CHAUVIN ARNOUX
CHAUVIN ARNOUX GROUP

C.A 8335

Power & Quality Analyser

Recorder and analyser for measurements on electrical power networks

Technical Specifications

The QualistarPlus C.A 8335 is synonymous with simplicity, performance, versatility and powerful analysis.

It offers all the necessary functions with demanding specifications usually reserved for top-of-the-range laboratory instruments
This instrument is ideal for engineers and technicians seeking all the functions of an electrical network analyser in a portable, battery-powered instrument.

- Real-time display of wave forms (4 voltages and 4 currents)
- RMS voltage and currents per half-period
- Intuitive use
- Automatic recognition of the different types of current sensors
- Integration of all the DC components
- Measurement, calculation and display of the harmonics up to the 50th order, along with the phase information
- Calculation of Total Harmonic Distortion (THD)
- Capture of transients per sample (1/256th of a period)
- Display of phasor diagram
- Measurement of VA, W and var power values (total and per phase)
- Measurement of VAh, Wh and varh energy values (total and per phase)
- Calculation of the K-Factor
- Calculation of the cos φ displacement power factor (DPF) and the power factor (PF)
- Capture of up to 300 transients
- Flicker calculation
- Unbalance calculation (current and voltage)
- Monitoring of the electrical network with setting of alarms
- Back-up and recording of screenshots (image and data)
- Software for data recovery and real-time communication with a PC
- Recording and export onto PC

1. GENERAL SPECIFICATIONS

1.1. Casing

Casing:	Rigid moulded casing overmoulded with a yellow thermo-adhesive elastomer.
Connectors:	5 voltage measurement sockets.
	4 special current connectors (automatic recognition of clamp-on ammeters).
	A connector for the specific mains power supply.
	A connector for the USB link.
	A connector for the SD memory card. This is located in the compartment on the back of the C.A 8335, under the rechargeable batteries.
Keys:	For functions, navigation and mode changes. Designed to allow use with gloves.
Metal ring:	Located on the back of the C.A 8335. It can be used to attach the instrument with a padlock.
Stand:	To keep the instrument at an angle of 53° in relation to the horizontal.
Compartment:	For access to the rechargeable batteries at the rear of the instrument.
Dimensions:	Total: 200 x H 250 x P 67 Screen: 320 x 240 pixels W 118 mm x H 90 mm diagonal 148 mm
Weight:	1.950 g (with rechargeable batteries)

1.2. Power supply

1.2.1. Mains power supply

Type:	Specific external mains power supply: 600 V_{RMS} category IV – 1,000 V_{RMS} category III
Operating range:	230 V ± 10 % @ 50 Hz **and** 120 V ± 10 % @ 60 Hz
Max. power:	40 VA

1.2.2. Battery power supply

The C.A 8335 can be used without a mains power supply. The battery also allows the Qualistar+ to be used in the event of mains power cuts.

Battery:	8 rechargeable NiMH batteries
Capacity:	minimum 4,000 mAh
Rated voltage:	1.2 V per element, 9.6 V in total
Life span:	at least 500 recharge-discharge cycles
Recharge current:	1 A
Recharge time:	Approximately 5 hours
Operating T°:	[0 °C ; 50 °C]
Recharge T°	[10 °C ; 40 °C]
Storage T°:	Storage for ≤ 30 days: [-20 °C ; +50 °C]
	Storage for 30 to 90 days: [-20 °C ; +40 °C]
	Storage for 90 days to 1 year: [-20 °C; +30 °C]

1.2.3 Consumption

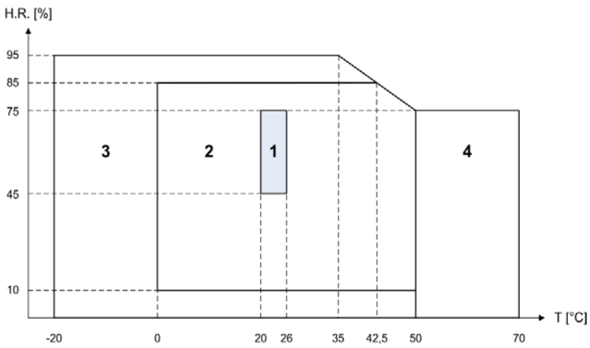
With 50% brightness:	300 mA
Standby mode without display:	100 mA

1.3 Operating range

1.3.1 Environmental conditions

1.3.1.1 Climatic conditions

The ambient temperature and humidity requirements are shown in the graph below:



1 = Range of reference
2 = Operating range

Caution: above 40 °C, the instrument must be used **EITHER** with the "battery only" **OR** with the "specific external mains power pack only" – use of the instrument with the battery **AND** the specific external mains power pack simultaneously is **prohibited**.

3 = Storage range with batteries
4 = Storage range without batteries

1.3.1.2 Altitude

Operation: [0 m ; 2 000 m]
Storage: [0 m ; 10 000 m]

1.3.2 Mechanical conditions

According to the IEC 61010-1 standard, the C.A 8335 is considered to be a **PORTABLE (HANDHELD) INSTRUMENT**.

- Operating position: any position.
- Position of reference in operation: on a horizontal surface, fitted on its stand or placed flat.
- Rigidity (IEC 61010-1): 30 N force applied to the whole of the instrument, with the instrument maintained in place (test carried out at 40 °C).
- Falls (IEC 61010-1): 1 m in the position supposed to be the most severe; the acceptance criterion for falls is: no permanent mechanical damage and no functional deterioration.
- Leakproofing: IP 50 as per NF EN 60529 A1 (electrical IP2X for the terminals).

1.3.3 Electromagnetic compatibility

1.3.3.1 Immunity according to NF EN 61326 - 1 A3

- Resistance to electrostatic discharges (as per IEC 61000-4-2)

Level 1	: Severity	: 4 kV in contact
	Acceptance	: CRITERION A
Level 2	: Severity	: 8 kV in the air
	Acceptance	: CRITERION A

- Resistance to radiated fields (as per IEC 61000-4-3 and IEC 61000-4-8)

  Severity: 10 $V.m^{-1}$
  Acceptance: CRITERION B (THD_A altered on the Rogowski line)

- Resistance to fast transients (as per IEC 61000-4-4)

  Severity:
  2 kV on the voltage inputs and on the power supply
  1 kV on the current inputs
  Acceptance: CRITERION A

- Resistance to electric shocks (as per IEC 61000-4-5)

  Severity:
  2 kV on the voltage inputs in differential mode
  1 kV on the voltage inputs in common mode
  Acceptance: CRITERION A

- Conducted RF disturbances (as per IEC 61000-4-6)

  Severity: 3 V on the voltage inputs and on the power supply
  Acceptance : CRITERION A

- Voltage interruption (as per IEC 61000-4-11)

  Severity: 100 % de perte sur une période de l'alimentation
  Acceptance: CRITERION A

1.3.3.2 Emissions according to NF EN 61326 - 1 A3

- Class A equipment (without power supply – mains power pack).
- Class B equipment (with power supply – mains power pack – power-pack lead is involved).

1.4 User safety

- Application of the safety rules in compliance with IEC 61010-1.
  (Insulation between voltage inputs by protective impedances).
- Pollution degree 2.
- Installation category IV*, operating voltage 600 V_{RMS}.
- Dual insulation on the I/Os in relation to the earth (⧈ symbol).
- Dual insulation between the voltage inputs, the power supply and the other I/Os (⧈ symbol).
- Indoor use

(*) **Caution**: the rated voltage and measurement category of the overall "instrument + current sensor" assembly may differ from the specifications of the instrument alone.

- use of the Amp***FLEX™***, Mini***FLEX*** and C clamps maintains the rating of the overall "instrument + current sensor" assembly at **600 V Category IV** or **1,000 V Category III.**
- use of the PAC, MN93 and MN93A clamps downgrades the overall "instrument + current sensor" assembly to **300 V Category IV** or **600 V Category III.**
- use of the 5 A adapter box downgrades the overall "instrument + current sensor" assembly to **150 V Category IV** or **300 V Category III.**

2. FUNCTIONAL SPECIFICATIONS

2.1 Conditions of reference

This table shows the conditions of reference for the quantities to be used by default in the specifications provided in §2.2.4.

Influencing quantity	Conditions of reference
Ambient temperature	23 °C ± 3 K
Relative humidity	[45 % ; 75 %]
Atmospheric pressure	[860 hPa ; 1060 hPa]
Phase voltage	[50 V_{RMS} ; 1,000 V_{RMS}] without DC (< 0.5 %)
Input voltage of standard current circuit	[30 mV_{RMS} ; 1 V_{RMS}] without DC (< 0.5 %) *N.B.* I_{rated} ⇔ 1 V_{RMS} and 3 × I_{rated} ÷ 100 ⇔ 30 mV_{RMS}
Input voltage of Rogowski current circuit	[11.73 mV_{RMS} ; 117.3 mV_{RMS}] without DC (< 0.5 %) I_{rated} ⇔ 117.3 mV_{RMS} at 50 Hz I_{rated} ÷ 10 ⇔ 11.73 mV_{RMS} at 50 Hz
Electrical network frequency	50 Hz ± 0,1 Hz and 60 Hz ± 0.1 Hz
Phase shift	0° (active power) and 90° (reactive power)
Harmonics	< 0.1 %
Voltage unbalance	< 10 %

2.2 Electrical specifications

2.2.1 Voltage input specifications

Operating range:	0 V_{RMS} to 1,000 V_{RMS} AC+DC phase-neutral and neutral-earth 0 V_{RMS} to 2,000 V_{RMS} AC+DC phase-phase (subject to compliance with 1,000 V_{RMS} in relation to the earth in Category III)
Input impedance:	969 kΩ (between phase and neutral and between neutral and earth)
Admissible overload:	1.2 x V_{rated} permanently
	2 x V_{rated} for 1 second.

2.2.2 Current input specifications

Operating range:	[0 V ; 1 V]
Input impedance:	1 MΩ.
Admissible overload:	1.7 V.

The Amp***FLEX™*** configuration switches the current input onto an integrating assembly (Rogowski line) capable of interpreting the signals delivered by the Amp***FLEX™*** sensors. In this case, the input impedance is reduced to 12.4 kΩ.

2.2.3 Bandwidth

Measurement channels:	256 counts per period, i.e.: For 50 Hz : 6.4 kHz (256 × 50 ÷ 2) For 60 Hz : 7.68 kHz (256 × 60 ÷ 2)
Analogue at -3 dB:	> 10 kHz

2.2.4 Specifications of instrument alone (excluding current sensor)

The information which follows corresponds to a situation involving "ideal current sensors" (perfect linearity with no phase shift). The current specifications (and derived quantities) are stipulated, respectively, for each of the two configurations: "without Amp***FLEX™*** & Mini***FLEX*** » and "with Amp***FLEX™*** & Mini***FLEX***".

Measurement		Measurement range: Minimum	Measurement range: Maximum	Display resolution	Maximum error in reference range
Frequency		40 Hz	69 Hz	0,01 Hz	±(1 ct)
TRMS phase voltage		10 V	1,000 V(1)	0.1 V V < 1,000 V	±(0.5 % + 2 cts)
				1 V V ≥ 1,000 V	±(0.5 % + 1 ct)
TRMS composite voltage		10 V	2,000 V(2)	0.1 V V < 1,000 V	±(0.5 % + 2 cts)
				1 V V ≥ 1,000 V	±(0.5 % + 1 ct)
DC voltage		10 V	1,000 V	0.1 V V < 1,000 V	±(1 % + 5 cts)
				1 V V ≥ 1,000 V	±(1 % + 1 ct)
TRMS current	**Without** Amp***FLEX™*** **&** **Mini-**Amp***FLEX***	I_{rated} ÷ 1,000 [A]	1.2 × I_{rated} [A]	0,1 A I < 1,000 A	±(0.5 % + 2 cts)
				1 A I ≥ 1,000 A	±(0.5 % + 1 ct)
	Amp***FLEX™*** **&** **Mini-**Amp***FLEX***	10 A	6,500 A	0,1 A I < 1,000 A	±(0.5 % + 1 A)
				1 A I ≥ 1,000 A	
DC current		1 A	1,200 A(3)	0,1 A I < 1,000 A	±(1 % + 1 A)
				1 A I ≥ 1,000 A	
Peak current	**Without** Amp***FLEX™*** **&** Mini***FLEX***	I_{rated} ÷ 1,000 [A]	1.7 × I_{rated} [A](4)	0,1 A I < 1,000 A	±(1 % + 1 A)
	Amp***FLEX™*** **&** **Mini-**Amp***FLEX***	10 A	9,190 A(5)	1 A I ≥ 1,000 A	
Half-period TRMS current (7)	**Without** Amp***FLEX™*** **&** **Mini-**Amp***FLEX***	I_{rated} ÷ 100 [A]	1.2 × I_{rated} [A]	0,1 A I < 1,000 A	±(1 % + 1 A)
				1 A I ≥ 1,000 A	
	Amp***FLEX™*** **&** **Mini-**Amp***FLEX***	100 A	6,500 A	0,1 A I < 1,000 A	±(1.5 % + 4 A)
				1 A I ≥ 1,000 A	
Peak phase voltage		10 V	1,414 V(6)	0.1 V V < 1,000 V	±(1 % + 1 V)
				1 V V ≥ 1,000 V	
Peak composite voltage		10 V	2,828 V(7)	0.1 V U < 1,000 V	±(1 % + 1 V)
				1 V U ≥ 1,000 V	

(1) Rating 1,000 V_{RMS} Category III, as long as the voltages between each of the terminals and the earth do not exceed 1,000 V_{RMS}.
(2) With two-phase (opposing phases) – same remark as for (1).
(3) Limitation of the PAC clamp.
(4) $1.2 \times Irated \times \sqrt{2} = 1.7 \times Irated$
(5) $6,500 \times \sqrt{2} = 9,190$
(6) $1,000 \times \sqrt{2} = 1,414$
(7) $2000 \times \sqrt{2} = 2828$

Measurement		Measurement range		Display resolution	Maximum error in reference range
		Minimum	Maximum		
Half-period TRMS phase voltage[3]		10 V	1,000 V[1]	0.1 V V < 1,000 V	±(0.8 % + 1 V)
				1 V V ≥ 1,000 V	
Half-period TRMS composite voltage[3]		10 V	2,000 V[2]	0.1 V U < 1,000 V	±(0.8 % + 1 V)
				1 V U ≥ 1,000 V	
Crest factor		1	3.99	0.01	±(1 % + 2 cts)
		4	9.99	0.01	±(5 % + 2 cts)
Puissance active	Without Amp***FLEX™*** & Mini-Amp***FLEX***	0 W	9,999 kW	1 V U ≥ 1,000 V	±(1 %) Cos ϕ ≥ 0.8
					±(1.5 % +10 cts) 0,2 ≤ Cos ϕ < 0.8
	Amp***FLEX™*** & Mini-Amp***FLEX***	0 W	9,999 kW	4 digits	±(1 %) Cos ϕ ≥ 0.8
					±(1.5 % +10 cts) 0.5 ≤ Cos ϕ < 0.8
Inductive & capacitive reactive power values	Without Amp***FLEX™*** & Mini-Amp***FLEX***	0 VAR	9,999 kVAR	4 digits	±(1 %) Sin ϕ ≥ 0.5
					±(1.5 % +10 cts) 0.2 ≤ Sin ϕ < 0.5
	Amp***FLEX™*** & Mini-Amp***FLEX***	0 VAR	9,999 kVAR	4 digits	±(1.5 %) Sin ϕ ≥ 0.5
					±(2.5 % +20 cts) 0.2 ≤ Sin ϕ < 0.5
Apparent power		0 VA	9,999 kVA	4 digits	±(1 %)
Power factor		-1	1	0.001	±(1.5 %) Cos ϕ ≥ 0,5
					±(1.5 % +10 cts) 0.2 ≤ Cos ϕ < 0.5

(1) Rating 1,000 V_{RMS} Category III, as long as the voltages between each of the terminals and the earth do not exceed 1,000 $V_{RMS.}$

(2) With two-phase (opposing phases) – same remark as for (1).

(3) **Caution**: the absolute offset value must not exceed 95% of the peak amplitude.

In other words, $s(t) = S \times \sin(\omega t) + O$, so we will have $|O| \leq 0.95 \times S$ (with S positive).
The MAX and MIN values in the waveform mode and the V_{RMS} and A_{RMS} values (excluding neutral channels) in the Alarm and Inrush Current modes are half-period values.

Note:
the uncertainties indicated for the power and energy measurements are maximum values for |Cos ϕ| = 1 or |Sin ϕ| = 1 and are typical for the other phase shifts.

Measurement		Measurement range – Minimum	Measurement range – Maximum	Display resolution	Maximum error in reference range
Active energy	**Without** Amp***FLEX™*** **&** **Mini-**Amp***FLEX***	0 Wh	9,999 MWh	4 digits	±(1 %) Cos ϕ ≥ 0.8
					±(1,5 %) 0,2 ≤ Cos ϕ < 0.8
	Amp***FLEX™*** **&** **Mini-**Amp***FLEX***	0 Wh	9,999 MWh	4 digits	±(1 %) Cos ϕ ≥ 0.8
					±(1.5 %) 0.5 ≤ Cos ϕ < 0.8
Inductive & capacitive reactive energy values	**Without** Amp***FLEX™*** **&** **Mini-**Amp***FLEX***	0 VARh	9,999 MVARh	4 digits	±(1 %) Sin ϕ ≥ 0,5
					±(1.5 %) 0.2 ≤ Sin ϕ < 0.5
	Amp***FLEX™*** **&** **Mini-**Amp***FLEX***	0 VARh	9,999 MVARh	4 digits	±(1.5 %) Sin ϕ ≥ 0.5
					±(2.5 %) 0 2 ≤ Sin ϕ < 0.5
Apparent energy		0 VAh	9,999 MVAh	4 digits	±(1 %)
Phase shift		-179°	180°	1°	±(2°)
Tangent VA ≥ 50 VA		-32.76	32.76	0.001 Tan ϕ < 10	±(1°) on ϕ
				0.01 Tan ϕ ≥ 10	
Displacement power factor (DPF)		-1	1	0.001	±(1°) on ϕ & ±(5 cts) on DPF
THD order ∈ [1; 50] (V_{RMS} > 50 V)		0 %	999.9 %	0.1 %	±(1 % + 5 cts)
Without Amp***FLEX™*** **&** **Mini-**Amp***FLEX*** **(I_{RMS} > 3 × I_{rated} ÷ 100)**					
Amp***FLEX™*** **&** **Mini-**Amp***FLEX*** **(I_{RMS} > I_{rated} ÷ 10)**					
Harmonic angles (V_{RMS} > 50 V)		-179°	180°	1°	±(3°) rang ∈ [1 ; 25]
Without Amp***FLEX™*** **&** **Mini-**Amp***FLEX*** **(I_{RMS} > 3 × I_{rated} ÷ 100)**					
Amp***FLEX™*** **&** **Mini -**Amp***FLEX*** **(I_{RMS} > I_{rated} ÷ 10)**					±(10°) rang ∈ [26 ; 50]
Total harmonic distortion (THD or THD-F) order ≤ 50		0 %	999.9 %	0.1 %	±(1 % + 5 cts)
Distortion factor (DF or THD-R) order ≤ 50		0 %	999.9 %	0.1 %	±(1 % + 10 cts)
K-Factor		1	99.99	0.01	±(5 %)
Unbalance (three-phase network)		0 %	100 %	0.1 %	±(1 %)

2.2.5 Specifications of the current sensors (after linearization)

The sensor errors are offset by typical correction inside the instrument. This typical correction is applied to the phase and the amplitude depending on the type of sensor connected (detected automatically) and the gain of the current acquisition line used.

The RMS current measurement error and the phase error correspond to additional errors (they must therefore be added to the instrument errors) indicated as influences on the calculations performed by the analyser (power values, energies, power factors, tangents, etc.).

Sensor type	TRMS current	Maximum error on I_{RMS}	Maximum error on φ
PAC93 clamp 1,000 A	[1 A ; 10 A]	±(1.5 % + 1 A)	N.S.
	[10 A ; 100 A]		±(2°)
	[100 A ; 800 A]	±(3 %)	±(1.5°)
	[800 A ; 1,200 A]	±(5 %)	
C193 clamp 1,000 A	[1 A ; 3 A]	±(0.8 %)	N.S.
	[3 A ; 10 A]		±(1°)
	[10 A ; 100 A]	±(0.3 %)	±(0.5°)
	[100 A ; 1,200 A]	±(0.2 %)	±(0.3°)
Amp***FLEX™*** **A193 6,500 A**	[10 A ; 100 A]	±(3 %)	±(1°)
	[100 A ; 6,500 A]	±(2 %)	±(0.5°)
Mini-Amp***Flex*** **MA193 6,500 A**	[10 A ; 100 A]	±(3 %)	±(1°)
	[100 A ; 6,500 A]	±(2 %)	±(0.5°)
MN93 clamp 200 A	[0.5 A ; 2 A]	±(3 % + 1 A)	N.S.
	[2 A ; 10 A]		±(6°)
	[10 A ; 100 A]	±(2.5 % + 1 A)	±(3°)
	[100 A ; 240 A]	±(1 % + 1 A)	±(2°)
MN93A clamp 100 A	[100 mA ; 300 mA]	±(0.7 % + 2 mA)	N.S.
	[300 mA ; 1 A]		±(1.5°)
	[1 A ; 120 A]	±(0.7 %)	±(0.7°)
MN93A clamp 5 A	[5 mA ; 50 mA]	±(1 % + 0.1 mA)	±(1.7°)
	[50 mA ; 500 mA]	±(1 %)	±(1°)
	[500 mA ; 6 A]	±(0.7 %)	
5 A adapter	[5 mA ; 50 mA]	±(1 %)	±(1°)
	[50 mA ; 6 A]	±(0.5 %)	±(0°)

N.S. means "Not Specified"

3. FORMULAE

This chapter presents the mathematical formulae used to calculate the various parameters for the C.A 8335.

3.1 Mathematical formulae

3.1.1 Network frequency and sampling

The sampling is slaved to the network frequency to obtain 256 samples per period from 40 Hz to 70 Hz. This slaving is essential for calculation of the reactive power, unbalance, THD and harmonic angles.

The frequency measurement is determined by analysing seven consecutive positive zero crossings on the first voltage channel (V1) or on the first current channel (I1) after digital low-pass filtering and digital suppression of the DC component.

Precise time measurement of the zero crossing point is carried out by linear interpolation between two samples to achieve a resolution better than 0.002 %.

The signals are acquired with a 16-bit converter and (for current acquisition) dynamic gain switching.

3.1.2 Half-period RMS values of the voltages and currents (excluding neutral)

Half-period RMS phase voltage of phase i +1

$$\mathrm{Vhp}[i]=\sqrt{\frac{1}{NsamHalfPer}\cdot\sum_{n:Zero}^{Nextzero}V[i][n]^2}$$

Half-period RMS composite voltage of phase i +1

$$\mathrm{Uhp}[i]=\sqrt{\frac{1}{NsamHalfPer}\cdot\sum_{n:Zero}^{Nextzero}U[i][n]^2}$$

Half-period RMS current of phase i +1

$$\mathrm{Ahp}[i]=\sqrt{\frac{1}{NsamHalfPer}\cdot\sum_{n:Zero}^{Nextzero}A[i][n]^2}$$

Note: these values are calculated for each half-period to avoid missing any faults.

3.1.3 Minimum and maximum half-period RMS values (excluding neutral)

$$\mathrm{Vmax}[i]=\max(\mathrm{Vhp}[i]),\ \ \mathrm{Vmin}[i]=\min(\mathrm{Vhp}[i])$$

$$\mathrm{Umax}[i]=\max(\mathrm{Uhp}[i]),\ \ \mathrm{Umin}[i]=\min(\mathrm{Uhp}[i])$$

$$\mathrm{Amax}[i]=\max(\mathrm{Ahp}[i]),\ \ \mathrm{Amin}[i]=\min(\mathrm{Ahp}[i])$$

3.1.4 Flicker for voltages (excluding neutral)

Method based on the IEC 61000-4-15 standard.

The input values are the half-period phase voltages. Blocks 3 and 4 are produced digitally. The classifier of block 5 comprises 128 levels.

The Vflk[i] values are updated every 10 minutes.

3.1.5 Peak values for voltages and currents

i = 3 ⇔ neutral – except for Upp and Upm

$$\mathrm{Vpp}[i]=\max(\ \mathrm{V}[i][\mathrm{n}]\ )\ ,\ \ \mathrm{Vpm}[i]=\min(\ \mathrm{V}[i][\mathrm{n}]\ )\ \ \mathrm{n}\in[0..\mathrm{NSAMPER}-1]$$

$$\mathrm{Upp}[i]=\max(\ \mathrm{U}[i][\mathrm{n}]\ )\ ,\ \ \mathrm{Upm}[i]=\min(\ \mathrm{U}[i][\mathrm{n}]\ )\ \ \mathrm{n}\in[0..\mathrm{NSAMPER}-1]$$

$$\mathrm{App}[i]=\max(\ \mathrm{A}[i][\mathrm{n}]\ )\ ,\ \ \mathrm{Apm}[i]=\min(\ \mathrm{A}[i][\mathrm{n}]\ )\ \ \mathrm{n}\in[0..\mathrm{NSAMPER}-1]$$

3.1.6 Crest factors for voltages (excluding neutral)

Phase voltage crest factor of phase i+1

$$\mathrm{Vcf}[i]=\frac{\max(\mathrm{Vpp}[i],\mathrm{Vpm}[i])}{\sqrt{\frac{1}{NSAMPER}\cdot\sum_{n=0}^{NSAMPER-1}V[i][n]^2}}$$

Composite voltage crest factor of phase i+1

$$\mathrm{Ucf}[i]=\frac{\max(\mathrm{Upp}[i],\mathrm{Upm}[i])}{\sqrt{\frac{1}{NSAMPER}\cdot\sum_{n=0}^{NSAMPER-1}U[i][n]^2}}$$

Current crest factor of phase i+1

$$\mathrm{Acf}[i]=\frac{\max(\mathrm{App}[i],\mathrm{Apm}[i])}{\sqrt{\frac{1}{NSAMPER}\cdot\sum_{n=0}^{NSAMPER-1}A[i][n]^2}}$$

3.1.7 1 s RMS values of voltages and currents

(i = 3 ⇔ neutral – except for Urms)

RMS phase voltage i + 1

$$\mathrm{Vrms}[i]=\sqrt{\frac{1}{NSamSec}\cdot\sum_{n=0}^{NSamSec}V[i][n]^2}$$

RMS composite voltage of phase i +1

$$\mathrm{Urms}[i]=\sqrt{\frac{1}{NSamSec}\cdot\sum_{n=0}^{NSamSec}U[i][n]^2}$$

RMS current of phase i +1

$$\mathrm{Arms}[i]=\sqrt{\frac{1}{NSamSec}\cdot\sum_{n=0}^{NSamSec}A[i][n]^2}$$

NSamSec: Number of samples per second

3.1.8 Voltage and current unbalances

These are calculated from the filtered values (1 s) VFrms and AFrms (ideally, the fundamental of the signals).

(vectorial operations by complex notation with: $a = e^{j\frac{2\pi}{3}}$)

$$Vrms_{+} = \frac{1}{3}(VFrms[0] + a \cdot VFrms[1] + a^2 \cdot VFrms[2]) \quad \text{forward voltage}$$

$$Vrms_{-} = \frac{1}{3}(VFrms[0] + a^2 \cdot VFrms[1] + a \cdot VFrms[2]) \quad \text{reverse voltage}$$

$$Vunb = \frac{|Vrms_{-}|}{|Vrms_{+}|}, \quad Aunb = \frac{|Arms_{-}|}{|Arms_{+}|}$$

3.1.9 Harmonic calculations (excluding neutral)

These are performed by 1024-count FFT (16 bits) over four periods without windowing (see IEC 1000-4-7). On the basis of the real parts b_k and imaginary parts a_k, the rates are calculated for each order and for each phase Vharm[3][51], Uharm[3][51] and Aharm[3][51] in relation to the fundamental value, and the angles Vph[3][51], Uph[3][51] and Aph[3][51] in relation to the fundamental.

The following principle is used for this calculation:

% modulus $\mathrm{mod}_k = \frac{c_k}{c_1} \times 100$

Angle in degrees $\varphi_k = \arctan\left(\frac{a_k}{b_k}\right)$

with
$$\begin{cases} c_k = |b_k + ja_k| = \sqrt{a_k^2 + b_k^2} \\ b_k = \frac{1}{512} \sum_{s=0}^{1024} F_s \times \sin\left(\frac{k\pi}{512}s + \varphi_k\right) \\ a_k = \frac{1}{512} \sum_{s=0}^{1024} F_s \times \cos\left(\frac{k\pi}{512}s + \varphi_k\right) \\ c_0 = \frac{1}{1024} \sum_{s=0}^{1024} F_s \end{cases}$$

C_k: amplitude of the component with a frequency $f_k = \frac{k}{4} f_1$

F_s: signal sampled

C_0: DC component

K: ordinal number (order of the spectrum line)

3.1.10 Harmonic distortion (excluding neutral)

Two global values are calculated which indicate the relative quantity of harmonics: the THD as a proportion of the fundamental and the DF as a proportion of the RMS value.

$$Vthd[i] = \frac{\sqrt{\sum_{n=2}^{50} Vharm[i][n]^2}}{Vharm[i][1]}, \quad Uthd[i] = \frac{\sqrt{\sum_{n=2}^{50} Uharm[i][n]^2}}{Uharm[i][1]}, \quad Athd[i] = \frac{\sqrt{\sum_{n=2}^{50} Aharm[i][n]^2}}{Aharm[i][1]}$$

$$Vdf[i] = \frac{\sqrt{\sum_{n=2}^{50} Vharm[i][n]^2}}{Vrms[i]}, \quad Udf[i] = \frac{\sqrt{\sum_{n=2}^{50} Uharm[i][n]^2}}{Urms[i]}, \quad Adf[i] = \frac{\sqrt{\sum_{n=2}^{50} Aharm[i][n]^2}}{Arms[i]}$$

By multiplying the voltage THDs by the current THDs, the power THDs can be calculated. By differentiating the voltage harmonic angles with the current harmonic angles, the power harmonic angles can be calculated.

VAharm[3][51], VAph[3][51]

3.1.11 Facteur K

Facteur K pour la phase i+1

$$Akf[i] = \frac{\sum_{n=1}^{n=50} n^2 \cdot Aharm[i][n]^2}{\sum_{n=1}^{n=50} Aharm[i][n]^2}$$

3.1.12 Different 1 s power values (excluding neutral)

Active power, phase i + 1

$$W[i] = \frac{1}{NSamSec} \cdot \sum_{n=0}^{NSamSec-1} V[i][n] \cdot A[i][n]$$

Apparent power, phase i + 1

$$VA[i] = Vrms[i] \cdot Arms[i]$$

Reactive power, phase i + 1

$$VAR[i] = \frac{1}{NSamSec} \cdot \sum_{n=0}^{NSamSec-1} VF[i][n - NSAMPER/4] \cdot AF[i][n]$$

or $VAR[i] = \sqrt{VA[i]^2 - W[i]^2}$ if using the calculation method with harmonics.

The reactive power values are calculated using the filtered signals (without harmonics), as required by EDF, or on the basis of the apparent and active power values (with harmonics). The calculation method is chosen by the user.

Total active power

W[3] = W[0] + W[1] + W[2]

Total apparent power

VA[3] = VA[0] + VA[1] + VA[2]

Total reactive power

VAR[3] = VAR[0] + VAR[1] + VAR[2]

3.1.13 Different rates (excluding neutral)

$$PF[i] = \frac{W[i]}{VA[i]} \quad \text{Power factor, phase i+1}$$

$$DPF[i] = \cos(\phi[i]) \quad \text{Displacement power factor, phase i+1}$$

$$Tan[i] = \tan(\phi[i]) \quad \text{Tangent phase i+1}$$

Cosine of angle between voltage fundamental and current fundamental, phase i + 1

$$\cos(\phi[i]) = \frac{\sum_{n=0}^{NSamSec-1} VF[i][n] \cdot AF[i][n]}{\sqrt{\sum_{n=0}^{NSamSec-1} VF[i][n]^2} \cdot \sqrt{\sum_{n=0}^{NSamSec-1} AF[i][n]^2}}$$

$$PF[3] = \frac{PF[0] + PF[1] + PF[2]}{3} \quad \text{Total power factor}$$

$$DPF[3] = \frac{DPF[0] + DPF[1] + DPF[2]}{3} \quad \text{Total displacement power factor}$$

$$Tan[3] = \frac{Tan[0] + Tan[1] + Tan[2]}{3} \quad \text{Total tangent}$$

3.1.14 Different energy values (excluding neutral)

- Case 1: consumed energy values (W[i] ≥ 0)

Consumed active energy, phase i + 1

$$Wh[0][i] = \sum_{Tint} \frac{W[i]}{3600}$$

Consumed apparent energy, phase i + 1

$$VAh[0][i] = \sum_{Tint} \frac{VA[i]}{3600}$$

Consumed inductive reactive energy, phase i + 1

$$VARhL[0][i] = \sum_{Tint} \frac{VAR[i]}{3600} \text{ for } VAR[i] \geq 0$$

Consumed capacitive reactive energy, phase i + 1

$$VARhC[0][i] = \sum_{Tint} \frac{-VAR[i]}{3600} \text{ for } VAR[i] \leq 0$$

Total consumed active energy

Wh[0][3] = Wh[0][0] + Wh[0][1] + Wh[0][2]

Total consumed apparent energy

VAh[0][3] = VAh[0][0] + VAh[0][1] + VAh[0][2]

Total consumed capacitive reactive energy

VARhC[0][3] = VARhC[0][0] + VARhC[0][1] + VARhC[0][2]

Total consumed inductive reactive energy

VARhL[0][3] = VARhL[0][0] + VARhL[0][1] + VARhL[0][2]

- Case 2: generated energy values (W[i] < 0)

Generated active energy, phase i + 1

$$Wh[1][i] = \sum_{Tint} \frac{W[i]}{3600}$$

Generated apparent energy, phase i + 1

$$VAh[1][i] = \sum_{Tint} \frac{VA[i]}{3600}$$

Generated inductive reactive energy, phase i + 1

$$VARhL[1][i] = \sum_{Tint} \frac{-VAR[i]}{3600} \text{ for } VAR[i] \leq 0$$

Generated capacitive reactive energy, phase i + 1

$$VARhC[1][i] = \sum_{Tint} \frac{VAR[i]}{3600} \text{ for } VAR[i] \geq 0$$

Total generated active energy

Wh[1][3] = Wh[1][0] + Wh[1][1] + Wh[1][2]

Total generated apparent energy

VAh[1][3] = VAh[1][0] + VAh[1][1] + VAh[1][2]

Total generated capacitive reactive energy

VARhC[1][3] = VARhC[1][0] + VARhC[1][1] + VARhC[1][2]

Total generated inductive reactive energy

VARhL[1][3] = VARhL[1][0] + VARhL[1][1] + VARhL[1][2]

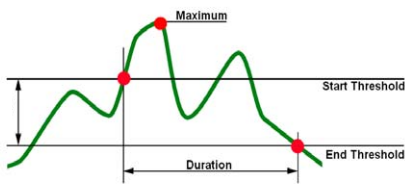
3.2 Hysteresis

Hysteresis is a filtering principle frequently used after a threshold detection stage, in Alarm mode.

Correct adjustment of the hysteresis value prevents repeated status changes when the measurement oscillates around the threshold.

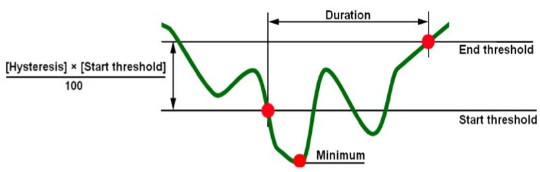
3.2.1 Overvoltage detection

For a hysteresis of 2 %, for example, the return level for an overvoltage detection will be equal to (100 % - 2 %), or 98 % of the reference threshold voltage.



3.2.2 Detection of undervoltage or interruption

For a 2 % hysteresis, for example, the return level in the event of undervoltage detection will be equal to (100 % + 2 %) or 102 % of the threshold voltage Uref.

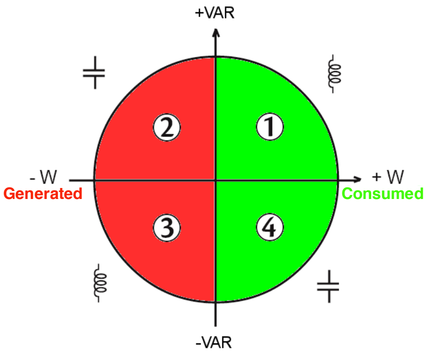


3.3 Minimum scale values and minimum displayed values in the Waveforms mode

Type of current sensor	Minimum displayed current value [A]	Minimum scale current value [A]
Amp*FLEX*™ 6500 A	30	60
Mini-Amp*FLEX* 6500 A	30	60
PAC93 1,000 A clamp	1	10
C193 1,000 A clamp	0.5	10
MN93 200 A clamp	0.5	2
MN93A 100 A clamp	0.2	1
MN93A clamp with 5 A probe	(Primary × 5) ÷ (Secondary × 1,000)	(Primary × 5 × 10) ÷ (Secondary × 1,000)
5 A adapter	(Primary × 5) ÷ (Secondary × 1,000)	(Primary × 5 × 10) ÷ (Secondary × 1,000)

3.4 Diagram of the 4 quadrants

This diagram is used for power and energy measurements W.



3.5 Half-tube values for transient capture

Threshold	100 %	50 %	20 %	10 %	5 %	2 %	1 %	Type
Half-width of tube (L)	200	100	40	20.01	10	4	2	**MN93 200 A**
	100	50	20	10	5	2	1	**MN93A 100 A**
	3,000	1,500	600	300	150	60	30	**MN93A 5 A / 5 A adapter [3,000 / 1]**
	1	0.5	0.2	0.1	0.05	0.02	0.01	**MN93A 5 A / 5 A adapter [1 / 1]**
	1,000	500	200	100	50	20	10	**PAC93 1,000 A**
	3,000	1,500	600	300	150	60	30	**Amp*FLEX*™ / Mini-Amp*FLEX* 3,000 A**
	500	250	100	50	25	10	5	**Voltage 500 V**

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