A Method for Residual Error Analysis of a Calibrated VNA

HF-Circuits Workshop
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PTB, Germany

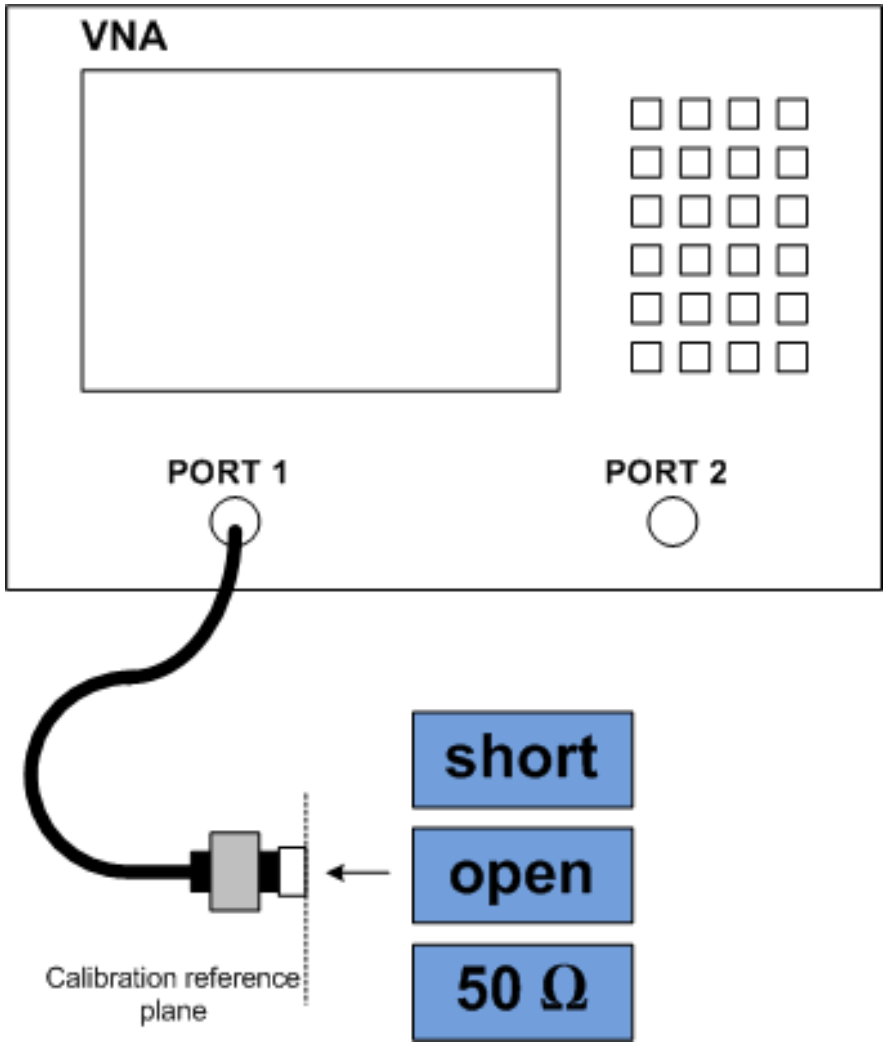
Dutch
Metrology
Institute

Presentation outline

- Motivation
- 1-port measurement model & calibration
- Uncertainty assessment & airline ripple measurement
- Airline measurement model & data generation
- Data Analysis
- Conclusions

Motivation

How to assess the quality of VNA calibration?



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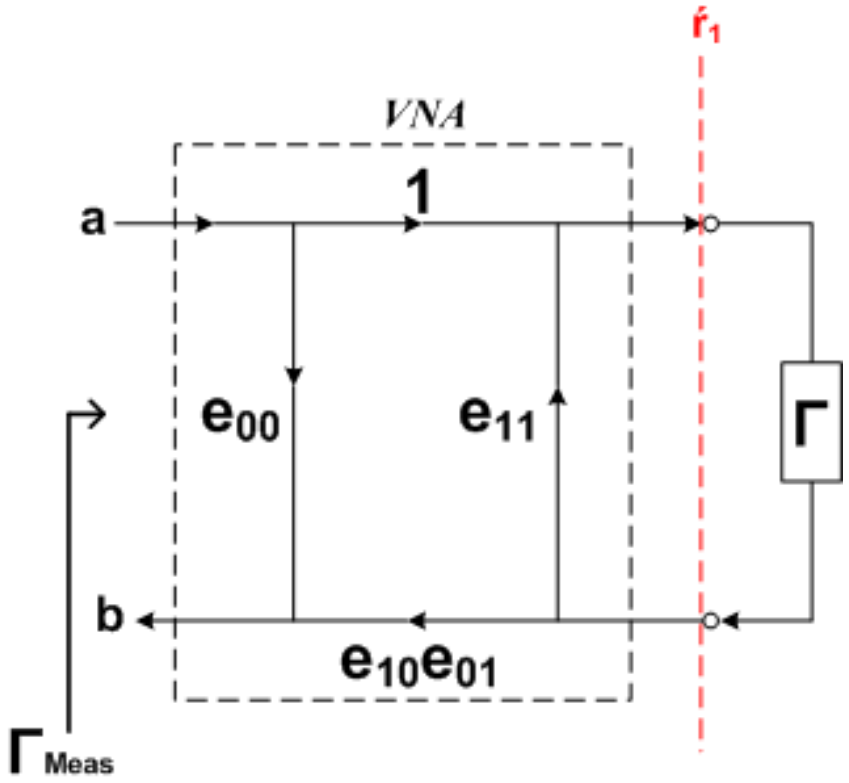
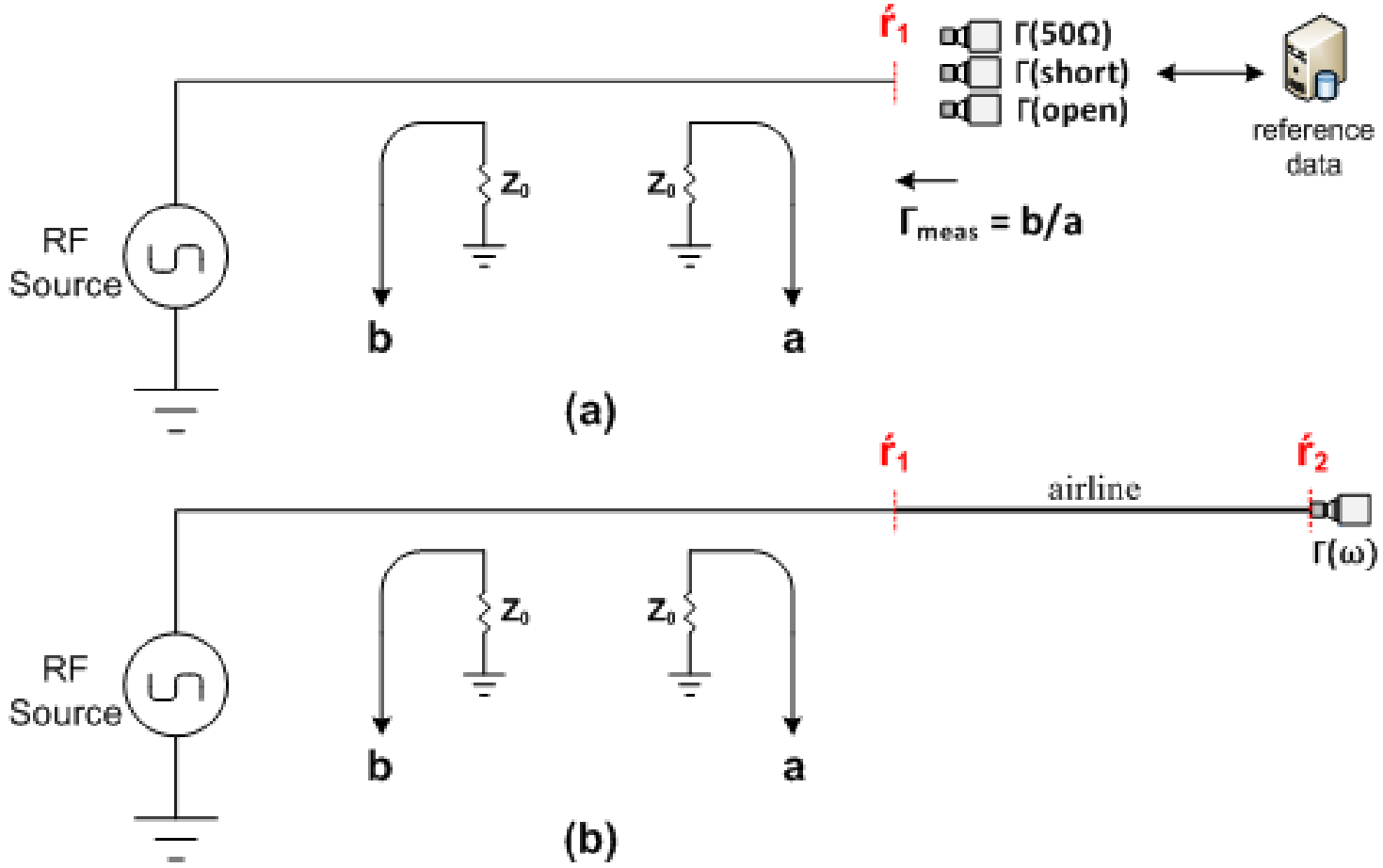
one-port measurement model & calibration



$$\Gamma = \frac{\Gamma_{meas} - e_{00}}{e_{10}e_{01} + e_{11} \cdot (\Gamma_{meas} - e_{00})}$$

Unc. assessment & airline ripple measurement

Extending the calibration reference plane



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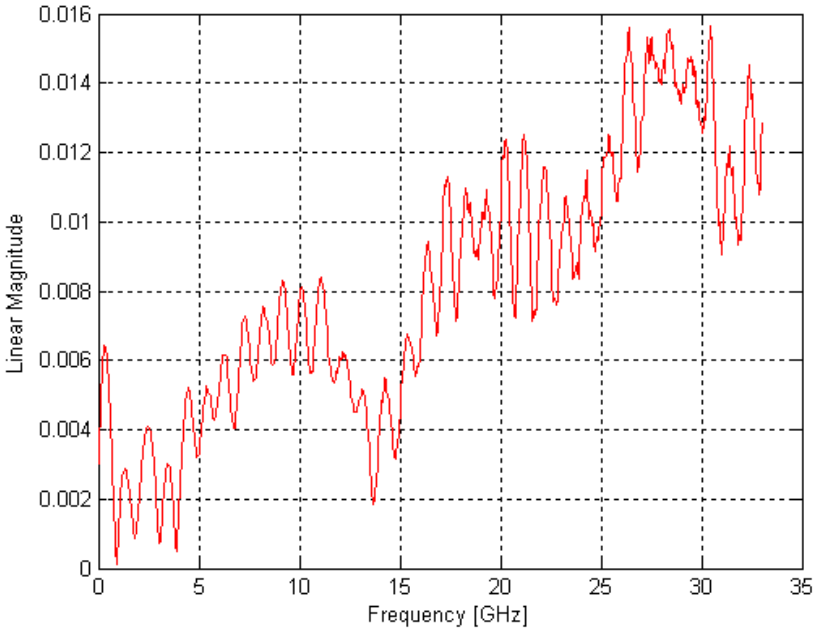
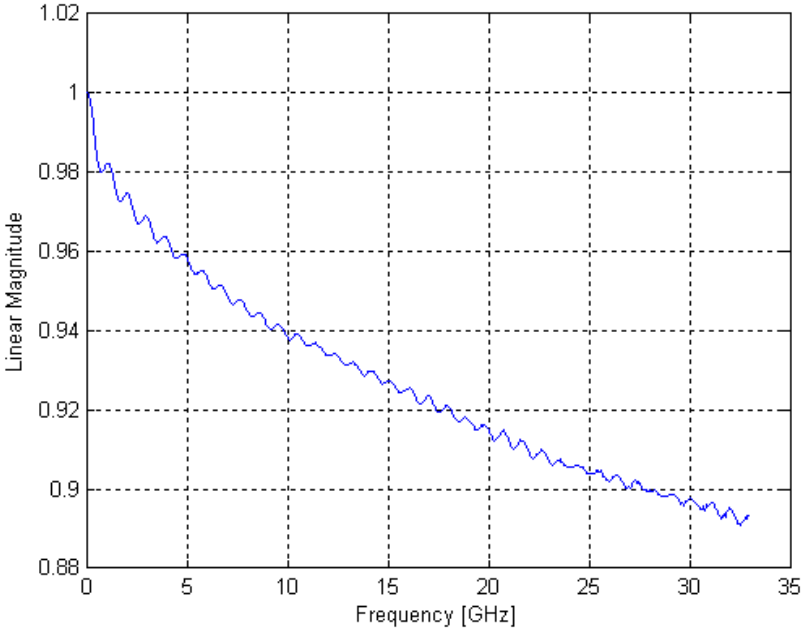
Unc. assessment & airline ripple measurement

Not good enough for small uncertainties

One-port airline measurement results for VNA calibration in 3.5 mm connector up to 33 GHz and using a 15 cm beadless precision airline.



A 50 Ω termination is used.



A short termination is used.

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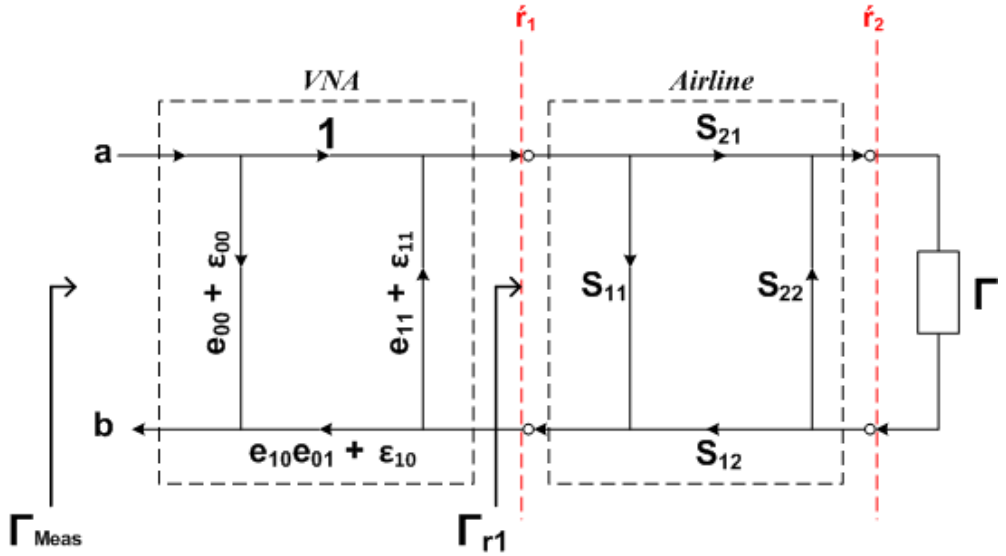
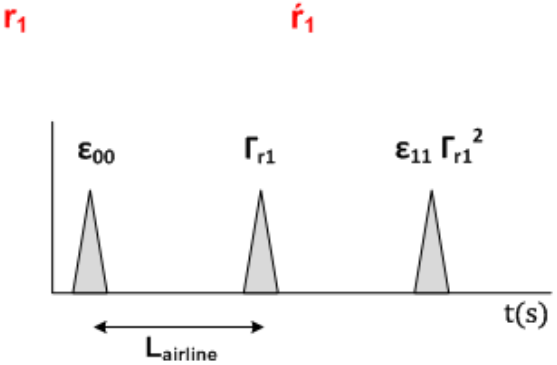
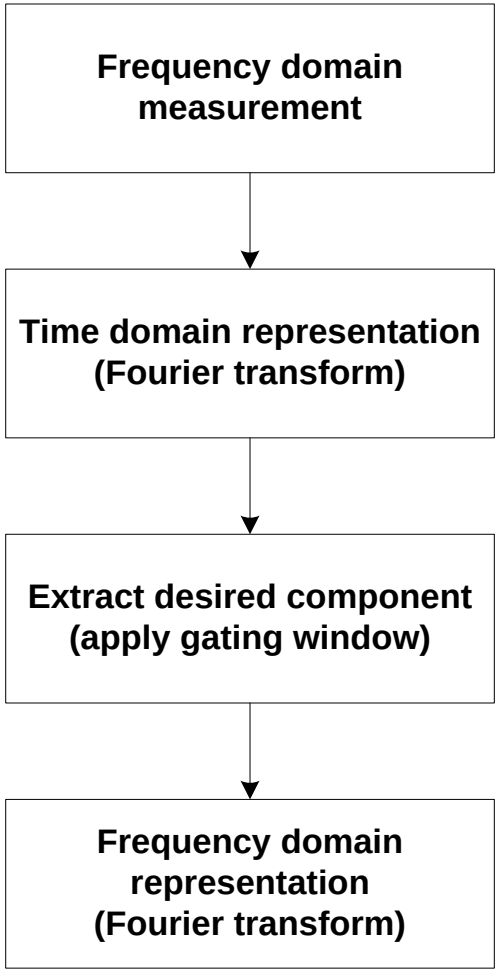
Unc. assessment & airline ripple measurement

Go to time domain to distinct different uncertainty components







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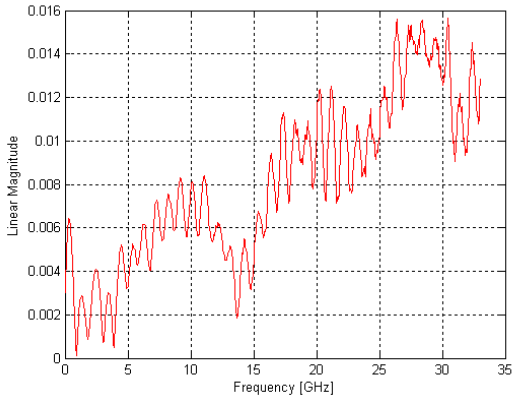
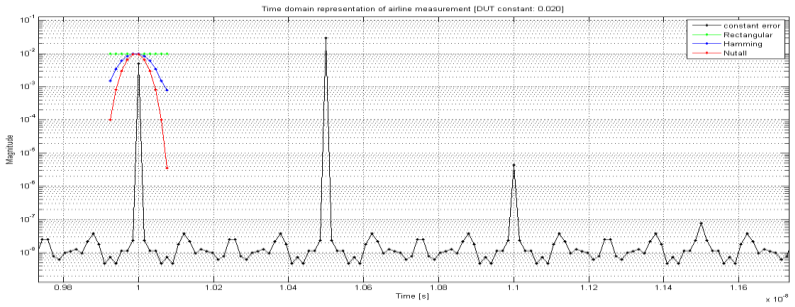
Unc. assessment & airline ripple measurement

What about interaction between error-terms?

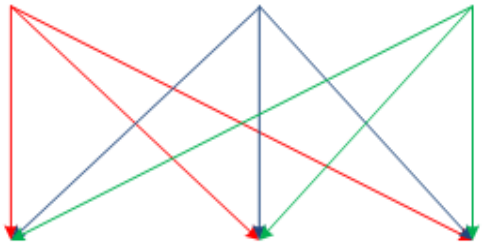




residual error uncertainties

Frequency domain

$\varepsilon_{00}(\omega)$ $\varepsilon_{11}(\omega)$ $\varepsilon_{10}(\omega)$



Time domain

$\varepsilon_{00}(\omega)$ $\varepsilon_{11}(\omega)$ $\varepsilon_{10}(\omega)$

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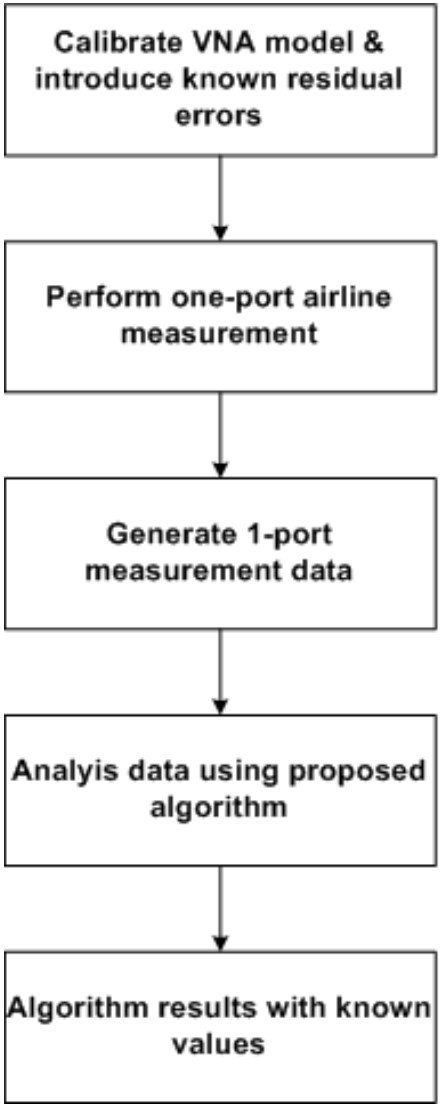
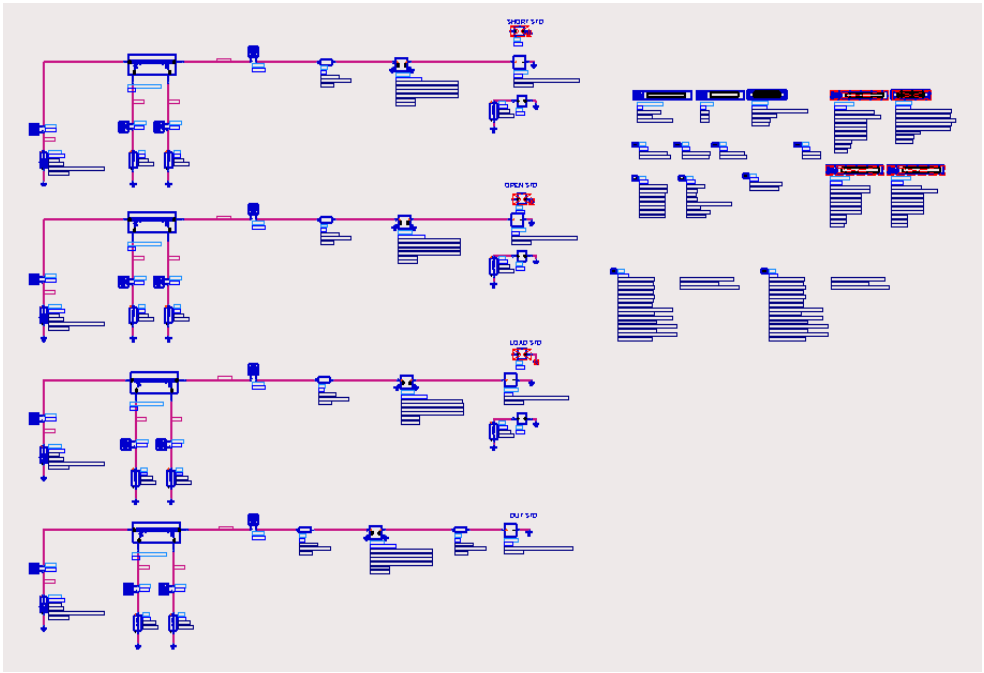
One-port airline measurement model in ADS





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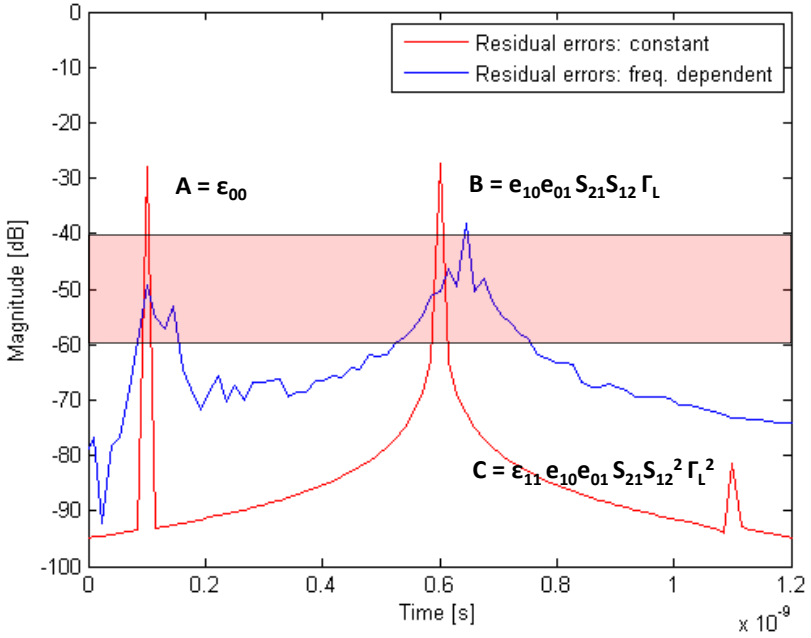
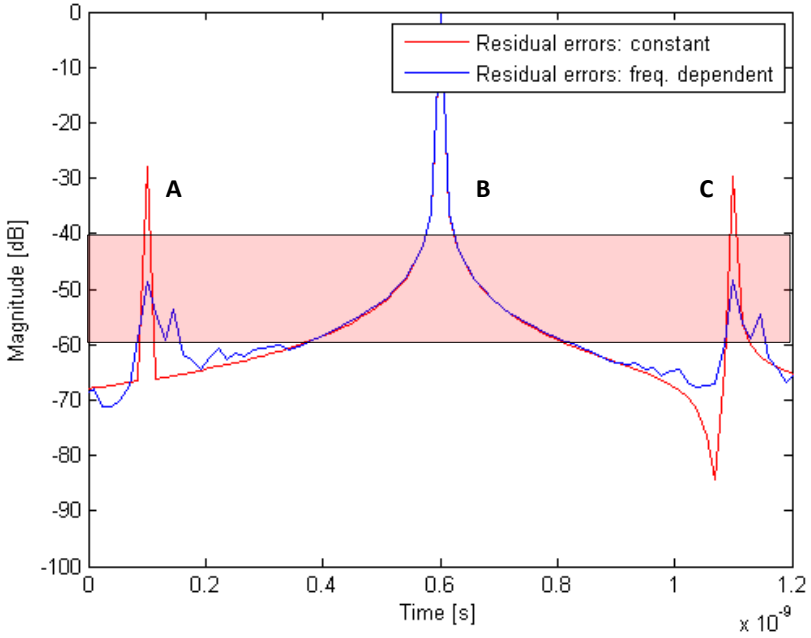
One-port airline measurement model & Data generation

Data generation for algorithm verification

One-port airline measurement results for VNA calibration in 3.5 mm connector up to 33 GHz and using a 15 cm airline.



A 50 Ω termination is used.



A short termination is used.

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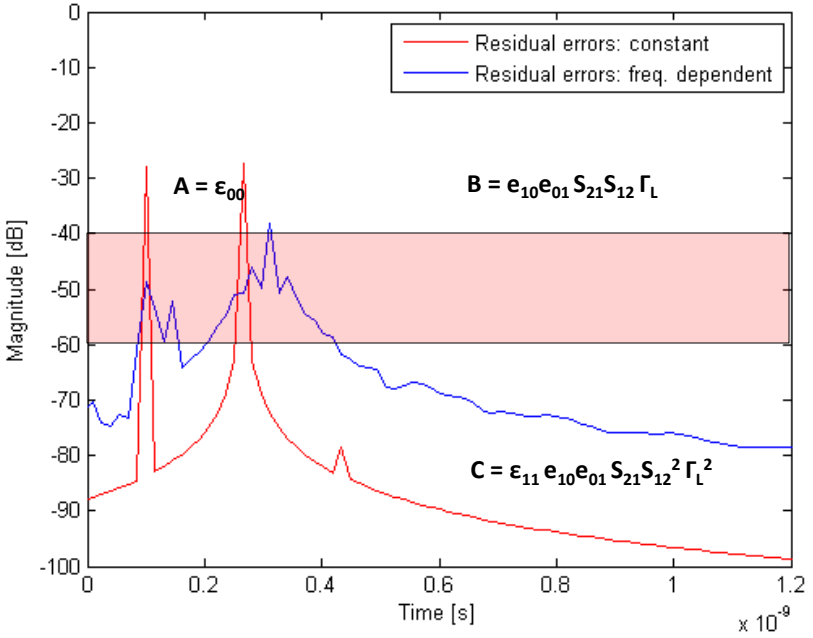
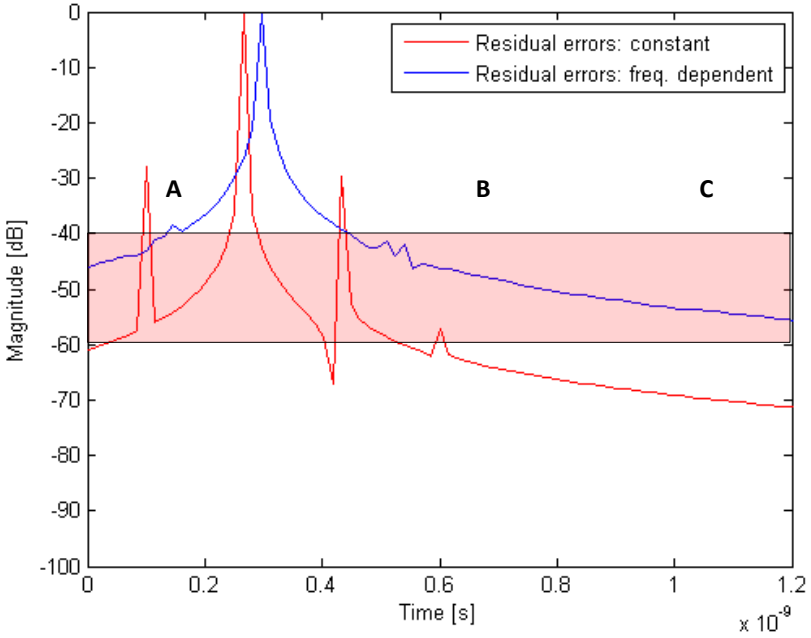
One-port airline measurement model & Data generation

Data generation for algorithm verification

One-port airline measurement results for VNA calibration in 3.5 mm connector up to 33 GHz and using a 5 cm airline.



A 50 Ω termination is used.



A short termination is used.

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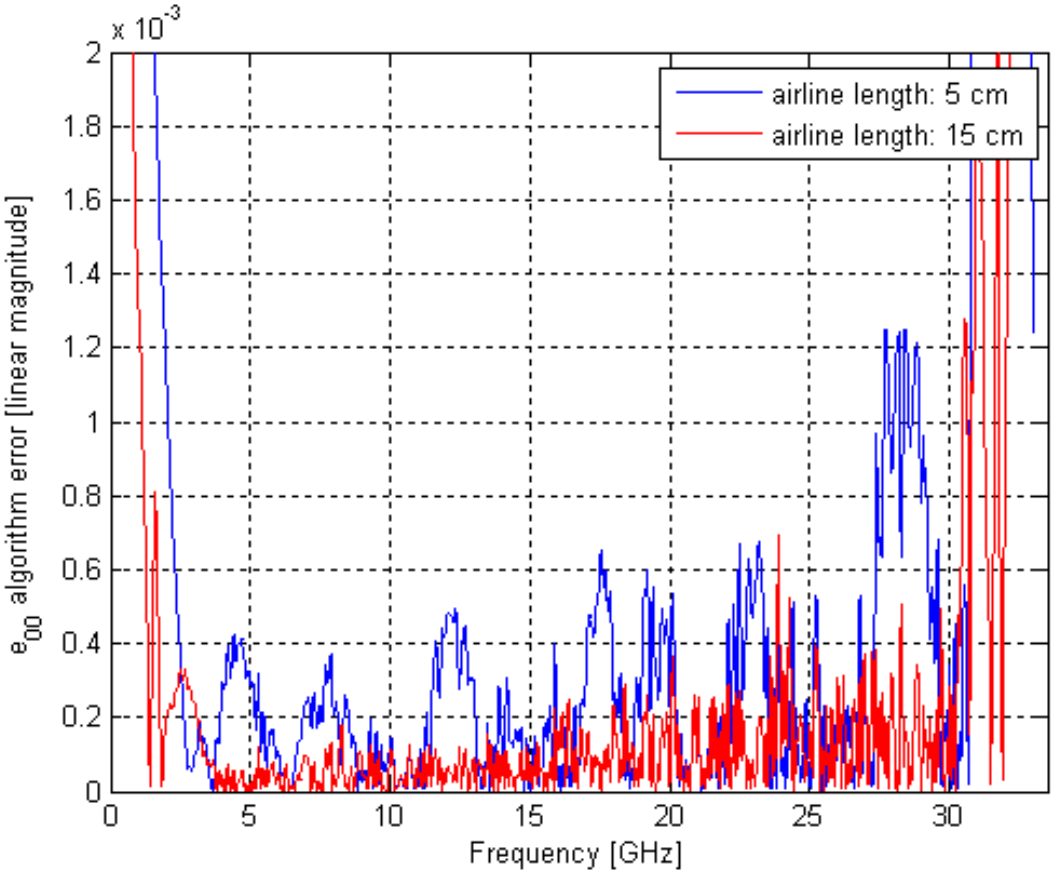
Data Analysis

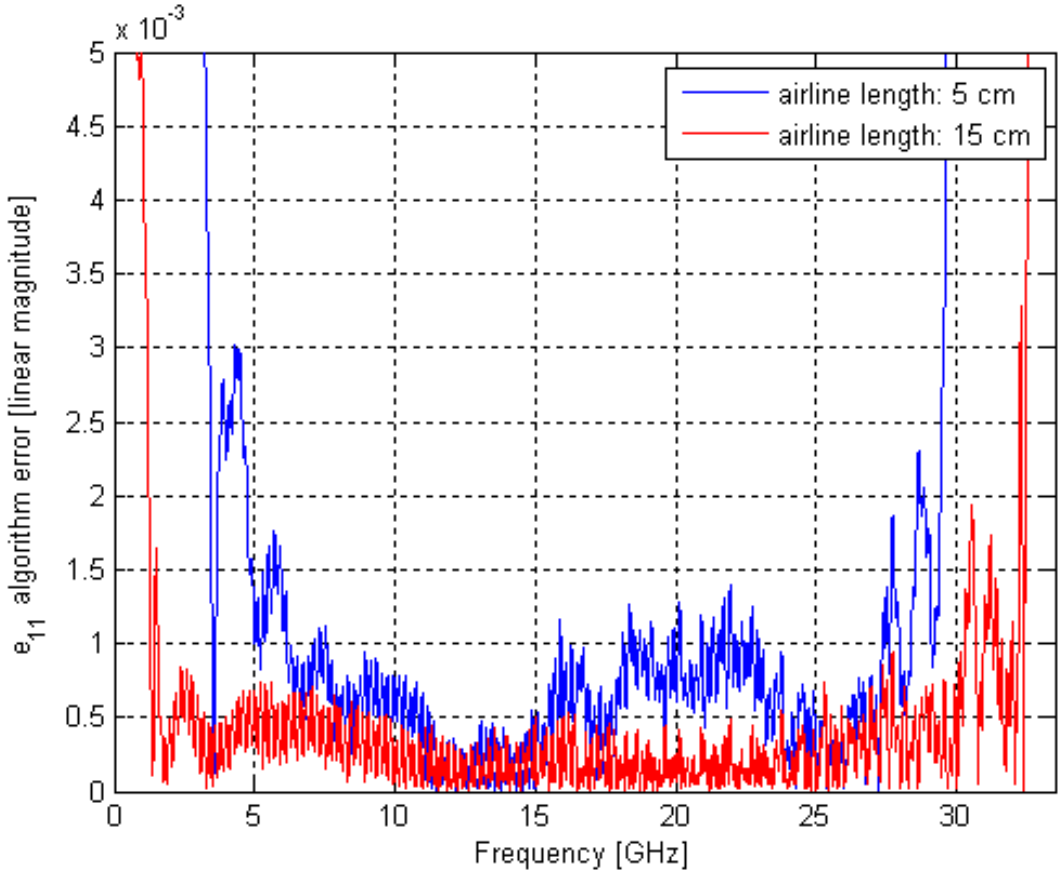
assessment of e_{00} uncertainty term



Assessment is based on one-port airline measurement with a 50 Ω load used as airline termination. A lossy airline model with ideal connectors is used.

Data Analysis

assessment of e_{11} uncertainty term



Assessment is based on one-port airline measurement with a short used as airline termination. A lossy airline model with ideal connectors is used.

Conclusions & Future work

- The length of the airline and frequency dependency of res. errors severely impact the assessment accuracy.
- A 5 cm airline is not long enough to validate uncertainties targeted. (3.5 mm connectors)

Future work

- Include connector effects for airline based uncertainty assessment.
  - Connector pin-gaps, inner-conductor centricity.
- Investigate accuracy limitations for typical available airlines.
- Extract complex residual errors.

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Ministerie van Economische Zaken

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