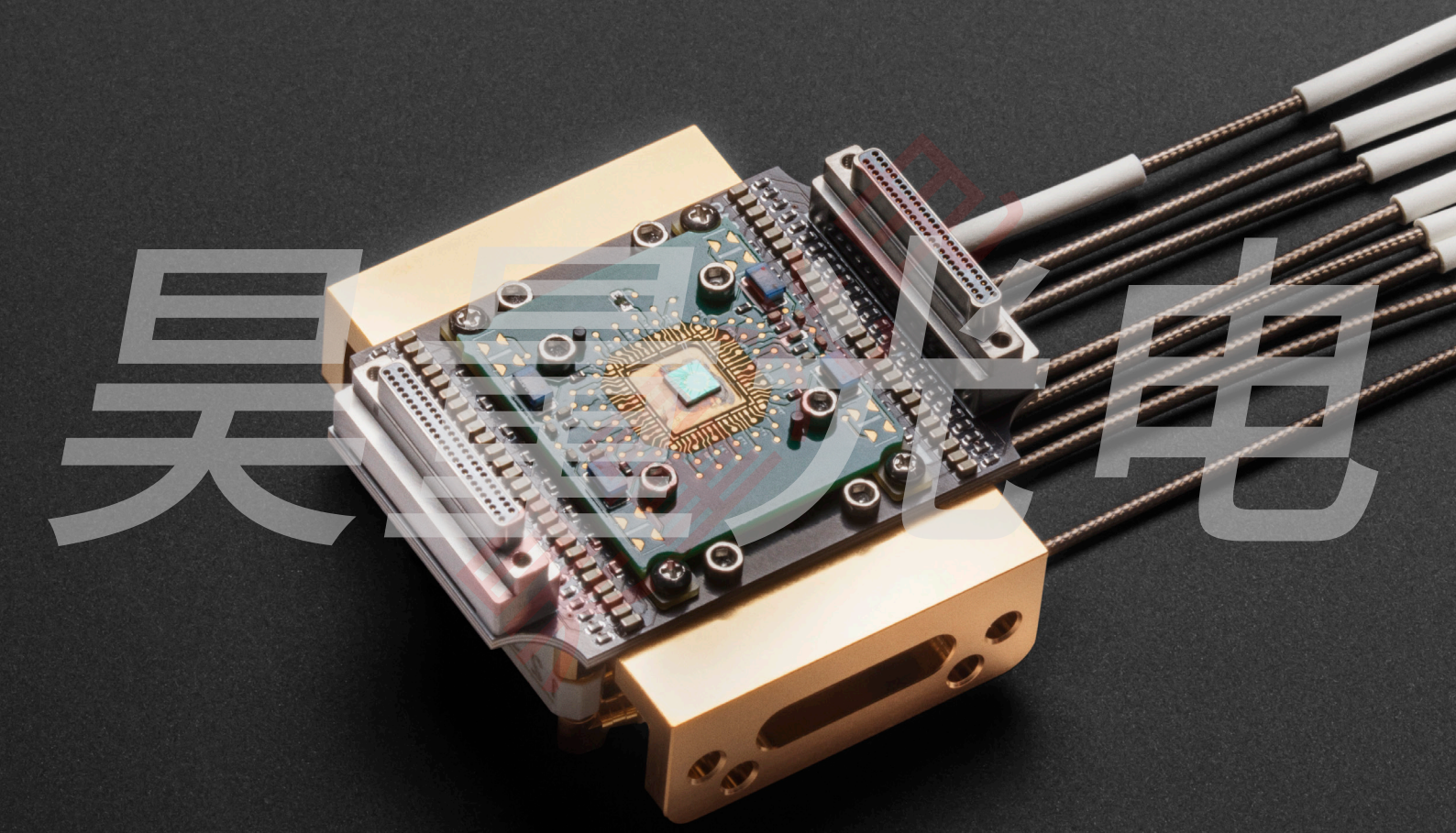
QBoard

Complete sample holder system for cryogenic electrical characterization of quantum-electronic chips at low and high frequencies



QDevil
The Devil is in the detail

昊量光电

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The QBoard

QBoard is a modular, PCB-based sample holder system for low-temperature electronic devices, such as spin-qubit chips and superconducting circuits. It has 48 DC/low-frequency channels and 16 high-frequency channels (GHz) and offers excellent thermalization down to millikelvin.

QBoard is based on a multi-board design for multiqubit devices[1)] which is used for example at the University of Sydney and the University of Copenhagen (Center for Quantum Devices). It consists of a motherboard, a daughterboard (which serves as a chip carrier), an interposer, a mounting bracket, plus all necessary cables for connecting the QBoard to the cold finger of a typical dilution refrigerator (or to the inside of cryostat's measurement insert).

With this optimized, tested and well documented system you do not need to spend valuable research hours on designing and manufacturing chip carriers and connectors for contacting your quantum chip.

Highlights

- Motherboard with two 51-pin nano-D connectors wired in parallel, facilitating sample check in bottom-loader cryostats or grounding during connection.
- 48 RC-filtered low-frequency lines.
- 16 RF lines with two 8-pin mini-coax connectors.
- 16 bias tees on motherboard for all RF lines.
- Made of non-magnetic materials.
- Daughterboards for sample mounting via wire bonding. Daughterboards are inexpensive – no more need to unbond good samples!
- Daughterboards are prepared for mounting of resonator circuits for reflectometry.
- Mounting bracket for inserts of popular dilution refrigerators. QDevil supplies CAD files for customers who need to make their own brackets.

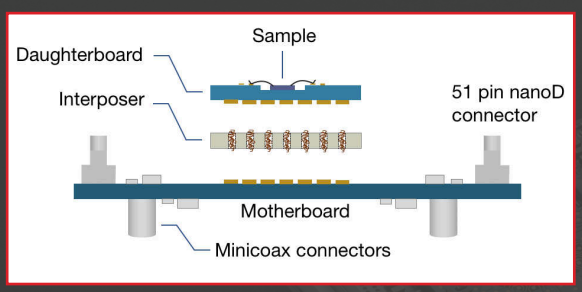
The motherboard

The motherboard serves as the main hub. It supports up to 48 DC/LF lines via two 51-pin nano-D connectors, and 16 RF signals via two 8-pin mini-coax connectors. It has integrated RC low-pass filters for all DC lines and bias tees for the capacitively coupled RF lines. It is made of non-magnetic materials and has 7 layers, optimized for minimum cross talk and RF loss.

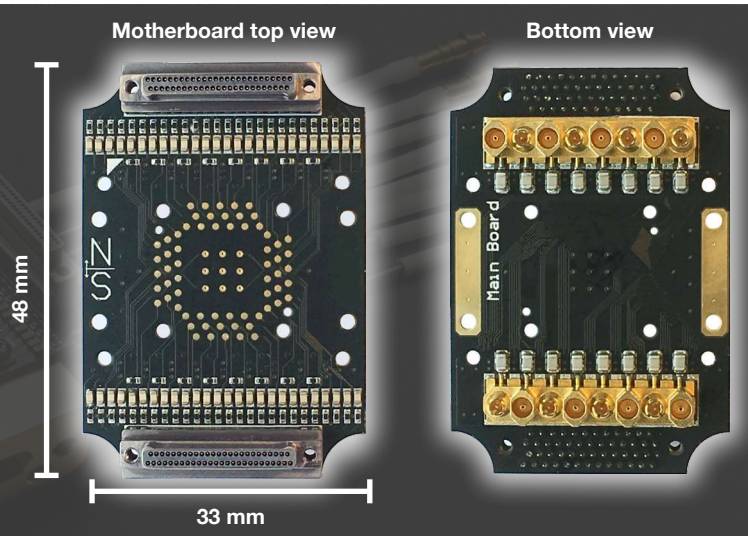
The 48 low-frequency lines can be accessed either via the connector at the north end of the board, or via the connector at the south end. This allows grounding one side while making connection to the other, avoiding ESD damage to the sample. In bottom-loader cryostats, this also allows measurement in the load lock (via the south connector) before the north connector makes electrical contact to the cold finger of the cryostat through the top of the insert. Having two connectors also facilitates bias cooling.

The perpendicularly mounted connectors ("straight nano-D connectors") allow the QBoard to be mounted either parallel or perpendicular to the main axis of superconducting magnet, useful in fridges with sufficiently large sample inserts. However, in order to fit the QBoard system into small sample spaces, QDevil offers the option to mount nano-D connecters that launch in-plane with the board ("right-angle nano-D connectors").

Each RF line is connected to a DC line via a bias tee. If the RF lines are not in use, the associated DC lines can be used just like any of the other DC lines.



The sample is glued and wire-bonded onto the daughterboard PCB, which is connected to the motherboard through the small contact springs of the interposer. The assembly is fixed with non-magnetic Titanium screws.



[1)] *Modular cryogenic interconnects for multiqubit devices, J. I. Colless and D. J. Reilly, Rev. Sci. Instrum. 85, 114706 (2014). http://dx.doi.org/10.1063/1.4900948*

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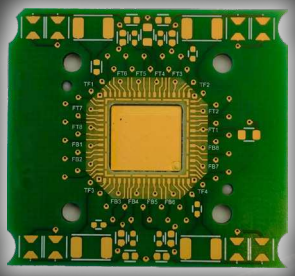
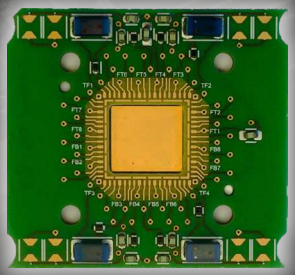


Top view of bare daughter board as delivered by QDevil



Daughter board fitted with resonator (tank) circuitry

The daughterboard and interposer

The daughterboard is where the sample is mounted and wire bonded. It serves as a chip carrier, offering a high degree of flexibility. It has a 0.5 mm deep recess into which the sample chip can be glued. The bottom of this cavity is gold-plated, and grounded and thermally linked to the motherboard by 9 interposer contact springs. If the contact springs are removed, the cavity plane becomes floating. It is possible to apply voltages to the cavity, useful for back-gated samples, as the cavity plane is connected to four bonding pads.

The daughterboard also enables users to mount components for up to four tuneable tank circuits for reflectometry measurements, for example of spin qubits. When these components are mounted, some of the DC lines are used for biasing and tuning.

The interposer is a thin polymer plate with small orifices, each holding a non-magnetic contact spring (Au coated BeCu), which acts like a robust spring contact between the motherboard and the daughterboard.

The interposer contact springs are good for many hundreds of mating cycles. Accurate alignment between the two boards and the interposer is ensured by guide posts. This makes it easy to exchange daughterboards.

Spare contact springs are available from QDevil.

Mounting of the QBoard

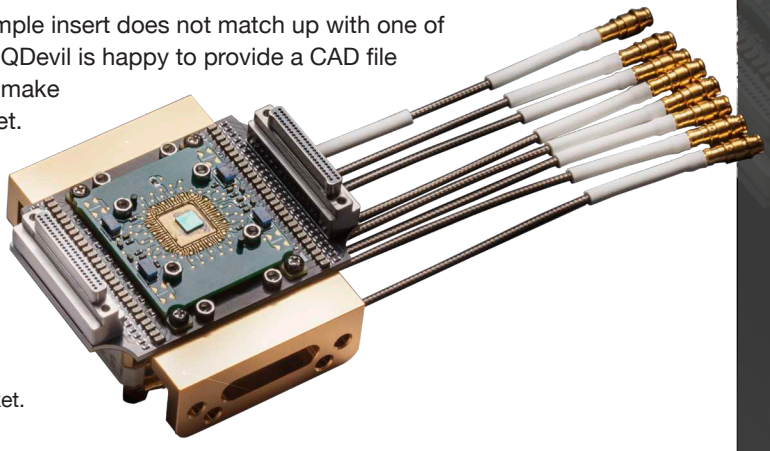
The motherboard is mounted on a carefully designed gold-plated high-thermal-conductivity copper bracket. Large gold-plated contact electrodes on the motherboard ensures good thermal connection. QDevil supplies 3 different brackets:

Type A. This bracket is used, for example, in 73mm bottom-loader sample inserts (Oxford Instruments Triton 400 dilution refrigerators), where it allows the board to be mounted parallel or perpendicular to the main axis of the superconducting magnet.

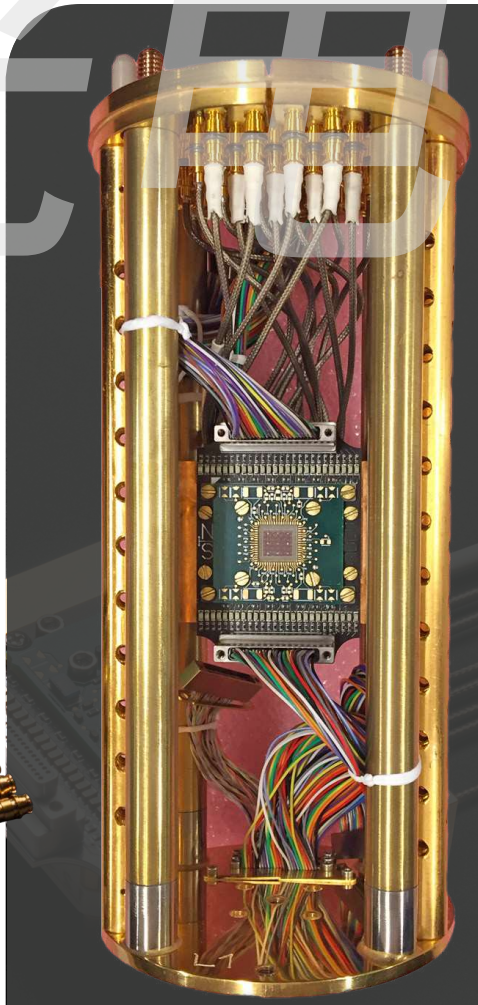
Type B. Used together with bracket A in 80mm bottom-loader sample inserts (Bluefors XLD dilution fridges), where it allows the board to be mounted parallel or perpendicular to the main axis of the superconducting magnet.

Type C. This bracket is used, for example, in 43mm bottom-loader sample inserts (Oxford Instruments Triton 200 dilution refrigerators), where it allows the board to be mounted parallel to the main axis of the superconducting magnet.

In case your sample insert does not match up with one of these brackets, QDevil is happy to provide a CAD file enabling you to make your own bracket.



QBoard mounted on a type A bracket.



Cryogenic sample insert which mates with the cold-finger end-piece of a dilution refrigerator via a 51-pin nano-D connector and several SMP connectors. The QBoard is mounted in its center.

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Item no.	Description
Q101	QBoard motherboard with interposer (vertically mounted nano-D connectors)
- Option 1	Horizontally mounted nano-D connectors for small inserts
Q102	QBoard daughterboard (with gold-plated cavity)
Q103	Type A QBoard mounting bracket, standard shape (e.g. for 73 mm Oxford inserts)
Q111	Type B QBoard mounting bracket adaptor for 80 mm Bluefors inserts
Q112	Type C QBoard compact mounting bracket (e.g. for 43 mm Oxford inserts)
Q104	8-channel Mini-Coax cable assembly
Q105	Nano-D jumper cable, 51 pin, female-female, 4" length
Q106	Jumper cable, 51 pin, micro-D to nano-D

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.

QDevil is continuously improving its products and reserves the right to change specifications without notice

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