International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 2 Issue 8, August-2013, pp: (18-23), Available online at: www.erpublications.com

Power quality improvement in DFIG system using D-STATCOM

Shailendra Kumar[1], Mrs. Preeti Jain[2]
[1,2]Department of Electrical Engineering, Jabalpur Engineering College, Jabalpur, M.P., India

Abstract: The wind energy conversion system (WECS) differs from other power systems. It is clean and pollution free. But the output of wind power plant is fluctuated in nature. It depends on the wind speed. The nature of wind is variable. The variable wind generates fluctuated power. Fluctuated output is the major problem of wind power plant. This problem can be solved by using convertor units. The second problem of wind power plant is different types of fault occurring in wind power plants, like line fault and grid fault etc. This paper discusses the fault in wind power plant or fault analysis in DFIG system, using D-STATCOM. The D-SATCOM is a shunt device which is used to solve fault problem in distribution system. These papers discuss the analysis and output characteristics of doubly feed induction generator (DFIG) due to the normal and abnormal condition. This paper has presented the power quality problems such as voltage dips, swells and interruptions, and mitigation techniques of custom power electronic device D-STATCOM. This device is used for controlling the voltage fluctuation, flicker reduction and to maintain voltage stability.

Keywords: Doubly feed induction generator, VSC (voltage source converter), D-SATCOM, MATLAB simulink.

1. INTRODUCTION

In recent years, the demand of electricity is increased due to industrialization and globalization, but the source of energy are limited in the earth like coal, gas, uranium and other conventional sources of energy. This problem can be solved by using non conventional sources of energy like solar energy, wind energy, geothermal energy and any others non conventional sources. Wind is the useful non conventional source of energy in India and others countries. [1] The most important source of the non conventional sources of energy is wind power. Wind power plant generally used doubly fed induction generator to generate the electrical power. But the nature of wind is variable at time to time. This variable speed of wind also affected the rotor of the generator. The output of generator is fluctuated. This problem can be solved by using the AC/DC/AC convertor unit. This paper discusses the investigation of different types of fault created in wind power plant, and clearing the fault by using D-SATCOM.

The use of doubly fed induction generators (DFIGs) in large wind energy conversion systems (WECS) has significantly increased during the last few years. The DFIG is interfaced to the AC network through a grid side voltage source converter (GSC) and a rotor side voltage source converter (RSC) to enable the variable speed operation of the wind turbine. Moreover, it provides reactive power support to the AC grid during disturbances. Due to large inductive load voltage sag occurs in the system that affects the voltage stability. By using D-STATCOM in DFIG system improves power transfer capability of the system up to thermal limit without affecting the stability. [3]

The main objective of using D-STATCOM is to improve the voltage profile and power quality in distribution system during normal as well as abnormal condition and also to improve the transient stability of system during fault condition so that to meet continuity of supply. The ultimate objective of compensation is to increase transmittable power. This may required to improve the steady state transmission characteristics as well as stability of system.

2. RESEARCH METHODOLOGY

A. Doubly Fed Induction Generator

A doubly fed induction machine is basically a standard, wound rotor induction machine with its stator windings directly connected to the grid and its rotor windings connected to the grid through a converter. The AC/DC/AC Converter is divided into two components: the rotor side converter and the grid side converter. These converters are voltage source converters that use force commutation of a DC source. A capacitor connected on the DC side acts as the DC voltage source. A coupling inductor is used to connect the grid side converter to the grid. [5] The three phase rotor winding is connected to the rotor side converter by slip rings and brushes. The three phase stator windings are directly connected to the grid. The control system generates the pitch angle command and the voltage command signals Vr and Vgc for the rotor, Grid side converters respectively in order to control the power of the wind turbine, the DC voltage and the reactive power or the voltage at the grid terminals. After the fault is removed, the grid-side converter can be controlled again to establish the dc-link voltage; however, the dc-link voltage is likely to be fluctuated during this period. In addition, the rotor current control might be affected by the dc-link voltage fluctuation when the DFIG is running back to the normal condition. The ride-though capability of a DFIG system has been evaluated under different levels of voltage dips. It is shown that power electronic converters may be kept in operation during a non-serious voltage dip.

However, it is important to keep the dc-link voltage stable and limit the fluctuation of the grid-side converter current during a grid fault, so that the dc-link capacitor could be protected and the adequate voltage on the rotor could be provided. [8]

The wind power developed by the turbine is given by the equation (1)

$$P=\frac{1}{2}c_p\rho AV^3 \text{ .... (1)}$$

where P = power developed, Cp is the Power Co-efficient, ρ is the air density in kg/m3, A is the area of the turbine and V is the wind velocity in m/sec. The power coefficient Cp gives the fraction of the kinetic energy that is converted into mechanical energy by the wind turbine.

B. D-STATCOM

Basically, D- STATCOM is comprised of three main parts, a voltage source inverter (VSI), a step-up coupling transformer, and a controller. In a very-high-voltage system, the leakage inductances of the step-up power transformers can function as coupling reactors. The main purpose of the coupling inductors is to filter out the current harmonic components that are generated mainly by the pulsating output voltage of the power converters.

I. Voltage Source Converter (VSC)

A voltage-source converter is a power electronic device, which can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. Voltage source converters are widely used in adjustable speed drives, but can also be used to mitigate voltage dips. The VSC is used to either completely replace the voltage or to inject the 'missing voltage'. The 'missing voltage' is the difference between the nominal voltage and the actual. The converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage. [4]

II. Coupling Transformer

Coupling transformer is used to connect the grid to D-STATCOM.

III. Controllers

The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The control system only measures the RMS 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. The controller input is an error signal obtained from the reference voltage and the value RMS of the 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, indirectly controlled converter, there is active and reactive power exchange with the network simultaneously: an error signal is obtained by comparing the reference voltage with the RMS voltage measured at the load point. The PI controller process the error signal generates the required angle to drive the error to zero, i.e., the load RMS voltage is brought back to the reference. [9]

Shunt injected current I_{sh} corrects the voltage sag by adjusting the voltage drop across the system impedance Z_{th}. The value of I_{sh} can be controlled by adjusting the output voltage of the converter. The shunt injection current I_{sh} can be written as

$$I_{sh} = I_L - I_S = I_L - [\frac{V_{TH}}{Z_{TH}} - \frac{V_L}{Z_{TH}}] \text{ .... (2)}$$

The complex power of D-STATCOM is given as

$$S_{sh} = V_L I_{Sh}^* \text{ .... (3)}$$

It may be mentioned that the effectiveness of the D-STATCOM in correcting voltage sag depends on the value of Z_{th} or fault level of the load bus. When the shunt injected current I_{sh} is kept in quadrature with V_L, the desired voltage correction can be achieved without injecting any active power into the system. On the other hand, when the value of I_{sh} is minimized, the same voltage correction can be achieved with minimum apparent power injection into the system.

3. MODEL DESCRIPTION

MATLAB simulation is done in 11kv system, and D-STATOM of $\pm 3\ Mvar$ is used for compensation. Analysis is done with considering LG and line to line fault with various loading conditions. Simulation of DFIG system with D-STATCOM is shown in fig. 1. The stator of the DFIG is directly connected to the grid through the transformer. 0.44/11 kV transformer is used for step up the voltage for commercial and industrial load. Three phase fault is used for generate the voltage sag in this system. This model basically considers only two faults, (a) Line to ground fault, and (b) Line to line fault. D-STATCOM plays the most important role in this system to improve the voltage sage and flickers.

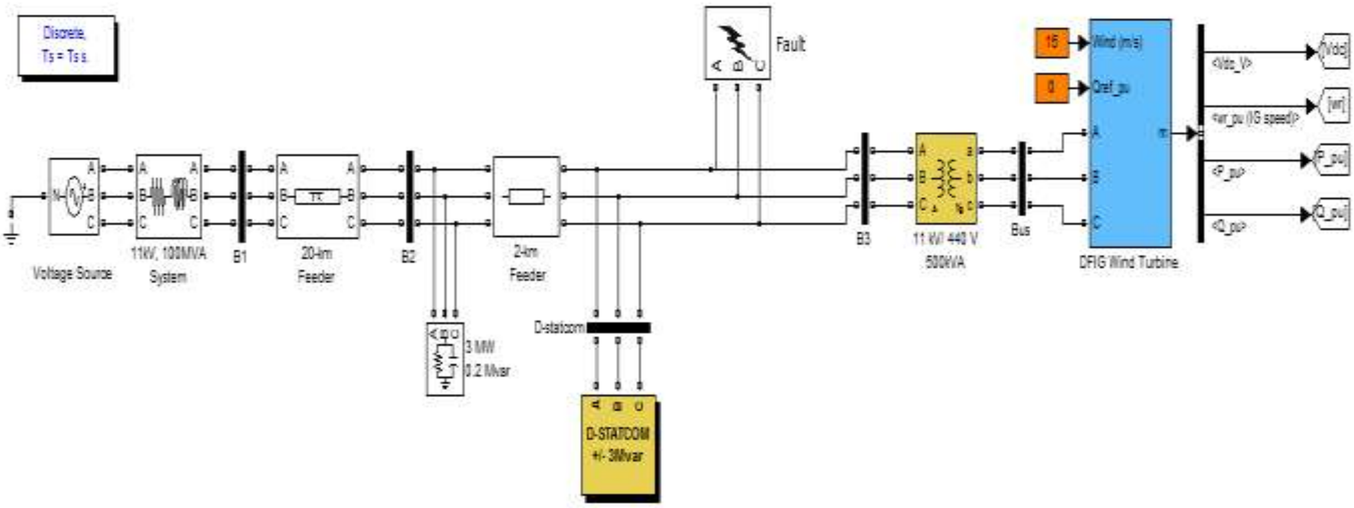

FIG 1: SIMULATION OF DFIG SYSTEM WITH D-STATCOM

4. SIMULATION RESULTS

The output results of DFIG model shown in figure given below. When apply the faults at different loading condition in that case current increase and value of voltage is reduce under the fault duration and this problem is solved by using D-STATCOM. After the fault is removed the system Voltage may recover to a correct value than its pre-fault value.

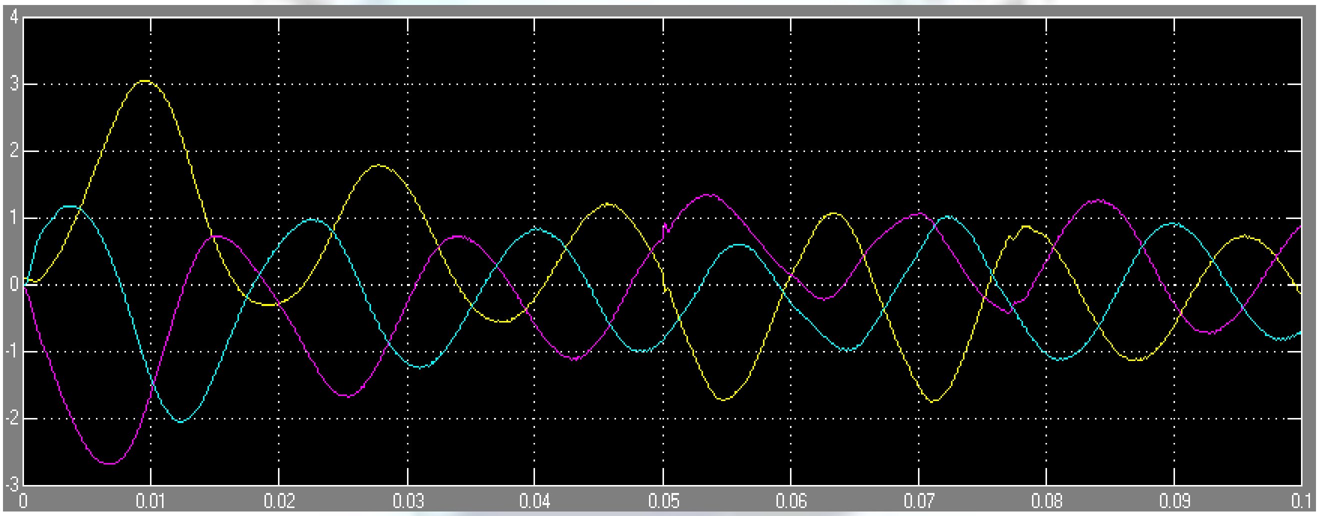

Fig.2 Current waveform during LG fault without D-STATCOM

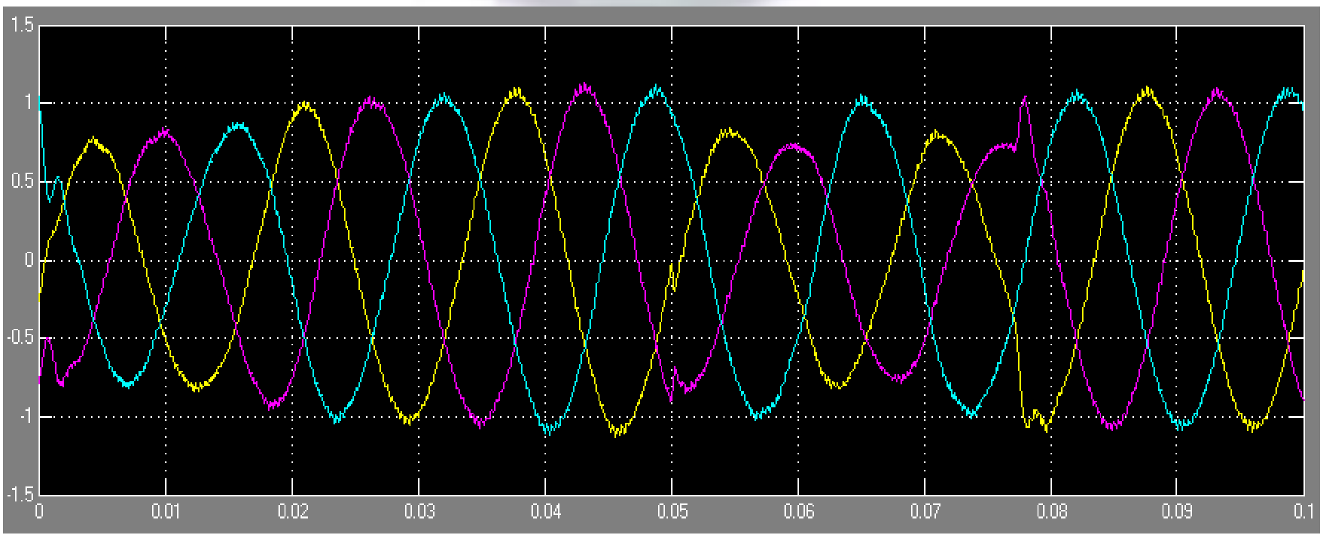

Fig.3 Voltage waveform during LG fault without D-STATCOM

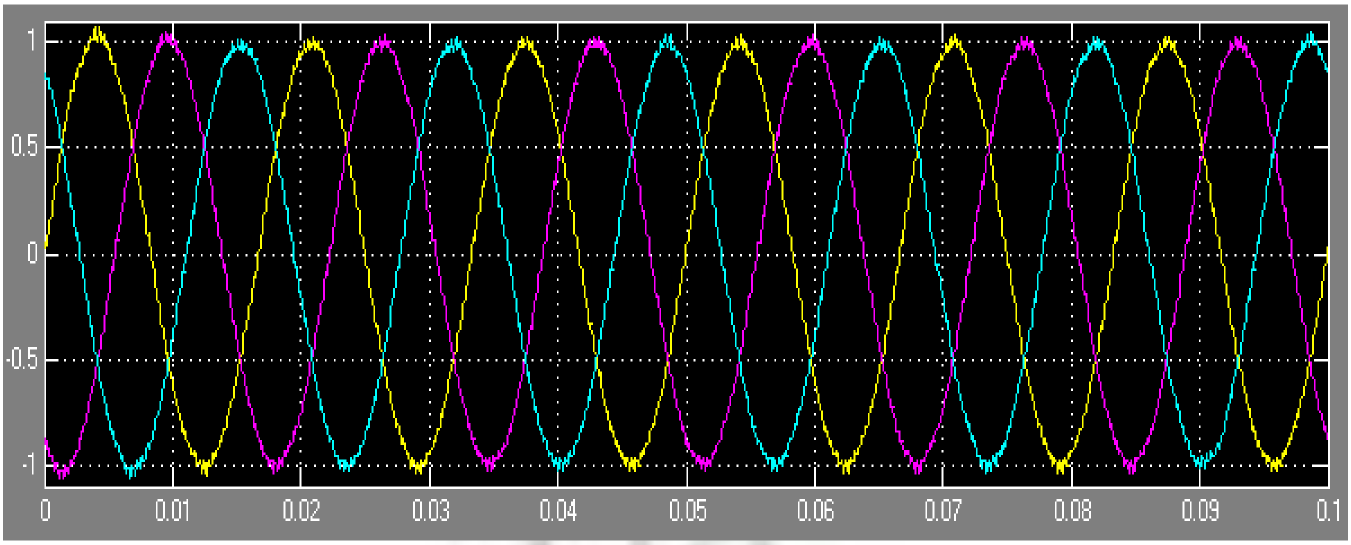

Fig.4 Voltage waveform during LG fault with D-STATCOM

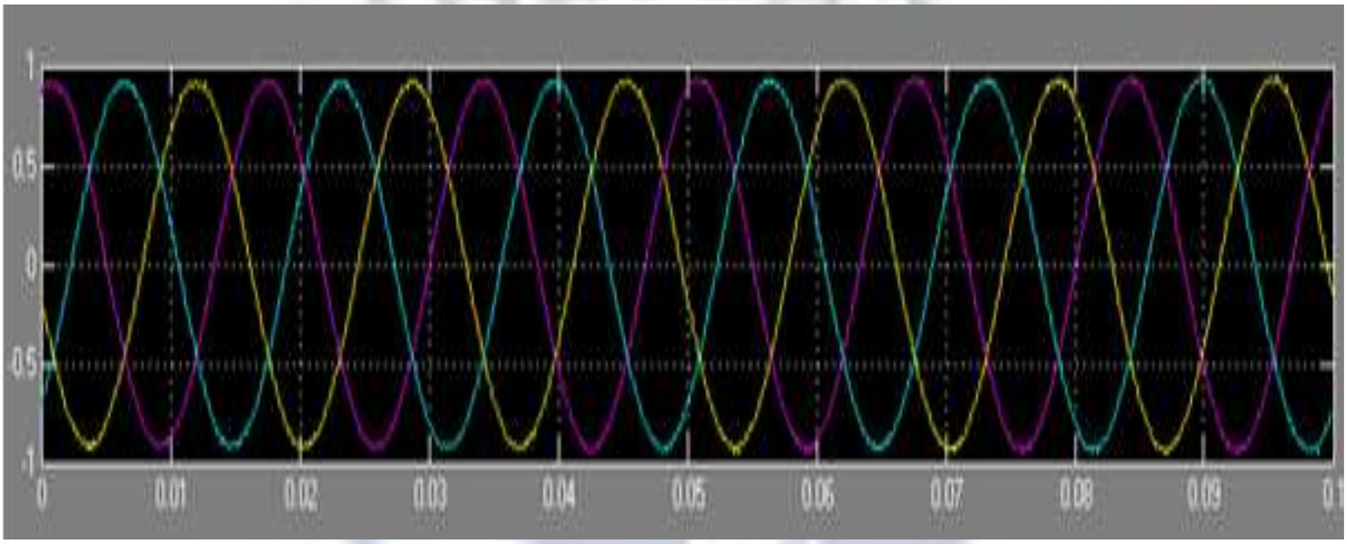

Fig.5 Current waveform during LG fault with D-STATCOM

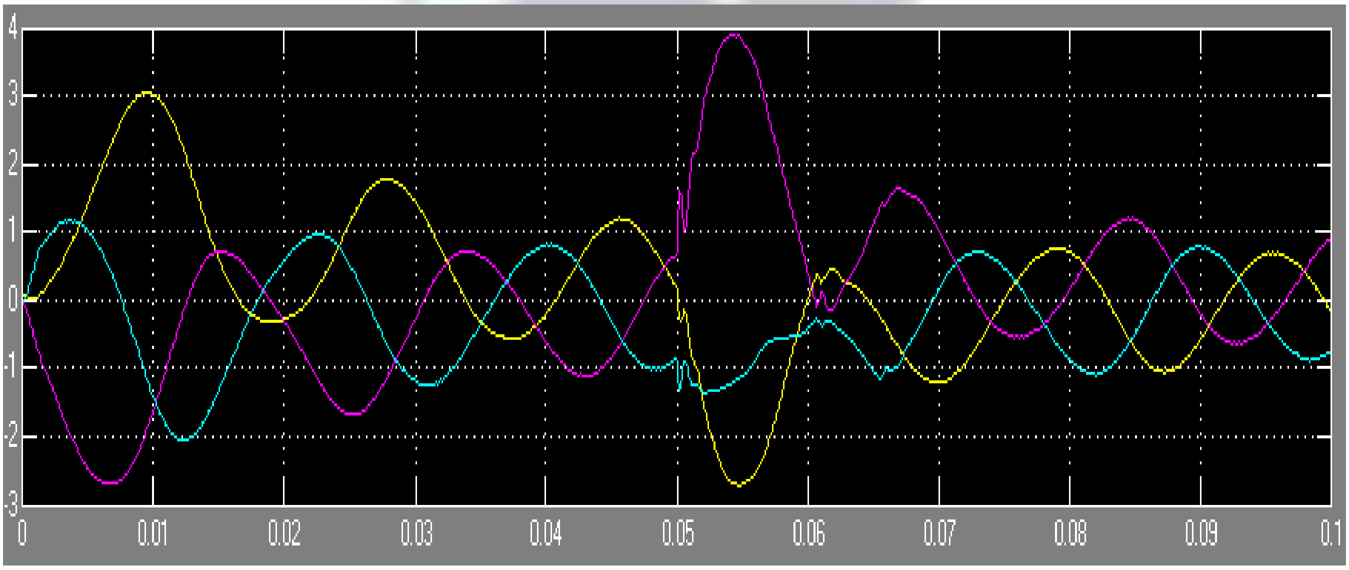

Fig.6 Current waveform during LL fault without D-STATCOM

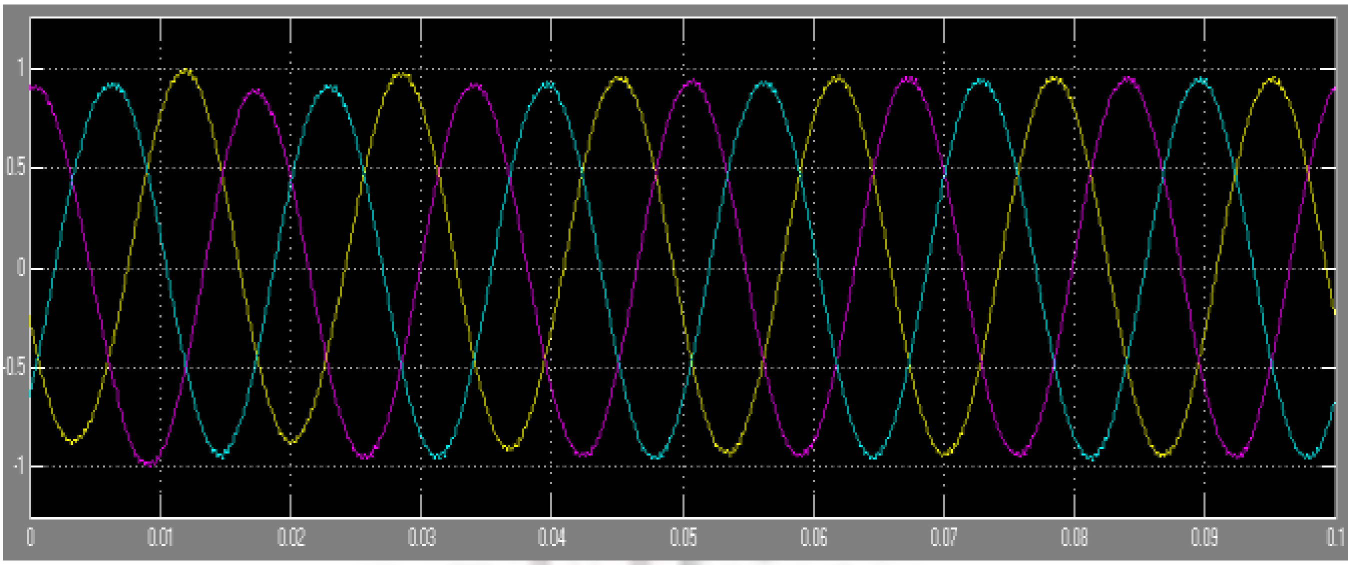

Fig.7 Current waveform during LL fault with D-STATCOM

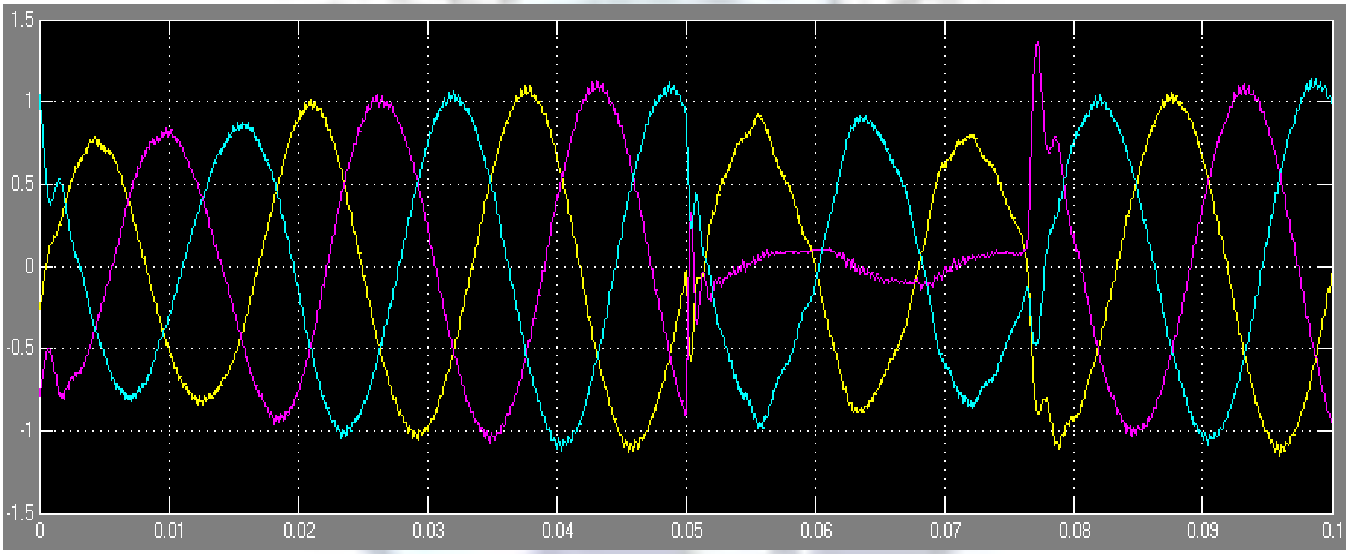

Fig. 8 Voltage waveform during LL fault without D-STATCOM

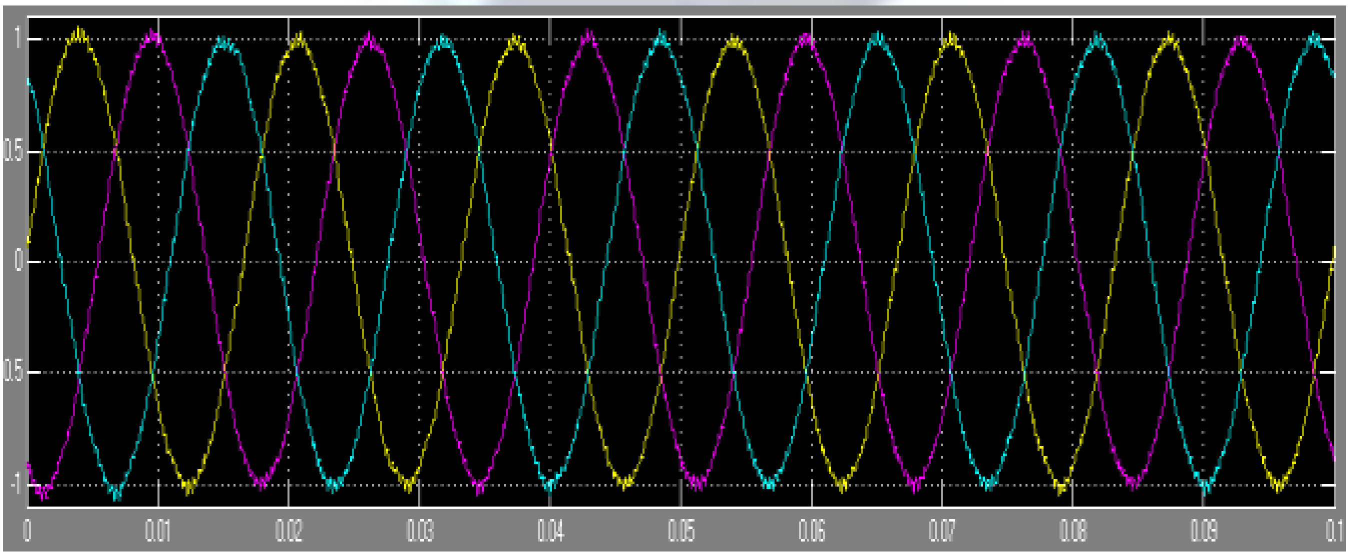

Fig. 9 Voltage waveform during LL fault with D-STATCOM

5. CONCLUSION

Voltage dip and voltage flickering are the two major power quality problems which are frequently seen in the distribution systems. These power quality problems in 11KV distribution systems are investigated in this paper. The analysis and simulation of a D-STATCOM application for the mitigation of voltage flicker problems are presented in DFIG system. From the above results it is clear that D-STATCOM is able to compensate the voltage and current during various fault conditions. It is also able to compensate both overvoltage and under voltages. This paper has presented the application of D-STATCOM to improve the voltage flickers in a power system during and after fault.

REFERENCES

[1] S. Muller, M. Deicke, and R. W. De Doncker, "Doubly fed induction generator systems for wind turbines," IEEE Ind. Appl. Mag., vol. 8, no. 3, pp. 26–33, May/Jun. 2002.

[2] J. M. Rodríguez, J. L. Fernández, D. Beato, R. Iturbe, J. Usaola, P. Ledesma, and J. R. Wilhelmi, "Incidence on power system dynamics of high penetration of fixed speed and doubly fed wind energy systems. Study of the Spanish case," IEEE Trans. Power Syst., vol. 17, no. 4, pp. 1089–1095, Nov. 2002.

[3] M. Yamamoto and O. Motoyoshi, "Active and reactive power control for doubly-fed wound rotor induction generator," IEEE Trans. Power Electron., vol. 6, no. 4, pp. 624–629, Oct. 1991.

[4] B. Hopfensperger, D. J. Atkinson, and R. A. Lakin, "Stator-flux-oriented control of a doubly-fed induction machine with and without position encoder," Proc. Inst. Elect. Eng., Electr. Power Appl., vol. 147, no. 4, pp. 241–250, Jul. 2000.

[5] P.Jintakosonwit, H.Fujita, and H.Akagi, "Control and performance of a fully – digital – controlled shunt active filter for installation on a power distribution system," IEEE Trans. Power Electron., vol.17, no.1, pp.132–140, Jan.2002.

[6] H.Akagi and H.Fujita, 2007, "Voltage – RegulationPerformance of a Shunt Active Filter Intended for Installation on a Power Distribution System", IEEE transactions on power electronics, vol.22, no.3, (May 2007)

[7] R.Inzunza and H.Akagi, 2005, "A 6.6 – kV transformer less shunt hybrid active filter for installation on a power distribution system", IEEE Trans. Power Electron., vol.20, no.4, pp.893–900, Jul.2005.

[8] P.S.Sensarma, K.R.Padiyar, and V.Ramanarayanan, "Analysis and performance evaluation of a distribution STATCOM for compensating voltage fluctuations," IEEE Trans. Power Delivery, vol.16, no.2, pp.259–264, May2001.

[9] M. P. Papadopoulos, S. A. Papathanassiou, N. G. Boulaxis, and S. T. Tentzerakis, "Voltage quality change by grid-connected wind turbines," in European Wind Energy Conference, Nice, France, 1999, pp. 783–785.

[10] R. Pena, R. Cardenas, G. Asher, J. Clare, J. Rodriguez, and P. Cortes, "Vector control of a diesel-driven doubly fed induction machine for a stand-alone variable speed energy system," in IEEE Annual Conference of the Industrial Electronics Society, vol. 2, lines," IEEE Trans. Ind. Appl., vol. 36, no. 4

[11] Hendri Masdi , Norman Mariun, S.M.Bashi, MIEEE, A.Mohamed, Sallehhuddin Yusuf MIEEE, "Design o a Prototype DSTATCOM or voltage sag mitigation".