Earth-Fault Protection in a Low-Resistance-Earthed System

1. General earth-fault information

In a low-resistance-earthed power system the earth fault is a short-circuit and must therefore be tripped by the short-circuit protection. In most cases, in an impedance-earthed network (predominantly medium voltage) the earth-fault current is limited to a maximum of 2000 A. The minimum short-circuit current occuring in the case of faults at a greater distance is the standard pickup value for earth-fault protection (I_E>). It must be ensured that any earth fault is safely tripped. If short-circuit calculations for the power system are carried out, it is useful to have the minimum short-circuit currents calculated as well as the maximum ones. These values less a safety margin then form the basis of the I_E> set value. The pick-up value for the earth fault is lower than that for phase failure, and in unfavorable cases can actually be below the rated current.

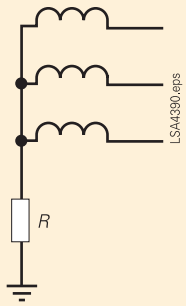
When distance protection relays (7SA5.., 7SA6.) are used, the pickup value I_E> merely acts to release the phase-to-earth measuring systems. The same setting considerations nevertheless apply.

2. Earth fault in an overhead line system

Since an earth fault is by far the most frequent fault in medium-voltage overhead line systems, measures for its quick correction are welcome. The most frequently used method is auto-reclosure (AR). On the medium-voltage level auto-reclosure is always triple-pole, and in the case of high-voltage single-pole. Single-pole auto-reclosing circuit-breakers are therefore a precondition here. If an earth fault occurs on the overhead line, the protection relays concerned will pick up.

Following a TRIP command, there is a dead time (500 ms for medium voltage, 1 s for single-pole AR at high voltage), after this the line is reconnected. If the earth fault is corrected, operation continues. If not, final disconnection takes place within the set time. Approximately 70 % of earth faults are corrected in this way without any major interruption to operation.

Fig. 1 SIPROTEC relay with earth-fault protection



- Earth fault = short-circuit
- Disconnected by the short-circuit protection
- Earth-fault detection is more sensitive than phase current detection

Fig. 2 Low-resistance-earthed system

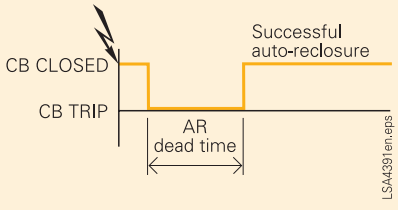


Fig. 3 Earth short-circuit in an overhead line system

Overcurrent-time protection relays 7SJ5.., 7SJ6.. can be ordered with this functional option, as can the distance protection relays 7SA5.., 7SA6..

Settings for medium voltage:

Auto-reclosure	Triple-pole
Dead time	500 ms
Action time	300 ms

Settings for high voltage (≥ 110 kV):

Auto-reclosure	Single-pole
Dead time	1 s
Action time	300 ms

3. Earth fault in a cable system

Auto-reclosure is not appropriate for a cable system. In such cases, final disconnection is unavoidable since an earth fault does not correct itself. Selective grading avoids unnecessary tripping in such cases.

4. Locating faults

It is possible to locate earth faults with the 7SJ6.. definite time overcurrent-time relay as well as with the distance protection relays 7SA5.., 7SA6... The precise setting of the line's X layer is required. This can be taken from the appropriate tables in the cable manual. In contrast, the setting of the Z_E/Z_L factor is more difficult. Only measurements can reveal the true facts here. The relays measure the impedance loop as far as the fault location. If the above-mentioned set values are correct, an accuracy of 3 % of the given fault distance can be expected. In practice, the set values can be optimized on the basis of an exact empirical analysis of faults that have occurred.

5. Summary

In a low-resistance-earthed system an earth fault is always a short-circuit.
The sensitivity of the pickup value for the earth-fault protection has to be set adequately to reliably trip upon each earth fault.
SIPROTEC line protection relays are available with the earth-fault protection function as an option.
In an overhead system about 70 % of the earth faults are successfully eliminated by AR without significant system interruptions.