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Stability Improvement in HVDC Transmission System by Unified Power Flow Controller

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Abstract

This paper presents An Improvement of Stability of HVDC Transmission System using a FACTS Device UPFC.

Control methods based on selective harmonic elimination pulse-width modulation (SHE-PWM) techniques with fuel cell system offer the lowest possible number of switching transitions and improve the voltage level in HVDC transmission system. 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 project discusses optimized modulation patterns which offer controlled harmonic elimination 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 results are presented to confirm the validity of the proposed switching patterns.

Keywords: ***Harmonic control, HVDC Insulated-gate bipolar transistor (IGBT), Pulse-width modulation, Voltage Source Converters (VSCs), High Voltage Direct Current (HVDC), Radial Basis Network algorithm (RBN).***

1. Introduction

HIGH Voltage Direct Current (HVDC) HIGH Voltage electricity (HVDC) technology has characteristics that make it particularly attractive for certain transmission applications. HVDC has been utilized in power systems for fifty years.

The interaction between HVDC convertor and alternative facility parts is of complicated nature and has been paid vital attention. The growing variety of HVDC links worldwide is making enhanced interest within the field of power quality and harmonic. HVDC converters introduce each AC and DC harmonics that area unit injected into the AC system and DC line severally shown. This model is often accustomed derive the system harmonic impedances at the purpose of common coupling as required in filter style. With the advances in semiconductor trade, DC cable system and control technology, the Voltage supply device primarily based High Voltage electricity (VSC-HVDC) is receiving respectable interest in recent years for its helpful characteristics. Compared with typical HVDC with current supply converters, VSC-HVDC may be a comparatively innovative technology and has several benefits over the traditional one in several aspects. The event of power semiconductors devices, particularly IGBT's has led to the transmission of power based on Voltage source converters (VSCs).

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HVDC lightweight is additionally known as voltage source converter HVDC or VSC HVDC. HVDC lightweight will management each active and reactive power severally while not commutation failure within the inverters, each device station consists of a VSC. For active power equalisation, one amongst the devices operates on dc voltage control and different converter on active power control. Once dc line power is zero, the two converters, will operate as independent STATCOMs. Each VSC encompasses a minimum of three controllers for regulation active power outputs of individual VSC. It doesn't need reactive power compensator ensuring a lot of smaller equipment size. The continuous growth of electricity demand and ever increasing society awareness of climate change issues directly affect the development of the electricity grid infrastructure. The utility industry faces continuous pressure to transform the way the electricity grid is managed and operated. On one hand, the diversity of supply aims to increase the energy mix and accommodate more and various sustainable energy sources.

On the other hand, there is a clear need to improve the efficiency, reliability, energy security, and quality of supply. With the breadth of benefits that the smart grid can deliver, the improvements in technology capabilities, and the reduction in technology cost, investing in smart grid technologies has become a serious focus for utilities. A typical configuration of the VSC-based HVDC power transmission system is shown in Fig. 1. This paper focuses on the conventional three-phase two-level VSC topology (Fig. 2) and associated optimized modulation.

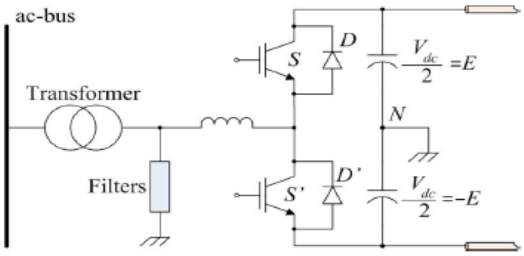

Fig. 1 Phase of the two-level VSC for the HVDC power transmission system

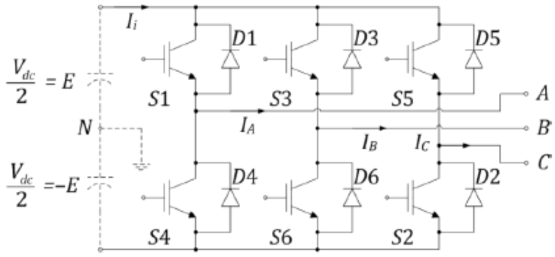

Fig. 2 Three-phase two-level VSC

2. ANALYSIS OF THE PWM CONVERTER AND 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:

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

When w0 is the operating frequency of the ac, and Vdc is the dc-link voltage.

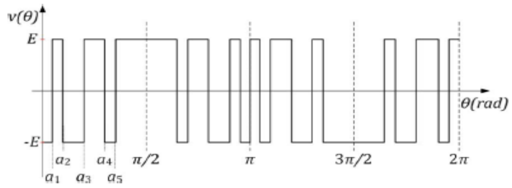

Fig. 3 Typical two-level PWM switching waveform with five angles per quarter cycle

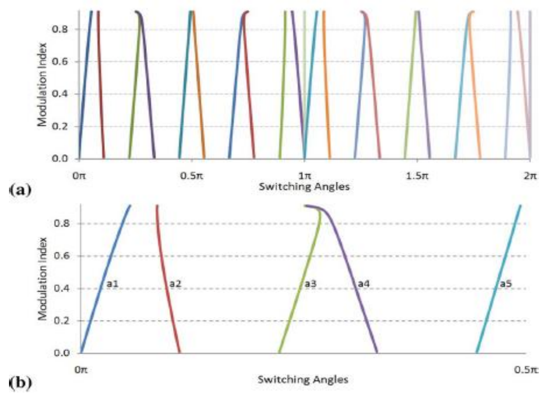

Fig. 4 Solution trajectories (a) Per-unit modulation index over a complete periodic cycle. (b) Five angles in radians

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

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

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

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

Where N +1 are the angles that need to be found

3. RIPPLE REPOSITIONING TECHNIQUE

The switching angles are pre calculated for every available modulation index (M) to obtain the trajectories for the SHE-PWM, as shown in Fig. 4.

$$V'_{LN} = V_{LN}\left(1 + k \sin \omega_r t\right). \quad (4)$$

4. HVDC AND FACTS

4.1 HVDC Converters and Functionalities for Power Transmission Enhancements

The installation of smoothing reactor the DC Current and reactive power compensation at the sending and Receiving-ends smoothing reactor and AC harmonics filter as Shown in Fig. 5.

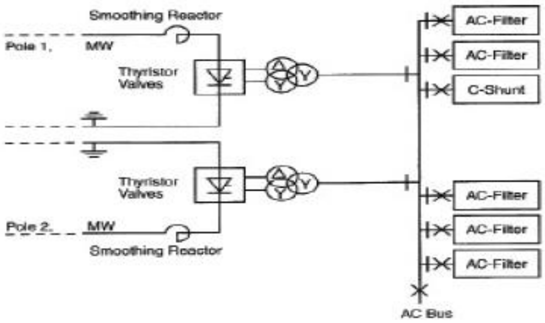

Fig. 5 HVDC terminal station in cable transmission

HVDC used for submarine cables connection will normally have 12-pulse converters as shown in Fig. 6.

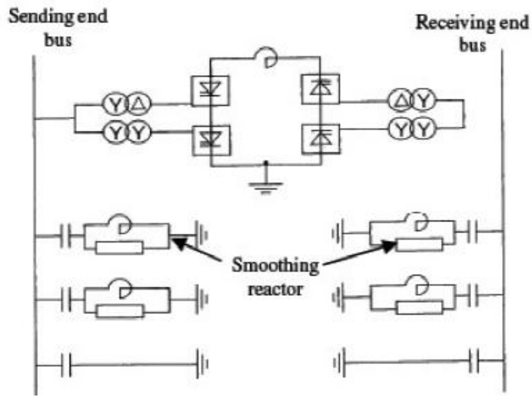

Fig.6 Schematic diagram of HVDC back-to-back converter station

4.2 Operation Condition of HVDC converter

The assumption and representation of HVDC block-set are expressed in equations for MATLAB.

$$I_{dc} = (V_{Rdc} - V_{Idc} - R_{dc} I_{dc}) / L_{dc}$$

$$x_r = K_I(I_{RO} - I_{dc}) \text{ --------------------}$$

$$x_I = K_I(I_{RO} - I_{dc}) \text{ --------------------}$$

$$P_{km} = \frac{V_{ndc} I_{ndc}}{S_n} V_{Rdc} I_{dc} \text{ -------}$$

$$Q_{mk} = \sqrt{S_r^2 - \left[\frac{V_{ndc} I_{ndc}}{S_n} V_{Rdc} I_{dc}\right]^2} \text{ --------------------}$$

$$P_{mk} = \frac{V_{ndc} I_{ndc}}{S_n} V_{Idc} I_{dc} \text{ --------------------}$$

$$Q_{mk} = \sqrt{S_I^2 - \left[\frac{V_{ndc} I_{ndc}}{S_n} V_{Idc} I_{dc}\right]^2} \text{ --------------------}$$

The assumptions for the algebraic equations are then

$$\cos\alpha = x_R + K_p(I_{RO} - I_{dc}) \text{ --------------------}$$

$$V_{Rdc} = \frac{3\sqrt{2}}{\Pi} V_k \cos\alpha - \frac{3}{\Pi} V_k \cos\alpha - \frac{3}{\Pi_{IR}} I_{dc} \text{ ---}$$

$$I_{RO} = \frac{V_k}{m_R} \text{ --------------------}$$

$$V_{Idc} = \frac{3\sqrt{2}}{\Pi} V_m \cos(\Pi - \gamma) - \frac{3}{\Pi} X_d I_{dc} \text{ --------}$$

$$S_I = \frac{3\sqrt{2}}{\Pi} \frac{V_{ndc} I_{ndc}}{S_n} V_m I_{dc} \text{ --------------------}$$

$$I_{IO} = \frac{V_m}{m_I} \text{ --------------------}$$

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4.3 Flexible AC Transmission System (FACTS)

The quality of the sine wave is dependent on the size or amount of the power electronics installed. The following types of FACTS devices are VSC type based controllers:

- Shunt Controller
- Series Controller
- Shunt-Series Controller

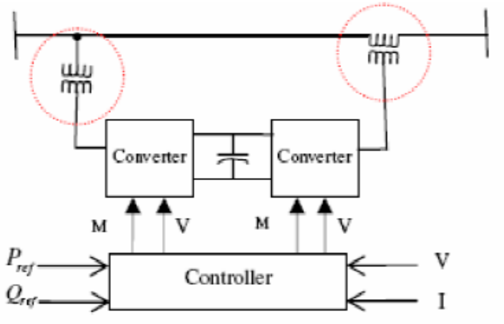

Fig. 7 Series-shunt compensator, UPFC

5. SIMULATION RESULTS

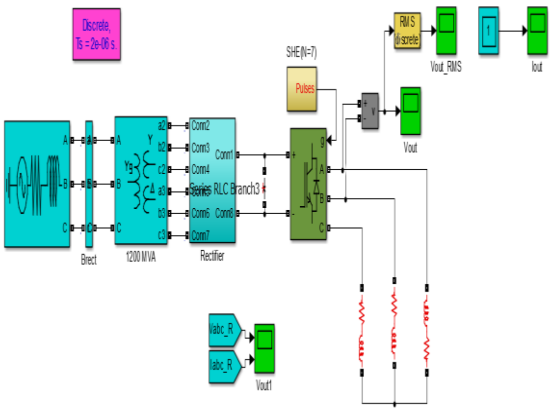

Fig. 8 Simulation of VSC based HVDC Transmission System

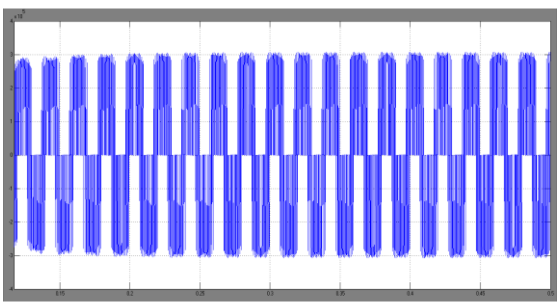

Fig. 9 Inverter Output Voltage

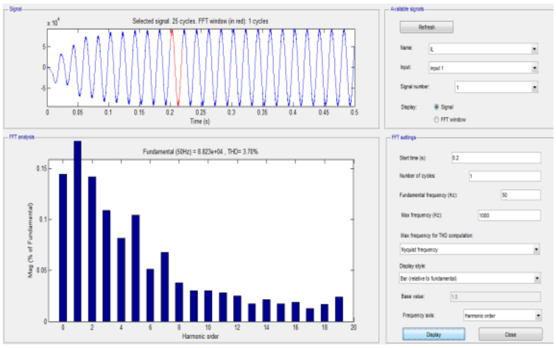

Fig. 10 THD Spectrum of Source Currents

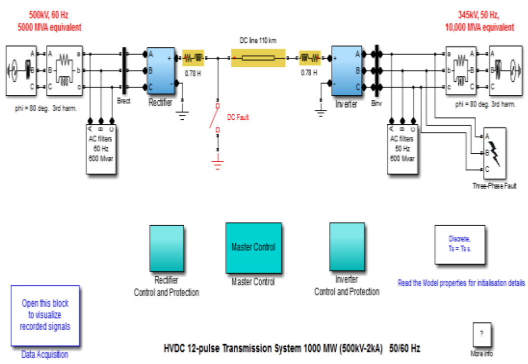

Fig. 11 Simulation of Proposed System

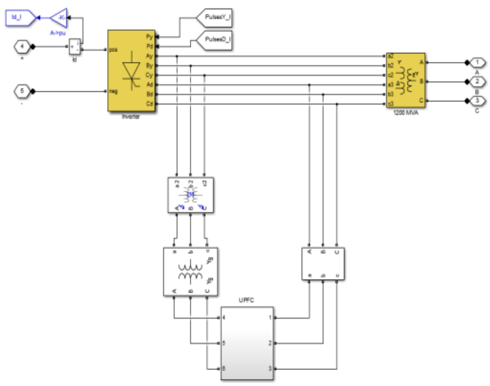

Fig. 12 UPFC Connected on Inverter Side

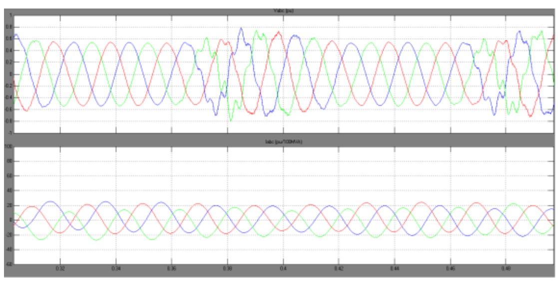

Fig. 13 Inverter Output Voltages and Currents

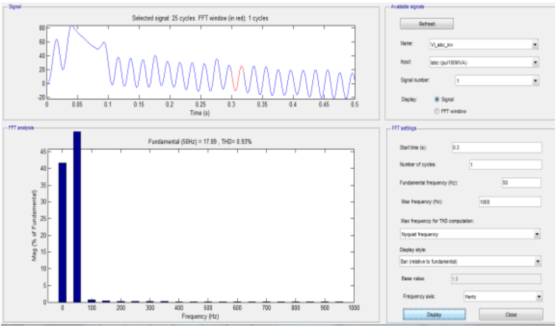

Fig. 14 THD Spectrum of Currents

6. CONCLUSIONS

Increasing demand of wattage and need for bulk economical wattage gear result in the event of HVDC Transmission. HVDC Transmission nowadays becomes one in all the simplest different for transmittal bulk power over long distance with terribly less losses.

Controlled ways supported selective harmonic elimination pulse-width modulation (SHE-PWM) techniques provide all-time low attainable range of switch transitions. This feature conjointly ends up in all-time low attainable level of convertor switch losses.

Although, such kind of system offers complicated computing and having lesser potency than the sof computing. Thus we've got used the Neural networks system to scale back the complexness thus on the planned algorithmic rule give a coffee loss, high performance system for interconnection of the HVDC system and expected to be providing prime quality HVDC system. There exist a lot of ways of soppy computing; formal logic is one in all them that offers higher ends up in computations. The long run analysis are going to be supported some hybrid technique Fuzzy logic and Neural Networks. 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.

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