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On-Chip Digital Readout of a Superconducting Qubit Using a Josephson Digital Phase Detector

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***Abstract*—Recent demonstrations of quantum error correction fuel attempts to realize fault-tolerant superconducting quantum computers capable of practical applications. Despite the remarkable progress, achieving fast and high-fidelity single-shot readout of the qubits states remains a challenge to reliably cross the threshold of efficient error correction. Existing experimental schemes to readout the state of a superconducting qubit necessitate microwave components both at room and cryogenic temperatures, providing significant technological and economic barriers to system scalability. Therefore, it is highly desirable to implement a fast and high-fidelity readout scheme directly inside the fridge to reduce the overall system footprint and allow for low-latency operations. Here, we propose an approach to accomplish high-fidelity diabatic cryogenic readout of superconducting qubits based on the Josephson Digital Phase Detector (JDPD). When properly excited by an external flux, the JDPD can quickly switch from a single-minima to a double-minima potential and, consequently, relax in one of the two stable configurations discriminating between two phase values of a coherent input tone at GHz frequencies. We experimentally verified the possibility for the JDPD to sense the phase response of a tunable resonator with a 100 ns duration protocol and 99% fidelity. We are already working on an improved design which includes a dedicated SFQ (Single Flux Quantum) architecture. The expected performance of the new device meets the requirements of efficient error correction techniques.**

***Keywords (Index Terms)*— Superconducting quantum circuits, Josephson detector, Superconducting devices–superconducting microwave devices**

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