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VNA Tools - Splitter Characterization

M. Wollensack, J. Hoffmann, J. Ruefenacht, M. Zeier

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Outline

Splitter

Equivalent Source Match

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

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

Tracking

The following equation describes the tracking of the splitter.

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

What is METAS VNA Tools and UncLib?

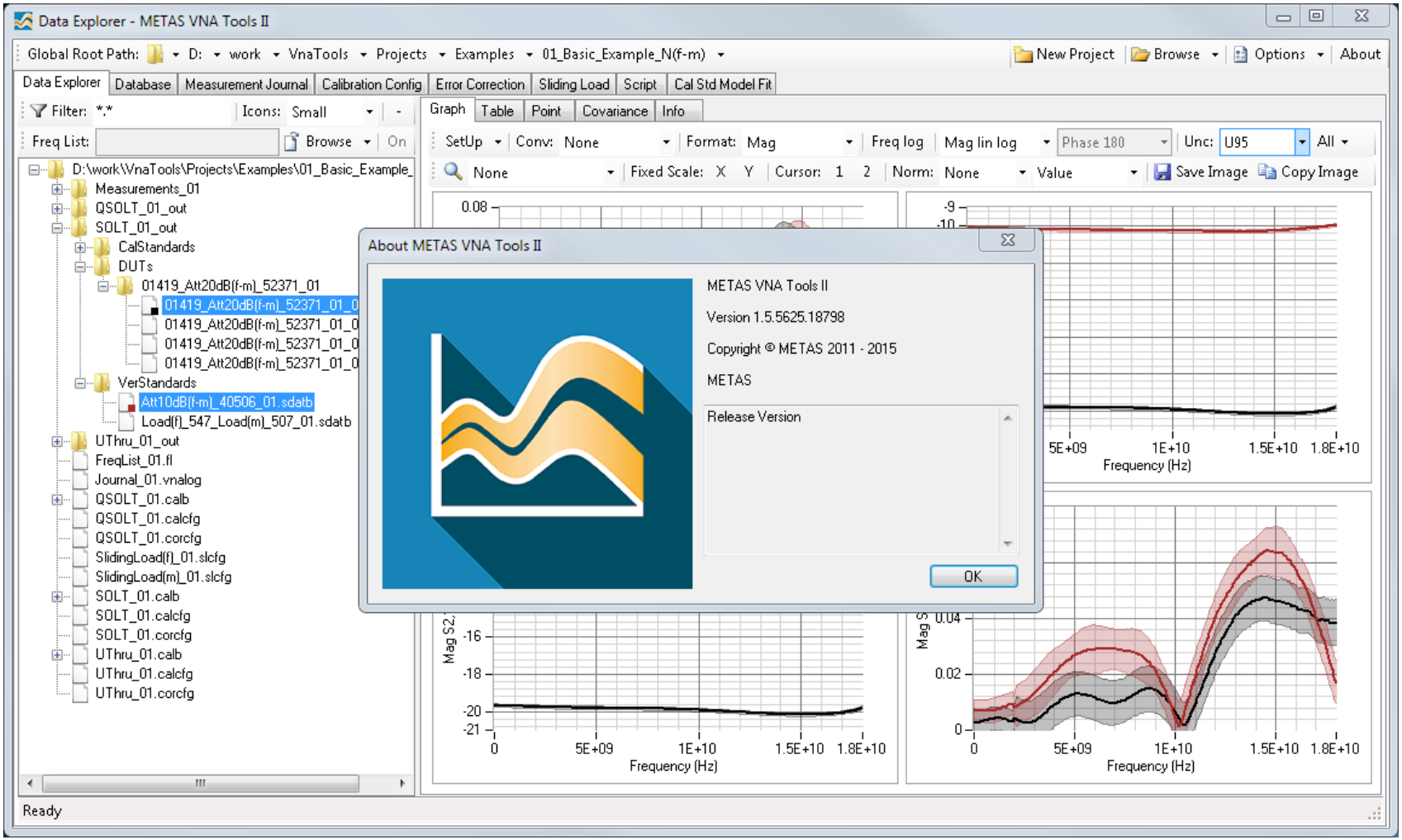


Figure : METAS VNA Tools

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 $\mathbf{V}_Y = \mathbf{J}_{YX}\mathbf{V}_X\mathbf{J}_{YX}'$

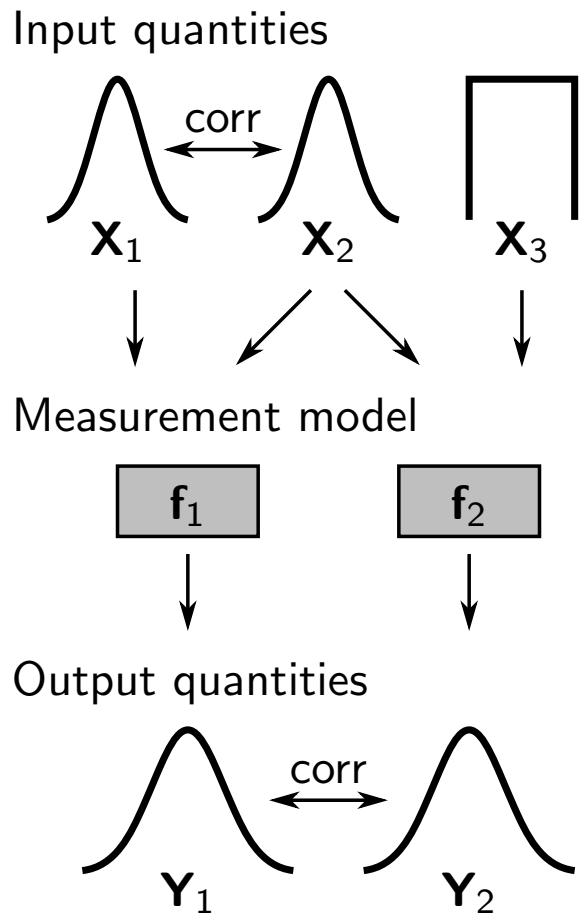
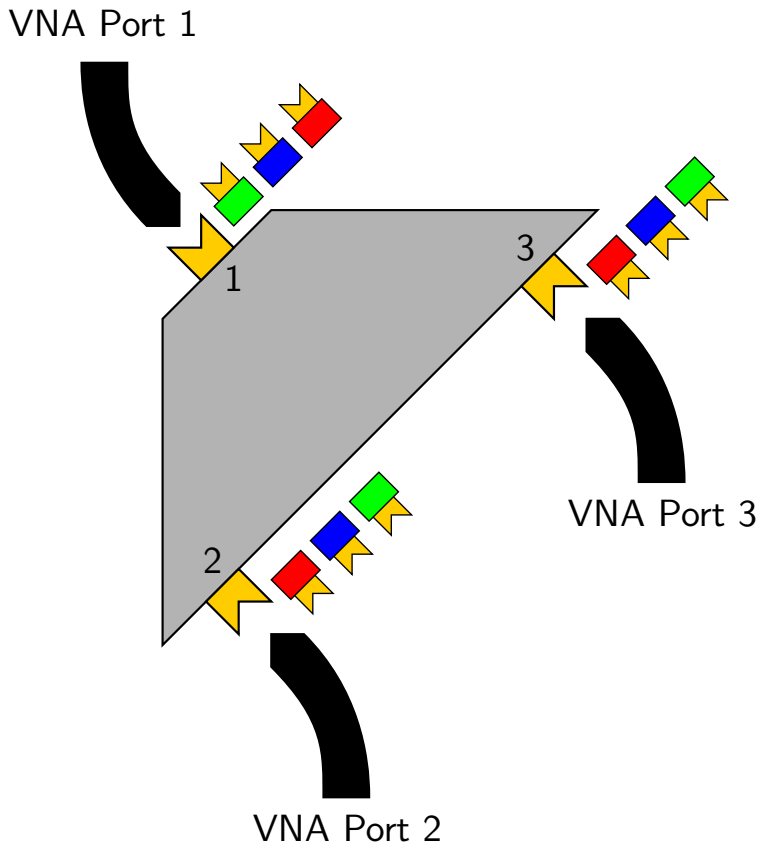


Figure : METAS UncLib

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 $\mathbf{S}_{raw}$.
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**($\mathbf{S}_{cor}$) method in a script.

3-Port Method - Calibration

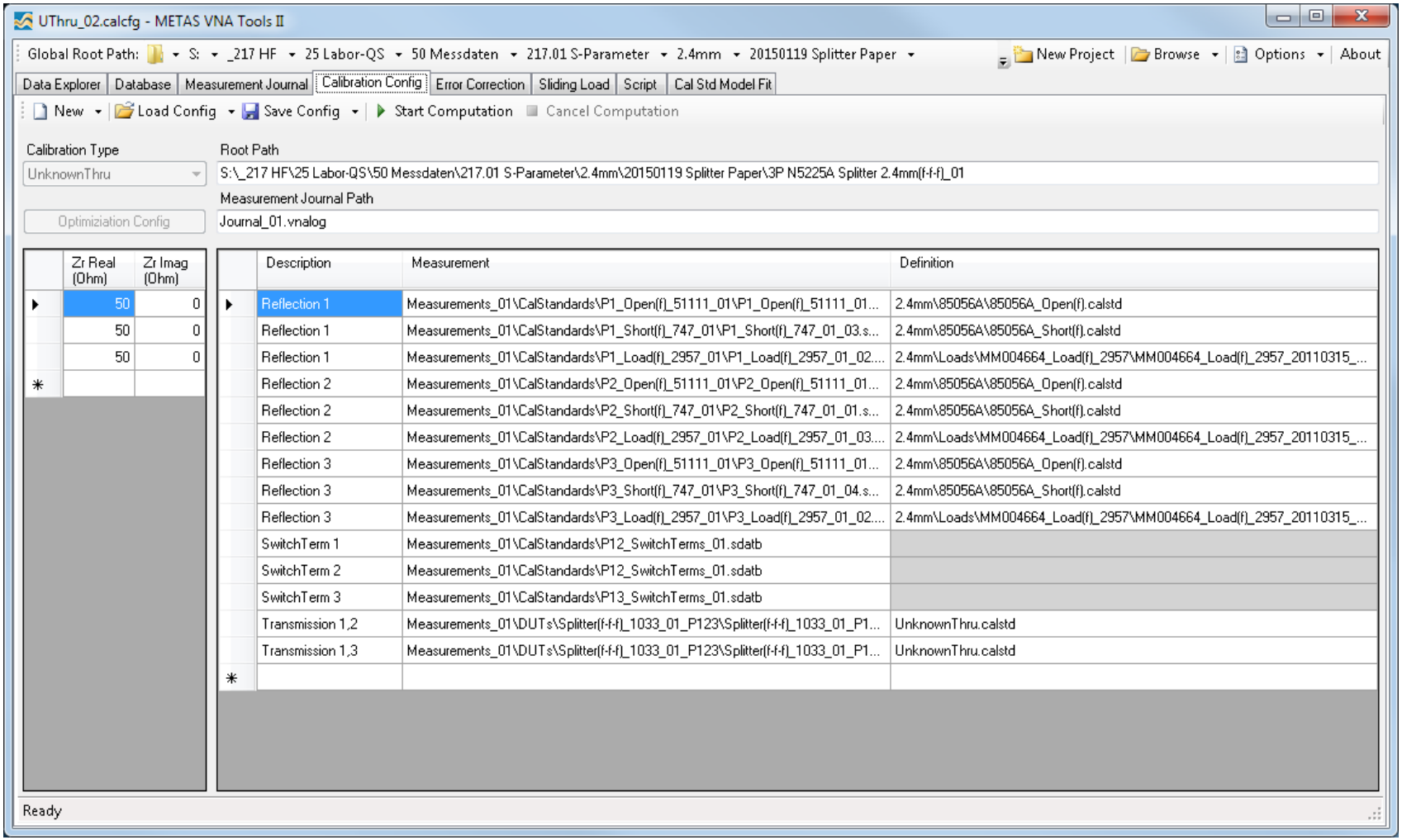


Figure : 3-Port Unknown Thru Calibration Configuration

3-Port Method - Post Processing

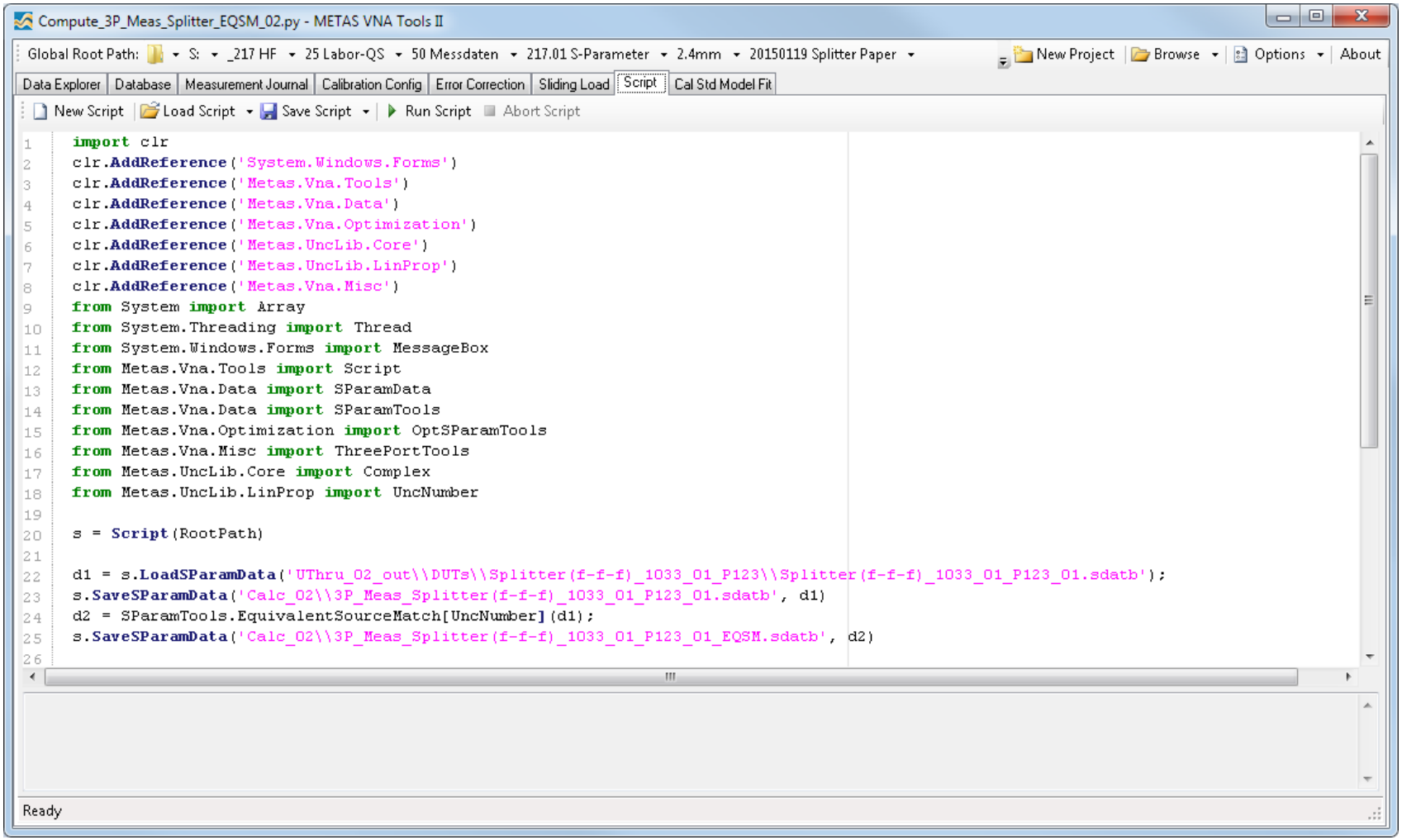
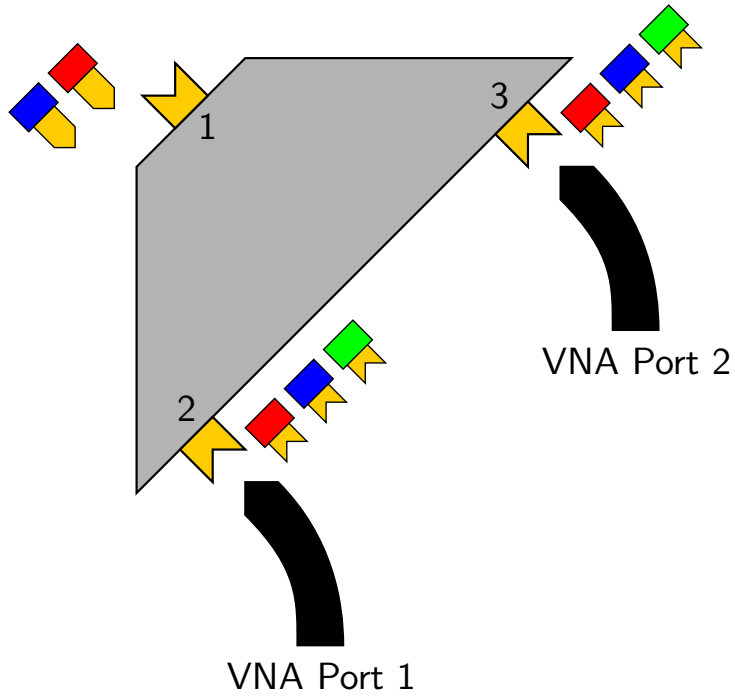


Figure : Script which computes equivalent source matches of the splitter.

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 $\mathbf{S}_{load\ raw}$ with a load at the splitter port 1.
3. Measure the switch terms.
4. Compute 2P Unknown Thru Cal.
5. Measure $\mathbf{S}_{short\ raw}$ with a short at the splitter port 1.



Post Processing

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

2-Port Method (Palmer) - Calibration

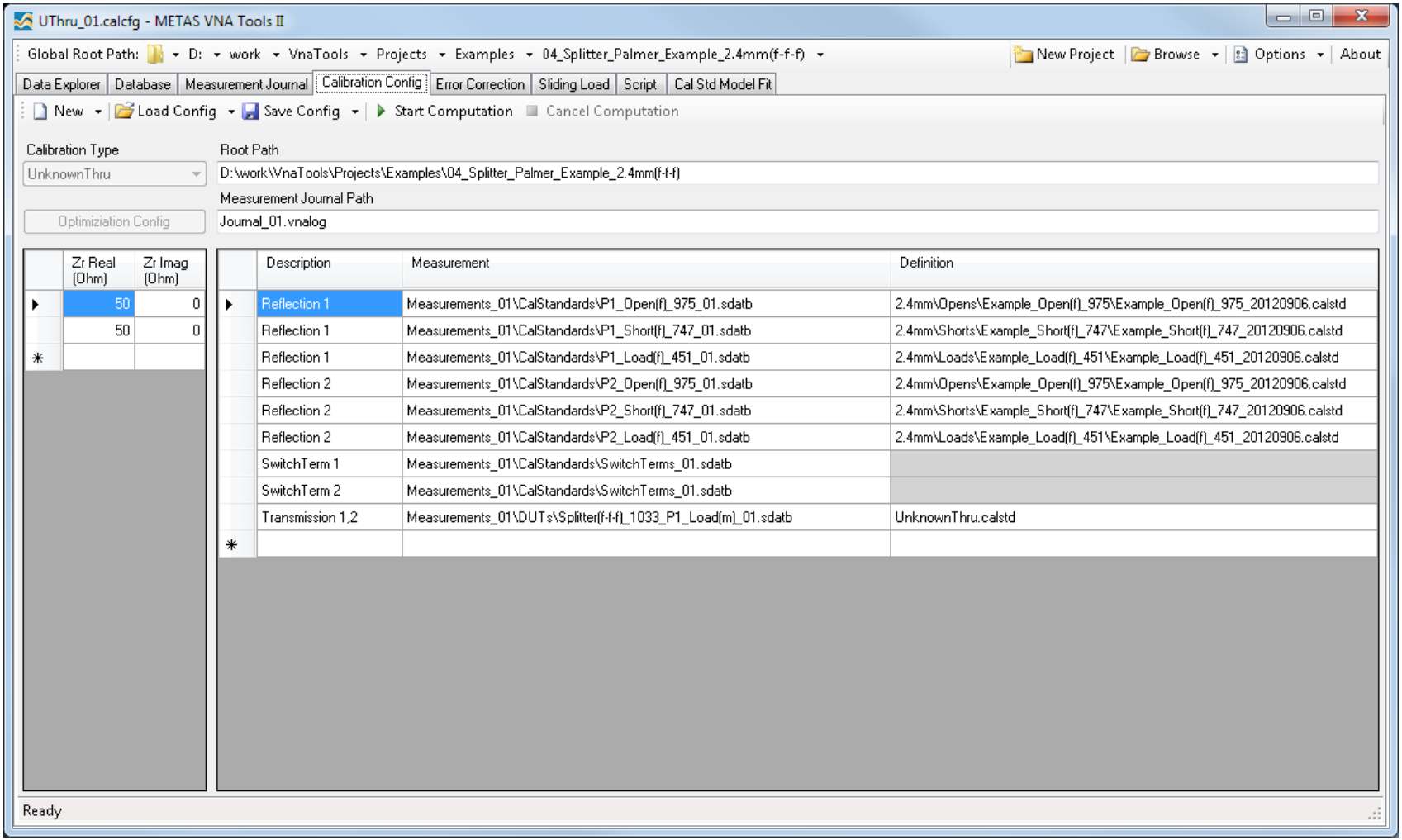


Figure : 2-Port Unknown Thru Calibration Configuration

2-Port Method (Palmer) - Post Processing

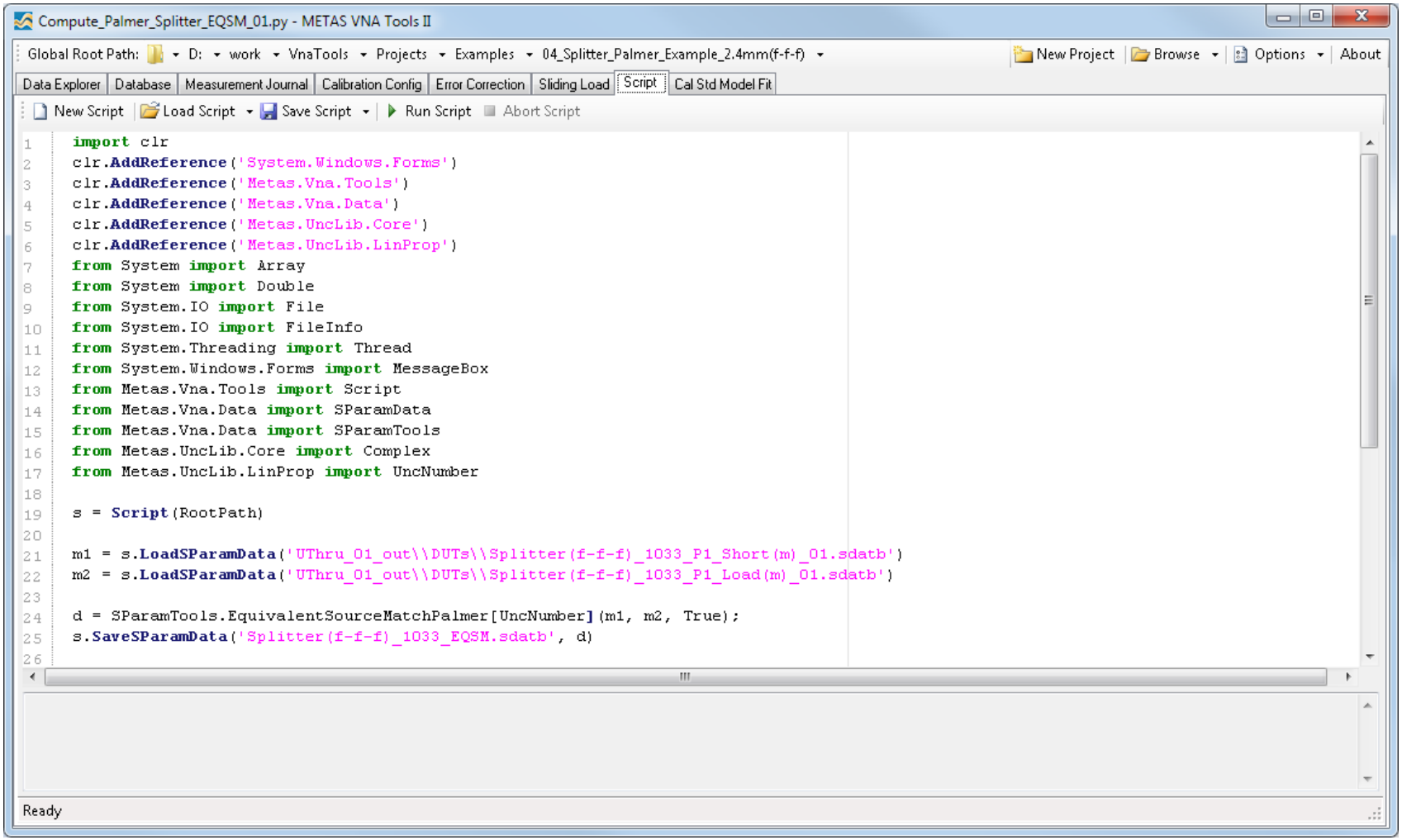
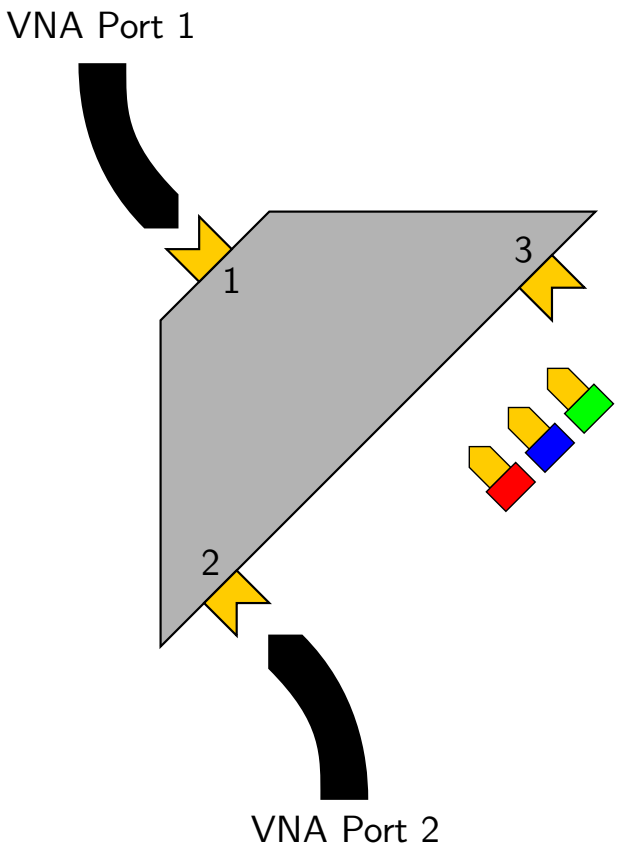


Figure : Script which computes equivalent source matches of the splitter.

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.

Juroshek Method - Calibration

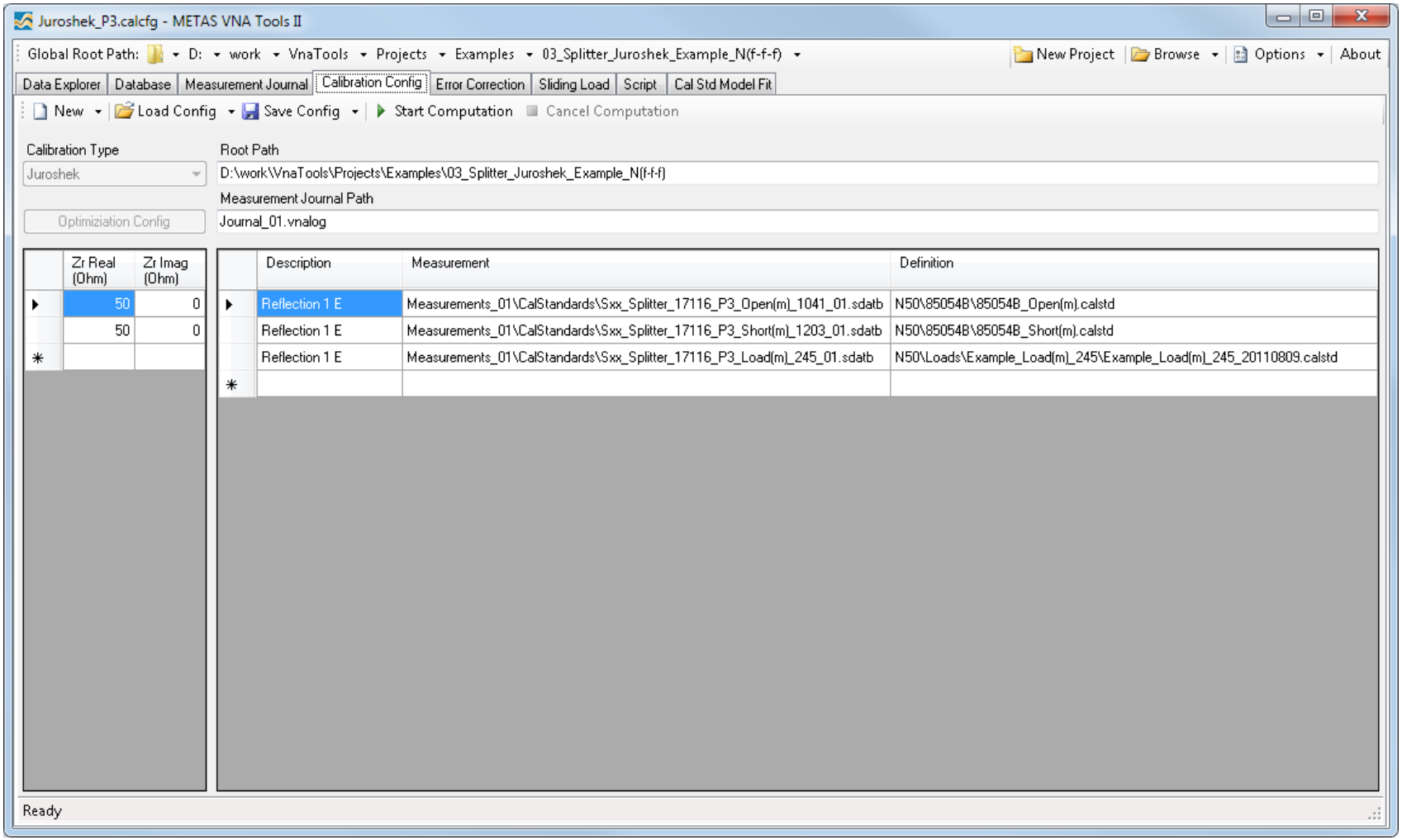
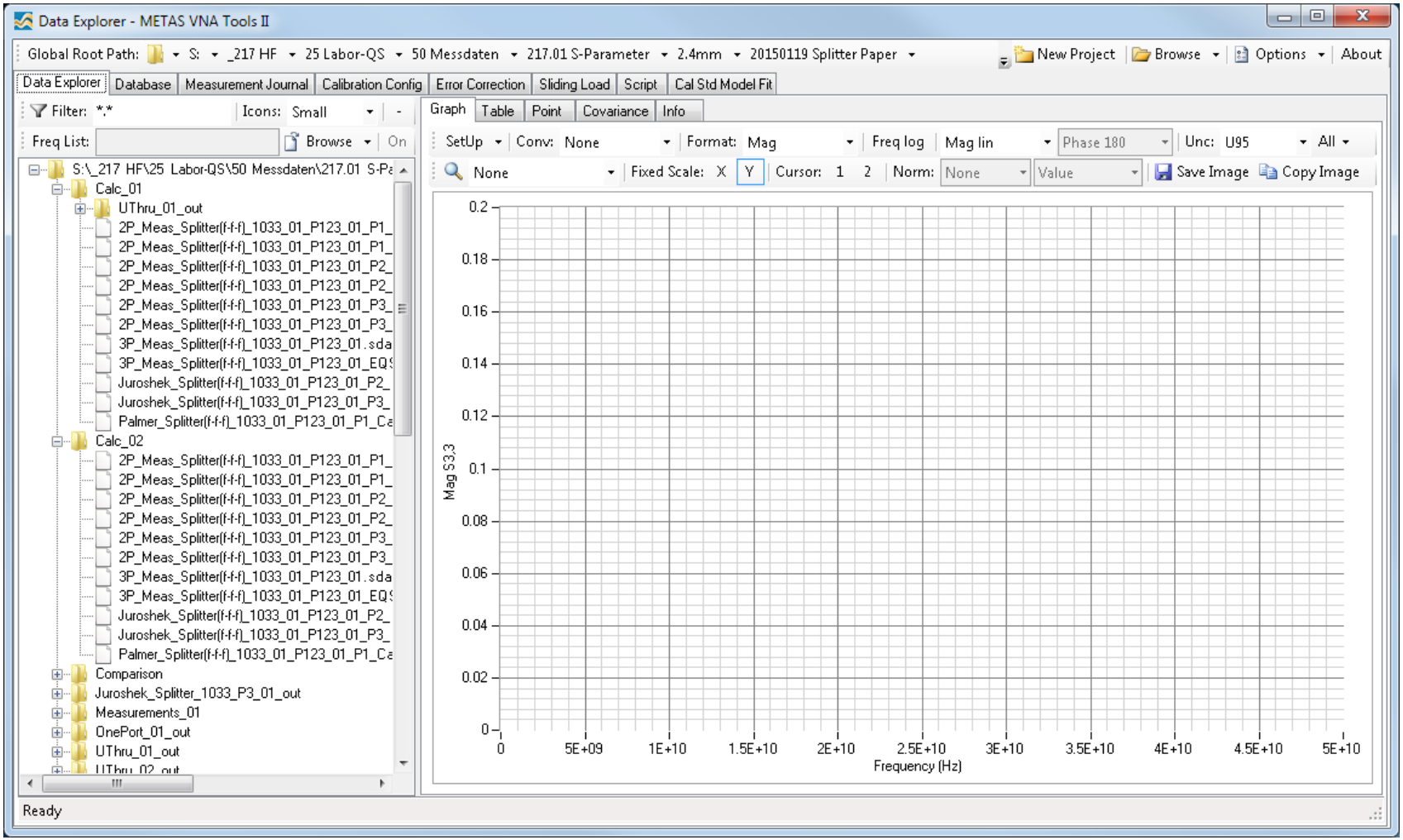


Figure : Juroshek Calibration Configuration

Demo


Data Explorer - METAS VNA Tools II
Global Root Path: S: _217 HF 25 Labor-QS 50 Messdaten 217.01 S-Parameter 2.4mm 20150119 Splitter Paper
New Project
Browse
Options
About
Data Explorer
Database
Measurement Journal
Calibration Config
Error Correction
Sliding Load
Script
Cal Std Model Fit
Filter: *.*
Icons: Small
Freq List:
Browse
Graph
Table
Point
Covariance
Info
SetUp
Conv: None
Format: Mag
Freq log
Mag lin
Phase 180
Unc: U95
All
Fixed Scale: X Y
Cursor: 1 2
Norm: None
Value
Save Image
Copy Image
Calc_01
UThru_01_out
Calc_02
Comparison
Juroshek_Splitter_1033_P3_01_out
Measurements_01
OnePort_01_out
UThru_01_out
Mag S3,3
Frequency (Hz)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
5E+09
1E+10
1.5E+10
2E+10
2.5E+10
3E+10
3.5E+10
4E+10
4.5E+10
5E+10
Ready

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