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Evolution of The Performance of BTFCL-BR with Genetic Algorithm for Enhancing The Power Quality of Grid Connected DFIG

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***Abstract*-— Performance of Bridge Type Fault Current-Limiter with Bypass Resistor (BTFCL-BR) for enhancing the power quality of Grid connected Double Fed Induction Generator (DFIG) is evaluated in this paper. The normal BTFCL can enhance the power quality of DFIG. However, the Fault current limiting Inductor (FCLI) is periodically inserted into the stator circuit of DFIG under normal operation for compensating power losses of the FCLI. The insertion of the FCLI induces stator voltage spikes, which causes significant Electromagnetic torque oscillations and stator flux. One feasible way to solve this problem is to use a BTFCL-BR with GA (Genetic Algorithm) is presented to the Bypass Resistor (BR) absorbs the majority of current harmonics during normal operation and eliminates the stator voltage spikes. The electromagnetic torque as fluctuations and flux can thus be significantly reduced. The performance of BTFCR-BR with Genetic Algorithm is evaluated by simulating on a typical 1.5MW wind turbine driven DFIG system. By simulation evaluation it seems that the BTFCR-BR with GA approach is the most promising solution among common BTFCL.**

***INDEX TERMS*: Double Fed Induction Generator (DFIG),Bridge type fault current-limiter with Bypass Resistor (BTFCL-BR), Genetic Algorithm(GA), Fault current limiting Inductor (FCLI).**

I. INTRODUCTION

ENERGY will be considered as the pivotal input for development. At present due depletion of available conventional resources and concern environmental degradation, the wind energy sources are being utilized to meet the ever increasing energy demand. This chapter introduces the enhancing the power quality of grid connected Doubly-fed Induction Generator (DFIG) system [1]. Now a days DFIG is mainly used in multi-MW wind turbines. The DFIG system operates both sub and super synchronous modes with a rotor speed range around the synchronous speed. The stator circuit of DFIG directly connected to the grid while the rotor winding is connected via slip rings to a converter circuit. For variable speed operation where the speed limit requirements are small, for example ±30% of synchronous speed, the Double Fed Induction Generator offers good performance for the variable speed range systems [2]-[4]. DFIG rotor circuit consists of an AC-DC-AC converter. This chapter will introduces the Evolution of the performances of BTFCL-BR with genetic algorithm for enhancing power quality of DFIG

II. OPERATIONAL PRINCIPLE OF BTFCL FOR DFIG

1. Operational Principle of the BTFCL: The basic configuration of the BTFCL incorporated in a DFIG It consists of coupling transformers, a diode bridge, and an FCLI .During normal operation, as long as the stator current is lower than the threshold value , the diode bridge is fully conducting. The BFCL shows non-inductive impedance. The forward voltage drop of the diode strings and the voltage drop of winding resistance and leakage inductance of isolation transformers are the only voltage drop on the circuit, which are negligibly small. When the stator current increases in amplitude and reaches the threshold value, one pair of diode strings become reverse biased and cease to conduct[5]-[6]. Once one pair of diode strings goes into the blocking state, the FCLI is inserted into one phase of stator circuit so as to compensate the power losses of FCLI. The FCLI is inserted into three phases of stator circuit alternatively on each crest and trough of stator current. During insertion of FCLI, high-voltage spikes on the FCLI are induced due to the switching operation of RSC, which causes stator voltage distortions and induces electromagnetic torque fluctuations. The electromagnetic torque fluctuations may reduce lifetime of turbine shaft and

gear box. The fault-current-limiting principle of the BTFCL is the same as that of the BTFCL [7]-[9]. Upon occurrence of a grid fault, when the fault current increases in amplitude and reaches the value of IFCLI/n, one pair of diode strings becomes reverse biased and cease to conduct. When one pair of the diode strings goes into blocking state, the FCLI is automatically switched into one phase of stator circuit and limits the rate of increase of the fault phase current. When the grid fault is cleared and the stator current becomes lower than the value of IFCLI/n, the blocked diodes regain forward conducting and the FCLI is disconnected from the stator automatically. Since the DFIG can be regarded as rotating transformer, the rotor overcurrent is limited by transformer coupling, which helps to protect the RSC from overcurrent.

2. Operational Principle of the BTFCL-BR: The BR is connected in parallel with the primary side of the isolation transformer. Thyristor Bridge is used instead of the diode bridge to activate or deactivate the BR. During normal operation, all of the thyristors are kept turned on and operate as that of the diodes. The FCLI is also inserted into the stator circuit on each crest and trough of stator current. However, high-order current harmonics are diverted into the BRs since the impedance of BR is much lower than that of the FCLI at high frequency. High-voltage spikes on the stator are therefore eliminated, and the harmonic distortions of stator voltage and current are relieved. When a grid fault is detected, the triggering signals of all of the thyristors are removed[10]-[12]. The fault current is initially limited by the shunt impedance of FCLI and BR. When the thyristor current decreases to zero, the BR is completely inserted into the stator branch. The BR helps to damp stator flux, limit the stator overcurrent, and restore the stator voltage. The enhancement of power quality of DFIG thus evaluated.

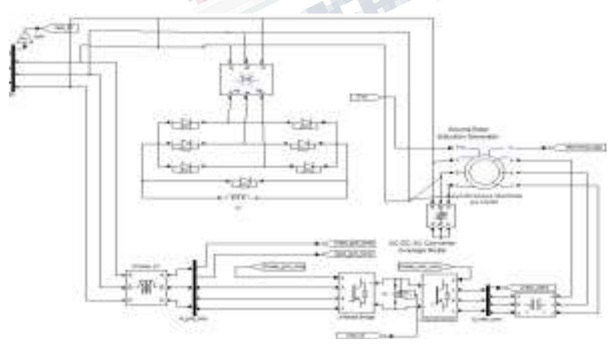

Fig.BTFCL-BR

2.1. Operational-Mode Analysis of the BTFCL-BR

The BTFCL-BR circuit has six modes of operations after occurrence of a fault, which is illustrated as follows:

Mode I: Co-fault Current-Limiting Mode: This mode occurs almost instantly after the fault occurs. The stator overcurrent is limited by the shunt impedance composed of the FCLI and the BR. The shunt fault-current limiting impedance also restores the stator voltage to some extent. The triggering signals of all of the thyristors are removed upon detection of the grid fault in this mode. However, the thyristor cannot be turned off until the current flowing through it decreases to zero. Because of the rectifying effect provided by the thyristor rectifier, the stator voltage keeps charging the FCLI until the thyristors are turned off. The FCLI current increases and the stator flux decreases. Part of the energy stored in the stator is transferred to the FCLI, the other part are consumed by the BR.

2) Mode II: DC Flux Demagnetizing Mode: This mode occurs when the thyristor current decrease to zero and the thyristors turn off naturally. The FCLI is disconnected from the stator. The FCLI current goes to zero with a time constant determined by the inductance and resistance of the FCLI. The BR limits the fault current all alone. With the damping effect of the BR and the flux counteracting control of RSC, the dc component of stator flux is demagnetized fast to zero in this mode.

3) Mode III: Fault Energy Consuming Mode: This mode occurs when the dc component of the stator flux goes to zero. The LVRT control of RSC only suppresses the dc and negative-sequence stator flux, the positive sequence stator flux is not affected. The positive-sequence stator flux is magnetized by three-phase balance stator current, which restores the stator voltage by the three BRs. With balanced three-phase stator current, the restored stator voltage is also balanced. The stator voltage and current goes to zero while the BRs consumes the excessive fault energy.

4) Mode IV: Fault-Clearing Mode: This mode Occurs when the grid voltage recovers to its nominal value. The sudden changes in the grid voltage cause stator overcurrent, and the BRs limit the stator overcurrent. The RSC keeps using LVRT control to counteract the dc and negative sequence stator flux induced in the fault recovery transient to protect the RSC and gear box. The stator voltage and current become balanced at the end of this mode, which is also due to that the dc and negative-sequence stator flux is suppressed by BR and the LVRT control of RSC.

5) Mode V: Fault-Recovery Mode: This mode occurs when the dc and negative-sequence of the stator flux goes to zero.

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The RSC keeps using LVRT control to make the stator current decrease into acceptable range so as to make less transient oscillation during control mode switching. The stator voltage increases as the stator current decreases, which is due to that the voltage drop on the BR is decreased.
6) Mode VI: Normal-Operation-Resuming Mode: This mode occurs when control of RSC switches from LVRT mode to normal operational mode. Upon occurrence of this mode, the stator voltage has recovered nearly to its nominal value. The DFIG is thus able to switch smoothly from LVRT mode to normal mode.

III. GENETIC ALGORITHM

Genetic algorithm is a larger branch of evolutionary algorithm, used to find solutions for constrained and unconstrained problems of optimization by means of natural process similar to biological evolutions. The crossover and mutation are the two main components of genetic algorithm. Generally the problems will have a population of possible solutions and these solutions will undergo recombination and mutation to generate a new solution. The process has been continued out till a solution equal to the fittest to the survival is arrived. Crossover is a process of selecting genes from the parents and creating a new off springs. Mutation is a process of preventing all solutions from falling to a local optimum. In order to tune a suitable value of k_p,$k_i$and k_d value for PID controller, the genetic algorithm has been used in this work, with which the LVRT performance is improved[13-14]

IV. RESULTS

The performance of the Genetic Algorithm in improving LVRT is proved with grid voltage performance shown in fig.2 below

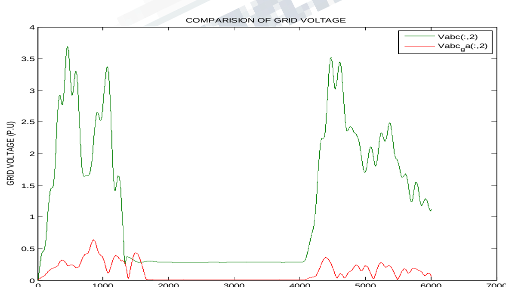

Fig.2: Variation of grid voltage magnitude at fault condition

The performance of the Genetic Algorithm in improving LVRT is proved with DC link voltageperformance shown in fig.3 below

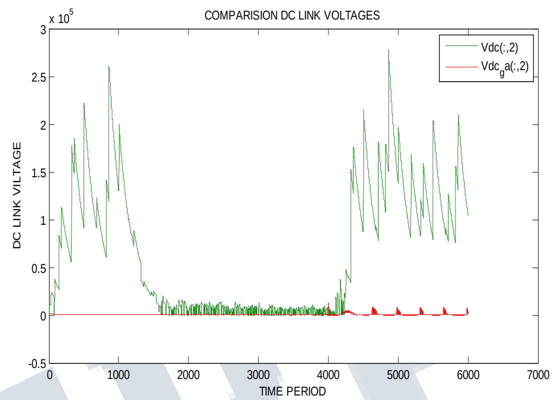

Fig.3: The oscillation damping during the grid voltage

The Total Harmonics Distortion of grid voltage values with and without Genetic Algorithm is given below table.1.1

Particulars	Without GA	With GA
THD	0.8843	0.3674

Table 1.1:THD Values with and without Genetic Algorithm

V. CONCLUSION

The operational performance BTFCL-BR with Genetic Algorithm is evaluated inthispaper.Using this tuning the gscpid converter controller gains kp, ki and kd values were tuned with Genetic algorithm, with which the LVRT performance is improved. The common BTFCL can automatically insert FCLIintothestatorcircuituponoccurrenceofagridfault, which helps to weaken the rotor back-EMF voltage and reduce the rotor overcurrent. The LVRT capability of RSC is therefore effectively strengthened. However, the common BTFCL has adverse impact on the normal operation of DFIG. The FCLI is insertedintothestatoroneach c standtroughofstatorcurrent, which induces high stator voltage spikes and causes stator flux, rotor current, and electromagnetic torque oscillations. The life cycle of turbine shaft and gear box will be shortened. To increase the power generation reliability and efficiency, BTFCL-BR solution is presented and evaluated. However, the cost can be lowered, reliability

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canbeincreased,andpowerlossescanbereduced.TheBTFCLBR is therefore a most promising solution to solve the LVRT problem of DFIG .

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