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Optimal approximation of analog PID controllers of complex fractional-order

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Abstract

Complex fractional-order (CFO) transfer functions, being more generalized versions of their real-order counterparts, lend greater flexibility to system modeling. Due to the absence of commercial complex-order fractance elements, the implementation of CFO models is challenging. To alleviate this issue, a constrained optimization approach that meets the targeted frequency responses is proposed for the rational approximation of CFO systems. The technique generates stable, minimum-phase, and real-valued coefficients based approximants, which are not always feasible for the curve-fitting approach reported in the literature. Stability and performance studies of the CFO proportional-integral-derivative (CFOPID) controllers for the Podlubny's, the internal model control, and the El-Khazali's forms are considered to demonstrate the feasibility of the proposed technique. Simulation results highlight that, for a practically reasonable order, all the designs achieve good agreement with the theoretical characteristics. Performance comparisons with the CFOPID controller approximants determined by the Oustaloup's CFO differentiator based substitution method justify the proposed approach.

Keywords Complex fractional-order system (primary) · Complex fractional-order PID controller · Approximation · Constrained optimization · Differential evolution

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