International Journal of Modern Agriculture, Volume 10, No.2, 2021
ISSN: 2305-7246

ANALYSIS OF GRID INTEGRATED WIND ENERGY CONVERSION SYSTEM WITH MODERN AGRICULTURE USING ADAPTIVE MOTH FLAME OPTIMIZATION TECHNIQUE

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Abstract

In the article, an adaptive technique is improving the dynamic performance of the grid-integrated Wind Energy Conversion System (WECS). The adaptive technique is Moth Flame Optimization (MFO) Algorithm technique. The proposed method is utilized to analyze the grid-side performances. A cascaded H-bridge Multilevel Inverter (MLI) is proposed to analyze the grid-side variations. For the optimal pulses of cascaded MLI, the proposed adaptive MFO technique is developed and analyzed the grid-side performances. The need of optimal switching operation is to avoid the complexity of the error voltage category. In the controller part, MFO is utilized to improve the gain parameters of the PID controller. The proposed adaptive MFO technique is realized in MATLAB/SIMULINK environment and the dynamic performance is analyzed.

Keywords: Cascaded H-bridge multilevel inverter, Grid, MFO, and voltage regulation

1. INTRODUCTION

In current few years, for a clean energy environment, the entire world has been drifting towards the alternates of fossil fuels to wind energy conversion systems (WECSs) as electricity source [1-3].Wind energy is one among the past developing renewable energy sources every year in many countries [4].The permanent magnet synchronous generator (PMSG) has mostly used in wind-energy applications. The usage of permanent magnet in the rotor of the PMSG does not require magnetizing current. The PMSG will work at a unity power factor since magnetizing current is not present. The multi-pole PMSG also significantly enhances the robustness of the variable-speed wind turbine that uses a direct-drive train system. It is low cost [5-7].

2. GRID INTEGRATED WIND ENERGY CONVERSION SYSTEM

The stability analysis scheme of the MFO algorithm based cascaded multilevel H-bridge inverter is discussed in this section. Figure 1 shows the wind energy conversion system using a cascaded multilevel inverter. In this Figure, the WECS contains the resistance, the inductance, and the DC-link voltage correspondingly. The PMSG indicates the basis region and it is associated with the grid in WECS. The PMSG related WECS is used to reduce the complication of the system and decrease the general size and expenditure which do not require gear or drive-train system. The PMSG initiator is a variable speed generator which is activated in an extensive collection of wind speed. The Dynamic Braking Resistors (DBR) is an appropriate pattern for synchronous generator because it does not necessitate magnetizing current. The DBR is used to alter the AC to DC to eliminate the harmonics because of linearity in wind speed. The DC voltage is acquired from the DBR, which is associated with the boost code to manage the torque and to acquire the greatest power. A smoothing capacitor C_{dc} is used to eliminate swell in the

DC voltage.The cascaded h-bridge MLI is used to generate nine level output voltage of the system. The proposed model is used to improve the performance by controlling the gain parameters of the controller and generating optimal pulses for the cascaded h-bridge MLI.

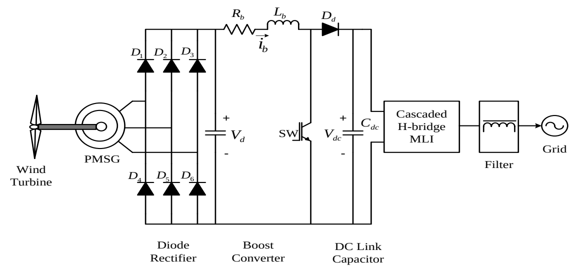


Figure 1: Structure of the WECS with MLI and proposed controller

2. CONTROL STRATEGY ANALYSIS OF MFO TECHNIQUE

In the control strategy of grid-connected WECS is described and analyzed the dynamic characteristics of the MFO method. The control structure of the MFO method is shown in the Fig.4. The detailed analysis of the proposed control topology is described with the following section.

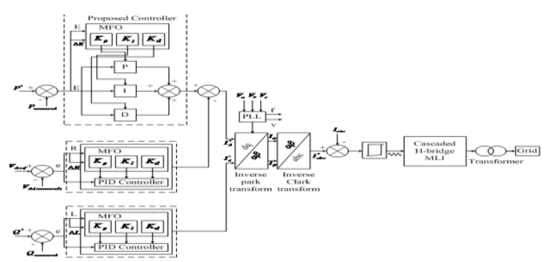


Figure 2: Proposed controller with PID controller

2.1. Power and Voltage Control loops

Generally, each control strategy has its own distinct parameters a specific task. In power-control strategy, the real power is measured by utilizing the PLL method and compared with the reference power. After that, the error values are determined and mentioned as the factor as. The power control loop is fed through MFO-ANN technique for optimizing the gain factors of the controller. Here, the PID controller is utilized to analyze the real power of the proposed system. Initially, the error value of power is provided to the input part of the PID controller and the corresponding gain parameters are tuned optimally. For the optimal tuning process, the MFO technique is applied. In the MFO, the gain parameters, and are randomly generated and the error values are considered as the input. Based on that, the optimal gain parameters and corresponding inputs are evaluated. The optimized gain parameters are given to the input of the PID controller. After that, the PID controller is tuned for optimal and produces the optimal control pulses. Similarly, the other blocks are worked and analyzed their performances. Based on the three blocks, the control pulses of cascaded h-bridge MLI is generated and analyzed the dynamic characteristics. For connecting WECS to grid, the optimal pulses of cascaded h-bridge MLI is analyzed [10]. The d-axis and q-axis currents component of the inverter are used for controlling the instantaneous reactive and active power that is exchanged between the DC-link voltage and the grid. The inverter output voltage is a square wave that is of high frequency. Fig.4. Shows that, the synchronous reference frame of the control variables translated into DC quantities. Thus the grid-side converter was controlling and filtering can be done normally. PID regulator yields an enhanced performance during the regulation of variables. After that, the PLL is utilized to get the grid angle for the transformation process.

A Phase Locked Loop (PLL) is taken for getting the grid angle θ for grid synchronization and coordinate transformation operations. This control mechanism takes a fast transient response form. The dynamic performance is because of internal control loops [8,13,14,15]. Grid currents are disintegrated into d and q-axis currents to yield individual control for active and reactive power. This control is useful in achieving the unity power factor and sinusoidal grid currents. The active and reactive power that the wind energy conversion system generates is measured with the help of equations (15) and (16).

$$P = \frac{3}{2}\left(E^d.i^d + e^q.i^q\right) + \left(R^d.i^d + R^q.i^q\right) + \left(L^d.i^d + L^q.i^q\right) \tag{15}$$

$$Q = \frac{3}{2}\left(E^d.i^d - e^q.i^q\right) + \left(R^d.i^d - R^q.i^q\right) + \left(L^d.i^d - L^q.i^q\right) \tag{16}$$

The d-axis of synchronous reference frame has an absolute alignment on the grid voltage vector E^q, R^q and L^q. Equation (17) and (18) clearly specify that active power is in proportion to direct axis i^d and the reactive power is in proportion to quadrature axis current i^q.

$$P = \frac{3}{2}\left(E^d.i^d\right).\left(R^d.i^d\right).\left(L^d.i^d\right) \tag{17}$$

$$Q = -\frac{3}{2}\left(E^d.i^q\right).\left(R^d.i^q\right).\left(L^d.i^q\right) \tag{18}$$

2.2. Moth Flame Optimization Algorithm for grid connected WECS

In this proposed scheme, adaptive technique has performed for controlling the optimal gain parameter and generates the optimal pulses for cascaded h-bridge MLI. In the controller process, the MFO algorithm is utilized to optimize the control gain parameters. In the paper, the MFO algorithm is developed for the optimization of the voltage and power blocks. For the controllers, the gain parameters are randomly generated and the power, voltages are considered as the input of the proposed algorithm.

2.2.1. General Behaviors of MFO algorithm

Moth-Flame Optimization (MFO) is natural inspired optimization algorithm.

The optimal result selection procedure

The position of objective flame is updated when any of the moths turns fitter compared to it. As per this rule, the location and the fitness of flames would get updated. Next, the best result is re-decided and its position is updated when any moth turns fit compared to the best flame chosen from the earlier iteration. The iteration condition is reach, and the best solution would be retrieved as the best achieved approximation of the optima.

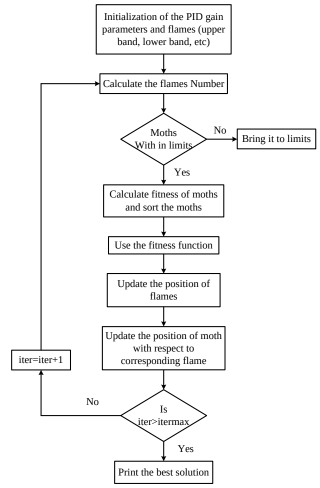


Figure 3: Flow chart for MFO algorithm

Flowchart of MFO algorithm is illustrated in figure 3.

3. Results and Discussions

In this section, the performance analysis of the discussed technique is analyzed with the grid integrated WECS. It describes the cascaded h-bride MLI of the grid integrated power system. Here the operating dynamic performance of the MFO controller is implemented in the MATLAB/SIMULINK platform. The SIMULINK diagram of the system with the grid integrated WECS is demonstrated in the Figure 4, the implementation parameters are analyzed and illustrated in the table 2.

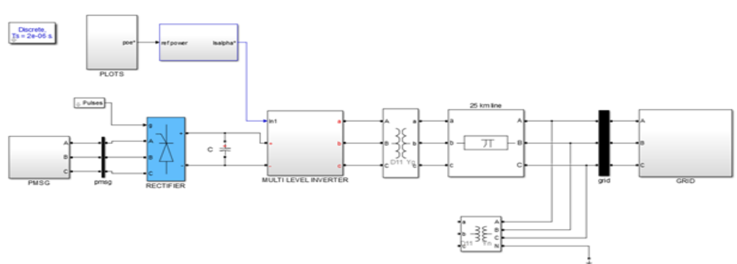


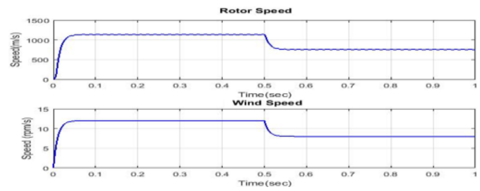
Figure 4: MATLAB/SIMULINK model of the MFO method with cascaded H-bridge multilevel inverter

3.1. Performance analysis

In the performance of the controller is analyzed. The propose technique is utilized to regulate the dc link voltage and cascaded h-bridge MLI according to their control signals. The performance of the PID controller is analyzed in the variable wind speed condition. The detailed analysis of the discussed technique is described in the section that follows.

Analysis of Case 1

The voltages are analyzed in the various speed conditions. Utilizing the proposed controller based cascaded h-bridge MLI the active power, reactive power, dc-link voltage and harmonic compensation performance are analyzed. The proposed model is tested with varying wind speed as shown in figure 5.



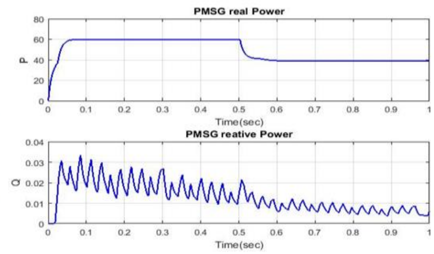
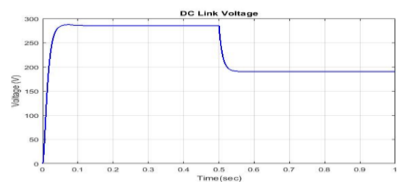


Figure 5: Performance analysis of various speeds of rotor and wind **Figure 6:** Performance of active , reactive powers in the PMSG



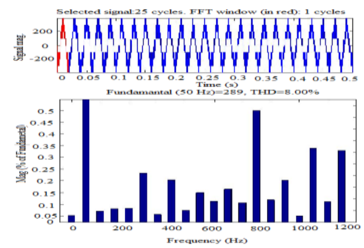


Figure 7: DC-link voltage at various operations **Figure 8:** THD analysis of proposed method

From the figure 6 shows that, the performance of the PMSG real and reactive power using the proposed technique has been illustrated. In the figure 7, DC-link voltage of the proposed system has been analyzed. Here the dc-link rise time is 0.001 second, peak overshoot time is 0.05 seconds and steady state reach the 0.55 seconds i.e., settling process at corresponding voltage is 200V respectively. In the figure 8 shows that for the output THD analysis of proposed method output has been illustrated. The THD is 10% for the output of proposed control technique of the grid integrated power system.

5. Conclusion

In the paper, the adaptive MFO technique was proposed to analyze the grid connected WECS. The cascaded h-bridge MLI was designed for getting the optimal results. For the controller designing process, the voltage, real and reactive power blocks are analyzed with the help of the MFO method. Initially, the voltage control blocks are analyzed and determine the optimal pulses for the cascaded h-bridge MLI. The error voltage was determined and regulated the voltage using the adaptive MFO technique. For the analysis process, the PID controller was tuned and minimized the corresponding error functions. The proposed MFO based grid connected WECS was implemented in MATLAB/SIMULINK platform. The proposed technique was utilized for controlling and analyzing the power flow in the grid integrated WECS.

References

1. Hua Geng, Geng Yang, Dewei (David) Xu and Bin Wu, “Unified Power Control for PMSG-Based WECS Operating Under Different Grid Conditions”, IEEE Transactions On Energy Conversion, Vol.26, No.3, pp.822-830, 2011
2. Akie Uehara, Alok Pratap, Tomonori Goya, Tomonobu Senjyu, Atsushi Yona, Naomitsu Urasaki and Toshihisa Funabashi, “A Coordinated Control Method to Smooth Wind Power Fluctuations of a PMSG-Based WECS”, IEEE Transactions On Energy Conversion, Vol.26, No.2, pp.550-558, 2011
3. Francisco Huerta, Ronald L.Tello and Milan Prodanovic, “Real-Time Power Hardware-In-The-Loop Implementation of Variable-Speed Wind Turbines”, IEEE Transactions on Industrial Electronics, Vol.64, No.3, pp.1893-1904, 2017

4. Venkata Yaramasu, Apparao Dekka, Mario J.Duran, SamirKouro and BinWu, “PMSG-based wind energy conversion systems: survey on power converters and controls”, IET Transactions on Electric Power Applications, Vol.11, No.6, pp.956-968, 2017
5. Fujin Deng, Dong Liu, Zhe Chen and Peng Su, "Control Strategy of Wind Turbine Based on Permanent Magnet Synchronous Generator and Energy Storage for Stand-Alone Systems”, An International Journal of Electrical Engineering, Vol.3, No.1, pp.51-62, 2017
6. Shao Zhang, King-Jet Tseng, D.Mahinda Vilathgamuwa, Trong Duy Nguyen and Xiao-Yu Wang, "Design of a Robust Grid Interface System for PMSG-Based Wind Turbine Generators", IEEE Transactions On Industrial Electronics,Vol.58, No.1, pp.316-328, 2011
7. Omid Alizadeh, Amirnaser Yazdani, “A Strategy for Real Power Control in a Direct-Drive PMSG-Based Wind Energy Conversion System”, IEEE Transactions On Power Delivery, Vol.28, No.3, pp.1297-1305, 2013
8. Yinru Bai, Baoquan Kou and C.C.Chan, "A Simple Structure Passive MPPT Stand-alone Wind Turbine Generator System”, IEEE Transactions on Magnetics, Vol.51, No.11, pp.1-4, 2015
9. Venkata Yaramasu, Apparao Dekka, Mario J.Duran, Samir Kouro and Bin Wu, “PMSG-based wind energy conversion systems: survey on power converters and controls”, IET Transactions on Electric Power Applications, Vol.11, No.6, pp.956-968, 2017
10. Hua Geng,Xinze X and Geng Yang, "Small-signal stability of power system integrated with ancillary-controlled large scale DFIG-based wind farm", IET Renewable Power Generation,Vol.11, No.8, pp.1191-1197, 2016
11. Z.Zhang, F.Wang, J.Wang, J.Rodriguez and R.Kennel, "Nonlinear Direct Control for Three-Level NPC Back-to-Back Converter PMSG Wind Turbine Systems: Experimental Assessment With FPGA”, IEEE Transactions on Industrial Informatics, Vol.13, No.3, pp.1172-1183, 2017
12. Daniel J.Trudnowski, Andrew Gentile, Jawad M.Khan and Eric M.Petritz, "Fixed-Speed Wind-Generator and Wind-Park Modeling for Transient Stability Studies", IEEE Transactions on Power Systems ,Vol.19, No.4, pp.1911-1917, 2004
13. Kathirvel, C. and Porkumaran, K “Design And Simulation Of An Advanced Rectifier Stage Topology With Maximum Power Point Tracking For Hybrid Energy Systems” Asian Journal of Information Technology, Volume: 15 Issue: 1 , Page No.: 162-168 , February, 2016.
14. Kathirvel, C. and Porkumaran, K “Design and Implementation of Improved Electronic Load Controller for Self-Excited Induction Generator for Rural Electrification” Scientific World Journal, Volume 2015, Article ID 340619, August, 2015.
15. Vanajaa V.R. and Kathirvel .C, “A Novel Approach using PID Controlled P&O MPPT Algorithm for PV system” International Journal of Electrical Engineering (ISSN-1582-4594).PP 1-9, July 2018.