A Grid-Connected New Hybrid Dual Voltage Source Multi-Level Inverter with DC-Fault Blocking Capability and Power Quality Improvement

Nithin Nair[1], Prof. Priyavand Bundela[2], Prof. Deepika Masand[3]

[1]*M. Tech. Scholar,* [2]*Guide,* [3]*HOD*

Department of Electrical Engineering, OIST, Bhopal

Abstract - This paper presents a hybrid dual voltage source inverter (HDVSI) scheme to enhance the power quality and reliability of the Alternate Arm Converter (AAC) system. The proposed scheme is comprised of two inverters, which enables the AAC to exchange power generated by the distributed energy resources (DERs) and also to compensate the local unbalanced and nonlinear load. The control algorithms are developed based on multi level inverter (MLI) to operate HDVSI in grid sharing and grid injecting modes. The proposed scheme has increased reliability, lower bandwidth requirement of the main inverter, lower cost due to reduction in filter size, and better utilization of AAC power while using reduced dc-link voltage rating for the main inverter. These features make the HDVSI scheme a promising option for AAC supplying sensitive loads. The topology and control algorithm are validated through extensive simulation and experimental results. Extensive results has been shown that the total harmonic distortions are also lower than the AAC with Hybrid Multi-level Converter. The simulation results have been achieved to block all the DC faults better.

Keywords - AAC, HDVSI, THD, Arm, DC Faults.

I. INTRODUCTION

In recent years many efforts are made to research and use new energy sources because the potential for an energy crisis is increasing. Multilevel converters have gained much attention in the area of energy distribution and control due to theirs advantages in high power applications with low harmonics. They not only achieve high power ratings, but also enable the use of renewable energy sources. The general function of the multilevel converter is to synthesize a desired high voltage from several levels of dc voltages that can be batteries, fuel cells, etc.

Power converters are electronic circuits associated to the conversion, control, and conditioning of electric power. The power range can be from milliwatts, mobile phone, for example, to megawatts, in electric power transmission systems. Reliability of the power converters become a key industrial focus. Electronic devices and control circuit must be highly robust in order to achieve a high useful life. A special accent must be set on the total efficiency of the power electronic circuits. Firstly, because of the economic and environmental value of wasted power and, secondly, because of the cost of energy dissipated that it can generate. Even a small improvement in converter power efficiency translates to improved profitability of the investment in the electronic market.

Multi-terminal high voltage direct current (HVDC) grids are a technically and economically viable solution for future bulk power transmission for the development of large scale renewable energy. By connecting different power sources such as wind, hydro and solar, HVDC grids have advantages of flexibility and reliability. The renewable energy power source such as offshore wind power farms is usually located in remote areas. Compare to an AC system, HVDC is more economic for transmission over long distance, especially when using cable to transmit the power.

Currently HVDC system exist mostly point-to-point systems with Line Commutated Converter (LCC) or Voltage Source Converter (VSC). VSC is more suitable for HVDC grids since it does not need to reverse voltage polarity to change power lower direction. As one of the topologies of VSC, Modular

Multi-level Converters (MMC) could provide high voltage, high performance waveforms with a low switching frequency. Its modularity allows the increase of the voltage rating of converter by adding more sub-modules. One of the challenges of building a HVDC system is how it would react to a DC side fault. MMC with full-bridge sub-modules is able to continue to produce the rated AC waveform up to a complete reversal of the DC-Link voltage; as such it has a DC fault blocking response. And after DC fault, full-bridge MMC can partially transmit power.

II. MULTILEVEL INVERTER

The general principle of multilevel behaviour of the system has been shown in figure to understand the concept of multilevel inverter. Figure 2.1 shows the working of multilevel converters. The leg of a 2-level converter is represented in Figure 2.1a) in which the semiconductor switches have been substituted with an ideal switch. The voltage output can assume only two values: 0 or E . Considering Figure 2.1b), the voltage output of a 3-level inverter leg can assume three values: 0 , E or 2E . In Figure 2.1c) a generalized n-level inverter leg is presented. Even in this circuit, the semiconductor switches have been substituted with an ideal switch which can provide n different voltage levels to the output. In this short explanation some simplifications have been introduced. In particular, it is considered that the DC voltage sources have the same value and are series connected. In practice there are no such limits, and then the voltage levels can be different. This introduces a further possibility which can be useful in multiphase inverters, as it will be shown in the following. A three-phase inverter composed by n-level legs will be considered for the analysis. Obviously the number of phase-to-neutral voltage output levels is n.

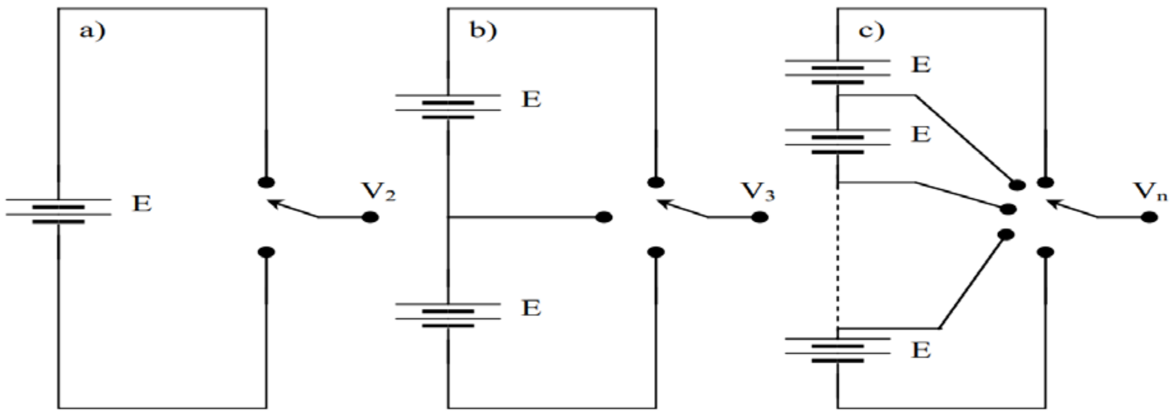

Figure 2.1 Inverter phases. a) 2-level inverter, b) 3-level inverter, c) n-level inverter.

Higher is the number of levels better is the quality of output voltage which is generated by a greater number of steps with a better approximation of a sinusoidal wave. So, increasing the number of levels gives a benefit to the harmonic distortion of the generated voltage, but a more complex control system is required, with the respect to the 2-level inverter.

III. PROPOSED SYSTEM MODEL

A dual multi-level inverter has been shortly introduced in this work with DC-fault blocking capability and power quality improvement as shown in Figure 3.1.

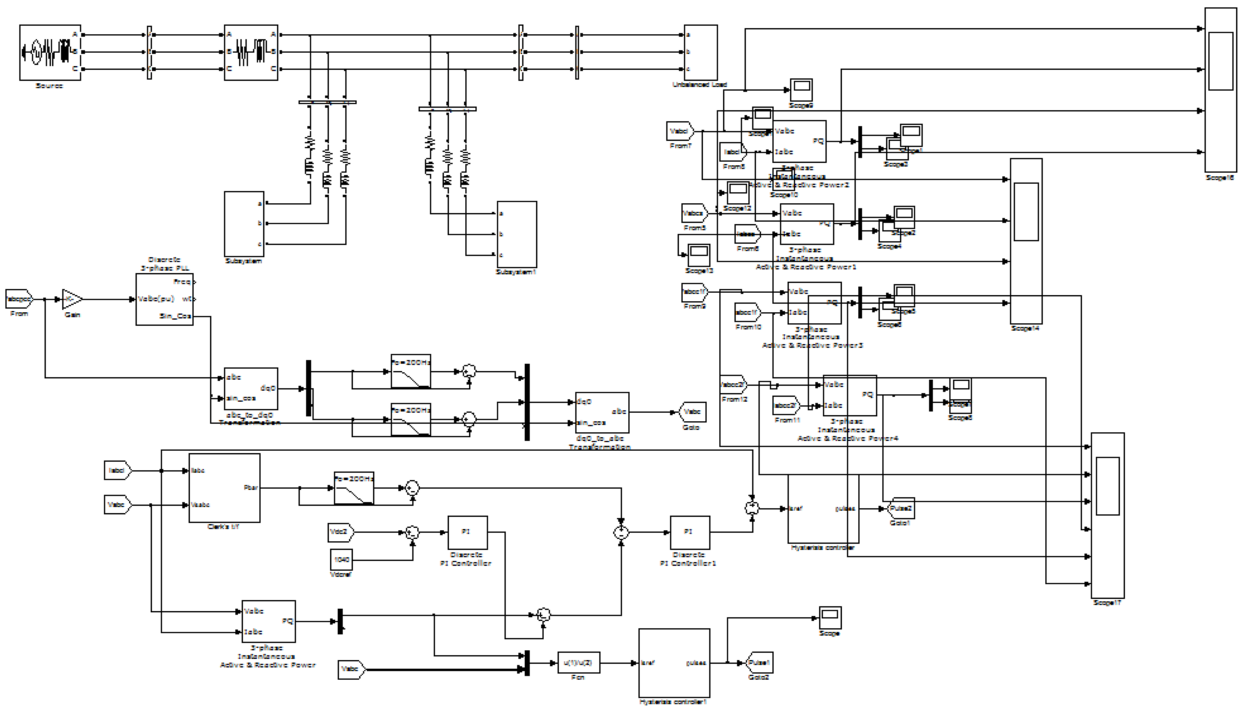

Figure 3.1 Proposed System with Multi Level Dual Inverter Circuit.

This topology consists of two standard 3-phase multilevel inverters with AC sides connected to the same 3-phase open-end 6-wire load and the DC sides connected to two different voltage sources. It could be said that the dual multi-level inverter is a derivation of the 3-level cascade H-bridge like standard 3-phase inverter is for the single-phase converter: in both cases the strong bond among the phases is exploited to reduce the number of required components. The implementation of proposed work has shown in Figure 3.1 has completed on MATLAB and the performance of proposed system has been evaluated based on simulation performed on MATLAB Simulink simulation environment.

Moreover, in Figure 3.2 a sub block of proposed system Multi Level Dual Inverter Circuit topology has shown. The advantage of this choice is the great availability and the high reliability of the components because they are standards wide commercialized.

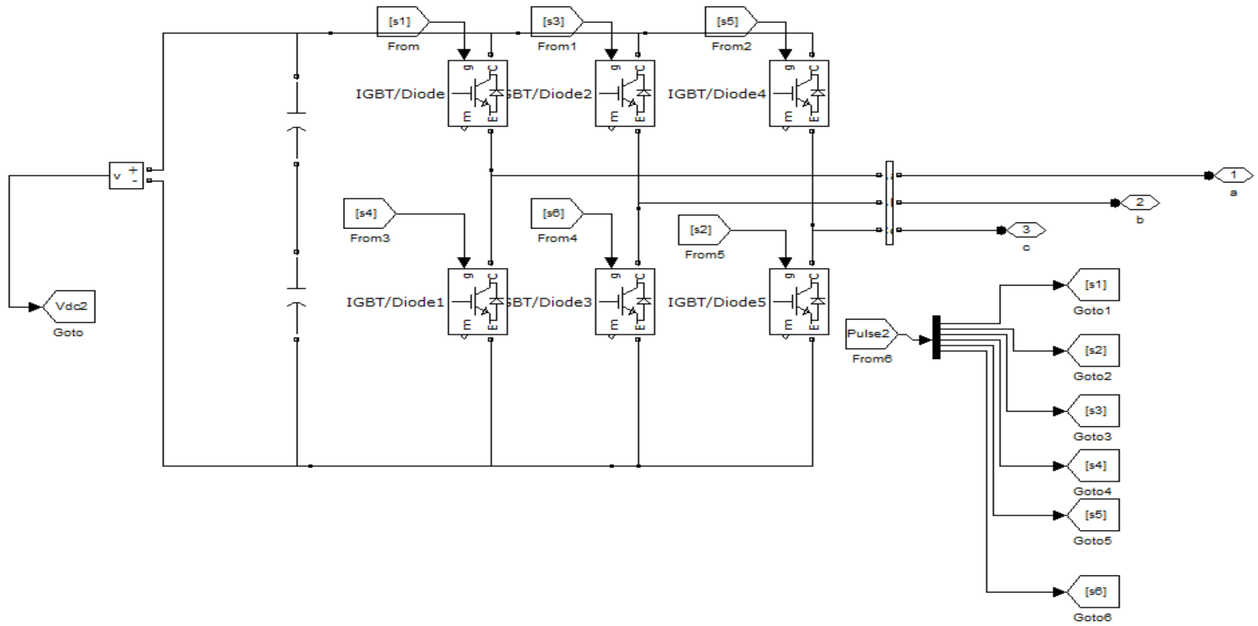

Figure 3.2 Multi Level Dual Inverter Circuit

IV. SIMULATION RESULTS

The simulation of proposed model has been performed on Matlab Simulink. In this simulation, output voltage and current are imposed and the operation of the system is then observed. The Simulationl results of a grid-connected new hybrid dual voltage source multi-level inverter with dc-fault blocking capability and power quality improvement are shown in Figure. Total harmonic distortion (THD) is derived respectively. THD is defined as the ratio of the sum of the amplitudes of all harmonic components to the amplitudes of fundamental frequency is shown in Table The same load is used to test the output voltage and current based on the previous method.

Table 1: Comparison of Total Harmonic Distortion (THD).

Systems	THD %
Previous System	*0.51 %*
Proposed System	*0.09 %*

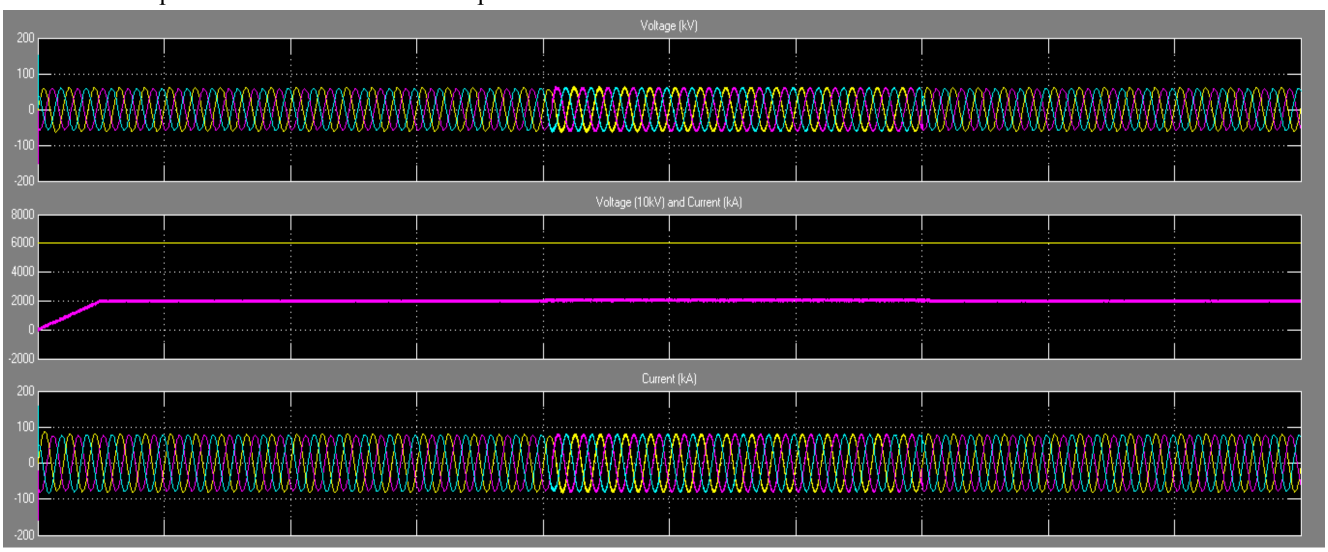

Figure 4.1 Simulation outcomes Source Voltage and Currents.

The outcome of proposed work has been compared with the outcome of existing work it is observed that the proposed work has better performance against existing work.

Figure 4.1 shows the outcome scope waveform of Source Voltage and Currents based on Simulation. Where voltage and currents are taken in kV and kA.

Another simulation waveform of voltage, current, arm current and cell voltages are shown in Figure 4.2.

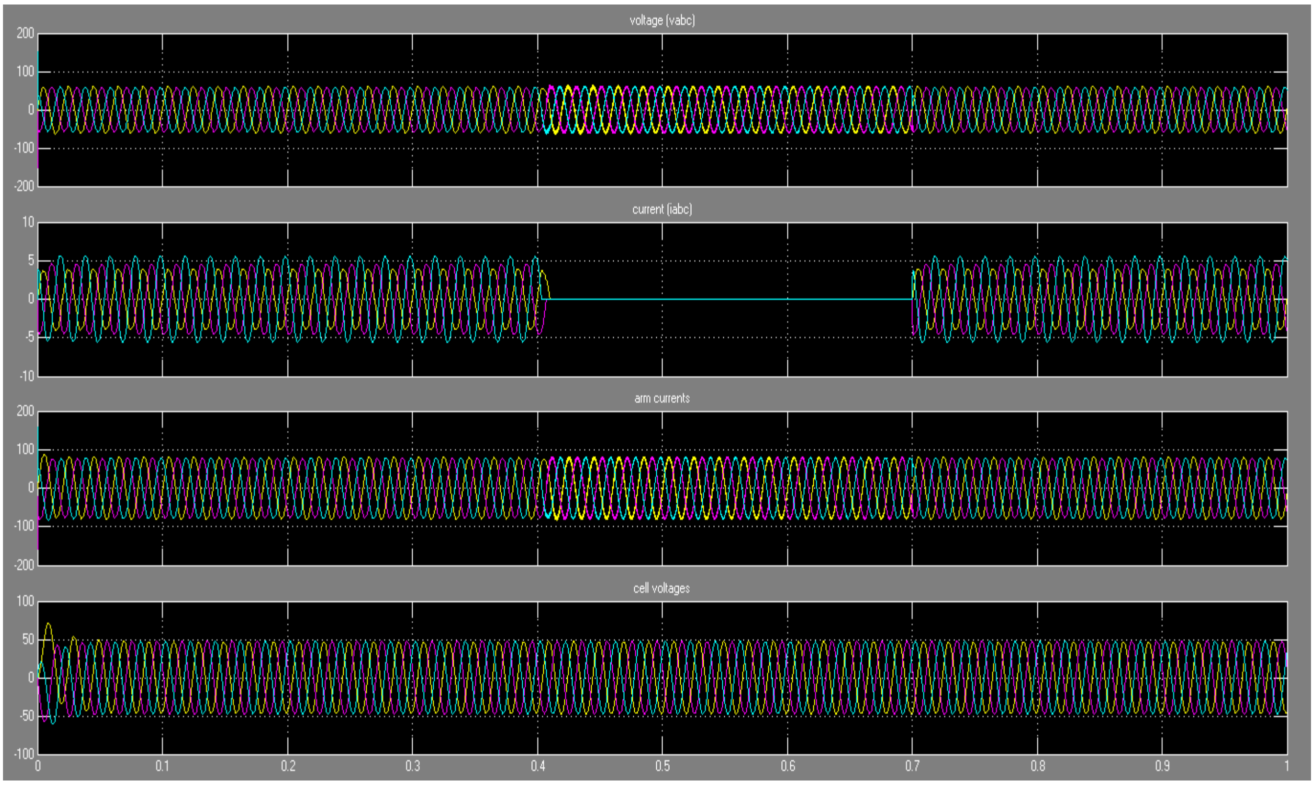

Figure 4.2 Simulation outcomes voltage, current, arm current and cell voltages.

The simulation results and normalized FFT analysis with proposed dual inverter method are shown in Figure 4.3. FFT Analyzed is THD is 0.09%. The proposed methods have a low harmonic and their phase currents are close to sinusoidal.

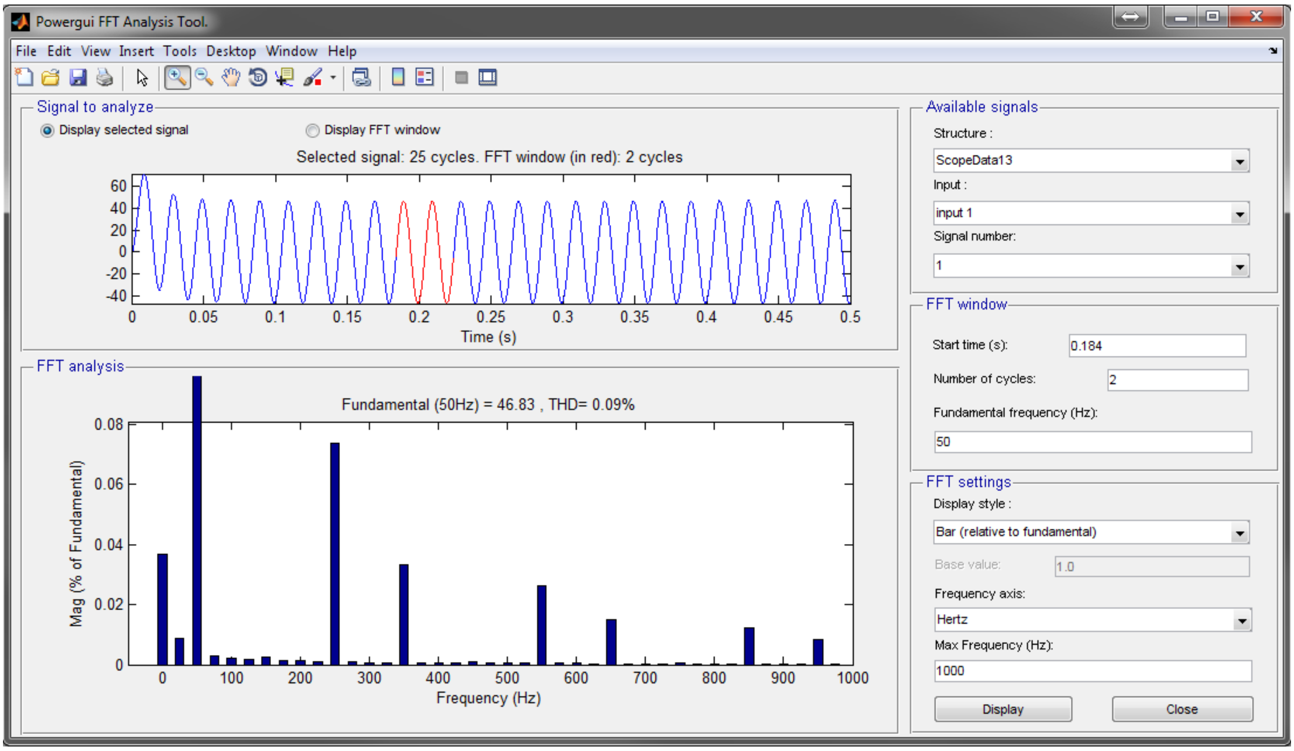

Figure 4.3 FFT Analysis THD is 0.09%.

V. CONCLUSION AND FUTURE SCOPE

In this work a grid-connected new hybrid dual voltage source multi-level inverter with dc-fault blocking capability and power quality improvement has reported. Multilevel inverters are attracting an increasing interest in power conversion field because they can offer high power possibility with low output harmonics. Modular multilevel converters (MMC) provide the ability to create high voltage waveforms by increasing the number of sub-modules. The large number of sub-modules leads to a high quality waveform despite the low switching frequency. They can be used in a variety of areas such as traction motor drive or renewable energy utility interface. Its structure, simulation models and results, development of prototype inverter, results, and applications are provided. This work has presented several fault operation methods using a hybrid dual voltage source multi-level inverter with dc-fault blocking capability to keep the DC system operational after a DC side fault.

Efficiency is an important criterion for a power converter system. In this work, the efficiency of the proposed inverter and existing work on inverter has been acquired and compared. It is recommended to do an accurate semiconductor loss calculation under fundamental frequency, PWM and other modulation schemes respectively in future work

REFERENCES

[1] M. M. C. Merlin et al., "The Alternate Arm Converter: A New Hybrid Multilevel Converter With DC-Fault Blocking Capability," in IEEE Transactions on Power Delivery, vol. 29, no. 1, pp. 310-317, Feb. 2014.

[2] R. Marquardt, "Modular Multilevel Converter topologies with DC-Short circuit current limitation," 8th International Conference on Power Electronics - ECCE Asia, Jeju, 2011, pp. 1425-1431.

[3] C. M. Franck, "HVDC Circuit Breakers: A Review Identifying Future Research Needs," in IEEE Transactions on Power Delivery, vol. 26, no. 2, pp. 998-1007, April 2011.

[4] D. Jovcic, D. van Hertem, K. Linden, J. P. Taisne and W. Grieshaber, "Feasibility of DC transmission networks," 2011 2nd IEEE PES International Conference and Exhibition on Innovative Smart Grid Technologies, Manchester, 2011, pp. 1-8.

[5] R. Marquardt, "Modular Multilevel Converter: An universal concept for HVDC-Networks and extended DC-Bus-applications," The 2010 International Power Electronics Conference - ECCE ASIA -, Sapporo, 2010, pp. 502-507.

[6] J. Yang, J. E. Fletcher and J. O'Reilly, "Multi-terminal DC wind farm collection and transmission system internal fault analysis," 2010 IEEE International Symposium on Industrial Electronics, Bari, 2010, pp. 2437-2442.

[7] S. Kraftnat, “An analysis of offshore grid connection at kriegers flak in the baltic sea,” Energinet.dk, Tech. Rep., 2009. [Online]. Available: http://www.svk.se/global/02_press_info/090507_ kriegers- flak-pre-feasibility-report-final version.pdf.

[8] B. Andersen, L. Xu, P. Horton, and P. Cartwright, “Topologies for vsc transmission,” Power Engineering Journal, vol. 16, no. 3, pp. 142-150, 2002.

[9] R. Jose, L. Jih-Sheng, and P. Fangzheng, “Multilevel inverters: A survey of topologies, controls, and applications,” IEEE Transactions on Industrial Electronics, vol. 49, no. 2, pp. 724-738, 2002.

[10] M. Bahrman and B. Johnson, “The abcs of hvdc transmission technolo¬gies,” Power and Energy Magazine, IEEE, vol. 5, no. 2, pp. 32-44, mar 2007. High-voltage direct current (HVDC) power transmission using voltage sourced converter (VSC), BSi, 2011, pD IEC/TR 62543:2011.

[11] J. Ainsworth, M. Davies, P. Fitz, K. Owen, and D. Trainer, “Static var compensator (statcom) based on single-phase chain circuit converters,” Generation, Transmission and Distribution, IEE Proceedings-, vol. 145, no. 4, pp. 381 - 386, jul 1998.

[12] A. Lesnicar and R. Marquardt, “An innovative modular multilevel converter topology suitable for a wide power range,” in Power Tech Conference Proceedings, 2003 IEEE Bologna, vol. 3, jun 2003.

[13] S. Allebrod, R. Hamerski, and R. Marquardt, “New transformerless, scalable modular multilevel converters for hvdc-transmission,” in Power Electronics Specialists Conference, 2008. PESC 2008. IEEE, jun 2008, pp. 174-179.

[14] J. Dorn, H. Huang, and D. Retzmann, “Novel voltage sourced converters for hvdc and facts applications,” in Conference proceeding CIGRE - Osaka, 2007.