A Hand-book of OBD Modes and Services:
Your go-to-guide for the OBD Software

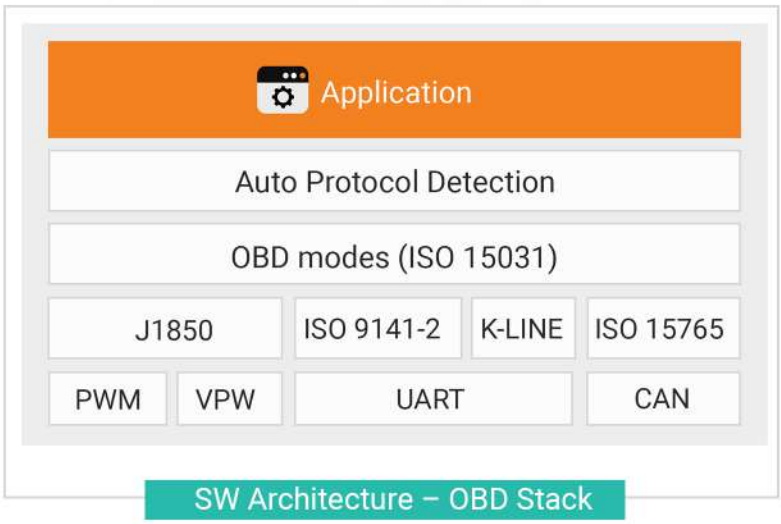
embitel
delivered with passion

An **On-board diagnostics (OBD) software stack** is designed to monitor the emissions of the exhaust gases from an internal combustion engine.

There are several components that regulate the amount of toxic gases released through the exhaust system. These components need to be monitored, as per the rules described in various standards such Euro 6, Bharat Stage, and more.

An OBD software stack performs this emission monitoring with the help of clearly defined set of rules. These rules are implemented using software codes which are called as Modes and Services.

These Software Architecture will help you understand OBD stack better.

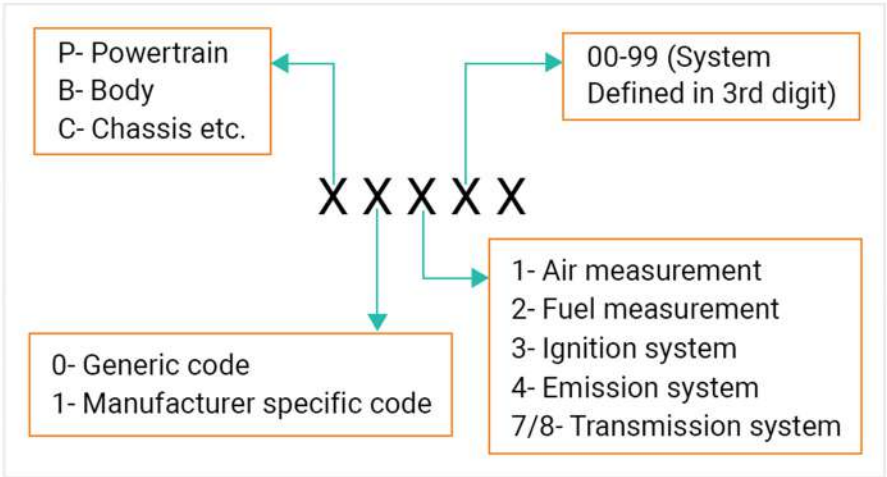


SW Architecture – OBD Stack

Before delving into the modes and services of OBD, here are a few terms that you will come across in the document.

DTC- Diagnostic Trouble Codes:

These are the codes specified in the OBD specs that describe the component where the trouble has occurred and the nature of the fault. DTC format is XXXXX.



Example- P0301. It signifies the fault is in powertrain; the code is generic and not OEM specific; specific system where the fault is diagnosed is the Ignition system.

PID- Parameter Identifiers:

The PIDs are nothing but codes defined in the OBD protocol. These codes are used to request diagnostics data from the vehicle.

The OBD stack also helps the tester too to communicate with the on-board diagnostics system with help of PIDs (Parameter Identifiers).

The purpose of this handbook is to give the readers a glimpse of some of the important OBD Modes/Services and their functions.

After 2008, most of the automobiles use CAN as the in-vehicle network protocol. However, physical medium such as K-Line, ISO9141-2, J1850 etc. are also in use by some OEMs. OBD-II will have provision for all these protocols.

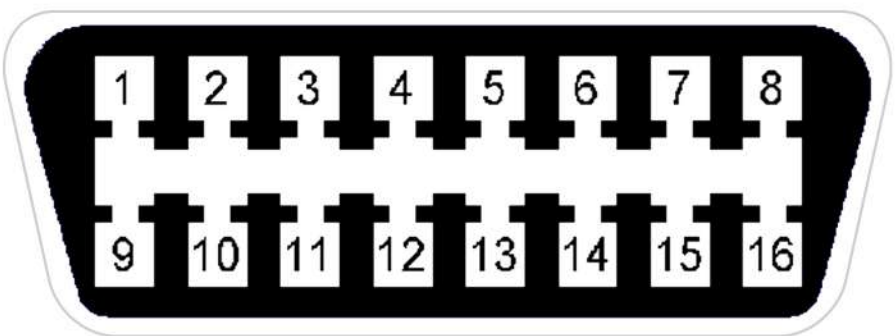
Some of the communication protocols (other than CAN) available under OBD II spec:

- **SAE J1850:** There are two variants of this protocol- J1850 PWM and J1850 VPW. The PWM (Pulse Width Modulation) protocol runs at 41.6 kbps. It utilizes OBD connector port pin numbers- 2,4,5,10 and 16.

  The VPW (Variable Pulse Width) is slower at 10.4 kbps and utilizes pins- 2,4,5 and 16 of the OBD connector port.

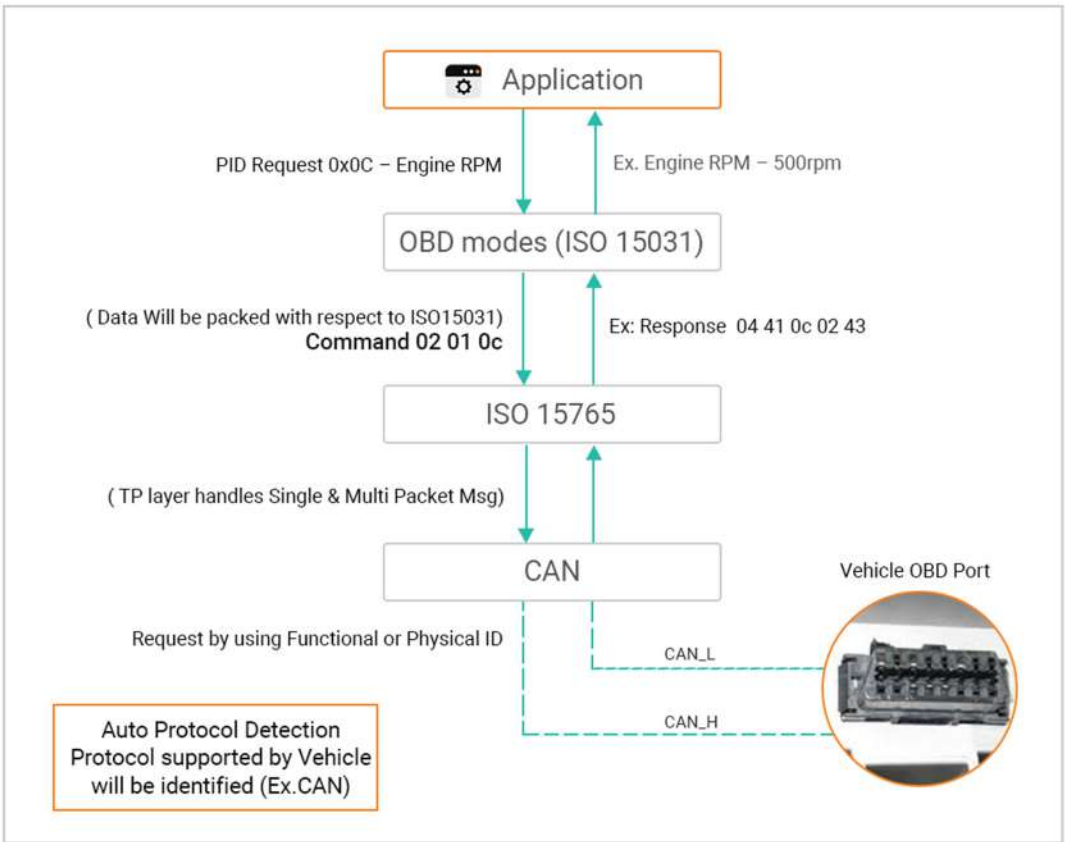
- **ISO 9141-2 (K-Line):** Some European, Asian vehicles implement this communication protocol in the vehicles. It is an asynchronous serial communication and runs at 10.4 kbps data rate. Pins 4,5,7,15,16 are reserved for this.

The image shows an OBD-II Connector:



Pin 2 - J1850 Bus+	Pin 4 - Chassis Ground	Pin 5 - Signal Ground
Pin 6 - CAN High (J-2284)	Pin 7 - ISO 9141-2 K Line	Pin 10 - J1850 Bus
Pin 14 - CAN Low (J-2284)	Pin 15 - ISO 9141-2 L Line	Pin 16 - Battery Power

The following Data Flow diagram will help you understand flow of data from the OBD port (shown in the above diagram) and an **Application**.



OBD Modes of Operation

Modes of Operation define how an 'OBD Tester Device' requests data from a vehicle and how the vehicle sends the response

Mode of operation: Purpose and associated Standard

Diagnostic Service/ Mode of Operation	Purpose	Standard
$01	Request current diagnostics data from Powertrain	ISO, SAE
$02	Request freeze frame data from Powertrain	ISO, SAE
$03	Request Diagnostics trouble codes related to emission	ISO, SAE
$04	Clear/Reset diagnostic information related to emission	ISO, SAE
$05	Request Test Results for Oxygen Sensor monitoring	ISO, SAE
$06	Request diagnostics result from monitored systems like Exhaust Gas Sensors	ISO, SAE
$07	Request Diagnostics Trouble Codes during current or last driving	ISO, SAE
$08	Request for control ofOn-Board Diagnostics	ISO, SAE
$09	Request vehicle related information	ISO, SAE
$0A	Request for DTCs with permanent status	SAE

Detailed Analysis of Some Important Diagnostic Modes, PIDs and Diagnostics Trouble Codes

- **Mode $01:** This service is used to access the emission related data values. The data values consist of System Status Information and Analog/Digital Input and Output.

Following are the mandatory PIDs that are defined for the Mode $01:

PID	DESCRIPTION	REQUIRED
00	PIDs supported [01 – 20]	Mandatory
01	Monitor status since DTCs cleared	Mandatory
02	DTC that caused required freeze frame data storage	Mandatory
04	Calculated LOAD Value	Mandatory
05	Engine Coolant Temperature	Mandatory
0C	Engine RPM	Mandatory
0D	Vehicle Speed Sensor	Mandatory
1C	OBD requirements to which vehicle or engine is certified	Mandatory
20	PIDs supported [21 – 40]	Mandatory
21	Distance Traveled While MIL is Activated	Mandatory
30	Number of warm-ups since DTC cleared	Mandatory
31	Distance since DTCs cleared	Mandatory

How Mode $01 in OBD works?

The Request from the Client (e.g. OBD Testing Device or OBD Tester) has a PID that indicates the specific data/ information that has been requested by the vehicle On-Board System.

The Server (e.g. an Automotive ECU or Control Unit) responds to the request by sending the requested data. The data value last determined by the system is sent as a response.

- **Mode $02 :** This Automotive OBD Service is used to request the freeze frame data. A DTC is raised as soon as a system or a component fails.

Freeze frame data is the set of vehicle parameters captured at that very moment.

Only the vehicle parameters defined as PIDs can be requested as freeze frames.

How Mode $02 in OBD Works?

A DTC is raised for a fault in exhaust catalyst at high vehicle speed. To understand all possible causes of the fault, the OBD Tester will need values of certain vehicle parameters including Engine RPM.

For example: 0X0C will be used as the PID to request for Engine RPM Freeze Frame Data.

- **Mode $03:** Purpose of this service is to allow the external OBD Tester Tool access emission related Diagnostics Trouble Codes, from the On-Board System.

  Mode $03 service only sends the "confirmed DTCs". A trouble code is given 'confirmed' status during the second driving cycle after the fault has been detected.

  Example: The code P1461 indicates that A/C pressure sensor circuit voltage is high.

- **Mode $04:** This On-Board Diagnostics (OBD) mode is used to clear the recorded fault codes.

  List of diagnostics trouble codes and data that can be erased with this service:

  - Data requested by Mode 06
  - Freeze Frames
  - Monitor status
  - Readiness for maintenance or inspection
  - Distance covered/ Idling time after Malfunction Indicator light (MIL) is on

  The service is used by the Automotive Mechanic/Engineer to delete the stored DTCs and turn-off the MIL, after the repair is completed.

- **Mode $06:** This is a special OBD mode that allows access to diagnostics results of certain components/ systems that are not monitored continuously. For example - A Catalyst System

  The tests of these specific systems are performed using the Test IDs, defined by the Vehicle Manufacturers (OEM).

  Example: A monitoring test for Oxygen Sensor is defined as per Mode $06.

Some Test IDs that requests for parameters of oxygen sensor output voltage:	
$01	Rich to lean sensor threshold voltage (constant)
$02	Lean to rich sensor threshold voltage (constant)
$03	Low sensor voltage for switch time calculation (constant)
$04	High sensor voltage for switch time calculation (constant)
$05	Rich to lean sensor switch time (calculated)

- **Mode $07:** This OBD service is used to request the pending trouble codes. The pending DTCs are those which are not confirmed after a second driving cycle.

  It is an important service used by the mechanic to verify that the fault does not recur without having to do a second test run.

  The codes used are similar to those used in Mode $03.

  Example codes: P0000- No pending trouble codes
  P0301- Misfire Detected in Powertrain

- **Mode $09:** The mode helps the external OBD Tester Tool to request for vehicle Identification Information.

  The info includes:

  - Vehicle Identification Number (VIN)
  - Calibration Verification Number (CVN)
  - In-use Performance Ratio
  - Module Calibration Number (MCN)

- **Mode $0A:** This diagnostic service provides access to the DTCs with "permanent" status. These trouble codes are stored in the non-volatile memory of the Electronic Control Unit (Automotive ECU), until they are resolved and MIL is not set to 'ON' for any one of them.

  The codes used for Mode $0Aare similar to Modes $03 and Modes $07.

  ** DTCs with Permanent status cannot be cleared with Mode$ 04. They are automatically cleared when the issue is resolved.*

The OBD Handbook covers the widely implemented OBD services over CAN. For complete list of the PIDs and codes, you can refer to the OBD II standard document by ISO.

CONNECT WITH US

INDIA : +91 80 41694200 **USA :** +1-248-385-2017

GERMANY: +49 711-60 17 47-789 **UK :** +49 170 1688028

EMAIL : sales@embitel.com

CMMI DEV /3 SM Exp. 2019-03-30 / Appraisal #26476 TÜV NORD ISO 9001 TÜV NORD ISO 27001 ISO 26262