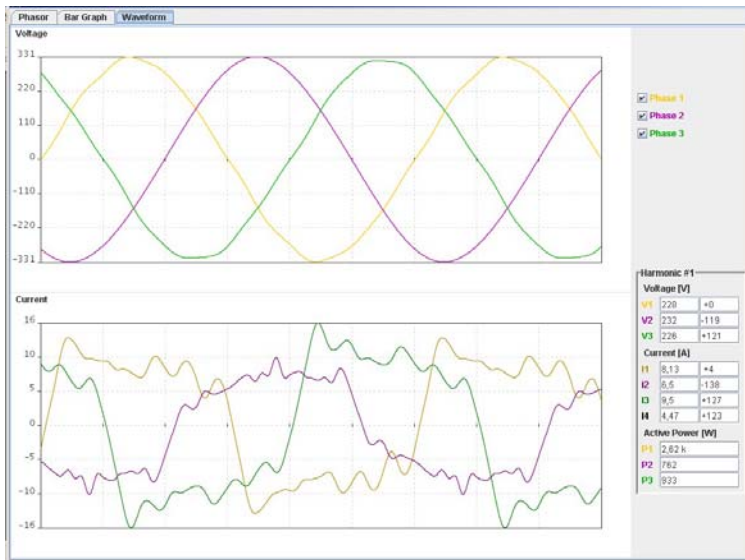


FFT HARMONICS OPTION

For instruments type
X3M, X3M-H, Flash-N, Flash-NH



Instructions manual

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1 Introduction

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

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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 Akse 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, X3M-H, Flash-N and Flash-NH (96x 96 flush 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 o s E ▼ ▲ keys).

- 1) Press the t key until the OPT 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 ! key must be used to confirm and exit.
- 4) The instrument displays "RSW#RN" to confirm a correct PUK code entry and the permanent enabling of the FFT harmonics option.
- 5) The "Hu#SXN" 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-priority, 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_{os} 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:

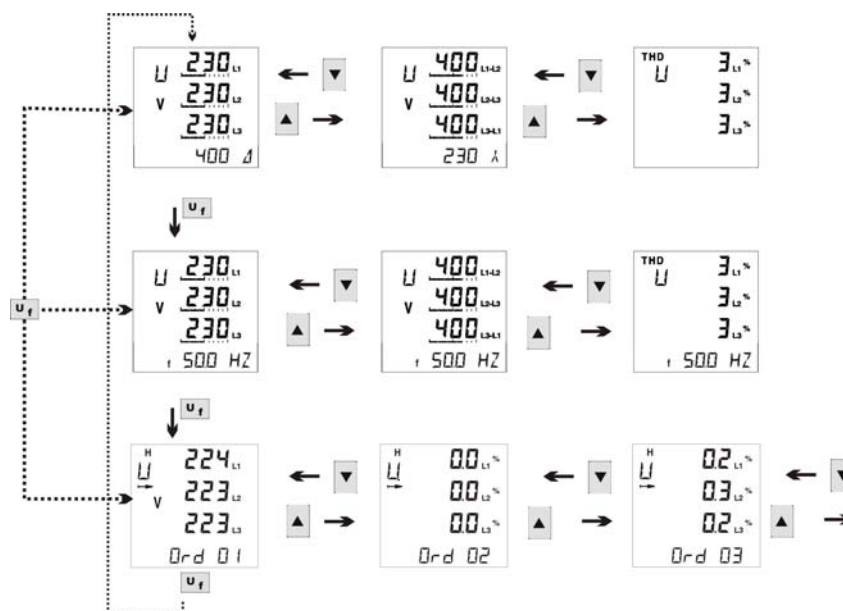
- phase-phase voltages and average phase-neutral system voltage and
- total harmonic distortion (THD-V) per phase

- a 3rd page, identified by the symbols **H** 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  key.



Several presses of the  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

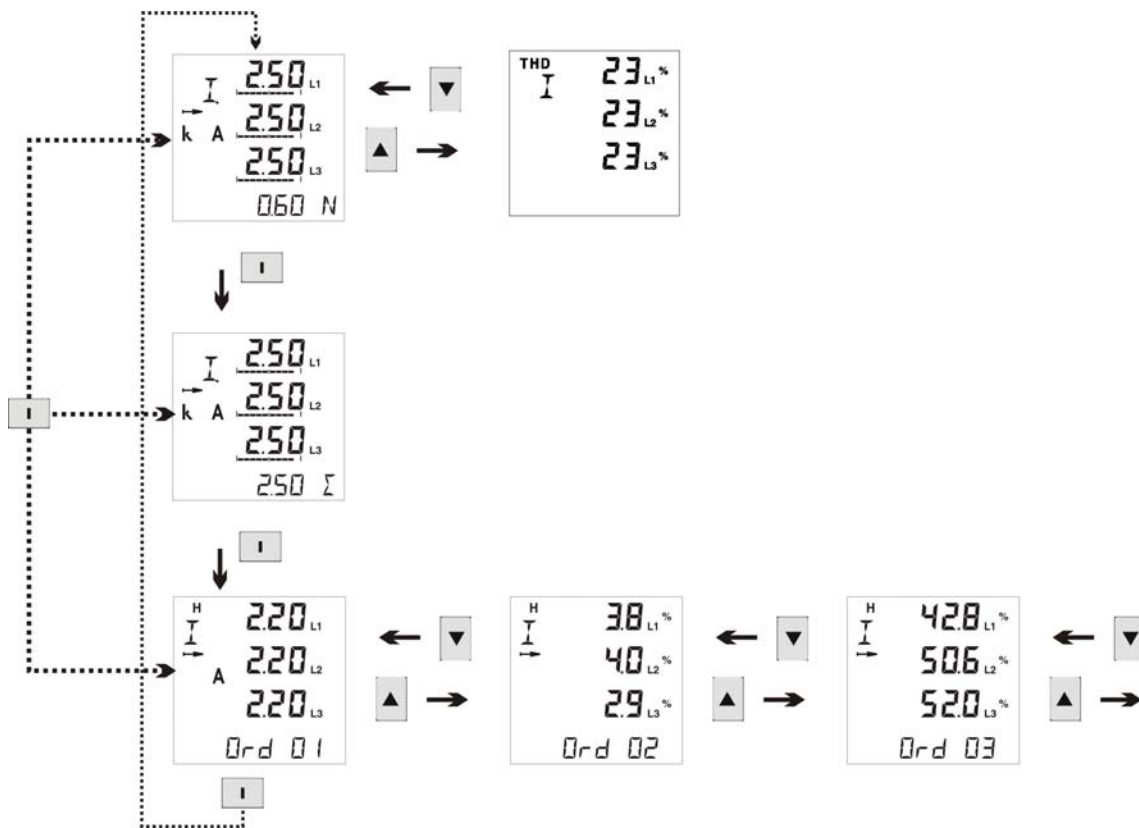
- Total Harmonic distortion (THD-I) per phase

- a 3rd page, identified by the symbol $K\#L$ 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_{Qs}** key.

Several pressures of the **P_{Qs}** 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 **Hz** 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.

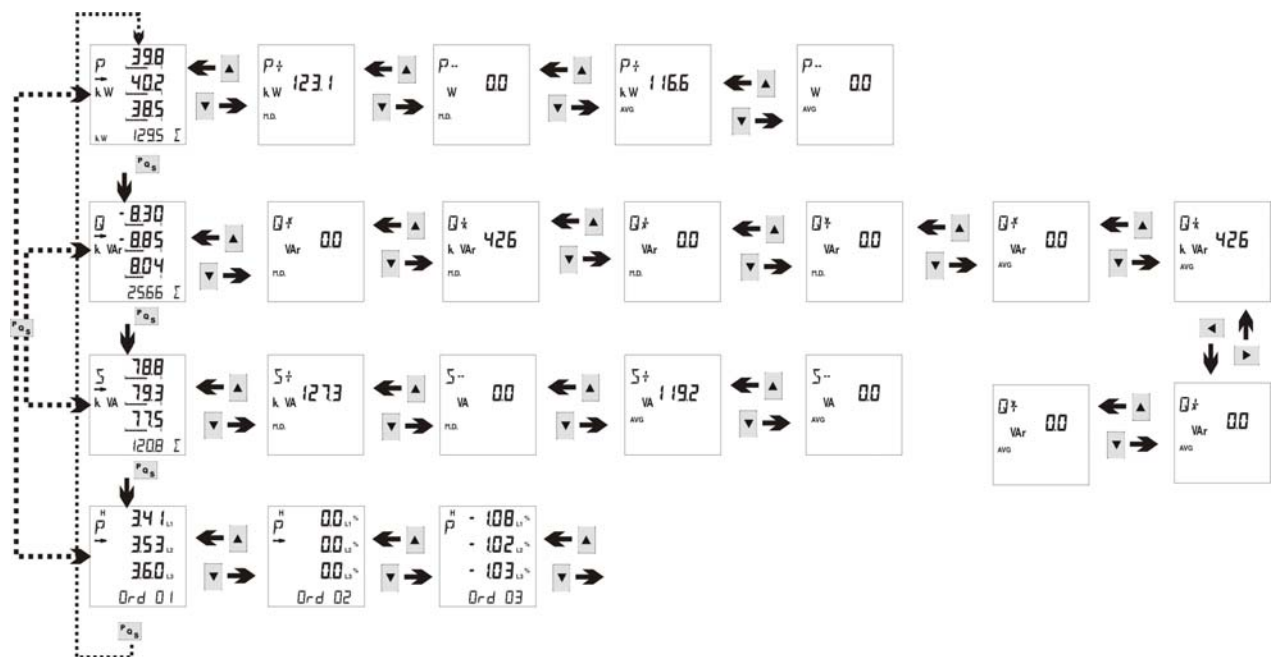
A power value with positive sign (no sign) indicates an harmonic flow from mains to load (*import*).

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 $\pm 180.0^\circ$ (H1)	$^\circ/10$	U_{L1} H1ϕ
413	Integer 16 bit signed	U_{L2} fundamental voltage phase angle $\pm 180.0^\circ$ (H1)	$^\circ/10$	U_{L2} H1ϕ
414	Integer 16 bit signed	U_{L3} fundamental voltage phase angle $\pm 180.0^\circ$ (H1)	$^\circ/10$	U_{L3} H1ϕ
415	Integer 16 bit signed	I_{L1} fundamental current phase angle $\pm 180.0^\circ$ (H1)	$^\circ/10$	I_{L1} H1ϕ
416	Integer 16 bit signed	I_{L2} fundamental current phase angle $\pm 180.0^\circ$ (H1)	$^\circ/10$	I_{L2} H1ϕ
417	Integer 16 bit signed	I_{L3} fundamental current phase angle $\pm 180.0^\circ$ (H1)	$^\circ/10$	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	$V_{L1} H2\phi$
419	Integer	H3 voltage	%	$V_{L1} H3$	449	Integer	H3 voltage phase angle	°/10	$V_{L1} H3\phi$
420	Integer	H4 voltage	%	$V_{L1} H4$	450	Integer	H4 voltage phase angle	°/10	$V_{L1} H4\phi$
421	Integer	H5 voltage	%	$V_{L1} H5$	451	Integer	H5 voltage phase angle	°/10	$V_{L1} H5\phi$
422	Integer	H6 voltage	%	$V_{L1} H6$	452	Integer	H6 voltage phase angle	°/10	$V_{L1} H6\phi$
423	Integer	H7 voltage	%	$V_{L1} H7$	453	Integer	H7 voltage phase angle	°/10	$V_{L1} H7\phi$
424	Integer	H8 voltage	%	$V_{L1} H8$	454	Integer	H8 voltage phase angle	°/10	$V_{L1} H8\phi$
425	Integer	H9 voltage	%	$V_{L1} H9$	455	Integer	H9 voltage phase angle	°/10	$V_{L1} H9\phi$
426	Integer	H10 voltage	%	$V_{L1} H10$	456	Integer	H10 voltage phase angle	°/10	$V_{L1} H10\phi$
427	Integer	H11 voltage	%	$V_{L1} H11$	457	Integer	H11 voltage phase angle	°/10	$V_{L1} H11\phi$
428	Integer	H12 voltage	%	$V_{L1} H12$	458	Integer	H12 voltage phase angle	°/10	$V_{L1} H12\phi$
429	Integer	H13 voltage	%	$V_{L1} H13$	459	Integer	H13 voltage phase angle	°/10	$V_{L1} H13\phi$
430	Integer	H14 voltage	%	$V_{L1} H14$	460	Integer	H14 voltage phase angle	°/10	$V_{L1} H14\phi$
431	Integer	H15 voltage	%	$V_{L1} H15$	461	Integer	H15 voltage phase angle	°/10	$V_{L1} H15\phi$
432	Integer	H16 voltage	%	$V_{L1} H16$	462	Integer	H16 voltage phase angle	°/10	$V_{L1} H16\phi$
433	Integer	H17 voltage	%	$V_{L1} H17$	463	Integer	H17 voltage phase angle	°/10	$V_{L1} H17\phi$
434	Integer	H18 voltage	%	$V_{L1} H18$	464	Integer	H18 voltage phase angle	°/10	$V_{L1} H18\phi$
435	Integer	H19 voltage	%	$V_{L1} H19$	465	Integer	H19 voltage phase angle	°/10	$V_{L1} H19\phi$
436	Integer	H20 voltage	%	$V_{L1} H20$	466	Integer	H20 voltage phase angle	°/10	$V_{L1} H20\phi$
437	Integer	H21 voltage	%	$V_{L1} H21$	467	Integer	H21 voltage phase angle	°/10	$V_{L1} H21\phi$
438	Integer	H22 voltage	%	$V_{L1} H22$	468	Integer	H22 voltage phase angle	°/10	$V_{L1} H22\phi$
439	Integer	H23 voltage	%	$V_{L1} H23$	469	Integer	H23 voltage phase angle	°/10	$V_{L1} H23\phi$
440	Integer	H24 voltage	%	$V_{L1} H24$	470	Integer	H24 voltage phase angle	°/10	$V_{L1} H24\phi$
441	Integer	H25 voltage	%	$V_{L1} H25$	471	Integer	H25 voltage phase angle	°/10	$V_{L1} H25\phi$
442	Integer	H26 voltage	%	$V_{L1} H26$	472	Integer	H26 voltage phase angle	°/10	$V_{L1} H26\phi$
443	Integer	H27 voltage	%	$V_{L1} H27$	473	Integer	H27 voltage phase angle	°/10	$V_{L1} H27\phi$
444	Integer	H28 voltage	%	$V_{L1} H28$	474	Integer	H28 voltage phase angle	°/10	$V_{L1} H28\phi$
445	Integer	H29 voltage	%	$V_{L1} H29$	475	Integer	H29 voltage phase angle	°/10	$V_{L1} H29\phi$
446	Integer	H30 voltage	%	$V_{L1} H30$	476	Integer	H30 voltage phase angle	°/10	$V_{L1} H30\phi$
447	Integer	H31 voltage	%	$V_{L1} H31$	477	Integer	H31 voltage phase angle	°/10	$V_{L1} H31\phi$

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	$V_{L2} H2\phi$
539	Integer	H3 voltage	%	$V_{L2} H3$	569	Integer	H3 voltage phase angle	°/10	$V_{L2} H3\phi$
540	Integer	H4 voltage	%	$V_{L2} H4$	570	Integer	H4 voltage phase angle	°/10	$V_{L2} H4\phi$
541	Integer	H5 voltage	%	$V_{L2} H5$	571	Integer	H5 voltage phase angle	°/10	$V_{L2} H5\phi$
542	Integer	H6 voltage	%	$V_{L2} H6$	572	Integer	H6 voltage phase angle	°/10	$V_{L2} H6\phi$
543	Integer	H7 voltage	%	$V_{L2} H7$	573	Integer	H7 voltage phase angle	°/10	$V_{L2} H7\phi$
544	Integer	H8 voltage	%	$V_{L2} H8$	574	Integer	H8 voltage phase angle	°/10	$V_{L2} H8\phi$
545	Integer	H9 voltage	%	$V_{L2} H9$	575	Integer	H9 voltage phase angle	°/10	$V_{L2} H9\phi$
546	Integer	H10 voltage	%	$V_{L2} H10$	576	Integer	H10 voltage phase angle	°/10	$V_{L2} H10\phi$
547	Integer	H11 voltage	%	$V_{L2} H11$	577	Integer	H11 voltage phase angle	°/10	$V_{L2} H11\phi$
548	Integer	H12 voltage	%	$V_{L2} H12$	578	Integer	H12 voltage phase angle	°/10	$V_{L2} H12\phi$
549	Integer	H13 voltage	%	$V_{L2} H13$	579	Integer	H13 voltage phase angle	°/10	$V_{L2} H13\phi$
550	Integer	H14 voltage	%	$V_{L2} H14$	580	Integer	H14 voltage phase angle	°/10	$V_{L2} H14\phi$
551	Integer	H15 voltage	%	$V_{L2} H15$	581	Integer	H15 voltage phase angle	°/10	$V_{L2} H15\phi$
552	Integer	H16 voltage	%	$V_{L2} H16$	582	Integer	H16 voltage phase angle	°/10	$V_{L2} H16\phi$
553	Integer	H17 voltage	%	$V_{L2} H17$	583	Integer	H17 voltage phase angle	°/10	$V_{L2} H17\phi$
554	Integer	H18 voltage	%	$V_{L2} H18$	584	Integer	H18 voltage phase angle	°/10	$V_{L2} H18\phi$
555	Integer	H19 voltage	%	$V_{L2} H19$	585	Integer	H19 voltage phase angle	°/10	$V_{L2} H19\phi$
556	Integer	H20 voltage	%	$V_{L2} H20$	586	Integer	H20 voltage phase angle	°/10	$V_{L2} H20\phi$
557	Integer	H21 voltage	%	$V_{L2} H21$	587	Integer	H21 voltage phase angle	°/10	$V_{L2} H21\phi$
558	Integer	H22 voltage	%	$V_{L2} H22$	588	Integer	H22 voltage phase angle	°/10	$V_{L2} H22\phi$
559	Integer	H23 voltage	%	$V_{L2} H23$	589	Integer	H23 voltage phase angle	°/10	$V_{L2} H23\phi$
560	Integer	H24 voltage	%	$V_{L2} H24$	590	Integer	H24 voltage phase angle	°/10	$V_{L2} H24\phi$
561	Integer	H25 voltage	%	$V_{L2} H25$	591	Integer	H25 voltage phase angle	°/10	$V_{L2} H25\phi$
562	Integer	H26 voltage	%	$V_{L2} H26$	592	Integer	H26 voltage phase angle	°/10	$V_{L2} H26\phi$
563	Integer	H27 voltage	%	$V_{L2} H27$	593	Integer	H27 voltage phase angle	°/10	$V_{L2} H27\phi$
564	Integer	H28 voltage	%	$V_{L2} H28$	594	Integer	H28 voltage phase angle	°/10	$V_{L2} H28\phi$
565	Integer	H29 voltage	%	$V_{L2} H29$	595	Integer	H29 voltage phase angle	°/10	$V_{L2} H29\phi$
566	Integer	H30 voltage	%	$V_{L2} H30$	596	Integer	H30 voltage phase angle	°/10	$V_{L2} H30\phi$
567	Integer	H31 voltage	%	$V_{L2} H31$	597	Integer	H31 voltage phase angle	°/10	$V_{L2} H31\phi$

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	$V_{L3} H2\phi$
659	Integer	H3 voltage	%	$V_{L3} H3$	689	Integer	H3 voltage phase angle	°/10	$V_{L3} H3\phi$
660	Integer	H4 voltage	%	$V_{L3} H4$	690	Integer	H4 voltage phase angle	°/10	$V_{L3} H4\phi$
661	Integer	H5 voltage	%	$V_{L3} H5$	691	Integer	H5 voltage phase angle	°/10	$V_{L3} H5\phi$
662	Integer	H6 voltage	%	$V_{L3} H6$	692	Integer	H6 voltage phase angle	°/10	$V_{L3} H6\phi$
663	Integer	H7 voltage	%	$V_{L3} H7$	693	Integer	H7 voltage phase angle	°/10	$V_{L3} H7\phi$
664	Integer	H8 voltage	%	$V_{L3} H8$	694	Integer	H8 voltage phase angle	°/10	$V_{L3} H8\phi$
665	Integer	H9 voltage	%	$V_{L3} H9$	695	Integer	H9 voltage phase angle	°/10	$V_{L3} H9\phi$
666	Integer	H10 voltage	%	$V_{L3} H10$	696	Integer	H10 voltage phase angle	°/10	$V_{L3} H10\phi$
667	Integer	H11 voltage	%	$V_{L3} H11$	697	Integer	H11 voltage phase angle	°/10	$V_{L3} H11\phi$
668	Integer	H12 voltage	%	$V_{L3} H12$	698	Integer	H12 voltage phase angle	°/10	$V_{L3} H12\phi$
669	Integer	H13 voltage	%	$V_{L3} H13$	699	Integer	H13 voltage phase angle	°/10	$V_{L3} H13\phi$
670	Integer	H14 voltage	%	$V_{L3} H14$	700	Integer	H14 voltage phase angle	°/10	$V_{L3} H14\phi$
671	Integer	H15 voltage	%	$V_{L3} H15$	701	Integer	H15 voltage phase angle	°/10	$V_{L3} H15\phi$
672	Integer	H16 voltage	%	$V_{L3} H16$	702	Integer	H16 voltage phase angle	°/10	$V_{L3} H16\phi$
673	Integer	H17 voltage	%	$V_{L3} H17$	703	Integer	H17 voltage phase angle	°/10	$V_{L3} H17\phi$
674	Integer	H18 voltage	%	$V_{L3} H18$	704	Integer	H18 voltage phase angle	°/10	$V_{L3} H18\phi$
675	Integer	H19 voltage	%	$V_{L3} H19$	705	Integer	H19 voltage phase angle	°/10	$V_{L3} H19\phi$
676	Integer	H20 voltage	%	$V_{L3} H20$	706	Integer	H20 voltage phase angle	°/10	$V_{L3} H20\phi$
677	Integer	H21 voltage	%	$V_{L3} H21$	707	Integer	H21 voltage phase angle	°/10	$V_{L3} H21\phi$
678	Integer	H22 voltage	%	$V_{L3} H22$	708	Integer	H22 voltage phase angle	°/10	$V_{L3} H22\phi$
679	Integer	H23 voltage	%	$V_{L3} H23$	709	Integer	H23 voltage phase angle	°/10	$V_{L3} H23\phi$
680	Integer	H24 voltage	%	$V_{L3} H24$	710	Integer	H24 voltage phase angle	°/10	$V_{L3} H24\phi$
681	Integer	H25 voltage	%	$V_{L3} H25$	711	Integer	H25 voltage phase angle	°/10	$V_{L3} H25\phi$
682	Integer	H26 voltage	%	$V_{L3} H26$	712	Integer	H26 voltage phase angle	°/10	$V_{L3} H26\phi$
683	Integer	H27 voltage	%	$V_{L3} H27$	713	Integer	H27 voltage phase angle	°/10	$V_{L3} H27\phi$
684	Integer	H28 voltage	%	$V_{L3} H28$	714	Integer	H28 voltage phase angle	°/10	$V_{L3} H28\phi$
685	Integer	H29 voltage	%	$V_{L3} H29$	715	Integer	H29 voltage phase angle	°/10	$V_{L3} H29\phi$
686	Integer	H30 voltage	%	$V_{L3} H30$	716	Integer	H30 voltage phase angle	°/10	$V_{L3} H30\phi$
687	Integer	H31 voltage	%	$V_{L3} H31$	717	Integer	H31 voltage phase angle	°/10	$V_{L3} H31\phi$

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 $-180.0 \div 180.0$.

2nd to 31st order amplitudes in percent of 1st order value;

3 digit fixed dot indication, range $0.0 \div 100.0$);

2nd to 31st order phase angle in degrees

referred to corresponding 1st order harmonic; 3 digit fixed dot indication, range $0.0 \div 100.0$);

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 $-180.0 \div 180.0$.

2nd to 31st order amplitudes in percent of 1st order value

3 digit fixed dot indication, range $0.0 \div 100.0$);

2nd to 31st order phase angles in degrees

referred to corresponding 1st order harmonic; 3 digit fixed dot indication, range $0.0 \div 100.0$);

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 $0.0 \div 100.0$);

6.2 Accuracy

Voltage Harmonics:

1st order : $\pm (0.1\% \text{ Rng} + 1 \text{ LSD})$ from 50 to 500VRMS (at meter inputs); minimum measurement: 20V
2nd- 31st order : from $\pm 0.1\%$ for order 02 to $\pm 2.0\%$ for order 31; minimum measurement: 1%

Current harmonics:

1st order : $\pm (0.1\% \text{ Rng} + 1 \text{ LSD})$ from 100mA to 5ARMS (at meter inputs); minimum measurement: 20 mA
2nd-31st order : from $\pm 0.1\%$ for order 02 to $\pm 2.0\%$ for order 31; minimum measurement: 1%

Phase angle:

from $\pm 0,1$ deg. for the 1st order up to $\pm 3,0$ deg for the 31st order

Harmonics power:

1st order : $\pm (0.2\% \text{ Rng} + 2 \text{ LSD})$, 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

<i>Type</i>	<i>Description</i>	<i>Part Number</i>
FFT harmonics option	Harmonics analyses option	PFSW399-00

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



*Preliminary
Version March 2006.
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