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Three Ways to Optimize Signal Analysis with NI Oscilloscopes

Jacob Sees
Jonathan Rivera

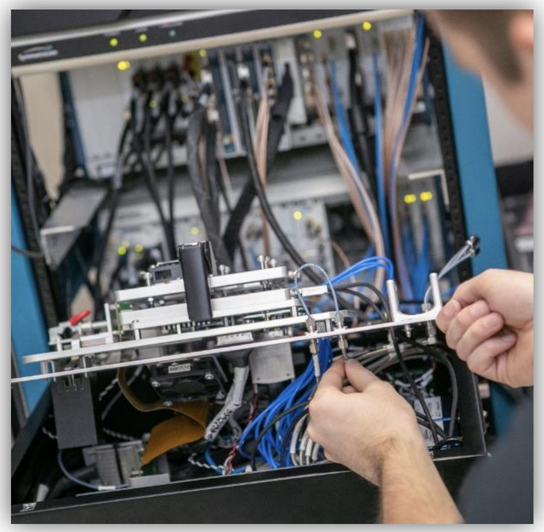
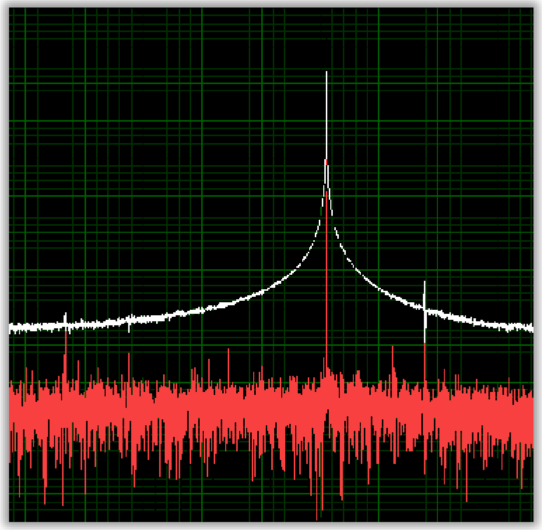
Test System Downtime and Synchronization

Inaccurate Measurements?

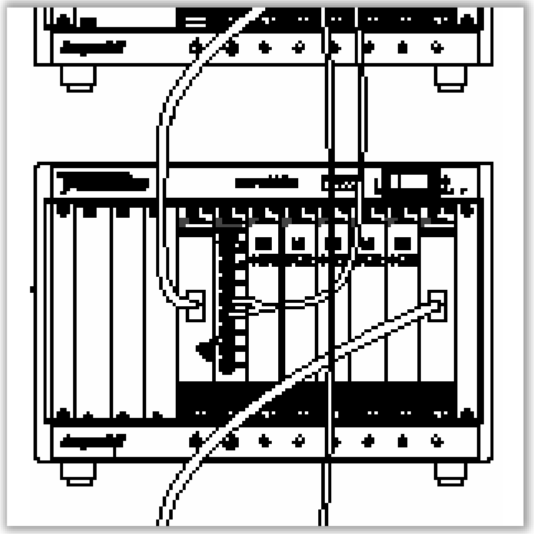
Test downtimes?

System failures?

Synchronization problems?





Three Ways to Optimize Signal Analysis with NI Oscilloscopes

1. Choosing the Optimal Oscilloscope Probe
2. Avoiding Downtime With CableSense™
3. Synchronizing Multiple Scopes with NI-TClk

Choosing the Optimal Oscilloscope Probe

Oscilloscope Probes

- Instrumental for analog measurement by providing connectivity between oscilloscope and DUT
- Many types of oscilloscope probes exist each with their own application area
- Choosing the correct probe for measurement set-up will help to optimize signal acquisition

Important Probe Characteristics

Bandwidth

Difference between the upper and lower frequencies in a continuous band of frequencies

Attenuation Ratio

Ratio of the probe's input signal amplitude to the output signal amplitude

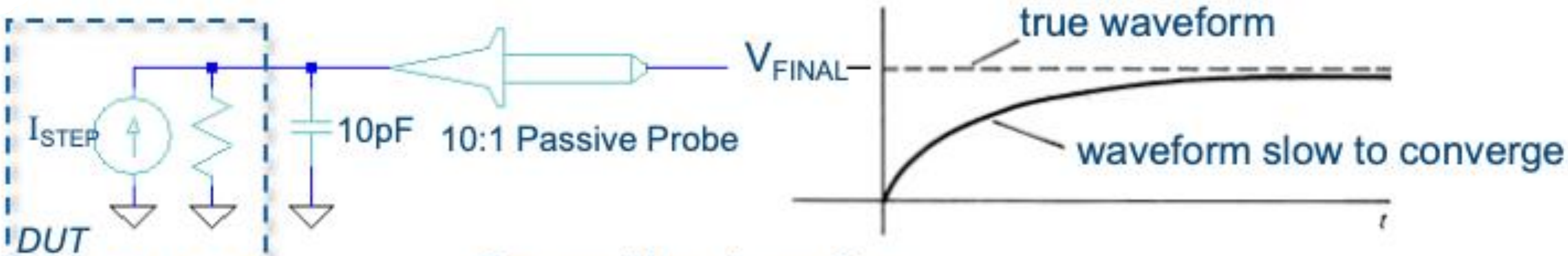
Impedance

The value of the device impedance influences the effect of probe loading

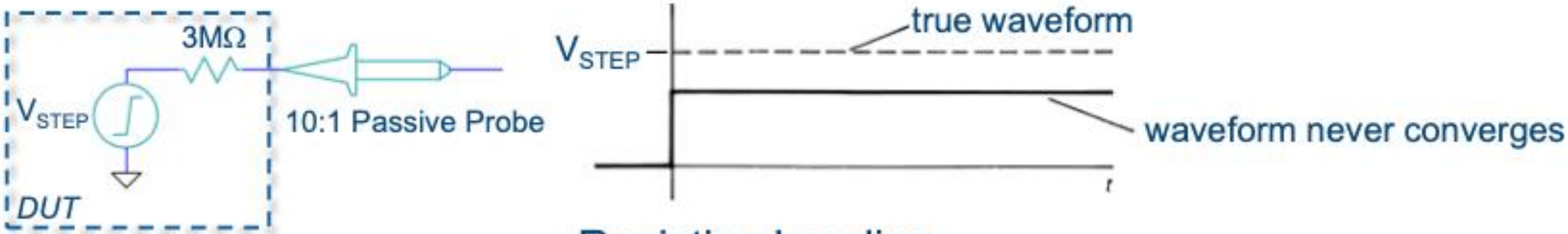
Capacitance

The value of the capacitance measured at the tip of the probe

Loading Effects



Capacitive Loading



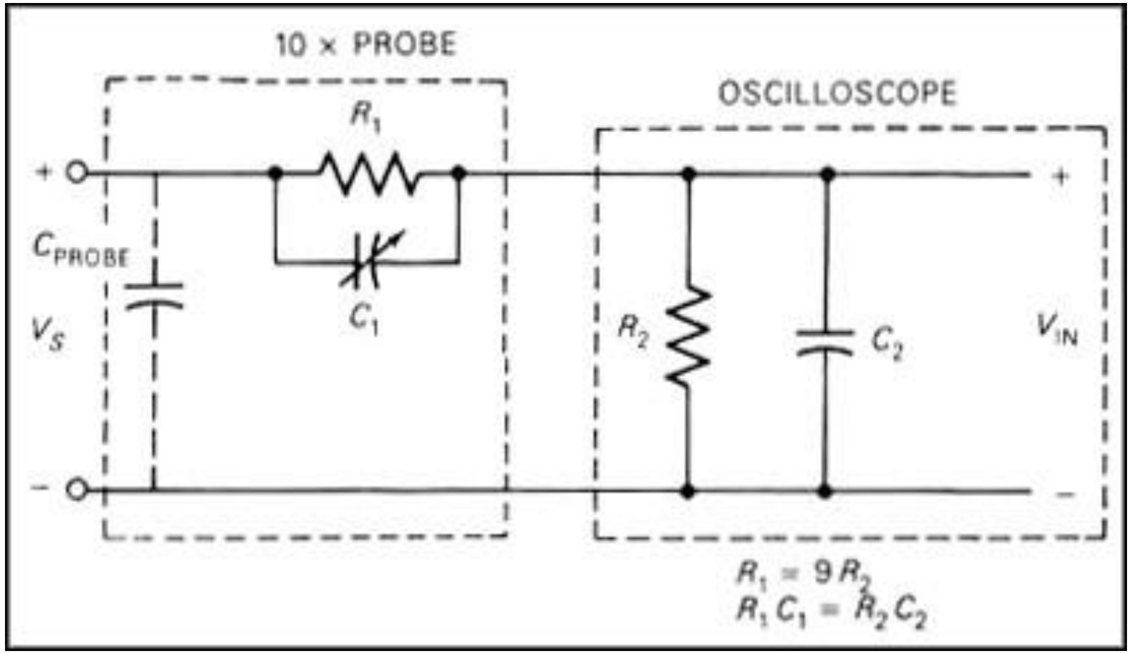
Resistive Loading

Types of Probes

Configuration	Description	Pros	Bandwidth
Direct BNC	• Fastest, most basic measurement. • Does not add source impedance to prevent loading on source • Does not match impedances at higher frequencies. • Scope Setting of 50Ω	• Simple • Low-cost	Tens of GHz
Passive Probe	• Can provide impedance near the scope & source • Scope Setting of 1MΩ • Does not require external power supply	• Low-cost probe option • Limits ringing • Attenuation options	Up to 500 MHz
Active Probe	• Reduces loading on probe location with amplifier • Scope Setting of 50Ω • Requires external power supply	• Higher Bandwidth than passive probes • Lower input capacitance than passive	Several GHz

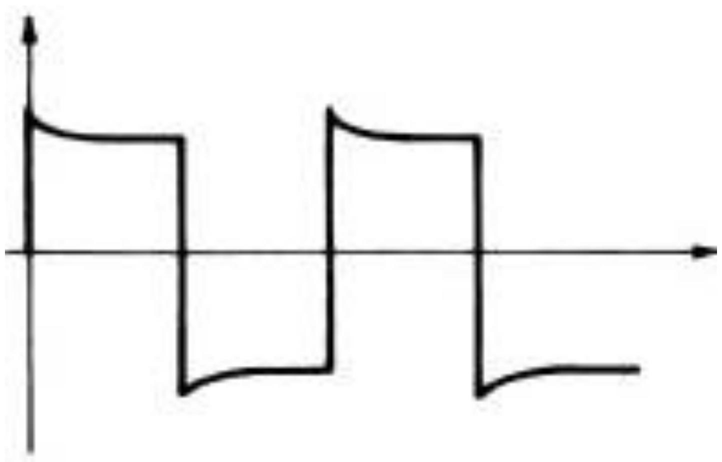
Passive Probe Attenuation

Attenuation Ratio	Description	Benefits
1:1	• Low bandwidth	• Designed for minimal loss • Easy to connect
10:1	• Also called divider or attenuating probes • Parallel resistor and capacitor built into the probe • Compensation required	• Wider bandwidth than 1:1 probe

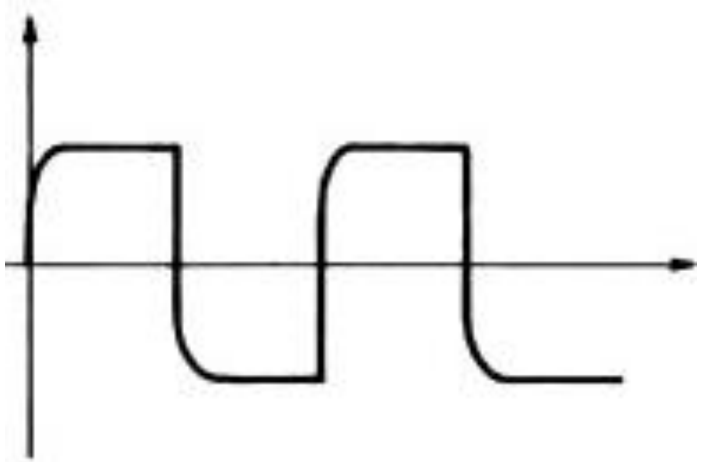


Probe Compensation

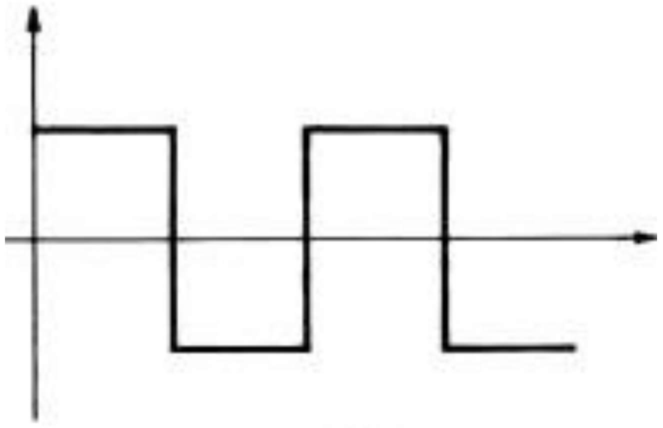
- The process to which the input capacitance of the scope is canceled by adjusting the value of the probe capacitor.



Overcompensated



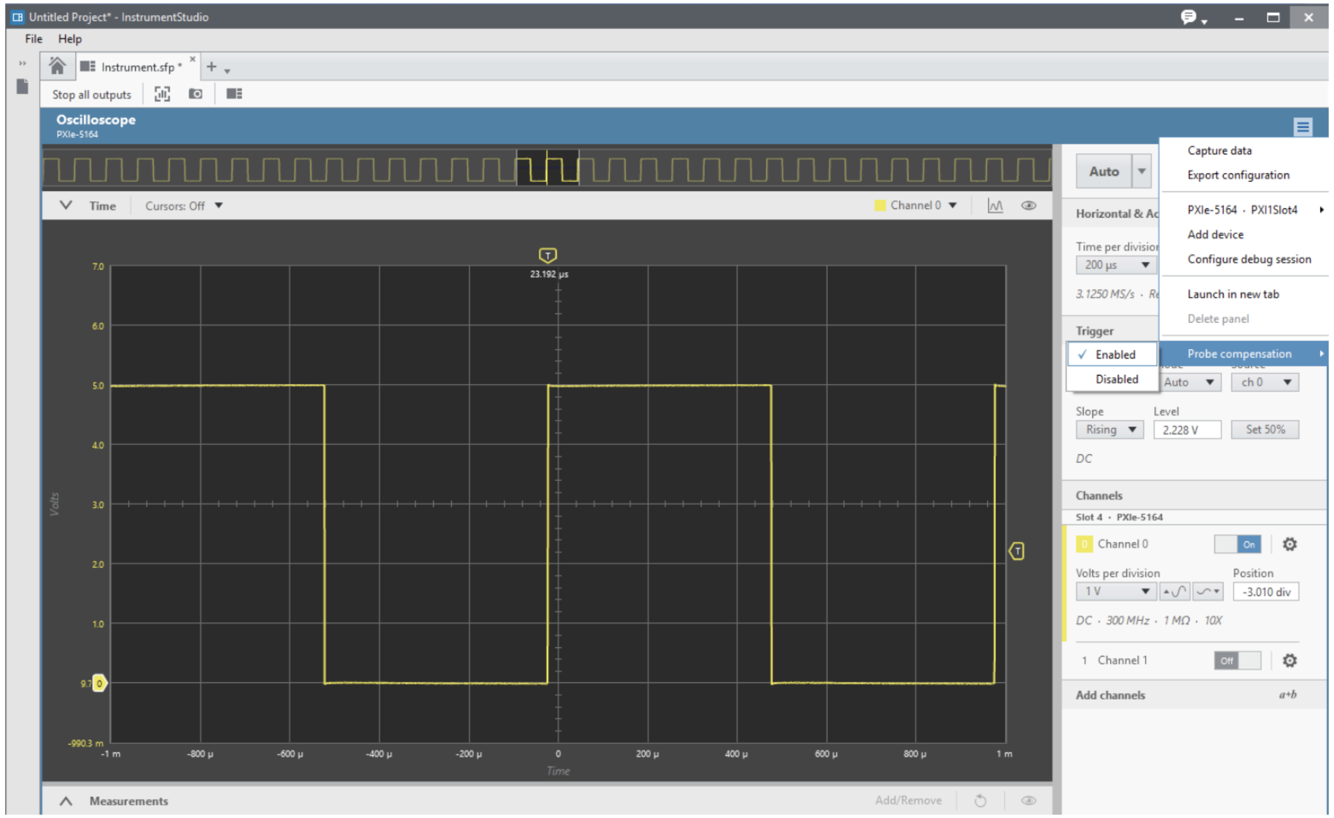
Undercompensated

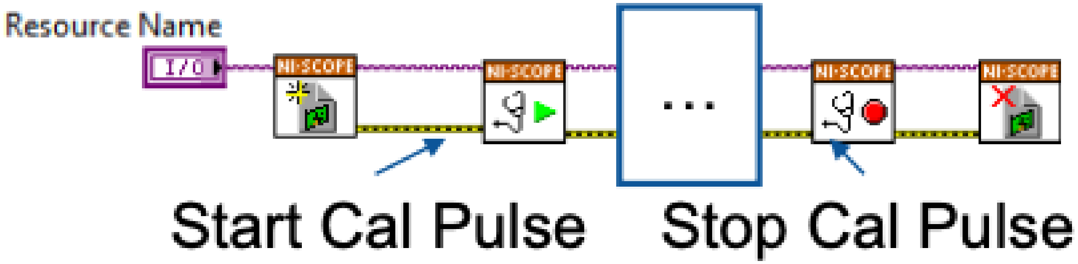


Properly Compensated

Probe Compensation

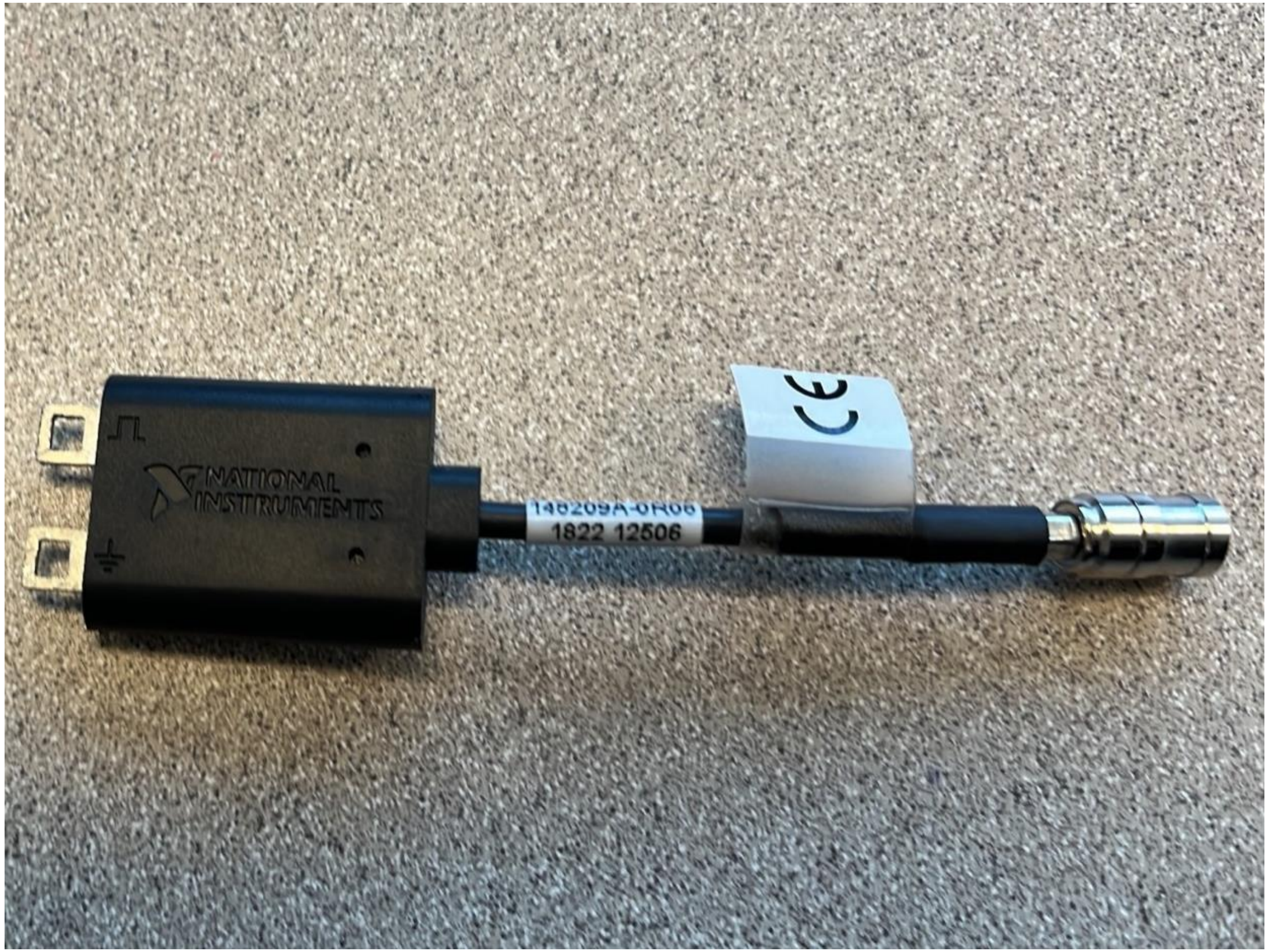
Calibration can be performed in either Instrument Studio or LabView





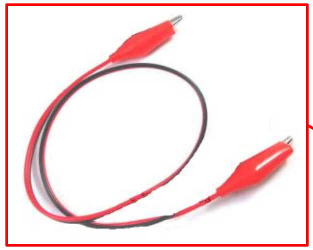
Calibration pulse once enabled can be generated on PFI0 or 1

Probe Compensation



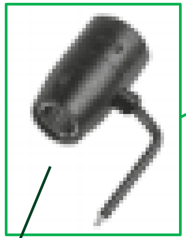
Minimize Ground Lead Inductance

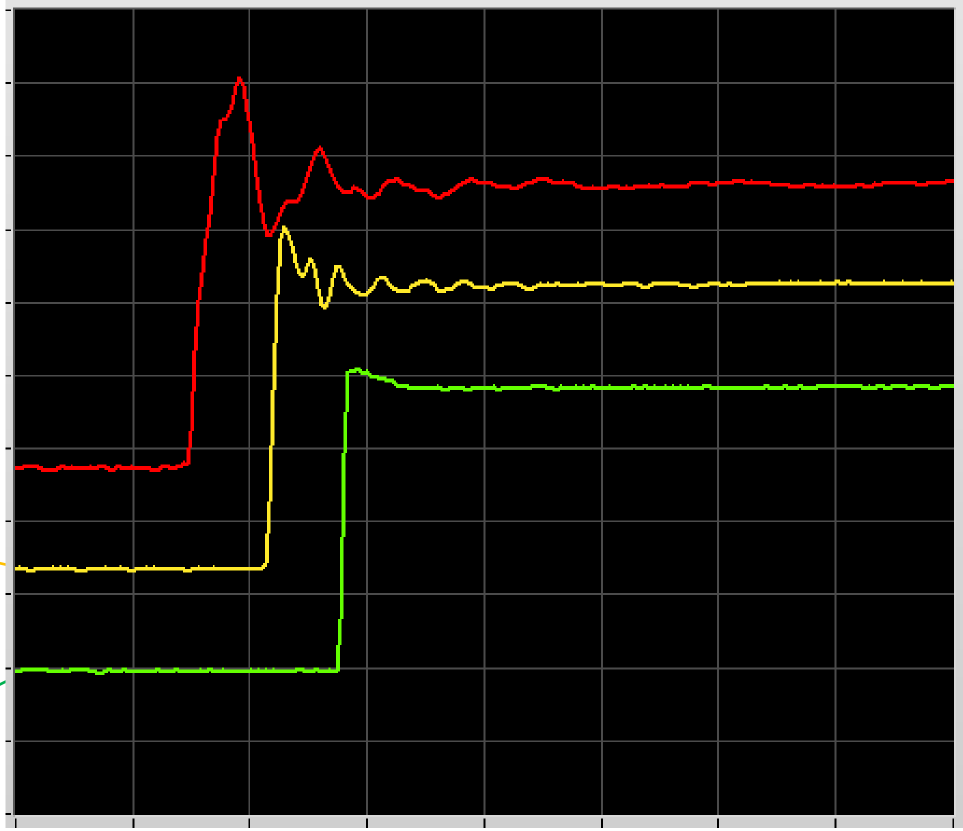
30cm clip lead



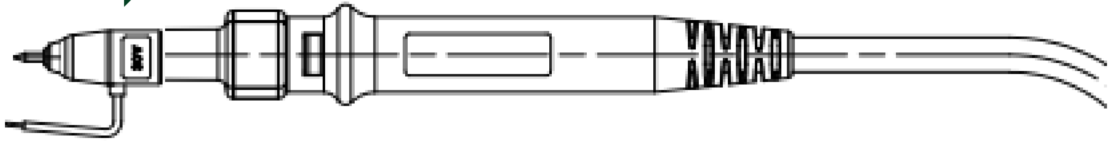
Reference lead with crocodile clip

Push-on reference contact **suppresses all ringing**.





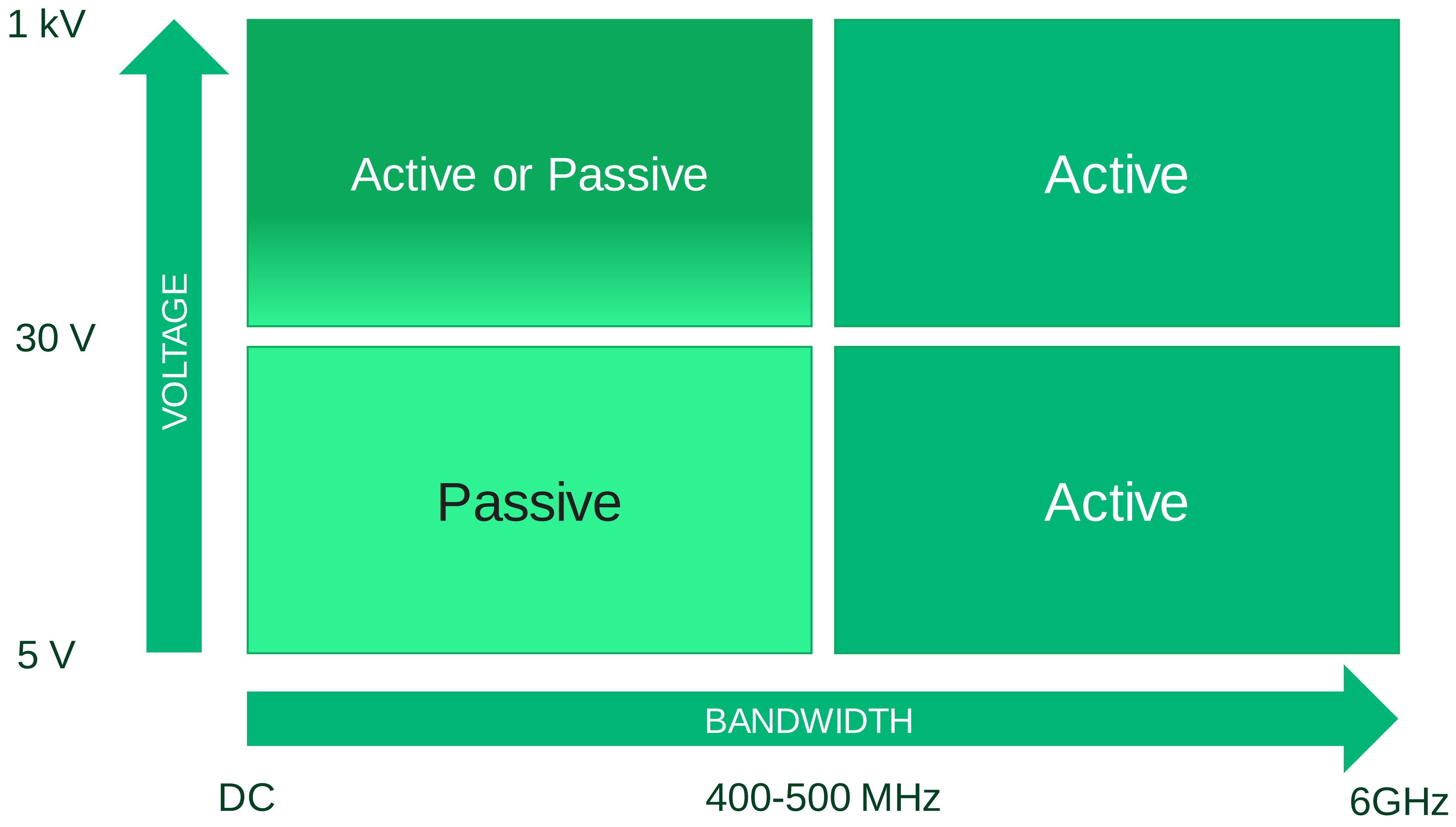
25ns/div



Active & Differential Probes

Probe Type	Description
Active Probes	• Use of buffer or amplifier inside of the probe • Require use of external power supply • Ideal for high-frequency measurements due to low input capacitance
Differential Probes	• Allow for measurements to be taken without a reference to the ground plane • Eliminates combining two channels for floating voltage measurements • Error specified in terms of CMRR

Types of Probes

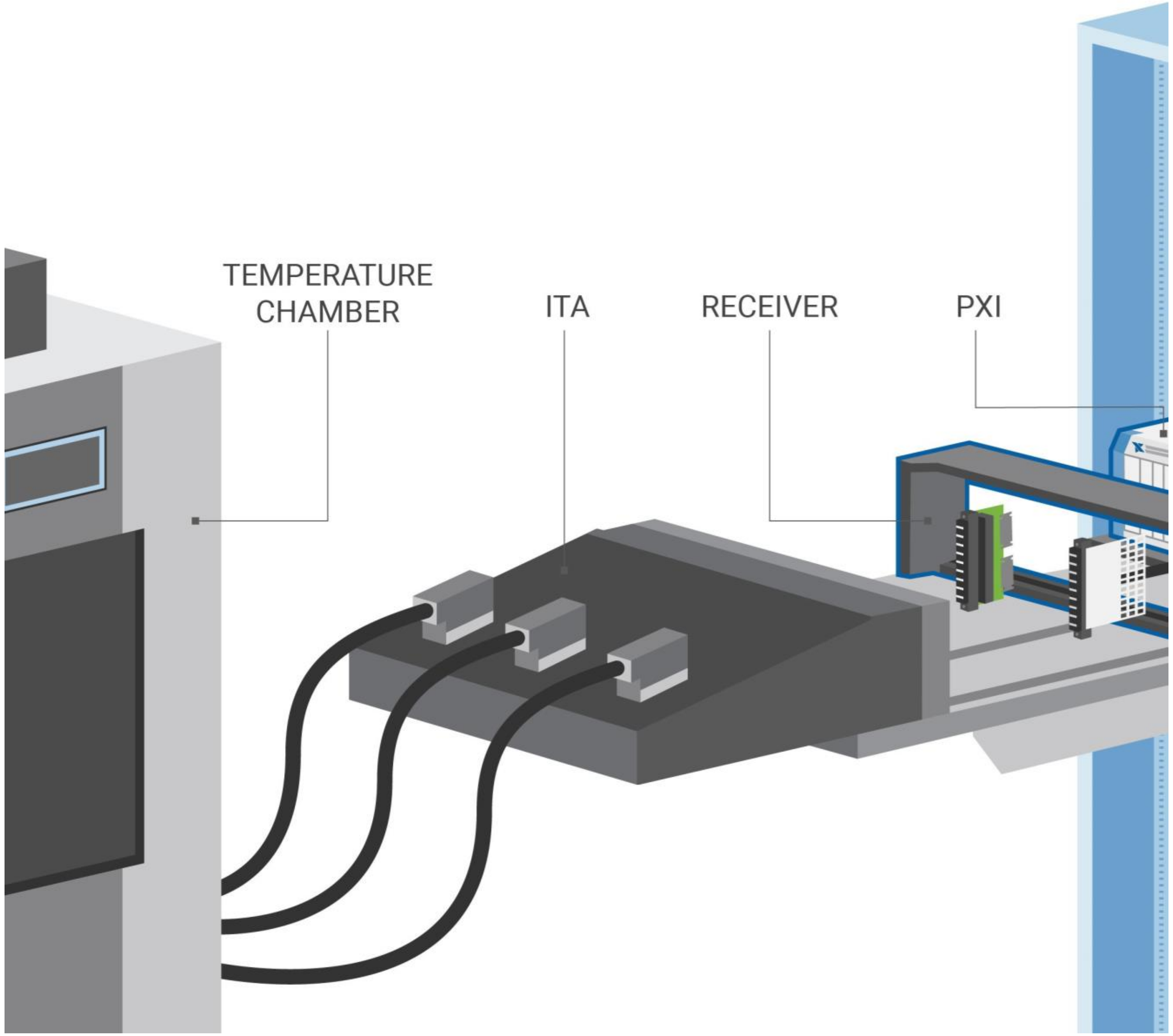


Current Probes

- Wire is inserted through the probe rather than a direct connection to the DUT
- NI's current probes capable of measuring both AC & DC
- Current probes utilize a Hall sensor
- Require use of external power supply

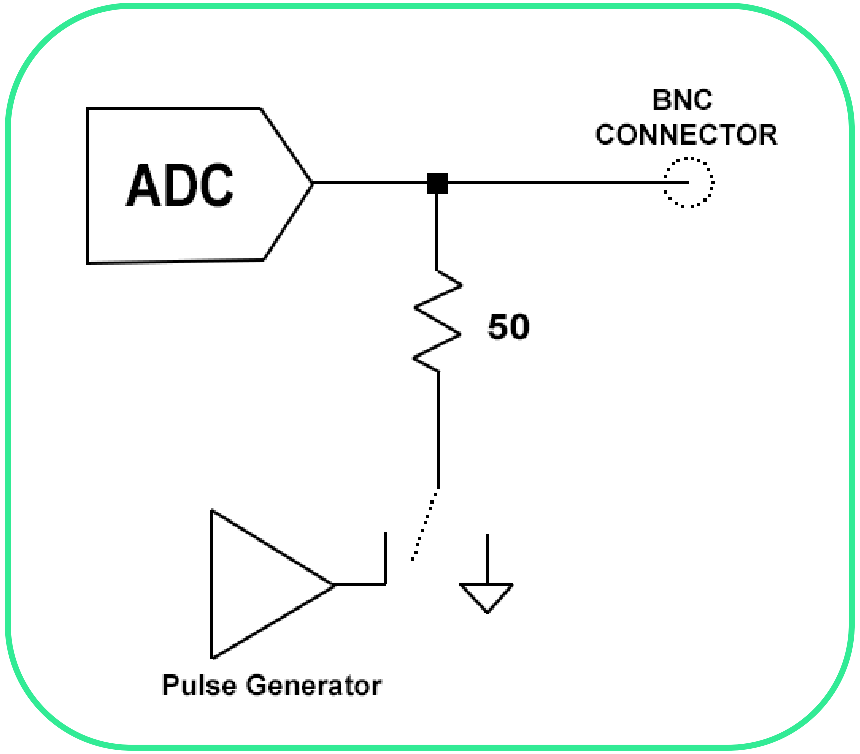
Avoiding Downtime with CableSense™

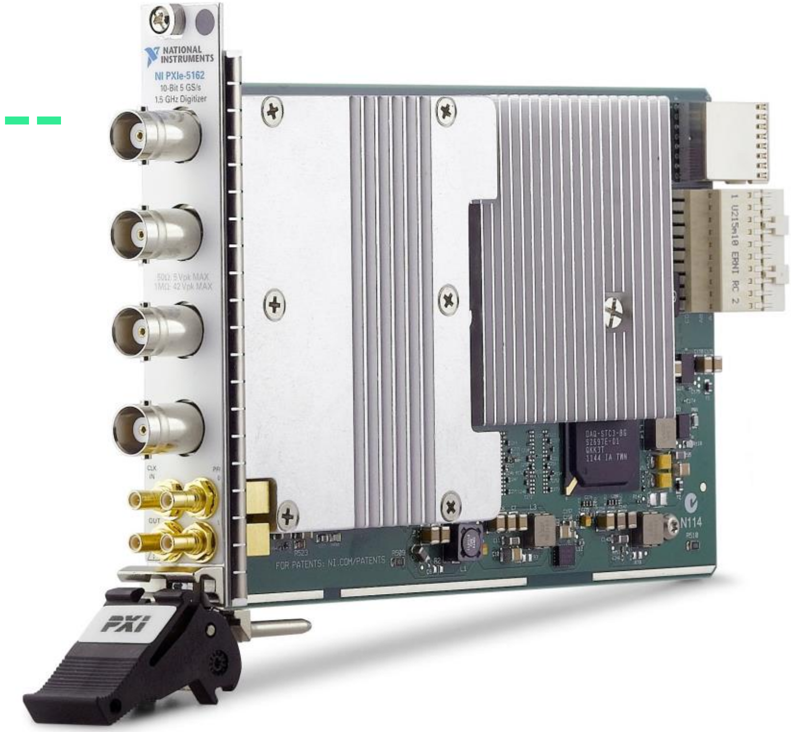
CableSense™ Overview



- Detect changes from a known, good setup with user-defined limit masks
- Identify loose cables, bad relays, bent pins, wrong cable lengths, etc.
- Qualify the integrity of measurements that follow
- Ensure test repeatability to prevent false failures
- Built-in functionality is a lower cost solution than dedicated TDR unit

CableSense™ Overview





Similar to a traditional TDR:

- PXI Scope will send pulse along electrical path
- Characterize impedance or reflection coefficient from reflected pulse
- Impedance/Reflection coefficient are then correlated to distance

CableSense™ vs. Traditional TDRs

CableSense™:

- No alteration to connections needed
- Built-in comparison logic allowing for automation of validation check
- Slower Rise Times
  - Hundreds of picoseconds to several nanoseconds
- Limited to oscilloscope bandwidth

Traditional TDRs:

- Connections must be altered manually limiting ability to automate
- No built-in comparison logic
- Faster pulse rise times
  - Tens of picoseconds
- Higher pulse sampling bandwidths

Supported Oscilloscopes & Digitizers

Scope Model	PXIe-5160	PXIe-5162	PXIe-5110	PXIe-5111	PXIe-5113	PXIe-5774
Oscilloscope 50Ω Path Bandwidth	500 MHz	1.5 GHz	100 MHz	350 MHz	500 MHz	3 GHz
CableSense Pulse Voltage	0.5 V	0.5 V	0.4 V	0.4 V	0.4 V	0.01 V
CableSense Pulse Rise Time	950 ps	650 ps	4 ns	1.6 ns	1.3 ns	550 ps

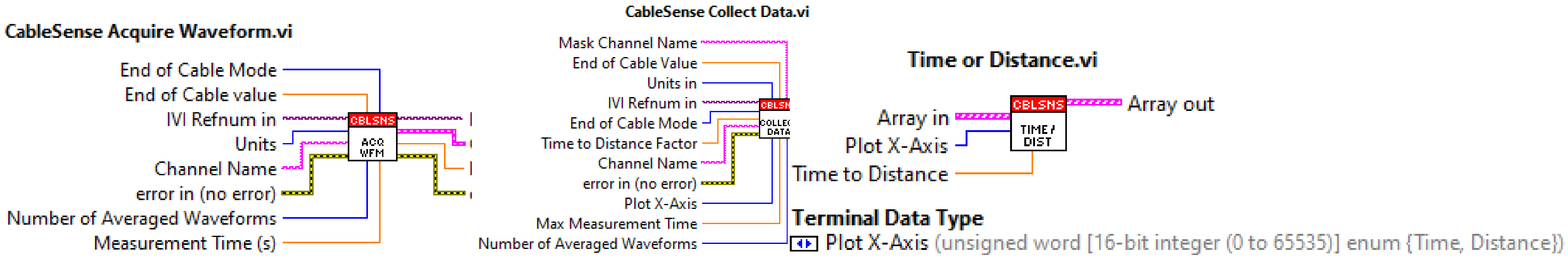
Setting Up CableSense™ in LabView

- Few SubVIs are required to in order to utilize CableSense™

CBLSNS Acquire Waveform SubVI sends out pulse down the line and acquires the reflected waveform.

CBLSNS COLLECT DATA SubVI compiles all data from the input waveform, cable distances, number of waveforms, etc into one cluster.

CBLSNS Time & Distance SubVI creates the x-axis for the mask plots using either time or distance.



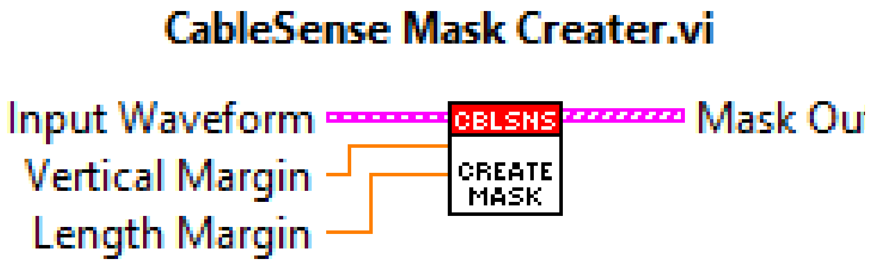
Setting Up CableSense™ in LabView

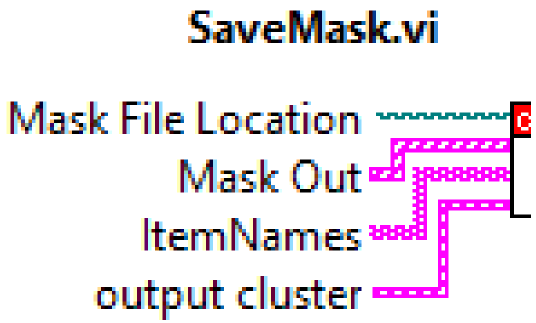
- Few SubVIs are required to in order to utilize CableSense™

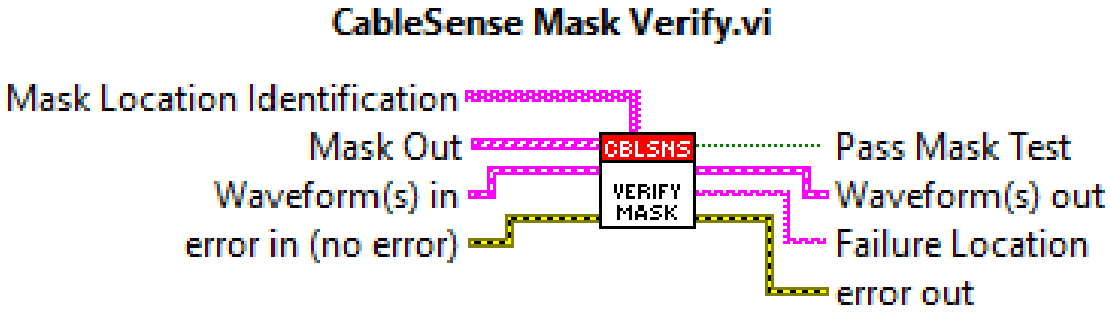
CBLSNS Create Mask SubVI creates the upper and lower masks from the input waveform.

CBLSNS Save Mask SubVI creates TDMS file for the masks.

CBLSNS Verify Mask SubVI compares the TDMS mask file to the newly acquired waveform.







CableSense™ Demonstration

In this demo:

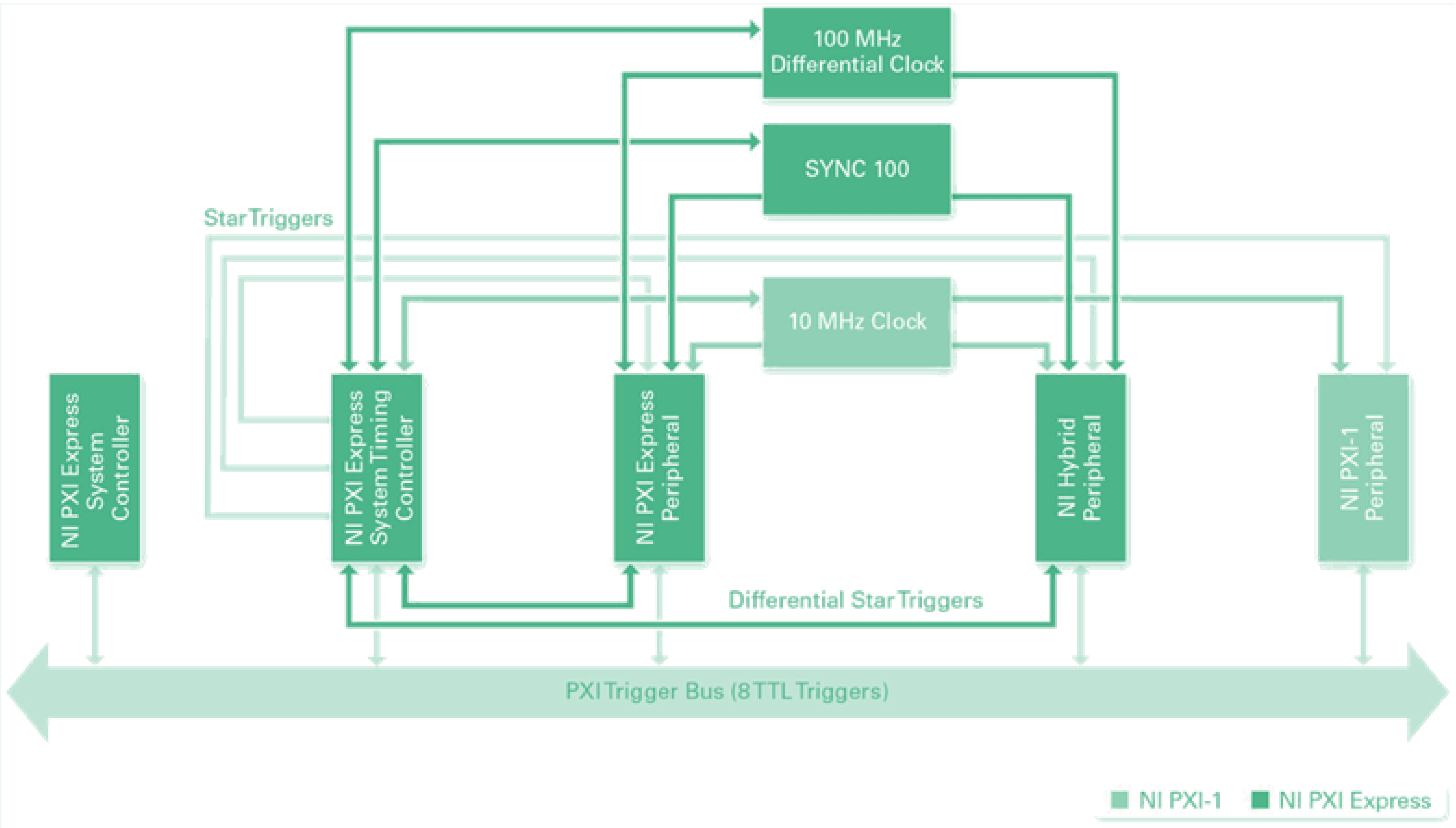
- Setting the parameters in the Create and Save Mask VI
- Saving the TDMS file to verify against
- Comparing three “test results” versus the proper mask setup

Mitigating Synchronization Issues with NI-TClk

Synchronization in NI Systems

Synchronization in the PXI Express architecture allows one to:

- Match time base & triggering of several instruments for channel expansion purposes



Synchronization Methods

There are several methods of synchronization between modules used in NI systems:

Software-Based

- Using software to send a trigger
- Accuracy: tens of milliseconds

Signal-Based

- Routing triggers and events.
- Accuracy: tens of nanoseconds

Time-Based

- Timing and sync card that uses GPS, IRIG-B, etc.
- Accuracy: under 100 nanoseconds

NI-TClk

- Compensation based on skew measurement
- Accuracy: 10-500 picoseconds

Introduction to NI-TClk

NI-TClk is used to:

- Align sample clocks, even when PLLs can't.
- Enable accurate triggering of synchronized devices.

Instances where implementing NI-TClk may be the optimal solution for your system:

- System requires more simultaneous channels than a single modular instrument can provide
- Synchronization of two different instruments such as a Scope and AWG are required to characterize a DUT
- Simply exporting and sharing a clock and/or trigger works for DAQ boards, but the small error that remains is significant for High-Speed Devices

Using NI-TClk API

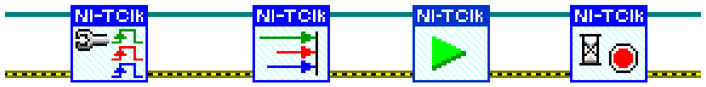
Although TClk is a complex technology, using TClk requires only a few function calls.

- Use **Get Session Reference VIs** to build an array of references to instruments that require synchronization.

niScope Get Session Reference.vi

- **niTClk Configure For Homogeneous Triggers VI** configures reference clock and trigger properties for all the instruments.
- **niTClk Synchronize VI** performs the synchronization sequence.
- **niTClk Initiate VI** initiates all devices (no need to call each of the instrument initiates individually).

niTClk Configure For Homogeneous Triggers.vi niTClk Synchronize.vi niTClk Initiate.vi



NI-TClk Pros

NI-TClk offers many advantages over the other means of synchronization. Some of those are:

- Sub-nanosecond synchronization of 2 or more PXI devices.
- Clocks do not need to be running at the same rate if the onboard clocks are used.
- Can use an externally supplied sample clock, however all devices must then run at the same rate.
- All the hard work is done automatically – no need to understand it to use it.

For more on NI-TCLK,

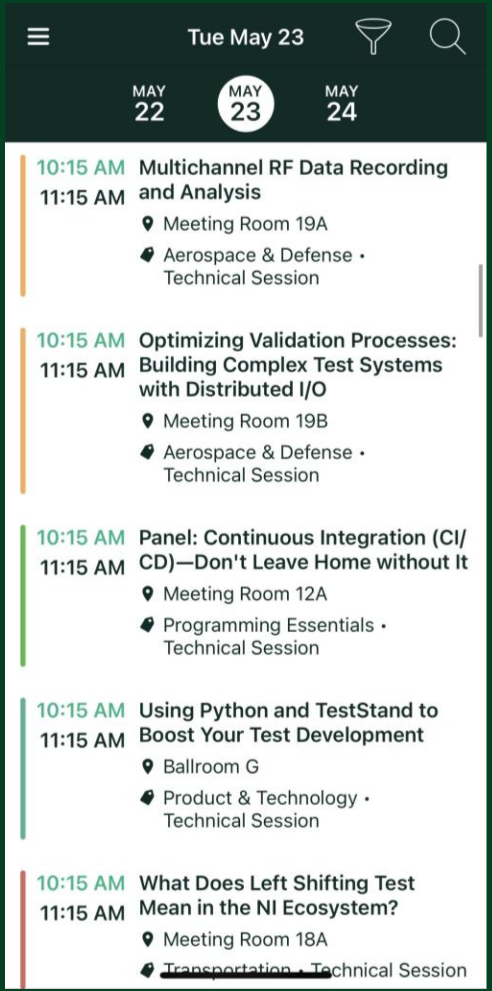
come back after lunch for the technical session from James Thornton

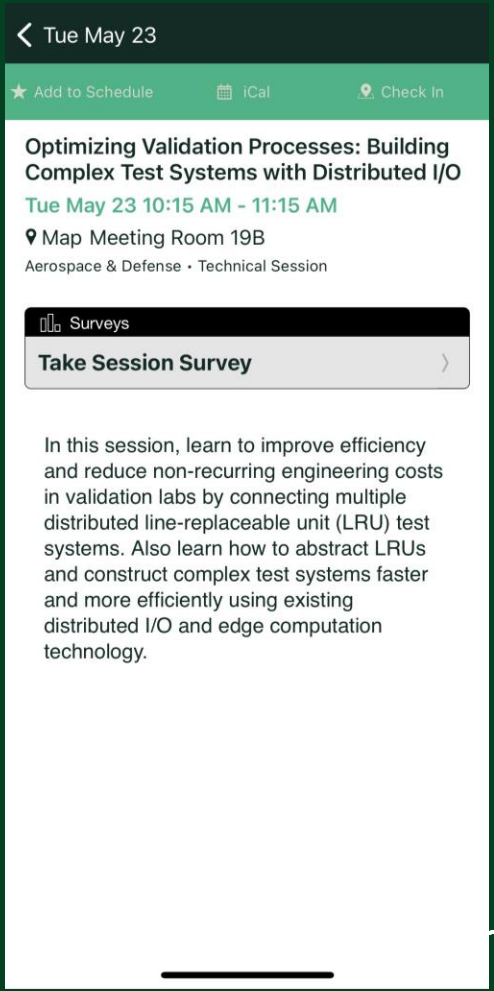
NI CONNECT

2023 AUSTIN

Give us your feedback!
Quick 2 Question Survey

In the mobile app, click into the session you would like to provide feedback for





Click “Take the Session Survey”

Appendix

Reference Links and Materials

Helpful Links

Top Ten Things to Consider When Choosing an Oscilloscope or Digitizer:

https://www.ni.com/en-us/shop/electronic-test-instrumentation/oscilloscopes/top-10-things-to-consider-when-selecting-a-digitizer-oscilloscop.html

Selecting the Right Probe for Your Application White Paper:

https://www.ni.com/en-us/shop/electronic-test-instrumentation/oscilloscopes/what-are-oscilloscopes/select-the-right-oscilloscope-probe-for-your-application.html

Helpful Links

CableSense White Paper:

https://www.ni.com/en-us/shop/electronic-test-instrumentation/oscilloscopes/what-are-oscilloscopes/avoid-test-system-downtime-with-cablesense--technology.html

CableSense Project to Help You Get Started:

https://forums.ni.com/t5/Example-Code/Utilizing-CableSense-in-a-Test-Environment/ta-p/3893957

NI-TClk White Paper:

https://www.ni.com/en-us/shop/pxi/national-instruments-ni-tclk-technology-for-timing-and-synchroni.html

Scope & Probe Compatibility Chart

NI Oscilloscope	PXIe-5105	PXIe-5110	PXIe-5111	PXIe-5113	PXIe-5114	PXIe-5122	PXIe-5160	PXIe-5162	PXIe-5163	PXIe-5164	PXIe-5170	PXIe-5171	PXIe-5172	PXI-5922
Scope Connector	SMB	BNC	BNC	BNC	BNC	BNC	BNC	BNC	BNC	BNC	SMA	SMA	SMB	BNC
Single Ended Passive Probe														
SP400x		Y	Y	Y	-	-	Y	Y	Y	Y	-	-	Y	
SP500c		Y	Y	Y	-	-	Y	Y	Y	Y	-	-	Y	
CP500x		Y	Y	Y	-	-	Y	Y	Y	Y	-	-	Y	
CP400x		Y	Y	Y	Y	Y	Y	Y	Y	Y	-	-	Y	
Single-Ended and Differential Active Probes														
SA1000x	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SA1500x	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SA2500x	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
DA200025x	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Current Probe														
CC0550x	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
CC05120x	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
CC15010x	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
CC30100X	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
CC3050X	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Rise Time

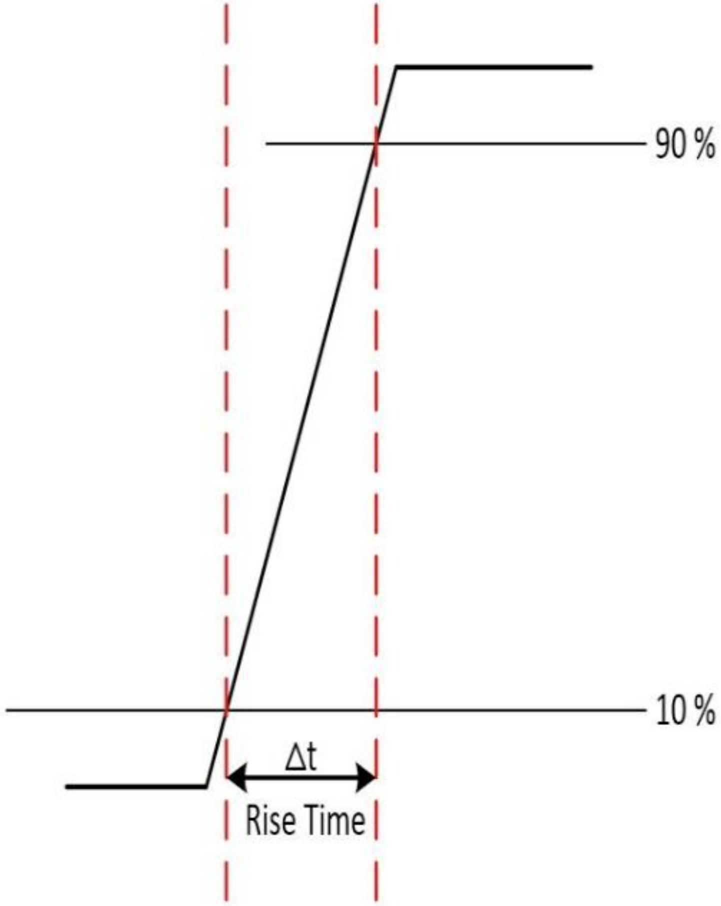
rule of thumb : $t_r = \frac{k}{BW}$

k ~ 0.35: BW<1 GHz (typically)

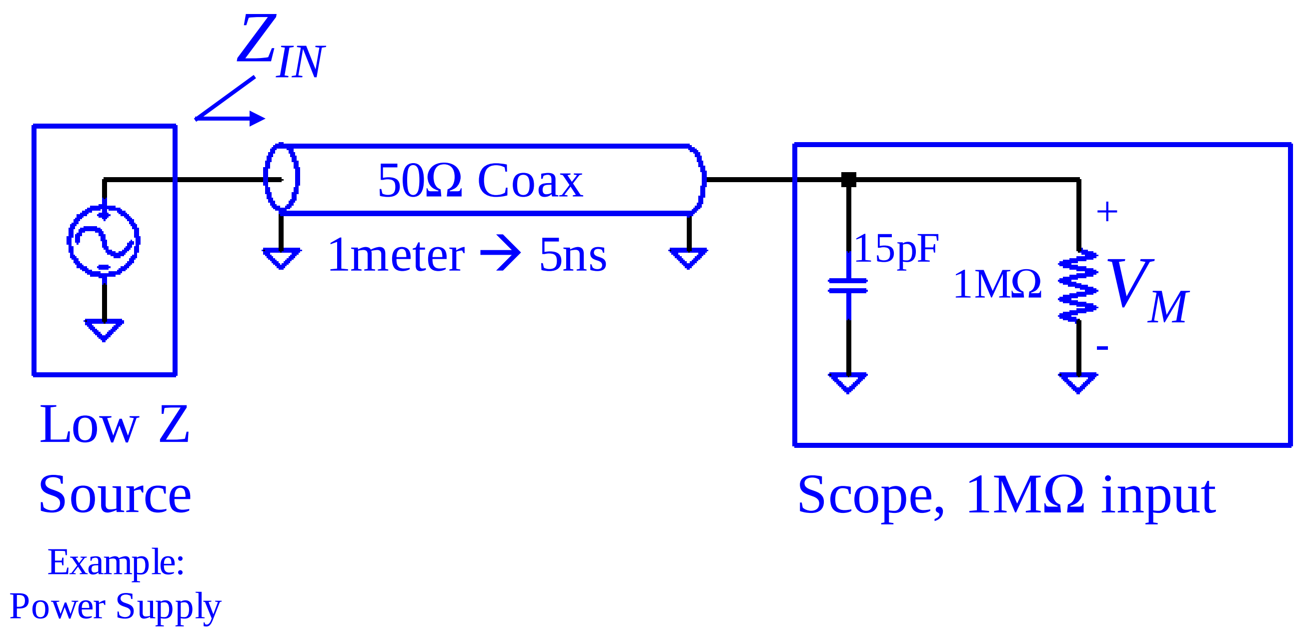
k ~ 0.45: BW≥1 GHz (typically)

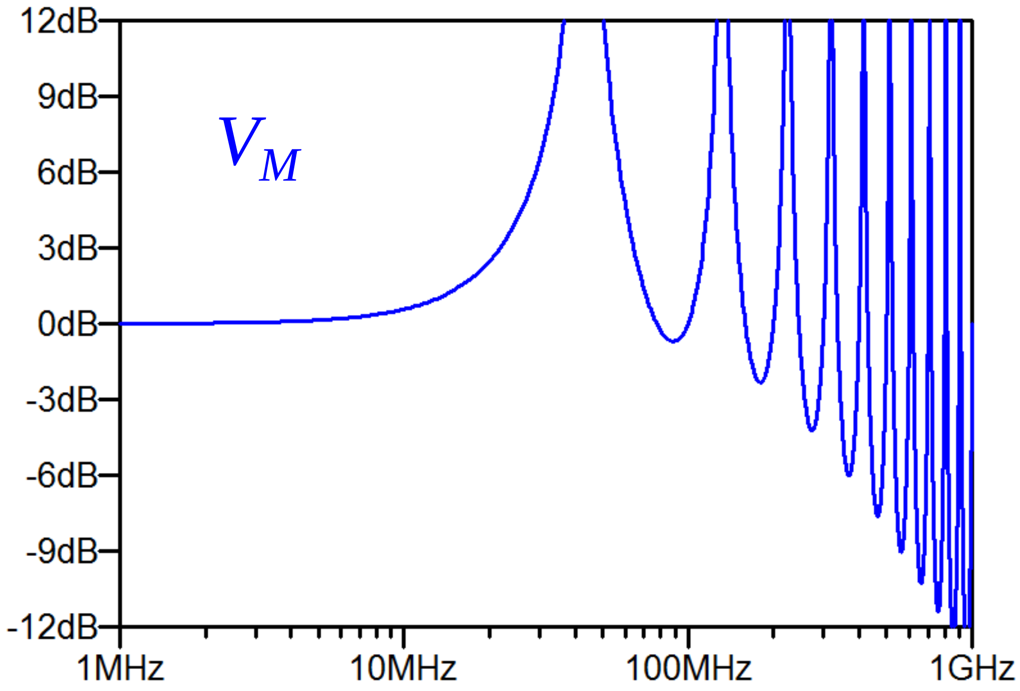
$$t_{r_{system}} = \sqrt{t_{r_{scope}}^2 + t_{r_{probe}}^2}$$

$$t_{r_{measurement}} = \sqrt{t_{r_{system}}^2 + t_{r_{signal}}^2}$$



Coax Cable, No Terminations





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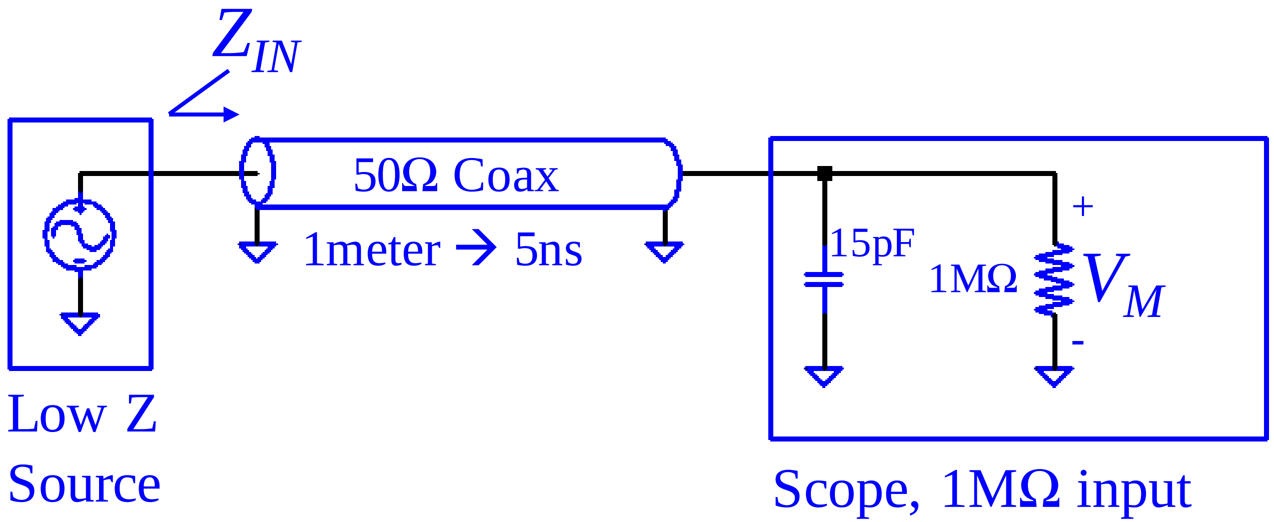
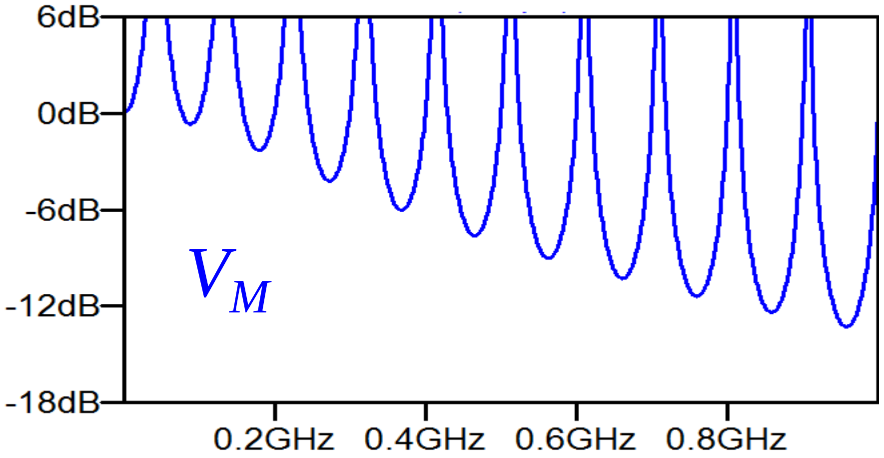
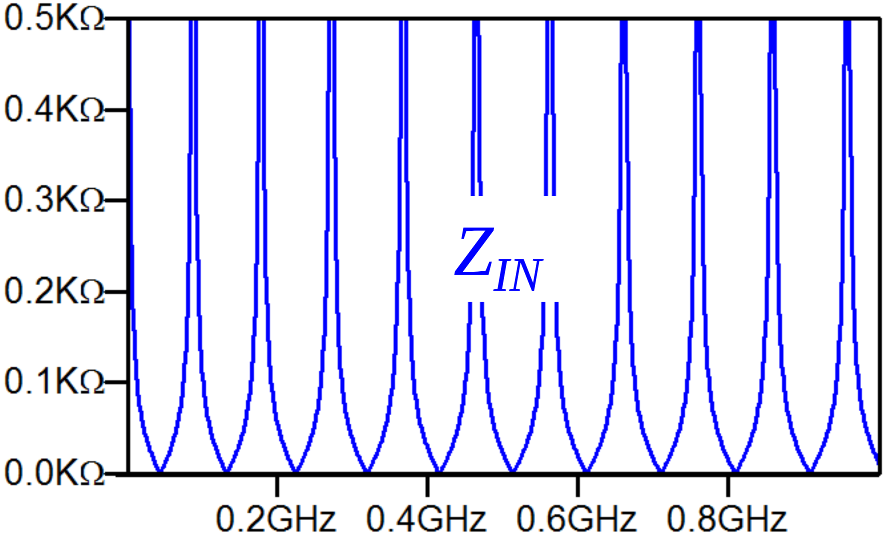
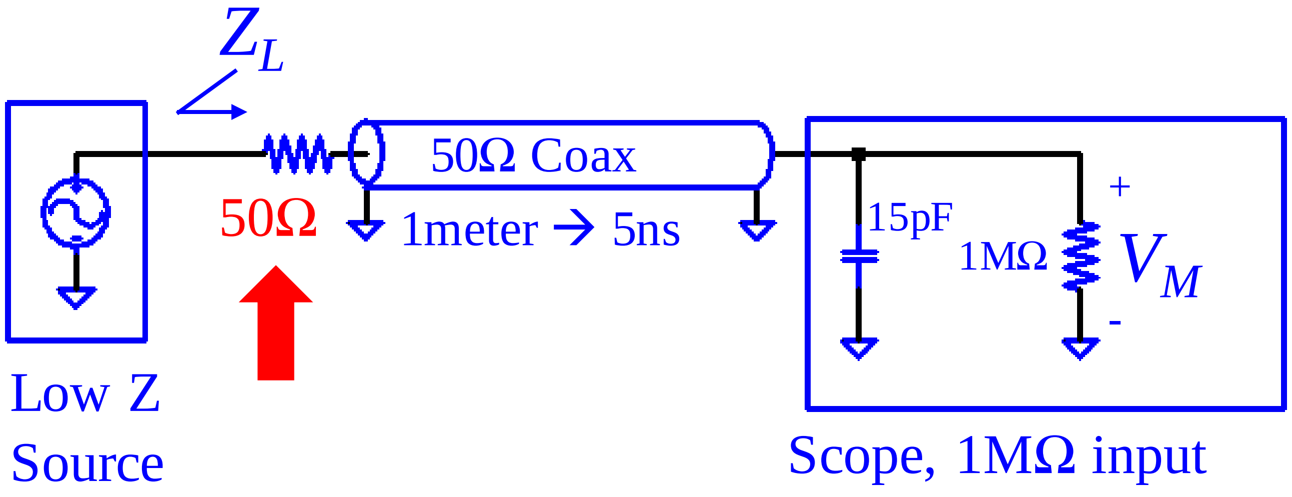
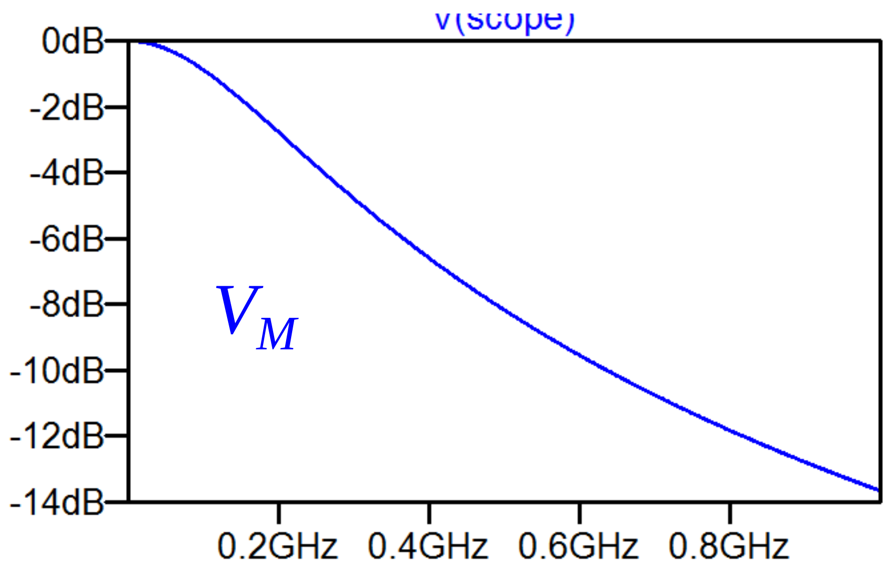


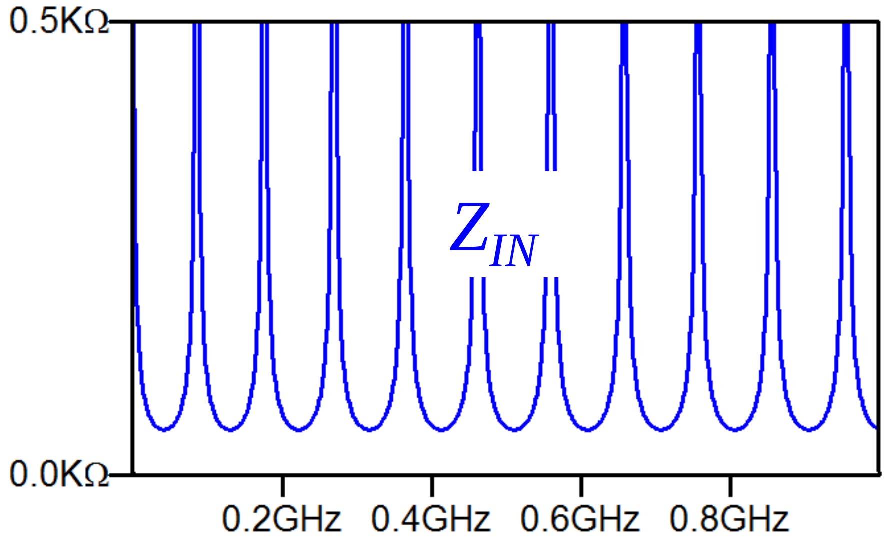




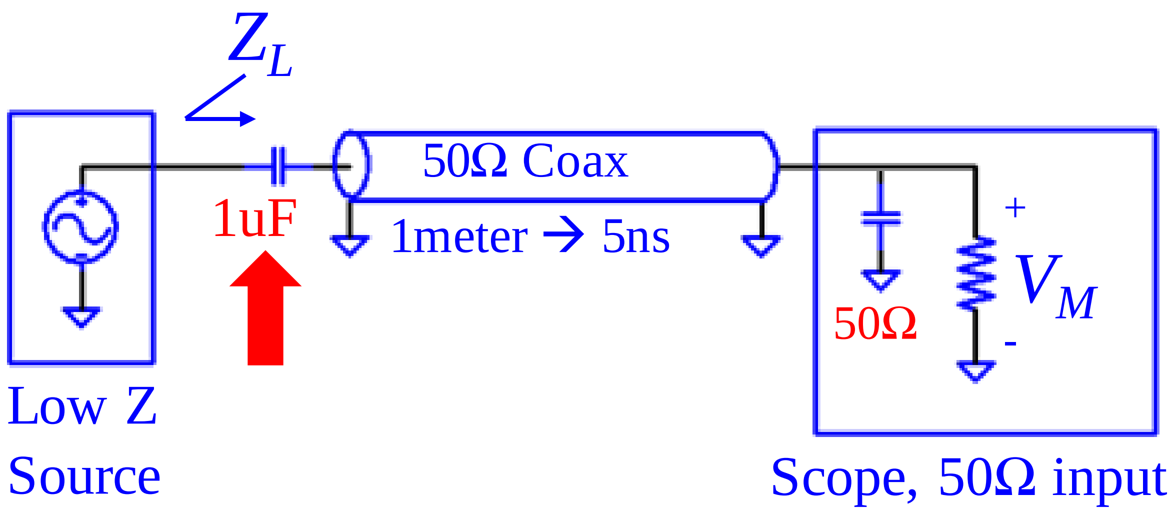
Coax Cable, Back Termination

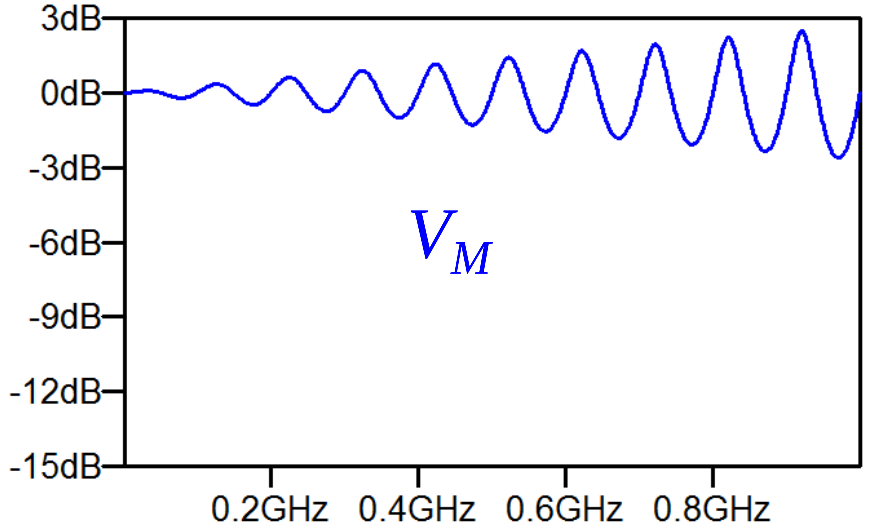


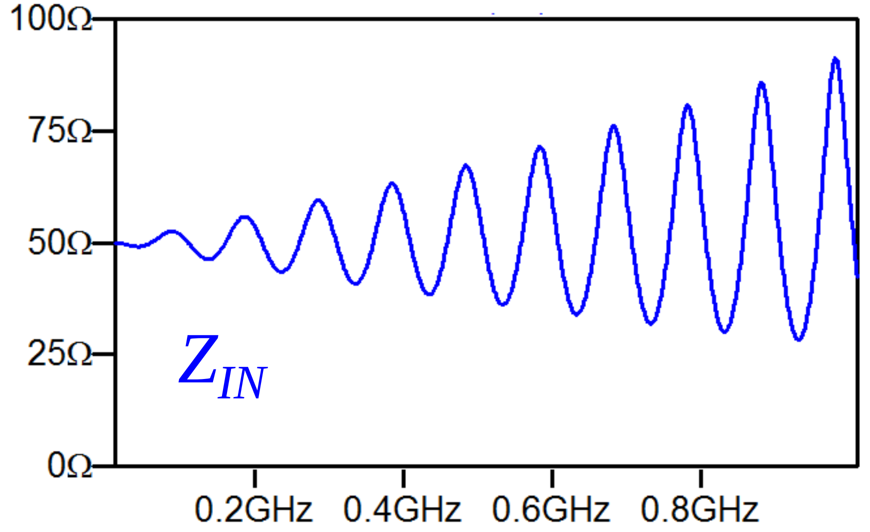




Coax Cable, End-Termination







Coax Cable, End-Termination