



INNOVATION STRATEGY CLOSE-OUT REPORT

| | |
|----------------------|--|
| PROJECT TITLE | Special K – Improved Continuity for 20kV earth faults by reducing the range of SEF operation |
| PROJECT OWNER | Stephen Walsh, System Protection and Earthing Manager, ESB Networks Assets |
| CONTRIBUTOR(S) | Niall Canavan |
| INTERNAL DOCUMENT NO | DOC-161019-FEU |
| VERSION | 1.1 |
| DATE | 10 th March 2019 |

BRIEF OVERVIEW OF PROJECT & EXPECTED BENEFITS

Approximately 80% of faults on the network are transient e.g. wildlife, lightning, branch falling on an overhead line. Protection devices (reclosers) will attempt to clear these faults from the network and restore electricity supply to customers as quickly and safely as possible.

This project is focused on improving the continuity of supply by reducing the range over which Selective Earth Fault (SEF) operates. At present, SEF operates for low current faults, ranging from 4A to an upper limit of 30A, 40A or 50A, depending on the device. For temporary faults, SEF will cause a trip and lock-out the circuit breaker. No attempt is made to clear faults by reclosing, which then results in a permanent power outage.

The proposed solution to this issue is to reduce the upper limit to a common setting of 22A. An overall reduction and standardisation of this upper limit across all devices would lessen the number of SEF operations, which would directly improve the continuity of supply to customers. These settings are also referred to as 'Special K'.

This proposal would reduce the overall duration of an Earth Fault (EF). The duration of a temporary EF with SEF is currently 5 seconds, which would be reduced to 0.2 seconds (under normal circumstances) by use of a fast open & reclosing system. The long supply interruptions would then be replaced by an increased number of momentary outages for reclosing, lasting between 1 & 10 seconds.

In permanent fault situations, the new EF settings would make very little overall difference, the total time the fault is live would be 0.1s + 0.1s + 4.7s, where the 4.7 seconds is a cut-off time for EF set below SEF 5s time.

The standardisation of the upper limit of SEF will still allow devices in series to be selective. By default, the upper limit of SEF is the nominal amp setting for normal EF operation. Up to now the nominal EF setting was increased by 10A per device in series. However, this is not the only way to have selectivity between devices in series. Alternatively, it is possible to slow down devices in series by having a larger time-multiplier setting, rather than larger nominal amp settings.

| Location of CB | Old setting | New setting |
|--------------------------|------------------------------------|------------------------------------|
| HV station | 4A - <u>50A</u> , time delay 240ms | 4A - <u>22A</u> , time delay 240ms |
| 1 st Recloser | 4A - <u>40A</u> , time delay 140ms | 4A - <u>22A</u> , time delay 140ms |
| 2 nd Recloser | 4A - <u>30A</u> , time delay 40ms | 4A - <u>22A</u> , time delay 40ms |

TABLE 1 - SEF OPERATIONS

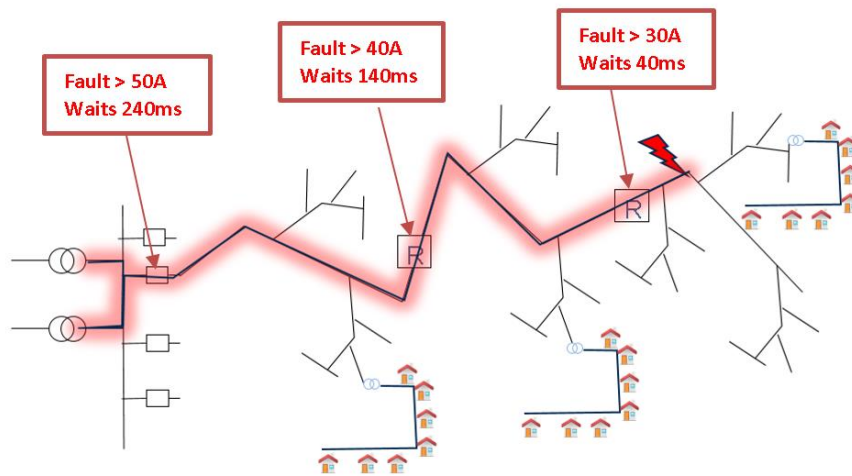


FIGURE 1 - FAULT ON THE NETWORK

This proposal would result in a 5% increase in the chance of preventing a fault going from temporary to permanent. There would also be a small reduction (<1%) in the chances of a full station tripping out.

There are some additional considerations to this proposal, including the risk that an entire station will trip while SEF is switched off during paralleling operations. This risk is mitigated by having a maximum cut-off time for the earth fault stage, and by lowering the upper current limit to 22A. This coordination of the UREF and the upper limit will reduce the risk of a station outage.

In the rare instances where the fault current is close to the setting, the time trips must be coordinated. Failure to apply this ruling can result in one device seeing the fault, and the downstream device not seeing the same fault. To mitigate this risk, lower nominal current settings must be implemented. By lowering downline devices by 1A, the potential for unselective operation is reduced.

An earth fault must be directional if the capacitive current on a single feeder exceeds 80% to allow for all other feeders to contribute capacitive current to the NVD (Neutral Voltage Displacement). By having a lower nominal setting, the earth fault will occur most often at the head of the feeder. Having the EF cut-off times below the SEF times will help avoid spurious tripping on healthy lines for faults in the lower current range (less than 100A).

RESULTS

Development of innovative settings while continuing to comply with existing standards. Proposal has been extensively discussed and risk assessed within System Protection and Earthing Section Group before new innovative settings were finalised.

This proposal was successfully trialled in two stations, Julianstown, Co. Meath & Cahersiveen, Co. Kerry. This resulted in the proposal being upgraded from proof of concept to BAU.

Each substation with EF tripping mechanisms will require this new settings update.

LEARNINGS

The implementation of the new SEF settings across ESB Networks reclosers has shown to lessen the number of SEF operations, reducing outages and improving the continuity of supply to customers.

BENEFITS REALISED/VALIDATED

2017/2018 - Trial in Julianstown (Co. Meath) and Cahersiveen (Co. Kerry) completed.

Ongoing monitoring and logging of SCADA alarms regarding protection activations.

Reducing Customer Minutes Lost by:

- 5% increase in the chance of preventing a fault going from temporary to permanent
- Small reduction in occurrences where stations fully trip out

Cost benefits:

- Increased continuity of customer supply with savings related to continuity penalties
- Reduced man-hours to call to sites to restore permanent faults

NEXT STEPS – BAU, TRANSFER OF OWNERSHIP

Full scale implementation to all 20kV EFT stations with downline reclosing in line with BAU settings update. This change of new settings shall be carried out at the same time as other work in station.

FINAL TIMELINES (REASONS FOR ANY DELAYS IF THEY OCCURRED)

Proposal of new settings finalised in 2016. New protection settings have been trialled and assessed over a two year period in 2017 and 2018 before project closure in 2019.

FINAL COSTS

No costs involved with the changing of settings, as changes to 'Special K' will be done over time whenever settings are due to be changed during normal circumstances.