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Program ATP/EMTP in overvoltage education

1. Introduction

Characteristic feature of present electric and electronic devices and systems is a small resistance for different types of overvoltages. Design and realization the correct operation of electric and electronic systems required the basic information about the overvoltages and overvoltages protection in these systems.

Taking above facts into account, from few years at the Bialystok Technical University the information about these problems were presented in the Electric Engineering program in two subjects:

- High voltage technique,
- Protection against electrical disturbances.

The current power engineering education has been influenced greatly by the difficulty of fully analyzing the large and complex power systems. Therefore a well-planned overall concept is required. In above subjects some part of student's exercises was made using ATP/EMTP.

2. Alternative Transients Program for Electromagnetic Transients calculations

EMTP is a summary from Electromagnetic Transients Program. Licensing to use ATP (Alternative Transients Program) is free of all charge for all who have not engaged in EMTP commerce – so it's ideal for education purposes. Undergraduate students are not licensed personally, i.e. they should be supervised by professors and lecturers at universities. ATP is a universal program system for digital simulation of transient phenomena of electromagnetic as well as electromechanical nature. With this digital program, complex networks and control systems of arbitrary structure can

be simulated. ATP has extensive modeling capabilities and additional important features besides the computation of transients [1].

Typical EMTP studies are: lightning and switching transients analysis, statistical and systematic overvoltage analysis, very fast transients in GIS and groundings, machine modeling, motor startup, shaft torsional oscillations, ferroresonance, power electronic applications, circuit breaker duty (electric arc), current chopping, FACTS devices: STATCOM, SVC, UPFC, TCSC modeling, harmonic analysis, network resonances, protective device testing [1].

3. ATP/EMTP in overvoltage education

For illustrative purpose how the ATP/EMTP can be used, we considered the following systems: medium-voltage (MV) overhead line - MV/LV transformer - LV power underground cable connecting the distribution transformer and electrical installation in residential house without lightning protection system (Fig. 1). This is a typical electric circuit used for households.
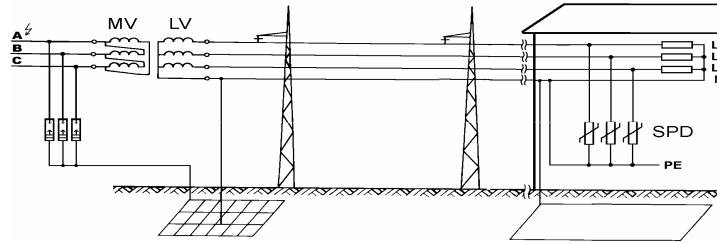

Fig. 1. Analyzed MV/LV distribution system [3].

In analysis, the lightning currents 10 kA (peak value) and shapes 10/350µs or 0,25/100 µs were used for simulation the first and subsequent lightning strokes. These lightning currents were defined by typical equation:

$$i = \frac{I_{max}}{h} \cdot \frac{(t/\tau_1)^{10}}{1+(t/\tau_2)^{10}} \cdot \exp\left(-\frac{t}{\tau_2}\right) \qquad (1)$$

where:

I_{max} – the peak value, h – the correction factor for the peak value, t – time,

τ_1 and τ_2 – front and tail constants.

The elements in ATP/EMTP program and circuits diagram of MV/LV distribution system are presented in Fig. 2 and 3.

Fig. 2. Lightning voltage/current sources in ATP/EMTP program (from left side: two exponentials surge source, Heidler surge source, 1-phase metal oxide varistor, 3-phase metal oxide varistor, Zener's diode).
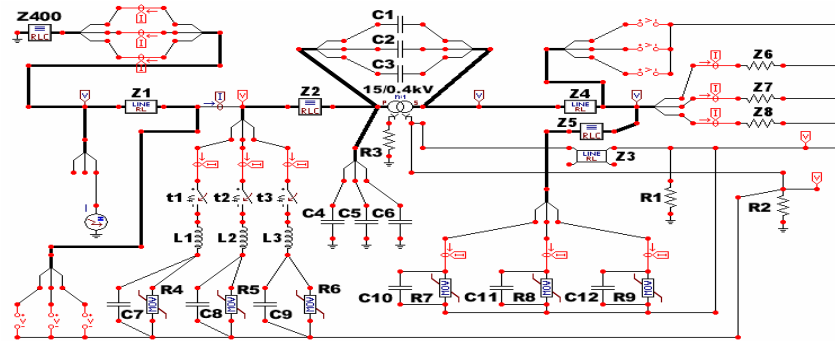

Fig. 3. Circuit diagram in ATP/EMTP of MV/LV system used in calculation [3].

The computer simulation allowed an evaluation of voltage and current surge distribution in MV/LV electric systems, giving information about currents in MV and LV arrester's, voltages on the loads in LV installation, potential differences between the LV phase conductors and trough earth. Direct connection between surge arrester grounding and substation grounding by the MV side creates dangerous to the LV side. The overvoltages, which were caused by the surge currents in earthing system of transformer, were transferred to the LV installation and normalized by SPD's (Fig.4).

Using of ATP/EMTP permit to evaluate basic and advance system's behavior during lightning strike to the wires of MV overhead lines.

ATP has got build in module called MODELS. This part of the ATP/EMTP is a description language supported by an extensive set of simulation tools for the representation and study of time-variant systems. MODELS can be use by students to modify and improve ATP/EMTP.
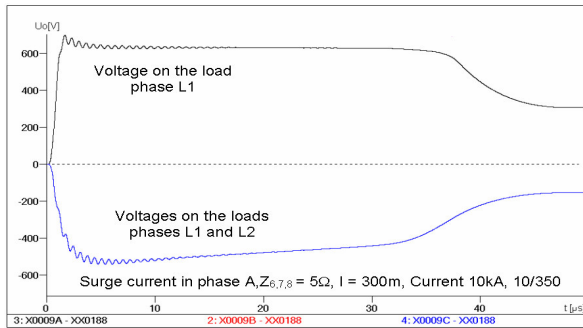
Fig. 4. Lightning overvoltages on the distribution system load protected by SPDs [3].
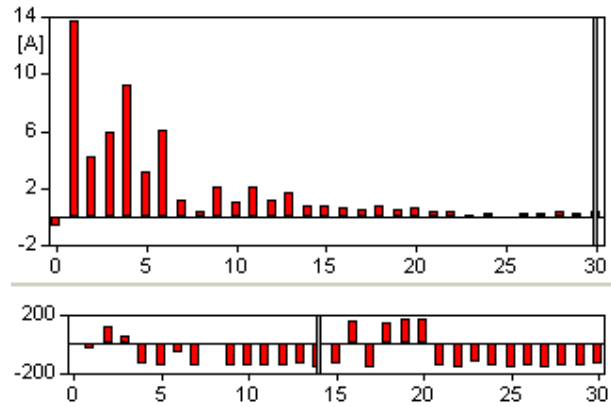

Fig. 5. Calculation of frequency response of household load using frequency scan feature.

4. Conclusions

Students in lab can describe different systems during education process. From time dependent RLC elements to the complicated FFT analyzes. No absolute limits have ever been observed in Bialystok Technical University. Hardware requirements are low for current processors. ATP/EMTP is also available for LINUX. Many universities in a world changed computer operation systems from Windows based to LINUX ones. Major conclusions: this program is ideal for education purposes.

Literature:
1. http://www.emtp.org/
2. Silva J.P., E Araujo A., Paulino J.O. "Calculation of Lightning Induced Voltage in Overhead Power Distribution Lines Protected by Metal Oxide Arresters: EMTP Simulations". 25th International Conference on Lightning Protection, 9.8, ICLP 2000, Rhodes-Greece
3. Sowa A., Wiater J. "Overvoltages in low-voltage power distribution systems caused by direct lightning strokes to medium voltage lines". VII International Symposium on Lightning protection : VII SIPDA, Curitiba, Brasil, November 17-21, 2003

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