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COMMUNICATIONS

CO–ORDINATION OF THE OPERATION OF THE RELAY PROTECTION AND SURGE PROTECTIVE DEVICES IN ELECTRICAL POWER NETWORKS MEDIUM VOLTAGE 20 kV

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The paper presents a model of electrical power network 20 kV in MATLAB Simulink and results based on it. The aim of the paper is to research the co- ordination of the operation of the numerical relay protection and surge protective devices in these grids. The researches are fulfilled in case of a direct stroke of a single or repeated lightning over the phase conductor of an overhead power line at different relay protection settings.

The recommendations about the setting up of quick operating relay protection and energy capability of the metal oxide surge arresters are given based on the model researches in MATLAB Simulink.

K e y w o r d s: lightning overvoltages, metal oxide surge arrester, numerical relay protection

1 INTRODUCTION

The most widespread electrical distribution network medium voltage in Bulgaria is this with the voltage of 20 kV. There are different kinds of erection of the grids 20 kV — the overhead power line or the cable. The bigger part of them is an overhead power line. Reliability of the overhead power lines is the most important feature for the continuity of the supply of the consumers.

Nowadays the following reliability indexes are used to measure distribution reliability of electric power utilities

- Customer Average Interruption Duration Index (CAIDI);
- Customer Average Interruption Frequency Index (CAIFI);
- System Average Interruption Duration Index (SAIDI);
- System Average Interruption Frequency Index (SAIFI);
- Momentary Average Interruption Frequency Index (MAIFI).

Thereby ensuring of the continuity of the supply is a very important task for the electrical power companies.

One of the methods to achieve the reliability of the electric power utilities is the correct operation of the relay protection and the advisable choice of the surge protective devices.

The aims of the paper are:

– To coordinate the operation of the quick operating relay protection (QORP) and the surge protective devices (SPD) under an influence of the lightning overvoltages due to strokes of lightning over the electrical power networks 20 kV

– To suggest recommendations about setting up of quick operating relay protections and energy capability of metal oxide surge arresters in order not to activate wrongly QORP due to lightning overvoltages.

2 THEORETICAL PART

Maximum Current Protection Relays (MCPR), Instantaneous Overcurrent Protection Relays (IOPR) and Earth Fault Protection Relays (EFPR) are usually used for protection against short circuits in the overhead power networks 20 kV. Current settings of MCPR depend on maximum load current and the time settings - by grading of the tripping time.

The use of the Earth Fault Protection Relays depends on the work regime of the neutral of the power transformer — 20 kV and relay protection activation is with a delay.

IOPR are used for receiving of fast tripping for the short circuits. The current setting is determined by the maximum short circuit current at the end of the protected power line and the over dimension factor. IOPR is a fast tripping relay and the overall tripping time is equal to the own delay time of the relay. Nowadays the numerical protective relays are usually used due to their advantages. One of them is their fast tripping, *eg* they can activate the breaker within the frames of 4 to 10 ms.

Metal oxide surge arresters (MOSA) are the devices for limiting of the overvoltages and they are with the best protective parameters. They can ensure large coordination interval at the insulation coordination under lightning and switching overvoltages [4]. Except their good characteristics MOSA have considerable energy capability under the lightning overvoltages. According [3] MOSA

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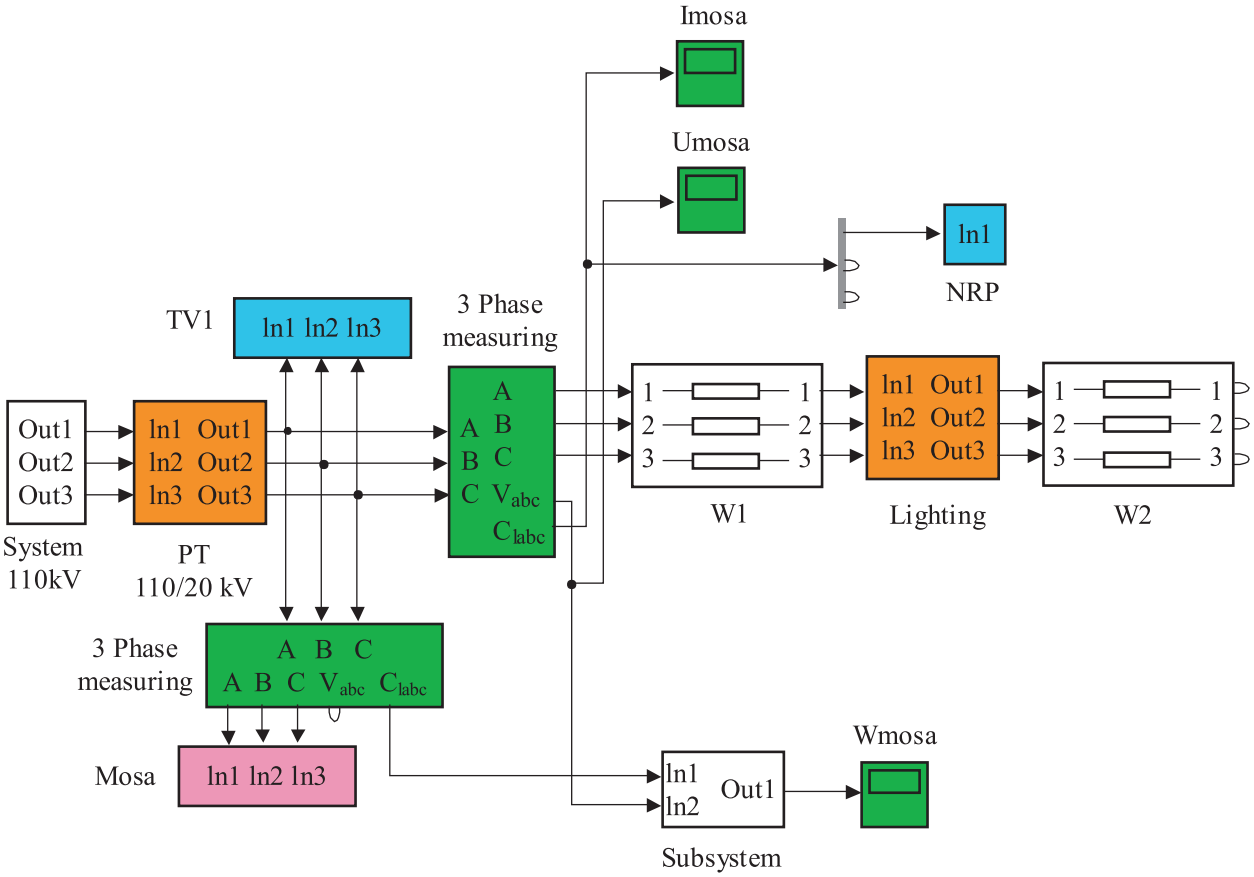

Fig. 1. Model scheme of the researched system

can stand a lightning current up to 100 kA in the electrical grids 20 kV.

3 DESCRIPTION OF THE RESEARCH MODEL

The electrical system under consideration consists of: a supply system 110 kV, a power transformer 110/20 kV, an overhead power line 20 kV (OPL) and voltage measuring transformers. As protective devices against overvoltages MOSA are used and as a protective relays against short circuits IOPR are used.

The model of the researched system is built in MATLAB SIMULINK and it is given in Fig. 1. The researches are done at the different parameters of the model:

- The kind of the OPL conductor (non-insulated aluminium- steel conductors with a cross-section 50, 70 and 95 mm^2);
- The length of the OPL (from 5 to 40 km);
- The power of the transformer 110/20 kV (25 MVA and 40 MVA).

The results for the short circuit currents in the electrical grid 20 kV are received. The current setting of the IOPR is determined in relation to the maximum current of the three-phase short circuit at the end of the protective OPL and its tripping time is $10 \div 30$ ms.

The processes of limiting of the lightning overvoltages are studied in case of a direct stroke of a single lightning 80 kA, $1/10\,\mu$s and repeated lightning over the phase conductor. The operation of the IOPR is observed at the different line lengths and time tripping settings.

4 PERFORMANCE RESULTS

Some of the results about the influence of a repeated lightning in the distance between the last two poles of the OPL for the voltages; currents and energy, dissipated in MOSA are illustrated in Fig. 2 and Fig. 3. According to the results the protective operation of MOSA (Fig. 2 b) and their energy loading at the discussed influences can be assessed (Fig. 3). Researched MOSA are with maximum continuous operating voltage $U_c = 20$ kV. Their limit energy loading is $W_L = 110$ kJ [3]. The energy, dissipated in MOSA, installed in the struck by lightning conductor, is 170 kJ according to Fig. 3. Therefore MOSA can not stand energy loading and will be destroyed. It is observed only for the above mentioned variant of the researches. Other variants (direct stroke of a single lightning) show that the energy loading of MOSA does not exceed the permissible values.

The results about IOPR operation from the different researches are given in Tab. 1.

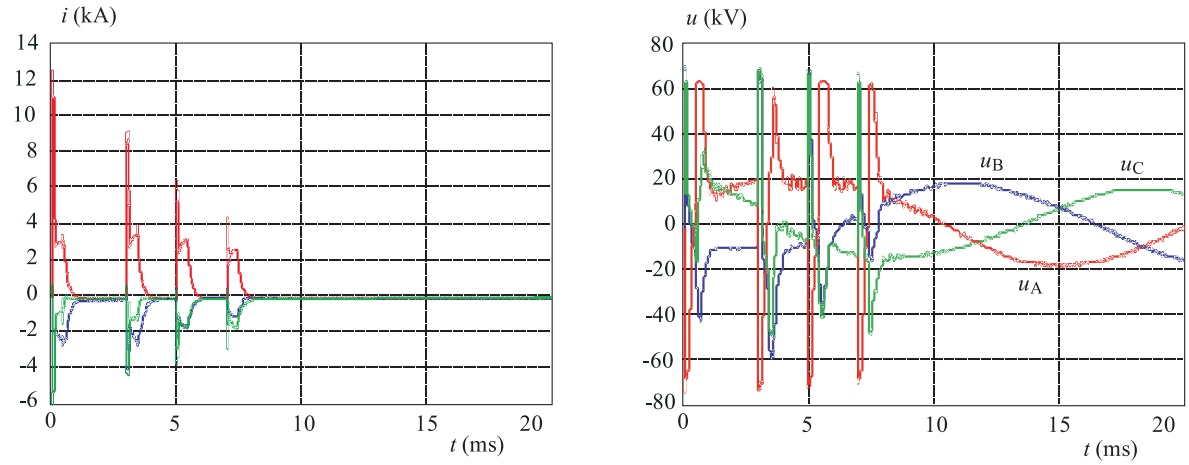

Fig. 2. Currents (a) and voltages (b) of MOSA under influence of the repeated lightning

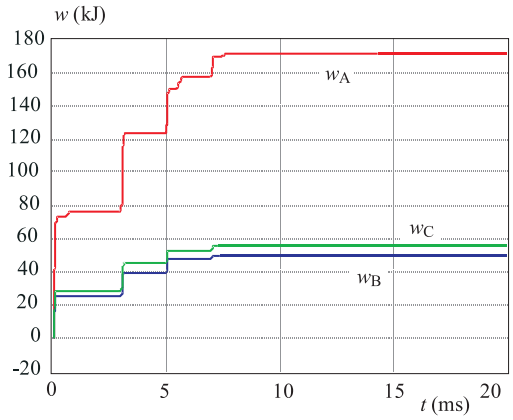

Fig. 3. Energy of MOSA under influence of the repeated lightning

Table 1. Overlap between sectors

L (km) / t_{IOPR} (ms)	5	10	15	25	30	40
10	no	no	no	yes	yes	yes
20	no	no	no	yes	yes	yes
30	no	no	no	no	no	no

5 CONCLUSION

1) At the tripping time settings up to 20 ms and OPL's length over 15 km the IOPR start working under influences of the researched lightning overvoltages.

2) In case of a repeated lightning over the phase conductor in the distance between the last two poles of the OPL the energy, dissipated in MOSA, exceeds the limit energy capability according to the catalog data [3].

3) Researched MOSA with $U_c = 20$ kV limit influencing overvoltages for all researched variants. It is recommended the time tripping setting of the IOPR in the OPL with a length over 15 km to be more than 20 ms.

About the choice of MOSA: it is necessary to be kept strictly recommendations of the producers and normative requirements. MOSA with high energy capability should be preferred in the areas with intensive lightning activity.

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