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A DTMF and RFID Controlled Multi-Compartment Automated Vehicle

Niveditha Muniraj *, Kavya Manohar *, Mahalashmi Patchamuthu*, Kiruba Muniraj *, Mrs. Chitra Varadhan **

**(Student, Department of ECE, Misrimal Navajee Munoth Jain Engineering College, Thoraipakkam, Chennai, Tamil Nadu, India-600097)*

***(Assistant Professor, Department of ECE, Misrimal Navajee Munoth Jain Engineering College, Thoraipakkam, Chennai, Tamil Nadu, India-600097)*

ABSTRACT

In this paper the proposed system comprises two-part, an automated vehicle transporting two to four materials in different compartments of a container for time saving and transferring the materials to their respective places. This prototype is working by supplying 9V. Arduino is communicating with Arduino IDE platform interfaces with DTMF and RFID. Initially DTMF decoder, ultrasonic sensor, motor driver and servo motor are interface with Arduino mega is functioning the vehicle for carrying container and transportation, and secondly the RFID reader, servo motor and load amplifier are interface with Arduino Uno for the precise distribution of the specific materials by recognizing the tags wirelessly placed at the destination. In expansion, LDR is used to detect the surface of the vehicle's arrival. The benefits of this proposed system are reliability, time saving, energy efficiency, affordability, user friendly and also being able to be used in human restriction zones. This system is highly suitable for wireless and robotics applications such as mining, commercial, logistics.

Keywords- automated vehicle, DTMF, precise distribution, obstacle evasion, RFID.

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I. INTRODUCTION

Transportation and distribution of materials is one of the major factors that plays a vital role in industries. But during transportation, energy and time consuming is more by reason of transporting one material in a vehicle at one time. Even though a vehicle carries two to three materials in separate compartments of a container at the same time, in some cases, a random fault may occur while transferring the materials. In order to get better of these downside, this paper comprises two sections namely Dual-Tone Multi-frequency (DTMF) combined with obstacle evasion controlling robotic vehicle is utilized for transportation which container carrying two to four materials in partitioned compartments, and Radio Frequency identification (RFID) technology is support for accurate distribution of each material from their respective compartment of a container. Here, the vehicle carrying container contains two diverse compartments, having limestone and iron ore to the delivering place which needed these two materials.

Dual-Tone Multi-frequency(DTMF) is a touch-tone device utilized in telecommunication technology and this DTMF technology is based on frequency signaling rather than pulse signaling. As the name implies, DTMF is a combination of two contrast frequencies for a tone signal generation from each key. DTMF is a 4x4 keypad matrix. Using this technology, the robotic vehicle has been wirelessly controlled with a mobile phone [1]- [2]. Extending from Home appliances to limited workplaces, like military area, hazardous zone and industries. DTMF incorporates a wide range of scopes and applications. In the case of home, this DTMF technology is used in some of the home appliances like room cleaner, fan, etc., these devices operated according to instructions by keypad, along with this, ultrasonic sensors are used for obstacle identification [4] - [5].

For farming applications instead of humans, a movement of armed robots for climbing the tree is controlled by DTMF [6]. In the field of restricted areas, the robot is installed with DTMF technology and some sensors, like temperature, fire and ultrasonic sensors are used to detect any hazardous events for precaution, rescuing and identification of suspicious metals [7]- [8]. Generally, applications of DTMF technology show that it can reduce manual work as much as possible.

Radio Frequency identification (RFID) is short-range and low-power wireless communication

which is a part of Automatic Identification and Data Capture (AIDC) technology. RFID systems consist of two important components: transponder (tag) and transceiver (interrogator or reader). RFID systems have different types. Each type of RFID system has some individual characteristics, like the size, environment, range, frequency, data and power requirement. The RFID reader antenna produces the electromagnetic field energy received by the RFID tag antenna and the microchip, which stores the data information, is sending the data signal back to the interrogator and then sending the information to data of Unique identifier to the Arduino Uno for examine [9]- [11]. RFID technology is used for security and data storing purposes. One of the security applications is that the house is installed with an RFID reader placed at the entrance of the house, controlled with Arduino UNO. The door will open only when the correct password is entered and the RFID tag is authorized. Without those two, the entry is unauthorized [12]. Based on this survey, a passive RFID tag is used for this prototype.

II. METHODOLOGY

2.1 DTMF Driving Robot

In this paper, the activity of robotic vehicle command from a farther place through a cell phone is done by support of both DTMF and cellular communication technology. User phone (TX) from a remote region directs the key-value commands to the receiver phone. DTMF analog signal from receiver phone is send to the MT880 decoder module through a 3.5mm audio connector, which decode and transmit the digital output (Q1, Q2, Q3 and Q4) of BCD to the Arduino mega for processing conjointly sends signals to the servo motors, or to the motor driver.

An ultrasonic sensor utilizing ultrasonic sound waves used for distance measurement. It consists of two parts, specifically trigger and echo. The calculation method to measure the distance(D) between sensor and object is shown is equation (1).

$$\boldsymbol{D = (0.025s \times 343)/2} \qquad \textbf{(1)}$$

In this prototype, the ultrasonic sensor is utilized as obstacle detection and evasion. Ultrasonic sensor continuously evaluates the distance of the robot vehicle and echoes the returning surface. When there is no object at that point, the vehicle follows the keypad instruction and the work process is done appropriately with the support of Arduino mega. On the off chance that there is an object or obstacle, then the Arduino transmits the signal to the motor driver to move the DC motors of the robot vehicle away from the object.

Two DC motors (D1 and D2) attached to the motor driver follow a dual-channel H-bridge circuit technique for moving the vehicle in a given direction using direction control pins (IN1, IN2, IN3 and IN4) connected to Arduino Mega. Here servo motors use two MG996R servo motors (S1 and S2) for lifting and down the container and two SG90 mini servo motors (S3 and S4) for turning two ultrasonic sensors front and back simultaneously. Figure 1 explains the block diagram of transportation section. The flow chart of transportation section is shown in figure 2.

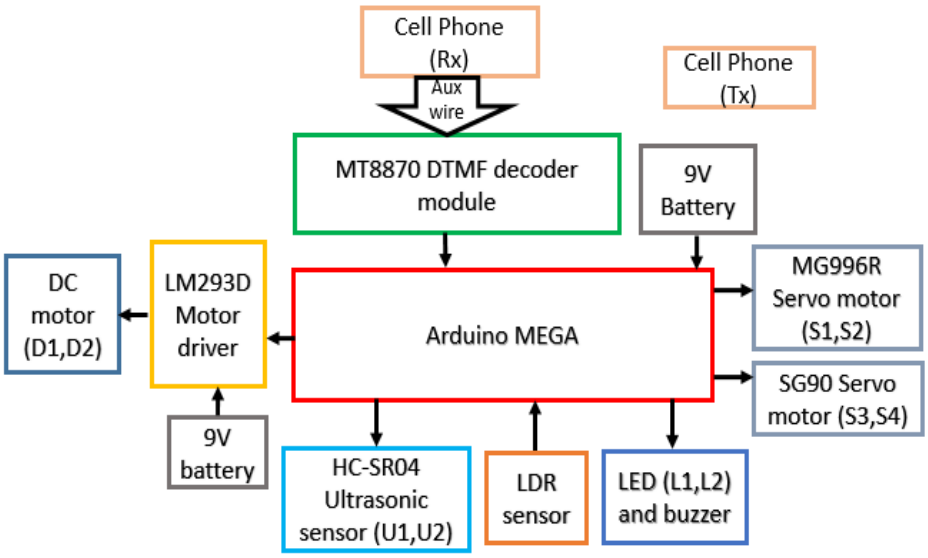


Figure 1: Block Diagram of Transportation Section

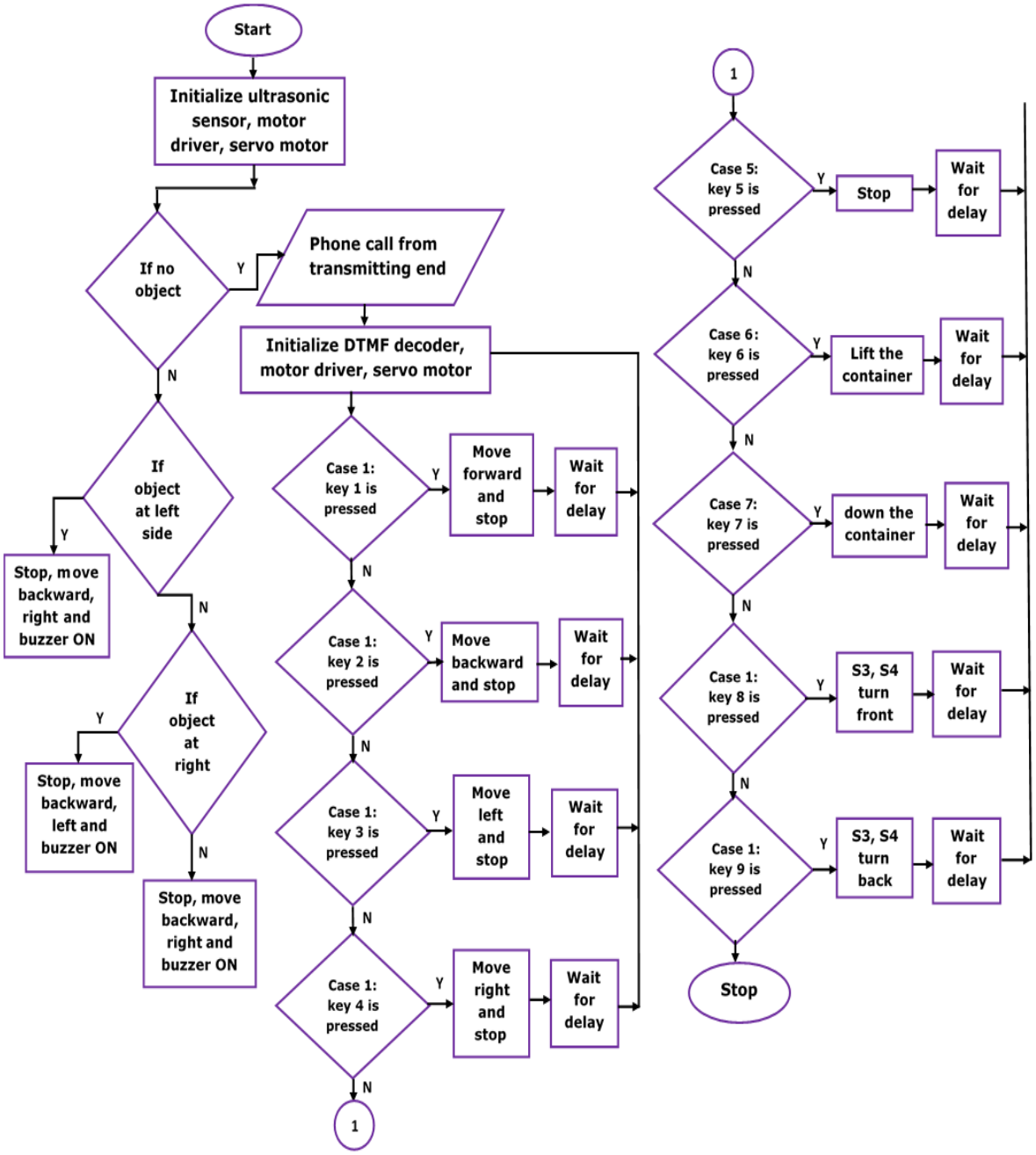


Figure 2: Flow Chart of Transportation Section

Rehash this method until they reach the delivery place of the materials in industries. At the delivering place, press key 5 S3 and S4 turn the two ultrasonic sensors back side simultaneously to avoid obstacle detection and press key 8 to lift the container using S1 and S2 servo motors.

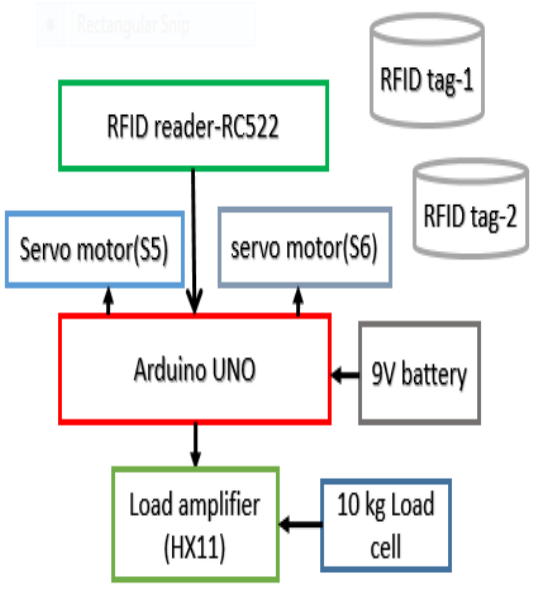
To spot the intensity of brightness or dullness in the vehicle's surroundings and indicator light, glow in darkness with the support of Light Dependent Resistor (LDR) and Light Emitting Diode. The LDR sensor and two LEDs (L1 and L2) which utilized 10kΩ and two 200Ω resistors (R) in series connection. The intensity of luminance can be calculated by equation (2).

Intensity of luminance ∞ 1/R **(2)**

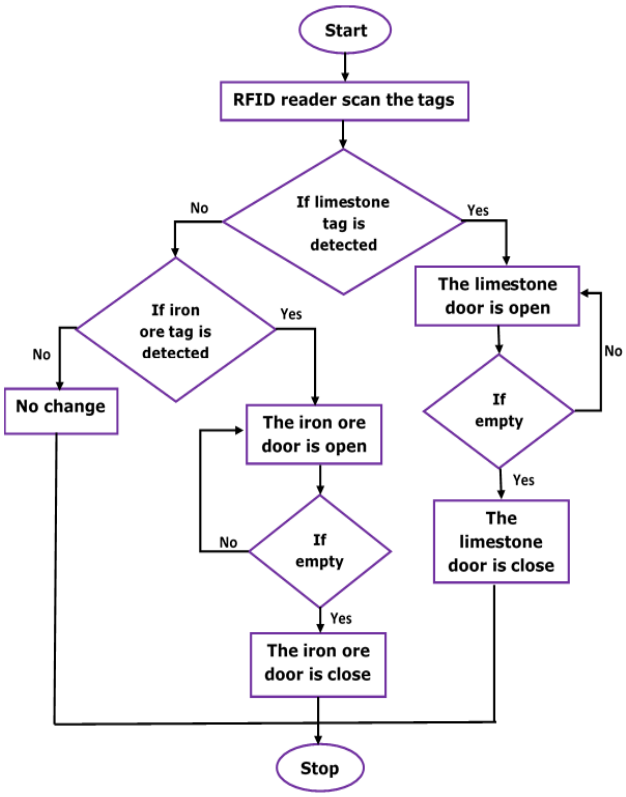
LDR is connected to the Arduino Mega analog input pin and two LEDs are attached with Arduino Mega (Pulse-width modulation) PWM digital output pins (2-13 and 44-46) because these pins are capable of modifying the glowing nature of LEDs. When a high intensity of light is observed by LDR, the LED indicator is OFF. LED indicator glow's light varying with PWM according to the darkness intensity of light detected by LDR.

2.2 RFID for Material Transfer

In this prototype, Arduino Uno is connected with the MFRC522 RFID reader, two servo motors and Load amplifier HX11 for processing the signal sent by these components. The block diagram (a) & flow chart (b) for distribution section is depicted in figure 3. Here, the RFID reader module assists SPI to interact with Arduino Uno. Now bring the RFID reader near to the limestone or iron ore delivering place where the tag is fixed. In case the tag data is coordinated with any one of the data collection signals from the RFID reader, then it sends data information to the Arduino Uno. Arduino sends the signal to a particular servo motor SG90 which is matched with a tag and turns the shaft to open the door of that specific compartment only and transferring the material to the delivering place, the weight being reduced from the container is measured with the help of a load cell and it is joined with the load amplifier HX11. An analog to digital convertor of HX11 load amplifier is connected to Arduino Uno which send the information load cell of measured container weight to Arduino as digital output and send the information to servo motor when attain value peruses from load amplifier which implies that the particular compartment of a container completed the transferring. The servo motor now rotates the shaft to close the compartment door. If the tag sense by the RFID reader is not matched, then the compartment doors are not opened because of the access denied. The block diagram (a) & flow chart (b) for distribution section is depicted in figure 3.



(a)

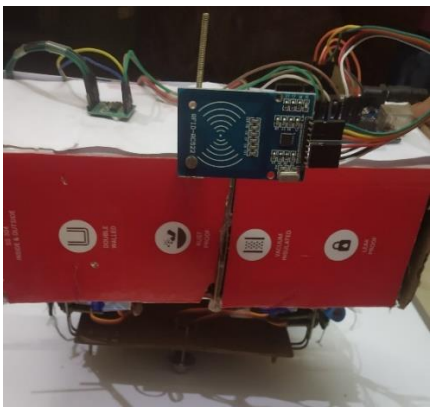


(b)

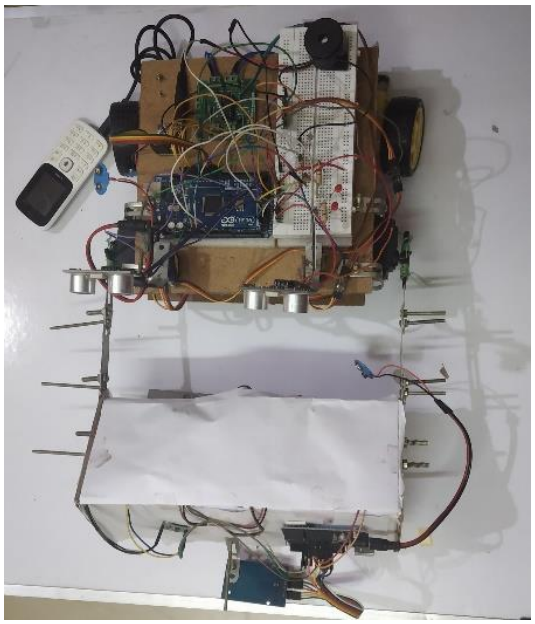
Figure 3: (a) Block Diagram & (b) Flow Chart for Distribution Section

III. RESULT AND DISCUSSION

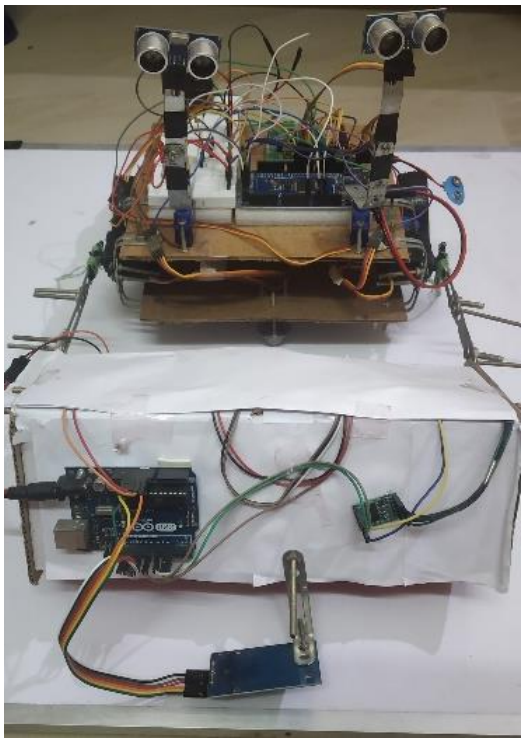
The result of this paper is mainly to concentrate on the time conservation while transportation, by carrying two to four materials on a single vehicle and precise distribution of these materials from that respective compartment of container. The (a), (b) and (c) of figure 4 shows the prototype model of multi-compartment automated vehicle is shown in different angle.



(a)



(b)



(c)

Figure 4: The Prototype of Multi-Compartment Automated Vehicle

DTMF sends the information over long distances. DTMF will travel through the distance, depending on the service provider. The DTMF decoder receives signal tones from the sender phone precisely only when there is an adequate power is supplied in the transmitter as well as the receiver. The power supply battery 9V is connected to Arduino Uno and mega which has operating voltage 5V and 3.3V. This is due to the voltage regulator output. The device of various components is connected to the 5V of Arduino except RFID, which is connected to 3.3V of Arduino. If the operating voltage increases, the operating speed also increases. This is shown in equation (3).

Operating voltage(V) ∞ Operating speed(s) (3)

SG90 mini servo motor and MG996R servo motor operating speed is 0.15s/60° and 0.17s/60°. The DC motor is measured in rpm and its operating speed is 200 rpm.

In ultrasonic sensors, the actual time taken to sense the distance is 0.15s, but in this paper, the time duration to identify the distance is 1s for getting better results and also data conserving. The sensing range is varying from 2 to 400 cm distance and its operating frequency is 40kHz. The height of the prototype is 30 cm, so based on the prototype, two ultrasonic sensors distance value is fixed as 40cm to detect the distance for obstacle avoidance and buzzer makes sound for 2s. The table 1 shows the vehicle movement with operating speed of motor driver and table 2 shows servo motor operating speed and rotation are observed and tabulated.

Table 1: Vehicle Movement Direction/Speed

Vehicle (D1,D2) movement	Operating speed (s) of motor driver	
	Before object detected	After object detected
Forward direction	1s	-
Backward direction	1s	1s
Turn left	1s	0.5s
Turn right	1s	0.5s
Stop	Key 1-4= 0.2s, key 5= 5s	0.2s

Table 2: Servo Motor Operating Speed and Rotation

Servo motor (S1,S2,S3,S4)		
Action	**Operating speed (s)**	**Rotation**
Lift the containers	0.25s	S1=160°, S2=20°
Down the containers	0.25s	S1=90°, S2=90°
S3, S4 rotate front side	0.5s	S3=180°, S4=0°
S3, S4 rotate back side	0.5s	S3=0°, S4=180°

For safety purposes, this prototype uses an automatic light system with the help of a photoresistor and buzzer that makes a sound when the obstacle is detected.

The outcome of luminance around the vehicle gives analog voltage of 0 to 5V is converted to digital from 0-1023 with the medium of ADC in Arduino built-in function. The modification of two LED luminance is done by the built-in function of Arduino Mega specific pins using PWM ranges from 0 to 255 and its frequency is 490Hz. Figure 5 compares the LED luminance and LDR intensity of light.

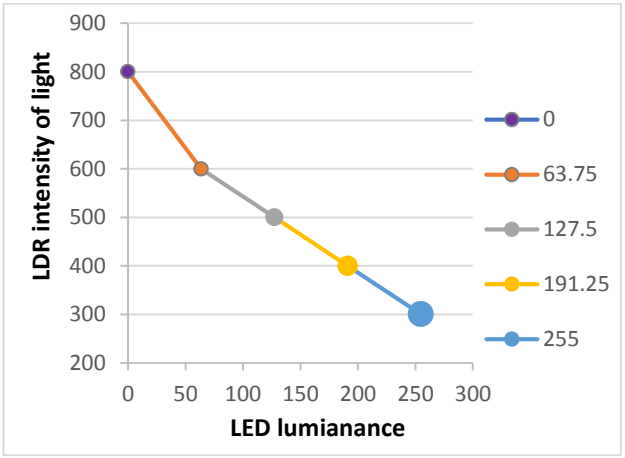


Figure 5: Comparison of LED Luminance vs LDR Intensity of Light

The main purpose of using the RFID system in this prototype is secure, accurate confirmation of tags at 5cm distance wirelessly by the RFID reader and transferring of material from their respective compartment of a container. Memory rate of the mfrc522 is the 10Mbps and RFID tag or ID is 1Kbps and its frequency is 13.56MHz. Passive tag is encased with PVC lamination for protection from severe environments and doesn't require any external or internal power. Each RFID tag has a unique serial number, so that RFID reader can identify the tag without any complication. Table 3 represents the operating speed and shaft rotation of servo motor.

Table 3: Representation of Operating Speed and Shaft Rotation

		Container is full				Container is empty			
		Limestone compartment (S5)		Iron ore compartment (S6)		Limestone compartment (S5)		Iron ore compartment (S6)	
		Rotation & speed	Door	Rotation & speed	Door	Rotation & speed	Door	Rotation & speed	Door
RFID Tag	Limestone tag-1 is detected (33 BF 72 3D)	180° & 0.45s	Open	0°	Close	0° & 0.45s	Close	0°	Close
	Iron ore tag-2 is detected (39 8E E3 C2)	0°	Close	180° & 0.45s	Open	0°	Close	0° & 0.45s	Close
	Other tag is detected	0°	Close	0°	Close	0°	Close	0°	Close

IV. CONCLUSION

In this communication, the overall merits of this model are time saving, reliability, energy conservation, inexpensive, user friendly conjointly being able to be used in human restriction zones. The 9V voltage power provided to the system is converted into 5V and system speed is processed as

per applied voltage of 5V. Arduino is an open-source electronic device communicating with Arduino IDE platform, that is programed in C++ language which interfaces with DTMF and RFID. User phone (TX) from remote regions transmit commands to the receiver phone. Initially DTMF decoder is decoding the received signal from TX, ultrasonic sensor is able to identify objects at distance of 40cm for obstacle avoidance, motor driver is for directing the DC motors and servo motor for carrying the container are interfaced with Arduino mega all together functioning the vehicle. Secondly the RFID reader, servo motor (S5 & S6) and HX11 load amplifier interface with Arduino Uno for the precise distribution of each material from the compartment of a container((S5 or S6)=180°) by sensing the tags wireless at delivery places and after distribution is measured by the load cell attached to HX11, then compartment door is closed((S5 & S6)=0°). Here, the serial number of RFID tags is able to change in the program according to the materials carried for distribution without any complication. A photo resistor for sensing the surrounding luminance of the vehicle's arrival and LED indicator glowing with the assist of PWM, has varying range-from 50 to 250 according to the surrounding darkness. This prototype is highly relevant for wireless and robotics applications including mining, commercial and logistics. This prototype is successfully designed and implemented practically.

Acknowledgements

Ms. Niveditha Muniraj is a student, Bachelor degree in Department of Electronics and Communication Engineering, Misrimal Navajee Munoth Jain Engineering College, Thoraipakkam, Chennai, Tamil Nadu, India, Affiliated to Anna university. Her area of interest includes Embedded Systems, RFID communication, Internet of things (IoT) and Robotics.

Ms. Kavya Manohar is a student, Bachelor degree in Department of Electronics and Communication Engineering, Misrimal Navajee Munoth Jain Engineering College, Thoraipakkam, Chennai, Tamil Nadu, India, Affiliated to Anna university. Her area of interest includes Embedded Systems and Wireless communication.

Ms. Mahalakshmi Patchamuthu is a student, Bachelor degree in Department of Electronics and Communication Engineering, Misrimal Navajee Munoth Jain Engineering College, Thoraipakkam, Chennai, Tamil Nadu, India, Affiliated to Anna university. Her area of interest includes Embedded Systems, Wireless communication and Robotics.

Ms. Kiruba Muniraj is a student, Bachelor degree in Department of Electronics and Communication Engineering, Misrimal Navajee Munoth Jain Engineering College, Thoraipakkam, Chennai, Tamil Nadu, India, Affiliated to Anna university. Her area of interest includes Embedded Systems, Internet of Things (IoT) and Signals & systems.

Mrs. Chitra Varadhan, received Bachelor degree in Electronics and Communication Engineering from Regional Engineering College (NIT- affiliated with Bharathidhasan University) Trichy in 1996 and completed Master of Engineering in College of Engineering, Anna University, Guindy, Chennai in 2008. Currently, she is working as Assistant Professor in Misrimal Navajee Munoth Jain Engineering College, Chennai, Tamil Nadu, India. Her area of specialisation includes Antenna, RF and Microwave Engineering and Embedded System.

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