Improved Converter Design for Ac–Dc Harmonic Immunity in VSC HVDC Transmission

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Abstract: This paper provided a most effective technique to scale back the harmonics contents within the HVDC transmission by up the electrical converter topology through Selective Harmonic Elimination Technique. management strategies supported selective harmonic elimination pulse-width modulation (SHE-PWM) techniques provide the bottom attainable range of change transitions. This feature additionally ends up in the bottom attainable level of device change losses. For this reason, they're terribly engaging techniques for the voltage-source-converter-(VSC) primarily based high-voltage dc (HVDC) power transmission systems. The paper discusses optimized modulation patterns which supply controlled harmonic immunity between the ac and dc facet. The application focuses on the traditional two-level convertor once its dc-link voltage contains a combination of low-frequency harmonic parts. Simulation and experimental results area unit conferred to verify the validity of the planned change patterns. Finally a 5 level Multi 8level convertor topology is applied for this application.

Keywords- Amplitude modulation (AM), dc-ac power conversion, harmonic control, HVDC, insulated-gate bipolar transistor (IGBT), power electronics, power transmission system, pulse-width modulation, voltage-source converter (VSC).

I.INTRODUCTION

The conception of construction inverters, introduced concerning twenty years agone entails activity power conversion in multiple voltage steps to get improved power quality, lower shift losses, higher magnetism compatibility, and better voltage capability. the advantages are particularly clear for medium-voltage drives in industrial applications and are being thought of for future military service ship propulsion systems. many topologies for construction inverters are projected over the years; the foremost fashionable cascaded H-bridge excluding alternative construction inverters is that the capability of utilizing totally different dc voltages on the individual H-bridge cells which ends up in ripping the facility conversion amongst higher-voltage lower-frequency and lower-voltage higher-frequency inverters. The utility trade faces continuous pressure to transform the approach the electricity grid is managed and operated. On one hand, the variety of provide aims to increase the energy combine and accommodate a lot of and various property energy sources. On the opposite hand, there is a clear ought to improve the potency, dependability, energy security, and quality of provide. With the breadth of advantages that the sensible grid will deliver, the enhancements in technology capabilities, and therefore the reduction in technology cost, investing in smart grid technologies has become a serious focus for utilities.

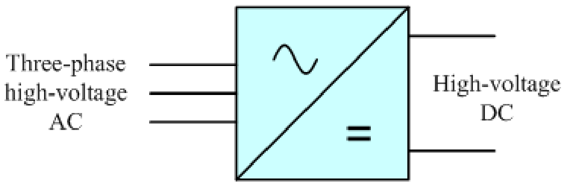

Fig.1. Symbol for HVDC converter

Advanced technologies, like versatile electrical energy transmission (FACTS) and voltage-source device (VSC)-based high-voltage dc (HVDC) power transmission systems, ar essential for the restructuring of the ability systems into additional automatic, electronically controlled sensible grids. an summary of the recent advances of HVDC supported VSC technologies is obtainable in [1]. The foremost necessary management and modelling ways of VSC-based HVDC systems and also the list of existing installations are on the market in [1].

The primary generation of utility power devices is predicated on current-source converter (CSC) topologies [2], [3]. Today, several comes still use CSCs owing to their ultra-high power capabilities. With the invention of absolutely controlled power semiconductors, like insulated-gate bipolar transistors (IGBTs) and integrated gate-commutated thyristors (IGCTs), the VSC topologies are additional enticing owing to their four-quadrant power-flow characteristics. A typical configuration of the VSC-based HVDC power transmission is shown in Fig. 1 because it is shown in [7] .

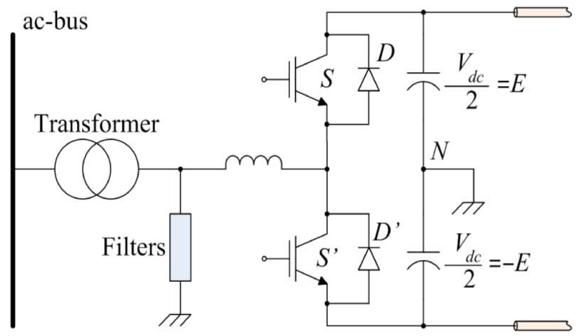

Fig. 2. Phase of the two-level VSC for the HVDC power transmission system.

With the advancement of power physics and emergence of latest structure convertor topologies, it's attainable to figure at voltage levels on the far side the classic semiconductor limits. The structure converters attain high-voltage shift by suggests that of a series of voltage steps, every of that lies at intervals the ratings of the individual power devices. Among the structure Converters, the cascaded H-bridge topology (CHB) is especially enticing in high-voltage applications, as a result of it needs the smallest amount range of elements to synthesize a similar range of voltage levels. in addition, because of its standard structure, the hardware implementation is quite easy and therefore the maintenance operation is simpler than different structure converters.

The structure voltage supply electrical converter is recently applied in several industrial applications like ac power provides, static volt-ampere compensators, drive systems, etc. one in every of the many benefits of structure configuration is that the harmonic reduction within the output wave shape while not increasing switching frequency or decreasing the electrical converter power output. The output voltage wave form of a structure electrical converter consists of the quantity of levels of voltages, generally obtained from capacitance voltage sources.

The supposed structure starts from 3 levels. because the variety of levels reach infinity, the output doctorate approaches zero. the quantity of the possible voltage levels, however, is restricted by voltage unbalance issues voltage clamping demand, circuit layout, and packaging constraints. On the opposite hand, optimized modulation strategies supply several benefits toward tight management of converter-generated harmonics. A step-down methodology to seek out the whole set of solutions by determination the SHE-PWM equations for two-level inverters is mentioned . during this paper, the dc-link voltage is assumed to be constant. In [10], a technique is projected to forestall the dc-link ripple voltage from making low-order harmonics on the ac aspect of fastened and variable frequency inverters. However, only 1 of the multiple SHE-PWM sets of solutions is rumoured. AN investigation of the harmonic interaction between the ac and dc aspect for STATCOM is given as well as the alleged dynamic SHE-PWM theme supported pre calculated angles for higher doctorate.

However, the dynamic SHE-PWM theme is applied just for a three-level convertor and might be applied just for identified magnitude and frequency of the ripple. Another methodology for rising the harmonic performance of a two-level VSC with SHE-PWM is studied in [9]. However, only 1 set of SHE-PWM solutions is taken into account for the strategy of [10] which needs the precise values of magnitude, phase, and frequency of the ripple so as to be implemented.

Control methodology to compensate unbalances is reported in the literature. Mild imbalances caused by unbalanced loads of the ac side are regulated by using separate control loops for the positive- and negative-sequence components of the voltage as proposed in [8]. Efficient control of unbalanced compensator currents can be achieved by a control algorithm based on the D-STATCOM model. D-STATCOM allows separate control of positive- and negative-sequence currents and decoupled current control of the d-q frame. An advanced strategy based on direct power control under unbalanced grid voltage conditions has been recently presented for a doubly fed induction generator.

To take the full advantages of VSCs for HVDC power transmission systems, an auxiliary controller is added to the main controller which is conventionally implemented in the positive-sequence d-q frame. To compensate for unbalanced ac-side loads, the auxiliary controller is implemented in the negative-sequence d-q frame.

The objective of this paper is to debate the effectiveness of optimized modulation supported precalculated SHE-PWM during a two-level three-phase VSC to create the ac facet immune from the fluctuations of the dc link while not the utilization of passive elements. However, since the VSC studied here doesn't embody a closed-loop controller, ways to compensate unbalances are not addressed during this paper.

This paper is organized within the following approach. In Section II, a short analysis of the VSC and therefore the modulation methodology is provided. Section III contains the characteristics of the tactic on a VSC with dc-side ripple voltage. Section IV provides in depth experimental results to support the theoretical arguments. Conclusions are explained in Section V.

II. ANALYSIS OF THE PWM CONVERTER & SHE-PWM

The optimized SHE-PWM technique is investigated on a two level three-phase VSC topology with IGBT technology, shown in Fig. 2. A typical periodic two-level SHE-PWM waveform is shown in Fig. 3. The waveforms of the line-to-neutral voltages can be expressed as follows:

$$V_{LN} = \begin{bmatrix} V_{AN} \\ V_{BN} \\ V_{CN} \end{bmatrix} = V_{dc} \begin{bmatrix} \sum_{n=1}^{\infty} A_n \sin n\omega_0 t \\ \sum_{n=1}^{\infty} A_n \sin n\left(\omega_0 t - \frac{2\pi}{3}\right) \\ \sum_{n=1}^{\infty} A_n \sin n\left(\omega_0 t + \frac{2\pi}{3}\right) \end{bmatrix} \quad (1)$$

When ω_0 is the operating frequency of the ac, and V_{dc} is the dc-link voltage.

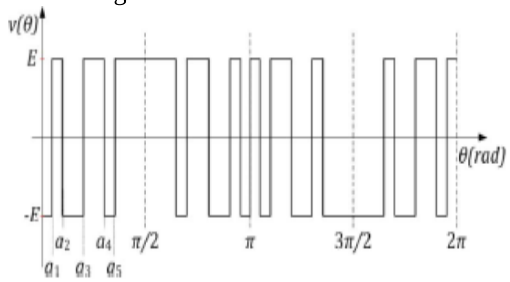

Fig. 3. Typical two-level PWM switching waveform with five angles per quarter cycle.

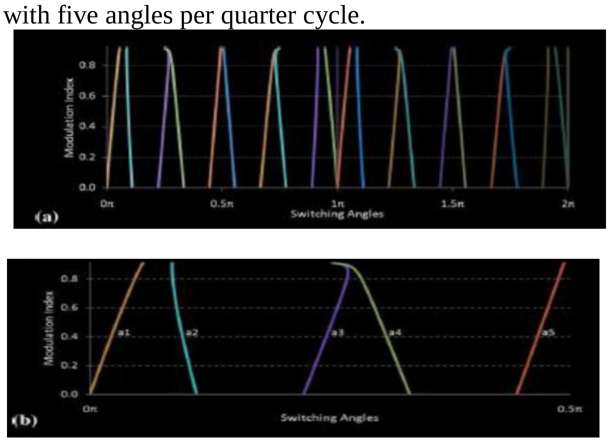

Fig. 4. Solution trajectories. (a) Per-unit modulation index over a complete periodic cycle. (b) Five angles in radians.

Thus, the line-to-line voltages are given by

$$V_{LL} = \begin{bmatrix} V_{AB} \\ V_{BC} \\ V_{CA} \end{bmatrix} = \sqrt{3}.V_{dc} \begin{bmatrix} \sum_{n=1}^{\infty} A_n \sin n\left(\omega_0 t + \frac{\pi}{6}\right) \\ \sum_{n=1}^{\infty} A_n \sin n\left(\omega_0 t - \frac{\pi}{2}\right) \\ \sum_{n=1}^{\infty} A_n \sin n\left(\omega_0 t + \frac{5\pi}{6}\right) \end{bmatrix} \quad (2)$$

The SHE-PWM method offers numerical solutions which are calculated through the Fourier series expansion of the waveform.

$$M=1 + 2 \sum_{i=1,2,3\ldots}^{N+1} (-1)^i \cos(\alpha_i)$$

$$0=1 + 2 \sum_{i=1,2,3\ldots}^{N+1} (-1)^i \cos(k\alpha_i)$$

Where N+1 are the angles that require to be found. mistreatment 5 switch angles per quarter-wave in (N=4) SHE-PWM, k= 5, 7, 11, thirteen to eliminate the fifth, 7th, 11th,and thirteenth harmonics. throughout the case of a balanced load, the third and every one different harmonics that are multiples of 3 square measure off, owing to the 120 symmetry of the switch perform of the three-phase device. The even harmonics are cancelled attributable to the half-wave quarter-wave symmetry of the angles, being affected by

$$0 < \alpha_1 < \alpha_2 \ldots\ldots\ldots\ldots < \alpha_{N+1} < \pi/2$$

III.FULL H-BRIDGE

Fig.6 shows the Full H-Bridge Configuration. By using single H-Bridge we can get 3 voltage levels. The number output voltage levels of cascaded Full H-Bridge are given by 2n+1 and voltage step of each level is given by Vdc/n. Where n is number of H-bridges connected in cascaded. The switching table is given in Table 1 and 2.

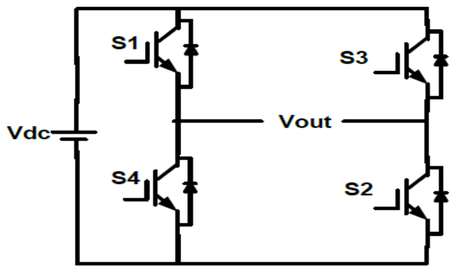

Fig. 5 Full H-Bridge

Table 1. Switching table for H-Bridge

Switches Turn ON	Voltage Level
S1,S2	Vdc
S3,S4	-Vdc
S4,D2	0

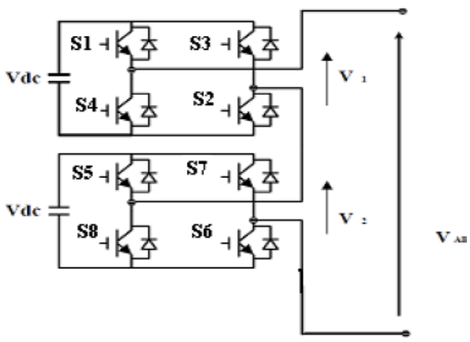

Table 2. Switching table for Cascaded H-Bridge

Switches Turn on	Voltage Level
S1, S2	Vdc
S1, S2, S5, S6	2Vdc
S4, D2, S8, D6	0
S3, S4	-Vdc
S3, S4, S7, S8	-2Vdc

This is also termed as the optimized PWM technique. By reversing the phase voltages a few times during each half cycle, it is possible to eliminate lower order harmonics selectively. However, the higher order harmonics may increase in magnitudes, but the current harmonics are not significantly affected due to low pass filter characteristics of the AC system. The voltage reversals are affected at chosen instants such that the notches (caused by the voltage reversals) are placed symmetrically about the centre line of each half cycle.

IV. CONCLUSIONS

This paper presents Novel Hybrid H-Bridge multilevel converter. The proposed converter produces more voltage levels with less number of switches compared to H- bridge configuration. In this paper, recent advances of the VSC-HVDC technology are presented. This will reduce number of gate drivers and protection circuits which in turn reduces the cost and complexity of the circuit. Finally a five level single H-bridge is proposed.

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