Fayoum University

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Degree: Masters of Science
Title of Thesis: A study of fractional calculus and its engineering applications
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Approval-: / /٢٠١٦

ABSTRACT

This work is an investigation of fractional order applications in engineering specially in circuits and systems. Fractional calculus is a field of mathematics that studies the effects of using non-integer order differential and integral operator in system modeling and control. The term fractional is a misnomer as the order can be real or even complex. Fractional calculus has been proved by numerous papers superior to integer order calculus in describing non-local and unconventional physical phenomena due to the extra degrees of freedom it provides that are not available in the integer order subspace.

Based on this motivation, this work investigates the basics of fractional calculus، fractional differential equations and some of its engineering applications: control, bioengineering and viscoelasticity. The fractional order Taylor series method is used to solve fractional Hermite, Legendre and Chebyshev differential equations. The solutions are further investigated to obtain fractional versions of the well known polynomials after some proper scaling in reparation for use in filter magnitude response.

A review of fractional order filters in literature is then carried out followed by three new approaches to generalize Chebyshev low-pass filter. The first approach is based on fractional power Chebyshev-like polynomials and a generalization of pole generating formula. The second is based on the integer order poles of the traditional low-pass filter which were used to construct the fractional order transfer functions having the same poles in the s-plane. The third approach uses the polynomials obtained before to construct the fractional order complex filter. All filters are realized using passive circuits or active circuits or both and the ADS circuit simulation results are always compared to Matlab numerical simulation of the transfer functions to prove the reliability of the approaches developed. An investigation is carried out discussing the effect of nonzero initial conditions on the transient response of RCα circuit modeled using Riemann Liouville and Caputo fractional operator.

The summary not more than ٥٠٠ words