Demonstration of a 1000-Fold Voltage Multiplier Using Double-flux-Quantum Generation

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Abstract - We demonstrate operation of a 1000-fold voltage multiplier designed for single-flux-quantum (SFQ) digital-to-analog converters (DACs). The voltage multiplication is based on the double-flux-quantum amplifier (DFQA) that was originally proposed by Herr in 2005 for wide bandwidth signal transmission from Josephson circuits to semiconductor electronics. A DFQA is composed of stacked three-junction (3J) loops. Each 3J-loop includes two critically-damped Josephson junctions and one under-damped Josephson junction. In the first 3J-loop stage, one DFQ is generated at the under-damped junction for one input SFQ, resulting in one SFQ reflection. The reflected SFQ is transferred to the 2nd 3J-loop, and induces double-flux-quantum generation there. N-fold voltage multiplication is realized using an (N − 1)-stage DFQA. Although the possibility of quantum amplification was noted in the original paper, the accuracy of voltage multiplication was not evaluated. We have designed and fabricated a 999-stage DFQA using a Nb/AlOx/Nb integration technology. In experiments, we have used two methods for feeding the input SFQ pulse train. The one is an over-biasing method; the input SFQ pulse train is generated at an over-biased input junction. 1000-fold voltage multiplication with errors less than ±1%has been confirmed for the input voltages of up to 27 μV, of which the corresponding Josephson frequency is 13 GHz. In the other method, a dc/SFQ converter is used for feeding the input SFQ pulse train. 1000-fold voltage multiplication with an error of −0.03% has been obtained for the input frequency of 600 MHz, of which the corresponding Josephson voltage is 1.2 μV.

Keywords - voltage multiplier, single-flux-quantum (SFQ), digital-to-analog converter (DAC), double-flux-quantum amplifier (DFQA), Josephson junction.

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