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Design and Implementation of Car Black Box with Collision Avoidance System using ARM

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Abstract*—This paper is proposed to develop a low cost system which provides solution to the existing automotive control issues. This system has two main principle components namely Vehicle to Vehicle Collision Avoidance Unit (VVCAU) is used to avoid crashing between vehicles and Black Box (BB) records the relevant details about a vehicle such as Engine Temperature, Distance from obstacle, Speed of vehicle, Brake status, CO_2 Content, Alcohol content, Accident Direction, trip Time and Date. The design selects ARM 7 (LPC 2148) as embedded controller, UART (Universal Asynchronous Receiver Transmitter) is the common peripheral found on microcontrollers widely used for communication with the external devices and systems, I2C (Inter-Integrated Circuit) for on-board communication, Real Time Clock, Electrically Erasable Programmable Read Only Memory and GSM module.

***Keywords*—Black Box, Collision Avoidance, UART, I2C Protocol, GSM**

I. INTRODUCTION

The vehicle accident is a major public problem in many countries, particularly India. Despite awareness campaign, this problem is still increasing due to rider's poor behaviors such as speed driving, drunk driving, riding without sufficient sleep, etc. The numbers of death and disability are very high because of late assistance to people who got the accident. These cause huge social and economic burdens to people involved. Therefore, several research group and major motorcycle manufacturers have developed safety devices to protect riders from accidental injuries. However, good safety device for vehicles is difficult to implement and very expensive [1]. On the roadway driver usually keep a safety distance from one another. On the other hand, due to the driver's interruption, long-time driving tiredness, or a sudden break applied by another car, a serious collision may occur. Even though the driver is in a conscious mind, he cannot respond immediately to control his/her vehicle. Sometimes crash may occurs due to bad weather situations as mist, vapor, fog and so on. Therefore, with the help of obstacle detection and distance measurement sensor, a front end collision warning system is developed to prevent vehicle from the collision is named as VVCAU [2]. Many cases remain pending due to unknown reason of an accident. To avoid these problems, a design is proposed to enhance on-board recording device (i.e. Black Box). Car black box is a digital electronic device, which records and store vehicle speed, real time and vehicle's other status information.

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It helps to discover and to analyze the reason of an accident easily and to settle many disputes related to car accident such as crash litigation, insurance settlements. It can be used to not only reconstruct what happened before an accident by Insurance agents and police but improve vehicle design, roadway design and emergency medical service by automakers, government and hospital. Hence a combined system is essential to provide the solution for all the above problems. The proposed system will make use of all the above mentioned modules like VVCAU, and BB at a low cost.

II. SYSTEM DESCRIPTION

The Block diagram of system hardware is shown in the figure 1.

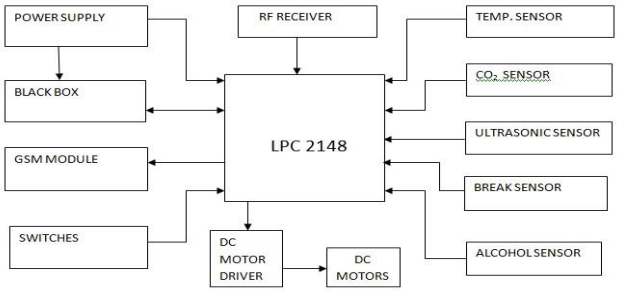

Fig -1: Design of System Hardware

In above paper heart of above system is ARM7LPC2148, Black Box, VVCAU and GSM Module. Here we have used 12V battery as Power Supply and it is step down to 3.3V for ARM7LPC2148, Black Box, VVCAU and 5V for GSM Module. This system also contains Alcohol Sensor, Brake Sensor, CO_2 Sensor, Temperature Sensor and Ultrasonic Sensor is used for pre-accident detection system. GPS module is used to send the SMS to relative person to indicate accident has been occurred.

III. HARDWARE COMPONENTS AND DESIGN

A. ARM7 TDMI PROCESSOR

The system uses ARM 7 (LPC 2148) microcontroller as a master controller.

Feature:

- 32-bit ARM7 TDMI-S microcontroller in a tiny LQFP64 package,
- 40kB of on-chip Static RAM,
- 512kB of On-chip Flash Program Memory.
- One or two 10-bit ADCs provide a total of 6/14 analog inputs, with conversion times as low as 2.44 µs per channel, Single 10-bit DAC provides variable analog output.

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- Multiple serial interfaces including two UARTs (Universal Asynchronous Receiver and Transmitter), Two Fast I2C-bus (400 Kbit/s), SPI (Serial Peripheral Interfaces) with buffering and variable data length capabilities.
- In-System Programming/In-Application Programming (ISP/IAP) via on-chip boot loader Software, Single flash sector or full chip erase in 400 ms and programming of 256 bytes in 1 ms.
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog, Low power Real-Time Clock (RTC) with independent power and 32 kHz clock input.
- On-chip integrated oscillator operates with an external crystal from 1 MHz to 25 MHz.
- CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O pads[3].

B. Temperature Sensor

Engine temperature is important in engine control unit, if this value goes to abnormal, some unwanted gases exhaust from vehicles due to improper combustion. In this project, in order to obtain the vehicle engine temperature, we have used LM35 temperature sensor. This temperature sensor continuously reads the engine temperature and fed to the microcontroller. The output of LM35 is given to pin P0.28 of LPC2148. It converts temperature value into electrical signals. Its temperature sensing range is -55 to +150°C.

C. Alcohol Sensor

In this project, MQ-3 gas sensor is used for alcohol detection. It is high sensitive to alcohol, simple drive circuit, stable and long life. If driver has drunk, then alcohol sensor sends signal to microcontroller. The output of MQ-3 is given to pin P0.29 of LPC2148 and message is displayed on LCD.

D. CO2 Sensor

In this project, MQ-7 gas sensor is used for CO_2 detection. It is high sensitive to carbon monoxide, simple drive circuit, stable and long life. If the level CO_2 from smoke emitted from car is more than the desired level, MQ-7 gas sensor sends signal to microcontroller. The output of MQ-7 is given to pin P0.30 of LPC2148 and message is displayed on LCD.

E. Brake Sensor

Here we have used small injection as engine oil pump and we have placed LDR (Light Dependent Resistor) on moving part of injection and reflector paper on stationary part of injection. If we press the injection inside the distance between LDR and reflector decreases the light reflects with full intensity. This indicates brakes are in good working condition. When we pull injection outside the distance between LDR and reflector increases and intensity of light reflection decreases. This indicates brake fail condition. This is displayed on LCD.

F. GSM Module

GSM (Global System for Mobile communications) is an open, digital cellular technology used for transmitting mobile voice and data services. GSM is a digital mobile telephone system that is widely used in Europe and other parts of the world. GSM uses a variation of Time Division Multiple Access (TDMA) and is the most widely used of the three digital wireless telephone technologies (TDMA, GSM, and CDMA). It operates at either the 900 MHz or 1,800 MHz frequency band. It supports voice calls and data transfer speeds of up to 9.6 kbit/s, together with the transmission of SMS (Short Message Service). Here we have used SIM300 GSM Module, it is a Tri-band GSM/GPRS that works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS1900 MHz. SIM300 provides GPRS multi-slot class 10/ class 8 (optional) capability and supports the GPRS coding schemes. The SIM300 is designed with power saving technique, the current consumption to as low as 2.5mA in SLEEP mode.

G. Switches

Here we have used four SPDT (single pole, double throw) Switches, one switch on each side to detect the accident direction. If anyone the switch is pressed then GSM Module sends the SMS to relative person such as ACCIDENT OCCURRED and also display the message on LCD.

H. RF Transmitter and Receiver

To send the information wirelessly from the source to the destination, ASK transmitter and receiver is used which are tuned at 433MHZ and supported with encoder and decoder HT12E and HT12D. The receiver unit receives the signal and that will be used for computation. HT12E and HT12D are the encoder and decoder CMOS ICS with working voltage range of 2.4V to 12V. This will work with the RF Links at 434MHz at either baud rate. Only one 434MHz transmitter will work within the same location. Encoder HT12E has eight address and 4 data lines. The data which is set on 4 data lines is serially transmitted when transmit enable (TE) is low. The data output appears serially on D OUT pin. The encoder circuit converts parallel signal D0, D1, D2, D3 to serial and the same is transmitted through transmitter. This receiver type is good for data rates up to 4800bps and will only work with the 434MHz transmitter. The receiver is operated at 5V. This receiver has a sensitivity of 3uV. The receiver receives serial data, and same data goes to decoder circuit converts serial signal to the parallel and can be used for controlling purpose.

I. Motor Driving Circuit

In order to control the speed of car voltage controlled method is used. The LM317 is an adjustable 3−terminal positive voltage regulator capable of supplying in excess of 1.5 A over an output voltage range of 1.2 V to 37 V is used to control output voltage. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. We have given 12V input to LM317 and we have used three BC548 transistors and three different resistors to adjust RPM of Motor. The Motor used in this project is 12V, 60 RPM (Revolutions Per Minute) Geared DC Motor.

The relation between Distance and Speed is shown below in table 1.

Distance (cm)	Speed (KM/h)
<=10	0
<=20	30
<=30	50
<=40	80
>40	100

Table 1: Distance vs. Speed

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IV. VEHICAL TO VEHICAL COLLISON AVOIDANCE UNIT

A VVCAU operates, in the following manner: an ultrasonic sensor installed at the front end of a vehicle frequently scans the highway for detecting vehicle or an obstacle. If such an obstacle is found, the system determines whether the vehicle is in imminent danger of crashing, and if so, a collision warning is given to the driver. It is constructing with help of Ultrasonic Sensors which measures the distance between the vehicles. The sensor determines distance between vehicles continuously and displays the predicted value on a display screen. Based on the distance Speed of a vehicle is controlled by varying voltage given to the motor. The system uses Max Sonar High Performance Range finder sensor for predicting distance. This sensor operates on 2.5-5.5V range. It detects objects from 0 to 2.5 meters.

V. BLACK BOX

Vehicle Black box referred as Electronic data recorder. It records main driving data such as Engine Temperature, Distance from obstacle, Speed of vehicle, Brake status, CO_2 Content, Alcohol content, Accident Direction, trip Time and Date. The recorded data will be analyzed to find out reason for the accident. EEPROM device is interfaced with microcontroller by I2C bus. I2C is "synchronous serial, Half Duplex, 2 wired bus communication protocols". I2C supports "MASTER AND SLAVE CONCEPT". It has 2 lines or bus namely SDA (Serial Data), SCL (Serial Clock). SDA is bi-directional and SCL is uni-directional. I2C supports 7 bit and 10 bit addressing format. Data is valid only when the clock is in high state. When clock is low the data is placed on the SDA line. When the clock is HIGH the data start moving in the SDA line and reaches the slave or the master depending on who is the destination. EEPROM is an electrically erasable programmable read only memory. This system uses IC AT24C16 two wire serial EEPROM. Here we have used eight AT24C16 EEPROM chips each having capacity of 16 kilo bytes. The memory organized with 128 pages of 16 bytes each, the 16K requires an 11-bit data word address for random word addressing. This device holds the memory until applying electrical erasing signal. The collected data is analyzed in PC (personal computer).

VI. RESULT AND DISCUSSION

This Black Box System Classified into two main sections. This classification can be done by the System working functionality. These two sections are

1. Vehicle section
2. Controlling section

A. Vehicle Section

The vehicle section consists of an ARM7 Micro Controller(LPC 2148), RF Receiver, and various sensors like Temperature sensor(LM35), Alcohol Sensor, Brake Sensor, CO_2 Sensor, Ultrasonic sensor, GSM modem, Black Box, Power supply and LCD. The sensors are used to record values at the time of the accident. The values are very useful in the post accident investigations. LCD is used to display all the recorded values. These values are retrieved from the Black Box. The SIM300 GSM module is used to send the message to the relative person when an accident is occurred to the vehicle.

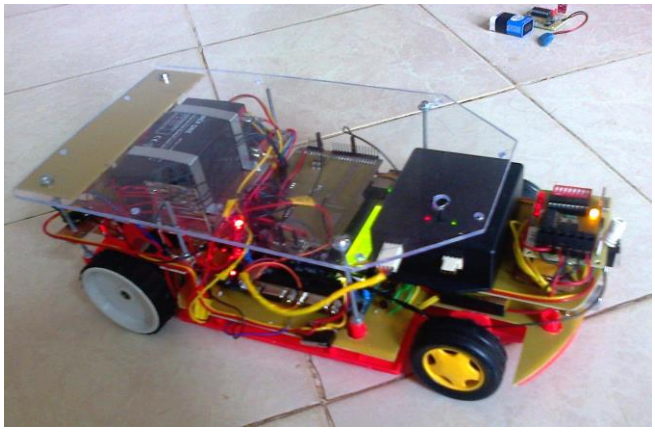

Fig -2: Vehicle section

B. Controlling Section

The controlling section consists of only RF transmitter.

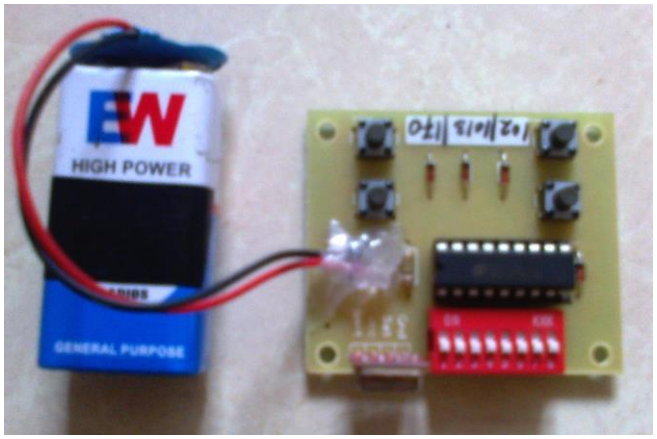

Fig -3: Controlling section

C. Experimental Results

When we give the power supply to system, it has to initialize the LCD. Then it displays the data from all the sensors For Vehicle Diagnosis. The below figures represents the outputs of all sensors.

Fig -4: Display of Distance, Brake Condition, Temperature and RPM of Motor

Fig -5: Display of CO_2 content and alcohol content

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Fig -6: Display of Time and Date

D. Retrieving Data from EEPROM:

After the accident is occurred then every details of sensors is calculated and stored in the memory. These values are very useful to know how the accident is occurred. To obtain these values or data Black Box is connected to the personal computer by using a RS232 cable and Windows HyperTerminal. The data which are recovered are shown in the below figures.

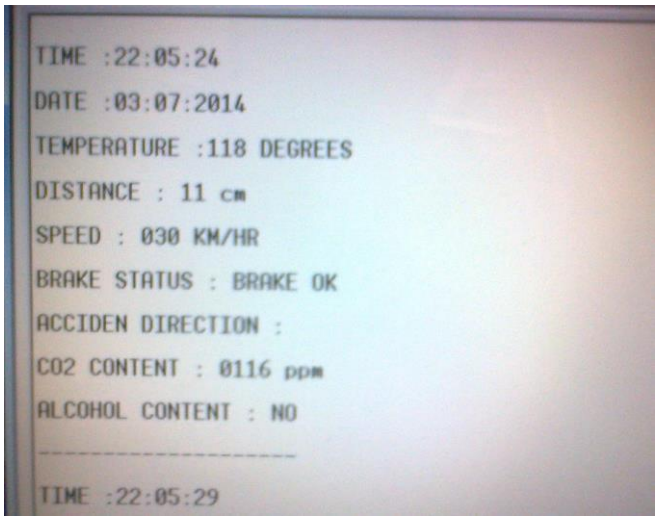

Fig -7: Recorded data from Black Box

The message is displayed in the phone after the accident is occurred to the vehicle. This is sent to the emergency numbers by the GSM module which is fixed in the vehicle.

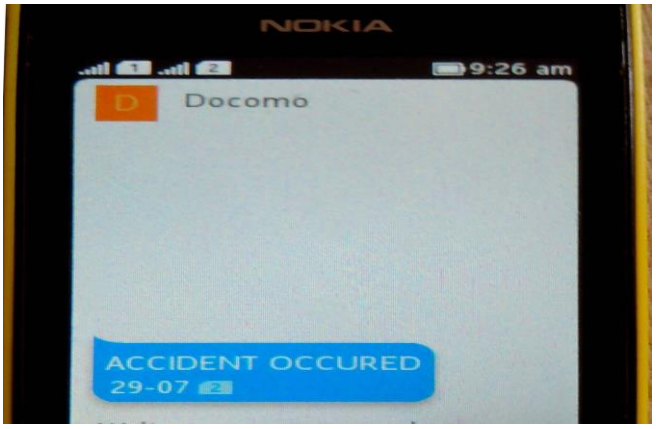

Fig -8: Messages indicating ACCIDENT OCCURRED

VII. Conclusion

This paper has presented a new vision for the vehicles industry, which is the Black Box system and Collision Avoidance System used for vehicles. A full and detailed description was made for every part of this system. This paper has also offered a user friendly embedded program to analyze the data of the accident. This Black Box system built can be implemented in any vehicle. As soon as the driver runs the motor, this system will begin to collect the data from all the sensors and stores in EEPROM along with Date and Time. The data is stored in Black Box for every 6 seconds. The data saved can be retrieved after the accident for privacy purposes. Using serial transmission the EEPROM and display it to the user. By using RS232 cable and MAX232 user can view the data from Black Box on HyperTerminal. In addition, a detailed report will be given to the user containing the recorded data in the memory.

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