MECHANICS OF AN INNOVATIVE FRACTIONAL ORDER CONTROLLER

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The paper describes recent research results regarding the development of an innovative fractional order control (FOC) device. The concept of fractional order control capitalizes on the formalism of fractional order calculus which expands the scope of the classical integer order differentiation and integration by including non-integer order operations. This theory has been effectively utilized in modeling of viscoelastic attenuating media, material damping, signal processing, system identification and wave propagation. Within this application range, the theory of fractional order control has been recognized as a powerful instrument in controlling the dynamics of actual physical systems in which such phenomena as energy dissipation, relaxation, and memory effects are significant [1].

To date, fractional order control methods have been based exclusively on computer simulations, or a so-called "software" realization of control functions. The respective control strategies commonly rely on analog or digital discretization of continuous systems represented by either n-dimensional networks of conventional resistors and capacitors [2]. These techniques entail inherent approximation errors and suffer from severe bandwidth limitations. However, a more robust and economically effective fractional order control of dynamic systems can be achieved through the deployment of fractional order control hardware, namely, a dedicated device designed exclusively as a fractional order controller [3].

The study reported in this paper focuses on the development of a fractional order control device ("fractor"). The device is characterized in terms of such properties as impedance and loss factor with the objective to achieve a response close to Warburg impedance characteristics over a broad range of frequencies.

The fractor represents an electromechanical cell consisting of a solid electrolyte in the form of a baked gel placed between two metal electrodes. The essential part of the device is the fractal shape of the surface at the gel-metal interface. The paper describes the manufacturing process involving such stages as ionic gel preparation, abrasion, and encapsulation. An experimental protocol has been developed to determine the effects of various manufacturing conditions and the use of different electrode materials. Further, the study has involved the sensitivity analysis of the fractor in terms of its response under various stress, vibration, temperature and humidity conditions. The results of the study provide the basic understanding of the functional performance, effectiveness and general capabilities of the developed fractional order controller.

References

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Keywords: fractional order control