Coherent Control of Triangular and Multi-Rail Exchange-Only Spin Qubits in the Sledge Architecture

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Si/SiGe exchange-only spin qubits encoded in a decoherence-free subsystem (DFS) are a compelling platform for quantum computing because of their compatibility with advanced fabrication techniques and their exclusive use of baseband pulses for control. Using the Single-Layer Etch-Defined Gate-Electrode (SLEDGE) architecture, which implements a CMOS-like separation between active front-end gates and electrical routing layers, we recently demonstrated high-fidelity two-qubit DFS-encoded gates in a single-rail device. Scaling to geometries, where qubits are connected to more than two neighbors, is an essential step towards quantum fault tolerance because it improves robustness and connectivity.

We investigate a triple quantum dot (TQD) with the dots arranged in a close-packed triangular geometry. This includes measurements of the charge stability in the few-electron regime as well as the dynamical characterization of a three-electron exchange only (EO) qubit encoded into TQD, which serves as a proxy for the coherent performance of the joint electronic spin state of the dots. In all cases, we find that performance is comparable to state-of-the-art demonstrations of EO qubits in linear dot arrays. Thus, our results represent a step towards scaling up quantum dot arrays to larger and more complex structures.

Furthermore, we report on the fabrication of a two-rail, six-dot device with three distinct back-end routing layers. We also discuss the electrostatic tune-up, the initial parametric characterization, and the single-qubit randomized benchmarking performance of this device.