Frequency Multiplication in a Distributed Array of SIS Junctions

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We report the experimental study of the off-chip detection of frequency multiplication in a distributed array of Superconductor-Insulator-Superconductor (SIS) junctions. A test device consisting of a series array consisting sixty eight Nb/Al-AlOx/Nb tunnel junctions was designed for this study, and was fabricated using in-house Nb thin-film technology.

The test device with SIS array was optimized for the study of second harmonic generation in 182−192 GHz output frequency band. The SIS array was exited with microwave radiation at 3 mm band using a quasi-optically coupled Gunn oscillator and the output response of the device was studied using a double sideband SIS mixer operating in 163 − 211 GHz range with 4−8 GHz. The Josephson-effect for both the SIS multiplier and the detector mixer was carefully suppressed using magnetic field. We observed very sharp second harmonic spectral signals, due to frequency multiplication by the SIS array. We also observed distinct multi-photon process in the SIS array tunnel junction response to the applied microwave signal, and the amplitude of the multiplied signal shows dependence on the bias voltage of the SIS array. We observed that the output power of the multiplied signal increases linearly with the power of the pumping signal up to certain level and them saturates. Increasing the input power beyond this level results in the heating of the chip. When the output of the test device was connected to the LO port of the SIS-mixer, an increase of 10 − 20% in the SIS -mixer dark current was observed when the SIS mixer was voltage biased in the middle of first photon step below the gap voltage. The device, although far from providing sufficient power to pump a practical SIS mixer, may be considered as a first experimental step towards SIS frequency multipliers.