SNR calculation of the nanoforce estimation obtained by the deconvolution of the noisy output of a force-displacement transductor

Research framework

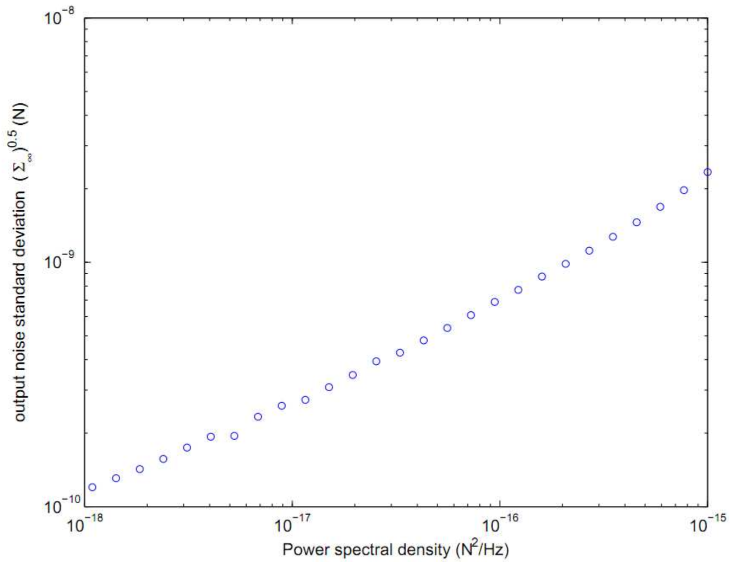
In micro and nano force measurement using rigid macroscopic force-displacement transducers connected to magnetic springs, the under-damped and long transient response due to the transducers mass inertia can not be neglected for time-varying force measurement. It is thus necessary to deconvolve the transducer noisy output displacement measurement to correctly estimate the unknown input force, which leads to a trade-off between the SNR of the estimation and the bandwidth of the force sensor.

Proposed approach

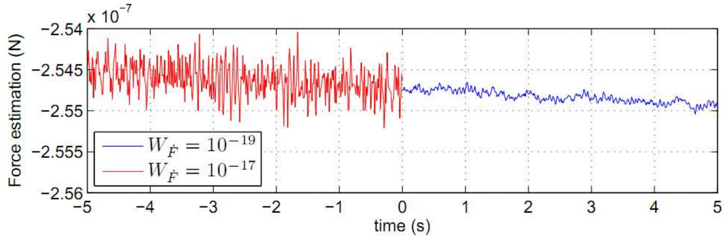
The deconvolution approach implemented is based on a discrete Kalman filter with an uncertain *a priori* model to represent the unknown micro-nano force to be estimated. This model is a discretized Wiener process including a W_F parameter which is a power spectral density whose value has to be adjusted by the end-user.

The W_F parameter makes possible the adjustment of the trade-off between the SNR of the nano-force estimation (view as the ratio mean / standard deviation of the estimation) and the force sensor bandwidth (correlated to the response time of the estimation).

The W_F parameter can be modified at any time by the end-user to adjust the estimation quality. The SNR (or simply the standard deviation of the estimation which is directly correlated to the force resolution) and the frequency response versus W_F can be pre-computed and plotted in order to make this choice easier.



Pre-computed force estimation standard deviation versus the W_F parameter chosen by the end-user



Force estimation SNR evolution with 2 different values of W_F chosen by the end-user

Major article: E. Piat, J. Abadie, S. Oster, Nanoforce estimation based on Kalman filtering and applied to a force sensor using diamagnetic levitation, Sensors and Actuators: A Physical, 2012, 179:223-236.

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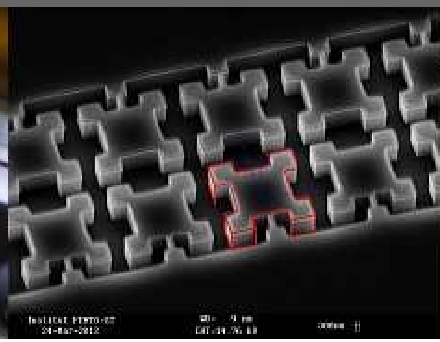
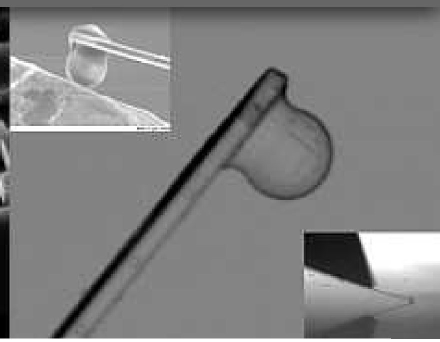

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