Readout Fidelity of the Superconducting Flux Qubit through a DC-SQUID

Kouichi Semba [1, 2], Irinel Chiorescu [2], Yasunobu Nakamura [2,3], Kees J. P. M. Harmans [2], and J. E. Mooij [2]

[1]NTT Basic Research Laboratories, NTT Corporation, Atsugi, Kanagawa 243-0198, Japan

[2] Quantum Transport Group, Nano-Science Department, Delft University of Technology, Lorentzweg 1, 2628 CJ, Delft, Netherlands

[3]NEC Fundamental Research Laboratories, 34 Miyukigaoka, Tsukuba, Ibaraki 305-8501, Japan

We have observed coherent time evolution between two quantum states of a superconducting flux qubit which is composed of three Josephson junctions configured in a loop, with a superconducting quantum interference device (DC-SQUID) switching detector attached to it [1]. The superposition of the two states carrying opposite macroscopic persistent currents is manipulated by resonant microwave pulses. After the qubit operation by the microwave, the SQUID readout is enabled by applying a bias current pulse. The SQUID switching probability is obtained by repeating the sequence of applying microwave control pulses, readout and re-equilibration, typically 2000 times.

Through the switching-event measurement, we measured the switching probability as a function of the bias current pulse amplitude. Observed variation in switching probability up to 65 % indicates the fidelity in a single shot readout of this order (Fig.1). By taking the derivative of the switching probability against the bias current amplitude I_b, we obtained the double-peaked structure (Fig.2) which is equivalent to the switching histogram of the SQUID. Each peak represents the ground state and the 1st excited state of the qubit. Applying a π-pulse, reversed occupancy between the ground state and the 1st excited state was observed. The width of the π-pulse was determined by the Rabi oscillation at resonance. Plotting these peak positions as a function of applied magnetic field, the crossed transition steps for both ground state and the 1st excited state were obtained; similar results were obtained in Ref. [2]. The readout fidelity was strongly suppressed in the crossing region of the ground state and the 1st excited state and therefore the spectroscopy signal became weaker in this region.

[1] I. Chiorescu, Y. Nakamura, C. J. P. M. Harmans, J. E. Mooij, published online in Science : 13 February 2003 10.1126/science.1081045

[2] H. Tanaka, S. Saito, M. Ueda, H. Nakano, K. Semba, F. Deppe, and H. Takayanagi, submitted.

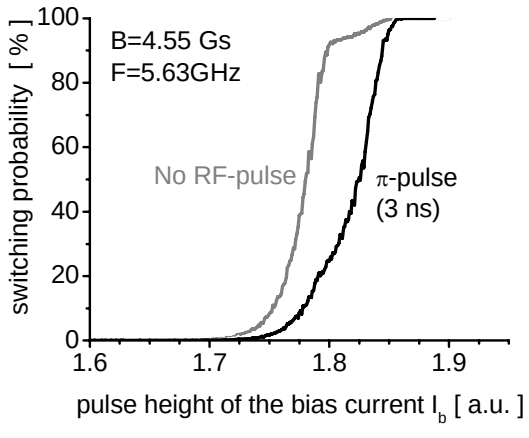

Fig. 1 The SQUID switching probability

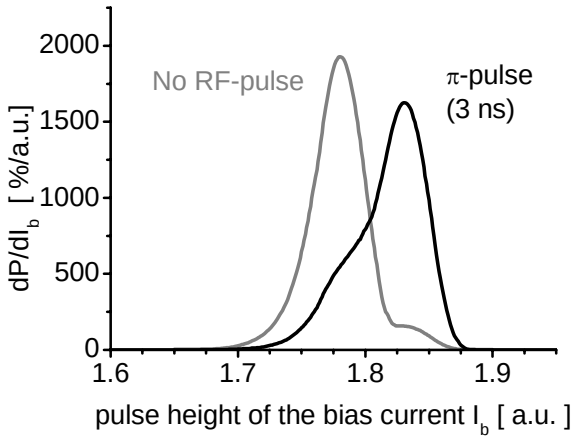

Fig. 2 The derivative of the switching curve