

Fractional Control of Dynamic Systems

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Abstract

The concepts involved with fractional calculus (FC) theory - the area of mathematics that handles the derivatives and integrals to an arbitrary order (real or complex order) - are, nowadays, applied in almost all areas of science and engineering. Its ability to yield superior modeling and control in many dynamical systems is well recognized. In this presentation, we will introduce the fundamental aspects associated with the application of FC to the control of dynamic systems. The following topics will be briefly covered: introduction to fractional-order calculus, frequency and time domain analysis of fractional-order systems, approximations to fractional-order operators, controller design for fractional-order systems and analog and digital circuits for fractional-order control systems. Finally, we will show some applications of fractional order controllers in the real time control of an experimental system.

Keywords: Fractional calculus; Fractional-order control; Fractional dynamics;

References

- [1] K. B. Oldham, J. Spanier, The Fractional Calculus. Academic Press, New York (1974).
- [2] I. Podlubny, Fractional Differential Equations. Academic Press, San Diego (1999).

- [3] Ramiro S. Barbosa, J. A. Tenreiro Machado, Isabel M. Ferreira, Tuning of PID Controllers Based On Bode's Ideal Transfer Function, *Nonlinear Dynamics*, Kluwer, 38, 305-321 (2004).
- [4] Ramiro S. Barbosa, J. A. Tenreiro Machado, Manuel F. Silva, Time Domain Design of Fractional Differentiators Using Least-Squares, *Signal Processing*, Elsevier, 86, 2567-2581 (2006).
- [5] Ramiro S. Barbosa, J. A. Tenreiro Machado, Alexandra M. Galhano, Performance of Fractional PID Algorithms Controlling Nonlinear Systems with Saturation and Backlash Phenomena, *Journal of Vibration and Control*, Sage, 13, 1407-1418 (2007).
- [6] Ramiro S. Barbosa, J. A. Tenreiro Machado, Isabel S. Jesus, On the Fractional PID Control of a Laboratory Servo System, *Proceedings of the 17th IFAC World Congress*, Seoul, Korea, 15273-15278 (2008).