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Power Quality Mitigation & THD Reduction using STATCOM for Renewable Energy System

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Abstract

Electric power is the growing demands with Renewable Energy system power makes huge impact on power generation side. Wind System generates considerable amount of power that has unstable conditions. Grid interfacing the wind power is quiet difficult task as harmonics generated in the power. Voltage Flicker is main Power quality issues that causes Industrial and Domestic disturbances that affect the power quality leads to serious Issues in wind power supply. Static VAR (SVAR) is a Compensator Power works under VSC. The SVAR shunted as compensating device to improve Voltage quality by injecting a controllable current, which will increase the quality of the load current. The stability of SVAR is decreased as output voltage decrease. STATCOM is used belong to family of FACTS. In this paper 24 pulses STATCOM has been performed harmonics content is high. An LC filter has been used in STATCOM to reduce harmonics. The proposed model is verified using MATLAB/SIMULINK.

Keywords: *STATCOM, Wind power, Voltage Flicker, THD, SVAR compensator*

I. INTRODUCTION

Power Demands gets increasing day by day. The source of conventional power generation Methods is getting worse. The grid is supplying only one third of generated power to distributor losses in distribution are unlimited one. As that case Renewable Energy system is attracted more and more power generation through system. The advantage with Sources at free of cost, storage of power, pollution free added advantage of Renewable energy system. The Solar and Wind power are major contributors of renewable energy systems. Solar power is made available only in day light times which able to store energy in Batteries and inverted when power is required. The wind generation is available depends on external condition it is unstable one. The generated wind power is in form of Three Phase Alternating. The wind turbine is converted to be converted using electronics converters. The Wind Energy is depended on weather condition Wind Flow cannot predicted is a Natural Factor.

The generated wind has limitations. The Wind energy power can’t able to maintain constant power deliver to the connected grid. The influence on voltage fluctuation and flicker causes Power quality issues in the generated wind power. The Wind energy power plant is shown in Fig.1 power quality issue in generated wind power has concern to connect to grid. The Power Compensation Device has been introduced in wind power to overcome power quality issues. Over the years as many compensation devices have come up with different compensation techniques in Grid interfacing. The Compensator power Device Such has Dynamic Voltage Restorer and SVR device.

II. DYNAMIC VOLTAGE RESTORER

The Dynamic Voltage Restorer (DVR) installed in series or a STATCOM connected in shunt with the critical load, the line voltage can be restored to its nominal value within the response time of a few milliseconds, thus avoiding any power disturbances to the load. The STATCOM has a function of compensating reactive power, absorbing the harmonic and compensating the voltage flickering problems. The Voltage Flicker as increases in generated wind power as the turbulence of wind plant. The Flicker level increases as three times from lower to higher due to turbulence of wind power. For Variable speed wind turbines, the flicker level has maximum level as wind speed increases. As the wind turbines reaches its rated power will have bland out and limit the flicker.

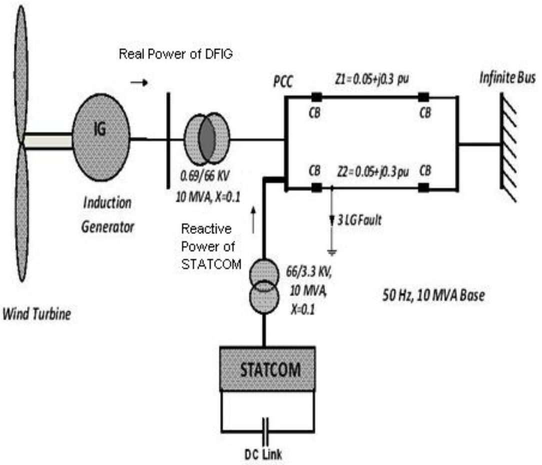

Figure 1. Power STATCOM Model of Wind Power Plant

The Power Quality in grid interfacing has different issues with load side calculations[1] Voltage Flicker[2],Harmonics[3],lighting and over voltages Protection[4].Issues in power quality upon Wind turbines has been discussed[5]. The measurement of Power Quality parameters in wind turbines has is presented by Jorgensen [6]. Even Wind power shaft Cause disturbance in System which leads to voltage variations[7].

III. COMPENSATION AND POWER CONTROL

To overcome power quality issues a compensator has been introduced in transmission line. Flicker levels are determined by timeless measurements in wind turbine. The measured flicker levels compared with IEEE standard IEC 61400-21. The proposed Method attached a transmission line[8]. The IEC 61400-21 flicker coefficient in wind turbine.

$$\boldsymbol{c(\Psi k)^1} = \mathbf{Pst.fic}\,\frac{\mathbf{Skfic}}{\boldsymbol{S\,ref}} \quad (1)$$

Where $c(\Psi k)$is coefficient of Flicker and Sref is apparent power, Pst,fic is angle of grid angle

$$\boldsymbol{k} = arctan\frac{Xk}{Rk} (2)$$

Xk = Grid Reactance; Rk = Grid Resistance

$$Ps = \boldsymbol{c(\Psi k)^1}\frac{\boldsymbol{Sref}}{\boldsymbol{Sk}} \quad (3)$$

The Equation of flicker from IEC 61400-21 connected to grid in transmission line

$$Pts = \sqrt{\textstyle\sum_i Pst, i} \quad (4)$$

Where Pts, i is the flicker emission from wind turbine. The ultimate purpose in the design of a STATCOM for medium voltage (MV) applications is to generate fully controllable sinusoidal line currents on the MV side of STATCOM system. Line current waveforms of STATCOM can be approximated to a sine wave which should comply with IEEE 519-1992 primarily by the use of a proper PWM technique and secondly by carefully designing the input filter of STATCOM.

Theinstantaneousreactivepowerisused maintaining stability in a system. The 3 phase voltage transformation technique is applied to converted the (Ia, Ib, Ic, to d, q, o) axes. The park transformation is techniques to transform Three phase axes to d,q axis followings equation is expressed in terms of MATLAB simulink model for transformation[9].

$$V_d=\frac{2}{3}\left(Va\,Sin\,(wt) + Vb\,Sin\left(wt - \frac{2\pi}{3}\right) + Vc\,\sin(wt + \frac{2\pi}{3}\right) \quad (5)$$

$$V_q=\frac{2}{3}\left(Va\,Cos\,(wt) + Vb\,Cos\left(wt - \frac{2\pi}{3}\right) + Vc\,Cos(wt + \frac{2\pi}{3}\right) \quad (6)$$

$$V_{O}= \frac{1}{3}(Va + Vb + Vc) \quad (7)$$

The dynamic charters-ices of voltage fluctuations in connected node of voltage flicker that are generated by load. The three vectors current has been placed in to derive compensation current that overcomes from the SVAR compensator.

$$Ic = j\left(im + \frac{irR}{x}f + \left(\frac{1}{\omega}\right)\frac{dir}{dt} + K\right) \quad (8)$$

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Where R and X are the resistance and reactance of the line and *f* is the correcting coefficient.

IV. RESULTS AND ANALYSIS

In this paper 69kv, 3Φ, for 100 km 3-Φπ section lines is leads to 3Φ transformer for step-down operation are proposed. The power so obtained from wind power plant. Harmonics is generated by Programmable VSC with amplitude mod of 0.3pu, frequency of 10 Hz. The proposed model is simulated using MATLAB SIMULINK fig. 2. To eliminateharmonics such as 11th and 13th order content a low pass filter is connected across the 24 pulse VSC output.

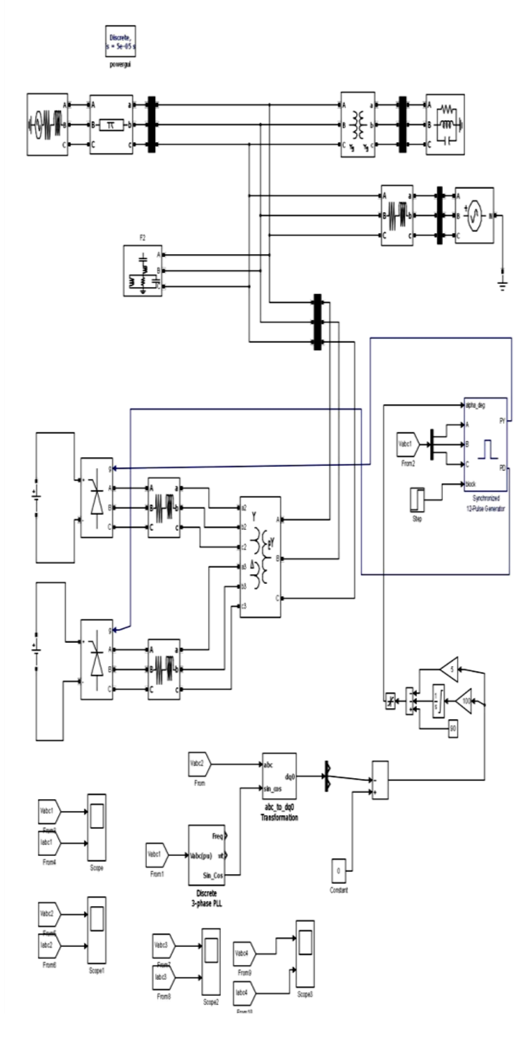

Figure 2. SIMULINK Model of 24 pulse VSC-STATCOM with harmonic filter

Fig. 2 shows SIMULINK diagram of 24 pulses VSC-STATCOM with 3Ø harmonic filter connected to the power system. The wind power is connected to VSC through π- network. The input voltage of wind power plant is shown in Fig. 3 and given as input to VSC. The harmonic has been injected in power lines as shown in Fig. 4. The output of VSC based STATCOM is shown in Fig. 4 in which the harmonics is completely eliminated by using STATCOM and filter. The harmonic spectrum been analyzed from Output voltage from STATCOM is shown in Fig.5. Comparison is made between 6 pulse, 12 pulse and 24 pulse compensator as shown in Table.1.

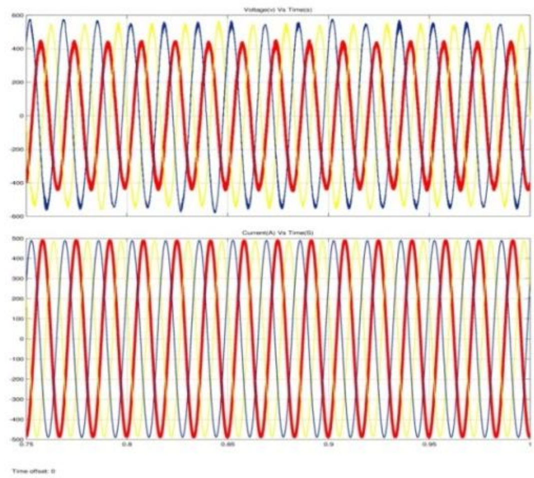

Figure 3. Harmonics injected in voltage and current of wind Plant

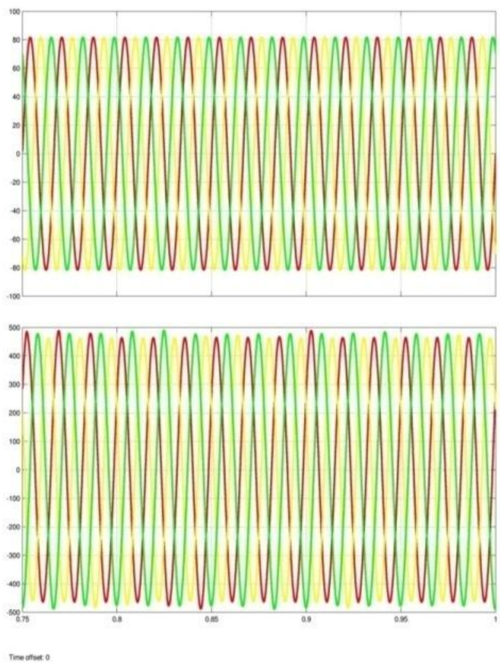

Figure 4. Harmonics injected in voltage and current of wind Power plant.

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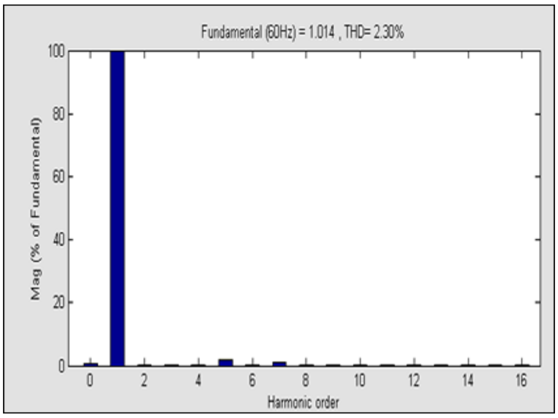

Figure 5. Harmonic Spectrum of Output Voltage 24- pulse VSC with filter

Table 1. Comparison of voltage flicker mitigation and THDvalueof STATCOM compensators

Compensator	**Compensated outputloadvoltage(maximumvalue)**	**Voltage Flicker**	**THD**
6 pulse VSCSTATCOM	1.15pu	Mitigatedby50%	8.95%
12 pulse VSCSTATCOM	1.15pu	Existingis0.15pu(15%)	4.47%
12pulseVSCSTATCOMwith3Øharmonicfilter	1.10 pu	Mitigatedby 75%	4.12%
24 12pulseVSCSTATCOMwith3Øharmonicfilter	1.0 pu	Completelymitigated	2.30%

V. CONCLUSION

Wind turbines have an uneven power production following the natural variations of the wind. The uneven power production is the same for all kinds of wind turbines. The power disturbances through by the tower shadow may cause flicker quality issues in power plant. In this paper the implementation of STATCOM has been proposed with VSC to mitigate power quality issues in wind Power Plant. The Harmonic spectrum and output results clearly verify that the proposed 24 pulse STATCOM equipped with harmonic filter is valuable candidate for power quality issues in Wind power plant.

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