

APPLICATION AND SETTINGS INVERSE TIME RELAY CHARACTERISTICS FOR FEEDERS OVERCURRENT PROTECTION

Seila GRUHONJIĆ-FERHATBEGOVIĆ
JP EP BiH, ED Tuzla – Bosnia and Herzegovina
s.gruhonjic@elektroprivreda.ba

Rinan AL-TAWIL
JP EP BiH, EP Sarajevo – Bosnia and Herzegovina
r.altawil@elektroprivreda.ba

INTRODUCTION

The situation which can appear during switching on a long and loaded 10(20) kV distribution feeders are considered. The high inrush currents can cause unnecessary operation first or second stage of the overcurrent protection. The possibility of application time delay overcurrent characteristics of numerical protections are analysed. For characteristic distribution feeders 10(20) kV settings of overcurrent protections and other available options are checked by using simulation program as so as program for protective device coordination.

1. SELECTIVITY OF OVERCURRENT PROTECTION FOR RADIAL DISTRIBUTION FEEDERS 10(20) kV

The primary protection of radial distribution network against phase faults is overcurrent protection. Considered 10(20) kV network operates with isolated zero point and protection against phase to ground faults is performed by directional earth fault protection. Overcurrent protection of distribution feeders 10(20) kV, most frequently, provide two stages. First stage of overcurrent protection, at older performances, has definite time operating characteristic and second stage operates without time delay. Primary zone of the first stage overcurrent protection is complete distribution feeder from overload and remote part of the feeder from the faults. Setting time delay of the first stage overcurrent protection is limited with range $t_{dj}=1-1,25$ [s]. In the aim of providing necessary selectivity with transformer protection, operation time of feeders protection 10(20) kV should be for selective interval less than operated time of overcurrent protection for secondary transformer winding (transformers 35/10 kV or 110/10(20) kV). New generation of numerical protections, for this stage of overcurrent protection, have a large number of inverse time characteristics. Second stage of overcurrent protection is planned as protection against near short circuits and most frequently operates instantaneously, i.e. without time delay. If it is possible, complete distribution feeder 10(20) kV is included by second stage of overcurrent protection. At considerable number of numerical protections, for second stage of overcurrent protections, for second stage of overcurrent protection, in the aim of switching on without disturbances, it is possible to select function of inrush stabilization. Therefore, operating current of second stage of overcurrent protection should be greater than maximum current through the relay at short circuit on the 0,4 kV side of the nearest transformer 10(20)/0,4 kV. Protection against short circuits in 0,4 kV network should be taken over by fuses or automations on the low voltage feeders with reference to the backup zone protection of transformer 10(20)/0,4 kV

which is done by MV fuses.

2. SWITCHING ON 10(20) kV FEEDERS

There are evident problems with unnecessary operation of overcurrent protection in the case of long 10(20) kV feeders with great number of transformer stations 10(20)/0,4 kV during exploitation of distribution network. Unnecessary switching off have been recorded in the case of distribution feeders which supply motors with high starting currents or rapidly motors loading. Regarding to values of inrush currents, it is shown that for the first stage of overcurrent protection should be selected inverse time operation characteristic (IDMT). By observing great number of feeders, general rule for which feeders is necessary to apply IDMT characteristic was conformed. Namely, for small values of Z_s/Z_f the most frequent is necessary to apply IDMT characteristic for the first stage of overcurrent protection. For great values of Z_s/Z_f ratio it can be kept definite time characteristic for the first stage of overcurrent protection. Z_s is the source impedance and Z_f is the complete impedance of distribution feeder. Also in the case of feeders with considerable length of underground network, inrush stabilization for the second stage of overcurrent protection should be activated. In the case of switching on and faults matlab computer simulations were done for calculation line impedances, time-current consideration and harmonic analysis. In accordance with possibilities in the field, results of simulations are compared with measurement values. Also for accepted selective interval, it has been done, in program Aspen, testing of protection device coordination for considered part of power system. From the group of considered feeders, two feeders are shown in this paper (DV 10 kV A and DV 10 kV B) and analysed for the case of switching on (inrush) and phase faults.

2.1. Measured current values

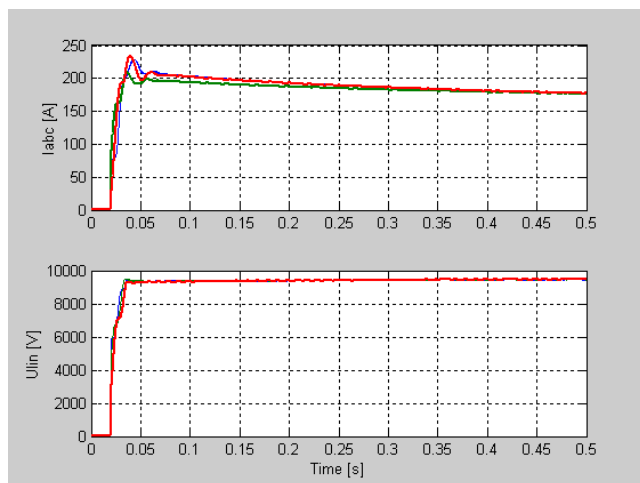
In the purpose of comparison with computer simulations it has been done measurement of several current values during switching on feeders 10(20) kV. In the table 1 current values were read by SCADA program during switching on feeder 'DV 10 kV A'. In this case those currents were registered by numerical distribution protection SPAC 535. Stationary measurement currents, by phases, are 53, 57, 53 [A]. Registered maximum load for this feeder is 75 [A].

TABLE 1
MEASURED VALUES OF INRUSH CURRENTS

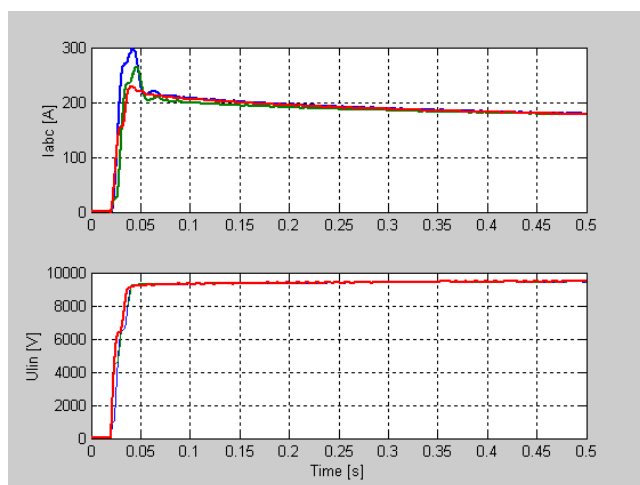
Time [s]	Inrush currents [A]		
	I_A	I_B	I_C
0,1	290	233	285
0,5	183	189	182
0,75	164	173	165
1	144	154	142

2.2. Moment of switching on and harmonic analysis

It was observed influence to the moment of switching on current values (inrush currents) by computer simulations. It can be seen that maximum current of switching on can be expected in the case of switching on in the moment of passing voltage through zero point. Also, diagrams show the moment of switching on influence only to possible operating second stage of overcurrent protection. Diagrams of inrush currents were got by computer simulations (for DV 10 kV A) are shown on the figure 1.



a.)



b.)

Fig. 1. Diagrams of inrush currents and voltages in the case of switching on in the moment a.) $t=0,015$ [s], b.) $t=0,02$ [s]

Values of the second harmonic components in the inrush currents, for analysed DV 10 kV A, in the moment of $t=0,02$ [s] from the moment of switching on is about 14 % of the fundamental harmonic value. For DV 10 kV B, the values of the second harmonic components in the moment of $t=0,02$ [s] from the moment of switching on is about 23 % of the fundamental harmonic value. Therefore, for feeders with large number of substations 10(20)/0,4 kV it is reasonable selecting of protection which have restraint of operation for second harmonic (these function have modern numerical distribution protection).

3. SETTINGS OF OVERCURRENT PROTECTION FOR TYPICAL 10(20) kV FEEDERS

Examples of settings are shown here. Apart from eliminating fault it is necessary to provide selectivity with other protection in system. During manipulation in substations 35/10 kV it is necessary to switch on complete feeder. Switching on section by section from control dispatch centre or from substation 35/10 kV is not possible.

3.1. DV 10 kV A

Distribution feeder DV 10 kV A supplies 20 TS 10(20)/0,4 kV and has complete length of overhead 10 kV network of 25,523 [km] and underground network of 0,212 [km]. Inrush characteristic of the complete feeder from the TS 35/10 kV is shown on the figure 1 (three phase currents are shown).

Figure 2 is a single line diagram of the system which protections have been checked.

$Z_s/Z_f=0,1403$; $I_{load}=53$ [A].

Current of phase-to-phase faults at the end of feeder is $I_{k2}=305,4$ [A].

Currents of phase-to-phase fault and three phase fault at the 35 kV bus of TS 35/10 kV are: $I_{k2}=1069$ [A], $I_{k3}=1236$ [A].

Accepted minimum selective time interval is $\Delta t=0,5$ [s].

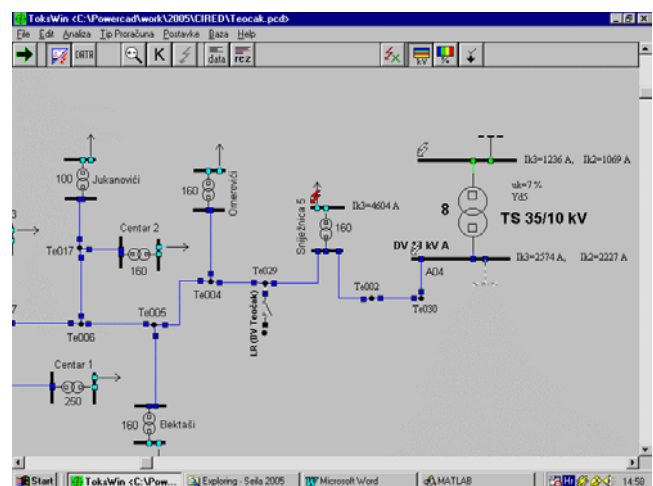


Fig. 2 Radial distribution system protected by overcurrent relays - DV 10 kV

A

Current of three phase fault at the 0,4 kV bus of nearest TS 10/0,4 kV ($S_n=160$ [kVA]) is $I_{k3}=4604$ [A]

Settings of overcurrent protections have been checked by using program Sigraide for protective device coordination and presented on the accompanying diagrams.

3.2. DV 10 kV B

Distribution feeder DV 10 kV B supplies 19 TS 10(20)/0,4 kV and has complete length of overhead 10 kV network of 5,125 [km] and underground network of 6,172 [km].

$Z_s/Z_f=0,2891$; $I_{load}=128,5$ [A].

Current of phase-to-phase faults at the end of feeder is $I_{k2}=812,7$ [A].

Currents of phase-to-phase fault and three phase fault at the 35 kV bus of TS 35/10 kV are: $I_{k2}=2841$ [A], $I_{k3}=3294$ [A]. Characteristic of switching on (inrush characteristic) of the complete feeder from the TS 35/10 kV is shown on the figure 3.

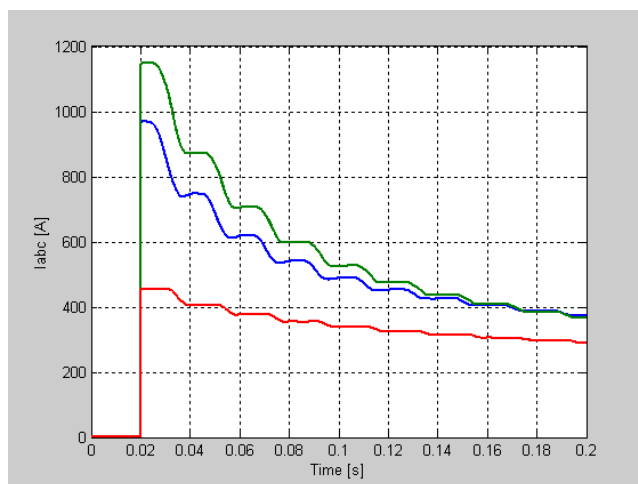


Fig. 3; Characteristic of switching on feeder DV 10 kV B

For protection on the MV side also it can be used extremely inverse time characteristics of the first stage overcurrent protection. Setting protection selection of feeder DV 10 kV B can be as; $I >= 1 \times I_n$, $k=0,3$ ex. inv. (150/5), $I >= 5 \times I_n$. In this case, for second stage is necessary to predict activating of inrush stabilization (automatic doubling function of $I > >$ during connection of the protected object to the network) or blockade for second harmonic components.

Current of three phase fault at the 0,4 kV bus of nearest TS 10/0,4 kV ($S_n=630$ [kVA]) is $I_{k3}=19,68$ [kA].

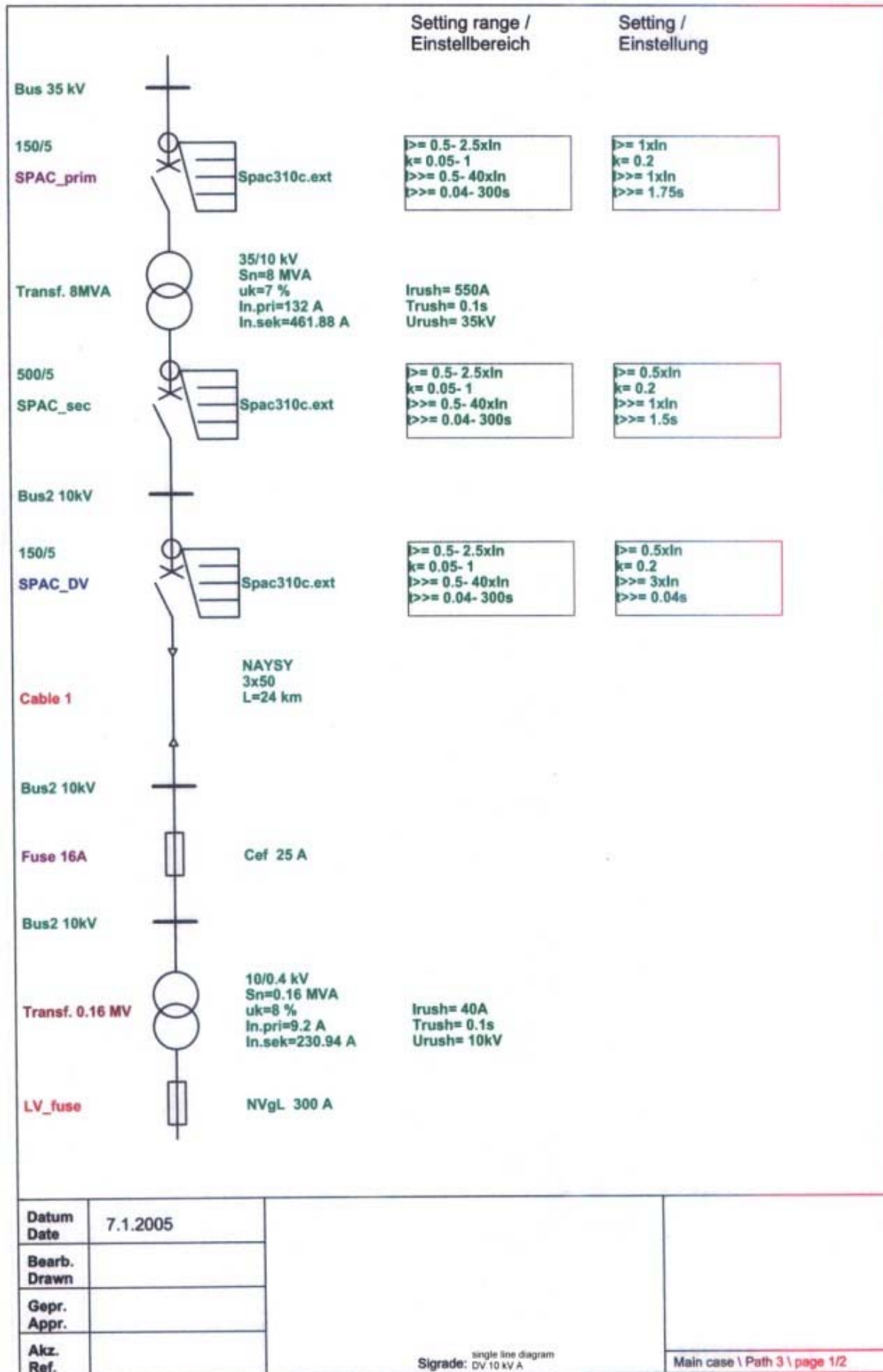
Protection of TS 10/0,4 kV can be realized by fuses $I_n=63$ [A].

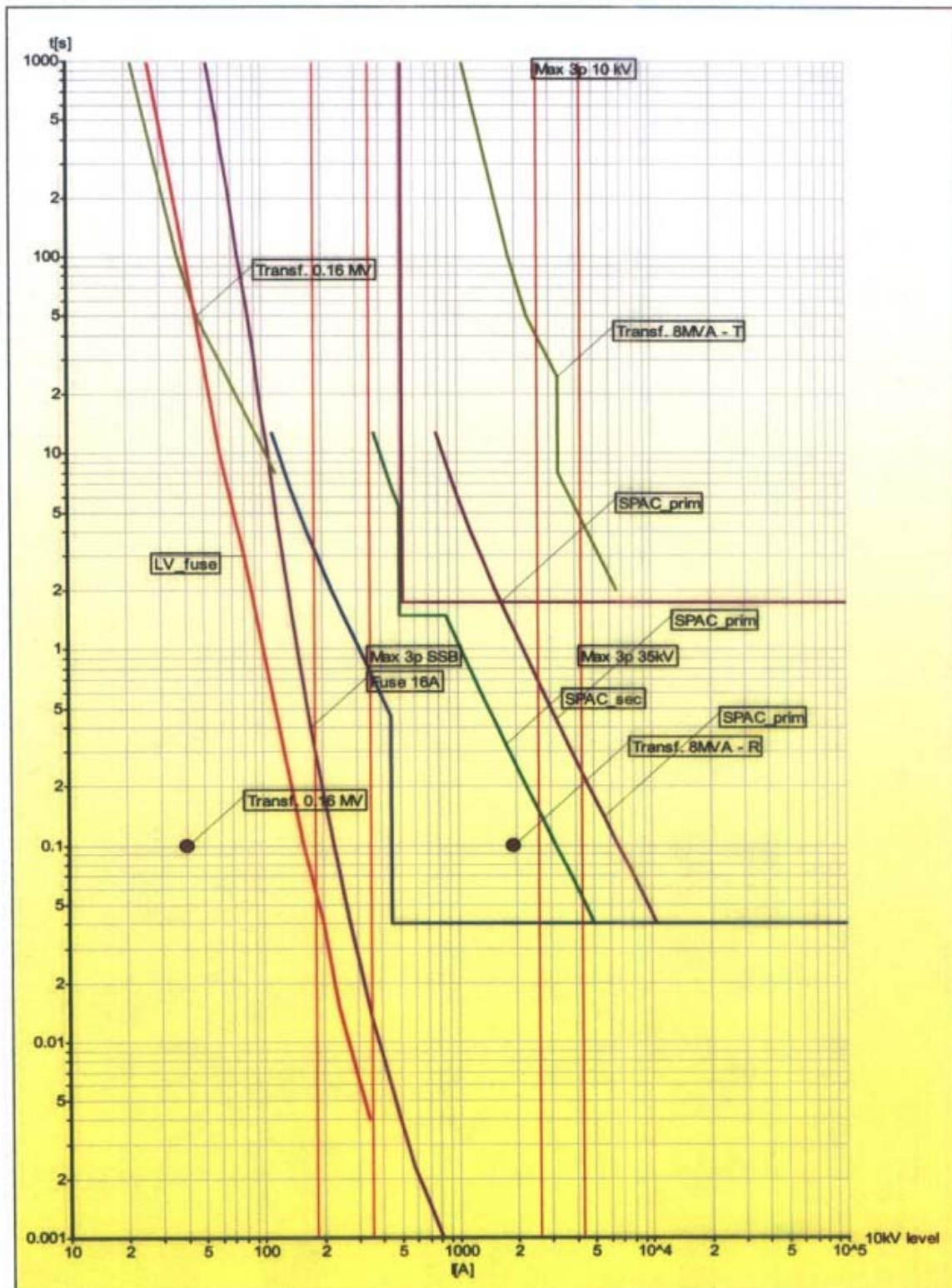
4. CONCLUSION

Numerical protections, in this case for distribution feeders 10(20) kV, have function which provide better adoption for protected object. On that way, for long distribution feeders with great number of TS 10(20)/0,4 kV, it can be selected inverse time operating characteristics of overcurrent protection. During protection setting of protection it is necessary to estimate feeder characteristics according to planned operating conditions of system and number of supply TS 10(20)/0,4 kV. Of course during selection of setting and operating characteristics it is necessary to check is there is achieved selectivity with other protections in system. In this case these are overcurrent protection of transformer 35/10 kV or 110/10(20) kV as so as protections (fuses) in the nearest TS 10(20)/0,4 kV. Switching on section by section it can be accepted only if the system has remote control because in that case periods without voltage are minimum.

REFERENCES

- [1] F. Božuta i ost.; 1988, *Aspekti zaštite elektroenergetskog sistema*, Svjetlost, Sarajevo, BiH
- [2] Y. G. Paithankar; 1998, *Transmission Network Protection - Theory and Practice*, Marcel Dekker, New York
- [3] Protective Relays Application Guide - ABB and Siemens
- [4] User Manuals for Matlab PSB and Sigraide software





Datum Date	7.1.2005		
Bearb. Drawn			
Gepr. Appr.			
Alz. Ref.			

Sigraide: protective coordination

Main case \ Path 3 \ page 2/2