VSL

An automated system for investigation of the impact of cable flexure on VNA measurements

Project : HF Circuits
Workshop : Electronic Calibration Units
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SP, Boras, Sweden

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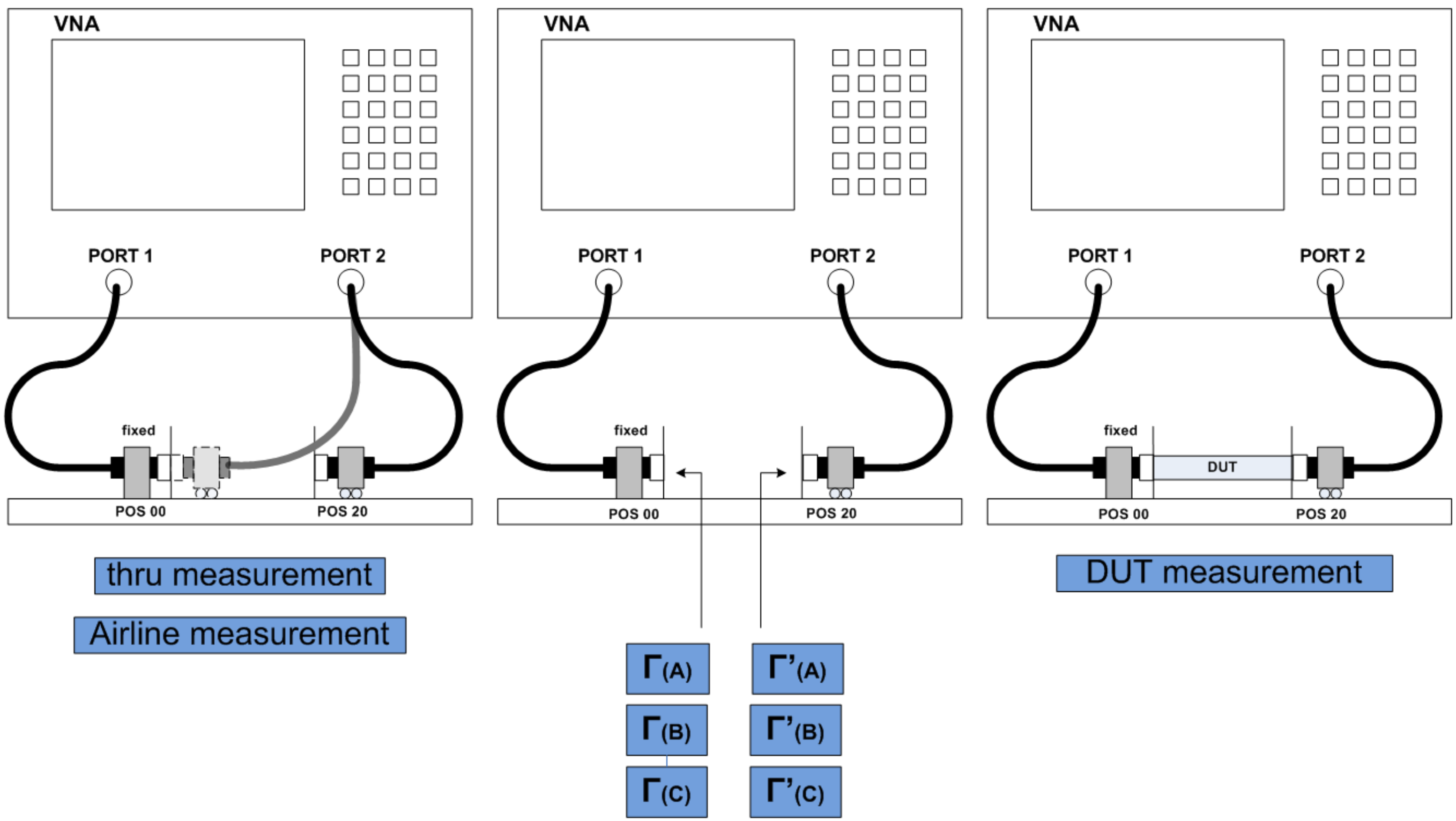
Dutch Metrology Institute

Presentation outline

- Motivation
- Monte Carlo simulations
- Measurement method
- Data Analysis
- Conclusions

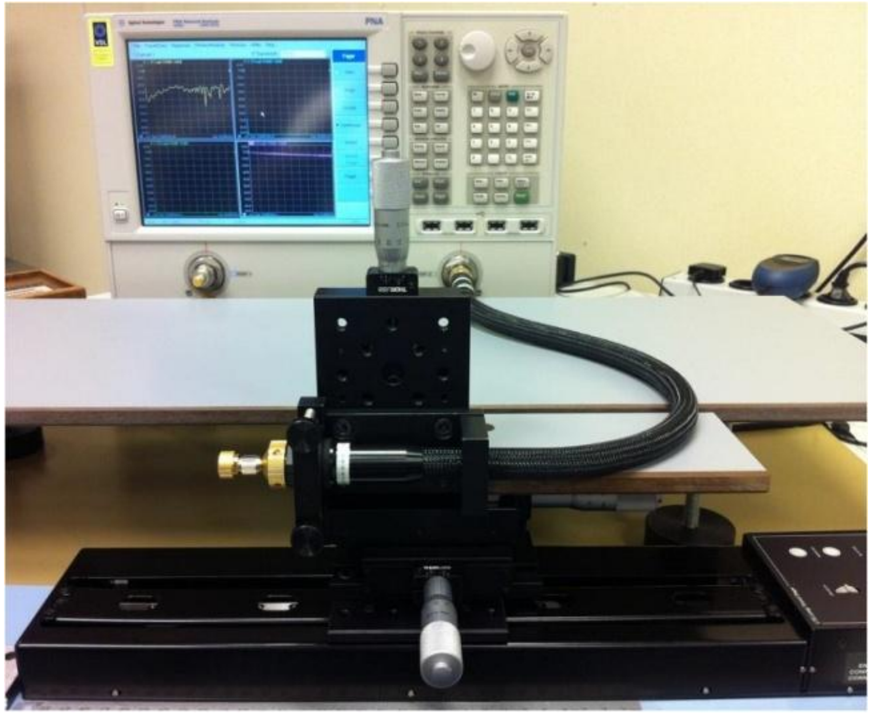
Motivation

Vector Network Analyzer Calibration



Automated cable characterization

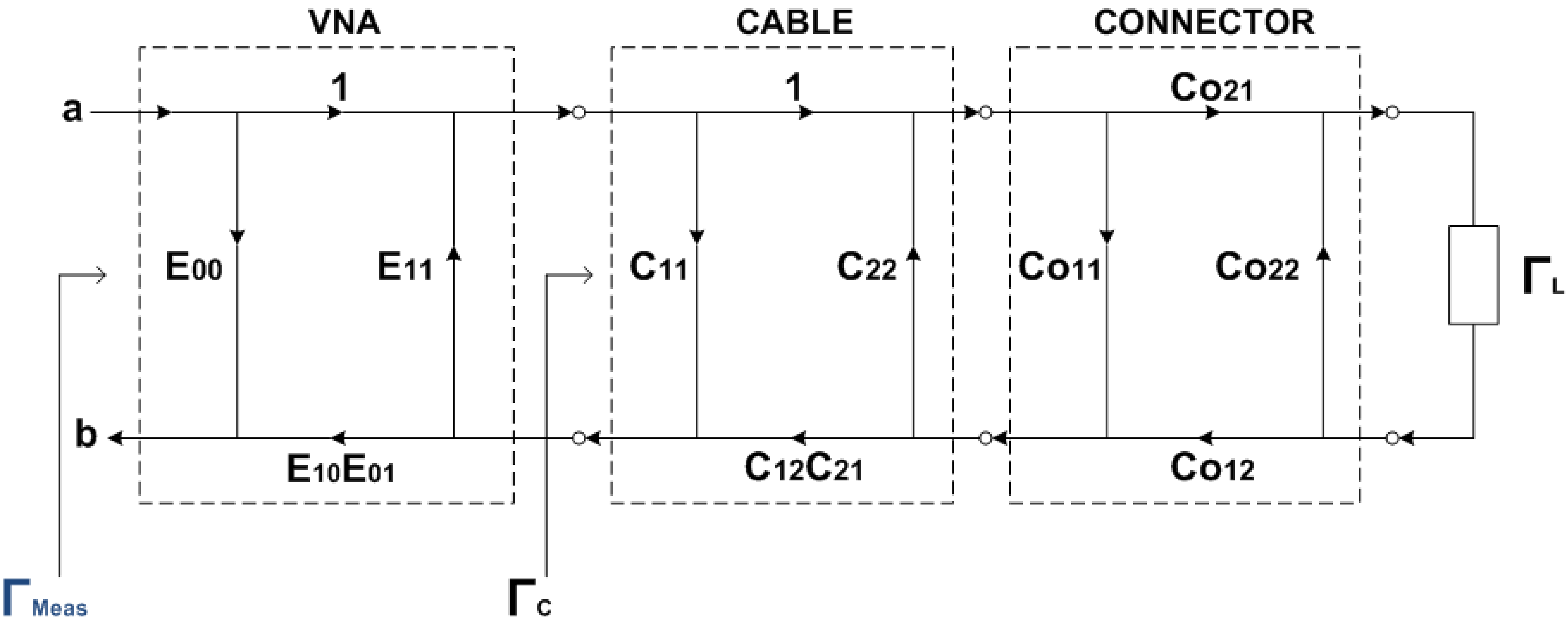
Precision linear translation stage



Cable flexing errors are investigated by means of 1-port reflection coefficient measurements.

Montecarlo simulations

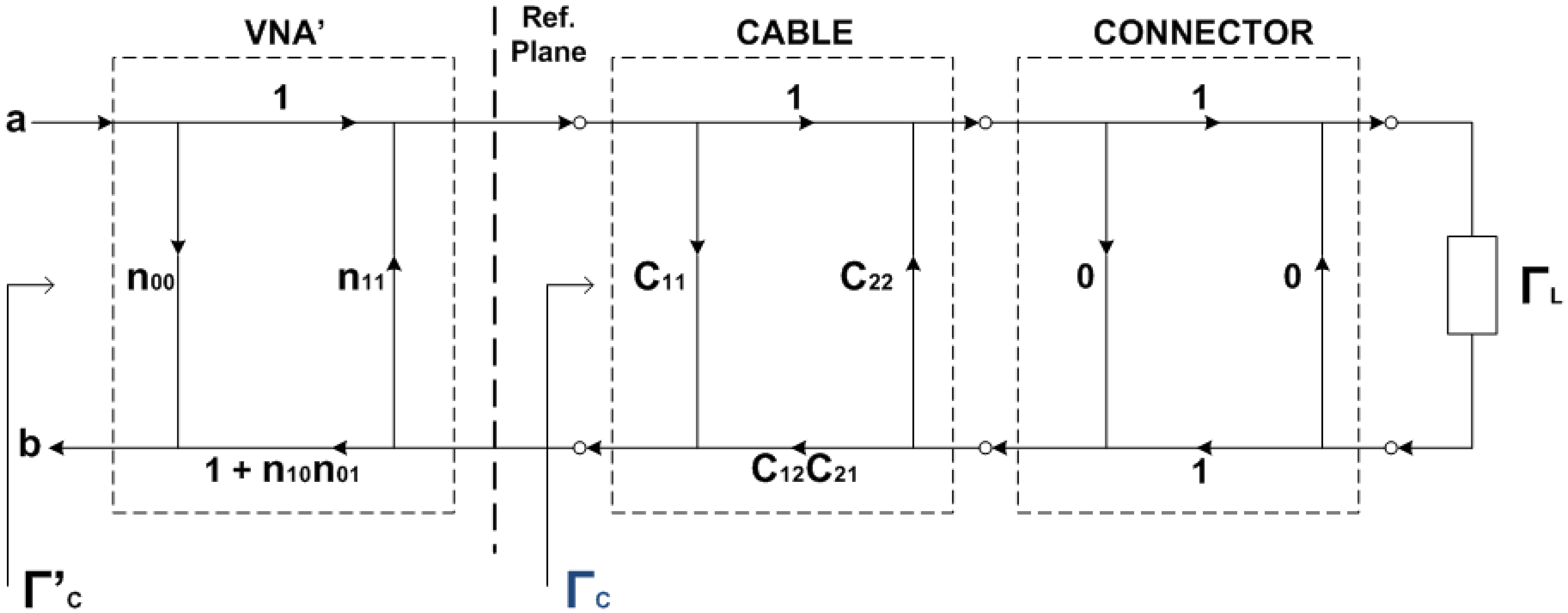
Measurement set-up model



$$\Gamma_{Meas} = \frac{b}{a} = E_{00} + \frac{E_{10}E_{01}\Gamma_C}{1 - E_{11}\Gamma_C}$$

Flexing of high-precision cables

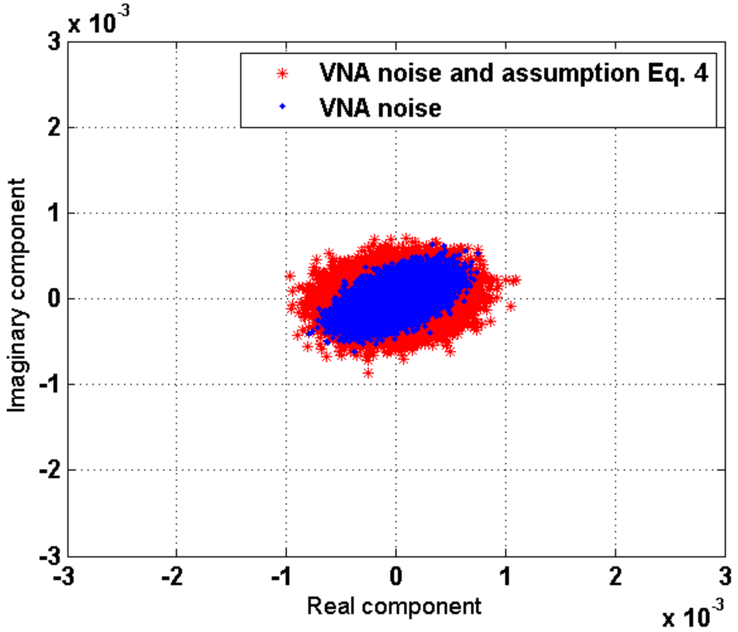
Measurement set-up model

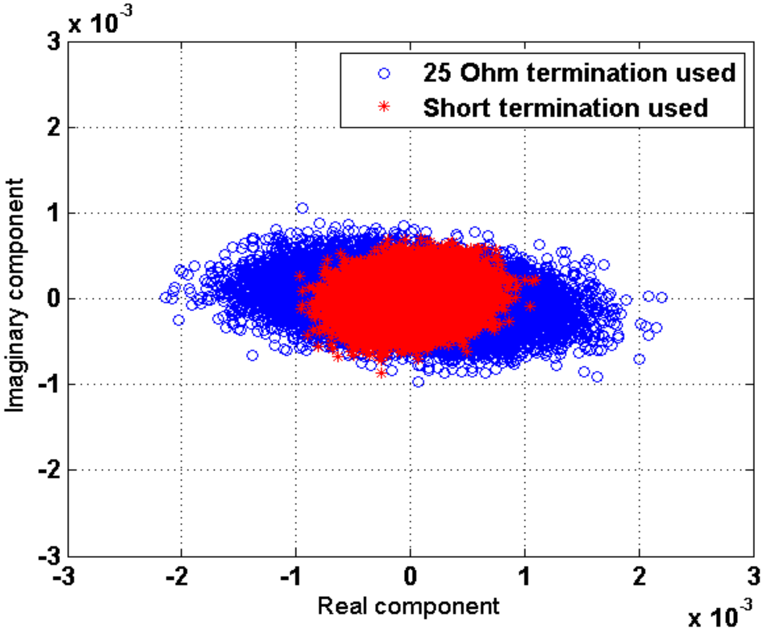


$$\Gamma_C = C_{11} + \frac{C_{12}C_{21}\Gamma_L}{1 - C_{22}\Gamma_L}$$

Flexing of high-precision cables

Measurement setup model





$$C_{12}C_{21}(m) = \frac{(\Gamma_c'(m) - C_{11}(1))(1 - C_{22}(1)\cdot\Gamma_L)}{\Gamma_L}$$ Eq. 4

Only marginal increase in error results from assumption in Eq.4

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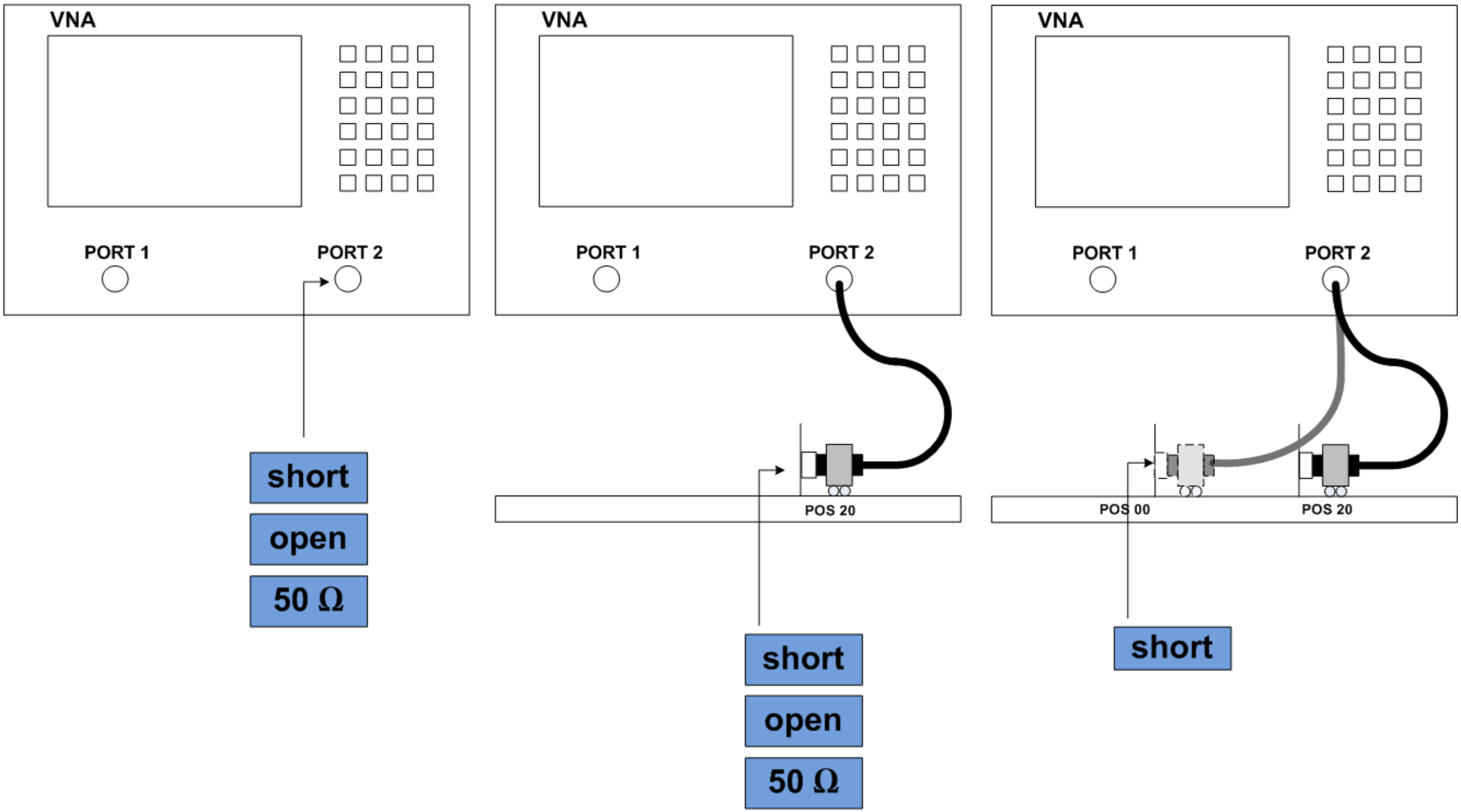
Proposed measurement method

Automated cable characterisation fixture

Step 1: Calibrate VNA

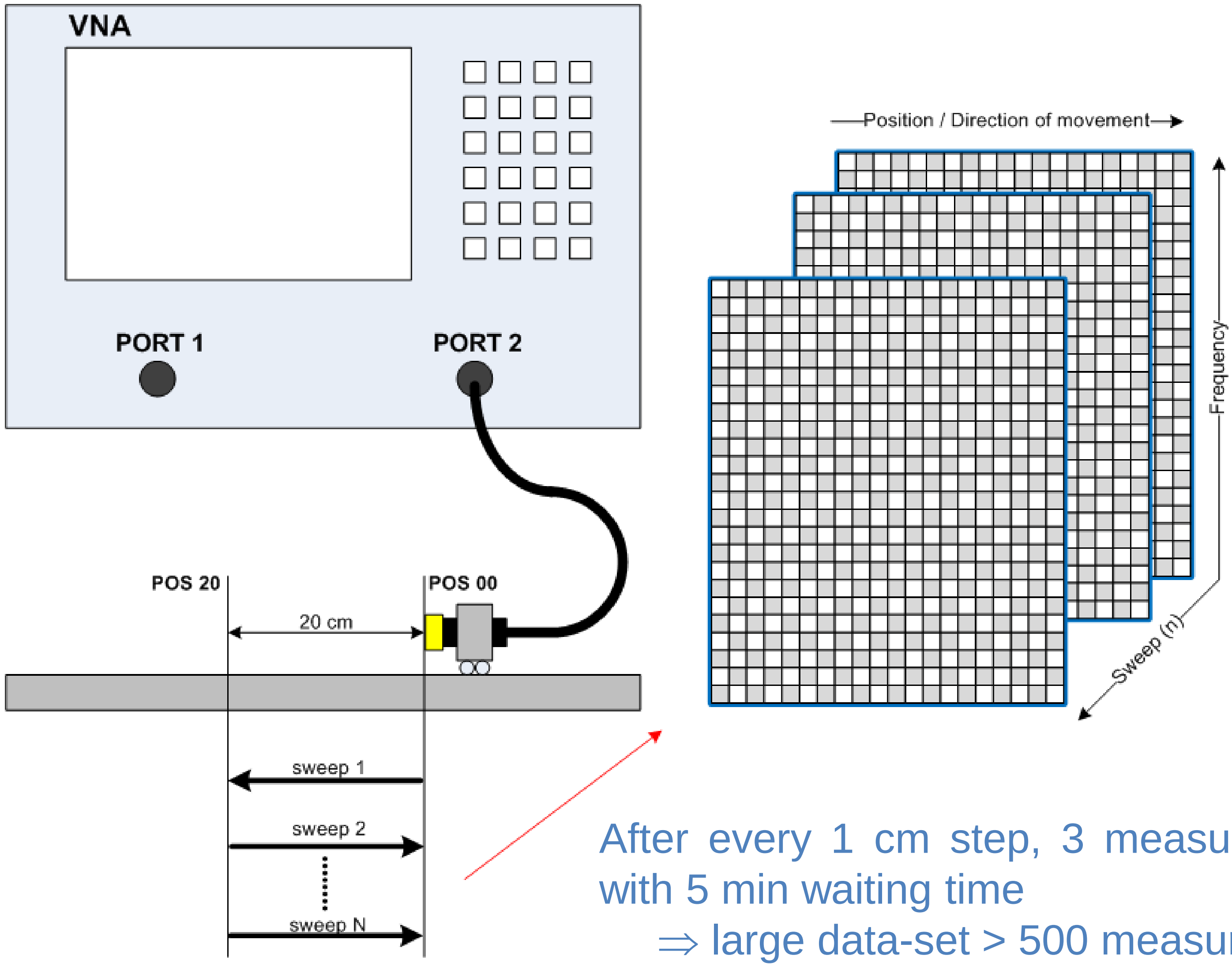
Step 2: Calibrate at reference plane of cable

Step 3: Use high-reflect termination



Proposed measurement method

2.4 mm flexible coaxiable cable



After every 1 cm step, 3 measurements with 5 min waiting time

⇒ large data-set > 500 measurements

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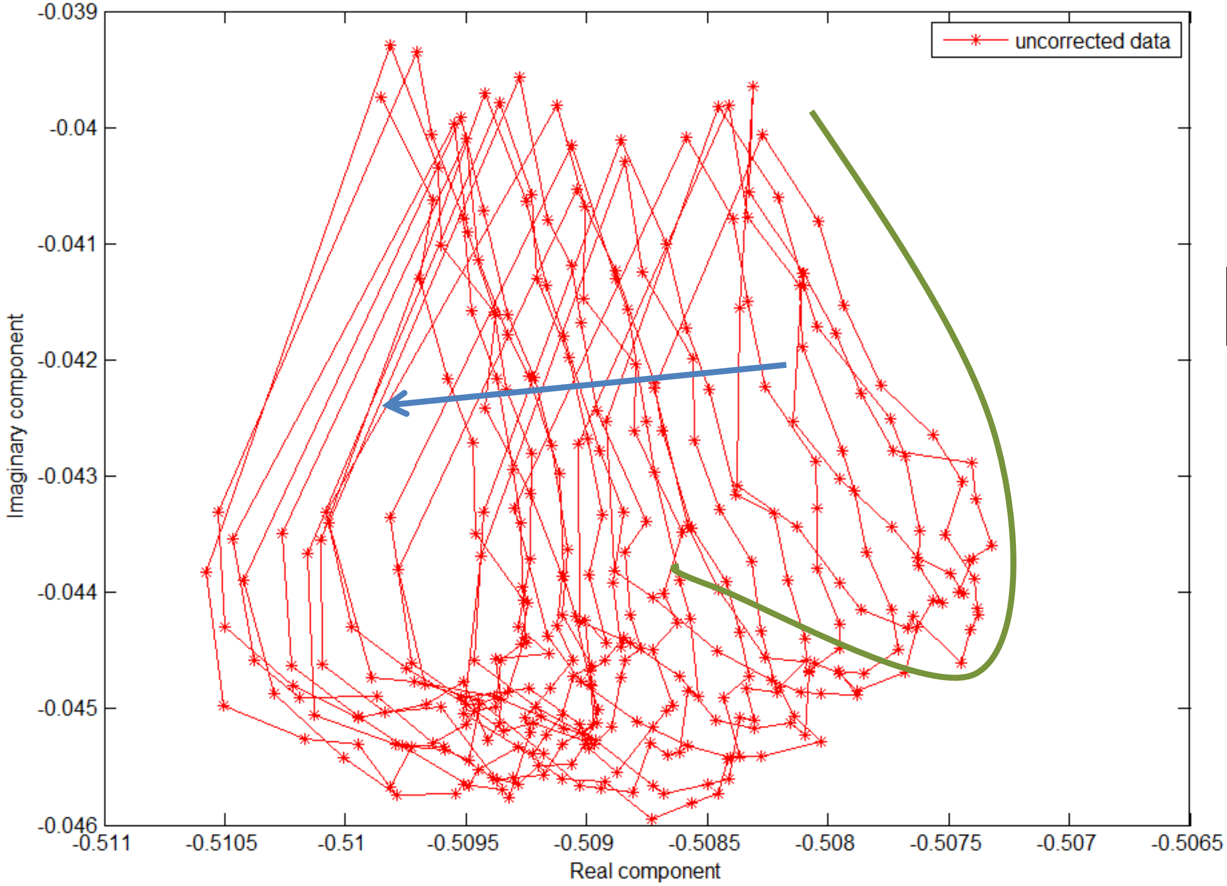
50 GHz raw measurement data

2.4 mm flexible coaxiable cable tested



drift

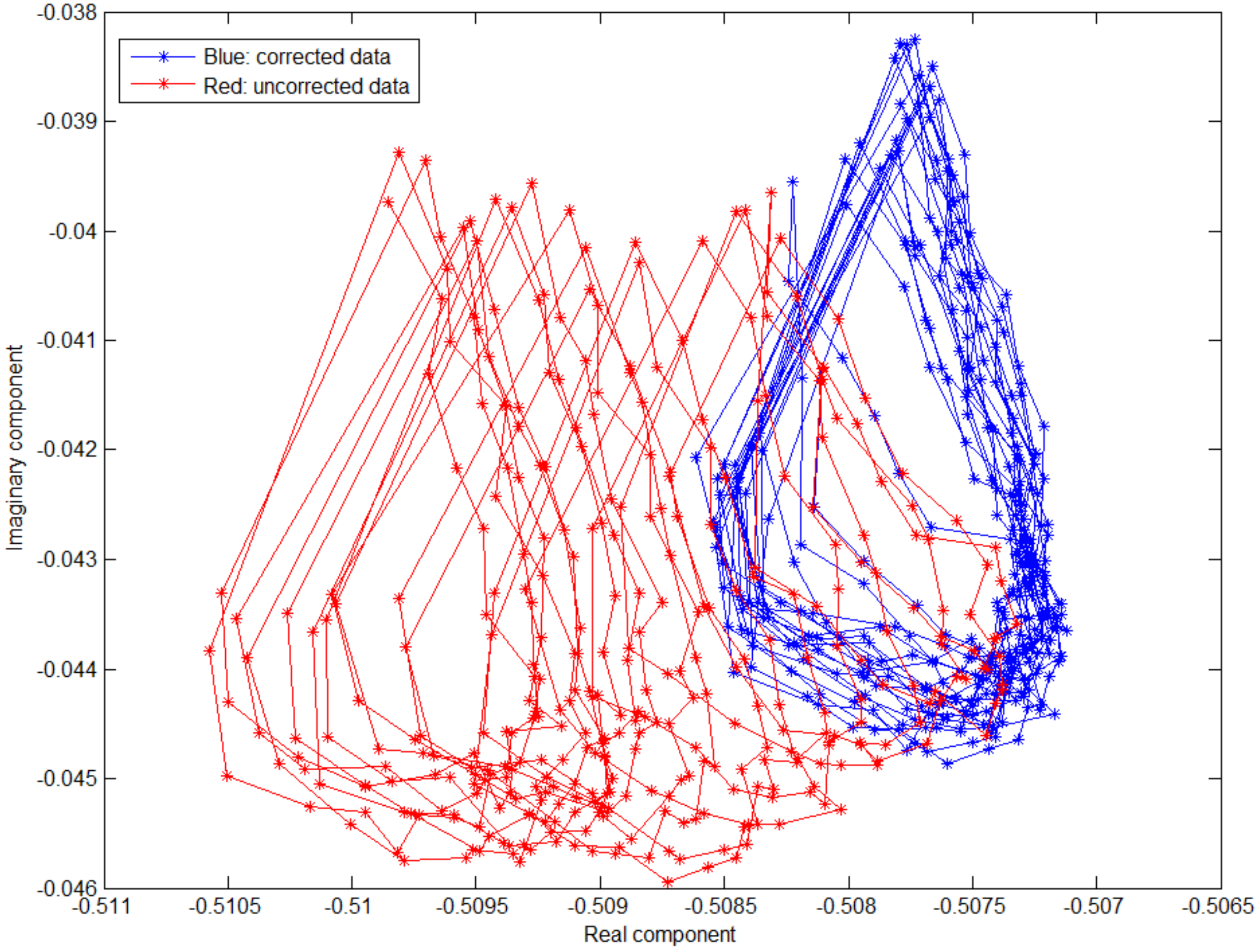
Systematic

Random

Raw measurement data of relfection coefficient measurements at 50 GHz with 4 days measurement duration

50 GHz measurement data

Drift correction cable transmission



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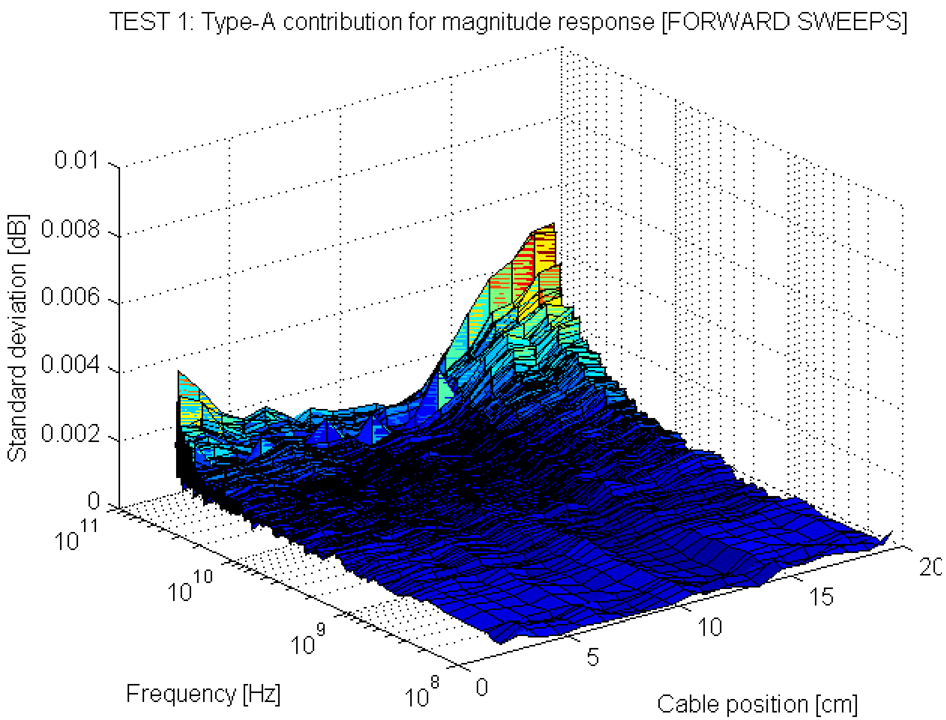
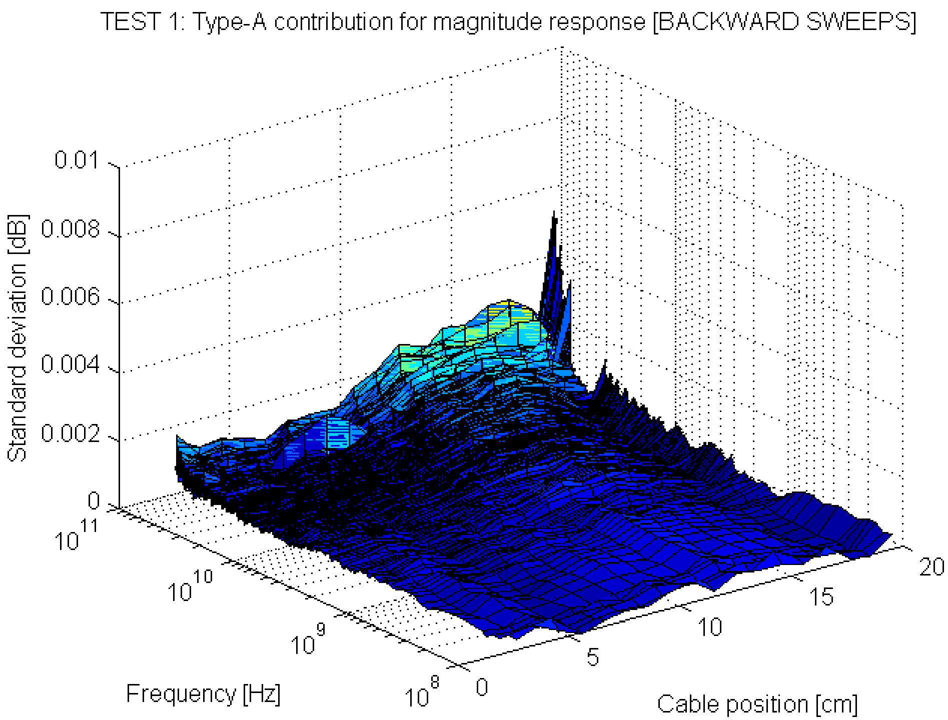
Measurement results

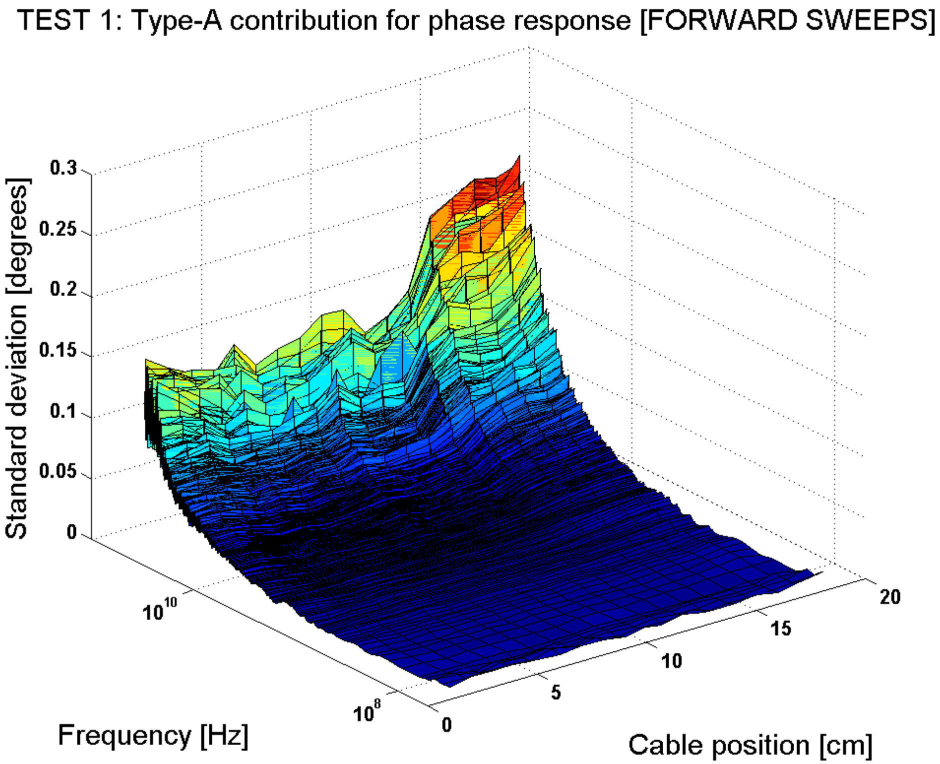
Type A uncertainty magnitude (random error)

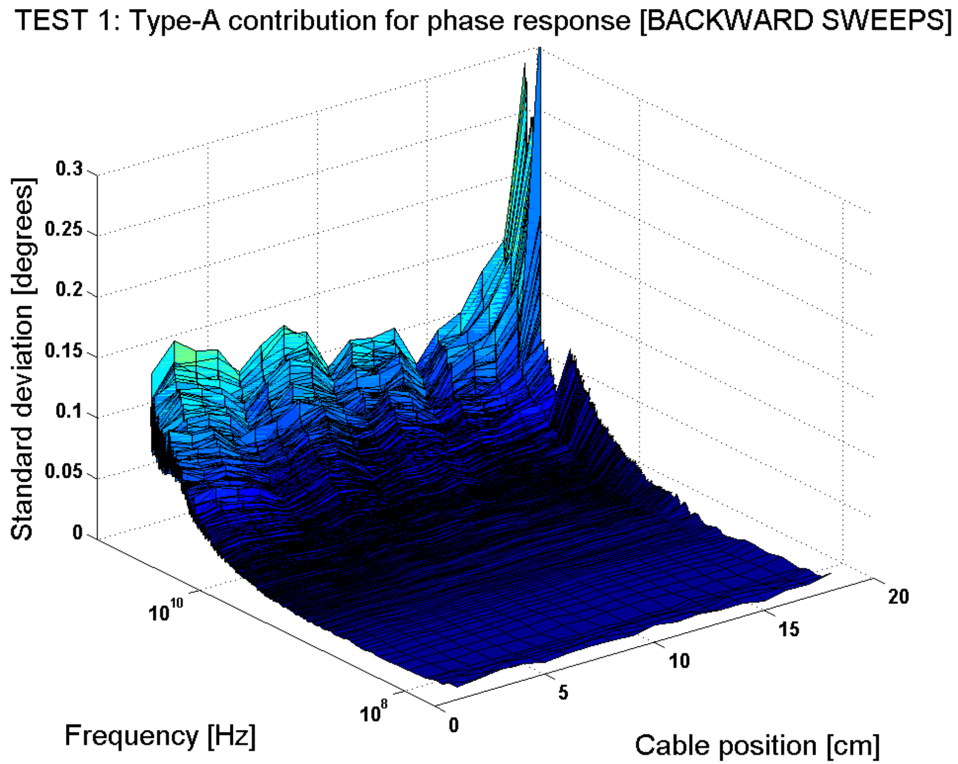




Measurement results

Type A uncertainty phase





Direction of movement does impact the random behaviour of the cable.

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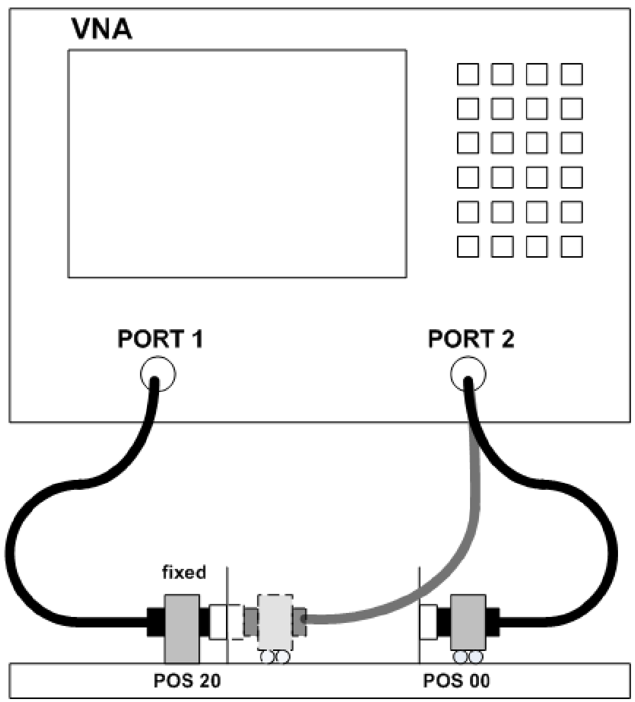
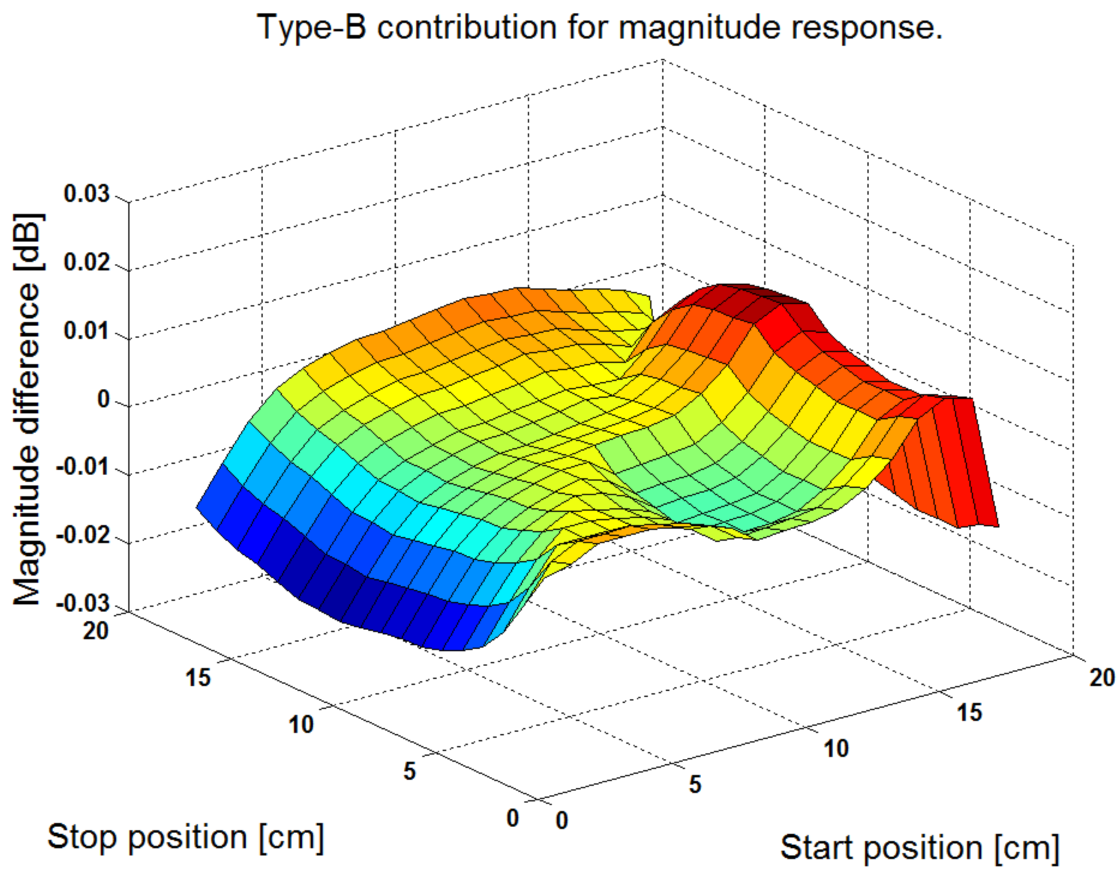
Measurement results

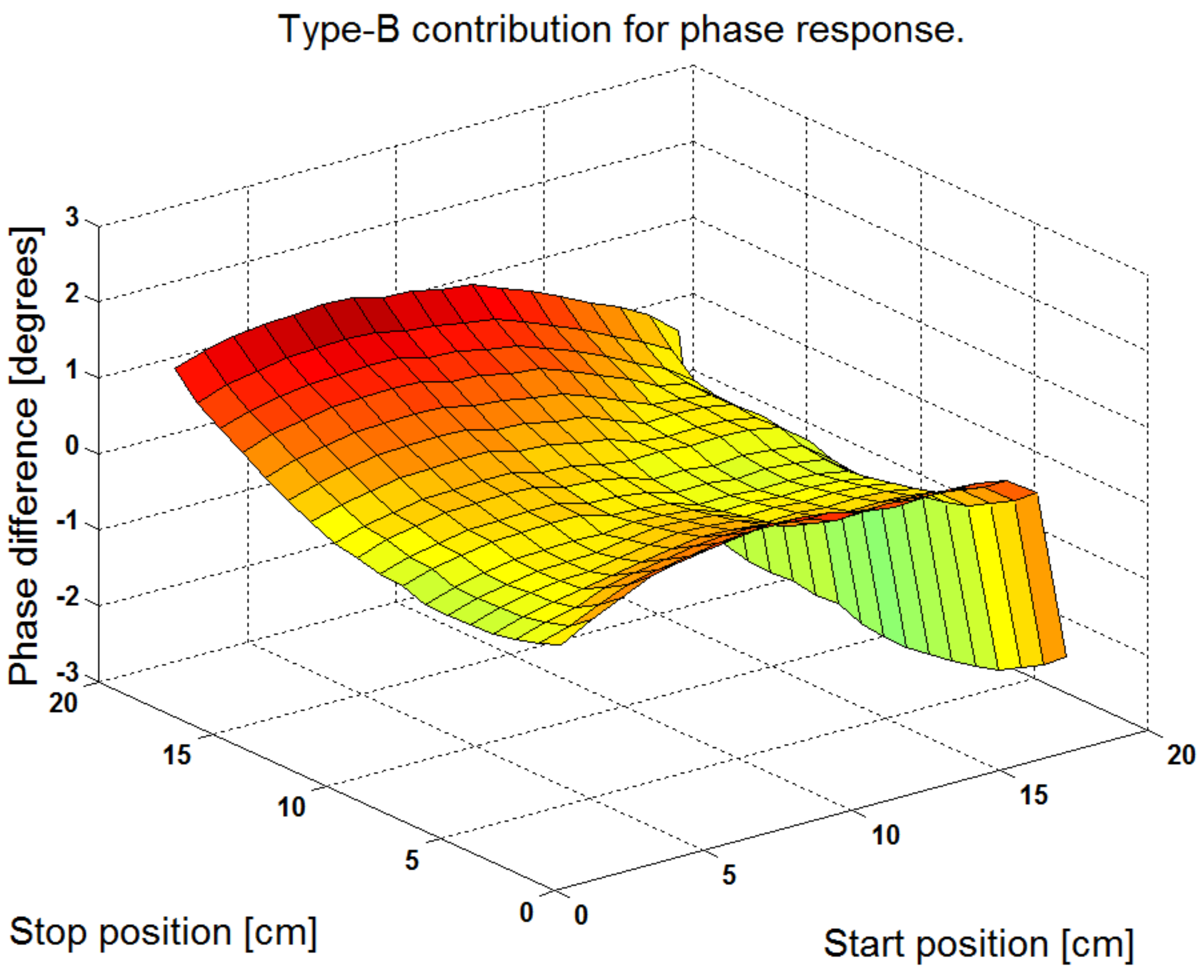
Systematic error: transmission magnitude





Measurement results

Systematic error: transmission phase



Movement in forward direction is more stable.

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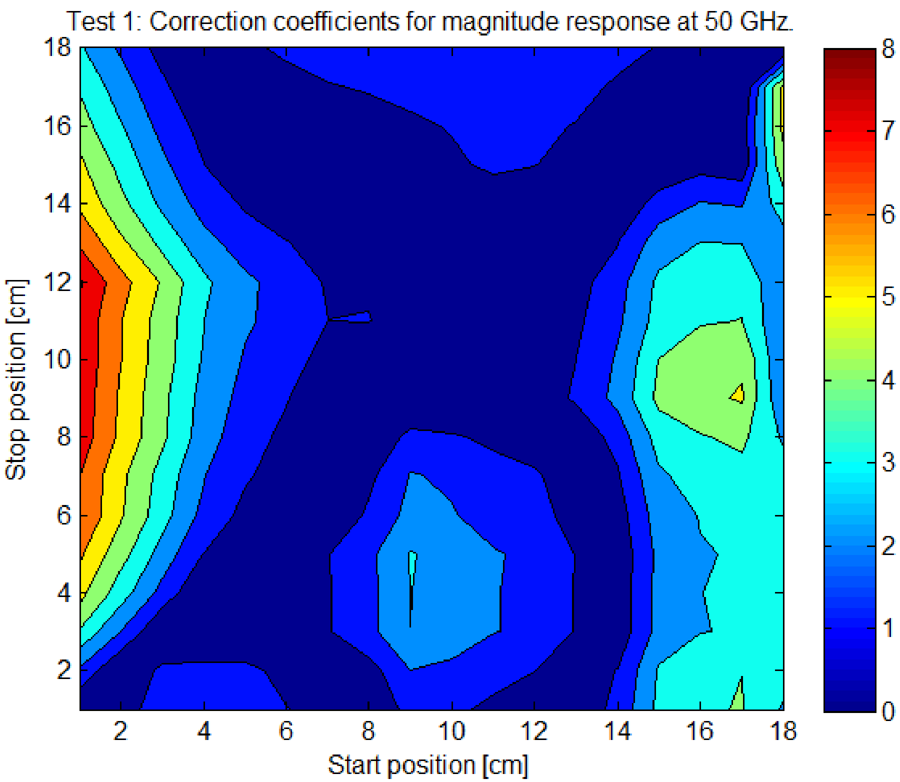
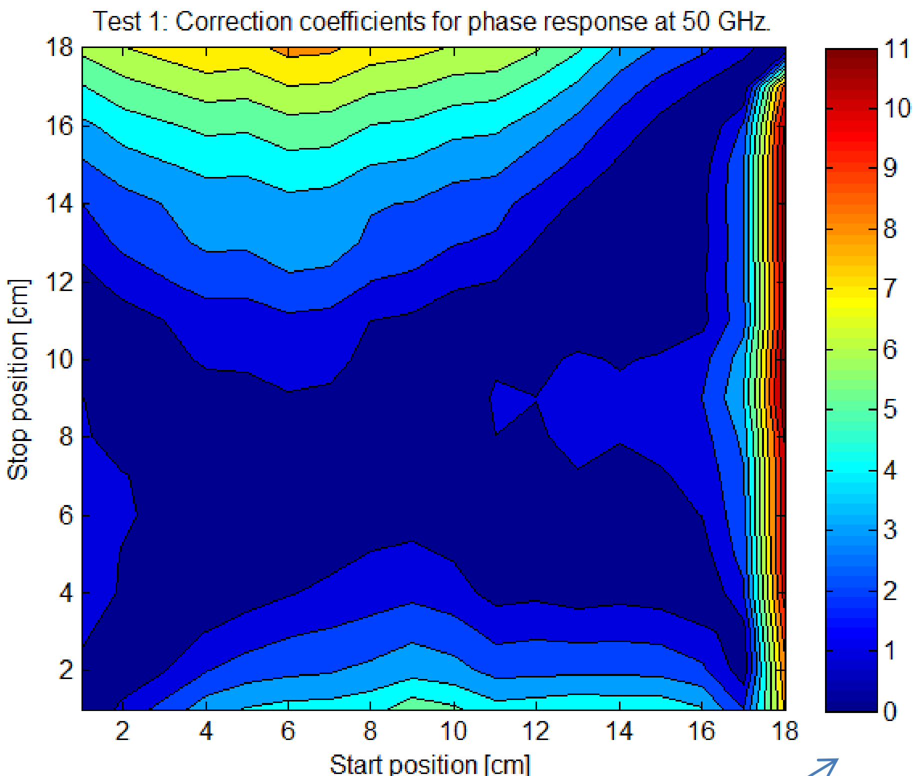
Measurement results

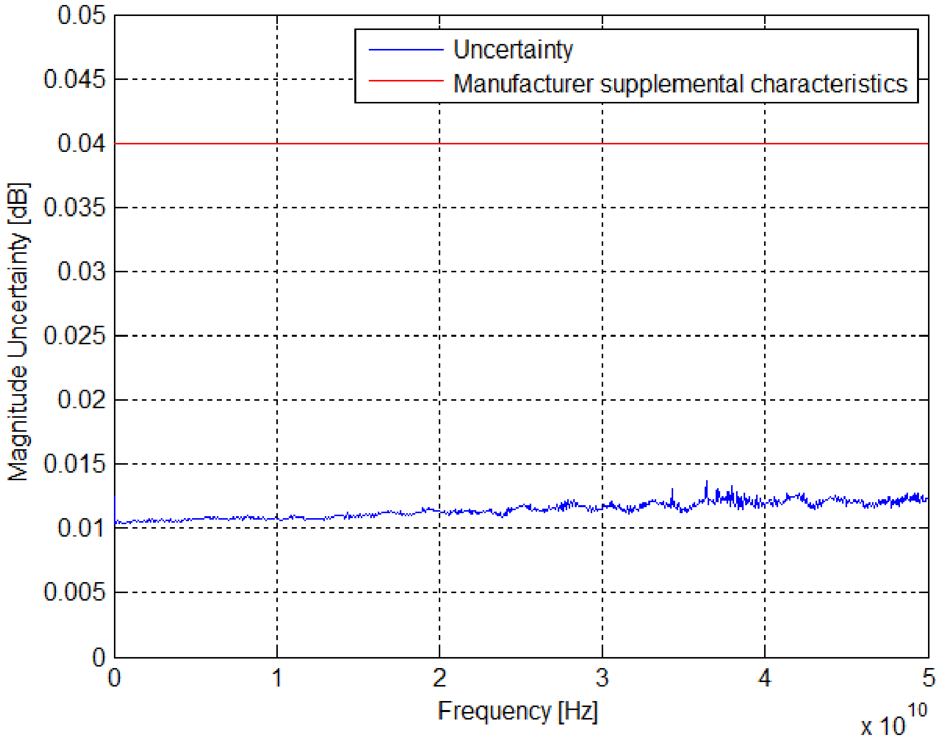
Systematic error: de-embedding

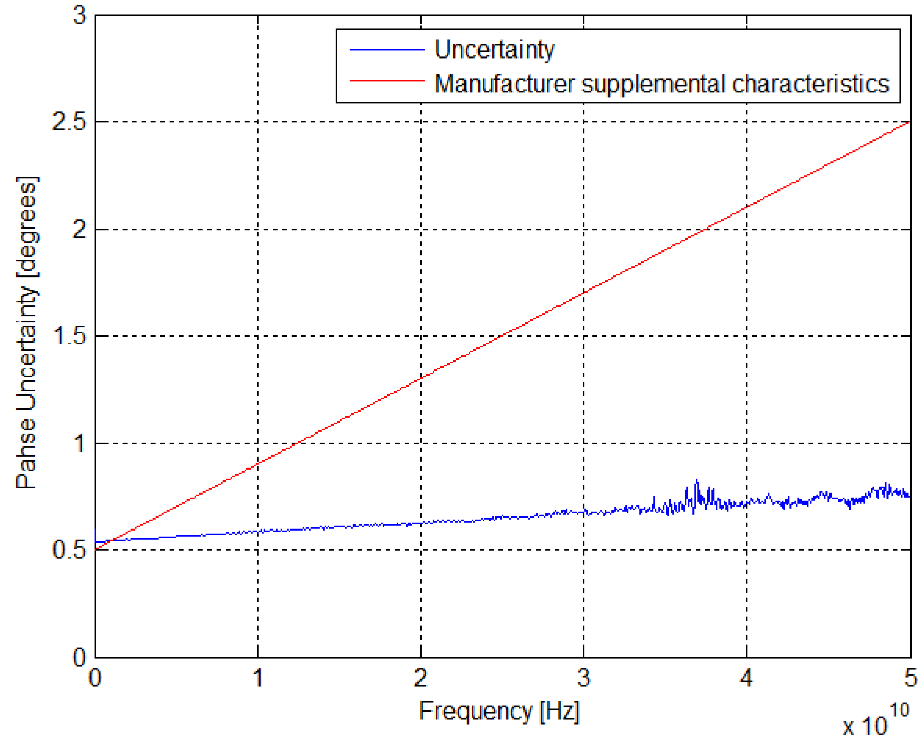




De-embedding criterium: (systematic error / random error) > 3

Measurement results
Total uncertainty calculation





Conclusions & Future work

- Simulations show high-reflect termination is most suitable for characterizing cable flexure effects
- Cable drift can be substantially reduced by thermal isolation
- Electrical performance of the cable of the cable is strongly correlated with position and direction of movement
  $\Rightarrow$ choose optimal position and direction
  $\Rightarrow$ uncertainty can be factor 2 – 4 reduced
  $\Rightarrow$ via de-embedding further uncertainty improvement

Future work

- Validate proposed method with automated calibration (Ecal)

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Ministerie van Economische Zaken

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