International Journal of Latest Trends in Engineering and Technology
Vol.(16)Issue(1), pp.051-056
DOI: http://dx.doi.org/10.21172/1.171.08
e-ISSN:2278-621X

ANALSIS OF OVER VOLTAGE DUE TO IMPULSE IN A POWER SYSTEM OF 400KV TRANSMISSION LINES NEAR SUBSTATION: A CASE STUDY

Niranjan Kumar Mandal[1], Narayan Malakar[1]

Abstract- Analysis has been done for over voltage caused by impulse due to switching action and lightning in a 400 kV transmission lines near substation of a power system. This study has been carried out using ATP (Alternative transient programme) simulator. Comparison has been made between the power frequency voltage and withstand switching voltage and that of withstand lightning voltage. Study has also been carried out to find the effect switching without and with pre-insertion resistor. Voltage waveforms have been shown. Some numerical calculations have been done. A flow chart has been drawn to show the methods of finding system parameters. Results have been tabulated and discussed.

Key words : ATP simulation; switching over voltage; lightning over voltage; withstand over voltage; pre-insertion resistor

I. INTRODUCTION

The study of the effects of lighting and switching surges on the power system is very important because these surges cause over voltages which effects on the performance of the circuit interrupting equipments and protecting devices [1, 2]. These surges are temporary in nature and exist for a very short duration (a few hundred micro-second). The most of the over voltage are not of large magnitude but still sufficient to cause damage to the insulators and other equipment in the power system if they are not suitably protected [3,4]. The lightning is an external cause which gives rise system voltage several times to the normal voltage. But switching surge is created by internal causes which do not produce transient voltage of large magnitude.

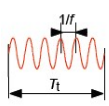
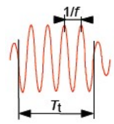
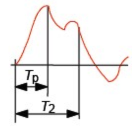
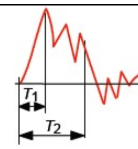
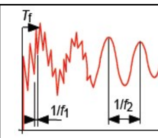
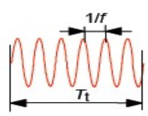
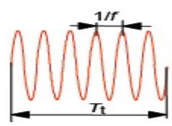
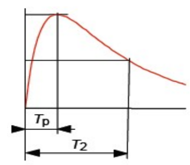
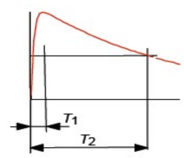
The selection of overvoltage is based on types of equipment strength during operation. It is essential to reduce over voltage to preserve of continuity of service and number of the outages.

The Table 1 shows a typical data showing the regarding the shapes of the standard normal voltage, over voltage, frequency range at different conditions. In this paper, an attempt has been made to present the results of simulation based work to control the over voltages due to switching and lightning phenomenon. Results have been tabulated, shown graphically and discussed.

Table 1: – The shapes and classes of over voltages with frequency range.

Class	Low frequency		Transient		
	Continuous	Temporary	Very front	Slow front	front of Very fast

[1] *Department of Electrical Engineering, University of Engineering & Management, Kolkata, India.*

Shapes of Voltage or Overvoltage					
Range of shapes for overvoltage or voltage	f = 50 Hz or 60 Hz $Tt \geq 3$ 600s	10 Hz < f < 500 Hz 0,02 s ≤ Tt ≤ 3 600 s	20 µs < Tp ≤ 5 000 µs $T2$ ≤ 20 ms	0,1 µs < $T1$ ≤ 20 µs $T2$ ≤ 300 µs	Tf ≤ 100 ns 0,3 MHz < $f1$ < 100 MHz 30 kHz < $f2$ < 300 kHz
shapes of Standard voltage	 f = 50 Hz or 60 Hz	 48 Hz ≤ f ≤ 62 Hz Tt = 60 s	 Tp = 250 µs $T2$ = 2 500 µs	 $T1$ = 1,2 µs $T2$ = 50 µs	

II METHODOLOGY AND SYSTEMS

A. Methodology: To study over voltage phenomena due to switching and lightning, a Flow chart has been developed as shown in Fig.1.Considering the typical level of classes and shapes of standard over voltage and withstand voltage and shapes and range of frequency, analysis has been done using ATP simulation tool. Table –I shows the above data.

Following steps have been followed to implement the flow chart according to IEC60071-1 [5].

Step-1: Assignment of Represented voltage and over voltage for Temporary over voltage, Slow front over voltage and Fast front over voltage.

Step-II : Assignment of coordination withstand voltage for power frequency, switching and lightning. Step-III : Assignment of required withstand voltage. The standard level of withstand voltage of insulator as per IS/TEC60091-112006 is shown in Table-2. [6,7].

Step –IV: Comparison of required withstand voltage with that of simulated standard output voltage and their conversion.

Calculation of voltages:

i) POWER –FREQUENCY VOTAGE AND SOURCE OF NOMINAL VOLTAGE:

In the simulation model, the nominal voltage source (Us(p-p)) is 400V is set as 1.0 p.u or 326.60 kV (crest).

The maximum operating voltage (Um(p-e)) of the equipment as 420kV is selected for the voltage of the nominal system according to[1]. The Us and Um have used further simulation and calculating model of a proper LIW and SDW voltage from Table 2 for HV types of equipment.

$$(Us(p\text{-}p)) = k_{PF} \times Us(p\text{-}e)), \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

k_{PF} is the horizontally configured of the line is 0.70 and configuration of vertical phase is 0.40

Here, Us(p-e) is crest nominal of the line to the voltage of neutral.

ii). TEMPORARY OVERVOLTAGE ($U_{rp,t}$):

The overvoltage of temporary for load rejection and earth fault conditions are determined by load rejection is 400kV line to line or 1.75 multiplier of power-frequency voltage from figure 2. The earth –fault overvoltage is 327.36kV (line to earth).

$$Urp(p\text{-}e) = 1.75 \times (U_s) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

iii) SLOW-FRONT OVERVOLTAGE ($U_{rp,s}$)

The substation 1st and substation 2nd slow-front overvoltage are 537.2kV and 565.69kV for the entrance times of capacitor bank and re-energization during conditions. The re-energization and energization of substation slow –front overvoltage times are obtained as 235.26kV and 408kV.

iv) FAST –FRONT OVERVOLTAGE ($U_{rp,f}$):

The lightning arresters rating against fast-front overvoltage at the entrance of the substation 1st is considered by overvoltage of switching impulse (Ups) and overvoltage of lightning impulse(Upl). The Upl(L-L) is 950kV and Ups(L-e) is 1050kV. .

B. Systems:

A part of the power system without pre-insertion resistor is shown in Fig.2 and another part of power system with pre-insertion resistor is shown in Fig.3.

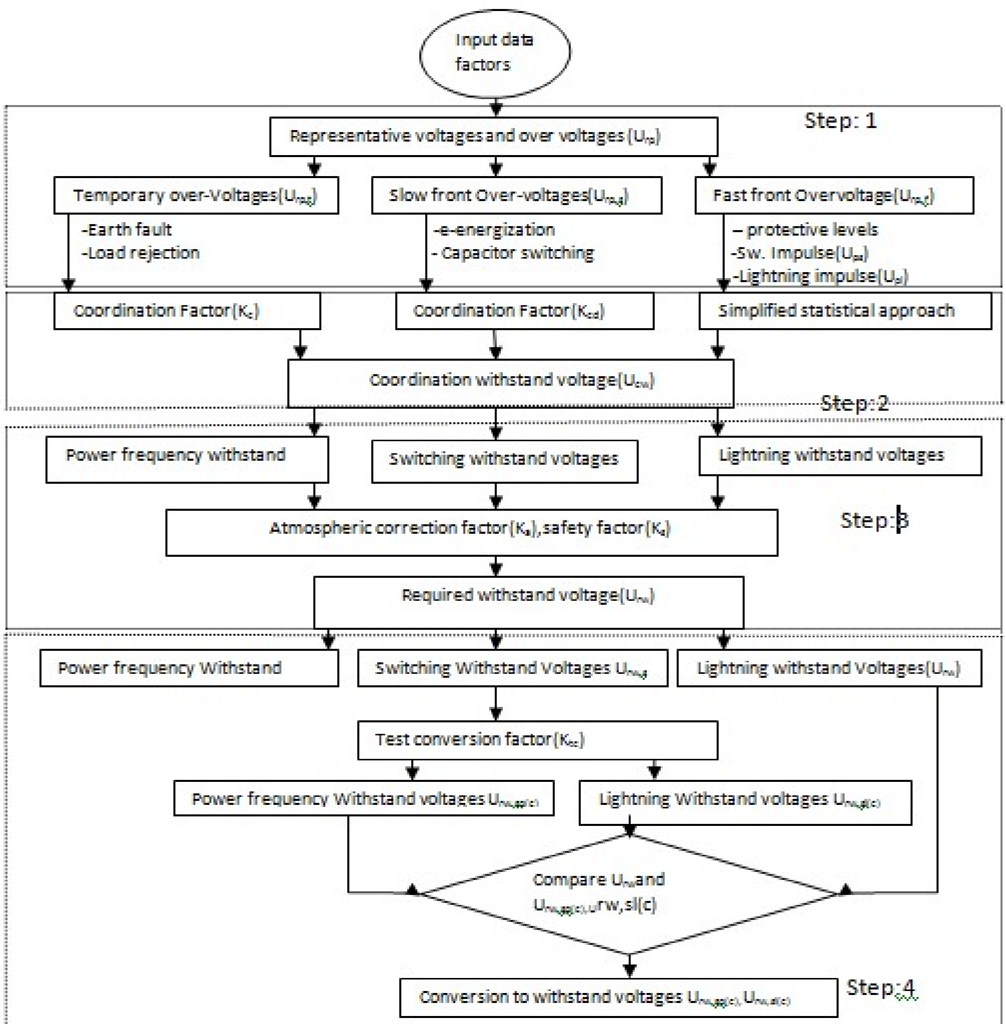


Figure 1 : Flow chat for ATP Simulation

Table 2: –Standard levels of insulation for range I (Um ≥ 245 kV) IS/IEC 60071-1 : 2006

HV equipment (U_m) kV (r.m.s value)	Short duration standard rate voltage of power frequency in kV (r.m.s.)	Withstand voltage of lightning impulse in kV (peak to peak)
920	850 950 950	850 950 1050

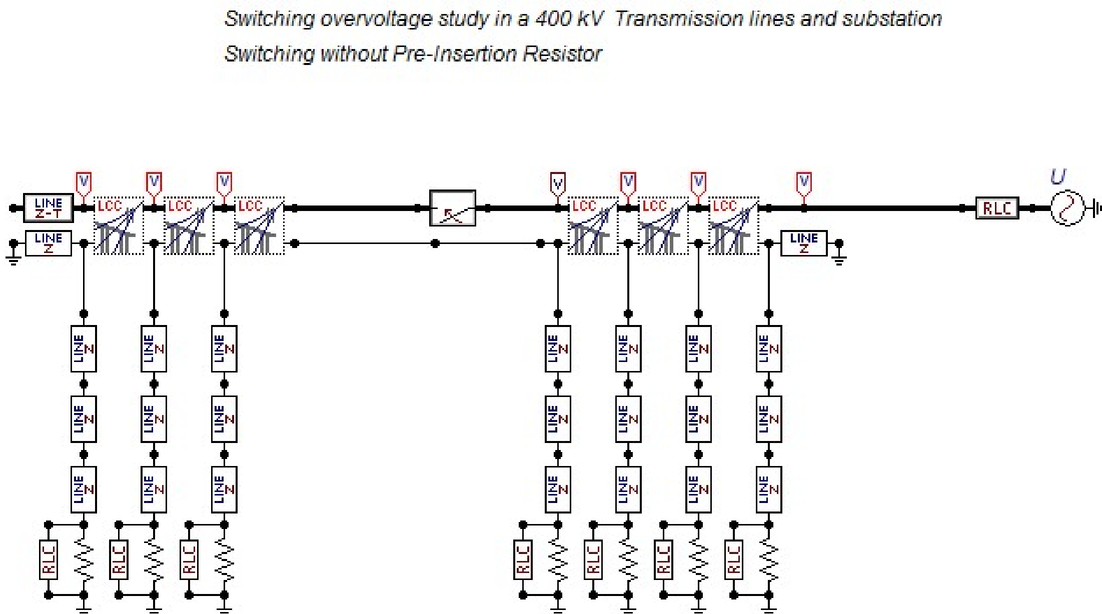


Fig.2: System without pre-insertion resistor

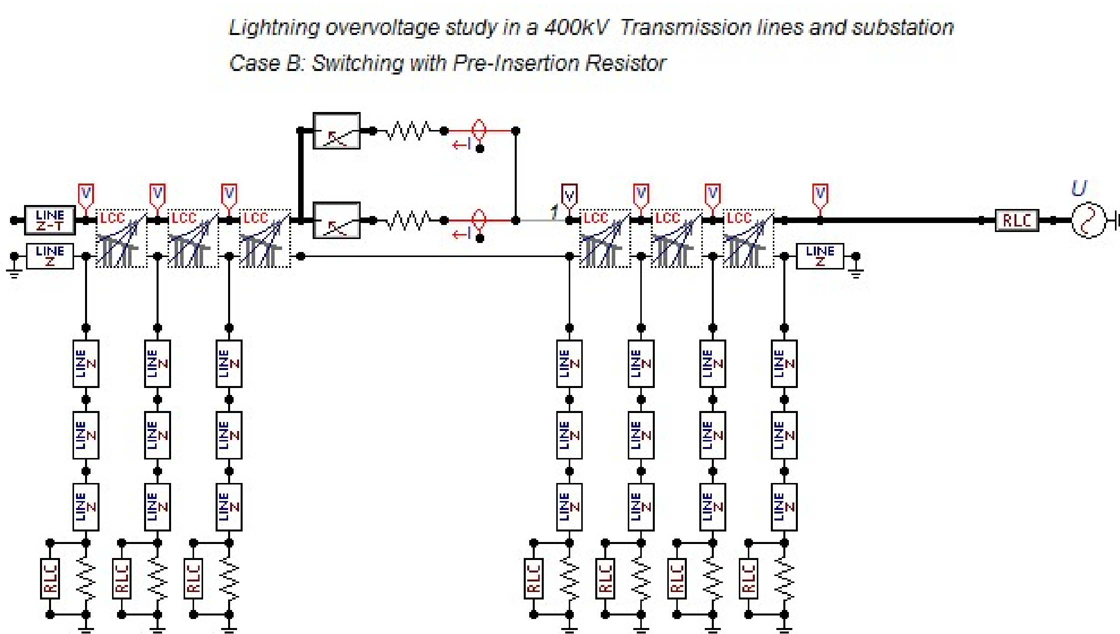


Fig.3: System with pre-insertion resistor

III. RESULTS AND DISCUSSIONS

The data obtained after simulation work are shown in TABLE-3. The Fig.4 shows the voltage waveform without pre-resistor insertion and Fig.5 shows the same with pre-resistor insertion. The function of pre-resistor is to prevent the inrush current at the time of switching. The current waveform due to switching effect is shown graphically in Fig.6.

TABLE 3:- THE SIMULATION PARAMETERS

Voltage types	**Simulation cases**		**p(p-e)KV**	**p(p-p)KV**
Power- frequency voltage (Us)				400
Temporary Overvoltage (Urp,t)	Earth -fault		327.36	-
	Load rejection		404.15	700
Switching Overvoltage($U_{rp,s}$)	Sub-2 from Overvoltage switching	Re-energization		565.69
		Switching of Capacitor banks		537.2
	ub-1 from Re-energization and Energization		235.56	408
Selected				
`Fast –front Overvoltage($U_{rp,f}$)	Voltage of Switching impulse (U_{ps})			950
	Voltage of Lightning impulse (U_{pl})		1050	

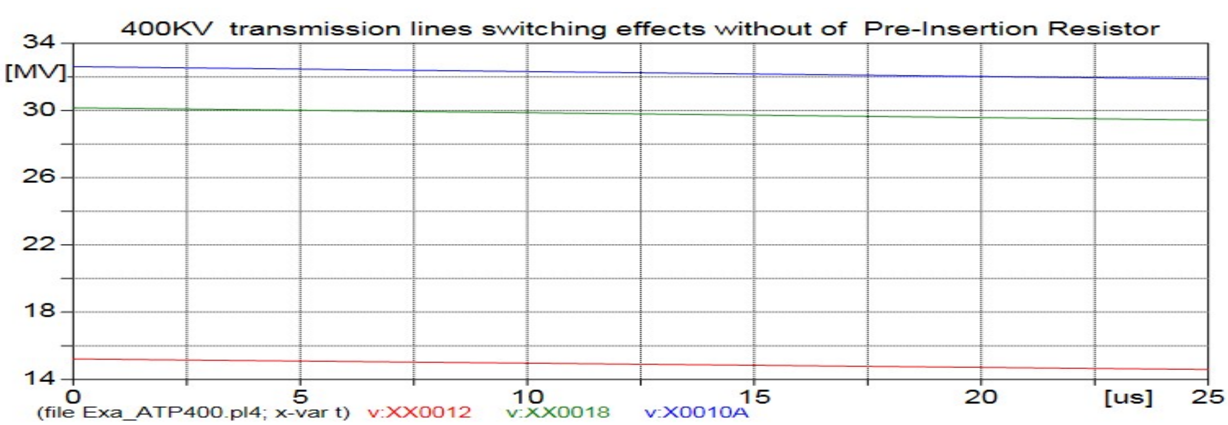


Figure 4: Voltage wave form for switching without the pre-insertion resistor

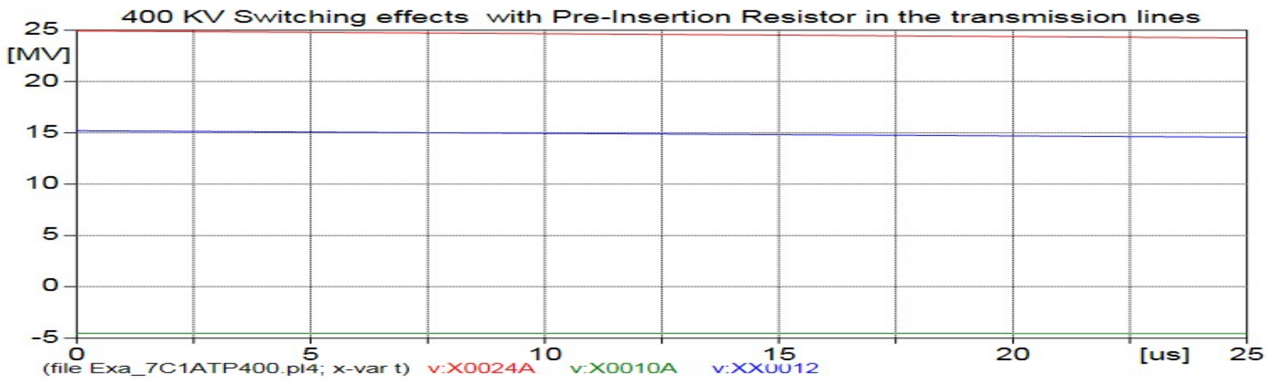


Figure 5: Voltage Waveform of Switching with Pre-Insertion Resistor

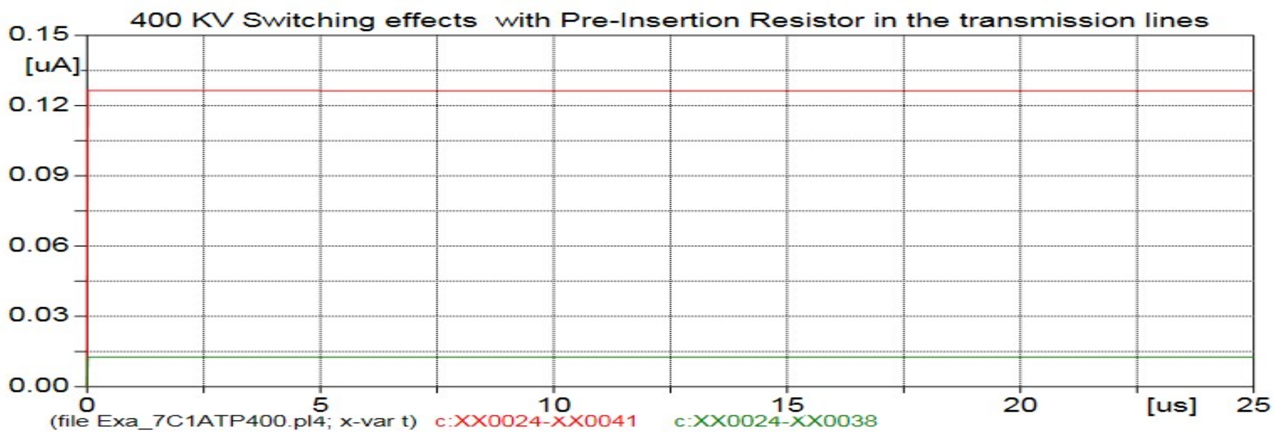


Figure 6: Current waveform due to switching action with a pre-insertion resistor

IV. CONCLUSION

The results presented in this paper are based on the simulation work done using ATP tool considering some typical standard values of the system parameters. But actual results can be obtained if we design such practical systems and do some experiments. We obtained these results making some simplifying assumptions. So, results may vary if we consider the effects of environmental and other stray parameters. But, this case study can help in finding the transient phenomena due to different faults that occur in power system.

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