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A new type of superconducting qubit: How the transmon thwarts the T_2 problem TERRI M. YU, JENS KOCH, JAY GAMBETTA, ANDREW A. HOUCK, DAVID I. SCHUSTER, JOHANNES MAJER, ROBERT J. SCHOELKOPF, STEVEN M. GIRVIN, Yale University — Superconducting qubits have long been dogged by small energy relaxation (T_1) and dephasing times (T_2). Here we propose a new type of superconducting qubit that we call the "transmon." This device consists of a Cooper pair box shunted by a large capacitance. The two quantities crucial to the operating the transmon as a qubit are a) energy level anharmonicity and b) charge noise sensitivity. Sufficient anharmonicity is required to prevent transitions out of the qubit two-level system. Low sensitivity is desired so that fluctuations of the gate charge do not appreciably change the qubit transition frequency. Decreasing (increasing) the Josephson energy to charging energy ratio (E_J/E_C) of the transmon raises (reduces) anharmonicity and charge noise sensitivity. By operating the transmon in a radically different parameter regime $10^1 < E_J/E_C \ll 10^3$, the qubit becomes exponentially more stable to charge fluctuations compared to the Cooper pair box, yet it retains enough anharmonicity for fast qubit operations. For large enough E_J/E_C, dephasing due to charge noise becomes completely negligible so that greatly enhanced T_2 times should be achievable.

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