Electromagnetic Torque Ripple Attenuation of WECS using an Improved On–Off Control based on PSO

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ABSTRACT

The aim of this paper is to present an improved On-Off control of wind energy conversion system (WECS) based on Squirrel cage induction generator (SCIG) using Particle swarm optimization algorithm (PSO). The benefit of such command is its robustness vis-a-vis the disturbances and uncertainties of the model. The appearance of the chattering phenomenon caused by the discontinuous part of the control which can have a harmful effect on the wind turbine life. To resolve this problem an improved On-Off controller has been proposed. So, the goal of this work is to reduce the electromagnetic torque ripple using an improved On-Off controller tuned by PSO. The performances of the proposed controller are tested with a wind profile obtained using the Von Karman spectrum in the International Electrotechnical Commission (IEC) standard. The results obtained by the proposed controller are analyzed and compared with those attained by the improved On-Off controller.

Keywords: Wind Energy Conversion System (WECS), Improved On-Off Controller, Particle Swarm Optimization (PSO)

1 Introduction

Wind power, in particular, represents a promising source of green energy and production. This explains the evolution of the worlds installed wind power capacity from 283 GW in 2012 to 906 GW in 2022 [1]. There are many different types of generators used in wind power generation systems. SCIG is one of the most common generators used in the production of wind energy. This generator offers control flexibility and high power density and making it an interesting machine for wind energy [2]. Many academics have concentrated on variable speed control of wind turbines in the literature over the last years [3]. Among the control methods that have been studied is the method of controlling the electromagnetic torque by an On-Off controller [4]. In this work, we propose to improve the performance of the improved on-off controller by searching for the optimal values of the improved controller parameters using particle swarm optimization algorithms (PSO). This concept makes it possible to better solve the problem of chattering.

2 Improved On–Off Control based PSO for Electromagnetic Torque Ripple Minimization of WECS

To find the optimal parameters of the improved On-Off controller, PSO is proposed to minimize the following objective function (Figure 1):

$$MISE = Fit = \int((\Gamma_{em}^{*} - \Gamma_{em})^2)dt \quad \text{subject to} \begin{cases} \beta_{min} \le \beta \le \beta_{max} \\ K_{fmin} \le K_f \le K_{fmax} \\ T_{fmin} \le T_f \le T_{fmax} \end{cases} \tag{1}$$

With : $$\Gamma_{em}^{*} = u^{eq} + u^{n} + u^{nf} \tag{2}$$

And : $$u^{eq} = 0.5.\pi.\rho.R^3.v_s^2.\frac{C_p(\lambda_{opt})}{G.\lambda_{opt}} \;; u^{n} = \beta.sign(\sigma) \;; u^{nf} = u^{n}.\frac{K_f}{T_f.s+1} \tag{3}$$

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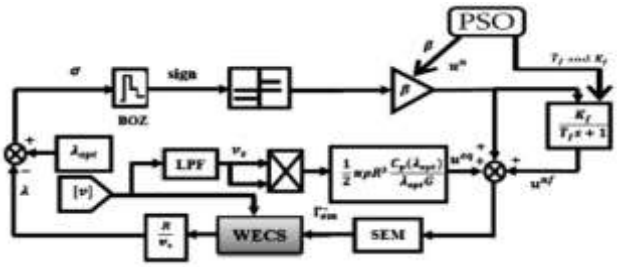

Figure 1: *PSO layout diagram block for adjustment of improved controller parameters.*

3 Results and Discussion

The wind energy conversion system and its proposed control approach were implemented in MATLAB/Simulink‖ environment through two-class studies of the turbulence categories—low turbulence intensity and high turbulence intensity obtained using the von Karman spectrum depicted in Figure 2 and Figure 3 respectively.

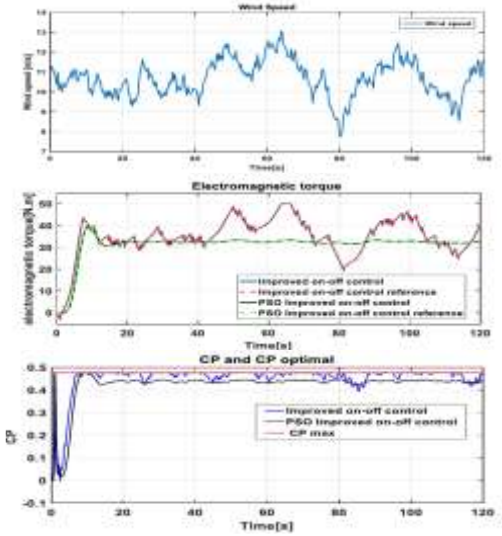

Figure 2*: SCIG response under low turbulence wind speed.*

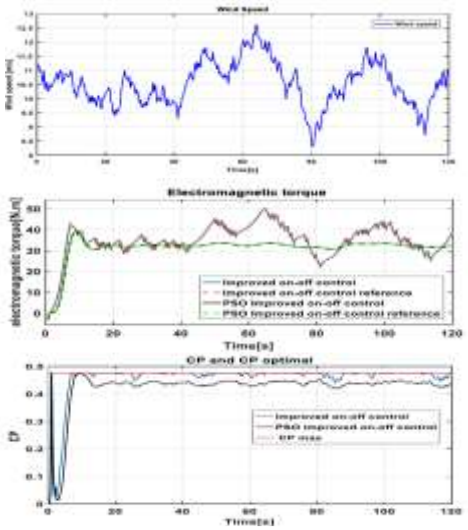

Figure 3: *SCIG response under high turbulence wind speed.*

4 Conclusion

In this paper, we introduced an improved On-Off control based PSO to reduce electromagnetic torque ripple of a wind power conversion system equipped by a squirrel-cage induction generator. PSO has been used to find the optimal values for the improved On-Off control parameters to minimize the effect of chattering, while limiting the mechanical loads on the drive shaft. According to the results, the proposed controller presented a good performance under the different wind speed profiles. It was noticed that we lose the maximum power point tracking function and thus we find a decrease in the power production, and this represents a new problem that will be the focus of our study in the next research work.

How to Cite

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