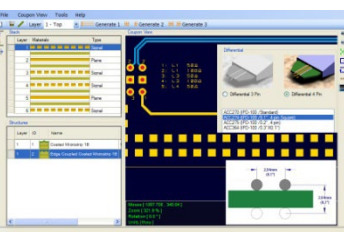
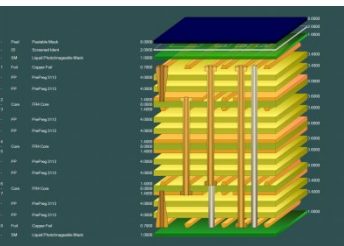
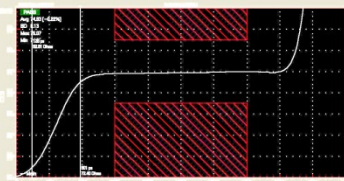
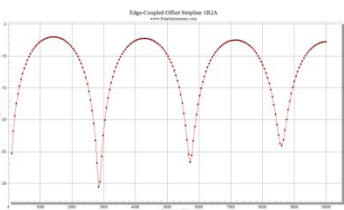
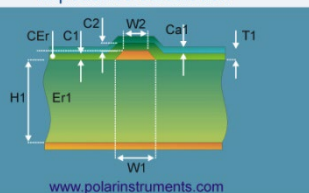


Si9000e 2021 - 2024 Preview

Richard Atrill – March 2024 (Rev 7)

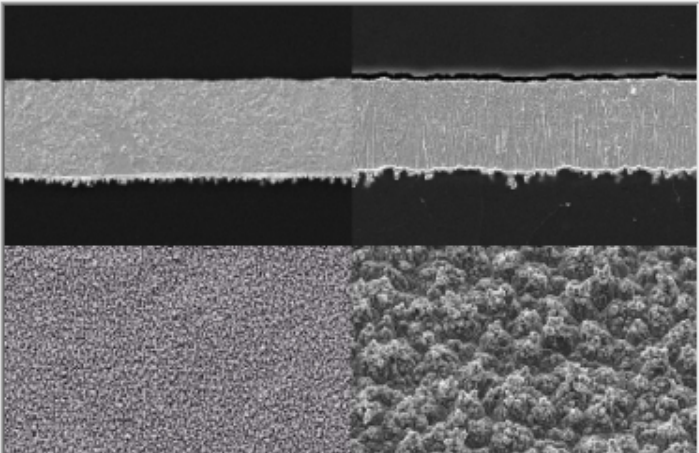
Impedance calculation



Si9000e v24.03.13 (March 2024)

Update Cannonball-Huray Method to Simonovich-Cannonball Method

Surface Roughness Compensation - Huray



Images by courtesy of Circuit Foil Luxembourg

Ratio of Areas: 1.0000
Effective Ball Radius (μm): 0.2240
Area of Ball Count ($\text{sq } \mu\text{m}$): 1.8060
Number of Balls in Area: 14

Apply
Cancel

Smoother Rougher

Simonovich-Cannonball Model

Enable Simonovich-Cannonball

Matte-Side Roughness
Rz Matte (μm): 4.4430 <<

Drum-Side Roughness
Rz Drum (μm): 3.0480 <<

Calculate

www.polarinstruments.com

Courtesy of Bert Simonovich, Lamsim Enterprises Inc [Application Note](#)

Update / rebrand of the Cannonball-Huray Method to Simonovich-Cannonball Method.

Application Note now links to two papers

Si9000e v24.02.08 (February 2024)

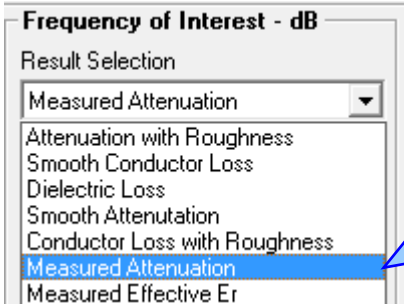
New Frequency of Interest option enhancements

The screenshot shows the Polar Si9000 PCB Transmission Line Field Solver interface. The main window displays a graph titled "Edge-Coupled Offset Stripline 1B1A Differential" showing Attenuation - dB/line versus Frequency - MHz. The graph includes several data series: Smooth Conductor Loss, Dielectric Loss, Smooth Attenuation, Conductor Loss with Roughness, Attenuation with Roughness, and Measured Attenuation : SPP. The frequency range is from 0 to 25,000 MHz, and the attenuation ranges from 0 to -0.8 dB/line.

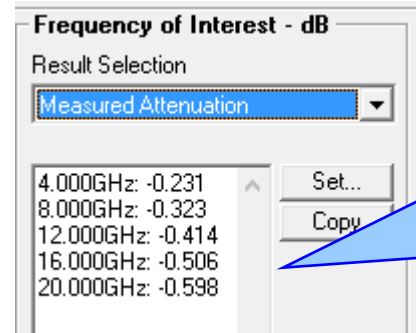
A blue callout box points to the "New Result Selection options" which allow displaying the Measured Attenuation and Measured Effective Er at user-specified Frequencies of Interest. The "Frequency of Interest - dB" panel (highlighted in red) shows the following data:

Frequency (GHz)	Measured Attenuation (dB)
4.000GHz	-0.231
8.000GHz	-0.323
12.000GHz	-0.414
16.000GHz	-0.506
20.000GHz	-0.598

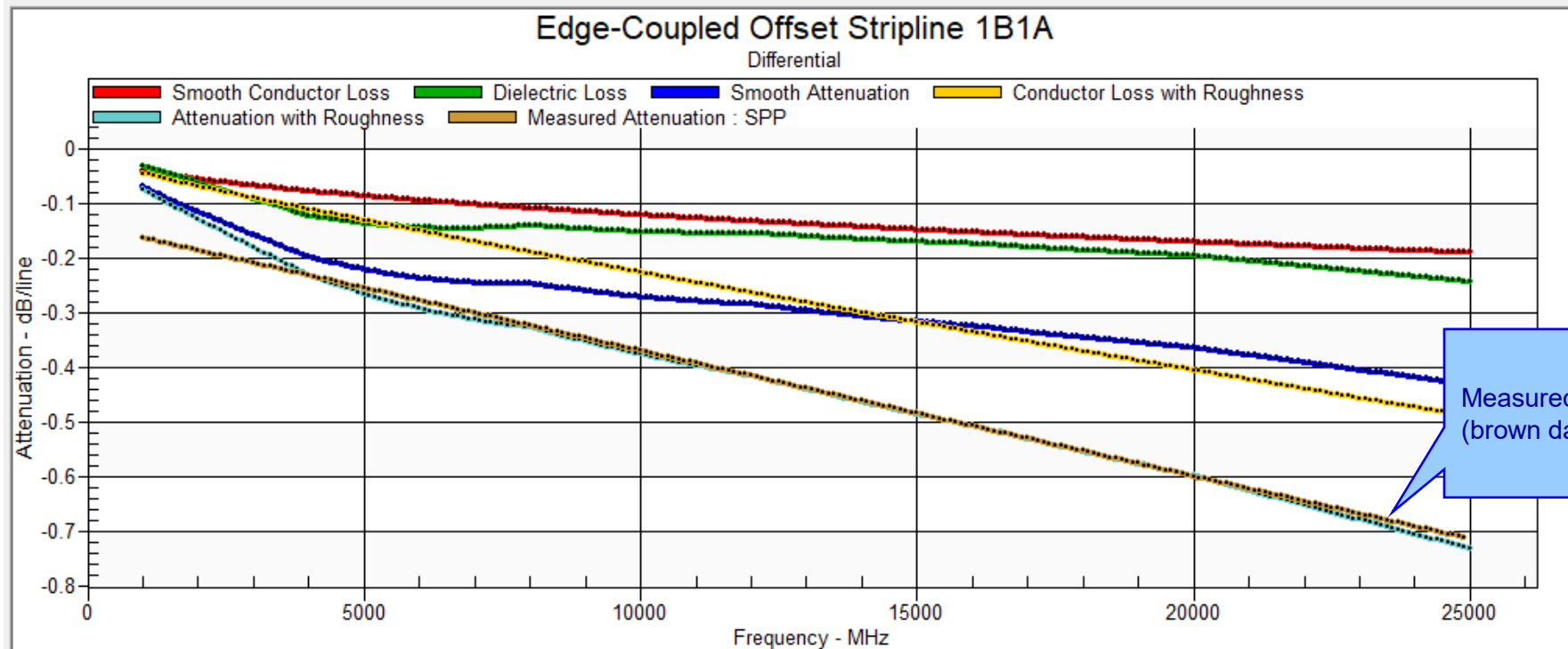
New Frequency of Interest option enhancements



When importing insertion loss measurement data from the Polar Atlas it is often useful to know the exact measured attenuation dB values as specific frequencies. The new Result Selection options have been introduced to achieve this.

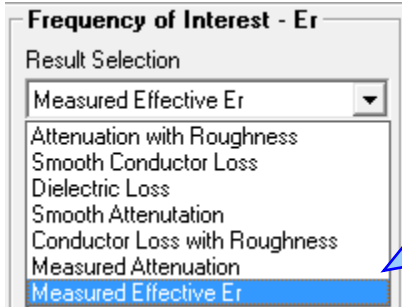


In this example the Frequency of Interest values have been set to 4, 8, 12, 16 and 20GHz. The measured attenuation (brown data series on the plot below) is examined and the dB loss values at those frequencies are displayed here

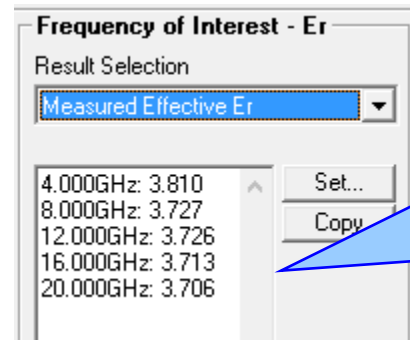


Measured Attenuation (brown data series)

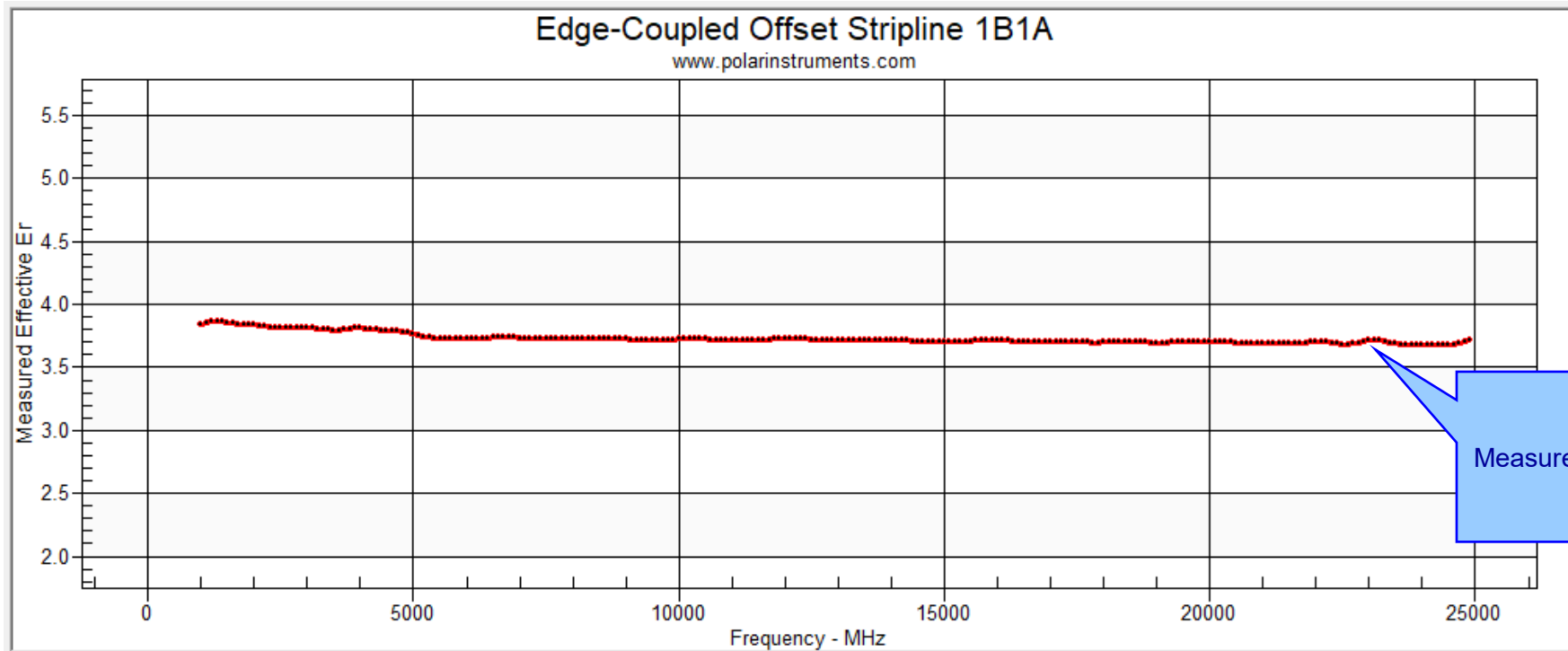
New Frequency of Interest option enhancements



Similar to the new Measured Attenuation selection, it is now possible to select the Measured Effective Er.



Using the same Frequency of Interest values of 4, 8, 12, 16 and 20GHz, the imported measurement data is examined and the effective dielectric constant values at those frequencies are displayed here



Measured Effective Er

New Loss Tangent Goal Seek – Multiple Frequency option

The screenshot displays the Polar Si9000 PCB Transmission Line Field Solver interface. The main window shows the configuration for an 'Edge-Coupled Offset Stripline 1B1A'. The configuration parameters include:

- Length of Line: 10.00
- Trace Conductivity (S/m): $5.80E+07$
- Loss Tangent: 0.0082
- Rise Time (ps): 10
- Frequency Minimum (MHz): 1000.000
- Frequency Maximum (GHz): 25.000
- Frequency Steps: 241

The 'Frequency Distribution' is set to Linear. The 'Result Presentation' is set to Length of Line. The 'Extended Substrate Data' section includes 'Constant Er / TanD' and 'Multiple Er / TanD', both with 'GoalSeek' options. The 'Surface Roughness Compensation' section includes 'Smooth', 'Hammerstad', 'Grosse', 'Gradient (Beta)', and 'Huray', with 'GoalSeek' options for the latter three.

The graph shows 'Attenuation - dB/line' vs 'Frequency - MHz' for the 'Edge-Coupled Offset Stripline 1B1A'. The graph displays several data series: Smooth Conductor Loss, Dielectric Loss, Smooth Attenuation, Conductor Loss with Roughness, Attenuation with Roughness, and Measured Attenuation : SPP. The attenuation values range from approximately -0.2 dB/line at 0 MHz to -0.9 dB/line at 25,000 MHz.

The 'Graph Settings' panel on the right shows 'Display Series' set to 'All Losses', 'Differential' mode, and 'Measured Attenuation' selected. The 'Picked Data Point Information' panel shows the following data points:

Frequency (GHz)	Attenuation (dB)
4.000	-0.231
8.000	-0.323
12.000	-0.414
16.000	-0.506
20.000	-0.598

Building upon the positive feedback for the existing Loss Tangent Goal Seek – Single Frequency facility, a new Multiple Frequency option has been introduced.

This allows for up to five Loss Tangent values to be calculated in a single process, with an option to export the calculated results to the Extended Substrate Data Library

The new Loss Tangent Goal Seek - Multiple Frequency option allows for up to five Loss Tangent values to be calculated in a single process. The input data and results for each frequency are contained in a separate column.

Loss Tangent Goal Seek

Step 1 : Enter Total Attenuation from measurements and the Dielectric Constant values for each frequency

Frequency	Hz	4.00E+09	8.00E+09	1.20E+10	1.60E+10	2.00E+10	Set from FOI
Total Attenuation (S21 / SDD21)	dB / LL	-0.2310	-0.3230	-0.4140	-0.5060	-0.5980	
Substrate 1 Dielectric	Er1	3.8100	3.7270	3.7260	3.7130	3.7060	Set from EEr
Substrate 2 Dielectric	Er2	3.8100	3.7270	3.7260	3.7130	3.7060	
Substrate 3 Dielectric	Er3	3.8100	3.7270	3.7260	3.7130	3.7060	
Substrate 4 Dielectric	Er4	3.8100	3.7270	3.7260	3.7130	3.7060	
Coating Dielectric	CEr	3.8100	3.7270	3.7260	3.7130	3.7060	
2nd Coating Dielectric	CSEr	3.8100	3.7270	3.7260	3.7130	3.7060	
Separation Region Dielectric	REr	3.8100	3.7270	3.7260	3.7130	3.7060	

Please Note: If you wish to Goal Seek less than five frequencies, set the Frequency in the unused columns to 0 Hz.
When using the 'Set from FOI' option the Total Attenuation data used will depend on Frequency of Interest Result Selection dropdown setting on the main interface. The first frequency / attenuation values will be supported. For differential structures, the differential / odd mode results will be used.

Step 2 : Calculate Conductor and Dielectric Loss

Conductor Loss with Roughness	dB / LL	-0.1102	-0.1872	-0.2618	-0.3334	-0.4030	Calculate
Dielectric Loss (Attenuation - Conductor Loss)	dB / LL	-0.1208	-0.1358	-0.1522	-0.1726	-0.1950	

Step 3 : Calculate Loss Tangent

Loss Tangent	TanD	0.0171	0.0095	0.0072	0.0061	0.0055	Calculate
0.0055 Dielectric Loss: -0.1935							

Step 4 : Export Results as an Extended Substrate Data table (optional)

Extended Substrate Data Table Name: Loss Tangent Goal Seek Results Export

Er1	Frequency Hz	Dielectric Constant Er	Loss Tangent TanD
<input checked="" type="radio"/>	4.00E+09	3.8100	0.0171
<input type="radio"/>	8.00E+09	3.7270	0.0095
<input type="radio"/>	1.20E+10	3.7260	0.0072
<input type="radio"/>	1.60E+10	3.7130	0.0061
<input type="radio"/>	2.00E+10	3.7060	0.0055

Please Note: After you Export the results to an Extended Substrate Data Table it will be necessary to select this table using the Multiple Er / TanD - Edit option

Setup Goal Seek Parameters

Loss Tangent Goal Seek Parameters	Min	Max	Conv.
	0.0010	0.5000	0.0020

The calculated Conductor and Dielectric Loss results will be displayed here

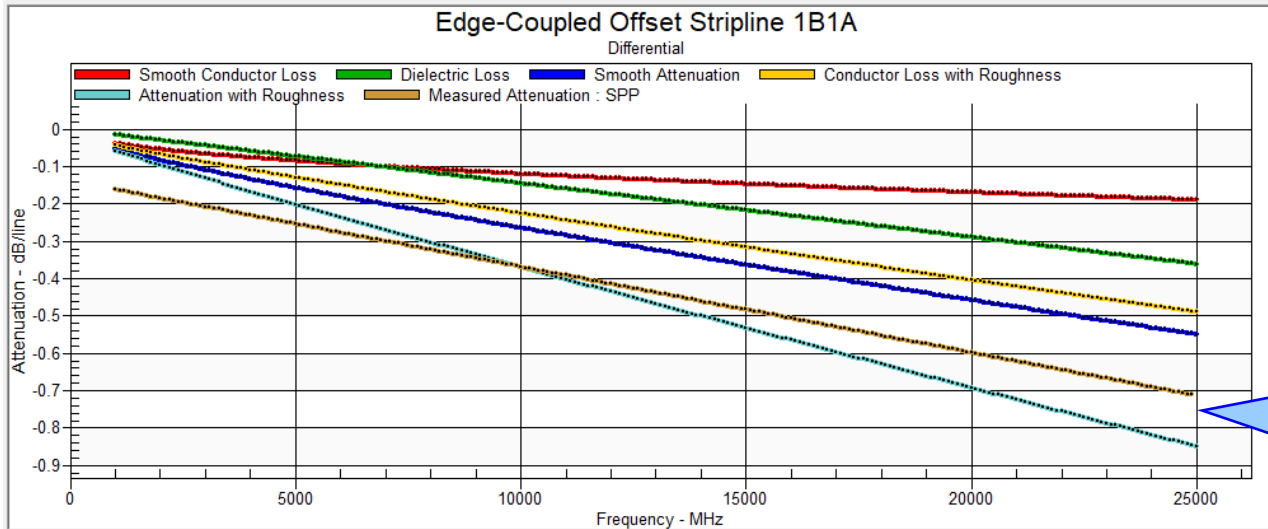
The calculated Loss Tangent results will be displayed here

The results can also be exported to the Extended Substrate Data Library

The input parameter data can be keyed in or the Set from FOI (Frequency of Interest) button will automatically set the Frequency and Total Attenuation values from the main dialog.

Dielectric Constant varies with frequency so the Set from EEr button will populate these fields from the Measured Effective Er data

New Loss Tangent Goal Seek – Multiple Frequency option



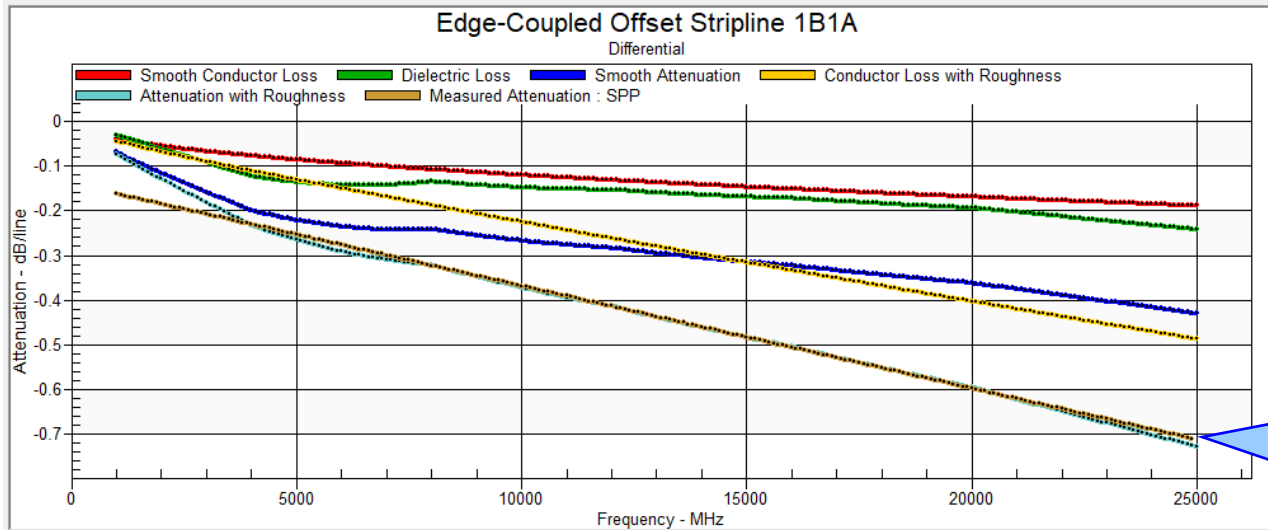
Extended Substrate Data

Constant Er / TanD GoalSeek

Causally Extrapolate Er / TanD Edit...

Multiple Er / TanD Edit... GoalSeek i

The Attenuation with Roughness (cyan) and Measured Attenuation (brown) do not correlate very well when using Constant Er / TanD mode



Extended Substrate Data

Constant Er / TanD GoalSeek

Causally Extrapolate Er / TanD Edit...

Multiple Er / TanD Edit... GoalSeek i

Once the Loss Tangent Goal Seek is complete it is possible to use the exported results to improve the correlation between the calculated Attenuation with Roughness (cyan) and Measured Attenuation (brown).

Si9000e v24.01.01 (January 2024)

Enhancements

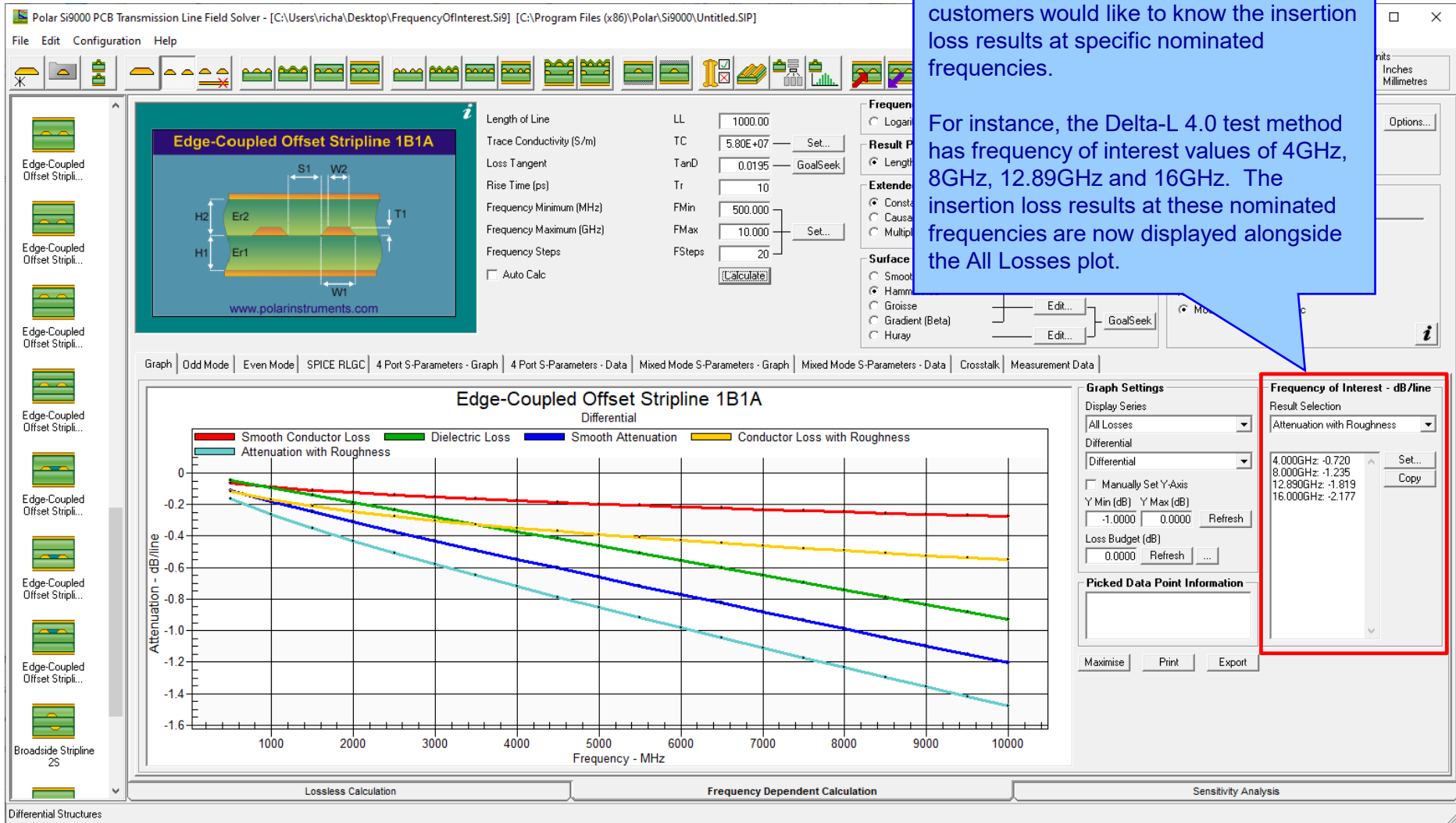
- From 2024 the Track Resistance Calculator (TRC) will be running on the Microsoft .Net Framework 4.8. It has migrated as a result of customer IT policy requests.

Si9000e v23.09.21 (September 2023)

New Frequency of Interest option added

In addition to the insertion loss plots that are generated with Si9000e, some customers would like to know the insertion loss results at specific nominated frequencies.

For instance, the Delta-L 4.0 test method has frequency of interest values of 4GHz, 8GHz, 12.89GHz and 16GHz. The insertion loss results at these nominated frequencies are now displayed alongside the All Losses plot.



New Frequency of Interest option added

Frequency of Interest - dB/line

Result Selection
 Attenuation with Roughness

4.000GHz: -0.720	Set...
8.000GHz: -1.235	Copy
12.890GHz: -1.819	
16.000GHz: -2.177	

Frequency of Interest

Edge-Coupled Offset Stripline 1B1A

www.polarinstruments.com

Frequency of Interest (GHz)	
Frequency 1	4.000
Frequency 2	8.000
Frequency 3	12.890
Frequency 4	16.000
Frequency 5	0.000
Frequency 6	0.000
Frequency 7	0.000
Frequency 8	0.000
Frequency 9	0.000
Frequency 10	0.000

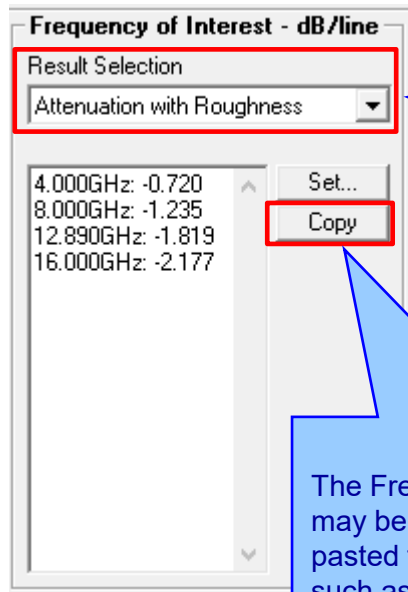
Apply to Current Structure
 Apply to All Structures
 Cancel

Select the Set... button to load the Frequency of Interest dialog

This dialog allows the user to nominate 10 frequency values per structure, so each structure inside Si9000e can have 10 unique frequency values.

- Selecting Apply to Current Structure will place those frequency values with the current selected structure so the next time the structure is calculated the results for each specified frequency will be placed on the main dialog, giving immediate feedback of the results at those frequency values.
- Selecting Apply to All Structures will place those same nominated frequency values on all structures in the Si9000e, including those structures that exist in a Project.
- In this example we have keyed in the four Delta-L 4.0 frequencies of 4GHz, 8GHz, 12.89GHz and 16GHz

New Frequency of Interest option added



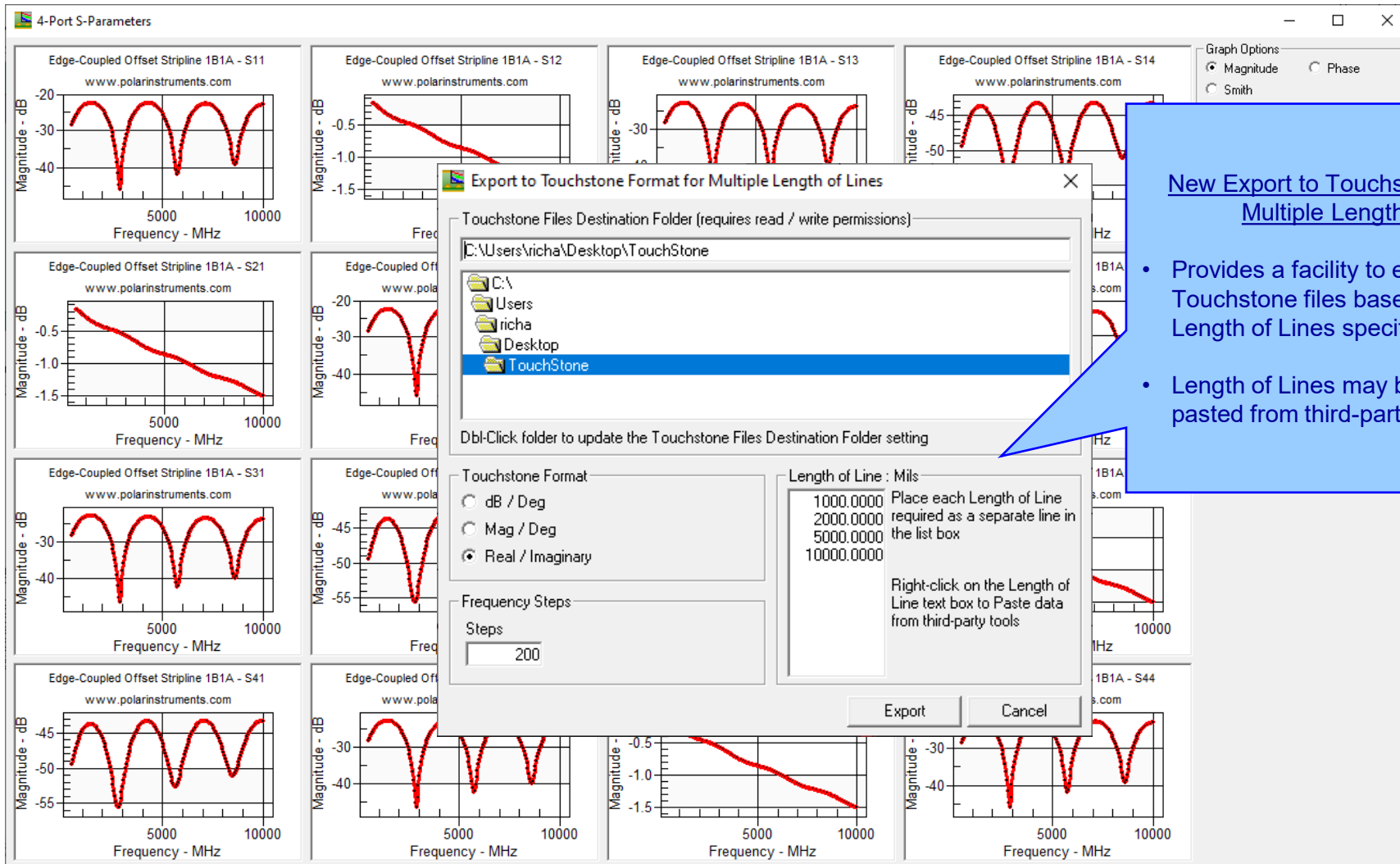
Use the Result Selection dropdown to choose which loss result is displayed. The options available are Attenuation with Roughness, Smooth Conductor Loss, Dielectric Loss, Smooth Attenuation and Conductor Loss with Roughness.

Like the All Losses plots, the formatting of the dB results will match that as specified by Result Presentation, so the dB results will be by /Length or /inch or /metre

The Frequency of Interest results may be copied to the clipboard, then pasted to third-party applications such as Excel

Si9000e v23.08.02 (August 2023)

New Export to Touchstone Format for Multiple Length of Lines



The screenshot displays the '4-Port S-Parameters' software interface. It features a grid of plots for various components (S11, S12, S13, S14, S21, S22, S31, S32, S41, S42, S43, S44) showing Magnitude in dB versus Frequency in MHz. A central dialog box titled 'Export to Touchstone Format for Multiple Length of Lines' is open. The dialog includes a file explorer showing the destination folder 'C:\Users\richa\Desktop\TouchStone', a list of line lengths (1000.0000, 2000.0000, 5000.0000, 10000.0000 Mils), and radio buttons for 'Touchstone Format' (dB / Deg, Mag / Deg, Real / Imaginary). The 'Frequency Steps' are set to 200. 'Export' and 'Cancel' buttons are at the bottom.

[New Export to Touchstone Format for Multiple Length of Lines](#)

- Provides a facility to export multiple Touchstone files based upon the Length of Lines specified
- Length of Lines may be keyed in or pasted from third-party applications

Si9000e v23.06.01 (June 2023)

New Gradient Surface Roughness Compensation Method added

Polar Si9000 PCB Transmission Line Field Solver - [C:\Program Files (x86)\Polar\Si9000\Untitled.Si9] [C:\Program Files (x86)\Polar\Si9000\Untitled.SiP]

File Edit Configuration Help

Edge-Coupled Offset Stripline 1B1A

www.polarinstruments.com

Length of Line LL: 25400.00

Trace Conductivity (S/m) TC: 5.80E+07

Loss Tangent TanD: 0.0195

Rise Time (ps) Tr: 10

Frequency Minimum (MHz) FMin: 500.000

Frequency Maximum (GHz) FMax: 10.000

Frequency Steps FSteps: 20

Auto Calc

Calculate

Frequency Distribution

Logarithmic Linear

Result Presentation

Length of Line / in / m

Extended Substrate Data

Constant Er / TanD

Causally Extrapolate Er / TanD

Multiple Er / TanD

Surface Roughness Compensation

Smooth

Hammerstad

Groisse

Gradient (Beta)

Huray

Measurement Data

No Data Imported

Options...

Parameter Entry Units: Mils Inches Microns Millimetres

Graph Odd Mode Even Mode SPICE RLGC 4 Port S-Parameters - Graph 4 Port S-Parameters - Data Mixed Mode S-Parameters - Graph Mixed Mode S-Parameters - Data Crosstalk Measurement Data

The Gradient method has been added to the Surface Roughness Compensation options

Edge-Coupled Offset Stripline 1B1A

Differential

Attenuation - dB/line

Frequency - MHz

Lossless Calculation

Frequency Dependent Calculation

Sensitivity Analysis

Graph Settings

Display Series: All Losses

Differential: Differential

Manually Set Y-Axis

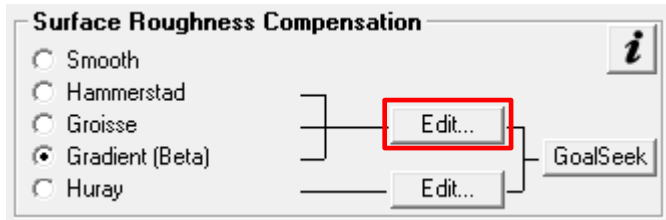
Y Min (dB): -1.0000 Y Max (dB): 0.0000 Refresh

Loss Budget (dB): 0.0000 Refresh ...

Picked Data Point Information

Maximise Print Export

New Gradient Surface Roughness Compensation Method added



Selecting the Edit button will allow the RMS roughness values to be entered.

In this example 1 μ m roughness for all significant surfaces

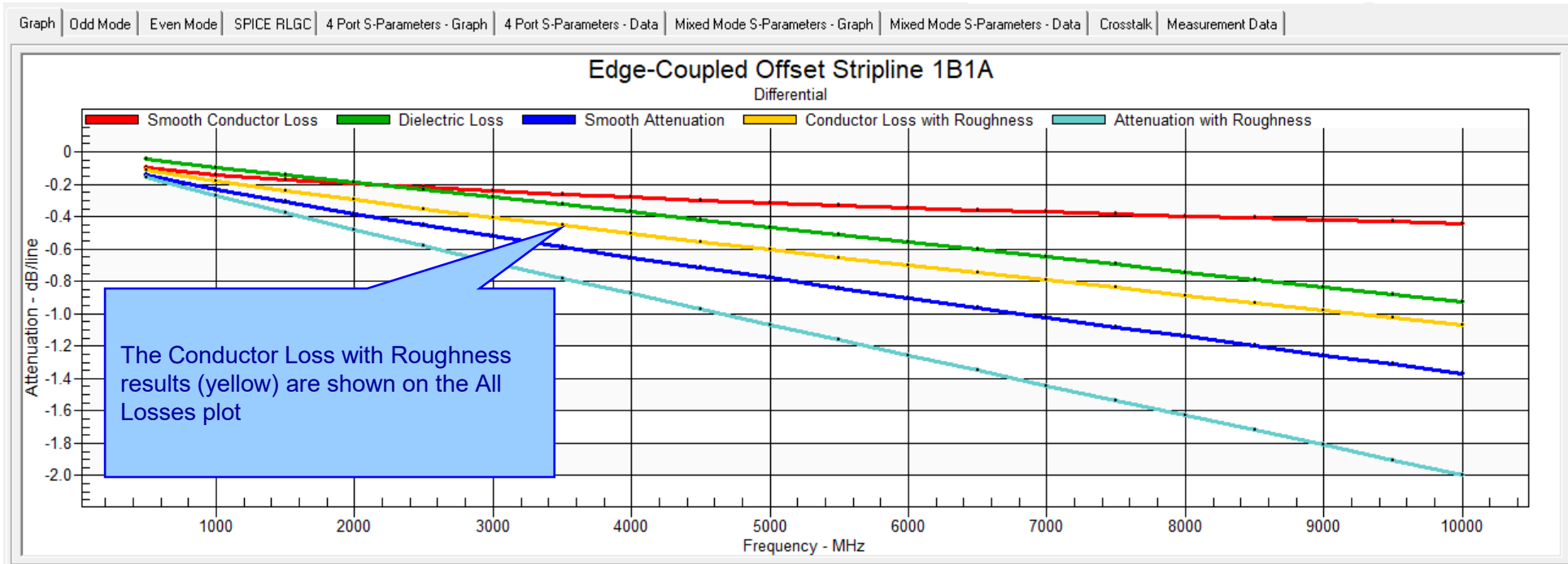
Surface Roughness Compensation - Hammerstad / Grosse / Gradient

Surface Roughness Compensation

Guidance for the Gradient Method is available here: [Application Note](#)

		RMS : Microns	
Surface 1 Roughness	R1	1.0000	Apply
Surface 2 Roughness	R2	1.0000	Cancel
Surface 3 Roughness	R3	1.0000	
Surface 4 Roughness	R4	1.0000	

New Gradient Surface Roughness Compensation Method added



New Gradient Surface Roughness Compensation Method added

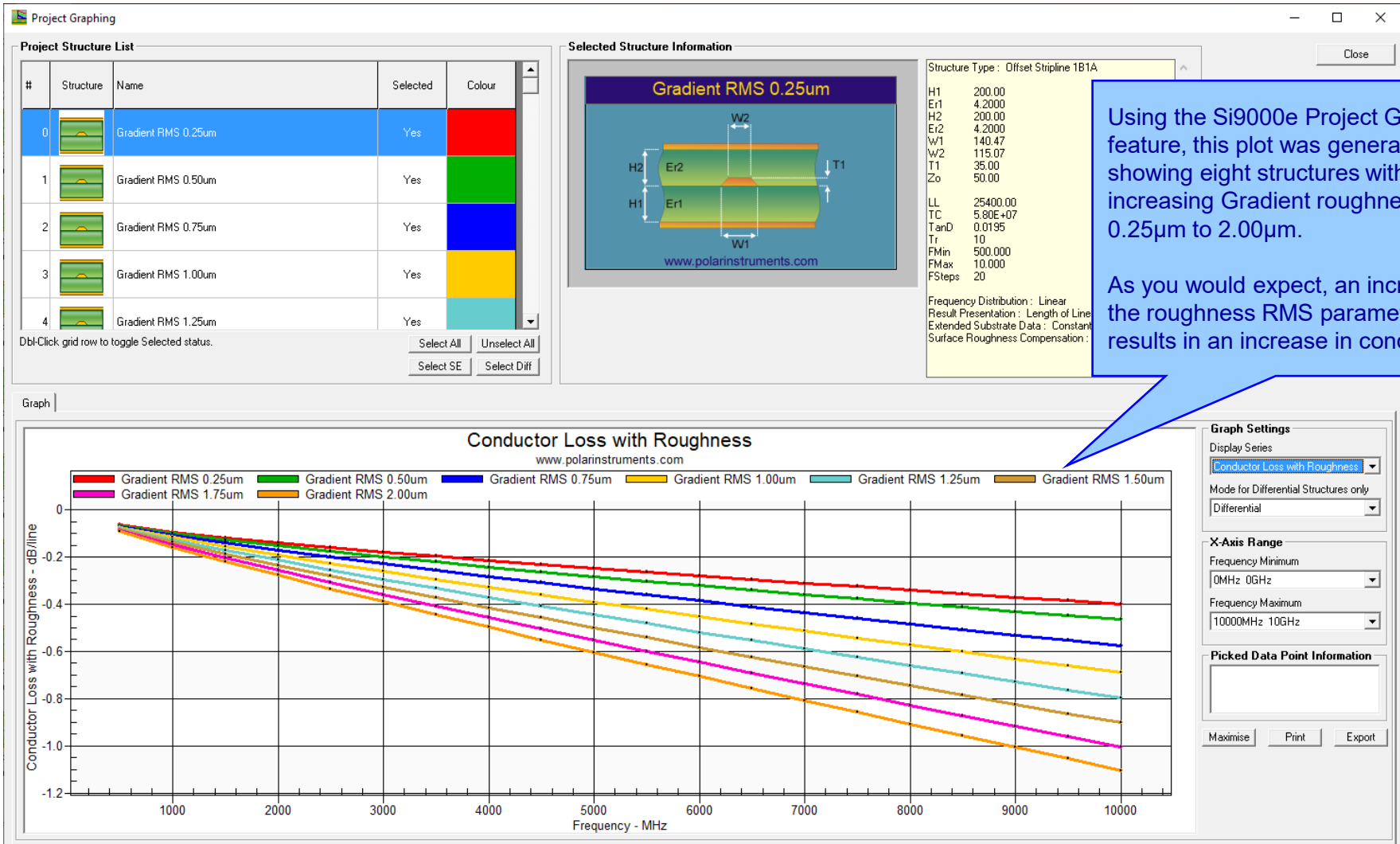
Graph	Odd Mode	Even Mode	SPICE RLGC	4 Port S-Parameters - Graph	4 Port S-Parameters - Data	Mixed Mode S-Parameters - Graph	Mixed Mode S-Parameters - Data	Crosstalk	Measurement Data								
Frequency Hz	Impedance Real Ohms	Impedance Imaginary Ohms	Impedance Magnitude Ohms	Inductance H/line	Resistance Ohms/line	Capacitance F/line	Conductance S/line	Skin Depth m	Smooth Conductor Loss dB/line	Dielectric Loss dB/line	Smooth Attenuation dB/line	Conductor Loss with Roughness dB/line	Attenuation with Roughness dB/line	Modal Phase Velocity m/s	Alpha Np/line	Alpha dB/line	Beta rad/line
5.000E+08	3.161E+01	-3.664E-01	3.161E+01	5.955E-09	7.989E-01	5.964E-12	3.653E-04	2.955E-06	-9.873E-02	-4.717E-02	-1.459E-01	-1.128E-01	-1.599E-01	1.348E+08	1.841E-02	-1.599E-01	5.921E-01
1.000E+09	3.138E+01	-2.268E-01	3.138E+01	5.869E-09	1.253E+00	5.964E-12	7.307E-04	2.090E-06	-1.399E-01	-9.376E-02	-2.337E-01	-1.792E-01	-2.730E-01	1.358E+08	3.142E-02	-2.730E-01	1.176E+00
1.500E+09	3.126E+01	-1.675E-01	3.126E+01	5.827E-09	1.660E+00	5.964E-12	1.096E-03	1.706E-06	-1.715E-01	-1.403E-01	-3.118E-01	-2.391E-01	-3.794E-01	1.363E+08	4.368E-02	-3.794E-01	1.757E+00
2.000E+09	3.119E+01	-1.330E-01	3.119E+01	5.799E-09	2.043E+00	5.964E-12	1.461E-03	1.478E-06	-1.982E-01	-1.867E-01	-3.849E-01	-2.957E-01	-4.824E-01	1.366E+08	5.554E-02	-4.824E-01	2.337E+00
2.500E+09	3.113E+01	-1.097E-01	3.113E+01	5.779E-09	2.410E+00	5.964E-12	1.827E-03	1.322E-06	-2.217E-01	-2.331E-01	-4.548E-01	-3.501E-01	-5.832E-01	1.368E+08	6.714E-02	-5.832E-01	2.916E+00
3.000E+09	3.109E+01	-9.260E-02	3.109E+01	5.763E-09	2.766E+00	5.964E-12	2.192E-03	1.207E-06	-2.429E-01	-2.795E-01	-5.224E-01	-4.028E-01	-6.823E-01	1.370E+08	7.856E-02	-6.823E-01	3.495E+00
3.500E+09	3.105E+01	-7.937E-02	3.105E+01	5.750E-09	3.112E+00	5.964E-12	2.557E-03	1.117E-06	-2.624E-01	-3.259E-01	-5.883E-01	-4.543E-01	-7.802E-01	1.372E+08	8.982E-02	-7.802E-01	4.072E+00
4.000E+09	3.102E+01	-6.871E-02	3.102E+01	5.739E-09	3.452E+00	5.964E-12	2.923E-03	1.045E-06	-2.806E-01	-3.723E-01	-6.529E-01	-5.047E-01	-8.770E-01	1.373E+08	1.010E-01	-8.770E-01	4.650E+00
4.500E+09	3.100E+01	-5.988E-02	3.100E+01	5.730E-09	3.785E+00	5.964E-12	3.288E-03	9.851E-07	-2.976E-01	-4.187E-01	-7.163E-01	-5.543E-01	-9.730E-01	1.374E+08	1.120E-01	-9.730E-01	5.227E+00
5.000E+09	3.097E+01	-5.241E-02	3.097E+01	5.721E-09	4.114E+00	5.964E-12	3.653E-03	9.346E-07	-3.138E-01	-4.650E-01	-7.788E-01	-6.032E-01	-1.068E+00	1.375E+08	1.230E-01	-1.068E+00	5.803E+00
5.500E+09	3.095E+01	-4.597E-02	3.095E+01	5.714E-09	4.437E+00	5.964E-12	4.019E-03	8.911E-07	-3.291E-01	-5.114E-01	-8.405E-01	-6.515E-01	-1.163E+00	1.376E+08	1.339E-01	-1.163E+00	6.379E+00
6.000E+09	3.094E+01	-4.034E-02	3.094E+01	5.707E-09	4.757E+00	5.964E-12	4.384E-03	8.532E-07	-3.438E-01	-5.577E-01	-9.015E-01	-6.992E-01	-1.257E+00	1.377E+08	1.447E-01	-1.257E+00	6.955E+00
6.500E+09	3.092E+01	-3.536E-02	3.092E+01	5.702E-09	5.073E+00	5.964E-12	4.750E-03	8.197E-07	-3.579E-01	-6.040E-01	-9.619E-01	-7.464E-01	-1.350E+00	1.377E+08	1.555E-01	-1.350E+00	7.531E+00
7.000E+09	3.091E+01	-3.091E-02	3.091E+01	5.696E-09	5.387E+00	5.964E-12	5.115E-03	7.899E-07	-3.714E-01	-6.503E-01	-1.022E+00	-7.931E-01	-1.442E+00	1.378E+08	1.662E-01	-1.442E+00	8.105E+00
7.500E+09	3.089E+01	-2.691E-02	3.089E+01	5.691E-09	5.697E+00	5.964E-12	5.480E-03	7.631E-07	-3.845E-01	-6.967E-01	-1.081E+00	-8.395E-01	-1.530E+00	1.378E+08	1.769E-01	-1.530E+00	8.679E+00
8.000E+09	3.088E+01	-2.327E-02	3.088E+01	5.686E-09	6.005E+00	5.964E-12	5.846E-03	7.389E-07	-3.971E-01	-7.430E-01	-1.140E+00	-8.855E-01	-1.618E+00	1.378E+08	1.875E-01	-1.618E+00	9.253E+00
8.500E+09	3.087E+01	-1.995E-02	3.087E+01	5.682E-09	6.310E+00	5.964E-12	6.211E-03	7.168E-07	-4.093E-01	-7.893E-01	-1.199E+00	-9.311E-01	-1.720E+00	1.380E+08	1.981E-01	-1.720E+00	9.831E+00
9.000E+09	3.086E+01	-1.690E-02	3.086E+01	5.678E-09	6.613E+00	5.964E-12	6.576E-03	6.966E-07	-4.212E-01	-8.356E-01	-1.257E+00	-9.764E-01	-1.812E+00	1.380E+08	2.086E-01	-1.812E+00	1.041E+01
9.500E+09	3.085E+01	-1.409E-02	3.085E+01	5.674E-09	6.914E+00	5.964E-12	6.942E-03	6.780E-07	-4.328E-01	-8.819E-01	-1.315E+00	-1.021E+00	-1.903E+00	1.381E+08	2.191E-01	-1.903E+00	1.098E+01
1.000E+10	3.084E+01	-1.148E-02	3.084E+01	5.671E-09	7.213E+00	5.964E-12	7.307E-03	6.609E-07	-4.441E-01	-9.282E-01	-1.375E+00	-1.066E+00	-1.994E+00	1.381E+08	2.296E-01	-1.994E+00	1.155E+01

Copy Results to Clipboard (for Excel)

The Conductor Loss with Roughness results data is also shown alongside the other field solver results.

The complete set of results can be exported to third-party tools like Excel using the right-click menu | Copy Results to Clipboard

New Gradient Surface Roughness Compensation Method added



Using the Si9000e Project Graphing feature, this plot was generated showing eight structures with an ever increasing Gradient roughness from 0.25µm to 2.00µm.

As you would expect, an increase in the roughness RMS parameter value results in an increase in conductor loss

Project Graphing Enhancements - now supports structures within the Project with varying Length of Line

Project Structure List

#	Structure	Name	Selected	Colour
0		2.5in Diff	Yes	Red
1		5in Diff	Yes	Green
2		7.5in Diff	Yes	Blue
3		10in Diff	Yes	Yellow

Dbl-Click grid row to toggle Selected status.

Select All Unselect All
Select SE Select Diff

Selected Structure Information

Structure Type: Edge-Coupled Offset Stripline 1B1A

```

H1 7.0000
Er1 4.2000
H2 6.0000
Er2 4.2000
w1 3.7500
w2 2.7500
S1 8.0000
T1 1.2000
Zdiff 99.93

LL 2500.00
TC 5.80E+07
TanD 0.0195
Tr 10
FMin 500.000
FMax 10.000
FSteps 20
        
```

Frequency Distribution: Linear
Result Presentation: Length of Line
Extended Substrate Data: Constant Er / TanD
Surface Roughness Compensation: Huray

The Project Graphing feature now supports different Length of Lines. The four structures show loss increases as the length of line increases

Graph

Attenuation with Roughness
www.polarinstruments.com

Attenuation with Roughness - dB/line

Frequency - MHz

Graph Settings

Display Series
Attenuation with Roughness

Mode for Differential Structures only
Differential

X-Axis Range

Frequency Minimum
0MHz 0GHz

Frequency Maximum
10000MHz 10GHz

Picked Data Point Information

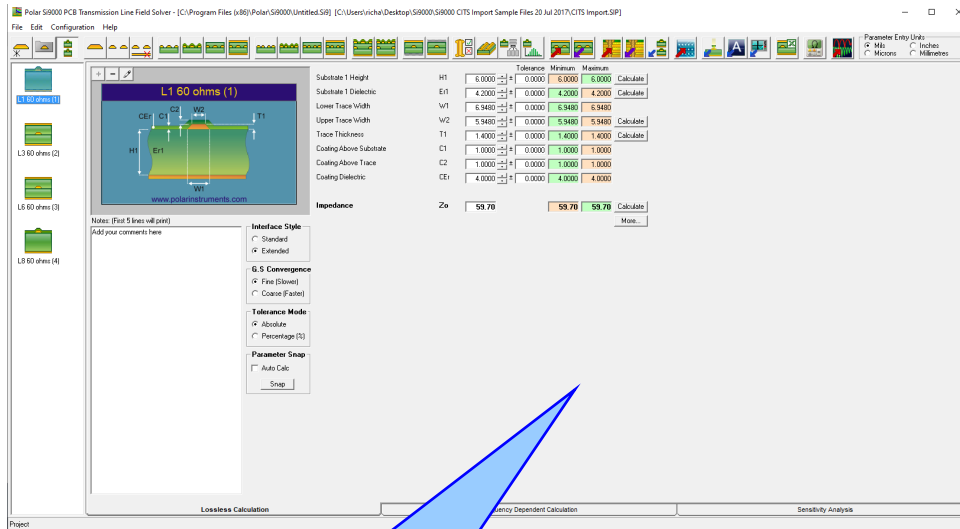
Maximise Print Export

Other enhancements

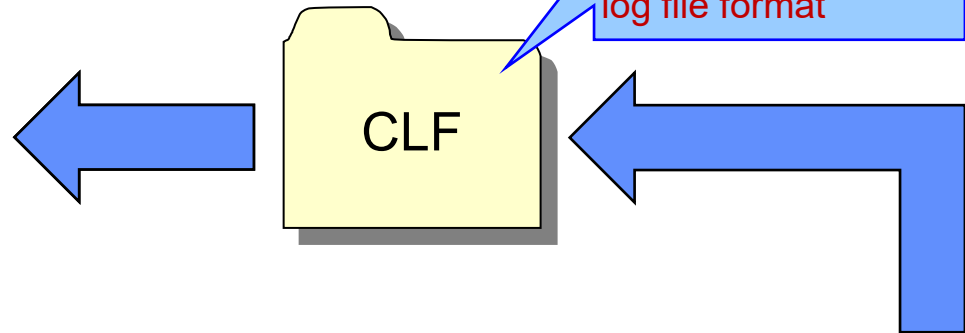
- FlexNet Publisher / FLEXIm v11.19.0.0 supported

Si9000e v22.09.01 (September 2022)

Enhancements to the Import Polar CITS Datalog File option



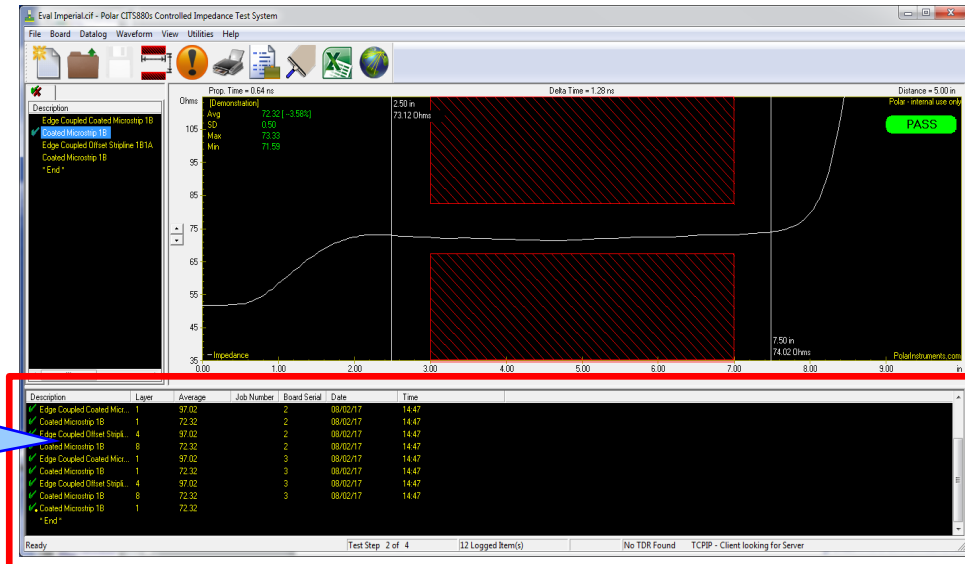
New for v22.09.01
Now supports the latest CITS880s data log file format



Overview

The Polar Si8000m / Si9000e field solver products have the capability to read a Polar CITS Data Log File (.CLF). This file contains comprehensive impedance measurement data and, along with existing modelled structure information, offers graphing capabilities and statistical analysis where the modelled and measured data can be presented together.

The Data Log of the CITS software is stored in a CLF file



Import CITS Datalog File option – feature recap

Whilst working with controlled impedance designs it is often desirable to compare the reality of the measurement data against the modelled structure.

‘Closing the loop’ between the predicted and actual measured results has a number of benefits for both the design and fabrication environments. It allows for fine tuning of the structure parameters in future manufacturing batches, statistical analysis and improved overall process control.

This capability within the Polar’s Si8000m / Si9000e field solver products allows the user to quickly import measurement data directly from the industry-standard Polar Controlled Impedance Test System (CITS).

If you are a design customer using the Si8000m / Si9000e and would like to use this feature, please request the Polar CITS Datalog File from your fabricator.

Import CITS Datalog File option – feature recap

ansmission Line Field Solver - [C:\Program Files (x86)\Polar\Si9000\Untitled.Si9] [C:\Users\richa\Desktop\Si9000\Si9000 CITS Import Sample Files 25 Aug 2022\CITS Import.SIP]

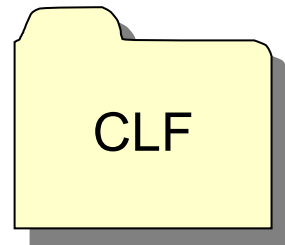
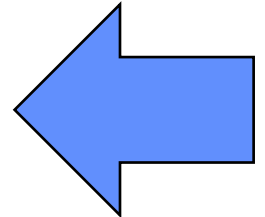
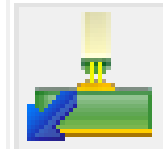
on Help

		Tolerance	Minimum	Maximum	
Substrate 1 Height	H1	± 0.0000	6.0000	6.0000	Calculate
Substrate 1 Dielectric	Er1	± 0.0000	4.2000	4.2000	Calculate
Lower Trace Width	W1	± 0.0000	6.9480	6.9480	
Upper Trace Width	W2	± 0.0000	5.9480	5.9480	
Trace Thickness	T1	± 0.0000	1.4000	1.4000	
Coating Above Substrate	C1	± 0.0000	1.0000	1.0000	
Coating Above Trace	C2	± 0.0000	1.0000	1.0000	
Coating Dielectric	CEr	± 0.0000	4.0000	4.0000	
Impedance	Zo		59.70	59.70	

Notes: (First 5 lines will print)
Add your comments here

Interface Style
 Standard
 Extended

The 'Import CITS file' toolbar option. On selecting this option a dialog guides the user through the import process



Import CITS Datalog File option – feature recap

Step 1 : Read CITS Log File

Filename: C:\Users\richa\Desktop\Si9000\Si9000 CITS Import Sample Files 25 Aug 2022\CITS Imp...

Instrument Model: CITS880 Instrument Serial No: 17581

Data Log Record Count: 160 Per Board / Coupon: 4 Board / Coupon Count: 40

Step 2 : Select Data Log Record

Data Log Records: Description - L01, Layer - 1, Nominal - 60.00

Project Structure: L1 60 ohms (1)

Description: L01 Layer: 1

Nominal Impedance: 60.00 Tol+ %: 10.00 Tol- %: 10.00

Graph Settings

Impedance Options:

- Plot Nominal Impedance
- Plot Minimum / Maximum

Impedance Options:

- Plot Nominal Impedance
- Plot Tolerances (plus / minus)

Impedance Results:

- Fail
- Short

Picked Data Point Information

Callout 1: Once the CITS CLF data log file has been identified the software reads key information – Instrument Model, Serial Number, Data Log Record Count, Tests per Board / Coupon

Callout 2: A Data Log Records dropdown list built from the data log file, allowing the user to select the appropriate test records they would like to view / plot

Callout 3: The Project Structure dropdown presents a list of structures currently available within the Project. Together with the Data Log Records dropdown it allows the user to quickly match the data log records against the correct structure

Callout 4: It is possible to plot the modelled and measured impedance data in a number of ways. The following slides provide more details

Import CITS Datalog File option – feature recap

Step 2 : Select Data Log Record

Data Log Records	Description - L01, Layer - 1, Nominal Impedance - 60.00
Project Structure	Description - L01, Layer - 1, Nominal Impedance - 60.00 Description - L03, Layer - 3, Nominal Impedance - 60.00 Description - L06, Layer - 6, Nominal Impedance - 60.00 Description - L08, Layer - 8, Nominal Impedance - 60.00
Description	
Nominal Impedance	60.00 Tol+ % 10.00 Tol- % 10.00

Each test record type found in the data log file is listed in the drop down. In this case there are four tests.

Step 2 : Select Data Log Record

Data Log Records	Description - L01, Layer - 1, Nominal Impedance - 60.00
Project Structure	L1 60 ohms (1)
Description	L1 60 ohms (1) L3 60 ohms (2) L6 60 ohms (3) L8 60 ohms (4)
Nominal Impedance	

To match one of the four modelled structures from the Project group against a data log test record simply select the structure from the Project Structure dropdown

Polar Si9000 PCB Trace

File Edit Configurati

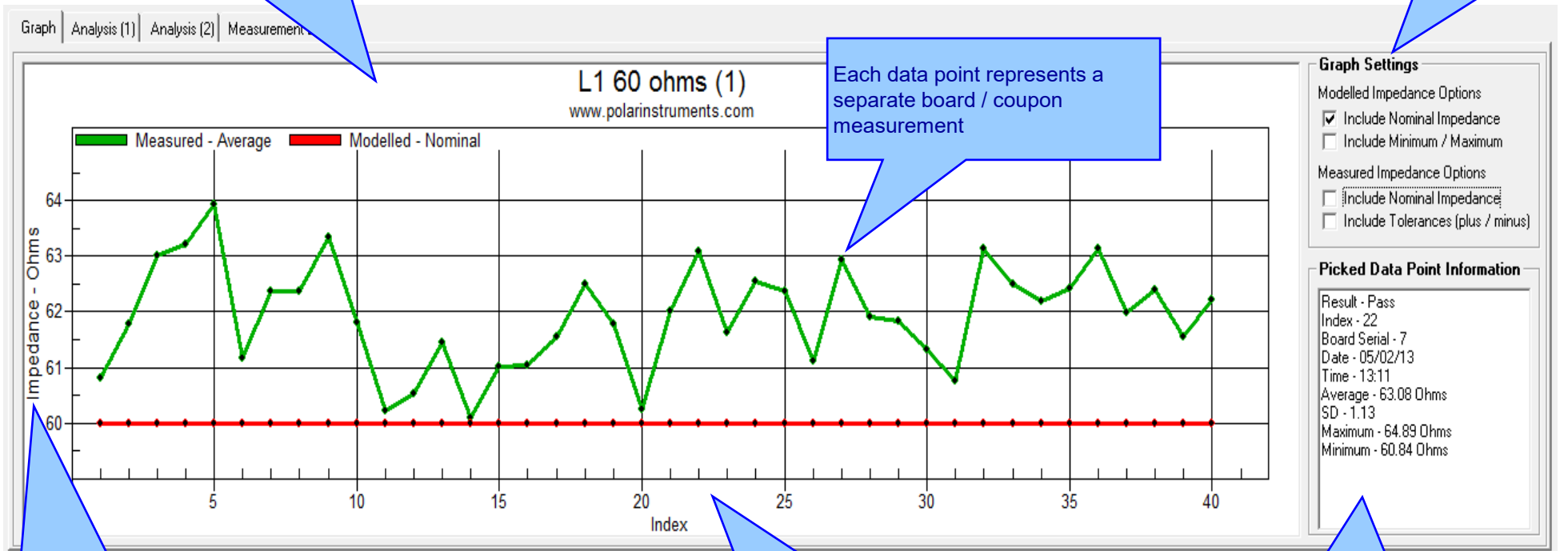
- L1 60 ohms (1)
- L3 60 ohms (2)
- L6 60 ohms (3)
- L8 60 ohms (4)

Four structures loaded into the Project group

Import CITS Datalog File option – feature recap

The Graph tab provides a number of plot options. In this case the measured data is shown in Green, the modelled data in Red

Graph Settings allow the selection of modelled / measured data to be plotted



Each data point represents a separate board / coupon measurement

The y-axis is the measured impedance for each board / coupon

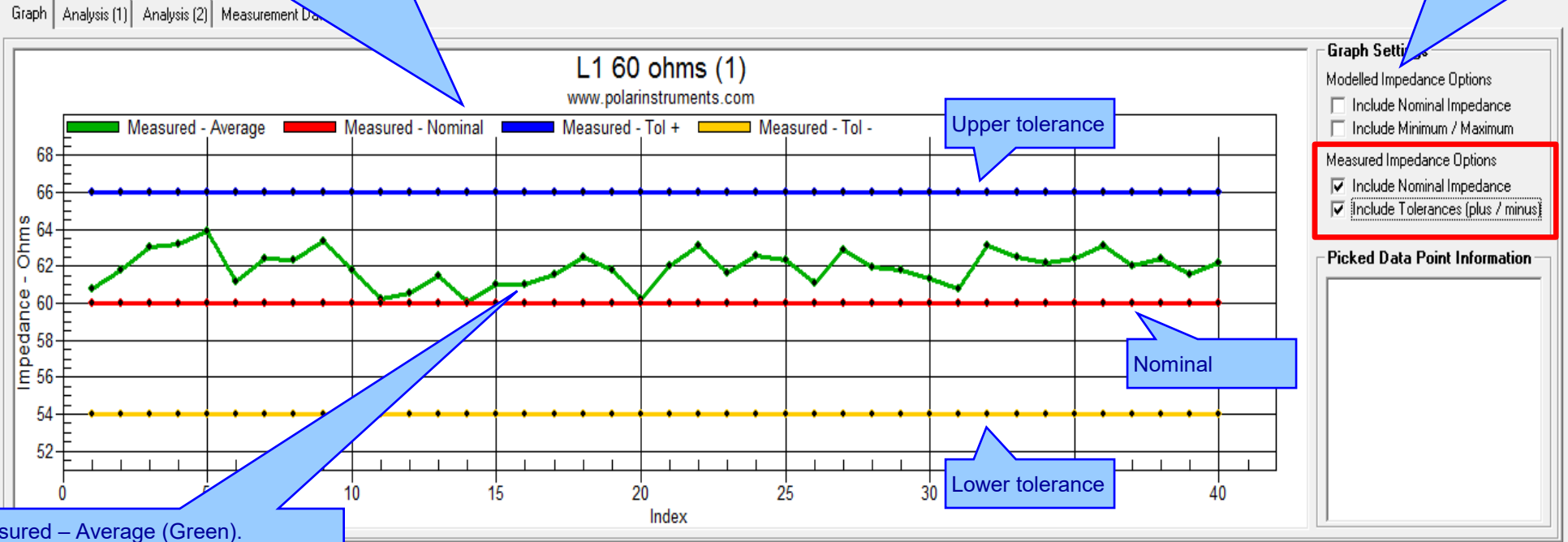
The x-axis is the identifying Index of the board / coupon read from the data log file

It is possible to pick a measured data point, key information is displayed here

Import CITS Datalog File option – feature recap

In this case the Graph contains:
Measured – Average (Green)
Nominal (Red)
Upper Tolerance (Blue)
Lower Tolerance (Yellow)

Graph Settings allow the selection of modelled / measured data to be plotted

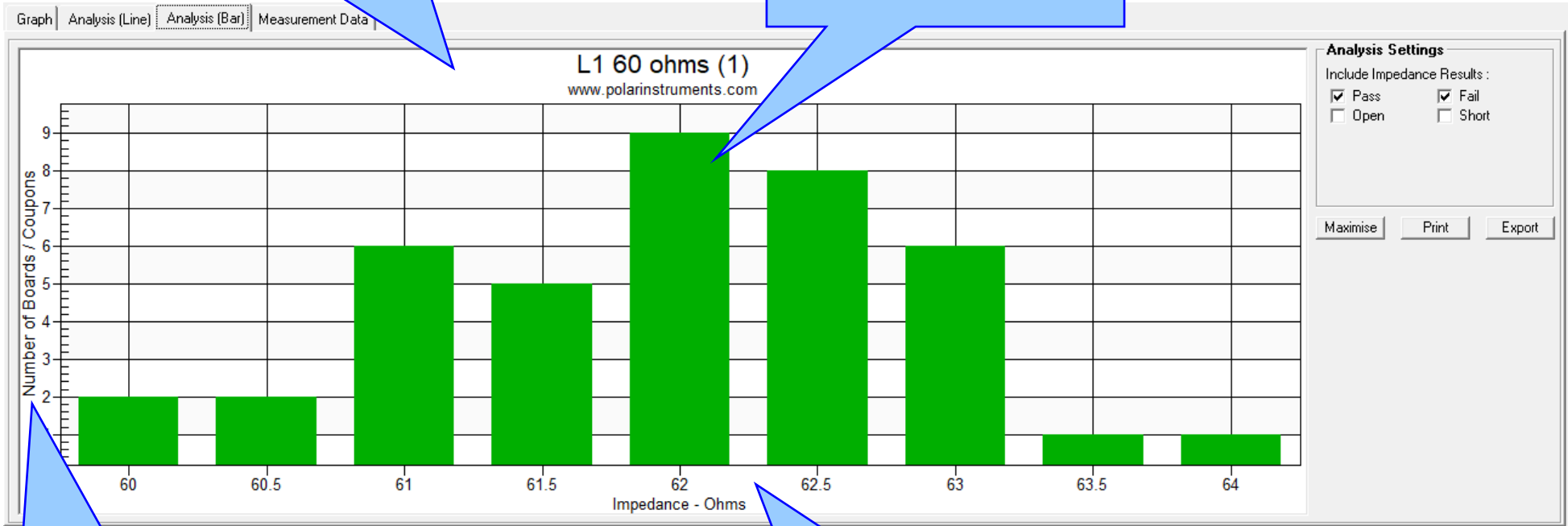


Measured – Average (Green).
Whilst reading slightly higher than the Nominal (60 ohms) all measured data points are within the upper and lower tolerance bands

Import CITS Datalog File option – feature recap

Analysis options:
This bar chart shows the distribution of measurement results over an impedance range

From this batch of 40 board / coupon measurements, 62 +/- 0.25 ohms is the most common result



The y-axis is the number of boards / coupons that fall within a given impedance as detailed on the x-axis

The x-axis is the measured impedance in 0.5 ohm increments

Import CITS Datalog File option – feature recap

Measurement Data:
 The CITS Data Log data may also be viewed in a data grid layout. This is especially useful for viewing the Result data (Pass / Fail)

Graph | Analysis (Line) | Analysis (Bar) | **Measurement Data**

Result	Index	Board Serial	Date	Time	Average	SD	Maximum	Minimum	Station	Description	Layer	Nominal	Tol+ %	Tol- %	Instrument	Serial No
Passed	1	24	05/02/13	12:48	60.8	0.8	61.9	59.56	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	2	29	05/02/13	12:50	61.77	0.95	63.21	59.93	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	3	17	05/02/13	12:51	63.01	0.94	64.48	61.68	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	4	39	05/02/13	12:52	63.22	1.07	64.62	61.29	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	5	8	05/02/13	12:59	63.93	0.95	65.32	62.2	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	6	10	05/02/13	13:00	61.17	0.89	62.69	59.63	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	7	32	05/02/13	13:01	62.38	0.88	63.58	60.72	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	8	21	05/02/13	13:01	62.37	0.82	63.88	60.98	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	9	4	05/02/13	13:02	63.35	0.68	64.41	61.75	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	10	33	05/02/13	13:03	61.81	0.78	62.95	60.09	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	11	18	05/02/13	13:03	60.22	0.62	61.48	59.09	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	12	3	05/02/13	13:04	60.54	0.75	62.1	59.19	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	13	15	05/02/13	13:05	61.46	0.73	62.83	60.12	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	14	2	05/02/13	13:05	60.09	0.67	61.24	58.57	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	15	23	05/02/13	13:06	61.01	0.78	62.4	59.69	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	16	5	05/02/13	13:07	61.05	0.63	62.14	59.49	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	17	6	05/02/13	13:07	61.54	0.8	62.98	60.11	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	18	76	05/02/13	13:08	62.49	0.92	63.44	60.32	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	19	11	05/02/13	13:09	61.79	0.83	63.08	60.37	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	20	31	05/02/13	13:09	60.25	0.65	61.37	58.85	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	21	12	05/02/13	13:10	62.01	0.69	63.24	60.65	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	22	7	05/02/13	13:11	63.08	1.13	64.89	60.84	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581
Passed	23	19	05/02/13	13:11	61.63	0.72	62.81	60.19	_TEST STATION 1_	L01	1	60	10	10	CITS880	17581

New Manually Set Y-Axis option for the All Losses plot

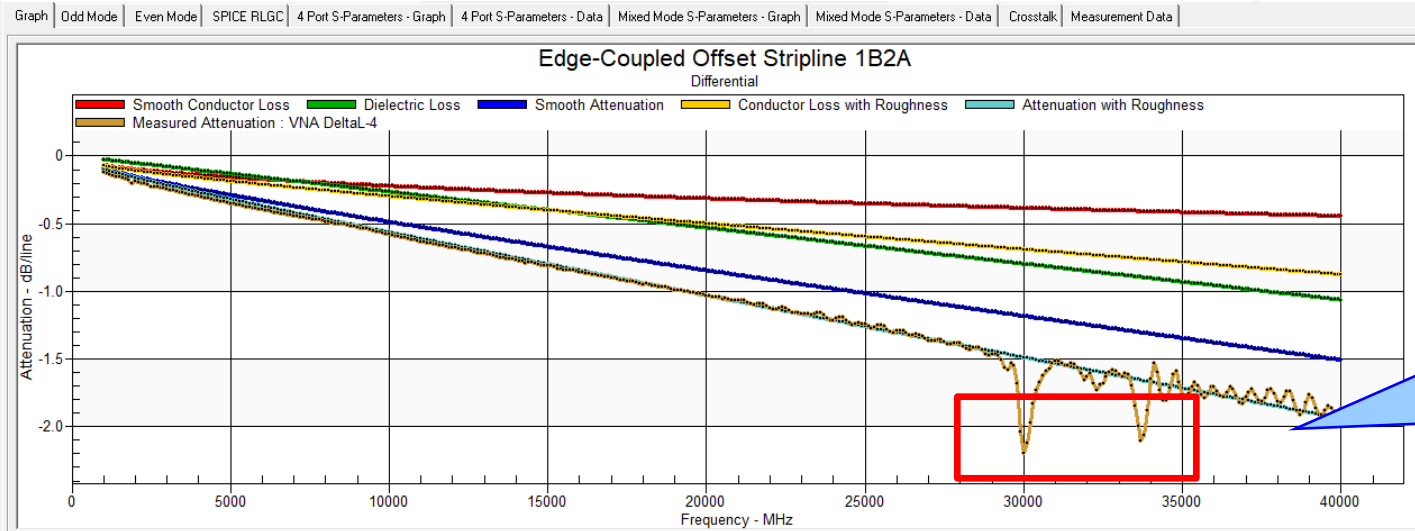
The new 'Manually Set Y-Axis' option provides more control over how the All Losses plot is presented.

The All Losses plot defaults to Y-axis auto-scale, where the Y-axis is resized to fit all data series.

When the 'Manually Set Y-Axis' option is checked, the Y-axis min and max values can be fixed to user-defined values.

This is especially useful after importing measurement data (brown) which often has measurement error artefacts that are not useful when comparing against the modelled data.

New Manually Set Y-Axis option for the All Losses plot



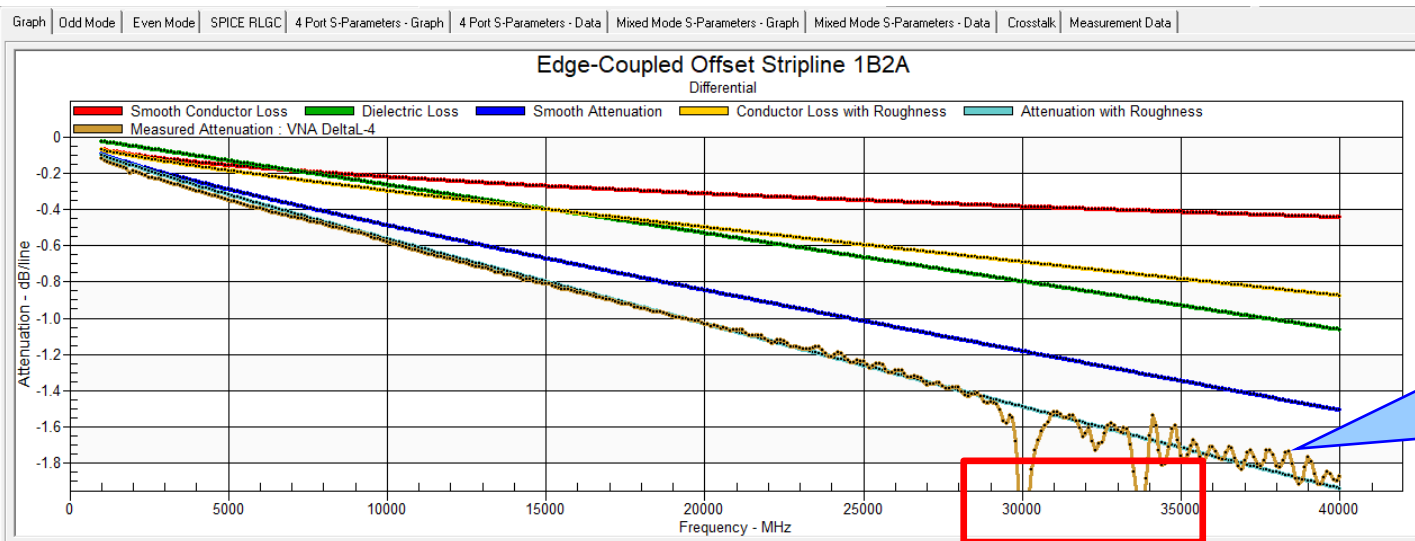
Manually Set Y-Axis

Y Min (dB) Y Max (dB)

-1.9500 0.0000 Refresh

'Manually Set Y-Axis' unchecked, the Y-axis will auto-scale.

Notice the plot will scale the Y-axis to include all the measurement data including the measurement error artefacts



Manually Set Y-Axis

Y Min (dB) Y Max (dB)

-1.9500 0.0000 Refresh

'Manually Set Y-Axis' is checked, the Y Min is set to -1.95 dB

Notice the plot will fix the Y-axis min / max to the values specified, the measurement error artefacts will be ignored.

Enhancements to the Import Touchstone Format option



Edge-Coupled Coated Microstrip 2B

www.polarinstruments.com

Read Touchstone File

Filename: C:\Users\vricha\Desktop\ECCM2B_2Inch.s4p

Overlay Calculated S-Parameter Data

Import

Touchstone files contain S-Parameter data exported from VNA instruments and modelling software, including the Polar Si9000e.

The Si9000e allows a Touchstone file to be imported (green) and then compared against the structure currently being modelled (red).

Graphing options exist to display Magnitude, Phase and present S-Parameters as a Smith chart.

V22.09.01 enhances the Import Touchstone Format option to support S-Parameter data from a wider range of frequencies.

4 Port S-Parameters - Graph | 4 Port S-Parameters - Data

S21
www.polarinstruments.com

Magnitude - dB

0

-1

-2

-3

-4

-5

-6

-7

-8

Graph Options

Magnitude Phase

Smith

Data Series

S11 S12 S13 S14

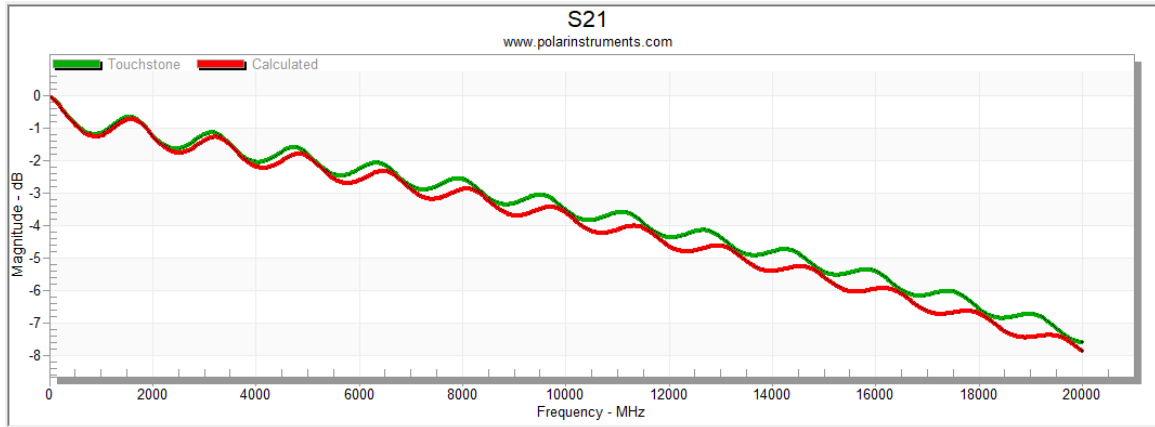
S21 S22 S23 S24

S31 S32 S33 S34

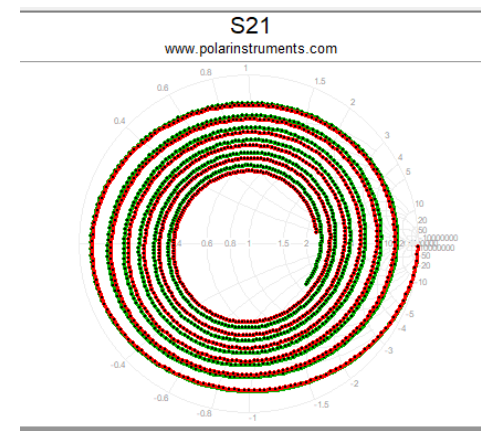
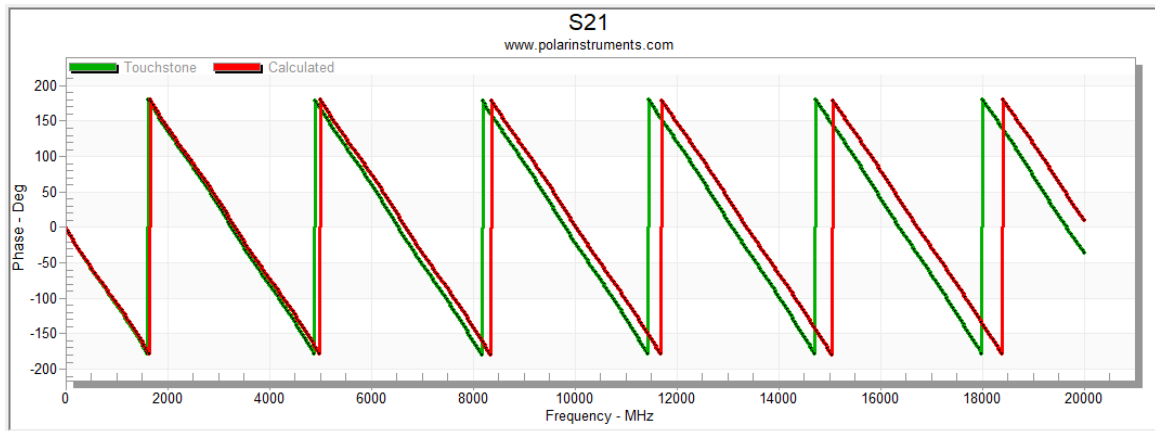
S41 S42 S43 S44

Maximise | Print | Export

Enhancements to the Import Touchstone Format option



In this example a Touchstone 4-port file (.S4P) has been imported into the Si9000e. Magnitude, Phase and Smith Chart are shown for S21



Si9000e v22.04 (April 2022)

New Differential Via Calculation capability

Parameter Entry Units
 Mils Inches
 Microns Millimetres

	Tolerance	Minimum	Maximum	
H1	8.5000	0.0000	8.5000	Calculate
Er1	4.2000	4.2000	4.2000	Calculate
W1	5.0000	0.0000	5.0000	
W2	4.0000			
S1	2.2810			
T1	1.2000			
C1	1.0000			
C2	1.0000			
C3	1.0000			
CEr	4.2000			

Differential Impedance
 Zdiff **85.02**

Interface Style
 Standard
 Extended

G.S Convergence
 Fine (Slower)
 Coarse (Faster)

Tolerance Mode
 Absolute
 Percentage [%]

Parameter Snap
 Auto Calc

Notes: (First 5 lines will print)
 Add your comments here

Lossless Calculation | Frequency Dependent Calculation | Sensitivity Analysis

The new Via Checks toolbar option.

This Differential Via Calculation is now part of a new tabbed Via Checks dialog accessible from the toolbar. It also contains the Via Stub Check and Via Pad / Anti Pad Coaxial Calculation that were previously present on the main interface

New Differential Via Calculation

Via Checks
✕

Via Stub Check
Via Pad / Anti-Pad Calculation
Differential Via Calculation

Differential Via Calculation

www.polarinstruments.com

Please refer to the parameters in parentheses when reading [Application Note](#)
 Courtesy of Bert Simonovich, Lamsim Enterprises Inc

Note: The model works for a simple differential pair structure with no pads and several planes throughout the board. If there is, say, only a 4 or 6 layer stackup, there will not be sufficient excess capacitance from the planes so the accuracy will suffer. When planes are spaced like modern designs it will be more accurate.

Anti-Pad Style
 Horizontal Oval Anti-Pad Round / Oblong Anti-Pad

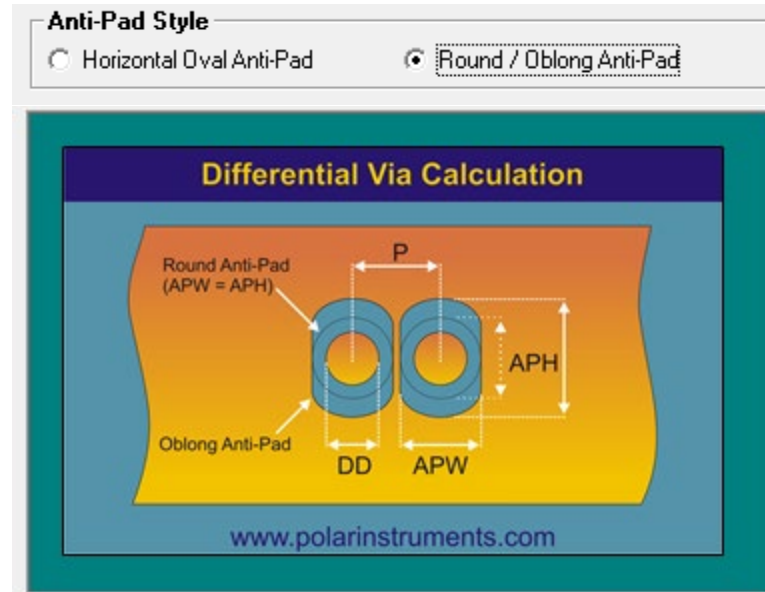
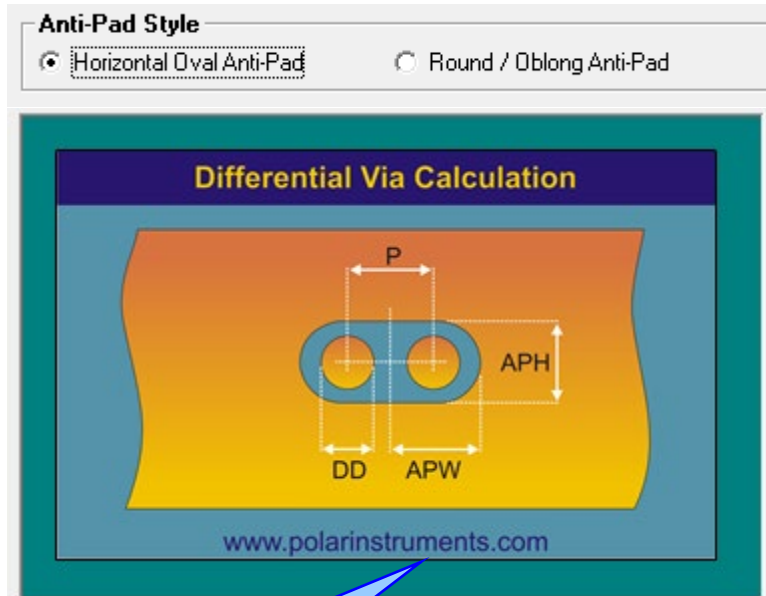
Drill Diameter (t)	DD	<input type="text" value="15.0000"/>	
Via Pitch (S)	P	<input type="text" value="35.0000"/>	
Anti-Pad Width (b)	APW	<input type="text" value="50.8000"/>	
Anti-Pad Height (w')	APH	<input type="text" value="50.8000"/>	
Dielectric Constant (Dkz)	Dkz	<input type="text" value="3.6350"/>	
Dielectric Anisotropy (%)		<input type="text" value="0.00"/>	
Odd Mode Impedance (Zvia)	Zodd	<input type="text" value="42.44"/>	
Differential Impedance	Zdiff	<input type="text" value="84.88"/>	
Effective Dielectric Constant	DkEff	<input type="text" value="4.4430"/>	

Close

Calculation results are presented here

Enter via structure parameters by either keying the dimension values or use sliders to gauge the impact of varying each parameter

New Differential Via Calculation



Two different selectable Anti-Pad Styles available

New Differential Via Calculation

Via Checks

Via Stub Check | Via Pad / Anti-Pad Calculation | **Differential Via Calculation**

Please refer to the parameters in parentheses when reading [Application Note](#)
 Courtesy of Bert Simonovich, Lamsim Enterprises Inc

Note: The model works for a simple differential pair structure with no pads and separate reference planes so the accuracy will be high.

The Application Note link provides further details of how the model works

AP8204.pdf | 1 / 9 | 100% | [Icons]

A Practical Alternative to 3D Via Modeling

You are a backplane designer and have been assigned to engineer a new high-speed, multi-gigabit serial link architecture from several line cards to multiple fabric switch cards across a backplane. These links must operate at 6GB/s day one and be 10GB/s (IEEE 802.3KR) ready for product evolution. The schedule is tight, and you need to come up with a backplane architecture to allow the rest of the program to progress on schedule.

HLD Plan

You come up with a concept you think will work, but the backplane is thick with over 30 layers. There are some long traces over 30 inches and some short traces of less than 2 inches between card slots. There is strong pressure to reuse the same connector you used in your last design, but your gut tells you its design may not be good enough for this higher speed application.

Finally, you are worried about the size and design of the differential via footprint used for the backplane connectors because you know they can be devastating to the quality of the received signal. You want to maximize the routing channel through the connector field, which requires you to shrink the anti-pad dimensions, so the tracks will be covered by the reference planes, but you can't easily quantify the consequences on the via of doing so.

You have done all you can think of, based on experience, to make the vias as transparent as possible without

Si9000e v22.03 (March 2022)

New Surface Roughness Compensation Preset Values option

The screenshot shows the Polar Si9000 PCB Transmission Line Field Solver interface. The Configuration menu is open, and the 'Surface Roughness Compensation Preset Values' option is highlighted with a red box. The dialog box for this option is also open, showing a table of preset values.

Description	RMS (μm)	Rz (μm)
Smooth Copper Laminate Side	2.2500	1.5000
Smooth Copper Oxide Side	2.3500	1.6000
Rough Copper Laminate Side	8.2500	7.5000
Rough Copper Oxide Side	5.2500	4.5000

Buttons: Add Entry, Delete Entry, Edit Entry, Apply, Cancel

A new entry has been added to the Configuration menu to manage a table of Surface Roughness Preset Values composed of Description, RMS and / or Rz values

New Surface Roughness Compensation Preset Values option

The image shows two software dialog boxes. The top dialog, titled "Surface Roughness Compensation - Hammerstad / Groisse", contains a diagram on the left and input fields on the right. The diagram shows a cross-section of a surface with two roughness parameters, R1 and R2, indicated by vertical arrows. The right side of the dialog has two rows of input fields: "Surface 1 Roughness R1" with a value of 2.2500 and a red box around the '<<' button, and "Surface 2 Roughness R2" with a value of 2.3500 and a red box around the '<<<' button. Below these are "Apply" and "Cancel" buttons. The bottom dialog, titled "Select Surface Roughness Compensation Preset Values", contains a table with the following data:

Description	RMS (μm)	Rz (μm)
Smooth Copper Laminate Side	2.2500	1.5000
Smooth Copper Oxide Side	2.3500	1.6000
Rough Copper Laminate Side	8.2500	7.5000
Rough Copper Oxide Side	5.2500	4.5000

The "Smooth Copper Laminate Side" row is highlighted in blue. "Select" and "Cancel" buttons are on the right side of this dialog.

The Hammerstad / Groisse dialog has been updated with the addition of '<<' options to select the required Surface Roughness Preset Values.

Once chosen the roughness preset item Description and RMS value are passed back to the surface roughness dialog.

New Surface Roughness Compensation Preset Values option

The Cannonball-Huray dialog has been updated with the addition of '<<' options to select the required Surface Roughness Preset Values.

Once chosen the roughness preset item Description and Rz value are passed back to the surface roughness dialog.

Surface Roughness Compensation - Huray

Ratio of Areas

Effective Ball Radius (μm)

Area of Ball Count (sq μm)

Number of Balls in Area

Images by courtesy of Circuit Foil Ltd

Select Surface Roughness Compensation Preset Values

Description	RMS (μm)	Rz (μm)
Smooth Copper Laminate Side	2.2500	1.5000
Smooth Copper Oxide Side	2.3500	1.6000
Rough Copper Laminate Side	8.2500	7.5000
Rough Copper Oxide Side	5.2500	4.5000

Select

Cancel

Cannonball-Huray Model

Rz Matte

Matte-side

Drum-side

Rz Drum

www.polarinstruments.com

Courtesy of Bert Simonovich, Lamsim Enterprises Inc [Application Note](#)

Enable Cannonball-Huray

Matte-Side Roughness

Rz Matte (μm) <<<

Smooth Copper Laminate Side

Drum-Side Roughness

Rz Drum (μm) <<

Smooth Copper Oxide Side

Calculate

Si9000e v22.02 (February 2022)

Track Resistance Calculator (TRC Plus) enhancements

Parameter Entry Units
 Mils Inches
 Microns Millimetres

	Tolerance	Minimum	Maximum	
Substrate 1 Height	H1	2.5000 ±	0.0000	2.5000 2.5000 Calculate
Substrate 1 Dielectric	Er1	4.2000 ±	0.0000	4.2000 4.2000 Calculate
Lower Trace Width	W1	3.9752 ±	0.0000	3.9752 3.9752
Upper Trace Width	W2	2.9752 ±	0.0000	2.9752 2.9752 Calculate
Trace Thickness	T1	0.7000 ±	0.0000	0.7000 0.7000 Calculate
Coating Above Substrate	C1	1.0000 ±	0.0000	1.0000 1.0000
Coating Above Trace	C2	1.0000 ±	0.0000	1.0000 1.0000
Coating Dielectric	CEr	4.2000 ±	0.0000	4.2000 4.2000
Impedance	Zo	50.00	50.00	50.00 Calculate More...

Notes: (First 5 lines will print)
 Add your comments here

Interface Style
 Standard
 Extended

G.S Convergence
 Fine (Slower)
 Coarse (Faster)

Tolerance Mode
 Absolute
 Percentage [%]

Parameter Snap
 Auto Calc
 Snap

Single-Ended Structures

The optional TRC Plus calculator includes a number of enhancements including new graphing capability.

Selecting this toolbar option will pass the current structure dimensions to the TRC Plus in order to calculate the track resistance

Track Resistance Calculator (TRC Plus) enhancements

TRC Plus
Si9000

Single Ended Coated Microstrip 1B

Material & Calculated Impedance
-- From Si8000 / Si9000 --

Calculated Impedance (Zo)

Resistivity (Ohm Metres)

TCR

Units

Mils Inches

Microns Millimetres

Track Resistance Ω

Single Trace

Dual Trace

Voltage Drop (Single Trace)

Current (Amps)

VD (Volts)

Ohms per division : 0.25

Resistance Ω

Line Length (Mils)

This new TRC Plus graphing feature shows the track resistance (y-axis) plotted against the line length (x-axis)

Track Dimensions from the Si Quick Solver

Lower Trace Width	W1	<input type="text" value="3.9752"/>
Upper Trace Width	W2	<input type="text" value="2.9752"/>
Trace Thickness	T1	<input type="text" value="0.7000"/>
Length of Line	LL	<input type="text" value="8000.0000"/>

Track Dimensions

Lower Trace Width

Upper Trace Width

Trace Thickness

Length of Line

Track Resistance Ω

Single Trace

Dual Trace

Voltage Drop (Single Trace)

Current (Amps)

VD (Volts)

Graphing Options

Show Grid Lines

Tracking

Dark Mode

TDR View On

Adjust Y Scale

Close

Track Resistance Calculator (TRC Plus) enhancements

TRC Plus

File Tools Help

Si9000

Material & Calculated Impedance

-- From Si8000 / Si9000 --

Calculated Impedance (Zo)

Resistivity (Ohm Metres)

Conductivity (Siemens / m)

Temp. Coefficient (/ °C) TCR

Reference Temp. (°C)

Operating Temp. (°C)

Units

Mils Inches

Microns Millimetres

Track Resistance Ω

Single Trace

Dual Trace

Voltage Drop (Single Trace)

Current (Amps)

VD (Volts)

Track Dimensions

Lower Trace Width W1

Upper Trace Width W2

Trace Thickness T1

Length of Line LL

TDR indicative Ω

Ohms per division : 1

Line Length (Mils)

Show Grid Lines

Tracking

Dark Mode

TDR View

On ?

Adjust Y Scale ▲ ▼

Close

Si9000e v21.09 (Sept 2021)

Project Graphing – Introduction *(requires the Si Projects feature)*

It is often useful to compare the results from similar structures, especially with frequency dependent calculations where changing just one or two parameters can have significant impact.

Until now the Si9000e Quick Solver graphing has focused on a single structure, for instance the All Losses graph will display a single plot that includes multiple data series for the same structure.

The new Project Graphing option calculates all the results for a group of structures contained in the Project and then plots the selected data series (total attenuation, conductor loss or dielectric loss etc) on the same graph.

A single graph that combines results from multiple structures is useful in a number of ways. Comparing the impact of different dielectric materials, different roughness, sensitivity analysis for lossy calculations and many more uses.

Project Graphing

A project with five structures, all with matching parameters and Z_0 of 50 ohms. The only difference between the structures is the loss tangent (TanD), ranging from 0.001 to 0.030

The screenshot shows the software interface with a project titled "Si9000 V21_09 Project Graphing Surface Roughness GoalSeek\Loss Tangent 0.010 - 0.030.SIP". The main window displays a cross-sectional diagram of a PCB structure with parameters: $H1$, $Er1$, $C1$, $C2$, $W1$, $W2$, and $T1$. The current structure is labeled "TanD=0.010".

Parameter	Value	Tolerance	Minimum	Maximum	Action
H1	4.3098	± 0.0000	4.3098	4.3098	Calculate
Er1	4.2000	± 0.0000	4.2000	4.2000	Calculate
W1	7.0000	± 0.0000	7.0000	7.0000	Calculate
W2	6.0000	± 0.0000	6.0000	6.0000	Calculate
T1	1.2000	± 0.0000	1.2000	1.2000	Calculate
C1	1.0000	± 0.0000	1.0000	1.0000	Calculate
C2	1.0000	± 0.0000	1.0000	1.0000	Calculate
CEr	4.2000	± 0.0000	4.2000	4.2000	Calculate
Impedance	Zo		0.00	0.00	Calculate

The right-click menu is open, showing options: Add Structure to Project, Delete Structure from Project, Rename Structure within Project, Move Up, Move Down, Duplicate Selected Structure, Clear Project, **Graphing ...** (highlighted in red), and Demo Mode: Load Sample Structures into Project.

The Projects right-click menu contains a new Graphing option. When selected the Si9000e runs a full frequency dependent calculation for each structure in the project and stores the results.

The following new dialog then displays ...

The Project Structure List provides options to choose which structures from the Project are plotted. Individual structures can be toggled between selected / deselected by double-clicking the grid row

Project Graphing

Project Structure List

#	Structure	Name	Selected	Colour
0		TanD=0.010	Yes	Red
1		TanD=0.015	Yes	Green
2		TanD=0.020	Yes	Blue
3		TanD=0.025	Yes	Yellow
4		TanD=0.030	Yes	Cyan

DbI-Click grid row to toggle Selected status.

Selected Structure Information

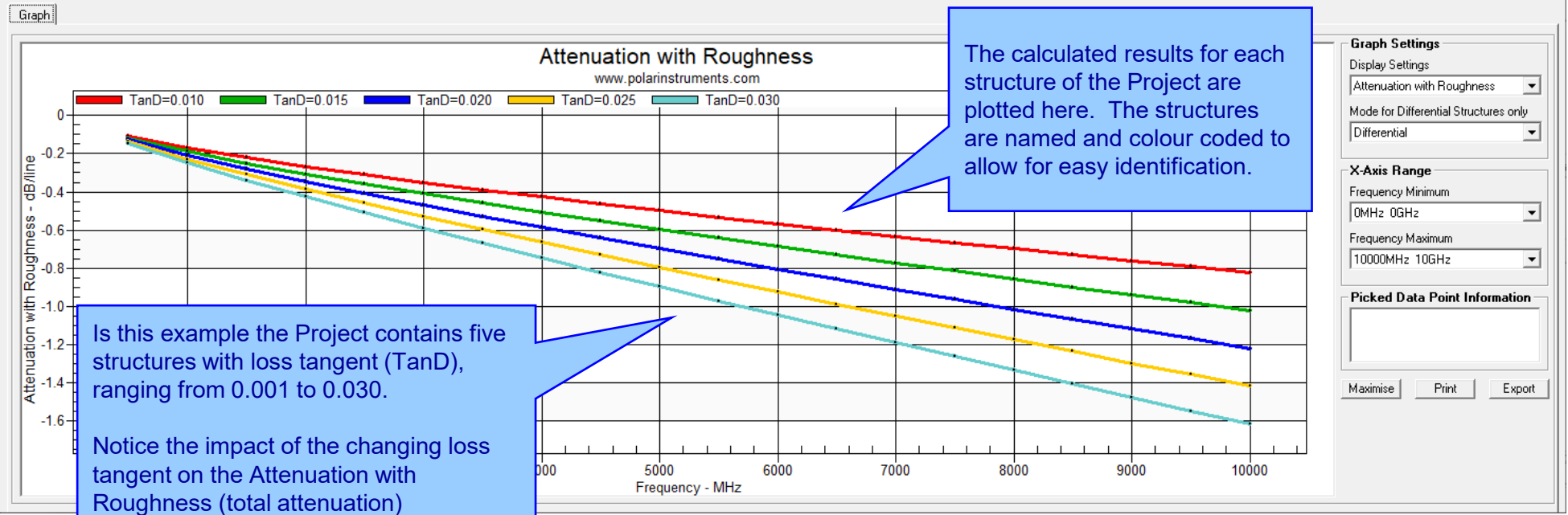
Structure Type : Coated Microstrip 1B

H1	4.3098
Er1	4.2000
W1	7.0000
W2	6.0000
T1	1.2000
C1	1.0000
C2	1.0000
CEr	4.2000
Zo	50.01

LL	1000.00
TC	5.80E+07
TanD	0.0100
Tr	10
FMin	500.000
FMax	10.000
FSteps	20

Frequency Distribution : Linear
 Result Presentation : Length of Line
 Extended Substrate Data : Constant Er / TanD
 Surface Roughness Compensation : Hammerstad

Summary parameter information for the selected Project Structure List grid row is shown here.



Is this example the Project contains five structures with loss tangent (TanD), ranging from 0.001 to 0.030.

Notice the impact of the changing loss tangent on the Attenuation with Roughness (total attenuation)

The calculated results for each structure of the Project are plotted here. The structures are named and colour coded to allow for easy identification.

Project Graphing

Project Structure List

#	Structure	Name	Selected	Colour
0		Roughness 0.5um	Yes	Red
1		Roughness 1.0um	Yes	Green
2		Roughness 1.5um	Yes	Blue
3		Roughness 2.0um	Yes	Yellow
4		Roughness 2.5um	Yes	Cyan

Dbl-Click grid row to toggle Selected status.

Selected Structure Information

Structure Type : Offset Stripline 1B1A	
H1	6.2992
Er1	4.2000
H2	6.2992
Er2	4.2000
W1	4.1339
W2	3.0709
T1	1.3780
Zo	50.02
LL	1000.00
TC	5.80E+07
TanD	0.0195
Tr	10
FMin	500.000
FMax	50.000
FSteps	100
Frequency Distribution : Linear	
Result Presentation : Length of Line	
Extended Substrate Data : Constant Er / TanD	
Surface Roughness Compensation : Huray	

Graph

Conductor Loss with Roughness

www.polarinstruments.com

■ Roughness 0.5um
 ■ Roughness 1.0um
 ■ Roughness 1.5um
 ■ Roughness 2.0um
 ■ Roughness 2.5um

Graph Settings

Display Settings

Mode for Differential Structures only

X-Axis Range
 Frequency Minimum: 0GHz
 Frequency Maximum: 50GHz

Picked Data Point Information

Is this example the Project contains five structures with copper surface roughness ranging from 0.5 μm to 2.5 μm .

Notice the impact of the surface roughness on the Conductor with Roughness

Project Graphing

Project Structure List

#	Structure	Name	Selected	Colour
0		3/2.5/2.378	Yes	Red
1		3.5/3/2.7551	Yes	Green
2		4/3.5/3.1783	Yes	Blue
3		4.5/4/3.6647	Yes	Yellow
4		5/4.5/4.2267	Yes	Cyan

Dbl-Click grid row to toggle Selected status.

One or more Structures has greater than 175 data points. Mouse over for more info.

Select All Unselect All
Select SE Select Diff

Selected Structure Information

3/2.5/2.378

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Structure Type : Edge-Coupled Offset Stripline 1B1A	
H1	8.0000
Er1	3.5000
H2	8.5000
Er2	3.5000
W1	3.0000
W2	2.5000
S1	2.3780
T1	0.6000
Zdiff	100.01
LL	1000.00
TC	5.80E+07
TanD	0.0020
Tr	10
FMin	100.000
FMax	20.000
FSteps	200
Frequency Distribution : Linear	
Result Presentation : Length of Line	
Extended Substrate Data : Causally Extrapolate Er / TanD	
Surface Roughness Compensation : Huray	

Graph Settings

Display Settings
Attenuation with Roughness

Mode for Differential Structures only
Differential

X-Axis Range
Frequency Minimum
0MHz 0GHz
Frequency Maximum
20000MHz 20GHz

Picked Data Point Information

Maximise Print Export

Graph

Attenuation with Roughness

www.polarinstruments.com

10 differential structures using the same dielectric substrate materials but with differing trace widths / separations to achieve Zdiff = 100 ohms.

Notice that whilst all structures are 100 ohms, the structures with narrower trace widths are significantly more lossy than those with wider trace widths.

Project Graphing – Summary

- The new Graphing option for Si Projects provides useful plots that contain data from multiple structures
- There are numerous uses for this type of option - comparing the impact of different dielectric materials, different roughness, sensitivity analysis for lossy calculations and more
- ‘What if’ scenarios where one structure in the project would use the current design parameters and the second structure would contain a modified set based on a newer material. The plots comparing the original versus the new material will instantly show the impact
- Useful to both fabricators and design companies

Populate a Project from Sensitivity Analysis Results

(requires the Si Projects feature)

When using the Sensitivity Analysis option it is often useful to examine the calculated results in more details. It is now possible to auto-create a Project containing structures based upon the Sensitivity Analysis results data.

The following slides provide further details:

Populate a Project from Sensitivity Analysis Results

Coated Microstrip 1B

Parameter Entry Units:
 Mils
 Inches
 Microns
 Millimetres

Impedance vs Changing Parameter(s)

Parameter	H1	None	Calculate
Range Start Value	3.0000	4.0000	
Range Finish Value	12.0000		
Increment	1.0000	1.0000	

Constant Impedance vs Changing Parameters

Parameter	W1	Calculate
Target Impedance	50.0000	
<input type="checkbox"/> Process Window: Minimum / Maximum	67.5000	82.5000

Graph Settings

2D 3D

Display Series: Constant Impedance

Target Impedance: 0.0000 Refresh

Picked Data Point Information

H1 (Mils): 5.000
W1: 8.436

Maximise Print Export

Coated Microstrip 1B - 50 Ohms

The plot shows Substrate Height (H1) X-axis and the Trace Width (W1) Y-axis. Each data point represents the H1 / W1 parameter values to achieve 50 ohms.

H1 (Mils)	W1 (Mils)
3.0	4.5
4.0	6.5
5.0	8.5
6.0	10.5
7.0	12.5
8.0	14.5
9.0	16.5
10.0	18.5
11.0	20.5
12.0	22.5

Lossless Calculation | Frequency Dependent Calculation | **Sensitivity Analysis** | Via Checks

Populate a Project from Sensitivity Analysis Results

Coated Microstrip 1B

Impedance vs Changing Parameter(s)

Parameter: H1 Range Start Value: 3.0000 Range End Value: 12.0000

Parameter: W1 Range Start Value: 4.7000 Range End Value: 18.0300

H1	Er1	W1	W2	T1	C1	C2	CEr	Zo	Calc Success
3.0000	4.2000	4.7096	3.7096	1.2000	1.0000	1.0000	4.2000	50.0095	Yes
4.0000	4.2000	6.5638	5.5638	1.2000	1.0000	1.0000	4.2000	49.9943	Yes
5.0000	4.2000	8.4360	7.4360	1.2000	1.0000	1.0000	4.2000	49.9913	Yes
6.0000	4.2000	10.3381	9.3381	1.2000	1.0000	1.0000	4.2000	49.9909	Yes
7.0000	4.2000	12.2522	11.2522	1.2000	1.0000	1.0000	4.2000	49.9953	Yes
8.0000	4.2000	14.1663	13.1663	1.2000	1.0000	1.0000	4.2000	49.9973	Yes
9.0000	4.2000	16.0923	15.0923	1.2000	1.0000	1.0000	4.2000	50.0056	Yes
10.0000	4.2000	18.0303	17.0303	1.2000	1.0000	1.0000	4.2000	49.9967	Yes
11.0000	4.2000	19.9567	18.9567	1.2000	1.0000	1.0000	4.2000	49.9867	Yes
12.0000	4.2000	21.8823	20.8823	1.2000	1.0000	1.0000	4.2000	50.0058	Yes

Results

Copy Results to Clipboard (for Excel)

Create Project Structures

The Results tab contains the calculated results data used for the Sensitivity Analysis plot

The right-click menu now has a new Create Project Structures option. On selection the software will create an individual structure per row of the Results grid and add it to the Project. In this example there are 10 result rows so 10 structures will be created

The Project now contains 10 structures. Notice the structure name is auto-assigned based upon the sensitivity analysis parameters selected. In this example the H1 and W1 parameter values are used

Populate a Project from Sensitivity Analysis Results

The structure name is auto-assigned from the sensitivity analysis parameters / result

Once the Project has been generated the structures within work in exactly the same way as if they were created manually.

The parameter values / results used for the structure name

Parameter	Tolerance	Minimum	Maximum	Calculate
H1	± 0.0000	5.0000	5.0000	Calculate
Er1	± 0.0000	4.2000	4.2000	Calculate
W1	± 0.0000	8.4360	8.4360	Calculate
W2	± 0.0000	7.4360	7.4360	Calculate
T1	± 0.0000	1.2000	1.2000	Calculate
C1	± 0.0000	1.0000	1.0000	Calculate
C2	± 0.0000	1.0000	1.0000	Calculate
CEr	± 0.0000	4.2000	4.2000	Calculate
Impedance Zo		49.99	49.99	Calculate

Structure Name: H1=5.0000 W1=8.4360 Zo=49.99

Project List:

- H1=3.0000 W1=4.70...
- H1=4.0000 W1=6.56...
- H1=5.0000 W1=8.4360 Zo=49.99**
- H1=6.0000 W1=10.33...
- H1=7.0000 W1=12.25...
- H1=8.0000 W1=14.16...
- H1=9.0000 W1=16.09...
- H1=10.0000 W1=18.03...

Project Graphing

Project Structure List

#	Structure	Name	Selected	Colour
0		H1=3.0000 W1=4.7096 Zo=50.01	Yes	Red
1		H1=4.0000 W1=6.5638 Zo=49.99	Yes	Green
2		H1=5.0000 W1=8.4360 Zo=49.99	Yes	Blue
3		H1=6.0000 W1=10.3381 Zo=49.99	Yes	Yellow
4		H1=7.0000 W1=12.2522 Zo=50.00	Yes	Cyan

DoubleClick grid row to toggle Selected status.

Select All Unselect All
Select SE Select Diff

Selected Structure Information

H1=3.0000 W1=4.7096 Zo=50.01

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Structure Type : Coated Microstrip 1B

H1	3.0000
Er1	4.2000
W1	4.7094
W2	3.7094
T1	1.2000
C1	1.0000
C2	1.0000
CEr	4.2000
Zo	50.01

LL	1000.00
TC	5.80E+07
TanD	0.0195
Tr	10
FMin	500.000
FMax	10.000
FSteps	20

Frequency Distribution : Linear
Result Presentation : Length of Line
Extended Substrate Data : Constant Er / TanD
Surface Roughness Compensation : Hammerstad

Graph

Attenuation with Roughness

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Legend:

- H1=3.0000 W1=4.7096 Zo=50.01 (Red)
- H1=4.0000 W1=6.5638 Zo=49.99 (Green)
- H1=5.0000 W1=8.4360 Zo=49.99 (Blue)
- H1=6.0000 W1=10.3381 Zo=49.99 (Yellow)
- H1=7.0000 W1=12.2522 Zo=50.00 (Cyan)
- H1=8.0000 W1=14.1663 Zo=50.00 (Brown)
- H1=9.0000 W1=16.0923 Zo=50.01 (Magenta)
- H1=10.0000 W1=18.0303 Zo=50.00 (Orange)
- H1=11.0000 W1=19.9567 Zo=49.99 (Dark Blue)
- H1=12.0000 W1=21.8823 Zo=50.01 (Light Green)

Graph Settings

Display Settings: **Attenuation with Roughness**

Mode for Differential Structures only: Differential

X-Axis Range: Frequency Minimum: 0MHz 0GHz, Frequency Maximum: 10000MHz 10GHz

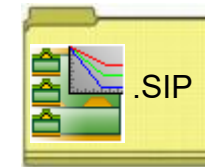
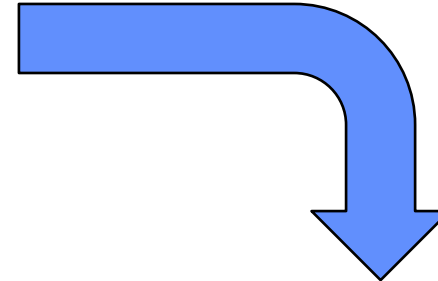
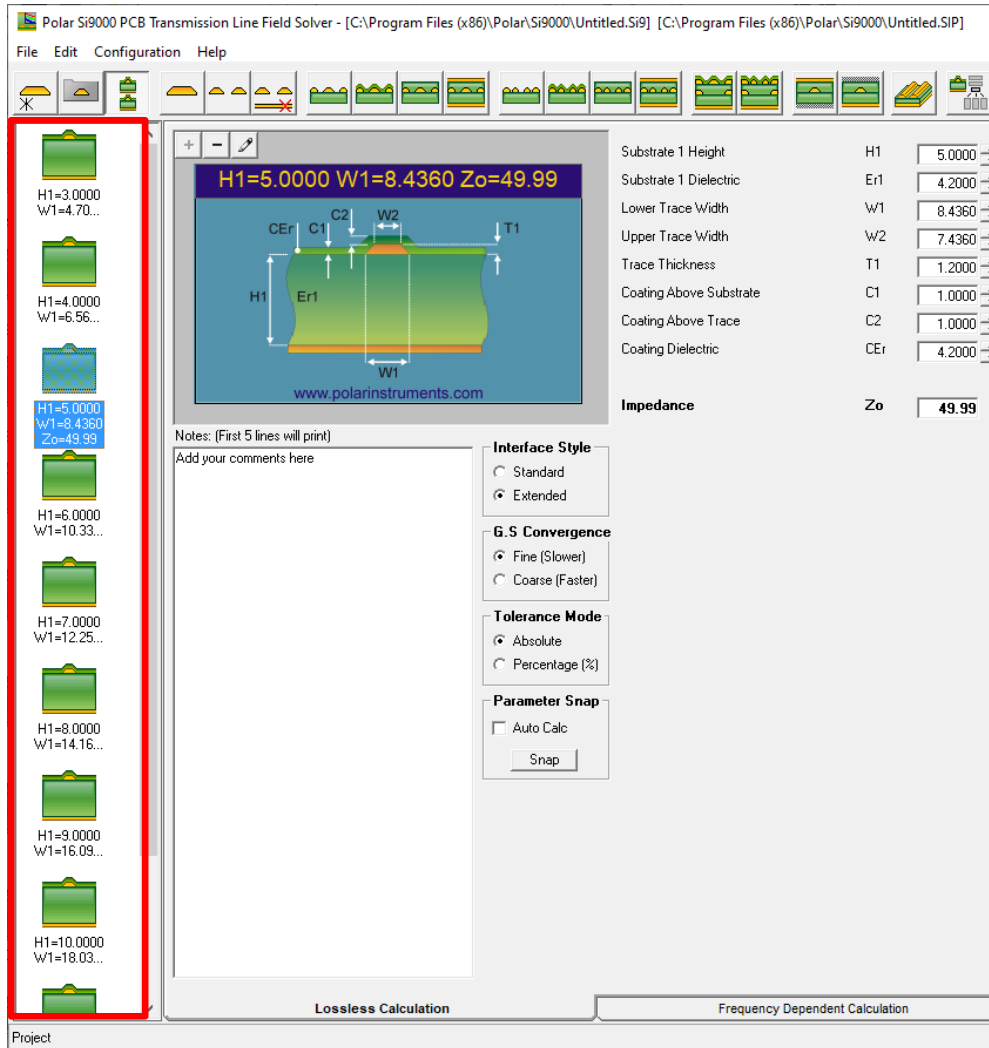
Picked Data Point Information: [Empty]

Maximise Print Export

Once the structures have been automatically created from sensitivity analysis they can also be examined using the Project Graphing.

Notice that whilst all structures are 50 ohms, the structures with narrower trace widths are significantly more lossy than those with wider trace widths.

Populate a Project from Sensitivity Analysis Results



Save the newly created project to the Si Project file format (.SIP) so that it can be recalled at a later date.

Populate a Project from Sensitivity Analysis Results - Summary

- As separate structure in a Project it is now possible to examine the results in a lot more detail than when in sensitivity analysis
- Lossy calculations can be performed and compared
- As a Project the structure data can be stored as a .SIP file and recalled later
- Useful to both fabricators and design companies

Surface Roughness Goal Seek option

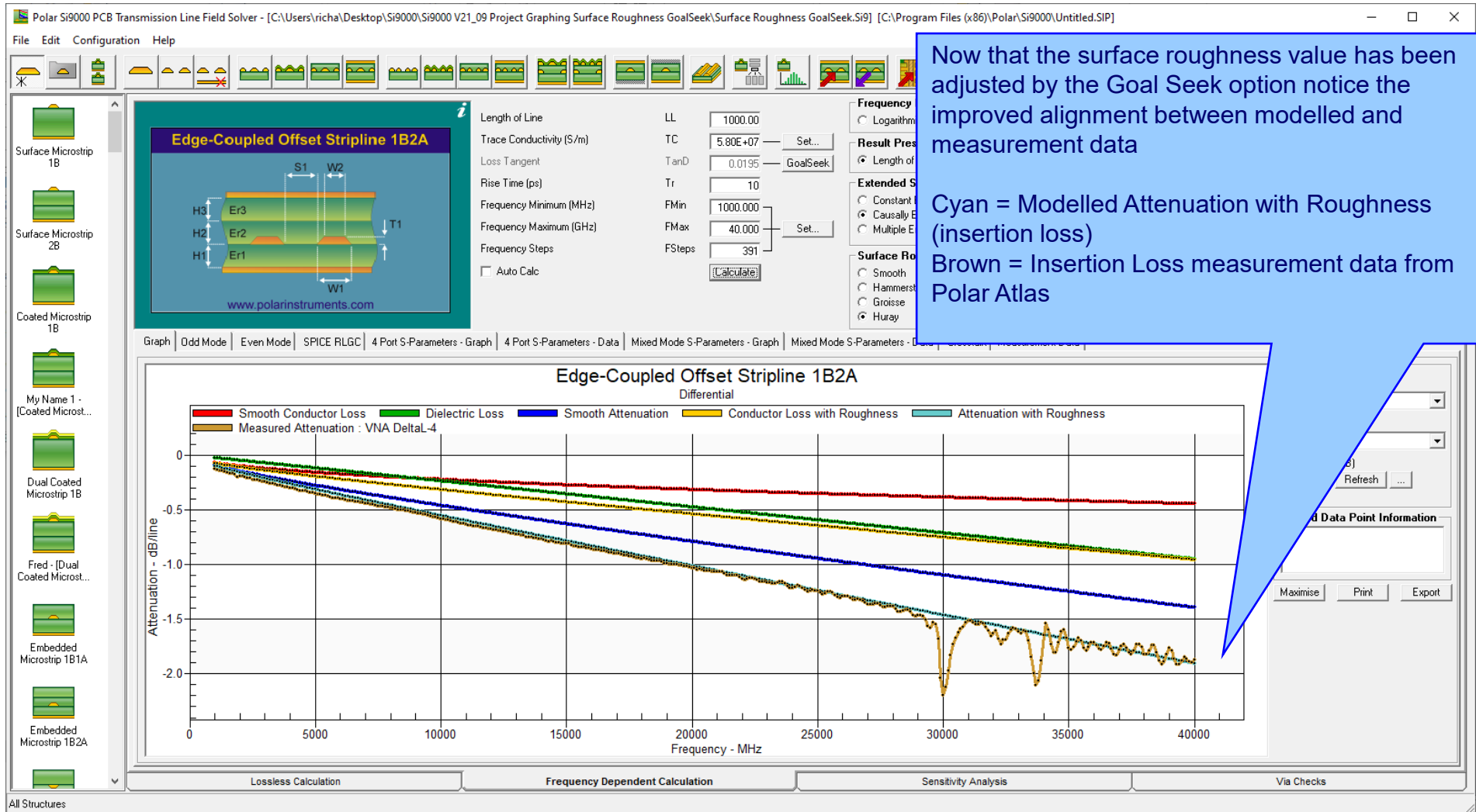
New option to back calculate the surface roughness value for a structure from the insertion loss measurement data. The measurements can be generated using the Polar Atlas system or others that are capable of measuring insertion loss.

Cyan = Modelled Attenuation with Roughness (insertion loss)

Brown = Insertion Loss measurement data from Polar Atlas

The screenshot shows the Polar Si9000 PCB Transmission Line Field Solver interface. The main window displays the 'Edge-Coupled Offset Stripline 1B2A' structure with parameters: Length of Line (LL) = 1000.00, Trace Conductivity (S/m) (TC) = 5.80E+07, Loss Tangent (TanD) = 0.0195, Rise Time (ps) (Tr) = 10, Frequency Minimum (MHz) (FMin) = 1000.000, Frequency Maximum (GHz) (FMax) = 40.000, and Frequency Steps (FSteps) = 391. The 'Surface Roughness Compensation' section is active, with the 'GoalSeek' option selected. The graph shows Attenuation (dB/line) vs Frequency (MHz) for a differential mode. The legend includes: Smooth Conductor Loss (red), Dielectric Loss (green), Smooth Attenuation (blue), Conductor Loss with Roughness (yellow), Attenuation with Roughness (cyan), and Measured Attenuation: VNA Delta-4 (brown). The graph shows that the measured attenuation (brown) closely follows the modelled attenuation with roughness (cyan) across the frequency range from 0 to 40,000 MHz.

Surface Roughness Goal Seek option



Track Resistance Calculator (TRC Plus)

The screenshot displays the Polar Si9000 PCB Transmission Line Field Solver software. The main window shows a graph titled "Surface Microstrip 1B" with the following data series:

Frequency (MHz)	Smooth Conductor Loss (dB/line)	Dielectric Loss (dB/line)	Smooth Attenuation (dB/line)	Conductor Loss with Roughness (dB/line)
1000	-0.05	-0.05	-0.10	-0.15
2000	-0.08	-0.12	-0.20	-0.25
3000	-0.10	-0.18	-0.30	-0.35
4000	-0.12	-0.25	-0.40	-0.45
5000	-0.13	-0.32	-0.50	-0.55
6000	-0.14	-0.38	-0.60	-0.65
7000	-0.15	-0.45	-0.70	-0.75

The TRC Plus calculator window is overlaid on the graph, showing a 3D model of a microstrip track with dimensions $W1$, $W2$, and $T1$, and length LL . The calculator includes the following input fields:

Parameter	Value
Material	-- From Si9000 --
Resistivity (Ohm Metres)	1.724E-08 Ω m
Conductivity (Siemens / m)	5.80E+07 S/m
Temp. Coefficient (/ °C)	TCR 0.00386
Reference Temp. (°C)	20
Operating Temp. (°C)	20
Lower Trace Width	W1 7.0000
Upper Trace Width	W2 6.0000
Trace Thickness	T1 1.2000
Length of Line	LL 1000.0000

The calculator also shows the following output fields:

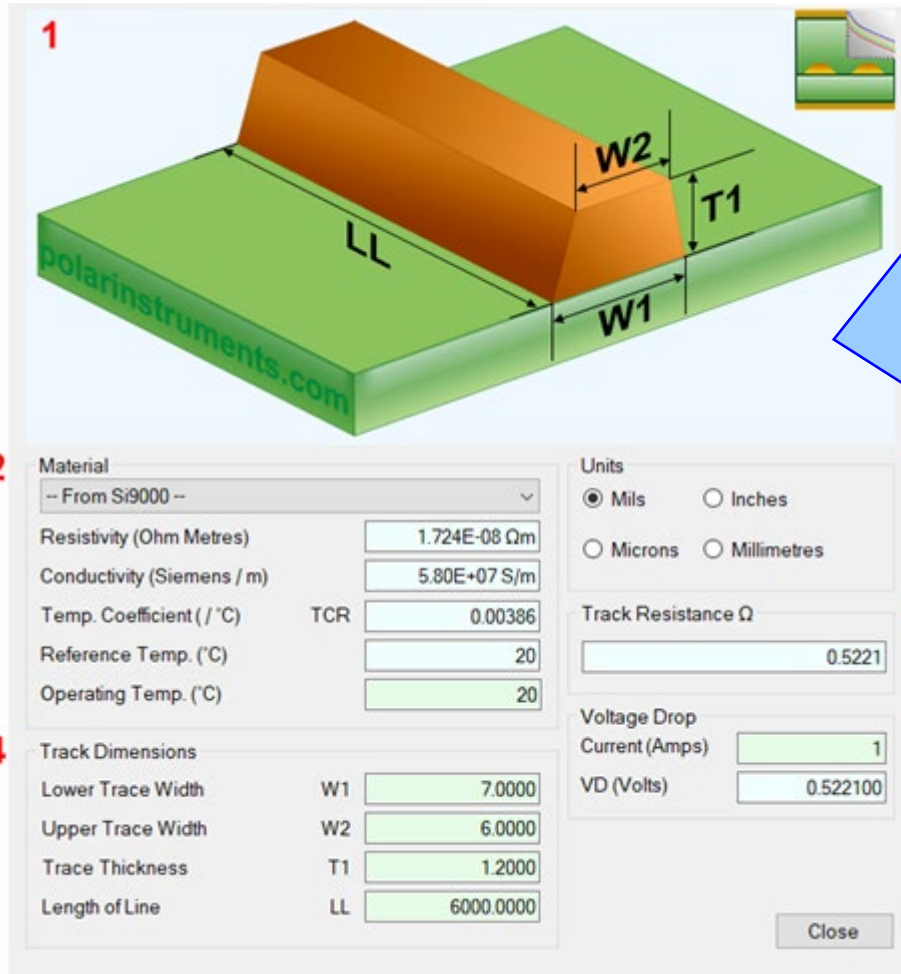
Parameter	Value
Track Resistance Ω	0.0870
Voltage Drop Current (Amps)	1
VD (Volts)	0.087000

A blue callout box highlights the calculator's features:

The new TRC Plus calculator includes a number of enhancements including:

- Support for longer Length of Line (LL) values
- Support for Temperature Coefficient of Resistance

Track Resistance Calculator (TRC Plus)



1 Interactive track material image.

2 Material selection and properties.

3 Units.

4 Track or trace dimensions.

5 Resistance result.

6 Voltage Drop calculation result.

Material	Units	Track Dimensions	Resistance	Voltage Drop
-- From Si9000 --	<input checked="" type="radio"/> Mils <input type="radio"/> Inches	Lower Trace Width (W1): 7.0000	Track Resistance Ω : 0.5221	Current (Amps): 1
Resistivity (Ohm Metres): 1.724E-08 Ω m	<input type="radio"/> Microns <input type="radio"/> Millimetres	Upper Trace Width (W2): 6.0000		VD (Volts): 0.522100
Conductivity (Siemens / m): 5.80E+07 S/m		Trace Thickness (T1): 1.2000		
Temp. Coefficient (/ °C) TCR: 0.00386		Length of Line (LL): 6000.0000		
Reference Temp. (°C): 20				
Operating Temp. (°C): 20				

1. Interactive track material image.

Clicking on a track parameter label will highlight the associated Track Dimension field (text box). Enter data into the active field.

Double-clicking anywhere on the image will bring up the Materials Editor.

2. Material selection and properties

Select the material via the drop-down list.

Fields coloured in light-blue are not directly editable but the field values can be in the Materials Editor.

Fields coloured in light-green are editable by the user. For example, Operating Temperature will determine a material's resistivity at that temperature, which in turn will be applied in calculating the track resistance.

3. Units

Switch to your preferred units by clicking the associated option button – imperial units include Mils (Thou) and Inches; for metric units choose Microns (Micrometres) or Millimetres.

4. Track or trace dimensions

Enter or change track dimensions in the Track Dimensions in the chosen units.

5. Resistance result

Calculation of the track resistance. The result should update immediately upon any changes to the editable (light-green) fields.

6. Voltage Drop calculation result

The calculated Voltage Drop is displayed in the VD (Volts) text box

Other enhancements

- Monte Carlo Analysis. New option added to export the Iterations / Results to Clipboard (for Excel), accessible from the right-click menu
- Causally Extrapolated Substrate Data. New option added to export the Results to Clipboard (for Excel), accessible from the right-click menu

Si9000e v21.04 (April 2021)

Monte Carlo Analysis maximum iteration increased to 9000

Coated Microstrip 1B

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	Nominal	Tol (Abs)	Minimum	Maximum	Mean	Std Dev
Substrate 1 Height	H1	8.5000 ± 0.0000	8.5000	8.5000	8.5000	1.0000
Substrate 1 Dielectric	Er1	4.2000 ± 0.0000	4.2000	4.2000	4.2000	0.0000
Lower Trace Width	W1	14.9629 ± 0.0000	14.9629	14.9629	7.0000	0.0000
Upper Trace Width	W2	13.9629 ± 0.0000	13.9629	13.9629	6.0000	0.0000
Trace Thickness	T1	1.2000 ± 0.0000	1.2000	1.2000	1.2000	0.0000
Coating Above Substrate	C1	1.0000 ± 0.0000	1.0000	1.0000	1.0000	0.0000
Coating Above Trace	C2	1.0000 ± 0.0000	1.0000	1.0000	1.0000	0.0000
Coating Dielectric	CEr	4.2000 ± 0.0000	4.2000	4.2000	4.2000	0.0000
Impedance	Zo	49.99	49.99	49.99	49.99	49.99

Settings
 Iterations:

Uniform Distribution (Tol/Min/Max)

Normal Distribution (Mean/Std Dev)

Close

Nom -> Mean

Tol -> Std Dev

It is now possible to run a Monte Carlo Analysis for 9,000 calculations on any selected structure

Graph | Iterations / Results

Coated Microstrip 1B - Monte Carlo Analysis

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Results Summary

Impedance - Zo

Nominal: 49.99

Minimum (worst case): 52.50

Maximum (worst case): 84.69

Monte Carlo Analysis

Mean: 70.85

Standard Deviation: 3.93

Maximize | Print | Export

Import from Atlas enhanced to support measurement data to 50GHz

The Polar Atlas VNA Delta-L insertion loss test system now exports measurement data up to 50 GHz.

The Si9000e Import from Atlas option allows the insertion loss measurement data (brown data series) to be overlaid on the All Losses plot.

In this example the Anritsu ShockLine™ instrument was used, Delta-L maximum frequency set to 40GHz

Si9000e v21.01 (January 2021)

Monte Carlo support added for Dual Coated structures

Edge-Coupled Dual Coated Microstrip 1B

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	Nominal	Tol (Abs)	Minimum	Maximum	Mean	Std Dev
Substrate 1 Height	H1	8.5000 ± 0.0000	8.5000	8.5000	8.5000	0.5000
Substrate 1 Dielectric	Er1	4.2000 ± 0.0000	4.2000	4.2000	4.2000	0.0000
Lower Trace Width	W1	7.0000 ± 0.0000	7.0000	7.0000	7.0000	0.0000
Upper Trace Width	W2	6.0000 ± 0.0000	6.0000	6.0000	6.0000	0.0000
Trace Separation	S1	5.9669 ± 0.0000	5.9669	5.9669	5.9669	0.0000
Trace Thickness	T1	1.2000 ± 0.0000	1.2000	1.2000	1.2000	0.0000
Coating Above Substrate	C1	1.0000 ± 0.0000	1.0000	1.0000	1.0000	0.0000
Coating Above Trace	C2	1.0000 ± 0.0000	1.0000	1.0000	1.0000	0.0000
Coating Between Traces	C3	1.0000 ± 0.0000	1.0000	1.0000	1.0000	0.0000
Coating Dielectric	CER	4.2000 ± 0.0000	4.2000	4.2000	4.2000	0.0000
2nd Coating Above Substrate	CS1	1.0000 ± 0.0000	1.0000	1.0000	1.0000	0.0000
2nd Coating Above Trace	CS2	1.0000 ± 0.0000	1.0000	1.0000	1.0000	0.0000

Differential Impedance

Zdiff: 99.99 99.99 99.99

Settings

Iterations: Uniform Distribution (Tol/Min/Max) Normal Distribution (Mean/Std Dev)

	Nominal	Tol (Abs)	Minimum	Maximum	Mean	Std Dev
2nd Coating Between Traces	CS3	1.0000 ± 0.0000	1.0000	1.0000	1.0000	0.0000
2nd Coating Dielectric	CSEr	4.2000 ± 0.0000	4.2000	4.2000	4.2000	0.0000

Nom -> Mean
Tol -> Std Dev

Graph | Iterations / Results

Edge-Coupled Dual Coated Microstrip 1B - Monte Carlo Analysis

www.polarinstruments.com

Results Summary

Impedance - Zdiff

Nominal: 99.99

Minimum (worst case): 96.41

Maximum (worst case): 102.72

Monte Carlo Analysis

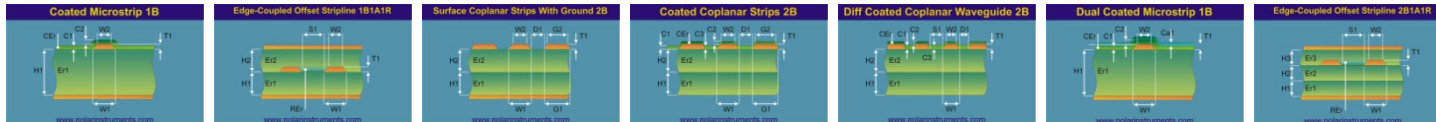
Mean: 99.94

Standard Deviation: 1.11

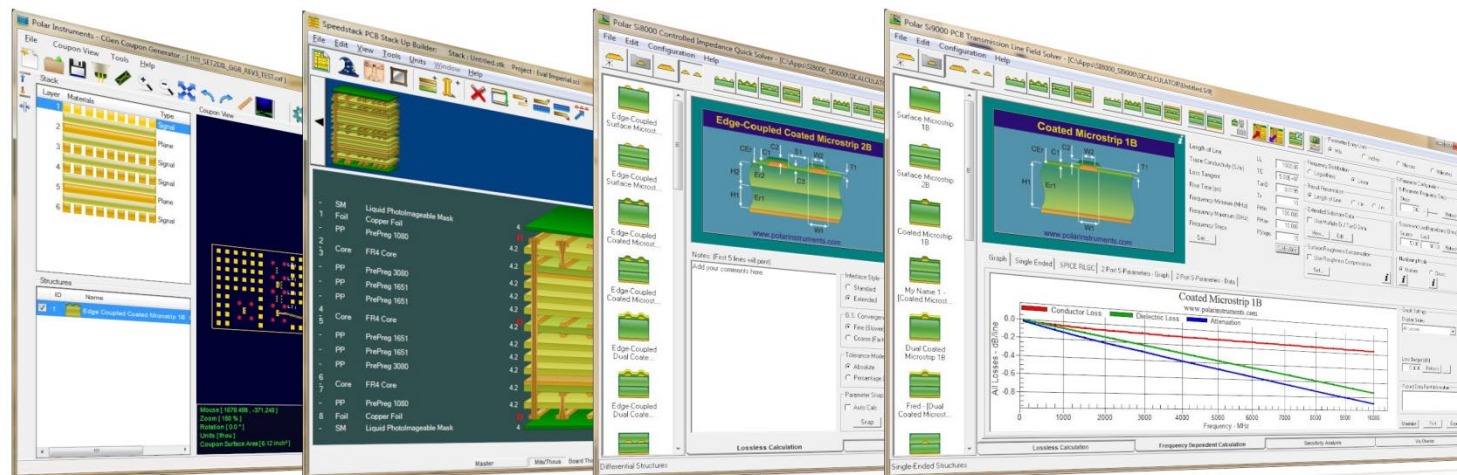
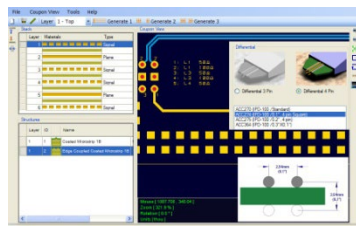
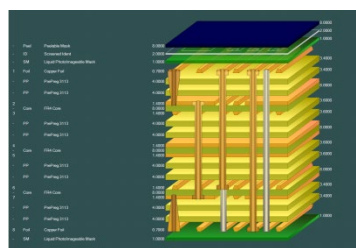
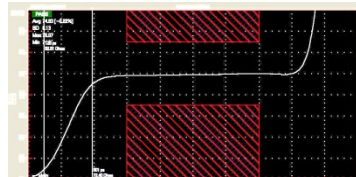
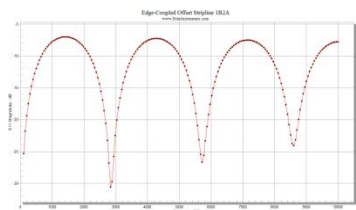
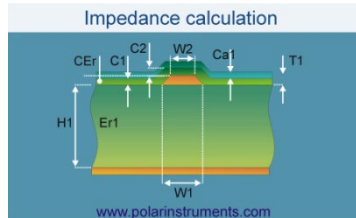
The Monte Carlo Analysis option now supports Dual Coated structures

Other enhancements

- FlexNet Publisher / FLEXIm v11.17.2.0 supported

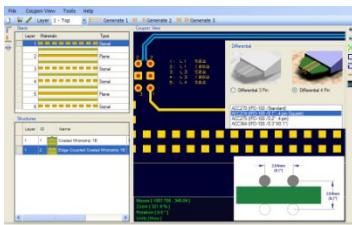
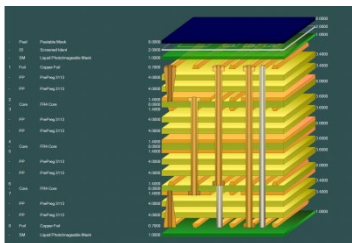
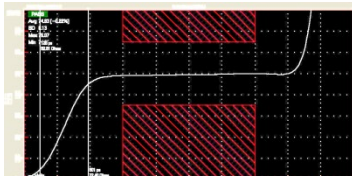
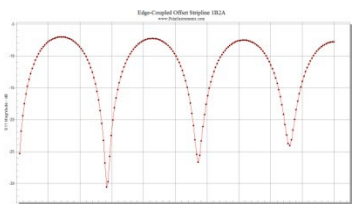
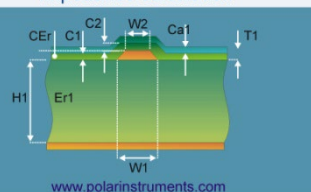


Thank you for viewing this Si9000e 2021 – 2024 preview. If you have questions we would be delighted to help you. Your local contact information is contained on the following slide





Impedance calculation



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