bottom (2) superconductors. The kinetic inductance fraction, $\alpha = \frac{L_k}{L_T}$, is defined as the ratio of the kinetic inductance L_k to the total inductance, $L_T = L_k + L_m$, where L_m is the magnetic inductance of the transmission line. Using Equation 1 and the phase velocity of a normal metal transmission line $v_{pN} = c/\sqrt{\epsilon_r}$ we can calculate α for a uniform distribution of quasiparticles in both the top and bottom microstrip wiring as:

$$\alpha = 1 - \left(\frac{v_p}{v_{pN}}\right)^2 \tag{2}$$

$$= 1 - \left(1 + \frac{\lambda_1}{d}\coth\left(\frac{t_1}{\lambda_1}\right) + \frac{\lambda_2}{d}\coth\left(\frac{t_2}{\lambda_2}\right)\right)^{-1} \tag{3}$$

The microstrip MKID is read out by sending a microwave probe signal past the resonator, and a homodyne mixing scheme is used to recover the phase and dissipation changes imprinted onto the carrier by the MKID [1]. Using Equation 3 and Equation 4 [14], we can express the expected responsivity, normalized so the microwave transmission past the resonator S_{21} far off resonance is unity, of a microstrip MKID in both dissipation and phase as:

$$\frac{\partial S_{21}}{\partial N_{qp}} = \frac{\alpha|\gamma|\kappa Q_m^2}{V Q_c} \tag{4}$$

with

$$\kappa \approx \frac{1}{\pi N_0}\sqrt{\frac{2}{\pi k T \Delta_0}}\sinh(\xi)K_0(\xi) + j\frac{1}{2N_0\Delta_0}\left[1 + \sqrt{\frac{2\Delta_0}{\pi k T}}e^{-\xi}I_0(\xi)\right]$$

where N_{qp} is the number of quasiparticles in the resonator, Q_m is the measured quality factor, Q_c is the coupling quality factor, V is twice the volume of the top microstrip wiring layer since this is where the current flows and where quasiparticles effectively contribute to the surface impedance, N_0 is the single spin density of states, Δ_0 is the effective gap at $T \approx 0$, $\xi = \hbar\omega/2kT$, and γ is constant that varies from -1/3 in the extreme anamalous limit to -1 in the thin film local limit. The predicted phase responsivity in radians per quasiparticle, $\partial\theta/\partial N_{\mathrm{qp}}$, can be found by taking the imaginary part of Equation 4, while the dissipation response $\partial D/\partial N_{\mathrm{qp}}$ is found by taking the real part. Q_m is related to Q_c and the quality factor resulting from any source of dissipation in the system, Q_i, by the relation $Q_m^{-1} = Q_c^{-1} + Q_i^{-1}$. We operate the devices in this paper at $T < T_c/8$, so there are