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QSOLID

Quantum Computer in the Solid State

Advanced High-Fidelity Qubit Control (Electronics|System)

Motivation

Quantum computers are promising candidates to solve tasks that seem unsolvable with state-of-the-art computers. Because of the significant progress in qubit quality, error correction and scaling quantum computing (QC) is of increasing practical interest. Still, many open scientific and engineering challenges need to be solved for the realization of a universal quantum computer.

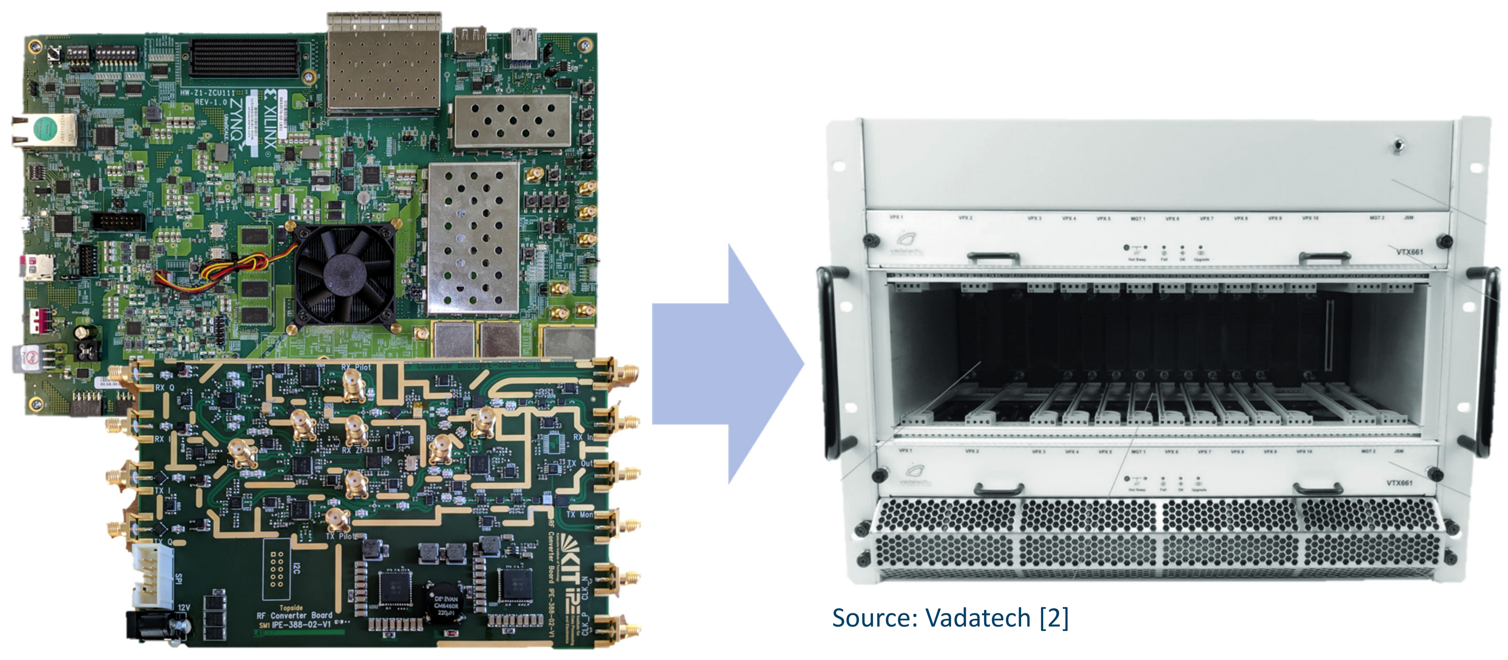
State-of-the-art quantum control systems can be improved in terms of:

- Full control over hardware, firmware and software
- Fully customizable form factor
- Optimized feature set
- Future performance improvements

Approach

Partners of subproject T5-1 "Cost-Effective Room Temperature Electronics"

- PGI-13 (FZJ) – Technical requirements of the QPU
- IPE (KIT) – System architecture and configuration of the control electronics
- ZEA-2 (FZJ) – Driving the development of the advanced QC demonstrator



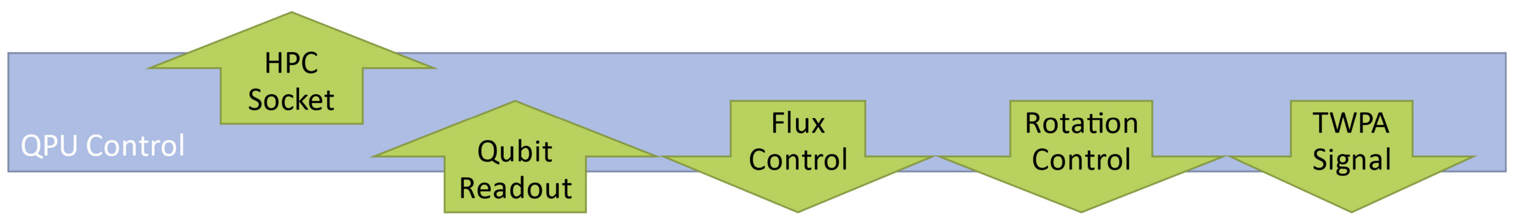
Source: KIT – IPE [1]

Source: Vadatech [2]

Controller for Quantum Computing and crate architecture e.g. OpenVPX

Full integration of the hardware system includes:

- Data acquisition infrastructure
- Individual optimizable rotation and flux control pulse generation
- Specific optimized firmware and software
- Low-level processing performed in real-time on FPGAs



This demonstrator system enables ultimate optimization of fidelities due to:

- Cryogenic superconducting QPU
- Flexible control over the behavior of the electronics
- Embedding into an HPC system

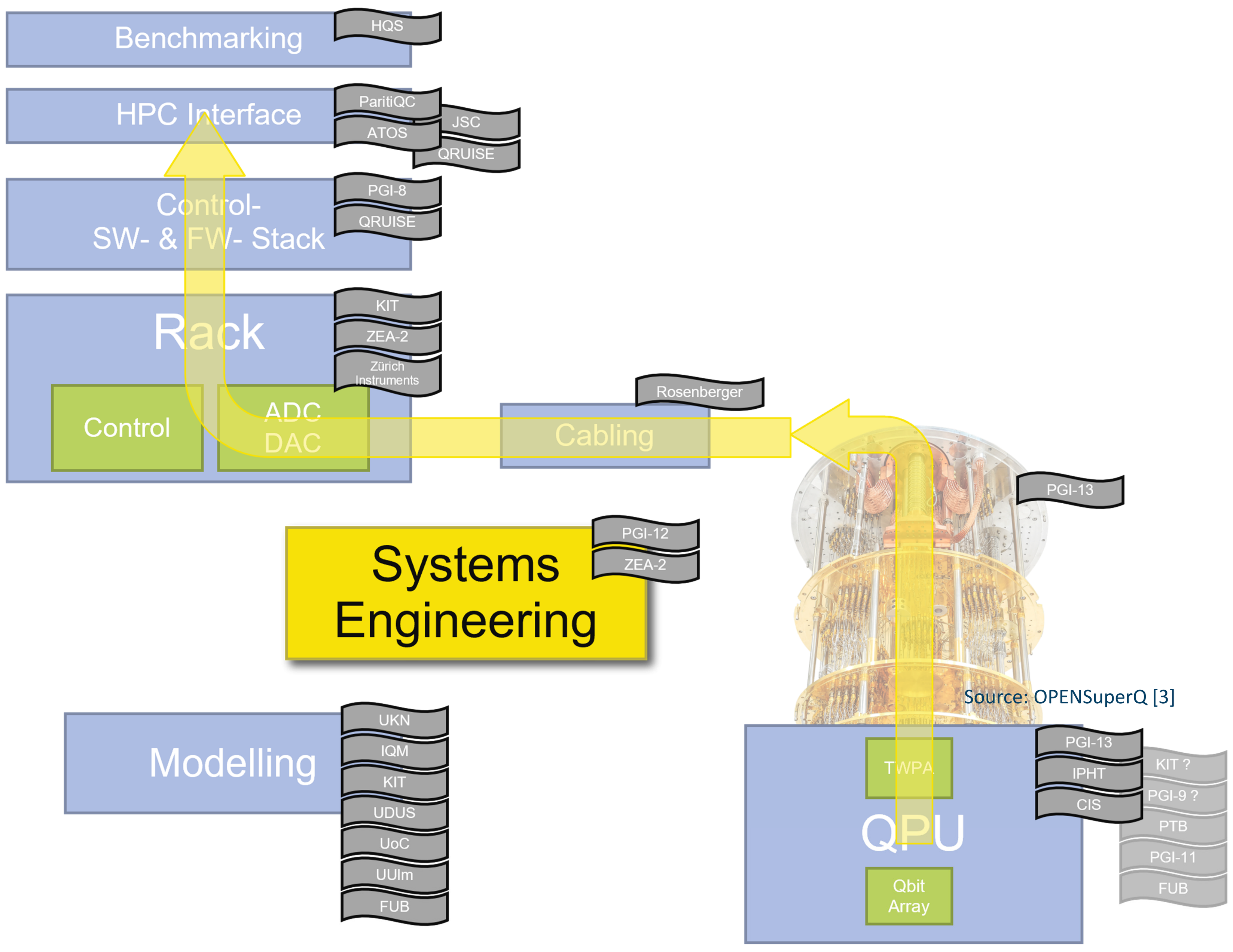
References

[1] Sander, Oliver, "Controller für Quantencomputing", URL: https://www.ipe.kit.edu/3052.php (visited: 04/19/22)
[2] Vadatech, "OpenVPX Chassis", URL: https://www.vadatech.com/media/pdf_VPX_Chassis_Brochure.pdf (visited: 04/15/22)
[3] Wilhelm-Mauch, Frank, "OpenSuperQ", URL: https://opensuperq.eu (visited: 04/19/22)

Systems Engineering

Combine quantum expert knowledge with industrial systems engineering

- Identify critical development dependencies (risk-management)
- Optimization through interdisciplinary cross-group design/status reviews
- Interdisciplinary approach enables optimized trade-off analysis



Development phases/steps:

→ 2-Qubit Gate – first general performance evaluation (pipe cleaning)
→ 10-Qubit system in ladder geometry explore high-value components
→ 30-Qubits in ladder geometry as a benchmarking platform (Keystone)

Profiles

IPE (KIT)

The IPE research focuses on custom instrumentation for physics experiments. Our work covers the full data acquisition chain and includes ASICS, PCB, FPGA, software, and algorithms. For several years we are active in the quantum technologies domain with a focus on superconducting sensor readout and superconducting qubit control.

ZEA-2 (FZJ)

As a partner of the scientific institutes, we perform research and development in teams and enable cutting-edge science as well as innovations for society with our electronic system solutions using model-based system analysis and scientific methods taking the full potential of integrated circuits.

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