecommunication technology.

MODEL DESIGN

The adaptive nature of Internet of Things (IoT) to home electrical appliances and other environmental sensing systems can never be over emphasized. IoT in its term is a platform for devices to communicate electronically with the world around them. It is the network of physical objects—devices, vehicles, buildings, and other

items which are embedded with electronics, software, sensors, and network connectivity, that enables objects to collect and exchange data. IoTs allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy, and economic benefit.

The design specifications of the GSM based [4] garbage management system comprises of the following components as modelled in the block diagram below (Figure 1):

- Ultrasonic sensors
- Supply Voltage: $\pm 12V, 5VDC$
- 3.4V to 4.5V.
- GSM Modem SIM 800L (GSM Module)
- 2A (Maximum Current)
- ATMEGA328P Micro Controller

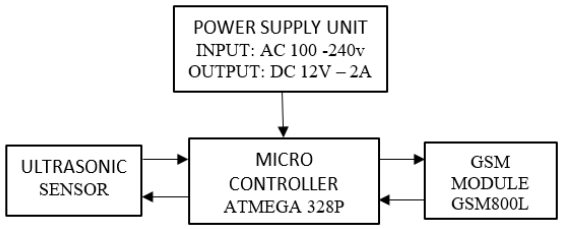

Figure 1: Model Block Diagram.

The Smart Garbage Management [6] in Smart Cities uses GSM modules as a proposed method. The level of garbage in the dustbins is detected with the aid of ultrasonic sensors system and communicated to the authoritative control room and user through GSM system. ATMEGA328P Micro Controller is used to interface the sensor system with GSM system. However, Sensors in this context are used to monitor the desired information related to the garbage for different selected locations towards effective management and disposal of garbage.

Then the output of level detector is given to microcontroller. Two sensors (level sensors detectors and Distance sensor detector) are used to indicate the different levels of the amount of the garbage collected in the dustbin which is placed in public area. When the dustbin is filled up to the highest level, Distance sensor sense the level of garbage. This output is given to microcontroller to send the message to the Control room via GSM module.

The hardware description of this models (Figure 1) are stated as follows:

A. ATMEGA328P Micro Controller

The ATMEGA328P is one of the most advanced micro controller from microchip. It is widely used for the experimental and modern application because of its low price, high quality, multiple futures which has inbuilt ADC/DAC, timer, shift registers.

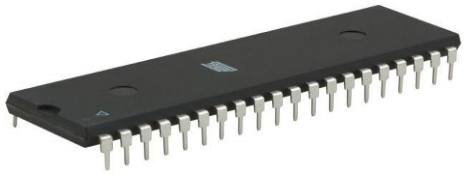

Figure 2: Micro Controller.

B. Ultrasonic Sensors

Ultrasonic distance sensors use a sound transmitter and a receiver. It creates an ultrasonic pulse, often called a "ping", and then listens for reflections (echo) of the pulse. This pulse of sound is generally created electronically using a sonar projector consisting of a signal generator, power amplifier and electroacoustic transducer/array. A beam former is usually employed to concentrate the acoustic power into a beam, which may be swept to cover the required search angles. However, the level of the garbage is measured by an Ultrasonic sensor.

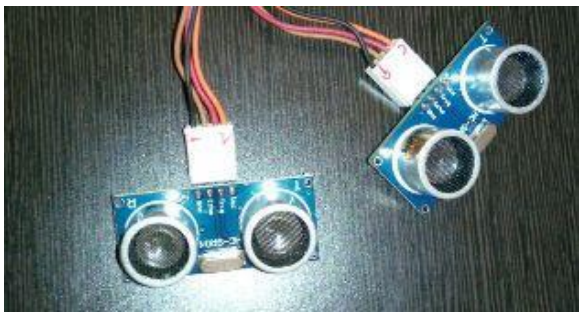

Figure 3: Ultrasonic Sensors.

To measure the distance to an object, the time from transmission of a pulse to reception is measured and converted into a range by knowing the speed of sound. This signal together with noise is then passed through various forms of signal processing, which for simple sensors may be just energy measurement. It is then presented to some form of decision device that calls the output either the required signal or noise. This decision device may be an operator with headphones or a display, or in some systems this function may be carried out by software. Further processes may be carried out to classify the target and localize it, as well as measuring its velocity. Some ultrasonic sensors have multiple beams to provide all round cover while others only cover a narrow arc, although the beam may be rotated, relatively slowly, by mechanical scanning.

C. GSM Module

The GSM module is used in this system for communication purposes for send and receiving messages by using sim card. SIM800L is a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls. Low cost and small footprint and quad band frequency support make this module perfect solution for any project that require long range connectivity. After connecting power module boots up, searches for cellular network and login automatically. On board LED displays connection state (no network coverage - fast blinking, logged in - slow blinking). NOTICE: it handles huge power consumption with peek up to 2A. Maximum voltage on UART in this module is 2.8V as higher voltage will kill the module.

This module has two antennas included. The first is made of wire (which solders directly to NET pin on PCB) - very useful in narrow places. The second - PCB antenna - with double sided tape and attached pigtail cable with IPX connector. This one has better performance and allows putting your module inside a metal case - as long the antenna is outside (Figure 4).

Specifications

Supply voltage: 3.8V - 4.2V
Recommended supply voltage: 4V
Power consumption:
Sleep mode < 2.0mA
Idle mode < 7.0mA
GSM transmission (avg): 350 mA
GSM transmission (peek): 2000mA
Module size: 25 x 23 mm
Interface: UART (max. 2.8V) and AT commands
SIM card socket: microSIM (bottom side)
Supported frequencies: Quad Band (850/950/1800/1900 MHz)
Antenna connector: IPX
Status signaling: LED
Working temperature range: -40 do + 85 ° C
Set includes:
SIM800L module
Goldpin headers
Wire antenna
PCB antenna with pigtail and IPX connector
Module pinout
Pinout (bottom side - left):
RING (not marked on PBC, first from top, square) - LOW state while receiving call
DTR - sleep mode. Default in HIGH state (module in sleep mode, serial communication disabled). After setting it in LOW the module will wake up.
MICP, MICN - microphone (P + / N -)
SPKP, SPKN - speaker (P + / N -)
Pinout (bottom side - right):

NET - antenna
VCC - supply voltage
RESET - reset
RXD - serial communication
TXD - serial communication
GND – ground

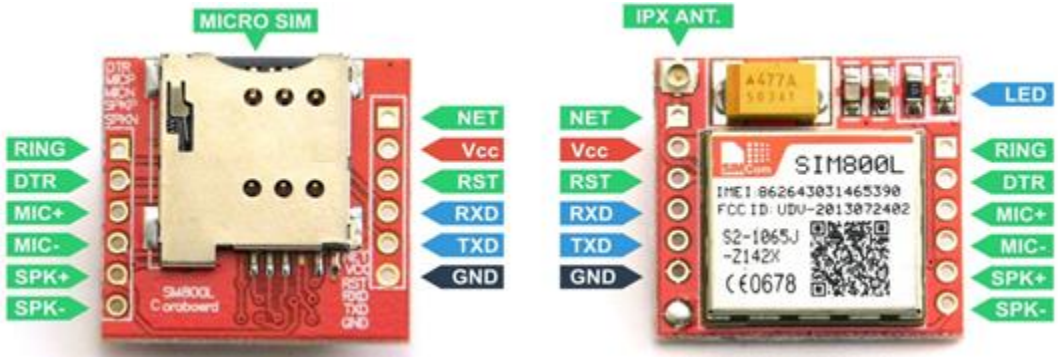

Figure 4: Micro Controller.

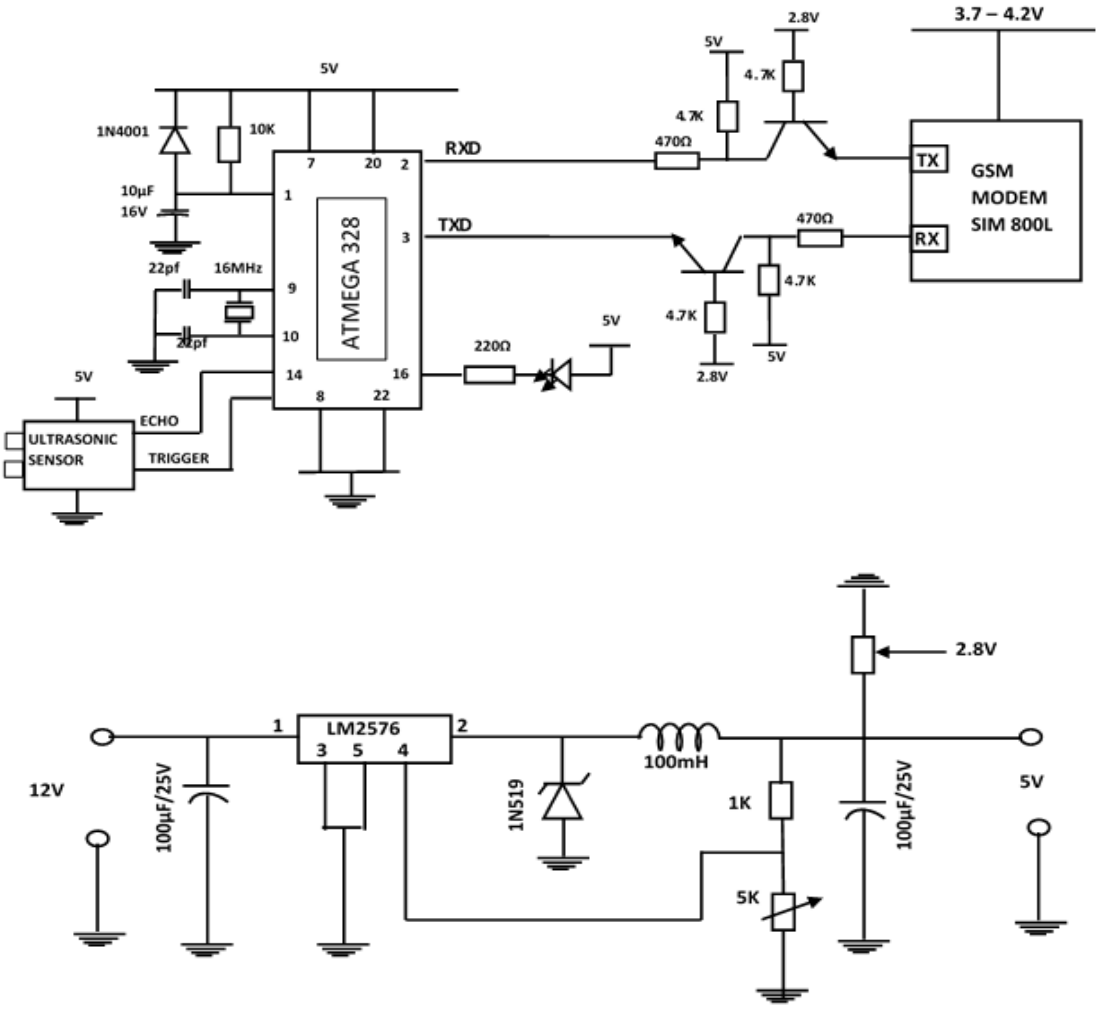

Figure 5: Circuit Diagram of an Intelligent Waste Bin and the Power Supply Section.

SOFTWARE LINKEAGE

This SMS based design is implemented using SIM800L developmental kits. Programs were written
using Arduine Software (IDE) for the sketches in the text editor and are saved with the file extension .ino. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor. Arduino Language is used for programming in Arduino IDE using sets of C/C++ functions that can be called from the code and then is passed directly to a C/C++ compiler (aver-g++).

SYSTEM DESIGN AND IMPLEMENTATION

The model design is divided into two modules - detection of garbage level by Ultrasonic sensor (Figure 6) and the second module is the information transfer using GSM module. However, the model is an SMS based project using SIM800L development. The circuit diagram for the system design and implementation is shown below (Figure 5).

For description of the circuit modules (Figure 7), an AC adapter with input AC 100-240v and output DC 12v with 2A of current are used to supply power to the circuit. But capacitors are used for filtering purposes. The 7805 voltage regulator are used to provide constant +5 voltage supply to the system. Meanwhile the heat sink

supports the regulator for cooling purpose. The ultrasonic sensor is then connected to the dustbin to sense the garbage level in the dustbins. This sensor (ultrasonic sensor) comprises of two (2) terminals which works on property of sound and frequency. These two sensor terminals used are echo and trigger, respectively.

Figure 6: Sensor Installation.

Figure 7: Components and Circuit Connection.

Echo transmits the waves and these reflected waves and are captured by the trigger. The captured signals by the trigger is sent to the micro controller which (micro controller) sense the signal then takes immediate action accordingly. The atmega 328p AVR family micro-controller is used in this system with an inbuilt ADC/DAC, timer, and shift registers.

The 16MHz crystal oscillator is provided to the micro controller for the internal operation with SIM 800L GSM modules for the communication purposes. This works on a frequency of 850/900/1800/1900 MHz; which is high frequency as compare to the other GSM module.

Figure 8: Smart Dustbin

RESULTS AND DISCUSSION

Once the threshold level is reached it will immediately send a message to the authorized person for efficient waste disposal. Also, when the waste is thrown into the bin, the system can be queried and immediately send message that the dustbin has started collecting wastes. This is performed using GSM module [1] which sends SMS message accordingly.

Each garbage can will be allocated with the mobile number such that the message will be sent to the authorized person via GSM. Once the threshold level is reached it will immediately and automatically send message to the authorized person that the garbage level is overloaded (Figure 9).

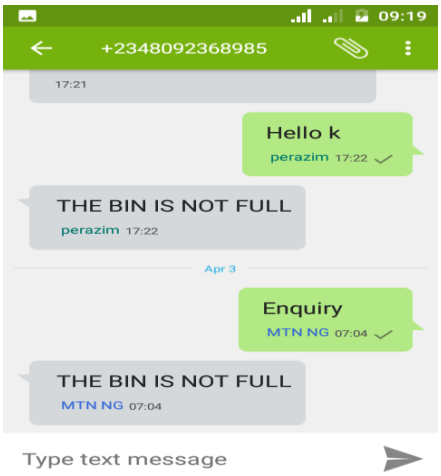

Figure 9: GSM Query Response via SMS.

CONCLUSION

While the thought originates for Smart Cities, there is a requirement for Smart Waste Management Systems using Smart Dustbin for smart buildings, hospitals, and bus stations. This paper has shown the implementation of smart garbage management system using ultrasonic sensors, microcontroller, and GSM module. This system assures the cleaning of dustbins as soon as the garbage level reaches its maximum. If the dustbin is not cleaned in specific time, then the record is sent to the higher authority who can take appropriate action against the concerned contractor, agencies, or concerned individual [5].

In this system the smart dustbins (which is an improvement of normal dustbin by elevating it to be smart using sensors and logics) information status can be accessed from anywhere and anytime by the concern person and he/she can take a decision accordingly.

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SUGGESTED CITATION

Shoewu, O.O., O.J. Ayangbekun, and K.O. Odo. 2020. “Development of a Smart Bin for Garbage Level Detection”. *Pacific Journal of Science and Technology*. 21(2):53-58.

Pacific Journal of Science and Technology