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Readout and Noise Sensing Schemes for Qubit-Based Detectors

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Superconducting qubits are intrinsically sensitive to environmental fluctuations, making them promising platforms for sub-eV energy sensing. In this regime, qubits can operate as Cooper pair breaking detectors, where incident energy generates phonons in the substrate (eg; Sapphire) that subsequently break Cooper pairs in the qubit's superconducting film. The resulting quasiparticles tunnel across the Josephson junction, altering the qubit's charge parity and occasionally inducing energy relaxation. By monitoring charge parity switching, energy relaxation rates, and multi-level qubit spectroscopy, one can infer changes in quasiparticle density from energy depositions. We present a comparative study of readout sensitivities for multiple qubit based energy sensing schemes, along with recent qudit spectroscopy measurements of the charge environment in a sapphire substrate using a tantalum transmon.

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