International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 8, August - 2014

Management of DFIG Wind Turbine against the Transitional State and Short - Circuit

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***Abstract*— The renewable wind energy is growing in a fast rate and will be the prominent clean energy source within the coming few years. Among the different generators used for conversion of wind energy to electrical energy is DFIG which has higher energy absorption efficiency and higher power quality improvement considering its variable rotation speed. Therefore, this system has received high attention over the past years. DFIG system utilizes back-to-back convertors, one in the rotor side and another in the stator site. These two convertors serve as tracing interface of optimum performance between generator and grid or another load. To reach optimum power output, pulse width modulation controllers installed in both rotor and stator sides are utilized. To reduce effects of transitional state and short contact in the wind turbine induced by the three-phase harmonic and short contact loads, some suggestions were presented in this work.**

Keyword*— *Doubly fed induction generator (DFIG), Fault, series compensation, transient management

I. INTRODUCTION

Presence of a control system seems to be necessary for making a balance between input and output energies of the power plant and, especially, wind plants; as wind conditions are changing in this state. The wind turbine control system is designed to seek two goals: reducing the dynamic loads inserted on rotor axis and power transfer system, so that the control system could minimize the effect of different undesired forces on wind turbine components by applying a proper algorithm; and control electrical power generation in a wide range of wind speeds, up to the nominal wind speeds.

In the near future, the environmental concerns would be grown due to the growth in energy demand, increase in generation costs of fossil fuels, and having access to a proper wind source in most parts of the world [6]. In this regard, power electronic technology plays a key role in integration of distributive generation (DG) system in power grid and affects stability of power system [8]. The back-to-back power converter system is proposed for squirrel cage induction generator with vector control for lowering the mechanical problems of the stator and stability of power system in grid side. This convertor facilitates details of control design, control stator, and sensor-free flow [3]. In this design, a back-to-back- converter with fuzzy control controls active and reactive power in simultaneous and independent states [10]. In this paper, a system was proposed for damping the sub-synchronized fluctuations in wind energy generation system which is based on a doubly fed-induction generator (DFIG) to a transfer line to which a compensator capacitor is attached. In this system, the sub-synchronized fluctuations are lowered by a supplementary signal in the control cycles of DFIG. Effect of error site and time in error elimination and effect of the distance between wind farms and generator turbine in efficacy of proposed supplementary control in damping of sub-synchronized fluctuations were studied in this work by adjusting displacement of three phase-three cycle error from Bus B to Bus A [4]. In this paper, the maximum wind energy yield for a wind energy conversion system consisting of a wind turbine, squirrel cage induction generator, and concentration matrix convertor (MC) is presented. The available mechanical power in a wind turbine is a function of shaft speed. To have maxim power, MC regulates frequency of induction generator and, consequently, active power in the grid side,voltage, and power coefficient. The maximum power point tracing (MPPT) algorithm controls the power turbine for yielding maximum output power [2]. To damp sub-synchronized fluctuations, a DFID-based wind turbine attached to a transfer line connected to compensator capacitor is utilized. Here, the compensator capacitor is for lowering the sub-synchronized fluctuations by a supplementary signal in DFIG control cycles. Effect of error site and time in error elimination and effect of the distance between wind farms and generator turbine in efficacy of proposed supplementary control in damping of sub-synchronized fluctuations were studied in this work by adjusting displacement of three phase-three cycle error from Bus B to Bus A [7].

Using the power electronic convertors enables the wind turbine to work with variable wind velocity [1].

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II. SYSTEM CONFIGURATION

Once wind speed exceeds the nominal speed, it is required to generate the output power in its nominal value by taking a suitable control method. Among the different generators used for conversion of wind energy to electrical energy is DFIG which has higher energy absorption efficiency and higher power quality improvement considering its variable rotation speed. Therefore, this system has received high attention over the past years. DFIG system utilizes back-to-back convertors, one in the rotor side and another in the stator site.

A. Structure of the proposed circuit

Fig.1 presents a schematic view of the proposed circuit simulation.

In the studied wind turbine a DFIG system was used. The specifications of the studied systems are presented in Table 1.

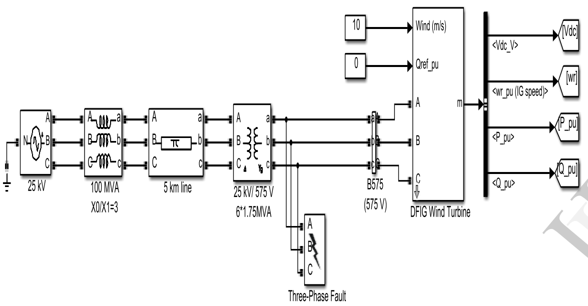

Figure 1 Schematic diagram of the simulated system under study

DFIG wind turbine system has been used in the study of the characteristics of the system under study is shown in Table 1.

III. SYSTEM MODELING

A. Equivalent circuit of wind turbine systems

The equivalent circuit of DFIG wind turbine is presented in Fig. 1 [11], while the reference equations for control of GSC and RSC are introduced in Ref. [12].

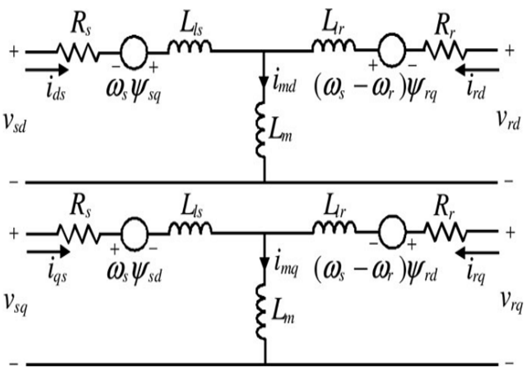

Fig 2. The equivalent circuit of DFIG

Where, the active and reactive power equations are shown as Eq. (1) and Eq. (2), respectively.

$$Ps = 1.5 v_{sq} i_{sq} = -1.5 \frac{Lm}{Ls} (v_{sq} i_{sq}) \qquad (1)$$

$$Qs = 1.5 v_{sq} i_{sq} = 1.5 \frac{v_{sq}}{Ls} (\psi_{sd} - L_m i_{rd}) \qquad (2)$$

B. Wind turbine model

The original prototype of DFIG is illustrated in Figure .3.

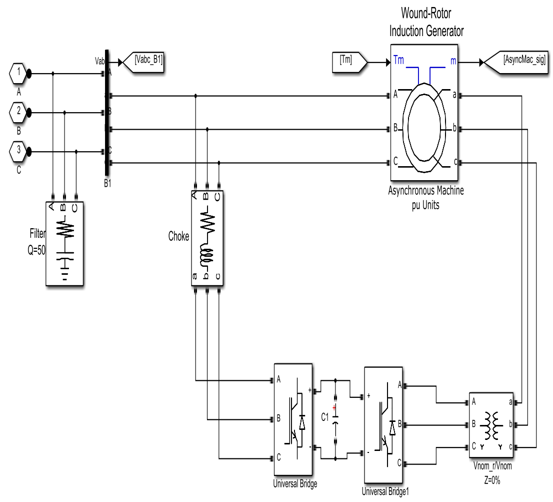

Figure 3 DFIG wind turbine model

C. Prototype of DFIG wind turbine with series transformer

The prototype of DFIG wind turbine with series transform is shown in Fig. 4.

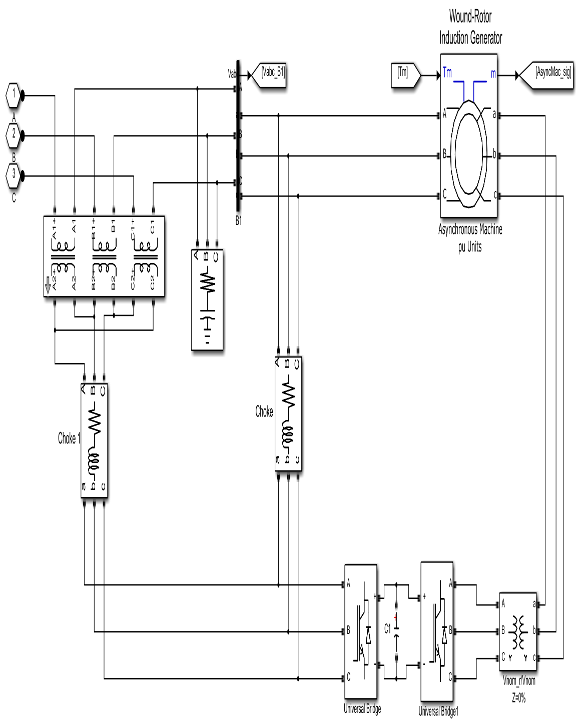

Figure 4. DFIG wind turbine model

Table 1. System parameters

Generator data
$P_{nom}=1.5MW * 6$
$V_{nom}=575v$
Frequency=60Hz
Stator resistance=0.0023pu
Stator inductance=0.18pu
Magnetizing inductance=2.9pu
Rotor resistance=0.016pu
Rotor inductance=0.16pu
DC-link voltage=1150V
Wind speed=10m/s
Series Transformer
Pnom=10MW
Vnom_winding1=575V
Vnom_winding2=575V
R=0.0002
X=0.005

IV. SIMULATION RESULTS

To verify the model proposed for wind turbine system with and without series transforms in the grid side-convertor side, the system simulation was carried out and studied for different scenarios using the Simulink / Matlab.

A. Scenario 1: The wind turbine without installing series transformer in the grid side-converter side

In this state, the wind turbine is considered without series transformer in the grid side-converter side. Simulation time is 3 sec and short contact error occurs in the range of 2.3 to 2.45 sec. the voltage, current, active power, reactive power, DC voltage, and rotor speed are presented in Fig. 5.

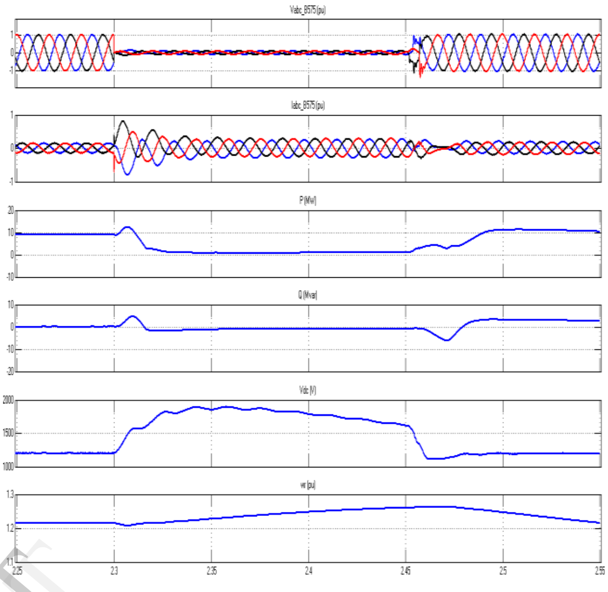

Figure 5. Voltage, current, active power, reactive power, DC voltage and rotor speed wind turbine

B. Scenario 2: The wind turbine with installing series transformer in the grid side-converter

In this state, the wind turbine is considered with series transformer in the grid side-converter. Simulation time is 3 sec and short-circuit occurs in the time of 2.3 to 2.45 sec. The voltage, current, active power, reactive power, DC voltage, and rotor speed are showed in Fig. 6.

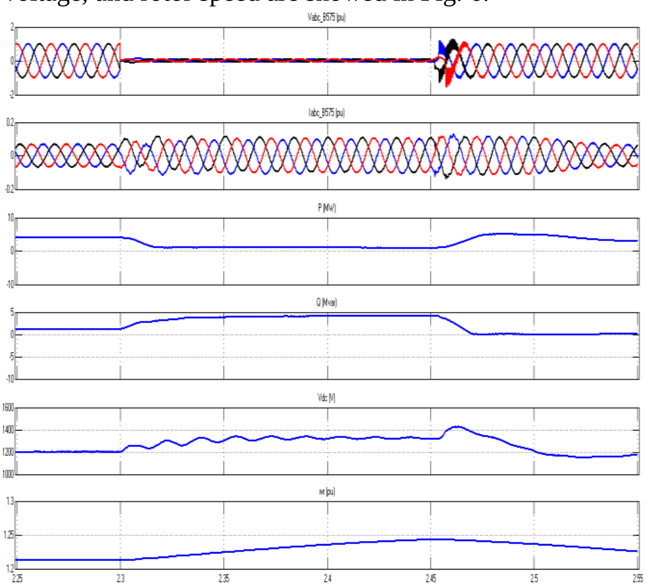

Figure 6. Voltage, current, active power, reactive power, DC voltage and rotor speed wind turbine

V. CONCLUSION

In this paper, management of DFIG wind turbine for transitional and short contact states was studied for the case of assigning a three-phase contact in the grid side. The proposed model was studied for both states with and without transformer. The results show that the proposed model (simulated in MATLAB Simulink environment) has appropriate conditions against the sudden voltage swell and can be considered as an economic solution.

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