Advanced Safety system for Vehicles using Controller Area Network

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ABSTRACT

Today the CAN bus has been used for automotive applications as a method to enable robust serial communication. The goal of the project is to create a system more reliable, safe and efficient for automobile vehicles while decreasing complexity and wiring harness. Generally most of the time people don't know the environmental conditions or Engine unit parameters which may cause problems or sometimes accident. Therefore in this paper we give the detail systematic architecture to provide safety and avoid accident to the automobile vehicles. In this we create a system to connect a group of sensors to a pair of microcontrollers acting as slaves which in turn send the collected data to a master microcontroller through CAN bus technology for safety of people. Our system uses multiple transmitter nodes to acquire data from sensors and transmit the data in packets over a CAN bus. In addition to this, the data acquired is transmitted to server PC through GSM Module. The current location of system is recorded by GPS Module and can be sent to remote PC on request. Our system is designed to be implemented in vehicles where sensors are used to acquire different parameters of vehicles and send it to owner of vehicle at remote position.

Keyword: - *CAN, ARM2129, Master and Slave unit, GSM and GPS etc.*

1. INTRODUCTION

The modern automobile may have as many as 70 electronic control units (ECU) for various subsystems. Typically the biggest processor is the engine control unit (also engine control module/ECM or Power train Control Module/PCM in automobiles); others are used for transmission, airbags, antilock braking/ABS, cruise control, electric power steering/EPS, audio systems, power windows, doors, mirror adjustment, battery and recharging systems for hybrid/electric cars, etc. Some of these form independent subsystems, but communications among others are essential. A subsystem may need to control actuators or receive feedback from sensors. The CAN standard was devised to fill this need.

The CAN bus may be used in vehicles to connect the engine control unit and transmission, or (on a different bus) to connect the door locks, climate control, seat control, etc. Today the CAN bus is also used as a fieldbus in general automation environments, primarily due to the low cost of some CAN controllers and processors. The CAN bus was developed by BOSCH as a multi-master, message broadcast system that specifies a maximum signaling rate of 1 megabit per second (bps). Unlike a traditional network such as USB or Ethernet, CAN does not send large blocks of data point-to-point from node A to node B under the supervision of a central bus master.

Recently it has been reported that nearly 36% of the accidents in the India are occurred due to bad environmental conditions and some of accidents occurred due to internal engine unit control problem. So, in this paper we created a reliable, safe and efficient system to provide safety and avoid accident from the automobile vehicles. Our system uses multiple transmitter nodes to acquire different type of physical data from sensors which are connected to a pair of microcontrollers acting as slaves and transmit the data in packets over a CAN bus to a master microcontroller. Each microcontroller of the system has a four channel 10 bit ADC which records the data from different sensors and transmit it over the CAN bus to the Master unit. In addition to this, the data acquired by the master microcontroller is transmitted to server PC through GSM Module. The GPS Module is continuously track the current location of vehicle system and the achieved data can be sent to remote position on request.

2. CONTROLLER AREA NETWORK BUS

The Controller Area Network (CAN) is a serial bus communications protocol developed by Bosch in 1986 upon request by Mercedes to develop a system that would allow for communication between three electronic control units (ECU). It defines a standard for efficient and reliable communication between sensor, actuator, controller, and other nodes in real-time applications. It was noted that a standard UART communication could not complete the task because it only allowed for point-to-point communication. Although the CAN bus was originally designed for automotive applications, it has been applied to many areas of automation and control. CAN has been used in applications including warehouse shipping automation, packaging machines, medical devices including X-ray collimators and patient tables, and building controls including alarm and sprinkler systems.

2.1 The development of CAN BUS

The development of CAN began when more and more electronic devices were implemented into modern motor vehicles. Examples of such devices include engine management systems, active suspension, ABS, gear control, lighting control, air conditioning, airbags and central locking. All this means more safety and more comfort for the driver and of course a reduction of fuel consumption and exhaust emissions. This bus had to fulfill some special requirements due to its usage in a vehicle. With the use of CAN, point-to-point wiring is replaced by one serial bus connecting all control systems. This is accomplished by adding some CAN-specific hardware to each control unit that provides the "rules" or the protocol for transmitting and receiving information via the bus.

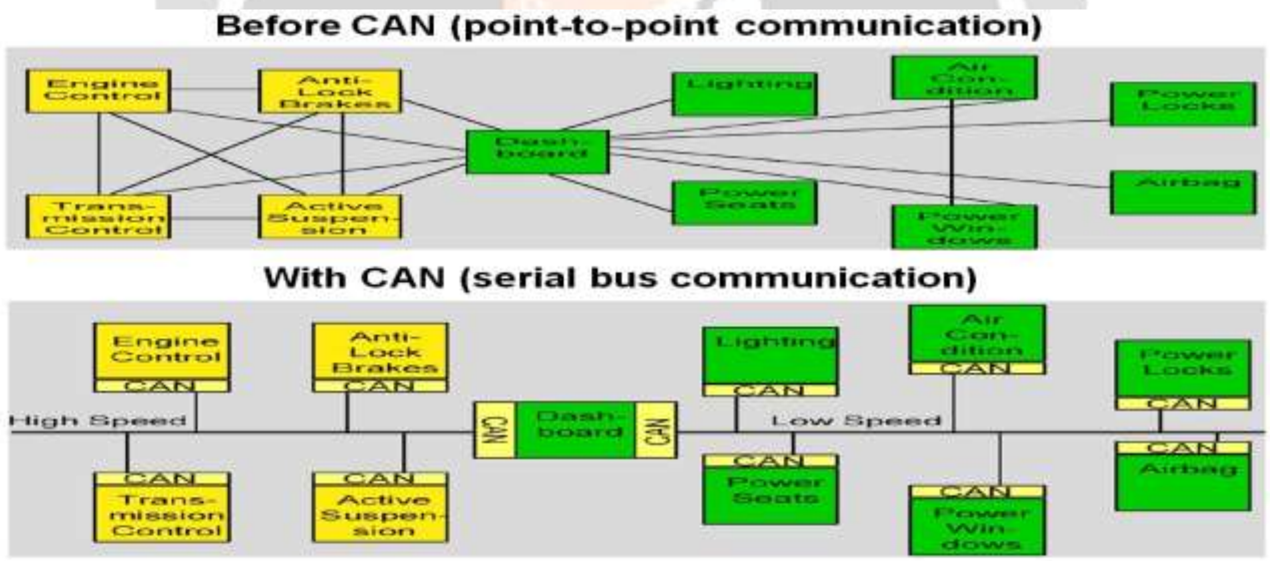


Figure 1: Block Development of CAN Bus Protocol

2.2 Features of CAN

CAN is a computer network message based protocol and bus standard designed to allow microcontrollers and devices to communicate with each other without a host computer. The unique aspect of a CAN network is that each message is preceded with an identifier that is unique to the transmitting controller and that multiple controllers can communicate over a single two-wire bus. These wires are the CANH and CANL. These wires are required for the node to assert the two different voltage levels defined by the CAN protocol. In CAN the data are stuffed into frames and are transmitted serially on to the bus with the bit rate up to 1MB/s at network length below 40m and decreases with increase in network distance. If two messages are sent simultaneously, an automatic arbitration process ensures that the highest priority message is sent first. The lower priority message then has the opportunity to retransmit upon completion of the first message. Incoming messages are filtered by the ECUs based on the unique message identifier of the sender (CAN-CIA). Whenever the bus is free the most dominating message will be executed first and the lower priority will sense these and will back off.

There are three separate CAN standards: CAN Version 1.0, Version 2.0A (Standard CAN), and Version 2.0B (Extended CAN). The main difference in the three standards is the length of the identifiers that precede each message. All work presented in this manuscript is based on the CAN 2.0B standard.

3. SYSTEM SPECIFICATION AND BLOCK SCHEMATIC

3.1 System Specifications

The most important need of our project is CAN controller. Since LPC 2129 has 2 inbuilt CAN controller, that's our best choice. LPC 2129 along with GPS and CAN driver works on 3.3V, we need to design power supply that can supply regulated voltage of 3.3V. For this we used power regulator IC LM 1117. Along with this we need power supply of 5V for the working of sensors, LCD and GSM module. For this we used power regulator LM 7805. 1.8 V is needed for internal working of LPC 2129 for this we used power regulator LM 317. We need MAX 232 to provide voltage interface between microcontroller and GPS & GSM module during serial communication. TTL logic of ±5 V is converted into RS 2323 logic of ±25 V. MAX 232 also facilitates On-chip Flash Burning of LPC 2129. LCDs are needed to monitor sensors' output. To receive GPS coordinates and sensors' output on remote PC, we need a GSM module attached to that PC that also contains a SIM card whose number is programmed into transmitter. Transmitter sends a SMS containing all the information to receiver. To see the coordinates of vehicle's present location, we need Visual Basic program running on our PC. Visual Basic Program provides a screen where we can see the location of our vehicle on Google map. Sensors' outputs are shown on sidebar. Information are regularly updated every 1 minute.

3.2 Block Diagram

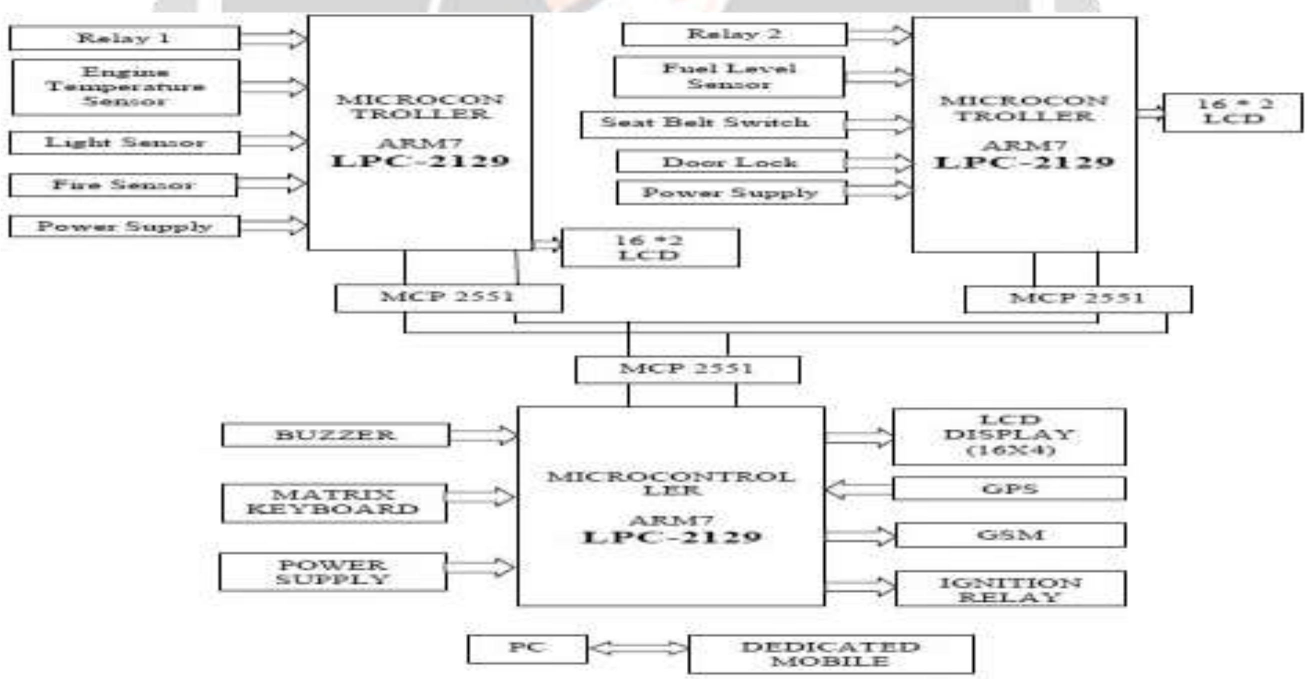


Figure 2: Block diagram of Advanced Safety system for Vehicles using CAN

3.3 Block diagram description

3.3.1 *LPC 2129*

The main reason behind selecting this microcontroller is that it contains inbuilt CAN controller. LPC 2129 is a 16/32-bit ARM7TDMI-S microcontroller. It has 16 kB on-chip Static RAM.128/256 kB on-chip Flash Program Memory with In-System Programming (ISP) and In-Application Programming (IAP) via on-chip boot-loader software. Flash programming takes 1 ms per 512 byte line. Single sector or full chip erase takes 400 ms. It has two interconnected CAN interfaces with advanced acceptance filters and four channel 10-bit A/D converter with conversion time as low as 2.44 ms. LPC 2129 has multiple serial interfaces including two UARTs (16C550), Fast I2C (400 Kbits/s) and two SPIs. The on-chip crystal oscillator of ARM 2129 has operating frequency range of 1 MHz to 30 MHz.LPC 2129 has Dual power supply:

- CPU operating voltage range of 1.65 V to 1.95 V (1.8 V ±0.15 V).
- I/O power supply range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/Opads.

3.3.2 CAN Driver MCP 2551

The MCP2551 is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus. The MCP2551 provides differential transmit and receive capability for the CAN protocol controller and is fully compatible with the ISO-11898 standard, including 24V requirements. It will operate at speeds of up to 1 Mb/s. typically each node in a CAN system must have a device to convert the digital signals generated by a CAN controller to signals suitable for transmission over the bus cabling (differential output). It also provides a buffer between the CAN controller and the high-voltage spikes that can be generated on the CAN bus by outside sources (EMI, ESD, electrical transients, etc.)

3.3.3 Transmitter Function

The CAN bus has two states: Dominant and Recessive. A dominant state occurs when the differential voltage between CANH and CANL is greater than a defined voltage (e.g. 1.2V). A recessive state occurs when the differential voltage is less than a defined voltage (typically 0V). The dominant and recessive states correspond to the low and high state of the TXD input pin, respectively. However, a dominant state initiated by another CAN node will override are excessive state on the CAN bus.

3.3.4 Receiver Function

The RXD output pin reflects the differential bus voltage between CANH and CANL. The low and high states of the RXD output pin correspond to the dominant and recessive states of the CAN bus, respectively. The MCP2551 CAN outputs will drive a minimum load of 45Ω, allowing a maximum of 112 nodes to be connected (given a minimum differential input resistance of 20 KΩ and a nominal termination resistor value of 120Ω).

3.3.5 Temperature Sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. It is a 3 pin device which runs on input supply of 4-30 V. The LM35 is rated to operate over a -55ºC to +150 ºC temperature range. Temperature sensor is an analog sensor and gives the output into form of analog signal. This signal is feed to ADC which will convert it into digital form. Once converted into analog form, the microcontroller can process the digital temperature signal as per the application.

3.3.6 Light Dependent Resistor

LDR consist of two cadmium sulphide photoconductive cells with spectral response similar to that of the human eye. The cell resistance falls with increasing intensity of light. Application includes automatic light control, batch counting, and burglar alarm. Its operating voltage is 3 - 50 V while operating temperature is -60ºC to +75ºC.

3.3.7 Fire Sensor

Fire sensor used in a project is a sensor which detects a fire around it. Fire sensor is a digital sensor which is directly connected to the microcontroller input/output port pin. As fire signal is a digital sensor, it always gives digital output. Under normal condition the microcontroller gets active low signal. When fire sensor detects the fire around it, it sends active high signal to the microcontroller and as per the program the necessary action is taken well on time.

3.3.8 Fuel Level Sensor

As the name suggest, it measures the level of fuel in tank. The AKCP Fuel Level Sensor is a float-type liquid level Sensor, used to monitor the fuel level in your storage tank. By using the Fuel Level sensor you can ensure that your tanks are filled and ready for the most critical moments. The intelligent sensor port powers the sensor. It is compatible with any of the security Probe series base units, or the E-sensor 8 expansion modules. We can instantly be alerted if there is any drop below critical levels in our fuel. Advance alerting of possible fuel leaks or theft will ensure your tanks never run dry again.

- Ideal for remote sites that depend on backup generator power
- Normal, Low and Critical alerting
- Easy setup and installation
- Can monitor several liquids, including fuel, oil and water
- Monitor your tanks for critically low levels of fuel
- Powered by the security Probe, no additional power required.

3.3.9 GPS MODEM

The GPS smart receiver features the 16 channels .Ultra low power GPS architecture. This complete enabled GPS receiver provides high position, velocity and time accuracy performances as well as high sensitivity and tracking capabilities.

A GPS tracker essentially contains GPS module to receive the GPS signal and calculate the coordinates. It is a device that uses the Global Positioning System to determine the precise location of a vehicle, person, or other asset to which it is attached and to record the position of the asset at regular intervals. The recorded location data can be stored within the tracking unit, or it may be transmitted to a central location data base, or internet-connected computer, using a cellular (GPRS or SMS), radio, or satellite modem embedded in the unit. This allows the asset's location to be displayed against a map backdrop either in real time or when analysing the track later, using GPS tracking software (e.g. Telematics 2.0).

A GPS tracker essentially contains GPS module to receive the GPS signal and calculate the coordinates. For data loggers it contains large memory to store the coordinates, data pushers additionally contains the GSM/GPRS modem to transmit this information to a central computer either via SMS or via GPRS in form of IP packets.

3.3.10 GSM MODEM

GSM (Global System for Mobile communication) is a digital mobile telephony system. With the help of GSM module interfaced, we can send short text messages to the required authorities as per the application. GSM module is provided by SIM uses the mobile service provider and send SMS to the respective authorities as per programmed. This technology enables the system a wireless system with no specified range limits. It operates at either the 900 MHz or 1800 MHz frequency band. In our project a Tri-band GSM/GPRS module SIM300 is used for message sending which is operating at the frequencies of EGSM 900 MHz, DCS 1800 MHz and PCS1900 MHz and it provides GPRS multi-slot class 10/ class 8 (optional) capabilities and supports the GPRS coding schemes. By using antenna connector and antenna pad interface is achieved using SIM300 module. The main feature available with SIM 300 is it is designed in power saving mode and current consumption is low as to 2.5mA in SLEEP mode. Both GPS and GSM are interfaced to the control unit using serial communication protocol [13].

4. WORKING AND PROCESS FLOW

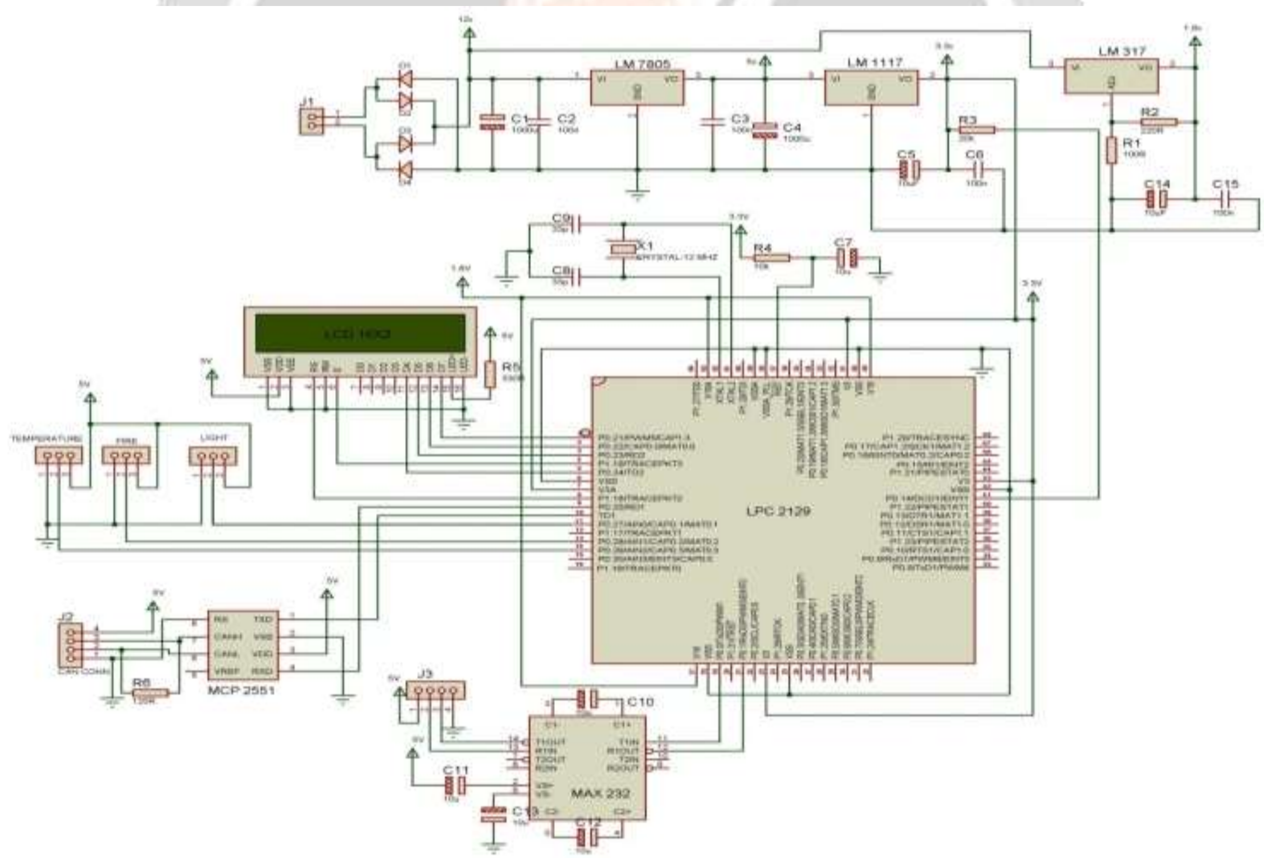
We have basically divided our circuit into three parts: A, B and C. Part A and B consist of slaves microcontrollers connected to dedicated sensors, placed at different locations. While Part C consist of master microcontroller connected to GPS and GSM module.

4.1 For Slaves (Part A and Part B)

First Set pins of LPC 2129 as GPIO using PINSEL command and initialize LCD. Then Set timer delay to 1ms. When the system starts, the display shows the title of the project on LCD. Then the sensors start scanning and the obtained analog value is converted into digital by ADC channel of microcontroller. The slave part A is connected with the light sensor, Temperature sensor and fire sensor. Since fire sensor output is digital. So, it is directly displayed on LCD. When fire not detected, output=0. When fire detected, output=1.Slave controller 'A', when receive request containing MsgID = 11, send message frame containing data of Temperature sensor and MsgID = 21 send message frame containing data of Light sensor. On receiving request containing MsgID = 12, send message frame containing data of Fire sensor.

We have to do same initial settings for other Slave controller also. The slave part B is connected with the Fuel level sensor, Seat belt switch and door switch. Since seat belt switch's and door switch's output are digital. So, it is directly displayed on LCD. Slave controller 'B', when receive request containing MsgID = 13, send message frame containing data of Fuel level sensor and MsgID = 31 send message frame containing data of Seat Belt Switch. On receiving request containing MsgID = 14, send message frame containing data of Door Switch.

Figure 3: Circuit diagram of Slave Unit



4.2 For Master Unit

First Set pins of LPC 2129 as GPIO using PINSEL command and initialize LCD, Keyboard, GPS etc. Then Set timer delay to 1ms. When the system starts, the display shows the title of the project on LCD. Then on LCD it is shown “Enter Password “to activate the master unit. The password protection to the master unit is given due to security purpose. After entering significant 4 digit number as password. The system verifies Password. If invalid, return 0. Ask to enter password again. If valid, return 1. The system Set message buffer A and B. Also Set message frame. No RTR. Set DCR to 16 bytes after it set message ID for slaves to send request,

- Set MsgID = 11 for Temperature and light.
- Set MsgID = 12 for Fire.
- Set MsgID = 13 for Seat Belt and Door switch.
- Set MsgID = 14 for Fuel Level.

Then, Set data field in Msg Buffer to zero as master is requesting. So no data is needed to send. To receive response containing data, again set MsgID.To receive response,

- Set MsgID = 21 for Temperature and Light.
- Set MsgID = 22 for Fire.
- Set MsgID = 31 for Seat Belt and Door Switch.
- Set MsgID = 32 for Fuel Level.

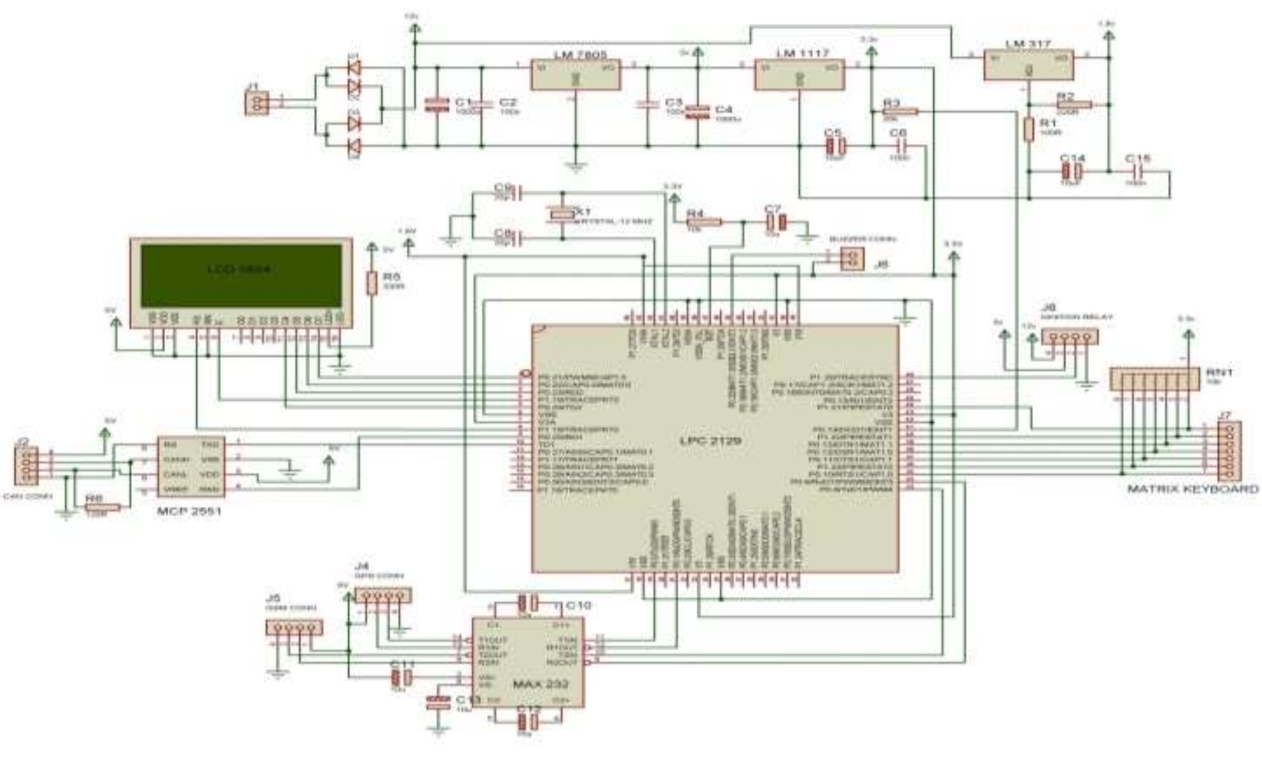


Figure 4: Circuit diagram of Master Unit

At an interval of 2 seconds keep sending message frames containing MsgID = 11, 12, 13, 14 individually. On receiving data for MsgID = 11, display it at line 3 and 4 respectively. It is provided delay of 2 seconds to clear line 3 and 4. In the same way display other information on line 3 and 4. Then Scan for GPS coordinates and display it on line 1 and 2 and finally Send SMS every 60 seconds via GSM to server PC and user mobile number.

Figure 5: Actual Implemented circuit of Advanced Safety system for Vehicles using CAN

5. RESULTS AND DISCUSSION

This application project presents an introduction to the CAN fundamentals, operating principles, and the implementation of a basic CAN bus with TI's CAN transceivers and Microcontrollers. This paper gives a defend way of approaching the problem. Here first we try to provide safety and avoid accident to the automobile vehicle. And if any disturbance or undesired things happened then the message will appeared on the master display unit with alarm alert, the incident location can be located easily and the detection of accident is precise unlike the prior approaches, and the information of vehicle location will be sent to already predefined numbers. After many trials we got the desired result of our project.

Figure 6: A part of output on Master display unit

6. CONCLUSION

A controller area network (CAN) is ideally suited to the many high-level industrial protocols embracing CAN and ISO-11898:2003 as their physical layer. Its cost, performance, and upgradeability provide for tremendous flexibility in system design. CAN is ideally suited in applications requiring a large number of short messages with high reliability in rugged operating environments. Because CAN is message based and not address based, it is especially well suited when data is needed by more than one location and system-wide data consistency is mandatory. Among the applications finding solutions with CAN are automobiles, trucks, motorcycles, snowmobiles trains, buses, airplanes, and agriculture, construction, mining and marine vehicles.

CAN provide an inexpensive, durable network that helps multiple CAN devices communicate with one another. An advantage to this is that electronic control units (ECUs) can have a single CAN interface rather than analog and digital inputs to every device in the system. This decreases overall cost and weight in automobiles. The CAN specification includes a Cyclic Redundancy Code (CRC) to perform error checking on each frame's contents with priority wise message transmission.

7. FUTURE WORK

The practical use of CAN technology is mostly in vehicles to connect the different engine control unit and transmission. Such as streetcars, trams, undergrounds light, railways, and long-distance trains incorporate CAN. One can find CAN on different levels of the multiple networks within these vehicles – for example, in linking the door units or brake controllers, passenger counting units, and more. In aircraft engine control such as fuel systems, pumps and linear actuators also Can is used. Apart from these applications in medical equipment also, CAN systems are used. In Hospitals control operating room components such as lights, tables, cameras, X-ray machines, and patient beds are CAN-based systems. Lifts and escalators use embedded CAN networks, and hospitals use the CAN open protocol to link lift devices, such as panels, controllers, doors, and light barriers, to each other and control them. CAN open also is used in nonindustrial applications such as laboratory equipment, sports cameras, telescopes, automatic doors, and even coffee machines.

In our project, we can include few more sensors such as proximity sensors, ultrasonic sensors, IR sensors etc. to make the system so efficient in accident detection. We can incorporate few more slaves unit and sensors to make the system multi functional such as security, safety and few other aspects can be full filled by a single system, only.

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