ISSN No:-2456 –2165

Various Mitigation Techniques for Very Fast Transient Over Voltages in Gas Insulated Substation

Neha Shivaji Gaikwad
PG Student,
SND College Engineering,
Yeola, Nashik, Maharashtra, India

Pawan Tapre
Assistant Professor,
SND College of Engineering,
Yeola, Nashik, Maharashtra, India

Abstract— The very fast transient over voltages (VFTOs) generated due to switching operations of gas insulated substations (GIS) are dangerous to the equipment's connected to the substations. In special cases these transients may cross the Basic Insulation Level (BIL) of the GIS. In this paper, these transient voltages are investigated at the different sensitive locations of a 400 KV GIS. Different techniques for mitigation and analysis of very fast transient over voltages (VFTOs) in the 400KV GIS are applied and the results are analyzed in these paper. Hence, the suppression of the VFTOs is also an important field of interest. The Different suppression techniques to reduce the VFTOs are also discussed.

Keywords— Very Fast Transient Over Voltages (VFTOs), Basic insulation level (BIL), Gas insulated substation (GIS), Air insulated substations (AIS).

I. INTRODUCTION

In current scenario, GIS are used extensively due to several benefits over air insulated substations (AIS) i.e compact size, small ground space requirement, easy maintenance, less field erection time, environment friendly, highly reliable etc.but the main problem related to the GIS facing no of problem during switching operations and these switching operation generates the transients in the system.These transients are increased rapidly after passing the junctions in the GIS. Their duration is quite short (microseconds to milliseconds) and could be of large magnitude. As part of the design stage, studies must be performed to ensure the reliability and the efficiency of the system, to prevent and lessen the damage of transient overvoltage on the utility system, to confirm that no equipment will be subjected to stresses exceeding the equipment insulation withstand limits. A Transient study has been performed to assess protective devices requirement on the proposed GIS and to confirm that the insulation strengths have to be fulfilled the major possible over voltages occurred in the system. Overvoltages (VFTO) due to switching operations inside GIS such as disconnector interruption during normal operation condition has been considered in the paper. There are some mitigation techniques developed which has been extensively used by the industries like shunt resistors, ferrite rings and RC filters etc. Some important mitigation techniques which are mostly used by industries today are discussed in the paper.

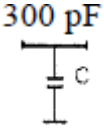
II. MODELING OF GAS INSULATED SUBSTATION

Different components of the GIS can be modeled in to lumped elements due to the traveling nature of the transients. These lumped elements are defined by surge impedances, GIS sections and wave velocity,

$$C = \frac{2\pi\varepsilon_0\varepsilon_r}{\ln R/r}, \quad L = \frac{\mu \ln R/r}{2\pi},$$

$$v = 1/\sqrt{LC}$$

Where C and L are the capacitance and inductance of the GIS busbar, Z_0 is the surge impedance, r and R are the outer radius of GIS busbar and inner radius of GIS enclosure. In Table-1, the equivalent circuit models used in the modeling of GIS components are given.

Components	Values
GIS bus bar	Transmission line with distributed parameters with
DS,CB & EARTHING SWITCH	(a) Closed position 42Ω  (b) Open position (4 pf)  (c) During operation 
Potential transformer (PT)	

ISSN No:-2456 –2165

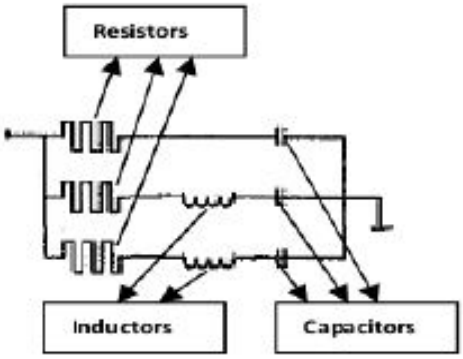
Current Transformer (CT)	300 pf
Power Transformer (Termination)	
Surge Arrestor	15 pf in series with grounding resistance of 0.1 Ω
Cable	Transmission line with distributed parameters with R_0 =0.0010679 ohm/m,Z_0=30 Ω , v=165 m/ μ
Overhead transmission line	Z_0 =350 Ω,v= velocity of light

Table 1: GIS Modeling Data

The VFTOs are studied for closing operation of the disconnect or. The circuit breaker CB2 is open and CB1 and CB3 are closed during the closing operation of The total simulation time of 4 μs with the simulation step size of 0.1 ns is taken for the investigation.

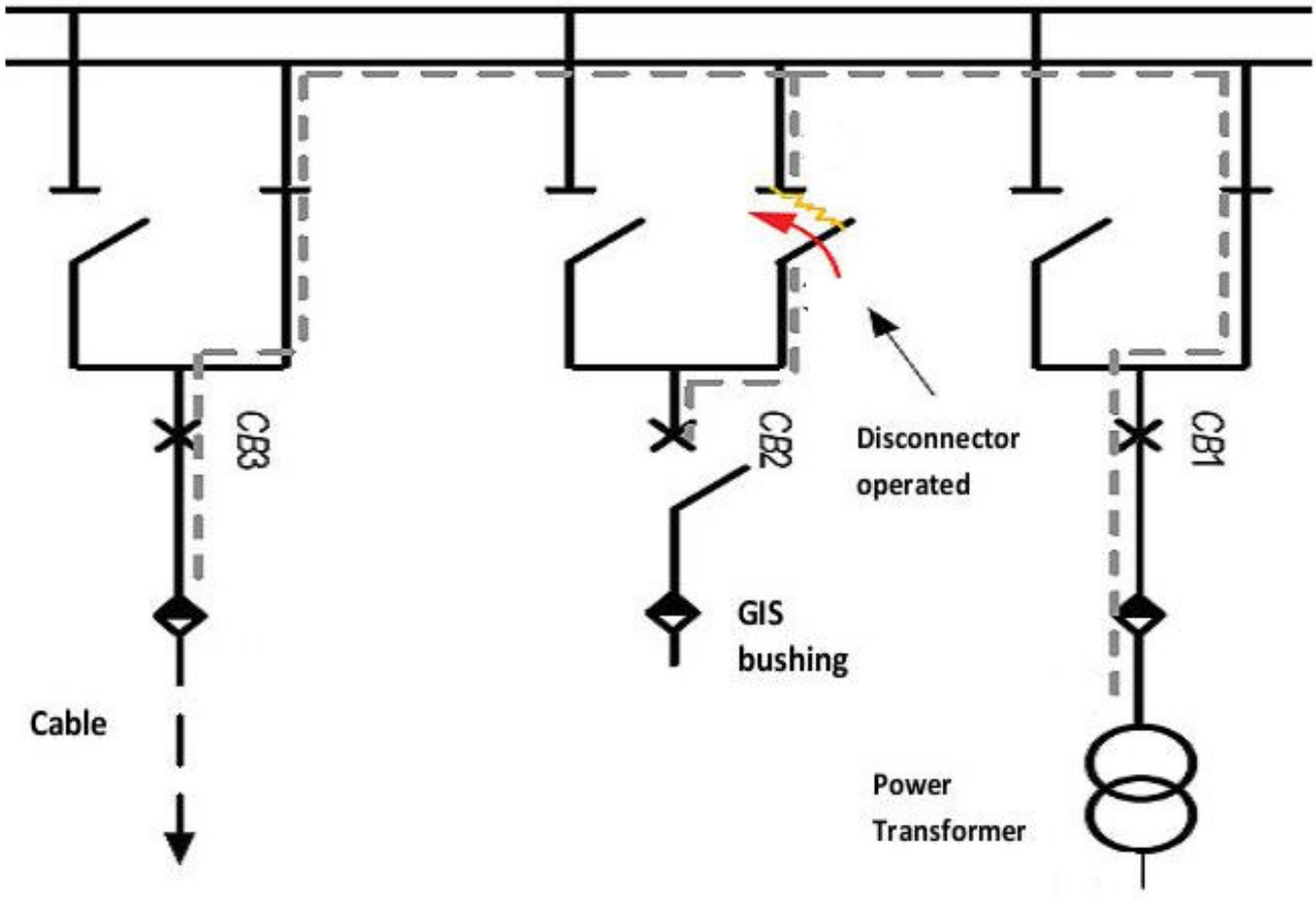


Fig. 1 GIS Layout for VFTOs Analysis

ISSN No:-2456 –2165

III. VFTO$_S$ MITIGATION TECHNIQUES

There are no research are going on mitigation techniques to suppress the VFTOS . Generally, fast operating disconnectors are used to reduce the break down time. But still it cannot eliminate the VFTOs completely. There are some techniques which are used recently to reduce these VFTOs are discussed here.

A. Disconnector Switching using Shunt/ Damping Resistors

With the use of shunt resisters with the disconnected switch in closing and opening operation decreases the VFTOs in GIS. In opening operation the main contacts breaks first and the remaining charge on the stationary side contact leaks through shunt resistor and after that vice contact closes.

While in closing operation vice contact closes first the current flowing through the shunt resistor and main contact close. hence transient decay process is delay by shunt resistors.

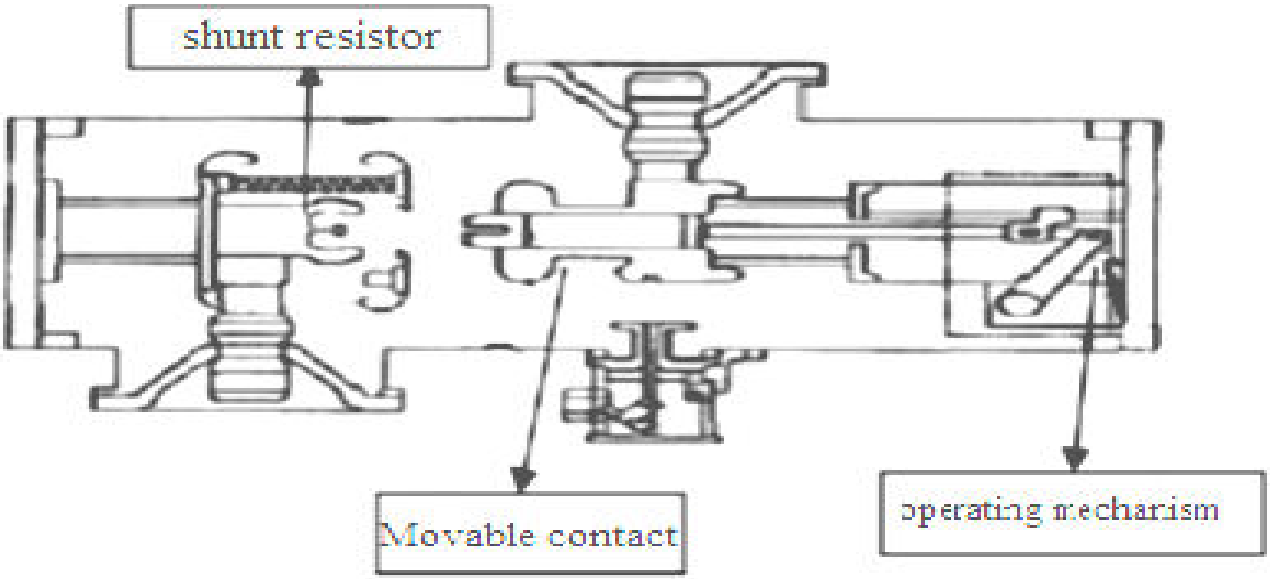


Fig. 2 Disconnector with Shunt Resistor

B. Using Ferrite Ring

Ferrite material is a magnetic of high frequency, which is non-linear in nature and these rings are placed around the conductor shown in figure-3. Mostly the ferrite rings were tested under low voltage conditions. the rings were placed around the inner conductor inside the GIS. Ferrite rings absorb the transient energy when the Pre/Re-strike occurs during operation of the switch .These rings can be represented by a nonlinear inductor and nonlinear resistor connected in series with the conductor of the GIS. Normally values o resistance of ferrite rings is taken equal to the surge impedance of busbar. Disadvantage of ferrite rings method is the rings may saturate at any instant due to high magnitude and high frequency of the VFTOs.

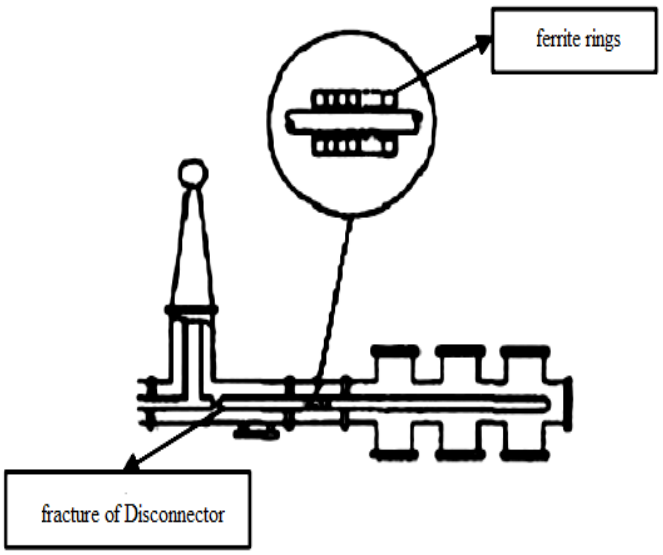


Fig. 3 Ferrite Rings used in Disconnector Switch

Rings of different ferrite materials were investigated and the number of rings inside the GIS was varied between 1 and 6. Also the diameter of the rings was different.

C. Use of RC Filters

In these typr resistance R is used to attenuate the energy while the capacitor C is used to reduce the oscillation frequency.

These RC filters are paralleled next to the power transformer to protect it from the VFTOs. The typical values of R for different types of loads. Limitation of these system is that it is used only for the transformer used in GIS.

D. High Frequency RF Resonator for VFTO Damping

RF resonator is use with optimized quality factor (Q). The resonator could be installed inside the GIS and gets stimulated by the VFTOs. For example, a cavity of an electric shielding could serve as a resonator. The novelty of this idea is not only the design of the low Q resonator. The resonator consists of an aluminium tube which is connected to the inner conductor on one side. The other side of the tube forms a thin, but long gap between resonator and inner conductor. Therefore the electric capacitance C of the resonator is determined by this gap.

IV. CONCLUSIONS

The different mitigation techniques of VFTOs were also discussed in this paper. It was found from the discussion that RC filter techniques have no effects on the open ends of the GIS while ferrite rings may saturate due to high magnitude and frequency of VFTOs. Hence, the use of shunt resistors is more reliable than the other methods. These techniques are widely used.

REFERENCES

[1]. Nikhil Pathak, Prof.T.S. Bhatti and Prof. Ibraheem, “Study of Very Fast Transient Overvoltages and Mitigation Techniques of a Gas Insulated Substation”2015 International Conference on Circuit, Power and Computing Technologies [ICCPCT]

[2]. Simon Burow, Simon Burow, Wolfgang Köhler and Stefan Tenbohlen,“New mitigation methods for transient overvoltages in gas insulated substations”.

[3]. Hussam Saeed Alamoudi, Dr. Abdulaziz Uthman Alghamdi “Investigation of Transient Overvoltages on GIS Busbars and External Enclosures”, ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online) Vol.8, No.1, 2017.

[4]. K.Prakasam, Prof. M. Surya Kalavathi, D.Prabhavathi, “mitigation and analysis of very fast transient over voltages (vftos) of transformer in 765kv gas insulated substation (gis) using wavelet transform”.