How to use the OBD2 scanner

Diagnose, Check, and Customize vehicles using the OBD2 system

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Introduction

Hi, I am Yuri, the creator of Iamcarhacker.com where I post blogs and videos about OBD2 scanners. I decided to learn to work with the OBD2 system and diagnose my own problems since I got a check engine light on my Volkswagen Jetta.

I took it to 2 shops, one told me I needed a new NOx sensor ($600+labor and the other hooked up his expensive scan tool and told me the oxygen sensor code with the verdict something was something is off because Diesels doesn't use oxygen sensors.

Well, first of all, a lot of Diesels have oxygen sensors. Second, If I pay a professional mechanic to diagnose an issue and they either diagnose it wrong costing me money, or have no clue about how engines work, I might as well learn this stuff myself and do my own diagnosis.

I ended up buying a cheap OBD scanner, replaced the oxygen sensor and the car ran as new again. Since then I have tested several scanners, and done hundreds of scans/codings on my and my friends' vehicles and now I have solid knowledge of how these tools work.

About eBook/Course,

This course teaches you how to use an OBD2 scanner to find out what's wrong with vehicles. It includes an eBook for the theory and technical stuff and a video course to show you how to do it.

The course is split into five chapters, and each chapter has a few short parts so it's easy to understand without too much reading at once.

Important!

Video Course URL

https://iamcarhacker.com/obd2-course

Mentioned Tools

https://iamcarhacker.com/best-obd2-scanners-for-diy

Legal Notice

Chapter 1: Introduction to OBD

First chapter of this OBD course provides a concise overview of On-Board Diagnostics (OBD), covering its operation, history, and the use of OBD scanners. You'll learn how OBD systems monitor vehicle performance, detect issues, and understand its evolution from basic emission control in 1980 to the sophisticated OBD-II system post-1996.

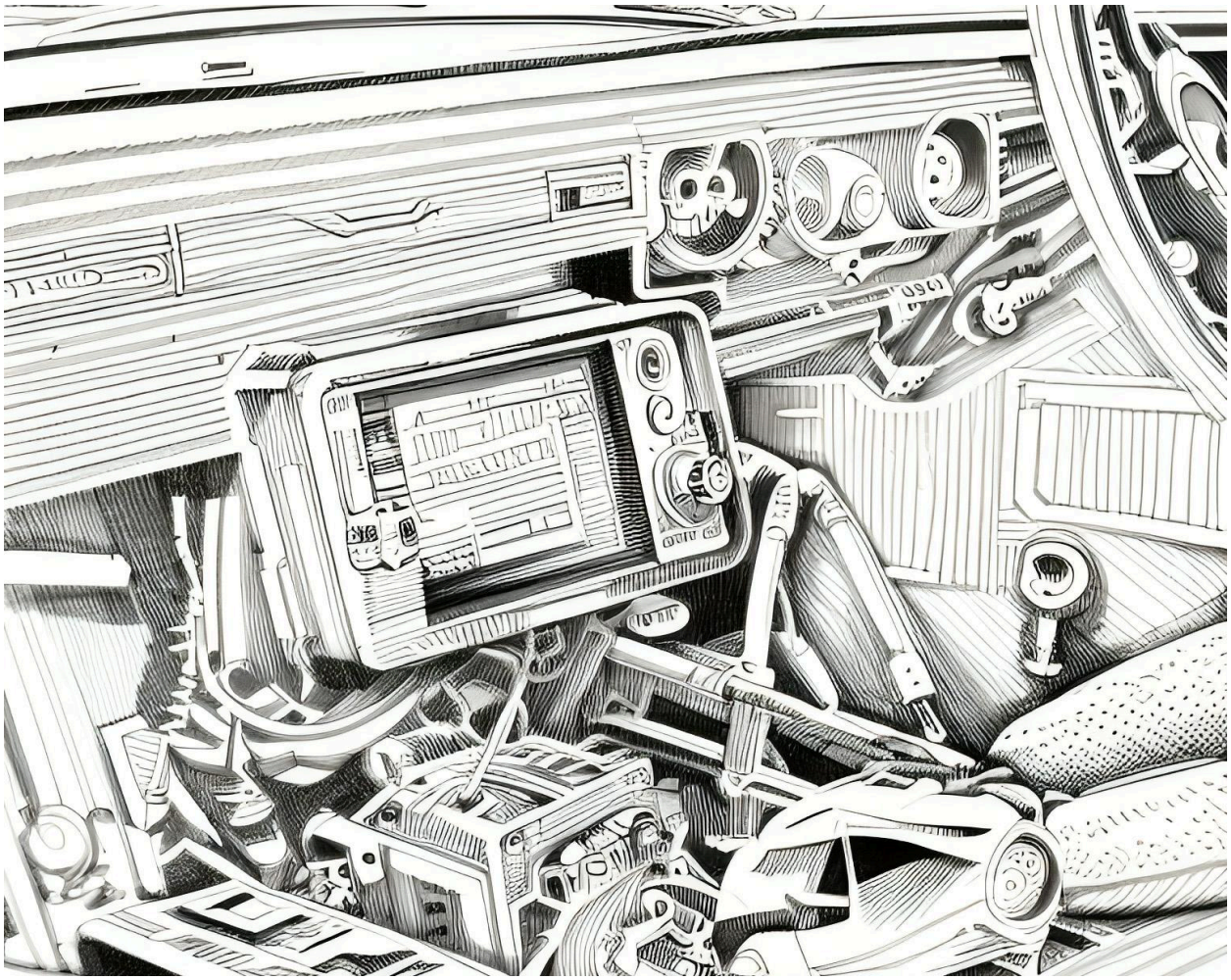
What to expect from an OBD scanner

Remember that an OBD scanner is a tool for reading data from your vehicle's OBD system and using it isn't as straightforward as just connecting it to your car to find out what's wrong.

When a part of your vehicle fails, the scanner will show a fault code, but this code could be due to various issues. To accurately pinpoint the problem, you'll often need to use other functions of the scanner and sometimes additional tools like a multimeter.

To avoid using other tools, you can order the needed replacement part online based on your diagnosis with an OBD scanner. If the new part doesn't solve the issue, most stores allow you to return it. This approach simplifies the diagnostic process, making it accessible even for those who don't use other diagnostic tools.

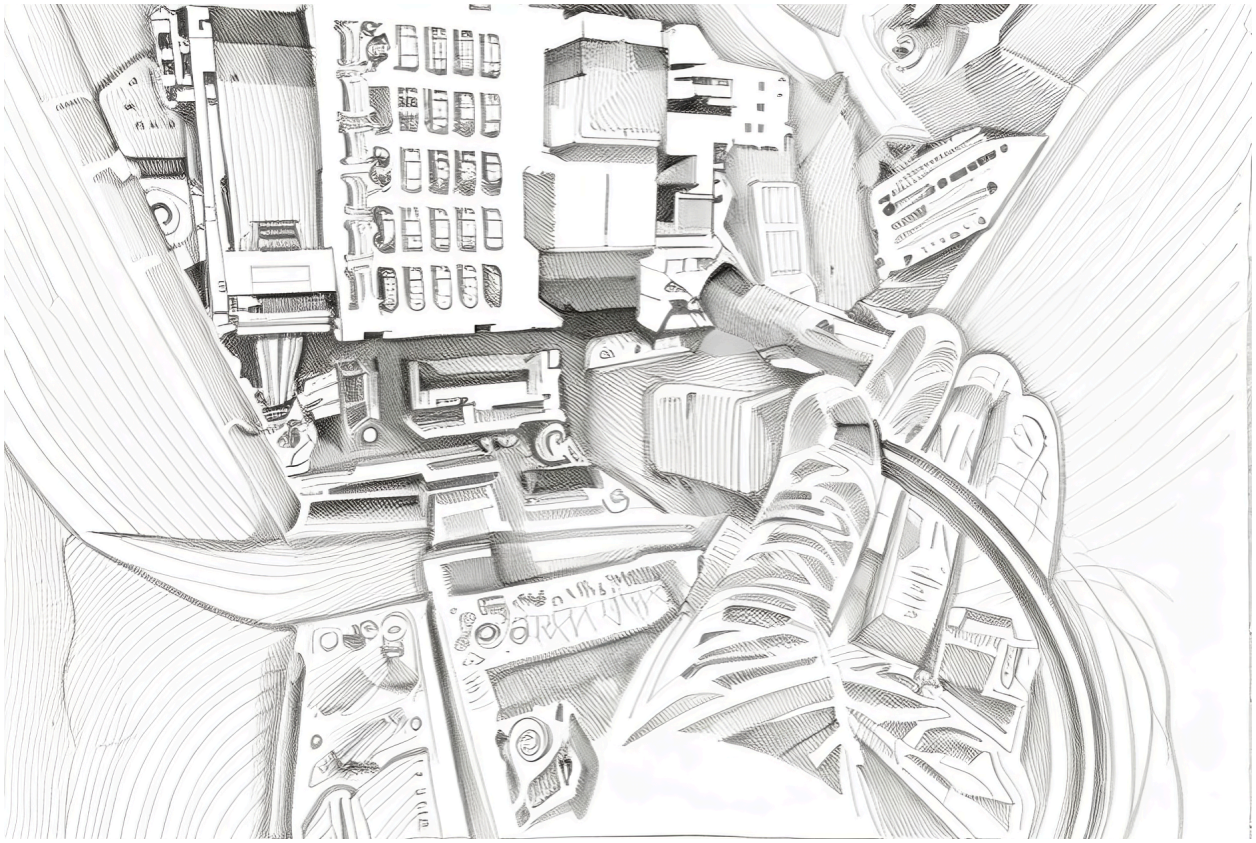
OBD history



OBD, or On-Board Diagnostics, was developed to help reduce vehicle emissions. It began with the simpler OBD1 system (implemented around 1980), which could display only a limited number of fault codes. At that time, scanners were expensive, costing around a thousand dollars, and you needed different scanners for each car brand.

In 1994, the automotive industry transitioned from OBD1 to OBD2. A significant advancement of OBD2 is its standardized connection port and protocols, allowing any OBD2 scanner to work with it, as detailed in Chapter 3 of this course. Additionally, OBD2 offers advanced features like coding and bi-directional controls, which are covered in Chapter 4.

How OBD2 works



When it comes to vehicle diagnostics, the Engine Control Module (ECM) plays a crucial role. It stores Diagnostic Trouble Codes (DTCs) in the fault code memory whenever it detects data that falls outside the normal parameters set for the engine. In the world of OBD2 diagnostics, there's no subjective 'right or wrong'; DTCs are set based on specific, measurable data and engine parameters.

If the data received by the ECM deviates from these set parameters, a DTC is recorded in the vehicle’s computer. These fault codes are already present in your vehicle's OBD2 system.

When you use an OBD2 scanner, it simply translates these codes into a language that you can understand, indicating which system in your vehicle is experiencing a fault. This information is crucial for pinpointing and addressing issues within your vehicle.

5 Basic OBD2 protocols

These are the 5 standardized OBD2 protocols. You can think of it as OBD language dialects.

- **SAE J1850 PWM** - Used by Ford and General Motors vehicles produced before 2003
- **SAE J1850 VPW** - Used by Chrysler vehicles produced before 2003
- **ISO 9141-2** - Used by Asian and European vehicles produced before 2004
- **ISO 14230 KWP2000** - Used by Asian and European vehicles produced after 2004
- **ISO 15765 CAN** - Used by all vehicles produced after 2008. Most common today.

Chapter 2: Choosing OBD2 scanner

In Chapter 2, we'll look at OBD scanners. You'll learn about cheap and expensive scanners and see that a less expensive one often works well for basic OBD needs. We'll talk about different kinds of scanners, how to choose a good one and some of the best ones to consider. Lastly, I'll show you how to easily connect your new scanner.

Understand OBD2 scanner functions

Global OBD functions

Global functions are standardized across all OBD2 scanners and you can find them in almost any scanner regardless of the price.

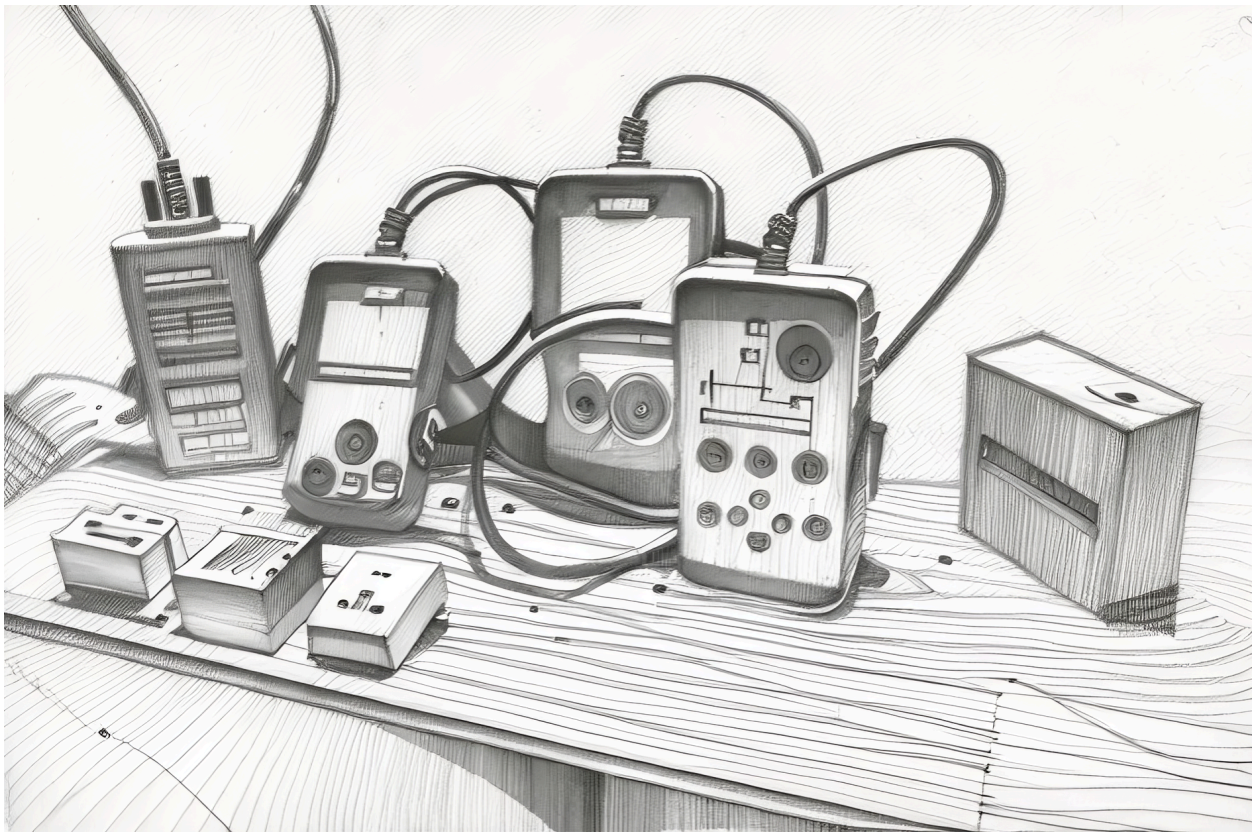
Function	**Description**
Read Codes	Retrieves Diagnostic Trouble Codes (DTCs) to identify issues in the vehicle.
Erase Codes	Clear DTCs and reset the Check Engine Light (CEL).
Live Data	Displays real-time data from various sensors and systems within the vehicle.
Freeze Frame	Captures the engine's condition at the time a DTC is set, helping in troubleshooting.
I/M Readiness	Checks if the vehicle's emission-related systems are ready for an emissions test.
O2 Sensor Test	Tests the performance of the vehicle's oxygen sensors.
Vehicle Information	Provides information about the vehicle, such as VIN and calibration IDs.
Component Test	Allows testing of individual components or systems to check their functionality.

Advanced Functions (Found in better scanners)

Better scanners will have some or even all of these advanced features.

Function	Description
Bi-Directional Control	Allows the scanner to send commands to the vehicle, testing various functions and operations.
Coding and Programming	Enables updating or changing the software of vehicle modules.
Advanced Graphing	Displays complex data in graph format for detailed analysis.
Service Procedures	TPMS, Key programming, DPF regeneration, and other functions are must-haves to work on modern vehicles
Full live data	Read live data in all modules to diagnose systems other than engine and check mileage and other data for used vehicle check
Key programming	Works with immobilizer and programs new key to the vehicle
TPMS	Servicing your tire pressure monitoring system
Topology mapping	Shows diagram of control modules and relations between them
Data logging	Record and playback the recorded live data streams
OEM libraries	OEM data libraries like wiring diagrams or TSBs (technical service bulletins)

OBD2 scanner types



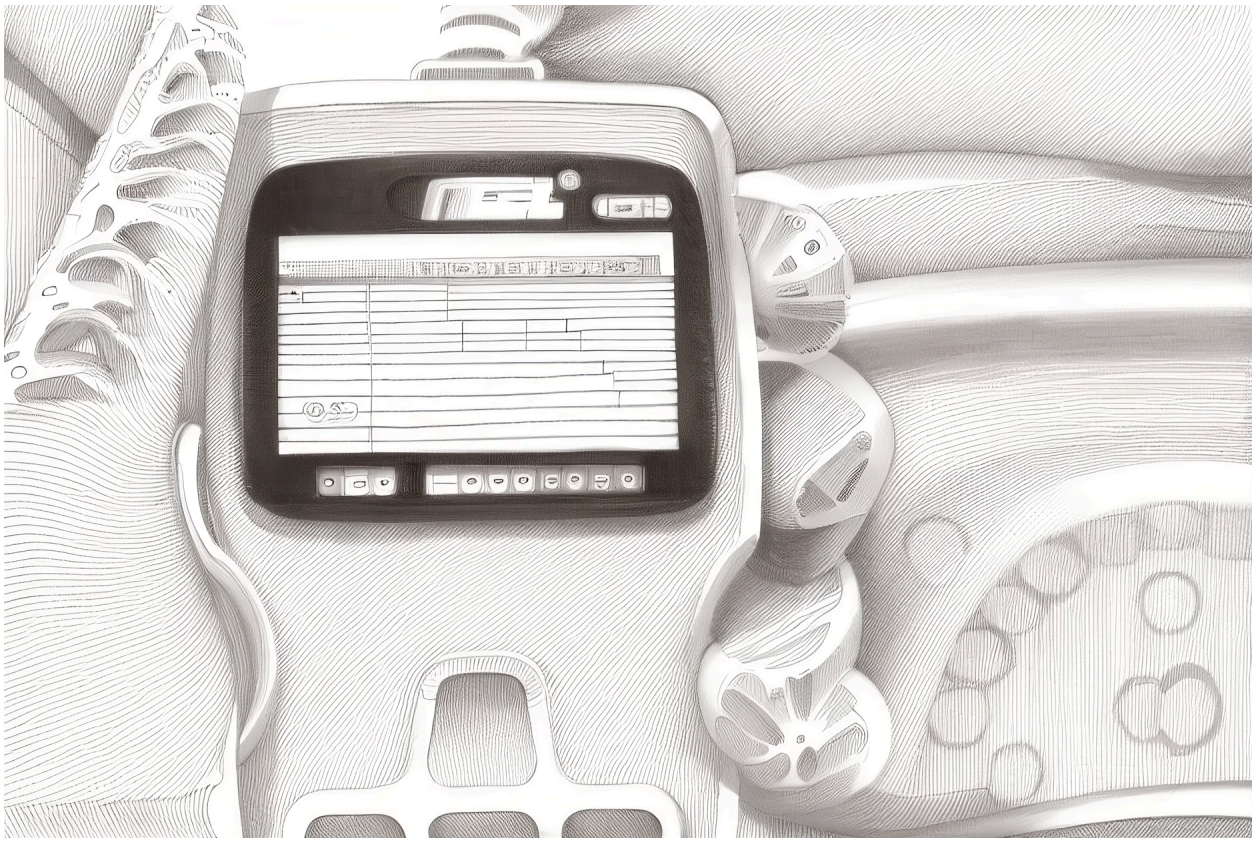
Understanding the different types of scanners available can help you choose the right one for your needs.

This section compares four primary types of scanners and also mentions specialized tools like TPMS tools, key programming devices, brand-specific scanners, and odometer correction tools.

Main 4 OBD2 scanner types:

- Engine code reader
- Bluetooth OBD scanner
- Laptop scanner
- Scan tool

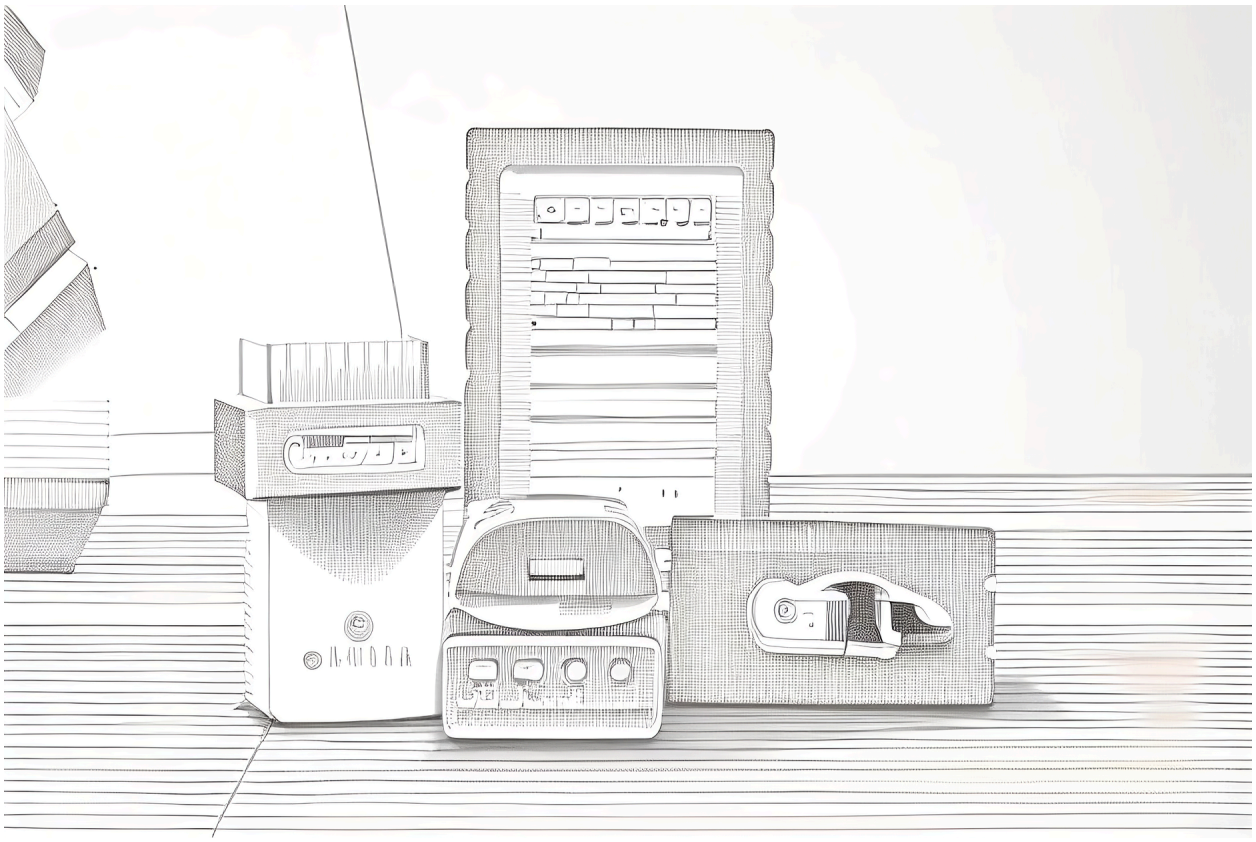
Code reader



A code reader stands out for its ease of use, speed, and affordability, making it a popular choice for basic vehicle diagnostics. It supports all global OBD modes and is compatible with most cars, though it offers primarily basic functionality.

- User-Friendly: Quick and easy to operate.
- Affordable: Cost-effective solution for diagnostics.
- Functionality: Supports all global OBD modes; mainly basic features.
- Advanced Options: Some can perform battery tests and display live data graphs.
- Top Picks: Kingbolen YA200, Launch CR3008.

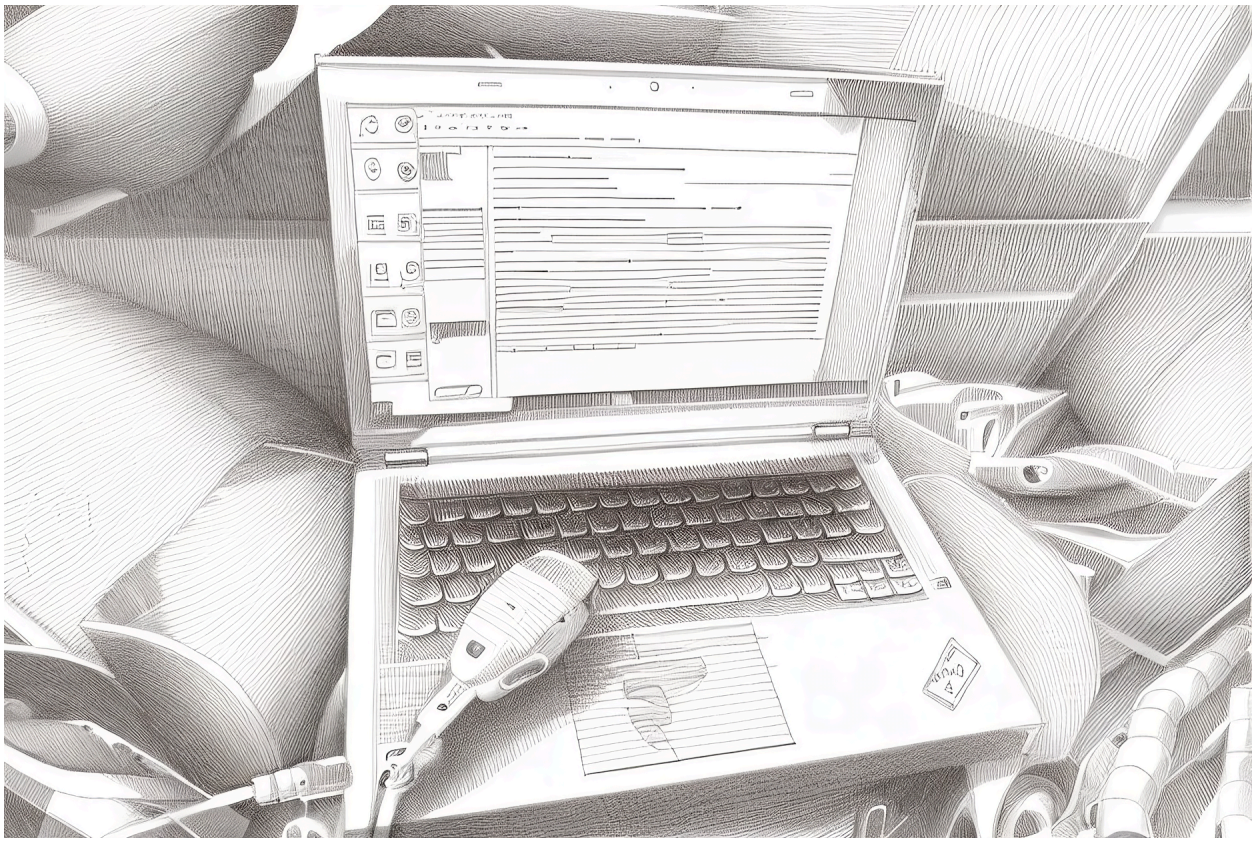
Bluetooth OBD scanner



Bluetooth OBD scanners offer enhanced functionality and convenience for vehicle diagnostics, working effortlessly with smartphones. While they provide more features than standard code readers, they tend to be slower and require careful selection to avoid connectivity issues.

- Portability: Compact and easy to carry.
- Smartphone Compatibility: Operates with various smartphone apps.
- Enhanced Functionality: Offers more features compared to basic code readers.
- Adapter Versatility: One adapter is usable with multiple apps.
- Speed Consideration: Generally slower than traditional code readers.
- Quality of Adapters: Selection is crucial to avoid connection problems.
- Top Adapter Picks: OBDLink and Veepeak.
- Recommended Apps: Car Scanner ELM, Carista, ELM Scan Identifier, DTC-Fix, OBD-Connector.

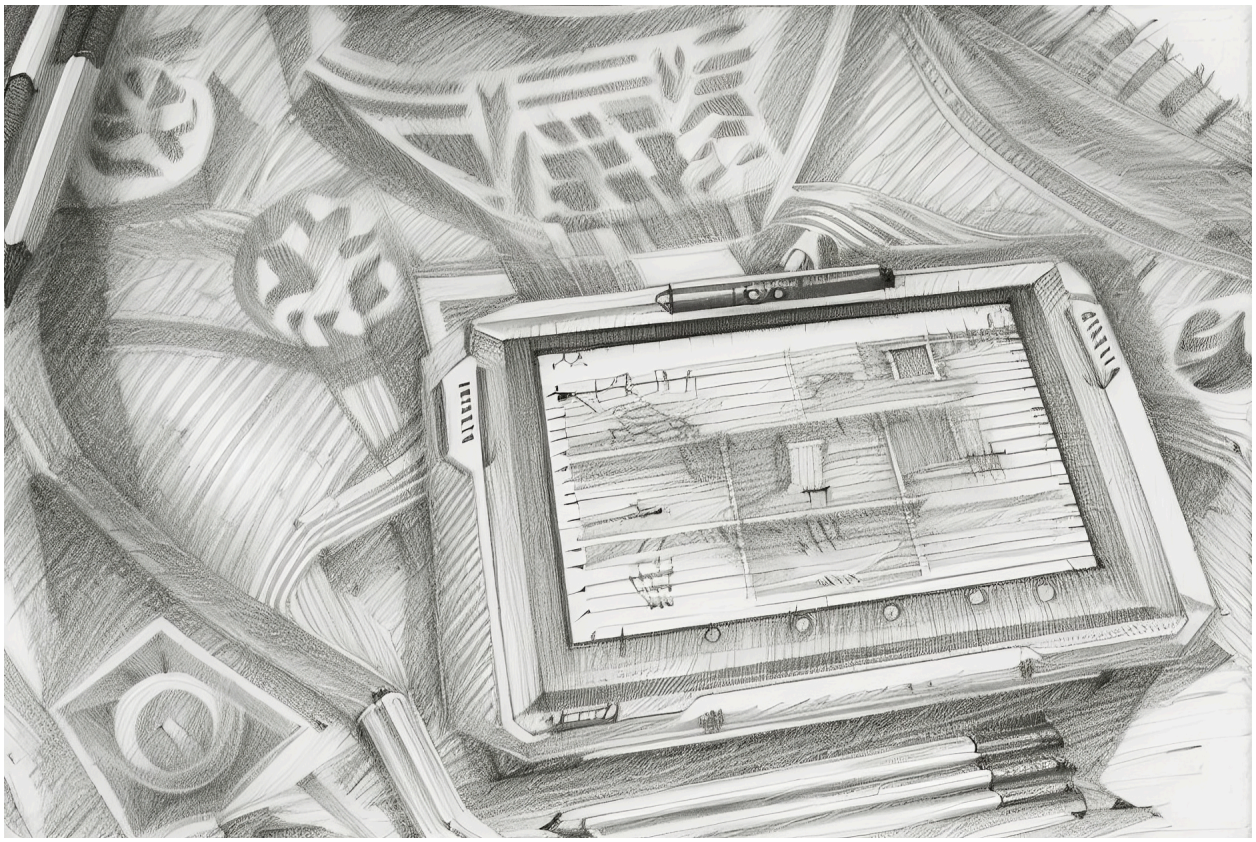
Laptop scanner



Laptop scanners provide a broad spectrum of software options for vehicle diagnostics, including advanced programs and clones of original software. Their versatility is unmatched, but they are less portable and may require a dedicated laptop, preferably refurbished, to avoid damage to personal devices. The best choice depends on the specific car brand, with VCDS and Techstream being notable mentions.

- Software Variety: Access to diverse and advanced diagnostic software.
- Advanced Software Options: Includes clones/copies of original software for in-depth diagnostics.
- Portability: Less convenient to carry compared to handheld devices.
- Dedicated Device Recommended: Advisable to use a separate, possibly refurbished, laptop.
- Brand-Specific Choice: Ideal scanner varies depending on car brand.
- Notable Software: VCDS for VAG Group vehicles, Techstream for Toyota.

Handheld scan tool



Handheld bi-directional scan tools are specifically engineered for vehicle diagnosis, offering speed, advanced features, and extensive vehicle coverage. They combine the convenience of portability with the capability of sophisticated diagnostics.
Purpose-Designed: Exclusively built for in-depth vehicle diagnostics.

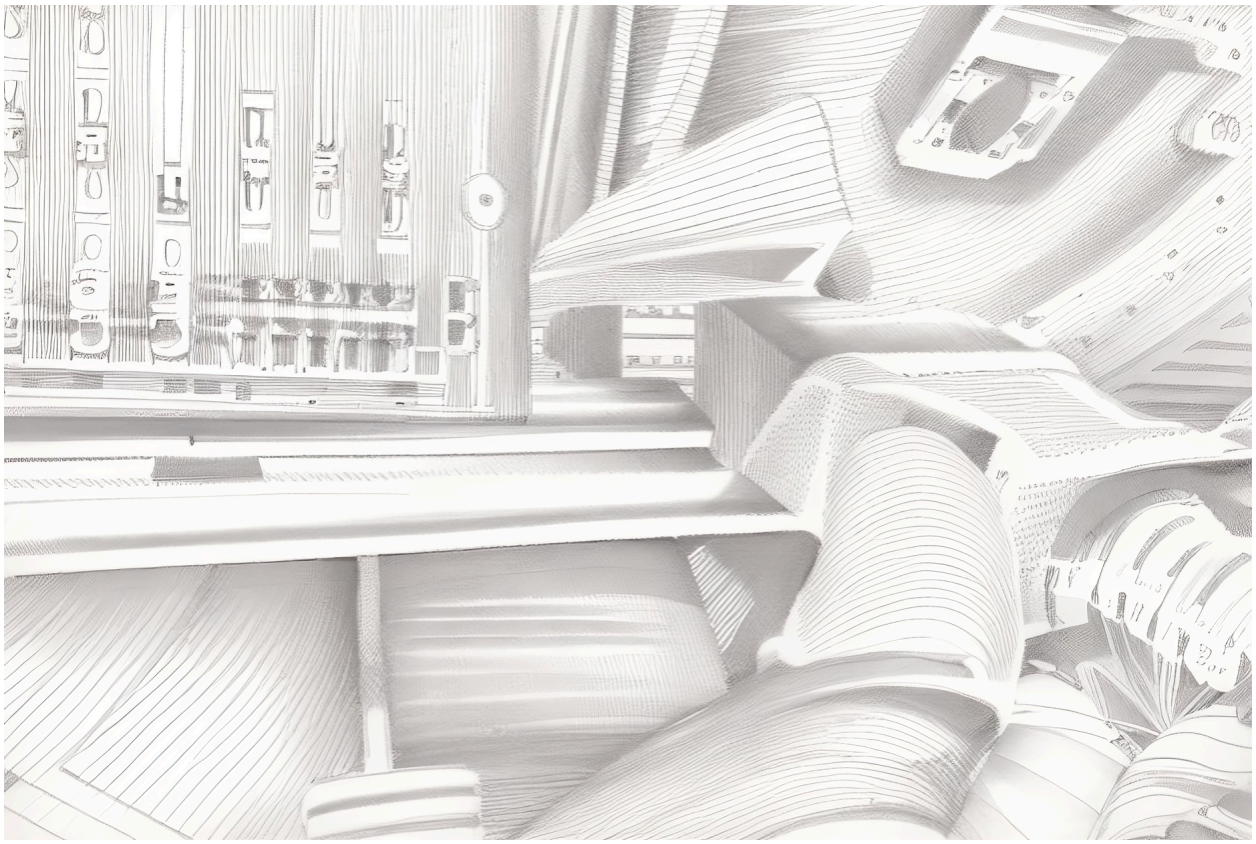
- Speed: Provides quick and efficient scanning.
- Advanced Capabilities: Equipped with high-level diagnostic features.
- Vehicle Compatibility: Offers wide coverage across different vehicle makes and models.
- Top Choice: Topdon Artidiag 900 lite
- Budget-Friendly Option: Thinkdiag2 offers similar features at a lower cost; pairing with a tablet enhances its professional utility.

Other OBD2 scanner types

While the standard OBD2 scanner types cover a broad range of diagnostic needs, there are other specialized tools designed for specific vehicle maintenance tasks. These include TPMS tools, odometer correction devices, brand-specific scanners, and key programmers. Each of these tools caters to a unique aspect of vehicle diagnostics and maintenance.

- TPMS Tool: Specifically designed for managing the Tire Pressure Monitoring System, ensuring proper tire pressure and safety.
- Odometer Correction Tool: Used for correcting or setting the odometer reading, often required in dashboard repair scenarios.
- Brand-Specific OBD Scanner: Tailored to specific car brands, these scanners offer more in-depth diagnostics for particular vehicle models.
- Key Programmer OBD2: Essential for programming new keys or key fobs to the vehicle's OBD system.

How to connect



Location

- Location: The OBD2 port is typically located under the dashboard, near the steering wheel. It can vary slightly depending on the vehicle's make and model.
- If you can’t find it under the dashboard, look in the interior fusebox.

OBD port PINs

- Pins: The port usually has 16 pins, arranged in two rows. Not all pins are used in every vehicle; their configuration depends on the vehicle's make and the communication protocols it supports.

Can You Leave the Scanner Plugged In?

- It's generally safe to leave an OBD2 scanner plugged in for short periods, especially if it's a basic code reader or Bluetooth adapter.

- However, for longer durations or with more complex scanners, it's advisable to unplug it to avoid draining the car's battery or accidentally interfering with the vehicle's normal operation.

Connection Basics

- Ignition ON: Most OBD2 scanners require the vehicle's ignition to be turned on, or in some cases, the engine must be running.
- Secure Connection: Ensure the scanner is securely connected to the OBD2 port. A loose connection can lead to inaccurate readings or communication errors.
- Compatibility Check: Before connecting, verify that your scanner is compatible with your vehicle's make and model to ensure accurate diagnostics.

Using the OBD2 scanner correctly ensures that you get the most accurate diagnostics without causing any unintended issues with your vehicle.

What to do if you can’t connect

Check the OBD2 Port: Look at the back of the OBD2 port under your car's dashboard. If you see no cables connected to it, it means that you have the OBD2 port, but the car is missing the whole OBD2 system. This is an indication that your vehicle does not have the necessary components for OBD2 diagnostics.

Connect an OBD Scanner: You can further verify the absence of the OBD2 system by connecting an OBD scanner or diagnostic tool to the port. If the scanner does not power on or cannot communicate with the vehicle's computer, it's a strong indication that the OBD system is indeed missing.

Connect the scanner to another car: If you have problems connecting, simply take your scanner and try to connect to another car. You will learn if the fault is in the scanner or the car. If the scanner is faulty, contact the seller for a solution.

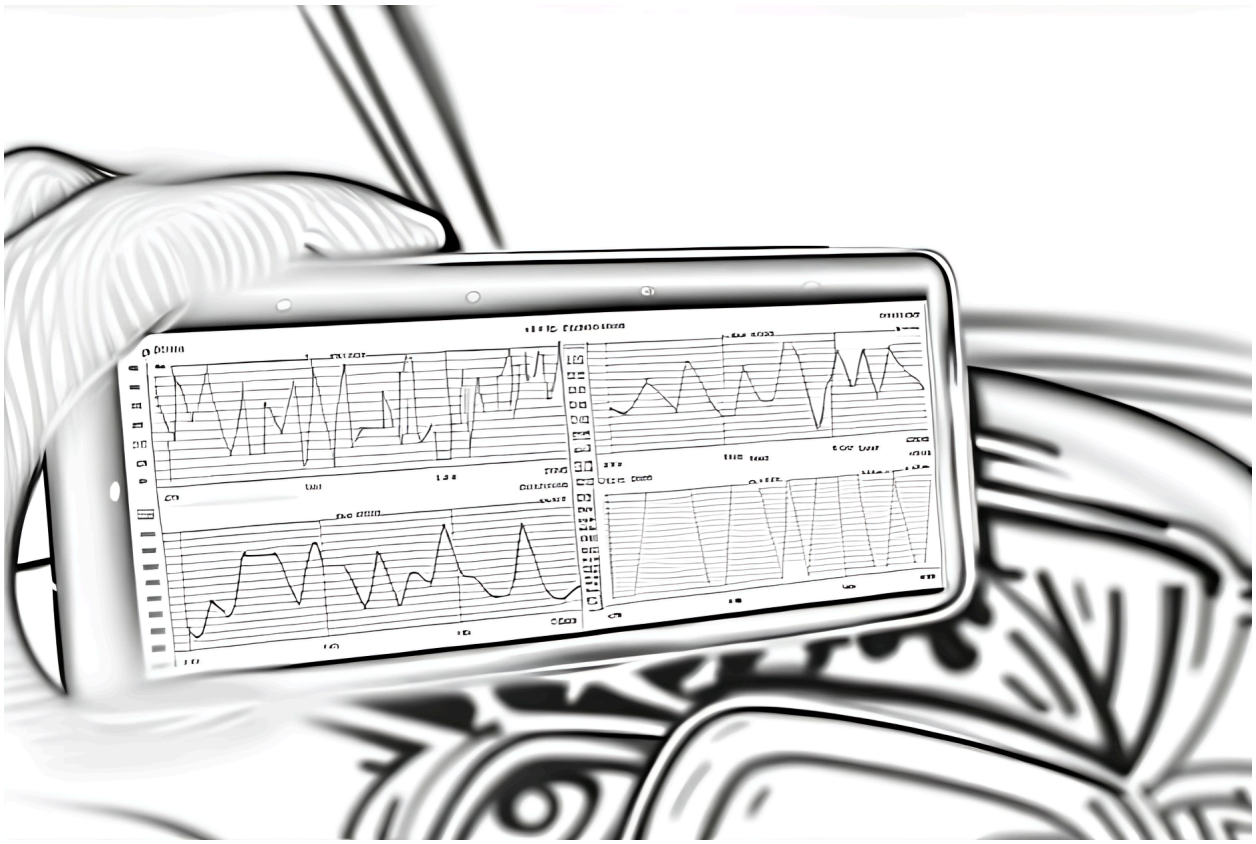
Chapter 3: Global OBD modes

The On-Board Diagnostics (OBD) system in vehicles uses a set of standardized communication protocols and modes for retrieving diagnostic information and performing various tasks. These modes are commonly referred to as OBD Modes, and they serve different purposes in diagnosing and communicating vehicle Information.

The most common OBD Modes are often referred to as "Global OBD Modes," and they are defined by the OBD-II standard, which is the second generation of OBD systems used in most vehicles manufactured after 1996. Here are the ten Global OBD Modes:

- Module 1: Mode $01 - Engine live data
- Module 2: Mode $02 - Freeze frame data
- Module 3: Mode $03 - Read fault codes
- Module 4: Mode $04 - Clear fault codes
- Module 5: Mode $05 - Oxygen sensor test
- Module 6: Mode $06 - Onboard monitoring
- Module 7: Mode $07 - Pending codes
- Module 8: Mode $08 - Component control
- Module 9: Mode $09 - Vehicle information
- Module 10: Mode $0A - Permanent codes

Mode $01 - Engine live data



- Live data explained briefly
- Most important data - fuel trims, oxygen sensor data

Bank 1 vs Bank 2

In vehicles with V-shaped engines, "Bank 1" and "Bank 2" refer to the two sets of cylinders on either side of the engine. Bank 1 is typically the side with Cylinder 1, located closer to the front bumper.

These banks are used for diagnostic purposes, such as identifying issues with oxygen sensors or exhaust systems. In 3 or 4-cylinder engines, and some inline engines, there's only Bank 1.

In contrast, V-shaped engines have both Bank 1 and Bank 2, each associated with its own set of cylinders, sensors, and intake/exhaust systems.

Fuel system status

The Fuel System Status on a scanner shows how your car's engine is using fuel. "CL" means Closed Loop, where the engine adjusts the fuel based on current data, good for a warm engine.

"OL" means Open Loop, used by a cold engine, where the engine uses set information to control fuel.
Cars with V6 or V8 engines often have two fuel systems, each monitored separately. This status helps find problems with fuel use or the engine's oxygen sensors.

- Fuel system 1 = Bank 1
- Fuel system 2 = Bank 2

Fuel trims

Fuel trims are adjustments made by your car's computer to balance the fuel-air mixture in the engine. They ensure the engine runs efficiently and reduce emissions. There are two types: Short Term Fuel Trim (STFT) and Long Term Fuel Trim (LTFT).

STFT adjusts quickly to changes, like sudden acceleration, while LTFT changes over time to keep the engine running smoothly under normal conditions. By looking at these trims, mechanics can figure out if there are issues like air leaks or problems with the fuel system.

Normal fuel trims are in -10% to +10% range. You can calculate your absolute fuel trim by adding both STFT and LTFT. If your STFT is +6% and LTFT +12%, your absolute fuel trim is +18%, meaning you have an issue with your vehicle (fuel trim too high).

Oxygen sensor data (O2)

Oxygen Sensor 1 (upstream sensor) measures the oxygen levels in exhaust gases before they pass through the catalytic converter, helping to control the air-fuel ratio for efficient combustion.

Oxygen Sensor 2 (downstream sensor) checks the efficiency of the catalytic converter by measuring oxygen levels in exhaust gases after they exit the converter.

Some vehicles use Air/Fuel Ratio Sensors instead of Oxygen sensors to provide more precise data on the air-fuel mixture, enabling finer adjustments for optimal engine performance and reduced emissions. These sensors play a crucial role in maintaining your vehicle's fuel efficiency and emission standards.

Manifold absolute pressure (MAP)

The Manifold Absolute Pressure (MAP) sensor is key to managing your car's engine. It measures pressure inside the intake manifold, telling the Engine Control Module (ECM) or Engine Control Unit (ECU) about the engine's load.

This helps in adjusting fuel injection and ignition timing for better performance and fuel efficiency. When using a scan tool, you can see the MAP sensor's data, including its voltage (representing pressure or vacuum level) and calculated engine load, shown as a percentage. This data is crucial for ensuring optimal engine operation.

Engine Load

Engine load on a scan tool is a data parameter that shows how hard your engine is working. It's usually displayed as a percentage. A high engine load indicates heavy throttle usage, like when accelerating quickly.

A low engine load means light throttle or idling, like when the car is stopped. This information is helpful for understanding the demands being placed on your engine at any given time, which can assist in diagnosing performance issues or optimizing fuel efficiency.

Mass airflow (MAF)

The Mass Airflow (MAF) sensor measures the amount of air entering the engine. This information is crucial for the Engine Control Unit (ECU) to balance the air-fuel mixture accurately, ensuring optimal engine performance and fuel efficiency.

The MAF sensor helps in adjusting fuel injection based on the air intake, which is essential for smooth engine operation and reducing emissions. Understanding the MAF sensor readings can assist in diagnosing issues related to air intake, such as air leaks or clogged air filters.

Intake air temperature

The Intake Air Temperature (IAT) sensor measures the temperature of the air entering the engine. This temperature reading helps the Engine Control Unit (ECU) adjust the air-fuel mixture and ignition timing.

Cold air is denser and requires more fuel for optimal combustion, while hot air, being less dense, requires less fuel. Accurate IAT readings are vital for efficient engine performance, reducing emissions, and preventing issues like engine knocking. It's

especially important in turbocharged engines where air temperature can vary significantly after being compressed.

Throttle position

The Throttle Position Sensor (TPS) measures how far the throttle valve is open, indicating how much air is entering the engine. This information helps the Engine Control Unit (ECU) to adjust the fuel injection and ignition timing.

A correct reading from the TPS is essential for smooth acceleration and overall engine performance. It's particularly useful in diagnosing issues like erratic idling, stalling, or hesitation during acceleration, as these can be signs of a malfunctioning TPS.

Alternator voltage

The alternator voltage reading on a scan tool indicates the charging system's health, usually showing how much voltage the alternator is sending to the battery. It's essential to ensure the battery is charged properly and the electrical systems are functioning well.

Normal readings typically range around 13.5 to 14.5 volts. If the voltage is too low or too high, it could signal a problem with the alternator or the vehicle's electrical system, potentially affecting battery life and the reliability of electrical components.

Battery voltage

Battery voltage reading on a scan tool shows the electrical charge level of the car's battery. It's crucial to ensure the battery is functioning properly. A normal battery voltage when the engine is off should be around 12.6 volts.

If the engine is running, the alternator should charge the battery above this level, typically between 13.7 to 14.7 volts. Low voltage might indicate a failing battery or charging system issues, while unusually high voltage could suggest a problem with the voltage regulator or electrical system.

Catalyst temperature

Catalyst temperature readings on a scan tool indicate the temperature of the catalytic converter, a critical component in reducing exhaust emissions. This temperature is monitored to ensure the converter is operating within its optimal range for effectively processing exhaust gases.

Too low a temperature may mean the converter isn't working efficiently, while an excessively high temperature can signal potential issues like clogged exhaust systems or engine misfires. The proper functioning of the catalytic converter is essential for maintaining the vehicle's emission standards and overall engine health.

EGR data

EGR (Exhaust Gas Recirculation) data on a scan tool refers to information related to the EGR system, which reduces nitrogen oxide emissions by recirculating a portion of the exhaust gas back into the engine cylinders.

This data helps in monitoring the EGR valve's operation and the flow of exhaust gases. The proper functioning of the EGR system is vital for emission control and engine efficiency. Issues with EGR data can indicate problems such as clogged EGR passages or a malfunctioning EGR valve, affecting the vehicle's emissions and performance.

Engine coolant temperature

The Engine Coolant Temperature (ECT) sensor measures the temperature of the coolant in the engine. This information is crucial for the Engine Control Unit (ECU) to manage engine functions such as fuel injection and ignition timing.

Proper ECT readings ensure optimal engine performance and efficiency. Abnormal temperatures can indicate issues like cooling system problems or engine overheating, which need prompt attention to prevent engine damage.

Engine oil temperature

The Engine Oil Temperature sensor provides the temperature of the oil in the engine. This is vital for understanding the engine's operating condition. Proper oil temperature ensures efficient lubrication and cooling of engine components.

Too high a temperature can indicate oil breakdown or engine overheating, while too low a temperature might suggest insufficient engine warming. Monitoring this temperature helps in maintaining engine health and preventing potential damage.

Malfunction indicator lamp

The MIL (Malfunction Indicator Lamp), commonly known as the "Check Engine" light, is a warning signal on the vehicle's dashboard. It illuminates when the Engine Control Unit (ECU) detects a problem that may affect the vehicle's emissions, performance, or safety. This lamp helps alert the driver to potential issues that require diagnostic

attention. The specific cause for the MIL being on can be determined by using an OBD scanner to read the diagnostic trouble codes stored in the ECU.

Vehicle speed

The vehicle speed reading on a scan tool shows how fast the vehicle is moving. It's measured by the vehicle speed sensor, which is important for functions like the speedometer, transmission shifting, and engine control.

Knowing the vehicle speed helps in diagnosing issues with the speedometer or transmission, and it's also useful for checking the accuracy of the speed sensor against the speedometer reading. Accurate speed data is crucial for safe and efficient vehicle operation.

Mode $02 - Freeze frame data

When you get a trouble code, you will also get some freeze frame data for that code. The freeze frame is something like a black box for each code. You get some live data values saved from the time the code was stored.

Example: Engine Overheating

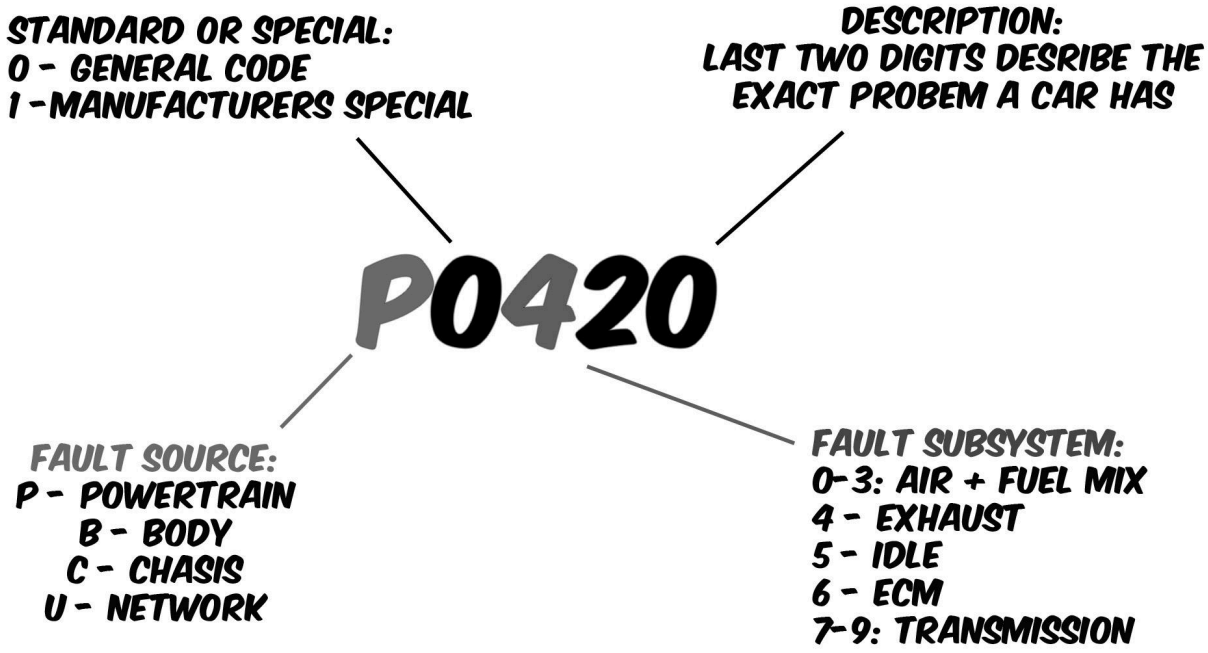
Fault Code: P0128 - Coolant Thermostat (Coolant Temperature Below Thermostat Regulating Temperature)
Coolant Temperature: 65.6°C - Below normal operating range, indicating the engine isn't reaching the desired temperature.
Ambient Air Temperature: 15.6°C - Moderate outside temperature.
Vehicle Speed: 30 mph - Light driving conditions.
Engine Speed: 1500 RPM - Consistent with light driving.
Engine Runtime: 20 minutes - Enough time for the engine to reach normal operating temperature.

Diagnosis and Solution: The low coolant temperature despite a sufficient warm-up time suggests a thermostat stuck open, preventing the engine from reaching and maintaining the optimal operating temperature. Replacing the thermostat typically solves this issue.

Mode $03 - Read fault codes

The most basic function of OBD2 scanners is reading fault codes. There are thousands of different OBD2 codes, and each of them is triggered if some test fails. These codes are not just random numbers and you can get a lot of insights from general rules that apply to all codes. First of all, there are different types of OBD2 Codes:

- Confirmed codes are serious and continuously active.
- Pending codes are triggered after a certain number of faults.
- Permanent codes can't be cleared with a scan tool.
- Current codes show a failed test in the current cycle.
- Historical codes show a failed test since the last clearing of codes.



How to decode OBD2 codes?

They are usually 5-digit/letter codes. For example, the P0420 or C0036.

- P – Powertrain codes. You will see these most common codes when scanning vehicles for faults. Powertrain DTCs are faults with the engine and transmission.
- B – Body codes. This can be seatbelt or airbag faults, for example.
- C – Chassis codes. Systems like suspension, steering, or brakes.
- U – Network codes. Car systems and computers fail to communicate with each other.

Manufacturer vs. Generic code

The second digit in the OBD code will tell you if the code is specific to one car brand or if it applies to all cars.

- 0, 2, 3 is a generic code. This code is the same for every car brand
- 1 is a special manufacturer code.

The third digit identifies a subsystem in which the malfunction happened. (applies to Powertrain codes)

● 0, 1, and 2: Fuel + Air mixture.
● 3: Ignition system.
● 4: Exhaust / Emissions.
● 5: Vehicle speed / Idle.
● 6: ECM.
● 7, 8, and 9: Transmission.
● A, B, and C: Hybrid drive.
The last two digits complete the description of the fault.

5-digit vs. 7-digit codes

You can also come across 7-digit DTCs where the first 5 digits are the same, but the last 2 digits provide an extra code specification.
Sometimes your code reader will show an extra two zeros at the end. So the code P0420 is the same as code P042000.
However, the last 2 digits in the 7-digit code can further specify the problem.

Last 2-digits of 7-digit codes (P0000XX), the XX meanings

00 = Not specified
04 = Open
11 = Short to ground
12 = Short to B+
13 = Open
14 = Short to the ground or open
15 = Short to B+
16 = Circuit voltage below the threshold
17 = Circuit voltage above the threshold
18 = Current below the threshold
31 = No signal
44 = Data memory failure
47 = Controller failure
49 = Internal electronic failure
51 = Not programmed
62 = Signal comparison failure
64 = Plausibility failure
72 = Actuator stuck closed
74 = Actuator slipping

77 = Commanded position not achievable
7E = Actuator stuck on
1A = Circuit resistance below the threshold
1C = Voltage out of range
1D = Current out of range
23 = Signal stuck low
24 = Signal stuck high
27 = Single rate of change above a threshold
29 = Performance signal invalid
2A = Stuck in range
2B = Signal cross-coupled
2F = Signal erratic
7F = Actuator stuck off
85 = Signal above the allowable range
87 = Missing communication message
93 = Performance no operation
96 = Component internal failure
9C = Low insuffi cient flow
9E = Stuck on

OBD2 codes lists

A list of generic OBD2 codes with explanations can be found on my website:
https://www.iamcarhacker.com/car-scanner-codes/

Mode $04 - Clear fault codes

Not all the codes can be erased. Permanent codes can be reset only by repairing the issue. For example, the seatbelt airbag wiring is open and you have the Airbag light ON with a permanent code. You will not be able to erase this code with a scanner, you must repair the wiring or issue casing the code, and it will disappear by itself.

Before you erase codes

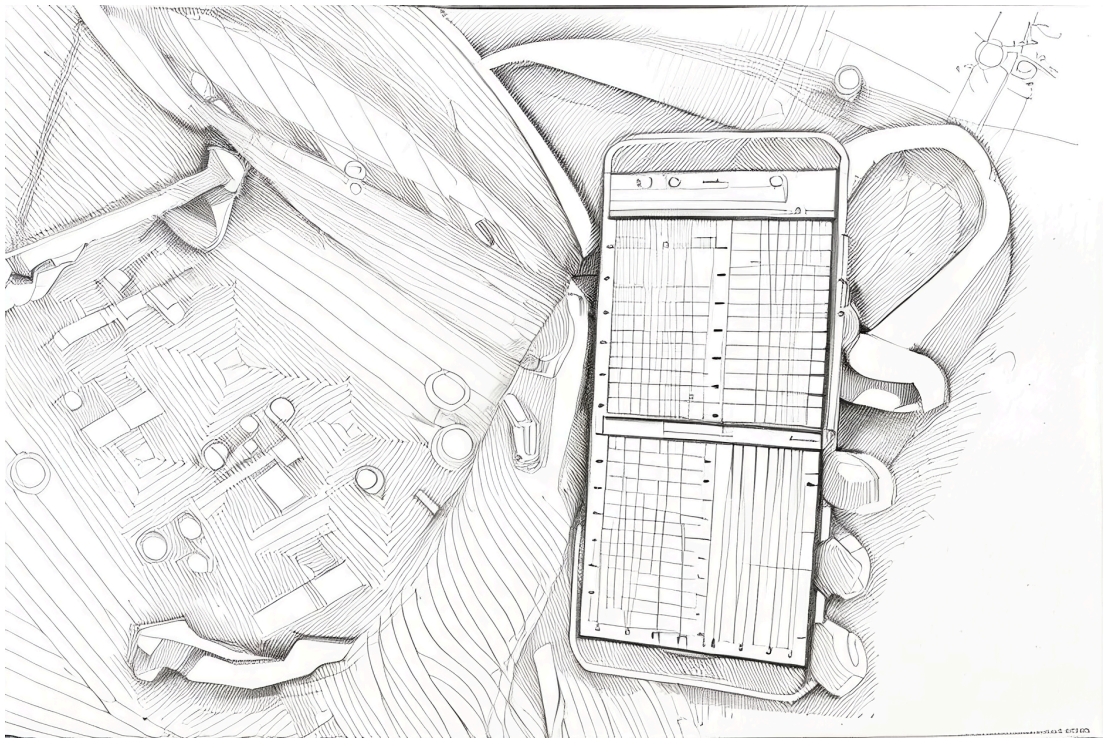
You will lose a lot of stored information when you erased codes. With code deletion, you are also getting rid of your freeze frame data (mode $02), and resetting monitors that keep an eye on your emission-related systems (mode $06).

Make sure you take a screenshot of these modes before erasing codes. You never know when you will need it to diagnose your problem.

Why should you erase codes?

Once you make sure, the code isn't permanent and can be erased and you save all the related information, you can delete DTCs from OBD2 memory. After driving your vehicle, you will see if the problem comes back. Sometimes you can get a random fault code and it will never appear again after you delete it for the first time.

Mode $05 - Oxygen sensor test



The O2 sensor test option is for vehicles without a Canbus system (usually older than 2008). It will show different test options like switching between rich/lean or checking minimum and maximum output voltage. Each test will also state the result of passing/not passing.

You can do an O2 sensor test for both sensors, however, that isn't that much help since the trouble code with the check engine light should be set anyway when these values get out of range.

Purpose of Mode 05: The O2 sensor test is used to access information related to the monitoring and testing of oxygen sensors (O2 sensors) in the vehicle's exhaust system.

Oxygen Sensor Monitoring: Oxygen sensors are crucial for measuring the amount of oxygen in the exhaust gasses. They help the engine control module (ECM) adjust the air-fuel mixture for optimal engine performance and emissions control.

When you access Mode 05 on a scan tool, you can retrieve

specific data related to the status and performance of the oxygen sensors. This data may include:

● Oxygen sensor test results (e.g., whether tests have passed or failed).
● Oxygen sensor readiness status (whether the sensors are ready to monitor exhaust gasses).
● Oxygen sensor monitoring conditions (information about when and how the sensors are tested).

Using Mode 05: You can use Mode 05 to check the status of the oxygen sensors and related components. It's particularly useful when diagnosing emissions-related issues or verifying the readiness of the vehicle for emissions Testing.

Interpreting Mode 05 Data: Interpretation of Mode 05 data requires an understanding of the specific codes and values returned by the scan tool. However if the data is out of range, it will set a code for a faulty O2 sensor so just check your trouble codes or live data if the sensor is switching between lean/rich.

Completing OBD-II Emissions Testing: In many regions, vehicles must pass OBD-II emissions tests as part of the inspection process. Mode 05 data can be used to confirm that the vehicle's oxygen sensors and related emissions components are operating as expected

Mode $06 - Onboard monitoring

OBD2 readiness monitors (continuous/non-continuous) run their test either continuously throughout the drive or just once per drive cycle (trip). After special conditions to run tests are met, each monitor is evaluated as “complete/OK” or “incomplete/not OK”. Monitors that are not present in the vehicle will display N/A (not available).

When you erase fault codes, all monitors are reset and need to be evaluated by completing the drive cycle. There are specific conditions, just driving as you like is not enough.

Continuous Monitors

Misfire
Ignition
Comprehensive component (sensors)

Non-Continious Monitors

Catalyst efficiency
Heated catalyst
EGR system
EVAP system
Heated Oxygen sensor
Secondary air injection
A/C, PCV, Thermostat (NEW)

Continuous Monitors

Continuous monitors are the most important ones and their primary function is to protect your catalytic converter from failure. Now you might ask why the catalyst efficiency monitor is non-continuous and the answer is very simple.
It measures the efficiency of your CAT, which can be helpful when you are diagnosing your catalytic converter. But even if it measures inefficient values, the damage to the cat has been already done and this is just reporting it. Unburned fuel or oil is usually a common destroyer of converters, that's why misfire and fuel system monitors need to be watched more frequently than non-continuous monitors.

Non-Continuous Monitors

Little less important monitors as they don't have the same effect of negatively impacting the vehicle's emissions if something is wrong. They also have more criteria to enable the test and run less occasionally than continuous monitors: usually a once for the trip if conditions for tests are met.

Monitors after deleting codes

All monitors show incomplete because I just erased the codes which also reset the monitors. These monitors run their test by driving procedure called a "drive cycle". A couple of days of driving will usually run all the monitors, but if you are in a hurry, knowing the drive cycle procedure can help you with running them faster.

Run monitors for emission inspection

As I already mentioned, checking these monitors can be part of your state emission check. They do this, especially in the US and you can only have 1 or 2 monitors

marked as incomplete to pass the inspection. (1 or 2 depending on the state).

Don’t forget that if you recently cleared the fault codes, your monitor will be incomplete resulting in a failed inspection. To run the monitors as fast as possible, try performing a general OBD drive cycle.

OBD drive cycle

Every car brand has its own drive cycle, but this is the general one that should work in most cases.

1. Start and idle until the coolant temperature reaches 160°F/71°C
2. Accelerate to 40-55 MpH/ 65-88 KmH
3. Maintain steady speed with 25% throttle for 5 minutes
4. Decelerate to 20 MpH/ 32 KmH or less WITHOUT using the brake, then stop the vehicle
5. Let the engine idle for 10 sec, turn the key off, and wait 1 minute
6. Restart, accelerate to 40-55 MpH/ 65-88 KmH
7. Maintain this speed for 2 minutes at 25% throttle
8. Decelerate to 20 MpH/ 32 KmH or less BY using brake/downshifting
9. Let the engine idle for 10 sec, turn the key off, and wait 1 minute

You also want to have around 50-75% fuel in your tank and have the alternator and battery in great condition. If you are successful with your drive, all your monitors should be passed (if all systems are OK)

Mode $07 - Pending codes

The pending codes are a bit different. It's only triggered if the fault is detected a certain number of times in a certain number of drive cycles. The number of recurrences and drive cycles can vary depending on the fault.

For example, the vehicle PCM (powertrain control module) knows that if the rear oxygen sensor output gets out of optimal range 2 times, the code for the oxygen sensor must be set.

The first time it happens, the check engine light is not illuminated yet, because the condition happened only 1 out of 2 times required to confirm the code. Now it is just a pending code.

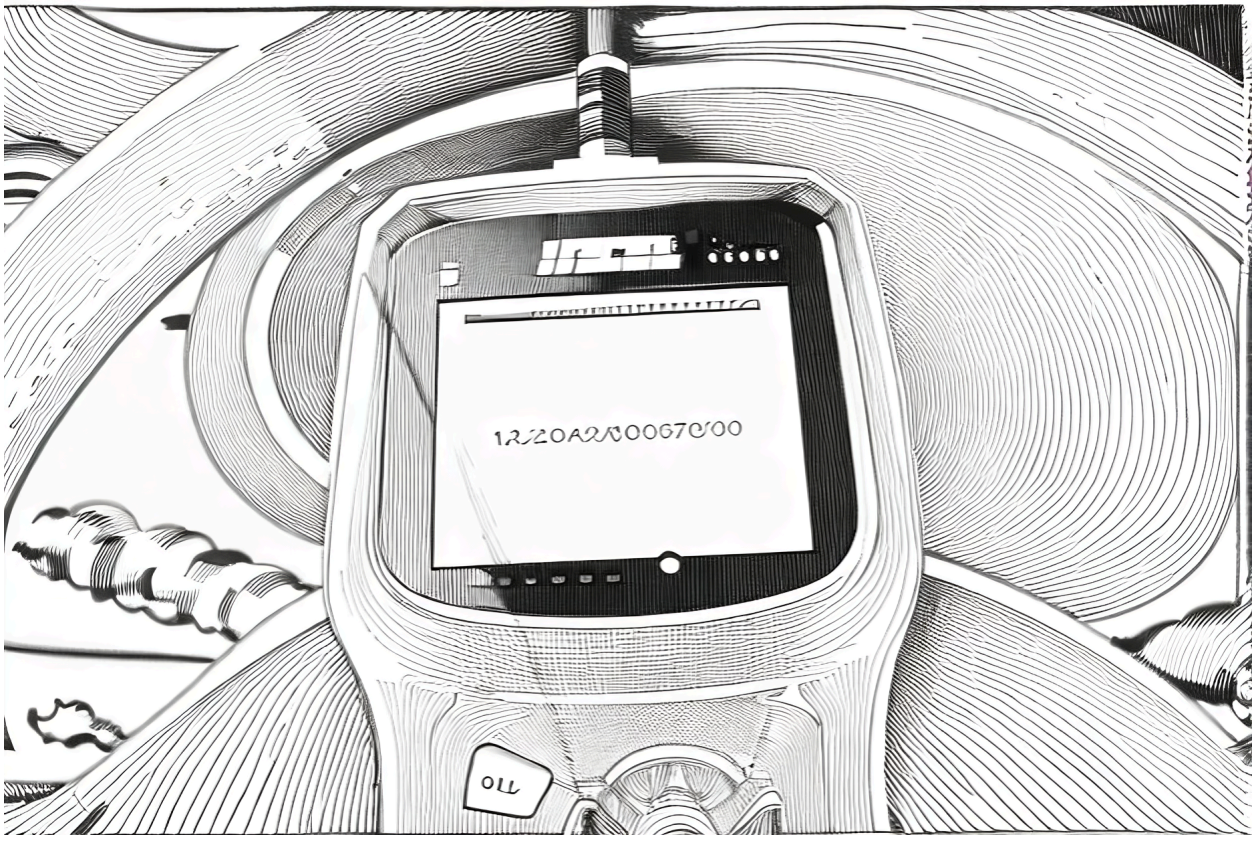
Once the sensor output voltage is out of the limit for a second time, the code is now confirmed, and the check engine light will illuminate

Mode $08 - Component control

If you are familiar with OBD2 scanner functions, you may know the Bi-Directional function that can test various components in the car just by command on the scanner. You can test the engine cooling fan, relays, solenoids, and hundreds of other components with your scanner.

The Mode $08 is the same, however, the only test available in global OBD is fully closing the EVAP system. This can be used to find EVAP leaks with the smoke machine. You need to seal the system first and you can do it by command from the scanner. This won't be supported on all vehicles.

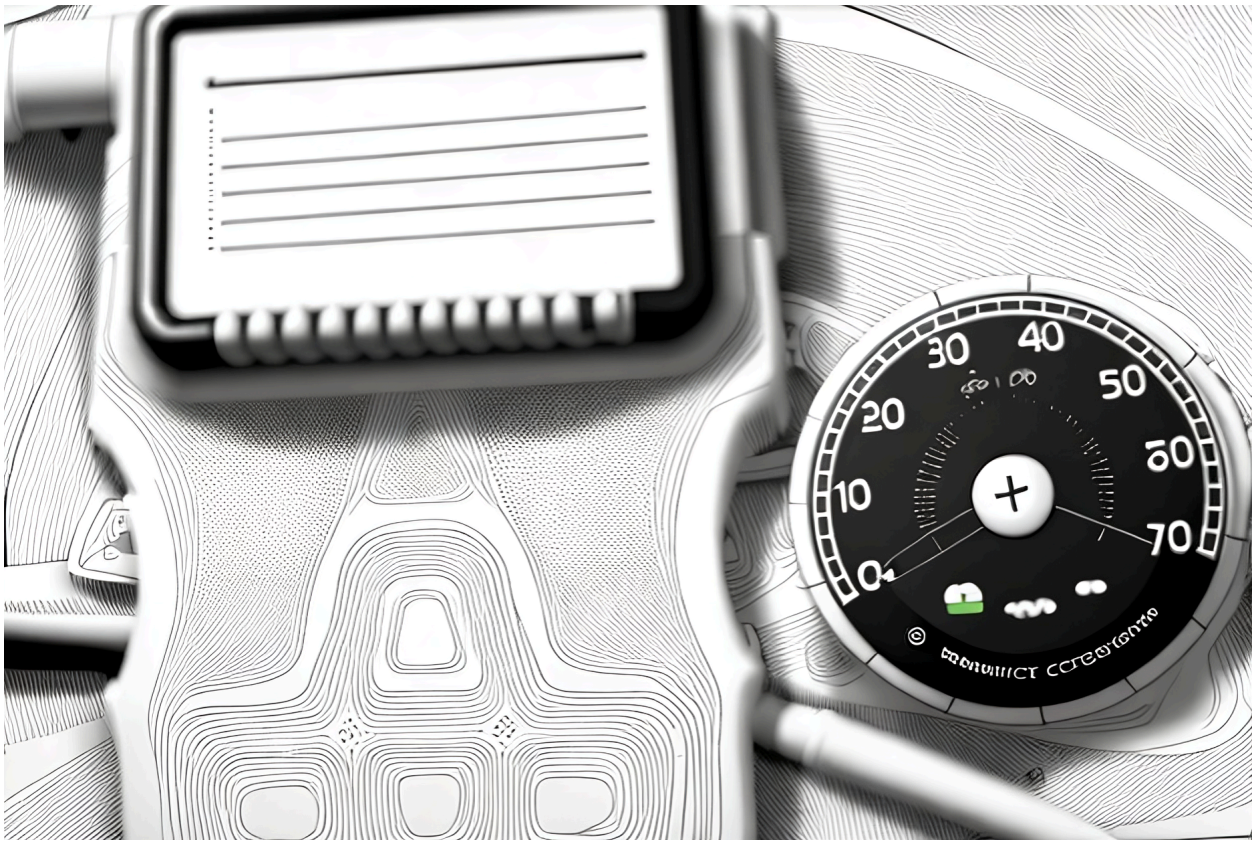
Mode $09 - Vehicle information



Vehicle information like VIN number. If you are diagnosing more complex issues that could possibly be caused by PCM, compare the VIN from the OBD2 scanner to the VIN found on your vehicle’s frame. If it is different, the PCM/ECU was swapped for the used one, which can help you solve the issue.

Vehicle information like VIN number. If you are diagnosing more complex issues that could possibly be caused by PCM, compare the VIN from the OBD2 scanner to the VIN found on your vehicle’s frame. If it is different, the PCM/ECU was swapped for the used one, which can help you solve the issue.

Mode $0A - Permanent codes



Mode $0A (mode 10) is reading permanent fault codes from your car. These permanent codes cannot be erased with any scan tool/battery reset. The only way to get rid of it is to repair the part that is causing the issue.

A common problem causing permanent codes is damaged wiring. If the wire for some sensor gets damaged, there is a permanent fault unless the circuit is repaired. You can’t erase permanent codes with any scan tool!

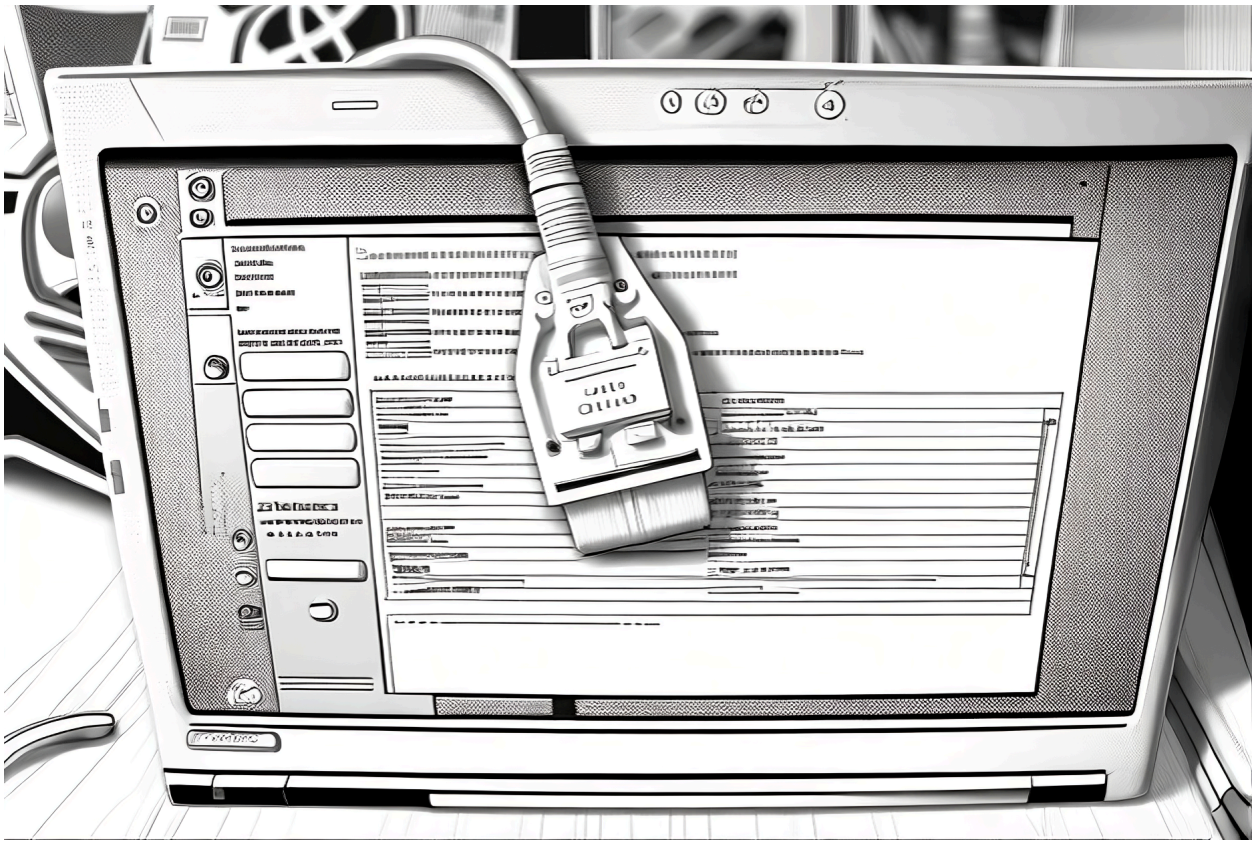
Chapter 4: Advanced OBD2 scanner features

Now that you've got a handle on global OBD modes and their role in identifying vehicle issues, you're all set for more advanced learning. The next section of our eBook will guide you through the advanced features of OBD scanners.

We'll cover how to send commands directly to your vehicle, unlock new features through ECU coding, and analyze complex car data. These enhanced techniques will equip you with the knowledge to tackle more sophisticated diagnostic challenges.

Warning: Be careful when playing around on scan tools with these functions. While the Global OBD modes cannot do any harm, these ones can be dangerous to your vehicle in rare situations. Make sure you follow all safety precautions.

Full live data

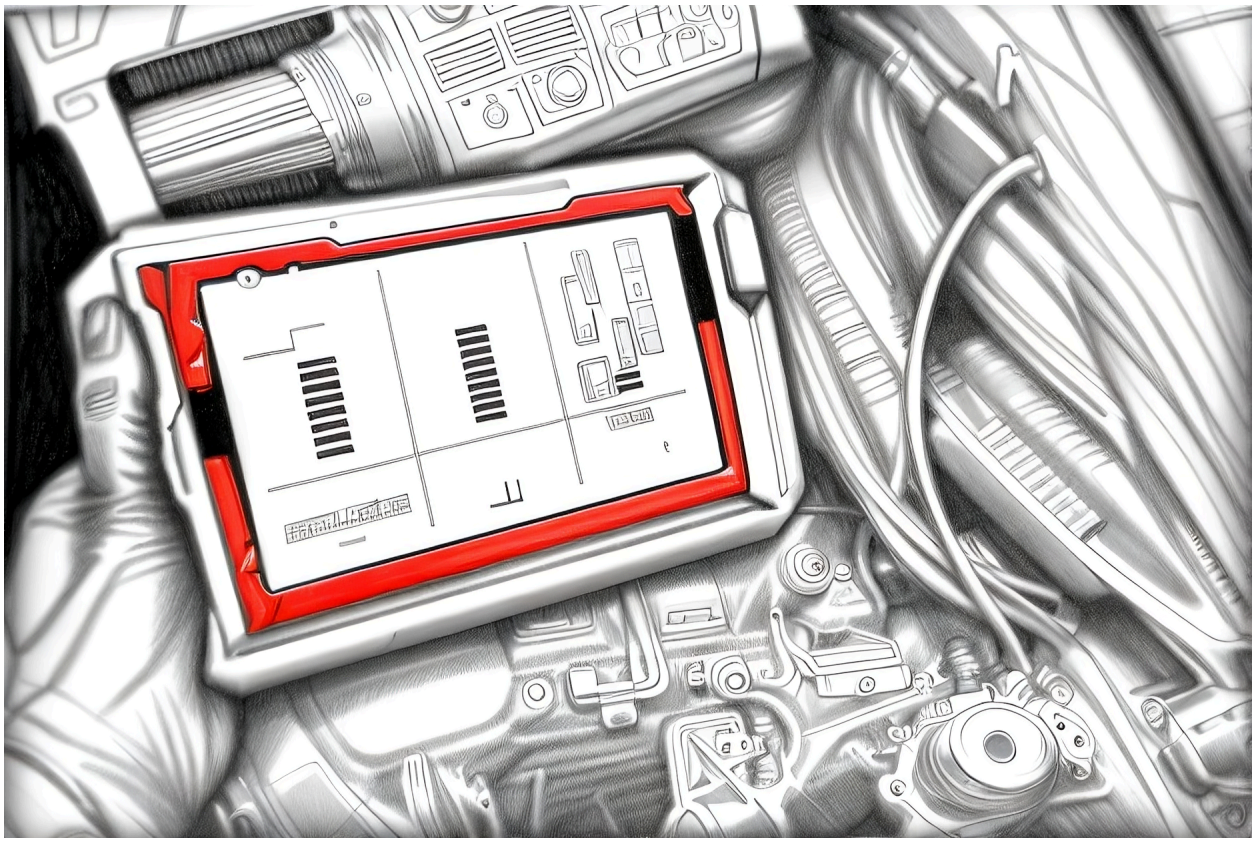


Advanced scan tools take checking cars to the next level with full live data. Unlike basic tools that just show simple engine info, these advanced tools let you see live details from every part of the car. This means you can watch live info from the gearbox, brakes, airbags, and more, all in real time. For example, you can see if the gearbox is shifting gears properly, or if the brakes are working as they should.

This is really useful because it helps you spot problems quickly. Like, if a car's brakes are acting up, full live data can show you if it's because of the ABS system. Or, if the airbag light is on, this tool can tell you exactly what's wrong. By seeing all this detailed info as it happens, you can figure out car problems more accurately and fix them faster.

Full live data can be found in Bi-directional scan tools, laptop OBD2 software, and in the few best Bluetooth scanners like Thinkdiag2.

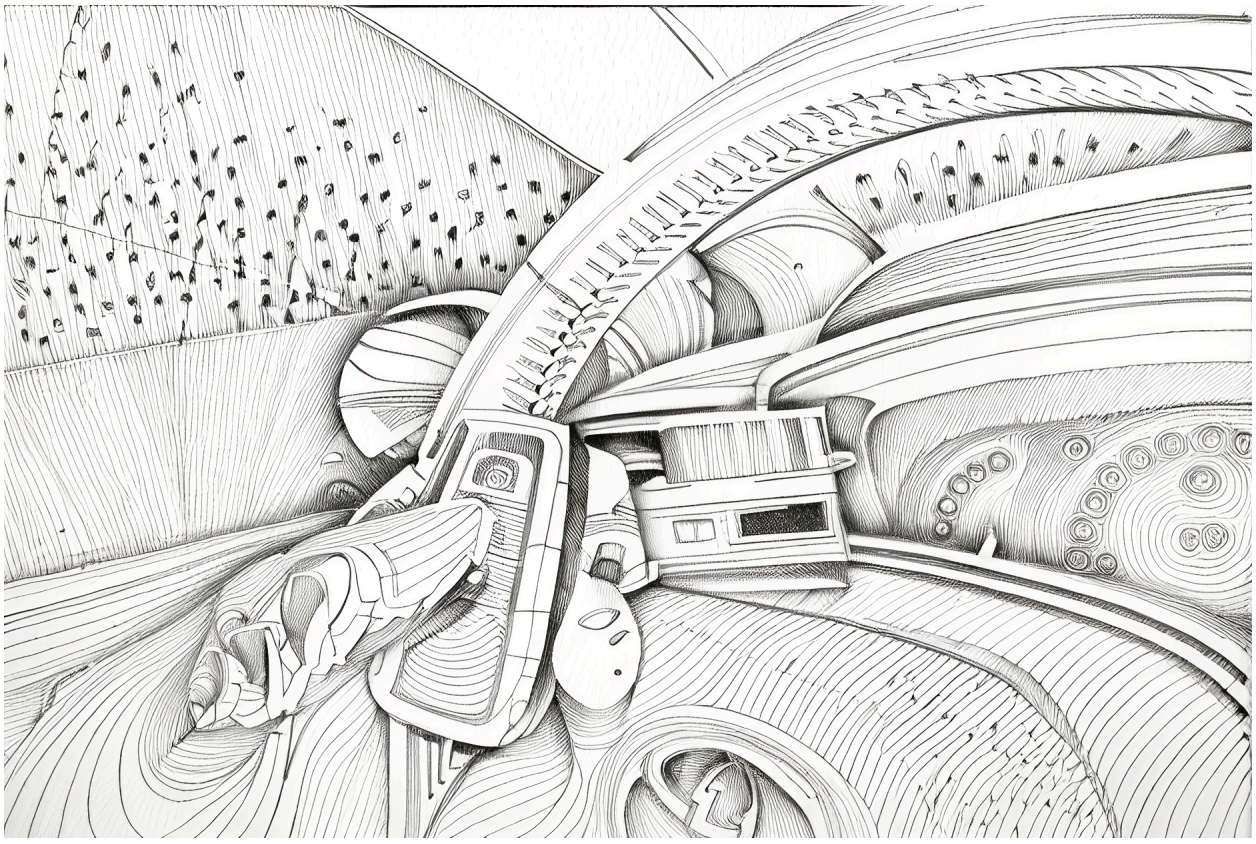
Bi-Directional Control



Bi-directional testing is another cool feature of advanced scan tools. It's like having a conversation with your car. Instead of just reading info from the car, you can also send commands to it. This helps you test different parts without physically touching them. For example, you can tell the fuel pump to turn on and off or make the cooling fans spin. This is super helpful for checking if things are working right.

Let's say your car's window isn't rolling up. With bi-directional testing, you can send a command to see if the problem is with the control system or the window motor itself. It saves a lot of time because you can check these things directly from the tool, without needing to take apart your car to test each part.

Service procedures

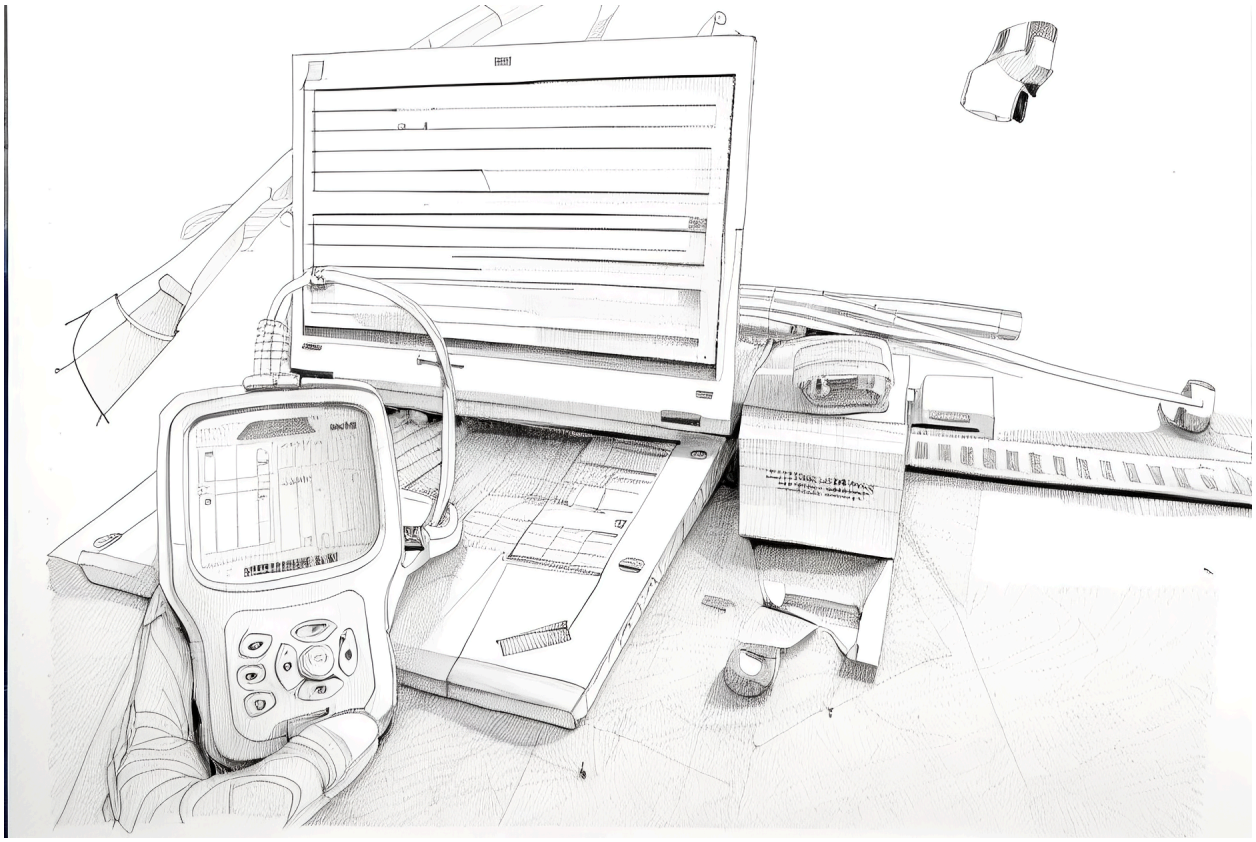


Service procedures on advanced scan tools are like having a mechanic's toolbox inside your scanner. These tools can do special jobs that keep your car running smoothly. For example, there's DPF regeneration, which cleans out the Diesel Particulate Filter in diesel cars.

Without this, the filter can get blocked and cause problems. Another handy feature is the EPB (Electronic Parking Brake) reset. After you work on the brakes, this resets the parking brake system so it works correctly.

There are lots of other things these tools can do, too, like resetting the oil service light, programming new keys, or even recalibrating the steering angle sensor. These procedures make maintenance tasks easier and faster because you can do them right from the scan tool without needing to go to a garage.

ECU coding/ECU programming



ECU coding and ECU programming are 2 different things on the scan tool and in this guide, I will only talk how to use the ECU coding. Before we get into that, we will briefly learn what is ECU programming, although this isn’t part of the features, that you should be learning about as a beginner.

What is ECU programming

ECU programming is a bit like updating the software on your phone or computer, but it's for your car's 'brain', known as the Engine Control Unit (ECU). The ECU manages lots of important functions in your car, like how much fuel gets injected and when the spark plugs fire.

By reprogramming or 'flashing' the ECU, you can update the software to improve performance, fix issues, or even add new features. For example, a software update might make your car more fuel-efficient or give it more power. Sometimes, ECU programming is needed after replacing parts in the car, so everything works together

properly. It's a powerful tool, but it has to be done right – using the wrong software or making a mistake can cause big problems with how your car runs.

What is ECU coding?

ECU coding is adjusting the hidden car settings like disabling seatbelt alarms or adding the coming/leaving home function. Every car model has different settings (some can have none) and the availability of coding features depends on the vehicle's brand, model, and production year.

German car brands like Volkswagen, Audi, BMW, and others typically offer more coding possibilities, while Asian and American cars may have fewer options

ECU coding example uses

1. Disable Annoying Features:
● ECU coding can be used to deactivate annoying features like seat belt warnings, start-stop functions, or artificial exhaust sounds generated by Speakers.

2. Unlock Hidden Features:
● This aspect of ECU coding is more exciting, as it involves enabling hidden features that the manufacturer may have disabled. Examples include:
● Adjusting turn signal brightness.
● Allowing video playback while driving.
● Activating cornering lights.
● Enabling lock/unlock sound confirmation.
● Customizing the number of flashes for turn signals.
● Implementing a needle sweep effect on the instrument cluster.

3. Code Retrofitted Components:
● ECU coding can also facilitate the integration of new hardware components into your vehicle, ensuring seamless communication between the ECUs and the added components.

Safety rules for ECU coding

To code your car effectively, follow these general guidelines:
● Make a Backup: Make a backup file of current coding to have a way to go back if anything goes wrong
● Keep an eye on the battery: Make sure your battery is not low on charge. Connect the power supply if it is. You don’t want to code with a low battery as it can damage your control modules.
● One coding at a time: Some scanners can code multiple features simultaneously. Code one feature, save it, and then move to another one.

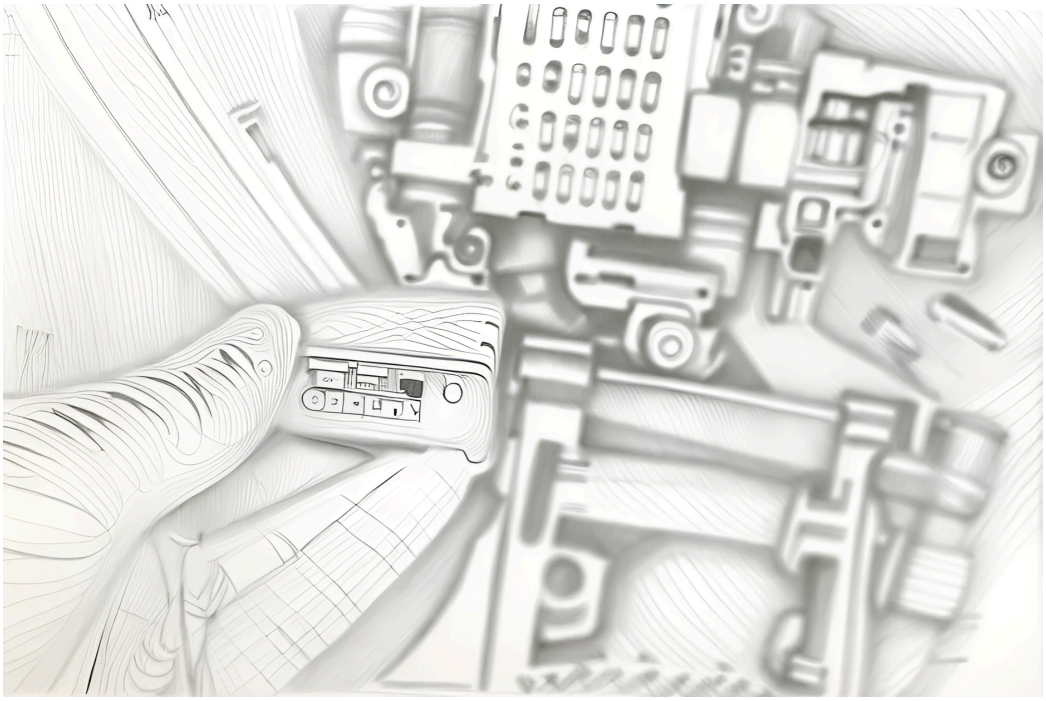
Scanners with ECU coding

● Thinkdiag2: A budget-friendly Bluetooth OBD2 scanner that works with various car brands, offering coding capabilities.
● OBDeleven/VCDS: Specialized tools for VAG group vehicles (Audi, Volkswagen, Skoda, Seat) known for their extensive coding options.
● Bimmercode + OBDLínk MX+: Coding new features for BMW/Mini vehicles.
● Techstream: A laptop-based software for Toyota/Lexus vehicles, allowing customization of specific features.
● Carista: An app-based solution compatible with multiple car brands, offering cost-effective coding features when used with an ELM327 adapter.
● Forscan: Diagnosing and coding for Ford/Mazda/Lincoln/Mercury
It's important to note that not all cars have extensive coding options.

Chapter 5: Using OBD2 Scanner to Diagnose Issues

In this chapter, we'll look at how OBD scanners are crucial in solving car problems. These scanners make tough car issues easy to handle. They help in understanding check engine lights and improve regular car check-ups. With these tools, diagnosing car problems becomes simpler, giving you a clear view of your car's condition. This leads to more effective and accurate car maintenance.

Check Engine Light Troubleshooting



It’s hard to put together one guide for check engine light troubleshooting as each combination of problem, scan tool, and car model is different. If you went over Global OBD modes and advanced diagnostic features, you now have a solid foundation of knowledge to solve check engine problems. Here is a general step-by-step guide to solving your MIL (check engine light).

Read Car Codes: Begin by connecting an OBD2 scanner to your car’s diagnostic port. Once connected, use the scanner to read the Diagnostic Trouble Codes (DTCs) stored in the car’s computer. These codes are critical in identifying which system or part might be causing the check engine light to turn on.

Research the Code: After obtaining the DTCs, research each code to understand what issues it might indicate. This step is crucial as it provides a list of potential problems related to that specific code. You can use the scanner's built-in database, automotive repair manuals, or online resources for this research.

Utilize Additional Diagnostic Features:

- Live Data: Use the scanner to monitor live data from the car's sensors. This can give you real-time insights into the functioning of various components.

- Readiness Monitors: Check the readiness monitors to see if all the systems have been checked and passed by the car's computer.

- Bi-Directional Testing: If your scanner supports it, perform bi-directional tests. This allows you to operate certain parts of the vehicle via the scanner, helping to isolate the issue.

Analyze this information to eliminate possible issues and narrow down the likely cause of the problem.

Identify and Address the Faulty Part:
If your diagnosis points to a specific part, you have two options:
Use Additional Tools: If available, use specialized tools to further test the suspected part to confirm its malfunction.

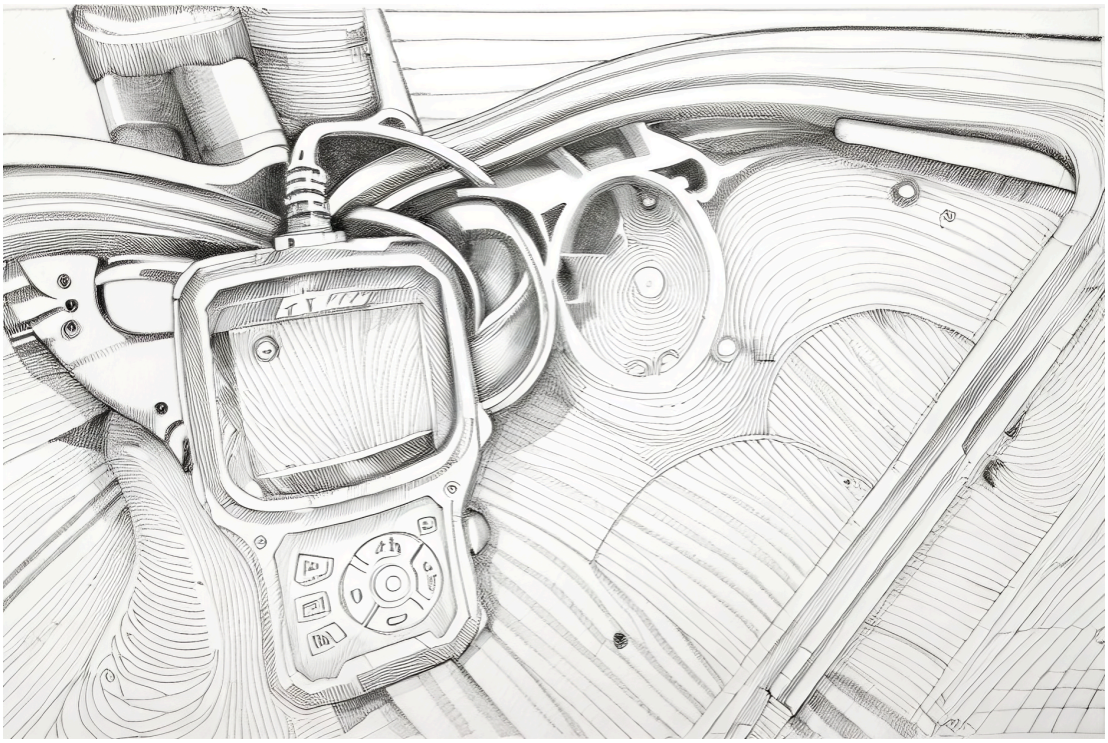
- Replace the Part: Alternatively, order the suspected faulty part online and replace it. This approach is often quicker but involves a bit of risk.

- Post-Replacement Check: After replacing the part, clear the codes with your scanner and take the car for a test drive to ensure the issue is resolved.

- Return Policy: If the new part doesn't fix the problem, utilize the return policy to send it back.

Remember, this process requires careful analysis at each step to ensure accurate diagnosis and efficient repair. Some issues may be complex and require professional assistance.

Check used vehicle before buying



Your OBD2 scanner is not just a tool for diagnosing issues in your own vehicle; it's also incredibly useful for evaluating used cars before purchase. With an OBD2 scanner, you can uncover a wealth of information about a used vehicle's history and current condition.

Check a used car with a simple scanner

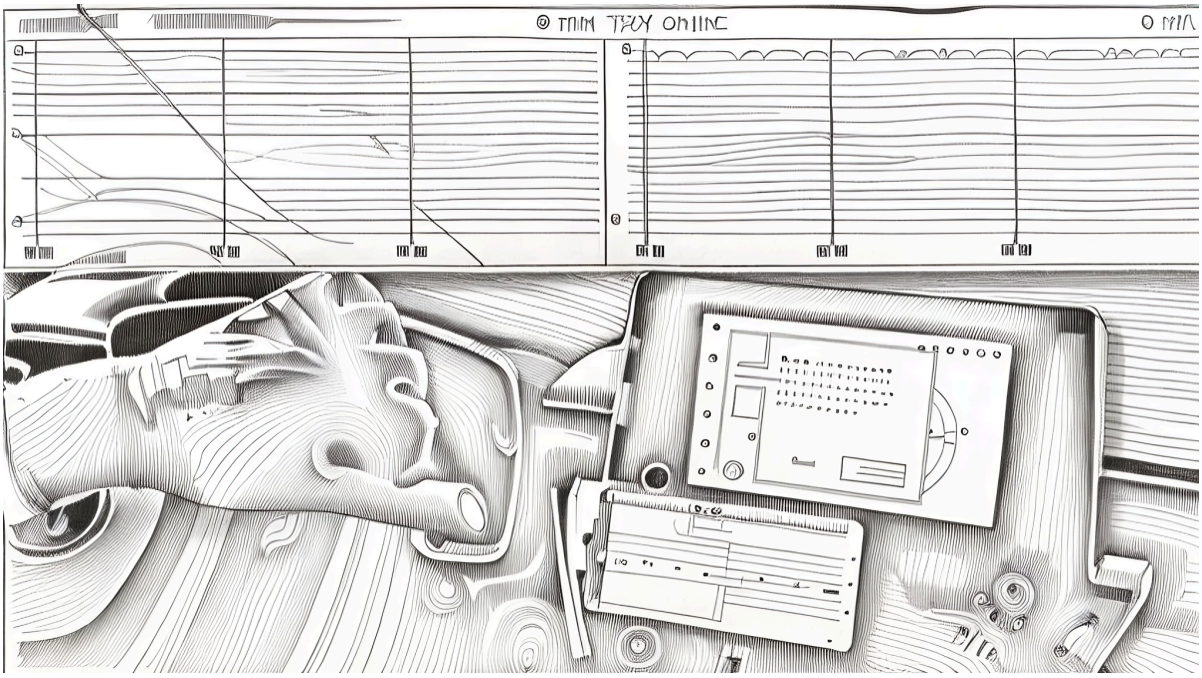
Read DTCs	Check engine codes
Freeze frame	Is there any freeze frame? In rare cases, it can even detect mileage fraud
Fuel trims, and Oxygen sensor data	Best indicator of a healthy engine (gasoline) is the healthy STFT, LTFT, and O2 sensor values
Distance traveled since codes cleared	This live data will tell you if the seller didn’t just erase faults (hiding something)
Readiness monitors	Are all OK? If not, you might have trouble

	passing emission inspection in the future
Battery test	Check if the battery is in good condition

Check a used car with an advanced scanner

Scan all systems	Check for faults in other systems like airbags, brakes, or power steering
Find mileage records	Use full live data to find mileage records in all control modules
Bi-Directional tests	If the car is selled with some faulty part, confirm it with Bi-Directional tests (example cooling fan causing overheating)
Vehicle information	Confirm the ECU has same VIN number as on chassis and car papers (ECU hasn’t been replaced)

Volumetric efficiency test



If your engine passes this test, you know that your engine's internal parts and both intake and exhaust systems are in good condition.

Volumetric efficiency (VE) is a way to measure how well an engine moves air in and out. It's a percentage that shows the actual air movement compared to the ideal amount it could move.

If an engine doesn't "breathe" well due to things like a clogged air filter or a bad catalytic converter, its VE goes down. This affects how the car drives. The engine's computer, or ECM, needs to know how much air comes in to mix the right amount of fuel for good performance. If the air reading is wrong, the fuel mix will be off. To test VE, you need a scan tool to record data and a VE calculator (you can find these online).

For a good naturally aspirated engine, the volumetric efficiency (VE) typically falls within the range of 75% to 85%. This range can vary depending on the specific design and condition of the engine. Higher-performance engines, especially those with modifications for improved airflow, can have a VE exceeding 85%, sometimes approaching 100%.

However, in most standard passenger vehicles, a VE near or slightly above 80% is generally considered normal and indicative of an engine that is breathing efficiently. It's important to note that these values can vary based on factors like engine design, the condition of the engine, and the methods used for calculation.

Volumetric efficiency test for turbocharged engine

Gather Necessary Data: For a turbocharged engine, the reader needs to record the following data during a wide-open throttle (WOT) test drive: engine displacement, engine RPM, measured airflow (MAF reading), boost pressure, and ideally, intake air temperature (IAT). This data is crucial for calculating VE in a turbocharged engine.

Perform Two VE Calculations:

- First Calculation: Use the standard method to calculate VE using barometric pressure. This gives an initial VE percentage.
- Second Calculation: Adjust this calculation by replacing the barometric pressure with the actual boost pressure recorded during the test drive. This adjusted VE more accurately reflects the engine's efficiency with the turbocharger's influence.

Interpreting Results:

- Good VE Percentage: In turbocharged engines, a good VE percentage typically ranges from 90% to 100% after adjustment. This range indicates efficient engine breathing and proper turbocharger function.
- Bad VE Percentage: VE numbers significantly lower than 90% suggest issues such as air metering problems, boost leaks, or exhaust restrictions. VE numbers much higher than 100% could indicate the system is measuring more air than what is effectively used by the engine, possibly due to a boost leak.

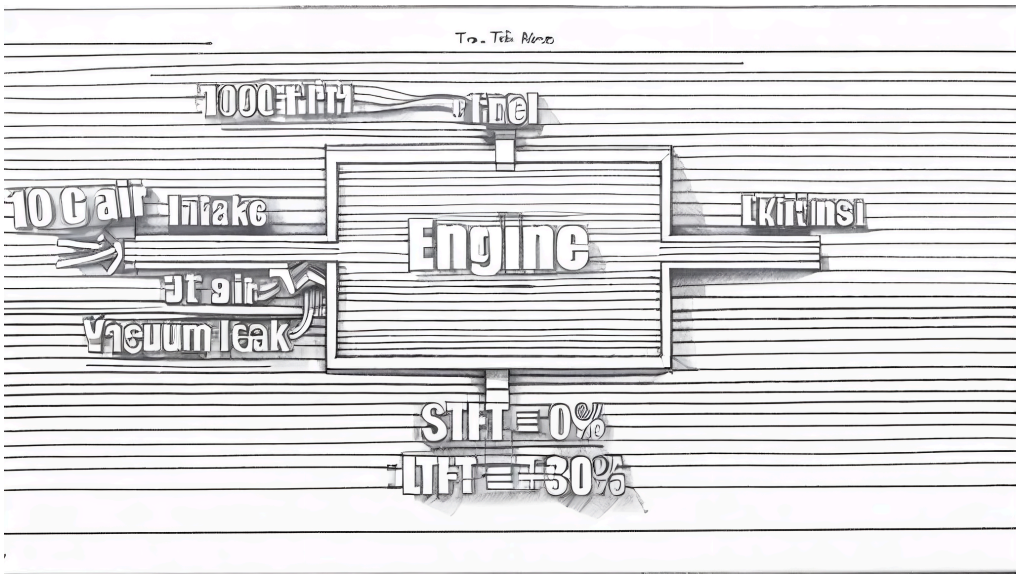
Comparing with Known Good Values: If possible, compare the VE results with known good values for the specific make and model. This comparison can provide a benchmark for what is considered normal for that particular turbocharged engine.

Diagnosing Based on VE Data: Use the VE data to guide diagnostics. For example:

- If VE is low with lean fuel trims at WOT, investigate air metering issues.
- If VE is high with rich fuel trims, consider a boost leak.

By following these steps, the reader can effectively adjust the VE test for turbocharged engines and interpret the results to diagnose issues. It's important to remember that VE values can vary widely between different engines, so understanding the specific characteristics of the engine being tested is crucial.

Find Vacuum leaks



There is a simple way you can confirm a vacuum leak in your vehicle. If you see high STFT (for example 20%) at idle, try increasing the RPM.

If the STFT gets close to 0% with increased RPM, you have a vacuum leak in your engine.

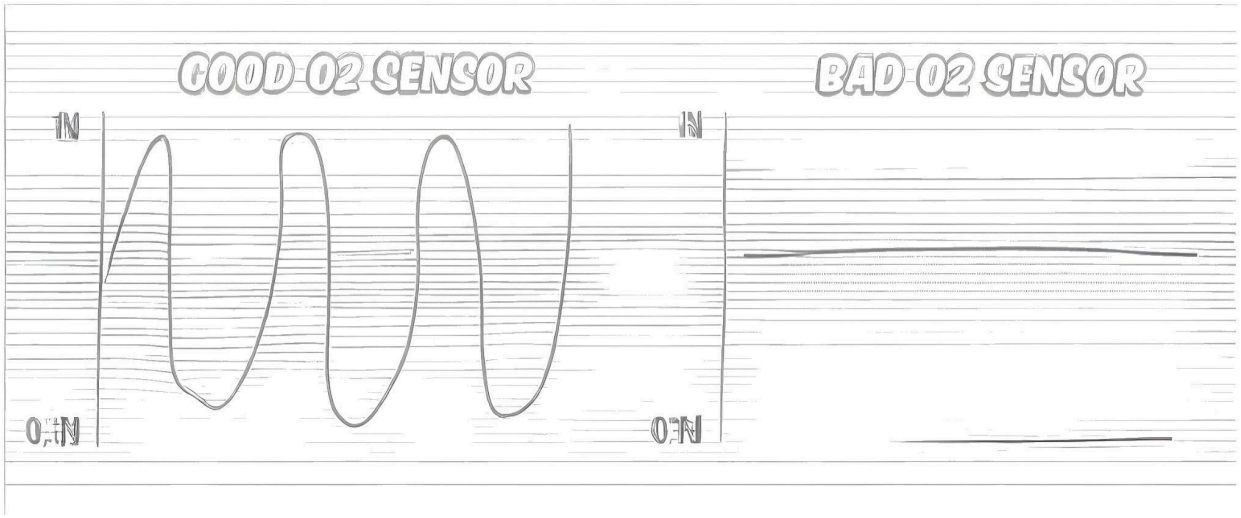
If the STFT is around +20%, meaning there is 120% of fuel going in the combustion chamber. But when we increase RPM, the STFT will start dropping to 0%. That is because at idle, a vacuum leak can add an extra 20% of the air in your engine which must be compensated with more fuel so STFT must be high.

But when I open the throttle and increase RPM, the vacuum leak becomes less significant because there is a lot more air coming in the intake. Now the vacuum leak adds maybe only 2-3% of extra air, which returns STFT to a specified range. Now you just have to locate the leak.

Negative STFT values

Negative STFT (for example -15%) is slashing the amount of fuel, so now only 85% of fuel is sent to the engine. This means, your car is running rich so you have either a problem with your fuel system, or there are some restrictions in intake/exhaust and your engine doesn't have enough air.

Diagnosing Oxygen sensor



Every gasoline car has at least 2 oxygen sensors. Sensor 1 is before the catalytic converter, and sensor 2 is after the cat.

The Oxygen sensor 1 (upstream sensor) measures the amount of air in the exhaust, determining the current condition. If it detects too much air, it lets the PCM know that the engine is running lean, and the PCM will increase STFT to achieve the correct air/fuel ratio again.

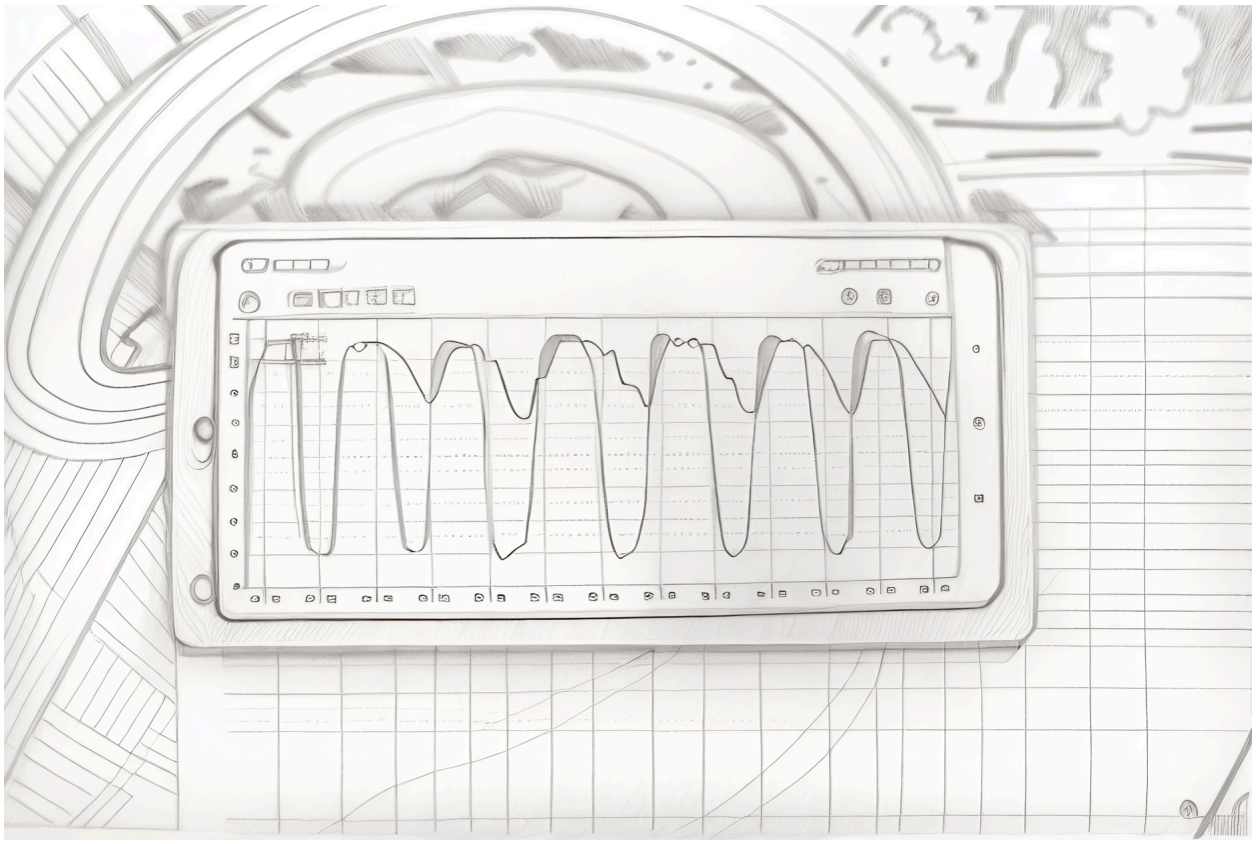
You want to see O2S1 fluctuate between 0.1V (lean) to 0.9V (rich) and should be constantly switching. The sensor is bad when it gets stuck at one value like 0.45V and doesn't fluctuate. This only applies to narrowband oxygen sensors.

Some brands like Toyota use a wideband oxygen sensor, which is also known as an air/fuel ratio sensor. It is a more sophisticated version of the classic oxygen sensor and if you look at its data, you would think it doesn't work because it is always very close to one value at idle.

Test oxygen sensor with scan tool

Open the oxygen sensor 1 data to check if it fluctuates between rich and lean conditions (narrowband sensor), or test it by simulating rich and lean conditions to see any changes in voltage on the scan tool for A/F sensor testing (press gas pedal, or let off the gas pedal to see the voltage change)

Diagnose catalytic converter



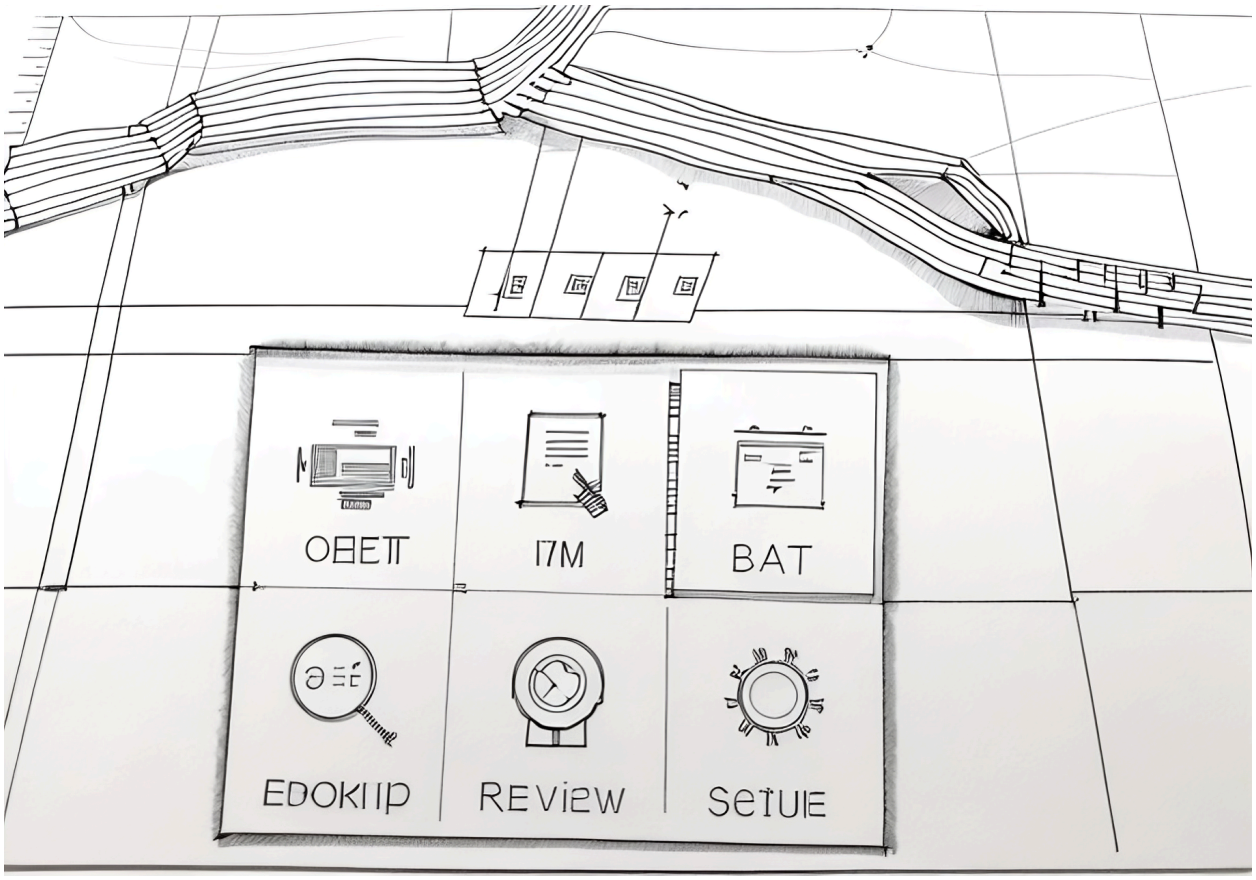
The O2S2 oxygen sensor is a downstream (post-cat) sensor. It measures the air again to determine if the catalytic converter is doing a good job of reducing emissions. The O2S2 should be more stable and shouldn't switch like sensor 1.

Make sure you take a graph scale into consideration when looking at your oxygen sensor’s data. It can seem like sensor 2 is switching from 0.1 to 0.9 like sensor 1, but it just looks that way because it jumps between 0.6 - 0.7V.

Check catalytic converter with O2 sensors live data

The oxygen sensor 1 (red) is switching between rich and lean conditions which is repeated by the rear sensor (green). However, sensor 2 is keeping a steady range of 0.5 - 0.65V, while sensor 1 is switching from 0.1 to 0.8V.
I would say that the catalytic converter in this case is working fine and there is no need for replacement even though the data are not in perfect spec

Battery and charging system



Most scan tool shows battery voltage right in the main menu. In order to test your car battery, you want to check this voltage when you are starting the vehicle. If the voltage drops below 10V during the start, it means your battery is not in good condition anymore.

On the other hand, not all OBD2 scanners will display alternator voltage data but if it does, the good alternator is producing 13.5 - 14.5 Volts. A bad alternator should also illuminate the battery light on your dashboard immediately.

In case you missed important links:

Video Course URL

https://iamcarhacker.com/obd2-course

Mentioned Tools

https://iamcarhacker.com/best-obd2-scanners-for-diy

Congratulations on completing your beginner's OBD training. You are now able to use the OBD2 scanner to its full potential and start gaining real experience with diagnosing, customizing, and servicing vehicles.

Written by: https://iamcarhacker.com

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