Modular flip-chip architecture for generalized flux qubits

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Superconducting circuits are a promising and widely-used platform to implement quantum information processing hardware. However, scaling up to more sophisticated devices requires major engineering efforts due to the complexity of the mandatory coupling, readout and control circuitry. To investigate innovative coupling and scaling strategies, we developed a modular flip-chip architecture, in which the various circuit elements reside on dedicated chips that are capacitively coupled. A unit cell of our architecture consists of a qubit chip that is flipped above a control chip. The qubit chip contains a single generalized flux qubit (GFQ) and a harmonic readout mode, through which dispersive readout is possible. The control chip is used to excite, read out and flux bias the qubit. We tested our architecture by characterizing the GFQs in all conventional flux qubit regimes by modifying the qubit loop inductance as well as the shunt capacitance and the Josephson energy of the alpha junction. This resulted in qubit frequencies between 150 MHz and 7.5 GHz, and dispersive shifts of 60 kHz to 6 MHz. Coupling between unit cells may be achieved through coupler chips, so that our unit cell can be used as a basic building block of a scalable qubit array.