

Limits and improvement of qubit readout in circuit QED

QED

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Circuit quantum electrodynamics (cQED) has emerged as a powerful platform for quantum computation and for the investigation of quantum optics at microwave frequencies [1]. A critical component of all cQED experiments is qubit readout, which relies on microwave drives. In principle, higher drive amplitudes should lead to faster and more accurate readout. However, experiments have consistently shown that as the drive amplitude increases, the readout quality rapidly deteriorates, severely limiting performance in the laboratory [2,3].

We begin by reviewing the basics of qubit measurement in circuit QED. Building on previous theoretical and experimental advances, we then present a comprehensive theoretical framework that provides a physical picture of the origin of this limitation, together with a set of tools that can be used to predict its occurrence [4]. Finally, approaches to mitigate this issue and improve qubit readout to the level required for fault-tolerant quantum computation are discussed, see Figs. 1 and 2 [5,6,7].

References

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- [2] Sank et al. *Phys. Rev. Lett.* **117**, 190503 (2016)
- [3] T. Walter et al. *Phys. Rev. Applied* **7**, 054020 (2017)

- [4] Dumas et al. *Phys. Rev. X* **14**, 041023 (2024)
- [5] A. A. Chapple et al. *Phys. Rev. Applied* **24**, 034026 (2025)
- [6] A. A. Chapple et al. *Phys. Rev. Lett.* **135**, 256002 (2025)
- [7] G. Beaulieu et al. *arXiv:2601.04975*

Figures

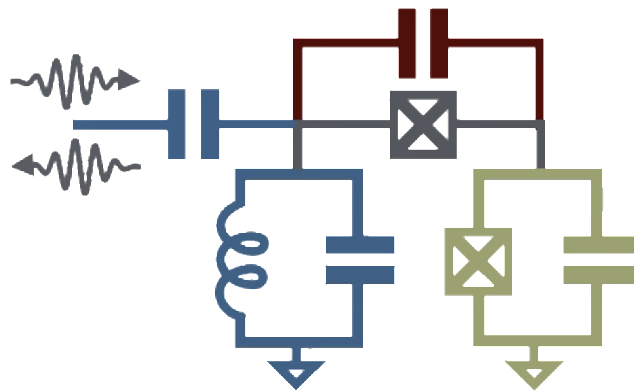


Figure 1: Circuit for junction readout where a Superconducting transmon qubit (green) is coupled to a readout resonator (blue) through a Josephson junction (red) and a capacitor [6].

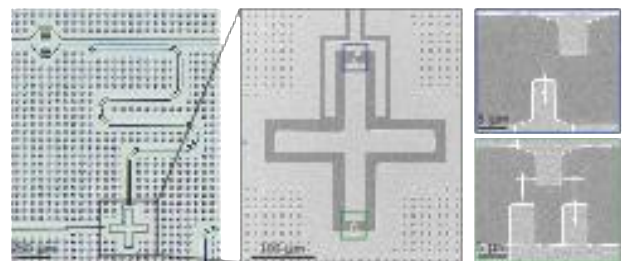


Figure 2: Experimental realization of junction readout by the Scarlino group at EPFL [7]

