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Impact of Distributed Generation on Short Circuit Level of Power System

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Abstracts

Renewable energy is that as it is sustainable and so will never run out . Renewable energy facilities generally require less maintenance than traditional generator. Importance of conventional energy wind form is the best of energy for future. DFIG are nowadays widely used in variable speed wind power plant. The ability of the wind power plant to stay connected to the grid during disturbance is important to avoid a cascading effect due to lack of power. This paper investigate the impact of short circuit fault on the stability of DFIG wind turbine using crowbar resistance. Simulation test using MATLAB-Simulink toolbox is implemented on a 9MW, six 1.5MW turbine of wind form export its power to 120KV grid. The variation of the rotor current , rotor speed active and reactive power on wind form are investigated.

Keywords: DFIG, IGBT, Rotor current and Active power.

Introduction

Organized by UBM India, the 7th Renewable Energy India 2013 Expo was the epicenter of deliberations and brainstorming towards Up-scaling and Mainstreaming Renewable in achieving Energy Security and Economic Development. Held from the 12th – 14th September 2013 at the India Expo Centre & Mart, Greater Noida (National Capital Region of Delhi), the event urged the industry to step up innovations and leverage on the multiple investment opportunities being created by the Indian Government. The expo proved to be a catalyst for industry stakeholders, domestic and International, in exploring business opportunities and served as a hub for knowledge exchange whilst widening the sector's insights on sustainable financing models, cutting-edge technologies and successful, proven business practices. The sector has grown at an annual rate of 23% to achieve 28,446 MW by May 2013. The renewable power installed capacity forms 12.5% of the total installed capacity in FY 2011- 2012 Additional capacity of 30,000 MW is planned from various renewable energy technologies in the next five years.

India now ranks as a "wind superpower" with an installed wind power capacity of 1167 MW and about 5 billion units of electricity have been fed to the national grid so far. Wind resource assessment programmed, wind monitoring, wind mapping, are in programs covering 800 stations in 24 states with 193 wind monitoring stations in operations. Altogether 13 states of India have a net potential of about 45000 MW. Wind turbines based on the DFIG are very sensitive to grid disturbance especially to voltage dips[1]

The power system switchgear and power system protection for WPPs should be carefully designed to be compatible with the operation of conventional synchronous generators connected to the same grid. This paper attempts to illustrate the behavior of SC current contributions of WTGs.[2]

One aspect of planning a wind power plant is the calculation of short circuit (SC) current contribution from a wind power plant (WPP). With the different types of wind turbine generators (WTGs) available from different turbine manufacturers, the task of computing SC current is no longer a simple task as in calculating SC current for a synchronous generator in a conventional power plant[3].

As a mainstream configuration for large wind turbines, DFIG wind turbines are required to remain grid connected during grid faults so that they contribute to the stability of the power transmission system. This raises problems in terms of generator/converter protection and control. In the case of grid faults, the controllability of the DFIG variable speed wind turbine embraces both the wind turbine control for preventing over-speeding of the wind turbine and the control and protection of the power converter during and after grid faults. The DFIG wind farm equipped with voltage grid support control are help a nearby active stall wind farm to remove a grid fault,

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without implementation of any additional fault removing control setup in the nearby active stall wind farm. [4].

DFIG System

DFIG are more use because it allow extracting maximum energy from the wind speed by optimizing the turbine speed, while minimizing mechanical stresses on turbine during gusts of wind

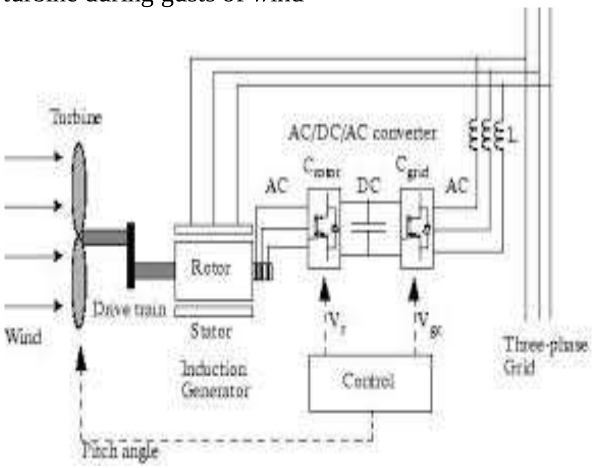

Fig 1

Most doubly-fed induction generators in industry today are used to generate electrical power in large (power-utility scale) wind turbines. This is primarily due to the many advantages doubly-fed induction generators offer over other types of generators in applications where the mechanical power provided by the prime mover driving the generator varies greatly (e.g., wind blowing at variable speed on the bladed rotor of a wind turbine). To better understand the advantages of using doubly-fed induction generators to generate electrical power in wind turbines, however, it is important to know a little about large-size wind turbines. In fixed-speed wind turbines, three phase asynchronous generators are generally used. Because the generator output is tied directly to the grid (local ac power network), the rotation speed of the generator is fixed (in practice, it can generally vary a little as the slip is allowed to vary over a range of typically 2% to 3%), and so is the rotation speed of the wind turbine rotor.

Any fluctuation in wind speed naturally causes the mechanical power at the wind turbine rotor to vary and, because the rotation speed is fixed, this causes the torque at the wind turbine rotor to vary accordingly. Whenever a wind gust occurs, the torque at the wind turbine rotor thus increases significantly while the rotor speed varies little. Therefore, every wind gust stresses the mechanical components (notably the gear box) in the wind turbine and causes a sudden increase in rotor torque, as well as in the power at the wind turbine generator output. Any fluctuation in the output power of a wind turbine generator is a source of instability in the power network to which it is connected [5]

The IGBT combines the simple gate-drive characteristics of the MOSFETs with the high-current and low-saturation-voltage capability of bipolar transistors. The IGBT combines an isolated gate FET for the control input, and a bipolar power transistor as a switch, in a single device. The IGBT is used in medium- to high-power applications like switched-mode power supplies, traction motor control and induction heating. Large IGBT modules typically consist of many devices in parallel and can have very high current handling capabilities in the order of hundreds of amperes with blocking voltages of 6000 V, equating to hundreds of kilowatts. AC/DC/AC IGBT based PWM(pulse width modulation) convertor.

The model includes detailed representation of power electronic IGBT converters. In order to achieve an acceptable accuracy with the 1620 Hz and 2700 Hz switching frequencies used in this model , the model must be discretized at a relatively small time step (5 microseconds). This model is well suited for observing harmonics and control system dynamic performance over relatively short periods of times (typically hundreds of milliseconds to one second). IGBT convertor contain Rotor Side Convertor and Grid Side Convertor. RSC controls independently the active and reactive power injected by the DFIG into the grid in a stator . When the voltage in the utility grid changes abruptly due to sudden load changes and abrupt wind speed variations, it makes an effect on the machine, as a result the system voltages available across stator as well as rotor changes. Since the converters are connected back-to-back the same effect is also observed across these two converters and on the dc-link capacitor as well.

Without any protection system, the concern in DFIG is usually the fact that grid disturbances can lead to large fault currents in the stator due to the stator's direct connection to the grid. Because of the magnetic coupling between the stator and the rotor and of the laws of flux conservation, the stator disturbance is further transmitted to the rotor. High voltages are thus induced in the rotor windings that on their turn cause excessive currents in the rotor as well. Furthermore, the surge following the fault includes a "rush" of power from the rotor terminals towards the converter. Since the stator-rotor ratio of the DFIG is designed according to the desired variable speed range, in the case of grid faults it might not be possible to achieve the desired rotor voltage in order to control the high rotor currents, So when

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converter reaches fast its limits it looses the control of the generator during the grid fault. As the grid voltage drops in the fault moment, the GSC is not able to transfer the power from the RSC further to the grid and therefore the additional energy goes into charging the dc bus capacitor, i.e. dc bus voltage rises rapidly. A protection system of DFIG converter is thus necessary to break the high currents and the uncontrollable energy flow through the RSC to the dc-link and thus to minimize the effects of possible abnormal operating conditions. The protection system monitors usually different signals, such as the rotor current, the dc-link voltage and when at least one of the monitored signals exceeds its respective relay settings, the protection is activated. [4]

Simulation

A 9 MW wind farm consisting of six 1.5 MW wind turbines connected to a 25 kV distribution system exports power to a 120kV grid through a 30 km, 25 kV feeder shown in Fig 2.

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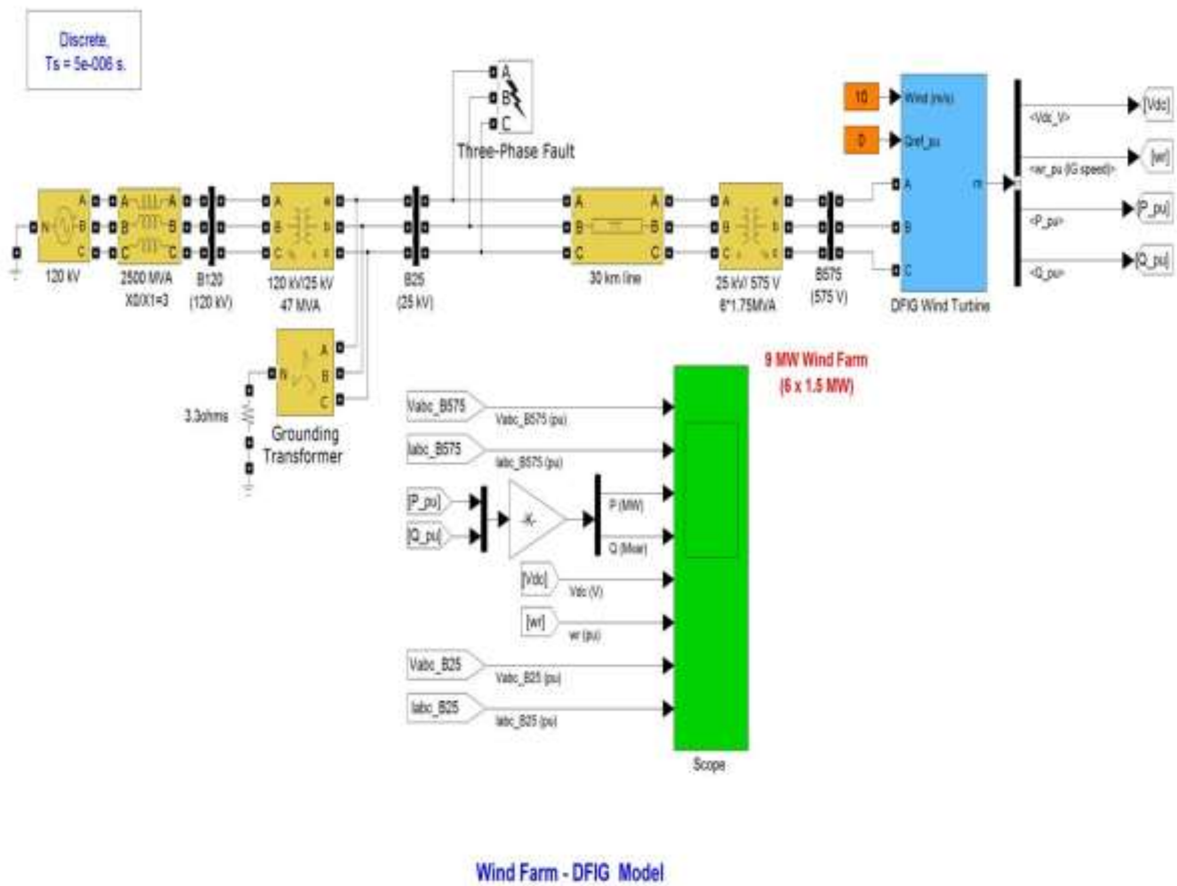

Fig 2

Wind turbines using a doubly-fed induction generator (DFIG) consist of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The stator winding is connected directly to the 60 Hz grid while the rotor is fed at variable frequency through the AC/DC/AC converter. In this model the wind speed is maintained

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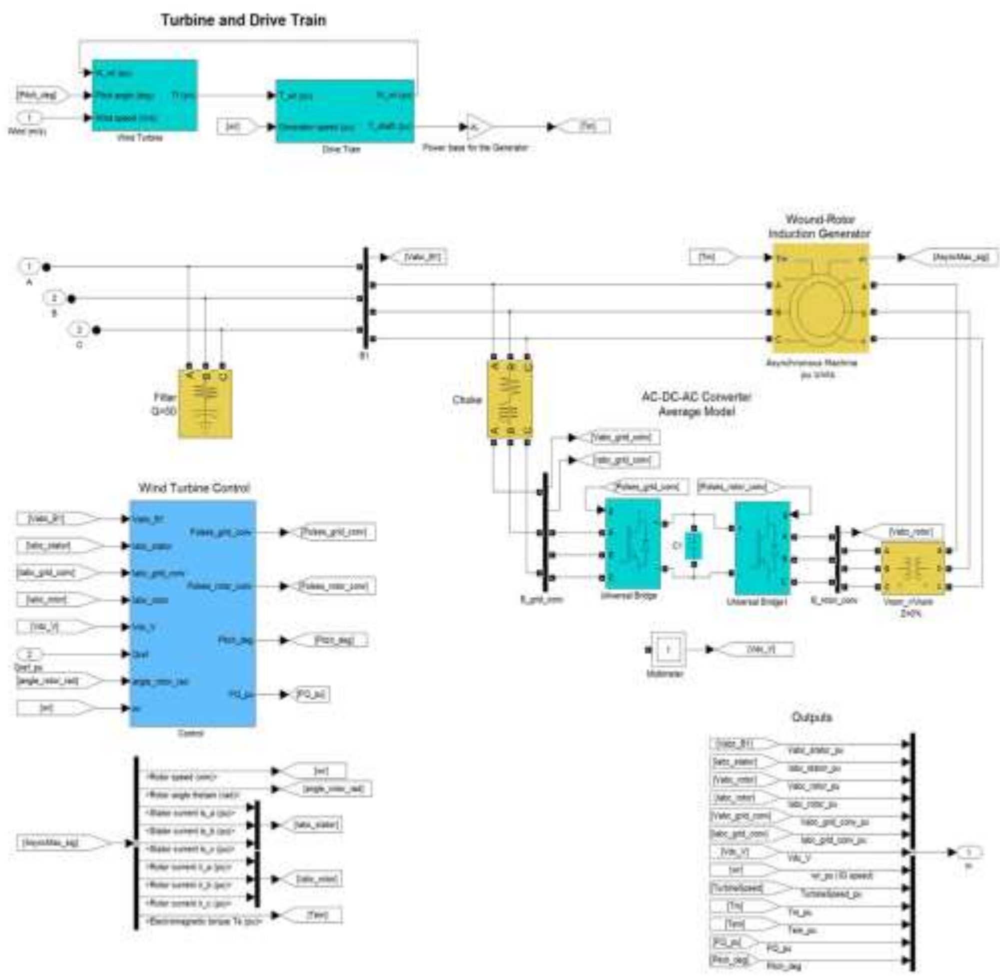
constant at 10 m/s. The control system uses a torque controller in order to maintain the speed at 1.2 pu. The reactive power produced by the wind turbine is regulated at 0 Mvar. For a wind speed of 10m/s, the turbine output power is 1 pu of its rated power, the pitch angle is 8.7 deg and the generator speed is 1.2 pu.

In this model observe the steady-state operation of the DFIG and its dynamic response to voltage sag resulting from a remote fault on the 120-kV system. Observe voltage and current waveforms on the Scope.

Fig 3



Initially the DFIG wind farm produces 9 MW. The corresponding turbine speed is 1.2 pu of generator synchronous speed. The DC voltage is regulated at 1150 V and reactive power is kept at 0 Mvar. At t=0.03 s the positive-sequence voltage suddenly drops to 0.5 p.u. causing an oscillation on the DC bus voltage and on the DFIG output power. During the voltage sag the control system tries to regulate DC voltage and reactive power at their set points (1150 V, 0 Mvar). The system recovers in approximately 4 cycles.

Simulation result

The simulation result show the investigated of rotor current , rotor speed , active power, DC link voltage , line current and line voltage with different crowbar resistor during grid fault or 3 phase ground fault. Fault time 0.03sec and relies 0.013sec.

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Increased of rotor current by 3pu is observed during fault condition is shown in the Fig 4. The variation in rotor resistance 10,50 & 100 times & corresponding resistance on fault current level are shown on Fig 5,6 &7, Reduction upto 1.5 pu is observed on the system.

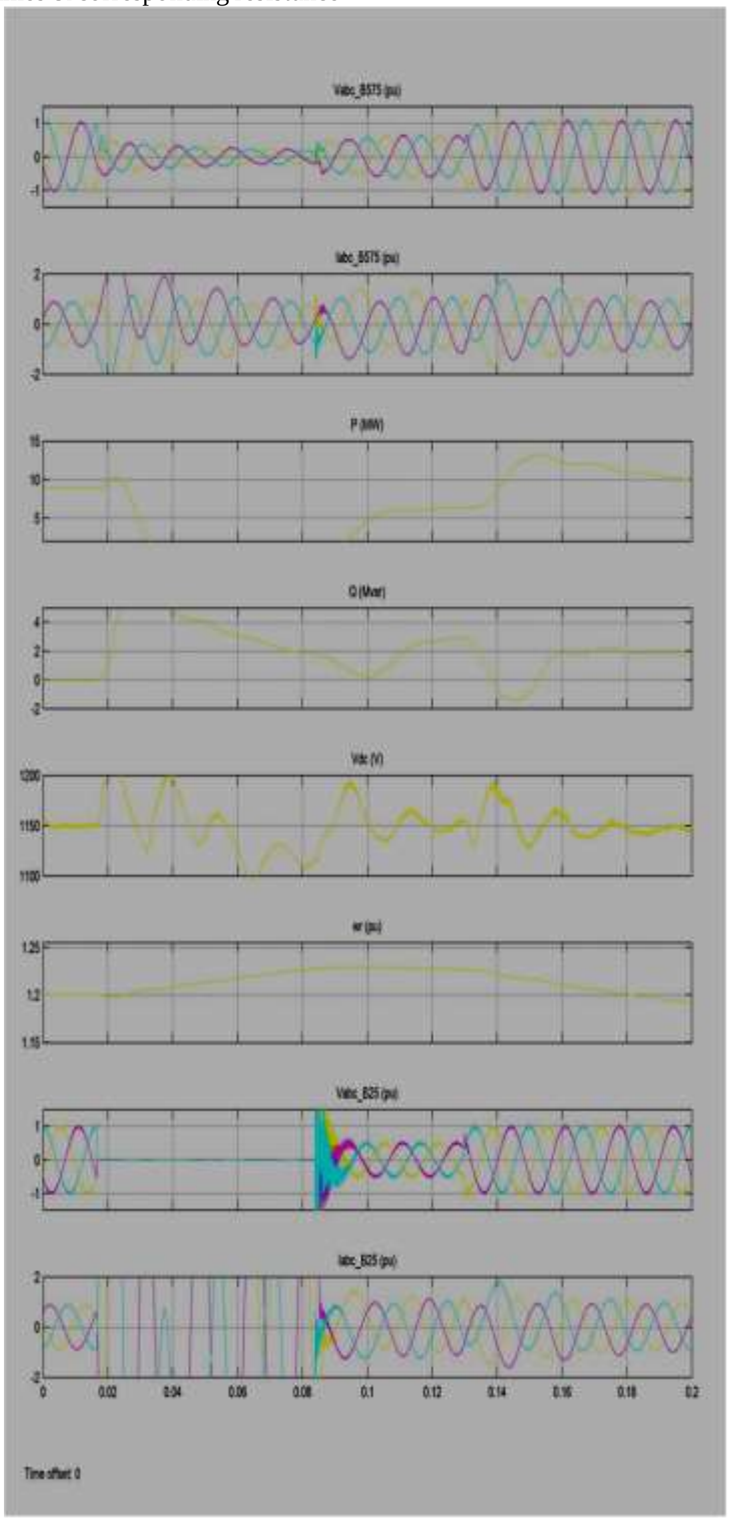

Fig 4

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The variation in rotor speed with different values of rotor resistance are also investigated during fault condition. It is observed that , there is wide variation of rotor speed occurs with the inserting rotor resistance. So that to limit the rotor speed rotor resistance is an important tool.

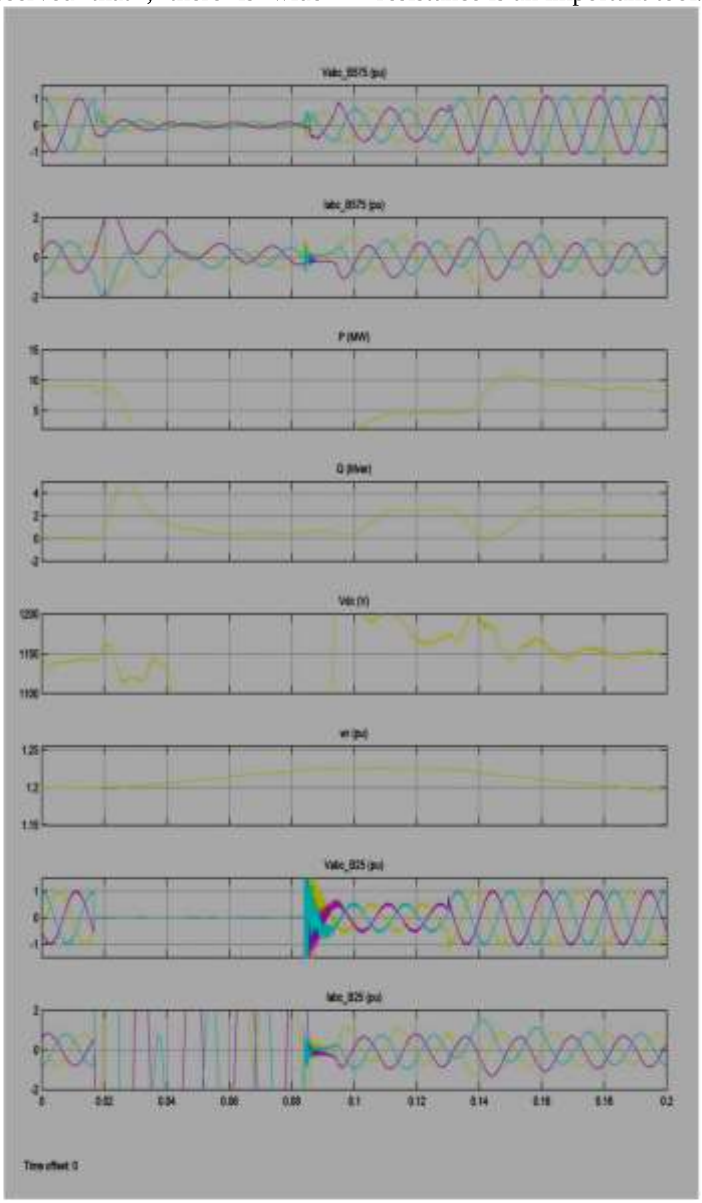

Fig 5

Also the effect of this rotor resistance on active power generation is of upmost important. Different result draw many such creation to control & sustain steady state operation of the given system. This can be evaluated by observing the variation of active power with change of rotor resistance.

Active power generation with a wind speed of 10m/s before the occurrence of fault was observed to be 9MW, during fault condition by inserting rotor resistance with rotor speed & maintain rotor speed will going to reduced upto 0.47MW. it is going to uplift upto 11MW generation after clearances the fault & return to steady state operation shown in Fig 4.

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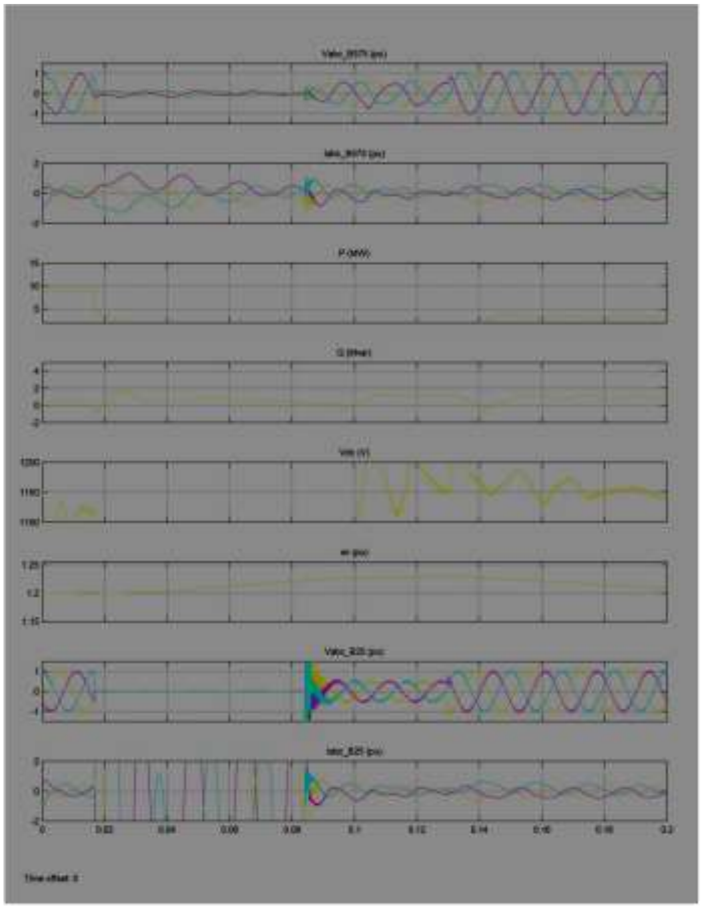

Fig 6

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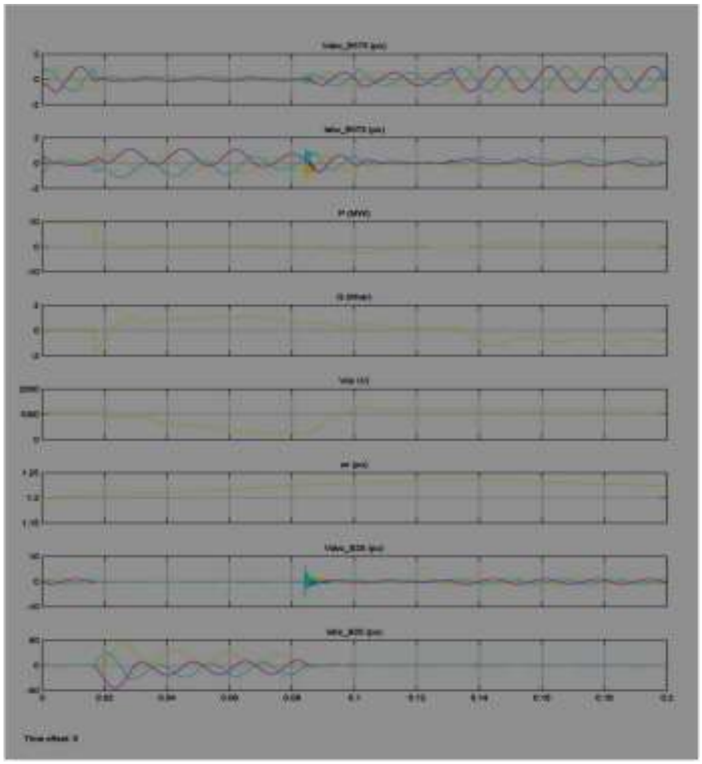

Fig 7

Conclusion

In the present simulation of 9MW, 6* 1.5MW wind turbine connected to the grid system is investigated.

The parameters such as DFIG rotor current, rotor speed & active power are selected to study the performance of wind form system. So all these parameter are compared for normal running condition & during fault condition . the fault duration is mainted with 10 ms delays with the opposition of rotor resistance which will tends to increased rotor circuit resistance in the short circuit level.

It is observed that by increased in the rotor circuit resistance there is sufficient improvement in the active power generation and rotor speed, reduction in the rotor current are observed so as to stabilizing the system & overall uplifting of the performance.

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