QBLOX

QRC

Qubit Readout and Control Module

Release: V26.07



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DESCRIPTION

The Qubit Readout and Control (QRC) module sets a new standard for the readout and control of qubits in both research and high-performance computing.

The QRC is a high channel density RF solution that offers excellent performance and flexibility for controlling a growing number of qubits with the highest fidelities inside the Qblox control stack.

Scalable and modular

With 6 output and 2 input channels, the QRC interfaces with multiple qubits at once, supporting extensive signal requirements for superconducting, spin, and optically addressable qubits.

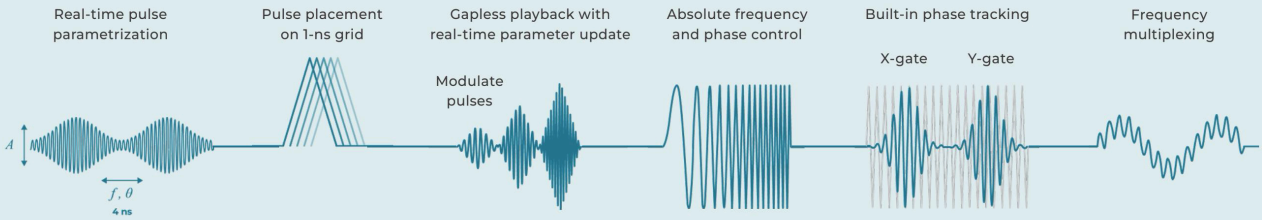
Excellent performance

Engineered on the state-of-the-art RFSoC technology, QRC ensures precise control with high gate fidelities through an excellent signal-to-noise ratio and low phase noise.

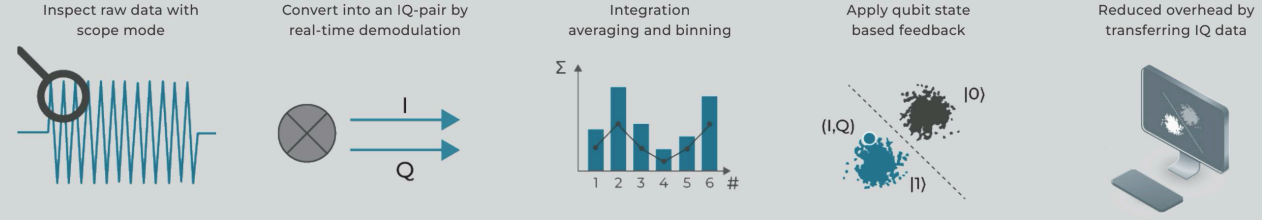
Fast time to results

Calibration-free operation and automatic signal path optimization enable rapid success. Seamless integration with the Qblox portfolio ensures synchronized ports and fast feedback across the entire stack

Control pulse generation



Readout data acquisition



FEATURES

Fully independent ports with continuous frequency range from 100 MHz to 10 GHz offers generation of all signals for your qubits.

Channel-independent instantaneous bandwidth of >800 MHz is available across the full frequency range for frequency multiplexed operations.

The calibration-free unique conversion scheme seamlessly combines direct digital synthesis (DDS) and single mixing for optimal performance, achieving high spurious free dynamic range (SFDR) and high signal-to-noise ratio (SNR) in the full frequency range.

Unrivalled time-domain performance through short rise times and low ringing enable ultra-fast high fidelity gates.

The intuitive open-source software Qblox Scheduler enables easy scheduling of quantum experiments, while assembly layer access allows third-party integrations (e.g., Qiskit) and enhances experimental speed.

Integrate seamlessly into the Qblox control stack with the precise Q1 real-time sequencer and ensure fully deterministic operation for long pulse sequences and measurement loops.

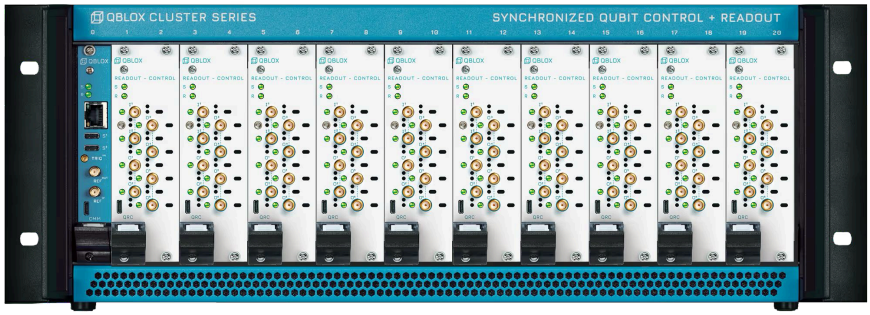
What you program is what you get: gapless playback ensures full predictability and reliability of signals, crucial for phase coherent operations.

Create short parametrized pulses with the industry-fastest parameter update rate of 4 ns.

Get ultimate freedom of channel configurations with 12 independent sequencers, allowing modularity for control and readout ports to adapt to your experiment.

SCALABILITY

The Cluster mainframe hosts up to 10 QRC modules, counting up to 80 microwave channels within a single 19" rack for seamless scalability. The Cluster supports all signals needed for your qubit by synchronizing and linking the QRC with the complete Qblox Cluster portfolio.



SYNQ

SYNQ protocol: Ensures fully deterministic timing of all outgoing signals by creating a synchronized start and establishes fixed timing relations between all the modules in the Cluster. SYNQ Isolator box is provided to establish SYNQ protocol between multiple Clusters to further protect ground-loop free operation.

LINQ

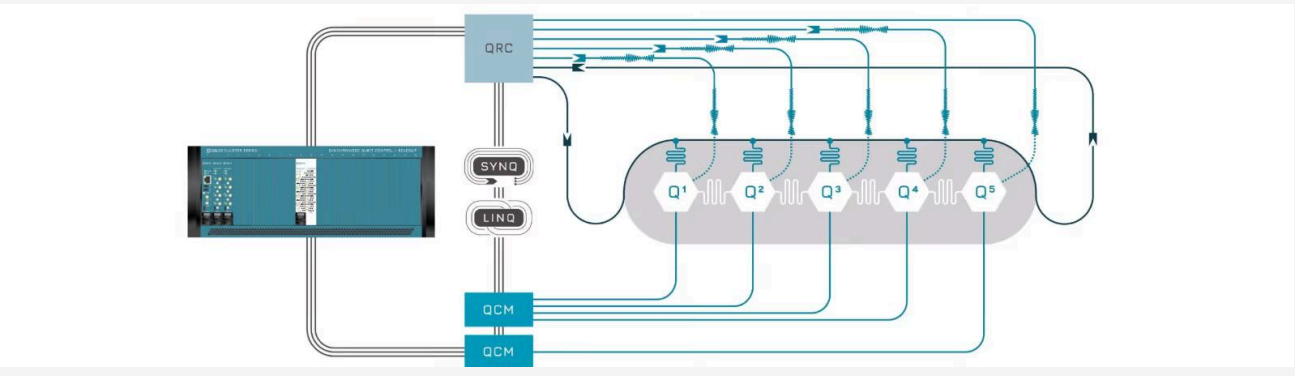
LINQ protocol: Facilitates low-latency feedback with an arbitrary control flow by distributing the measurement outcomes to all modules.

APPLICATIONS

Superconducting qubits

QRC is the high-channel density solution for superconducting systems to seamlessly scale up to 100s of qubits.

- Provides an all-in-one solution for superconducting qubit control and readout, with each module supporting fully parallelized operations up to 5 qubits and a mainframe capacity of 50 qubits.
- Offers compatibility with a wide range of superconducting qubit types, including fluxoniums, transmons and cat qubits.
- Enables frequency-multiplexed readout up to 8 qubits on single feedline in the bandwidth of >800 MHz.

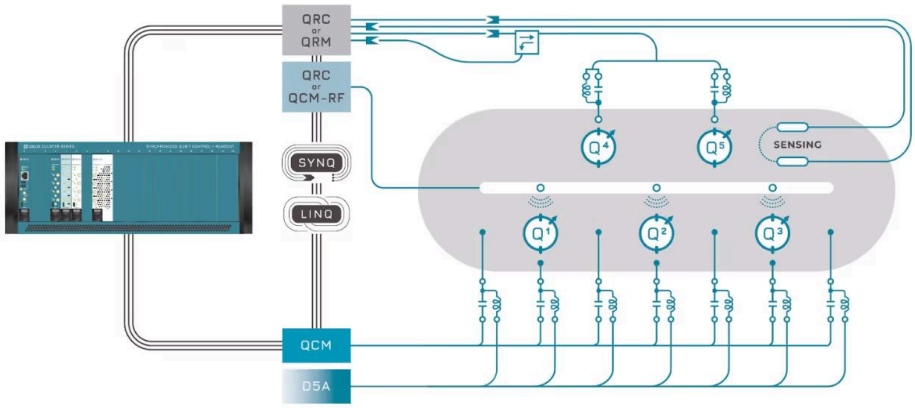


APPLICATIONS

Spin qubits

QRC ensures precise signal processing to enable reliable and scalable spin-qubit systems.

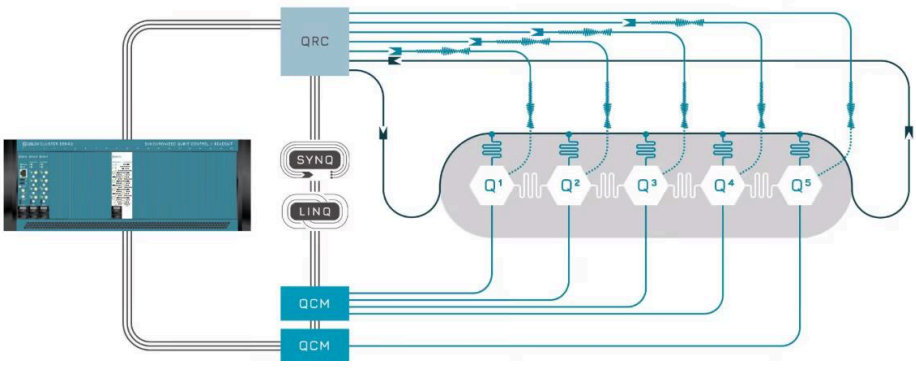
- Provides improved sensitivity at lower noise and high speed by up to 8 multi-tone RF-reflectometry in a wide frequency range.
- Enables high-fidelity operations by pulse resolution on a 1 ns time grid.
- Provides a clean spectrum limiting undesired excitations and error injection in the system, thanks to high SFDR and SNR.
- Facilitates running long quantum circuits with limited dephasing over time due to high output and phase stability.



Optically addressable qubits

QRC is the solution for high quality multiplexed RF and MW control signals.

- Enables driving multiple qubits via a single antenna by QRC's ability to output 8 tones per output channel.
- Provides full spin register control with automatic phase tracking, and together with QTM, optical transition readout by photon counting or time tagging for photon correlation experiments.
- Makes EOM sweeps over a broad range ideal by multiplexing without reducing output power per tone.



SPECIFICATIONS

SOURCING / OUTPUT

Output frequency range:	**100 MHz - 10 GHz**
Number of output channels:	**6**
Max number of carrier frequencies per output channel:	**8**
Analog bandwidth:	**800 MHz**
Max output power:	**+5 dBm**
DAC vertical resolution:	**14 bits**
DAC sampling rate:	**5 GSa/s**
SFDR (excluding harmonics):	**-50 dBc (typical)**
Phase noise:	**-108 dBc/Hz at 10 kHz offset at 6 GHz**
Signal-to-noise ratio:	**-150 dBc/Hz across entire freq. range**
Mute switch isolation:	**50 dB**
Number of digital outputs:	**1**

INPUT CHANNELS

Input frequency range:	**100 MHz - 10 GHz**
Number of input channels:	**2**
Max number of carrier frequencies per input channel:	**8**
Analog bandwidth:	**800 MHz**
ADC vertical resolution:	**15 bits**
ADC sampling rate:	**5 GSa/s**
Input power at full ADC range:	**-45 dBm**
Variable attenuator range:	**50 dB**

GENERAL SPECIFICATIONS

Number of pulse processing units:	**12 sequencer cores**
Parameter update rate (Amplitude, offset, frequency, phase):	**4 ns**
NCO frequency step size:	**0.25 Hz**
Waveform granularity:	**1 ns**
Module to module skew:	**<1 ns**
Channel to channel skew:	**<600 ps**
Connector type:	**SMA for analog outputs / SMP for digital outputs**
Power supply:	**via Cluster mainframe**
Reference clock:	**10 MHz via Cluster mainframe or external clock**
Dimentions single module:	**235 X 130 X 20 mm^3**
Weight:	**0.868 kg**