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S-Parameter Measurement Methods for Adapters

S-Parameter Messverfahren für Adapter

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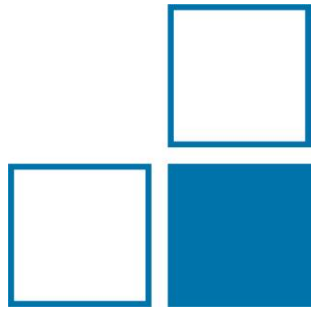
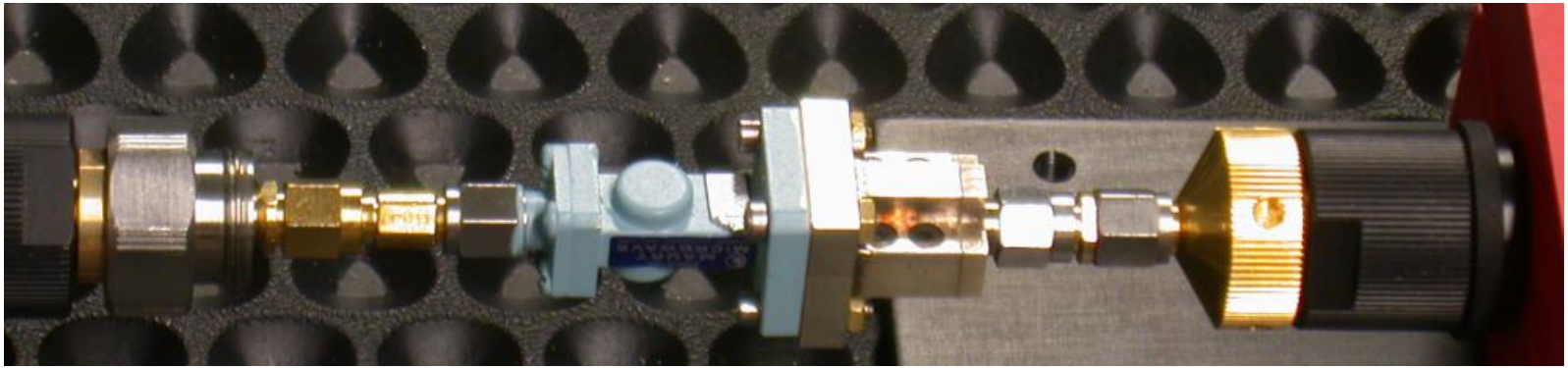
2.22



Adapters

- Devices with different interfaces at their two ports
- Various interfaces are available
- Several methods for characterization in literature
- Obtained measurement uncertainties are different



Adapter measurements

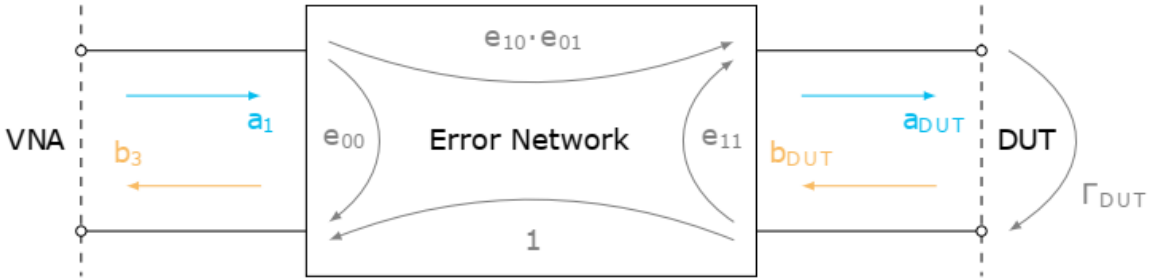
- This work is based on student research project in 2020
- Presentation at national conference
  Kleinheubacher Tagung 2021
- Extended paper in
  Advances in Radio Science (ARS),
  Special issue: Kleinheubacher Berichte 2021
  Comparison of S-Parameter Measurement Methods for Adapters
  https://doi.org/10.5194/ars-20-1-2023

Outline

- Error model and Methods
- Theoretical Approach
- Uncertainty Budgets
- Measurements and obtained uncertainty components
- Required time and effort

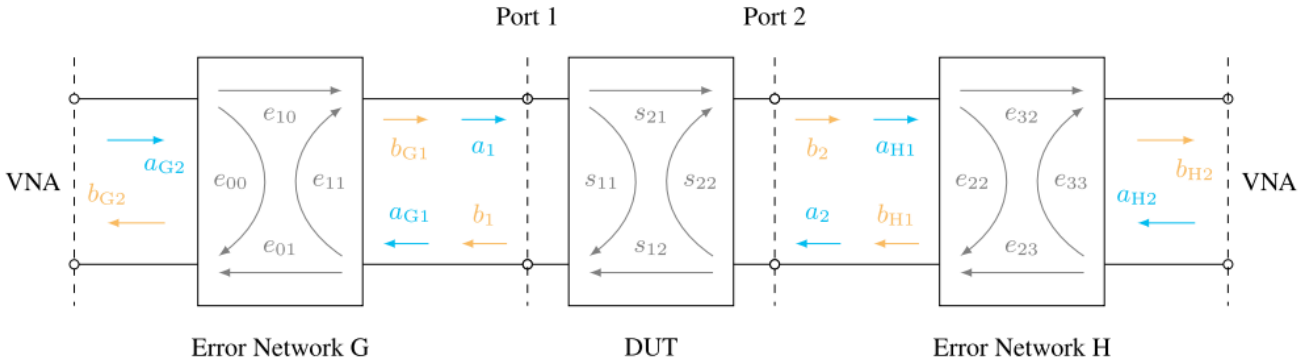
- Conclusion

OSM measurement



- Perform two one-port calibrations
- Using different calibration kits
- Calculate both error boxes
- Invert and decascade one

UOSM Two-Port measurement



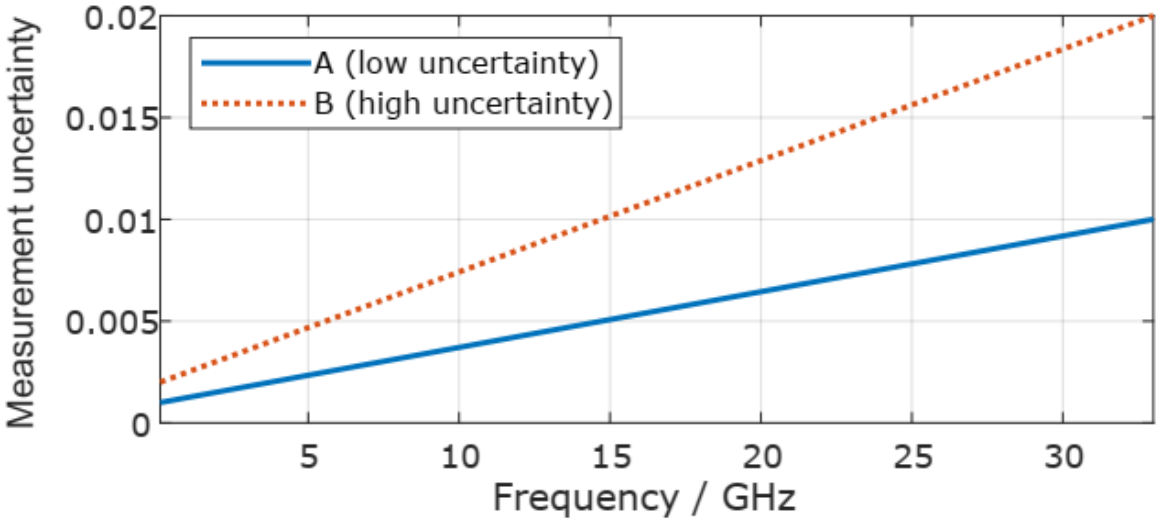
- Full two-port calibration
- The adapter is used as an unknown Thru
- Avoid cable movements
- Measure one port - Measure adapter - Measure other port

Uncertainty Contributions

- VNA drift
- VNA noise
- VNA linearity
- Connection repeatability
- Cable movements
- Calibration Standards
  - Outer conductor diameter
  - Inner conductor diameter
  - Conductivity
  - Length

Theoretical approach:
Only calibration standards

Theoretical Investigation



- Only calibration standard uncertainties
- Once with equal lower uncertainty at both ports
- Once with higher uncertainty a interface B (2.4mm)

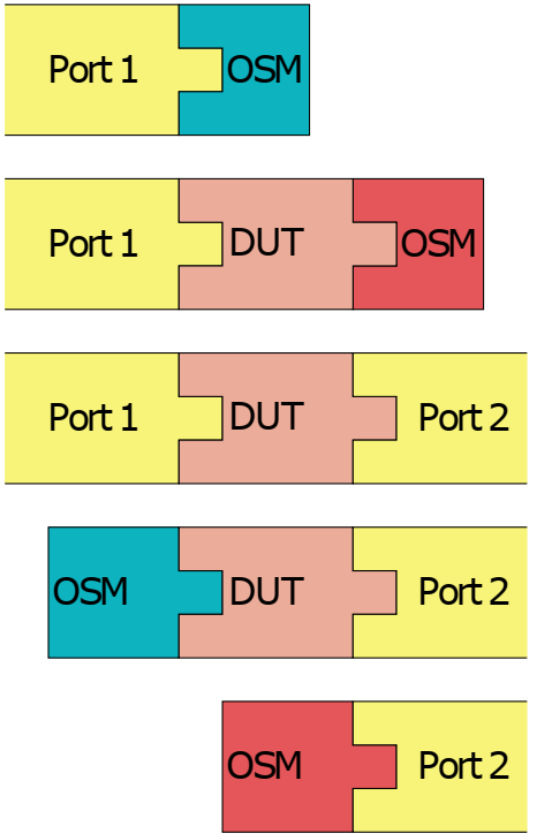
Theoretical Adapter

- Beadless air-dielectric 3.5 mm to 2.4 mm
- Impedances deviate from ideal 50 Ω

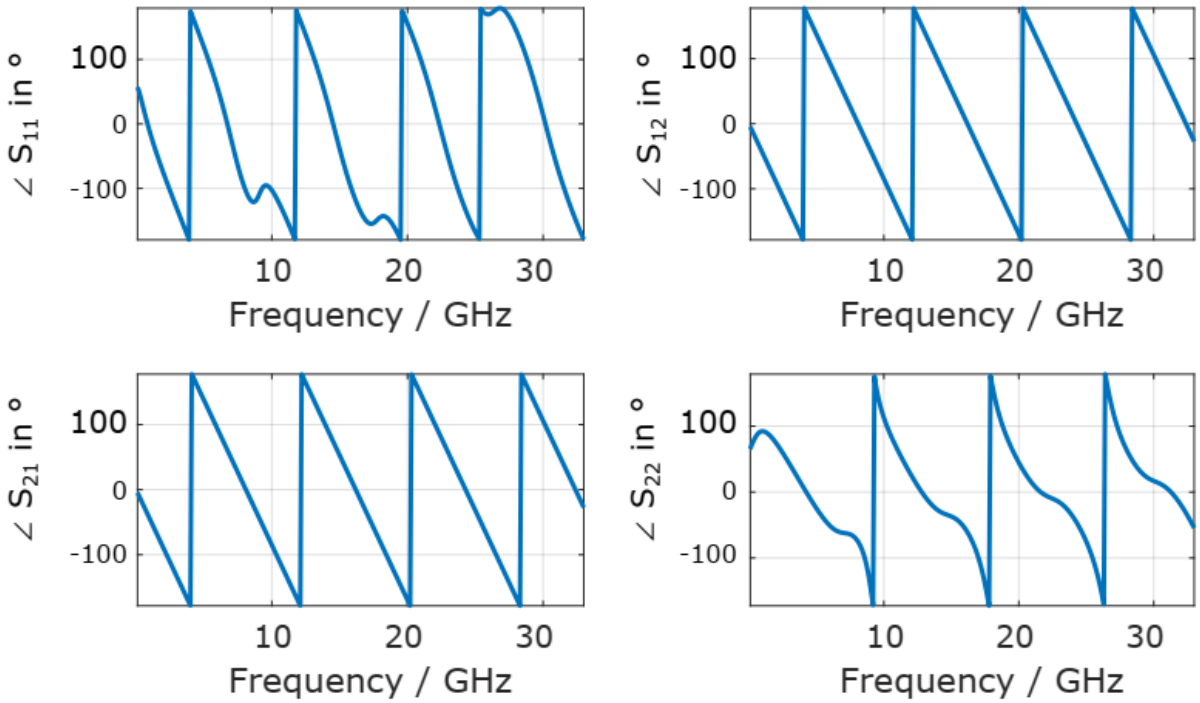
	3,5 mm section	2,4 mm section
Outer conductor diameter	3,50 mm	2,40 mm
Inner conductor diameter	1,55 mm	1,00 mm
Conductivity	20 MS/m	20 MS/m
Length	20 mm	17 mm

Simulation steps

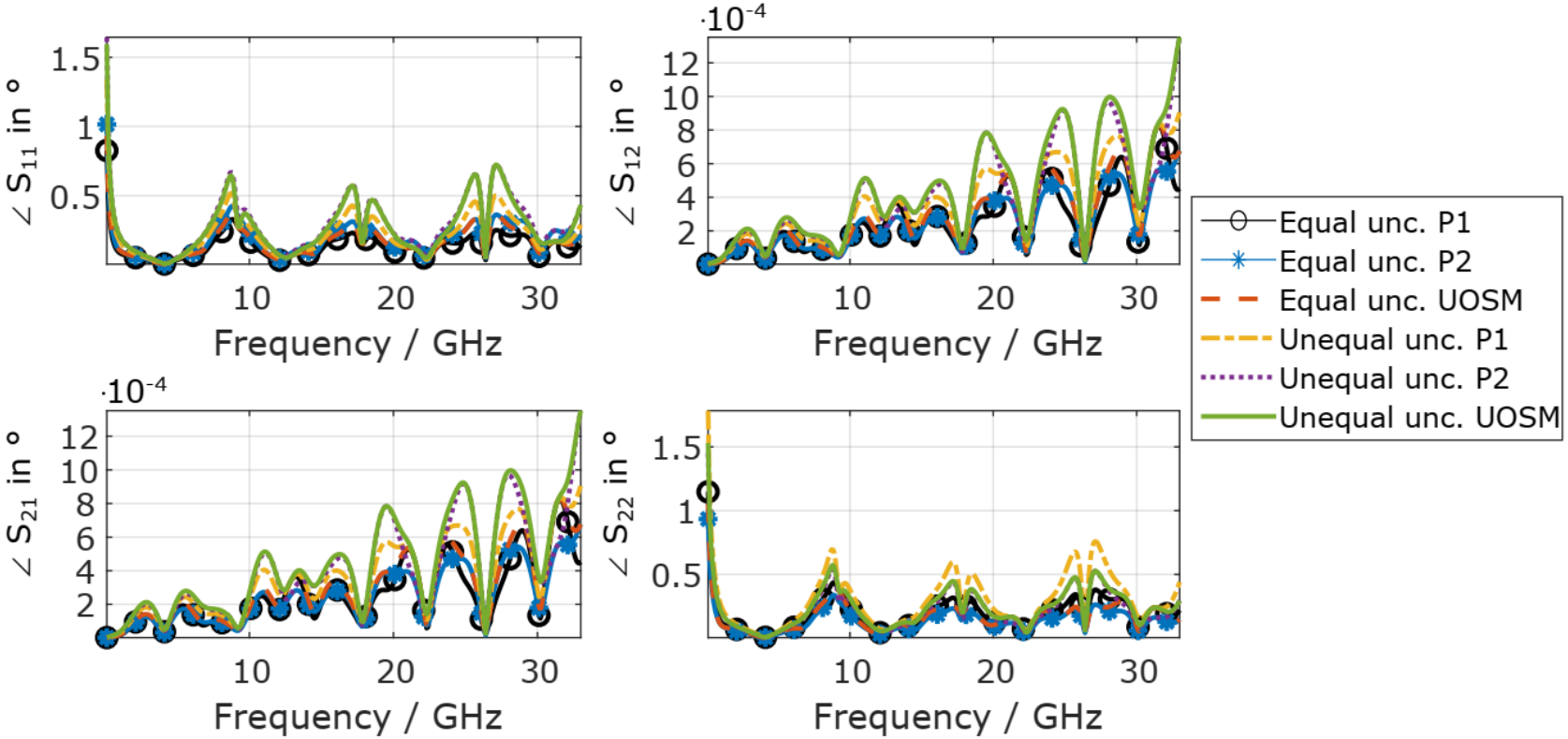
- OSM and UOSM
- OSM performed at both ports
- Only calibration standard uncertainty included
- Typical values for source match, directivity, and tracking



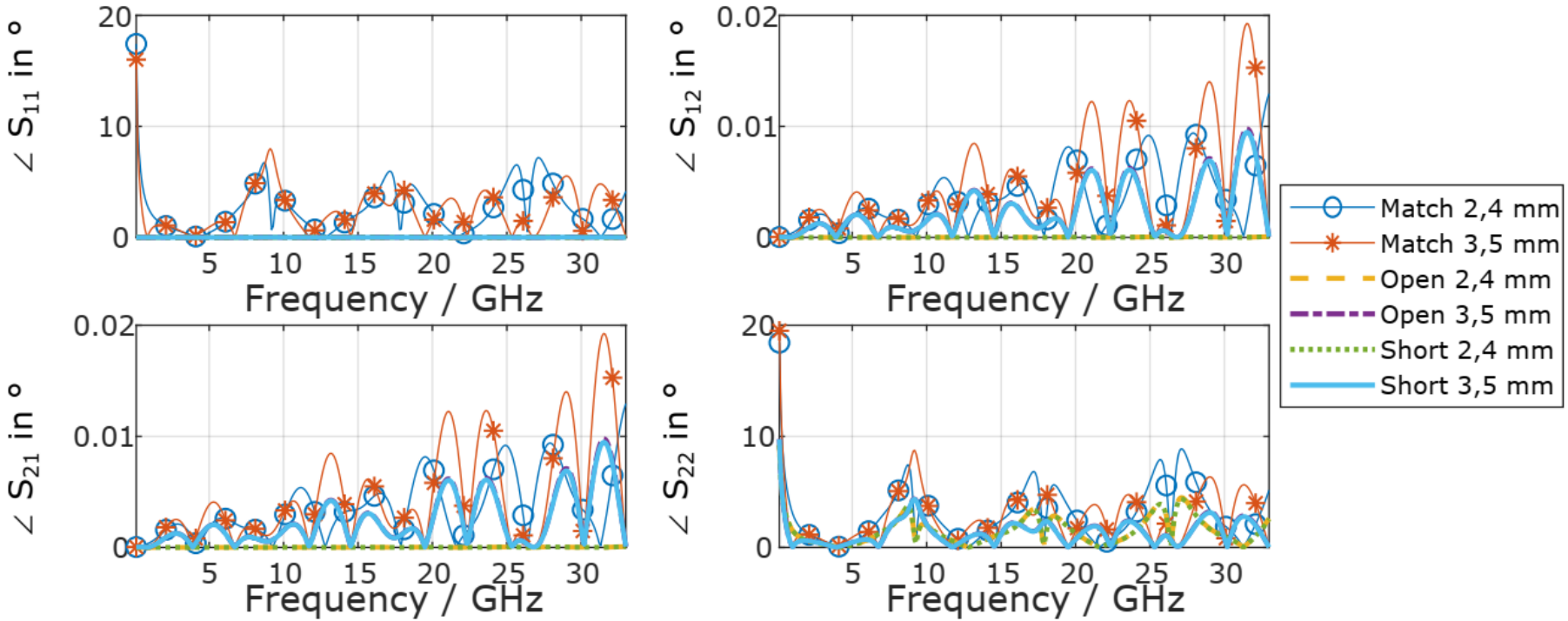
Theoretical Adapter



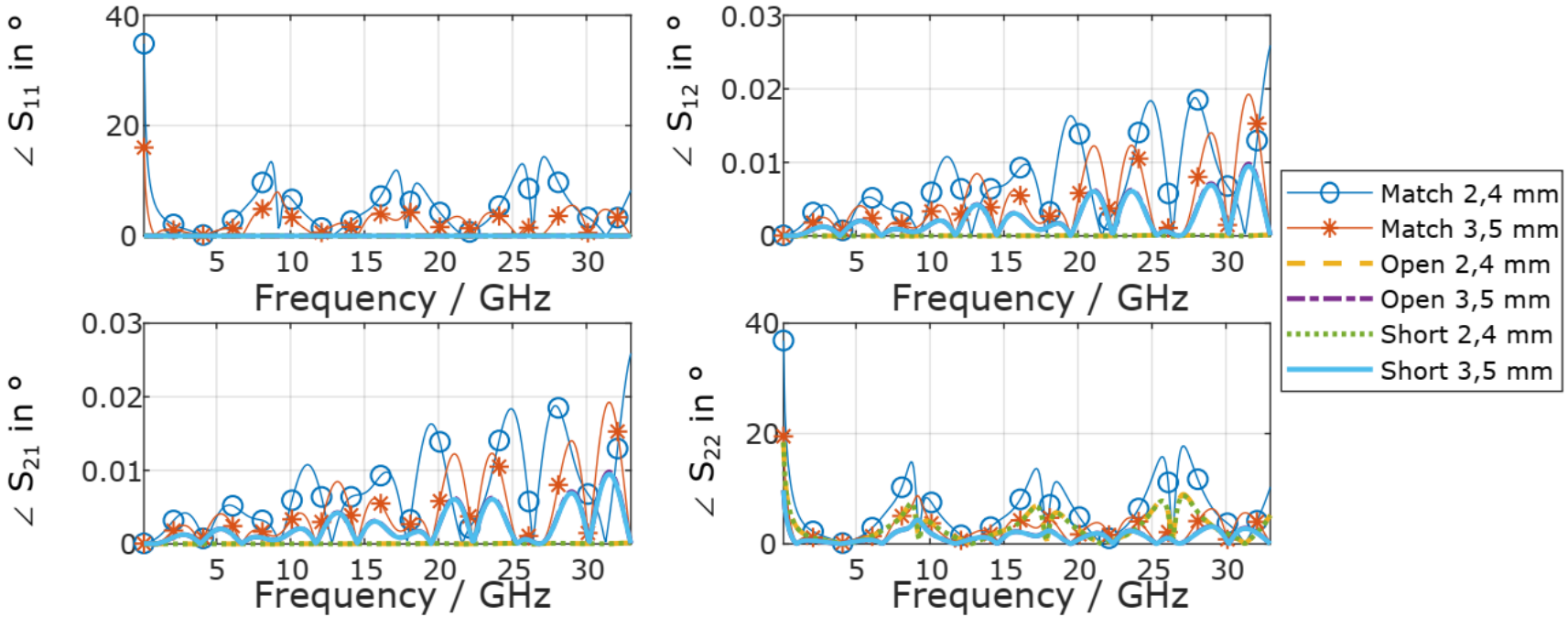
Theoretical Results



Uncertainty Budgets (equal unc.)

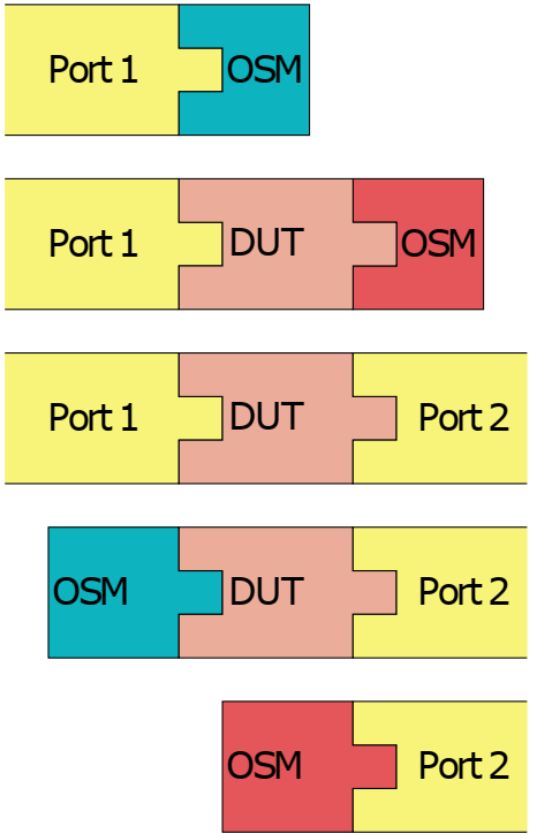


Uncertainty Budgets (different unc.)

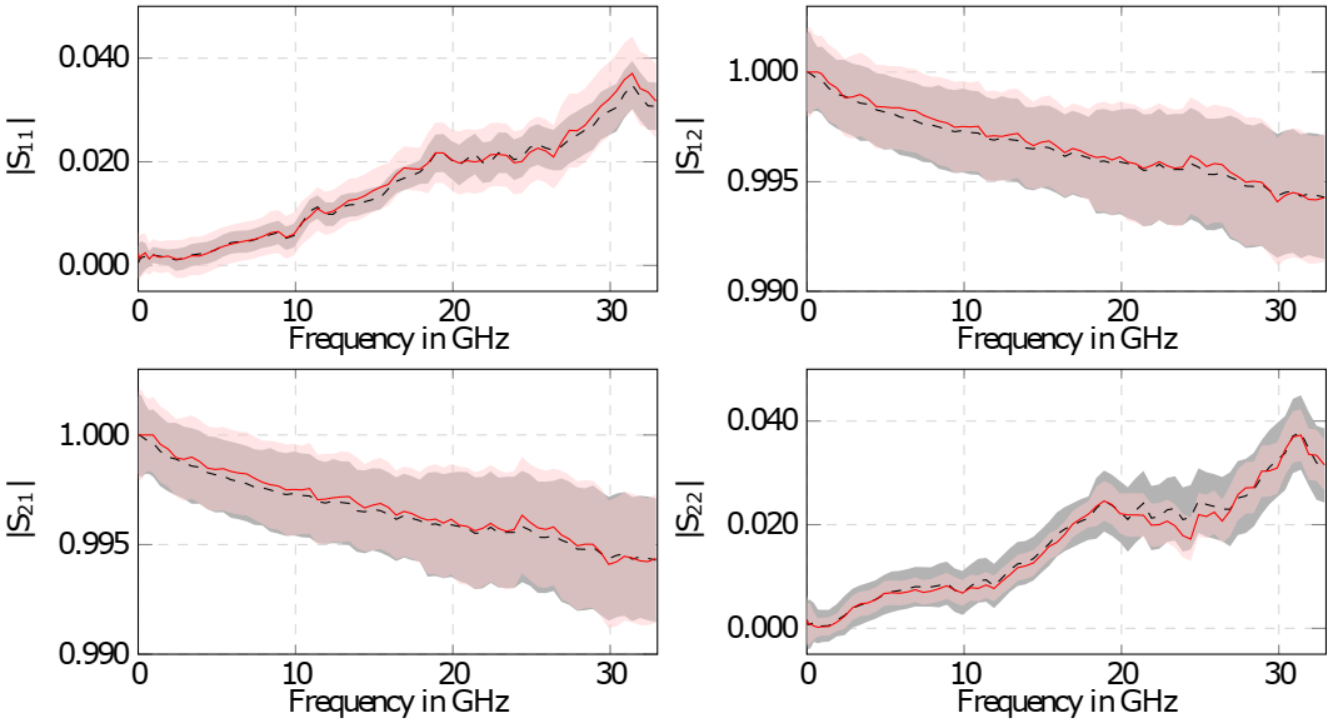


Measurement

- Measurements to confirm theoretical investigation
- Many measurement results used in both methods
- Each connection performed four times for repeatability
- Cable movements avoided



Measurement Result



OSM
UOSM

Uncertainty Budgets (equal unc.)

	Unc. OSM method in %	Unc. UOSM method in %
Standards	77.364	83.482
Connection repeatability	21.615	12.292
VNA Drift	0.765	0.392
VNA Linearity	0.245	3.703
VNA Noise	0.011	0.131

- MU budget of $|S_{11}|$ at 15 GHz
- Calibration standards dominate the MU
- Second is connection repeatability
- VNA itself plays a very minor role

(metrology grade device in a laboratory with excellent environmental control)

Required Effort

Number of DUTs	Meas. for OSM	Meas. for UOSM	Meas. UOSM wo. cable mov.	Connections for OSM	Connections for UOSM	Connection UOSM wo. cable mov.
1	6	7	7	7	8	8
2	9	8	11	11	10	13
3	12	9	15	15	12	18
4	15	10	19	19	14	22

- Meas.: One measurement recorded
- Connection: One physical connection made

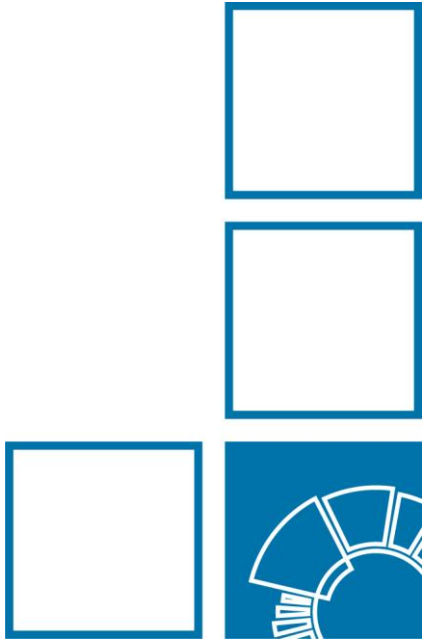
- New error boxes must be derived to avoid cable movements

Conclusion

- Both methods compared are suitable and yield low MU
- allowing for cable movements, the UOSM method requires fewer connections and is faster
- cable movements increase the MU significantly and should be avoided or minimized

Trade-off between:

- Desired measurement uncertainty
- Time required for measurement and evaluation
- Wear on laboratory equipment



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