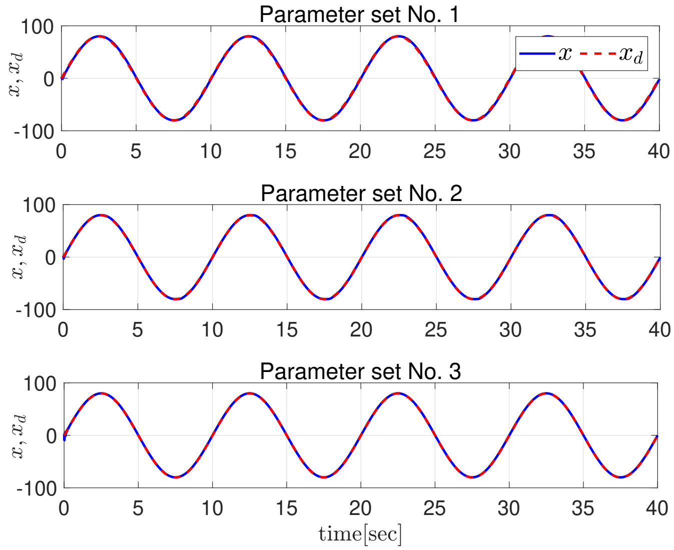
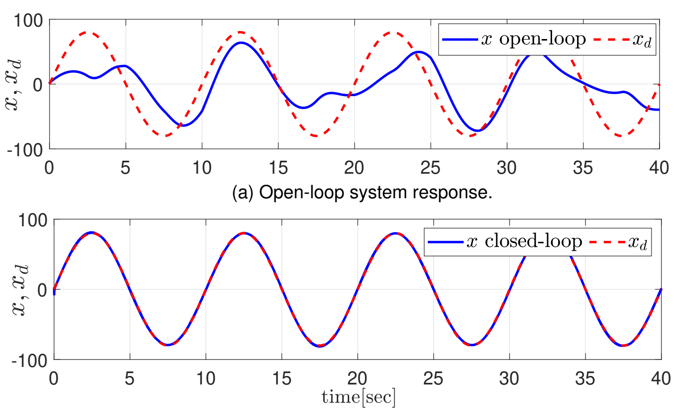


Fig. 7: Input-Output response with set of parameters corresponding to Tab. I.

conduct simulations with the parameter set No. 1 in Tab. I. The system response is depicted in Fig.8. Notice that the open-loop system response is highly disturbed, while in the closed-loop system case, the error due to disturbances is negligible.



(a) Open-loop system response.

(b) Closed-loop system response.

Fig. 8: Input-Output response for the open-loop system (a) and the closed-loop system (b) under the effect of disturbances: $\delta_x = 30\mu m$ and $\delta_h = 25\sin(t)\,\mu m$.

VI. Conclusions

We have presented a robust controller to stabilize a piezoelectrically actuated robotic hand, modeled using the generalized nonlinear Bouc-Wen model, a high nonlinear system that is not differentiable in a finite number of points. Besides, the system takes into account exogenous disturbances.

The proposed control is based on the use of a nonlinear observer that converges in finite time. The observer estimates the hysteresis, which is a variable usually unavailable for feedback. Once we have estimated the hysteresis, we design a controller into two steps: the first step considers the design of a desired hysteresis h_d, while the second finds the control u through a nonlinear model predictive control. The experiments show promising results, and up to our knowledge, this is the first work that solves the problem of stabilization of a piezoelectrically actuated robotic hand, modeled by the generalized nonlinear Bouc-Wen model considering disturbances.

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