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Vehicle Safety & Security using CAN Protocol

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Abstract—*Networked Electronic Control Units (ECUs) areincreasingly being deployed in automobiles to realize various functions and Controller Area Network (CAN) is deployed for the communications among ECUs.In order to reduce point to point wiring harness in vehicle automation, Controller Area Network (CAN) is suggested as a means for data communication within the vehicle environment. The advantages of Controller Area Network bus based network over traditional point to point schemes will offer increased flexibility and maximum expandability for future technology.*
This paper describes the ARM7 based design and implementation of CAN Bus prototype for vehicle automation.
To track the location, Vehicle tracking system is installed in the vehicle. The place of the vehicle is identified with the help of Global positioning system (GPS) and Global system for mobile communication (GSM). These systems constantly watch a moving Vehicle and report the status on demand. This is more secured, reliable and low cost.

I. INTRODUCTION

In today's world, automation is needed in many systems which provide better performance. Vehicle system is composed of automotive electrical architectures consist of a large number of electronic control units (ECU) carrying out a variety of control functions. In vehicle system, generally greater safety, more comfort, convenience, pollution control and less fuel consumption is required. A modern vehicle may have many electronic control units (ECU) for various subsystems. Different such subsystems are airbags, antilock braking, audio systems, windows, doors, mirror adjustment etc. Communications among dependent sub systems is essential.
In order to solve several problems, the vehicle network technology has been created.The Controller Area Network (CAN) is a serial communication protocol. CAN is a bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without using a host computer.
In early 80's, German BOSCH corporation invented the CAN BUS which is a serial data communication.CAN provides a mechanism which can be used in the hardware and the software using which different electronic modules can communicate with each other using a common cable. Communication speed is up to 1MBPS.

CAN is an International Standardization Organization (ISO) defined serial communications bus originally developed for the automotive industry to replace the complex wiring harness with a two-wire bus.

The CAN communication protocol is a carrier-sense, multiple-access protocol having collision detection and arbitration on message priority (CSMA/CD+AMP).

- CSMA(Carrier sense multiple access) means that each node on a bus must wait for a prescribed period of inactivity before attempting to send a message.
- CD+AMP mean that collisions are resolved through a bit-wise arbitration, based on a pre-programmed priority of each message in the identifier field of a message.

CAN transmission medium is formed by: High-level transmission line CANH; and Low-level transmission line CANL.

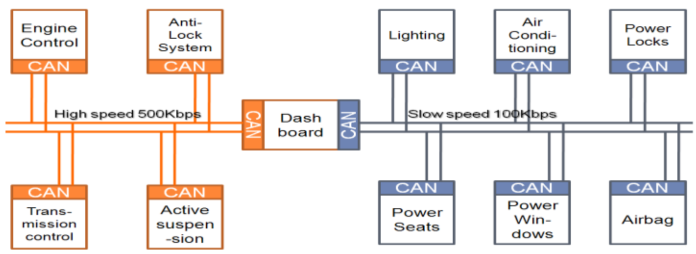

Fig.1 CAN Network Topology

CAN Data Frame:

Start of Frame	Arbitration Field	Control Field	Data Field (up to 8 bytes)	CRC Field	ACK Field	End of Frame

Fig.2 Data Frame

A CAN Data frame is composed of seven different bit fields as:

SF=Start of frame, AF=Arbitration field, CF=Control field, DF=Data field, CRC field, ACK field, EF=End of frame.

II. SYSTEM DESCRIPTION:

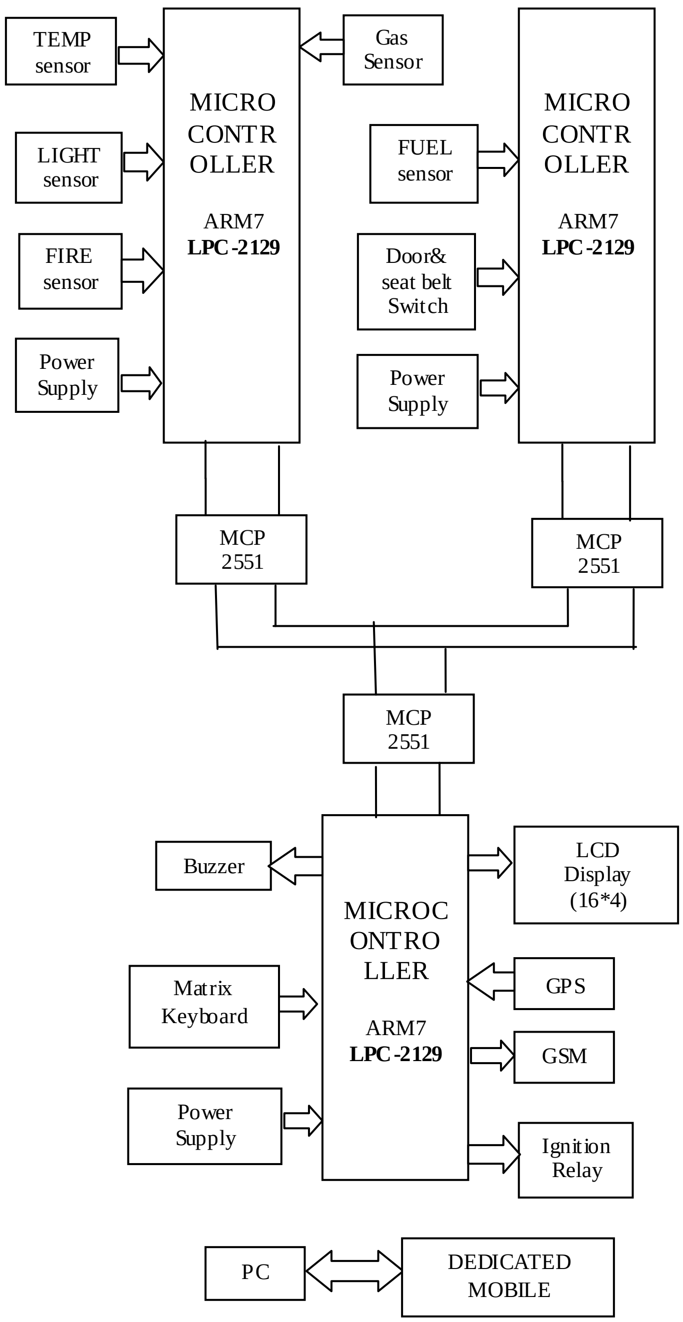

Fig.3 Block Diagram

The proposed block diagram for CAN bus communication system is as shown in above figure. The different nodes are ECUs, which are connected to each other using CAN bus. The devices that are connected by a CAN network are typically actuators, sensors, and other control devices. These devices connected indirectly to the bus, through a host processor and a CAN controller. CAN node consist of a host processor, CAN transceiverand CANcontroller.

In proposed CAN bus prototype for vehicle automation, LPC2129 ARM7 TDMI-S processor is used as host processor. MCP2551 is Stand-Alone CAN Controller with SPI Interface. MCP2551 is used as CAN transceiver. LPC2129 ARM processor is having inbuilt CAN controller used for designing monitor node.
This system consists of CAN driver IC MCP2551, temperature sensor, light sensor, fuel sensor,door& seat-belt switch, Fire sensor, Gas Sensor,GPS, GSM Modem, Matrix Keyboard and the LCD display(16x4) interfaced with the microcontroller.
A master-slave concept is used, where, one master will control tthe two slaves. The sensors are interfaced to the two slaves. All the micro-controllers are connected through the common CAN bus cable MCP 2551. It carries the information from one module to another. The remaining devices, that is, LCD, Keypad, buzzer are interfaced to the master. Keypad is used to enter a password, for security. The output will be displayed on the LCD. Buzzer will indicate any kind of emergency situation. For tracking of vehicle, GPS and GSM is implemented, which will be seen on the dedicated mobile and PC on the server side.

III. HARDWARE DESIGN:

A) ARM-7 LPC 2129 Microcontroller

The LPC2129 is based on a 16/32 bit ARM7 TDMI-S CPU with real-time emulation and embedded trace support, together with 128/256 kilobytes (kB) of embedded high speed flash memory. It has avarious 32-bit timers, compact 64 pin package, and low power consumption,2 advanced CAN channels, 4-channel 10-bit ADC, 46 GPIO lines with up to 9 external interrupt pins& PWM channels. These kinds of microcontrollers are suitable for industrial control applications andautomotive as well as medical systems and fault-tolerant maintenance buses.

B) MCP 2551

The MCP2551 is a fault-tolerant, high-speed CAN device that serves as the interface betweenthe physical busand a CAN protocol controller.
It will operate at speeds of up to 1 Mb/s.

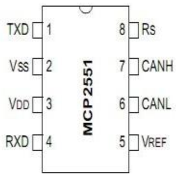

Fig. 4 Pin diagram of MCP2551

Pin no	Pin name	Pin function
1	TxD	Transmit Data Input
2	Vss	Ground
3	VDD	Supply voltage
4	RxD	Receive data out
5	Vref	Reference output voltage
6	CANL	CAN Low level voltage I/O
7	CANH	CAN High level voltage I/O
8	Rs	Slope-control input

Pin description of MCP 2551

C) Temperature Sensor LM 35

The LM35 istemperature sensor with a precision integrated-circuit, and its output voltage is linearly proportional to the temperature in Celsius
The temperature of any machine to which it is connected orthe temperature of the atmosphere around it is sensed with these sensors.
Temperature sensor is an analog sensor which gives the output into form of analog signal. This analog signal is fed to ADC which will convert this signal into digital form. After converting into digital form, the digital temperature signal are processed with the help of microcontroller as per the application requirement. The output voltage changes linearly at a rate of 10mV per degree Celsius (Centigrade).

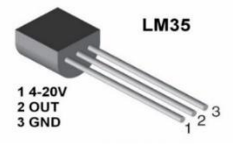

Fig. 5 LM35

D) Light Sensor LDR

An LDR is a component that has a (variable) resistance that changes with the light intensity which falls upon it and allows them to be used in light sensing circuits.
A light dependent resistor works on the principle of photo conductivity, which is an optical phenomenon in which the materials or object conductivity (hence resistivity) reduces when light is absorbed by that material.

Fig.6 Light Dependent Resistor LDR

E) Fuel Sensor

Fuel sensor is used to calibrate the fuel available in a fuel tank. The fuel (level) sensor is used get the information of:

- current fuel volume in vehicle tank;
- fuelling volume;
- the fuel theft;
- To determine the fuel consumption.

The fuel monitoring circuit working is based on sensing the voltage variation developed across the meter and activates the beeper when the fuel tank is almost empty.

Fig.7 Fuel Sensor

F) Gas Sensor MQ6

MQ6 is a highly sensitive gas sensor to petroleum based gases. MQ6 gas sensor is a 6 pin device which requires 5 volt DC maximum and is derived from a Zener based power supply. It consists of a heating element inside the sensor, that becomes hot at 5 volt and remains stand by. In the atmosphere when the gas molecules detected by the sensor are between 100 ppm to 1000 ppm, , its output turns high and triggers the transistor to activate the buzzer.

Fig.8 MQ6

G) Buzzer

Buzzers are used in a system as an indicator or to grab the attention as an emergency situation. Buzzer act as a panic horn which indicates the need of instant attention as the condition goes haywire.

H) Liquid Crystal Display

LCD is used in a project to visualize the output of the application. We have used 16x4 LCD which indicates 16 columns and 4 rows. So, we can write 16 characters in each line.

I) Global Positioning System

A GPS tracking unit is a device that uses the Global Positioning System to determine the precise location of an object to which it is attached and to record the position of the asset at periodic intervals. The recorded location information can be transmitted to a central location data base,or stored within the tracking unit, otherwise to internet-connected computer, using a cellular (GPRS or SMS).
The GPS module can receive the information when connected to ARM7 development-board URAT0 using RS232 port. When the ARM7 chip sends the instruction AT to GPS module, the GPS module starts receiving the information and stores it into memory. This instruction sends the vehicle license information along with region information to the support-server center through GSM net.

Fig.9 GPS modem

J) TheGlobal System for Mobile Communication

GSM is a digital mobile telephony system. We can send short text messages to the required authorities as per the application, with the help of GSM module interfaced. The GSM module can send the information out by
SMS (Short Message Service) message, including realtime
position of the "lost" car.
GSM uses a variation of (TDMA)time division multiple access and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA).

Fig.10 GSM modem

K) Power Supply

In our system most of the components used require 5 V as operating voltage such as micro controller, MAX 232, LCD. Also 3.3V and 1.8V is needed for regulator IC LM317.

We have used Regulator IC 7805 that gives output voltage of 5V. The minimum i/p voltage required for the IC 7805 is around 7V. Therefore we have used the transformer withcurrent rating 500 mA& the voltage rating 230V-10V. The output obtainedby the transformer is 12 V AC. Bridge rectifier circuit converts this Ac voltage into 12 V DC. LM 317 requires an operating voltage of 1.8V for its internal circuitry.

The LM317 is adjustable 3-terminal positive voltage regulators whichover a 1.2V to 37V output range is capable of supplying in excess of 1.5A.

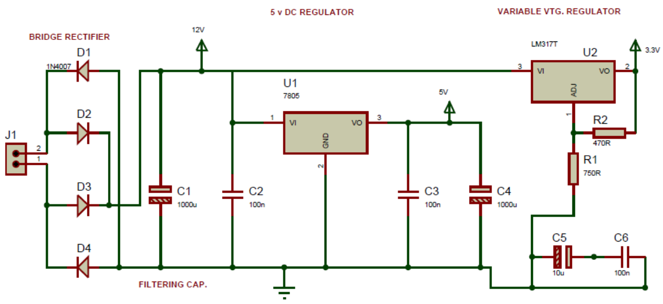

Fig. 11 Power supply design

IV. SOFTWARE DESIGN:

Softwares used include, 'Keil uVision 4.0', for programming purpose. 'Proteus 7', for software simulation, 'Dip trace' for layout design, 'Flash magic' for downloading program in the chip.

V. METHODOLOGY:

In this project, a master slave concept is used. One master will control two slaves. The communication between all 3 boards is shown using CAN protocol. The CAN is a serial communication bus which will reduce wiring.
The controller used for all the 3 boards is ARM-7 micro controller LPC 2129. The special feature of this IC is that it has two advanced CAN channels in built for serial communication.
The CAN controller used is MCP 2551 which will help to transfer data serially from one port to another. CANH and CANL are the two lines for transfer of information.
Different sensors are interfaced to the two slaves. An LCD and a matrix keypad is interfaced to the master. All the data from sensors will be displayed on the LCD.
LM35 will sense the surrounding temperature and it will be converted into digital form through analog to digital convertor, and the temperature will be displayed on the LCD. As the temperature increases, voltage will increase and ADC count increases.
LDR is used for detection of light in the car. As the intensity of light decreases, the voltage decreases, and ADC count will increase. And the digital value will be displayed on the LCD.

For detection of fire in the vehicle, a metallic strip is used. Initially it is at logic 0. When fire is detected, the strip gets short and the buzzer is activated.
A level sensor is used for detecting the amount of fuel in the vehicle. As the level increases, the potentiometer value changes, hence the voltage increases and ADC count increases. The value is displayed on LCD.
Also a door switch and seat belt switch is used. When they are pressed, the door and seat belt are closed. Else they are left open.
The buzzer will indicate any emergency situation. It operates on 3.3V.
The 4*3 matrix keypad is interfaced to the master. It is used for entering the password which will be displayed on LCD.
For the safety of vehicle, GPS and GSM are also interfaced which will track the location of the vehicle.

VI. RESULT AND DISCUSSION:

We have successfully tested the communication between the three boards through CAN protocol.
Also the information of sensors is converted into digital form through analog to digital convertor.LCD displays the converted digital values of all sensors.

Fig.12 shows the working of fuel sensor and door & seat belt switch. When the switch is pressed, the door or seat belt is closed.

Fig.13 shows working of other sensors, that is, temperature, light, gas and fire sensors.

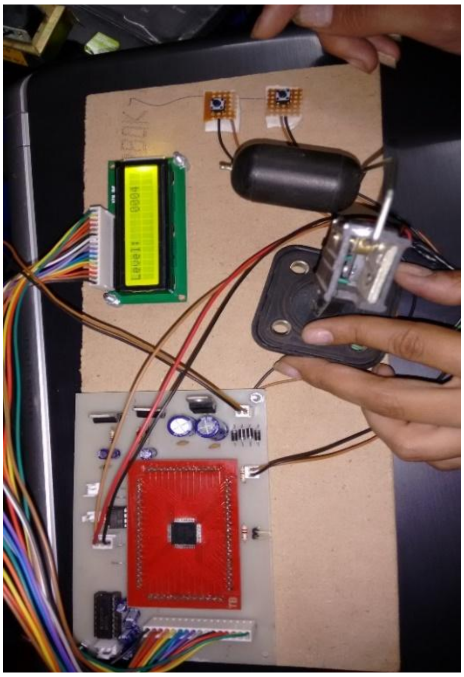

Fig.12 working of slave-1 board

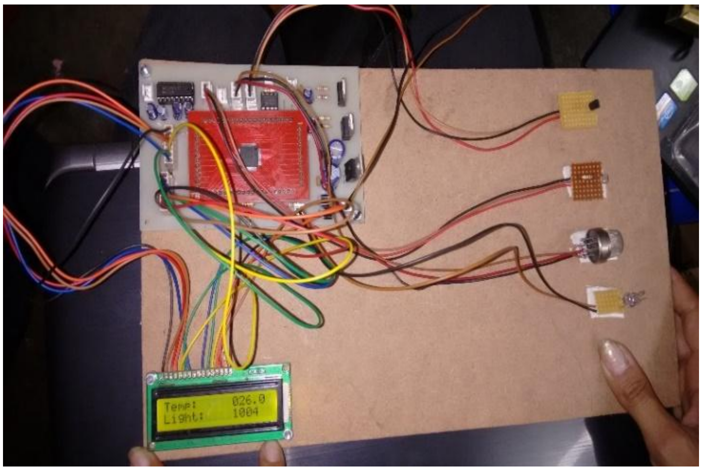

Fig.13 working of slave-2 board

Fig.14 shows the main master board in which 16*4 LCD and 4*3 matrix keypad are placed. The password is entered through the keypad and if valid, the system starts working.
All the data of the other two boards is displayed on this main LCD.

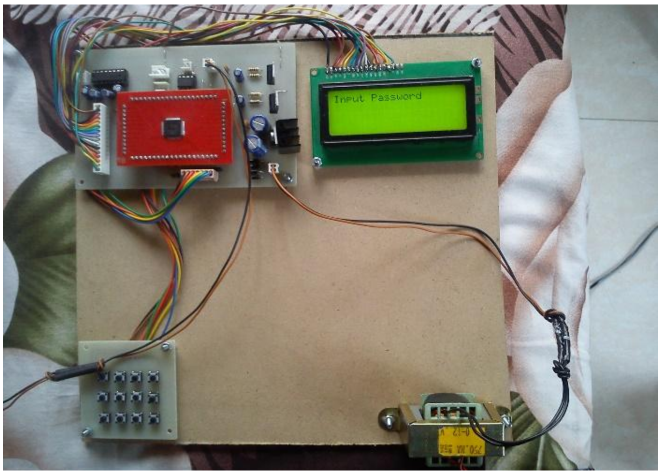

Fig.14 Master board

The communication between master and slave is done, and the information of all the sensors is displayed on the LCD of master board. Fig.15shows their communication.

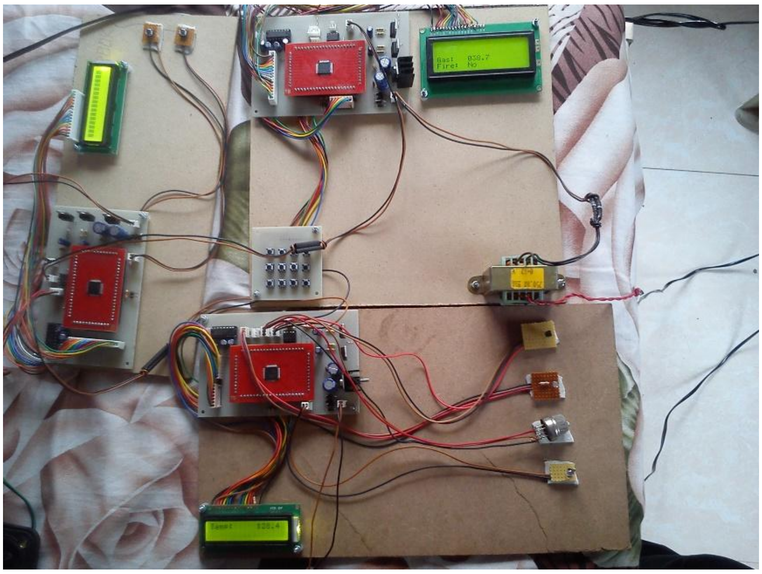

Fig.15 Communication of the boards

VII. CONCLUSION

The paper presents our project that successfully shows the communication between different control units within a vehicle using CAN protocol. The CAN protocol is applied in almost all the vehicles now-a-days.
The main feature of our project is the tracking of the vehicle, that is, finding its location using GPS and GSM.
Hence the safety as well as security of the vehicle is successfully achieved.

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