NUMERICAL MODELING OF THE QUASIPARTICLE NON-LINEAR TRANSMISSION LINE

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An analysis is presented for the behavior of the quasiparticle non-linear transmission line driven by a high frequency local oscillator. The theory developed includes a large-signal non-linear analysis, a small-signal analysis and a noise analysis. This model is used to simulate the conversion loss and noise temperature of distributed quasiparticle mixers based on the non-linear transmission line. The numerical code has been verified by comparing the theoretical conversion loss and mixer noise temperature with that of an experimental mixer that operates in the 400 GHz band. Reasonable agreement between the calculated and measured data has been obtained.

The numerical simulation shows that good conversion efficency and low mixer noise temperature are realizable at relatively low source resistance where the optimum line lengths are spaced half guided wavelength apart. From the results of the claculation, one can also derive the optimum critical current density of the long SIS junctions used for this type of non-linear transmission line based SIS mixer.

The theory also predicts that if the non-linear transmission line is terminated by an RF load, the signal waveform along the line may be amplified parametrically if the idler frequency is inductively terminated. The inductive load for the idler should roughly tune out the capacitance of the entire line at the same frequency. In one specific simulation, for example, a peak gain of 5.2 could be obtained with a line length of 5.4 guided wavelengths at 460 GHz. The required pumping power is about 300 nW and the input return loss is about -16 dB. The corresponding single-side-band mixer noise temperature is only about 58 K. This new possibility of low-noise stable parametric amplification may present new opportunities to low-noise receiver systems at sub-millimeter frequencies.

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