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On the Development and Implementation of the OBD II Vehicle Diagnosis System

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Abstract: *Nowadays, several new technologies support the high way transportations to decrease risk and to achieve secure driving. With the improved software and hardware, Computer and Smartphone technology are able to monitor and use the vehicle useful information to improve the vehicle performance, fuel consumption, reduce emission, driving risk and the maintenance time and costs. This paper aims to improve the performance of the on-board diagnostics unit (OBD-II) type (ELM 327), by modifying the Bluetooth unit and using it on a personal computer or Smartphone without an Internet connection. An Excel sheet of all available defects is collected, prepared and feed to PC and Smartphone. It works on Smartphone formula (APK) and on PC windows formula (EXE), both are Depends on a database of the Excel file. The two technologies (PC and Smartphone) are decoding the malfunction code and referred to it. In addition to providing the database, the main and most common reasons which cause the malfunctions, without the need for the Internet for easy use by any user of the vehicle, whether a driver, technician or a specialist.*

Keywords: *Development, Application, OBD-II, Diagnostics, Bluetooth, Android System, Internet, Malfunctions Code, Vehicle Repair Information, Smartphone, Computer.*

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I INTRODUCTION

The automobiles industry is one of the most important industries in the world, different developments have been done to improve its performance, fuel consumption, comfort, safety and reduce emission, the major vehicle companies have taken the durability of these automotive electronic devices into account when designing modern vehicles, however, the human failure or improper operation will still lead to unnecessary fuel consumption and exhaust pollution. Because of these modern vehicles are equipped with lots of electronic components, it is not easy to diagnose these vehicle faults using traditional fault detection methods. According to previous researches [1], the time for finding vehicle fault is 70%, while the time for troubleshooting and maintenance accounts is just 30%. Therefore, the major vehicle companies developed a fault diagnosis system, namely, on-board diagnostic or OBD, into vehicle electronic control unit (ECU).

To reduce the stopping time, reduce maintenance cost, and improve the reliability of the ground vehicle, the OBD system is designed to consecutively monitor the running condition of the vehicle [2-4]. Once there is a malfunctioning element such as; that controls the emission of exhaust, the OBD system will turn on the Malfunction Indicator Lamp (MIL) or the Check Engine light, to notify the driver to repair the vehicle immediately. When the OBD system detects malfunctions, OBD regulations will inform the ECU of the vehicle to save a standardized Diagnostic Trouble Code (DTC) about the information of malfunctions in the memory. An OBD Scan Tool for the servicemen can access the DTC from the ECU to quickly and accurately confirm the malfunctioning characteristics and location in accordance with the prompts of DTC. In addition to DTC, the OBD system can monitor more than 80 items of real-time driving status, e.g., vehicle speed, engine rpm, throttle position, intake air temperature, engine coolant temperature, and etc. [2-4]. The OBD system is widely used in the current vehicle workshops or service dealers.

In spite of the OBD is started to be used in 1960's, in the mid- 90s, a new standard was introduced that provides almost complete engine control and also monitors parts of the chassis, body and accessory devices, as well as the diagnostic control network of the car. The new standard is called OBD-II. The ECU gathers information through a network of sensors in the automobile. The data collected are used for decision making by the ECU. The information logged by the ECU is used to trace faults in the automobile's operation. The OBD standard provides an interface for the user to access the information gathered by the ECU. Access to the sensors and diagnostic data gathered by the ECU via the OBD-II requires special hardware and software. When a system failure occurs, the corresponding fault code will be generated. The fault codes can be acquired from ECU via certain programs; therefore, the nature and location of the fault can be determined accurately. In addition, a wide range of monitoring systems has been added, which makes it possible to carry out real-time monitoring of the working conditions of automobiles. OBD-II system requests to monitor any part or system related to exhaust, with the focus on monitoring the faults in fuel and air measuring system, ignition system, engine flameout and auxiliary device for exhaust gas control. The OBD-II system monitors the auto parts and system failure on a real-time basis so that the exhaust of automobiles will not exceed the requirement of regulations in its service life.

The CAN/OBD-II adapter is based on ELM 327 chip and follows SAE/ISO standards [6-9]. The main features of CAN/OBD-II are (1) unified J1962 16-pin socket and data link connector (DLC); (2) unified DTC and meanings; (3) storage and display DTC; (4) vehicle record capability; and (5) auto-clear or reset function for the DTC. In other words, just one set of CAN/OBD-II scan tool is able to perform the diagnosis task and can scan against variety of vehicles which equipped with CAN/OBD-II system as shown in Figure 1.

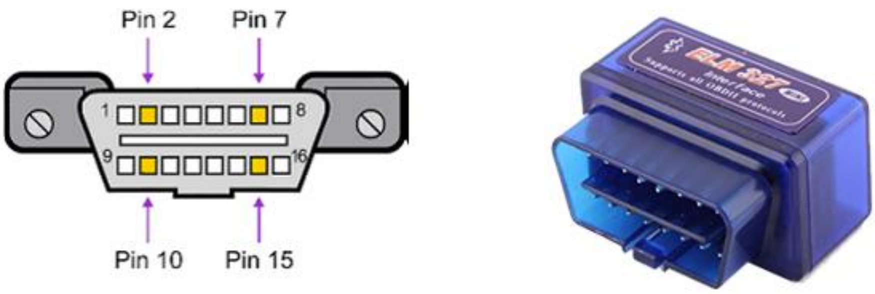


Figure 1. (a) J1962 CAN/OBD-II 16-pin socket, (b) CAN/OBD-II DLC.

There are five codes in total to represent the OBD-II DTC message as shown in Figure 2. The first code is an English alphabet to stand for the established malfunction system. The remaining four codes are digits; the second code indicates the meaning of malfunction formulated by ISO/SAE or customized by the vehicle manufacturer; the third code shows the area of the vehicle system; the remaining two codes represent the definition of the subject malfunction [5].

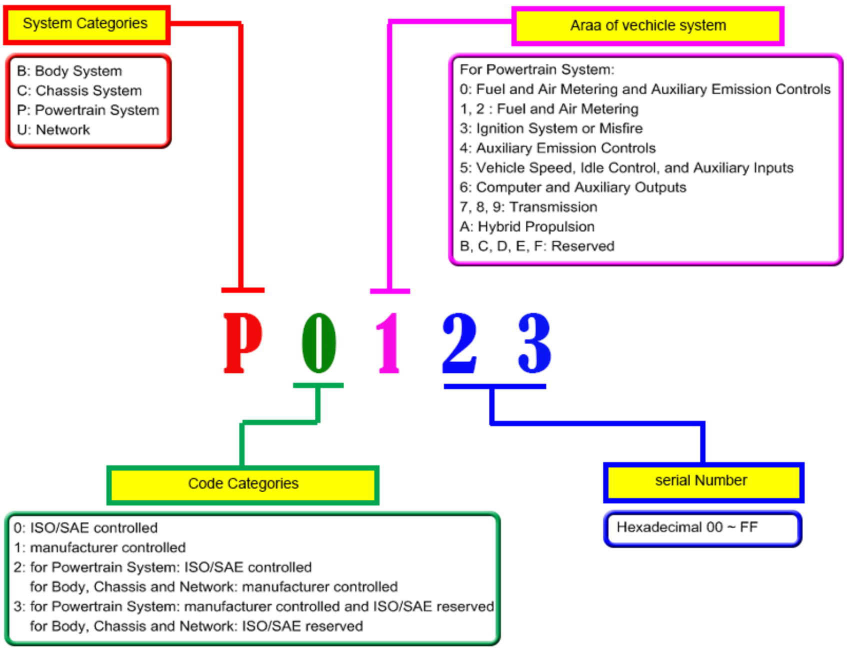


Figure 2. Definition of the CAN/OBD-II diagnostic trouble code (DTC).

Gathering information, inform the driver about vehicle and tracking error code processes can be performed easily with OBD technology [10]. Access to ECU data with mobile devices of the drivers is performed by a diagnostic device connected to OBD-II connector. An OBD-II device that enables the export of data on the CAN-Bus undertook the converter task [11]. Smartphone access the ECU data by providing a connection to the diagnostic device. Thus, the driver can monitor the vehicle data in real time via Smartphone as shown in Figure 3. Vehicle status information can be transmitted to drivers while driving by using an appropriate interface with Smartphones that provides high calculation speed and wireless communication facility [12].

Figure 3. System Structure.

Access to ECU of the vehicle is performed via OBD. OBD-II provides access to vehicle's data network can bus as a standard extended by SAE. There are a lot of OBD-II device designed by using OBD-II protocols to monitor vehicle data network. Combination of OBD and wireless technologies monitoring and control applications of mobile devices has been emphasized [13]. OBD-II diagnostic devices are being produced by the wireless communication technology with Wi-Fi and Bluetooth [14, 15]. Wireless capabilities of Smartphone and OBD-II devices are given in Figure 4.

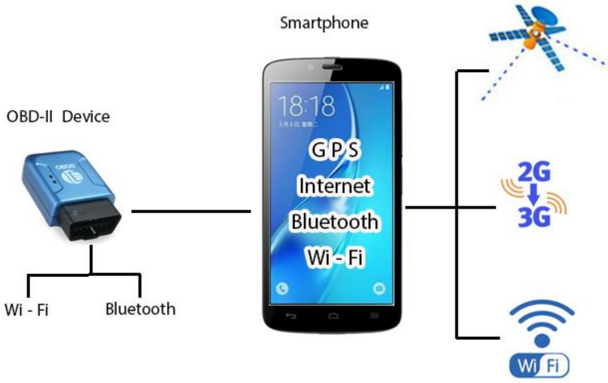


Figure 4. OBD-II Device and Smartphone Communication Structure.

Due to the operation of OBD is quite difficult, the general drivers could not access OBD data easily. Hence, this paper presents low cost and simplified diagnostic systems compatible with most vehicles made after 1996, without needs to Internet connections. The interfaces are an Android or/and PC application which connects to a Bluetooth adapter attached to the vehicle. It uses a high-speed Bluetooth network to send requests and receives data which is converted by the application to a human readable format to help driver or repairer to determine the faults of the vehicle. The vehicle diagnosis system proposed in this paper consists of on-board unit (OBU) and vehicle diagnostic server (VDS) on Smartphone or/and PC as shown in Figure 5.

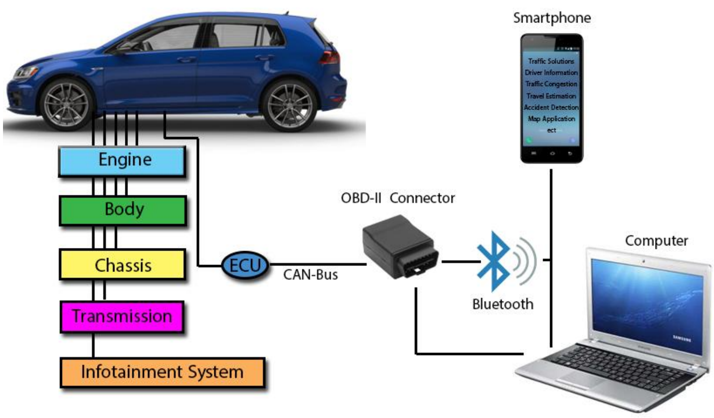


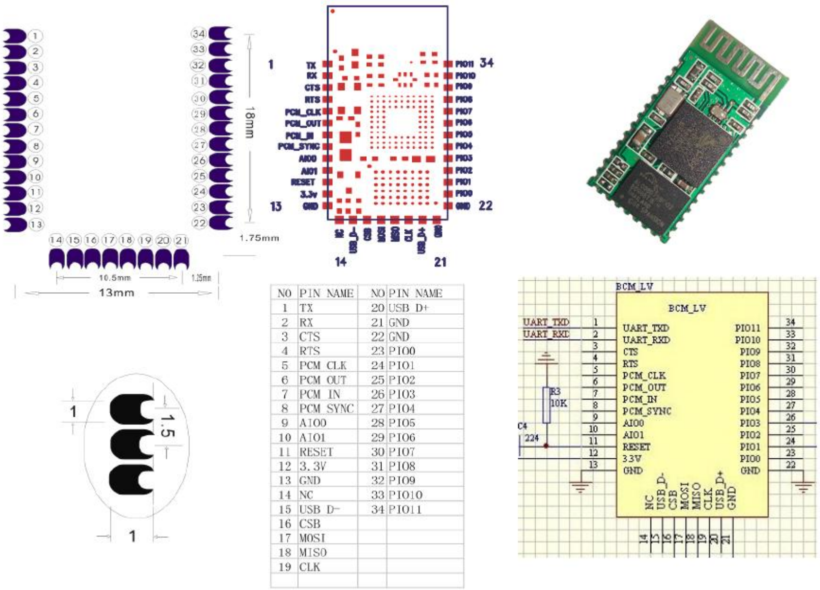
Figure 5. ECU and Smartphone and Computer Communication

II DEVELOPMENT OF THE ON-BOARD DIAGNOSTICS UNIT (OBD-II)

2.1. Development of the on-board diagnostic unit.

The OBD-II is used by specialists and technicians to show faults in the form of code when it is connected to the control unit (ECU) to follow up the sensors reading. The results can be monitored via Smartphone when OBD-II is connected via Bluetooth. It is the basis for the exchange of data between the OBD-II referred to it and mobile phone, and according to a specific protocol. To speed up the information transfer between ECU, OBD II and reduce the pairing time as well as the diagnosis time, a new type of high-speed Bluetooth is used With OBD-II, which is shown in Figure 6.

The new Bluetooth has many advantages compared with the old one such as; smaller in size, low power consumption, has high-performance wireless transceiver system, low Cost, has an EDR module, the change in range of modulation depth is 3Mbps, has a built-in 2.4GHz antenna, sensitivity (Bit error rate) can reach 80dB/mw, can work at the low voltage (3.1V~4.2V)m and the current in pairing is in the range of 30～40mA.



NO	PIN NAME	NO	PIN NAME
1	TX	20	USB D+
2	RX	21	GND
3	CTS	22	GND
4	RTS	23	PIO0
5	PCM CLK	24	PIO1
6	PCM OUT	25	PIO2
7	PCM IN	26	PIO3
8	PCM SYNC	27	PIO4
9	AIO0	28	PIO5
10	AIO1	29	PIO6
11	RESET	30	PIO7
12	3.3V	31	PIO8
13	GND	32	PIO9
14	NC	33	PIO10
15	USB D-	34	PIO11
16	CSB		
17	MOSI		
18	MISO		
19	CLK		

Figure 6. The new Bluetooth that is used with OBD-II unit.

2.2. DESIGN OF THE APPLICATION TO WORK ON MOBILEPHONE

The speed of the fault finding using the existing OBD-II unit depends not only on the pairing time as well as the diagnosis time but also on the speed of the internet, to find information about the fault code as shown in Figure 7. These make it difficult to be used especially in case of the low-speed internet or in case of loose connection. Also, to find the causes that lead to each fault separately, it needs a lot of effort and time [16].

Figure 7. Identification and illustration of the fault code using the Internet.

To make it easy to be used by different users with an easy-to-use interface, to speed up the fault finding, reduce the maintenance time, reach the optimal performance and reduce the risk of faults and the consequent damage to

the environment and accidents, it is decided to make the same application running on the Smartphone, which is connected with OBD-II through Bluetooth without need to the Internet In the clarification of the faults and its causes as shown in Figure 5. All the needed data about the faults are stored in the phone memory; therefore, an application is designed to run on the mobile phones in APK formula using use Java language.
During the vehicle examination, once the ECU is connected to the developed OBD-II, which is connected to the Smartphone via the high-speed Bluetooth, the fault code will be seen on screen. Once the fault code is found, it will be written in this application to work on the mobile phones as shown in Figure 8.

Figure 8. Application fault on Smartphone.

The entire needed database which containing the faults and the causes that lead to each fault separately which can be found in [17 - 20] have been saved in the mobile database through an excel sheet. This application is helpful not only to vehicle driver with low technical and maintenance experiences but also to the experienced technician because it will save time.

2.3 DESIGN OF THE PROGRAM TO WORKING ON COMPUTER

In some cases, the specialists and technicians need to print the diagnosis of faults that appear during the examination of the automobiles, which is difficult to implement through the existing OBD-II. That is because it needs to find one of the specialized sites to recognize malfunctions that codes appear as a result of the examination. Therefore, in this study to facilitate the use of OBD-II diagnostic tools by specialist and technicians by a new program working on the computer in the Windows environment is designed to work as an executive file in the EXE formula, and its flowchart is shown in Figure 9.

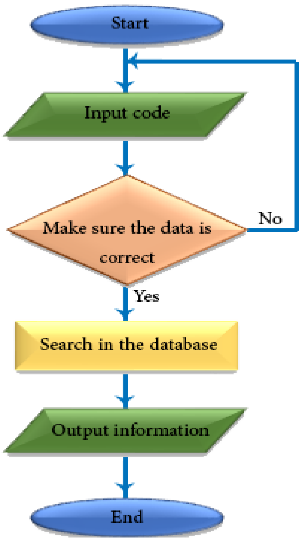


Figure 9. Flowchart

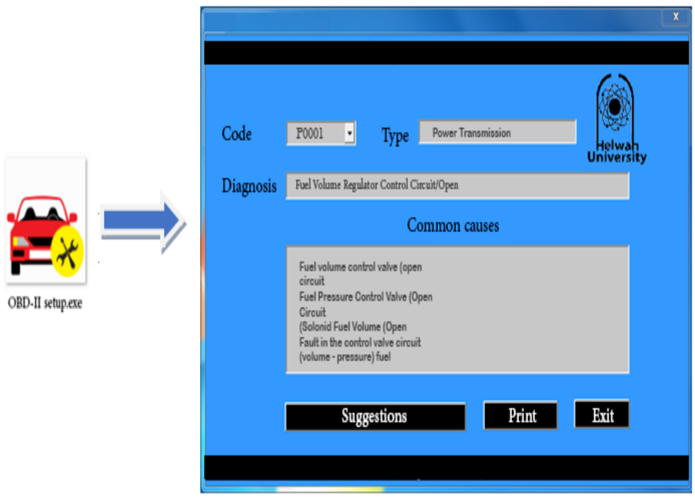


Figure 10. The program works in the PC environment

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As shown in Figure 5, during the vehicle examination, once ECU is connected to the developed OBD-II, which is connected to the Computer via the high-speed Bluetooth, the fault code will be seen. Once the fault code is found, it will be inserted in a program that is designed to work on Windows environment, the results will as shown in Figure 10. This application is helpful and useful for technicians and specialists.

III MEASUREMENT RESULTS AND DISCUSSION.

The efficiency of the newly developed system can be checked in different methods such as; pairing time, diagnosis time, the credibility and the total time to find the fault code and its causes. But the comparison using the last criterion will be very difficult because it is a function of internet speed, so it is decided to start with the first three criteria.

3.1 Pairing, diagnosis and reasons times

Throughout this test, to compare the original (standard) and modified OBD-II unites equipped with Smartphone, three vehicles of different brands are used as shown in Table (1). The required time is registered using a stopwatch.

Table 1: Comparing coupling, diagnosis, and reasons times for automobile under test using Smartphone.

Automobiles	**HYUNDAI VERNA 2006**			**HYUNDAI ELANTRA 2015**			**KIA SPORTAG 2012**		
Time (sec.)	pairing	diagnosis	reasons	pairing	diagnosis	reasons	pairing	diagnosis	reasons
Original	9.11	6.14	176.44	7.45	4.41	140.41	8.01	4.55	120
Modified	5.34	4.03	1	4.56	2.54	1.02	5.28	3.02	0.87

From these results, it can be seen that the modified OBD-II unit reduce the pairing time from 50 to 70% percent, and the diagnosis time from 51 to 73 percent, while the reasons time cannot be compared because the time in case of modified OBD- II unit is less than 1 percent of the original one. The reasons' time is the time to find information about the fault; for the modified OBD-II unit, the needed data is saved in the Smartphone and the fault code must be rewritten while in the original OBD-II unit the fault code must be rewritten and the needed information is gotten from the internet using a 4G speed. It can be also, possible to mention that the reasons that it appears on the Smartphone are well organized and more useful than such appears from the internet search which mostly needs a lot of time to be used because it contains a huge amount of information. In this case, it can be concluded that the modified OBD-II unit also, reduce the repair time.

To compare between the original (standard) and modified OBD-II unites, which are equipped with Personal Computer, three vehicles of different brands are used as shown in Table (2).

Table 2: Comparing between coupling, diagnosis, and reasons times for automobile under test using PC.

Automobiles	**HYUNDAI VERNA 2006**			**HYUNDAI ELANTRA 2015**			**KIA SPORTAG 2012**		
Time (sec.)	pairing	diagnosis	reasons	pairing	diagnosis	reasons	pairing	diagnosis	reasons
Original	12.22	9.03	174.17	8.63	6.38	123	8.53	6.31	121.69
Modified	8.02	6.34	5.01	6.3	5.5	3.95	1.39	1.1	0.87

3.2 Credibility of the developed OBD-II unit

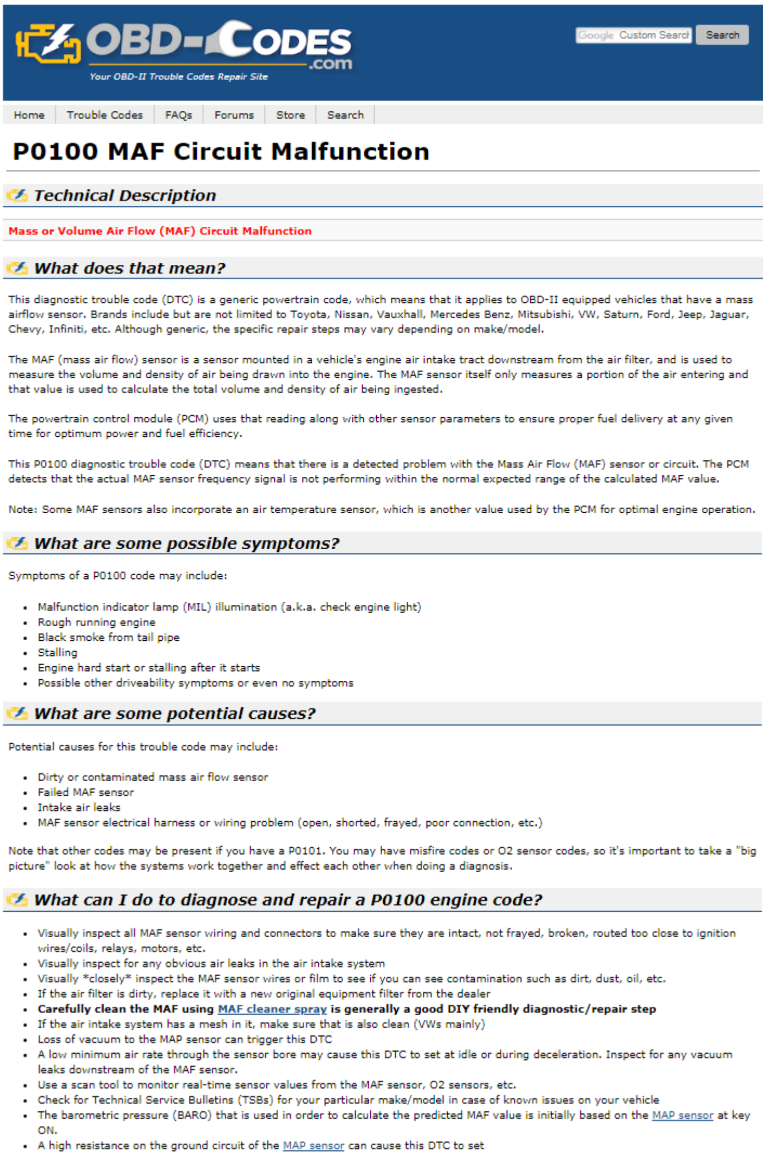
To check the Credibility of the modified OBD-II unit, its fault codes have been compared with the original one as shown in the table (3). It is clear from the results the modified OBD-II unit does not have any negative effect on results.

Table 3: Comparison between the Modified Unit and the Original Unit.

automobiles	**HYUNDAI ELANTRA 2008**	**BYD 2013**	**KIA SOUL 2012**
Original unit	P0760 Shift Solenoid "C" P0765 Shift Solenoid "D"	No faults	P0303 Cylinder 3 – misfire detected
Modified unit	P0760 Shift Solenoid "C" P0765 Shift Solenoid "D"	No faults	P0303 Cylinder 3 – misfire detected

3.3 Internet and Smartphone Information

Comparison between Internet and Smartphone information are shown in Figure **11** and Figure 12. By comparing both results for the same code, it can be seen that the Internet gives a huge amount of information and the way to diagnostic and repair in case of the powertrain unit and there are very rare information in case of Body, Chassis, Transmission, and information system, while the Smartphone gives only the important information.


OBD-CODES .com
Your OBD-II Trouble Codes Repair Site

Google Custom Search | Search

Home | Trouble Codes | FAQs | Forums | Store | Search

P0100 MAF Circuit Malfunction

Technical Description

Mass or Volume Air Flow (MAF) Circuit Malfunction

What does that mean?

This diagnostic trouble code (DTC) is a generic powertrain code, which means that it applies to OBD-II equipped vehicles that have a mass airflow sensor. Brands include but are not limited to Toyota, Nissan, Vauxhall, Mercedes Benz, Mitsubishi, VW, Saturn, Ford, Jeep, Jaguar, Chevy, Infiniti, etc. Although generic, the specific repair steps may vary depending on make/model.

The MAF (mass air flow) sensor is a sensor mounted in a vehicle's engine air intake tract downstream from the air filter, and is used to measure the volume and density of air being drawn into the engine. The MAF sensor itself only measures a portion of the air entering and that value is used to calculate the total volume and density of air being ingested.

The powertrain control module (PCM) uses that reading along with other sensor parameters to ensure proper fuel delivery at any given time for optimum power and fuel efficiency.

This P0100 diagnostic trouble code (DTC) means that there is a detected problem with the Mass Air Flow (MAF) sensor or circuit. The PCM detects that the actual MAF sensor frequency signal is not performing within the normal expected range of the calculated MAF value.

Note: Some MAF sensors also incorporate an air temperature sensor, which is another value used by the PCM for optimal engine operation.

What are some possible symptoms?

Symptoms of a P0100 code may include:

- Malfunction indicator lamp (MIL) illumination (a.k.a. check engine light)
- Rough running engine
- Black smoke from tail pipe
- Stalling
- Engine hard start or stalling after it starts
- Possible other driveability symptoms or even no symptoms

What are some potential causes?

Potential causes for this trouble code may include:

- Dirty or contaminated mass air flow sensor
- Failed MAF sensor
- Intake air leaks
- MAF sensor electrical harness or wiring problem (open, shorted, frayed, poor connection, etc.)

Note that other codes may be present if you have a P0101. You may have misfire codes or O2 sensor codes, so it's important to take a "big picture" look at how the systems work together and effect each other when doing a diagnosis.

What can I do to diagnose and repair a P0100 engine code?

- Visually inspect all MAF sensor wiring and connectors to make sure they are intact, not frayed, broken, routed too close to ignition wires/coils, relays, motors, etc.
- Visually inspect for any obvious air leaks in the air intake system
- Visually *closely* inspect the MAF sensor wires or film to see if you can see contamination such as dirt, dust, oil, etc.
- If the air filter is dirty, replace it with a new original equipment filter from the dealer
- **Carefully clean the MAF using MAF cleaner spray is generally a good DIY friendly diagnostic/repair step**
- If the air intake system has a mesh in it, make sure that is also clean (VWs mainly)
- Loss of vacuum to the MAP sensor can trigger this DTC
- A low minimum air rate through the sensor bore may cause this DTC to set at idle or during deceleration. Inspect for any vacuum leaks downstream of the MAF sensor.
- Use a scan tool to monitor real-time sensor values from the MAF sensor, O2 sensors, etc.
- Check for Technical Service Bulletins (TSBs) for your particular make/model in case of known issues on your vehicle
- The barometric pressure (BARO) that is used in order to calculate the predicted MAF value is initially based on the MAP sensor at key ON.
- A high resistance on the ground circuit of the MAP sensor can cause this DTC to set

Figure 11. Powertrain fault information using the Internet via Smartphone.

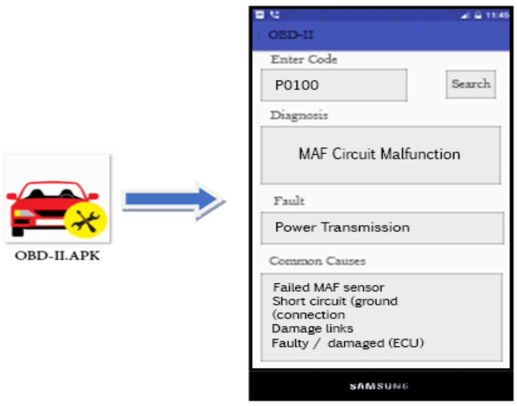


Figure 12. Powertrain fault information using Smartphone only.

3.3 Computer and Internet Information

Comparison between Computer and Internet information is shown in Figure 13 and Figure 14. By comparing both results for the same code, it can be seen that the PC data is much more useful than the Internet data. The PC gives all the important information which is very difficult to find it through the internet especially for Body, Chassis, Transmission and Information System because these data is collect from, different textbooks and paid website. In case of Power Train unit, the available data on the Internet is much more than the PC as shown in Figure 11, but more time is needed to be used.

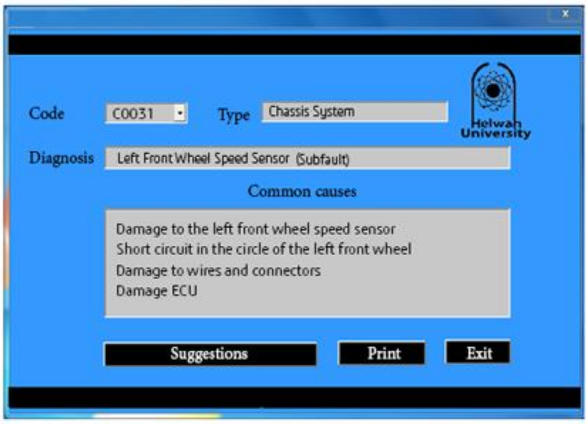
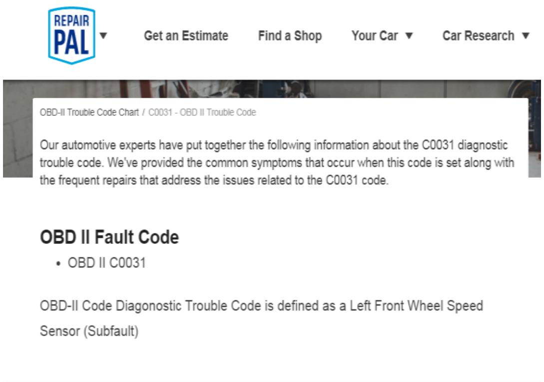
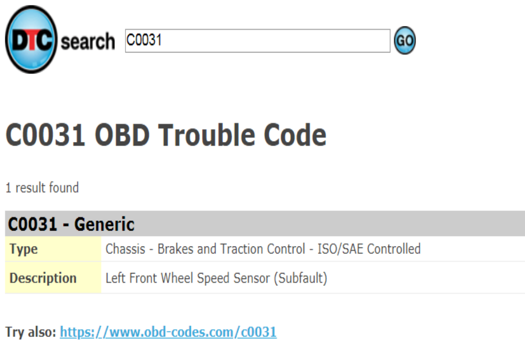


Figure 13. Tested C0031 fault code using developed PC program.



(a)



(b)

Figure 14. Tested C0031 fault code using different Internet Websites.

Different facilities have been added to the Smartphone and PC program such as; to print the fault codes, type, and reasons, vehicle type, and model, date of the check, connect to the internet to communicate with the developers and check the missing data.

IV CONCLUSION

To facilitate, speed up and reduce the maintenance cost and cost, the existing on-board diagnostics unit (OBD-II), type (ELM 327) is modified and a new high capability Bluetooth unit is installed. An Excel sheet of the entire available malfunction is collected, prepared and feed to PC and Smartphone. It works on Smartphone formula (APK) and on PC windows formula (EXE), both are Depends on a database of the Excel file without the need for Internet Connection. Also, the developed units reduce the fault finding and diagnostics times up to 70% and it reduce the reasons time up to 3000%.

The developed OBD-II unit will be even more helpful if the intermediate stage which contains fault finding and writing it in another program to get information about the code. It will be better to get rid of this intermediate stage and directly get the code, diagnosis, and common causes.

V CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the published results of this article.

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