Dynamic and simulation of a Linear Electrical Actuator.

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Abstract. This paper presents the kinematic and dynamic model of a linear electrical actuator. The kinematic model was obtained by geometric analysis. The dynamic model was obtained with Lagrange's methodology. This linear actuator forms part of parallel prosthetic elbow with 3 DOF developed in the Instituto Nacional de Astrofisica, Optica y Electrónica.. In this paper we show the behavior the electromechanical according to the equations of the system and its physical parameters. The model includes the analysis of electrical and mechanical parts. The model includes conversion of rotational movement to linear movement and relation torque-force necessary for emulating a human muscle. Finally we present the simulation of this linear electrical actuator in order to know its capacities and behavior. This linear actuator will be used in the elbow prosthesis in order to emulate the capacity of a muscle to extend and contract in a linear way

Keywords: dynamic model, simulation, linear actuator.

I. INTRODUCTION

A linear electrical actuator (Figure 1) is an electromechanical system composed by: electric motor, planetary gearhead and ball-screw. This kind of system let us emulate an electromechanical muscle and to have enough force to emulate the behavior of a human muscle.

The ball-screw is a mechanical element having a very low coefficients of friction [2]; therefore it is used in this linear electrical actuator. In addition, these elements are used to execute linear movements with great performance because they provide a transmission with relatively high rigidity and reduction coefficient that allows to have enough force after conversion of rotational to linear movement.. The motor is an electric component that transduces voltage in torque and angular displacement [4]. Controlling the level of voltage we can control the position and speed of the system.

In this article, we show the equations of the electromechanical system, its transference function and representation in space of states for an actuator of DC with a planetary gearhead and a load of ball-screw, which transform the angular displacement of the motor to linear movement. Graphics of behavior obtained in Matlab are presented to show the capacity of this linear electric actuator.

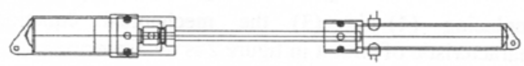

Figure 1. Scheme of proposed linear mechanism.

II. MOTOR DC MODEL WITH ROTATIONAL LOAD

Figure 2 shows an electric diagram of an electric motor. There is a magnetic field by means of stationary permanent magnets called fixed field. In the armor a current $i_a(t)$ circulates trough this magnetic field to right angles and detects a force, $F = Bl^* i_a(t)$, where B is the intensity of magnetic field and l is the motor's inductance.

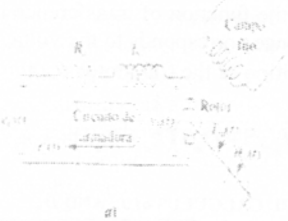

Figure 2. Schematic diagram of the actuator .

Moreover, there is another phenomenon that happens in the motor: a conductor who moves to right angles respect to a magnetic field generates a voltage in the terminals of the conductor, equal to $e = B^*l^*v$, where e is the voltage and v the speed of the motor. Since the carrying armor of current is turning in a magnetic field, its voltage is proportional to the speed. Then,

$$v_b(t) = k_b \frac{d\theta_m(t)}{dt} \qquad (1)$$

Where $v_b(t)$ is the electromotive force ; k_b is the *fem* constant ; and $d\theta_m(t)/dt = \omega_m(t)$ is the angular speed of the motor.

The relationship among the armor current $i_a(t)$, the applied voltage of armor $e_a(t)$, and the electromotive force $v_b(t)$, can be obtained from fig 2 using mesh equations as:

$$R_a i_a(t) + L_a \frac{di_a(t)}{dt} + k_b \frac{d\theta_m(t)}{dt} = e_a(t) \quad (2)$$