# BLACK BOX SYSTEM FOR AUTOMOTIVE VEHICLES

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***Abstract:*** **Higher number of accidents takes place on daily basis in our metropolitan cities. The Black Box for automotive vehicles has functions similar to an airplane black box. With the help of black box in vehicles we can construct safe vehicles and we can help the insurance companies for investigations of vehicle crash and also it will contribute to enhance the road status particularly for decreasing death rate. Black box system helps to prevent those damages which occurs due to accidents. This paper represents a prototype of Black Box System for automotive vehicles that can be installed into vehicles.**

***Index Terms-*** Black box, Automotive Vehicle, Microcontroller, Sensors, Accidents.

## I. INTRODUCTION

As per the reports of the World Health Organization, more than a million people in the world die each year because of transportation-related accidents. In order to react to this situation, the black box system draws the first step to solve this problem that crosses national boundaries and threatens the safety and health of people worldwide.

Like Flight Data Recorder (FDR) in aero planes, "black box" technology can now play vital role in automotive vehicle crash investigations. A significant number of vehicles currently on the roads contain electronic systems that record information in the event of a crash. Because of that it is so important to have recorders that objectively track what goes on in vehicles before, during and after a crash as a complement to the subjective input that is taken usually from victims, eye witnesses and police reports.

We can get those information by two ways, firstly how to present the data recorded to the user in a simplified way and secondly how to detect and record data from vehicles. We can apply first approach by using .NET program. For implementation of second method, we must require some sorts of sensors and some major components. In order to know what sorts of sensors should be installed into the automotive vehicle, research was carried out to identify the main information needed for better accident analysis. The following data were found to be the most important ones needed after an accident: Belt status, Road condition, Brake status, Speed Measurement, Position of the accident, Main Lights status.

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## II. TYPES OF SENSORS

1. Water Sensor: The water sensor module used is very sensitive to water level, and its sensitivity can be increased by turning the potentiometer. This module consists of two uncovered and unconnected wires equidistant of each other, as seen in the figure 1. When this sensor detects water, the two wires will be connected through water conductivity, and the status of the sensor will be on. The module is implemented inside the black box, whereas the sensors are placed in the front of the vehicle behind the front wheels to detect the first change in the road status.

Figure 1:- Water sensor

2. Speed Sensor: An inductive proximity sensor HYP-18RL8P is used to detect the number of wheel turns per unit of time. This sensor can be used for the detection of all good electrical conductors. It has a sensing distance of maximum 8 mm, and Current Voltage 12 – 24VDC. If this sensor detect any sorts of metal then its output voltage and input voltage will be same. However, when there is no detection, the output will be zero volts. Because of the 14VDC of its output, a voltage divider was placed between the sensor's output and the microcontroller's input pin to decrease the voltage to 5VDC. Finally In order to detect the speed in the PIC Basic Pro, the 'COUNT' command was used.

Figure 2:- Speed sensor

3. Belt sensor: One push button is used to detect the place of the seat belt during the drive. The seat belt of the driver is only taken into consideration in this paper, but can be extended to include all the belts of the vehicle, depending on the traffic regulations of each country. The push button is placed on the seatbelt and gives a logic 'zero' when the belt is used and a logic 'one' when the belt is not placed by the driver.

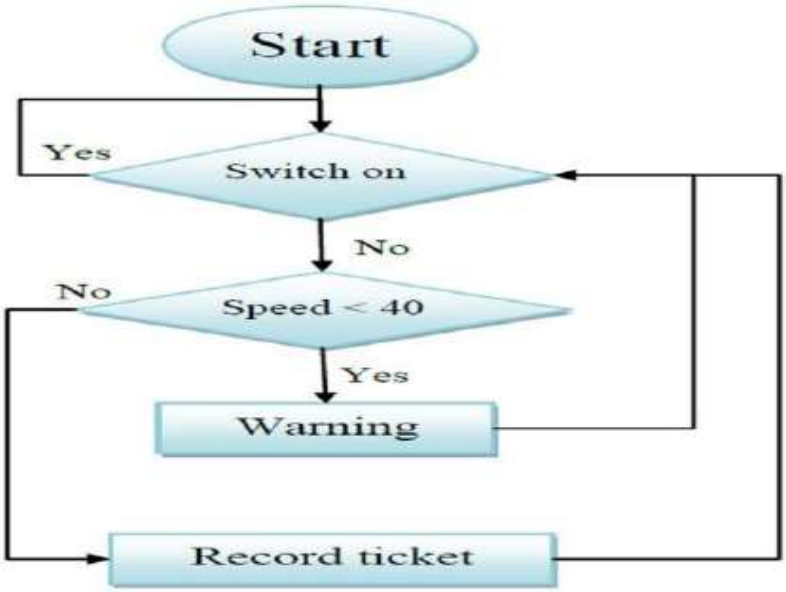


Figure 3:- Belt sensor

4. Brake sensor: The brake sensor is a type of switch implemented in the vehicle underneath the brake footstep. This switch controls the brake lights. In order to know if the driver pushed the brake during the accident, this switch is connected to the input of the microcontroller. However, the brake sensor has an output of 14V. So it needs a voltage divider in order to have 5V at the input of the brake switch pin of the microcontroller.

5. Light sensor: This sensor consists of a small magnetic switch, connected to the input of the microcontroller, and a bobbin wire all around it. This wire is in series with the light connection of the vehicle. Whenever the light is "ON", a current will pass in the wire, creating a magnetic field. This magnetic field will cause the switch to close. Thus the microcontroller will detect 5V in case of the flashers, and 0V in case of the other lights. However, an additional circuit was connected between the sensor's output and the microcontroller's input pin for the flashers sensors. This circuit converts an ON/OFF period to an ON period. This circuit is added so the sensor's status will be ON for the total duration when the flasher is turned ON.

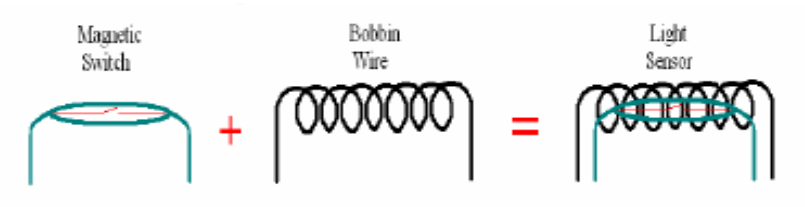


Figure 4:- Light sensors

6. Accident sensor: The purpose is to detect only accidents that hit the chassis of the vehicle so that only eight pushbuttons are used around the vehicle. The distribution of sensors is shown in figure 6. Accident Sensor Distribution when an accident is detected logic '0' will be applied to the corresponding input pin of the microcontroller. In other cases the input of the 8 pins connected to the accident sensors is logic '1' due to the pull up resistors connected to these pins.

7. Temperature sensor: The temperature sensor particularly LM 75 includes a delta-sigma analog to-digital converter, and a digital over temperature detector. The host can query the LM75 through its I2C interface to read temperature at any time. The open-drain over temperature output (OS) sinks current when the programmable temperature limit is exceeded. The OS output operates in either of two modes, either comparator mode or interrupt mode. The figure of temperature sensor LM 75 as shown below,

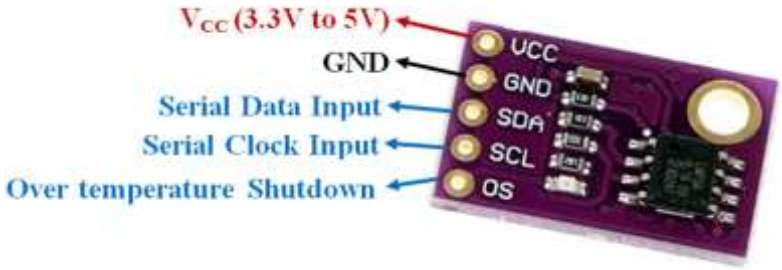


Figure 5:- Temperature sensor

8. Door sensor: we can use leaf switch as a door sensor to ensure that whether the door is closed or open. As this leaf switch is connected, it gives the logic ‘’ that means door is closed and if it gives the logic ‘0’ it means leaf switch is separated from each other and door is open.

Figure 6:- Door sensor

9. Infrared sensor: The infrared sensor is generally used to measure the minimum distance from the vehicle. Infrared sensor generate high frequency sound wave and evaluate the heat being emitted by an object and detecting motion which is received back by the sensor. Its distance sensing range is 2cm to 3cm.

Figure 7:- Infrared sensor

## III. DIGITAL PROCESS

A digital process can be used for controlling all sensors as well as their inputs. As a prototype, a microcontroller is selected to control the black box of automotive vehicles. This will allow the control circuit to be realized by a minimum of circuits. Thus resulting in less maintenance, minimization of the occupied space on a PCB, and reduced costs. For this prototype, we must require EEPROM, to enable recording as much data as possible about the accident, and a large amount of inputs. Thus, PIC16F877A was used because it has 8 K bytes of Flash Program Memory, 368 bytes of Data Memory, 256 bytes EEPROM data memory, 15 interrupts, 8 input channels, 5 I/O Ports, and many other characteristics.

**1.** Connections of micro controller:

The inputs to the microcontroller, which contain information about the accident, are distributed as follows: 8 pins for the 8 accident sensors, 8 for the lights (flashers included), 1 for the speed sensor, 1 for the belt sensor, 1 for the brake switch, 1 for the water sensor, and 1 pin for the serial switch. The outputs of the microcontroller are three pins for the LEDs, and two pins for serial

transmission and reception. The three LEDs will show the user whether the black box is recording, waiting, or transmit.

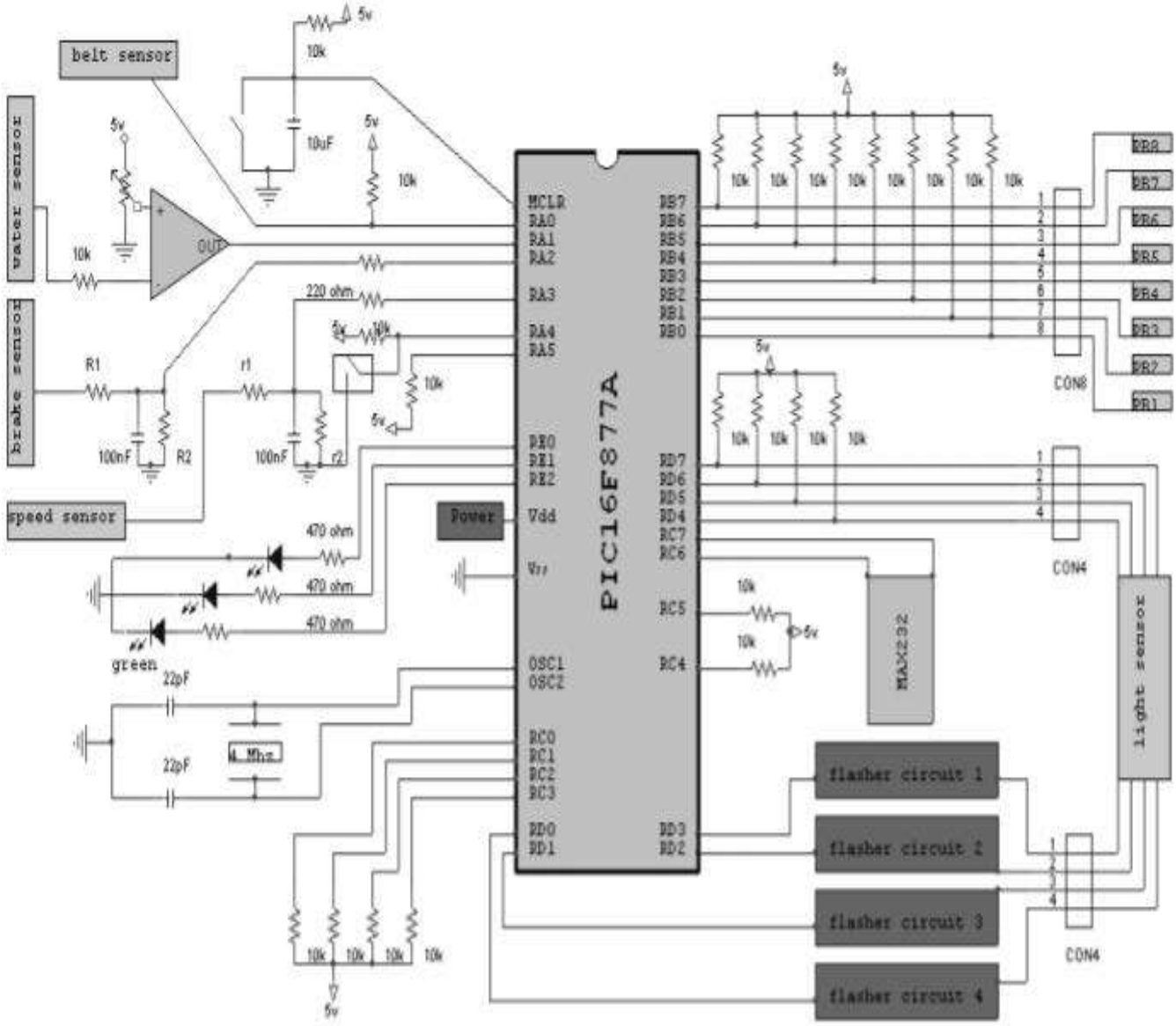


Figure 8:- Microcontroller's connection

**2.** Microcontroller's Program: The main function of the microcontroller program is to take input samples from different ports each 0.5 seconds. These samples are taken from the sensors installed in the vehicle, respectively in the following order: Pushbuttons, Miscellaneous, Speed, and Lights. After that, each sensor sample is saved into the microcontroller's EEPROM. Also the value of the current pointer is updated and saved after each block of four samples. Note that the pointer will return to 0 after saving on the 251 address of the EEPROM. So the newest sample will be saved on the oldest sample at address 0

and the process will start again. This process will keep a maximum of 63 samples saved in the EEPROM.

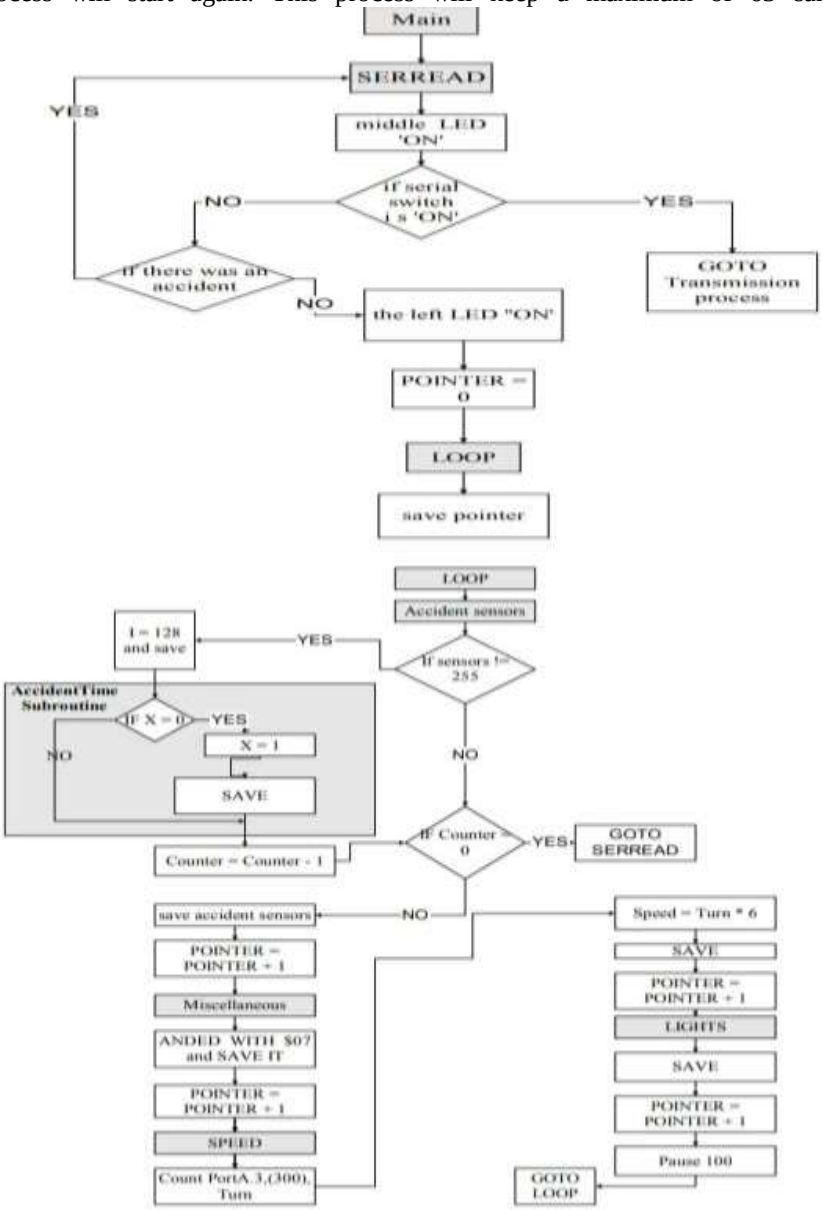


Figure 9:- Flow chart of microcontroller's program

3. Data transmission: One of the main characteristics of this system is that only the authorized people could access the true interpretation of the black box data. The choice of the microcontroller's transmission protocol was the standard asynchronous format using 8 data bits, no parity bit and one stop bit with a 9600 baud rate. Since the transmission is not as much difficult as the interpretation so that we only want those sorts of format which gives a guarantees of minimum simplicity with maximum reability. In addition, a MAX232 is used as an intermediary station, to connect the PIC to the serial port of the computer.

## IV. RESOURCES OF SOFTWARE

After covering the Black Box system's hardware part, now we can take a look at the main functions of the Visual Basic .NET program and how the user will be shown the data recorded before, during, and after the accident. The main duty of this program are to receive data serially, interpret, and finally display it to the user in a clear and simple way.

The VB.NET program consists of two functional and four graphical forms. One of the functional forms is the Main Page as shown in the figure 6. The EXIT button is used to exit the program while the SERIAL button is used for the serial reception of data. Also found on this page are the steps that the user should follow in order to have a successful transmission. Once the SERIAL button is pressed; the serial port settings will be set as the ones used for data transmission in the microcontroller, 9600 baud rate, 8 data bit, no parity, and 1 stop bit.


Figure 10:- Black box system

In order to have a reliable transmission, a handshake program was written to interface the microcontroller and the VB.NET program. The VB.Net program sends an 'A' character to the PIC before receiving every byte. Once it is received, the program will save it into its corresponding place. After the transmission is successfully completed the corresponding bytes are converted to bits and the program will move on to the second functional form, the Display Page. Figure 11 shows this page which contains 7 buttons; 4 for display purposes, 1 to open and save the report excel file, the EXIT and the BACK buttons. Each one of these buttons has its own mouse click event. So each one of them has its own program that will run once clicked on

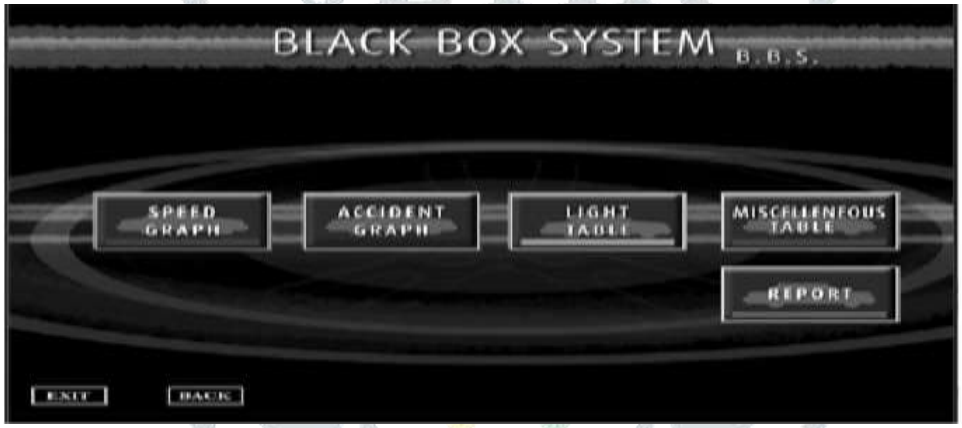


Figure 11:- VB.NET program display

In order to show how the program displays the recorded data in a clear and simple way using its 4 display forms, an accident example will be given and the result will be shown in the display forms. In all the forms, an interval of 31 seconds will be used from the oldest value recorded to the newest one.

In this example the following will be considered: The speed will vary before the accident from 20 to 70 km/h. Then it will decrease to 0km/hour after the accident. - The accident position will be next to the driver and after 3 seconds the vehicle is hitting again in its left back. - The right flashers will be on from the fifth to the tenth second. - There will be water on the road before the accident, so the water sensor will be ON during the time interval of the accident. The brake and the brake lights will be ON between 7.5 seconds and 8.5 seconds then between the 20 and 27.5 seconds. - The belt sensor will be off. The other lights unspecified during this example were off. When the user presses on the "Speed Graph" button will open.

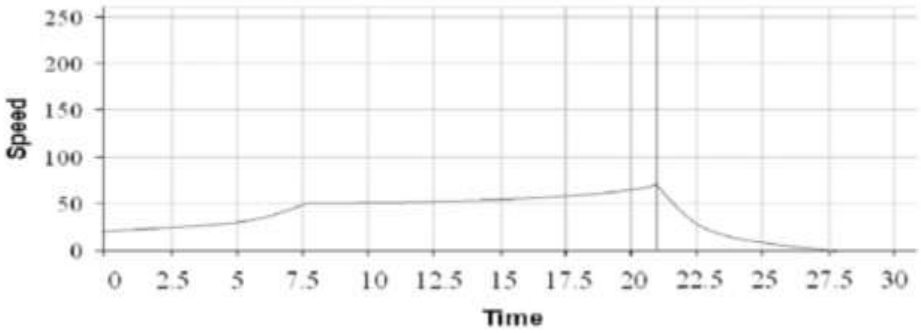


Figure 12:- Speed Graph

Figure 13 shows the "Miscellaneous Table" button when it is open. The true icon represents an ON status of the sensor while the false icon represents its OFF status. This table represents the Belt, water, and brake sensors for each 0.5 second sample saved

into the microcontroller's EEPROM.

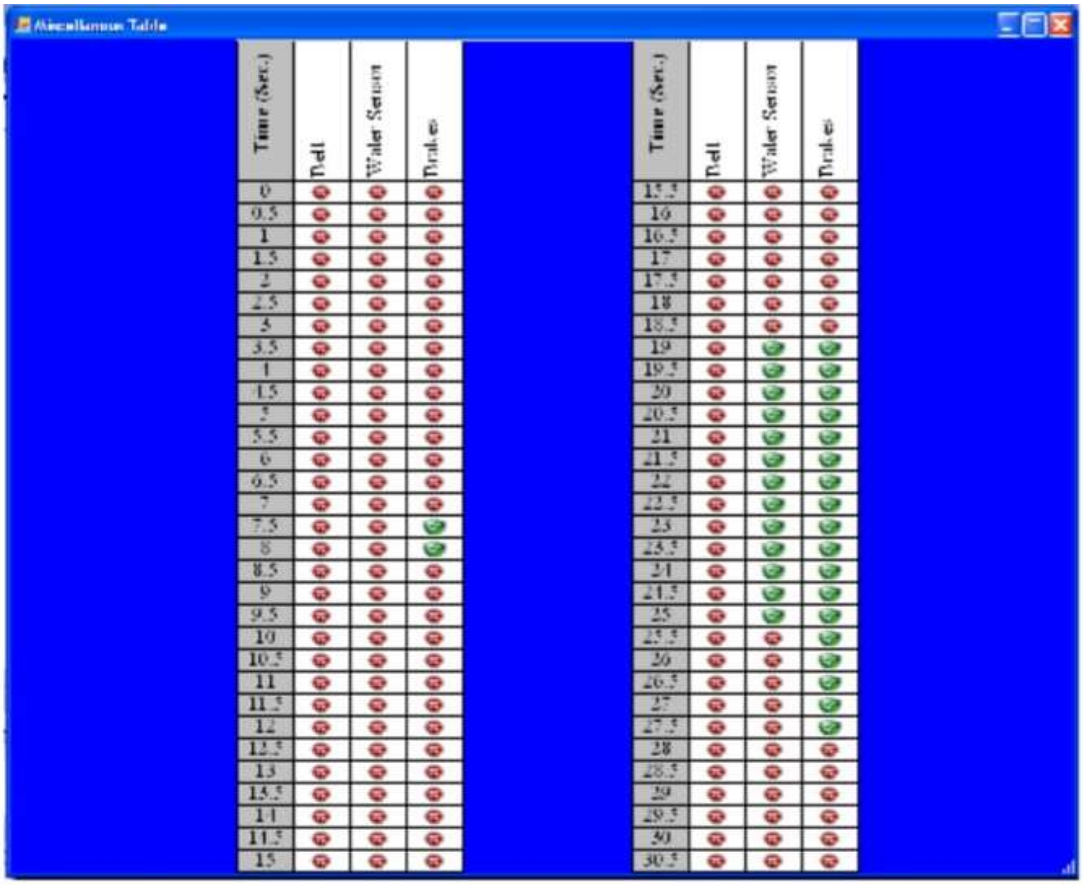


Figure 13:- Miscellaneous Table

We can use the same method for light status when the "Lights Table" Button is pressed; however this table shows 8 lights sensors as shown in the figure 14.

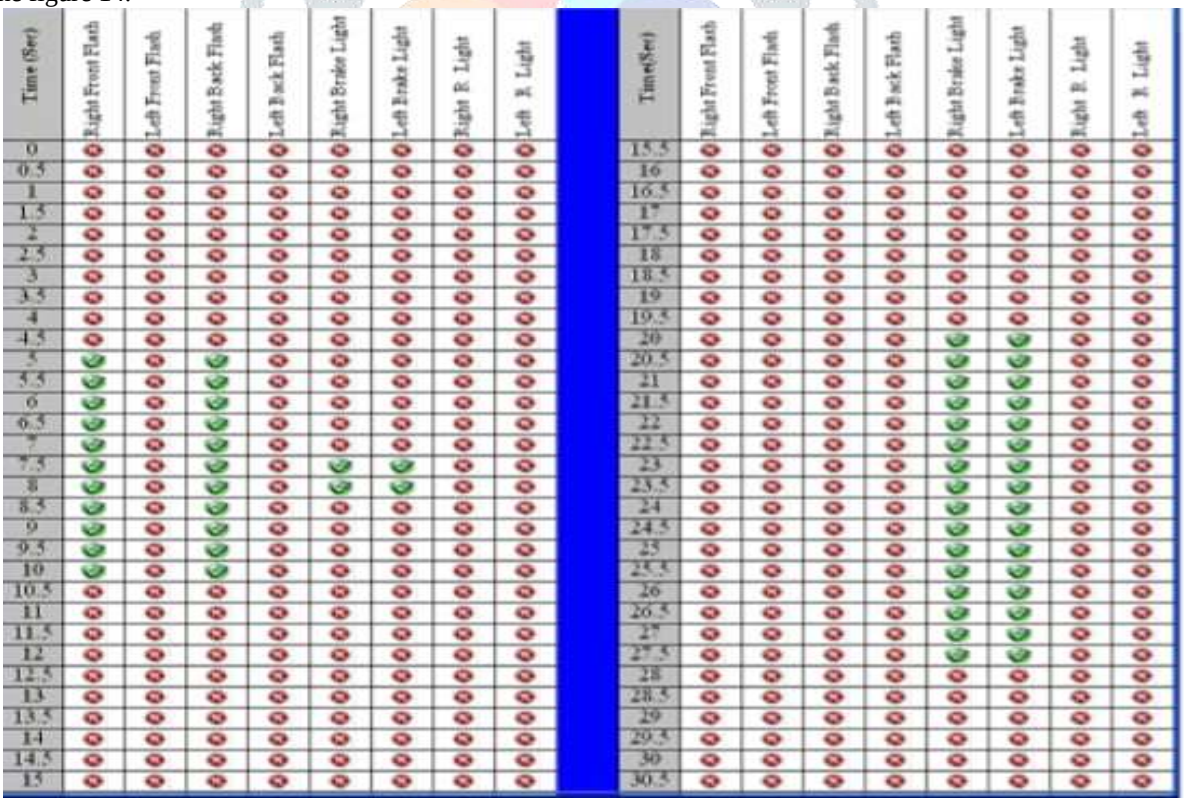


Figure 14:- Light Table

The "Accident Graph" button, when pressed will open the form shown in the figure 15. This form shows 20 vehicle samples (after the accident's samples). On each vehicle 8 icons are placed exactly where the accident sensors were installed in the vehicle. The true icon represents ON status of the sensor while the false icon will represent an OFF status of the sensor. Note that only 20 samples were shown in this form since all the accident sensors are OFF before the accident.

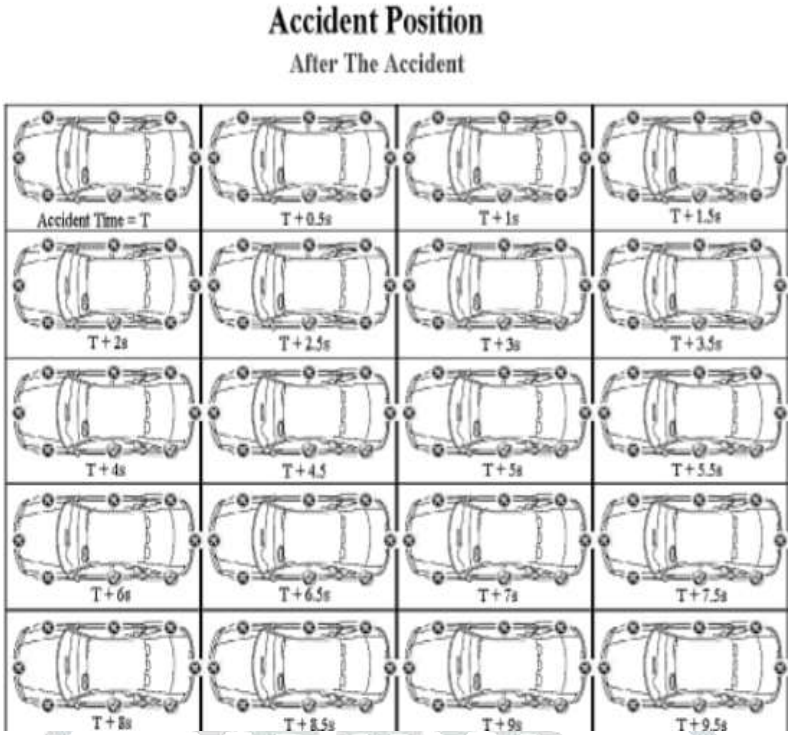


Figure 15:- Accident Graph

The only button which remains unexplained is the Report button. Once pressed, it will send to a formal EXCEL report all the data received from the black box so they can be saved and printed. Additional information should be entered in this formal report by the user. This information includes Vehicle, type Driver name, and accident information.

## IV. CONCLUSION

The Black box can play vital role in embedded system and we also gain required results as well as expected work from it. A full and detailed description was made for every part of this system. We can offer a user friendly visual basic program to analyze the data of the accident. In addition, the transmission method between the two parts has been introduced and developed. We can built The Black Box system in any automated vehicle. As soon as the driver runs the motor, this system will begin saving the events of the corresponding vehicle. The last 21 seconds are always saved in the EEPROM of the Black Box, and in case of an accident, an additional 10 seconds of events after this accident will be saved. The data saved can be retrieved only after the accident for privacy purposes. Using serial transmission, a VB.NET program will read the data from the EEPROM and display it to the user in Graphical format. The Black Box system will definitely helpful for police department and insurance companies in reconstruction of events before and after the accident. Black box system also helps in emergency medical services.

## REFERENCES

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