Impact of adapters on LISN's input impedance calibration: How to improve accuracy and reliability of the measurements ?

Part 1

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Le progrès, une passion à partager

50 let/years

Outline

- Problematics of AMN calibration (input impedance)
  - Strong impact of the adapters to a phase measurement
  - No correction applied
  - No traceability
- Calculable adapter developed
- Introduction of correction method
- Example: Phase calibration
- Conclusion

Calibration of AMN

- Requirements of the standard CISPR 16-1-2
  - Impedance (absolute impedance and phase) (L-PE; N-PE)
  - Voltage division factor
  - Isolation

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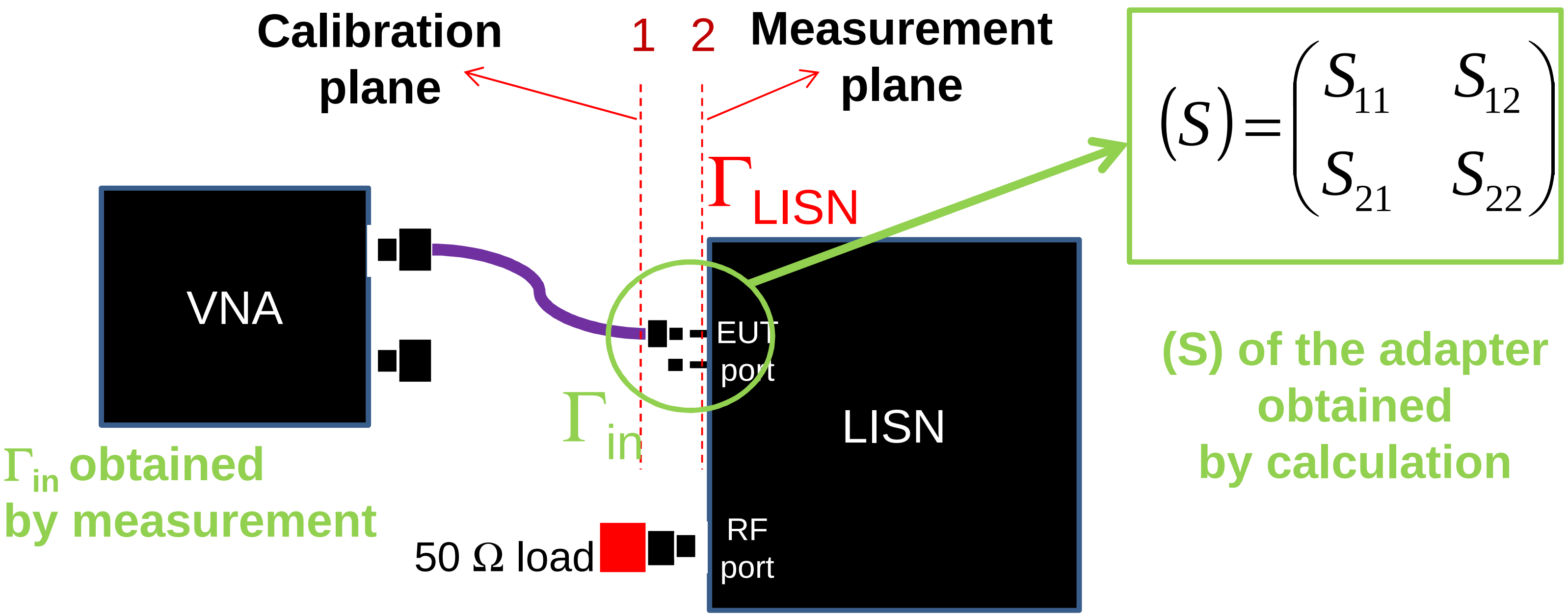
Impedance calibration

- Impedance is measured between N-PE and L-PE
- Tolerance CISPR 16-1-2 is 20% of the magnitude and 11,5° of the phase
- OPEN, SHORT, LOAD is made at the end of VNA cables (N-type)
- Traceability is lost by adding undefined adapter

Calibration plane definition

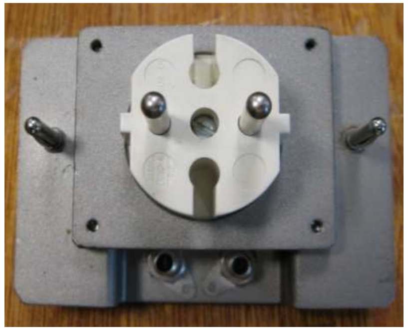
The correction to be applied is calculated by taking into account the input reflection coefficient Γ_{in} measured by the VNA and the S matrix of the adapter.

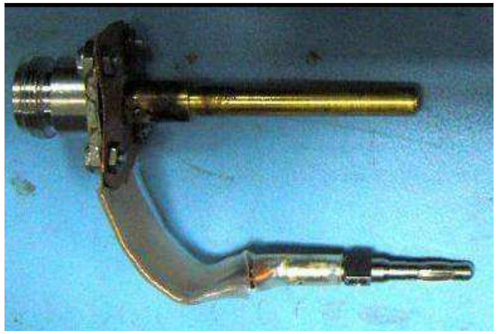
- Calibration and measurement plane is different
- Use of an homemade adapter whose input impedance is unknown
- No calibration kit exists to make the calibration at the input of the EUT port



$$\Gamma_{LISN} = f(S_{11}, S_{12} S_{21}, S_{22}, \Gamma_{in})$$

Undefined adapters – poor reliability & reproducibility











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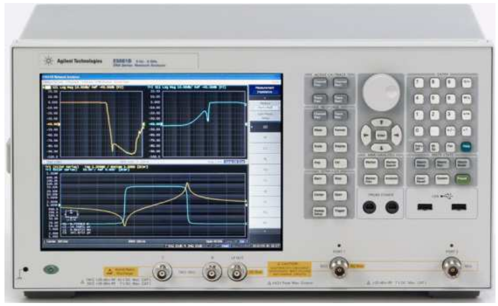
Impedance calibration comparison

- Impedance calibration of ESH2-Z5 using 3 different adapters
- Measurements were done using E5061B.
  - Compensation at the end of VNA cables (adapter influence not included)



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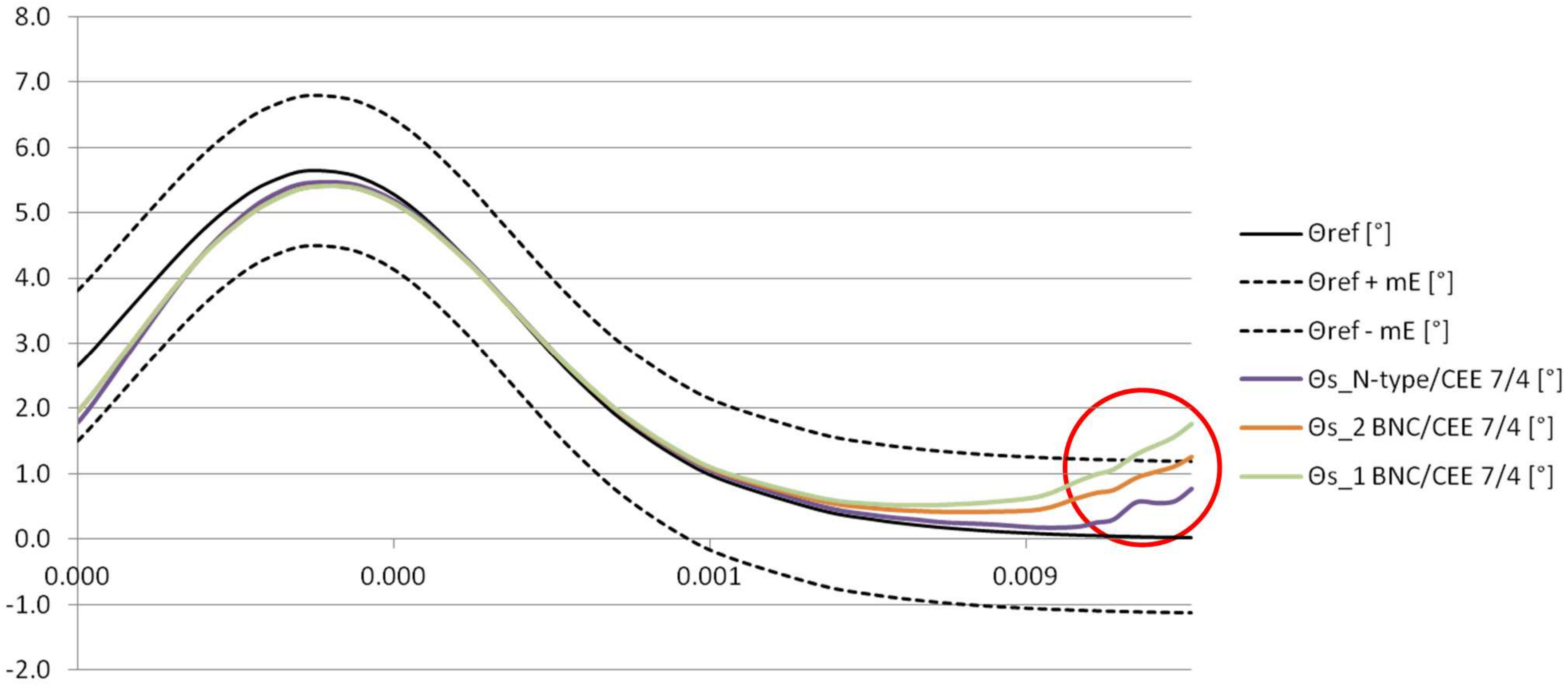
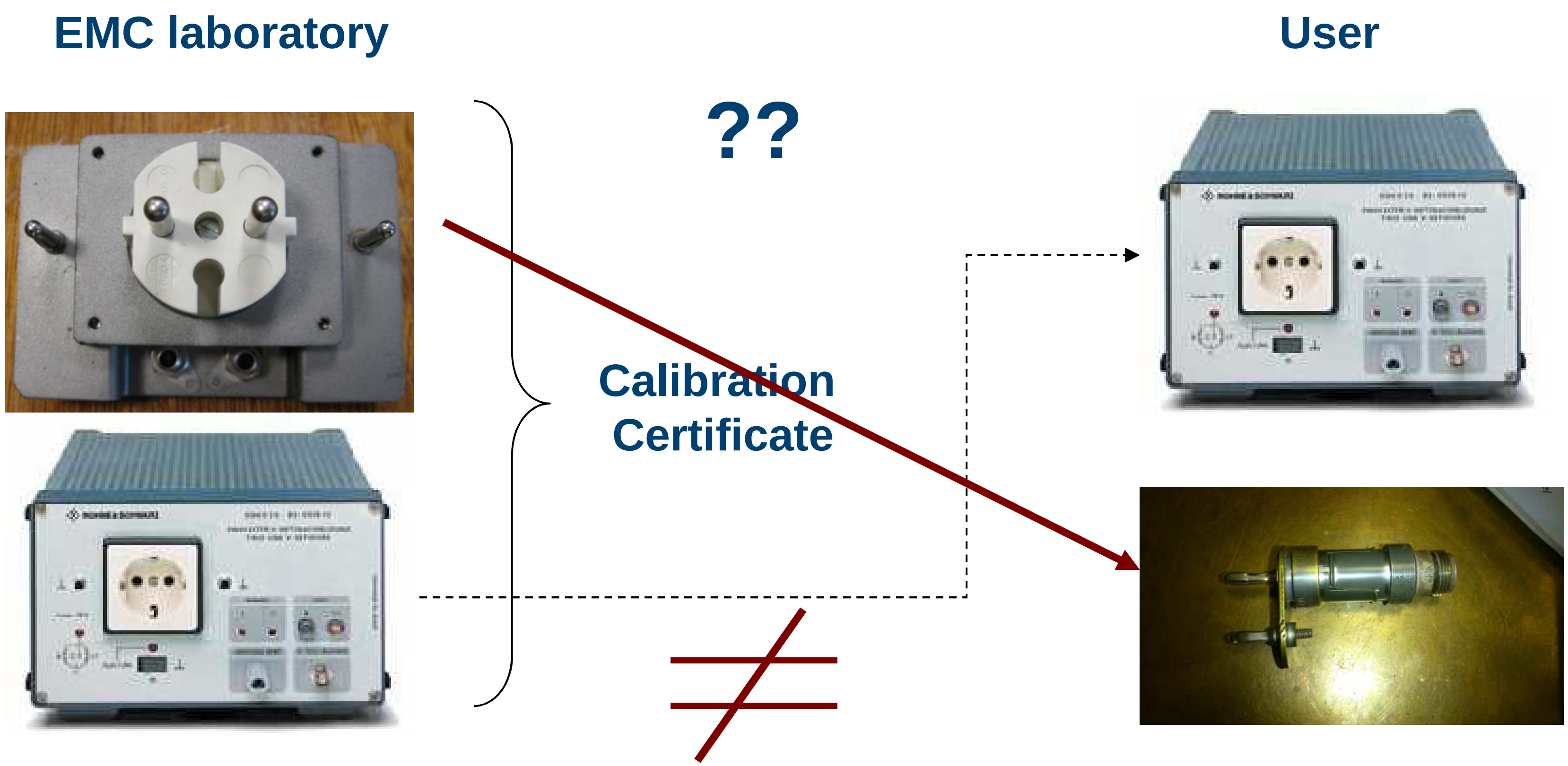
Phase calibration comparison :Results

- Example of phase measurement comparison
- Newly developed adapter is the only one within specification at higher frequecies according to the CISPR 16-1-2
- New adapter is the most suitable for higher frequencies



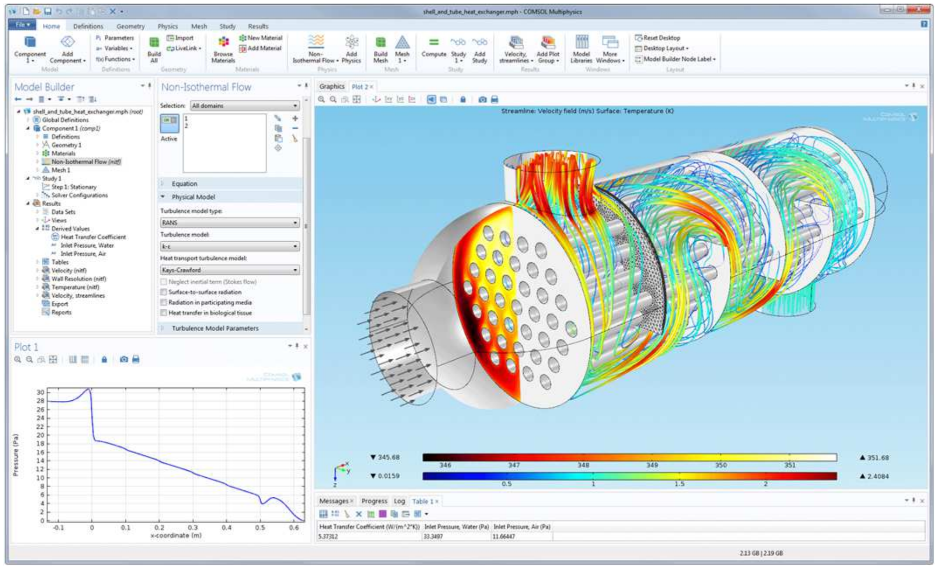
Lost traceability

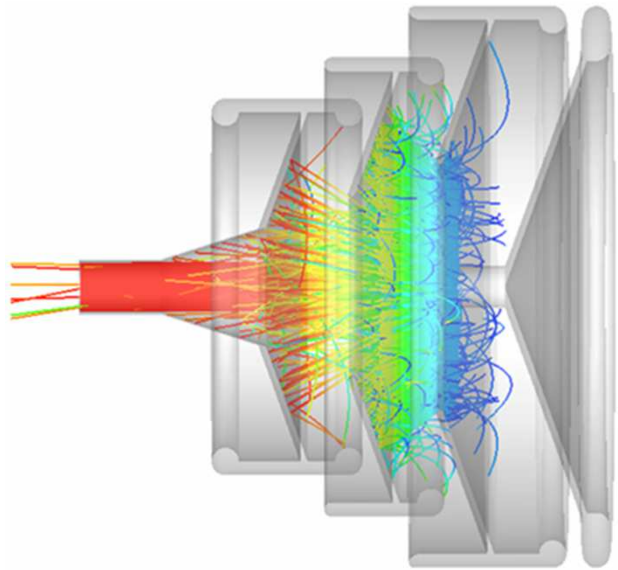
- LISN: poor reproducibility and reliability
  - For the same device, EMC laboratory measurements are performed with an adapter and the user performs his tests with the LISN network with another adapter without applying any corrections.



Adapter development: 3 different methods

- Aim: S-matrix of the adapter (for each frequency)
- 3 methods (COMSOL, CST Microwave Studio and MATLAB)
- Simulation are in good accordance





Adapter N-type/CEE 7/4

$$(S)=\begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix}$$

- Material: brass + gold plated
- Dielectric is macor εr = 6
- Effectively remove the systematic errors from the measured data (directivity effects, cable losses, mismatches)

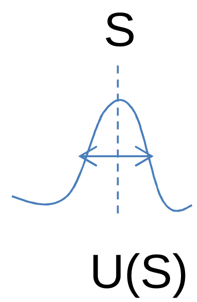
VNA site

AMN site

Recalculation and uncertainty

- S matrix of the adapter obtained
- Recalculation of „true“ reflection coefficient on measurement plane
- Uncertainty was evaluated using Monte Carlo method

Monte Carlo



$$\left(S\right)=\begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix} \Rightarrow \Gamma_{\mathrm{LISN}}=\frac{S_{11}-\Gamma_{in}}{S_{22}\left(S_{11}-\Gamma_{in}\right)-S_{12}S_{21}} \Rightarrow Z_{\mathrm{LISN}}=Z_0\frac{1+\Gamma_{\mathrm{LISN}}}{1-\Gamma_{\mathrm{LISN}}}$$

Adapter S matrix

Recalculation of reflection coefficien

Impedance

Impact of the adapter is removed

- Impact on magnitude: 0.5 Ω(*f*=30 MHz)
- Impact on phase: 2.8° (*f*=30 MHz)
- Type A: 0.01 Ω and 0.03° (repeatability)
- Type B: 0.24 Ω and 0.32° (systematic error of the method)
- Uncertainty (k=2) 0.50 Ω; 0.65 °

CISPR 16-1-2	**Results of measurement and results of corrected measurement of the impedance magnitude (Ω) at 30 MHz**			
	VNA Measurement	*CST*	*COMSOL*	*ANALYTIC*
49.99	43.63	43.10	43.12	43.24
CISPR 16-1-2	**Results of measurement and results of corrected measurement of the impedance phase (°) at 30 MHz**			
	VNA Measurement	*CST*	*COMSOL*	*ANALYTIC*
0.30	7.99	5.13	5.24	5.24

Impact

- Error correction method for removing systematic error developed
- Published paper in:
  - CPEM 2014
  - IEEE Transaction on Instrumentation and Measurement (2015)
  - EMC Europe 2015
- Few adapters were already sold to calibration laboratories
- Output of this task is discussed in CISPR/WG1/A about LISN calibration issues