Integrated and Scalable Quantum Control

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Realizing intermediate-scale quantum computers and fault-tolerant quantum computers requires controlling 1000s of qubits. For this purpose, Qblox has developed a highly distributed control architecture, called the Cluster, where fully-integrated modules are incorporated in a massively scalable fashion. The Cluster modules are based on multiple cores of Q1 processors based on FPGAs and RF-SoCs that in real-time generate and sequence pulses, their parameters and measurement operations [1].

We here present a new level of scalability that paves the way for quantum computers with practical applications. The Qblox Cluster can control and readout up to 60 superconducting qubits in a 4U 19" rack with frequency multiplexing and calibration-free MW channels. Real-time IIR and FIR predistortion filters are further added to battle linear distortions like in-cable reflections, on-chip charging effects and the skin effect [2,3]. This enables back-to-back operations in arbitrary control flows (feedback and feedforward), which are not possible with in-software precompiled waveform programs. The proprietary SYNQ protocol, coupled with Q1 sequencer's real-time precision of 1 ns timegrid, allows generating advanced and coherent control pulse sequences with minimal jitter of a few picoseconds, low drift and low 1/f noise. The LINQ protocol assures fast-scalable feedback with all-to-all connectivity for active reset operations and error mitigation algorithms.

Together with the newly launched Qubit Timetag module that hosts 8 configurable digital input and output channels, Qblox's Quantum Control Stacks provide an integrated and scalable solution for most common qubit modalities to pave the way to quantum advantage.

References

[1] W. Vlothuizen et al. (TU Delft, APS MM P48.014, 2016)
[2] Rol et al. PRA 7, (2017) 041001
[3] Rol et al. APL 116, (2020) 054001