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MECHATRONIC PLATFORMS FOR STUDYING DRIVING SYSTEMS BASED ON LORENTZ ACTUATORS

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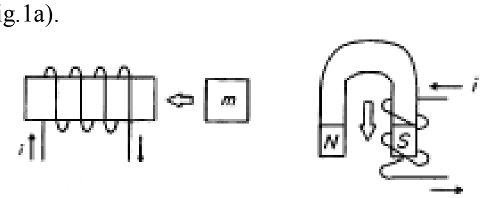
Abstract: *The aim of the paper is to present basic aspects about Mechatronic platforms for studying driving systems based on Lorentz actuators. The electro-mechanical integration, together with the informational component which such a kind of actuator possesses, makes it very suitable for both educational and research purpose. In order to understand the working principle of a Lorentz actuator, the first part of the paper presents the physical phenomenon on which the actuator's operation is based. There are analyzed some constructive layouts for Lorentz actuators, then the educational platform within the laboratory is presented. Aspects concerning the control of the high-precision intelligent drive are presented and then the control strategy – PID is implemented using the motion controlling component of the educational stall. In the end of the paper there is presented a representative application within the robotics or industrial machinery field, taking in consideration the available Lorentz actuator.*
Keywords: *linear actuator, PID control, Lorentz force*

1. INTRODUCTION

Lorentz actuators are working based on the electrodynamic Lorentz force, determined by the interaction between an electrical current *i* and a magnetic field produced by a permanent magnet (Fig. 1b, Fig. 2), in opposition to the electromagnetic actuators, where, the mass m made of ferromagnetic material is attracted due to the Maxwell electromagnetic force, determined by the magnetic field induced by the electrical current *i* within the coil in the magnetic core (Fig.1a).



a)Maxwell electromagnetic force b) Lorentz electrodynamic force
Figure 1: Manner to generate forces

Many various but efficient applications for this type of actuator are based on the facility to realize a stable levitation they can offer, and thus to control the position and orientation of a solid-rigid body in space, being in levitation state. These actuators allow reaching high velocities concurrent with maintaining a high positioning accuracy. They can offer a good alternative to servomotors because they do not produce motion using gear trains like servomotors, thus the dissipated energy in form of heat can be dropped drastically. Lorentz actuators can offer solutions for precision positioning, and can find interesting applications in robotics, in the case when other actuation systems do not offer efficient solutions. There were developed both rotational and translational actuators based on this principle.

The orientation for the Lorentz force is given by the orientation of the magnetic field produced by the permanent magnet and the electric current *i* which travels within the conductor placed in the respective magnetic field (Fig. 2).

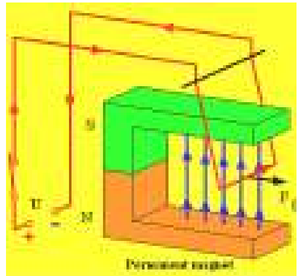


Figure 2: Generating Lorentz force

The modulus of the Lorentz force in a conductor placed in the magnetic induction field B and which is roamed by the electric current i_a is given by:

$$F = q(E + vXB) = lBi_a = K_F i_a \quad (1)$$

Figure 3 presents the main components of a typical actuator, and the most common configurations. Thus, the actuator consists of: - the inductor

- the mobile cart, in turn, the inductor consists of the permanent magnet North-South, the core 2, the base plate 1 and the polar plate 3 and the mobile cart of coil 4, frame 5 and rolls 6.

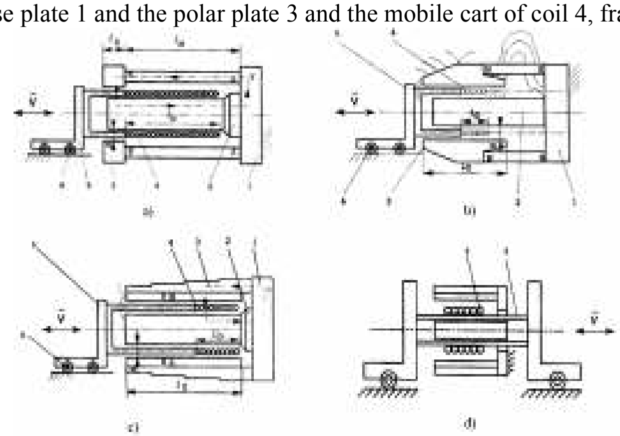


Figure 3: Components of a Lorentz actuator, main configurations of a typical actuator

2. THE EDUCATIONAL STALL, COMPONENTS OF THE INTEGRATION

The three main components of the educational stand are: the actuator, controller and power supply (figure 4). Another important component of the educational stall is the Easy-V interface, which offers a good possibility to edit the program within the controller.

The Lorentz actuator is the result of electromechanical integration, thus the mechanical structure can be easily modified in accordance with each application apart. Thus, the integration means putting together the mechanical structure of the actuator (linear or rotational) together with the coil in order to generate the Lorentz force. Another step concerning the obtaining of intelligent Lorentz actuators, concerns also integrating the informational component, represented by the sensors attached to the actuator, together with the controller which processes the respective signals, in accordance with the application's needs.

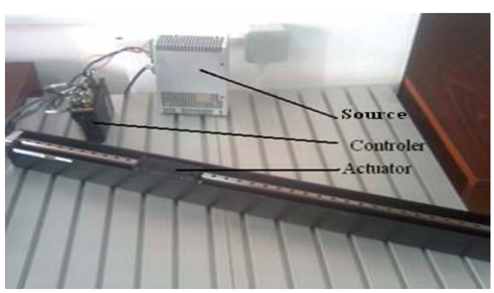


Figure 4: The educational stall, main components

3. CONTROL OF THE TRANSLATIONAL UNIT

The control strategy used in our case is the Proportional Integrative Derivative one. The necessity of implementation a PID controller is due to the fact that real systems have nonlinear transfer functions, and thus there can be introduced delays between cause and effect. The parameters of the PID controller can be adjusted using the special interface (fig. 5) of the controller.

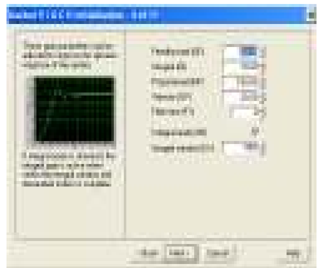


Figure 5: Interface for configuring PID controller

Thus, the configured controller can be commanded using the serial interface of the computer (direct mode or programmed mode). An example of defining a moving profile of the mobile cart of the actuator is presented in figure 6:

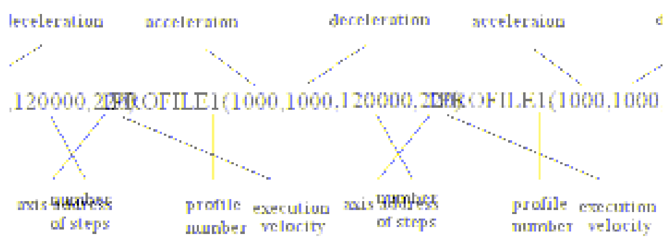
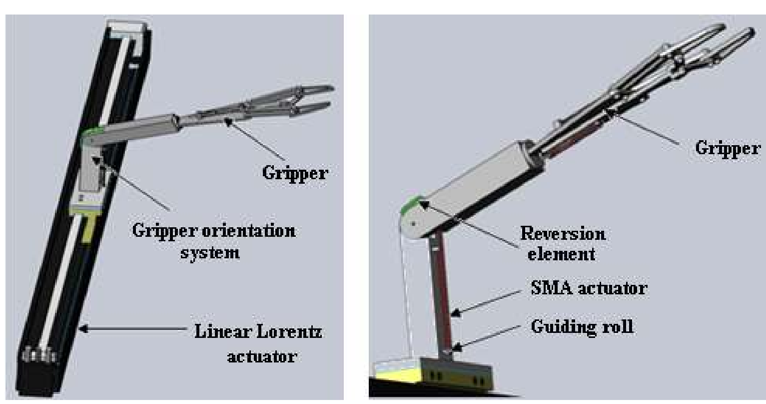


Figure 6: Defining a moving profile

4. PICK AND PLACE SYSTEM BASED ON LORENTZ ACTUATOR

A developed system based on Lorentz actuator is presented in figure 7. The system is designed to manipulate in a quick manner components with a weight up to 100 grams, with velocities up to 3m/s on a maximum range of 750 mm. The developed system has two major components:

- the positioning system based on Lorentz actuator;
- the gripper based on SMA actuator;



a) b)

Fig.7. Pick and place system based on Lorentz actuator and shape memory alloy actuated gripper

In order to position the gripper above the desirable object to manipulate, respectively above the position where the manipulated object needs to be placed, there was developed the following program sequence for positioning the mobile cart together with the gripper. Thus, there were developed two subroutines (MOVE1 and MOVE2) corresponding to the desired moves of the mobile cart of the actuator.

```
1K
1CLEAR(ALL)
1START:
        1DECLARE(MAIN)
        1DECLARE(MOVE1)
        1DECLARE(MOVE2)
        1GOTO(MAIN)
1END
1MAIN:
         1PROFILE1(2000,2000,120000,220)
         GOTO(MOVE1)
1END
1MOVE1:
        1USE(1)
        1G
        1PROFILE2(2000,2000,-120000,220)
        GOTO(MOVE2)
1END
1MOVE2:
        1USE(2)
        1G
1END
```

5. CONCLUSION

Lorentz actuators offer new actuation solutions, with a good possibility for miniaturization and adaptation in correlation to each application apart. The good controllability of such type of actuator is given by the nature of the parameters which should be modified in order to obtain different velocities, and accelerations of the mobile cart. The scope of understanding the working principle of actuation systems based on Lorentz actuators and their mathematical model is given by the need to develop an advanced control technique for such systems.

6. ACKNOWLEDGEMENT

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