

Activities

[1] We successfully had a proposal accepted for the Fujitsu Quantum Simulator Challenge 2025–26 event. Click [here](#) for more information.



[2] We recently secured approval for five Ministry of Education–funded programs in Taiwan, creating valuable learning pathways for young people. These programs support international exchange and advanced training at globally recognized universities, helping students build interdisciplinary knowledge, research skills, and global perspectives in fields such as artificial intelligence, quantum computing, biomedical science, systems medicine, and robotics. Click [here](#) for more information.

I-9-10	Ⓣ	IBM量子夢：紐約研習營	美國紐約	(九)科技網絡及數位服務	制霸IBM量子科技巔峰	115年7月13日至7月28日，共計16日（含飛行日）
I-9-11	Ⓣ	醫工量子：UCLA 菁英計畫	美國加州洛杉磯	(九)科技網絡及數位服務	探索腦科學與量子計算	115年7月6日至9月3日，共計60日（含飛行日）
I-9-12	Ⓣ	量子金融：赴美職涯領航	美國大紐約區	(九)科技網絡及數位服務	跨足量子與AI金融實務	115年7月6日至8月9日，共計35日（含飛行日）
I-9-13	Ⓣ	AI與石黑浩：探索擬真界	日本大阪	(九)科技網絡及數位服務	台日共創人形機器人新未來	115年8月1日至116年1月15日，共計168日（含飛行日）
I-9-14	Ⓣ	勇闖 WVVU：太空機器人實戰	美國摩根敦	(九)科技網絡及數位服務	太空探集機器人見習	115年7月6日至7月23日，共計18日（含飛行日）

Ultrafast QND Readout Enabling Dynamic Feedback in Superconducting Quantum Systems

In fault-tolerant quantum computers, fast and high-fidelity qubit readout is essential. That means qubits must be measured quickly and accurately because quantum states are fragile and easily disturbed by noise and decoherence. Ideally, this readout should be quantum non-demolition (QND), meaning the measurement reveals the qubit state without inducing transitions or destroying the state itself.

Quantum Non-Demolition (QND) measurement

QND measurements are especially important in this context because they allow repeated or mid-circuit measurements without unnecessarily disturbing the qubit’s computational state. The feedback must be fast and accurate because qubits lose coherence quickly. These mechanisms also support tasks like deterministic quantum teleportation and other adaptive quantum protocols, making rapid, high-fidelity readout a key requirement for building fault-tolerant quantum computers.

In superconducting qubit readout, QND measurement is achieved by operating in the dispersive regime, where the qubit state shifts the resonator frequency, allowing the qubit state ($|0\rangle$, $|1\rangle$) to be inferred from the microwave output signal without inducing qubit transitions.

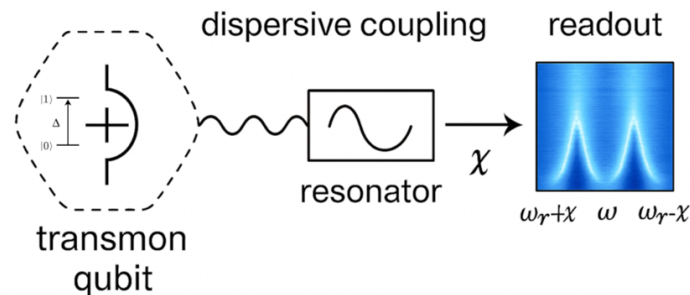


Figure 1. The schematic diagram of Quantum Non-Demolition (QND) measurement in superconducting qubit readout.

In the dispersive regime, energy exchange between the qubit and the resonator is strongly suppressed, so the measurement does not directly induce qubit state transitions; however, there can still be dephasing (loss of coherence). This makes it possible to read out the qubit state in a QND manner, which is crucial for preserving the correctness of quantum computations, especially during mid-circuit measurements.

Dynamic, active feedback schemes

Rapid, high-fidelity readout allows the system to detect errors in real time and apply corrections before those errors spread to other qubits. This process is essential for quantum error correction, which repeatedly checks qubits during a computation. If measurements are slow or inaccurate, the control system may apply the wrong correction or miss the error entirely. Therefore, fast and reliable qubit readout is a fundamental requirement for maintaining stable quantum computations in large-scale quantum processors. These precise measurements are crucial for facilitating dynamic, active feedback schemes.

Dynamic, active feedback schemes allow a quantum computer to measure qubits during a computation and immediately use the results to decide the next operation. This creates a real-time control loop: the system measures a qubit, processes the outcome with classical electronics, and conditionally applies new gates. Such mid-circuit measurements enable active error correction, where detected errors are quickly fixed before they spread.

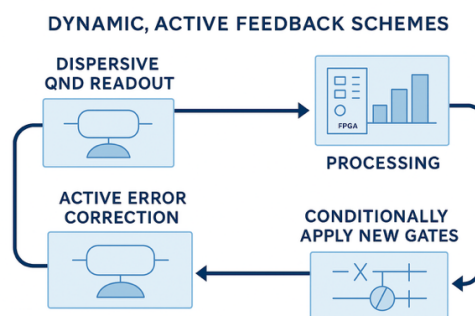


Figure 2. A superconducting qubit is measured mid-circuit using dispersive QND readout, suppressing state flips. The readout signal is processed in real time by classical electronics, such as, FPGA, which dynamically and actively applies conditional gates, forming a continuous feedback loop that enables rapid error correction and prevents error propagation.

A recent work (1) proposes an ultrafast, high-fidelity QND readout scheme for superconducting qubits using a qurton coupler to engineer a nonperturbative cross-Kerr interaction between a transmon qubit and its readout resonator. Unlike conventional dispersive readout, where the cross-Kerr strength is limited to about 10 MHz, the qurton coupler enables cross-Kerr interactions exceeding 200 MHz, allowing the resonator linewidth to be increased accordingly without inducing linear coupling or Purcell decay. Numerical master-equation simulations show that this design achieves ~5 ns readout times with >99% readout fidelity and >99.9% QND fidelity, while preserving qubit coherence. This approach demonstrates that engineering strong, purely nonlinear light-matter couplings can overcome fundamental speed limits of standard dispersive readout, enabling much faster mid-circuit measurements and feedback for quantum error correction.

Reference

1. Ye Y, Kline JB, Chen S, Yen A, O'Brien KP. Ultrafast superconducting qubit readout with the qurton coupler. *Science Advances*. 2024;10(41):eado9094.

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