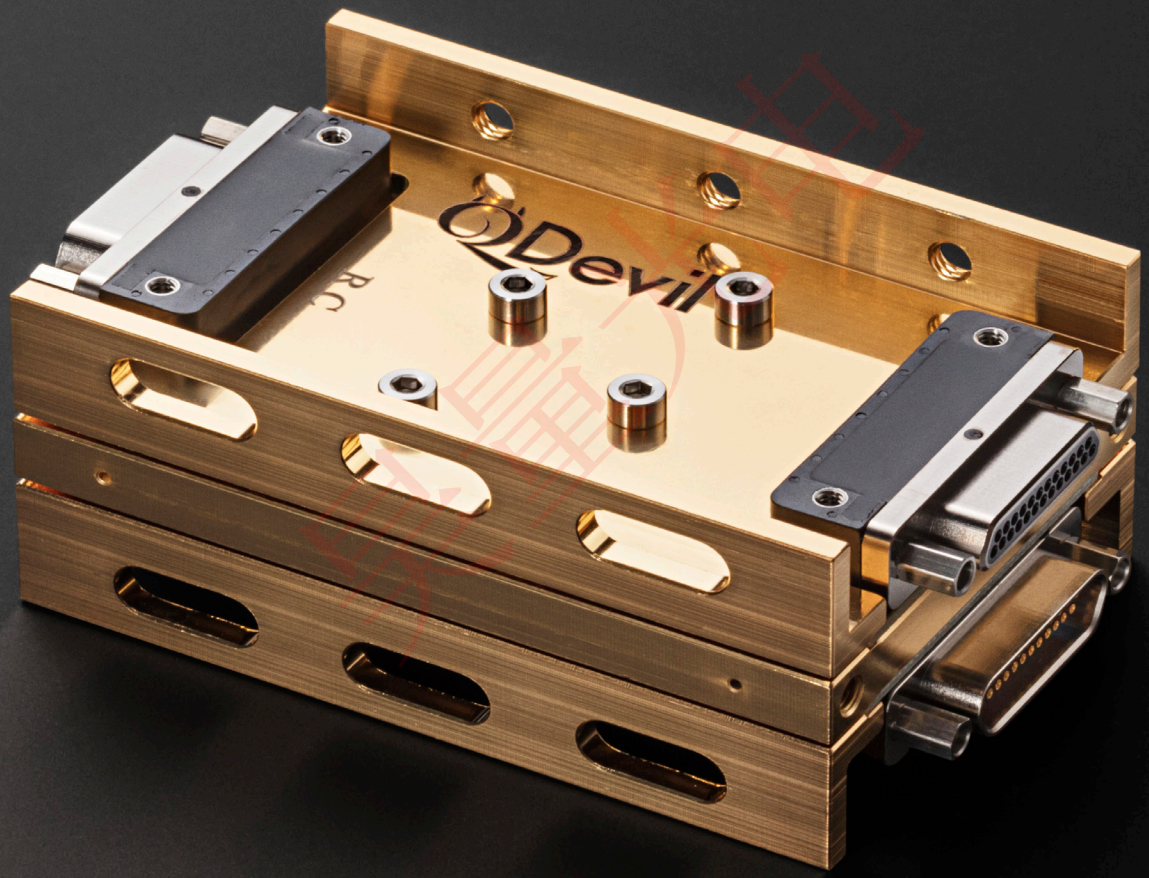
QFilter

Using patented technology, the QFilter rejects high frequency noise and thermalizes electrons to the cryostat, ensuring millikelvin electron temperature in quantum electronics



QDevil

The Devil is in the detail

The QFilter

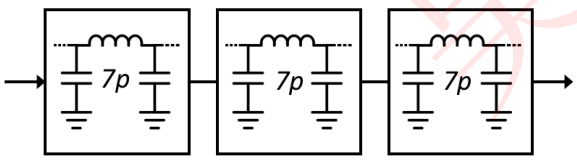
The QFilter is a compact multi-stage low-pass filter which applies patented technology* to reject noise and to ensure mil-likelvin electron temperature in up to 48 signal lines going to your quantum electronics devices and other sensitive cryogenic circuits. It is the result of several years of development at Harvard University and University of Copenhagen on achieving the lowest possible noise and electron temperature in quantum circuits. The standard QFilter contains two filter banks, one with RC circuits and one with LC circuits, but other combinations can also be supplied.

Highlights

- One audio frequency (RC) and one radio frequency (RF) filter board with 24 low-pass channels each
- Designed for easy mounting on the mixing chamber plate of common dilution refrigerators
- Sturdy design makes it possible to stack multiple filters for higher channel counts
- Signal lines are thermally anchored to non-magnetic gold-plated copper brackets
- Compatible with low temperatures and high magnetic fields
- Non-magnetic shielded 25-pin microD connectors, female input, male output
- Pinout compatible with Cinch connectors used in most dilution refrigerators
- Optimal performance is achieved by connecting the RC and RF lines in series using an optional jumper cable
- QFilters can be stacked or mated in-series to save space or cables respectively

Radio frequency low-pass filter bank (RF)

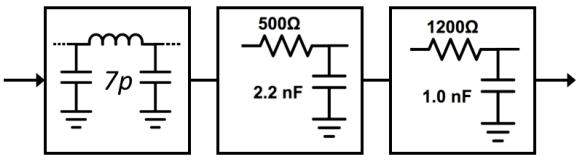
- Three reflective 7-pole Pi filter stages, individually shielded
- Attenuates above 80 MHz
- Total resistance (room temp.): 2.5±0.2 Ω
- Isolation to ground and other channels > 2 GΩ (room temp.)



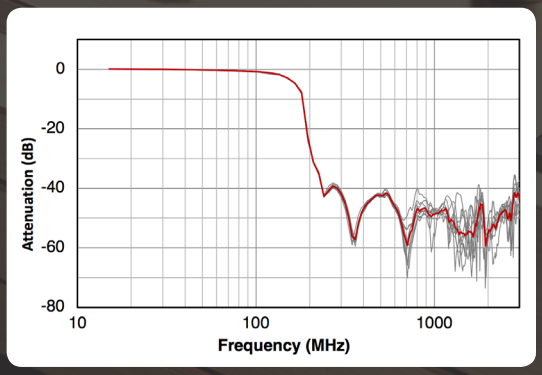
80 MHz 1.45 GHz 5 GHz

Low frequency low-pass filter bank (RC)

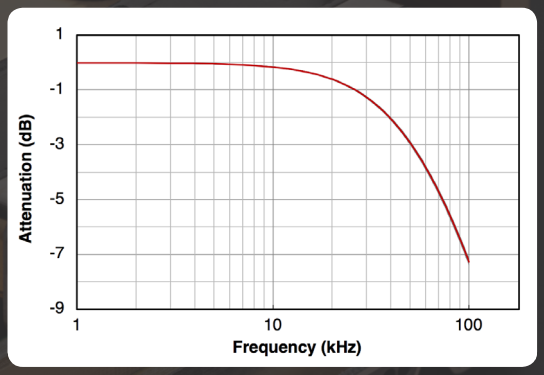
- One reflective 7-pole Pi and two dissipative RC filter stages, individually shielded
- Attenuates from 50 kHz or lower
- Total resistance (room temp.): 1700±10 Ω
- Isolation to ground and other channels > 2 GΩ (room temp.)



80 MHz 50 kHz

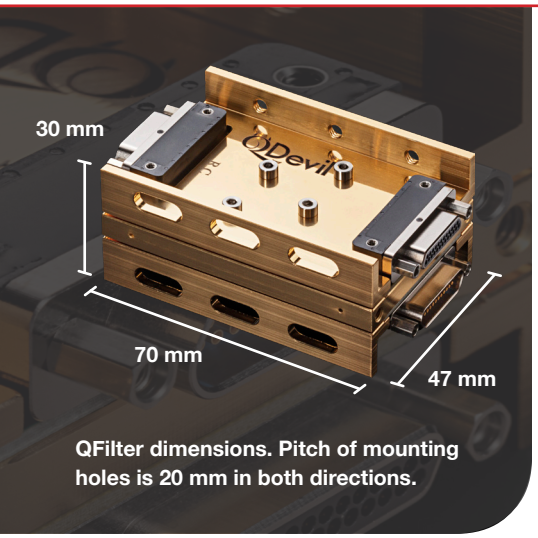


Typical attenuation vs. frequency of the RF filter measured using a 50 Ω HP8753D Network Analyzer at room temperature. Note that fridge wiring typically differs in impedance.



Typical attenuation vs. frequency of the RC filter, measured with a Stanford SR830 Lock-in Amplifier at room temperature. Note that the cut off frequency may vary depending on the resistance of the connecting leads.

*)US patent US 9,826,622 B2 (2017)



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

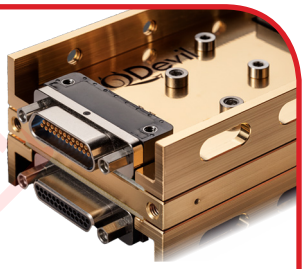
Filtering and thermalizing below 1 Kelvin

As phonon-electron interactions become very weak at millikelvin temperatures it is a significant challenge to ensure that electrons in the signal lines, which go all the way from room temperature to the sample through multiple thermalization stages, are as cold as the sample holder when reaching the sample.

High-frequency noise transmitted from room temperature or being picked up by the wiring down to the cold space not only reduces the signal-to-noise ratio but is also a source of heat, dramatically disturbing measurements.

By mounting the QFilter, with its rigid body of gold-coated high-conductivity copper and multiple filtering stages, firmly onto the coldest plate of the cryostat it will both thermalize the electrical leads and electrons to the sample, and filter out electrical noise from about 50 kHz to tens of GHz.

QFilter at work

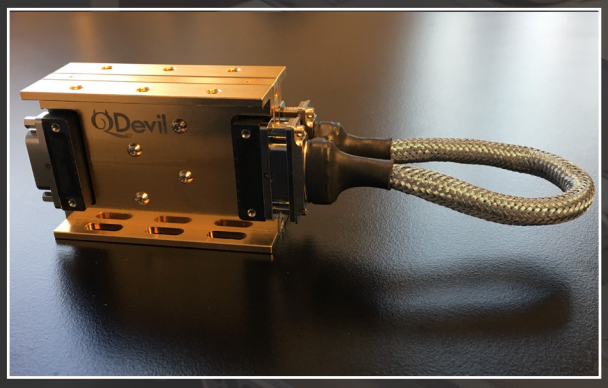


More than 15 leading quantum electronics research groups world wide rely on the QFilter in their cryostats, and its usage is widely growing.

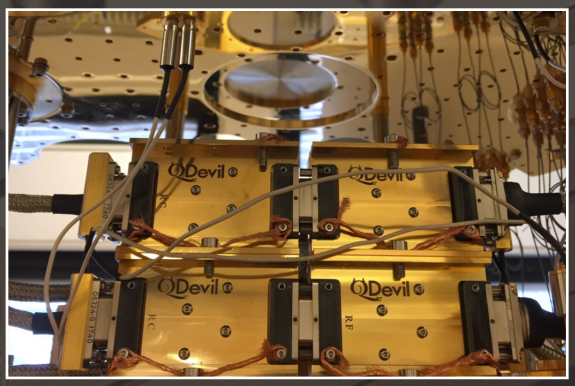
Thermometry measurements at the Niels Bohr Institute of University of Copenhagen (Center for Quantum Devices, 2018) confirmed that electron temperatures of 18-25 mK are reached in typical noisy cryofree dilution refrigerators (at a mixing chamber temperature of about 14 mK). The electron temperature was determined by measuring the conductance of SIN junctions, and fitting the IV-characteristics.

Options

- The standard filter assembly is configured with one 24 channel RC filter bank and one 24 channel RF filter bank. For optimal noise reduction and thermalization, these are connected in series using a short jumper cable.
- Shielded microD jumper cables, both 6” and 12”, can be supplied for connecting the output to the sample.
- The filter can also be delivered with two RC banks or two RF banks, which can then be mated in series without the need for a jumper cable. This gives optimal filtering for 48 channels on the footprint of two QFilters.
- The microD connectors have 25 pins, whereas the QFilter has only 24 channels. Our standard choice is that pin 13 of the microD connectors is not connected (consistent with most fridge manufacturers). Modifications are possible on request.



The QFilter with the optional 6-inch jumper cable connecting the 24-channel RC and RF filter banks in series.



QFilters can be mated and stacked. For in-series mating filters are usuallly ordered in pairs: one filter with two RF banks and one filter with two RC banks.

Item no.	Description
Q001	QFilter assembly, standard configuration with one 24-channel RC and one 24-channel RF filter bank
Q002	QFilter assembly with two 24-channel RF filter banks
Q007	QFilter assembly with two 24-channel RC filter banks
Q005	Shielded jumper cable, 6 inches, 25-pin microD male to female connector
Q006	Shielded jumper cable, 12 inches, 25-pin microD male to female connector

About QDevil

QDevil was founded in 2016 with the mission of developing and producing auxiliary electronic components specialized for quantum electronics research. Product development is done in close collaboration with universities, in particular with the University of Copenhagen.

QDevil's first product is the 24 channel QFilter for reducing electron temperature below 100 mK. It is built on a design developed and patented by Ferdinand Kuemmeth and Charles Marcus while working at Harvard University. The QFilter has been improved since the initial introduction, with high-quality metal connectors and better shielding.

The product portfolio has quickly increased with a 24-channel breakout box, the QBox, two sample holder boards, several specialty cables, and the QDAC, a 24- or 48-channel gate controller DA converter.