Notes on European On-Board Diagnostics

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2 Introduction

The increased vehicle complexity has driven forth a transformation in the automotive service and repair industry, from being a mechanical business to a hi-tech industry dependent on electronic equipment to diagnose and repair malfunctions. Strict regulation places increased demands on the accuracy of diagnosis and repair. Furthermore, the continued pressure to reduce costs and improve time to market pushes for cost-effecting solutions.

Nevertheless, today’s diagnostic engineering and delivery methods are inefficient and unresponsive to these challenges. Franchised repair shops have moved ahead of the independent garages in terms of technical capabilities. They are provided with assistance from their respective vehicle manufacturers, while independent garages have been left to support themselves with diagnostics products from the independent equipment manufacturers. Ill-equipped service technicians are left with inefficient methods and outdated information, resulting in increased repair costs and warranty claims – and a decline in customer satisfaction.

These realities have a major impact on the service technicians’ ability to efficiently maintain vehicles. The diagnostics tasks are growing more complex and time consuming. There is a need for more accurate diagnostics means such as on-board diagnostics tools.

3 OBD / OBD-II (the US)

3.1 The History

OBD – On-Board Diagnostics – is a concept that has its origin in the US environmental protection policies. During the '70s, vehicle manufacturers started using electronic means to control engine functions and diagnose engine problems, primarily to meet EPA[1] (Environmental Protection Agency) emission standards. The vehicle manufacturers turned to electronically controlled fuel feed and ignition systems, with sensors measuring engine performance and adjusting the systems to provide minimum pollution. These sensors were also accessed to provide early diagnostic assistance. Initially, each manufacturer had their own systems and signals.

Since then, OBD systems have been developed and enhanced in line with the US government requirements. In 1988, SAE (Society of Automotive Engineers) presented a standard connector plug and set of diagnostic test signals. EPA adapted most of their standards from the SAE OBD programs and recommendations.

The current OBD-II standard was introduced in the mid-'90s, providing almost complete engine control, together with monitoring parts of the chassis, body and accessory devices, as well as the diagnostic control network.

All cars built in the US and sold on the US market since 1996 must have OBD-II systems. Some vehicle manufacturers started incorporating OBD-II in various models as early as 1994, even though some early OBD-II cars were not fully compliant.

3.2 Different Implementations

There are three basic OBD-II protocols in use, each with minor variations on the communication pattern between the on-board diagnostic computer and the scanner console / tool. The following division can be used as a rule of thumb:

- OBD-II using ISO 9141 circuitry (used by Chrysler, all European and most Asian manufacturers)
- OBD-II using SAE J1850 VPW[2] modulation (GM cars and light trucks)
- OBD-II using SAE J1850 PWM[3] (Ford)

Even though there are three OBD-II electrical connection protocols, the command set is fixed according to the SAE J1979 standard for diagnostic test modes.

3.3 Access

Pre-OBD-II cars had connectors in various positions under the dashboard and under the hood. All OBD-II cars have a connector located in the passenger compartment easily accessible from the driver's seat. A cable is plugged into the OBD-II J1962 connector.

3.4 The Use

OBD-II signals are most often sought in response to a "Check Engine Light" / “Malfunction Indicator Light” (MIL) appearing on the dashboard, or driveability problems experienced with the vehicle. The data provided by OBD-II can often pinpoint the specific component that has malfunctioned, saving substantial time and cost compared to guess-and-replace repairs. Scanning OBD-II signals can also provide valuable information on the condition of a used car purchase.

3.5 The Service Codes

OBD was was developed to provide improved, information-rich visibility to complex operation and control mechanisms. The diagnostic read-outs used by dealership technicians are read through the OBD-II connector. These service codes show:

- knock sensor operation
- FI[4] pulse width
- ignition voltage
- individual cylinder misfires
- transmission shift points
- ABS[5] brake condition

There are more than 300 readings available, depending on the vehicle manufacturer and model. There are also variations in the readings supported (scanners vary widely in the number of these signals that they can read – some show just the basic OBD or OBD-II signals, others show the full range of service codes).

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2 VPW = Variable Pulse Width
3 PWM = Pulse Width Modulation
4 FI = Flexible Injection
5 ABS = Anti-lock Braking Systems

When a simple correlation exists between the OBD malfunction data and its root cause, OBD is a useful troubleshooting tool, but it provides little assistance in diagnosing more complex situations such as multiple fault codes, or conflicting or inconsistent information. Studies have shown that:

- there are alarmingly high rates of incorrect initial diagnosis of electrical problems
- OBD-readings do not always provide sufficient data to identify a root cause, dismissing a MIL illumination as “No Fault Found”)
- OBD-readings do not always result in repairs being emission compliant

4 EOBD (the EU)

4.1 Introduction

EOBD is an European equivalence to OBD-II, with one notable exception – EOBD includes the CAN[6] communication protocol. It is utilized by European and Asian manufacturers for vehicles not sold on the US market from 2000 and onwards.

4.2 The Legislation Background

EOBD was introduced as part of the Euro III emissions legislation.

EURO III is the emission standard introduced in the EU in 1999 that limits car emissions to 5 g/kWh of nitrogen oxide and 0.10 g/kWh of particle matter. The directive regulating the EURO III emission standard is the 98/69/EC directive from 1998, “relating to measures to be taken against air pollution by emissions from motor vehicles”. The directive defines the emission standards for the vehicles (cars and light trucks), together with the mandatory requirements to run on-board diagnostic strategies and communicate to off-board equipment using standardized procedures. The legislation also requires the release of all information necessary to repair the car for faults relating to on-board diagnostics, and to enable the manufacture of on-board diagnostics compatible parts (the details of this latter issue are still being clarified for later legislation).

In terms of time frame for implementation, EOBD required newly type-approved cars with petrol engines to be compliant from 1st January 2000 onwards, and all new registrations from the beginning of 2001 onwards. In the case of diesel cars, new type-approvals had to comply with EOBD from 2003 onwards, while all registrations needed to do so by start of 2004. There are variations on this for CVs, 4x4s and for dual-fuel vehicles. EURO III is replaced by EURO IV in 2005, limiting car emissions to 3.5 g/kWh of nitrogen oxide and 0.02 g/kWh of particle matter. EURO IV will be replaced by EURO V in 2008, limiting car emissions to 2 g/kWh of nitrogen oxide and 0.02 g/kWh of PM particle matter.

4.3 EOBD Functions

The various functions that can be performed by any independent garage (provided they have the necessary equipment) are:

- Read and clear a standard set of fault codes,
- Read emissions related dynamic data,
- Access freeze frame data relating to emissions,
- Monitor information from the lambda sensor,

[6] CAN = Control Area Network

- Perform evaporative purge testing, and
- Access vehicle information such as the VIN[7]

4.4 Access: Hardware Connectivity

EOBD allows off-board equipment to perform these functions through a standard J1962/EOBD connector fitted in the car. Although the standard connector was implemented in vehicles well before the implementation of EOBD, access to proprietary communication protocols and diagnostics data was given only post-EOBD. The pins in the connector have also been standardized to a certain degree with nine out of the total sixteen pins having pre-defined functions. The remaining seven pins are discretionary, meaning that the vehicle manufacturer uses these pins for communication of data other than that specified by EOBD.

4.5 Access: Bus Types

In addition to the hardware connectivity, the directive also requires that the in-vehicle bus network (allowing the off-board diagnostics equipment to communicate with the vehicle) is from one of the four specified bus types:

- ISO9141
- J1850 VPW
- J1850 PWM
- CAN

4.6 What about EOBD-II?

EOBD-II, “Enhanced On-Board Diagnostics, Second Generation”, is *not* a new version of EOBD. EOBD-II refers usually to manufacturer-specific features available on some OBD-II/EOBD tools to access additional parameters/information from a car, over and above the normal parameters and information available within the EOBD/OBD-II standard. EOBD-II features are normally highly manufacturer-specific, and will usually only be available for a certain car manufacturer (e.g. Ford). There are, as such, no “EOBD-II cars”, i.e. cars that require an EOBD2 tool to access their diagnostics information. EOBD-II functionality might however allow more information to be extracted from an EOBD/OBD-II compliant car.

5 OBD-II / EOBD Scanning Devices

With the introduction of more economical and user friendly scanning devices, it is now practical for almost anyone to access OBD-II / EOBD signals and use them for their own testing and repairs.

Scanners vary greatly in their complexity. The best connect easily and use software to quickly and automatically call up the OBD-II information. They should have recording ability so that data can be collected during a test drive without distracting the technician driving the car. A system connecting to a laptop or desktop computer provides expanded memory for data and the ability to export data to a spreadsheet or graphing utility.

There are also variations in the readings supported. Scanners vary widely in the number of these signals that they can read. Some show just the basic signals, others show the full range of service codes.

[7] VIN = Vehicle Identification Number

6 IDB – Intelligent Data Bus

Another challenge for service technicians comes from the introduction of IDB - Intelligent Data Bus (IDB) vehicles and telematics. IDB enables customers to equip their cars with additional electronics and add features easily at any time.

The IDB standard is still under development, but does not address testability and built-in diagnostics, and complete and safe compatibility compliance is only voluntary.