REPORT

Polesight Monitoring Design Specification

Prepared for: Northern Powergrid

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Final Approval

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Business	30/11/2022	1.0	David Mills – Head of Net Zero Transition
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1. Introduction

Polesight is a Northern Powergrid NIA funded project that seeks to trial pole mounted monitoring equipment both to explore the ease of installation of the equipment, the robustness and effectiveness of the equipment, and whether pre-faults exist and can be detected on LV overhead lines (OHLs). The project will build on the learnings from Foresight (2017-2021), which developed equipment and methods aimed at finding and fixing LV cable faults, on underground circuits fed from ground mounted substations, before they fail. Foresight produced a dataset from a fleet of low-cost detectors that is being used to provide health index information for LV underground cable circuits, which are of use in both the areas of Asset Management and Operational Network Management.

EA Technology Ltd, the technology partner for Foresight, will continue as the primary partner for Polesight. The project aims to deploy 10 ALVIN Guards and 10 VisNet Hubs at pole mounted substations. ALVIN Guards were the technology choice during Foresight and their primary use case is pre-fault detection. VisNet Hubs are more sophisticated than Guards and can be loaded with a series of applications including pre-fault detection. Other types of LV monitoring applications are available for VisNet Hubs. These could potentially provide additional project benefit.

Polesight which will run for a duration of 17 months (November 2022 – March 2024), has been divided into four workstreams:

- Workstream 1 – Monitoring design and performance.
- Workstream 2 – Monitoring installation and data gathering.
- Workstream 3 – Use of data for network performance improvement.
- Workstream 4 – Project management, reporting and dissemination.

This Design Specification is the first project deliverable for Workstream 1, which aims to address the functional and practical design requirements for instruments to be used for monitoring overhead and mixed networks fed from pole mounted substations.

It should be noted that this Design Specification seeks to meet the requirements of Northern Powergrid, who have requested that each monitoring device is to be housed within a suitable weatherproof enclosure. Whilst the Guard and the VisNet Hub are rated IP54 and IP55 respectively and are sufficient for outdoor use, Northern Powergrid have requested that the Guards and VisNet Hubs are installed in weatherproof plain enclosures to reduce the chance of vandalism and to provide additional environmental protection.

2. ALVIN® Guard / VisNet® Hub General Descriptions

2.1 ALVIN® Guard

The Guard detects pre-fault events by measuring three phase voltage and 8 current channels. The Guard detects dips in voltage that coincide with a current peak. When an event is detected, a waveform set is wirelessly transmitted to EA Technology's Substation 360 system. Substation 360 is EA Technology's custom data platform that, through a collection of micro-services and back-end databases, can ingest data from multiple sources. Data is aggregated, analysed, and modelled before being presented as information to the client via a dedicated user interface.

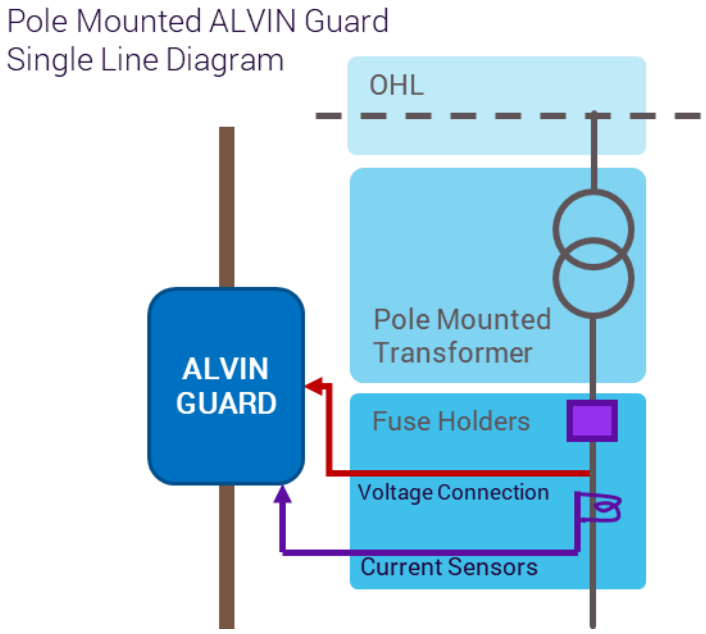

Figure 1 A simplified typical Guard installation for a single feeder

Figure 1 shows a single line visualisation of the Guard installation for a single feeder, the Installation Guide[1] will provide a detailed diagram showing connection points for all 3 phases and the neutral. The Guard is able to monitor up to 2 feeders, with the additional connections required being the Rogowski coils on the second feeder. If a second feeder was connected there would be an additional 4 Rogowski coils connected to the Guard from the other feeder's 3 phases and neutral. The voltage connections have been requested by Northern Powergrid to be after the fuses for this project. The disadvantage of this method of installation is that the unit will lose supply if multiple fuses blow. The advantage is that the fuses provide an additional level of protection should there be an electrical fault.

The unit consists of a single IP54 IK08 rated casing housing all power, measurement and communication circuits to which CATIV 300V rated external current and voltage sensors connect.

For the purposes of this project and for ease of installation, the Guard will already come fitted in an enclosure (see Section 5) and fully wired for fitting to the pole and appropriate phase and neutral conductors. The monitoring device will be fitted live by Northern Powergrid linesmen, who will be required to make the voltage connection to each of the 3 phases as well as the neutral by fixing an Insulation Piercing Connector (IPC) to each cable. When the neutral plus any one phase is connected power will be applied to the unit automatically (see Section 7).

[1] EA9744-TR05 Polesight Installation Checklist.

Each of the current sensors (Rogowski coils) are fitted by wrapping them around each individual phase of the outgoing LV circuits (see Section 8). As the Guard can accommodate 8 individual Rogowski coils, the Guard is only suitable for substations with up to 2 outgoing circuits (i.e. if all 3 phases and the neutral are measured).

2.2 VisNet® Hub

The VisNet Hub is designed to provide visibility of voltage and current on LV distribution substations. The Hub monitors the outgoing ways of a LV board providing insight about load, faults and condition across the network. It can measure three phase current, plus neutral, for up to six low voltage circuits and the busbar voltage.

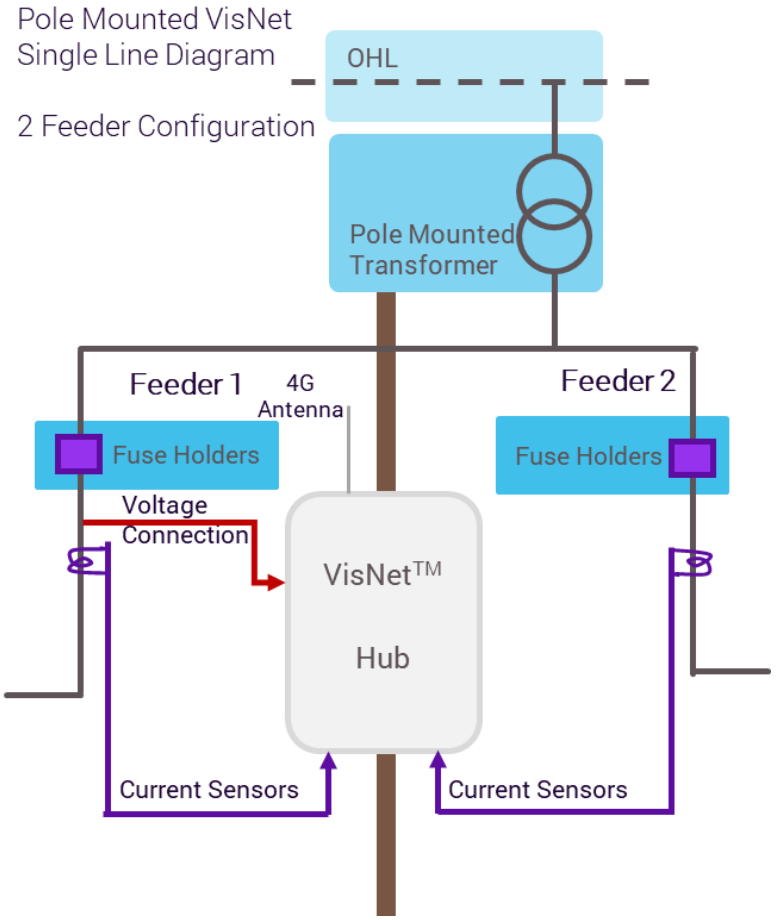

Figure 2 Typical VisNet Hub Installation for two feeders

Figure 2 shows a single line visualisation of the VisNet installation for two feeders, the Installation Guide will provide a detailed diagram showing connection points for all 3 phases and the neutral. The VisNet Hub utilises EA Technology's Low Voltage Common Application Platform (LV-CAP™) operating system, which allows a range of Applications (Apps) to be deployed at the distribution substation to expand the functionality of the unit beyond simple measurement.

For the purposes of this project and for ease of installation, the VisNet Hub will already come fitted in an enclosure (see Section 5) and fully wired for securing to the pole and connecting to the phase plus neutral conductors. The monitoring device will be fitted live by Northern Powergrid linesmen, who will be required to make the voltage connection to each of the 3 phases and the neutral by fixing an Insulation Piercing Connector (IPC) to each cable. When the neutral plus any one phase is connected power will be applied to the unit automatically (see Section 7). Typically, the connections would take place between the transformer and fuse to ensure reliable supply in the event of fuse failure. However, for this project Northern Powergrid have requested connection after the fuse as represented in the figure above.

Each of the current sensors (Rogowski coils) will need to be fitted by simply wrapping them around each phase and neutral of the outgoing LV circuits (see Section 8). Unlike with the Guard, where the Rogowski coils are supplied individually, the VisNet Rogoskwi coils are supplied in a bundled cable of four. As the VisNet Hub can accommodate 6 sets of 4 Rogowski coils, the VisNet Hub is suitable for substations with up to 6 outgoing circuits.

3. ALVIN® Guard / VisNet® Hub Specifications

3.1 ALVIN® Guard Specification

Figure 3 ALVIN® Guard

Size	242 (H) x 200 (W) x 50 (D) mm
Weight	1.1 kg
Casing	Injection moulded plastic case with cable cover sealed by a formed-in-place foam gasket
IP Rating	IP54
IK Rating	IK08 (EN 62262)

For the full version refer to EA Technology's '3473-PRSPC-GRD1-V01.03.00 Guard Product Specification'.

3.2 VisNet® Hub Specification

Figure 4 VisNet® Hub

Size	438 (H) x 279 (W) x 73 (D) mm
Weight	1.9 kg
Casing	Injection moulded plastic case with cable cover sealed by a formed-in-place foam gasket
IP Rating	IP55 When fully installed, mounted vertically and with the lid on
IK Rating	IK08 (EN 62262)

For the full version refer to EA Technology's '3473-PRSPC-VNH1-V01.02.00 VisNet Hub Product Specification'.

4. Proposed Location of Monitoring Device

The Polesight device should be mounted on the rear side of the wooden pole behind where the LV fuses are mounted. The device should be connected downstream of the fuses and should be installed above the anti-climbing guard. The device will come installed in its enclosure with all cables ready to be attached by the linesmen.

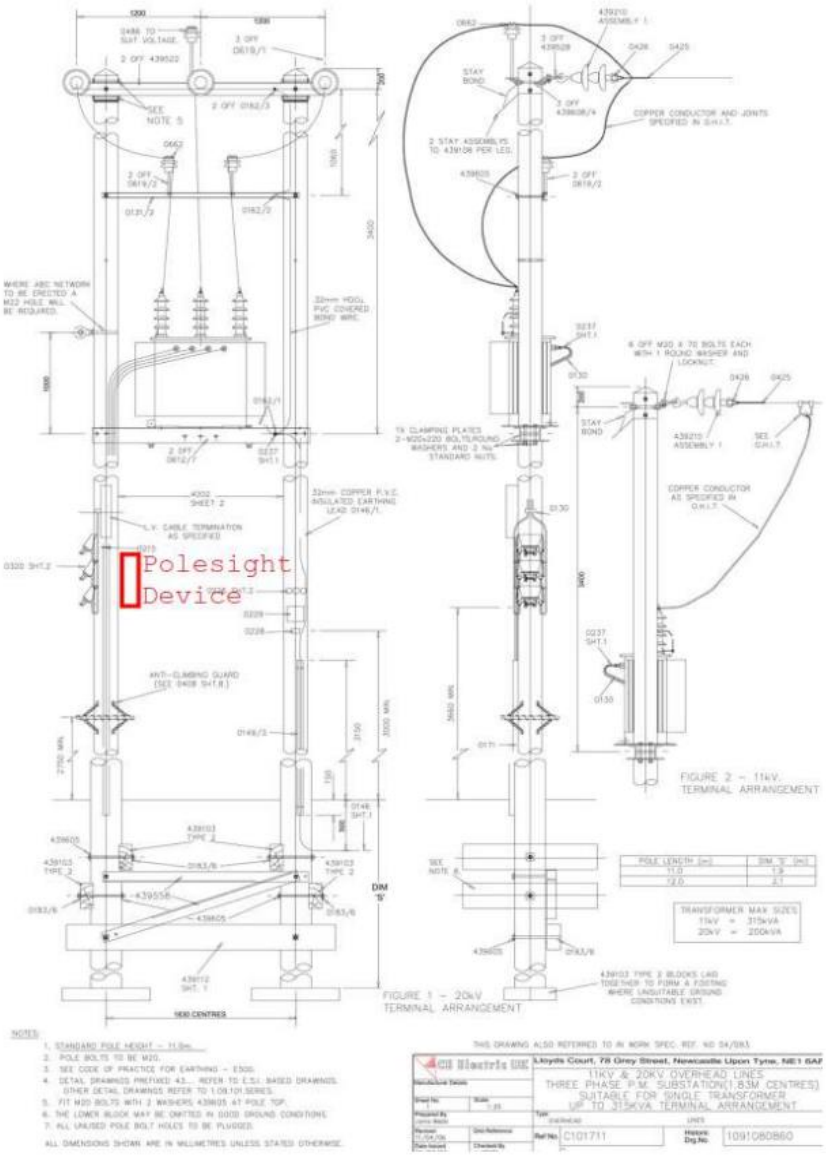

Figure 5 Drawing showing proposed location of monitoring device

For the Polesight project, installations will only be carried out where it is not necessary to take an outage on the HV (11kV or 20kV) network. To avoid requiring an outage there must be a safety clearance of 1.1m between any part of the installer and the nearest exposed live HV conductor at all times during the installation. Some substations are not suitable as the neutral cable between transformer neutral bushing and the LV overhead lines does not drop down the pole far enough so it is not possible to attach the required IPC or Rogowski coil.

The device will be installed above the anti-climbing guard. Where a clearance less than 3m (but greater than 1.1m) is required, an Authorised Person is required to issue a Limitation of Access (LOA). A two-person team with one person being an Authorised Person is the preferred arrangement.

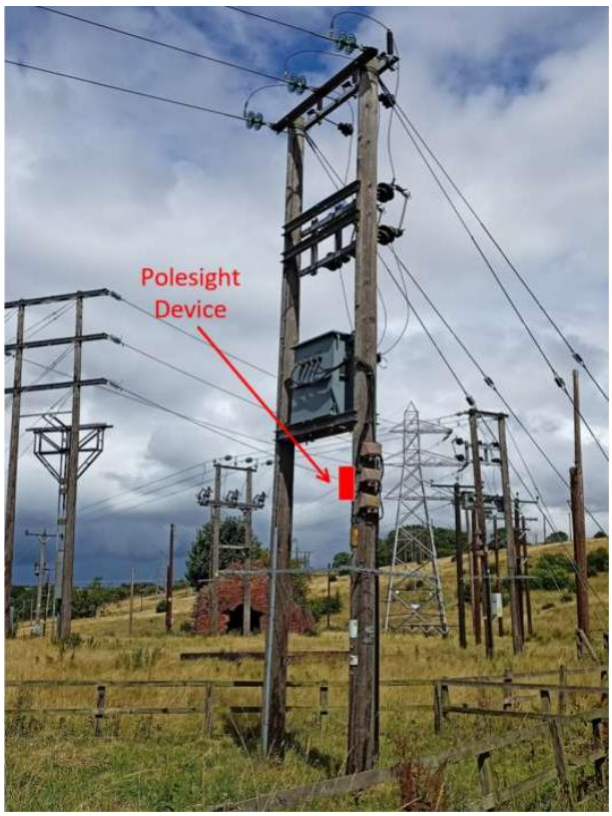

Figure 6 Image showing proposed location of monitoring device

For H-pole sites with limited space on the reverse of the pole from the fuses the device can be fitted on the pole with the most suitable clear space and the connections can be made from there.

Further details regarding installation can be found in the project report: EA9744 – TR02 Polesight Installation Guide.

5. Enclosures

DE Door Enclosures are made from ABS HB material to IP65 standard and can be used in various environments including seaside conditions, dry dusty environments and in heavy humidity (also refer to datasheet). The Guard / VisNet Hub will be securely fixed to the steel back plate along with the terminal block underneath.

Figure 7 DE Door Enclosures which will house the monitoring devices

The cables are fed through a cable gland installed at the bottom of the enclosure.

Enclosure	UL approved ABS-HB flame retardant plastic
Enclosure colour	Grey (RAL 7035) with solid door
Back plate	Steel
IP Rating	IP65
IK Rating	IK08
Temperature range	–20° to +85°
Compliance	EN 60439-1, EN 62208, CEI 23-48, CEI 23-49

5.1 Guard Enclosure Dimensions and Weight

Model No.	DED004
External Size	400 (H) x 300 (W) x 170 (D) mm
Weight	3.14 kg
Weight inc. Guard	4.24 kg

5.2 VisNet Hub Enclosure Dimensions and Weight

Model No.	DED008
External Size	600 (H) x 400 (W) x 200 (D) mm
Weight	5.9 kg
Weight inc. VisNet	7.8 kg

5.3 Labelling Requirements

An electrical hazard label, as shown in Figure 8, will be applied to the front of the enclosure. The label shall be suitable for outdoor use and state “Danger High Voltage”.

Figure 8 Example of electrical hazard label to be applied to front of enclosure

In addition, a label will be placed inside the front door of the enclosure with the following text:

POLESIGHT XX[2]

This equipment forms part of the Polesight innovation trial. For further information contact the project manager: francis.shillitoe@northernpowergrid.com

[2] Where XX is replaced by the number given to the unit, i.e. 01, 02, 03, etc

6. Mounting Method

Following discussions with NPg linesmen the following mounting solution was proposed and accepted for use on this project. Two metal strips will be attached to the reverse of the enclosure and secured. The top metal strip will be engineered to allow the device to be hung from a coach bolt drilled into the pole. Once the device has been hung from the top bracket another coach bolt will be installed in the bottom bracket.

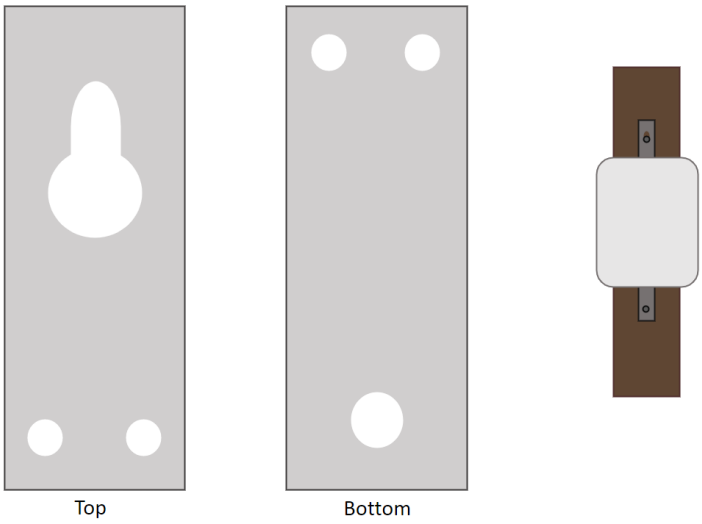

Figure 9 Diagram of the mounting method being used to secure the devices

This method of installation allows the device to be installed by a single linesman, so the number of people on the installation crew can be kept to a minimum of two.

7. Voltage Connection

The voltage connection will consist of the following:

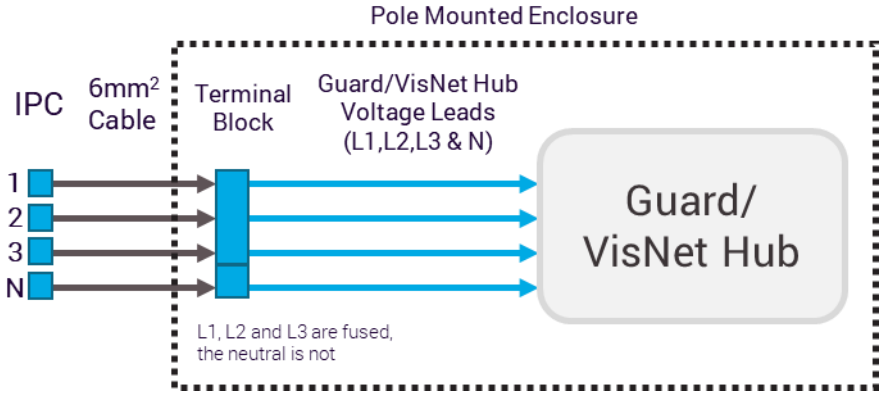

Figure 10 Voltage Connection

The IPCs will be attached to the 3 phases and the neutral on the customer side of the transformer. All cables shall be labelled according to the phase they are attached to, including neutral connections.

7.1 Insulation Piercing Connector (IPC)

The 'TTD 241' IPC pictured below will be fixed to the cables of the 3 phases and the neutral. The "primary" side can fit on 16-150mm^2 cables and the "secondary" side can support 6-35mm^2 cables. The voltage connection cable chosen for this project does not require and stripping before it is clamped but the supply cable will be appropriately stripped of its external coating to ensure a suitable connection.

Figure 11 Insulation Piercing Connector

For the Polesight project, Northern Powergrid will supply the IPCs from their stock as this is a standard component that the installers will have experience handling.

7.2 Voltage Cable Connection

The enclosures supplied for Polesight will come with the 6mm^2 cables pre-installed connected to a fused terminal block and fed through the waterproof glands at the bottom of the enclosure. The pre-installed cable length will be approximately 2m for the Guards and 4m for the VisNets. The other end of the cable will be fitted to the secondary side of the IPC. Section 11 provides the specifications of the connection cable.

To reduce excess cable that will need to be managed, once the connections have been assessed it is recommended that the cable be cut to size onsite before fitting to the IPC. Each cable will be appropriately labelled to identify the phases and neutral.

7.3 Fused Terminal Block

To comply with the Guard / VisNet Hub fuse specifications, a UT 6-HESI (6.3x32) fused terminal block will be used for the connection between the 6mm^2 cable and Guard / VisNet Hub voltage lead. **Note:** an unfused terminal block will be used for the neutral connection.

Figure 12 Fused Terminal Block

Model No.	Phoenix Contact UT 6-HESI (6.3x32)
Fuse	G / 6.3 x 32
Fuse type	Glass
Rated surge voltage	6 kV
Pollution degree	3
Surge voltage category	III
Insulating material group	I
Connection in acc. with standard	IEC 60947-7-3
Nominal current I_N	10 A
Nominal voltage U_N	630 V

For the full specification refer to UT 6-HESI (6.3X32) datasheet[3]

The three fused terminal blocks and neutral passthrough, including two end clamps, will be clipped onto a standard DIN rail attached to the back plate. Each terminal block will be labelled (i.e. L1, L2, L3, N). For safety reasons, the terminal blocks will sit under a cover, marked with a warning label (“Danger of death, 400V”).

[3] Phoenix Contact, UT 6-HESI (6,3X32) Order No.: 304601: https://docs.rs-online.com/a110/0900766b811d5569.pdf

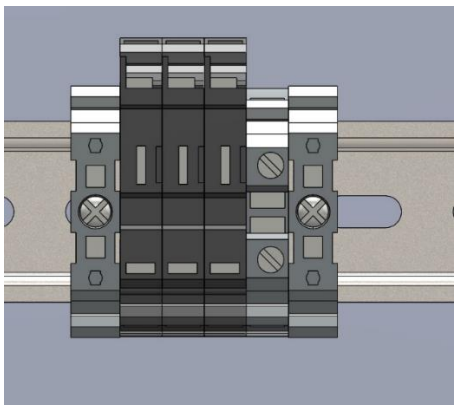

Figure 13 Arrangement of terminal blocks on DIN rail – two end clamps, three fuse holders (black) and one neutral passthrough

7.4 Guard / VisNet Hub Voltage Lead

The Voltage Lead Cable will be connected to the Guard / VisNet Hub PCB.

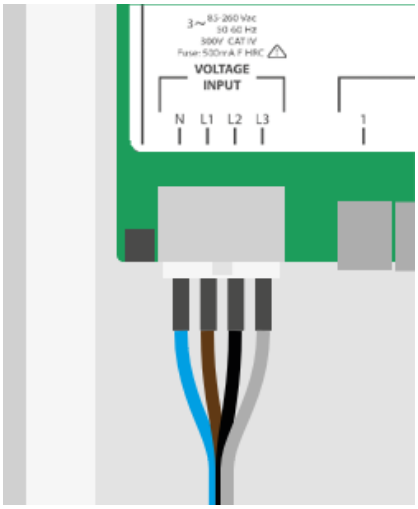

Figure 14 Connection of Voltage Cable to VisNet Hub

The Brown, Black and Grey (phases 1 ,2 and 3 respectively) leads of the voltage cable will be fitted to the appropriate fused terminal blocks. The Blue (Neutral) Lead of the Voltage Cable will be fitted to the unfused terminal block (i.e. neutral passthrough). When neutral plus any one phase is connected, power will be applied to the unit.

8. Current Sensor

Two sets of 4 x 100mm Rogowski Current Sensors will be supplied with the VisNet Hub and 8 x 100mm Rogowski Current Sensors will be supplied with the Guard. The Rogowski current sensor cable will be connected to the Guard / VisNet Hub Current Inputs Channel.

The current sensor cables will be fed through a cable gland at the bottom of the enclosure. Each current sensor will need to be fitted to the relevant L1, L2, L3 and neutral LV cables.

8.1 Guard Current Sensor Specification

The Guard can connect up to 8 individual Rogowski current sensors which will be supplied with the Guard. The Rogowski Current Sensor Cables will be connected to the Guard Input Channels through the enclosure. They will be labelled in an appropriate method to delineate which phase and feeder, in the case where two feeders are being monitored by one Guard, each Rogowski is connected.

Figure 15 Rogowski Current Sensor for the Guard

Four of the cable shown in Figure 15 are needed to monitor a single three phase feeder. The Guard is ideal for monitoring split phase systems as the extraneous current sensor does not have to be installed.

Sensor Type	Rogowski Coil
Cable Length	1.5m
Window size	100mm
Cable specification	UL 21223, low smoke zero halogen
Connector	Mini DIN, 4 pin
IP Rating	IP65

For full details refer to EA Technology's '3473-PRSPC-GCS1 Guard current sensor'.

8.2 VisNet Hub Current Sensor Specification

The VisNet can connect up to 6 sets of 4 Rogowski current sensors and 2 sets will be fitted to each VisNet before being supplied to Northern Powergrid. On the Polesight project it is not expected that any more than 3 sets of Rogowski coils will be required at any site. The Rogowski Current Sensor Cables will be connected to the VisNet Input Channels through the enclosure. They will be labelled in an appropriate method to delineate which phase and feeder, in the case where two feeders are being monitored by one VisNet, each Rogowski is connected.

Figure 16 Rogowski Current Sensors for the VisNet Hub, with coloured heat shrink labels

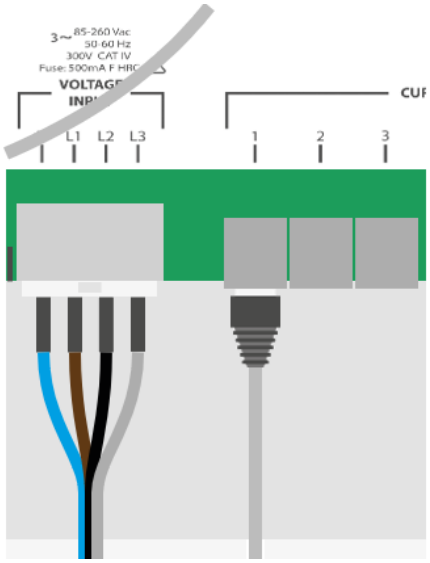

Figure 17 Connection of Rogowski Current Sensor Cable to VisNet Hub

Sensor Type	Non-Invasive Rogowski Current Sensor
Aperture Size	100mm and 175mm
Weight	Aperture and cable length dependant.
Cable Length	3m, 6m and 9.5m
IP Rating	IP55 (In accordance with EN 60529-1992+A2-2013)
Impact Rating	IK08 (In accordance with EN 62262:2002)

For full details refer to EA Technology's '3473-PRSPC-VCS1 VCS1 Product Specification'.

8.3 Rogowski Installation Through Cable Glands

The appropriate type of Rogowski coils will be supplied with each hub and installed once the number of feeders required to be monitored on a site has been established.

The first feeder on any site will be monitored by the shortest Rogowski cable length, 1.5m for Guards and 3m for VisNets, and subsequent feeders will be monitored by Rogowskis of appropriate length as chosen by the linesmen. The use of LAPP SKINTOP Cube Cable Glands (see Section 11 for parts specification) will allow for the Cat 5 cable ends of the sensors to be inserted into the outer enclosure and secured on site. The cable glands are rated to IP64 and clip into the frame that will be secured in the enclosure.

This method of installation will reduce the length and number of trailing wires on the pole.

9. Overall Design Drawings

Figure 18 and Figure 19 show the EA Technology monitoring devices in their enclosures excluding the wired connections that would connect the voltage leads externally. The current sensors will be inserted to the right of the voltage connectors and fed through the cable gland at the base of the device.

Figure 18 Guard in the DED004 enclosure

Figure 19 VisNet Hub in the DED008 enclosure

10. Exterior Indications

To ensure the device is installed and booted correctly there are multiple indicator lights that will provide visual cues to the installer without requiring a laptop connection. These are different across both devices and have been described below.

EA Technology will record the serial numbers of the devices they build for this project before shipment but for the avoidance of doubt the serial number can be clearly seen in Figure 20 and Figure 21.

10.1 Guard Exterior Indications

The exterior of the Guard displays its current operating status.

Figure 20 Guard External Label with location of serial number highlighted in red

Installers should familiarise themselves with the status indicators of each indicator to ensure they can troubleshoot while the installation is ongoing. If further support is required EA Technology will require this information to diagnose possible issues.

INDICATOR	STATUS
POWER	Off: unit not powered Red: unit is powered
STATUS	Green: all systems working Green flashing: An event is being sent
COMMS	Amber: communication link is OK Amber flashing: attempting to establish a communication link Off: no communication link
SIGNAL STRENGTH	Green: excellent signal strength Amber: medium signal strength Red: bad signal strength Off: no signal connection
CHANNEL 1-8	Green: current channel connected Flashing: error while trying to read the calibration Off: channel disconnected

10.2 VisNet Hub Exterior Indications

The exterior of the VisNet Hub displays the units current operating status indicating faults with communication, power supply or general operation.

Figure 21 VisNet Hub External Label with location of serial number highlighted in red

If an issue is found while the installation is in process the indicator colour should be reported to EA Technology to support diagnosis of the possible error.

INDICATOR	STATUS
POWER	Off: unit not powered Green: unit is powered Amber: L1/L2/L3 voltage error – any phase outside statutory limits
STATUS	Green: all systems working Amber flash: sensor error detected
COMMS	Off: communications not started yet Green on: communication link is OK Green flash: communication in progress Red: communications error connecting to LV Cloud

11. List of Parts

11.1 For the Guard Enclosed Solution

Item	Description	Multiple	Specification
Guard	EA Technology's Guard monitors three phase voltage and up to 8 current channels.	1	3473-PRSPC-GRD1-V01.03.00 Guard Product Specification
Voltage Lead (unfused)	Connection between terminal block and Guard	1	BE EN 61010-1
Rogowski Coil	Rogowski Coils shall be appropriately labelled showing phases + neutral.	8	3473-PRSPC-GCS1 Guard current sensor
Enclosure	Hylec DED004	1	Layout 1 (farnell.com)
Fused terminal block	Phoenix Contact Black UT 6-HESI (6.3x32) Fused DIN Rail Terminal	3	0900766b811d5569.pdf (rs-online.com)
Unfused terminal block	Phoenix Contact Grey UT 6 Feed Through Terminal Block	1	0900766b816f90eb.pdf (rs-online.com)
Terminal block labels	Phoenix Contact Zack Marker Strip – ZB CUS – 0825 (supplier can label on order request)	1	Item Details (rs-online.com)
End clamp	Phoenix Contact CLIPFIX Series End Stop for use with DIN Rail Terminal Blocks	2	0900766b8171504e.pdf (rs-online.com)
DIN rail	RS PRO Steel Slotted DIN Rail	1	A700000007356992.pdf (rs-online.com)
Cube Gland - frame	Lapp SKINTOP Series Black Glass Fibre Reinforced Plastic (GRP) Cable Gland	1	Vorlage Data sheet (rs-online.com)
Cube Gland - cube modules	Lapp SKINTOP Series Black GRP Cable Gland (Small)	9	Vorlage Data sheet (rs-online.com)
Cube Gland - cube modules	Lapp SKINTOP Series Black GRP Cable Gland (Blind)	3	Vorlage Data sheet (rs-online.com)
Voltage Connection Cables	Staubli Solar Cable 6 mm² CSA 70 A Flame Retardant, Halogen Free, -40 → +90 °C Black, 2m length	4	Photovoltaic main catalogue I (rs-online.com)
Insulation Piercing Connector (IPC)	Sicame TTD 241 FTA	4	Supplied by Northern Powergrid
Pole clamp	Manufactured steel strip	2	
Pole fixing	Coach bolt	2	Supplied by Northern Powergrid

Item	Description	Multiple	Specification
Labels on enclosure	Information label on inside of door Warning label exterior	1 1	Printed by EA Technology RS PRO Black/White/Yellow Vinyl Safety Labels, Danger High Voltage-Text 200 mm x 150mm

11.2 For the VisNet Hub Enclosed Solution

Item	Description	Multiple	Specification
VisNet Hub	EA Technology's VisNet Hub monitors three phase voltage and up to 6 feeder current channels.	1	
Voltage Lead (unfused)	Connection between terminal block and VisNet Hub	4	BE EN 61010-1
Rogowski Cable Set	A set of Rogowski coils includes 4 leads. Each set shall be labelled for phase connections.	2	3473-PRSPC-VCS1 Product Specification
Enclosure	Hylec DED008	1	Layout 1 (farnell.com)
Fused terminal block	Phoenix Contact Black UT 6-HESI (6.3x32) Fused DIN Rail Terminal	3	0900766b811d5569.pdf (rs-online.com)
Unfused terminal block	Phoenix Contact Grey UT 6 Feed Through Terminal Block	1	0900766b816f90eb.pdf (rs-online.com)
Terminal block labels	Phoenix Contact Zack Marker Strip – ZB CUS – 0825 (supplier can label on order request)	1	Item Details (rs-online.com)
End clamp	Phoenix Contact CLIPFIX Series End Stop for use with DIN Rail Terminal Blocks	2	0900766b8171504e.pdf (rs-online.com)
DIN rail	RS PRO Steel Slotted DIN Rail	1	A700000007356992.pdf (rs-online.com)
Cube Gland - frame	Lapp SKINTOP Series Black Glass Fibre Reinforced Plastic (GRP) Cable Gland	1	Vorlage Data sheet (rs-online.com)
Cube Gland - cube modules	Lapp SKINTOP Series Black GRP Cable Gland (Small)	4	Vorlage Data sheet (rs-online.com)
Cube Gland - cube modules	Lapp SKINTOP Series Black GRP Cable Gland (Large)	2	Vorlage Data sheet (rs-online.com)
Cube Gland - cube modules	Lapp SKINTOP Series Black GRP Cable Gland (Blind)	4	Vorlage Data sheet (rs-online.com)
Voltage Connection Cables	Staubli Solar Cable 6 mm² CSA 70 A Flame Retardant, Halogen Free, -40 → +90 °C Black, 4m length	4	Photovoltaic main catalogue | (rs-online.com)

Item	Description	Multiple	Specification
Insulation Piercing Connector (IPC) for voltage connection	Sicame TTD 241 FTA	4	Supplied by Northern Powergrid
Pole clamp	Manufactured steel strip	2	
Pole fixing	Coach bolt	2	Supplied by Northern Powergrid
Labels on enclosure	Information label on inside of door Warning label exterior	1 1	Printed by EA Technology RS PRO Black/White/Yellow Vinyl Safety Labels, Danger High Voltage-Text 200 mm x 150mm