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EPPE CX
Requirements to be met by a measuring system for efficiently monitoring supply systems and technical equipment

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As network operators and consumers become more and more aware of the importance of the security of supply in electrical power systems, they are becoming increasingly interested in the continuous measurement of power quality. In order to identify problems at an early stage and to be able to take appropriate preventative measures, the first step is to use a suitable measuring system to closely analyse the supply system or technical equipment over a longer time period. Depending on the specific facility and application, the requirements to be met by a suitable measuring system are very varied and include a wide range of different measurement functions.

A high quality of supply is extremely important for electrical power utility companies and industrial customers alike. For many manufacturing processes, poor power quality can lead to costly production outages and even destroy plants and machinery in some cases.

Some examples of the consequences of power system disturbances:

- Malfunctioning of the control electronics of machines
- Production outages
- System crashes
- Melted conductors
- Overheated motors, motors which do not run smoothly
- Overloading or fires
- Uncontrolled tripping of switch disconnectors or fuses
- Damage to compensation equipment
- Flickering screens
- Corrosion of conduits and earthing systems
- Problems with data networks
- Data loss
- Flickering lights
- Unexplained rises in energy costs
- Danger to people and property
- Drop in performance of machinery and plants, high losses
- Reduced equipment lifetime

Minimum requirements for power quality are defined in the EN 50160 standard, „Voltage characteristics of electricity supplied by public distribution systems". Continuous moni-toring with reference to the characteristics specified in this standard should be carried out as a matter of principle at critical nodes. Only when appropriate measurement data is available over a longer time period is it possible to draw conclusions about the quality of the power system by performing meaningful analyses and take any ameliorative measures which may be required. Measurements made using portable measuring devices are limited in their ability to provide data for meaningful analysis as the period of time measured only constitutes a small sample and disturbances usually occur sporadically.
The additional storage and analysis of environmental factors is becoming increasingly relevant, particularly for measurements in the renewable energy sector (PV systems, wind power plants, etc.) and in industrial plants. Factors such as light irradiation, ambient temperature, module temperature, humidity, wind speed, wind direction, sound intensity, motor speed, generator temperature, etc. can provide helpful information for analysis or fault diagnostics.

Requirements to be met by the monitoring system

The employees of industrial concerns and network operators alike have less and less time to devote to problems connected with power quality. Comprehensive power quality analysis often proves difficult to carry out in practice because of the constant increase in the workload of individual employees, unfortunately caused in part by cutbacks in personnel, coupled with a lack of specialist knowledge. This makes it all the more important for measuring systems to be as simple as possible to configure. It must be possible to configure standard measurements, such as measurements to EN 50160, at the touch of a button. What is more, an analysis tool must be able to fulfil an automatic evaluation in accordance with predefined guidelines and present the result in a report.

Fully automated monitoring systems continually transfer the measured data to a central data system and perform evaluation automatically. Should a fault occur, a built-in alarm system informs the employees responsible who can then take appropriate measures. Service companies like KoCoS Engineering GmbH can help with carrying out analysis or determining effective remedial measures.

Structure of an efficient measuring system

Some of the technical prerequisites for measuring systems used for long-term power systems analysis are listed below:

- Integration in various communication networks
- Easy installation and operation of the measuring device
- Absolute synchronisation of data acquisition
- High-accuracy measuring device
- Secure data acquisition
- Large measurement data memory
- Dual-processor system for data security
- Central evaluation and monitoring
- Number of analog and binary channels commensurate with the measurement task

In order to be able to analyse the power quality precisely, at least four voltage channels and four current channels with an accuracy of at least 0.1% are required. The fourth channel enables additional measurement of the current in the neutral conductor, for example. This can be important for detecting overloading of the neutral conductor. In addition, sensor measurement inputs for monitoring environmental conditions are also required. In the case of a fault, this additional measurement data is helpful for the purposes of analysis and for the

Fig. 1: EPPE CX power quality analyser

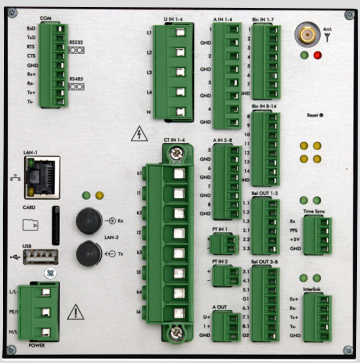

Fig. 2: EPPE CX connections

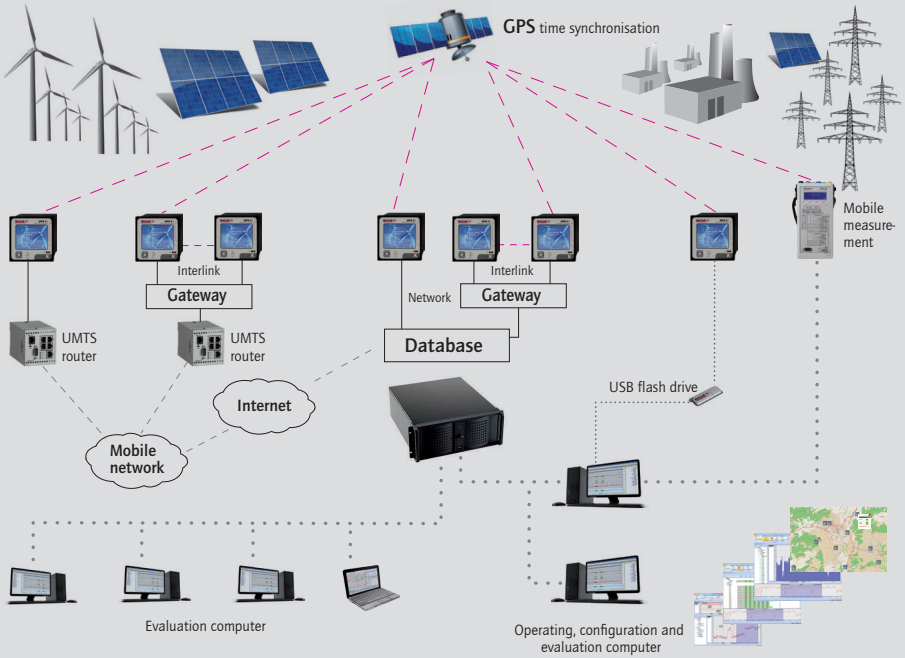

Fig. 3: Communication and time synchronisation model

determination of remedial measures, especially when a fault has been caused by a number of different factors. One measuring system which meets and exceeds the abovementioned requirements is the „EPPE CX" power quality analyser made by KoCoS Messtechnik AG.
This measuring system offers a choice of three different analog modules and an additional sensor module, making it extremely flexible. The analog inputs have an accuracy of 0.05% and are generally sampled at a rate of 200 kHz. This allows high-resolution analyses to be carried out.

Analog module 1: 4 x 600 V (L-N), 4 x 600 V (L-N) (measurements of two voltage systems)
Analog module 2: 4 x 600 V (L-N), 4 x 40 A (measurements on protection or measurement transformers)
Analog module 3: 4 x 600 V (L-N), 4 x 3 V (measurements via external current sensors)

Sensor module: 8 x analog inputs (300 V/10 V/2 V/20 mA)
2 x temperature inputs
1 x analog output

Furthermore, a sufficient number of binary inputs should be available with a measuring range adequate for the application in order to record the status of breaker positions or industrial machines, for example. Status recordings of this kind can provide useful information for subsequent troubleshooting. If the measuring system is connected to a control system, freely configurable relay outputs should be available which can be used for status and alarm signals.

Internal emergency power supply

Power quality analysers are usually connected to a secure power supply. If this is not possible with certain applications, then the measuring device must be equipped with an internal emergency power supply in order to be able to record the loss of voltage. However, the battery used in most measuring devices has the

disadvantage that it must be replaced after a specified period of time and this can often only be done by the manufacturer. To make matters worse, if there is no battery monitoring functionality, the user is not even aware of the situation and only finds out when a power failure occurs and no recording is made. The EPPE CX power quality analyser provides a better solution with an emergency power supply which is completely maintenance-free.

Communication

In order to be able to transfer measurement data, the measuring system must be capable of being integrated in any kind of communication network, including wireless network structures. The use of UMTS/LTE routers is now very popular in this type of situation. The measurement data can be transferred quickly and easily to a database via the mobile network without having to use a wired network. Another, cheaper solution is to download the data regularly with the aid of a USB flash drive or laptop. However, with this method it is not possible for the user to be notified should a fault occur.

A sensible solution is to copy the measurement data regularly from the measuring system to a database at pre-defined intervals in order to ensure fast access at all times. The EPPE CX

power quality analyser is equipped with all common communications interfaces, such as RS232, RS485, electrical Ethernet, optical Ethernet (FO) and USB (active/passive). Data transfer with optical Ethernet over optical fibre has the major advantage of being particularly insusceptible to interference. The transfer of data is not affected by external electrical or electro-magnetic interference fields.

The acquisition of measurement values is decoupled from the operating and communication process in the device by means of a dual processor system, ensuring that the process of acquiring and saving data is secure too. As well as being saved in the database, the data can also be saved in each individual device for a certain period of time before being overwritten if the measuring systems feature a circular buffer. The memory capacity of the measuring system should be capable of recording data for a period of at least one year.

For integration in substation control or other systems, the measuring system should feature a range of communications services such as Modbus or the international IEC 61850 standard which is accepted all over the world.

Time synchronisation

Power quality measurements with wide area coverage call for the values measured by all devices to be recorded absolutely simultaneously. The measurement results of a number of measuring systems can only be monitored and analysed simultaneously if a suitable method of time synchronisation is employed. Which method of synchronisation is most suitable from a technical and economic point of view depends on the specific conditions at the individual location. The basic version of the EPPE CX already includes all common time synchronisation interfaces:

- Internal GPS receiver
- Electrical GPS telegram and time pulse input
- DCF77 pulse telegram input
- Seconds/minutes pulse input
- IRIG-B input
- NTP/SNTP synchronisation via the communication network
- Interlink bus for networking several devices

This means that the user can select or change the type of synchronisation on site without having to make any changes to the hardware of the device.

Measurement functions

Which specific measurement functions are required

always depends on the measurement task or application. If a simple measurement to the European EN 50160 standard is needed, only the „Power Quality Recording“ and „Event Recording“ measurement functions are required. Other measurement functions can deliver useful information for more accurate investigations of systems and detailed analysis of the causes of a disturbance.

Záznam kvality elektrické energie
Power quality recording

The continuous recording of all power system parameters allows comprehensive power quality analysis to DIN EN 50160 or quality criteria defined by the individual user. Automatic evaluation and the creation of quality reports as PDF files make it easy to provide proof of quality whenever required, even without specialist knowledge.

Continuous data recording

The data logger function records measurement data continuously. The recorded data can be downloaded to a central computer without interrupting the measurement.

As a result, data can be recorded continuously for a number of years. Long-term recordings provide comprehensive information on the entire power system, expose slow changes, as can result from a changing load or generator structure, and reveal potential for energy savings.

Event recording

Event recording provides information on the time, level and duration of limit value violations and a classification of events to EN 50160, UNIPEDE, CBEMA or ITIC, for example. It should also be possible for the event signatures to be recorded and displayed graphically if desired.

Fast fault recording

When a limit value violation occurs, all analog and binary signals are recorded with a configurable resolution of 100 Hz to 30 kHz. The recording comprises separately configurable time windows for pre-fault, fault and post-fault periods. The fault recording duration can either be set to a fixed length or can be controlled by the actual duration of the event. These recordings make it possible to carry out comprehensive and detailed analyses of power system faults.

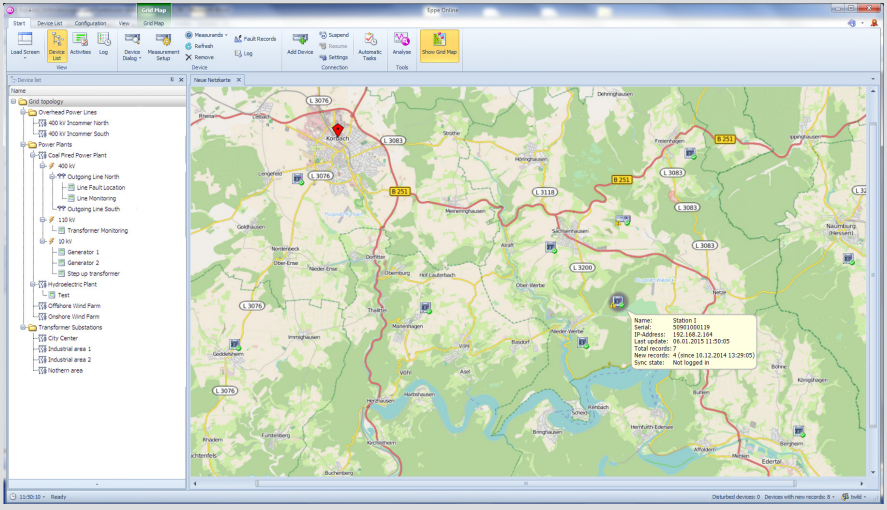

Fig. 4: Device management

Slow fault recording

In addition to the analog and digital signals which are measured directly, the RMS recorder can also record all the quantities calculated on the basis of these signals, such as frequency, unbalance, positive sequence system, negative sequence system and zero sequence system, active power, reactive power and apparent power, harmonics, etc. The sampling rate can be set between 1 Hz and double the system frequency. The recording is ideal for detecting and assessing slow processes, such as power swings, for generator monitoring or machinery start-ups.

Recording of digital events and states

Binary inputs are primarily used to read in signals from protection relays, circuit breaker positions or machine conditions, for example, which are of decisive importance for the analysis of fault records. The binary inputs can also be used to trigger fault records in order to obtain a high-resolution record of the state of the power system at the moment of switching.

Logical events

Logical links can be created with the analog and binary measurement signals. If conditions configured by the user are fulfilled, alarm signals can be sent via relay outputs or email. To avoid time delays, emails should be sent directly by the measuring device itself and not by a central data server. Using this function, it is possible to implement a very flexible monitoring system with the EPPE CX power quality analyser in conjunction with the sensor measuring module. The user is informed immediately if, for example, the module temperature in the case of PV plants, the wind speed in the case of wind power plants or the power consumption of machines is exceeded.

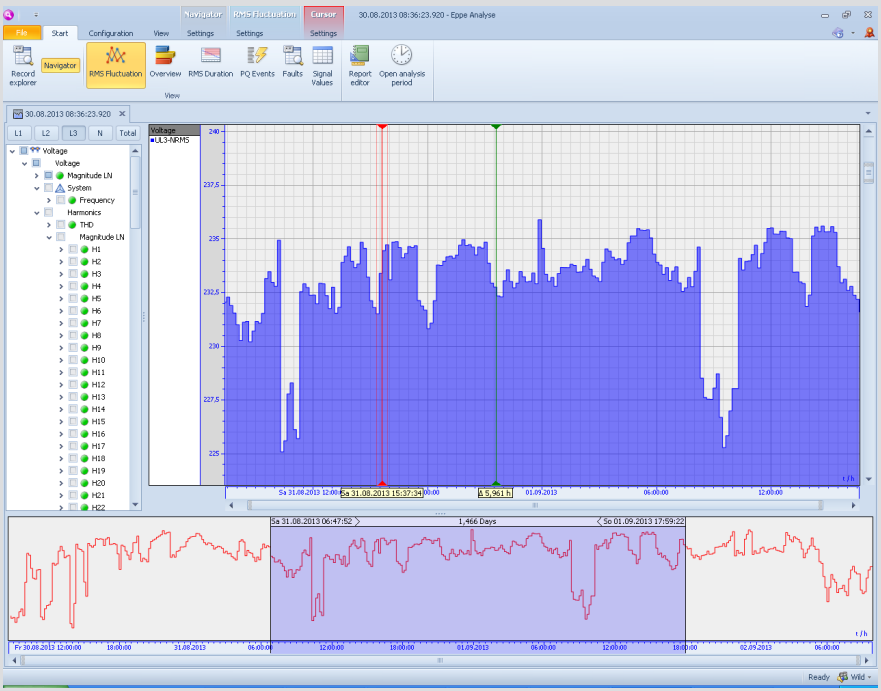

Fig. 5: Trend analysis

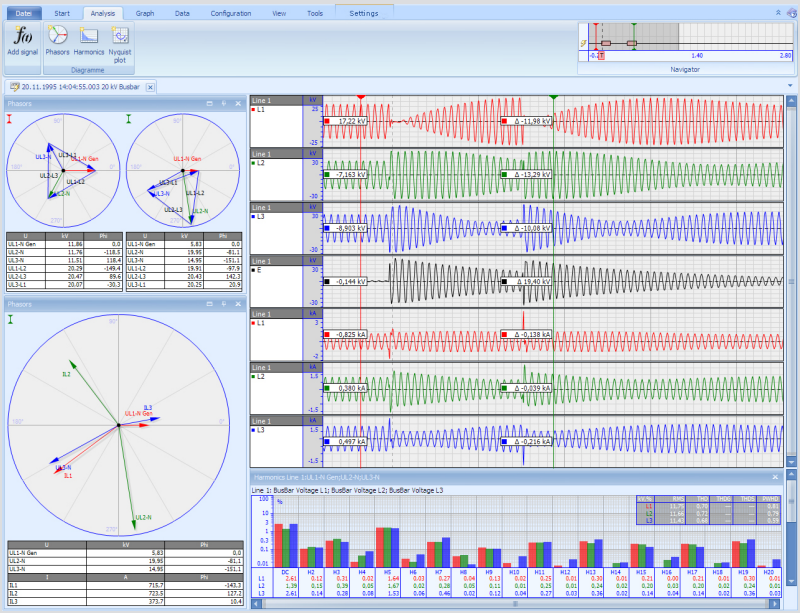

Fig. 6: Analysis of a fault record

Energy meter

In addition to measuring power quality, a built-in energy meter can also be used to monitor power consumption and optimise consumption with the aid of long-term trend analysis. It should be possible to record and precisely analyse active, reactive and apparent energy. Depending on the measurement task, a detailed 4 quadrant measurement is required.

Software

The software designed for the measuring device should offer a wide variety of possibilities, ranging from the operation of an individual measuring device up to the administration of complex groups of measuring devices. As mentioned previously, the time available to the user is often very limited. For this reason the software should be geared to meet real-world requirements and be easy to operate. The user must be able to carry out a measurement in accordance with a specific standard (e.g. EN 50160) without spending a lot of time getting used to the software or having to attend a special training course. However, the software should feature the option of managing and configuring comprehensive measurements with complex groups of measuring devices and should be able to comprehensively analyse the measurement results. A number of tools for analysing data are provided which simplify the evaluation.

The software developed by KoCoS Messtechnik AG is a good solution for meeting the abovementioned requirements. All the versions of the software are very easy to use and feature a variety of functions, including the following:

- Flexible configuration for optimum adaptation to a wide range of measurement tasks
- Remote configuration/administration
- Fully automatic operation of the measuring system with:
  - Long-distance data transmission
  - Archiving of records in a database
  - Printout or dispatch of fault reports or PQ reports
  - Export in common PQ and fault record formats
  - Online monitoring

- Import and export functions enable data to be exchanged between different systems using standard file formats such as PQDIF, COMTRADE, CSV and XML(Nequal)
- Easy-to-use analysis tool with automatic evaluation and assessment of power quality to international standards (e.g. EN 50160)
- Multi-screen capability (optimum overview, a wealth of information at a glance)

Device management

The status information for all the devices connected to the software is displayed in a clearly structured device list, device settings can be changed quickly and easily. In addition, graphical device management allows measuring devices and their status information to be displayed in a map or a circuit diagram, for example. This provides the user with an optimum overview of all measurements, even in comprehensive monitoring systems.

Evaluation of measurement data

Power systems and power quality analysis can be carried out automatically to the selected standard (e.g. EN 50160). A number of analysis tools are provided for this purpose. The software also includes a comprehensive range of powerful analysis tools for the assessment of fault records.

Examples:

- Slow changes with trend analysis
- Event recording with signature display
- Flicker analysis
- Harmonic analysis
- Analysis of interharmonics
- Event classification and assessment (UNIPEDE, ITIC, etc.)
- Graphical display of extreme value duration distribution
- Table overview of limit value violations
- User-defined limit value and analysis settings
- Automatic generation of weekly, monthly, quarterly and annual reports
- Calculation and signal display of differential current measurements
- Useful zoom functions and variable scaling
- Superimposition of different signal characteristics
- Formulary and editor for the calculation of further power system quantities
- Vector displays
- Individual report creation using the clipboard
- Automatic report creation

Conclusions

In order to cope with the variety of measurement tasks faced in practice, modern measuring systems must offer a broad range of functions and a high degree of flexibility. However, users need measuring systems which can be operated easily and intuitively. They need to be able to carry out measurements in accordance with pre-defined standards (e.g. EN 50160) and export the measurement results in a clearly structured form, such as a report, without having specialist knowledge. At the same time, users with expert knowledge want to be able to carry out complex measurements followed by highly detailed analyses. But even the best measuring system is useless without user-friendly software which is technically mature. This surely gives visionary manufacturers the edge over the competition.

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