Product note

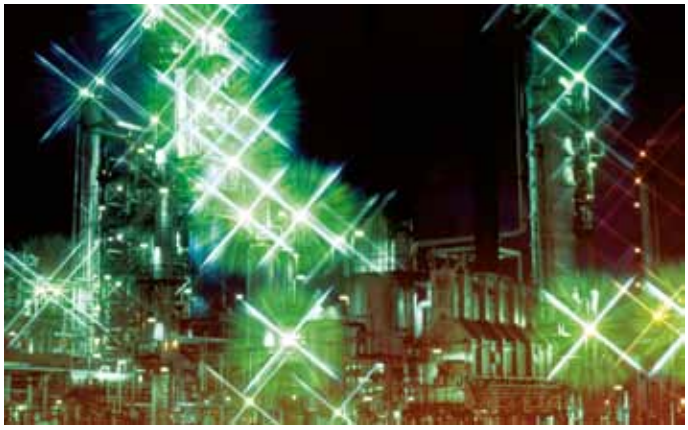
SACE Emax 2 as a network analyzer
Beyond the traditional current & voltage measurements

Emax 2, the new Circuit Breaker for Low Voltage applications by ABB, offers for the first time a Network Analyzer function that is in alignment with IEC 61000-4-30 and IEEE's 1250; *Guide for Identifying and Improving Voltage Quality in Power Systems*.
The Network Analyzer is a function of its Ekip Hi-Touch embedded trip unit and the control of several important indicators:

- Average Voltage value
- Short Voltage interruptions and spikes
- Slow Voltage sags and swells
- Voltage unbalance
- Harmonic analysis

Applications

Voltage is the input of every electrical appliance: countless travelers face this point every year, for example, when travelling from 230V/50 Hz countries to 120V/60 Hz ones.
Electrical equipment is designed for optimum operation under a smooth, constant voltage level, as close as possible to the rated value. In addition, industrial equipment, working on three-phase supply, requires the three phase voltage levels to be equal (balanced).
Power quality is a description of how well a power system complies to the above ideal conditions. Deviations, i.e. power quality issues, can have negative consequences on the components and on the energy efficiency of the network as a whole.
Power quality monitoring is thus becoming more and more important with modern power systems, and will be a key part of the smart grid of the future.



In detail, power quality evaluation includes the following aspects:

- Deviations of voltage average value from the rated value
- Short decreases (sags) or increases (swells) of voltage value
- Voltage unbalance, i.e., difference in voltage values between different phases
- Presence of voltage harmonics.

Distortions of voltage value (sags, swells) and/or frequency can have fatal consequences, especially for process industries: possible stoppage of production with consequent expensive downtime, damages to motor drives and damages to PLCs are just some examples.
Examples of process industries that can be badly hit by voltage instabilities include plastics, petrochemicals, textiles, paper, semiconductor, and glass.
Voltage sag is defined as the case when the value of the voltage is reduced below the rated one for a certain amount of time. Similarly, voltage swell is defined as the case when the voltage is increased above the rated value for a certain amount of time.
RMS value and frequency of the voltage are two fundamental features of a voltage signal, but the "pureness" of the voltage waveform is also an important point.
An ideal voltage waveform should be a perfect sinusoid, but this is not something that is normally seen in the real world. Frequencies other than the fundamental one are always present. These frequencies are called harmonics: a harmonic of a signal is a component frequency of the wave spectrum that is a multiple of the fundamental frequency.
Harmonic content is an issue that is becoming increasingly debated: technological developments in the industrial and household field have led to the spread of electronic equipment which, due to their operating principle, absorb a non-sinusoidal current (non-linear load). Such current causes a voltage drop of non-sinusoidal type on the supply side of the network with the consequence that the linear loads are also supplied by a distorted voltage.

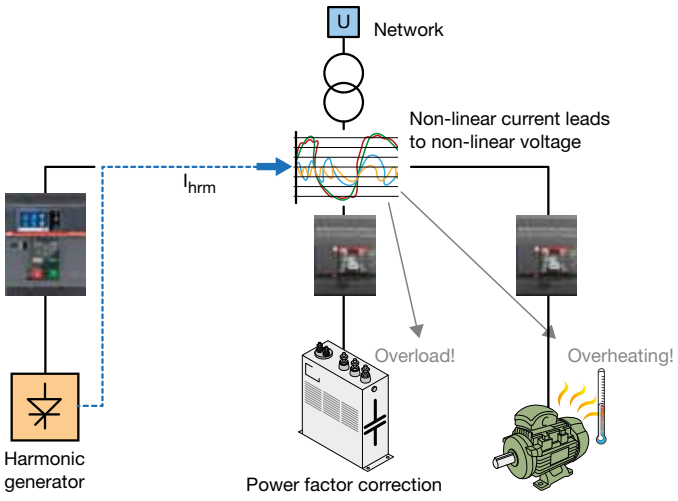


Figure 1: Power electronics produces harmonic content (Ihrm) that can affect other loads in the plant: the result can be an overheating of the asynchronous motor and an overload (that could lead to a trip of the protecting MCCB) on the power factor correction capacitors

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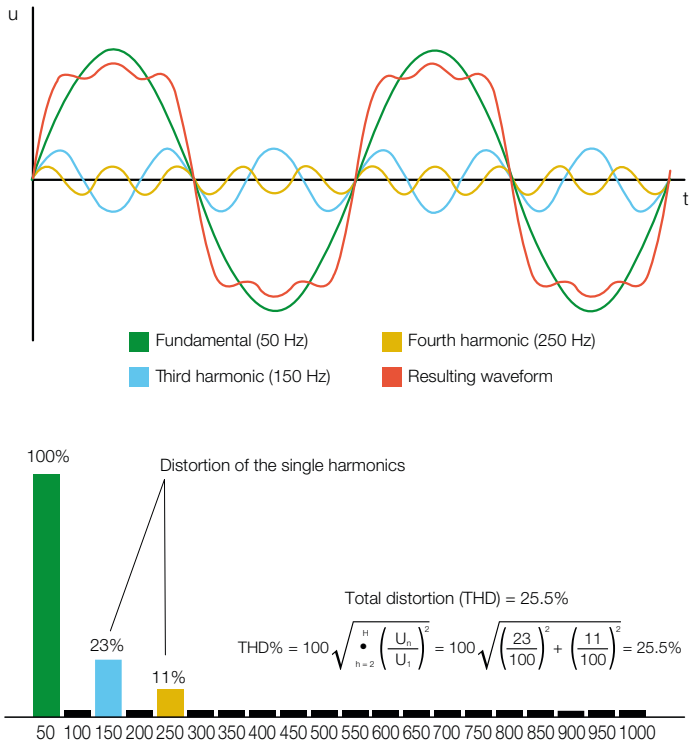
To get information about the harmonic content of voltage and current waveforms and to take measures if such values are high, a dedicated index has been defined. The total harmonic distortion, or THD, of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.

Figure 2: The effects of harmonic distortion and relevant THD



The presence of harmonics in the electrical network may be the cause of equipment malfunctions, such as overloading of the neutral conductor, an increase of losses in the transformers, disturbances in the torque of motors, etc…
In particular, harmonics are the phenomenon that most heavily power factor correction capacitors.
Voltage quality, as described above, is the backbone of the famous and comprehensive expression “Power Quality” (PQ). Standards have been issued that mandate certain PQ requirements. Different standards may be applicable to different kinds of installation. For power distribution, the most widely used standards are EN50160 in the IEC world and IEEE 1250 in the UL world.
A more specific example is the ITI (formerly known as “CBEMA”) curve, which summarizes voltage sags and swells that data processing equipment can tolerate.

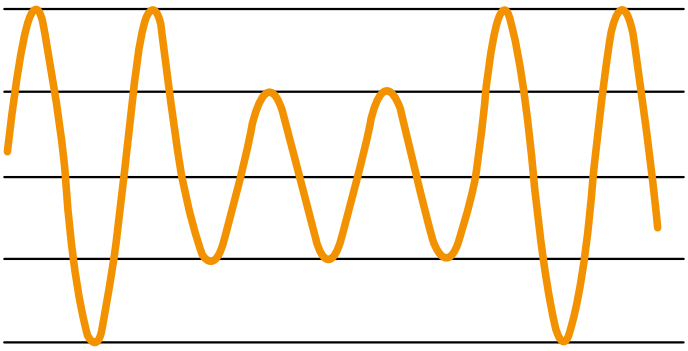
The most common Power Quality problem: voltage sag

Voltage sags are the most important power quality problem faced by several process industries.

Single line-to-ground faults (lack of insulation or short-circuit between one phase and ground) on the utility system are a common cause of voltage sags. These kinds of faults are often caused by lightning, ice storms, tree limbs and wild animals (squirrels). The voltage on the faulted phase goes to zero at the fault location; the voltage drop on loads present in the area will depend on the location of the fault. The voltage sag condition will last until the fault is cleared by a protective device (fuse, breakers).

Another common cause is the start-up of large loads, inside or outside the facility.

Figure 3: Example of voltage sag



The first step towards better Power Quality: Measurement

A Power Quality monitor is the most commonly used tool for detecting voltage sags and Power Quality issues. Measurement is the first step for checking the status of the installation and starting the root cause analysis.

Power Quality measurements and related instrumentation are described in specific industrial standards such as the IEC61000-4-30 and IEEE 1250.

For the first time, thanks to the Ekip HI-Touch trip unit of Emax 2, the new air circuit breaker for IEC 60947 and power circuit breaker for UL 1066, the power quality monitor is embedded in the main low voltage breaker.

The ***Network Analyzer*** function allows the user to set controls on voltage in order to analyze the operation of the system: any time a control parameter overcomes the preset threshold, an alarm is generated. The accuracy of voltage measurements of Emax 2 is excellent at 0.5%.

Emax 2 ***Network Analyzer*** is compliant to IEEE 1250-2011, Section 3 for the monitoring of voltage value, unbalance and harmonic content,which is the equivalent of IEC61000-4-30 Class S for voltage value and unbalance and Class B for harmonic content.

Table 1: Available power quality monitoring functions embedded in Emax 2

Network Analyzer
Hourly average voltage value
Short voltage interruption
Short voltage spikes
Slow voltage sags and swells
Voltage unbalance
Harmonic analysis

Referring to the voltage sag ambit, as an example, the ***Network Analyzer*** function gives the possibility of controlling three kinds of sag classes, defined by the user:

Table 2: Voltage sags parameters

Parameter	Description
Sag Threshold (First Class)	Defines the first alarm threshold. It is expressed as % Un.
Sag Times (First Class)	In the event of dropping under the first alarm threshold, it defines the time beyond which the alarm counter is increased.
Sag Threshold (Second Class)	It defines the second alarm thresold. It is expressed as % Un.
Sag Times (Second Class)	In the event of dropping under the second alarm threshold, it defines the time beyond which the alarm counter is increased.
Sag Threshold (Third Class)	Defines the third threshold. It is expressed as % Un.
Sag Times (Third Class)	In the event of dropping under the third alarm threshold, it defines the time beyond which the alarm counter increased.

Two different types of counters for each power quality monitoring function are made available directly on the trip unit touch screen: one is a cumulative counter , that stores all the alarms (for example, all the voltage sags) since the beginning, and one is a 24H counter, that shows the alarms in the last 24 hours.
With the optional communication module (Modbus, Profibus, Profinet, etc…) eight counters for each power quality monitoring function are available: one is the cumulative and the other seven are the daily counters of the last 7 days of activity.

Conclusion

Using Emax 2 with Ekip Hi-Touch trip unit as a power quality monitor is a very interesting option, just considering:

-The ease of use: the power quality functions are already programmed inside the trip unit

-The wide choice of communication protocols: information about power quality can be transmitted via several protocols, embedded in the Ekip trip unit

-The cost-effectiveness: voltage sensors are already embedded inside the Air Circuit Breaker: no additional voltage transformers have to be purchased, and no wiring is required.

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