STEK PQA 18 Power Quality Clamp Meter

STEK PQA 18 has ***Automatic AC/DC detection***,is IP54 protection. The large backlit 10,000-count triple display makes it easy to read in all circumstances. The fact that each rotary-switch position corresponds to a single function means that it is simple to use.

With its 60 mm clamping diameter and current measurements up to 3000A, It is ideal for low-voltage electrical power distribution and transmission applications. Equipped with a fast 12-bit TRMS digital acquisition system, PQA18 clamps offer particularly accurate measurements. Due to their large bandwidth and high crest factor, these clamps guarantee accurate measurements whatever the type of signal.

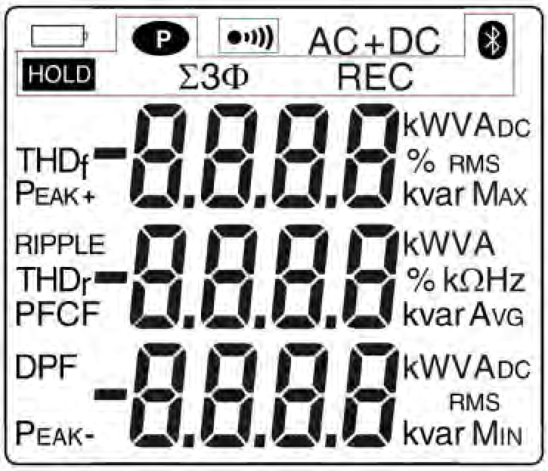
Features / Specifications:

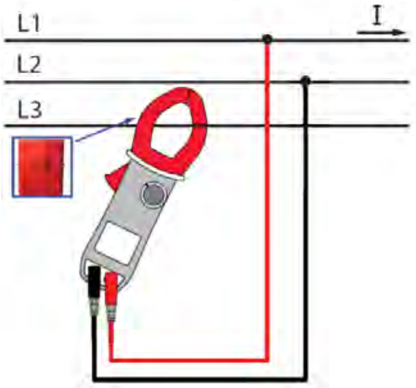
- Power and energy measurements
- Decomposition of harmonic orders
- Measurement recorder Min, Max and Peak±
- TrueInrush current measurement
- Data recording
- *Bluetooth interface and PC software*
- 10,000-count triple display
- Current: 2,000 AAC/ 3,000 ADC
- AC and DC voltage up to 1,000 V
- Power values: W/VA/var, PF & DPF
- Harmonics up to the 25th order, THD-f & THD-r
- Ripple function
- Resistance and audible continuity
- AC and DC measurements

CATIV
1000V

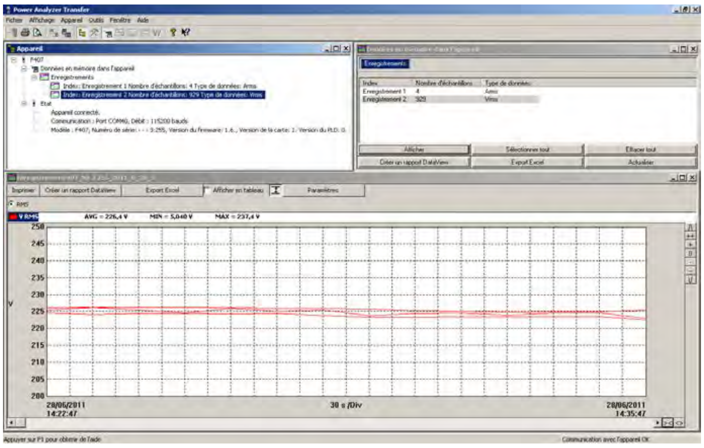
IP54

Android/Apple Application Bluetooth Communications





Graphical Data Representation



F407
Données en mémoire dans l'appareil
Enregistrements
Index: Enregistrement 1 Nombre d'échantillons: 4 Type de données: Arms
Index: Enregistrement 2 Nombre d'échantillons: 929 Type de données: Vrms
Etat
Appareil connecté.
Communication : Port COM6, Débit : 115200 bauds
Modèle : F407, Numéro de série : - - - 3:255, Version du firmware: 1.6., Version de la carte: 1. Version du PLD: 0.

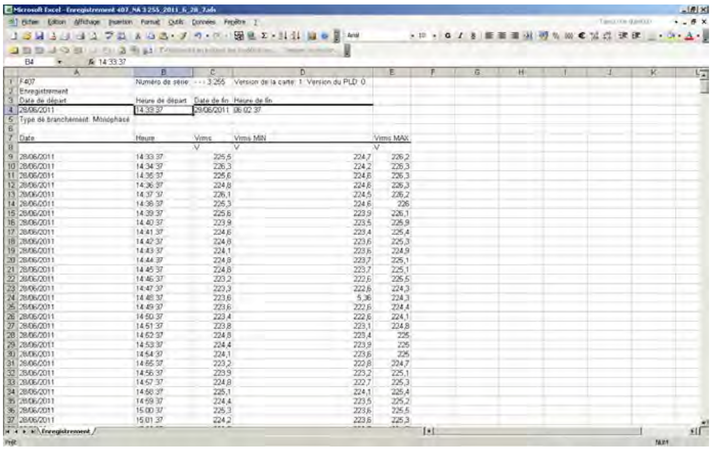
Index	Nombre d'échantillons	Type de données
Enregistrement 1	4	Arms
Enregistrement 2	929	Vrms

AVG = 226,4 V MIN = 5,040 V MAX = 237,4 V

28/06/2011 14:22:47
28/06/2011 14:35:47

Appuyer sur F1 pour obtenir de l'aide
Communication avec l'appareil OK

Export Data with Date & Time Stamping to Excel



	A	B	C	D	E
1	F407	Numéro de série	- - - 3:255	Version de la carte: 1 Version du PLD: 0	
2	Enregistrement				
3	Date de départ	Heure de départ	Date de fin	Heure de fin	
4	28/06/2011	14:33:37	29/06/2011	06:02:37	
5	Type de branchement: Monophasé				
6					
7	Date	Heure	Vrms	Vrms MIN	Vrms MAX
8			V	V	V
9	28/06/2011	14:33:37	225,5	224,7	226,2
10	28/06/2011	14:34:37	226,3	224,2	226,3
11	28/06/2011	14:35:37	225,6	224,8	226,3
12	28/06/2011	14:36:37	224,8	224,6	226,3
13	28/06/2011	14:37:37	226,1	224,5	226,2
14	28/06/2011	14:38:37	225,3	224,6	226
15	28/06/2011	14:39:37	225,6	223,9	226,1
16	28/06/2011	14:40:37	223,9	223,5	225,9
17	28/06/2011	14:41:37	224,6	223,4	225,4
18	28/06/2011	14:42:37	224,8	223,6	225,3
19	28/06/2011	14:43:37	224,1	223,6	224,9
20	28/06/2011	14:44:37	224,8	223,7	225,1
21	28/06/2011	14:45:37	224,8	223,7	225,1
22	28/06/2011	14:46:37	223,2	222,6	225,5
23	28/06/2011	14:47:37	223,3	222,6	224,3
24	28/06/2011	14:48:37	223,6	5,36	224,3
25	28/06/2011	14:49:37	223,6	222,6	224,4
26	28/06/2011	14:50:37	223,4	222,6	224,1
27	28/06/2011	14:51:37	223,8	223,1	224,8
28	28/06/2011	14:52:37	224,8	223,4	225
29	28/06/2011	14:53:37	224,4	223,9	225
30	28/06/2011	14:54:37	224,1	223,6	225
31	28/06/2011	14:55:37	223,2	222,8	224,7
32	28/06/2011	14:56:37	223,9	223,2	225,1
33	28/06/2011	14:57:37	224,8	222,7	225,3
34	28/06/2011	14:58:37	225,1	224,1	225,4
35	28/06/2011	14:59:37	224,4	223,5	225,2
36	28/06/2011	15:00:37	225,3	223,6	225,5
37	28/06/2011	15:01:37	224,2	223,6	225,3

STEK PQA 18 Power Quality Clamp Meter

PQA 18 Basic Specifications	
Ø Clamping diameter	60 mm
Display	Backlit LCD
Resolution	10,000 counts
Number of values displayed	Three
Type of acquisition	TRMS [AC, AC+DC] / DC
Autorange	Yes
Automatic AC / DC detection	Yes
A AC	0.25 A to 2,000 A (3,000 A peak); Frequency Response: 50/60/400Hz
A DC	0.25 A to 2000 A (3,000 A peak)
A AC+DC	0.25 A to 2000 A (3,000 A peak)
Best accuracy	1% of reading + 3 counts
V AC	0.15 V to 1,000 V (1,400 V peak); Frequency Response 50/60/400Hz
V DC	0.15 V to 1,000 V
V AC+DC	0.15 V to 1,000 V (1,400 V peak)
Accuracy	1% of reading + 3 counts
Hz	Current: 5.0 Hz to 1,000 Hz Voltage: 5.0 Hz to 20.00 kHz
Ohm	0.1 Ω to 99.99 kΩ
Open-circuit voltage	≤ 3.6 V
Measurement current	≤ 550 µA
Audible continuity	Yes
Continuity threshold	40 Ω
Single-phase and total three-phase power values	
Active power values	1 W to 2,000 kW
Reactive power values	1 VAR to 2,000 KVAR
Apparent power values	1 VA to 2 000 kVA
Power Factor(PF) / Differential Power Factor (DPF)	Yes / Yes
Harmonic Analysis	
THD(fundamental) / THD(RMS)	Yes / Yes
Frequential analysis	25th order
Function & Features	
True InRush (measurement of over currents)	YES
Motor start up	YES
Load evolution	YES
Hold	YES
Min / Max	YES
Peak+ / Peak-	YES
Data recording	YES
Communication interface	BLUETOOTH
Ingress protection	IP54
Electrical safety as per IEC 61010	CAT1V 1000 V
Power supply	4 x 1.5 V AA batteries
Dimensions & weight	111 x 296 x 41 mm / 640 g

Measurement of electrical power

Instantaneous, mean, active, reactive and apparent electrical power, power factor, etc.
We would like to remind you about these basic parameters in electronics and about three-phase measurement methods.

Definition of electrical power

At a given moment, when a current **i** travels from generator **G** to receiver **R** in the direction defined by the voltage **v** delivered by the generator *(figure 1)*, the **instantaneous power** supplied to the receiver R is equal to **product v·i.**

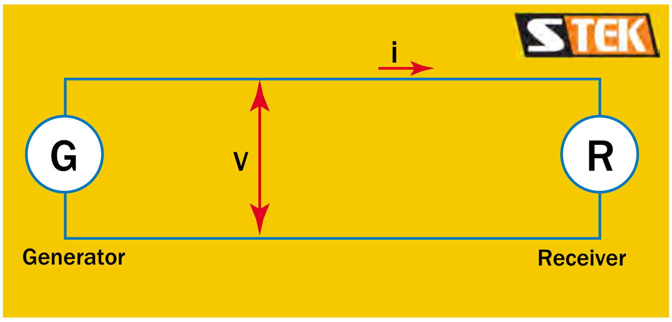


figure 1

If the voltage and current are DC, the mean power V·I is equal to the instantaneous power v·i.
If the voltage and current are **sinusoidal AC**, there is generally a **phase shift** φ between the voltage and the current *(figure 2)*.
The **instantaneous values** of voltage **v** and current **i** have the form:
$\mathbf{v = V_{max} \cos \omega t}$
$\mathbf{i = I_{max} \cos (\omega t - \varphi)}$
Where ω, the pulse, is proportional to the frequency F ($\omega = 2\pi F$).

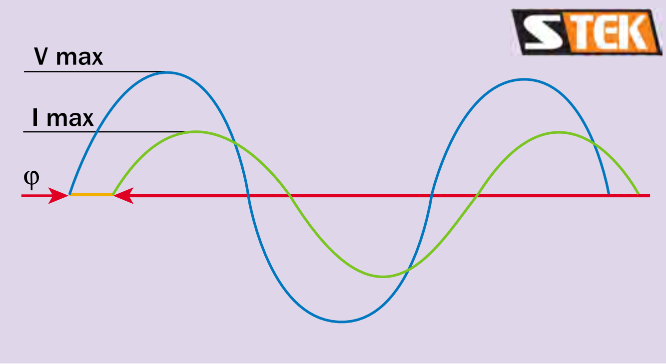


figure 2

The **phase shift** φ is, conventionally, counted as positive when the current is delayed in relation to the voltage.

The **instantaneous power** has a value of: $\mathbf{V_{max} \cdot I_{max} \cdot \cos \omega \cdot \cos (\omega t - \varphi)}$.
You must take the average value of this product during a period to obtain the expression of the power provided by generator G to receiver R. This power is called the **active power** and is expressed by the formula:

$$P = \frac{V_{max} \cdot I_{max}}{\sqrt{2}} \cos \varphi = V_{eff} \cdot I_{eff} \cdot \cos \varphi$$

The **wattmeters** provide the expression of this product, either by causing a deviation of the pointer in the case of a device with an electrodynamic or ferrodynamic moving coil, or by supplying a DC current or a voltage proportional to the product in the case of electronic wattmeters; this current or this voltage is then applied to an analogue or digital display.

The existence of a phase shift φ between the current and the voltage leads, for AC currents, to the introduction of 3 additional quantities:

- **The apparent power** $\mathbf{S = V_{eff} \cdot I_{eff}}$, in VA (volt-amperes), defining the voltage V_{eff} not to be exceeded (insulator breakdown, increase in core loss) and the intensity I_{eff} circulating in the receivers.

- **The power factor:**
  $$\cos \varphi = \frac{P}{S} = \frac{P}{V_{eff} \cdot I_{eff}}$$
  when the current and voltage are sinusoidal quantities.

- **The reactive power** $\mathbf{Q = V_{eff} \cdot I_{eff} \cdot \sin \varphi}$, in rva (reactive volt-amperes). The latter may be directly measured by a wattmeter if for voltage $V_{max} \cdot \cos \omega t$ we substitute a phase-shifted voltage of $\pi/2$, i.e. $V_{max} \times \cos (\omega t - \pi/2)$.

The mean product measured will be

$V_{max} \cdot I_{max} \cdot \cos (\omega t - \pi/2) \times \cos (\omega t - \varphi)$ which is expressed by:

$$Q = \frac{V_{max} \cdot I_{max}}{\sqrt{2}} \cos (\pi/2 - \varphi) = V_{eff} \cdot I_{eff} \cdot \sin \varphi$$

Knowing P and Q, we can calculate the apparent power and the power factor:

Apparent power: $\mathbf{S = \sqrt{P^2+Q^2}}$

Power factor: $\mathbf{PF = P/S = P/\sqrt{P^2+Q^2}}$

Knowing the parameters defined above: active power, reactive power, apparent power, power factor, is fundamental in electrical engineering and enables accurate calculation of the characteristics of the equipment used: yield, load, cos φ, utilisation limits. The wattmeters used for these measurements are classified in three major families: electrodynamic, ferrodynamic and electronic.

Measurement of active power

4-wire balanced three-phase measurement (3 phases + neutral)

The intensities circulating in the three phases are equal in terms of rms values $I_1 = I_2 = I_3$ and show the same phase shift φ in relation to the respective voltages of the 3 phases.

If U_{1N} is the simple voltage measured between phase 1 and neutral, power P_1 supplied by phase 1 will be obtained by connecting a wattmeter as shown in figure 3.

Its value will be: $\mathbf{P_1 = U_{1N} \cdot I_1 \cdot \cos \varphi}$
The total power supplied P will be equal to 3 P_1.

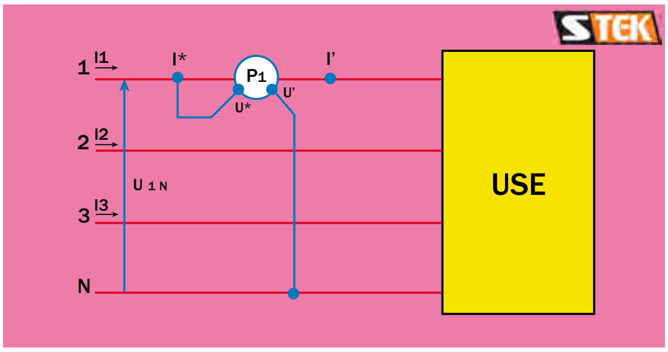


figure 3

Note: The expression $P_1 = U_{1N} \cdot I_1 \cdot \cos\varphi$ in the scalar product of the 2 vectors $\vec{U}_{1N}$ and $\vec{I}_1$ which enables use of the notation

$P_1 = \vec{U}_{1N} \cdot \vec{I}_1$

and in three-phase:

$P = \vec{U}_{1N} \cdot \vec{I}_1 + \vec{U}_{2N} \cdot \vec{I}_2 + \vec{U}_{3N} \cdot \vec{I}_3$

Measurement in 3-wire balanced three-phase (3 phases no neutral)

The intensities circulating in the three phases are equal $I_1 = I_2 = I_3$.
An artificial neutral is created using three resistors R, R et R'. The sum R' + r must be equal to R (r is the resistance of the voltage circuit of the unit).

This returns us to the previous case with U_{1N} between phase 1 and the artificial neutral *(figure 4).*

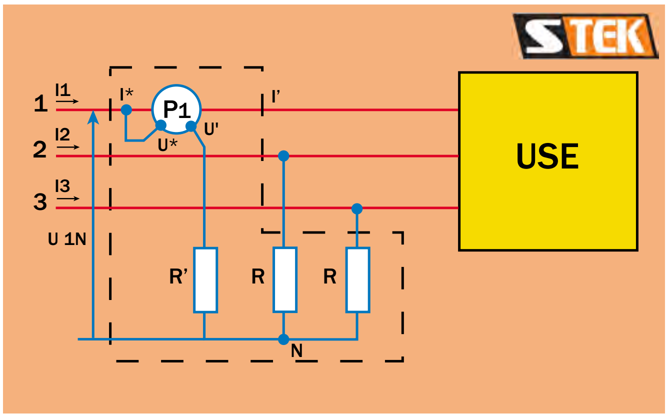


figure 4

P_1 = Power supplied on phase 1

Totale P supplied = $3\, U_{1N} \cdot I_1 \cdot \cos\varphi = 3P_1$.

With many wattmeters, the balanced three-phase measurements (3 phases no neutral) are performed directly; the artificial neutral point recreated by the resistors R, R and R' is included in the instrument (astatic wattmeter, CdA 778 wattmeter, for example). This design is shown in the diagram by the dotted section.

Measurement in 3-wire unbalanced three-phase (3 phases no neutral) - method using two wattmeters.

Whether the circuit is **balanced** or **not in the absence of a neutral, there remains $I_1 + I_2 + I_3 = 0$.**

In this case, the general expression of the power given above is simplified

$$P = (\vec{U}_{1N} - \vec{U}_{3N} \cdot \vec{I}_1 + (\vec{U}_{2N} - \vec{U}_{3N}) \cdot \vec{I}_2$$

so $P = \vec{U}_{13} \cdot \vec{I}_1 + \vec{U}_{23} \cdot \vec{I}_2$

and the measurement of the total power may be carried out using two wattmeters *(figure 5).*

U_{13} and U_{23} are the phase-to-phase voltages measured respectively between phase 1 and phase 3 and then between phase 2 and phase 3.

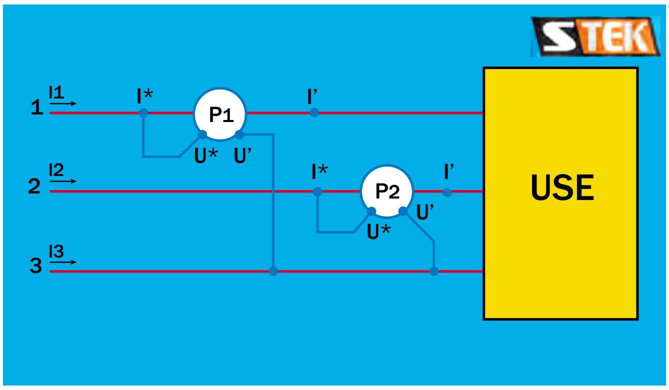


figure 5

Two cases may arise:

a) $P_1 \geq 0$ and $P_2 \geq 0$, then $P_{total} = P_1 + P_2$

b) one wattmeter deviates to the right and the other is as far as it will go to the left. To read the second; transfer the feed wires to the voltage circuit: U*·U' becomes U'·U*.
The value will be considered negative and we will obtain: $P_{total} = P_1 - P_2$

If it is a digital wattmeter we will add together the algebraic values displayed.

Note: it is possible to use a single wattmeter successively connected to 2 positions, using an inverter switch. This type of switch contains auxiliary contacts ensuring short-circuiting of the unused contacts.

Measurement in 4-wire balanced three-phase (3 phases + neutral)

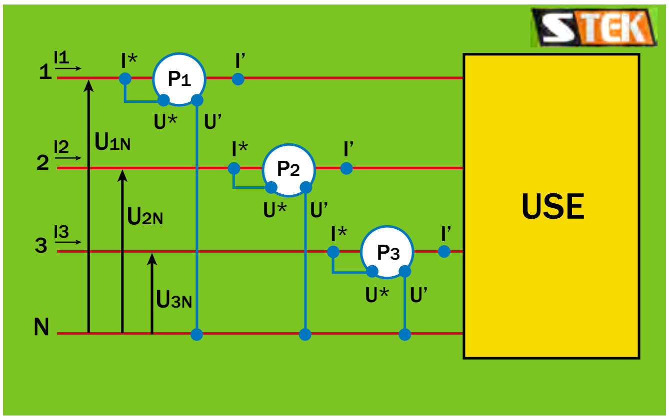


figure 6

We obtain $P_{total} = P_1 + P_2 + P_3$ *(figure 6).*

In this case, we must use 3 wattmeters and add the readings together. If the measurement is stable, we can successively carry out 3 measurements with a single wattmeter. Caution: it is recommended to use a system preventing the intensity circuits from being cut off during switching.

Correctly Sizing Electrical Installations

True*InRush*

To measure all the overcurrents, a single solution: the True*InRush* function

Industry

Factory

Maintenance

The Situation

When an installation or machine is started up or used intensively, it usually causes a significant variation of the current in the electricity supply circuit.

- When it starts up, a motor may require several times the full-load current. This starting current is called the Inrush.
- A transformer is another device which may cause overloads on its own. When a transformer is powered up, there is an Inrush current of approximately 25 times the rated current for approximately 10 ms.
- Electronically-controlled power supplies are a source of overcurrents caused by the capacitors used to store energy.
- The same principle is used in many mass-consumer electronic appliances by means of a switching power supply. These devices may cause very strong current surges which may sometimes lead to a spark when they are powered up.

As a result, electricians often have difficulty determining the right sizing of electrical installations in terms of both the conductors and the protective systems used.

- It becomes more complex to choose the overcurrent protection systems, such as fuses and circuit-breakers when high Inrush currents have to be tolerated.
- The overcurrent protection must react quickly to any overload or short-circuit, but must not trip in the event of a high overcurrent resulting from normal use rather than from a fault.

The Chauvin Arnoux solution: **integration of the True*InRush* function in all the clamps in the F200, F400 and F600 Series.**

The TrueInRush Function

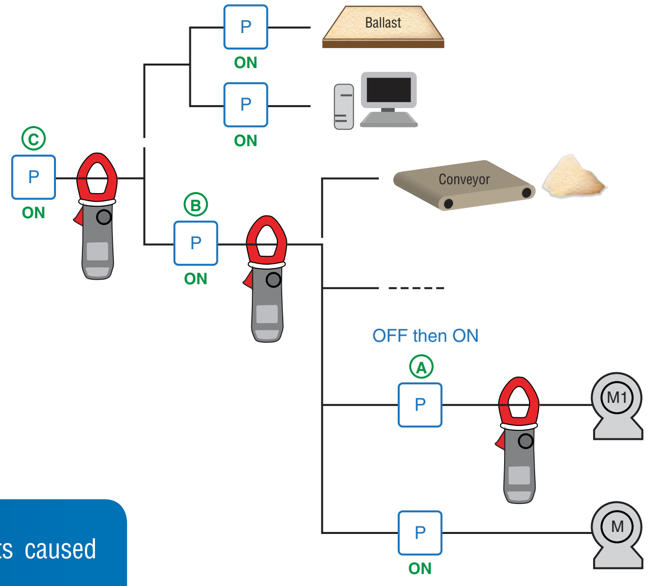
TrueInRush

Diagram of an installation in normal operation

When the motor M1 starts up:

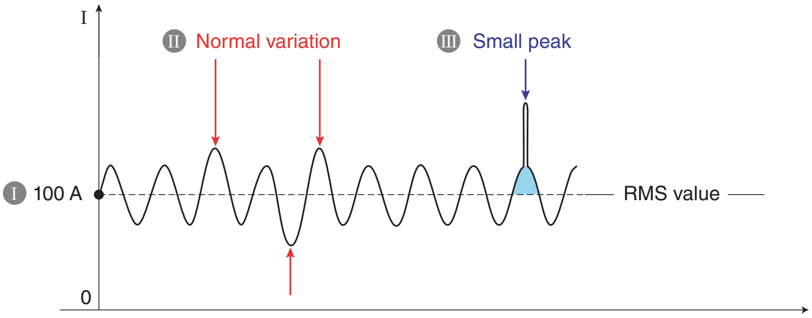
- protection Ⓐ may be activated and may be tripped
- protection Ⓑ may or may not be activated
- protection Ⓒ may or may not be activated

To prevent tripping of protections Ⓑ and Ⓒ, it is not enough simply to find out the Inrush current of motor M1.

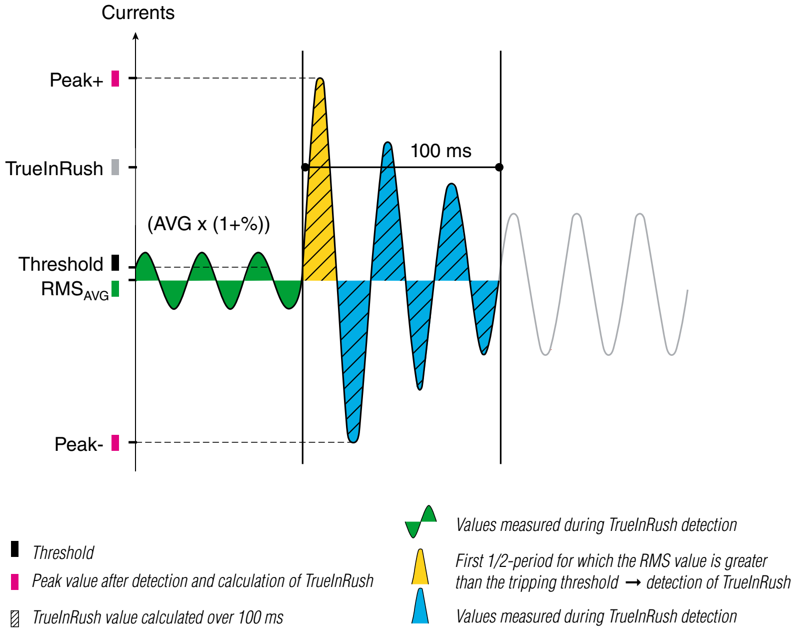


> Most products on the market can only measure the Inrush currents caused by powering up an installation or machine.
> **Only the TrueInrush function allows you to capture an overcurrent on an installation in operation, as is the case with Ⓑ and Ⓒ.**

The TrueInRush function involves:



- Ⅰ Acquisition of the average steady-state current value on the installation
- Ⅱ Adjustment of the sensitivity to filter out the normal variations inherent to any installation in operation
- Ⅲ ½-period monitoring to include the energy and heat aspects when the protective systems are tripped and to exclude spurious peaks
- A TRMS measurement over a 100 ms period and the peak amplitudes of the overcurrent



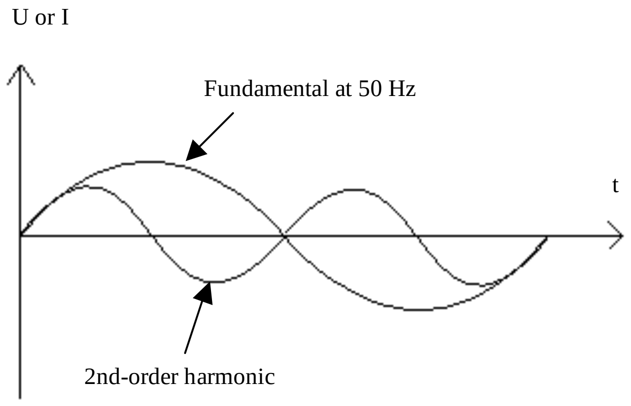
Harmonics Basis

In recent years, there has been a big increase in the number of non-linear loads connected to the electrical network: computers, fax machines, discharge lamps, arc furnaces, battery chargers, uninterruptible power supplies, electronic power supplies, etc.

The growing use of such equipment and the application of electronics to nearly all electrical loads are beginning to have worrying effects on the electricity supply system. A non-linear load draws considerable current from the network, but this current is distorted and can be broken down into harmonics. Harmonic currents have negative effects on almost all the components of the electrical system, by causing new dielectric, thermal and/or mechanical stresses.

What are harmonics?

From the electrical network, a non-linear load draws a distorted current which will modify the shape of the sinusoidal voltage. Non-linear loads generate harmonic currents which flow from the load towards the power supply, following the route with the lowest impedance. Harmonic currents are currents whose frequency is an integer multiple of the fundamental (fundamental of the power supply). Superimposition of the harmonic currents on the fundamental current causes the non-sinusoidal waveforms associated with non-linear loads.

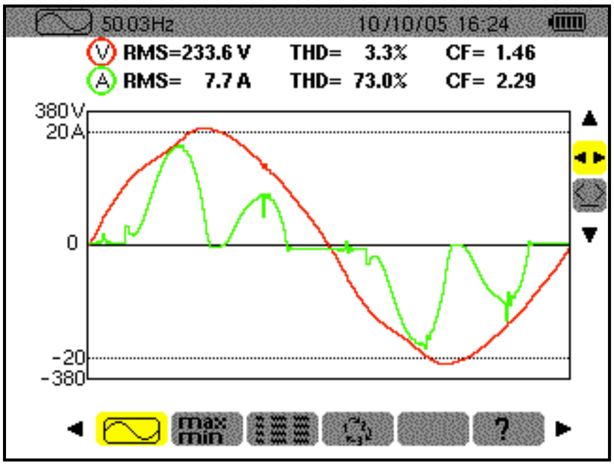


The curve above shows the original signal, with the fundamental at 50 Hz, along with its 2nd-order harmonic at 100 Hz.
The frequency of the 3rd-rank harmonic will thus be 3 times the frequency of the fundamental, i.e. 150 Hz.

Even or odd orders

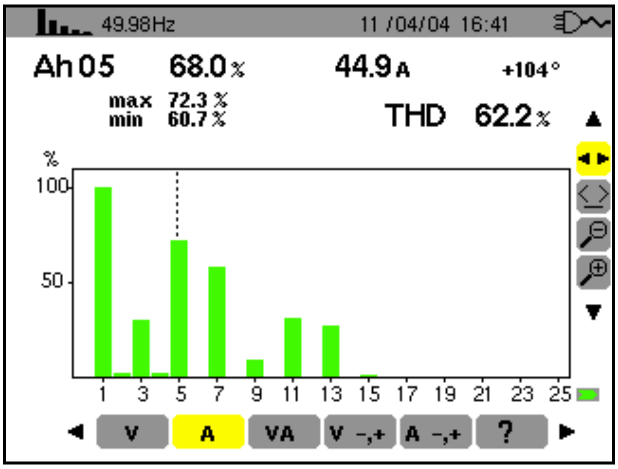
Harmonics are distinguished by their order, which may be even or odd. Even-order harmonics (2, 4, 6, 8…), which are often negligible in industrial environments, cancel one another out due to the symmetry of the signal. They only occur in the presence of a DC component.
Odd-order harmonics (3, 5, 7, 9…), however, are frequently encountered on the electrical network.

Harmonics higher than the 25th order are usually negligible.


50.03Hz 10/10/05 16:24
V RMS=233.6 V THD= 3.3% CF= 1.46
A RMS= 7.7 A THD= 73.0% CF= 2.29

On the screenshot above, the green curve corresponds to the sum of the harmonics present. The red curve shows a distorted network voltage signal. It is only clearly visible when the harmonic signal reaches high amplitudes, leading to a voltage drop.

It is possible to obtain a spectral representation of the harmonics by means of Fourier series decomposition.


49.98Hz 11 /04/04 16:41
Ah05 68.0% 44.9 A +104°
max 72.3 %
min 60.7 %
THD 62.2%

The harmonic spectrum above shows all the harmonics from the 1st order to the 25th.

Symptoms and consequences of harmonics

The presence of harmonics disturbs the other loads connected to the terminals of the same voltage source, even when they are linear. Indeed, these loads may no longer be supplied in conditions complying with the voltage references required.

Other possible consequences include:

- Heating of the neutral conductor: currents with triplen harmonics (3rd order and multiples of 3) are added together in the neutral conductor, leading to a neutral current which is often 120 to 130 % of the phase currents
- Untimely main circuit-breaker tripping due to overcurrents
- Untimely tripping of RCDs due to the frequencies of the harmonics, linked to the network's stray capacitances.
- Higher RMS current values than those required for the load's energy needs.
- Overheating of installations (transformers, cables, etc.) due to the skin effect
- Voltage resonance on a system composed of capacitors designed to raise the displacement power factor.

Are harmonics present or not?

The harmonic currents flowing through the impedances in the electrical system cause harmonic voltage drops, observed as harmonic distortion of the voltage. One of the solutions for detecting the presence of harmonics is calculation of the THD (total harmonic distortion). There are 2 sorts of THD: voltage THD (occurs at the source) and current THD (due to the loads). When the THD is equal to zero, it can be concluded that there are no harmonics on the network.

This THD value corresponds to the ratio between the true root-mean-square value of a signal's harmonics (U or I) and its root-mean-square value at the fundamental frequency (I_{rms1} in the example that follows).
For example, for an Nth-order harmonic, the **individual current distortion rate** per harmonic can be calculated as follows:

$$\tau_N = \frac{I_{rmsN}}{I_{rms1}}$$

To find out the total distortion of this signal, you must take into account all the harmonics present. There are 2 measurement methods: THD_f (total harmonic distortion in relation to the fundamental) and THD_r (total harmonic distortion in relation to the TRMS value of the signal).

The following equations are used to define these two THD values:

$$THD_F = \frac{\sqrt{\left(I_2{}^2 + I_3{}^2 + \ldots + I_n{}^2\right)}}{I_1}$$

$$THD_R = \frac{\sqrt{\left(I_0{}^2 + I_2{}^2 + \ldots + I_n{}^2\right)}}{\sqrt{\left(I_0{}^2 + I_1^2 + \ldots + I_n{}^2\right)}}$$

The 2 formulae can be used interchangeably. The only constraint is that the same formula must be used for the whole duration of a different measurement campaign.

One of the characteristics for identifying a distorted signal is its crest factor (Fc). For an undistorted sinusoidal signal, this corresponds to:

$$Fc = \frac{I_{\max}}{I_{rms}} = \sqrt{2} = 1.414$$

When the current is distorted, the crest factor is higher than this value.

Conclusion

Current harmonics cannot be eliminated: they are generated by the load!

They must therefore be confined to an area as close to the polluting loads as possible in order to prevent them from reaching the overall network. The main methods used involve installing a filtering or isolating system (transformers).

These methods will limit the deterioration of energy quality (dequalification of the source voltage) and other harmful effects.
Once the harmonics are "under control", the associated power losses disappear. All the power supplied by the network is then available for the other loads.
The power supplied by the network will therefore be optimized, thus reducing energy costs.

The IEC 61000-4-7 standard defines the methods for measuring harmonics.
The EN 50160 standard defines all the parameters to be tested in order to define electrical network distribution quality, particularly in terms of electrical disturbances.

Aviation Installations

Special focus on installations operating at 400 Hz

MAINTENANCE

In general, the **frequencies of industrial AC supplies** are usually either **50 Hz** (Europe, Asia, Africa) or **60 Hz**, as in North America. Some electrical applications, however, use a different fundamental frequency.

For example, **400 Hz** is used in **civil and military aviation.** Designed specially for such applications, the transformers and motors operating at 400 Hz are much more compact and lightweight than their 50 or 60 Hz equivalents.

At such frequencies, the current cannot be transmitted over long distances at low cost, so the use of 400 Hz supplies is usually restricted to vehicles or buildings for **economic** reasons.

The main advantages of 400 Hz equipment and motors are their compact size and light weight, which is why they are used in the aviation sector. Furthermore, 400 Hz applications usually have a power of few hundred kW with relatively low short-circuit currents which rarely reach 4 times the rated voltage.

- 400 Hz network
- Harmonics
- Electrical disturbances

Even at 400 Hz, there are still harmonics present...

The waveform of the current consumed by the loads hooked up to the electricity distribution network is often no longer purely sinusoidal. This current distortion leads to voltage distortion which also depends on the source impedance.
The **disturbances** called **harmonics** are caused by the use of non-linear loads on the network, such as equipment containing power electronics, switching power supplies, variable speed drives, etc. They may have immediate consequences on some electrical appliances: functional problems (synchronization, switching), untimely tripping, measurement errors on energy meters, etc. More seriously and more expensively, the additional heating which results may reduce the life span of rotating machines, capacitors, transformers and neutral conductors in the medium term. To avoid these problems, regular **preventive maintenance** is carried out.

At 400 Hz, some disturbances are amplified…

When an aircraft is parked at the stand, it is recharged either via a jetway or by a mobile generator set. When the power is supplied via a jetway fitted with a 400 Hz transducer upstream, new disturbances introduced by the earth bond may appear.
On a source with a fundamental frequency of 400 Hz, the harmonics will cause high earth leakage currents due to stray capacitances between a piece of equipment or conductor and the earth. They offer a possible route for the leakage currents whose effects may include untimely tripping of RCDs.

Overheating of cables carrying harmonic currents occurs even more quickly on all parts of the installation. As 400 Hz sources are usually low-power, the values of their harmonics are higher.

Although specific cables are available for these applications, harmonic filtering solutions must be implemented after taking the necessary **measurements.** These filters will be sized according to the harmonic frequencies encountered and their amplitudes.

How to perform the measurements

STEK PQA 18 Clamps can be used for installation maintenance on 50Hz, 60Hz, 400Hz and 800Hz electrical Networks. They are ideal for all the measurements need: power valuse, harmonics with harmonic decomposition, Min/Max Values, etc.,

PQA18 Screen
H3 Harmonic Measurement with a 400 Hz Fundamental Frequency