International Journal of Scientific & Engineering Research, Volume 4, Issue 8, August 2013
ISSN 2229-5518

Low Cost Fault Diagnostics System for Vehicles

Nishanth P R, Chinn Mohanan

Abstract— On-board diagnostics, or OBD, is an automotive term which refers to a vehicle's self-diagnostic and reporting capability. These systems give the vehicle owner or a repair technician access to state of health information for various vehicle sub-systems. The amount of information available via OBD has varied widely since its introduction in the early 1980s. Early instances of OBD would simply illuminate a malfunction indicator light, or MIL, if a problem was detected but would not provide any information about the nature of problem. This project proposes the development of vehicle diagnostics system based on low cost microcontrollers which can provide real-time readings of vehicle subsystems, which allow one to rapidly identify and remedy malfunctions within the vehicle. The proposed system has a microcontroller based processing system which consists of transducers installed at different parts of vehicle for observation of various parameters, microcontroller unit for processing the output of sensors and signal conditioners, calculate the real- time values of vehicle parameters and give output to display systems. The system will be able to diagnose faults in parameters, abnormal abrupt changes and notify user of any abnormal condition. The system is basically intended for vehicles that do not have built-in OBD systems. It is a user friendly system with LCD display, MIL, GSM and Keypad interfacethroughwhichusercanviewparameter values, warning notifications and defines custom limits for different parameters according to vehicle.

Index Terms— Automobile Transducers, Data logging system, Global System for Mobile Communication, Graphical User Interface, Microcontrollers, Onboard Diagnostics System, Signal Conditioners.

———————————— ◆ ————————————

1 Introduction

THE On-Board Diagnostics systems [1] used standardized protocols for communicating with scan tools through a standardized data link connector (DLC) located in an easily accessible location near dash board. Due to improved technology and resolving compatibility issues in communication, manufacturers are now phasing in a common communication protocol: Controller Area Network (CAN). The CAN communication system operates over two wires in the DLC [9] at much faster rates than any previous communication protocol. Vehicles communicating with CAN are capable of providing over 200 data parameters with a greatly increased update rate. The OBD II hand-held scan tool can be connected to the DLC and can communicates with the OBD system using trouble codes and then displays the information on its LCD. The limitation of these hand-held tools is that whenever they communicate with the OBD system, they send the trouble codes and in return get information which was previously stored by the system. It does not give real-time values and does not mention the time when the information, being displayed, had occurred in the vehicle. It does not provide any repair guidance. Every time MIL indicates a warning, the handheld OBD scanner has to be used to diagnose the problem. The OBD scanner [3] is a costly device and is mainly owned by workshops. In this paper a system is proposed in which standardized scan codes are not used. Fault scanning is done within the system itself, fault is recorded in a data logging system, real-time parameter values are communicated to the user via LCD Display and MIL. An additional feature of reporting engine faults via GSM is also incorporated.

2 Basic Block Schematic

Major sections of the system are shown in figure 1. The main objective of an automobile system is to analyze emission from engine. But it is not directly measured. A system built around microcontroller monitors the performance of emission-related [2] components for malfunctions. For that it uses information from various sensors. The programme loaded in the microcontroller continuously runs in the background, monitors various parameter values from sensors, compare it with the set limits and displays error reports if the read values goes beyond.

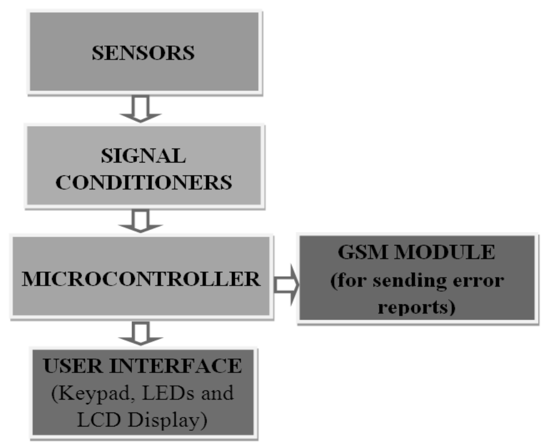

Fig. 1. Basic Block Schematic

The system consists of various types of sensors like Coolant temperature sensor, Coolant flow sensor, Battery voltage level sensor, RPM sensor, Speed sensor and Fuel level sensor [6]. More number of parameters can be included if the number of ADC channel of system is increased. The outputs of sensors are in the form of analog signals or pulse of various voltage levels. In order to apply these signals to a microcontroller, it must be converted to lower voltage and current levels. For this purpose we are using signal conditioners.

The system consists of various types of sensors like Coolant temperature sensor, Coolant flow sensor, Battery voltage level sensor, RPM sensor, Speed sensor and Fuel level sensor. More number of parameters can be included if the number of ADC channel of system is increased. The outputs of sensors are in the form of analog signals or pulse of various voltage levels. In order to apply these signals to a microcontroller, it must be converted to lower voltage and current levels. For this purpose we are using signal conditioners.

User interface provided are Keypad, Malfunction Indication Light, MIL [2] – a set of LEDs and LCD Display. The keypad is a 4X4 matrix keyboard which can be used to enter user data. Some additional Push button switches are provided to obtain error report via SMS and tochange set values of parameters at any time by invoking external hardware interrupt.

3 System Overview

The system is built around a PIC18F452 [5] high performance, low cost microcontroller, which is having an in-built 8 channel Analog to Digital converter. Most of the sensor outputs are in the form of analog voltages. These analog inputs are applied to the controllers built-in ADC. Parameter reading is taken in a Time Division Multiplexing format. ie at a time only one channel is selected and the parameter corresponding to sensor connected to that particular input channel is converted to digital value. After getting the parameter value in the 10 bit format, it is copied to the internal data RAM location corresponding to the particular parameter and displayed through LCD panel. In this way all the sensor values are read and displayed. The process happens in such a fast rate, that we get the real time values of all sensors in the same LCD panel at the same time. Some of the sensor outputs are in the form of pulses (for example rpm and speed sensor outputs). So we need to count these pulses to get the parameter value. For that we connect these inputs to built-in counter units of microcontroller.

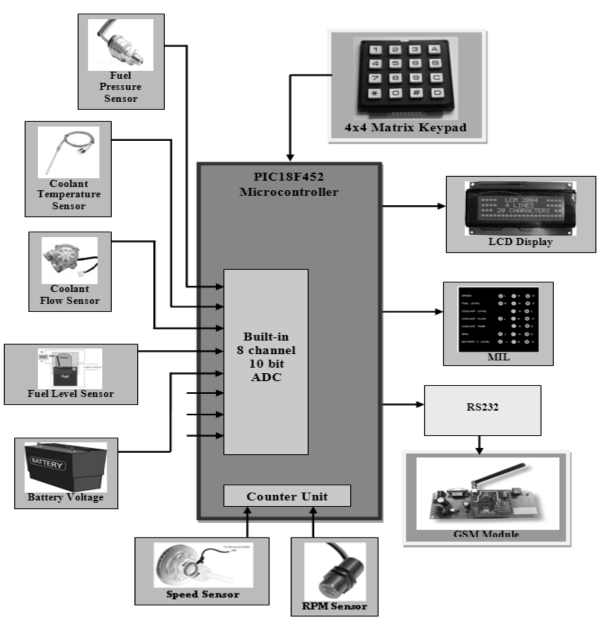

Fig. 2. System Overview

To display the highest and lowest readings of each readings of a particular trip, two more set of variables are used whose values areinitialized with the minimum and maximum possible values respectively. These values are continuously checked with the current readings. As the variable for storing highest values are initialized with lowest possible value and the variable for storing lowest values are initialized with highest possible value, when the system starts these values will be replaced by the first reading. For the next time the same parameter is checked, the current reading is compared with these two updated values, and if found lesser or greater, the corresponding low and high value of the trip are replaced.

To indicate a malfunction via Malfunction Indication Light, we need to know the upper and lower operating limits of each parameter. For this purpose another two sets of variables are used and their values will be automatically taken from the internal ROM at the time of start or user can enter user defined data during operation, at any time. Current readingsarecontinuously compared with upper and lower limits and correspondingMIL is activated.

Thewhole processis repeated in an infinite loop and the real time values are displayed in the LCD display. Two push button switches “SHigh Value” and “Slow Value” are used to see the highest values and lowest values. If these buttons are pressed the corresponding screen will appear for around 8 seconds and go back to the real time value display screen automatically.

If we need to change the upper and lower limits of parameters, we have to press the switch “SChange Parameters” which is attached to one of the external interrupts. When this switch is pressed, authorized persons can access the change parameter window, by keying in a preset password. Now the person can enter parameters one by one following displayed instructions.

Another advantage of the system is the capability to send parameter readings via sms to user’s mobile number. This process also runs within an interrupt service routine for which we use the switch “Ssend SMS” which is attached to another external hardware interrupt. The sms report consists of realtime values, trip low and trip high values.

4 Sensor Sections

Fuel Pressure Sensor: If the fuel lacks in either pressure or volume the vehicle may "starve", causing poor performance or possible internal engine damage [3]. To ensure this does not happen, fuel pressure testing is performed. The fuel pressure sensor is usually screwed into the common fuel rail. It signals the pressure in the fuel rail to the microcontroller. Fuel pressure can run between 25 to 60 psi of pressure depending on the vehicle and manufacturer.

Coolant temperature Sensor: Resistance thermometers, also called resistance temperature detectors RTDs [6], are sensors used to measure temperature by correlating the resistance of the RTD element with temperature. Most RTD elements consist of a length of fine coiled wire wrapped around a ceramic or glass core.The RTD element is made from a pure material, platinum, nickel or copper. The material has a predictable change in resistance as the temperature changes. It is this predictable change that is used to determine temperature. RTD sensors (eg: PT-100, PT 200) are located inside coolant passage in the engine. The normal operating temperatures are around the 80-90 degrees Celsius and 120 is the absolute maximum.

Measurement of Fuel level, Engine oil Level and Coolant level in reservoir: The sending unit is located in the fuel tank of the car. It consists of a float, usually made of foam, connected to a thin, metal rod. The end of the rod is mounted to a variable resistor. A resistor is an electrical device that resists the flow of electricity. The more resistance there is, the less current will flow. In a fuel tank, the variable resistor consists of a strip of resistive material connected on one side to the ground. A wiper connected to the gauge slides along this strip of material, conducting the current from the gauge to the resistor. If the wiper is close to the grounded side of the strip, there is less resistive material in the path of the current, so the resistance is small. If the wiper is at the other end of the strip, there is more resistive material in the current's path, so the resistance is large. These changes in resistance value is converted to voltage variations using signal conditioners and given to controller for processing and displaying fuel level through LCD display.

Speed Sensor: The speed sensor [4] gives off an electrical signal when rotated that is used by the microcontroller to calculate speed. This signal is transferred to the digital display to illustrate speed. It can be re-calibrated to compensate for differences in tires and final gears. The speed sensor is situated in the tail housing of a conventional rear wheel drive vehicle. In front wheel drive vehicles, it is situated on the topside of the transmission on the differential housing near the drive axles.

RPM Sensor: Hall Effect based RPM sensors can be used for getting RPM pulses and it can be applied to microcontroller timer unit to count the number of pulses per minute. Another easy way to find out the RPM of engine is to count the number of pulses produced by the negative terminal of ignition coil in every one second. For a four cylinder engine, the count per second is multiplied by 60 giving counts per minute and each pulse produces a spark in one cylinder producing one crankshaft revolution. So the count per minute is actually revolution per minute. Ignition coil produces pulses of 12 volts which are converted to 5volts using opamp comparator. Internal counter of the microcontroller is used for counting purpose. After each second, the previous count value is stored and then count is refreshed for next reading.

Battery status: Standard power backup systems in automobiles rely upon a 12 volt rechargeable battery system which consists of a dynamo, inverter, regulator and a battery recharging system. If vehicle is off, battery terminal must have 12 to 12.5 volts and lesser voltage shows weak battery. In running condition the terminal voltage must be 13 to 15 volts and lesser values shows fault in charging system. This voltage is firstly brought down to a range executable by the built-in analog to digital conversion unit of micro-controller. For this purpose, a simple voltage divider followed by a voltage buffer is used and output of buffer goes to the input ADC pin of controller. Controller produces a 10-bit result and displays the value in the display device.

Coolant Flow sensor: The "typical coolant flow rate range" is between about 2 and 14 gallons per minute. Flow sensors [8] (eg. Koolance's inline flow meter - INS-FM17N) provides electronic indication of real-time coolant flow rate. Another simple, cost effective way is to use reed switch based flow sensor (eg. MC-1425 and SM-1322) which can be connected in the coolant line of automobiles. As long as the coolant is flowing, the reed sensor does not actuate. If by chance, there is a block or if the coolant valve malfunctions, an indication is given to the microcontroller.

5 Algorithm

Main Programme:
Step1: Load stored parameter limit values from internal memory (EEPROM)
Step2: Initialize Lowest and Highest value display variables with Highest and Lowest possible values.
Step 3: Initialize various ports and pins according to interfaced devices or signals (Display, Keypad, LEDs, Analog signals, Pulses etc)
Step4: Set a timer for providing 1 Second delay
Step5: Configure another two counters to count rpm and speed pulses.
Step6: Call ADC programme to read parameters
Step7: Read counter values to get number of pulses
Step8: Covert read analog values and pulse counts to proper values based on properties of transducers.
Step9: Compare these current values with lowest and highest value display variables andif found lesser or greater, replace with current values.
Step10: Display values through LCD panel.
Step11: Call MIL programme to compare read values with set limits and activate corresponding MIL if some values are found beyond limits.
Step12: Check status of switch S Low Value, if not pressed go to step 14
Step13: Display lowest values of the trip for 8 seconds.
Step14: Check status of switch S High Value, if not pressed go to step 16
Step15: Display highest values of the trip for 8 seconds.
Step16: Go to step 6
Step17: End

Interrupt Programme 1 (for Changing Parameter Limits):
Step1: Display “Enter Password”
Step2: Check entered password with stored password and if incorrect display “Invalid password” and go to main programme
Step3: Display messages to enter various limits one by one.
Step4: Enter limits one by one.
Step5: Return from interrupt to main programme.
Step6: End

Interrupt Programme 2 (for sending sms report):
Step 1: Initialize gsm module with proper baud rate, mode of operation and message centre number using AT commands.
Step2: Send command to modem for sending sms to stored mobile number
Step3: Output parameter names and values by calling serial

data write programme.
Step5: Send the sms using proper AT command.
Step6: Return from interrupt to main programme.
Step7: End

6 Simulation Results using MikroC and Proteus

MikroC PRO for PIC was used for writing and debugging code for the system and the circuitry was simulated using Proteus. The hex code generated by Mikro C was loaded in to the PIC using Proteus and the operation was successfully simulated. The outputs of most of the parameters are in the form of analog voltage variations. To test these, output from varistors are used and calibrated based on the actual sensor outputs. Only temperature sensor is available as such in Proteus for simulation. For testing speed and rpm sensors, analog pulses are applied to PIC and calibrated based on the actual sensor outputs. The simulated output is shown in figure3.

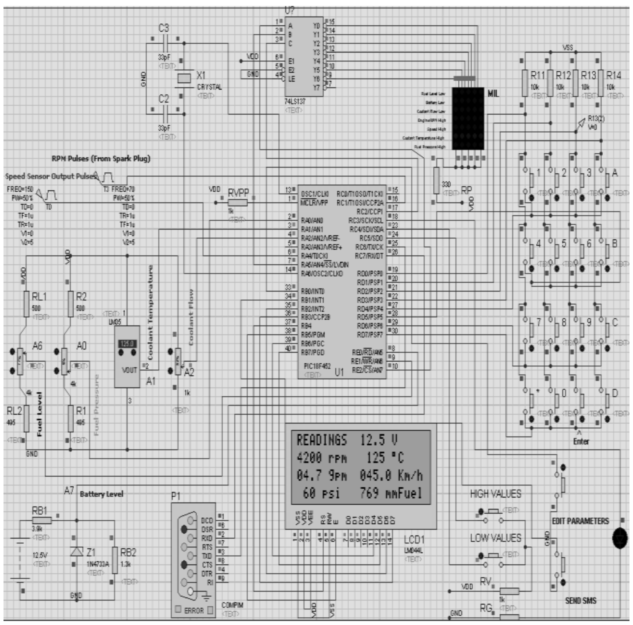

Fig. 3. Simulation result displaying real time readings.

To test the operation of gsm module using proteus, one COM port is connected to RXD and TXD pins of PIC [5] and the COM port is linked to the actual COM port of computer using Proteus COM port settings. The SIM300 modem is connected to computers COM port. To send the sms switch "Ssendsms" was pressed and the message was successfully sent to stored mobile number. Message sent to the stored mobile number using proteus is given in figure 4.

Fig. 4. Sending SMS report of parameters – Simulation result using Proteus.

7 Conclusion

As the systems monitors vehicle performance while the vehicle is being operated, it provides real-time diagnostics information to the user. It is a low cost diagnostic system which is mainly intented for vehicles without any factory fitted OBD systems. It can be fitted to the vehicle without much modification to the vehicle parts. User can access the real time report of system parameters at any time to his mobile in the form of SMS. So no need of any standard fault codes, communication protocol, connection hardware, and the scan tools to check the system - the user can directly show the error report to technicians. So this system has a reduction in the complexity and cost compared to the existing OBD systems. As a future development, touch screen graphic displays can be incorporated which can avoid the need of Keypad and more information can be displayed. If an extrnal data memory is interfaced with the system, all the instantaneous values can be logged and we will be able to get detailed report. Main limitation is the number of available ADC channels in the system. But the number of parameters under observation can be increased by interfacing an external multichannel ADC with the PIC Controller.

References

[1] Nouman Naim Hasan, AdeelArif, Usman Pervez, Muhammad Hassam, Syed ShabeehUlHusnain, "Micro-controller Based On-Board Diagnostic (OBD) System for Non-OBD Vehicles", *978-0-7695-4376-5/2011 IEEE.*

[2] C. E. Lin, Y.-S. Shiao, C.-C. Li, S.-H. Yang, S.-H. Lin, C.-Y. Lin, "Real-Time Remote Onboard Diagnostics Using Embedded GPRS Surveillance Technology," *IEEE Trans. on Vehicular Technology,* Vol. 56, No. 3, pp. 1108-1118, May 2007.

[3] "SAE J2178/4 FEB95", *SAE Diagnostics for Light and Medium Duty Vehicles Standard Manual*, 1997.

[4] C. E. Lin, C. C. Li, S. H. Yang, S. H. Lin; C. Y. Lin, "Development of On-Line Diagnostics and Real Time Early Warning System for Vehicles", *Proc. IEEE Sensors for Industry Conference*, pp. 45-51, Feb. 2005

[5] PIC18FXX2 Data Sheet - 39564c.pdf, *ww1.microchip.com/ download*

ds/en/devicedoc/

[6] Xu Zun, Liu Lili, "The Application of Temperature Sensor in Automobile", *July 2011 IEEE* , 978-1-4577-0859-6.

[7] Jim Luyckx, Mohan Sethi, Mike Clancy. "Completely integrated diagnostic platform using industry standard PCs and internet update". *SAE 2004*-01-0674

[8] Hu Jie, Yan Fuwu, Tian Jing, Wang Pan, Cao Kai, "Developing PC-Based Automobile Diagnostic System Based on OBD System" 978-1-4244-4813-5/10 /$25.00 ©*2010 IEEE*

[9] Kher, S., Shri G.S., Chande, P.K., Sharma, P.C. "Automobile engine fault diagnosis using neural network", 0-7803-7194-1/ Intelligent Transportation Systems, 2001. *Proceedings. 2001 IEEE*