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Power Quality Improvement in Renewable Energy Sources Using of STATCOM

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ABSTRACT: Renewable energy resources (RES) are being increasingly connected in distribution systems utilizing power electronic converters.The inverter is controlled to perform as a multi-function device by incorporating active power filter functionality. The inverter can thus be utilized as: 1) power converter to inject power generated from RES to the grid, and 2) shunt APF to compensate current unbalance, load current harmonics, load reactive power demand and load neutral current. Therefore, the DG systems are required to comply with strict technical and regulatory frameworks to ensure safe, reliable and efficient operation of overall network. With the advancement in power electronics and digital control technology, the DG systems can now be actively controlled to enhance the system operation with improved PQ at PCC. However, the extensive use of power electronics based equipment and nonlinear loads at PCC generate harmonic currents, which may deteriorate the quality of power. Generally, current controlled voltage source inverters are used to interface the intermittent RES in distributed system. Recently, a few control strategies for grid connected inverters incorporating PQ solution have been proposed. In an inverter operates as active inductor at a certain frequency to absorb the harmonic current.The study has been carried out using MATLAB/SIMULINK.The proposed method has been proved to be effective in improvement of power quality with all disturbances.

KEYWORDS: Active Power Filter (APF), Distributed Generation (DG), Distribution System, Grid Interconnection, Power Quality (PQ), Renewable Energy.

I.INTRODUCTION

Power quality can be analyzed based on voltage and current qualities as it is defined in terms of voltage and current. Poor power quality has undesirable effects on electrical equipment. The continuity and reliability degrade with the poor power quality of supply power. One of the major components for degrading the power quality is harmonics because of spreading of non-linear loads which are variable in nature. Improvement of poor power quality used on facts devices. Facts devices are power electronics family and it have different types. One of the distribution static compensator (DSTATCOM) is the reliable solutions for the current related power quality problems according to the international standards.

The FACTS concept is based on the substantial incorporation of power electronic devices and methods into the high-voltage side of the network, to make it electronically controllable (IEEE/CIGRE, 1995). Many of the ideas upon which the foundation of FACTS rests evolved over a period of many decades. Nevertheless, FACTS, an integrated philosophy, is a novel concept that was brought to fruition during the 1980‘s at the Electric Power Research Institute (EPRI), the utility arm of North American utilities.

FACTS looks at the ways of capitalizing on many breakthroughs taking place in the area of high-voltage and high current power electronics, aiming at increasing the control of power flows in the high voltage side of the network during both steady-state and transient conditions. Power electronic devices have had a revolutionary impact on the electric power systems around the world. The availability and application of thyristors has resulted in a new breed of thyristor-based fast operating devices devised for control and switching operations.

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Electric utilities and end users of electric power are becoming increasingly concerned about meeting the growing energy demand. A similar approach in which a shunt active filter acts as active conductance to damp out the harmonics in distribution network is proposed in. In a control strategy for renewable interfacing inverter based on– theory is proposed. In this strategy both load and inverter current sensing is required to compensate the load current harmonics. The non-linear load current harmonics may result in voltage harmonics and can create a serious PQ problem in the power system network.

There are the two stages over excited and under excited in synchronous machine that provides leading current and lagging currents respectively in two stages. And why are we talking about synchronous machine because STATCOM's working principle is quite similar to synchronous machine. STATCOM can exchange the active power and as well as the reactive power with an external DC source.

There are two stages of exchanging of active power and real power. For generating reactive power there are two condition and Interchange of Active Power: For the switches DC capacitor provides the active power. To maintain constant capacitor voltage for AC system the active power interchange is needed. And to make the constant capacitor voltage this active power of DC source will be given to AC system but for that case the system voltage will be guided by output voltage of VSC.

Active power filters (APF) are extensively used to compensate the load current harmonics and load unbalance at distribution level. This results in an additional hardware cost. However, in this paper authors have incorporated the features of APF in the, conventional inverter interfacing renewable with the grid, without any additional hardware cost.

Here, the main idea is the maximum utilization of inverter rating which is most of the time underutilized due to intermittent nature of RES. It is shown in this paper that the grid-interfacing inverter can effectively be utilized to perform following important functions:1) transfer of active power harvested from the renewable resources (wind, solar, etc.); 2) load reactive power demand support; 3) current harmonics compensation at PCC; and 4) current unbalance and neutral current compensation in case of 3-phase 4-wire system. Moreover, with adequate control of grid-interfacing inverter, all the four objectives can be accomplished either individually or simultaneously. The PQ constraints at the PCC can therefore be strictly maintained within the utility standards without additional hardware cost.

II.SYSTEM DESCRIPTION

A Voltage Source Converter (VSC) is a power electronic device that connected in shunt or parallel to the system. It can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. It also converts the DC voltage across storage devices into a set of three phase AC output voltages. It is also capable to generate or absorbs reactive power .As in the Fig.1 the system consist of an RES connected to the dc-link of a grid-interfacing inverter.

The voltage source inverter interfaces the renewable energy source to the grid. The RES may be a DC source or an AC source with rectifier coupled to dc- link. The fuel cell and photovoltaic energy sources generate power at variable low dc voltage, but the production of power in variable speed wind turbine is variable ac voltage. So before connecting on to a dc-link, the power generated from these renewable sources needs to be power conditioned (i.e., dc/dc or ac/dc). Usually the fuel cell integration is provided by using a unidirectional DC/DC converter (to obtain regulated high voltage DC), an inverter and a filter in order to accommodate the DC voltage to the required AC voltage (single phase or three phases).

A. DC-Link Voltage and Power Control Operation

Because of the intermittent nature of RES, the generated power is of variable nature. The dc-link connected aids in transferring this variable power from RES to the grid. RES are represented as current sources connected to the dc-link of a grid-interfacing inverter. The current injected by renewable into dc-link at voltage level V dc can be given as

$$\mathbf{Idc1 = Pres / Vdc}$$

where Pres is the power generated from RES.The current flow on the other side of dc-link can be represented as,

$$\mathbf{Idc2=Pinv/Vdc= +PLoss/Vdc}$$

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wherePinv, PG and PLoss are total power available at grid interfacing inverter side, active power supplied to the grid and inverter losses, respectively. If inverter losses are negligible then Pres = p

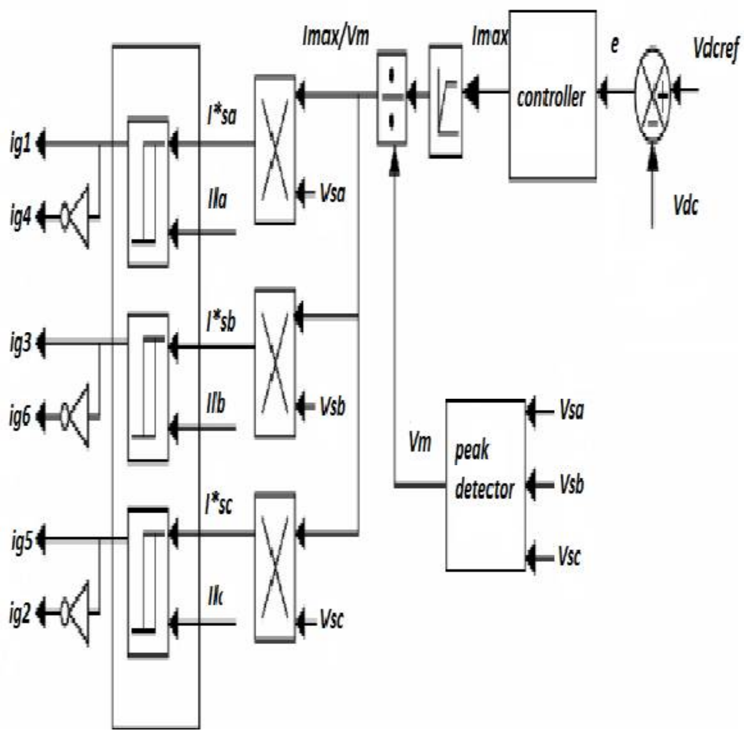

Fig 2.1 synchronous reference controller

B. Control of Grid Interfacing Inverter

A VSC-based DSTATCOM is connected to a three-phase ac mains feeding three-phase linear/non-linear load with internal grid impedance (Zs) which is shown in Fig.2.1. The steady state and dynamic performances of DSTATCOM depend upon the accuracy of detection of harmonics currents or disturbances. Interfacing inductors (Lf) are connected at ac output of the VSC to limit the ripple in compensating currents. A series combination of capacitor (Cf) and a resistor (Rf) represents the shunt passive ripple filter which is connected at the point of common coupling (PCC) to suppress the high frequency noise because of switching of the VSC.

The instantaneous currents can be written as

$$\mathbf{I_S(T) = I_L(T) - I_C(T)}$$

The capacitor voltage is compared with the reference dc voltage and the error signal is processed in a PI controller and is given by

$$e = \mathbf{V_{dc\,ref} V_{dc}}$$

III. SIMULATION AND RESULTS

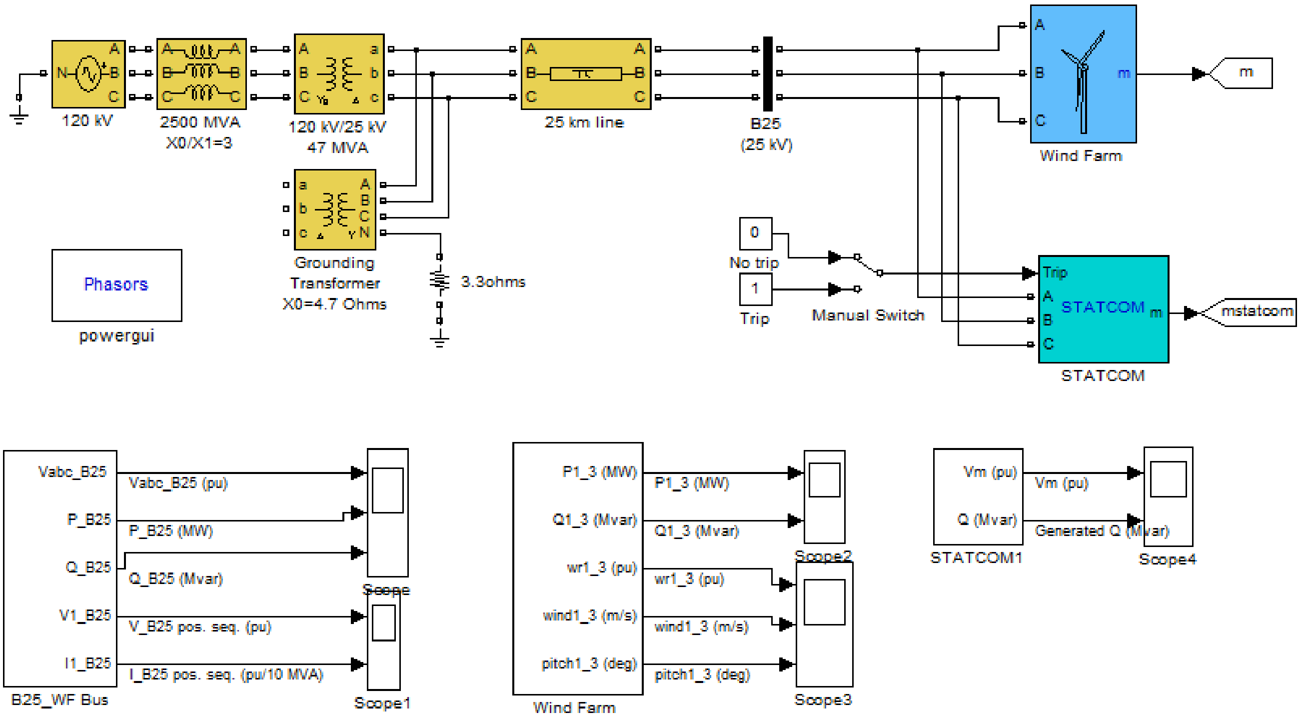

Fig 3.1 simulation diagram

The simulation diagram shows the combining of renewable energy source with grid system. A wind farm consisting of six 1.5-MW wind turbines is connected to a 25-kV distribution system exports power to a 120-kV grid through a 25-km 25-kV feeder. The 9-MW wind farm is simulated by three pairs of 1.5 MW wind-turbines. Wind turbines use squirrel-cage induction generators (IG). The stator winding is connected directly to the 60 Hz grid and the rotor is driven by a variable-pitch wind turbine. The pitch angle is controlled in order to limit the generator output power at its nominal value for winds exceeding the nominal speed (9 m/s). In order to generate power the IG speed must be slightly above the synchronous speed. Speed varies approximately between 1 pu at no load and 1.005 pu at full load. Each wind turbine has a protection system monitoring voltage, current and machine speed.Reactive power absorbed by the IGs is partly compensated by capacitor banks connected at each wind turbine low voltage bus (400 kvar for each pair of 1.5 MW turbine). The rest of reactive power required to maintain the 25-kV voltage at bus B25 close to 1 pu is provided by a 3-Mvar STATCOM with a 3% droop setting.

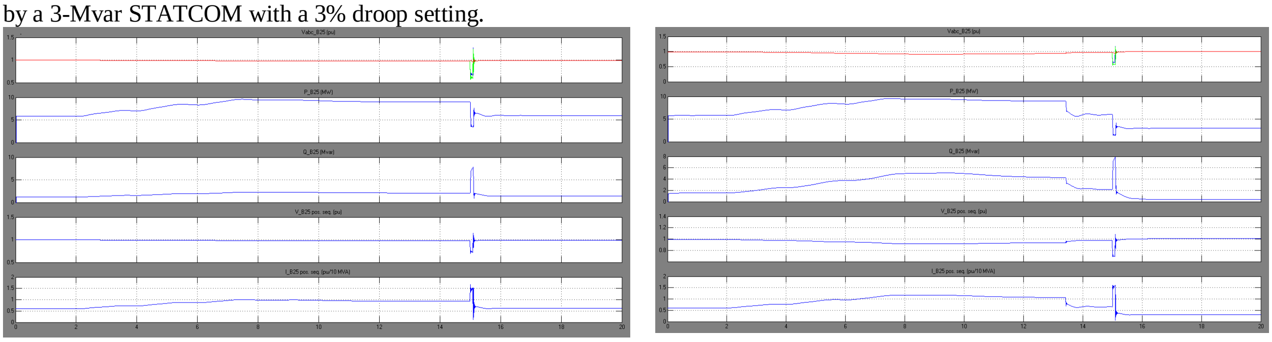

Fig 3.2 output waveform connecting with and withoutstatcom of V_{abc}, Active power, Reactive power, Voltage, Current

The simulation start observe the signals on the "Wind Turbines" scope monitoring active and reactive power, generator speed, wind speed and pitch angle for each turbine. For each pair of turbine the generated active power starts increasing smoothly (together with the wind speed) to reach its rated value of 3 MW in approximately 8s. Over that time frame the turbine speed will have increased from 1.0028 pu to 1.0047 pu. Initially, the pitch angle of the turbine blades is zero degree. When the output power exceed 3 MW, the pitch angle is increased from 0 deg to 8 deg in order to bring output power back to its nominal value. Observe that the absorbed reactive power increases as the generated active power increases. At nominal power, each pair of wind turbine absorbs 1.47 Mvar. For a 11m/s wind speed, the total exported power measured at the B25 bus is 9 MW and the statcom maintains voltage at 0.984 pu by generating 1.62 Mvar.

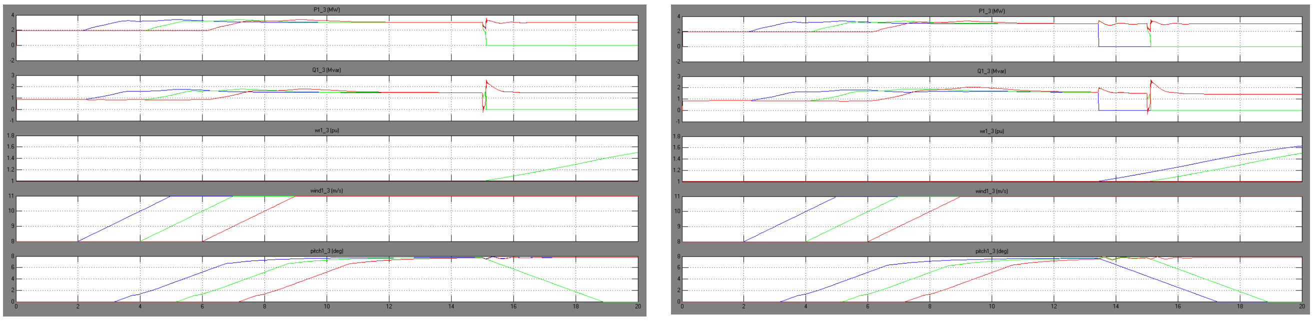

Fig 3.3 output waveform with and without statcom of Active power, Reactive power, Wind, Wind pressure, Pitch angle

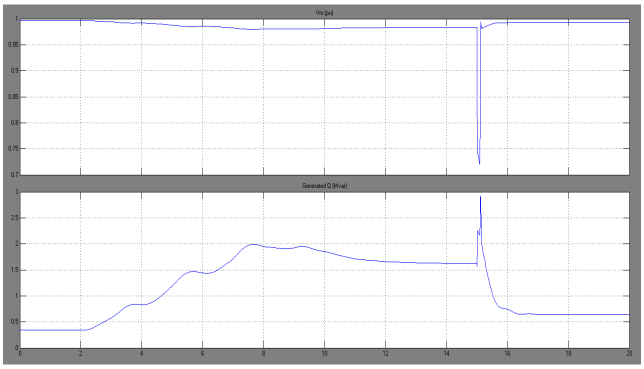

Fig 3.4 output waveform of statcom generated voltage nd reactive power

The power quality problem occur due to the internal and external faults of transmission system. In variation of voltage is controlled by using of statcom. The statcom is produce the real and reactive power to control the real power flow of the power system.

IV. CONCLUSION

The proposed research work investigates into PQ events associated with distribution network due to grid disturbances such as voltage sag, swell, load switching, feeder tripping and re-closing. The DSTATCOM has been proposed to improve the power quality in the above events. The proposed DSTATCOM with SRF based control has been proved to be effective in improving the power quality in these events at grid level. From, these studies it has been established that the DSTATCOM can effectively be used to improve the power quality in the distribution network with wind generation and during grid disturbances. The results have been validated in real time utilizing RTDS. The real time results are very close to the simulation results which shows the effectiveness of proposed DSTATCOM with

BESS for improvement of PQ in the distribution. The using of wind generation is capable to compensating load demand in power system. Wind speed variation to produce the fluctuation of output power. In this paper connecting of statcom to control the real and reactive power flow. Using of statcom the output of wind power is produced at grid interconnection level.

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