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VNA Tools - Splitter Characterization

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Outline

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Splitter

Equivalent Source Match

The following equations describe the equivalent source match for port 2 and 3 of the splitter.

$$\Gamma_{Eq2} = S_{22} - \frac{S_{32}S_{21}}{S_{31}} \quad \Gamma_{Eq3} = S_{33} - \frac{S_{23}S_{31}}{S_{21}}$$

Tracking

The following equation describes the tracking of the splitter.

$$Tracking = \frac{S_{21}}{S_{31}}$$

What is METAS VNA Tools and UncLib?

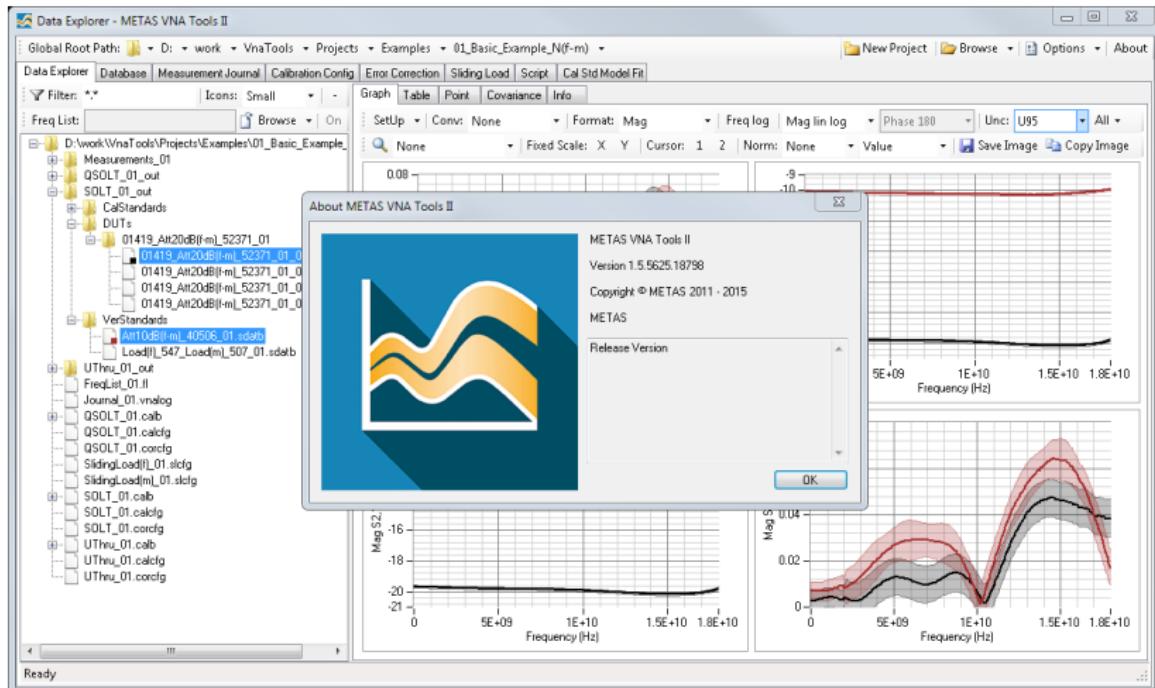


Figure : METAS VNA Tools

METAS VNA Tools

METAS VNA Tools is a software which is designed to compute uncertainties of S-parameter measurements:

- ▶ It uses a VNA measurement model for N -port Vector Network Analyzers.
- ▶ It supports the following calibration types: One Port, SOLT, GSOLT, QSOLT, Unknown Thru, TRL, Juroshek and Optimization.
- ▶ It allows the definition of all influences that affect VNA measurements.
- ▶ It uses the Linear Propagation module of METAS UncLib to propagate all uncertainties through the VNA measurement model.
- ▶ It can visualize S-parameter data with uncertainties.

METAS VNA Tools - Step by Step

The following steps describes the typical use of VNA Tools:

1. Specify all uncertainty influences in the Database of VNA Tools.
2. Collect raw measurement data and protocol the measurement process in the Measurement Journal.
3. Configure a VNA calibration and compute the error terms.
4. Error correct the raw measurement data.
5. Post processing of error-corrected data (optional).
6. Visualize the error-corrected data in the Data Explorer.

METAS UncLib

UncLib is a generic measurement uncertainty calculator.

The user specifies

- ▶ input quantities \mathbf{X} with input covariance matrix \mathbf{V}_X
- ▶ measurement model \mathbf{f}

METAS UncLib computes

- ▶ output quantities $\mathbf{Y} = \mathbf{f}(\mathbf{X})$
- ▶ Jacobi matrix \mathbf{J}_{YX} of \mathbf{f} using automatic differentiation
- ▶ output covariance matrix $\mathbf{V}_Y = \mathbf{J}_{YX}\mathbf{V}_X\mathbf{J}_{YX}'$

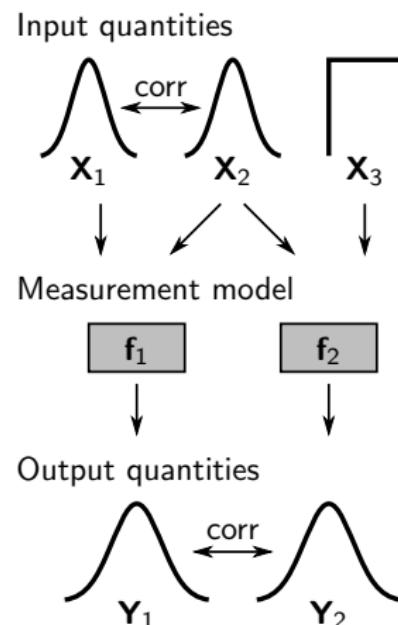


Figure : METAS UncLib

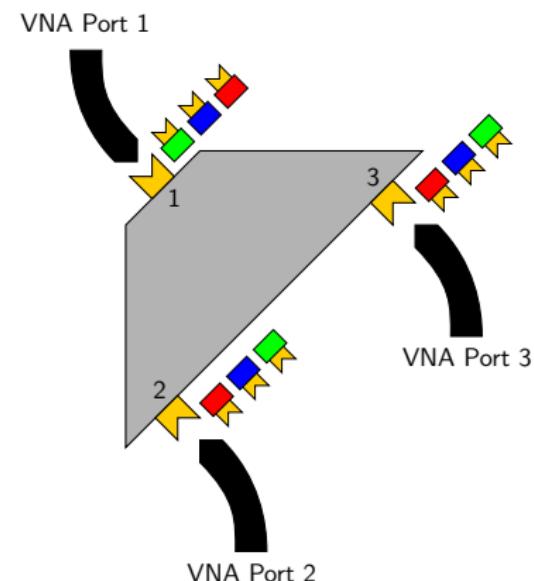
3-Port Method

Measurements and Calibration

1. Measure open, short, load at VNA ports 1, 2 and 3.
2. Connect splitter and measure all 9 S-parameters S_{raw} .
3. Measure the switch terms.
4. Compute 3-Port Unknown Thru Calibration, where the splitter is used as unknown thru between ports 1, 2 and 1, 3.

Post Processing

5. Call **SParamTools.EquivalentSourceMatch(S_{cor})** method in a script.



3-Port Method - Calibration

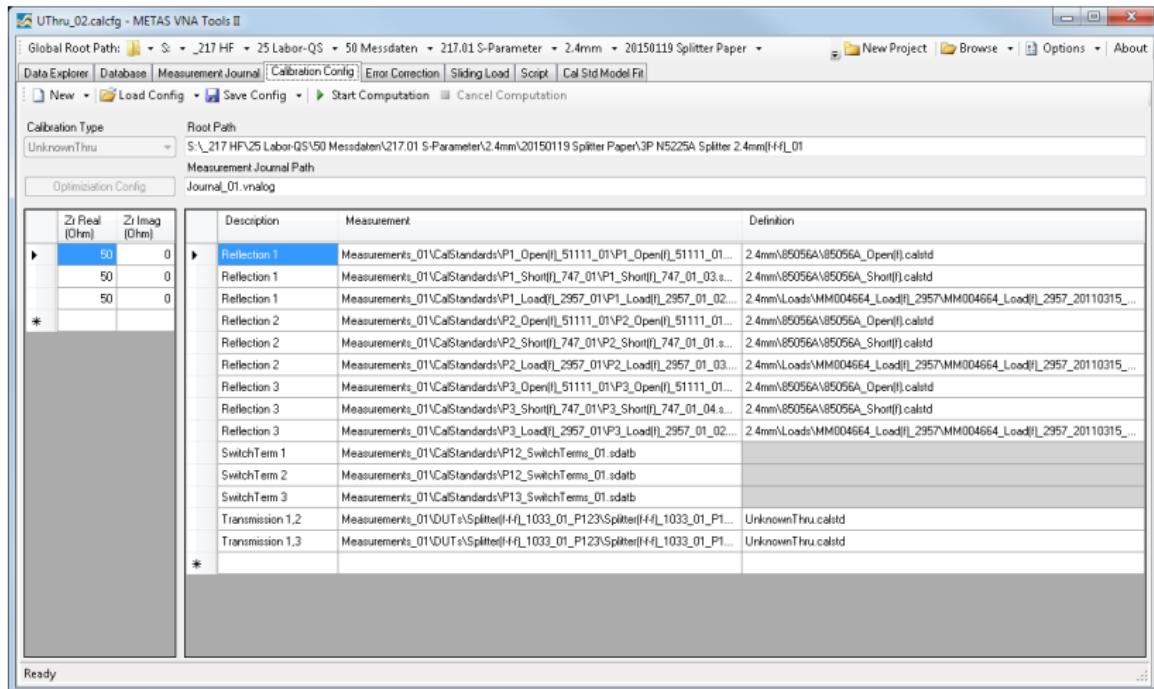


Figure : 3-Port Unknown Thru Calibration Configuration

3-Port Method - Post Processing

The screenshot shows the 'Compute_3P_Meas_Splitter_EQSM_02.py' script in the METAS VNA Tools II application. The script uses the Metas.Vna namespace to interact with a VNA, specifically performing a three-port measurement on a splitter and saving the results as an EQSM file.

```
Compute_3P_Meas_Splitter_EQSM_02.py - METAS VNA Tools II

Global Root Path: S: - 217 HF - 25 Labor-QS - 50 Messdaten - 217.01 S-Parameter - 2.4mm - 20150119 Splitter Paper -
File New Project Browse Options About
Data Explorer Database Measurement Journal Calibration Config Error Correction Sliding Load Script Cal Std Model Fit
New Script Load Script Save Script Run Script Abort Script

1 import clr
2 clr.AddReference('System.Windows.Forms')
3 clr.AddReference('Metas.Vna.Tools')
4 clr.AddReference('Metas.Vna.Data')
5 clr.AddReference('Metas.Vna.Optimization')
6 clr.AddReference('Metas.Unclib.Core')
7 clr.AddReference('Metas.Unclib.LinProp')
8 clr.AddReference('Metas.Vna.Misc')
9 from System import Array
10 from System.Threading import Thread
11 from System.Windows.Forms import MessageBox
12 from Metas.Vna.Tools import Script
13 from Metas.Vna.Data import SParamData
14 from Metas.Vna.Data import SParamTools
15 from Metas.Vna.Optimization import OptSParamTools
16 from Metas.Vna.Misc import ThreePortTools
17 from Metas.Unclib.Core import Complex
18 from Metas.Unclib.LinProp import UncNumber
19
20 s = Script(RootPath)
21
22 d1 = s.LoadSParamData('UThru_02_out\\DUTs\\Splitter(f-f-f)_1033_01_P123\\Splitter(f-f-f)_1033_01_P123_01.sdatb');
23 s.SaveSParamData('Calc_02\\3P_Meas_Splitter(f-f-f)_1033_01_P123_01.sdatb', d1)
24 d2 = SParamTools.EquivalentSourceMatch(UncNumber)(d1);
25 s.SaveSParamData('Calc_02\\3P_Meas_Splitter(f-f-f)_1033_01_P123_01_EQSM.sdatb', d2)
26
```

Ready

Figure : Script which computes equivalent source matches of the splitter.

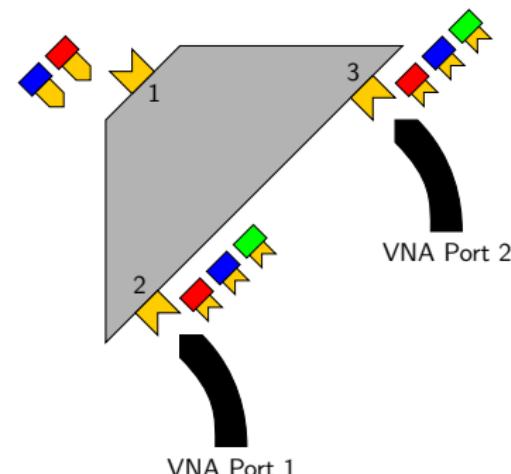
2-Port Method (Palmer)

Measurements and Calibration

1. Measure open, short, load at VNA ports 1 and 2.
2. Connect splitter and measure all 4 S-parameters $S_{load\ raw}$ with a load at the splitter port 1.
3. Measure the switch terms.
4. Compute 2P Unknown Thru Cal.
5. Measure $S_{short\ raw}$ with a short at the splitter port 1.

Post Processing

6. Call **SParamTools.EquivalentSourceMatchPalmer($S_{load\ cor}$, $S_{short\ cor}$)** method in a script.



2-Port Method (Palmer) - Calibration

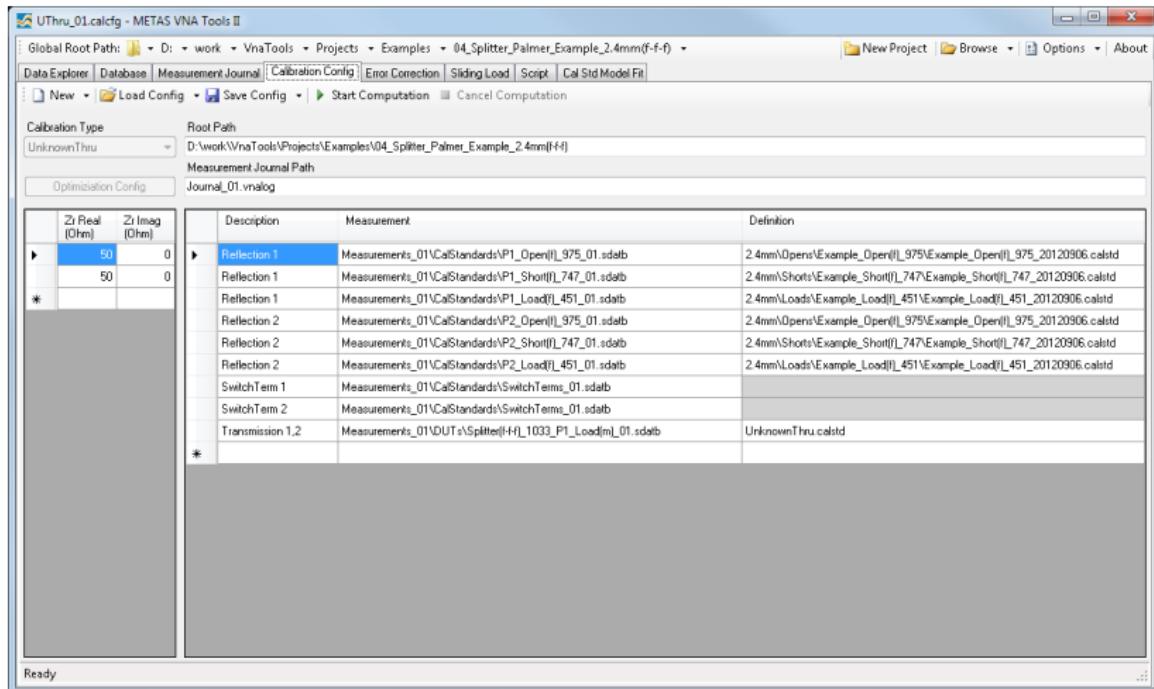


Figure : 2-Port Unknown Thru Calibration Configuration

2-Port Method (Palmer) - Post Processing

The screenshot shows the 'Compute_Palmer_Splitter_EQSM_01.py' script in the METAS VNA Tools II application. The script uses the SParamTools module to load S-parameter data from two files, perform a Palmer equivalent source match calculation, and save the results. The code is as follows:

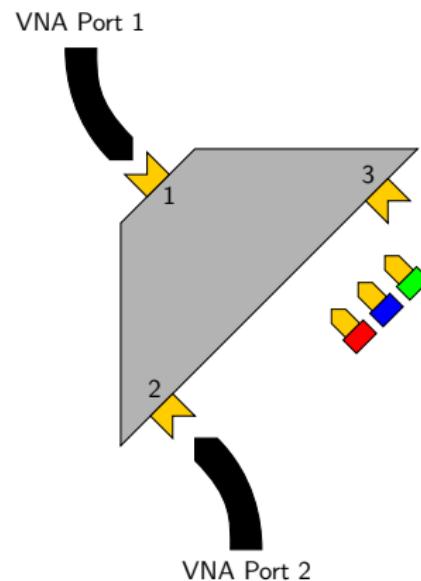
```
1 import clr
2 clr.AddReference('System.Windows.Forms')
3 clr.AddReference('Metas.Vna.Tools')
4 clr.AddReference('Metas.Vna.Data')
5 clr.AddReference('Metas.Unclib.Core')
6 clr.AddReference('Metas.Unclib.LinProp')
7 from System import Array
8 from System import Double
9 from System.IO import File
10 from System.IO import FileInfo
11 from System.Threading import Thread
12 from System.Windows.Forms import MessageBox
13 from Metas.Vna.Tools import Script
14 from Metas.Vna.Data import SParamData
15 from Metas.Vna.Data import SParamTools
16 from Metas.Unclib.Core import Complex
17 from Metas.Unclib.LinProp import UncNumber
18
19 s = Script(RootPath)
20
21 m1 = s.LoadSParamData('UThru_01_out\\DUTs\\Splitter(f-f-f)_1033_P1_Short(m)_01.sdatb')
22 m2 = s.LoadSParamData('UThru_01_out\\DUTs\\Splitter(f-f-f)_1033_P1_Load(m)_01.sdatb')
23
24 d = SParamTools.EquivalentSourceMatchPalmer(UncNumber)(m1, m2, True);
25 s.SaveSParamData('Splitter(f-f-f)_1033_EQSM.sdatb', d)
26
```

Figure : Script which computes equivalent source matches of the splitter.

Juroshek Method

Measurements and Calibration

1. Connect splitter port 1 to VNA port 1 and splitter port 2 to VNA port 2.
2. Measure open, short, load at splitter port 3.
3. Compute Juroshek Calibration.
4. Γ_{Eq3} is the match term of the calibration error terms.



Post Processing

- ▶ Not needed.

Jurosek Method - Calibration

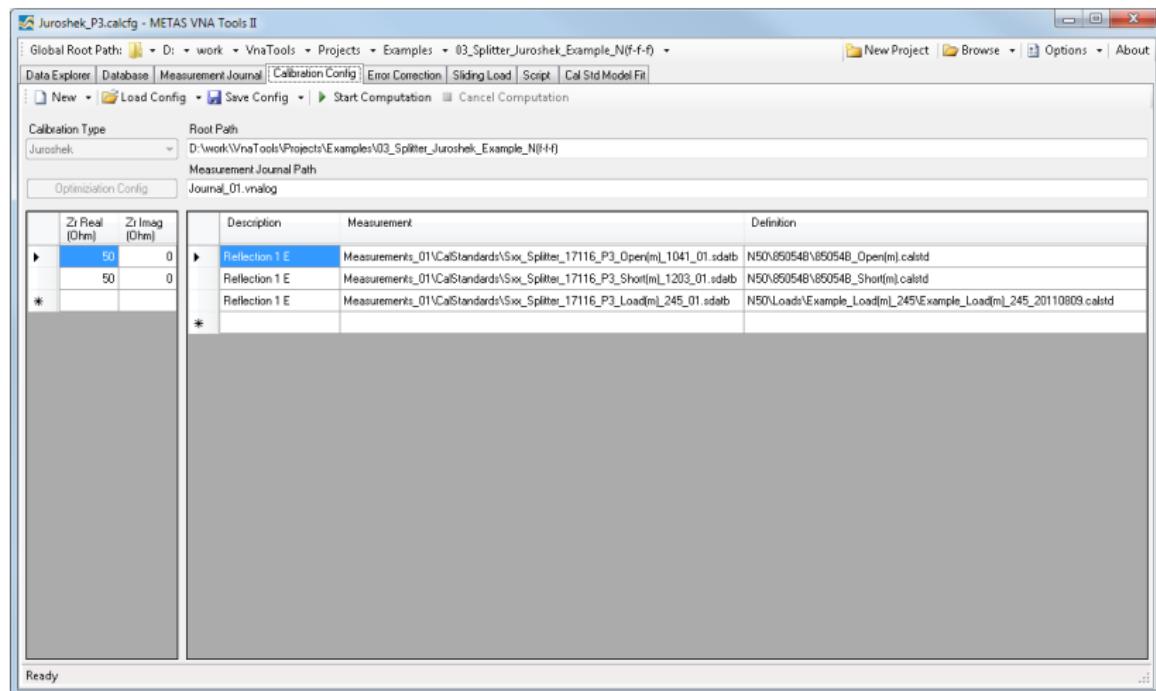


Figure : Jurosek Calibration Configuration

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Conclusion
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Demo

Conclusion

- ▶ Definition of influences that affect the measurement.
- ▶ Linear propagation of uncertainties through the measurement model.
- ▶ Visualization of S-parameter data with uncertainty budget.
- ▶ VNA Tools supports 3-Port, 2-Port (Palmer) and Juroshek methods for characterizing a splitter.
- ▶ Different methods can be compared.

[1] J. Hoffmann, M. Wollensack, J. Ruefenacht, M. Zeier, "Comparison of Methods for Measurement of Equivalent Source Match", 45th European Microwave Conference, EuMC 2015, Paper ID: EuMC40-01, September 2015.

<http://www.metas.ch/vnatools>