Study of Very Fast Transient over-Voltages and Mitigation Techniques of 1200kv Gas Insulated Substation

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Abstract— According to the gas insulated system, throughout the switch operation and also the insulation of the in no time transient over voltage are generated. So the VFTOs can reach to the massive amplitude and additionally slope. Owing to the VFTOs secondary breakdown are created which can will increase the magnetic force interface, so this result are created by the VFTOs once the disconnected shift of the magnetic force interference which ends up the failure of electronic system that is affiliation to the GIS. Consistent with the VFTOs non conductor strength of the SF6 gas are decreases and also the VFTOs are failure of insulation parameter like electrical device. This document depict the variations of VFTO magnitudes of a 1200 kV GIS during different switching operations have been computed and compared by using EMTP software. Hence, the suppression of VFTO’S is also an important aspect. The suppression strategies are also discussed.

Index Terms— Gas Insulated Substation, VFTO, Disconnector switching, EMTP Software.

I. INTRODUCTION

The increase in demand for electricity and also the growing energy demand in metropolitan cities have created it necessary to increase the prevailing high voltage network right up to the patron. For reliable power offer and economic blessings, Gas Insulated Substations (GIS) are put in in increasing variety over the last 20years and a number of distinctive units square measure below erection. GIS of up to 800kV are developed and square measure being wide used. Initially, GIS were put in solely wherever land prices square measure and needs of environmental compatibility were the most interest over a amount of your time as a results of speedy progress of GIS technology, GIS became economical and common. GIS is “compact, multi element assembly fogbound within a grounded aluminium encapsulation, that shields all energized components from the surroundings the first insulating medium is SF6 gas.

II. INTRODUCTION To EMTP-RV

With the presentation of EMTP-RV the reenactment of office has turned out to be straightforward.
Disconnecter switches are utilized principally to segregate agent segments of high voltage establishments from each other as a security live. Likewise, they have to try and have the capacity to play out certain change obligations like load exchange from one transport block to a unique transport block off load affiliation or detachment of transport segments, circuit breakers and so forth. The affiliation or detachment of empowered yet clear station segments includes the disconnector changing little physical marvel streams, some of the time few mA, all through shutting partner degreed hole operations the voltages create over the correction contacts that a while later fall in a passing arrangement of start releases by and large in broadened.

Successions inside nanoseconds, the channel of such a start release quickly sets up a directing extension over the contacts. Enduring couple of a few little seconds, it quickly associates the potential accomplishment is among transient motions with high frequencies inside the nearby GIS components, providing for VFTOs.

IV. CALCULATION OF VARIOUS PARAMETERS OF GIS

A. Calculation of inductance:
The inductance of the transport channel can be computed by utilizing the recipe given beneath: Where r1, r2, r3, r4, are the radii of the conductors in the request of diminishing greatness and 'l' is the length of the area.

\[
L = 0.001 \times \frac{\ln \frac{r_1}{r_2} + \ln \frac{r_2}{r_3} + \ln \frac{r_3}{r_4} + 2 \times \left( \frac{r_4^2 - r_1^2}{r_1^2 - r_2^2} \right) \times \ln \left( \frac{r_4}{r_2} - 1 \right)}{\ln \left( \frac{r_1}{r_2} - 1 \right)}
\]

B. Calculation of Capacitance in micro farad:
The Capacitance is calculated with the idea that the conductors are Cylindrical. Capacitance is calculated by victimization the quality formulae given below:

\[
C = \frac{2 \times \Pi \times \varepsilon_0 \times \varepsilon_r \times l}{2.3 \times \ln_{10} \left( \frac{b}{a} \right)}
\]

\[
b = \text{Outer cylinder radius} \\
a = \text{Inner cylinder radius} \\
l = \text{Length of the section}
\]

C. Calculation of Capacitance due to Spacer
Spacers are utilized for supporting the inward conductor with reference to the external fenced in area. They are made with Alumina filled epoxy material whose relative permittivity (εr) is 4. The thickness of the spacer is thought to be the length of the capacitance for count.

D. Calculation of Variable Arc Resistance
In view of prior investigations in SF6 gas, Toepler's Spark Law is substantial for figuring of Variable Arc Resistance. The Variable Arc Resistance because of Toepler's formulae is given underneath

\[
R(t) = \frac{K l \times l}{q_0 + \int_0^t i(t) dt}
\]

Where KT = Toepler's Constant
L = Spark Length in meters
q0 = Initial Charge or Charge at the instant of breakdown
\(t\) = Spark collapse time in sec

The estimation of time changing sparkle protection R (t), is computed until the point that it achieves an estimation of 1 to 5 ohms. The indispensable in the denominator aggregates up the outright estimation of current 'I' through the protection R (t) over the time starting at breakdown commencement. In this way, it compares to the charge led through the start channel up to time 't'. Beginning charge q0 is an imperative parameter while considering the non-uniform fields. However, the field between the disconnector contacts is practically uniform. Along these lines q0 is little.
E. A TYPICAL 1200 KV GAS INSULATED SUBSTATION

Fig: A Typical 1200KV GIS Substation

F. TYPICAL SECTION OF SEGREGATED-PHASE 1200KV GIS SYSTEM

Fig: Typical section of Segregated –Phase 1200KV GIS System

V. GIS (EMTP-RV) MODEL OF DS1 CLOSING OPERATION WITH FIXED ARC RESISTANCE (RARC=0.5Ω)

VS –VFTO at Source side
VL = VFTO at Load side
Vgh = VFTO at Air to SF6 bushing

GIS MODEL OF DS1 CLOSING OPERATION WITH FIXED ARC RESISTANCE
VI. MODELING OF FERRITE RING RINGS

Ferromagnetic rings can be utilized to effectively cover the amieness of VFTO delivered inside GIS; however assurance of ferromagnetic materials for high voltage applications is of unprecedented significance. The ferrite material picked must have particular characteristics of inundation, appealing conductivity, and repeat response and adversity properties. Each one of these parameters affect the VFTO camouflage affect. The ferrite material is picked with the ultimate objective that the alluring movement thickness is generally extraordinary. The alluring conductivity parameter is eccentric and nonlinear. The covering sway on VFTO is directed by corresponding inductance of Ferro appealing ring that relate to the size and the alluring conductivity of ferrite ring.

\[
\frac{P}{V} = \frac{1}{\sqrt{2}} \mu H H^2 f
\]

\(\mu\) is magnetic hysteresis conductivity
\(H\) is magnetic field strength
\(h\) is magnetic hysteresis coefficient
\(f\) is a magnetizing frequency
\(V\) is volume of the ferrite ring

A. Equivalent Characteristics

The appropriate strong arrangement rings are regularly associated with transport bar of GIS frameworks to restrain the extents of VFTOs produced because of disconnector operations. The proportional circuit of the strong arrangement ring settling it on the GIS conductor bar is taking after associating protection and inductance between the disconnector and transport bar. The reenactment circuit for VFTO examines is inductance of the strong arrangement loop parallel to protection of the curl. The effect of reflected waves is dismissed.

B. Losing Attributes Of Ferrite Rings

The ferrite ring settled on GIS channel should have no effect on the power repeat electric current and the most loss of the ferrite ring produces at high repeat, so the essentialness of the VFTO can be expended. The loss of unit volume of ferrite material is
from above equation the loss of the ferrite ring is in direct proportion to f and B.

C. Design aspects of ferrite rings

Mn-Zn ferrite is picked as its high attractive immersion Bs i.e. about Bs > 47mt at 250C and the center shape chose is toroid. Ferrite attributes as a component of working conditions. while choosing a ferrite rings it is important to think of some as essential application viewpoints. The recurrence where most extreme lessening is required will decided the material necessities. The most reasonable ferrite would offer the most elevated impedance levels at the high frequencies, which more often than not cover an abroad range center shape, which is typically characterized by transport bar sort and size. Establishment prerequisites to settle on a whole or split center sort. Constriction/impedance level of most extreme concealment the Mn-Zn material (3S4) is chosen for show application. It can smother high frequencies request of MHz [40]. With MnZn-Ferrite exact control of material creation has brought about an expansion of its resistivity to an estimation of 103ω m. The extra preferred standpoint of 3S4 is that it doesn't have nickel which is a substantial metal and consequently a potential peril to nature. Additionally, its high porousness gives it amazing high-recurrence qualities.

\[
P = P_r - P_h - P_e
\]
 Total power loss can be expressed as \( p = k f^n B^m \)
- \( K \) is constant
- \( f \) is frequency
- \( B \) is flux density
- \( N \) and \( m \) are the index parameters

\[\begin{align*}
+C_1 & 2nF \\
+C_2 & 0.003nF \\
+C_3 & 0.003nF \\
+C_4 & 0.2nF \\
+C_5 & 0.1nF \\
+C_6 & 0.0045nF \\
+C_7 & 0.003nF \\
+C_8 & 0.003nF \\
+C_9 & 0.003nF \\
+C_{10} & 0.0045nF \\
+C_{11} & 0.003nF \\
+C_{12} & 0.003nF \\
+C_{13} & 0.0045nF \\
+C_{14} & 0.003nF \\
+C_{15} & 0.005nF \\
+C_{16} & 0.005nF \\
+C_{17} & 0.1nF \\
+C_{18} & 0.4nF \\
\end{align*}\]

\[
+R_{L1C} \left\{ \begin{array}{c}
0.250 \mu H, 0 \\
0.800 \mu H, 0 \\
0.800 \mu H, 0 \\
0.680 \mu H, 0 \\
0.800 \mu H, 0 \\
0.800 \mu H, 0 \\
0.800 \mu H, 0 \\
0.680 \mu H, 0 \\
\end{array} \right. \\
\end{align*}\]

\[
+R_1 \ \ \ 0.5 \\
+R_2 \ \ \ 0.02 \ \ \ mH \\
+R_3 \ \ \ 70 \\
\]

Fig: Equivalent circuit of the ferrite ring.
VII. RESULTS

The change operations during a Gas Insulated Systems results in in no time transient Over voltages, these over voltages propagates among the GIS chambers with terribly steep wave front and extremely high amplitude, and conjointly stress the instrumentations in GIS and cut back the reliableness of the switchgear equipment. Such over voltages might cause some faults in GIS and interconnected elements, like transformers. For knowing the height values of VFTO the EMTP-RV computer code is employed, and simulations are allotted by planning appropriate equivalent circuits and its models.

The parameters like arc resistance and variable arc resistance model ar thought of for simulations. There ar some deficiencies within the existing suppressing strategies. The existing technique for suppression of VFTOs in GIS systems is by victimisation gap and shutting resistance across the disconnector switch (DS), this technique is termed resistance change.

There ar sure difficulties ar gift with this technique. typically the Bus ducts ar stuffed with SP6 Gas at sure pressure within the GIS systems, due to this, the installation of resistors is tough in GIS systems as in air blast circuit breakers.

The resistance change may result material decompositions and by merchandise within the gas, which may increase the particle contamination and partial discharge issues in GIS systems. VFT have a really short rise time within the vary of four to one hundred ns, and followed by high frequency oscillations within the vary of some many kc to a few few tens of megacycle per second. The resistance change mechanism isn't appropriate due to massive time interval throughout nanoseconds. during this chapter, a replacement technique is projected by victimisation high frequency magnetic rings for suppressing VFTO close to by the supply has been researched. during this technique magnetism rings ar mounted on the conductors joined to the disconnectors to effectively suppress each the amplitudes and abruptness of VFTOs. The results ar compared with results obtained with resistance change technique.

VIII. CONCLUSION

The fast transient over voltages that are obtained due to switching operations in GIS are simulated and validity of the results are verified with the experimental results. In this work an attempt is made to reduce the amplitudes of VFTO’S using ferrite rings.
The steepness and maximum peak of the transient over voltages are reduced with application of ferrite rings is observed. The fast transient over voltages can be reduced by 60% with use of ferrite rings to bus duct. It is observed that the peak magnitudes are 26% to 30% higher in case of dis connector switch closing operation. With effective design and use of the same can effectively reduce the steepness and maximum peak of VFTO generated. The simulation result has diversity with the experimental results this is because some parameters have ignored. To remove diversity further research on GIS equipment to perfect the model should be carried out. However, these simulations are helpful for an effective shielding of the control circuits within GIS against transient voltages.

IX. Scope For Future Work

- The measurements of in no time transient over voltages is meted out beneath completely different gas mixtures, and conjointly at completely different gas pressures.
- during this thesis transients square measure calculable throughout disconnector switch operations. The transients is calculable even beneath completely different fault conditions.
- As mentioned during this thesis, the analysis has been meted out with one GIS system. The analysis is extended to variety of GIS assemblies as found in follow.
- The estimation of magnetism fields is done, throughout fault conditions.
- Modeling and simulations square measure meted out to appraisal the impact of those transients on electrical device windings, bushings, enclosures, circuit breakers etc.
- The in no time transient over voltages is calculable victimization completely different formulae and results is compared
- Experimental measurements of VFTOs is meted out beneath fault conditions by providing shunt switch from bus bar to enclosure. The result obtained is compared with the VFTOs obtained through switch operations.

REFERENCES


