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NIA Project Registration and PEA Document

Date of Submission

Nov 2020

Project Reference Number

NIA_SSEN_0051

Project Registration

Project Title

Synaps 2 - Fault Detection, Classification & Location Solution

Project Reference Number

NIA_SSEN_0051

Project Licensee(s)

Scottish and Southern Electricity Networks Distribution

Project Start

December 2020

Project Duration

3 years and 4 months

Nominated Project Contact(s)

Kevin Dennis - Scottish and Southern Electricity Networks (SSEN) Chino Atako - UK Power Networks (UKPN)

Project Budget

£1,160,432.00

Summary

This will continue from the previous SYNAPS 1 project — the installation of the current sensors on LV feeders with known faults to determine their location. This work will focus on optimising the network calibration procedure and tuning the location technology to improve accuracy of the fault information and minimise the time required to generate it.

Preceding Projects

NIA_UKPN0037 - SYNAPS Fault Detection, Classification & Location Solution

Third Party Collaborators

Fundamentals

Lucy Gridkey

Powerline Technologies

RINA

Megger

ACUTEST

PNDC

Energy Innovation Centre

Nominated Contact Email Address(es)

fnp.pmo@sse.com

Problem Being Solved

A large proportion of faults on the low voltage (LV) network are caused by the gradual degradation of underground feeder cables.

As the cables age, insulation layers gradually break down allowing the ingress of moisture which starts to cause momentary short circuits between the conductors. This causes an arc which often vaporises the water and clears the fault. These faults are known as ‘transient faults’, and they are invisible to the DNO and customers. As the cables degrade further the arc current may cause a fuse to rupture or LV protection to activate, causing an interruption to the electricity supply.

If the fuse is replaced, the fault will appear to have cleared. However, the underlying problem will remain, meaning that the fuse will most probably rupture again, giving rise to an ‘intermittent fault’. Eventually fuse replacement will not clear the fault and the fault becomes permanent.

Current DNO practice is mostly reactive, with faults only becoming visible when they are reported by customers. Standard practice is to replace the fuse. If the fault is not cleared, then technologies such as Time Domain Reflectometry (TDR) may be employed to locate the fault. These types of faults account for a significant proportion of LV network Customer Interruptions (CIs) and Customer Minutes Lost (CML). To technically and economically improve the performance of the LV network there is a requirement to move from reactive to proactive management of LV faults.

The SYNAPS 1 (NIA_UKPN0037) project was successful in trialling a solution which predicted fault locations from waveforms gathered prior to any noticeable LV activity, detecting transient or “pecking” fault events of short duration and low energy that did not rupture a fuse or trigger an LV network circuit breaker. Whilst not yet ready for a wider roll-out, this technology was certainly of interest and a follow-on project is required to bring the technical readiness level (TRL) to a commercially ready solution.

Method(s)

The SYNAPS 1 project closedown report identified that:

- SYNAPS detects a transient or “pecking” fault event of short duration, usually shorter than 1 cycle, and lower energy that does not rupture a fuse or does not trigger an LV network circuit breaker

- SYNAPS can classify the type of fault (phase-to-phase or phase-to-neutral)

- The SYNAPS AI algorithm assigns a classification to an event to predict whether the fault occurred along the main cable or a spur

The SYNAPS (synchronous analysis and protection system) solution will be deployed in substations and feeder link-boxes/feeder pillars. It applies innovative algorithms to power waveforms to detect and classify fault events.

SYNAPS uses state-of-the-art advanced statistical signal processing and machine learning algorithms to identify unique features of LV feeder cable faults (including early transient faults). A high sample rate detector is then employed. When a manifesting fault is detected the sensor records the fault waveform and transmits data to the server software for further processing. The server software classifies fault type and location (target accuracy 3m) utilising Powerline Technologies (PLT) proprietary algorithms.

Existing solutions use voltage/current analysis that give an approximate location of the fault, which is then pinpointed with gas sniffers and thermal cameras. These techniques are mainly used for permanent faults.

Returned SYNAPS data enables the DNO to make significant reductions in the cost of LV network operations. The detection and location of faults at an early stage, before they become permanent, will facilitate efficient asset cable replacement schemes rather than expensive reactive emergency action.

Scope

The Project will be organised into two trial stages:

- Basic Fault Location (3-4 months duration) will be trialled on two sets (four units) of the existing generation of prototype sensors to collect more data to improve the algorithm model for the advanced fault location stage

- Advanced Fault Location (8-9 months duration) will be trialled on ten sets of next generation sensors to continue collecting the data while improving the algorithms on different cable architectures and fault scenarios.

There will be a project review after 6 months.

Objective(s)

Basic Fault Location

This will continue from the previous SYNAPS 1 project — the installation of the current sensors on LV feeders with known faults to determine their location. This work will focus on optimising the network calibration procedure and tuning the location technology to improve accuracy of the fault information and minimise the time required to generate it.

Once a fault is identified the equipment will be moved between feeder locations at regular intervals after liaison with UKPN. This will allow continued collection of fault data in multiple cable type environments. Fault location information will be communicated to asset teams for investigation and validation.

DNO Operational IT System Connection Specification

Development of a specification for an interface between the SYNAPS cloud server and DNO operational IT systems to enable DNO operational staff to be informed in real time when LV faults are detected on specific feeders and to provide fault location information when this is available. The target system will be determined through mutual discussion between the NIA partners and could include iHost or similar platform.

Advanced Fault Location

This will be based on around ten sets of the next generation SYNAPS sensors. These will be divided between SSEN and UKPN and the installation of the sensors will be on LV feeders with known faults and/or fault history. In addition to increasing the number of data collection sites, this work package will also aim to test and validate the technology in support of the following use cases:

- Low voltage networks that run in parallel known in the industry as fully meshed networks

- Long Term Fault Evolution. Investigation of the network disturbances noted in SYNAPS 1 project. to determine which are early faults, to follow their evolution into permanent faults, to seek to determine at what stage they can be located and to ascertain the scope for predicting the time before they become critical.

- Investigate if faults can be identified as either cable or joint faults.

Prototype DNO Operational IT System Connection

Based on the “DNO Operational IT System Connection specification” developed above, implementation and testing of a working interface between the SYNAPS system and the DNO Operational IT system.

Business as Usual Demonstration

A demonstration of the final TRL8 commercial prototype will be carried out on the distribution network with the intent to demonstrate the solution in a network environment and to evaluate the data connectivity.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The new project will aim to achieve the following Success Criteria:

- Demonstrate that the SYNAPS system locates faults on an LV network with a precision similar to or better than existing technologies.

- Improve the accuracy of the fault position estimate with specific emphasis on calibration procedures

- Improve the speed with which the location can be determined.

- Validate the technology on a wider range of feeders and cable types, including fully meshed networks

- Identify if the fault is either cable (main cable or spur) or a joint fault.

- Specify and demonstrate a basic interface between the SYNAPS system and DNO IT systems.

- Investigate long term fault evolution on faulty cables (asset management).

- Improve deployment procedures and expose more operational staff to the technology.

- Demonstrate installation on an operational meshed LV network.

- Implement a pilot trial, with limited documentation, in an operational environment taking the SYNAPS solution from TRL6 to TRL7.

- Demonstration of data connectivity of the final TRL8 commercial prototype with the DNO network.

- Document network trials, DNO Operational IT System Connection specification and learnings.

Project Partners and External Funding

UK Power Networks, Powerline Technologies Ltd and the Energy Innovation Centre. There is no additional funding.

Potential for New Learning

The main learning, from stage 1 & 2, that will be shared with other DNOs is expected to include:

- How the SYNAPS system can be used for early detection, classification and location of pre-faults (transient, 'pecking' faults) on a live network

- The reliability with which the equipment can detect early transient and permanent faults using the system

- The reliability of characterisation of faults

- The accuracy of fault location using the SYNAPS system

- Opportunities for the SYNAPS solution in operational and asset management applications

- Standards and specifications related to the SYNAPS system that are required for network installation

- Requirements for a working interface between the SYNAPS technology and DNO Operational IT system for successful connectivity

This will demonstrate the capability of the pre-emptive fault detection solution.

Scale of Project

In the SYNAPS 1 project, the trial was limited to two prototype systems (one for each DNO). In SYNAPS 2 the next generation pre-production sensors will be introduced and the network trials scaled up to ten sets across the two DNOs. This is deemed to be the appropriate number of sensors to collect sufficient amount of data to improve the algorithms within the project timescales.

Technology Readiness at Start

TRL6 Large Scale

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

Trials will take place on selected UK Power Networks, including meshed networks in London, and SEPD network.

Revenue Allowed for the RIIO Settlement

There was no revenue allowed in the RIIO settlement for investigating innovative ways of detecting, classifying and locating intermittent faults.

Indicative Total NIA Project Expenditure

TOTAL: £661,140The total expenditure is £661,140, of which 90% (£595,026) is allowable NIA expenditure

Scottish and Southern Electricity Networks: £323,000 (90% £290,700)

UK Power Networks: £338,140 (90% £304,326)

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

n/a

How the Project has potential to benefit consumer in vulnerable situations:

n/a

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

Savings for the SYNAPS solution were calculated in a cost benefit analysis (CBA) based on the operation of 50 units for a year: 10 used during the NIA project and further 40 purchased on a business as usual basis

It is assumed that 25% of the 50 units will be rotated to new sites throughout the year. So, in total there will be 62 unique installations of the SYNAPS solution over a 12-month period.

The SYNAPS solution will provide savings in two areas:

1) Fuse Rupture Avoidance

It is assumed that each installation will avoid one fuse rupture per year, leading to CI and CML savings of £783 per installation per year, and operation time savings of £85 per year.

2) Fault Repair Savings

It is assumed that each installation will improve one fault repair per year (on top of the above fuse rupture avoidance). This is achieved through better locating the fault with the SYNAPS solution. It is assumed this will save 90 minutes of CML (£1,126) and 90 mins of operational time (£270) for one fault per installation per year.

There will also be additional savings through avoiding excavations (these have not been quantified).

Please provide a calculation of the expected benefits the Solution

Base cost – Method cost = £702,016 – £476,400 = £225,616 benefit over 5 years (based on 2020/21 prices),

Please provide an estimate of how replicable the Method is across GB

The SYNAPS solution will be fully transferable to all DNOs who want to acquire the technology. The solution will be most applicable to LV substations and feeder link-boxes/pillars of aged cables most at risk of transient faults.

Please provide an outline of the costs of rolling out the Method across GB.

Costs and the associated benefits can be extrapolated out to include other GB networks if the technology is taken up. These will depend on the region-specific requirements, i.e. number of units required, number of low voltage feeders on the network etc.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☑ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☐ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☐ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

The learning from this project will be about a new method to enable proactive LV fault management. This will be of value to all Network Licensees, as low voltage fault management is an issue affecting each one. If the SYNAPS system is able to accurately detect, characterise and locate faults, it will feed into a potential wider scale trial that will seek to deliver customer and network benefits such as improved network asset reliability and reduced customer interruptions.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

n/a

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

This project is being carried out collaboratively between Scottish and Southern Electricity Networks and UK Power Networks with assistance from the Energy Innovation Centre.

The SYNAPS 1 project established TRL 4 – 5 Prototype development, validated on PNDC Test Network and small DNO network calibration against PNDC data. SYNAPS 2 is not a duplication of the activities carried out in the SYNAPS 1 project. SYNAPS 2 will complete the technologies evolution from TRL 6 – 8 collecting data to improve algorithms to build commercially ready devices suitable for the business as usual environment.

The project technology providers, PowerLine Technologies, are familiar with the work carried out under previous projects such as the TP22, Kelvatek Bidoyng and also Northern Powergrid project, FORESIGHT – LV pre-fault recognition and management. There is no replication or duplication in this project as it is utilising a completely different type of technology than has been used in other LV fault projects which has the potential to deliver improved results.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

n/a

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

Traditionally LV fault location has used well known techniques such as impulse reflection and volt drop. SYNAPS provides innovative and sophisticated real-time fault monitoring, diagnosis and location capability using unique state-of-the art machine learning algorithms to detect, classify and accurately locate fault conditions by examining voltage and current waveforms from multiple locations in real-time. This has not been used previously, because machine learning technology was not advantageous in technology or cost.

Relevant Foreground IPR

n/a

Data Access Details

n/a

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

The project is still at a low TRL level and there are a number of issues and risks to overcome before the technology is mature enough to be used as part of business as usual activity.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

This technology will reduce CIs and CMLs, will lower the cost of pro-active fault management and if successful it can be replicated by every DNO, so NIA is the most appropriate funding to carry out this project. The project can only be undertaken as an innovation pilot given the operational risks associated with the deployment of an unproven solution in network operations. The technology has been tested in a laboratory environment but requires a true network test to prove its viability. The proposed approach to LV fault finding also has an unproven business case, and the range of potential benefits should be tested before the tool can be deployed. As noted in the NIA guidance, certain projects are speculative in nature and yield uncertain commercial returns. This is the case for this project. There is a commercial risk that the solution trialled in the project is not adopted by the stakeholders involved following the trial period. This could be due to the fact that the solution has not reached the level of maturity required for business as usual application. If the project is successful, it will have proven a technical solution which will improve network performance. The specific details regarding the benefits are captured under section 2b of this document.

This project has been approved by a senior member of staff

☑ Yes