GRIDKEY
UNLOCKING THE SMART GRID

GridKey Developments for Electricity North West's 'LV Network Solutions'

June 2014

Electricity North West – GridKey Developments

When originally proposed to Electricity North West, an initial GridKey design (the white box) had been produced and a number of early installations had been carried out. This had started to create a list of areas where improvement was needed. When Electricity North West issued their specification for competitive tender this created some additional areas – for example in the area of anti-tamper. This resulted in a redesign of the box housing and the addition of an anti-tamper cover however the original circuit cards were retained largely unchanged. There were a number of additional design changes introduced at the same time such as internal mounting of the GPRS antenna and a revised voltage connection block rather than using the previous 4mm banana plugs. The revised MCU design was put out to tender for initial rate manufacture, a supplier selected and production started with the first unit being handed over just under 3 months after contract award.

Hardware

Initially we had planned to just use Gridhound sensors but early installs had highlighted that in approximately 25% of cases they would not fit and so the GridKey team researched and identified a flexible Rogowski sensor which was then modified to meet the GridKey requirements. It also required a software modification to correct the different electrical sensitivity of the different sensor types.

These changes in the design of the electronics unit (MCU) and the additional sensor type were all carried out in partnership with Electricity North West but also discussed with other DNOs who had been involved in the initial installations to ensure the resulting system met the needs of all the UK DNOs.

The only hardware problem encountered was with the SanDisk micro-SD card which showed early signs of degradation. The micro-SD card is used to provide all the non-volatile memory in the unit –the storage of measured data but also the configuration settings for the unit. Rather than having units fail a significant engineering effort was carried out to find an alternative (Samsung) card and also improving the way we wrote to and read from the card. Having identified, tested and certified the upgade a joint activity was carried out to swap out the installed units with updated units then overnight Selex would upgrade the boxes and use them to swap ones the next day. On-site times for the swap out including the commissioning of the new unit was reduced to less than 20 minutes.

Communications

The original design concept on GridKey was that we would supply and fit the GPRS Sim cards and the unit had been previously been tested using the O2 network. Electricity North West however wanted to use Vodafone Sims in line with their corporate supply agreement and these were supplied and fitted. Ultimately this proved to be an area where we had issues – for example with units that were reported as not working only to find that Vodafone had disabled the Sims. At present the Sim cards are fitted internally during

manufacture and although consideration has been given to providing the ability to field swap Sims there are a number of issues related to cost and maintaining the IP65 protection for this solution. Instead we are working with a company who can provide a cost effective roaming sim which can also be directed to a specific network.

Getting reliable GPRS comms was a specific issue encountered at the start of the project and a number of software changes as well as the operational use of external antennas were introduced during the project. This has dramatically improved the reliability of the communications but it has highlighted the fragility of relying on just GSM comms. The use of the roaming sim which selects the best network when the system is installed would further improve. The development of the Ethernet module has also allowed alternative communications to be used.

Software

The system had a series of software updates during the deployment both to correct errors and to add additional features. This was carried out using an over the air software upgrade capability – this was essential as the costs of updating the systems in the field would have been very high. This capability also provides the ability to change the configuration of the units without needing to visit the substations and this features has been used on several occasions.

Data Management

The initial concept was the systems would all communicate directly to an iHost system installed on the Electricity North West network. This created a number of problems and delays which ultimately delayed getting data to the University of Manchester. The biggest problem was getting access to the Electricity North West network and access through the associated firewalls. In the interim the units were installed and pointed at the GridKey data centre however this data centre was never designed to be used for so many units so there were a number of reliability problems with the data centre itself.

The use of feature numbers to identify feeders was only introduced half way into the programme and the configuration of units with this additional data was done when the boxes were swapped out for the SD-card upgrade.

The amount of data produced when the units were reporting at their maximum rate of a data report every minute also caused problems with the iHost system. This was one of the key drivers that meant we have now developed a new data centre and associated analytics engine. This new data centre will also allow batch updates of the units when changing reporting periods or doing over the air software upgrades.

In order to allow on-site rather than just remote configuration of the units, software was developed for a laptop which could be connected to the units via an IR puck. This software is now routinely used by Electricity North West when installing systems (including the mid and end point units).

Mid/End Point Monitors

A key development working with Electricity North West has been in the use of the GridKey device as a mid- and end-point monitoring system. A lot of effort was spent looking at how best to install the GridKey current sensors and connect voltage leads onto underground cables within smart joints on Electricity North West's network.

In addition, the GridKey collaboration worked closely with Electricity North West and Ritherdons (a supplier of metal outdoor enclosures and cabinets) to provide a GridKey system already wired up in a suitable overground pillar/cabinet with all necessary connections in place for jointers to quickly connect voltage leads and current sensors into on site. Throughout the programme, further developments were made to these pillars to better seal them at the base to prevent the ingress of ground water, as well as improve ventilation through the addition of multiple air vents on either side of the cabinet.

As a result, the GridKey collaboration is now able to offer an off-the-shelf, end-to-end tested LV monitoring cabinet that DNOs can use to monitor the LV network anywhere along a feeder from a transformer.

Project Management

Both Electricity North West and GridKey recognised that for the project to be successful a team approach needed to be adopted. This result in almost daily communications between the companies with the principle of complete openness. The GridKey team spent a lot of time (outside of contract) supporting the installations – this allowed both companies to learn together and solve problems together. From the GridKey side there were a significant number of activities which were carried out without contract cover but the decision was made to invest as it was clearly creating a better solution.

Assessment of the GridKey system

In 2013, the GridKey system was assessed alongside a number of other systems in an LCNF Tier 1 "Assessing Substation Measurement Equipment" project run jointly by WPD and UKPN. This project considered two elements – system accuracy (which was carried out by the National Physical Laboratory) and practical installation (carried out by UKPN and WPD). The result put the GridKey system in joint first position in the comparison table – this was a direct result of the development of the system and the processes to install and use it, which were achieved as a result of the partnership relationship with Electricity North West on this project.

Further Developments informed by project learning

The following provides a complete list of the new capabilities being produced as a result of our experience gained from LV Network Solutions and other LCNF projects, but not incorporated in LV Network Solutions monitoring.

Auxiliary Ethernet Module

Following discussions about monitoring feeder temperature with ENW at some of the mid- and end-points on this programme, the GridKey collaboration has developed a new auxiliary Ethernet module to interface with the GridKey unit.

As well as providing an Ethernet interface (allowing easy integration with 3rd party backhaul communications), this module also offers the ability to measure a number of external temperatures – these could include the external temperature of the distribution transformer, busbar temperatures, or ambient temperatures within a sub-station enclosure.

These temperature values can either be used for health monitoring (for example, indicating a transformer running close to, or above, its correct operating temperature, a transformer which has suffered oil loss, or a loss in correct substation ventilation), or combined with advanced analytics to show the impact on transformer life. Within the new Auxiliary module there are also a couple of opto-isolated Inputs and Outputs, that can allow interfacing to a range of other sensors or actuators at a sub-station location.

Current Sensor Development Roadmap

Currently we offer a range of current sensor types to suit fitment on a variety of conductors. The standard GridHound current sensor fits most conductors, but a flexible Rogowski coil is also offered for the limited number of locations where the standard sensor will not fit. Following work with Electricity North West, the GridKey collaboration have recognised that a single, cost effective, sensor would be a more optimal solution for customers. As a result, investment has been made in the development of a new flexible SlimSensor, which has all the cost and accuracy advantages of the GridHound current sensor, whilst being slimmer and flexible such that a single sensor fit for the majority of installs. Initial prototypes of this new sensor are currently under test.

Expanded Power Quality Capabilities

Under contract with Electricity North West for the IFI ‘Customer Voltage & Power Quality’ proejct, the GridKey collaboration developed more detailed harmonic analysis measurements than offered by a simple Total Harmonic Distortion measurement. GridKey is now able to provide calculated Total Harmonic Distortion on voltage, current and power, using calculations at the data server.

The “present” GridKey THD functionality is as follows:

For each phase of each feeder, the MCU calculate the total power and the fundamental-only power, for both real and reactive components, [over a 5-minute window]. The difference between these is the harmonic power, reported by the MCU, which caused by

harmonic current flowing and creating voltage harmonics. The MCU also uses the harmonic power to calculate the total harmonic distortion of the power, which is the (total-fundamental)/fundamental power.

There is also some post-processed THD that GridKey can also provide as follows:

The fundamental-only power can also be used to calculate the fundamental-only current, using the RMS voltage, provided the voltage distortion is not excessive. From this and the RMS current, the current harmonics, and if appropriate the current THD, of each feeder's current can be calculated in post-processing of the data. As excessive current harmonics are usually the root cause of end-customer voltage harmonic issues on feeders, when combined with specific feeder size and length information current harmonics can be a useful parameter to highlight potential voltage harmonic issues.

Data Storage, Presentation and Analytics Capabilities

Experience with Electricity North West and other DNOs has shown that some data systems are not designed to cope adequately with the volume of measurement data being created by hundreds of deployed systems. As a result the GridKey collaboration has been developing its own support tools, including a data centre capability using "best in class" database/software engines to provide a data centre which is designed to easily and efficiently scale for much larger deployments of LV monitoring equipment, providing a solution which can provide a robust and reliable datastore for large-scale business-as-usual deployments.

As well as receiving and securely storing LV measurement information, and allowing easy operator interrogation/ review, extended capabilities will be available to provide business driven analytics. The aim is to provide prioritised, actionable information to planners, control room engineers, outage management teams, and network maintenance planners. These analytics tools are being generated by discussions with Electricity North West, subject matter experts, and our own in-depth research to unearth the value bearing information within the raw measurement data. The capabilities will include the ability to provide real-time alerts based on either raw measurement data or derived information feeds, in a variety of methods (e.g. e-mail, SMS, etc.).

Device Administration & Configuration

The last key element of GridKey's support tools being developed is the Device Administration module. The GridKey devices have a wide range of configurable parameters which can be controlled (e.g. alert parameters, reporting periods) The ability to easily remotely manage the configuration of these devices, both in terms of user configuration and any over-the-air software updates, is essential. The Device Administrator will allow system managers to remotely manage configuration of multiple GridKey systems easily and reliably. Facilities will be provided to control the configuration of a single GridKey system, or to control larger operator defined "groups of systems", thereby increasing the speed of introduction of changes and reducing any systems management effort.