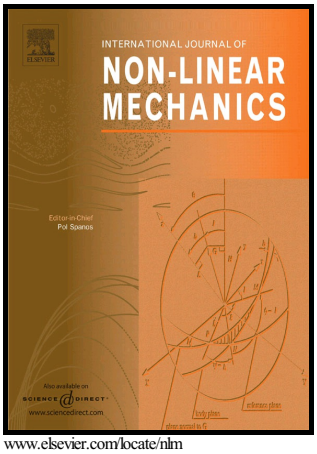

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PII: S0020-7462(17)30030-6
DOI: http://dx.doi.org/10.1016/j.ijnonlinmec.2017.01.006
Reference: NLM2766

To appear in: *International Journal of Non-Linear Mechanics*

Received date: 20 December 2016
Accepted date: 14 January 2017

Cite this article as: Zsolt Veraszto and Gabor Stepan, Nonlinear dynamics o hardware-in-the-loop experiments on stick-slip phenomena, *International Journa of Non-Linear Mechanics,* http://dx.doi.org/10.1016/j.ijnonlinmec.2017.01.006

Nonlinear dynamics of hardware-in-the-loop experiments on stick-slip phenomena

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Abstract

A single degree-of-freedom nonlinear mechanical model of the stick-slip phenomenon is studied when the Stribeck-type friction force is emulated by means of a digitally controlled actuator. The relative velocity of the slipping contact surfaces is considered as bifurcation parameter. The original physical system presents subcritical Hopf bifurcation with a wide bistable parameter region where stick-slip and steady-state slipping are both stable locally. Hardware-in-the-loop experiments are performed with a physical oscillatory system subjected to the emulated Stribeck forces. The effect of sampling time is studied with respect to the stability and nonlinear behavior of this experimental system. The existence of subcritical Neimark-Sacker bifurcations are proven in the digital system, the stability and bifurcation characteristics of the continuous and the digital systems are compared, and the counter-intuitive stabilizing effect of sampling time is shown both analytically and experimentally. The conclusions draw the attention to the limitations of hardware-in-the-loop experiments when the corresponding systems are strongly nonlinear.

Keywords:
Hopf bifurcation, Neimark-Sacker bifurcation, hardware-in-the-loop, substructuring

1. Motivation and introduction

There is a set of historical dynamical problems in engineering that causes permanent difficulties in the design of certain machines, machine parts. One common feature of these systems is that the desired steady-state behavior