Choosing an Oscilloscope

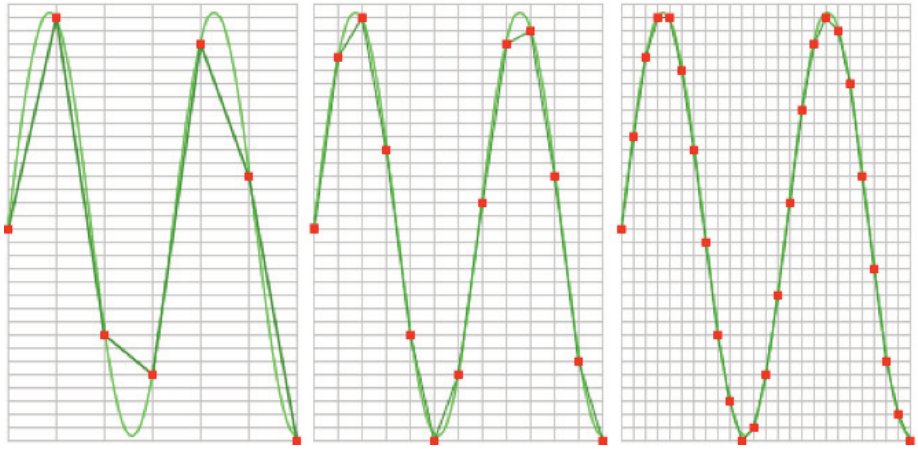
Have you ever looked at an oscilloscope and been bewildered by the different specifications? Sampling, Bandwidth, Differential or Single Ended, Resolution, Input Voltage, and the list goes on. Ryan's Automotive's Seamus Ryan explains some of the basic terminology and what you should consider when buying a scope.

There are many factors to consider when choosing an Oscilloscope. The three that are the most important to consider are Sampling Frequency, Bandwidth and Differential inputs.

1. Sampling Frequency

The rate at which samples (red dots in the scope trace shown) are taken by the oscilloscope is called the sample frequency, the number of samples per second. A higher sample frequency, the shorter the interval between samples. With a higher sample frequency, the original signal can be seen much clearer from the measured samples.

Theoretically, it is possible to reconstruct the input signal with a sampling rate 3 times higher than the highest frequency of the measured signal. But in practice, at least 10 to 20 samples per period are recommended, to be able to examine the signal thoroughly on an oscilloscope. When the sample frequency is not high enough, aliasing (i.e. a false signal) will occur.



Low Sampling Frequency produces poor results | **Better results at a higher frequency** | **High Sampling Frequency produces good results**

Higher sampling frequency is required to get a true picture of what the signal actually looks like

2. Bandwidth

The bandwidth of an oscilloscope determines the frequency spectrum that can be measured. The bandwidth is specified as the frequency where the signal amplitude is reduced to -3dB (or 0.707 times) of the peak amplitude.

In plain English, this means that if the bandwidth of the oscilloscope is too low for the signal being measured, then the amplitude (maximum/minimum voltage) displayed on the screen will start to decrease and you will not see the correct signal.

It is recommended that the band width of your scope is 5 times higher than the highest frequency signal you are going to measure.

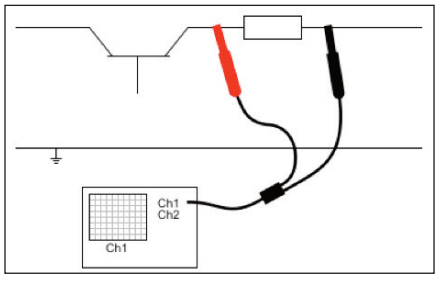
3. Differential Oscilloscope Inputs

Some oscilloscopes are equipped with differential inputs, the ability to measure voltage difference across a component without measuring to ground. A differential input is not referenced to ground, but both sides of the input are "floating".

It is therefore possible to connect one side of the input to one point in the circuit and the other side of the input to the other point in the circuit to measure voltage difference directly.

Advantages of a differential input:

- No possibility to create a short circuit to ground through the oscilloscope.
- Only one channel is used to measure the signal.
- More accurate measurement, since only one channel introduces a measurement error.
- Possibility to measure more combinations of components correctly without creating the possibility of shorts. For example, you can test multiple common rail injectors or multiple inductive speed sensors at once, or any combination of components where the positive and negative leads of the scope channel has to be connected across 2 points on the component or circuit, which neither of them are ground
- The Common Mode Rejection Ratio of a differential input is high. If both points have a relative high voltage, but the voltage difference between the two points is small, the voltage difference can be measured in a low input range, resulting in a high resolution.
- The voltage limit specified for a differential scope is also important. For example, some differential scopes are only rated as a differential scope to 20 volts, while others are rated to higher voltages.



Differential Inputs allows voltage differences across a component to be directly measured

Non-differential Input Disadvantages

In a standard automotive oscilloscope without differential inputs, the ground terminals of all input channels are connected to each other. If channel 1 is used to measure battery voltage, and then the ground lead of channel 2 is accidentally connected to battery positive, a dead short will occur. This large current can damage the car wiring, electronics and the scope

When using an automotive oscilloscope without differential inputs, damage can be caused as result of connecting the automotive oscilloscope incorrectly.

Also, with a non differential scope, it is not possible to correctly measure some combinations of automotive components correctly. For example, testing multiple common rail injectors or multiple inductive speed sensors at once, or any combination of components where the positive and negative lead of the scope channel has to be connected across 2 points on the component or circuit which neither of them are ground is not possible.

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