

Lab 4: The Attenuating Probe

Object: To learn how to properly adjust the compensating capacitor on an attenuating probe.

Apparatus: Tektronix TDS2004B Digital Oscilloscope, 10X Attenuating Probe.

Introduction: In the previous lab exercise you found that the internal resistance of a voltage source (in this case the HP 200CD Oscillator) can cause a noticeable reduction in the voltage appearing at its terminals if the circuit to which it is attached has a comparable (or smaller) resistance. Until now we have not worried about the input resistance of the Tektronix TDS2004B oscilloscope because $1\text{ M}\Omega$ is so much higher than the resistances in our circuits. However there are occasions when even a $1\text{ M}\Omega$ input resistance to an oscilloscope can cause unwanted “loading” of the circuit to be measured. In these cases you need to use an **attenuating probe**. The most common type of attenuating probe is a 10X probe, a probe that “attenuates” the measured voltage by a factor of 10, and at the same time increases the effective input resistance of the scope. Figure 1 below shows that the voltage appearing on the oscilloscope display is the result of a voltage divider composed of the probe resistor and the input resistance of the scope. Determine the resistance of the probe that is required to make this a 10X attenuator.

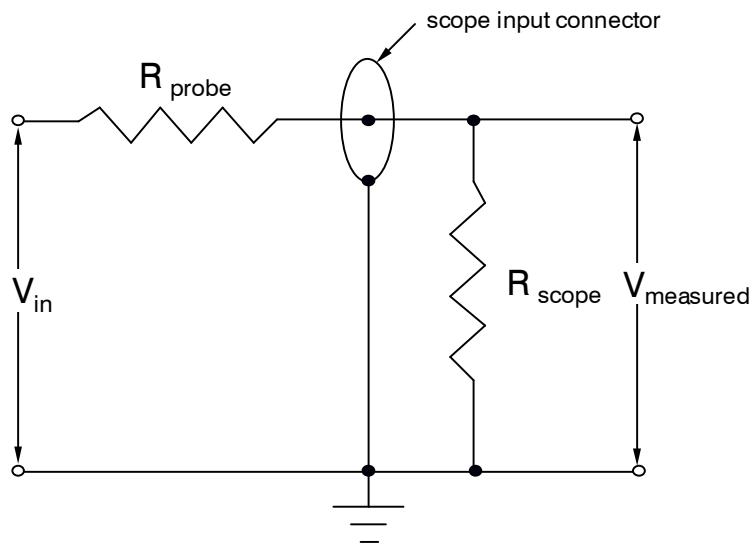


FIG. 1 The probe resistance and the input resistance of the scope are in series and form a voltage divider.

Oscilloscopes not only have input resistance, but also input capacitance (20 pF in the case of the TDS2004B). Notice that the attenuating probe resistor and the input capacitance of the oscilloscope form a RC low pass filter (neglecting for the moment the input resistance of the scope in comparison to the probe resistance). Calculate the -3 dB (or half-power) frequency for this circuit. This low pass filtering effect would severely limit the usefulness of the attenuating probe to measurements at very low frequencies only if there were no way to compensate for the poor frequency response. Fortunately there is a way to recover high frequency response. All attenuating probes incorporate a variable capacitor (See Fig. 2 below). By appropriate tuning of the adjustable capacitor, the

attenuating probe provides good (i.e. flat) frequency response out to much higher frequencies than would otherwise be the case. The exercise below leads you through the proper method of tuning the adjustable capacitor on the 10X attenuating probe.

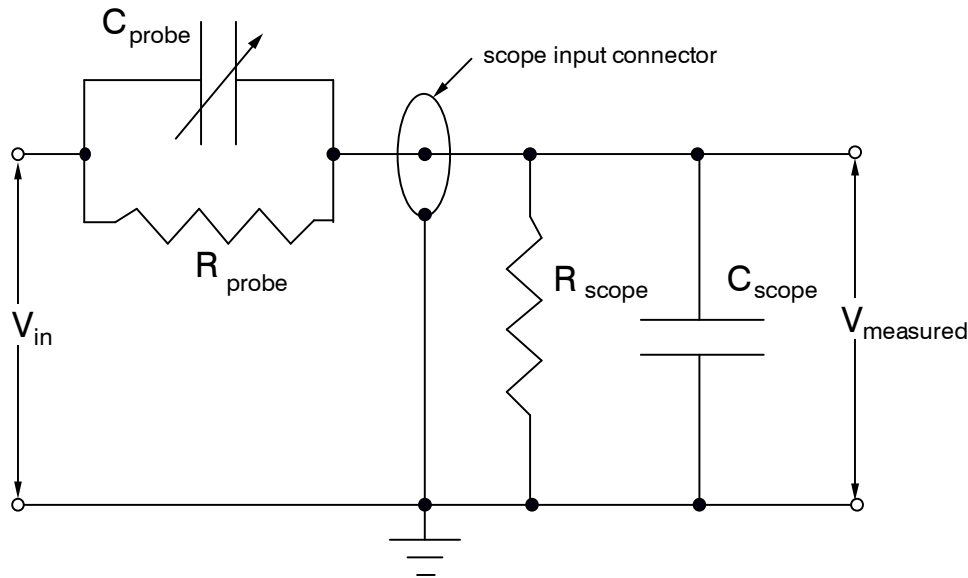


FIG. 2 Effective circuit when an attenuating probe with frequency response compensating variable capacitor.

Exercise: The TDS2004B oscilloscope generates a 5 V, 1 kHz square wave between the two *Probe Comp* pins. Attach the (spring loaded) tip of the 10X probe to the top *Probe Comp* contact point and the (alligator) ground clip to the other end contact point. Connect the probe to the CH 1 input. Adjust the triggering controls, the sweep rate, and the channel 1 sensitivity until you clearly observe two or three cycles of the square wave. Unless you have been very lucky, the square wave will not look very square. This is because the variable capacitor in the probe is not properly tuned to give flat frequency response.

Using a small screwdriver, tune the variable capacitor until you get the nicest square wave possible. You have now properly compensated the attenuating probe. Note that the *Probe Comp* feature of the oscilloscope is intended for just this purpose... namely *compensation* of the attenuating *probe*.

Verify that the probe does in fact attenuate the amplitude of the signal by a factor of ten. To do so, set the Probe Attenuation setting on the CH 1 menu to 1X. This will tell the scope to display the actual input voltage value without correcting for any attenuation. What is the amplitude of the square wave signal?

Using the complex impedance formalism, derive an expression for the probe capacitance that gives a flat frequency response (in terms of the probe resistance and the input resistance and capacitance of the scope).