NEMSUITE: A Software Tool for Analyzing Nanoelectromechanical Sensing Systems

Tarık KARGIOGLU Alper DEMIR

Koç University, Istanbul, Turkey

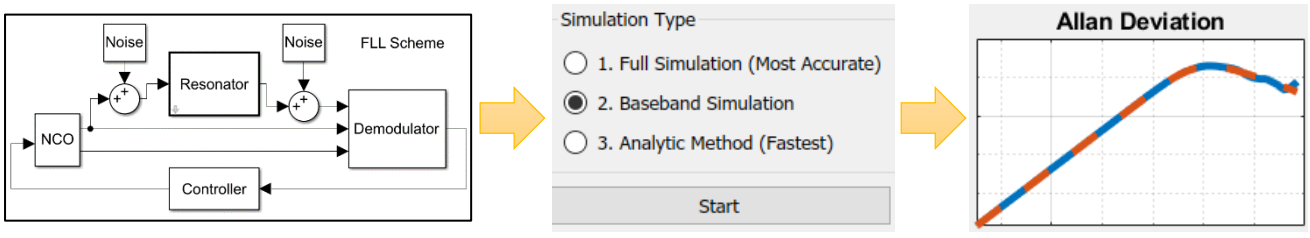
tkargioglu19@ku.edu.tr *aldemir@ku.edu.tr*

We present NEMSUITE, a software tool for the analysis and simulation of nanoelectromechanical sensing systems based on resonance frequency tracking. NEMSUITE consists of a custom MATLAB® Simulink® block library and associated MATLAB® scripts that run in the background. NEMSUITE can be used to build and analyze NEMS based sensing schemes with the familiar graphical Simulink® interface. Custom models included in the block library capture various nonidealities and noise. NEMSUITE is designed as a purely software equivalent to widely used lock-in amplifier based setups. Analysis and simulation results that can be obtained with NEMSUITE can be directly compared with experimental measurements. NEMSUITE features several user selectable analysis modes, including very fast analysis-based model evaluations as well as detailed stochastic simulations that include various sources of noise and customizable sensor events. Analysis and simulation results are directly mapped to Allan Deviations or fractional resonance frequency power spectral densities for ease of interpretation.

NEMSUITE offers three analysis modes. Full stochastic simulation mode produces the most accurate results but takes hours to run. Baseband equivalent stochastic simulation mode reduces analysis runtime considerably with little loss of accuracy. Finally, analysis-based model evaluation mode, that is based on a detailed analytical theory [1], avoids lengthy stochastic simulations and produces results that very well match the ones produced by expensive simulations.

We have implemented NEMSUITE models corresponding to almost all resonance frequency tracking schemes studied in the literature, e.g., the feedback-free, frequency-locked loop, and self-sustained oscillator schemes. These models are included in NEMSUITE as examples.

We believe that NEMSUITE can serve as a trusted platform through which various sensor conceptions can be rigorously evaluated and compared before they are tested in expensive and time consuming experiments. NEMSUITE can also be used to corroborate experimental data.



NEMSUITE flow: Build sensor model, choose analysis, run, obtain characterizations.

[1] A. Demir, “Understanding fundamental trade-offs in nanomechanical resonant sensors,” Journal of Applied Physics, vol. 129, no. 4, p. 044503, 2021.