Mitigating Non-linear DAC Glitches Using Dither in Closed-loop Nano-positioning Applications

Ahmad Faza'[1], John Leth[2], Arnfinn A. Eielsen[1]

[1]Dept. of Energy and Petroleum Engineering, University of Stavanger, Norway

[2]Dept. of Electronic Systems, Aalborg University, Denmark

• Background:

Noise and distortion in **digital-to-analog converters** (DACs) result in **reduced performance** for high precision mechatronics, such as **nano-positioning stages**. Such systems experience lightly damped response at **resonance frequencies** related to vibrational modes of stage the geometry. **Glitches** are dynamic disturbances of impulse like behavior seen in commercial DACs. They are not easily removed by conventional control laws.

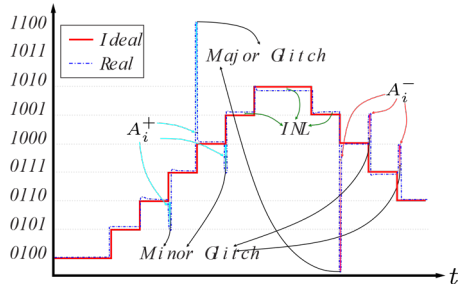
• Contribution:

This paper **extends** the application of high-frequency large-amplitude **dithering** to mitigate a glitch non-linearity in a standard **closed-loop nano-positioning system**. It utilizes a **DAC model** that includes all significant, observed non-linearities, with **parameters fitted to the measured response of an off-the-shelf commercial device**. The simulations demonstrate significant mitigation of the glitch.

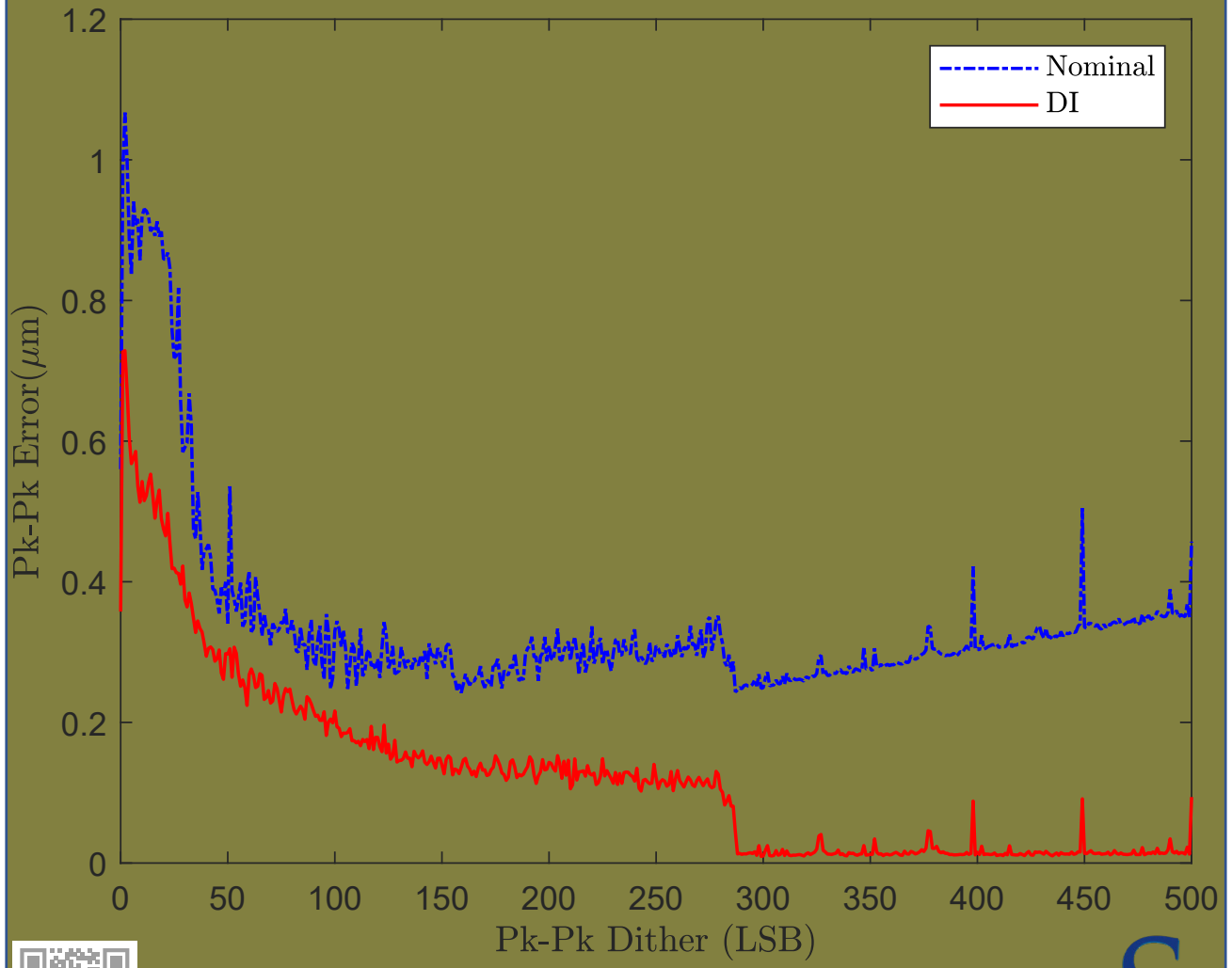
• Method:

Dither is a high-frequency periodic or stochastic signal introduced into a system to modify its non-linear characteristics. The proposed approach **incorporates** the standard **lowpass filtering** components at the D/A and A/D interfaces **in control law synthesis**. A sufficiently large dither amplitude is shown to achieve considerable glitch mitigation.

• But What is a Glitch?



DAC **glitches** can be mitigated using Dither.



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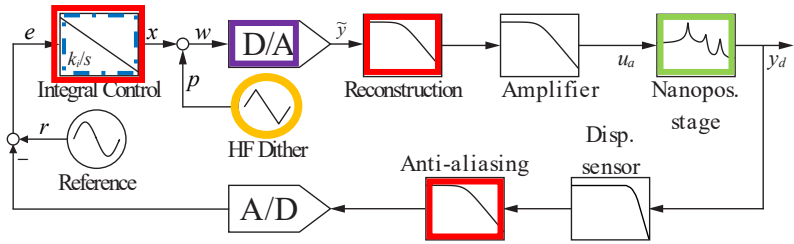
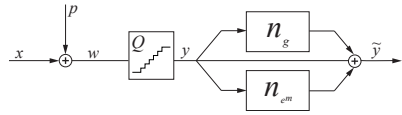
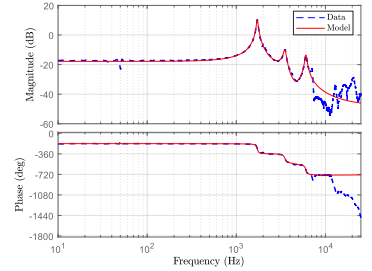
Standard closed-loop nano-positioning system



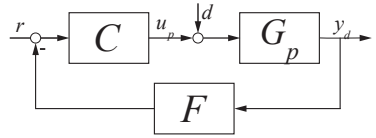
Modeling non-linearities in a commercial DAC





Fitting the response of a nano-positioning stage

Non-linear DAC deviations modeled as a plant disturbance

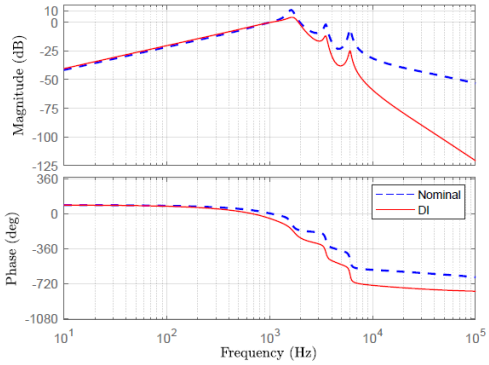


Control synthesis for optimal reference tracking

Nominal Design (Nyquist Criterion)

vs

Damping Integral Incorporated Design



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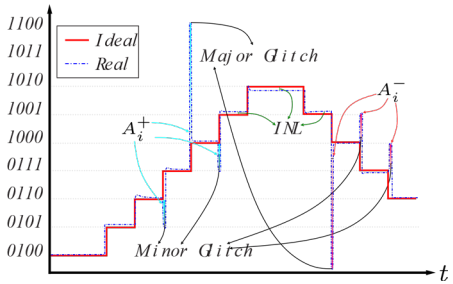

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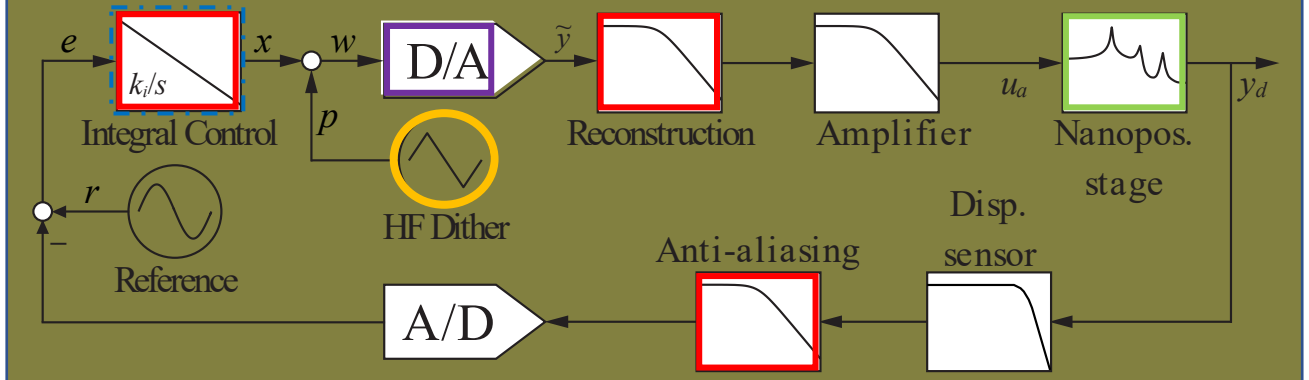

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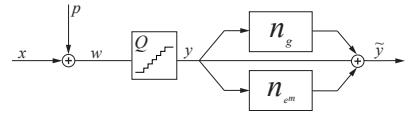
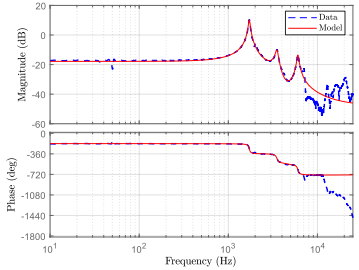
Modeling non-linearities in a commercial DAC





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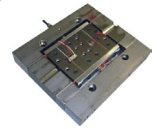

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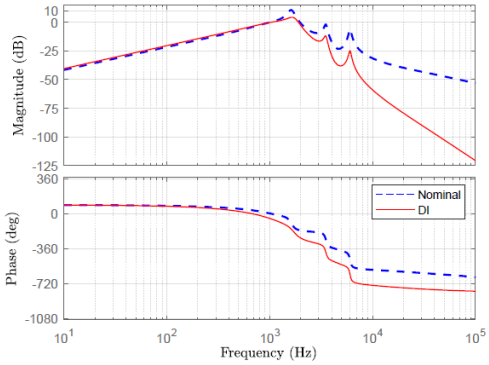

Glitch mitigation