

TH1F 319-XE605

A D-Band Vector Network Analyzer Extension Module Based on a SiGe Reflectometer MMIC

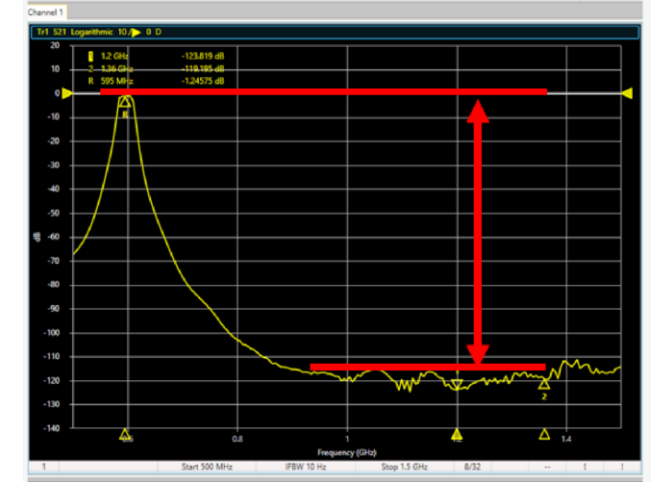
**J. Romstadt¹, S. Hauptmeier¹, T. T. Braun¹, A. Zaben¹,
M. Krüner¹, K. Aufinger², J. Barowski¹, N. Pohl^{1,3}**

¹Ruhr-University Bochum, Bochum, Germany

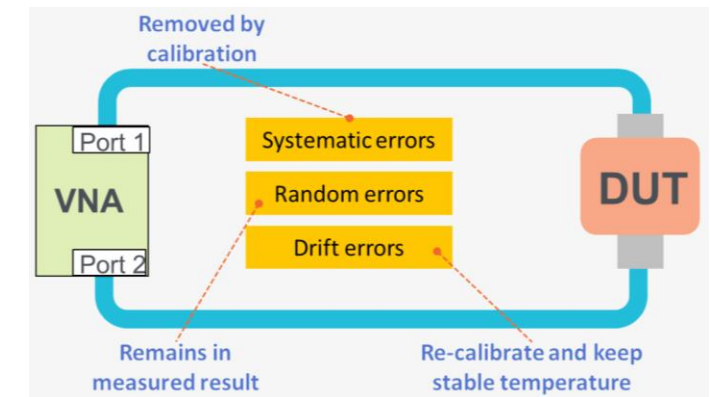
²Infineon Technologies, Neubiberg, Germany

³Fraunhofer FHR, Wachtberg, Germany

- Interest in D-Band (110 – 170 GHz) in research and industry rises
- Enabled by high-quality measurement technology
- Vector network analyzers used to characterize discrete and integrated circuits, systems, antennas, or materials
- Capability of calibration enables measurements with a high dynamic range

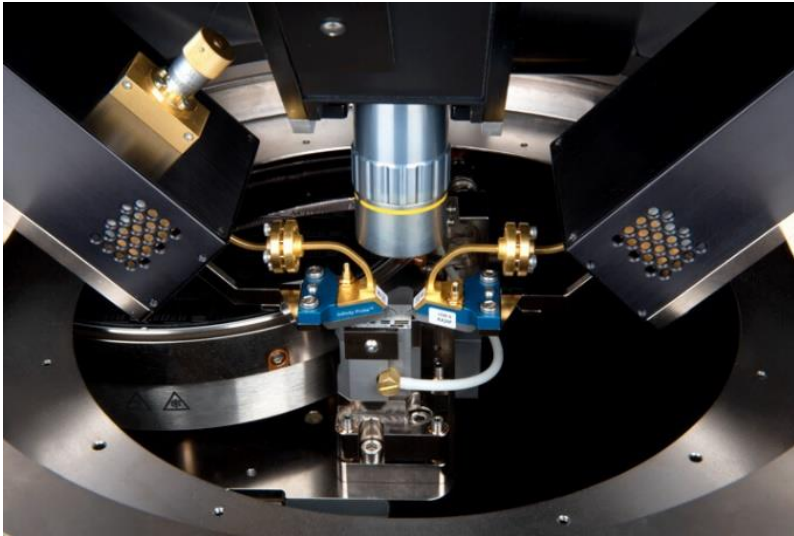


Tektronix, "Introduction to VNA Basics," March 2017
https://download.tek.com/document/70W_60918_0_Tek_VNA_PR.pdf

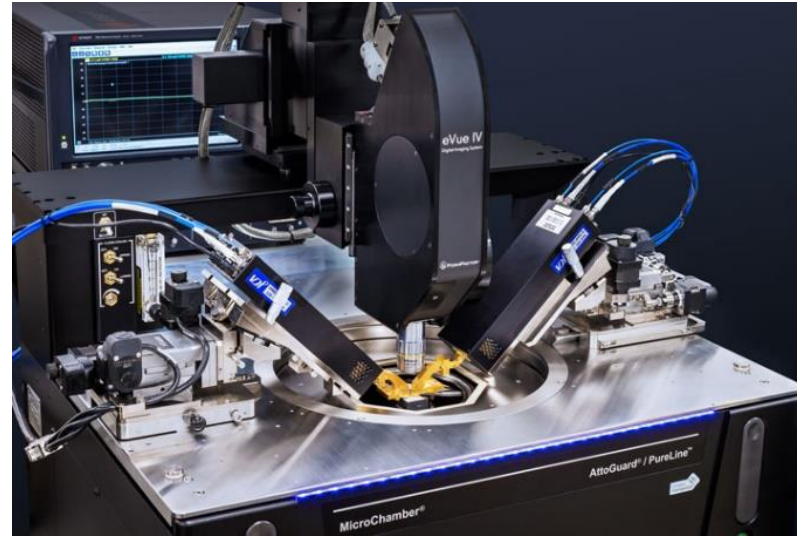


Tektronix, "Introduction to VNA Basics," March 2017
https://download.tek.com/document/70W_60918_0_Tek_VNA_PR.pdf

- **Vector network analyzers require external frequency extension modules**
 - Expensive
 - Limited flexibility in some measurement setups, e.g., on-chip measurements



<https://www.formfactor.com/product/probes/infinity/infinity-waveguide-probe/>

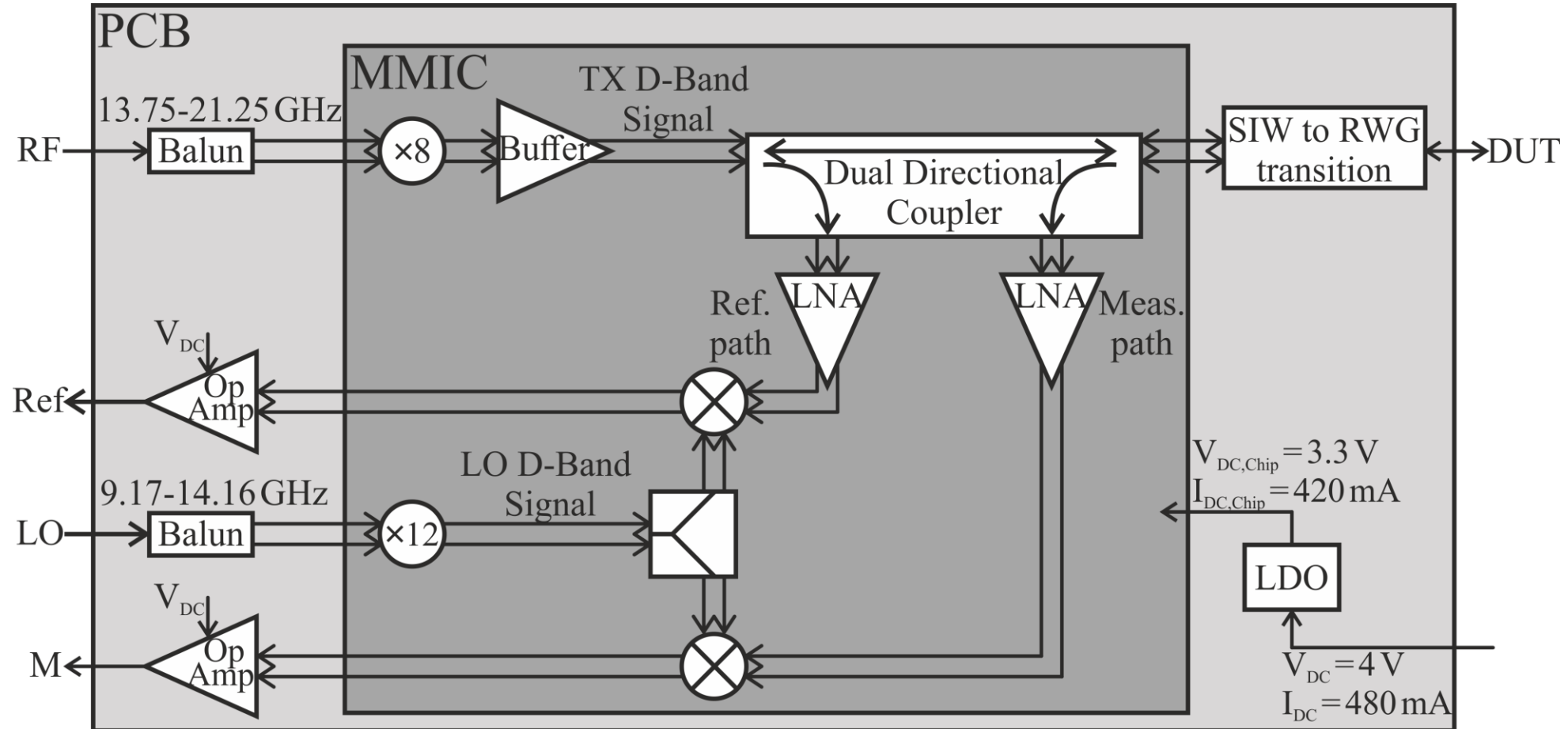


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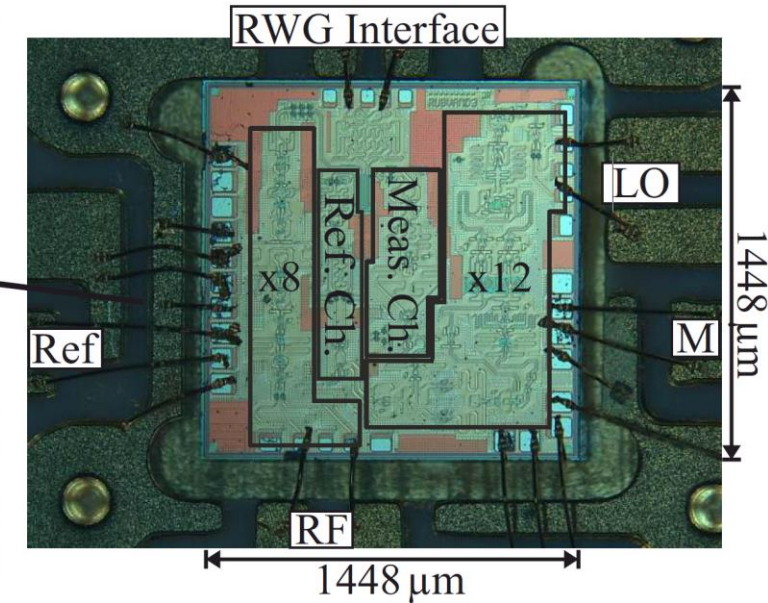
Overview

- **Architecture**
- **Characteristics**
- **DUT measurement**
- **Conclusion**

Idea: Integrate high-frequency circuit elements on one SiGe MMIC

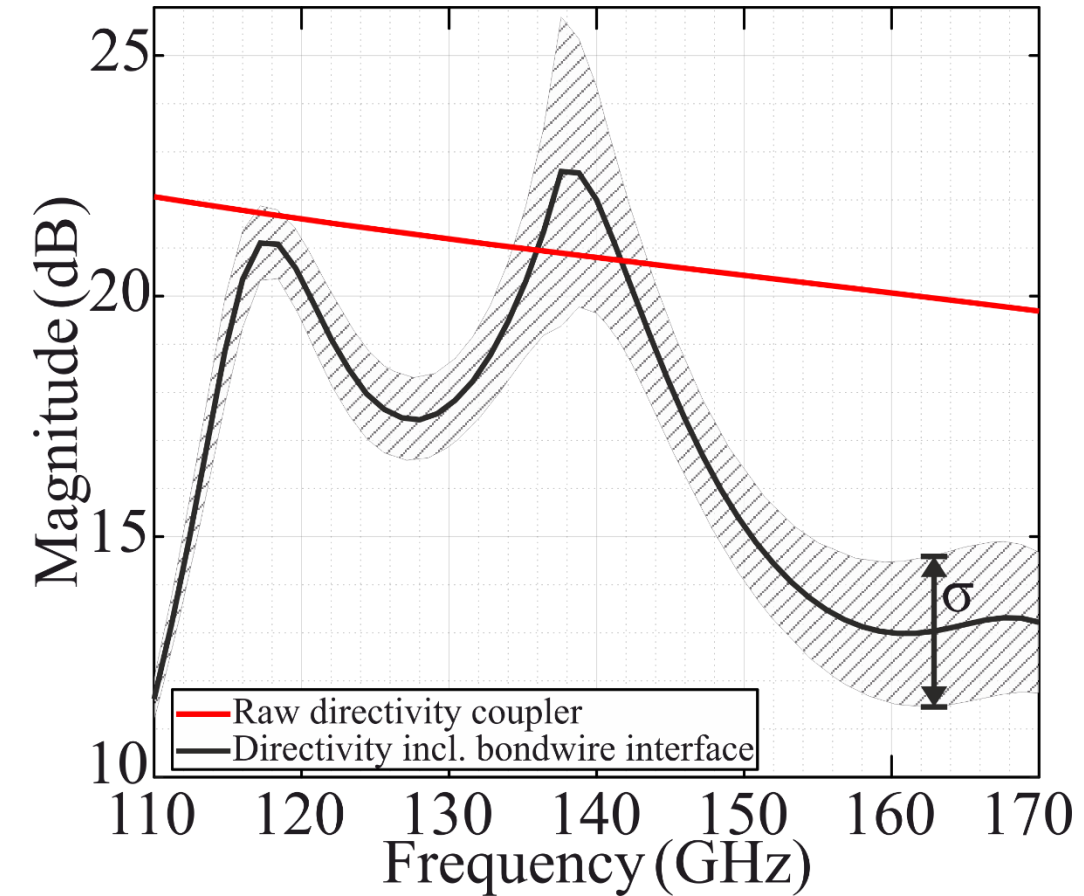
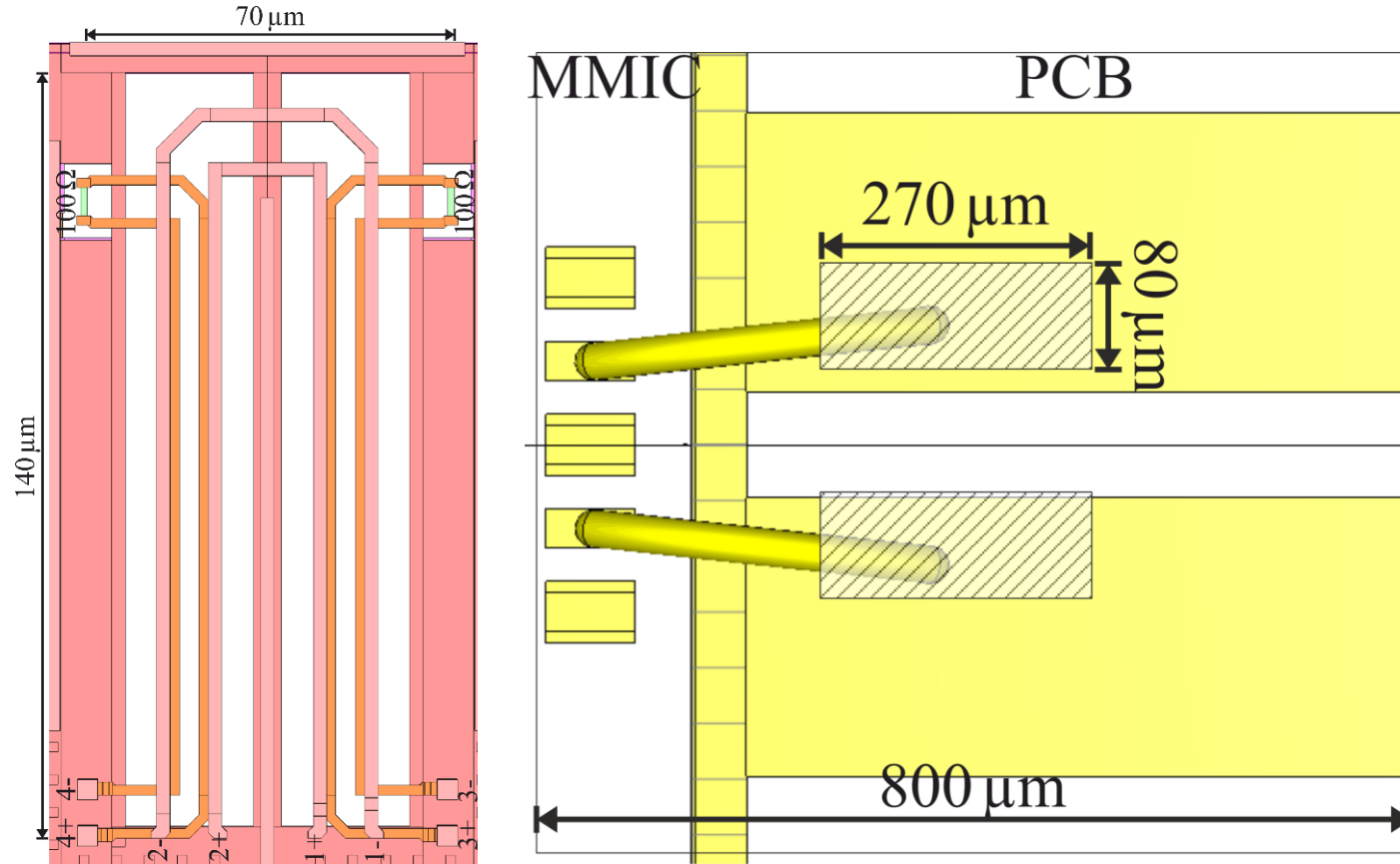


- **MMIC mounted on Rogers RT/duroid 5880 Board**
 - Connections via Bondwires
- **Differential MMIC in- and outputs**
- **D-Band Interface:**
 - Differential substrate integrated waveguide to rectangular waveguide interface
- **Additional FR4 with OP-Amps is plugged on**



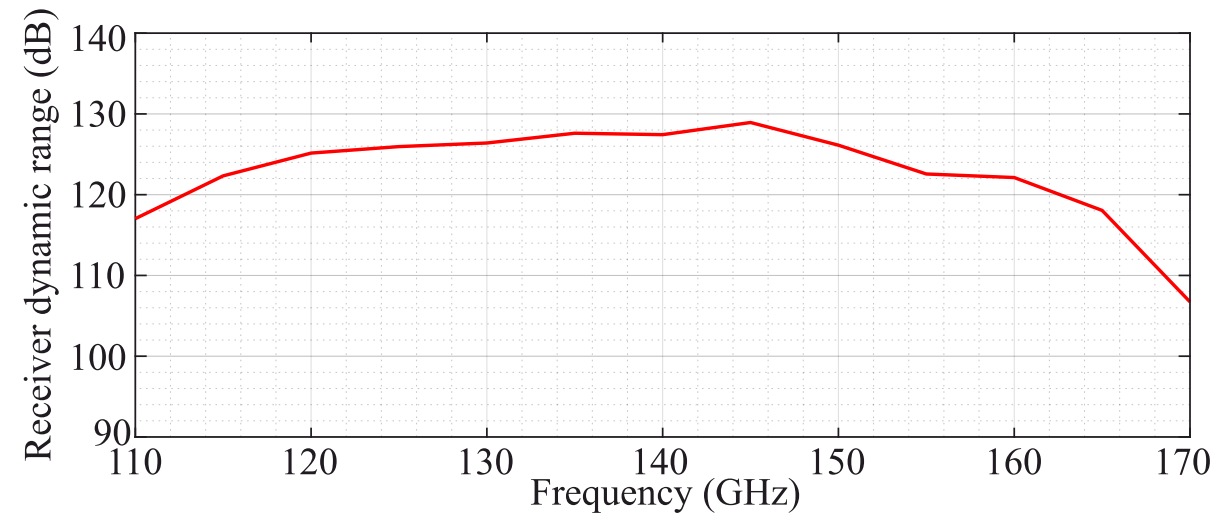
- Architecture
- **Characteristics**
 - Directivity
 - Dynamic range
 - Stability
- DUT measurement
- Conclusion

Characteristics - Directivity



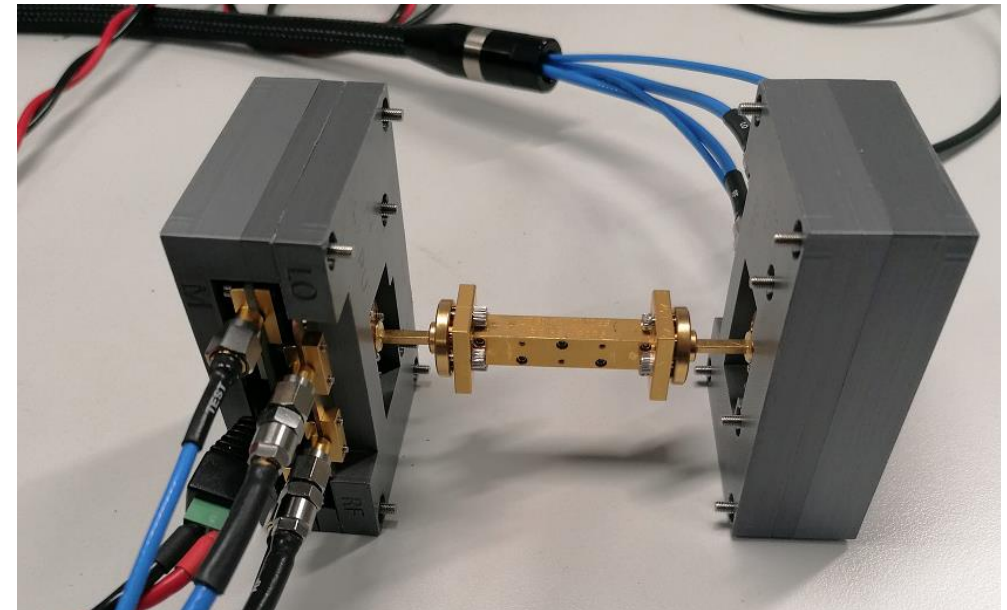
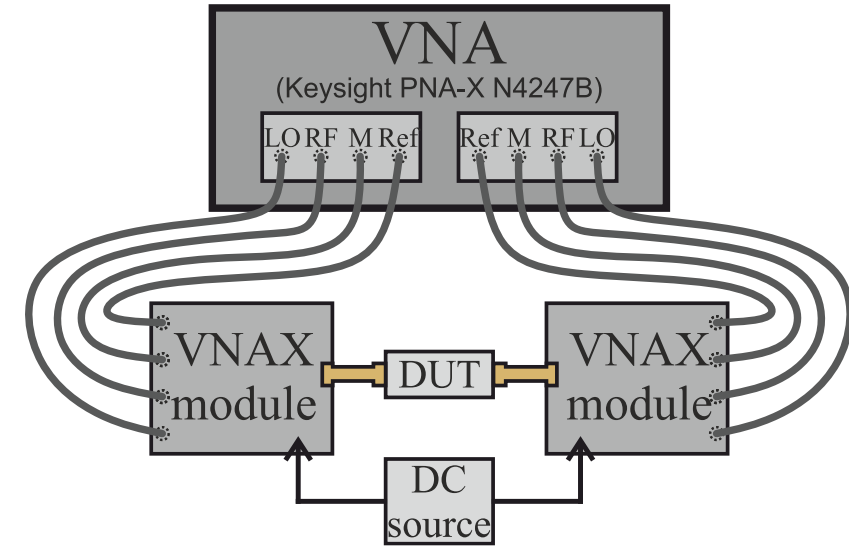
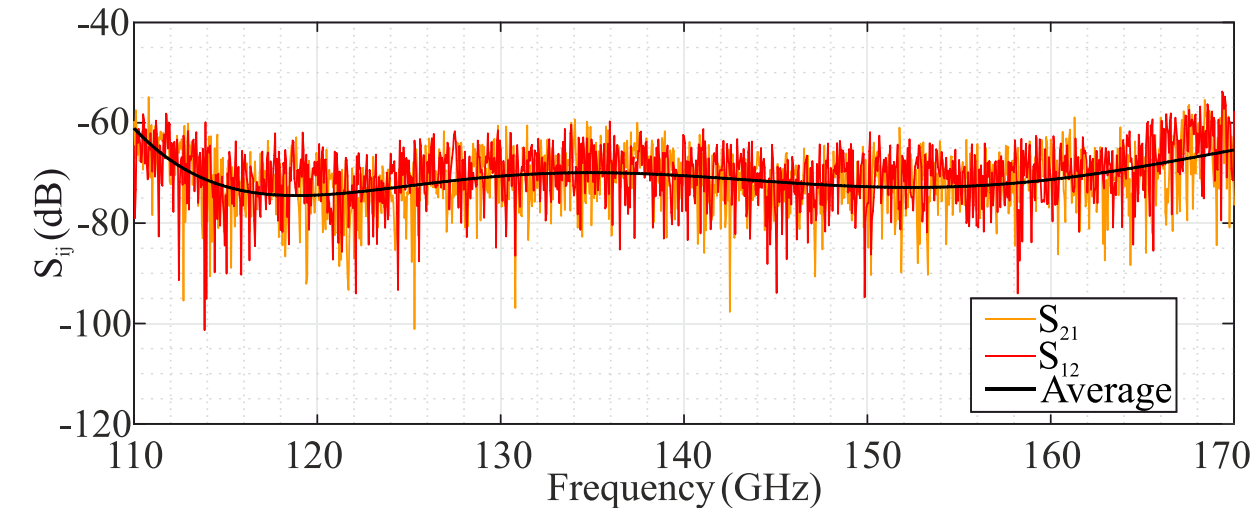
Receiver dynamic range (RDR)

- Difference between OIP1dB of one receiver and noise floor at an RBW of 10 Hz
- Receiver could not be driven into saturation due to limitations of measurement equipment
- Noise floor of receive signal is calculated
 - Noise figure could only be simulated
- RDR ranges from 106 dB to 126 dB

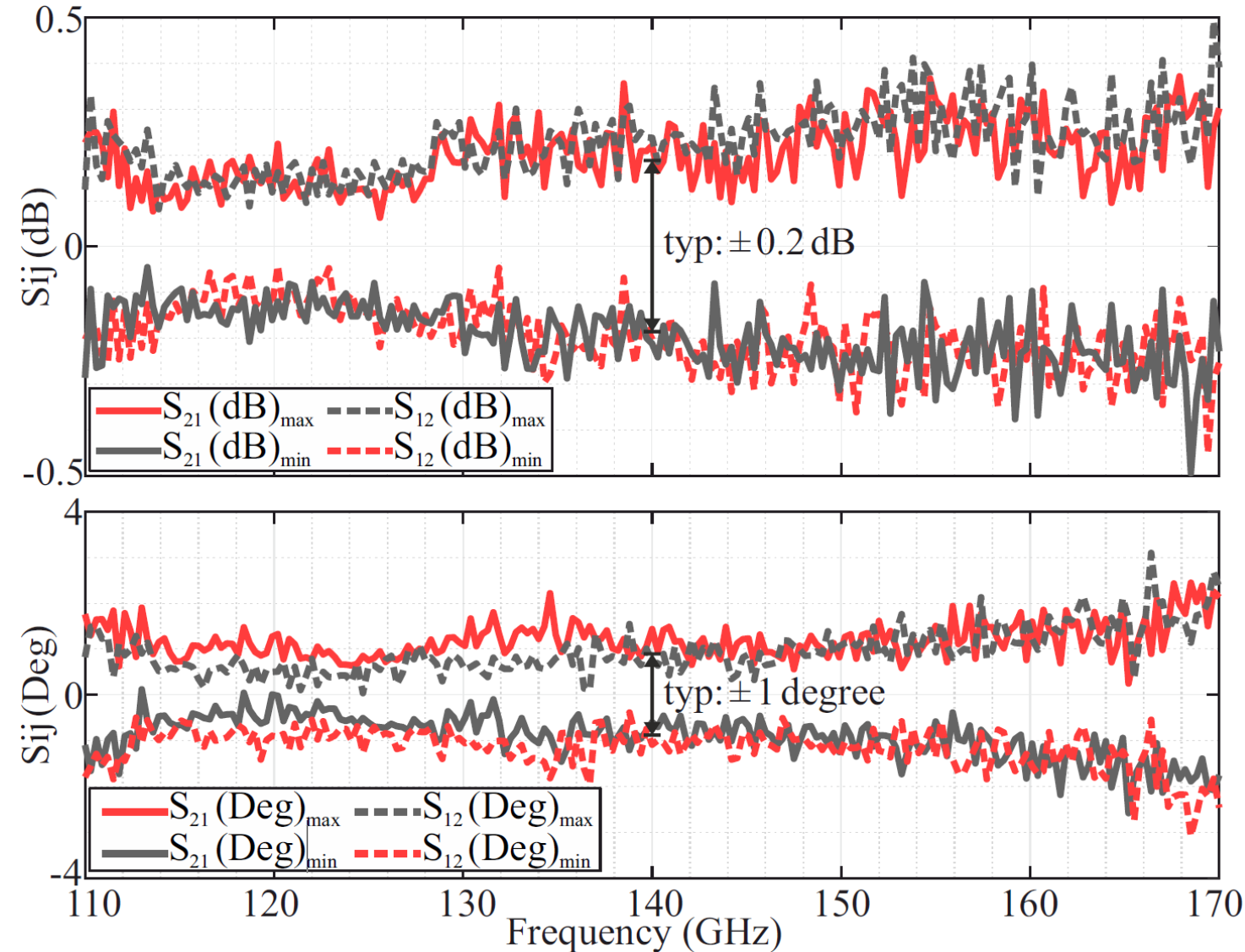


System dynamic range (SDR)

- Connect two modules with a thru
- Normalize traces of S_{21} and S_{12}
- Disconnect modules
- Ranges from 61 dB to 75 dB



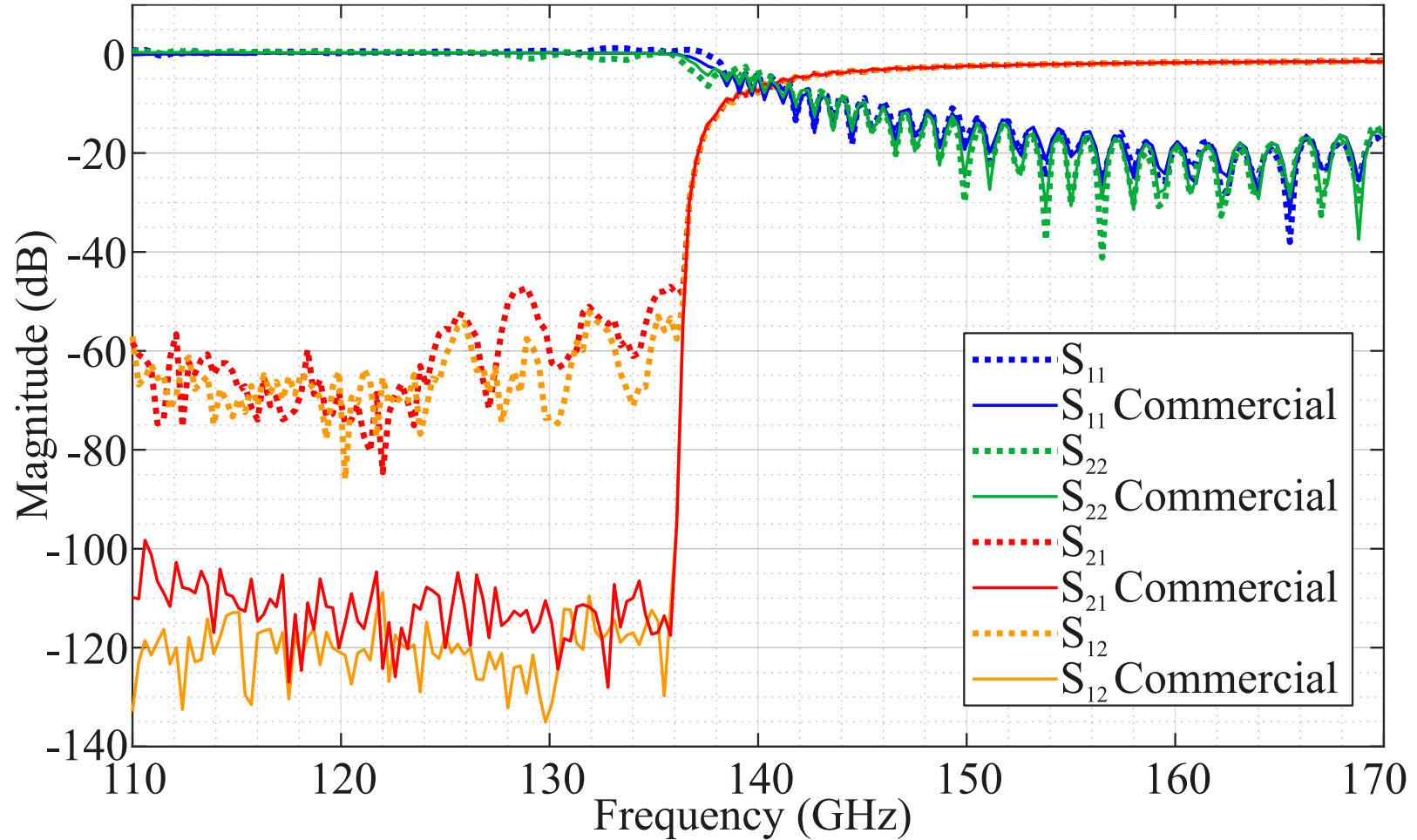
- Magnitude and phase stability
- Connect models with a thru
- Normalize S_{ij} traces
- Monitored maximum deviation is plotted after monitoring for 1 hour



Overview

- Architecture
- Characteristics
- **DUT measurement**
- Conclusion

- Measurement of WR4.3 waveguide
- Comparison to VDI VNAX modules
- TRL calibration
- Below cut-off:
 - SDR is exceeded
- Capability of calibration is verified



Overview

- Architecture
- Characteristics
- DUT measurement
- **Conclusion**
 - Comparison
 - Summary

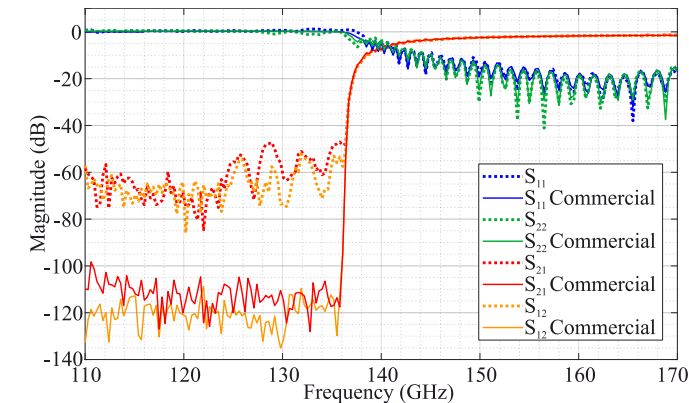
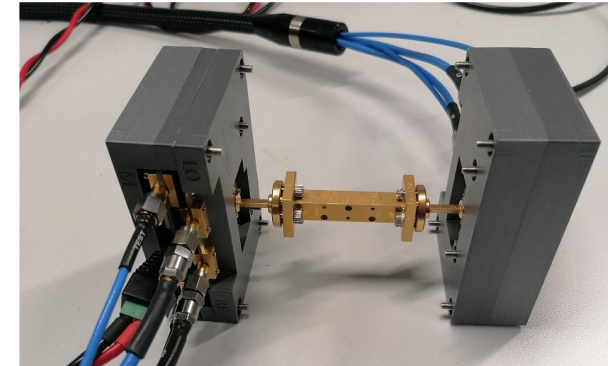
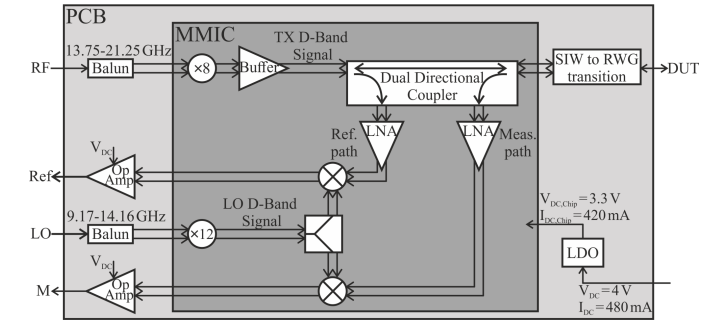
Conclusion - Comparison

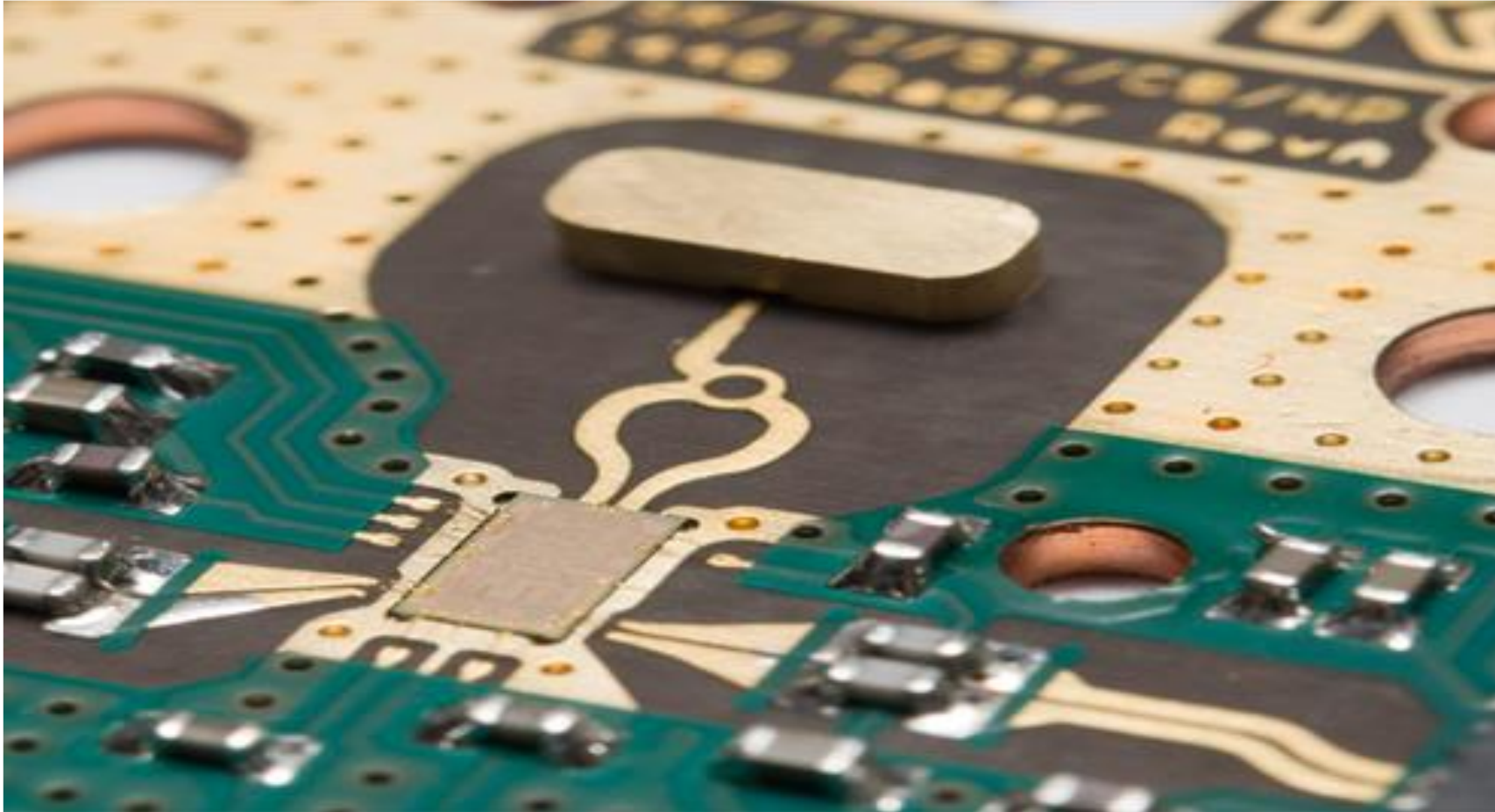
Ref.	Topology (Ports)	Freq. (GHz)	Dynamic range (dB)[RBW]	DUT Interface
[11]	VNA (1)	50-100	RDR: 72.5[100 kHz] SDR: 72.5[100 kHz]	Chip-Pads Probe
[12]	VNA (2)	4 - 32	RDR: 100.9[100 kHz] SDR: 76.6[100 kHz]	Coax
[13]	VNAX (1)	70-110	RDR: 125[10 Hz]	Chip-Pads Probe
[14]	VNAX (1)	75-110	SDR ¹ : 110[10 Hz]	Chip-Pads Probe
[15]	VNA (2)	0.01-26	RDR: 133[10 Hz]	Coax
This work	VNAX (2)	110-170	RDR: 129[10 Hz] SDR: 75[10 Hz]	RWG

¹ Uses max. TX power at DUT interface instead of max. lin. output IF power

Conclusion - Summary

- A D-Band VNA extension module based on a SiGe MMIC was presented
- Crucial parameters were discussed
 - Stability measurement shows potential of SiGe MMIC-based modules
- Proof of concept with WR4.3 measurement
- System dynamic range can be increased with higher transmit power





Thank you for your attention!