

Protection of Combined Cable and Overhead Lines

■ 1. Distance protection with auto-reclosure on mixed lines

On mixed lines with cables and overhead lines the distance zone signals can be used with a distance protection relay 7SA6 to distinguish to a certain extent between cable and overhead line faults. Mixed lines mean that part of the protected line is designed – within the same grading zone – as a cable section and the other part of that line as an overhead line section. The auto-reclosure function is only useful on the overhead section of the line. The section of the line to be protected must be selected accordingly in the grading. The auto-reclosure function can be blocked (in the event of a fault in the cable section) by interconnection by means of the user-programmable logic functions (CFC) in the DIGSI parameterization and configuration tool.

■ 2. System configuration

According to the system configuration in the distance zones Z1, Z2, Z3 and Z5 with their line impedances (impedances of the line as R and X values, resistance values and reactance values) the line sections are graded as usual in the distance protection relay SIPROTEC 7SA6. Zone Z1B serves above all for the automatic reclosing function and for switching functions (e.g. “manual close”). Zone Z4 is used to measure and select the cable or overhead line part of the line to be protected.

Zone Z1B can also be used for fast disconnection of the line to be protected when closing onto a fault, in addition to application in conjunction with the auto-reclosure function. The protection must trip fast if, when closing onto the line to be protected, the feeder at the remote end is e.g. still earthed. The 7SA6 also provides the “high-current – instantaneous tripping” function for this protection as an alternative. Both applications are described here.

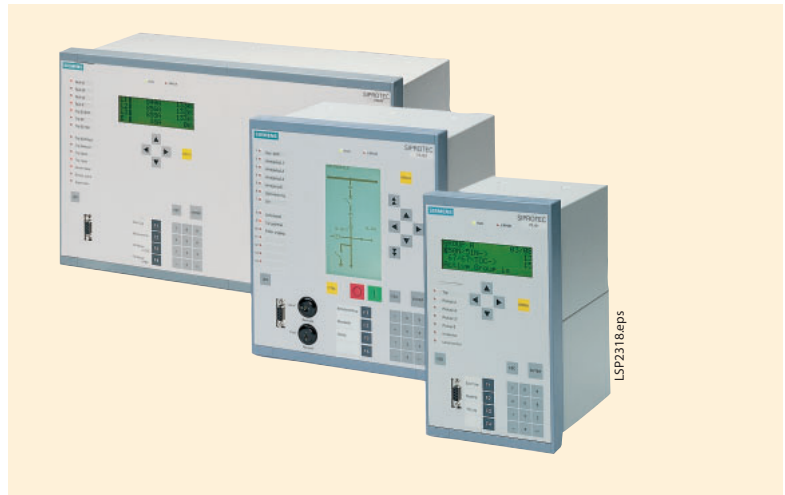


Fig. 1 SIPROTEC 7SA6 distance protection

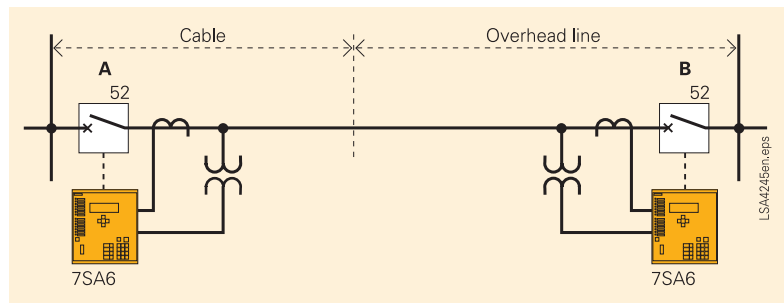


Fig. 2 Protection of combined cable and overhead lines

The application is described on the basis of a line <A-B> with two SIPROTEC 7SA6 distance protection relays.

A solution for the protection relay at location “A” is described in the following. Here the line sections of the mixed line are selected with the distance zones Z1B and Z4.

The protection relay at location “B” can be set for auto-reclosure on mixed lines either

- by the distance zone Z1B and the high-current instantaneous tripping or
- alternatively with grading of zones Z1B and Z4.

■ 3. Settings in the configuration with DIGSI

First the following settings must be made in the configuration matrix in the parameter set for the 7SA6, for configuration in DIGSI.

Configuration matrix (group: “Auto-reclosure” or “General distance protection”)

- a) FNo. 2703 – “>Block auto-reclose function” configured to “Source CFC”
- b) FNo. 3747 – “Distance pickup Z1B, loop L1E” configured to “Target CFC”
- c) FNo. 3748 – “Distance pickup Z1B, loop L2E” configured to “Target CFC”
- d) FNo. 3749 – “Distance pickup Z1B, loop L3E” configured to “Target CFC”
- e) FNo. 3750 – “Distance pickup Z1B, loop L12” configured to “Target CFC”
- f) FNo. 3751 – “Distance pickup Z1B, loop L23” configured to “Target CFC”
- g) FNo. 3752 – “Distance pickup Z1B, loop L31” configured to “Target CFC”
- h) FNo. 3759 – “Distance pickup Z4” configured to “Target CFC”

Parameterization: (parameter group A, distance protection – polygon, zone 4)
Parameter 1335 “T4 DELAY”

The tripping time for zone 4 (parameter 1335 = T4) must be set to infinite ($T4 = \infty$) because this zone is only used for selecting the cable or overhead line part of the line. Zone 4 should only signal a pickup in this application. Tripping in this zone is irrelevant. This function is particularly important for the single-pole auto-reclosure function because the tripping then takes place exclusively via zone Z1B.

■ 4. Creating the logic flowcharts

All that need now be done is to create, link and translate the appropriate logic diagrams in the CFC in DIGSI. The “fast” PLC task (PLC0) is used as a run level in the CFC.

The individual logic functions and the effect on the protected zone are described below.

Appropriate allocations must be performed (with the execution of an auto-reclosure function) for the described line <A – B> in both distance protection relays, to detect the zone of the overhead line.

4.1 Control of auto-reclosure in the 7SA6 for protection relay A

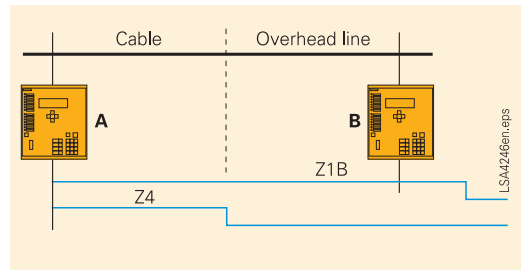


Fig. 3 Control of the auto-reclosure for protection relay A

7SA6 – protection relay A:

The setting values of zone Z4 correspond to the grading with the R and X values of the cable section. Zone Z1B is designed as usual for about 120 % of the line length. Since no auto-reclosure is to be performed in the cable section, the overhead line section is selected in zone Z1B by a CFC plan. With the result of the CFC plan (FNo. 2703: “>AR block.”) auto-reclosure can be blocked in the event of a fault in the cable section (zone Z4) (see Fig. 4).

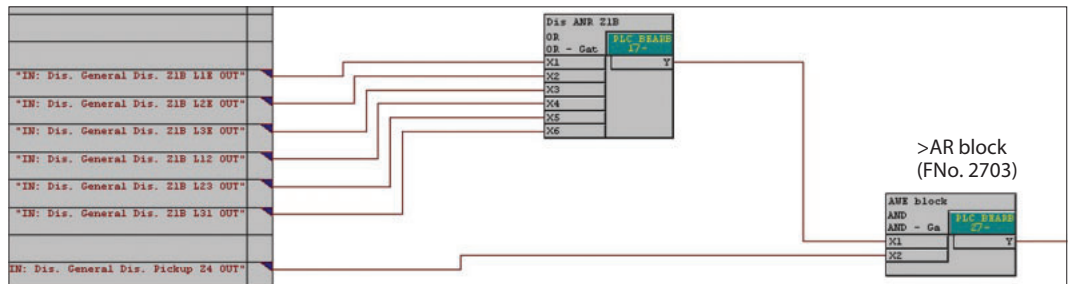


Fig. 4 CFC plan for protection relay A

4.2 Control of auto-reclosure in the 7SA6 for protection relay B

4.2.1 Version 1

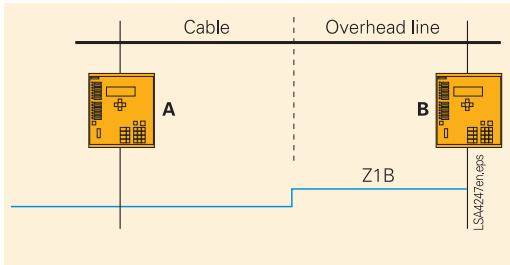


Fig. 5 Distance protection with zone Z1B and the instantaneous high-current tripping

7SA6 – protection relay B:

The setting values of zone Z1B correspond to the grading with the R and X values of the overhead line on which the auto-reclosure function is to be performed. The instantaneous “high-current tripping” function is used in 7SA6 for instantaneous tripping when closing onto a fault, to completely protect the <A – B> line.

The task of the *instantaneous high-current element (instantaneous high-current switch-onto-fault)* is to perform tripping immediately and without delay when a feeder is closed onto a high-current short-circuit. It serves primarily as fast-acting protection when connecting an earthed feeder, but can also become effective (settable) with every closing – including auto-reclosure. The connection of the line is reported to the protection by the “detection of the circuit-breaker position” (parameter 1134).

In order to make use of the instantaneous high-current tripping, the function must have been enabled in the relay scope configuration. The value of the short-circuit current which leads to pickup of the instantaneous tripping function is set as ‘ $I_{>>>}$ ’ value (parameter 2404). The value must be high enough to avoid the protection tripping (whatever the circumstances) in the event of a line overload or current increase – e.g. as a result of a brief interruption on a parallel line.

At least 2.5 times the rated current of the line is recommended as a pickup value for the instantaneous high-current tripping.

4.2.2 Version 2

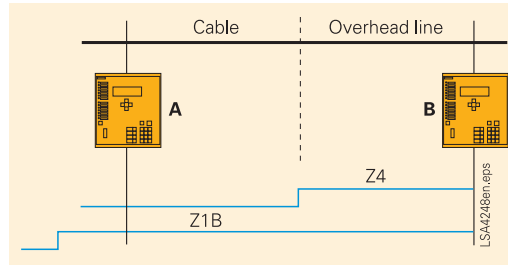


Fig. 6 Distance protection with grading of the zones Z1B and Z4

7SA6 – protection relay B:

The setting values of zone Z4 correspond to the grading with the R and X values of the overhead line. Zone Z1B is designed as usual for about 120 % of the line length. Since no auto-reclosure is to be performed in the cable section, the overhead line section is selected in zone Z1B with a CFC plan. With the result of the CFC plan (FNo. 2703: “>AR block.”) automatic reclosing is blocked in the event of a fault in the cable section. This means that an auto-reclosure is only performed in the case of pickup of the protection in zones Z1B and Z4 (see Fig. 7).

■ 5. Summary:

By division into two distance protection zones (Z1B and Z4), selection of the cable and overhead line sections for double-end feeding in the event of a fault is substantially simplified. In the practical application the auto-reclosure function can only be performed restricted to the overhead line. A fault in the cable section leads immediately to a final TRIP command.

As shown, special requirements (such as selection of the faulty line section) can be implemented easily and at low cost with the CFC logic in the SIPROTEC distance protection.

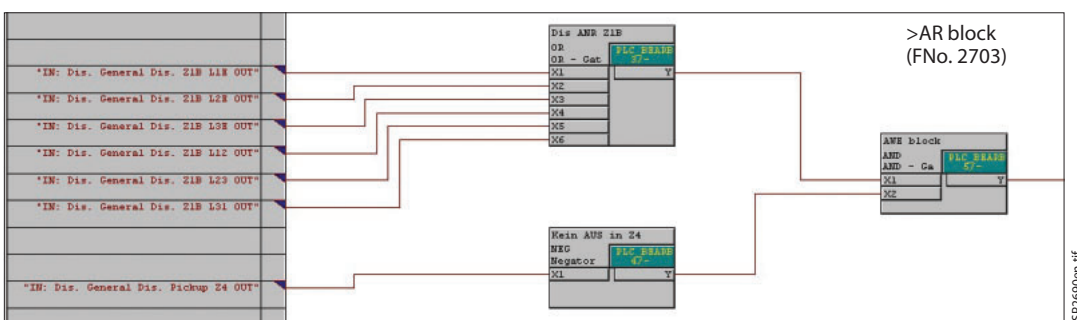


Fig. 7 CFC plan for protection relay B

