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Application of SHE-PWM for Harmonic Immunity in VSC HVDC Transmission

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ABSTRACT:

Control methods based on selective harmonic elimination pulse-width modulation (SHE-PWM) techniques offer the lowest possible number of switching transitions. This feature also results in the lowest possible level of converter switching losses. For this reason, they are very attractive techniques for the voltage-source-converter-(VSC) based high-voltage dc (HVDC) power transmission systems. The paper discusses optimized modulation patterns which offer controlled harmonic immunity between the ac and dc side. The application focuses on the conventional two-level converter when its dc-link voltage contains a mix of low-frequency harmonic components. Simulation and experimental results are presented to confirm the validity of the proposed switching patterns.

INDEX TERMS:
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).

INTRODUCTION:

For the last ten years or so, the level and size of capability of power handling of the VSCs has improved considerably and had reached innovative heights for usefulness applications. As the interface among the ac and dc methods raises and the power treatment ability of these converters rises, it is significant to advance appreciate and learn the possessions of current and voltage harmonics on the design of converter and function and performance of system.

Any procedures for minimizing or even for eliminating such avoidable flow of harmonics between the two modules (i.e., the dc and ac) are valuable. For example, an advance that decides the spectrum of harmonic of the bus currents of VSC offered. For a 2-level 3-phase VSC, a common method for evaluating the currents of dc-bus for disturbed, balanced, nonlinear, and linear loads is explained. Traditions for selecting the suitable dc capacitor for VSCs and voltage-stiff-inverters are examined correspondingly.

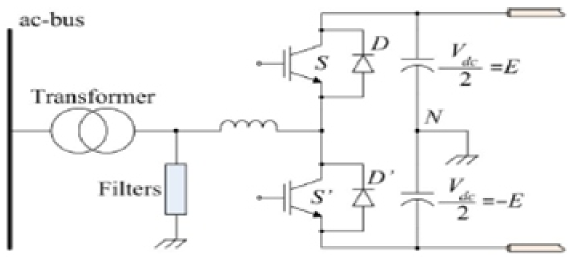

Fig.1 Phase of the two-level VSC for the HVDC

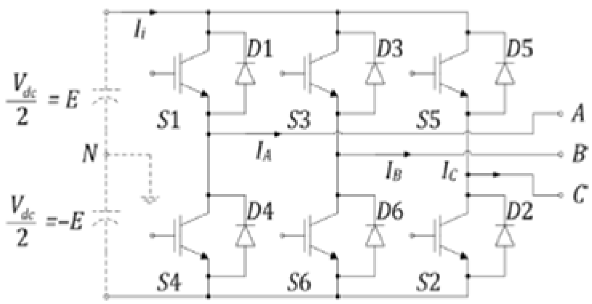

Fig.2 Three-phase two-level VSC

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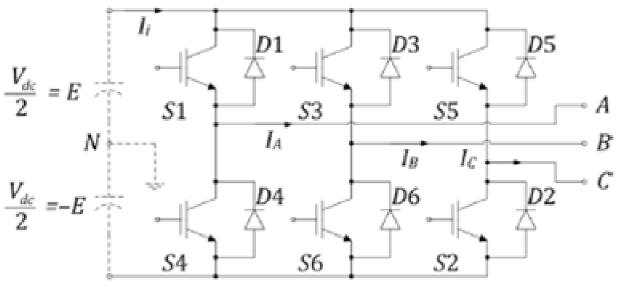

Fig.3 Three-phase two-level VSC

POWER SYSTEM CONTROL:

Known the power system difficulty and its active phenomenon, one should anticipate that diverse controls had been urbanized above moment to control diverse phenomenon. These expansions have followed the accessibility of allowing hardware technology such as communications, microprocessors and electronics in addition to the advancement of control methodology.

Power System Protection:

From the extremely establishment there was the requirement of shielding electrical apparatus from flaming up owing to the short circuit. From the retiring blend to present day's microprocessor based protection gear, relay and methodology have advanced to the position where shielding might be seemed ahead as a quick technique for controlling. If an error occurs, the equipment which is faulted is needed to be separated. A short circuit is distinguished by very small voltages and extremely large currents, such can be noticed and the error apparatus recognized. When the error lies on a shunt element, similar to a distribution feeder or a generation, the relay will separate it by breaching the linking circuit breakers. When the fault lied on a series element, similar to a transformer or transmission line, the both sides breakers have to be unlocked to separate it. The major distinguishing of the safeguarding network is that it functions rapidly, frequently in tens of milliseconds, in order to protect the apparatus from failure.

Novel Technologies:

Basically, there are three classes of technologies that are appropriate:

» Cheaper and faster computers,

» Broad-band, cheap communications, and

» Improved controls of power electronics (in addition called as FACTS -which wraps this group of knowledge specially urbanized for controlling the AC-power network).

What we are suggesting at this time is the expansion of new controls exploiting a mixture of these skills. These controls should be considerably dissimilar in theory than the accessible ones, and may be quick and network-wide to considerably raise constancy limits.

NEW CONTROLS:

The projected control theory portrayed here are all wide-region manages. Though limited controls persist to be enhanced by means of newer methods, the theoretical functionality of these limited controls will stay the similar. The wide-region controls offered here will frequently take concern of the limited controllers but the chief purpose is to progress the general constancy of the power system. The theories are accessible in the sort of rising difficulty, in addition implying that the ones offered primary can be easier for implementing.

Transmission control of power flow:

The majority power systems contain free flowing lines of transmission. It means that even though power insertions and node voltages are restricted pretty narrowly, the flow of power on each transmission line is generally not restricted. Though, such control is practicable. A transformer of phase shifting be able to control the flow of power across it by altering the phase by means of taps. The control is discrete, slow and local. A power electronic description of this is currently beneath Experimentation. Stream over DC lines of transmission is constantly restricted and the control is very rapid. The numeral of DC lines is simply furnished.

Voltage Control:

As is stated prior to, one method to manage node voltages is through changing the excitation of the generators rotating. This is finished by a feedback controlling loop that alters the excitation current in the generator for maintaining a scrupulous node voltage. This method is very quick. One more method for controlling node voltage is to modify the setting tap of a transformer linked to the node.

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Additional methods are to control shunt reactors or capacitors at the nodes. These variations might be finished physically by automatically or the operator by executing a feedback network that wits the node voltage and stimulates the control. Contrasting the excitation control of generator, taps of Transformer and shunt reactance's can merely be distorted in distinct quantities. Frequently this kind of controlling methods has time delays build into them for avoiding unnecessary controlling events.Further in recent times controlling devices for power electronics had been initiated in the schemes of voltage control for shunt reactance. This creates the control a lot further constant and frequently is finished it in a much quicker time frame than the standard shunt controlling. This Static Var Controllers (SVC) is flattering more widespread.

Frequency Control:

As illustrated earlier, complementary load through generation controls the frequency. The prime control of governor at the generators is confined whereas the secondary AGC control so as to alter the governor set points is region-wide. The prime control is constant where the secondary control is distinct typically with 2-4 second casing. Known that all the generators in a section are never longer possessed by the equivalent association, this region wide AGC control will turn into further decentralized.

Control of Voltage stability:

Instability of Voltage results while a alteration in the power system creates a working condition that is lacking in support of reactive power. Protecting adjacent to such instability needs the expectation of such possibilities that may result instability of voltage and captivating protective accomplishment. New protective schemes of control are desired that may too contain particular safeguarding methods that might separate those regions with var shortages. This is not a control for stability in the conventional logic that reacts to an interruption. This is an accomplishment arrangement to make sure that the network operating state does not drift into a region wherever a perturbation can create instability of voltage.

Transient stability control:

The growth of such a control method is through distant the mainly complex since an interruption that might create instability can simply be controlled if a considerable sum of calculation (study) and communication can be skilled really quickly. This notion is advanced in three progressively more complex levels:

» The foremost is to employ off-line studies to physically regulate protecting schemes which should control barely if the interruption occurs;
» The succeeding is to mechanically correct these protecting schemes with calculations of on-line;
» The final could be to openly activate the controlling measures past the occurrence of an interruption.

Soft-wired' remedial action schemes:

A pace progress in this course will be to oversimplify remedial action schemes (RAS), as well recognized as particular protective systems, for controlling stability of transient. These RAS now are urbanized from the consequences of large off-line studies and are applied with a 'hard-wired' statement network. Therefore, the network statuses and values observed and the controlled breakers cannot be personalized. What planned here is the expansion of a comprehensive system of communication that may allow the execution of fresh corrective schemes of action by software alteration.

DISTRIBUTION STATIC COMPENSATOR (DSTATCOM):

In distribution systems, reactive power is the major reason for rising losses in distribution system and diverse problems of power quality. Conservatively, Static Var Compensators (SVCs) had been worn in combination with reactive filters at the level of distribution for reactive power reparation and power quality problems mitigation. Even if SVCs are awfully efficient system regulators used for providing compensation of reactive power at the level of transmission, their narrow bandwidth, higher reactive element tally that raises losses and size, and time-consuming response create them unfit for the existing day requirement for distribution.

SIMULATION RESULTS
SIMULATION DIAGRAM FOR SHE-PWM ELIMINATING HARMONICS:

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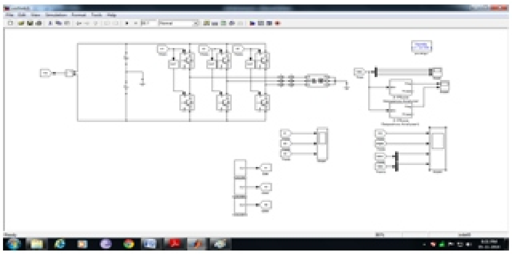

Fig. 4 Simulation diagram for SHE-PWM eliminating harmonics.

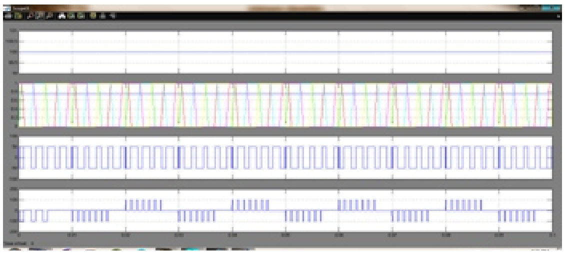

Fig. 5 Simulation results for SHE-PWM eliminating 5th, 7th, 11th, and 13th harmonics. (a) DC-link voltage. (b) Solution trajectories to eliminate harmonicsand intersection points with the modulating signal (M=0.75). (c) Line-to-neutral voltage. (d) Line-to-line voltage.

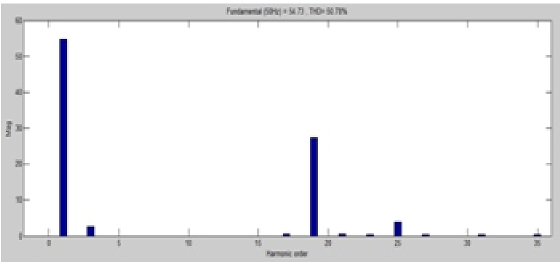

Fig. 6 Positive sequence line-to-line voltage spectra

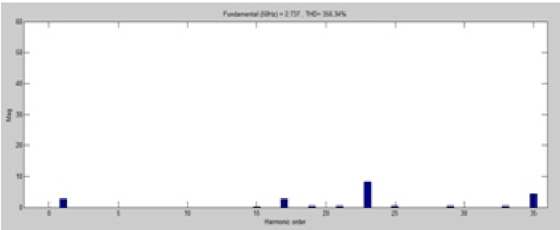

Fig.7 negative-sequence line-to-line voltage spectra

SIMULATION DIAGRAM FOR CONVENTIONAL SHE-PWM RIPPLE OF HARMONIC AT THE DC BUS (WITHOUT THE REPOSITIONING TECHNIQUE):

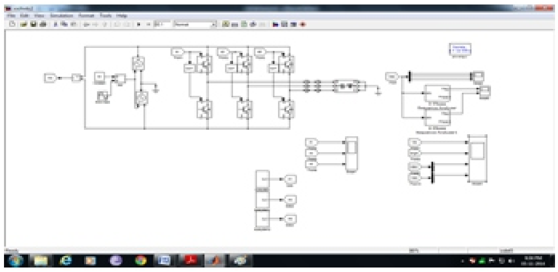

Fig. 8 Simulation diagram for conventional SHE-PWM with 10% ripple of 2nd harmonic at the dc bus (without the repositioning technique).

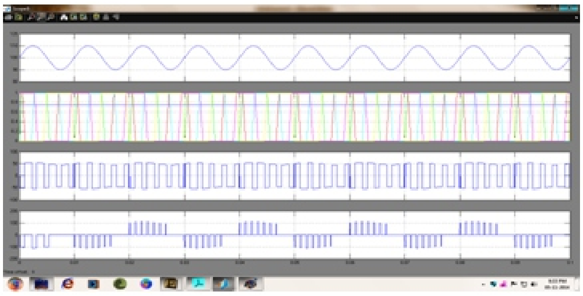

Fig. 9 Simulation results for conventional SHE-PWM with 10% ripple of 2nd harmonic at the dc bus (without the repositioning technique). (a) DC-link voltage with 10% ripple. (b) Solution trajectories to eliminate harmonics and intersection points with the modulating signal (M=0.75). (c) Line-to-neutral voltage. (d) Line-to-line voltage.

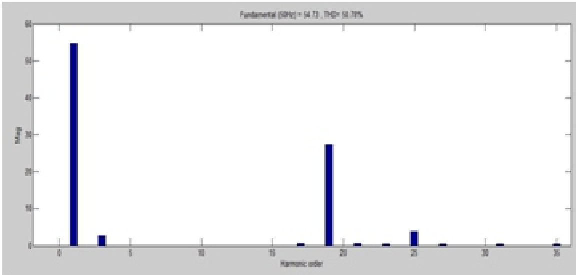

Fig. 10 Positive sequence line-to-line voltage spectra

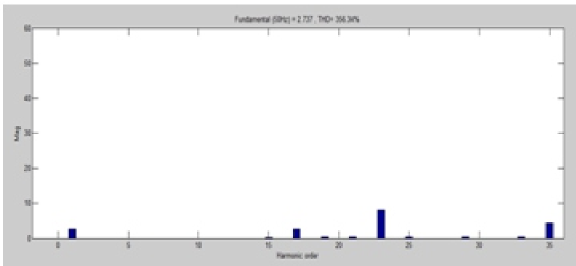

Fig.11 negative-sequence line-to-line voltage spectra

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SIMULATION DIAGRAM FOR RIPPLE OF THE HARMONIC AT THE DC BUS BY USING THE REPOSITIONING TECHNIQUE:

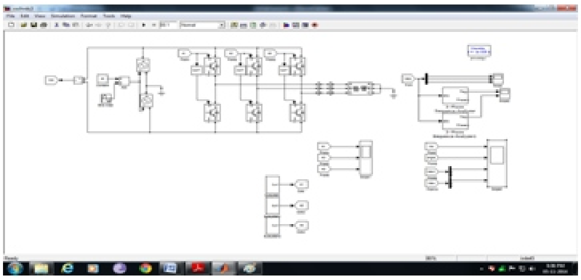

Fig.12 Simulation diagram for ripple of the harmonic at the dc bus by using the repositioning technique.

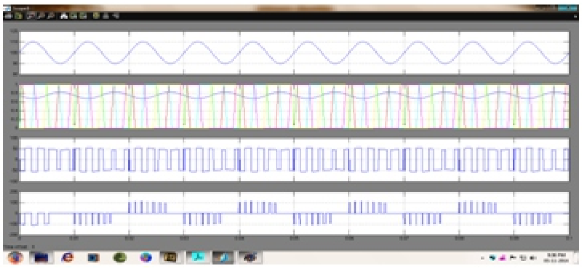

Fig. 13 Simulation results for 10% ripple of the 2nd harmonic at the dc bus by using the repositioning technique.
(a) DC-link voltage with 10% ripples. (b) Modified modulating function and its intersection with the solution trajectories. (c) Line-to-neutral voltage. (d) Line-to-line voltage.

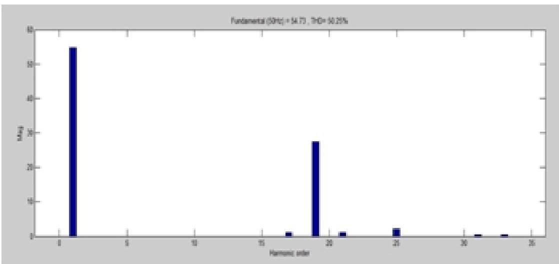

Fig. 14 Positive sequence line-to-line voltage spectra

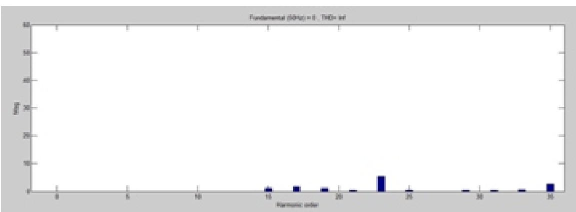

Fig.15 negative-sequence line-to-line voltage spectra

CONCLUSION:

An optimized SHE-PWM technique, which offers immunity between the ac and dc side in a two-level three-phase VSC, is discussed in this project. The technique is highly significant in HVDCs due to the elimination of every low-order harmonic of the ac side produced by the dc-link ripple voltage. The dc-link ripple repositioning technique regulates the magnitude of the fundamental component and eliminates the low-order harmonics of the ac side even when the dc bus voltage fluctuates.

This is an online method which can be applied for eliminating any low-order harmonic frequency regardless of amplitude or phase shift of the ripple. There are some limitations related to the maximum modulation index available for SHE-PWM angles.The repositioning technique also causes a reflection with respect to the midpoint between the fundamental component and the first significant harmonic. There are cases where the technique is not beneficial. On the other hand, it eliminates all low-order ac-side harmonics for every dc-bus ripple voltage of frequency below the midpoint harmonic.

FUTURE WORK:

As the interface among the ac and dc methods raises and the power treatment ability of these converters rises, it is significant to advance appreciate and learn the possessions of current and voltage harmonics on the design of converter and function and performance of system. Rapid development in the field of power electronics devices especially Insulated Gate Bipolar Transistors (IGBTs) has led to the High Voltage Direct Current (HVDC) transmission based on Voltage Source Converters (VSCs).

This new innovative technology provides substantial technical and economical advantages for direct applications compared to conventional HVDC transmission system. The VSC-HVDC transmission system analysis by using Neural Networks. The data has been analyzed and a method is proposed to classify the faults by using back propagation algorithm.

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