QBLOX

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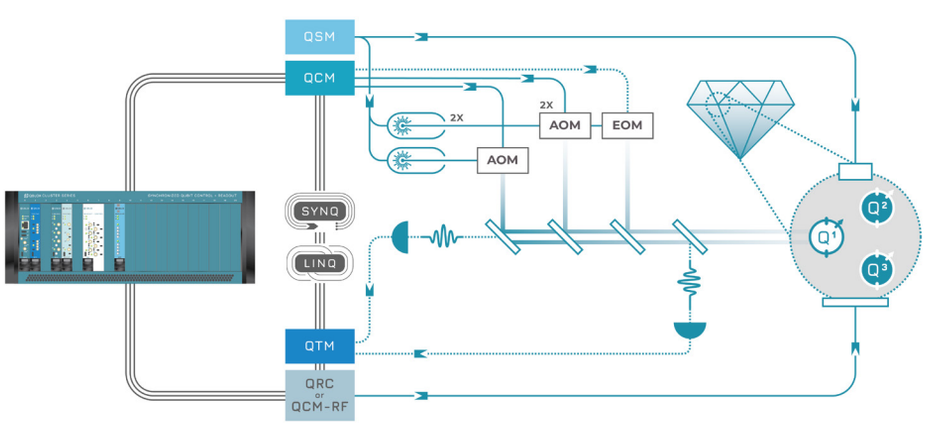
# Quantum Control Stacks for Spins in Diamond

The Qblox quantum control stack provides all the necessary electronics and software for controlling and reading out spins in diamond. This full-stack approach significantly speeds up experiment and facilitates applications in quantum computing, communication, and sensing.

The Cluster's scalable architecture integrates AWG's, local oscillators, analyzers, digitizers and timetagging. Multiple cores of advanced sequence processors enable independent scheduling, full phase control and frequency-multiplexing through configurable routing.

The combination of analog and digital channels allows for the synchronization of qubit operations, (direct) laser control and TTL acquisition. All channels in the system are synchronized down to <<1 ns via the SYNQ protocol, the LINQ protocol supports low latency feedback by distributing measurement outcomes to all sequence processors within < 400 ns.

NV-CENTER MULTI-QUBIT CONTROL STACK LAYOUT | QBLOX CLUSTER SIERIES




**QCM** **> Drive optical modulators**

The Qubit Control Module drives AOMs and EOMs to shape laser pulses, using:

4 analog outputs in the range of 0-400 MHz
Output amplitude range of ± 2.5V
Arbitrary long square pulses

**QCM-RF** **QRC** **> Single- and Two-qubit gates**

QCM-RF or QRC controls the electron spin-state of the NV-center:

**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

**QTM** **> Readout photodetectors** **> Direct laser control**

The Qubit Timetag Module facilitates digital signal generation and acquisition for:

Time tagging with 20 ps resolution
Trigger counting and thresholding
Laser control on 39 ps grid

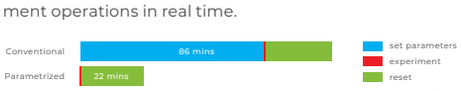
**QSM** **> Tuning energy levels**

QSM voltage source controls the laser frequency and the energy levels of the defect center:

**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

## 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.



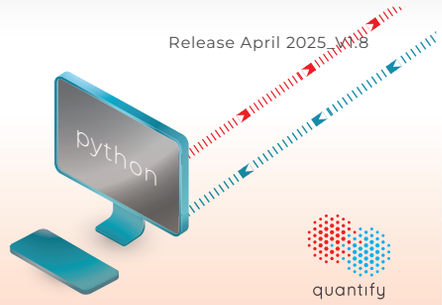

*Roi et al. PRA 7, (2017)*

Parametrized operations avoid repeated wave up-loading, 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 acquired signals (integration, averaging, binning, and storing up to 131.072 count values)




## Organize Workflows with Quantify Software

*Powered by Qblox and Orange Quantum Systems*

Qblox Quantum Control Stacks are controlled via Quantify, an open-source data acquisition platform based on Python and QCoDeS drivers.


***Fig. 1 Intuitive Scheduling***

1. The Quantify-scheduler allows hybrid classical/quantum schemes, where an experiment is prepared by combining pulses from the gate library (Xπ/2, RΦ, Yπ, CNOT) with arbitrary pulse shapes. The resulting pulse scheme is fully time deterministic on a 1 ns time grid. As an example, in Fig. 1 we prepare and readout a Bell-state on the electronic spin(q1) and nuclear spin(q2) of an NV-center.

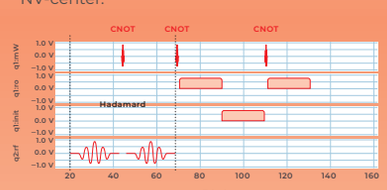



***Fig. 2 Pulse vizualization of the schedule***

2. High-level instructions are converted to pulse parameters such as amplitudes, frequencies, offsets etc., using device and hardware specific configuration files. The pulse visualization tool automatically creates diagrams (Fig. 2) to show pulses for every specified port of each qubit. This visualization gives fast user feedback on the compiled schedule.
3. Pulses are executed on module outputs with fully deterministic timing using the advanced sequence processors.
4. Readout is performed with the deterministic schedule and data is temporarily saved in the module's memory.
5. Live plotting and data analysis tools are provided by Quantify Core 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.

Get in Touch: sales@qblox.com
Whether you have a price inquiry, need technical support, or want to talk with our application scientists, we're here for you. Connect with us today for a tailored experience!