Fundamentals

QUEST algorithm development on the SuperTAPP SG AVC relay

Lessons Learned Report

Fundamentals Reference F12649-4-05-LL v1.0
24/11/2023

Classification: Unrestricted

Fundamentals Ltd., Registered office Unit 2, Marshall Road, Swindon, Wiltshire, SN5 5FZ, United Kingdom
Company No. 2939559 VAT No. GB641612170 | **fundamentals.tech**

Version Information

Rev	Date	Purpose of Issue / Changes	Authored	Checked	Approved
1.0	24/11/2023		E. Macharia	V. Thornley	V. Thornley

Table of Contents

Abbreviations

AVC	Automatic Voltage Control
ANM	Active Network Management
BSP	Bulk Supply Point
CLASS	Customer Load Active System Services
DNO	Distribution Network Operators
ENWL	Electricity North West Ltd
EV	Electric Vehicles
FAT	Factory Acceptance Testing
HP	Heat Pumps
QUEST	Reactive Power (Q) Utilisation Energy System and Terms
SAT	Site Acceptance Testing

1 Introduction

1.1 Introduction to QUEST

Over the years, human activities have increased carbon dioxide emissions, driving up the earth's average temperature. Most of the world's human-caused carbon emissions are released by the burning of fossil fuels for electricity and heat, industry, and transportation.

To manage climate change, mitigation strategies have been adopted by numerous countries. The UK has committed to reach net zero carbon emissions by 2050, making Britain the first economy to do so.

Due to this commitment, there has been an increase in the uptake of Low Carbon Technologies (LCTs) such as heat pumps (HP), electric vehicles (EV) and low carbon generation such as solar and wind generation which has led to a greater demand being placed on the distribution network as it is structured.

To cater for this subsequent increase in demand and generation, Distribution Network Operators (DNOs) have investigated and deployed techniques such as Active Network Management (ANM) connects separate components of a network by implementing software to take continuous measurements and monitor and control the operation of these devices and voltage optimisation.

Although these techniques have been successful in helping DNOs to manage the network and have demonstrated benefits to customers, they have some limitations.

Because the techniques are deployed in isolation, are not currently co-ordinated, use worst case planning assumptions, and are reliant on a robust communications infrastructure, they present restrictions.

QUEST has developed and introduced a distribution network-wide fully co-ordinated voltage control architecture, with appropriate balance between centralised and decentralised control hierarchy which will integrate discrete voltage control techniques into one overarching, co-ordinated and optimised system.

1.2 The SuperTAPP SG AVC relay

The SuperTAPP SG is an Automatic Voltage Control (AVC) relay for transformer and tapchanger management designed and developed by Fundamentals. The relay provides practical options to deliver a Smart Grid approach for distributed generation, network interconnection and reconfiguration, flexible and highly variable loads, and many other scenarios which cause challenges for voltage control.

Figure 1: SuperTAPP SG AVC relay

Following the successful rollout of the SuperTAPP SG during the rollout of CLASS, further functionality was added to the relay to facilitate the requirements for QUEST and enable integration with the QUEST software module.

SuperTAPP SG's relays were also deployed to new sites including Bulk Supply Points (BSPs) where the relays had not been deployed before, and existing SuperTAPP SGs were upgraded to enable the new algorithms developed.

2 QUEST work programme and lessons learned

The project was split into phases and work packages.

QUEST Phase 1-1 system design was scheduled to run from April 2021 to April 2023 consisting of the various required to get the system from design stage to Factory Acceptance Testing (FAT).

2.1 Phase 1 Scope

2.1.1 Work Package 1 – Developing use cases

Fundamentals in conjunction with ENWL and all relevant project partners, provided technical input into the definition of use cases and scenarios for the QUEST system.

We did this by examining a range of use cases and architecture options which defined the design of the overarching system.

2.1.2 Work Package 2 – Engaging with stakeholders and customers

As part of the use case development, Fundamentals supported stakeholder and customer engagement required to ensure that the use cases were correct and covered all the necessary requirements.

2.1.3 Work Package 3 – Designing a software solution for the QUEST system architecture

Fundamentals in conjunction with all the relevant project partners and Electricity North West, designed the software solution and architecture on the SuperTAPP SG to facilitate the QUEST functionality.

2.1.4 Work Package 4 – Algorithm Development and Implementation

Fundamentals developed and implemented the algorithm to meet the agreed design document into the SuperTAPP SG relay. Factory Acceptance Testing of the algorithm was conducted at the Fundamentals factory in Swindon.

2.2 QUEST Phase 1-2

QUEST Phase 1-2 implementation was scheduled to run from April 2023 to September 2023 consisting of the various tasks required to get the system from a Factory Acceptance Testing (FAT) stage to a Site Acceptance Testing (SAT) stage and ready for the trials.

2.2.1 Work Package 5 - Developing Offline Models and Bench Testing Regime

Fundamentals provided technical support for the development of the simulation models and bench testing regime for the simulated trials.

2.2.2 Work Package 6 - Survey, Design, Install and Commission SuperTAPP SG relays

Fundamentals conducted site surveys of the proposed installation locations for the SuperTAPP SG relay. Electricity North West confirmed the site locations following site selection. The output of the surveys was then used by Fundamentals to complete a full installation design for each site. Fundamentals installed and commissioned the SuperTAPP SG relay with the new algorithm at all proposed sites within the trial area with support from ENWL.

2.2.3 Work Package 7 - Site Materials for Installation of SuperTAPP SG relays

Fundamentals purchased the Automatic Voltage Control (AVC) wallboxes including ENVOY and all other necessary site materials to facilitate the installation in Work Package 6.

2.2.4 Work Package 8 - Feeder Measurement and Firmware Upgrade

Fundamentals will, with support from ENWL, upgraded some of the existing CLASS enabled sites within the trial area to facilitate feeder measurements to be included with the QUEST functionality.

2.2.5 Work Package 9 - Site Materials for Feeder Measurement and Firmware Upgrade

Fundamentals purchased the necessary equipment to facilitate the installation of the feeder measurement upgrade in Work Package 8.

2.3 Lessons learned

Algorithm Development

The development and delivery of the SuperTAPP SG algorithms for QUEST was successful (Work Packages 3 and 4).

Whilst developing the algorithm for the SuperTAPP SG relays, we used Scrum, an agile framework and delivered iterations of the software monthly.

This method allowed us to address high priority requirements first and test and release versions of the software on a regular basis decreasing the time it took to deliver the software to ENWL.

We would have benefited from more information when developing some of the functions. In the future, we will hold requirements gathering sessions with our customers for more ambiguous demands.

By the end of Phase 1, we were able to define a development process which will be transferrable to other customer projects as follows:

- High level and detailed design to be signed off by customer;
- Development plan;
- Review plan progress with customers;
- Agree test plan with customer;
- Deliver development to customer;
- Support testing and trials.

Site work

It was often difficult to determine what site drawings needed to be updated. Additionally, the quality of the customer supplied drawings were very difficult to read and edit. We would have recommended a digitisation service to bring all the drawings into a useable AutoCAD format.

The work that had been done and the work that was still required was confusing.

For this reason, we would have recommended regular project meetings specifically for Phase 2 throughout the project and a spreadsheet showing work completed, planned and invoicing schedule/status.

Although site work was delayed due to a shortage of resources, the installation process and feeder measurement and firmware upgrade (Work Packages 5-9) was successful.

When performing installs and upgrades in the future , Fundamentals would recommend a full rewire of AVC schemes which would ensure the reliable operation of the AVC schemes/QUEST system once installed.