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ON BOARD DIAGNOSTIC (OBD) SYSTEMS[2]

The vehicles in used today provide more and more information for drivers. This information is not only referring of comfort parameters - eg.inside temperature or outside temperature - directly, but also the state of running of the car. Because of the emissions and the timely maintenance are becoming more and more known as an OBD system. This study gives an overview of the evolution of OBD systems, development and their operation. The study also contains an overview about a company which made electric cars and own developed OBD systems for electric vehicles.

ON BOARD DIAGNOSTIC (OBD) RENDSZEREK

A ma használatban lévő járművek egyre több információt szolgáltatnak vezetőjüknek. Ezek az információk nem csak komfortérzeti paraméterekre, - mint pl. külső vagy belső hőmérséklet - vonatkoznak, hanem az autó üzem állapotára is. A káros anyag kibocsátás és a megfelelő időben történő karbantartás miatt egyre inkább előtérbe kerülnek az úgynevezett OBD rendszerek. A tanulmány egy áttekintő képet ad az OBD rendszerek kialakulásáról, fejlődéséről és azok működéséről, valamint betekintést nyújt egy elektromos autókat gyártó cég saját fejlesztésű rendszeréhez.

INTRODUCTION

The machines and vehicles which are used today is becoming increasingly important to check their condition. This condition monitoring consists of two components. The first component is meet the requirements for enviromental standards and the second is to maximize the vehicles availability. Variety of OBD[3] systems developed by engineers to solve these problems. The Gorvernments of the World have an obligation to use the OBD system all over the world. The systems that we use today provides more more detailed picture of the state of the vehicle's condition. These systems are not just a simple pullutant emissions and monitoring systems specifications.

The development of the OBDs is a multi-level research area. The development could be seperate in several different way. The first use of the conventional fuel vehicles, and the second is a hybrid or electric vehicles. The system keeps track of the physical parameters due to different various types of power trains.

The next step is monitoring the observed data stored in the memory of the OBD system. If the OBD's error detected by the sensors it sends a signal to the user. Thanks for these informations the users or drivers can survey how long they can use the vehicle without any seriuous damage. Many maintenance steps designed for the error indicators. Indicators and maintenance steps help to reduce the time of service.

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[3] OBD – On Board Diagnostic

The study describes the evolution of OBD systems. It is shows the structure of OBD and various parts of the OBD system. The article gives an overview of plugs and sockets of the on board diagnostic settings. It is contains a short description about MIL lamp and TESLA electric vehicle management system.

In [25] Pokorádi and Szabolcsi dealt with diagnostics of the technical state of the aircraft on-board systems. Szabolcsi in [26] summarized mathematical background for analysis of the technical systems and created computer codes to numerous problems met in the practice of system analysis and design.

HISTORY OF OBD SYSTEMS

The Californian State supervisor of the air quality (California State, United States of America) realized how important the condition monitoring of the vehicle is. This state was the first which one made the usage of condition monitoring system mandatory for the vehicles. The emission fluctuations shows a lot of technical errors [4][9][12].

So every new vehicles have to meet strict requirements and the operation of vehicles have to checked in a regular interval. Various authorities can check the cars' exhaust emission on a simple road check [4][9][12].

The first standard diagnostic system was the OBD I.. All vehicles had to use such a system in the State of California since the model year of 1988. A new system had to answered to the new standards. Every car manufacturer used OBD II in 1994. (Figure 1.) [4][9][12].

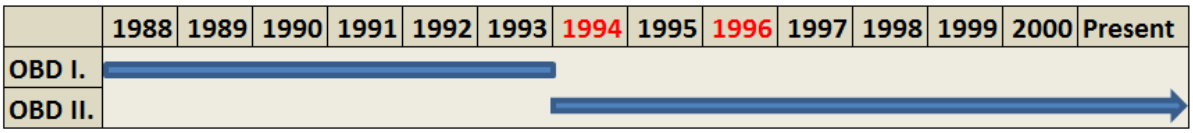

Figure 1. The OBD introduction in the USA

The OBD systems is equivalent with the EOBD[4] in Europe. The EOBD is an European norm which is linked to the Euro3. The EOBD introduction is required for every carmaker since 2000 (Figure 2.) [4][9][12].

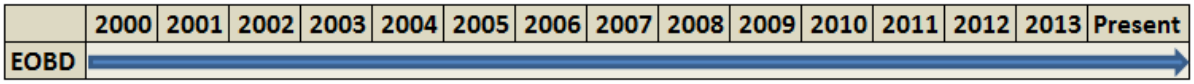

Figure 2. The EOBD introduction

OBD I.

The OBD I. contains: the system has to check every part of the vehicle which has emission restrictive task and the parts have electric connections with the control unit. The OBD I. contains only error detection. The system has to save the error codes in its memory. When the

[4] EOBD – European On Board Diagnostic

OBD get an error code a MIL[5] light or a CHECK ENGINE light gives information for the user (Figure 3.) [2][3][5][18].

Figure 3. MIL and CHECK ENGINE light combinations [18]

After the alert light was flashed the maintenance group can read out the error codes from the memory with a serial readout. Other type of on board diagnostic equipments can connect to the OBD I. by a lot of different supplier or producer. The OBD I. contains standards only for the exhaust system monitoring [2][3].

OBD II.

The OBD II. monitoring strategy is more complex than the OBD I. Thanks for the new regulations a lot of test and measuring process works on different parts of the cars that never before [1][2][3].

The MIL light has new functions [2]:

- off;
- on;
- flash.

The new systems are able to identify the rate of degradation and it can save the enviroment parameters when the problem(s) occured. The Table 1. shows the main differences between Diesel engine OBD II. and Otto engine OBD II system [2][3][9].

OBD II. watch	
Diesel engine	Otto engine
Exhaust gas recirculation control	Fuel supply
Injection system	Lambda sensor aging and stress control
Boost pressure control	Secondary air supply system
Connectors, sensor, actuators control	Leakage control
Flame failure	Antievaporation system
Automatic torque converter check	Flame failure
Injection start regulation	Motronic control unit
	CAN-bus
	Check control unit connected to sensors and actuators
	Catalytic converter efficiency

Table 1. OBD II. condition monitoring [2]

[5] MIL – Malfunction Indicator Light

The Table 2 shows the main different between OBD I. and OBD II.

OBD I.	OBD II.
Non standard diagnostic connector (every vehicle has a different type)	Standardized protocol and socket
Non standard error codes (different for each producer)	Standardized emission control system
Non standard engine and emission control system	Standardized error codes (DTC)
Non standard MIL light	Save enviroment datas when the system get a failure (Freeze Frame)
Different technical approaches for the same error (different for each producer)	Standardized MIL and MIL functions
	Operating status skills (Readiness)

Table 2. OBD I. and OBD II. [3]

EOBD II.

The EOBD is similar with the OBD II.. This standard is applies for those M1 category vehicle which is can't carry more than 8 people and the mass is not more than 2500 kg. The cars with gasoline engine has to used this system since 2001 and the diesel engines has to used since 2004. The vehicle (gasoline) with more than 2500 kg mass has to used it since 2000, the diesels has to used since 2007. [2][3][8][9].

The EOBD use the same standard parameters like OBD II.. The EOBD also works with SAE[6] J1962 diagnostic protocol. The emission rate will be lower than Euro3 and Euro4 standards thanks for the new Euro5 and Euro6 standards [1][8][5].

MIL LIGHT

The vehicle's monitoring is an OBD function. If the parameters show different results from the prescribed results the system has to save the datas in its memory. The system has to sent a massage or any other information for the driver. MIL light or the „CHECK ENGINE' light can show the information about the problems on the dashboard. The OBD I., OBD II. and the EOBD also use these kind of indicators [1][2][3][5][19].

These lights get a place on the dashboard where the drivers can find them. The MIL light is an dark orange engine symbol (figure 4.) [1][2][3][5][19].

[6] SAE – Society of Automotive Engineers

Figure 4. MIL lights on the dashboard [19]

Some manufacturers put text informations next to the MIL light. These informations can be the followings:

- Check Engine
- Service Engine Soon
- Check Powertrain
- Check Powertrain Soon
- Engine symbol [2]

The OBD II. and EOBD standards contains the following 3 status for the MIL lights:

- not light
- light
- flashing [2]

The 3 status depends on what kind of problem get in the car:

- If the emission limit is more than one and the half the MIL is lighting
- If the catalyst get injury the MIL is flashing
- If the system can save the problem and knows about it the MIL is not lighting [2]

DIAGNOSTIC CONTACT OF OBD II. AND EOBD

The regulations contain the standard connections for the OBD systems. The place of the diagnostic socket, the type of the diagnostic cable the diagnostic protocol and the IT help desk are parts of a huge standard regulation [1][3][21].

The ideal place of the OBD socket is the place where the maintenance group can get it easily the socket. This place has to save the spocket against physical damage and the drivers have to drive undisturbed. The manufacturers or the producers put the spocket into the dashboard with a cover or put it under the panel [1][3][21].

Figure 5. OBD socket under the dashboard [20]

The socket and the diagnostic tool connection have two parts. The fist one is the spocket which is always in the vehicle. It is a (sometimes called „mum" spocket) spocket with 16 pin (5. and 6. figure) [1][3][21].

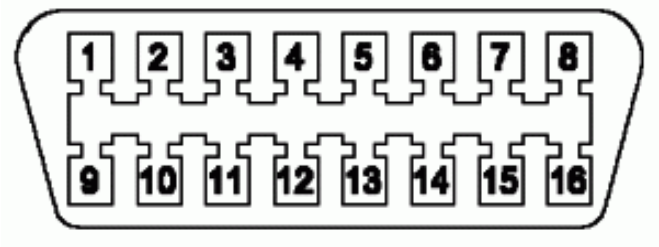

Figure 6. The „mum" spocket [21]

The second one is the „dad" jack. It has also 16 pin (Figure 7.) [1][3][21].

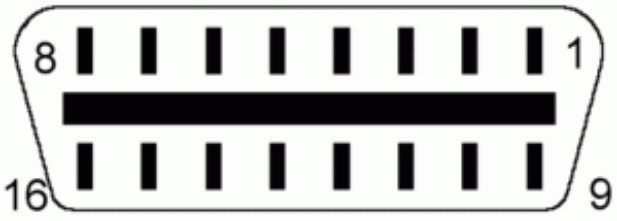

Figure 7. The „dad" jack [21]

Every jack feet has a dedicated serial port. So every jack has a standard number codes for the good connection [1][3][21].

The numbers are the following:

- 2: J1850+
- 4: Vehicle body
- 5: Signal body
- 6: CAN huge signal
- 7: ISO 9141-2/ISO 14230 K-line
- 10: J1850 –
- 14: CAN low signal
- 15: ISO 9141-2/ISO14230 L-line
- 16: Battery +12V [1][3][21]

The used protocol by the car can be identify from the serial ports. Which feet works or not:

- SAE J1850W PWM: 2, 4, 5, 10, 16 (Ford Motor Company standard)
- SAE J1850 VPW: 2, 4, 5, 16 (no 10) (General Motors standard)
- ISO 9141-2/ISO 14230: 4, 5, 7, 16 (might 15) (Chrysler, European and Asian standard)
- CAN: 4, 5, 6, 14, 16 [1][3][21]

The release do not extend on the other legs. The factories use these legs freely. Lot of manufacturers and producers offer different types of OBD computers to read out the information from the cars.

The Figure 8. shows a computer which produced by Robert Bosch.

Figure 8. BOSCH OBD computer [22]

TESLA ELECTRIC CAR VMS

One of the World biggest electric car maker company is the TESLA Motors, INC.. The company headquarters is in California, United States. The CEO is Elon Musk who is an owner of PayPal, TESLA Motors and SpaceX companies [16][23][24].

Dozen of engineers works on the electric cars of the future. The company use a special VMS[7] for their vehicles. This system developed by TESLA engineers [16].

The VMS is monitoring the vehicle power management, motor control, engine diagnostic, HVAC[8] system, door locks and etc. (figure 9.). Touch screen monitor shows these informations for the driver [16].

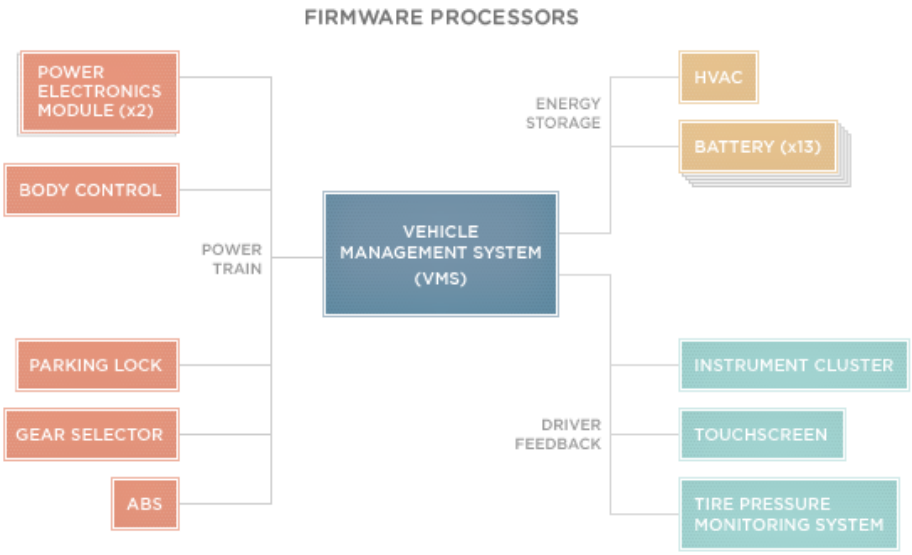

Figure 9. TESLA VMS [16]

The system contains different types of processors. Every processor has an operating system, but the system do not use the same operating systems for the different physical parameters. This is necessary for obtaining the measured results. The TESLA engineers developed a new type of firmware. This firmware allows for continous update and the company doesn't have to wait for the different suppliers to get updates. Sometimes the suppliers need 3-6 months to make a new update for the vehicle condition systems [16].

The VMS has a lot of any other function. When the ignition key get in the car the touch screen automatically turn on and prepare the car for the start. The system calculate the mileage rate and make strategis about the batteries recharge. The VMS works with complex algorythm to save the betteries life. The TESLA system can give more information about the car condition like a typicall OBD system [16].

[7] VMS- Vehicle Management System
[8] HVAC – Heating, Ventilation, Air Conditioning

Figure 10. The touch panel [16]

The battery processors control the temperature and voltage in the battery pack by monitoring more than 100 sensors. When the temperature results are not appropriate (low or high) the heating or cooling unit turn on automatically [16].

The Power Electroincs Modules have a job to send power to the motor from the battery and manage the charge. The Power Electronics Module is instructed to send current to the light ring in the charge port and white LEDs turn on. When the driver attaches the connector cable and slides the pilot switch closed the lights turn blue. If the battery is empty, the LED lights flash quickly. As the battery charges the rate of the LEDs flashing slow. When the battery is complitly charged the lights turn into green (Figure 11.) [16].

Figure 11. LED lights [16]

The TESLA systems are suitable for the Open Vehicle Monitoring System. The owners get informations about their cars from the internet with a mobile phone if they use this programm

SUMMARY

As one can see the OBD systems went through on a great development way. The first OBD standards contained only some rules about the condition monitoring. Nowadays, the new OBD II. and EOBD systems standards contain a lot of measuring point, process and rules for vehicle health monitoring.

Long time had to elapse before the car companies and governments started to create new standards and rules. The standards contains rules for every part of the vehicles like emission control, HVAC systems and etc.. Now every manufacturer use these standards and they managed every technical failure in the same way.

We can use the OBD systems not just for emission system monitoring, but we can extend it for the other parts of the vehicles. The system not only monitor the exhaust system thanks for this reason. The OBD has to save every data and failure in its memory. The maintenance group can read out this datas from the system memory with a special computer. If the OBD get a critical result it can alert the driver. The vehicles life can be longer thanks for the measuring system.

Nowadays the modern vehicles started to use a new power source. This power source is the electricity. The electric cars efficiency still behind the convential fuel cars. The electric or hybrid cars also required a current system like OBD.

The electric and hybrid cars are very complex systems. They made up a lot of mixed and complex machine parts. Just know about the hybrid cars they are use mixed power trains. These facts and the costumer requirements show how important the condition monitoring systems are. The conclusion is: the modern vehicle condition monitoring system research area is a very important business line. In the future we will use bigger, faster and more complex cars. Every car will be made from more machine parts with a lot of failure and we would like to use these cars as long as possible. The engineers of the future have to make a system which can show when the drivers will have to take the vehicle to a service point to the gas station or to the recharge station.

LITERATURE

[1] OBD DIAG KFT OBD2 információk (online) url: http://www.autodiagnosztika.com/obd2.html (2013.11.11.)

[2] DR. LAKATOS ISTVÁN Fedélzeti diagnosztika (OBD, EOBD). Új Magyarország Fejlesztési Terv, TÁMOP 2.2.1 08/1-2008-0002, „A képzés minőségének és tartalmának fejlesztése”, Nemzeti Szakképzési és Felnőttképzési Intézet (online) url: http://109.74.55.19/tananyag/tananyagok/13.%20K%C3%B6zleked%C3%A9s/0619-06%20K%C3%B6rnyezetv%C3%A9delmi%20fel%C3%BClvizsg%C3%A1lat%20feladatai/003%20Fed%C3%A9lzeti%20diagnosztika%20(OBD,%20EOBD)%20.pdf (2013.11.12.)

[3] DR. LAKATOS ISTVÁN OBD, EOBD (fedélzeti diagnosztika). (online) url: http://rs1.sze.hu/~lakatos/OBD_EOBD.pdf (2013.11.10.)

[4] [WIKIPÉDIA THE FREE ENCYCLOPEDIA ON-BOARD DIANOSTICS. (online) url: http://en.wikipedia.org/wiki/On-board_diagnostics (2013. 11.10.)

[5] GEREE.HU – A motorok világa, Az OBD rendszerek. (online) url: http://www.geree.hu/motormenedzsment-es-diagnosztika/az-obd-rendszerek/ (2013.11.10.)

[6] LÁNG KFT. Környezetvédelmi önfelügyelő rendszer - EOBD (Hetedik rész – a fedélzeti diagnosztika információ). (online) url: http://webshop.langauto.hu/kepek/muszaki/6.7.pdf (2013.11.10.)

[7] LÁNG KFT. Környezetvédelmi önfelügyelő rendszer - EOBD (Második rész – Az OBD információs rendszer általános felépítése). (online) url: http://webshop.langauto.hu/kepek/muszaki/6.2.pdf (2013.11.10.)

[8] LÁNG KFT. Környezetvédelmi önfelügyelő rendszer - EOBD (Ötödik rész – Otto motoros járművek károsanyag-kibocsátás csökkentő rendszerei és azok OBD felügyelete III.. (online) url: http://webshop.langauto.hu/kepek/muszaki/6.5.pdf (2013.11.10.)

[9] SZABÓ JÓZSEF ZOLTÁN Gépjármű Diagnosztika, BMF Mechatronika és Autótechnika Intézet, 7. előadás, OBD – EOBD fedélzeti diagnosztikai rendszerek. (online) url: http://siva.banki.hu/jegyzetek/Gepjarmu_diagnosztika/GJD_7EA_OBD.pdf (2013.11.12.) – in Hungarian
[10] FORD MOTOR COMPANY 2010 MY OBD System Operation Summary for Hybrid Electric Vehicles. p.3-35. (online) url: http://www.motorcraftservice.com/vdirs/diagnostics/pdf/OBDSM1001_HEV.pdf (2010.01.14.)
[11] DR. IPEK SARAC HEINZ Control Systems Fulfilling Future OBD and Service Diagnosis Requriments, based on a publication by: Lehle, Leideck, Willimowski. ICE 2013: Inter. Conference on Engines & Vehicles (online) url: http://www.sae-na.it/Control%20Systems%20Fulfilling%20Future%20OBD%20and%20Service%20Diagnosis%20Requirements%20-%20Ipek%20Sarac%20Heinz.pdf (2013.11.12.)
[12] DR. GÖMÖRI TIBOR Üzemfenntartás, jegyzet. Debreceni Egyetem Műszaki Kar – in Hungarian
[13] CHRIS MI, M. ABUL MASRUR, DAVID WENZHONG GAO Hybrid Electric Vehicles, - Principles and Applications with Practical Perpectives, John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, United Kingdom, ISBN 978-0-470-74773-5
[14] PAUL BALTUSIS, HAL ZATORSKI Interactive Breakout Session – Hybrid Electric Vehicles, United States Pasadena, Kalifornia, (online) url: http://www.gobookee.org/get_book.php?u=aHR0cDovL3d3dy5zYWUub3JnL2V2ZW50cy90cmFpbmluZy9zeW1wb3NpYS9vYmQvcHJlc2VudGF0aW9ucy8yMDA1YmFsdHVzaXMucGRmCkludGVyYWN0aXZlIEJyZWFrb3V0IFNlc3Npb24gLSBIeWJyaWQgRWxlY3RyaWMgVmVoaWNsZXM== (2013.11.20.)
[15] DEREK MATTHEWS Challenges facing the harmonization of Hybrid HD Vehicles and HD Engine OBD, Hybrid Manufacturers Regulatory Collaboration, BAE Systems, (online) url: https://s3.amazonaws.com/automotiveworld/slides/cvisusa2011/Derek+Matthews+-+BAE+Systems.pdf (2011.09.28.)
[16] TESLA MOTOR INC. Advanced software, A Silicon Valley Approach to Vehicle Software (online) url: http://www.teslamotors.com/roadster/technology/firmware (2013.11.11.)
[17] MAKKONEN, NUUTINEN, HONKAPURO, SILENTOINEN, PARTANEN, LASSILA, KAIPIA INCA Report, Intelligent Electric Car Charging System. (online) url: http://webhotel2.tut.fi/units/set/research/inca-public/tiedostot/Raportit/INCA%20Report%20-%20Intelligent%20electric%20car%20charging%20system.pdf (2013.11.10.)
[18] SAMARINS.COM Why a car won't start troubleshooting tips. (online) url: http://www.samarins.com/diagnose/check-engine-light-large.jpg) (2013.11.10.)
[19] OUTILS OBD FACILE OBD presentation, Malfunction Indicator Lamp (MIL). (online) url: http://www.outilsobdfacile.com/obd-presentation.php (2013.11.10.)
[20] [AUTO NEWS KFT. www.azaauto.hu, (online) url: http://www.azauto.hu/Files/Image/obd/obd2n.jpg) (2013.11.10.)
[21] GEREE.HU – A motorok világa, Az OBD-II Diagnosztikai kapcsolat. (online) url: http://www.geree.hu/motormenedzsment-es-diagnosztika/az-obd-rendszerek/obd-ii-diagnosztikai-kapcsolat/ (2013.11.10.)
[22] IMAGE SHACK MEDIA HOSTING COMPANY (online) url: http://img24.imageshack.us/img24/3227/boschfl.jpg (2013.11.10.)
[23] WIKIPÉDIA THE FREE ENCYCLOPEDIA Tesla Motors, (online) url: http://hu.wikipedia.org/wiki/Tesla_Motors (2013.11.24)
[24] WIKIPÉDIA THE FREE ENCYCLOPEDIA Elon Musk, (online) url: http://hu.wikipedia.org/wiki/Elon_Musk (2013.11.24.)
[25] POKORÁDI L., SZABOLCSI R., Mathematical Models Applied to Investigate Aircraft Systems", Monographical Booklets in Applied and Computer Mathematics, MB-12, PAMM, Műegyetemi Kiadó, ISSN 1417-278X, Budapest, 1999., p. 146.
[26] SZABOLCSI R. Korszerű szabályozási rendszerek számítógépes tervezése, ISBN 978-615-5057-26-7, p.415, Zrínyi Miklós Nemzetvédelmi Egyetem, 2011.