Journal of the Nigerian Association of Mathematical Physics
Volume26, (*March, 2014*), pp 441 – 446
© *J. of NAMP*

A Study to Ascertain the State of Health of OBD II Compliant Cars Using Dealership Grade Scanner

[1]Bello N. and [2]Osaze R. I.

Electrical/Electronic Engineering Department,
University of Benin, Benin City, Nigeria

Abstract

The aim of this study is to access the OBD system in cars that are OBD II compliant for faults and also proffer solutions to these fault.. To achieve the aim of this study, a Launch X431 GDS scanner was used to access the OBD system of different brands of cars after each car user must have filled out our questionnaire which were shared out during the course of this study. The fault codes retrieved from these cars were used for this study. It is observed that a bulk of these codes are powertrain codes.On Board Diagnostics system which is embedded in most cars and light trucks uses electronics means to control engine functions and diagnose engine problems was setup to meet emission control requirements. This technology has not been fully utilized by car owners and service technicians in Nigeria. The data used for this study was collected from different brands of cars with the consent of the car owners over a period of six (6) months within which a total of forty-three (43) cars were scanned with about thirty four (34) of them having Diagnostics Trouble Codes (DTCs). Twenty eight (28) out of these thirty four (34) cars had OBD II codes upon which this study is based while the remaining six (6) had OBD I codes.

Keywords: On-Board Diagnostics (OBD), Engine Control Unit (ECU), Society of Automotive Engineers (SAE), Diagnostic Trouble Codes (DTCs), Vehicle Identification Number (VIN), Powertrain.

1.0 Introduction

The level of technology obtainable in cars nowadays is very sophisticated. With this level of technology, it is easy to monitor the emission release in a car, driveability condition of that car and its overall condition. In addition, issues like safety, fuel consumption, pollution check are of utmost importance which depends on vehicle condition, road infrastructure and driver behavior [1]. To this end, an On Board Diagnostics (OBD) system was embedded in cars. Every automobile is equipped with an electrical instrumentation panel that is used as a driver information centre, formerly known as a dashboard. It contains various gauges and indicators that provide valuable information to the driver [2].Gauges provide scaled indication of the system condition such as distance, engine speed, vehicle speed, and fuel level. Whereas, the Malfunction Indicator Light (MIL) supply information of something is being turned on or warn the driver about system malfunctioning problems.

However, this instrumentation panel has limitation in providing more information on specific areas such as malfunctioning problems, trip information, scheduled maintenance reminder and data logging system.

The information displayed on the dash board is retrieved from the electronic control unit (ECU) of the vehicle. The ECU that can provide this information normally has On-Board Diagnostic (OBD) software (known as a diagnostic management system). This management system performs diagnostic testing, record the result of the tests, and request the test fail actions [3]. The information relating to malfunction problems which are provided by the ECU are commonly displayed on an OBD equipment as fault codes known as Diagnostics Trouble Codes (DTCs).

Currently, most of the ECUs are equipped with On-Board Diagnostic II (OBD-II) standard. The OBD-II has been installed inside the engine management ECU (known as PCM) in the United State since 1996.With the success of the OBD-II, European countries require all petrol cars since 2001 and diesel cars manufactured from 2003 onwards, to equip with European On-Board Diagnostic systems (EOBD) that is equivalent to OBD-II standard. The OBD-II had been standardized

Corresponding author: ***Bello N.,*** E-mail: nosabello@yahoo.com, Tel.: +2348025373737

by the Society of Automotive Engineers (SAE) and supported by the International Standardization Organization (ISO).This standardization includes common terms and acronyms, a common diagnostic link connector and location, common diagnostic test modes (generic and enhanced), common scan tools, common diagnostic trouble codes, and a common communication protocol standard[4].

The aim of this work is to diagnose different brands of cars to ascertain their state of health by using Launch X431 GDS scanner to interact with the OBD system of these cars.

The instrument used for the scanning process is a Launch X431 GDS scanner. It is a sophisticated diagnostic product with powerful functions developed by LAUNCH. It has diagnostic functions and with an expansion module, it can be made to function as an oscilloscope, ignition, sensor, multimeter, battery test and service function such as wireless LAN [5]. The figure 1 (A) shows the sreen of the Luanch X431 GDS scanner and the vehicle manufactural it support. The figure 1 (B) shows the Luanch X431 GDS scanner and its accessories.

2.0 OBD II Systems

On Board Diagnostics systems is an automotive term referring to a vehicle`s self-diagnostics and reporting capability. OBD systems give the vehicle owners or repair technicians' access to the state of health information for various vehicle sub-systems. The primary reason for the introduction of OBD was to meet Environmental Protection Agency (EPA) standard.The name On-Board Diagnostics is actually a very accurate description of the system. The II added to the OBD name tells us that it is the second generation, the successor to OBD I systems used on EPA-certified cars starting in 1998 [6].

As the drive for environmental protection increased and technology became more advanced, OBD systems also became more sophisticated. Car manufacturers used the electronic means to control the fuel feed to the engine and the ignition systems. In addition, sensors were used to measure engine performance to adjust the systems to provide minimum pollution. In all of these, the OBD systems went beyond just emission control. It was able to monitor parts of the chasis, body and accessory devices and the diagnostic control network of the car.

There are five (5) basic OBD II protocols in use, each with minor variations on the communication pattern between the On Board Diagnostic computer and the scanner console or tool. While there have been some manufacturer changes between protocols in the past few years, as a rule of thumb, Chrysler products and all European and most Asian imports use ISO9141 circuitry or KWP 2000. GM cars and light trucks use SAE 1850 Variable Pulse Width (VPW) Modulation, and Ford use SAE J1850 Pulse Width Modulation (PWM) communication pattern. However, Controller Area Network (CAN) is the newest protocol added to the OBD II specification and it is mandated for all 2008 and newer model years.

Manufacturers started incorporating OBD II in various models as early as 1994. Though most of these early models were not 100% compliant. Full compliance of OBD II started in January 1, 1996. The OBD II standard specifies the type of diagnostic connector and its pin out, the electrical signaling protocols available and the messaging format. It also provides a candidate list of vehicle parameters to monitor along with how to encode the data for each.

Figure 2 shows the schematics of the OBD II connector port located in vehicles. `

OBD II provides access to numerous data from the Engine Control Unit (ECU) and offers a valuable source of information when troubleshooting problems inside a vehicle. The SAE J1979 standard defines a method for requesting various diagnostic data and a list of standard parameters that might be available from the ECU.

According to the SAE J1979 standard, there are ten (10) modes of operation described in the latest OBD II. They are as follows (the 0X prefix indicates a hexadecimal radix) in Table 1. Vehicle manufacturers are not required to support all modes.

The physical transmission media used in vehicle networks are:

- Single wire
- Twisted pair
- Fibre optics
- IEEE 1394

2.0 Data Presentation/Analysis

OBD II codes consist of a letter followed by four numbers. There are four different letters for OBD II, and they are as follows:

P- Power train codes, meaning engine and transmission. All emission codes start with P
B - Body codes
C - Chassis codes
U - Communication bus/ network codes.

In the "P" code group, if the first number is "0" (zero), all the codes are "generic". This means that any light truck and car sold in America from 1996 on share the same P0 codes. The codes mean the exact same thing on all vehicles. P1 codes, however, are OEM assigned, and mean whatever the manufacturer wants them to mean as long as they are powertrain related. The meaning of the second number in the P0 codes is as follows:

1 – Fuel metering, things like MAF, MAP, O_2 sensors, etc.
2 – Fuel metering, but injector and injector circuit only
3 – Misfire and ignition
4 – Emission controls, like EVAP, EGR, CAT, etc.
5 – Vehicle and idle speed control
6 – Computer problem
7 – Transmission
8 – Transmission

The last two numbers give you the specific identification within the general system. Example: P0101. The P in DTC P0101 indicates that it is a powertrain fault. The "0" after the P indicates that the DTC is generic. The 1 after the "P0" indicate that the powertrain fault is related to fuel metering and the last two numbers "01" indicate that the part of the fuel metering system like MAF, MAP or O_2 sensor is faulty [7].

The data used for this study was collected from different brands of cars with the consent of the car owners over a period of six (6) months within which a total of forty-three (43) cars were scanned with about thirty four (34) of them having Diagnostics Trouble Codes (DTCs). The various car owners filled a questionnaire (see Appendix 1) as a pre-requisite for scanning their cars. From the questionnaire, the following information was gathered:

1. 48.83% of the car owners were ignorant of the presence of OBD II port for diagnosis in their cars.
2. 78.05% of the cars owners could consciously notice that their "Check Engine" light was ON.
3. 74.40% of the car owners chose their engine oil based on popular demand without considering the proper SAE rating for their cars. While 16.30% of them had no idea about the use of SAE rated oil for their cars. However, only 9.30% of them actually chose their oil based on the SAE rating for their cars.
4. 65.12% of the car owners inflated their tyres based on the vulcanizer`s recommendation instead of the tyre manufacturer`s specification. While 9.30% of them had no idea that there existed a tyre manufacturer`s specification on the amount of pressure (in Pounds per Square Inch – PSI) for their tyres. However, 25.58% of them actually adhered to the tyre manufacturer`s specifications.

After scanning all the cars, only 20.93% of them had no DTC while the remaining percentage had one or more trouble codes. That is, only 1 out of every 5 car scanned was actually "healthy". The table 2 shows the DTCs generated by the different cars using their unique Vehicle Identification Number (VIN) commonly called Chasis Number in Nigeria. The cars that are pre-OBD II compliant were not considered for this table.

4.0 Conclusion and Recommendation

OBD II is now an integral part of vehicles (cars, light, medium and heavy duty trucks) manufactured from 1996 till date and has been improving over the years. The electronic network on OBD II vehicles have become more comprehensive and have changed almost all mechanical functions that controls the powertrain into electromechanical functions making diagnosis of vehicles a little easier and precise.

Most vehicle owners know so little about their cars. The basic service and maintenance work done on their cars are at the mercy of roadside mechanics who are barely literate. Also, pumping of their tyres was done by road-side vulcanizers who gauged the tyres beyond the recommended PSI. The specification of oil used for their car servicing was not the recommended specification and this could lead to the formation of sludge causing the check engine light to be illuminated even when car is not due for servicing.

Hence, this study should become an eye-opener to all car owners whose cars are OBD II compliant – the essence of the technology.

During the collation of data for this study, we took note of the ignorance of many car owners concerning the concept of OBD II. OBD II is very essential in all vehicles to reduce emissions, help in early detection of faults, and prolong the life span of vehicles. Therefore, car owners should always ensure that the OBD II systems in their cars (if available) is intact and has not been tampered with. Service technicians popularly known as "mechanics" should learn more about this technology to enable them meet up with the technological challenges that come with fixing modern cars.

(A)

(B)

Fig 1: (A) Screen of a Launch X431 GDS Scanner. (B) Launch X431 GDS scanner and its accessories.

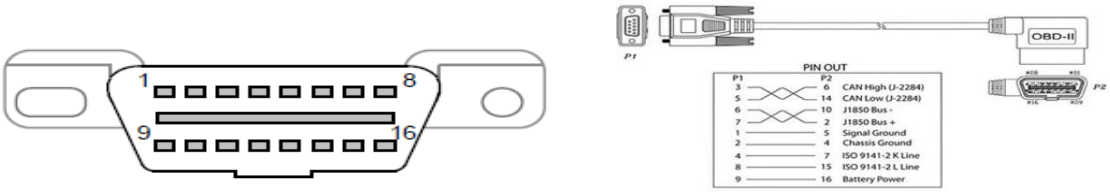

Fig. 2: OBD-II Port with Pin Layout

Table 1: OBD II Modes

Mode	Description
0X01	Show current data
0X02	Show freeze frame data
0X03	Show stored diagnostic trouble codes
0X04	Clear diagnostic trouble codes and stored value
0X05	Test results, oxygen sensor monitoring
0X06	Test result, other components/system monitoring
0X07	Show pending diagnostic trouble codes
0X08	Control operation of On Board components/system
0X09	Request vehicle information
0X0A	Permanent DTCs (cleared DTCs)

Table 2: The DTCs retrieved from the OBD II compliant cars using the Launch X431 GDS Scanner

S/N	Cars/Chassis Number	Diagnostic Trouble Code (DTC)
1	Toyota Corolla 2004 Model-VIN:271BR32EX4C2199XX	No DTC
2	Nissan Pathfinder 2000 Model- VIN:JN8AR07Y1W4288XX	No DTC
3	Toyota Corolla 2006 Model- VIN:JTDBR32E3600703XX	No DTC
4	Toyota Camry 1997 Model- VIN:4TIBG22K6VU0224XX	P0325, P0441, P1210
5	Benz C-Class 2001 Model- VIN:WDB202020IF3628XX	C1102, C1012, B1470, B1471, B1473, B1478, B1226, B1227, B1228, B1229, B1230, B1232, B1419, B1422
6	Toyota Camry 1998 Model- VIN:4T1BG22K4WU2279XX	P0171, P1130
7	Nissan Sunny 2011 Model- VIN:KNMC4C2HMBP8911XX	B1401, B1412
8	Nissan Altima 2003 Model- VIN:IN4AL11E33C3502XX	P0335, P0037, P0128,
9	Ford Windstar 2000 Model- VIN:2FMDA5348YBC969XX	P1246, P1000, P0171, P0174, C1155, C1233, C1236, C1235, C1185, C1198, C3194, C1254, C1246, C1250, C1242, C1214, C1210, C1184, C1222, C1140, C1225, C1141, C1142, C1143, C1144, B1342, U1262
10	Kia Cerato 2012 Model- VIN:KNAFU411BC59552XX	P0134
11	Honda 2003 Model- VIN:IHGCM66513A0666XX	B1234
12	Honda Accord Sedan 2003 Model- VIN:IHGCM55643A0206XX	B1056, B1057, B1060, B1061, B1177, B1159, B1157, B1008, P0141, P0325, P0341, P0011, P0113
13	Toyota Camry 1998 Model	P0110
14	Toyota Camry 1997 Model- VIN:4TIBF22K2VU0081XX	P0440, P0441

15	Ford Taurus SE 2007 Model- VIN:IFAFP53U67A1001XX	P0059, P1116, P2197, P0104, P0118
16	Mercedes Benz C-Class 2002 Model- VIN:WDB2020182F7120XX	C1100, C1101, C1200, C1010, C1012, C1025, C1207
17	Toyota Highlander 2008 Model- VIN:JTEDP21A2701376XX	B1153
18	Lexus GX 470 2003 Model- VIN:JTJBT20X1300120XX	P0031, P0037, P0051, C0200, C0205, C0210, C0215, C0278, C0279, C1200, C1223, C1241, C1246, C1253, C1254, C1256, C1335, C1340, B1153
19	Toyota Sienna 1998 Model-VIN:4T3GF19CXWU0054XX	P0741, P0770
20	Nissan Infinity 2001Model- VIN:JNRDR07XB1W1031XX	P1130, P1145, P0175
21	Toyota Camry 2000 Model- VIN:JT2BG22K9404693XX	P0300, P0301, P0302, C0215, B0101, B0107, B0136
22	Nissan SUV Pathfinder 2001 Model- VIN:JN8DR09YB1W5712XX	P1148, P0135, P0141, P0161
23	Mercedes Benz E200 2001 Model- VIN:WDB2100651A7171XX	P0115,P0110, P0100, P1179, P1177, P1178, P0155, P0135, P0119, P0122, P0152, P0193, P1270
24	Toyota 4 Runner 2001 Model- VIN:JT3HN86R6103337XX	P0300, P0141, P0440, C0276, C1201, C1223, C1253
25	Honda CRV 2008 Model- VIN:JHLRE48747C0364XX	B1152, B1177, P0843, P2185
26	Toyota Corolla 2003 Model-VIN:JTDBR32E2300298XX	P0135, B0103, B0108, B0138, B1100
27	Ford Windstar Space Wagon 2002 Model-VIN:2FMDA56U1YBB172XX	P0401, P1131, P1151, B2527, B1806, B1332, B1676, B2562, B2564, B2560, B2527, B2373, B1299, B2595, B2476, B1519, B1462, B1319, B2486, B2488, B1676, B1431, B2597, B1244, B2507, B2501, B2503, U1123, U1262, U1041, U1043, U1130, P1780, P1462, P1127, P1408, P0135, P0722, P0720, P1462
28	Toyota Camry 2003 Model- VIN:4T1BE32K53U6453XX	P0031, C0210, C0215, C1241

*The 'XX' written at the end of theVIN represent the last two digits which were omitted for reasons of confidentiality of the respective car owners.

APPENDIX 1: VEHICLE ON-BOARD DIAGNOSTICS (QUESTIONNAIRE)

Optimum level of sincerity is required while filling this form.

1. Make of car----------
2. Model of car----------
3. Car year----------
4. Vehicle VIN (Chasis Number)----------
5. In what state did you purchase your car?
   Please tick appropriately
   Belgium [ ] Nigeria used [ ] Brand New [ ]
6. Car Odometer reading or Mileage …… Km [ ] Mile [ ]
7. Has your car been scanned before Yes [ ] No [ ]
   If yes, where you charged for it and how much? ……
   ……..
8. Is there any light that is permanently "ON" on your dash board while driving? Yes [ ] No [ ].
9. How many years have you been using this car?.....
10. From the range of 1- 100% give your car a reliability score……
11. How often do you service your car? In mileage [ ] After some time [ ]
12. Does your servicing depend on
    i. ***Mileage*** [ ]
    ii. ***Time*****:** Weekly [ ] Monthly [ ] Others specify ……..……
13. What oil do you use for servicing your car?
    Total 4000 [ ]
    Total 7500 [ ]
    Total 9000 [ ]
    Mobil 1 [ ]
    Otherssspecify……
14. Do you know if this oil is Mineral, Semi-Synthetic or Pure Synthetic Yes [ ] No [ ]
15. Specify, if yes in Question 14 above: Mineral [ ] Semi-Synthetic [ ] Pure Synthetic [ ]
16. Are you aware of the possibility of sludge formation due to infrequent (delayed) oil change in your engine? Yes [ ] No [ ]
17. Are you aware that your engine has a life span? Yes [ ] No [ ]
18. Have you done any major overhaul on your engine? Yes [ ] No [ ]
19. Are you aware that if your car is 1996 and older, that it has a part for diagnosis called OBD port? Yes [ ] No [ ]
20. Can you point us to this port if it exists Yes [ ] No [ ]
21. Do you have any filling station in mind that you can recommend? ……...

22. Have you ever had to service your gearbox? Yes [ ] No [ ]
23. If yes above, how was your choice of ATF (Automatic Transmission Fluid) chosen? Mechanic Recommended [ ] As stated by manual of car [ ] Popular opinion/intuition [ ]
24. Are you aware of SAE (Society of Automotive Engineers) rating for engine oil? Yes [ ] No [ ]
25. Did you choose this oil based on your car manual or popular recommendation? Car manual [ ] Popular recommendation [ ]
26. What do you have in your radiator?Water [ ]Coolant only [ ] Water + Coolant [ ]
27. Specify vehicle engine type by ticking correctly I4 [ ] V6 [ ] V8 [ ]
28. Specify your vehicle engine capacity in litres…….
29. Is your vehicle Chain driven [ ] Belt driven [ ]
30. What is your average monthly fuel cost?.....
31. What is the diameter of your Rim?.....
32. How often do you top your engine oil? Weekly [ ] Monthly [ ]
33. How often do you change your tyres? Every year [ ] 2 years [ ]
    Others specify……..
34. What is the average cost in purchasing one of your tyres?.....
35. How many kilometers do you drive per day? ……...
36. How much pressure do you pump your tyres to in PSI?.....
37. Was this pressure level recommended by your Vulcanizer Yes [ ] No [ ]
    Others specify……
38. Have you had any Accident with this car? Yes [ ] No [ ]
39. What type of Gear Transmission does your car use? Automatic driven [ ] Manually driven [ ]
40. Do you drive With AC[ ] Without AC [ ] everyday?
41. How often do you replace your car battery?.....
42. At what cost do you replace your battery?.....
43. How do you tell when it is time to replace your battery? ……..
44. Does your car have any history of overheating? Yes [ ] No [ ]
    If yes what was the possible cause……..
45. What is the biggest repair you have ever made on this car and how much did it cost?.....
    .....
46. Are you aware that the year of Manufacture of your car can be deduced from your Chasis Number? Yes [ ] No [ ]
47. How many cars do you have presently? .....
48. Are you aware of Carfax or Autocheck for checking a vehicle's previous history if it is not brand new? Yes [ ] No [ ].
49. Why did you choose this particular Make of car?
    .....
    ……
    ……..

48. Does your car have Air-bag or any other Safety measure?.....
49. Do you read your Vehicle Manual for easy Maintenance? Yes [ ] No [ ]
50. Is there any other information you would share about your car?

.....……
……..……

References

[1] JyolhiKiran M. and Ravi teja S. (2012). 'International Journal of Engineering Research and Applications (IJERA)' *Vehicle Health Monitoring System.* ISSN: 2248-9622 Vol. 2, pp.1162-1167

[2] Erjavec J. (2005). *Automotive Technology, 4th Ed*. New York: Thomson Delmar Learning.

[3] Hollembeak, B., (2005). *Classroom Manual for Automotive Fuels & Emissions*. New York: Thomson Delmar Learning.

[4] Society of Automotive Engineer. (2003). *On-Board Diagnostics for Light and Medium Duty Vehicles Standards Manual (2003) Ed.* SAE International: USA.

[5] LAUNCH (2011), "X-431 GDS user's manual.

[6] NAPA: Institute of Automotive Technology "*OBD II and Second Generation Scan Tools".*

[7] Steve Zack and Chuck Eaves, "*Driveability Diagnostics, OBD I and II*". Volume 1, pp5