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Comparison of IEEE and Pinceti Models of Surge Arresters

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Abstract

The main causes over voltages in power system are switching and lightning. The over voltages can damage the insolation of lines and equipment's connected to the power system. To protect of insulations and equipment of the power systems from the damaging effects by lightning over voltages, metal oxide surge arresters have been used. Because of dynamic behavior of the surge arresters, they can't be simulated using non-linear resistors. Therefore, several models are proposed for simulate the dynamic properties of surge arresters. IEEE and pinceti models are the main models that proposed in order to simulate the dynamic behavior of surge arresters. In this paper, for identification of surge arrester parameters, a novel algorithm has been proposed and then a comparison among IEEE model and pinceti model has been investigated.

Keywords: Metal oxide surge arrester, IEEE model, Pinceti model, parameter estimation, EMTP.

Introduction

Main causes of over voltages in power system are switching and lightning [1,2]. The over voltages in power systems can damage the insolation of lines and equipment's connected to the power system[3,4]. Surge arresters have been used to protect the insulations of apparatus in power systems from the lightning over voltages[5]. First, silicon carbide arresters are developed in power systems to protect the equipment from lightning over voltages. But this kind of surge arresters has some advantages, such as power losses, low level reliability and low speed response to the over-voltages. So, silicon carbide arresters are replaced by metal oxide surge arresters. The substitution of silicon carbide arresters for metal oxide surge arresters has brought benefits to overvoltage protection. The proper nonlinear behavior, negligible losses, very good reliability and quick response to the over-voltages are some advantages of metal oxide surge arresters[6]. Metal oxide surge arresters have frequency depended properties such as time-to-crest of the arrester current effect on residual voltage of arresters[7,8]. Because of these dynamic behaviors, surge arresters modeling in power systems software is very difficult and modeling and simulating of surge arresters is a main topic for researchers [9, 10]. IEEE and pinceti models are two models that proposed for modeling of surge arresters. These models can reproduce the frequency depended behaviors of metal oxide surge arresters properly. In this paper, IEEE and pinceti models are investigated. Also, a comparison between these models in simulating has been done

Models of Surge arresters

In power systems, the dynamic models of surge arrester are very important for insulation coordination and reliability studies [11]. Several models, at different voltage levels, are proposed to represent the frequency depended characteristic of metal oxide surge arresters[5,6]. IEEE, Fernandez, Pinceti and Popov models are the main models of surge arresters. IEEE and pinceti are more popular than other models.

Figure 1 shows the IEEE model. This model is presented by IEEE WG 3-4-11 group[7].

A_0 , A_1,R_0,R_1,L_0,L_1 and C are the elements of this model. A_0 and A_1 calculate based on data listed in table 1 [6,7].

Table-1
Data for estimated A_0 and A_1

Current (kA)	Voltage (per unit of V_{10})	
	A_0	A_1
0.01	0.875	---
0.1	0.963	0.769
1	1.050	0.850
2	1.088	0.894
4	1.125	0.925
6	1.138	0.938
8	1.169	0.956
10	1.188	0.969
12	1.206	0.975
14	1.231	0.988
16	1.250	0.994
18	1.281	1
20	1.313	1.006

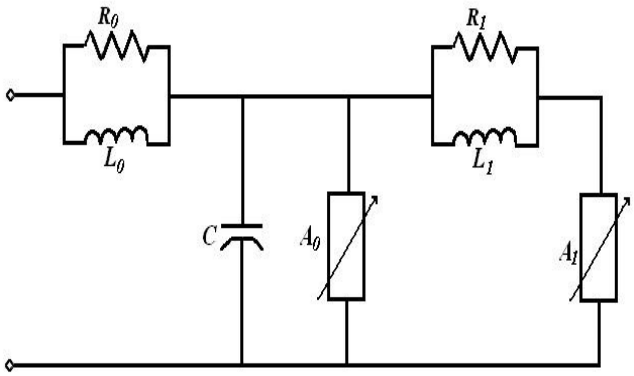

Figure-1
IEEE model

Figure 2 shows the pinceti model. For parameters estimation in pinceti model all necessary data are easily collected in datasheets, there is no need for an iterative correction of the parameters[8]. The two parallel resistances are substituted for only one, in order to avoid numerical overflow.

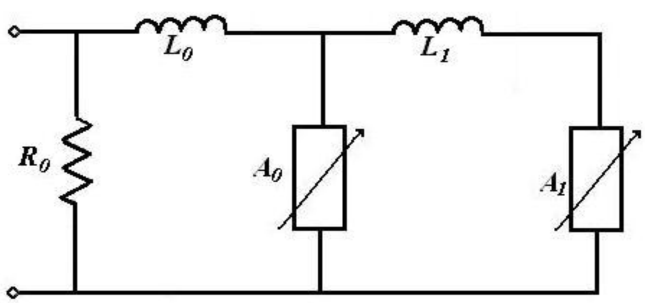

Figure-2
Pinceti model

Simulation of surge arresters by using EMTP: EMTP is popular software for simulating the transient phenomena in power systems [12]. In the EMTP Program, many types of surge arrester models are exist. The exponential non-linear resistive device is the more popular element that used for simulating the nonlinear resistors in surge arresters models. The voltage-current characteristic is represented by equation (1).

$$i = p\left(\frac{v}{Vref}\right)^{q} \quad (1)$$

Where: q: the exponent, p: a multiplier, and Vref : an arbitrary reference voltage.

Vref normalizes the equation and prevents numerical overflow during exponentiation. So, By using this software, electrical engineers can simulate the surge arresters models. Figures 3 and 4 show the simulated IEEE and pinceti models by using EMTP.

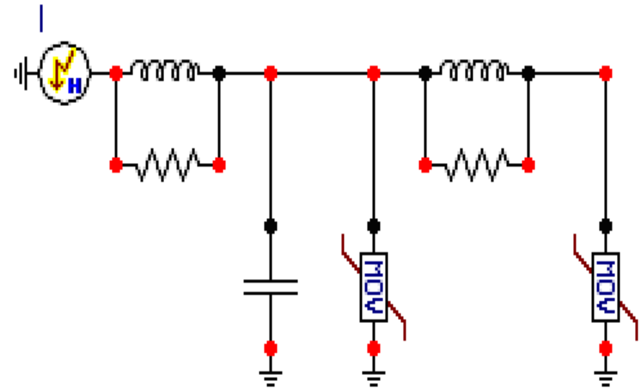

Figure-3
IEEE model in EMTP

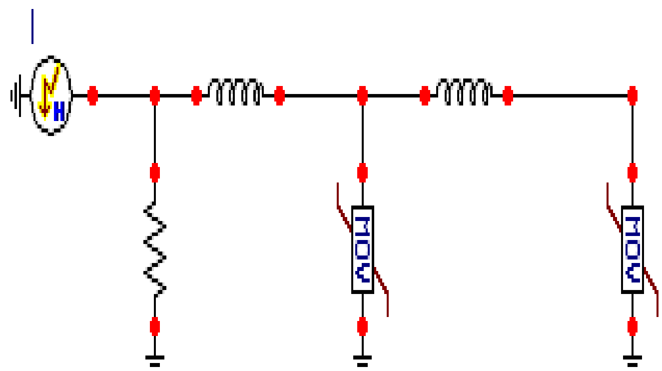

Figure-4
Pinceti model in EMTP

Presented method for parameter estimation of metal oxide surge arresters: Procedure that proposed by IEEE WG 3-4-11 group for IEEE model and procedure that proposed by pinceti et al for pinceti model cannot determine the best parameters for mentioned models, but they can used as a good estimation [5,6]. The IEEE and pinceti procedure can only apply to these models. For determination of surge arresters parameters, a common method is proposed by Nafar et al [5, 6]. The presented method is according to equation 2.

$$Error = \int_0^T [Vr(t,\bar{x}) - Vrm(t)]^2 dt \quad (2)$$

In equation 2, Error is the sum of the quadratic error,T is the duration of applied impulse current, $Vr(t, \bar{x})$ is the estimated residual voltage obtained from simulation results,Vrm(t) is the measured voltage and $\bar{x}$ is the state variable vector.

Using this procedure parameters of IEEE and pinceti Models are estimated based on experimental data given by Kim et al.[11]. The parameters of estimated models are listed in table 2.

Table-2
Parameters of estimated models

parameter	IEEE Model	Pinceti Model
$R_0(\Omega)$	0.0990	15.00
$R_1(\Omega)$	0.0891	---
$L_0(\mu H)$	0. 3998	0.0398
$L_1(\mu H)$	2.0	0.397
$C(nF)$	2.0	---
p_0	2752.79	2174.26
q_0	20.00	8.50
p_1	3641.9	2848.98
q_1	6.989	8.95
$Vreff_0[V]$	6946.225	7920.06
$Vreff_1[V]$	6999.503	6941.58

By using the data given in table 2, IEEE and pinceti models are simulated in EMTP software. Figure 5 shows the result of simulations.

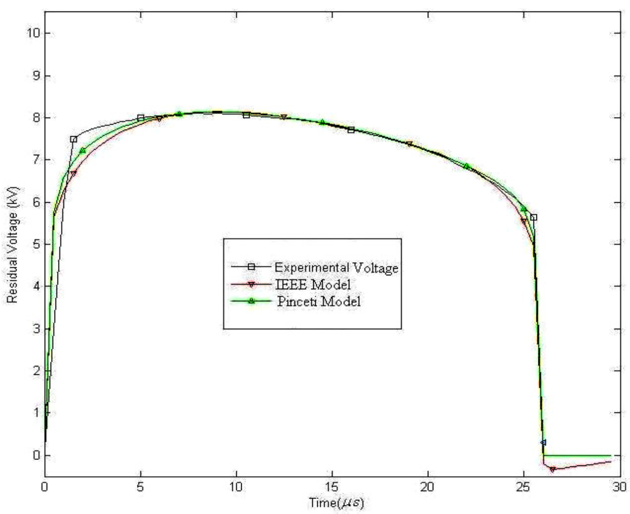

Figure-5
Residual voltage of estimated models and experimental data

Considering the results, the following points could be drawn: i. Both models can reproduce the property of metal oxide arresters precisely, ii. The presented method is a common method, iii. The presented method can be done by using any heuristic algorithm easily, iv. In pinceti model, nine parameters must be estimated and in IEEE model, eleven parameters must be estimated, so pinceti's convergence speed is faster.

Conclusion

In this paper, IEEE and pinceti models of surge arresters are studied and compared. These models have been simulated using EMTP software. The mentioned models can estimated using a new method that proposed by authors. The proposed method is a common method and using this algorithm parameters of all model can determine. Both models can reproduce the property of metal oxide arresters precisely. In pinceti model, nine parameters must be estimated and in IEEE model, eleven parameters must be estimated, so pinceti's convergence speed is faster.

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