Application Brief

# Spin-Based Quantum Computing. Controlled.

Spin-based quantum computing is a leading technology for the realization of scalable quantum computers. The Zurich Instruments Quantum Computing Control System (QCCS) provides all the key tools for spin qubit characterization, control, and readout, providing a low-noise and scalable solution that improves setup reliability and simplifies setup control.

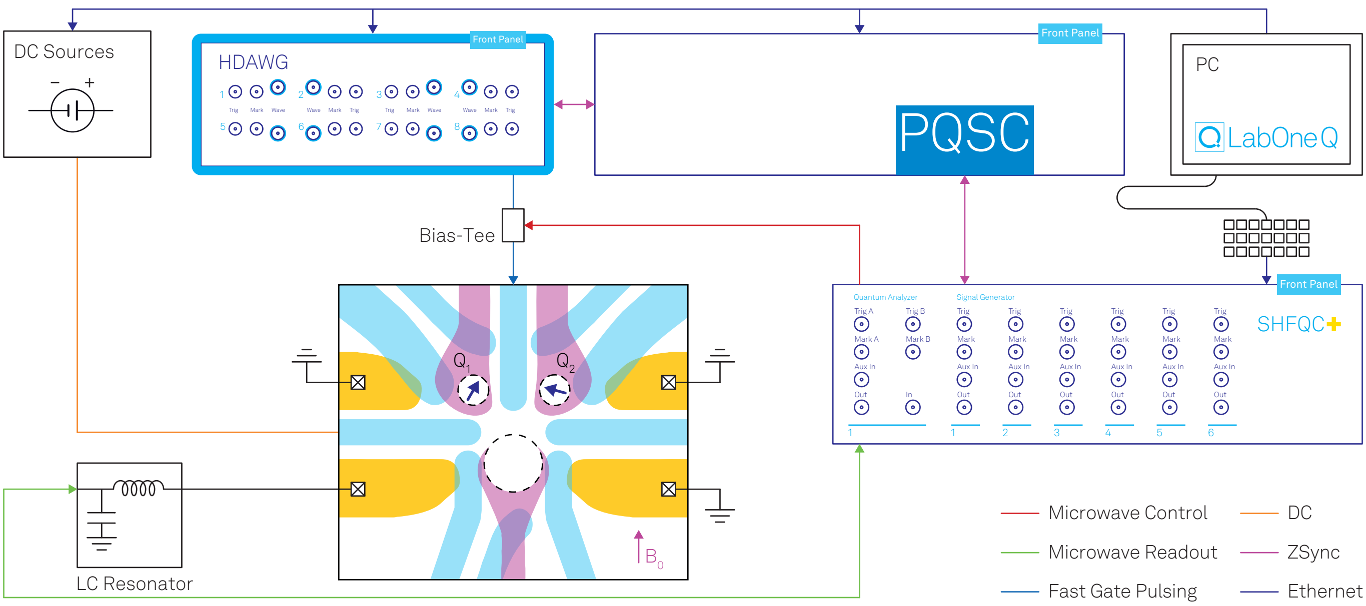


**Figure 1.** Simplified diagram of a typical setup providing all control signals for RF control and readout of a spin qubit sample.

## Your Benefits

- Ultra-low skew for precise compensation of sensing dots while changing occupancy of other dots
- Low output noise, phase noise, and drift to ensure no impact on long measurements
- Fast, high-fidelity single-shot readout. Multiplex up to 8 readout tones (≤ 2 µs) or up to three phase-coherent readout tones (≤ 30 µs)
- Reflectometry readout without the need for external analog up-/down-conversion
- Improve qubit characterization and gate fidelity with real-time pre-compensation of gate voltage pulses
- State classification and low-latency feedback on readout results using the PQSC

## Your Application Resources

- Blog posts: Pre-compensation, RF reflectometry, Synchronizing multiple AWG channels.
- Code examples: standard characterization measurements in LabOne Q, 3rd party instrument sweeps such as DC voltage sources, and more.

Discover more online

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## Universal Control Made Easy – a Modified Ramsey

- Advanced arbitrary waveform generator for any pulse shape, phase, or amplitude and large waveform memory
- Fast sequence upload and real-time phase control thanks to digital modulation
- Compensation of virtual gates
- Hardware and software logic to ensure accurate timing of signals
- Output simulator and pulse sheet viewer to visualize all experimental signals, analog and digital
- Fast integration into your setup with LabOne Q or one of the LabOne APIs

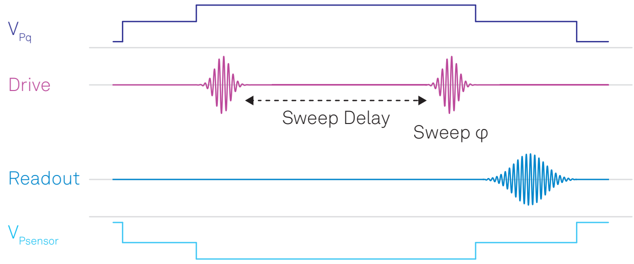
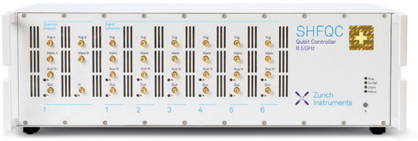


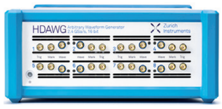

**Figure 2.** Pulse diagram for a modified Ramsey experiment. The phase sweep on the second drive pulse allows for reaching arbitrary positions on the Bloch sphere. The plunger voltage on the qubit ($V_{Pq}$) is used to control the electrochemical potential of the dots and the couplings between the different dots and the sensor. The plunger voltage on the sensor ($V_{Psensor}$) is used to compensate capacitive crosstalk.

## Product Highlights




### SHFQC+
### Qubit Controller

Control pulses for high-fidelity gates and high-fidelity, single-shot readout from DC–8.5 GHz in one instrument without the need for mixer calibration. Combine with a Rohde & Schwarz microwave source for control pulses beyond 8.5 GHz.




### HDAWG
### Arbitrary Waveform Generator

AWG functionality from DC–750 MHz with up to 2.4 Gsa/s sampling rate and the ability to perform real-time pre-compensation.


### PQSC
### Quantum System Controller

Perform low-latency feedback between any instrument in < 550 ns. Out of the box, sample-precise synchronization of up to 144 microwave channels.

All instruments are controlled by LabOne Q, an open-source Python-based software framework offering both high- and low-level access. Achieve results quickly with extensive code examples, documentation, and support.

## Meet Our Quantum Technology Experts

Every member of our Quantum Technology team has a background in advanced scientific research, including quantum error correction, quantum sensing, quantum computing, and theory of quantum algorithms.

## Our Customers' Accomplishments

- IBM Quantum: Direct Microwave Spectroscopy of Andreev Bound States in Planar Ge Josephson Junctions, PRX Quantum **5,** 030357 (2024)
- Bluhm Group (RWTH Aachen Univ.): Si/SiGe QuBus for single electron information-processing devices with memory and micron-scale connectivity function, Nat. Commun. **15,** 2296 (2024)
- Intel Corporation: Probing single electrons across 300-mm spin qubit wafers, Nature **629,** 80–85 (2024)
- Katsaros Group (ISTA): Automated long-range compensation of an rf quantum dot sensor, Phys. Rev. Applied **22,** 064026 (2024)
- PHELIQS (Univ. Grenoble Alpes): Gate-reflectometry dispersive readout and coherent control of a spin qubit in silicon, Nat. Commun. **10,** 2776 (2019)
- Laboratory for integrated quantum systems (Seoul Nat. Univ.): Passive and active suppression of transduced noise in silicon spin qubits, arXiv:2403.02666 (2024)

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