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Artificial Intelligence Interfaced LVRT Control for Double Fed Induction Generator Wind Energy Conversion System

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ABSTRACT

The world's future energy needs will largely be met by renewable energy sources (RES). Numerous non-linear loads and distributed generations (RESs) are a part of the electrical electronics-based construction of today's power systems, which has led to the emergence of a number of PQ problems. For a DFIG-based wind energy converting framework, this study suggests a recurrent neural robust control (RNN) technique. The stator of the generator is directly connected to the grid in a wind turbine that uses doubly-fed induction generator converters (DFIG). A back-to-back power converter connects the rotor to the electrical grid. Advanced regulator system is used for adaptable modification of the discontinuity control amplitude while maintaining the resilience of the closed-loop system to eliminate stuttering problems in the system that stimulates.

Key words: RES-Renewable Energy Sources, DFIG- Doubly Fed Induction Generator, ANN- Artificial Neural Networks, RNN-Recurrent Neural Network.

1. INTRODUCTION:

A type of renewable energy technology that uses wind generators and turbines to harness the power of the breeze to generate useful power is the DFIG-based wind turbine. The rotor and stator of the induction turbines known as DFIGs are both wound. As a result, the electrical system and shaft can receive active power from the rotor and stator [1]. Doubly fed machines are typically used in circumstances where the machine's shaft speed must be varied within a specific range of synchronized speed. According to data on the worldwide energy scenario by 2021, there will be a steady increase in the need for power along Social, Technological, and Environmental Pathways, however, with a level of global development that will make coal-generated production seem nearly antiquated [2]. Renewable energies are warmly embraced with the anticipated growth in green energy production to surpass 45% in 2030 from approximately 30% in 2020. The need for solar energy would increase by twice as much to 60% interconnected within the STEPs at the most highest level of the Non-Zero Emission (NZE) [3].

In comparison to fixed speed wind systems, the variable wind generation system with a DFIG offers better efficiency. A smart control strategy is required to further increase effectiveness, equilibrium, and grid synchronization. Regarding the regulation of a wind production system that generates power at changing speeds, extensive and ongoing study has been ongoing [4]. Instead of particularly discussing the DFIG-based wind turbine control system, a great deal of research papers focus on the system for converting wind energy in its entirety. The wound rotor inducement generating and slip ring in the DFIG-equipped turbine's construction connects the rotor currents in both directions to two back-to-back voltage-fed pulse width modulation converter [5]. The DFIG-equipped wind farms can operate in a variable speed operation mode because to this framework's capacity to alter the amount and direction of power transferred to the AC supply network. The insulating gate bipolar transistors' changeable signals are managed to control the wind turbine's speed. In contrast, wind turbines with a set speed endure (1-2%) rotor speed deviations. Given the expected increase in global population, the dire predictions of fossil fuel shortages and pollutants are seen as a global warning [6]. Modern society depend on energy, thus renewable sources were seen as the most viable means of meeting the global need for energy. The markets for conversion energy systems have been developing steadily during the past few decades. This was also true of the Wind Turbine. A recentestimate from 2020 indicates that wind power now meets more than 35% of the world's electrical needs [7].

A wind turbine simulation model based on a doubly-fed induction generator has a complex model framework and numerous control variables. A suitable mathematical model is required to investigate the static and dynamic features of doubly fed induction generator-based offshore turbines and the system that is linked to the grid [8]. Depending on the observed findings of low voltage ride-through testing, this item proposes an integrated approach of parameters determination. Curve fitting is used combined with time-domain computational assessment to select a control approach for a wind turbine using doubly-fed induction motors [9]. It is based on the idea that the active and reactive powers of the rotor currents should be managed independently so that they may be governed. This can produce satisfactory dynamic performances. However, it requires precise machine specifications and is still vulnerable to outside disturbances and changes in drive parameter. Direct torque control (DTC) is yet another extensively utilised method. This method can manage the drive uncertainties, but its main flaw is the torque and flux ripples when running at low speeds [10].

2. PROPOSED WORK EXPLANATION

For a distributed power system based on a Wind Energy Conversion System, a novel Distribution Static Compensator design is provided in this system. A parallel interfacing inductor connects the DSTATCOM to the utility grid and linear load. The capacitor C_{dc} which is located on the dc-side of the DSTATCOM, receives the output from the DFIG-based WECS.

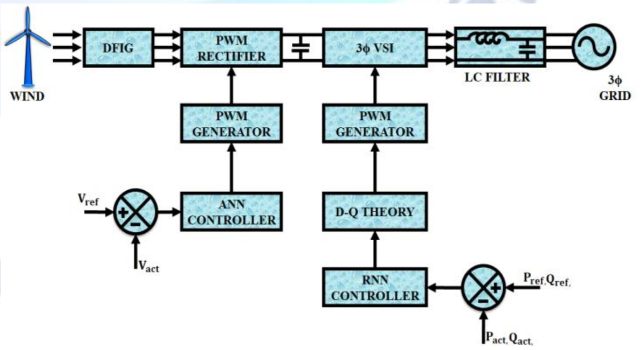

Fig.1. Proposed Diagram

A PWM rectifier is used to convert the WECS output to direct current. These RNN controller algorithms are used to suppress PQ problems and guarantee grid unity power factor. In this project, a controller is used to maintain a constant voltage level in the dc-link. Additionally, the production of the reference current for DSTATCOM uses the D-Q theory. RNN controller is used to remove harmonics from the produced benchmark frequency.

3. PROPOSED SYSTEM MODELLING

3.1 Doubly Fed Induction Generator (DFIG)

The power-supplying circuit link controls the rotor currents to provide the widely used DFIG with the variable speed required for the best energy harvest in varying winds.

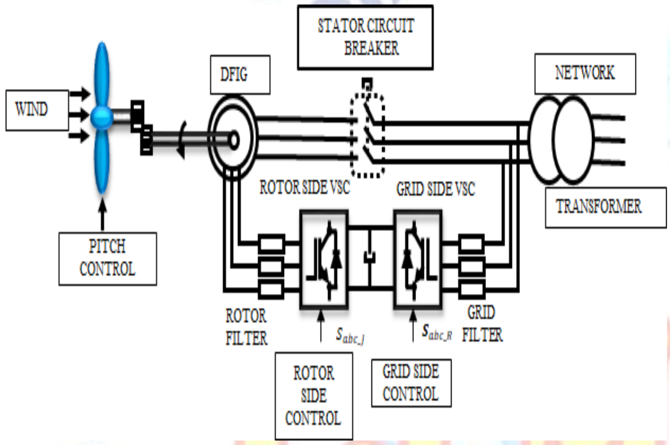

Fig.2. Equivalent DFIG System

The different equations that make up the DFIG model are derived in the stator reference frame in this section.All rotor characteristics and magnitudes are referred to the stator under the assumption that a general DFIG has been constructed with various stator and rotor turns. You can obtain the DFIG model by:

$$\vec{V}^S{}_S = R_S \vec{\imath}^S{}_S + \frac{d\vec{\lambda}^S{}_S}{dt} \quad (1)$$

$$\vec{V}^S{}_r = R_r \vec{\imath}^S{}_r + \frac{d\vec{\lambda}^S{}_r}{dt} - j\omega_m \vec{\lambda}^S{}_r \quad (2)$$

$$\vec{\lambda}^S{}_S = L_S \vec{\imath}^S{}_S + L_m \vec{\imath}^S{}_r \quad (3)$$

$$\vec{\lambda}^S{}_r = L_m \vec{\imath}^S{}_S + L_r \vec{\imath}^S{}_r \quad (4)$$

$L$is the inductance, R is the resistance, Lm is the magnetizing inductance, and m is the angular frequency. v is the voltage. i is the current. The subscripts s and r stand for stator and rotor quantities, respectively.

3.2 ANN Controller

Artificial neural networks, also known as neural networks or neural nets, are computer architectures that are modelled after the neural networks present in both natural and brains of animals. Artificial neurons, which are a collection of connected components or node that resemble brain neurons, form the basis of an ANN. The "signal" at the juncture of interaction is an actual number, and each neuron's output is derived from an exponential distribution of the sum of its impulses. Relationships are indicated by the borders. As training advances, neurons' and synapses' weights frequently shift. The quantity of mass boosts or depresses the signal strength of an interaction. It's possible for synapses to have an upper limit they must pass through in order to send a signal.

3.3 Three Phase VSI

For the sake of this experiment, it is additionally presumed that the structure functions properly and that the VSI switching frequency is high enough to have no impact on the dynamics of the inverters controlling loops. In accordance with these presumptions, the conversion network may be modelled using a linearized "average switching model (ASM)," in which the switches used by the inverter are substituted by an equation that represents their averaging value across each carrier interval. This transformed inverter architecture has been demonstrated to yield very precise results in this type of implementation, presuming the controller does not overload the VSI outputs.

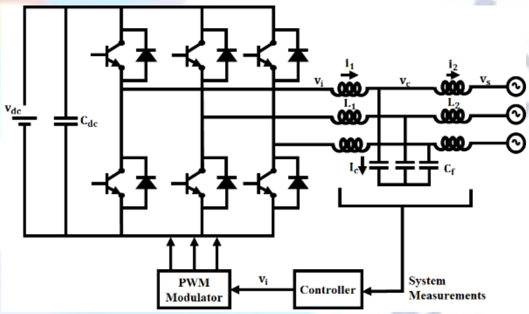

Fig.3. Three Phase VSI

The converting system taken into consideration for this study is depicted in Fig. 3. It consists of a typical three-phase VSI that is powered by a constant voltage DC bus and connected to the grid via an LCL filtering. It should be noted that if the dc inductance is high or the PWM control method includes dc bus voltage ripple reimbursement, the presumption of a steady dc voltage is justified.

3.4 RNN Controller

The forward feed Hidden layer of RNN. The hidden and outputting layer's node selects the sigmoid stimulating algorithm. There are two fixed weight vectors, such as Wa and Wb. Between the invisible and the output layer, Wb exists while Wa exists between the hidden and the input layers.

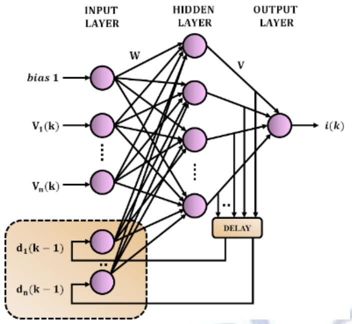

Fig.4. Feed Forward Structure of the RNN

RNN is generally used to address specific harmonics reduction issues with PWM inverters. By predicting the ideal changing degrees of the staircase waveform generated by multilevel inverters, the feed forward neural network is proven to be effective. This technique enables effective voltage management as well as the reduction of a particular harmonic set.

3.6 PWM Generator

The pulse width message signal is created by the PWM generator and applied to the inverter's switches. The PWM generator actually divides the average power reduction into distinct portions. The load side is supplied with averaged values of voltage and current when the switch is left on for a prolonged period of time. Due to this extended ON time, more electricity will be provided. Pulse width modulated gate pulse signals are primarily produced by the Generator and then supplied to the switching inside the converter.

4. RESULT AND DISCUSSION

The modelling findings are analyzed using the MATLAB/ SIMULINK programme. The easy to use environment of MATLAB, an efficient languages for professional computation, integrates computation, visualization, and scripting in order to display issues and solutions using well-known symbols from mathematics.

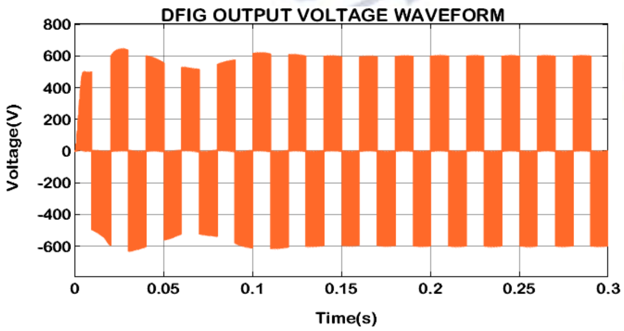

Fig.5. (a) DFIG based WECS output voltage

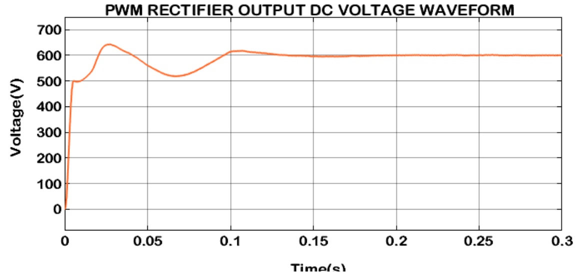

Fig.5. (b)PWM rectifier output voltage

The AC output voltage obtained by the DFIG-based WECS is unstable because of the wind's erratic behavior. The DFIG-based WECS and PWM rectifier connection effectively remove fluctuations and convert AC voltage to DC voltage.

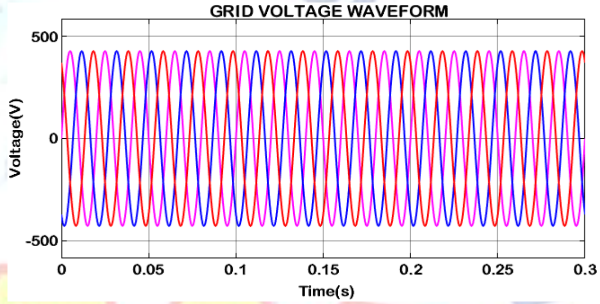

Fig.6. (a)Waveforms of 3φ grid Voltage

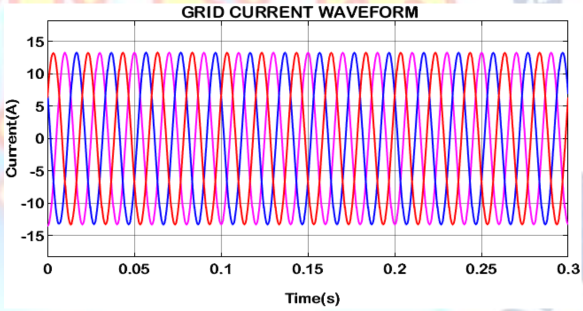

Fig.6. (b)Waveforms of 3φ grid Current

The 400V, which is maintained constant and fluctuation-free, is the grid output voltage that is obtained. Grid output current is stable and equals 12.3A in accordance with the constant output voltage.

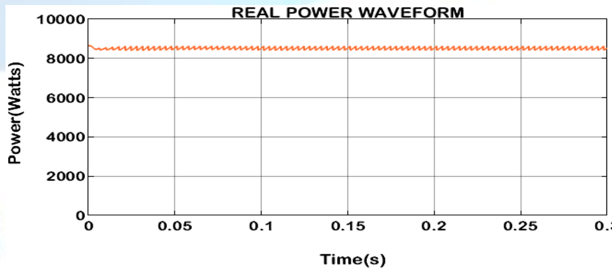

Fig.7. (a) 3φ Grid Real power waveform

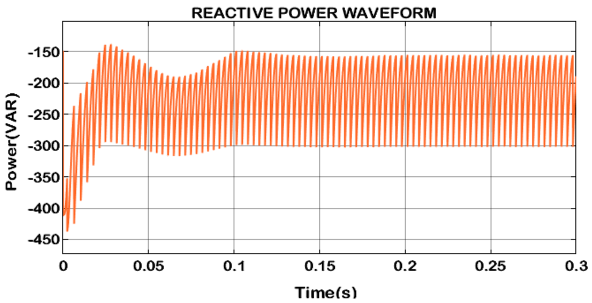

Fig.7. (b) 3φ Grid Reactive power waveform

Figure 7 displays the wave forms for the 3 grid's real and reactive power, with the real power having a high value of 8200W and the reactive power having a relatively low value of -150VAR.

The Comparison of the THD values are listed in Fig. 8, in which they are listed as 1.6%, 1.3% and 1.1% for PI, SVM and ANN Respectively.

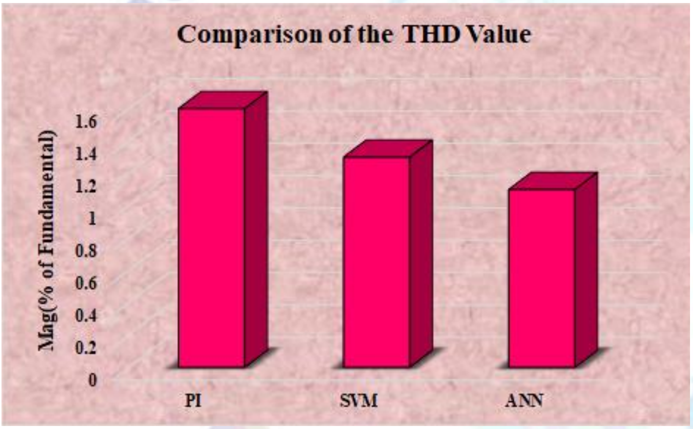

Fig.8. THD Value Comparison

5. CONCLUSION

In this reading, a WECS scheme for compensating reactive power in distribution systems using RNN controller is proposed. This procedure's D-Q theory-based recurrent neural network extracts the referencing current from the source current for the reduction of harmonics and reactive power. The DSTATCOM's dc-link receives current from the WECS, and the dc-link voltage is stabilized and regulated by an ANN controller. With the aid of the PWM rectifier, the wind turbine's ac output is changed from ac to dc in WECS. The three phase inverter that helps with DC-AC conversion then feeds the link voltage to the grid, assisting in grid synchronization. By synchronizing the inverter output current with the injected grid voltage, the grid synchronization is accomplished. The aim of the synchronization algorithm is to determine the grid voltage's phase angle. The retrieved grid angle is used to convert the feedback values into the proper reference frame.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Nduwamungu, Aphrodis, Etienne Ntagwirumugara, Francis Mulolani, and Waqar Bashir. "Fault ride through capability analysis (FRT) in wind power plants with doubly fed induction generators for smart grid technologies." Energies, Vol. 13, no. 16, pp. 4260, 2020.

[2] Karad, Shivaji, and Ritula Thakur. "Recent trends of control strategies for doubly fed induction generator based wind turbine systems: A comparative review." Archives of Computational Methods in Engineering, Vol. 28, pp. 15-29, 2021.

[3] Angala Parameswari, G., and H. Habeebullah Sait. "A comprehensive review of fault ride-through capability of wind turbines with grid-connected doubly fed induction generator." International Transactions on Electrical Energy Systems, Vol. 30, no. 8, pp. 12395, 2020.

[4] Abouheaf, Mohammed, Wail Gueaieb, and Adel Sharaf. "Model-free adaptive learning control scheme for wind turbines with doubly fed induction generators." IET Renewable Power Generation, Vol. 12, no. 14, pp. 1675-1686, 2018.

[5] Adouni, Amel, Dhia Chariag, Demba Diallo, Mouna Ben Hamed, and Lassaâd Sbita. "FDI based on artificial neural network for low-voltage-ride-through in DFIG-based wind turbine." ISA transactions, Vol. 64, pp. 353-364, 2016.

[6] Yan, Xiangwu, Sen Cui, Xuewei Sun, and Ying Sun. "Transient modelling of doubly-fed induction generator based wind turbine on full operation condition and rapid starting period based on low voltage ride-through testing." IET Renewable Power Generation, Vol. 15, no. 5, pp. 1069-1084, 2021.

[7] Benyahia, Khaled, Larbi Boumediene, and Abdelkader Mezouar. "Reliability and performance improvement of double-fed induction generator-based wind energy conversion system." International Journal of Modelling, Identification and Control, Vol. 28, no. 4, pp. 370-382, 2017.

[8] Yunus, AM Shiddiq, Ahmed Abu-Siada, Mohammad AS Masoum, Mohamed F. El-Naggar, and Jian Xun Jin. "Enhancement of DFIG LVRT capability during extreme short-wind gust events using SMES technology." IEEE Access, Vol. 8, pp. 47264-47271, 2020.

[9] Naik, B. Sudhakar, and S. Sunil Naik. "ANFIS based Control Strategy for Low Voltage Ride through Capability in DFIG based Wind Farm." 2017.

[10] Zamzoum, Othmane, Youness El Mourabit, Mustapha Errouha, Aziz Derouich, and Abdelaziz El Ghzizal. "Active and reactive power control of wind turbine based on doubly fed induction generator using adaptive sliding mode approach." International Journal of Advanced Computer Science and Applications, Vol. 10, no. 2, 2019.