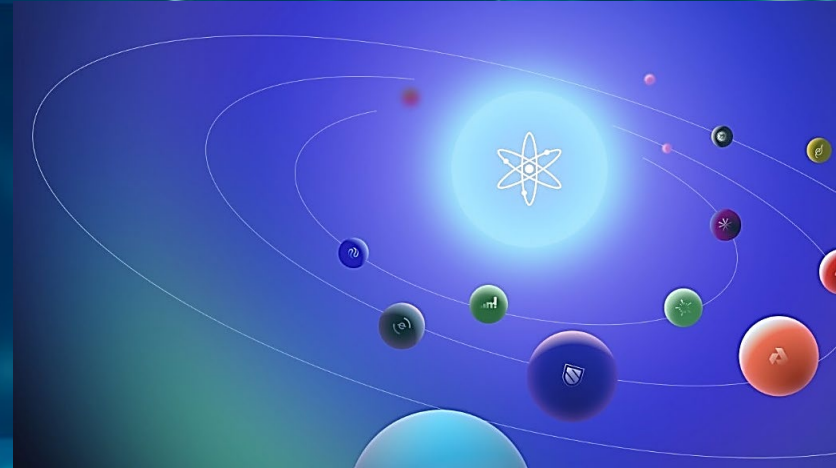




SIMPLIFICATION
is our INNOVATION

Enabling technologies

the challenge of interconnect



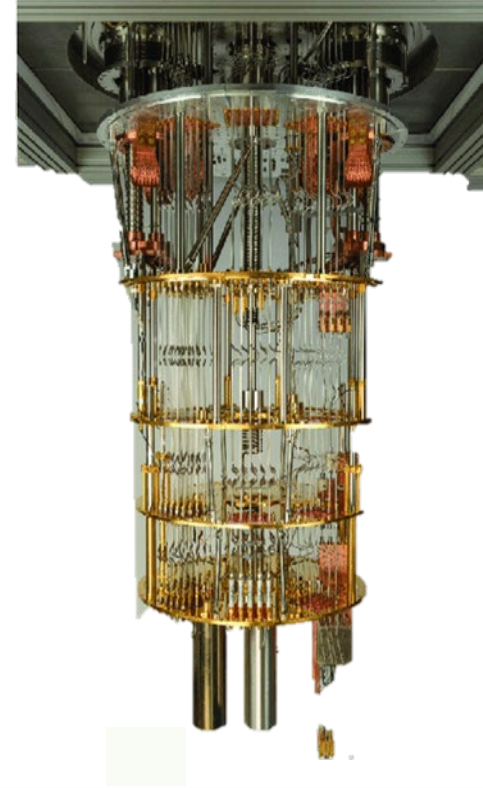
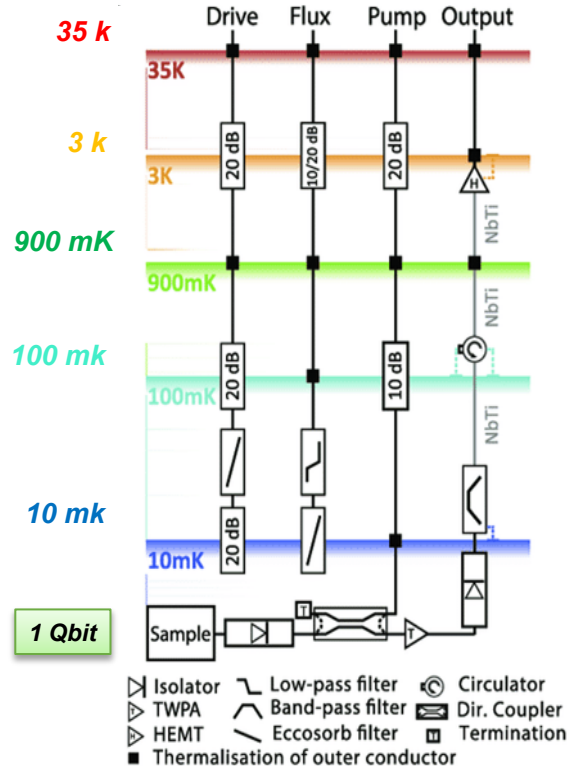
HF Connection on Quantum Computer

Enabling Technologies for Quantum Computer

Each stage of the Thermal Dilution Refrigerator required many microwave links (with 4 lines/Qbit)

Incl. cables assemblies, filter, connectors, attenuator, switch

With various constraints, packed in harness (side loader)



Enabling Technologies Challenges

The Challenge : preserve the quantum coherence & minimize external perturbation



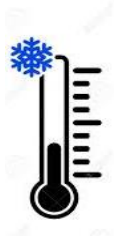
Shielding effectiveness



High hermeticity
(10^{-8} mbar l/s)



Thermal management



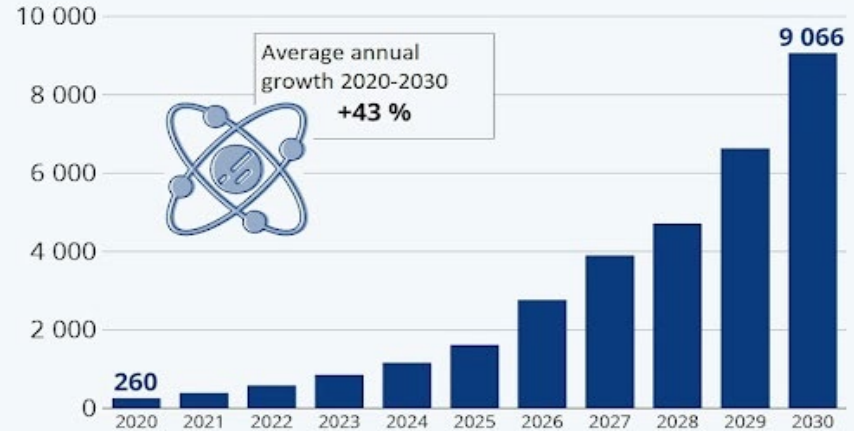
Thermal cycling
from- to 20 mK^o



Non Magnetic environment

Computing enters the quantum era

Global Quantum computing market Size
forecast, millions of US dollars



Source : Statista Digital Economy Compass 2021



statista

How to Answer the Challenges

Engineering & design for reliable solution



Densification: Miniature connector, Multi coaxial harness (bundle), small diameter semi-rigid cables, Multi-pin coax connector.



Thermalization: Through Panel, Thermal conductivity Insulator,



Solution: A-magnetism, Solderless connector, HF & material expertise.
Cryo-Switches & Cryo-attenuators

Anticipate **scale-up** for ultra connectivity 'in' & 'out'.



Networking : External academic & industrial expertise knowledge

QRYOLINK : Collaborative R&D consortium

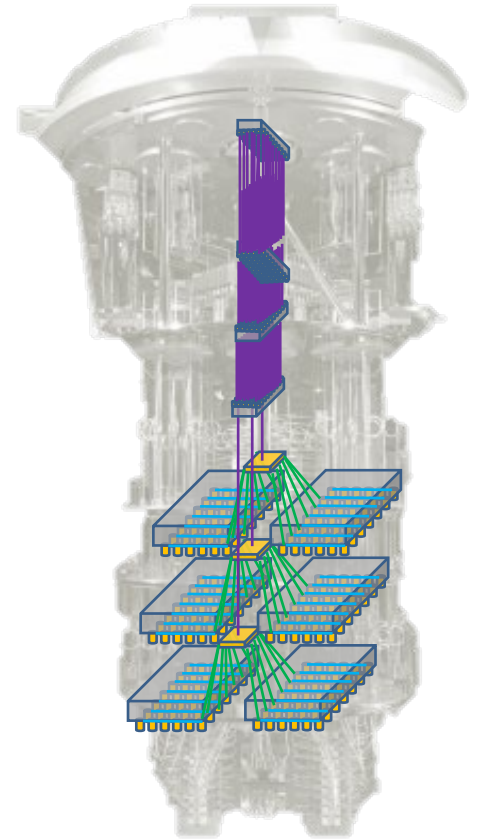
Quantum cRYogenic Link

Radiall is part of **QRYOLink** to develop the routing system accompanying the quantum computer scale-up to 1 million qubits Q3-22 / Q1-27:

- Full Quantum Hardware Ecosystem
- Connector & cables MW Harnes 'side loader'
- Components: attenuators, switches..



ALICE & BOB



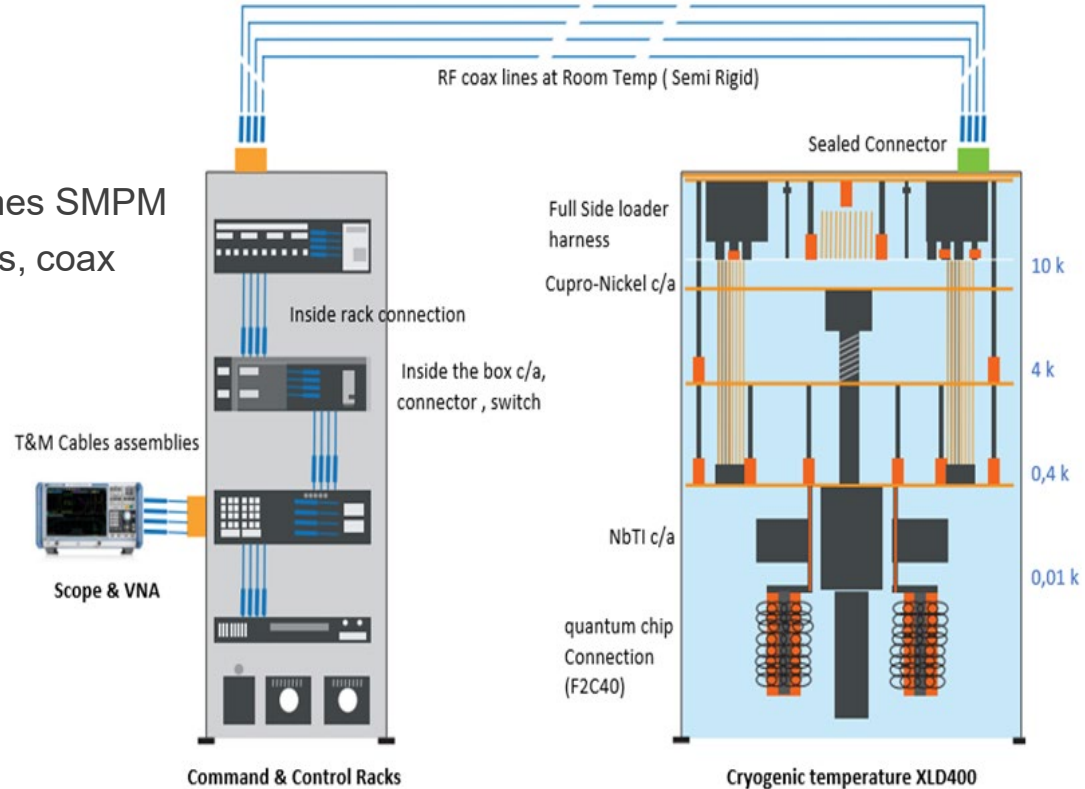
RF solution for Quantum computer – Global Overview

Inside Cryostat RF solution

- Modular full side loader, 180 coax lines SMPM
- RF component: switches, attenuators, coax lines, connectors, IR filters, etc..

Outside cryostat: T&M lines

- Rack wiring (fixe cables)
- T&M versatile c/a
- Inside the box component



Cable Assemblies for T&M applications

1-Inside The Box

- **High Speed Data & IA** to test connectors
- **Electric/autonomous automotive** to test collision radar sensors
- ▶ For Switches Matrices, General Purpose Test Equipment, Benchtop test
- ▶ RG & AEP C/A, Shortbend, Semi-Rigid and conformable

2-Laboratory Test

- **Anechoic Chambers**
- **Benchtop test**
- **Research (R&D, R&T) test DUT**
- ▶ For Switches Matrices, General Purpose Test Equipment, Benchtop test
- ▶ TestPro cables Assemblies (TP2,TAP3, T4.2), VNA

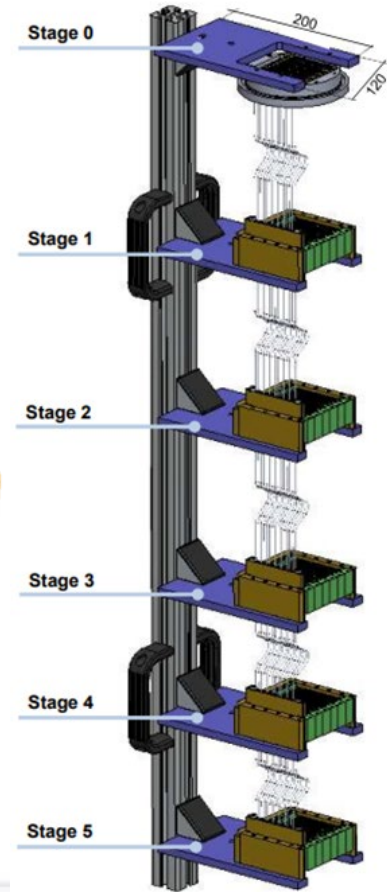
3-Production Test

- **Automatic Test Equipment**
- **High Speed Data Test**
- **Telecom device test**
- ▶ For test bench, automation test, simulation, performance test
- ▶ RG&AEP cable assemblies, SHF2.4 to 4M.
- ▶ New 110GHz Cable assembly

High Density Rf Modular Solution

**BLUE
FORS**

- Designed according to XLD400 Bluefors
- Up to 180 channels per side-loader
- Configuration & number stages as customer's required
- High modularity with supra & standards lines
- Product available with prototype





CryoConcept
an Air Liquide affiliate

High density **Vacuum** Hermetic solution

Up to **390** SMPM cables per level for
100x200 mm (or 195 for 100x100)

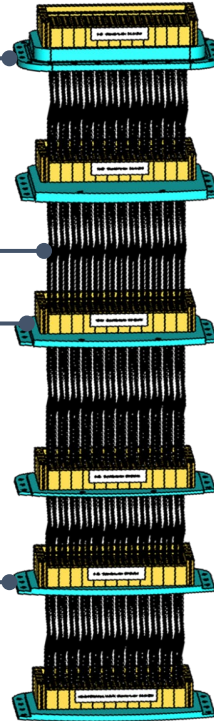
Semi rigid cables (**Cu-Ni, Nb-Ti, Cu-Be...**)

Solderless connector technology

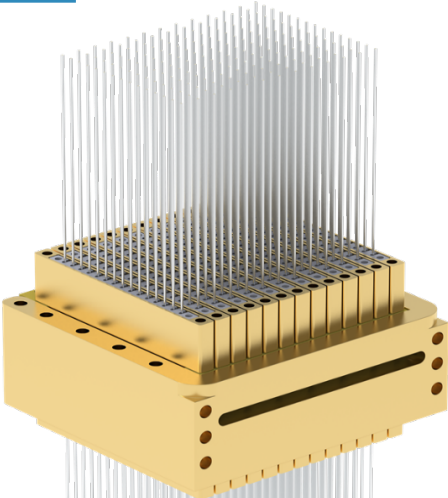
Multiport housing hold from **1 to 26 strips**
of connections for *100x200 form factor*
(*13 in 100x100 side port*)

The housing integrates DC-20 GHz
Attenuators with optimized Thermal design

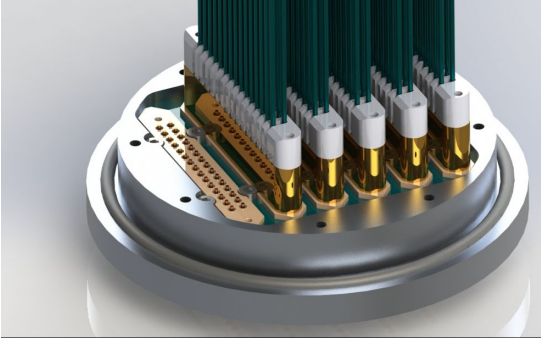
0-10-20-30 dB value as required



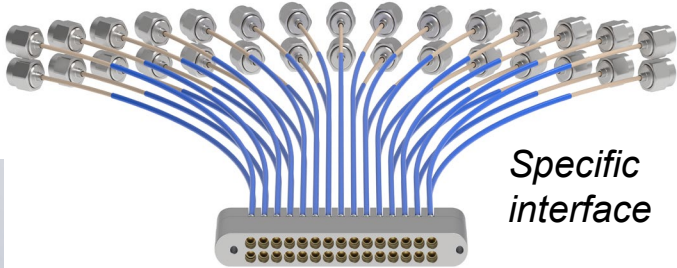
Hermetic High-Density Module



*High density module
(up to 180 channels,
embedded attenuator)*



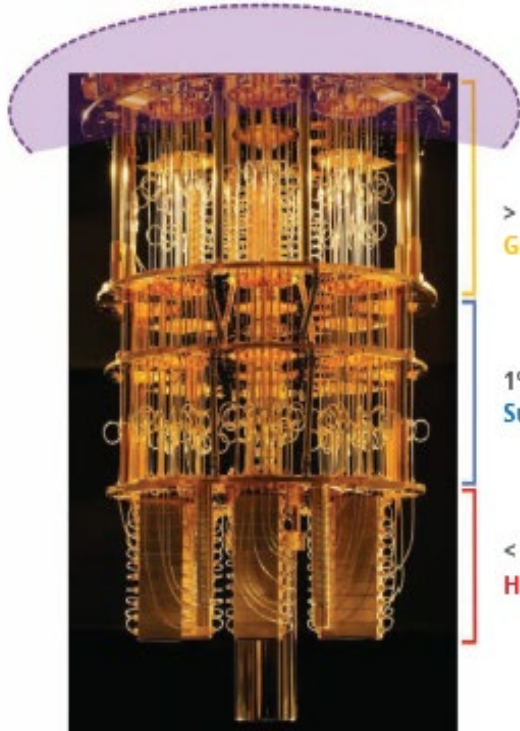
Hermetic feedthrough



*Specific
interface*

PART NUMBER	DESCRIPTION
EPT2201-70	SMPM interconnexion matrix equipped with attenuators (0-20 dB)

Cable Assemblies

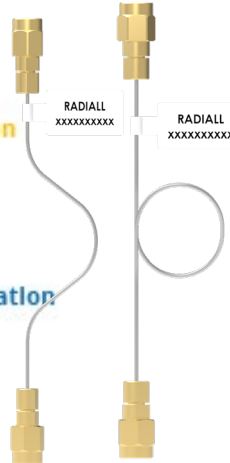


Room Temperature
Long Semi-Rigid

> 4°K
Good Thermal Isolation

1°K - 4°K
Superior Thermal Isolation

< 1°K
Highly Conductive



Up to 180 SMPM c/a per level

- Raw Material : CuNi or NbTi
- Connectors : **SMPM Solderless**
- Others: **options available** (SMA, cable diam)
- Shaping : **S-shape** or **Loop-shape**

PART NUMBER	DESCRIPTION
C291052005	Semi Rigid .034" (0.86 mm) NbTi
C291850016	Semi Rigid .034" (0.86 mm) CuNi

RF & Interconnect Solutions

Radial RF connectors & assemblies product line design for quantum environment :

- **Densification:** Miniature connectors, multi coaxial harness, small diameter cables,
- **Thermalization:** Through panel, thermal conductivity
- **Solution:** A-magnetism, solderless connectors, large range of product,

Cryo-temperature test for SMA, SMP, SMPM & harness:
VSWR, insertion loss, mechanical properties remain stable

- Radial is developing more modular, miniaturization solution for cryogenic environments.



SMPM-LOCK



SMPW



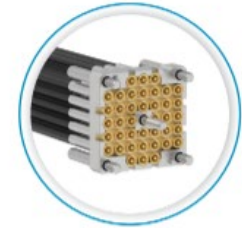
IMP (LP-SR-HD)



ATTENUATOR



SEMIRIGID 3D BENDING



F2C-40



SMA



2.92



SMP

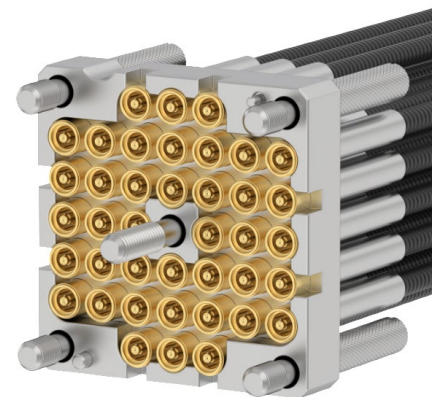
RADIALL F2C-40 Floating Cluster Solution

Radiall F2C-40 patented solution

- Solderless, compression mount PCB interface
- Guiding & floating structure: Outer & centre conductor 0.15mm
- High-density: 40 pin in 30*30mm board, pitch=3.5mm
- Flexible and non magnetic cable assemblies
- Frequency up to 18GHz
- Cryogenic (10 mK) & Non magnetic
- Qualified by 100 QUBITS quantum computers

Next product with pitch < 2.8mm

PART NUMBER	DESCRIPTION
RF2C-00010040	Solderless, compression mount PCB interface

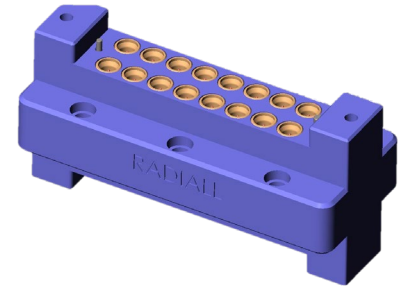


Cryo Attenuators



In quantum computing, cryogenic microwave attenuators are used in different stages of the thermal dilution refrigerator to reduce the thermal noise in the signal. The RF lines within each layer increases the signal-to-noise ratio (SNR), requiring the attenuator for the thermalized layer to protect the signal level.

PART NUMBER	DESCRIPTION
R429800000	SMA attenuator cryo 0dB 18GHz 2W female female
R429803000	SMA attenuator cryo 3dB 18GHz 2W female female
R429806000	SMA attenuator cryo 6dB 18GHz 2W female female
R429810000	SMA attenuator cryo 10dB 18GHz 2W female female
R429820000	SMA attenuator cryo 20dB 18GHz 2W female female

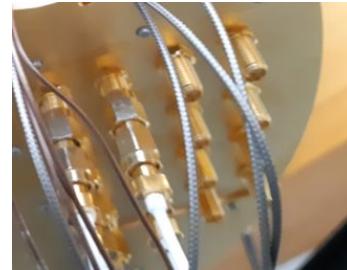
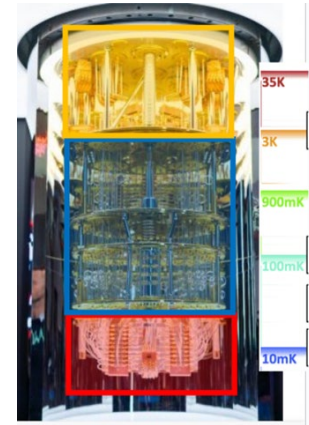


16 SMPM Attenuator

Infrared (Ir) Filters



- Block infrared transmission between stages with a special resin.
- This product is a result of a partnership with Alice & Bob, a French start up
- Around 200 IR filters per quantum computer
- Gains :
 - Better and longer performances for the quantum computer
 - Reliability : accurate and consistent attenuation values near 0°K
 - Coherence time : extends the Qbit lifetime



Cryo Switches



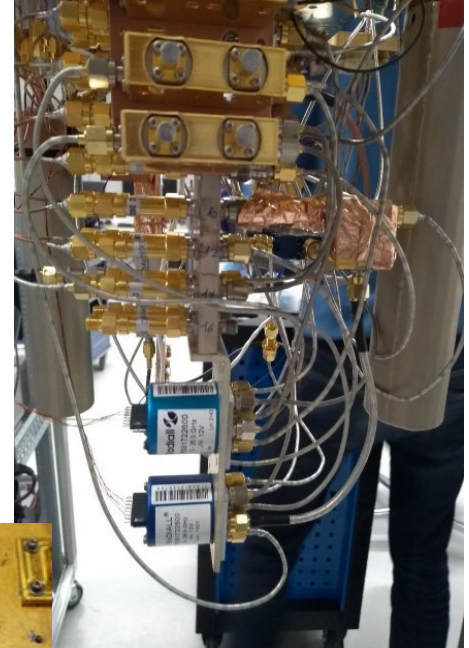
RF SWITCHES

With cryogenic switches, Radiall provides a solution to meet emerging market demands. These switches function at extremely low temperatures (0 Kelvin/-273 °C) and actuate at very low power. They can be easily integrated into equipment and are a perfect solution for a variety of laboratory applications.

PART NUMBER	DESCRIPTION
R583423141	Specific SP6T Ramses SMA 18 GHz Latching 28 Vdc D-SUB Male Connector Bipolar Actuator Command for Cryogenic Application
R571433141	Specific SPDT Ramses SMA 18 GHz Latching 28 Vdc Pins Terminals Bipolar Actuator Command for Cryogenic Application
R5927B2141	Specific SP6T Ramses Sub-Miniature SMA 26.5 GHz Latching 12 Vdc Pins Terminals Bipolar Actuator Command for Cryogenic Application

Cryo Switches - Application

- **First Product:** SP6T SMA 18GHz
- **Efficient use at low temperature**, qualified by several customers
- **Excellent RF performances**
- **Low magnetic field**
- **Easy integration** in the equipment (D-Sub cable, square flange)
- **Cryogenic switches** created upon customer's requests:
 - Ramses SP6T
 - Sub-miniature SP6T



WANT TO KNOW MORE?

- [Radiall Quantum Landing page](#)
- Insights on Quantum Techs
 - [A cryogenic solution for the quantum revolution](#)
 - [The future of computing](#)
 - [RF cable assemblies for quantum computing](#)





SIMPLIFICATION
is our INNOVATION

THANK YOU!

