

Noise Analysis and Sensitivity of a Micromechanical Displacement Detector Based on the Radio-Frequency Single-Electron Transistor

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We investigate the intrinsic noise limits on the sensitivity of a micromechanical displacement detector based on the radio-frequency single-electron transistor. Using the noise analysis of Korotkov [Phys. Rev. B **49**, 10381 (1994)] as our starting point, we determine the spectral density of fluctuations in force acting on the mechanical oscillator due to the fluctuating island charge. The resulting mechanical displacement noise increases approximately linearly with increasing gate voltage. In contrast, the equivalent displacement noise due to shot noise in the tunneling current decreases in inverse proportion to the increasing gate voltage [M.P. Blencowe and M.N. Wybourne, Appl. Phys. Lett **77**, 3845 (2000)]. Taking into account both these noise sources results in an optimum gate voltage value for the best displacement sensitivity. As an example, a displacement sensitivity of $10^{-6} \text{ \AA} / \sqrt{\text{Hz}}$ is predicted for a micron-sized cantilever with a realizable resonant frequency of 100 MHz and quality factor $Q \sim 10^4$. Such a sensitivity would allow the detection of quantum squeezed states in the mechanical motion of the micron-sized cantilever.