IMPROVEMENT OF TRANSIENT STABILITY IN DOUBLY FED INDUCTION WIND GENERATOR USING BRIDGE-TYPE FAULT CURRENT LIMITER

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Abstract: *For a doubly fed induction machine transient stability is one of the important factors which we have to consider improving performance of wind generator. The stator windings of DFIM wind generator is interfaced to grid because of that reason transient faults arises in grid. Even in fault conditions also wind generator remain connected in accordance with grid code necessity, to achieve the transient stability improvement for DFIM wind generator a bridge type fault current limiter is proposed. Here to check the efficiency of BFCL in transient stability improvement, both symmetrical and unsymmetrical faults were applied to test system. To prove the strength of BFCL in transient stability improvement it should be compared with Series Dynamic Braking Resistor (SDBR).Simulation can be done in MATLAB or in the SIMULINK. The results show the effectiveness of BFCL than SBDR for transient stability improvement in DFIM wind generator.*

Index Terms: Bridge-Type Fault Current Limiter (BFCL), Double Fed Induction Machine (DFIM), Variable Speed Wind Turbine (VSWT), Series Dynamic Braking, Series Dynamic Braking Resistor (SDBR).

I.INTRODUCTION

With an increase electrical power demand renewable energy resources play an important role now-a-days to compete with electrical power demand to provide power quality to the end user. Amid of renewable energy resources wind energy is the fast growing and prominent to generate electrical power with less fuel cost. Due to flexible operation higher output power, higher efficiency, no fuel cost, provide power quality and low mechanical stress on turbine. Compare to variable speed wind generators having high rated full converters, DFIM wind generators are more efficient in this stator windings are directly connected to grid and rotor windings are connected to grid by rotor side converter(RSC) and grid side converter(GSC) are connected back to back through a dc link capacitor. At the time of grid fault, terminal voltage of the DFIM goes low and high current flows through stator and rotor windings. According to grid code DFIM have better stabilization and fault ride through capability.

The Bridge type Fault Current Limiter (BFCL) technique is applied to DFIM wind generator. It consists of wind turbine equipped with DFIM, a transformer and double circuit transmission lines are connected to infinite bus. Temporary symmetrical and unsymmetrical faults were applied at the most weak point of the system. BFCL is compared with SDBR regarding performance and efficiency.

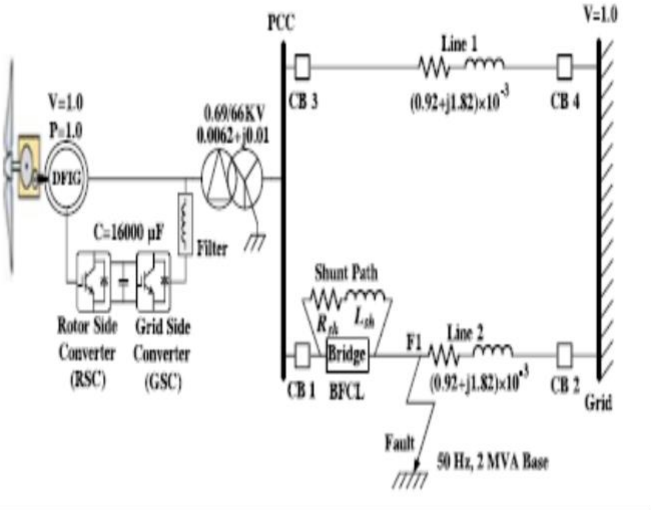

Fig.1.Basic diagram of the DFIM with the test system.

I.WIND TURBINE AND MODELLING:

For modelling of wind turbine single mass system is used, turbine mechanical dynamic parts are neglected due to small fraction of faults. As DFIM stator windings are connected to grid and rotor connected through ac/dc converter. A 2MW DFIM is connected to point of commoncoupling (PCC) through step-up transformer.BFCL is connected in series with one of the transmission line as shown in fig.1.SDBR is also connected in similar way.

A. Wind Turbine Modelling:

Considering the electrical behaviour of system, a simplified normal model is used. The mechanical harness can be expressed as

$$P_w = \frac{1}{2}\pi\rho R^2 V_w^3 C_p(\lambda,\beta) \quad .... \quad (1)$$

Where Pw is the extracted power from the wind, ρis the air density, R is the blade radius,Vw is the wind velocity and Cp is the power coefficient which is a function of both the tip speed ratio λ and the blade pitch angle β and it is given by

$$C_p(\lambda,\beta) = \frac{1}{2}(\lambda - 0.022\beta^2 - 5.6)e^{-0.17\lambda} \quad .... \ (2)$$

$$\lambda = \frac{\omega_r R}{V_w} \quad .... \ (3)$$

Where ωr is the angular mechanical speed.The wind turbine parameters are used.

B.DFIM Modelling

For modelling of a DFIM parks transformation with fifth order two axis representation. Asynchronouslyrotating d-q reference frame is used aligned with d-axis with stator flux. A decouple control between rotor excitation current and electrical torque is obtained. Reference frame is rotating with same speed as stator flux.

C.RSC Controller:

The RSC is a two-level, sixpulse, insulated gate bipolar transistor based full bridge electronic ac/dc converter that couples the rotor side to the dc link. It takes the active power Pt, reactive power Qt and the terminal voltage Vt as inputs and controls the active power and reactive powers. It uses PI controller to generate three phase pulse signal reference using Space Vector PulseWidth Modulation. Here slip angle is generated by comparison of rotor position and terminal voltage angle with the help of phase locked loop.

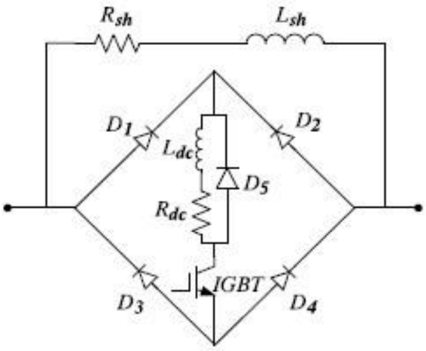

Fig.2. RSC Controller

D.GSC Controller:

GSC converter helps to maintain constant power factor at connection point. It is significant to take the switching frequency to maintain harmonics at minimum level. It take the terminal voltage Edc and rotor reactive power Qt as inputs sends output to SVPWM generator to generate required pulses to GSC controller. Atransfer function is used to generate shorter time to come to normal position gives faster response without effecting normal operation.

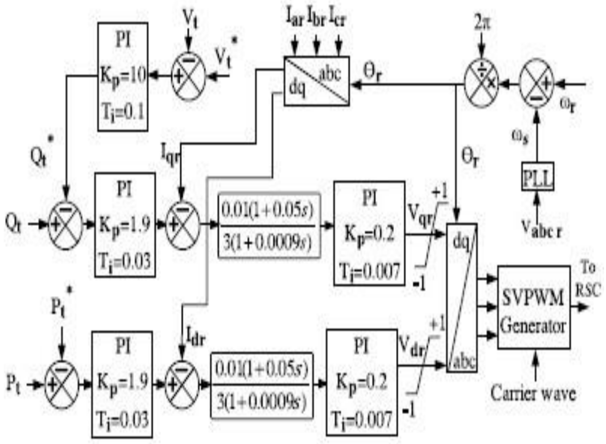

Fig.3. GSC Controller

2. BFCL

A.BFCL configuration:

BFCL consists of bridge part and the shunt path. Bridge part consists of diodes D1-D4, small value dc reactor Ldc equipped with parallel freewheeling diode D5 in series with IGBT.Shunt path consists of resistor Rsh and inductor Lsh placed in parallel with bridge part.

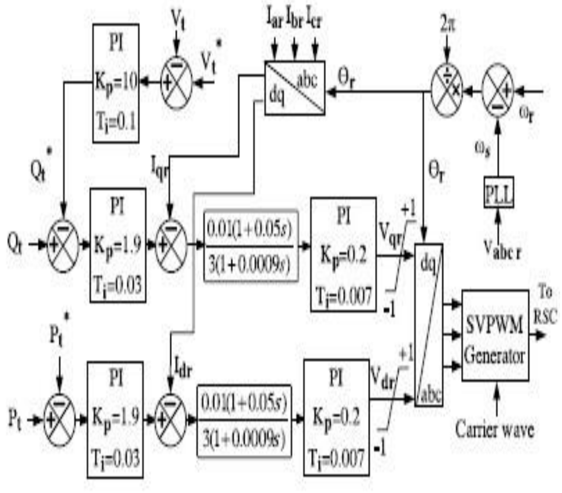

Fig.4.BFCL Configuration

B.BFCL operation

During normal operation of BFCL at bridge path remain closed. The dc reactor transmits resistance; IGBT turn on due to forward voltage there will be voltage which is negligible which has no effect on normal operation. The shunt path impedance is high enough to flow line current to the bridge path except some leakage current. At fault condition line current increases but dc reactor Ldc reduces line current. The ith value is equal to 1.3 times of the nominal idc.

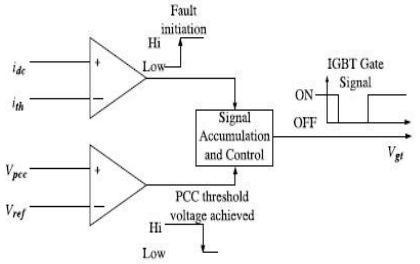

Fig.5.BFCL Operation

C.BFCL considerations:

During normal operation each of double circuit carries same power. To check the least disturbance towards machine at fault, the BFCL should consume power at leastequal to which fault line carries.The power devoured by the BFCL at post fault Pbfcl, is given by (4) and (5)

$$P_{\text{bfcl}} \le \frac{P_g}{2} \qquad \text{.............} \quad (4)$$

$$P_{\text{bfcl}} = \frac{V_{\text{pcc}}^2 R_{sh}}{R_{sh}^2 + X_{sh}^2} \qquad \text{...........} \quad (5)$$

Where Pg, Xsh and Vpcc are the power delivered by the machine, shunt inductance and the PCC voltage, respectively. (4) And (5) give

$$R_{sh} \ge \frac{V_{\text{pcc}}^2 + \sqrt{V_{\text{pcc}}^4 - P_g^2 X_{sh}^2}}{P_g}. \qquad \text{..........} \quad (6)$$

For Rsh to be real valued the necessary condition is

$$X_{sh} < \frac{V_{\text{pcc}}^2}{P_g}. \qquad \text{..............} \quad (7)$$

The estimation of Xsh is observed to be 0.029p.u that fulfils (7) and gives the best execution for the system. The same methodology was connected in observing Rsh to be 0.0077 p.u. that conforms to (6) alongside the best result. To make the BFCL down to earth, a little estimation of Rdc is considered which 0.3 mω is. Grabbing an estimation of Ldc to be 1 mH gives a period steady (τ = Ldc/Rdc) of 3.33 s which is adequate for smoothing the dc reactor current.

D.BFCL control strategy:

The line voltage, generator terminal current, active power and reactive power are the parameters of BFCL control strategy. Here dc current idc through dc reactor is used to control IGBT switch. By using idc as a control parameter faster response can be achieved. It is used to turn off IGBT when idc becomes zero when IGBT is opening; to turn on IGBT another control parameter is required. As the voltage at the PCC Vpc crosses some reference value Vref, IGBT is closed after pre-set delay provided by the circuit breaker is open. IGBT will turn on, current flows through the bridge and normal operating conditions.

4. SDBR

In this section the proposed model BFCL is compared with SDBR it is a conventional provedmethod on transient stability and improve fault ride capability.

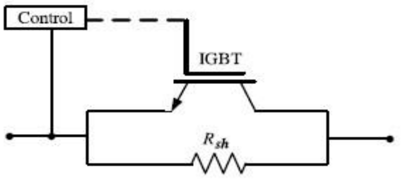

Fig.6.Single phase SDBR topology.

A.SDBR Configuration

The SDBR is demonstrated by organizing a resistor with a parallel switch as appeared inFig.6.This study considers this change to be the IGBT based, because of its quick reaction and particular configuration. The free-wheeling diode of the IGBT is not appeared.

B.SDBR Operation

During the typical condition, the SDBR would work with the IGBT switch shut. The line current will course through the IGBT switches by passing the braking resistors. At the occasion of short coming, the line currents tend to rise pointedly. The shunt resistor will be progressively embedded into the system by opening the GBT switch. The deficiency current will then move through the embedded resistor and the resistor will keep on being in the circuit until a wanted voltage Vref is accomplished at PCC.As Vpcc passes Vref, The IGBT will be shut and the circuit will come back to its ordinary state.

C. Design Considerations

The SDBR idea works by contributing straight forwardly to the parity of the active power. At shortcoming, the SDBR system powerfully embeds resistor in the circuit. By expending active power during the irregular time frame, the resistor mitigates the destabilizing electrical torque subsequently keeps up the voltage at the terminals of the generator at more elevated amount.

5. SIMULATION DIAGRAM

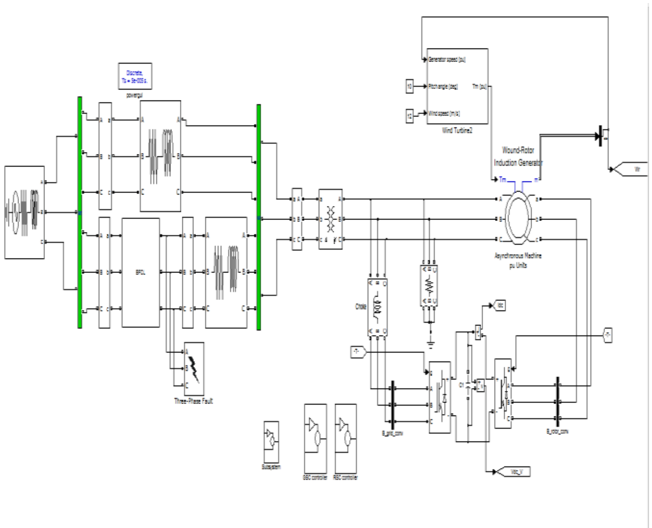

Fig.7.BFCL Simulation

6. SIMULATION RESULTS

SDBR Results

Fig.8.SDBR Voltage

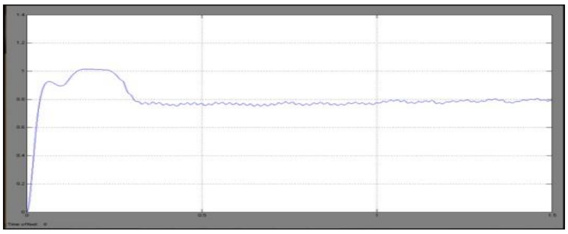

Fig.9.Active power response

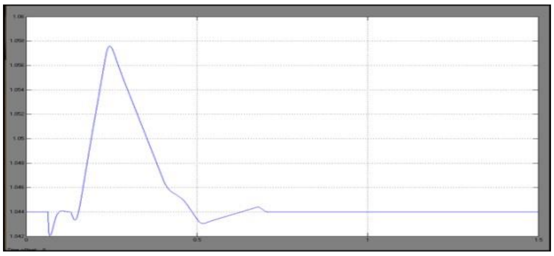

Fig.10.Vdc

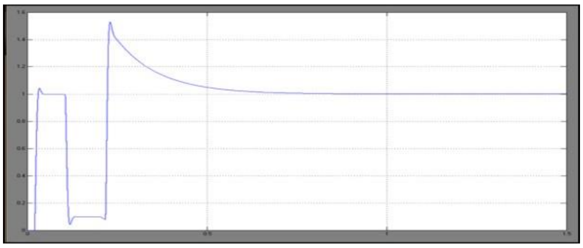

Fig.11.Speed

Fig.12.Terminal Voltage

Without Controller Three Phase Fault

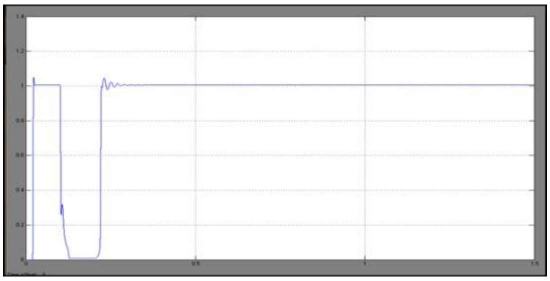

Fig.13 .Machine output active power response

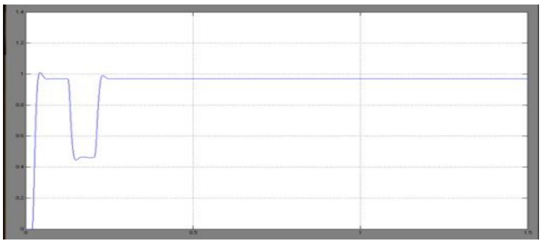

Fig.14.Vdc

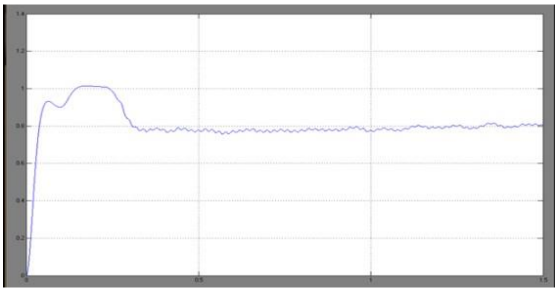

Fig.15.Speed

WITHOUT CONTROLLER SINGLE PHASE FAULT

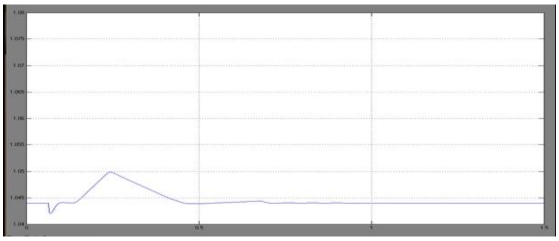

Fig.16.Machine output active power response

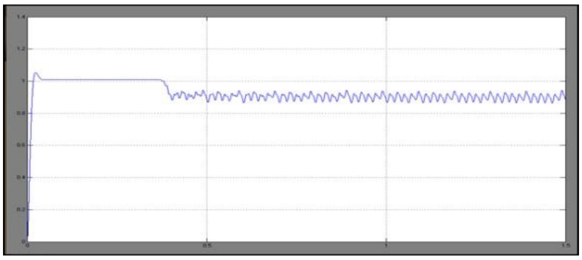

Fig.17.Vdc

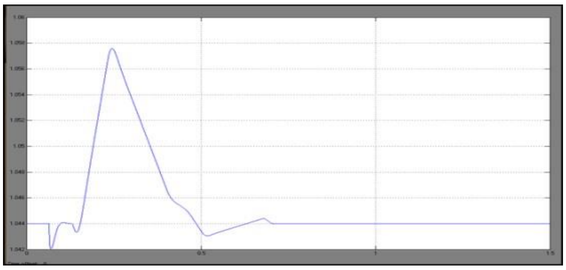

Fig.18.Speed

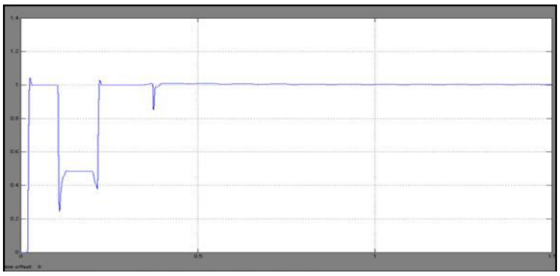

Fig.19.Terminal Voltage

B. Single Phase Fault Conditions
SDBR Single Fault

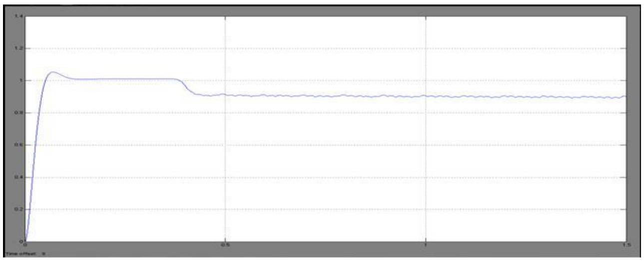

Fig.20.Active power Response

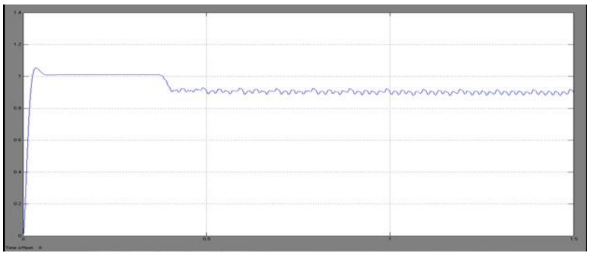

Fig.21.Vdc

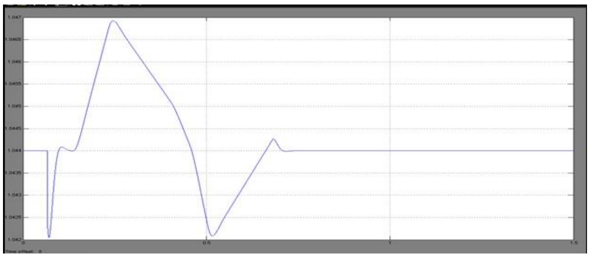

Fig.22.speed

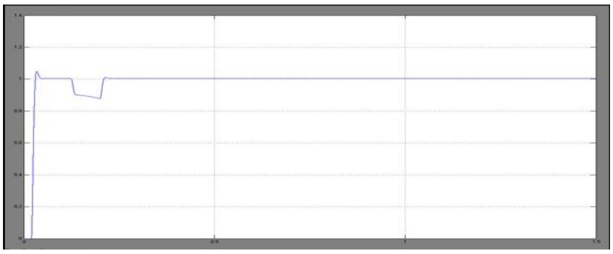

Fig.23.Terminal Voltage

BFCL REULTS

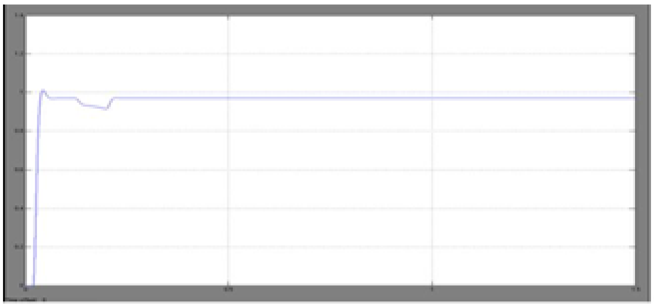

Fig. 24, BFCL Active Power Response

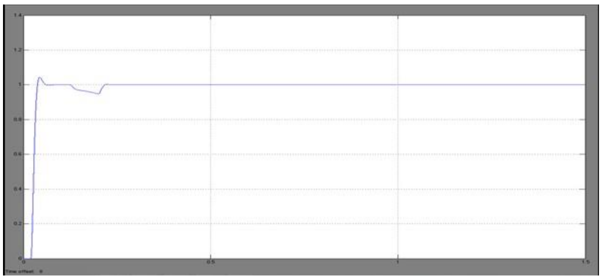

Fig.25.Vdc

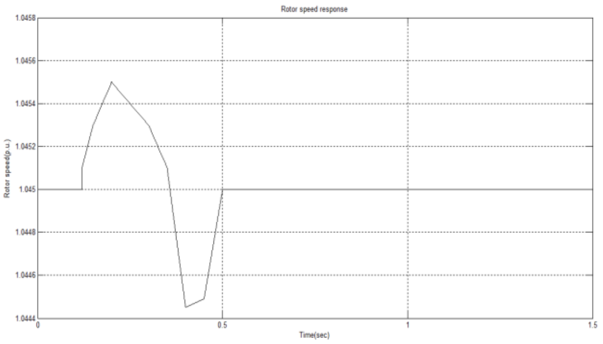

Fig.26.Rotor Speed

BFCL Three Phase

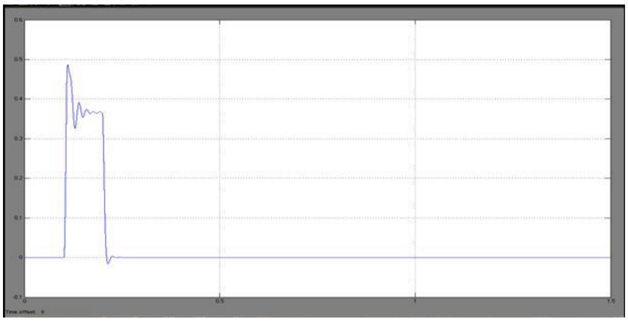

Fig.27.Active power response.

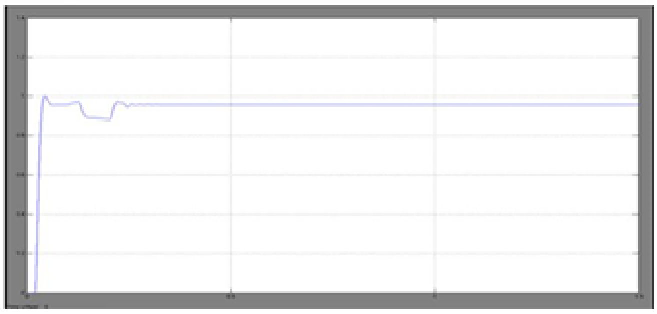

Fig.28 PCC Active Power Response

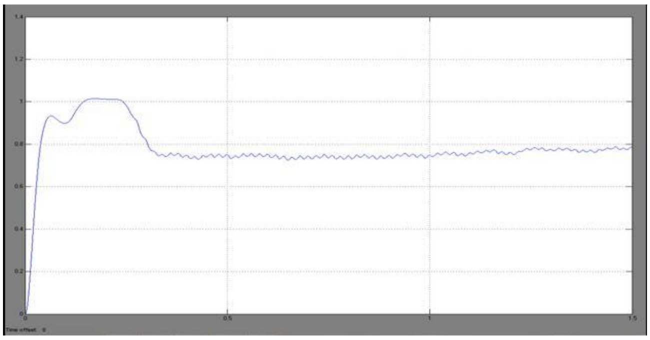

Fig.29.Vdc.

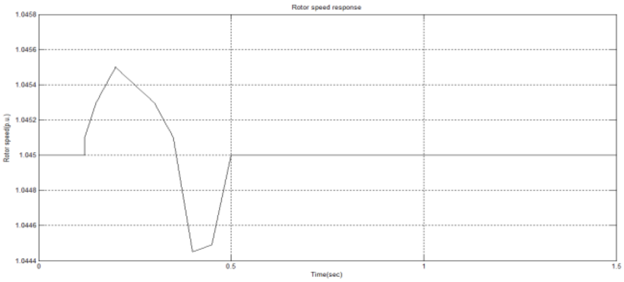

Fig.30.Rotor Speed Response

CONCLUSION

Finally simulating BFCL and SBDR at three phase fault and single phase fault to improve the transient stability.BFCL is a very efficient to raise the transient stability of the DFIM-based variable speed wind generator. It can help the DFIM-based wind farms support by the grid code requirements. BFCL is far better than SBDR except in cost. BFCL is more efficient in transient stability.

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