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Reduction of Harmonics in HVDC Transmission System using High Pulse Converter

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ABSTRACT: HVDC is capable of transmitting power over long distances economically and connects two asynchronous AC systems. HVDC transmission can be made more feasible by eliminating problems faced in it such as cost of converting stations and harmonics. This paper presents high pulse converters like 12, 24, 48 in the HVDC transmission system to reduce harmonics in the DC link.

KEYWORDS: HVDC, high pulse converters, harmonics, .

I. INTRODUCTION

During the last 20 years, HVDC has become the dominating technology for long distance transmission of bulk power. For long distance power transmission, the DC transmission system is proved to be very efficient and economic rather than AC transmission system. Rapid development in the field of power electronic devices with turn off capability like insulated gate bipolar transistors (IGBT) and gate turn-off thyristors (GTO), makes the voltage sourced converters (VSC) more and more attractive for high voltage direct current transmission (HVDC). This new innovative technology provides substantial technical and economical advantages for different applications compared to conventional HVDC transmission systems based on thyristor technology. Since thyristor-based switches (i.e., solid-state rectifiers) were incorporated into them, hundreds of HVDC sea cables have been laid, and have worked with high reliability, usually better than 96% of the time. This paper proposes high pulse converters to reduce the harmonic content in the HVDC Transmission.

II. HARMONIC REDUCTION IN HVDC TRANSMISSION

The actual level of harmonics generated by an AC/DC converter is a function of the duration over which a particular phase is required to provide unidirectional current to the load. Hence, the higher the Pulse number of the converter, which means the more switching between phases within a cycle, the lower the harmonic distortion in both the AC line current and the DC terminal voltage. The Harmonics generated in the link can be minimized by

(A) USING DC SMOOTHING REACTORS

The smoothing reactor provides high impedance to the flow of the harmonic currents, reduce their magnitude and thus smoothens the DC current.

(B) USING DC & AC HARMONIC FILTERS

The filter has a zero impedance at the tuned frequency thus absorbing the harmonic of interest.

(C) BY INCREASING THE PULSE NUMBER

The higher the pulse number of the converter, which means the more switching between phases within a cycle, the lower the harmonic distortion in both the AC line current and the DC terminal voltage.

The basic building block used for HVDC conversion is the three-phase, full-bridge referred to as a 6-pulse or Graetz bridge. The term 6-pulse is due to the characteristic harmonic ripple in the dc output voltage, which is at multiples of 6 times the fundamental frequency. Each 6-pulse bridge is comprised of 6 controlled switching elements or thyristor valves. Each valve is comprised of a number of series-connected thyristors to achieve the desired dc voltage rating.

The figure 1 shows the voltages of each half wave bridge of this topology, V_D^{pos} and V_D^{neg}, the total instantaneous dc voltage V_D, and the anode-to-cathode voltage V_{AK} in one of the bridge thyristors. The maximum value of V_{AK} is $03 \cdot V_{MAX}$ which is the same as of the half-wave converter and the inter phase transformer converter. The double star converter presents a maximum anode-to-cathode voltage of 2 times V_{MAX}.

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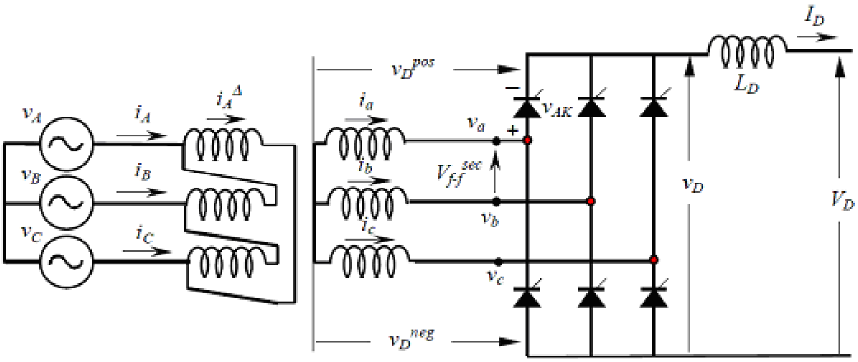

Fig.1 Six-pulse converter (Graetz Bridge)

An ideal input wave would like to be completely sinusoidal. The waveform of the converters however contains many harmonics. Analysis of the input show that the lowest harmonics is not the 6th. Even number harmonics, such as the 6th cannot exist in any waveform that is symmetrical in its positive and negative half cycles. The predominant harmonics are 5th and the 7th. The amplitude variation with respect to harmonics is shown in figure 2.

h = np ± 1
h = harmonic numbers of the spectrum
n = 1, 2, 3, . . .
p = 6 for a 6-pulse converter
Therefore,
h = 5, 7, 11, 13, 17, 19, 23, 25, . .

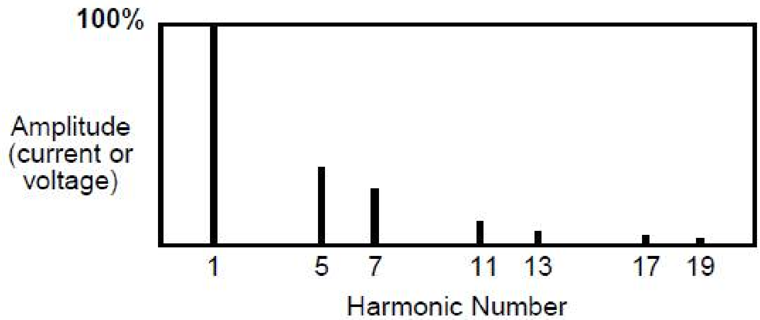

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Fig. 2 Amplitude Vs harmonic number

These input harmonics are much more difficult to filter than output harmonics. Although a low pass filter might be used, it becomes difficult to design a filter that attenuates the harmonics, while still passing the fundamental line frequency. The better method is to use a notch filter rather than a low-pass filter. Yet, even notch filters when used in converter applications are sometime difficult to implement. The filter relies on resonating components such as inductors and capacitors to perform its function. In a facility wide installation, there are many unknowns that affect the proper tuning of these filters.

Table. 1 Harmonic reduction with the increase in Pulse number

Pulse Number	Harmonics in input current (K=1,2,3,4...)	Ripple frequency on DC side
6	6K±1	6*supply
12	12K±1	12*supply
18	18K±1	18*supply
24	24K±1	24*supply
48	48K±1	48*supply

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III. SIMULAION AND RESULTS

(A) Simulink model of Thyristor based 6 Pulse Converter in HVDC Transmission:

The firing pulses for the thyristors is obtained from synchronized six pulse generator. Simulink model of basic six pulse converter followed by corresponding voltage and current waveforms is shown as below:

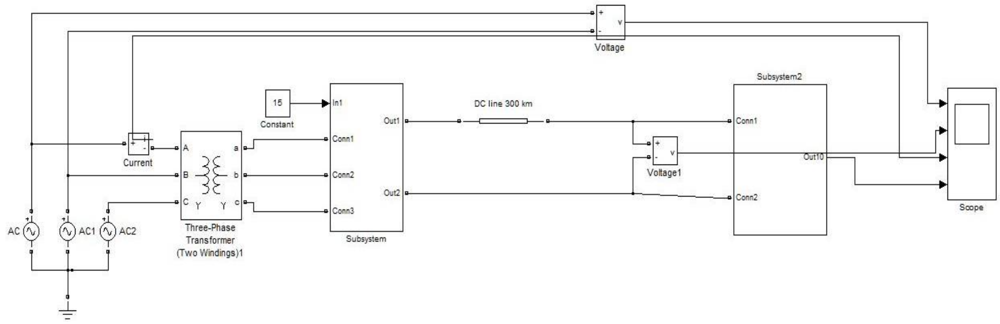


Fig. 3 Thyristor based 6 pulse converter

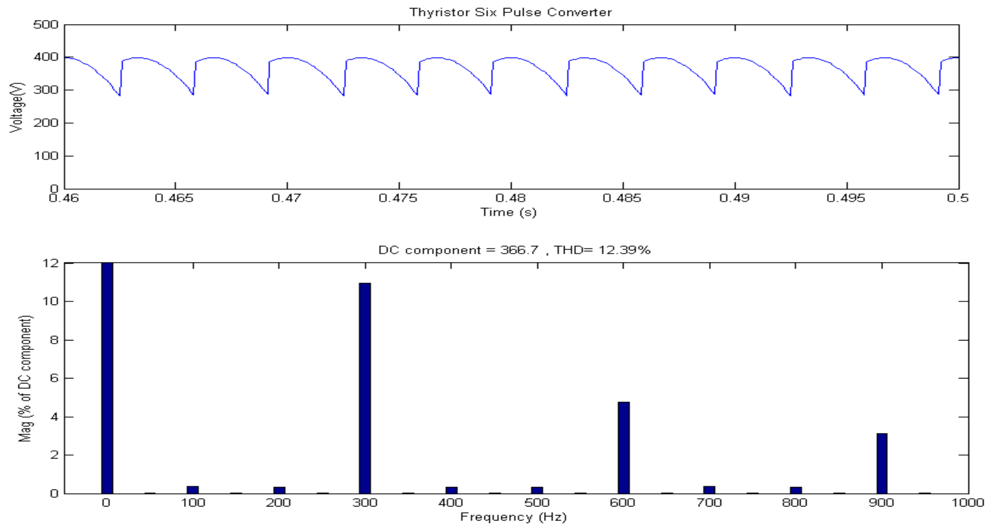
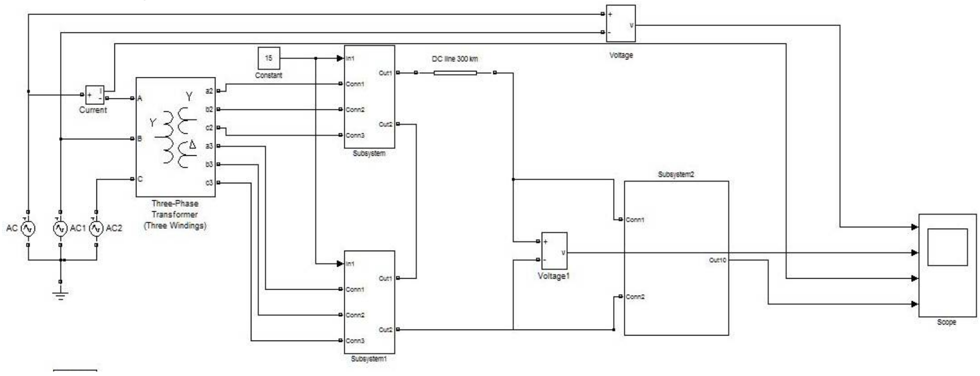


Fig. 4 Thyristor based 6 pulse converter output voltage

(B) Simulink model of Thyristor based 12 Pulse Converter in HVDC Transmission:



Fig, 5 Thyristor based 12 pulse converter

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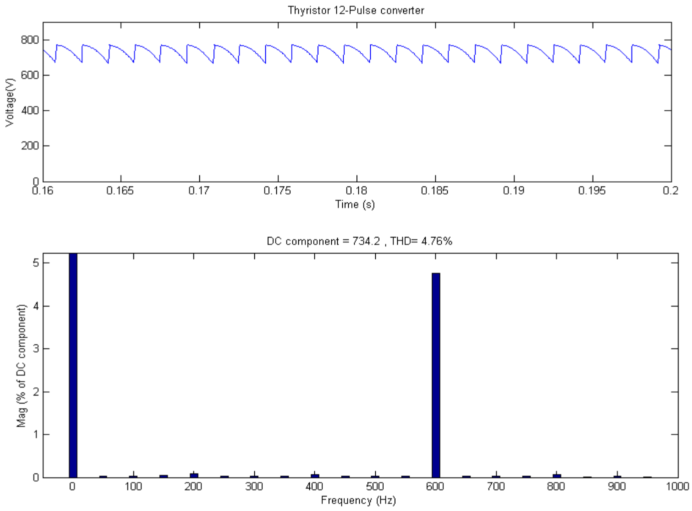

Fig. 6 Thyristor based 12 pulse converter output voltage

(C) Simulink model of Thyristor based 24 Pulse Converter in HVDC Transmission:

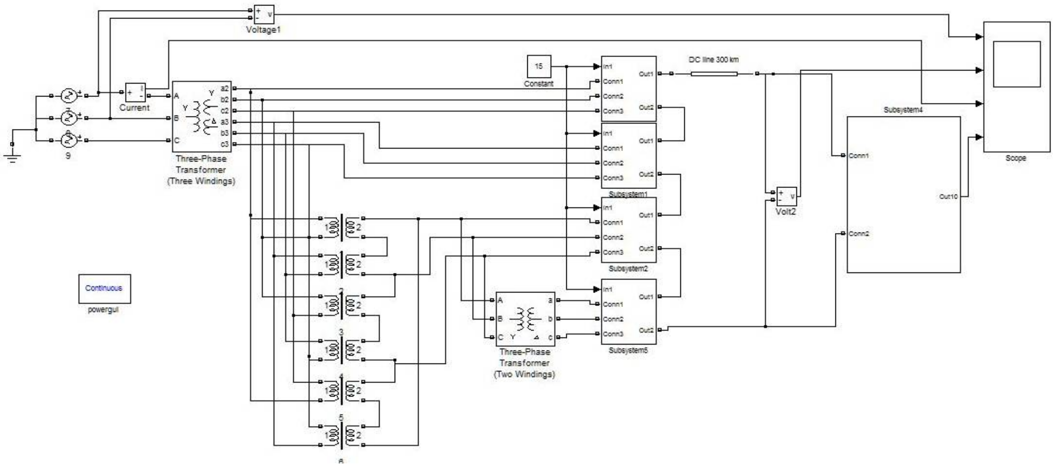

Fig. 7 Thyristor based 24pulse converter

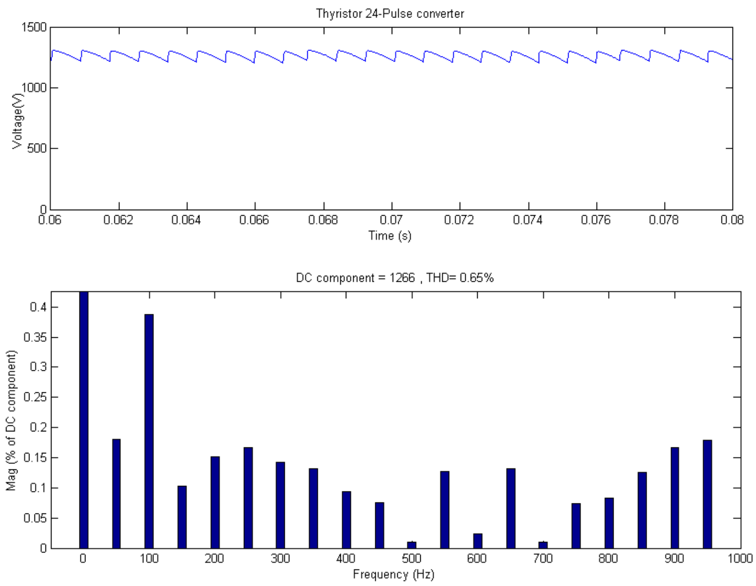

Fig. 8 Thyristor based 24 pulse converter output voltage

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(D) Simulink model of Thyristor based 48 Pulse Converter in HVDC Transmission:

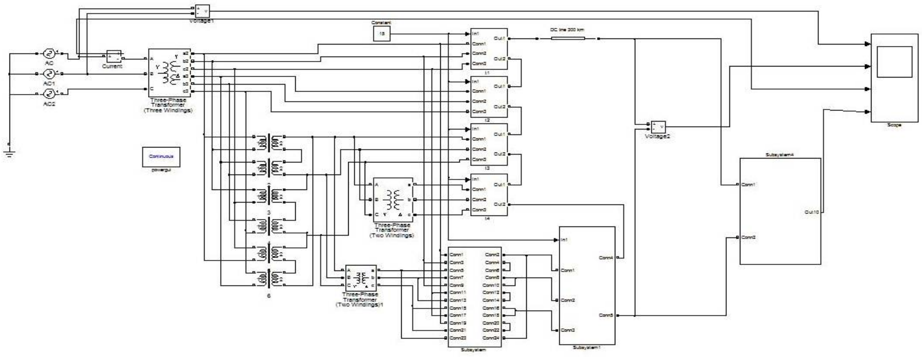

Fig. 9 Thyristor based 48 pulse converter

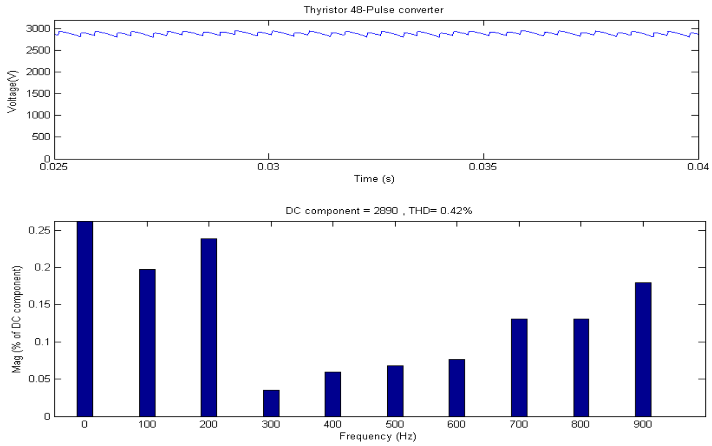

Fig. 10 Thyristor based 48 pulse converter output voltage

IV.CONCLUSION

Thus by reducing harmonic and ripple content DC transmission can be made more reliable. Since harmonic content affects every element in transmission it has to be reduced to minimum level using efficient techniques. According to IEEE 519 standards, the voltage THD% of the converter output must be below 1.5% for a HVDC line of voltage capacity161.001KV and above. In order to obtain the voltage THD% below the specified value a fourty-eight pulse converter is implemented. By comparing the simulation results obtained for six, twelve, twenty four and fourty eight pulse converters, it can be concluded that by increasing pulses in converter harmonic content in HVDC transmission can be reduced to maximum extent.

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