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# Measurement and Evaluation of Notches for NB-PLC Devices

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# Background

- Narrowband power line communication selected for Smart-Meter roll-out in Austria
- Up to now no harmonized EMC-standard for the selected frequency band (FCC) exists
- CE certification based on notified body is possible
- Risk analysis for usage of the frequency band was done
  - ➔ Interference with aeronautical navigation and amateur radio is possible
  - ➔ Notching of selected frequencies by communication standard is supported
- Notching not yet implemented by manufacturers
- Tender of utilities require notching with a defined quality
- Verification during prequalification tests required
- Measurement process proposed by communication standard is not applicable
- New test process has to be defined and implemented
  - Test environment: ETSI TS 103 909, *Power Line Performance Test Method Guide*
  - Measurements based on MATLAB calculation

# Test environment: ETSI TS 103 909

## Filter:

- Disturbance from line
- > 90dB atten. TX → RX

## V-Network:

- LISN ( $50\Omega \parallel 5\Omega + 50\mu\text{H}$ )

Realistic Line Impedance for TX  
(CENELEC A-Band, not used)

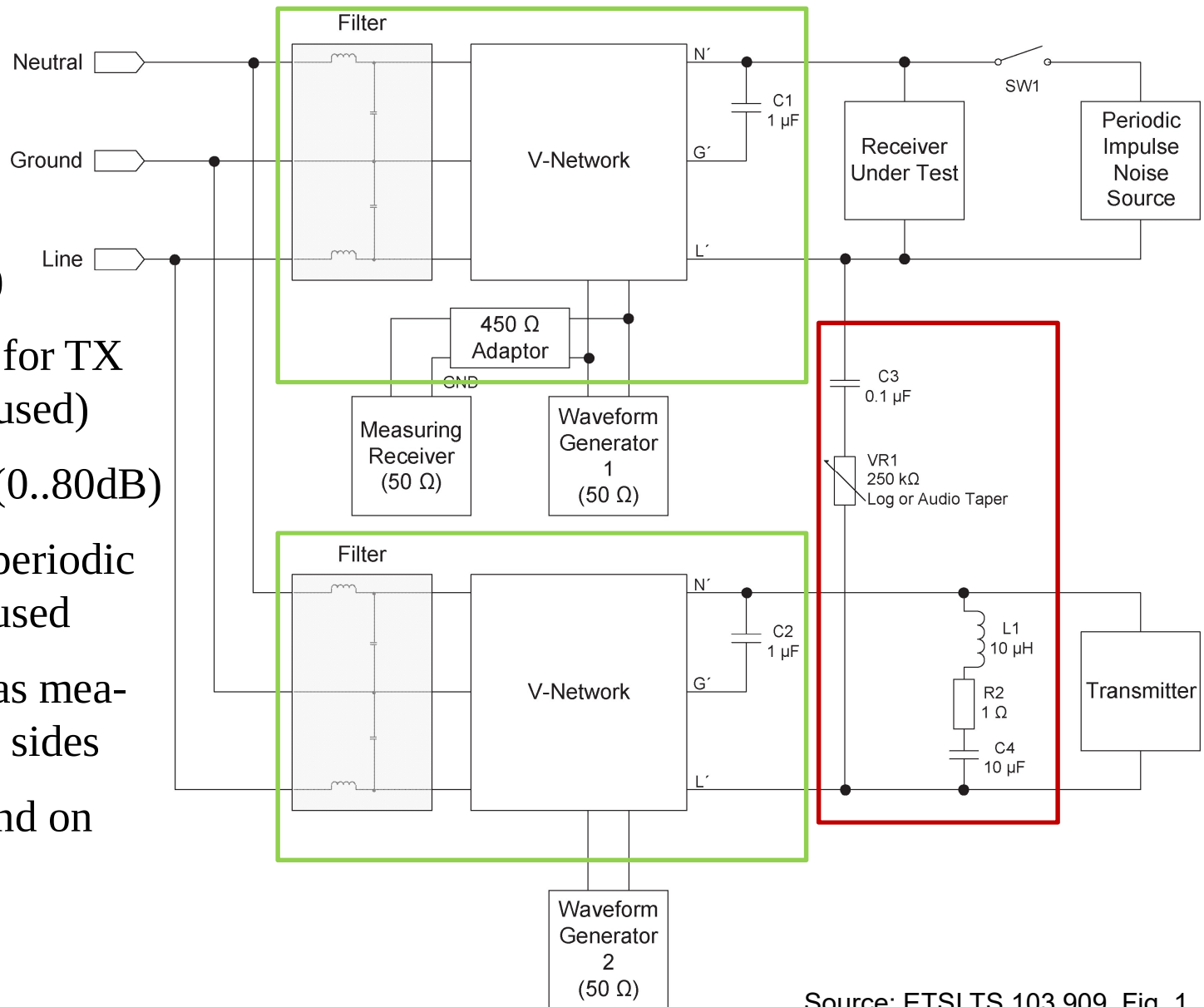
Configurable attenuation (0..80dB)

Waveform generator and periodic impulse noise source not used

PICO 4824 Oscilloscope as measurement receiver on both sides

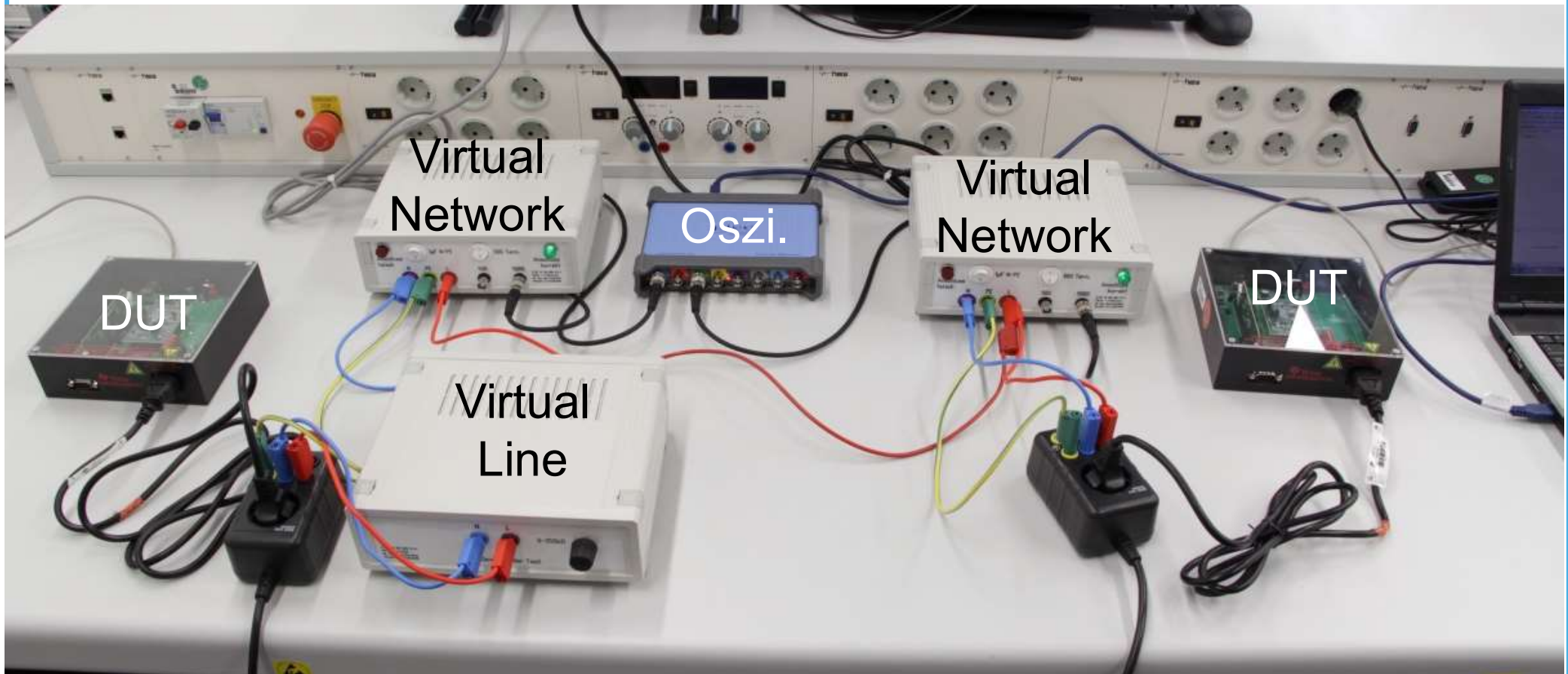
450 Ω adaptor modified and on both sides

Integrated in 3 boxes



Source: ETSI TS 103 909, Fig. 1

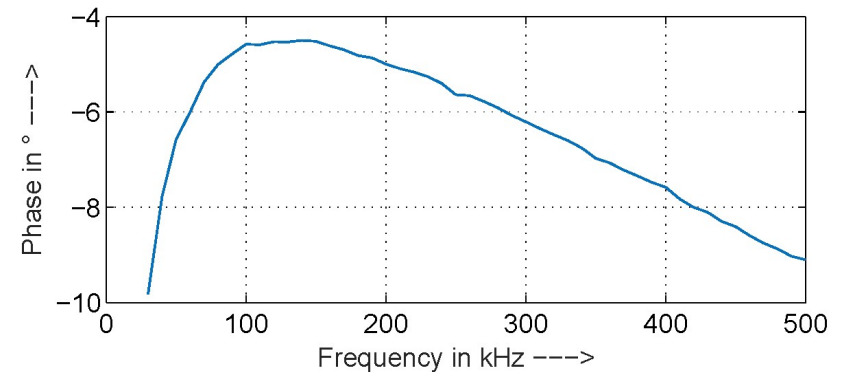
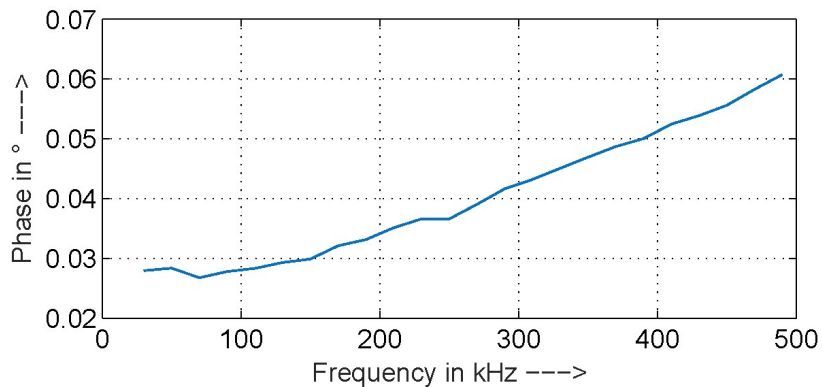
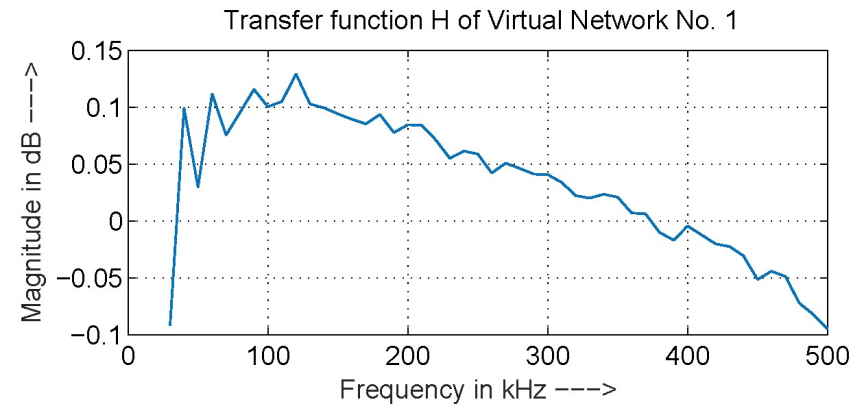
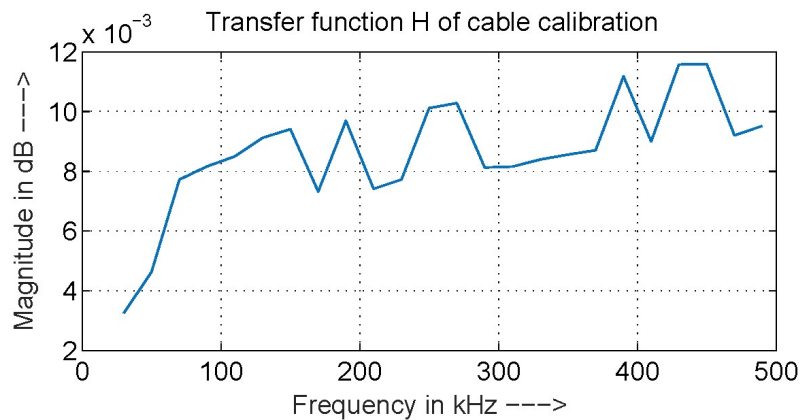
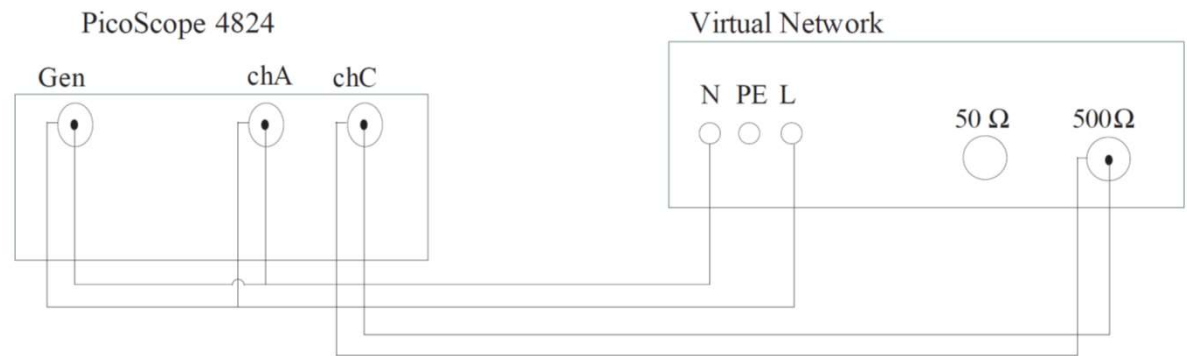
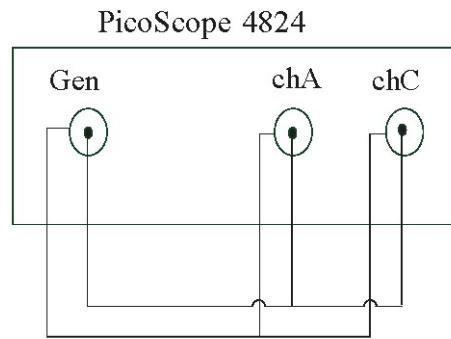
# Test- Setup



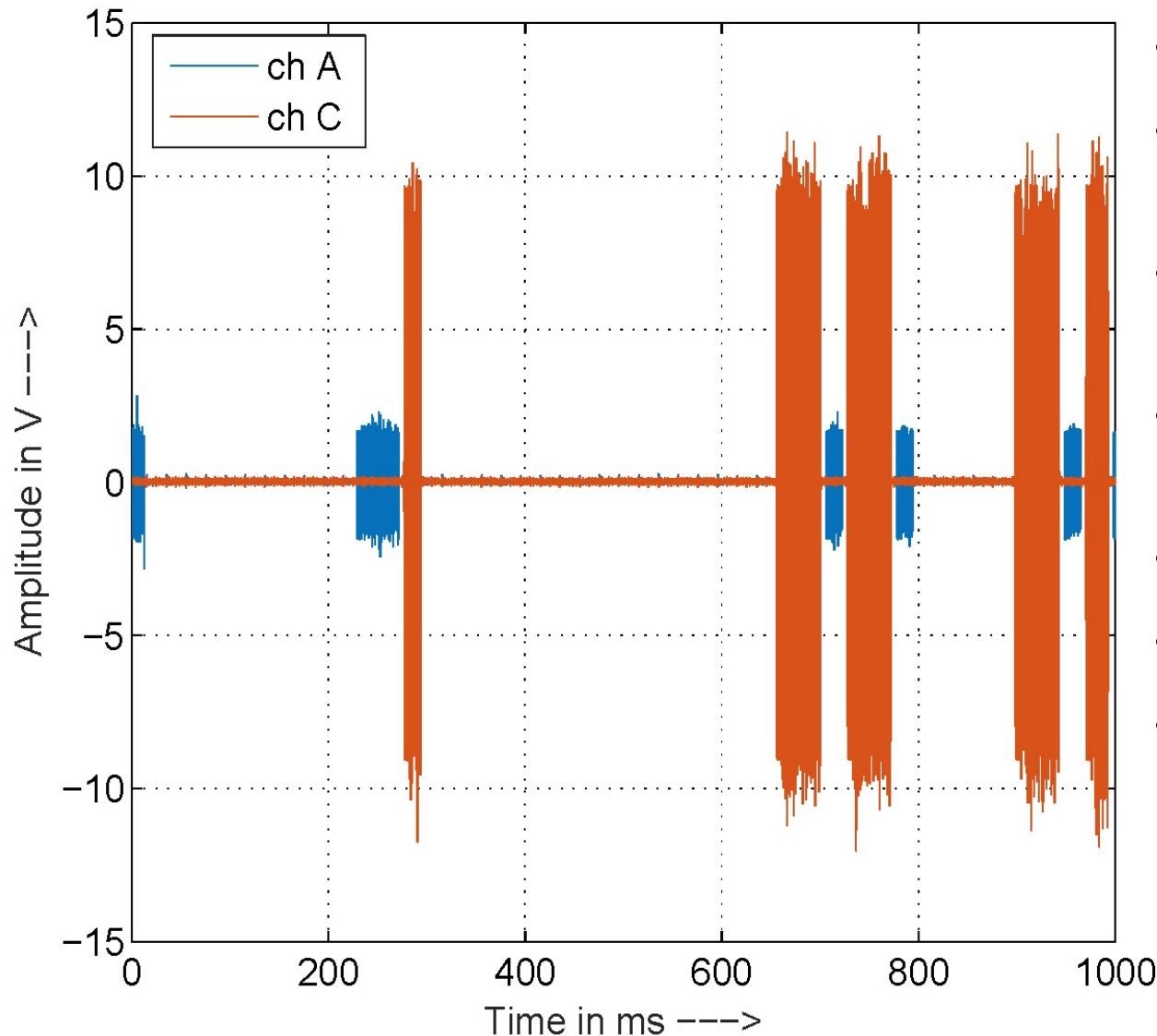
Required calibration measurements:

- Verification of isolation from line ( $> 90$  dB attenuation between DUTs)
- Characterization of network between DUT and Oscilloscope
- Available network analyzer did not fulfill requirements

# Verification of network compensation between DUT and Osci.

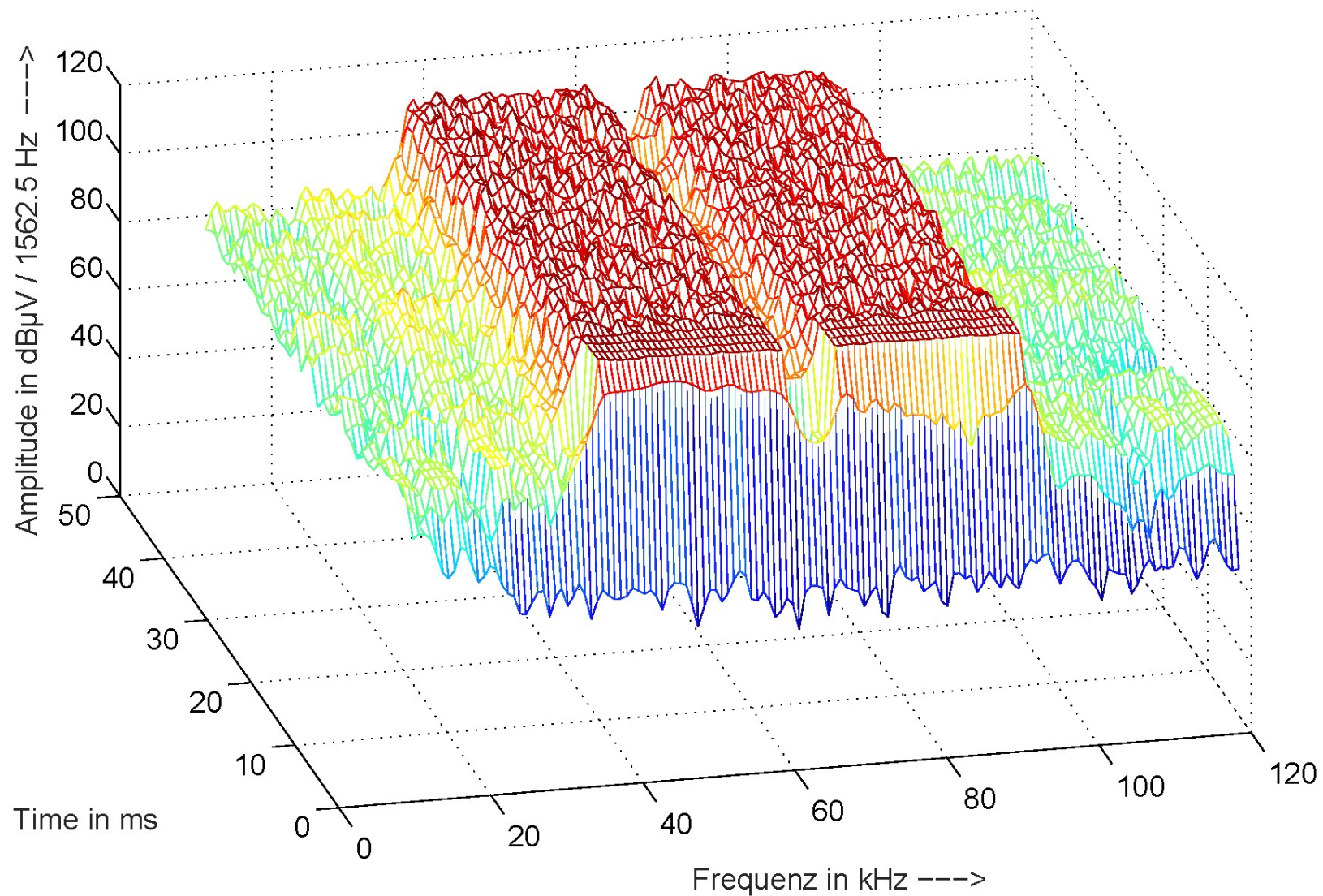


# Transmitted signal by two different DUTs



- Sampling frequency: 10 MHz
  - Period of 1 second stored
  - Selection of telegrams for analysis is done manually
  - Strong attenuation (50-60 dB) separates DUTs
  - Presented Signals are without attenuation
  - Real line impedances not used
  - DUTs use CENELEC A-Band
  - DUTs see LISN as for certification of EN 50065-1
- ➔ **Strong differences in magnitude of TX-Signals**
- ➔ **Allowed signal levels often not used**

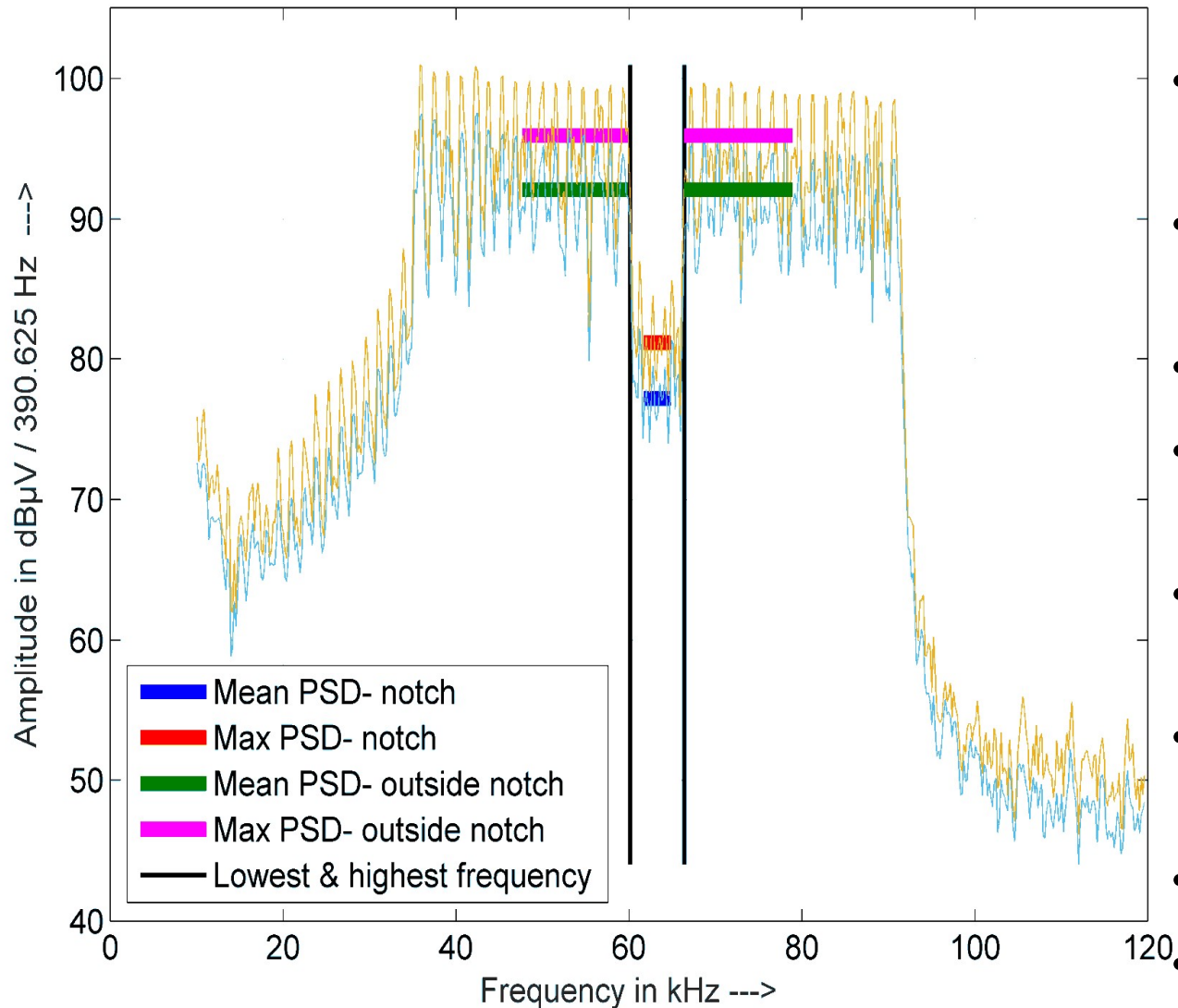
# 3D-Spectrogram Notch Analysis



- **Measurements observed, notch was not present all the time!**

# Power Spectrum Density (PSD) Notch Analysis

(Notch max: 14.7796 dB, Notch mean: 14.8993 dB)



- CENELEC A-Band modems used (availability)
- Digital implementation allows transfer of result
- Subcarrier index 39-42 suppressed
- Subcarrier spacing 1,562 kHz
- Several power spectrum density analysis performed
- Mean and max value of each frequency point calculated
- Mean values within selected frequency range used
- Notch:  $f_c \pm 1 \cdot \Delta f$
- Outside:  $f_o \dots f_o + 8 \cdot \Delta f$   
and  $f_u \dots f_u - 8 \cdot \Delta f$

## Results

- Notch deep of 14 – 16 dB expected by simulations
- Notch deep of 12 dB sufficient to avoid interference with aeronautical navigation
- Notch deep of 13 dB requested in tender of utility
- All measured modems have notch deep  $> 13$  dB and  $< 17$  dB

→ **Requirements of risk analysis can be achieved**

- IEEE Standard 1901.2-2013 require notch deep  $> 20$  dB

→ **Certification of notching based on IEEE Standard 1901.2:2013 is not possible**

- G3-PLC devices bases on ITU-T G.9903
- ITU-T G.9903 references for PSD requirements ITU-T G.9901
- ITU-T G.9901 require notch deep  $> 25$  dB

→ **Certification of notching based on ITU-T G.9901 and ITU-T G.9903 is not possible**



# Measurement Setup for Notch Evaluation of Narrowband PLC Devices

