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Single-Shot State Measurement of Coupled Phase Qubits

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A major reason that superconducting Josephson tunnel junctions are promising quantum bit (qubit) candidates for a quantum computer is their potential for scalability using conventional integrated-circuit technology. We have taken a first step toward implementing multi-qubit systems by fabricating pairs of capacitively coupled Josephson phase qubits with individual control and measurement circuitry. Spectroscopic measurements verify that the two qubits become coupled when they are tuned into resonance with each other. Furthermore, with the benefit of a fast state measurement technique, we are able to perform simultaneous single-shot measurements of the two qubits individually. The success of these experiments relies on an understanding of classical measurement crosstalk, where the readout of one qubit may cause unwanted transitions in the second qubit. Because the crosstalk does not occur instantaneously, it can be largely avoided by timing the separate qubit measurements to be coincident. Time-domain experiments reveal antiphase oscillations between the two-qubit basis states $|01\rangle$ and $|10\rangle$, with the frequency of oscillation determined by the engineered capacitive coupling strength between the two qubits. These results are consistent with quantum mechanical entanglement of the two qubits, and they open the possibility for the characterization of multi-qubit gates and elementary quantum algorithms.