Basic Busbar Protection by Reverse Interlocking

Busbars have a particular key role in power transmission and distribution. They are the central distribution point for many feeders. In the event of a fault, the short-circuit current on the busbar is very high, resulting potentially in mechanical destruction and the consequent long repair times, which would affect all feeders. On the high and extra-high-voltage level, a fast 7SSx busbar protection relay is used, which, with a tripping time of <12 ms, limits the damage by busbar faults. Fast busbar protection is also used in all important medium-voltage switchgear.

For basic medium-voltage switchgear with one incoming feeder, no special busbar protection is used (for reasons of economy). In such cases busbar protection is provided by the time-overcurrent relay of the incoming feeder. As shown in Fig. 1, tripping of the time-overcurrent protection for the E1 feeder occurs with a grading time of 300 ms more than the longest grading time of the A1-A3 feeder protection. The times selected in Fig. 1 have been taken as examples. The E1 protection serves as backup protection for each A1-A3 feeder protection.
A busbar fault is however then only disconnected after 0.9 seconds, which would result in damage of considerable magnitude.

In the case of single busbars with one defined incoming feeder and otherwise only defined outgoing feeders, fast busbar protection can be provided with no major additional effort by means of reverse interlocking. Such busbar configurations are common in medium-voltage systems and in auxiliary supply networks. The time-overcurrent relays already available for feeder protection are used, as shown in Fig. 1. An additional benefit is that all SIPROTEC relays are equipped with at least two definite-time current stages, which can be blocked individually.

The reverse interlocking concept is shown in Fig. 2. With the time-overcurrent protection E1 of the incoming feeder, a further stage $I>>$ with a time delay of $t_2 = 50$ ms is provided in addition to stage $I>$ with t_1. The expiry of time t_2 can be blocked via the binary input BI1.

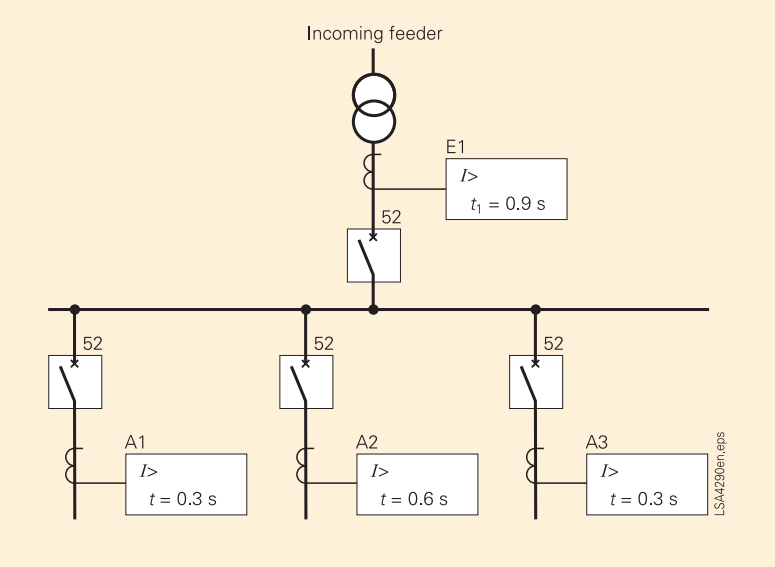

Fig. 1 Single busbar with feeder protection

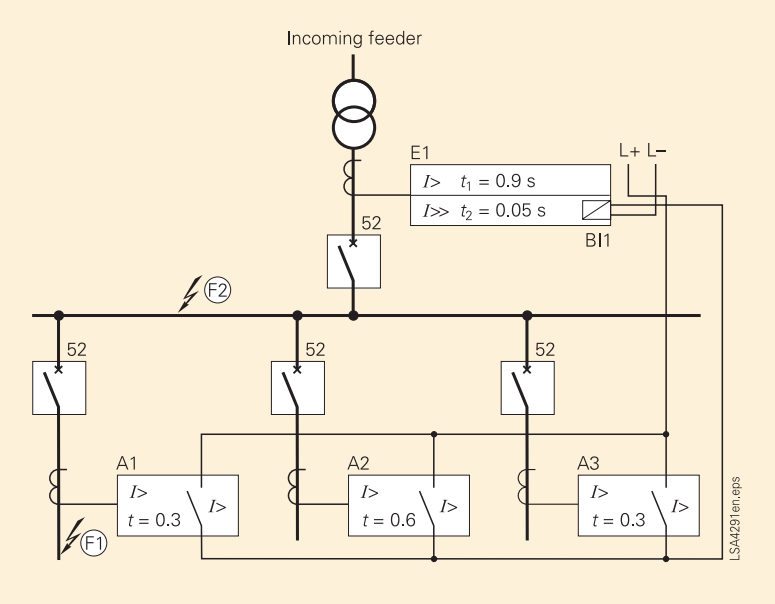

Fig. 2 Single busbar with feeder protection and busbar protection by reverse interlocking

The tripping threshold of the stages $I>$ and $I>>$ is set at the same level in accordance with the network conditions (approximately 1.5 x I_{rated}). For the time-overcurrent relays of outgoing feeders A1-A3, the pick-up signal is allocated to a dedicated contact. The pick-up signals of all feeders are connected in parallel and given as a blocking signal to the binary input BI1 of the relay of the incoming feeder. Wiring is effected by means of a copper core, looped from panel to panel (see Fig. 2). This means that a pickup in an outgoing feeder A1-A3 will block the tripping of the $I>>$ stage (t_2) of the incoming feeder E1.

Function in the case of a fault in the outgoing feeder:
In the case of a fault on the outgoing feeder (see "F1" in Fig. 2), both stages in relay E1 of the incoming feeder pick up. The relay A1 of the outgoing feeder also picks up and issues a blocking signal via the pick-up signal to binary input BI1 of the relay E1 of the incoming feeder. The expiry of t_2 is thus blocked. The fault is disconnected from the relay A1 of the outgoing feeder. The relay E1 of the incoming feeder operates as backup protection with t_1.

Function in the case of a fault on the busbar:
In the case of a busbar fault (see "F2" in Fig. 2), both stages in relay E1 of the incoming feeder pick up and t_1 and t_2 are started. From an A1-A3 outgoing feeder there can be no infeed onto the fault. Consequently there is no blocking signal. In the relay E1 of the incoming feeder, time t_2 expires and trips the circuit-breaker after 50 ms. The busbar fault is thus disconnected within a short time and the extent of the fault is limited.

Summary

For busbars with one incoming feeder and radial outgoing feeders, i.e. without back-feeding, the reverse interlocking principle grants an effective and fast busbar protection. Additional hardware is not required, because the SIPROTEC devices incorporate this function in their basic versions. Attention shall be paid to motor feeders, which may feed a busbar fault in the generating mode. They cannot always be treated as feeders without back-feeding.

Prospects for further applications

In the case of ring busbars with two incoming feeders or single busbars with sectionalizer, a similar reverse interlocking principle can be applied by way of short-circuit direction detection. This case will be presented in a separate application.