International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 05, May-2015

HVDC System Fault Analysis Through Wavelet Analysis Technique

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Abstract: **Nowadays, power system has become more complex, interconnected and vary in sizes and configurations. Some of the amount of electricity is generated through non-conventional sources of energy. Transmission networks are commonly classified into four parts: transmission system, sub transmission system, primary distribution system and secondary distribution system. It is possible to go for high voltage (HVDC) transmission for long-distance power transfer through high voltage semiconductor devices. As, we know that the high voltage direct current (HVDC) is most important for large power transfer and high power demands. Maintenance of the power quality has become very difficult because of the large scale demands. Faults that occur on the system are classified as symmetrical and non- symmetrical faults. These faults may lead damage to HVDC system and other equipment's of system due to high power transfer. Presently, the fast identification of fault is the one of the primary concern for the stability of any power system. For the fast identification of faults, WAVELET ANALYSIS technique is one of the best methods which is used to identify the different types of faults in HVDC transmission system. The faults that occur in HVDC system due to some disturbances can be classified by monitoring the signals both on AC and DC sides of the HVDC system. In this report, the modelling and the simulation of a typical network of HVDC system is consider with the help of WAVELET ANALYSIS. This WAVELET technique provides a proper and reliable solution for fault identification of fault and is used to improve the performance of the HVDC system using MATLAB/SIMULINK in power system block set.**

Keywords: HVDC, Faults, Wavelet, Multi Resolution Analysis.

I. INTRODUCTION

The use of application of electricity is getting started with the use of direct current. The very first power station was established in 1882 in New York (USA). That station was a first dc station and the power supplied by this station is 110V dc to an area of the 1.5 mile radius. In few years of the development of this power station, many dc stations were built. In the last few years the demand of power system increases day by day. There are some problems of long transmission system using ac are: voltage regulation, dynamic stability, steady state and transient state with different load conditions. To overcome with these problems of ac transmission system is replaced with the high voltage transmission system. With the use of high voltage dc (HVDC) transmission long distance power is possible. The control of the ac power over the line is possible through high voltage devices. HVDC link requires converter stations at each end of the line. Main equipment which is used in a converter station are transformers and thyristor valves. At the sending end of the converter station the thyristor valves act as rectifiers to convert the ac to dc which is transmitted over the line and at the receiving end of the converter stations the thyristor valves act as a inverters to convert dc to ac which is utilized at the receiving end of the line. In this HVDC system each converter can function as rectifier or inverter. For the fast identification of faults, WAVELET ANALYSIS technique is one of the best methods which is used to identify the different types of faults in HVDC transmission system.

II. MATLAB/SIMULINK MODEL OF 12 PULSE HVDC SYSTEM

In this paper work we have considered a 12- pulse HVDC system in MATALB/Simulink environment. A 1000 MW DC interconnection is used to transmit power from 500 KV, 50 Hz network to 345 KV, 1000MVA, 50 Hz network. In this model AC networks represent the L-R equivalents with an angle of 80 degree at fundamental frequency of 50 Hz or 60 Hz and at the third harmonic.

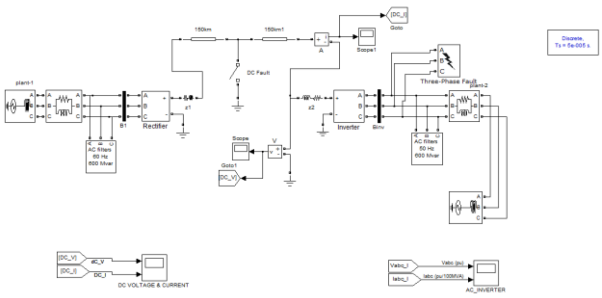


Figure 1 Simulink Model of 12 Pulse HVDC System

III. RESULT AND DISCUSSION

To identify and classify the different faults in HVDC system (i.e. AC faults and DC faults) wavelet transform is used. From the system, voltage and current signals are monitored at ac inverter side and dc rectifier side.

The following fault cases were simulated

1. Normal operating case
2. Dc line fault
3. Ac fault(LG) at inverter end

For each case following four signals were discussed.

Dc voltage, DC current, inverter side phase voltage and inverter side phase current. In this two signals were monitored an AC side and two signals at DC side of the system. After that the wavelet based extraction technique was applied to these signals to identify the faults. The following steps are used to identify the type of fault

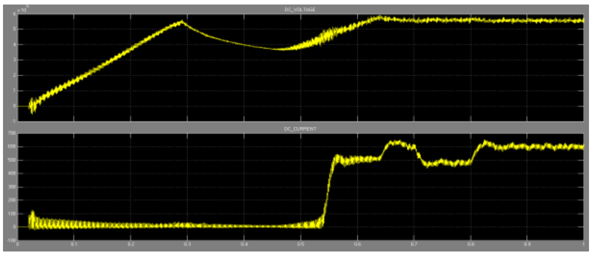


Figure 2 Dc Voltage and Current Under Normal Condition

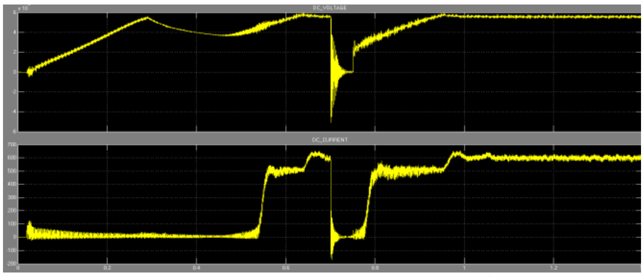


Figure 3 DC voltage and DC current for DC Fault

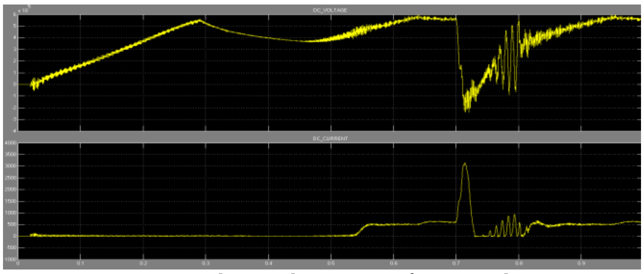


Figure 4 DC Voltage and DC Current for AC Fault

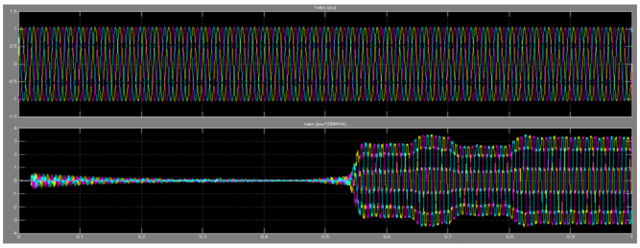


Figure 5 Phase Voltage and Current Signals for Normal Case

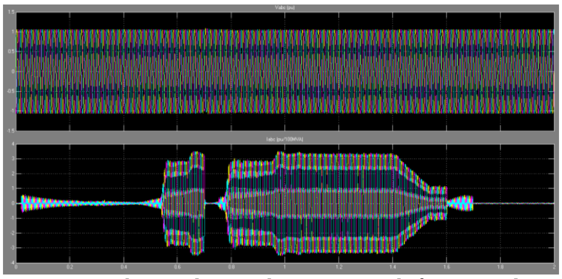


Figure 6 Phase Voltage and Current Signals for DC Fault

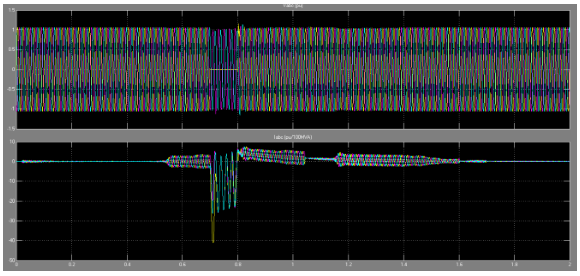


Figure 7 Phase Voltage and Current Signals for AC Fault

IV COMPARISON OF WAVELETS AND THEIR COEFFICIENTS

- *Normal voltage case*

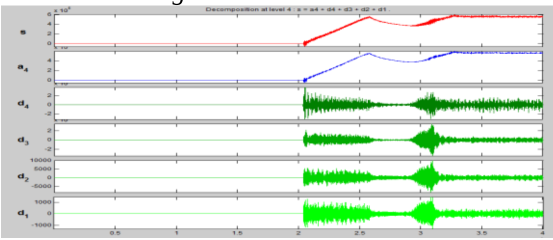


Figure 8 db4 for DC Voltage for Normal Condition

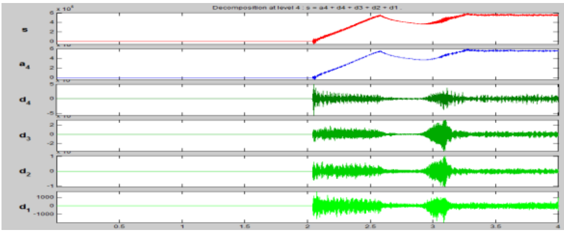


Figure 9 sym4 for DC Voltage for Normal Condition

Table 1 Comparisons of Coefficients of db4 and sym4 for DC Voltage for Normal Condition

Coefficients/wavelets	db4	Sym4
Mean	-0.3058	-3.11365
Standard deviation	6552.5	6600.2

- *Normal current case*

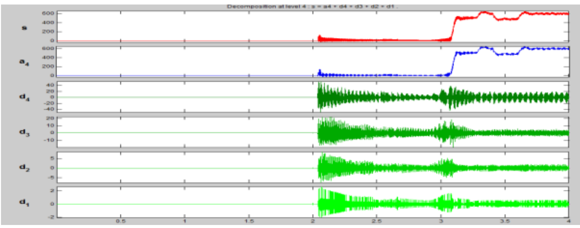


Figure 10 db4 for DC Current for Normal Condition

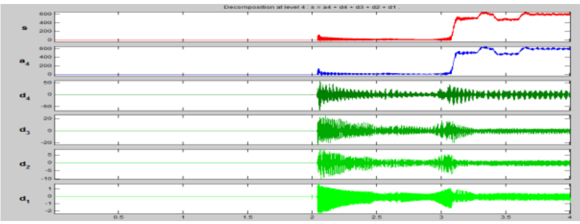


Figure 11 sym4 for DC Current for Normal Condition

Table 2 Comparisons of Coefficients of db4 and sym4 for DC Current for Normal Condition

Coefficients/wavelets	db4	Sym4
Mean	-0.013	0.0
Standard deviation	8.839	8.829

- *DC fault for voltage case*

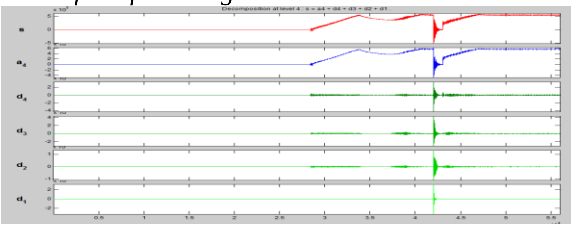


Figure 12 db4 for DC Voltage for DC Fault Case

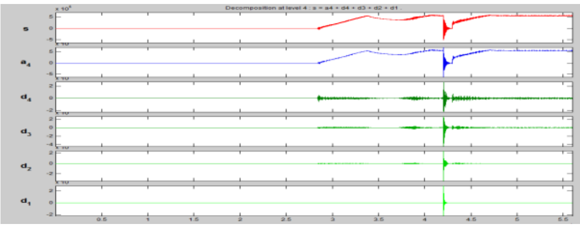


Figure 13 sym4 for DC Voltage for DC Fault Case

Table 3 Comparisons of Coefficients of db4 and sym4 for DC Voltage for DC Fault Case

Coefficients/wavelets	db4	Sym4
Mean	63.206	176.89
Standard deviation	16707	16040.25

- **DC fault for current case**

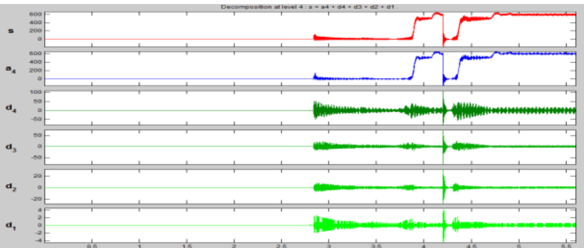


Figure 14 db4 for DC Current for DC Fault Case

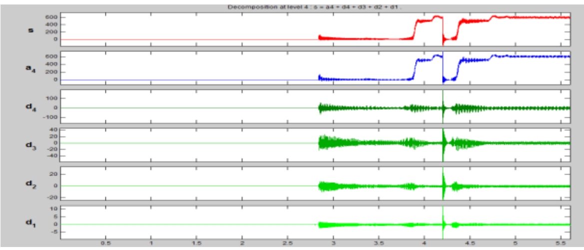


Figure 15 sym4 for DC Current under DC Fault Case

Table 4 Comparisons of Coefficients of db4 and sym4 for DC Current for DC Fault Case

Coefficients/wavelets	db4	Sym4
Mean	0.00464	0.0460
Standard deviation	8.3765	10.636

- **AC fault for voltage case**

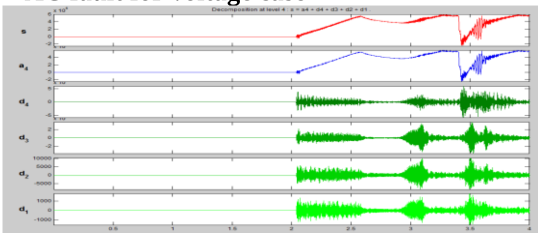


Figure 16 db4 for DC Voltage under AC Fault Case

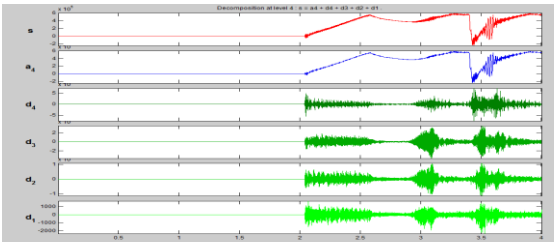


Figure 17 sym4 for DC Voltage under AC Fault Case

Table 5 Comparisons of Coefficients of db4 and sym4 for DC Voltage for AC Fault Case

Coefficients/wavelets	db4	Sym4
Mean	3.4481	-4.053
Standard deviation	9342.55	3202.81

- **AC fault for current case**

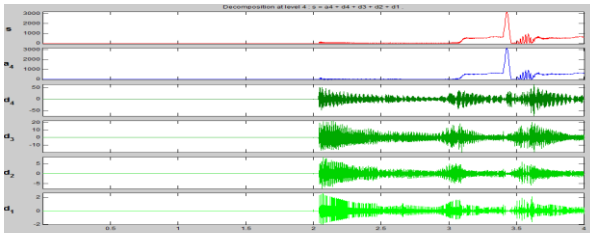


Figure 18 db4 for DC Current for AC Fault Case

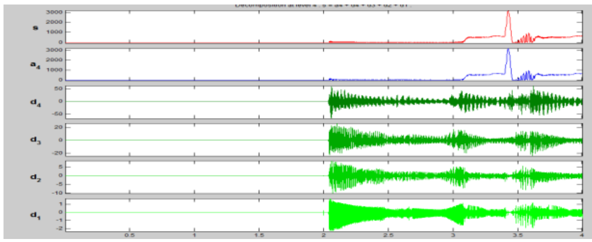
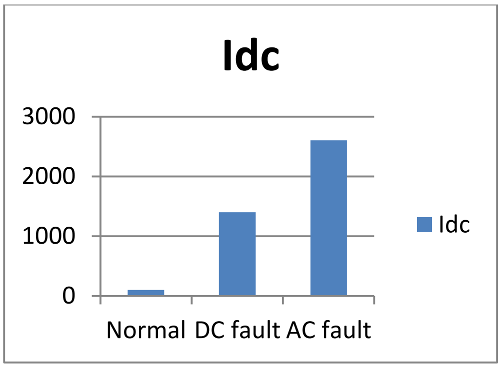


Figure 19 sym4 for DC Current for AC Fault Case

Table 6 Comparisons of Coefficients of db4 and sym4 for DC Current for AC fault Case

Coefficients/wavelets	db4	Sym4
Mean	-0.0465	0.0290
Standard deviation	10.322	10.319



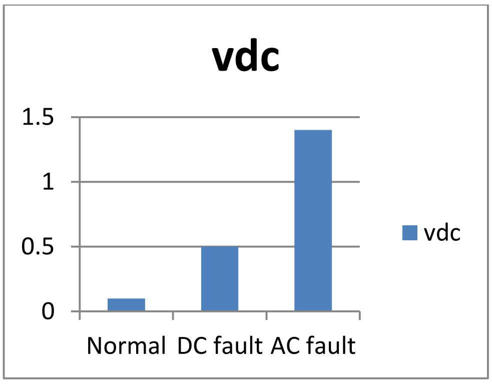


Figure 20 Variations in DC Voltage and Current under Three Conditions

Figure 20 shows that when DC side is observed whenever the disturbance occurs correspondingly the mean and standard deviation values of DC current and DC voltage deonised signals are increased with respect to disturbance. If it is DC fault the mean values and standard deviation of current and voltage value is increased and if the disturbance is AC fault correspondingly the mean values and standard deviation of current and voltage is more increased compared to normal operating condition.

V CONCLUSION

In this paper, a new technique wavelet based multi resolution analysis is used to extract the features of the signals with and without faults. This technique is also used to identify the fault that occurs in the system. So, that after the identification of fault we can provide the high speed of protection to the system which make the system more accurate, reliable and improve the performance of the system. In this dissertation technique we use two wavelets namely Dabuchies and Symlet at level 4 and decompose the signals at different levels and calculate the mean and standard deviation of the system with and without fault and compare the wavelet which one is more accurate. Results show that Symlet wavelet is more accurate as compare to Dabuchies.

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