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Demonstration of the QCCD trapped-ion quantum computer architecture STEVEN MOSES, JUAN PINO, JOAN DREILING, CAROLINE FIGGATT, JOHN GAEBLER, MICHAEL ALLMAN, CHARLES BALDWIN, MICHAEL FOSS-FEIG, DAVID HAYES, KARL MAYER, CIARAN RYAN-ANDERSON, BRIAN NEYENHUIS, Honeywell Quantum Solutions — We report on the integration of all necessary ingredients of the trapped-ion QCCD (quantum charge-coupled device) architecture into a robust, fully-connected, and programmable trapped-ion quantum computer. The system employs $^{171}Yb^{+}$ ions for qubits and $^{138}Ba^{+}$ ions for sympathetic cooling and is built around a Honeywell cryogenic surface trap capable of arbitrary ion rearrangement and parallel gate operations in multiple zones. Using two of these zones in parallel, we can execute arbitrary four-qubit quantum circuits. We benchmark the architecture at both the component level and at the holistic level through a variety of means. State preparation and measurement errors, single-qubit gates, and two-qubit gates are characterized with randomized benchmarking. Holistic tests include parallelized randomized benchmarking showing that the cross-talk between different gate regions is negligible, a teleported CNOT gate utilizing mid-circuit measurement, and a quantum volume measurement of 2^4.

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