Directional Phase Overcurrent Protection ANSI 67 with 7SA522 and 7SA6

■ 1. Introduction

The implementation of a directional overcurrent stage (ANSI 67) in the distance protection relays 7SA522 and 7SA6 is possible via a simple coupling of the distance protection directional stage (in this case Zone 5) with one of the overcurrent stages (in this example stage $I>$) in the relay.

The distance protection and the directional overcurrent protection use the same measured signals, phase current and phase voltage, but the impedance measurement achieves both higher sensitivity and higher selectivity.

This document illustrates how easily the ANSI 67 function can be implemented in the 7SA522 and 7SA6 by using the CFC logic.

■ 2. General parameters for implementation of directional overcurrent (ANSI 67)

The settings of the relay can be applied as required by the application as usual. For the ANSI 67 function at least the functions 0112 Phase Distance, 0113 Earth Distance and 0126 Backup Overcurrent must be activated in the relay configuration (Fig. 2):

Setting parameter of 67	Designation	Example Value (secondary 1 A)
Pick-up threshold	I_{67}> pick-up	2.5 A
Time delay	Time 67	0.5 s

Table 1 Parameters for directional overcurrent I_{67}

Setting block: Relay configuration

The distance protection must be enabled (quadrilateral or MHO) for phase faults: Parameter 0112. Backup overcurrent must be enabled (time overcurrent IEC or ANSI): Parameter 0126

Fig. 1 SIPROTEC line protection 7SA522 and 7SA6

Fig. 2 Setting of functional scope

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Matrix: Masking I/O (configuration matrix)

Assign the signal "3719 Distance forward" in the "Distance General" block to destination CFC.

Fig. 3 Masking of dist. signals in configuration matrix

Select that stage in the backup overcurrent that must be directional (ANSI 67). For this stage assign the corresponding blocking input signal to source CFC. Therefore either:

7104   >Block O/C I>>   or
7105   >Block O/C I> (used in this example) or
7106   >Block O/C I_p

Multiple assignment is also possible.

Fig. 4 Masking of overcurrent signals in configuration matrix

■ 3. Special setting for the distance protection

The distance protection sensitivity must be greater than or equal to that of the required directional overcurrent protection. This does not present any problems, as the directional overcurrent protection will be set less sensitive than the maximum load current while the distance protection is set more sensitive than the smallest fault current.

In the relevant setting group (e.g. Setting Group A) the following distance protection settings must be checked:

Fig. 5 Distance protection function general setting

1201 Distance protection is **ON**
1202 Phase current threshold for distance measurement $\leq I_{67}$> pick-up (Table 1)

To calculate the minimum reach setting of the distance protection, the overcurrent characteristic is shown in the impedance plane below in Fig. 6:
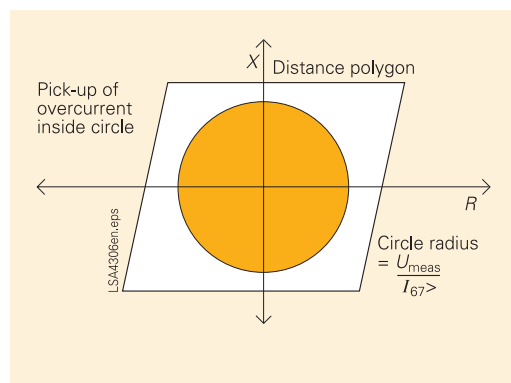

Fig. 6 Pick-up characteristic of overcurrent protection in impedance plane

From Fig. 6 it is apparent, that the largest circle radius must be determined to set the minimum impedance reach so that a direction decision is available when the overcurrent stage picks up. The maximum circle radius is obtained when the measured fault voltage together with fault current at pick-up threshold occurs. If the maximum operating voltage (unfaulted) is used, a large safety factor is already incorporated as the fault voltage will always be less than this.

$$Circle\_radius = \frac{U_{operating\ \max}}{\sqrt{3} \cdot (I_{67} > pick-up)}$$

In this example the rated secondary VT voltage is 100 V. The maximum operating voltage is 110% of rated, so the following circle radius can be calculated:

$$Circle\_radius = \frac{100 \cdot 1.1}{\sqrt{3} \cdot 2.5}$$

$$Circle\_radius = 25.4\ \Omega$$

The setting 1243 R load, minimum load impedance (ph-ph) must be greater than the calculated circle radius. In practice, this is no problem because this setting is calculated with a similar equation using the maximum load current instead of the overcurrent pick-up (I_{67}> pick-up) which must be greater than the maximum load current. Therefore, this setting when applied is by nature greater than the circle radius calculated here.

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At least one of the set distance protection zones with forward or non-directional reach must have a reach greater than the circle radius. In this example the Zone 5 has the largest reach, and it is set non-directional. In this case the following must be checked:

1341 Operating mode Zone 5 is non-directional

1342 R(Z5) resistance for ph-ph faults ≥ Circle radius (25.4 Ω)

1343 X+(Z5) reactance for forward direction ≥ Circle radius (25.4 Ω)

If none of the applied zones has a sufficiently large reach, a special zone must be selected for this purpose. This zone must then be set as non-directional (for MHO set forward) with an *X* and *R* reach equal to the calculated circle radius (25. 4 Ω in this example). The time delay of this zone can be set to infinity (∞) to avoid tripping by the distance protection in this zone if required.

Fig. 7 Zone settings of non-directional zone

■ 4. Setting the backup overcurrent stage for ANSI 67

The backup overcurrent must be operated as backup protection so that it is always active:

2601 Operating mode ON: always active

In the backup overcurrent proctection the following settings must be applied to the stage that is intended for the ANSI 67 function. In this example stage *I>* will be used:

2620 $I_{ph}>$ pick-up value
set equal to required $I_{67}>$ pick-up (in this example 2.5 A)

2621 T $I_{ph}>$ time delay
set equal to the desired 67 time delay (in this example 0.5 s)

2622 $3I_0>$ pick-up value
disabled by setting to infinity (∞)

Fig. 8 Settings for backup overcurrent function (*I>* in this example)

■ 5. Setting up the CFC logic

In the CFC logic, the absence of a forward detection by the distance protection (in this case Zone 5) will be used to block the backup overcurrent stage (in this example stage *I<*).

In the fast PLC, insert a negator and route the signal "Dis forward" to its input. Route the negator output to the relevant blocking input to the backup overcurrent stage.
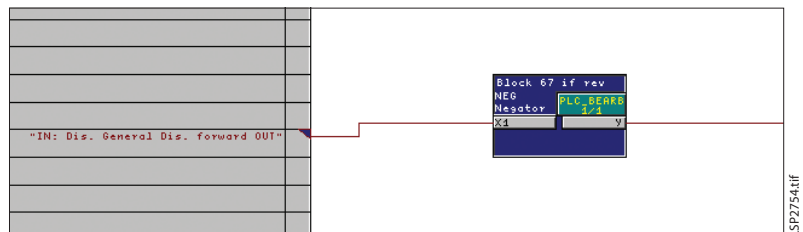

Fig. 9 Input signal allocation in the CFC logic

■ 6. Testing the ANSI 67 function

To test the directional overcurrent, a forward and a reverse fault condition were simulated with the Omicron® state sequencer. For both faults, the fault current level was set to 10 % above pick-up of the ANSI 67 function, 2.75 A. The angle between current and voltage for the forward fault was 0° and for the reverse fault 180°.

The fault recordings and trip log for these two cases are shown on the following page:

The trip log (Fig. 10) shows the trip signal by the backup O/C $I>$ stage after 510 ms.

Fig. 10 Trip log for forward fault

Fig. 11 Trip log of reverse fault

■ 7. Summary

The implementation of a directional overcurrent stage (ANSI 67) in the distance protection relays 7SA522 and 7SA6 is possible via a simple coupling of the distance protection directional release with one of the overcurrent stages in the relay.

If one of the other backup overcurrent stages is required as an emergency protection in the event that the distance protection is blocked due to fuse failure, a similar logic may be implemented whereby the blocking signal is derived from the Fuse Fail alarm (170).

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