Mathematical model of MOV surge arrester

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Abstract **The paper deals with a mathematical model of surge arrester which is a very important part of the overvoltage protection of transmission lines and the connected equipment. There is described the basic model and solved numerically. The obtained results from script in MATLAB are verified by model in LTSpice.**

Keywords **Arrester, numerical model, FDTD, Matlab, surge wave.**

I. Introduction

The paper deals with a mathematical model of surge arrester. There are three basic models of MOV surge arrester almost used for their dynamic behaviour simulation in program EMTP-ATP and Simulink. Most of publications focusing on this topic are devoted on searching parameters of those models but only some of them [1] deal with mathematical description of arrester that is needed for numerical analysis. Very often are observed following models: IEEE model [2], Pinceti model and Fernandez model. The IEEE model depicted on Fig. 1 is more detailed than others. The V-A characteristic of resistors $A0$ and $A1$ takes into account the dynamic behaviour of arrester.

II. Mathematical model of IEEE model

The nodal voltage method was used to describe the IEEE model on Fig. 1. Three differential equations for unknown voltages u_1, u_2 (on $A0$) and u_3 (on $A1$) have been formulated

$$L_0\frac{\mathrm{d}}{\mathrm{d}t}\left(-\frac{u_1}{R_0}+\frac{u_2}{R_0}\right)+u_2-u_1=-\frac{L_0}{R_v}\frac{\mathrm{d}u_0}{\mathrm{d}t}, \qquad (1)$$

$$C\frac{\mathrm{d}u_2}{\mathrm{d}t}+\frac{u_1}{R_v}+\frac{u_3}{R_z}+I_0(u_2)+I_1(u_3)=\frac{u_0}{R_v}, \qquad (2)$$

$$L_1\frac{\mathrm{d}}{\mathrm{d}t}\left(-\frac{u_2}{R_1}+\frac{u_3}{R_1}+I_1(u_3)\right)+u_3-u_1=0. \qquad (3)$$

Functions $I_0(u_2)$ and $I_1(u_3)$ are given by V-A characteristics of nonlinear resistances $A0$ and $A1$. These functions depend on the type of arrester and they can be expressed by exponential or power functions. The system of eq. 1 - 3 was solved numerically in Matlab.

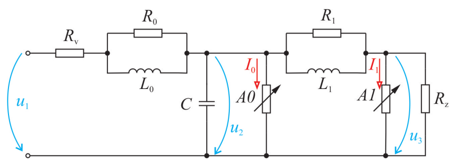

Fig. 1. Electric circuit model used for IEEE arrester

III. Illustrative example

The dynamic behaviour of 20kV arrester was studied by usage of the proposed algorithm. To verify the obtained result the same circuit was analysed in LTspice. On the fig. 2 is depicted the response on the input voltage surge wave $8/20\,\mu$s and on the fig. 3 is seen the graph received in LTspice. The agreement is sufficient, the disturbances on fig. 2 are caused by numerical oscillations.

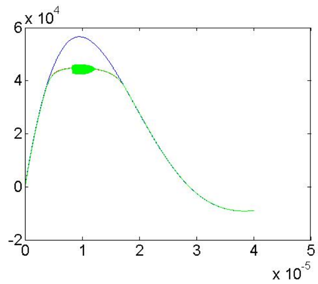

Fig. 2. The dynamic characteristics of the arrester - results from Matlab

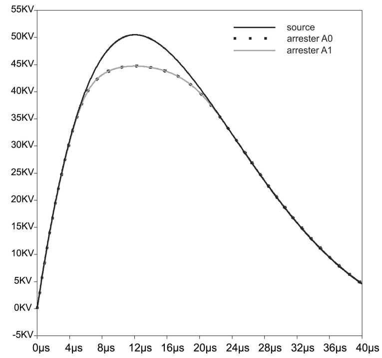

Fig. 3. Comparison of the results from LTspice

IV. Conclusion

The presented mathematical model of arrester provides a very similar response like a simulation in LTspice. The agreement with results obtained by simulation in EMTP and published in literature is also very good. From it follows the proposed mathematical description can be implemented in our algorithm for numerical solution of very fast transient phenomena on transmission line which was introduced in our previous works.

References

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