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Calculation of VFTO's in a 3- Phase 400kV GIS by using MATLAB

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Abstract
This paper represents the magnitudes of voltages of peak voltages and rise times for in case of 3-phase faults for voltages 400kV are obtained using MATLAB software and tabulated. It was observed that the rise times are nearly the same though there is an increase in peak voltages and for different voltage levels. Transient over voltages are also obtained for 3-phase 400kV GIS systems for opening, closing of circuit breaker and re- strikes. Effect of variable arc resistance on the magnitude of transient overvoltage is also studied. For the development of Equivalent circuit low voltage step response measurements of the GIS components have been made. The estimation of transient over voltages in a3-Phase 400kV GIS by using MATLAB.

Keywords: GIS System, Transient over voltages, Switching operations, 3-Phase faults and Control circuitry.

I. INTRODUCTION:

A distributed parameter model for a three phase GIS system of length 10mtrs is shown in fig.1.1. The peak magnitude of transient voltages rise time depends upon the model parameters like inductance, capacitance and resistance. Faults on transmission line can be caused by flashover on contaminated insulator surface, lightning strikes, broken conducting line, etc.

Fault which occurs on transmission lines not only effects the equipment but also the power quality. So, it is essential to determine the fault and location on the line and clear the fault as soon as possible in order not to cause such damages. Flashover, lightning strikes, snow, birds, wind, and ice-load lead to short circuits. The fault may appear at any instant of time, and thus voltage or current ranging from 0 to 360 degrees. The angle at which fault occurs is called fault inception angle and it effects the amplitude of fault current. The fault distance changes then corresponding line impedance changes which is going change the fault current. Fault resistance affects the fault current. The faults have the role on VFTOs is disturbed are called unsymmetrical or unbalanced faults.[1][2]

The most common type of unbalanced fault in a system is a single line to ground fault (LG fault). Almost 60 to 75% of faults in a system are LG faults. The other types of unbalanced faults are line to line faults (LL faults) and double line to ground faults (LLG faults). About 15 to 25% faults are LLG faults and 5 to 15% are LL faults. Faults in which the balanced state of the network is disturbed are called unsymmetrical or unbalanced faults. Majority of the faults occur on transmission lines as they are exposed to external elements. Lightening strokes may cause line insulators to flashover, high velocity winds may cause tower failure, ice loading and wind may result in mechanical failure of line or insulator and tree branches may cause short circuit.

Much less common are the faults on cables, circuit breakers, generators, motors and transformers. Fault analysis is necessary for selecting proper circuit breaker rating and for relay settings and coordination. The symmetrical faults are analyzed on per phase basis while the unsymmetrical faults are analyzed using symmetrical components. These faults can be of two types: (a) line to line to line to ground fault (LLLGfault) or (b) line to line to line fault (LLLfault). Since the three phases are equally affected, the system remains balanced.

That is why, this fault is called a symmetrical or a balanced fault and the fault analysis is done on per phase basis. LLLfault is identical due to the balanced nature of the fault. This is a very severe fault that can occur in a system. two widely used program packages for electric network simulation were compared.[3]

It has to be pointed out that both tools are capable of simulating the same class of problems, since it is possible to build user defined elements in both cases (though this requires experience and is time-consuming).

There are however some differences between the predefined components. Fault resistance increases fault current decreases .The faults currents are generated using MATLAB The fast transients over voltages are caused due to switching operations and fault with fixed resistance and variable arc resistance. The very fast transient over voltages in GIS is estimated and simulated using the MATLAB software in 3-phase gas insulated substations in fig.1.1.

The maximum values of VFTO, the MAT LAB software is used and a simulation is carried out by designing suitable equipment circuit and its models are developed. The main advantages of such models are used to enable the transient analysis in GIS. [4] The fault distance changes then corresponding line impedance changes which is going change the fault current. Fault resistance affects the fault current.

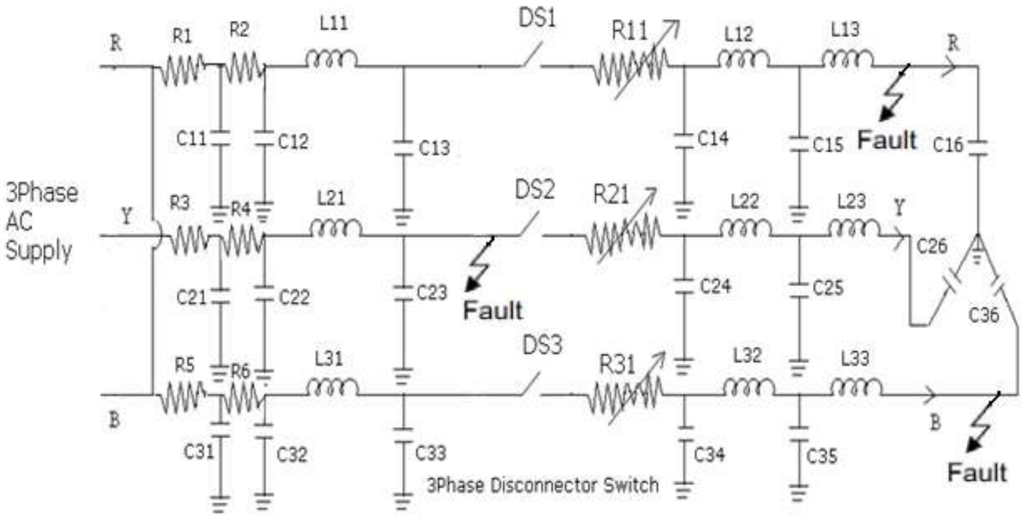

Fig 1.1 Three phase diagram of typical section of GIS system

During the current operation of dis-connector switch in a GIS, re-strikes (pre-strikes) occur because of low speed of the dis-connector switch moving contact, hence very fast transient over voltage are developed. These VFTO's are caused by switching operations and 3-phase fault. When a fault occurs, there is a short circuit in the system.[5] Transients are also produced due to the faults in the system. Due to this VFTOs are caused by switching operation and can also lead to secondary breakdown with in GIS.

Using MATLAB Software of the equivalent model is developed.

II. Three -phase modeling circuit for 400KV GIS system for 10mtrs length:

The MATLAB circuit for 10mtrs length in a 3-phase 400kV GIS shown in figures 1.2. This effect makes the transmission line 3-phase only. The GIS bushing is represented by a capacitance of 500pF. A fixed resistance of 2.2Ω of the spark channel is connected in series with the circuit breaker.

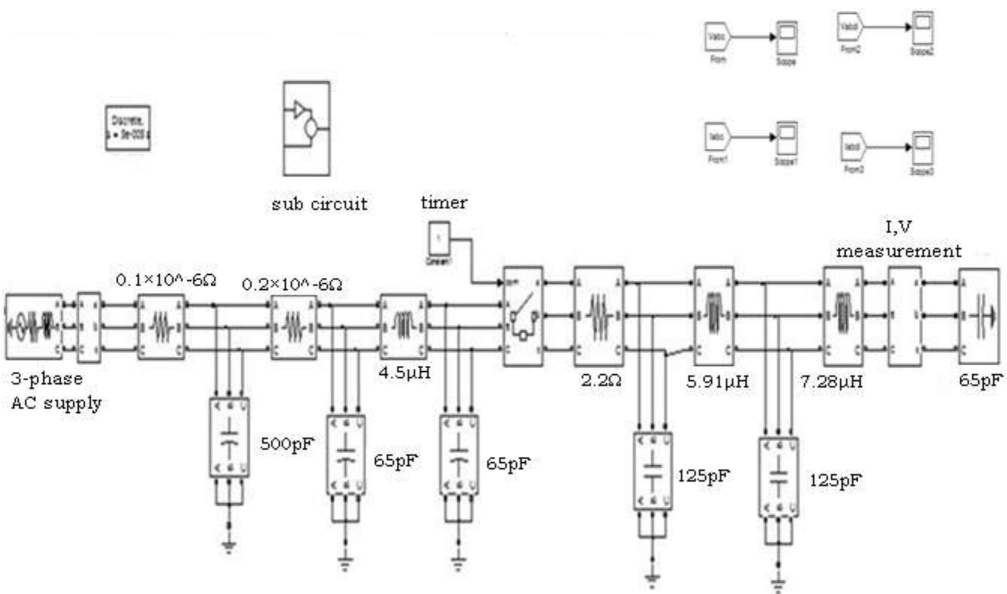

Fig.1.2 MATLAB circuit for 10mtrs length in a 3-phase 400kV GIS

To introduce current chopping the circuit breaker is opened.[6]

III. RESULTS AND DISCUSSION

The transients obtained during opening operation are shown in Fig 1.3. From the graph, the maximum voltages obtained are 3.76, 3.76 and 3.76p.u at rise times of 111, 140, and 168ns respectively. Assuming a second re-strike occurs the transients are calculated by closing another switch at the time maximum voltage difference occurs across the circuit breaker.[7][8]

The transients obtained due to second re-strike are shown in Fig 1.4, Fig 1.5, Fig 1.6 respectively. From the graph, the maximum voltages obtained are 5.45, 5.28 and 5.28p.u at rise times of 199, 228, and 258ns respectively. The magnitudes and rise times of 10mtrs length GIS are tabulated in the table 1.1.

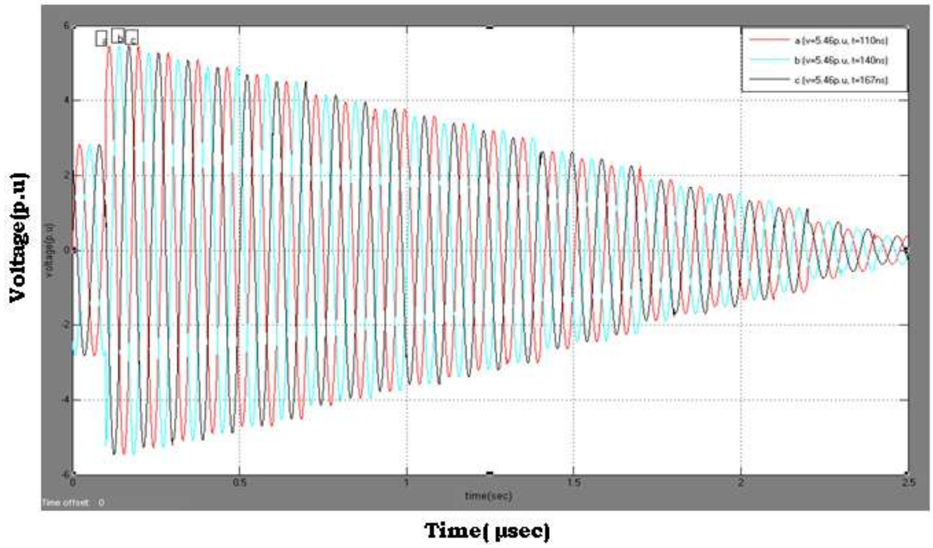

Fig.1.3 Transient (For LLL Fault) Voltage waveform during closing operation of CB for 10 mtrs from load side in a 3-Phase 400kV GIS.

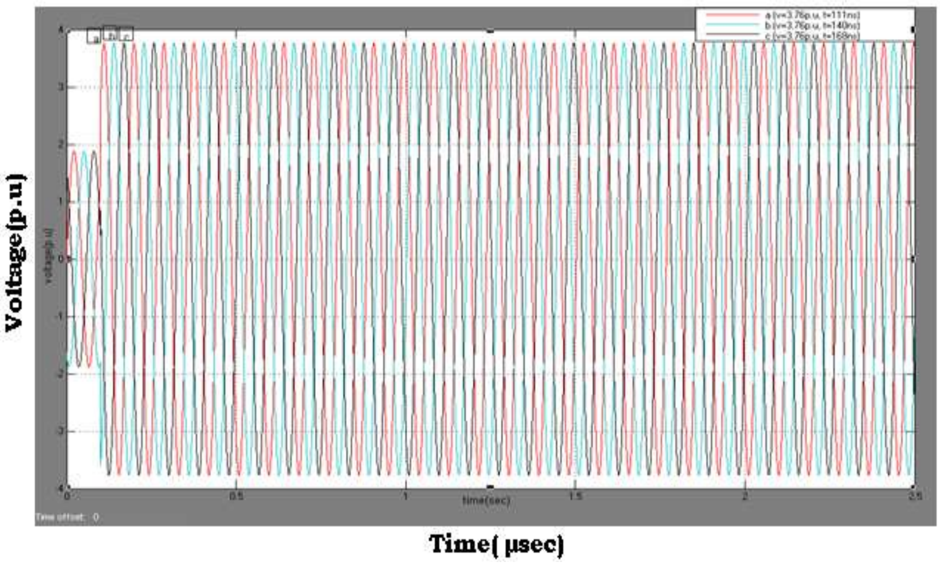

Fig.1.4 Transient (for LLL fault) voltage waveform during opening operation of CB for 10mtrs from load side in a 3-phase 400kV GIS.

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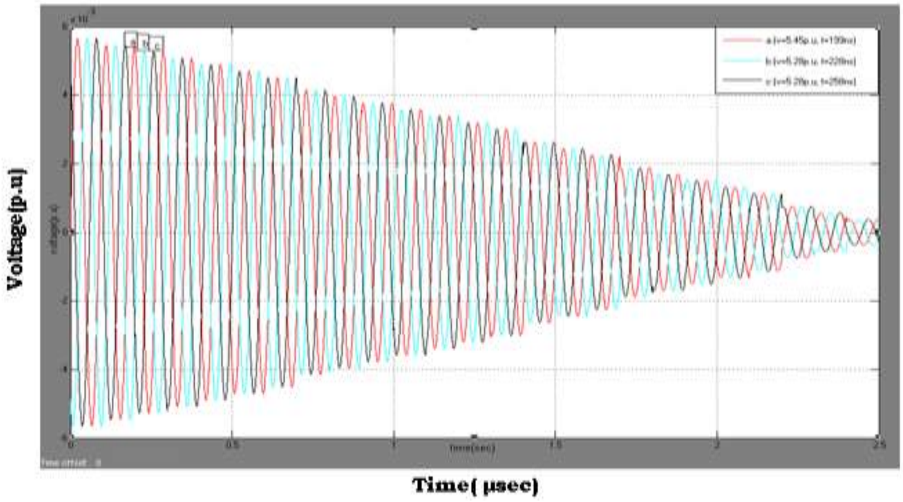

Fig.1.5 Transient voltage waveform during second re-strike of CB for 10mtrs from load side in a 3-phase 400kV GIS.

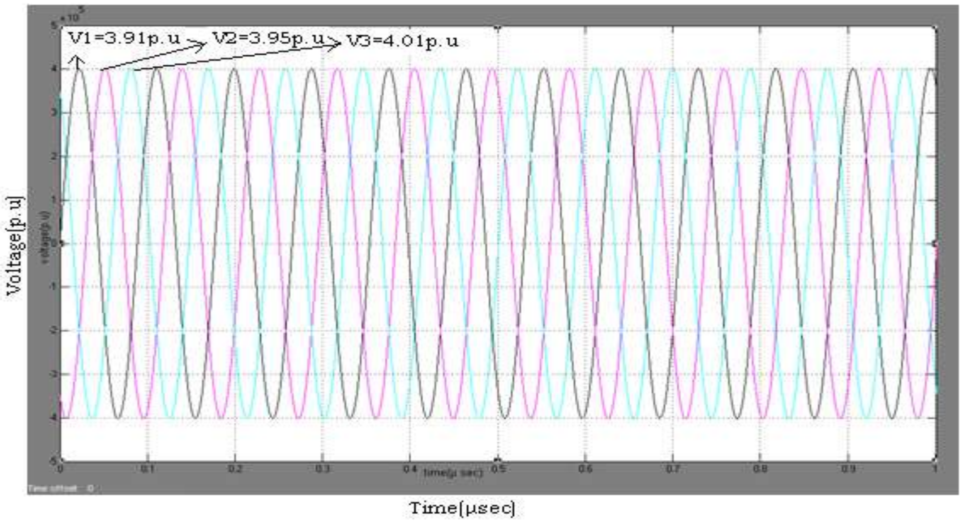

Fig.1.6 Transient voltage waveform during closing operation of CB for 10mtrs from source side in a three-phase 400kV GIS.

Table.1.1 Transients due to switching operations for 10mtrs length in a 3-phase 400kV GIS.

Mode of operation	**Peak Magnitude of voltages(p.u)**			**Rise time (Nano secs)**		
	RPhase	**YPhase**	**BPhase**	**tR**	**tY**	**tB**
During closing operation	5.46	5.46	5.46	110	140	167
During opening operation	3.76	3.76	3.76	111	140	168
During second re-strike	5.45	5.28	5.28	199	228	258

IV. CONCLUSION:

The fast transient over voltages are obtained due to switching operation of 3-phase fault with GIS system are studied. The transient voltages are calculated initially with fixed arc resistance and then variable arc resistance. The variable arc resistance is calculated by using Toepler's formulae. Transient voltages with load and without load are also calculated. The peak magnitudes of fast transient voltages are generated during switching event changes from one position to another in a 3 -phase gas insulated substations 400kV for a particular switching operation. These transient over voltages are reduced by connecting suitable resistors in series with three lines.

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