Technical note

Transparency and power quality in distribution networks with the correct measurement technology

In its distribution network study, the German Energy Agency (dena) calculated a figure of 27.5 billion euros for required development and modification tasks by 2020. However, new studies prove that intelligent technology can almost halve these costs. But for this, the network operator must know the load flows in their network precisely. Comprehensive measurement technology for recording, transmitting and evaluating the data make him master of the system. Here, scalable solutions ensure transparency for the initial investments.

In the past, distribution networks were planned in accordance with the "top-down" direction of energy flow, from high voltage, through medium voltage to low voltage at the end customer. The planning concept changed a few years ago. In doing so, the requirements for more efficient networks play as great a role as the increase in renewable energies. These influences mainly apply to the low voltage network: 98% of all renewable energies are fed into regional and local distribution networks. In doing so it is becoming apparent that the progression of development cannot keep pace. Decentralised power generation plants (e.g. wind turbines, PV, biogas ...) lead to voltage rises that must be regulated out. On the other hand, the increased use of power electronics has caused significant distortion of the sinusoidal current progression thus endangering the stipulated power quality per standard EN 50160.

Consequences for the energy industry:

The conversion of the electricity network has profound consequences: Reversed load flow through to return feeding, overloading operational resources, the increasing of voltage ranges at feed-in points, asymmetries, fluctuating load flows... it is difficult to localise these disruptions in meshed networks in order to tackle them in a targeted manner. However, this is imperative because the requirements on the quality of the power supply are increasing. For a long time Power Quality was synonymous with supply security, i.e. the absence of noticeable interruptions. Electronic loads, such as IT systems or industrial controls need far more: Short-term voltage dips, harmonics, transients, etc. can cause significant damage.
Class A certification: Quality seal for power quality analysers

The increased requirements on the power quality even have legal consequences: In February 2014, the German Federal court ruled that electricity is subject to the product liability law. As a result, the DSOs (distribution system operators) are liable if electrical equipment is damaged due to poor power quality. A comprehensive analysis and documentation of the power quality with a certified process, as described in standard IEC 61000-4-30 class A, is thus even more important. It provides detailed specifications that a mains analyser must meet so that the results can also be consulted in case of disputes. Since 2011, Janitza has had selected power quality analysers certified - naturally also the current flagship UMG 512. The device features continuous monitoring of the power quality, harmonics analysis and checking of the internal supply network in accordance with the EN 61000 series of standards. Online and historical measurement data can be viewed via the integrated device homepage (image 1) as well as via much more comprehensive GridVis®-software for in depth PQ analysis. Of course, such complex technology is not required for all measurement tasks. The next sections describe the layout of an effective and cost-efficient distribution network monitoring solution and the infrastructure necessary for this.

Monitoring over 3 levels

Comprehensive monitoring for the energy distribution network takes place on three levels (image 2):

• Substation

• Local distribution stations (secondary substations)

• Cable distributors, decentralised energy producers or critical special contract customers

In doing so the following tasks must be fulfilled:

• Increase availability / reduce downtimes

• Reduce transmission, distribution and non-technical losses

• Voltage control in local distribution stations

• Incorporate decentralised energy producers (e.g. photovoltaic, biogas, etc.)

• Fulfil regulatory and tariff-related requirements (documentation obligation)

• Continuous power quality monitoring (e.g. per EN 50160)

• Incorporate new technologies (e.g. electric vehicles, storage)
Level 1: Substations

The transfer points in the substations deserve great care. Typical application situations are supplies, transfer points from overlapping suppliers or significant outlets to critical major customers. Class A power quality analysers that are certified in accordance with IEC 61000-4-30 are essential here. In addition to highly precise power measurement, power quality with its numerous parameters is at the forefront here. The UMG 512 described above offers both the necessary performance in the measurement technology and the protocols and interfaces for simple incorporation and data transfer. In addition it can take over the documentation in the event of transmission faults, thanks to a large measured values memory. The integrated WEB server with its EN 5160 PQ snapshot function as well as the optional EN50160 APP enable local monitoring of the power quality. Due to the local intelligence the amount of data communication can be minimized as well.

Level 2: Secondary sub-stations

The second level (the secondary sub-stations) was virtually excluded, with regards to measurement technology, in the past. In the meantime it has received closer attention as it plays a key role in the layout of the distribution network. It is responsible for tasks such as:

- Adherence to the voltage range
- Recording the utilisation level of the operating equipment
- Continuous monitoring and analysis of the energy network components
- Minimising interruption times and downtimes

Here, the measurement technology must prepare the PQ and energy measurement data for documentation and fault analysis, for example for EN 50160 PQ reports. From an economic point of view, it makes sense to monitor only the incoming feeder or just a few outlets at first. If there are then repercussions for the network or customer complaints about insufficient power quality (e.g. short-term interruptions), or if a general network development or an additional development with decentralised energy systems is available, you can monitor additional outlets in the secondary sub-station. This is also possible afterwards without interrupting network operation and with minimal effort. Scalability is an important topic!

The UMG 605 PQ analyser from the Janitza portfolio is the ideal master device in the incoming supply feeder. For comprehensive monitoring of the power quality per EN 50160, it records all relevant parameters, such as flicker, short term interruptions, transients, etc. RS 485 Modbus, PROFIBUS and
Ethernet (TCP/IP) are available as interfaces. Many power utility companies also frequently rely on the particularly attractively priced UMG 96RM range.

Slave devices such as the UMG 20CM or the UMG 103 are suitable for the outputs in the secondary substations. The UMG 20CM has 20 current measurement channels, which are designed as low power current inputs. This saves the user space and costs in the IKT area of the intelligent local distribution station as the current transformer shortening terminals can be omitted. Finally, the UMG 103 is a particularly compact device for monitoring individual outputs.

With such scalable structures the costs for the initial investments can be reduced. In addition, it is future-proof as the measurement points can be extended easily.

**Level 3: Decentralised distributors or energy producers**

Cable distributors, house junction boxes, decentralised energy producing systems and special contract customers can be found in this level. Compact and attractively priced measuring devices such as the UMG 103 are suitable for this level. To connect renewable energy producers or critical special contract customers it is also possible to expand with higher-end power quality analysers such as the UMG 605. Both devices have already been described in the "Level 2" section.

**Manage the data flood**

At present, data entry frequently concentrates only on the high and medium voltage levels. However, the distribution level is following along as described above - with significant consequences for data management. Monitoring at 15 minute intervals produces 35,040 data records for each individual measurement point per each electrical parameter per year! Without practical filtering and channelling, this data is not only dearly bought but also paradoxically worthless. In order to limit the data volume, Janitza measuring devices allow an individual selection of individual measurement parameters and definition of the averaging times. The programming option for the network analysers via graphical editors or Jasic® source code enables critical parameters to be monitored at the measuring points and only relevant data to be sent to the centralized data server. Furthermore, local intelligence such as the EN50160 APP can rein in the flood of data. A wide range of transfer protocols and protocol converters guarantee a simple system connection to the SCADA system or a centralized data server. A simple and secure managed solution such as Connect-2-Control (C2C) along with the EASYgateway modem allows wireless access to the measurement devices via public IP networks (internet, mobile data networks, company networks) independent of location. The certificate protected, SSL encryption from PC to Gateway is implemented without VPN tunnelling.
Visualisation and documentation

Janitza offers a three-stage solution for the visualisation and evaluation of the measured data:

1) WEB server: Homepage and APPs on the measurement device itself  
2) GridVis®: Central data logger, reporting and analysis tool, interface for higher-level systems such as a GIS or to the master display  
3) GridVis® Energy: Web-based visualisation

The basic version GridVis®-Basic, which is part of the scope of supply of the measurement devices, serves both for programming and configuring the UMG measuring devices and also for reading out, saving, displaying, processing and analysing the measurement data.

The GridVis® software provides reports specially for energy supply companies, distribution network operators and regulatory authorities. An enhanced EN 50160 power quality annual report can be created with it for example. It provides a rapid overview of supply areas in which the limit values of EN 50160 were not complied with (image 3) at times.

Janitza stays on target

In order to ensure that we always keep a close eye on the latest developments, Janitza is also participating in the ENERGIE sponsorship project, which includes a field test for real-time network condition monitoring. Amongst other things, the findings from this work allow distribution networks with a high proportion of decentralised energy producers to be stabilised. Here, universities and industry specialists have come together and developed a concept for the holistic evaluation of network planning and strategies for better utilisation of the distribution networks. The objective is to make reliable statements about the condition of the whole network with fewer measurements at strategically important points of the low voltage network. Janitza develops their own power quality analyser for the project.
Image captions

Lead image

Image 1: High quality measurement devices such as the UMG 512 can display online and historical data via the integrated homepage.

Image 2: Comprehensive monitoring for the energy distribution network takes place on three levels: Transformer stations, local substations, decentralised distributors or energy producers.

Image 3: Faster overview of the entire supply area: According to the traffic light principle, the heat map documents the power quality at a specific measuring point in a calendar week.

((Image source)) Janitza electronics GmbH