IJOSTHE

ISSN: 2349-0772 | Volume 5 Issue 6 December 2018 |www.ijosthe.com

REVIEW ON CONTROL METHODOLOGIES IN HVDC TRANSMISSION SYSTEM

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ABSTRACT

Multi-terminal HVDC networks are emerging as the most promising technologies to develop such a concept. Moreover, multi-terminal HVDC grids are based on highly controllable devices, which may allow not only transmitting power, but also supporting the AC grids to ensure a secure and stable operation. This paper aims to present an overview of different control schemes for multi-terminal HVDC grids, including the control of the power converters. This paper studies the recent control strategies that have been used in wind farm based HVDC systems. A theoretical analysis of each control strategy has been provided followed by a comparison between their individual characteristic indices as well as their pros and cons.

Index Terms- High Voltage Direct Current (HVDC), Wind Farm Based Systems, Control Strategies, Voltage Source Converter (VSC).

I. INTRODUCTION

Recently, Renewable energy sources are gaining more attention because of no dissipations of any fossil fuel and no emission [1-2]. One of them is the wind power, which has become a major source of renewable energy and has been widely implemented with good results [3-4]. It’s said that the total capacity of offshore wind power plants in china have been rapidly expanding that has exceeded 1000MW per plant [5-6].

Generally offshore wind farms are located far away from the onshore grid connection point [7], which makes (HVdc) links a good option over (HVac) links because they present lower losses and can be used in submarine connections [8][9]. Generally in our power systems, AC transmission systems are used but in the recent years, the importance of HVDC transmission systems is also increasing [10]. HVDC transmission systems have many merits as compared to the conventional AC transmission systems like [11-14]

The components of an HVDC transmission system To assist the designers of transmission systems, the components that comprise the HVDC system, and the options available in these components, are presented and discussed. The three main elements of an HVDC system are: the converter station at the transmission and receiving ends, the transmission medium, and the electrodes.

1.1 The Converter Station

The converter stations at each end are replica’s of each other and therefore consists of all the needed equipment for going from AC to DC or vice versa. The main component of a converter station are:

Thyristor valves: The thyristor valves can be build-up in different ways depending on the application and manufacturer. However, the most common way of arranging the thyristor valves is in a twelve-pulse group with three quadruple valves. Each single thyristor valve consists of a certain amount of series connected thyristors with their auxiliary circuits. All communication between the control equipment at earth potential and each thyristor at high potential, is done with fibre optics.

VSC valves: The VSC converter consists of two level or multilevel converter, phase-reactors and AC filters. Each single valve in the converter bridge is built up with a certain number of series connected IGBTs together with their auxiliary electronics. VSC valves, control equipment and cooling equipment

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would be in enclosures (such as standard shipping containers) which make transport and installation very easy. All modern HVDC valves are water-cooled and air insulated

Transformers: The converter transformers adapt the AC voltage level to the DC voltage level and they contribute to the commutation reactance. Usually they are of the single phase three winding type, but depending on the transportation requirements and the rated power, they can be arranged in other ways

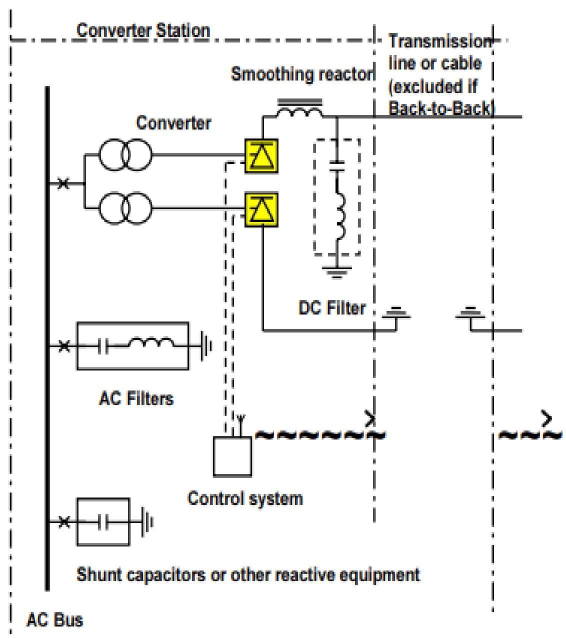

Fig 1: components in HVDC system

AC Filters and Capacitor Banks: On the AC side of a 12-pulse HVDC converter, current harmonics of the order of 11, 13, 23, 25 and higher are generated. Filters are installed in order to limit the amount of harmonics to the level required by the network. In the conversion process the converter consumes reactive power which is compensated in part by the filter banks and the rest by capacitor banks. In the case of the CCC the reactive power is compensated by the series capacitors installed in series between the converter valves and the converter transformer.

The elimination of switched reactive power compensation equipment simplify the AC switchyard and minimise the number of circuit-breakers needed, which will reduce the area required for an HVDC station built with CCC. With VSC converters there is no need to compensate any reactive power consumed by the converter itself and the current harmonics on the AC side are related directly to the PWM frequency. Therefore the amount of filters in this type of converters is reduced dramatically compared with natural commutated converters

DC filters: HVDC converters create harmonics in all operational modes. Such harmonics can create disturbances in telecommunication systems. Therefore, specially designed DC filters are used in order to reduce the disturbances. Usually no filters are needed for pure cable transmissions as well as for the Back-to-Back HVDC stations. However, it is necessary to install DC filters if an OH line is used in part or all the transmission system The filters needed to take care of the harmonics generated on the DC end, are usually considerably smaller and less expensive than the filters on the AC side. The modern DC filters are the Active DC filters. In these filters the passive part is reduced to a minimum and modern power electronics is used to measure, invert and re-inject the harmonics, thus rendering the filtering very effective

1.2 India's Offshore Wind Potential

India is blessed with coastline of about 7600 Km. In India - onshore wind energy deployment has crossed 19600 MW - attracted $16.5 billion of investment in 2012, created 179,000 'green collar' jobs in manufacturing, project development, installation, operation, maintenance, consulting etc., saving 131 million tons CO2/year. Estimated that by 2030, installed capacity could reach 191 GW. • Centre for Wind Energy Technology has reassessed India's on shore wind power potential as 102,778 MW (at 80 metres height and 2% land availability).
Globally installations have reached over 5,000 MW (Europe : 4995 MW followed by China: 390 MW and Japan: 25 MW).

Preliminary studies by C-WET and Indian National Centre for Ocean Information Services (INCOIS), Hyderabad suggest potential along Tamil Nadu, Gujarat and Maharashtra coasts. Going by the success of demonstration on-shore wind power project, MNRE has decided to go for a demonstration offshore wind power project. Some sites were identified along the Gujarat and Tamil Nadu coast which have good wind power potential. Since GPCL had shown interest, Gujarat was chosen as the demonstration venue. The project will be of about 100 MW capacity. The JVC will undertake detailed feasibility study based on the inputs received from pre-feasibility studies and necessary steps for implementing the project.

II. LITERATURE SURVEY

[1] In this paper The technical status, cost, and applications of major renewable energy technologies and implications for increased adoption of renewable will be reviewed. Wind, solar biomass, and geothermal technologies are cost-effective today in an increasing number of markets, and are making important steps to broader commercialization. Each of the renewable energy technologies is in a different stage of research, development, and commercialization, and all have differences in current and future expected costs, current industrial base, resource availability, and potential impact on greenhouse gas emissions.

[4] This paper gives an overview and discusses some development trends in the technologies used for wind power systems. First, the developments of technology and market are generally discussed. Next, several state-of-the-art wind turbine concepts, as well as the corresponding power electronic converters and control structures, are reviewed, respectively. Furthermore, grid requirements and the technology challenges for the future WTS are also addressed.

[5] A linear piezoelectric step motor (LPS) driver using a current source inverter is proposed in this study. The mechanism of operation of an LPS motor is first described. Then, a single-phase equivalent model of the LPS motor is introduced. A detailed theory of the driving circuit design using current source inverter for the LPS motor is explained. At the end the simulation and experimental results are presented and compared.

[6] A new kind of three-phase multilevel CSI topology is presented in this paper. The new multilevel CSI's synthesize the staircase current wave from several levels of balance inductor currents. The switching strategy that can ensure equal current division among the branches and current harmonics reduction is presented. A three-phase 6-level CSI and a three-phase CSI using the new topology are discussed by the simulations. An experimental prototype of a three-phase 6-level CSI has been built to practise the proposition in the paper.

[7] In this paper, a zero-current switching (ZCS) current source converter (CSC) topology is proposed by adding an auxiliary circuit between the dc side. During each commutating process, the auxiliary circuit is activated, so that the outgoing switches can be turned off with zero current switching. As a result, all active switches can reach ZCS operations. This feature makes it possible to increase the switching frequency to improve the line current quality where a small size of ac filter is required. That means the presented ZCS CSC topology is very suitable for some applications with high PWM frequency. Simulation gives the verification

III. METHODOLOGIES SURVEYED

3.1 Hierarchical control structure in MT-HVDC networks

A generic representation of a MT-HVDC network consisting of N stations is sketched in Fig. 1. At each terminal, a VSC connects the HVDC grid with an AC grid. Some of these grids inject power into the multi-terminal grid and others extract power. The first group includes for instance WPPs and the second main shore networks.

The main purpose of a multi-terminal network is to share power among the AC grids. To fulfil this objective, one or more VSC must regulate the DC voltage at every terminal j. Since MTHVDC networks are systems based on power electronics (which provide high controllability), there is also an increasing interest in MT-HVDC networks providing additional services for improving stability of main

AC grids; such as frequency support, damping power oscillations, among others.

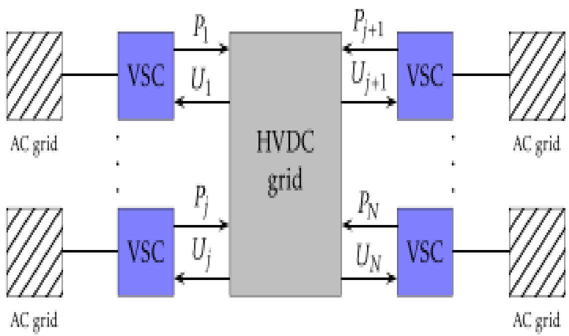

Fig. 2. Representation of a generic MT-HVDC network.

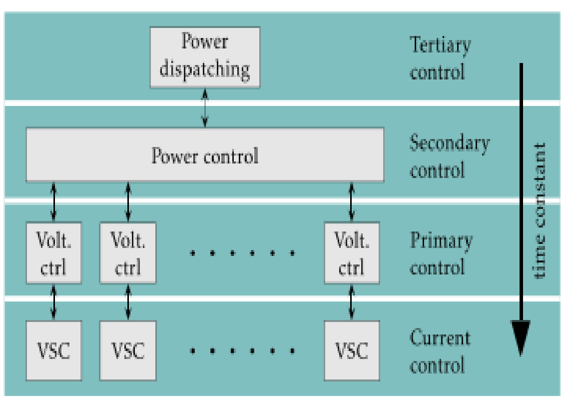

Fig. 3. Hierarchical control structure for MT-HVDC networks.

3.2 Margin voltage control

The margin voltage control scheme has been proposed to improve reliability by sharing the responsibility for regulating the voltage among two or more terminals. Basically, this configuration is a master–slave scheme with back-up stations capable of taking over the voltage regulation in case of outage of the master.

In normal operation, VSC1 is the master terminal and the rest of the stations are slaves working in constant power mode. Thus, the master station maintains the DC voltage at the set-point Un 1 and the back-up station VSC2 works in constant power mode with set-point in P2. In case of an outage of station 1 or reaching its power limits, the DC voltage starts to rise. When the voltage reaches the level Un 2, the converter in terminal 2 leaves the constant power mode and starts the regulation of the DC voltage. In order that this configuration can properly work without communications, the main master station (used in normal operation) must have a lower voltage set-point and the last back-up terminal must be the one with higher voltage set-point

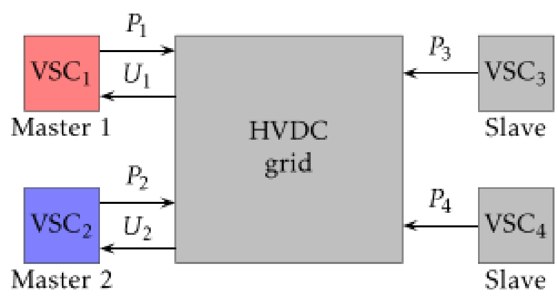

Fig. 4. Example of a voltage margin control strategy

3.4 Fuzzy Logic based Adaptive Droop Control

This method combines fuzzy logic control with fixed droop control strategy with the objective of reducing voltage deviation in the system. For a Multi-Terminal HVDC (MTDC) system with Modular Multi-level Converters (MMC) csn be considered.

IV.PROPOSED OBJEVTIVE

Intended to work on wind energy system the simulated model has be implemented firstly in MATLAB/SIMULINK environment. The work can be further enhanced by using various topologies and its control strategies while using a CSC. The MPPT algorithm can further be implemented to enhance its power output efficiency.

Further we can use the control system proposed to be implemented with a hybrid system while improving the reliability of the system

V. CONCLUSION

Power transmission systems based on MT-HVDC technologies are foreseen as one of the key elements in future power systems including offshore grids. As each station is equipped with electronic interfaces, the behaviour of MT-HVDC networks is dominated by the control strategies. In general, the control in MTHVDC grid involves several levels, each one with a particular goal. The power sharing among stations is mainly governed by the primary control level. This level is, in general, a decentralised control scheme in order to ensure a proper operation even under communication faults.

The control strategies for power oscillation damping are focussed on the regulation of the active power in the AC side without significantly affecting the DC grid stability. The use of reactive power for damping oscillations, as proposed for other power electronic based technologies (e.g., FACTS or wind power), as well as the impact of power converter loading, has not been extensively analyzed in the literature.

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