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Implementation of the control strategy for a 2D nanopositioning long range stage

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Abstract

A 2D-platform stage able to obtain an effective metrological positioning with nanometer resolution and long working range (50 x 50 mm^2) is on development at the University of Zaragoza. The 2D stage has already been designed, manufactured and assembled. The movement of the platform is performed by four custom-made linear motors, and mirror laser interferometers work as positioning sensors in XYRz degrees of freedom. The work here presented focuses on the hardware implementation of the motor control, for one actuator on a 1D linear stage. The developed control strategy acts on three-phase PWM (Pulse-Width Modulation) signals and a feedback is provided by measuring the phase currents. As a preliminary solution, a sensorless algorithm substitutes the positioning sensor before implementing the laser interferometers.

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Keywords: Linear motors; nanopositioning; control implementation; 2D-stage, vector control

1. Introduction

The importance of nanotechnology and nanomanufacturing has rapidly increased in the last decades. Positioning stages are fundamental in devices used in nanotechnology applications such as nanomanufacturing machine tools or measuring machines. The wide number of available options is characterized by their working range and metrological performance. Therefore, to provide effective positioning at a nanometer scale with a long range of motion (50x50 mm^2), a 2D-nanopositiong platform stage (NanoPla) has been developed [1].

The NanoPla consists of three stages or main parts (see Fig. 1): an inferior fixed base, a moving platform and a superior fixed base. Four custom-made linear motors displace the moving platform that is levitating by vacuum preloaded air bearings. The original design of the linear motors was made by Trumper et al. [2], and they have been

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integrated in other high-precision nanopositioning stages [3, 4]. The linear motors consist of the stator and the linear magnet array (see Fig. 2), the stators are located in the superior base of the NanoPla and the magnet arrays are fixed to the moving platform. The motors are symmetrically assembled, so that each parallel pair generates a force in X and Y axes, respectively. Three plane mirror laser interferometers measure the displacements and rotation in the horizontal plane (XYRz).

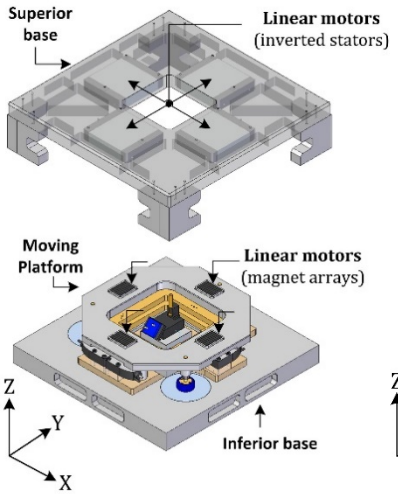

Fig. 1. NanoPla prototype [4].

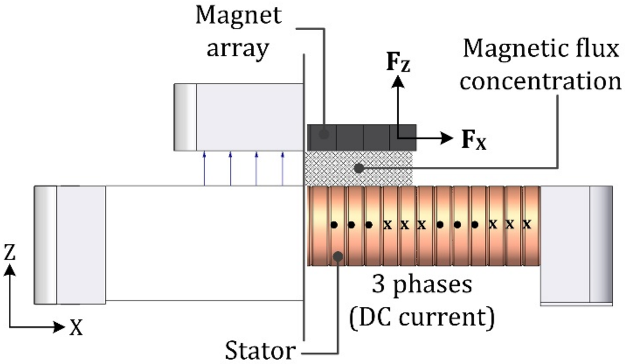

Fig. 2. NanoPla linear motor: created dual forces [4].

2. Materials and methodology

To facilitate the control issue and considering a low-cost solution, the selected device to perform the control of the motor is the DRV8302-HC-C2-KIT of Texas Instruments: Digital Motor Control Kit (DMC) to operate with Permanent Magnet Synchronous Motors, even with real-time control applications. It provides the closed-loop digital control feedback and analog integration and it is comprised by the current sense amplifiers and the required inverter stage for commutation.

The associated software results in several advantages. The control of the used microcontroller from Texas Instruments is based on the Target Support Package^{TM} for Embedded Code. That integrates MATLAB® and Simulink® with Texas Instrument tools and C2000 processors, to generate, compile, implement and execute the optimized control code after experimentation, with a user-friendly graphic interface and without programming in a specific language (see Fig. 3). Furthermore, it allows real-time controlling.

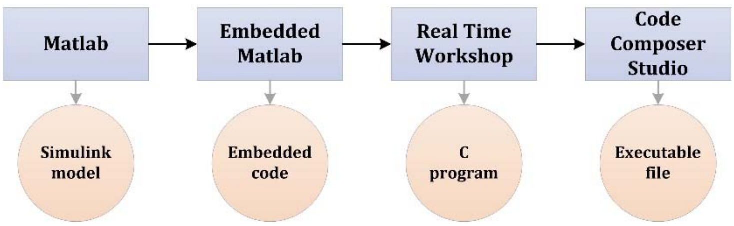

Fig. 3. Code implementation process.

The experimental validation has been carried out on a setup consisted of 1D-linear stage, which was already used in [4] for the experimental characterization of the transfer function of the motor (Fig. 4). The stator of the linear motor is mounted over a pneumatic linear guide. This scheme imitates the free plane motion of the NanoPla achieved by