ValiFrame
USB Type C Cable and Connector Test Automation

Method of Implementation

The ValiFrame Test Automation software provides physical testing of USB Type-C connectors and cable assemblies with test instruments listed in 1. The tests are implemented according to the requirements of the “Universal Serial Bus Type-C Cable and Connector Specification Revision 1.1”, “Universal Serial Bus Type-C Connectors and Cable Assemblies Compliance Document 1.0” and “Keysight Method of Implementation (MOI) for USB Type-C™ Connectors and Cables Assemblies Compliance Tests”. The software *also offers some custom characterization tests to provide more details on DUT behavior beyond the limits of the specification.*

The software *supports automatic control of* the *Keysight E5071C ENA Series Network Analyzer.* It calibrates the stress conditions and controls all test electronic equipment for automated measurements.

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Required Test Instrumentation

The following table lists all the hardware required.

Product	Description	Quantity
E5071C	Economic Network Analyzer (ENA)	1
E5071C-4K5	Option 4K5 (20 GHz). 300 KHz to 20 GHz range up to 4-port S-parameter test set	1
E5071C-TDR	Option TDR Enhanced Time Domain Analysis. Enhanced Time-Domain analysis with real-time simultaneous Time-Domain and Frequency-Domain measurements	1
83059B	Coaxial adapters for E5071C	4
N4433A	ECal Electronic calibration module (4-port, 20 GHz)	1
E5071C-810	Keyboard	1
E5071C-820	Mouse	1
BIT-1040-0070-0	USB 3.1 and Type C Complete Cable and Receptacle Assembly Test Fixture Kit	1
BIT-1005-0002-0	50 Ohm SMA Termination.	8
Additional Hardware		
BIT-4040-0000-1	USB Type-C Cable Test Switch System Bundle. Contains all the needed different cables alongside with the Switch System. "Plug and Play" Option It comprises:	1
BIT-4000-2190-0	2100 Series Switch System Bundle, 4x 6:1 Modules, Terminated, 6x 2:1 Module, Unterminated, DC to 26.5 GHz.	1
BIT-1005-0000-0	SMA Snap-On Connectors.	4
BIT-1004-0009-0	Matched Cable Pairs for Fixtures connections to ENA and Switch	9
BIT-1004-0011-0	GP High Performance Machted Cable Pairs, SMA (m), 45 cm for Switch to Switch connection	6
BIT-1005-0002-0	50 Ohm SMA Termination.1 in addition to the above mentioned position	8

Table 1: Instrumentation Requirement List

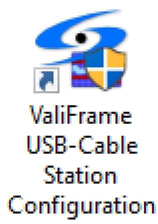
Required Software

1. Windows XP or 7 operating system
2. Current Keysight IO libraries
3. .Net Framework redistributable 2.0
4. E5071C firmware revision A.11.31 or above (Windows XP), or B.13.01 or above (Windows 7)
5. E5071C-TDR application software revision A.01.57 or above (Windows XP), or B.02.02.00.00 or above (Windows 7)
6. N5990A-010: Test Sequencer (if not already an exiting N5990A customer)
7. BIT-2001-0002-0: ValiFrame Option 002 – Switch System support, when using the Switch System
8. BIT-2041-0402-1: ValiFrame Option 402 – USB CabCon Test Software for Keysight ENA-TDR
9. BIT-2041-9402-1: ValiFrame Option 9402 – USB CabCon Test Software for Bundle Keysight ENA-TDR (comprises BIT-2001-0009-0 and BIT-2011-0402-0)
10. BIT-2041-0032-0: ValiFrame Option 032 – USB CabCon Test Software Bundle Upgrade to Current CTS for Keysight ENA-TDR (requires previous purchase of BIT-2001-0009-0 and BIT-2011-0402-0 or BIT-2041-9402-1)

System Setup and Operation

Step 1. Configuring the Station

First step, prior to start with the testing, is to choose the instruments setup and connect to them. Then start the ValiFrame USB-Cable Station Configuration software by clicking on the icon or acceding from “All Programs/ BitifEye / USB-Cable / ValiFrame USB-Cable Station Configuration”.



1. In the Station Selection window the USB Cable Test Station option is pre-selected. Some settings can be selected here such as:

- Database Option: When the N5990A opt. 001 was purchased, the interface to SQL is available and the test configurations and results will be saved on the server.
- Results Viewer: Select here the test results to be represented in Excel or HTML format.
- Sounds: Configure the sound options

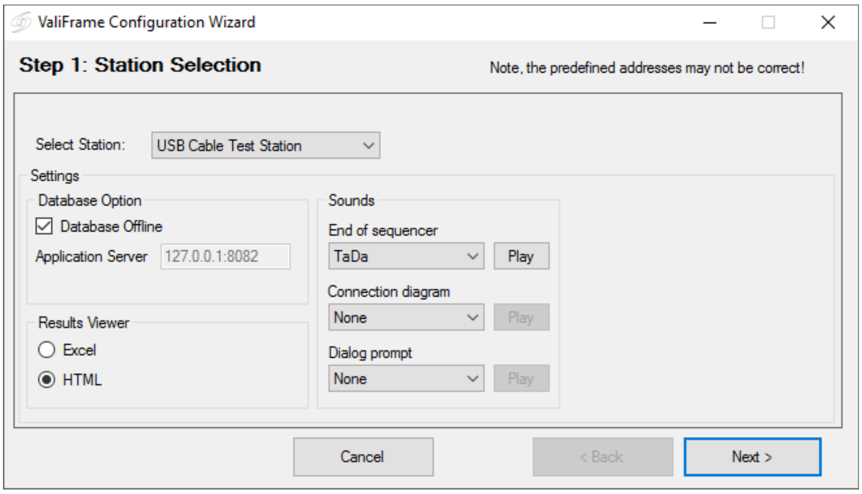


Figure 1: Station Selection dialog

2. After pressing "Next" the Station Configuration window allows to select the instrument setup.

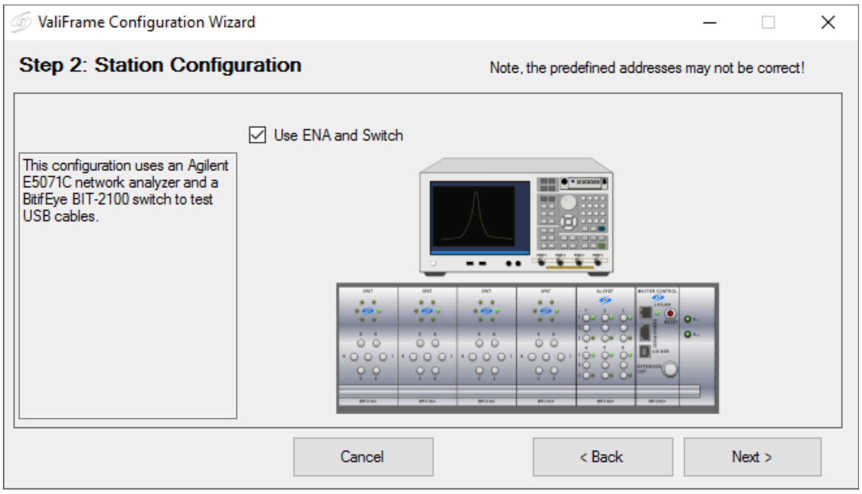


Figure 2: Station Configuration dialog

5071C ENA

The system configuration must include a Keysight E5071C network analyzer. It performs all the connectors and cable assemblies measurements required per USB Type-C.

BIT-2100 Switch

The ENA can be complemented with a BitifEye BIT-2100 switch.

The use of the switch highly reduces the number of necessary re-connections in the setup. Therefore there will be a highest level of test automation, fastest test execution and ultimately a shortest test time.

To add the switch in the configuration check the “Use ENA and Switch” option.

3. Once the desired setup is selected continue to the instrument configuration window. Here all the instruments that need to be connected are listed.

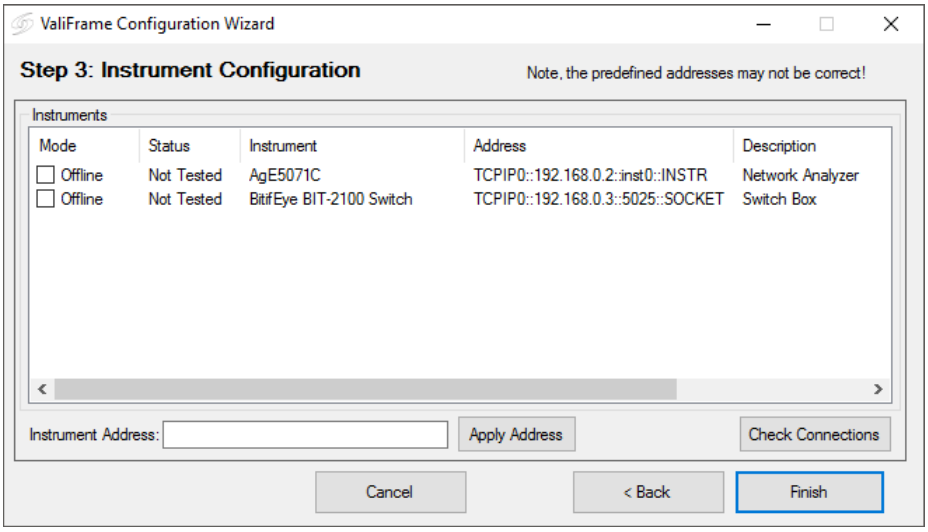


Figure 3: Instrument Configuration dialog

All instruments are configured by default in “Offline” mode. In this simulation mode, hardware does not need to be physically connected to the test controller PC. ValiFrame can not connect to any instrument in this mode. In order to control the instruments that are connected to the PC, the instrument address must be entered. The address depends on the bus type used for the connection, for example, GPIB (General Purpose Interface Bus) or LAN (Local Area Network). The Keysight E5071C ENA requires a VISA (Virtual Instrument System Architecture) connection. To determine the VISA address, run the “VISA Connection Expert” (right-click on the Keysight IO Control icon in the task bar and select the first entry “Keysight Connection Expert”). Enter the instrument addresses in the “Station Configuration Wizard”, for example, by copying and pasting the address strings from the Connection Expert entries. After the address strings have been entered, click on the “Apply Address” button before checking the “Offline” box to set the instruments needed to be online and then press “Check Connections” button to verify that the connections for the instruments are established successfully. If anything is wrong with the instrument address, a window is displayed with a message describing the problem.

Step 2. Configuring the DUT

After the Station is configured open the ValiFrame USB Cable software by clicking in the icon or acceding from “Start / All Programs / Bitifeye / USB-Cable / ValiFrame USB Cable”.

First step in ValiFrame is to configure the DUT and test options. Click on the “Configure DUT” button to open the dialog.

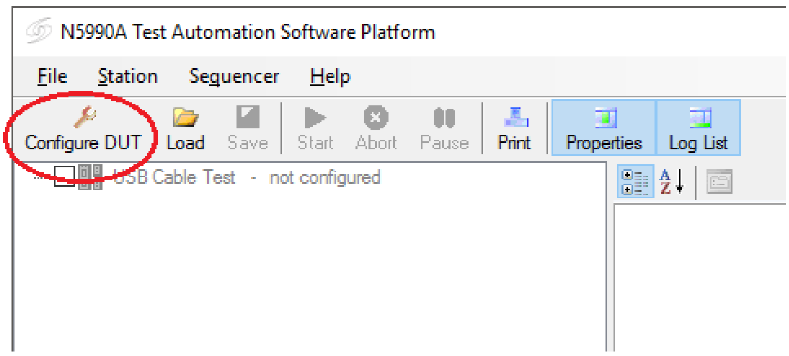


Figure 4: Selecting Configure DUT

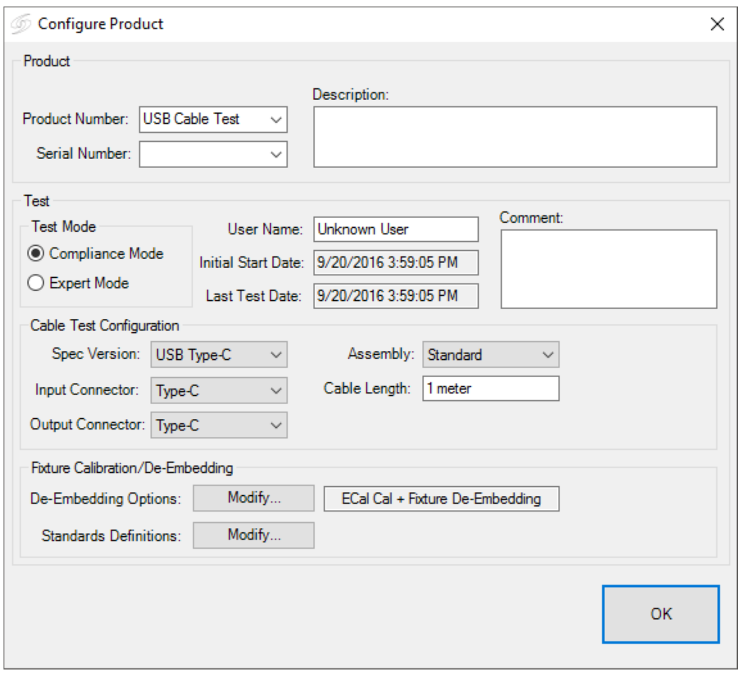


Figure 5: Configure DUT dialog

Here different properties can be selected as describe bellow:

Product parameters

- **Product Number**: Used to identify the product when database option is selected.
- **Serial Number**: Used to identify the product when database option is selected.
- **Description**: Description of the product.

Test parameters

- **User Name**: User name text field.
- **Comment**: Text field for user comments.
- **Initial Start Date**: Time stamp of the start of the current test session.
- **Last Test Date**: Time stamp of the last test conducted in the current session.
- **Compliance Mode**: In this mode, the tests are conducted as mandated by the CTS, the test parameters used in the calibration and test procedures are shown but cannot be modified by the user.
- **Expert Mode**: Calibrations and tests can be conducted beyond the limits and constraints of the CTS; the test parameters used in the calibration and test procedures can be modified by the user.

Cable Test Configuration

- **Spec Version**: The USB specification can be selected as USB 2.0, USB 3.0, USB 3.1 or USB Type-C. For the purpose of this MOI select USB Type-C.
- **Assembly**: Can be selected as:
    - Standard (Type C to Type C Cable Assemblies)
    - Legacy Cable (Type C to Legacy Cable Assemblies)
    - Legacy Adapters (Type C to Legacy Adapter Assemblies)
- **Input Connection**: For USB Type C spec the input connector is always Type-C.
- **Output Connection**: Depends on the selected assembly:
    - For standard assembly the output connector is always Type-C
    - For Legacy Cable assembly the output connector can be Standard-A, Standard-B or Micro-AB.
    - For Legacy Adapters assembly the output connector can be Standard-A or Micro-AB.
- **Cable Length**: Set here the cable length

- **De-Embedding options**: In order to remove the fixture trace effect, two calibration methods are available:
    - Use Ecal Calibration + Fixture De-Embedding Files
    - Use TRL Calibration (not available for with the Switch System)

The calibration method can be selected in the “Fixture De-Embedding Options” dialog:

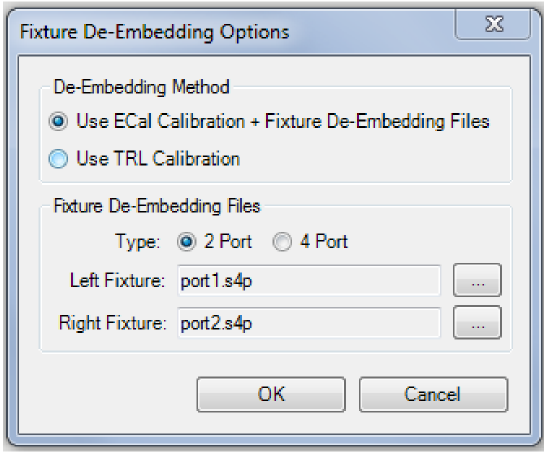


Figure 6: Fixture De-Embedding Options

If the “Ecal Calibration + Fixture De-Embedding Files” method is selected, the effect of the fixture is removed by de-embedding the fixture traces with S-parameter files.

The De-Embedding files must be selected for the left and right fixtures in the “Fixture De-Embedding Options” dialog.

- **Standards definitions**: The Standards Definitions dialog allows to set the values of the different standards.

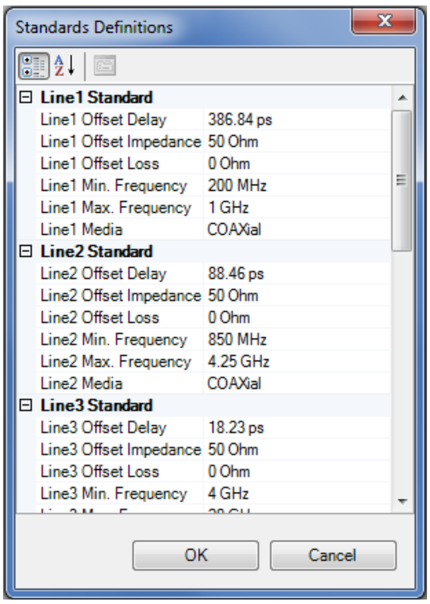


Figure 7: Standard Definitions dialog

Step 3. Selecting Procedures

When the Configure DUT dialog is closed, the ValiFrame main window shows the corresponding test tree:

- Calibrations
- High Speed Measurements
  - First SS Pair Measurements
  - Second SS Pair Measurements
  - Shielding Effectiveness

All the procedures can be selected globally by clicking on the check box at the top of the group. Alternatively, you can expand each test group with the '+' marker in front of each group so that the individual procedure can be selected by checking the specific selection boxes in front of the tests. Only the procedures which are selected will be executed.

Calibrations

Before any cable test procedure can be run, the USB Cable test system must be calibrated. The purpose of the calibrations is to calibrate the RF effects such as delay, loss or mismatch of RF cables and test fixture traces before measurements.

The calibrations needed depends on the three possible scenarios:

1. No switch and De-Embedding option: "Use ECal Calibration + Fixture De-Embedding File"

- ENA Initial Configuration. Besides the ENA initialization, it performs the ECal calibration for time and frequency domain.
- Rise Time Adjustment

2. No switch and De-Embedding option: "Use TRL Calibration"

- ENA Initial Configuration. Besides the ENA initialization, it creates the calibration kit file which contains the selection of the TRL standards to be calibrated.
- TRL Calibration: It measures the TRL calibration standards such as Thru, Short, Lines or Load. The calibration is performed for time domain and frequency domain.
- Rise Time Adjustment

3. With switch

- Switch ECal Calibration: Besides the ENA initialization, it performs the ECal calibration for time and frequency domain. The calibration must be repeated for each switch path combination used in the measurements.
- Rise Time Adjustment

After the calibration procedure, the ENA state is saved in a file. Then at the beginning of every measurement test the ENA State file is recalled and the fixture De-Embedding files are applied.

For more detailed description about the calibrations refer to chapter 5.3 of the "Keysight Method of Implementation (MOI) for USB Type-C^{TM} Connectors and Cables Assemblies Compliance Tests"

Measurement Procedures

The measurement tests are defined in the "USB Type-C Compliance Document rev 1.1" as:

- Test Group B-2: USB 2.0 and Low Speed Signal Tests of Type-C Cable and Adaptor Assemblies
  - B-2-1 D+/D- Pair Attenuation
  - B-2-2 D+/D- Impedance
  - B-2-3 D+/D- Propagation Delay Skew
  - B-2-4 D+/D- Intra-Pair Skew
- Test Group B-3: USB SuperSpeed Signal Tests of Type-C Cable and Adaptor Assemblies
  - B-3-1 Differential Insertion Loss
  - B-3-3 Differential NEXT & FEXT Between SS Signal Pairs
  - B-3-4 Differential NEXT & FEXT Between D+/D- Pair and SS Signal Pairs
  - B-3-6 Differential Return Loss
  - B-3-7 Differential to Common Mode Converstion
- Test Group B-4: USB Type-C Cable Assembly Shielding Effectiveness
  - B-4-1 Shielding Effectiveness

They have been implemented according to the "Keysight MOI f USB Type-C Connectors & Cable Assemblies Compliance Tests".

For more detailed description about the measurement procedures refer tto chapter 5.4 of the "Keysight Method of Implementation (MOI) for USB Type-C^{TM} Connectors and Cables Assemblies Compliance Tests"

Step 4. Modifying Procedure Parameters

For most procedures specific parameters can be set. These parameters are shown on the right side of the ValiFrame User Interface when a specific calibration or test procedure is selected. These values are editable when the “Expert Mode” was chosen in the configuration. If the parameters are not displayed press the “Properties” button of the main menu.

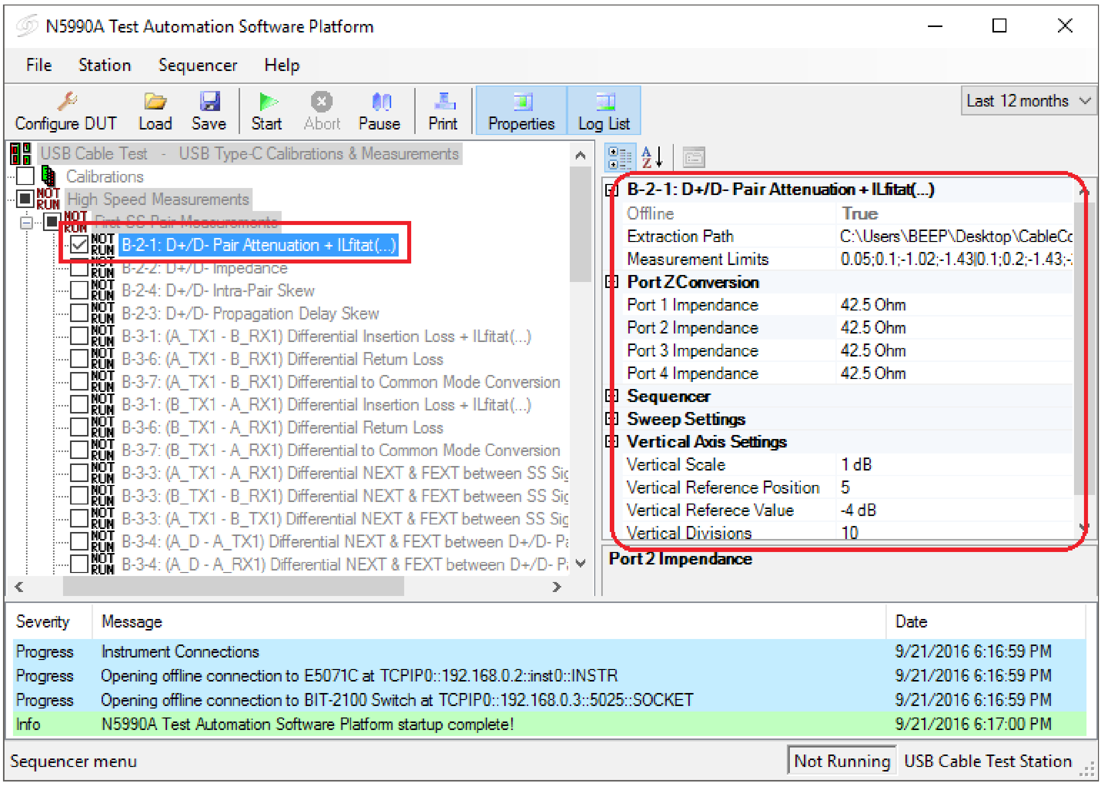


Figure 8: Modifying Procedure Parameters

For detailed description of all the parameters refer to “USB_Cable_Procedure_Descriptions” document.

Step 5. Start the Testing

Once the tests are selected the “Start” button is enabled and colored in green. When clicking on the “Start” button the test are run in the order shown in the test procedure selection tree.

Step 6. Connecting the Setup

The connection diagram is displayed automatically when the selected procedure is started. It can also be displayed by right-clicking on the desired test or calibration and selecting “Show Connection”.

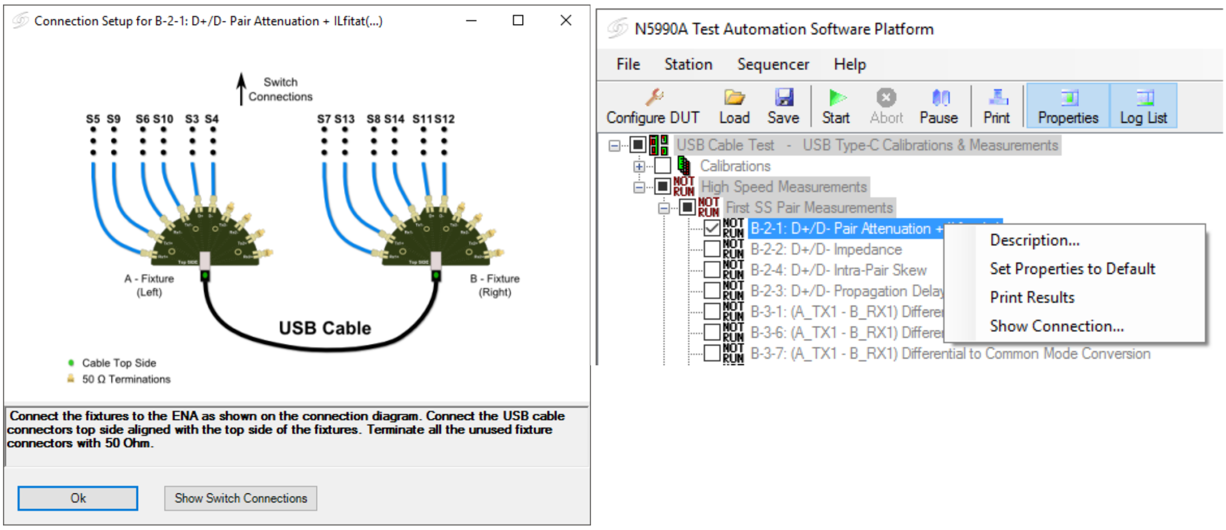


Figure 9: Showing Connection Diagram dialog

Refer to Appendix A: Connection Setups for detailed description of the setup connection for the different system configurations.

When the setup is correctly connected press “OK” and the procedure will continue.

Step 7: Saving the Project

It is possible to save the current state of the project in “File → Save Project / Configuration...”. This will save the selected DUT configuration, the value of all procedure parameters and the results of all the test executed until that time.

That allows to close ValiFrame and continue with the testing on another moment by loading the project (File → Load Configuration…).

Result Description

Run-Time Data Display

While the program is running the data is displayed in a temporary MS Excel or HTML worksheet, which opens automatically for each individual test

The worksheet is closed once the specific test is finished. As long as the Test Automation Software is running, each worksheet can be reopened by double clicking on the procedure name. However, the individual worksheets will be lost when ValiFrame is closed, unless individual worksheets or a collection of them were saved by the user.

Interpreting Results

Once the selected procedures are run successfully, the smiley at the front of each individual procedure indicates the result (Pass / Fail / Incomplete) by displaying it's face in specific ways as given below.

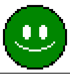
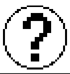
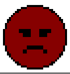
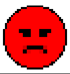
Smiley	Description
	It indicates that the procedure passed successfully in a previous run and the results are available.
	It indicates that the procedures passed in offline mode in a previous run and the results are available
	It indicates that the procedure is passed successfully in the present run
	It indicates that the procedure was not run completely in the previous run.
	It indicates that the procedure could not be run in the present run. Most likely the DUT failed during initialization, so no test(s) were conducted.
	It indicates that the procedure failed in the previous run.
	It indicates that the procedure is failed in the present run.
	Generally this kind of smiley displays two results such as the first half indicates that the result of the present run and the second half shows the result of the previous run. In this example, the first half indicates that the procedure is passed successfully in the present run and the second half means that it was not completely run in the previous run.

Table 2: Smiley's Result Description table

Test report Document

After all tests have been run, a test report document can be generated. All individual worksheets are combined in a summary Excel/HTML workbook at the end of the test run. The workbook must be saved explicitly (File > Save Results as Workbook...), otherwise the data will be lost.

Appendix A: Connection Setups

Connection Diagrams for Configuration without Switch

ENA Initial Configuration

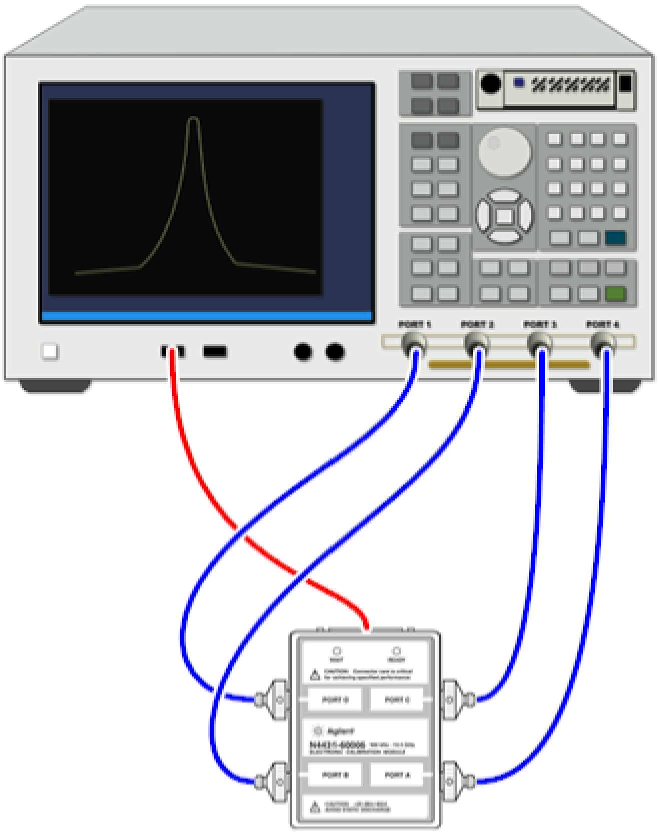


Figure 10: Connection diagram for ENA Initial Configuration

TDR Calibration

- **Thru calibration**

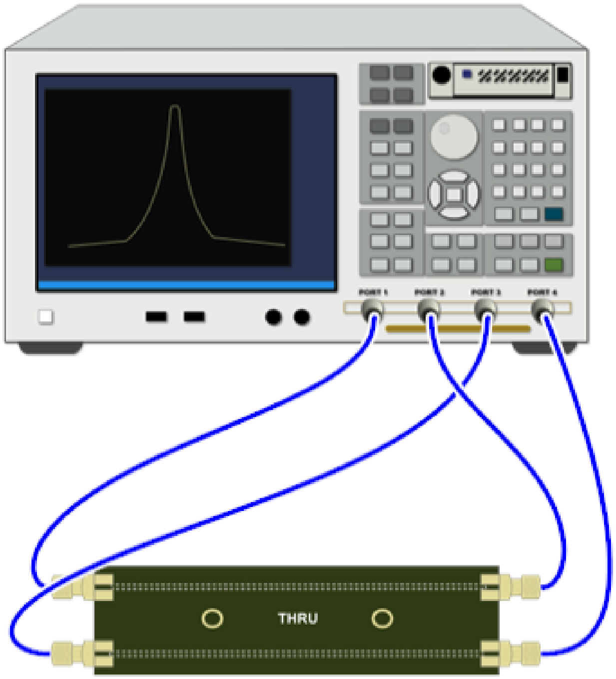


Figure 11: Connection diagram for TDR Calibration – Thru 1-2:3-4

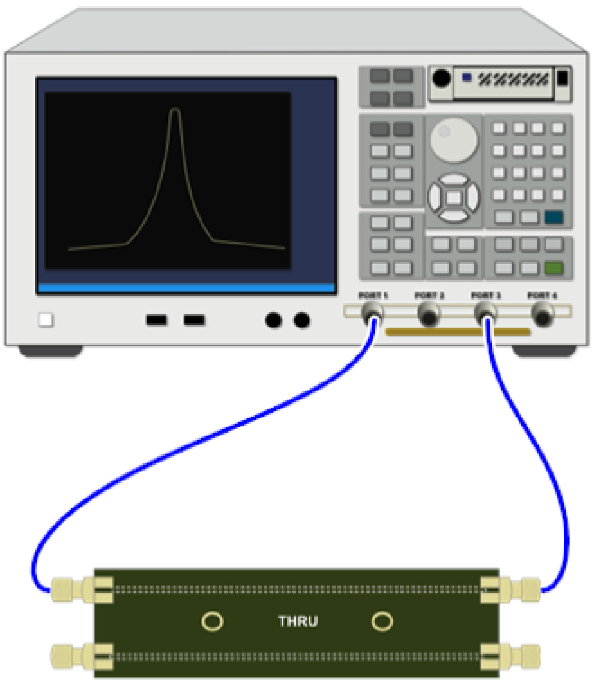


Figure 12: Connection diagram for TDR Calibration – Thru 1-3

- **Short Calibration**

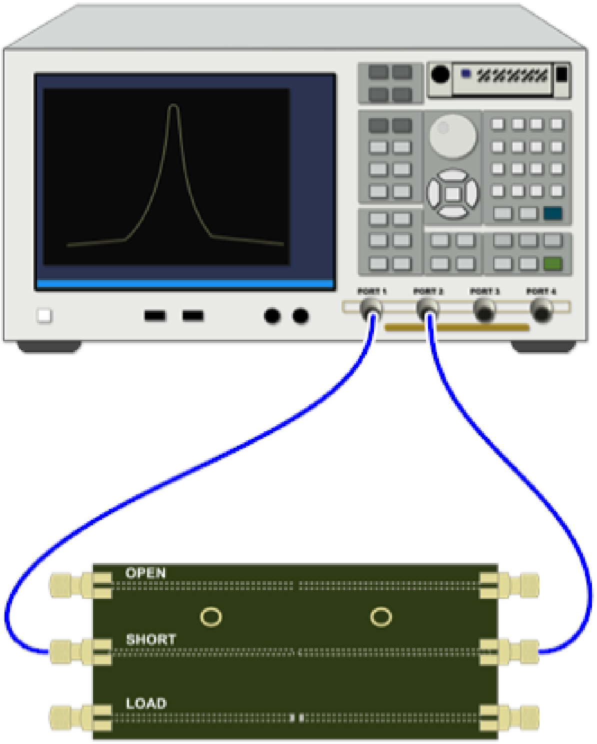


Figure 13: Connection diagram for TDR Calibration – Short 1:2

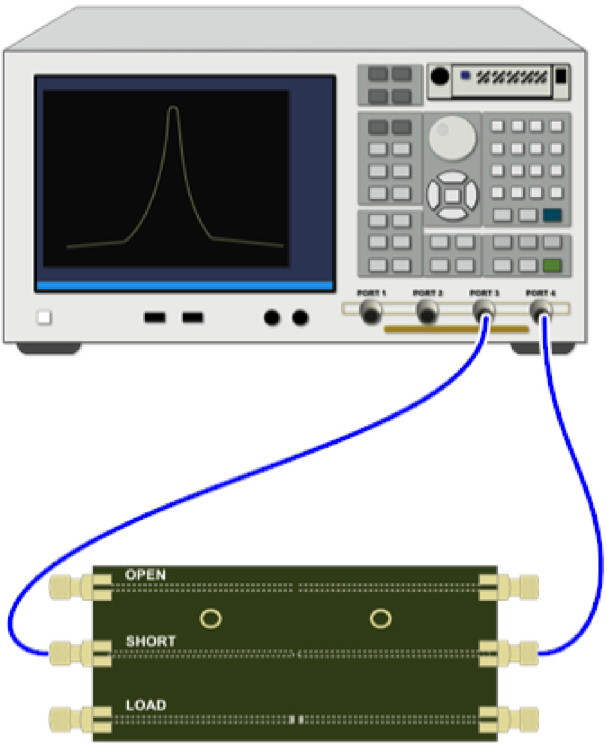


Figure 14: Connection diagram for TDR Calibration – Short 3:4

- **Line1 Calibration**

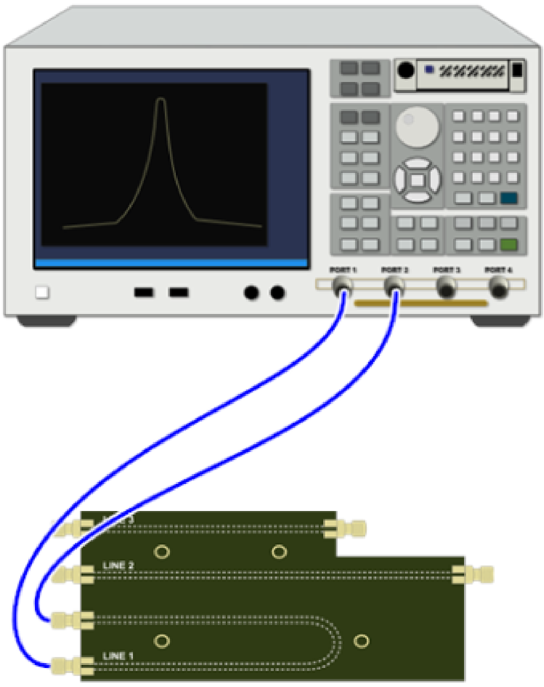


Figure 15: Connection diagram for TDR Calibration - Line 1 Ports (1-2)

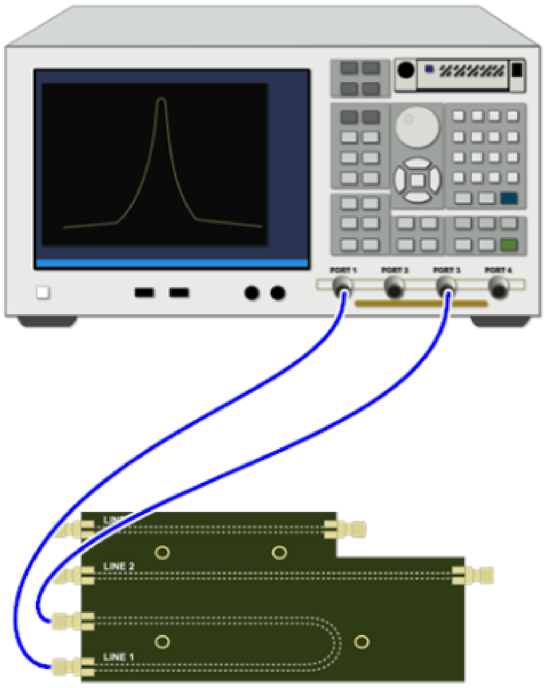


Figure 16: Connection diagram for TDR Calibration - Line 1 Ports (1-3)

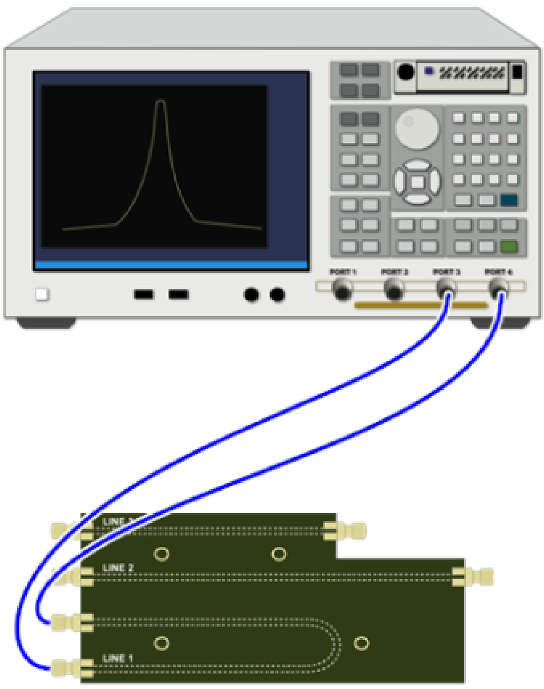


Figure 17: Connection diagram for TDR Calibration – Line1 Ports (3-4)

- **Line 2 Calibration**

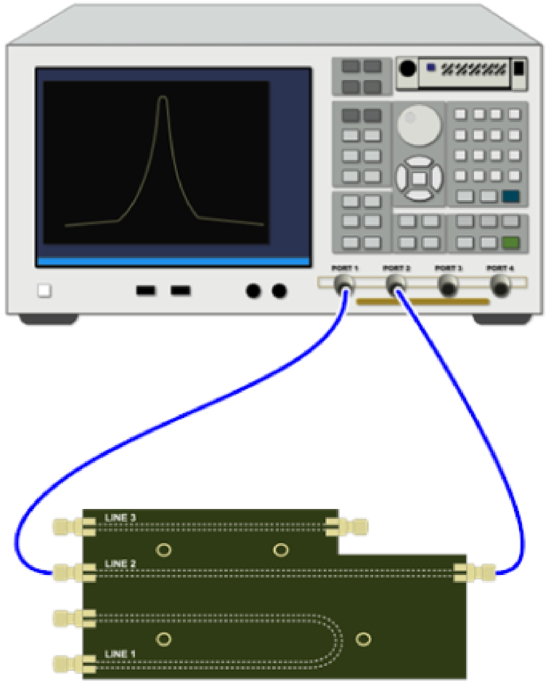


Figure 18: Connection diagram for TDR Calibration - Line 2 Ports(1-2)

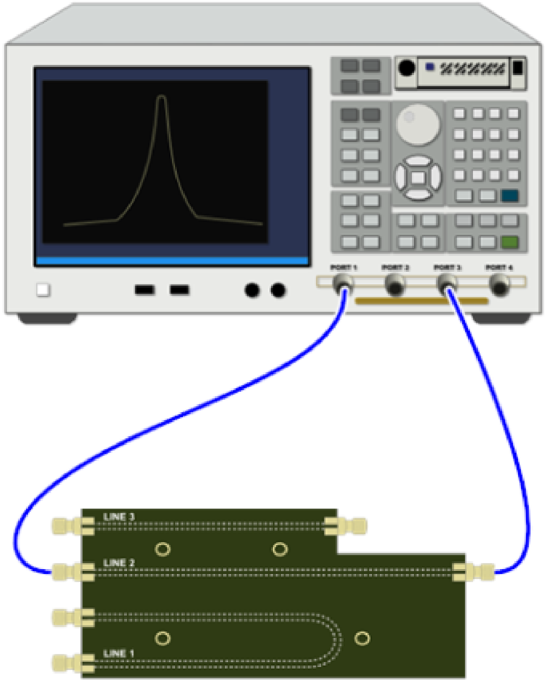


Figure 19: Connection diagram for TDR Calibration - Line 2 Ports (1-3)

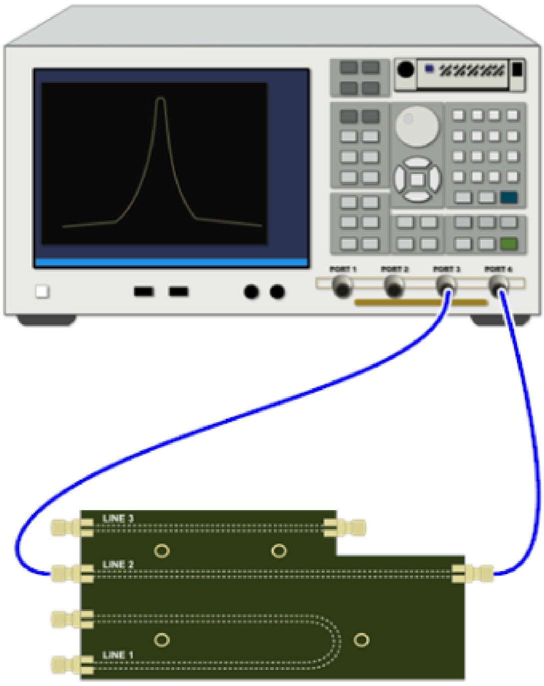


Figure 20: Connection diagram for TDR Calibration – Line 2 Ports (3-4)

- **Line 3 Calibrations**

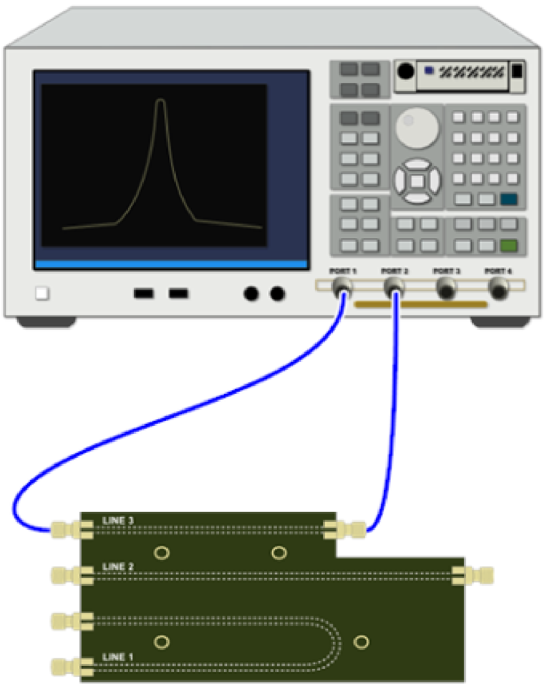


Figure 21: Connection diagram for TDR Calibration - Line 3 Ports(1-2)

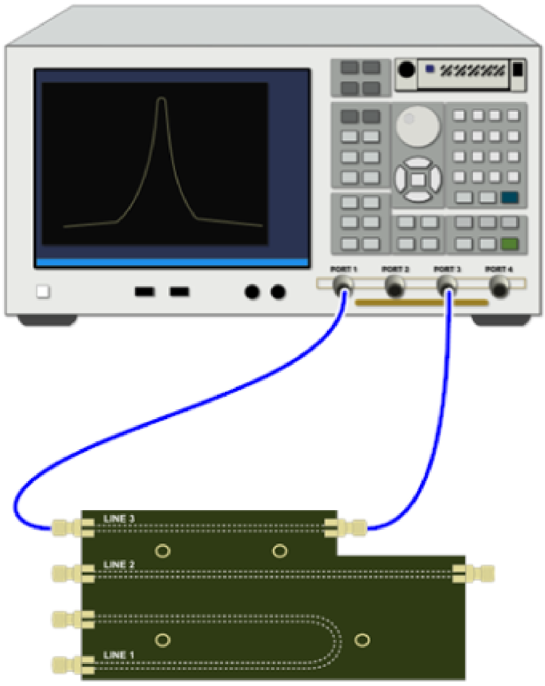


Figure 22: Connection diagram for TDR Calibration - Line 3 Ports (1-3)

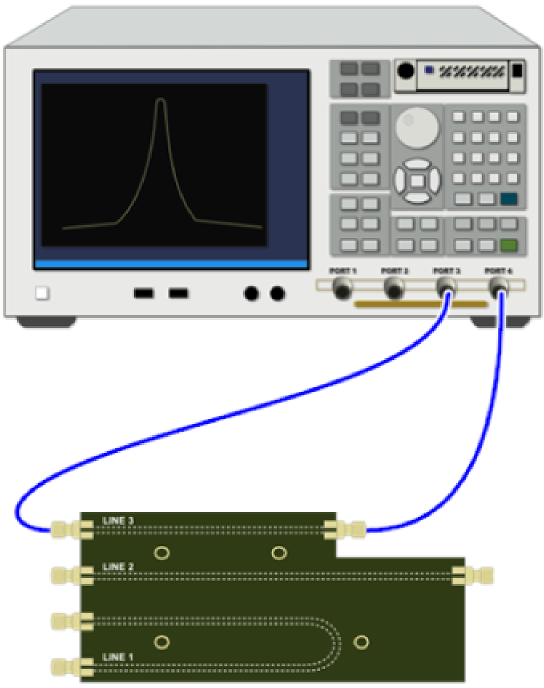


Figure 23: Connection diagram for TDR Calibration – Line 3 Ports (3-4)

- **Load Calibrations**

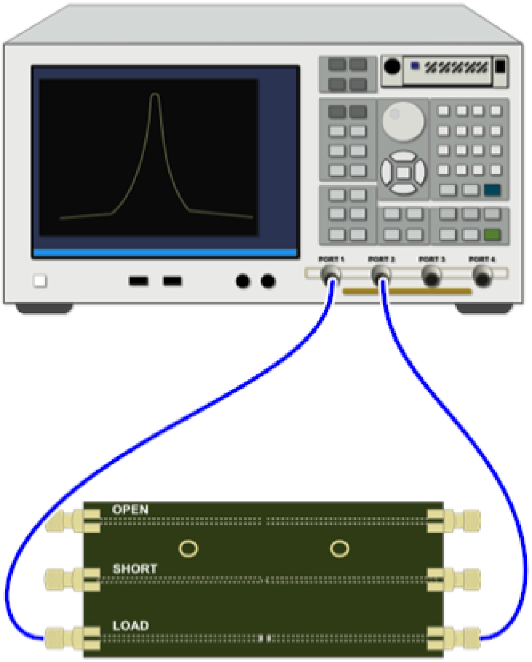


Figure 24: Connection diagram for TDR Calibration - Load Ports(1-2)

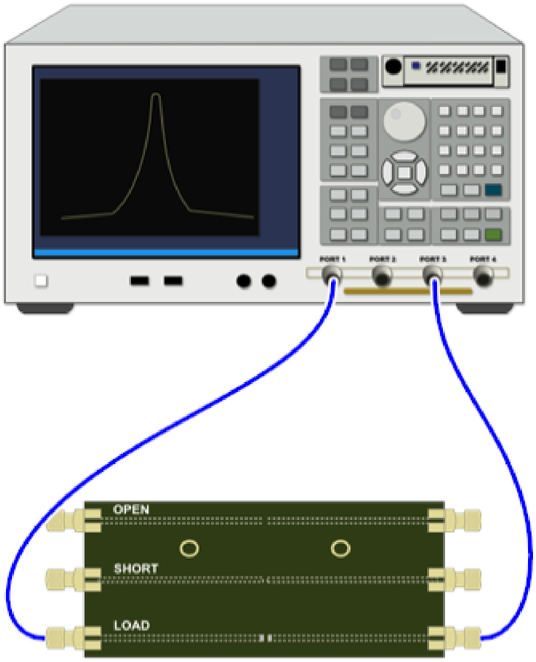


Figure 25: Connection diagram for TDR Calibration - Load Ports (1-3)

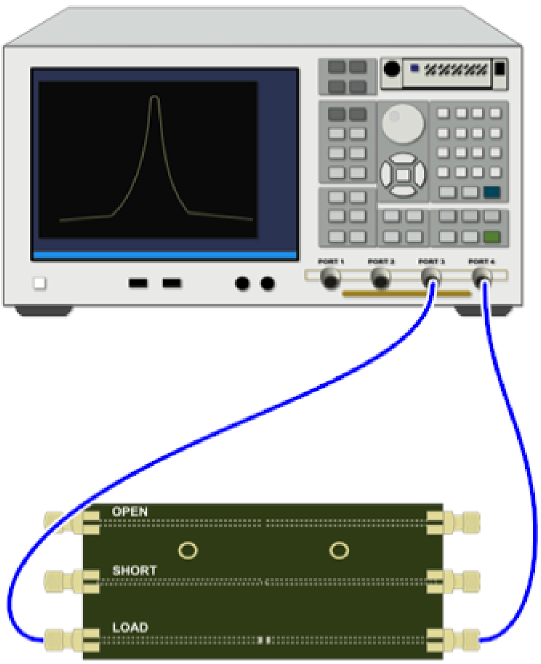


Figure 26: Connection diagram for TDR Calibration – Load Ports (3-4)

Rise Adjustment Calibration

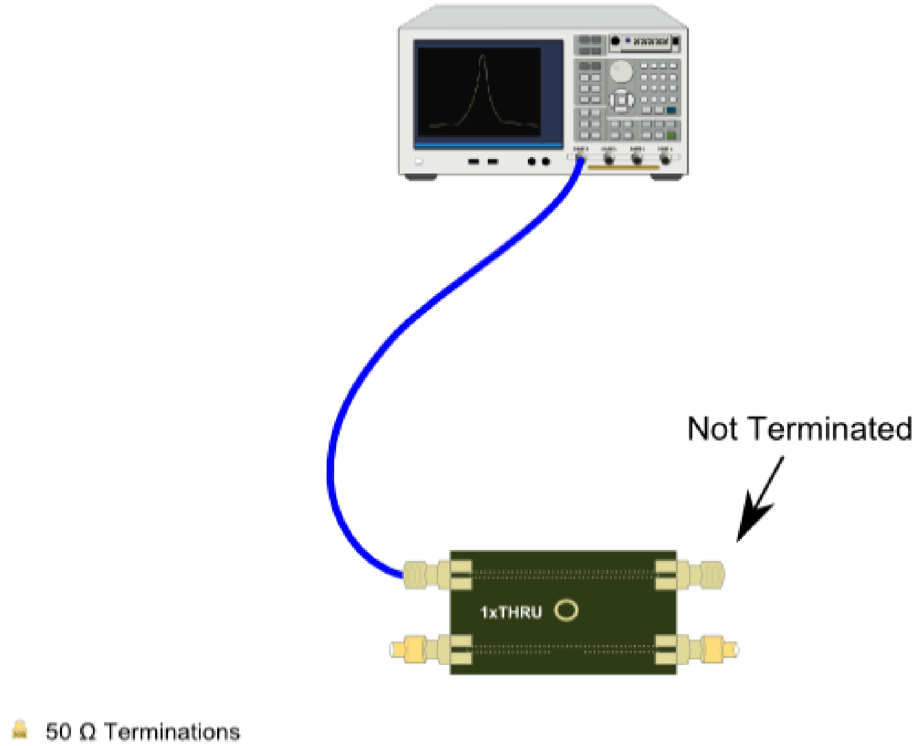


Figure 27: Connection diagram for Rise Adjustment Calibration

SS Pair Measurements

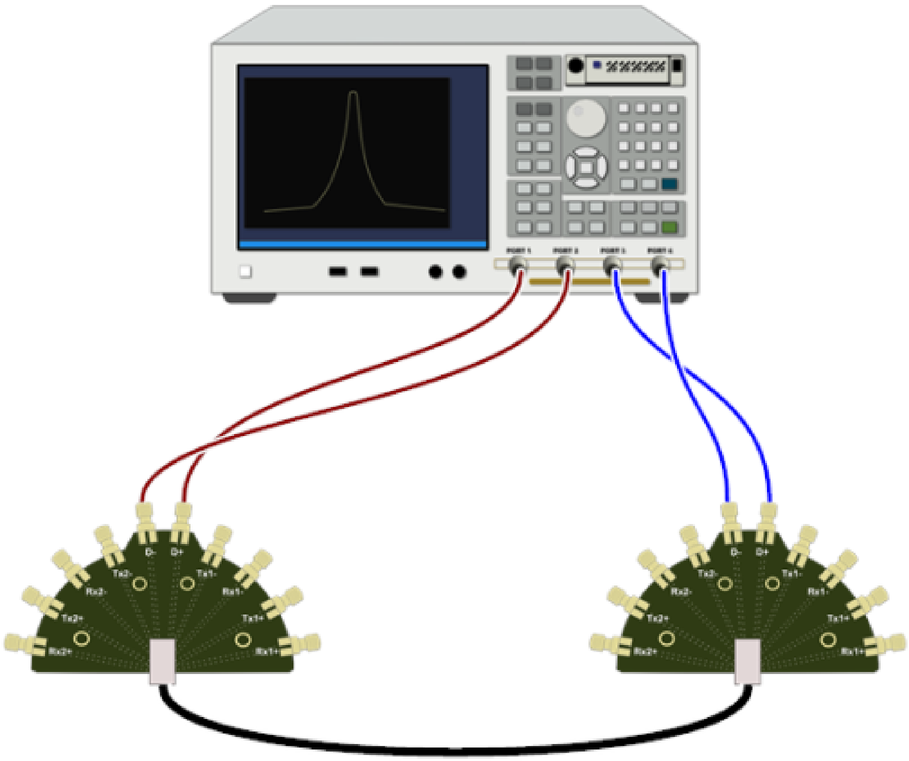


Figure 28: Connection diagram for First SS Pair measurements – D+/D- Pair

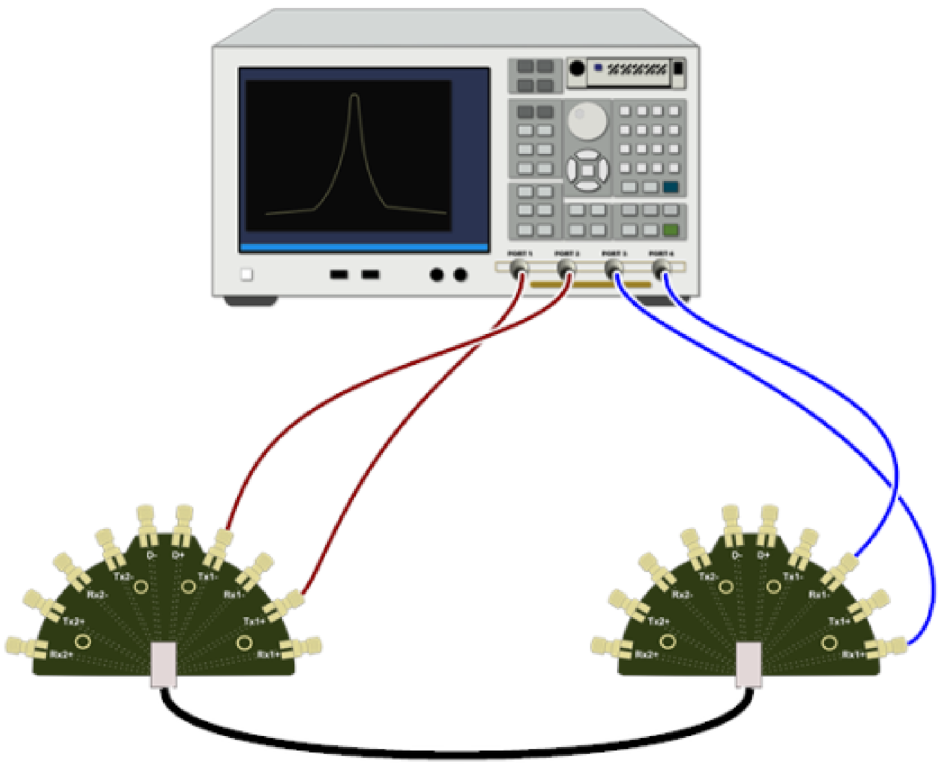


Figure 29: Connection diagram for First SS Pair measurements – A_TX1 - B_RX1 Pair

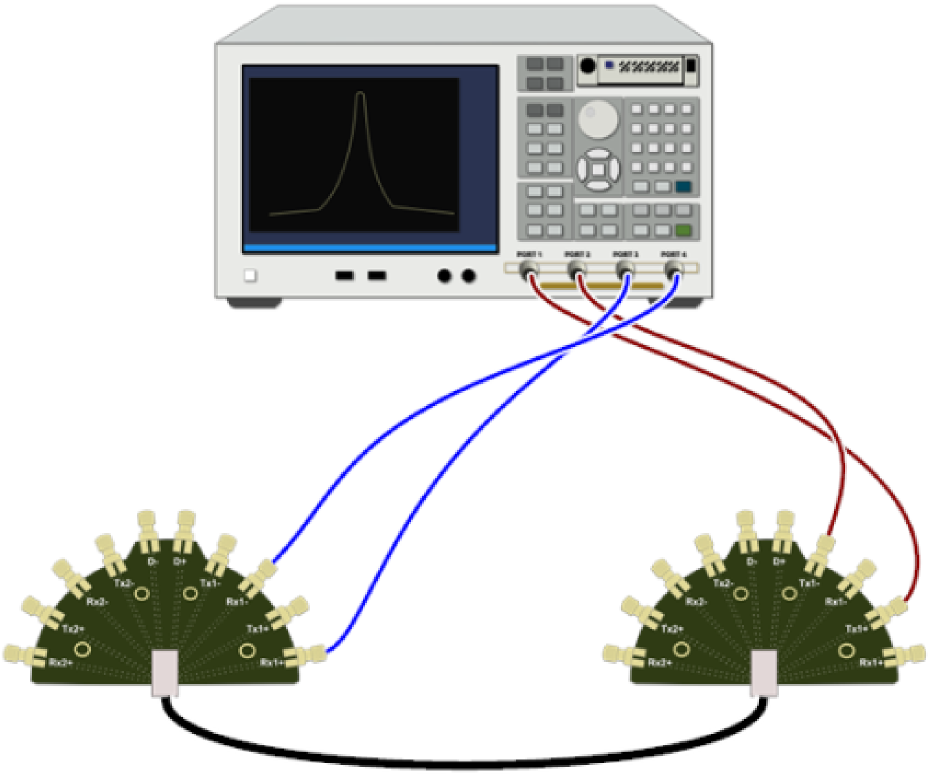


Figure 30: Connection diagram for First SS Pair measurements – B_TX1 - A_RX1 Pair

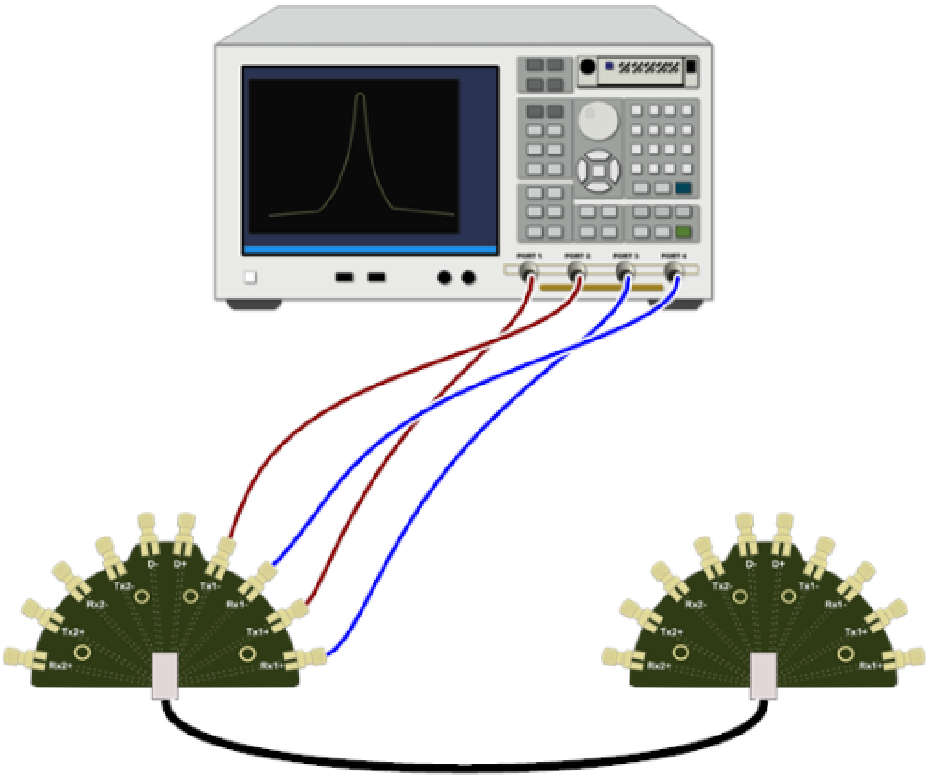


Figure 31: Connection diagram for First SS Pair measurements – A_TX1 - A_RX1 Pair

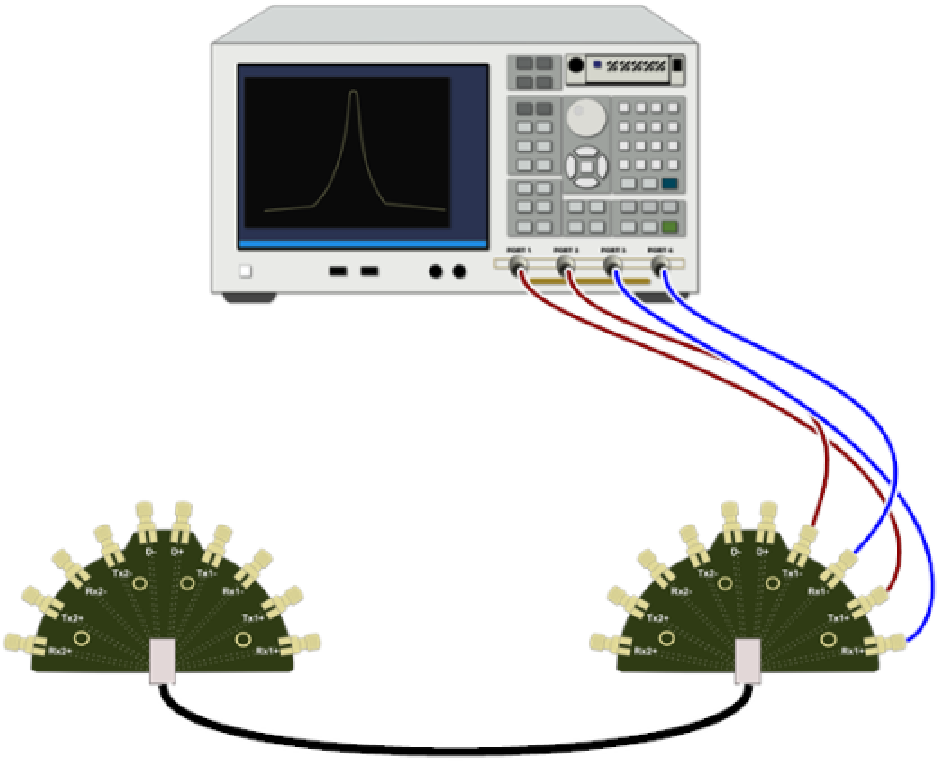


Figure 32: Connection diagram for First SS Pair measurements – B_TX1 - B_RX1 Pair

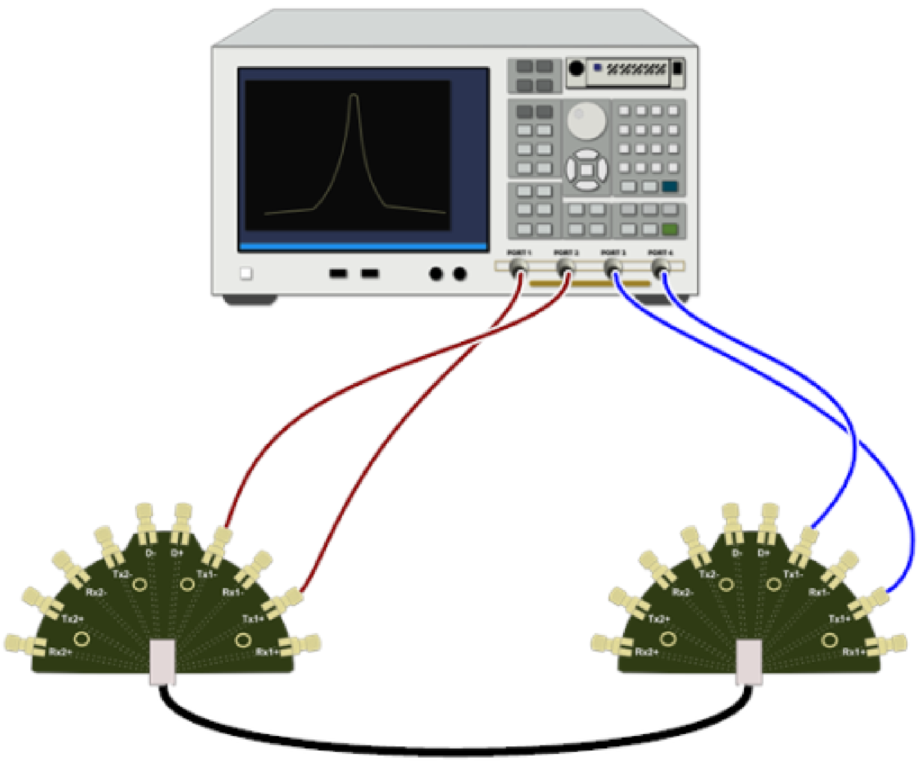


Figure 33: Connection diagram for First SS Pair measurements – A_TX1 - B_TX1 Pair

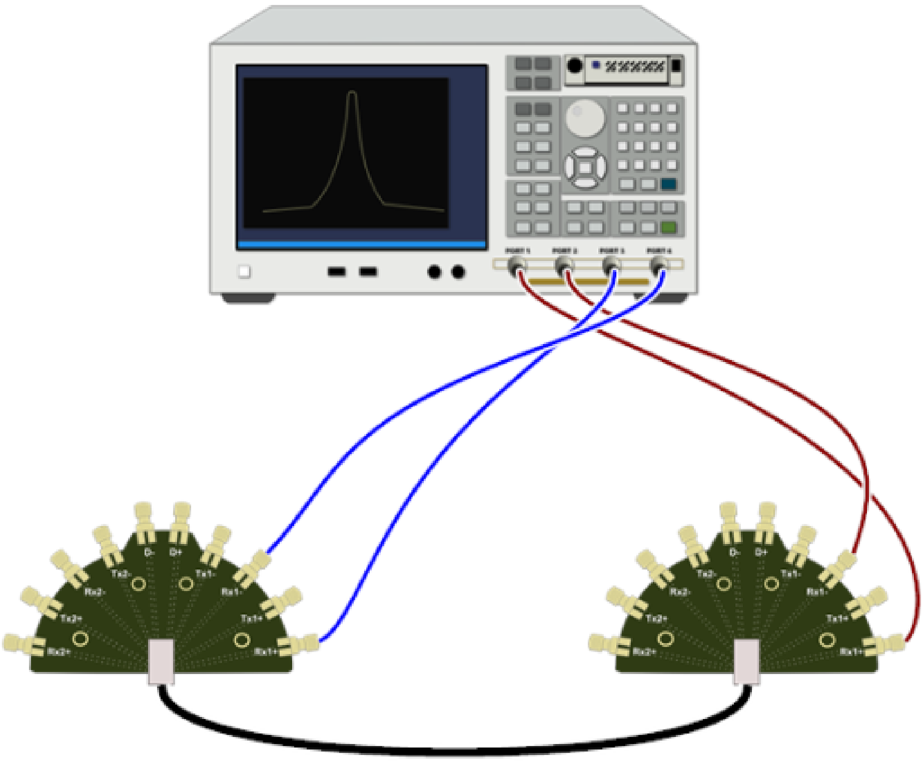


Figure 34: Connection diagram for First SS Pair measurements – B_RX1 - A_RX1 Pair

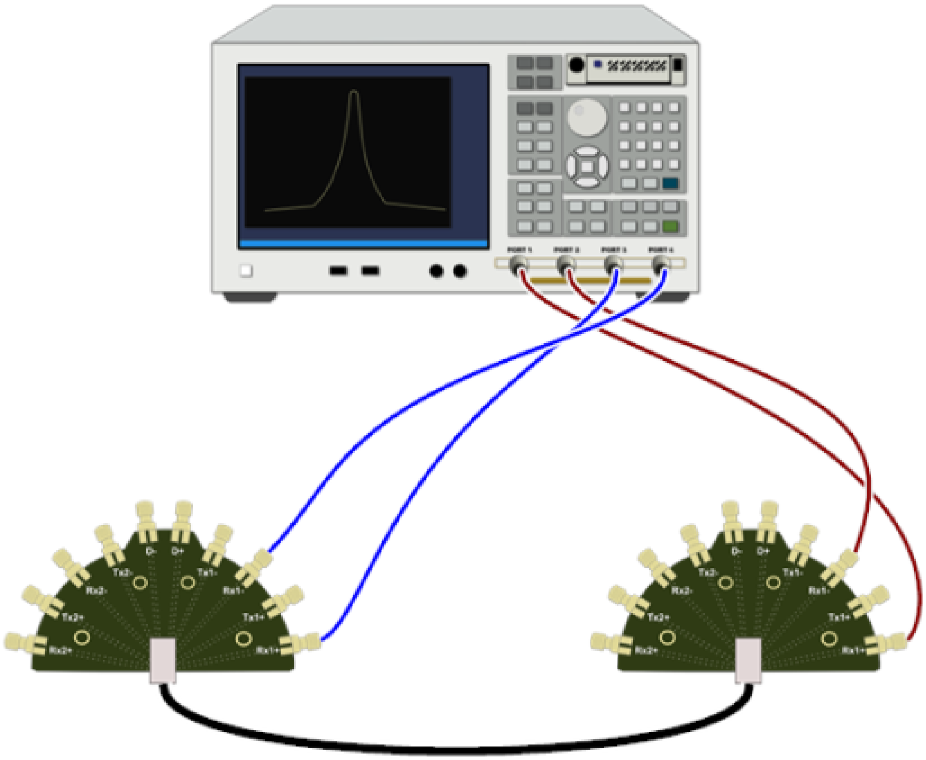


Figure 35: Connection diagram for First SS Pair measurements – B_RX1 - A_RX1 Pair

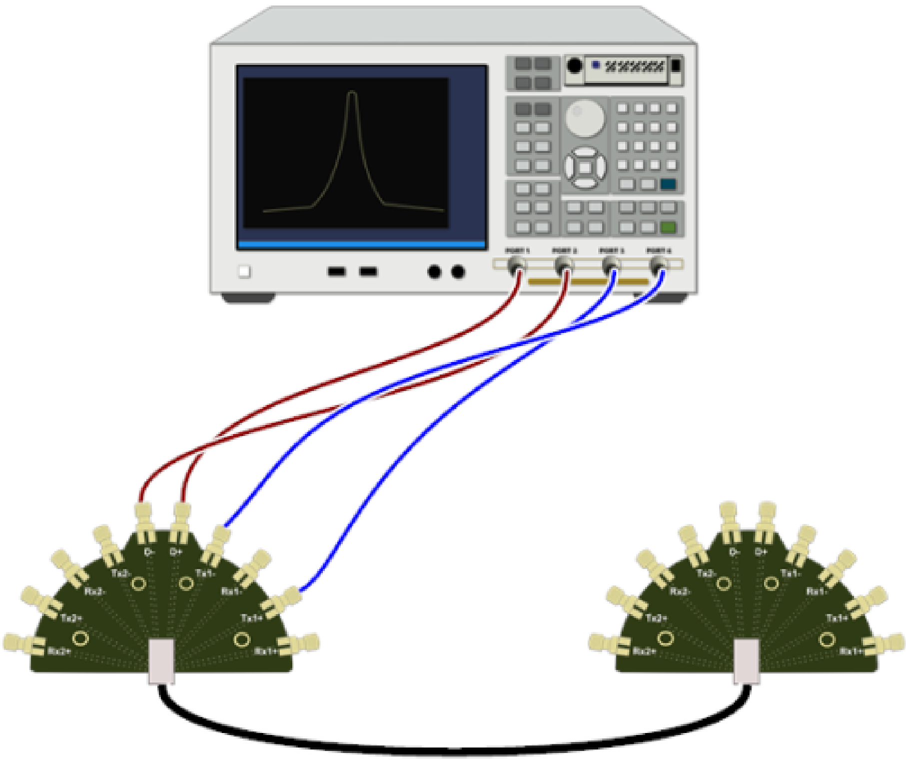


Figure 36: Connection diagram for First SS Pair measurements – A_D - A_TX1 Pair

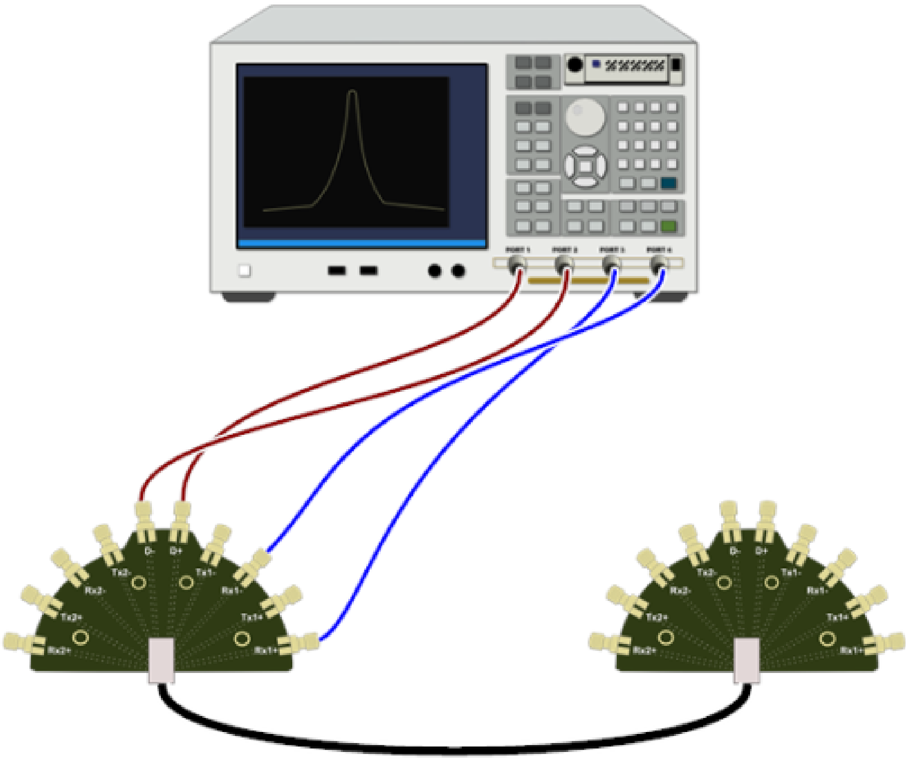


Figure 37: Connection diagram for First SS Pair measurements – A_D - A_RX1 Pair

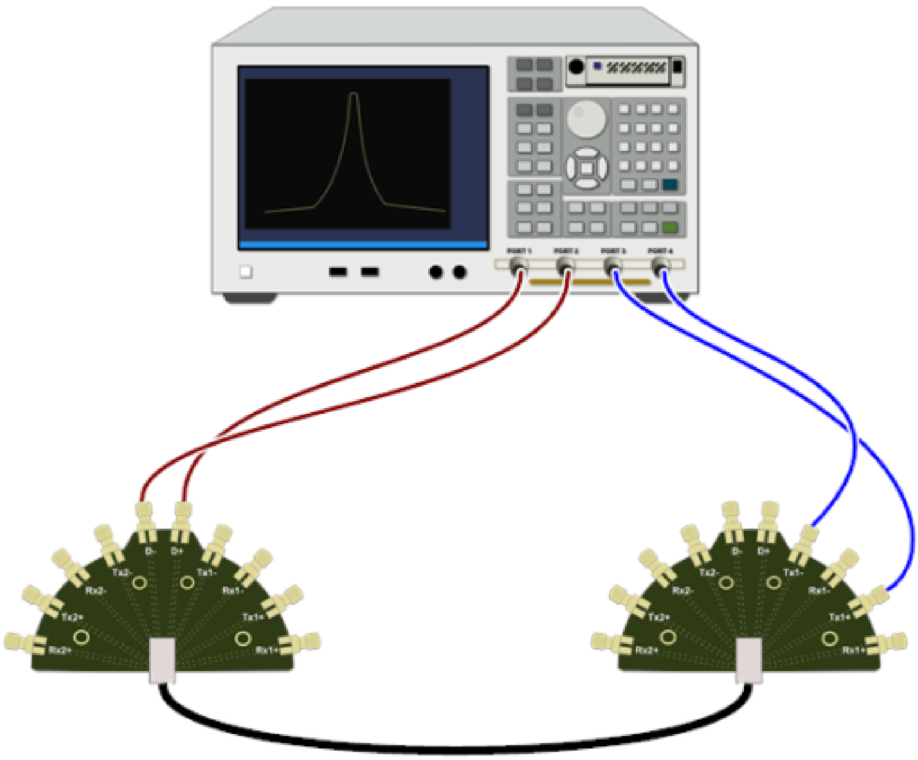


Figure 38: Connection diagram for First SS Pair measurements – A_D - B_TX1 Pair

Figure 39: Connection diagram for First SS Pair measurements – A_D - B_RX1 Pair

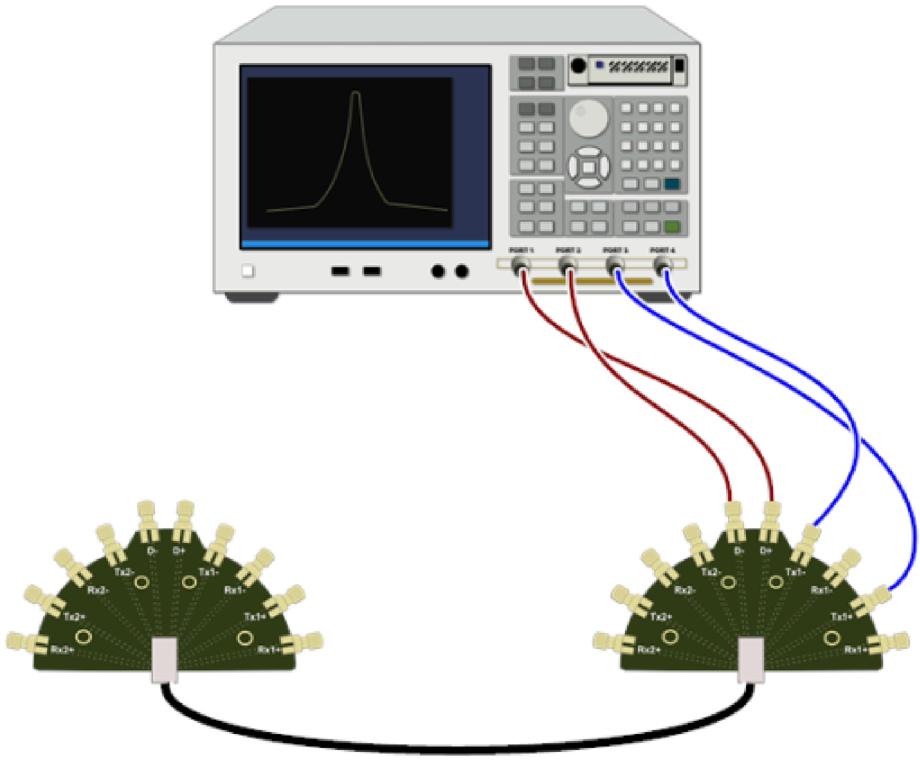


Figure 40: Connection diagram for First SS Pair measurements – B_D - B_TX1 Pair

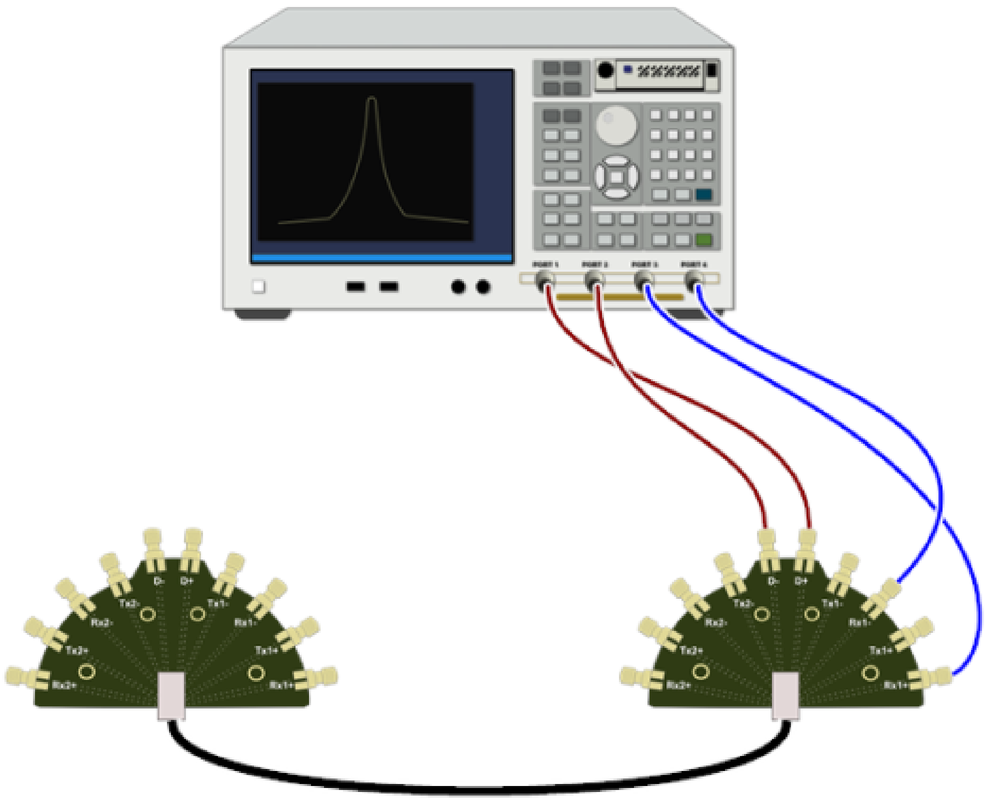


Figure 41: Connection diagram for First SS Pair measurements – B_D - B_RX1 Pair

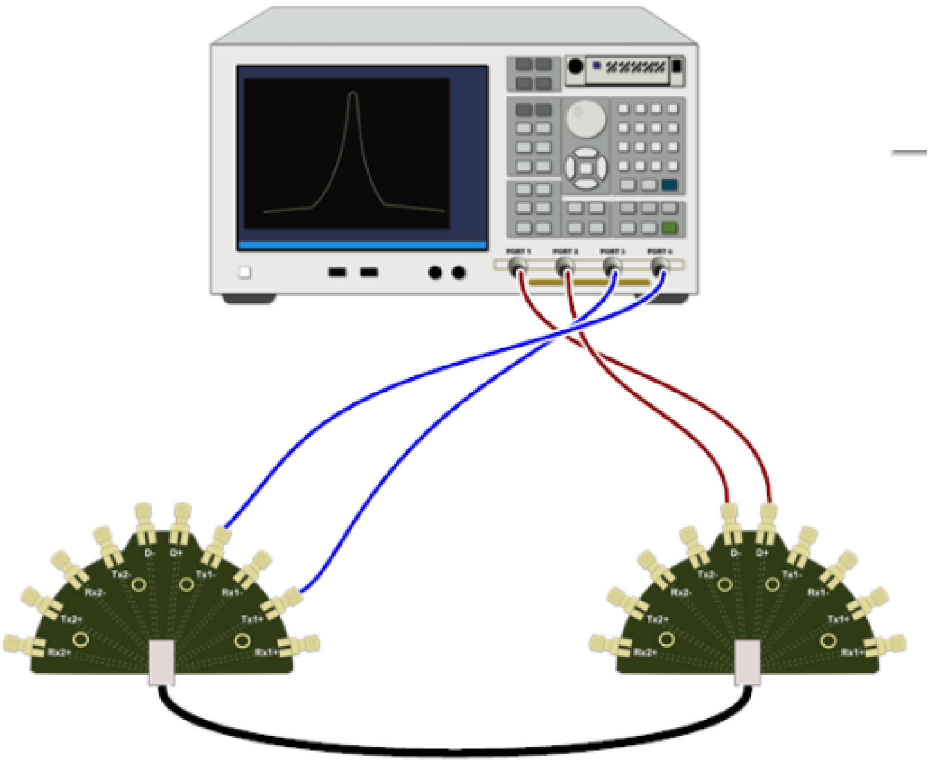


Figure 42: Connection diagram for First SS Pair measurements – B_D - A_TX1 Pair

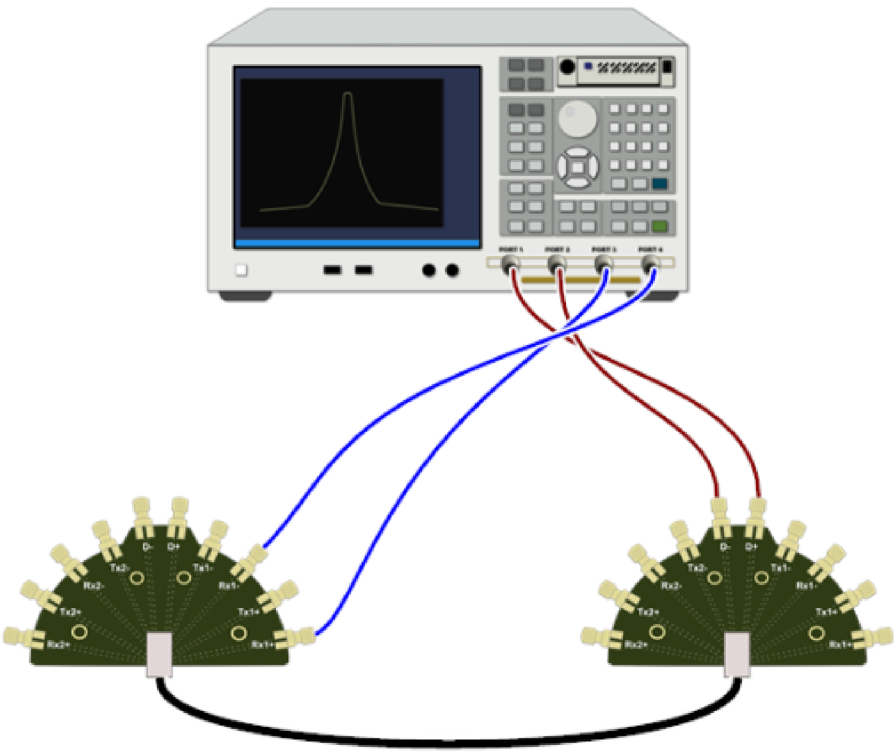


Figure 43: Connection diagram for First SS Pair measurements – B_D - A_RX1 Pair

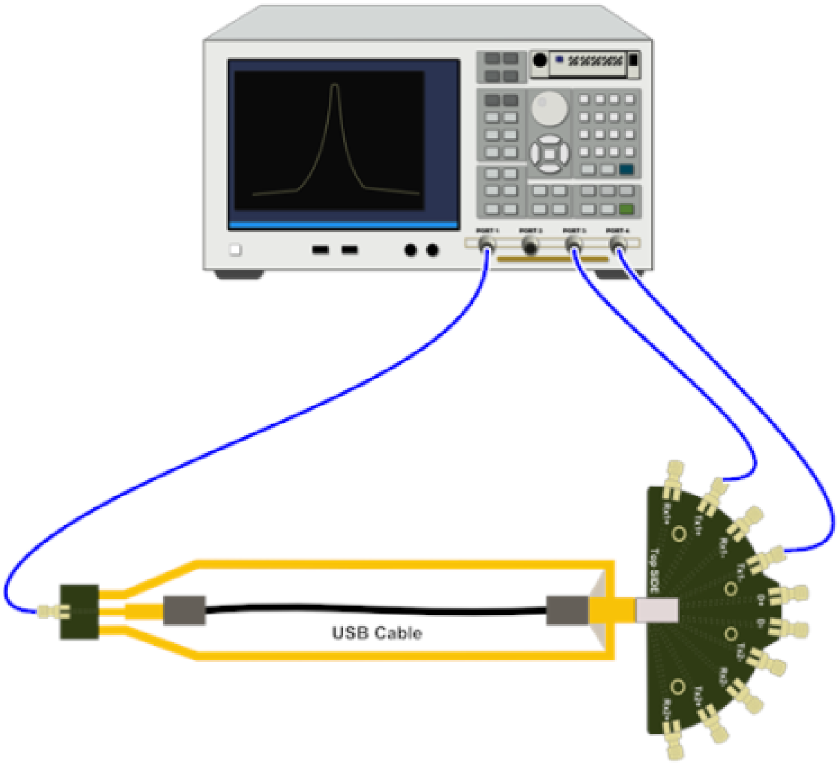


Figure 44: Connection diagram for Shielding Effectiveness - B_TX1

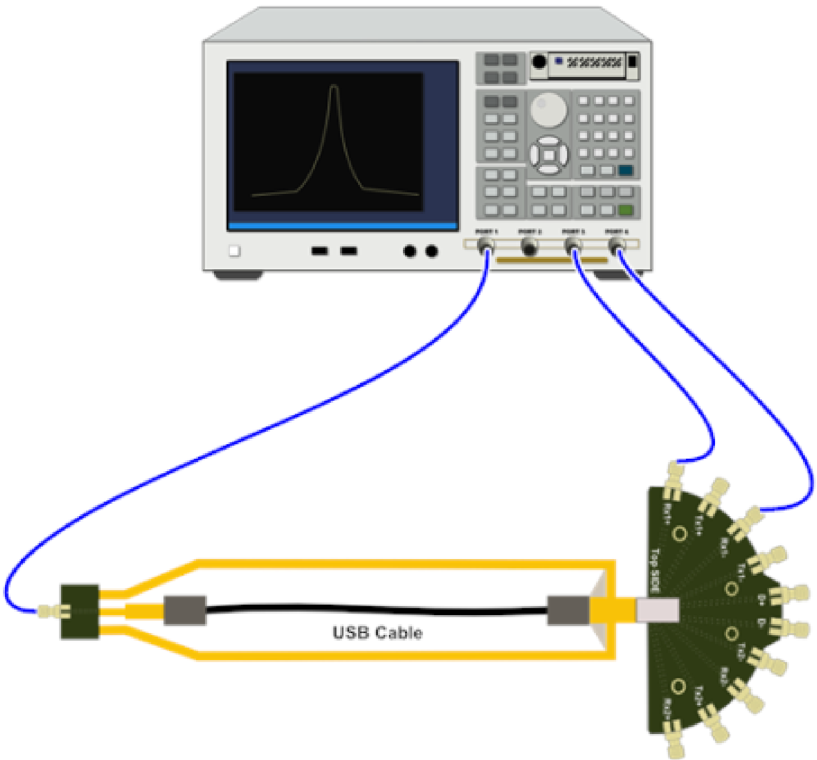


Figure 45: Connection diagram for Shielding Effectiveness - B_RX1

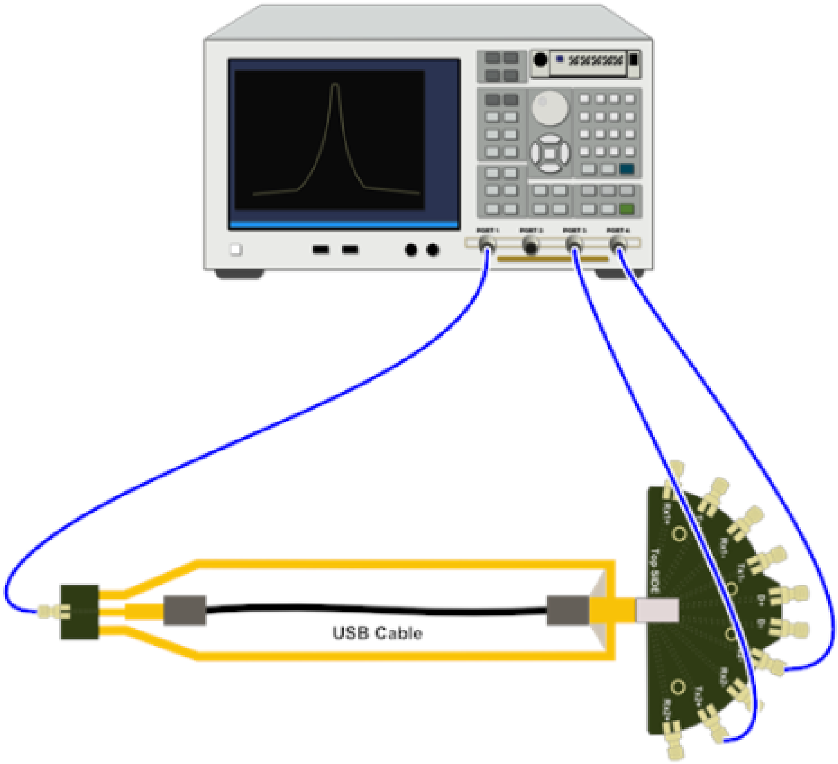


Figure 46: Connection diagram for Shielding Effectiveness - B_TX2

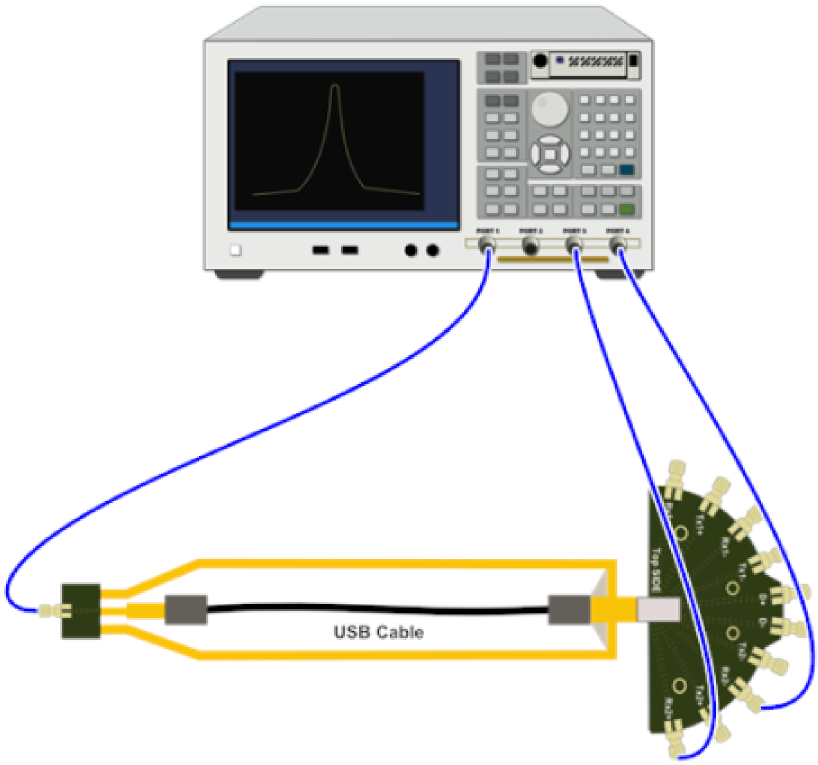


Figure 47: Connection diagram for Shielding Effectiveness - B_RX2

Connection Diagrams for Configuration with Switch

When the Switch System is selected in the Station Configuration, the switch is used in all the calibrations and tests.

The use of the switch reduces the number of different test setup connections to three. One for the First SS Pair measurements, one for the Second SS Pair measurements and other for the Shielding Effectiveness tests.

For calibrations is required to change the connections to the Ecal fixture several times. But they only need to be performed once and will be valid until the switch wears out or is replaced.

The switch interconnections are common for all the procedures. They can be visualize by clicking the button “Show Switch Connections” in the Connection dialog.

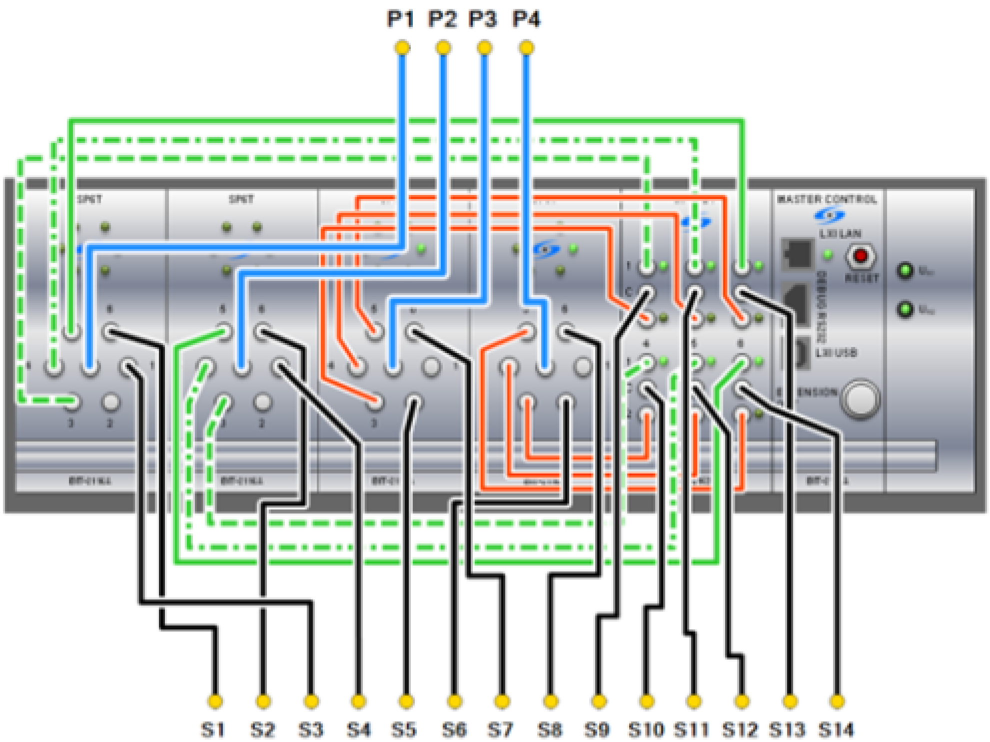


Figure 48: Switch connections

Switch Ecal Calibration

The Switch Ecal calibration needs to be performed for different switch paths. For each calibration the connection diagram easily describes which switch cables connect to the Ecal ports.

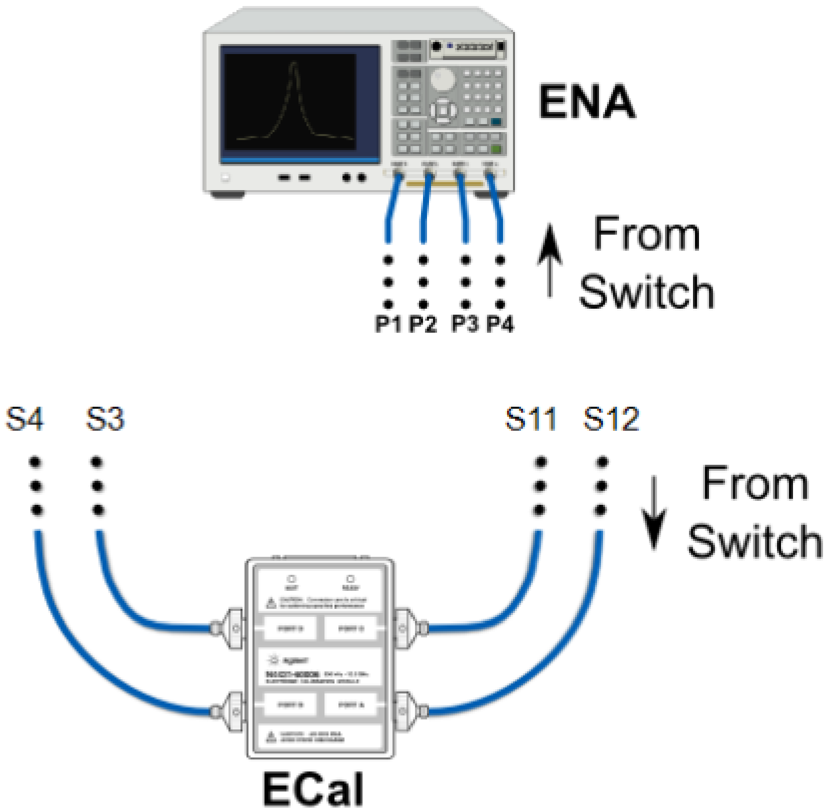


Figure 49: Connection diagram for Switch Ecal Calibration

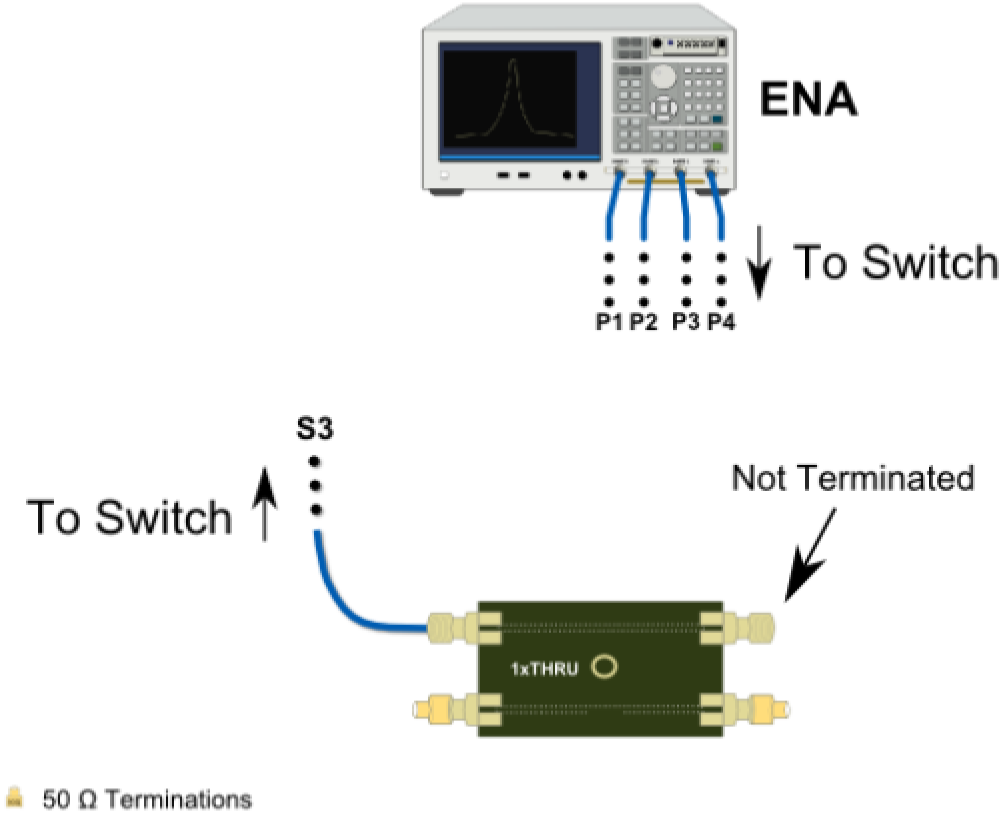


Figure 50: Connection diagram for Rise Adjustment Calibration with Switch System

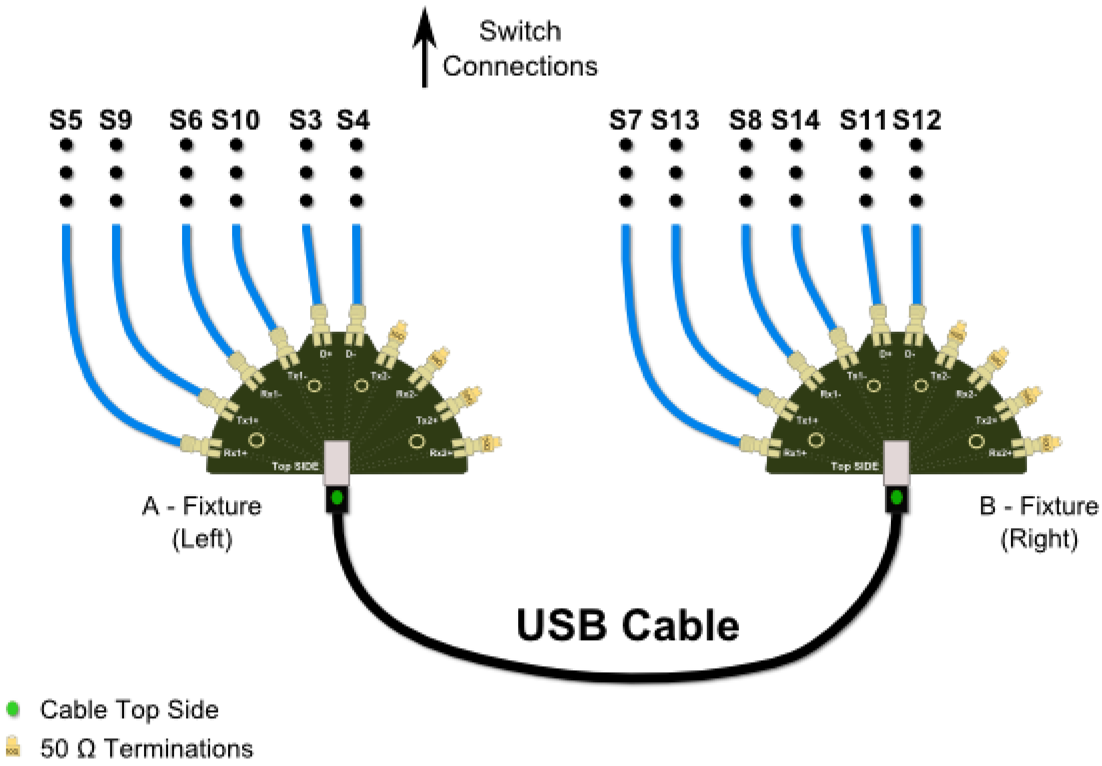


Figure 51: Connection diagram for First SS Pair measurements with Switch System

The setup for the First SS Pair and the Second SS Pair are almost the same. The only difference is that the following:

- First SS Pair: Connect the USB cable connectors **top** side aligned with the **top** side of the fixtures.
- Second SS Pair: Connect the USB cable connectors **bottom** side aligned with the **top** side of the fixtures.

Shielding Effectiveness

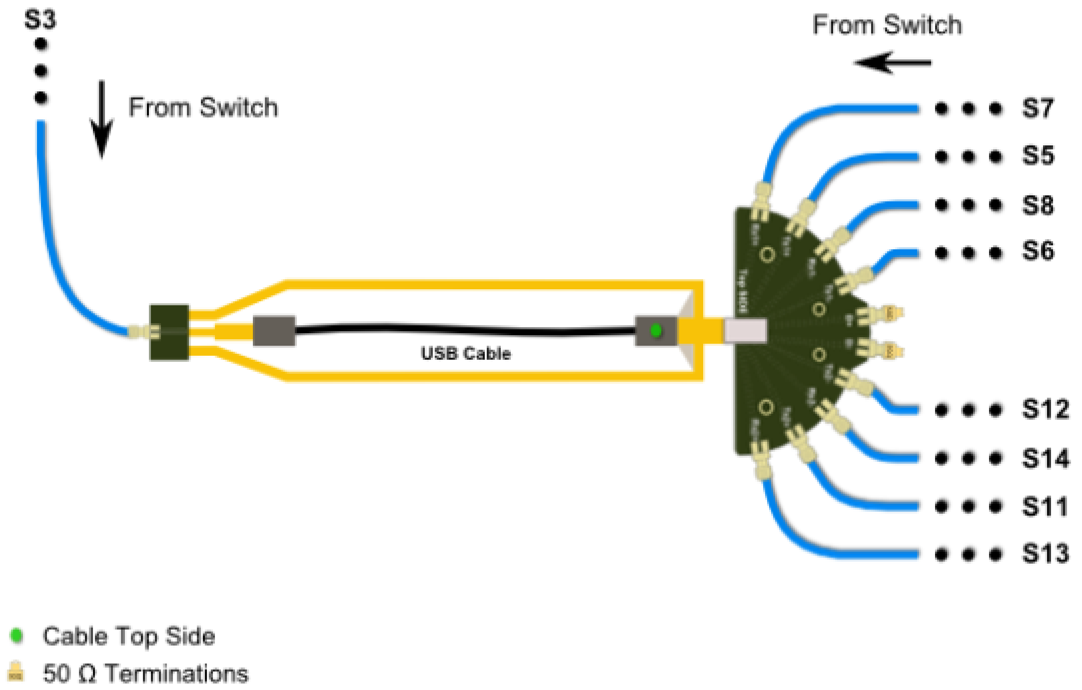


Figure 52: Connection diagram for Shielding Effectiveness measurements with Switch System