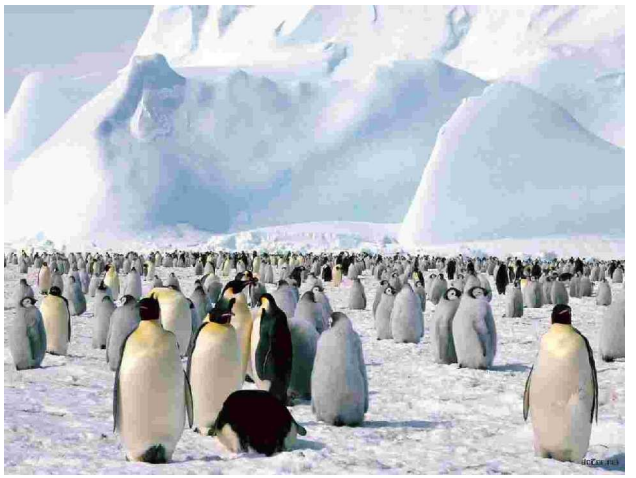
NMDG
LEADING BEYOND S-PARAMETERS

Contactless loop probes @ ICE

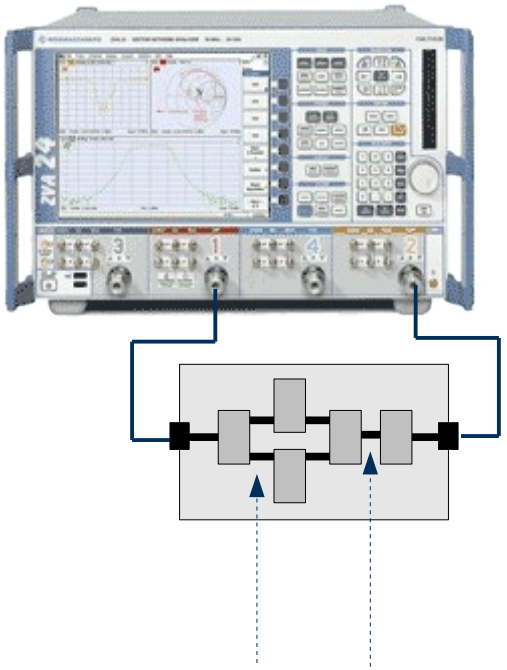
using loop probes for in-circuit voltage and current time-domain and impedance measurements



6/2012

Summary

Goal: accurate in-circuit measurement of time-domain voltage and current and impedance using one or more loop probes within a large-signal network analysis context at locations normally unreachable using a vector network analyzer.

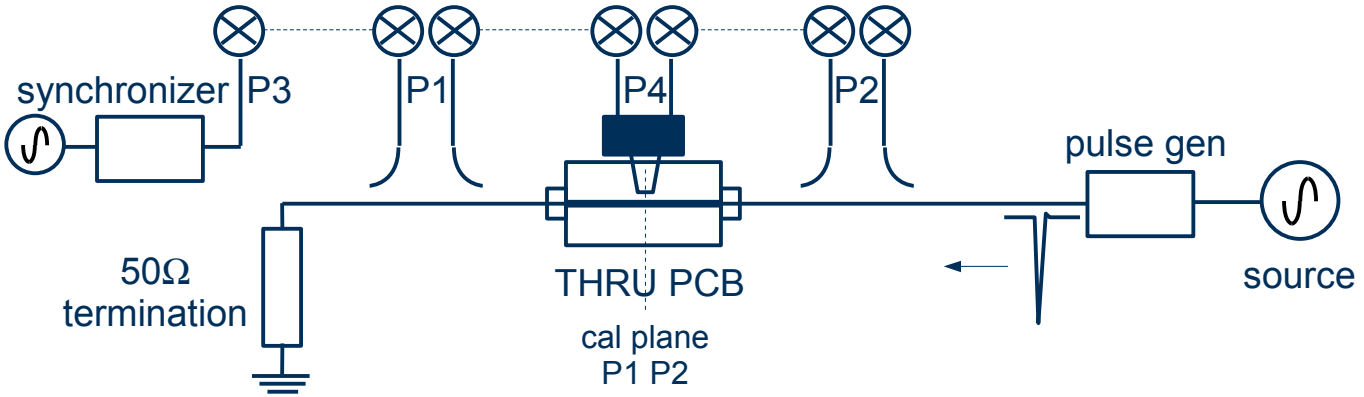


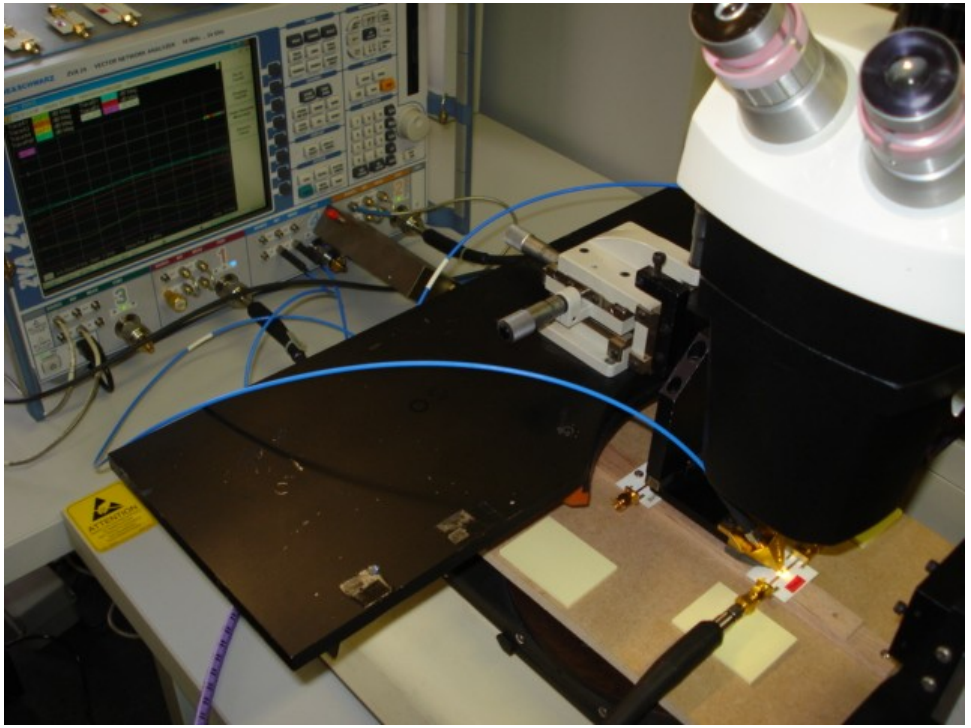
Supported:
- Multiple probes
- Probing on PCB

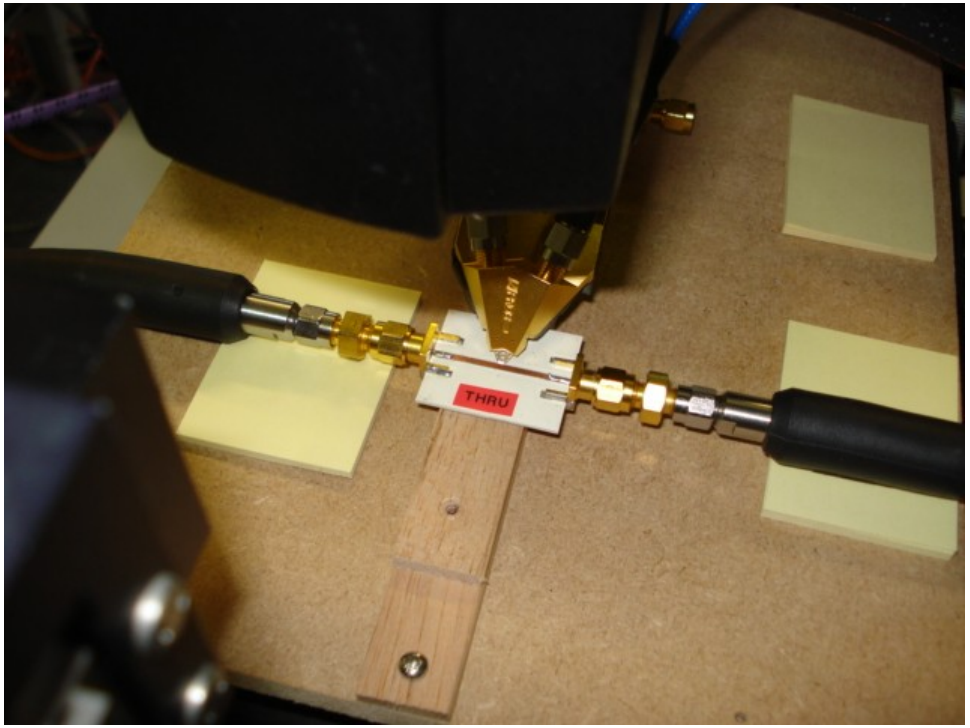
What are the voltage and current waveforms in-between the components?

How to measure these accurately? Apply proper calibration techniques
How to minimize their disturbance? Use loop probes

Measurement using calibrated loop probe on thru



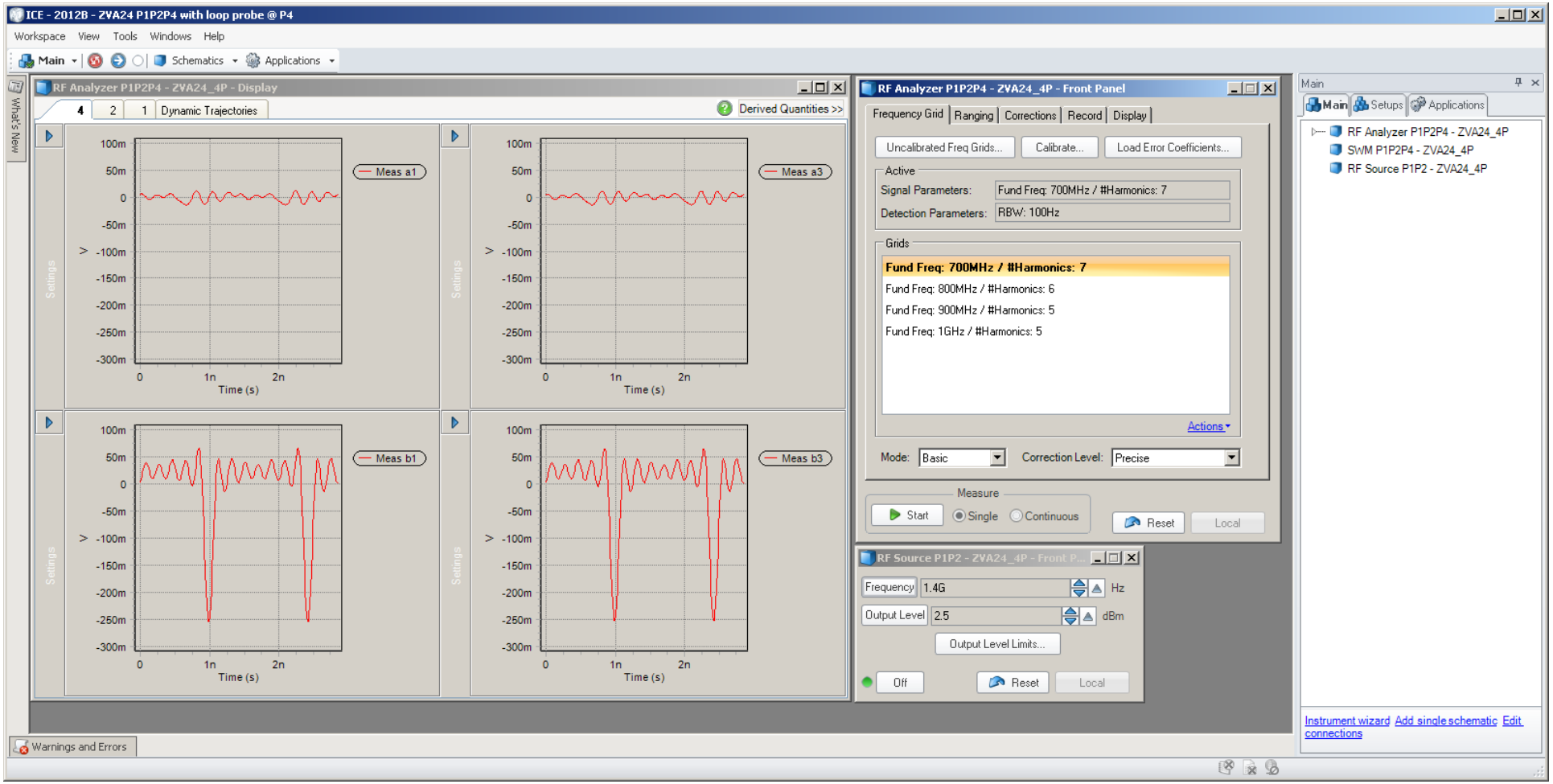




The loop probe which was used to perform the measurements was kindly provided by Rosenberger HF-Technik

Pulse measurement in 50 Ohm

measurement of pulse applied @ 700 MHz to THRU
via “Source In” @ P2 while load connected to “Source In” @ P1



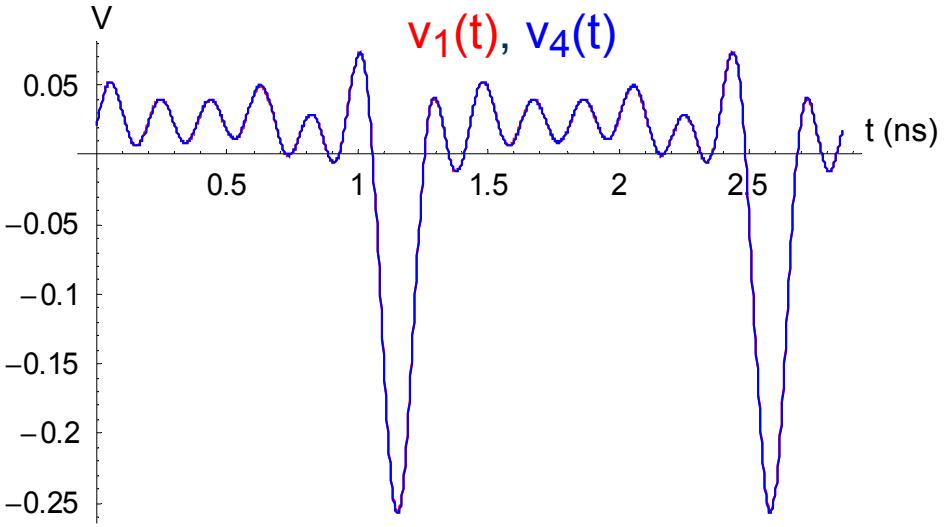
measurement
@ primary cal P1

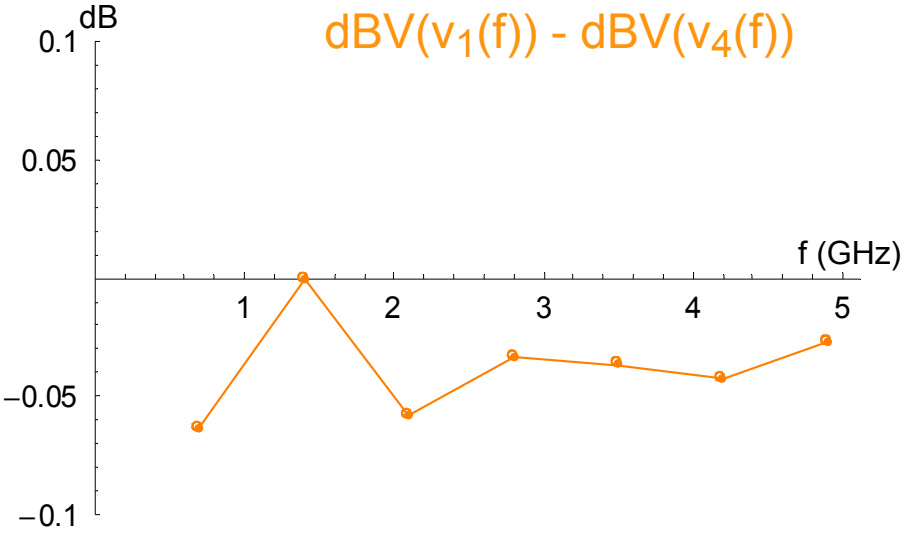
measurement
using probe @ P4

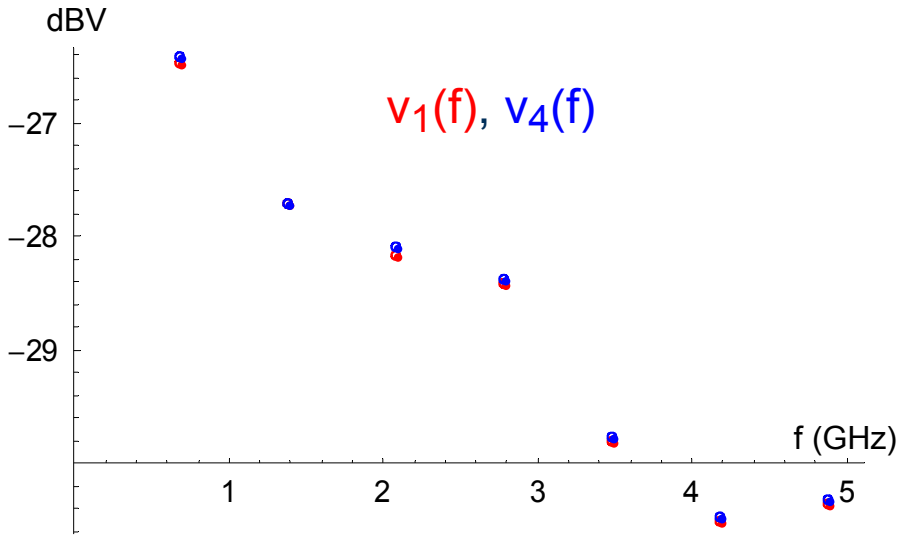
measurement
700 MHz .. 4.9 GHz

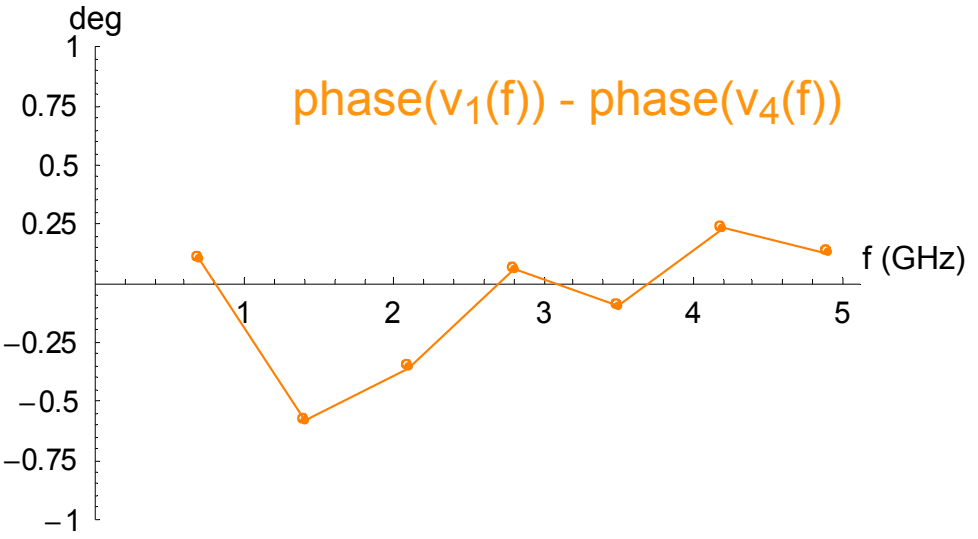
Pulse @ thru : quantify voltage difference @ 700 MHz .. 4.9 GHz

excellent agreement between voltage measured using coupler @ P1
and voltage measured by calibrated loop probe @ P4



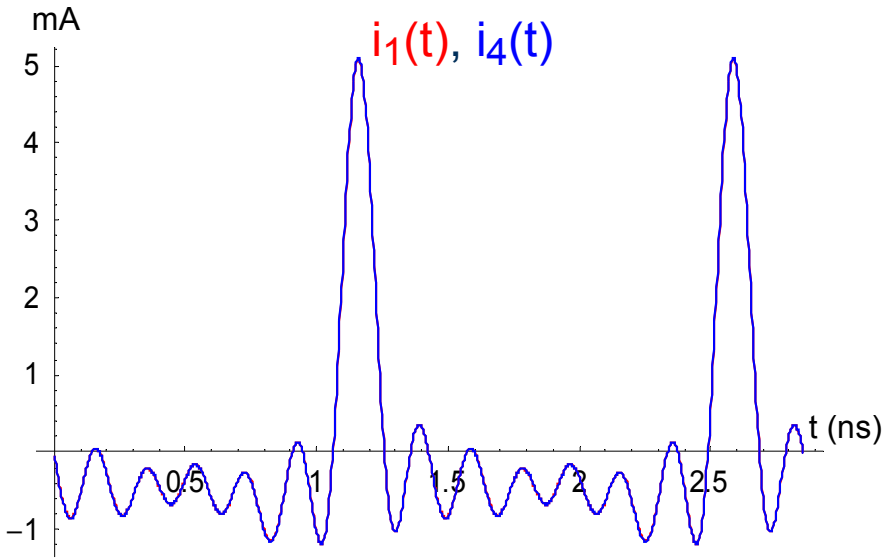


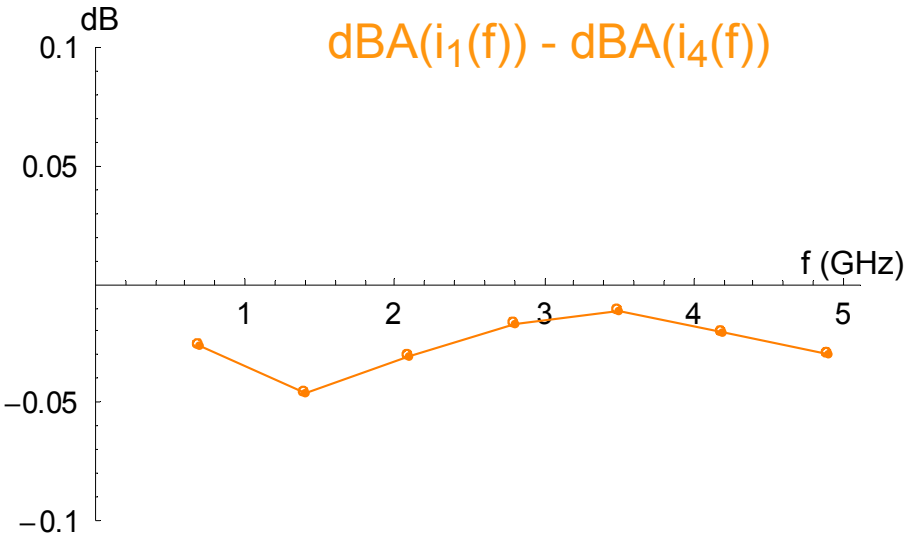


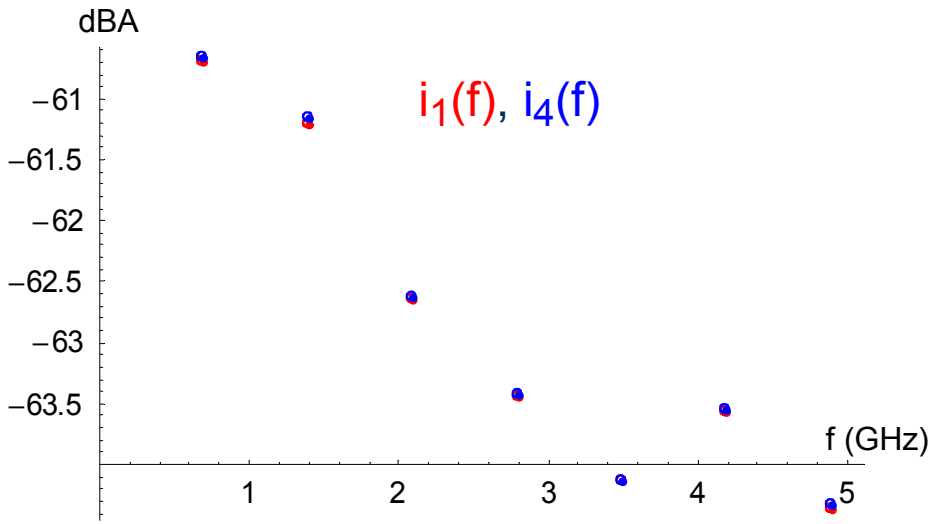


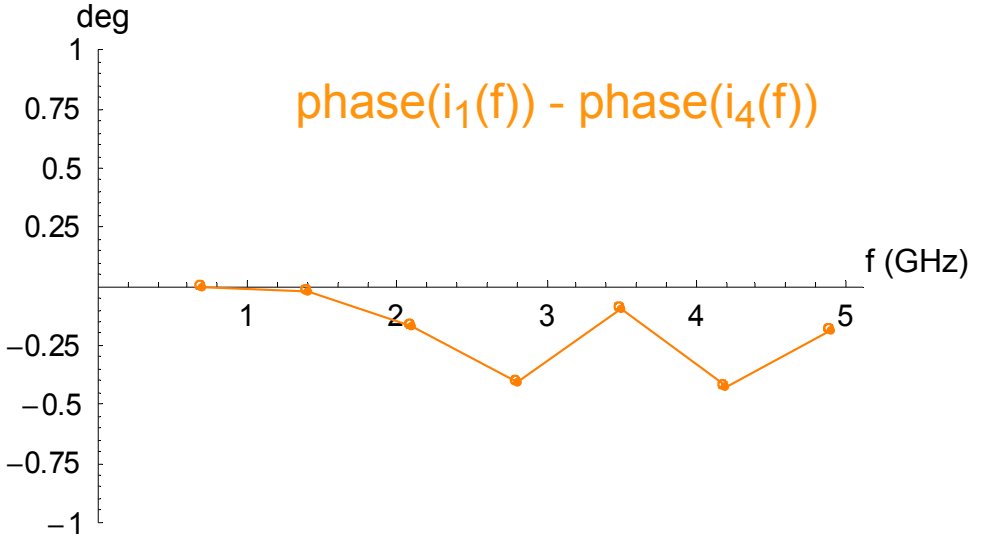
Pulse @ thru : quantify current difference @ 700 MHz .. 4.9 GHz

excellent agreement between current measured using coupler @ P1
and current measured by calibrated loop probe @ P4

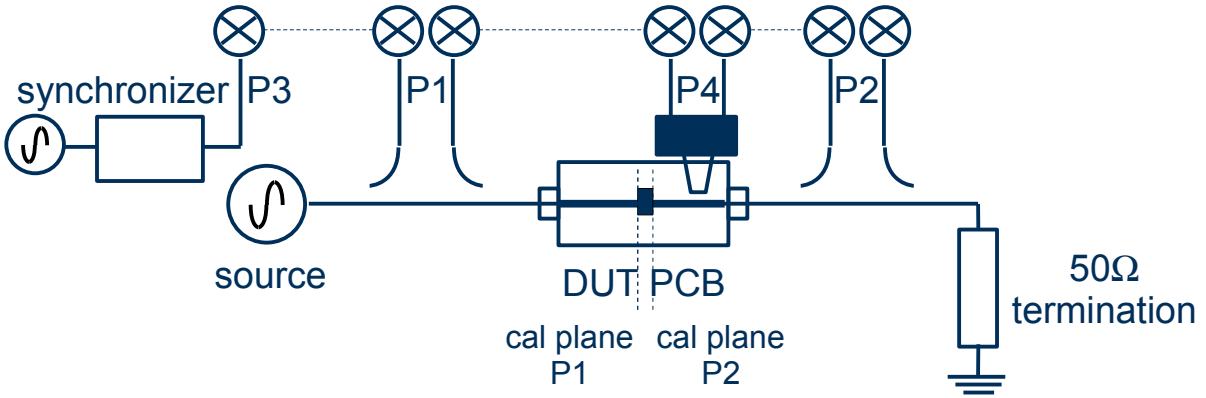


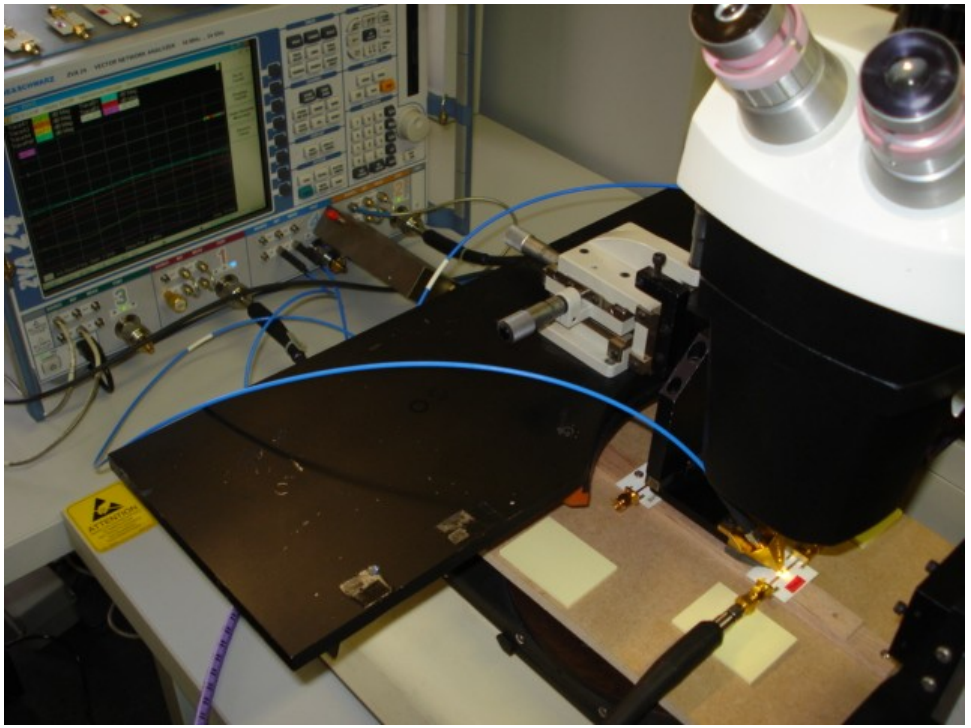


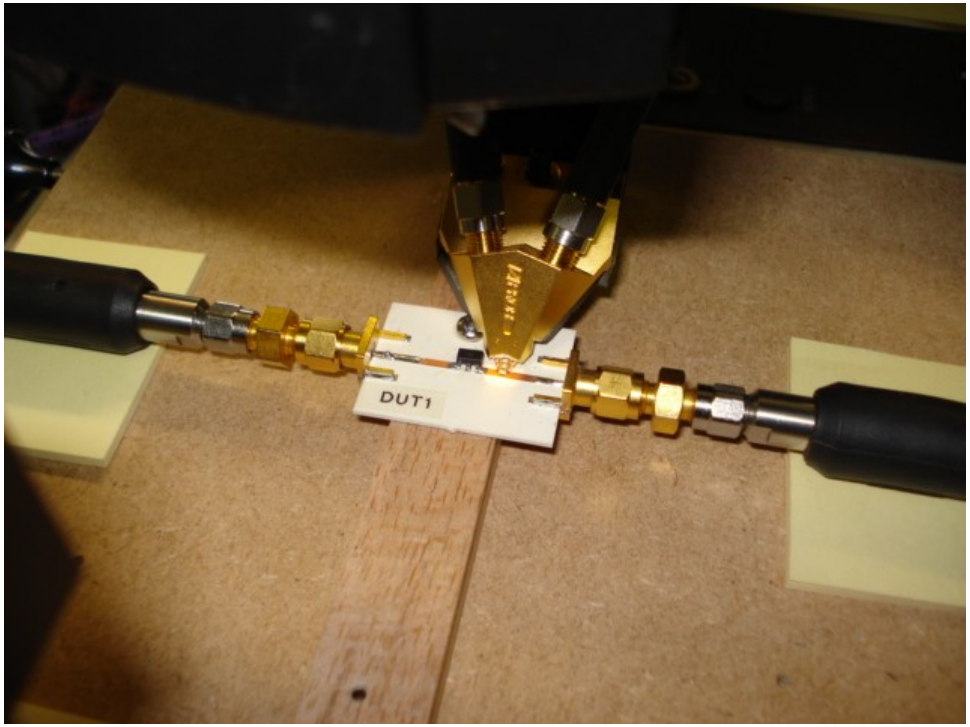




Measurement using calibrated loop probe on FET

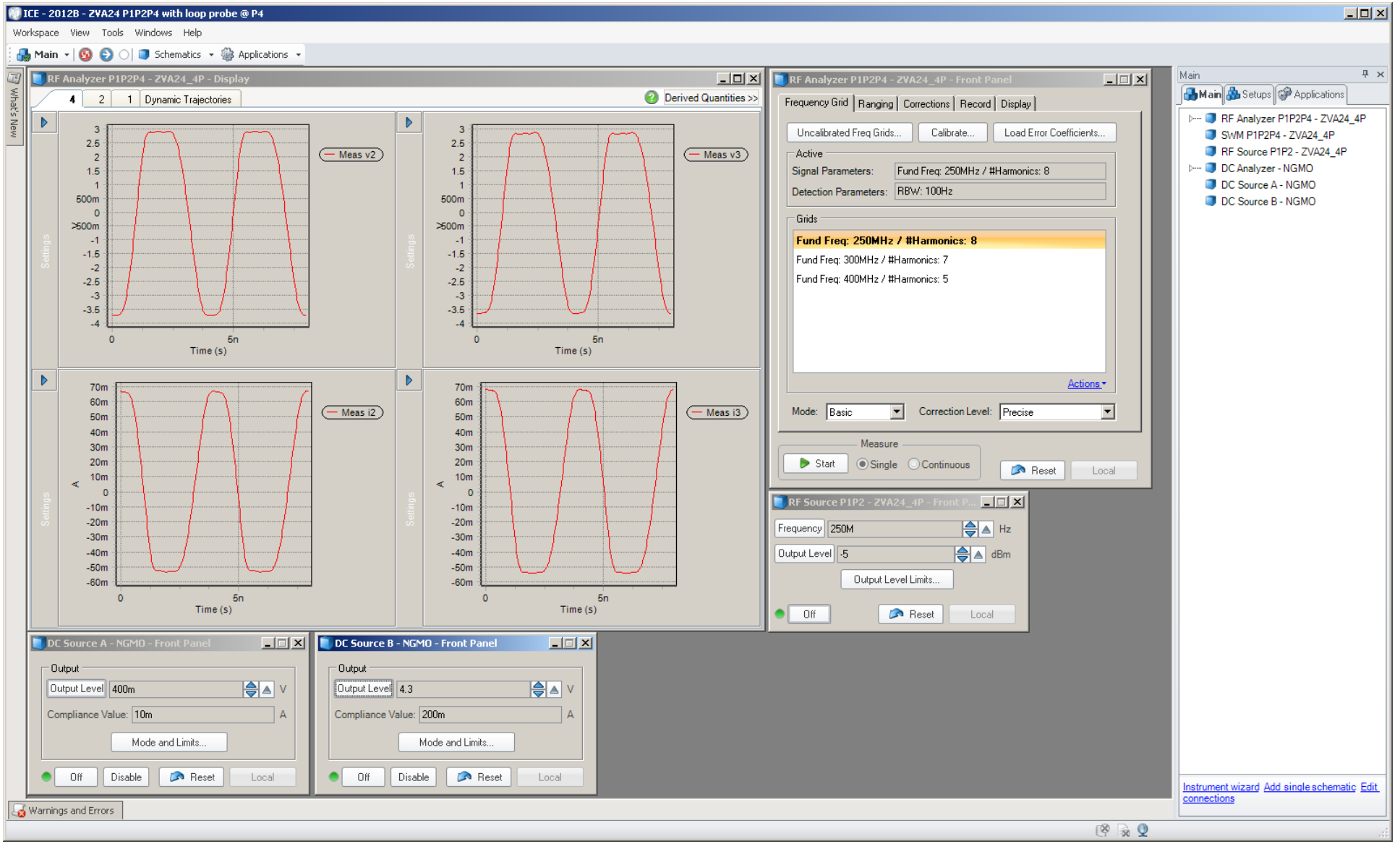






The loop probe which was used to perform the measurements was kindly provided by Rosenberger HF-Technik

E-pHEMT FET pinch-off measurement in 50 Ohm



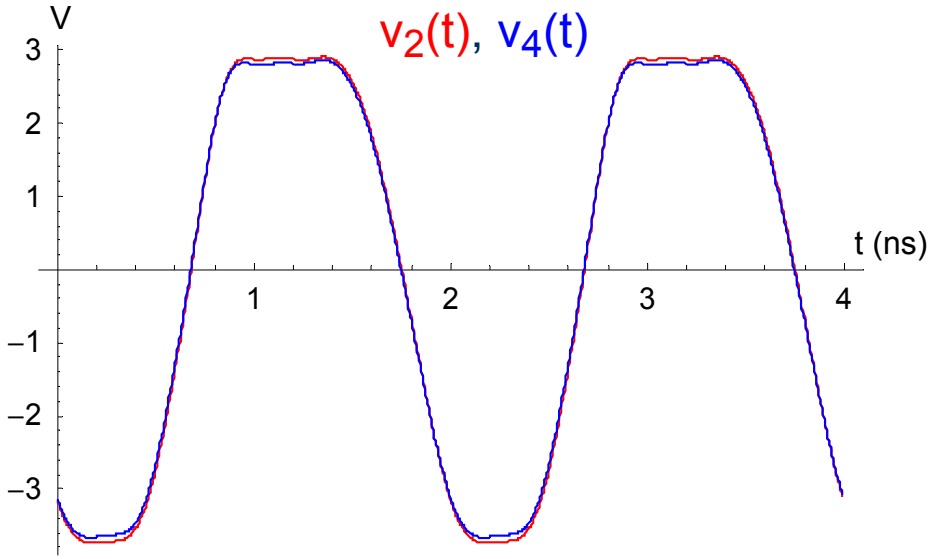
measurement
@ primary cal P2

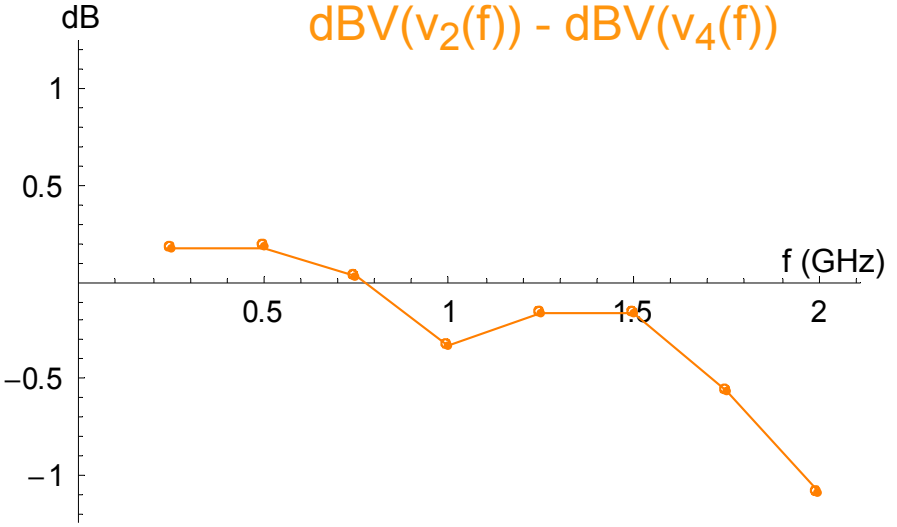
measurement
using probe @ P4

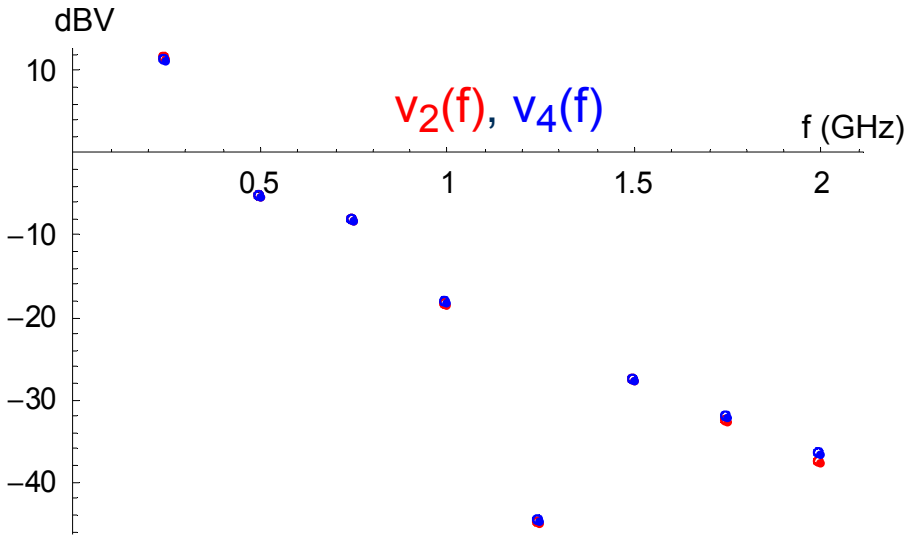
measurement
250 MHz .. 2 GHz

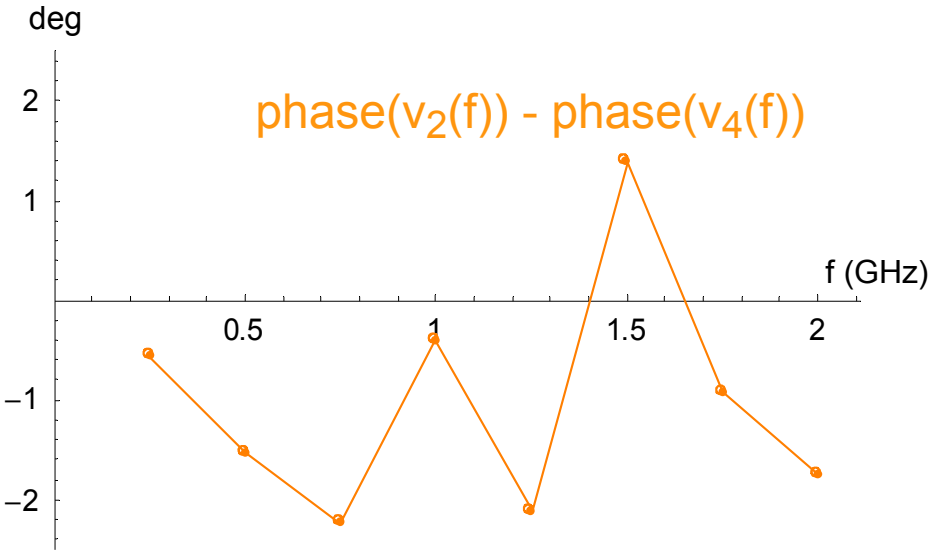
E-pHEMT : quantify voltage difference @ 250 MHz .. 2 GHz

very good agreement between voltage measured using coupler @ P2
and voltage measured by calibrated loop probe @ P4





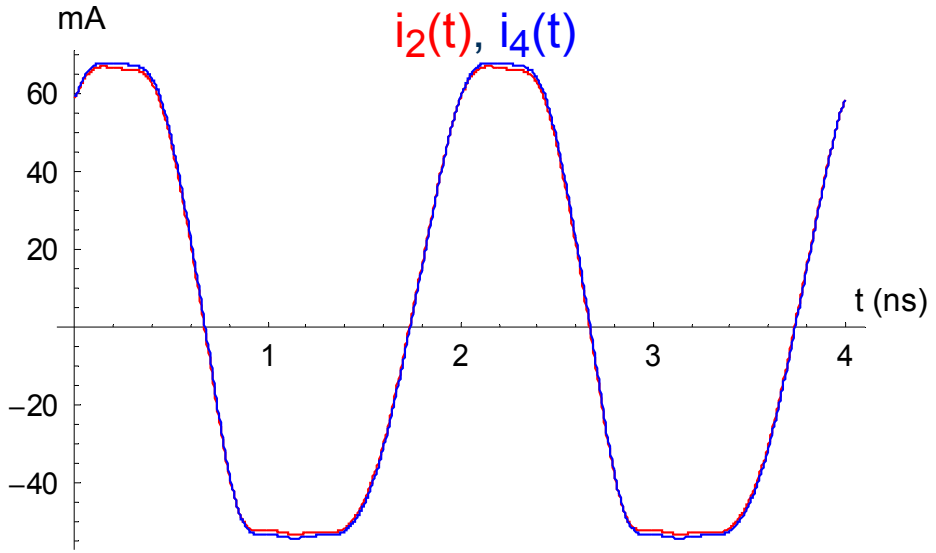


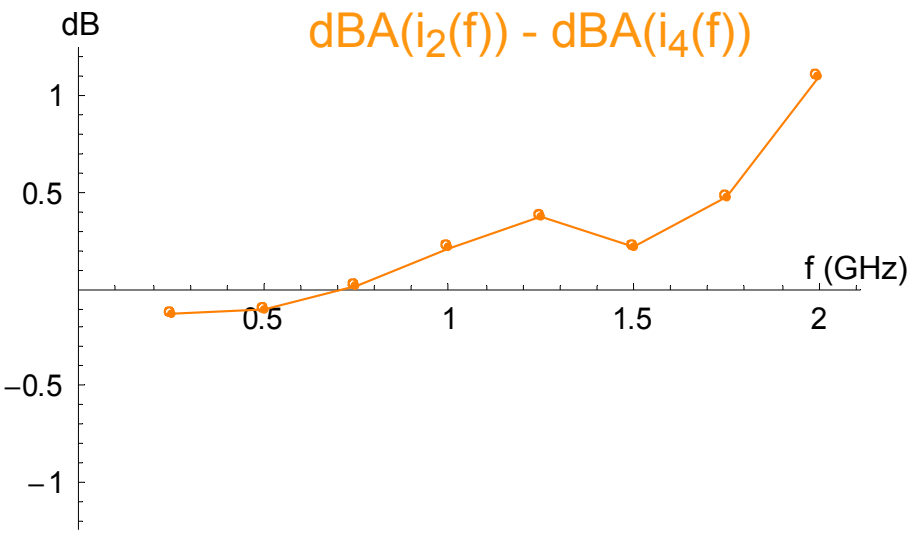


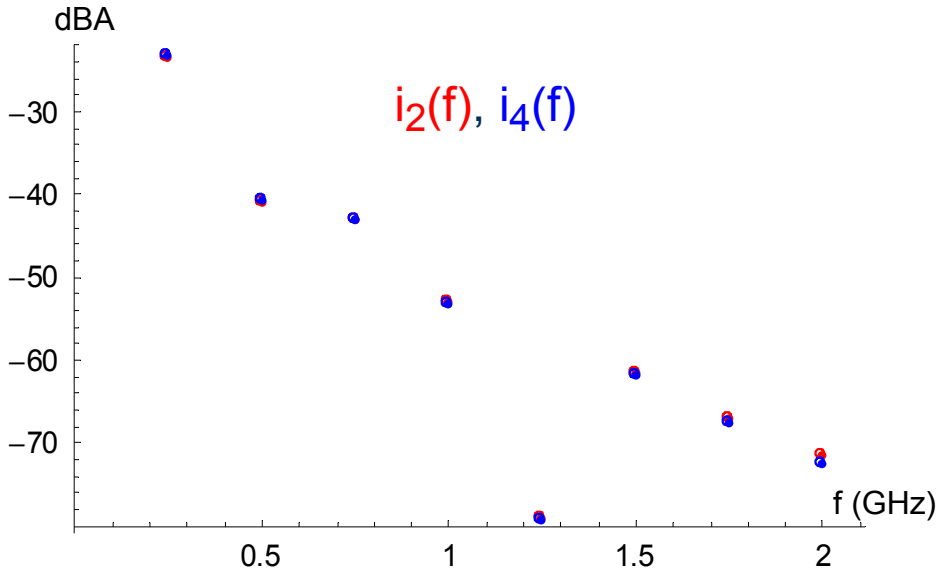
after elimination of 56.7 ps delay based on b2(f) and b4(f)

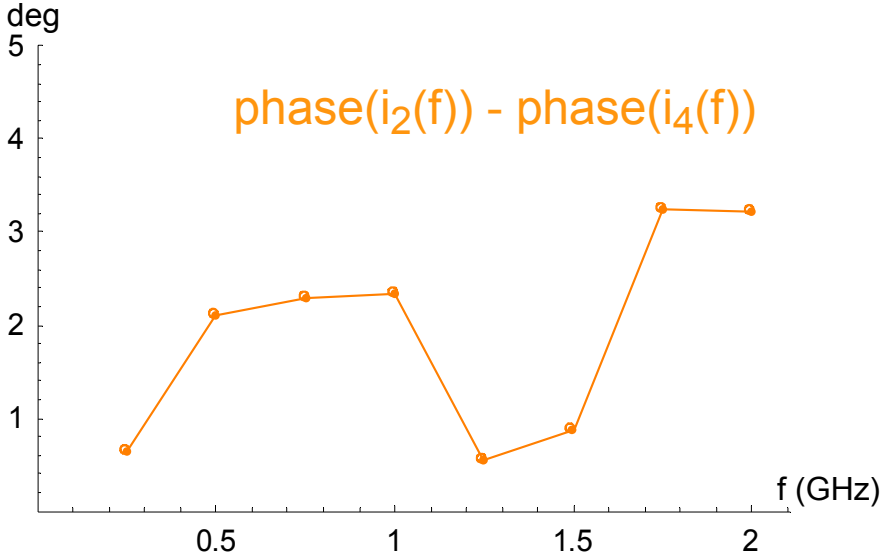
E-pHEMT : quantify current difference @ 250 MHz .. 2 GHz

very good agreement between current measured using coupler @ P2
and current measured by calibrated loop probe @ P4



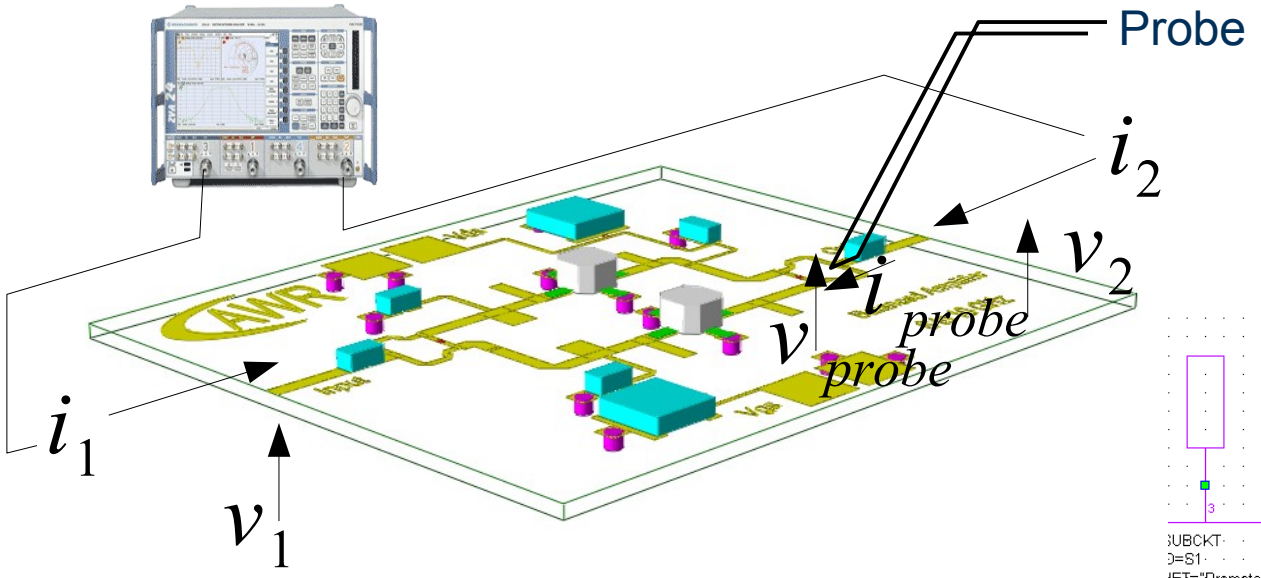


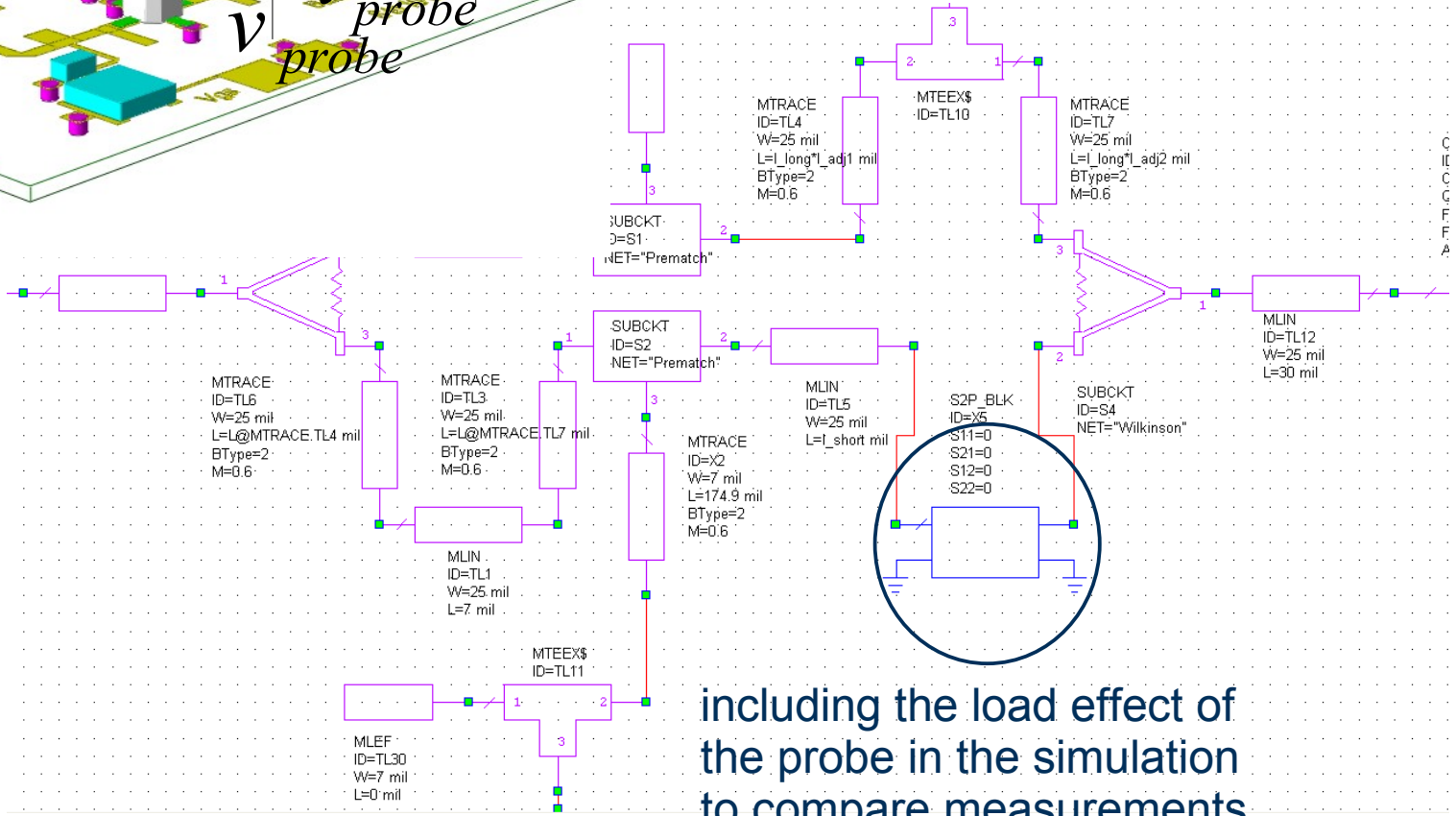




after elimination of 56.7 ps delay based on b2(f) and b4(f)

Including impact of loop probe during simulation





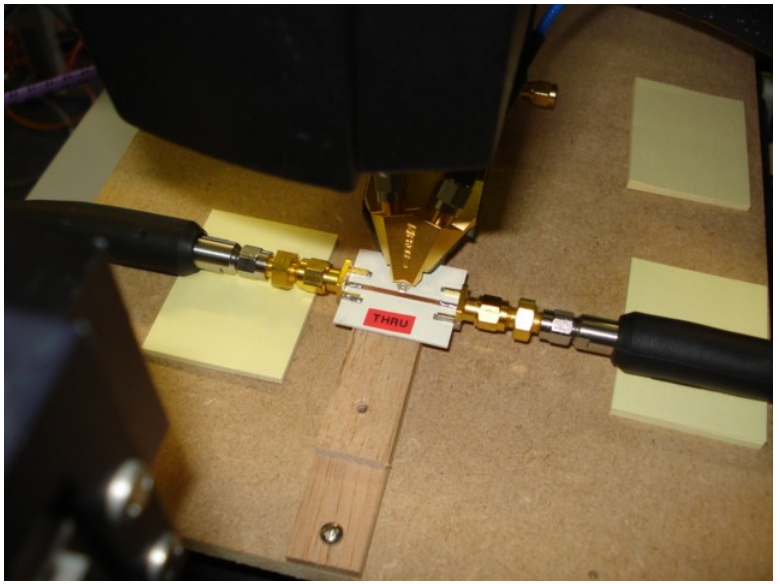
including the load effect of the probe in the simulation to compare measurements with simulations

Figure and schematic courtesy of AWR

Calibration process

- **Step 1:** perform a “standard” two-port TRL-based VNA calibration, extended with power and phase calibration to measure time-domain information

- **Step 2:** use the calibrated system resulting from step 1 to calibrate the loop probe by positioning it above the thru or middle of the line of the TRL calibration kit and applying different terminations to the two-port VNA



- **Step 3:** use the calibrated loop probe to measure the time-domain voltage and current (hence impedance) in-circuit

Acknowledgements and References

- NMDG wants to thank Rohde & Schwarz, Rosenberger HF-Technik and Prof. Dr.-Ing. Bernd Geck of the Institut für Hochfrequenztechnik und Funksysteme of the Leibniz Universität Hannover for their support

- “Contactless Scattering Parameter Measurements”, Thomas Zelder and Bernd Geck, IEEE Microwave and Wireless Components Letters, Vol. 21, No. 9, September 2011

- “Contactless Loop Probe”, Patent US 20110267088A1

Contact info

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at
info@nmdg.be