Using Of MATLAB Simulink for Education in High Voltage Technics and Relay Protection

Mediha Mehmed- Hamza [1] Margreta Vasileva[2]

Abstract – **Models of the electrical grid medium voltage (20 kV) and relay protection, developed in MATLAB SIMULINK, are presented in the article. These models are used for researching the short circuits processes and relay protections operation. The developed models are used for determination of the temporary overvoltages` rate frequency and metal oxide surge arrestors` energy capability. Standard libraries of SIMULINK are used as well as authors' own models.**

Keywords – **Relay Protection, Surge Protective Devices**

I. Introduction

Using MATLAB SIMULINK gives opportunities for visualizing of the studied work regimes of the equipment in the power system. Creating of the laboratory exercises and seminars in High Voltage Technics, Relay Protection and Control systems gives opportunities to increase the interest of the students and to intensify their self work.

Models of the electrical grid medium voltage (20 kV) and relay protection, developed in MATLAB SIMULINK, are presented in the article. These models are used for researching the short circuits processes and relay protections operation. The developed models are used for determination of the temporary overvoltages` rate frequency and metal oxide surge arrestors` energy capability. Standard libraries of SIMULINK [3, 4] are used as well as authors' own models.

II. Description of the simulation model

Figure 1 shows the model scheme of the researched electrical grid 20 kV. The model includes the following blocks: System 110 kV (S), Power Transformer 110/20 kV (PT), Power Line Model (AC-70), load (B), short circuit model (Fault), subsystem for relay protection (RP), subsystem for metal oxide surge arresters (MOSA) and measuring elements. The standard libraries of MATLAB SIMULINK for the blocks PT, AC70, B, Fault and MOSA and authors' own models for the subsystem – relay protections and supply system are used.

[1] Mediha Hamza is with the Faculty of Electrical Engineering at Technical University of Varna, 1 Studentska Street, Varna 9010, Bulgaria, E-mail: mediha.hamza@mail.bg.

[2] Margreta Vasileva is with the Faculty of Electrical Engineering at Technical University of Varna, 1 Studentska Street, Varna 9010, Bulgaria, E-mail: greta_w@mail.bg.

III. Short circuit originate processes researching

Using the model scheme (Fig. 1) the short circuits originate processes in the grid can be visualized. Figure 2 shows the current and voltage variation at single-phase fault in the power line beginning.

In MOSA there is no follow current because this is prevented by the extremely non-linear voltage current characteristic. It is for this reason that MOSA are capable of bearing increased operational voltages over a longer period of time. The strength T of the arrester in the presence of such temporary overvoltages is described in [1]. T is then a measure for the permissible height of U_{TOV}. The higher T and respectively U_{TOV}, the greater the power generated in the arrester. Because the MO temperature cannot exceed a certain value for reasons of stability, is the energy supplied to the arrester also limited. For that reason the permissible load duration t decreases with the magnitude of T resp. U_{TOV}. The curve is valid for arresters which at the time t = 0 are already preloaded with the specified energy E.

$$T = \frac{U_{TOV}}{U_r} \quad (T_r) \quad \text{or} \quad T = \frac{U_{TOV}}{U_c} \quad (T_c) \qquad (1)$$

U_r – Rated voltage of MOSA; U_c – maximum continuous operating voltage of MOSA [1].

The magnitude of the temporary overvoltages at single-phase fault can be read on Figure 2,a.

MOSA`s U_c or U_r should read from catalogues and the coefficient T is calculated. The energy capability time can be read from the curves [1].

IV. Short circuit Relay protection operation

For fault protection in the electrical grids MV Maximum Current Protection Relays (MCPR), Instantaneous Overcurrent Protection Relays (IOPR) and Earth Fault Protection Relays (EFPR) are mostly used [2]. Developed models of MCPR, IOPR, EFPR need the following entrance data: the primary operation currents and the tripping time. When the regime parameters monitored by the protection are bigger then set up parameters the simulation stops.

The researched power line is built from conductors type AC 70 and its length is 15 km. IOPR is used as quickly acting protection against interphase short circuits.

Figure 3 shows the current and voltage variation at three phase short circuit. The distance between the beginning of the power line and the fault point is 5 km. The fault arises in the

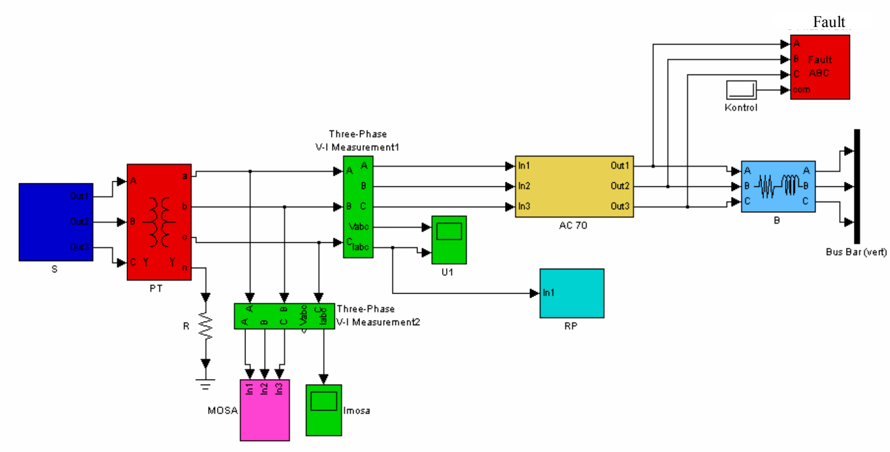

Fig. 1. Model scheme of the researched electrical grid 20 kV

moment 0, 02 s after starting of the simulation. IOPR trips after time delay of 0,03 s and stops the simulation.

MCPR is used for protection against interphase short circuit. It hasn't got a dead zone but it hasn't got and quick operation. The setting up of the MCPR is 240 A and tripping time 0,8 s. Figure 4 shows the current and voltage variation at two phase short circuit at the end of the power line.

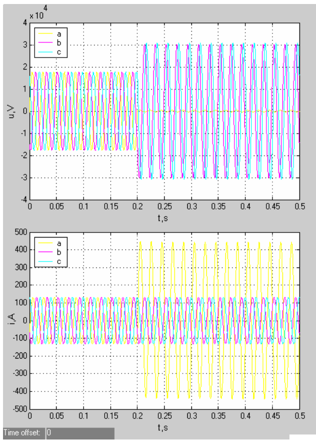

Fig. 2. Voltages and current at one phase fault in the power line beginning

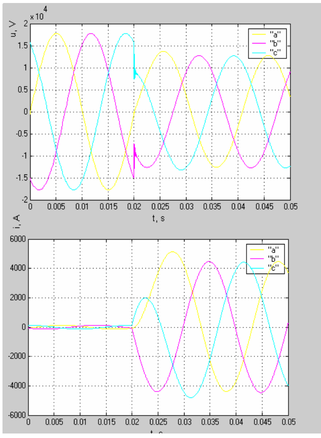

Fig. 3. Voltages and currents in three phase fault distant 5 km from the beginning of the power line

The power transformer neutral is grounded via an active resistance on the medium voltage side. This gives a possibility for used of a selective EFPR. The setting up of this protection is 42 A and tripping time 0,5 s. The protection operation and the simulation stops at one phase fault. Figure 5 shows the current and voltage variation at one phase fault at the end of the power line.

The stop of simulation is not viewed because of the tripping time is too big.

V. Analysis and Conclusion

The students can mould the following situations by switching on or switching off the different blocks and plot the graphics. The advanced approach and the simulation scheme

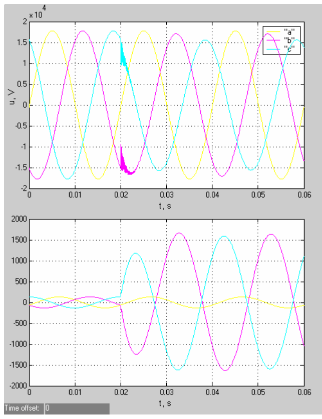

Fig. 4. Voltages and currents at two phase fault at the end of the power line

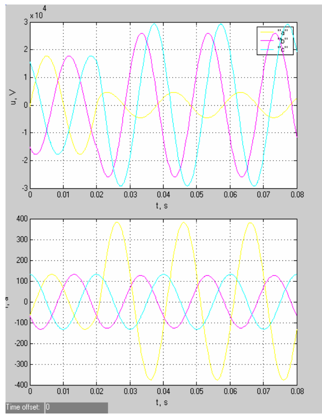

Fig. 5. Voltages and currents at one phase fault at the end of the power line

offer to the students a possibility for unaided study of each short circuit, overvoltage, MOSA` energy capability and relay protection operation. This will undoubtedly lead to most sound knowledge.

References

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