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# Special Publication

## Voltage quality at all grid levels

Sophisticated measuring and control technology  
is precisely what is needed.

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Extending power grids is going to be expensive: according to German's Federal Network Agency, 18 billion € will be needed for onshore measures with additional 15 billion € being required for the offshore sector.

The aim for power utilities is on one hand to guarantee voltage quality and on the

other to ensure that the costs for this do not get out of hand. However, to be able to do this, the grid operators must be completely familiar with load flows.

A. Eberle makes available reliable measuring and control technology to acquire, transfer and control such data exactly.



Only few years ago, power grids were designed for the top-down flow of energy from high-voltage, via medium-voltage to low-voltage used by the end customer. In the meantime, that's all water under the bridge. For several years now, the requirements for much more efficient grids and the rise in renewable energy installations have forced people to rethink things. Such facts have a major effect on the distribution grid. It is also interesting to consider high-voltage grids in the context of an increase in powerful feed-in stations, like large wind farms and solar parks, for example. However, more than 90% of renewable energy is fed into regional and local distribution grids.

Even now, it can be seen that current expansion measures will not be adequate in avoiding the increases in voltage that energy generation plants will cause. They must also be corrected manually. In addition, the increased use of power electronics that are installed in the electric vehicles charging stations and household solar energy systems, for example, result in severe distortions of the sinusoidal flow. "This endangers the voltage quality that is specified in EN 50160", explains Till Sybel, CEO of A. Eberle GmbH & Co. KG.

### Conversion of grids has serious consequences

Overall, the conversion of the power grids has had serious consequences. Issues like reversed load flow, resource overloading at feed-in points and asymmetry are everyday occurrences these days. "However, it's not a trivial matter to locate these disturbances and take specific countermeasures", Mr. Sybel explains. But this is crucial because the demands made of the quality and stability of the power supply are very high.

Before it used to be possible to avoid tangible interruptions to suppliers, electronic consumers like EDP or industrial controllers very sensitive to short voltage dips, harmonics and transient events in the voltage sinusoidal curve. But now, in a worst-case situation, these factors can cause considerable damage.

### Be aware of legal consequences

If grid operators are unlucky, and they are not able to ensure the high requirements of voltage quality, there may be even legal consequences. In 2014, the German Federal Court made electricity part of product liability legislation. Therefore: Distribution grid operators have to pay up if electrical devices are damaged due to bad voltage quality, a very expensive endeavor. This is above all the case if high-quality transformers are destroyed or production at an automotive supplier's factory comes to a standstill and the supplying of product on a just-in-time basis is prevented.

Companies are well advised to keep an eye on the grid quality at all times. It happens often enough that the person responsible deploys their mobile grid data analyzers once a disturbance has occurred and tries to explain and assess it after the event. However, this is rarely possible or relevant. "Comprehensive analysis and documentation of the mains quality using certified procedures like the ones in the IEC 61000-4-30 Class A standard is an absolute must. It gives detailed specifications that grid analysis tools must meet to make it possible for the results to verify that operating companies have completely met their obligations in the case of possible disputes", Mr. Sybel explains.

This means that all the grid data analyzers produced by A. Eberle comply with the demanding requirements of IEC 61000-4-30 in the latest Edition 3 (2015) and supply data that stands up in court.



As such exhaustive monitoring of energy distribution networks concentrates on:

- Transmission substations
- Local grid stations
- Substations of large consumers (industrial customers)
- Distributed generators on the feeders of the local grid

the focus is on the following targets:

- Improving availability and at the same time minimizing downtimes
- Regulating voltage in local grids
- Integrating distributed generators and new technologies, like batteries
- Guaranteeing regulatory and tariff requirements
- Ensuring voltage quality and documenting it continuously.

### **Setting our sights on transmission substations**

Grid operators should focus in particular on transmission substations. Power feeds, the substations of higher-level suppliers and important outputs to critical bulk

purchasers are sensitive points. Certified Class A voltage quality analyzers complying with IEC 61000-4-30 Ed. 3 are linked to this. In addition to the fault recording function, the voltage quality with its various parameters is paramount at this level. To measure the voltage quality, A. Eberle uses the PQI-D smart fault recorder and grid data analyzer (Figure 1).

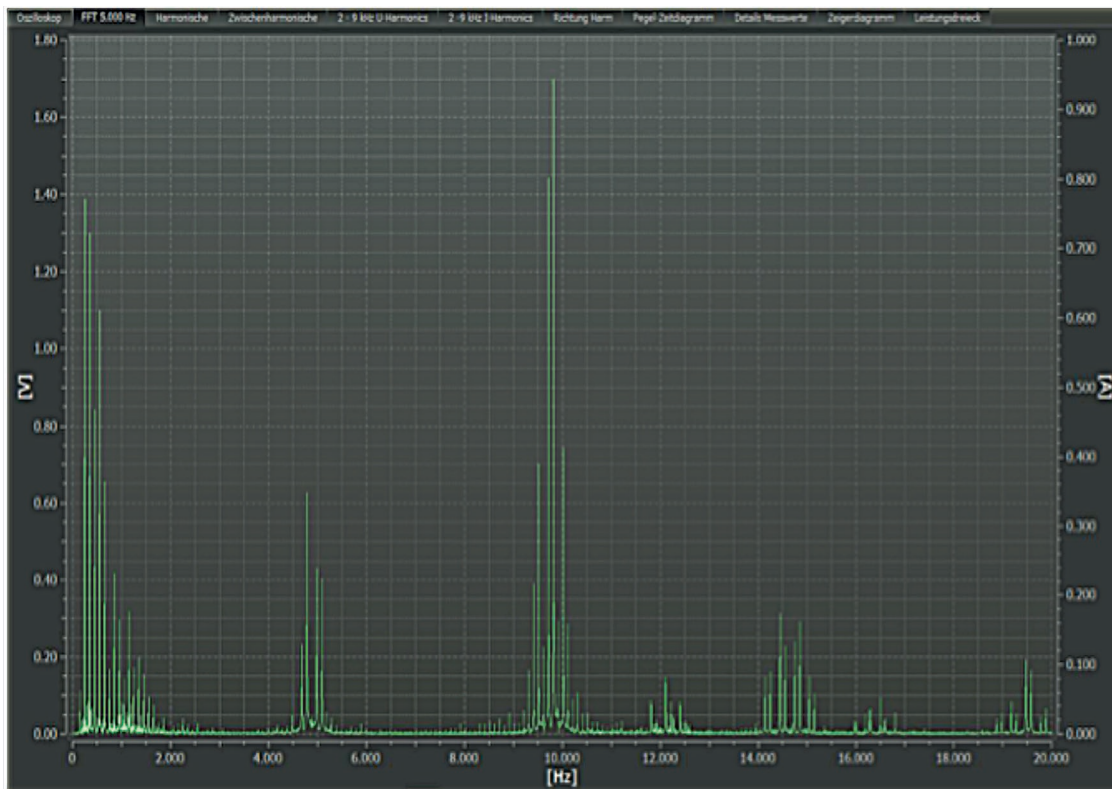
This instrument is of a modular structure and you can fit as many voltage and current inputs, relay inputs and output and SCADA technology functions as you like. The requirements of the transmission substation can be configured appropriately.

For instance, it is advisable to make a critical assessment of harmonic effects on a medium- or high-voltage grid based on the frequency transmission response of current and voltage transducers (Figure 2).

In this figure one can observe a high limitation of the frequency bandwidth. However, transducer manufacturers have already responded by offering broadband transducers for power quality measurement.



**Figure 1** Monitoring many outputs using the compact PQI-DA smart Power Quality Analyser: (in this case, eleven devices)



**Figure 2** Typical harmonic effects due to power electronics – DC current frequency spectrum up to 20 kHz of the voltage. Clock speeds of 5 and 10 kHz are apparent.

### The leading role of local grid substations

Local grid substations play a leading role in extending the distribution grid. They are responsible for complying with the voltage range, acquiring the load status of equipment, continuous monitoring and analysis of energy grid components and minimizing interruptions or non-productive time.

As Mr. Sybel makes it clear, “the measuring technology must here to supply the power quality and energy measurement data for documentation and fault analysis”. Taking into account economic issues and due to the large number of measuring points, these devices must be favourably priced and compact, while still having a very high performance. By contrast with

transmission substations, in the depths of the grid, the disturbances to consumers with power electronics are much greater, because of the low short-circuit power. Disturbances in the range up to 20 kHz are not unusual. It is often not just one consumer that causes the disturbance on the low-voltage grid. Generally, it is an interaction between specific groups of consumers with a malfunction of specific devices.

“To be on the safe side and to guarantee transparency with regard to load flows, it is absolutely essential to monitor the grid for a long period of time if not permanently and to document it”, is Mr. Sybel's advice. This is the only way to detect the time when specific levels on the grid occurred and which consumers were added and when.



### **Distributed generators on the feeders of the local grid.**

In Germany, there are currently distribution grids on which the majority of the energy comes from distributed renewable sources. Grid feeding often takes place at the lowest voltage level, e.g. from photovoltaic systems on the feeders of the local grids. The direction of power flow has become a dynamic variable and consumers like IT equipment are omnipresent.

Whereas with classical resistive loads, such as light bulbs (where the power consumption just follows the supply voltage), switching power supplies, actively keep the power consumption constant across wide ranges. This makes controlling power grids more complicated. Even though the typical distribution of new Renewable Energy Sources Act-compliant generating units pushes the limits of distribution grids, a lot of grid problems go undetected because in many places even the simplest measuring devices are not available.

### **Smart innovation project**

"We want to plug this gap and this is why we have launched the We Sense innovation project", explains Mr. Sybel. This means that people in Franconia can use simple hardware and mobile phones, Big Data and

Cloud Computing methods to drastically reduce the hardware costs for new measuring points as well as the time and effort needed for fault analysis on the grid.

The We Sense measuring system comprises an intelligent USB charging adapter, a commercially available smartphone and an app that runs on it. If you plug the charger into a socket, it supplies the device that is connected via USB with charging current as well as with high-resolution samples of the power supply grid. In conjunction with the free Android app, this transforms a modern mobile phone into a high-precision measuring device that allows users to get information about the grid status at the plug-in location in the simplest possible way. It starts at the lowest measuring point in the power grid. The lowest short-circuit power and the range with the worst voltage quality are located there. At this point, there is currently no measuring technology, since up to now it has been either too expensive or prohibited (e.g. smart meters in Germany).

Using a smartphone as the measuring device means that the initial outlay is no longer an issue.

### **Cost-efficient remedies**

To allow companies to locate and eliminate grid problems, A. Eberle has added

a scalable control system to its range of products. The LVRSys can improve the voltage quality in low-voltage grids on a demand-driven and cost-efficient basis. There are systems in performance classes from 22 to 250 kVA for voltage stability problems in individual feeders. In this connection, the structures can be implemented as pole mountiers or by means of controllable street cabinets. Systems of up to 630 kVA are available for control directly at the local grid substation.

In the case of applications in local grid substations, grid operators can choose between regulated and unregulated outputs, which allows them to respond in a highly flexible way to possible voltage problems. All the LVR systems carry out regulation on a selective-phase basis and in this way improve the symmetry of the voltage.

### **Conclusion**

Ensuring voltage quality is a major issue in the extension of power grids. This applies to high-, medium- and low-voltage grids.

A. Eberle has set itself the goal of making a contribution to guaranteeing voltage quality at all grid levels using powerful measuring and control technology.



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