INNOVATIVE APPROACH TO VEHICLE DIAGNOSTICS

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Essay

Summary

Vehicle diagnostics or On Board Diagnostics (OBD) is an automotive term referring to a vehicle’s self-diagnostic and reporting capability. OBD systems give the vehicle owner or repair technician access to the status of the various vehicle subsystems. The amount of diagnostic information available via OBD has varied widely since its introduction in the early 1980s versions of on-board vehicle computers. Early versions of OBD would simply illuminate a Malfunction Indicator Lamp (MIL) if a problem was detected, but did not provide any information about the problem. Modern OBD systems use a standardized digital communications port to provide real-time data in addition to a standardized series of Diagnostic Trouble Codes (DTC), which allow a technician to identify and remedy faults on the vehicle. The current versions are OBD–2 in USA, EOBD in Europe, JOB in Japan, KOBD in Korea, etc. These standards are quite similar.

Key words: communication; DTC; EOBD; MIL; OBD; vehicle diagnostics

1. Introduction

When automotive started, cars were purely mechanical devices. Repairs of such vehicles were not particularly complicated and did not involve a significant number of parts. With the rapid advancement in technology, the mechanic's job has evolved from purely mechanical, to include electronic technology. Because vehicles today possess complex computer and electronic systems, mechanics need to have a broader base of knowledge than in the past. To facilitate mechanics and repair technician work it was necessary to design an electronic system for vehicle diagnostics.

Caring for the environment through reduction measures of exhaust emissions has prompted the development of OBD systems. OBD innovations followed the innovations of emission reduction systems and recently, the innovations of other systems installed in the vehicle (ABS, ESP, etc.). OBD innovations also followed the innovations in communication technology (Bluetooth, Wi-Fi, mobile applications). Today, the creativity in the area of diagnostics has resulted in the fact that the owners themselves can perform basic diagnostics of their vehicle via smartphone. The beginning and purpose of the primary design of diagnostic systems is explained in the next section.
2. OBD Development – Application to Exhaust Emissions Control

2.1 Pre-OBD Emissions Requirements

In 1967, California created the California Air Resources Board (CARB) in order to help establish and enforce emissions standards in that state. In 1970, the federal government formed the Environmental Protection Agency (EPA) to create and enforce emissions standards in all 50 states. In response to those new federal and state guidelines, automobile manufacturers started to equip their vehicles with simple emissions equipment beginning with the 1970 model year. The first piece of emissions equipment was a simple charcoal canister that collected hydrocarbon vapours. The Exhaust Gas Recirculation (EGR) system that routed spent exhaust gases back into the combustion chamber was also introduced early in the 1970s, and it reduced tailpipe emissions of nitrogen oxides. In 1975, the first catalytic converters that significantly reduced the emissions of hydrocarbons and carbon monoxide were introduced. At the time, emissions tests only analysed tailpipe emissions. Samples of the vehicle’s exhaust were tested for particular pollutants, including unburned hydrocarbons, nitrogen oxides, carbon monoxides, and carbon dioxides. [1]

2.2 Proprietary OBD: 1980-1987

Starting in 1980 on California-bound vehicles, and on all vehicles in the 1981 model year, General Motors equipped its vehicles with its own proprietary Engine Control Management (ECM), which controlled the engine as well as emissions equipment. Ford, Chrysler, Honda, and Nissan introduced their own proprietary diagnostics in 1983. A diagnostic port inside the passenger compartment was included. This diagnostic port was originally called the Assembly Line Communications Link (ALCL) and was later renamed the Assembly Line Diagnostics Link (ALDL). At the time, scan tools capable of reading data from this diagnostic port were only available to assembly-line workers to ensure that the ECM was functioning properly. When the ECM detected a fault, a Check Engine Light (CEL) illuminated on the dashboard. To determine what fault the ECM had detected, the ECM was put into a polling mode - with the ignition ON and the engine OFF, pin A and pin B were shorted together with a wire or paper clip (an early diagnostic tool). The specific two-digit codes blinked in sequence on the CEL. The technician looked up this code in a dealership’s technical manual to determine the fault illuminating the CEL. [1]

2.3 OBD–1

In 1987, CARB issued a ruling that all vehicles sold in California would be required to be equipped with a rudimentary OBD system to diagnose engine malfunctions and emissions equipment malfunctions, turning ON Malfunction Indicator Lamp (MIL). At this time, CARB did not standardize connector style, connector location, or fault codes (Fig. 1). But, this was the foundation for building the OBD (also known as OBD–1) standard. Thanks to the rulings by CARB in 1968 that an on-board diagnostic system must be included on all vehicles weighing less than 6350 kg sold in California, for model year 1987, the Society of Automotive Engineers (SAE) in 1988, and the International Organization for Standardisation (ISO) in 1989, delivered standards that were known as OBD. Later, after OBD–2 was introduced, the previous standards were referred to as OBD–1. [1]
2.4 OBD–2

In 1994, CARB and the EPA realized that there were many downfalls with the current manufacturer's OBD systems. The EPA amended the Clean Air Act (CAA) of 1990 to include the requirement that all vehicles sold in the United States be equipped with some type of OBD system. CARB worked with the EPA to establish the rules for an OBD system that included standardized fault codes, connector locations, connector pinouts, information on the data bus, etc. The OBD–2 specifications are constantly evolving as fuel economy requirements increase, emissions standards continue to change, and electronic hardware continues to perform better at lower cost. Each Original Equipment Manufacturer (OEM) must now comply with OBD–2 standards instituted by ISO and SAE (Fig. 2). The benefits of developing OBD–2 are not limited to ensuring that vehicle systems are performing within specifications. Standardization also made it easy for a technician or home enthusiast to read and understand a single set of information when diagnosing a potential system failure. [1]

3. Innovation of OBD–2 – Creative Vehicle Diagnostics

Until the late 1970s there were generally only mechanical systems in vehicles (Fig. 3). Then began the era of electronics built into vehicles. With the increase of the number of electronic devices (sensors and actuators), the number of Electronic Control Units (ECU’s) that control the processes of such devices increased as well (Fig. 4). Consequently, electronic control for proper operation of these components was enabled.
The ECU, or simply called computer, can detect system problems even before the driver notices a driveability problem because many problems that affect emissions can be electrical or even chemical in nature. When the OBD system determines that a problem exists, a corresponding “diagnostic trouble code” is stored in the computer’s memory. The computer also illuminates a yellow dashboard light indicating “check engine” or “service engine soon” or displays an engine symbol. This light informs the driver of the need for service, not of the need to stop the vehicle. A blinking or flashing dashboard lamp indicates a rather severe level of engine misfire. When this occurs, the driver should reduce engine speed and load and have the vehicle serviced as soon as possible. After the problem has been fixed, the dashboard lamp will be turned off.

To allow insight into all faults recorded in the vehicle, it is necessary to access the data from the individual ECU’s. This is achieved by connecting a diagnostic device to the vehicle via Data Link Connector (DLC). Generally, there are two types of diagnostic devices: Code reader and Scan tool. Code reader enables the user to read DTC’s from the on-board computers. This gives the user the ability to quickly determine the cause of the MIL coming ON (Fig. 5). Scan tools support enhanced features which include the ability to read manufacturer-specific DTC’s, graph live engine data, record and playback stored vehicle information, and print the information through a PC (Fig. 6). Some types can get access to vehicle diagnostics using smartphone via the Bluetooth or Wi-Fi (Fig. 7).

Request-response is one of the basic methods computers use to communicate with each other, in which the first computer sends a request for some data and the second computer responds to the request. This method is used in the ECU’s communication in today’s vehicles. Because the message transfer is encrypted, instructions for decryption are used to read individual errors. OBD–2 system and fault codes are standardized and therefore easy to identify faults.
A DTC is made up to 5 digits. First digit structure is as follows: P (for powertrain), B (for body), C (for chassis) and U (for network). Also, two categories of trouble codes exist (second digit): Generic (0) and manufacturer specific (1). Generic codes are standard for all vehicle manufacturers, according to SAE J2012. Manufacturer specific codes are not unique and may overlap with another manufacturer, or even the same manufacturer on different models. The third digit shown refers to the system. The fourth and fifth digit indicate the fault code (0-99). [8] With this information it is easier to trouble shoot a DTC without knowing the description of the code.

In addition to reading faults, diagnostics is possible to grant access to the list of all the electronic systems installed in the vehicle as well as the condition of their validity. Moreover, it is possible to monitor the values of the individual sensors on the vehicle in real time, have a look at the values of the sensors at the time of occurrence of individual fault, etc. Vehicle diagnostic possibilities in the future will be even greater due to the introduction of an increasing number of electronic systems in vehicles.

The procedure for reading trouble codes by using ScanMaster ELM is shown below (Fig. 8).

![Fig. 8 A reading trouble codes by using diagnostic software ScanMaster ELM [8].](image)

### 4. Conclusion

Innovative diagnostics significantly simplifies the work of mechanics and repair technicians because it is not necessary to disassemble a large number of components and to test them. After determining which component is out of function, the elimination of the failure may begin. Such innovative approach to detecting and removing failures, using diagnostics built into the vehicle, has great advantages and even greater future. OBD innovations also followed the innovations in automotive and communication technology. Today, the creativity in the area of diagnostics has resulted in the fact that the owners themselves can perform basic diagnostics of their vehicle via notebook, tablet or smartphone. Diagnostics usage in the near future will become mandatory during the technical inspection of vehicles in the Republic of Croatia.
REFERENCES


