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NPS/001/014 – Technical Specification for Overhead Line Fault Passage Indicators

1. Purpose

This document details the requirements for pole mounted remote FPI's (Fault Passage Indicators) for use on the Northern Powergrid HV (high voltage) distribution networks.

This document supersedes the following documents, all copies of which should be destroyed.

Document Reference	Document Title	Version	Published Date
NPS/001/014	Technical Specification for Overhead Line Fault Passage Indicators	3.1	Feb 2019

2. Scope

This document applies to pole mounted equipment that identifies the passage of fault current in 3-phase 3-wire and single-phase 2-wire overhead line systems of earthed and unearthed construction operating between 6.6kV and 20kV.

FPI's shall be supplied with the ability to identify the fault status locally via a visual flashing light and simultaneously send a signal to a centralised remote monitoring centre via an inbuilt GPRS communications system.

System Control or Field Engineers shall be able to simply follow the "flashing" lights or GPRS indication along the overhead line circuit. The fault will lie in the section of line beyond the last instrument to be triggered and before the next unit not to be triggered. With the exception of battery replacement every 10 years, this item shall be designed to be maintenance free.

The following appendices are included within this specification:

- Appendix 1 - Schedule of Requirements
- Appendix 2 - Addendum to Supplier Requirements
- Appendix 3 - Schedule of Suppliers Technical Data
- Appendix 4 - Self Certification Conformance Declaration
- Appendix 5 - Pre-commissioning testing, Routine Inspection and Maintenance Requirements
- Appendix 6 - Technical Information Check List

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3. Technical Requirements

3.1. General Requirements

3.1.1. Description

The FPI shall be designed to continuously monitor the residual current and voltage fields from the overhead line conductors. The FPI shall be triggered when fault current passes in the line conductors. In the "alarmed" state it shall flash a high intensity light or red LED (dependent upon fault type). Products that vary from the current system installed across Northern Powergrid shall provide communication and feature compatibility.

3.1.2. Technical Particulars

System Operating Voltage (kV)	6.6 – 20kV
11kV Sensitive Earth Fault Level (A)	15A
20kV Sensitive Earth Fault Level (A)	30A
Live/Dead Line Trip Level (A)	7 – 20A
Temperature Range (°C)	-40°C to +70°C
Humidity Range	0 – 100%
IP Rating	IP67
High intensity flash Rate (s)	10- 12 seconds
High intensity light brightness (Candela)	3000 Mill Candela
Voltage Reset Time (s)	60 seconds
Battery Type	Lithium
Minimum battery life under normal operating conditions	10 years
Battery Shelf Life	15 years
Installation Distance from Conductors (metres)	3m
Unit Impact Resistance (Joules)	2 Joules

3.2. General Conditions

3.2.1. System Conditions

The equipment shall be suitable for use on distribution systems in which the neutral point is earthed either directly with typical maximum earth fault passage levels of 2000A for 1.5 secs or by means of a neutral earth resistor in which the earth fault passage levels have been limited to 1200A for 1.5 secs.

On certain parts of the distribution system, the above earthing methods have been replaced by or supplemented with arc suppression coils.

The arc suppression coils have been installed to manage earth faults that are transient in nature. The protection system has been designed in such a way that the coil remains in circuit for a specific period of time limiting the flow of fault current. This action negates the requirement for an immediate circuit breaker operation and thus allows the system to operate normally for transient faults. If the fault is sustained, the protection system reverts back to the more traditional resistance earthed protection environment detailed above.

Typically the arc suppression coils have been designed to be in circuit for the following times before reverting to resistance earthing:

11kV - up to 30secs.

20kV - up to 5 secs.

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A review carried out on the Northern Powergrid distribution system has identified that under certain fault conditions on primary substations fitted with arc suppression coils, a fault on one circuit may lead to a displaced neutral condition and as a result the production of unbalanced capacitive currents flowing down non faulted circuits. Since this can result in false operation of the FPI's, those equipped with GPRS communications shall be capable of having their earth sensitivity levels remotely updated during the next heartbeat health check.

3.2.2. Environmental Conditions

Fault passage indicators shall be completely weatherproof and shall operate under conditions of shock and vibration normally encountered in service. Indicators shall be environmentally tested to IP67.

They shall be suitable for continued reliable operation in the temperature range -40°C to +70°C with humidity levels of between 0 - 100%. The equipment enclosure shall be UV stable.

Variation in system frequency of 2Hz from the nominal frequency of 50Hz shall not cause a variation of more than 5 per cent in the operation or resetting characteristics of a fault passage indicator.

3.2.3. Temperature

The unit shall demonstrate stability of operation for the equipment on both Earth Fault and Instantaneous threshold trip levels against the stated temperature range.

3.2.4. Vibration Endurance Testing

The equipment shall be suitably designed to withstand all likely vibrations present on a wood pole supporting structure.

3.2.5. UV Stability

The equipment shall be manufactured from Ultra Violet stable materials including all manufactures markings as detailed in clause 3.7.6

3.3. Modes of Operation

3.3.1. Desired Operating Modes

The unit shall be suitable for recognising permanent, intermittent and transient faults. Since many overhead line faults are intermittent or transient type, both of which cause auto- reclose operations and no obvious signs of damage, the FPI shall be designed to interpret the difference between these fault types and respond accordingly.

A passage of fault current combined with a sustained loss of voltage shall result in a high intensity light flashing for a designated period of time (as detailed in section 3.3.2 and 3.3.3) depending upon the fault type. This period will provide sufficient time for field staff to inspect the indicators on the system and patrol the faulty section of network. A passage of fault current without a sustained loss of voltage shall not result in the flashing of the high intensity light.

3.3.2. Permanent Fault

If the fault is permanent (indicated by a sustained loss of voltage) then any upstream FPI's shall be designed to alarm with the flashing of the high intensity light until the voltage is restored or for a period of 3 hours, whichever occurs first. To save battery capacity, once the high intensity light stops flashing the red LED or low energy identifier will commence flashing and continue for 24 hours. At the time of the fault, the GPRS module shall signal back to the I-Host server to record the permanent fault event. An additional signal shall also be generated when the units are reset and normal system voltage is restored.

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3.3.3. Intermittent and Transient Faults

In the instances where there has been a successful auto-reclose and the system volts have been restored, only the red LED will flash for a period of 24 hours. The high intensity light shall have been reset by the system voltage after 60 seconds. At the time of the fault event, the GPRS module shall record the transient fault event.

3.4. Earth Fault Sensitivity Levels

In general the FPI's shall be designed to be graded with the protection curves of adjacent ground or pole mounted reclosers, thus operating effectively at all fault levels down to as low as 7amps.

By default the FPI's units shall be supplied preset with earth fault sensitivity levels programmed for use on the 11kV system with earth fault sensitivity levels set to 15A. Where these units are required for use on the 20kV system the default setting shall be amended to 30A.

The FPI's shall be designed such that earth fault sensitivity level can be amended from it's default value to a user entered value both before it is installed and post installation via the GPRS remote communication system. All such remote changes to the FPI settings shall be designed to be achieved during the heartbeat health check process by amending the values in the I Host server software.

FPI's shall be designed to discriminate between magnetic inrush current and fault current.

3.5. Battery Life

FPI's shall utilise a single monitored battery suitably sized to provide the specified operation for a minimum of 10 years, assuming the following typical operating conditions:

- Average ambient temperature of 16°C giving an average self discharge of -2% remaining capacity per annum.
- 2 Weekly health check messages..
- Minimum shelflife of 2 years before installation on the distribution system.

FPI's shall incorporate a battery test facility allowing field staff to confirm the battery health status on site.

3.6. Communications

3.6.1. Communications Medium

The FPI's shall incorporate a modem that is capable of communicating on the UK GPRS system.

The outstation FPI unit shall be designed to communicate via the GPRS network system into an I-Host Data Management Software System to report the specified activity detailed in section 3.6.2.

Northern Powergrid utilises iHost to collect and manage GPRS data from FPIs and to link data into other IT systems. The FPI shall be supported on iHost and use a compatible open protocol such as DNP3. A further interface has been developed that allows this information to be integrated with the company's GE Harris Enmac NMS control system.

3.6.2. Functionality

- The system shall be designed to allow fault alarms to be sent via SMS Text messages, or Data Calls. The modem unit shall be capable of generating multiple alarm events, e.g. permanent faults,

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transient faults, system reset after permanent fault, signal strength, battery condition and next heartbeat time/date.

- Once a fault has been detected, the GPRS modem within the FPI shall send an alarm to the I Host software server. The software shall be designed to populate the customer's chosen database.
- The FPI shall be capable of receiving updated earth fault settings via the communication system.
- The FPI unit shall be capable of generating an unsolicited heartbeat message. The scheduled timing of the message being user definable between day/week/month. At the time for the scheduled heartbeat check there shall be a maximum of 3 attempts with 2 minute intervals for a successful transmission. If the heartbeat message is not received due to communication failures etc. then the controlling server software will generate an alarm event 15 minutes after first heartbeat due time.
- The FPI shall be able to time stamp events with reference to the Server's clock as time messages are received by the Server and to give differential event stamping to within 1 sec.

3.6.3. Modem

The modem unit shall be designed to accept a Northern Powergrid free issued SIM card that operates with the companies chosen network provider and comply with the following standards: -

ETSI 300342 Part 2

ETSI 31489 Part 7

3.6.4. Software Requirements

See clause 3.6.1 for details of existing FPI management software being utilised by Northern Powergrid.

3.6.5. On Board Diagnostics

FPI's shall incorporate on board diagnostics software that carries out a scheduled low battery health check. The unit shall be programable to allow an alarm event to be generated when the remaining battery life reaches a user definable limit. This alarm event shall be communicated back to the I-Host Software during the next programmed health call.

3.7. Testing

3.7.1. Electromagnetic Compatibility

Fault passage indicators shall have been fully EMC tested to the following standards:

BS EN 61000-6-3: 2007: Emission standards for residential, commercial and light-industrial environments

BS EN 61000-6-2: 2005: Immunity standards for industrial environments.

BS EN 60801-2: 1993: Electrostatic discharge requirements

(Min Values Air 4kV, Contacts 8kV)

BS EN 61000-4-3: 2002: Radiated, radio-frequency, electromagnetic field immunity test

(Min Values 27Mhz - 1Ghz @ 10V/M)

IEC 61000-4-4: 2004: Fast Transients/Bursts

(Min Values +/- 1kV)

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3.7.2. Communications - GPRS Electromagnetic Compatibility Tests for the Communication Equipment

The modem unit shall be compatible with the following generic EMC standards:

BS EN 61000-6-3: 2007 - Generic Emissions standard

BS EN 61000-6-2: 2005 - Generic Immunity standard

BS EN 61000-4-2: 1995 - Electrostatic discharge immunity Test

(Requirement Air 8kV, Contact 4kV)

BS EN 61000-4-3: 2006 Radiated radio Frequency, Electromagnetic Field Immunity. (Requirement 80MHz - 1GHz @ 10V/m)

BS EN 61000-4-6: 2007 Immunity to conducted disturbances induced by radio frequency fields

(Requirement 150kHz - 80MHz @ 10V/m)

BS EN 61000-4-4: 2004 Electrical Fast Transient/Bursts Immunity

(Requirements +/- 1kV).

3.8. General

3.8.1. Equipment Location

The equipment shall be designed for permanent attachment to wood poles with mounting locations approx. 3.0m symmetrically below the line conductors. They shall operate on flat, triangular and wishbone formation lines operating in three or single phase modes of operation. There shall be no physical connection between the FPI and the line or conductors.

3.8.2. Pole Fixing

The Northern Powergrid preference for fixing the FPI's to the pole shall be by means of a two point fixing bracket complete with keyhole style fixing holes suitable for 75mm long M10 or M12 coach screws.

3.8.3. Product Markings

All units shall be marked with the following information:-

External Markings

- Name of manufacturer
- Year of manufacture
- Serial Number
- The units shall be designed to have no visible antenna or aerial

Internal Markings

- Serial Number
- Manufacturing Batch Code
- Battery Installation Date Label (To allow information update when battery is changed)

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4. References

The products described within this specification shall comply with all current versions of the relevant International Standards, British Standard Specifications and all relevant Energy Networks Association Technical Specifications (ENATS) current at the time of supply.

4.1. External Documentation

Reference	Title
BS EN 60801-2 : 1993	Electromagnetic compatibility for industrial-process measurement and control equipment. Electrostatic discharge requirements
BS EN 61000-4-2 :2009	Electrostatic Discharge Immunity test
BS EN 61000-4-3 :2006 (Amended 2010)	Testing and measurement techniques. Radiated, radio-frequency, electromagnetic field immunity test
BS EN 61000-4-4:2012	Testing and measurement techniques - Electrical fast transient/burst immunity test
BS EN 61000-6-2 :2005	Generic standards - Immunity standards for industrial environments.
BS EN 61000-6-3:2007 (Amended 2011)	Generic standards - Emission standards for residential, commercial and light-industrial environments

4.2. Internal Documentation

Reference	Title
n/a	

4.3. Amendments from Previous Version

Reference	Description
Whole Document	Doc approved by email Mark Callum 13/12/2023 Doc republished to grid and externally - LB 18/03/2024

5. Definitions

Term	Definition
FPI	Fault Passage Indicators
GPRS	General Packet Radio Services (GPRS) is a packet-based wireless communication service that provides data rates from 56 up to 114 Kbps and continuous connection to the Internet for mobile phone and computer users. GPRS is based on Global System for Mobile (GSM) communication system.
NMS	Network Management System
Sim Card	GPRS phones use a Subscriber Identity Module (SIM) smart card that contains user account information.

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6. Authority for Issue

6.1. CDS Assurance

I sign to confirm that this document has been assured for issue on to the CDS system

		Date
Liz Beat	Governance Administrator	18/03/2024

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period.

Standard CDS review of 3 years?	Non Standard Review Period & Reason	
Yes	Period: n/a	Reason: n/a
Should this document be displayed on the Northern Powergrid external website?		Yes
		Date
Steve Salkeld	Policy and Standards Engineer	10/04/2014

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Date
Ged Hammel	Senior Policy and Standards Engineer	08/04/2014

6.4. Authorisation

Authorisation is granted for publication of this document

		Date
Paul Black	Head of System Engineering	13/12/2023

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Appendix 1 – Schedule of Requirements

Cat Number	Description
245894	11/20kV Fault Passage Indicator with remote GPRS reporting facilities

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Appendix 2 – Addendum to Suppliers Requirements

A1 Battery Life

Manufacturers shall provide sample calculations demonstrating the design capacity of the battery over the 10 year service life. The calculations shall include all assumptions, in particular the units remaining capacity for dealing with fault events after removing the estimated drain detailed in section 3.4 of this specification.

A2 Protection and Packaging

The units shall be suitably protected and packaged prior to despatch to prevent damage in transit and ensure their "fit for service" status prior to installation by the company.

A3 Packaging Markings

Each package must be marked with the following information:

- (i) Manufacturers name.
- (ii) Manufacturer's product type reference.
- (iii) Description of item.
- (iv) Date of supply.
- (v) Purchasing Companies Stock Cat Number.
- (vi) Weight of each unit or package.

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Appendix 3 – Schedule of Suppliers Technical Data

Description	Parameters Available on offered equipment
System Operating Voltage (kV)	
11kV Sensitive Earth Fault Level (A)	
20kV Sensitive Earth Fault Level (A)	
Live/Dead Line Trip Level (A)	
Initial Time Delay	
Voltage Reset Time (s)	
Temperature Range (°C)	
Humidity Range	
Enclosure IP Rating	
Enclosure construction material	
Quiescent drain	
High Intensity Light Flash Rate (s)	
High Intensity Light Power Demand – 3 hour flash period (mA.hrs)	
Low current demand flash –	
Transient fault Power demand – 24 hour flash period (mA.hrs)	
Battery Type	
Battery Life	
Battery Shelf Life	
Installation Distance from Conductors (meters)	
Unit Impact Resistance (Joules)	
Typical fault handling capability for – Units with communication set at 2 weekly heartbeat - (number of faults)	

To be completed for each unit being offered

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Appendix 4 – Self Certification Conformance Declaration

Fault Passage Indicators for overhead lines shall comply with the latest issues of the IEC's and British Standards quoted within this specification.

Key elements from the above standards and this specification have been quoted to amplify and/or clarify the requirements of those Standards. This check sheet identifies the particular clauses of the aforementioned Standards relevant to overhead line fault passage indicators.

The manufacturer shall declare conformance or otherwise, clause by clause, using the following levels of conformance declaration codes for each conductor.

Conformance Declaration Codes

N/A = Clause is not applicable/ appropriate to the product

Cs1 = The product conforms fully with the requirements of this clause

Cs2 = The product conforms partially with the requirements of this clause

Cs3 = The product does not conform to the requirements of this clause

Cs4 = The product does not currently conform to the requirements of this clause, but the manufacturer proposes to modify and test the product in order to conform.

Note

Separate Self Certification Conformance Declaration sheets shall be completed
For each product being offered.

Instructions for Completion

- When Cs1 code is entered no remark is necessary
- When any other code is entered the reason for non-conformance shall be entered
- Prefix each remark with the relevant 'BS EN' or 'ENATS' as appropriate

Manufacturer:

Product Reference:

Name:

Signature:

Date:

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Electromagnetic Compatibility			
Clause/Sub-clause	Requirements	Conformance Code	Remarks
BS EN 61000-6-3:2007	Emission standards for residential, commercial and light industrial environments.		
BS EN 61000-6-2:2005	Immunity Standards – Immunity for industrial environments		
BS EN 60801-2:1993	EMC for industrial-process measurement and control equipment – Electrostatic discharge requirements Min values Air – 4kV Contacts – 8kV		
BS EN 61000-4-3:2002	EMC – Radiated, radio- frequency, electromagnetic field immunity test Min Values 27Mhz – 1Ghz @ 10V/m 80Mhz – 1Ghz @ 10V/m		
IEC 61000-4-4:2004	EMC – Electrical fast transient/burst immunity test Min values +/- 1kV		
BS EN 61000-4-6:2007	EMC - Immunity to conducted disturbances induced by radio frequency fields Min Values 150khz – 80Mhz @ 10V/m		

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Specific requirements within this specification			
Clause/Sub-clause	Requirements	Conformance Code	Remarks
Clause 3.2.2	Environmental conditions Temp -40°C to +70°C Tested to IP67		
Clause 3.2.3	Temperature stability during fault conditions		
Clause 3.3	Desired Operating modes Differentiate between permanent, intermittent and transient faults for installation on main lines and tee's.		
Clause 3.4	Adjustable Earth fault Sensitivity 11kV – 15Amps 20kV – 30Amps		
Clause 3.5	Battery Life 10 years, based on two weekly heartbeat calls		
Clause 3.6.1	Communication requirements Capable of GPRS A proven capability to interface into the I Host Data management software.		
Clause 3.6.2	Functionality requirements		
Clause 3.8.3	Product markings External Markings Internal markings		

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Appendix 5 – Pre-Commission Testing, Routine Inspection and Maintenance Requirements

Appropriate installation, operation and maintenance instructions shall be supplied with each unit which include all necessary commissioning procedures.

Sufficient numbers of any special equipment or tools needed to test and commission the FPIs shall be provided so as not to hamper the efficient testing and installation of the FPIs.

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Appendix 6 - Technical Information Check List

The following information shall be provided by the supplier for review by Northern Powergrid. Additional information shall be provided if requested.

Requirement	Provided (Y/N)
Full product descriptions and part number/reference	
Appendix 3 – completed self-certification conformance declaration	
Complete set of drawings for each item	
Type test evidence	
Manufacturing routine test plan	
Packaging information	
Instructions/Manuals for transportation & handling, installation, maintenance and disposal	
Spares availability list	
ISO:9001, ISO:14001 and ISO:18001 certificates	