VEHICLE HEALTH MONITORING SYSTEM

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Abstract

This paper deals with developing an embedded system for detecting the vehicle condition by monitoring the internal parameters that are used in evaluating the vehicle's current health condition. Traveler information plays a critical role in supporting safety, security, mobility, and in improving the reliability of travel. This traveler information can be a continuous data on performance of the vehicle and the status of its internal components. In this project, an in-vehicle embedded system is being developed to generate a vehicle health report (VHR) whenever needed by the user. It also acts as an eco friendly vehicle by monitoring the emissions from the car which in turn helps in regulating (by taking proper actions to reduce the emissions as per the faults indicated in the VHR) the environmental pollution. It predicts the future errors so that the driver can have an uninterrupted journey and can avoid accidents. Thus, it alerts the driver about future errors and assists him for a safe drive. The data required for generating the health report consists of parameter values (outputs of in-built sensors) of different systems inside the vehicle. This data can be obtained using the OBD-II protocol which is followed by the vehicles manufactured after 1996. It uses LabVIEW as platform that has automotive diagnostic command set tool kit which helps in building up the software required to communicate with the vehicle's ECU through OBD-II system.

Keywords: NI(national instruments), Tpc(touch panel computer),OBD(on board diagnostic system),

I. INTRODUCTION

The total car sales rose to 2.6 million units in India alone by the year 2009.With the increase in number of cars along with other modes of transport such as public transport system, vehicles for supply chains and two wheelers on road, the issues like safety, fuel consumption, pollution check are of utmost importance which depends on vehicle condition, road infrastructure and driver behavior.

This project aims at developing an embedded system for detecting the vehicle condition by monitoring the internal parameters that are used in evaluating the vehicle's current health condition. These parameters are obtained using OBD2 protocol through a port provided by the manufacturers to the vehicles.

A real time evaluation system is being defined that can be used for rapid condition screening and provide reliable information about the vehicle conditions. This real time evaluation system can be called Vehicle Health Monitoring System. This system uses HMI display so that the reports and the alerts can be displayed on it and also feedback from the user can be taken using its touch response.

The system model being developed is a standalone on-board model which will be a black box for outside world. This model can be extended to identify and report the faults in car to the authorized service centre through wireless communication, a concept of remote diagnostics.

II. TOOLS REQUIRED

- LabVIEW-2009 platform
- Automotive diagnostic command set tool kit
- NI LabVIEW Touch panel module
- **2** Port High-Speed & Low-speed CAN Module: NI9853
- CAN (High speed CAN interface) to OBD (standard J1962 diagnostic connector) cable
- CompactRIO
- NI TPC 2106T Touch panel

III. ON-BOARD DIAGNOSTIC SYSTEM-II

On-Board Diagnostics refers to a vehicle's self-diagnostic and reporting capability. OBD systems give the vehicle owner or a repair technician access to state of health information for various vehicle sub-systems.

A. Use of OBD to Monitor Vehicle Performance:

Since 1996, OBD systems have been incorporated into vehicles to help manufacturers meet emission standards set forth by the Clean Air Act in 1990 and the Environmental Protection Agency (EPA). The Society of Automotive Engineers (SAE) developed a set of standards and practices that regulated the development of these diagnostic systems. The SAE expanded on that set to create the OBD-II standards. The EPA and the California Air Resources Board (CARB) adopted these standards in 1996 and mandated their installation in all light-duty vehicles.

The OBD-II system allows for monitoring of most electrical systems on the vehicle. The OBD-II standard specifies the type of diagnostic connector and its pinout, the electrical signaling protocols available, and the messaging format. It also provides a candidate list of vehicle parameters to monitor along with how to encode the data for each.Monitored items include speed, rpm, ignition voltage, and coolant temperature. This system also informs an engineer when an individual cylinder has a misfire. The OBD-II standard also provides an extensible list of DTCs. As a result of this standardization, a single device can query the on-board computer(s) in any vehicle.

The SAE recognizes at least four communication patterns described in **Error! Reference source not found.**. The SAE J1850 VPW standard uses a variable pulse width modulation signal. It operates at 10.4k Baud with one signal wire and a ground wire. The SAE J1850 PWM standard uses a pulse width modulation signal. This operates at 41.7k Baud by using a differential transmission scheme. The ISO 9141-2 standard uses two signals (K and L). One signal travels on a full-duplex wire, and the other operates on a half-duplex wire. Most communications with the OBD-II bus occur on the K signal while the L signal is required for initialization of the bus. The latest standard is based on the controller-area network (CAN) standard (ISO 15765). This network can provide up to 500 Kbit/s data rates operating on either a differential signal or single-wire configuration.

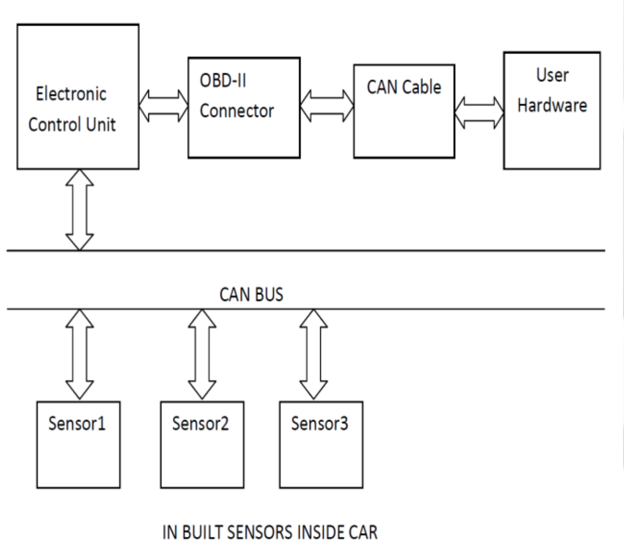

Fig 2: Block diagram of OBD system

B. OBD-II Diagnostic connector*:*

The OBD-II specification provides for a standardized hardware interface—the female 16-pin (2x8) J1962 connector.

The SAE recognizes four protocols in the J1850 standard, which define how electrical signals will propagate through the vehicles communication bus, are in Table1.

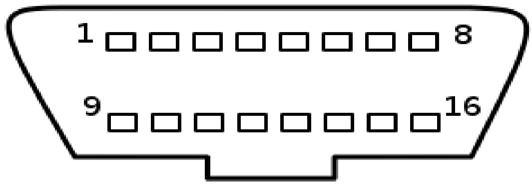

Fig 3: Diagnostic connector

Table1: Signaling protocols in OBD-II

Protocol	**Signal Type**	**Manufacturer(s)**
SAE J1850 VPW	Variable Pulse Width	GM
SAE J1850 PWM	Pulse Width Modulation	Ford
ISO 9141-2	Two Serial Lines: Half-duplex (L) Full-duplex (K)	European, Asia, and Chrysler
ISO 15765 (CAN)	Single or Dual Wire Serial Lines	Most manufactures are beginning to incorporate CAN

We are developing for Asian Vehicles like Honda which use ISO 9141 that uses the same OBD-II diagnostic connector J1962.

C. Modes of Operation:

There are ten modes of operation described in the latest OBD-II standard SAE J1979.

Out of which mode1,mode3 are important for this application as they contain the required vehicle current data and the diagnostic trouble codes(DTCs).Mode4 can be used for clearing or resetting DTCs.

Each mode gives information on a group of vehicle parameters. There are nearly 50 parameters in mode1. Some of them are shown in table. Each parameter is identified by a code called parameter identification number or simply parameter ID (PID).For example , for engine rpm the code is 01 0C. The first code 01 represents the mode and the second code 0C represents the PID. The ECU sends the parameter value on receiving the corresponding PID.

The min and max values give the dynamic range of the parameter. The data received from the ECU is the binary data. A formula is used to convert binary value of the parameter to its actual physical value. This formula used varies for different parameters as shown in the table 2.

Table 2: Modes and parameters from ECU

Mode (hex)	PID (hex)	Data bytes returned	Description	Min value	Max value	Units	Formula
01	04	1	Calculated engine load value	0	100	%	A*100/255
01	05	1	Engine coolant temperature	-40	215	°C	A-40
01	0A	1	Fuel pressure	0	765	kPa (gauge)	A*3
01	0B	1	Intake manifold absolute pressure	0	255	kPa (absolute)	A
01	0C	2	Engine RPM	0	16,383.75	rpm	((A*256)+B)/4
01	0D	1	Vehicle speed	0	255	km/h	A
01	0F	1	Intake air temperature	-40	215	°C	A-40
01	10	2	MAF air flow rate	0	655.35	g/s	((A*256)+B) / 100
3	N/A	n*6	Request trouble codes				3 codes per message frame, BCD encoded.
04	N/A	0	Clear trouble codes / Malfunction indicator lamp (MIL) / Check engine light				Clears all stored trouble codes and turns the MIL off.

IV. AUTOMOTIVE DIAGNOSTIC COMMAND SET TOOL KIT:

The Automotive Diagnostic Command Set supports the following services:

- Diagnostic Management
- Data Transmission
- Stored Data Transmission (Diagnostic Trouble Codes)
- Input/output Control
- Remote Activation of Routine

A. Structure*:*

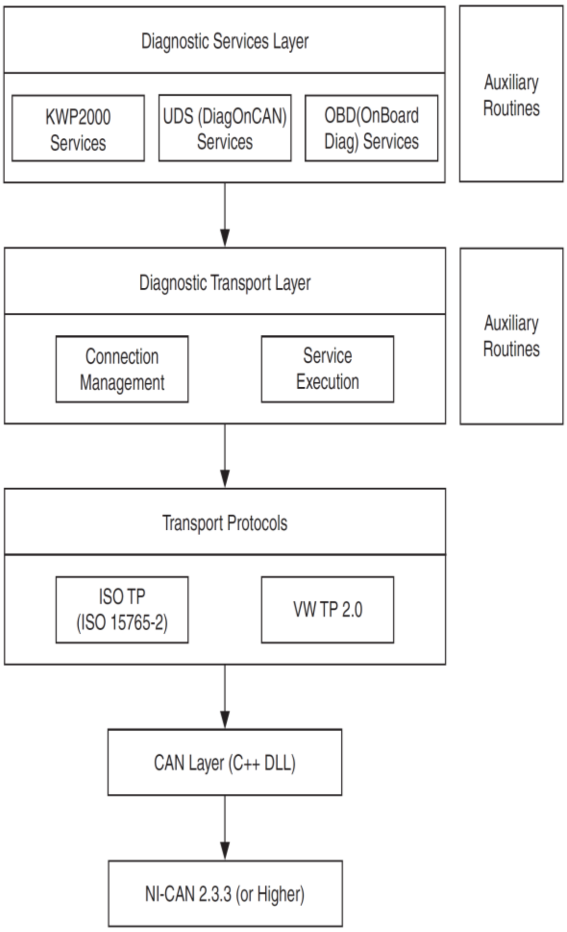

Fig 4: Structure of ADCS working

The Automotive Diagnostic Command Set is structured into three layers of functionality:

- The top layer implements three sets of diagnostic services for the diagnostic protocols KWP2000, UDS (DiagOnCAN), and OBD (On-Board Diagnostics)
.
- The second layer implements general routines involving opening and closing diagnostic communication connections, connecting and disconnecting to/from an ECU, and executing a diagnostic service on byte level. The latter routine is the one the top layer uses heavily.

- The third layer implements the transport protocols needed for diagnostic communication to an ECU. The second layer uses these routines to communicate to an ECU.

All three top layers are fully implemented in LabVIEW.

The transport protocols then execute CAN Read/Write operations through a specialized DLL for streamlining the CAN data flow, especially in higher busload situations.

V. HMI DISPLAY USING TPC 2106

The LabVIEW Touch Panel Module is an extension of the LabVIEW graphical development environment, which you can use to quickly create, build, and deploy HMIs. It provides a single, integrated graphical environment for developing HMI and PAC applications. The LabVIEW Project Explorer window facilitates the distribution of these complex systems across multiple targets and operating systems. With the Touch Panel module, the LabVIEW Project includes supports for programming touch-screen HMIs as well.

With the LabVIEW 8.5 Touch Panel Module, simply selects your TPC target, choose a template for development, and deploy over Ethernet using the run button.

A. Remote Display Software:

A TPC-2106/T includes remote display software already installed on the TPC when it is shipped. To view the entire screen and interact through your PC with the embedded touch panel computer, simply install the free host program and connect to the hardware. From the Windows CE start menu, select the Remote Display application and enter the IP address of the host PC. With the Remote Display function, you can quickly interact with the embedded touch panel hardware using your PC keyboard, mouse, and screen.

B. HMI for PAC-Based Machine Control Systems with NI CompactRIO:

For embedded machine control systems with CompactRIO, a TPC-2106/T is ideal as a local operator interface to provide input and feedback to the CompactRIO machine control unit. A TPC-2106/T functions as the local HMI for CompactRIO, as shown in Fig 5.

C. Output on HMI display:

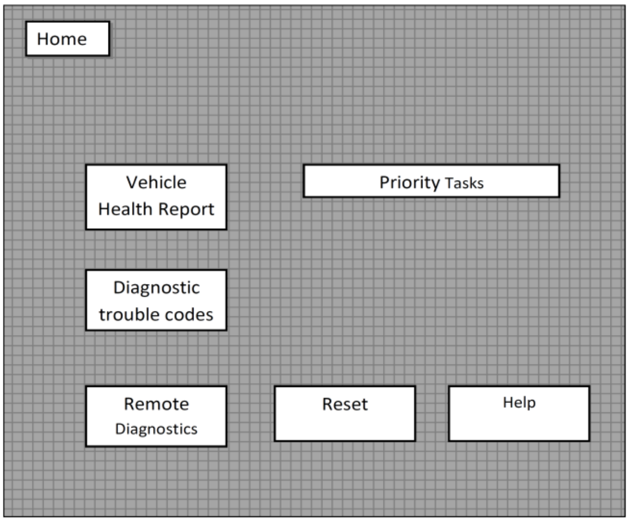

Fig 8: Home Page on Touch Panel

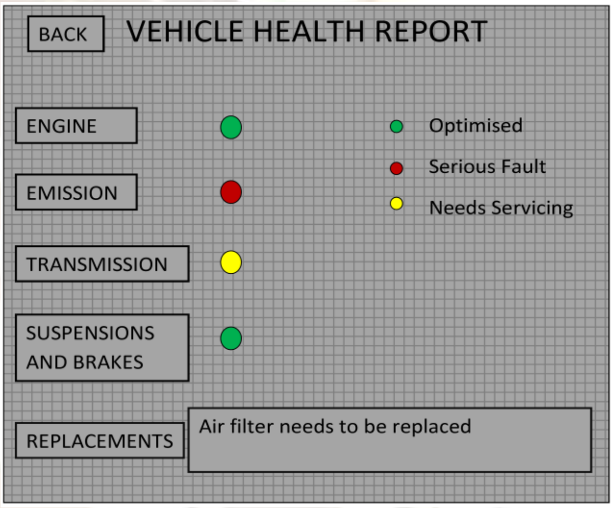

Fig 9: VHR HMI on pressing VHR on Home Page

VI. WORKING OF THE MODEL

The main innovative functionality of this system is the auto diagnostics of the vehicle.

Firstly, the communication VI and the processing VI are dumped into cRIO to enable it to work as a standalone system. The cRIO through the CAN module acts as an interface between in-vehicle ECU CAN bus (from which vehicle data is extracted) and the touch panel (where the report is displayed).

The CAN module on cRIO is connected to the OBD-II port in car using a CAN cable available in NI. The touch panel is connected to cRIO through the Ethernet. The touch panel is programmed such that as soon as the modules are powered (using a portable 12V supply) the display on the touch panel is the home page shown in Fig 8. Also, at the same time the communication VI in the cRIO starts running and thus starts communicating with the ECU and dynamically extracts the vehicle parameters.

To generate the health report user needs to press on the VHR on the home page. Then, the dynamically collected vehicle parameters are loaded into the processing VI. Using the prognostics and diagnostics for a specified vehicle in the processing VI, the condition of significant systems in the vehicle is found and represented as shown in Fig 9.

The ECU generates some codes to indicate problems arising in the functioning of several components and inbuilt sensors inside the car. These codes are called diagnostic trouble codes. On pressing DTCs on the home page, the malfunctions of the components if any are reported. If there are more troubles or malfunctions arising in the car, the problem that needs prior attention from the user can be listed in the order of its priority in the priority tasks tab provided on the home page. The user on noticing these can take an appropriate action on a problem to make it optimized as before. The user then can reset the diagnostic trouble codes.

Hence, this model can act as a stand alone embedded system which can be fitted into the car along with other electronics during manufacturing or can be separately attached to the car below 3 feet from the steering.

This model uses NI touch panel which has a programming environment that supports it to act as an interface for integrating various other user applications like audio/video inside the car. So, other applications can also be accessed using the same touch panel.

VII. VI DEVELOPMENT

The VI's to be developed are classified as Communication VI's and Processing VI's.

A. Communication VI:

The communication VI is used to communicate with internal ECU CAN bus of the car. This VI generates the required control signals that manage the communication protocols and transfer of data. This VI is developed using the automotive diagnostic command set tool kit available on the LabVIEW platform. This tool kit provides the nodes or inbuilt VI's to be used for establishing a connection and extracting data. This VI dumped on to the cRIO starts communication procedure through the CAN module on powering up the module.

Initially, for acquiring data a 'start diagnostics' command is sent to the CAN bus, which in turn responds to the request. The present values of all the inbuilt sensors are passed through CAN bus. Mode number is given as input such that all the sensor values in that mode are obtained as output. After obtaining the VHR, to close the connection a 'close diagnostic' command can be issued. Acquisition of values from both inbuilt sensors and others must be synchronized and processed.

B. Processing VI:

The VI measures different parameters. One of the major features which make this VI different from the other algorithms is that it also uses the probabilities, prognostics and other statistics to display the present status of vehicular components.

The main VI comprises of several subVIs each for individual parameters. These individual subVIs are then clubbed together to bring out a single VI which can be manipulated according to the user or manufacturer needs. The VI's front panel is displayed on a HMI display for a human to machine interface. For better human response the status is displayed in red, yellow, green colors indicating various status levels. The sub Vis includes:

1. When a problem has occurred in any of the components of the car the ECU produces trouble codes. These are in large numbers and the sub VI DTCVI then identifies and decodes the trouble code which is generated by the ECU and displays the same on the HMI when requested.
2. The next aspect is the throttle. The pedal is a form of potentiometer circuit which controls the throttle position for fuel injection according to the inlet air. For throttle position manipulation, the vehicle consists of an inbuilt sensor which has three reference levels. The ECU produces voltage pulses by this sensor which are received by this sub VI which indicates the position of the throttle.(if voltage equals to 1 then the throttle is fully closed, if voltage equals to 5 then throttle is fully open, generally the voltage varies between these values.
3. The other one is the transmissions. Measured in terms of number of miles, there are different types if transmissions namely, automatic and manual. The VI has two separate sections for these types. The automatic VI has a unique algorithm, calculating the temperature continuously. According to research it is found that for every 20 degrees rise in fluid temperature the life time (measured in miles) reduces to half the initial value. The same is for the manual transmissions.
4. Various sensors give the engine temperature, ambient temperature and are given to the ECU, which are then routed to the Sub VI. These are then compared with their threshold and principle values and the corresponding results are then displayed on the HMI screen. The car is then rated accordingly.
5. Emissions: It has been found that it is impractical inserting the Carbon dioxide and oxygen sensors directly into the emission tubes. This is because the sensors are not robust enough to withstand high temperatures. So, the emissions are calculated when the vehicle is in standby mode.
6. The battery status, fuel status and other fluids status is directly- routed from the ECU to the

respective sub VI and compared with their principle and threshold values- and status is displayed.

7. The most important feature, the replacement algorithms takes into consideration the outputs of the entire sub VIs, prioritizes them and displays the status whether any of the parts, fluids, and sensors is to be replaced. A separate VI governing all these VIs is developed making the VHR a completely user friendly one.

IX. APPLICATIONS

1. **Auto insurance:** As it provides health of the vehicle the insurance companies pay according to its health and usage.

2. **Remote monitoring**: In this every car has an in built system which continuously monitors and sends information to server, when the car health reaches alarming rate's the service provider warns the customer (thus reducing system failure and accidents).

3. **Future scope:** we can develop voice-controlled wireless technology that connects drivers to various health-monitoring technologies and services for things such as Web-based allergen alerts, asthma management tools and diabetes control.

X. CONCLUSION

The project is started with gathering of information required for generating the health report. This information includes the dependence of vehicles performance on various parameters of car subsystems. Also different methods for health monitoring, which differ by the way of extraction of parameter values, are observed regarding their feasibility and economic factors and is finally decided upon using ADCS of LabVIEW platform.

In the next stage, the building of the software i.e. Vis is started. As currently the automotive diagnostic tool kit is not available to write the communication VI's, processing VI coding is started. The data collection procedures required for this VI are completed. Several IEEE papers are referred regarding the statistical and probabilistic methods for grading the health of the vehicle. The algorithm designs for the processing VI as well as its coding are completed. The VI code is also tested for its working.

The programming of the touch panel module is understood. Its connection with the system through the Ethernet is tested successfully. The design of the HMI pages by writing the VI code is completed. The working of these pages is also tested successfully.

The processing VI coding is dumped into the cRIO which is interfaced with the touch panel on which HMI pages are running. Thus, a stand alone system is built and can be demonstrated using an external sensor in the absence of the tool kit.

In the days to come, integration of two or more applications with the touch panel will be achieved. We will also be working upon communication VI's if the ADCS tool kit is procured. Later wireless communication of the vehicle data to a central location will be worked upon.

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