QBLOX

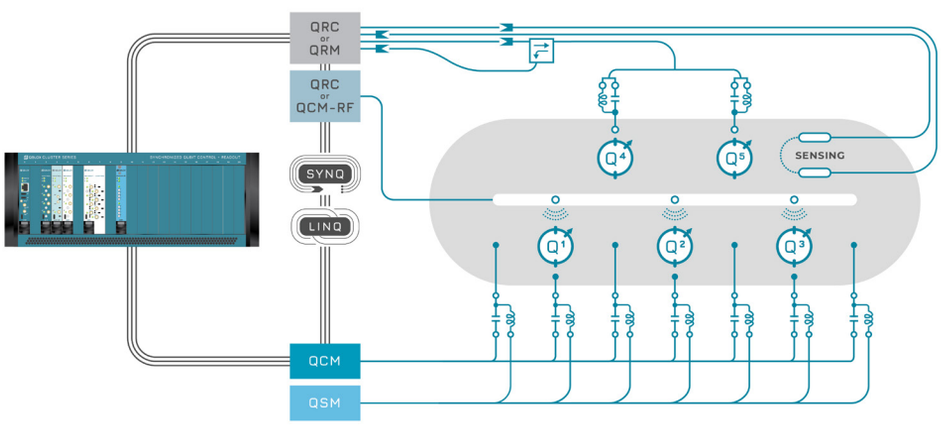
Quantum Control Stacks for Spin Qubits

Release August 2025_V1.0

The Qblox quantum control stacks provide all the necessary instrumentation and software for controlling and reading out spin qubits in **GaAs, Si or Ge** quantum dots. This full-stack approach accelerates experiments significantly and facilitates NISQ applications due to its highly scalable and fast electronics.

The Cluster architecture simplifies system complexity by incorporating AWGs, digitizers, advanced sequence processors, self-calibrated microwave up- and down-conversion, and enabling synchronized and frequency-multiplexed measurements.

5 QUANTUM DOT CONTROL STACK LAYOUT | CLUSTER SERIES



QCM QSM **> Gates / Tuning barrier potentials, Gate sweeps**

QSM modules are coupled with QCM baseband modules via bias tees and are connected to the gates for tuning barrier potentials and performing fast gate sweeps.

QCM:
- 4 outputs in the range 0 - 400 MHz
- 1 GSPS sampling rate
- 4 digital outputs
- Lowest 1/f noise in the market

QSM:
- Ultrastable DC voltage source
- +/- 10 Volts range
- 28 bit resolution
- QSM is housed in DC Cluster mainframe to ensure interference and ground-loop free operation.

QRM QRC **> Readout lines / DC and RF-reflectometry**

QRM is connected to readout ports for DC, gate-based or RF-reflectormetry readout. QRC is ideal for high-frequency RF-reflectometry measurements.

QRM:
- 2 input / output pairs
- DC to 400 MHz range

QRC:
- 2 input / output in the range 0.1 - 10 GHz
- 800 MHz bandwidth

QCM-RF QRC **> Gates / ESR & EDSR**

QCM-RF or QRC is suitable for qubit manipulation via ESR and EDSR, or for driving parametric amplifiers. The outputs can be connected to the strip lines and metallic gates for microwave control.

QCM-RF II:
- 2 direct RF outputs in the range 2 - 18.5 GHz
- 720 MHz bandwidth

QRC:
- 6 outputs in the range 0.1 - 10 GHz
- 800 MHz bandwidth

SYNQ LINQ **> Cluster backplanes Intermodular protocols**

The backplanes host two proprietary protocols that enable all channels and modules across multiple Clusters to function as one monolithic system.

SYNQ ensures simultaneous start of all modules, providing time-deterministic behavior with ~ps jitter.

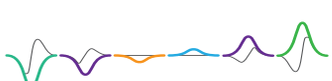
LINQ provides low-latency feedback by distributing measurement outcomes across multiple Clusters, enabling real-time error correction for systems with >1000 qubits.

Advanced Sequence Processing for Fast Execution

The Cluster's advanced sequence processor is capable of sequencing pulses, their parameters, and measurement operations in real time.

Roi et al. PRA 7, (2017)

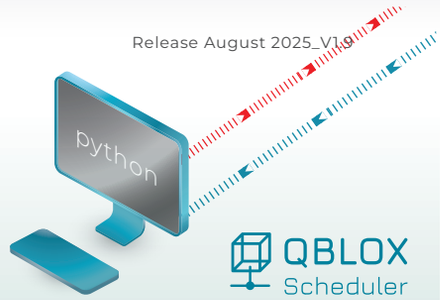
Parametrized operations avoid repeated wave uploading, speeding up experiments by reducing the overheads caused by software-controlled loops.



Pulse parametrization

Multi-parameter real-time pulse modification (modulation frequency, phase, amplitude and offset)

On-board data-processing of readout signals (integration, averaging, binning, and storing up to 131072 outcomes)

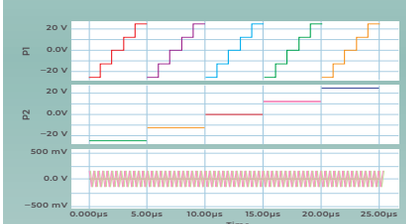


Organize Workflows with Qblox Scheduler

Qblox Quantum Control Stacks are controlled via Qblox Scheduler, an open-source data acquisition platform based on Python.

Fig. 1 Intuitive Scheduling

1. Qblox Scheduler allows hybrid classical/quantum schemes, where an experiment is prepared by selecting pulses from the gate library (Xπ/2, RΦ, Yπ) and arbitrary pulse shapes. This is exemplified here by scheduling an entire charge-stability diagram in one experimental run.



2. High-level instructions are converted to pulse parameters such as amplitudes, frequencies, offsets etc., using device and hardware specific configuration files. The visualization back-end provides fast user feedback on the compiled schedule.

3. Pulses are executed on module outputs with fully deterministic timing.

4. Readout is performed with the deterministic schedule and data is temporarily saved in the module's memory.

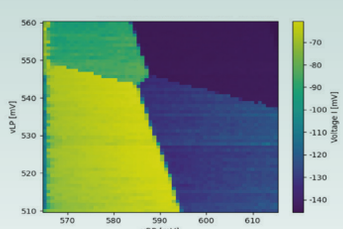


Fig. 2 Charge-stability diagram. Courtesy of QuTech

5. Live plotting and data analysis tools are used for data visualization and interpretation.

Free and Open-source Experiment Library

An extensive set of free and open-source experiment libraries allows for plug-and-play qubit measurements, saving time for further, more sophisticated qubit operations.