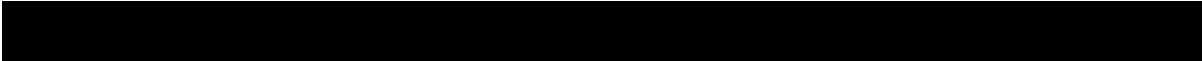


Revision 1.00

May-21, 2013



**10GBASE-T Ethernet Cable
Agilent Method of Implementation (MOI) for
10GBASE-T Ethernet Cable Tests
Using Agilent E5071C ENA Option TDR**

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1. Revision History

Revision	Comments	Issue Date
1.00	Initial Revision.	May-21, 2013

2. Purpose

This test procedure was written to explain how to use the Agilent ENA Option TDR to make the 10GBASE-T Ethernet cable measurements.

3. References

- IEEE 802.3-2008 Section 4 (Jun. 2010)

4. Required Equipments

1. E5071C ENA Series Network Analyzer
 - Option 440 or 445 (4.5 GHz) / 460 or 465 (6.5 GHz) / 480 or 485 (8.5 GHz) / 4D5 (14 GHz) / 4K5 (20 GHz)
 - Option TDR (Enhanced time domain analysis)
2. Test Fixture
 - Agilent U7237A 10GBASE-T Ethernet Test Fixture (2/ea)
3. 4-port ECal Module
 - N4431B (for E5071C-440/445/460/465/480/485)
 - N4433A (for E5071C-4D5 or 4K5)
4. Coaxial RF cables
5. 50 Ohm terminators

5. Test Procedure

5.1. Outline of Test Procedure

1. Instrument Setup

- Automatic setup by recalling a state file or manual setup.

2. Calibration

- ECal Calibration and Fixture Compensation (Time-domain measurements)
- ECal Calibration and Port Extension (Frequency-domain measurements)

3. Measurements

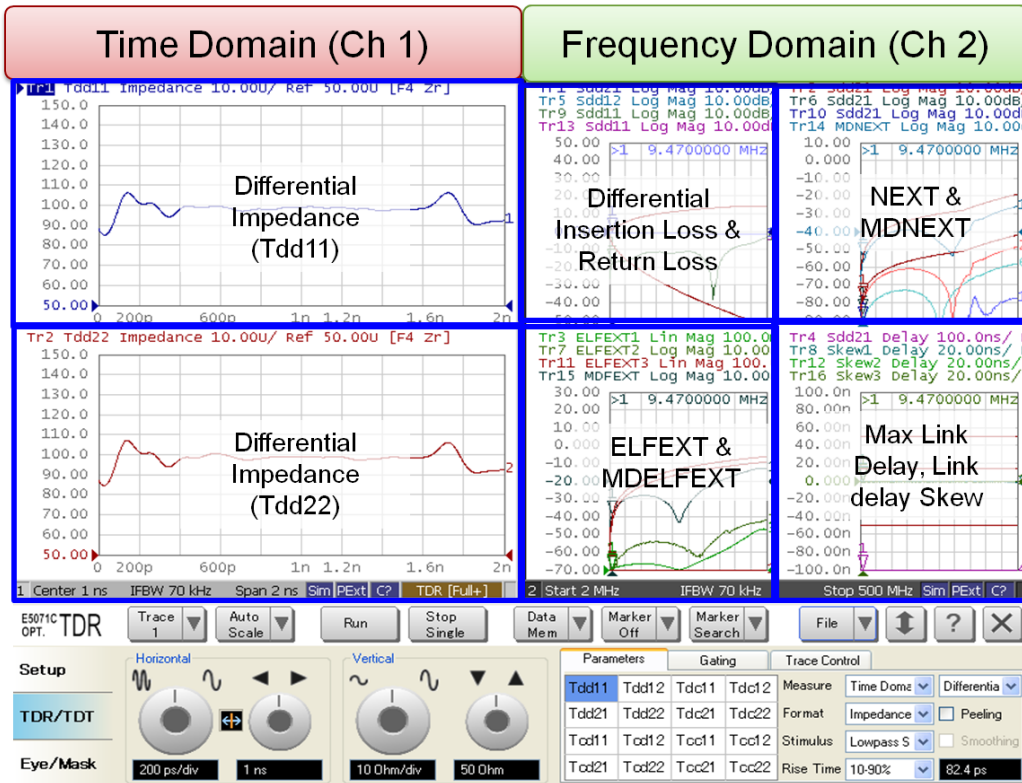
4-1. Time-domain Measurements

- Differential Characteristic Impedance

4-2. Frequency-domain Measurements

- Insertion Loss
- Return Loss
- Differential Near-end Crosstalk (NEXT)
- Multiple Disturber Near-end Crosstalk (MDNEXT)
- Equal Level Far-end Crosstalk (ELFEXT)
- Multiple Disturber Equal Level Far-end Crosstalk (MDELFFEXT)
- Maximum Link Delay
- Link Delay Skew

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Note: Hard Keys (Keys on the E5071C's front panel) are displayed in **Blue** color and **Bold**. (Example: **Avg**, **Analysis**)

Note: Soft keys (Keys on the E5071C's screen) are displayed in **Bold**. (Example: **S11**, **Real**, **Transform**)

Note: Buttons of the TDR software are displayed in **Green** color and **Bold**. (Example: **Trace**, **Rise Time**)

Note: Tabs of the TDR software are displayed in **Brown** color and **Bold**. (Example: **Setup**, **Trace Control**)

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5.2. Instrument Setup

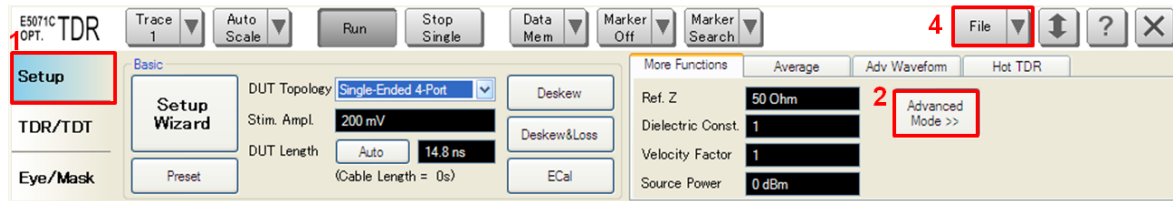
5.2.1. Recalling a State File

This section describes how to recall a state file of the E5071C that includes all the measurement settings for 10GBASE-T Ethernet cable tests. The state file can be downloaded at: www.agilent.com/find/ena-tdr_ethernet-cabcon

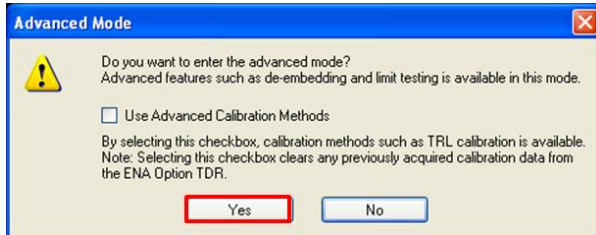
Copy the state file into the E5071C's directory via USB mass storage device and recall the state file using the TDR software. Necessary parameters for testing are automatically set up in the E5071C. Refer to Appendix for the details about manual setup.

If TDR setup wizard is shown, click **Close** button in the TDR setup wizard main window.

1. Open **Setup** tab.
2. Click **Advanced Mode** to show the dialog box.



3. A dialog box appears requesting for confirmation. Then click **Yes**. (Uncheck “Use Advanced Calibration Methods”)

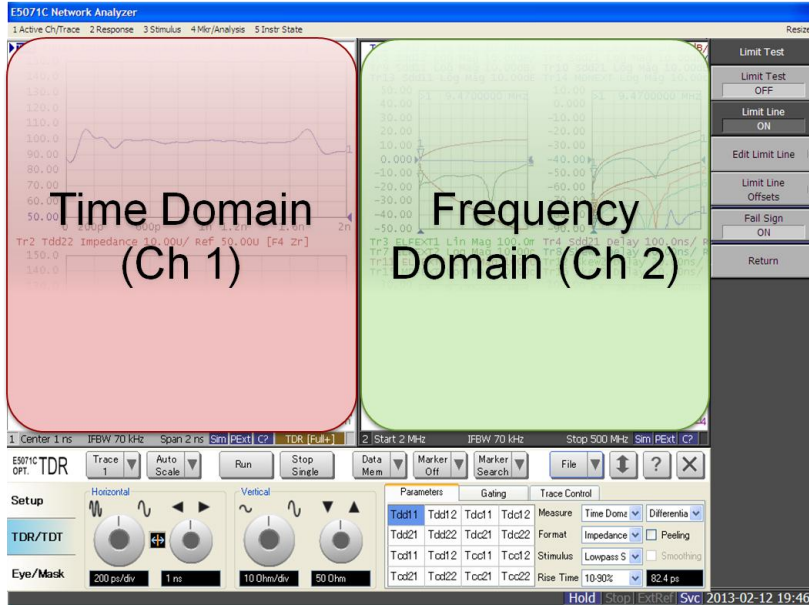


4. Click **File** and select **Recall State** to open the Recall State dialog box.
5. Specify a folder and a file name, and click **Open**.

The E5071C's channel 1 is used for time-domain measurements by using the TDR software at the bottom of the E5071C's screen. The channel 2 is used for frequency-domain

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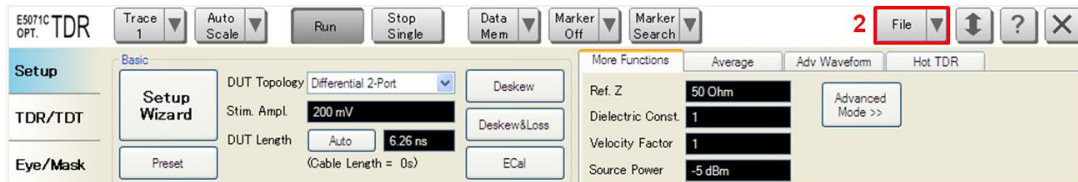
measurements by using the soft key on the right side of the screen or hard key on the front panel.



5.2.2. Saving a State File

All the measurement settings including calibration information can be saved in a state file (*.tdr). After performing calibration, all necessary calibration coefficients are saved in a state file and can be recalled for the next measurements.

1. Press **Save/Recall** > **Save Type** and select **State & Cal** as a state file type.
2. Click **File** of the TDR software.



3. Select "Save State".
4. Enter file name and save the state file with calibration information

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5.3. Calibration

5.3.1. Time Domain Calibration

The purpose of this step is to calibrate the delay and loss of the RF cables (and test fixtures) by following the wizard of the E5071C TDR software. Full calibration is performed by using the 4-port ECal Module at the end of RF cables connected to the E5071C's test ports. After connecting the test fixture to the cables, the effect of the fixture is removed by the fixture compensation function of the TDR software. This calibration is applied for time-domain measurements in Channel 1.

5.3.1.1. ECal Calibration & Fixture Compensation

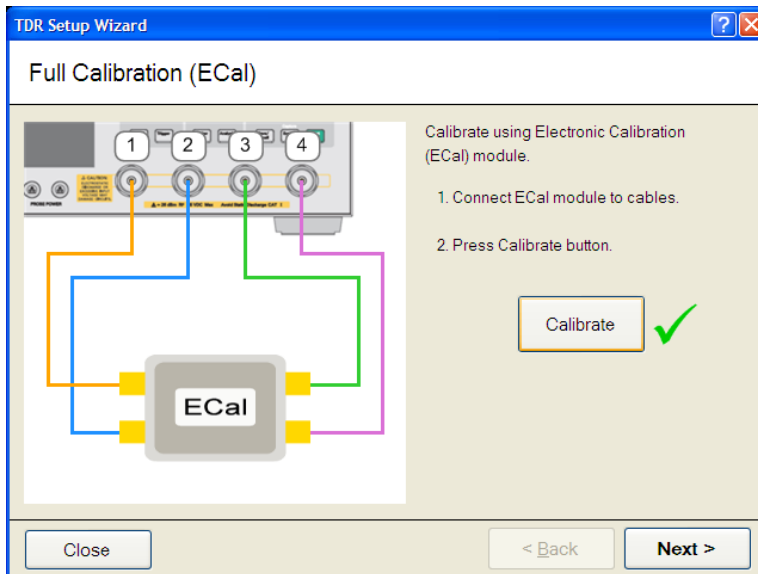
Calibration for time-domain measurements is performed by the TDR software. The 4-port ECal Module (i.e. N4431B) connected to the USB port of the E5071C is necessary for the calibration procedure.

1. Press **Channel Next** to select Channel 1.
2. Open **Setup** tab of the TDR software.
3. Click **ECal** to launch calibration wizard.

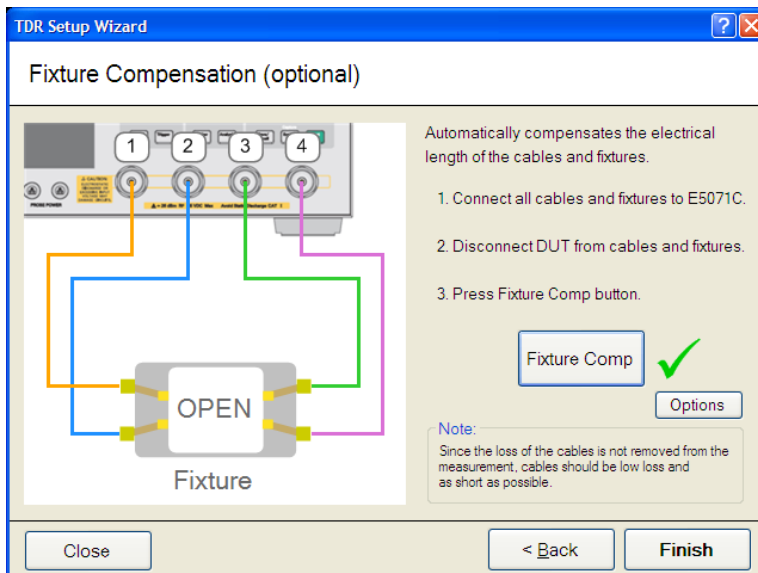


4. Connect all test cables to the ECal Module and click **Calibrate**. Once green check mark appears, click **Next>**.

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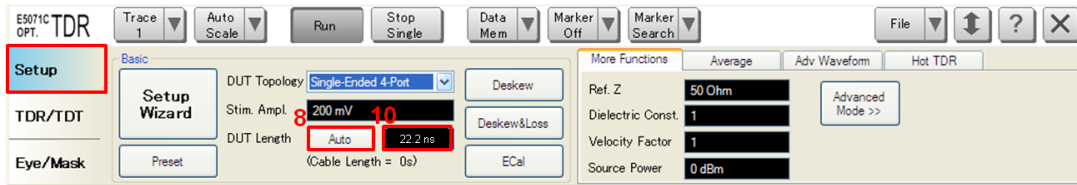


5. Disconnect the ECal Module and connect the test fixtures to the RF cables. Click **Fixture Comp** to perform fixture compensation. Once green check mark appears, click **Finish** to complete the compensation.

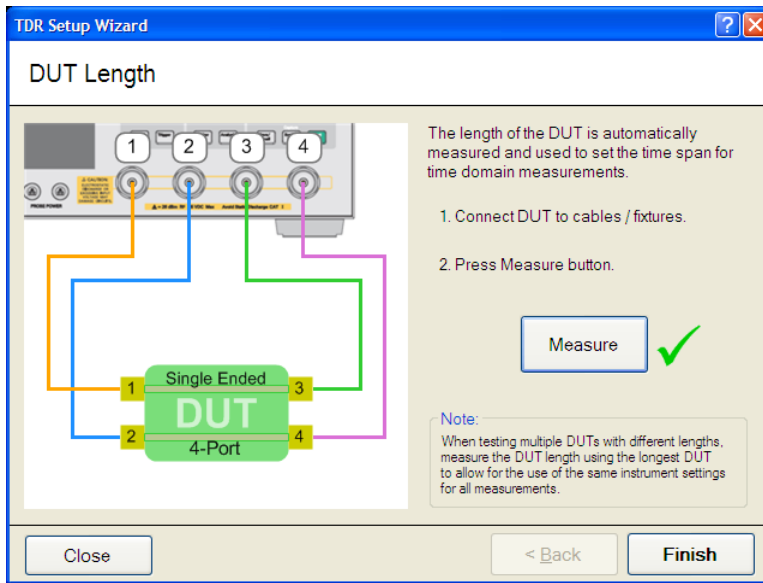


6. Connect DUT to the test fixtures.
7. Open **Setup** tab.
8. Click **Auto** to launch the diagram.

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9. Click **Measure** to specify DUT's electrical length in the dialog box. Once green check mark appears, click **Finish**.



5.3.2. Frequency Domain Calibration

The purpose of this step is to calibrate out the RF effects (i.e. mismatch, loss or delay) of RF cables and test fixtures. Full calibration is performed by using the 4-port ECal Module at the end of RF cables connected to the E5071C's test ports. And then the test fixtures are connected to the RF test cables, and the fixture's effect will be eliminated by auto port extension function of the E5071C's firmware.

The calibration is applied for frequency-domain measurements in Channel 2.

5.3.2.1. ECal Calibration

Calibration for the frequency-domain measurement is performed by selecting the E5071C's

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soft key. The 4-port ECal Module (i.e. N4431B) connected to the USB port of the E5071C is necessary for the calibration procedure.

1. Press **Channel Next** key to select Channel 2.
2. Connect all RF test cables to the ECal Module.
3. Press **Calibrate > ECal > 4-Port Cal.**

5.3.2.2. Auto Port Extension

The effect of the test fixtures (i.e. delay) are removed by auto port extension function of the E5071C's firmware. The calibration plane (at the RF test cables by ECal calibration) is moved to the end of test fixtures by auto port extension.

1. Connect the test fixture to the RF cable. The DUT is not connected to the test fixture (the fixture end is left open).

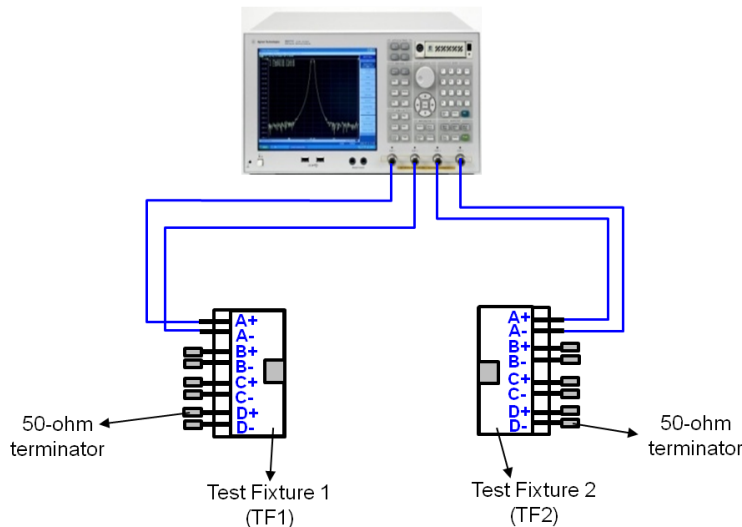


Figure 5-1 Auto Port Extension Test Setup

2. Press **Cal > Port Extension > Auto Port Extension > Select Ports** and check all ports (Port 1 to Port 4).

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3. Press **Cal** > **Port Extension** > **Auto Port Extension** > **Measure Open** and select **All** to enable auto port extension.

5.4. Measurement

The procedures for time-domain and frequency-domain measurements are introduced in this section. The duplex channel 1 of the 10GBASE-T Ethernet cable under test is a disturbed channel and the other three channels (channel 2, 3 or 4) are disturbing channels when making crosstalk (i.e. NEXT, ELFEXT) measurements.

The duplex channel 1, 2, 3, and 4 of DUT should be connected to the A+/A-, B+/B-, C+/C- and D+/D- differential pairs of the test fixtures respectively.

5.4.1. Differential Characteristic Impedance

1. Connect the E5071C and the test fixture with the RF cables. (Figure 5-2).

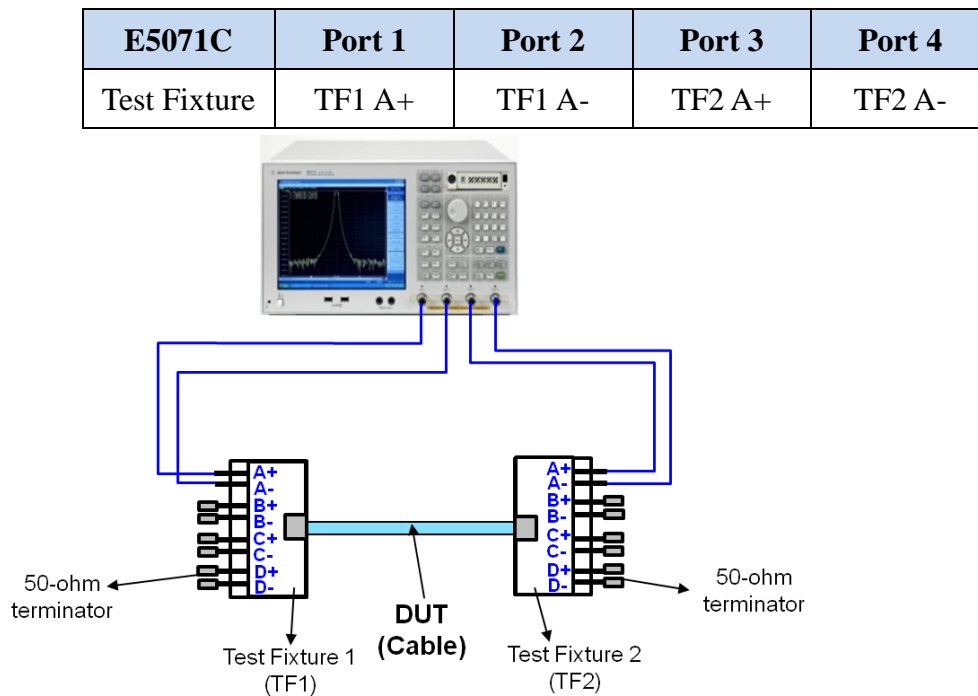


Figure 5-2 Differential Characteristic Impedance Test Setup

Note: Unused fixture ports should be terminated with 50 ohm terminators.

2. Press **Channel Next** to select Channel 1 of the E5071C.
3. Select **Trace 1**. (Tdd11)
4. Press **Stop Single**.

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5. Confirm the nominal differential characteristic impedance is 100 ohm.
6. Select **Trace 2** and repeat the same operations of Step 4 to 5 at the far end of the DUT (Tdd22).

5.4.2. Insertion Loss

1. Connect DUT to the test fixtures with the RF cables (Figure 5-2).
2. Press **Channel Next** to select Channel 2 of the E5071C.
3. Press **Trigger > Single**.
4. Press **Trace Next** to select Trace 1 (Sdd21).
5. Confirm the measured differential insertion loss is lower than the limit shown below.

$$\text{Insertion loss}(f) \leq 1.05 \left(1.82 \times \sqrt{f} + 0.0169 \times f + \frac{0.25}{\sqrt{f}} \right) + 4 \times 0.02 \times \sqrt{f} \quad (\text{dB})$$

where

f is the frequency in MHz; $1 \leq f \leq 500$

6. Press **Display > Data -> Mem** to copy the trace data to memory. The measured differential insertion loss is used for calculation of Equal level far-end crosstalk (ELFEXT) in 5.4.6.
7. Press **Trace Next** to select Trace 5 (Sdd12).
8. Confirm the measured differential insertion loss is lower than the limit of Step 5.
9. Press **Display > Data -> Mem** to copy the trace data to memory.

5.4.3. Return Loss

1. Connect the E5071C and the test fixtures with the RF cables. (Figure 5-2)
2. Press **Trigger > Single**.
3. Press **Trace Next** to select Trace 9 (Sdd11).
4. Confirm the measured return loss is lower than the limit shown below.

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$$\text{Return loss} \geq \left\{ \begin{array}{ll} 19 & 1 \leq f < 10 \\ 24 - 5\log_{10}(f) & 10 \leq f < 40 \\ 32 - 10\log_{10}(f) & 40 \leq f < 400 \\ 6 & 400 \leq f \leq 500 \end{array} \right\} \quad (\text{dB})$$

where
 f is the frequency in MHz.

Note: The reference impedance for the return loss specification is 100 ohm.

5. Press **Trace Next** to select Trace 13 (Sdd22).
6. Confirm the measured return loss is lower than the limit of Step 4.

5.4.4. Differential Near-End Crosstalk (NEXT)

The differential pair-to-pair near-end crosstalk (NEXT) between a duplex channel of the DUT and the other three duplex channels is specified. The following procedure guides how to make measurements of the NEXT of a duplex channel 1 (at the near end of A+/A- in the test fixture 1) coupled with the other three duplex channels (at the near end; B+/B-, C+/C- and D+/D- in the test fixture 1).

1. Connect the E5071C's ports (Port 1 to 4) and the test fixture with the RF cables. (Figure 5-3)

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 B+	TF1 B-	TF1 A+	TF1 A-

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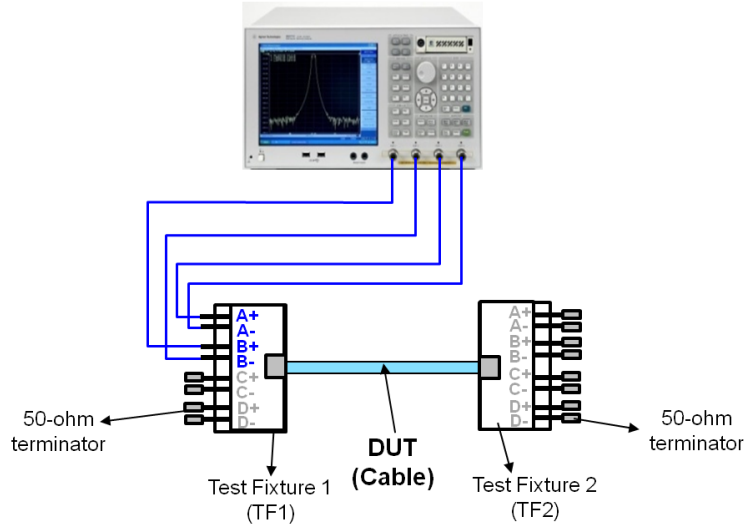


Figure 5-3 Differential Near-end Crosstalk (NEXT) Test Setup

2. Press **Trace Next** to select Trace 2 (Sdd21).
3. Press **Trigger > Single**.
4. Confirm the measured differential near-end crosstalk is lower than the limit shown below.

$$\text{NEXT loss}(f) \geq \left\{ \begin{array}{ll} -20 \log_{10} \left(10^{\frac{74.3 - 15 \log_{10}(f)}{-20}} + 2 \times 10^{\frac{94 - 20 \log_{10}(f)}{-20}} \right) \text{ (dB)} & 1 \leq f < 330 \\ 31 - 50 \log_{10} \left(\frac{f}{330} \right) \text{ (dB)} & 330 \leq f \leq 500 \end{array} \right\}$$

where
 f is the frequency in MHz.

5. Press **Display > Data -> Mem** to copy the trace data to memory.
6. Connect the E5071C's ports and the test fixture with the RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 C+	TF1 C-	TF1 A+	TF1 A-

7. Press **Trace Next** to select Trace 6 (Sdd21).
8. Repeat the same measurement as Step 3 to Step 5.

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9. Press **Display > Data -> Mem** to copy the trace data to memory.
10. Connect the RF cable to the test fixture.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 D+	TF1 D-	TF1 A+	TF1 A-

11. Press **Trace Next** to select Trace 10 (Sdd21).
12. Repeat the same measurement as Step 3 to Step 5.
13. Press **Display > Data -> Mem** to copy the trace data to memory.

The NEXT of a duplex channel 1 at the near end (test fixture 1) between the other three channels is measured by following Step 1 to Step 13.

14. Repeat the same measurements of Step 1 to Step 13 for the following combinations of connections. The NEXT of a duplex channel 1 at the far end (test fixture 2) between all the other three channels is measured.

NEXT Test #	Port 1	Port 2	Port 3	Port 4
#1 (Tr 2)	TF2 B+	TF2 B-	TF2 A+	TF2 A-
#2 (Tr 6)	TF2 C+	TF2 C-	TF2 A+	TF2 A-
#3 (Tr 10)	TF2 D+	TF2 D-	TF2 A+	TF2 A-

5.4.5. Multiple Disturber Near-end Crosstalk (MDNEXT)

To ensure the total NEXT coupled into a duplex channel is limited, multiple disturber NEXT (MDNEXT) loss is specified as the power sum of the individual NEXT losses. As the measurement results of all NEXT traces are used for calculation of MDNEXT, NEXT measurements in 5.4.4. should be performed before the MDNEXT measurements.

1. Press **Trace Next** to select Trace 14 (MDNEXT).
2. Perform Step 1 to Step 13 of 5.4.4. Near-end Crosstalk measurements.
3. Confirm the calculated MDNEXT at the near end (test fixture 1) is lower than the limit

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shown below.

$$\text{MDNEXT loss}(f) \geq \begin{cases} -20 \log_{10} \left(10^{\frac{72.3 - 15 \log_{10}(f)}{-20}} + 2 \times 10^{\frac{90 - 20 \log_{10}(f)}{-20}} \right) \text{ (dB)} & 1 \leq f < 330 \\ 28 - 50 \log_{10} \left(\frac{f}{330} \right) \text{ (dB)} & 330 \leq f \leq 500 \end{cases}$$

where
 f is the frequency in MHz.

4. Perform Step 14 of 5.4.4. Near-end Crosstalk measurements.
5. Confirm the calculated MDNEXT at the far end (test fixture 2) is lower than the limit of Step 3.

5.4.6. Equal Level Far-End Crosstalk (ELFEXT)

Equal level far-end crosstalk (ELFEXT) is specified to limit the crosstalk at the far end of each duplex channel. Far-end crosstalk (FEXT) is crosstalk that appears at the far end of a disturbed channel, which is coupled from another disturbing channel. The ELFEXT is equal to FEXT minus the insertion loss of the disturbed channel.

The following procedure guides how to make the ELFEXT measurement of a disturbed channel 1 (connected to A+/A- pair of the test fixtures) coupled with the other three disturbing channels (B+/B-, C+/C- and D+/D- pairs of the test fixtures).

Because the result of differential insertion loss is needed for calculation of ELFEXT, insertion loss measurement (5.4.2) should be performed before ELFEXT measurement.

1. Connect the E5071C's ports (Port 1 to 4) and the test fixture with the RF cables. (Figure 5-4)

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 B+	TF1 B-	TF2 A+	TF2 A-

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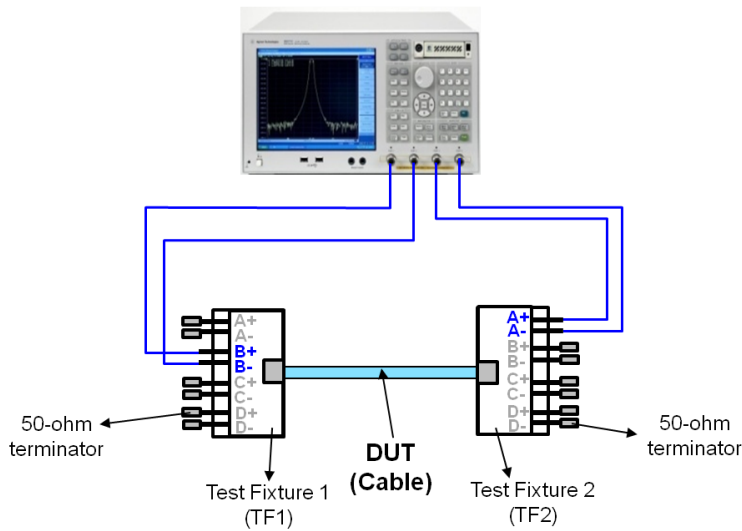


Figure 5-4 Equal Level Far-end Crosstalk (ELFEXT) Test Setup

2. Press **Trace Next** to select Trace 3 (ELFEXT1).
3. Press **Trigger > Single**.
4. Press **Display > Data -> Mem** to copy the trace data to memory.
5. The ELFEXT (= FEXT – Insertion loss) is calculated by the equation editor function of the E5071C's firmware. Confirm the calculated ELFEXT is lower than the limit shown below.

$$\text{ELFEXT} \geq -20 \log_{10} \left(10^{\frac{67.8 - 20 \log_{10}(f)}{-20}} + 4 \times 10^{\frac{83.1 - 20 \log_{10}(f)}{-20}} \right) \quad (\text{dB})$$

where

f is the frequency in MHz and $1 \leq f \leq 500$.

6. Connect the E5071C's ports and the test fixtures with the RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 C+	TF1 C-	TF2 A+	TF2 A-

7. Press **Trace Next** to select Trace 7 (ELFEXT2).
8. Repeat the same measurement as Step 3 to Step 5.
9. Connect the E5071C's ports and the test fixtures with the RF cables.

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E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 D+	TF1 D-	TF2 A+	TF2 A-

10. Press **Trace Next** to select Trace 11 (ELFEXT3).
11. Repeat the same measurement as Step 3 to Step 5. The ELFEXT of a duplex channel 1 at the far end (test fixture 2) between all the other three channels is measured by following Step 1 to Step 10.

The following steps guide how to make all the ELFEXT measurements of a duplex channel 1 at the near end (test fixture 1).

12. Press **Trace Next** to select Trace 3.
13. Press **Display** > **Equation Editor...** > Enter an equation “**ELFEXT1 = mem(3)/mem(2)**”.
14. Press **Trace Next** to select Trace 7.
15. Press **Display** > **Equation Editor...** > Enter an equation “**ELFEXT2 = mem(7)/mem(2)**”.
16. Press **Trace Next** to select Trace 11.
17. Press **Display** > **Equation Editor...** > Enter an equation “**ELFEXT3 = mem(11)/mem(2)**”.
18. Repeat the same measurements of Step 1 to Step 11 for the following combinations of connections. The ELFEXT of a duplex channel 1 at the near end (test fixture 1) between all the other three channels is measured.

ELFEXT Test #	Port 1	Port 2	Port 3	Port 4
#1 (Tr 3)	TF2 B+	TF2 B-	TF1 A+	TF1 A-
#2 (Tr 7)	TF2 C+	TF2 C-	TF1 A+	TF1 A-
#3 (Tr 11)	TF2 D+	TF2 D-	TF1 A+	TF1 A-

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5.4.7. Multiple Disturber Equal Level Far-end Crosstalk (MDELFEEXT)

To ensure the total FEXT coupled into a duplex channel is limited, multiple disturber ELFEXT is specified as the power sum of the individual ELFEXT disturbers. The measurement result of ELFEXT of each disturbing channel is used for calculation of MDELFEEXT.

1. Press **Trace Next** to select Trace 15 (MDELFEEXT).
2. Perform Step 1 to Step 11 of 5.4.6. Equal Level Far-end Crosstalk measurements.
3. Confirm the calculated MDELFEEXT at the far end (test fixture 2) is lower than the limit shown below.

$$\text{MDELFEEXT}(f) \geq -20 \log_{10} \left(10^{\frac{64.8 - 20 \log_{10}(f)}{-20}} + 4 \times 10^{\frac{80.1 - 20 \log_{10}(f)}{-20}} \right) \text{ (dB)}$$

where

f is the frequency $1 \leq f \leq 500$.

4. Press **Display** > **Equation Editor...** > Enter an equation “**MDELFEEXT = mag(mem(3)/mem(2))+mag(mem(7)/mem(2))+mag(mem(11)/mem(2))**”.
5. Perform Step 12 to 18 of 5.4.6. Equal Level Far-end Crosstalk measurements.
6. Confirm the calculated MDNEXXT at the near end (test fixture 1) is lower than the limit of Step 3.

5.4.8. Maximum Link Delay

1. Connect DUT to the test fixtures with the RF cables (Figure 5-2).

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 A+	TF1 A-	TF2 A+	TF2 A-

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2. Press **Trace Next** to select Trace 4 (Sdd21).
3. Press **Start** > Set start value to “2 MHz”.
4. Press **Trigger** > **Single**.
5. Press **Marker** > **Max** to read the maximum value of the group delay (in ns).
6. Confirm the measured maximum link delay is within the limit. If the delay does not exceed 570 ns at all frequencies from 2 MHz to 500 MHz, then PASS. Otherwise FAIL
7. Press **Display** > **Data** -> **Mem** to copy the trace data to memory.

5.4.9. Link Delay Skew

As the measurement result of Maximum Link Delay is used for calculation of delay skew, Maximum Link Delay measurement in 5.4.8 should be performed before Link Delay Skew measurement.

1. Connect DUT to the test fixtures with the RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 B+	TF1 B-	TF2 B+	TF2 B-

2. Press **Start** > Set start value to “2 MHz”.
3. Press **Trace Next** to select Trace 8 (Skew1).
4. Press **Trigger** > **Single**.
5. Press **Display** > **Data** -> **Mem** to copy the trace data to memory.
6. Confirm the calculated delay skew between the duplex channel 1 and channel 2 is within the limit. If the delay does not exceed 50 ns at all frequencies from 2 MHz to 500 MHz, then PASS. Otherwise FAIL
7. Connect DUT to the test fixtures with the RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 C+	TF1 C-	TF2 C+	TF2 C-

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8. Press **Trace Next** to select Trace 12 (Skew2).
9. Press **Trigger > Single**.
10. Press **Display > Data -> Mem** to copy the trace data to memory.
11. Confirm the calculated delay skew between the duplex channel 1 and channel 3 is within the limit of Step 6.
12. Connect DUT to the test fixtures with the RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixture	TF1 D+	TF1 D-	TF2 D+	TF2 D-

13. Press **Trace Next** to select Trace 16 (Skew3).
14. Press **Trigger > Single**.
15. Press **Display > Data -> Mem** to copy the trace data to memory.
16. Confirm the calculated delay skew between the duplex channel 1 and channel 4 is within the limit of Step 6.

5.4.10. Measurements of Other Duplex Channels

The above procedure describes the measurement steps for a duplex channel 1 (A+ & A- pair of the test fixture 1 and 2). The same measurement should be performed for all the combinations of the other duplex channels such as channel 2 (B+ & B-), channel 3 (C+ & C-) and channel 4 (D+ & D-). Repeat the measurements 5.4.1 to 5.4.9 for the following connections between the E5071C's ports and the test fixtures.

1. Connections for measurements of duplex channel 2 (B+/B- pair)

Parameter / E5071C Port	Port 1	Port 2	Port 3	Port 4
Differential Characteristic Impedance Insertion Loss Return Loss Maximum Link Delay	TF1 B+	TF1 B-	TF2 B+	TF2 B-
Differential NEXT, MDNEXT (at near end, in TF1)	TF1 A+ TF1 C+ TF1 D+	TF1 A- TF1 C- TF1 D-	TF1 B+ TF1 B+ TF1 B+	TF1 B- TF1 B- TF1 B-

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Differential NEXT, MDNEXT (at far end, in TF2)	TF2 A+ TF2 C+ TF2 D+	TF2 A- TF2 C- TF2 D-	TF2 B+ TF2 B+ TF2 B+	TF2 B- TF2 B- TF2 B-
ELFEXT, MDELNEXT (at far end, in TF2)	TF1 A+ TF1 C+ TF1 D+	TF1 A- TF1 C- TF1 D-	TF2 B+ TF2 B+ TF2 B+	TF2 B- TF2 B- TF2 B-
ELFEXT, MDELNEXT (at near end, in TF1)	TF2 A+ TF2 C+ TF2 D+	TF2 A- TF2 C- TF2 D-	TF1 B+ TF1 B+ TF1 B+	TF1 B- TF1 B- TF1 B-
Link Delay Skew	TF1 A+ TF1 C+ TF1 D+	TF1 A- TF1 C- TF1 D-	TF2 A+ TF2 C+ TF2 D+	TF2 A- TF2 C- TF2 D-

2. Connections for measurements of duplex channel 3 (C+/C- pair)

Parameter / E5071C Port	Port 1	Port 2	Port 3	Port 4
Differential Characteristic Impedance Insertion Loss Return Loss Maximum Link Delay	TF1 C+	TF1 C-	TF2 C+	TF2 C-
Differential NEXT, MDNEXT (at near end, in TF1)	TF1 A+ TF1 B+ TF1 D+	TF1 A- TF1 B- TF1 D-	TF1 C+ TF1 C+ TF1 C+	TF1 C- TF1 C- TF1 C-
Differential NEXT, MDNEXT (at far end, in TF2)	TF2 A+ TF2 B+ TF2 D+	TF2 A- TF2 B- TF2 D-	TF2 C+ TF2 C+ TF2 C+	TF2 C- TF2 C- TF2 C-
ELFEXT, MDELNEXT (at far end, in TF2)	TF1 A+ TF1 B+ TF1 D+	TF1 A- TF1 B- TF1 D-	TF2 C+ TF2 C+ TF2 C+	TF2 C- TF2 C- TF2 C-
ELFEXT, MDELNEXT (at near end, in TF1)	TF2 A+ TF2 B+ TF2 D+	TF2 A- TF2 B- TF2 D-	TF1 C+ TF1 C+ TF1 C+	TF1 C- TF1 C- TF1 C-
Link Delay Skew	TF1 A+ TF1 B+ TF1 D+	TF1 A- TF1 B- TF1 D-	TF2 A+ TF2 B+ TF2 D+	TF2 A- TF2 B- TF2 D-

3. Connections for measurements of duplex channel 4 (D+/D- pair)

Parameter / E5071C Port	Port 1	Port 2	Port 3	Port 4
Differential Characteristic Impedance Insertion Loss Return Loss Maximum Link Delay	TF1 D+	TF1 D-	TF2 D+	TF2 D-
Differential NEXT, MDNEXT (at near end, in TF1)	TF1 A+ TF1 B+ TF1 C+	TF1 A- TF1 B- TF1 C-	TF1 D+ TF1 D+ TF1 D+	TF1 D- TF1 D- TF1 D-
Differential NEXT, MDNEXT (at far end, in TF2)	TF2 A+ TF2 B+ TF2 C+	TF2 A- TF2 B- TF2 D-	TF2 D+ TF2 D+ TF2 D+	TF2 D- TF2 D- TF2 D-

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ELFEXT, MDELTEXT (at far end, in TF2)	TF1 A+ TF1 B+ TF1 C+	TF1 A- TF1 B- TF1 C-	TF2 D+ TF2 D+ TF2 D+	TF2 D- TF2 D- TF2 D-
ELFEXT, MDELTEXT (at near end, in TF1)	TF2 A+ TF2 B+ TF2 C+	TF2 A- TF2 B- TF2 C-	TF1 D+ TF1 D+ TF1 D+	TF1 D- TF1 D- TF1 D-
Link Delay Skew	TF1 A+ TF1 B+ TF1 C+	TF1 A- TF1 B- TF1 C-	TF2 A+ TF2 C+ TF2 D+	TF2 A- TF2 C- TF2 D-

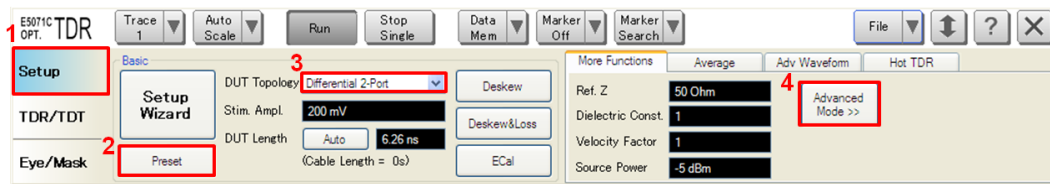
6. [Appendix] Manual Setup

The procedures of manual setup for time-domain and frequency-domain measurements are introduced in the section. All the following parameters are saved in the E5071C's state file, which is available at: www.agilent.com/find/ena-tdr_ethernet-cabcon

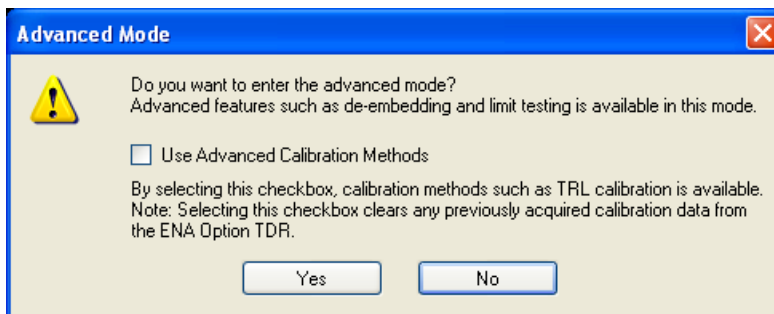
6.1. Channel & Trace Setup

If TDR setup wizard is shown when launching the TDR software, click **Close** button in the TDR setup wizard main window.

1. Open **Setup** tab in the TDR software.
2. Click **Preset** to preset the instrument. Click **OK** in a dialog box to continue.
3. Set **DUT Topology** to “Differential 2-Port”. Click **OK** in a dialog box.
4. Click **Advanced Mode>>**.

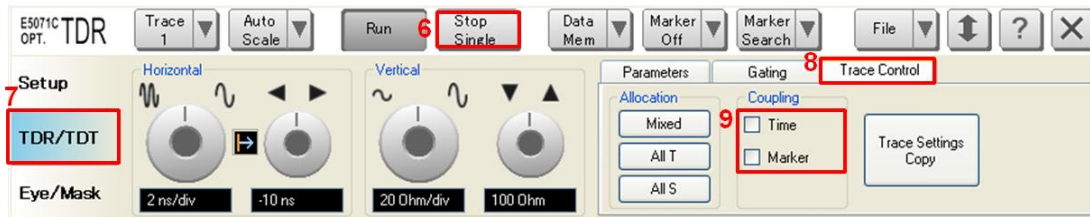



5. A dialog box appears requesting for confirmation. Then click **Yes**. (Clear the check box for “Use Advanced Calibration Methods”)



6. Click **Stop Single**.
7. Open **TDR/TDT** tab.
8. Click **Trace Control** tab.
9. Clear **Time** and **Marker** check box under Coupling.

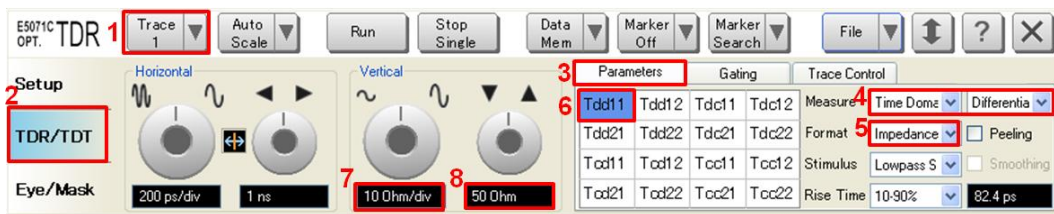
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10. Press **Display** > **Allocate Channels** > .
11. Press **Display** > **Num of Traces** > 2.
12. Press **Display** > **Allocate Traces** > x2 (1 column by 2 rows).
13. Press **Channel Max** to maximize the screen of Channel 1.

6.2. Differential Characteristic Impedance

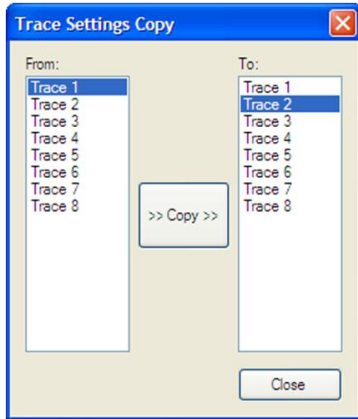
1. Select **Trace 1**.
2. Open **TDR/TDT** tab.
3. Open **Parameters** tab.
4. Select “Time Domain” and “Differential” for Measure.
5. Select Format to “Impedance”
6. Click **Tdd11**.
7. Click the box below the left knob under Vertical. Set the vertical scale to “10 Ohm/div” in a dialog box.
8. Click the box below the right knob under Vertical. Set the vertical center to “50 Ohm” in a dialog box.



9. Open **Trace Control** tab.
10. Click **Trace Settings Copy** to launch trace copy dialog box.
11. Select the Trace 1 in the From list.

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12. Select the Trace 2 in the To list.
13. Click **Copy**.
14. Click **Close**.



15. Select **Trace 2**.
16. Open **Parameter** tab.
17. Click **Tdd22**.

6.3. Common Parameters Setup for Frequency-domain Measurements

1. Press **Channel Next** to select Channel 2.
2. Press **Start** > Set start value to "1 MHz".
3. Press **Stop** > Set stop value to "500 MHz".
4. Press **Analysis** > **Fixture Simulator** and turn it **ON**.
6. Press **Analysis** > **Fixture Simulator** > **Topology** > **Device** > **Bal-Bal**
7. Press **Analysis** > **Fixture Simulator** > **Topology** > **Port1 (bal)** > **1-2**
8. Press **Analysis** > **Fixture Simulator** > **Topology** > **Port2 (bal)** > **3-4**
9. Press **Display** > **Num of Traces** > 16.
10. Press **Analysis** > **Fixture Simulator** > **BalUn ON All Traces** to enable mixed-mode S-parameter (i.e. Sdd11) measurements on all traces.
11. Press **Display** > **Allocate Traces** > x4 (2 columns by 2 rows).

6.4. Insertion Loss

1. Press **Trace Next** to select Trace 1.
2. Press **Meas** > **Sdd21**.
3. Press **Scale** > Set **Scale/Div** to 10 dB/div.
4. Press **Scale** > Set **Reference Value** to -10 dB.
5. Press **Trace Next** to select Trace 5.
6. Press **Meas** > **Sdd12**.
7. Press **Scale** > Set **Scale/Div** to 10 dB/div.
8. Press **Scale** > Set **Reference Value** to 0 dB.

6.5. Return Loss

1. Press **Trace Next** to select Trace 9.
2. Press **Meas** > **Sdd11**.
3. Press **Scale** > Set **Scale/Div** to 10 dB/div.
4. Press **Scale** > Set **Reference Value** to -20 dB.
5. Press **Trace Next** to select Trace 13.
6. Press **Meas** > **Sdd22**.
7. Press **Scale** > Set **Scale/Div** to 10 dB/div.
8. Press **Scale** > Set **Reference Value** to -20 dB.

6.6. Differential Near-end Crosstalk (NEXT)

1. Press **Trace Next** to select Trace 2.
2. Press **Meas** > **Sdd21**.
3. Press **Scale** > Set **Scale/Div** to 10 dB/div.

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4. Press **Scale** > Set **Reference Value** to -20 dB.
5. Press **Trace Next** to select Trace 6.
6. Press **Meas** > **Sdd21**.
7. Press **Scale** > Set **Scale/Div** to 10 dB/div.
8. Press **Scale** > Set **Reference Value** to -20 dB.
9. Press **Trace Next** to select Trace 10.
10. Press **Meas** > **Sdd21**.
11. Press **Scale** > Set **Scale/Div** to 10 dB/div.
12. Press **Scale** > Set **Reference Value** to -20 dB.

6.7. Multiple Disturber Near-end Crosstalk (MDNEXT)

1. Press **Trace Next** to select Trace 14.
2. Press **Meas** > **Sdd21**.
3. Press **Display** > **Equation Editor...** > Enter an equation “**MDNEXT = mag(mem(2))+mag(mem(6))+mag(mem(10))**”.
4. Check **Enabled** to enable the equation on trace.
5. Click **Apply**.
6. Click **Close**.
7. Press **Scale** > Set **Scale/Div** to 10 dB/div.
8. Press **Scale** > Set **Reference Value** to -20 dB.

6.8. Equal Level Far-end Crosstalk (ELFEXT)

1. Press **Trace Next** to select Trace 3.
2. Press **Meas** > **Sdd21**.
3. Press **Display** > **Equation Editor...** > Enter an equation “**ELFEXT1 = mem(3)/mem(1)**”.

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4. Press **Scale** > Set **Scale/Div** to 10 dB/div.
5. Press **Scale** > Set **Reference Value** to -20 dB.
6. Press **Trace Next** to select Trace 7.
7. Press **Meas** > **Sdd21**.
8. Press **Display** > **Equation Editor...** > Enter an equation “**ELFEXT2 = mem(7)/mem(1)**”.
9. Press **Scale** > Set **Scale/Div** to 10 dB/div.
10. Press **Scale** > Set **Reference Value** to -20 dB.
11. Press **Trace Next** to select Trace 11.
12. Press **Meas** > **Sdd21**.
13. Press **Display** > **Equation Editor...** > Enter an equation “**ELFEXT3 = mem(11)/mem(1)**”.
14. Press **Scale** > Set **Scale/Div** to 10 dB/div.
15. Press **Scale** > Set **Reference Value** to -20 dB.

6.9. Multiple Disturber Equal Level Far-end Crosstalk (MDELFFEXT)

1. Press **Trace Next** to select Trace 15.
2. Press **Meas** > **Sdd21**.
3. Press **Display** > **Equation Editor...** > Enter an equation “**MDELFFEXT = mag(mem(3)/mem(1))+mag(mem(7)/mem(1))+mag(mem(11)/mem(1))**”.
4. Check **Enabled** to enable the equation on trace.
5. Click **Apply**.
6. Click **Close**.
7. Press **Scale** > Set **Scale/Div** to 10 dB/div.
8. Press **Scale** > Set **Reference Value** to -20 dB.

6.10. Maximum Link Delay

1. Press **Trace Next** to select Trace 4.
2. Press **Meas** > **Sdd21**.
3. Press **Format** > **Group Delay**.
4. Press **Scale** > Set **Scale/Div** to 100 ns/div.
5. Press **Scale** > Set **Reference Value** to 500 ns.

6.11. Link Delay Skew

1. Press **Trace Next** to select Trace 8.
2. Press **Meas** > **Sdd21**.
3. Press **Format** > **Group Delay**.
4. Press **Display** > **Equation Editor...** > Enter an equation “**Skew1=mem(8)/mem(4)**”.
5. Check **Enabled** to enable the equation on trace.
6. Click **Apply**.
7. Click **Close**.
8. Press **Scale** > Set **Scale/Div** to 20 ns/div.
9. Press **Scale** > Set **Reference Value** to 0 ns.
10. Press **Trace Next** to select Trace 12.
11. Press **Meas** > **Sdd21**.
12. Press **Format** > **Group Delay**.
13. Press **Display** > **Equation Editor...** > Enter an equation “**Skew2= mem(12)/mem(4)**”.
14. Check **Enabled** to enable the equation on trace.
15. Click **Apply**.
16. Click **Close**.
17. Press **Scale** > Set **Scale/Div** to 20 ns/div.
18. Press **Scale** > Set **Reference Value** to 0 ns.
19. Press **Trace Next** to select Trace 16.

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20. Press **Meas** > **Sdd21**.
21. Press **Format** > **Group Delay**.
22. Press **Display** > **Equation Editor...** > Enter an equation “**Skew3=mem(16)/mem(4)**”.
23. Check **Enabled** to enable the equation on trace.
24. Click **Apply**.
25. Click **Close**.
26. Press **Scale** > Set **Scale/Div** to 20 ns/div.
27. Press **Scale** > Set **Reference Value** to 0 ns.

6.12. Defining Limit Line Tables

1. Press **Trace Next** to select trace to set the limit line table.
2. Press **Analysis** > **Limit Line** and turn it **ON** to display limit lines.
3. Press **Analysis** > **Edit Limit Line** to edit the limit line table.

	Type	Begin Stimulus	End Stimulus	Begin Response	End Response
1	MAX	0 s	600 ps	105 u	105 u
2	MIN	0 s	600 ps	75 u	75 u
3					

4. Press **Analysis** > **Limit Test** and turn it **ON**.
5. Press **Analysis** > **Limit Test** > **Fail Sign** to switch the fail sign ON/OFF. When turned on, the Fail sign is displayed on the E5071C's screen, if one or more failed traces are within the channel.
6. Press **System** > **Misc Setup** > **Beeper** > **Beep Warning** to turn ON/OFF the warning beeper.