Impulse response invariant discretization of a generalized commensurate fractional order filter

Li, Y.; Hu, S.; Chen, Y.-Q.


Abstract

In this paper, we derive the impulse response of a generalized commensurate fractional-order filter of the form $(s^{2\alpha} + as^{\alpha} + b)^{-\gamma}$, where $a, b \geq 0$, $\alpha \in (0,1]$ and $\gamma \in (0,1)$. The asymptotic properties of the impulse responses are obtained. Moreover, based on the derived analytical impulse response, we show how to perform the discretization of the above fractional-order filter. Finally, a number of illustrated examples in time and frequency domains are provided as proofs of concepts. © 2010 IEEE.

References

1. Oldham, K.B., Spanier, J.
   The Fractional Calculus,
2. Miller, K.S., Ross, B.
   An Introduction to the Fractional Calculus and Fractional Differential Equations,
3. Podlubny, I.
   Fractional Differential Equations,
   Theory and Applications of Fractional Differential Equations,
5. Bagley, R.L., Torvik, P.J.
   A theoretical basis for the application of fractional calculus to viscoelasticity
6. Oustaloup, A.
(1991) La Commande CRONE (in French),
Hermés, Paris, France

7. Podlubny, I.
Fractional-order systems and PI\(^3\) D\(^\mu\) - controllers
January

8. Laskin, N.
Fractional schrödinger equation

9. Yangquan, C., Moore, K.L.
Discretization schemes for fractional-order differentiators and integrators
March

10. Yangquan, C., Vinagre, B.M.
A new IIR-type digital fractional order differentiator

11. Lubich, C.
Discretized fractional calculus

Continued fraction expansion approaches to discretizing fractional order derivatives - An expository review
December

Two direct tustin discretization methods for fractional-order differentiatorintegrator
August

14. Barbosa, R.S., Tenreiro Machado, J.A.
Implementation of discrete-time fractional-order controllers based on LS approximations

15. Ferdi, Y.
Impulse invariance-based method for the computation of fractional integral of order $0 < \alpha < 1$

16. Oustaloup, A.
Fractional order sinusoidal oscillators: Optimization and their use in highly linear FM modulation

October

17. Radwan, A.G., Elwakil, A.S., Soliman, A.M.
Fractional-order sinusoidal oscillators: Design procedure and practical examples

August

Design equations for fractional-order sinusoidal oscillators: Practical circuit examples

December

19. Kwan, H.K., Jiang, A.
FIR, allpass, and IIR variable fractional delay digital filter design

September

Iterative design of variable fractional-order IIR differintegrators

On the generalization of second-order filters to the fractional-order domain

First-order filters generalized to the fractional domain

23. Lim, S.C., Teo, L.P.
The fractional oscillator process with two indices

24. Davies, B.

25. Tarasov, V.E.
   Fractional derivative as fractional power of derivative

26. Yangquan, C., Moore, K.L.
   Analytical stability bound for a class of delayed fractional order dynamic systems

27. Sabatier, J., Agrawal, O.P., Tenreiro Machado, J.A.
   Advances in Fractional Calculus-Theoretical Developments and Applications in Physics and Engineering,
   (2007) Springer

28. Smith, J.O.
   Physical Audio Signal Processing., 2008. online book

   On generalized fractional kinetic equations
   December

30. Signal Processing Toolbox, 6.12

31. Yangquan, C.

32. Yangquan, C.
   (2003) A New IIR-Type Digital Fractional Order Differentiator

33. Yangquan, C.

34. Yangquan, C.
   (2008) Impulse Response Invariant Discretization of Fractional Order Low-Pass Filters

Authors’ affiliations
LY: School of Control Science and Engineering, Shandong University, Jinan 250061, China
HS: Department of Electronic Engineering, Dalian University of Technology, Dalian 116024, China
CY: Center for Self-Organizing and Intelligent Systems (CSOIS), Department of Electrical and Computer Engineering, Utah State University, 4120 Old Main Hill, Logan, UT 84322, United States

Correspondence Address
Li Y.; School of Control Science and Engineering, Shandong University, Jinan 250061, China; email: yan.li@ieee.org