SELECTED ASPECTS OF VEHICLE'S ONBOARD DIAGNOSTIC

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Abstract

The American On Board Diagnostic System, known as OBD2, is installed in passenger cars and light trucks for 1996. The European Union adopted similar standards in the year 2000 for spark ignition engines, and then in 2003 for passenger cars equipped with diesel engines. In Poland, the popularity of OBD2/EOBD system and knowledge about it are still not adequate. In current publications the EOBD tests of different passenger cars have been presented and discussed. The authors, on the basis of these tests, experiences and inspections, have formulated their own opinion about the practical usefulness of the current OBD2/EOBD systems in engine diagnostics.

1. Introduction

The history of the On Board Diagnostic Systems implemented in passenger cars is closely connected with environment protection. The first standards of air protect regulations were published over 40 years ago in The United States of America. In that country, environmental protection has a crucial problem for many years. For this reason, the Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) have been created. These institutions are known worldwide as important centers of modern ecology legislative initiatives. From the late 1960's on, emissions have been reduced to trace amounts when compared to the vehicles produced just 20 years ago. This has been influenced by the new standards of engine exhaust emissions, called the "Clean Air Act." However, the first significant reduction in exhaust gases came in the years 1974 to 1976 with the introduction of the electronic ignition, the catalytic converter, unleaded fuel, and oxygen sensors. It is helpful to know that the first oxygen sensor was introduced by Bosch Corporation in 1976, and was used in Volvo cars. The first automotive oxygen sensors needed to be replaced every 30,000 km. At present, the expected lifetime service of the latest Bosch LSU-4 oxygen sensor is an estimated 160,000 km. Such favorable results were made possible, for the most part, from using planar technology in the production of oxygen sensors [1, 2]. That kind of planar type oxygen sensor is illustrated in Figure 1.

All passenger cars and light trucks built in the United States after the year 1996 were required to be OBD II-compliant. The On Board Diagnostic System is used in passenger cars and light trucks, but in the future this system will also be implemented into the ECU engine of heavy-duty vehicles. Advanced investigations of this are conducted by members of the SAE Truck and Bus Control and Communications Subcommittee (SAE J1939). Additionally, CARB and EPA are planning to require OBD II on heavy-duty trucks starting with the 2007 model year.

At the CARB workshop, held October 16, CARB announced that it would accept either SAE J1939 or ISO 15765 protocols as the official emissions OBD protocol to communicate generic modes to the state I/M (Inspection and Maintenance) tools. CARB would not, however, allow both protocols on the same vehicle.

At present, all standardized on board diagnostics systems are concerned mainly with engine exhaust emissions. In the future, however, this could change. Already, Diagnostic Trouble Codes of Chassis, Body and Network use in vehicles are prepared.

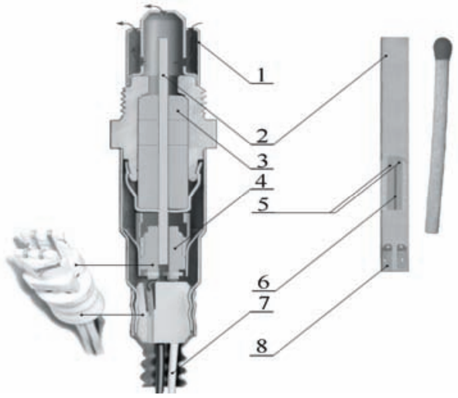


Fig. 1. Diagram of a planar heated oxygen sensor used in Fiat Stilo 1.6: 1 – Double protective tube, 2 – planar sensor element, 3 – Ceramic support tube, 4 – contact holder, 5 – layers of oxygen sensor heater, 6 – reference air inside of planar sensor element, 7 – wires, 8 – contacts for heater element

Beginning January 1st, 2005, all Polish Vehicle Inspection Stations are required to have OBD2/EOBD-certificated test benches. This is only one of many others important reasons why knowledge about the EOBD system should be more widespread. It is interesting to examine the practical usefulness of that kind of on-board system for comprehensive I.C. engine diagnoses. In this paper, the attempt to answer this last formulated question has been made.

2. Eobd compliant test bench – amx 530 diagnostic equipment

AMX 530 hardware interface, its software, and personal computer allows to realize vehicle diagnostics according to the OBD2/EOBD standard. At present, these are limited only to emissions-related components and subsystems of the engine. The AMX 530 diagnostic equipment connected to the vehicle's Data Link Connector has been illustrated in Figure 2. Establishing communication can be successfully finished when the car's ignition is first turned on. The AMX 530 software automatically detects OBD2/EOBD compliant transmission protocol supported by Engine Control Unit [3]. Next, the main screen of the AMX 530 program is displayed (see Fig. 3). On this screen, the user of the diagnostic program can read the number of detected Diagnostic Trouble Codes (stored and pending). Not all EOBD diagnostic modes are supported in tested on board system. For example, when the DTC's are not detected by the on-board diagnostic system its mode #02 (freeze frame) will not be available. Beside that, the following diagnostic modes of AMX 530 software are given:

- mode 00$: supported monitors and their results,
- mode 01$: real-time data,
- mode 04$: system reset and clearing the DTCs,
- mode 05$: oxygen sensors tests and results,
- mode 06$: monitored systems,
- mode 08$: actuator test,
- mode 09$: vehicle data identification,
- mode 13$: extended DTCs,
- reports.

The complete list of all diagnostic modes is longer, but the above-presented items are the most common in EOBD/OBD2 compliant software.

Fig. 2. View of AMX 530 diagnostic interface connected to Ford Fusion Data Link Connector (DLC)

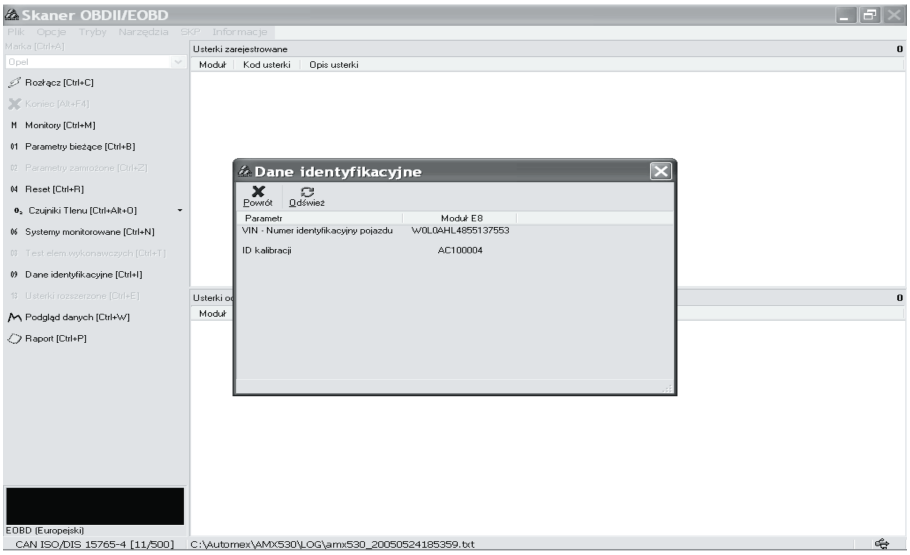


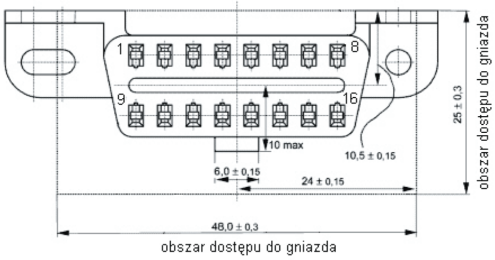
Fig. 3. AMX 530 Diagnostic Mode Main Screen (Diagnostic Trouble Codes not detected)

Each function of the AMX 530 software is displayed on a computer screen, and can be selected and controlled by the simple click of a mouse. Communication between DLC (Data Link Connector) and the computer can be made by wire or cordless using Bluetooth standard protocol. The latter way is more common, and should be even more so in the near future. An unfavorable effect of using communication by wire is the necessity of DLC locators in the car. Some car manufacturers refuse to comply with the EOBD standards, and place the DLC in the wrong places on vehicles.

The AMX 530 interface must be connected to the vehicle's DLC and PC in order to work. There are two types of diagnostic/data link connectors defined by SAE J1962, Type A and Type B, shown in Figures 4a and 4b, respectively. The main difference between the two connectors is the shape of the alignment tab.

To connect the Scan Tool Unit to the vehicle, the vehicle's diagnostic connector must be located. On most OBD2/EOBD-compliant vehicles, the data link connector is located under the driver's side dashboard in full view. In some vehicles it may be recessed behind a panel,

a)



b)

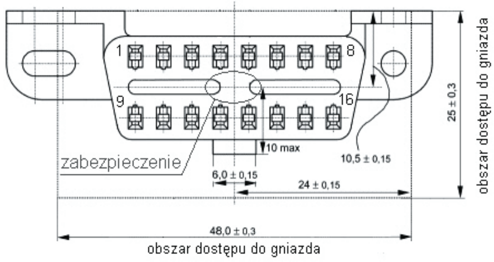
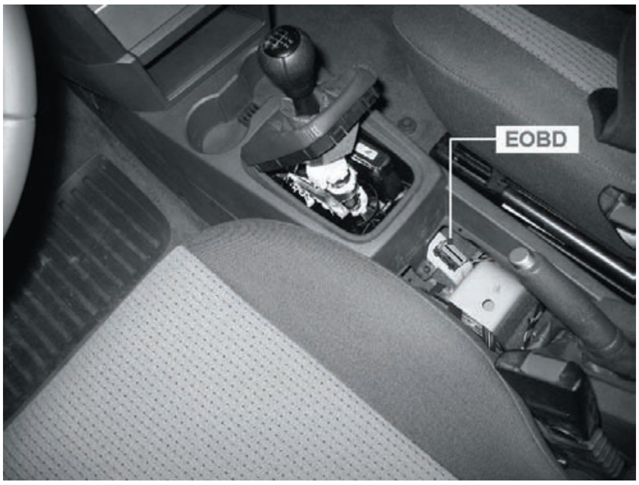


Fig. 4. OBD2/EOBD DLC- Data Link Connectors: a) Type A, b) Type B

which must be removed to gain access to the connector. The DLC should then be attached to the dashboard, and be easy to access from the driver or passenger seat, or from the outside. Figures 5a and 5b show unfavorable and favorable locations for the DLC in vehicles, respectively.

a)



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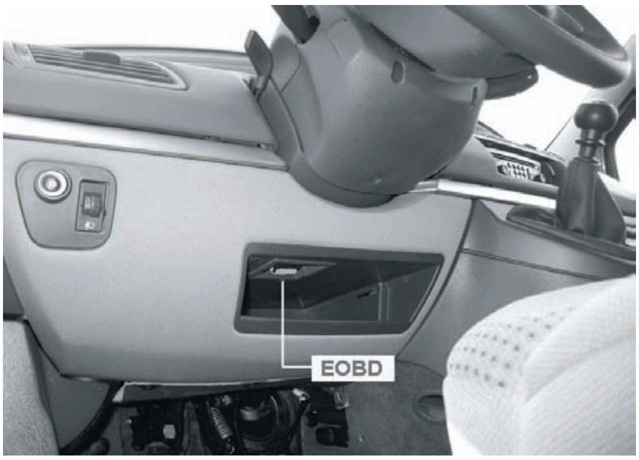


Fig. 5. Data Link Connector - 16 position connector located in: a) Opel Meriva, b) Fiat Ulysse

3.1. Data transmission protocols

Communication between an OBD-II-compliant vehicle on-board diagnostic system and external Generic Scan Tool equipment can use any of the five different communication protocols. All of these are standardized, and known as follows: ISO 9141-2, ISO 11519-4 (PWM), ISO 11519-4 (VPW), ISO 15765-4 (CAN), ISO14230-4 (KW 2000). At present and in the future, the CAN protocol should be the most important. This protocol has four EOBD-compliant versions: CAN/A (11/250), CAN/B (11/500), CAN/C (29/250), CAN/D (29/500). Protocols CAN/A and CAN/B use the same 11 byte data frame identifier. Two others use a 29-byte identifier, which allows it to identify up to 536,870,912 different data messages [4]. All types of CAN protocols use two different speeds of data transmission: 250 and 500 byte per second. In the case of on-board diagnostics, the 500 byte/s transmission speed using CAN/B protocol is the more popular.

Different OBD2/EOBD-compliant diagnostic equipment can include one or more of the above-presented protocols for data transmission. The Generic Scan Tool uses all types of standardized protocols. For this reason, its use is more common than other diagnostic tools equipment with the service of selected transmission protocols. Table 1 shows detected transmission protocols used on test cars.

Table 1. Information about communication protocols used by different manufacturers in EOBD/OBD2 compliant vehicles

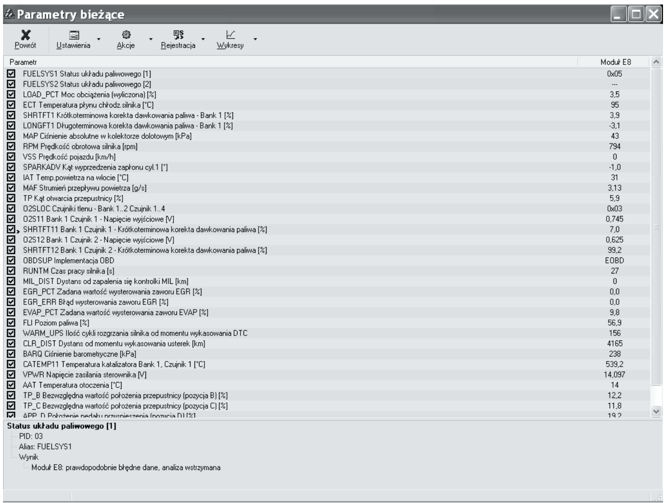
Nr	Vehicle	Model year	Engine type	Detected Protocol
1.	Toyota Yaris 1.0	2004	S. I.	ISO 9141-2
2.	Toyota Corolla 1.4 D-4D	2004	C. I.	ISO 9141-2
3.	Toyota Land Cruiser	2004	S. I.	ISO 9141-2
4.	Toyota Avensis	2004	C. I.	ISO 9141-2
5.	Toyota Avensis	2004	S. I.	ISO 9141-2
6.	Ford Focus 1.6	2003	S. I.	PWM
7.	Ford Fusion 1.4	2004	S. I.	CAN/B
8.	Ford Focus C-max 2.0	2004	C. I.	CAN/B
9.	Ford Mondeo 2.0 TDCi	2004	C. I.	PWM
10.	Fiat Panda 1.1	2005	S. I.	KW 2000
11.	Fiat Stilo 1.2	2002	S. I.	KW 2000
12.	Fiat Stilo 1.6	2002	S. I.	KW 2000
13.	Fiat Punto 1.2	2000	S. I.	KW 2000
14.	Opel Astra III 1.6	2005	S. I.	CAN/B
15.	Suzuki Liana 1.6	2005	S. I.	KW 2000

3.2. Research results of eobd implementation level

The Engine Control Unit has a built in self testing system called self-diagnosis, which means the on-board system will monitor the vehicle's sensors and devices for proper operation. After communication is established between the vehicle and the software, Diagnostic Trouble Codes (or DTC, which are stored and pending) are detected and set when one of the monitored devices or sensors is not working properly. The sample results of the Opel Astra III inspection have been illustrated in figure 3. The tested Astra does not have any of the DTC's stored or pending in the ECU memory. The EOBD system uses diagnostic monitors as well as real-time data parameters. The Real-Time Data Screen contains a vehicle's data parameters to be viewed while updating in real-time mode. The sampling rate of only one selected parameter amounts to about 0.35 seconds. In the case of two parameters recording the sampling rate, each of them will be amount to about 0.7 seconds. OBD II is a request/response protocol, meaning that the higher the number of parameters being requested, the longer it will take for a parameter to be sampled.

Mode 01$ of Generic Scan Tool allows the user to get results from 3 continuous and 8 non-continuous monitors. These 11 monitors are called Inspection and Maintenance, or I/M, Monitors. Not all monitors are supported by all vehicles. The below tables shows monitors used by different EOBD/OBD2-compliant vehicles being sold in Poland.

a)



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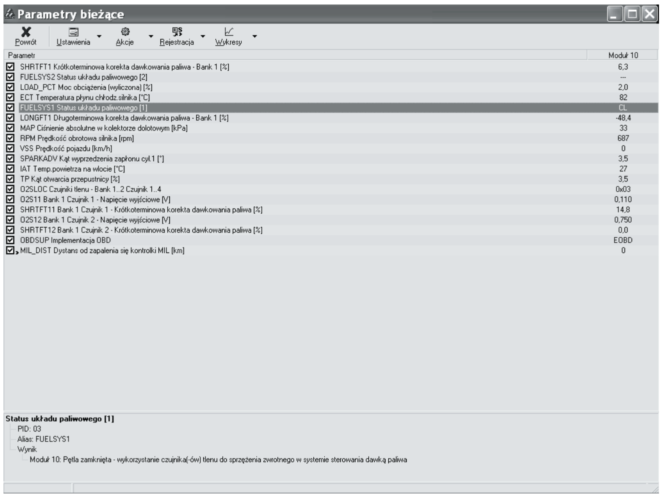

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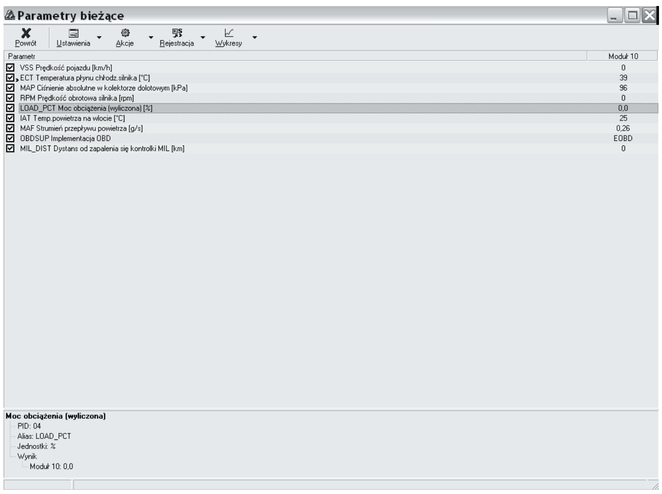

Fig. 6. Real Time Data Screen of parameters that are supported by tested: a) Opel Astra III 1.6; b) Fiat Stilo 1.6; c) Toyota Avensis 2.0 D-4D

Table 2. Monitors supported in EOBD/OBD2 compliant tested cars powered with spark ignition engines

No.	Vehicle	MIS	FUEL	CC	CAT	HCAT	EVAP	SAS	A/C	O2S	HTR	EGR
1.	Yaris 1.0	✓	✓	✓	✓					✓	✓	
2.	Land Cruiser 4.0	✓	✓	✓	✓					✓	✓	
3.	Avensis 2.0	✓	✓	✓	✓					✓	✓	
4.	Focus 1.6	✓	✓	✓	✓					✓	✓	
5.	Fusion 1.4	✓	✓	✓	✓					✓		
6.	Panda 1.1	✓	✓	✓	✓					✓	✓	
7.	Stilo 1.2	✓	✓	✓	✓					✓	✓	
8.	Stilo 1.6	✓	✓	✓	✓					✓	✓	
9.	Punto 1.2	✓	✓	✓	✓					✓	✓	✓
10.	Astra III 1.6	✓	✓	✓	✓		✓			✓	✓	
11.	Liana 1.6	✓	✓	✓	✓					✓	✓	✓

Table 3. EOBD/OBD2 Monitors used in diesel engines of different passenger vehicles

No.	Vehicle	MIS	FUEL	CC	CAT	HCAT	EVAP	SAS	A/C	O2S	HTR	EGR
1.	Corolla 1.4 D-4D			✓								✓
2.	Avensis 2.0 D-4D											✓
3.	Focus C-max 2.0		✓	✓								✓
4.	Mondeo 2.0 TDCi											✓

An analysis of tables 2 and 3 as well as figure 6 suggests that EOBD implementation level of spark ignition engines is much higher than diesel engines.

4. Conclusion

When compared to the manufacturer-specific diagnostic equipment like: EXAMINER, VAG-COM, TECH, KTS and others which are specifically designed for a great number of repair applications, the OBD2/EOBD Scan Tool applications offers a clearly smaller range of capacities. This has been confirmed during vehicle research with using AMX530 test bench. In the case of spark ignition engines, the implementation level of EOBD is clearly higher than in tested diesel engines. The ECU (Engine Control Unit) of the tested spark ignition engines uses 6 basic diagnostic monitors: misfire, fuel system, comprehensive components, catalyst converter, oxygen sensor and its heater. Only one vehicle (Opel Astra III) was equipped with an EVAP monitor. In the cases of the Suzuki Liana and the Fiat Punto, the Exhaust Gas Recirculation monitor has been used. It is interesting to note than tested Punto does not have an EGR system physically implemented into the engine, but rather an on-board diagnostic system to show that its results are successfully completed. The most complicated on-board diagnostic system of the tested diesel engines support up to 3 diagnostic monitors; but in the cases of the Toyota Avensis and Ford Mondeo vehicles, only EGR monitor is available.

The list of real-time data parameters is longer for spark ignition engines. In the case of the Opel Astra III, there are an estimated 35 different parameters. In the case of the Toyota Avensis 2.0 D-4D (diesel), however, there are only 9. No one diesel engine's EOBD system shows information such as the value of fuel-injected pressure or value of injection angle. For this reason, the possible uses for the EOBD system for comprehensive diagnoses of diesel engines seem more restricted than in the case of the spark ignition engines.

The Work Mode no. 9 of Generic Scan Tool allows a readout electronic version of the Vehicle Identification Number. With all of the 15 vehicles tested, only one EOBD-compliant ECU allows to read the VIN.

At present, the OBD2/EOBD standards are confined to emissions-related components and subsystems of the internal combustion engines used in light-duty vehicles. The importance of standardized Generic Scan Tool Units and OBD2/EOBD systems could be greater, but will require a wider range of on-board supported devices for the chassis, network, and body of the vehicle. The OBD2/EOBD Diagnostic Trouble Codes for these additional devices are ready, but are not used by manufacturers yet.

The most important advantage of the OBD2/EOBD systems is that the standardized application range is not restricted to the vehicles of a specific manufacturer, but can be used by all vehicles of any make or model.

References

[1] www.can.bosch.com

[2] Merkisz J., Mazurek S.: Pokładowe Systemy Diagnostyczne Pojazdów Samochodowych, WKiŁ, Warszawa 2004.

[3] www.automex.pl

[4] www.ely.pg.gda.pl

The list of most important acronyms used in the paper

A/C	-	Air Condition
CAN	-	Controller Area Network
CAT	-	Catalyst
CC	-	Comprehensive Components
C. I.	-	Compressed Ignition
DLC	-	Data Link Connector
DTC	-	Diagnostic Trouble Code
ECU	-	Engine Control Unit
EGR	-	Exhaust Gas Recirculation
EOBD	-	European On Board Diagnostic
EVAP	-	Evaporative Emission Control System
FUEL	-	Fuel System
HCAT	-	Heated Catalyst
HTR	-	Oxygen Sensor Heater
MIS	-	Misfire
OBD2	-	On Board Diagnostic – Level 2
O2S	-	Oxygen Sensor
SAS	-	Secondary Air Injection System
S. I.	-	Spark Ignition