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Review Paper Work on Power Controllability of a Three-Phase Converter with an Unbalanced AC Source

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Abstract- To enhance the power controllability under this adverse condition new series of control strategies are proposed in this paper which utilize the zero sequence components. Three-phase dc–ac power converters suffer from power oscillation and over current problems in case of the unbalanced ac source voltage that can be caused by grid/generator faults. To overcome these problems existing solutions are properly selecting and controlling the positive- and negative-sequence currents. It is concluded that by introducing proper zero-sequence current controls and corresponding circuit configurations, the power converter can enable more flexible control targets, achieving better performances in the delivered power and the load current when suffering from the unbalanced voltage. By using the simulation results we can analyze the proposed method.

Index Terms*—*Control strategy, dc–ac converter, fault tolerance, unbalanced ac source.

INTRODUCTION

In many important applications for power electronics such as renewable energy generation, motor drives, power quality, and microgrid, etc., the three-phase dc–ac converters are critical components as the power flow interface of dc and ac electrical systems. As shown in Fig. 1, a dc–ac voltage source converter with a corresponding filter is typically used to convert the energy between the dc bus and the three-phase ac sources, which could be the power grid, generation units, or the electric machines depending on the applications and controls.

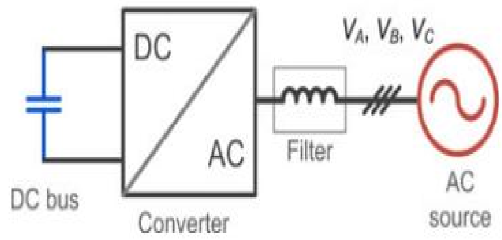

Fig. 1.Typical dc–ac power converter application

Since the power electronics are getting so widely used and becoming essential in the energy conversion technology, the failures or shutting down of these backbone dc–ac converters may result in serious problems and cost. It is becoming a need in many applications that the power converters should be reliable to withstand some faults or disturbances in order to ensure certain availability of the energy supply. A good example can be seen in the wind power application, where both the total installed capacity and individual capacity of the power conversion system are relatively high.

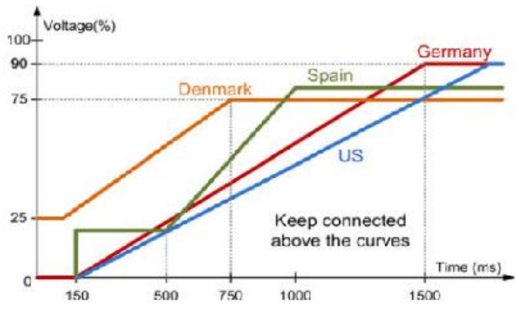

Fig. 2. Grid codes of wind turbines under the grid voltage dip by different countries.

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The sudden disconnection of the power converter may cause significant impacts on the grid stability and also on the high cost for maintenance/repair. As a result, transmission system operators (TSOs) in different countries have been issuing strict requirements for the wind turbine behavior under grid faults. As shown in Fig. 2, the wind power converter should be connected (or even keep generating power) under various grid voltage dips for certain time according to the dip severity, and in some uncritical conditions (e.g.,90% voltage dip), the power converter may need long-time operation.

When the ac source shown in Fig. 1 becomes distorted under faults or disturbances, the unbalanced ac voltages have been proven to be one of the greatest challenges for the control of the dc–ac converter in order to keep them normally operating and connected to the ac source. Special control methods which can regulate both the positive- and negative sequence currents have been introduced to handle these problems. However, the resulting performances by these control methods seem to be still not satisfactory: either distorted load currents or power oscillations will be presented, and thereby not only the ac source but also the power converter will be further stressed accompanying with the costly design considerations.

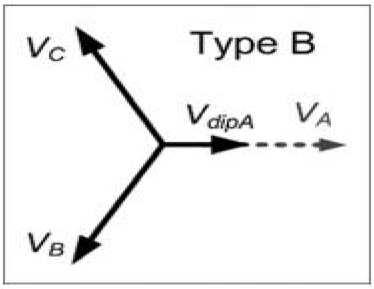

Fig. 3. Phasor diagram definitions for the voltage dips in the ac source of Fig. 1. *VA* , *VB* , and *VC* means the voltage of three phases in the ac source.

This paper targets to understand and improve the power control limits of a typical three-phase dc–ac converter system under the unbalanced ac source. A new series of control strategies which utilizes the zero-sequence components are then proposed to enhance the power control ability under this adverse condition. Besides the grid integration, the proposed control methods have the potential to be applied under other applications like the motor/generator connections or microgrids, where the unbalanced ac voltage is likely to be presented; therefore, the basic principle and feasibility are mainly focused.

RELATED WORK

[1] F. Blaabjerg, et.al proposes the steady growth of installed wind power together with the up scaling of the single wind turbine power capability has pushed the research and development of power converters toward full-scale power conversion, lowered cost pr kW, increased power density, and also the need for higher reliability. In this paper, power converter technologies are reviewed with focus on existing ones and on those that have potential for higher power but which have not been yet adopted due to the important risk associated with the high-power industry. The power converters are classified into single- and multicell topologies, in the latter case with attention to series connection and parallel connection either electrical or magnetic ones (multiphase/windings machines/transformers). It is concluded that as the power level increases in wind turbines, medium-voltage power converters will be a dominant power converter configuration, but continuously cost and reliability are important issues to be addressed.

[2] J. W. Kolar et.al proposed In the first part of this paper, three-phase power factor correction (PFC) rectifier topologies with sinusoidal input currents and controlled output voltage are derived from known single-phase PFC rectifier systems and/or passive three-phase diode rectifiers. The systems are classified into hybrid and fully active pulsewidth modulation boost-type or buck-type rectifiers, and their functionality and basic control concepts are briefly described. This facilitates the understanding of the operating principle of three-phase PFC rectifiers starting from single-phase systems, and organizes and completes the knowledge base with a new hybrid three-phase buck-type PFC rectifier topology denominated as Swiss Rectifier.

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Finally, core topics of future research on three-phase PFC rectifier systems are discussed, such as the analysis of novel hybrid buck-type PFC rectifier topologies, the direct input current control of buck-type systems, and the multi-objective optimization of PFC rectifier systems. The second part of this paper is dedicated to a comparative evaluation of four rectifier systems offering a high potential for industrial applications based on simple and demonstrative performance metrics concerning the semiconductor stresses, the loading and volume of the main passive components, the differential mode and common mode electromagnetic interference noise level, and ultimately the achievable converter efficiency and power density..

[3]J. Rocabert, et.al proposes the high penetration of distributed generation power plants, based on renewable energy sources (RESs), is boosting the connection of power converters to the electrical network. This generation concept would permit to form local networks, microgrids, when the main grid falls due to any kind of contingency in the network. However, the connection and disconnection of these local networks may give rise to undesired transient overcurrents that should be avoided. In order to solve this drawback, this paper presents a method oriented to carry out a stable intentional disconnection/reconnection of local grids from the main electrical network under grid-fault conditions. This control method has been implemented in a grid-connected power converter that acts as an intelligent connection agent (ICA) and adapts its operation mode according to its connection state. The proposed control also manages the operation of a controlled switch, which is responsible of disconnecting/reconnecting the microgrid from the mains. In this paper, the behavior of the ICA under transient conditions will be discussed using simulation results.

[4] L. Shang, et.al proposes a new direct active and reactive power control (DPC) for the three-phase grid connected dc/ac converters. The proposed DPC strategy employs a nonlinear sliding mode control (SMC) scheme to directly calculate the required converter's control voltage so as to eliminate the instantaneous errors of active and reactive powers without involving any rotating coordinate transformations. Meanwhile, there are no extra current control loops involved, which simplifies the system design and enhances the transient performance. Constant converter switching frequency is achieved by using space vector modulation, which eases the design of the ac harmonic filter. Simulation results are provided and compared with those of the classic voltage-oriented vector control (VC) and conventional lookup table (LUT) DPC strategies. The proposed SMC-DPC is capable of providing enhanced transient performance similar to that of the LUT-DPC, and keeps the steady-state harmonic spectra at the same level as those of the VC scheme. The robustness of the proposed DPC to line inductance variations is also inspected during active and reactive power changes.

[5]C. Wessels, et.al proposes the application of a dynamic voltage restorer (DVR) connected to a wind-turbine-driven doubly fed induction generator (DFIG) is investigated. The setup allows the wind turbine system an uninterruptible fault ride-through of voltage dips. The DVR can compensate the faulty line voltage, while the DFIG wind turbine can continue its nominal operation as demanded in actual grid codes. Simulation results for a 2 MW wind turbine and measurement results on a 22 kW laboratory setup are presented, especially for asymmetrical grid faults. They show the effectiveness of the DVR in comparison to the low-voltage ride-through of the DFIG using simulation results that does not allow continuous reactive power production.

[6]F. Aghili, et.al proposes Fault tolerance is critical for servomotors used in high-risk applications, such as aerospace, robots, and military. These motors should be capable of continued functional operation, even if insulation failure or open-circuit of a winding occur. This paper presents a fault-tolerant (FT) torque controller for brushless dc (BLdc) motors that can maintain accurate torque production with minimum power dissipation, even if one of its phases fails. The distinct feature of the FT controller is that it is

applicable to BLdc motors with any back-electromotive-force waveform. First, an observer estimates the phase voltages from a model based on Fourier coefficients of the motor waveform. The faulty phases are detected from the covariance of the estimation error. Subsequently, the phase currents of the remaining phases are optimally reshaped so that the motor accurately generates torque as requested while minimizing power loss subject to maximum current limitation of the current amplifiers.

[7]Y. Xiangwu, et.al proposes with the increasing penetration of wind turbines in the utility grid, new regulation codes have been issued that require them to have low-voltage ride-through capability. In this paper, a passive resistive network consisting of shunt and series elements that are applied at the stator side of a doubly fed induction generation wind turbine is presented. The network is inactive during steady-state operation and enabled for short intervals of time during the initiation of voltage sag and recovery events. By using the simulation results confirming the validity of this operation during balanced and unbalanced voltage sags are shown in this paper.

[8]B. A. Welchko, et.al compares the many fault tolerant three-phase AC motor drive topologies that have been proposed to provide output capacity for the inverter faults of switch short or open-circuits, phase-leg short-circuits, and single-phase open-circuits. Also included is a review of the respective control methods for fault tolerant inverters including two-phase and unipolar control methods. The output voltage and current space in terms of dq components is identified for each topology and fault. These quantities are then used to normalize the power capacity of each system during a fault to a standard inverter during normal operation. A silicon overrating cost factor is adopted as a metric to compare the relative switching device costs of the topologies compared to a standard three-phase inverter.

[9]F. Blaabjerg, et.al proposes power Electronics are needed in almost all kind of renewable energy systems. In this paper an overview on the power electronic circuits behind the most common converter configurations for wind turbine and photovoltaic is done. It is used both for controlling the renewable source and also for interfacing to the load, which can be grid-connected or working in stand-alone mode. More and more efforts are put into making renewable energy systems better in terms of reliability in order to ensure a high availability of the power sources, in this case the knowledge of mission profile of a certain application is crucial for the reliability evaluation/design of power electronics. Next different aspects of improving the system reliability are mapped. Further on examples of how to control the chip temperature in different power electronic configurations as well as operation modes for wind power generation systems are given in order to reduce the temperature cycling.

[10]Y. Song and B. Wang et.al proposes with the wide-spread application of power electronic systems across many different industries, their reliability is being studied extensively. This paper presents a comprehensive review of reliability assessment and improvement of power electronic systems from three levels: 1) metrics and methodologies of reliability assessment of existing system; 2) reliability improvement of existing system by means of algorithmic solutions without change of the hardware; and 3) reliability-oriented design solutions that are based on fault-tolerant operation of the overall systems. The intent of this review is to provide a clear picture of the landscape of reliability research in power electronics. The limitations of the current research have been identified and the direction for future research is suggested.

CONCLUSION

In this paper proposes a new series of control strategies which utilizes the zero-sequence components are then proposed to enhance the power control ability under this adverse condition. In the three-phase converter structure with the zero sequence current path, there are six current control freedoms. The extra two control freedoms coming from the zero sequence current can be utilized to extend the controllability of the converter and improve the control performance under the unbalanced ac

source. By the proposed control strategies, it is possible to totally cancel the oscillation in both the active and the reactive power, or reduced the oscillation amplitude in the reactive power. Meanwhile, the current amplitude of the faulty phase is significantly relieved without further increasing the current amplitude in the normal phases. The advantage and features of the proposed controls can be still maintained under various conditions when delivering the reactive power. analysis and proposed control methods are analyzed by using simulation results.

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