Measuring the Quantum Efficiency of SIS Receivers

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The efficiency with which RF photons are absorbed and converted to DC current is a fundamental parameter for determining the noise performance of millimeter and sub-millimeter heterodyne receivers. According to the photodiode theory of mixing, this quantum efficiency determines the noise contribution associated with the down conversion process. This noise must necessarily dominate in receivers whose noise is close to the quantum limit and is found to be a major component in all of the SIS receivers we have evaluated. Other noise contributions arise from the "dark current" and the IF amplifier chain.

This paper describes a method for measuring the quantum efficiency of heterodyne receivers. The method does not require a calibrated RF source, but uses the same ambient and LN_2 cooled loads used for receiver noise measurements to calibrate a CW oscillator. This calibration technique automatically includes the optical losses in the signal path in the quantum efficiency measurement. The measured quantum efficiencies of several SIS receivers operating at frequencies from 85 to 270 GHz are presented. Photodiode theory is used to interpret the measurements and quantitatively evaluate the different contributions to the receiver noise.

The measurement procedures described in this paper can be applied to most heterodyne receivers and the photodiode interpretation does not depend upon a detailed theory for the mixing process. These techniques should thus prove useful for evaluating the performance of a wide variety of heterodyne receivers operating at terahertz frequencies and beyond.

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