Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, May : 2023

Implementation of ANN controller to mitigate voltage fluctuations in Wind Energy Based PMSG by DSTATCOM

Mrs. R. Jaya Lakshmi[1], Mr. P. Subhani Khan[2]

[1, 2]Assistant Professor, Department of EEE, PSCMRCET, Vijayawada, Andhra Pradesh, India

ABSTRACT

Generally, the non-conventional energy sources are being extensively used in case of power electronic converter-based distribution systems. This paper mainly focuses on the wind energy system integrating with grid connected system and also improvement of power quality features. The wind energy power plant is modelled based on associated equations. For improving this power quality problems, this paper proposes the concepts of shunt converter controllers. This paper also proposes the concepts of ANN based Thyristor Switched Capacitor and Static Compensator and STATCOM. And also, the results are compared for these cases. Thus, with such a control, a balanced load currents are obtained even in the presence of non-linear load. The experimental setup is done in Matlab and verified the simulation results.

INTRODUCTION

An increasing demand for high quality, reliable electrical power and increasing number of distorting loads may leads to an increased awareness of power quality both by customers and utilities. The most common power quality problems today are voltage sags, harmonic distortion and low power factor. Voltage sags is a short time (10 ms to 1 minute) event during which a reduction in r.m.s voltage magnitude occur. It is often set only by two parameters, depth/magnitude and duration. The voltage sags magnitude is ranged from 10% to 90% of nominal voltage and with duration from half a cycle to 1 min.

Voltage sags is caused by a fault in the utility system, a fault within the customer's facility or a large increase of the load current, like starting a motor or transformer energizing. Voltage sags are one of the most occurring power quality problems. For an industry voltage sags occur more often and cause severe problems and economical losses. Utilities often focus on disturbances from end-user equipment as the main power quality problems.

Harmonic currents in distribution system can cause harmonic distortion, low power factor and additional losses as well as heating in the electrical equipment. It also can cause vibration and noise in machines and malfunction of the sensitive equipment. The development of power electronics devices such as Flexible AC Transmission System (FACTS) and customs power devices have introduced and emerging branch of technology providing the power system with versatile new control capabilities. There are different ways to enhance power quality problems in transmission and distribution systems. Among these, the D-STATCOM is one of the most effective devices.

A new PWM-based control scheme has been implemented to control the electronic valves in the DSTATCOM. The D-STATCOM has additional capability to sustain reactive current at low voltage, and can be developed as a voltage and frequency support by replacing capacitors with batteries as energy storage. In this paper, the configuration and design of the DSTATCOM with LCL Passive Filter are analyzed. It is connected in shunt or parallel to the 11 kV test distribution system. It also is design to enhance the power quality such as voltage sags, harmonic distortion and low power factor in distribution system.

The reactive power compensation is also one of the application of shunt converter devices [4]. Figure 1 shows the basic diagram for the shunt connected inverter based grid connected system.

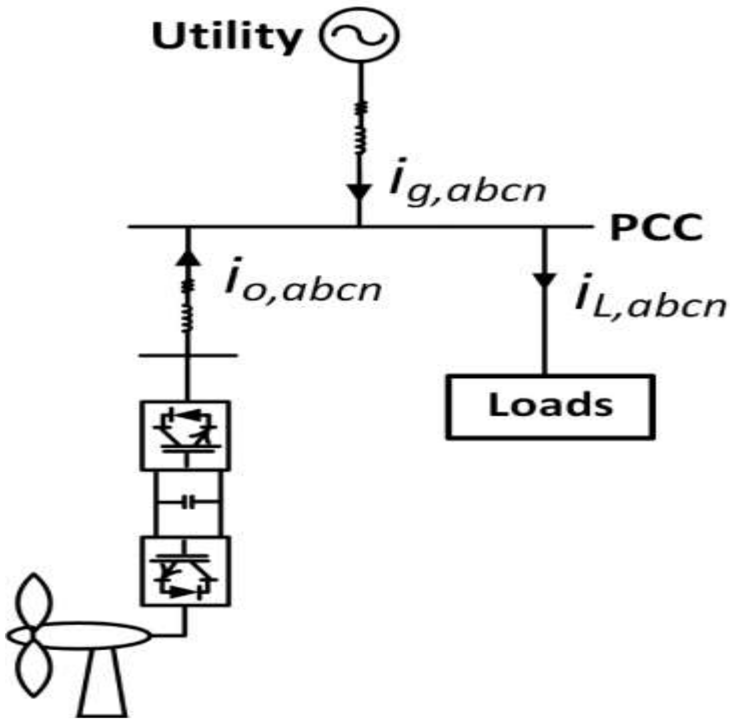

Figure 1: Diagram for Proposed System

WIND TURBINE:

Wind turbines square measure classified into 2 general types: Horizontal axis wind turbine and Vertical axis wind turbine. A vertical axis wind machine has its blades rotating on axis perpendicular to the bottom. The square measure variety of obtainable styles for each and every kind has bound benefits and downsides [7].

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, May : 2023

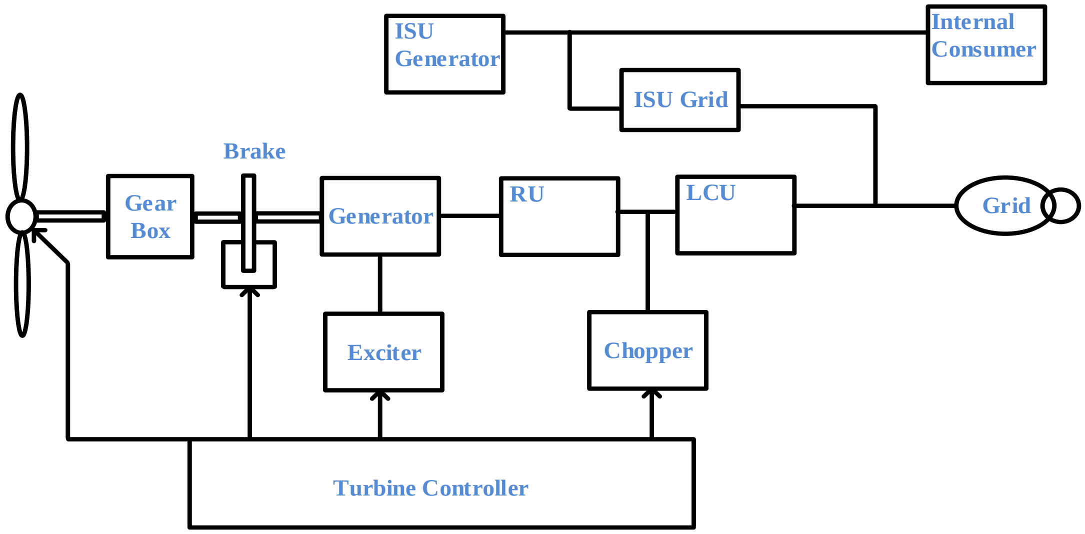

Figure 2: Basic Wind Turbine System

The wind turbines with a squirrel cage generator are equipped with a soft starter mechanism for reactive power compensation as coop generators consume reactive power. This generator and also the turbine rotor area unit coupled through a shell, because the best rotor and generator speed ranges are totally different.

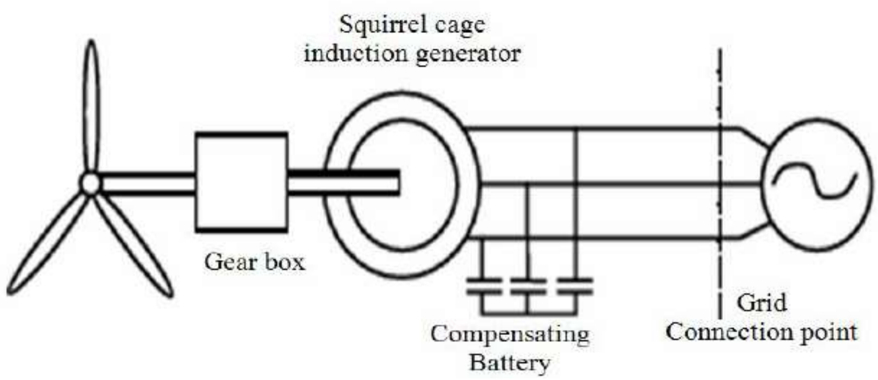

Figure 3: SCIG based WES

STATCOM and its Control Technique:

A STATCOM is a one of the compensated device which is obtained from the FACTS family [11] and is a combination of power electronic converter along with reactor. Mostly, the converter is constructed by the use of fully controlled devices such as GTO, IGBT or MOSFET. The main purpose of this STATCOM converter control technique is used to compensate the deviations in power system for improving power quality. In this paper grid interfaced wind turbine based STATCOM control scheme is proposed for improving the reliability of electrical power [12].

• The Dc voltage obtained for STATCOM is generated from Solar Cells. The schematic diagram of Static compensator is given in figure 4.

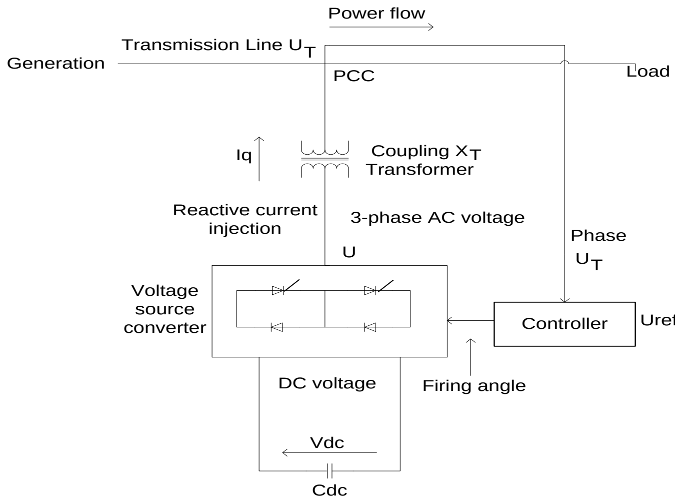

Figure 4: Basic block diagram for static compensator.

The utilization of different types of electrical loads in three phase system, produces an unbalances in current, which causes the unreliable power [13]. Thereby for maintaining the electrical reliability the statcom controller plays a key role. In this statcom control technique, the reference voltage and dc link capacitor voltages are compared and the result obtained from this is converted to two phase coordinators called as orthogonal vectors.

Control for Reactive Power Compensation

The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load under system disturbances is connected. The control system only measures the root mean square (r.m.s) voltage at the load point, i.e., no reactive power measurements are required. The VSC switching strategy is based on a sinusoidal PWM technique which offers simplicity and good response. Since custom power is a relatively low-power application, PWM methods offer a more flexible option than the fundamental frequency switching methods favored in FACTS applications. Apart from this, high switching frequencies can be used to improve on the efficiency of the converter, without incurring significant switching losses.

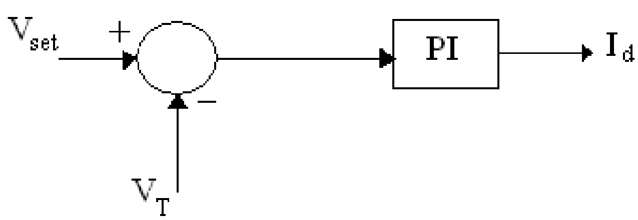

Figure 5: PI Control Scheme

The controller input is an error signal obtained from the reference voltage and the r.m.s terminal voltage measured. Such error is processed by a PI controller; the output is the angle δ, which is provided to the PWM signal generator. It is important to note that in this case, of indirectly controlled converter, there is active and reactive power exchange with the network simultaneously. The PI controller processes the error signal and generates the required angle to drive the error to zero, i.e. the load r.m.s voltage is brought back to the reference voltage.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, May : 2023

Artificial Neural Networks

Figure 6 shows the basic architecture of artificial neural network, in which an hidden layer is indicated by circle, an adaptive node is represented by square. In this structure hidden layers are presented in between input and output layer, these nodes are functioning as membership functions and the rules obtained based on the if-then statements is eliminated. For simplicity, we considering the examined ANN have two inputs and one output. In this network, each neuron and each element of the input vector p are connected with weight matrix W.

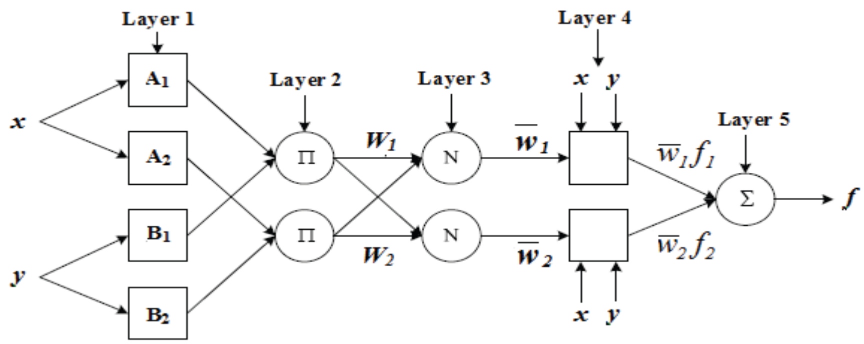

Figure 6: ANN architecture for a two-input multi-layer network

Where the two crisp inputs are x and y, the linguistic variables associated with the node function are Ai and Bi. The system has a total of five layers are shown in Figure 6.

Step by step procedure for implementing ANN:

1. Identify the number of input and outputs in the normalized manner in the range of 0-1.

2. Assume number of input stages.

3. Identify number of hidden layers.

4. By using transig and poslin commands create a feed forward network.

5. Assume the learning rate should be 0.02.

6. Choose the number of iterations.

7. Choose goal and train the system.

9. Generate the simulation block by using ‘genism’ command.

SIMULATION STUDY

The simulation is done based on the figure 1. The simulation results for the proposed grid interfaced wind energy system with D-STATCOM is shown in below figures.

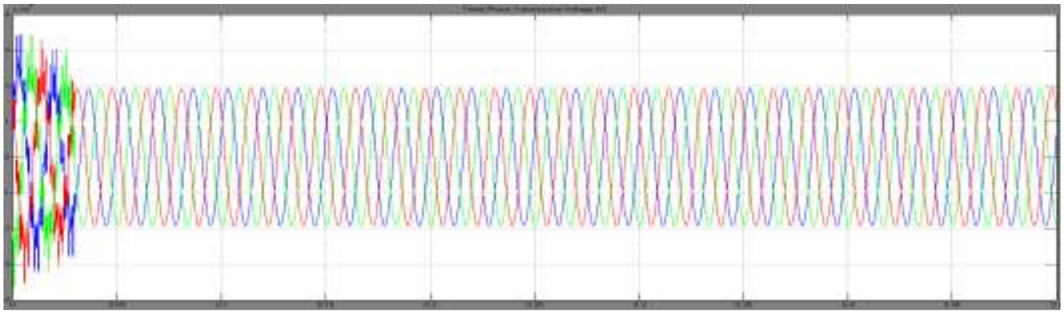

Figure 7: Simulation Result for Three Phase Output Voltage from Sending End

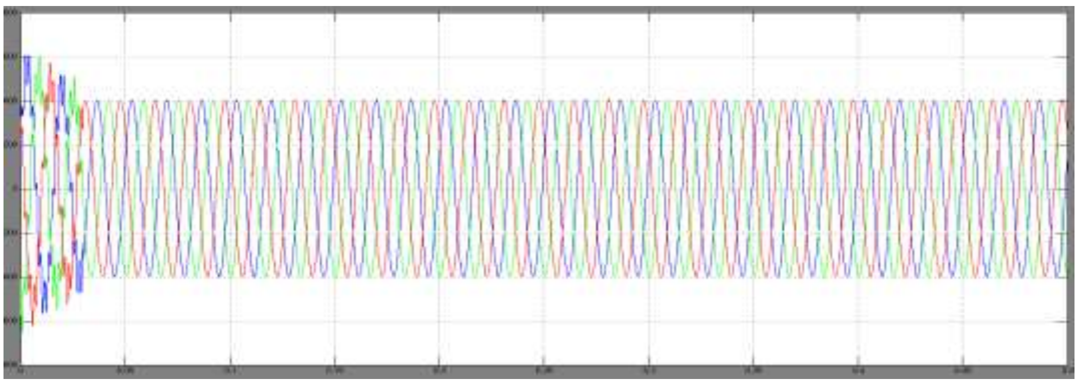

Figure 8: Simulation Result for Three Phase Output Voltage at Distribution Level

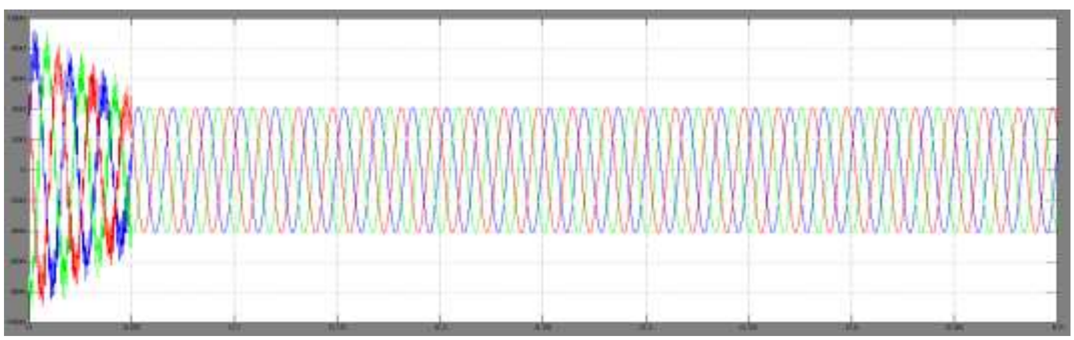

Figure 9: Simulation Result for Three Phase Output Voltage from wind System

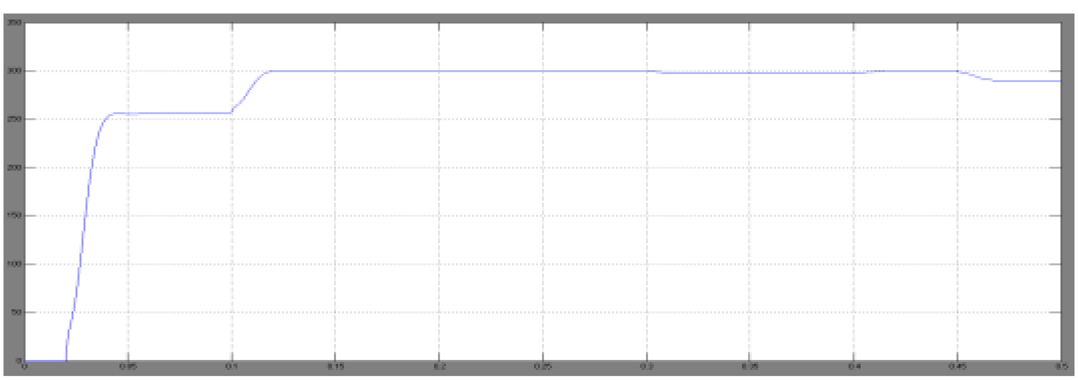

Figure 10: Simulation Result for Power Generated from the Transmission System

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, May : 2023

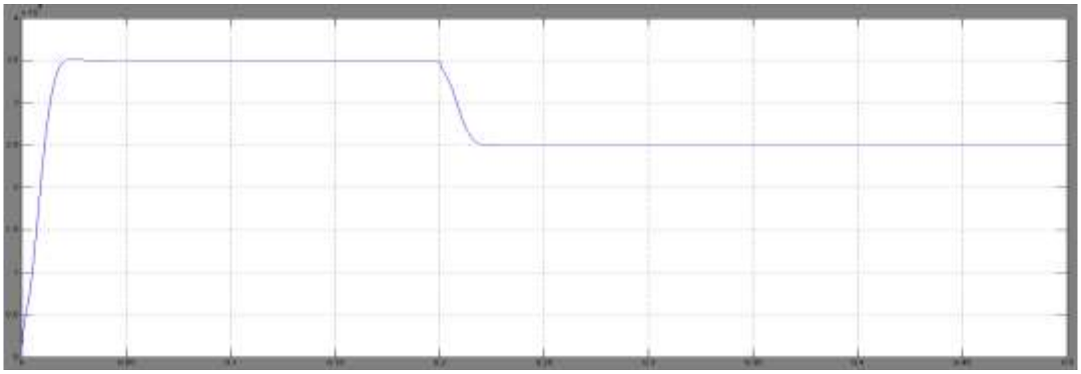

Figure 11: Simulation Result for Power Generated from the wind System

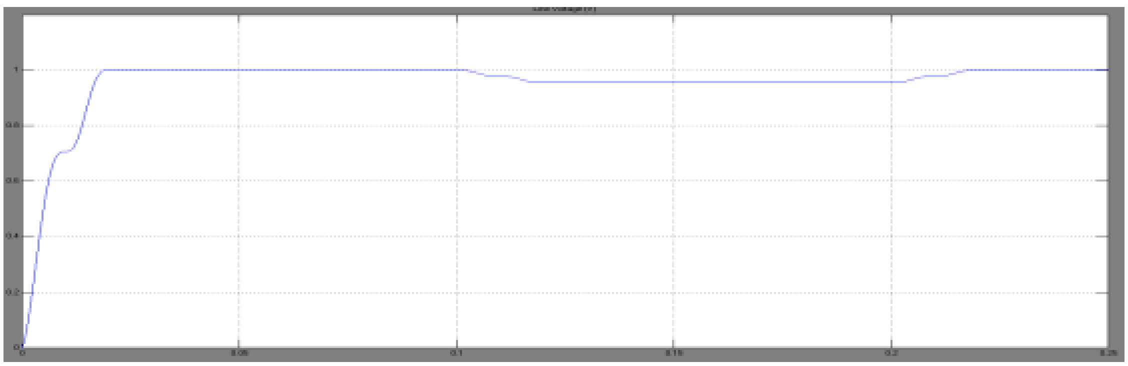

Figure 10: Simulation Result for Line Voltage under RMS with DSTATCOM and ANN

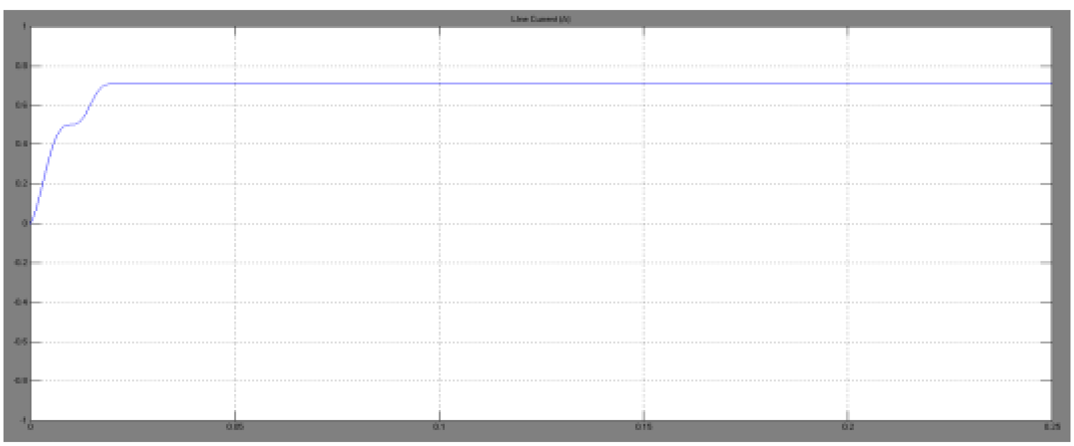

Figure 11: Simulation Result for Line Current under RMS with DSTATCOM and ANN

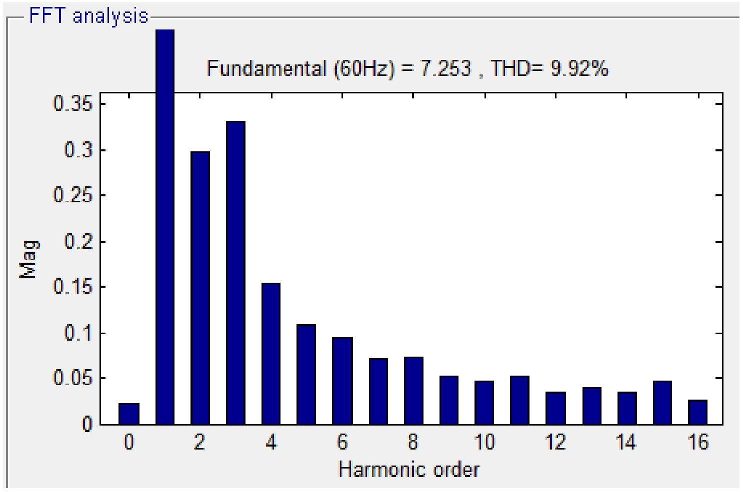

Figure 12: THD value for Line Current with ANN

CONCLUSION

The paper presents a novel concept of integration of STATCOM with grid inter faced wind energy system for power quality improvement. The paper also presents effects of power quality on consumer and power utility systems. The shunt devices proposed here, while reducing the distortions in currents, improved the power factor thus reducing the reducing the reactive power demand from the wind generator and the load at point of common coupling. Thus, the integration of FACTS devices maintains the desired power quality requirements. The operation of STATCOM and their control strategies are simulated in MATLAB/SIMULINK.

REFERENCE

[1] A.Q.Huang, M Baran, S.Bhattacharya "STATCOM importance on the integration of a large wind farm into a weak loop power system," IEEE Trans. Energy Conv., vol. 23, no. 1, pp. 226–232, Mar. 2008.

[2] Hook, Y. Liu, presents a paper on "Mitigation of the wind generation integration related power quality problems by energy storage," at EPQU J., vol. XII, no. 2, in 2006.

[3] Wind Turbine Generating System—Part 21, International standard-IEC 61400-21, 2001.

[4] J.Manel, "Power electronic system for grid integration of renewable energy source: A survey," IEEE Trans. Ind. Electron., vol. 53, no. 4, pp. 1002–1014, 2006, Carrasco.

[5] S. Ezhilarasan, P. Palanivel, S. Sambath "Design and Development of Energy Management System for DG Source Allocation in a Micro Grid with Energy Storage System" Volume 8, Issue 13, July 2015.

[6] S.Heier, Grid Integration of Wind Energy Conversions. Hoboken, NJ: Wiley, 2007, pp. 256–259.

[7] J.J.Gutierrez, J.Ruiz, L.Leturiondo, and A.Lazkano, "Flicker measurement system for wind turbine certification," IEEE Trans. Instrum. Meas., vol. 58, no. 2, pp. 375–382, Feb. 2009.

[8] Indian Wind Grid Code Draft report on, Jul. 2009, pp. 15–18, C-NET.