Comparison of Source Match Measurements

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

Introduction

Methods

Results
What is Equivalent Source Match

Splitters are used in direct comparison systems for power sensor calibration. The equivalent source match is a parameter of a splitter.

\[ \Gamma_G = S_{33} - \frac{S_{23}S_{31}}{S_{21}} \]
Motivation

Several different methods for measuring $\Gamma_G$ exist:

- How well do they match up?
- What are the uncertainties?
- Which equipment and measurement effort is needed?
Measurements for 3-Port Method

VNA Port 1

VNA Port 2

VNA Port 3

O

S

L

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Measurements for 3-Port Method

VNA Port 1

VNA Port 2

VNA Port 3
Measurements for 3-Port Method

VNA Port 1

VNA Port 2

VNA Port 3

O

S

L

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Measurements for 3-Port Method

VNA Port 1

VNA Port 2

VNA Port 3
Data Processing

1. Compute 1-port error coefficients
2. Use splitter for unknown thru at ports 1-2 and 1-3
3. Compute all S-parameters of splitter and $\Gamma_G$
Comments

- Requires 12 connections
- Requires expensive 3-Port VNA
- Requires cable movement
- Yields all S-parameters, all $\Gamma_G$, and all tracking terms
Measurements for Juroshek Method
Measurements for Juroshek Method

VNA Port

1

2

3

O

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Measurements for Juroshek Method
Data Processing

1. Convert S-parameters \( J_{33} = \frac{S_{11}}{S_{21}} \)
2. Do 1-Port cal with converted S-parameters
3. Source match equals equivalent source match \( \Gamma_G = e_{11} \)
Comments

- Requires only 5 connections
- Works with 2-port VNA
- No cable movement
- Yields only $\Gamma_G$ of one port
Measurements for 2-Port Method

VNA Port

VNA Port

L

S

Measurements for 2-Port Method
Measurements for 2-Port Method

VNA Port 2

VNA Port 3

O
S
Measurements for 2-Port Method
Measurements for 2-Port Method
Data Processing

1. Do 1-Port cal at each port
2. Perform unknown thru with splitter
3. $\Gamma_G = \frac{S_{33L}S_{23S} - S_{33S}S_{23L}}{S_{23S} - S_{23L}}$
Comments

- Requires 10 connections
- Works with 2-port VNA
- Requires cable movement
- Yields $\Gamma_G$ for each port and tracking ratio
VNA Tools II supports Juroshek, 3-Port and 2-Port technique. All methods work with linear uncertainty propagation.
Results with Generic Definition

\[ |\Gamma_G| \]

- \( \text{Ju} \)
- \( 2P \)
- \( 3P \)

Frequency (Hz)

0 1 2 3 4 5

\( x \times 10^{10} \)

Uncertainties with Generic Definition

\[ |\Gamma_{GJu} - \Gamma_{G3P}| \]
\[ |\Gamma_{G2P} - \Gamma_{G3P}| \]
\[ |\Gamma_{G3P} - \Gamma_{G3P}| \]

Frequency (Hz) \( \times 10^{10} \)
Results with Connector Effect

\[ |\Gamma_G| \]

Frequency (Hz)

\[ \times 10^{10} \]

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Uncertainties with Connector Effect

\[ |\Gamma_{GJ} - \Gamma_{G3P}| \]
\[ |\Gamma_{G2P} - \Gamma_{G3P}| \]
\[ |\Gamma_{G3P} - \Gamma_{G3P}| \]

Frequency (Hz)
Conclusion

- Including the connector in the standard definition improves agreement
- METAS characterized standards have smaller uncertainty
- Juroshek puts high demands on noise and linearity of VNA
- 2-Port and 3-Port method yield comparable results