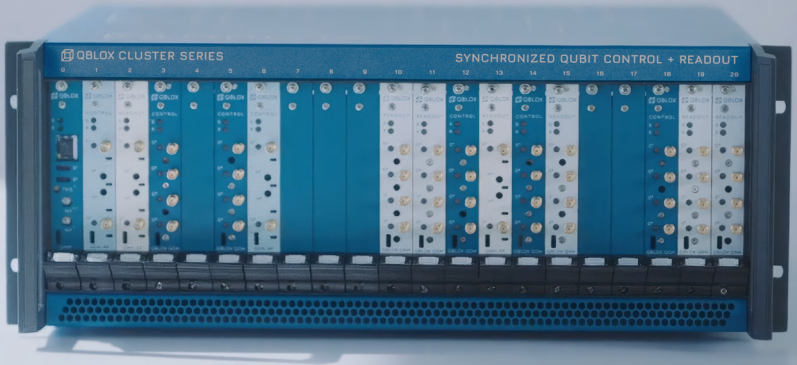
Quantum control stacks

Integrated. Scalable.



QBLOX


QBLOX

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Qblox
Ultra scalable quantum control

Modular solution for scalable qubit control and readout

Qblox is a leading provider of scalable and modular qubit control electronics. Our control stack comprises of modular, qubit-agnostic hardware and device-agnostic high and low level software for manipulating and measuring qubits. The Qblox quantum control stack, known as the Cluster, offers an integrated, modular solution that integrates all the necessary electronics into one device. The Cluster can be scaled up to control hundreds, or even thousands of qubits.

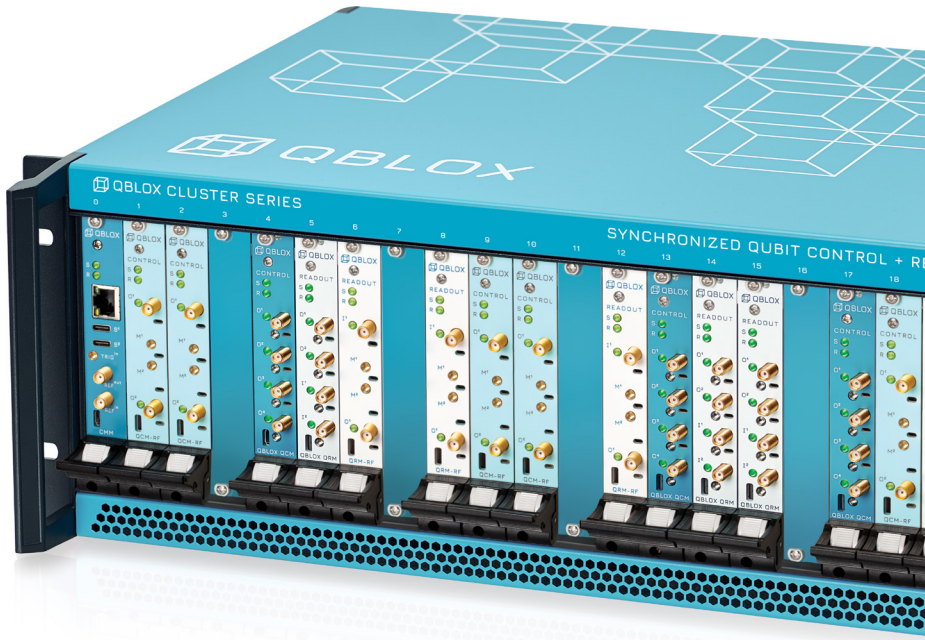
Ideal for research organizations and industries that operate at the forefront of innovation, the product portfolio includes access to qubit agnostic electronics that are application for superconducting, spin, and optically addressable qubits. Qblox is dedicated to supporting quantum researchers with integrated quantum control architecture with immediate NISQ applications and looking towards a future of fault-tolerant quantum computing. Control the quantum future by heading to www.qblox.com.

The Cluster series control stack

Control and readout

The Cluster series control stack scales from a handful of qubits to 100s without losing analog excellence. Control and readout tasks are assigned and fully synchronized to baseband (0 - 400 MHz) or microwave regime (2 - 18.5 GHz) modules.

The Cluster 19” mainframe integrates the state-of-the-art electronics needed to control quantum computers. The dedicated hardware is tailored to reduce size and error rates to speed up experiments by orders of magnitude making it ideal for both university research labs an industrial R&D labs.



QUBIT CONTROL

QCM
QUBIT CONTROL MODULE
0-400 MHz

4 Output channels
5 Vpp

16 bits
16k wave memory

4 Digital outputs
1 GS/s sampling rate

QCM- RF
QUBIT CONTROL MODULE
2-18.5 GHz

2 Output channels
-40 to +5 dBm

750 MHz analog bandwidth
16 bits
16k wave memory

2 Digital outputs
1 GS/s sampling rate

0-400 MHz — **2-18.5 GHz**

QRM
QUBIT READOUT MODULE
0-400 MHz

2 Output channels / 1 Vpp
2 Input channel / 0.1 - 2 Vpp

12 bits
16k wave memory

4 Digital outputs
1 GS/s sampling rate

QRM-RF
QUBIT READOUT MODULE
2-18.5 GHz

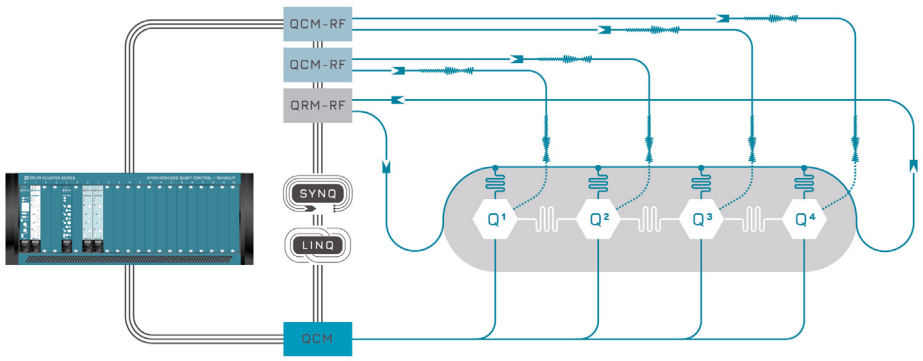
1 Output channel / -40 to +5 dBm
1 Input channel / -26 to 0 dBm

750 MHz analog bandwidth
12 bits
16k wave memory

2 Digital outputs
1 GS/s sampling rate

QUBIT READOUT

Superconducting 4-qubit Control Stack Layout



QCM-RF — MW drive lines
Single-qubit operations
2-18.5 GHz control

QRM-RF — Readout feedline Frequency-multiplexed Readout
2-18.5 GHz

QCM — Flux lines
Two-qubit operations

SYNQ — Deterministic timing
Intermodular protocol

LINQ — Fast Scalable Feedback
All-to-all connectivity

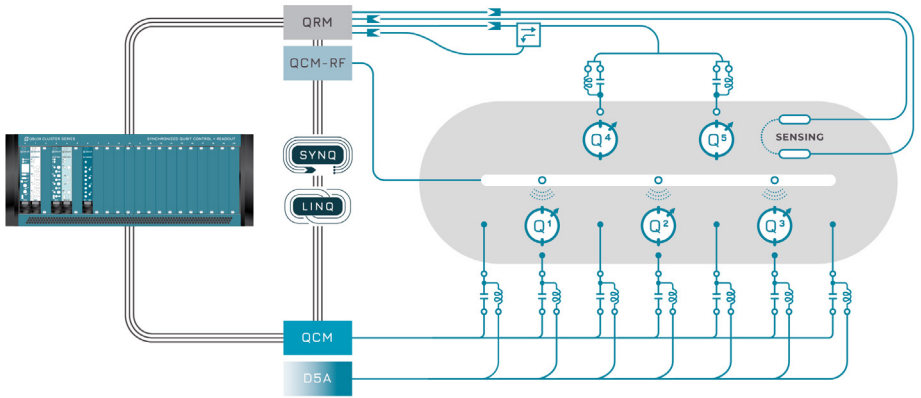
Modular control stacks for superconducting applications

All-in-one integrated solution for superconducting qubits

Qblox's quantum control stacks seamlessly integrate all the instrumentation needed for precise control and readout of superconducting qubits, providing researchers with an unparalleled platform. The Qblox Cluster's modular architecture provides exceptional flexibility and scalability, supporting 1000s of qubits, addressing the growing demands of quantum computing research.

- Ultra-low 1/f noise and minimal drift to ensure precise flux pulsing and DC offset generation;
- Fast scalable feedback operation for quantum error correction and active reset;
- On-board data processing to reduce data transfer latency and to enable real-time averaging;
- Intuitive software package to simplify quantum experiments, libraries of quantum operations, calibration routines, and visualization.

5 Quantum Dot
Control Stack Layout



QRM	Readout lines / 0-400 MHz DC and RF-reflectronomy
D5A	Ultrastable DC voltage source tuning energy levels
QCM-RF	Gates / ESR & EDSR 2-18.5 GHz control
SYNQ	Deterministic timing Intermodular protocol
QCM	Gates / Tuning barrier potentials 0-400 MHz Control
LINQ	Fast Scalable Feedback All-to-all connectivity

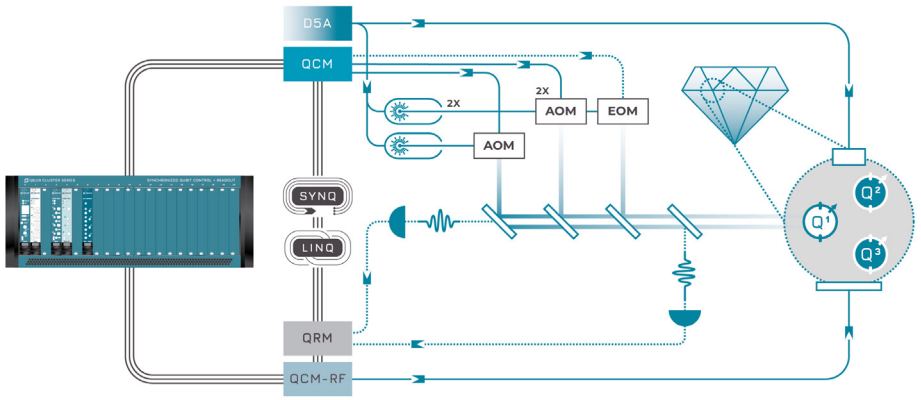
Modular control stacks for spin qubit applications

All-in-one integration for quantum dot systems

Qblox's quantum control stacks integrate all the instrumentation required for the control and readout of spin qubits in Si, Ge, and GaAs. Qblox's Cluster simplifies and accelerates quantum dots and spin-qubits measurements due to:

- FPGA-based real-time programming (shorter software-controlled loops overheads);
- Open source low and high-level software layers, including a spin-qubit specific library;
- Modular architecture that configures for any type of spin-qubit device configuration;
- RF-reflectometry-based read-out measurements from DC to 18.5 GHz.

NV-Center qubits
Control Stack Layout



QCM	Drive optical modulators 0-400 MHz Control
D5A	Ultrastable DC Voltage Source Tuning energy levels
QRM	Readout photodetectors configurable 12 bit threshold
SYNQ	Deterministic timing Intermodular protocol
QCM-RF	(multiplexed) qubit driving 2-18.5 GHz control
LINQ	Fast Scalable Feedback All-to-all connectivity

Modular control stacks for spins applications

All-in-one integration with optical systems

Unparalleled low-level noise performance analog channels, combined with precise digital channels make the Qblox Cluster the ideal choice for next-level experiments on optical setups for quantum computing. The Qblox Cluster's modular architecture provides scalability and configurability, and includes:

- Binned or direct histogram photon counting of photodetector signals via a configurable threshold;
- Multi-core FPGA-based pulse sequencer to enable multiplexing and simultaneous phase tracking of multiple qubits;
- Photon count-based conditional feedback for in experiment charge state resetting;
- Intuitive software package to simplify quantum experiments, including quantum operations libraries, calibration routines, and analysis and visualization tools.

Fast Scalable Feedback all-to-all channels connectivity

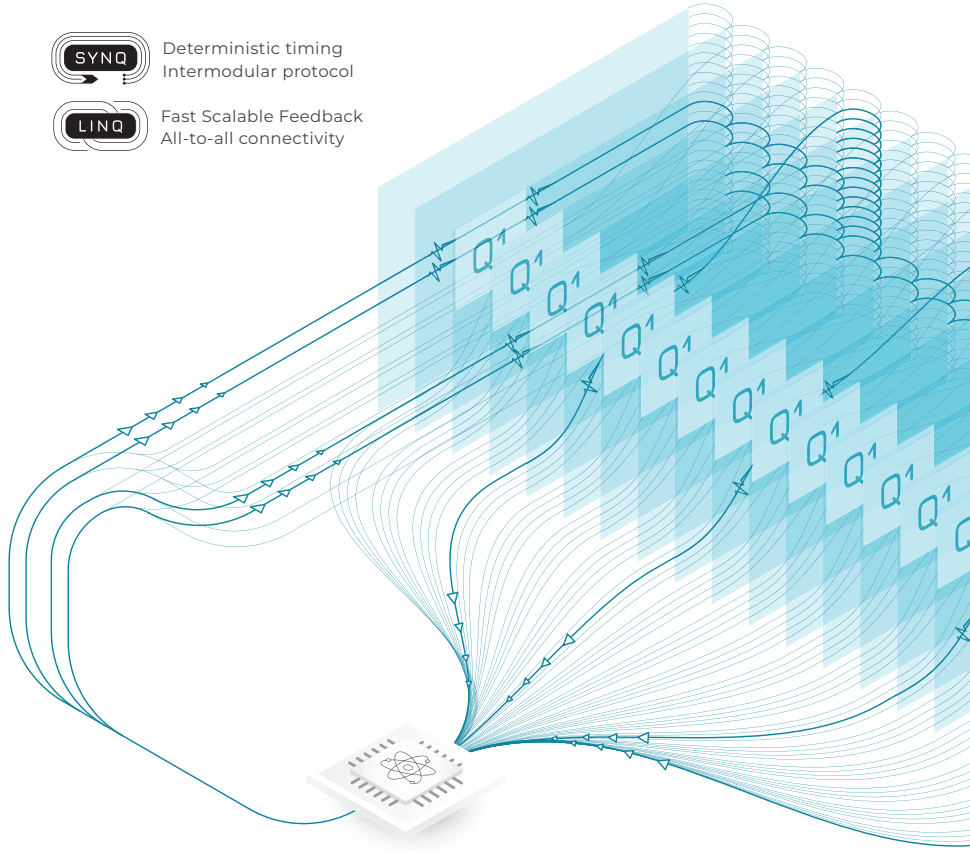
Synchronized & real-time Qubit Control

Qblox introduces fast scalable feedback to open the door for real-time error correction algorithms that can be seamlessly scaled to >1000 qubits.

The proprietary backplane protocols SYNQ and LINQ ensure all channels and modules to act as one monolithic system with full deterministic timing and allowing low-latency feedback.

The LINQ protocol distributes measurement outcomes to all modules within 364 ns for feedback applications. Fast feedback functionalities allow applying pulses and pulse parameter updates conditioned on the measurement results from the readout module.

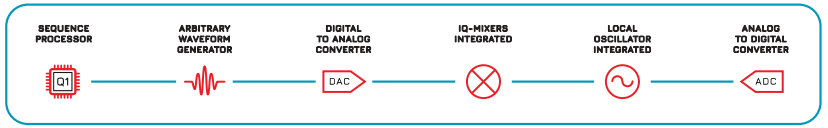
The SYNQ protocol organizes a synchronized start to ensure fully deterministic timing of all incoming and outgoing signals. It synchronizes all analog and digital channels mounted in a mainframe and also in between multiple frames down to picoseconds level.



Q1 sequence processors within fully integrated architecture

6 cores of sequence processors per Cluster

Fully-integrated design



Q1 advanced sequence processors speed up characterization and calibration experiments by avoiding repeated wave uploading and large overhead in software-controlled loops.

This includes real-time updates of pulse parameters (modulation phase, amplitude, offset), and on-board data-processing of readout signals. The result is real-time integrations, averaging, binning and storing up to 131072 measurement results per experimental run.

Real-time pulse parametrization

Q1 sequence processors generate control and readout pulses using waveform memory, and shape output by gain and offset parameters.

Modulation is also added in the digital domain through a numerically controlled oscillator (NCO). The modulation frequency and phase of the NCO can be set arbitrarily to create frequency chirps, to track the qubit phase or for virtual Z-gates.

Upconversion stage + mixer corrections

Once pulses are created in the digital domain, they are converted to analog signals by the state-of-the-art 16 bit DACs that run at 1 GSPS. The integrated upconversion stage includes 2 IQ-mixers and 2 local oscillators per module for directly outputting in the frequency regime 2 - 18.5 GHz.

Self-calibration tools allow correcting mixer imbalances and local oscillator leakage, without disconnecting modules from your measurement setup. The NCO can be set to arbitrarily create frequency chirps, to track the qubit phase or for virtual Z-gates.

Quantify: Software framework for seamless qubit experimentation

Simplify qubit control with high-Level abstraction and intuitive tools

A high-level software framework to control instruments, managing data-acquisition loops, live plotting, data and instrument settings storage, and data analysis. With Quantify, an experiment can easily be defined in the form of a schedule of gate instructions, arbitrary pulses, or a combination. The pulse visualisation tool ensures effortless verification of the hybrid gate-pulse schedule.

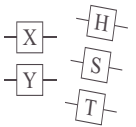
Quantify includes libraries for various qubit modalities to streamline qubit control and readout. The libraries feature pre-defined time-deterministic pulse schemes of typical experiments, such as continuous wave and time-domain spectroscopy pulse schemes for superconducting qubits, charge stability diagrams and spin shuttling sequences for spin qubits and TTL acquisition schemes for NV centers.

This high-level software package allows the hybrid gate-pulse scheme, ideal for both setting up and operating qubit experiments.

quantify

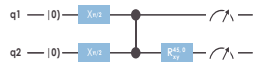
Intuitive and scalable programming of your Quantum Experiments.

Comprehensive hybrid gate-pulse library



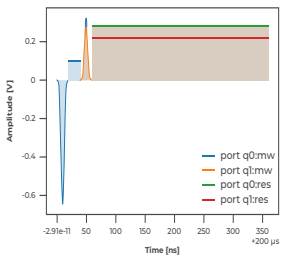

```
.add(X90("q0"))
.add(RampPulse())
```

Easy scheduling with deterministic timing

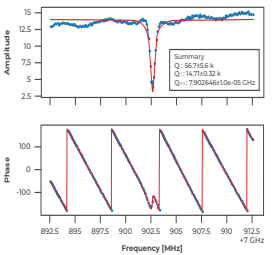


Advanced tools to enhance your results analysis.

Visual Debugging aids



Data analysis and fitting



Aftersales support

Your research goals are our priority. Our support team is made up of passionate people with experimental physics backgrounds. We want to ensure that you reach your goals, so we make sure to understand which features you need and meet you every step of the way.

Our aftersales support includes:

- On-site onboarding and first qubit tune-up;
- A dedicated Slack channel for fast response to questions;
- Regular check-up calls from our support engineers;
- Free firmware/feature upgrades.

Control the quantum future with us:

Save time and unlock analog excellence, scalability, and the flexibility of open-source software tailored to your needs.
Experience the efficiency of our products firsthand with personalized live demonstrations from one of our expert application scientists. Request a demo today and discover how our solutions can empower your business to thrive.

Scan the QR code to book a meeting with one of our Sales Engineer.

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