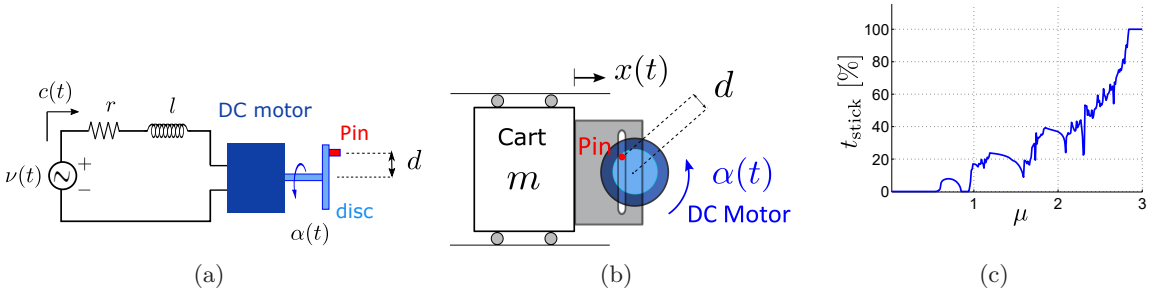
Stick-slip oscillations in an electromechanical system

R. Lima* **and R. Sampaio***

* Departamento de Engenharia Mecânica
Pontifícia Universidade Católica do Rio de Janeiro
Rua Marquês de São Vicente, 225, 22451-900, Gávea, Rio de Janeiro, RJ, Brazil
e-mail: robertalima@puc-rio.br, rsampaio@puc-rio.br

ABSTRACT

Electromechanical systems present an interesting behavior characterized by the mutual influence between the electromagnetic and mechanical parts of the system. The dynamics of an electromechanical system is given by an initial value problem (IVP) comprising a set of coupled differential equations involving mechanics and electromagnetic variables. This work analyzes the dynamics of an electromechanical system with dry-friction, composed of a cart whose motion is excited by a DC motor. The coupling between the motor and the cart is made by a mechanism that transforms the motor rotational motion α into horizontal cart motion in a rail, Figs. 1(a) and 1(b). A voltage is imposed in the motor. The dynamical variables are the current c and the angle α. It is considered the existence of Coulomb dry-friction between the cart and the rail. The resulting motion of the motor can be characterized by two alternate modes, the stick- and slip-modes, with a non-smooth transition between them [1, 2]. The focus of the work is to find the stick- and slip-mode parts of the trajectory for different values of the friction coefficient, μ. This analysis could help in the development of control techniques to mitigate the occurrence of stick when this mode is not desirable in the system response. During the stick-mode, the cart



(a) (b) (c)

Figure 1: (a) DC motor. (b) Electromechanical system with dry-friction. (c) Total time of stick as function of the friction coefficient.

does not move, so that the angle of disc is constant. The frictional force and the current can vary. The stick mode occurs when $\dot{\alpha} = 0$ and when the frictional force is in the interval $[-f_{max}\,, f_{max}]$, where f_{max} is fixed for a given μ. Besides of this, the number of equations in the IVP that describes the dynamics of the system is reduced to just one, the equation of the electromagnetic part. During the slip-mode, the dry-friction force is $f_r(t) = f_{max}\ \mathrm{sgn}(-\dot{\alpha}(t)\, d\, \sin(\alpha(t)))$. Defined a time interval for analysis, one of the variables of interest is the total time of stick t_{stick} as function of μ. For the system analyzed in this work, we got a surprising result, an increase of μ does not assure an increase in t_{stick}, Fig. 1(c).

REFERENCES

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[2] Lima, R. and Sampaio, R. Construction of a statistical model for the dynamics of a base-driven stick-slip oscillator. *Mechanical Systems and Signal Processing* (2017) **91**:157–166.