ABSTRACT

Reliability and quality of power are some of the important tasks for a power system engineer. Transmission of electrical power through High Voltage Direct Current (HVDC) is becoming an established technology. Rapid advances are taking place in the field of HVDC transmission due to the fact that it possesses numerous advantages when compared to HVAC or EHVAC transmission. HVDC transmission has definite economic benefits when large blocks of power are to be transmitted over long distances.

The satisfactory performance of the HVDC system is one of the necessary conditions to obtain uninterrupted power supply. However few faults in the HVDC system such as faults on the transmission line, faults in the converter transformer, faults on the ac side of inverter and rectifier may lead to the failure of the HVDC system. Thus, to ensure greater reliability the detection and fast clearance of faults in HVDC lines are indispensable.

The major faults associated with HVDC transmission system are dc line to ground fault, faults on the ac side of the inverter, commutation failure at the inverter. The protection principle based on travelling wave theory provides the fastest protection. Long HVDC lines can be modeled using distributed elements. According to Travelling Wave Theory, when the fault occurs on the transmission line the voltage and current
travelling waves appear on the line. The travelling waves generated will carry information related to the condition of the transmission system.

In this work, the analysis and identification of HVDC system faults, different cases are studied. A standard model of 12-pulse HVDC system under the MATLAB environment is used for the simulation. The simulation model in which a 1000MW (500kV, 2kA) DC line is proposed to transmit power over a DC line of 300km from a 500kV, 5000MVA, 60Hz network to a 345kV, 10000MVA, 50Hz network.

One of the major components in the HVDC system is the convertor transformer. Fault diagnosis of converter transformer is necessary for reliable operation during its service. Proper design of insulation not only provides trouble free operation of the transformer, but also reduces the over all cost of it. The purpose of impulse test is to ascertain the ability of insulation of the transformer to withstand the application of the definite magnitude of the test voltage. The neutral currents are compared both at reduced and full voltages. In the event of partial or complete failure of transformer, the voltage and current characteristics undergo significant change. Any distortion in wave shape of recorded current and voltage signal shows that the fault takes place in the transformer winding. When a transformer is subjected to high fault currents, the structure and the windings experience large mechanical stresses.
To characterize the neutral currents obtained during the internal faults in the converter transformer, mathematical modeling is found necessary. In the present study of the converter transformer for theoretical evaluation of neutral currents a 315MVA, single phase, three winding transformer is considered. For the purpose of theoretical evaluation of neutral currents transformer model is simulated with equivalent electrical model by considering equivalent circuit parameters say inductance and capacitance of transformer windings. Neutral currents are computed for healthy as well as fault conditions i.e. section to section, winding to ground, winding to winding and turn to turn. FFT analysis has been carried out for neutral current signal analysis from different fault conditions.

An experimental study has been conducted on a 61MVA, 11kV/220kV high power transformer winding and is considered for the simulation of various faults. However, the core has been removed, since the measurement relates to impulse voltage, a transformer has same behavior with or without core. Since a thick rod of iron is provided in the center of the winding, the capacitance o ground is simulated. The paper insulation is removed from the winding conductor, so that there is a proper accessibility to these conductors at various coil depth (CD). The faults are physically created between the turns of a disc. The neutral currents are measured by applying Low Voltage Impulse (LVI) using Recurrent Surge Generator (RSG). The recorded neutral currents have been characterized for different types of faults in a transformer winding.
The neutral currents for healthy and faulted conditions are recorded using Digital Oscilloscope and plots are drawn using PC. The conventional methods cannot detect the faults which occurs in a single turn of the winding. To overcome the above drawback a new method called Transfer Function Method has been used in recent years. In this method Transfer Function is calculated which is the ratio of the neutral current to input voltage deconvoluted into the Frequency Domain. This method involves comparison of transfer function at different voltage levels and any change in the frequency spectrum is considered as an internal fault. However this technique based on evaluation does not have clarity in conforming the time of occurrence of fault.

In view of the above Fast Fourier Transform, Artificial Neural Network and Wavelet Transform basic techniques are proposed. The fault generated signals have been recorded and analyzed using the FFT technique to obtain the dominant frequencies. These frequency signals have been analyzed to classify and locate the faults. The recorded signals have been processed by sampling and normalizing. This data has been used to train the neural networks. ANN has been trained using back propagation feed forward algorithm. Based on the training and testing of ANN the fault classification and location techniques were proposed. Similarly the recorded data has also been analyzed using the wavelet transform technique. From the analysis of the wavelet coefficients the fault classification and location techniques have been proposed.