

# Power train and emission control: allocation procedure by OBD-II system for automotive technology

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**Abstract.** OBD-II, systems were designed to maintain low emissions of in use vehicles, including light and medium duty vehicles. In 1989, the California code of Regulations (CCR) known as OBD – II was adopted by the California Air Resource Board (CARB) and the objective to reduce hydrocarbon (HC) emission caused by malfunction of the vehicles emission control systems. OBD-II provides additional information to engineer for diagnosis and repair of emissions related problems. OBD-II, standardizes on the amount of memory (Freeze Frame) it uses to store the readings of the vehicle sensor when it logs on emission related Intermittent Trouble code (IT). The intent of OBD-II, systems is to detect most vehicle malfunctions when performance of a power train component or system deteriorates to the point that the vehicle's HC emission exceed standard. The vehicle operator is notified at the time when the vehicle begins to marginally exceed emission standards, by illuminating the Malfunctions Indicator Light (MIL).

## 1. Introduction

The biggest question today before the metropolitan population of our country like India, is “pollution” is snuffing us out and will pollution ever be controlled? The reason for this type of thinking may be because of the fact that in spite of several legislation from 1964 onwards in India, not much of progress can be visualized in this area, even through; we are much more apparently concerned and aware of the environmental degradation today than a few decades earlier. In our country like India, after spending a lot of money and also enacting several statutory laws, the country could not make much headway because of several factors i.e. we could not make this problem an electoral-issue like that of USA.

The first major clean air act was adopted by the congress in 1970 in USA. Congress established the Environmental Protection Agency (EPA), with the overall responsibility of regulating motor vehicle pollution to the atmosphere. Congress also identified the inspection and Maintenance for improving the air quality.

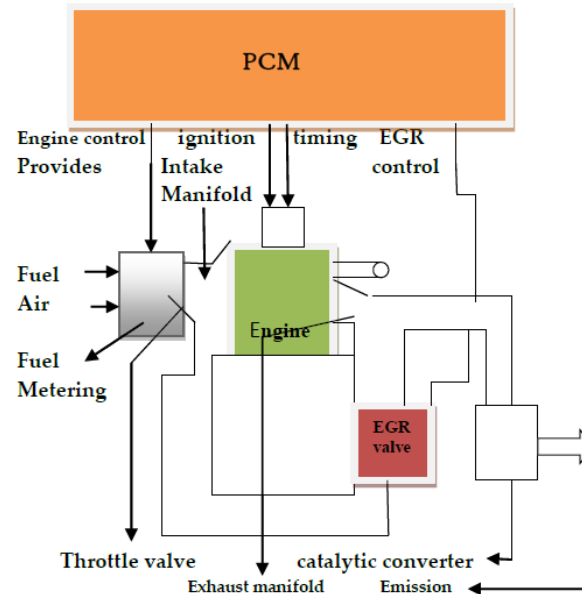
The power train components towards emission controls are:

- Throttle and Manifold,
- Exhaust and Fuel system,
- Combustion and Rotational dynamic,
- Automatic Transmission, etc.



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Throttle & intake manifold, the throttle body assembly is an air valve. It regulates the air flow into the engine and thereby contributes to the control of engine and power. Idle air control valve; bypass the throttle to provide additional air to compensate for the loads during closed throttle.



**Figure 1.** Major controller out-put to engine.

## 2 Present engaged (in India)

In June 1999, the honourable supreme court of India ruled that vehicular emission had to be reduced at a much quicker pace than planned so far, and therefore, engine manufactures are facing the challenging engineering task to quickly find solution by Euro-norms and remarkable change in the concept of I.C. engines designs, MPFI, catalytic converter and incorporation of EGR.

Catalytic converter converts harmful gases to harmless gases. As India prepares to make the use of catalytic converter compulsory for drastically reduce automobile exhaust emission and however, EPA of USA has observed that catalytic converter has become a significant and growing cause of Global warming. EGR is a small amount of exhaust gases, which are feed back into intake system by EGR valve. However, as per study on Indian condition, while the vehicle speed is increasing the peak combustion temperature also increasing, as a result less time available for heat transfer in the combustion chamber, because the maximum bsfc value increases by the increasing of speed. At the higher speeds there is a need to supply more fuel to overcome greater frictional losses and due to heat losses, will increase turbulence and consequent improper combustion. Therefore, OBD –II regulations in the USA for light and medium duty vehicle for I.C. Engines are introduced to implement the air quality standard and need of implementing on Indian condition.

On-line diagnosis of internal combustion engines in passenger vehicles is mandated due to the strict environmental regulations in the U.S.A. and in some European Countries (e.g. , the EFTA ( European Free Trade Agency ) Partners') to control Hydro carbon emissions from the exhaust.

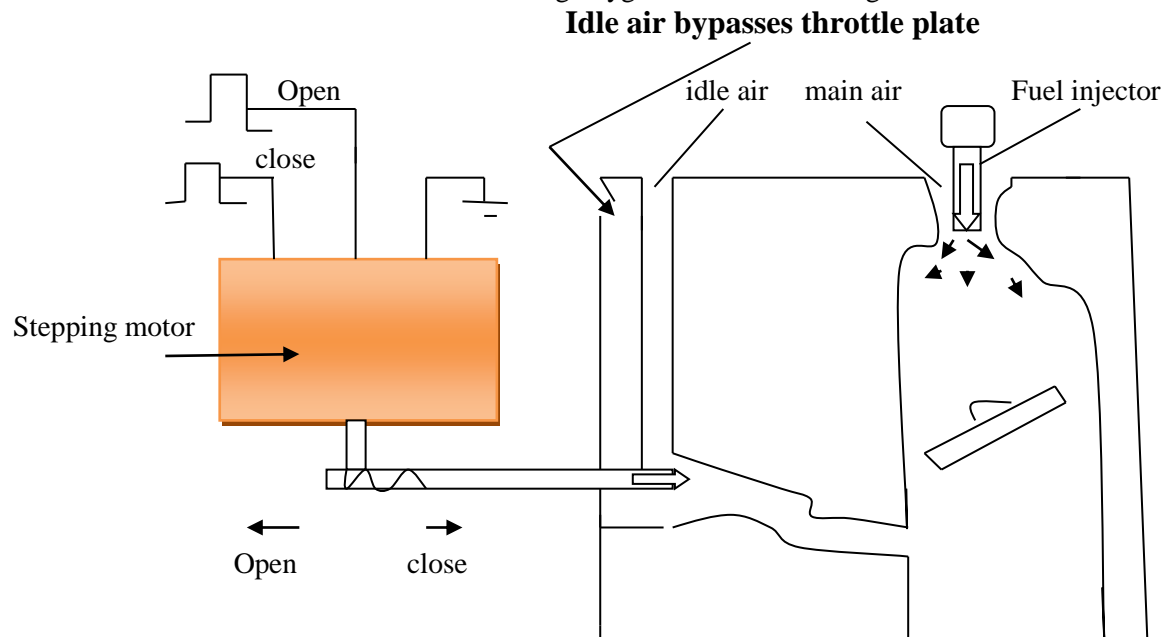
## 3. Methodology

The power train functions are described to show how the PCM controls the emissions while delivering the torque to the vehicle requested to the driver.

### 3.1. Throttle and intake manifold

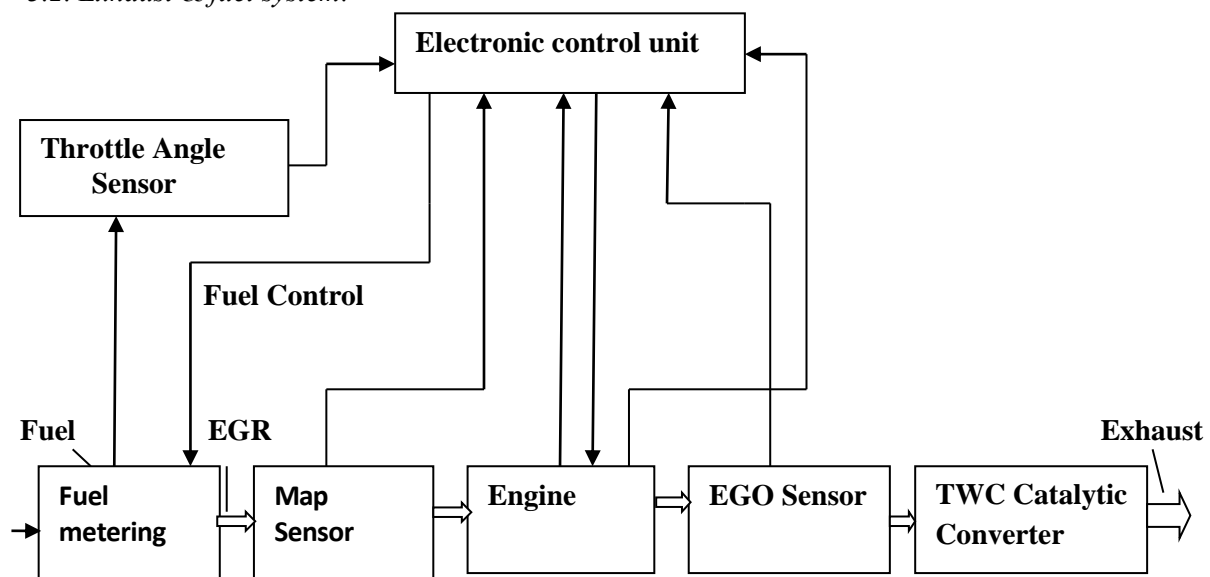
The throttle body assembly in an air valve, it regulates the air flow into the engine and thereby contribute to the control of engine speed and power. IACV (Idle Air Control Valve) provides additional air flow during starting of the engine and during idle. IACV by pass the throttle to provide

additional air to compensate for the load during closed throttle. EGR provides exhaust gases to the intake manifold. This has the effect of reducing oxygen content in the engine.



**Figure 2.** Idle air control.

### 3.2. Exhaust & fuel system:



**Figure 3.** Simplified block diagram of fuel control systems.

Exhaust valves of the engine cylinders purge the exhaust through the Exhaust Gas line which then passes through the catalytic converters in which most of the HC and CO are oxidized to CO<sub>2</sub> and Water. The extra oxygen required for this oxidation is supplied by adding air to exhaust stream from an engine driven air pump. This air called secondary air is normally introduced into the exhaust manifold. This has a considerable effect in reducing emissions. The Fuel Pump supplies metered fuel which is electronically injected through nozzles operated by solenoids under control of the PCM. The

fuel in the fuel tank is filtered. The Fuel Level Sensor measures the inlet vacuum which is a measure of fuel pump suction which affects pump priming.

#### 4. Result & Discussion

The oxygen sensor is used to monitor the residual oxygen (after catalysts in the converter) in the exhaust gases, because catalytic converter is most efficient in eliminating all pollutants by oxidizing HC to CO<sub>2</sub> and reducing NO<sub>x</sub> to N<sub>2</sub> when the exhaust gases indicate Stoichiometric ( 14.7) air /fuel ratio, indicated by the Exhaust Gas Oxygen sensor. Catalytic converter is a three way catalyst which will oxidize the Hydro carbons including CO and CO<sub>2</sub> and reduce the NO<sub>x</sub> to N<sub>2</sub> in the exhaust gases simultaneously thus removing.

**Automatic Transmission:** The Automatic Transmission uses a hydraulic or fluids coupling to transmit engine power to the wheels, (*Fluid Coupling: A device in the power train consisting of two rotating members. It transmits power through a fluid from the engine to the remainder of the power train*). Efficient transmission of engine output to the automatic transmission input shaft is performed through a transmission lockup clutch similar to a standard pressure plate clutch placed inside the torque converter.

In order to smoothly engage the lockup clutch the hydraulic pressure is adjusted by controlling the output current applied to the lockup solenoid valve. (*Solenoid is a type of electro-magneto, often used to operate the starter motor switch*).

Automatic transmission is controlled by inputs from the vehicle speed sensor and throttle position sensor which senses the vehicle load. The automatic gear shift points, the point at which the lockup clutch is activated, and the clutch's hydraulic pressure level are controlled by the Power Control Module (PCM). The optimal shifts and lockup operations are carried out using a solenoid valve to open and close the hydraulic circuit, primed by the hydraulic pump.

The transmission's input-shaft speed is monitored during shifting by the speed sensor after the ON/OFF signal is output from the shift solenoid valves. The shifting process is adjusted by the hydraulic pressure of the clutch so that the clutch is smoothly engaged. The engine torque is controlled in synchronism with the shift to reduce impact due to shift. During cruise, the lockup clutch is engaged and is disengaged during shifts, which improves fuel economy and emissions.

**Resistance to the Motion of the vehicle:** A thrust known as tractive effort or force is provided by the power unit of a vehicle at the driving road wheels. Varying at different engine speeds and gear positions, it is mainly required to overcome the force of opposing motion of the vehicle. The resistance to the motion of the vehicle is known as tractive resistance.

##### 4.1 Rolling resistance

It is the force necessary to maintain constant speed on a level road and the rolling resistance generally varies with the type of the road surface, load on each tyre, inflation pressure and type of tyre trend.

The value rolling resistance can be calculated from the formula:

$$R_r = k_r \cdot W$$

where, W = Total weight of the vehicle in kg.

$k_r$  = constant of rolling resistance.

**Gradient resistance:** It is the force opposing forward motion of a vehicle up a gradient. This resistance does not depend upon the speed of the vehicle. It is expressed as,

$$R_g = W \sin \theta,$$

where, W= Total weight of the vehicle kg.

$\theta$  = inclination of the slope to the horizontal,

When expressed as a percentage, it is percent gradient,

$$= 100 \times \tan \theta = 100 \sin \theta$$

#### 4.2 Wind or air resistance

Wind or air resistance is dependent upon speed, the shape of the vehicle body and wind velocity and it is given by:

$$R_a = K_a \cdot A \cdot V^2$$

where, A = projected frontal area in m<sup>2</sup>

V = speed of the vehicle in km/hr.

K<sub>a</sub> = Co-efficient of air resistance.

= 0.00235 for best stream lined cars,

= 0.0032 for average cars,

= 0.0046 for trucks and Lorries.

#### 5. Type of data

Power train subsystem consist of the engine and transmission including the exhaust emission control apparatus which needs to be continuously monitored by the engine controller i.e. computer for potential defects leading to decreased effectiveness in emission control system. Exhaust & Fuel system consists of the following components : Exhaust valves; Exhaust Gas line; Fuel pump; Fuel Level Sensor; Vacuum Sensor ; Canister vent; Fuel feed and metering ; Fuel injection nozzles; Oxygen sensor; catalytic converter etc.

For example, a petrol engine consumes 6.35 kg of petrol per hour. The specific gravity of petrol is 0.7. The fuel air ratio is 0.066. The diameter of the single jet of the carburetor 1.27 mm and its top is 3 mm above the petrol level. Average condition of air is 15.5 C and 1,027 kg/cm<sup>3</sup>. The values discharge coefficient for fuel and air respecting are 0.6 and 0.8. Find the critical air velocity and effective throat diameter of the venturi. What is the drop of pressure in the venture, expressed in cm of water.

Solution:

Density of air at given conditions:

$$\begin{aligned} P\gamma &= \frac{1.027 \times (10)^4}{29.27 \times 2888.5} \\ &= 1.215 \text{ kg/m}^3 \end{aligned}$$

Neglecting the compressibility effect on air, critical air velocity:

$$\begin{aligned} V_a (\text{critical}) &= K_a \sqrt{2g \times \frac{pf}{pa}} \\ &= 0.8 \sqrt{\frac{2 \times 9.81 \times 3 \times 700}{1000 \times 1.215}} \\ &= 4.65 \text{ m/sec} \end{aligned}$$

Petrol flow per second,

$$W_f = A_f \cdot K_f \sqrt{2g \cdot pf (\Delta Pa - x \cdot Pf)}$$

$$\begin{aligned} \text{Or, } &= \frac{6.35}{60 \times 60} \\ &= \frac{\pi (1.27)^2 \times 0.6}{4 (10)^4} \sqrt{(2 \times 9.31 \times 700)} \sqrt{(\Delta Pa - \frac{3}{1000} \times 700)} \end{aligned}$$

$$\begin{aligned} \text{Or, } &\sqrt{1.4000 \times 9.81 (\Delta Pa - 2.1)} \\ &= 2.310 \quad \therefore \Delta Pa = 390.1 \text{ kg/cm}^2 \end{aligned}$$

Using the relation,  $p = wh$ ,  $h = \frac{p}{w}$

$$\Delta Pa = \left(\frac{390.1}{1000}\right) \text{meters of water.}$$

= .39 meters of water,

= 39 cm of water.

Air flow per second:

$$\begin{aligned}
W_a &= K_a \cdot A_a \sqrt{2g \cdot Pa \cdot \Delta Pa} \\
&= \frac{6.35}{0.066 \times 3.600} \\
&= 0.8 \times A_a \sqrt{2 \times 9.81 \times 1.215 \times 390.1} \\
&\therefore 0.8 \times A_a \sqrt{9.320} \\
&= 2.7 \times (10)^{-2} \\
&\therefore \frac{\pi}{4} d_a^2 = \frac{2.67 \times (10)^2}{0.8 \times \sqrt{9.320}} \\
&\therefore d_a^2 = 4.41 \times (10)^{-4} \\
&d_a = 2.1 \times 10^{-2} \text{ meters.} \\
&\therefore \text{Throat diameter venturi} \\
&= 2.1 \text{ cm}
\end{aligned}$$

## 6. Conclusion

Combustion and Rotational dynamics: The engine provides the mechanical power to the vehicle. The engine cylinders perform the combustion of air/fuel mixture at stoichiometric ratio (14.7). The Crankshaft assembly and flywheel house the crank angle which senses the position of the Top Dead Centre (TDC) of the cylinder and provides the necessary ignition spark at the correct crank angle between the reference point on the flywheel and the horizontal centerline of crank shaft. The amount of fuel needed for the combustion in the engine cylinder is a direct function of the throttle position and the mass of air through the intake manifold which is controlled by the drivers accelerator pedal. This mass of air is measured with the Mass Air Flow (MAF) sensor. The throttle plate is mechanically linked to the accelerator pedal which is operated by the driver. When the pedal is pressed the throttle plate rotates and allows more air to pass through the intake manifold. During engine off condition, the fuel stored in the fuel system tends to evaporate into the atmosphere. To reduce these HC emissions, they are collected by a charcoal filter in a canister. The collected fuel is released into fuel intake through a purge solenoid valve controlled by the PCM periodically.

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