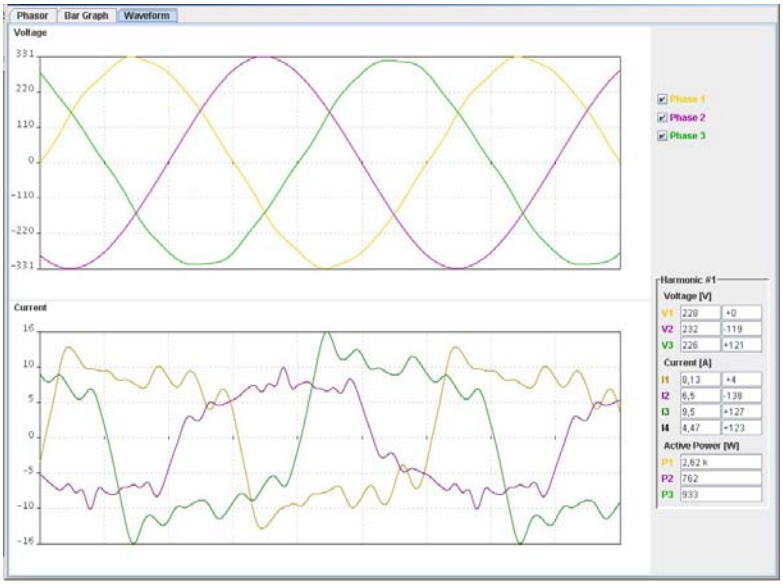
FFT HARMONICS OPTION

For instruments type
X3M-D, X3M-DH, Flash-D, Flash-DH



Instructions manual

akse srl Via Aldo Moro, 39 42100 Reggio Emilia Italy
Tel. +39 0522 924 244 Fax +39 0522 924 245 info@akse.it www.akse.it
P.I. 01544980350 R.E.A. 194296 Cap. Soc. Euro 85.800,00 i.v.

ELECTREX
the energy saving technology
www.electrex.it info@electrex.it

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1. Introduction

We thank you for choosing Electrex; we invite you to carefully read this instructions manual for the best use of the FFT harmonics option.

1.1 COPYRIGHT

2 Preliminary operations

2.1 Applicable instruments

The FFT harmonics option can be implemented only on the instrument types as below indicated:

X3M, X3M-D, Flash-N e Flash-D.

- The FFT option for these instruments is ordered and supplied separately in the form of an individual PUK code to be used for enabling the option.
- Each PUK code is unique and it is individually matched to the instrument serial number the option was ordered for.
- The FFT Harmonics option may be used only with instruments bearing a firmware version 2.0 or higher. In the case of lower versions, the firmware must be up-graded; contact Electrex for instructions.

X3M-H, X3M DH, Flash-NH and Flash-DH

- The FFT harmonics option is supplied together with the instrument.
- A label placed on the instrument and marked S/No. ..... H opt PUK….. indicates the individual PUK code to be used for enabling the option.

The following instructions apply to the instruments type X3M-D, X3M-DH, Flash-D and Flash-DH (DIN rail mount types).

2.2 Enabling the FFT harmonics option

Whether ordered separately or supplied with the instrument, the FFT harmonics option needs to be activated by the user by means of a simple PUK code entry as below indicated

Enter into the SET-UP mode by pressing the PROGRAM button located in the instrument rear panel *(alternatively, by simultaneously pressing the* U_f P_{os} E ▼ ▲ *keys).*

1) Press the t key until the **HARMONIC OPT - ENTER PUK** page is prompted (see figure).

2) Enter your PUK code into the 00-00-00 fields by pressing the ▲ ▼ keys to increase/decrease the flashing digit and the ▶ key to move to the next digit.

   - *Make sure to enter the PUK code matching the instrument serial number it was issued for.*
   - *The PUK code may be composed of numbers and letters in the range 0…..9 A B C D E F.*

3) Upon completing the last digit, press the PROGRAM button to confirm and exit the SETUP mode.
   NB. For the alternative entry into set up mode, the I *key must be used to confirm and exit.*

4) The instrument displays "**OPTION ENABLED**" to confirm a correct PUK code entry and the permanent enabling of the FFT harmonics option.

5) The "**INVALID PUK**" message is otherwise displayed to indicate an incorrect entry. Repeat all the entry procedure and ensure to enter a correct PUK code.

3 Description

The FFT option supports the analyses of voltage and current waveforms up to the 31st order; it provides the individual harmonics readings on display and it enables these readings as Modbus registers on serial line.
In addition to voltage and current harmonics it provides the individual readings of harmonics active power with a sign indicating the harmonic origin; negative sign indicating a flow from load to mains, no sign (positive) indicating a flow from mains to load.

Thanks to the high calculation power of the instrument, all the harmonics readings, though non-prioritary, up date with an interval of 1 sec (however approximate because influenced by other measurement activities).
Accuracy < 1% and sensitivity of 0,5% are figures that validate an especially high performance (particularly when comparing to similar industrial instruments) and that make possible the calculation of power and the determination of flow for the most significant harmonics.
Voltage harmonics are generally very low and, consequently, the harmonics powers turn to be infinitesimal values of the fundamental power and quite difficult to calculate. For these reasons and being not possible to ensure accuracy, the harmonics powers readings must be understood as indicative values. The power readings are set to zero and the sign disappear whenever the harmonic powers attain values considered not consistent.

The readings of voltage and current of the fundamental waveform are expressed in Volt and Ampere; the phase angle (available only on Modbus registers) is expressed in degrees with respect to the L1 voltage.
The readings of voltage and current of the higher harmonics orders are expressed in percentage of their fundamentals. The phase angle (available only on Modbus registers) is expressed in degrees with respect to the L1 voltage.

The conversion is made on 64 samples corresponding to one cycle of the 3 voltage and 3 current signal then an FFT calculation (Fast Fourier Transform) is executed. It operates in asynchronous mode with respect to the other readings by analysing a group of 64 samples every measurement cycle corresponding to approximately 1 sec.

4 Reading selection keys

The parameter category selection is operated by means of the following keys:

U f Voltage and frequency readings	I Current readings
P Q S Power readings.	P.F. Power factor readings.
E Energy readings.	t Life time reading.

The ▲ ▼ keys, then, scroll the several reading pages up/down within each parameter category.

The ▶ key is not used for readings display.

4.1 Voltage

Voltage harmonics readings are available within the U f key.

Several pressures of the U f key scroll the voltage parameters pages; namely:

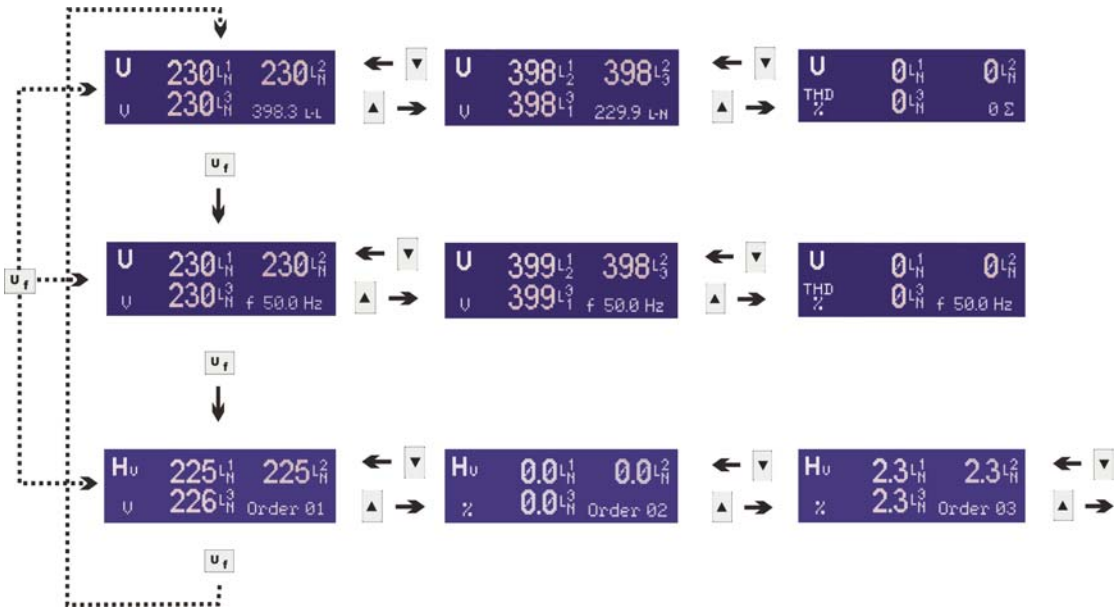
- a 1st page with phase-neutral voltages and average 3-phase system voltage.
- a 2nd page with phase-neutral voltages and frequency.

  In the above two situations, further pressures of the ▲ ▼ keys, prompt consecutively:
  - phase-phase voltages and average phase-neutral system voltage and
  - total harmonic distortion (THD-V) per phase
- a 3rd page, identified by the symbols **H V** on top, with the readings of harmonics order 01 (fundamental).

  In this situation, further pressures of the ▲ ▼ keys scroll the readings of harmonics orders 02 to 31.

When using the bottom row keys for viewing different parameter categories, the instrument always prompts the last selected page within each parameter category.

4.1.1 3P 4W configuration



4.1.2 Other configurations

In 3P-4W-BAL configuration, the readings relate to V1 only
In 3P 3 W configuration, the readings relate to the three phase-to-phase voltages.
In 3P-3W-BAL configuration, the readings relate to V12 only.
The display mode follows the logic described in the instructions manual of the base instrument.

4.2 Current

Current harmonics readings are available within the [I] key.

Several pressures of the [I] key scroll the current parameters pages; namely:

- a 1st page with phase currents and neutral current.
- a 2nd page with phase currents and average three-phase current.

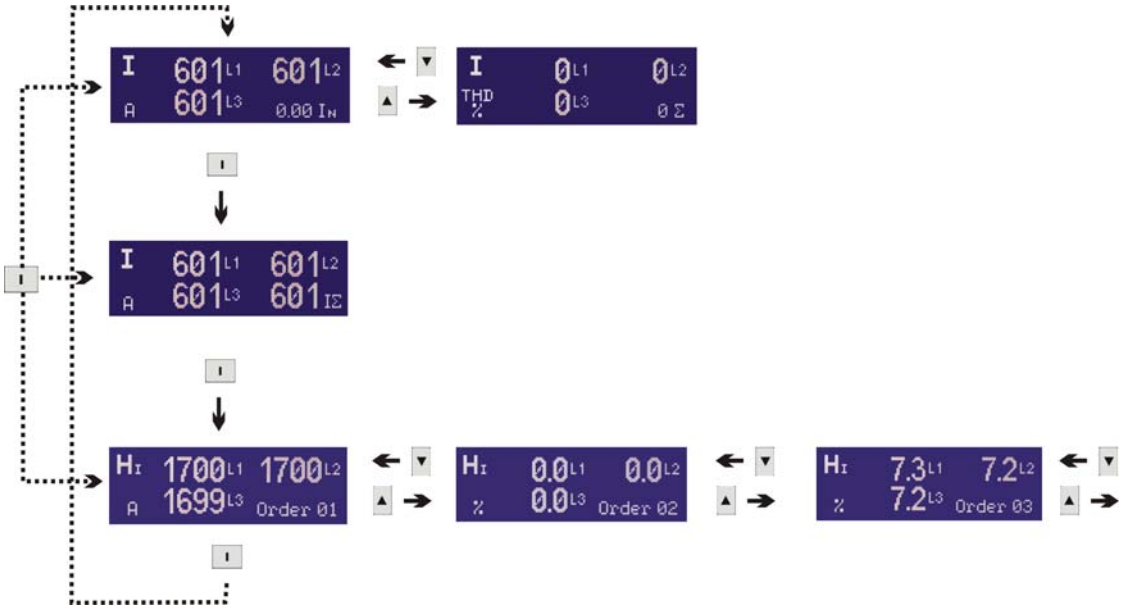
  In the above situation, further pressure of the [▲] [▼] keys, prompts
  - Total Harmonic distortion (THD-I) per phase

- a 3rd page, identified by the symbol **HI** on top, with the readings of harmonic order 01 (fundamental).

  In this situation, further pressures of the [▲] [▼] keys scroll the readings of harmonics orders 02 to 31.

When using the bottom row keys for viewing different parameter categories, the instrument always prompts the last selected page within each parameter category.

4.2.1 3P 4W configuration



4.2.2 Other configurations

In 3P-4W-BAL configuration, the readings relate to I1 only
In 3P 3 W configuration, the readings relate to the three line currents.
In 3P-3W-BAL configuration, the readings relate to I3 only.
The display mode follows the logic described in the instructions manual of the base instrument.

4.3 Power

Harmonics power readings are available within the [P Q S] key.

Several pressures of the [P Q S] key scroll the power parameters pages; namely:

- a 1st page with active powers (P)

- a 2nd page with reactive powers (Q)

- a 3rd page with apparent powers (S)

  In the above situations, further pressure of the [▲] [▼] keys, prompt
  - the rolling average values
  - the Max Demand values

- a 4th page, identified by the symbol **H P** on top, with the power readings of harmonic order 01 (fundamental).

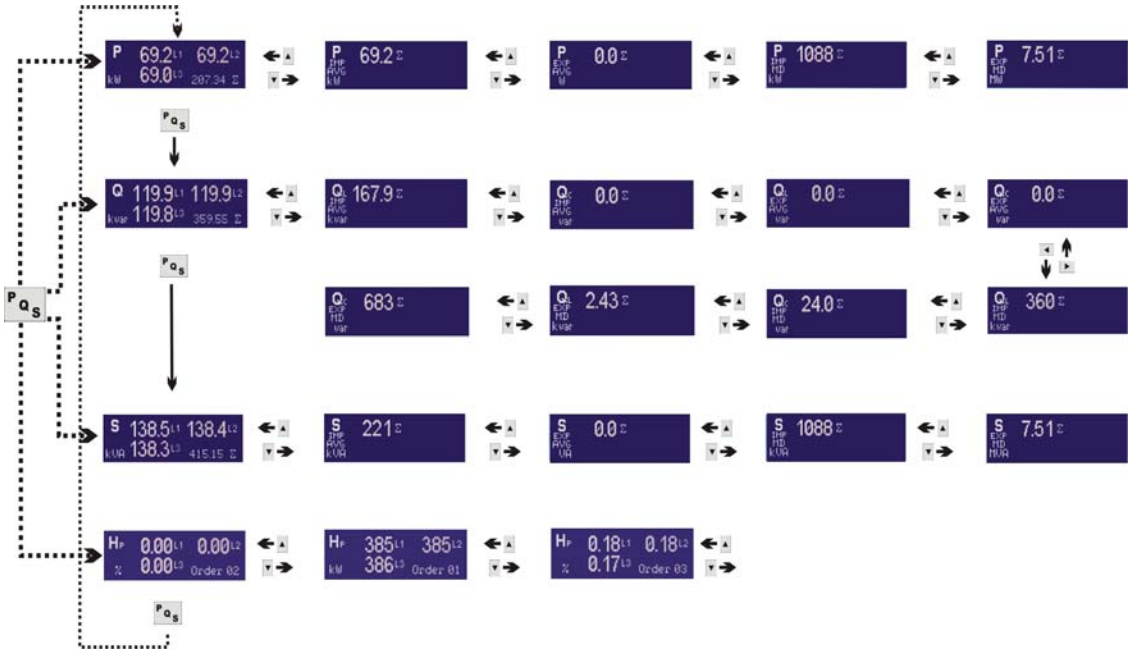
  In this situation, further pressures of the [▲] [▼] keys scroll the readings of harmonics orders 02 to 31.

A power value with positive sign (no sign) indicates an harmonic flow from mains to load (*import*).
A power value with " – "sign indicates an harmonic flow from load to mains (*export*).

NB. The sign detection strictly depends upon the orientation of the CTs. therefore, a proper orientation and wiring of the CTs is ESSENTIAL for a correct sign indication. Please refer to the instrument installation manual for details.

When using the bottom row keys for viewing different parameter categories, the instrument always prompts the last selected page within each parameter category.

4.3.1 3P 4W configuration



4.3.2 Other configurations

In 3P-4W-BAL configuration, the readings relate to V1 and I1 only
In 3P- 3W configuration, the readings of power are not available.
In 3P-3W-BAL configuration, the readings of power are not available.
The display mode follows the logic described in the instructions manual of the base instrument.

5 MODBUS Protocol

5.1 Foreword:

The instrument modbus protocol is implemented according to the document "*MODBUS Application Protocol Specification V1.1*", available in www.modbus.org .

The following "Public functions" are implemented:

- ((0x04) Read Input Registers

5.2 Modbus registers mapping

The data resulting from the FFT calculation of a 64-sample cycle are available simultaneously on serial port communication.
For the purpose of a proper data analyses and correlation it is essential to be able to collect the data relating to the same sample. The overall number on input registers, however, exceeds the possibilities of interrogation by a "multiple register" command therefore, in order to allow the possibility of interrogating congruent values, the readings are kept on Hold between one sampling and the successive, and updated in real time only upon interrogation of the L1 voltage fundamental value.
This enables to interrogate all registers of the same sample (and hence congruent data) irrelevant the number of queries.

Harmonics				
Value of the fundamentals of the three phase system				
Addr	**Type**	**Description**	**Unit**	**Symbol**
400	Float IEEE754	**U**$_{L1}$ fundamental voltage (H1)	**V**	**U**$_{L1}$ H1
401				
402	Float IEEE754	**U**$_{L2}$ fundamental voltage (H1)	**V**	**U**$_{L2}$ H1
403				
404	Float IEEE754	**U**$_{L3}$ fundamental voltage (H1)	**V**	**U**$_{L3}$ H1
405				
406	Float IEEE754	**I**$_{L1}$ fundamental current (H1)	**A**	**I**$_{L1}$ H1
407				
408	Float IEEE754	**I**$_{L2}$ fundamental current (H1)	**A**	**I**$_{L2}$ H1
409				
410	Float IEEE754	**I**$_{L3}$ fundamental current (H1)	**A**	**I**$_{L3}$ H1
411				
412	Integer 16 bit signed	**U**$_{L1}$ fundamental voltage phase angle ± 180.0° (H1)	°/10	**U**$_{L1}$ H1φ
413	Integer 16 bit signed	**U**$_{L2}$ fundamental voltage phase angle ± 180.0° (H1)	°/10	**U**$_{L2}$ H1φ
414	Integer 16 bit signed	**U**$_{L3}$ fundamental voltage phase angle ± 180.0° (H1)	°/10	**U**$_{L3}$ H1φ
415	Integer 16 bit signed	**I**$_{L1}$ fundamental current phase angle ± 180.0° (H1)	°/10	**I**$_{L1}$ H1φ
416	Integer 16 bit signed	**I**$_{L2}$ fundamental current phase angle ± 180.0° (H1)	°/10	**I**$_{L2}$ H1φ
417	Integer 16 bit signed	**I**$_{L3}$ fundamental current phase angle ± 180.0° (H1)	°/10	**I**$_{L3}$ H1φ

Harmonics on voltage phase L1										
Voltage value as % of the fundamental						Phase angle referred to the fundamental of the voltage on phase L1				
Addr	**Type**	**Description**	**Unit**	**Symbol**		**Addr**	**Type**	**Description**	**Unit**	**Symbol**
418	Integer	H2 voltage	‰	V_{L1} H2		448	Integer	H2 voltage phase angle	°/10	V_{L1} H2φ
419	Integer	H3 voltage	‰	V_{L1} H3		449	Integer	H3 voltage phase angle	°/10	V_{L1} H3φ
420	Integer	H4 voltage	‰	V_{L1} H4		450	Integer	H4 voltage phase angle	°/10	V_{L1} H4φ
421	Integer	H5 voltage	‰	V_{L1} H5		451	Integer	H5 voltage phase angle	°/10	V_{L1} H5φ
422	Integer	H6 voltage	‰	V_{L1} H6		452	Integer	H6 voltage phase angle	°/10	V_{L1} H6φ
423	Integer	H7 voltage	‰	V_{L1} H7		453	Integer	H7 voltage phase angle	°/10	V_{L1} H7φ
424	Integer	H8 voltage	‰	V_{L1} H8		454	Integer	H8 voltage phase angle	°/10	V_{L1} H8φ
425	Integer	H9 voltage	‰	V_{L1} H9		455	Integer	H9 voltage phase angle	°/10	V_{L1} H9φ
426	Integer	H10 voltage	‰	V_{L1} H10		456	Integer	H10 voltage phase angle	°/10	V_{L1} H10φ
427	Integer	H11 voltage	‰	V_{L1} H11		457	Integer	H11 voltage phase angle	°/10	V_{L1} H11φ
428	Integer	H12 voltage	‰	V_{L1} H12		458	Integer	H12 voltage phase angle	°/10	V_{L1} H12φ
429	Integer	H13 voltage	‰	V_{L1} H13		459	Integer	H13 voltage phase angle	°/10	V_{L1} H13φ
430	Integer	H14 voltage	‰	V_{L1} H14		460	Integer	H14 voltage phase angle	°/10	V_{L1} H14φ
431	Integer	H15 voltage	‰	V_{L1} H15		461	Integer	H15 voltage phase angle	°/10	V_{L1} H15φ
432	Integer	H16 voltage	‰	V_{L1} H16		462	Integer	H16 voltage phase angle	°/10	V_{L1} H16φ
433	Integer	H17 voltage	‰	V_{L1} H17		463	Integer	H17 voltage phase angle	°/10	V_{L1} H17φ
434	Integer	H18 voltage	‰	V_{L1} H18		464	Integer	H18 voltage phase angle	°/10	V_{L1} H18φ
435	Integer	H19 voltage	‰	V_{L1} H19		465	Integer	H19 voltage phase angle	°/10	V_{L1} H19φ
436	Integer	H20 voltage	‰	V_{L1} H20		466	Integer	H20 voltage phase angle	°/10	V_{L1} H20φ
437	Integer	H21 voltage	‰	V_{L1} H21		467	Integer	H21 voltage phase angle	°/10	V_{L1} H21φ
438	Integer	H22 voltage	‰	V_{L1} H22		468	Integer	H22 voltage phase angle	°/10	V_{L1} H22φ
439	Integer	H23 voltage	‰	V_{L1} H23		469	Integer	H23 voltage phase angle	°/10	V_{L1} H23φ
440	Integer	H24 voltage	‰	V_{L1} H24		470	Integer	H24 voltage phase angle	°/10	V_{L1} H24φ
441	Integer	H25 voltage	‰	V_{L1} H25		471	Integer	H25 voltage phase angle	°/10	V_{L1} H25φ
442	Integer	H26 voltage	‰	V_{L1} H26		472	Integer	H26 voltage phase angle	°/10	V_{L1} H26φ
443	Integer	H27 voltage	‰	V_{L1} H27		473	Integer	H27 voltage phase angle	°/10	V_{L1} H27φ
444	Integer	H28 voltage	‰	V_{L1} H28		474	Integer	H28 voltage phase angle	°/10	V_{L1} H28φ
445	Integer	H29 voltage	‰	V_{L1} H29		475	Integer	H29 voltage phase angle	°/10	V_{L1} H29φ
446	Integer	H30 voltage	‰	V_{L1} H30		476	Integer	H30 voltage phase angle	°/10	V_{L1} H30φ
447	Integer	H31 voltage	‰	V_{L1} H31		477	Integer	H31 voltage phase angle	°/10	V_{L1} H31φ

Harmonics on current phase L1										
Current value as % of the fundamental						Phase angle referred to the fundamental of the voltage on phase L1				
Addr	**Type**	**Description**	**Unit**	**Symbol**		**Addr**	**Type**	**Description**	**Unit**	**Symbol**
478	Integer	H2 current	‰	I_{L1} H2		508	Integer	H2 current phase angle	°/10	I_{L1} H2φ
479	Integer	H3 current	‰	I_{L1} H3		509	Integer	H3 current phase angle	°/10	I_{L1} H3φ
480	Integer	H4 current	‰	I_{L1} H4		510	Integer	H4 current phase angle	°/10	I_{L1} H4φ
481	Integer	H5 current	‰	I_{L1} H5		511	Integer	H5 current phase angle	°/10	I_{L1} H5φ
482	Integer	H6 current	‰	I_{L1} H6		512	Integer	H6 current phase angle	°/10	I_{L1} H6φ
483	Integer	H7 current	‰	I_{L1} H7		513	Integer	H7 current phase angle	°/10	I_{L1} H7φ
484	Integer	H8 current	‰	I_{L1} H8		514	Integer	H8 current phase angle	°/10	I_{L1} H8φ
485	Integer	H9 current	‰	I_{L1} H9		515	Integer	H9 current phase angle	°/10	I_{L1} H9φ
486	Integer	H10 current	‰	I_{L1} H10		516	Integer	H10 current phase angle	°/10	I_{L1} H10φ
487	Integer	H11 current	‰	I_{L1} H11		517	Integer	H11 current phase angle	°/10	I_{L1} H11φ
488	Integer	H12 current	‰	I_{L1} H12		518	Integer	H12 current phase angle	°/10	I_{L1} H12φ
489	Integer	H13 current	‰	I_{L1} H13		519	Integer	H13 current phase angle	°/10	I_{L1} H13φ
490	Integer	H14 current	‰	I_{L1} H14		520	Integer	H14 current phase angle	°/10	I_{L1} H14φ
491	Integer	H15 current	‰	I_{L1} H15		521	Integer	H15 current phase angle	°/10	I_{L1} H15φ
492	Integer	H16 current	‰	I_{L1} H16		522	Integer	H16 current phase angle	°/10	I_{L1} H16φ
493	Integer	H17 current	‰	I_{L1} H17		523	Integer	H17 current phase angle	°/10	I_{L1} H17φ
494	Integer	H18 current	‰	I_{L1} H18		524	Integer	H18 current phase angle	°/10	I_{L1} H18φ
495	Integer	H19 current	‰	I_{L1} H19		525	Integer	H19 current phase angle	°/10	I_{L1} H19φ
496	Integer	H20 current	‰	I_{L1} H20		526	Integer	H20 current phase angle	°/10	I_{L1} H20φ
497	Integer	H21 current	‰	I_{L1} H21		527	Integer	H21 current phase angle	°/10	I_{L1} H21φ
498	Integer	H22 current	‰	I_{L1} H22		528	Integer	H22 current phase angle	°/10	I_{L1} H22φ
499	Integer	H23 current	‰	I_{L1} H23		529	Integer	H23 current phase angle	°/10	I_{L1} H23φ
500	Integer	H24 current	‰	I_{L1} H24		530	Integer	H24 current phase angle	°/10	I_{L1} H24φ
501	Integer	H25 current	‰	I_{L1} H25		531	Integer	H25 current phase angle	°/10	I_{L1} H25φ
502	Integer	H26 current	‰	I_{L1} H26		532	Integer	H26 current phase angle	°/10	I_{L1} H26φ
503	Integer	H27 current	‰	I_{L1} H27		533	Integer	H27 current phase angle	°/10	I_{L1} H27φ
504	Integer	H28 current	‰	I_{L1} H28		534	Integer	H28 current phase angle	°/10	I_{L1} H28φ
505	Integer	H29 current	‰	I_{L1} H29		535	Integer	H29 current phase angle	°/10	I_{L1} H29φ
506	Integer	H30 current	‰	I_{L1} H30		536	Integer	H30 current phase angle	°/10	I_{L1} H30φ
507	Integer	H31 current	‰	I_{L1} H31		537	Integer	H31 current phase angle	°/10	I_{L1} H31φ

Harmonics on voltage phase L2

Voltage value as % of the fundamental						Phase angle referred to the fundamental of the voltage on phase L1				
Addr	**Type**	**Description**	**Unit**	**Symbol**		**Addr**	**Type**	**Description**	**Unit**	**Symbol**
538	Integer	H2 voltage	‰	V_{L2} H2		568	Integer	H2 voltage phase angle	°/10	V_{L2} H2φ
539	Integer	H3 voltage	‰	V_{L2} H3		569	Integer	H3 voltage phase angle	°/10	V_{L2} H3φ
540	Integer	H4 voltage	‰	V_{L2} H4		570	Integer	H4 voltage phase angle	°/10	V_{L2} H4φ
541	Integer	H5 voltage	‰	V_{L2} H5		571	Integer	H5 voltage phase angle	°/10	V_{L2} H5φ
542	Integer	H6 voltage	‰	V_{L2} H6		572	Integer	H6 voltage phase angle	°/10	V_{L2} H6φ
543	Integer	H7 voltage	‰	V_{L2} H7		573	Integer	H7 voltage phase angle	°/10	V_{L2} H7φ
544	Integer	H8 voltage	‰	V_{L2} H8		574	Integer	H8 voltage phase angle	°/10	V_{L2} H8φ
545	Integer	H9 voltage	‰	V_{L2} H9		575	Integer	H9 voltage phase angle	°/10	V_{L2} H9φ
546	Integer	H10 voltage	‰	V_{L2} H10		576	Integer	H10 voltage phase angle	°/10	V_{L2} H10φ
547	Integer	H11 voltage	‰	V_{L2} H11		577	Integer	H11 voltage phase angle	°/10	V_{L2} H11φ
548	Integer	H12 voltage	‰	V_{L2} H12		578	Integer	H12 voltage phase angle	°/10	V_{L2} H12φ
549	Integer	H13 voltage	‰	V_{L2} H13		579	Integer	H13 voltage phase angle	°/10	V_{L2} H13φ
550	Integer	H14 voltage	‰	V_{L2} H14		580	Integer	H14 voltage phase angle	°/10	V_{L2} H14φ
551	Integer	H15 voltage	‰	V_{L2} H15		581	Integer	H15 voltage phase angle	°/10	V_{L2} H15φ
552	Integer	H16 voltage	‰	V_{L2} H16		582	Integer	H16 voltage phase angle	°/10	V_{L2} H16φ
553	Integer	H17 voltage	‰	V_{L2} H17		583	Integer	H17 voltage phase angle	°/10	V_{L2} H17φ
554	Integer	H18 voltage	‰	V_{L2} H18		584	Integer	H18 voltage phase angle	°/10	V_{L2} H18φ
555	Integer	H19 voltage	‰	V_{L2} H19		585	Integer	H19 voltage phase angle	°/10	V_{L2} H19φ
556	Integer	H20 voltage	‰	V_{L2} H20		586	Integer	H20 voltage phase angle	°/10	V_{L2} H20φ
557	Integer	H21 voltage	‰	V_{L2} H21		587	Integer	H21 voltage phase angle	°/10	V_{L2} H21φ
558	Integer	H22 voltage	‰	V_{L2} H22		588	Integer	H22 voltage phase angle	°/10	V_{L2} H22φ
559	Integer	H23 voltage	‰	V_{L2} H23		589	Integer	H23 voltage phase angle	°/10	V_{L2} H23φ
560	Integer	H24 voltage	‰	V_{L2} H24		590	Integer	H24 voltage phase angle	°/10	V_{L2} H24φ
561	Integer	H25 voltage	‰	V_{L2} H25		591	Integer	H25 voltage phase angle	°/10	V_{L2} H25φ
562	Integer	H26 voltage	‰	V_{L2} H26		592	Integer	H26 voltage phase angle	°/10	V_{L2} H26φ
563	Integer	H27 voltage	‰	V_{L2} H27		593	Integer	H27 voltage phase angle	°/10	V_{L2} H27φ
564	Integer	H28 voltage	‰	V_{L2} H28		594	Integer	H28 voltage phase angle	°/10	V_{L2} H28φ
565	Integer	H29 voltage	‰	V_{L2} H29		595	Integer	H29 voltage phase angle	°/10	V_{L2} H29φ
566	Integer	H30 voltage	‰	V_{L2} H30		596	Integer	H30 voltage phase angle	°/10	V_{L2} H30φ
567	Integer	H31 voltage	‰	V_{L2} H31		597	Integer	H31 voltage phase angle	°/10	V_{L2} H31φ

Harmonics on current phase L2

Current **value as % of the fundamental**						**Phase angle referred to the fundamental of the voltage on phase L1**				
Addr	**Type**	**Description**	**Unit**	**Symbol**		**Addr**	**Type**	**Description**	**Unit**	**Symbol**
598	Integer	H2 current	‰	I_{L2} H2		628	Integer	H2 current phase angle	°/10	I_{L2} H2φ
599	Integer	H3 current	‰	I_{L2} H3		629	Integer	H3 current phase angle	°/10	I_{L2} H3φ
600	Integer	H4 current	‰	I_{L2} H4		630	Integer	H4 current phase angle	°/10	I_{L2} H4φ
601	Integer	H5 current	‰	I_{L2} H5		631	Integer	H5 current phase angle	°/10	I_{L2} H5φ
602	Integer	H6 current	‰	I_{L2} H6		632	Integer	H6 current phase angle	°/10	I_{L2} H6φ
603	Integer	H7 current	‰	I_{L2} H7		633	Integer	H7 current phase angle	°/10	I_{L2} H7φ
604	Integer	H8 current	‰	I_{L2} H8		634	Integer	H8 current phase angle	°/10	I_{L2} H8φ
605	Integer	H9 current	‰	I_{L2} H9		635	Integer	H9 current phase angle	°/10	I_{L2} H9φ
606	Integer	H10 current	‰	I_{L2} H10		636	Integer	H10 current phase angle	°/10	I_{L2} H10φ
607	Integer	H11 current	‰	I_{L2} H11		637	Integer	H11 current phase angle	°/10	I_{L2} H11φ
608	Integer	H12 current	‰	I_{L2} H12		638	Integer	H12 current phase angle	°/10	I_{L2} H12φ
609	Integer	H13 current	‰	I_{L2} H13		639	Integer	H13 current phase angle	°/10	I_{L2} H13φ
610	Integer	H14 current	‰	I_{L2} H14		640	Integer	H14 current phase angle	°/10	I_{L2} H14φ
611	Integer	H15 current	‰	I_{L2} H15		641	Integer	H15 current phase angle	°/10	I_{L2} H15φ
612	Integer	H16 current	‰	I_{L2} H16		642	Integer	H16 current phase angle	°/10	I_{L2} H16φ
613	Integer	H17 current	‰	I_{L2} H17		643	Integer	H17 current phase angle	°/10	I_{L2} H17φ
614	Integer	H18 current	‰	I_{L2} H18		644	Integer	H18 current phase angle	°/10	I_{L2} H18φ
615	Integer	H19 current	‰	I_{L2} H19		645	Integer	H19 current phase angle	°/10	I_{L2} H19φ
616	Integer	H20 current	‰	I_{L2} H20		646	Integer	H20 current phase angle	°/10	I_{L2} H20φ
617	Integer	H21 current	‰	I_{L2} H21		647	Integer	H21 current phase angle	°/10	I_{L2} H21φ
618	Integer	H22 current	‰	I_{L2} H22		648	Integer	H22 current phase angle	°/10	I_{L2} H22φ
619	Integer	H23 current	‰	I_{L2} H23		649	Integer	H23 current phase angle	°/10	I_{L2} H23φ
620	Integer	H24 current	‰	I_{L2} H24		650	Integer	H24 current phase angle	°/10	I_{L2} H24φ
621	Integer	H25 current	‰	I_{L2} H25		651	Integer	H25 current phase angle	°/10	I_{L2} H25φ
622	Integer	H26 current	‰	I_{L2} H26		652	Integer	H26 current phase angle	°/10	I_{L2} H26φ
623	Integer	H27 current	‰	I_{L2} H27		653	Integer	H27 current phase angle	°/10	I_{L2} H27φ
624	Integer	H28 current	‰	I_{L2} H28		654	Integer	H28 current phase angle	°/10	I_{L2} H28φ
625	Integer	H29 current	‰	I_{L2} H29		655	Integer	H29 current phase angle	°/10	I_{L2} H29φ
626	Integer	H30 current	‰	I_{L2} H30		656	Integer	H30 current phase angle	°/10	I_{L2} H30φ
627	Integer	H31 current	‰	I_{L2} H31		657	Integer	H31 current phase angle	°/10	I_{L2} H31φ

Harmonics on voltage phase L3

Voltage value as % of the fundamental						Phase angle referred to the fundamental of the voltage on phase L1				
Addr	**Type**	**Description**	**Unit**	**Symbol**		**Addr**	**Type**	**Description**	**Unit**	**Symbol**
658	Integer	H2 voltage	‰	V_{L3} H2		688	Integer	H2 voltage phase angle	°/10	V_{L3} H2φ
659	Integer	H3 voltage	‰	V_{L3} H3		689	Integer	H3 voltage phase angle	°/10	V_{L3} H3φ
660	Integer	H4 voltage	‰	V_{L3} H4		690	Integer	H4 voltage phase angle	°/10	V_{L3} H4φ
661	Integer	H5 voltage	‰	V_{L3} H5		691	Integer	H5 voltage phase angle	°/10	V_{L3} H5φ
662	Integer	H6 voltage	‰	V_{L3} H6		692	Integer	H6 voltage phase angle	°/10	V_{L3} H6φ
663	Integer	H7 voltage	‰	V_{L3} H7		693	Integer	H7 voltage phase angle	°/10	V_{L3} H7φ
664	Integer	H8 voltage	‰	V_{L3} H8		694	Integer	H8 voltage phase angle	°/10	V_{L3} H8φ
665	Integer	H9 voltage	‰	V_{L3} H9		695	Integer	H9 voltage phase angle	°/10	V_{L3} H9φ
666	Integer	H10 voltage	‰	V_{L3} H10		696	Integer	H10 voltage phase angle	°/10	V_{L3} H10φ
667	Integer	H11 voltage	‰	V_{L3} H11		697	Integer	H11 voltage phase angle	°/10	V_{L3} H11φ
668	Integer	H12 voltage	‰	V_{L3} H12		698	Integer	H12 voltage phase angle	°/10	V_{L3} H12φ
669	Integer	H13 voltage	‰	V_{L3} H13		699	Integer	H13 voltage phase angle	°/10	V_{L3} H13φ
670	Integer	H14 voltage	‰	V_{L3} H14		700	Integer	H14 voltage phase angle	°/10	V_{L3} H14φ
671	Integer	H15 voltage	‰	V_{L3} H15		701	Integer	H15 voltage phase angle	°/10	V_{L3} H15φ
672	Integer	H16 voltage	‰	V_{L3} H16		702	Integer	H16 voltage phase angle	°/10	V_{L3} H16φ
673	Integer	H17 voltage	‰	V_{L3} H17		703	Integer	H17 voltage phase angle	°/10	V_{L3} H17φ
674	Integer	H18 voltage	‰	V_{L3} H18		704	Integer	H18 voltage phase angle	°/10	V_{L3} H18φ
675	Integer	H19 voltage	‰	V_{L3} H19		705	Integer	H19 voltage phase angle	°/10	V_{L3} H19φ
676	Integer	H20 voltage	‰	V_{L3} H20		706	Integer	H20 voltage phase angle	°/10	V_{L3} H20φ
677	Integer	H21 voltage	‰	V_{L3} H21		707	Integer	H21 voltage phase angle	°/10	V_{L3} H21φ
678	Integer	H22 voltage	‰	V_{L3} H22		708	Integer	H22 voltage phase angle	°/10	V_{L3} H22φ
679	Integer	H23 voltage	‰	V_{L3} H23		709	Integer	H23 voltage phase angle	°/10	V_{L3} H23φ
680	Integer	H24 voltage	‰	V_{L3} H24		710	Integer	H24 voltage phase angle	°/10	V_{L3} H24φ
681	Integer	H25 voltage	‰	V_{L3} H25		711	Integer	H25 voltage phase angle	°/10	V_{L3} H25φ
682	Integer	H26 voltage	‰	V_{L3} H26		712	Integer	H26 voltage phase angle	°/10	V_{L3} H26φ
683	Integer	H27 voltage	‰	V_{L3} H27		713	Integer	H27 voltage phase angle	°/10	V_{L3} H27φ
684	Integer	H28 voltage	‰	V_{L3} H28		714	Integer	H28 voltage phase angle	°/10	V_{L3} H28φ
685	Integer	H29 voltage	‰	V_{L3} H29		715	Integer	H29 voltage phase angle	°/10	V_{L3} H29φ
686	Integer	H30 voltage	‰	V_{L3} H30		716	Integer	H30 voltage phase angle	°/10	V_{L3} H30φ
687	Integer	H31 voltage	‰	V_{L3} H31		717	Integer	H31 voltage phase angle	°/10	V_{L3} H31φ

Harmonics on current phase L3										
Current value as % of the fundamental						Phase angle referred to the fundamental of the voltage on phase L1				
Addr	**Type**	**Description**	**Unit**	**Symbol**		**Addr**	**Type**	**Description**	**Unit**	**Symbol**
718	Integer	H2 current	‰	I_{L3} H2		748	Integer	H2 current phase angle	°/10	I_{L3} H2φ
719	Integer	H3 current	‰	I_{L3} H3		749	Integer	H3 current phase angle	°/10	I_{L3} H3φ
720	Integer	H4 current	‰	I_{L3} H4		750	Integer	H4 current phase angle	°/10	I_{L3} H4φ
721	Integer	H5 current	‰	I_{L3} H5		751	Integer	H5 current phase angle	°/10	I_{L3} H5φ
722	Integer	H6 current	‰	I_{L3} H6		752	Integer	H6 current phase angle	°/10	I_{L3} H6φ
723	Integer	H7 current	‰	I_{L3} H7		753	Integer	H7 current phase angle	°/10	I_{L3} H7φ
724	Integer	H8 current	‰	I_{L3} H8		754	Integer	H8 current phase angle	°/10	I_{L3} H8φ
725	Integer	H9 current	‰	I_{L3} H9		755	Integer	H9 current phase angle	°/10	I_{L3} H9φ
726	Integer	H10 current	‰	I_{L3} H10		756	Integer	H10 current phase angle	°/10	I_{L3} H10φ
727	Integer	H11 current	‰	I_{L3} H11		757	Integer	H11 current phase angle	°/10	I_{L3} H11φ
728	Integer	H12 current	‰	I_{L3} H12		758	Integer	H12 current phase angle	°/10	I_{L3} H12φ
729	Integer	H13 current	‰	I_{L3} H13		759	Integer	H13 current phase angle	°/10	I_{L3} H13φ
730	Integer	H14 current	‰	I_{L3} H14		760	Integer	H14 current phase angle	°/10	I_{L3} H14φ
731	Integer	H15 current	‰	I_{L3} H15		761	Integer	H15 current phase angle	°/10	I_{L3} H15φ
732	Integer	H16 current	‰	I_{L3} H16		762	Integer	H16 current phase angle	°/10	I_{L3} H16φ
733	Integer	H17 current	‰	I_{L3} H17		763	Integer	H17 current phase angle	°/10	I_{L3} H17φ
734	Integer	H18 current	‰	I_{L3} H18		764	Integer	H18 current phase angle	°/10	I_{L3} H18φ
735	Integer	H19 current	‰	I_{L3} H19		765	Integer	H19 current phase angle	°/10	I_{L3} H19φ
736	Integer	H20 current	‰	I_{L3} H20		766	Integer	H20 current phase angle	°/10	I_{L3} H20φ
737	Integer	H21 current	‰	I_{L3} H21		767	Integer	H21 current phase angle	°/10	I_{L3} H21φ
738	Integer	H22 current	‰	I_{L3} H22		768	Integer	H22 current phase angle	°/10	I_{L3} H22φ
739	Integer	H23 current	‰	I_{L3} H23		769	Integer	H23 current phase angle	°/10	I_{L3} H23φ
740	Integer	H24 current	‰	I_{L3} H24		770	Integer	H24 current phase angle	°/10	I_{L3} H24φ
741	Integer	H25 current	‰	I_{L3} H25		771	Integer	H25 current phase angle	°/10	I_{L3} H25φ
742	Integer	H26 current	‰	I_{L3} H26		772	Integer	H26 current phase angle	°/10	I_{L3} H26φ
743	Integer	H27 current	‰	I_{L3} H27		773	Integer	H27 current phase angle	°/10	I_{L3} H27φ
744	Integer	H28 current	‰	I_{L3} H28		774	Integer	H28 current phase angle	°/10	I_{L3} H28φ
745	Integer	H29 current	‰	I_{L3} H29		775	Integer	H29 current phase angle	°/10	I_{L3} H29φ
746	Integer	H30 current	‰	I_{L3} H30		776	Integer	H30 current phase angle	°/10	I_{L3} H30φ
747	Integer	H31 current	‰	I_{L3} H31		777	Integer	H31 current phase angle	°/10	I_{L3} H31φ

6 Technical specification

Harmonics range:

Odd and Even harmonics up to 31st order

Parameters:

Voltage and Current harmonics per phase, power and direction (where applicable), per order, per phase depending upon wiring configuration

- In 3P-4W configuration, the readings relate to the three phase-to-neutral voltages and to the three line currents.
- In 3P-4W-BAL configuration, the readings relate to V1 and I1 only
- In 3P-3W configuration, the readings relate to the three phase-to-phase voltages and to the three line currents. The readings of power are not available in this configuration.
- In 3P-3W-BAL configuration, the readings relate to V11 and I3 only. The readings of power are not available in this configuration.

Sampling:

PLL synchronised with the frequency of voltage 1st order on input 1.

Sampling frequency:

64 x f (where f = voltage fundamental on L1 input; $45 \leq f \leq 65$ Hz);

AD converter resolution:

10 bits

FFT size:

64 points

FFT calculation accuracy:

32 bits

Windowing:

rectangular

Parameters up date interval:

approx. 1 s

6.1 Parameters

Voltage:

1st order amplitude in Volt
: 3 ½ digit floating-point indication and automatic (unit/kilo/Mega) multiplier.

1st order phase angle in degrees
: referred to 1st order voltage of phase 1; 3 ½ digit fixed dot indication, range –180.0 ÷ 180.0.

2nd to 31st order amplitudes in percent of 1st order value;
: 3 digit fixed dot indication, range 0.0 ÷ 100.0);

2nd to 31st order phase angle in degrees
: referred to corresponding 1st order harmonic; 3 digit fixed dot indication, range 0.0 ÷ 100.0);

Current:

1st order amplitude in Ampere
: 3 ½ digit floating-point indication and automatic (unit/kilo/Mega) multiplier.

1st order phase angle in degrees
: referred to 1st order voltage of phase; 3 ½ digit fixed dot indication, range –180.0 ÷ 180.0.

2nd to 31st order amplitudes in percent of 1st order value
: 3 digit fixed dot indication, range 0.0 ÷ 100.0);

2nd to 31st order phase angles in degrees
: referred to corresponding 1st order harmonic; 3 digit fixed dot indication, range 0.0 ÷ 100.0);

Power:

1st order amplitude in Watt
: 3 ½ digit floating-point indication and automatic (unit/kilo/Mega) multiplier.

2nd to 31st order amplitudes in percent of 1st order value
: 3 digit fixed dot indication, range 0.0 ÷ 100.0);

6.2 Accuracy

Voltage Harmonics:
1st order :± (0.1% Rng +1 LSD) from 50 to 500VRMS (at meter inputs); minimum measurement: 20V
2nd- 31st order : from ± 0.1% for order 02 to ± 2.0% for order 31; minimum measurement: 1%
Current harmonics:
1st order : ± (0.1% Rng + 1 LSD) from 100mA to 5ARMS (at meter inputs); minimum measurement: 20 mA
2nd-31st order : from ±0.1% for order 02 to ±2.0% for order 31; minimum measurement: 1%
Phase angle:
from ± 0,1 deg. for the 1st order up to ± 3,0 deg for the 31st order
Harmonics power:
1st order : ± (0.2% Rng + 2 LSD), range from 10W to 2.5kW
Sensitivity on V and I:
0,1 %
Minimum measurement:
1 %

7 Firmware revisions

Only the instruments that hold the operating firmware version 2.0 support the functions described in this instructions manual.

- 1st release

8 Ordering code

Type	*Description*	*Part Number*
FFT harmonics option	Harmonics analyses option	PFSW399-00

The S.No. of the instrument to be upgraded must be indicated with the order.

Preliminary
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Subject to modification without prior notice

AKSE SRL
Via Aldo Moro, 39
42100 Reggio Emilia (Re) ITALY
Tel : +39 0522 924244
Fax : +39 0522 924245
E-Mail : info@akse.it
Internet : www.akse.it