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RESPOND

Fault Current Limiting Service Equipment Specifications and Installation Report

4 April 2018

VERSION HISTORY

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APPROVAL

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CONTENTS

GLOSSARY OF TERMS AND ABBREVIATIONS

Abbreviation/Term	Definition
AP	**Adaptive Protection** is the use of adjustable protection settings that can be changed in real time
CB	**A circuit breaker** is a device that interrupts the flow of current in an electric circuit
CRMS	**Control room management system**
CT	A **current transformer** is a transformer designed to scale down large primary currents to smaller values for the purpose measurement and protection.
DNO	A **distribution network operator** is the owner and/or operator of an electricity distribution system and associated assets
FLAT	The **Fault Level Assessment Tool** is intelligent software which assesses near real time fault current peaks on the network and decides to enable or disable the mitigation technologies
Fault current	Actual current which flows during a fault
FCL Service	The **Fault Current Limiting Service** is a distributed generation and/or industrial and commercial customer-provided response to reduce overall fault current on the distribution network
Fault level	Prospective maximum current which will flow during a fault
FLRCB	**Fault level reducing circuit breaker**
I_S-limiter	A fault current mitigation technology
LCN Fund	**Low Carbon Networks Fund**
Near real time	A measure of the frequency of the calculation by the Fault Level Assessment Tool. For Respond this will be every five minutes
NMS	**Network management system**
Primary substation	A point on the network where the voltage changes from 33kV to 11kV or 6.6kV
Protection relays	Device that analyses power system voltages and currents to detect faults and sends signals to circuit breakers to open
SDRC	**Successful delivery reward criteria** are key milestones to be delivered throughout the project
Substation	A point on the network where voltage transformation occurs
Switchgear	Device for opening and closing electrical circuits (including circuit breakers)

1 EXECUTIVE SUMMARY

This report is one of a series of documents, submitted as part of Electricity North West's Second Tier Low Carbon Networks (LCN) Fund project, Respond.

Respond seeks to demonstrate the viability and effectiveness of near real time fault level assessment and adaptive mitigation techniques to overcome fault level challenges faced by distribution network operators (DNOs).

The Ofgem project direction document outlines certain successful delivery reward criteria (SDRC), against which the success of the Respond project will be assessed. For each criterion, the project direction defines the evidence that is required to demonstrate successful delivery.

There are SDRC reports for the technology phase of the project and this report is the document to deliver evidence on the SDRC stated below.

Publish equipment specifications and installation reports for the FCL Service by April 2018

2 INTRODUCTION

The Respond project is investigating how fault current on distribution networks can be managed by the use of various techniques which in turn are selected by a near real time fault level assessment tool (FLAT). The FLAT calculates fault level on a periodic (every five minutes) or network topology basis (network switching operations). It can select one of three techniques:

- I_S-limiter in series with a primary substation transformer or across an open 11kV bus-section circuit breaker (CB)
- Adaptive Protection (AP) which, during a fault, reduces fault current by opening an 11kV bus-section CB before the downstream 11kV CB has been issued with a trip command from its' protection relay
- Enabling a Fault Current Limiting Service (FCL Service) from customers' generators and motors, which causes the protection relays of these devices to trip their respective CBs more rapidly than normal in order to reduce their fault current contribution to a fault on the DNO system.

Extensive Respond trials have taken place to assess the FLAT for its performance and frequency of operation.

This report shows the equipment specifications and installation configurations that could be used to provide an FCL Service at a customer's premises.

The scope of the work was to produce a design for a customer to provide an FCL Service followed by the installation and commissioning of the equipment to prove that the new FCL Service modules can communicate correctly with the SCADA system (telecontrol, CRMS, NMS and the FLAT tool) to locally monitor on-site CB status.

3 FAULT CURRENT LIMITING SERVICE

The FCL Service standard contract has been completed and published on the project website. The project aim was to establish up to five FLC Service contracts during the trial period for existing customers, two of which were to be by project partners United Utilities.

The Respond project team have found it challenging to engage with customers willing to participate in the FCL Service trial due to a number of barriers previously identified and documented. Active discussions have taken place with 13 organisations who had indicated a willingness to participate with only one moving into the final stage of technical and commercial discussions which did not prove competitive with other existing commercial contracts already in place.

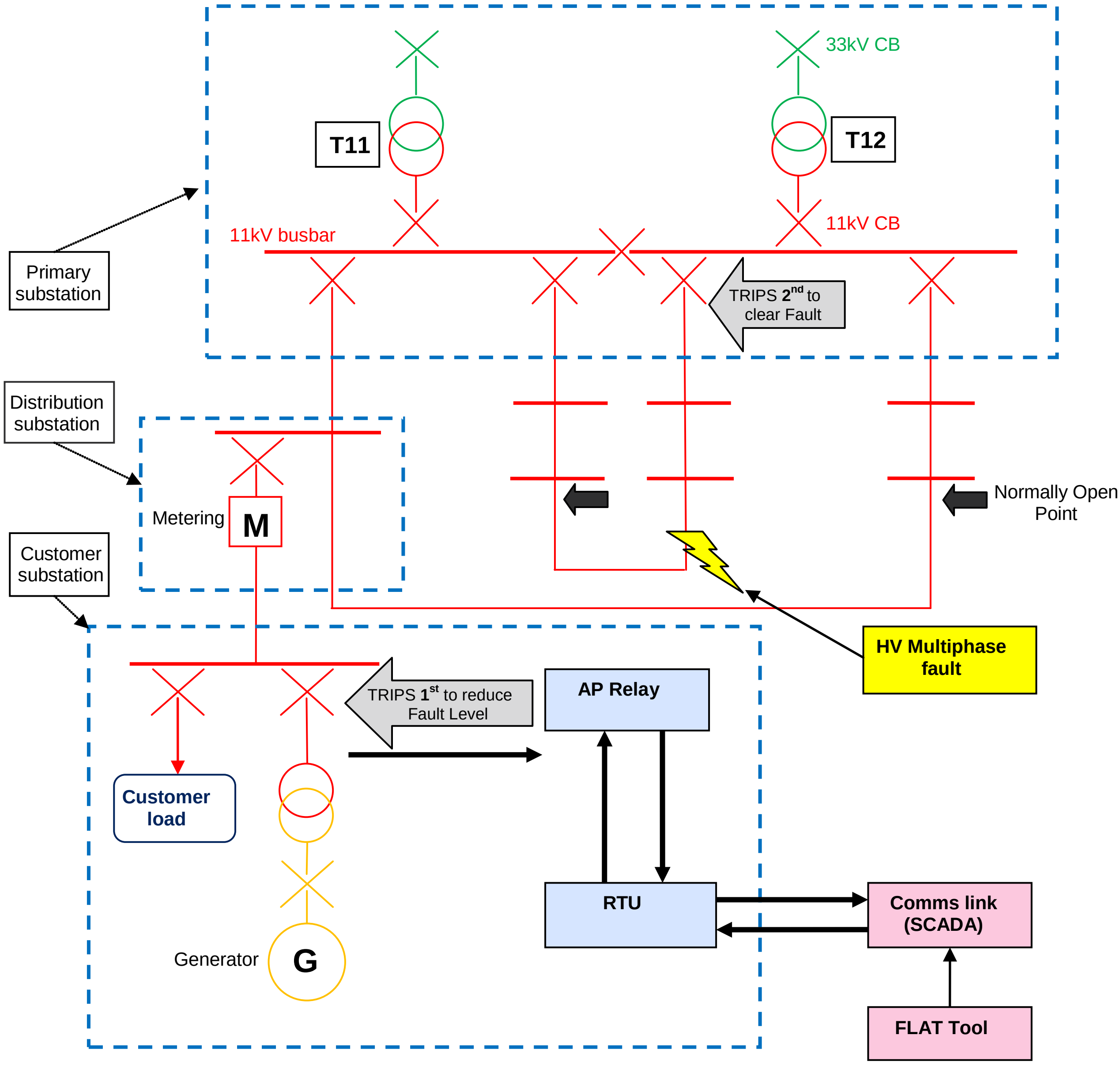
Due to the perceived commercial risk, contract negotiations to commence trials with project partner, United Utilities, took considerably longer than was originally envisaged. This delay restricted the time available to develop the design and technical arrangements required to actively trial the interface technologies at two proposed sites and consequently it was not possible to proceed to the installation stage.

Therefore, this report defines and documents a generic version of the proposed installation arrangements that could be utilised for future installations where an FCL Service is required.

4 SPECIFICATION AND DESIGN

While the project team recognised that it may be feasible to use the existing protection relay in a customer's installation by utilising an additional settings group, this would not be the case in all circumstances. Therefore a generic design was developed, incorporating new protection and tripping relays which could then be tailored to suit any particular installation. Figure 1 shows a typical schematic layout of a design that could be utilised to trip a customer's HV circuit breaker to provide an FCL Service.

Figure 1 Generic Adaptive Protection scheme for a customer substation



4.1 Generic design

The generic design consists of an Argus-1 relay (the AP relay) and a tripping relay fitted to a panel situated within the customer's switch room. The AP relay has an input from the customer's existing switchgear CTs and is connected to the existing CB trip circuit via the tripping relay. There are also outputs to enable and disable the protection and to monitor the protection status. The AP relay communicates with the Electricity North West telecontrol (SCADA) system via a remote terminal unit (RTU). The RTU has an internal battery powered from a standard 230v 13amp socket; the relay panel requires a 110v DC supply from the existing substation battery or alternatively from a dedicated battery and charger arrangement. As not every customer's switch room has a suitable wall space to mount new equipment, an optional freestanding arrangement was utilised for the RTU and the AP panel.

Photograph 1: RTU and Adaptive Protection panel

The AP relay is configured so that it cannot be enabled to operate unless the following pre-requisites are met:

- The AP relay is powered by an 110v DC supply
- The self-checking process in the AP relay confirms it is in a 'Healthy' condition
- The on-site AP 'enabled/disabled' switch is in the 'enabled' position
- The telecontrol (SCADA) AP' in/out' latching interposing relay is in the 'in' state
- The AP relay locally confirms that the CB is closed.

Once the above pre-requisite conditions are met, the AP relay can be enabled in one of two ways.

If the AP relay has not received a FLAT 'hold off' signal from telecontrol (SCADA) before its internal fail-safe timer has operated (five minutes) then the AP relay will assume a loss of communications/NMS/FLAT has occurred and will 'fail-safe' and enable the AP relay. If any of the pre-requisites change, the AP will automatically be disabled.

If the network topology changes in such a way that the FLAT calculates the fault level to have risen above the upper threshold value, it will send a 'FLAT enable' signal to the AP relay. This could occur just after a FLAT 'hold off' signal has been received by the AP relay. In this case the AP relay will change within one second to being enabled without waiting for its timer (five minutes) to operate. If, subsequent to this, any of the pre-requisites change, the AP will automatically be disabled. If the network topology changes again and the FLAT calculates the fault level to have dropped to below the lower threshold value, it will send a ‘FLAT hold off’ signal to turn off the AP mode in the relay.

When the AP relay is enabled, it measures the current contribution from the customer’s network into the Electricity North West network and if this rises above a preset value it then sends a trip signal to the fault level reducing circuit breaker (FLRCB).

Consideration was given to preventing the FLRCB being reclosed until the fault was isolated but it was decided that this was not necessary as any attempt at reclosure would fail safe as the FLRCB would simply trip again if the fault remained on the network.

Photograph 2: Adaptive Protection and tripping relays

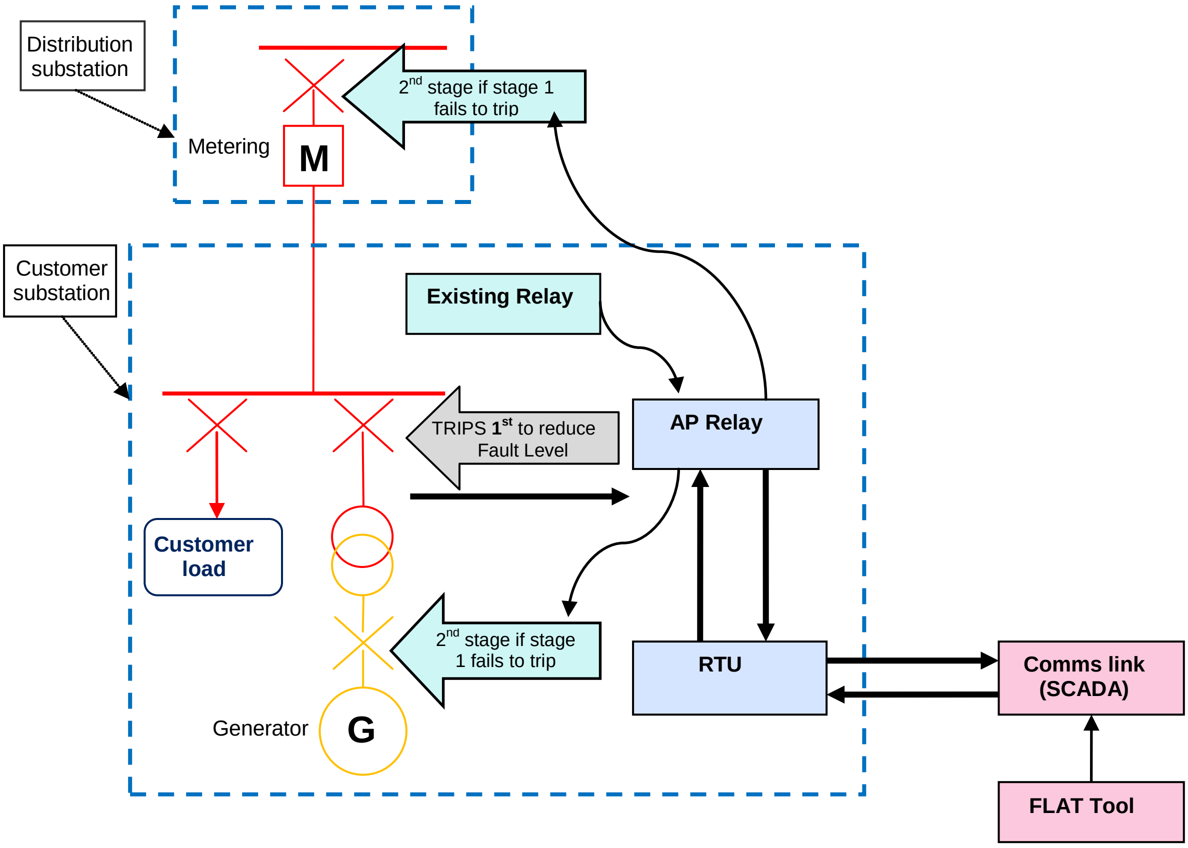
4.2 Safety case and resilience

As the AP system is required to operate and thereby reduce fault level within 200ms, consideration was given to the consequence of failure and how this may be mitigated.

In the event of the AP relay failing to operate correctly a backup or second stage delay could be provided by utilising a setting group on the customer’s existing relay to trip the FLRCB.

In the event of an FLRCB failing to operate, a second stage of fault level reduction could be provided by tripping another CB. For instance it may be feasible to use the main incoming high voltage CB to the site as a backup; or in the case of a generator setup it may be practical to trip the LV CB. Figure 2 shows details of the various options of providing a second stage of tripping.

Figure 2: Adaptive Protection scheme showing options for second stage tripping.



5 INSTALLATION AND COMMISSIONING

As a network outage is required for the final connection, testing and commissioning of the Adaptive Protection relays to the customer's FLRCB and the communication path to telecontrol (SCADA), as much work as possible should be scheduled to be undertaken in advance.

The strategy to be adopted is firstly to physically install the AP panel and RTU in the switch room. After installing 110v DC cabling, the new Adaptive Protection relays can be initialised with logic mapping and settings. The RTU power supply can also be connected so that the communications link can be established.

After the network has been shut down, the cabling to the FLRCB can be installed and connected, following which the final commissioning tests can be completed.

The installation will be recorded in the company asset data base to ensure that scheduled inspection and maintenance is undertaken.

Photograph 3: Internal view of RTU

Photograph 4: Internal view AP cabinet