How to Calibrate 10X Probe

How 10X Probe Works

Standard oscilloscope probe has a switch on its handle (see Fig. 1 below) which can select probe attenuation between 1X and 10X. By placing the switch at 10X position what it actually does is putting a 9M ohm resistor (Ra) in series with oscilloscope input, as shown in the schematic of Fig. 2. Since typical oscilloscope has input resistor (Rs) of 1M ohm the 9M resistor Ra and oscilloscope input impedance form a 1/10 divider. This divider delivers 1/10 of input voltage to oscilloscope.
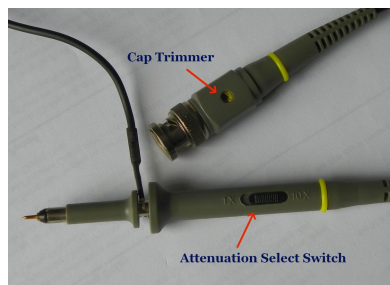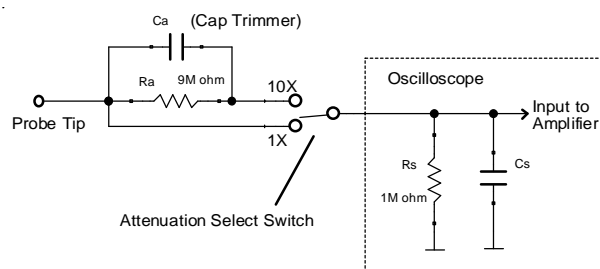

Fig. 1

Fig. 2

Why Calibration of 10X Probe Is Required

As you may know oscilloscopes always have some kind of input capacitance (Cs). Ra and Cs act as a low-pass filter. This low-pass filter could significantly impact oscilloscope performance for signals that have high frequency components because they get larger attenuation here. As a result what we see on oscilloscope screen is not the real signal but a distorted one.

Obviously this problem is caused by Cs. To de-effect Cs we can add another capacitor Ca in parallel with Ra so as to "compensate" losses caused by Cs. With Ca in place higher frequency components can bypass through it and result in less attenuation. We can reasonably expect that Ca will improves 10X probe performance. But what value of Ca should be? We know that in order to keep signal original we should ensure all frequency components are equally maintained in given bandwidth. Mathematics can prove that for the circuit in Fig. 2 all frequency components are equally passed when the following equation holds.

$$Ca/Cs = Rs/Ra$$

Since Rs, Ra, and Cs are determined we can use a trimmer as Ca (see Fig. 1) and tune it so that the above requirement is met.

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To calibrate 10X probe (tuning Ca) we need a good quality square signal source. The reason for choosing square signal is that it contains rich frequency components and is easy to generate. There is no strict requirements for its frequency and amplitude. Frequency from several hundred Hz to several KHz and amplitude from less then 1 volt to several volts are acceptable. But most importantly the waveform shape must be good. It should have nice and sharp right angles at its corners. When you have the signal ready follow the steps listed below to complete the calibration.

1. Connect probe to signal source. Select 10X attenuation by placing the switch at 10X position.

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2. Change oscilloscope settings so that 1 ~ 2 cycles are displayed on screen with amplitude being 2 ~ 3 divisions. (see Fig. 3 as an example)
3. Turn Ca with a small screw driver so that best waveform shape (the middle of Fig. 3) is obtained.
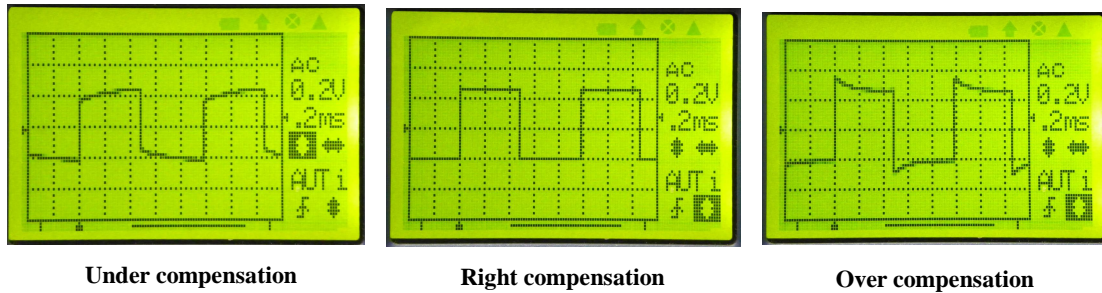

Under compensation **Right compensation** **Over compensation**

Fig. 3

Why we know the calibration is done when good square waveform is obtained?

From signal theory we know that square signal consists of many different frequency components. When it passes a circuit if some components loss (or gain) more than others we will see its shape distorted at output. Reversely, if we see a perfect waveform is obtained at output we know that all frequency components are maintained.

(zliu)

Revision History

Version	Date	Descriptions
01	2012.05.23	First draft