PERMANENT POWER QUALITY MEASUREMENT, MONITORING AND RECORDING – CHALLENGES TO FACE FOR LARGE IMPLEMENTATION

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SUMMARY

This paper reflects the main challenges that the Belgian utility Electrabel has to face in order to build up a national database of Power Quality records in the distribution network. Beside the distribution network, a selection of key customers is also monitored using similar equipment.

After briefly describing the topology of the power grid as well as the usual PQ outages encountered, the paper presents the complete solution developed by and implemented in cooperation with ACT'L.

This solution integrates

- The measurement devices located on critical nodes of the network
- The communication aspects to gather the information in a central database
- The availability of the data for different users spread within Electrabel and at some customers

The main problems encountered are pointed out as well as the advantages of the implemented solution.

DISTRIBUTOR MEASUREMENT CAMPAIGN & NETWORK DESCRIPTION

Electrabel's distribution MV network serves 3,900,000 LV customers with 50,000 MV/LV substations and 23,000 substations for MV customers. The LV and MV networks are mostly radial and are used in an open-loop configuration. The MV networks are supplied by 330 HV/MV substations.

The MV and LV network serves both industrial and residential customers. The distributor has to supply energy with the quality required by its customers and in line with the compatibility levels set out in the standards.

The distributor takes quality measurements to this end. The measurement campaign needs to be organized in a rational way. Readings and the processing of results quickly become unmanageable if they are not well structured from the outset.

The measurement campaigns have 2 different aspects. One is general, assessing of the global quality as a whole, and the results are then used to generate a set of statistics. These provide a sustainability index that helps the distributor assess the overall quality of supply and select its development strategies. The other focuses on monitoring specific and local supply scenarios in order to initiate and develop discussion and analysis between the distributor and the customer or future customer.

The needs and expectations of the customers generally focus on:

- the constancy of supply and thus the absence of interruptions;
- a voltage that only fluctuates within set limits;

- the absence of voltage dips.

Moreover, the distributor has to make sure that customers using certain equipment are not generating abnormal disturbances that can be transmitted to other customers over the public distribution network. This essentially concerns the levels of:

- harmonics;
- flicker.

Constancy of Supply

A constant supply is checked through the careful collecting of network incidents by the supplier. The distributor does not need to use any special measuring devices.

Voltage Variations

Voltage variations are less critical in underground MV networks, which are improved more quickly for cable saturation than for voltage drops. For overhead power lines, however, voltage has to be controlled, the figures being calculated rather than measured.

On the LV network, voltage is measured each time a problem arises using recording voltmeters set to operate for periods of one week.

Voltage Dips

Voltage dips are for the most part random phenomena and thus require constant network monitoring. Measurement points need to be identified since it is not possible to take readings at every location on the network. The MV busbars of the HV/MV substations are felt to be the locations that best represent the customer's situation. Distribution is therefore in the process of installing permanent measuring devices at these points.

Harmonics

Although the current levels of harmonic voltage in the distribution network are less than compatibility levels, it is still in the distributor's best interests to monitor them over time. Dispersion among LV customer applications can be kept under control by applying product standards that limit the emissions of mass-produced equipment. Such standards have a delayed effect on the overall level of network harmonics, so to prevent this from eventually exceeding the compatibility threshold it is necessary to anticipate events. To date only a few Electrabel HV/MV substations with a residential load have been monitored. In the future this kind of monitoring will be coupled with voltage dip monitoring using a single measuring device making it possible to extend the observance frame of reference and to simplify data processing.

Emissions from industry are, by their very nature, located and handled individually.

Flicker

Flicker phenomena usually result from a specific source. Systematic measuring campaigns are therefore not justified. Flicker cases are treated on a case-by-case basis as and when they occur.

Key customers

Besides the monitoring of the voltage on important nodes of the network, Electrabel offers for large customer a "quality contract" that includes the monitoring of the delivered power. Therefore, both voltage and current are monitored at the point of delivery. Compliance reports towards the EN50160 [1] can be issued while power factor and power demand can be monitored as well.

LARGE NETWORKS AND GLOBAL PQ MONITORING

The main needs expressed by utilities when monitoring the MV-LV network or the key customers are the following:

- High resolution recording when disturbances occur
- Statistical overview reducing time for off line data analysis
- Relevant data, quickly available for different users: network management, maintenance, board,…

In order to meet those three criteria, the measuring devices installed in the field provide the recording of every disturbance coming on the network: dips and swells, flicker, harmonics,…

All those data are automatically gathered in a central database and made available for networked analysis.

Data recorded from the network and from Key customers are gathered in a single database. The access to those data is limited, as described in following paragraph: 'providing available data to the end user'.

To achieve those measurements and the data retrieval, a global solution based on a central database has been developed by ACT'L. The architecture can be summarised in three stages:

1. Measurement of the data

QWave® devices installed at more than 50 locations on the network provide the basic measurements. These QWave measure and record all the parameters described in EN50160 [1] in compliance with the latest standard (IEC 61000-4-7 [2]). They automatically store the data to hourly -, daily - and weekly statistical files and EN50160 [1] compliance reports that are stored within the devices memory for several weeks. This offers two main advantages:

- ◊ the statistical analysis of the network is already provided by the devices themselves, and thus reduce drastically the off line work
- ◊ Communication time with the devices is significantly reduced due to data concentration in the devices themselves

As the data are only read (and not erased) from the devices, even in the case communication would be interrupted, the data are kept safe.

Different kind of recordings are provided:

- for dips and swells, the signature of the rms value is recorded with a resolution of $1/8^{th}$ of a cycle;

- On specific sites, the user defines the electrical parameters that have to be incrementally recorded as well: flicker and typical harmonics (3,5,7,11,13) are generally recorded at 10-min intervals.

- On all the sites, hourly-, daily- and weekly statistical analyses are provided for all the measured parameters, storing the average -, max - and min values.
- EN50160 [1] compliance reports are automatically issued at the end of every week

2. Gathering of the data

The main challenge in setting up the global database is due to the high number of devices that have been implemented. Gathering automatically data coming from 100+ of locations on an easy way was essential for the utility. Therefore, the solution implemented has been thought to meet different requirements:

Independently from the kind of data, automatic data retrieval had to be performed but manual connection must be possible as well. Following solution is now implemented in the system:

1. For dips and swells, data are read automatically at least once a day
2. For harmonics and flicker, a daily upload is sufficient

3. For compliance reports, a weekly upload is sufficient
4. For long term statistics, the upload can be performed once a month or even less

Those functions are from far sufficient for the distribution management. But as this system also gathers the data from the key customers, several functions had to be added. For example, when a dip occurs, the Key Account Manager must be able to get the latest data coming from the relevant customer(s).

To reach this target, the central server integrates a scheduler, which gathers automatically the data at the required interval. To provide this, a pool of several modems automatically uploads the data from the devices spread on the network. On user request, specific devices can be uploaded as well.

After gathering by the scheduler, all the data are stored in the central database and provide a basis for statistics on a national scale.

3. Providing available data to the end-user

According to their scope, users connected to the database may be interested in specific topics such as harmonics, dips, flicker and so on. The central database is therefore available through Electrabel's Intranet.

The server, whose task is also to check the clients, insures confidentiality of the data by setting user profiles defined by a central administrator. Those profiles include geographical and voltage level parameters. ACT'L provides a generic graphical interface to read out all the data contained in the database, while Electrabel developed specific functions such as statistical dip analysis. Those expert functions use special routines developed by Laborelec -Electrabel research Dept- and relying on the central database, using ODBC connectivity of the SQL database.

CONCLUSION

As Electrabel wanted to rapidly build up a global solution, the teamwork deployed here has been especially successful. Electrabel could concentrate on specific aspects such as the treatment of the electrical data, while ACT'L was in charge of the development of both the hardware and the software solution to made the data available. This global database is a fair aspect of the Power Quality policy of Electrabel.

REFERENCES

[1] EN51060: Voltage characteristics of electricity supplied by public distribution systems

[2] IEC 61000-4-7: General guide on Harmonics and Interharmonics measurement and instrumentation, for power supply systems and equipment connected thereto