

## HOW TO CHOOSE AN AUTOMOTIVE OSCILLOSCOPE?

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### Introduction

The automotive diagnostic oscilloscope is a necessary tool for troubleshooting sensors, solenoids, actuators, primary and secondary ignitions, communication data stream, etc. The specialized automotive oscilloscope is also called automotive lab scope, engine analyser or motor-tester.

When checking circuits, power supplies and grounding, the signals often change too rapidly to check with a Multimeter. Often there are no trouble codes saved in the ECU but the problem exists because a trouble code is only recorded when there is a broken or short to the positive or the negative power supply or the sensor/actuator is faulty. However, if a sensor/actuator has stopped working in some mid position, there is no DTC recorded. In such case the automobile diagnostic oscilloscope is your most needed instrument. It's an irreplaceable tool, when you have to observe output signals from inductive sensors, slow-changing analogue signals, starter current waveforms, charging currents and etc. It can visualize the ignition spark process to help isolate intermittent issues. It's important to mention that almost every digital oscilloscope can show the ignition waveform on one cylinder but only a specialized automotive diagnostic oscilloscope will show all cylinders simultaneously (depending on how many channels you use).

There are several very important things explained below, you should consider before choosing an automotive oscilloscope:

#### 1. It's not a good idea to have the oscilloscope and the scan tool in one unit.

- The first and main reason is you can't use both the oscilloscope and the scan tool at once;
- Second and no less important, oscilloscope in a scan tool means that both units share a same Printed Circuit Board, same power supply and quite possibly this type of oscilloscope will not perform as a good automotive one.

#### 2. User interface recommendations for an automotive diagnostic oscilloscope?

- Avoid the oscilloscopes originally intended for scientific and industrial applications. Such scopes require lots of time on learning and training. Not to mention they usually do not have any pre-sets or are not capable of automotive measurements without adapters that usually are not included.
- Is there an automotive pre-sets data base included? Pre-sets automatically adjusts the vertical scales, time base, the trigger position and etc. for easy setup and operation. Does the oscilloscope have the capability to add new pre-sets and edit them?
- Can the user interface allow the user to add new or edit various already present input probes for high voltage measurements, ignition pick-ups, current clamps, pressure transducers, temperature sensors, etc.?
- Is there a built-in pattern waveform library and is it possible to add new custom waveforms?
- Is it possible to visualize the ignition spark process and show the cylinders displayed next to each other, or under one another in a "parade" style?
- Is there a possibility to overlay a 720-degree frame on the current waveform? A full 720 degrees of crankshaft rotation measurement ruler is very useful for observing of all engine cycles.
- Is there an opportunity to share the saved real waveforms with other oscilloscope users in universal output format?

### 3. PC vs. handheld scope

If you have to use the oscilloscope out in the field, a handheld oscilloscope might be the right choice. Their main advantage is that they can also offer the performance of bench oscilloscopes in a mobile and rugged form factor. Handheld scopes often are easier to setup because of the fewer connections compared to the PC-based scopes. Real-time embedded system in the handheld oscilloscopes is often a big advantage because there is no operating system which can cause problems.

However, PC based scopes have larger screens and often allow you to save more measurement data on the PC hard drive. Often the oscilloscopes, in which the received data is mainly processed in the PC, have a very large memory depth.

In order to avoid transferring high voltages through the grounds which can cause a failure of the PC used or to damage the ECUs in the car, it's good to make sure that there is no galvanic connection between the PC and the PC oscilloscope which not all oscilloscopes have.

### 4. How many channels?

Oscilloscopes have one channel, two-channel, four-channel and up to ten-channel varieties. When deciding which one to choose, you should consider the number of signals to be displayed.

If we want to perform a quick diagnosis to determine the presence of a signal and whether it is within the normal range, one channel is sufficient.

Two channels are enough for camshaft/crankshaft correlation and reading signals from sensors, looking at injector and coil waveforms, watching thermistor voltage outputs, looking at throttle position sensor outputs and etc.

Oscilloscopes with four independently isolated channels are generally used when simultaneous view of the ignition circuit is needed or dealing with a typical crank no start condition where looking at the major inputs and outputs together helps to determine where the fault is quickly.

### 5. Important specifications

Most automotive technicians find it difficult to read and understand scope specifications and then match them to the test requirements.

#### - Bandwidth

Bandwidth is a specification that defines the highest frequency electrical signal that the scope can display. To ensure an accurate representation of the waveform, you have to make sure that the oscilloscope bandwidth is higher than the maximum frequency of the signal you need to measure. But notice that unnecessarily high bandwidth will result in noise or unwanted signals showing up on the oscilloscope screen. It's good if the scope bandwidth is matched to the measurement task.

High-bandwidth scopes can be quite expensive, so you may have to compromise somewhat on this. Bandwidth refers to the frequency that the input signal is attenuated by 3dB. This means that signals cannot be accurately captured near the oscilloscope's bandwidth. So, the oscilloscope bandwidth has to be about two times larger than the maximum measured frequency.

#### - Sampling rate

Sample rate is the number of times per second that the oscilloscope samples the circuit under test. Most oscilloscopes have two different sampling rates or modes: real-time sampling and equivalent-time sampling (repetitive) which are specified in mega or giga samples per second (MS/s or GS/s). When choosing an oscilloscope, make sure you know the type of sampling the specification applies to. For automotive use the equivalent-time sampling is **not** recommended because it's useful for periodic signals only and so not suitable. With an insufficient sample rate, you will not be able to reveal the true amplitude and duration of any given pulse. A good choice would be around 20 Million Samples Per Second for almost all diagnostic applications.

### - Memory depth

The size of the buffer memory where the captured data are stored in the oscilloscope is known as the memory depth. An oscilloscope with deep memory allows users to keep a higher sample rate for a longer period of time. This is most obvious when zooming in on a signal. A limited memory depth will prevent the oscilloscope from capturing waveform accurately since the sample points are placed too far apart from each other.

A major disadvantage of the very big memory depth is that the data is too large and you'll have to scan through it manually to find the event you are looking for.

Another downside of the excess memory depth is that under certain conditions it slows the oscilloscope and/or there would be more dead time. This could lead to necessity of using too powerful and expensive PC or tablet.

### - Resolution

This is the ability of the oscilloscope to resolve small voltages and it depends on several oscilloscope parameters:

- The number of bits of the embedded analog to digital converters. Usually vertical resolution of 8 bits is quite sufficient for all automotive applications;
- The ADC's (Analog to Digital Converter) reference voltage;
- Input attenuator circuit;
- Type of the input signal preamplifier if it exists.

## 7. Probes and Input ranges

When choosing an oscilloscope, look for a manufacturer which offers a complete set of accessories for extending the input ranges and the application of their device.

To perform high voltage or current signals measurements such as: injectors, primary and secondary ignition and etc., you have to extend the input range of the oscilloscope with a suitable input probe. There are 10:1, 20:1 attenuators, capacitive and inductive pick-up clamps, current clamps, AC coupling adapters and etc. It's very important that the input probes should at least match, if not exceed, the bandwidth of the scope.

## 8. Summary and general recommendations

Some manufacturers will give you a free demonstration PC software program, which allows you to see and test almost all functions and menus before you actually buy the oscilloscope! You can always try and compare oscilloscopes from different manufacturers to make the right choice for your application. Make sure that you have asked the following questions:

- What's included in the oscilloscope package set. Which cables, accessories, probes are included in the set and which are available to be purchased in the future?
- What software does the tool come with? What updates? What applications does the software cover? Because of changes in vehicle design and capabilities, how often is the software updated? Are the software updates paid or free?
- Who is the seller and do they have the required qualification and experience to provide support or is it just a vendor that sells equipment and only offers whatever manufacture support is available?
- If a hardware repair is needed during the warranty period as well as and the after-warranty period, where it is performed and is there such a possibility?

All of these are things to consider when purchasing an automotive oscilloscope. Your best friend when purchasing an oscilloscope is you. Not everyone needs the same thing. Make this a personal choice based on your needs and skill level.