Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676, p-ISSN: 2320-3331, Volume 20, Issue 3 Ser. 1 (May. – June. 2025), PP 60-65
www.iosrjournals.org

Automotive Diagnostics Fuel Monitoring Operation And Consumption Using OBD-II Sensor

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Abstract
Fuel consumption is continuously monitored through measurements of physical parameters such as temperature, air flow and rotational rate. The measured data are retrieved by electronic sensors and communicated over the internal vehicle communications protocol, towards the Main Control Unit for further processing. This work present selected parameters for monitoring fuel operations and briefly describe the sensors employed for the retrieval of these parameter data. The data was retrieved through the OBD-II diagnostics protocol and they were related with the vehicle operation and with the fuel consumption. To establish the fact, experiments was carried for a 10 km trip with low and heavy traffic. Data obtained from the OBD-II scanner was analyzed. In terms of evaluation, the raw data as well as the calculated values related to fuel consumption are compared with manufacturer standards. Result showed that driving behavior has been identified as the key factor influencing the fuel consumption for a given model.
Keywords: *Automobile; OBD-II; Sensors; CANBus; Fuel consumption*

Date of Submission: 25-05-2025 Date of Acceptance: 05-06-2025

I. Introduction

A new generation of these systems, OBD II, is present on 1996 and newer vehicles [1]. OBD II monitors the engine management system and can detect a malfunction or deterioration of the system components usually well before the driver becomes aware of the problem through a decrease in performance or mechanical damage. When a problem is detected, the OBD II system turns on a dashboard warning light to alert the driver of the need to have the vehicle checked by a repair technician.

OBD II systems alert drivers when something in the engine management or emission control system begins to deteriorate or fails. Early diagnosis followed by timely repair can often prevent more costly repairs. For example, a poorly performing spark plug can cause the engine to misfire, a condition sometimes unnoticed by the driver. This engine misfire can, in turn, quickly degrade the performance of the catalytic converter. With OBD II detection of the engine misfire, the driver would be faced with a relatively inexpensive spark plug repair. However, without OBD II detection, the driver could be faced with an expensive catalytic converter repair in addition to the spark plug repair. A vehicle identified by the OBD II system as having a problem may be running inefficiently - resulting in poor fuel economy and vehicle performance while shortening the life of the engine. OBD II systems provide more information than ever before to help auto technicians diagnose and properly repair vehicles during their first visit to the repair shop, saving time and money for consumers.

When the OBD II system determines that a problem exists, a corresponding “Diagnostic Trouble Code” is stored in the computer memory and a dashboard light. Figure 1 shows signs that alert the driver that a problem has been detected and vehicle service is needed. By law this dashboard light can only be used to indicate an actual problem. It cannot be used for example, as a reminder for regularly scheduled maintenance.

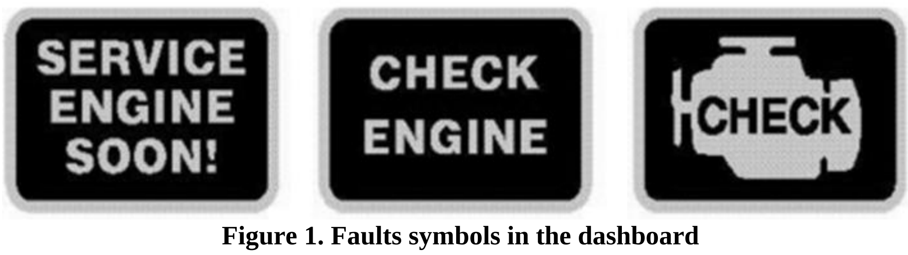

Figure 1. Faults symbols in the dashboard

Monitoring engine operation has attracted researchers that are interested in effectively improving efficiency. Gilman developed a driving assistant system called Driving Coach which monitors certain parameters to help increase fuel efficiency depending on the driving style [2]. Szalay et al. modelled two different scanning methods (CANBus and FMS CANBus) which allowed third party access and found that the measurements were almost identical [3].

Gallardo F stated are two different CAN nets. One works with a higher speed (1 Mbit/s) and is used to monitor the engine and interconnect the ECU. The other one is used to communicate the rest of the parts of the vehicle such as doors, seats or lights and works with less speed (250 Kbit/s).[4]

Kushiro et al. logged OBD-monitored data and transmitted them to a telematics centre via mobile network. This data is used for a prognostics model (in python), as built on correlations among fault codes (cautions/warnings from sensors in the vehicle), to prevent potential components breakdown [5].

Sik compared OBD and CAN sampling on the go with the Sensor HUB Framework and using GPS made a prediction model helping drivers with recommendations for their route (avoid traffic jams, find empty parking space) [6]. D'Agostino used OBD data to create a model for the upgrade of a conventional vehicle to hybrid. Thus, through operation in pure electric mode or hybrid mode (depending on which gear is engaged), the kit can help achieve 18%–22% save in fuel and CO_2 emissions [7].

While the interest in remote monitoring and control is being increased, we expect that will be gradually used to support innovative services sharing the values in real time in cloud facilities for more effective monitoring, logging and pattern extraction [8].

II.Method

This work employed the established methods and protocols and 3rd party (off-the-shelf) tools to extract the values of sensor parameters through the CAN (Controlled Area Network) using the OBD-II diagnostics protocol.

The Selection of parameters to be monitored was based on the importance of the parameters to key composite parameters including but not limited to consumption, the consequences of their possible malfunctioning and the possibility of retrieving the data through the CANBus and subsequent translation into the OBD-II protocol.

Below are the parameters selected for retrieval are presented along with justifications for their selection;

Mass Air Flow Sensor (MAF).

This measures air flow rate in the engine and it is installed between the air filter and the intake manifold. There are two types of MAF sensors: the hot wire sensor, where the wire is electrically heated. When the intake air passes through, it brings the air to the required temperature. This current is proportional to the air flow and it is sent as a pulse to the ECU. Cold wire sensor, which has the same principle as the hot wire but with the addition of a cold wire measuring ambient air as a reference point. Then the temperatures of the two wires can be compared. A malfunctioning MAF sensor can cause issues at the engine unit such as: Running rich at idle, low fuel efficiency, stalling and uneven idle

Engine Coolant Temperature Sensor (ECT).

Engine Coolant Temperature Sensor (ECT) measures the temperature of the engine. The Power Control Module (PCM) recognizes this signal and activates other components (such as the engine's cooling fan to maintain proper operating temperature). This signal affects EGR (Exhaust Gas Recirculation) valve flow, enriches fuel mixtures, and delays torque converter or A/C compressor engagement. Excessive resistance in the connector or anywhere in this circuit can alter the signal to the PCM, increasing injector pulse width and advancing the engine's ignition timing. When the engine reaches operating temperature the coolant sensor gives way to the lambda sensor. The coolant temperature affects the engine overheating, influencing its lifetime, as well as the fuel consumption;

Short-Term Fuel Trim (STFT) sensor.

When the driver accelerates, the airflow intake in the engine is changed. The fuel injection is then controlled by the ECU. Sensors are used to measure airflow and then send the correct pulse to the central unit, to match the airflow by adjusting (add or reduce) the fuel quantity and keep the stoichiometric ratio. This adjustment is called Fuel Trim. Short Term Fuel Trim (STFT) is related to the immediate changes in fuel flow occurring several times per second, while Long Term Fuel Trim (LTFT) includes the average changes over time.

Lambda Sensor (λ)

Lambda Sensor measures the proportion of oxygen in the exhaust gases and retrieves the stoichiometric Air–fuel ratio which is 14.7:1 for petrol engines with the ideal value for the combustion being 1. The air–fuel ratio is affecting performance and horsepower, the emissions (Nitrogen Oxides, Carbon Monoxide) and the consumption. The application of correct ratio prevents engine pinging and knocking, while it supports the lifetime of the catalytic converter.

The data collected by the sensors are transferred within the vehicle electronics system using the CANBus protocol. CAN is an acronym for communications serial bus used for the automobile industry to replace the complex wiring strap with a simple two-wire system standard. This does not allow electrical interference and uses priorities among the communicating entities.

Automobiles from starting from 1996 are required to be equipped with the On-Board Diagnostics (OBD) OBD-II system, which enables them to retrieve the exchanged data through the Data Link Connector (DLC). DLC is the 16-pin connector that allows access to the underlying protocol that each vehicle uses for module communications. In principle the OBD-II system uses 2 types of codes:

1. Diagnostic Trouble Code (DTC): Each code is used to describe an issue, for example Pxxxx is a powertrain code error and Cxxxx a chassis error. Each code can be unique or manufacturer specific.
2. Parameter ID (PID): Codes used to require data from the ECU, like RPM in idle speed.

Table 1. Parameters considered

S/No	OBD II ID	Parameters
1	0 x 05	Engine Coolant temperature
2	0 x 06	Short term fuel trim
3	0 x 0C	Engine RPM
4	0 x 0D	Vehicle Speed
5	0 x 10	Air flow rate
6	0 x 34	0_2 Lambda equivalent

To retrieve these data the OBD-II scanner is connected to the OBD-II port (16 pin connector).

III. Experimentation And Results

Experimentation was carried out to retrieve data from live automobile i.e vehicle in motion. A Lunch Bluetooth scanner and SX-431 PRO3S+ V7.00.005 software. The scanner is connected to the vehicle OBD-II using DLC, it retrieves the data of the parameters and communicates through Bluetooth with a laptop. The data were collected while driving a total distance of 10 km, split into 5km one-lane residential road with medium traffic lights and medium traffic and 5km double-lane road (with overtaking allowed).

Ambient temperature was 25 ◦C at 11 am and the whole test lasted 22 min or 1320s. The data collected were Speed and RPM measurements. They were compared with those at the driver's speedometer and tachometer as a first validation of the system. The average speed of the car was 30 km/h. The engine load varied from 14.5% (idle) to 88.8% which is referred to the moment the car is at medium to high RPM at uphill and maximum torque is required. Short fuel trims (S.F.T) reached values from −9% to 7%, indicating that fuel injection from the ECU was stable overall.

The average Lambda value was 1.030 and the oxygen sensor is working properly. Fuel flow with 0 km/h speed i.e idle or accelerating has an average amount of 0.44 l/h while for other conditions, consumption is in average 1.36 l/h. Fuel flow mass rate range: 0.094 g/s for idle to 1.32 g/s at max load. More fuel was consumed at lower speeds.

Short fuel trims — lambda data

Figure 2 shows that short fuel trim is constantly changing; this can follow a change in the value of air flow which is indicated by the lambda sensor. As the driver accelerates air flow mass increases, ECU reads the lambda sensor data and adjusts fuel injection. When SFT is 0%, the car is at idle speed.

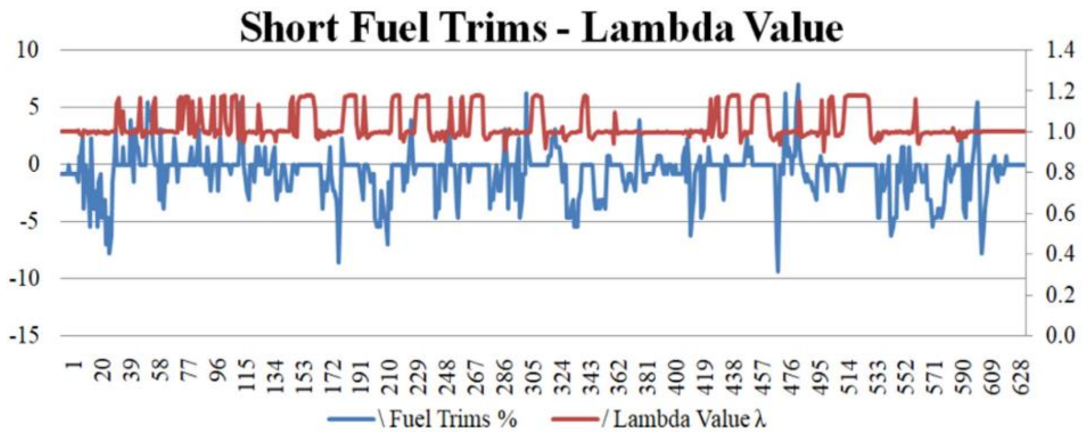

Fig. 2. Short load fuel trim versus lambda values.

From figure 2, the Left Axis represents the fuel trim percentage (Blue one) while the right one is the lambda value (Red) at each measurement. The ECU responds adjusting fuel depending on lambda output.

Fuel mass flow rate — load

Load in automobile means the rate of power required from the engine for the car to accelerate or speed up. Engine loading comes from forces acting against the motion of the engine. Internal friction (pistons, crankshaft, transmission), external friction (tyres on road surface), drag, gravity (when going uphill).

When a vehicle is cruising on the highway, it only needs a small percentage of its total available power output to maintain speed. We calculate the load based upon the following formula:

$$Engine\ Load = \frac{\text{Current Air flow}}{\text{Max Air flow Rpm} \ \text{x} \ \frac{\text{Baro}}{29.92} \text{x} \sqrt{298}\ T_{amb} + 273} \qquad (1)$$

In the load calculation formula, Current Air Flow is the MAF output in g/s, Max Airflow in Rpm, Baro is the barometric Pressure found by the MAP sensor and its changes are considered insignificant. T_{amb} is the ambient Temperature which is stable. At cruising both MAF and MAP sensors outputs were zero.

As shown in Figure 3, fuel mass flow peak is at no. 505 while engine load peak is reached 3 times (num. 55, 91, 480). This indicates that load is of the factors that determines fuel flow. Hence fuel consumption can increase as a result of driving style e.g aggressive driving. Note that when a car is cruising i.e going over 2200–2500 RPM with gear on but not accelerating, e.g. at speed of 153–172, the wheels is driving the engine and almost no fuel is used, so efficiency is maximized.

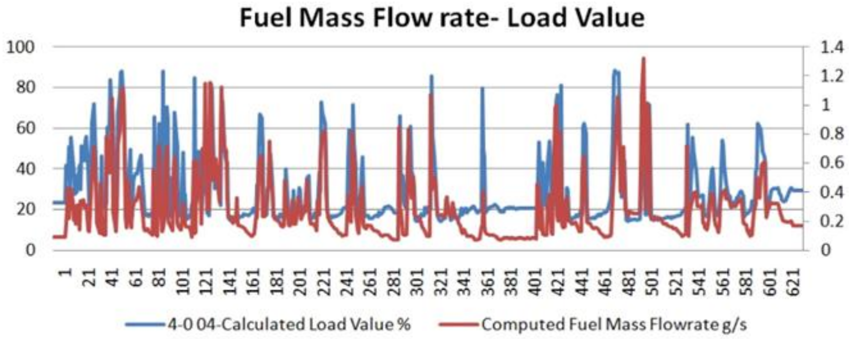

Fig. 3. Fuel mass flow rate versus load. Left axis describes load data while the right one stands for Fuel Mass Flow rate.

Vehicle speed — fuel consumption

Fuel consumption changes when the vehicle speed increases (during acceleration), meaning that it is mainly affected by ineffective driving and traffic. For example, random starts and stops, present massive fuel consumption whereas normal driving without aggressive acceleration–deceleration reduce fuel consumption. Low consumption occurs at cursing speeds, while at idle status fuel consumption is cut-off. Figure 4, shown the relation between vehicle speed and fuel consumption;

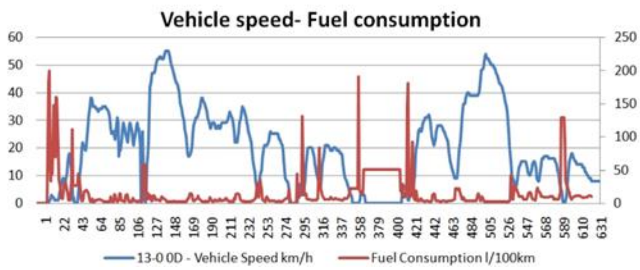

Fig. 4. Vehicle speed versus fuel consumption.

From figure 4, left axis presents vehicle speed and right one is the fuel consumption in litres per 100 km. The high values at consumption typically precede the increase in speed.

Fuel efficiency — lambda value

At lean fuel mixture i.e high lambda values maximum fuel efficiencies (up to 56 km/l or 1.78 l/100 km) are achieved. However at rich mixture low lambda values is achieved and fuel efficiency drops to 0.99km/ - that is almost 100 l/100 km.

At lambda close to one ($\lambda \approx 1$) efficiency goes to factory standard values (4.4 l/100 km mixed cycle). Idle status is cut off. Figure 4shows Fuel efficiency versus lambda.

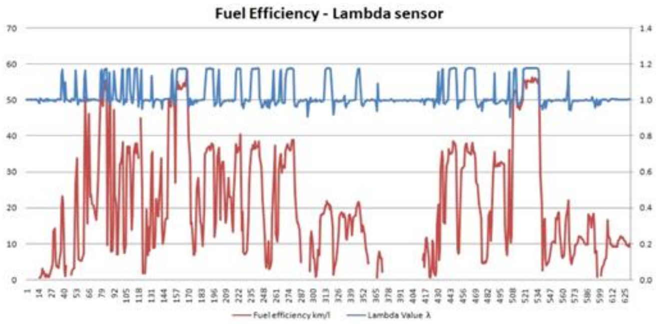

Figure 5. Fuel efficiency versus lambda. Left axis presents fuel efficiency and right one is the lambda equivalent.

Fuel Consumption Calculations

Motoring AA [9], worked on calculating fuel consumption in automobile. Equations for calculating fuel consumption.

$$fuel_{gram} = \frac{Air\ mass_{grams}}{\lambda x AFR_{stoich}} \quad 2$$

where: λ is the lambda value computed by the OBD II Scanner
$AFR_{(stoich)}$ is the stoichiometric ratio (14.7)
Air Mass in g/s by MAF Sensor
According to Meseguer et al. [10], to calculate the fuel flow, the following equation is used:

$$fuel\ flow = \frac{fuel_{\frac{g}{s}} x\ 360s}{\rho} \quad (3)$$

Where ρ is the gasoline's density and according to AA motoring, 770 g/l was chosen as an approach. To calculate fuel consumption at l/100 km:

$$fuel\ Consumption_{\ 1/100km} = \frac{fuel\ flow}{Vehicle\ Speed} \times 100 \quad (4)$$

IV. Discussion

In an ideal condition the average consumption for lambda was 4.73 [l/100 km] while with the measured lambda it was 4.67 [l/100 km]. So on average, the records are accurate even without the measured lambda value. However this estimation depends on vehicle maintenance. It also depends efficient driving behavior. In the experiment carried out, the vehicle was driven both at highway and streets with traffic and the mixed cycle value of 4.4 l/100 km was obtained.

V. Conclusions

In this work we selected and retrieved values for key parameters related to road vehicle operation. In terms of the equipment and tools used, the work has proceeded seamlessly verifying collaboration of the underlying vehicle platform with the OBD-II reader and software. This was further confirmed during parameter (speed and load) retrieving in vivo and verifying with the vehicle instruments, as available for the driver. During our experimentation, we have retrieved the specified parameters and analysed them. The results obtained have been consistent and the diagnostic protocol as well as the hardware and software equipment worked as expected. Parameters load and fuel consumption was calculated. The result obtained in fuel calculation was in line the manufacturer values. This work verified that driving behavior affects fuel consumption, since random stops stop and starts requires more fuel consumption whereas normal driving without aggressive acceleration or deceleration less fuel consumption. This so because aggressive driving style causes inconsistent changes at engine load, which is the main factor that cause fuel consumption increase. It was established that low consumption appeared at top speeds where normally high fuel usage is expected. It has also been experimentally identified that vehicles get better fuel economy when cruising at highway speeds.

References

[1] Baba Z., Jacob N., Issifu I. (2018) Assessing The Skills Of Roadside Mechanics In Diagnosing And Fixing Problems Of Modern Electronic Managed Vehicles In Ghana (Tamale Metropolis) American Scientific Research Journal For Engineering, Technology, And Sciences (ASRJETS) 45(1) 207-225.

[2] Gilman E, Keskinarkaus A, Tamminen S, Pirttikangas S, Röning J, Riekki J. Personalised Assistance For Fuel-Efficient Driving. Transp Res C 2015;58:681–705.
[3] Szalay Z, Kanya Z, Lengyel L, Ekler P, Ujj T, Balogh TT, Charaf H. ICT In Road Vehicles — Reliable Vehicle Sensor Information From OBD Versus CAN. In: International Conference On Models And Technologies For Intelligent Transportation Systems (MT-ITS). 2015. Gallardo F. Extraction And Analysis Of Car Driving Data Via OBD-II: Bachelor Thesis. Elche, 2018. 65 P
[4] Kushiro N, Oniduka Y, Sakurai Y. Initial Practice Of Telematics-Based Prognostics For Commercial Vehicles. Procedia Comput Sci 2017;112:2155–64.
[5] Sik D, Balogh T, Ekler P, Lengyel L. Comparing OBD And CAN Sampling On The Go With The Sensorhub Framework. Procedia Eng 2016;168:39–42.
[6] D’Agostino M, Naddeo M, Rizzo G. Development And Validation Of A Model To Detect Active Gear Via OBD Data For A Through-The-Road Hybrid Electric Vehicle. IFAC Proc Vol 2014;47(3):6618–23.
[7] Zahariadis T, Papadakis A, Alvarez F, Gonzalez J, Lopez F, Facca F, Al-Hazmi Y. FIWARE Lab: Managing Resources And Services In A Cloud Federation Supporting Future Internet Applications. In: 7th International Conference On Utility And Cloud Computing. IEEE/ACM; 2014.
[8] ISO 11898-1:2015 Road Vehicles – Controller Area Network (CAN) – Part 1: Data Link Layer And Physical Signalling. 2015
[9] Motoring AA. Calculating Fuel Consumption [Online]. 2018, Available From: Https://Www.Aa.Co.Nz/Cars/Motoring-Blog/Calculating-Fuel-C Onsumption/ (Accessed: 28 March 2019).
[10] Meseguer J, Calafate C, Cano J, Manzoni P. Assessing The Impact Of Driving Behavior On Instantaneous Fuel Consumption. In: 12th Annual IEEE Consumer Communications And Networking Conference (CCNC). Las Vegas, U.S.A; 2015.