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Design and High-speed Test of an SFQ-based Single-chip FFT Processor

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Fast Fourier transform (FFT) processor is custom hardware for computing discrete Fourier transform (DFT) at high speed, where DFT can convert a signal from a time domain to a frequency domain, and is widely used in digital signal processing. High-performance FFT processors based on single flux quantum (SFQ) circuits are attractive in many fields because of their high-speed operation with low power consumption [1]. In our previous study, we have designed and implemented a 4-bit 8-point SFQ FFT processor using the AIST 10 kA/cm^2 Nb advanced processor (ADP 2.2) [2] and confirmed the correct operation of the first stage at low-speed test [3]. In this study, we designed a 7-bit 8-point SFQ-based single-chip FFT processor and fabricated it using the ADP 2.2 process. The correct operation of the FFT processor was confirmed at the on-chip high-speed test [4]. We input 8-point discrete time-domain signals such as a sine wave and a cosine wave and demonstrated the spectrum analysis ability of the FFT processor. The FFT processor can perform 2.55×10^{11} times of FFT calculations per Joule at the maximum frequency of 47.8GHz, where it takes 7.4 ns for one time of FFT calculation. We also evaluated the energy efficiency of a 32-bit 64-point SFQ FFT processor and compared it with that of a CMOS FFT processor under a 45 nm technology. We confirmed it is two orders of magnitude better than that of the CMOS FFT processor with serial architecture.

Keywords: single flux quantum circuits, FFT, processor, superconducting