Dušan Medveď

Modeling of Power Systems Using of Matlab/SimPowerSystem

This paper deals with the modeling of transient phenomena in power system using the tool Matlab / SimPowerSystem.

Keywords: electric power system, transient phenomena, SimPowerSystem

I. INTRODUCTION

For a correct dimensioning of electric overhead lines and the correct setting of electrical relays in the power system (PS), it is necessary to know the short-circuit current conditions at the particular place of the system. It is necessary to determine the maximal and steady-state values of short-circuit currents in the PS. Calculation of the above-mentioned variables is done on the known parameters of network elements and also the connection of particular equipment – resources, overhead lines, loads. The calculation of short-circuit conditions includes all the power sources and contributions from electrical rotating machines.

Calculation of short-circuit currents is based on solving differential equations or simplified algebraic equations – it is necessary to know the impedances and power supply values of the particular circuit branches to the point of short circuit. From these data, there is calculated the value of short circuit current in the point of short circuit and also there is determined the contributions from particular power sources.

Because of arising the asymmetrical fault conditions in the three-phase systems, it is appropriate to simplify the system of nonlinear equations. Unsymmetrical three-phase system is usually replaced by symmetrical components of positive sequence, negative sequence and zero sequence system phasors.

Currently, there are many commercial and free downloadable tools that can carry out the mentioned analysis. One of the frequently used is the tool of Matlab and its toolbox Simulink/SimPowerSystem, in which there were realized the following simulations of transients on the selected part of the radial network (area in the eastern part of Slovakia).

II. ANALYSIS OF TRANSIENT PHENOMENA IN 22 KV GRID

In this section, there will be presented the results of simulations of some selected transients that may occur in the 22 kV network.

Network model is determined by parameters of the model elements. As the network is ineffectively grounded, one of the transients can be a ground connection. Model of PS is a part of the 22 kV network located in eastern Slovakia. The data of transformers, overhead lines and power supply were assigned according to provided data. The loads were intended on the optimal operation loads conditions. The system has 17 load locations; every load location has its switch for disconnection, respectively connection. In the case of multi-load branches in one node, there is placed common switch for switching the entirely section.

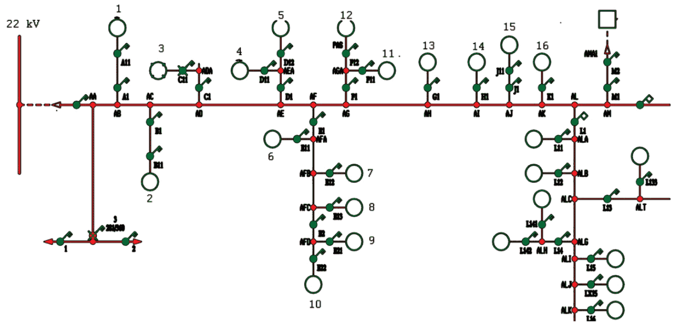


Figure 1. Scheme of a selected part of the PS

According to presented scheme in Fig. 1, there is created in Matlab/SimPowerSystem a network model (Fig. 2).

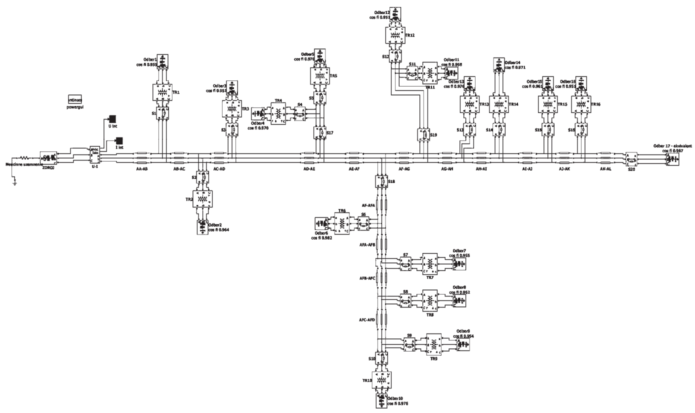


Figure 2. Scheme of a selected part of the PS in Matlab/SimPowerSystems

In Fig. 2 there is presented the PS model, it is an inefficient grounded network. There are located also particular out-coming lines, respectively loads. The presented part (section) has a length of main overhead line AA-AL 8121 m. Sections have their main switches, which are labeled S17-S20. These switches, if it is necessary, in the case of repairing or revision, disconnect the entire section from the supply voltage source. Transformers transform voltage level from 22 000 V to 420 V in the loads sections. Another data of model elements were assigned by available technical specifications.

III. 3-PHASE SHORT-CIRCUIT ON OVERHEAD LINE

In this type of failure there it occurs by the metal connection of all three phases. In Fig. 3 there is a part of a network, where there was localized 3-phase short-circuit failure. In this case, the load No. 17 is disconnected. Three-phase short circuit occurred before load switch No. 8 at time $t_1 = 0{,}04$ s, and the failure was removed at time $t_2 = 0{,}1$ s.

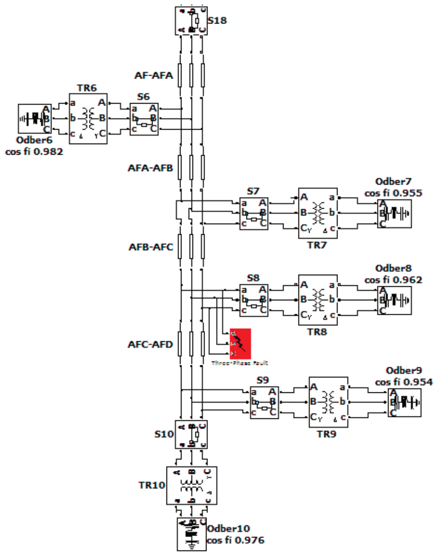
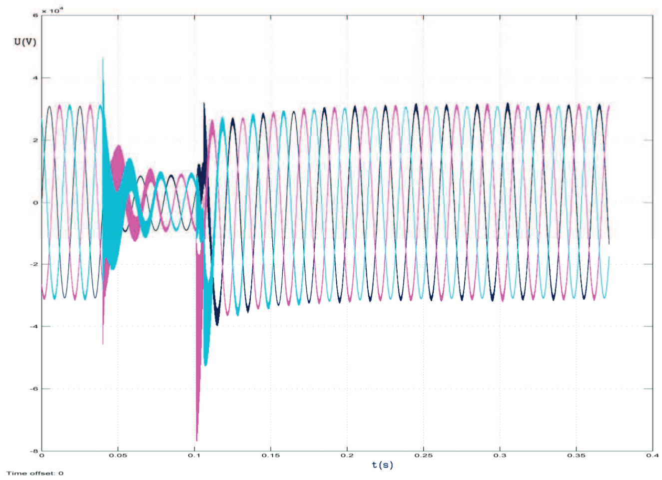


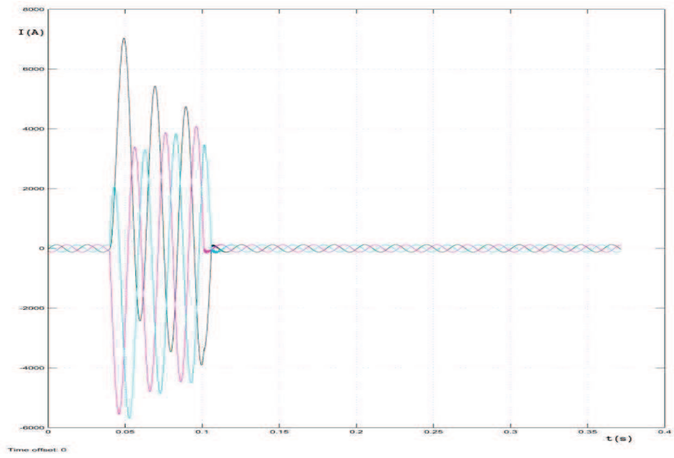
Figure 3. Part of the PS with highlighting on fault location (3-phase short-circuit)

As one can see in figure. 4a, there is a occurring of overvoltage in all three phases. During a short circuit rising, in phase L3 it can be read at the time of $t_{k1} = 0{,}0401$ s the value of overvoltage on voltage level $U_{3k,\max} = 32\ 996$ V. After removing the fault (at the time of 0,1 s) then occurs to repeat overvoltage with the highest voltage level in phase L2 to $U_{2K,\max} = 54\ 327$ V (at the time of $t_{k2} = 0{,}1017$ s) in the negative half period. To eliminate overvoltage and impulse currents, it is recommended, as in this case, using of overvoltage arresters.

During a short circuit there are occurred the increasing of current from $I = 89{,}02$ A to a peak short-circuit current in phase L3 of $i_{p3} = 4977$ A (at time $t_1 = 0{,}049$ s) (Fig. 4b). Such impulse currents can be very dangerous for the devices in the network. For dimensioning of the equipment and setting overcurrent protection it is therefore necessary to ensure proper setting of the protection. Improper setting of protections could cause a permanent dynamic and thermal effects of short-circuit current that can damage equipment in the network.



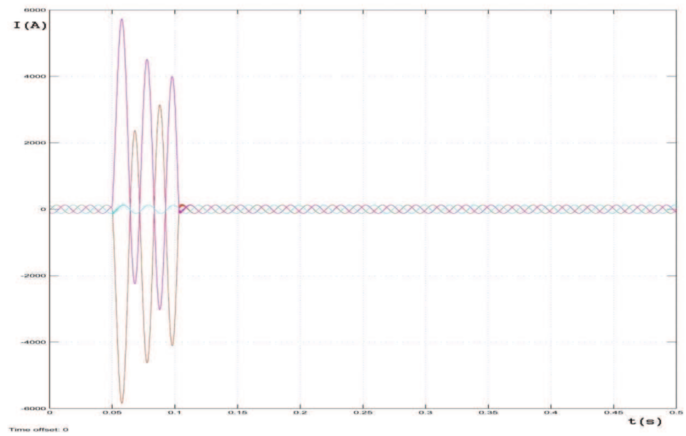
a)



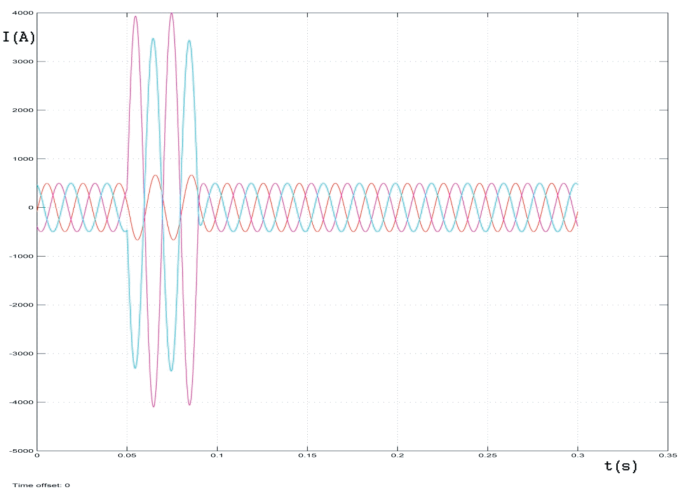
b)

Figure 4. Characteristics of voltage (a) and current (b) during the three-phase short circuit

According to similar procedure there can be determined the characteristics and values of another types of failures, such as the example in Fig. 5.



a)



b)

Figure 5. Characteristics of the current during the two-phase metal (a) and 2-phase earth short-circuit (b)

ACKNOWLEDGMENT

This publication is the result of the Project implementation: Research centre for efficient integration of the renewable energy sources, ITMS: 26220220064 supported by the Research & Development Operational Programme funded by the ERDF.

We support research activities in Slovakia / Project is cofinanced from EU funds.

REFERENCES

[1] NEMERGUT, Lukáš: *Modelovanie elektrizačných sústav využitím nástroja Matlab/SimPowerSystem*. (Modeling of power systems using the tool of Matlab/SimPowerSystem). Diplomová práca. Košice: Technická univerzita v Košiciach, Fakulta elektrotechniky a informatiky, 2012.

[2] KOLCUN, Michal - CHLADNÝ, Vladimír - VARGA, Ladislav - BEŇA, Ľubomír - ILENIN, Stanislav - LEŠČINSKÝ, Peter - MEŠTER, Marián: *Analýza elektrizačnej sústavy*. Košice: FEI-TU, 2005. 419 s. ISBN 80-89057-09-8.

[3] MEDVEĎ, Dušan: *Electric losses modeling of decentralized power sources connection using EMTP ATP*. In: ELEN 2010, ČVUT Praha, 2010, p. 1-9. ISBN 978-80-254-8089-2.

[4] MEDVEĎ, Dušan - HVIZDOŠ, Marek: *Modelovanie v prostredí EMTP - ATP*. 1. vyd. Košice: TU 2011. 74 s. ISBN 978-80-553-0776-3.

[5] MEDVEĎ, Dušan: *Modelovanie prechodných dejov pri pripojovaní rozptýlených zdrojov energie v prostredí EMTP ATP*. In: Elektroenergetika, Vol. 3, No. 7, 2010, p. 15-18. ISSN 1337-6756.

[6] HVIZDOŠ, Marek: *Modelovanie prevádzkových a poruchových stavov v elektrizačnej sústave*. In: E2006/10 - Simulace a dynamické modelování systémů a procesů v elektrizační soustavě, EGÚ Praha, 2006, p. 1-16.

[7] *Documentation – SimPowerSystems*. [Online] Dostupné na internete: < http://www.mathworks.com/help/toolbox/physmod/powersys/ >

[8] *SimPowerSystems™ – User's Guide* [Online] < http://www.mathworks.cn/help/pdf_doc/physmod/powersys/powersys.pdf >

ADDRESS OF AUTHOR

Ing. Dušan Medveď, PhD., Technická Univerzita Košice, Katedra elektroenergetiky, Mäsiarska 74, Košice, SK 04210, Slovak Republic, Dusan.Medved@tuke.sk