Using LeCroy's Eye Doctor to De-Embed Probes (LAB_WM772)

Eye Doctor™ is a software tool that operates inside of LeCroy oscilloscopes. The tool consists of two major features:

- Virtual Probing
- Ideal Equalizer Emulation

The Virtual Probing feature, which is the focus of this application brief, enables a variety of advantages in signal probing situations including:

1. The ability to compensate for probe loading effects by allowing you to see waveforms that occur in a circuit as they would with and without the probe connected to it.

2. The ability to acquire waveforms that occur in locations other than the probing point.

This is an initial investigation into compensating for probe loading use the D11000PS/D13000PS Differential Probe System and the SDA11000 Serial Data Analyzer.

This application brief assumes that you are familiar with the basics of LeCroy's Eye Doctor software as described in the operator's manual available on LeCroy's Website at: http://www.lecroy.com

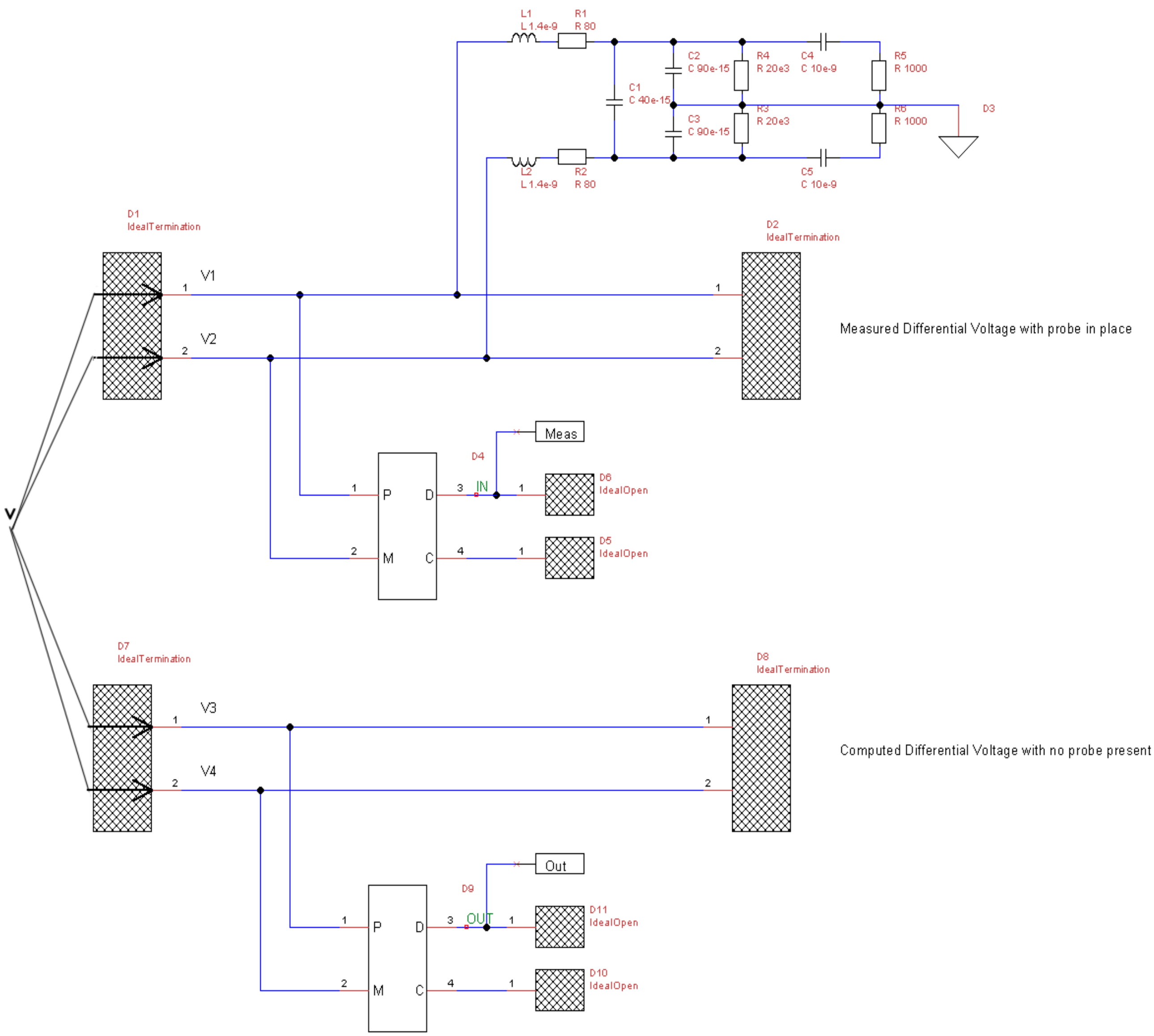

Figure 1: The system diagram of the measurement is used to generate the netlist file.

The schematic used to generate the netlist file is shown in Figure 1. The upper circuit represents the probe impedance placed on a perfectly matched differential pair. The scope is measuring the differential component of the signal. The mode conversion blocks are used to provide a differential signal that represents the signal measured by the scope.

The lower circuit is simply the same ideal differential pair of signals with no probe impedance present. The filter calculated using this schematic will transform the signal acquired by the scope (Meas) to that with no probe (Out).

The resulting netlist is shown as the text file in Figure 2, with the manually added stimulation lines shown in bold.

The netlist shown in this file was compiled and filter response of the loading correction filter was plotted, using a third party math program, as a check to make sure that the results were as expected. The correction filter response plot is shown in Figure 3.

Based on measurement and simulation of the actual probe tip loading loss and loss of the loading equivalent circuit this looks exactly as it should. This step is not required but it was included as an assurance check.

```
.Device D1 2 IdealTermination
.Device D2 2 IdealTermination
.Device L1 2 L 1.4e-9
.Device L2 2 L 1.4e-9
.Device C1 2 C 40e-15
.Device C2 2 C 90e-15
.Device C3 2 C 90e-15
.Device C4 2 C 10e-9
.Device C5 2 C 10e-9
.Device R1 2 R 80
.Device R2 2 R 80
.Device R3 2 R 20e3
.Device R4 2 R 20e3
.Device R5 2 R 1000
.Device R6 2 R 1000
.Device D3 1 IdealShort
.Device D4 4 MixedMode
.Device D5 1 IdealOpen
.Device D6 1 IdealOpen
.Device D7 2 IdealTermination
.Device D8 2 IdealTermination
.Device D9 4 MixedMode
.Device D10 1 IdealOpen
.Device D11 1 IdealOpen
.Node N000000 D1 1 D4 1 L1 1 D2 1
.Node N000001 D1 2 D4 2 L2 1 D2 2
.Node N000002 L1 2 R1 2
.Node N000003 L2 2 R2 2
.Node N000004 C2 2 C3 1 R4 2 R3 1 D3 1 R5 2 R6 1
.Node N000005 C4 1 R5 1
.Node N000006 C5 1 R6 2
.Node N000007 R1 1 C1 1 C2 1 R4 1 C4 2
.Node N000008 R2 1 C1 2 C3 2 R3 2 C5 2
.Node IN D4 3 D6 1
.Meas IN
.Node N000009 D4 4 D5 1
.Node N000010 D7 1 D9 1 D8 1
.Node N000011 D7 2 D9 2 D8 2
.Node OUT D9 3 D11 1
.Output OUT
.Node N000012 D9 4 D10 1
.Stim V1 D1 1
.Stim V2 D1 2
.Stim V3 D7 1
.Stim V4 D7 2
.Stimdef V defines V1 V2 V3 V4 as 0.5 -0.5 0.5 -0.5
```

Figure 2: The netlist corresponding to the system diagram in Figure 1

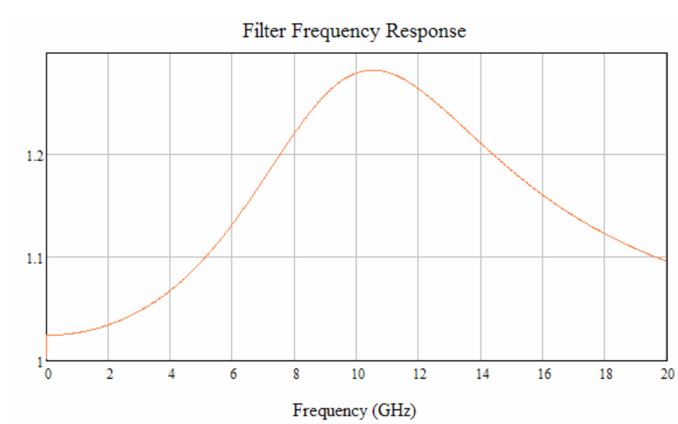

Figure 3: Frequency response of the loading correction filter

At this point the SDA 11000 scope and D13000PS probe were set up to acquire a pseudo-random bit sequnce (PRBS) test signal. The result of that signal acquisition is shown in Figure 4.

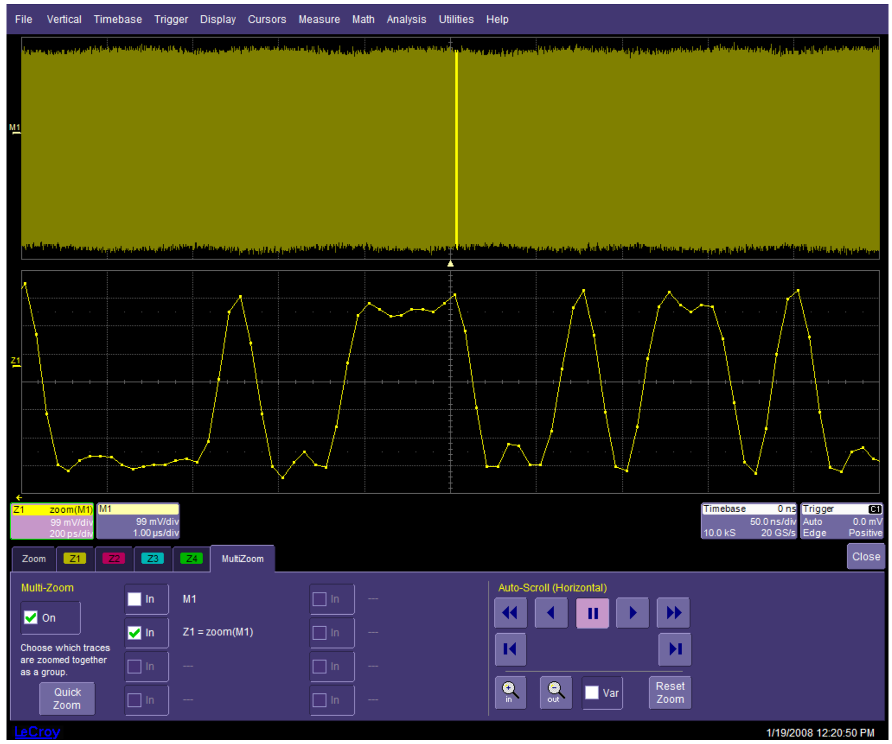

Figure 4: The PRBS signal as measured using the D13000PS probe and SDA11000.

The next step is to setup a math function using the Eye Doctor Virtual Probe Math function as shown in Figure 5. Note that the text file, “diff_probe_comp_1.txt”, containing the netlist is entered into the System Description field. The settings for the other fields are to be found in the Eye Doctor operator’s manual

Figure 5: The setup for the Virtual Probe math function.

The output of the Virtual Probe function shows the waveform as it would be seen if the probe was not present to load the signal. Figure 6 shows the acquired trace overlaid by the output of the virtual probe. Note that the ‘unloaded’ trace shows slightly higher peak values immediately after each state transition. The effects are minimal because the scope’s 11 GHz bandwidth is less than that of the probe.

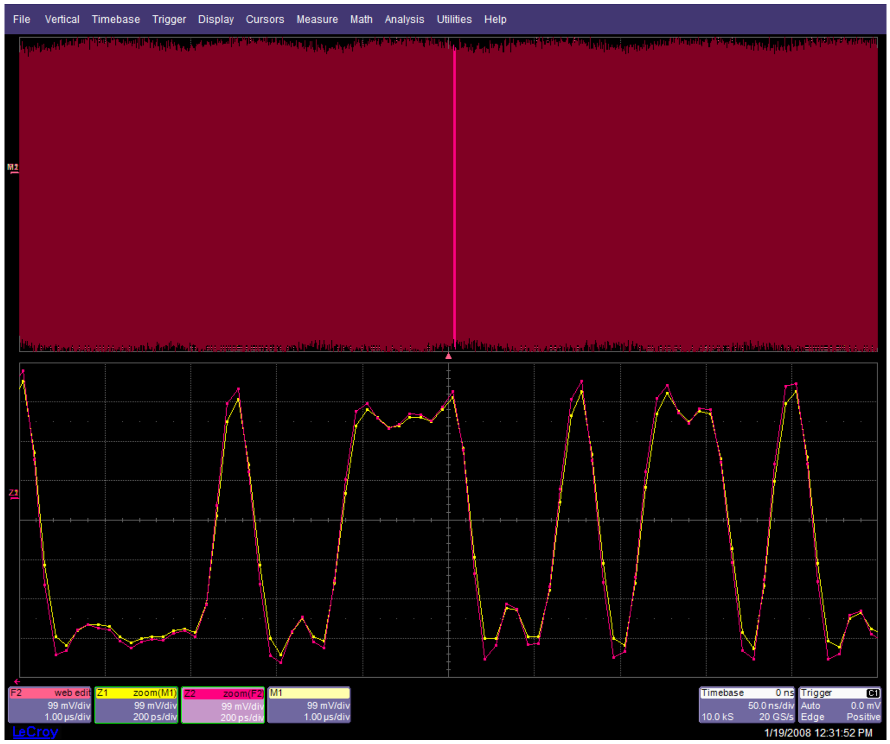

Figure 6: A comparison of the “loaded” (trace Z1) and “unloaded” (trace Z2) responses of a 13 GHz probe using an 11 GHz Scope

Figure 7 shows a similar measurement using an 11 GHz, D11000 probe on an SDA13000 which has a bandwidth of 13 GHz. The probe loading effects are more pronounced in this example.

In these examples we have shown how LeCroy’s Eye Doctor Virtual Probing feature can be used to de-embed probe loading effects from your measurement data. This capability greatly enhances the usability of the scope in signal integrity measurements by improving accuracy.

Figure 7: A comparison of the “loaded” (trace F1) and “unloaded” (trace F2) responses of an 11 GHz probe using a 13 GHz Scope