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Doubly Fed Induction Generator in Wind Mill

Prof. Suraj R.Karpe [1], Prof.B.N.Bedre [2], Prof. V.P.Dhote [3]

Assistant Professor, Dept. of Electrical Engineering, S.B.Patil College of Engineering, Indapur, Maharashtra, India [1]

Assistant Professor, Dept. of Electrical Engineering, S.B.Patil College of Engineering, Indapur, Maharashtra, India [2]

Assistant Professor, Dept. of Electrical Engineering, Government college of Engineering, Aurangabad, Maharashtra, India [3]

ABSTRACT: This paper deals with the analysis, modelling, and control of the doubly-fed induction generator in wind mill. Here different rotor current control methods are determined with the objective of eliminating the influence of the back electromotive force (EMF). Method that utilizes both feed forward of the back EMF and so-called “active resistance” manages best to suppress the influence of the back EMF on the rotor current, particularly when voltage sags occur. This method also gives the best stability properties & best robustness to parameter deviations. The response of the DFIG system is simulated and verified experimentally. Voltage sag to 80% is handled very well. The energy production of the DFIG wind turbine is investigated and compared to that of other wind turbine systems. The result found is that the energy capture of the DFIG wind turbine is almost the same as for an active stall-controlled fixed-speed (using two fixed speeds) wind turbine.

Keywords: Doubly-fed induction generator (DFIG), wind turbine, wind energy, current control, voltage sag, harmonically distorted grid voltage; vector proportional integrated (VPI) regulator

I.INTRODUCTION

Induction generator or parallel operated induction generators are focused according to available analysed references. These induction generator driven by the individual prime movers employed excitation capacitor bank to build up desired voltage via self-excited phenomena. Hence the value of the excitation capacitor bank and the rotor speed determine the magnitude of the generated voltage and its frequency. Both voltage and frequency need to be controlled to feed the power to the load. But for grid connected operation, there are two types of generators are used. (i.e., single output and double outputs).In order to feed the active power to the grid, the machine should run at a speed greater than the synchronous speed of the revolving magnetic field. (i.e. slip should be negative).The single output generator feeds active power to the grid via only stator side and double output generator feeds electrical power to the grid via both stator as well as rotor side. The latter is also called static Kramer, double-fed or double outputs induction generators. This is only the generator which generates the power more than rated power without overheating. Besides, this kind of power generation usually causes problems in the utility grid system. Because the control on active and reactive power of the machine is complex one. Wind turbines often do not take part in voltage and frequency control and if a disturbance occurs, the wind turbines are disconnected and reconnected when normal operation has been resumed. As the wind power penetration continually increases, power utilities concerns are shifting focus from the power quality issue to the stability problem caused by the wind power connection. In such cases, it becomes important to consider the wind power impact properly in the power system planning and operation. This paper will focus on the grid-connected induction generator feeding power with DOIG during steady state and transient conditions. This paper describes the transient behaviour of a doubly fed induction generator (DFIG) driven by wind turbine after its disconnection from the grid. The induction machine runs at a specific speed with the stator disconnected from the grid (Is=0), the rotor is suddenly excited with slip-frequency voltages derived from voltage regulators so as to produce commended open-circuit stator terminal voltage. Behaviour under varying rotor speed typically observed in wind turbine is also reported.

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II. DFIG DYNAMIC MODELLING

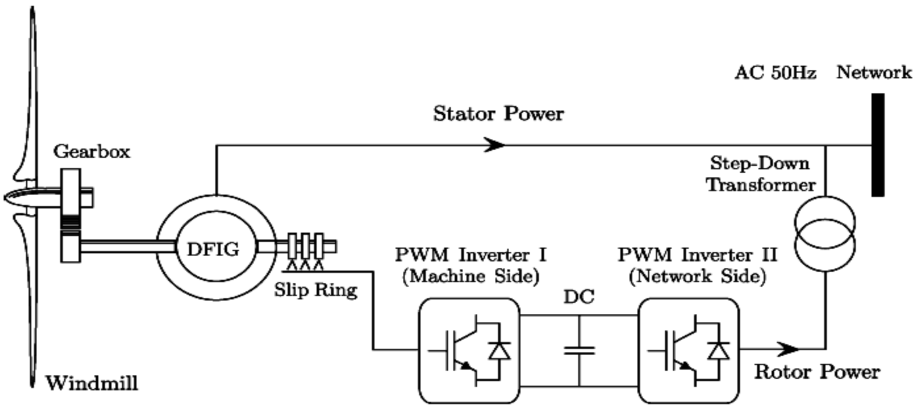

Fig-1: Model of DFIG in wind turbine

A commonly used model for induction generator converting power from the wind to serve the electric grid is shown in Fig.1.The stator of the wound rotor induction machine is connected to the low voltage balanced three-phase grid and the rotor side is fed via the back-to-back IGBT voltage-source inverters with a common DC bus. The network side converter controls the power flow between the DC bus and the AC side and allows the system to be operated in sub synchronous and super synchronous speed. The proper rotor excitation is provided by the machine side power converter. The general model for wound rotor induction machine is similar to any fixed-speed induction generator as follows.

A. Stator Voltage Equations is

$$V_{qs} = p\lambda_{qs} + w_{ds} + r_s i_{qs}$$
$$V_{ds} = p\lambda_{ds} - w_{qs} + r_s i_{ds}$$

B. Rotor Voltage Equations

$$V_{qr} = p\lambda_{qr} + (w - w_r)\lambda_{dr} + r_{sr} i_{qr}$$
$$V_{dr} = p\lambda_{dr} + (w - w_r)\lambda_{qr} + r_{sr} i_{dr}$$

C. Power Equations

$$P_s = \frac{3}{2}(V_{ds} i_{ds} + V_{qs} i_{qs})$$

$$Q_s = \frac{3}{2}(V_{qs} i_{ds} - V_{ds} i_{qs})$$

D. Torque Equation

$$T_e = -\frac{3}{2}\frac{p}{2}(\lambda_{ds} i_{qs} - \lambda_{qs} i_{ds})$$

III. ROTOR POWER CONVERTERS

This section will detail the AC-DC-AC converter used on the rotor which consists of two voltage-sourced converters, i.e., rotor-side converter (RSC) and grid-side converter (GSC), which are connected “back-to-back.” Between the two converters a dc-link capacitor is placed, as energy storage, in order to keep the voltage variations (or ripple) in the dc-link voltage small. With the rotor-side converter it is possible to control the torque or the speed of the DFIG and also the power factor at the stator terminals, while the main objective for the grid-side converter is to keep the dc-link voltage constant regardless of the magnitude and direction of the rotor power. The grid-side converter works at the grid

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frequency (leading or lagging in order to generate or absorb a controllable magnitude of reactive power). A transformer may be connected between the grid-side inverter or the stator, and the grid. The rotor-side converter works at different frequencies, depending on the wind speed.

III.SIMULATION WORK AND RESULTS

Simulation model of Doubly Fed Induction Generator has been developed by using SIMULINK MATLAB. The simulation work has been performed for this drive system at different load conditions. Input supply voltage is 3-phase, 415 V (rms), 50 Hz & Induction Motor: 5 hp 415 V, 50 Hz, 1430 rpm induction motor is used. Also with this fig.(3) for speed and torque characteristics & fig.(4) for 2-phase current and fig.(5) for 3-phase current are given with this paper.

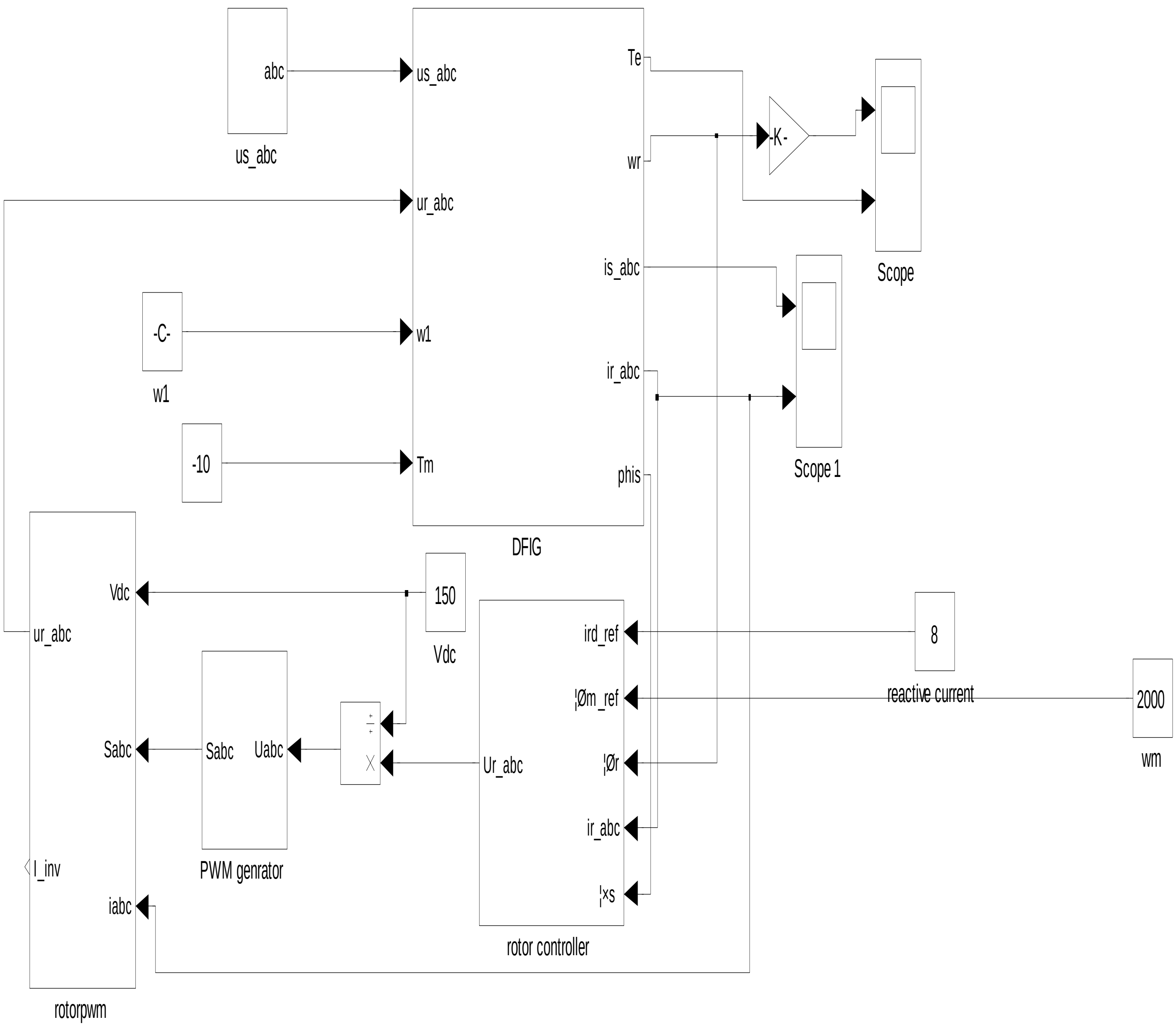

Fig.2 Simulink diagram

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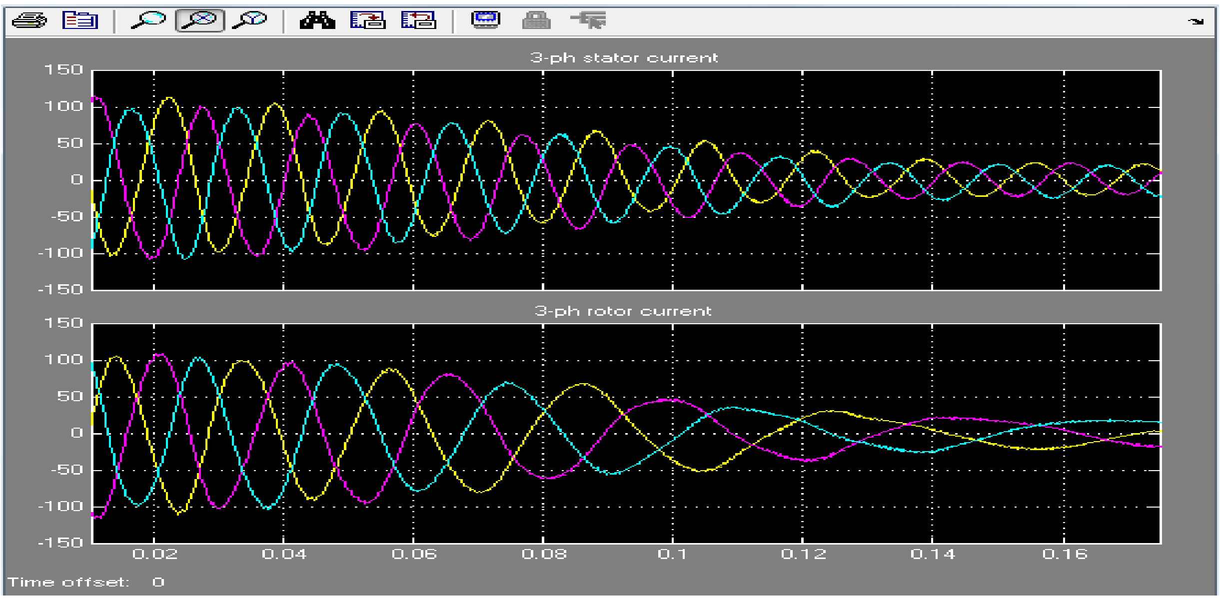

Fig.3 3-ph stator current & rotor current

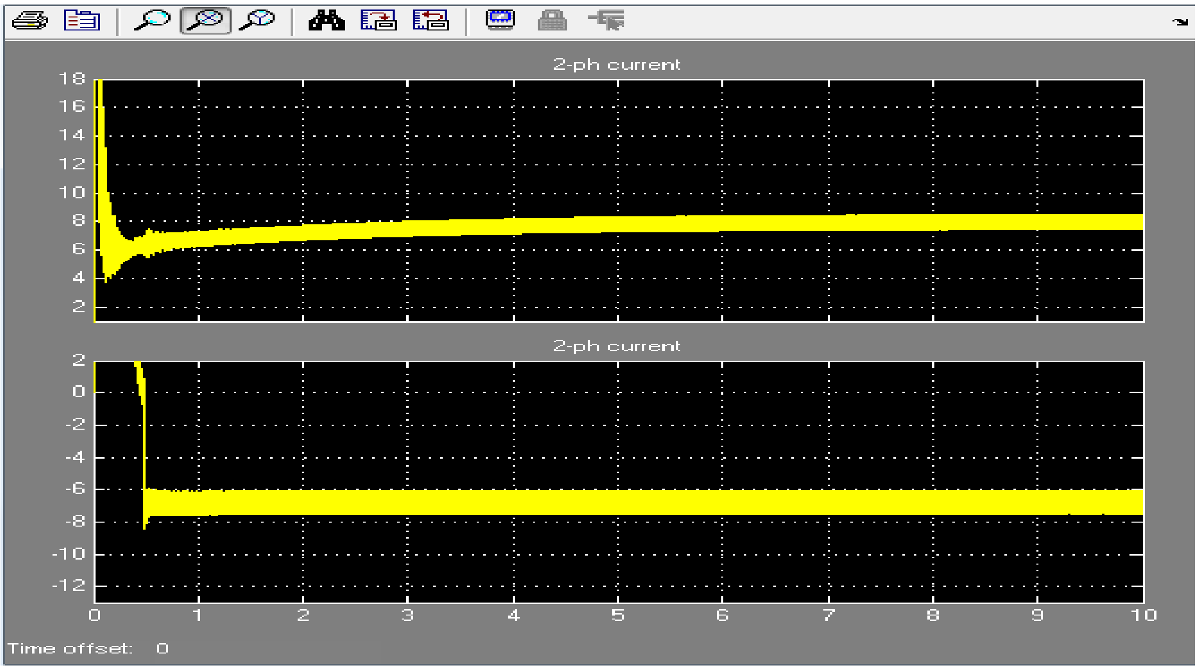

Fig.4 2-ph stator current & rotor current

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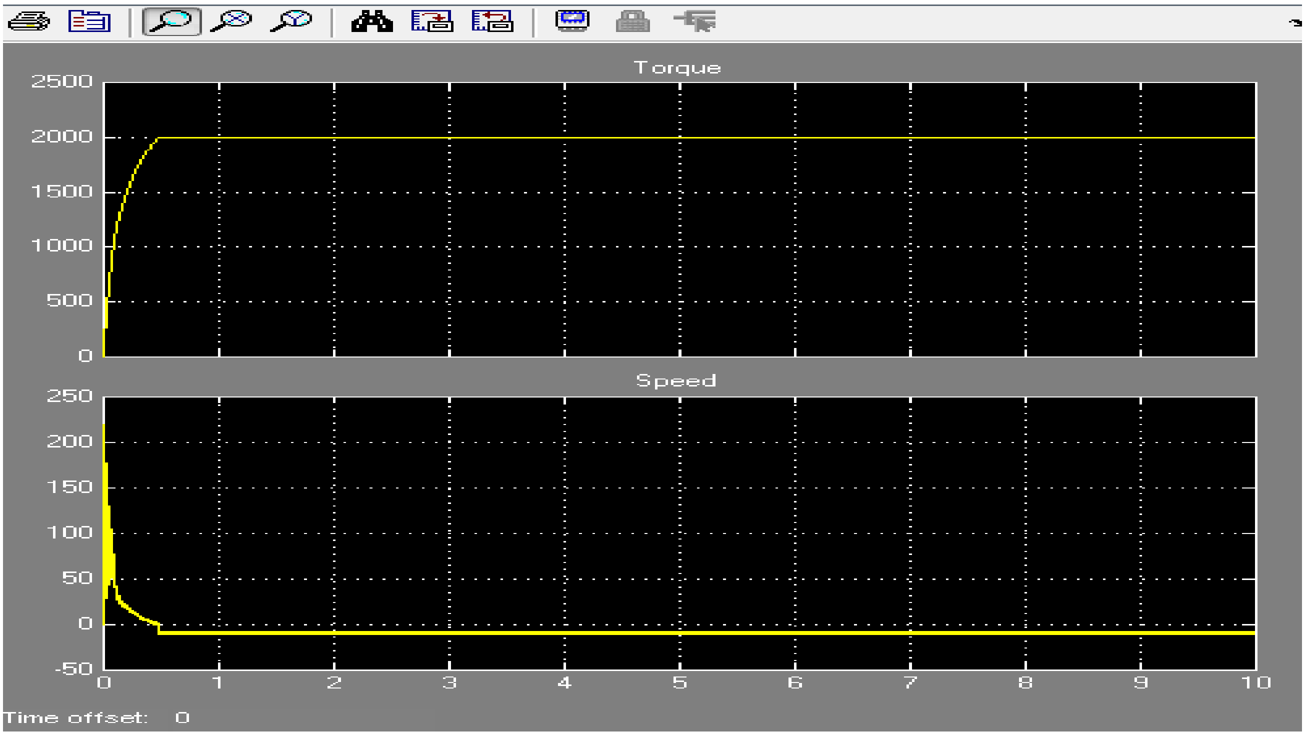

Fig.5 Speed-Torque characteristics

IV. CONCLUSION

In these paper, dynamic characteristics of double-fed induction generator has been studied during abnormal conditions of the grid. For this, dynamic d-q model was used to derive the dynamic equations of such machine in a synchronous reference frame. The choice of synchronous rotating reference frame makes it particularly favourable for the simulation of double-output configuration in transient conditions. When the stator is disconnected from the grid, the rotor is suddenly got excited due to slip frequency rotor voltages from the voltage regulators in order to produce the commended stator terminal voltage. So active and reactive power of the machine have been decreasing rapidly. For reactive power compensation during these conditions, rotor side converter has to supply necessary reactive power.

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BIOGRAPHY

[1]. Prof.S.R.Karpe
S.B.P.C.O.E., Indapur

[2]. Prof.B.N.Bedre
S.B.P.C.O.E., Indapur

[3]. Prof.V.P.Dhote
G.E.C.A., Aurangabad