直列分散型SIS接合アレイミキサーのシミュレーション

Simulation of SIS Mixers with Series-Connected Distributed Junction Arrays

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Mixers comprising series-connected distributed Superconductor-Insulator-Superconductor tunnel junctions (SDJ) have been given attention as sensitive heterodyne millimeter and sub-millimeter wave detectors for radio astronomical observations. Compared to mixers consisting of parallel-connected junctions (PDJ), SDJ mixers offer wider instantaneous bandwidth and higher dynamic range as well as easier magnetic field tuning. However, SDJ mixers are more complicated in simulation and design. Commonly an SDJ is regarded as a single junction with an assumption that all the junctions are identical in size and behave equally in mixing. However, in practices this assumption is not available when the parasitic inductance between junctions is not ignorable. While all junctions have the same bias voltage in a PDJ mixer, the bias voltage of each junction in an SDJ one can be quite different from each other and the junctions can be unequally pumped. Since the bias voltage of the junctions in an SDJ mixer cannot be measured individually in experiment, the actual operation state can only be identified by numerical simulation. For the simulation of an SDJ mixer of an N-junction series array, nonlinear equations containing 5N unknowns must be solved. Because the solving of the nonlinear equation is not practical by applying the conventional Newton's iteration, we design a fixed-point iterative method for this purpose. This numerical method is verified to be effective and can achieve convergence rapidly. We attribute the effectiveness of this algorithm to the fact that this iteration approach is a good analogue of the real physical evolution of the LO distribution. Once this large signal problem is solved, the rest of the numerical modelling is a perturbation analysis, which is purely linear and straightforward.