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Dynamical decoupling and noise spectroscopy with a superconducting flux qubit JONAS BYLANDER, SIMON GUSTAVSSON, FEI YAN, Massachusetts Institute of Technology, FUMIKI YOSHIHARA, KHALIL HARRABI, Institute of Physical and Chemical Research RIKEN, DAVID CORY, MIT and University of Waterloo, YASUNOBU NAKAMURA, JAW-SHEN TSAI, RIKEN and NEC Corporation, WILLIAM D. OLIVER, MIT Lincoln Laboratory — We demonstrate dynamical decoupling in a superconducting flux qubit with a long energy-relaxation time, $T_1 = 12\,\mu$s. Low-frequency noise acts to dephase the qubit, reducing its transverse coherence time T_2. At the noise-optimal bias point we observe a free-induction decay time $T_2^* = 2.5\,\mu$s and T_1-limited spin-echo decay, $T_{2E} = 2\,T_1$. Biased away from this point, the increased sensitivity to flux noise leads to increased echo and free-induction decay rates. We moderate the dephasing effects of this noise by applying dynamical-decoupling sequences with up to 200 π-pulses. Using the CPMG sequence, we achieve a more than 50-fold enhanced decay time over T_2^*, and Gaussian pure-dephasing times $T_\varphi > 100\,\mu$s. We use the filtering property of this pulse sequence to facilitate spectroscopy of the environmental noise and reconstruct its $1/f$ power spectral density, which we independently confirm by a Rabi-spectroscopy approach. We characterize the noise sources coupling to the energy-bias and tunnel-coupling terms of the Hamiltonian.

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