Tech Note

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WITTENSTEIN Group

40 GHz semi-rigid coaxial cables for attocube top-loader cryostats

RF performance characterization at room & low temperature

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Abstract

The attocube microscope portfolio offers a comprehensive range of advanced research tools for nanoscale imaging across variable temperature environments. In response to the growing demand for RF applications in diverse areas of science and technology, attocube has developed the seamless integration of RF semi-rigid coaxial cables into cryogenic microscope inserts. Most commonly, RF cables are used with scanning probe microscopes and confocal microscopes, together with the closed-cycle attoDRY1000, attoDRY2100, and attoDRY2200 top-loading cryostats. These systems offer high magnetic fields in a low-vibration environment. Applications range from the characterization of quantum devices to the precise control of instrumentation components, including spintronics, quantum emitters, magnetic dynamics, resonator driving, RF switching, as well as the operation of state-of-the-art cryogenic detectors such as SNSPDs.

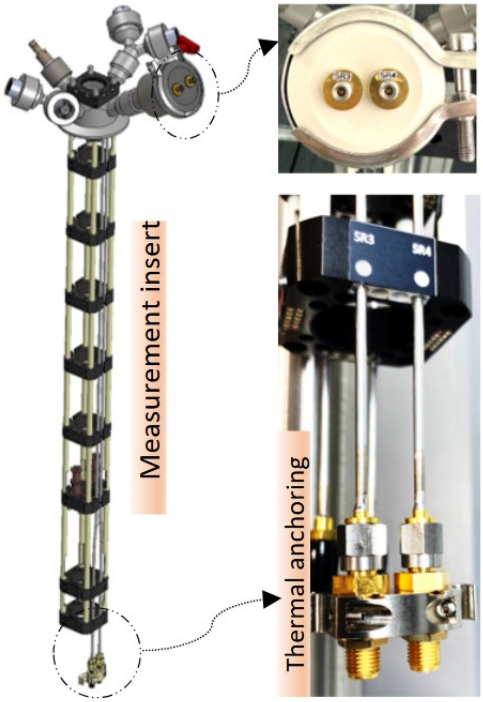

Fig. 1: *Semi-rigid coax cables assembled in an attocube microscope stick.*

1. General Considerations

The RF solution (Fig. 1) covers a frequency spectrum of up to 40 GHz, making it suitable for broadband measurements. To ensure minimal heat conductivity from the top of the cryostat, austenitic-steel semi-rigid cables are employed, terminated with K-connectors at both ends. These semi-rigid cables terminate slightly above the sample space, providing flexibility for further research-specific developments such as adding low-temperature RF components (filters, attenuators, etc.). Furthermore, flexible cryogenic RF cables and RF PCB-based sample holders complete a fully integrated solution for the customer. To ensure top-tier performance and reliability, attocube RF upgrades undergo rigorous testing to guarantee the highest standards and meet customer expectations. Transmission and reflection coefficients are measured across the full frequency range, both at room and low temperatures.

2. Experimental procedure

The in-house experiment was performed using a 40 GHz VNA after a SOLT (Short-Open-Load-Through) calibration, applying two methods. Two-port measurements were carried out at room temperature (RT), where both ends of the semi-rigid cable were accessible for connection to the VNA ports. One-port measurements were performed in an attoDRY top-loading cryostat at low temperature (LT), where only one end of the semi-rigid cable was accessible outside the cryostat. This was achieved by performing short and open measurements and calculating the transmission and reflection coefficients using de-embedding software. To validate this method, one-port measurements were also conducted at RT and compared with the corresponding two-port measurements under the same conditions.

f (GHz)	$\lvert S_{11}\rvert$ (dB)	$\lvert S_{21}\rvert$@RT (dB)	$\lvert S_{21}\rvert$@LT (dB)
1.0	> -20.0	-1.2	-1.0
10.0	> -20.0	-3.9	-3.4
20.0	> -18.0	-5.7	-4.9
40.0	> -12.0	-8.6	-7.4

Tab. 1: *S-parameter of semi-rigid coax cable at room (RT) & low temperature (LT).*

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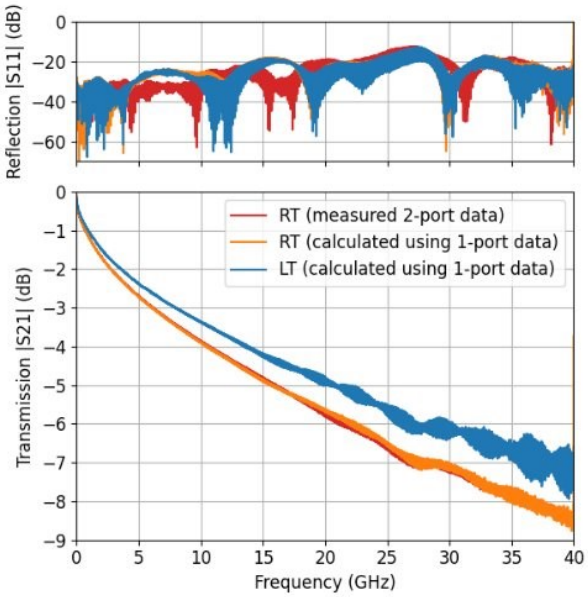

Fig. 2: *S-parameter of semi-rigid coax cable at room (RT) & low temperature (LT).*

3. Results and conclusions

The RF performance of our semi-rigid GHz upgrade was evaluated at room temperatures and at low temperatures (Tab. 1 and Fig. 2). The results indicate an almost linear variation of transmission across the broadband regime. The maximum transmission loss remains below 8 dB at 40 GHz, making this solution highly attractive for a wide range of research applications. Reflection losses are minimal, effectively preventing the formation of standing waves. Overall, the attocube RF solution fully meets the RF specifications required for today's cutting-edge research.

Application References

Scientific work using attocube semi-rigid coax cables

[1] CFM strain base kit :: www.attocube.com.

[2] Clemens Schäfermeier *et al.,* Commercial scanning nitrogen vacancy magnetometer in a closed-cycle cryostat, arXiv (2025).

[3] Qiang Li *et al.,* Electronically phase separated nano-network in antiferromagnetic insulating LaMnO3/PrMnO3/CaMnO3 tricolor superlattice, Nature Commun 13, 6593 (2022).

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