Quantum control stacks

Integrated. Scalable.

QBLOX


QBLOX

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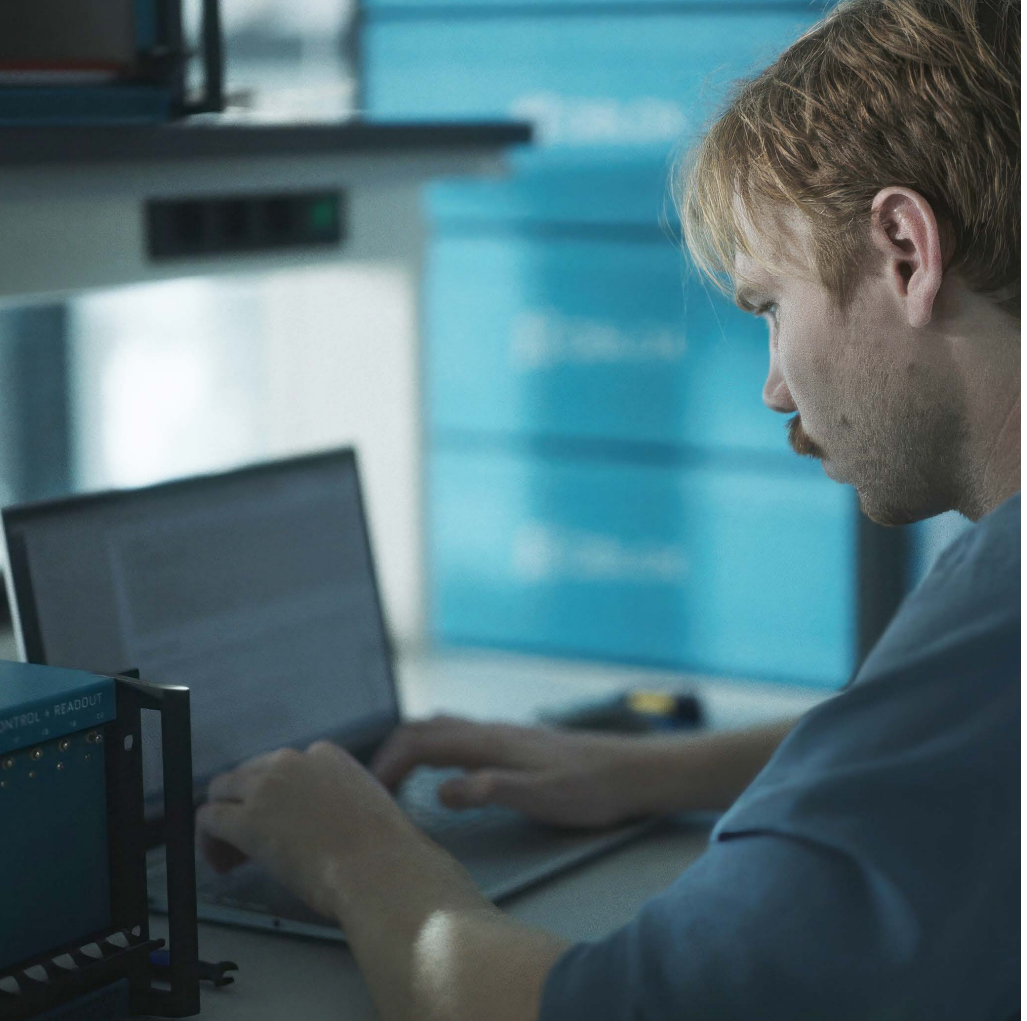


Qblox

Ultra scalable and fully-integrated quantum control

With a team of 150+, Qblox is a leading provider of modular, fully integrated, and scalable quantum control electronics. We offer precision control with the accuracy for error mitigation required to advance quantum setups beyond NISQ applications.

The Qblox Cluster control stack integrates key technologies for pulse generation and acquisition, supporting different qubit types.

With our solutions for quantum control and readout, academic and industrial customers worldwide can scale their setups to hundreds or even thousands of qubits. We believe in the power of collaboration and are dedicated to supporting your quantum journey.

Control the quantum future by visiting www.qblox.com.

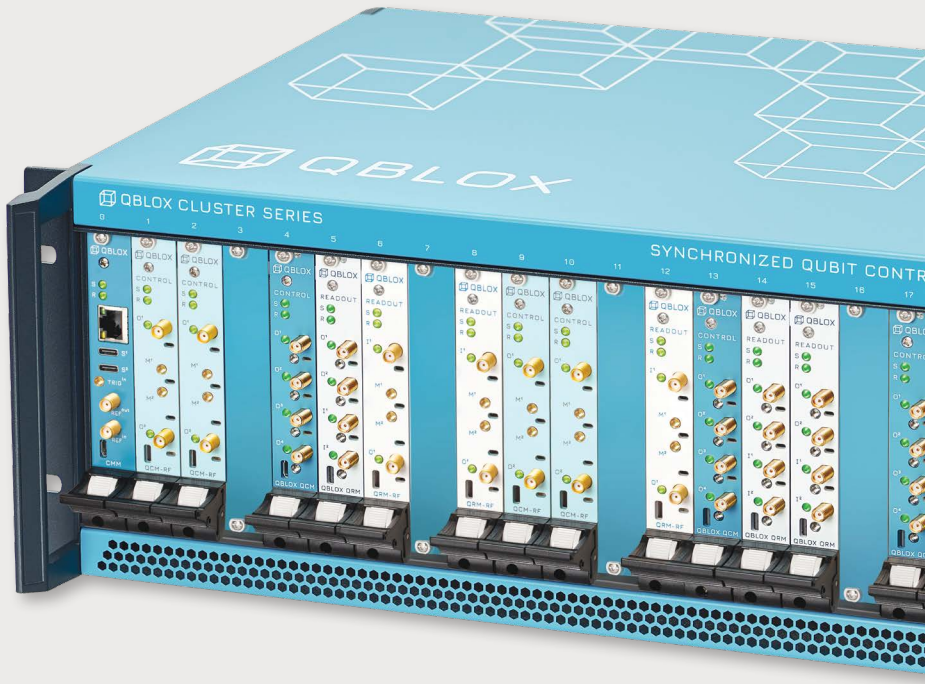
The Cluster series control stack

Control and readout, integrated

The Cluster series control stack incorporates digital pulse processing and analog excellence to control quantum computers.

The analog modules cover a wide frequency range, while the digital module offers state-of-the-art timetagging. By configuring the correct modules, your setup can be tailored for the ideal superconducting qubit, spin qubit, or optically addressable qubit control and readout. Each module provides precise synchronicity and all-to-all connectivity between channels. The top-of-the-line scalable architecture with high channel density enables research labs and industry to scale from a handful of qubits to hundreds seamlessly.

The Cluster 19” mainframe encompasses distributed intelligence where control and readout tasks are orchestrated on the nanosecond scale by multiple cores of Q1 sequence processors, speeding up experiments by orders of magnitude. The scalable architecture and customizable software stack ensure that the system is future-proof and well-aligned with the development roadmaps of industrial labs and the growing demands of quantum experiments.



Module overview

Build your ideal setup with streamlined control

DC modules

QSM
Source & Measure
8 Inputs/Outputs

S4g
± 50 mA
4 channels

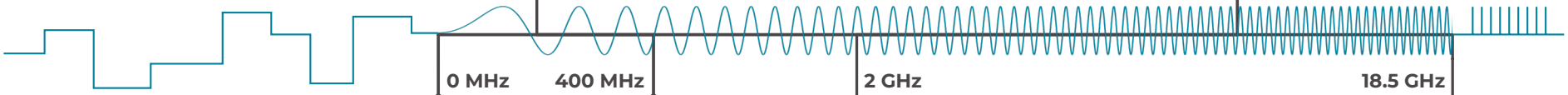
D5a
± 4 Volts
16 channels

Analog modules

QRC
2 Inputs
6 Outputs

Digital modules

QTM
Timetag module
8 Digital I/O



QCM
4 Outputs

QRM
2 Inputs
2 Outputs

QCM-RF
2 Outputs

QRM-RF
1 Input
1 Output

0 - 400 MHz

QUBIT CONTROL MODULE

Ultra-low noise and real-time signal generator with distortion correction

4 Output channels
5 Vpp

16 bits
16k wave memory

4 Digital outputs

1 GS/s sampling rate

QCM

QUBIT READOUT MODULE

Readout module for signal generation, acquisition, and onboard data processing

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

2 - 18.5 GHz

RF QUBIT CONTROL MODULE

Direct RF signal generator up to 18.5 GHz with high SFDR

2 Output channels
Max output power +10 dBm
Attenuation range 30 dB

720 MHz bandwidth
16 bits
16k wave memory

2 Digital outputs
1 GS/s sampling rate

QCM-RF 2

RF QUBIT READOUT MODULE

Multiplex readout up to 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

QRM-RF

100 MHz - 10 GHz

QUBIT READOUT AND CONTROL

Complete RFSoC based solution for qubit control and readout up to 10 GHz

6 analog outputs, 2 analog inputs

12 Q1 Sequencers
(8 Readout, 4 Control)

Analog bandwidth:
800 MHz

5 GS/s DAC/ADC rate

Calibration-free

QRC

DIGITAL I/O

QUBIT TIMETAG MODULE

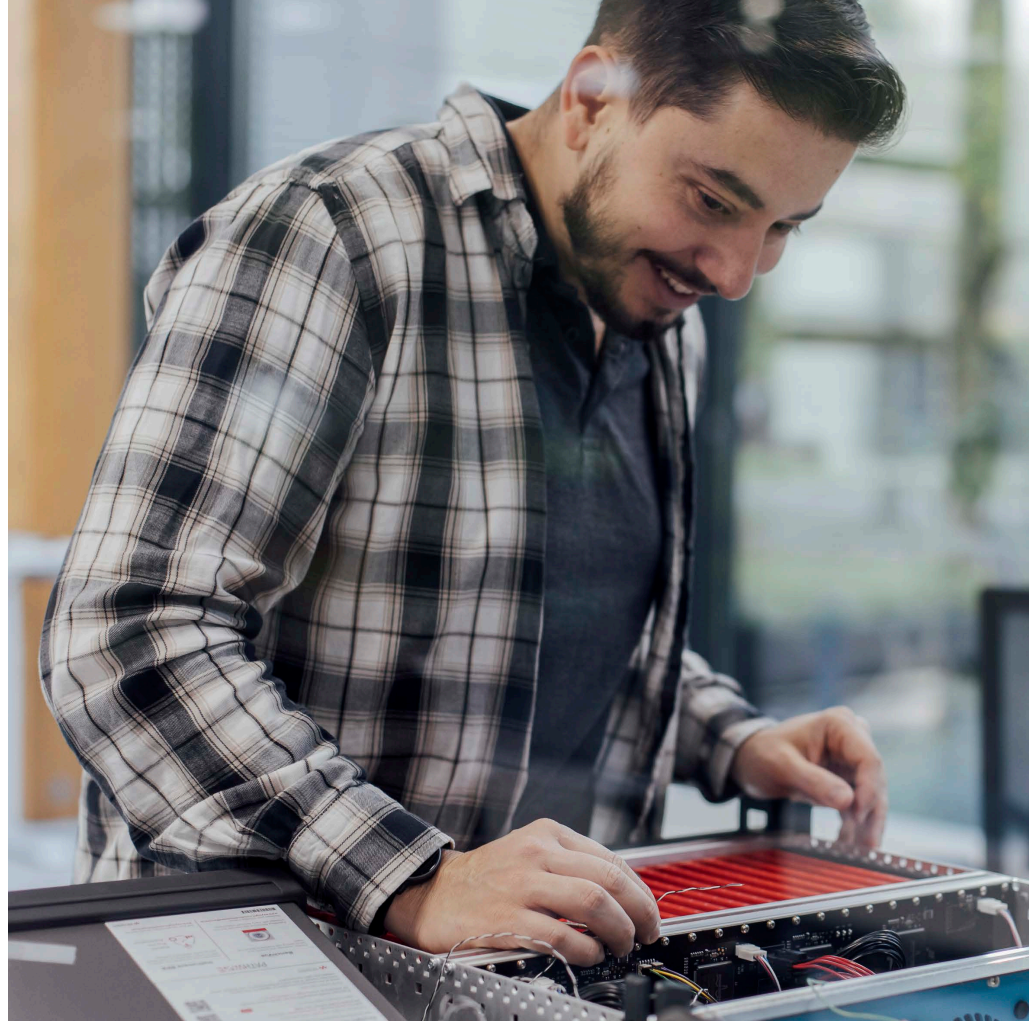
Timetagging module with
8 configurable digital inputs
and outputs

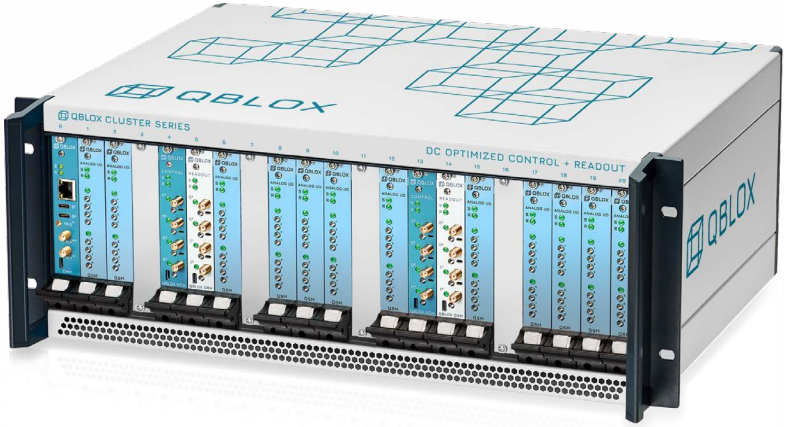
1.5 V (50 Ohm) / 3.1 V (high-Z)
39 ps control resolution

20 ps readout resolution
Rising edge detection

Trigger counting
Input gating

QTM





The DC Cluster

The Qblox DC Cluster mainframe is a 19” rack designed for DC transport experiments. It offers ground-loop free operation and interference isolation. The mainframe can host up to 20 modules, supporting QSM Quantum Source and Measurement modules, along with QCM and QRM baseband modules.

Key features of the DC Cluster include

- Optimized mainframe for ultra stable DC signals
- Up to 160 DC channels in a single mainframe
- The ability to operate QCM and QRM modules together with QSM
- A safety ramp-down feature for emergencies

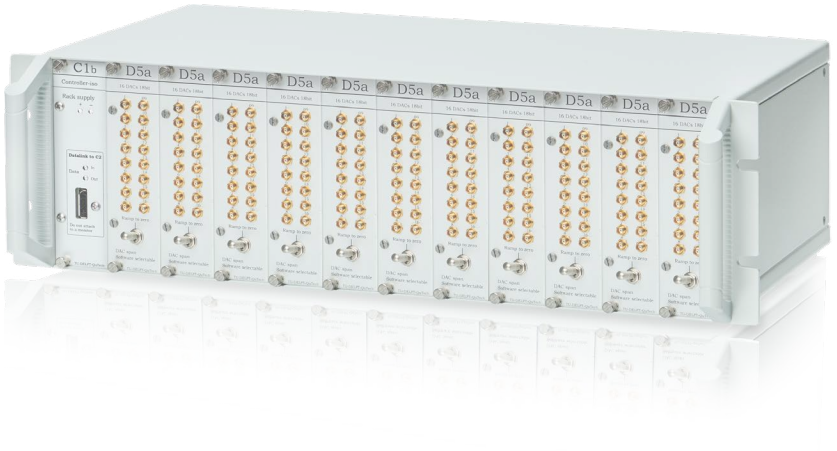
QUANTUM SOURCE AND MEASUREMENT

8 re-configurable DC input and output channels.

28-bit resolution over +/- 10 V voltage sourcing range.
Upto 50 mA current sourcing.

µV voltage voltage measurement range.
pA-µA current measurement range.

Simultaneous (gate) leakage current monitoring.
Safe ramp down emergency switch



The SPI Rack

The SPI rack is a stable and scalable system for housing DC source modules. A gyrator-filtered power supply eliminates ground loops and interference and a galvanically isolated control interface eliminates noise from the host PC.

Overall, the SPI rack offers a versatile and high-performance solution for applications requiring a stable and precise power supply.

DC SOURCE

SPI S4g
Current source module

Ultra-stable current source for quantum computing experiments

4 analog output channels
18 bit DAC resolution

Output range
±50 mA, ±25 mA, +50 mA

4 monitor output channels

SPI D5a
Voltage source module

Ultra-stable low noise DC voltage source for quantum computing experiments

16 analog output channels
18 bit DAC resolution

Output range
±4 V, ±2 V, +4 V

Qblox Scheduler

Open-source, Python-based framework for translating qubit experiments into code optimized for hardware execution.

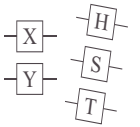
Qblox Scheduler is a high-level software package for quantum R&D, integrating streamlined code generation, direct hardware compilation, and synchronized experiments. The Hardware Agent automates the optimization of configuration, qubit parameters, and connectivity for peak performance. Experiments combine pulse- and gate-level instructions, executed on Q1 sequencers with precise, deterministic timing. Multidimensional parameter sweeps are easily defined, with data automatically organized into visualizable datasets.

The Applications Toolkit offers ready-to-use libraries with time-deterministic pulse schemes, including continuous-wave and spectroscopy for superconducting qubits, charge stability and spin shuttling for spin qubits, and TTL acquisition for NV centers. Supported by experts and a growing use-case library, Qblox Scheduler delivers a scalable environment for quantum control and measurement across diverse platforms.

QBLOX Scheduler

Intuitive and scalable programming of your Quantum Experiments.

Comprehensive hybrid gate-pulse library

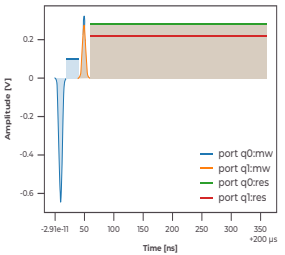



```
.add(X90("q0"))
.add(RampPulse())
```

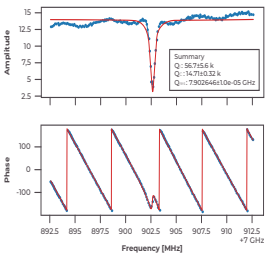
Easy scheduling with deterministic timing

Advanced tools to enhance your results analysis.

Visual Debugging aids



Data analysis and fitting



Fast Scalable Feedback all-to-all channels connectivity

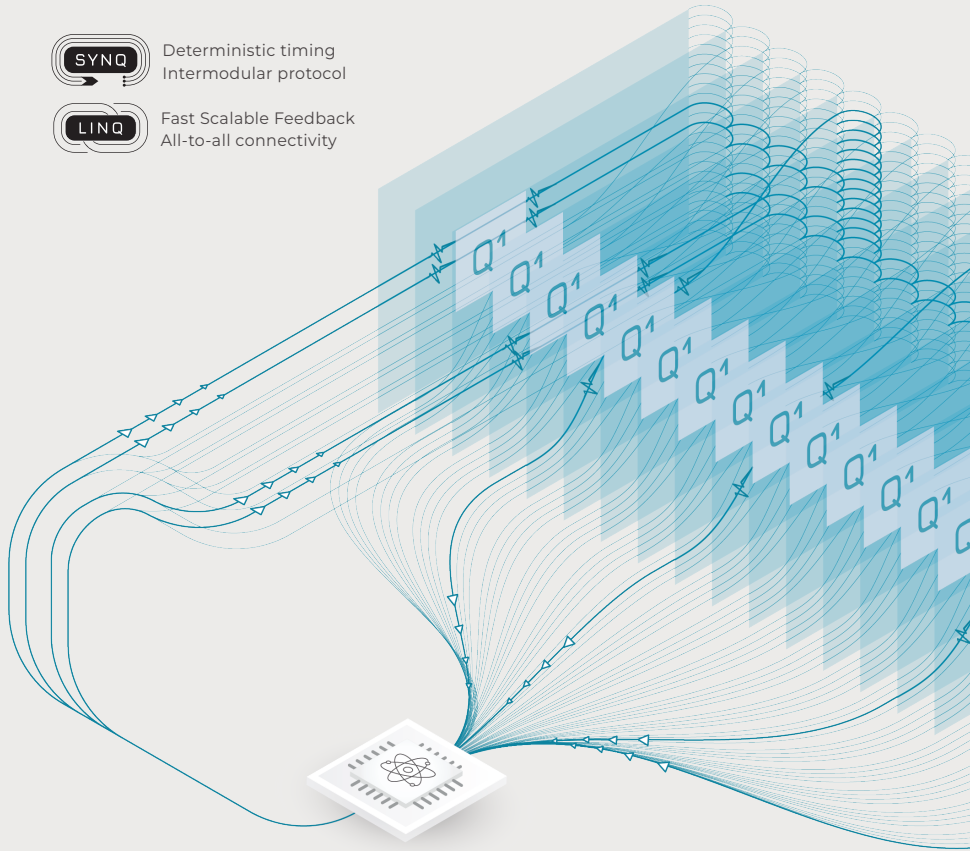
Synchronized & real-time qubit control

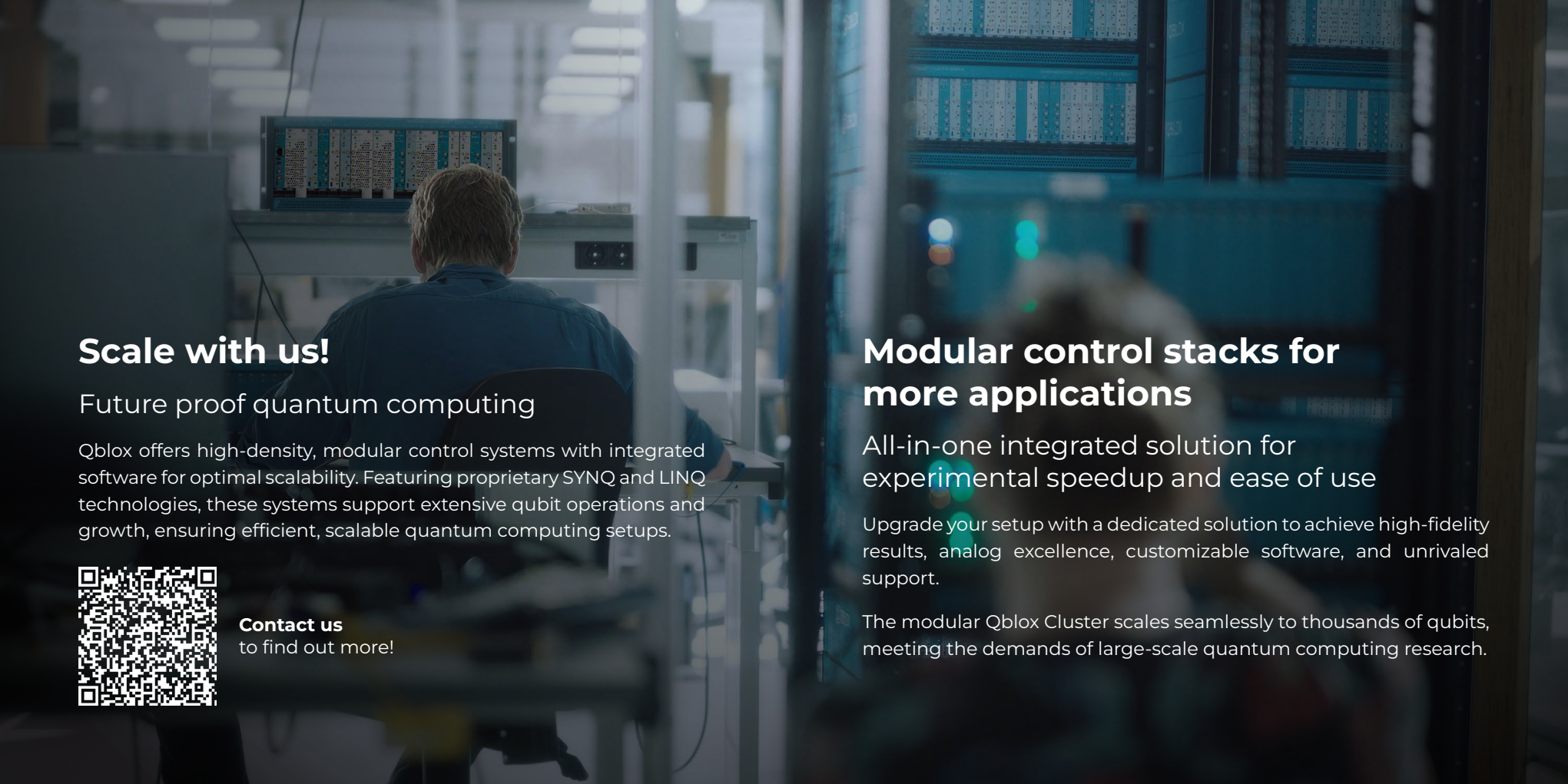
Qblox's fast scalable feedback opens the door for real-time error correction algorithms that can be seamlessly scaled over 1000 qubits.

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

The LINQ protocol distributes measurement outcomes to all modules within less than 400 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 between multiple frames down to the picosecond level.





Scale with us!

Future proof quantum computing

Qblox offers high-density, modular control systems with integrated software for optimal scalability. Featuring proprietary SYNQ and LINQ technologies, these systems support extensive qubit operations and growth, ensuring efficient, scalable quantum computing setups.

Contact us
to find out more!

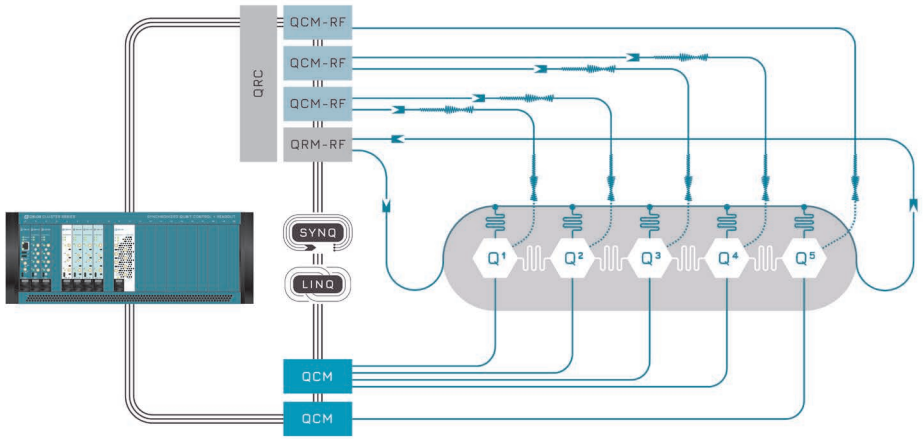
Modular control stacks for more applications

All-in-one integrated solution for experimental speedup and ease of use

Upgrade your setup with a dedicated solution to achieve high-fidelity results, analog excellence, customizable software, and unrivaled support.

The modular Qblox Cluster scales seamlessly to thousands of qubits, meeting the demands of large-scale quantum computing research.

5 Transmons



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

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

QCM — Flux lines
Two-qubit operations

QRC — MW drive lines & readout feed lines
Frequency multiplexed readout
0.1 - 10 GHz

SYNQ — Deterministic timing
Intermodular protocol

LINQ — Fast Scalable Feedback
All-to-all connectivity

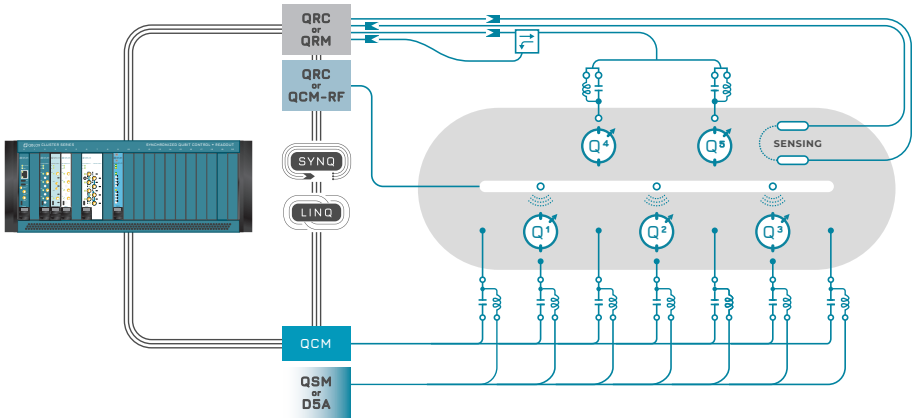
Superconducting qubit control and readout

Unlock high-fidelity results faster with our key features, including:

- Parallel operations together with frequency multiplexing, enabling large-scale computing
- Ultra-low 1/f noise and minimal drift, ensuring precise flux pulsing and DC offset generation
- Fast, scalable feedback for active reset and quantum error correction
- On-board data processing to enable weighted averaging and reduce data transfer latency
- Intuitive software package to simplify quantum experiments with libraries of quantum operations, calibration routines, and visualization

QBLOX
Scheduler

5 Quantum dots



QRM — RF-reflectometry and DC readout at 0 - 400 MHz.

QRC — RF-Reflectometry and Qubit Control at 0.1 - 10 GHz.

QCM-RF — Qubit control by ESR and EDSR experiments at 2 - 18.5 GHz.

QSM or D5A — Ultrastable DC voltage sources for setting barrier and quantum dot potentials.

SYNQ — Deterministic timing Intermodular protocol

QCM — Control quantum dots by fast gate pulses at 0 - 400 MHz.

LINQ — Fast Scalable Feedback All-to-all connectivity

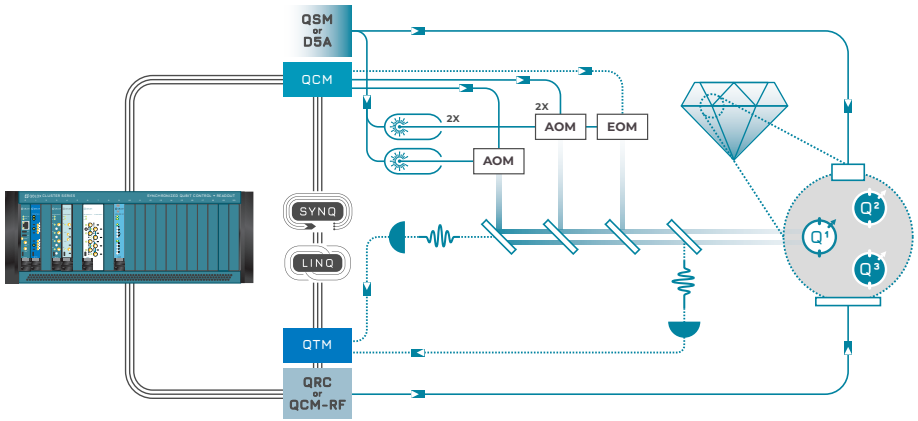
Spin qubit control and readout

Unlock high-fidelity results faster with our key features, including:

- Fast charge scans due to minimized overheads
- Multi-tone RF-reflectometry readout between 0 to 18.5 GHz
- Ultra-low 1/f noise for precisely tuned quantum dot potentials
- Pulse resolution on a 1-ns time grid for high-fidelity operations
- Real-time correction of setup-induced distortions (e.g., bias-tee compensation)
- Monitoring leakage current upon a gate breakdown on voltage output channel, simultaneously
- Intuitive software package to simplify quantum experiments with libraries of quantum operations, calibration routines, and visualization

QBLOX Scheduler

Color center register of 3 qubits



QTM — Digital I/O module for direct laser control, photon counting and time tagging supporting fast feedback

QRC — Qubit control of the spin-state of the defect center from 0.1 - 10 GHz

QSM or D5A — Ultrastable DC voltage sources for laser control and tuning energy levels in-situ.

QCM-RF — Qubit control of the spin-state of the defect center from 2 - 18.5 GHz

SYNQ — Deterministic timing Intermodular protocol

QCM — DC - 400 MHz source to drive AOM and EOMs to shape laser pulses

LINQ — Fast Scalable Feedback All-to-all connectivity

Optically addressable qubit control and readout

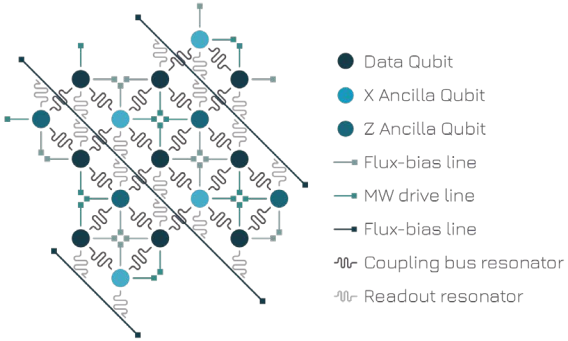
Unlock high-fidelity results faster with our key features, including:

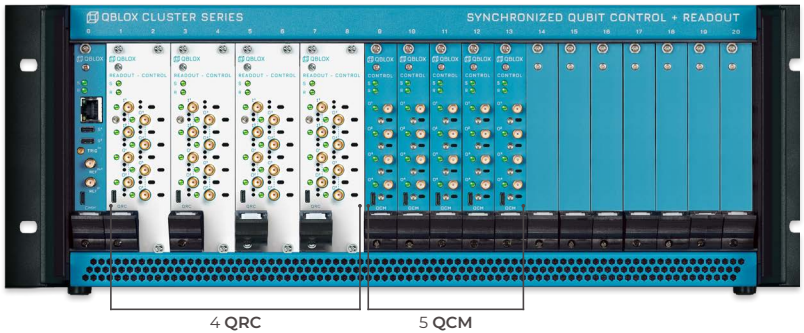
- Photon counting and timetagging via a configurable analog threshold
- Configurable lookup tables for coincidence detection protocols up to 4 channels
- Relative timetagging between channels for correlation measurements
- Photon count-based conditional feedback for in-experiment charge-resetting
- Frequency multiplexed outputs for manipulating registers
- Seamless phase tracking, factoring in frequency updates and phase kicks
- Intuitive software package to simplify experiments with a quantum operations library, analysis, and visualization tools

QBLOX Scheduler

Quantum error correction

Controlling surface-17





All-in-one integrated solution for quantum error correction

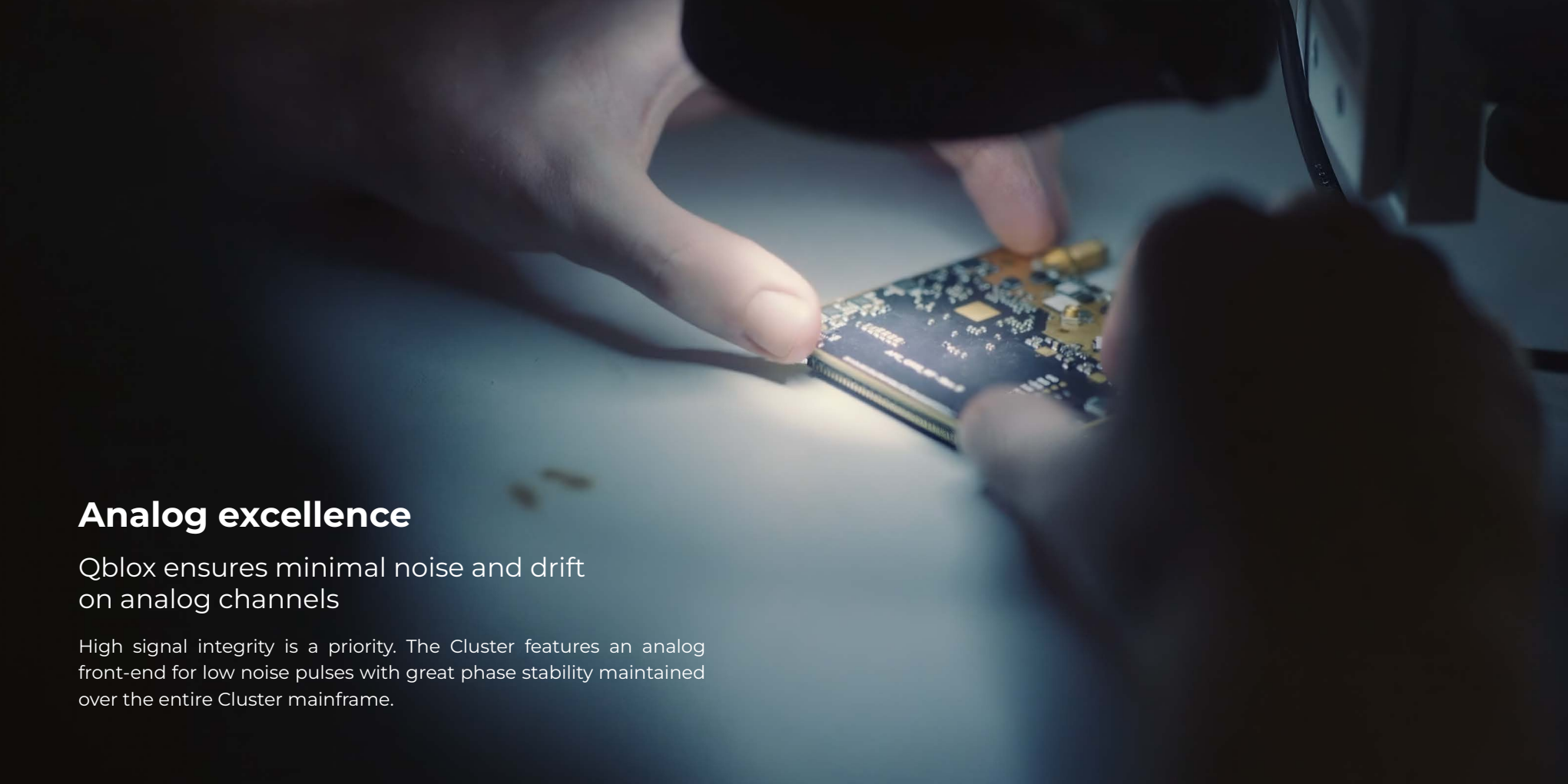
The Distance-3 surface code with 17 superconducting qubits is a promising approach for the development and implementation of quantum error correction (QEC) for fault-tolerant quantum computation.

The Qblox Cluster system provides precise control and efficient readout of individual and coupled qubits, facilitating the study of interactions between them.

The key features of the Qblox Cluster that enable scalable QEC include:

- Modular architecture that seamlessly scales the system to handle more qubits as research needs grow, going beyond surface-17
- Fully parallelized operations enable fast, high-fidelity complex algorithms
- Precise timing control guarantees the proper execution of the error correction algorithm

QBLOX Scheduler



Analog excellence

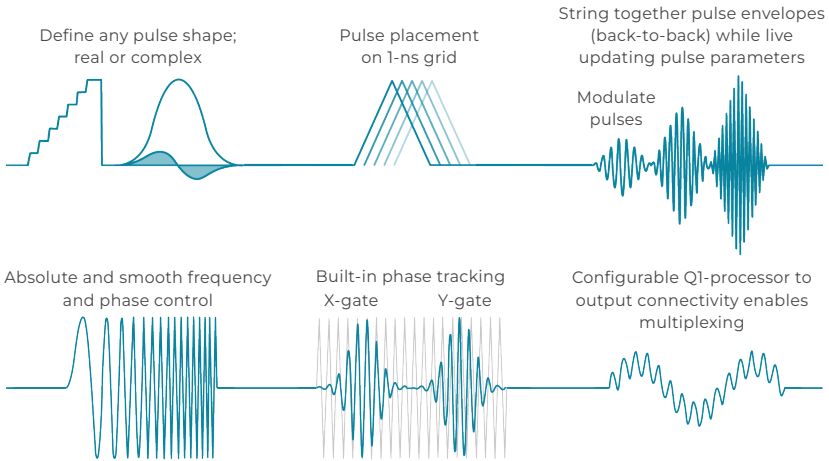
Qblox ensures minimal noise and drift on analog channels

High signal integrity is a priority. The Cluster features an analog front-end for low noise pulses with great phase stability maintained over the entire Cluster mainframe.

Q1 sequence processor

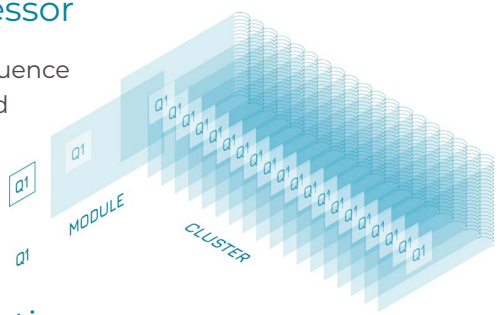
Real-time pulse generation and on-board data processing

The Q1 sequence processor enables powerful and customizable qubit control and readout operations. Real-time pulse sequencing and processing eliminate large overheads in software-controlled loops, avoid uploading lengthy sequences, and minimize data transfer latency through on-board data processing.



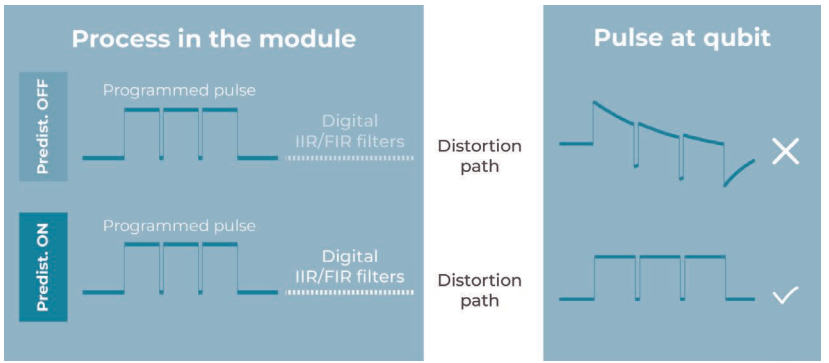
Q1 sequence processor

Multiple cores of Q1 sequence processors are integrated in each module, creating a distributed intelligence over the whole Cluster mainframe.



Real-time predistortion

The Cluster QCM effectively compensates for setup and on-chip induced distortions using digital real-time predistortion filters.

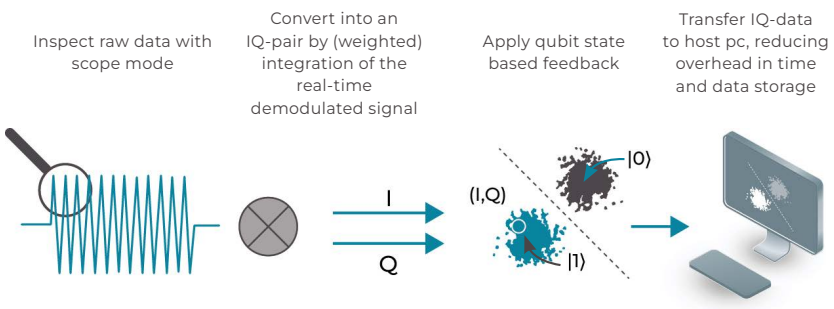


Data acquisition

Qblox Cluster seamlessly integrates signal generation with signal acquisition to optimize time orchestration, ensure phase-locked setups, and enable fast measurement-based conditional feedback.

Scope acquisition mode facilitates inspection and processing of the raw input signal. This simplifies time-of-flight calibrations and debugging purposes.

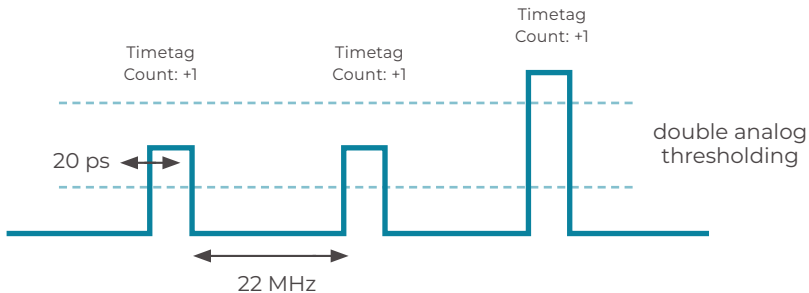
On-board processing power effortlessly demodulates the incoming signal in real-time. Follow this, the signal is converted into an IQ-pair via (weighted) integration. IQ rotation and discretization enable measurement-based feedback across the whole Cluster.



TTL acquisition

Cluster QTM offers TTL signal readout from photodetectors. Rising edge detection based on a configurable (double) analog threshold enables photon counting and timetagging.

Incidence measurements between two channels enables time-based multi-photodetector measurements. High-precision windowing mitigates dark counts. This embedded solution facilitates fast conditional feedback based on photon counts.



Check out the Qblox instruments webpage for tutorials and application examples

Aftersales support

Your research goals are our priority. Our support team of experts, with backgrounds in experimental physics and electrical engineering, ensure that you have the features you need to reach your goals with reliable results.

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
- Feature upgrades made available through the support channel

Control the quantum future with us

Save time and unlock analog excellence, scalability, and the flexibility of open-source software with the Qblox control stack.

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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