EN

ME110-230.3M

3-Phase Power Measurement Module

User guide

ME110-230.3M_2017.09_0261_EN

CE

Contents

1 Overview

1.1 Functions

The module ME110-230.3M is an input module for measuring the electrical data in a 3-phase AC power system and transmission of the measured and calculated data over RS485 network.

The device has three voltage analog inputs and three current analog inputs. The phase currents, phase voltages and line-to-line voltages are measured on inputs and digitalised. The digitalised values are used to calculate the effective (root mean square) values and other 3-phase AC power system values: powers (active, reactive, apparent), power factors and phase angles.

The module provides following basic functions:

- transmitting the measured and calculated values over RS485 network
- RS485 network diagnostic
- fault indication
- Slave in the RS485 network.

The module is to be configured using ‘M110 Configurator’ software (included on CD) via RS485-USB interface adapter IC4 (not included). The latest version of the configuration software is available for download on www.akytec.de.

1.2 RS485 network

I/O modules of series Mx110 use the common standard RS485 for data exchange.

Serial interface RS485 enables communication via two-wired line in half-duplex mode. The module supports Modbus-RTU, Modbus-ASCII and akYtec protocols. The network consists of a Master device and can contain up to 32 Slave devices. Maximum length is 1200 m. The number of Slave devices and network length can be increased using RS485 interface repeater.

Devices are connected to a network according to linear (bus) topology. It means that the line goes from the first device to the second one, from the second one to the third one, etc. Star connection and spur lines are not allowed.

Line reflections always occur at each of the 2 ends of the bus (the first and the last node). The higher the data transmission rate, the stronger they are. A terminating resistor is needed to minimize reflections. Line termination may be a 150 ohms value (0.5 W) resis-tor.

All modules can be used as Slave devices only. Master device can be PLC, computer with SCADA software or control panel.

2 Specifications

Table 2.1 General data

Power supply	
Power supply	230 (90…264) V AC, 45…65 Hz
Power consumption, max.	7.5 VA
Phase voltage measurement	
Measuring range	1...400 Veff
Measuring range with external transformer	$1x10^{-3}$...$4000x10^{3}$ Veff
Max. voltage for the duration of 1 s	800 V
Basic accuracy	0.25 %
Resolution	0.1 V
Input resistance, max.	500 kohm
Sampling time, max.	1 s
Measuring channels	3
Line-to-line voltage measurement	
Measuring range	2...580 Veff
Measuring range with external transformer	$2x10^{-3}$...$5800x10^{3}$ Veff
Max. voltage for the duration of 1 s	800 V
Basic accuracy	0.5 %
Resolution	0.1 V
Input resistance, max.	500 kohm
Sampling interval, max.	1 s
Measuring channels	3
Current measurement	
Measuring range	0.005…5 Aeff
Measuring range with external transformer	$0.005x10^{-3}$…$50x10^{3}$ Aeff
Max. current for the duration of 1 s	10 A
Basic accuracy	0.25%
Resolution	1 mA
Input resistance, max.	0.01 ohm
Sampling interval, max.	1 s
Measuring channels	3
Power measurement	
Measuring range	0.02…2 kW, kVA, kvar
Measuring range with external transformer	$0.2x10^{-6}$…$200x10^{9}$ kW, kVA, kvar
Basic accuracy	0.5 %
Resolution	1 kW, kVA, kvar
Calculating time, max.	1 s
Measuring channels	3
Frequency measurement	
Measuring range	45…65 Hz
Basic accuracy	0.15%
Resolution	0.01 Hz
Sampling interval, max.	1 s
Measuring channels (active)	1
Power factor measurement (cos φ)	
Measuring range	0…1
Basic accuracy	1.0%
Resolution	0.01

Calculating time, max.		1 s
Measuring channels		3
Phase angle measurement		
Measuring range		10…170 grad
Basic accuracy		0.4%
Resolution		1 grad
Sampling interval, max.		1 s
Measuring channels		3
Communication		
RS485 interface	Connection	D+, D-
	Protocols	Modbus RTU/ASCII, akYtec
	Baud rate	2.4…115.2 kbit/s
	Data bits	7, 8
	Parity	even, odd, none
	Stop bits	1, 2
Enclosure		
Dimensions		96x110x73 mm
Weight		approx. 500 g
Material		plastic

2.1 Environmental conditions

The following environment conditions must be met:

- clean, dry and controlled environment, low dust level
- closed non-hazardous areas, free of corrosive or flammable gases

Table 2.2

Condition	Permissible range
Ambient operating temperature	-20…+55°C
Storage temperature	-25…+55°C
Relative humidity	up to 80% (at +35°C, non-condensing)
IP Code	IP20
Altitude	up to 2000 m above sea level

3 Safety

Explanation of the symbols and keywords used:

DANGER ***DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.***

WARNING ***WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.***

CAUTION ***CAUTION indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury***

NOTICE ***NOTICE indicates a potentially harmful situation which, if not avoided, may result in damage of the product itself or of adjacent objects.***

3.1 Intended use

The device has been designed and built solely for the intended use described in this guide, and may only be used accordingly. The technical specifications contained in this guide must be observed.

The device may be operated only in properly installed condition.

Improper use

Any other use is considered improper. Especially to note:

- This device should not be used for medical devices which receive, control or otherwise affect human life or physical health.
- The device should not be used in an explosive environment.
- The device should not be used in an atmosphere with chemically active substance.

4 Design and control elements

– Enclosure plastic, grey, for DIN-rail or wall mounting
– Terminal blocks 2 plug-in terminal blocks with 18 screw terminals

Table 4.1 Control elements

LED	Indication	Description
POWER (green)	lights	Power supply indicator
RS-485 (yellow)	blinks at the rate of data exchange	Data exchange over RS485 interface
	blinks at the rate of 1 Hz	Data exchange with factory settings
FAULT (red)	blinks at the rate of 1 Hz	1. No connection with ADC (higher priority) 2. Phase reversal (lower priority)
FAULT lights and RS-485 is off		Timeout error (see Table 6.1)
UA, UB, UC, IA, IB, IC (green)	lights	Signal within the valid range
	blinks at the rate of 1 Hz	No signal or the signal exceeds the valid range

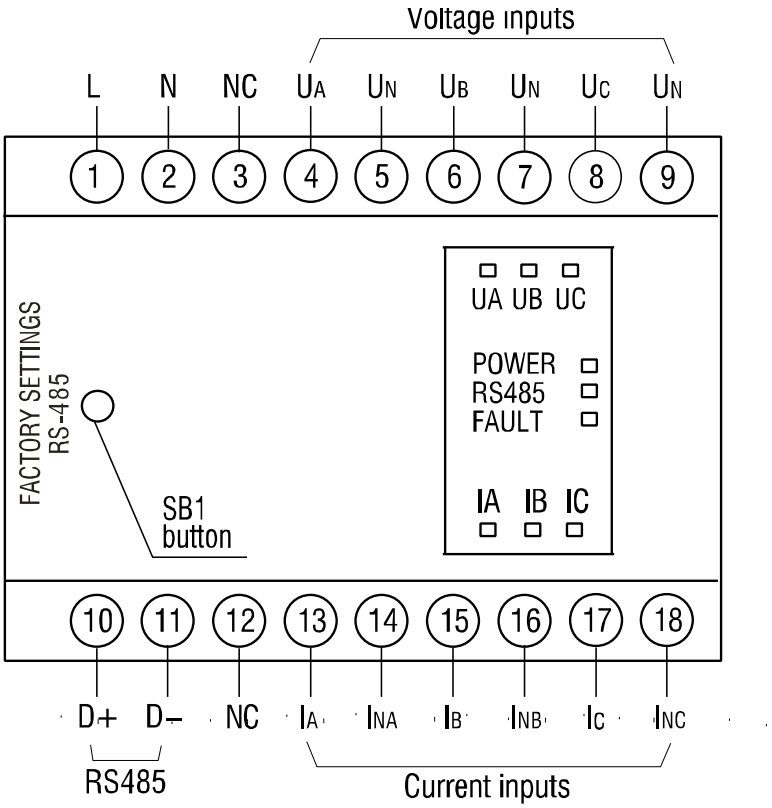

Fig. 4.1

Dimensional drawings are given in App. A.

There is the SB1 button “Factory settings” behind the left front cover (Fig. 4.1). With this button the default settings of the RS485 interface can be restored.

5 Installation

⚠ CAUTION

Improper installation
Improper installation can cause serious or minor injuries or damage the device.
Installation must be performed only by fully qualified personnel.

- The module is intended to be mounted in a cabinet on DIN-rail or on the wall. For the dimensional drawings see Appendix A.
- Install the module in a cabinet with clean, dry and controlled environment. For further details see 2.1.
- The module is designed for natural convection cooling. It should be taken into account when choosing the installation site.

5.1 Wiring

⚠ DANGER

Dangerous voltage
Electric shock could kill or seriously injure.
All electrical connections must be performed by a fully qualified electrician.
Ensure that the mains voltage matches the voltage marked on the nameplate!
Ensure that the device is provided with its own power supply line and electric fuse!

⚠ DANGER

Switch on the power supply only after the wiring of the device has been completely performed.

- The electrical connections are shown in Fig. 4.1 and the terminal assignments in Table 5.1.
- The inputs should be wired in accordance with Fig. 5.1–5.2.
- Connect the power supply to the L/N terminals.
- The maximum conductor cross-section for power supply is 1.5 mm².

▶ NOTICE

Signal cables should be routed separately or screened from the supply cables.
Only a shielded cable may be used for signal lines.

- Connect the RS485 lines to terminals D+ and D-.
- Twisted pair cable should be used for the connection to RS485 interface. Maximal cable length is 1200 m.

Table 5.1 Terminal assignments

No	Indication	Description	No	Indication	Description
1	L	Power supply	10	D+	RS485 +
2	N		11	D-	RS485 -
3	NC	not connected	12	NC	not connected
4	U_A	Voltage L1	13	I_A	Current L1
5	U_N	Neutral	14	I_{NA}	Neutral
6	U_B	Voltage L2	15	I_B	Current L2
7	U_N	Neutral	16	I_{NB}	Neutral
8	U_C	Voltage L3	17	I_C	Current L3
9	U_N	Neutral	18	I_{NC}	Neutral

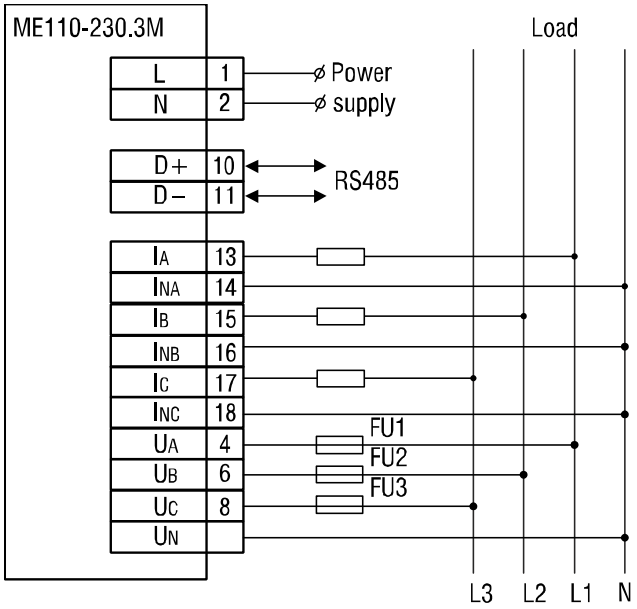

Fig. 5.1 3-phase, 4-wire Wye, Direct connection

FU1, FU1, FU3 – 1.0 A / 600 V fuses of type T

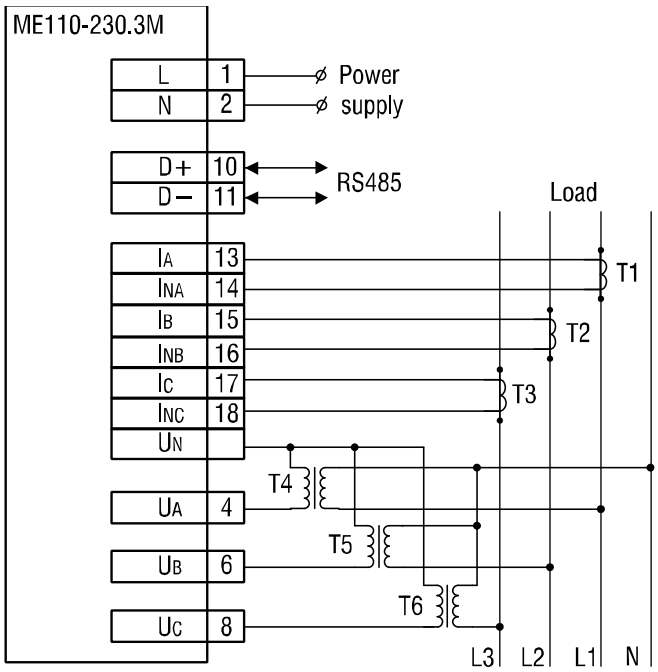

Fig. 5.2 3-phase, 4-wire Wye, Connection with transformers

6 Configuration

▶ NOTICE

Before starting
Before switching on, make sure that the device was stored at the specified ambient temperature (-20 ... +55 °C) for at least 30 minutes.

The configuration tool 'M110 Configurator' provides viewing, editing and saving of parameters. The full list of parameters is shown in the Table 6.1.

The software and the manual are included on the CD.

The module has to be configured in order to use it in RS485 network. Proceed as follows:
– Install the M110 Configurator on the PC.
– Connect the module to the USB interface of the PC over RS485-USB interface adapter IC4 (not included). Connect the D+/D- terminals of the module with the D+/D- contacts of the adapter.
– Connect 230 V AC power supply to the L/N terminals of the module.
– Turn on the power supply.
– Start the M110 Configurator.

If the factory settings of the module have not been changed, the connection to the module is established automatically, the module recognized, its configuration read out and an appropriate configuration mask opened.

Otherwise, the network parameters of the configurator have to be changed.

The complete list of Modbus Registers is represented in Appendix B.

Table 6.1 Configuration parameters

Name	Parameter	Valid value	Meaning	Default
Basic parameters				
dev	Device	up to 8 characters		ME110-3M
ver	Firmware version	up to 8 characters		manufacturer
Network parameters				
bPS	Baud rate, kbit/s	0	2.4	9.6
		1	4.8	
		2	9.6	
		3	14.4	
		4	19.2	
		5	28.8	
		6	38.4	
		7	57.6	
		8	115.2	
PrtY	Parity *	0	none	none
		1	even	
		2	odd	
Sbit	Stop bits *	0	1	1
		1	2	
LEn	Data bits *	0	7	8
		1	8	
A.Len	Address bits **	0	8	8
		1	11	
Addr	Device address **	1…255 (2047)		16
T.pro	Protocol **	0	Modbus ASCII	2
		1	Modbus RTU	

		2	akYtec	
t.out	Timeout, s	0…600		600
rs.dl	Response delay, ms	0…255		2
Input parameters				
N.u	Voltage transformation ratio	0.001…9999		1.0
N.i	Current transformation ratio	0.001…9999		1.0
Uk.hi	Voltage upper limit for calibration ***	100…300		300
Uk.lo	Voltage lower limit for calibration ***	1…10		6
Ik.hi	Current upper limit for calibration ***	1…5		5
Ik.lo	Current lower limit for calibration ***	0.01…0.1		0.02

***** *Invalid network parameter combinations:*

- *prty=0; sbit=0; len=0*
- *prty=1; sbit=1; len=1*
- *prty=2; sbit=1; len=1*

****** *The values Address bits = 11 and Device address = 256…2047 are available if the Protocol = akYtec is selected*

******* *Factory calibration. Changing these parameters is not recommended.*

7 Operation

7.1 Measurement

The phase currents, phase voltages, line-to-line voltages and fundamental frequency are measured on inputs and digitalised. The digitalized values are used to calculate the effective (root mean square) values and other 3-phase AC power system values: powers (active, reactive, apparent), power factors and phase angles.

Effective voltage

$$V_{RMS} = K_V \sqrt{\int_0^T V^2(t)dt}$$

where
V_{RMS} – effective value of phase voltage
T – integration time
K_V– voltage factor

Effective current

$$I_{RMS} = K_I \sqrt{\int_0^T I^2(t)dt}$$

where
I_{RMS} – effective value of phase current
K_I – current factor

Apparent power

$$S = V_{RMS} * I_{RMS}$$

Active power

$$P = V_{RMS} * I_{RMS} * cos\varphi$$

where
cosφ – power factor

Reactive power

$$Q = V_{RMS} * I_{RMS} * sin\varphi$$

Fundamental frequency
To measure the fundamental frequency a zero-crossing function of the ADC is used. The ADC forms signals for the microcontroller in the first voltage channel. The time difference between the signals is converted into the frequency. The frequency value must be within the range from 45 to 65 Hz.

Power factor

$$cos\varphi = \frac{P}{S}$$

The power factor is calculated within the power range from 0.02 to 2 kW.

Phase angle
The measurement of the angle between phases is carried out similarly to fundamental frequency, but the zero-crossing function for different phases is used.

Using of transformers

The Voltage transformation ratio **N.u** and Current transformation ratio **N.i** (see Table 6.1) are set to 1 by default. If voltage or current transformers are used, the parameters **N.u** and **N.i** have to be set to their transformation ratios. The values can be set in the range from 0.001 to 9999.

7.2 Modbus addressing

In the operation mode the module is controlled by a network Master. The addresses from 1 to 247 can be used. The address 0 is reserved for broadcasting.

The following Modbus functions are supported:

- 03 (0x03) Read Holding Registers
- 04 (0x04) Read Input Registers
- 06 (0x06) Preset Single Register
- 16 (0x10) Preset Multiple Registers
- 17 (0x11) Report Slave ID

The list of Modbus Registers is represented in Appendix B.

The list of Modbus Error Codes is represented in Appendix C, Table C.1.

The list of Operation Status Codes is represented in Appendix C, Table C.2.

8 Restore factory settings

⚠ **DANGER**

Dangerous voltage
The voltage on some components of the circuit board can be dangerous! Direct contact with the circuit board or penetration of a foreign body in the enclosure must be avoided!

If the communication between the module and PC cannot be established and network parameters of the module are unknown, the default network settings have to be restored. Proceed as follows:

- Connect the module to PC
- Start the M110 Configurator
- Turn on the module
- Remove the left front cover with the inscription 'FACTORY SETTINGS RS-485'
- Push and hold the SB1 button for at least 5 seconds
- When the button is released the RS-485 LED starts to flash and the module starts to operate with the default network settings, while the user settings remain stored.
- Click the *'Use factory settings'* key or enter the values from the Table 8.1 in the *'Connection to device'* dialog box (see Fig. 8.1).

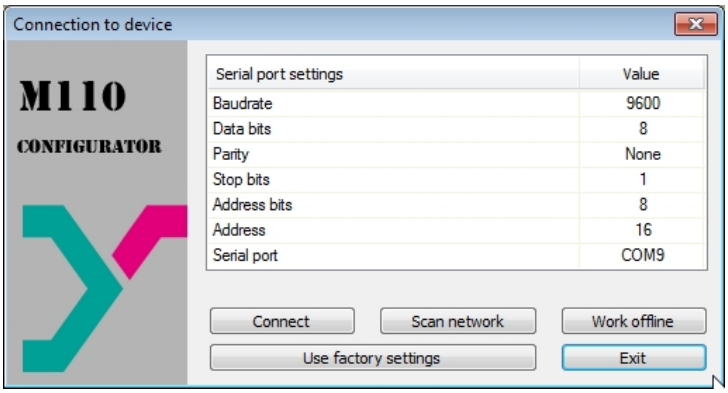

Fig. 8.1 'Connection to device' dialog box

- Click *'Connect'* to establish the connection with the factory settings
- The main window of the Configurator opens. Use the *'Device>Read all'* menu path to read the user network settings from the device (see Fig. 8.2).
- Open the *'Network parameters'* folder and note the user network settings.
- Close the M110 Configurator
- Push and hold the SB1 button for at least 5 seconds
- When the button is released the RS-485 LED goes out and the module starts to operate with the user network settings

Note: If in the 'Factory Network Settings' mode the new network settings will be applied (using the *'Device>Commands>Apply new network settings'* menu path), the module goes into operating mode, and the RS-485 LED goes out, because the command restarts the device.

- Start the M110 Configurator
- Enter the noted network settings in the *'Connection to device'* dialog box
- Click *'Connect'* to establish the connection with the user settings
- Check the connection to the device by using the *'Device>Check connection…'* menu path
- Close the cover

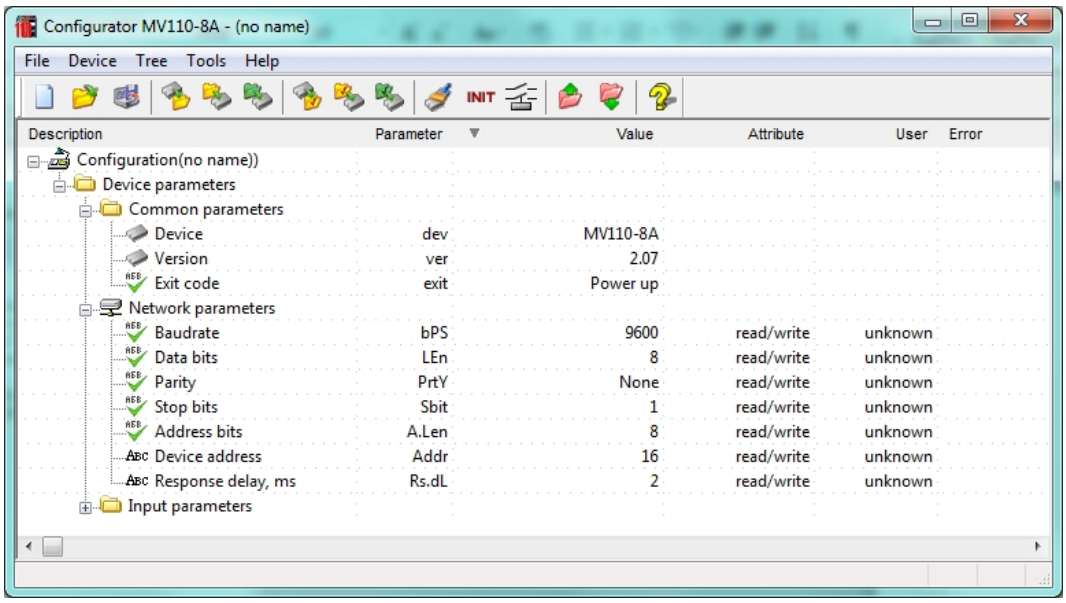

Fig. 8.2 M110 Configurator main window

Table 8.1 Default network parameters

Parameter	Name	Default
Baud rate, bit/s	**bps**	9600
Data bits	**len**	8
Parity	**prty**	none
Stop bits	**sbit**	1
Address bits	**a.len**	8
Address	**addr**	16
Response delay, ms	**rs.dl**	2

9 Maintenance

The maintenance includes:

- cleaning of the housing and terminal blocks from dust, dirt and debris
- checking the fastening of the device
- checking the wiring (connecting leads, fastenings, mechanical damage).

The device should be cleaned with a damp cloth only. No abrasives or solvent-containing cleaners may be used. The safety information in section 3 must be observed when carrying out maintenance.

10 Transportation and storage

Pack the device in such a way as to protect it reliably against impact for storage and transportation. The original packaging provides optimum protection.

If the device is not taken immediately after delivery into operation, it must be carefully stored at a protected location. The device should not be stored in an atmosphere with chemically active substances.

Permitted storage temperature: -25...+55 °C

▶ **NOTICE**

Transport damage, completeness
The device may have been damaged during transportation.
Check the device for transport damage and completeness!
Report the transport damage immediately to the shipper and akYtec GmbH!

11 Scope of delivery

–	Module ME110-230.3M	1
–	User guide	1
–	CD with software and documentation	1

Appendix A Dimensions

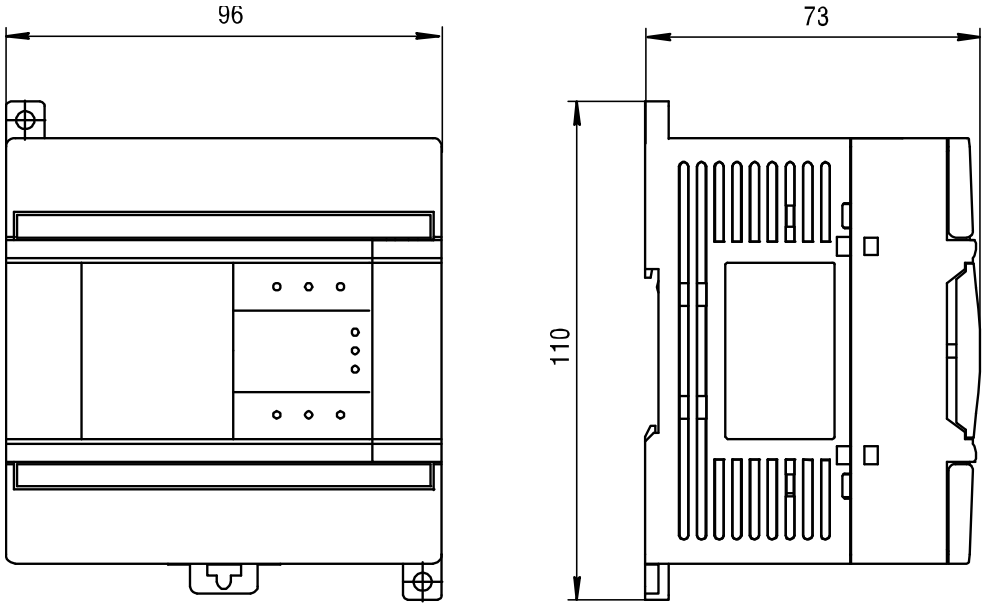

Fig. A.1 External dimensions

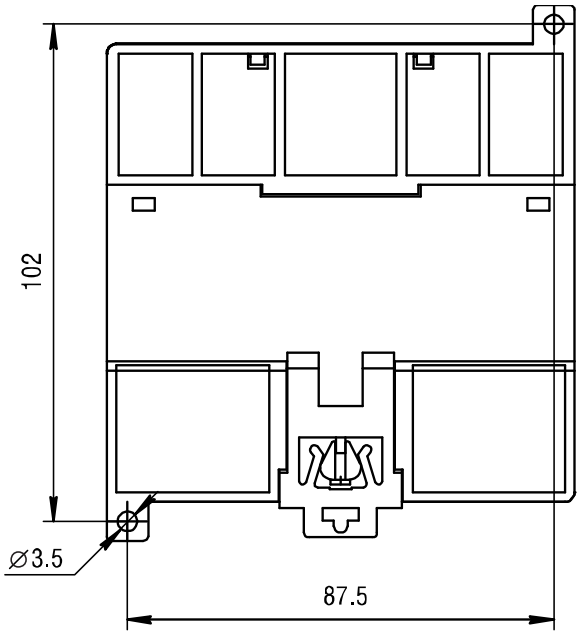

Fig. A.2 Wall mounting dimensions

Appendix B Modbus registers

Table B.1 Data formats

Type	Size (bit)	Min	Max
CHAR	8	-128	127
UCHAR	8	0	255
SHORT	16	-2^{15}	$2^{15}-1$
USHORT	16	0	$2^{16}-1$
LONG	32	-2^{31}	$2^{31}-1$
ULONG	32	0	$2^{32}-1$
FLOAT	32	IEEE 754	IEEE 754

Table B.2 Modbus registers

No	Parameter	Register	Valid value	Meaning	Data type	Default (Note)	Access
Basic parameters							
1	Device name	0x0000.. 0x0003	ASCII string, 8 bytes		CHAR [8]	ME110-3M	R
2	Firmware	0x0004, 0x0005	ASCII string, 4 bytes vX.YY		CHAR [4]	Manufac-turer	R
Network parameters							
1	Baud rate, kbit/s	0x0006	0	2.4	UCHAR	2	RW
			1	4.8			
			2	9.6			
			3	14.4			
			4	19.2			
			5	28.8			
			6	38.4			
			7	57.6			
			8	115.2			
2	Data bits	0x0007	0	7 bits	UCHAR	1	RW
			1	8 bits			
3	Parity	0x0008	0	none	UCHAR	0	RW
			1	even			
			2	odd			
4	Stop bits	0x0009	0	1 stop bit	UCHAR	0	RW
			1	2 stop bits			
5	Response delay, ms	0x000A	0..255		UCHAR	2	RW
6	Timeout, s	0x000B	0..600		UCHAR	600	RW
7	Device address	0x000C	1..247		UCHAR	16	RW
8	Protocol	0x000D	0	Modbus ASCII	UCHAR	2	RW
			1	Modbus RTU			
			2	akYtec			
9	Address bits	0x000E	0	8 bits	UCHAR	0	RW
			1	11 bits			

No	Parameter	Register	Valid value	Meaning	Data type	Default (Note)	Ac-cess
10	Last Network Error Code	0x000F	See Table C.1		UCHAR		R
Input parameters							
1	Device Error Code	0x0010	0	EEPROM error	CHAR		R
			1	ADC connection error			
			2	Error while parame-ter initialization			
			4	Phase A over range			
			5	Phase B over range			
			6	Phase C over range			
2	Status Code	0x0011	See Table C.2		USHORT	0	RW
3	DP for voltage ratio integer *	0x0012	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
4	Voltage ratio integer *	0x0013, 0x0014	1..9999999		ULONG	1	RW
5	DP for current ratio integer *	0x0015	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
6	Current ratio integer *	0x0016, 0x0017	1..9999999		ULONG	1	RW
7	DP for measured voltage integer *	0x0018	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
8	DP for measured current integer *	0x001F	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
9	DP apparent power integer *	0x0026	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
10	DP for active power integer *	0x002D	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
11	DP for reactive power integer *	0x0034	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			

No	Parameter	Register	Valid value	Meaning	Data type	Default (Note)	Access
12	DP for power factor integer *	0x003B	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
13	DP for frequency integer *	0x0042	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
14	DP for phase angle integer *	0x0045	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
15	Voltage ratio	0x004C, 0x004D	0.001..9999		FLOAT	1.0	RW
16	Current ratio	0x004E, 0x004F	0.001..9999		FLOAT	1.0	RW
17	APLY	0x007C	Initializing and permanent saving of new settings		UCHAR	0x0000 after executing	W
Operating values							
1	Voltage integer, Phase A *	0x0019, 0x001A			LONG		R
2	Voltage integer, Phase B *	0x001B, 0x001C			LONG		R
3	Voltage integer, Phase C *	0x001D, 0x001E			LONG		R
4	Current integer, Phase A *	0x0020, 0x0021			LONG		R
5	Current integer, Phase B *	0x0022, 0x0023			LONG		R
6	Current integer, Phase C *	0x0024, 0x0025			LONG		R
7	Apparent power integer, Phase A *	0x0027, 0x0028			LONG		R
8	Apparent power integer, Phase B *	0x0029, 0x002A			LONG		R
9	Apparent power integer, Phase C *	0x002B, 0x002C			LONG		R
10	Real power integer, Phase A *	0x002E, 0x002F			LONG		R
11	Real power integer, Phase B *	0x0030, 0x0031			LONG		R
12	Real power integer, Phase C *	0x0032, 0x0033			LONG		R
13	Reactive power integer, Phase A *	0x0035, 0x0036			LONG		R

No	Parameter	Register	Valid value	Meaning	Data type	Default (Note)	Access
14	Reactive power integer, Phase B *	0x0037, 0x0038			LONG		R
15	Reactive power integer, Phase C *	0x0039, 0x003A			LONG		R
16	Power factor integer, Phase A *	0x003C, 0x003D			LONG		R
17	Power factor integer, Phase B *	0x003E, 0x003F			LONG		R
18	Power factor integer, Phase C *	0x0040, 0x0041			LONG		R
19	Frequency integer *	0x0043, 0x0044			ULONG		R
20	Phase angle integer A-B *	0x0046, 0x0047			LONG		R
21	Phase angle integer B-C *	0x0048, 0x0049			LONG		R
22	Phase angle integer C-A *	0x004A, 0x004B			LONG		R
23	Voltage Phase A	0x0050, 0x0051			FLOAT		R
24	Voltage Phase B	0x0052, 0x0053			FLOAT		R
25	Voltage Phase C	0x0054, 0x0055			FLOAT		R
26	Current Phase A	0x0056, 0x0057			FLOAT		R
27	Current Phase B	0x0058, 0x0059			FLOAT		R
28	Current Phase C	0x005A, 0x005B			FLOAT		R
29	Apparent power Phase A	0x005C, 0x005D			FLOAT		R
30	Apparent power Phase B	0x005E, 0x005F			FLOAT		R
31	Apparent power Phase C	0x0060, 0x0061			FLOAT		R
32	Active power Phase A	0x0062, 0x0063			FLOAT		R
33	Active power Phase B	0x0064, 0x0065			FLOAT		R
34	Active power Phase C	0x0066, 0x0067			FLOAT		R
35	Reactive power Phase A	0x0068, 0x0069			FLOAT		R
36	Reactive power Phase B	0x006A, 0x006B			FLOAT		R

No	Parameter	Register	Valid value	Meaning	Data type	Default (Note)	Access
37	Reactive power Phase C	0x006C, 0x006D			FLOAT		R
38	Power factor Phase A	0x006E, 0x006F			FLOAT		R
39	Power factor Phase B	0x0070, 0x0071			FLOAT		R
40	Power factor Phase C	0x0072, 0x0073			FLOAT		R
41	Frequency	0x0074, 0x0075			FLOAT		R
42	Phase angle A-B	0x0076, 0x0077			FLOAT		R
43	Phase angle B-C	0x0078, 0x0079			FLOAT		R
44	Phase angle C-A	0x007A, 0x007B			FLOAT		R
45	Line-to-line voltage A-B	0x007D, 0x007E			FLOAT		R
46	Line-to-line voltage B-C	0x007F, 0x0080			FLOAT		R
47	Line-to-line voltage C-A	0x0081, 0x0082			FLOAT		R
48	Neutral current	0x0083, 0x0084			FLOAT		R
49	DP for line-to-line voltage integer *	0x0085	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
50	Line-to-line voltage AB *	0x0086, 0x0087			ULONG		R
51	Line-to-line voltage BC *	0x0088, 0x0089			ULONG		R
52	Line-to-line voltage CA *	0x008A, 0x008B			ULONG		R
53	DP for neutral current integer *	0x008C	0	(----)	UCHAR	0	RW
			1	(---.-)			
			2	(--.--)			
			3	(-.---)			
54	Neutral current integer *	0x008D, 0x008E			ULONG		R

** The measured value is in two formats available:*

- *Integer (LONG, ULONG)*
- *Floating-point (FLOAT)*

Both formats are saved in different data registers (see Table B.2).

The integer is calculated by multiplication of the measured value by 10^{DP}. The parameter DP is used for a decimal point and can be set within the range 0…3 as an input parameter (see Table 6.1, B.2, section 'Input parameters').

Appendix C Error and status codes

Table C.1 – Last Network Error Code (0x000F, see Table B.2 Modbus registers)

Code	Description
0	Error-free frame reception
2	Decimal point position greater than 3
3	Attempt to write the ‘read only’ register
33	Hardware framing error
39	Incorrect frame checksum
40	Descriptor not found
49	Actual number of registers less than specified

Table C.2 – Status Code (0x0011, see Table B.2 Modbus registers)

Bit Number	Assignment
15	Use the integer transformation ratio
14	Wrong phase sequence
8	Start calibration
7	Waiting for U = 100V, I = 1A, cos φ = 1. Calibration is completed
6	Waiting for U = **Uk.hi ***, I = **Ik.hi ***, cos φ = 0.5
2	Waiting for U = **Uk.lo ***, I = **Ik.lo ***
1	Waiting for U = **Uk.hi ***, I = **Ik.hi ***
0	Calibration error / Calibration failed

** Parameters **Uk.hi**, **Uk.lo**, **Ik.hi**, **Ik.lo** have to be set when configuring the device (see Table 6.1)*