Investigation of THD on A 6-Pulse HVDC Transmission Network and Analysis of Power Quality Issues

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***Abstract* - Harmonics are caused by highly non-linear devices. Which affect the performance and reliability of the system. In HVDC power system harmonic analysis plays an important role in power system planning, control and operation.. The essence of this paper is basically to analysis the issues caused by 6-pulse converter according to IEEE 519 & IEC standards. In this paper A 500 MW (250 kV) HVDC interconnection is utilized to transfer power from a 315 kV, 5000 MVA AC network. The 6-pulse rectifier connected to the system links 300 km distributed parameter line via a 0.5 H smoothing reactor. The THD analysis is done at a point of coupling .Voltage harmonics an current harmonics are done using FFT analysis using MATLAB Simulink**

Key word:* *HVDC, Harmonic analysis, FFT ,THD , Power quality , Harmonics ,6-pulse rectifier.

I. INTRODUCTION

In a High voltage direct current (HVDC) system, from the transmitting station AC voltage is being converted into DC voltage with the help of a rectifier and then DC power is transported through the transmission line, subsequently, at the receiving station DC power is being reconverted into AC power through an inverter and the power is supplied in the system [1]. The semiconductor devices in HVDC converter stations are non-linear power electronic devices. Harmonic currents injected by some of these devices are usually too small to cause a significant distortion in transmission networks. However, when operating in large numbers, the cumulative effect has the capability of causing serious harmonic distortion levels. The harmonics that come from the HVDC will not only increase loss, thermal stress of equipment, reduce equipment life, and in some cases, it can even lead to the collapse of the system. The presence of harmonics results to low system efficiency, poor power factor, increased loss and reactive power components from AC and on the equipment present in the system [1-3].

In an HVDC, power system some system components, such as converters and drives, possess the non-linear characteristics, which produces system harmonics. In particular, the converters are the major harmonic sources during a steady state operation. The harmonics in an HVDC system reduce the efficiency of power transmission. They also lower the efficiency of power utilization and damage the insulation of system components. In addition, the plant mal-function can occur if the system has high harmonic contents. The harmonics entering the ac network and the dc line may result in the overheating of capacitors and generators and the instability of the system controls [1],[3].

Mitigation of harmonics have been the major concern of power Engineers on any power systems, therefore, much of the recent studies in this field focus on harmonics mitigation in power systems.in this paper harmonic analysis done using FFT algorithm and matlab simulink tool

HARMONICS ON HVDC TRANSMISSION LINE.

Power system harmonics is an area that is receiving a great deal of attention recently. This is majorly due to the fact that non-linear loads are comprising an ever-increasing portion of the total load for a typical industrial plant. Therefore, more stringent recommendations in IEEE Std. 519 have been developed due to the increase in proportion of non-linear loads and also stricter limits imposed by utilities. The performance of HVDC power system is being affected by the harmonics created by the higher use of non-linear devices. Due to the presence of solid state drives or electric furnaces and capacitor banks in the HVDC power system, harmonics are generated regularly [1],[8].

1.1 Sources of HVDC Harmonics.

In HVDC power system, non-linear loads, that is, loads that draw a non-sinusoidal current from a sinusoidal voltage source cause Harmonics. Some examples of harmonic producing loads are electric arc furnaces, static VAR compensators, inverters, DC converters, switch-mode power supplies, and AC or DC motor drives. Specifically, converters are the considerable sources of harmonic in an HVDC network during a steady state operation and cause harmonics on both AC and DC sides of their valve groups [9].

1.2 Effects of Harmonics.

Power system problems related to harmonics are rare but it is possible for a number of undesirable effects to occur. High level of harmonic distortion can reduce the efficiency of power transmission, damage the insulation of system component as a result of overheating (transformer, capacitor etc.), incorrect readings on meters, mis-operation or system malfunction. The pierce of harmonics in a network cause additional network losses due to the increase of the effective values of current. Harmonic currents increased the harmonic voltage drops across circuit impedances. The likelihood of such ill effects occurring is greatly increased if a resonant condition occurs. Resonance occurs when the harmonic frequency produced by a non-linear load closely coincides with the power system natural frequency. There are two forms of resonance, which occur: Parallel and series resonance. Parallel resonance occurs when the natural frequency of the parallel combination of capacitor banks and the system inductance falls at or near a harmonic frequency. This can cause substantial amplification of the harmonic current that flows between the capacitors and the system inductance and lead to capacitor fuse blowing, failure, or transformer overheating. Series resonance is a result of a series combination of inductance and capacitance and presents a low impedance path for harmonic currents at the natural frequency. The effect of a series resonance can be a high voltage distortion level between the inductance and capacitance [2],[10],[11].

1.3 Harmonic Limits.

According to IEEE 519, harmonic voltage distortion on power systems 69 kV and below is limited to 5.0% total harmonic distortion (THD) with each individual harmonic limited to 3%. The current harmonic limits vary based on the short circuit strength of the system they are being injected into. Essentially, the more the system is able to handle harmonic currents, the more the customer is allowed to inject [12].

Table 1: IEEE Std 519-1992 Harmonic Voltage Limits [12].

Bus Voltage at PCC	Individual voltage distortion (%)	Total Voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001 kV through 161 kV	1.5	2.5
161.001 kV and above	1.0	1.5

High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.

II. SIMULATION RESULTS -1

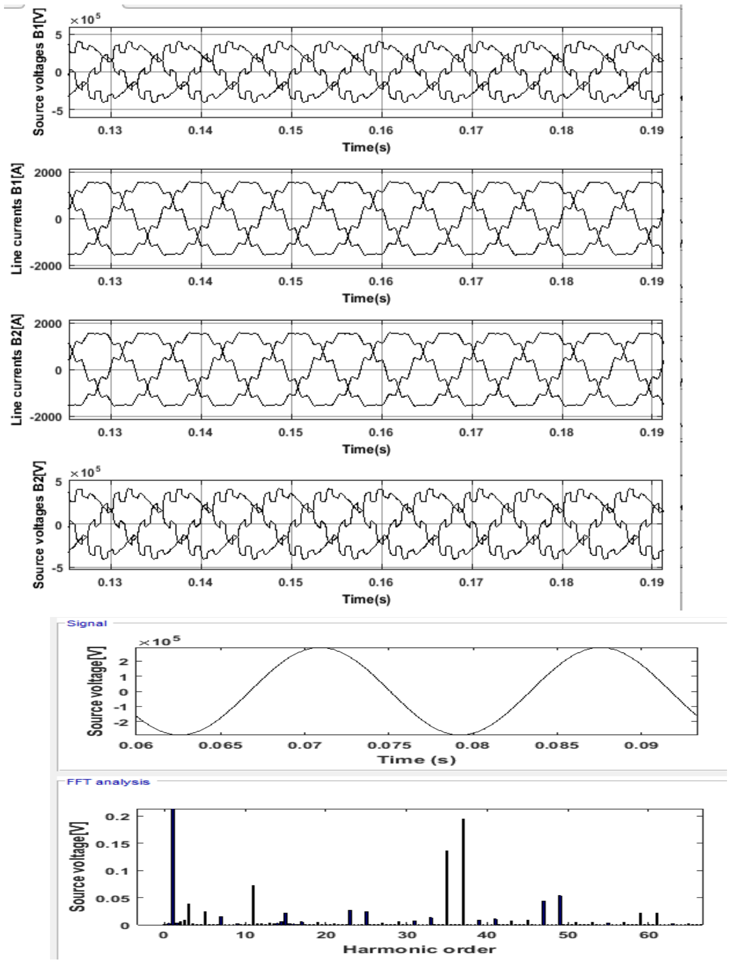
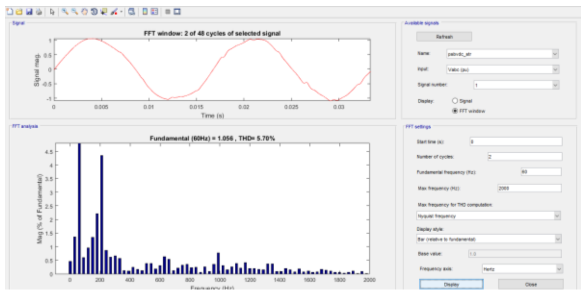


Fig 10 voltage and current profile of grid system at PCC connected with Induction motor

Distortion in voltage profile of the gird is high due to the power electronics switing devices , Harmonics caused by the driver circuit affect the entier gird system which leads to unstablity in power system where degree of Quality and safty of power transmit



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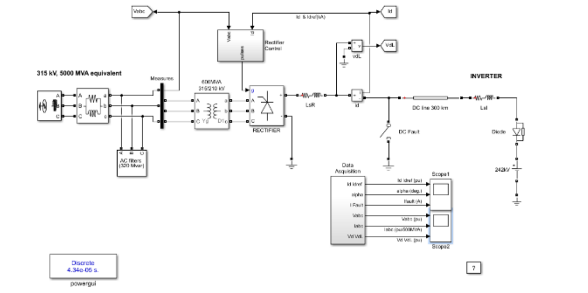

Current Harmonics	Amplitude (A)%
I_3	87
I_{11}	78
I_{23}	25
I_{27}	20
I_{33}	15
I_{37}	17

3. CONCLUSION

This paper accounts the harmonic analysis in a basic HVDC transmission system and the importance of using filters for the reduction of the harmonic distortions in the system to improve the efficiency and reduce various ill effects due to the harmonics. Due to the presence of non-linear component, passive filters were installed to suppress the harmonics in the system and subsequently improve the efficiency and reduce various unpleasant effects due to the harmonics. After using passive and shunt active filter, the harmonics level was reduced within the harmonic limit, which is in accordance with the IEEE std. 519, which states that high voltage systems can have up to 2.0% THD. It can be deduced that SAPF has the highest harmonics reduction, followed by the 12-pulse HVDC system.