Measurement Method

- Available Methods
- Measurement DUT Impedance Range for Each Method
- Configuration for Each Method

Other topics about Impedance Measurement Quick Start

Available Methods

This section describes the impedance measurement method. Five methods shown in the following table can be used to make an impedance measurement. For the connection for each method, see Preparation for Measurement.

When you select Impedance (**Meas** > **Impedance Analysis Menu**) as the Measurement type, the measurement method is made available (**Meas** > **Impedance Analysis Menu** >**Method**).

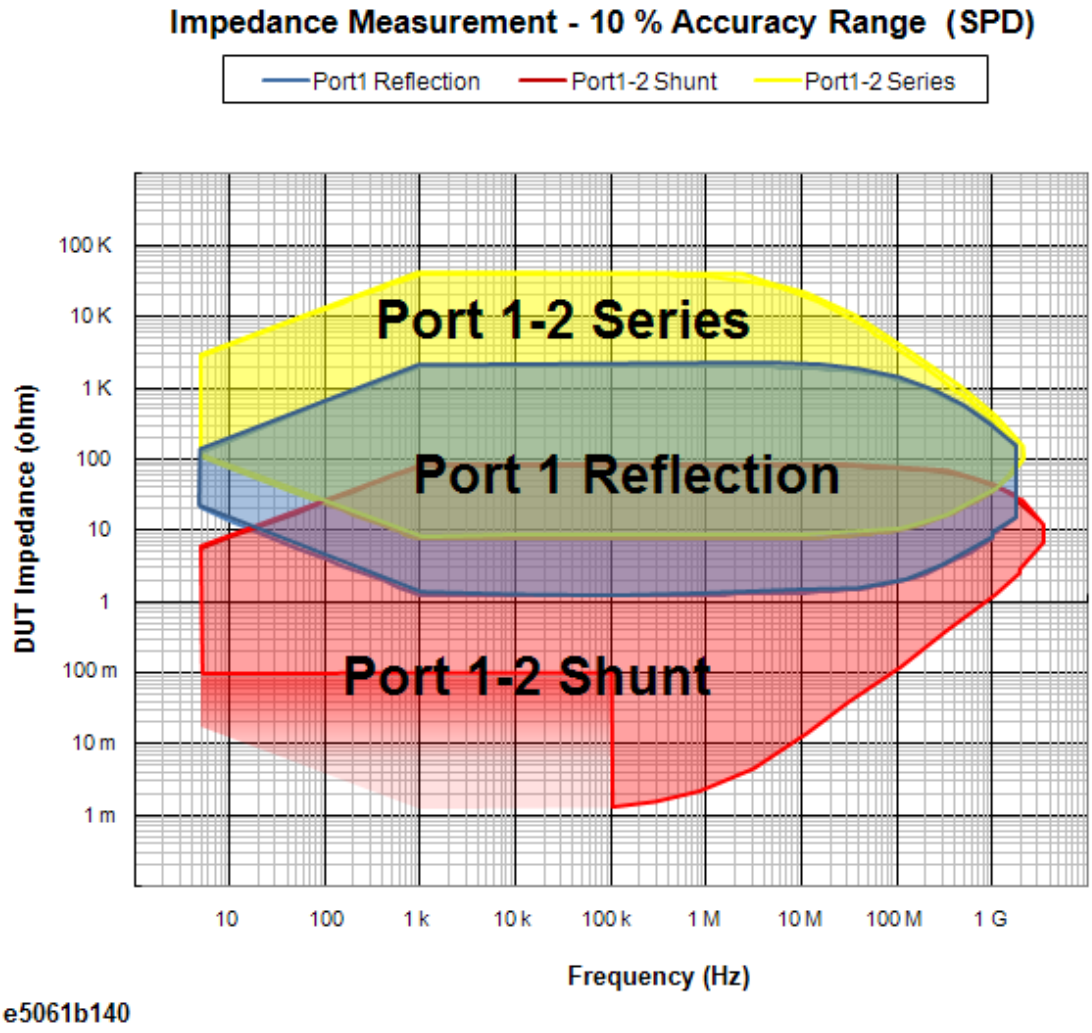
The characteristics of the measurement method is as described in the following table:

Method	Port 1 (or 2) Reflection	Port 1-2 Series	Port 1-2 Shunt	GP Series	GP Shunt
Measurement DUT Impedance Range	Low to middle impedance	Middle to high impedance in the high frequency range Not applicable to grounded DUTs	Very low impedance in the high frequency range	Middle to high impedance in the low frequency range	Very low impedance in the low frequency range
Formula	Zdut = 50 x (1+S11)/(1-S11)	Zdut = 50 x 2 x (1-S21)/S21	Zdut = 50 x S21/(2 x (1-S21))	Zdut = 50 x (1-S21)/S21	Zdut = 50 x S21/(2 x (1-S21))

Measurement DUT Impedance Range for Each Method

The following figures show the 10% accuracy range for each method. You can select the appropriate method according to your DUT impedance.

Ports 1 and 2



Conditions of 10 % measurement accuracy range

The following table shows the condition where the 10% measurement accuracy range shown above is specified.

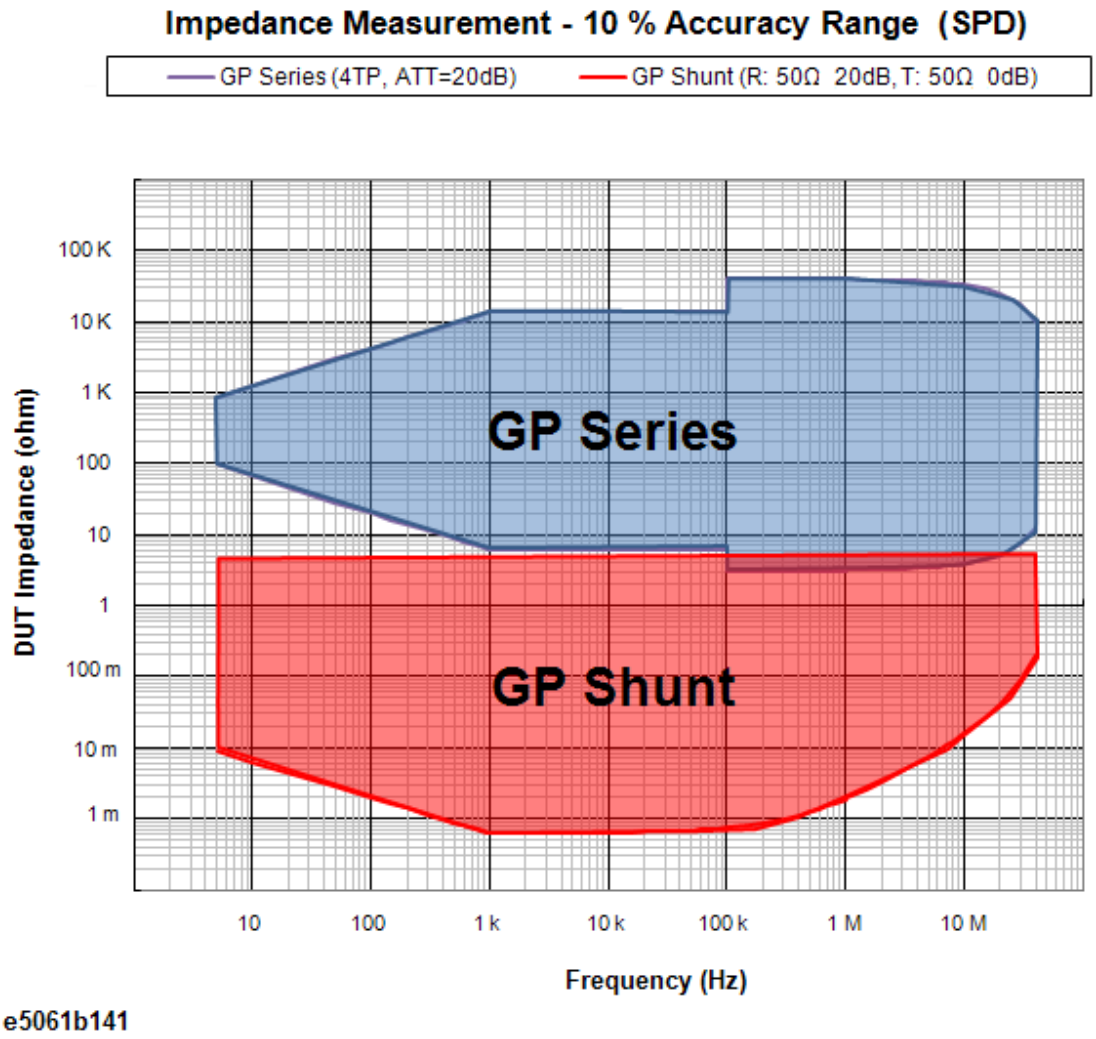
Method	Frequency	Calibration	IFBW	Source Power	Note
Port 1-2 Series	5 Hz to 3 GHz	Full 2-port calibration at measurement terminals of fixture or Full 2-port calibration + Open/Short/L	See the following table Measurement Frequency: < 200 Hz IF BW: ≤ (1/5 × Measurement	-20 to 0 dBm	

<table>
<tr><td></td><td rowspan="2"></td><td>oad fixture compensation
Note</td><td rowspan="2"><table><tr><td></td><td>Frequency) Hz</td></tr><tr><td>≥ 200 Hz</td><td>≤ 40 Hz</td></tr></table></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Port 1 Reflecti on</td><td>Open/Short/L oad calibration at 7 mm terminal of the 16201A.
Calibration kit: 16195B or 85031B</td></tr>
<tr><td>Port 1-2 Shunt</td><td>100 kHz to 3 GHz</td><td>Full 2-port calibration at measurement terminals of fixture
or
Full 2-port calibration + Open/Short/L oad fixture compensation
Note</td><td>10 Hz</td><td>10 dBm</td><td>Measurem ent error in the short calibration is included. (10 pH residual inductance of short standard is included.)
A ferrite core is required to measure DUTs with 100 mΩ or below at ≤100 KHz.</td></tr>
</table>

Temperature Condition

- 23±5 °C at calibration
- (calibration temperature) ±1 °C at measurement

Gain-Phase Ports



Conditions of 10 % measurement accuracy range

The following table shows the condition where the 10% measurement accuracy range shown above is specified.

Method	Frequency	Calibration	Receiver Setup	IFBW	Source Power	Note
GP Series	5 Hz to 30 MHz	Open/Short/Load calibration at measurement terminals of fixture Fixture: 16047E or	Rch: Zin=50 Ω, Att=20 dB Tch: Zin=50 Ω, Att=2	See the following table Meas. Frequency: < 200 Hz IF BW: ≤ (1/5 × Measurement	-20 to 0 dBm	Only with the response-thru calibration at the terminals of fixture, the measure

<table>
<tr>
<td></td>
<td></td>
<td>16034E/G/H

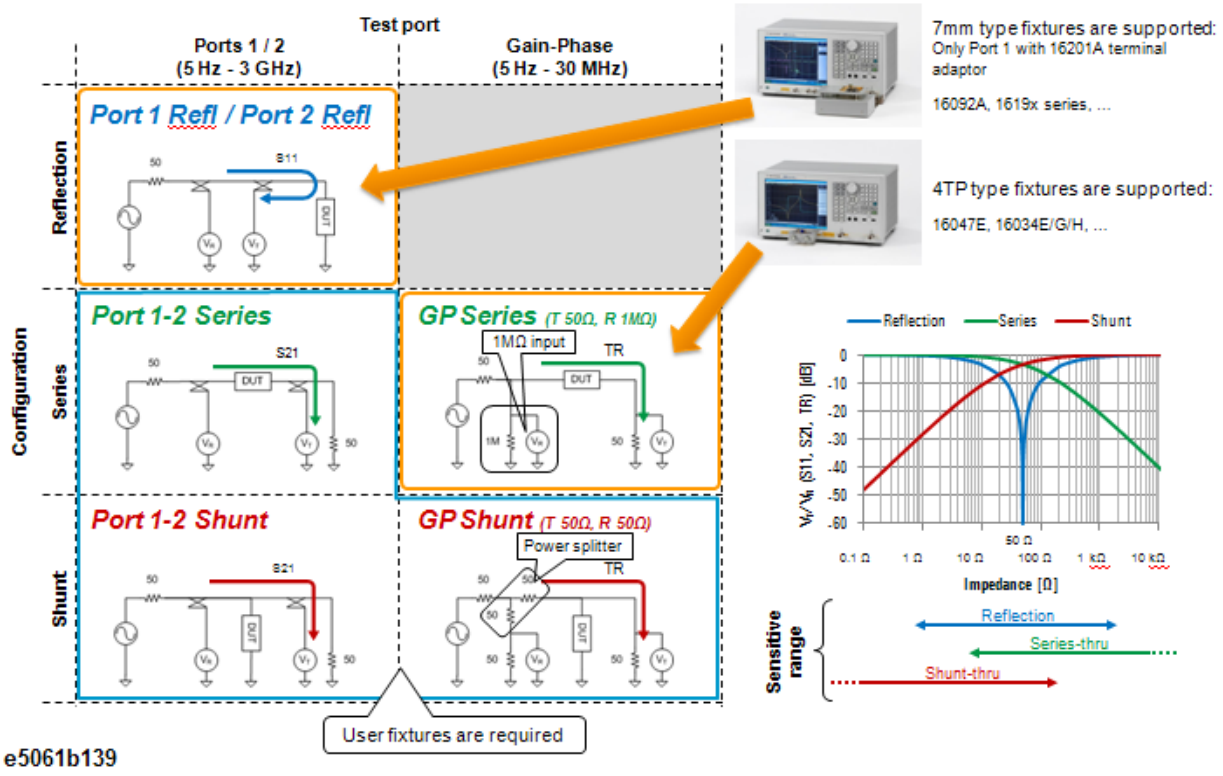
Load Standard: Agilent PN 5012-8646 (THT) or 0699-2829 (SMD)</td>
<td>0 dB</td>
<td><table><tr><td></td><td>Frequency) Hz</td></tr><tr><td>≥ 200 Hz</td><td>≤ 40 Hz</td></tr></table></td>
<td></td>
<td>ment accuracy may be degraded due to a parasitic capacitance of receiver port at RF range (≥1 MHz)</td>
</tr>
<tr>
<td>GP Shunt</td>
<td></td>
<td>Open/Short /Load calibration at measurement terminals of fixture
(Source=-10 dBm at calibration)
Note</td>
<td>Rch: Zin=50 Ω , Att=20 dB
Tch: Zin=50 Ω , Att=0 dB</td>
<td>See the following table<table><tr><th>Meas. Frequency</th><th>IF BW</th></tr><tr><td>< 50 Hz</td><td>≤ (1/5 × Measurement Frequency) Hz</td></tr><tr><td>≥50 Hz</td><td>≤ 40 Hz</td></tr></table></td>
<td>10 dBm</td>
<td>Measurement error in the short calibration is included (10 pH residual inductance of short standard is included.)
Maximum DUT impedance is 5 Ω in this condition in order to avoid a receiver saturation</td>
</tr>
</table>

Temperature Condition

- 23±5 °C at calibration
- (calibration temperature) ±1 °C at measurement

Configuration for Each Method

The following figure shows the configuration for each method.


Test port
Ports 1 / 2
(5 Hz - 3 GHz)
Gain-Phase
(5 Hz - 30 MHz)
Configuration
Reflection
Series
Shunt
Port 1 Refl / Port 2 Refl
Port 1-2 Series
GP Series (T 50Ω, R 1MΩ)
Port 1-2 Shunt
GP Shunt (T 50Ω, R 50Ω)
1MΩ input
Power splitter
TR
DUT
S11
S21
S21
User fixtures are required
7mm type fixtures are supported:
Only Port 1 with 16201A terminal adaptor
16092A, 1619x series, ...
4TP type fixtures are supported:
16047E, 16034E/G/H, ...
Reflection
Series
Shunt
Impedance [Ω]
Sensitive range
Reflection
Series-thru
Shunt-thru
e5061b139

Measurement Example of a Capacitor (Port 1 / Reflection)

This section describes how to measure a Capacitor. In this example, apart from E5061B option 005, 16201A terminal adapter and 16196A test fixture are used. The measurement is performed with 10 pF capacitor, hence, to measure another device under test (DUT), change the measurement conditions to suit accordingly. Prior to the measurement, ensure that the 16201A terminal adapter is connected to the E5061B network analyzer. See Connecting Terminal Adapter.

STEP 1. Setting Measurement Conditions

1. Preset the E5061B.

   Preset > **OK**

2. Set the trace display settings.

   Display > **Num of Traces** > **2**

   Display > **Allocate Traces** > **x2**

3. Set the measurement port to S-Parameter.

   Meas > **Measurement Port** > **S-Parameter**

4. Set the measurement method to Port 1 Reflection.

   Meas > **Impedance Analysis Menu** > **Method** > **Port 1 Refl**

5. Set the measurement type of each trace.

   Select Trace 1 as the active trace. **Meas** > **Impedance Analysis Menu** > **|Z|**

   Select Trace 2 as the active trace. **Meas** > **Impedance Analysis Menu** > **θz**

6. Set the format of the measurement of each trace.

   Select Trace 1 as the active trace. **Format** > **Exp Phase** > **OFF**

   Select Trace 2 as the active trace. **Format** > **Exp Phase** > **OFF**

7. Set the sweep setup power.

   Sweep Setup > **Power** > **-10dBm**

8. Set the sweep type.

   Sweep Setup > **Sweep Type** > **Log Freq**

9. Set the frequency bandwidth.

Avg > **IF Bandwidth** > **100 Hz**

STEP 2. Calibration

Once the measurement condition is set, impedance calibration should be performed. The 16195B calibration kit is required to perform the calibration.

1. Connect the E4991-60022 OPEN standard to the 16201A terminal adapter (which is connected to Port 1 of E5061B).

   Cal > **Cal Kit** > **16195B**

   Cal > **Calibrate** > **Impedance Calibration** > **Open**

   Once the open calibration is completed, a checkmark  is displayed to the left of the **Open** menu.

2. Remove the OPEN standard and connect the E4991-60021 SHORT standard to the terminal adapter.

   Cal > **Calibrate** > **Impedance Calibration** > **Short**

   Once the short calibration is completed, a checkmark  is displayed to the left of the **Short** menu.

3. In the same way, measure the calibration data for LOAD standard and LOW LOSS C standard. Use 04287-60021 50 Ω termination LOAD standard and 04287-60022 LOW LOSS Capacitor standard.

   Cal > **Calibrate** > **Impedance Calibration** > **Load**

   Cal > **Calibrate** > **Impedance Calibration** > **Low-Loss C**

   Once the calibrations are completed, a checkmark  is displayed to the left of the **Load** and **Low-Loss C** menu.

4. Set the calibration to DONE to save the performed calibration.

STEP 3. Fixture Compensation

As 16196A test fixture is used in this measurement example, fixture compensation should be performed to reduce possible errors induced by the test fixture. Ensure that the insulator assembly used is appropriate with the DUT. Refer to 16196A Test Fixture Operation and Service Manual to learn more about the fixture.

1. Connect the 16196A test fixture to the terminal adapter and set the electrical length:
   a. Turn the adapter's 7-mm connector in the counterclockwise direction when viewed from above and screw the connection sleeve in fully.

   b. Align the text fixture with the adapter's mount post and 7-mm connector and set it gently in place.
   c. Turn the adapter's 7-mm connector counterclockwise, connecting the bottom of the test fixture with the connector.
   d. **Cal** > **Fixture Compen** > **Fixture** > **16196A**
2. Set the open state by using the open state supplied.
   a. Using the Tweezers, place the open plate on top of the insulator assembly.
   b. Set the open plate with the protruding surface down.
   c. Fit the cap in place with the mark toward the front, and turn it to the right until it is locked.
   d. **Cal** > **Fixture Compen** > **Compensate** > **Open**
   e. Once the open compensation is completed, a checkmark  is displayed to the left of the **Open** menu.
3. Set the short state by using the open state supplied.
   a. Remove the cap. Remove the open plate used to measure the open compensation data.
   b. Place the short plate on the insulator assembly with tweezers. Place the rod-shaped protrusion of the short plate downward, and insert it into the DUT insertion hole.
   c. Fit the cap in place with the mark toward the front, and turn it to the right until it is locked.
   d. **Cal** > **Fixture Compen** > **Compensate** > **Short**
   e. Once the short calibration is completed, a checkmark  is displayed to the left of the **Short** menu.
4. Set the compensation to DONE to save the performed fixture compensation. Now, the fixture compensation should be automatically turned ON (**Cal** > **Fixture Compen** > **ON**).

STEP 4. Connecting Device Under Test (DUT)

1. Remove the cap.
2. Insert the DUT into the insulator hole with tweezers. Use a magnifying glass to check that the DUT is inserted deeply enough into the insulator hole for it to contact the bottom electrode.
3. Fit the cap in place with the mark toward the front, and turn it to the right until it is locked.
4. Set the log scale for Trace 1

   Select Trace 1 as the active trace. **Scale** > **Y-Axis** > **Log**

5. Set the appropriate scale for both traces by executing the auto scale.

Scale > **Auto Scale All**

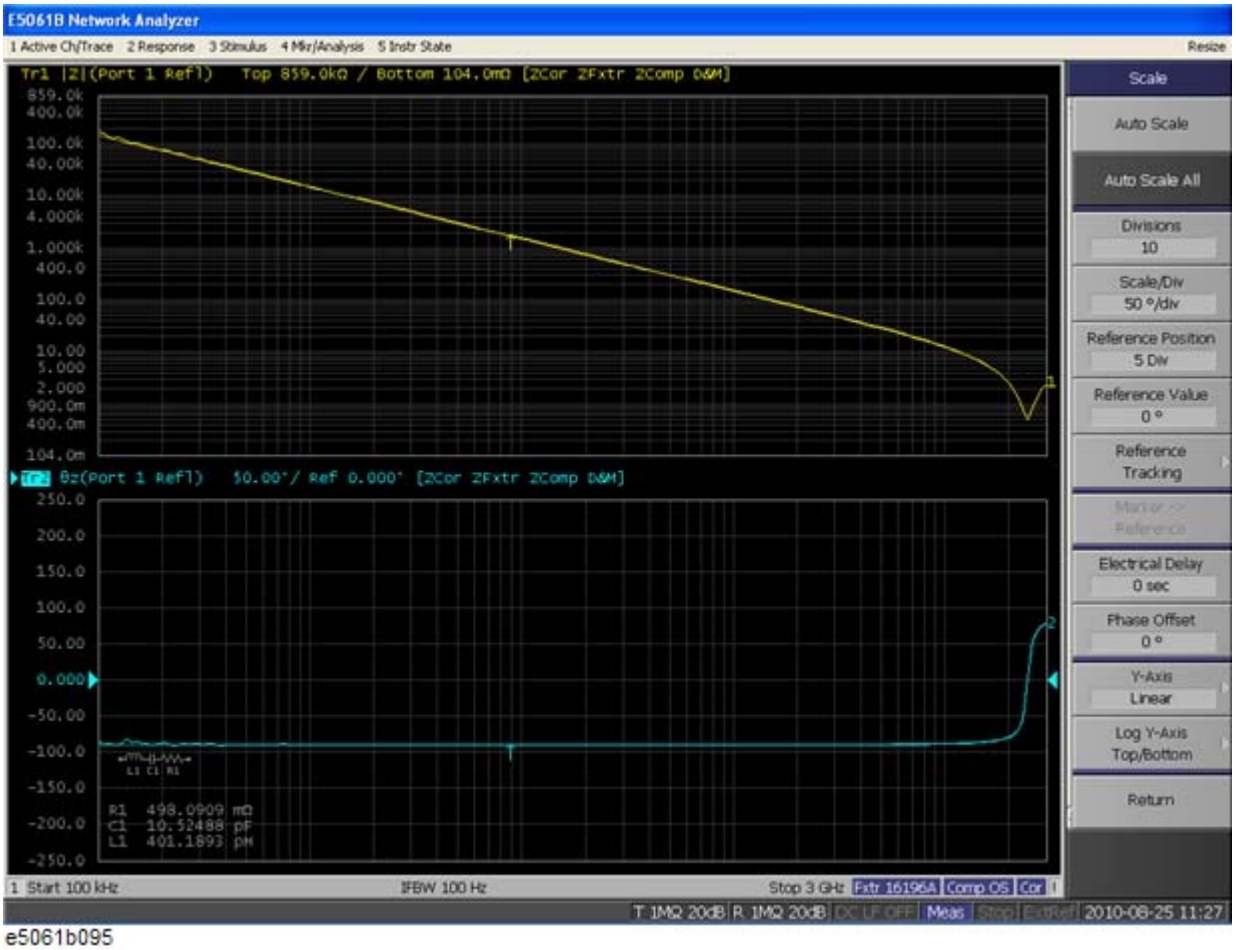
STEP 5. Analyzing Measurement Results

This section describes how to use Equivalent Circuit function to analyze the measurement.

1. **Analysis** > **Equivalent Circuit** > **Select Circuit** > **D**.
2. **Analysis** > **Equivalent Circuit** > **Calculate**. The calculated equivalent circuit parameters are displayed in each box of R1, C1 and L1.
3. **Analysis** > **Equivalent Circuit** > **Simulate** > **ON**.
4. **Analysis** > **Equivalent Circuit** > **Display** > **ON**.

Sample results as shown below:

DUT: 10 pF capacitor



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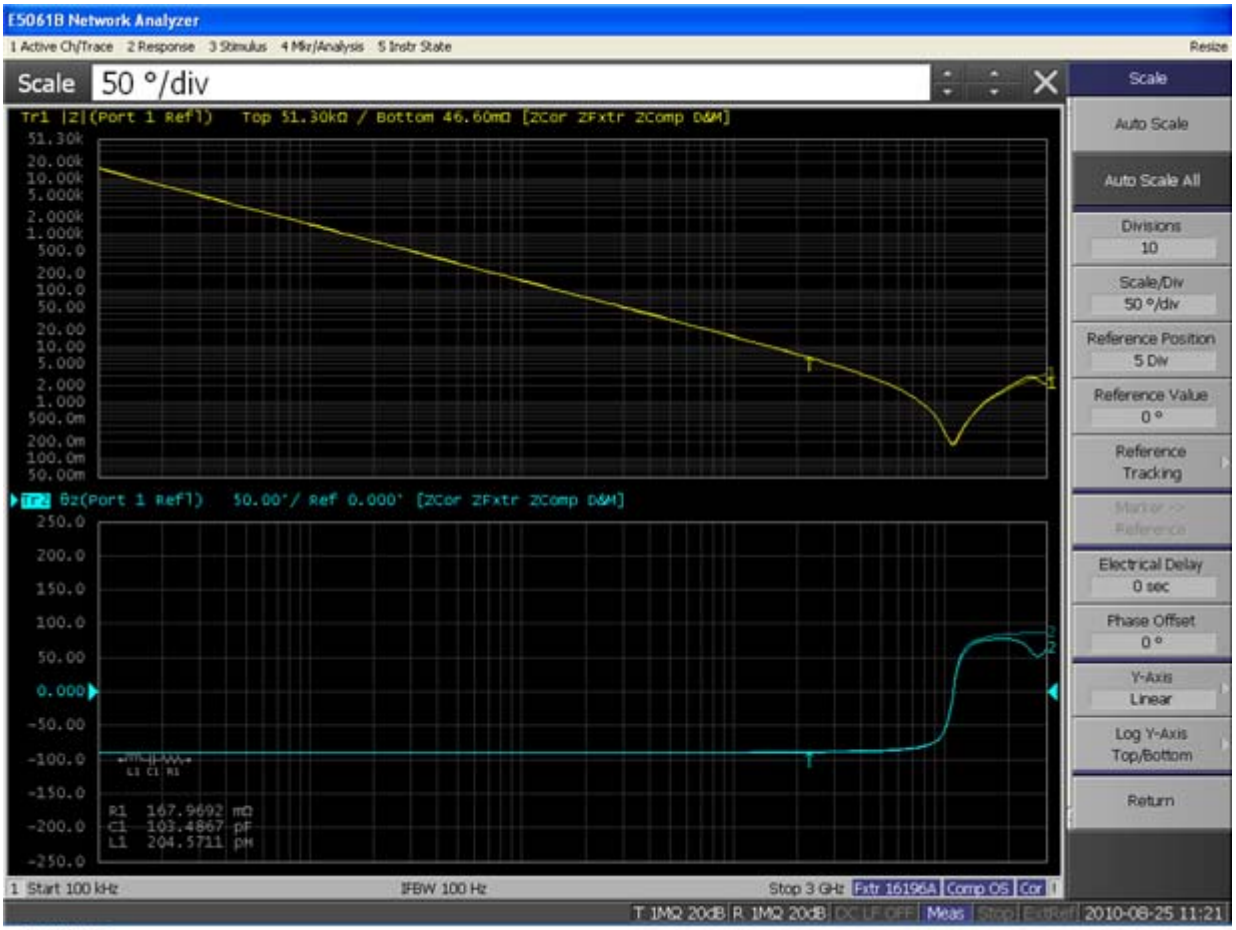
DUT: 100 pF capacitor


E5061B Network Analyzer
1 Active Ch/Trace 2 Response 3 Stimulus 4 Mkr/Analysis 5 Instr State
Resize
Scale 50 °/div
Tr1 |Z|(Port 1 Refl) Top 51.30kΩ / Bottom 46.60mΩ [ZCor ZFxtr ZComp D&M]
Tr2 θz(Port 1 Refl) 50.00°/ Ref 0.000° [ZCor ZFxtr ZComp D&M]
R1 167.9692 mΩ
C1 103.4867 pF
L1 204.5711 pH
1 Start 100 kHz
IFBW 100 Hz
Stop 3 GHz
Fxtr 16196A
Comp OS
Cor
T 1MΩ 20dB
R 1MΩ 20dB
DC LF OFF
Meas
Stop
ExtRef
2010-08-25 11:21
Scale
Auto Scale
Auto Scale All
Divisions 10
Scale/Div 50 °/div
Reference Position 5 Div
Reference Value 0 °
Reference Tracking
Marker => Reference
Electrical Delay 0 sec
Phase Offset 0 °
Y-Axis Linear
Log Y-Axis Top/Bottom
Return

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