Reliable, Low Cost Earth Fault Detection for Radial Overhead Line Systems

Our earth fault detection project successfully developed and trialled fault passage indicator units for overhead line networks. These allow us to detect faults in real time, speed up restoration times and improve service to customers.

The overhead line fault passage indicator.

Background

Rural electricity distribution networks are largely comprised of long overhead lines which can represent an operational challenge to network operators owing to the higher-than-average incidence of faults, the large geographic regions they serve and the reduced availability of network automation.

Faults on overhead lines can be difficult to find and repair teams often need to patrol large areas on foot to locate them. This means some customers can be without power until the damage is located and repaired, particularly in storm conditions. As well as affecting customers' electricity supplies, these faults can become a safety hazard for the public and the engineers who repair them if they are not detected quickly.

In order to improve restoration times, network operators need reliable, robust, low-cost solutions to accurately identify the location of faults and improve the performance of rural networks.

Project overview

The aim of this two-year project, funded under the Network Innovation Allowance, was to improve the way we respond to faults on overhead lines by providing fault passage information to control engineers in real time. Building on existing designs, already deployed for underground cable fault detection, we extended this functionality to rural overhead lines.

Working with project partner Nortech, we specified, developed, tested and demonstrated a low cost, clip-on-the-line sensor, capable of detecting earth faults and over-current safely. This 'fault passage indicator' (FPI) can be deployed at volume and reliably communicates back to the main network management system.

Installation and field commissioning procedures were designed to be as quick and straightforward as possible. The installation and removal of the trial FPI units take only minutes using standard live-line techniques and therefore requires no customer interruptions.

The FPIs have significant potential to speed up fault identification, location and isolation on rural overhead lines, and consequently improve customer service.

Installation and approach

We installed prototype devices at ten sites using live-line techniques. Locations were selected based on a range of factors including historic network performance, number of customers served and the overall length of overhead line.

The FPIs communicate in real time through our existing 'Supervisory Control and Data Acquisition' (SCADA) system to allow control engineers to see if fault current has passed specified points on the network. This significantly reduces the possible number of circuit sections where the fault may be located. Reliable communication to a central system was achieved using secure Distributed Network Protocol 3 (DNP3) communications over the Global System for Mobile (GSM) network.

Trial findings

During the trial the FPIs installed on the network detected several faults. Both over-current and earth faults were detected and fault indications were sent back to the central system within seconds. This is a significant improvement on the traditional method of locating faults using foot and vehicle patrols, which can take hours.

The FPIs are self-powered and harvest energy from the overhead line. It was noted during the trial that network reconfiguration resulted in no current flowing through an FPI for a period of four weeks, but the unit continued to communicate reliably using its back-up battery. Based on extrapolated results, we anticipate that the FPI could have sustained operation for three months without harvesting any further energy from the overhead line.

Although these devices are aimed at locating faults on 11kV networks the voltage presence function was able to detect a loss of voltage caused by a 33kV network event which affected several FPIs fed from the same 33kV primary substation. This is a useful additional feature which allows rapid visibility of the extent of a fault, and helps the control engineer to assign the correct response team.

The FPIs also continuously record load currents and periodically communicate these back to a central database. The load currents were found to be significantly different to standard network planning estimates for several sites, indicating that the FPIs could be used to provide useful data. This could reduce uncertainty for network planning processes and network reinforcement decisions. By using refined estimates, we can target network reinforcement investment where it is most needed.

Summary and recommendations

Our project has demonstrated that it is possible to detect over-current and earth faults using line-mounted sensors. The use of FPIs on overhead networks can improve post-fault location by at least 20 minutes versus traditional methods. This is because the FPIs provide additional information regarding the location and type of fault.

We recommend the following to other network operators looking to adopt the overhead line FPI method:

1. Choose installation locations that are readily accessible (eg adjacent to roads) for ease of installation, inspection and maintenance.
2. Loading data should be used to help inform the installation location to ensure the load current at the site is sufficient for self-sustaining operation. (The FPIs could be used to monitor the load current at site for a period of time and then a decision can be made regarding the suitability of the location).
3. Carry out a GSM coverage survey as part of the installation location planning to confirm that communications can be established.

A technical specification based on our findings is available as an appendix to the project closedown report.

Example installation of overhead line fault passage indicators.

NEXT STEPS

Following the successful outcome of this project, we have modified our operations through the use of overhead line FPIs to locate faulty 11kV circuit sections more quickly.

Over 700 devices have been deployed on the network, each delivering an average 20-minute reduction in time off-supply. The next step will be to integrate the FPIs into our new network management system. This will unlock the potential to use the devices as part of our automatic restoration scheme.

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