WESTERN POWER DISTRIBUTION

OPEN LV

OPENING UP THE SMART GRID

Method Statement

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Document Control

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Prepared by:	Tim Butler	March 2020
Reviewed by:	Dave Russell	March 2020
Recommended by:		
Approved (WPD):		

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Date	Issue	Status
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Telephone +44 (0) 1332 827446. E-mail wpdinnovation@westernpower.co.uk

Glossary

Term	Definition
ALVIN	Automated Low Voltage Intelligent Network
HV	High Voltage
ISD	Intelligent Substation Device
ISP	Initial Screening Proforma
LV	Low Voltage
LV-CAP™	Low Voltage Common Application Platform
NOP	Normally Open Point

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1. Introduction

In February 2016 EA Technology responded to a request from Western Power Distribution (WPD) for ideas for Network Innovation Competition projects. Following this request, the OpenLV Initial Screening Proforma (ISP) and subsequent Full Bid Submission were submitted to Ofgem in April 2016 and August 2016 respectively. Ofgem confirmed the project would be funded in November 2016.

In terms of the working relationship between WPD and EA Technology the following key points should be noted:

1) Both companies worked in partnership to develop the OpenLV Full Bid Submission; and
2) Both companies will continue to work in partnership to deliver the OpenLV project.

2. Background

LV-CAP™ is a distributed intelligence network software platform, designed for development as part of a low-cost network monitoring solution to enable network operators to reduce data transmission costs and enable network automation in a cost-effective manner.

Local processing of monitored data, enables just the pertinent information to be transmitted, significantly reducing communication costs incurred by the DNO. Additional benefits that arise from the use of LV-CAP™ are related to the ability to distribute data cost effectively, to third party companies enabling, the provision of additional services to the network, and communities, for use in community energy schemes.

LV-CAP™ platform was developed by EA Technology and Nortech as part of an InnovateUK project, and OpenLV will demonstrate the potential of the platform to provide benefits to DNOs, customers and third-party organisations.

Within the OpenLV Project, LV-CAP™ will be installed on rugged PCs suitable for installation in a substation environment.

EA Technology will be responsible for managing and delivering the OpenLV Project on behalf of WPD although all work undertaken on WPD’s network will be undertaken by WPD’s staff.

EA Technology staff will provide on-site installation support and undertake the commissioning tests once installation is complete.

3. System overview

The trial system being deployed in the OpenLV Project consists of a combination of hardware and software. The purpose of the project is to demonstrate the capability of a software platform (LV-CAP™), to provide distributed intelligence capability to the LV network and make useful data available to third party companies, Universities and community groups.

LV-CAP™ is a hardware agnostic software platform, designed as a framework on which third party applications can be run. The framework provides a number of core services for third party application developers to utilise, including access to data gathered by the platform, communications functionality and data storage.

The LV-CAP™ software platform will be installed on an embedded PC. Communications will be provided via an ethernet connected modem. LV network data will be provided by a connected Lucy Electric GridKey MCU520 platform. Thermal monitoring of the local transformer and ambient temperature will be undertaken using thermal probes.

3.1 Enclosure - External

The overall solution is to be deployed within a suitable, non-conducting enclosure, capable of being mounted via multiple methods, including direct wall mounting or magnetic mounting on switch-gear or a transformer.

Figure 1 shows an example of the enclosure mounted on a transformer, demonstrating the magnetic bracket and mounting capability. Key features of the enclosure are highlighted in the picture.

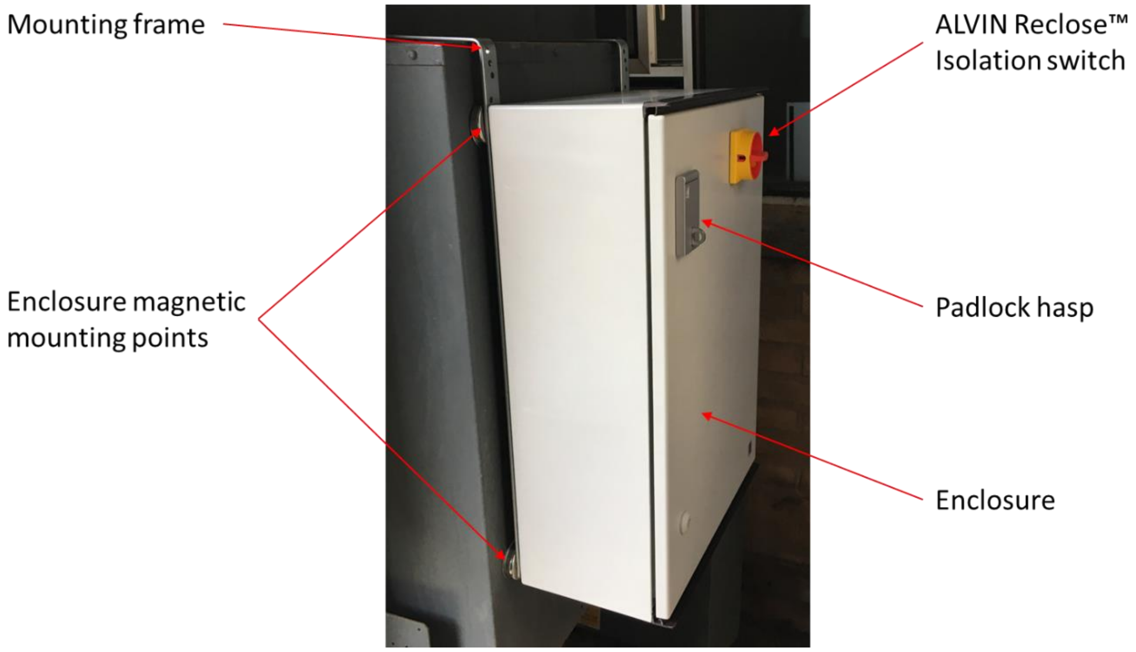

Figure 1: OpenLV Solution - Enclosure

The enclosure is a plastic based enclosure with an IP rating of IP66 and is capable of being mounted via multiple methods. Figure 1 demonstrates the enclosure magnetically mounted on the side of an item of switch-gear with a mounting frame supporting some of the weight. If the enclosure is to be wall-mounted, the mounting frame can be removed, and the same mounting points utilised for bolting wall brackets to the enclosure, see Figure 2.

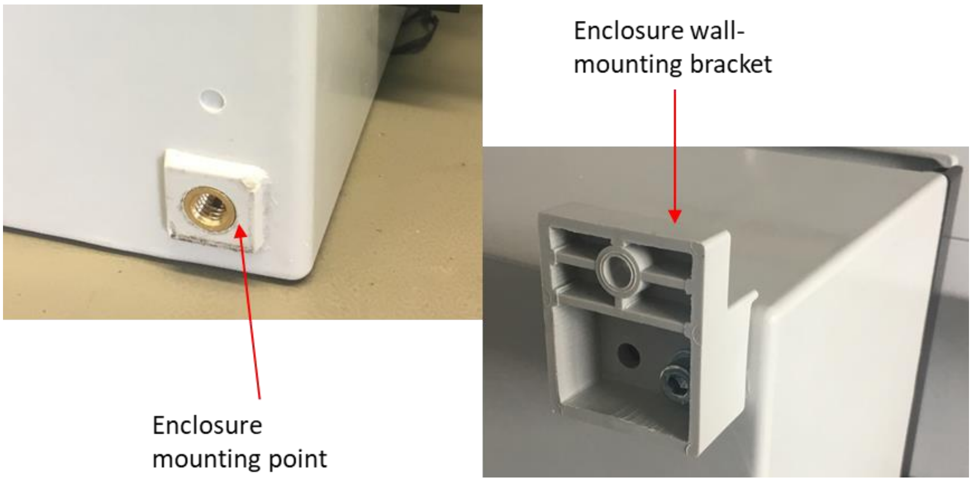

Figure 2: OpenLV Solution – Enclosure mounting points

In the event the unit is to be mounted on top of the LV fuse board enclosure, the magnets will still be utilised to prevent accidental dislodging of the enclosure.

The outside of the enclosure includes an isolation switch to be utilised for disconnecting the ALVIN Reclose™ devices from the LV-CAP™ platform control system if necessary for safety on-site. This switch can be locked 'off' to prevent inadvertent or unauthorised reactivation of the system.

When deploying ALVIN Reclose™ devices in the substation to provide automated network meshing, the front mounted isolation switch must be readily accessible in the event isolation is necessary.

A padlock hasp is included to prevent unauthorised access to the LV-CAP™ platform; only the OpenLV Project team will have the ability to unlock the enclosure, once access to the substation has been provided by WPD staff.

3.2 Enclosure - Internal

The enclosure contains most of the key components of the OpenLV solution, specifically the industrial PC (Advantech UNO-2484G), the modem and digital I/O terminal providing connections to the thermocouples and ALVIN Reclose™ devices.

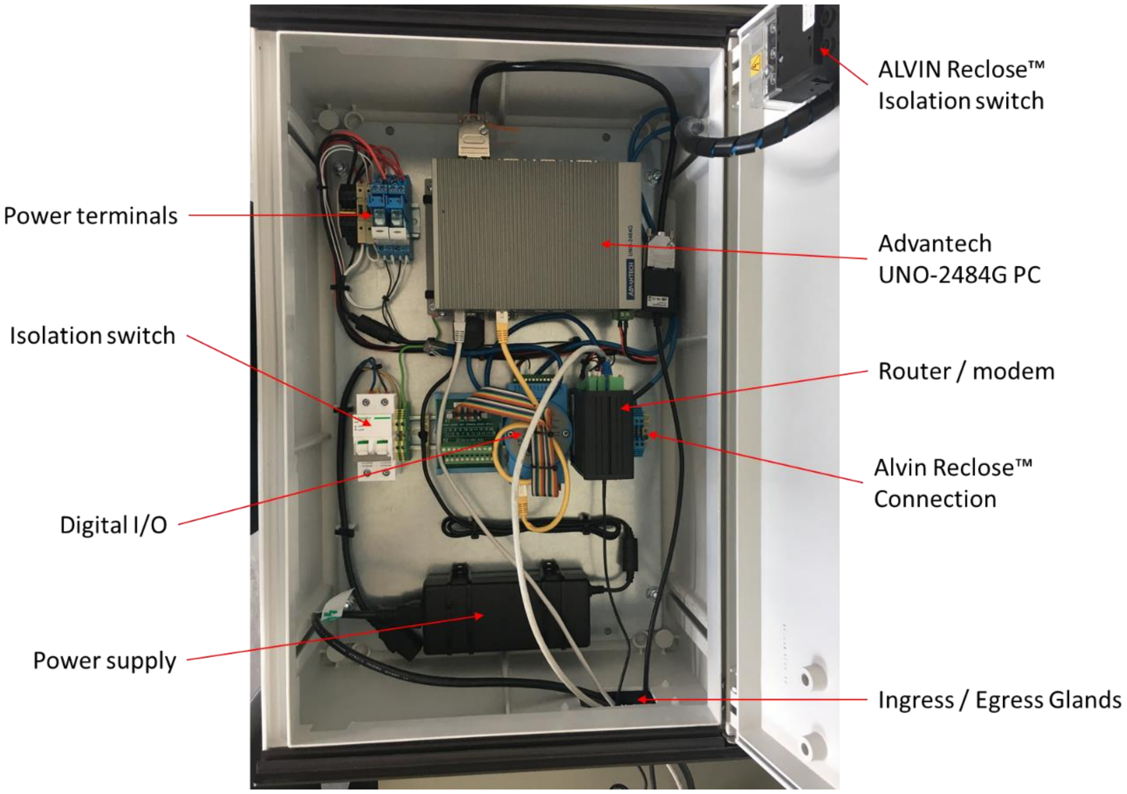

Figure 3: OpenLV Solution – Enclosure Internals[1]

Connections to and from the enclosure pass through the cube glands at the bottom of the enclosure and will be routed as appropriate on a site-by-site basis.

[1] The enclosure shown in Figure 3 has a temporary power cable for direct connection to the power supply. When installed on-site, the incoming power feed will be routed through the isolation switch on the left, allowing the power to be disabled for all system components within the enclosure.

3.3 Ancillary equipment

3.3.1 ALVIN Reclose™ devices

ALVIN Reclose™ devices will only be installed in 10 substations (five pairs) within the project trial.

These devices will be connected to the LV-CAP™ platform when installed allowing the system to control operation of the circuit breaker within each device.

For the avoidance of doubt, the autonomous protection functionality within the devices will continue to operate as normal and cannot be overridden by the LV-CAP™ platform.

Figure 4: OpenLV Solution – ALVIN Reclose™ devices

A deployment of Alvin Reclose™ units, using typical ‘off-the-shelf’ variants, will automatically attempt to reclose the circuit breaker after opening in the event of a fault. This functionality has been disabled, at the request of WPD, for the units being installed as part of the OpenLV project.

The installed units will instead open the circuit breaker in the event of a fault and will require manual intervention by a WPD engineer to reenergise the circuit, in a similar manner to replacement of a fuse.

3.3.2 LV System monitoring – Lucy Electric GridKey MCU520

Monitoring of the LV network within the OpenLV Project is via a GridKey MCU520 platform that communicates with the LV-CAP™ hardware via an ethernet connector.

Depending on the substation arrangement, the MCU520 monitors either:

1. All feeders and summates the values to provide the total transformer load; or
2. The LV busbars and the single feeder (to be meshed).

The first option is always applied for Method 2 and 3 substations.

The MCU520 is designed to be installed via the use of magnetic mountings or direct wall-fixings. Each site inspected at the site-survey (phase 2) stage will identify the preferred installation arrangements.

Figure 5: OpenLV Solution – GridKey MCU520

3.3.3 Temperature monitoring

The dynamic rating application utilises calculated transformer and monitored ambient temperatures to model the available and predicted capacity of the transformer in question. The ambient temperature will be measured using a thermocouple temperature probe installed within a radiation shield (note that in the picture the probe is partially removed from the shield) to prevent or mitigate the effects of wind and direct sunlight on the thermocouple.

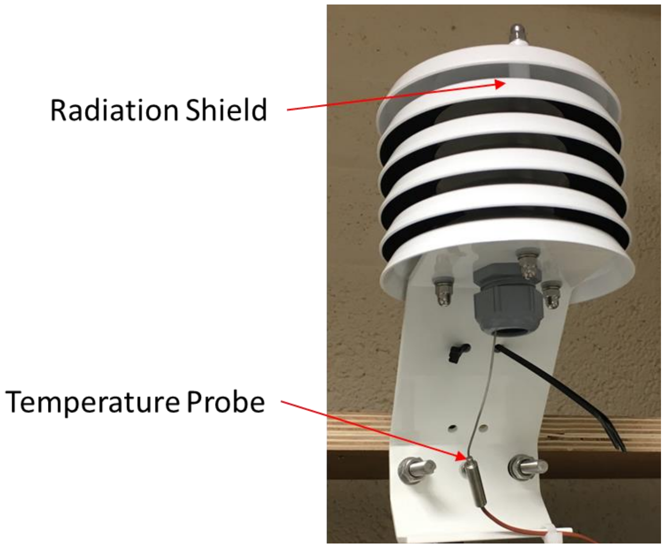

Figure 6: OpenLV Solution – Thermal probe & radiation shield

The internal temperature of the associated transformer will also be monitored (to allow comparison of the calculated and actual values), utilising a similar thermal probe, however a radiation shield is not required in this instance. Instead the transformer thermal pocket will be filled with oil with the probe inserted into this.

Figure 7: Example of a transformer oil pocket and cap

Figure 8: Example transformer oil pocket and test cap, including thermal probe

4. Management of safety

4.1 Key documents

The following key documents relating to WPD's working practices will be adhered to at all times. If specific trial locations require working methods covered by additional policies, these shall also be adhered to. It shall remain the responsibility of WPD's staff to ensure adherence with WPD's safe working practices.

Standard Technique: SP2KD

Relating to the Retro-Fitting of Monitoring Equipment In Live LV Cabinets.

Policy Document: GE21/2

Relating to Approval of Equipment and Software for Use as Part of the Distribution System and the Conduct of Trials.

Generic Risk Assessment: Work Activity – Electrical Fitting

Detailing identified hazards, their assessment, control measures and required on-site actions to avoid or mitigate them.

WPD's Distribution Safety Rules

WPD have a published set of Distribution Safety Rules (DSR's) which are in place for the protection of employees and the safety of all who may work on distribution network operator systems.

These are based upon the ENA's published 'Model Distribution Safety Rules'[2] and must be adhered to in line with WPD's normal working practices.

4.2 Key working practices

The following key working practices / principles must be adhered to throughout all on-site working in relation to the OpenLV Project.

3. Installation, maintenance of hardware and removal of hardware from the network shall only be undertaken by WPD staff who hold suitable authorisation to undertake the work. This applies whether the equipment is being installed when the associated assets are 'Live' or 'Dead'.
4. No work must be undertaken under 'lone working' conditions.
5. All applicable safety rules and other procedures must be followed whilst undertaking work in accordance with this work instruction.
6. Prior to carrying out any work a risk assessment shall be carried out in accordance with ST: HS 20A.
7. In addition to the use of the generic risk assessment, a task assessment to determine location specific risks to be considered. These shall include, but not be limited to:
   i. Sources of possible back-feeds.

[2] http://www.energynetworks.org/assets/files/electricity/she/ENA%20SHE%20Standard%2007%20-%20Model%20Distribution%20Safety%20Rules%20(2016).pdf

   ii. Condition of the LV cabinet.
   iii. Are links between the neutral bar and LV cabinet earthing connected.
8. Safety precautions and procedures applicable to low voltage systems as detailed in section 8 of the Operational Safety rules shall be followed at all times.
9. WPD control room will be advised prior to work starting and upon completion of the work.
10. Personal Protective Equipment will be worn in accordance with the following:
    i. LV rubber gloves complying with ST: HS 8B.
    ii. Suitable Eye protection complying with ST: HS 8D.
    iii. Flame resistant coveralls complying with ST: HS 8H.

5. Summary of the site selection process

The process for identifying and selecting trial locations is fully detailed in the Project document "OpenLV Identification of Trial Networks" however a brief summary is provided below.

The process consists of three phases:

Phase 1:	Desktop Survey
Phase 2:	Site Surveys
Phase 3:	Detailed Desktop Analysis

5.1 Phase 1 – Desktop Survey

Phase 1 consists of a desktop analysis of WPD's LV network using a combination of predicted load profiles and details of specific networks from WPD's Network Data Portal.

The desktop survey prioritised sites for investigation based on the following factors:

- Ground or pole-mounted: Ground mounted transformers (GMTs) required within the project. No pole-mounted transformers will be selected for use within the OpenLV Project.
- Estimated load as a proportion of transformer capacity – higher proportional usage, within the asset rating, were preferred.
- Substation has a feeder capable of being connected to an adjacent / nearby substation.
- Feeders are capable of withstanding loads likely to be transferred if meshing were implemented.
- Both substations are fed from the same HV network.

If all of these criteria are met, then the site will be selected for a site survey in Phase 2.

5.2 Phase 2 – Site Survey

The site survey in Phase 2 enables verification that the network and substations are suitable for the OpenLV Project to install the trial equipment. Consequently, the checks to be undertaken on-site are:

- Ability to install the equipment within the substation, considering space available and structural capability.
- Wireless communication (3G / 4G network) is suitable for project requirements.
- Phasing of the adjacent networks.
- LV networks able to be physically meshed at the Normally Open Point (NOP).
- Able to install ALVIN Reclose™ units in place of normal fuses on the distribution board.

5.3 Phase 3 – Detailed Desktop Analysis

Once a site is verified as suitable during a site survey a detailed analysis of the network will be undertaken to calculate the fault levels and associated protection settings for the site in the network's current configuration and under a Network Meshing scenario.

6. Installation

6.1 General requirements for installation

This method statement provides details regarding the installation of the LV-CAP™ platform trial equipment for the OpenLV Project. It focusses on the methods to be followed to make the necessary connections to the LV network, enabling the trial equipment to be powered and gather the required data for the trials. This method statement provides guidance regarding the provision of suitable enclosures and the positioning of the LV-CAP™ equipment within distribution substation.

The instructions for the installation of the LV-CAP™ platforms shall be followed in all instances. The ALVIN Reclose™ equipment to be utilised for automated network control will only be installed in a small subset of the network locations used in the OpenLV Project.

Installation of the LV-CAP Platform proceeds as follows:.

1. The LV-CAP™ platform will be contained within an enclosure suitable for both direct wall-mounting, the use of magnetic mounts or a supporting bracket.
2. The mounting approach to be utilised will be determined and documented during the site survey. This will be provided, including photographs of the installation location in the event that the LV-CAP™ enclosure can be mounted appropriately.
3. The LV-CAP™ platform, in the configuration utilised within the OpenLV Project utilises an MCU520 platform to monitor the LV Network. This data is then passed to the LV-CAP™ platform through an interconnecting data cable.
4. Current References – All 3-phase[3] current values for the transformer will be obtained by the MCU520 platform using fully insulated sensing transducers

[3] The neutral connection will be monitored where possible, also utilizing fully insulated Rogowski Coils.

(Rogowski coils). The sensors will be installed around the cable connections at suitable locations as close as practically possible to the MCU520 control cabinet.

5. If it proves impossible / impractical to directly monitor the feed from the transformer to the LV fuse board then it will be necessary to monitor all active feeders and summate the values to determine the total transformer load.
6. LV voltage monitoring will be achieved through connection to the LV network in one of two methods:
   - The use of Schneider modified fuse carriers; or
   - The use of G-Clamps connected directly to the bus-bars.
7. In either case, the connections shall be fused and the MCU520 platform will also draw its power via the same connection.
8. Where a generic installation instruction is to be followed, a full assessment of options for the connection of current sensors will be made prior to any work commencing.
9. Prior to work commencing, a visual inspection of the connection points will be carried out with particular attention being made to positions where current sensors are to be installed. If there is any doubt regarding the condition of the connection point, work shall not commence, and the issue shall be referred to the person responsible for instructing the installation.
10. Some substations may contain asbestos; if this is the case, a sign on the outside of the substation and at multiple locations within, will be clearly present. A folder will be present detailing the location of the asbestos materials within the substation. No work shall commence until the folder has been examined and the asbestos containing materials identified.

Figure 9: Asbestos Warning Sign

6.2 Order of installation

The exact arrangements for installation will depend on the individual sites. A site survey will be required in each case to confirm the suitability of the location for use in the trials. The order of site verification and installation will be the same in each case.

The equipment will be prepared as far as practicable prior to delivery to site for installation, with the intention being to minimise work required on-site.

Once all equipment is on site, all cable lengths and routing should be determined before any items are secured in place to ensure all lead lengths are long enough.

6.2.1 Installation of LV-CAP™ platform

In all instances of trial locations selected for use in the OpenLV Project, a system enclosure and Gridkey MCU520 platform will be installed. The proposed method of installation being:

1. Initial site survey to verify suitability
2. Visual inspection prior to work commencing
3. Any civil work required (identified and agreed with WPD following initial site survey)
4. Cable routes and ducting prepared and installed
5. Mounting of the Lucy GridKey MCU520 in an accessible location
    - This will ideally be final installation location but if not, ensure sufficient slack remains in the sensor tails to allow relocation of the enclosure post setup.
6. Installation of CTs / Rogowski coils (connect each cable to the MCU520 before proceeding to the next).
7. Installation of modified fuse carriers, or g-clamps for voltage monitoring
    - Where modified fuse carriers are required, WPD's normal working practices for installation must be followed.
8. Installation of LV-CAP™ enclosure
9. Connection of Lucy GridKey MCU520 to LV-CAP™.
10. Connection of power connections to LV-CAP™
11. Connection of joint voltage / power connections to Lucy GridKey MCU 520
    - Terminate connections into the MCU520 and replace protective cover before connecting the cable to the modified fuse carrier / G-Clamp to the busbar.
12. Add protective cover to the MCU520.
13. If necessary, relocate the MCU520 enclosure to final location.
14. Undertake commissioning tests

6.2.2 Installation of additional ALVIN Reclose™ devices

All LV-CAP™ platforms will be capable of ALVIN Reclose™ integration. The process for the installation and commissioning of ALVIN Reclose™ units is detailed in Appendix D. ALVIN Reclose™ devices will only be installed in a small sub-set (10 substations, in five pairs) of all project trial locations and these locations will not be finalised until some months after the other LV-CAP™ platforms have been deployed under Method 1.

It will be necessary to inform all staff working at the relevant depot area of the installation of the ALVIN Reclose™ devices, including how to manage their presence in the event of a fault on the connected network. WPD's control room must also be informed of the presence of an autonomously meshed network.

6.3 On-site installation works

Once the site location has been confirmed, equipment installation will be undertaken using the below guidance.

6.3.1 Detailed visual inspection

Regardless of the substation type, a detailed visual inspection shall be undertaken to confirm no fundamental changes have occurred since the site survey. The following key points must be verified prior to installation commencing:

1. There is sufficient space to safely install the enclosure such that access for working is not impeded and a viable escape route remains.
2. The existing substation assets are in good condition and do not obviously require maintenance to make them safe prior to further equipment being installed.
3. Cable routes planned during the initial site survey remain available for use.

6.3.2 Installation of LV-CAP™ enclosure

The mounting arrangement of the LV-CAP™ enclosure will depend on the type of substation in which it is to be installed and comprise one of the below approaches, as determined during the site-survey.

1. Direct fixing to the wall utilising the mounting points on each enclosure;
2. Magnetic mounting on substation assets;
3. Mounting on batons installed within the substation (e.g. on existing fence line); or
4. Ground mounting within substation.

Direct wall-mounting

The enclosure utilised for the LV-CAP™ platform deployed within the OpenLV Project trials is capable of direct wall-mounting using brackets shown in Figure 2.

If a substation selected for the trials has sufficient wall space, in a position suitable for installation when allowing for cable routes and safe access and egress to the substation, then a wall mounting arrangement, similar to that shown in Figure 10 should be undertaken.

The wall-mounting brackets enable installation to proceed without opening of the enclosure, minimising the risk of damage to the equipment.

The enclosure shown in Figure 10 is one of the units installed in the first ‘pair’ of Method 1 substations.

The enclosure will be mounted to the wall using Masonry Anchor Loose Bolts or an appropriate equivalent; these will be provided with the enclosure.

A fixing hole diameter of 14mm is required, of a depth 55mm, to securely wall-mount the enclosure.

Figure 10: Example of wall-mounted enclosure

Magnetic mounting

The enclosure can also be magnetically mounted on the side of substation equipment in the absence of suitable wall space within the substation. The enclosure is bolted directly to a frame, on which the magnets are connected.

This approach utilises the frame to support the weight of the enclosure whilst the magnets prevent it from falling or becoming accidentally dislodged.

An example of this approach is provided in Figure 11.


Figure 11: Example of a magnetic mounting

Ground mounting

If there is any history of a substation flooding, or it is not possible to mount the enclosure as demonstrated in either Figure 10 or Figure 11, Uni-Strut style frame with "Flexi feet" will be used to raise the enclosure off the ground (Figure 12). This may be independently mounted, as shown on the left of Figure 12, or mounted against the LV board as shown on the right.

Figure 12: Examples of frame used to ground mount an enclosure

Wherever possible, the enclosure shall be mounted such that it is secured against the LV pillar, transformer or substation fence to improve stability, as shown in Figure 12.

Wherever the cabinet is mounted the necessary cable route shall be determined on a site-by-site basis and selected to minimise risk of damaging the cables, reduce trip hazard potential, and prevent disruption to the substation's existing assets.

Above the LV pillar

In some instances, the preferred method of installation may be to locate the enclosure on its back directly above the LV board. Magnetic mounts can, if required still be fitted to the rear of the cabinet however they should be fitted with a thin rubber / neoprene gasket to prevent damage to the top of the LV board. The position of the LV CAP™ enclosure should be selected to best enable access to the enclosure and cable connections if required. Safe access to the LV board, including opening of the pillar door must be considered.

All cabling can be routed out the bottom of the LV-CAP™ enclosure and must be dressed in such a way it does not interfere with access or operation of equipment within the sub.

It is important to note if the ALVIN Reclose™ devices are to be installed at a later date it will be necessary for the isolation switch located on the front of the LV-CAP™ enclosure to be readily accessible. Where it is possible to install ALVIN Reclose™ devices within the LV fuse board, mounting of the LV-CAP™ enclosure on top of the LV pillar is not an option as this would render the isolation switch inaccessible.

In this situation, the LV-CAP™ enclosure must be mounted in a suitable location at the point of first installation or have sufficient spare cable lengths to allow an easy, safe, relocation of the enclosure if required at a later date.

Figure 13: Space on top of a package substation arrangement

Within the LV pillar (Lucy GridKey Platform only)

Where it is possible to locate the Lucy Electric GridKey platform within the base of the LV enclosure, this approach should be adopted as it minimises the risk of equipment being damaged, accidentally disconnected or otherwise tampered with, whilst also preventing trailing cables within the substation.

In the example below, the bottom panel can be removed and the GridKey platform located behind the panel once it is replaced. Where this approach cannot be utilised for any reason, the GridKey Platform can be magnetically mounted in an appropriate location within the vicinity of the LV board, being cognisant of the need to connect to both the LV feeders for monitoring and the LV-CAP™ (ISD) enclosure.

Figure 14: LV Enclosure Panel

Where space allows, as shown in Figure 13, the ISD enclosure will be located on top of the LV board where possible to minimise cable routing required within the substation.

6.4 Connection of 230Vac supply (ISD)

The LV-CAP™ enclosure requires its own 230Vac supply. The supply is to be connected directly to the internal isolation switch mounted within the cabinet through the glanding arrangement on the bottom of the enclosure, see Figure 3. The source of the supply will need to be confirmed on site but can be any one of the following methods identified below.

Note when using a method other than the use of the 230Vac socket a suitable fixed earth connection must be fitted that cannot inadvertently be removed. The preferred method is utilising the 230Vac socket within the LV pillar and the addition of a multiway socket on a short length of cable to ensure a spare socket remains available for use by site crews.

Socket within LV board (Preferred method)

The preferred approach to power the ISD enclosure is utilising the 230Vac socket with the LV board using a standard BS1363 UK type 3 pin plug fitted with a 5A fuse.

In order to avoid monopolisation of the existing 230Vac socket, a multiway socket will be incorporated, on a temporary basis, within the LV pillar. The cable will be secured in an appropriate cable route, utilising adhesive cable tie mounts ensuring that a spare 230Vac socket remains available at all times. The plug for this extension multiway socket will be clearly labelled “Do Not Unplug”.

The 230Vac supply cable from the installed multiway adapter and the LV-CAP™ enclosure is to be made up on site as required from a drum of flexible Triflex 3 core 1.5mm cable.

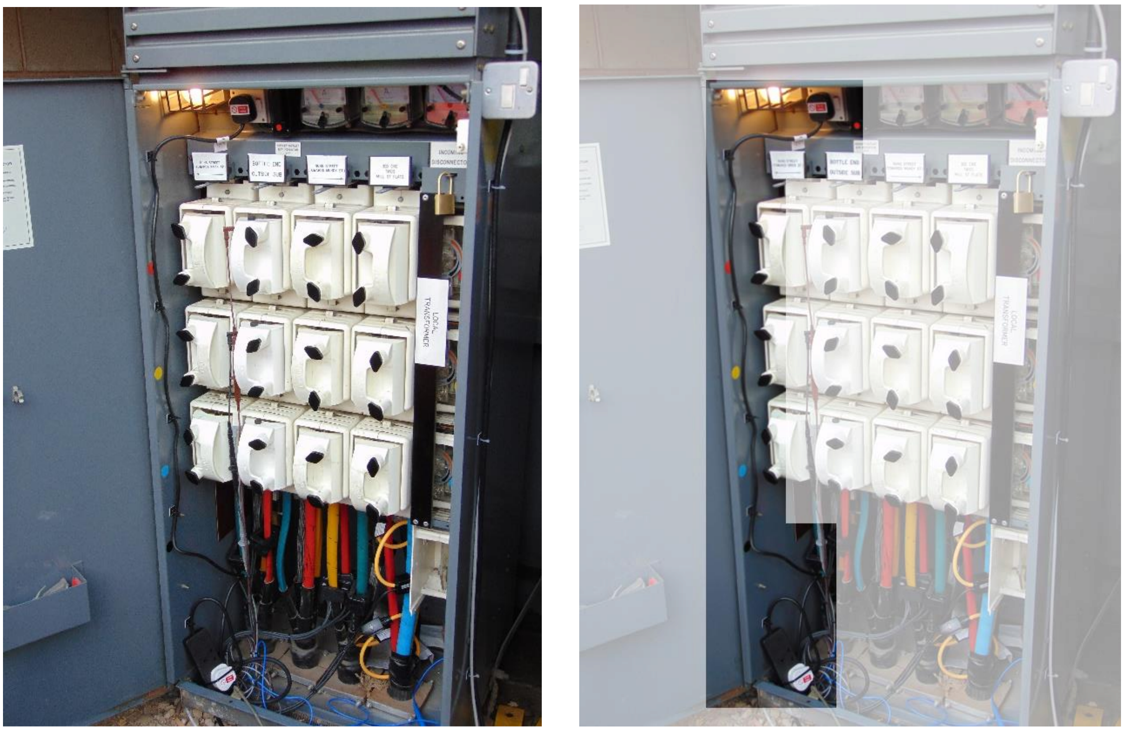

Figure 15: 230Vac socket

Terminals within the LV board

Where the 230Vac socket is unsuitable for any reason, but terminals providing a connection to the busbar are available, these can be utilised to provide power to the ISD. Check if fuses are fitted to the output terminals and they are suitably rated at 5A. If the terminals do not provide a method of fusing the cables must be fitted with in-line fuses as close to the point of connection as practicably possible and fitted with 5A rated fuses.

Figure 16: Terminals

Busbar G-clamps

In the event that neither a 13A socket nor terminal connections are available, the use of g-clamps connected directly to the LV busbars can be utilised to provide a power connection.

This approach should seek to replicate as far as possible the preferred option of utilising a 13A socket to make and break the ISD power connections for the ISD. This will enable appropriately authorised EA Technology staff to de-energise and restore power to the trial equipment if necessary.

The ISD will require three Drummond G-clamps:

1. Live connection – fused – connected to the busbar of any phase within the LV cabinet.
2. Neutral connection – fused – connected to the neutral busbar within the LV cabinet.
3. Earth connection – unfused – connected to an earth point within the LV cabinet and with a cable securely bonded to the g-clamp to prevent accidental disconnection.

Figure 17: G-Clamps with fuse carriers inserted (left) and revealed (right)

When utilising this approach to energise the ISD the following order must be followed for installation of the G-Clamps and associated power cables. The 13A socket will be already connected to the three cables to be connected to the G-Clamps.

1. Ensure the ISD is unplugged from the 13A socket.
2. Connect unfused G-Clamp to Earth point within the enclosure.
3. Place the cold-shrink wrap tube over the earth cable, but do not secure into place.
4. Connect earth cable to G-Clamp.
5. Move the cold-shrink wrap so it is located around the connection point on the G-Clamp, and seal into place, securing the earth cable to the G-Clamp.
6. Connect one of fused G-Clamps to a ‘live’ busbar; it is recommended that ‘Phase 3’ is utilised to minimise required cable lengths.
7. Connect the remaining fused G-Clamps to the neutral busbar.
8. Connect the ‘live’ power lead to the G-Clamp connected to Phase 3 busbar.
9. Connect the neutral power lead to the G-Clamp connected to the neutral busbar.

10. Mount the 13A socket in a suitable location for safe access if disconnection of the ISD is required.
11. Zip tie or otherwise secure all cables together and ensure they are routed appropriately to minimise clutter within the enclosure and the potential for accidental disconnection.

An additional warning label must be affixed to the outside of the LV enclosure door, warning of LV monitoring equipment power connections inside, including a temporary earthing connection.

Once the above steps are completed, the normal process for connecting and energising the ISD can be resumed.

6.5 Connection of voltage monitoring and 230Vac supply (GridKey MCU520)

Modified Fuse Carrier

Modified fuse carriers may be used for the voltage measurements required by the MCU520. As a least preferred option, these may also be used for the supply to the LV-CAP™ enclosure.

Furthermore, it is not recommended to power the ISD enclosure from the same modified fuse carrier as the GridKey MCU520 which will necessitate the use of a second feeder way being used.

If the modified fuse carrier does not incorporate a suitably rated fuse, a 5A fuse must be fitted, or the cables must be fitted with in-line fuses as close to the point of connection as practicably possible and fitted with 5A rated fuses.

Note that if this approach is used, a method of providing an earth connection will still be required.

Figure 18: Modified Fuse Carrier

Busbar G-Clamp

Where other methods of connection to a 230Vac supply are not possible then G-clamps with 4mm sockets can be used. The G-Clamps used for the Live and Neutral supply must be of fused type or in line fused leads used.

This connection will provide power to the Lucy Electric GridKey MCU520 device and enable monitoring of the voltages across all three phases.

G-Clamps can be installed either from the front or the rear of the busbars, depending on the arrangement of the LV board.

In Figure 19, G-Clamps were installed by sliding them onto the rear of the busbars prior to tightening the clamp.

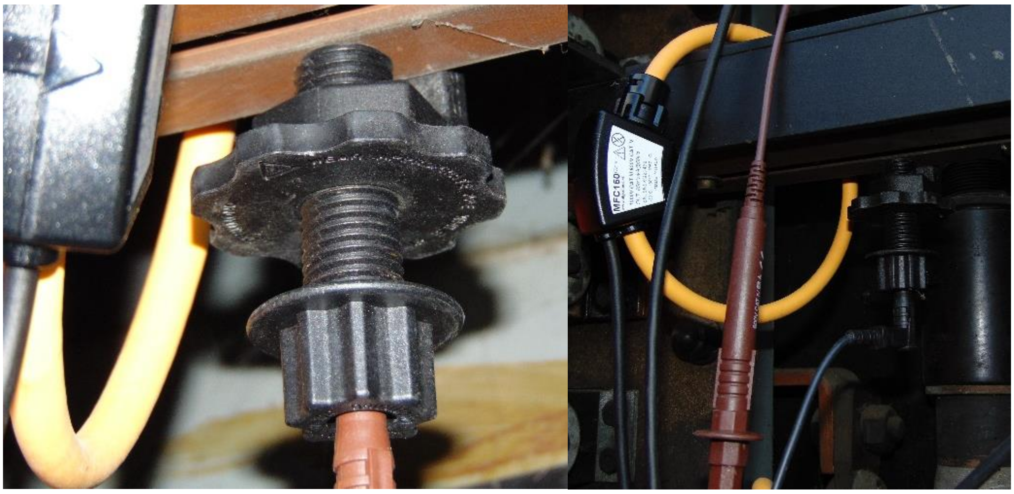

Figure 19: G-Clamp installation

Terminals within the LV board

Where the above options are unsuitable for any reason, but terminals providing a connection to the busbar are available, these can be utilised to provide power to the MCU520. The cables provided with the GridKey units are fitted with appropriately rated in-line fuses.

Figure 20: Terminals

6.5.1 Installation of Lucy GridKey equipment

Consideration must be taken to ensure the cables routing from the sensors to the GridKey MCU520 platform are safe, and within the maximum length of 5m for Rogowski coils.

The sensors to be utilised within the OpenLV Project comprise of either clip-on GridHound Rogowski sensors or Flexible Rogowski coils, depending on the site-specific installation capabilities.

Where possible, Gridhound sensors should be used in preference due to greater accuracy and lower sensor cross-talk. However, as shown in Figure 21, a mixture of both GridHound and Flexible Rogoowski sensors can be utilised.

Note: Sensor types cannot be mixed on individual feeders; all phases on one feeder must be monitored by the same type of sensor.

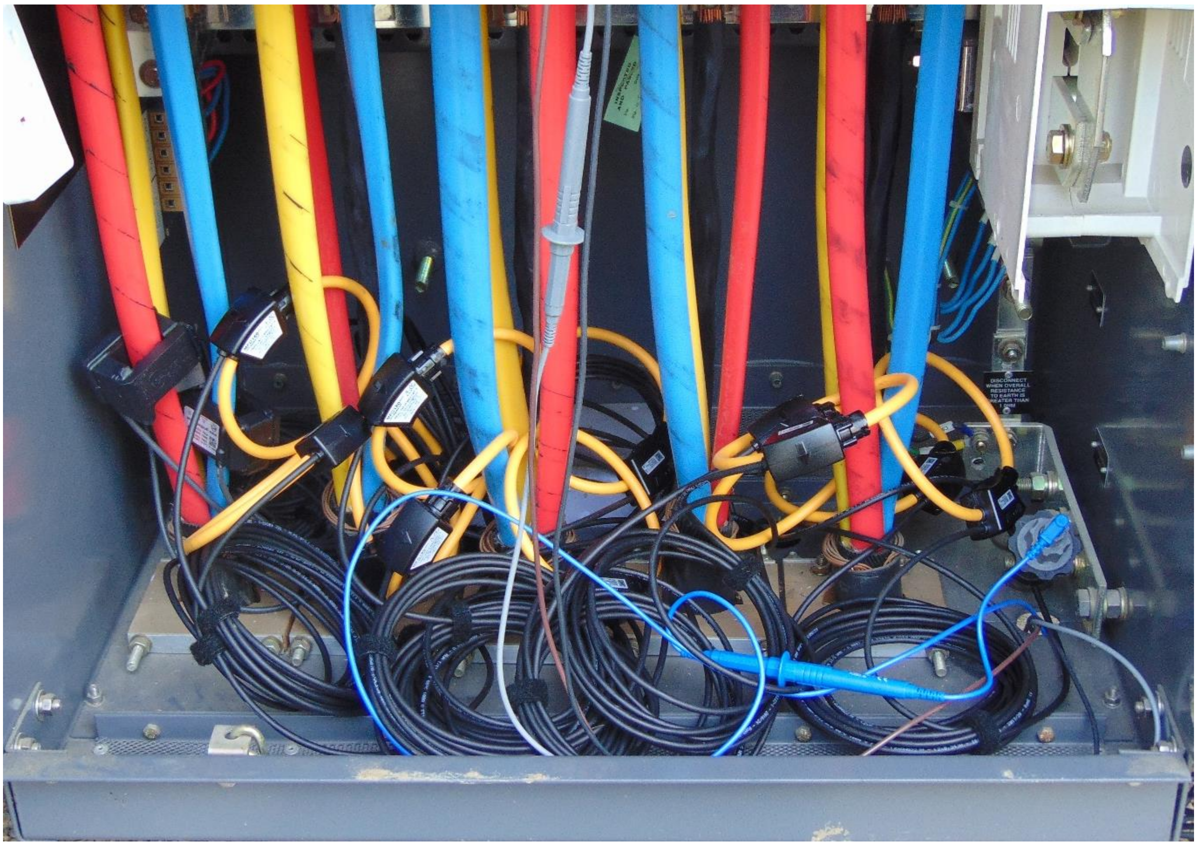

Figure 21: LV feeder & phase monitoring

Where it is not possible to install sensors around the individual phases as shown in Figure 21, then Flexible Rogowski coils shall be fitted around the fuse carriers as shown in Figure 22.

Figure 22: Flexible Rogowski Coils installed around fuse carriers

The preferred method of monitoring the transformer current and meshed feeder current is shown in drawing 109250-001 Sheet 1 of 2 (Appendix B).

In this arrangement the current from the transformer is measured using either Rogowski coils or CT's placed around the connection from the Transformer to the LV board.

Figure 23: Transformer – LV Board Monitoring

It is also possible, depending on the site-specific LV board arrangement, to monitor the busbars within the fuse board, as shown in Figure 24, instead of the transformer tails, thus avoiding the need to monitor each feeder individually.

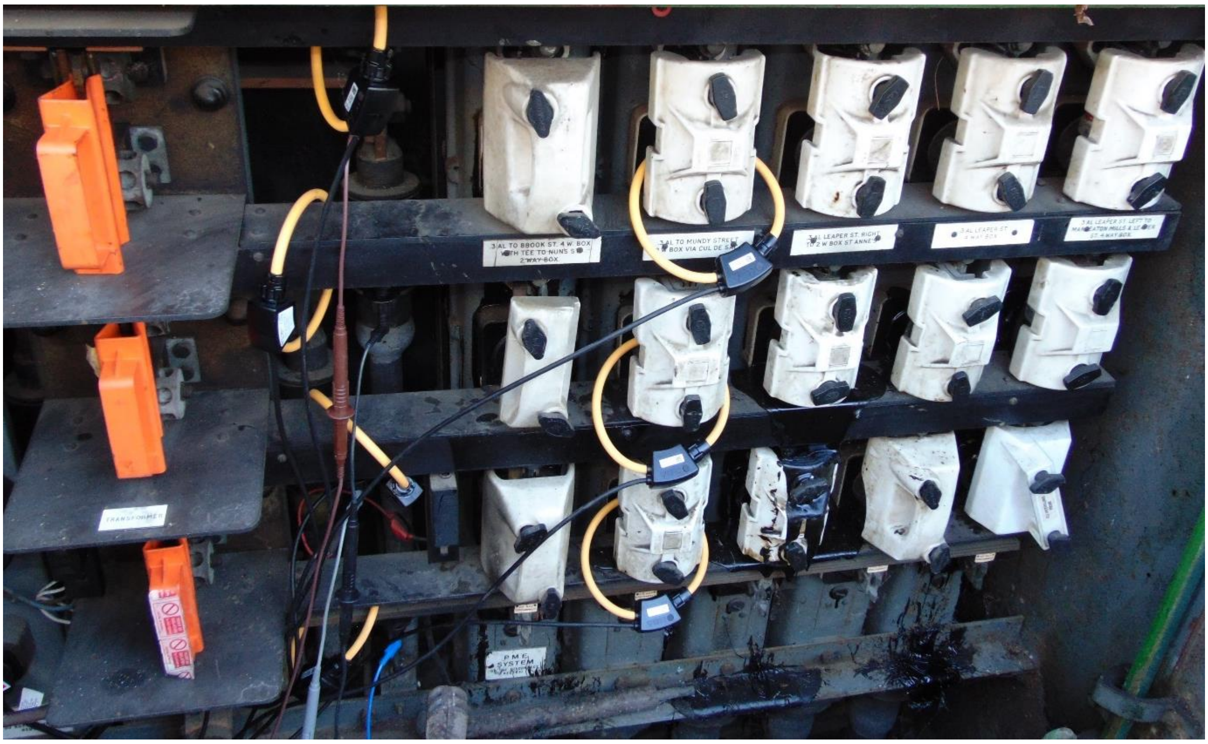

Figure 24: LV Busbar Monitoring

Figure 25: GridKey MCU520 Connections

The supply to the meshed feeder is then monitored using Rogowski sensors placed directly around the feeder cables (Figure 21) or fuse carriers (Figure 22).

Where it is possible to directly monitor the transformer output, via either approach, the monitored feeder should be connected to the corresponding 'way' on the MCU520 unit, with the transformer monitoring being assigned against the lowest free 'way' after the feeder is connected.

For example, as shown in Figure 24 if only Feeder 2 and the transformer were being monitored, the transformer sensors will be connected against 'way 1' on the MCU520 and Feeder 2 will be connected to 'way 2' as shown in Figure 25.

The MCU520 is pre-configured for this arrangement and connection of the various measurement points to the unit must be as shown, i.e. Feeder 1 measures the Transformer Current and Feeder 2 measures the meshed feeder current.

Where installation of current measuring sensors on the feed from the transformer to the LV board is not possible, transformer current will need to be measured through summation of all the LV feeder ways. Drawing 109250-001 Sheet 2 of 2 shows this method noting that the meshed feeder again utilises the Feeder 2 input on the MCU520.

This can be achieved through monitoring of individual phases on each feeder, (the preferred option); it can be seen in Figure 26 that access to each phase on each feeder is achievable for installation of monitoring sensors. Alternatively, if a substation arrangement does not facilitate access to individual phases, then installing flexible Rogowski coils around the individual fuse carriers can be employed.

In this situation, sensors for each feeder should be connected sequentially in the MCU520 unit. If a feeder way on the LV board is unutilised, that way will utilise the next available slot on the MCU520. In the fuse board shown in Figure 26, Feeder 2 is unutilised, except for the modified fuse carriers powering the MCU520 unit and so only feeders 1, 3 and 4 are monitored but are connected to way’s 1, 2 and 3 on the GridKey unit.

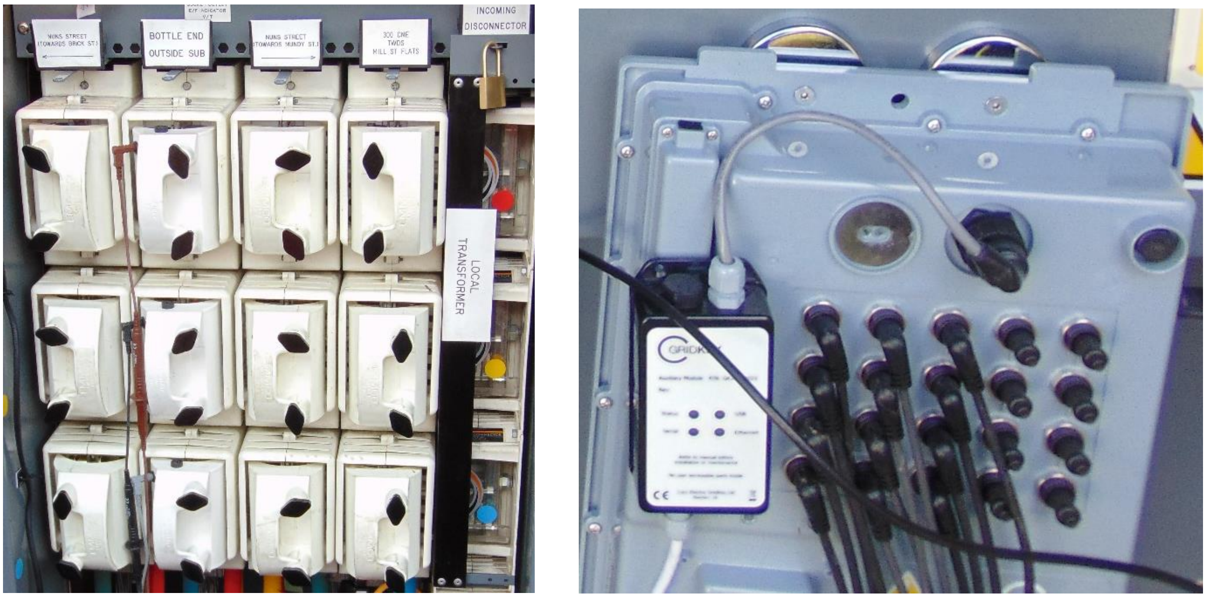

Figure 26: GridKey MCU520 Connection Example

6.5.2 Installation of thermal monitoring probes

Radiation shield and probe

The thermal probe for detection of the outdoor temperature in the vicinity of the substation requires a mounting point within reach of the LV-CAP™ platform enclosure where the maximum cable length is 5m. Where the substation is indoors, or of GRP construction, it is necessary for the radiation shield and corresponding thermal probe to be located outside, with the cable routed accordingly. Where possible try to mount the probe in a location where it is least likely to be vandalised, i.e. opposite sides to general footpath or access routes near the substation.

If the radiation shield is to be wall mounted, a 7-mm diameter hole will be required for affixing it securely.

The thermal probe cable should be routed externally through existing routes (e.g. ventilation blocks) wherever possible with dedicated holes being drilled only where necessary. Cables should be neatly secured once the radiation shield is fitted to the final position.

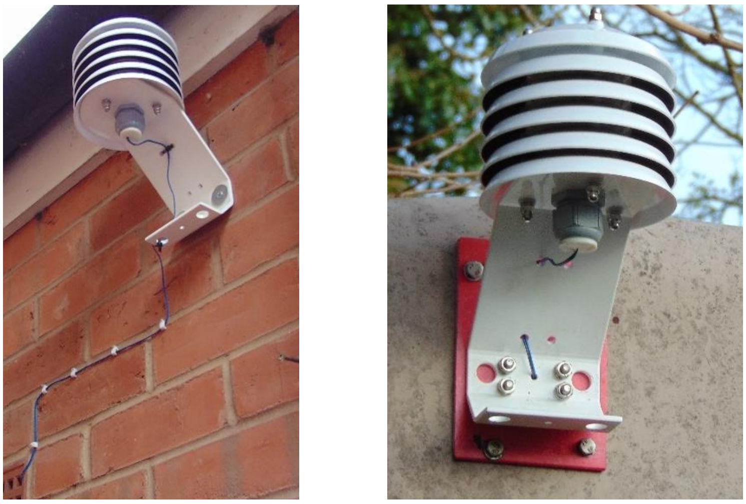

Figure 27: Radiation shield installation

Ambient temperature probe

Where the Transformer is located within a building an internal temperature probe will be fitted internally within the substation to enable monitoring of the internal substation temperature. The probe should be fitted at approximately the same height as the top of the transformer and secured in placed using either self-adhesive pads or other suitable means. The cabling from the probe is to be routed in a manner to ensure it does not interfere with the operation of any equipment within the substation and ensure it is secured at regular intervals.

Oil temperature probe

During the site surveys different thread sizes of oil pocket were identified. Ensure the correct size of sealing cap is available before commencing installation of the oil temperature probe.

Where access permits the insertion of a temperature probe into an oil pocket of the transformer then the probe is to be fitted. The protective cap from the oil pocket is to be removed and any debris or moisture removed from within the pocket using cotton wool swabs or syringe with flexible hose to enable the withdrawal of fluid and debris. Once the oil pocket has been cleaned the temperature probe can then be inserted.

Top the oil level pocket up with clean oil using a clean syringe and flexible tubing. Care should be taken to minimise any oil spillage on site and any spillages should be cleaned up immediately. Fill the oil pocket to just below the top of the threaded section and then fit the probe cap onto the oil pocket to prevent any further contamination of the oil or spillages.

Route the cabling from the oil temperature probe in a manner to ensure it does not interfere with the operation of any equipment within the sub station

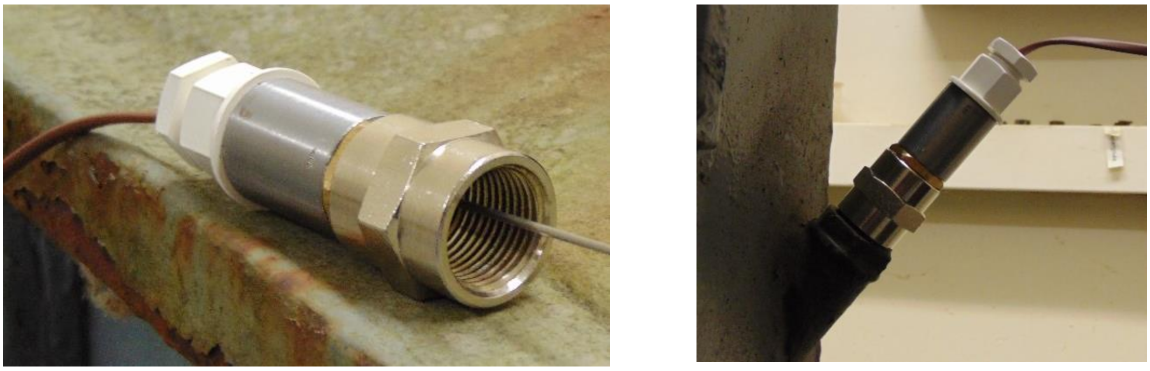

Figure 28: Oil Probe before and after installation

Note that it is the responsibility of WPD to provide standard transformer oil for use within the oil pocket.

6.5.3 Installation of mobile network antenna

The mobile network antenna requires a mounting point where evaluation of the local mobile networks suggests a reasonable signal can be achieved.

If deemed possible within the substation, the antenna should be installed internally to avoid the risk of vandalism with connecting cables routed and secured appropriately.

Figure 29: Mounting the mobile network antenna

Where mounting externally to the substation is required, taking into consideration the mobile network strength in locations around the substation, try to mount the antenna in a location where it is least likely to be vandalised, i.e. opposite sides to general footpath or access routes near the substation.

If the mobile antenna is to be wall mounted, a 5.5 mm diameter hole will be required for affixing it securely.

6.5.4 Installation of connection cables

Routing and arrangements for securing of the cables will be unique to each substation, but in all cases, cables connecting the LV-CAP™ enclosure, the MCU520 platform, the sensors, the mobile network antenna, the ALVIN Reclose™ devices if installed and power connections, must be routed such they do not introduce additional hazards to the substation.

Wherever possible, cables should be routed within existing cable ducting or defined cable routes.

Where this is not possible, cables should be tied together to avoid separate, trailing cables, then secured in a manner so to not affect other work within the substation.

6.5.5 Ancillary requirements

In all locations where Alvin Reclose™ units are installed, notifications must be installed, clearly indicating the presence of monitoring and automation equipment within the substation.

The LV-CAP™ enclosure has a label fitted to the door detailing the purpose of the equipment and the project contact details. Where the substation is also to be fitted with Alvin Reclose™ devices then a replicated magnetic label will be affixed to the LV board door or an otherwise visible location.

6.6 Installation of ALVIN Reclose™ Units

6.6.1 Introduction of Control Functionality with ALVIN Reclose™ units

The preceding sections cover the currently approved method statement for the installation of the monitoring and processing equipment, without any network control functionality.

This part of the method statement covers the conversion of the monitoring installation to introduce the control capability by replacing the fuse links on the LV board with ALVIN Reclose™ units controlled by the trial system.

6.6.2 Consideration of Existing Monitoring Installation

Current Measurement

In the monitoring installation Rogowski coils are used to measure the overall current on the transformer and to measure the current in the individual phases on the outgoing feeders.

The coils for the measurement of the individual phases on the outgoing feeders are ideally placed around the individual phase cores in the outgoing cables (see Figures 19). Where this has not been possible the coils have been installed around the individual phase fuse carriers (see Figure 20).

The coils for the measurement of the transformer current are placed either on the transformer connection cables on the busbars on the LV board. Where it is not possible to install coils around the connection or busbars then the currents in the individual outgoing phase conductors are summated in the monitoring unit to give the overall transformer current.

Where the coils have been placed around the fuse carriers AND the output of these coils is summated to calculate the transformer currents then it is not possible to replace the fuse carriers with the ALVIN Reclose™ unit. This is because in the prototype LV-CAP™ platform it is not possible to use the output from individual ALVIN Reclose™ units in place of the sensor readings provided by the Lucy Electric GridKey unit.

Voltage Measurement

The measurement of voltage may be by a busbar G-clamp (Figure 18) or by the use of modified fuse carriers (Figure 17).

6.6.3 Installation of the ALVIN Reclose™ Units

This installation procedure assumes that the Rogowski coils used to determine the transformer currents are not installed around the fuse carriers.

The full process for installation and commissioning of the Alvin Reclose™ units with the LV-CAP™ platform is detailed in the method statement / approved procedure in Appendix D.

6.6.4 Replacement of LV Enclosure Doors

In some locations it will be necessary to remove and replace the door of the LV Enclosure with a deeper alternative, to enable the installation of the Alvin Reclose™ units. An example of an enclosure with a standard door, in comparison to one with a deeper variant is below in Figure 30 below.

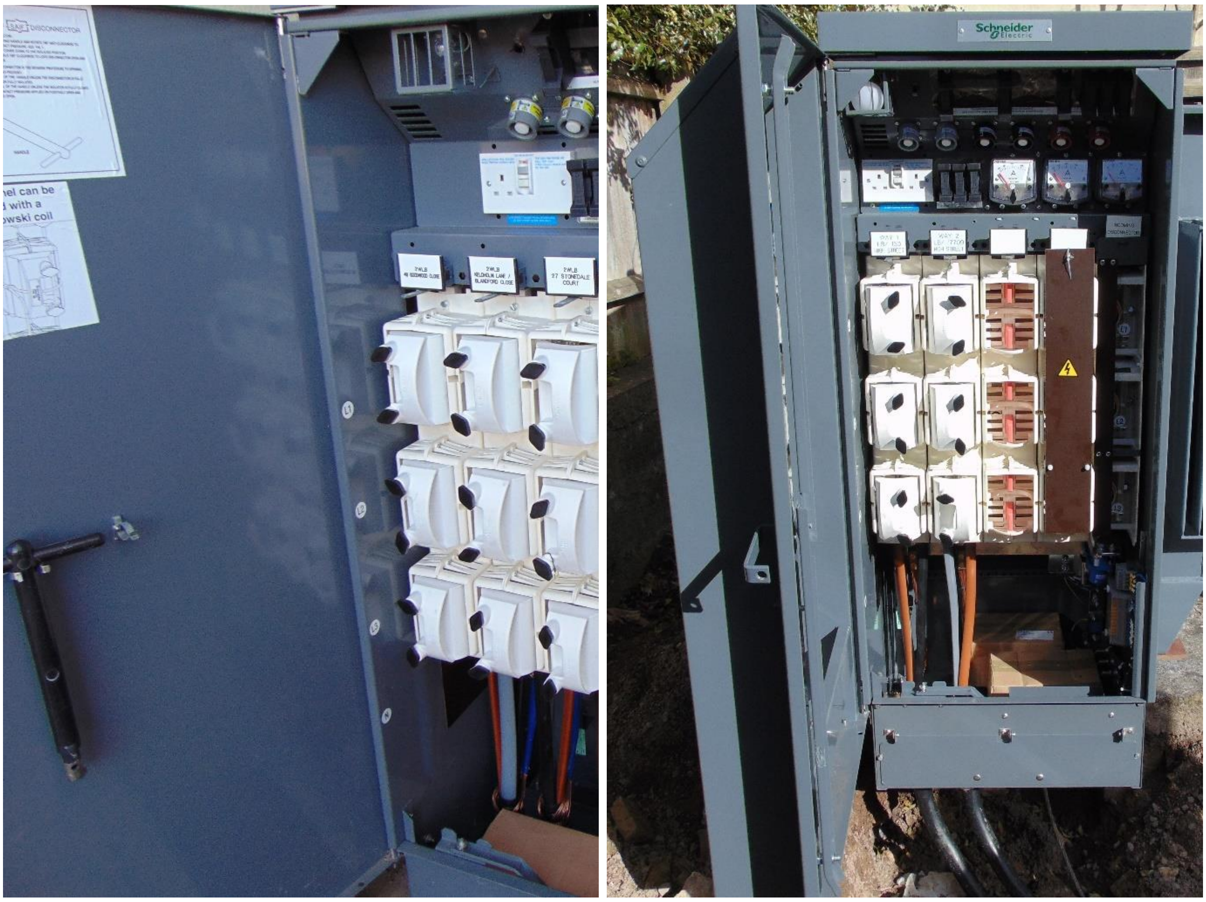

Figure 30: LV Enclosure - Standard (left) versus deeper door variant (right)

This will only be required in a small number of substations, and only those where Alvin Reclose™ units are to be installed.

The detailed method statement / approved procedure for undertaking this work is detailed in Appendix E.

7. Commissioning

7.1.1 Core LV-CAP™ system (excluding Alvin Reclose™ units)

Commissioning of the trial equipment requires verification of multiple elements of operation:

- Electrically safe installation of the equipment;
- Energisation of the LV-CAP™ platform and Lucy GridKey MCU520 system;
- Confirmed connection by LV-CAP™ platform to the iHost control server;
- Network monitoring by the Lucy GridKey MCU520 system;
- Successful transfer of recorded data to the LV-CAP™ platform;
- Storage of the received data into the LV-CAP™ platform's memory storage;
- Confirmation of data transfer from the LV-CAP™ platform to the iHost control server;
- Confirmation of setting update / container modification on the LV-CAP™ platform, triggered by the iHost control server; and
- Confirm functionality of the Isolation switch (when ALVIN Reclose™ devices are installed).

The full documentation detailing the commission process, tests to be undertaken and check sheets to be completed are included in Appendix C of this method statement.

Each trial installation requires all tests to be undertaken unless otherwise authorised by the OpenLV Project representative on-site.

7.1.2 Commissioning ALVIN Reclose™ Units

Full installation and commissioning of the Alvin Reclose™ units comprises three stages:

1. Stage 1 – Installation and data capture
2. Stage 2 – Control simulation
3. Stage 3 – Control implementation

The full installation and commissioning process for the Alvin Reclose™ units is detailed in Appendix D.

It is emphasised that whilst the Alvin Reclose™ are capable of multiple (user configurable) reclose attempts, those installed within the OpenLV Project will be programmed to operate as a smart fuse. Consequently, these units shall not automatically attempt to restore supply and a visit by depot staff will still be required to restore power in the event of a fault.

On completion of successful commissioning, check that the Alvin Reclose™ Isolation Switch is in the ON position, enabling communication between the installed trial equipment.

Do not apply a padlock to the isolation switch; the purpose of this switch is to enable WPD staff to isolate the network automation elements from the LV-CAP™ control unit and then lock the system into an isolated state.

8. Decommissioning & removal

8.1 General removal process

The OpenLV project deployed 80 GridKey LV Monitoring devices across WPD's licence areas, and it is intended to utilise them for a combination of BAU monitoring and supporting Community Groups across their four licence areas.

Where the Peak Recorded Tx Load reached or exceeded 80% of the asset rating the GridKey Platform will be retained. Substations with peak loading below this will be removed as required for other purposes, prioritising the lowest loaded substations.

Two tiers of decommissioning are therefore possible for each location.

- Full removal, where all trial hardware (LV-CAP™ enclosure [ISD], GridKey platform, current, voltage and temperature sensors) will be removed.
- LV-CAP™ removal, where the GridKey platform, along with current and voltage sensors will be retained, but all other hardware will be decommissioned and removed.

The 7 community groups (comprising 12 substations) participating in the OpenLV project requested continued access to the data being utilised by their participation in the trials. In response, these 12 locations were upgraded from trial equipment to business-as-usual suitable hardware to maintain the level of service provided by the trials. This necessitated the full removal of OpenLV trial equipment[4] as defined above, which was then replaced with hardware suitable for BAU deployment.

Many community groups not currently involved with the OpenLV project, within WPD's licence areas have expressed significant interest in gaining access to their local LV data. WPD therefore intend to reallocate a number of the GridKey LV Monitoring platform to support these groups removing monitoring assets from the lowest utilised substations in the OpenLV project to achieve this.

Where the substation has also been outfitted with ALVIN Reclose™ units as part of the automated LV control trials, the below process (Appendix F) for equipment removal must be followed. In addition, when decommissioning these locations, the control room must also be informed of the removal of the trial hardware, with specific emphasis being made that the ALVIN Reclose™ devices have been replaced with standard fuses.

The decommissioning process comprises multiple stages elements to remove all necessary equipment from a substation.

1. **Data back-up:** all data on the LV-CAP™ platforms has been backed up on a rolling basis
2. **Isolate ALVIN Reclose™ units:** if installed, isolate the communications switch and physically disconnect the blue cable from the ALVIN Reclose™ device.

[4] With the temporary exception of 2 substations (Kilburn Place and West Littleton Road) where the LV-CAP™ trial enclosure was retained for the purpose of parallel temperature monitoring to verify the accuracy of the new temperature probes. The LV-CAP™ enclosure will be fully removed as part of the main decommissioning works.

3. **Controlled shutdown:** this can be undertaken remotely or on-site. (It is preferable that the system is not shutdown via switching of at the power socket.)
4. **Remove ALVIN Reclose™ units** (if installed)
5. **Remove MCH520** platform and associated sensors (if required)
6. **Remove ancillary components**
7. **Removal of LV-CAP™ enclosure**

8.2 ALVIN Reclose™ Comms Isolation

It is important that when decommissioning a substation outfitted with ALVIN Reclose™ devices, that the ALVIN Reclose™ units are disconnected from the ISD in a controlled manner, **before the ISD is shutdown**. Refer to Appendix F.

8.3 Detailed removal process

8.3.1 Removal of ALVIN Reclose™ Devices

The detailed process for decommissioning the ALVIN Reclose™ devices is provided in Appendix F.

It is important to follow the process detailed in Appendix F to avoid possibility of disconnecting customers. ALVIN Reclose™ units, if installed, should be removed before any other equipment.

8.3.2 Full equipment removal (excluding ALVIN Reclose™ devices)

The below sequence should be followed during the decommissioning and removal of OpenLV trial equipment from substations identified as requiring full removal of all trial equipment.

1. Perform a controlled shutdown of the LV-CAP™ system.
    - This can be undertaken remotely from EA Technology offices, or via manual triggering of the power button on the PC within the enclosure.

2. Unplug the ISD; coil the cable inside the enclosure.
3. Remove the fused voltage / power leads connecting the MCU520 to the modified fuse carriers / G-clamps / terminal connections, as appropriate for the installation location.
4. Remove the anti-tamper cover of the MCU520.
5. Disconnect the ethernet cable connecting the MCU520 to the ISD.
6. Disconnect the voltage connection block from the MCU520.

7. Remove all sensor leads from the GridKey MCU520.
8. Disconnect the ethernet cable routed between the ISD and GridKey MCU520.
9. Remove the MCU520 and box for transport – make good any holes if required.
10. Disconnect the sensors from the feeder cables / busbars and box for transport.
11. Where used, remove G-clamps from the LV board.
12. Inside the ISD, disconnect the ethernet cable from the Gridkey, antenna and thermal probe cables.
13. Remove the ISD, and any attached mounting equipment (uni-strut frame, magnets and wall bolts) and make good any holes if required.
14. Remove antenna from mounting location and make good any holes if required.
15. Remove thermal probes.
16. Remove all cable ties and clips used to secure cable routes.
17. Replace cap over transformer oil pocket if necessary.
18. Remove radiation shield from mounting location and make good any holes if required.
19. Secure radiation shield, antenna and all ancillary connection cables for transport.
20. Verify that as far as is reasonably practicable the substation has been returned to the original state.

8.3.3 Partial removal locations (excluding ALVIN Reclose™ devices)

The below sequence should be followed during the decommissioning and removal of OpenLV trial equipment from substations identified as requiring removal of the ISD and thermal probes but retaining all LV monitoring equipment.

1. Perform a controlled shutdown of the LV-CAP™ system.
    - This can be undertaken remotely from EA Technology offices, or via manual triggering of the power button on the PC within the enclosure.

2. Unplug the ISD; coil the cable inside the enclosure.
3. Remove the anti-tamper cover of the MCU520.
4. Disconnect the ethernet cable connecting the MCU520 to the ISD.
5. ***Optional Stage: If Lucy Electric, or suitably trained WPD staff are present to reconfigure the MCU520 platform for standalone operation, this should be undertaken now.***
6. Replace the anti-tamper cover of the MCU520.
7. Inside the ISD, disconnect the ethernet cable from the Gridkey, antenna and thermal probe cables.

8. Remove the ISD and any attached mounting equipment (uni-strut frame, magnets and wall bolts) and make good any holes if required.
9. Remove antenna from mounting location and make good any holes if required.
10. Remove thermal probes.
11. Remove all cable ties and clips used to secure cable routes.
12. Replace cap over transformer oil pocket if necessary.
13. Remove radiation shield from mounting location and make good any holes if required.
14. Secure radiation shield, antenna and all ancillary connection cables for transport.
15. Verify that as far as is reasonably practicable the substation has been returned to the original state.

Appendix A. GridKey MCU520 LV Monitoring System Guide

Appendix B. Installation Schematic drawings 109250-001 SHT 1 & 2

Appendix C. Site Acceptance Testing & Commissioning

Appendix D. ALVIN Reclose™ installation and commissioning documentation

Appendix E. Replacement of LV Enclosure door documentation

Appendix F. Decommissioning of ALVIN Reclose™ units