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CONTROL STRATEGY OFDFIG GRID SIDE FAULT BY USING DVR CONTROLAND FUZZY CONTROLLER

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ABSTRACT: **Inthis** ***paper a detailed electromechanical model of a DFIG (double fed induction generator) based wind turbine connected to power system grid is development in the MATLAB/SIMULINK , the DFIG based on the DVR controller (dynamic voltage restorer) is used for the consumer protection from the grid side voltage fluctuations like voltage sag and voltage swell i.e long duration voltage and short duration voltage. The DVR is used to maintained the voltage levels during the fault condition. The primary aim of DVR is to inject the voltage in series to the stator side. This drawbacks are overcome by proposed this methodology. In this paper a coordinated control strategy of DVR controller and fuzzy controller circuits are proposed by using MATLAB/SIMULINK.***

Key words; DVR (dynamic voltage restorer) controller,DFIG, fuzzy logic controller, voltage sag and voltage swell.

INTODUCTION;

Wind energy plays an important in the world because it is friendly to the environment .wind turbines generators as one of the most important renewable energy resources, are very often used to power is landed individual loads . Wind energy conversion system is the overall system for converting wind energy into useful mechanical energy that can be used to power an electrical generator for generating the electricity. The DFIGs are widely used due to their variable speed operation .the DFIG operation during the voltage sags and swells and short circuits. When a short circuit occurs on the grid side , the rotor current rise and if the converter is not protected against these high currents damaged. An easy way to protect the converter is disconnect the generator during low voltage condition. Many regulation methods have been developed and are under development to support the grid during the short circuits with reactive and active powers and prevents disconnect the deliver power when the voltage is restored .this system is tested for a three phase grid side fault, different observations carried out. There are carried out in first case the system without DVR is observed and it is matter of the fact that the power quality of the output is not as per required .second case simulation model is created with DVR in this case power quality of is improved, other cases are simulations for swells with dvr and simulations for sag with dvr and consecutive sag and swell with dvr . this paper presents a systematic approach to solve the sag /swell with mitigation problem by using DVR. DFIG wind turbine system drawback of limited power quality control and narrow scope of improving system's dynamic behavior is overcome by the use of series compensation device DVR.

I. WIND POWER PRINCPLE

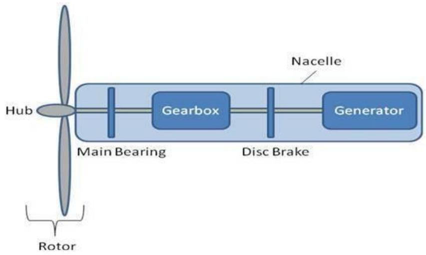


Figure no.1wind block diagram

Wind power is a good renewable, clean and free source of energy for power production. The air flow on earth is created due to the atmospheric air mass as a result of variation of air pressure . this difference in air pressure results due to difference in solar heating of different parts of the earth's surface.

The kinetic energy of air in motion is known as wind. This wind energy when comes in contact with wind turbine blades, it exert force on the blades which makes the wind turbine to rotate. This means wind turbine converts the kinetic energy of air into mechanical energy which is further used to coverts it into electrical energy by means of a generator coupled it. Generally wind turbine have much lower operating speed than the rated speed of electric generator. To compensate this mismatch gear box is used in turbine and generator i.e. generator is coupled to turbine through this gear box. The wind turbines are machinery that have a rotor with propeller blades. This propeller blades are specifically arranged in a horizontal manner to propel wind for generating electricity. This type of turbines are placed in areas that are high speed wind i.e. hilly areas. One wind turbine can generate enough electricity to be used by a single house hold.

II. DFIG WORKING PRINCPLE

When a wound rotor induction machine works as a generator and fed from both stator and rotor side, it is termed as Doubly Fed Induction Generator (DFIG). DFIG scheme is used as a variable speed fixed frequency topology.

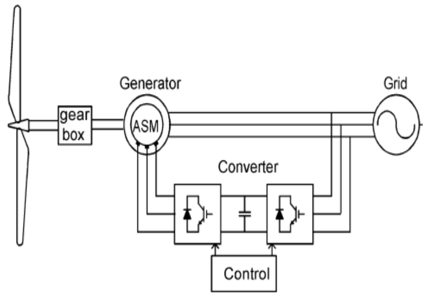


Figure no .2 DFIG block diagram

In this scheme, stator is directly connected to the grid while the rotor circuit is connected to grid through an AC/DC/AC back to back frequency converter. The rating of this converter is typically 25-30% of the total power rating of the generator. This is the main advantage of DFIG over other variable speed topologies as it provides same features at lesser cost and provides good efficiency . the following shows a typical DFIG configuration. The stator winding is connected directly to the 50 Hz load. While the rotor is fed at variable frequency through the AC/DC/AC converter. The DFIG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing mechanical stresses on the turbine during gusts of wind.

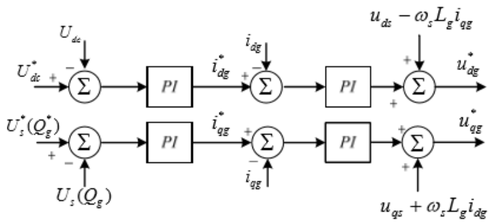
III. Behavior of the DFIG during control of Grid side converter faults

When a short circuit faults occurs in the power grid , the bus voltages at the point of common coupling drops, therefore introducing undesirable transients in the stator and rotor currents. The low voltages also prevents the full transmission of generated active power into grid from DFIG WT, leading to significantly increased fluctuations of the dc-link voltage. The grid side converter control is to keep the dc link voltage constant. When the grid voltage dips, the dc –link voltage may fluctuate due to the instantaneous unbalanced power flow between the grid and rotor side converter. To reduce the fluctuation of dc –link voltage, the item reflecting the instantaneous variation of the output power of the rotor converter should be introducing during grid faults.

IV. Control of grid side converter.

The grid side converter control is to keep the DC-link voltage constant. When grid voltage dips , the DC link voltage may fluctuate due to the instantaneous unbalanced power flow between and rotor side converter. To reduce the fluctuation of DC link voltage , the item reflecting the instantaneous variation of the output power of the rotor side converter should be introduced during grid faults .

The below figure shows the block diagram of the conventional control strategy for the GSC implemented in synchronous rotating dq reference frame with it's d-axis oriented with the grid voltage.



The GSC control scheme .the smaller dc –link voltage fluctuation can be achieved during grid voltage dips

$$P_r = u_{ds} i'_{dg} + R_g i'^2_{dg} + \frac{1}{2} L_g \frac{di'^2_{dg}}{dt}$$

In normal operation , the power flowing through the grid and rotor side converter is balanced, that is ,Pr is equal to Pg, so the dc link voltage is constant. When the grid voltage dips, Pr may not be equal to Pg due to the instantaneous unbalanced power flow between the grid and rotor side converters, and therefore the dc-link voltage fluctuation has been applied on the GSC. However, it ignores the power exchanged with the grid filter impedance. For high power DFIGs

DYNAMIC VOLTAGE RESTORER (DVR)

DVR is one of the most efficient and effective modern custom power device used in power distribution networks. DVR is a recently proposed series connected solid state device that injects voltage into the system in order to regulate the load side voltage. It is normally installed in a distribution system between the supply and critical load feeder at the point of common coupling (PCC). Other than voltage sags and swells compensation, DVR can also added other features like: line voltage compensation, reduction of transients in voltage and fault current limitations.

V. BASIC CONFIGURATION OF DVR

The below figure , the DVR consists of an injection / booster transformer , a harmonic filter, a voltage source converter(VSC), an energy storage unit and control system

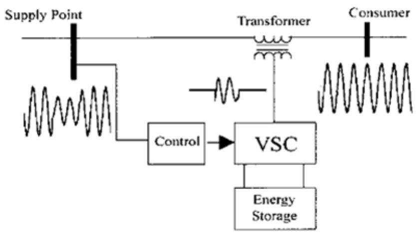


Figure no. 3 DVR complete diagram

1. Injection / booster transformer; is a specially designed transformers that attempts to limit the coupling of noise and transient energy from primary side to secondary side. Its main tasks are:1) it connects the DVR to the distribution network via the HV windings and transformers and couples the injected compensating voltages generated by the voltage source converter to the incoming supply voltage. 2). In addition the injection transformer serves the purpose of isolating the load from the system (VSC and control mechanism).
2. Energy storage unit / control system;

This unit is responsible for energy storage in dc form. Flywheels, batteries, superconducting magnetic energy storage and super capacitors can be used as energy storage device. It is supplies the real power requirements of the system when DVR is used for compensation.

3. PWM inverter ;

This is a power electronic switching cum storage device which generates the sinusoidal voltage at required frequency , amplitude & phase angle . the scheme used for the voltage generation is with the help of PWM technique . it is used for conversation of the DC voltage into sinusoidal AC voltage.

4. Filter circuit ;

Filter convert the inverted PWM waveform into a sinusoidal waveform easily this is achieved by eliminating the unwanted harmonics components distort the compensated output voltage.

VI. VOLTAGE INJECTION TECHNIQUES

The rating of the DVR system depends mainly on the depth of the fault voltage that is to be compensated. For voltage sag & swells with zero phase angle jump, the requirement of the active power of the DVR is given by

$P_{DVR} = (V1-V2/V1)\ P_{load}$.

Where V1& V2 are normal & faulty line voltages respectively. The fault having phase angle jump along with the voltage variation, the active power flowing into DVR charges the DC link. For full compensation of full voltage dip, the rating of the DVR must be as same as that of the DFIG.

There are four voltage injection methods that are normally used as follows.

A. Pre sag compensation.

This method is constant tracking method, here the supply voltage is consistently kept under observation & if any disturbance in supply voltage detected, it injects the value of the voltage which is equal to difference between the supply voltages& sag voltage , so that the load voltage is restored back as that of pre fault voltage. Compensation in both phase angle & amplitude sensitive loads is achieved .the amount of voltage fed to the system is determined by following expression

$V_{DVR} = V_{prefault} - V_{sag}$

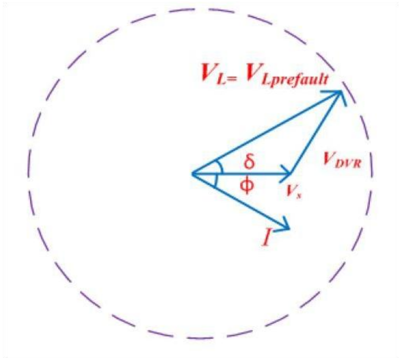


Figure no. 4 pre sag compensation

B. In phase compensation method;

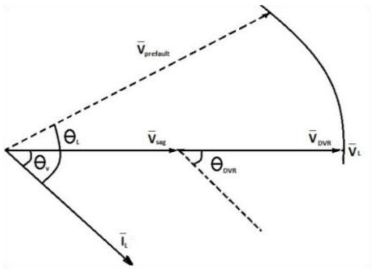


Figure no. 5 phase compensation method

The voltage that is to be injected is in phase with the supply voltage irrespective of the pre sag value. By this method the constant amplitude of the load voltage is maintained. The advantage with this method is that the amplitude of DVR injection voltage is minimum for the voltage sag condition.

C. In phase advanced compensation;

In previous two methods, the active power is injected into system during disturbances where as this method is based on the phase angle compensation. The phase angle of voltage sag & the load current is minimized to control the real power supplied. The active power supplied by the DVR is the energy stored in DC link. The values of the load current& voltage are fixed the change is done in only phase angle of the voltage sag. So reactive power is being used by this method , but not all voltages sags are mitigated by this system hence it is suitable for only limited range of voltage sags.

D. Voltage tolerance method with minimum energy injection

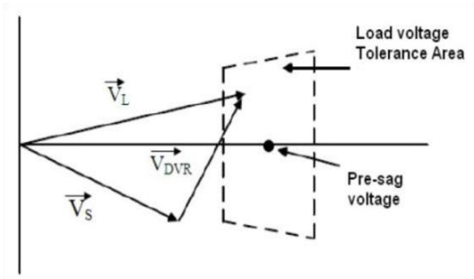


Fig no.6 voltage tolerance method

There always exists some tolerable limit in the system. Similarly, small amount of voltage drop & phase angle jump in allowable in the system. If the voltage magnitude lies in between the range of 90-110% of the nominal voltage & 5-10 % of nominal state that will not affect the performance characteristics of the load. Hence both magnitude & phase are the control parameters, which can be a achieved by this method of operation of DVR is going to control the voltage up to some desired accepted value so that the system will not change the load performance characteristics, as shown in the in the above fig no.6

VII. Modeling equations of DVR

The system impedance Zth depends on the fault level of the load bus. When the system voltage (Vth) drops , the DVR injects a series voltage V dvr through the injection transformer so that the desired load voltage magnitude $V_L$can be maintained . the series injected voltage of the DVR can be written as

$$V_{DVR} = V_L + Z_{TH} I_L - V_{TH} \quad (1)$$

Where;

V_{DVR};the desired load voltage magnitude

Z_L; is the load impedance

I_L ; Is the load current

V_{TH}; the system voltage during fault condition.

The load current I_L is given by,

$$I_L = \frac{P_L + jQ_L}{V} \quad (2)$$

When V_L is considered as a reference equation can be rewritten as,

$$V_{DVR}\angle 0 = V_L\angle 0 + Z_{TH}\angle(\beta - \theta) - V_{TH}\angle\delta \quad (3)$$

VIII. DFIG WITH DVR

The basic structure of DVR based DFIG is shown in fig 3. It consists of DFIG , decision making switch, voltage source inverter, T/F, PWM , PI controller, grid hybrid system.

The practical applications of simulated voltage variation are indicated by a discrete pulse width modulation scheme .the main aim of the control scheme is to maintain constant voltage magnitude even at system disturbances. The various phase faults are created at load voltage is passed through sequence analyzer after converting it into the per unit quantity.

The error signal is fed to PI controller after the magnitude is compared with reference signal . the magnitude is then compared with reference voltage through which error signal is fed to pi controller. This voltage is then fed to trigger circuit . PWM control technique is applied for inverter switching so as to produce a three phase 50 HZ sinusoidal voltage at the load terminals. The range of chopping frequency is a few kilo hertz. The PI controller is controls the IGBT to maintain '1' per unit voltage at the load terminals that is considered as base voltage is equal to '1' per unit.

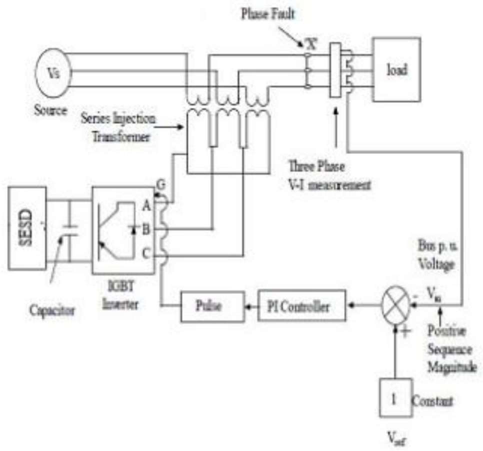


Figure no. 7 DFIG WITH DVR

An advantage of a proportional plus integral controller to be zero for a step i/p.thei/p for PI controller is an actuating signal which is difference between the

V ref and Vin. The controller block o/p is of the form of an angle delta , in the three phase voltages which introduce addition phase lag/lead.

The error detector o/p is given by

V ref –V in

V ref is equal to 1 P.U voltage.

V in voltage in P.U at the load terminals.

IX. Power transmission contingencies

The best know disturbances of the voltage waveform are voltages sags and swells. Harmonics, and voltage imbalances. These can be seen through the figure no.8 as shown in below. These types of contingencies occur when they are subjected to sensitive load changes towards the distribution side.

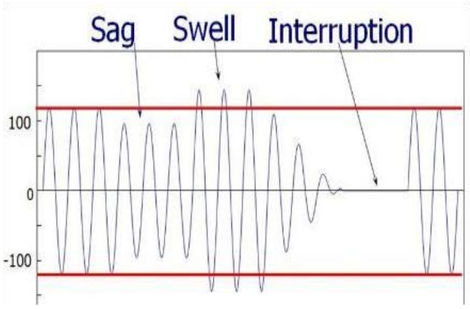


Fig no 8

X. Fuzzy controller

The drawbacks of the PI controller are improper tunings of the k p and k I values which will lead to increase in setting time of the system stability and the continuous usage of controller with fixed PI parameters leads to reduce the life time of DVR . this drawbacks can be overcome by using fuzzy controller.

In comparison to the linear PI controller , this is a non-linear controller that can provide satisfactory performance under the influence of various fault condition .

The symbolic structure of fuzzy controller is as shown in below.

Figure no 9

Simulation model of DVR operation;

To verify the working of a DVR employed to avoid voltage sags during short circuit , suppose a fault is applied at point X via a resistance of 0.4 ohms such fault is applied for 100m sec. the capacity of the dc storage id 5kv. Using the facilities available in MATLAB/ SIMULINK , the DVR is simulated to be in operation only for the duration of the fault, as it is expected to be the case in a practical simulation.

XI. Simulation analysis

To shown the effectiveness of the proposed strategy simulation have been performed using MATLAB/SIMULINK .

The simulation results s shown below figures.

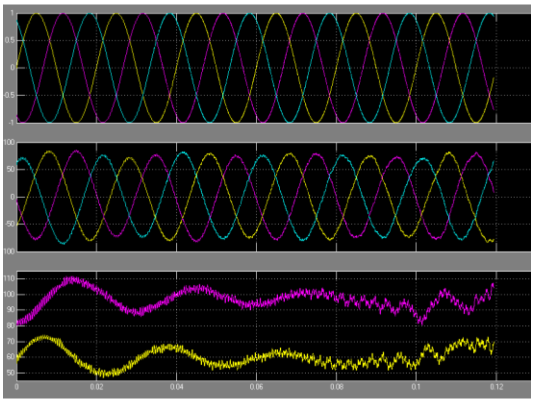


Fig no. 10 waveforms of Grid side input power active and reactive

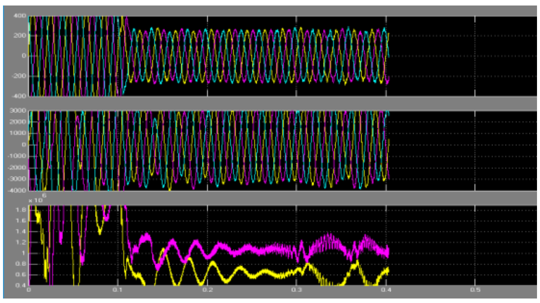


Fig no. 11 waveforms of applying fault analysis sag and swell

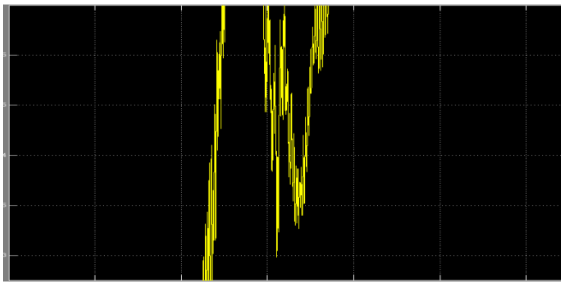


Fig no. 12 DVR controller waveforms

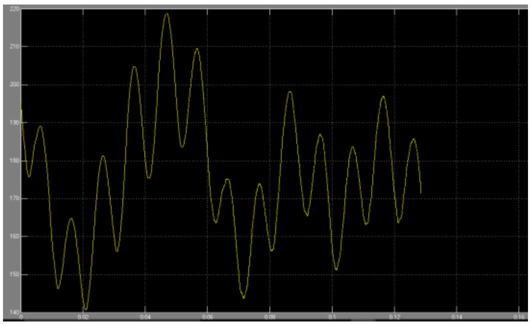


Fig no. 13 waveforms of fuzzy controller.

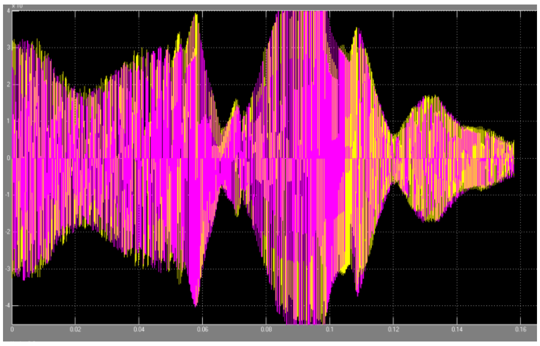


Fig no. 14 waveforms of Vab ,Iab

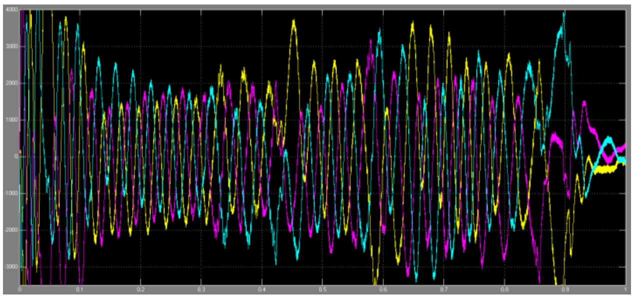


Fig no.15 waveforms of DFIG rotor current

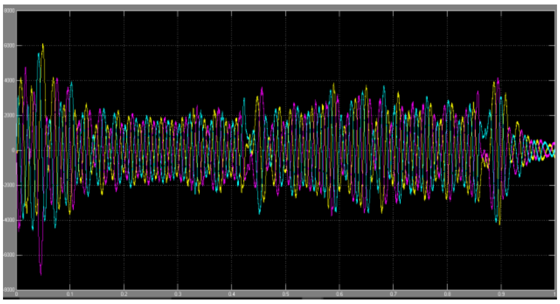


Fig no.16 waveforms of DFIG stator current.

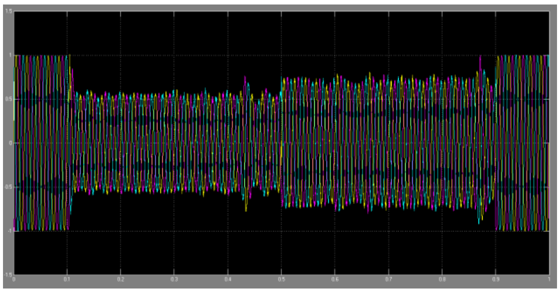


Fig no.17 waveforms of DFIG sag and swells

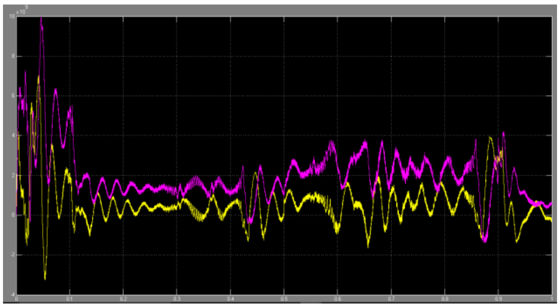


Fig no.18 waveforms of rotor and grid side circuit active & reactive powers.

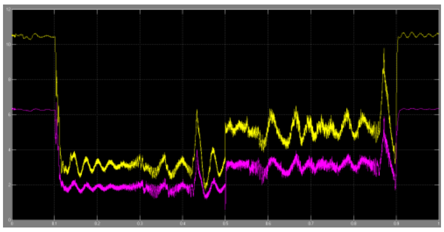


Fig no 19 waveforms of 3-phase active and reactive powers

XII. Conclusion

In this paper we have studied about the concept of "DFIG" and studied the working principle of grid converter. We have implemented the grid voltage of DVR control scheme to regulate the DC link voltage .

However we have seen that, when I/P voltage to the voltage source inverter changes. It could not maintain the voltage at constant value. So to get constant values of voltages, we have tried to maintain the I/P voltages of the Vsc constant even if the grid voltages was varying. For this we have adopted the dynamic voltage restoration technique and fuzzy controller.

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