A REVIEW ON POWER QUALITY CONTROL OF DFIG USING SMART NEURAL LEARNING

Krishna Kumar, Imran Khan, Anwar Ahmad, Apoorva Srivastava
Azad Institute of Engineering & Technology, Azad Institute of Engineering & Technology, Azad Institute of Engineering & Technology, Babu Banarasi Das National Institute of Technology & Management
Krishnamishra208@gmail.com,pe.imran@gmail.com,anwara931@gmail.com,apoorva019@gmail.com

Abstract

In this review paper, power system voltage improvement using wind turbine has been presented. Further their is an illustration of ANN controller which is being used along with the DFIG as this artificial neural network has certain advantages and applications in the power system. An important review that should be included in the design of electrical networks is controlling and improving the voltage stability. The modeling of various components of power quality is also discussed. The flow of power transferred between the wind turbine and the power system has been controlled in order to improve the bus voltage and making the system more stable and reliable. The reactive wind power control can significantly improve the system performance using field oriented control. Power generation through non conventional energy resources has become more viable and economical than the fossil fuel based power plants

Keywords: Artificial Neural Networks controller, double fed induction generator (DFIG), Field-oriented control (FOC), PI controller , power system voltage improvement

1. Introduction

The generation of electricity using wind energy system has been drawing a wide attention as a non conventional energy resources.. Owing to the decoupled active and reactive control possibilities, the main area of application for the DFIG is in variable-speed generating systems such as wind power and hydro power. [1]. The WECS basically includes wind turbine, generators, control system and an interconnection system. The basic principle of every windmill is to convert the kinetic energy of wind into mechanical energy which is further used to rotate the turbine of electrical generators to produce electricity. They are sometimes used to pump the water or to extract the ground water. For capturing the maximum wind energy, it is being necessary to install the power electronic devices between the WTG and the grid where the frequency is kept constant. Although the multitude of strategies and means of protection, power systems are confronted by numerous constraints such as the increase in demand, disturbances, planning, interconnection and network complexity. It is imperative to provide detailed information for each option. An important study that should be included in the design of electrical networks is controlling and improving the voltage stability, the main causes for occurrence of voltage instability are:

- Loss of a heavily loaded line (or generator)
- Voltage sources are too far from load centers;
- High Reactive Power Consumption at Heavy Loads
- Some equipments not suitable for power supply
- Unreliable grid system

Many techniques have been used to control and improve the power system voltage such as:

- The On-Load tap changer (OLTC) transformers;
- Automatic voltage control;
- Synchronous condenser;
- Shunt compensation;

- Voltage control by FACTS devices;
- Distributed generation;

For improving the quality of energy and to reduce the economic and social cost, there has been a large number of approaches that propose new restoration techniques as alternatives to these commonly used restoration procedures. The major focus which is being represented in this review paper is how to improve the system voltage and how to make the system more advantageous and useful by the use of artificial neural networks. In this review paper, an alternative of using artificial neural networks (ANNs) in power system voltage restoration is investigated.

Further this review paper is subdivided into many sections such as : Section 1 deals with an introduction, Section 2 deals with a sources and effects of power quality problems, Section 3 deals with control methodology, Section 4 deals with an overview of ANN applications, Section 5 deals with subsection, Section 6 deals with results and discussions, Section 7 deals with conclusion, Section 8 deals with an authors name and their affiliations, Section 9 deals with an acknowledgement and Section 10 deals with references.

2. Sources and effects of power quality problems

As we all know that the transmission and distribution network are the main carriers of an electrical power. Now a day's many new technologies has been in advancement for the design and installation of power electronics devices because of which many power quality problems has been existing in the system and also makes the voltage unstable. As in this review paper we have used DFIG which is being coupled with the wind turbine for converting the kinetic energy of wind into electrical energy and the energy which is generated is highly unstable because of the use of modern power electronic devices which creates many problems. Various sources of power quality problems are voltage sag, voltage dip, flickers, harmonics, over voltage, under voltage, voltage impulse, frequency variation and many more . And the sources of such problems are generally unbalanced load on three phase system, switching of heavy loads, unreliable grid system and some equipments not suitable for power supply. Because of radio frequency interference and electromagnetic interference many problems may exists in the system.

The most common types of Power Quality problems are presented below:

1. Voltage Sag
2. Voltage Dip
3. Flickers
4. Harmonics
5. Voltage Fluctuations
6. Over voltage/ Under voltage
7. Voltage Impulse
8. Voltage Spikes
9. Voltage Transient
10. Voltage Swell
11. Frequency Variation
12. Electrical Line Noise
13. Brownouts
14. Blackouts
15. Power Interruptions

Some sources of power quality problems are:

1. Rural location remote from power source

2. Unbalanced load on a three-phase system

3. Switching of heavy loads
4. Long distance from a distribution transformer with interposed loads
5. Unreliable grid systems
6. Equipments not suitable for local supply
7. Overburdened distribution system
8. Switch mode power supplies, Nonlinear loads
9. Unstable generators
10. Blackouts, Faulted or Overloaded

3. Control Methodology

Gaillard, P. Poure, S. Saadate a, M. Machmoumc presented a novel approach for simultaneous power generation and harmonic current mitigation using variable speed WECS with DFIG. A new control strategy is proposed to upgrade the DFIG control to achieve a stable voltage which will further get used.

Lata Gidwani, Harpal Tiwari, R.C,Bansal has shown keen interest and also presented a paper in which they have used a non conventional energy resources for the power generation. In their paper they have shown how to use DFIG based WECS and how to generate an efficient power and also shown how to improve the power quality and how to increase its efficiency. The models used in the work includes a pitch-angled controlled wind turbine model, a DFIG model, power system model and an UPEI having controlled converters [3]

Yun-Seong Kim emphasizes their interest on the use of wind turbine for the generation of electricity using mppt techniques. and also reduces the power quality problems by the use of filters and compensators (e.g., the short-circuit ratio, the grid impedance, and the load type).

S. K. Khadem: presented a technical review of power quality problems such as voltage sag ,voltage dip,flickers,harmonics,fluctuations and many more and also gives his views on how to overcome such problems by the use of STATCOM, DVR,COMPENSATORS.

We will firstly connect wind turbines to a grid with the controllers such that they should always maintain constant power. For maintaining the constant active power they have used DFIG based model and also shown various factors which are responsible for poor power quality. Various other power electronics devices were also used such as IGBT which operates in multi quadrant. RL filters were used for the removal of ripples and harmonics. Further simulation will be done in MATLAB and showed various results. Wind turbine basically takes wind as an input and generates mechanical power as an output and finally this generated mechanical power is fed to DFIG which further converts it into the electrical power.

In this paper, intelligent control scheme of artificial neural learning has been proposed.. ANN based rotor loop design is developed for variable speed wind turbine and the rotor side controller (RSC) is proposed for DFIG to improve its transient performance in all wind speed conditions. For comparative analysis, the conventional vector control scheme will also implement for the system under investigation. The simulations will be carried out using MATLAB platform

Currently there are two methods which is generally used to mitigate power quality problems firstly from the customers side and secondly from the utility side. The first approach is called as load conditioning and the second approach is called as the line conditioning. Some recent trends in the power generation and distribution system shows that now the system is getting much changed and advanced in terms of technology and up gradation of modern power electronics equipments.

4. OVERVIEW OF ANN APPLICATION

Just as human brain consists of billions of nerve cells which is called as neurons in the very same way artificial neural networks consists of numerous numbers of layers which further helps in the data processing just as our brains helps us in taking a right decision and the proper functioning of the body and called as the controlling part of the body in the very same way ANN also provides right path for the system by analyzing the data. ANN not only finds an applications in the fields of engineering but also used in medical fields for diagnosing cancer , apart from medical and engineering fields it is also used in the cyber security. Many applications of ANN has shown that they have considerable potential in overcoming the difficult tasks of data processing and interpretation. Some major steps involved in ANN applications are:[4]

1. Generation of data.
2. Input selection
3. ANN architecture selection
4. Testing and training the ANN
5. Data analyzing, processing, and interpreting

Here in this review paper the idea of using artificial neural networks controllers has been implemented instead of using PI controllers. Figures 1 show the Neural Network controller which is being used for reactive power control of DFIG, and it basically consists of two hidden layers having a pure line and sigmoid activation function. The output layer consists of one output neuron having linear activation function. For training of the artificial neural networks, we have used back propagation training algorithm, the input signals chosen are the measured and reference voltage and the reactive power as output. These variables are determined from field oriented control.

Though ANN has certain features and because of major advantages at present it is highly used and is giving quicker response that's why it is used in the power quality control when power is being generated by using wind turbine. It is connected across the three phase line for getting the proper signals and for removing the hindrances and drawbacks which may occur in the system and also interprets the data and generates the proper data and makes the system more stable and improves the voltage before sending it to the grid.

Although different types of controllers have been developed to improve the power quality in a micro grid system, new controllers addressing multiple power quality issues simultaneously needs to be developed. Hence, further research can be done in developing new robust control techniques for the micro grid systems to eliminate the problems associated with all power quality issues at the same time.

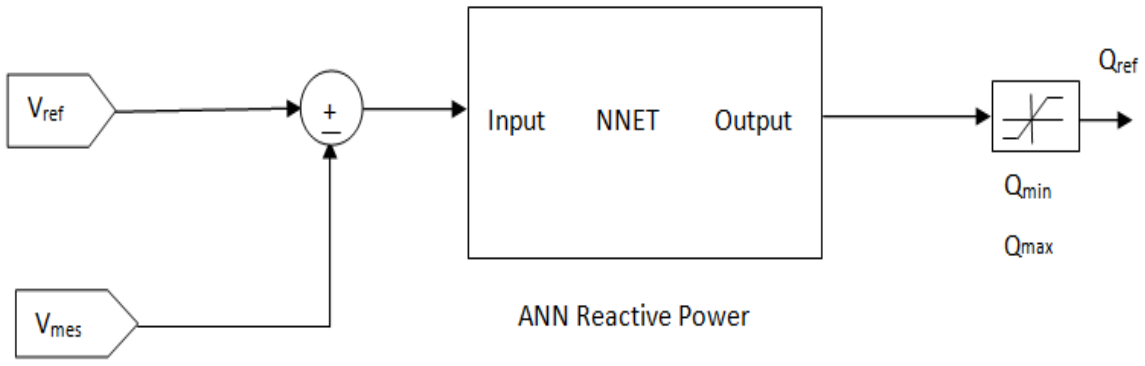

Figure: 1 (ANN Controller)

5. Subsection

Doubly fed induction generator. based wind turbine is mostly used at present because of higher advantages and features .Wind turbine is one of the best source for the generation of electricity which further becomes highly useful and generates a power in bulk and using WECS and by the use of DFIG it may create a huge power. A DFIG in a wind turbine has the ability to generate maximum power with varying rotational speed, to control active and reactive by integration of electronic power converters..

Doubly Fed Induction Generator (DFIG) has many advantages and features that's why now a days they are mostly used in wind energy generation systems and also they have high efficiency and independent control of active and reactive power using partial capacity converters. In the diagram drawn below first of all a wind turbine is taken and is connected to DFIG and further is connected to converters and finally it is connected to three phase transformer.. And then by using power electronics devices we may transfer the generated electric power to the grid by using ANN controller which has its own features.

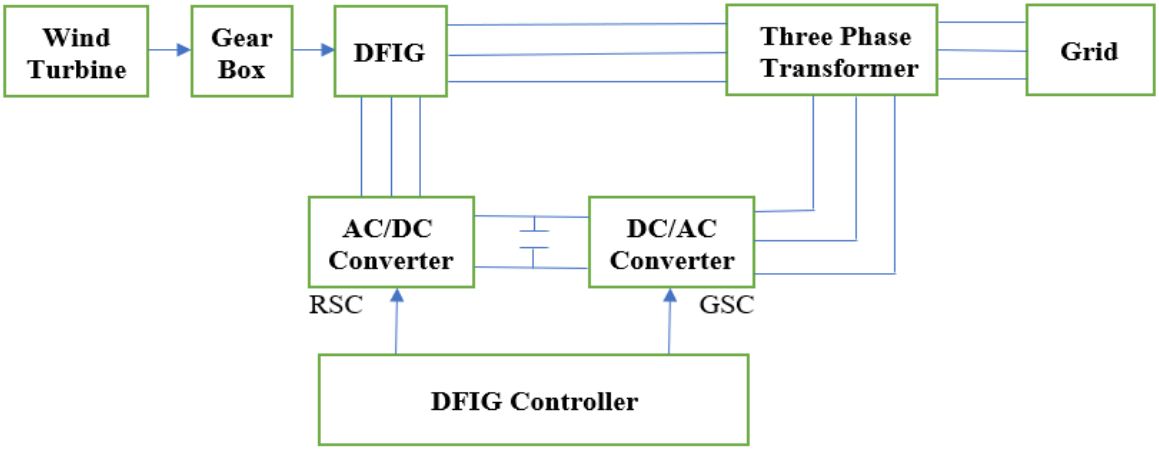

Figure: 2 (Wind Turbine and DFIG System)

By the end of the 90's the fixed speed WT was more in use but developed many short comings.. Due to higher demand of power from wind energy, off shore installations are becoming more popular and new wind turbine designs are being expected in the near future, with the development of the improved generators and converter designs The Doubly-Fed Induction Generators are generally fed by both the sides either by stator or through rotors.. The stator windings is being connected directly to the grid .[6]

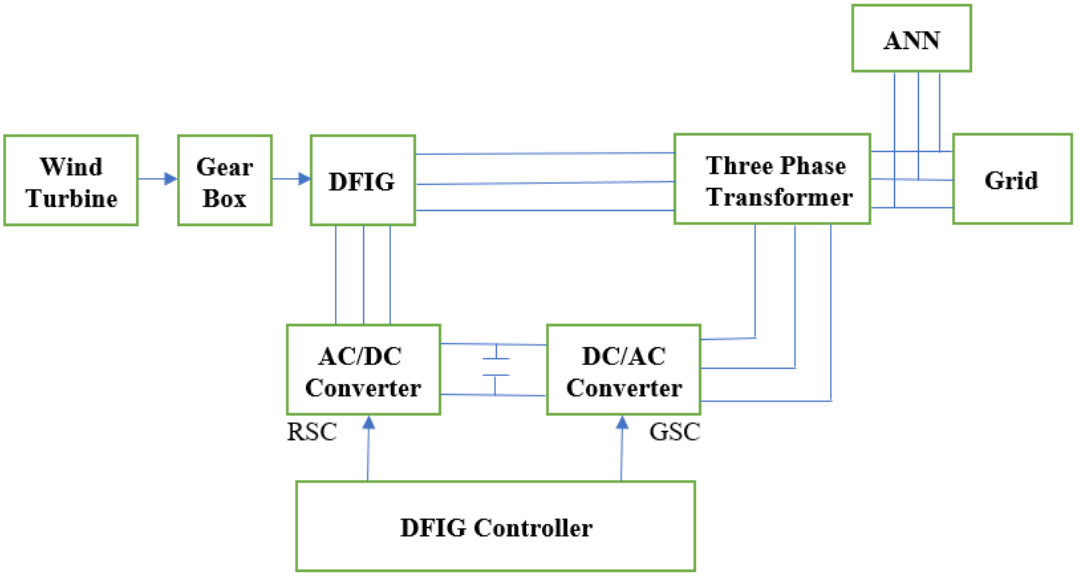

Figure:3 (Wind Turbine and DFIG System With ANN Controllers)

6. Results and Discussion

Finally the result section deals with the work perfomed in MATLAB and after doing many surveys and going through many review papers the outcome has been showed in this review paper.The proposed diagram of the variable speed wind turbine with DFIG has also been shown. Further an ANN controller has been used which shows that they have considerable potential in overcoming the difficult tasks of data processing and interpretation as shown in figure 3. The electrical power produced by wind turbine generators has been growing continuously. A wind turbine installation consists of a turbine tower, which carries the nacelle, and the turbine rotor, consisting of rotor blades and hub.[7-9]. Amongst all the non conventional energy resources, wind and solar are the most popular resources due to its ease of availability and its ease conversion into electricity .Because of fast increasing number of applications of industry electronics has been connected to the distribution system today and has been growing rapidly. At present in India mostly the electricity is being generated by the use of non conventional energy resources such as wind energy and solar energy and is growing rapidly, here in this paper we have used DFIG and ANN controllers and shows how the electricity is being generated and further by the use of ANN controllers and power electronics devices how it is being fed to the grid by making it more stable and reliable. Many surveys has already been done and many more are in continuation for the improvement of power quality. We may also improve the quality by the various techniques and power electronics devices and FACTS devices. DVR, UPQC, STATCOM, compensators these are now replaced by the use of filters and controllers.

7. Conclusion

This paper investigates the use of reactive power produced by wind turbine to improve the power quality. Here in this review paper a neural networks controller have been successfully used to improve power system voltage stability, which a new control strategy of reactive wind power has been successfully applied. The modeling of various components of power systems has also been discussed, and also shown that the wind turbine is based on a doubly-fed induction generator (DFIG), and a field-oriented control is also used. The rapid controllability of injected reactive provided by wind turbines are used to control and improve of the power system voltage. Simulations performed on single machine test system generally shows that both the proposed controllers ANN and PI controller can significantly improve the

voltage stability. Results indicate that the reactive wind power control can significantly improve the system performance. In this review paper various power quality problems and the available solutions has been discussed in details and also discuss about the MPPT by which the power is being generated . In this paper, we have also seen that the artificial neural networks is being quite beneficial. Though ANN controllers have various features and amongst them some are: data processing, data interpretation, and data generation. It just works like a brain.

8 . Author Name(s) and Affiliation(s)

Krishna Kumar (Azad Institute of Engineering & Technology)
Imran Khan (Azad Institute of Engineering & Technology)
Anwar Ahmad (Azad Institute of Engineering & Technology)
Apoorva Srivastava (Babu Banarasi Das National Institute of Technology & Management, Lucknow)

Affiliations

Krishna Kumar, Imran Khan, Anwar Ahmad, Apoorva Srivastava

[1]*Azad Institute of Engineering & Technology*

[2]*Azad Institute of Engineering & Technology*

[3]*Azad Institute of Engineering & Technology*

[4]*Babu Banarasi Das National Institute of Technology & Management, Lucknow*
Krishnamishra208@gmail.com,pe.imran@gmail.com,anwara931@gmail.com,apoorva019@gmail.com

9. Acknowledgement

Research papers have an important role in exposing real life situations in our industry. It was a great experience for me to do survey and review on the topic "A REVIEW ON POWER QUALITYCONTROL OF DFIG USING SMART NEURAL LEARNING ".

I am sincerely grateful to Mr. Imran Khan (Asst. Professor, AIET), who rendered me his valuable assistance, constant encouragement and able guidance which made this review actually possible. I wish to express my heart full of gratitude to my Mr. Anwar Ahmad (Asst. Professor) for letting me undertake this topic .I am deeply indebted to them for the help stimulating suggestion and encouragement helped me in the creation of this seminar report.

I would also like to thank Mr. Apoorva Srivastava (Asst .Professor, BBDNITM) and other faculty members for their regular motivation and guidance. Without their support this review would not have been possible.

Last but not the least I would like to thanks my parents and friends for their indomitable support without which the successful completion of this work would have been a distant dream.

10. References

[1] Sabir Messalti, Bilal Boudjellal , Azouz Said Electrical Engineering Department Faculty of Technology, University of M'sila, Algeria (messalti.sabir@yahoo.fr

[2] Lata Gidwani a,⇑, Harpal Tiwari b, R.C. Bansal c et. Al, " Improving power quality of wind energy conversion system with unconventional power electronic interface", Electrical Power and Energy Systems 44 (2013) 445–453

[3] Yun-Seong Kim, Student Member, IEEE, and Dong-Jun Won, Member, IEEE et.Al,"Mitigation of the Flicker Level of a DFIG Using Power Factor Angle Control", IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 24, NO. 4, OCTOBER 2009

[4] M. Boutoubat a, L. Mokrani a,*, M. Machmoumb et. Al, "Control of a wind energy conversion system equipped by a DFIG for active power generation and power quality improvement", Renewable Energy 50 (2013) 378e386

[5] S. K. Khadem, M. Basu and M.F. Conlon et.Al, "Power Quality in Grid connected Renewable Energy Systems: Role of Custom Power Devices", International Conference on Renewable Energies and Power Quality (ICREPQ'10) Granada (Spain), 23rd to 25th March, 2010

[6] Nishikata S, Tatsuta F. A new interconnecting method for wind turbine/ generators in a wind farm and basic performances of the integrated system. IEEE Trans Ind Electron 2010;57(2):468–75.

[7] Lian KL, Noda T. A time-domain harmonic power-flow algorithm for obtaining nonsinusoidal steady-state solutions. IEEE Trans Power Delivery 2010;25(99):1–11.

[8] Papathanassiou SA, Papadopoulos MP. Harmonic analysis in a power system with wind generation. IEEE Trans Power Delivery 2006;21(4):2006–16.

[9] Chang GW, Chen CI, Teng YF. Radial-basis-function-based neural network for harmonic detection. IEEE Trans Ind Electron 2010;57(6):2171–9.

[10] Chang G, Chen C. Virtual instrumentation and educational platform for timevarying harmonics and interharmonics detection. IEEE Trans Ind Electron 2010;57(10):3334–42.

[11] Papathanassiou SA. A technical evaluation framework for the connection of DG to the distribution network. Electr Power Syst Res 2007;77(1):24–34.

[12] S. Messalti, S. Saadate, A. Gherbi, D. Flieller, " Neural Networks for Assessment Power SystemTransient Stability", International Review on Modelling and Simulations, vol. 3. n. 3, 2010, pp. 381-387.

[13] Loi Lei Lai,*'* Intelligent System Application in Power Engineering Evolutionary Programming and Neural Network", Ed. John Wiley & sons Canada, 1999.

[14] S. Krishna, K.R. Padiyar, "Transient Stability Assessment Using Artificial Neural Networks", IEEE Transactions on Power Systems, pp. 627-632, 2000.

[15] A. Gaillard, " Système éolien basé sur une MADA contribution à l'étude de la qualité de l'énergie électrique et de la continuité de service", Ph.D. dissertation Henri Poincaré University, Nancy-I(2010).

[16] Wu J.S., Liu C.C., Liou K.L. and Chu R.F, "A Petri Net Algorithm for Scheduling of Generic Restoration Actions", IEEE Transactions on Power Systems, Volume 12, Number 1, pp.69-76, February 1997

[17] S. Messalti, S. Saadate, A. Gherbi, D. Flieller, " Neural Networks for Assessment Power System Transient Stability", International Review on Modelling and Simulations, vol. 3. n. 3, 2010, pp. 381-387.

[18] Loi Lei Lai,*'* Intelligent System Application in Power Engineering Evolutionary Programming and Neural Network", Ed. John Wiley & sons Canada, 1999.

[19] S. Krishna, K.R. Padiyar, "Transient Stability Assessment Using Artificial Neural Networks", IEEE Transactions on Power Systems, pp. 627-632, 2000.

[20] A. Gaillard, " Système éolien basé sur une MADA contribution à l'étude de la qualité de l'énergie électrique et de la continuité de service", Ph.D. dissertation Henri Poincaré University, Nancy-I(2010).

[21] Papathanassiou SA, Papadopoulos MP. Harmonic analysis in a power system with wind generation. IEEE Trans Power Delivery 2006;21(4):2006–16.

[22] Chang GW, Chen CI, Teng YF. Radial-basis-function-based neural network for harmonic detection. IEEE Trans Ind Electron 2010;57(6):2171–9.

[23] Chang G, Chen C. Virtual instrumentation and educational platform for timevarying harmonics and interharmonics detection. IEEE Trans Ind Electron 2010;57(10):3334–42.
[24] Papathanassiou SA. A technical evaluation framework for the connection of DG to the distribution network. Electr Power Syst Res 2007;77(1):24–34.