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ORIGINAL PAPER

A new robust tilt-PID controller based upon an automatic selection of adjustable fractional weights for permanent magnet synchronous motor drive control

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Abstract
This paper focuses on achieving a good trade-off between performance and robustness for a class of uncertainty models including unstructured multiplicative uncertainties. In robust control, the simultaneous improvement of the two secure margins for nominal performances and robust stability using a standard controller structure represents two contradictory objectives and guaranteeing simultaneously of these goals represents therefore a major challenge for most researchers. In this context, a robust tilt-proportional integral derivative (*T-PID*) controller synthesized with an automatic selection of adjustable fractional weights (*AFWs*) is discussed in our work. Their parameters are optimized through solving a weighted-mixed sensitivity problem using an optimization tool which is based on the genetic algorithm. This problem is formulated from performance and robustness requirements where a fitness function is accordingly determined. Furthermore, thus its search space is built according to some guidelines for ensuring an automatic selection of adequate *AFWs*. The proposed constrained optimization problem is initialized by using arbitrary *T-PID* speed controller as well as through initial fixed integer weights (*FIWs*) which were chosen previously by the designer. To highlight the proposed control strategy, the synthesized robust *T-PID* speed controller is applied on the permanent magnet synchronous motor. Their performance and robustness are compared to those provided by an integer-order *PID* (*IO-PID*) and two conventional fractional-order *PID* (*FO-PID*) controllers. This comparison reveals superiority of the proposed robust *T-PID* controller over the remaining controllers in terms of robustness with reduced control energy.

Keywords Weighted-mixed sensitivity problem · Tilt-proportional integral derivative controller · Fractional-order *FO-PID* speed controller · Permanent magnet synchronous motor

1 Introduction

In general, reaching a good trade-off between two conflicting objectives such as (*NP*) and (*RS*) presents a critical issue for the *PMSM* speed control [10]. It is considered as a main objective of most synthesis methods, especially when some undesired effects such as neglected and unmodeled dynamics uncertainty, model parameter variation and sensor noise are considered [10,31].

It is well known that satisfying the trade-off condition for the *PMSM* speed control leads systematically to ensur-

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