

# Choosing an Oscilloscope

Have you ever looked at an oscilloscope and been bewildered by the different specifications? Like

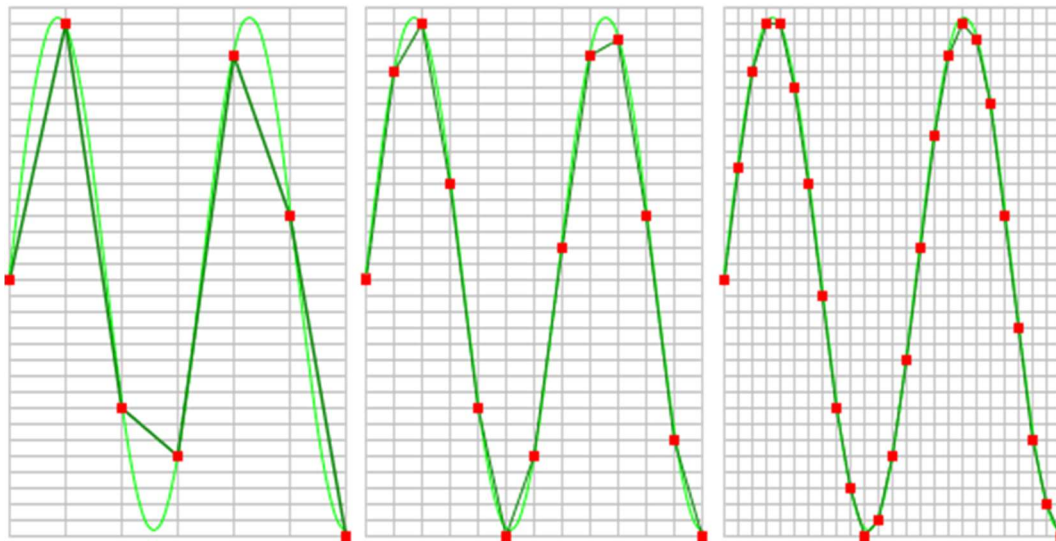
**Sampling, Band Width, Differential or single ended, Resolution, Input voltage, and the list goes on**

Below we have compiled descriptions of 3 of the most important specifications to consider when choosing an oscilloscope for the modern vehicle.

Of course there are many other factors to consider but these are the most important.

## 1 : Sampling Frequency.

The rate at which samples (samples = red dots on the below images) are taken by the oscilloscope is called the sample frequency, the number of samples per second. A higher sample frequency corresponds to a shorter interval between the samples. As is visible in the picture below, with a higher sample frequency, the original signal can be reconstructed much better from the measured samples.



**Poor**

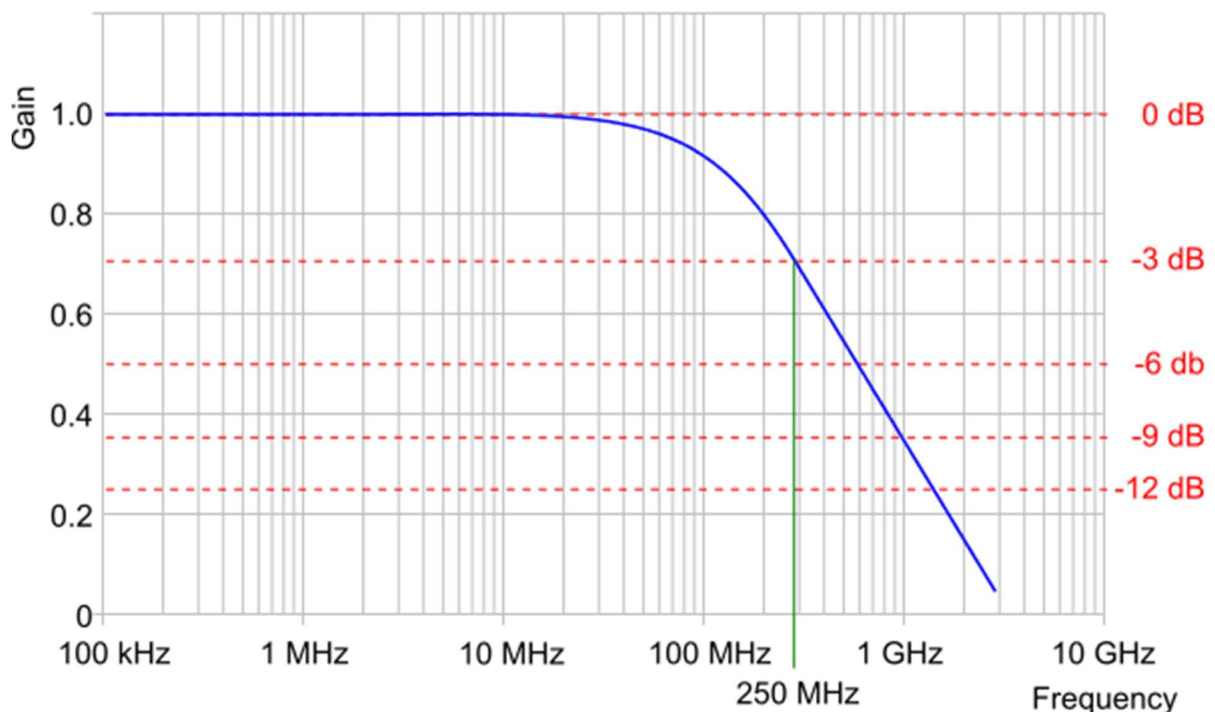
**Better**

**Adequate sampling rate**

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 in an oscilloscope. When the sample frequency is not high enough, [aliasing](#) will occur.

## 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.

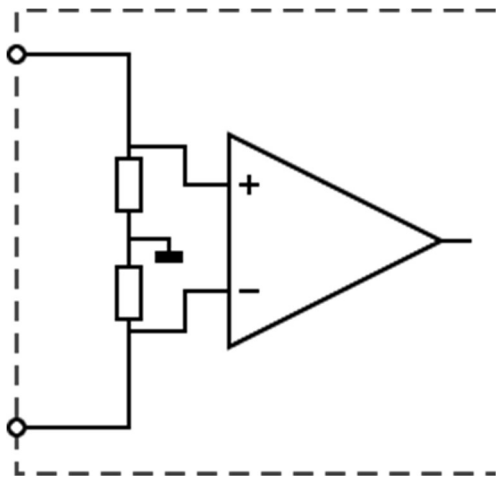


In plain English this means that if the bandwidth of the oscilloscope is too low for the signal being measured then the amplitude (maximum/minimum voltage) displayed on the screen will start to decrease and you will not see the correct signal.

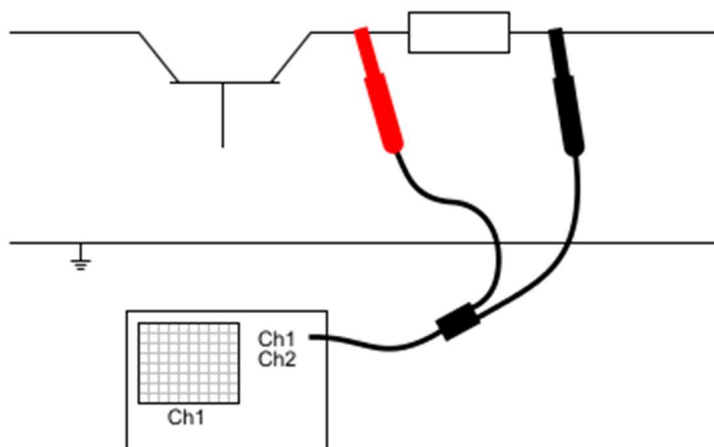
It is recommended that the band width of your scope is 5 times higher than the highest frequency signal you are going to measure

### 3 : Differential Oscilloscope Inputs

Some oscilloscopes are equipped with differential inputs. 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 and measure the voltage **difference** directly.



Advantages of a differential input:

- Not 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 multiple common rail injectors at once, 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 to which the scope is specified as a differential scope is also important. For example some differential scopes are only rated as a differential scope to 20 volts and others are rated to higher voltages.

### **Non-differential inputs Oscilloscope**

In a standard automotive oscilloscope without differential inputs, the ground terminals of all input channels are connected to each other.

So, if for example 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 both the car wiring as well as the car electronics and or the scope

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

Also, with a non differential scope it is not possible to correctly measure some combinations of automotive components correctly

For example, multiple common rail injectors at once, 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