Noise-bandwidth of Diffusion Cooled Hot-Electron Bolometers

Peter J. Burke, R.J. Schoelkopf, D.E. Prober
Depts. of Applied Physics and Physics, Yale University, New Haven, CT 06520-8284

A.Skalare, W.R. McGrath, B.Karasik, M. Gaidis, B.Bumble, H.G. LeDuc
Jet Propulsion Laboratory, California Institute of Technology, Pasadena• CA 91109

In recent years, superconducting hot-electron bolometers have demonstrated promising performance as low-noise mixers in THz receivers. Already, excellent results have been attained at rf frequencies of 0.5 THz[1], 1.2 THz[2], and 2.5 THz[3]. An important technological issue is the intermediate frequency gain and noise bandwidth for these mixers. We have therefore measured the spectrum of the output noise as well as the conversion gain for devices of several different lengths to study how the mixer noise of hot-electron bolometers depends on the intermediate frequency.

The gain-bandwidth, the frequency at which the conversion gain drops by 3 dB relative to its low frequency value, is given by $1/\tau_{thermal}$. The output noise at low intermediate frequencies is dominated by thermal fluctuation noise, while at high intermediate frequencies Johnson noise dominates the output noise. Since the spectrum of the output noise at low frequencies (where thermal fluctuation noise dominates) has the same dependence on frequency as the conversion gain, the mixer noise (T_{mix} (DSB) = $T_{out}/2\eta$, with η =SSB conversion efficiency) will be independent of frequency up to the crossover where the Johnson and thermal fluctuation noise are comparable. Therefore, the noise-bandwidth, the frequency at which the mixer noise is 3 dB higher than its low frequency value, can be larger than the gain-bandwidth.

We have measured the spectrum of the output noise and the conversion gain from 0.05-8 GHz under identical conditions for both diffusion and phonon-cooled Nb bolometers, using a 20 GHz LO. We do indeed find that the noise-bandwidth is 1.5 to 2 times higher than the gain-bandwidth, and that the low-frequency value of the mixer noise is low, $T_{mix} < 300$ *K(DSB).* We have done these measurements on a variety of devices varying in length from 0.08 µm to 3 µm, where the gain-bandwidth[4] varies between 100 MHz and > 6 GHz. We will also present modeling of this data, including modeling of the dependence of the noise and conversion efficiency as a function of dc bias and LO power.

References

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