Contribution ID: **23** Type: **Vortrag**

FPGA-based Quantum Feedback for Superconducting Qubits

Monday 16 April 2018 14:23 (23 minutes)

Summary

A typical measurement setup for superconducting qubits consists of arbitrary waveform generators, signal recorders and vector network analyzers. Although sufficient for simple experiments, its applicability is limited due to long data communication delays, poor scalability and static pulse sequences. A faster and more flexible solution for qubit readout and control is FPGA-based custom hardware. It not only dramatically reduces costs and space requirements but also simplifies measurements and enables customized control schemes like quantum feedback where a low response time is critical.

We implemented an FPGA design for experiments with superconducting qubits which also enables fast feedback loops to control qubits depending on their measured state. Thus, it provides the basis for experiments and algorithms like quantum error correction or active reset. While typically the signal-to-noise ratio is improved by averaging, feedback loops require single shot measurements. Therefore, we employ a Josephson parametric amplifier with its superior noise characteristics. In the current state of development, we demonstrate arbitrary qubit rotations around X and Y axis. Furthermore, we can perform all standard measurements for qubit characterization using an FPGA and will present first results on implementing quantum feedback.

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Session Classification: FPGAs in ihren Anwendungen