Simulation Models of the Automatic Transfer Switch in the Electrical Power Distribution Network

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Abstract – **The article presents simulations of distribution electrical power network, relay protection and automatic transfer switch, used in electrical networks 20 kV. For the development of simulation models standard libraries in software are used as well the own models. The developed simulation model allows to: visualize the research network's parameters for different modes of operation; to study of the automatic transfer switch; increase the quality learning by the trainees and enhance their self-employment.**

Keywords **– automatic transfer switch, power distribution network**

I. SIMULATION MODEL DESCRIPTION

The simulation model of electrical network 20 kV with 100% back- up is under consideration. The model scheme is shown in Fig. 1. The blocks of the scheme are: power systems 110 kV (S and S1), a main power transformer 110/20 kV (PT1), back-up power transformer 110/20 kV (PT2), RT1 breakers (Q1 and Q3), breakers of RT2 (Q2 and Q4), bus 20 kV (L1, L2, L3), model power lines (W1 and W2), loads (B1 and B2), block modeling short circuit (Fault), block relay protection line W1 (RP), breaker of W1 (Q5), unit for automatic transfer switch (AKQ) and measurement units (U/I, U).[2,3]

The blocks AKQ and RP includes models developed by the author for automatic transfer switch and relay protection. For the other blocks of model scheme, presented in Figure 1, are used standard software libraries.

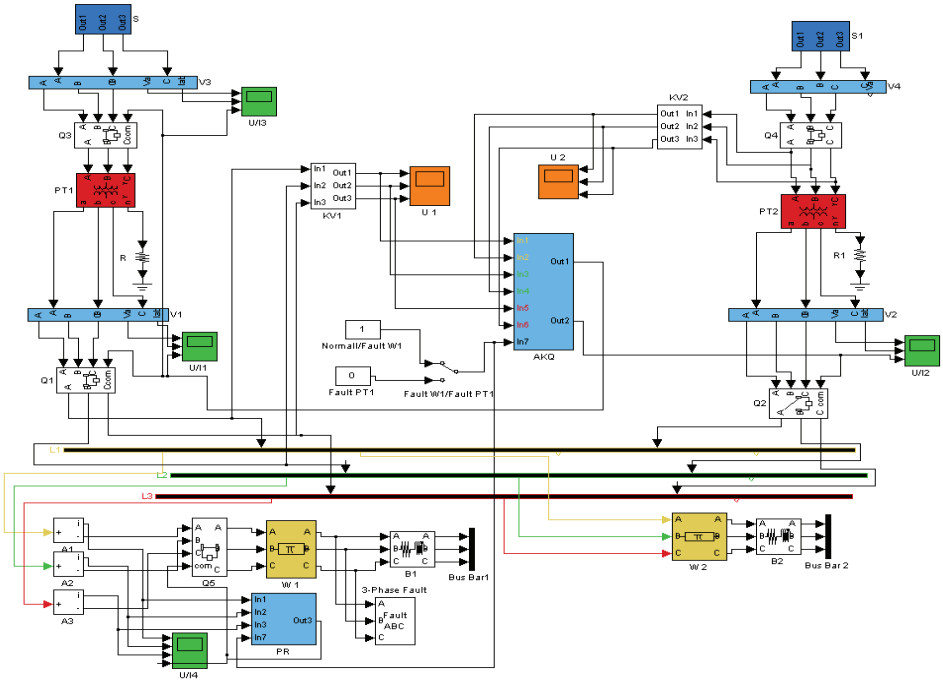

Fig.1. Simulation model scheme

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Block AKQ description

The block AKQ performs all logic functions, which are put in back- up automation. The input variables for the block are:

- Three phase voltages (KV1), measured on the bus (L), which is reserved;
- Three phase voltages (KV2), measured on feeders of the back-up power transformer;
- A signal that the scheme operates in normal mode (supplied by PT1, but PT2 is idling) or external short circuit (on the power line W2) and accordingly a signal at the failure in PT1(Fault W1/Fault PT1).

Thus the functions of the undervoltage relay (KV1) and overcurrent relay (KV2) in automation are realized by the variables and the logic in block AKQ. With the same block the time delay of the automaton is realized, too (time relay).[1]

The output values from the block AKQ are:

- Out1 - signal for switching off Q1 and Q3 of the main power transformer PT1;
- Out2 - signal for switching on Q2 of the back-up power transformer PT2.

The input parameters for the blocks that are assigned are: primary tripping voltage of the starting relay undervoltage (KV1) in [V], primary tripping voltage of the overvoltage relay (KV2) in [V] and tripping time of the automation in [s]. Set tripping time of the automation is aggregated over tripping time of the terminal protection.

Figure 2 shows the menu for setting- up of the Block AKQ.

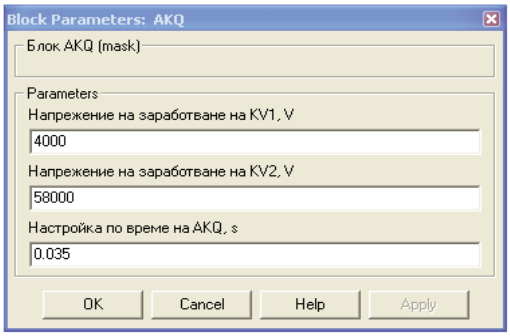

Fig.2. AKQ Menu for the Block AKQ set- up

Block RP description

Relay protection block perform the functions of overcurrent protection (OP), which is the most - often used protection for medium voltage networks as a protection against phase to phase fault.

Input parameters for the block that are assigned are: primary tripping current in [A] and the tripping time in [s]. At start-up the protection switches off the breaker Q5 of the power line W1.

Figure 3 shows the menu for setting- up of the Block RP

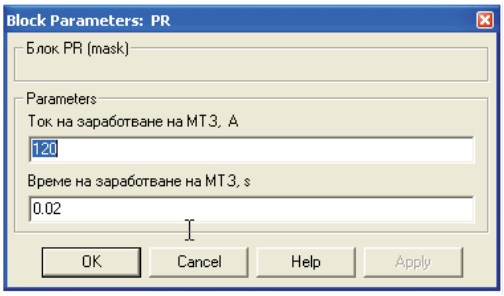

Fig.3. Menu for the Block PR set- up

The key "Fault W1/Fault PT1" chooses if the scheme operates in normal power supply of loads or under short circuit of the power line W1 (external short circuit) and hence the scheme works at failure over the main power source.

In blocks the phase voltages' and currents' alterations (U/I) and respectively phase voltages (U) are displayed.

II. THE PROCESSES' VISUALIZATION

The processes' visualization under three phase s.c. at the power line W1

Fig. 4 presents variations of phase voltages and currents under three phase s.c. at the end of the power line. The loads are supplied by the main power transformer of power line W1. In time t = 0.02 s a three-phase s.c. occurs. Breakers Q1, Q3, Q4 and Q5 are switched on and Q2 is off. Time delay of the protection of power line W1 is set up 0.02 s. and after this time the s.c. is switched off. Breaker Q5 switches to be opened. The automation of the back- up supply dos not trip, i.e. the supply of the loads remains from PT1.

The last graph, presented in Fig. 4, is a control signal of breaker Q1 (SQ1). It is 1, which means switched breaker. Time tripping set-up of the protection is less than those used in practice because the necessary computing time and the need visualization process.

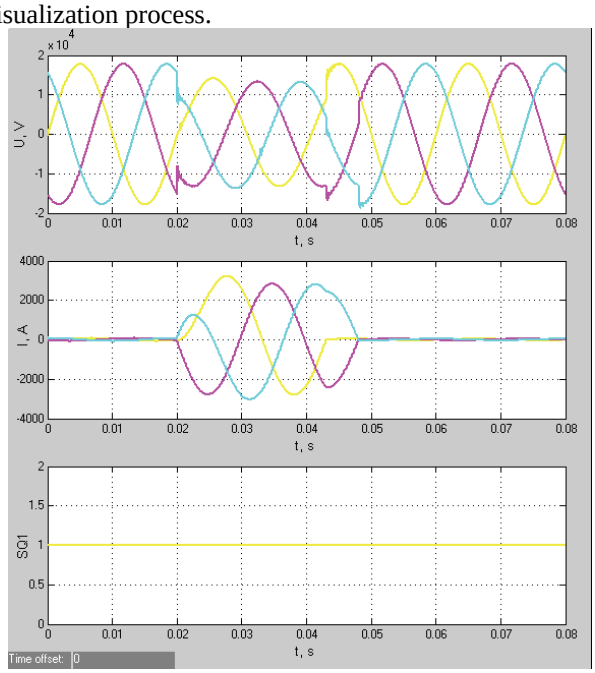

Fig. 4. Variations of phase voltages and currents under three phase s.c. at the end of the power line

The processes' visualization as a result of lowering the voltage due to fault in the main power transformer

Fig. 5 presents variations of phase voltages and currents at fault in the main power transformer. Values were measured before the breaker Q1. At the lowering of voltage of PT1 AKQ trips with set time 0.055 s and switches off breakers Q1 and Q3. The signal presented in the last graph of Fig. 5 is the control signal to the breaker Q1. It becomes from 1 to 0 which means switched off breaker Q1.

At the same time the signal 1 is given to switch on Q2 (Fig. 6). Consumers are supplied by PT2.

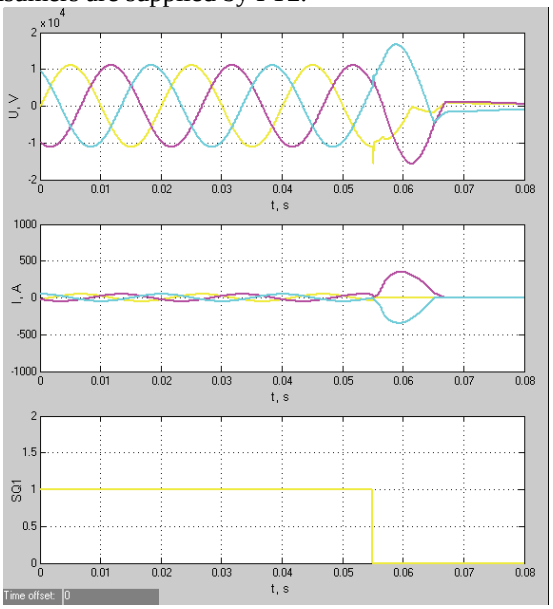

Fig. 5. Variations of phase voltages and currents, measured before Q1 at fault in PT1

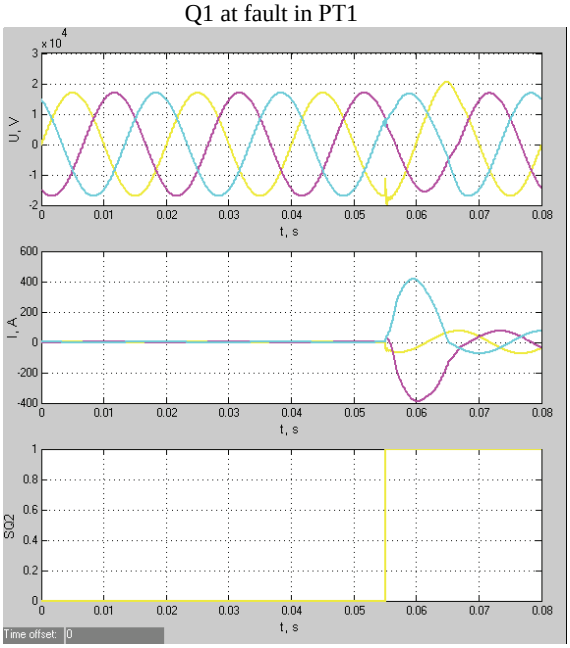

Fig. 6. Variations of phase voltages and currents, measured before Q1 at fault in PT1

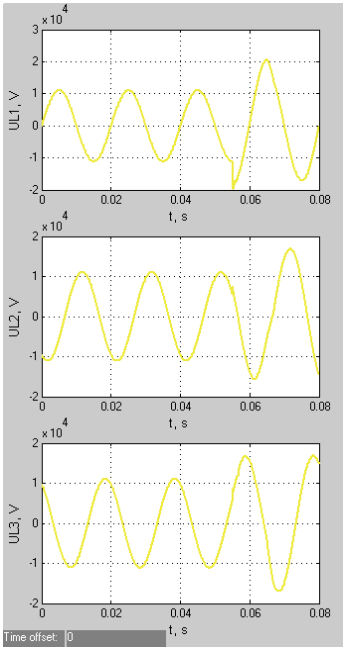

Fig. 6. Variations of phase voltages and currents, measured on the medium voltage bus at fault in PT1 and action of AKQ

After 0.055 s AKQ switches off the main power transformer and switches on breaker Q2 of the backup power transformer, which restores the normal power supply of 20 kV bus.

Conclusions:

Blocks "Automatic transfer switch " and "Relay Protection" have been developed., They model the operation of 100 percent back- up and overcurrent protection used in medium voltage electrical networks.

Students are free to model the above situations, to change relay protection settings and the back- up automat settings, to check whether at the specified settings the protection and AKQ will work, and to receive graphic data.

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