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Back To Back Converter Based Real and Reactive Power Control with Constant Speed Operation of Dfigin Wind Mill

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Abstract: ***The DFIG turbine could be a variable speed turbine typically used in world wide. In present world, DFIG wind turbines basically create utilization of the innovation that created ten years back. In any case, it's found within the paper that there's confinements regular management technique. The DTC is taken once for the direct power management (DPC) of electrical drives. The direct power management is accomplished by selecting exchanging applicable exchanging table that is formed by viewing the reference and assessed estimations of real and reactive power. The device potential difference is evaluated in light weight of the dc interface voltage and also the exchanging conditions of the device. The spatial relation of voltage vectors or position of virtual motion square measure used to regulate the real and responsive power. The dynamic and responsive power is controlled by rotor voltage, that experiences consecutive voltage supply device and DC-connect voltage is to boot sorted stable. the standard management approach is contrasted and also the projected management methods for DFIG turbine management underneath each consistent and breezy breeze conditions. A MATLAB primarily based copy frame work was work to approve the viability of the projected strategy. The projected strategy waveforms of real power, receptive power, DC interface voltage and generator speed square measure contrasted and ancient technique. This paper demonstrates that underneath the DPC management strategies, a DFIG framework have a prevailing execution in numerous angles.***

Index Term—DC-link capacitor, DVC, DFIG, DPC.

I. INTRODUCTION

In this world, wind turbine energy is the most significant renewable energy resources in this world. Most of the wind farms were equipped with slip ring induction generators. The facility potency of such fastened speed is fairly for many wind to enhance the potency, several trendy wind generators adopts a variable speed within the following ways: cycloconverter or by mistreatment of AC to DC as well as DC to AC converters using generators on condition that a static frequency [1], device employed to interface the machine to grid [2]. An anotherapproach of employing a slip ringinduction generator fed with variable frequency rotor voltage is increasing attention for wind power functions.

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With dynamic wind speed, one will regulate the frequency of injected rotor voltage of the DFIG to get a constant-frequency at the mechanical device [3]. There are many reasons for mistreatment DFIG in wind mill as following ways: converters regarding 25-30% of the generator rating more and more in style, four quadrant realand reactive power capabilities, device price and power loss area unit reduced compared wind turbines mistreatment fastened speed generators, increase turbine energy capture capability, cut back stress of the mechanical structure and create the realand reactive power manageable higher integration. It can be Reduced the power loss compared to wind turbines mistreatment fastened speed of slip ring induction generators or fully-fed synchronous generators with full-sized converters.

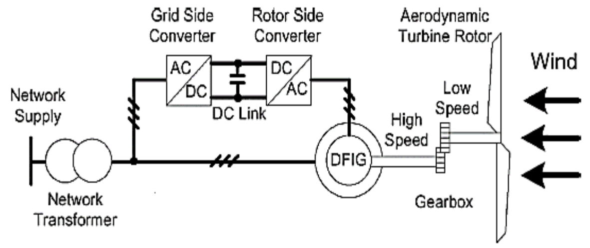

Fig .1DFIGwind turbinesystem

Then, projected management structure, the integrated management DFIG system was developed. As well as real power, reactive power and DC-link capacitor voltage. within the sections that follow, in this paper first introduces the overall operation of a DFIG system and overall management structure in section II. Then, section III presents the active and reactive management of DFIG in WECS. typical and electricity vector management of GCS is given in section IV. In section V presents$64000 and reactive power management of RSC. Then, the formal logic controller given in section VI. Simulation studies square measure in section VII to match the speed variation of DFIG turbine exploitation. The direct and ancient vector management configuration for steady and variable wind conditions.

II. DFIG MECHANICAL SYSTEM

(a) DFIG mechanical system

A DFIG turbine consists of 3 parts: turbine drive train,slip ring induction generator and power converter (Fig. 2) [2], [4]. within turbine drive train, the blades of rotor rotary engine catch wind energy that's transferred to theinduction generator .

The induction generator may be a normal wound rotor induction machine , with its stator coil winding directly connected to the grid and its rotor winding connected to the grid through a power electronicsconvertor.The convertor is constructed by 2 self-commutated converters, the RSC and GSC with intermediate dc-link capacitor voltage.

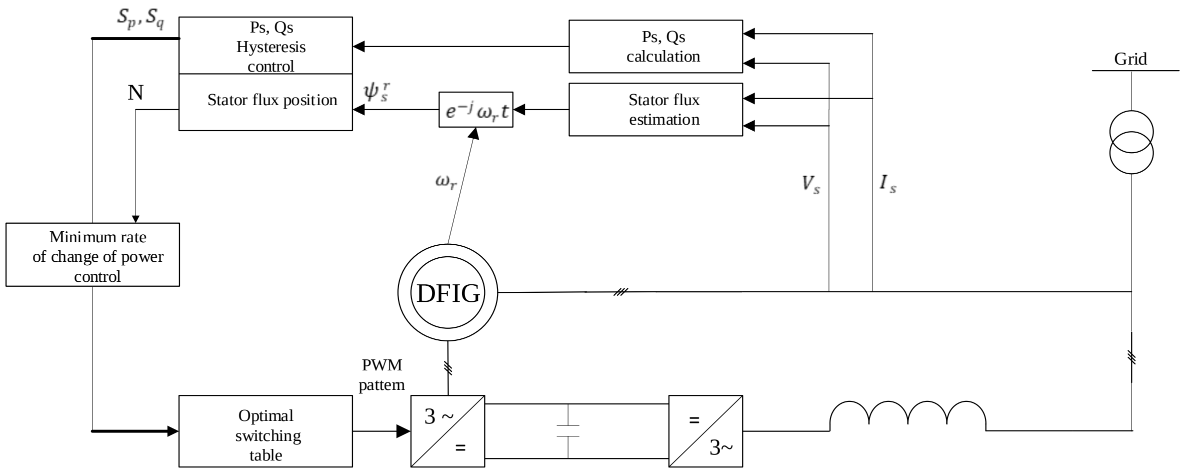

Fig. 2 configuration of DFIG system with active and reactive power management

(b) Power flow in DFIG

The DFIG is operated in 2 modes of operation namely; sub-synchronous and super-synchronous mode looking on the rotor speed below and on top of the synchronous speed. Figure.2 shows the essential theme adopted within the majority of systems. The stator coil winding is directly connected to the AC mains, while the rotor winding is fed from the facility physical science convertor via slip rings topermit DIFG to control at totally different speeds in response to dynamical thewind speed. Indeed, the essential thought is to interpose a frequency convertor between the variable frequency induction generator and stuck frequency grid. The DC condenser linking [5] stator-facet and rotor-side converters permits the storage of power from induction generator for any power generation. to realize full management of grid current and DC-link voltage.The slip powerwillflow ineachdirections grid to rotorsimilarlyas rotor to grid in, i.e. to the rotor fromoffer the availability |the provision and from supply to the rotor andthencethe speed of the machineare oftencontrolled from either rotor-side or stator-sideconvertorineachon top and below-synchronous speed ranges.

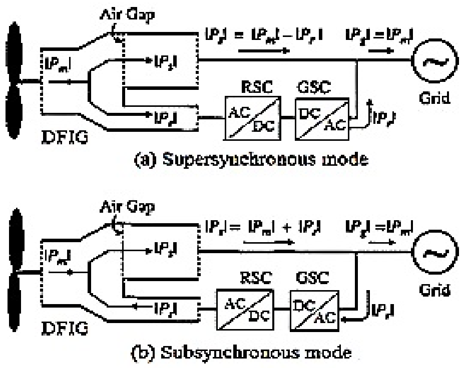

Fig.3 Flow of power direction in DFIG conversion system

The wound rotor induction machine is often controller in each above synchronous speed and below synchronous speed operational modes. [6] The below synchronous speed with in the driving mode and above synchronous speed with in the generating mode, RSC operates as a rectifier associate in GSC as an electrical converter at that point the slip power is came back to the stator coil. RSC operates as associate in nursing electrical converter and GSC as a rectifier at that point wherever slip power is equipped with the rotor winding. At the synchronous speed, the slip power is taken from rotor windings and during this case machine behaves as a synchronous machine.

III. POWER FLOW CONTROL INDFIG

The per part equivalent for a DFIG is shown within the figure4. Variables with the rotor quantities as seen from stator coil aspect. By neglecting the results of Rs, jXls and jXlr the per part stator coil power Ss and rotor power Sr may be expressed as

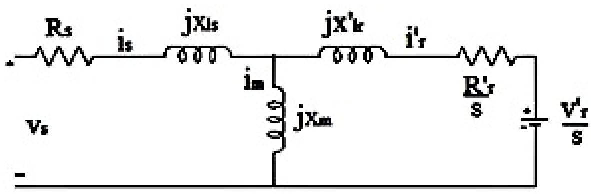

Fig.4 Equivalent Circuit of a DFIG

$S_S = P_S + jQ_S = V_S I^*_S$ -------------------------(1)

$S_r = P_r + jQ_r = V_r I^*_r$ --- -----------------------(2)

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Real and reactive powers square measure found by exploitation the Equations as below.

$$p_s \approx \frac{3}{2}(\overrightarrow{v_s})i_{sy} = -\frac{3}{2}(\overrightarrow{v_s})\frac{L_m}{L_s}i_{ry} \text{ ------------------ } (3)$$

$$Q_s \approx \frac{3}{2}(\overrightarrow{v_s})i_{s\alpha} = -\frac{3}{2}(\overrightarrow{v_s})\frac{L_m}{L_s}(|\overrightarrow{l_{ms}}| - i_{rx}|)$$

$$\approx \frac{3}{2}(\overrightarrow{v_s})\frac{L_m}{L_s}(\frac{|\overrightarrow{v_s}|}{2\Pi\Pi_s Lm} - i_{rx}) \text{ -------------------- } (4)$$

IV. DYNAMIC BEHAVIOR OFTHEROTORREFERENCE SYSTEM

The equivalent circuit of the DFIG with in rotor reference system rotating at the rotor speed is shown in Figure. The rotor reference system is diagrammatical as αr and βr.

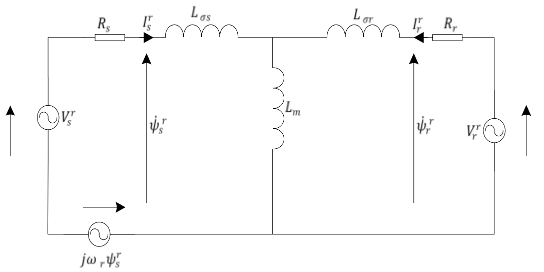

Fig. 5. Equivalent circuit of rotor reference frame

The rotor flux linkage vector may be expressed as

$$\psi_s^r = L_s I_s^r + L_m I_r^r$$

$$\psi_r^r = L_m I_r^r + L_m I_s^r \quad ------- (5)$$

According to the rotor flux linkages the stator coil current may be calculated as

$$I_s^r = \frac{L_r\psi_s^r - L_m\psi_r^r}{L_s L_r - L_m^2} = \frac{\psi_s^r}{\sigma L_s} - \frac{L_m\psi_r^r}{\sigma L_s L_r} \quad ----(6)$$

where $\sigma = {(L_s L_r - L_m^2)}/{L_s L_r}$ is the leakage factor.

From the equivalent circuit of DFIG, stator coil voltage vectors can be expressed as

$$V_s^r = R_s I_s^r + \dot{\psi}_s^r + j\omega_r\psi_s^r \quad --------(7)$$

From the stator coil voltage and current the stator coil real power input from the grid can be expressed as

$$P_s = \frac{3}{2}V_s^r . I_s^r = \frac{3}{2}(R_s I_s^r + \dot{\psi}_s^r + j\omega_r\psi_s^r). I_s^r \quad ----(8)$$

Neglecting the stator coil copper loss the top of equation becomes

$$P_s = \frac{3}{2}(\dot{\psi}_s^r + j\omega_r\psi_s^r). I_s^r \quad -------- (9)$$

In the same way the reactive power output to the grid is expressed as

$$Q_s = -\frac{3}{2}V_s^r * I_s^r = -\frac{3}{2}(\dot{\psi}_s^r + j\omega_r\psi_s^r) * I_s^r \quad ----(10)$$

The relationship between the stator and rotor flux in the stationary α-β and rotor α_r - β_r. reference frame is shown in Figure 3

The stator coil and rotor fluxes in rotor reference system is given by

$$\psi_s^r = |\psi_s^r|. e^{j\theta_s} \quad -------------(11)$$

$$\psi_r^r = |\psi_r^r|. e^{j\theta_r} \quad ------------- (12)$$

The transformation of stator coil flux on the reference frame is given by

$$\psi_s^r = \psi_s^s. e^{-j}\omega_r t \text{ ------------ } (13)$$

The relationship between rotor flux and stator coil is given by

$$\dot{\theta}_s = \omega_1 - \omega_r \text{ -------------- } (14)$$

The stator flux on the stationary reference is given by

$$\psi_s^s = \int (V_s^s - R_s I_s^s)dt \text{ --------- } (15)$$

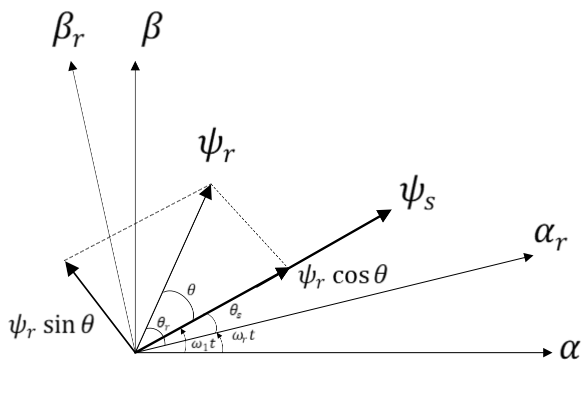

Fig 6. Relation of stator coil and Rotor Flux Linkage

Assuming the connection of stator coil to the balanced ac network such and there's no amendment in rotor speed for the analysis. The big inertia of the turbine the rotor.

$$I\psi_s^r I = |\psi_s^s e^{-j\omega_r t}| = \left|\int V_s^s\, dt\right| = constant \quad ---(16)$$

$$\frac{d|\psi_s^r|}{dt} = \quad --------------(17)$$

$$\dot{\psi}_s^r = |\psi_s^r|\, j\, \dot{\theta}_s e^{j\theta_s} = \mathrm{j}\,(\omega_1 - \omega_r)\psi_s^r$$

Based on the equations (6), (9), (13) and (18) the stator active power input and reactive power output is given by

$$P_s = -\frac{3}{2}\frac{L_m}{\sigma L_s}\omega_1 |\psi_s^r||\psi_r^r|\sin\theta \quad ------(18)$$

$$Q_s = \frac{3}{2}\frac{L_m}{\sigma L_s}|\psi_s^r|\left(\frac{L_m}{L_r}|\psi_r^r|\cos\theta - |\psi_s^r|\right) \quad --(19)$$

Where $\theta = \theta_r - \theta_s$ is the angle between the stator and rotor flux linkage vectors.Differentiating (18) and (19) results in the following equations

$$\frac{dP_s}{dt} = -\frac{3}{2}\frac{L_m}{\sigma L_s L_r}\omega_1|\psi_s^r|\frac{d(|\psi_r^r|\sin\theta)}{dt} \quad ---(20)$$

$$\frac{dQ_s}{dt} = \frac{3}{2}\frac{L_m}{\sigma L_s L_r}\omega_1|\psi_s^r|\frac{d(|\psi_r^r|\cos\theta)}{dt} \quad ---(21)$$

From equations (20) and (21) it is found that the active and rective power depends on $|\psi_r^r|\sin\theta)$ and $|\psi_r^r|\cos\theta)$ respectively. The $|\psi_r^r|\sin\theta)$and$|\psi_r^r|\cos\theta)$ are the perpendicular components of the rotor flux in the direction of stator flux. This indicates that the change in the rotor flux will change the active (P_S) and reactive powers (Q_S). It is also found that the initial status of the rotor position will not affect the active (P_S) and reactive powers (Q_S).

V. SIMULATION RESULTS

The DFIG based wind mill mostly power generation system is simulated in MATLAB computer code. A5MW DFIG is taken into account for the simulation studies .the 2converters, one for grid aspect and another for rotor aspect square measure developed in simulation model. within the grid aspect AC to DC convertor is employed to convert grid ac voltage into dc and maintains dc voltage within the dc link voltage is 1000V. Since the convers to manufacture harmonics, a RC filter is connected.

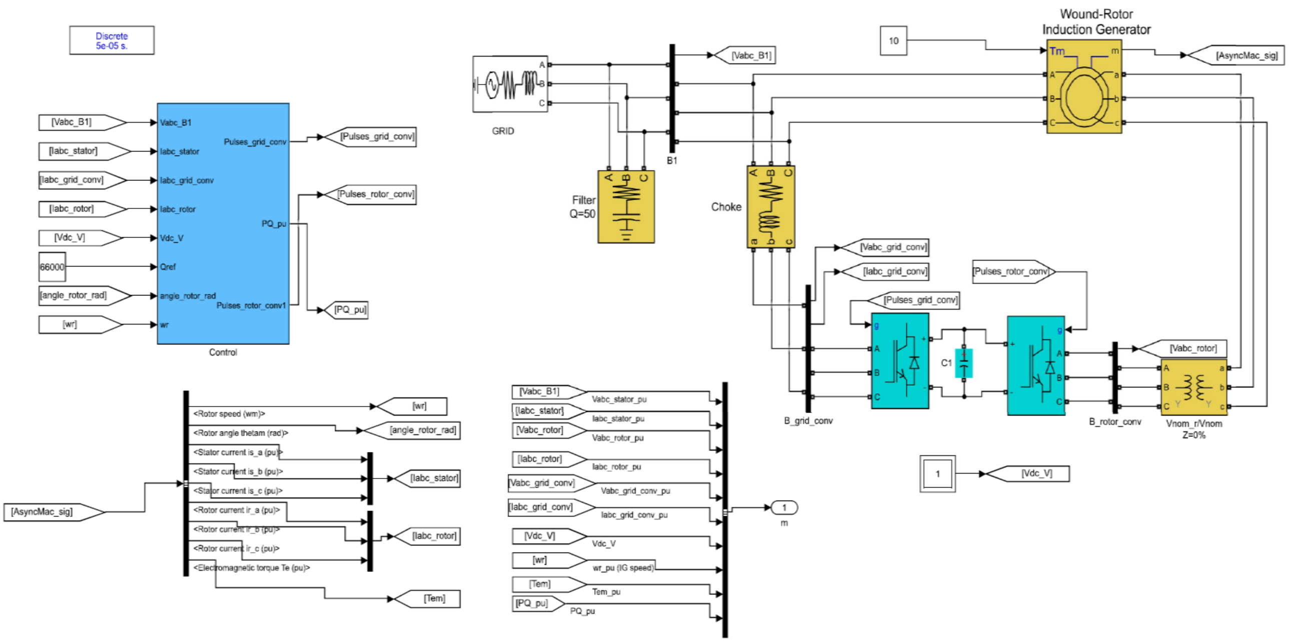

Fig 7. Simulation model of DFIG by the proposed system

The electrical condenser worth of the RC filter is 200µF. This RC filter can absorb the change harmonics of the convertor. The rotor aspect convertor is DC to AC electrical converter that is employed management to regulate the real and reactive power fromplanneddirect power control strategy.The aimof the gridconvertoristo keep upthe dc linkcapacitorvoltage toa relentlessworthof 1000V. Thechangefrequency of theconvertoris 2kHzand also theseries reactor is0.3mH.

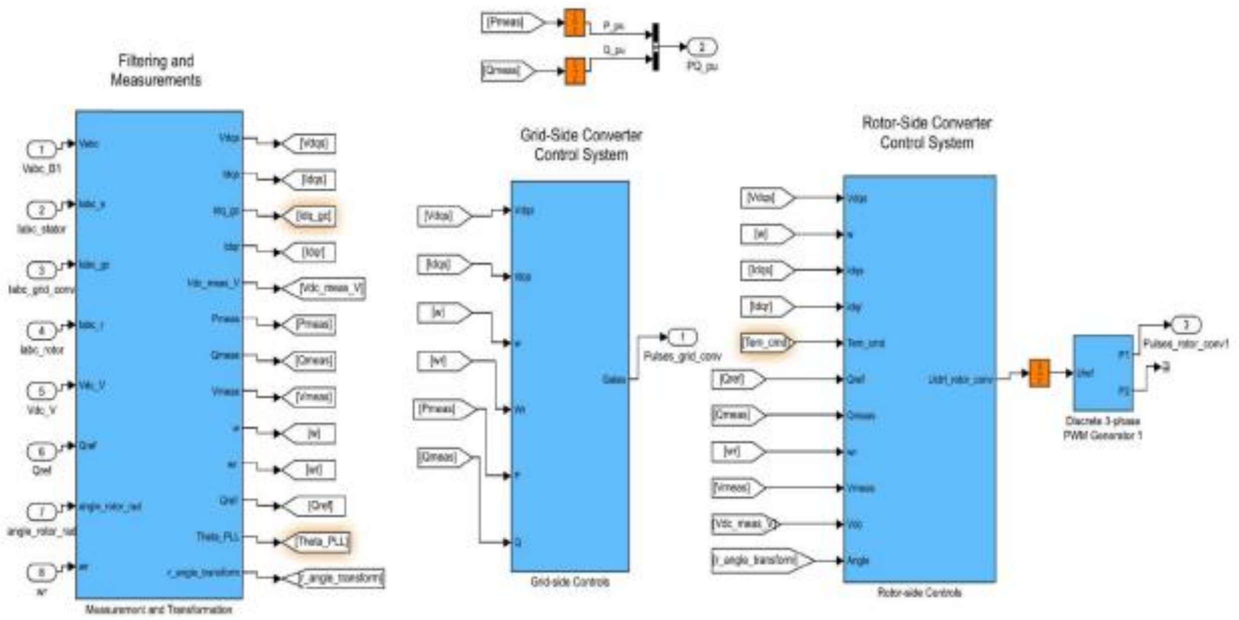

Fig 8. Proposed Control Scheme

First the gridaspectconvertoris operatedto controlthe dc link capacitor voltage.The rotor speedis aboutoutwardly. After 0.2 Sec rotoraspectconvertoris enabled. The initialstator coilreal and reactive power being set as -2.5MW and -0.7Mvarseverally.The negative sign indicates thatthe $64000power is generatedand also thereactive power is absorbed.the $64000and reactive power is varied by theplanneddirect powermanagementwith constant rotor speed.

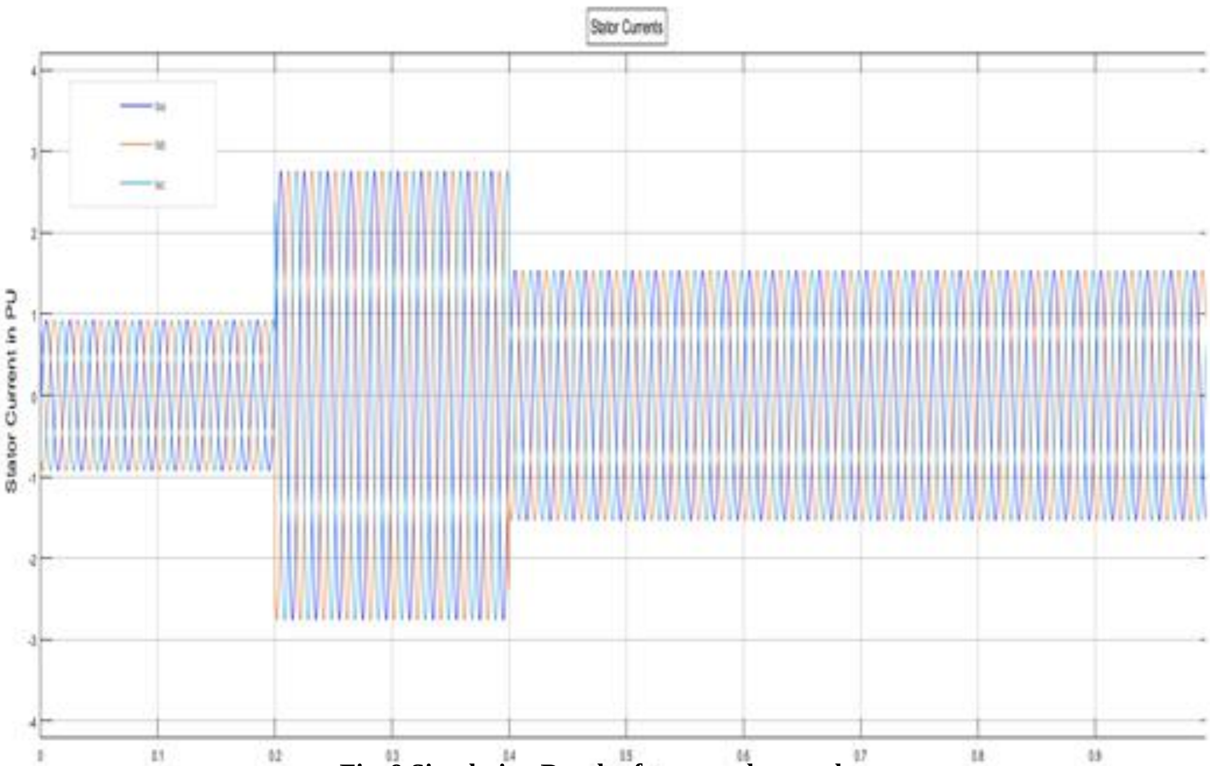

Fig. 9 Simulation Result of proposed control system

For the step amendment of active and reactive power there's overshoot of either the stator coil or rotor currents. Simulation is carried for alternative step amendment of active and reactive power with constant rotor speed. For any variations of active and reactive step amendment or the other fastened rotor speed there's no stator coil or rotor current overshoot. This shows the effectiveness of the planned direct power management for the doubly fed induction generator.

VI. CONCLUSION

In this paper shows DFIG turbine management study employs a direct power management style. that compares the projected management theme with normal standard DFIG management methodology. it shows that beneath the DVC management configuration. however, it's can integrated GSC and RSC management is intended to implement the dc-link capacitor voltage, real power, reactive power, and grid voltage management functions. comprehensiveMATLab simulation studies demonstrate the projected DFIG turbine structure will effectively accomplish in turbine. Variable speed wind conditions inside physical constraints of a DFIG system. the projected wind mill operates the system by control the AC to DC converter for real and reactive power management and by dominant the DC to AC converter to stabilize the dc-link voltage because of the main concern. The direct-current vector structure is additionally effective for power demand situation, power issue improvement and grid voltage support a voltage sag condition.

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