# Robustness Investigation for MRAC Control of a Doubly Fed Induction Generator in a Wind Energy System Based on Fractional-Order Integrators

Sihem Djebbri[1], Samir Ladaci[2*]

[1]Electrical Engineering Department, University of 20th August 1955, Skikda, 21000 Algeria.
[2]Department of Automatics, Ecole Nationale Polytechnique, Elharrach, Algiers, 16200 Algeria.
*Corresponding author's e-mail: samir.ladaci@g.enp.edu.dz

## ABSTRACT

The aim of this paper is to enhance the performances of active and reactive power control of doubly fed induction generator (DFIG) in systems of wind energy using a design of fractional order model reference adaptive control (FOMRAC) scheme. A fractional order integrator is introduced in the parameters updating adaptation law. The generator is modelized and a standard MRAC controller is designed for comparison sake. Then, a fractional order adaptive FO-MRAC configuration is applied to the energy system in order to improve its performance, by introducing a fractional order integrator. Simulation results give a comparative study based on the quadratic error criterion, in order to illustrate the superiority of the proposed adaptive control scheme.

**Keywords:** Doubly fed induction generator (DFIG), Fractional order integrator, FOMRAC

## 1 Introduction

The problem addressed in this work is the design of a control that can adapt to the parametric variations of the generator, based on the MRAC configuration and including a fractional order model which gives the FOMRAC control. The specialized literature is full of works on fractional order adaptive control design including the first publications of Vinagre *et al.* [1] and Ladaci *et al.* [2]- [4]. This success is due to its ease of implementation and its ability to improve the performance and robustness of legacy adaptive control schemes [5]. As a result of these advantageous properties, a very large number of applications of this adaptive control method in very wide and varied fields of engineering as: in Electric vehicle [6], voltage control of DC/DC converter in multiple renewable sources [7], and fractional-order Integrals in a multi-source renewable energy system [8] etc.

In this work, we propose a FOMRAC adaptive control design for a DFIG generator see Figure 1, using a fractional order integrator in the adaptation law. The objective is the RE system performance and improvement. Besides, the robustness of this control configuration is discussed.

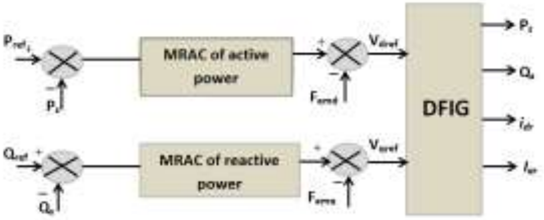

**Figure 1:** *Model reference adaptive control MRAC of active and reactive power of DFIG in wind system.*

## 2 Application of MRAC to DFIG active and reactive power control

The computation of the control signal is done using the equation,

$$u = \varphi^T . \theta \tag{1}$$

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Consider the algorithm of parameter adjustment represented in Figure1, we introduce an integral with α non-zero positive real such that: $0 < \alpha < 2$. We obtain then:

$$\theta = -\frac{\gamma}{s^{\alpha}} y_m (y - y_m) = -\frac{\gamma}{s^{\alpha}} y_m e \qquad (2)$$

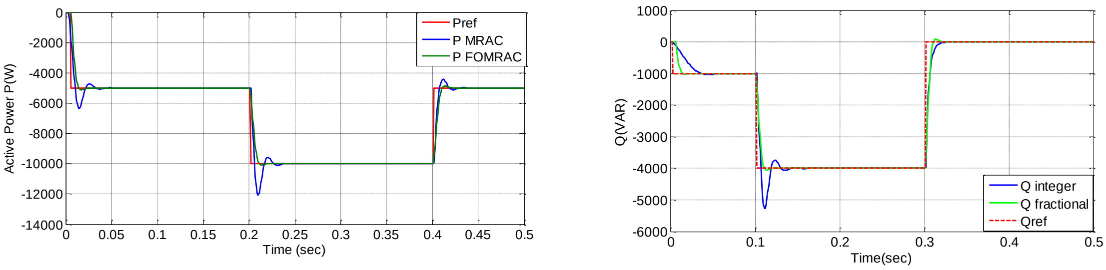

**Figure 2:** *Active and Reactive power output comparison between integer reference model and Fractional order reference models with α=0,4.*

The comparative simulation results for the FOMRAC vs the standard MRAC controllers is given in Figure 2 for both active and reactive power. It shows clearly the superiority of the proposed fractional order adaptive controller.

## 3 Conclusion

This work presents a fractional order MRAC control algorithm design using a fractional order integrator in the adaptation law in order to manage a DFIG induction generator in a wind RE system. Simulation results illustrated clearly the superiority of this adaptive controller when using a fractional order integrator.

## 4 Competing Interests

The authors declared that no conflict of interest exists in this work

## How to Cite

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## References

[1] Vinagre, B.M., Petras, I., Podlubny, I., Chen, Y.Q.: Using fractional order adjustment rules and fractional order reference models in model-reference adaptive control. Nonlinear Dyn. 29(1–4), 269–279 (2002)

[2] Ladaci, S., Charef, A.: Fractional order model reference adaptive control of a robot arm (in French), Revue Communication Sciences and Technologie, vol. 1, pp. 20–52. ENP Oran, Algeria (2002)

[3] Ladaci, S., Charef, A.: On fractional adaptive control. Nonlinear Dyn. 43(4), 365–378 (2006)

[4] Ladaci, S., Charef, A.: Fractional order adaptive control systems: a survey. In:Mitchell, E.W.,Murray, S.R. (eds.) Classification and Application of Fractals, pp. 261–275. Nova Science Publishers USA (2012)

[5] T. Seghiri, S. Ladaci, S. Haddad: Fractional order adaptive MRAC controller design for high-accuracy position control of an industrial robot arm. Int. J. Advanced Mechatronic Systems, 10: 1. 8-20, (2023).

[6] H. Balaska, S. Ladaci, H. Schulte, A. Djouambi, "Adaptive Cruise Control System for an Electric Vehicle Using a Fractional Order Model Reference Adaptive Strategy", 9th IFAC Conference on Manufacturing Modelling, Management and Control, MIM'2019. Berlin, Germany; August 28-30, 2019.

[7] S. Djebbri, S. Ladaci, A. Metatla and H.Balaska, "Robust MRAC Supervision of a Multi-source Renewable Energy System Using Fractional-Order Integrals", International Conference on Electrical Sciences and Technologies in Maghreb (CISTEM), IEEE, Algeria, 2018.

[8] S. Djebbri , S. Ladaci, A. Metatla, H. Balaska, "Fractional-order model reference adaptive control of a multi-source renewable energy system with coupled DC/DC converters power compensation", Energy Systems, 1-41, 2018.