PARSONS BRINCKERHOFF

Background

I_s-limiters, utilising a high speed fault current detection and an explosive activated switch mechanism, have been in extensive use in various countries worldwide.

Their use is primarily aimed at managing the fault breaking duty imposed on circuit breakers. In such situations the I_S-limiter either directly interrupts the fault current, or more commonly, the limiter is placed in a bus section position. It then reduces the fault infeed current from one side of the substation and hence reduces the fault breaking duty imposed on the circuit breaker that clears the fault. This mode of operation makes the I_S-limiter safety critical and will give some difficulties in complying with UK safety legislation, in that if the I_S-limiter fails to operate the circuit breaker duty could be exceeded. This was the conclusion of the report on 'Development of a Safety Case for the Use of Current Limiting Devices to Manage Short Circuit Currents on Electrical Distribution Networks' prepared by Parsons Brinckerhoff Ltd under the auspices of the DTI New and Renewable Energy Programme in 2005.

On the FLARE Project the trial of I_S-limiters is aimed at using them to manage through fault current levels in cables as opposed to breaking duty on circuit breakers.

Problem

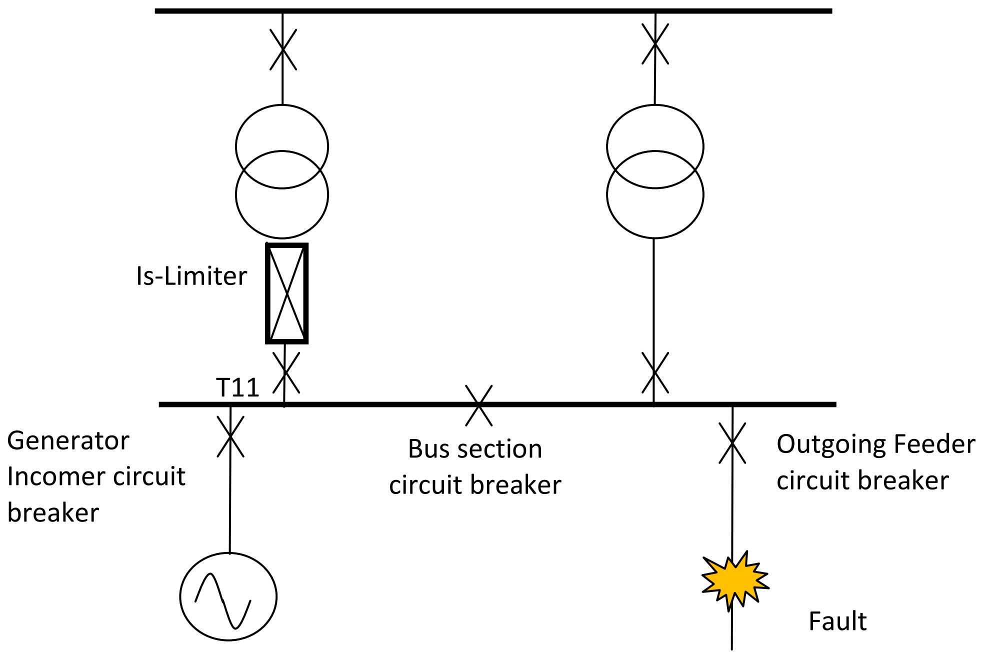
In dense urban conurbations the future increase in fault levels can be a particular problem close to main substations, especially those running at 11kV and 6.6kV. For faults occurring within the first 500-1000m of the substation the magnitude of the current can rapidly exceed the design limit for the cables and switchgear.

Whilst it is possible to upgrade switchgear relatively economically it is much more expensive to upgrade cable systems. Within the FLARE Project it is proposed to use the I_S-limiters to manage this cable through fault withstand condition, rather than the circuit breaker break duty.

Method

On a substation the circuit breakers which approach their design limit first are those on outgoing feeders. This is because the fault current flowing through the outgoing feeder circuit breaker is the summation of the fault current flowing through each of two infeeding transformers circuit breakers, plus any infeed from local generators plus any infeed from load connected to other outgoing feeders from the same substation. The circuit breakers on the infeeding transformers will see a lesser fault current.

The I_S-limiter will therefore be placed in one of the two infeeding transformer circuits (say T11) and hence when activated will operate for all downstream faults of sufficient current, these will be close in faults, within 1000m of the substation. The I_S-limiter will be set to not operate for faults of lower current magnitudes ie more than 1000m out. In conjunction with the I_S-limiter Adaptive Protection can also be fitted to T11, and be set so as to always open the T11 circuit breaker for any fault downstream of the substation. T11 will open before the relevant outgoing feeder circuit breaker. This is because the fault current flowing through T11 will always be lower than the fault current flowing through the outgoing feeder circuit breaker.



The fault infeed from T11 will therefore be interrupted before the outgoing feeder circuit breaker opens and hence all circuit breakers will be retained within their break duty.

If the I_S-Limiter is active it will of course operate faster than the T11 circuit breaker. The Adaptive Protection therefore acts as a backup to the I_S-limiter and hence there will be two levels of safety assurance on fault clearance by the circuit breakers ie fail safe if the I_S-limiter fails to work. This is the potential business as usual configuration, whereas in the FLARE Project the techniques will be deployed individually.

The through fault current on the cables will be reduced if the I_S-limiter operates. Should the I_S-limiter not operate then the cable will have to carry the full fault current until the Adaptive Protection opens the T11 switch, and then a lower level of fault current until the outgoing feeder circuit breaker opens. This could cause a second fault on the first 1000m of cable that has the first fault on. Put simply, if the I_S-limiter fails, the worst that can happen is that a second fault may occur on a piece of cable that is already faulty. As the circuit is wholly underground then this does not give rise to a hazard.

The FLARE project will test this method on a number of live substations but during the trial no cables or circuit breakers will be operating beyond their rating, ie the I_S-limiter and Adaptive Protection will be tested in a safe 'sand box' on systems that do not need them.

Solution

The Project will also carry out robust risk and technical assessments of the method, and will work closely with key stakeholders, including the HSE. The aim will be to test whether an acceptable Safety Case can be developed for using the

I_S-Limiter in isolation to manage through fault current levels in cables as opposed to breaking duty on circuit breakers. The demonstration of this, as well as the practical implementation on the trial sites, will provide a solution to managing through fault currents in cables, and will avoid or defer the upgrading of cable systems due to fault current problems.