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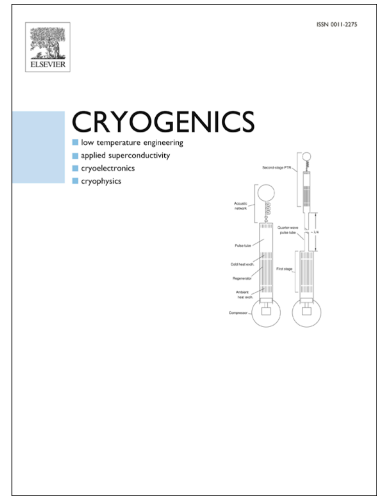

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Abstract–In the experiments for dark-matter QCD-axion searches, very weak microwave signals from a low-temperature High-Q resonant cavity should be detected using the highest sensitivity. The best commercial low-noise cryogenic semiconductor amplifiers based on high electron mobility transistors have a lowest noise temperature above 1.0 K, even if they are cooled well below 1 K. Superconducting quantum interference devices can work as microwave amplifiers with temperature noise close to the standard quantum limit. Previous SQUID-based RF amplifiers designed for axion search experiments have a microstrip resonant input coil and are thus called micro-strip SQUID amplifiers or MSAs. Due to the resonant input coupling they usually have narrow bandwidth. In this paper we report on a SQUID-based wideband microwave amplifier fabricated using sub-micron size Josephson junctions with very low capacitance. A single amplifier can be used in a frequency range of approximately 1–5 GHz.

Keywords: SQUID, MSA, HEMT, axion, microwave, amplifier.

INTRODUCTION

The hypothetical elementary particle axion was initially proposed as an elegant solution to the strong-CP problem in quantum chromodynamics (QCD) [1]. If it exists, it can also be considered as a very good dark matter candidate [2]. Dark matter has never been directly observed on Earth, but its existence could explain a number of puzzling astronomical observations such as gravitational lensing, stars' velocity distribution in galaxies, and observations in the cosmic microwave background.

The axion is a very light elementary particle and is very weakly coupled to baryonic matter, since axion couplings and its mass are proportional. Due to this it is extremely difficult to detect them in laboratory experiments on Earth. Nevertheless, it was theoretically shown that axions can be detected by converting them to photons in the presence of a very strong magnetic field [3]. This principle was first attempted in the axion dark matter experiments in the framework of the Rochester-Brookhaven-Fermilab (RBF) collaboration in 1989 [4]. Later it was used in the axion dark matter experiments, or ADMX, at Lawrence Livermore National Laboratory in 1995 [5]. ADMX was moved to the University of Washington in 2010. In these experiments axions can be detected as microwave photons inside a microwave cavity resonator immersed in a very strong magnetic field. To minimize thermal noise this microwave cavity resonator, as well as the first stage of a microwave preamplifier, should be cooled to the lowest possible temperature.