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Adaptive Fuzzy Logic Controller for MPPT Based DFIG Wind Turbine

*Ahmed M. Ismaiel[1, *], Basem E. Elnaghi[1], Fathy El Sayed Abdel-Kader[2], Reham H. Mohammed[3], Mohamed Nabil[1]*

1 Electrical Power and Machines Department, Faculty of Engineering, Suez Canal University, Ismailia 41522, Egypt
2 Electrical Power and Machines Department, Faculty of Engineering, Menoufia University, Menoufia, Egypt
3 Computer and Control Department, Faculty of Engineering, Suez Canal University, Ismailia 41522, Egypt

**Corresponding author, Email address: pgs.027636625@eng.suez.edu.eg*
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Abstract

It is important to use a reliable maximum power point tracking (MPPT) approach to guarantee that wind production systems are fully beneficial. This paper is discussing the operation principle of adaptive fuzzy logic controllers (AFLC) in double fed induction generator wind turbine. The acquired findings attest to AFLC's superiority over traditional PI control systems. The adaptive fuzzy logic controller has more promising results as compared to old PI controller. The investigation has been done by using MATLAB/ SIMULINK 2023a pakage. The proposed controller has less rising time than conventional PI controller by more the 40% and better power tracking by 32.21%. The results of using adaptive fuzzy logic controller revealed fast time response, high rate of convergence, less overshoot, and minimal steady state error compared to those achieved with conventional PI. These indicators are used to show that AFLC is feasible when compared to other controllers with the same WPP.

Keywords: *Double fed induction generator, Conventional PI, Adaptive Fuzzy Logic Controller, Wind power turbine*

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1. Introduction

Renewable energy sources, such as wind energy, solar energy, hydro energy, etc., have arisen as a new paradigm to meet the world's energy demand because of environmental concerns and the depletion of fossil fuels. Due to its plentiful resources, wind energy has garnered the most interest among the renewable energy sources [1]. The Global Wind Energy Council estimates that the total installed capacity of wind power globally reached 486.8 GW by the end of 2016 [2]; research from [3] forecasts that wind power might make up 19% of the world's energy generation by 2030. To get the wind turbine's maximum output power, an MPPT control method is required (WT). According to the MPPT principle, the best rotational speed tracking needs to be accomplished under various operating circumstances [4], [5]. The MPP from a wind turbine may be obtained in a variety of ways, including direct control techniques and indirect control methods (ICM) (DCM). The ICM includes a number of MPPT topologies in the literature, including the tip speed ratio (TSR), the optimum torque (OT), and the power signal feedback (PSF) [6]–[8].

2. Objectives

Through the use of turbine blades, kinetic energy from the wind is transformed into mechanical energy, which DFIG may then transform into electrical energy. The generator stator is connected to the network by means of the BTB converter. There are two primary sections in the BTB converter. The first portion, referred known as MSC, is tasked with achieving maximum power point tracking (MPPT). The reactive power is controlled and a steady DC-link voltage is maintained by the GSC, the second portion of the BTB converter.

3. Methods

The researches have focused on various MPPT control topologies to draw the maximum power of the wind system. In this section, the dynamic performance of two different control algorithm are thoroughly investigated via numerical simulation.

3.1. Conventional PI controller

PI controller method has been often used because it is easy to implement. The PI controller is simple to use, but the PI controller cannot successfully regulate the system performance when the grid characteristics are changed, especially when the grid is subjected to fault.

3.2. Adaptive Fuzzy Logic Controller

An adaptive fuzzy controller is one whose adjustable parameters, such as the output scaling factor, fuzzy rule, and membership function, alter in reaction to changes in the system. It can improve the efficiency of complicated, nonlinear wind systems with varying wind-speed profiles. By utilising the suggested AFLC gain scheduling, which tracks the MPP from the WT system with good dynamic behaviour in terms of steady and dynamic responses of the system under fluctuating wind conditions, this objective is accomplished. This scheduling method also ensures effective and trustworthy grid integration of the wind turbine [9].

4. Results and Discussion

The profile of the wind speed varies during a 5-second timeframe, as shown in Fig. 1, depending on step functions. As seen in Fig. 2(a), the MSC has control over the power coefficient (Cp), allowing it to remain at its maximum value (i.e., 0.48). The AFLC offers a quicker reaction than conventional PI at t = 0.9 s and t = 3.5 s. The mechanical power produced by a wind turbine is shown in Fig. 2(b). The generator's rotor speed tracks the reference speed, as seen in fig. 2 (c), demonstrating MSC's capacity to employ the MPPT approach. The AFLC responds more quickly than traditional PI at t = 2 s.

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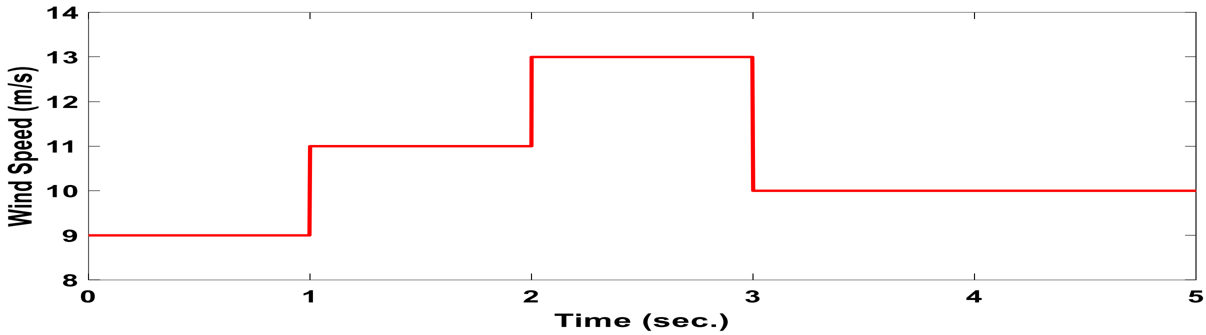
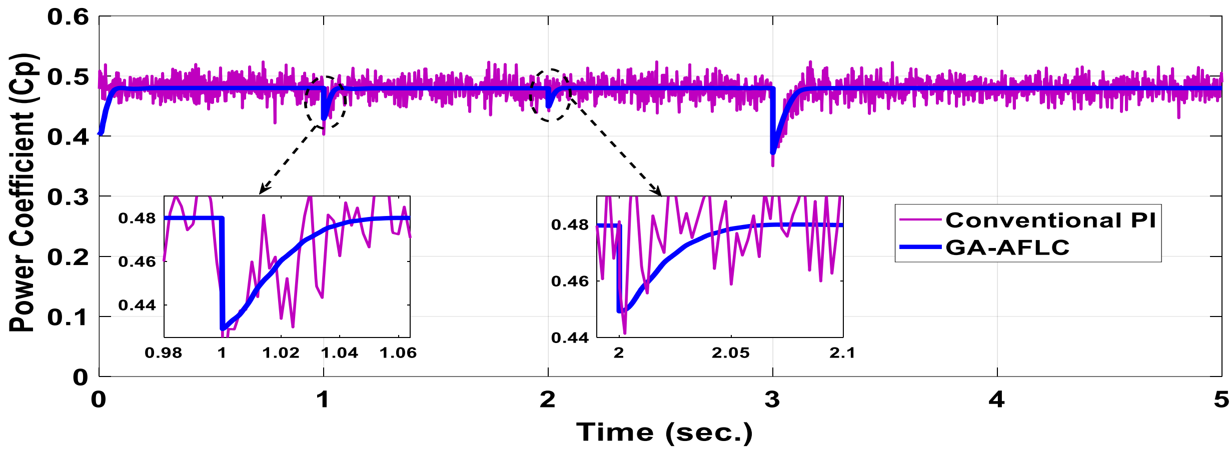
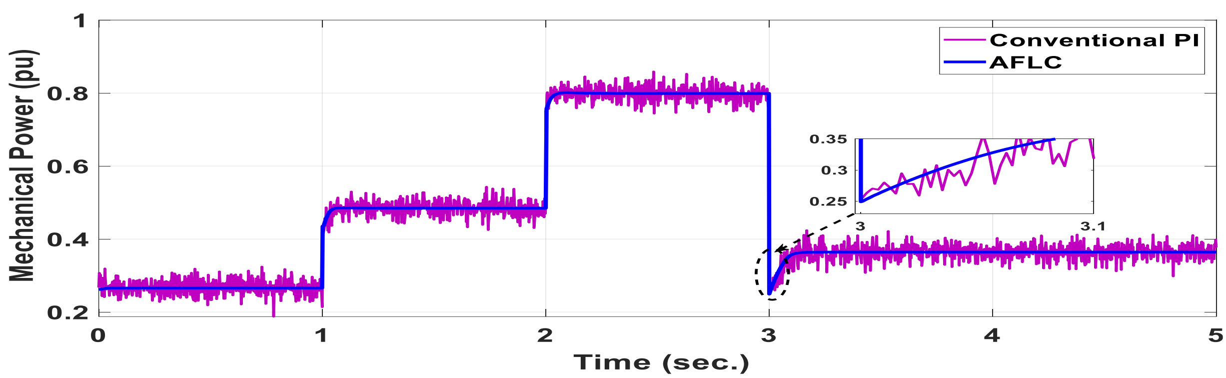


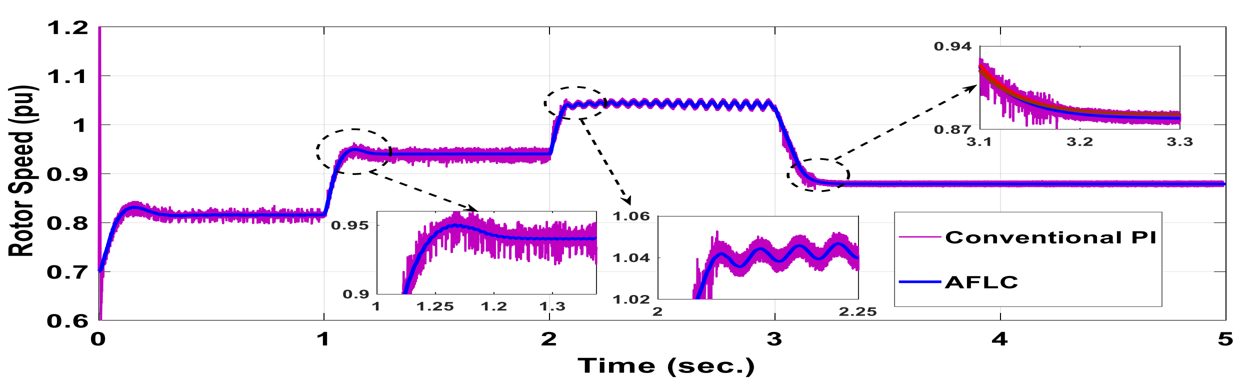
Fig.1: wind profile.



(a)



(b)



(c)

Fig.2: (A) power coaficient, (B) mechanical power, (C) rotor speed.

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5. Conclusions

This paper discusses using Matlab/Simulink 2023a for implementing adaptive fuzzy logic controller for maximum power point tracking. Based upon the results of the study, AFLC has improved the rising time by 40% and enhanced the power tracking by 32.21%. These indices provide a good indicator of WT performance and show that using conventional methods in conjunction with the AFLC scheme is feasible under the same wind turbine settings.

Credit Authorship Contribution Statement

Methodology, F.E.A., M.D.E. and M.N.A.; Software, M.N.A., and M.D.E.; Validation, A.M.I.; Re-sources, B.E.E.; Data curation, R.H.M., and A.M.I.; Writing—original draft, A.M.I. and F.E.A.; Writing—review & editing, M.D.E..; Visualization, B.E.E. and R.H.M.; Project administration, B.E.E. and A.M.I.; Funding acquisition, M.D.E. All authors have read and agreed to the published version of the manuscript.

Declaration of competing Interest

The authors declare that they have no known competing financial interests or personal rela-tionships that could have appeared to influence the work reported in this paper.

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