



# DESIGN AND DEVELOPMENT OF SMART SCHOOL BUS MONITORING SYSTEM

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**Abstract**— Despite of the hard work and research performed by agencies, organizations, safety bus manufacturers, unfortunately the number of death cases of kids and students left in the bus is still increasing. So there is an urgent need to develop a new system with the use of technological advancement to safe guard our future generation. This paper proposes smart school bus monitoring system with fully automated features that alerts the bus driver in an efficient way by overcoming the limitations of the existing systems. Two ultrasonic sensors placed in bus door are used to sense the entry and exit of students through the bus door and it is sent to microcontroller. There are three levels of alarm set in the system to make it robust. When the vehicle engine is made off, microcontroller compares the number of students entered and exit and if mismatch is detected the microcontroller sends commands to activate all alarms in the system to alert the driver and people surrounding the bus area. The system also performs the function of sending SMS to school management and parents if immediate action is not taken by the driver. To enhance the reliability of the system, there is a push button that checks the working of alarms. The system is implemented to alert the bus driver in order to ensure no children or student is left in the bus after vehicle engine is made off. The system is tested under various conditions and the results show that the smart bus monitoring system work efficiently with the reliability rate of 96%.

**Keywords**— Arduino UNO, Ultrasonic sensor, SIM900 GSM and Smart Counter

## I. INTRODUCTION

In spite of the efforts to guide the school bus drivers against children left in the bus while delivering them to school or home, the cases of

children fatality is increasing and indicating a fear to the society. This type of incidents are reported in several countries all over the world and becomes challenge to control these incidents for the governments and school management.

According to Kraemar many cases are reported about children left sleeping in school buses without attention of bus drivers. Also, he stated that 38 children die every year due to children left in hot buses and other vehicles. (Kraemer, 2011)

According to Environmental Protection Agency (EPA) and Centers for Disease Control and Prevention (CDC), figure 1 indicates children death rate for several causes and one of these causes is hyperthermia which is due to children left in hot buses.(CDC, 2015)

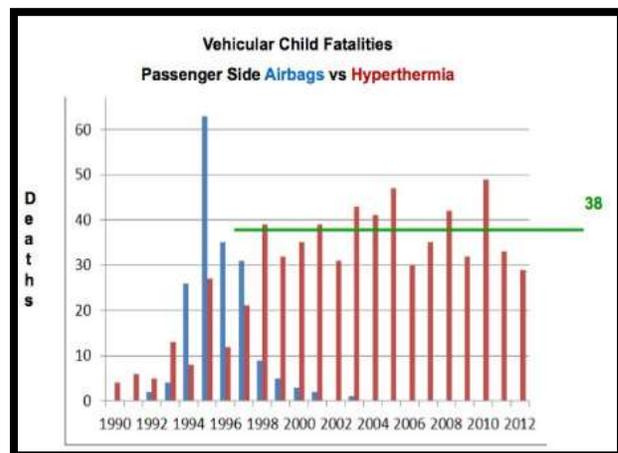


Figure I. Vehicular Child Fatalities (CDC, 2015)

Year by year, many efforts have been established to provide system for reducing such incidents of careless and forgetting children in the bus or car. The main aim of this work is to alert the driver in case of

any child is left in the locked bus. Following are some of the systems used to alert the driver in case children are left in the bus or car: ChildMinder, Toddler, Kidetect, Baby Reminder, Zonar's Electronic Vehicle Inspection Report (EVIR) system. Several limitations were identified in all the above systems in terms of interfacing with other electronic devices such as mobile and radio frequency, fault alarm sensitivity and easy to misuse and get damaged. The aim of this work is to overcome these limitations by developing an efficient system which will save children life and avoid growth of heat death yearly.

## II. RELATED WORK

There are many safety systems that have been developed for monitoring the safety of children inside the bus. The bus passenger alert system (Jerrin, Maneesha & Anju, 2015) gives alarm based on planned destinations which helps to use public transport in an easy way. It produces a voice alarm based on detection of next closest coming station. Also, the system is added with speed control feature to provide more safety during driving trip and sends signal alarm to Road Transport Control office in case if driver exceeds the speed limit.

Sleeping child check button is used in UAE due to death case of a four year old student reported in Abu Dhabi after found the student is left behind for about 6 hours in the bus. The system is very simple consisting of push button to be pressed by the bus driver after confirming no student left in bus and placing "No Passenger" sign board on left end of the rear glass. After the driver presses this button the activation of acknowledge will remain for 30 seconds where School Transport Services (STS) control room can take a note that no student is available in that particular bus. In case if the driver forgets to press the sleeping child button then alarm will be generated to STS control room to alert for action and another flash alarm will be generated on top of bus to alert the surrounding area. (Dhal, 2015)

Mekha (2016) introduced real time face identification system for identification of children during entry and exit from the bus with two webcams located in the bus. If someone forgets to exit from bus, the system sends message to the concerned

parents via GSM. Some drawbacks are observed in these systems in ensuring 100% safety of children due to lack of proper functioning of the devices, network connection and so on. So the objective of this work is to design and develop a smart bus monitoring system to overcome these drawbacks.

## III. PROPOSED SYSTEM DESIGN

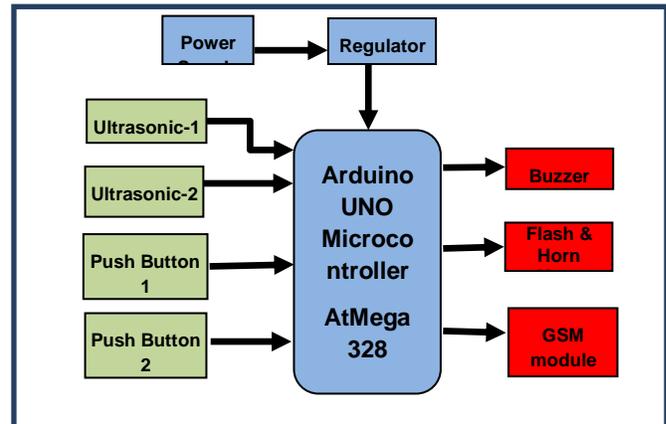


Figure 2. Block diagram of transmitter

The smart school bus monitoring system is controlled by Arduino UNO microcontroller as shown in figure 2. While system is made on, Arduino initializes the ultrasonic sensors, LCD and GSM module. After initializing process is completed, the two ultrasonic sensors start sending signals to the microcontroller. Both entry and exit counter values are displayed in the LCD till the bus engine is on.

When engine is off, the microcontroller compares number of students entered and exit. If both are equal then no alarm is generated and microcontroller sends command to LCD to display message as "No passenger in the bus". But if mismatch is found the buzzer starts activated and "Student left in the bus = XX" is displayed in LCD. If the driver does not take immediate action by pressing the acknowledge push button located in the rear side of the bus, then flash headlight of the bus and horn alarm are activated after one minute since buzzer is activated. These are used to alert the people surrounding in case the driver bypasses to reset the buzzer alarm. In case if no people surrounding the bus and no one reset the alarm, then SMS is sent to the school management and to parents. The SMS is sent after 2 minutes since buzzer alarm is activated.



The smart school bus monitoring system is controlled by Arduino UNO microcontroller built with ATmega328 microcontroller. The system consists of:

- Sensors
- Push buttons
- Microcontroller
- Alarm modules
- GSM modem

### **3.1 Sensors**

The sensor used in the project is used HC-SR04 ultrasonic sensor. It sends ultrasonic waves in the air till it detects object and shall reflect the waves from the object. It consists of transmitter and receiver, transmitter known as trigger which sends a pulse wave and receiver known as echo which receives the reflected wave. There are many applications where ultrasonic sensor is used like measuring the distance, level, diameter and presence.

Two ultrasonic sensors are used in this project to detect the entry and exit of students from bus. These are located in the bus doors. One ultrasonic is close to the edge entry and 2<sup>nd</sup> ultrasonic is located next to the 1<sup>st</sup> ultrasonic approximately 15 cm far away from 1<sup>st</sup> one. The length of the bus door is 71 cm. Hence if any object is crossing the bus door, then the distance is less than 71 cm. Based on this condition and distance the entry and exit counters are configured in the code accordingly.

### **3.2 Pushbuttons**

In this project, two push buttons are used for following purposes:

1. First push button is used to clear the alarm activated like buzzer and LED. Once it pressed it clears buzzer, LED will turn off and sets entry and exit counter to 0. This push button will be located in rear side of the bus which provides more restriction to the driver to cross all bus seats and then clear alarm.
2. Second Push button is used to check if Buzzer and LED\_Flash and Horn are functioning properly to ensure that all output are working and avoid failing to alert the driver or others. It is considered as prevent maintenance for school management.

### **3.3 Microcontroller**

Arduino UNO is the most used in Arduino family which is open source microcontroller board based on ATmega328. Basically, Arduino UNO microcontroller is fast, reliable and can be used for embedded systems as its response is faster and the code is easily programmed

### **3.4 Alarm modules**

Three different levels of alarm is used to ensure that the alert message is delivered to concerned person and system provides safety in an efficient way. The first alarm is a buzzer located in front of odometer of the bus to alert the driver, second alarm is flash light and horn of the bus which are used in case the first alarm is ignored and the third alarm is SMS to school management and parents in case the driver does not reset the first and second alarm.

### **3.5 Buzzer**

The function of the Buzzer is providing alarm alert to the driver in case if still student remaining inside the bus after turning engine off. The alarm shall be generated by microcontroller based on mismatch reading between the entry and exit counters.

### **3.6 LCD (Liquid Crystal Display)**

The LCD will be used to provide information of entry and exit bus students. Also it will provide the number of students remaining in the bus after alarm is activated.

### **3.7 LED (Light Emitting Diode)**

In this project LED is used as Flash headlight of the bus & Horn.

### **3.8 GSM Modem**

GSM modem is used to send and receive an SMS messages and calls through a SIM card associated with phone number. SIM900 GSM module modem assembled with power supply circuit, serious single-chip processor and SIM card housing package to allocated SIM card. SIM900 GSM module is used to alert the school manager or concern/responsible person in case if the bus driver bypasses the alarm and not clear it. Each bus is assigned with a unique SIM card and identified SIM number.

IV. SYSTEM IMPLEMENTATION

**4.1 Software Implementation**

The code written in Arduino IDE software detects and senses children crossing the bus door to count the entry and exit of children and to display in LCD. When the bus engine is made off, the system is programmed to perform comparison between entry and exit counters and if the comparison result is not equal to zero, then different levels of alarm are activated with in some delay. LCD, GSM and ultrasonic sensors are initialized using LiquidCrystal\_I2C.h, SoftwareSerial.h and NewPing.h respectively. The GSM module is initialized to send an SMS with command known as AT (Attention). The flowchart for the system operation is given in figure 3.

Figure 3. Bus monitoring system flow Diagram

**4.2 Hardware Implementation**

Initially, the circuit design of the system is made and simulation is carried out using Proteus professional 8.0 software to ensure proper functioning of the circuit which is shown in figure 4.

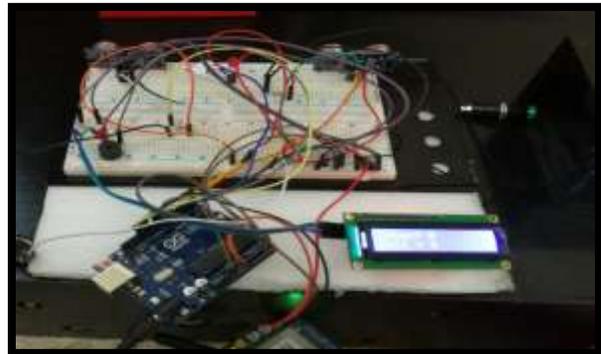
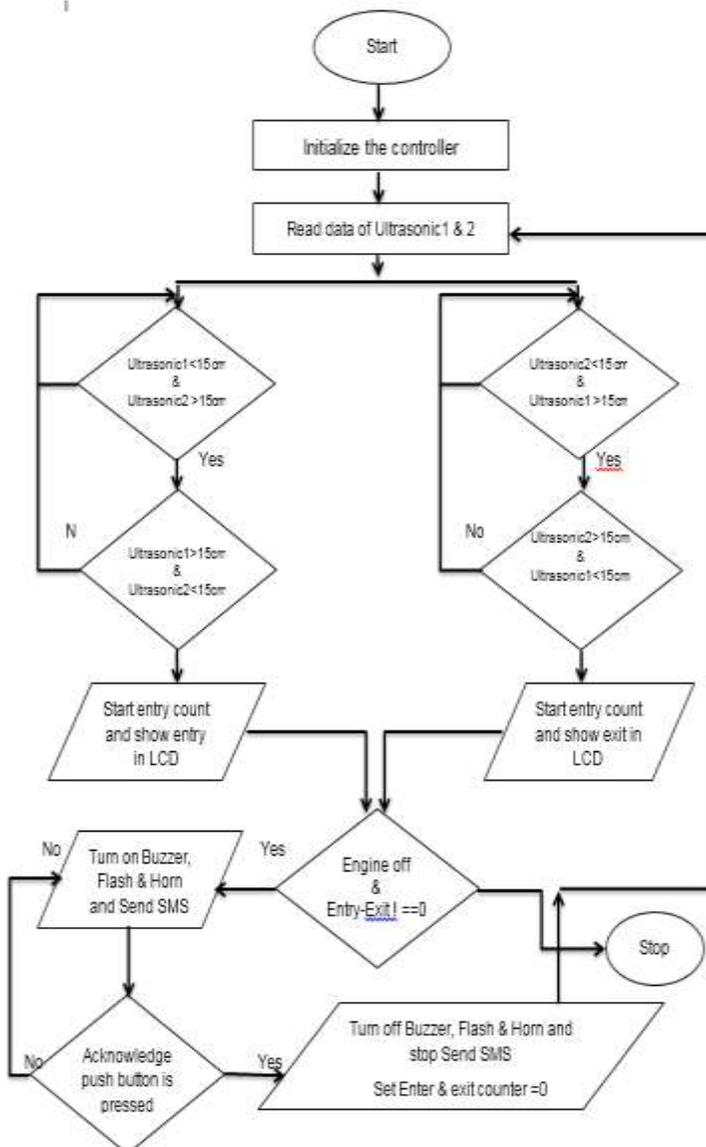


Figure 4. System design

While system is made on, Arduino initializes the ultrasonic sensors, LCD and GSM module. After initializing process is completed, the two ultrasonic sensors start sending signals to the microcontroller. The width of bus door is 71 cm if the ultrasonic sense less than 71 cm then it considers that a student has crossed the bus door. The code is made if the first ultrasonic reads less than 71 cm and then second ultrasonic reads also less than 71 cm then entry counter increases by 1 which means one student has entered the bus. However, if the second ultrasonic reads less than 71 cm and then if first ultrasonic reads less than 71 cm then accordingly the exit counter is increased by 1 which means one student has exit from the bus. Both enter and exit counter are displayed in the LCD while the driver still in the duty and picking up the students.

When engine is off, the microcontroller compares number of students entered and exit. If both are equal then no alarm is generated and microcontroller sends command to LCD to display message as “No passenger in the bus”. But if mismatch is found the buzzer starts activated and “Student left in the bus = XX” is displayed in LCD. If the driver does not take immediate action by pressing the acknowledge push button located in the rear side of the bus, then flash headlight of the bus and horn alarm are activated after one minute since buzzer is activated. These are



used to alert the people surrounding in case the driver bypasses to reset the buzzer alarm. In case if no people surrounding the bus and no one reset the alarm, then SMS is sent to the school management and to parents. The SMS is sent after 2 minutes since buzzer alarm is activated. The system is implemented with all the required components and is shown in figure 5.

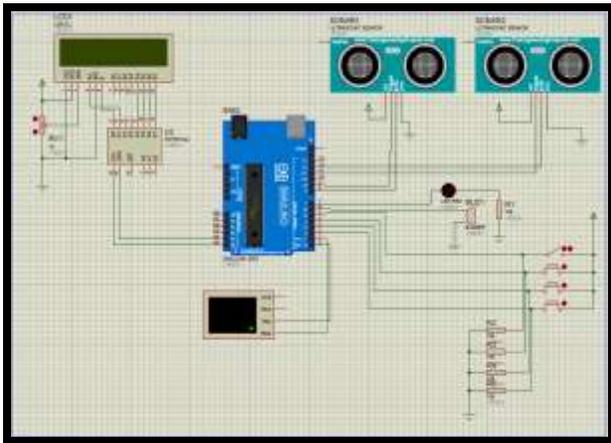


Figure 5. Implementation of Bus Monitoring System

## V. SYSTEM TESTING

When the bus engine is made off and the counter entry and exit are equal, the system remains normal with no alarm. LED, buzzer and GSM module were not activated because the Arduino UNO read the entry and exit counter as equal which is shown in figure 6. This result demonstrates that the driver picked up the students and dropped them without missing student left in the bus after duty is over.

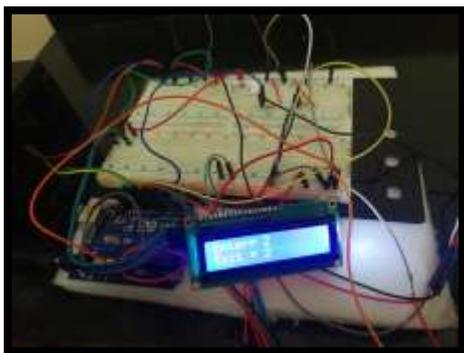


Figure 6. Display in LCD when number of students exit is equal to entered

When engine is made off and if it is found the entry and exit counters are not equal, message is displayed to the driver in LCD as “Student left in bus is 1”

which is shown in figure 7. Then the buzzer is activated first and after one minute the LED is activated and then after four minutes, warning message is sent to school management and parents as shown in figure 8. In case the reset push button is pressed in between these alarms, then the next alarm will not be generated.

This says that the driver has left the bus after the duty is over with students still left in the bus without pressing the reset push button located in the rear side of the bus to clear the alarm and perform cross checking.

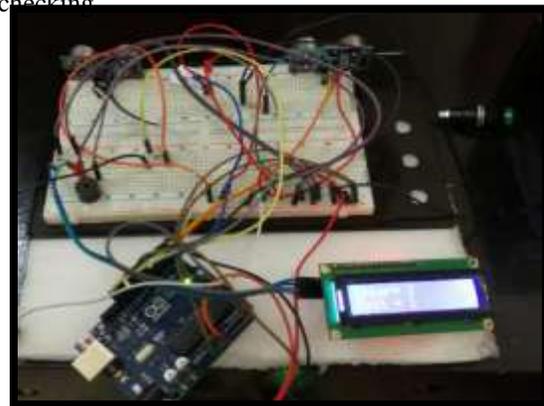


Figure 7. Display in LCD when number of students exit is not equal to entered

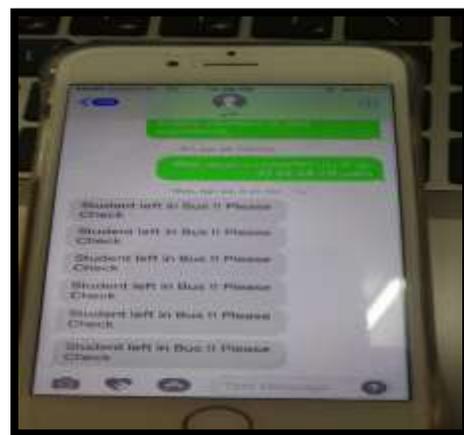


Figure 8. Receipt of SMS

## 5.1 Performance analysis

The performance of the system is analysed by testing the system several times. The hardware components are tested first to check their working. Figure 9 shows the testing applied to the hardware components in order to evaluate the system performance with total number of tests conducted and numbers of successful tests for each component. As per observation all



components have successfully passed the test except minor failure occurred in ultrasonic sensors due to the reason that can't detect very fast movement of objects.

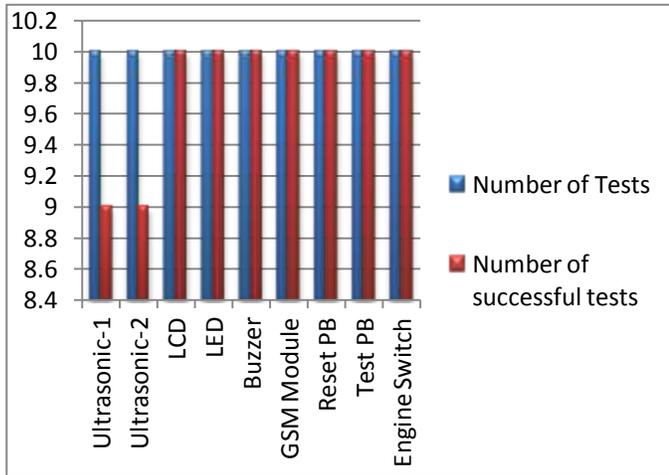


Figure 9. Testing results

### 5.2 System Reliability

The reliability of the system is measured based on the reliability of the individual components in the system. The reliability index R of the system is calculated based on the following equation.

$$R(\%) = \text{Passed tests} \times \text{Importance Weight (reference)}$$

The components are assigned with weightage based on their importance in the working of the system. Based on the test results of individual components, the reliability index of the components is calculated and is given in table 1.

Table 1. Components Reliability

Components	Passing test in %	Importance Weightage in %	R in %
Ultrasonic sensors -1 & 2	90	50	45
LCD	100	3	3
LED	100	5	5
Buzzer	100	20	20
GSM Module	100	20	20
Push button 1	100	1	1
Push button 2	100	1	1
Engine status switch	100	1	1

The over system reliability is measured in terms of reliability of individual components. The system reliability is calculated by summing the reliability of all the components given in table 1.

$$\text{System reliability} = 96\%$$

The system is with 96% reliability which can still be improved using high quality sensors with more sensitivity and by adding additional ultrasonic sensors to avoid to the failures of detection of students' entry and exit by ultrasonic sensors.

### VI. CONCLUSION

The smart school bus monitoring system is the system which helps to reduce the death cases reported over the world and helps the parents to send their kids to the schools without fear. Also, it helps the school management to reduce labor hours to perform daily checking in the bus and to save driver time after duty. The smart school bus monitoring system is very smaller in terms of size and simple as it is fully automated and very cheap. This system helps the society to avoid death occurs due to carelessness of the driver to check for students left in the bus.

The system is designed and tested based on the objectives of the project and user's requirements and to be as reliable and efficient system to alert the driver or others that student left in the bus. The results are obtained as per users requirements where buzzer, flash horn and SMS are activated in different time frames in case if no one pressed reset button after first alarm activated. After results are evaluated, the results analysis are discussed on collected data of system based on several tests carried out. The system is robust with 96% reliability which indicates that the system response is fast and users can fully depend on the system alert.

The system can be further improved in the following ways.

1. The system can be more improved and enhanced by adding two ultrasonic sensors to have more accuracy detection and increase the availability percentage in case if any sensors get failed.
2. Another enhancement could be achieved in this system is when buzzer alarm is activate the bus door should be energized to be open which add



more automated feature in case no one come to help student left in the bus even if all alarm are activated which allow student can get out from the bus and wait for the help.

3. Another recommendation is to add a GPS system to track the bus location in case if the alarm is activated.

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