Abstract for an Invited Paper
for the MAR09 Meeting of
The American Physical Society

Optimizing the Gain and Noise Temperature of Microstrip SQUID Amplifiers

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Micrrostrip SQUID amplifiers (MSA) offer near quantum-limited sensitivity and gains greater than 20 dB at frequencies around 1 GHz. These properties make them desirable for applications ranging from dark-matter axion detection to dispersive readout of superconducting qubits. The input of the MSA is a microstrip transmission line in the shape of a square spiral coil surrounding the hole in the SQUID washer that serves as the ground plane. Near the fundamental resonance, there is strong flux coupling between the input coil and SQUID. To obtain maximum performance it is necessary to know the complete set of complex scattering parameters. We present measurements of the scattering parameters of MSAs cooled to 4.2 K. The input impedance is found by measuring the reverse scattering parameter (S11) and is described well by a low-loss transmission line model. We map the low-loss transmission line model into an equivalent parallel RLC circuit that accurately predicts the observed gain given by the forward scattering parameter (S21). This information is used to optimize the input and output matching circuitry to achieve optimal noise temperature and gain. We will present results for the gain, dynamic range, linearity and noise temperature of these optimized MSAs at 30-500 mK as a function of frequency and SQUID bias. We will compare the results to the prediction of the circuit model and to the theoretical expectation that the lowest noise temperature occurs off-resonance. This work is in collaboration with John Clarke and a portion of this work was supported by DOE.