QICK box

QICK box is a comprehensive control and readout system for QIS including quantum computing, quantum networks and quantum sensors.

Open-Source MIT License

Includes hardware schematics/layouts, firmware, and software.
For more details, visit:

- github.com/openquantumhardware
- qick-docs.readthedocs.io/en/latest
- qick-docs.readthedocs.io/en/latest/papers.html

Features

DAC Outputs

- 16 channels; can be RF complex modulated up to 10 GHz or unmodulated from 0-1.5 GHz (your choice, no analog mixers)

RF Inputs

- 8 channels, frequency range 0.5-10 GHz
- Digital down-conversion (no analog mixers)

Bias Outputs

- 8 channels, ±10V, based on 20-bit DACs
- Ultra low noise: 0.7 nV/√Hz

I/O Ports

- 6 TTL I/O on SMA
- 8 TTL I/O on a separate connector
- 8 LEDs for function display

Cost

<$1000 per qubit

~$1 per detector pixel (e.g., MKID)

Power Consumption

Below 70 watts (fully populated) from a single 12 V supply

Form Factor

QICK box is 2U in height, 19 inches wide (rack-mountable) and 24 inches deep

Scalable Architecture

Supports multiple QICK boxes (up to 15 per rack)

PLL locked to an 80-fs jitter reference

Programs synchronized to the same clock in the fabric

Fast communication among boards (all-to-all); latency < 200 ns for 16-bit messages (in progress)

Collaborations

Collaborative efforts with academia, DOE labs and industry

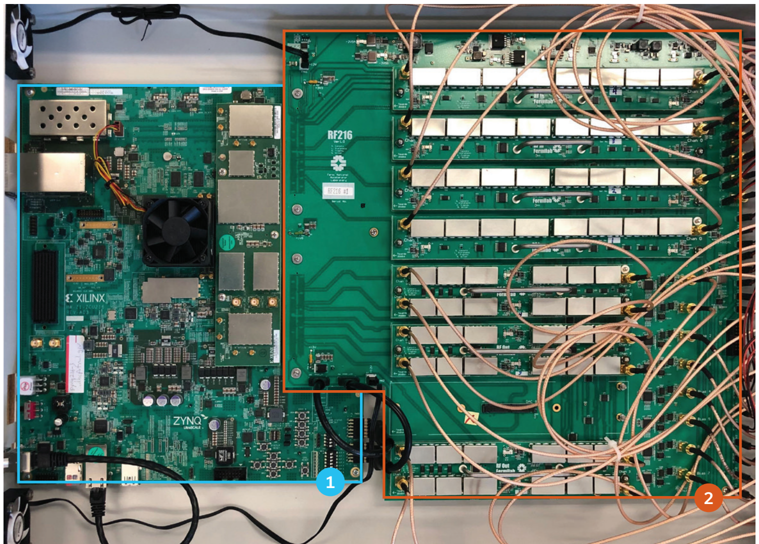
Community

Over 300 registered users in the Americas, Europe and Asia

Opportunities to become a QICK member or contributor

The QICK has not only let us do experiments more cheaply but it has changed the way we think about control, and we do things differently now.

— Prof. David Schuster, Stanford and QICK team member



1 AMD/Xilinx FPGA board ZCU216

2 Fermilab custom RF, DC, bias, I/O board for the ZCU216

The development of the Quantum Instrumentation Control Kit is an excellent example of U.S. investment in joint quantum technology research with partnerships between industry, academia and government to accelerate pre-competitive quantum research and development technologies.

— Dr. Harriet Kung, Acting Director of the Office of Science in the U.S. Department of Energy

Software Programmable RF Power Control

Dynamic Range: 60 dB total, adjustable in 0.25 dB steps

Maximum RF Output Power: 5 dBm at 5 GHz; -10 dBm at 9.5 GHz

RF Input Gain: Up to 90 dB

RF Input Noise Temperature: 100 K

RF Output and Input

Bandpass Filter
- Software programmable for noise reduction (refer to Analog Devices ADMV8818)

Signal Generator

Parametrized Complex Envelope
- Pre-stored in FPGA memory; options include Gaussian, DRAG, round-square and triangular

No Analog Mixers
- Ensures phase coherence without RF frequency and phase drift

Pulse Sequencing

Pulse Duration
- From 2 ns to ∞, with zero dead time

Example Application
- Two-qubit randomized benchmarking using a set of over 11,000 pulses

Control and Feedback

Fully Programmable
- Includes feedback and feedforward control capabilities

Memory and Processing

8 GB DDR
- For signal generation, readout, optimal control, AI and long DAQ

External Instrumentation

Trigger and Synchronization
- Supports external triggers and synchronization via I/O

Software

QICK Software
- Operates on PYNQ and Linux via RFSoC FPGA
- Python-based: Defines classes and methods for user-friendly, efficient operation of QICK firmware and hardware
- Includes ready-to-run examples for basic 1-qubit measurements and calibrations

3rd Party Software Integration
- Integrated with full stack solutions: Qibo and AWS-SideQICK

Support for Research

Quantum Computing
- Superconducting, spin and atomic qubits

Quantum Network Research
- Supports 100 ps pulses for optical experiments

Multiplexed Readout

Capacity
- Supports up to 16 qubits per RF line and up to 2000 detectors (e.g., MKIDs, TES, Quantum Capacitors)

Technology
- Utilizes Polyphase Filter Bank analysis and synthesis

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