PQSC
Programmable Quantum System Controller

Synchronization and communication hub for small and medium Quantum Computing Control Systems

Product Leaflet
Release date: 29.08.2023

Key Features

- Scale your quantum system up to 144 microwave channels
- Plug-and-play operation through automated instrument synchronization
- Perform low-latency feedback between any instrument in <550 ns
- Perform demanding quantum error correction algorithms through large processing power
- Intuitive system control through LabOne Q

Introduction

The Zurich Instruments PQSC enables scalable quantum processor control through automated synchronization and low-latency communication between all components of a Quantum Computing Control System (QCCS). It provides high-level software access to powerful real-time capabilities designed for the most pervasive use cases in quantum computing.

With 18 ZSync ports, the PQSC supports systems with up to 144 microwave channels for precisely timed and stable gate and readout operations. Central data processing enables feedback methods that require global information of the system state, e.g. for quantum error correction, with a latency down to 550 ns including all signal processing.

Decoding algorithms can be efficiently implemented on a powerful FPGA core using a ready processing infrastructure accessible in Python.

Applications

Quantum computing applications

- Small and medium scale quantum computing
- Quantum simulation
- QAOA
- Quantum error correction
- Surface codes
- Optimal control

Supported qubit types

- Superconducting qubits
- Spin qubit/superconducting resonator hybrids
- NV centers
- Qubits, qutrits, and ququads

Highlights

Proven system scalability

Up to 18 instruments can be synchronized through a PQSC, leading to coordinated readout and control of up to 100 fixed frequency qubits using only SHFQCs, or up to 60 tunable-frequency qubits. New instruments can be added by plugging one cable without rework of the existing system.

Simplified feedback programming

The QCCS comes with the LabOne Q software interface that lets users control feedback operations on the system level. LabOne Q translates a user's high-level sequence into real-time instructions for all components of the QCCS so they can operate in sync, with the PQSC at the center. A Python API gives users the full flexibility to integrate the PQSC into their own software.

High-fidelity feedback operations

Due to the star topology of the QCCS architecture, the PQSC is able to evaluate the global state of all the qubits that it controls. This enables feedback methods that require global knowledge of the system state, such as Quantum Error Correction. The low-latency global feedback is complemented with local feedback operations inside the SHFQC Qubit Controller with further reduced latency.

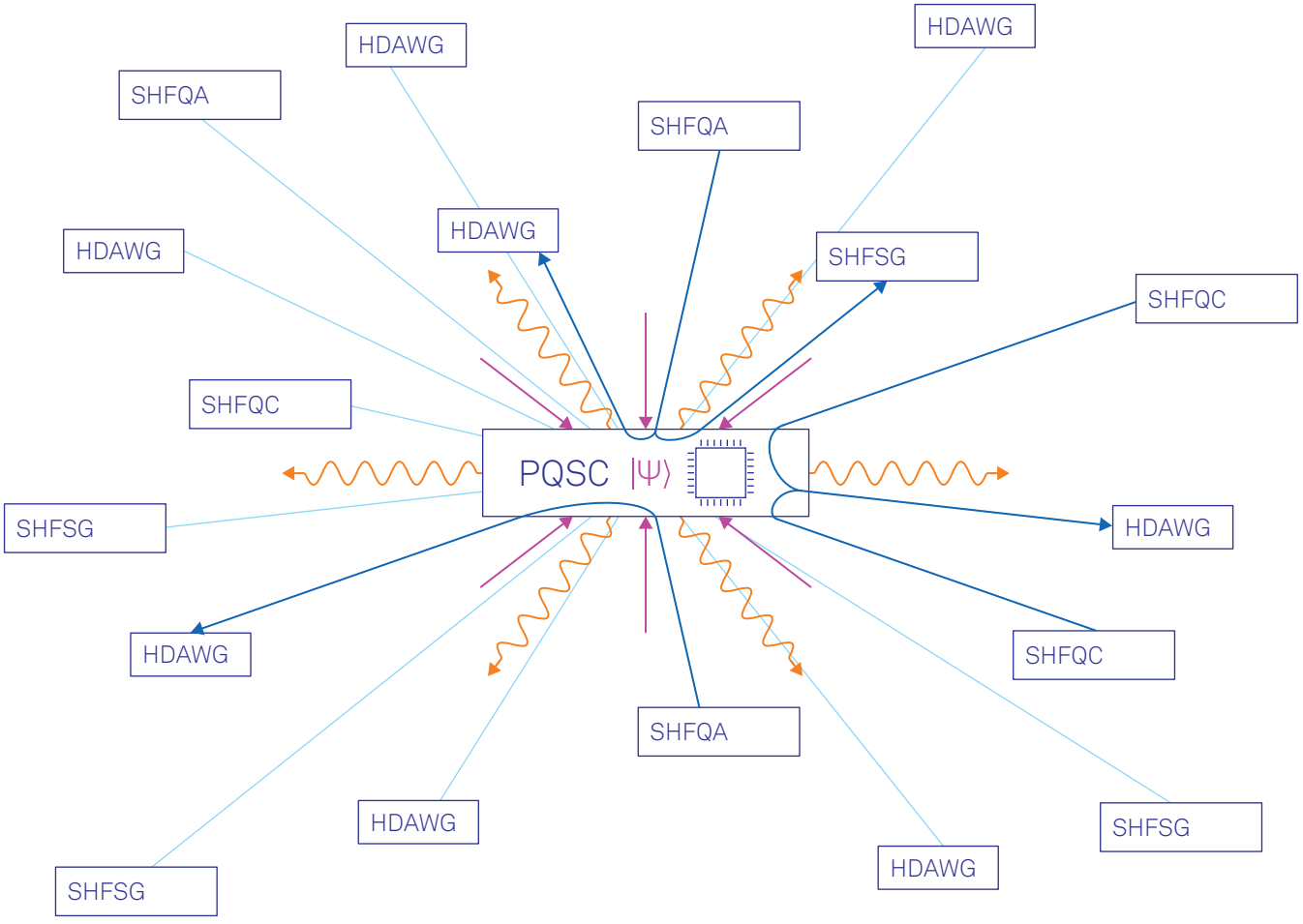
Reliable synchronization

The ZSync interface distributes all clocks and timing signals needed to synchronize the system. Automated calibration procedures make the synchronization stable across reboots and changing environmental conditions. You can count on weeks of operation without the need for delay calibration.

QCCS Instrumentation Compatibility

The PQSC is compatible with two classes of QCCS system configurations:

- Combinations of HDAWG, SHFQC, SHFQA and SHFSG
- Combinations of HDAWG and UHFQA



Advantages of the star architecture of the Quantum Computing Control System

Frequently Asked Questions

General

Where can I get a live demonstration of the PQSC Programmable Quantum System Controller? Call us on +41 44 515 0410 or send us an email with your contact details and preferred time slot. We are happy to schedule an online demo to discuss your requirements and see whether there is a match with the PQSC capabilities.

What kind of support will I receive if the instrument is purchased from a local partner and not from Zurich Instruments directly? All users receive support from Zurich Instruments independently of where the purchase took place. Local sales partners, where available, also provide first-level support in the local language. For extended support, instrument calibration or service, please check our Support page.

System integration

I want to control a system with few or few tens of qubits, what is the best solution? The PQSC is the right instrument for a system of such size. It can synchronize and distribute feedback across 18 instruments –up to 144 RF channels. That is suitable for around 50 tunable transmon qubits, depending on the specifics of the qubit technology.

I want to control a system with many qubits, up to hundreds. What is the best solution? QHub is the right instrument for system a of such size. It can synchronize and distribute feedback across 56 instruments –up to 448 RF channels. That is suitable for around 200 tunable transmon qubits, depending on the specifics of the qubit technology.

I have a single SHFQC. Do I need a PQSC to use it? No, a single device doesn't require a PQSC to run. It's required for systems with two or more instruments. An exception is a single HDAWG connected to a single UHFQA; such systems don't require a PQSC.

Can I mix UHFQA and SHF instruments in a single QCCS? No, a PQSC can be used to create either a system composed of multiple HDAWG and UHFQA, or a system composed of multiple SHFQA, SHFSG, SHFQC, and HDAWG.

I have a system composed of a PQSC, HDAWG and UHFQA. Can I add one or more SHF instruments? Yes, but the UHFQA can't be used in the new system. An SHFQA or SHFQC should adopt its role.

Can I use the SHFPPC Parametric Pump Controller with the PQSC? Yes, the SHFPPC is not directly connected to the PQSC, but it works with a Quantum Analyzer (SHFQC or SHFQA), which in turn can be connected to the PQSC.

Can I use the PQSC with instruments from another manufacturer? Yes, the PQSC can synchronize to an external reference clock or provide one. Triggers and markers of the SHF/HDAWG can be used to receive or send digital signals with other instruments. Additionally, the PQSC can generate a digital signal synchronous to the experiment and start signals are distributed to the worker devices.

Functionality

What is ZSync? ZSync is a Zurich Instruments proprietary interface to accurately synchronize instruments and enable low-latency feedback across them.

Do I need to calibrate trigger delays across runs or reboots to have stable skew across channels? No! PQSC performs all the necessary calibrations when a new instrument is connected through ZSync, and that ensures that the skew is always stable.

Do I need an external clock source or clock distribution system? No, the PQSC generates and distributes a reference clock over the ZSync cables. The PQSC can optionally lock to an external 10 MHz or 100 MHz reference clock and can provide an external copy of the internal reference clock or 10 MHz on an SMA port.

Where do I find ZSync cables? One ZSync cable is provided with each SHF or HDAWG instrument. If you need more, please contact us through our Support page.

How long are ZSync cables? ZSync cables are always 3m (9.84') long. This ensures that latency is always consistent across instruments.

Are different hardware configurations available? No, the PQSC comes always with 18 ZSync ports. If you need more ports, QHub might be a better alternative.

Software

With what software can I control the PQSC, and where can I get it? The main control and programming interface is provided by LabOne Q. It controls not only the PQSC, but the entire QCCS, including all the instruments attached to the PQSC as a single system. LabOne Q streamlines and automates time-consuming tasks such as optimizing instrument settings, generating and uploading waveforms, and synchronizing pulses between multiple instruments. Even with this control and measurement automation, users still have complete low-level access to the instruments. The LabOne Q software is produced by Zurich Instruments and upgraded on a regular basis, providing you with new features and functionalities for the instrument.

Can I integrate the PQSC and the QCCS in general into my existing control software? If you are already using Zurich Instruments devices with the LabOne Q software, the integration of the PQSC is straightforward; it's just matter of declaring the new instrument and starting to use the new available channels like before. The LabOne Q software operates either as a standalone control software, or is integrated into most existing frameworks and control frameworks.

Specifications

QCCS system specifications

Supported peripheral devices	Combinations of HDAWG*, SHFQC, SHFQC and SHFSG Combinations of HDAWG, UHFQA**
Supported system architecture	Star architecture
Maximum output channel skew	< 1.6 ns
Output channel skew repeatability over restarts	< 200 ps for HDAWG and SHF instruments
Real-time Communication latency	< 330 ns from UHFQA to PQSC < 100 ns otherwise

* Only with sample rate 2.0 GSa/s
** Needs one HDAWG per UHFQA as bridge over the DIO port. Only with HDAWG sample rate 2.4 GSa/s

Synchronization and real-time data exchange

Interface type	ZSync proprietary
Number of ports	18
Cable length	3 m

Clock

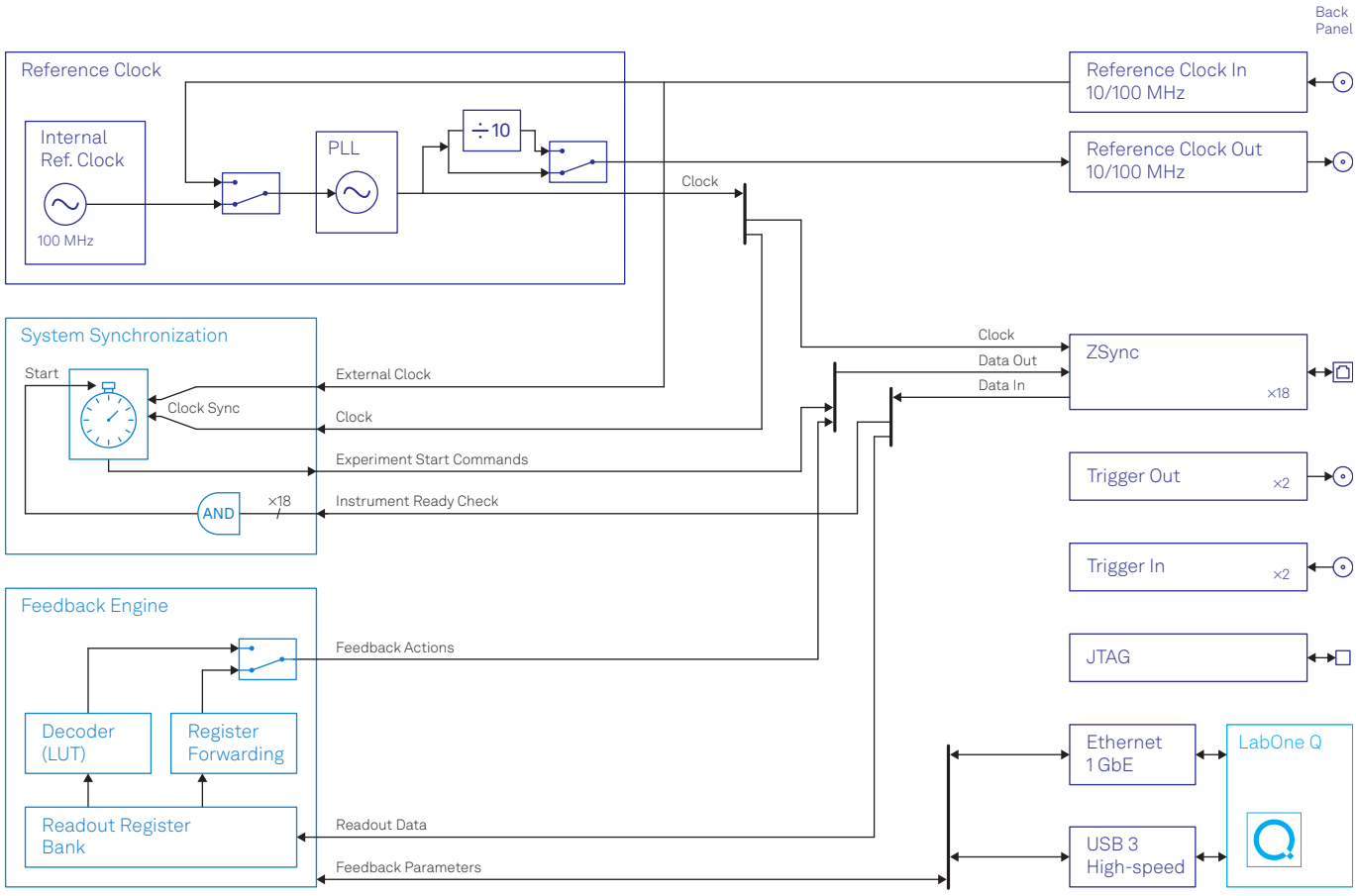
Interfaces	Input and Output
Input frequency	Auto-detect 10 MHz/100 MHz
Input Amplitude	-10 dBm to +13 dBm
Output frequency	Switchable 10 MHz/100 MHz
Output amplitude	+4dBm

Triggers

Trigger inputs	2
Trigger outputs	2
Output voltages	LVTTL (0 V low, 3.3 V high)

General

Dimensions	450 × 345 × 100 mm 17.7 × 13.6 × 3.9 inch
Weight	6 kg (13 lb)
Power supply	AC: 100 – 240 V; 50/60 Hz 100 W Maximum
Host connection	LAN, USB 3.0, JTAG (over USB)



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