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IMPACTS OF GROUNDING CONFIGURATIONS ON RESPONSES OF GROUND PROTECTIVE RELAYS FOR DFIG-BASED WECSS FAULTS

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Abstract—One of the prerequisites for sheltered, steady, feasible, and gainful operation of doubly bolstered enlistment generators (DFIGs)- based wind vitality change frameworks (WECSs) is the precise and solid security against electrical flaws, specifically, ground issues. The execution of defensive gadgets utilized to accomplish this necessity is profoundly reliant on the establishing arrangement of the DFIG-based WECS. This paper examines effects of the establishing arrangement on the execution of defensive gadgets used to shield DFIGs-based WECSs from electrical ground flaws. Explored establishing arrangements incorporate strong establishing, low-resistance establishing, high-resistance establishing, and no establishing. This paper additionally researches the utilization of a capacitor in parallel with a low resistance, as an establishing setup, to breaking point ground possibilities, decrease ground streams, and minimize impacts on reactions of ground defensive transfers. The effects of the establishing setups on defensive gadgets are seen through their capacity to distinguish issues, and also their rate to react to recognized issues. Reproduction and exploratory results uncover that satisfactorily planned low-resistance establishing offers the base effects on defensive gadgets utilized for ground insurance of DFIG-based WECS

I. INTRODUCTION

Amid the previous couple of years, noteworthy advancement has been made to use different sorts of renewable vitality sources. Among these renewable vitality sources, wind vitality has been driving the progressively developing levels of financial and practical electric vitality creation. These developing levels of wind vitality creation are upheld by various advances that are focused by the doubly nourished acceptance generators (DFIGs). DFIG-based wind vitality transformation frameworks (WECSs) can offer a few focal points, including variable pace operation, controlled catching of wind force, decreased mechanical weights on the turbine and sharp edges, autonomous control of dynamic and receptive forces, and somewhat evaluated power electronic converters (PECs) [1]–[8]. The expanding use of electric vitality created by DFIG-based WECSs have commanded setting conditions for interfacing these dispersed producing units to power frameworks. Another arrangement of framework codes has been built up to address the necessities for incorporating DFIG-based WECSs into force frameworks. One of the prerequisites of the new matrix codes is the compulsory interest of DFIG-based WECSs in voltage and recurrence control exercises of their host power frameworks. For

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motivations behind agreeing to the new framework codes, a DFIG based WECS needs to stay associated with its host power frameworks amid relentless state and transient conditions. Such a prerequisite makes requests for exact and dependable assurance, and control of DFIG-based WECSs. A few episodes have been accounted for gear harm in the DFIG and/or its energy electronic converters (see [7]–[9] and references in that) due to misidentified electrical ground deficiencies. Harm examinations for some of these occurrences have shown that disgraceful establishing designs have contributed essentially to the mal operation of ground defensive gadgets. As an outcome, the new network codes indicate introducing satisfactory groundings for DFIG based WECSs. All in all, establishing any segment in a force framework can be designed as strong establishing, low-resistance establishing high-resistance establishing, or no establishing. The establishing of any creating unit (counting DFIG based WECSs) in a force framework ought to have the capacity to diminish ground streams and farthest point ground possibilities, which show up over the establishing impedance because of ground ebbs and flows. It ought to be noticed that every wind turbine tower is furnished with a different establishing that is in charge of a protected release of lightning strikes. This different establishing is developed by an immediate association of the tower fortifications to ground anodes.

II. GROUNDINGCONFIGURATIONS IN DFIG-BASEDWECSS

1. A. Overview of Grounding Configurations

Different grounding configurations allow the limitation of ground fault currents, as well as the reduction of ground potentials experienced by various components in any power system. This becomes critical when considering the role of grounding in the stability, reliability, and operation of DFIG-based WECSs. The employment of PECs in rotors of DFIGs. These PECs generate current harmonic components that flow to the ground, and may disrupt the function of any ground protective device. The use of cables to connect the DFIG (located at the top of the wind turbine tower) to the collecting transformer. The significant equivalent capacitances of these cables can initiate transient overvoltages during asymmetrical electrical faults. Such transient overvoltages may lead to subsequent failures in DFIG-based WECSs. Standardized practices for grounding power systems components identify four basic configurations I- Solid Grounding: this grounding configuration is established by eliminating any intentional impedance between the neutral and ground points. The main advantage of the solid grounding is its ability to eliminate ground potentials. However, this grounding configuration does not offer any reduction of ground currents. Such a disadvantage raises concerns about its applications in DFIGbased WECSs, where ground faults in the rotor PECs can initiate higher currents than those initiated by 3φfaults, and may result in severe equipment damage.

B. Low-Resistance Grounding: industrial practices consider a low-resistance grounding as a resistance connecting the neutral and ground points, and is capable of maintaining the ground currentIGas [22]–[24]:

• $I_G \le 100A$: low-voltage($V_{sys} \le 1kV$);

• $I_G \le 400A$: medium voltage($1 < V_{sys} \le 35kV$).

It is to be noted that low and medium voltages are considered since they represent typical rated voltages

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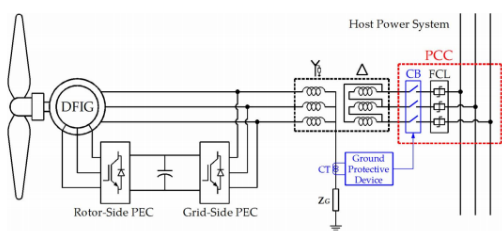
of DFIG-based WECSs. The low-resistance grounding configuration offers several advantages, including reduced arcing currents and limited arc-flash hazards leading to ground faults, reduced mechanical and thermal damages in the transformer and/or DFIG, and reduced ground potentials. However, this grounding configuration does not support fault location features.

C.High-Resistance Grounding: this grounding configuration is defined as a resistance connecting the neutral and ground points, and is capable of reducing ground currents to less than 25 A (in low and medium voltage systems). The high-resistance grounding offers some advantages that include facilitating the process of locating faults and minimizing the use of the ground.



Ground Protective Devices

The vast majority of electrical faults experienced by power system components, including DFIG-based WECSs, are ground faults. A ground fault is initialized by an unintentional connection between one and more of the energized phases to the nground point. Among the common causes of ground faults are insulation breakdown, improper connections, broken bus-bars, and failure of system component(s). Different power system components are generally protected against ground faults by employing ground protective devices. Ground protective devices are employed to detect either the current flowing to the ground and/or voltage (commonly called the ground potential) across grounding resistances or impedances. In the case of ground current or potential exceeding the pick-up value and time setting, ground protective devices initiate their response [trip one or more circuit breakers (CBs)] [21]–[25]. There are several designs of ground protective devices including overcurrent (inverse, inverse definite,digital and relays.

III. DESIGNINGLOW RESISTANCEGROUNDING FOR DFIG-BASEDWECSs

The employment of PECs in the rotor of a DFIG causes current harmonic components to flow to the ground. If a lowresistance grounding, with a resistanceRG,isusedforaDFIGbased WECS, the current harmonic components flowing to the ground will create a ground potential acrossRG. The design of a low-resistance grounding for a DFIG-based WECS is mainly constrained by the system nominal line-to-neutral voltageVP and the desired maximum value of the ground currentIG.The ohmic value ofRGfor low- and high-resistance groundings canbe determined .

$$R_G = \frac{V_P}{I_G}. \qquad (1)$$

The power rating of R_G can be specified as:

$$P_{R_G} = (I_G)^2 R_G. \qquad (2)$$

The ground potential across R_G can be limited by modifying the low resistance grounding to include a frequency selection

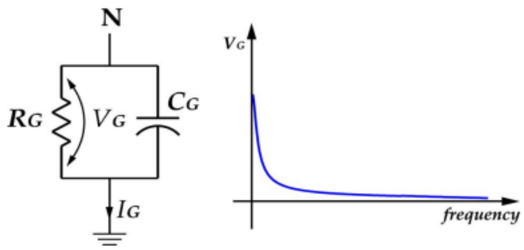


Fig. 2. Frequency selective circuit for the low-resistance grounding of a DFIG-based WECS and its ground potential V_G characteristics.

$$V_{C1} = \frac{(kn+1)D}{1-D}V_I \quad (8)$$

$$V_{C2} = \frac{knD}{1-D}V_I. \quad (9)$$

Substituting (8) into (2), yields

$$V_{C3} = \frac{kn+1}{1-D}V_I. \quad (10)$$

Substituting (9) and (10) into (6), the voltage gain is achieved s

$$M_{CCM} = \frac{2+kn+knD}{1-D}V_I. \quad (11)$$

IV. SIMULATIONTESTS

Several simulation tests were carried out to investigate impacts of grounding configurations on the responses of ground protective relays used in DFIG-based WECSs. Two DFIG based WECSs were used in these simulation tests; one was rated at 15 kW, and the other was rated at 2 kW. The model and test results for 15-kW DFIG-based WECSs are presented here, and the model of the 2-kW DFIG-based WECS, along with its test results, are provided in Appendix I.

TABLE I
PARAMETERS OF THE SIMULATED 15-kW DFIG-BASED WECS

Induction Generator	
Rated Power [kW]	15
Rated Frequency [Hz]	60
Number of Poles	8
Rated Voltage [rms]	430
Stator Winding Connection	Δ
Stator Resistance [Ω]	0.2147
Stator leakage Inductance [mH]	1
Rotor Resistance [Ω]	0.2205
Rotor leakage Inductance [mH]	0.94
Inertia Constant [kg.m^2]	0.102
Friction Coefficient [N.m/rad/sec.]	0.0098
Rotor PECs	
Grid-Side AC-DC Converter	3ϕ, VS, 6-pulse, PWM Converter
DC-link Capacitor [μF]	300
Rotor-Side DC-AC Converter	3ϕ, VS, 6-pulse, PWM Inverter
Transformer	27 kVA, 3ϕ, 60 Hz, $\Delta - Y$

A. Modeling the 15-kW DFIG-Based WECS

For purposes of investigating possible impacts of the grounding configurations, including the modified low-resistance grounding (as shown in Fig. 2), a DFIG-based WECS was implemented using a MATLAB/SIMULINK model, where the DFIG was constructed using the detailed model [26]. The specifications of the induction generator, rotor PECs, and main transformer in the implemented model are provided in Table I.

The implemented SIMULINK model utilized two vector controllers for generating reference signals, which were employed for producing pulse width modulated (PWM) switching pulses for the rotor PECs. These vector controllers were designed as detailed in [8], and with PWM switching signals were produced at a switching frequency of 8 kHz. Simulation tests were performed with a time step of Ts=50μs. The
tests for investigating impacts of grounding configurations were conducted on two different protective devices:

• An inverse definite minimum time overcurrent (IDMTOC) relay, with 20 A pick-up current and 0.3-s time

• A discrete Fourier transform (DFT)-based digital relay. The ground currentIGwas used as the input for both protective relays. The data in Table I was employed for specifying values for the resistances used in low- and high-resistance grounding configurations. These resistance values were specified as:

• Low resistance: the maximum ground current was set 30 A, which was selected to meet standards for ground currents in low-voltage systems(IG≤100A). Equation (1) was used to calculate(RG)LRG forVP=

(430/ √ 3)and IG=30A. The ohmic value of(RG)LRG was calculated as(RG)LRG=8.275 Ω. The power rating for (RG)LRG was specified using (2), forIG=30A, as(PR)LRG=7.45kW.

VI. CONCLUSION

The ground currents for the simulated 20-kW DFIG-based WECS were collected for purposes of determining their harmonic contents using MATLAB/SIMULINK built-in FFT function. These ground currents were collected when the grounding was configured as solid grounding. One ground current was collected during normal (nonfault condition), and its harmonic contents were determined. The ground current and its magnitude spectrum for a normal operating condition. One can see from Fig. 17 that the ground current IG contained significant harmonic contents, which were produced due
to the grid-side3φac–dc converter. Despite its low magnitude, IGwould flow through the ground path at all times. The second ground current was collected during the stator phaseA-toFig. 18. Ground current obtained from the 20-kW DFIG-based WECS during the stator phase A-to-ground fault.

REFERENCES

[1] K. Yamamoto, S. Yanagawa, K. Yamabuki, S. Sekioka, and S. Yokoyama, "Analytical surveys of transient and frequency-dependent grounding characteristics of a wind turbine generator system on the basis of field tests," IEEE Trans. Power Del., vol. 25, no. 4, pp. 3035–3043, Oct. 2010.

[2] P. Mahat, Z. Chen, B. Bak-Jensen, and C. L. Bak, "A simple adaptive overcurrent protection of distribution systems with distributed generation," IEEE Trans. Smart Grid, vol. 2, no. 3, pp. 428–437, Sep. 2011.

[3] H. Sheng, L. Xinchun, K. Yong, and Z. Xudong, "An improved lowvoltage ride-through control strategy of doubly fed induction generator during grid faults," IEEE Trans. Power Electron., vol. 26, no. 12, pp. 3653–3665, Dec. 2011.

[4] A. Mullane, G. Lightbody, and R. Yacamini, "Wind-turbine fault ridethrough enhancement,"IEEE Trans. Power Syst., vol. 20, no. 4, pp. 1929– 1937, Nov. 2005.

[5] H. Geng, C. Liu, and G. Yang, "LVRT capability of DFIG-Based WECS under asymmetrical grid fault condition ,"IEEE Trans. Ind. Electron., vol. 60, no. 6, pp. 2495–2509, Jun. 2013.

[6] C. M. Mohseni, S. Islam, and M. A. S. Masoum, "Impacts of symmetrical and asymmetrical voltage sags on DFIG-based wind turbines considering phase-angle jump, voltage recovery, and sag parameters,"IEEE Trans. Power Electron., vol. 26, no. 5, pp. 1587–1598, May 2011.

[7] S. Panetta, "Grounding of wind systems and wind power generators,"IAEI News, no. May/Jun., pp. 1–5, 2010.

[8] M. Chenet al., "Investigation on the faulty state of DFIG in a microgrid," IEEE Trans. Power Electron., vol. 26, no. 7, pp. 1913–1919, Jul. 2011.

[9] M. Tsili and S. Papathanassiou, "A review of grid code technical requirements for wind farms,"IET Renew. Power Gener . vol. 3, no. 3, pp. 308– 332, Sep. 2009.

[10] F. K. A. Lima, A. Luna, P. Rodriguez, E. H. Watanabe, and F. Blaabjerg, "Rotor voltage dynamics in the doubly fed induction generator during grid faults,"IEEE Trans. Power Electron., vol. 25, no. 1, pp. 118–130, Jan. 2010. 2818 IEEE TRANSACTIONSONINDUSTRYAPPLICATIONS, VOL. 51, NO. 4,

[11] J. Morren and S. W. H. de Haan, "Short-circuit current of wind turbines with doubly-fed induction generator, "IEEE Trans. Energy Convers., vol. 22, no. 1, pp. 174–180, Mar. 2007.

[12] J. Yang, J. E. Fletcher, and J. O'Reilly, "A series-dynamic-resistor-based converter protection scheme for doubly-fed induction generator during various fault conditions, "IEEE Trans. Energy Convers., vol. 25, no. 2, pp. 422–432, Jun. 2010.

[13] C. Zhe, J. M. Guerrero, and F. Blaabjerg, "A review of the state of the art of power electronics for wind turbines,"IEEE Trans. Power Electron., vol. 24, no. 8, pp. 1859–1875, Aug. 2009.

[14] L. Grcev and F. Dawalibi, "An electromagnetic model for transients in grounding system,"IEEE Trans. Power Del., vol. 5, no. 4, pp. 1773–1781, Oct. 1990.