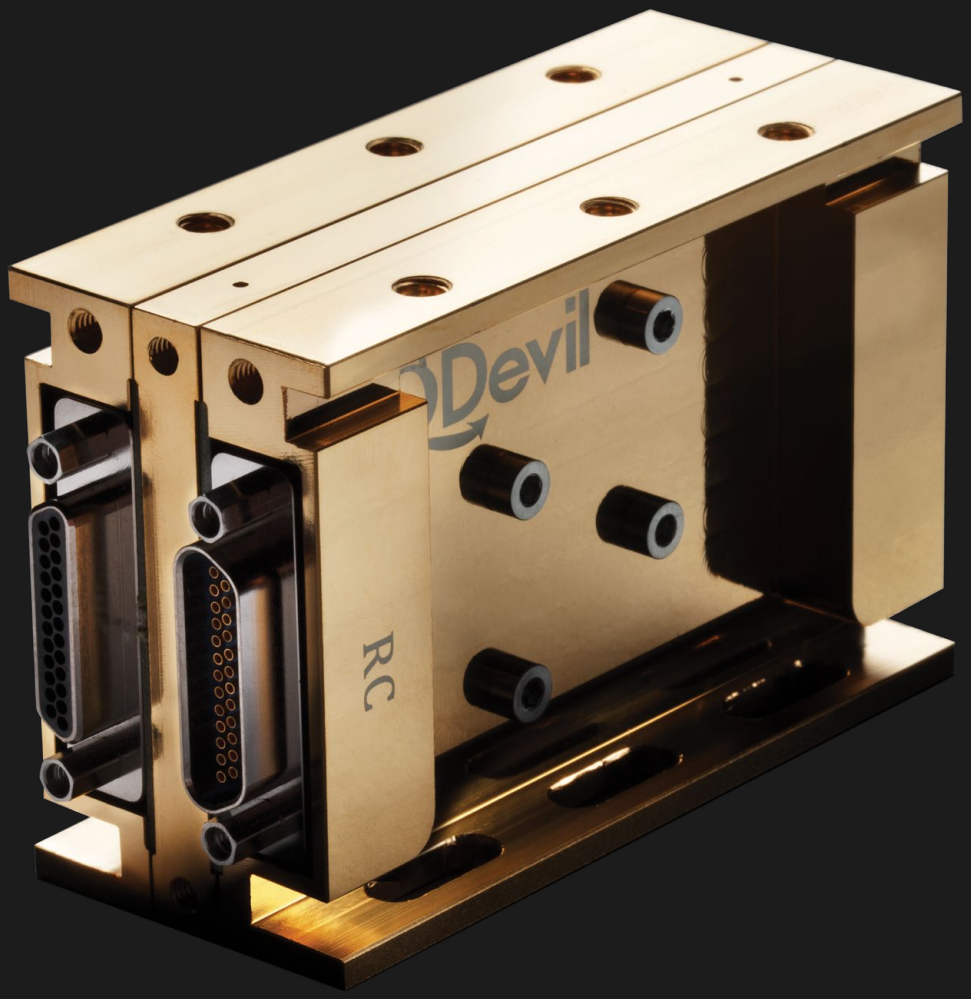
QUANTUM MACHINES



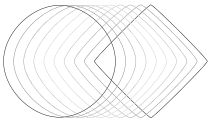
QFilter-II

High-Performance Cryogenic Low-Pass Filter

quantum-machines.co

QFilter-II is a compact, multi-stage low-pass filter that rejects noise and ensures millikelvin electron temperatures in signal lines going to your quantum electronic devices and other sensitive cryogenic circuits. It is the result of more than five years of development and testing at the University of Copenhagen.

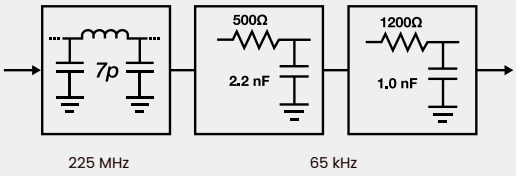
Highlights



- 24 channel low-pass filter comprised of one low frequency (RC) filter board and one radio frequency (RF) filter board.
- 25-pin micro-D connectors, pin-out compatible with most dilution refrigerators.
- Typically reduces electron temperatures to 5 - 10 mK above the mixing chamber temperature.
- Multiple space saving installation options available.
- Designed for easy mounting on or below the mixing chamber plate in dilution refrigerators.
- High conductivity copper enclosure, with non-magnetic gold plating.
- Compatible with low temperatures and high magnetic fields. Package includes titanium mounting screws.
- Non-magnetic, shielded, titanium connectors.

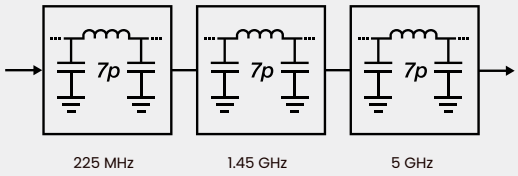
RC Filter Bank

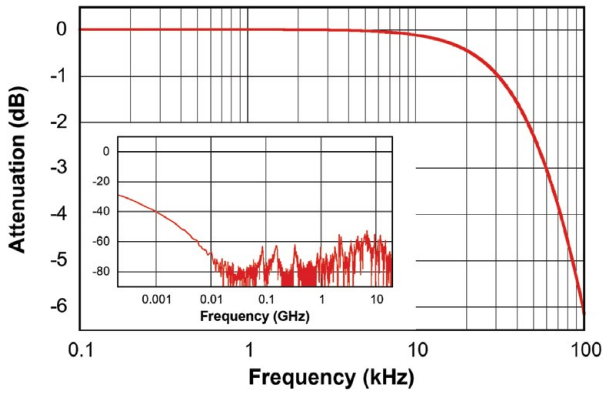
- One reactive 7-pole Pi and two dissipative RC filter stages, individually shielded.
- Transmits below[2] 65 kHz.
- Total resistance (room temp.): 1700±10 Ω.
- Isolation to ground and other channels[1] ≥ 2 GΩ.
- Maximum current 6mA, but should be kept low (<<100 µA) to minimize heat generation.
- Maximum voltage 10 V at room temperature, 150 V below 4 K.



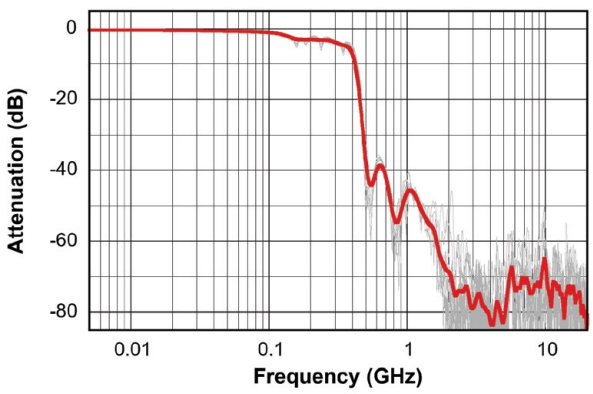
RF Filter Bank

- Three reactive 7-pole Pi filter stages, individually shielded.
- Transmits below 225 MHz.
- Total resistance (room temp.): 2.0±0.5 Ω.
- Isolation to ground and other channels ≥ 2 GΩ.
- Maximum current 10mA at cryogenic temperatures.
- Maximum voltage 10V at room temperature, 150 V below 4 K.

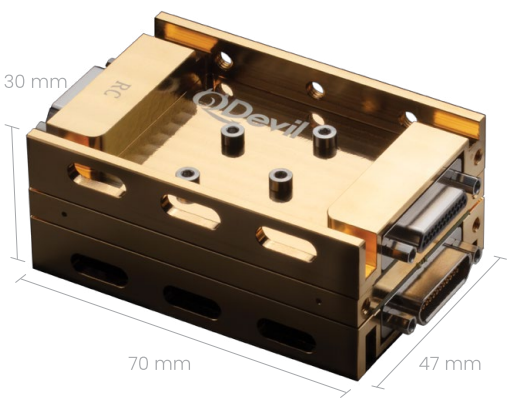




Typical voltage attenuation vs. frequency of the RC filter bank, measured with a Stanford SR830 lock-in amplifier at room temperature. The insert shows attenuation in 50Ω measured using a vector network analyzer.



Typical attenuation vs. frequency of the RF filter bank measured using a 50Ω referenced Rohde & Schwartz ZNB-20 vector network analyzer at room temperature.



QFilter-II dimensions. Pitch of mounting holes is 20 mm in both directions.

QFilter at work

More than 40 leading quantum electronics research groups world-wide rely on the QFilter in their cryostats, and its usage is widely growing. Thermometry measurements at the Niels Bohr at the Institute of the University of Copenhagen (Center for Quantum Devices) regularly confirmed that electron temperatures of 18-25 mK are reached in typical dilution refrigerators (at mixing chamber temperatures between 10 and 20 mK); without the QFilter the electron temperature was measured to be up to 150 mK. The electron temperature was determined by measuring the conductance of SIN junctions and analyzing transport characteristics through quantum dots and quantum dot arrays.

Filtering & Thermalization below 1 Kelvin

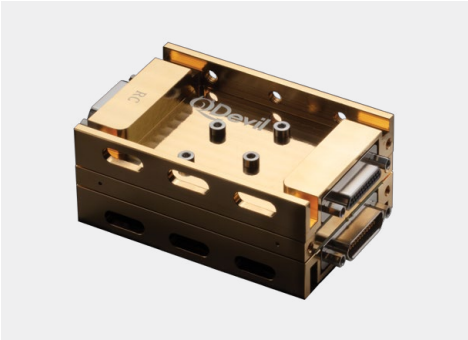
As phonon-electron interaction weakens at millikelvin temperatures, it is a significant challenge to ensure that electrons in the signal lines, going from room temperature to the sample through multiple thermalization stages, are as cold as possible when reaching the sample. Further, high-frequency noise transmitted from room temperature or being picked up by the fridge wiring, not only reduces the signal-to-noise ratio but is also a source of heat, both disturb measurements significantly. QFilter-II with its rigid body of gold-coated high-conductivity copper will, when mounted on the coldest plate of the cryostat, both thermalize the electrons going to the sample and filter out electrical noise from about 65 kHz to tens of GHz.

Customizations & Accessories

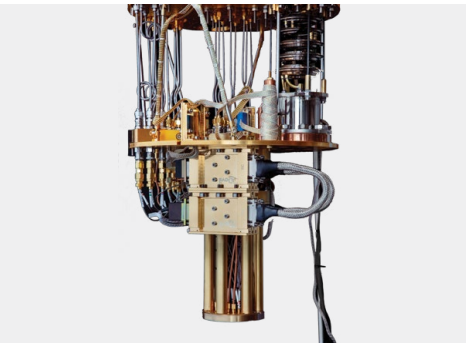
QFilter-II connectivity is compatible with 25-pin micro-D connectors used by most fridge manufacturers. 24 of these lines are filtered compatible with standard 24-line twisted pair looms. The remaining line is not connected. Users are offered to short the resistors of a few selected lines in the RC filter bank, allowing the use of currents up to a few milliamps without the added heat dissipation at the mixing-chamber plate; this may be used for current biasing flux-lines or similar experiments. Shielded micro-D jumper cables in lengths of 15cm or 30cm can be supplied for connecting the filter.

Flexible Mounting Options

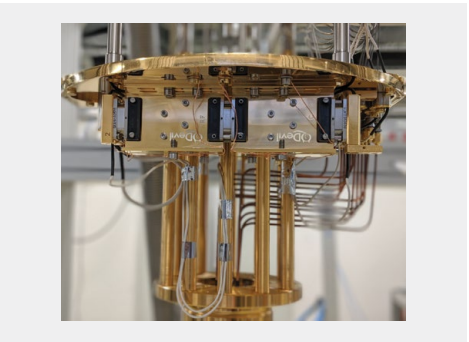
When mounting a single standard QFilter for filtering 24 lines the RC and the RF stages are series connected using a shielded jumper cable in one end of the filter unit. When filtering more than 24 lines, space may be saved by piggy-tailing two units without the use of jumper cables. For this purpose, QFilter units are configured with two identical banks inside (dual RC or dual RF). The piggy-tailed configuration separates inputs and outputs for an easier installation, as well as it reduces the number of components needed.



QFilters can be mounted stand alone with a jumper cable or stacked and/or mated in series. For in-series mating, units are usually ordered in pairs: One unit with two RF banks and one with two RC banks.



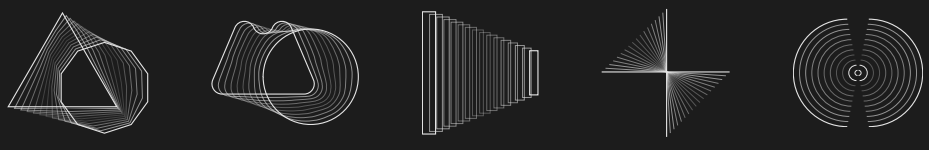
QFilter-II at The Niels Bohr Institute, Copenhagen.



Piggy-tailed dual-RC and dual-RF QFilters (previous version) at the Max Planck Institute, Halle.

About Quantum Machines

Quantum Machines (QM) is driving the future of quantum computing through Hybrid Control, seamlessly integrating quantum and classical computing. Conventional controllers struggle with disjointed operations, creating friction that limits scalability. The Pulse Processing Unit (PPU), at the core of QM's innovation, is a special processor for quantum control, designed to eliminate this barrier by bringing classical computing closer to qubits, reducing latency and enabling real-time execution of quantum error correction, and other advanced algorithms. The hybrid development platform further streamlines development, empowering quantum computer builders to create efficient quantum-classical programs. OPX1000, QM's flagship controller, embodies this hybrid approach. It is a modular, high-density control platform with a cutting-edge quantum-led analog front end. OPX1000 is tailored for large-scale quantum computers, offering unparalleled performance, scalability, and ready HPC integration, including an ultra-fast interface to GPU/CPU accelerators for boosting quantum control. With hundreds of deployments worldwide, Quantum Machines' solutions are trusted by quantum computer builders, research labs, and HPC centers. For more information, visit **quantum-machines.co**.



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