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Performance of Flywheel Energy Storage System for Fault Ride through Support of Grid Connected Vsc-Hvdc Based Offshore Wind Farms

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Abstract-For the sake of uninterrupted power supply to the loads we are using renewable energy sources. Among them wind energy and the solar energy is the most familiar renewable energy sources we are using now-a-days. Voltage source converter based high voltage DC transmission is considered as future of offshore power transmission. This paper proposes the high voltage DC power transmission system and maintains system balance during each faults. This results in the voltage and current losses on the switching devices. This strategy implements the flywheel energy storage system based on a squirrel cage induction machine connected in parallel to the grid side converter. It is connected in shunt which present on the grid side circuit of VSC-HVDC based squirrel cage induction motor. Due to this the FESS stores the trapped energy in the DC link during AC side faults for long transmission system using a voltage source converter. When there is insufficient of fault meet the grid at load demand. The series of simulation results we carried out the main part of theFESS system under fault conditions achieved using the software Matlab/Simulink. This project possesses the dynamic performance during 'steady state' during normal and fault operating conditions.

Index words- Fault ride through energy storage system, HVDC,IFOC,Offshore wind energy.

I.INTRODUCTION:

Due tothe great increase in population there is a greater demand in electrical energy which leads to increase the renewable energy. There are several types of renewable energy we are using among them wind energy is one of the most familiar renewable energy which installed in both onshore and offshore. This utilization of offshore wind farms is high because of high wind speed[1] compared to onshore wind farms.The installation cost and maintenance of offshore wind farms are high Compared to onshore wind farms is considered as a limitation.HVDC offshore wind farms play a crucial role. The transmission of HVDC is used for long distance from offshore wind farms is used in remote sources.HVDCsystem utilizes line-commutated converters[2] which is used for large power applications[3]. LCC generates a harmonic filters and VAR compensators is dependent on nonunity displacement factor on the AC side. VSC plays a crucial role to become a system stability depends upon variations and transients of each system during fault conditions.

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During and after short circuit fault of each system must be connected to the grid[4]. There are two methods to develop the power that is produced for wind turbines. The first method is to decrease the generator torque by maintaining of system frequency of offshore converter and active current component[5].The main drawback is to reduce the power of a wind turbine. The second method is to be used in short circuit of HVDC off shore converter to prevent the power transmission of onshore converter. This can be done by decreasing the modulation index, which Decrease the terminal voltage of offshore converter when there is a flow of high currents that flow through the converter is the main drawback of this method.The third method uses the braking resistance of DC choppers on ac side faults which prevents the crow bar ignition due to high power on dc side[6]-[7]. Among all the methods this method is reliable. The aboveresearch study about the new fault ride through a technique which is used to store the wind energy during normal conditions. Flywheel stores the energy in the form of kinetic energy which depends upon rotation of speed and mass in addition to the batteries and storage capacitors. The performance of FESS acts as super capacitor and batteries for the lifetime of high energy density during charging and discharging periods[8].The main aim of this project was FESS employs the VSC-HVDC transmission system of AC side faults through the grid side converter.The FESSinvestigates the power leveling during normal and abnormal conditions by using Matlab /Simulink softwar

II.INTRODUCTION OF THE PROPOSED SYSTEM

Fess has high power, high efficiency, high energy density low maintenance and simple in structure[9]. FESS mainly consists of electrical bearings, power conversion system, electrical machine and flywheel[10].FESS stores the kinetic energy in the form of speed and mass which works as a motor while charging and generator while discharging. Permanent magnet works as high speed generators and induction machine works as low speed flywheels [11]. Power electric circuits are employed at the wind side converter. Bearings are used to rotate the flywheel at certain balanced position. There are two types of bearings such as conventional mechanical bearings and magnetic bearings. Conventional mechanical bearings made up of steel used for low speed applications which increase the inertia results in large FESS and magnetic bearings for high speed applications where the rotor is made of composite materials [12].

III.DESCRIPTON OF PROPOSED SYSTEM

In this paper squirrel cage induction motor of large capacity low speed is connected in parallel to the grid side converter. The diagrammatic representation of proposed system is placed in figure 1. The doubly fed induction generator of ac side converter is converted into permanent magnet synchronous generator of dc side of offshore wind side converter [13].The DCcables is transmitted to the onshore networks and HVDCis converted to the ac side of grid and several methods has been implemented to increase the voltage.it can be used in high power applications such as output harmonic contents, modularity and power loss.

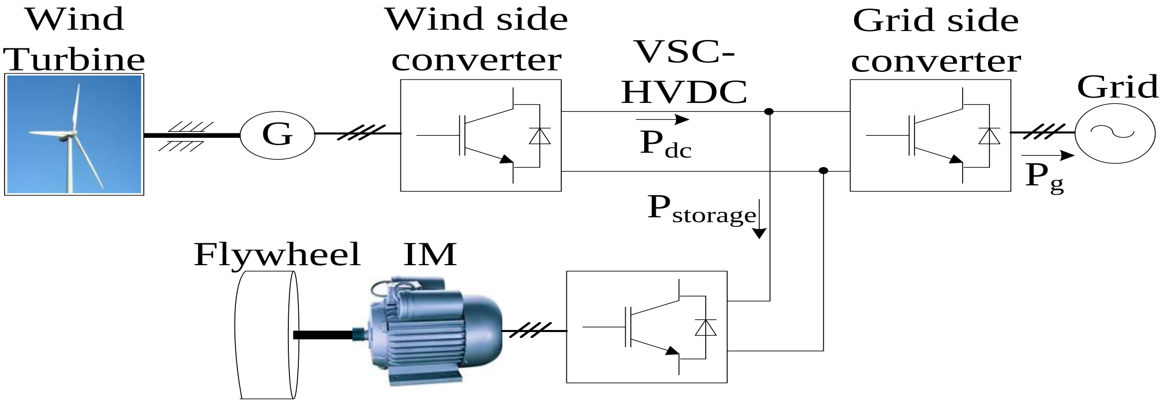


Fig1. VSC-HVDC transmission system

The demonstration of this paper is that if the generated power is less than the grid demand than the excess amount of energy is stored in the FESS in case of ac side fault. The FESS is utilized for leveling the wind power during normal conditions [14].During three phase to ground short circuit is regard as worst fault and in the ac side fault it will be tends to zero. Due to the robustness of the system FESS converter will decreased and trade off will be exists. FESS stores the energy in the ac side fault. During high power flywheel is set to an induction machine for power balancing applications under operating conditions. The Fess Converter and Induction Machine Modelling analysis is done as follows:

Modeling of fess converter and induction machine is done by the d-q frame[1]-[7]

The stator voltagesare shown in (1)&(2)

$$V_{ds} = r_s i_{ds} + p\lambda_{ds} - \omega_e \lambda_{qs} \quad (1)$$

$$v_{qs} = r_s i_{qs} + p\lambda_{qs} + \omega_e \lambda_{ds} \quad (2)$$

By considering equation (1)&(2) we get machine torque and rotor flux

$$P_s = \frac{3}{2}(v_{ds} i_{ds} + v_{qs} i_{qs}) = Pcu_{stator} + Pcu_{rotor} + Tm_{wm} \quad (3)$$

$$Q_s = \frac{3}{2}(v_{ds} i_{qs} - v_{qs} i_{ds}) = L_m \omega_e i2_{ds} \quad (4)$$

$$T_m = \frac{3}{2} P \frac{L^2 m}{Lr} i_{qs} i_{ds} \quad (5)$$

$$Pf_w = P_S \quad (6)$$

$$\lambda_s = L_m i_{ds} \approx \frac{v}{\omega} \quad (7)$$

A) Converter at grid side:

The voltage of d-q frame of grid side converter is given below

$$v_{dinv} = v_{dg} - r_g i_{dg} - L_g p i_{dg} - \omega L_g p i_{qg} \quad (8)$$

$$v_{qinv} = v_{qg} - r g_{iqg} - L g_{piqg} + \omega L_g p_i dg \quad (9)$$

$$P_g = \frac{3}{2}(v_{dg} i_{dg} + v_{qg} i_{qg}) \quad (10)$$

The total power flow of the flywheel is given as

$$P_{fw} = P_s = P_{dc} - P_g (11)$$

P_g = grid power

P_{dc} = dc link power

P_{fw} = flywheel power

Change in the energy can be obtained as:

$$\Delta E = \frac{1}{2} J(w2^2 - w1^2) \quad (12)$$

J is moment of inertia

The energy stored in the capacitor can be expressed as (13)

$$E = \frac{1}{2} CV^2 (13)$$

From equation (13) the voltage across the dc link voltage is obtained as:

$$V_{dc(t)} = \sqrt{\frac{2}{c}} \int (P_{dc} - P_g - Pf_w) dt + c \quad (14)$$

The dc link voltage controls the dc link power which remains constant and the dc power and grid power stores in flywheel under normal condition

IV.STRATEGY OF FAULT RIDE SYSTEM:

Fess used to control under fault and normal conditions. FESS of induction machine operates on indirect field oriented control. The basic strategy of fess based on IFOC (15) is as shown in figure 2

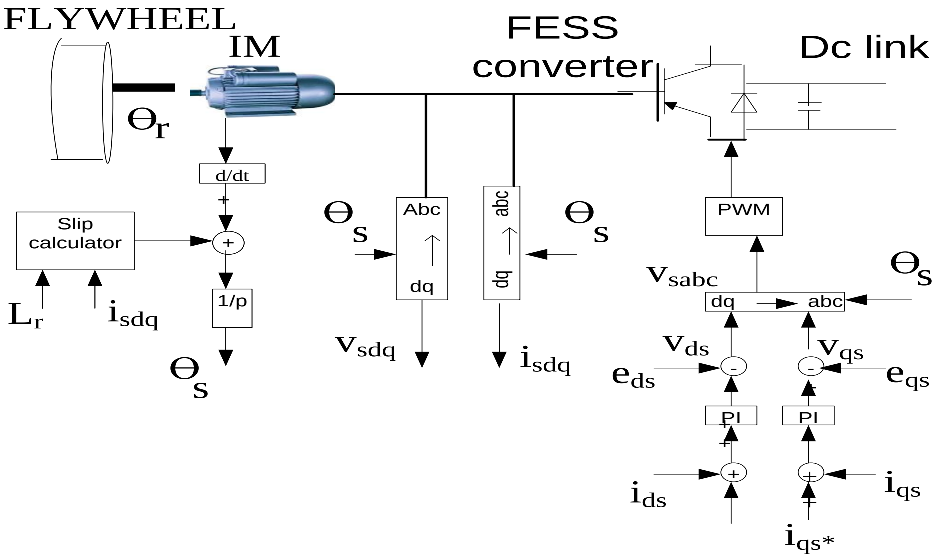


Fig 2.Proposed fess control strategy based on IFOC

Stator flux controls the direct axis current and voltage of the dc link controls the quadrature axis current. The dc link under operating conditions as shown in figure3.

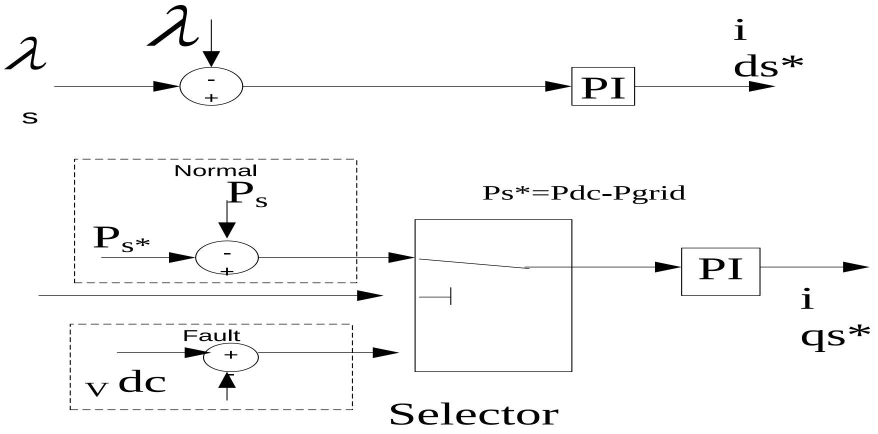
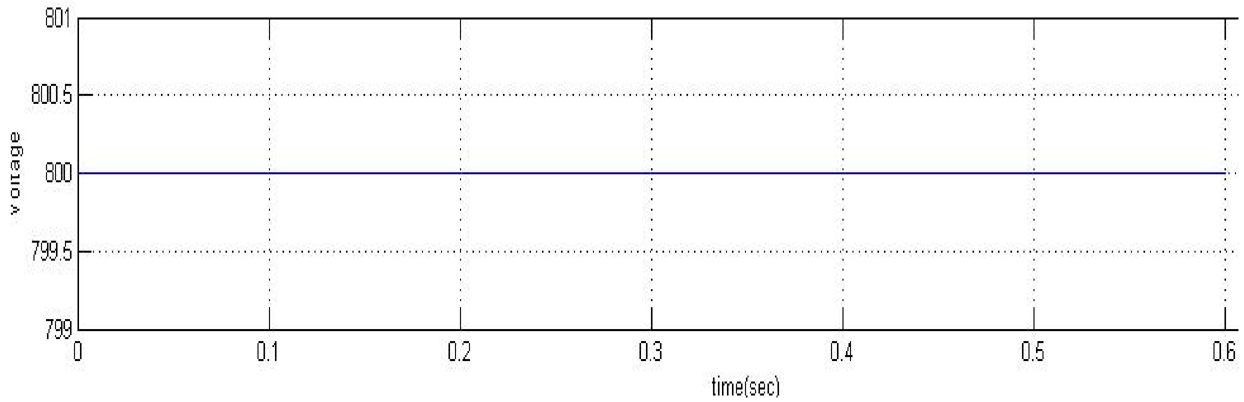


Fig 3Dc link under operating conditions

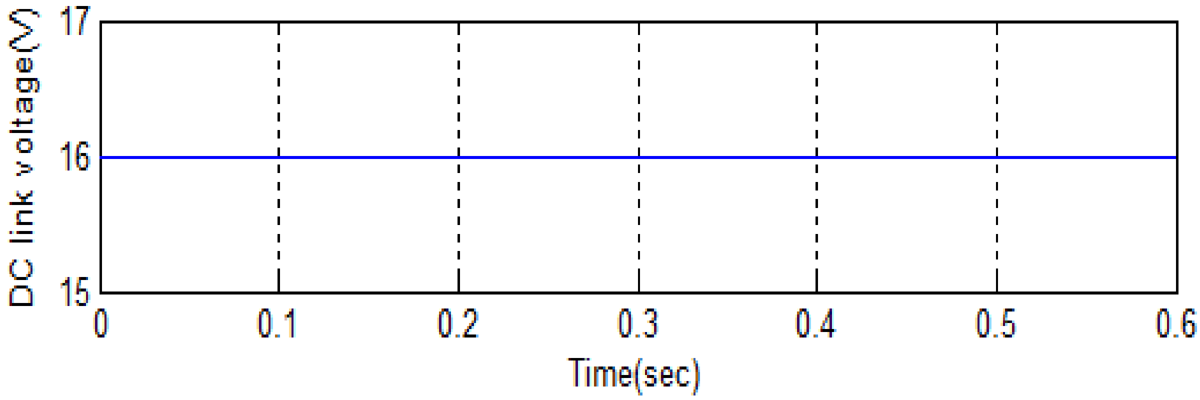
The error in the power controls the PI regulator.it controls the direct and the quadrature axis which operates under normal operating conditions.

V.SIMULATION RESULTS

a)DC-link voltage



b) grid voltage



In this we use a space vector pulse width modulation technique which operates at 5 kHz.. On the positive the flywheel operates in charging and in the negative the flywheel operates in discharged.

VI.CONCLUSION

This paper includes that FESS is used to meet the demand at the grid. The FESS is connected in parallel by a wind side converter is driven by a induction machine. Therefore the FESSoperates undernormal conditions for charging the power and for discharging the power for FESS to the grid was stored during normal condition.

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