République Algérienne démocratique et populaire

Ministère de l'Enseignement supérieur et de la Recherche Scientifique

Université 20 Août 1955 Skikda

Faculté de Technologie

# Attestation de participation

Il s'agit de certifier que :

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a participé à la Conférence nationale sur le contrôle et la sécurité des systèmes industriels (CNCSSI'22), qui s'est tenue du 05 au 06 octobre 2022, à Skikda, en Algérie, et a présenté l'article intitulé :

Performance Improvement for DC Motor using the Robust Fractional Adaptive PI Controller.

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Président de la conférence:
Pr. Youcef ZENNIR

06 Octobre 2022
**Date**

Conférence Nationale Sur le Contrôle et la Sécurité des Systèmes Industriels 05-06 Octobre 2022 Skikda- Algérie

# Performance Improvement for DC Motor using the Robust Fractional Adaptive PI Controller

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***Abstract*— Conventional Adaptive PI controller is one of the most widely used controllers in industry, but the recent advancement in fractional calculus has introduced applications of fractional order calculus in control theory. One of the prime applications of fractional calculus is fractional adaptive PI controller and it has received a considerable attention in academic studies and in industrial applications. Fractional order Adaptive PI controller is an advancement of classical integer order adaptive PI controller. In many a cases fractional order adaptive PI controller has outperformed classical integer order adaptive PI controller. This research paper, studies the control aspect of fractional order controller in speed control of DC motor. A comparative study of classical adaptive PI controller and fractional order adaptive PI controller has been performed.**

***Keywords*— *Fractional systems, Adaptive Control, PI controller, Robustness analysis , Stability***

## I. INTRODUCTION

The concept of extending classical integer order calculus to non-integer order cases is by no means new. For example, it was mentioned in [1] that the earliest systematic studies seem to have been made in the beginning and middle of the 19th century by Liouville, Riemann, and Holmgren. The most common applications of fractional order differentiation can be found in [2]. The concept has attracted the attention of researchers in applied sciences as well. There has been a surge of interest in the possible engineering application of fractional order differentiation. Examples may be found in [3] and [4]. Some applications including automatic control are surveyed in [5].

Robustness is one of the main advantages of Fractional Order Control (FOC). In fact, the first FOC scheme proposed in the literature since two decades is the so-called "Commande Robuste d'Ordre Non Entier" (CRONE) controller [15,18], which used the constant phase property of the ideal Bode's transfer function $1/s^{\alpha}$ to obtain a robust feedback control against gain variations. In the other hand, it has been proven that the use of fractional order systems which are long memory processes in feedback control systems, presents a certain benefit action on the system dynamical behavior and a good robustness effect against noises and perturbations. Many research works have then focused on new robust fractional order controllers design mainly based on the CRONE startegy [10,12,13,14].

The main contribution of this work is the use the fractional adaptive PI controller approach to reduce noise effect by introducing fractional order integrator in the classical feedback adaptive PI controller.
This paper is structured as follow: Section 2 is an fundamentals of fractional order systems. Section 3 presents the algorithms for the Integer and The Fractional adaptive PI Controller and simulation results are given is given in section 4 . Finally, the conclusion with future work are presented in section 5.

## II. FRACTIONAL ORDER SYSTEMS

### A. *Fractional calculs*

Fractional calculus is an old mathematical topic since 17th century. Fractional calculus is a subdivision of calculus theory which generalizes the derivative or integral of a function to non-integer order. Fractional calculus helps evaluating ($d^n y/dt^n$), n-fold integrals where n is fractional, irrational or complex. For fractional order systems n is considered to be fractional. The number of applications where fractional calculus has been used rapidly grows. These mathematical phenomena allow to describe a real object more accurately than the classical methods. The real objects are generally fractional however, for many of them the fractionality is very low. The main reason for using the integer-order models was the absence of solution methods for fractional differential equations. At present there are lots of methods for approximation of fractional derivative and integral and fractional calculus can be easily used in wide areas of applications (e.g.: control theory - new fractional controllers and system models, electrical circuits theory - fractances, capacitor theory, etc.) [6,7].

The generalized fundamental operator which includes the differentiation and integration is given as: