IJSEAT International Journal of Science Engineering and Advance Technology

Low-Frequency Transmission for renewable sources

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Abstract

Now a day renewable energy is widely used such as wind energy and solar energy, due to their extreme abundance. So they should be properly interfaced with the power grid with suitable devices. In this paper a system of offshore wind with low-frequency ac (LFAC) transmission system which increases the power capacity and transmission distance is proposed along with a photovoltaic integration on the offshore itself results more stability in the power system. A cyclo converter is designed for the low frequency transmission and also to interface with the main power grid. The wind power plant collection system is dc based, and connects to the LFAC transmission line with a 12-pulse thyristor converter. Simulation results are observed to analysis the output voltages and currents of the two renewable sources and to illustrate the performance of the system.

Introduction

Offshore wind power plants are expected to represent a significant component of the future electric generation portfolio due to greater space availability and better wind energy potential in offshore locations. The integration of offshore wind power plants with the main power grid is a subject of ongoing research. Presently, high-voltage ac (HVAC) AND high-voltage dc (HVDC) are well established technologies for transmission.

HVAC transmission is advantageous because it is relatively straightforward to design the protection system and to change voltage levels using transformers. However, the high capacitance of submarine ac power cables leads to considerable charging current, which, in turn, reduces the active power transmission capacity and limits the transmission distance. HVAC is adopted for relatively short (up to 50–75 km) underwater transmission distances.

Two classes of HVDC systems exist, depending on the types of power-electronic devices used: 1) line-commutated converter HVDC (LCC-HVDC) using thyristors and 2) voltage-source converter HVDC (VSC-HVDC) using self-commutated devices, for example, insulated-gate bipolar transistors (IGBTs). The main advantage of HVDC technology is that it imposes essentially no limit on transmission distance due to the absence of reactive current in the transmission line. LCC-HVDC systems are capable of handling power up to 1 GW with high reliability. LCCs consume reactive power from the ac grid and introduce low-order harmonics, which inevitably results in the requirement for auxiliary equipment, such as capacitor banks, ac filters, and static synchronous compensators. On the other hand, VSC-HVDC systems are able to independently regulate active and reactive power exchanged with the onshore grid and the offshore ac collection grid.

The reduced efficiency and cost of the converters can be identified as drawbacks of VSC-HVDC systems. Power levels (typically on the order of 300–400MW) and reliability are lower than those of LCC-HVDC. HVDC is applied for distances greater than 100 km for offshore wind power transmission.

Besides HVAC and HVDC, high-voltage low-frequency ac (LFAC) transmission has been recently proposed. In LFAC systems, an intermediate-frequency level is used, which is created using a cyclo converter that lowers the grid frequency to a smaller value, typically to one-third its value. In general, the main advantage of the LFAC technology is the increase of power capacity and transmission distance for a given submarine cable compared to 50-Hz or 60-Hz HVAC. This leads to substantial cost savings due to the reduction in cabling requirements (i.e., less lines in parallel for a desired power level) and the use of normal ac breakers for protection.

In this paper, a novel LFAC transmission topology is analyzed. The proposed system differs from previous work in that the wind turbines are assumed to be interconnected with a medium-voltage (MV) dc grid, in contrast with current practice, where the use of MV ac collection grids is standard. DC collection is becoming a feasible alternative with the development of cost-effective and reliable dc circuit breakers, and studies have shown that it might be advantageous with respect to ac collection in terms of efficiency and improved production costs.

The required dc voltage level can be built by using high-power dc–dc converters and/or by the series connection of wind turbines. For example, multi-MW permanent-magnet synchronous generators with fully rated power converters (Type-4 turbines) are commonly used in offshore wind plants. By eliminating grid-side inverters, a medium-voltage dc collection system can be formed by interconnecting the rectified output of the generators. The main reason for using a dc collection system with LFAC transmission is that the wind turbines would not need to be redesigned to output low-frequency ac power, which would lead to larger, heavier, and costlier magnetic components (e.g., step-up transformers and generators). The design of the dc collection system is outside the scope of this paper.

At the sending end of the proposed LFAC system, a dc/ac 12-pulse thyristor-based inverter is used to generate low-frequency (20- or 16 2/3-Hz) ac power, as shown in Fig. 1. At the onshore substation (the receiving end), a thyristor-based cycloconverter is used as an interface between the low-frequency side and the 60- or 50-Hz onshore power grid. Thyristor-based converters can transmit more power with increased reliability and lower cost compared to VSC-HVDC systems. However, large filters are necessary at both ends to suppress low-order harmonics and to supply reactive power. Furthermore, the system can be vulnerable to main power grid disturbances.

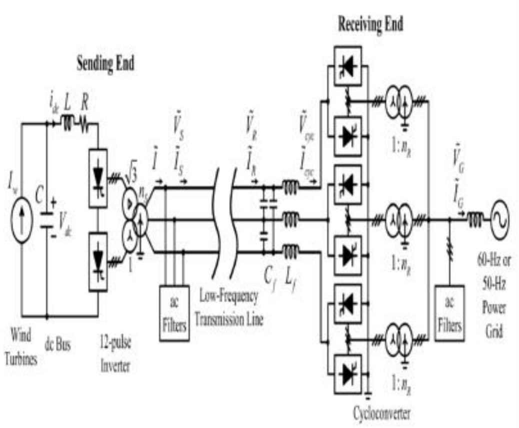

Fig. 1. Configuration of the proposed LFAC transmission system.

The proposed LFAC system could be built with commercially available power system components, such as the receiving-end transformers and submarine ac cables designed for regular power frequency. The phase-shift transformer used at the sending end could be a 60-Hz transformer derated by a factor of three, with the same rated current but only one-third of the original rated voltage. Another advantage of the proposed LFAC scheme is its feasibility for multi terminal transmission, since the design of multi terminal HVDC is complicated but the analysis of such an application is not undertaken herein. In summary, LFAC transmission could be an attractive technical solution for medium-distance transmission (i.e., in between HVAC and HVDC).

Simulation Results And Discussion

Simulation is performed by MATLAB/SIMULINK 9a version to verify the proposed solar and wind hybrid power with low frequency transmission. In this chapter simulation results of variable output results are discussed.

6.2Simulation Results:

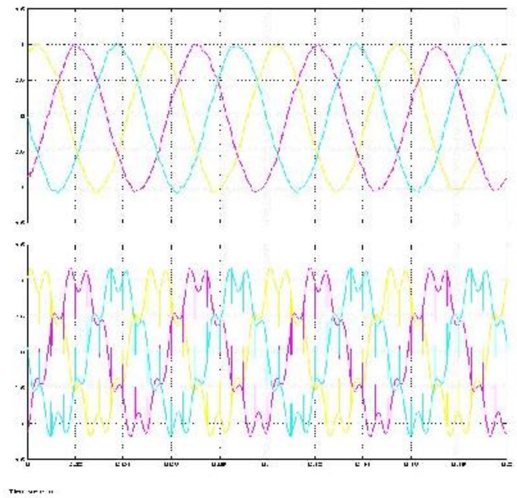

Fig 6.1 input voltage and current waveform at sending end fig 6.1 is input volatge and current wave forms in sending end side with ripple content. Figure 6.2 gives the information of voltage and current are filtered through active filters & supllied to marine cables.

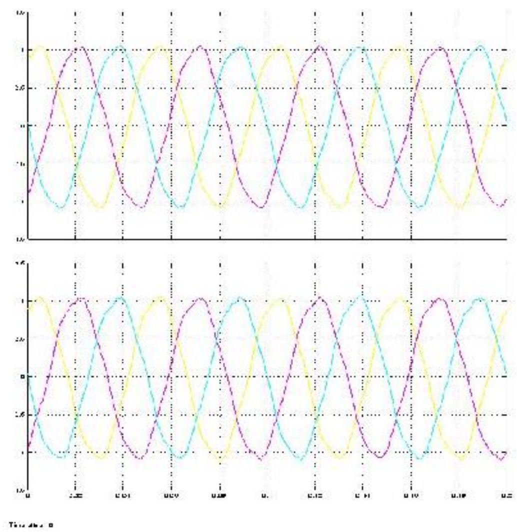

Fig 6.2 voltage and current wave forms at receiving end

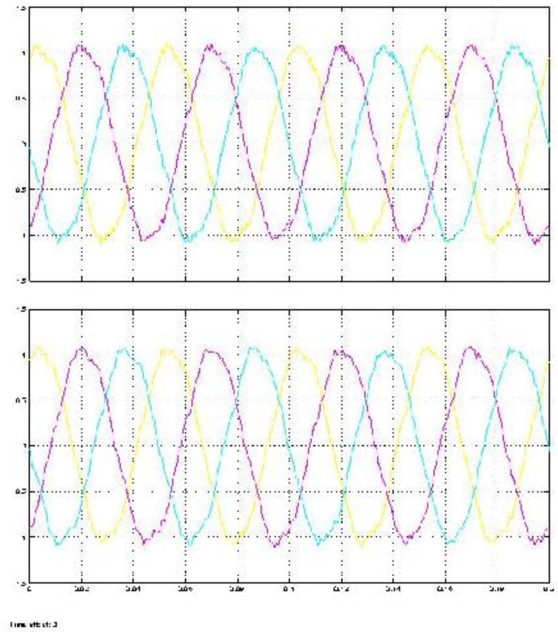

FIG 6.3input and output waveforms of cyclo converter 20Hz Fig 6.3 depicts the hormonic content at cycloconverter from available input i.e supplied from Lfac cables.

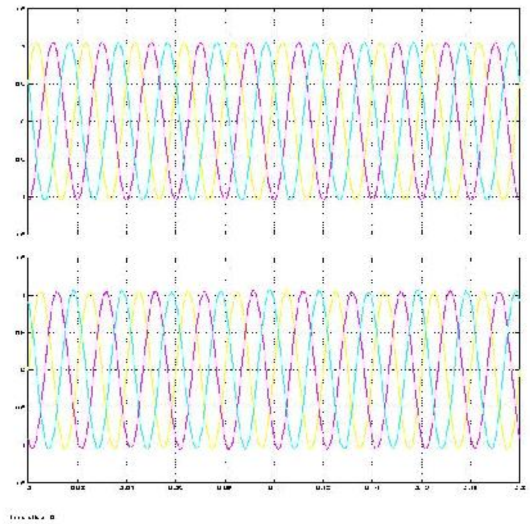

Fig 6.4 voltage and current waveforms at 60 Hz power grid

Fig 6.4 depicts the converion of 20hz frequency to 60 hz by cycloconverter and smoothning of voltage and current waveforms using active filters. And gives sinusoidal wave forms of constant magnitude.

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