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Self-Regulating Control of Dynamic Response of the Grid Tied Wind Power Generator

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Abstract: This paper focused is on dynamic response of wind power generation, nowadays wind generation is taken into account as alternate to traditional fuel power plants. It's attracting more attention,as quite half this turbine capacity has been installed within the past the decades. A Maximum point Tracking (MPPT) control technique is presented for extracting the utmost power from the turbine. The high passive filter to extract the present harmonics with low stop frequency is in a position to compensate an unbalance load, but the dynamic response are going to be slow, for this reason, the Multi-Variable Filter (MVF) is in a position to compensate highly unbalance load without affecting the dynamic response of the system. The inverter allows full control of dc bus voltage regulation, and it acts as power transfer from the turbine to the grid and to the load. The MVF filter is employed to estimate a fundamental voltage source which provides excellent performance when the voltage source is distorted. This will be done through simulation and hardware under various values of the wind speed of the turbine .

Key wards: MVF, CWVO, DWIG, PMSG

I.INTRODUCTION

The early Wind turbine was only based on squirrel cage induction generators (SCIG), connected directly to grid, therefore, rotor speed remains almost constant. In modern wind turbine technologies for maximum power extraction the gearbox, turbine designers are based on variable speed governor systems. Power electronic converters facility the variable speed governor systems.

Most of the variable speed wind turbine systems are based on Doubly- Fed Induction Generator (DFIG) or permanent Magnet Synchronous Generator (PMSG). The PMSG based wind turbine has a higher power density and efficiency; while suffering from the high cost of generator and partial-rated converter price are lower. Due to the environmental concerns and social/poltical restrictions, there is a growing demand for the offshore Wind turbine installation, where better wind condition is also an advantage.

The possible induction machine power generation schemes are identified. The scheme consists of an induction machine directly connected to a voltage-source PWM inverter that supplies the dc bus. In this scheme reactive power is supplied from the dc bus to the induction machine. Therefore, the inverter has to be designed for the rated power, and for decrease due to high ripple currents a filter capacitor (Cf) is necessary. To reduce the system cost, the scheme is proposed.

In this scheme, the induction generator is directly connected to the full-bridge diode rectifier to supply the dc bus. The excitation to the machine is supplied by means of a PWM-VSI connected across the machine terminals via filter inductors (Lf). A dc-bus electrical condenser acts as a voltage supply to the electrical converter. In this case, the inverter supplies the required reactive power to the machine and also charging current to the dc-bus capacitor so that it can be maintained at a predetermined voltage. The rating of the inverter in this scheme is considerably less than the inverter rating.

To further reduce the size of the inverter, a dual-winding-set induction generator scheme is also proposed. In this scheme, the main winding set is designed to carry rated active power and directly connected to the diode bridge rectifier. The excitation winding is designed for higher voltage than the main winding to reduce the inverter current rating which depends upon the turns ratio of the two winding sets. Through the direct connection between the excitation winding and the capacitors, the generator receives the necessary reactive power: in this way the apparent power of the main winding inverter should decrease by 40%.
This paper deal the Multi-Variable Filter (MVF) is able to compensate highly unbalance load without affecting the dynamic response of the system.

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II.DFIG WITH POWER CONVERTER

In this paper a grid connected variable speed DFIG wind energy generation system for power quality improvement is proposed. The system is connected to the power grid via a three phase converter used as an AC-DC converter and a three-phase inverter acting as a DC- AC converter. The energy generated by the wind system feeds a non-linear load and sends the surplus to the power grid; harmonic currents can degrade the voltage at the connection point. The converters are controlled to improve the quality of the transfer of all the power exchanged between the wind system, the load and the grid. Nonlinear control techniques for the energy supplied to the grid and allow the PMSG and the inverter is proposed.

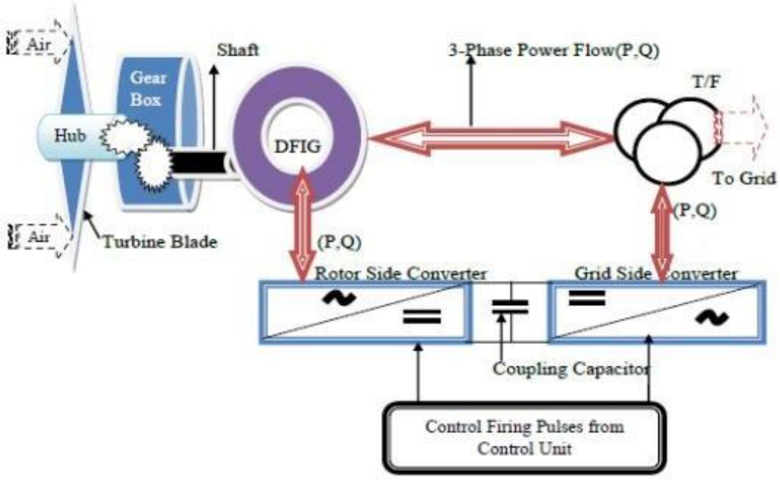

Figure 1 DFIG with power converter

In the present scenario due to penetration of large number of DFIG based WECS and interconnection to main grids gives rise to new steady state stability challenges for the researchers and scientists due to some power regulating issues under unbalance conditions such as Voltage sags or faults which occur in the network makes performance poor, fault ride-through(FRT), Low voltage ride through (LVRT) capabilities of DFIGWTs under transient periods, Inter area oscillations in long distance transmission to keep up constant output power to grid and to extract maximum power from continually fluctuating power, Sub- synchronous resonance (SSR) occurred in series compensated electrical networks becomes new area of research with DFIGWTs connected to series compensated networks, Large oscillations of the DC-link voltage cannot be avoided as the grid side converter controller was not optimized, Suitable choice of Insulated gate bipolar transistor (IGBT for converter equipment) thermal impedances, Small-Signal Stability Problems and steady state problems. Some other issues are also taken as research finding by the researchers such as converter's battery energy system optimization (BES), stator's harmonic current control, direct torque control, amplitude frequency control, load frequency control, open loop rotor control, Control based inertia contributed by DFIG, Hysteresis-Based Current Regulators and Dynamic Stability control using FACTS.

Battery Control Operation (BESS)

We Presented a new based on battery energy storage system (BESS) and tried to reduce the power fluctuations on the grid for uncertain wind conditions and also, compared with an existing control strategies like the maximum power point extraction at unity power factor condition of the DFIG, presented the modified rotor side of DFIG with DC link capacitor is replaced with the BES.

Stator Current Harmonic Control

It Proposed a sixth-order resonant circuit to eliminate negative sequence 5th harmonic and positive sequence 7th harmonics currents from fundamental component of stator current. A stator current harmonic control loop is added to the conventional rotor current control loop for harmonic suppression. The effects of voltage harmonics from the grid on the DFIG are also have been discussed. Resonant controllers have been widely used in harmonic control and unbalanced control for both DFIG and power converter systems.

Direct Torque Control

Direct power control (DPC) was supported the principles of direct torque control. The DPC applied to the DFIG power control has been presented. This strategy calculates the rotor voltage space vector supported stator flux estimated and power errors. an alternate to DPC is power error vector control. This strategy has less complex and obtains results almost like those of direct control of power. A anti jamming control has been proposed by to boost the

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controller performance.

Open Loop Rotor Position

The sensor less rotor position estimation schemes under open-loop category either employ a voltage integrator (for the flux estimation) or depend on inverse trigonometric computations in real time or recursive procedures. Some of the techniques suffer from saturation in the integration stage or at other levels of the process which results in poor performance when the machine operates at a synchronous speed or influence of machine parameter variations. Flux estimation based on a recursive approach was proposed in where the stator flux 18agnetizing current instead of the stator flux components is estimated using re-computation

Magnitude and Frequency Control

A magnitude and frequency control (MFC) strategy has been proposed for the doubly fed induction generator (DFIG). Flux magnitude and angle control (FMAC) were discussed. In order to get the rotor speed and position information, an accurate position encoder will be equipped or a sensor less algorithm will be applied. These methods increase the system complexity. Another useful control strategy is based on the direct power control (DPC). Although the proposed MFC 19 scheme has some benefits, the system dynamic response was not idea as shown in the previous section. The parameters of the PI control can be 19ptimized or advanced control methods can be used in future to improve the system performance..

Control based inertia contributed by DFIG

The paper designed a supplementary control of adjusting pitch compensation and maximum active power order to the converter in order to improve inertial response during the transient for the DFIG. An approach was introduced is proposed in. The technique was based on changing the DFIG torque set point based on the derivative of system frequency. This technique, however, has limitations. The work carried out in advocates a similar approach and proposes a supplementary control which provides a response to the natural inertial response. The primary frequency control based on deviation of grid frequency is proposed. A similar concept together with a scheme to provide frequency response by deloading the wind turbine is proposed.

Dynamic Stability Using FACT Devices

We Proposed a damping controller of the STATCOM is designed by using modal control theory to contribute effective .The analyzed results of stability improvement of power systems using STATCOMs and the damping controller design STATCOMs were presented in System modelling and controller design for fast load voltage regulation and mitigation of voltage flicker using a STATCOM were demonstrated. A new DSTATCOM control algorithm enabling separate control of positive- and negative-sequence currents was proposed investigated the dynamic performance of a STATCOM and a static synchronous series compensator (SSSC).

DFIG:

The doubly-fed induction generator (DFIG) system may be a popular system in which the power electronic interface controls the rotor currents to attain the variable speed necessary for maximum energy capture in variable winds. Because the power electronics only process the rotor power, typically but 25% of the overall output power, the DFIG offers the benefits of speed control with reduced cost and power losses. this technique model includes a mechanical model of the blades, hub, and shaft, a back-to-back converter including thermal loss calculations, a magnetic model of the three- phase transformer, and therefore the cable and grid.

DFIG WIND TURBINE SYSTEM:

The back-to-back converter comprises separate machine-side and grid-side portions, which are connected with one another via a DC-link capacitor. The machine side converter regulates the torque of the DFIG and thus the rotational speed with a double loop structure, where the outer speed loop generates the reference signal for the inner current loop. the present control is administered in rotational framework (dq) with stator flux orientation. additionally, the machine-side converter also regulates the reactive power injection of the DFIG.

CONTROL:

The back-to-back converter comprises separate machine-side and grid-side portions, which are connected with one another via a DC-link capacitor. The machine side converter regulates the torque of the DFIG and thus the rotational speed with a double loop structure, where the outer speed loop generates the reference signal for the inner current loop. the present control is administered in rotational framework (dq) with stator flux orientation. additionally, the machine-side converter also regulates the reactive power injection of the DFIG.

Advantages:

➢ Better performance while connecting with Grid.

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➢ Conduction Loss is a smaller amount

➢ Converter system provides reactive power compensation and smooth grid integration.

III.SIMULATION IN MATLAB MODELING

A wind energy conversion system is responsible to supply the active power required by a nonlinear unbalanced load. In order to compensate the unbalance load, the best way is to use the multivariable filter instead of traditionally high pass filter.

The MVF application allows avoiding the use of the high passive filter which affects the compensation performance especially for the unbalance load. The MVF allow using low cut off frequency to compensate efficacy the unbalance load without affecting the performance of the system.

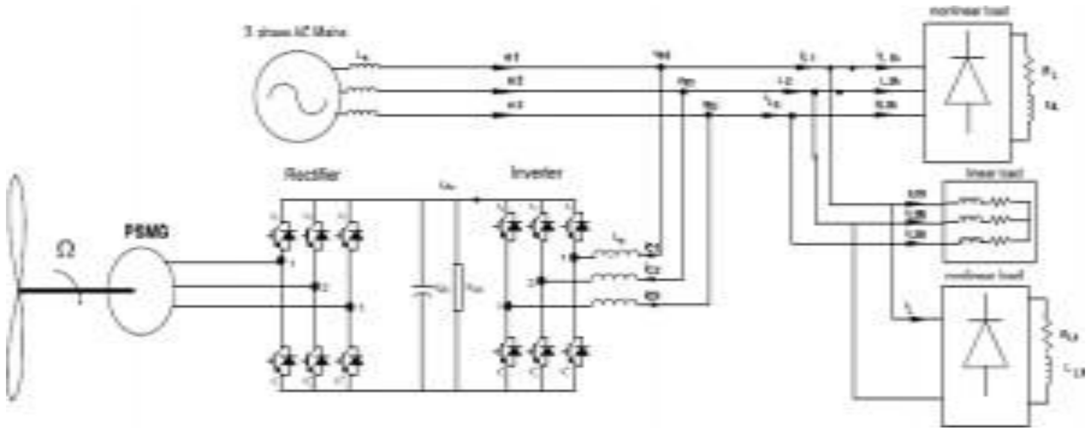

Figure 2 Variable speed grid connected wind energy conversion system

Simulations of the proposed control scheme for a PMSG based generation system were performed using MATLAB software. The DFIG used for simulation is rated at 2[MW] and the wind speed is constant at 10[m/s]. The grid voltage is 690[V] and 60[Hz]. For 2 [MW] DFIG system, 20% unbalance voltages are applied at the grid side. Initially, the system runs under balanced condition and then the grid voltage is disturbed at 1.5[sec] and then the voltage balance is recovered at 3.5[sec].

It shows the PMSG performance with the conventional stator-flux oriented control without considering the unbalanced condition. It is shown that the positive and negative sequence components of the rotor current include 120[Hz] components, which means the stator current highly unbalanced. Similarly, the stator active and reactive powers, and the electromagnetic torque all contain significant pulsations at 120[Hz]. The magnitude of the torque and speed ripples is 0.12[pu] and 13[rpm], respectively.

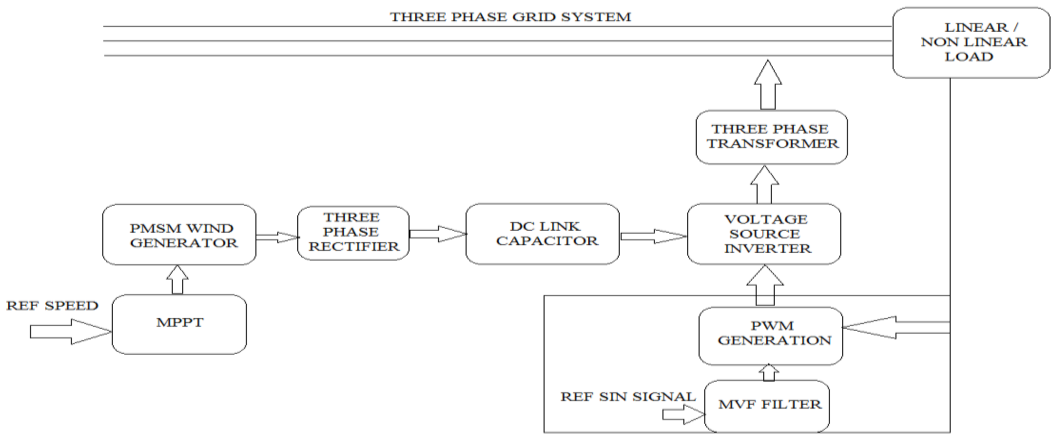

Figure 3 Block Diagram

The PMSG performance only with control of the generator-side converter considering unbalanced condition. Due to

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dual current control, the rotor current ripple is suppressed. Accordingly, the generator torque and speed ripples almost disappear. However, it is shown that the stator active power ripples increase, of which magnitude are 0.02[pu] and 1 [rpm], respectively.

Next, consider the case that the grid side converter is controlled together with the generator-side converter by the dual current control mode. It shows the PMSG power control performance is not changed with the additional dual current control of the grid-side converter. the active and reactive power of the stator, the grid-side converter, and the grid. The ripple component of the stator active power appears due to suppression control of the PMSG torque ripple.

To get rid of the power ripple, the grid side converter injects the compensating power into the grid. So, the grid active power ripple has been reduced to the level as The Power control without controlling the unbalanced grid voltage. shown in Instead, the stator active power ripple is increased a little higher, however, it is insignificant since it has no effect on the power factor.

A wind energy conversion system is responsible to provide the active power required by a nonlinear unbalanced load. so as to compensate the unbalance load, the most effective way is to use the multi-variable filter rather than traditionally high pass filter. The MVF application allows avoiding the employment of the high passive filter which affects the compensation performance especially for the unbalance load. The MVF allow using low cut off frequency to compensate efficacy the unbalance load without affecting the performance of the system.

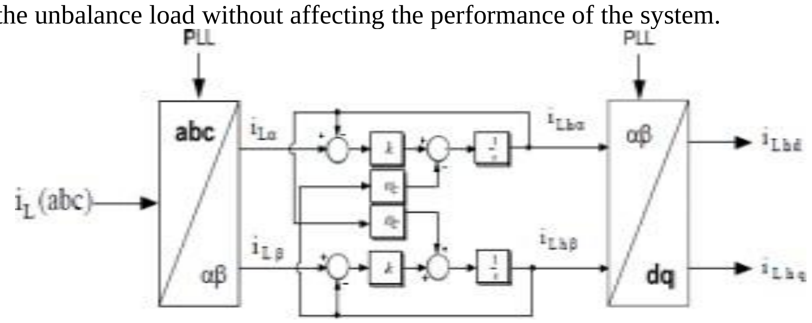

Figure 4 Control scheme of MVF filter

Simulation results using MATLAB/SIMULINK verify the viability and effectiveness of the proposed variable-speed wind-energy conversion system are presented. The simulation results have been studied for three different aspects:

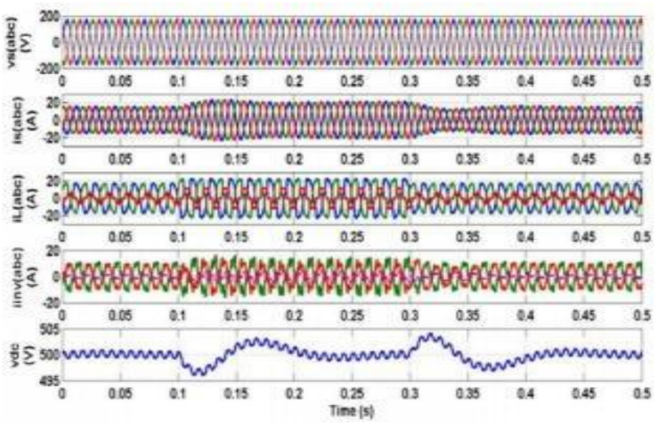

Figure 5 Dynamic response of wind turbine without wind turbine

IV.Hardware Description

In this hardware prototype a 12v 30 w dc motor will be placed for the wind arrangement. By rotation of the gear motor the voltage will be produced from the motor supply terminals. The voltage from the wind is fed to the rectifier unit for the rectification process after that the dc link capacitor will stores the energy to charge battery backup of 12v 4.5AH. The charged battery is connected to the voltage source inverter for the inversion process. The voltage source inverter

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consists of the 2 pairs and 4 sets of n channel Mosfet which is driven by the SG3525 PWM generator. The control signal for the SG3525 PWM is generator is taken from the micro controller PIC16F676. The output from the inverter circuit is connected to the coupling transformer for boost the AC voltage from 12V to 230V AC. The maximum power rating of 150W load is connected to the transformer for the load usage purpose. Finally the feedback from the inverter is given to the PWM generation unit by the load condition for the closed loop operations.

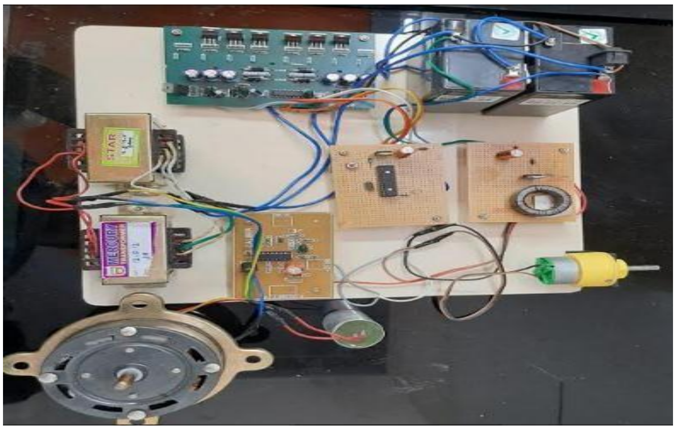

Figure 6 Output-Kit Image

V.CONCLUSION

This work is devoted to the analysis, the medullisation and the study of the behaviour of the system through the simulation of a variable speed wind turbine, using a PMSG associated with static converters. This is with the aim of to ensure a better quality of the current injected into the network by limiting as much as possible the harmonics originating from either the non-linear load or the conversion system. The study showed that the synchronous machine used as a generator is capable of fulfilling its role and providing the network with active power according to demand with good current quality, even in the case of an unbalanced load. The simulation results of the wind turbine system connected to the grid using nonlinear control technique for both PMSG and inverter have shown good performance. The deficiency of the high passive filter causing low dynamic response is corrected using a MVF filter for highly unbalance nonlinear load. The MPPT algorithm generating the reference speed tracks correctly the maximum power of the wind turbine.

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