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Embedded System Based On Board Diagnostic (OBD) Tool for Vehicle Management and Safety

[1]A.Sriramnath, [2]Mrs.Kolangiammal.S
[1]Post Graduate Scholar (Embedded System Technology), [2]Assistant Professor
[1]Department of Electronics & Communication Engineering
[1]SRM University, Chennai, India

Abstract - **This project aims at implementing a distributed On Board Diagnostics (OBD) system with a HMI that can be used for many purposes like safety, vehicle management and maintenance etc. For the implementation of this various electronic sub systems in the vehicle like the antilock braking system (ABS), the engine control system (ECU), fuel level, exhaust gases sensors, load cell and many other such sub systems that are critical to either the condition of the vehicle or the safety of the users are interfaced on to a single embedded network within the vehicle using CAN bus for communication. The embedded network is in turn connected to internal HMI that can gather, analyze and take respective action when required. Such a system if interfaced with a communication option like GSM / Bluetooth can interact with smart phones to automatically give contextual information to the users from time to time to ensure proper maintenance of the vehicle. Also the same can be used to automatically convey information to service centers about the problem with the vehicles and the maintenance that is needed**.

Index Terms-- ABS, ECU, CAN bus, GSM, HMI, sensors

I. INTRODUCTION

Automotive systems are safety-critical and are required to be highly fault-tolerant in operation. Automotive systems consist of mechanical, hydraulic, software and hardware components. There is a staggering amount of embedded computing within automotive systems. For instance, current vehicles contain dozens of microprocessors and dozens of sensors. Distributed electronic control systems are increasingly being used in the automobile industry to provide convenience and safety features to vehicle drivers and passengers, with increasing levels of automation and control authority there is a need for monitoring the overall automotive electronic control system in a vehicle ,in order to find out the faults inside the vehicle and there is a need to provide the information to vehicle users .With vehicles getting more and more sophisticated there is also a need for a sophisticated electronic system inside the vehicles that can manage and give information about various critical aspects of a vehicle. However since vehicles are used by civilians, the information from these systems must be easy to interpret and access through a unified human machine interface (HMI) which can be displayed in the dashboard of a vehicle . The main objective of this project is to evaluate the vehicles internal electronic systems, sensors and other major sub systems and to provide a reliable real time information about the vehicle conditions to the user of the vehicle and the same information can be shared with the service center's about the problem .

II. EXISTING METHODOLOGY

In the existing system, manual checking is needed to inspect the condition of the vechile.in many cases there are no indications to the user if there are some faults in the electronics systems ,sensors and other subsystems. Currently in developing countries like India, Pakistan etc., only MIL indicators are used to detect the faults., but it doesn't provide the information of the exact fault to the vehicle user .
From the literature ,it is found that Shi-Huang Chen and Yu Ru Wei[1] has proposed a OBD system to find out the major internal problems in a vehicle, but there are certain limitations which can overcome in the proposed system.

III. PROPOSED METHODOLOGY

This project proposes the development of On-Board Diagnostic (OBD) system for monitoring the electronics systems and subsystems of the vehicles . The proposed OBD system has a microcontroller based processing system and consists of sensors installed at different parts of vehicle to observe various parameters, processing unit that will take input from the sensors and signal conditioners, calculate the real-time values of vehicle parameters and give output and user interface. System will be able to diagnose faults in parameters, abnormal abrupt changes, notify user of any abnormal condition, and in some cases indicate the cause of fault.. It is user friendly system with LCD and keypad interface though which user can view parameter values, warning notifications and define custom limits for different parameters according to vehicle (other than default values).in the proposed system ,all the systems are interfaced on to a single embedded network within the vehicle using CAN bus for communication .

A. ABS module

The most important aspect of this project is monitoring the overall ABS [2]control unit .This module consist of a ABS control unit microcontroller ,speed sensor ,CAN transceiver ,brake actuator etc. ,the wheel speed sensors are used to monitor the hydraulic control unit and anticipate wheel lock .The CAN transceiver are used to gather the information from ABS control unit module and send the gathered data to the HMI unit .This module helps to monitor the ABS control unit and detect the faults in the ABS unit .

B. ECU module

These modules consist of a microcontroller unit ,sensors ,CAN transceiver. If there is any fault found in the ECU unit[3] the information will be sent to the HMI unit through the CAN data bus .The ECU microcontroller module will monitor all the sub systems and sensors which are placed in the engine control unit and a well as The ECU unit.

C. Sensors used in the project

There are various sensors used in this project for vehicle management and safety .the sensors used in this project are gas sensor, pressure sensor, alcohol sensor, load sensor etc., Gas sensor are used to detect the excessive pollution in the vehicle as well to detect the combustible gas such as methane gas, Freon and carbon monoxide etc., pressure sensor are used to monitor the various pressure systems in the vehicle and also it is used to monitor the fuel level .The load sensor are used to calculate the exact load in the vehicle ,this will help us to prevent the extra load in the vehicle.

D. HMI module

The human machine interface (HMI) consist of a Microcontroller Unit, a CAN controller ,LCD display .The HMI are interfaced with the ABS module, ECU unit ,sensors and GSM modem .HMI are used to display the gathered data to vehicle user and the same information is provided to the service center’s through the GSM modem.

E.GSM module

The GSM modules [4] are used to send a message or information about the vehicle problems to the vehicle user as well as to the service Centre. GSM modules are interfaced with the HMI unit ,whenever the message is displayed in the LCD screen of the HMI unit ,the intimation regarding the same is given to vehicle user’s mobile phone and to the service Centre.

IV. OVERALL MODULE OF THE OBD SETUP

The overall block diagram of the entire setup is given below. The processor used here is ARM (LM3S811).The various sensors such as the pressure sensor, load cell sensor, fuel level sensors and various Gas sensors are also interfaced to the controller. Apart from these, CAN is used for internal communication and to transfer the data from one controller to the main controller. The block diagram consists of ABS module, ECU module , Sensors and HMI module, GSM module.

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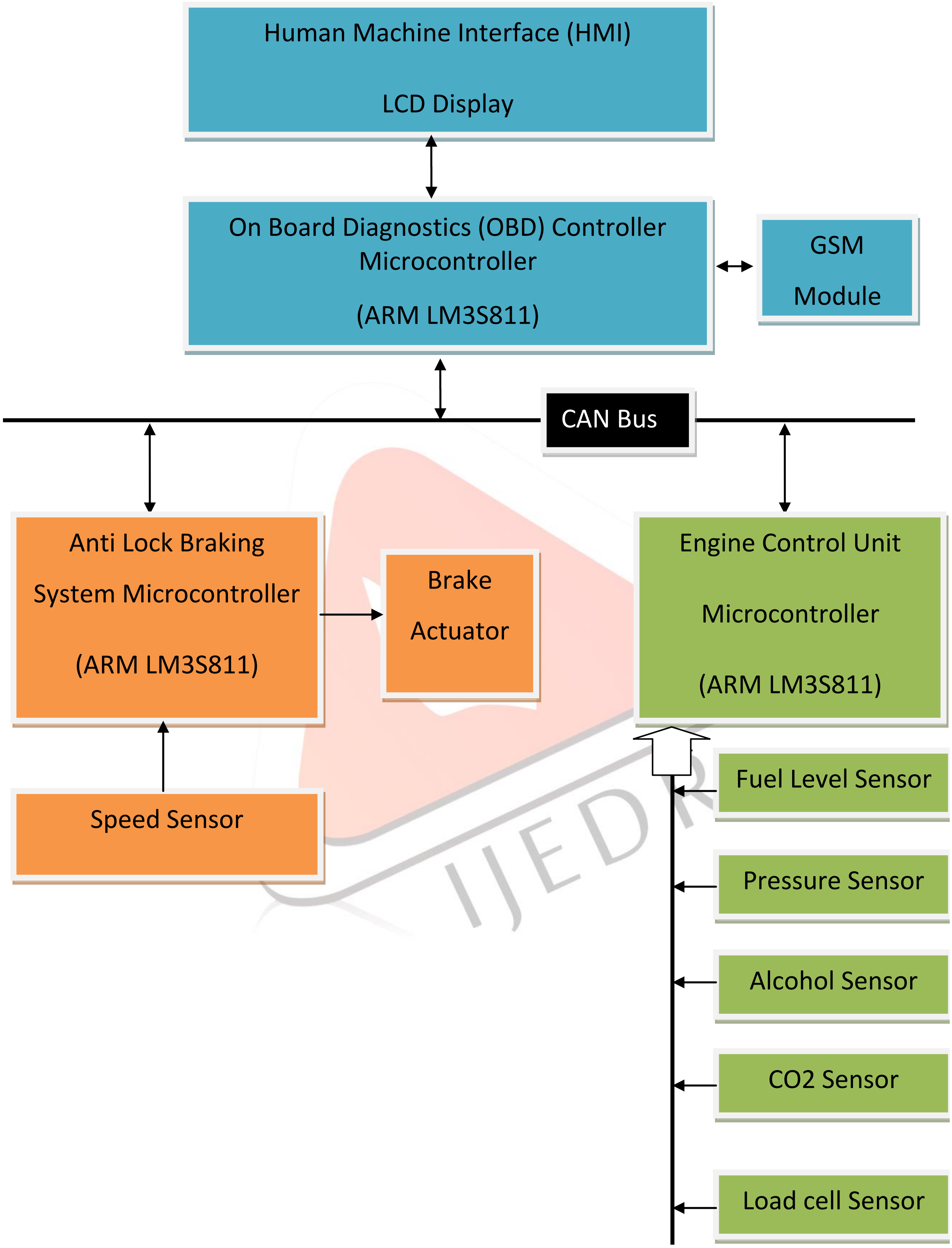

Figure 1. Embedded system based OBD block diagram

V. HARDWARE IMPLEMENTATION

A. ARM LM3S811

The microcontroller used is the ARM LM3S811[5],It is a 32-bit RISC processor and has a code memory of 64kb and data memory of 8kb.It has multiple peripheral like 2 UART ,4 ADC ,PWM etc., Three General-Purpose Timer Modules (GPTM), each of which provides two 16-bit timers/counters. Each GPTM can be configured to operate independently. It has a Thumb-2 instruction set, delivering the high-performance expected of an ARM core in the memory size usually associated with 8- and 16-bit devices; typically in the range of a few kilobytes of memory for microcontroller class applications. Memory protection unit (MPU) to provide a privileged mode of operation for complex applications.

B. *GSM module*

In this project SIM900A GSM module is used.SIM900A is manufactured by Simcomm. It works at DC 5V power input. It can directly be connected to a microcontroller or through an interface circuit to a computer. It is capable of both SMS and voice calls also. It Internally has a SIM card tray/slot for inserting the SIM card to use a specific service provides network.SIM900 is a quad-band GSM/GPRS engine that works on frequencies GSM 850MHz, EGSM 900 MHz, DCS 1800 MHz and PCS 1900 MHz.SIM900 features GPRS multi-slot class 10/class8 and supports the GPRS coding CS-1,CS-2,CS-3 and CS-4. But a GSM modem does not have user interfaces like keypads and displays. Instead it has a communication interface using which it can be connected to any computer or a microcontroller. Using special commands called AT Commands any operation can be performed in a GSM modem.

C. Speed Sensor

In this project MOC7811[6] is used . An optical switch is used as a feedback sensor. It has an IR transmitter and a receiver. It gives the exact speed in which the motor is operating. It gives pure digital pulses depending upon the speed of the motor rotation. It is connected to the digital pin of the microcontroller/PLC and it calculates the speed depending upon the number of pulses received within a particular time.

D. Load cell

Load cell converts a mechanical force into electrical signal. It has an internal strain gauge. When a force is applied, a strain is created and this leads to variation in the resistance of the strain gauge. The change in the resistance produces output voltage in few millivolts. This output voltage is fed to a differential amplifier. The input power supply to the load cell is 5V. The output of the load cell is in the order of millivolts, hence is amplified using a differential amplifier. It amplifies the difference signal between the two output terminals.IC 741 is used as the differential amplifier. The output of the differential amplifier is fed to the controller for load calculation

E. Gas Sensors

In this project MQ-5 is used for combustible gas detection. It can detect the presence and concentration of gases like methane, Freon, propane and butane. The sensing element used is SnO2.Resistance of SnO2 varies in the presence of gases. It is a six pin device, with an integrated heating coil. Sensitivity of SnO2 is greater at higher temperatures. The supply voltage is 5V DC. The output voltage proportional to the gas concentration is an analog voltage and is given to the ADC.

F. Pressure Sensor

MPX5010[7] is used for pressure sensing. It is a linear pressure sensor. The output voltage is given by 0v to 5v depending upon the pressure. It can measure pressure up to 10kPa Integrated sensor in a simple 3pin package. It is fabricated using micro machined piezo electric technology. It is integrated sensor and does not require any signal conditioning. The supply voltage input is 5V dc. The analog output from the pressure sensor is directly connected to the ADC input. This is used for fuel level sensing . When a liquid level varies, the pressure inside the tube also varies. This pressure is used for calculation of the level. The output voltage is given by 0v to 5v depending upon the pressure.

G. Alcohol sensor

In this project MQ-3 is used for alcohol detection. It can detect the presence and concentration of alcohol. It is a six pin device, with integrated heating coil. The supply voltage is 5V DC. The output voltage proportional to the alcohol concentration is an analog voltage and is given to the ADC.

H. CAN

CAN [8]or Controller Area Network is an advanced serial bus system that efficiently supports distributed control systems. It was initially developed for the use in motor vehicles by Robert Bosch GmbH, Germany, in the late 1980s, also holding the CAN license. CAN is internationally standardized by the International Standardization Organization (ISO) and the Society of Automotive Engineers (SAE). The Controller Area Network (CAN) is a serial communications protocol. CAN is widely used in automotive electronics for engine control, sensors. CAN is most widely used in the automotive and industrial market segments. Typical applications for CAN are motor vehicles, utility vehicles, and industrial automation.

CAN Controller

MCP2515 is the CAN controller used in the project. MCP2515 is a stand-alone Controller Area Network (CAN) controller that implements the CAN specification, version 2.0B. It is capable of transmitting and receiving both standard and extended data and remote frames. The MCP2515 has two acceptance masks and six acceptance filters that are used to filter out unwanted messages, thereby reducing the host MCUs overhead. The MCP2515 interfaces with microcontrollers (MCUs) via an industry standard Serial Peripheral Interface (SPI). Three transmit buffers with prioritization and abort features.

CAN Transceiver

The CAN physical interface used in the project is MCP2551.It is a CAN transceiver. The MCP2551[] is a high-speed CAN transceiver, 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

VI. DESIGN AND SIMULATION RESULTS

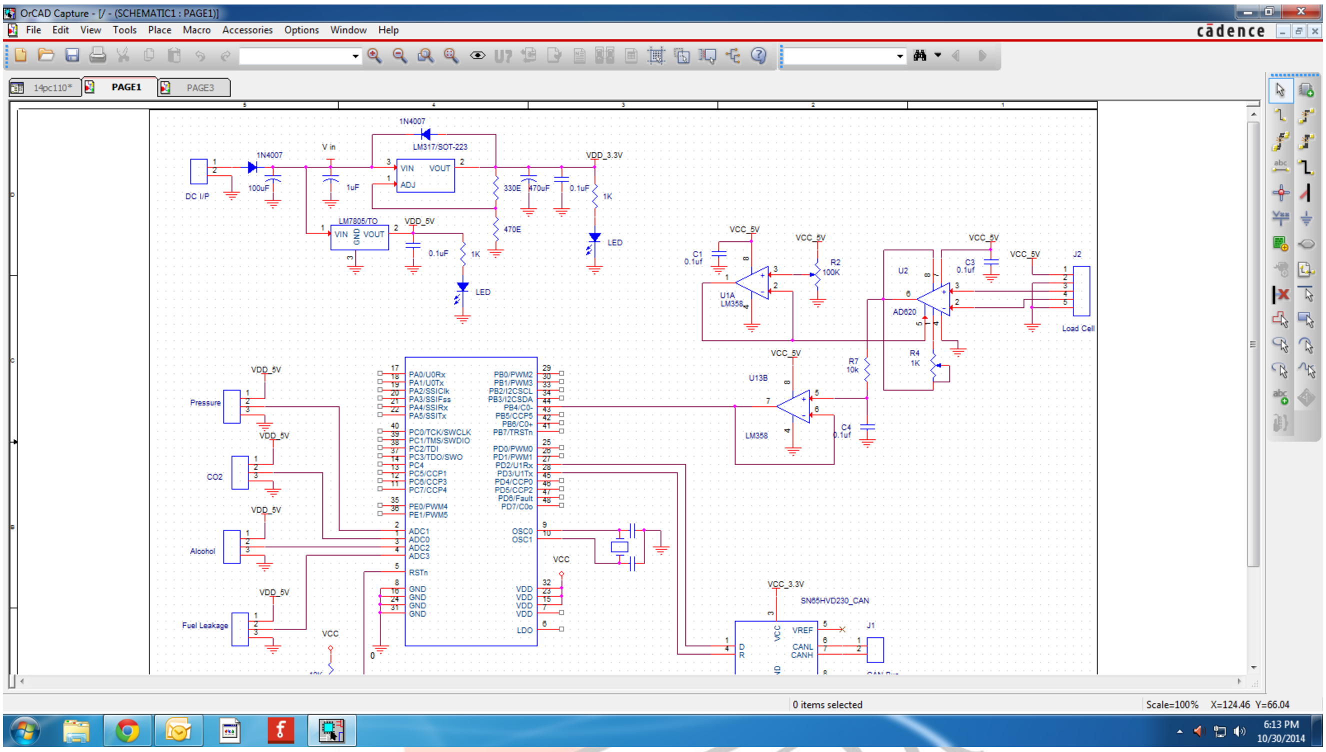

Fig.2.orcad schematic design of power supply, sensors and load cell.

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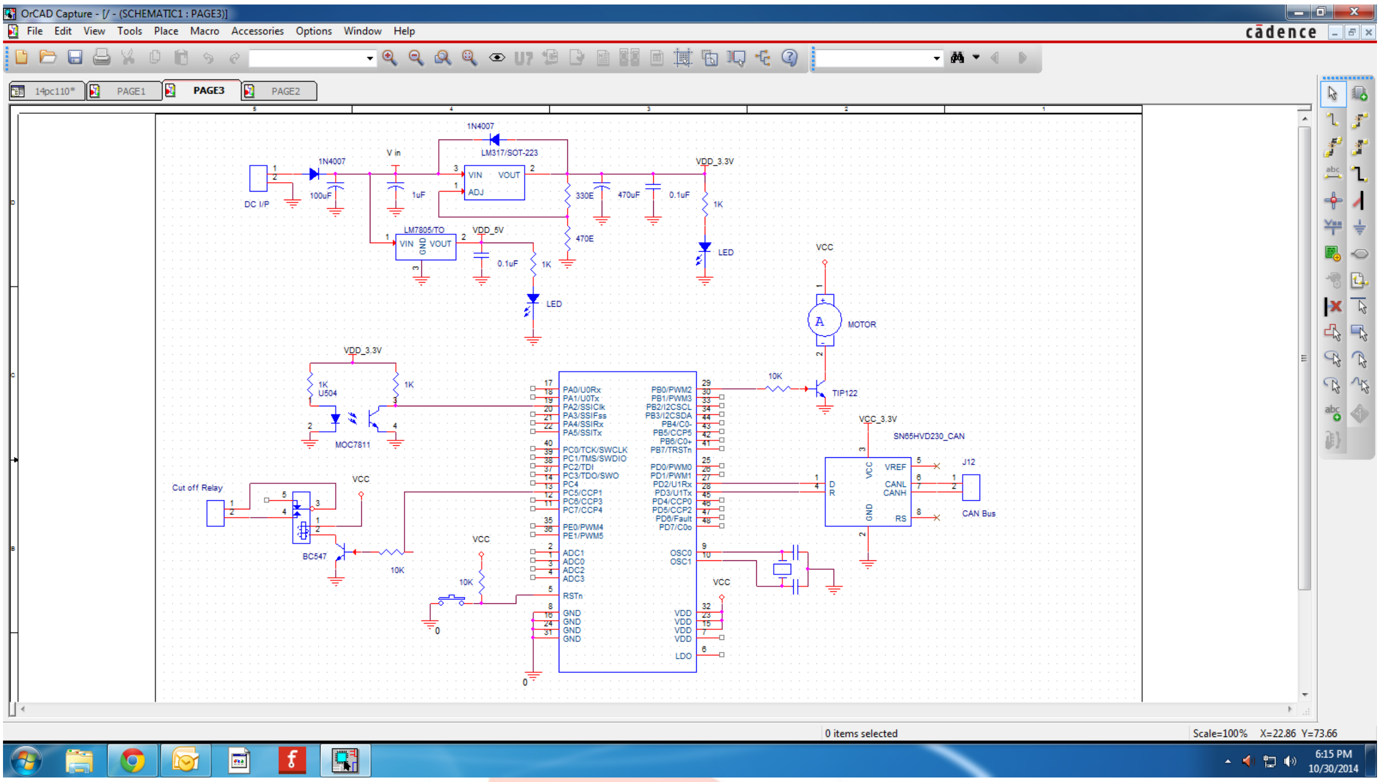

Fig.3.orcad schematic design of ABS unit and power supply

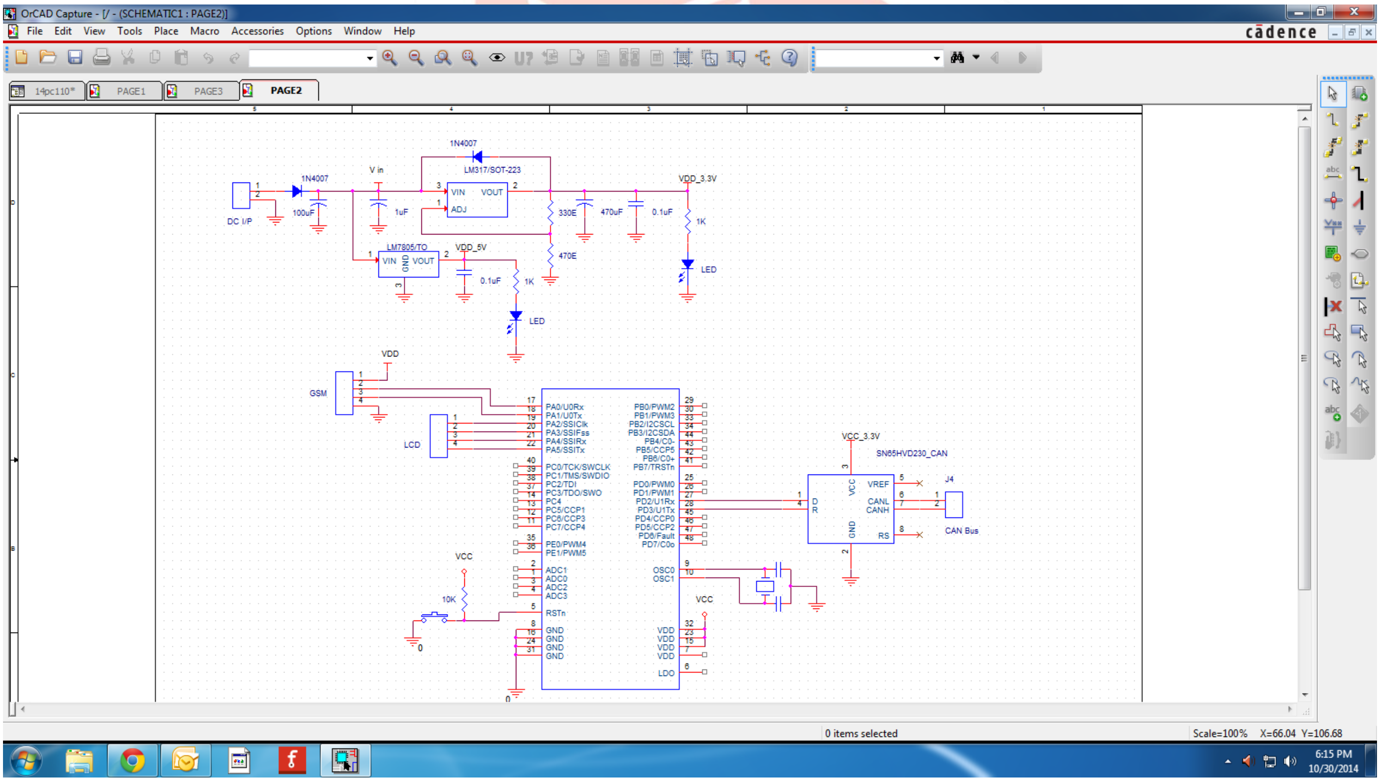

Fig.4. orcad schematic diagram HMI and OBD controller unit.

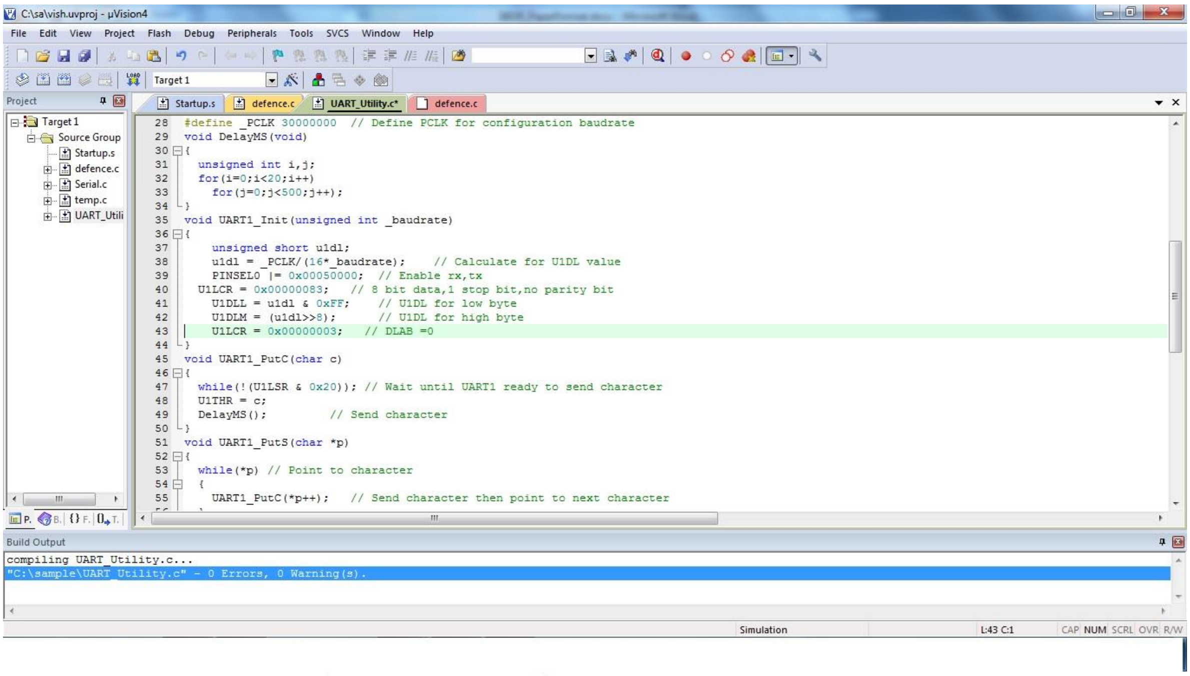

Fig.5.software simulation

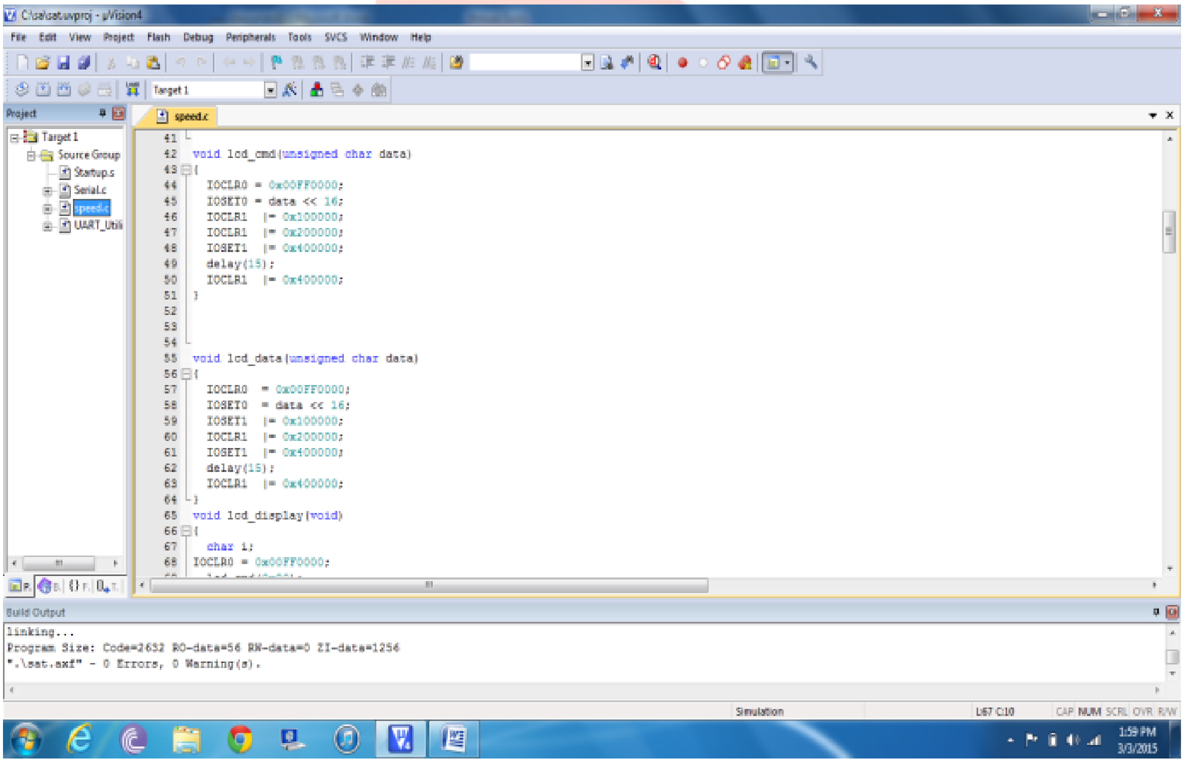

Fig.6.simulation results of uart and sensors

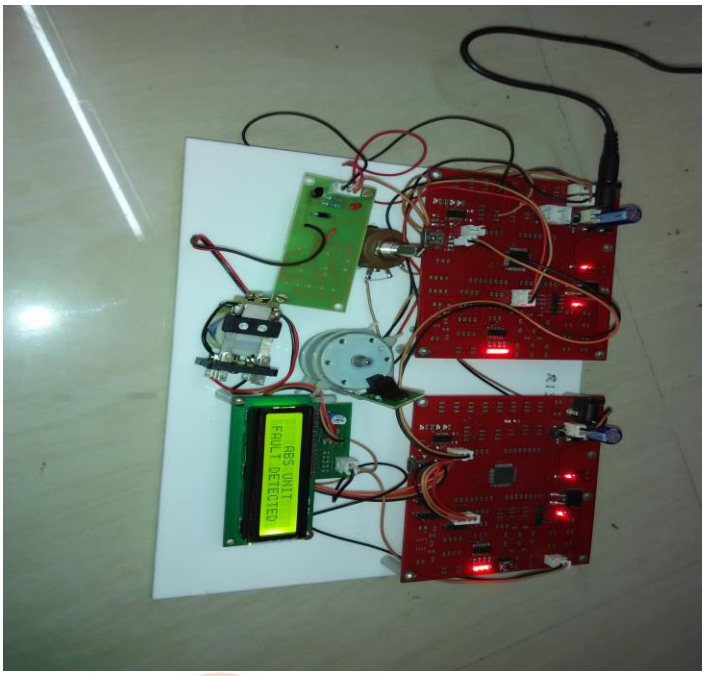

Fig 7. ABS unit interfaced with HMI unit

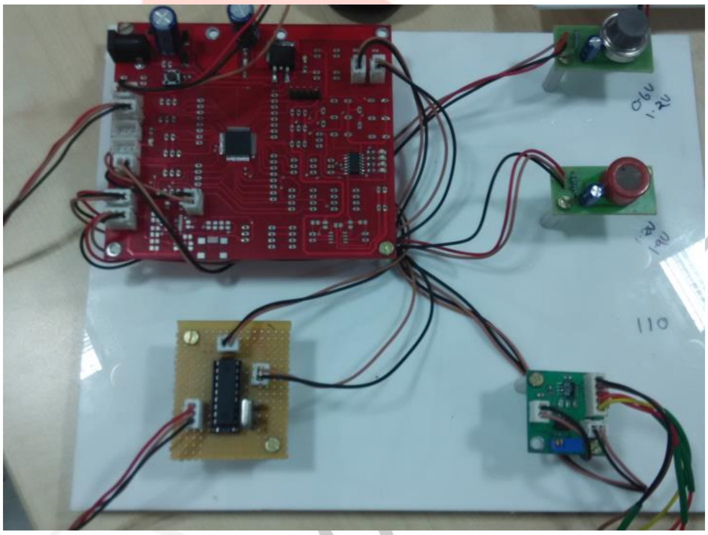

Fig.8. sensors connected in a microcontroller with CAN transceiver

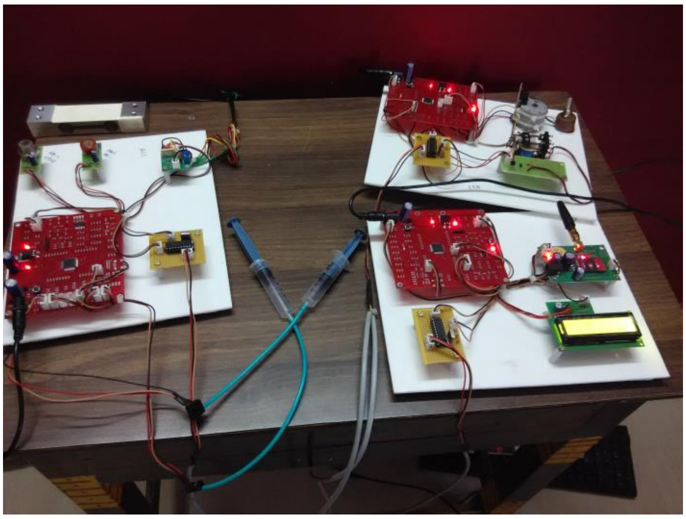

Fig.9. ABS unit ,ECU unit ,sensors are interfaced with HMI unit

VII. CONCLUSION

This project aims to detect and identify the various internal problems in a vehicle such as ABS unit fault,ECU fault and electronics and sub systems fault ,it provides real time information about the vehicle conditions to the vehicle user and the same information to the vehicle service center. This help us to find out the internal problems in a vehicle ,thus reduces the risk of any internal failures.it also increases the performance of the vehicle due to proper maintenance which reduces the operating cost and solves age degrading problems.

VIII. ACKNOWLEDGEMENT

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