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Title: The journey of scaling superconducting quantum computers

Abstract:

We provide an overview of the design and fabrication strategies employed at IQM for the development of scalable superconducting quantum processing units (QPUs). Our discussion encompasses critical building blocks of the QPU, comprising qubits, tunable coupling elements, and readout circuit, as well as planar and 3D-integrated fabrication methods of superconducting quantum devices. Progressing from these foundational elements, we detail the ongoing optimization efforts directed at achieving high-fidelity operations for both single and two-qubit gates [1]. Furthermore, we will delve into the complexities involved in scaling up to fully integrated quantum computing systems, highlighting concerns related to fabrication yield and nuanced aspects of system integration. Finally, we introduce the scaling roadmap concentrating on the first QPU generations with 5, 20 and 54 qubits with fully nearest neighbor coupled lattice based on the tunable couplers and present the latest experimental results from these integrated quantum computing systems.

[1] F. Marxer et al., “Long-Distance Transmon Coupler with CZ-Gate Fidelity above 99.8%”, *Phys. Rev. X Quantum* **4**, 010314 (2023).

