OBD II Data Interpretation

What is OBDII?
OBDII stands for on board diagnostics second generation superseding that of OBD1.OBDII is a system that was mandated by the Federal EPA and was developed by the society of automotive engineers (SAE). Its purpose is to standardize automotive electronic diagnostics so technicians can use the same scan tool to test all makes and model of automobiles without special adapters and or factory scanners. When the EPA mandated OBD11 computer systems, they also mandated that all manufactures would make available generic information that would be the same for all manufactures. They also mandated that anybody's scanner could have access to the computer system with the proper software and adapters. This information would have the same code terminology, data parameters, freeze frame data and system monitors. Updated scanner software will usually have OBDII generic mode capabilities. It will access any manufactures OBDII generic mode and allow you to retrieve codes, data, monitor information and freeze frame data without having to buy specific software for that manufacturer. For example, you may only have software for a GM if this software has the OBDII generic mode you would be able to use it on a NISSAN. OBDII vehicles were first introduced in year 1994 by the year 1996 all vehicles sold in the united states were required to be outfitted with OBDII complaint computer systems.

OBDII computer system require standardization of:

Universal diagnostic test connector known as the data link connector (DLC) with dedicated pin assignment
A standardized location for the DLC usually located under the dash on the driver's side.

A standardized list of generic diagnostic trouble codes used by all manufactures.

The ability of the computer system to record a frame of data as a fault occurs within the computer system known as "freeze frame" data.

Expanded diagnostic capabilities that record a code whenever a problem occurs that affects the emissions.
The ability to clear all hard and pending codes with a scan tool.
A standardization of acronyms and definitions used for system components.

Data parameters

(HO2S sensor monitors) this information is available in the codes and data area of the scan tool. This selection allows you to dissect the output of the HO2S (heated oxygen sensor) voltage by breaking it down to maximum voltage output, minimum voltage output and switching rate. The computer looks to see if the HO2S voltage rises above 600 MV and falls below 300 MV and switches in less than 100 milliseconds. The PCM will provide a rich or lean mixture to test the HO2S ability to rise above and below the voltage levels it's looking for. The PCM also looks at the reaction time to make sure the HO2S is not lazy. Testing of the HO2S this way assures that the catalytic converter will remain efficient. When the catalytic converter is working properly the computer sees almost no switching action from the rear o2 sensor. To test the rear O2 sensor the computer will force a rich or lean mixture that the catalytic converter can't compensate for and then monitors the HO2S voltage.

There are nine sensor tests available on OBDII vehicles.

Rich to lean threshold voltage. .

Lean to rich threshold voltage.

Low sensor voltage for switch time calculation.

High sensor voltage for switch time calculation.

Rich to lean sensor switch time.

Lean to rich sensor switch time.

Minimum sensor voltage for test cycle.

Maximum sensor voltage for test cycle.

Time between sensor transitions. Below is an illustration of the different test points.

AIR injection (range = upstream/downstream/atmosphere)

This parameter allows us to view the status of the air injection whether it is upstream, downstream or bypassing to the atmosphere. The normal state of operation is as follows: When the car is cold and in open loop the air should be in the upstream mode. This allows air to be dumped into the exhaust manifold to quicken O2 sensor heat up time and to oxidize HC that's in the hot exhaust. When the engine is hot and in closed loop the air will go down stream into the catalytic converter to allow it to oxidize. On declaration the air should move to the atmosphere mode to prevent the possibility of backfire. Under no circumstances should the air injection be in the upstream mode when the engine is in closed loop. While in closed loop the O2 sensor is the primary sensor for air/fuel mixture control. Since the O2 sensor's only job is to monitor oxygen in the exhaust, any air flowing past it from the air injection would cause the O2 sensor to give a false lean signal. The PCM would richen the mixture in response to it.

Airflow grams per second (range = low at idle and increase with engine load)

This parameter displays a calculated value of airflow across the MAF. The MAF then sends a varying signal output to the PCM that is calculated as grams per second, cubic meters per hour, or kilograms per hour. Most MAF sensors have a hot wire that stretches across the front of the sensor that is heated up to a certain temperature. As the throttle plate is opened, the air rushes past the wire and cools it off. The internal circuitry of the MAF sensor will then put more current to the wire to keep it at the same temperature. This will allow the sensor to generate a signal based on the current it took to keep the wire at the same temperature. The PCM will receive this signal and calculate mass airflow. If the wire is dirty it can skew the measurement of mass airflow and cause a biased rich or lean condition. This condition does not always set a code for the MAF. Note: an important fact to remember if the vehicle has a hard code for a MAF, the scanner will still display a changing value for the MAF parameter. While the MIL light is on the vehicle will be in limp home mode and the value that is observed on the scanner is a made up value based on RPM, TPS and look up tables within the PCM.

Coolant temp sensor (range = -40 to 389 F)
The CTS (coolant temperature sensor) is an NTC (negative temperature coefficient) thermistor that creates varying degrees of voltage drop on a 5-volt reference wire that's supplied by the PCM. The PCM will interpret the voltage drop on the 5-volt reference wire and convert these voltage changes into temperature readings and display it on the scanner. When the sensor is unplugged, the open circuit from the PCM will be reading 5 volts on the CTS wire and display -40 degrees on the scanner. When the CTS connector is jumped short circuit, the PCM will be reading "0" volts on the wire and display a reading of 389 degrees. Normal operating range for the sensor, when hot, should be 185 to 220 degrees. Voltage will be 3 volts cold .5 volts hot. This sensor has a major influence over fuel mixture when the engine is cold. Its influence diminishes as the engine warms up to operating temperature. The CTS and ACT readings should be compared when dealing with a cold start problem make sure they are within 10 degrees of each other when the engine is cold. The PCM also uses the CTS input to control the cooling fan operation, on some vehicles. The PCM will turn on the fan if it senses an open or shorted CTS circuit. This is a fail-safe mode of operation to protect the motor from damage due to overheating. CTS is also used by the PCM to determine when to activate the torque convert clutch.

Engine rpm
RPM is a measurement of engine speed. This information comes to the PCM from the crank sensor or ignition system. RPM is the only input that the PCM cannot substitute. RPM is the most important input to the PCM, without it the engine will not run. On some manufactures the rpm will display on the scanner while in the crank mode this, can be a useful tool when diagnosing no start problems. If there is an RPM signal while in the crank mode, the crank sensor and or ignition module must be sending distributor reference so don't look there for the no start problem. The PCM uses RPM to pulse the injectors and make the ignition coil fire. RPM is used by the PCM to control torque converter clutch operation. On computer controlled transmission the PCM will use the RPM in conjunction with the turbine and output shaft speed sensors to control shifting and determine transmission slippage.

Fuel pressure (range = 0 to 112 PSI)
This input comes to the PCM from a pressure sensor on the fuel rail. This input can be extremely useful in diagnosing intermittent fuel pressure problems that affect derivability. The fuel pressure specs very from manufacturer to manufacture so consult a service manual for exact specs. One of the best features of this parameter is the fuel pressure can be observed while driving the vehicle. The best volume test of a fuel pump is done while the vehicle it at wide-open throttle (WOT). When at WOT the PCM is commanding the richest mixture. The injectors are being held open for a long period of

time if the pressure drops at this time it means the fuel pump can’t keep up with the supply demand, determining the fuel pump is bad, the fuel filter is restricted or a line restriction could be causing the problem.

Fuel system status (range open loop or closed loop)

Fuel status bank 1

Fuel status bank 2

This parameter displays the status of the fuel system whether it is in closed loop or open loop. The term open loop means that the PCM is not using the O2 sensor signal voltage to influence the air fuel mixture. The term closed loop means that the O2 sensor signal voltage is directly influencing the air fuel mixture. When the engine is cold the fuel status will be open loop, as the engine reaches normal operating temperature the fuel status should switch to closed loop. It takes three occurrences to allow a vehicle to enter closed loop, engine at predetermined temperature, O2 sensor switching and the internal timer within the PCM has to time out. The vehicle can fall back to open loop for various reasons, WOT, deceleration, a hard code, O2 sensor heater circuit failure, sticking thermostat.

Ignition timing (range = plus or minus)

This parameter displays the amount of timing the PCM is adding or subtracting from base timing. The PCM uses sensor inputs to determine where to put the timing. When the engine is under a heavy load it will retard the timing to keep the engine from detonation. On decal the timing will advance. When a sensor such as a MAP sends a lean command signal to the PCM the timing will advance or vice versa when it sends a rich command signal the timing will retard. A sensor that is biased in either direction will have a drastic effect on timing advance.

Intake air temp sensor (range = -40 to 389 degrees F)

The ACT (air charge temperature) sensor is a (NTC) thermistor that creates varying degrees of voltage drop on a 5-volt reference wire that's supplied by the PCM. The PCM will interpret the voltage drop on the 5-volt reference wire and convert these voltage changes into temperature reading and display it on the scanner. When the sensor is unplugged (open circuit) the PCM will be reading 5 volts on the ACT wire and display -40 degrees on the scanner. When the ACT connector is jumped short circuit the PCM will be reading "0" volts on the wire and display a reading of 389 degrees. Normal operating range for the sensor when hot should be 75 to 110 degrees. Voltage will change with airflow across the sensor. Changes in air temperature affect air fuel mixture. When the ambient temperature is hot the air is thin and the system would be rich. The opposite is true when the ambient temperature is cold the air is dense the mixture would be lean. The PCM will compensate for air temperature changes and change the air fuel mixture. This sensor is not a high priority sensor; its influence over air fuel mixture is not like the CTS. The CTS and ACT reading on the scanner should be compared when dealing with a cold start problem make sure they are within 10 degrees of each other when the engine is cold.

Engine load (range = 0 to 100%)

This parameter indicates the actual load of the engine by dividing the actual manifold airflow volume by the maximum possible manifold airflow volume, the higher the number the heavier the load. This parameter will usually be around 2% at idle and increase with engine load to as high as 100%. It is common on some manufactures to have a high load value at idle when there is a MAF sensor circuit failure. Example: a poor ground on the MAF sensor will allow the sensor to output a higher voltage signal than the actual load of the engine. This will be interpreted by the PCM as a load condition and the PCM will richen up the mixture. OBDII will also look at the sensor reading and determine if it is rational. If it is not, a fuel trim code might be set.

Long term fuel trim bank 1 and bank 2 (range =-25% to +25%)
Note: bank one is where #1 cylinder is located.
This parameter displays information on the fuel correction status of the PCM over the long term. 0% represents the mid-point. Any number less than 0% indicates the PCM is leaning out the air fuel mixture with less injector on time. Numbers greater than 0% indicate the PCM is richening the air fuel mixture with increased injector on time. The purpose of the long term fuel trim is to keep the short term fuel trim averaging 0% it will move in either direction to achieve this goal. If the PCM is successful in achieving this goal the air fuel ratio will be around 14.7 to 1. The long-term fuel trim operates only in closed loop operation. In open loop it reverts the learned value it created while in closed loop operation.
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Map sensor (range = 0 to 60 HG)
This parameter displays manifold absolute pressure reading from the MAP sensor voltage signal. This parameter should be about 29.6 inch., with the engine not running at sea level and about 9.6 in. hg. while the engine is at idle. The engine runs at about 20 inches vacuum at idle so subtract 20 from 29.9 and this gives us 9.6 in.hg. of pressure in the intake. As the engine is placed under a load the pressure will increase to as high as 29.6 at wide open throttle. Keep in mind the scanner is displaying pressure not vacuum under this parameter. Whatever the display shows, figure how many inches to make 29.6 and there is the vacuum. Example: with a reading of 13 in.hg. we would have to add 16.9 in.hg. to equal 29.6 in.hg. This would mean the intake manifold vacuum is 16.9 in. hg were the pressure equals 13 in.hg.

O2 sensor Bank 1 SI: O2 sensor bank 2 S1 (range 0 to 1100 MV for all)
O2 sensor bank 1 S2: O2 sensor bank 2 S2
O2 sensor bank 1 S3: O2 sensor bank 2 S3
O2 sensor bank 1 S4: O2 sensor bank 2 S4

The PCM uses the O2 sensor input to determine if the air fuel mixture is rich or lean. The PCM will not control the mixture from the O2 sensor input until the operating strategy for closed loop operation has been met. After the PCM enters closed loop it will control the air fuel mixture in the opposite direction of what it sees from the O2 sensor. Example: 900 MV from the O2 sensor will cause the PCM to deliver a lean command. Any voltage over 450 MV would indicate rich condition and less than 450 MV would indicate a lean condition. The O2 sensor generates its own voltage signal that ranges from 0 to 1 volt or 0 to 1000 MV. When the fuel system is working normally the voltage will range from 100 to 900 millivolts averaging 450 millivolts. The O2 sensor voltage should cross over the 450 millivolt threshold a minimum 6 to 10 times a second this is known as O2 cross counts. The purpose of the switching of the fuel mixture is to allow the catalytic converter to be efficient. NOTE: BI AND B2 stands for bank 1 and bank 2. Bank 1 contains the number 1 cylinder. S1 is the prefix for pre catalyst O2 sensor and S2 is the prefix for post catalyst O2 sensor.

Short term fuel trim bank 1 (range = -20% to +20%)
Short term fuel trim bank 2
This parameter indicates weather the PCM is commanding a rich or lean air fuel mixture. The short-term fuel trim's job is to monitor the O2 sensor voltage and keep it averaging 450MV this would be equal to an air fuel mixture of 14.7 to 1. The range of the short-term fuel trim is -20% to +20% the base number is 0%. When the PCM is in control of the air fuel mixture the short-term fuel trim should be close to the base number 0%. Any number less than 0% would indicate the PCM is leaning out the air fuel mixture. Any number above 0% would indicate the PCM is richening the air fuel mixture. The short term fuel trim is live correction based on O2 sensor voltage. The PCM uses this as a corrective action to force the air fuel mixture in the opposite direction of the of the O2 sensor signal. Example: O2 sensor voltage high 800 MV = lean command from the PCM. Short-term fuel trim will go to a negative value. It's this corrective action that causes the O2 sensor voltage to move up and down above and below the 450 MV range. The purpose of switching the air fuel mixture rich and lean is to allow the catalytic converter to be efficient.

Throttle percentage (range 0% to 100%)
This parameter is a calculation of throttle position, indicating the amount of throttle opening. This information comes to the PCM from the throttle position sensor. The PCM converts a variable voltage signal to a percentage of throttle opening. It's hard to see glitches or drop outs in this circuit using a scan tool. The PCM transfers the data to the scan tool to slow to pick up all the bad spots in the TPS circuit. The DSO is the tool that should be used when checking TPS circuits. This sensor will normally be about 3% at idle to about 95% at wide-open throttle. The PCM may shut off the injectors during start up if it sees 80% or more coming from the TPS while in the crank position this is known as clear flood mode.

Vehicle speed sensor MPH (range = 0 to maximum allowed speed)
This parameter comes from the vehicle speed sensor on the transmission or rear axle. The PCM uses the VSS to control the torque converter clutch and shifting of the automatic transmission. There are other systems on the vehicle that share this information they are: speed sensitive steering, ABS brakes, traction control, cruise control, electronic controlled transmissions, and fuel control computer. The PCM may also put the fuel system into fuel cut when it sees too high a speed from the VSS.

OBDII readiness monitors (range = ready/not ready)
There are several monitored circuits within a PCM Each monitor requires that a certain sequence of events occurs before the PCM will flag it as ready this is known as a drive cycle. When a readiness monitor reads ready it means that a drive cycle has completed and the monitor is ready to report problems and set DTC's. A monitor that reads "not done" means that a drive cycle has not been performed and the monitor cannot report problems or set DTC's. The following is a list of the readiness monitors and a brief description.

Misfire monitor (range = ready/not ready)
Monitors engine misfires by looking at engine speed. The PCM can determine if a cylinder has a misfire by the time it takes to reach the next cylinder in the firing order.

The PCM uses crankshaft and camshaft position sensors to obtain this information. Example: there is low compression in #1 cylinder. When #1 cylinder comes to top dead center of the compression stoke the coil fires. The pressure produced by this cylinder is low. This causes the force pushing on the top of the piston to be weak during the power stroke. This in turn causes the crankshaft rotation to slow down. This slower motion of the crankshaft is how the PCM determines the severity of the misfire. When it detects a misfire the PCM will store a code for the cylinder with the problem. Anything that causes a cylinder not to fire will set a misfire code.

Comprehensive component monitor) (components)
Determines when a malfunction occurs with PCM inputs or outputs that are not exclusively monitored by another monitored system. This monitor is what allows the PCM to set codes for inputs and outputs circuits that are shorted, open or out of range. This monitor is enabled shortly after the engine is started. A drive cycle is not required for this monitor to report problems and set DTC.

Secondary air system monitor (range = ready/not ready)
Monitors the function of the air injection system and test the ability of the of the air system to add air into the exhaust manifold by observing the O2 sensor voltage. The PCM will force the air injection system to deliver air upstream into the exhaust manifold. The PCM will then look at the O2 sensor for low voltage indicating a lean mixture.

Oxygen sensor and oxygen sensor heater monitors (range = ready/not ready)
This monitor looks at the O2 sensor circuits for switching frequency and min/max voltage output.
This monitor also verifies that O2 sensor heater circuits are operational. Each manufacturer has their own way of testing the O2 sensor heater circuits.

Exhaust gas recalculation monitor (range = ready/not ready)
This monitor tests the integrity of the flow characteristics of the EGR valve by activating the EGR system on deceleration. This allows the valve to open. The PCM will view the map sensor for pressure changes, as the EGR valve is open. The reason for this test is to verify EGR passages are free and the valve is functioning properly. They may also look at the short-term fuel trim to verify EGR operation.

Fuel system monitor (range = ready/not ready)
This monitors the long and short term fuel correction and determines if the PCM has had to correct the air fuel mixture to a degree that is outside a specified threshold. Example: the air fuel mixture is rich the short term fuel trim responds by trying to lean out the mixture, if its unable to achieve a lean mixture, long-term fuel trim will move negative to lean out the mixture. It will keep moving down until it can achieve this goal. Once it has resolved the problem the PCM will learn what it had to do to resolve the problem and place this learned correction in its memory banks. This learned fuel correction is known as adaptive strategy. If this correction is outside its specified threshold it will set a code for rich.

Catalyst efficiency monitor (range =ready/not ready)
This monitor determines when the catalytic converter has fallen below a minimum level of effectiveness. The PCM uses pre and post O2 sensors to determine this. While the engine is running there is varying levels of oxygen left over from the combustion process. The front O2 sensor voltage will fluctuate rapidly to these levels of oxygen. This oxygen flows into the catalytic converter. The catalytic converter uses the oxygen to convert HC to CO2 and H20 this conversion process depletes the oxygen content within the converter. The converter has the ability to store and release oxygen. The rare earth metal "cerium" accomplishes this. When the mixture is lean, the excess oxygen is stored in the cerium. When the mixture is rich, the cerium releases the stored oxygen to help in the oxidation process. This causes the rear O2 sensor output to be somewhat of a flat line in comparison the front O2 sensor. If the rear O2 sensor voltage starts to duplicate the front O2 sensor the p.m. will determine the catalytic converter is not efficient and set a code.

Fuel evap system monitor (range = ready/not ready)
This monitor checks the ability of the evap system to flow fuel vapor into the engine. This monitor also performs check on the system for leaks.