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Path tracking control of electromechanical micro-positioner by considering control effort of the system

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Abstract
Position controlling with less overshoot and control effort is a fundamental issue in the design and application of micro-actuators such as micro-positioner. Also, tracking a considered path is very crucial for some particular applications of micro-actuators such as surgeon robots. Herein, a proportional–integral–derivative controller is designed using a feed-back linearization technique for path tracking control of a cantilever electromechanical micro-positioner. The micro-positioner is simulated based on a 1-degree-of-freedom lumped-parameter model. Three different paths are considered, and the capability of the designed controller on the path tracking with lower error and control effort is investigated. The obtained results demonstrate the efficiency of the designed proportional–integral–derivative controller not only for reducing the tracking error but also for decreasing the control effort.

Keywords
Feedback linearization, micro-electromechanical system, micro-positioner, path tracking, proportional–integral–derivative controller

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Introduction

These days, many scientists, as well as researchers, have devoted themselves to the quest of micro/nano-electro-mechanical system (MEMS/NEMS) technologies because of its astonishing potential in the field of fundamental research, as well as application in industrial engineering. Micro-positioner is an MEMS device that can utilize for positioning, orienting, and applying a force in various branches of science and engineering.[1] Micro-positioners have been used widely in the different miniature structures, including but not limited to scanning tunneling microscopy, atomic force microscopy, and ultrahigh-density probe storage systems.[2–4] There are several actuation techniques in the micro-positioners, such as electrostatic, electromagnetic, electro-thermal, and piezoelectric. Among these methods, electrostatic actuation is the most popular mechanism due to its simplicity, small actuation voltage, and as it requires limited mechanical components.[5] Electrostatic actuation usually relies on parallel plate capacitors. This actuation technique does not manufacture from special material such as piezoelectric or exited by external fields like electromagnetic. The sole requirement is the voltage difference, which is available in all electronic circuits. It is worth to note that the operating range of the micro-positioner is limited by the pull-in phenomenon. By applying a voltage difference between moveable and fixed electrodes, the electrical force moves the moveable part toward the fixed plane. At a critical voltage known as "pull-in voltage," the electrical force overcomes the mechanical restoring force, which results in additional deflection of the moveable electrode. This leads to an increase in electrical potential in a positive feedback loop. Previous researchers have studied the pull-in instability threshold and investigate the impact of the various physical phenomena on

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