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LVRT Characteristic of Scigwind Turbine System by Incorporating PMSG using Matlab/Simulink

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Abstract: ***The squirrel cage induction generator (SCIG) is the fixed speed turbine generator. Though, it is used because of its some advantages, it suffer greatly to meet the requirement of new wind farm grid code, due to dependency on reactive power. In this paper, the permanent magnet synchronous generator (PMSG) wind farm is incorporate with squirrel cage induction generator (SCIG) wind farm, for achieving the optimal performance and some benefits. The permanent magnet synchronous generator (PMSG) can support the reactive power of SCIG wind turbine as well as recover the voltage at the PCC point during the grid fault. The DC link boost chopper is connected with grid side inverter and it boost up the voltage during the grid fault. As well as it improves it can improve the low voltage ride through (LVRT) capability of squirrel cage induction generator (SCIG) based wind farms.***

Keyword: ***Permanent Magnet Synchronous Generator, Squirrel Cage Induction Generator, Low Voltage Ride through, Voltage recovery, Reactive Power Compensation, Wind turbine, DC link boost chopper.***

I. INTRODUCTION

Wind is one of the most usable renewable source of energy in nature. The worldwide concern about environmental pollution and a possible energy shortage has led to increasing interest in technologies for the generation of renewable electrical energy. [3].Historically, the SCIG wind turbine had been widely used because of its advantages like rugged construction, low cost easy operation less maintenance. It is also give the stable frequency control and constant rotating speed when it is connected to the grid. But now days, the penetration level of wind turbine is continuously increasing, so the SCIG Wind turbine is not capable to give the proper voltage control to the grid, because of its poor capability. So in this paper represent that the PMSG wind turbine is incorporate with SCIG wind turbine for increasing the voltage control of grid and support the reactive power of SCIG wind turbine during the fault as well as enhance the low voltage ride through capability of the SCIG wind turbine.

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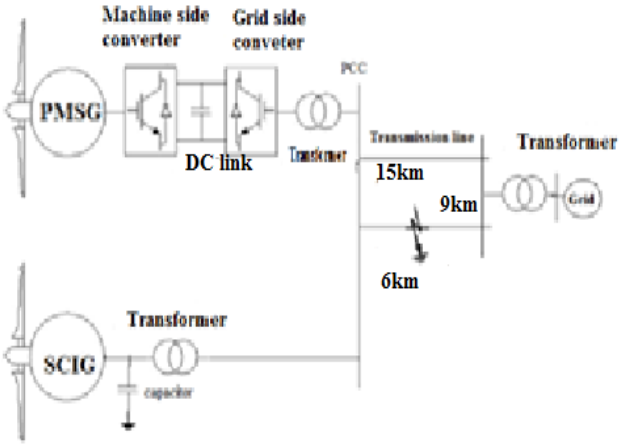

Fig. 1 Closely connected SCIG with PMSG

This is the block diagram of closely connected two wind farms. The fixed speed wind generator SCIG is connected with the capacitor and step up transformer. And the PMSG wind turbine is connected with the full scale converter to the pcc (point of common coupling) point. Both wind turbines are connected with a single coupling point, as well as both wind turbines are connected with 15 km transmission line to the grid. The full scale converter has ability to absorb and supply the amount of reactive power to the grid .when a fault occurs, the grid side converter can provide power up to its rated value to ride through the fault. In this paper, a control strategy for a MW class PMSG based wind turbine system with DC link boost chopper located closely to the SCIG based wind farm is proposed in order to improve LVRT characteristics of SCIG wind turbine by compensating the reactive power which is absorbed by the SCIG based wind farm. This configuration is cost effective solution to enhance LVRT capability of the SCIG wind farm. In the normal condition the control method of PMSG based wind turbine operation is efficient and reliable. It gives the proper voltage control to the grid. During grid fault the control priority to the grid side converter is automatically changed, it is controlling the voltage at the PCC point prior to the DC link voltage. Using this configuration the LVRT capability characteristic of SCIG based wind farms is increased.

II. LVRT CAPABILITY OF SCIG BASED WIND FARM PROBLEM DESCRIPTION

The most unstable kind of wind generator is the fixed speed SCIG. It is not capable to gives the proper voltage control to the grid,

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because it has poor capability of reactive power control. in normal condition it gives the proper operation or voltage control to the grid, but during grid fault condition the voltage is down at the PCC point, and reactive power is absorbed by the SCIG turbine generator. So for overcome this problem, The PMSG wind farm is incorporate with the SCIG based wind farm and obtain and achieve the optimal performance and economic benefits.

III. SOLUTION FOR INCREASING THE LVRT CAPABILITY OF SCIG BASED WIND FARMS.

For increasing the LVRT capability there are multiple FACTS devices are used such as staticvar compensator (SVC), static synchronous compensator (STATCOM), dynamic voltage restorer (DVR), solid state transfer switch (SSTS) and unified power flow controller (UPFC).[1] In this paper we are focus on PMSG based wind turbine with DC link boost chopper. The PMSG wind farm is coordinate with SCIG wind farm within 300 meters. The PMSG wind farm is consist the full scale converter. The full scale converter is divided in two parts namely machine side converter and grid side inverter and the DC link boost chopper is connected between them for boost up voltage and give the proper voltage control to the grid.

[A] MACHINE SIDE CONVERTER

Basically the machine side converter is used to convert the AC to DC voltage. This controller has a structure of two loops in cascade; an inner current control loop and an outer loop. The inner current control loop controls the d-q currents to the reference values while the outer control loop controls active power and stator voltage. The active power depends on the d-component of stator current while the reactive power depends on the q-component of the current only. This means that in the machine side converter's controller, the active power is controlled by the d- component current whereas the stator voltage is controlled by means of the q-component current. [2]

[B] GRID SIDE CONVERTER

The aim of this paper is to applied the control strategy to the controller grid side converter is to keep the DC- link voltage constant, thereby ensuring that the entire active power generated by the generator is delivered to the grid. In addition, it is the used to control the reactive power fed to the network. in this study, the objective of this controller is to keep DC- link voltage and grid voltage (VPcc) at their rated value. Besides, a reasonable order of control priority is established for purpose of grid voltage support. Hence, the grid side converter not only takes the responsibility for keeping the PMGS running properly but also provides adequate response of dynamic reactive power compensation for the fast voltage recovery after fault clearance.

[C] PMSG WIND TURBINE MODELING

The mathematical relation for the mechanical power extraction from the wind can be expressed as follows:

$$Pw = 0.5p\pi R^2 Vw^3 C_P(\lambda,\beta) \qquad (1)$$

Where, Pw is the extracted power from wind, p is the air density [kg/m³], R is the blade radius [m],Vw is the wind speed [m/s] and C_P is the power coefficient which is a function of both speed ratios, λ, and blade pitch angle ,β[deg]

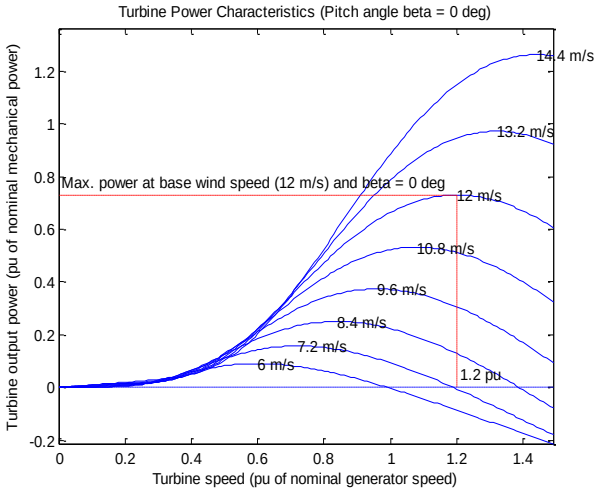

Fig. 2 (Maximum power of turbine in term of Wind and rotor speed)

TABLE-1 PARAMETERS OF WIND TURBINE

Base power	1.5e6/0.9[va]
Base wind speed	12[m/s]
Max power at base wind speed	0.73[pu]
Base rotational speed	1.2[pu]
Pitch angle	0 [deg]

TABLE-2 PARAMETERS OF PMSG

Number of pole pairs	3
Rated speed	152
Stator phase resistance	18.7[ohm]
Flux linkage inductance	8.5e-3[h]

TABLE -3 PARAMETER OF DRIVE TRAIN

Inertia at turbine	1/8
Shaft stiffness	0.3
Damping	1

TABLE-4 PARAMETER OF THREE PHASE CIRCUIT BREAKER

Initial status of breakers	closed
Transition time	5/60
resistance	0.001
Snubbers resistances Rp(ohms)	1e6
Snubbers capacitance cp (farad)	Inf

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TABLE- 5 PARAMETERS OF UNIVERSAL BRIDGE

Numbers of bridge arms	3
Snubber resistance RS (ohms)	0.1
Power electronic device	Diodes
Ron (ohms)	1e-3
Lon (ohms)	0

IV. SIMULATION MODEL OF PMSG WIND TURBINE WITH MSC & GSD SCHEME

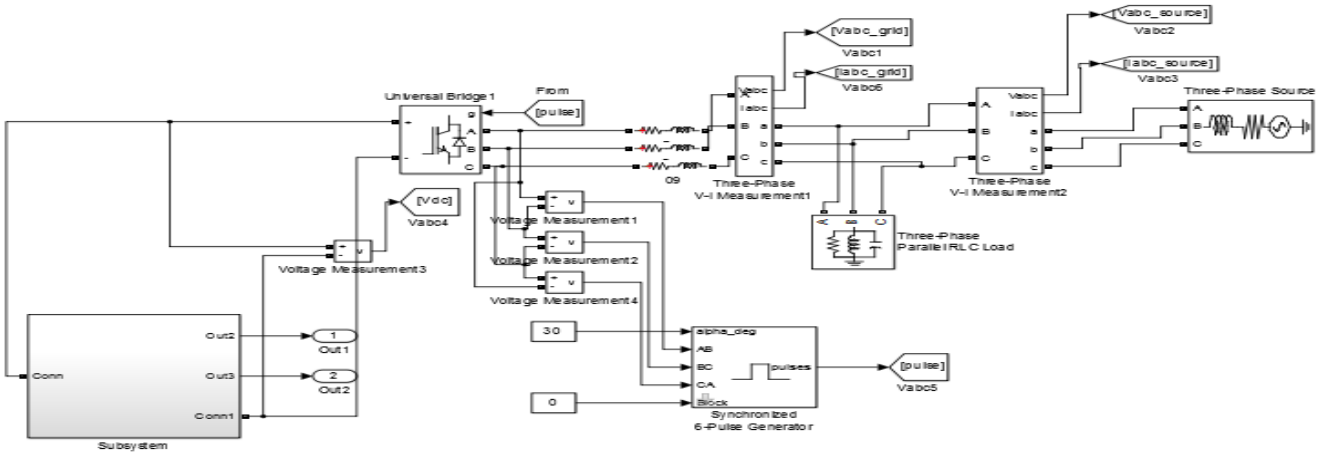

Fig. 3 Implementation of PMSG wind turbine with MSC & GSD scheme

The PMSG wind turbine generator is connected with the machine side converter, machine side converter is work in cascade manner, it consist two loops the inner current control loop controls the d-q currents to the reference values while the outer control loop controls active power and stator voltage. DC link boost chopper is connected between the machine side converter and the grid side converter. The dc link chopper is used to dissipate excess stored energy in DC capacitor. When the fault disappears.

V. SIMULATION RESULT

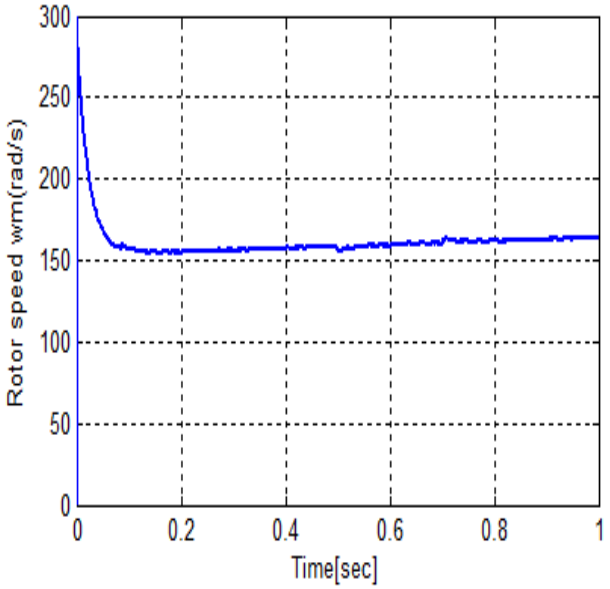

Fig. 4 Rotor speed of PMSG

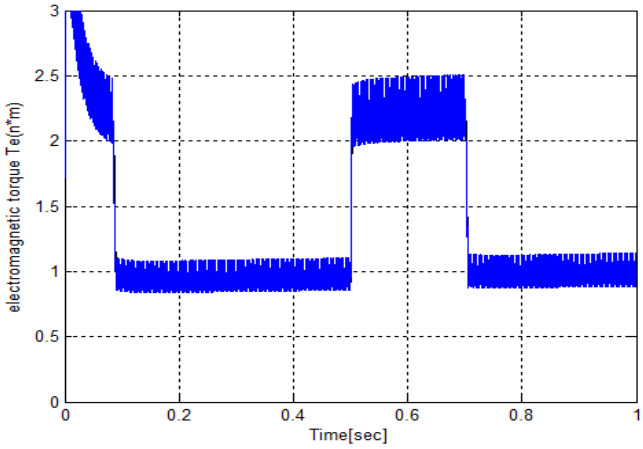

Fig. 5 Electromagnetic torque at wind speed 12 m/s

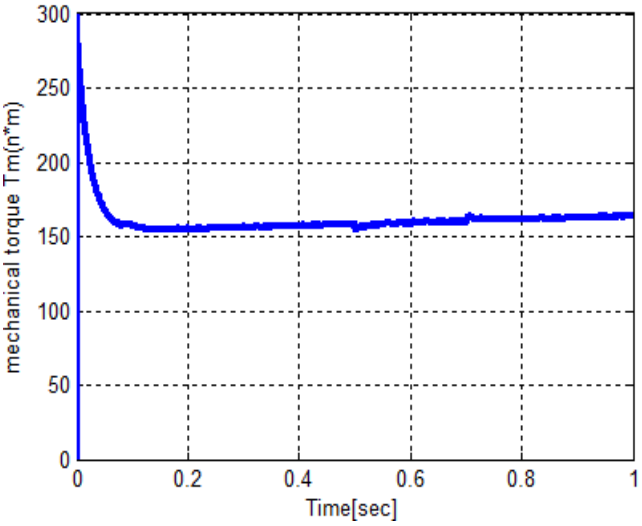

Fig. 6 Mechanical torque at wind speed 12m/s

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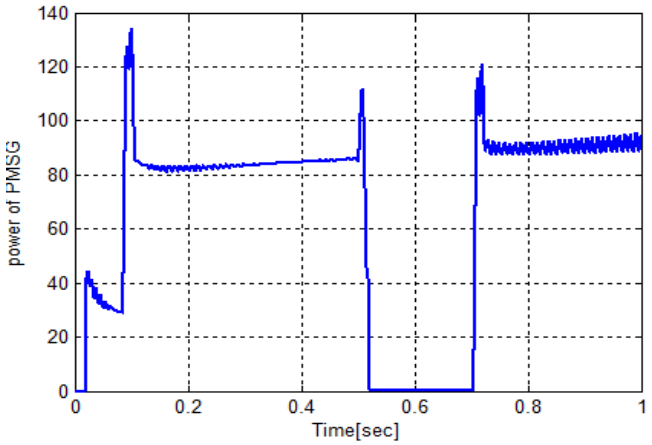

Fig. 7 Power at wind speed 12 m/s with fault

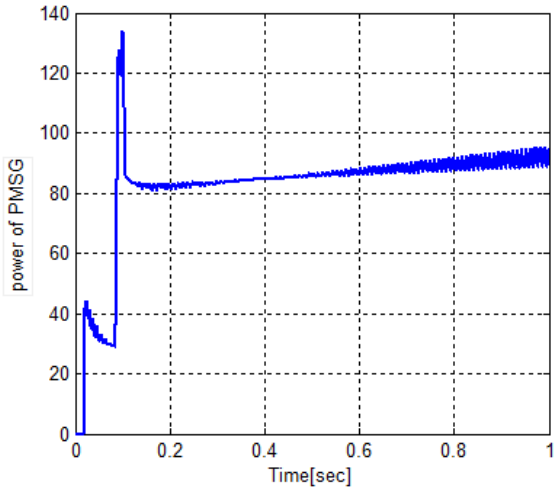

Fig. 8 Power at wind speed 12 m/s without fault

VI. CONCLUSION

In this paper, the PMSG wind turbine is connected with full scale converter to the grid. The full scale converter is used to maintain the voltage and control the reactive power to grid. In normal condition, it gives the total power and voltage to grid, during the grid fault the power and voltage of grid is totally down. in this paper the fault duration is 0.5 to 0.7, in this duration the power and voltage at the grid is totally down and as soon as the fault is clear, the voltage and power starts to increasing as shown in fig-7.

VII. FUTURE WORK

In future work we are going to simulate the control topology for the grid. That topology will be use to compensate the reactive power of the SCIG wind turbine and it recovers the voltage at the grid which been decreased during the fault condition in minimum time. and it improve the LVRT capability of SCIG wind turbine.

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