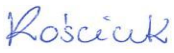
OPERATION AND MAINTENANCE MANUAL

Multi-system electrical energy meter EM3000 for DC 1,5kV and 3kV & AC 15kV 16⅔Hz and 25kV 50Hz systems

Device name	**Multi-system electrical energy meter EM3000**	
Device type	**EM3000**	
Documentation symbol	**OAMM-EM3000**	
Date	**September 2025**	
Version	**1.17**	
	Name and surname	Signature
Written by	Łukasz Kościuk	
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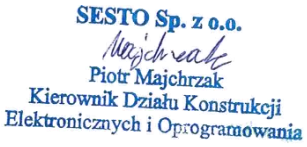
Approved by	Piotr Majchrzak	

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1. About this manual

1.1 For whom this document is dedicated for

This document describing both functions and parameters of an EM3000 electric energy meter is dedicated for:

- people operating the energy meter directly or remotely,
- electrical circuits designers concerned with the energy measurements
- people carrying out installation, maintenance and service of energy measurement system,
- DSO employees responsible for final acceptance of the electric energy meters,
- Measurement Data Acquisition Systems and Technical Monitoring Systems operators.

1.2 EM3000 multi-system meter purpose

EM3000 multi-system energy meter is SESTO company's first complex solution allowing for measurement of traction electrical energy in DC 1,5kV and 3kV & AC 15kV 16 2/3 Hz and 25kV 50Hz systems. The meter is an advanced device designed to meet TSI LOC&PAS requirements, taking into consideration all updates including 2020/387, set of EU standard and „ The requirements of PKP Energetyka S.A. for direct current measuring equipment". Vast range of meter applications, has been achieved thanks to numerous realizations for following vehicle types:

- for locomotives,
- for electric multiple units (EMU),
- for trams,
- for trolleybuses, and

stationary purposes:

- for traction substations,
- for traction posts.

Traction post variant deserves special attention. It allows the energy measurement for billing purposes e.g. measuring energy used for heating of a car of a train, 3kV DC / 400V AC transducer stations energy usage or recipients outside railroad industry.

1.3 Functions performed by the EM3000 multi-system meter

EM3000 multi-system meter performs following fundamental functions:

- automatic switching between monitored traction systems,
- calculating used and returned energies,
- calculating active and passive energies,
- energy values recording in 5 min intervals (for CEBD billing) and 1 min intervals (for statistical purposes),
- recording the place of energy usage (GPS) in 1 min intervals,
- energy measurements recording in various time zones in accordance with the defined settings,
- events registration,
- measurement and recording of the voltage and current values,
- wire communication with on-board systems of the traction vehicle,
- measurement data transmission to both energy supplier's and client's data acquisition systems (two independent GSM/3G/LTE modules),
- local measurements reading (using LCD touchscreen),
- auto diagnostics.

2. Safety

2.1 Usage safety

The device can be operated on site with use of the LCD touch screen, or remotely using the means of data transmission activated during the installation.

All covers of the meter modules should be closed and each of the modules should be properly grounded. Individual operating the meter should be familiar with the contents of this document.

2.2 Installation and maintenance safety

Installation, maintenance and servicing of the EM3000 energy meter system should be carried out by individuals trained by meter's producer – SESTO company.

Any installation or service activities should be carried out when the main (measured) supply is disconnected from the power source and with auxiliary voltages turned off.

2.3 Electric shock protection

Each module of the meter has the PE connection in form of the steel screw, located on the outer surface of the casing. To provide electric shock protection, this connection absolutely must be connected to grounding point with use of the characteristically marked yellow-green cable with cross section area that is not smaller than 2,5mm^2.

As means of electric shock safety protection C 2A class DC circuit breaker with overcurrent protection should be used – separate breaker for each meter module requiring auxiliary voltage.

EM3000 manufacturer has the EM3000 F+D module in his offer. It encapsulates an overcurrent circuit breaker with the required characteristics and voltage presence signalling. The above module is available in a sealed metal housing that meets the requirements of the operator of the energy distribution system - PKP Energetyka S.A.

3. Technical data

3.1 DHU module

User interfaces - display	
Display type	LCD, graphical, colour with backlight, touch sensitive
Resolution	320x240
Number of colours	262000
Communication interfaces	
Ethernet	10BASE-T/100BASE-TX
CANBUS (isolated)	max. 250 kbit/s
2xRS232/485/422 (isolated)	max. 115,2 kbit/s
2xOptical fibre input and output	optical fibre 1mm/2,2mm
2xGSM	GSM/3G/LTE
GPS	2,5m accuracy
USB A	2.0, host
Structural parameters	
Supply voltage	24V DC, 48V DC, 110V DC depending on the variant (in accordance with EN-50155)
Power consumption	Max. 25W
IP rating	IP54
Operating temperature	-35°C ÷ 70°C
Weight	3,56kg
Dimensions (height x width x depth)	96mm x 150mm x 263mm
Fire protection standard	PN-EN 45545-2+A1:2015

3.1.1 DHU module connectors description

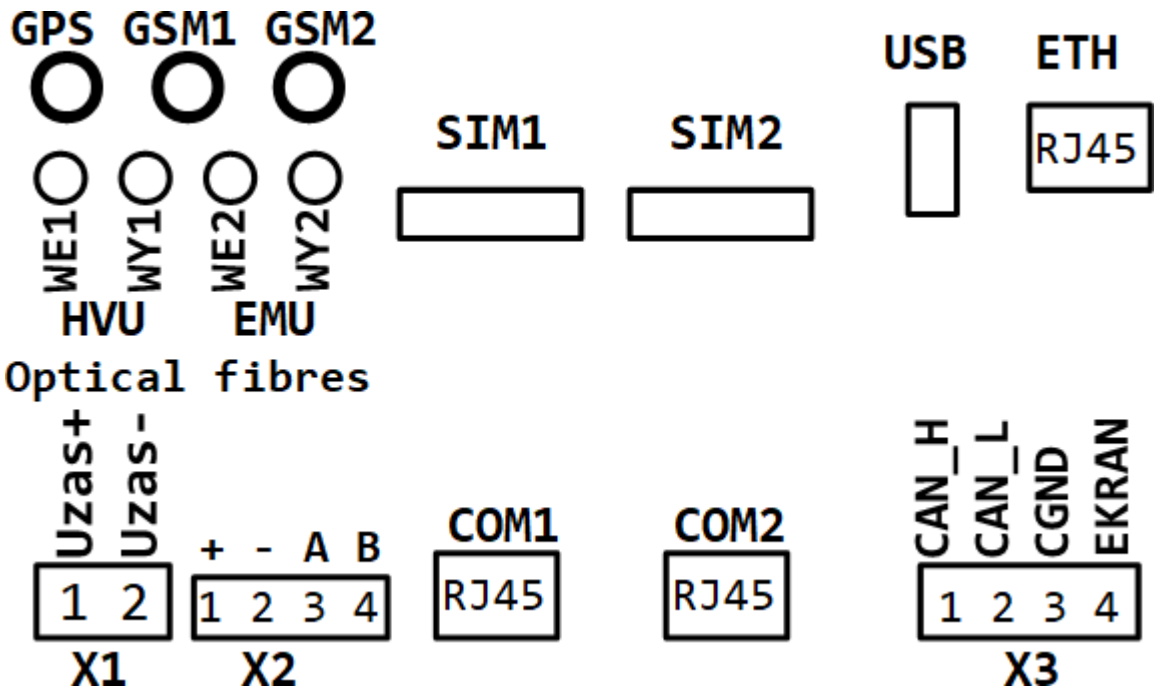
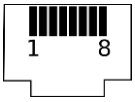
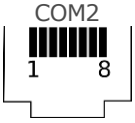


Fig. 1 DHU module connectors arrangement

DHU module connectors description:

Connector	Connector type	Marking	Function
SIM1	Mini SIM	SIM1	SIM card socket for DSO
SIM2	Mini SIM	SIM2	SIM card socket for user
GPS	SMA-F	GPS	GPS antenna connector
GSM1	SMA-F	GSM1	GSM antenna connector
GSM2	SMA-F	GSM2	GSM antenna connector
USB	USB type A	USB	USB Host
WE1	HFBR	WE1	Optical fibre input HVU
WY1	HFBR	WY1	Optical fibre output HVU
WE2	HFBR	WE2	Optical fibre input EMU
WY2	HFBR	WY2	Optical fibre output EMU

Connector	Connector type	Pin	Marking	Function
X1	GMSTB 2,5/2-ST-7,62	1	Vzas+	Module power supply – positive pole
		2	Vzas-	Module power supply – negative pole
X2 (optional)	MC 1,5/4-ST-3,81	1	+	12V DC output – positive pole
		2	-	12V DC output– negative pole
		3	A	RS485
		4	B	
COM1 	RJ-45	1	RVCC	5V DC supply output
		2	A	RS485
		3	B	
		4	Z	RS422
		5	Y	
		6	Rx	RS232
		7	Tx	
		8	RGND	RS ground
COM2 	RJ-45	1	RVCC	5V DC supply output
		2	A	RS485
		3	B	
		4	Z	RS422
		5	Y	
		6	Rx	RS232
		7	Tx	
		8	RGND	RS ground
X3	MSTB 2,5/ 4-ST-5,08	1	CANH	CANBUS
		2	CANL	
		3	CGND	CANBUS ground
		4	EKRAN	PE
ETH	RJ-45	1	white-orange	TCP/IP 10Base-T/100Base-TX communication
		2	orange	
		3	white-green	
		4	blue	
		5	white-blue	
		6	green	
		7	white-brown	
		8	brown	

X2 connector presence in DHU module is optional, depends on the module version.

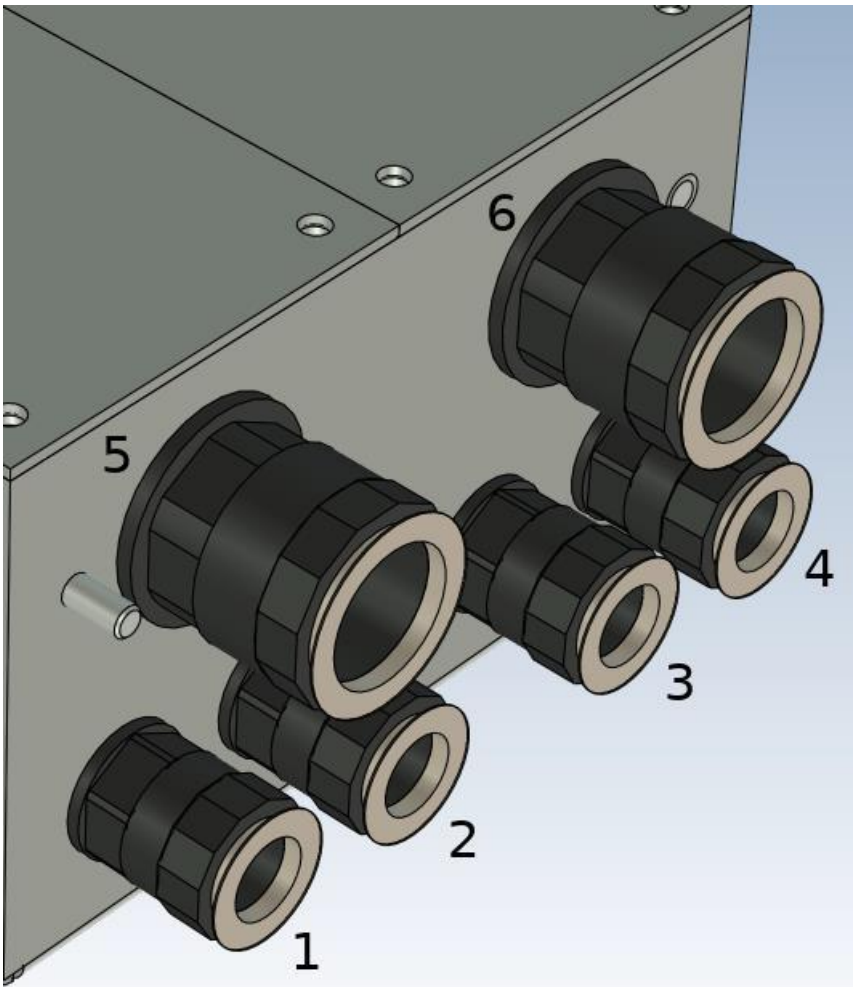


Fig. 2 DHU module cable glands view

Cable gland no.	Cable gland type	Function
1	MIR-10M16N	X1 power supply
2	MIR-10M16N	Optical fibre 1 / RS-485 X2
3	MIR-10M16N	Optical fibre 2
4	MIR-10M16N	CAN X3
5	MIR-17M25	Antennas
6	MIR-17M25	ETH

3.2 HVU module

Measured values	
Rated voltage	3000V DC / 1500V DC
Operating voltage	1000 ÷ 5000V DC
Rated current	Up to 6kA (depending on measurement shunt)
Operating current	$-1,4I_{NB}$ ÷ $2,8I_{NB}$
Measurement parameters	
Voltage measurement method	Measurement on internal voltage divider
Voltage measurement accuracy class	1 R
Voltage measurement resolution	1V
Current measurement method	Measurement on integrated shunt: 100mV @ I_{NB} 60mV @ I_{NB}
Current measurement accuracy class	1 R
Current measurement resolution	$0,0001I_{NB}$ (0.1A for 1000A/100mV shunt)
A/C transducers resolution	12 bits
Energy calculations accuracy class	1 R
Communication interfaces	
Optical fibre input and output	plastic optical fibre 1mm/2,2mm
Structural parameters	
Supply voltage	power supplied from measured voltage
Power consumption	Max. 12W
IP rating	IP54
Operating temperature	-35°C ÷ 70°C
Weight	5,65kg
Dimensions (height x width x depth)	115mm x 283mm x 250mm
Fire protection standard	PN-EN 45545-2+A1:2015
Immunity to external magnetic fields	2mT AC

3.2.1 HVU module connectors description

Connector	Connector type	Marking	Function
WE	HFBR	WE	DHU optical fibre input
WY	HFBR	WY	DHU optical fibre output

Cable gland no	Cable gland type	Function
1	MIR-10M16N	Optical fibres

3.2.2 F485C module

Communication interfaces	
Transmission speed	115200 bit/s
Optical fibre	plastic optical fibre 1mm/2,2mm
Structural parameters	
Supply voltage	12V/0,2A DC
Weight	0,08 kg
Dimensions (height x width x depth)	95×36×59 [mm]

Connector	Connector type	Pin	Marking	Function
X1	2091-1124	1	B	RS485
		2	A	
		3	Vcc	24V DC power supply
		4	GND	Ground
X2	2091-1124	1	B	RS485
		2	A	
		3	Vcc	24V DC power supply
		4	GND	Ground
WE	HFBR		WE	DHU optical fibre input
WY	HFBR		WY	DHU optical fibre output

3.3 EMU module

Measurement inputs	
6x analog inputs (AI1, AI2, AI3, AI4, AI5, AI6)	
A/C transducers resolution	24 bits
Input type	Current loop
Energy measurement inputs	
AI1 – AC current measurement channel	
Secondary current of the current measurement channel	200mA @ I_{PN} (Transducer's nominal current)
Input resistance	50Ω
Maximum instantaneous AC signal	300mA RMS
AI2 – AC voltage measurement channel	
Secondary current of the voltage measurement channel	50mA @ U_{MAX2} (29kV AC) 15mA/25mA @ U_N (15kV/25kV AC)
Input resistance	50Ω
Maximum instantaneous AC signal	75mA RMS
AI3 – AC voltage measurement channel	
Secondary voltage of the voltage measurement channel	100V/167V @ U_N (15kV/25kV AC)
Input resistance	50kΩ
Maximum instantaneous AC signal	217V RMS
AI4 – AC current measurement channel	
Secondary current of the current measurement channel	1A @ I_{PN} (Transducer's nominal current) 1 / 400 ratio
Input resistance	0,5Ω
Maximum instantaneous AC signal	2,4A RMS
AI5 – DC current measurement channel	
Secondary current of the current measurement channel	1,6A @ I_{PN} (Transducer's nominal current)
Input resistance	0,3Ω
Maximum instantaneous DC signal	2,4A RMS
AI6 – DC voltage measurement channel	
Secondary current of the voltage measurement channel	50mA @ 4200V DC
Input resistance	50Ω
Maximum instantaneous DC signal	75mA RMS
Energy measurement parameters	
Required accuracy class of the AC current transducer	0.5 R
Required accuracy class of the AC voltage transducer	0.5 R
Required accuracy class of the DC current transducer	1 R
Required accuracy class of the DC voltage transducer	1 R
Accuracy class of energy calculation	1 R
Communication interfaces	
2x Optical fibre input and output	plastic optical fibre 1mm/2,2mm

Outputs 24V DC, max 25W	Stabilized and isolated power source for external transducers
Structural parameters	
Supply voltage	24V DC, 48V DC, 110V DC depending on the variant (in accordance with EN-50155)
Power consumption	Max. 12W, (additionally: X2 max. 25W, X4 max. 20W)
IP rating	IP54
Operating temperature	-35°C ÷ 70°C
Weight	3,18kg
Dimensions (height x width x depth)	96mm x 150mm x 263mm
Fire protection standard	PN-EN 45545-2+A1:2015
Immunity to external magnetic fields	2mT AC, 0,5mT DC

3.3.1 EMU module connectors description

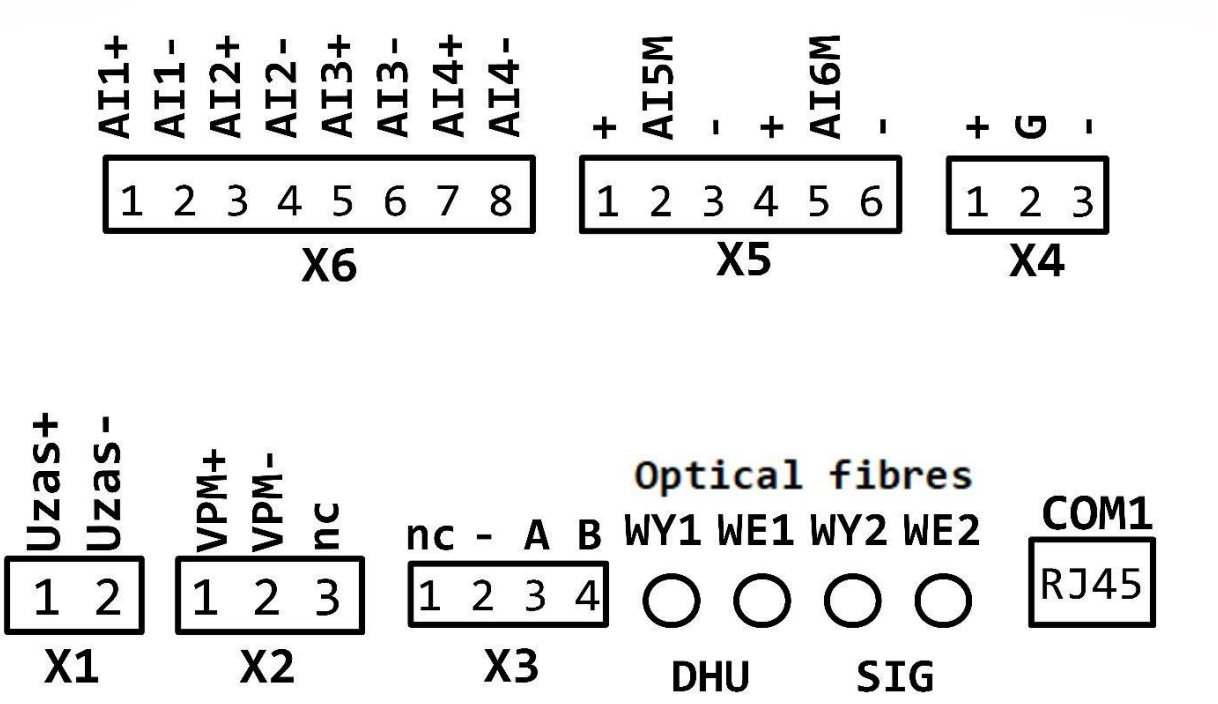


Fig. 3 EMU module connectors arrangement

EMU module connectors description:

Connector	Connector type	Pin	Marking	Function
X1	GMSTB 2,5/2-ST-7,62	1	Vzas+	Module power supply – positive pole
		2	Vzas-	Module power supply – negative pole
X2	MSTB 2,5/3-ST-5,08	1	VPM+	24V DC output – positive pole
		2	VPM-	24V DC output– negative pole
		3	NC	Not connected
X3 (optional)	MC 1,5/4-ST-3,81	1		Not connected
		2	-	RS485 ground
		3	A	RS485
		4	B	
WE1	HFBR		WE1	DHU optical fibre input
WY1	HFBR		WY1	DHU optical fibre output
WE2	HFBR		WE2	SIG optical fibre input
WY2	HFBR		WY2	SIG optical fibre output
X4	MSTB 2,5/3-ST-5,08	1	+	Power supply input for external transducer
		2	G	
		3	-	
X5	MSTB 2,5/6-ST-5,08	1	+	Power supply output – positive pole
		2	AI5M	Analog input AI5
		3	-	Power supply output – negative pole
		4	+	Power supply output – positive pole
		5	AI6M	Analog input AI6
		6	-	Power supply output – negative pole
X6	MSTB 2,5/8-ST-5,08	1	AI1+	Analog input AI1
		2	AI1-	
		3	AI2+	Analog input AI2
		4	AI2-	
		5	AI3+	Analog input AI3
		6	AI3-	
		7	AI4+	Analog input AI4
		8	AI4-	

X3 connector presence in EMU module is optional, depends on the module version.

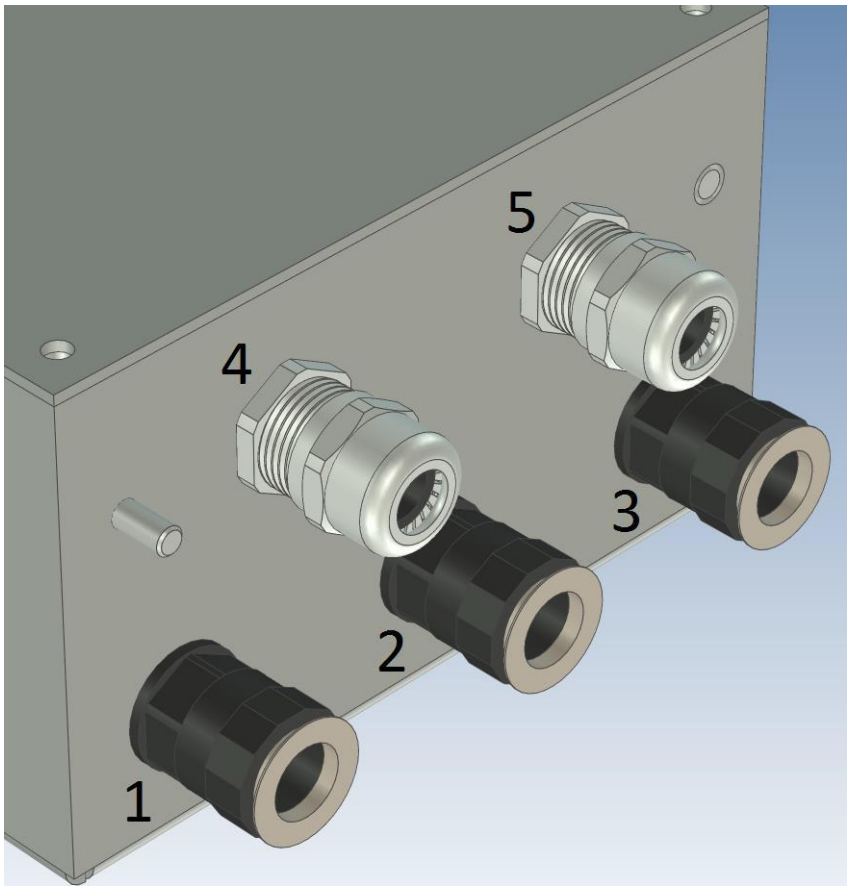


Fig. 4 EMU module cable glands view

Cable gland no	Cable gland type	Function
1	MIR-10M16N	Power supply X1
2	MIR-10M16N	Optical fibre SIG
3	MIR-10M16N	Optical fibre DHU
4	WKM/EMC M16x1.5	Analog signals AI1-AI4
5	WKM/EMC M16x1.5	Analog signals AI5-AI6

3.4 SIG module

Analog outputs	
3x current loop	4mA-20mA/0-20mA/0-24mA ranges
Communication interfaces	
Optical fibre input and output	plastic optical fibre 1mm/2,2mm
Binary outputs	
Output type	transistor, pull-up
Number of outputs	10
Outputs supply	24V DC, external
Binary inputs	
Input type	binary, isolated
Number of inputs	7
Rated voltage	24V
Structural parameters	
Supply voltage	24V DC, 48V DC, 110V DC depending on the variant (in accordance with EN-50155)
Power consumption	Max. 12W, (X3 max. 12W)
IP rating	IP54
Operating temperature	-35°C ÷ 70°C
Weight	2,92kg
Dimensions (height x width x depth)	96mm x 150mm x 263mm
Fire protection standard	PN-EN 45545-2+A1:2015

3.4.1 SIG modules connectors description

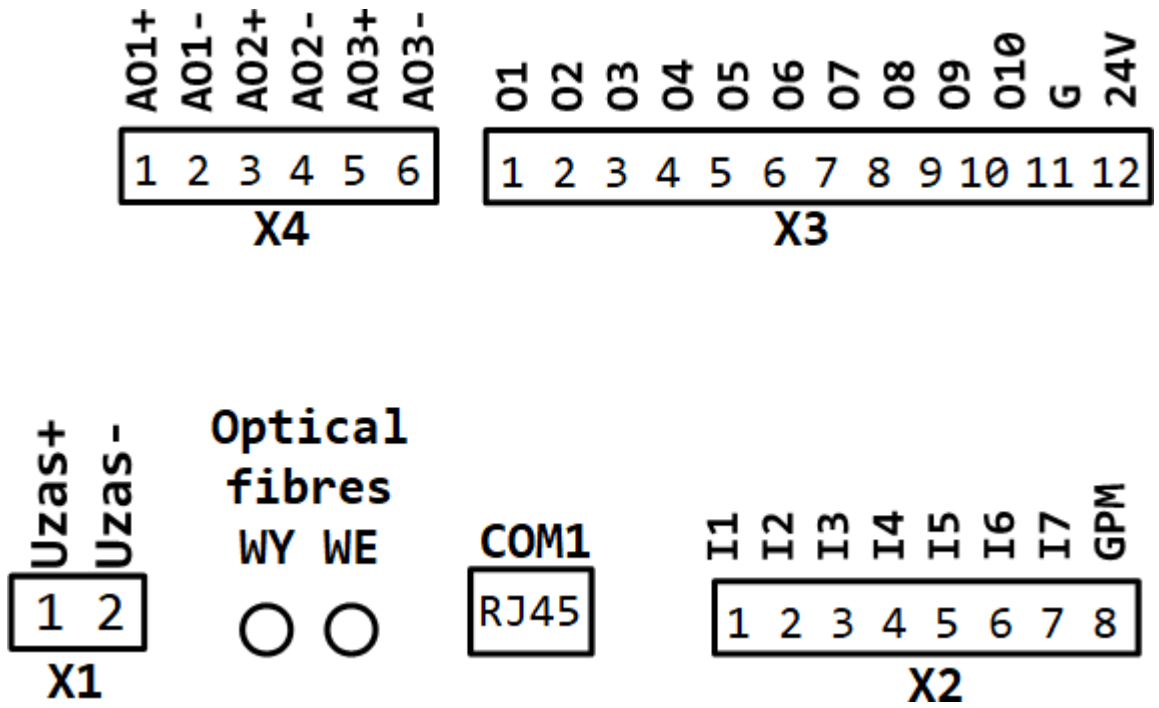


Fig. 5 SIG module connectors arrangemen

SIG module connectors description:

Connector	Connector type	Pin	Marking	Function
X1	GMSTB 2,5/2-ST-7,62	1	Vzas+	Module power supply – positive pole
		2	Vzas-	Module power supply – negative pole
X2	MSTB 2,5/8-ST-5,08	1	I1	Input I1
		2	I2	Input I2
		3	I3	Input I3
		4	I4	Input I4
		5	I5	Input I5
		6	I6	Input I6
		7	I7	Input I7
		8	GPM	Common ground for inputs I1-I7
X3	MSTB 2,5/12-ST-5,08	1	O1	Output O1
		2	O2	Output O2
		3	O3	Output O3
		4	O4	Output O4
		5	O5	Output O5
		6	O6	Output O6
		7	O7	Output O7
		8	O8	Output O8
		9	O9	Output O9
		10	O10	Output O10
		11	G	Outputs ground
		12	24V	Outputs power supply – positive pole
X4	MSTB 2,5/6-ST-5,08	1	AO1+	Analog output AO1
		2	AO1-	
		3	AO2+	Analog output AO2
		4	AO2-	
		5	AO3+	Analog output AO3
		6	AO3-	
WE	HFBR		WE	EMU optical fibre input
WY	HFBR		WY	EMU optical fibre output

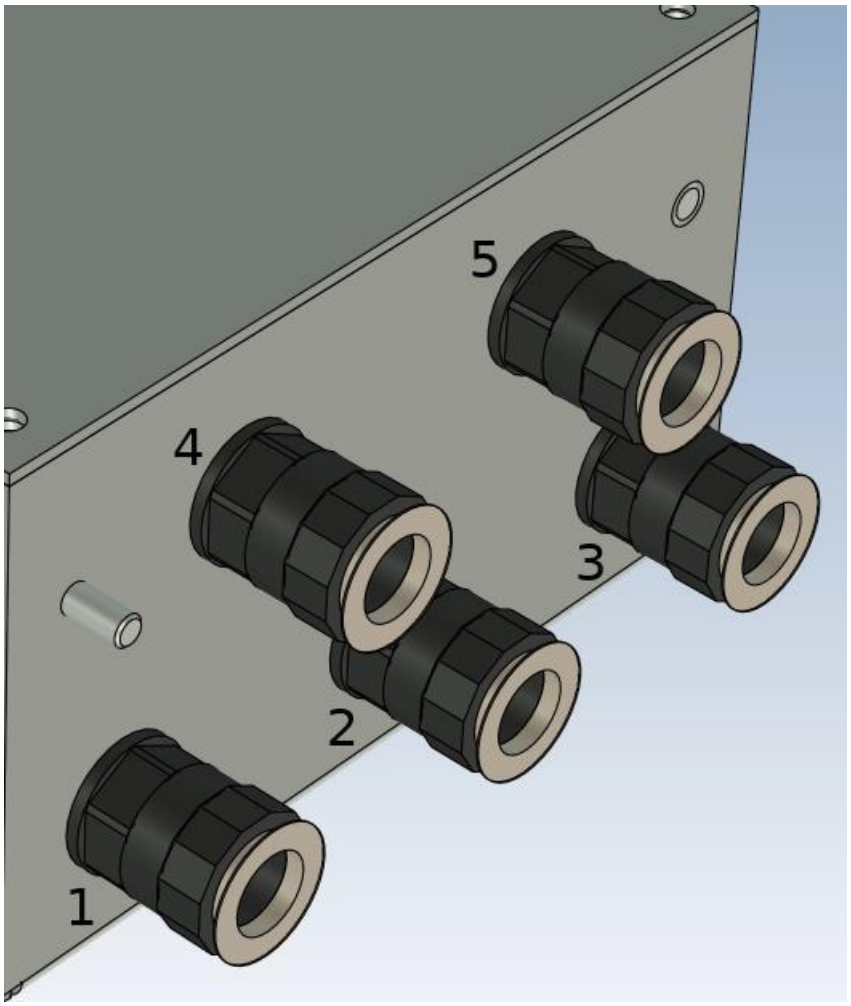


Fig. 6 SIG module cable glands view

Cable gland no.	Cable gland type	Function
1	MIR-10M16N	Power supply X1
2	MIR-10M16N	EMU optical fibre
3	MIR-10M16N	Digital signals PM25 X2
4	MIR-10M16N	Analog outputs X4
5	MIR-10M16N	Output signals X3

Digital output logic of the SIG module is as follows; low state on the output is marked as "0", high state is marked as "1".

In case of correct operation of the device and the presence of measurements on the output no. 1 („SIG_OK") and output no. 2 („pomiary_OK") 2Hz square signal is generated, whereas continuous signal indicates an irregularity in device operation.

Alarm state is immediately signalized, when alarm signal occurs. Alarm state will vanish 10 seconds after all of the alarm signals disappear.

Digital inputs and measurement values acquired from EMU module are used to create signalization logic. Following signals are present:

- presence of AC (Output O3)
- DC overvoltage (Output O4)
- presence of DC (Output O5)
- AC overvoltage (Output O6)
- AC short-circuit (Output O7)
- AC undervoltage (Output O8)
- DC undervoltage (Output O9)
- dangerous voltage (Output O10)

Configurable thresholds of distinct DC and AC values, enables customization of the signalization to the individual requirements of the device owner.

3.5 Nameplates

Each copy of the EM3000 multi-system electric energy meter is fitted with durable and legible nameplates. Plates in respective parts of the EM3000 meter are presented on pictures below. The plates include detailed information concerning the variant of each module.

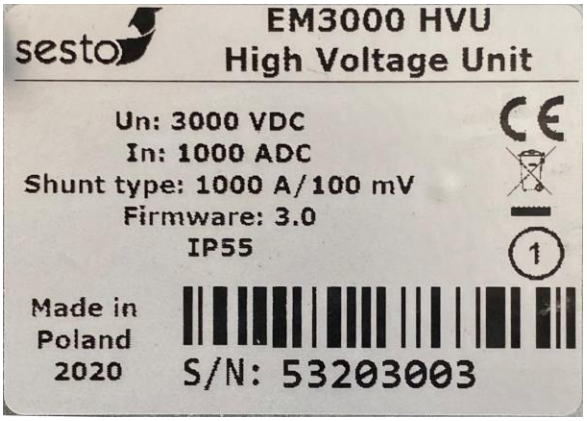


Fig. 7 HVU module nameplate

Fig. 8 DHU module nameplate

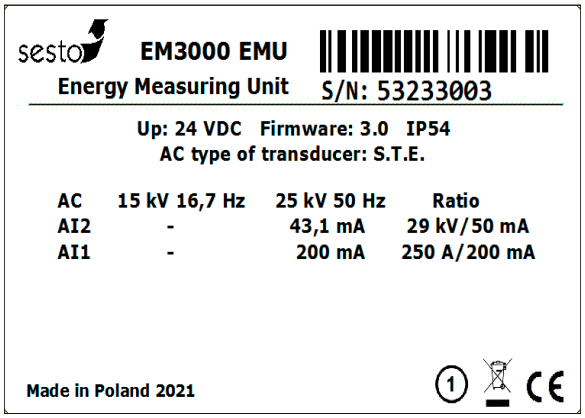


Fig. 9 EMU module nameplate (S.T.E.)

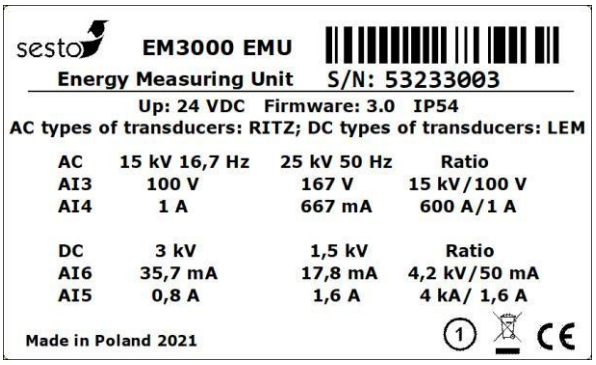


Fig. 10 EMU module nameplate (RITZ and LEM)

Fig. 11 SIG module nameplate

4. Description of operation

4.1 General description

EM3000 multi-system electric energy meter is the third version of the traction energy meter, which meets all newest requirements and standards. EM3000 meter is measurement system, which consists of following modules:

- DHU – Data Handling Unit,
- HVU – High Voltage Unit – DC (1,5kV DC and 3kV DC),
- EMU – Energy Measurement Unit – AC 15kV 16 2/3Hz and 25kV 50Hz, DC 3kV, DC 1,5kV,
- SIG – Signalization Unit.

Communication between high voltage – measurement module and low voltage – reading (DHU) module is realized with use of two-way optical fibre. Thanks to this solution the modules are fully galvanically separated from each other, which enables data transmission free from any interference.

Full autonomy of the EM3000 meter is another of its important features. HVU is powered straight from the measured voltage, without need for auxiliary power supply. Thanks to that the meter is resistant to auxiliary voltage failures.

Possibility to connect several measurement modules to one DHU module, enables use of the EM3000 meter as the comprehensive electrical energy solution dedicated for whole electric multiple units (EMU) or locomotives (multiple carriages/receiving points), thus allows for multi-system measurement setup.

Along the meter itself, configuration software is supplied. It is used for configuration and diagnostic of the device. Additional software, for full measurement data analysis by the user, may be supplied.

Each of the meter modules have preinstalled software, responsible for auto diagnostics and control the correctness of data exchanged between modules. All irregularities and breaks in modules power supply are recorded and signalized.

4.2 DHU module

DHU module – Data Handling Unit is part of EM3000 multi-system electrical energy meter. DHU module is a result of accumulated functionalities of NN module (communication module) and MK (communication module) of previous generation of EM3000 meter.

DHU characteristics are:

- two independent transmission channels (GSM/3G/LTE),
- Ethernet,
- ergonomic cable cavities for energy supplier and for user,
- independent sealing points for each individual cable,
- integrated EMZAB surge protection module.

Fig. 12 DHU module

Data handling unit (DHU) performs following functions:

- creation and storage of complete records for energy billing purposes (CEBD),
- data reading and module control using colour touchscreen,
- support for up to 4 measurement modules simultaneously,
- RS232/485 and GSM/3G/LTE communication compliant with IEC62065-21 protocol C mode,
- local control with use of the computer,
- GSM/3G/LTE communication with data acquisition system,
- GSM/3G/LTE communication with configuration program,

- regular transfer of billing data to FTP server in the form of XML or CSV files,
- sharing data (E, P, U, I) through CANBUS, RS485, Ethernet.

Depending on variant module may be powered module may be powered with: 24V DC, 48V DC or 110V DC. There is a possibility to supply a module variant dedicated for different supply voltages. EM3000 multi-system electric energy meter is equipped in backup power supply – maintenance-free battery bank, thus ensuring communication with data acquisition system even after loss of the power supply and transmission of most recent measurement data. Thanks to this solution system of data acquisition always has actual information.

4.3 HVU module

HVU – High Voltage Unit DC is part of EM3000 multi-system electric energy meter. It is used for measurements in 1,5kV DC and 3kV DC railway electric systems.

HVU module – measurement part of the multi-system EM3000 meter, is responsible for voltage and current measurement, energy and power calculations, storage of data necessary for further processing.

Fig. 13 HVU module

In order to perform measurement of the current, the voltage drop on the measurement shunt is used. Voltage is measured directly. Additionally, measurement part is characterized by low power consumption and resistance to electrical damage.

Communication between high voltage HVU – measurement module and low voltage – reading (DHU) module is realized with use of two-way optical fibre. Thanks to this solution the modules are fully galvanically separated from each other, which enables data transmission free from any interference.

EM3000 HVU measurement part consist of measurement transducer which has pre-installed connection cables. Cable of length shorter than 2m for the connection to the measurement shunt, which provides required accuracy class and noise resistance. Second cable is used to connect to the second pole of the railway electrification system. HVU module is powered directly from measured voltage 1,5kV DC or 3kV DC, which enables energy measurements even when no auxiliary voltages are present.

4.3.1 Accuracy classes and acceptable measurement errors

PN-EN 50463:2018 standard, table 3, requires that accuracy class of individual modules of the meter should be at least on 1 R level, and cumulated measurement error, calculated from equation below, does not exceed 2% of DC measurement:

$$\varepsilon_{EMF} = \sqrt{\varepsilon^2_{VMF} + \varepsilon^2_{CMF} + \varepsilon^2_{ECF}} = \sqrt{1{,}0^2 + 1{,}0^2 + 1{,}0^2} = 1{,}73$$

Where: ε_{EMF} – error for whole measurements system, ε_{VMF} – peak error for given accuracy class, ε_{CMF} – peak error for given current measurement class, ε_{ECF} – peak error for energy calculation class.

4.3.2 F485C module

F485C module is two-way converter between RS485 interface and optical fibre interface. This module allows to connect more than one high voltage module (HVU) to one communication module (DHU).

Usage of the optical fibre ensures full galvanic separation between circuits and enables reliable data transmission. RS485 transmission bus, and inputs are secured from overvoltage of peak power 600W, 10/1000µs. Pluggable connectors X1 and X2 allows easy connection of the power supply and RS485 interface. F485C module is mounted in specifically designed compartment in the case of the HVU module.

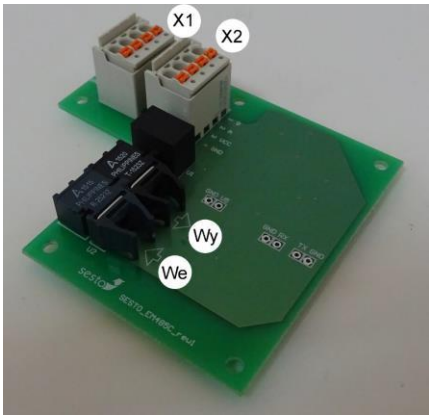


Fig. 14 F485C module

4.4 EMU module

EMU – Energy Measurement Unit is part of multi-system EM3000 energy meter.

EMU module interfaces with external high voltage transducers for traction current and voltage.

Module may be configurated to interface with following transducers:

- S.T.E. PM25 (25kV AC 50Hz),
- RITZ GSEB and RITZ GSOFB (15kV AC 16 2/3Hz and 25kV AC 50Hz),
- SECHERON TMS (15kV AC 16 2/3Hz and 25kV AC 50Hz),
- LEM DV 4200/SP3 and LEM ITC 4000-S (1,5kV DC and 3kV DC),
- LEM DV 4200/SP3 and LEM ITC 4000-S (1,5kV DC and 3kV DC) with S.T.E. PM25 (25kV AC 50Hz),
- LEM DV 4200/SP3 and LEM ITC 4000-S (1,5kV DC and 3kV DC) with RITZ GSEB and RITZ GSOFB (15kV AC 16 2/3Hz and 25kV AC 50Hz)
- LEM DV 4200/SP3 and LEM ITC 4000-S (1,5kV DC and 3kV DC) with SECHERON TMS (15kV AC 16 2/3Hz and 25kV AC 50Hz)

Device is responsible for indirect current and voltage measurement using transducers and energy measurement (it is possible to use the transducers already installed on the vehicle, if they comply with relevant standards, they have required certificates and measurement accuracy class). Transducers produced by train industry leading companies like STE, RITZ, LEM and SECHECRON are supported. It is possible to use other transducers with analogue current or voltage output.

Module can be supplied with: 24V DC, 48V DC or 110V DC.

Fig. 15 EMU module

Important characteristic of EMU module is fully secured and separated power output for transducers.

4.4.1 Accuracy classes and acceptable measurement errors

PN-EN 50463:2018, table 3, standard requires that accuracy class of individual modules of the meter should be at least on 1 R level, and cumulated measurement error, calculated from equation below, does not exceed 1,5% for AC measurement:

$$\varepsilon_{EMF} = \sqrt{\varepsilon^2_{VMF} + \varepsilon^2_{CMF} + \varepsilon^2_{ECF}} = \sqrt{1{,}0^2 + 1{,}0^2 + 1{,}0^2} = 1{,}73$$

Where: ε_{EMF} – error for whole measurements system, ε_{VMF} – peak error for given voltage measurement class, ε_{CMF} – peak error for given current measurement class, ε_{ECF} – peak error for energy calculation class.

4.5 SIG module

SIG (Signalization) module is part of multi-system EM3000 energy meter.

SIG module is an optional element of the EM 3000 system, which is responsible for:

- signalization of exceeding programmable thresholds of voltage and currents,
- reading the state of the transducer digital outputs,
- indication of the RMS value of current and voltage using 4mA – 20 mA current loop.

SIG module is controlled by EMU utilizing optical fibre. The device has 7 AC/DC optocoupler inputs dedicated for 24V and 10 transistor outputs (pull-up), externally powered with 24 V DC.

Depending on variant, SIG module may be powered with: 24V DC, 48V DC or 110V DC.

Fig. 16 SIG module

5. Usage

5.1 Local

The DHU module is equipped with a touchscreen liquid crystal display (LCD) with a resolution of 320 × 240 pixels. The main screen of the EM3000 meter displays information about the current energy meter readings as well as the electrical parameters of the traction system. Additionally, a set of icons indicating the device status is shown on the screen.

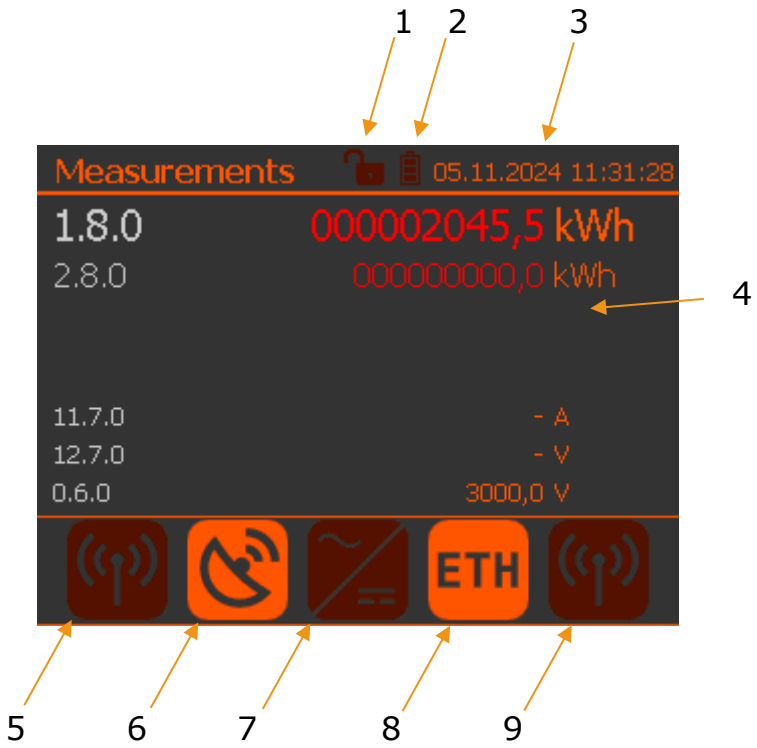


Fig. 17 Main screen

1 – icon indicating that the screen is locked

2 – icon indicating battery power supply

3 – current date

4 – general measurement data

5 – GSM1 data

6 – GPS data

7 – measurement data and billing periods

8 – information about the Ethernet connection

9 – GSM2 data

Through the intuitive user interface, it is easy to check the status of the communication interfaces, meter peripherals, and review measurement data. A highlighted icon indicates that a given function or module is active (in the example screen above, the GPS signal and the Ethernet connection are active).

All displayed data are described using international OBIS codes compliant with the metering standard. A detailed description of the codes and registers can be found in the following sections of this manual.

Navigation within the menu is performed by tapping the icons. To exit a given section, tap the screen twice. If there is no interaction for 5 minutes, the system automatically returns to the main screen. Pressing and holding a finger on the screen disables the automatic return to the main screen. The function can be re-enabled in the same way. The status of this function is indicated by a padlock symbol (1).

The GSM screen is shown as follows:

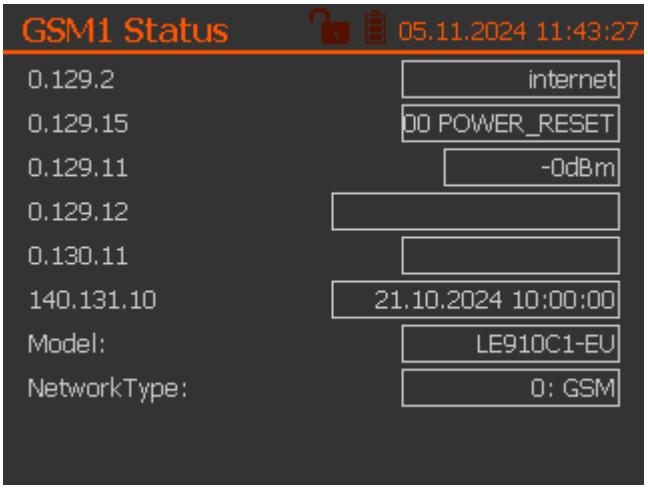


Fig. 18 GSM tab

The GSM tab displays basic information about the status of the cellular network connection. By swiping left or right on the screen, the user can switch to the next or previous GSM module. Additionally, pressing and holding the GSM1 or GSM2 icon on the main screen opens a more advanced diagnostics section:

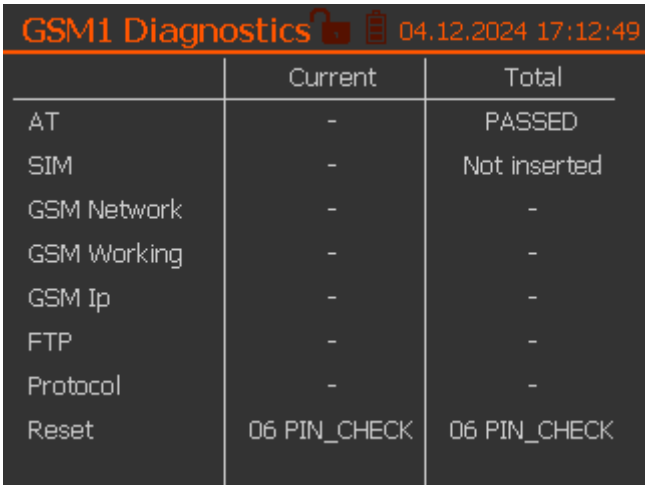


Fig. 19 GSM tab – advanced diagnostic section

The “Current” column indicates the current status of the selected GSM module, while the “Total” column shows the status recorded since the device was started. It should be noted, however, that the values of individual parameters also depend on the current configuration of the meter (including the absence or presence of a GSM card in the slot). Missing data does not necessarily indicate a meter malfunction.

The GPS screen contains information about the current position and vehicle speed:

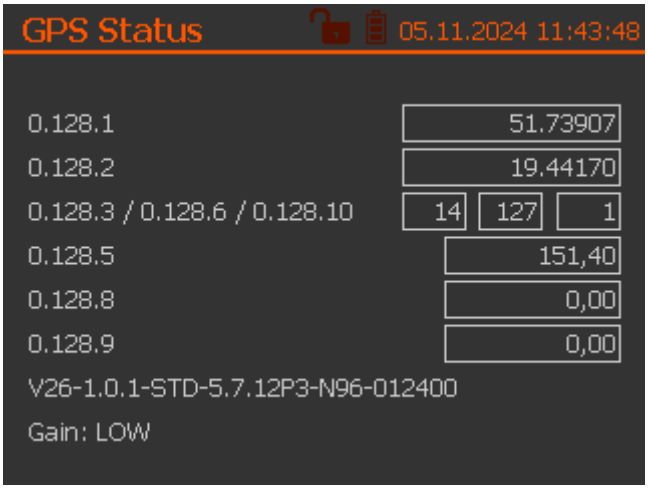


Fig. 20 GPS tab

The measurement data tab presents, with increased precision, the active energy consumed and returned, the current drawn, the current and nominal network voltage, as well as the shortened serial number of the meter:

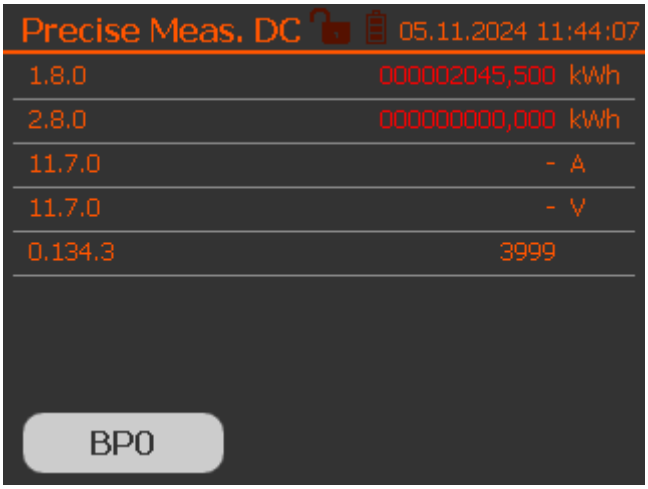


Fig. 21 Precise measurement tab

After clicking the BP0 button, a screen displaying the billing period data will appear:

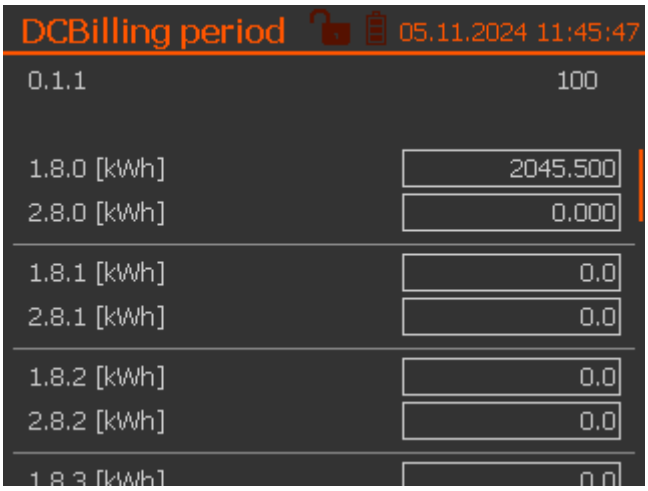


Fig. 22 Billing period tab

Similarly to the GSM modules, this tab also includes a diagnostics section, which can be accessed by pressing and holding the measurement data icon.

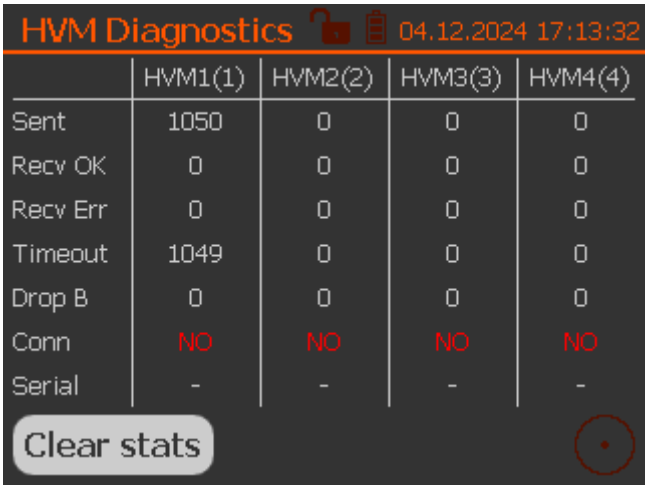


Fig. 23 Diagnostic section of HVM modules

The screen above presents communication statistics with the high-voltage modules. Each visible column corresponds to a consecutively connected HVM module. The “Clear stats” icon can be used to reset the collected data.

Information about the status and configuration of the Ethernet connection can be found in the tab labelled “ETH”:

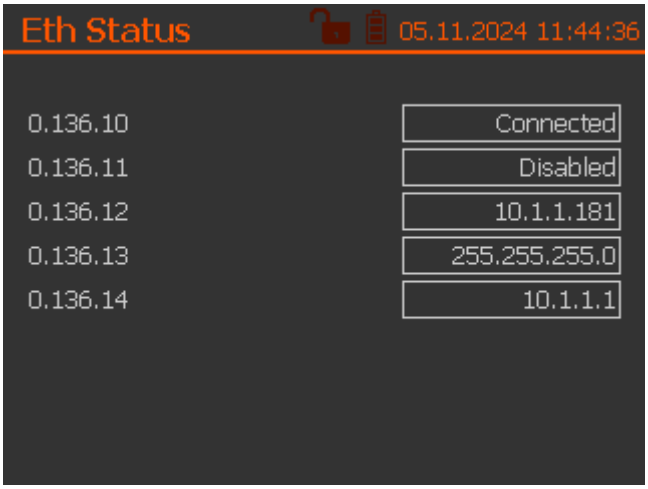


Fig. 24 Ethernet connection tab

In this tab, it is also possible to read information about the CAN bus configuration. To do this, swipe left or right on the screen. The tab should look as follows:

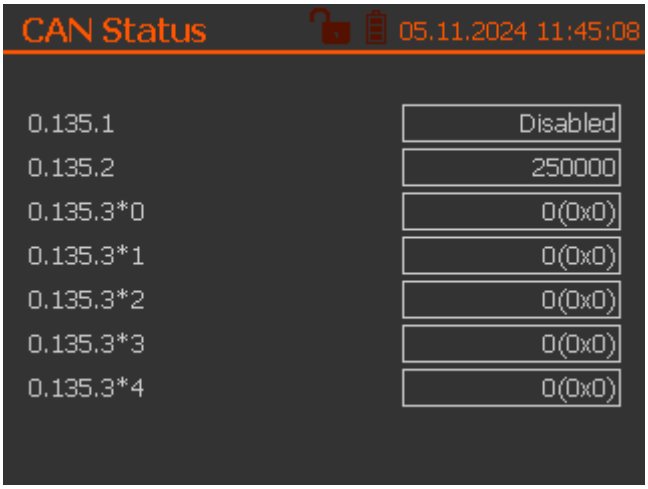


Fig. 25 CAN tab

5.2 Remote

Remote meter operation is carried out via the IEC62056-21-C protocol, which is available on both serial ports, ETH and the corresponding ports of both GSM/3G/LTE connections.

Dedicated KEN3000 software is intended for meter operation. A detailed description of the program is provided in a separate manual delivered with the software.

In addition, the meter can be integrated with the Technical Monitoring Software (Sesto OMT), which is used for real-time monitoring of electrical parameters, vehicle speed, and position.

5.2.1 Protocol of communication with EM3000 meter

Communication with EM3000 multi-system energy meter uses protocol compliant with IEC62056-21 standard (formerly IEC1107) mode C. Communication using this protocol is possible through GSM/3G/LTE connection, ETH and both serial interfaces RS232/485. Only deviation from the standard is constant transmission speed of the serial ports set to 115200bps with configurable registries. Due to this fact, during the transmission speed negotiation, the sign responsible for the speed should always be set to 0.

The protocol supports two modes: reading and programming. In reading mode, the meter provides constant packet of the data recorded and disconnects after the packet is sent. Programming mode allows reading any registry of the meter, configuration registers modification

and updating the software of the communication module. Browsing most of the register is accessible without authentication. Registers containing confidential data like passwords or PIN code are available only after authentication.

5.2.2 Technical Monitoring Software

The Technical Monitoring Software (Sesto OMT) is a system used for monitoring electrical parameters, vehicle position, and speed. Data is retrieved from the meter in real time via the GSM network using the IEC62056-21 protocol.

5.3 Measurement data acquisition

The meter sends measurement data in file form to configured FTP servers. The provision of billing data for the Distribution System Operator (DSO) is carried out via a dedicated GSM/3G/LTE modem. Billing data and detailed statistical data can be transmitted to the client via the second built-in GSM/3G/LTE modem or via the ETH connection. Both the existing standard file transmission scheme and FTP Mailbox are supported in accordance with PN EN 50463-4:2018. The configuration description can be found in section 10.5, “FTP Configuration”.

6. Special functions

6.1 Battery backup operation

EM3000 energy meter’s DHU module is equipped with internal battery backup, which supports full module capabilities for up to 15 minutes after disconnection of the auxiliary voltage. That period of time is sufficient for the meter to send all the data to Data Acquisition System. Due to this fact it is not necessary to wait for the return of the supply voltage to obtain the data. When battery backup is active, the remote connection to the meter is still possible and all functions of Technical Monitoring Systems.

6.2 CAN bus

DHU module of the meter has been equipped with CAN bus compliant with CANOpen. The data is being sent in PDO1-4 frames. Data concerning consecutive power supply systems are available under consecutive configurable NODE addresses. It is possible to configure additional NODE address for GPS localization data sharing. Meter supports HB frame.

6.3 ETH bus

ETH bus may be used to connect the meter to vehicle's internal bus, thus allowing acquisition of the meter's measurement data using IEC1107 protocol.

It is also possible to connect the ETH bus to device routing the data outside the vehicle. Using this connection, it is possible to configure settings of data transmission to Data Acquisition System using ETH bus.

6.4 GPS external source

External source of GPS data may be connected to serial port COM1. GPS data sent to serial port, must be in NMEA format, and the source of data must comply to accuracy of localization defined in PN-EN 50463-3:2018 standard.

6.5 Accelerometer and Gyroscope

The meter is equipped with a gyroscope and accelerometer module that provides additional vehicle acceleration data. Data from the module is made available only for the operation of the Sesto eDrive system and cannot be accessed outside this system. A brief description of the Sesto eDrive system is provided in section 9.

7. Faults servicing

Any faults of the EM3000 multi-system energy meter should be diagnosed by manufacturer's service or trained service personnel. If fault diagnosis is performed by personnel operating the meter, please proceed according to SAMD - service and maintenance documentation.

8. Waste management

EM3000 energy meter modules are marked with symbol of crossed trash can – in accordance with EN 50419. They cannot be thrown out into municipal solid waste. The device construction enables simple disassembly of the casing made from galvanized steel (it constitutes to most of the product mass) and disconnecting of the plastic elements like plastic mounting pegs, seals and cable glands. Disassembly may be carried out using simple tools like screwdrivers, pliers. Elements mentioned above can be handed over to selective waste collection point, whereas the PCB boards containing electronic elements, semiconductor elements are electronic waste, which must be disposed of by specialized entities.

Fig. 26 Marking indicating that device should not be disposed into municipal waste

9. Sesto eDrive

The Sesto eDrive system is a tool designed for railway and tram operators. Its main purpose is to support improvements in key performance indicators that influence the quality and efficiency of provided services.

Specifically, for the eDrive system, and to increase system precision, the meter recorder functionality can be extended with the following features:

- recording measurement and statistical data with 1-second resolution,
- recording gyroscope and accelerometer data with 1-second resolution.

In addition to data obtained from electrical energy meters installed on rolling stock, the system also uses data derived from timetables, vehicle fleet records, and driver work logs. Data may be transferred directly via network interfaces or retrieved from files exported by information systems.

Thanks to cloud technology, the system can continuously aggregate and combine all data to create detailed representations of completed journeys. This enables the execution of numerous analyses presenting data from different perspectives in order to best illustrate relationships between variables. The results are displayed on a specially designed web portal that does not require installation or maintenance of additional software. All functionalities are available after logging in directly through a web browser.

Sesto eDrive is a modular solution that allows functionalities to be freely selected according to needs, and, if necessary, to develop entirely new ones. Additionally, its computational engine can be adapted to the specifics of any passenger or freight transport, taking into account key differences between operators such as distance between stops, route characteristics, rolling stock, or cargo properties.

10. Annex

10.1 EMU connections schematics

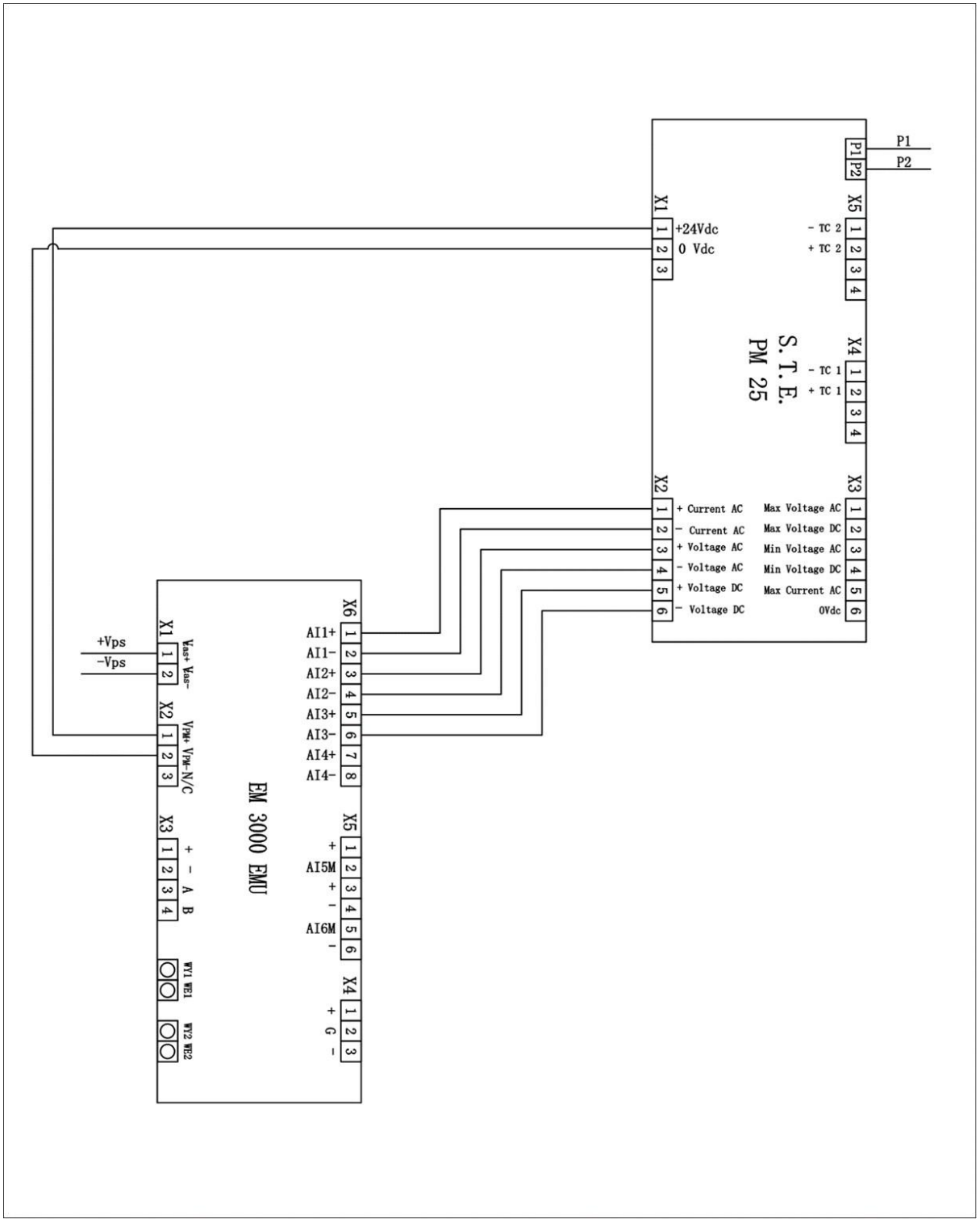


Fig. 27 Diagram of EMU connection with S.T.E. transducer

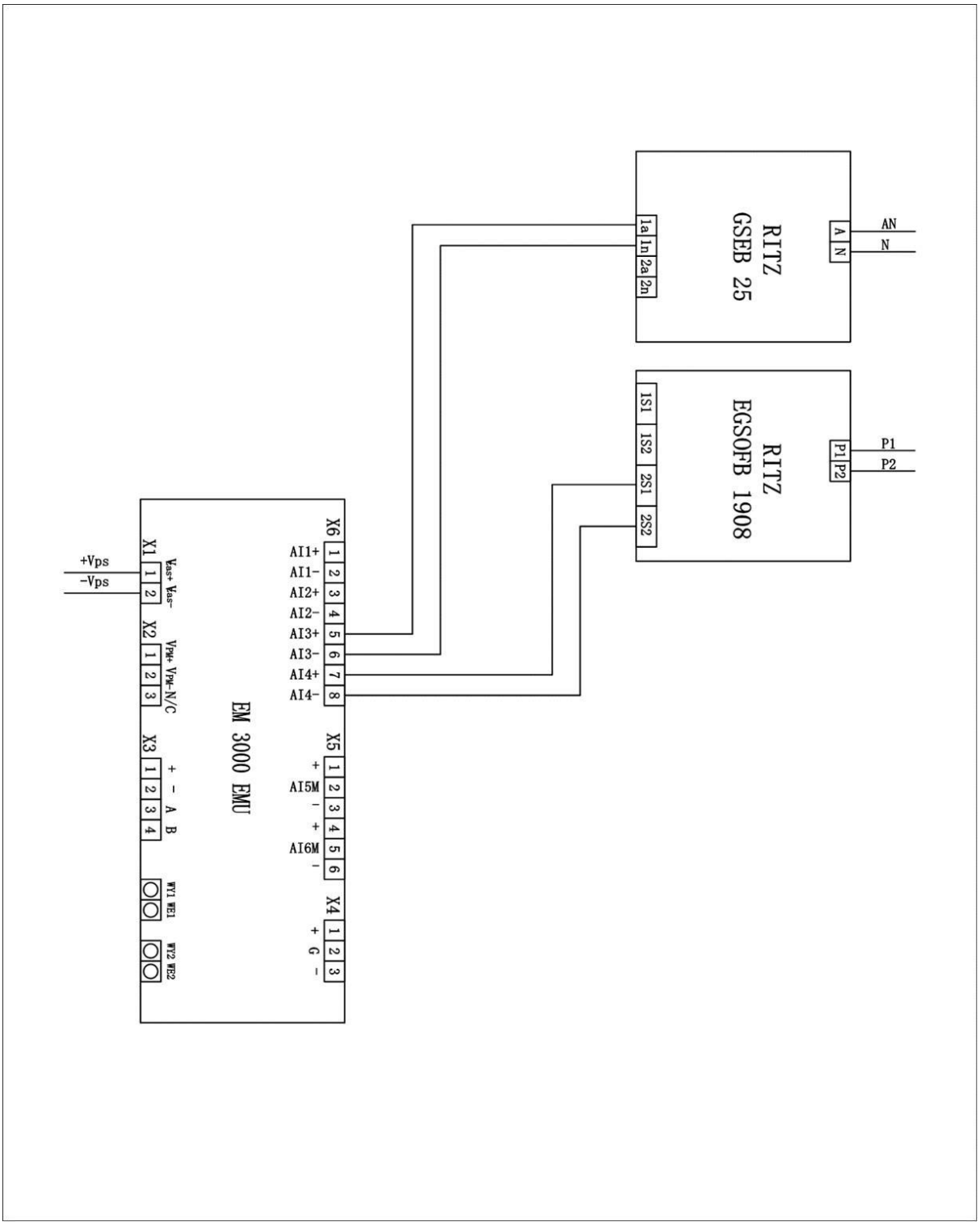


Fig. 28 Diagram of EMU connection with RITZ transducers

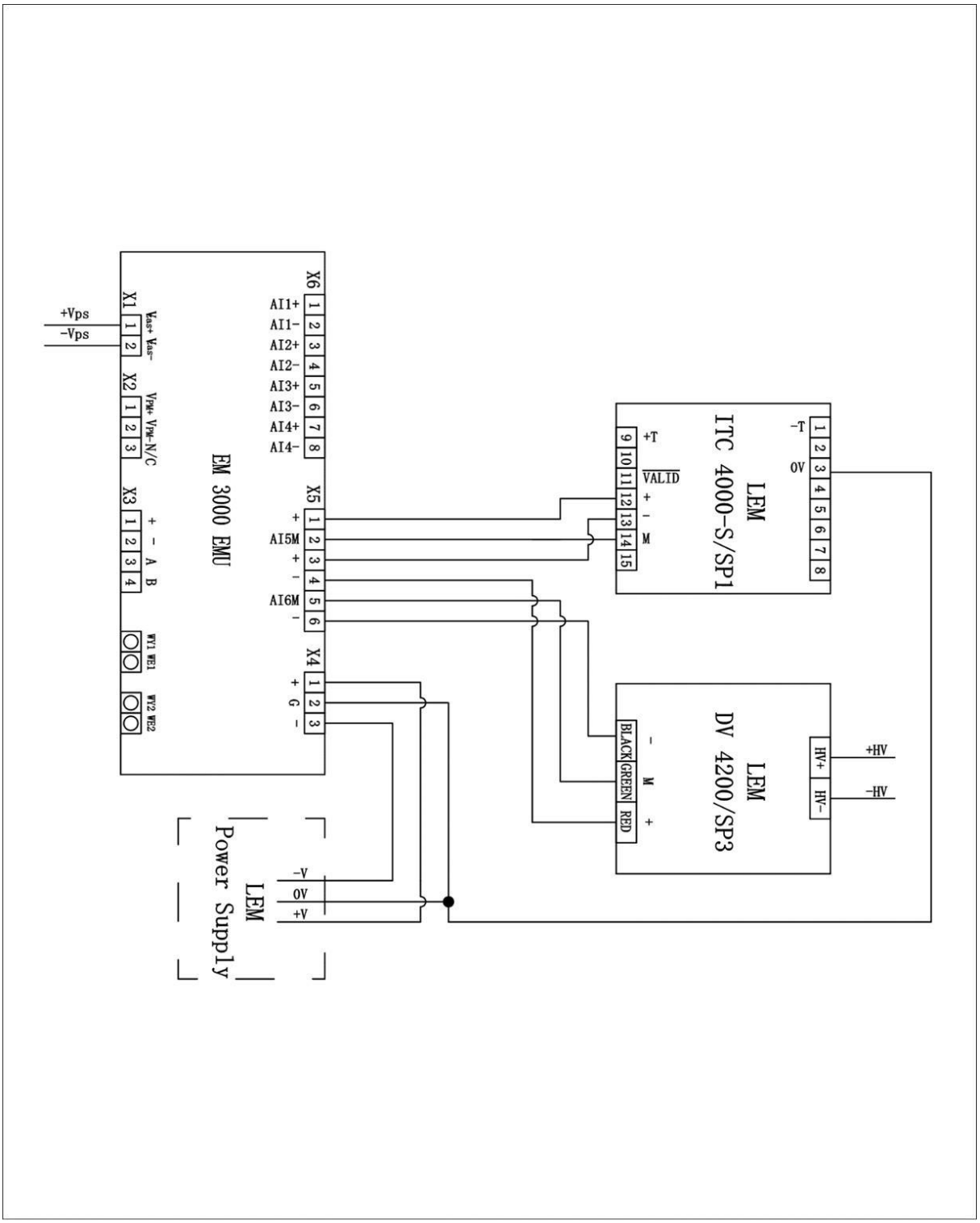


Fig. 29 Diagram of EMU connection with LEM transducers

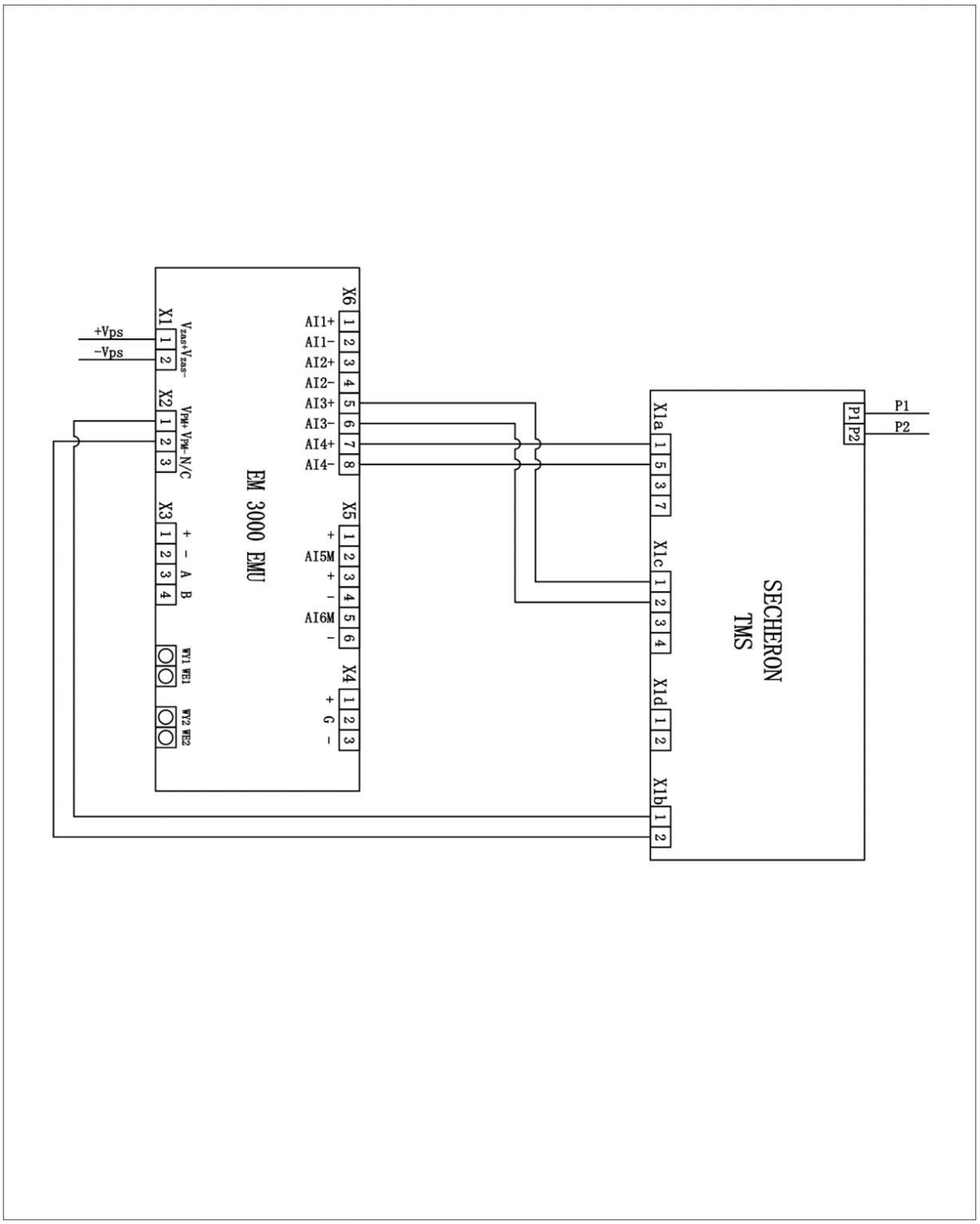


Fig. 30 Diagram of EMU connection with SECHERON transducer

10.2 SIG connection schematic

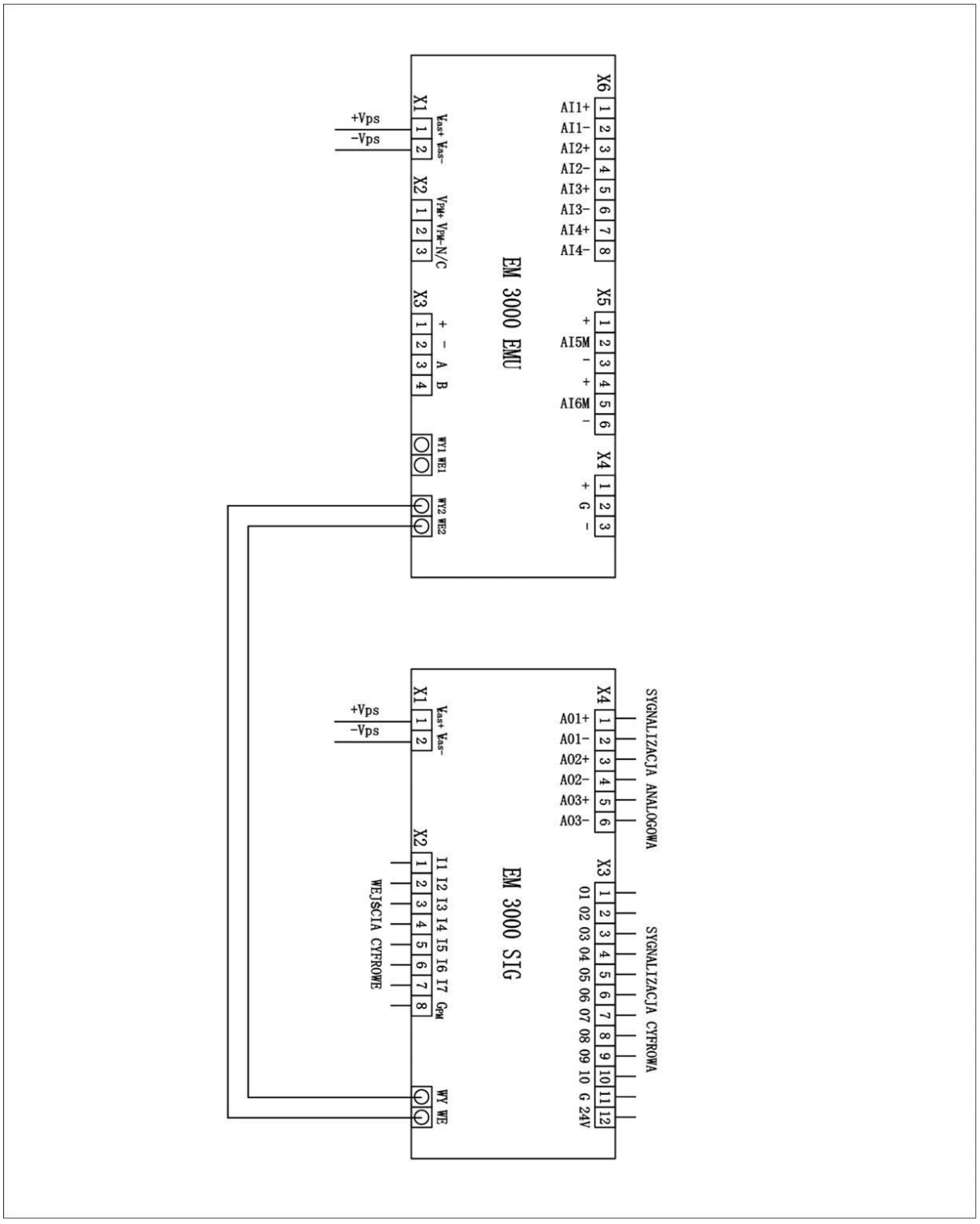


Fig. 31 Diagram of SIG connection with EMU

10.3 DHU connections schematics

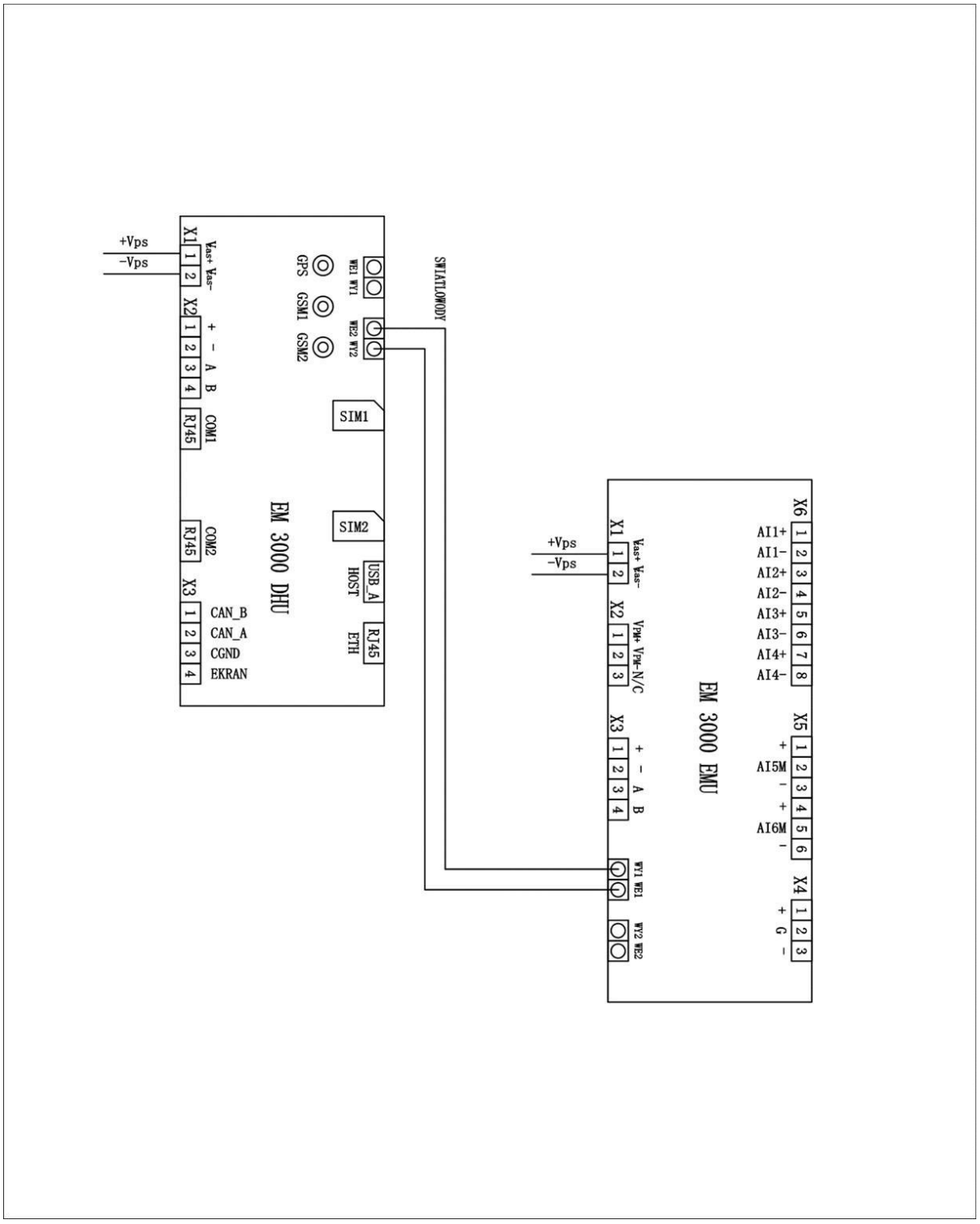


Fig. 32 Diagram of DHU connection with EMU

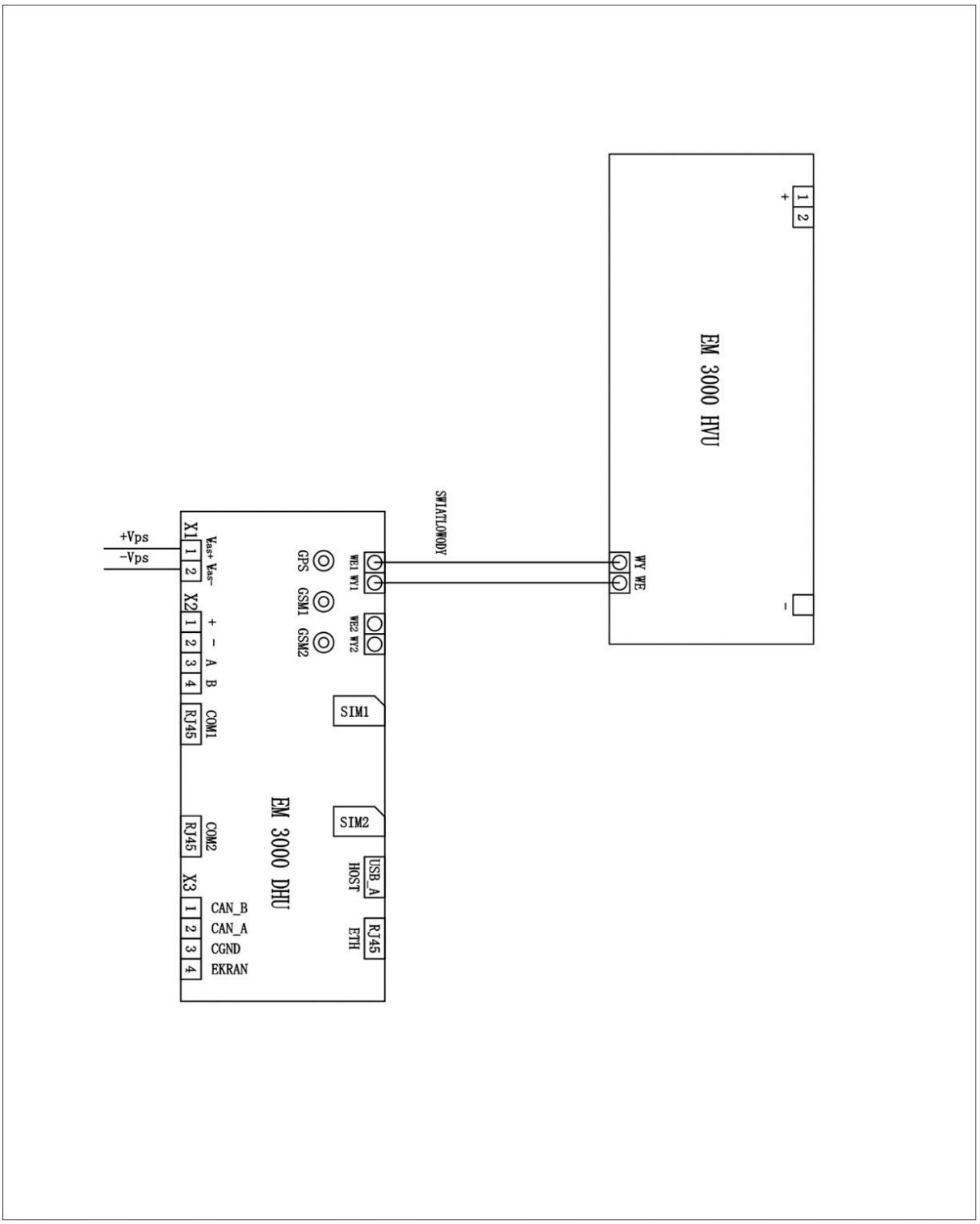


Fig. 33 Diagram of DHU connection with HVU

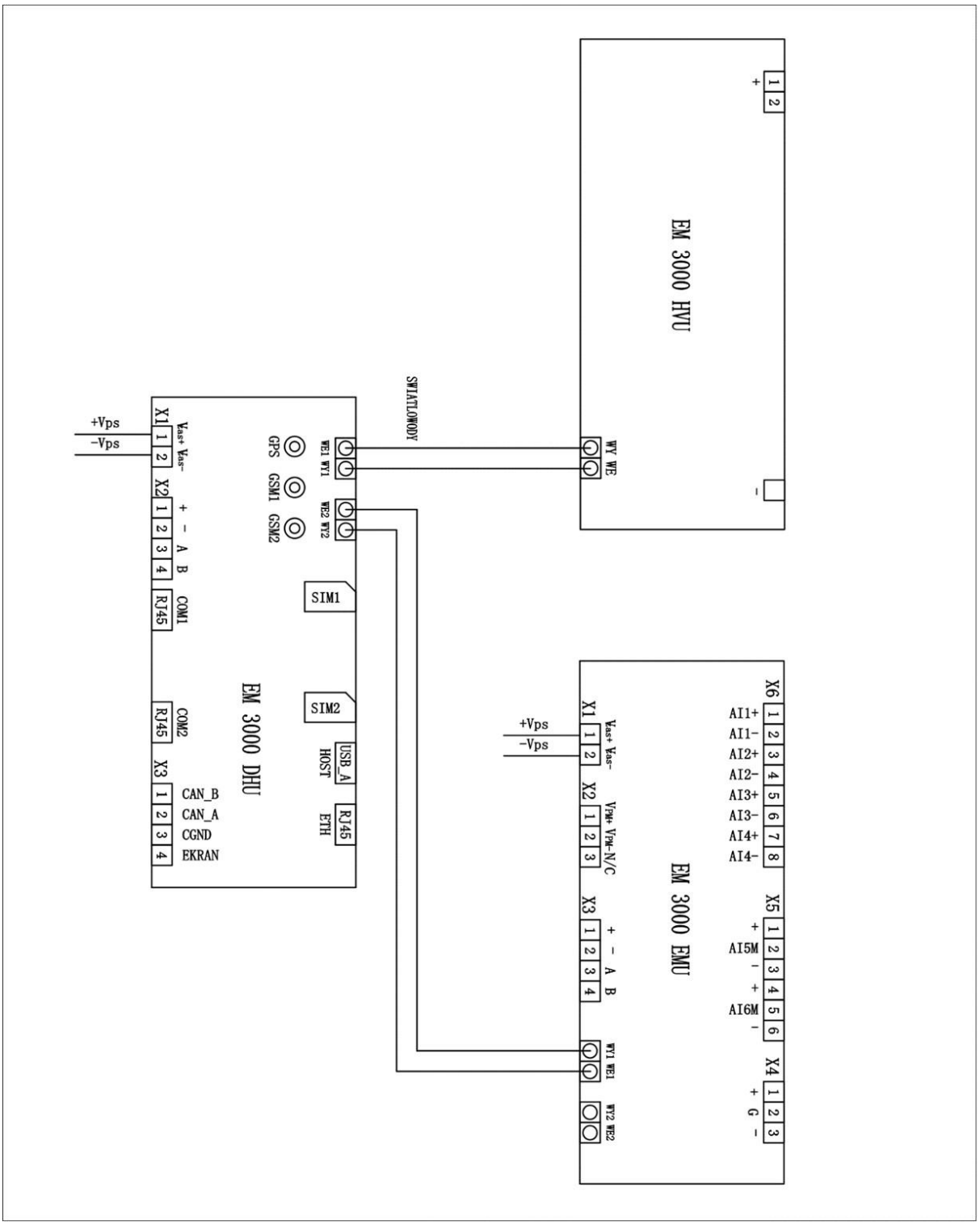


Fig. 34 Diagram of DHU and EMU connection with HVU

10.4 HVU connections schematics

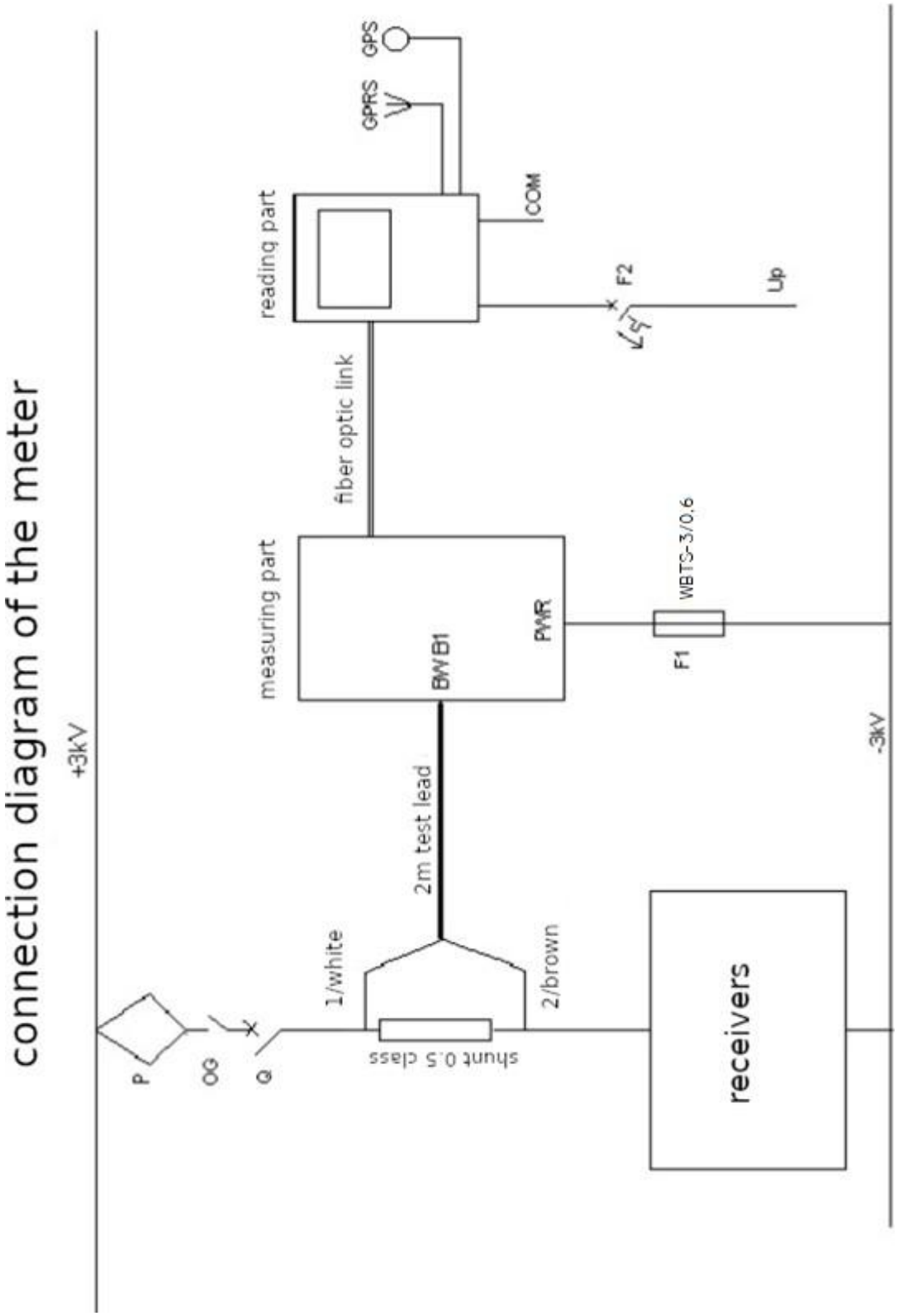


Fig. 35 3kV EM3000 HVU meter connection schematic

10.5 Table of OBIS registers and codes

Standard OBIS codes have been used for naming of the registers used in protocol and for on-screen data presentation. In places where non-standard functions are implemented for EM3000 meter (like GPRS connection, or data transfer to FTP server), their codes were created by using OBIS codes reserved for free use by the manufacturers.

Table below contains all registers utilized by EM3000 meter with their responding codes and sample values.

Register No	Example value	Description
Basic registers		
0.0 0.0.0 96.1 96.1.0	12345678	Device number
0.0.128		Transport operator code [16 HEX characters]
0.0.129		Software version
0.9.1	10:31:53	Current time hh:mm:ss
0.9.2	12-06-25	Current date YY-MM-DD
0.6.0	3000*V	Rated voltage
0.6.1	667*A	Rated current
0.6.3	1000*A	Maximal current
0.8.4	5*min	Load profile recording period
0.8.6	1*month	Billing period length
0.9.6	10:31:53	Time of last reset hh:mm:ss
0.9.7	12-06-25	Date of last reset YY-MM-DD
0.133.1	00000017	Mask of logged NN events (hex)
0.133.2		Minute of closing the billing period

0.133.3		Hour of closing the billing period
0.133.4		Day of closing the billing period
96.5.0	FFFFFFFF	Full auto-diagnostics state
96.5.1	FFFF	Auto-diagnostics status of the meter, first word – instantaneous value ("1" value – on corresponding positions it signalizes correct work and actual usage of meter's components: Bit 0 – real-time clock; Bit 1 – data memory; Bit 2 – communication with HV module; Bit 3 – COM1 communication; Bit 4 – COM2 communication; Bit 5 – GSM module; Bit 6 – GPS module; Bit 7 – all modules in working order)
96.5.2	FFFF	Auto-diagnostics status of the meter, second word – working order of component since last reset ("1" value – states that corresponding meter component was in working order at least for a while; bit assignment to components is similar to first word)
Data registered by the meter		
1.8.t	0123456789.50* kWh	Energy drawn– instantaneous value of energy drawn in all day zone
2.8.t	0000009876.00* kWh	Energy returned - instantaneous value of energy returned in all day zone
11.7.0	100.00*A	Current drawn
12.7.0	3000.00*V	Traction

1.6.t	04125.00*kW 12-06-25 12:30	Maximal value of power drawn in all day zone in current billing period and date and time of recording YY-MM-DD hh:mm
2.6.t	00637.00*kW 12-06-26 22:45	Maximal value of power returned in all day zone in current billing period and date and time of recording YY-MM-DD hh:mm
0.1.1	12	Number of available billing periods
0.1.2*n	12-06-01 00:00	Date of closure of "n" billing period YY-MM-DD hh:mm
1.8.t*n	0003456789.50*kWh	Energy drawn – meter value latched at "n" billing period
2.8.t*n	0000000876.00*kWh	Energy returned – meter value latched at "n" billing period
1.6.t*n	03125.00*kW 12-06-25 12:30	Maximal value of power drawn in all day zone in "n" billing period and date and time of recording YY-MM-DD hh:mm
2.6.t*n	00548.00*kW 12-06-26 22:45	Maximal value of power returned in all day zone in "n" billing period and date and time of recording YY-MM-DD hh:mm

Description: t – corresponds to number of time zone defined in tariff used by the meter basing on tables 130.x and 131.x; value 0 corresponds to main meters – summing; values from 1 to 4 corresponds with zone meters – partial; n – number of last closed billing period; 0 – most recent closed billing period; 1 – previous closed billing period; etc. Maximal value of "n" is stored in 0.1.1 registry		
GPS status		
0.128.1	51st45.0000'N	GPS coordinates – latitude
0.128.2	19st25.0000'E	GPS coordinates – longitude
0.128.3	10	Number of seen satellites
0.128.4	1.0	Height Dilution of Precision (HDOP)
0.128.5	127.9*m	Height above sea level
GSM configuration and status		
0.129.1	1234	SIM card's PIN
0.129.2	www.plusgsm.pl	APN name
0.129.3	User	APN user
0.129.4	Pass	APN password
0.129.11	-61*dBm	Signal strength
0.129.12	Plus GSM	Operator
0.129.13	A1B2	Cell ID
0.129.14	1A2B	Location Area Code
0.129.15	21	Modem status
TCP/IP configuration and status		
0.130.1	51007	Device's listening port

0.130.2	1.1.1.1	IP address allowed to pass through Firewall
0.130.3	0.0.0.0	IP mask allowed to pass through Fire-wall
0.130.4	300*s	Idle connection timeout
0.130.11	127.0.0.1	Device's IP address
0.130.12	127.0.0.1	Currently connected client's IP
FTP configuration		
0.131.1	ftp.sesto.pl	FTP server address
0.131.2	21	Port
0.131.3	user	User
0.131.4	pass	Password
0.131.5	Dir	Catalogue for upload
0.131.6	1440*min	Frequency of sending the files to FTP
0.131.7	3	Number of FTP connection attempts
0.131.8	30*min	Maximal length of FTP session
0.131.9	30*min	Another attempt to send data
0.131.10	12-05-01 00:00	Date of last properly sent to FTP server YY-MM-DD hh:mm
IEC protocol configuration		
0.132.1	wordpass	Protocol password
0.132.2	115200	Transmission speed on serial ports
0.132.3	3*min	Protocol idle time
0.132.4	30*min	Maximal protocol's session length
Scripts		

128	erase check;[length];[crc16] program	Registry for operations on memory space dedicated for script storage
128.x [0-127]	erase	Registry for operations on memory pages dedicated for script storage
128.x[0-126].y[0-63]	[data]	Registry for operations on 64-byte memory pages areas dedicated for script
Tariffs		
130.x[0-99]	03;01-02-XX	Special days table [id_dnia 0 – 9 where 0 means inactive entry];DD-MM-YY setting MM or YY to „XX" is treated as every
131.x[0-199]	03;06:00;12AB;01-02-XX;01-10-XX	Table of time zone changes schedule for use in tariffs [id_taryfy 0 – 4 where 0 means inactive entry];[time of change hh:mm];[activity bitmask during days of week and special days bit0-sunday ... bit6-saturday, bit7-special day id 1 ... bit15- special day id 9 written in HEX];[active from date - DD-MM-YY setting MM or YY to „XX" is treated as every];[active until the set date]
GSM adapter		
140.129.15	21	State of modem
140.129.11	-61*dBm	Signal strength
140.130.11	127.0.0.1	Device's IP address

140.130.12	127.0.0.1	Currently connected client's IP
140.131.10	12-05-01 00:00	Date of last properly sent to FTP server YY-MM-DD hh:mm
Registers of R3 reading block		
99.1.0		Energy profiles in 15 minutes periods
99.98.1		HV event log
99.98.2		NN event log
129.1.1		XML files generator
130		Readout of whole special days table
131		Readout of whole schedule table

Register 96.5.0 – Summary self-diagnostics, 64-bit register

Description	Bit no.	Interpretation
Current GSM1 modem status	0	0 – No communication with modem
		1 – Communication with modem established
	1...3	0 – SIM card status undefined
		1 – SIM card not detected
		2 – SIM card error
		3 – Incorrect SIM PIN
		4 – SIM card detected without PIN
		5 – Correct SIM PIN
		6 – Reserved
		7 – Reserved
	4	0 – Not registered in GSM network
		1 – Registered in GSM network
	5	0 – PPP protocol error
		1 – PPP protocol working correctly
	6	0 – No IP address assigned from GSM network

		1 – IP address assigned from GSM network
Current connection status with FTP server 1	7	0 – Data file has not been sent to FTP server or is currently being transmitted
		1 – Data file has been successfully sent to FTP server
Current status of IEC62056-21 protocol connection on GSM1 interface	8	0 – No active connection
		1 – Active connection established
Current GSM2 modem status	9	0 – No communication with modem
		1 – Communication with modem established
	10...12	0 – SIM card status undefined
		1 – SIM card not detected
		2 – SIM card error
		3 – Incorrect SIM PIN
		4 – SIM card detected without PIN
		5 – Correct SIM PIN
		6 – Reserved
		7 – Reserved
	13	0 – Not registered in GSM network
		1 – Registered in GSM network
	14	0 – PPP protocol error
		1 – PPP protocol working correctly
	15	0 – No IP address assigned from GSM network
		1 – IP address assigned from GSM network
Current connection status with FTP server 2	16	0 – Data file has not been sent to FTP server or is currently being transmitted
		1 – Data file has been successfully sent to FTP server
Current status of IEC62056-21 protocol connection on GSM2 interface	17	0 – No active connection
		1 – Active connection established

	18 … 31	Reserved
Saved GSM1 modem status since last device startup	32...38	Interpretation analogous to bits 0…6, except that at least one occurrence of the event since the last device startup is recorded
At least one data file has been sent to FTP1 server since last device startup	39	0 – No data file was sent to FTP2 server since last device startup
		1 – At least one data file was sent to FTP2 server
At least one IEC62056-21 connection via GSM1 interface since last device startup	40	0 – No connection since last device startup
		1 – At least one connection occurred since last device startup
Saved GSM2 modem status since last device startup	41...47	Analogous to bits 32…40 for GSM2 interface and FTP2 connection
At least one data file has been sent to FTP2 server since last device startup	48	
At least one IEC62056-21 protocol connection via GSM2 interface since last device startup	49	
	50...63	Reserved

Register 96.5.1 – Current self-diagnostics status, 32-bit register – duplicated information from bits 0…31 of register 96.5.0

Register 96.5.2 – Event occurrence self-diagnostics, 32-bit register – duplicated information from bits 32…63 of register 96.5.0

10.6 Supported file formats

EM3000 multi-system energy meter supports data exchange in file format compliant with PN-EN 50463:2018 standard and also CSV and XML files for compliance with previous solutions.

10.6.1XML NEW file description

File format is compliant with PN-EN 50463-4:2018 standard.

10.6.2XML OLD file description

File format is compliant with PN-EN 50463-4:2013 standard. File format is fully supported by HERMES measured data acquisition system.

10.6.3CSV file description

Device may be configured for cyclical upload of CSV files to FTP server. CSV files enable further analysis and visualization of the measurements gathered from the meter, with use of appropriate software. Further paragraphs describe CSV file structure. This file format is fully supported by the HERMES measurement data acquisition system.

10.6.3.1 Separation signs

Fields are separated with ";" sign, lines are separated with "/r/n"

10.6.3.2 Line types

Each line begins with field describing its type.

Following fields exist:

N – Header

C – CEBD registry E –

Event

P – Average powers (15-minute duration) G –

GPS position

M – Meters recorded values (each 1 minute) END –

End of file

10.6.3.3 Lines contents

Below the contents of each individual line type are described:

N – Header:

- N;
- meter number;
- meter model;
- software version;
- date of data beginning;
- date of data ending;
- date of file generation;
- latitude;
- longitude;

C – CEBD registry:

- C;
- date;
- time;
- time flag;
- latitude;
- longitude;
- position flag;
- time zone number according to tariff;
- CPID;
- drawn energy meter value;
- returned energy meter value;
- energy flag for meter values;
- increase in drawn energy meter value;
- increase in returned energy meter value;
- energy flag for value increases;
- (meters values and increases including flags are repeated number of times corresponding to number of connected HV modules)

E – Events:

- E;
- date;
- time;

- time flag;
- event type;
- additional data;

P – Average powers (15-minute duration):

- P;
- date;
- time;
- average drawn power in 15min;
- average returned power in 15min;
- (powers are repeated number of times corresponding to number of connected HV modules)

G – GPS position:

- G;
- date;
- time;
- latitude;
- longitude;
- position flag;

M – Meters recorded values (each 1 minute):

- M;
- date;
- time;
- time flag;
- latitude;
- longitude;
- position flag;
- drawn energy meter value;
- returned energy meter value;
- energy flag for meter values;
- (meter values are repeated number of times corresponding to number of connected HV modules)

END - End of file:

- END

10.7 Dictionary of terms

Word	Meaning
3G	Third-generation mobile telephony, enabling packet data transmission in the HSPA (High Speed Packet Access) technology.
AC	Alternating current.
CANBUS	Controller Area Network, serial communication bus.
CANOpen	CANOpen communication protocol, based on CAN (Controller Area Network).
CEBD	Compiled Energy Billing Data, collective data set for energy billing purposes.
CSV	Comma-separated values – format for storing data in text files.
DC	Direct Current.
E	Energy.
EMZAB	Overvoltage safety device.
Ethernet	Technology, which connects local area networks (LAN) and allows devices communicate with each other through common protocol.
EMU	Electric Multiple Unit, rail vehicle, usually consisting of two control carriages and intermediate carriages, adapted for transport of passengers.
FTP	File Transfer Protocol, communication protocol, client-server type. It uses Transmission Control Protocol (TCP) in TCP/IP model. FTP enables two-way data transfer between FTP server and FTP client.
GPS	Global Positioning System, satellite navigation system, which enables determination of location of points and moving receivers along with parameters of their movement on the Earth's surface.
GSM	Global System for Mobile Communications, a mobile telephony standard that enables packet transmission in GPRS technology (General Packet Radio Service) and EDGE (Enhanced Data rates for GSM Evolution).
HB	Heartbeat, node monitoring in CANOpen network.
I	Electrical current.

"IEC62056-21 tryb C /	Standard describing communication protocol for an energy meter.

IEC1107"	
IEC62056-21 tryb C	IEC 62056 standard defines the communication protocol that is intended for electricity metering, data exchange for electricity meter reading, tariff control and load regulation. In A, B, C mode, system control is active (Master) and the electricity meter is passive (Slave).
Kod OBIS	Identifies a given device variable. It is a text string built on the basis of the OBIS standard (IEC 62056-61).
LTE	Long Term Evolution, the fourth-generation packet data standard for mobile telephony.
NODE	Device's address in CANOpen protocol.
TMS	Technical Monitoring System.
DSO	Distribution System Operator, energy company dealing with distribution of electricity, responsible for network traffic in the distribution system.
P	Power.
PDO1-4	Process Data Object, used for data processing in real time between different CANOpen nodes.
PE	Marking of the protective conductor (yellow-green color).
PIN	Personal Identification Number, alphanumeric code or password used for user verification.
PN-EN 50463-4:2018	European Standard dealing with on-board communication and communication between on board and stationary units, ie includes data transfer using digital interfaces: (a) between functions performed within the Energy Measurement System (EMS); b) between the EMS function and other subsystems on-board; c) between EMS and stationary units.
RS232	Serial communication standard, point-to-point topology.
RS485	Differential serial transmission standard, bus topology.
TSI LOC&PAS	Technical Specifications for Interoperability, rolling stock – locomotives and passenger rolling stock.

U	Voltage.
XML	Extensible Markup Language, designed for structured data representation for example: in files.

11. Index of changes

Document version	Date	Changes
1.0	13.08.2020	Base version.
1.1	11.09.2020	Added description of cable glands and connectors. Chapters supplementation: „Waste management", „Faults servicing". Edition of photos.
1.2	25.09.2020	Editorial correction.
1.3	12.10.2020	Cable glands drawings and table descripting individual glands change for EMU and SIG modules. Correction of wrong labelling of module connectors. Editorial correction.
1.4	15.02.2021	HVU DC weight updated, DHU, EMU, SIG modules dimensions updated.
1.5	03.03.2021	EMU AC module inputs description updated.
1.6	09.03.2021	Nameplates photos updated.
1.7	29.03.2021	Constructional parameters update, Full translation to English pictures no. 1, 3 , 5, 18.
1.8	30.06.2021	EMU data update, connection schematics added for EMU, DHU, SIG, HVU.
1.9	22.09.2021	Chapter 2.3 update, Added power consumption for DHU, HVU, EMU and SIG modules, "HVU connection schematic" update; WBTS-3/0,6
1.10	30.09.2021	EMU technical parameters update, "Accuracy classes and acceptable measurement errors" chapters updated for HVU and EMU modules
1.11	7.12.2021	EMU nameplate update, EMU module AI4 ratio updated, AI5 and AI6 ratios added, DHU weight updated
1.12	4.08.2023	Schematics readability improved
1.13	12.04.2023	Error in TMS transducer fixed
1.14	05.09.2023	Measurement error value update
1.15	04.11.2024	Updated local meter operation manual – section 5.1 Updated sections 5.2 and 6. Added section 9 describing the Sesto eDrive system Updated the list of registers and OBIS codes – section 10.5

1.16	05.12.2024	Section 5.1 updated with diagnostic screens
1.17	01.08.2025	Update of the EMU module mass