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RESPOND

Managing Fault Level Reinforcement

31 October 2018

VERSION HISTORY

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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 of measurement and protection
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
HV	**High voltage** is the 11,000/6,600 volt network
I_S-limiter	A fault current mitigation technology
LCN Fund	**Low Carbon Networks Fund**
LCNI conference	**Low Carbon Networks and Innovation conference**
Primary substation	A point on the network where the voltage changes from 33kV to 11kV or 6.6kV
Protection relay	Device that analyses power system voltages and currents to detect faults and sends signals to circuit breakers to open
RTU	A **remote terminal unit** is the interface between the substation equipment and the **NMS**
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 INTRODUCTION

The purpose of this document is to fulfil the requirement associated with the Respond successful delivery reward criteria (SDRC) **9.5.2 – Publish Electricity North West's approach to managing fault level reinforcement.** The aim of this document is to outline Electricity North West's approach to managing fault level driven reinforcement based on the outcomes of the Respond project.

1.1 Background

The instantaneous surge of current that flows when a fault occurs on an electrical network is called the fault current and is significantly greater than the normal load current. The fault level is the potential maximum fault current that will flow when a fault occurs. This increases as new generators/motors are connected to the network.

Traditionally fault level was calculated based upon a steady network state and the network was reinforced by replacing assets that exceeded their rating. The Respond project utilises an intelligent fault level assessment tool (FLAT) to constantly monitor fault level which, in the event of a network fault occurring, is then reduced so that the fault can be safely cleared. Consequently, it is possible to release fault level capacity quicker and cheaper than by utilising traditional methods.

The project investigated three techniques to provide additional fault level capacity on the network namely:

- The retrofitting of adaptive protection to existing substation equipment to re-sequence the operation of circuit breakers
- The installation of I_S-limiters to detect and interrupt fault current before it reaches peak value
- The purchase of a fault current limiting service (FCL service) from a customer which requires them to operate their equipment to reduce fault level under certain defined circumstances.

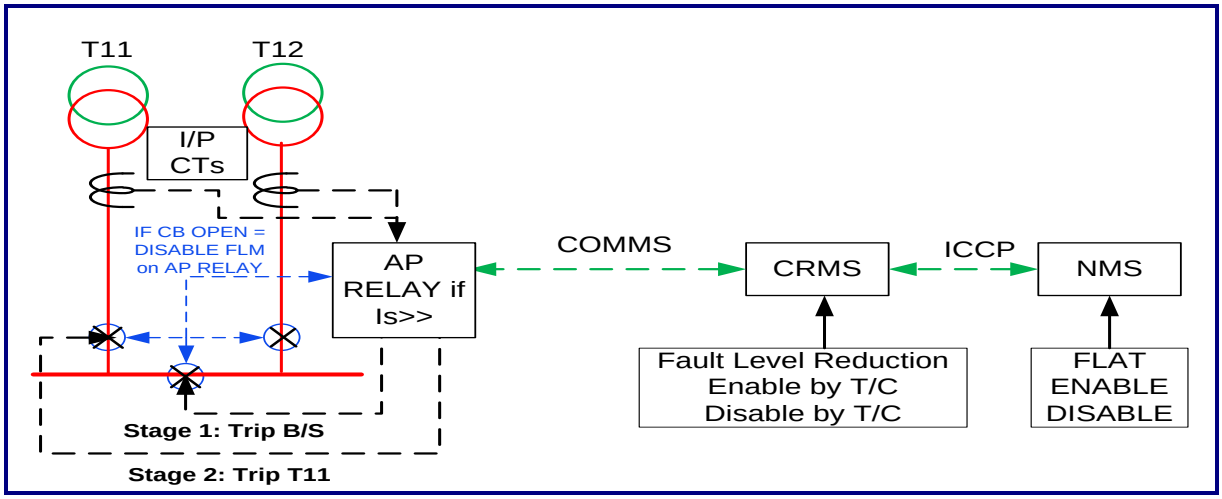
Adaptive protection and I_S-limiters were installed and trialled successfully by the team during the project albeit on networks where the fault level did not exceed the ratings of existing equipment. Extensive effort was made to recruit customers to trial the FCL service, however, it was only possible to reach agreement with the project partner, United Utilities, at a late stage in the project.

2 TECHNIQUES TRIALLED

2.1 Adaptive protection

Adaptive protection is retro-fitted onto the existing protection installed on-site allowing the tripping to be re-sequenced in order to control the fault level seen by the circuit breakers (CBs) as they operate. Essentially, when a fault occurs on a high voltage (HV) circuit out of a primary substation, the system instantaneously looks to trip either one of the transformer CBs or the bus section CB, reducing the fault current that the feeder CB is required to interrupt. Figure 2.1 below provides an overview of the scheme.

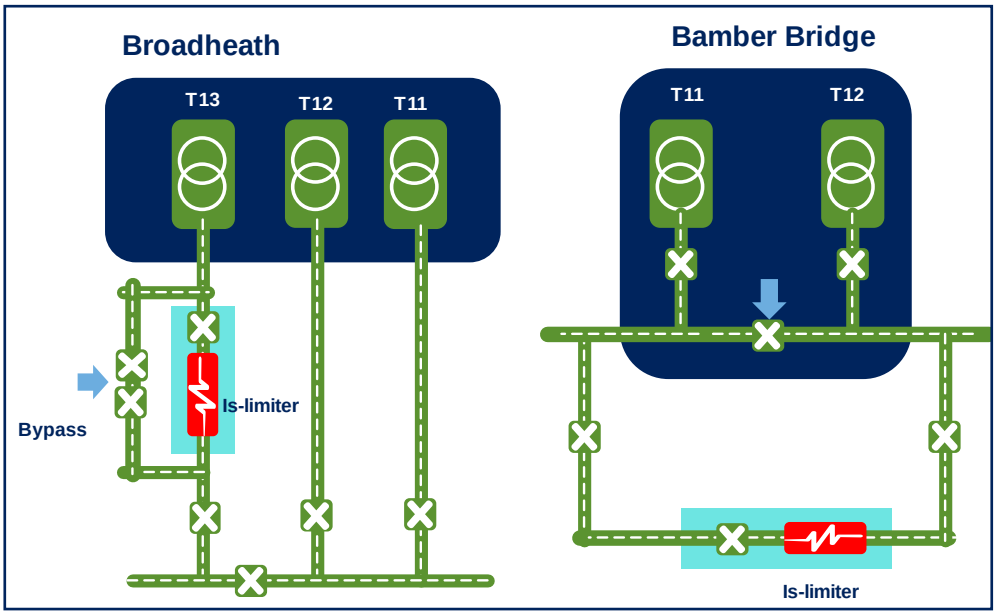
Figure 2.1: Adaptive protection set-up



I_S-limiter

The I_S-limiter is a fast acting device designed to interrupt fault current much faster than a standard CB. It consists of a section of busbar with an intentional weak point built in. When the connected relay detects an increase in the current flow above a certain rate, it triggers a small explosive charge, similar to that used in an airbag, which breaks the connection. This diverts the current through a fast acting fuse which ruptures to interrupt the flow. This also causes an in-line CB to trigger ensuring that all three phases are disconnected. In the course of the project, two separate configurations were trialled. See Figure 2.2 below, where the device was installed to either act as the bus section or in line with one of the primary transformers.

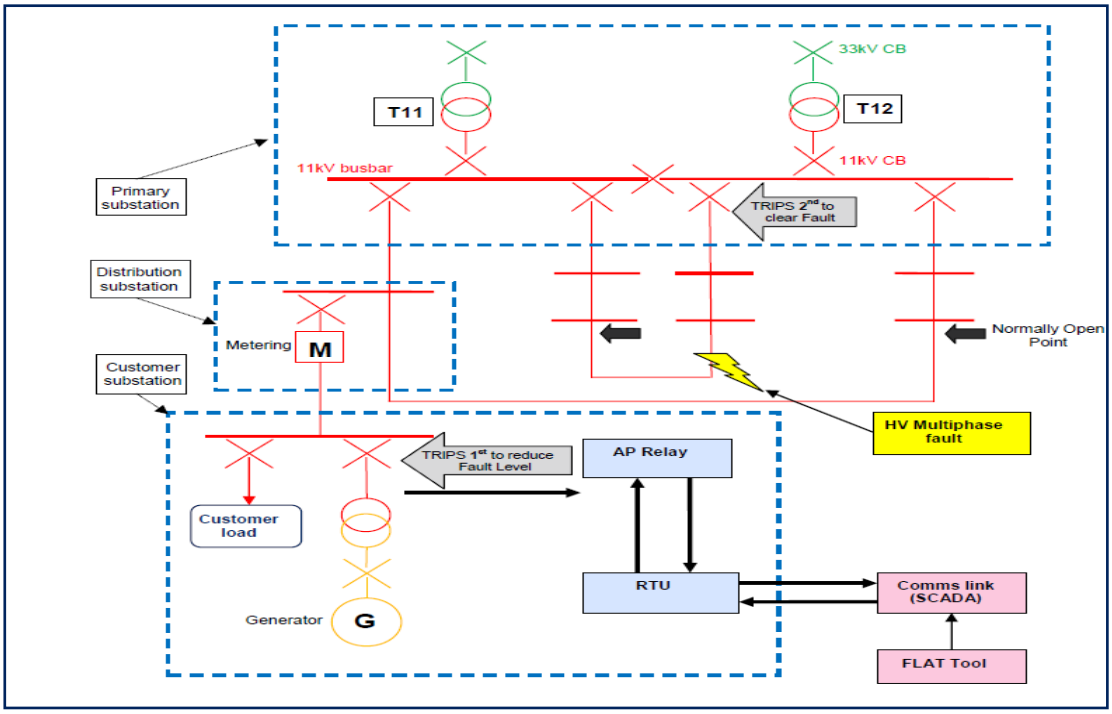
Figure 2.2: I_S-limiter set-ups



2.2 Fault current limiting service (FCL service)

The FCL service is a commercial arrangement whereby generation or demand customers whose load mix means that they are net contributors to fault levels at a site agree to have part of their system automatically suspended during faults. This system, shown in Figure 2.3 below, is similar in operation to the adaptive protect scheme in that it sequences the tripping of CBs to manage the fault current interrupted to ensure that all devices remain within their ratings.

Figure 2.3: FCL service set-up



3 POLICY UPDATES

As a part of the project Electricity North West undertook a review of its internal policies to determine what changes would be required to allow the use of the above techniques in a business as usual rollout. The full outcome of this review can be found here. These changes will allow for one of the above techniques to be used following a case by case cost/ benefit analysis (CBA) to identify the most suitable approach. A generic CBA, located here, was generated during the project to document the potential savings of employing these methods in place of traditional reinforcement.

In general the deployment of adaptive protection was both the quickest and cheapest method of responding to an increased fault level and as such is expected to form the majority of Electricity North West's use of the Respond techniques in BAU. The I_S-limiter, due to its extremely fast acting nature, was more suited to scenarios where this speed was required, ie where the cables as well as the switchgear had fault level issues. The use of the FCL service is limited to sites where suitable customers are connected, but is expected to form part of future connection agreements to facilitate the connection of customers without the cost and delays required by traditional reinforcement.

As each of the techniques trialled would be used where sites potentially exceeded the fault level ratings in a BAU situation, the project also created a safety case to cover the application of each method; these can be found here. The main point, which was common across the three documents, was that the total fault level should remain within the through flow rating of the equipment. All three safety cases found that the use of the Respond techniques fell within the 'broadly acceptable or 'tolerable' regions as described by the HSE methodology.