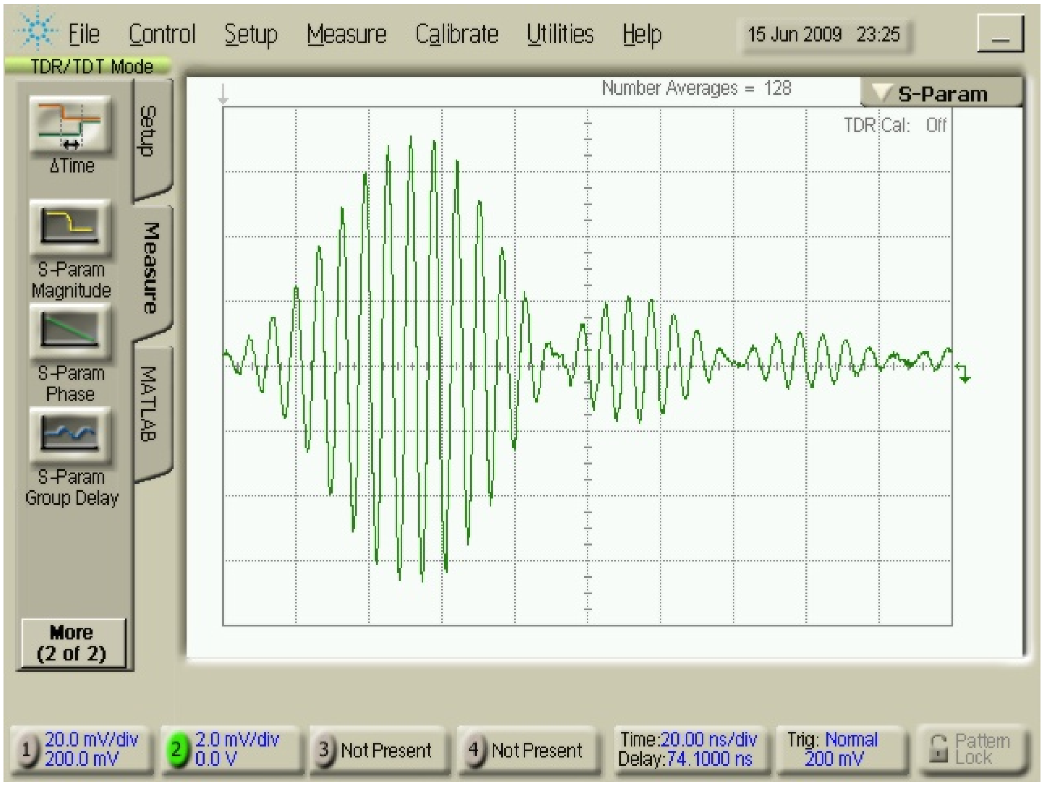

Step Response Measurement

Dmitry Teytelman and Dan Van Winkle

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Student name: ______________________________

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Contents

1 Introduction

Yesterday we spent some time working on time domain reflection (TDR) measurements. This lab will acquaint you with the complementary measurement - time domain transmission (TDT). Recall that TDR is measuring one-port reflection in time domain. With TDT we will look at the two-port transmission (S_{21}) in time domain.

WARNING: TDR plugin module inputs are precision 3.5 mm connectors. These connectors are quite fragile and sensitive to mishandling. To protect them we have mounted SMA "connector savers". Please do not remove them. When attaching hardware to "connector savers", do not use SMA wrenches — only your fingers!

WARNING: Wideband sampling scope inputs on 54574A plugin are very sensitive and can be easily damaged by excessive voltages or static electricity. Before connecting any coaxial cable to the connectors, momentarily short the center and outer conductors of the cable together. Avoid touching the front-panel input connectors without first touching the frame of the instrument.

2 Exercises

Having done the lab on Monday you are ready to blaze through this one. Start from setting the scope for TDT — perform default setup and TDR/TDT mode selection, then press `TDR/TDT Setup` button on the plugin module. The system will be in TDR measurement measurement mode on channel 1. Select the icon of a two-port device on bottom right. Channel 2 should become active with a TDT trace. Turn off channel 1 display.

NOTE: *One of the filters you will characterizing in Exercise 2.2 is shared with the network analyzer "Filters" lab. The sharing protocol is that before you start your lab, go and talk to the group working on the filter lab. Both labs are flexible, so adjust your schedules appropriately.*

2.1 Cable Response

Our first measurement will be very simple - measuring some SMA-to-SMA cables. We will start with the short 12" white cable. Connect the cable between channels 1 and 2. A step should appear on the display. If you don't see it, zoom out the timebase.

Using waveform measurement capabilities of 86100C oscilloscope, measure and record the rise time of the pulse: ______________________

Now connect the long 18' cable between ports 1 and 2. Find the rising edge on channel 2 display (cable delay is around 29 ns). Measure and record the rise time of the pulse[1]: ______________________

2.1.1 After Dinner Questions

Explain in a few sentences the difference in rise time between the two cables:

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2.2 Bandpass Filters

Now we will characterize some bandpass filters. As mentioned above, the order is arbitrary — you can start the measurements from any of the two filters.

2.2.1 Filter 1

One filter we will measure is a Texscan 6B160/20-KK. Connect the filter between ports 1 and 2. Adjust vertical and horizontal scales to optimize the response display. Use the waveform measurement tools and markers to

[1]Note that the pulse has very long tail coming up to the full voltage. If your horizontal span is too small, you will underestimate the rise time. The problem is that the automatic rise time measurement determines 10% and 90% voltages from the peak-to-peak signal swing seen on the screen. If the pulse continues to rise at later times, scope has no way of knowing that.

determine the peak-to-peak voltage, envelope rise time[2], and filter center frequency[3]. Record the measurements below:

2.2.2 Questions

Let's suppose we want to use this filter to measure individual responses from bunches in an accelerator. We are interested in bunch-to-bunch isolation, so the bunch spacing in time will depend on how long the filter continues ringing after a short transient is applied to it. Let's define our isolation goal as 20 dB. So we want the ringing to decay by a factor of 10 ($10^{20/20}$) from the peak response. You've measured the peak response above. Zoom in the vertical scale and look at the ringing after the main response. Find the time difference from the peak response to the point where the ringing falls below $V_{peak}/10$ (make sure you look further in time, more ringing reflections could be off the screen). Record the time difference you've just measured. That will be the minimum bunch spacing for 20 dB isolation.

2.2.3 Filter 2

This is the filter we are sharing with the network analyzer "Filters" lab: K&L 7B120-160/BT16-O/O. Connect the filter and repeat the peak-to-peak

[2] To measure the rise time, determine the amplitude as $V_{\text{peak-to-peak}}/2$. Calculate 10% and 90% voltages from that. Move the marker from the left to find the first peak with absolute value closest to 10%. Record that time position. Continue moving the marker until you find a peak with absolute value closest to 90%. The rise time is the difference between 90% and 10% marker positions.

[3] To roughly characterize the center frequency, measure the period of oscillation near the peak response.

voltage, envelope rise and fall time measurements, and filter center frequency:

2.2.4 Questions

Repeat the measurement of minimum time spacing for 20 dB isolation and record the result below:

2.2.5 After Dinner Questions

If you were designing a bunch-by-bunch signal processor, which of the two bandpass filters would you use and why:

Which one of the two filters has Bessel response?

3 Glossary

Glossary

time domain reflection (TDR)

A measurement of device characteristics, obtained by launching a fast-rise pulse to the device and observing the reflection signals. 2, 6

time domain transmission (TDT)

A two-port extension of TDR where device response is observed at a different port from the pulse-excited one. 2