Close and Return

K-FACTOR MEASUREMENT OF CABLES FOR OPTIMUM RELIABILITY OF DISTANCE PROTECTION AND FAULT LOCATORS

Dipl.-Ing. Ulrich KLAPPER, OMICRON electronics, (Austria), ulrich.klapper@omicron.at
Prof. Dipl.-Ing. Dr. Lothar FICKERT, TU Graz, (Austria), lothar.fickert@TUGraz.at

ABSTRACT

Distance relays are important elements for the reliability of electrical power transmission. The Positive Sequence Impedance and the Ground Impedance Matching Factor, or k-Factor, as it is often referred to, are some of the most important settings of such a relay. Should one of these settings be incorrect, the whole protection system, including the instrument transformers, the relay and the circuit breaker, is not used as effectively as it could be.

This paper explains the difficulty of making the k-Factor settings and illustrates cost effective solutions for preventing incorrect behavior of distance protection schemes.

IMPORTANCE OF K-FACTORS

Protective relays are needed to protect a power cable or an overhead line. When a fault occurs on the line, such as an insulation breakdown, it has to be cleared safely, selectively and quickly. Selectivity means that only the line on which the fault is located is switched off, thus minimizing the outage.

There are two principal methods to obtain selective tripping on power lines, these are differential protection and distance protection. Differential protection is often considered to be a better solution but is dependent on the availability of a secure communication channel because the relays at each end of the line need to communicate with each other. Furthermore, differential protection does not provide back-up protection. This paper does not discuss this method further. For cost reasons and because of the lack of back-up protection, on most power lines distance protection relays are used.

One of the most important settings of a distance protection relay is the Positive Sequence Impedance, which is strictly applicable only for fully transposed (symmetrized) lines and is half of the complex impedance of the phase to phase loops (Figure 1).

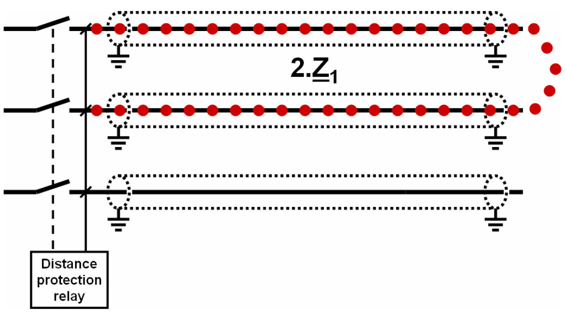

Figure 1: Impedance loop between two phases

When a fault occurs the distance relays on both ends measure the impedance. If the impedance is (typically) below 80% or 90% of the line impedance they trip as fast as possible (zone 1), because it is clear that the fault is on this particular section of line. If the impedance is higher, the relay will trip after a delay (≥ zone 2), to give another relay, that might be closer to the fault, a chance to clear it.

For faults of one or more phases to ground, the impedance of the fault loop is different (Figure 2). Because the impedance of the ground path, or to be more precise, of this ground loop, is different to that of the phase to phase loop, a factor within the relay gives the relationship between the line return and the ground return impedance. This factor is called the ground impedance matching factor, the residual compensation factor or simply the k-factor.

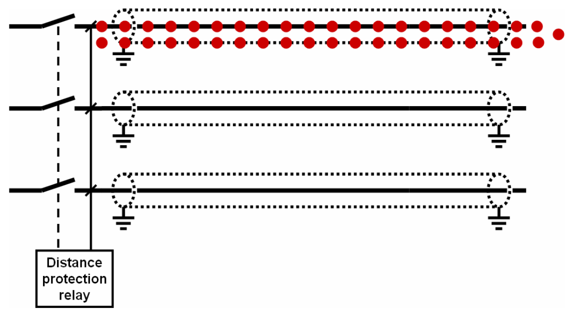

Figure 2: Impedance loop on a single phase to ground fault

If the relays are set properly, a consumer that is supplied from two sources (Figure 3) continues to receive energy from the healthy line if the other one trips.

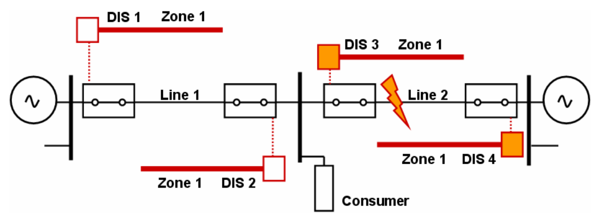

Figure 3: Relays with optimum zone 1 reach

If the impedances or k-factors of a relay are not set properly, zone over- or under-reach may occur (Figure 4).

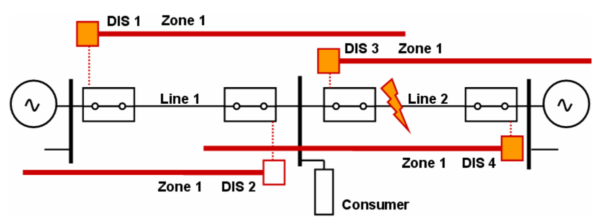

Figure 4: Relays with zone 1 over-reach