

SML 133

Multifunctional Meter

Operating Manual

Document revision	Release date	Valid for versions			
		hardware	bootloader	firmware	ENVIS
1.1	14.11.2019	2.6	4.0	3.0.27	1.8



The instrument measures line and phase voltages, currents, active, reactive and apparent powers, power factors, THD and harmonics of voltages and currents, as well as frequency in single-phase and three-phase low, medium and high voltage power systems.

Built-in electricity meter measures electric energy in four quadrants (both active and reactive energies), as well maximum active power demand.

The instrument further allows informative measurement of temperatures within a switchboard cabinet using an inbuilt temperature sensor.

Besides actual values, average values during preset time window are evaluated too. Maximum and minimum values of them are registered.

The instrument feature three voltage and three fully isolated current measuring inputs.

Nominal range of the voltage inputs can be in range from 57.7/100 up to 400/690 V_{AC}, optionally.

The current inputs are designed for indirect measurement only - they must be connected via external current transformers. The models with current-type inputs are available as either the „X/5A“, i.e. with 5 A_{AC} nominal range (for standard CTs), or the „X/100mA“ with nominal range of 0.1 A_{AC}. The „X/333mV“ models are determined either for CTs with output nominal voltage of 333 millivolts or for flexible current sensors (Rogowski coils) with embedded integrator and appropriate output voltage. Such models are equipped with auxiliary power supply of 5V for the sensors.

The instrument can be optionally equipped with two relays with programmable function or solid-state outputs that can be used as electricity meter impulse outputs and one digital input for general state monitoring.

Power supply of standard instrument models has universal range 85 ÷ 275 V_{AC} or 80 ÷ 350 V_{DC}.

Optional power supply range is 12 ÷ 48 V_{DC}.

The instruments can be equipped with an RS 485, Ethernet or M-Bus communication interface. Then the ENVIS software allows remotely viewing data measured. For custom design systems, the Modbus communication protocol can be used too.

LIST OF CONTENTS

1. PUTTING IN OPERATION.....	6
1.1 Meaning of the symbols used on instrument.....	6
1.2 Instrument Connection.....	6
1.2.1 Physical.....	6
1.2.2 Power Supply.....	7
1.2.3 Measured Voltages.....	7
1.2.4 Measured Currents.....	8
1.2.4.1 Current Type Current Inputs Instruments (Models „X/5A“, „X/100mA“).....	8
1.2.4.2 Voltage Type Current Inputs Instruments (Models „X/333mV“).....	8
1.3 Basic Operation.....	9
1.3.1 Setup.....	9
1.3.2 Measured Data.....	10
1.3.2.1 Average Values.....	12
1.3.2.2 Full Spectrum Values P/Q/PF & Fundamental Harmonic Values Pfh/Qfh/cos φ	13
1.3.2.3 Fundamental Harmonic Power Factor Formats $\cos\varphi/\tan\varphi/\varphi$	13
1.3.2.4 THDs and Harmonic Components.....	14
1.3.2.5 Electricity Meter.....	14
1.3.2.5.1 “4E+MD” Display Mode.....	14
1.3.2.5.2 “8E” Display Mode.....	15
1.3.3 Instrument State Symbols.....	15
1.3.4 Instrument Parameters.....	17
1.3.4.1 Main and Side Branch.....	17
1.3.5 Instrument Setup Locking / Unlocking.....	18
2. DETAILED OPERATION DESCRIPTION.....	19
2.1 Current and Voltage Multiplier.....	19
2.2 Method of Measurement.....	19
2.2.1 Voltage Fundamental Frequency Measurement Method.....	19
2.2.2 Voltage and Current Measurement Method.....	19
2.2.3 Harmonics and THD Evaluation Method.....	20
2.2.4 Power, Power Factor and Unbalance Evaluation Method.....	20
2.2.5 Temperature.....	22
2.2.6 “ The Fixscan” Mode.....	22
2.2.6.1 Function.....	23
2.3 Measured Values Evaluation and Aggregation.....	24
2.3.1 Actual Values Evaluation and Aggregation.....	24
2.3.2 Average Values Evaluation.....	24
2.3.3 Embedded Electricity Meter.....	25
2.3.3.1 Electric Energy Processing.....	25
2.3.3.2 Maximum Demand Registration.....	25
2.4 Display Contrast.....	25
3. DIGITAL INPUTS & OUTPUTS (I/O).....	26

3.1 I/O Connection.....	26
3.1.1 Power (Relay, RO) Output Connection.....	27
3.1.2 Signal (Solid-State, Transistor, DO) Output Connection.....	27
3.1.3 Digital Input Connection.....	27
3.2 Outputs Setup from the Instrument Panel.....	28
3.2.1 Pulse Output Mode.....	28
3.3 I/O Setup via Communication Link Using the ENVIS-Daq Program.....	29
3.3.1 I/O Setup Actions.....	30
3.3.1.1 Frequency Counters (FC).....	30
3.3.1.1.1 Frequency Mode.....	30
3.3.1.1.2 PWM Mode.....	31
3.3.1.2 Pulse Counters (PC).....	31
3.3.1.3 Digital Output (Standard).....	31
3.3.1.4 Pulse Output.....	32
3.3.1.5 Alarm Light.....	32
3.3.2 I/O Setup Conditions.....	33
3.3.2.1 Digital Input Condition.....	33
3.3.2.2 Measured Quantity Condition.....	33
3.4 I/O Processing.....	34
3.4.1 Digital Inputs.....	34
3.4.1.1 Digital Input Filter.....	34
3.4.1.2 Digital Input as Frequency Counter.....	34
3.4.1.2.1 "Frequency" Mode.....	34
3.4.1.2.2 "PWM" Mode.....	34
3.4.1.3 Digital Input as Pulse Counter.....	34
3.4.2 Digital Outputs.....	35
3.4.2.1 Pulse Outputs.....	35
4. COMPUTER CONTROLLED OPERATION.....	36
4.1 Communication Interface.....	36
4.1.1 RS-485 Interface (COM).....	36
4.1.1.1 Communication Cable.....	36
4.1.1.2 Terminating Resistors.....	36
4.1.2 Ethernet Interface (ETH).....	36
4.1.3 M-Bus Interface (M-BUS).....	37
4.2 Communication Protocols.....	37
4.2.1 KMB Communications Protocol.....	37
4.2.2 Modbus Communications Protocol.....	37
4.2.3 M-Bus Communications Protocol.....	37
4.2.4 Embedded Webserver.....	37
4.3 The ENVIS Program.....	38
5. EXAMPLES OF CONNECTIONS.....	39
6. MANUFACTURED MODELS AND MARKING.....	45
7. TECHNICAL SPECIFICATIONS.....	46

8. MAINTENANCE, SERVICE.....54

1. Putting in Operation

1.1 Meaning of the symbols used on instrument



Warning – read operating manual !



AC – alternating voltage



DC – direct voltage



CE marking guarantees compliance with the European directives and regulations



The instrument must not be disposed of in the normal unsorted municipal waste stream



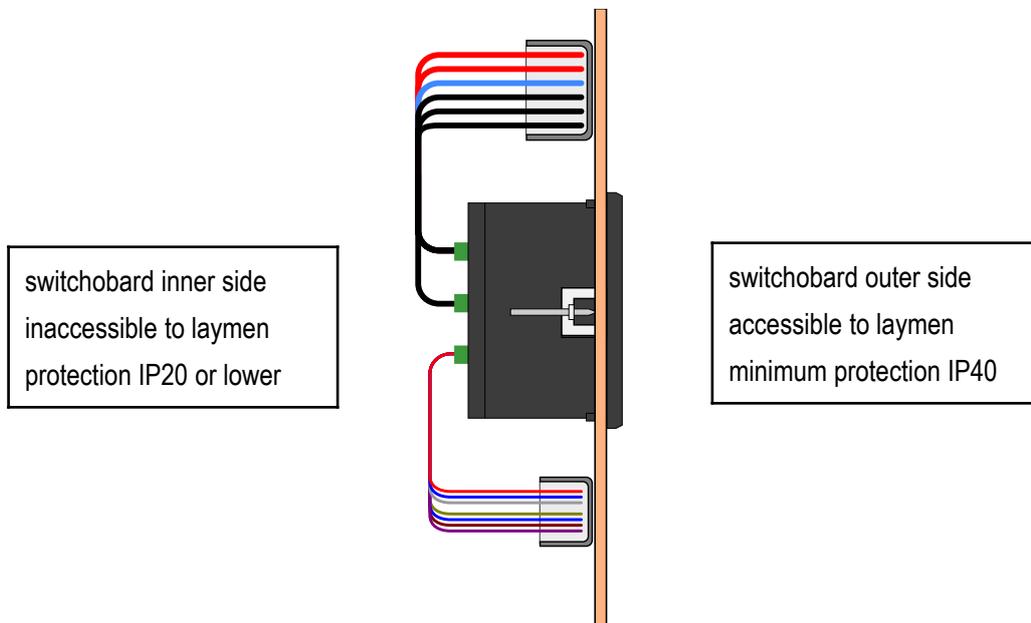
Double or reinforced insulation instrument

1.2 Instrument Connection

1.2.1 Physical

The instrument is built in a plastic box to be installed in a distribution board panel. As a rule, the panel is a part of a switchboard door - then the installation must be such that the switchboard door can be closed under all conditions of use. In any case, it must be ensured that only the front panel of the instrument is accessible to laypersons. Therefore, if the switchgear is located in an area accessible to laypersons, the switchgear door or panel must only be opened by means of a tool, or the door must be locked.

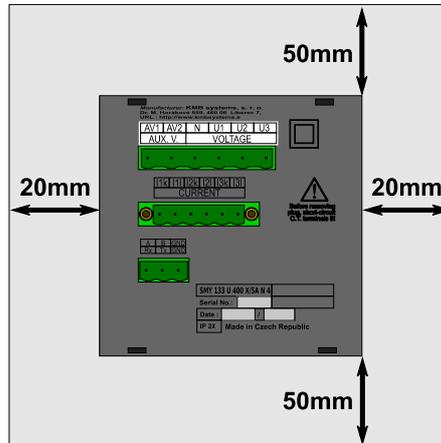
Panel Mounting



The instrument's position must be fixed with locks.

Natural air circulation should be provided inside the distribution board cabinet and in the instrument's neighbourhood no other instrumentation should be installed.

Space around the Instrument



Especially underneath the instrument, no other instrumentation that is source of heat should be installed or the temperature value measured may be false.

1.2.2 Power Supply

The supply voltage (in range according technical specifications) connects to terminals AV1 (No. 9) and AV2 (10) via a disconnecting device (switch – see wiring diagram). It must be located at the instrument's proximity and easily accessible by the operator. The disconnecting device must be marked as such. A two-pole circuit breaker with the C-type tripping characteristics rated at 1A makes a suitable disconnecting device. Its function and working positions, however, must be clearly marked.

In case of DC supply voltage the polarity of connection is generally free, but for maximum electromagnetic compatibility the grounded pole should be connected to the terminal AV2.

Recommended wire type : H07V-U (CY)

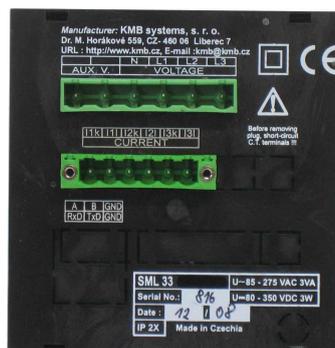
Recommended minimum conductor cross-section : 1.5 mm²

Maximum conductor cross-section : 2.5 mm²

1.2.3 Measured Voltages

The phase voltages measured are connected to terminals U1 (12), U2 (13), U3 (14), the common terminal to connect to the neutral wire is identified as N (11; it stays free at delta- (3D) and Aron- (3A) connections). It is suitable to protect the voltage lines measured for example with 1A fuses. Measured voltages can also be connected via instrument voltage transformers.

SML 133 U 400 X/5A Instrument Rear Panel



Recommended wire type : H07V-U (CY)

Recommended minimum conductor cross-section : 1.5 mm²

Maximum conductor cross-section : 2.5 mm²

1.2.4 Measured Currents

The instruments are designed for indirect current measurement via external CTs only. Proper current signal polarity (S1 & S2 terminals) must be observed. You can check the polarity by the sign of phase active powers on the instrument display (in case of energy transfer direction is known, of course).

In the P.01 parameter (see below), set the CT-ratio.

The I2 terminals stay free in case of the Aron (3A) connection.

1.2.4.1 Current Type Current Inputs Instruments (Models „X/5A“, „X/100mA“)

The current signals from 5A or 1A (or 0.1A for the „X/100mA“ models) instrument current transformers must be connected to the terminal pairs I11, I12, I21, I22, I31, I32 (No. 1 ÷ 6).

Recommended wire type: H05V-U (CY)

Recommended minimum conductor cross-section :

- “X/5A” instruments : 2.5 mm²
- “X/100mA” instruments : 0.75 mm²

Maximum conductor cross-section : 2.5 mm²

1.2.4.2 Voltage Type Current Inputs Instruments (Models „X/333mV“)

The instruments are equipped with separate connectors for particular measuring current input. Each connector has three terminals. Function of the terminals is described in following table :

“X/333mV“ Models Current Inputs Connection

terminal No.	signal
62	S11 ... signal corresponding to I1 current (in phase L1), CT terminal “S1”
65	S12 ... I2-S1 (phase L2)
68	S13 ... I3-S1 (phase L3)
63, 66, 69	SG ... common pole of the I1 ÷ I3 signals (CT terminals “S2”) and negative pole of the 5V built-in auxiliary power supply for current sensors (the terminals are interconnected)
61, 64, 67	SP... positive pole of the 5V built-in auxiliary power supply for current sensors (the terminals are interconnected)

The instruments are designed for cooperation with current transformers with output nominal voltage of 333 millivolts. They can be also used with flexible current sensors (Rogowski coils) with embedded integrator of appropriate voltage output signal.

The CTs must be connected with two-wire twisted cable. Again, proper current signal polarity (CT secondary terminals S1, S2) must be observed.

Recommended wire type : twisted pair, for example KU03G24 (Nexans)

Recommended minimum conductor cross-section: 0.2 mm²

Maximum conductor cross-section: 1.5 mm²



Maximum length of the cable is 3 metres !

The flexible current sensors with embedded integrator usually require a power supply. For such purpose the instruments are equipped with auxiliary power supply 5V. Maximum load of each sensor connected is 20 mA.



Connection of standard CTs with 5A or 1A nominal output current to the „X/333mV“ instruments is **forbidden** !!! Otherwise the instrument can be damaged !!!

1.3 Basic Operation

On connecting power supply the display shows all of the segments, then gradually screens with the instrument type and setting of basic parameters :

1. line 1 : **133** - instrument type number
line 2 : **5A** - current input type
line 3 : **r I** - digital output type : relay (**r**), pulse (**I**), or none (**n**)
2. when connection of voltage via voltage transformers set (otherwise the screen is skipped) :
line 1 : **U E** - voltage transformer connected identification
line 2 : nominal primary voltage [kV]
line 3 : nominal secondary voltage [kV]
3. line 1 : **C E** - current transformer/range specification
line 2 : nominal primary current [A]
line 3 : nominal secondary current [A]
4. line 1 : **F U** - nominal frequency and voltage
line 2 : nominal frequency
line 3 : nominal voltage

Then the instrument starts display actual measured values. Simultaneously, if the instrument has a communication line, the values can be read via the communication link using a PC.

1.3.1 Setup

At this moment it is necessary to set *instrument parameters* that are essential for proper instrument measurement :

- CT ratio – parameter 01 (and its multiplier, optionally)
- type of connection – parameter 02 (wye, delta, Aron)
- mode of connection – parameter 04 (direct or via VT, VT ratio and multiplier, optionally)
- nominal frequency f_{NOM} and nominal voltage U_{NOM} – double parameter 05

Usually, it is only necessary to adjust the CT ratio. Next example shows how to do it :

Assuming that the ratio of used CTs is 750/1 A. First off all, it is necessary to switch display from measured data branch (the ULN screen on the example below) to *the parameter branch* with the **P** button. The branch is indicated with the  symbol . Parameter 01 appears – this parameter is the CT ratio and its default value is 5/5 A.

Now enter editing mode by pressing and holding the **P** until the value gets flashing.

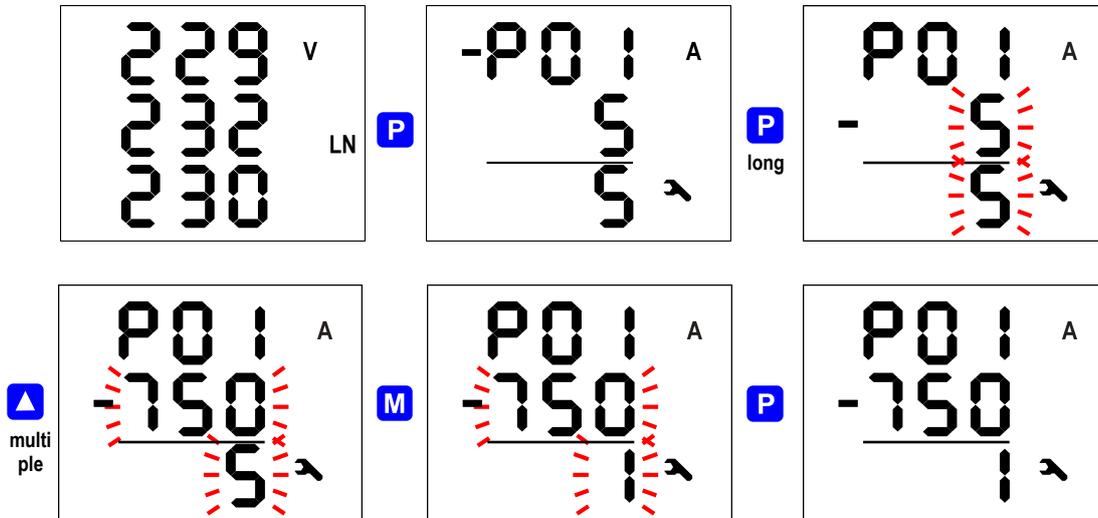
As soon as the value flashes, release the **P**. Now you can change it. Increase primary value by pressing of the **▲**. If you keep it pressed two-speed autorepeat helps to reach target value quickly. Then use multiple pressing of **▲** and **▼** for fine setup.

To change the secondary value, simply press the **M**. The button toggles between 5 and 1.

Target CT value is prepared now and we can leave the edit mode with (short) pressing the **P**. The value is stored into the instrument memory and the flashing stops.

Now return to so called main parameter branch (see description below) with next pressing the **P** and then you can scroll to other parameters with **▲** and **▼** and edit them in a similar way or you can return to the measured data branch with the **M**.

CT Ratio Change Procedure Example



The summary of all instrument parameters is stated in the table below. Their description is stated in following chapters.

1.3.2 Measured Data

The instrument starts display actual measured values on power-up. The screen that was selected before the last powerdown is displayed. You can navigate through all of measured and evaluated values with **▲**, **▼** and **M** buttons as shown on *the Measured Data Navigation Chart* below.

If phase values displayed, individual L1 / L2 / L3 - phase value is shown in the line 1 / 2 / 3. If a three-phase value is displayed, it is shown in the line 2 and the Σ symbol appears.

The quantities' meaning and evaluation formulas can be found in the appropriate chapter further below.

Most of data are arranged in four columns :

- Actual actual values, refreshed each 3 measurement cycles (30/36 mains cycles)
- Avg average values per appropriate averaging period (see below)
- AvgMax ... maximum of the avg-value reached since the last clearing
- AvgMin minimum of the avg-value reached since the last clearing

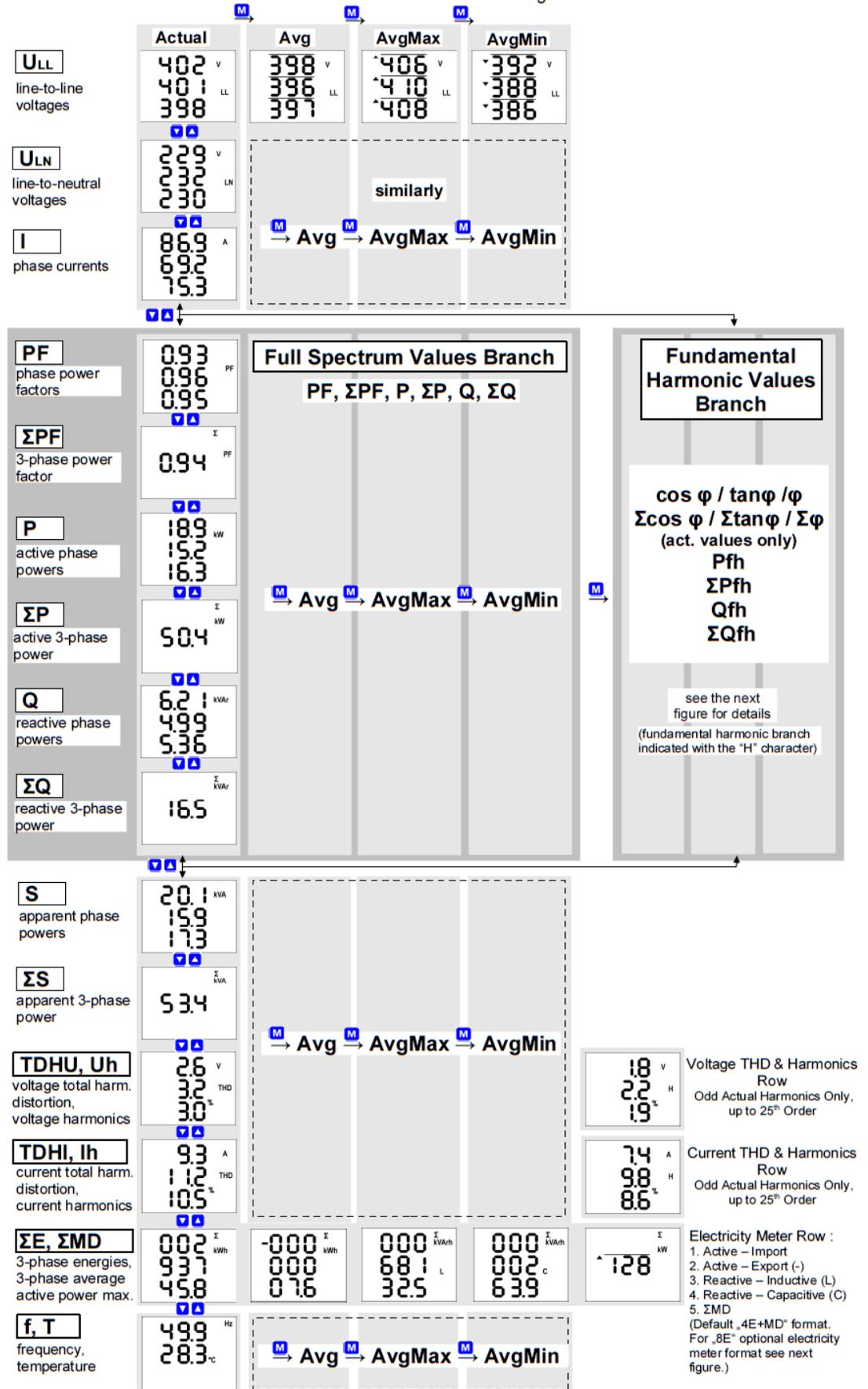
You can scroll inside a column down and up with the **▲** and **▼** keys and move horizontally from a column to the next right one cyclically with the **M** key.

Exception : Only actual values of harmonics and electrical energy are available. These values are arranged in different way – see further below.



If any of actual values of voltages or currents flashes, corresponding voltage / current exceeds measuring range of the instrument !

SML133 Measured Data Branch Navigation Chart



SML133 Fundamental Harmonic Values Branch

	Actual	Avg	AvgMax	AvgMin
cos (tan,φ) phase power factors	0.97 0.94 0.99	(actual values only)		
Σcos(tan,φ) 3-phase power factor	0.98	(actual values only)		
Pfh active phase powers	18.9 15.2 16.3			
ΣPfh active 3-phase power	50.4			
Qfh reactive phase powers	6.21 4.99 -0.36			
ΣQfh reactive 3-phase power	10.9			

Optional "8E" Electricity Meter Display Format

002 937 45.8	-000 000 076	000 681 32.5	-000 000 042	000 002 63.9	-000 000 02.5	003 176 28.3	-000 000 08.1
ΣEP+	ΣEP-	ΣEQL+	ΣEQL-	ΣEQC+	ΣEQC-	ΣEs+	ΣEs-

1.3.2.1 Average Values

Average values are processed according set averaging method and length of averaging window (individually for "U/I"-group and "P/Q/S"-group of quantities). Maximum and minimum values of them are registered into the instrument's memory. The maximums are displayed in the "AvgMax" column and they are identified with the ▲ symbol in the front of the value. Analogically, the minimums in the "AvgMin" column are identified with the ▼ symbol.



Neither maximum nor minimum of $\cos\phi$ values are evaluated due to special character of the quantity. Similarly, these extreme values are not evaluated at harmonics.

You can clear the "AvgMax"/"AvgMin" values. All of the maximums/minimums of appropriate quantity group are cleared simultaneously. To do it, follow next :

- navigate on corresponding AvgMax or AvgMin value
- press the **M** key until the value starts flashing
- with the ▲ or ▼ key, choose the **CL** option
- then confirm by pressing the **M**



The appropriate group (U/I or P/Q/S) of average maxs/mins is affected by single clearing only ! Each group must be cleared individually.



If the instrument is locked, the clearing is not possible.

1.3.2.2 Full Spectrum Values P/Q/PF & Fundamental Harmonic Values Pfh/Qfh/cos φ

As standard, active and reactive powers (and therefore power factor) are evaluated from full spectrum of harmonic components of both voltage and current.

Sometimes (for example for power factor compensation system checking), it is useful to know fundamental harmonic part of these quantities too. Such quantities are marked Pfh, Qfh, cos φ .

As you can see on the navigation chart you can navigate from *the full spectrum values branch* with the

M key further right into *the fundamental harmonic values branch* and vice versa. To distinguish actual displayed branch, the **H** symbol is displayed for the fundamental harmonic branch.

Exception : Actual values only of fundamental harmonic power factor – *the cos φ* – are evaluated (no average values available). Next, this fundamental harmonic power factor can be expressed not only as cos φ , but as tan φ or φ too, depending on setting of parameter 09.

1.3.2.3 Fundamental Harmonic Power Factor Formats cos φ /tan φ / φ

The fundamental harmonic power factor can be expressed not only as cos φ , but as tan φ or φ too, depending on setting of parameter 09.

For outright specification of the quadrant, the power factor of the fundamental harmonic component is accompanied with two attributes :

- a sign (+ or -), which indicates polarity of appropriate active power
- a symbol ϵ or \oplus , which indicates the power factor character

For detailed information see chapter *Power, Power Factor and Unbalance Evaluation Method* below.

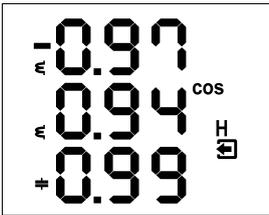
At the following figures there are examples of three-phase fundamental power factor presentations :

Fundamental Harmonic Power Factor Formats



- the left figure : $\Sigma \cos \varphi = 0.98$ inductive (choke symbol displayed). Furthermore, active three phase power is being negative, therefore the leading “minus”-sign (and the \ominus symbol displayed)
- the middle figure : $\Sigma \tan \varphi = 0.20$ inductive. Active three phase power is positive.
- the right figure : $\Sigma \varphi = 8$ degrees inductive. Active three phase power is positive.

Fundamental Harmonic Power Factor Sign & Character



On the figure on the left, there is phase $\cos \varphi$ values example :

- $\cos \varphi_1 = 0.97$ inductive. L1-phase active power is currently negative (because of leading “minus”-sign)
- $\cos \varphi_2 = 0.94$ inductive (L2-phase active power currently positive)
- $\cos \varphi_3 = 0.99$ capacitive (L3-phase active power currently positive)

1.3.2.4 THDs and Harmonic Components

You can check actual values of both voltage and current THDs and harmonic components in appropriate rows (see *the Measured Data Navigation Chart*).

When you scroll to one of this rows, THD values of all measured phases are displayed as default. Symbols **THD - V - LN** or **THD - A** indicate phase voltage or current THD values, respectively.

With the **M** key you can switch to harmonic components. The symbol **H** appears, indicating harmonic components (of voltage or current). Symbol **%** means that the values are expressed in percent of fundamental harmonic component. Order of harmonics just displayed flashes periodically in the display middle line – for example, string **H03** means 3rd harmonics.

By repetitive pressing of the **M** key you can check other harmonics. Although the instrument evaluates all of the harmonic components up to 50th order internally, only odd components to 25th order can be viewed of its display (full spectrum of the harmonics is available via communication interface only).

1.3.2.5 Electricity Meter

Electricity meter comprises three-phase energy data and maximum three-phase active power demand value. The values are situated in particular row.

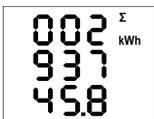
Depending on the parameter 08 setup, two electricity meter display modes can be chosen :

- “4E+MD” mode (default)
- “8E” mode

1.3.2.5.1 “4E+MD” Display Mode

In this mode, first four windows contain three-phase energies of four-quadrants :

- $\Sigma EP+$... three-phase imported active energy, indicated with Σ - **kWh** (or **MWh** or **kMWh** = **GWh**)
- $\Sigma EP-$... three-phase exported active energy, indicated with Σ - **kWh** and preceding — sign
- ΣEQL ... three-phase inductive reactive energy, indicated with Σ - **kVArh** – **L**
- ΣEQC ... three-phase capacitive reactive energy, indicated with Σ - **kVArh** - **C**



Each value occupies all of three display lines, 8 digits before the decimal point and one after it. For the exaple at left, $\Sigma EP+$ = 293745.8 kWh.

The values are registered since the last clearing. To clear the energies, display any of them and then follow the same procedure as for max/min average values. All of the energies are cleared simultaneously ant start to count from zero again.

In the 5th window there is

- **Σ MD** ... maximum of three-phase average active power (power demand), indicated with **Σ - kW** - ▲ and bar over the value

The value contains maximum of three-phase average active power since the last clearing. Averaging method and averaging period for this value can be set regardless of the method of standard average values, described above.

Similarly as the energies, the value can be cleared independently.



If the instrument is locked, clearing is not possible.



If the instrument is equipped with a communication interface, the values can be cleared remotely.

1.3.2.5.2 “8E” Display Mode

In this mode, reactive energies registered separately depending on actual three-phase active power (ΣP) sign are displayed (such format can be convenient for renewable sources monitoring, for example) :

- **Σ EP+** ... three-phase imported active energy, indicated with **Σ - kWh** (or **MWh** or **kMWh** = GWh)
- **Σ EP-** ... three-phase exported active energy, indicated with **Σ - kWh** and preceding — sign
- **Σ EQL+** ... three-phase inductive reactive energy registered during the Σ EP value was positive (import); indicated with **Σ - kVArh – L**
- **Σ EQL-** ... three-phase inductive reactive energy registered during the Σ EP value was negative (export); indicated with **Σ - kVArh – L** and preceding — sign
- **Σ EQc+** ... three-phase capacitive reactive energy registered during the Σ EP value was positive; indicated with **Σ - kVArh – C**
- **Σ EQc-** ... three-phase capacitive reactive energy registered during the Σ EP value was negative; indicated with **Σ - kVArh – C** and preceding — sign

Furthermore, energies in VAh are available too :

- **Σ Es+** ... three-phase apparent energy registered during the Σ EP value was positive; indicated with **Σ - kVAh**
- **Σ Es-** ... three-phase apparent energy registered during the Σ EP value was negative; indicated with **Σ - kVAh** and preceding — sign

The three-phase active power demand **Σ MD** is not displayed in this mode.

1.3.3 Instrument State Symbols

Except of measured data, the instrument indicates following states with dedicated symbols :

-  Export of three-phase active power. Displayed when the **ΣP** value is negative.
-  ... A1(top) and A2 (bottom) alarm lights off / on. See output setup below.
-  DI1 digital input state is active.
-  Instrument parameters are displayed.

SML 133 Instrument Parameters

#	parameter group	range	default	comment
00	lock	LOC / OPN	OPN	see Instrument Setup Locking / Unlocking
01	CT – ratio, multiplier screen 1 : row 2 : nominal primary current row 3 : nom. secondary current (for “X/100mA”, “X/333mV” fixed) screen 2 : MUL – current multiplier	primary : 1A ÷ 10 kA sec. : 5A / 1A (0.1A) (0.1 A, 0.333 V) 0.001 ÷ 999	5 / 5 A 1	secondary current selection with the M key par. placed in side branch if the current multiplier different from 1 the ▲ / ▼ flashes
02	connection type	3Y / 3D / 3A	3Y	
04	conn. mode: direct (---) or VT–ratio, mult. screen 1 : row 2 : primary U [kV] row 3 : secondary U [kV] screen 2 : MUL – voltage multiplier	0.001 ÷ 65 kV 0.001 ÷ 0.999 kV 0.001 ÷ 999	direct (- - -) 1	parameters placed in side branch if the voltage multiplier different from 1 the ▲ / ▼ flashes
05	f _{NOM} , U _{NOM} row 2 : f _{NOM} [Hz] row 3 : U _{NOM} [V / kV]	50 / 60 / FS (=“Fixscan”) 50 V ÷ 1MV	50 230	U _{NOM} specification depending on connection mode : - direct : line-to-neutral - via VT : line-to-line
06	ΣP _{NOM} [kVA / MVA]	1 kVA ÷ 999 MVA	-	
07	averaging period row 2 : for U/I group row 3 : for P/Q/S group	0.01 ÷ 60 (1 sec÷ 60 mins)	1 min 15 min	floating window type averaging method applied as default
08	avg period for ΣMD, EI-meter d. mode line 2 : averaging period for ΣMD line 3 : Electricity meter display mode	0.01 ÷ 60 “4E+MD” / “8E”	15 min “4E+ MD”	floating window type averaging method applied as default
09	fund. harmonic PF display format	cos / tan / fi	cos	
10	backlight	AUT / ON	AUT	AUT-mode : the backlight is switched off automatically after app. 5 mins if no key is pressed
11	output setup row 2 : output O1 row 3 : output O2 standard type : “-O-” pulse type : pulses / kWh(kvarh) control energy symbol : • none ... ΣEP+ • - ... ΣEP- •  ... ΣEQL •  ... ΣEQC	“ - - - ” = off “-O-” = standard output 0.001 ÷ 999000 = pulse output	- - - (off)	control energy selection with the M key Standard type output can be set via communication line only, not from instrument panel. Symbol ▲ indicates different setup of the alarm light A1 from the O1 and the A2 from the O2 If pulse type output set from instrument panel, the A1 and the A2 alarm lights are set identically as the O1 and the O2, respectively.
15 (16)	communication interface 1 (and 2, opt.) for RS-485 (M-Bus) : screen 1: row 2 : address row 3 : rate [kBd] screen 2: Prt (protocol) – databits & parity for Ethernet: screen 1 : DHCP screen 2÷5 : IP1÷ IP4 (IP) screen 6÷9 : MA1÷ MA4 (Subnet Mask) screen 10÷13 : Gt1÷ Gt4 (Gateway)	1 ÷ 255 2.4 ÷ 460 (2.4 ÷ 9.6) 8 / 9-n / 9-E / 9-0 ON / OFF 0 ÷ 255 0 ÷ 255 0 ÷ 255	1 9.6 (2.4) 8 (9-E) OFF 10.0.0.1 255.255.255.0 10.0.0.138	parameters placed in side branch
19	instrument status (read only) row 2 : failure specification row 3 : serial no. & version (scroll)	0 ÷ 255 -	0 -	r. 2 : 0 = failure-free r. 3 : S...serial no. F... firmware version b...bootloader version H...hardware version

1.3.4 Instrument Parameters

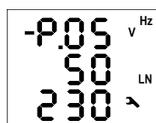
For proper operation in particular conditions, the instrument must be set. The instrument setup is determined using parameters, for example the current transformer [CT] conversion, type of measured voltage connection (direct connection or via a voltage transformer [VT] and its ratio), and connection configuration (wye / delta / Aron). Overview of all the parameters is listed in the table below.

To check or edit the parameters, press the **P** key. As default, parameter group 01 is displayed and symbol indicates, that setup data are displayed now.

The parameters are arranged in groups, numbered from 00 up. The number of group is displayed in the first line in format - P.n n (with preceding dash). You can browse through the parameter groups with the or keys.



If one parameter only in the group, its value is in the bottom line as shown at the example (nominal power 400 kVA).



If two parameters in the group, usually the first of them is displayed in the 2nd line and the second in the 3rd line (nominal frequency 50 Hz and nominal voltage 230 V).

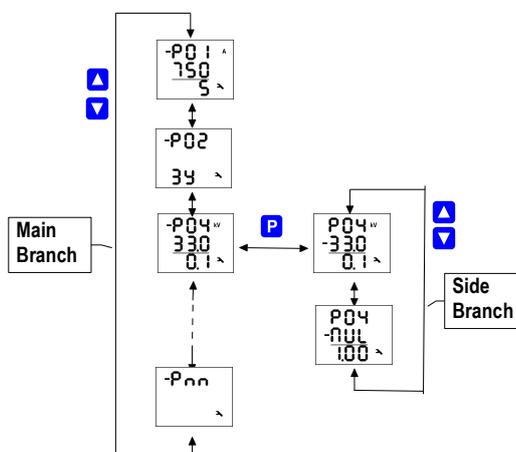
To edit a particular parameter, scroll to its group. Then press and hold the **P** until the value gets flashing. Now release the key and set target value with the or , or the **M** key for some of parameters. You can use autorepeat function by keeping one of the arrow keys pressed too. Finally, press the **P** and the value is stored into the memory.

If more parameters in the group, the first one is chosen when entering editing mode for the first time. If you want to modify the second parameter only, simply cancel editing of the first parameter without any change and reenter the editing again – now the second parameter is chosen.

To return back to measured values display, simply press the **M** key.

1.3.4.1 Main and Side Branch

Arrangement of Parameters in Branches

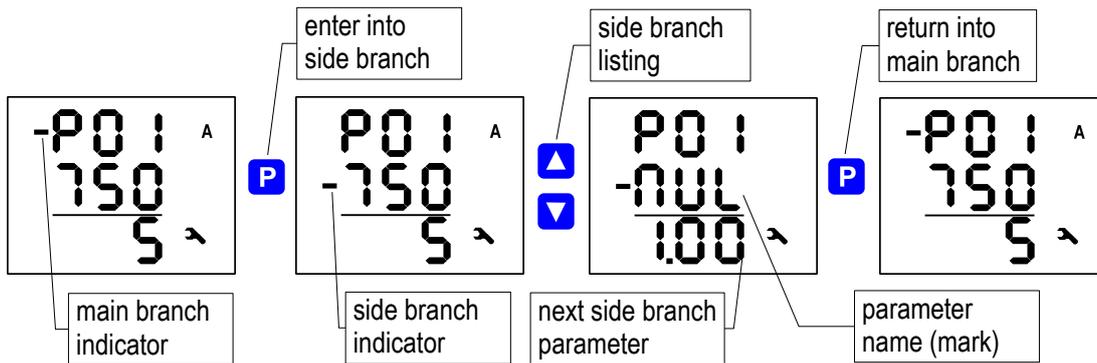


For better orientation, some of parameters (parameter group No. 01, 04, 15) are placed in so called side branches. To enter into a side branch, push **P**. The dash in the front of the parameter number skips down to the second row indicating the side branch position.

Now you can list through parameters of chosen group of parameters only with the and keys. Usually, there is name or mark of a parameter in the second line and the parameter value in the third line.

To return back into the main branch push the **P**.

Main and Side Branch Navigation



1.3.5 Instrument Setup Locking / Unlocking

When shipped, parameter editing is unlocked, that means :

- all of the parameters can be edited
- standard average maximums / minimums, electricity meter energies $\Sigma EP+$, $\Sigma EP-$, etc., and electricity meter maximum power demand ΣMD can be cleared

After being put in operation, such operations can be locked (=disabled) to protect the instrument against unauthorized changes. Then operator can only check measured values and parameters, but cannot change anything, excluding special parameter No. 00, that serves as the instrument lock. It has one of two values :

L O C instrument is locked

O P n instrument is unlocked (open)

If the instrument is locked, you can unlock it using the following procedure, which is similar to editing of other parameters:

1. Press the **P** key and scroll to parameter group 00 with arrow keys – value **L O C** is displayed.
2. Press the **P** and hold it down until the value is replaced with flashing number between **000** and **999**. As an example, you can imagine flashing **345** is displayed.
3. Press the following sequence: **▼**, **▲**, **▲**, **▼**. The value changes gradually to **344**, **345**, **346**, **345**, so the same value is shown at the end as at the beginning.
4. Press the **P**. The flashing number is replaced with **O P n**, indicating unlocked state.

The digit shown while entering the unlocking keypress sequence is random and it is not important for correct unlocking (it is there only to confuse). Only the sequence of keys pressed is important and must be followed exactly.

The instrument can be locked in a way analogous to unlocking but it is necessary to press any keypress sequence that is different from the unlocking sequence noted above.



*If an instrument is locked or unlocked by the user management (for details see the application note No. 004 : Users, passwords and PINs), message **U S r** is shown in the second line and unlocking/locking is available via a communication link by using the user management only.*

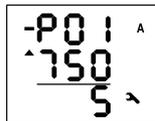
2. Detailed Operation Description

2.1 Current and Voltage Multiplier

To get better precision when using overweighted CTs, you can apply more windings of measured wire through the transformer. Then you must set so called multiplier. The current multiplier parameter is placed in side branch of the P.01 parameter group and it is marked as "MUL". For example, for 2 windings applied, set the multiplier to $1/2 = 0.5$.

For standard connection with 1 winding, the multiplier must be set to 1.

Similarly, the voltage multiplier can be set too (P.04 parameter group).



If the multiplier is set different from 1 the CT-ratio (or the VT-ratio) is displayed with leading flashing arrow ▲ or ▼, depending on the multiplier value is higher or lower than 1.

At direct voltage connection mode (without VT), the voltage multiplier is not used and its value is not displayed.

2.2 Method of Measurement

The measurement consists of three processes being performed continuously and simultaneously: frequency measuring, sampling of voltage and current signals and evaluation of the quantities from the sampled signals.

2.2.1 Voltage Fundamental Frequency Measurement Method

The voltage fundamental frequency is measured at the U1 voltage signal. It is measured continuously and evaluated every 10 seconds.

The fundamental frequency output is the ratio of the number of integral mains cycles counted during the 10 second time clock interval, divided by the cumulative duration of the integer cycles.

If value of frequency is out of measuring range, such state is indicated with flashing symbol **Hz**.

2.2.2 Voltage and Current Measurement Method

Both voltage and current signals are evaluated continuously as required by IEC 61000-4-30, ed. 2 standard. The unitary evaluation interval, a *measurement cycle*, is a ten / twelve (value behind slash is valid for $f_{NOM} = 60$ Hz) mains cycles long period (i.e. 200 ms at frequency equal to preset f_{NOM}), which is used as a base for all other calculations.

The sampling of all voltage and current signals is executed together with the frequency of 128 / 96 samples per mains cycle. The sampling rate is adjusted according to the frequency measured on any of the voltage inputs **U1**, **U2**, **U3**. If the measured frequency is in measurable range at least on one of these inputs, then this value is used for subsequent signal sampling. If the measured frequency is out of this range, the preset frequency value (f_{NOM}) is used and measured values may be incorrect.

When exceeding the measuring range of any voltage or current, the instrument indicates it by flashing of value being overloaded.

Effective values of voltages and currents are calculated from sampled signals over the measurement cycle using formulas (examples for phase No. 1):

Phase voltage (effective value):

$$U_1 = \sqrt{\frac{1}{n} \sum_{i=1}^n U_{1i}^2}$$

Line voltage (effective value) :

$$U_{12} = \sqrt{\frac{1}{n} \sum_{i=1}^n (U_{1i} - U_{2i})^2}$$

Current (effective value) :

$$I_1 = \sqrt{\frac{1}{n} \sum_{i=1}^n I_{1i}^2}$$

where : i sample index

n number of samples per measurement cycle (1280 / 1152)

U_{i1}, I_{i1} ... sampled values of voltage and current

The data for the longer measurements are aggregated from these measurement cycles.

Measured phase voltages U_1 to U_3 correspond to the potential of terminals **VOLTAGE / U1** to **U3** towards the terminal **VOLTAGE / N**.



Measuring voltage inputs impedance is in range of units of $M\Omega$. If no signal connected (for example when protection fuse is blown), due to parasite impedance of power supply input a parasite voltage of up to tens of volts can appear on the measuring voltage inputs. In such case the instrument can show non-zero voltages !

Three current signals - I_1, I_2, I_3 - are measured. Another current is calculated from samples of directly measured ones as negative vector sum of all measured current vectors (Kirchhoff rule). The calculated current is referenced as I_{PEN} . The I_{PEN} value is not displayed, it is available on a PC via communication with ENVIS program only.

2.2.3 Harmonics and THD Evaluation Method

Entire spectrum of harmonic components and THD is evaluated discontinuously - periodically every second from 10 / 12 mains cycles long signal according to IEC 61000-4-7 ed.2 as harmonic sub-groups (H_{sg}).

Following quantities are evaluated :

Harmonic components of voltage and current up to 50th order : U_{ih_1}, I_{ih_1}
(i order of harmonic component)

Absolute angle of voltage harmonic component phasor : $\varphi_{U_{ih_1}}$

Current harmonic component phasor angle relative to phasor U_{fh_1} : $\varphi_{I_{ih_1}}$

Relative angle between correspondent voltage and current phasors : $\Delta\varphi_{ih_1}$

Total harmonic distortion of voltage :

$$THD_{U_1} = \frac{1}{U_{1h_1}} \sqrt{\sum_{i=2}^{40} U_{ih_1}^2} * 100\%$$

Total harmonic distortion of current :

$$THD_{I_1} = \frac{1}{I_{1h_1}} \sqrt{\sum_{i=2}^{40} I_{ih_1}^2} * 100\%$$

2.2.4 Power, Power Factor and Unbalance Evaluation Method

Power and power factor values are calculated continuously from the sampled signals according to formulas mentioned below. The formulas apply to basic type of connection – wye (star).

Active power :

$$P_1 = \sum_{k=1}^{40} U_{k,1} * I_{k,1} * \cos\Delta\varphi_{k,1}$$

Reactive power :

$$Q_1 = \sum_{k=1}^{40} U_{k,1} * I_{k,1} * \sin \Delta \varphi_{k,1}$$

where : k ... harmonic order index, odd components only
 $U_{k,1}, I_{k,1}$... the k^{th} harmonic components of voltage and current (of phase 1)
 $\Delta \varphi_{k,1}$... angle between the k^{th} harmonic components $U_{k,1}, I_{k,1}$ (of phase 1)
 (these harmonic components of U and I are evaluated from each measurement cycle)

Apparent power :

$$S_1 = U_1 * I_1$$

Power factor :

$$PF_1 = \frac{|P_1|}{S_1}$$

Three-phase active power :

$$\sum P = P_1 + P_2 + P_3$$

Three-phase reactive power :

$$\sum Q = Q_1 + Q_2 + Q_3$$

Three-phase apparent power :

$$\sum S = S_1 + S_2 + S_3$$

Three-phase power factor :

$$\sum PF = \frac{|\sum P|}{\sum S}$$

Fundamental harmonic component quantities :

Fundamental harmonic power factor :

$$\cos \Delta \varphi_1 \quad (\text{or} \quad \tan \Delta \varphi_1, \Delta \varphi_1)$$

Fundamental harmonic active power :

$$Pfh_1 = Ufh_1 * Ifh_1 * \cos \Delta \varphi_1$$

Fundamental harmonic reactive power :

$$Qfh_1 = Ufh_1 * Ifh_1 * \sin \Delta \varphi_1$$

Fundamental harmonic three-phase active power :

$$\sum Pfh = Pfh_1 + Pfh_2 + Pfh_3$$

Fundamental harmonic three-phase reactive power :

$$\sum Qfh = Qfh_1 + Qfh_2 + Qfh_3$$

Fundamental harmonic three-phase power factor :

$$\sum \cos \Delta \varphi = \cos \left(\arctg \left(\frac{\sum Qfh}{\sum Pfh} \right) \right)$$

Powers and power factors of the fundamental harmonic component ($\cos \varphi$) are evaluated in 4 quadrants in compliance with the standard IEC 62053 – 23, appendix C, see figure below.

For outright specification of the quadrant, the power factor of the fundamental harmonic component – **cos φ** – is expressed according to the graph with two attributes :

- a *sign* (+ or -), which indicates polarity of active power
- a *character* ( or ), which indicates the power factor character (the polarity of reactive power relative to the active power)

Voltage and current unbalance evaluation is based on negative/positive sequences of voltage and current fundamental harmonic components :

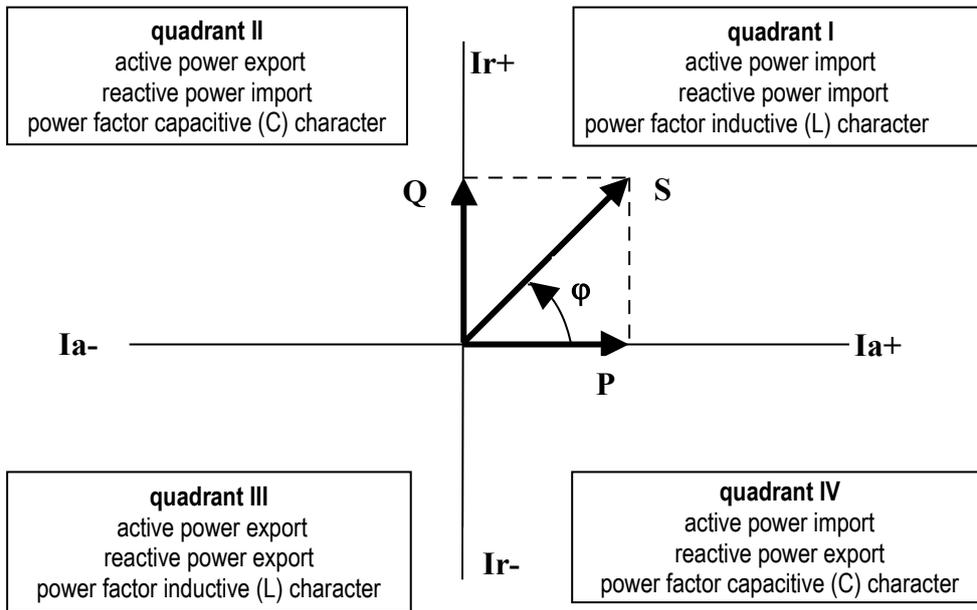
Voltage unbalance :
$$unb_U = \frac{\text{voltage negative sequence}}{\text{voltage positive sequence}} * 100 \%$$

Current unbalance :
$$unb_I = \frac{\text{current negative sequence}}{\text{current positive sequence}} * 100 \%$$

Current negative sequence angle : φ_{ns}

All of angle values are expressed in degrees in range [-180.0 ÷ +179.9].

Identification of consumption- supply and the character of reactive power according to phase difference



2.2.5 Temperature

The temperature is measured with built in sensor and updated each approx. 10 seconds.

2.2.6 “ The Fixscan” Mode

The instrument is primarily designed to measure distribution networks with the nominal frequency of 50 or 60 Hz. Sampling, processing, and aggregation of a measured signal when setting the f_{NOM} parameter to one of these two values is described above and corresponds to the standards specified in technical parameters.

However, there are other applications, such as:

- networks with $f_{NOM} = 400$ Hz
- variable frequency networks, such as frequency inverters output

The *Fixscan mode* is used to measure such networks.

2.2.6.1 Function

The *Fixscan mode* is activated by setting the f_{NOM} parameter to "FS". The device then works as follows:

- U and I signals sampled at the fixed sampling frequency of 6400 Hz
- fixed evaluation interval of measured quantities every 200ms
- DC component of voltage is also evaluated (DC component of current not measured)
- assortment of measured quantities is limited according to the table below; other variables, such as harmonic components, THDs, unbalances are not measured in this mode
- measurement uncertainties are defined by a separate table (see technical parameters)

The frequency of the measured signal can be in the range of 0 ÷ 500 Hz.



Due to the fixed evaluation window (200ms), a systematic error of incomplete number of evaluated waves may occur, especially in low frequency signals !

Temperature and analogue inputs are measured in the same way as in standard mode. Similarly, energy is evaluated standardly by integration of appropriate power.

The Fixscan Mode Quantities Measured Overview

Mark	Quantity	Evaluation method
f	frequency of voltage	voltage signal digital filtration + zero crossing period measurement
U1	phase-to-neutral alternating voltage (effective value)	$U1 = \sqrt{\frac{1}{1280} \sum_{i=1}^{1280} U_{i1}^2}$
Udc1	direct phase-to-neutral voltage (direct component of the signal)	$U_{dc1} = \frac{1}{1280} \sum_{i=1}^{1280} U_{i1}$
U12	phase-to-phase alternating voltage (effective value)	$U12 = \sqrt{\frac{1}{1280} \sum_{i=1}^{1280} (U_{i1} - U_{i2})^2}$
I1	alternating current (effective value)	$I1 = \sqrt{\frac{1}{1280} \sum_{i=1}^{1280} I_{i1}^2}$
P1	active power	$P1 = \frac{1}{1280} \sum_{i=1}^{1280} U_{i1} * I_{i1}$
Q1	non-active power	$Q1 = \sqrt{S1^2 - P1^2}$
S1	apparent power	$S1 = U1 * I1$
PF1	power factor	$PF1 = \frac{ P1 }{S1}$

Note : marks and evaluation formulas shown for phase No. 1

2.3 Measured Values Evaluation and Aggregation

As described above, measured values are evaluated according to IEC 61000-4-30 ed.2, based on continuous (gap-less), 10 / 12 mains cycles long intervals (measurement cycle) processing.

Further aggregation of the actual values from this evaluation is used to obtain values for displaying and recording.

2.3.1 Actual Values Evaluation and Aggregation

Actual (instantaneous) values of measured quantities, that can be viewed on instrument's display, are evaluated each *display refresh cycle* as average of integral number of measurement cycle values. The display refresh cycle is preset to 3 measurement cycles , corresponding approx. to 0.6 sec display refresh cycle duration.

Exceptions :

- frequency – the value is refreshed each frequency measurement cycle (see above)
- voltage and current harmonic components – the last measurement cycle values are displayed (no averaging). Only odd harmonic components to 25th order are displayed. Higher components are available via communication link only.
- temperature – the value is refreshed each temperature measurement cycle (see above)

Actual values, read from an instrument via a communication link for monitoring purposes are evaluated from one – the last – measurement cycle only.

2.3.2 Average Values Evaluation

From measurement cycle values, average values of all basic quantities are calculated. The averaging period in range from 1 second to 1 hour can be used.

As default, *the floating window* averaging method is applied. An internal cyclic buffer is used to store auxiliary partial averages. The buffer has depth of 60 values. If preset average period is 1 minute or shorter, partial averages of a quantity are buffered each second and new average values are updated from the preset averaging period each second. If the preset average period is longer than 1 minute, partial averages for longer duration are buffered and the average values are updated less frequently (for example, if the preset average period is 15 minutes, partial averages are buffered each 15 seconds and average values are updated with this frequency).

At instruments equipped with communication link, *the fixed window* averaging method can be set too.

The averaging period can be set in parameter group No. 07 independently for two groups of quantities : so called **U/I** -group and **P/Q/S** -group. Following table lists processed quantities of both groups.

Average Values Groups

Average values group	Averaged quantities
“ U / I ”	U_{LL}, U_{LN}, I, f, T
“ P / Q / S ”	$P, Q, S, PF, Pfh, Qfh, \cos\phi$



*Preset averaging parameters noted above are valid for so called standard average values. For the maximum power demand **ΣMD** in the Electricity Meter group, separate parameter is used (see below).*

2.3.3 Embedded Electricity Meter

For electric energy measurement, stand-alone unit – *electricity meter* - is implemented inside instruments. Energies are evaluated in compliance of the IEC 62053-24 standard : active energy from full harmonic spectrum and reactive energy from the fundamental harmonic component only.

Except of electric energy, maximum active power demands are registered in the unit.

2.3.3.1 Electric Energy Processing

Measured values of both active and reactive electrical energies are recorded separately in four quadrants. Following energy counters can be displayed :

- active energy consumed (**EP+**, import), active energy supplied (**EP-**, export)
- reactive energy :
 - either*
 - reactive energy consumed (**EQL**, inductive), reactive energy supplied (**EQC**, capacitive)
 - or*
 - reactive energy registered at the three-phase active energy being consumed (imported) : inductive (**EQL+**) and capacitive (**EQC+**) energy
 - reactive energy registered at the three-phase active energy being supplied (exported) : inductive (**EQL-**) and capacitive (**EQC-**) energy

Both single-phase and three-phase energies are processed. But on the instrument display, only three-phase (Σ) values can be viewed. Desired presentation format can be set with parameter 08.

Internal energy counters have sufficient capacity in order not to overflow during the whole instrument lifetime. On the instrument's display only 9 digits can be viewed – therefore, after energy value exceeds 99999999.9 kWh/kvarh, instrument's display format automatically switches to MWh/Mvarh, then to GWh/Gvarh.

2.3.3.2 Maximum Demand Registration

From the instantaneous measured values of all active powers the instrument evaluates their average values per preset period using preset averaging method. In the electricity meter unit, such quantities are called *actual demands* (**AD**). Note that the actual demands are processed individually and their averaging period is presetable independently on standard average values (**P_{AVG}**).

Their maximum values reached since the last clearing are called *maximum demands* (**MD**).

The AD values are not displayed on the instrument display – only their registered three-phase maximum Σ **MD** is.

The maximum can be cleared independently of standard average maximums/minimums.

2.4 Display Contrast

Although the display contrast is temperature compensated, there can be sometimes necessary to tune it slightly. To do it, in the measured quantities branch press keys  and  simultaneously and keep pressed. Then message **[0 n** appears in the first line and the contrast value in the second one.

Now, if the display too light, keep the  pressed and increase with repetitive pressing of the  key. Likewise, if too dark, keep the  and adjust with the  key. Finally, release the keys and new contrast is set.

3. Digital Inputs & Outputs (I/O)

Instruments can be optionally equipped with a combination of outputs and inputs (see manufactured models marking below).

Following I/O types are available :

- digital relay output (power relay, electromechanical), marked as **ROx** (x =output number)
- digital solid state output (semiconductor), **DOx**
- digital solid state input (semiconductor), **DIx**

Depending of instrument model following inputs & outputs are available :

I/O Type Assortment

model	I/O type	I/O character
RR	2 x RO + 1 x DI	bipolar (AC/DC)
RI	1 x RO + 1 x DO + 1xDI	bipolar (AC/DC)
II	2 x DO + 1 x DI	bipolar (AC/DC)
V	4 x DO/DI (universal)	unipolar (DC)

All of the „RR / RI / II“ models have 2 outputs and 1 input. Both outputs and input are bipolar, i. e. signal polarity is free and even AC signals can be switched and read.

By contrast, the „V“ models have 4 inputs/outputs and any of them can be used as either input or output. The signal polarity must be kept ; it depends on whether particular I/O is used as input or output (see description below).



Furthermore, all of instrument models feature two “alarm ” lights **A1** and **A2** for indication of various states, that can be considered as other special digital outputs. Function of these lights can be set in the same way as at standard digital outputs.

The behaviour of digital outputs can be programmed according to requirements as :

- *pulse output* ... transmitting electricity meter
- *standard output*, e.g. as a simple two-position controller or a defined status indicator

The digital input can be used :

- for *state indication* (a contact closure etc.)
- as *pulse* or *frequency counter* (at instruments equipped with a remote communication link only)
- as input quantity of an *I/O setup clause condition* (see description below)

The digital input **DI1** state is indicated with the  symbol and can be used for state monitoring via a communication link as well.

3.1 I/O Connection

Digital inputs & outputs are connected to terminals on a rear panel of an instrument according to the following tables.

RR / RI / II Models – Digital I/O Connection

terminal	signal	notes
15, 16	O1A, O1B ... DO1/RO1 digital output	- input and outputs are insulated both from instrument internal circuitry and mutually
17, 18	O2A, O2B ... DO2/RO2 digital output	
19, 20	I1A, I1B DI1 digital input	

V Models – Digital I/O Connection

terminal	signal	notes
41	D1 ... DO1 digital output or DI1 digital input	- input and outputs are unipolar - common pole of outputs „DO“ is positive (+) - common pole of inputs „DI“ is negative (-) - inputs and outputs are insulated from instrument internal circuitry - DO1/DI1 & DO2/DI2 pair is insulated from DO3/DI3 & DO4/DI4 pair
42	D2 ... DO2 digital output or DI2 digital input	
43	C12 ... DO1/DI1 & DO2/DI2 common pole	
44	D3 ... DO3 digital output or DI3 digital input	
45	D4 ... DO4 digital output or DI4 digital input	
46	C34 ... DO3/DI3 & DO4/DI4 common pole	

3.1.1 Power (Relay, RO) Output Connection

A SPST-NO (single-pole, single-throw, normally open) relay type is used. Maximum allowable voltage and load current according technical specifications must be observed.

3.1.2 Signal (Solid-State, Transistor, DO) Output Connection

The outputs are accomplished by a semiconductor switching device. It is assumed that the input optocouplers of the external recording or controlling system will be connected to these outputs via current-limiting resistors. The signal polarity for the V-models must be kept according the table above and for the RR/RI/II models it is free.

3.1.3 Digital Input Connection

The input supposes a voltage signal of appropriate magnitude is connected (see technical specifications). The signal polarity for the V-models must be kept according the table above and for the RR/RI/II models it is free.

If the voltage exceeds declared level, the input is activated (=value 1).

Usual 12 or 24 V DC/AC signals can be connected directly. If you need to connect a voltage signal of magnitude exceeding maximum digital input voltage, external limiting resistor of appropriate rating must be used.

Recommended wire type: H05V-U (CY)

Recommended minimum conductor cross-section :

- the V-models : 0.5 mm²
- other models : 0.75 mm²

Maximum conductor cross-section :

- the V-models : 1.5 mm²
- other models : 2.5 mm²



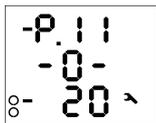
Any of the V-type inputs/outputs can be used as either input or output. When used as input there must not be output function set on the same terminal. Furthermore, proper polarity of signal terminal and appropriate common terminal must be kept.

3.2 Outputs Setup from the Instrument Panel

The O1 / O2 output function can be checked in parameter group 11. Possible setup options are :

- - - - ... the output DO1/2 (RO1/2) is disabled
- -  - ... the output DO1/2 (RO1/2) is set as *standard output* (standard mode, detailed setup available using the ENVIS program via a communication line only, see description below)
-  ... the output DO1/2 (RO1/2) is set to *pulse mode* with nnn pulses per kWh; in case the **k** character is displayed, the value is in thousands of pulses; the control quantity is $\Sigma EP+$ (no symbol shown). Other control quantities options according accompanying symbol :
 - $\Sigma EP-$
 -  ... ΣEQL
 -  ... ΣEQC

Example :



Output DO1(RO1) : set to standard output mode (details via communication link only)

Output DO2 (RO2) : set to pulse mode, 20 pulses/kWh of energy $\Sigma EP-$

The standard output function can be used at instruments equipped with communication link only – it can be adjusted only via connected PC using ENVIS program (see ENVIS program manual). The impulse output function can be set simply from the instrument panel too.

The alarm lights A1, A2 setup is not displayed, it is available via a communication line only. You can only check if the setup is the same as corresponding DO1/2 (RO1/2) setup or not. If any of signal lights A1, A2 is set, the outlines of both lights appear on the display. They stay hidden when function of both lights is disabled.

3.2.1 Pulse Output Mode

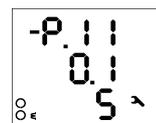
Any of digital outputs or alarm lights can be set as transmitting electricity meter. The frequency of generated pulses can be set depending on values of measured electric energy by the embedded electricity meter unit.



You can set to pulse output mode not only the **DO**-type (solid-state) outputs, but the **RO**-type (electromechanical relay) outputs too. But note lifetime of electromechanical relays, they have limited number of switchings.

The outputs DO1/2 (RO1/2) can be set to pulse output mode both manually from the instrument panel and remotely via a communication line. The manual setup is available in parameter group 11. After entering editing, set edited parameter (range 0.001÷999) with arrow keys and select desired energy with the **M** key.

Example :



Output DO1 (RO1) : 0.1 pulses/kWh = 1 pulse / 10 kWh, energy $\Sigma EP+$ (no additional symbol)

Output DO2 (RO2) : 5 pulses/kvarh , energy ΣEQL (due to symbol )



By setting any of the DO1/2 (RO1/2) outputs from the instrument panel, corresponding alarm light A1/A2 is set in the same way automatically too. Then the DO1/2 (RO1/2) activity can be checked by the A1/A2 lights on the instrument display. Separate setup of the lights is available using the ENVIS program via a communication line only. If any of lights is set different from corresponding DO1/2 (RO1/2) output the symbol  preceding appropriate setup appears.



Even if an instrument is equipped with neither any digital output nor any communication line, you can set pulse function of alarm lights A1, A2 by setting the DO1/2 (RO1/2) outputs.

3.3 I/O Setup via Communication Link Using the ENVIS-Daq Program

For the I/O setup, use *Config* → *I/O Management*. Complete I/O setup consist of so called *clauses*. Individual clauses are listed in the I/O management screen.

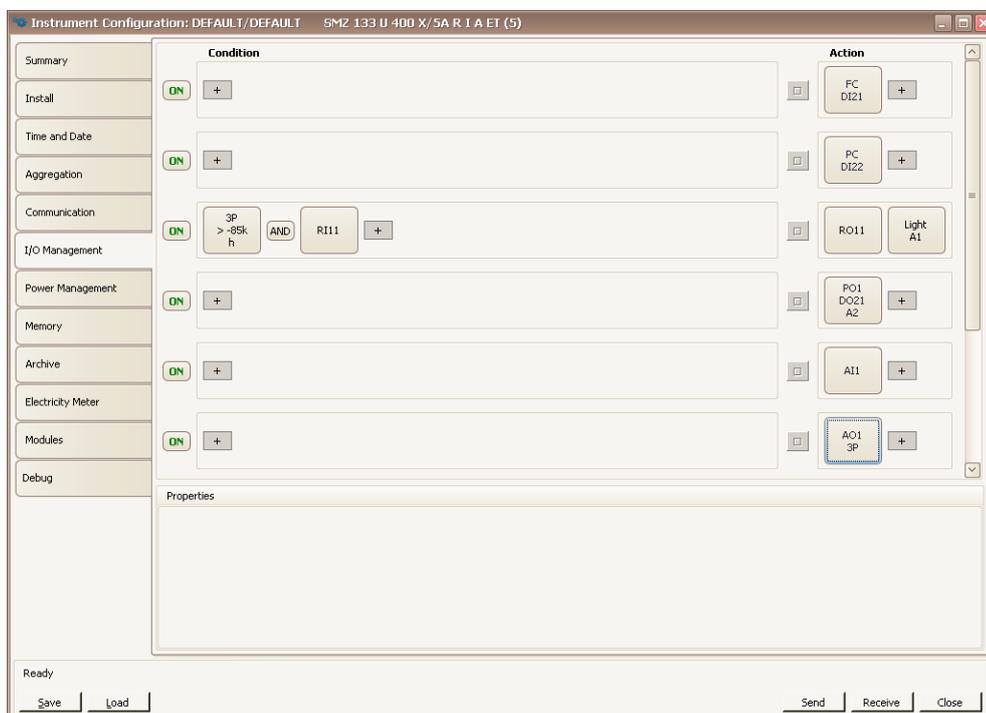
Each clause consists of :

-  ...*The clause switch* - If ON the clause is active, i.e. *the clause condition* (if any set) is evaluated and if it gets true (= logic 1), *the clause action* (or *actions*) are processed. By clicking on the switch you can toggle it to OFF – then the clause processing is suppressed and has no effect.
- *The clause condition* – a logic expression. When result of the expression is true (= logic 1) the clause action is performed. If the result is false (= logic 0), the action is not performed (=suppressed).

The clause condition can :

- be empty – then appropriate clause action is performed permanently (empty condition gets true result)
- be created by one condition item only (for example *the quantity value condition*)
- be formed by combination of two or more *condition items* joined with  and  operators (see the clause No. 2 in the example above)
- *The clause action* – with the actions you can set various functions concerning usually instrument inputs and outputs. Typical action is, for example, a digital output control.

The I/O Management Setup Example in the ENVIS-Daq Program





The symbol  is neither condition, nor operator nor an action – it is the button with which you can add conditions or actions into the clause.
Even if no I/O action is set the I/O Management folder contains one empty clause “template” with the -buttons prepared for new clause definition.

To add new clause, click on the -button in the action (= right) field of an empty clause template. In the pop-up menu choose required action. You can add either one or up to two actions into the same clause.

Optionally, you can add one or more conditions too with corresponding -button in the condition (=left) field. If more conditions added, you must set the logic operators OR/AND - simply click on it to toggle its value.



When designing the condition expression, note that the AND operator has higher priority - firstly, subexpressions joined with the AND-operators are evaluated and then the rest of the expression with the OR-operators.

To remove an action or a condition from a clause, click on it and press the *Delete* button in the the condition/action properties field (or push the *Delete* key).

For temporary disabling or enabling any of the clauses use the ON / OFF clause switch. When OFF, the clause operation is suppressed, but it stays in the setup prepared for future use.

3.3.1 I/O Setup Actions

3.3.1.1 Frequency Counter (FC)

The digital input can be used for monitoring of a quantity depending on frequency or duty cycle of incoming pulses.

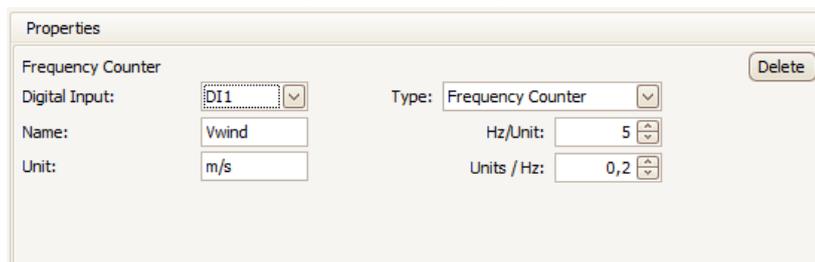
3.3.1.1.1 Frequency Mode

As example, flowmeters or anemometers with pulse output (often the „S0-type“) can be connected and the instrument can measure and record a flow rate or a wind speed. So despite being so called, this quantity is not any counter but a frequency controlled quantity.

Select an empty clause and add the *Frequency Counter* action. In the *Type* field choose *Frequency*. In the *Properties* field below you can set :

- *name* of the quantity (for example *Vwind*)
- *unit* of the quantity (*m/s*)
- transformation ratio in one of two formats :
 - either *Hz / Unit* ... frequency of the input pulses in hertzs corresponding to one unit
 - or *Units / Hz* ... value of the quantity (in the set units) in case the input pulse frequency is 1 Hz

I/O Setup – FC Action Properties



Properties		Frequency Counter		Delete	
Digital Input:	DI1	Type:	Frequency Counter		
Name:	Vwind	Hz/Unit:	5		
Unit:	m/s	Units / Hz:	0,2		

If the name is not defined, the quantity is referenced with its general name *FCxx* (when the *xx* is index of corresponding digital input).

3.3.1.1.2 PWM Mode

In this mode the duty cycle of incoming signal controls the counter value. Such signal is often called *PWM* (Pulse With Modulation) too.

In the *Type* field choose *PWM*. The other settings are the same as that of *Frequency* type excluding the transformation ratio – it is specified with limit values for duty of 100% (permanently active input) and 0% (permanently inactive input).

3.3.1.2 Pulse Counter (PC)

Similarly, counter of incoming pulses can be set. The counter usually represents amount of a media passing since the last counter clearing.

Add the *Pulse Counter* action and set :

- *name* of the counter (for example *Barrel1*)
- *unit* of the quantity (*hl*)
- transformation ratio in one of two formats :
 - either *Pulses / Unit ...* number of the input pulses corresponding to one unit
 - or *Units / Pulse ...* value of the quantity (in the set units) corresponding to one pulse

I/O Setup – PC Action Properties

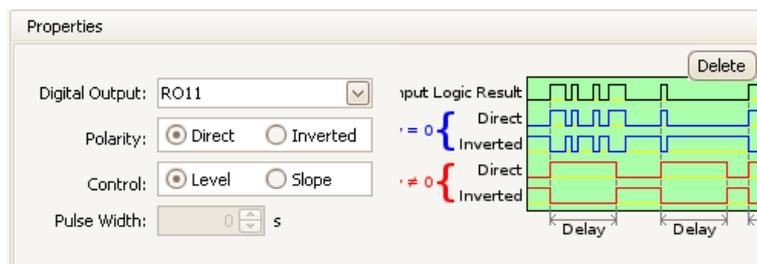


If the name is not defined, the quantity is referenced with its general name *PCxx* (when the *xx* is index corresponding digital input).

3.3.1.3 Digital Output (Standard)

In combination with a suitable condition (see *the quantity value condition* description below) you can create simple two-point controller or indicator with this action. This type of action will be called as *standard output*.

I/O Setup – Standard Digital Output Action Properties



Add the *Digital Output* action and set :

- desired *digital output*
- *polarity ...* choose *Direct* if the output to be switched *on* under true result of corresponding clause condition and vice versa

- *control* ... when set to 1 the output state simply follows the condition result value. If set to \uparrow the output switches on/off (depending on the polarity setup) temporary for preset *pulse width* only when the condition result changes *from false (0) to true (1)*



For simple „manual“ control of a digital output add the standard digital output action without any condition („empty“ condition gets permanent true (=1) result). Then set desired polarity and send the setup into the instrument..

3.3.1.4 Pulse Output

Any of digital outputs or alarm lights can be set as transmitting electricity meter. The frequency of generated impulses can be set depending on values of measured electric energy by the embedded electricity meter unit.

For pulse output following parameters must be set :

- target *digital output*
- target energy quantity ... the transmitted energy must be chosen here (see the electricity meter description for the energies explanation)
- number of *pulses per kWh/kvarh/kVAh*

I/O Setup – Pulse Output Action Properties

The screenshot shows a 'Properties' dialog box with the following fields:

- Pulse Output: PO1
- Outputs: DO21 (dropdown), A2 (dropdown)
- Quantity: 3p (dropdown), P+ (dropdown)
- Pulses / kWh: 1000 (spin box)



You can set one of alarm lights (A1, A2) as pulse output too and then you can check the pulse function on the instrument display simultaneously.

3.3.1.5 Alarm Light

Alarm lights A1, A2 can be set in the same way as digital outputs (see above) and used for indication of various events on the instrument display.

I/O Setup – Alarm Lights Properties

The screenshot shows a 'Properties' dialog box with the following fields:

- Analog Output: AO1 (dropdown)
- Control Quantity: P (dropdown)
- Phase: 3p (dropdown)
- Value at: 20 mA (dropdown), 500 (spin box)
- Value at: 4 mA (dropdown), 0 (spin box)

3.3.2 I/O Setup Conditions

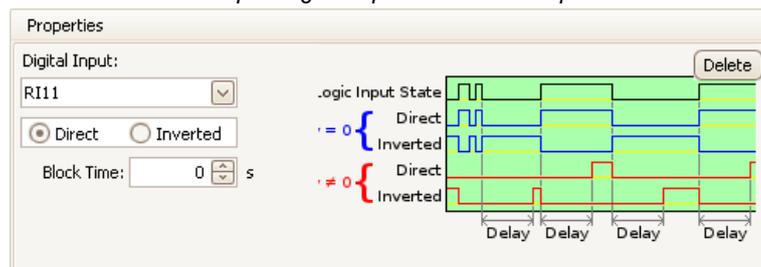
3.3.2.1 Digital Input Condition

Click on the -button in the condition part of target clause and choose the *Digital Input* option.

Then you must set :

- desired *Digital Input*
- *Direct* or *Inverted* ... if the *Direct*, the condition gets value *true* (logical 1) when the input is activated (i.e. appropriate voltage led to the input) and vice versa. If the *Inverted* is set, the behaviour is reverse (this is indicated with the “n” character in the condition icon).
- *Block Time* ... minimum duration of stable digital input state. If not zero, quick changes of the input signal are “filtered” and new state of the condition result occurs only if the signal lasts for at least set block time. This setup is indicated with the “b” character in the condition icon.

I/O Setup – Digital Input Condition Properties

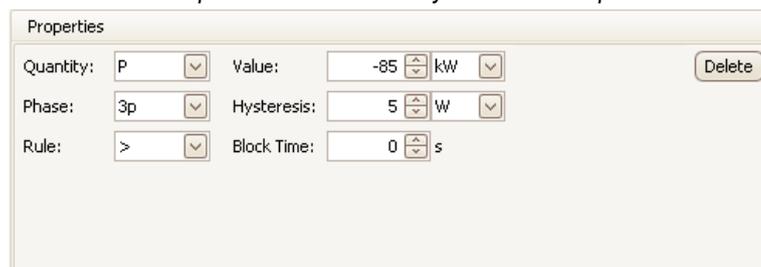


3.3.2.2 Measured Quantity Condition

Values of main measured quantities can be used as condition in the I/O setup clauses. Selected quantity size is compared with preset limit and gets either true(1) or false(0) result. For this, the following parameters must be preset :

- *control quantity & phase* ... desired measured quantity (single- or three-phase or AND/OR combination of them)
- *rule* ... specifies polarity of deviation between the control quantity and the preset limit value for true result of the condition
- *limit value* ... limit value of the control quantity
- *limit hysteresis* ... defines the insensibility range of the condition state evaluation
- *block time* ... defines minimum continuous duration of appropriate magnitude of control quantity until the condition result changes

I/O Setup – Measured Quantity Condition Properties



If value of the control quantity is not defined result of the condition is false.

3.4 I/O Processing

3.4.1 Digital Inputs

3.4.1.1 Digital Input Filter

Digital inputs are monitored with the period of 0.2 ms. For interference suppression, the signal is filtered digitally (by firmware). Default limit frequency of the filter is preset to 100 Hz.

The filter limit frequency can be set in *Advanced* parameters. *The DI filter minimum pulse width* parameter defines minimum pulse/gap width in milliseconds. When, for example, limit frequency of 100 Hz is desired set the parameter to 50 ms (pulse 50ms + gap 50 ms = 100ms). Pulses and gaps shorter than the set limit will be filtered.



It is not recommended to increase the limit frequency too much. Otherwise interference spikes can cause false measurement.

On contrary, when maximum output frequency of a sensor connected to the instrument is lower than 100Hz, it is suitable to decrease the limit frequency to corresponding value.

3.4.1.2 Digital Input as Frequency Counter

3.4.1.2.1 “Frequency” Mode

The frequency counter operation is based on measurement of duration between last two pulses. After the instrument startup, the quantity value is set to zero until at least two pulses come. Then the counter value is evaluated periodically each measurement cycle (cca 0,2 s).

Actual state of the counters can be checked via a communication link only using the ENVIS-Daq program.

3.4.1.2.2 “PWM” Mode

The quantity value is controlled by duty cycle of incoming signal. Evaluation runs as follows :

- after the instrument startup, the quantity value is undefined for 50 measurement cycles (cca 10 s)
- then the value is evaluated periodically each measurement cycle (cca 0,2 s)
- if the duty cycle drops below 0,5%, it is rounded to 0%; if it exceeds 99,5% it is rounded to 100%

Actual state of the counters can be checked via a communication link only using the ENVIS-Daq program.

3.4.1.3 Digital Input as Pulse Counter

The pulse counters have capacity of $2^{32} - 1$ pulses. Then overflow occurs and the counter starts to count from zero again. Contents of the counters is maintained in case of power failure.

Actual state of the counters can be checked via a communication link only using the ENVIS-Daq program.

3.4.2 Digital Outputs

Digital outputs are processed and refreshed after each measurement cycle, i.e. usually every 200 ms.

The only exclusion are the outputs set to *pulse function*.

3.4.2.1 Pulse Outputs

After the pulse function mode is set, every 200 milliseconds the instrument executes evaluation of the measured electric energy. If the increment of recorded electric power is higher or equal to the quantity of power per one pulse, the instrument will transmit one or two pulses. The mentioned description shows that the fluency of pulse transmission is +/- 200 ms.

The pulse width and minimum pulse gap are 50 / 50 ms (compliant with so-called S0-output definition), maximum frequency is 10 pulses per second.

4. Computer Controlled Operation

Monitoring the currently measured values and the instrument setup can using a remote computer connected to the instrument via a communication link. Such operation allows you to use all the setup options of the instrument, which it is not possible from the panel of the instrument.

Following chapters describe instrument communication links from the hardware point of view only. The detailed description of ENVIS program can be found in the program manual.

4.1 Communication Interface

4.1.1 RS-485 Interface (COM)

The link is isolated from other circuits of the instrument. Use terminals **A+** (No. 28/31), **B-** (29/32) and **G** (30/33) – the alternative numbering is valid for models with two communication interfaces. If both of them are of the RS-485 type, the second link (COM2) is marked **A+2** (No. 31), **B-2** (32) and **G2** (33).

Both of the links are insulated both from the instrument internal circuitry and mutually too, terminals No. 30 and 33 *are not connected internally* !

4.1.1.1 Communication Cable

For common applications (cable length up to 100 metres, communication rate up to 9,600 Bd) the selection of the right cable is not crucial. It is practically possible to use any shielded cable with two pairs of wires and to connect the shielding with the Protective Earth wire in a single point.

With cable lengths over 100 metres or with communication rates over 20 kilobits per second, it is convenient to use a special shielded communication cable with twisted pairs and a defined wave impedance (usually about 100 Ohm). Use one pair for the **A+** and **B-** signals and the second pair for the **G** signal.

Recommended wire type: shielded double twisted pair 2 x 2 x 0.2 mm², for example Belden 9842 or Unitronic Li2YCY (Lappkabel)

Recommended minimum conductor cross-section : 0.2 mm²

Maximum conductor cross-section : 2.5 mm²

4.1.1.2 Terminating Resistors

The RS-485 interface requires impedance termination of the final nodes by installation of terminating resistors, especially at high communication rates and long distances. Terminating resistors are only installed on the final points of the link (for example one on the PC and another on the remotest instrument). They are connected between terminals **A+** and **B-**. Typical value of the terminating resistor is 120 Ohm.

4.1.2 Ethernet Interface (ETH)

Using this interface the instruments can be connected directly to the local computer network (LAN). Instruments with this interface are equipped with a corresponding connector RJ- 45 with eight signals (in accordance with ISO 8877), a physical layer corresponds to 100 BASE- T.

Type and maximum length of the required cable must respond to IEEE 802.3.

Each instrument must have a different IP- address, preset during the installation. The address can be set from the instrument panel or you can use the ENVIS-DAQ program. For detection of actual IP- address you can use *the Locator* function.

Furthermore, you can set the DHCP function for dynamic IP-address allocation. Actual IP-address can be checked in the parameter group No. 15.

4.1.3 M-Bus Interface (M-BUS)

The interface is insulated from other instrument circuitry. Used signals are : **M+** (No. 28), **M-** (29).

Used cable must comply to the M-Bus interface specifications. Maximum conductor cross-section is 2.5 mm².

4.2 Communication Protocols

Instruments support both proprietary KMB protocol and Modbus and M-Bus protocols. Protocol detection is automatic; for proper link operation, the communication address, baudrate, number of data bits and, optionally, the parity too(parameter groups 15 and 16, optionally) must be set.

4.2.1 KMB Communications Protocol

This manufacturer proprietary protocol is used for communication with the ENVIS-DAQ or the ENVIS-Online program. Number of data bits (parameter No. 16) must be set to 8.

4.2.2 Modbus Communications Protocol

For the chance of easier integration of the instrument to the user's program, the instrument is also equipped with the Modbus–RTU / Modbus–TCP communications protocol. A detailed description can be found in *the Description of Communication Protocol* manual available on www.kmbystems.eu.

4.2.3 M-Bus Communications Protocol

Standard setup for this interface is address 1, communication rate 2400 Bd and 9 bits with even parity protocol. Secondary address is BCD-coded instrument serial number.

Maximum communication rate is 9600 Bd. Description of the protocol can be found in *the Description of Communication Protocol* manual available on www.kmbystems.eu.

4.2.4 Embedded Webserver

All of instruments with Ethernet remote communication interface are equipped with an embedded webserver, thus both all of main measured values and the instrument setting can be viewed with a standard web browser. It requires to set properly the instrument remote communication parameters and to connect it to the network. Then in the web browser enter appropriate IP-address of the instrument and information from the instrument appears.

Webserver

The screenshot displays the webserver interface for a 'Printing House' instrument. The top navigation bar includes 'Actual Data', 'Oscilograms', 'Harmonics', 'Electricity Meter', 'Configuration', 'Operating Manual', and 'KMB systems'. The main content is divided into two panels: 'Actual Data' and 'Oscilograms'.

Actual Data Panel:

- Object:** Printing House, **Record Name:** Main Switchboard, **Instrument Model:** SMC 144
- Voltages, Currents:**

Quantity \ Phase	L1	L2
U _{L1} [V]	410.5	413.8
U _{L2} [V]	233.4	237.1
I [A]	13.6	11.0
- Active, Reactive and Apparent Power:**

Quantity \ Phase	L1	L2
P [kW]	2.56	2.11
Q [kvar]	1.64	1.46
S [kVA]	3.17	2.60
PF [-]	0.8	0.8
- Fundamental Power and Distortion Power:**

Quantity \ Phase	L1	L2
P _{FM} [kW]	2.57	2.11
Q _{FM} [kvar]	1.65	1.47
D [kVA]	0.90	0.40
cosφ [-]	0.84L	0.82L
- Miscellaneous:**

Frequency [Hz]	Voltage Unbalance [%]	Current Unbalance [%]	Overflow flag
49.991	1.61	26.94	

Oscilograms Panel:

- Object:** Printing House, **Record Name:** Main Switchboard, **Instrument Model:** SMC 144, **Serial Number:** 66, **FW Version:** 2.0.15.3521, **IP Address:** 10.0.0.108
- Voltage:**

Phase	L1	L2	L3	L4
U _{RMS} [V]	233.4	236.0	241.3	0.0
THD _U [%]	2.8	2.6	2.6	---
- Current:**

Phase	L1	L2	L3	L4
I _{RMS} [A]	13.1	17.7	6.5	7.1
THD _I [%]	25.6	13.2	34.5	53.4
- Two line graphs show waveforms for U1, U2, U3 (voltage) and I1, I2, I3 (current).

Summary Table:

Phase	L1	L2	L3
EP+ [kWh]	18.3	16.6	8.2
EP- [kWh]	0.0	0.0	0.0
EOL [kvarh]	6.8	7.2	3.0
EOC [kvarh]	1.2	0.7	0.2
cosφ [-]	0.957L	0.931L	0.947L

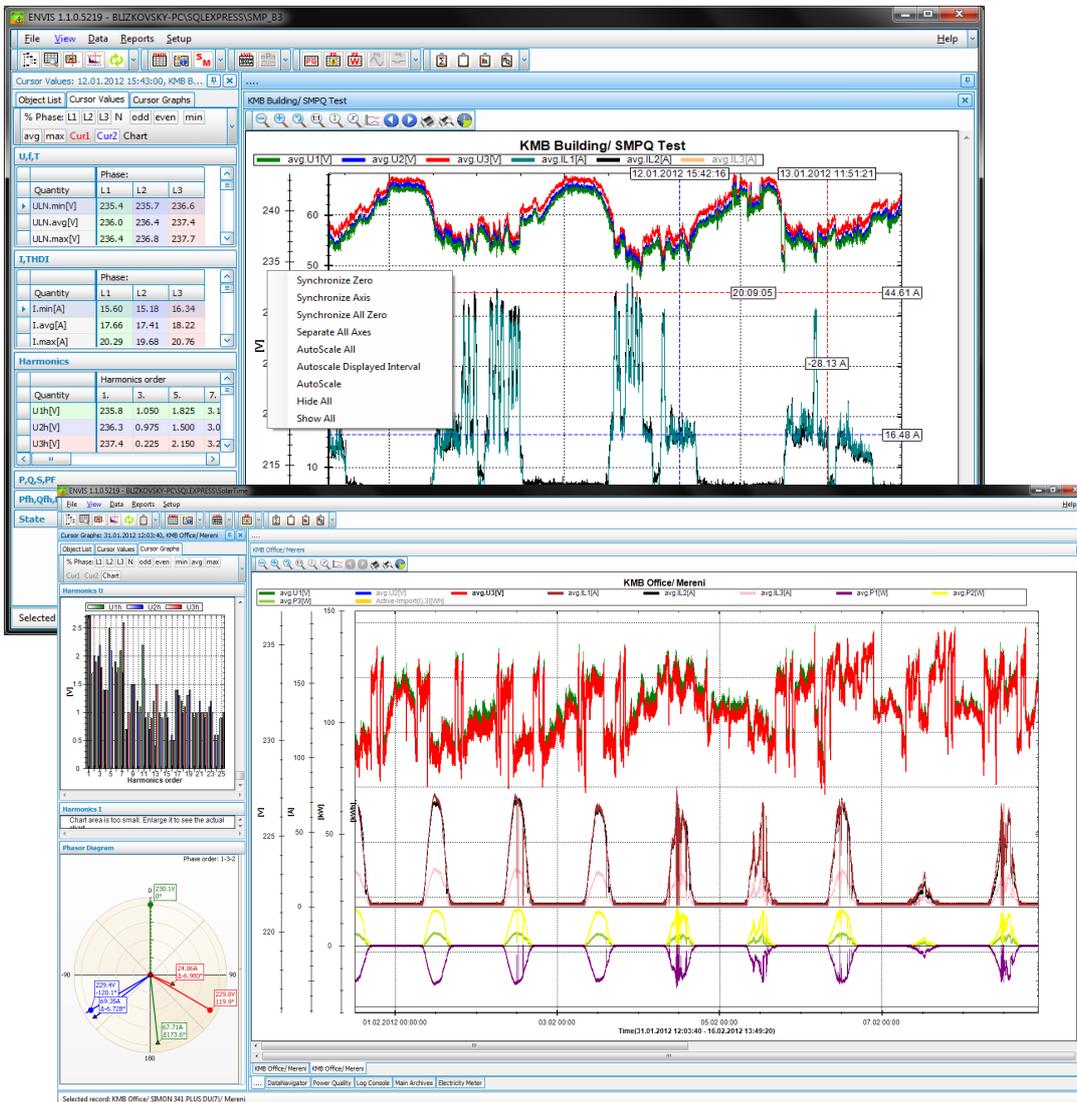
Additional summary data:

- Active Energy Export: 0.0
- Reactive Energy Inductive: 16.9
- Reactive Energy Capacitive: 2.0
- Average cosφ: 0.946L

4.3 The ENVIS Program

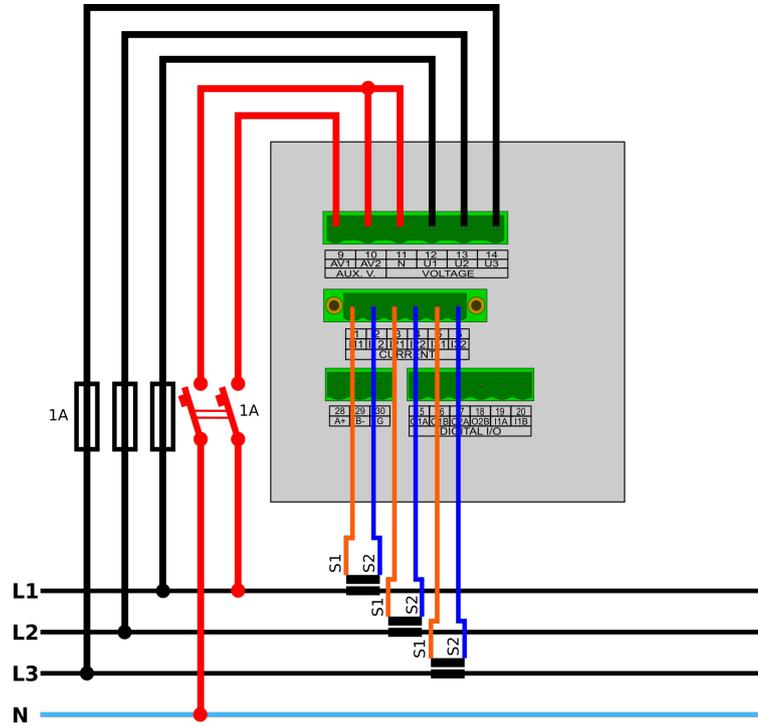
The ENVIS set of programs is used to set up the instruments, downloading actual measured data and to data visualization and archiving on a supervising PC. Detailed operation description can be found in manuals of the programs (www.kmbystems.eu).

Measured Data Visualization Examples

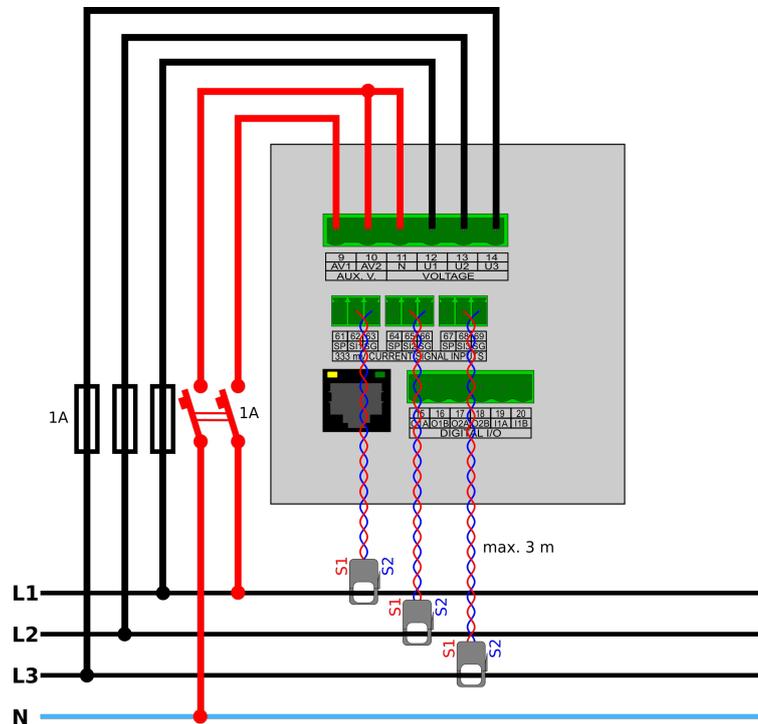


5. Examples of Connections

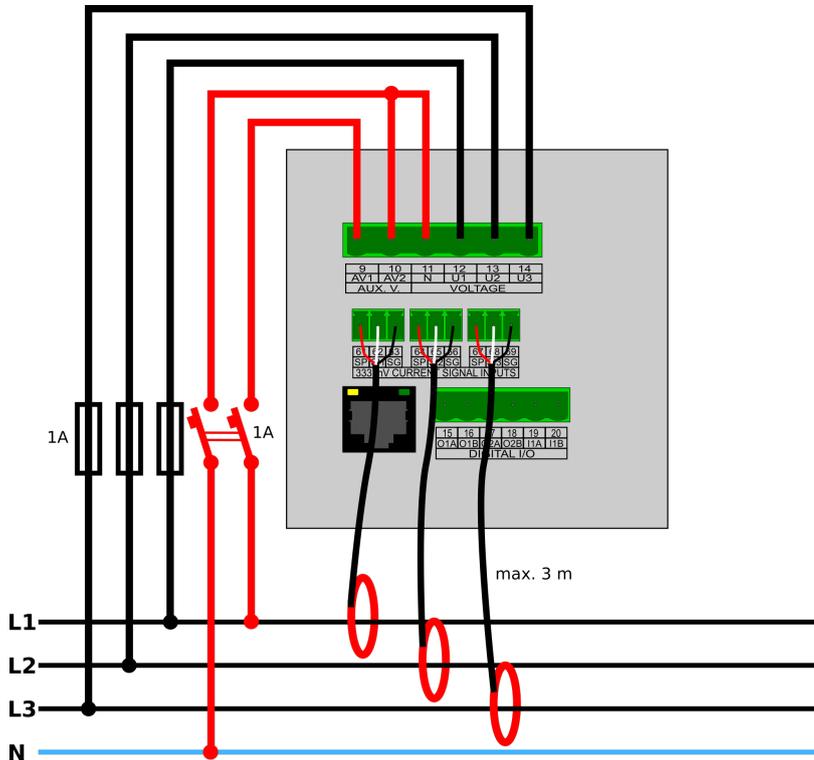
SML133 U 230 X/5A – Connection with 5A Nominal Output CTs TN-Network, Direct Star (“3Y”) Connection



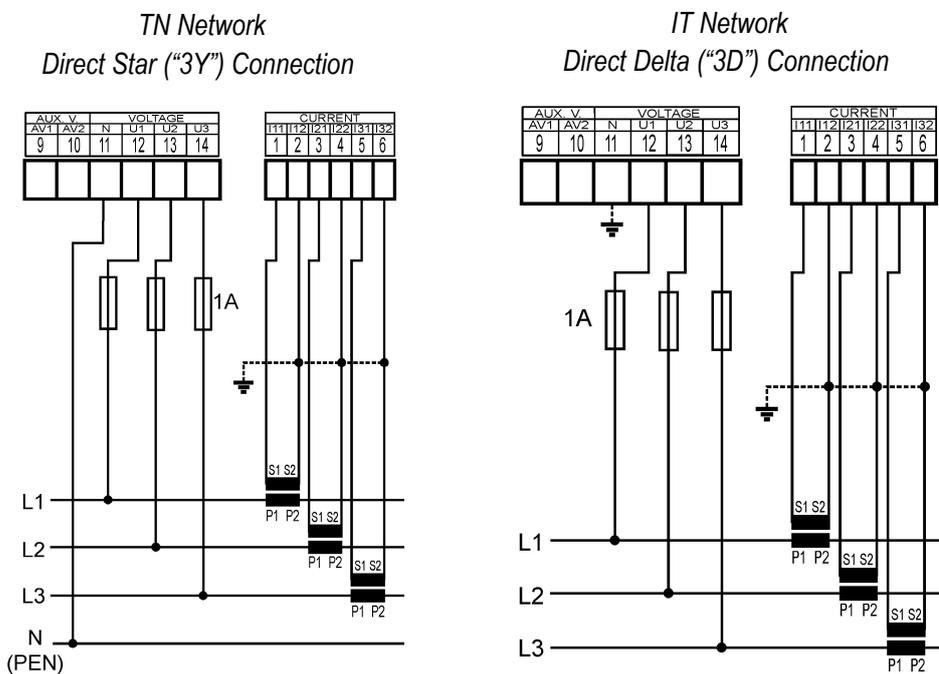
SML133 U 230 X/333mV – Connection with 333 mV Nominal Output CTs



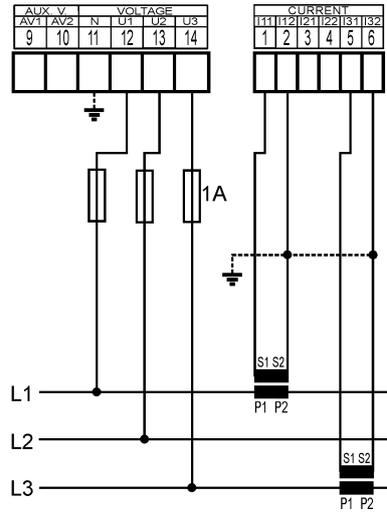
SML133 U 230 X/333mV – Connection with 333 mV Nominal Output Rogowski Current Sensors Equipped with Embedded Integrators



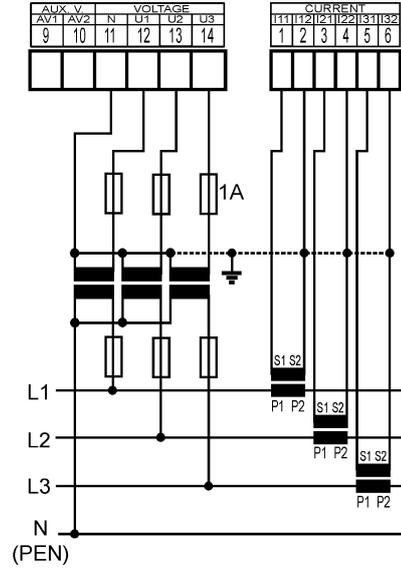
SML133 ... X/5A – Measured Signal Connection Examples



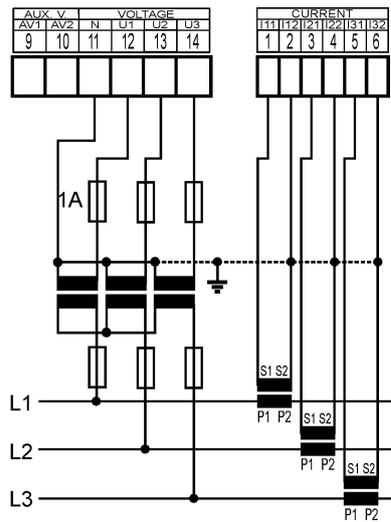
*IT Network
Direct Aron ("3A") Connection*



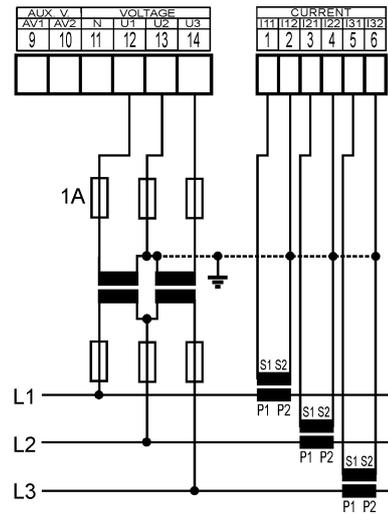
*TN Network
Star ("3Y") Connection via VT*



*IT Network
Delta ("3D") Connection via VT
(VT to Line-to-Neutral Primary Voltage)*

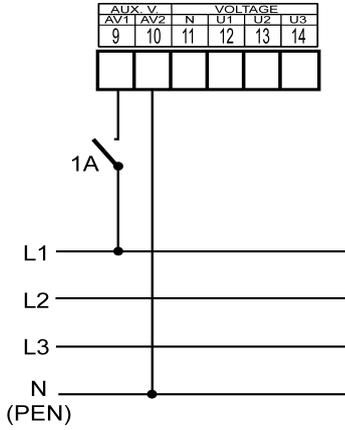


*IT Network
Delta ("3D") Connection via VT
(VT to Line-to-Line Primary Voltage)*

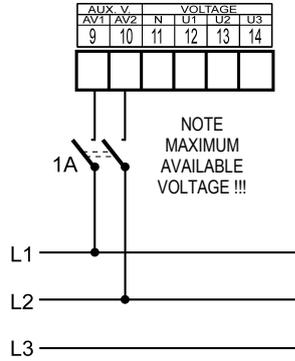


SML133 ... – Power Supply Options

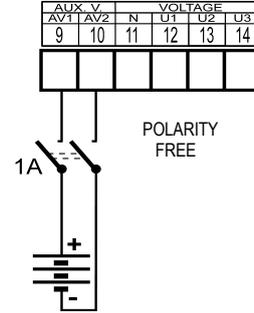
Line-to-Neutral Voltage
AC Power Supply



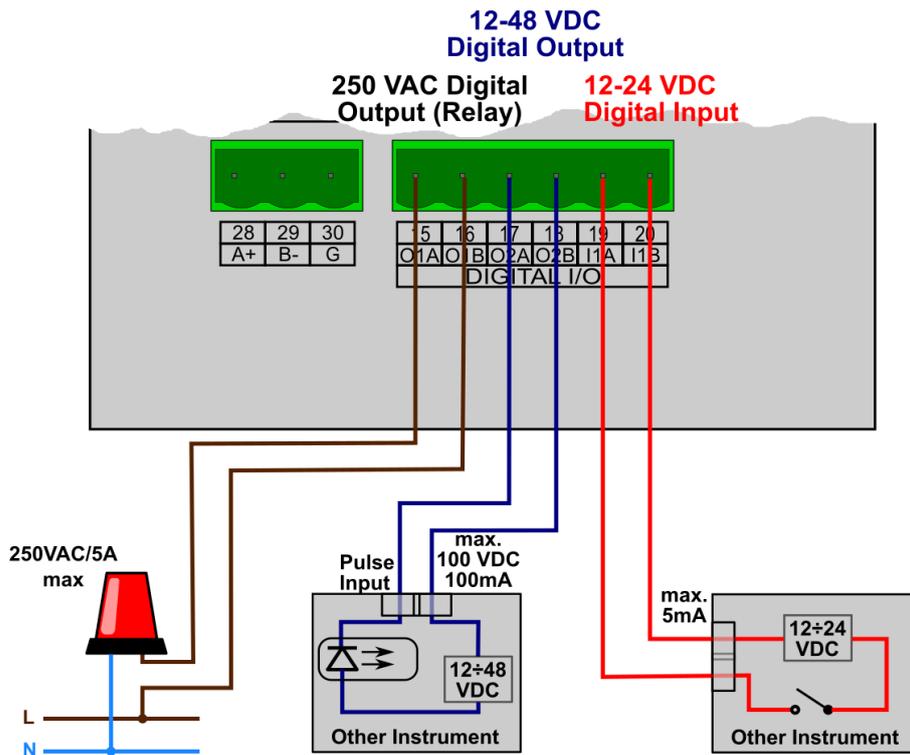
Line-to-Line Voltage
AC Power Supply



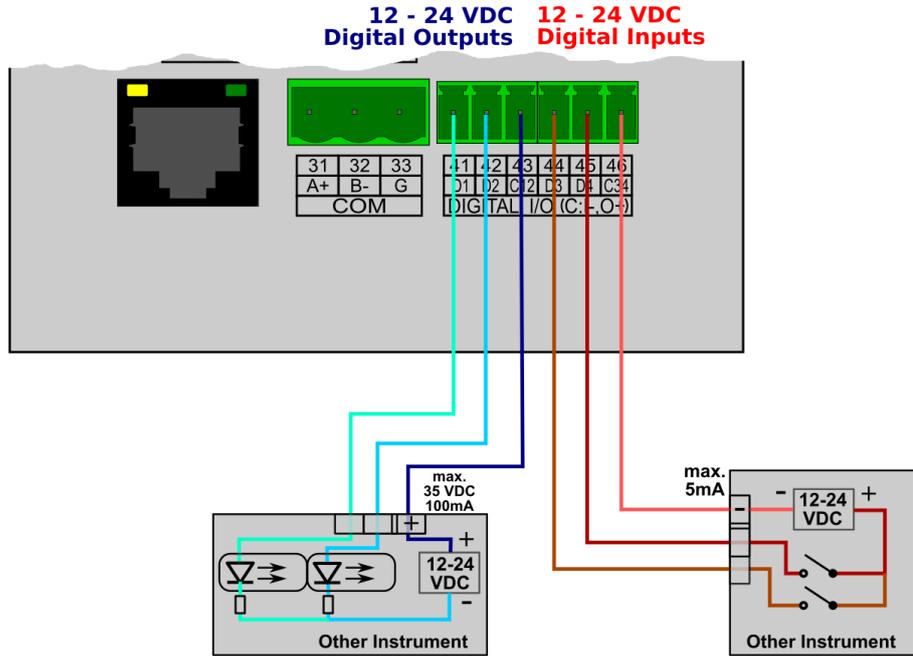
DC Power Supply



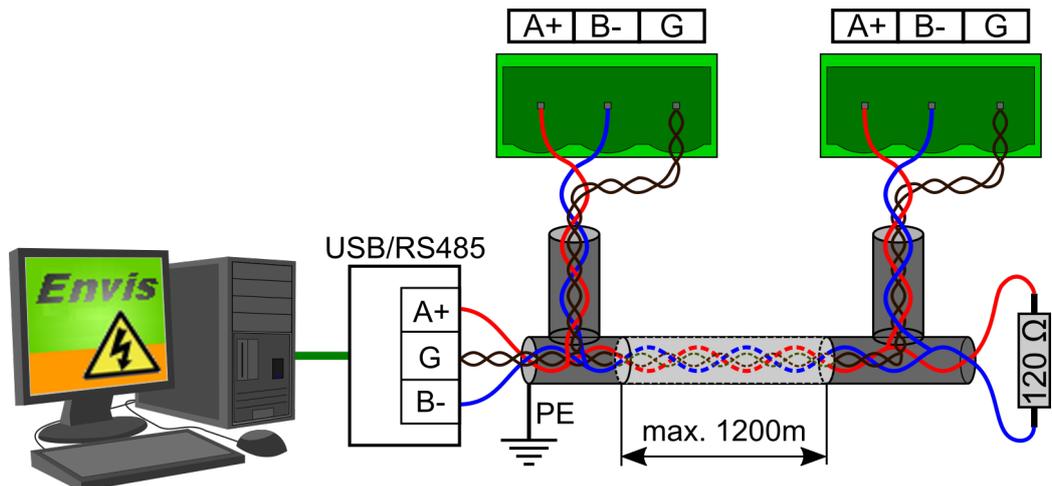
SMY133 ... RI – Digital I/O Connection Example



SML133 ... V – Digital I/O Connection Example



SML133 ... 4 – RS-485 Communication Link Connection



Numbering of Terminals – Measuring & Power Supply Inputs

signal	terminal No.
AV1	9
AV2	10
U1	12
U2	13
U3	14
N	11
I11 (SI1*)	1 (62*)
I12 (SG*)	2 (63*)
I21 (SI2*)	3 (65*)
I22 (SG*)	4 (66*)
I31 (SI3*)	5 (68*)
I32 (SG*)	6 (69*)
SP*	61, 64, 67 *) positive pole of 5V aux. supply for current sensors

*) ... valid for „X/333mV“ models

Numbering of Terminals – I/O

RR/RI/II models		V models	
signal	terminal No.	signal	terminal No.
O1A	15	D1	41
O1B	16	D2	42
O2A	17	C12	43
O2B	18	D3	44
I1A	19	D4	45
I1B	20	C34	46

Numbering of Terminals – Communication

RS – 485 (COM)		M-Bus	
signal	terminal No.	signal	terminal No.
A+ (A+2*)	28 (31*)	M+	28
B- (B-2*)	29 (32*)	M-	29
G (G2*)	30 (33*)	-	-

*) ... valid for models with two communication links

6. Manufactured Models and Marking

	SML 133	U	230	X/5A	RR	E
Instrument Model	SML 133 = Three-phase multimeter, 3U, 3I					
Auxiliary Power Supply	U = 90 V ÷ 275 VAC, 80 V ÷ 350 VDC S = 10 V ÷ 26 VAC, 10 V ÷ 36 VDC L = 20 V ÷ 50 VAC, 20 V ÷ 75 VDC					
Nominal Measuring Voltage	230 = 230V/400V 100 = 57,7V/100V 400 = 400V/690V					
Current Inputs	X/5A = 5A and 1A AC (standard indirect measurement) 333mV = input for sensors with 333mV output					
Digital I/O	N = without I/O RR = 2× relay output + 1× logical input 24V RI = 1× relay output + 1× pulse output + 1× logical input 24V II = 2× pulse output + 1× logical input 24V					
Remote Communication Interface	N = no remote comm. link M = M-Bus interface 4 = RS-485 E = Ethernet					

7. Technical Specifications

Function Characteristics according to IEC 61557-12				
Model „230 X/5A“, $U_{NOM} = 230\text{ V}$, $I_{NOM} = 5\text{ A}$				
Symbol	Function	Class	Measuring range	Notes
P	total effective power	0.5	0 ÷ 5400 W	
QA, QV	total reactive power	1	0 ÷ 5400 var	
SA, SV	total apparent power	0.5	0 ÷ 5400 VA	
Ea	total active energy	0.5	0 ÷ 5400 Wh	
ErA, ErV	total reactive energy	2	0 ÷ 5400 varh	
EapA, EapV	total apparent energy	0.5	0 ÷ 5400 VAh	
f	frequency	0.05	40 ÷ 70 Hz	
I	phase current	0.5	0.005 ÷ 6 AAC	
IN	neutral current measured	–	–	
INc	neutral current calculated	0.5	0.005 ÷ 18 AAC	2)
ULN	line-to-neutral voltage	0.5	40 ÷ 280 VAC	
ULL	line-to-line voltage	0.5	70 ÷ 480 VAC	
PFA, PFV	power factor	0.5	0 ÷ 1	
Pst, PIt	flicker	–	–	
Udip	voltage dips	–	–	
Uswl	voltage swells	–	–	
Utr	transients overvoltage	–	–	
Uint	voltage interruption	–	–	
Unba	voltage unbalance (amp.)	0.5	0 ÷ 10 %	2)
Unb	voltage unbalance (ph.&amp.)	0.5	0 ÷ 10 %	2)
Uh	voltage harmonics 50 Hz (60 Hz)	2	up to 50 th (40 th) order	1)
THDu	voltage total harm. distortion (rel. to fund.)	2	0 ÷ 20 %	1)
THD-Ru	voltage total harm. distortion (rel. to RMS)	2	0 ÷ 20 %	1, 2)
Ih	current harmonics 50 Hz (60 Hz)	2	up to 50 th (40 th) order	1)
THDi	current total harm. distortion (rel. to fund.)	2	0 ÷ 200 %	1)
THD-Ri	voltage total harm. distortion (rel. to RMS)	2	0 ÷ 200 %	1)
Msv	mains signalling voltage	–	–	1, 2)

Notes : 1) ...according to IEC 61000-4-7 ed.2

2) ... value available via communication link only, not displayed

Function Characteristics according to IEC 61557-12				
UNOM = 100 / 230 / 400 V for model "100" / "230" / "400"				
Model „X/5A“, INOM = 5 A				
Symbol	Function	Class	Measuring range	Notes
P	total effective power	0.5	0 ÷ (21.6 * UNOM) W	
QA, QV	total reactive power	1	0 ÷ (21.6 * UNOM) var	
SA, SV	total apparent power	0.5	0 ÷ (21.6 * UNOM) VA	
Ea	total active energy	0.5	0 ÷ (21.6 * UNOM) Wh	
ErA, ErV	total reactive energy	2	0 ÷ (21.6 * UNOM) varh	
EapA, EapV	total apparent energy	0.5	0 ÷ (21.6 * UNOM) VAh	
f	frequency	0.05	40 ÷ 70 Hz	
I	phase current	0.5	0.005 ÷ 6 AAC	
IN	neutral current measured	–	–	
INc	neutral current calculated	0.5	0.005 ÷ 18 AAC	2)
ULN	line-to-neutral voltage	0.5	0.2 ÷ 1.2 * UNOM	
ULL	line-to-line voltage	0.5	0.2 ÷ 1.2 * UNOM * √3	
PFA, PFV	power factor	0.5	0 ÷ 1	
Pst, PIt	flicker	–	–	
Udip	voltage dips	–	–	
Uswl	voltage swells	–	–	
Utr	transients overvoltage	–	–	
Uint	voltage interruption	–	–	
Unba	voltage unbalance (amp.)	0.5	0 ÷ 10 %	2)
Unb	voltage unbalance (ph.&.)	0.5	0 ÷ 10 %	2)
Uh	voltage harmonics 50 Hz (60 Hz)	2	up to 50 th (40 th) order	1)
THDu	voltage total harm. distortion (rel. to fund.)	2	0 ÷ 20 %	1)
THD-Ru	voltage total harm. distortion (rel. to RMS)	2	0 ÷ 20 %	1, 2)
Ih	current harmonics 50 Hz (60 Hz)	2	up to 50 th (40 th) order	1)
THDi	current total harm. distortion (rel. to fund.)	2	0 ÷ 200 %	1)
THD-Ri	voltage total harm. distortion (rel. to RMS)	2	0 ÷ 200 %	1)
Msv	mains signalling voltage	–	–	1, 2)

Notes : 1) ...according to IEC 61000-4-7 ed.2

2) ... value available via communication link only, not displayed

Function Characteristics according to IEC 61557-12				
UNOM = 100 / 230 / 400 V for model "100" / "230" / "400"				
Model „X/100mA“, INOM = 0.1 A				
Symbol	Function	Class	Measuring range	Notes
P	total effective power	0.5	0 ÷ (0.43 * UNOM) W	
QA, QV	total reactive power	1	0 ÷ (0.43 * UNOM) var	
SA, SV	total apparent power	0.5	0 ÷ (0.43 * UNOM) VA	
Ea	total active energy	0.5	0 ÷ (0.43 * UNOM) Wh	
ErA, ErV	total reactive energy	2	0 ÷ (0.43 * UNOM) varh	
EapA, EapV	total apparent energy	0.5	0 ÷ (0.43 * UNOM) VAh	
f	frequency	0.05	40 ÷ 70 Hz	
I	phase current	0.5	0.001 ÷ 0.12 AAC	
IN	neutral current measured	–	–	
INc	neutral current calculated	0.5	0.001 ÷ 0.36 AAC	2)
ULN	line-to-neutral voltage	0.5	0.2 ÷ 1.2 * UNOM	
ULL	line-to-line voltage	0.5	0.2 ÷ 1.2 * UNOM * √3	
PFA, PFV	power factor	0.5	0 ÷ 1	
Pst, Pit	flicker	–	–	
Udip	voltage dips	–	–	
Uswl	voltage swells	–	–	
Utr	transients overvoltage	–	–	
Uint	voltage interruption	–	–	
Unba	voltage unbalance (amp.)	0.5	0 ÷ 10 %	2)
Unb	voltage unbalance (ph.&amp.)	0.5	0 ÷ 10 %	2)
Uh	voltage harmonics	2	up to 50 th (40 th) order	1)
THDu	voltage total harm. distortion (rel. to fund.)	2	0 ÷ 20 %	1)
THD-Ru	voltage total harm. distortion (rel. to RMS)	2	0 ÷ 20 %	1, 2)
Ih	current harmonics 50 Hz (60 Hz)	2	up to 50 th (40 th) order	1)
THDi	current total harm. distortion (rel. to fund.)	2	0 ÷ 200 %	1)
THD-Ri	voltage total harm. distortion (rel. to RMS)	2	0 ÷ 200 %	1)
Msv	mains signalling voltage	–	–	1, 2)

Notes : 1) ...according to IEC 61000-4-7 ed.2

2)... value available via communication link only, not displayed

Measured Quantities – Voltage *)			
Frequency			
f_{NOM} – nominal frequency	50 / 60 Hz		
measuring range	40 ÷ 70 Hz		
measuring uncertainty	± 10 mHz		
Voltage			
model	„100“	„230“	„400“
U_{NOM} (U_{DIN}) – rated voltage (phase-to-neutral, $U_{\text{L-N}}$)	57.7 ÷ 125 VAC	180 ÷ 250 VAC	300 ÷ 415 VAC
crest factor at U_{NOM}	2.1		
measuring range $U_{\text{L-N}}$	3 ÷ 190 VAC	6 ÷ 375 VAC	10 ÷ 625 VAC
measuring range $U_{\text{L-L}}$	5 ÷ 330 VAC	8 ÷ 660 VAC	2 ÷ 1090 VAC
measuring uncertainty ($t_{\text{A}}=23\pm 2^{\circ}\text{C}$)	+/- 0.05 % of rdg +/- 0.02 % of rng		
temperature drift	+/- 0.03 % of rdg +/- 0.01 % of rng / 10 °C		
measurement category	150V CAT IV	300V CAT III	300V CAT III 600V CAT II
permanent overload	300 VAC	600 VAC	1000 VAC
peak overload ($U_{\text{L-N}}$ / 1 sec.)	600 VAC	1200 VAC	2000 VAC
burden power, impedance	< 0.013 VA $R_{\text{i}} = 1.8 \text{ M}\Omega$	< 0.025 VA $R_{\text{i}} = 3.6 \text{ M}\Omega$	< 0.05 VA $R_{\text{i}} = 6 \text{ M}\Omega$
Voltage Unbalance			
measuring range	0 ÷ 10 %		
measuring uncertainty	± 0.3		
Harmonics & Interharmonics (up to 50th order, or 40th order @ 60 Hz)			
reference conditions	other harmonics up to 200 % of class 3 acc. to IEC 61000–2-4 ed.2		
measuring range	10 ÷ 100 % of class 3 acc. to IEC 61000–2-4 ed.2		
measuring uncertainty	twice the levels of class II acc. to IEC 61000–4-7 ed.2		
THDU			
measuring range	0 ÷ 20 %		
measuring uncertainty	± 0.5		

Note *) : The quantities and their measurement uncertainties are valid for $f_{\text{NOM}} = 50/60$ Hz. For $f_{\text{NOM}} = \text{DC} \div 500$ Hz ("The Fixscan" mode), see separate table below.

Measured Quantities – Temperature (internal sensor, measured value affected by the instrument power dissipation)	
measuring range	- 40 ÷ 80 °C
measurement uncertainty	± 2 °C

Measured Quantities – Current *)			
model	„X/5A“	„X/100mA“	„X/333mV“
I_{NOM} (I _B) – rated current	1 / 5 AAC	0.1 AAC	I @ 333mV
crest factor at I_{NOM}	2.0	5.5	2.1
measuring range	0.005 ÷ 7 AAC	0.001 ÷ 0.39 AAC	0.002 ÷ 0.5 VAC
meas. uncertainty ($t_A=23\pm 2^\circ\text{C}$)	+/- 0.05 % of rdg +/- 0.02 % of rng		
temperature drift	+/- 0.03 % of rdg +/- 0.01 % of rng / 10 °C		
measurement category	150V CAT III	150V CAT III	undefined
permanent overload	7.5 AAC	1 AAC	15 VAC
peak overload - for 1 second, max. repetition frequency > 5 minutes	70 AAC	10 AAC	15 VAC
burden power (impedance)	< 0.5 VA (Ri < 10 mΩ)	< 0.01 VA (Ri < 40 mΩ)	< 3 uVA (Ri>100kΩ)
Current Unbalance			
measuring range	0 ÷ 100 %		
measuring uncertainty	± 1 % of rdg or ± 0.5		
Harmonics & Interharmonics (up to 50th order, or 40th order @ 60 Hz)			
reference conditions	other harm. up to 1000 % of class 3 acc. to IEC 61000–2-4 ed.2		
measuring range	500 % of class 3 acc. to IEC 61000–2-4 ed.2		
measuring uncertainty	I _h ≤ 10% I _{NOM} : ± 1% I _{NOM} I _h > 10% I _{NOM} : ± 1% of rdg		
THDI			
measuring range	0 ÷ 200 %		
measuring uncertainty	THDI ≤ 100% : ± 0.6 THDI > 100% : ± 0.6 % of rdg		

Note *) : The quantities and their measurement uncertainties are valid for $f_{NOM} = 50/60$ Hz. For $f_{NOM} = \text{DC} \div 500$ Hz ("The Fixscan" mode), see separate table below.

Measured Quantities – Power, Power Factor, Energy *)	
Active / Reactive Power, Power Factor (PF), cos φ (P_{NOM} = U_{NOM} x I_{NOM})	
reference conditions "A" : ambient temperature (t _A) U, I for active power, PF, cos φ for reactive power	23 ± 2 °C U = 80 ÷ 120 % U _{NOM} , I = 1 ÷ 120 % I _{NOM} PF = 1.00 PF = 0.00
act. / react. power uncertainty	± 0.5 % of rdg ± 0.005 % P _{NOM}
PF & cos φ uncertainty	± 0.005
reference conditions "B" : ambient temperature (t _A) U, I for active power, PF, cos φ for reactive power	23 ± 2 °C U = 80 ÷ 120 % U _{NOM} , I = 1 ÷ 120 % I _{NOM} PF ≤ 0.87 PF ≤ 0.87
act. / react. power uncertainty	± 1 % of rdg ± 0.01 % P _{NOM}
PF & cos φ uncertainty	± 0.005
temperature drift of powers	+/- 0.05 % of rdg +/- 0.02 % P _{NOM} / 10 °C
Energy	
measuring range	corresponds to U & I measuring ranges 4 quadrant energy counters for both active and reactive energies
active energy uncertainty	class 0.5S acc. to IEC 62053 – 22
reactive energy uncertainty	class 1S acc. to IEC 62053 – 24

Note *) : The quantities and their measurement uncertainties are valid for f_{NOM} = 50/60 Hz. For f_{NOM} = DC ÷ 500 Hz ("The Fixscan" mode), see separate table below.

Instrument Characteristics according to IEC 61557-12	
power quality assessment function	–
classification according to par. 4.3 direct voltage connection voltage connection via VT	SD SS
temperature according to par. 4.5.2.2	K55
humidity + altitude according to par. 4.5.2.3	< 95 % - noncondensation conditions < 3000 m
active power/energy function performance class	0.5

„FIXSCAN“ Mode - Measuring Uncertainties	
f_{NOM} set to „DC-500“	
Frequency Range : 350 ÷ 450 Hz	
Frequency	
measuring uncertainty	± 0.1 Hz
Voltage	
measuring uncertainty	+/- 0.2 % of rdg +/- 0.1 % of rng
Current	
measuring uncertainty	+/- 0.2 % of rdg +/- 0.1 % of rng
Active / Reactive Power, Power Factor (PF), cos φ (P_{NOM} = U_{NOM} x I_{NOM})	
reference conditions “A” : U, I for active power, PF, cos φ for reactive power	U = 80 ÷ 120 % U _{NOM} , I = 1 ÷ 120 % I _{NOM} PF = 1.00 PF = 0.00
act. / react. power uncertainty	± 0.5 % of rdg ± 0.01 % P _{NOM}
PF & cos φ uncertainty	± 0.01
reference conditions “B” : U, I for active power, PF, cos φ for reactive power	U = 80 ÷ 120 % U _{NOM} , I = 1 ÷ 120 % I _{NOM} PF ≥ 0.5 PF ≤ 0.87
act. / react. power uncertainty	± 2 % of rdg ± 0.1 % P _{NOM}
PF & cos φ uncertainty	± 0.02

Instrument Auxiliary Power Supply Voltage			
model	„U“	„L“	„S“
rated (nominal) auxiliary voltage range	110 ÷ 250 V _{AC}	23 ÷ 68 V _{DC}	12 ÷ 32 V _{DC}
aux. voltage range AC: f=40÷100 Hz; DC reference conditions “1” : - +5V aux. power load : 0 mA (for models "333mV") reference conditions “2” : - +5V aux. power load : 60 mA (for models "333mV")	85 ÷ 275 V _{AC} 80 ÷ 350 V _{DC} 90 ÷ 275 V _{AC} 85 ÷ 350 V _{DC}	20 ÷ 50 V _{AC} 20 ÷ 75 V _{DC}	10 ÷ 26 V _{AC} 10 ÷ 36 V _{DC}
power	8 VA / 4 W		
overvoltage cat.	III		
pollution degree	2		
connection	isolated, polarity free		

„X/333mV“ Instrument Model Auxiliary Voltage for Current Sensors	
connection	non-isolated (connected with the instrument internal circuitry)
output voltage	+5 V _{DC} ± 5 %
maximum permanent load	60 mA _{DC}
short-circuit current, max. duration	approx. 100 mA _{DC} , 5 seconds

Digital Outputs & Digital Inputs		
„R“-Type Outputs (relay)		
type	N.O. contact	
load rating	250 V _{AC} / 30 V _{DC} , 4 A	
„I“- and “V”- Type Outputs (solid state, opto-MOS)		
	“RR/RI/II” Models	“V” Models
typ	Opto-MOS, bipolar	Opto-MOS, unipolar
load rating	60 V _{AC} / 100 V _{DC} , 100 mA	35 V _{DC} , 100 mA
dynamic param. (pulse output) :	S0 - compatible	
- pulse duration	50 ms	
- gap duration	>= 50 ms	
- maximum frequency	10 Hz	
Digital Inputs		
model	“ RR / RI / II ”	“ V ”
type	optoisolated, bipolar	optoisolated, unipolar
maximum voltage	100 V _{DC} / 60 V _{AC}	35 V _{DC}
voltage for “logical “ 0 / 1	< 3 V _{DC} / > 10 V _{DC}	< 3 V _{DC} / > 10 V _{DC}
input current	1 mA @ 10V / 5 mA @ 24V / 10 mA @ 48V	3 mA @ 10V / 13 mA @ 24V / 20 mA @ 35V
dynamic parameters *) :		
- pulse/gap duration	>= 50 / 50 ms	>= 0.5 / 0.5 ms
- maximum frequency	10 Hz	1 kHz

Note *) : Limit that correspond to the instrument hardware. Real values depend on the firmware filter adjustment - see the chapter *Digital Input Filter*.

Other Specifications	
operational temperature	- 20 to 60°C
storage temperature	- 40 to 80°C
operational and storage humidity	< 95 % - non-condensable environment
EMC – immunity	EN 61000 – 4 - 2 (4kV / 8kV); EN 61000 – 4 - 3 (10 V/m up to 1 GHz); EN 61000 – 4 - 4 (2 kV); EN 61000 – 4 - 5 (2 kV); EN 61000 – 4 - 6 (3 V); EN 61000 – 4 - 11 (5 periods)
EMC – emissions	EN 55011, class A; EN 55022, class A (not for home use)
remote communication port (option)	RS-485 / 2400÷460800 Bd / protocols KMB, Modbus-RTU or Ethernet 100 Base-T / DHCP, webserver, Modbus-TCP or M-Bus (max. 9600 Bd)
display	Segment LCD FSTN with backlight
protection class front panel / back panel	IP 40 (IP 54 with cover sheet) / IP 20
dimensions front panel / built-in depth installation cutout	96 x 96 mm / 80 mm 92 ⁺¹ x 92 ⁺¹ mm
mass	max. 0.3 kg

8. Maintenance, Service

The SML 133 instruments do not require any maintenance in their operation. For reliable operation it is only necessary to meet operating conditions specified and not expose the instrument to violent handling and activity of water or chemicals which could cause mechanical damage.

If the product has a breakdown, you need to complain to the supplier at their address:

Supplier: Manufacturer : KMB systems, s.r.o.
 Dr. M. Horákové 559
 460 06 LIBEREC 7
 Czech Republic
 telephone: +420 485 130 314
 fax: +420 482 736 896
 e-mail : kmb@kmb.cz
 website : www.kmbsystems.eu

The product must be in proper package to prevent damage in transit. Description of the problem or its symptoms must be delivered together with the product.

If a warranty repair is claimed, the warranty certificate must be sent in. In case of an out-of-warranty repair you must enclose an order for the repair.

Warranty Certificate

Warranty period of 24 months from the date of purchase is provided for the instrument. Problems in the warranty period, provably because of faulty workmanship, design or inconvenient material, will be repaired free of charge by the manufacturer or an authorized servicing organization.

The warranty ceases even within the warranty period if the user makes unauthorized modifications or changes to the instrument, connects it to out-of-range quantities, if the instrument got damaged in out-of-specs falls or by improper handling or if it has been operated in contradiction with the technical specifications presented.

type of product: **SML 133** manufacturer's seal:
 serial number
 final quality inspection:
 date of dispatch:

date of purchase: supplier's seal: