

Solutions for Extreme Cold Environments

## Cryogenic and Quantum Technology

SEMICON & TEST





## Introduction

With extensive expertise in RF technologies, Rosenberger understands the current and future challenges of quantum computing. To mitigate the effects of thermal fluctuations, electromagnetic radiation and magnetic fields within cooling systems, we provide a comprehensive range of solutions for cryogenic applications.

Beyond our robust product portfolio, we leverage state-of-the-art precision manufacturing capabilities to offer virtually unlimited customization options.

As the demand for higher connection densities, smaller connectors and multi-channel solutions grows, we continuously develop innovative technologies to meet the evolving requirements of quantum computer manufacturers and research institutions.

Rosenberger is committed to delivering high-performance components and complete subsystems for every dilution refrigerator system.

## About Rosenberger

Rosenberger is a global leader in high-precision connectivity solutions for high-frequency, high-voltage and fiber optic technologies. Our advanced products ensure the reliable transmission of signals, data and power in demanding applications, including mobile and telecommunications, data centers, test and measurement, automotive electronics, industrial automation, medical technology and aerospace and defense.

At Rosenberger, we bring technology competencies together under one roof – from the initial concept and prototyping to full-scale series

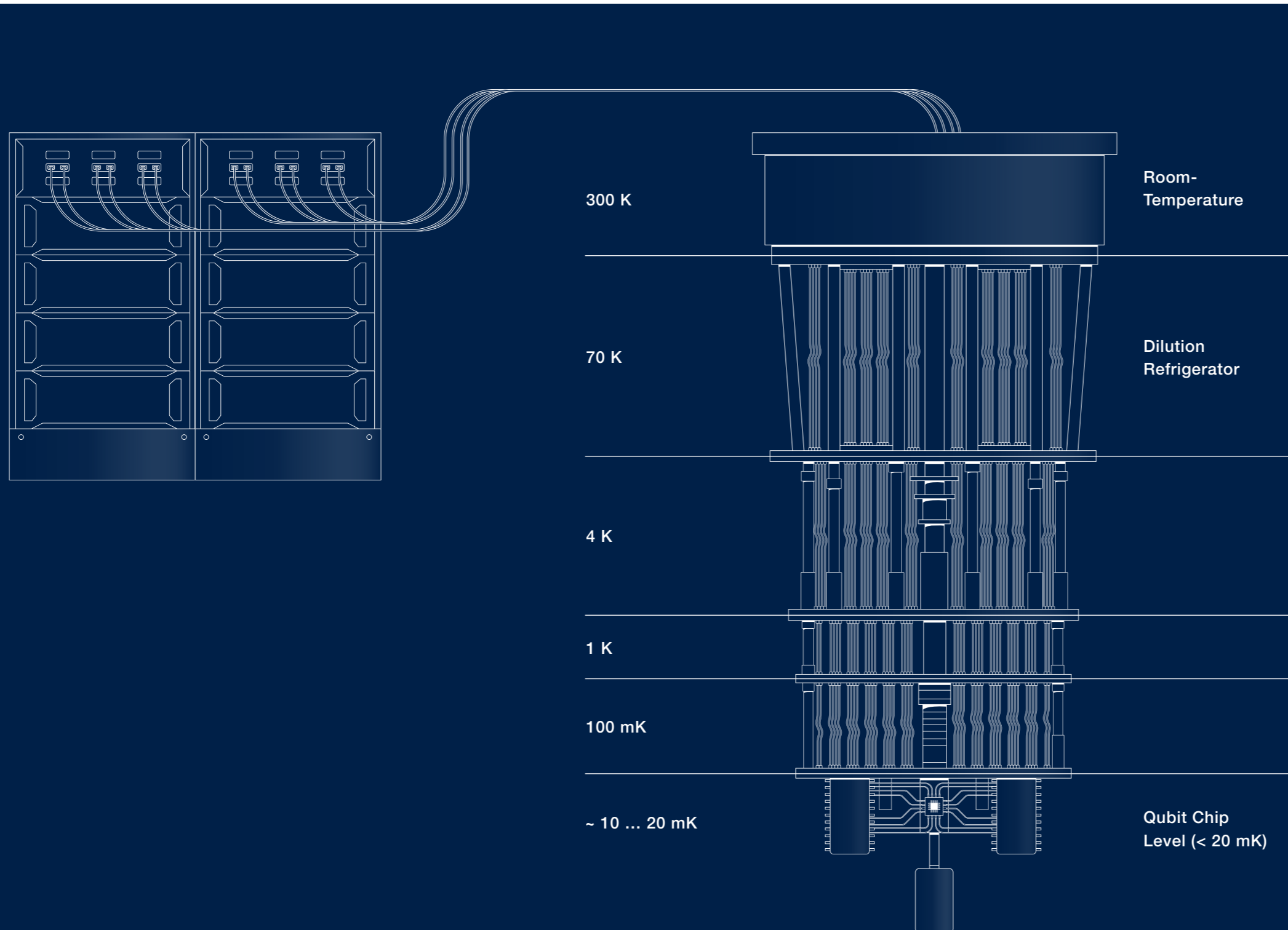
production. Our highly automated manufacturing processes enable the large-scale production of innovative, high-quality products.

Since our founding in 1958, Rosenberger has remained dedicated to innovation, precision and quality.

As a family-owned company, we prioritize long-term reliability, technical excellence, and customer-driven solutions.

# Solutions for Dilution Refrigerators

For all cryogenic conditions, Rosenberger provides high-precision connectivity solutions designed to ensure reliable signal transmission.



Cable assemblies flexible

Cable assemblies semi flexible

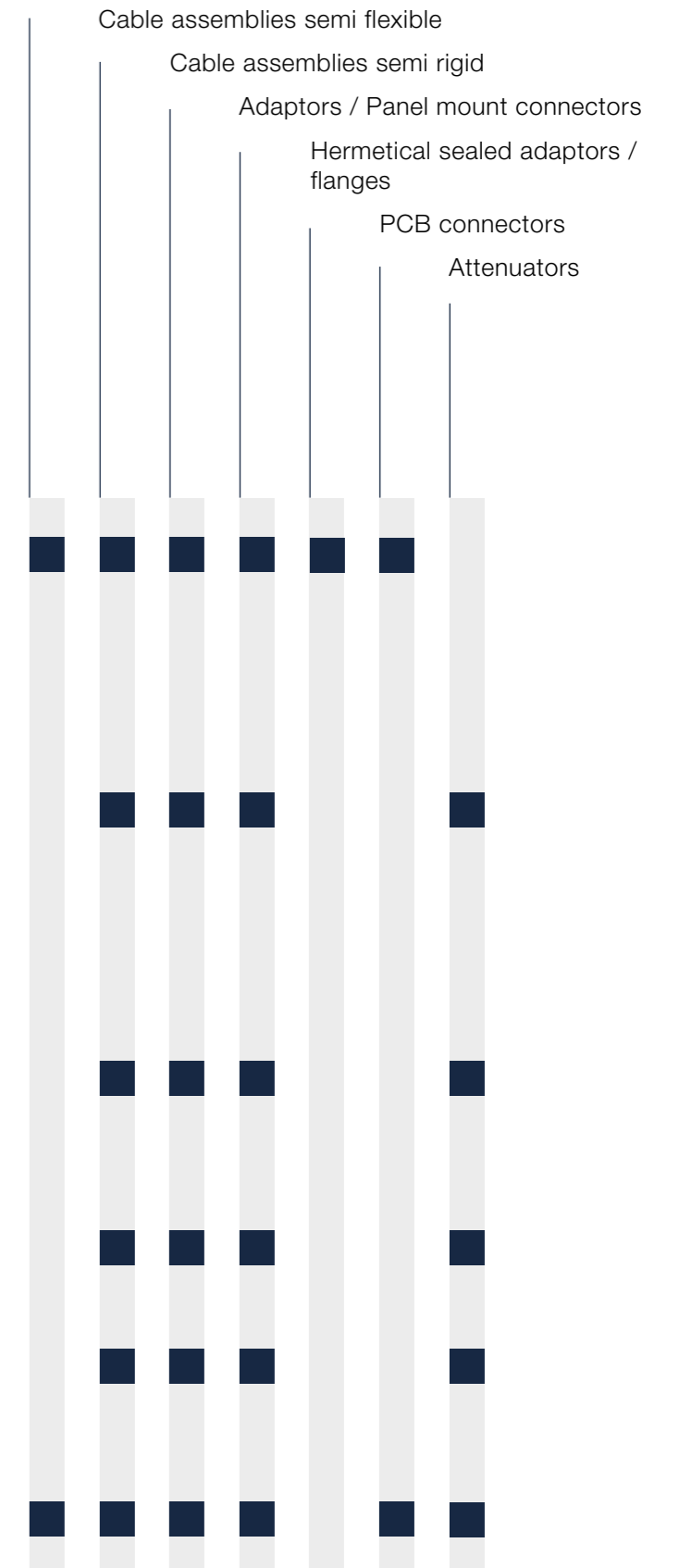
Cable assemblies semi rigid

Adaptors / Panel mount connectors

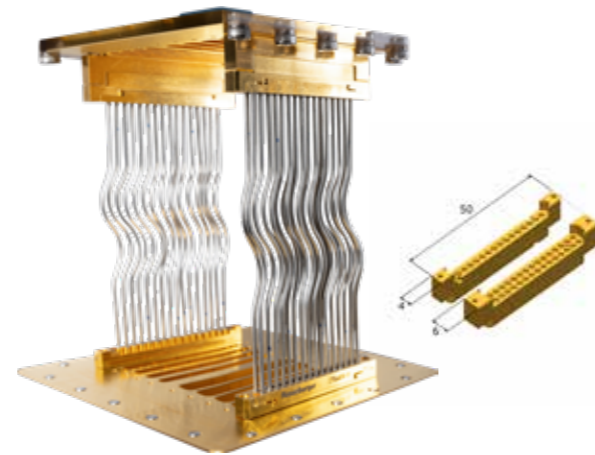
Hermetical sealed adaptors / flanges

PCB connectors

Attenuators



# Multichannel Connectors for Quantum Computing



## Multichannel WSMP®

### Specifications

Frequency Range:	DC to 65 GHz
Interface:	WSMP® (SMP3, IEC 61169-69 in progress)
Dimensions:	1 x 16 (single row) – 4 mm x 50 mm 2 x 16 (double row) – 6 mm x 50 mm
Pitch:	2.45 mm
Mating cycles:	≥ 500

### Features

- Additional mechanical fixing via screws
- Thermal coupling at each temperature stage with adaptors
- Copper based non-magnetic materials with AuroDur® plating
- Channel 1 marking
- Anti-rotation protection

## Cable Assemblies

Rosenberger offers high-quality cable assemblies for quantum computing applications, including flexible, semi-flexible and semi-rigid variants, as well as custom solutions.

For cryogenic environments and superconducting systems, we develop semi-rigid assemblies with optimized soldering processes to ensure maximum electrical and mechanical stability. Our connectivity technologies provide minimal signal attenuation, excellent shielding and maximum reliability – even under extreme temperature conditions.

### Features

- Available in 16- and 32-channel versions
- Customizable cable lengths for various applications
- High-quality soldered connectors for reliable signal transmission
- Single coaxial lines in a multichannel housing allows replacement of individual lines or mixed configurations
- 100% RF performance testing of each individual line at room temperature
- Ensuring highest signal quality and operational reliability



## Semi Rigid Cables

- UT-047 (1.19 mm) as standard
- S-shape bending for length compensation during temperature changes
- Variety of different materials available
  - Stainless steel
  - Silver plated stainless steel
  - CuproNickel
  - Silver plated CuproNickel
  - BerylliumCopper
  - NiobiumTitanium



## Semi Flexible Cables

- Non-magnetic RTK-FS 047-SPC (1.19 mm) as standard
- Hand-formable cable, with tin dipped braid
- Different fan-out solutions possible (e.g. SMA, SMP)



## Flexible Cables

- Non-magnetic RTK 047-F2-18 (1.19 mm) as standard
- Flexible cable with FEP jacket
- Different fan-out solutions possible (e.g. SMA, SMP)

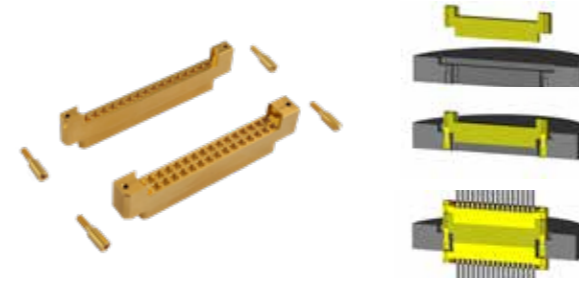
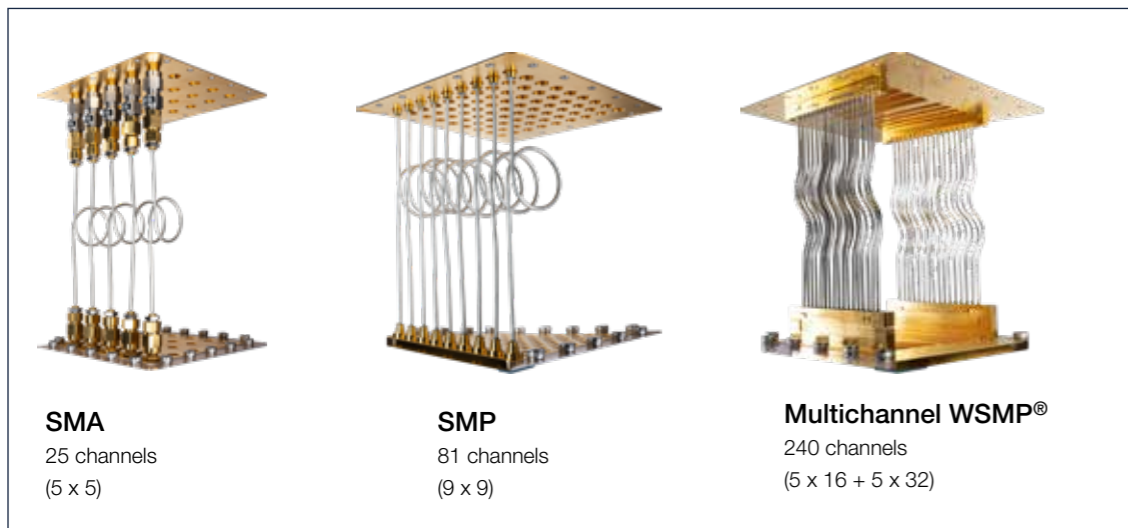
# Multichannel Connectors for Quantum Computing

## Connectors, Adaptors, Attenuators and PCB Connectors

Rosenberger offers high-quality connectivity solutions designed for demanding applications. Engineered for precision and reliability, our solutions ensure minimal signal loss, excellent shielding and maximum performance in critical environments.

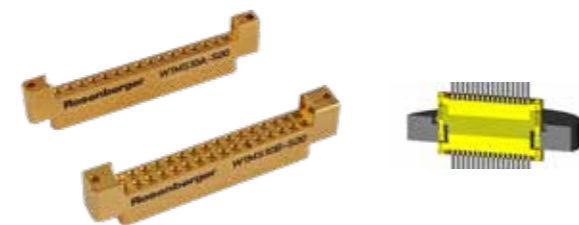
Available in 16- and 32-channel versions, our products meet the highest industry standards for high-frequency applications, cryogenic systems and custom requirements, delivering exceptional electrical and mechanical stability.

### Comparison of Density at Same Dimensions



## Hermetically Sealed Adaptor

- Leakage rate  $\leq 10^{-8}$  mbar \* l/s (qualified at room temperature), 100 % tested
- Each channel is completely sealed using an epoxy potting, with excellent RF performance
- Fixed to flange with screws in blind holes from the inside of the vacuum, then potted



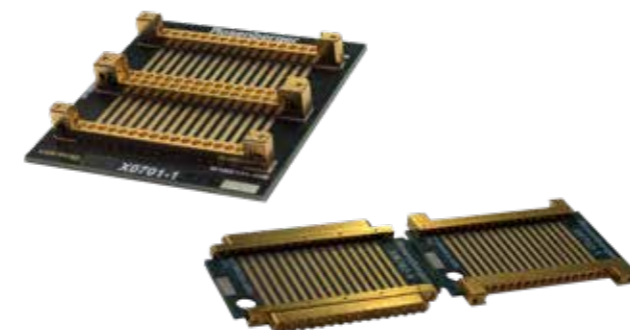
## Adaptor

- Heat dissipation from the coax cable to the thermal anchor
- Fixed to the thermal stages with screws from cable assembly



## Attenuator

- Heat dissipation from the coax cable center conductor to the thermal anchor
- Same form factor as adaptor
- Fixed to the thermal stages with screws from cable assembly
- 0 dB / 3 dB / 6 dB / 10 dB / 20 dB available
- Single attenuator per channel, which allow mixed configurations
- NiCr on  $AL_2O_3$  substrate
- Substrate is soldered to center conductors and outer conductor for good thermalization



## PCB Connectors

- Straight PCB connectors
  - Additional screws for better mechanical stability
- Edge-mount PCB connectors
  - 16 channel version
  - Male and female interface
  - Additional screws for better mechanical stability

# Standard Interfaces for Quantum Computing

Rosenberger's standardized connectors ensure maximum signal stability and minimal loss – essential for the next generation of computing technology.

## SMA

Cable - Panel - PCB connectors  
Cable assemblies  
Adaptors and attenuators

- Impedance 50  $\Omega$
- Interface according to IEC 60169-15, EN 122110, MIL-STD-348A, fig. 310
- Frequency range DC to 18 GHz
- Return loss (cable connector straight)  $\geq 30$  dB (typ.)
- Mating cycles CuBe/stainless steel  $\geq 500$ ; CuZn  $\geq 100$
- Coupling test torque: CuBe/stainless steel  $\geq 1.7$  Nm; CuZn  $\geq 0.6$  Nm
- Coupling torque recommended: CuBe/stainless steel 0.8 Nm to 1.1 Nm; CuZn  $\geq 0.5$  Nm
- Screw-on locking mechanism
- Butted outer contact



## SMP

Cable - Panel - PCB connectors  
Cable assemblies  
Adaptors, attenuators and bullets in diff. lengths

- Impedance 50  $\Omega$
- Interface according to MIL-STD-348, mateable with GPOTM (Gilbert Engineering Co. Inc)
- Frequency range DC to 40 GHz
- Return loss:  $\geq 23$  dB @ DC to 20 GHz;  $\geq 14$  dB @ 20 GHz to 40 GHz
- Minimum board-to-board distance 9.05 mm
- Axial misalignment  $\pm 0.3$  mm
- Radial misalignment 4°
- Mating cycles: full detent:  $\geq 100$ ; limited detent:  $\geq 500$ ; Smooth bore:  $\geq 1000$
- Snap-on locking mechanism
- Different detent types: smooth bore, limited detent and full detent



## Mini-SMP

Cable - Panel - PCB connectors  
Cable assemblies  
Adaptors and bullets in diff. lengths

- Interface according to MIL-STD 348A, fig. 328
- Frequency range DC up to 65 GHz
- Return loss:  $\geq 26$  dB @ DC to 26.5 GHz;  $\geq 17$  dB @ 26.5 GHz to 50 GHz;  $\geq 14$  dB @ 50 GHz to 65 GHz
- Impedance 50  $\Omega$
- Mating cycles full detent  $\geq 100$  smooth bore  $\geq 500$
- Minimum board-to-board distance 7.94 mm
- Axial misalignment  $\pm 0.1$  mm
- Radial misalignment 4°
- Snap-on locking mechanism



## RPC-2.92

Cable - Panel - PCB connectors  
Cable assemblies  
Adaptors

- Impedance 50  $\Omega$
- Interface according to IEC 60169-35
- Frequency range DC up to 40 GHz, extended for 5G up to 43.5 GHz
- Return loss  $> 23$  dB @ DC – 40 GHz
- Mating cycles  $> 500$
- Air dielectric with PS/PTFE bead
- Stainless steel outer contact



# Standard Interfaces for Quantum Computing

## WSMP®

Cable - Panel - PCB connectors  
Cable assemblies  
Adaptors and bullets in diff. lengths

- Impedance 50  $\Omega$
- Interface according to Rosenberger WSMP® (SMP3, IEC 61169-69 in progress)
- Frequency range DC up to 65 GHz
- Return loss:  $\geq 26$  dB @ DC to 26.5 GHz,  $\geq 19$  dB @ 26.5 to 65 GHz
- Mating cycles full detent  $\geq 100$ , smooth bore  $\geq 500$
- Minimum board-to-board distance 3.05 mm
- Axial misalignment  $\pm 0.13$  mm
- Radial misalignment  $\pm 0.25$  mm
- Push/snap-on locking mechanism



## Multiport Mini-Coax

Multiport PCB w/ 2,4,6,8 Channels  
Multiport cable assemblies

- Impedance 50  $\Omega$
- Interface according to Rosenberger Mini-Coax
- Frequency range DC to 20 GHz and DC to 40 GHz
- Return loss  $> 16$  dB @ DC to 20 GHz
- Mating cycles  $> 500$
- 2, 4, 6 and 8 channels



## Customized Hermetically Sealed Adaptor Flange

Hermetically sealed adaptor flanges made of Kovar with gold plating – with glass-to-metal gasket – to ensure high vacuum, can be designed and manufactured according to customer requirements.

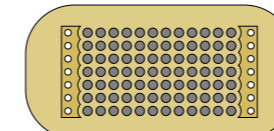
A specified leakage rate up to  $\leq 10^{-8}$  mbar \* l/s and 100% fine leakage tests are possible as well as multiport flanges.

- 36 SMPs
- $\varnothing$  73 mm
- Material: Kovar with gold plating
- Corning 7070 or equivalent direct glassing



### Hermetical Sealed Adaptor Flange (Concept)

- 84 Mini-SMPs
- Size: 41x82 mm
- Material: Kovar with gold plating
- Corning 7070 direct glassing



## Capabilities Cable Assemblies

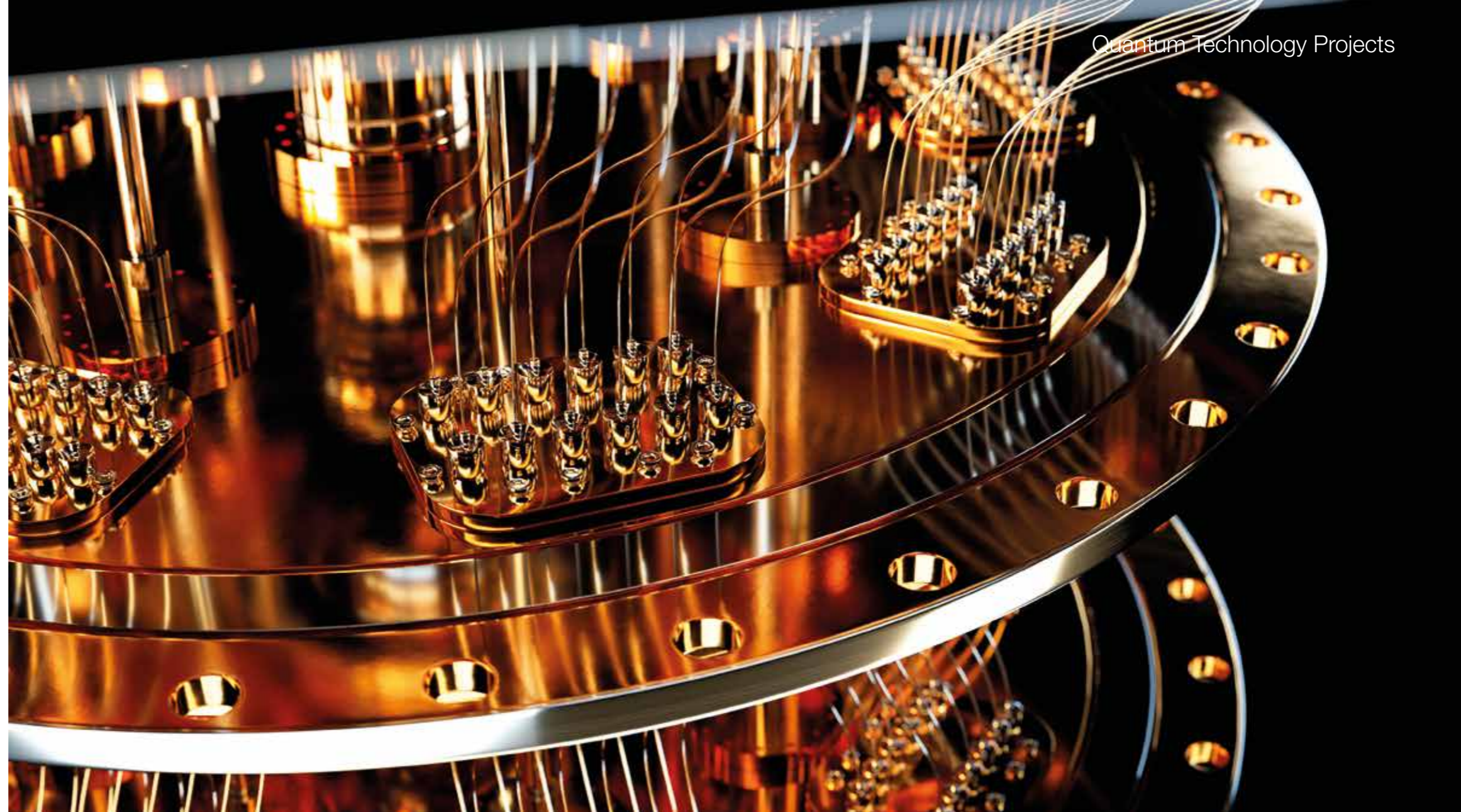
Rosenberger offers a large portfolio of standard cable assemblies (flexible, semi-flex, semi-rigid) and manufactures also customer-specific cable assemblies on request.

In addition to standard cable assemblies, Rosenberger is also able to manufacture special semi-rigid cable assemblies for cryogenic applications and superconducting cable assemblies using special soldering processes.

The results are cable assemblies that show excellent electrical and mechanical properties at the solder joints.

- Non-Magnetic cable assemblies
- Stainless Steel cable assemblies
- CuproNickel cable assemblies
- Niobium Titanium cable assemblies
- BerylliumCopper cable assemblies





## Advancing Innovation Through Collaboration and Standardization

Participation in German government-funded projects enables Rosenberger to collaborate with leading research institutions and jointly develop cabling solutions tailored to user requirements.

Rosenberger actively contributes to standardization efforts to establish a long-term standardized portfolio, offering users greater planning reliability, faster availability and more competitive pricing.

## Quantum Technology Projects

### qBriqs – Cornerstones of Cryogenic Quantum Technology



Project Duration: November 2021 – October 2024

Rosenberger's role in this project was the investigation and development of the measurement chain for superconducting qubits.

The objective was to overcome several bottlenecks through innovative approaches, assess the commercial potential of the enhanced measurement chain and leverage it effectively.

#### Rosenberger's Portfolio

- Multichannel connectors with low pitch (< 3 mm)
- Hermetically sealed adaptors
- Adaptors
- Attenuators
- Cable assemblies
- PCB connectors

### QSolid – Quantum Computer in the Solid State



Project duration: January 2022 – December 2026

Twenty-six German companies from science and industry are collaborating to develop a quantum computer with enhanced error correction, aiming to establish a comprehensive ecosystem that will be integrated into the JUNIQ supercomputing infrastructure at Forschungszentrum Jülich and made accessible to external users.

#### Rosenberger's Portfolio

- Multichannel connectors
- Hermetically sealed adaptors
- Additive manufactured cables with special materials





## Website

For further informationen please visit us online:  
[www.rosenberger.com/quantum](http://www.rosenberger.com/quantum)

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