ABSTRACT

In Gas Insulated Systems (GIS), Very Fast Transient Over voltages (VFTOs) are caused mainly due to switching operations and internal insulation flashovers. These VFTOs can reach to high amplitude and steepness. The generated VFTO’s can also lead to secondary breakdown in GIS. Further they may give rise to electro-magnetic interference (EMI). The VFTOs cause the following effects. The electromagnetic interference effect during Disconnector switching results failure of electronic and control circuits connected to GIS. Dielectric strength of SF₆ gas is reduced under VFTO, if non-uniform electric field is formed by the metallic particles. VFTOs results failure of insulation of components such as bushings and transformers. The suppression of VFTOs in GIS has been a long standing problem.

In the present study, the estimation and suppression of very fast transient over voltages in 245kV Gas Insulated Substations (GIS) having been carried out using Electromagnetic Transient program-Reconstructed version (EMTP-RV). The VFTOs are estimated under the various conditions like fixed and variable arc resistances.

The effect of trapped charge on VFTOs in GIS systems is more considerable. Hence the variations of VFTO peak with different magnitudes of trapped charges have been estimated. As the frequency
components of the switching transients are responsible for interference effects on the control and protection systems, hence its estimation is very important. The highest possible frequency components have been obtained by using Fast Fourier Transform (FFT) technique.

The VFTOs stress the adjacent equipment and cause electromagnetic interference to the secondary and control equipment. They also increase the dielectric stress in the transformer insulation. With the increase of GIS voltage level, the effect of VFTO should be taken into more consideration. So for all the above reasons the suppression of VFTOs is very important.

In this work, various methods of suppressing VFTOs have been modeled and simulated in EMTP-RV software. First the suppression effect is verified with opening and closing resistance. In the second case the new method is proposed to suppress the VFTOs i.e by using high frequency ferrite rings. The effect of both methods on VFTOs have been estimated by simulation and verified experimentally.
In order to validate the suppression effect of VFTOs, a series of experiments are conducted on 1-Ph, SF$_6$, 3.3kV, GIS system with disconnector arrangement. The VFTOs are generated by using high speed disconnector switch (DS). The VFTOs are captured by specially designed capacitive surge sensor. To know the effect of trapped charge on VFTO, a voltage of 4.7kV is applied in steps of 10%. The captured waveforms are recorded by using 250MHz, 1GS/sec, Dual channel Digital Storage oscilloscope (DSO). The DSO is interfaced to the computer and the stored data is transferred through RS-232 port. The frequency spectra of VFTO signals are obtained through inbuilt FFT function. The mitigation effect of VFTOs and high frequency components are observed. The results recorded are used for analysis of VFTO. It is observed from the experimental results the VFTO magnitudes are reduced by 50 to 60% and also high frequency components of VFTOs are also eliminated.

The very fast transient radiated electromagnetic fields (VFTEMF) generated during disconnector switching operations are computed and compared with measured data. The electric and magnetic field computations were carried out on the existing 245kV GIS system at Carnac, Mumbai. The electromagnetic field computations have been performed by using advanced soft wares ELECNET and OPERA. The simulated results are compared with the measured data of EM fields by ABB, Baroda. Four important locations were considered for field
computations at substation. The results are compared with experimental data.

The frequency spectrum of Very Fast Transient Current (VFTC) gives dominant frequencies present but does not have the time varying current amplitude with respect to any particular frequency. Hence VFTOs and associated VFTCs are generated during disconnector switch operations are analyzed using wavelet transforms. As the transient response of the control circuits is a function of frequency content of VFTC, it is essential to separate VFTC waveform both in time and frequency scale simultaneously. Hence wavelet transforms are employed to obtain time-frequency spectrum of VFTC waveform. The results are analyzed.