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Review Paper on Vehicle Diagnosis with Electronic Control Unit

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Abstract—An Automobile vehicle is prone to various faults due to more complex integration of electro-mechanical components. Due to the increasing stringency of emission norms improved and advanced electronic systems have been widely used. When different faults occur it is very difficult for a technician who does not have sufficient knowledge to detect and repair the electronic control system. However such services in the after sales network are crucial to the brand value of automotive manufacturer and client satisfaction. Development of a fast, reliable and accurate intelligent system for fault diagnosis of automotive engine is greatly urged. In this paper a new approach to Off- Board diagnostic system for automotive engine, and more particularly, to an off-board digital analyzer for diagnosing the fault in vehicle systems is presented. A diagnostic tool was designed and developed by Ram Kumar Arunachalam and Kapil G Krishnan of VE Commercial Vehicles Pvt. Ltd. Patent no. 131/MUM/2015. It is an automated method and system for vehicle diagnostics and health evaluation by a service Technician. The invention will clearly identify and display the faulty component by means of measuring electrical parameters automatically, without the assistance or intervention of a tool or a technician.

Keywords—Electronic; In-vehicle; Diagnostics; Intelligent; Control; Analyzer;

I. INTRODUCTION

Automotive vehicles are nowadays equipped with various number of networked electromechanical systems through which advanced vehicle control, elimination of bulky wiring, and sophisticated features can be achieved. Most of the features work by the use of electro-mechanical systems including sensors, switches, actuators and electronic control units(ECU).There are more than fifty individual ECUs communicating over multiplexed data networks such as Controller Area Network (CAN), Local Interconnect Network (LIN) etc. In addition rising feature levels have resulted in the embedded software and electronic components becoming an increasing part of the total value of the vehicle. The average cost for invehicle electronic system increased from 2% of the total car price in 1974 to 23% in 2004, and was forecasted to reach 40% by 2010[6]. To date Off- board diagnostic(OBD) systems have come into play to cope with faults. Off board diagnostics defines the systems methods and tools which are used to diagnose and isolate the fault in the diagnostic systems. With increasing severity of energy crisis and stringency of exhaust gas legislation, the electronically controlled system has been widely used in engines for performance optimization of the engine as well as vehicle propelled by the engine[1].The faults in the automotive engine may lead to increased emissions and more fuel consumption with engine damage. These affects can be prevented if faults are detected and treated in timely manner. A number of fault monitoring and diagnostic methods have been developed for automotive applications. The existing systems typically implement fault detection to indicate that something is wrong in the monitored system, fault separation to determine the exact location of the fault i.e., the component which is faulty, and fault identification to determine the magnitude of the fault. Many existing systems implement only the fault detection and isolation stages by means of diagnostic codes and failure sub types. Further determination of the exact fault requires the use of measurement tools and expertise of a technician. The invention is an automated method and system for vehicle diagnostics. It will clearly identify and display the faulty component by means of measuring electrical parameters automatically , without the assistance or intervention of a tool or a technician.

II. LITERATURE REVIEW

[1] From "An intelligent diagnostic tool for electronically controlled diesel engine" , Junxi Wang et al.,Shanghai. It is observed that a diagnostic tool was designed and developed based on KWP2000.It implemented physical connection and translation between personal computer and electronic control unit(ECU).The software and hardware were chosen for after sales service aftermarket characteristic. The tool has been successfully used in high pressure common rail electronically controlled diesel engine. The diagnostic tool software implemented GSS function and fundamental function module with six intelligent tests and four functions. The tests showed that the diagnostic tool could perform accurate and quick data communication, online DTC management etc. It significantly improved the efficiency and convenience of diagnosis, and shortened the diagnosis and maintenance period.

[2]From "A new strategy for automotive off-board diagnosis based on a meta heuristic engine" , A.Azarian,France. It is observed that there is a lack of solutions for accurately, comprehensively and efficient fault localization. Model based diagnostics are very accurate but time and labor demanding and therefore too expensive to be comprehensively applied in workshops. The different subsystems are more and more

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interconnected so that they can share information therefore a higher risk of multiple faults.

[3]From "Simultaneous-fault-detection based on a qualitative symptom descriptions for automotive engine diagnosis", Chi Man Vong,Macao. It is observed that a modern automotive engine consists of complex electromechanical components. Possible malfunction may occur on different engine components which is not easy to detect. In this paper a fuzzy framework of simultaneous fault diagnosis is introduced. Signal based diagnostics is the most popular method because it is suitable for laboratories and the development of automotive scan tools, engine condition monitoring and off-board diagnostic systems. The decision tree approach by Gelgele and Wang makes diagnosis through a sequence of questions and answers.

[4] From " Sensor fault diagnosis for automotive engines with real data evaluation" , M.S.Sangha,UK. it is observed that a new fault diagnosis method using an adaptive neural network for automotive engines is developed. Real engine data of five sensors is acquired from one-litre Volkswagen car engine test bed under different operating states, on which ten faults re superimposed. The RBF network with its width and weights on-line adapted is used in this search to classify sensor faults. The sensor faults as small as 2% are clearly detected and isolated for different data sets.

[5]From "Sparse Bayesian extreme learning committee machine for engine simultaneous fault diagnosis", Pak Kin Wong, Macau. It is observed that because of the complex structure and running conditions of the engine, vehicle failure is usually caused by the occurrence of engine fault. The engine fault diagnosis faces problems because of thee existence of simultaneous faults which are multiple single-faults. Engine fault diagnosis is mainly classified into Model based, Knowledge based and Data driven. The research paper proposes a framework based on data driven methods which rely on signal based analysis techniques.

III. IN-VEHICLE ELECTRONIC SYSTEMS

Over the last two decades, rapid growth in performance and complexity of electronic embedded systems has enabled vehicle manufacturers to implement complicated automotive control systems through the use of sophisticated integrated electro-mechanical devices so called mechatronics. Automotive vehicles are equipped with different electronic devices performing different functions, and mostly transferring signals via electric wiring.

A. In-vehicle electronics

Many sensors are used to measure controlled variables as input signals for ECUs, e.g. engine speed, temperature. The input signals can be analog, such as voltage signals from sensors, digital such as switch positions, or modulated e.g. Pulse Width Modulation (PWM) signals. From these input signals, ECUs calculate required parameters to adjust controlling devices such as actuators. Today’s in-vehicle electronic systems have become large and much more complicated. A number of electronic devices and software contents are integrated in modern automotive vehicles. Applications range from simple door and window control to distant wireless data transfer between vehicles or between a vehicle and the infrastructure. Fig. 1 illustrates the high complexity of today’s in-vehicle electronics.

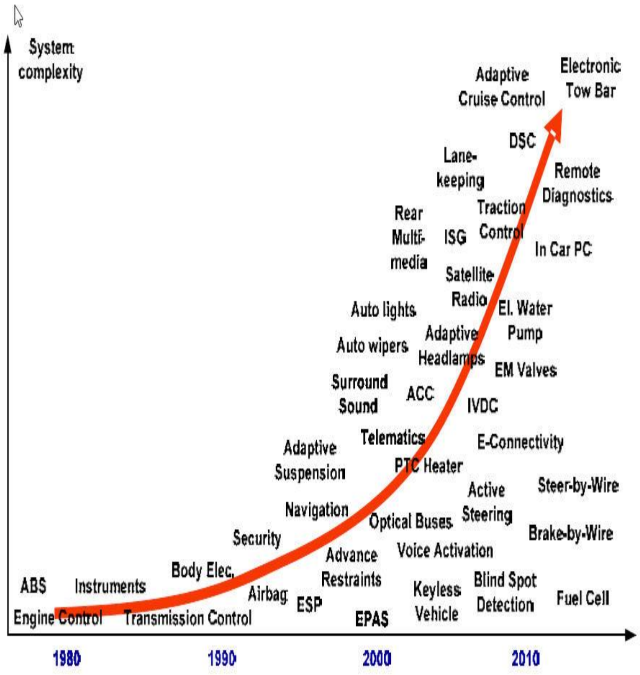

Fig 1. Rapid Increase in in-Vehicle Electronic Systems [7]

B. In-Vehicle Networks

Historically, the communication between simple electro-mechanical devices was mostly achieved by using point-to-point links, as shown in Fig. 2. Signals in the vehicle were transmitted and received among ECUs over non-multiplexed and hard-wired cables. This caused in bulky, expensive and complicated wiring when dealing with the increasing use of ECUs, because the number of required communication channels grew exponentially with the number of ECUs (Navet et al., 2005). To eliminate wiring difficulties and to improve automotive distributed control systems was a challenge for automotive manufacturers. A wiring harness of vehicle was roughly 1 mile long and included approximately 300 connectors with 2,000 pins (Robert Bosch GmbH, 2004a). Robert Bosch in mid 1980s invented a robust automotive control network known as CAN. CAN is based on a bus configuration, as shown in Fig. 2, which allows ECUs connected on the bus to receive in-vehicle signals digitally encoded in CAN messages at the same time. This significantly enhances real-time applications in the vehicle.CAN is currently one of the serial communication protocols used in automotive and industrial automation applications. Fig. 4 shows a CAN bus topology in a typical automotive application where a number of ECUs can be connected on a high-speed CAN (CAN-HS) and a low-speed CAN (CAN-LS) buses which are connected via a gateway A CAN communication controller is used in each ECU to control message transmission between ECUs connected on the same bus.

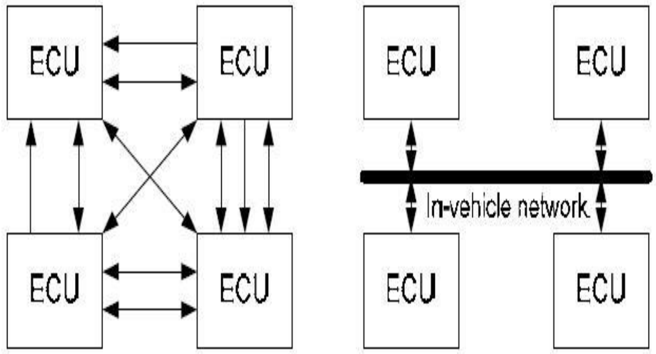

Fig. 2. Evolution of in-vehicle networks [8]

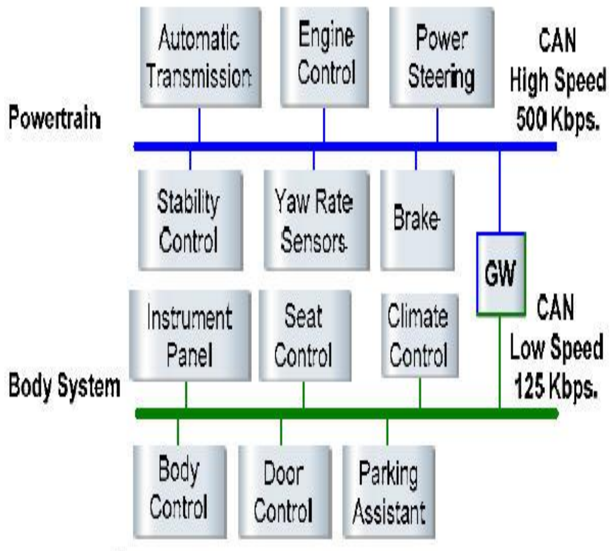

Fig. 3. CAN in Automotive Application[8]

IV. FAULT DETECTION AND DIAGNOSIS FOR IN-VEHICLE ELECTRONICS

The rapid growth in hardware and software content in today's vehicles results in increased overall system complexity. Fig. 3 illustrates the evolution of vehicle diagnostics together with the system complexity trend. Vehicle diagnostics with only conventional instruments, which has been used for simple measurement of normal or faulty electrical signals, is no longer effective. Enhanced in-vehicle diagnostic methods have been introduced in order that root causes of faults occurring during vehicle operation are efficiently detected and identified. For instance, OBD, which was initially intended for emission monitoring, is now able to provide logged DTCs and signal measurement for off-board diagnostics of other non-emission related functions. ECU's internal operation and communication are monitored by the ones in the feature and the network levels respectively. Once faults are detected, tested and confirmed, some default or alternative signal values are used by the ECU in a "limp-home" mode where the vehicle can be driven to the nearest service centre. The diagnostic processor then provides a warning to the driver as well as logging DTCs and additional environment parameters, e.g. speed, temperature and timestamp.

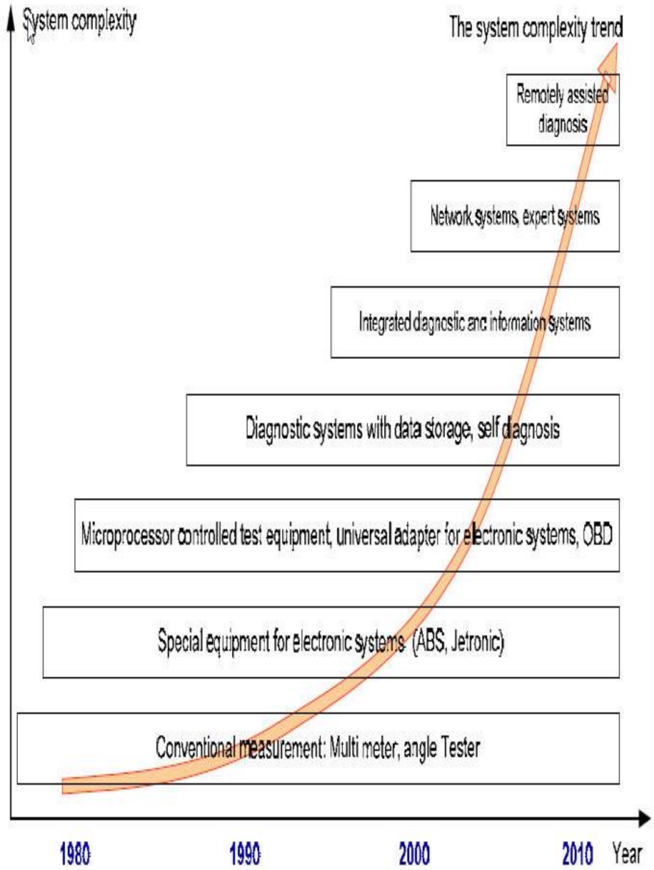

Fig. 4. Evolution of diagnostic test equipment [9]

V. INTELLIGENT DIAGNOSTIC ANALYZER

An electronic diagnostic tool which is connectable in-line in vehicle electronic system between ECU and the sensors by means of breakout harnesses. It is operable to measure the electrical signals from the ECU and sensors and measure continuity of wiring harness. It is able to identify the faulty component by analyzing the test results by means of combinational logic with respect to the reference values stored in the tool

The tool provides an off-board diagnostic system for automotive engines which uses electrical parameters to monitor and diagnose the vehicle system and clearly identify the faulty component thereby eliminating the need of multimeter, a breakout box. It provides single equipment solution for the entire range of trucks and buses which optimizes dealer's investments. Another object of the tool is to increase the productivity of the technician is enhanced through first time right diagnosis and Empower a normal technician to diagnose complex electronic systems by means of automated measurement, evaluation and decision making process of electrical and electronic diagnostics.

The IDA provides an off-board diagnostic system for automotive engines wherein , all the parameters of the electric circuits in the vehicles are measured in a single step by means of hardware and software. The software algorithm enables the checking of all currents and voltages and displays the conclusion derived which specifically identifies and displays the faulty component in the vehicle system.
Referring to Figure 1, there is shown a block diagram of an off-board diagnostic system.

A. IDA components

The system includes a microprocessor, switching integrated circuits, a key pad panel and an LCD display panel.

The microprocessor is the most important part of the system . It is the electronic component which has the software for controlling the input and output functions of the system namely keypad and LCD display. It controls the multiplexer for measuring the electrical signals. It also has the stored data base of the reference values of the ECU pins.

Further, the system includes switching integrated circuits, the multiplexer IC are digitally controlled analog switches that utilize silicon gate CMOS technology to measure voltage at ECU pins simultaneously , there are 4 switching circuit Multiplexer ICs and hence 64 pins can be simultaneously measured. The microprocessor sends command to the IC for measuring the voltage , current and reads back the actual measured value.

The system also includes a keypad panel. This is used by the user to send request to the tool. It consists of buttons whose output is sent to microprocessor, which then performs the operation as per the key input.

The LCD display panel is used to show the end results in the text format to the end user. The microprocessor sends information output to the LCD display panel.

The system is having a control unit and a storage memory . Further the system has provision to receive, manipulate and send electrical signal by means of input and has the LCD display panel as a primary output.

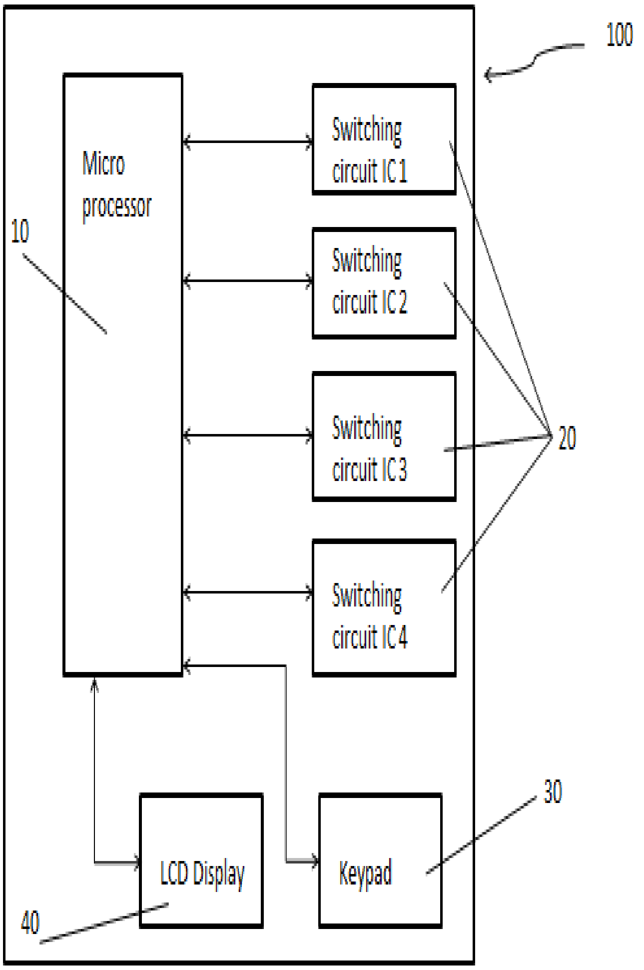

Fig. 5. Intelligent Diagnostic Analyzer Components[10]

B. Working of IDA

- When connected, the tool taps for electric signals between the ECU and the sensor unit.
- When connected on the Vehicle ECU side and in use, the tool measures voltage in each pins of the vehicle control unit by running a sweeping algorithm and outputs the signal to complete an expected action
- When connected to the sensor side the tool provides 5V supply to the component and measures the output voltage signal from the component
- When connected on both ends of the wiring harness with the electronic components disconnected, tool completes the circuit and detects open circuit by sending current through the wiring harness and measuring the result.
- The Control unit of the tool is connected to with 4 switching ICs
- The ICs measure the signal values and sends to the microprocessor.
- The microprocessor compares the stored reference values with the measured values and triggers an Graphical User Interface based test results displaying the measured values.

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- The output value corresponds to some information that needs to be displayed on the LCD screen

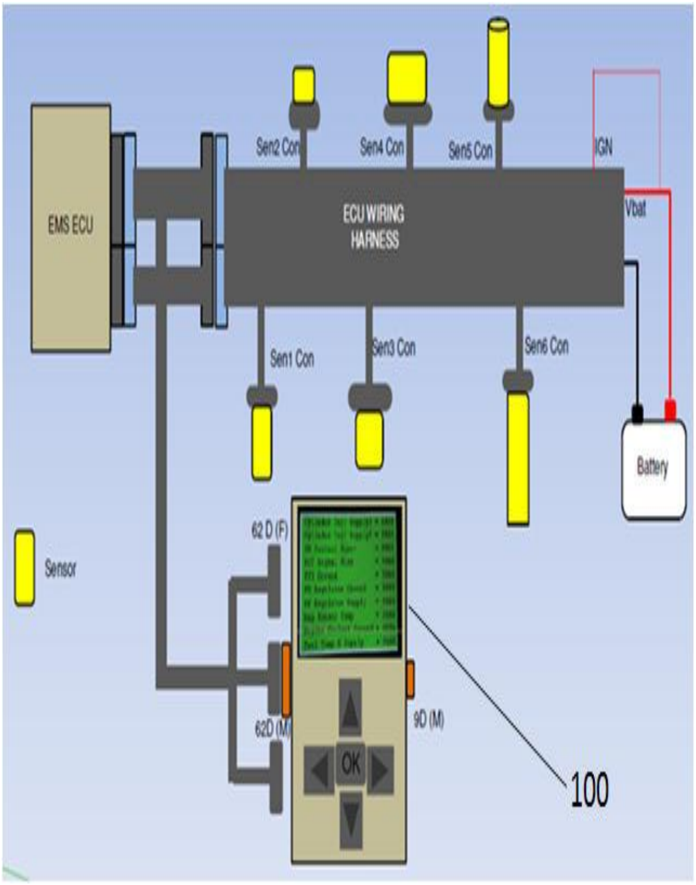
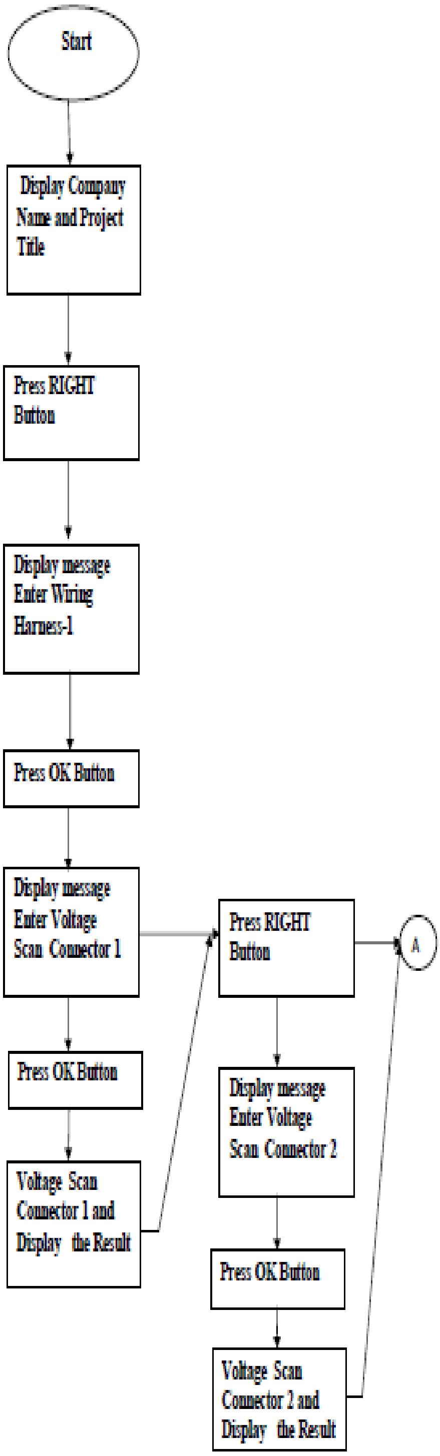
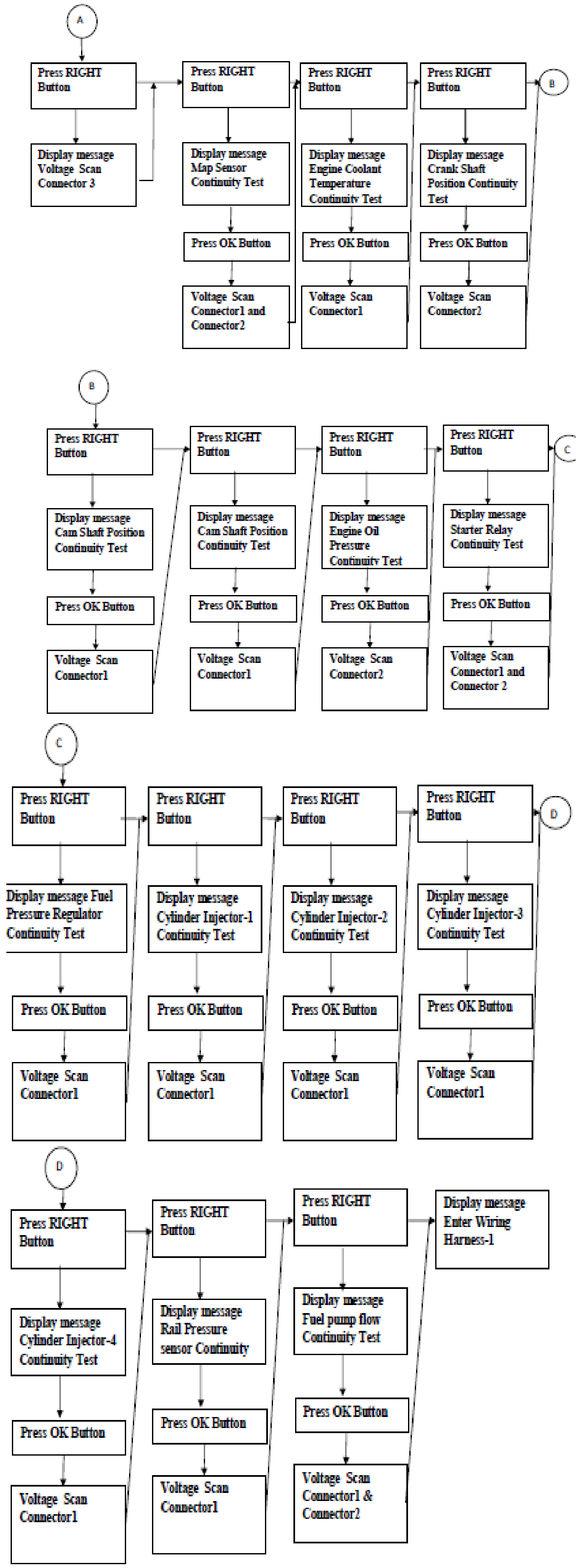


Fig.7. Block Diagram is Shown of Sensor Electronic Signal Measurement Method [10]

In order to measure the sensor electronic signal , following steps are carried out:

- The system is connected to the sensor side with the sensor disconnected from the vehicle harness.
- The system provides power supply to the sensor.
- The vehicle is run in the operating condition
- The system measures the signal voltage of the sensor.
- The system then compares the measured value with respect to the expected value and provides the test result status.
- The test results are shown in red or green colour based on the success or failure of the test respectively.





C. *IDA Tests* Cam Shaft Sensor Test

Error Code	P0107
Error Description	Cam Rationality

Table 1:

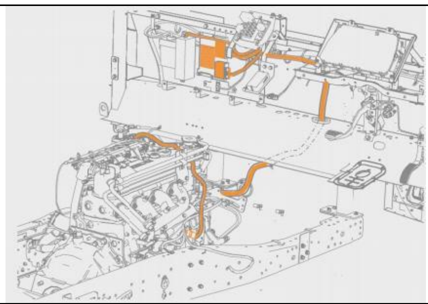
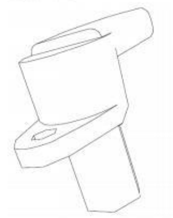
Sensor Location	Sensor View
	

Table 2:

Error Occurring Condition	Effect on Vehicle	Probable Causes
Error occurs if there is signal noise in 5V input voltage	Long Cranking Time	Due to misalignment of sensor or external noise, Missing pulses or extra pulses will be produces from the sensor

Table 3:

General Inspection: Visual inspection (Electrical):

1. Check that the connectors are properly connected and locked into position
2. Disconnect and check the component connector
3. Inspect pins and terminals for oxidations or corrosion
4. Ensure that the pins and terminals are locked into the connectors and that they are not pushed back out of the sockets
5. Check the pins and terminal are not damaged (which can cause poor connection)

Visual inspection (Mechanical):

1. Check Crankshaft sensor installation position
2. Check Camshaft sensor installation position
3. Check dust particles nearby sensor
4. Check proper torqueing of the sensor bolts

Inspection using Fault code status check:

A) If there is a Short circuit DTC in the ECU, to identify whether the fault is in wiring harness or the sensor, disconnect the component connector, (creating open circuit) and re-read fault code status to see if status changes (where applicable). o If the fault code changes i.e. open circuit DTC occurs, issue is with the internal circuit of the component o If the fault code does not change, issue is with the wiring harness.

B) Connect a new sensor with the ECU and check whether the fault gets erased o If the fault code gets erased, issue is with the internal circuit of the component o If the fault code does not change, issue is with the wiring harness

D. Advantages o f the IDA

1. Enable & empower a normal technician to diagnose complex electronic systems by means of automated measurement, evaluation and decision making process of electrical and electronic diagnostics.
2. Paradigm shift in vehicle diagnostics by bringing in machine intelligence to facilitate quick, reliable & efficient diagnosis.
3. Increases the productivity of the technician is enhanced through first time right diagnosis.
4. Reduces repair costs by lowering overall repair time.
5. This tool serves as single equipment solution for the entire range of trucks and buses which optimizes dealer's investments.
6. Drastically reduces the time for training the aftermarket in new technologies.
7. Higher customer satisfaction resulting in better brand value.
8. The present invention is simple in design, easy to operate, mobile, reliable and durable.

The present invention is proved highly reliable for all related application requirements.

VI. SUMMARY

In this paper In-vehicle electronics systems, fault detection and diagnosis in In-vehicle electronics is studied with Invehicle Networks. The paper also described An Off-board Diagnostic system for automotive engines, more particularly An Intelligent Diagnostic Analyzer for diagnosing the faults in vehicles and it's working.

REFERENCES

[1]. Junxi Wang*, Xiaojian Mao, Keqing Zhu, Junhua Song, Bin Zhuo."An intelligent diagnostic tool for electronically controlled diesel engine", Elsevier,Mechatronics 19 (2009),pp.859-867

[2]. A.Azarian*, A. Siadat, P. Martin. "A new strategy for automotive off-board ased on a meta heuristic engine". Elsevier, Engineering Applications of Artificial Intelligence 24 (2011), pp. 733-747

[3]. Chi Van Vong*, Park Kin Wong, Ka In Wong. "Simultaneous-fault detection based on qualitative symptom descriptions for automotive engine diagnosis". Elsevier, Applied Soft Computing 24 (2014), pp. 238-248

[4]. M.S.Sangha, D.L.Yu*, J.B.Gomm. "Sensor fault diagnosis for automotive engines with real data evaluation". International Journal of Engineering , Science and Technology Vol.3, No. 8, pp. 13-25

[5]. Pak Kin Wong*, Jianhua Zhong, Zhixin Yang, Chi Man Vong. "Sparse Bayesian extreme learning committee machine for engine simultaneous fault diagnosis". Elsevier, Neurocomputing 174 (20016), pp. 331-343

[6]. Ortega,Hirang,T.&Swanson.R."System design from wires to warranty". Automotive Electronics Magazine,February (2006),pp. 14-18

[7]. McMurran, R.; McKinney, F.; Tudor, N. J. & Milam, M. (2006). Dependable Systems of Systems, SAE paper: 2006-01-0597, *SAE World Congress*, Michigan, April 2006

[8]. Jittiwut Suwatthikul (2010). Fault detection and diagnosis for in-vehicle networks, Fault Detection, Wei Zhang (Ed.), InTech, DOI: 10.5772/9069. pp.284-305 . Available from: http://www.intechopen.com/books/fault-detection/fault-detection-and-diagnosis-for-in-vehicle-networks

[9]. Robert Bosch GmbH. (2004). Automotive Electrics Automotive Electronics, Professional Engineering Publishing Limited, ISBN 0470519371, Suffolk.

[10]. "Off-board diagnostic system for automotive engines" having Indian Patent Application Number 131/MUM/2015towards Indian Patent Office (IPO), Mumbai, for and on-behalf of V E Commercial Vehicles Ltd.