METROTEC

Systems for Measuring and Controlling Oxygen

Operating manual

U15-DIGITAL

Oxygen Measuring and Control Device

U15 Series Measuring module

*** Version 1.8 ***

EC Declaration of Conformity

for

Oxygen measuring and control unit Type U15-Serie

This device has been designed for industrial purposes in accordance with:

EN 61000-6-4
EN 61000-6-2

It is compliant with the directives:
EMC Directive: 2014/30/EU
Low Voltage Directive: 2014/35/EU
RoHs: 2011/65/EU
Radio Equipment Act Directive: 2014/53/EU

This device complies with following standards:
EN 61010-1
EN 61000-6-4
EN 61000-6-2
EN 63000
EN 300220-2

Description of measures taken to assure compliance:
Quality management system DIN EN ISO 9001:2015, No. 12 100 27736 TMS

This declaration becomes invalid if changes are made without our consent.

Kirchheim/Teck, 09/10/2024

Place, Date Signature

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1 Safety Instructions

Please read through this operating manual very carefully before installing and commissioning the unit.
Incorrect utilisation will invalidate the guarantee!

Correct functioning and the operating safety of the unit can only be guaranteed if the ambient conditions specified in the Specifications chapter are maintained.

Only qualified specialists are permitted to commission and operate the unit. The owner of the unit must ensure that the installation complies with the relevant laws and directives. These include, for example, the EU Directives covering safety in the workplace, national safety in the workplace regulations and the prevention of accidents regulations, etc.

You must ensure that the power supplies concur with the details listed on the nameplate. All of the covers needed to ensure that the unit cannot be touched when operating must always be fitted. You must consider the effects of the overall operation and take the necessary precautions if the unit will be linked up with other equipment and/or devices before you switch on.

Parts and surfaces will occasionally become and remain hot during the installation or de-installation. Suitable precautions must be taken in order to prevent injuries or damage to the unit from occurring.

If the unit shows signs of having been damaged and you are of the opinion that that safe operation is no longer possible then you must not run the unit. We recommend that periodical inspections are carried out at our factory or by our customer service department at least once a year.

Future disposal must always comply with the legal regulations.

2 Preface

With the aid of an oxygen sensor, the measurement unit serves to measure the oxygen partial pressure in gaseous atmospheres. Such sensors work at high temperatures and so it is necessary for measures to be taken to ensure that no flammable gas mixtures contact the sensor or the unit. In the event of the sensor ceramic suffering breakage the measurement gas could escape or air could enter the measurement gas side of the unit and so suitable measures have to be taken to avoid such an event leading to environmental pollution or damage being done to equipment.

In the event of incorrect parameters being set or the occurrence of leakage, corrosion, condensation, etc., damage could be done to the equipment and incorrect measurement results be indicated and so it is essential that all parts of equipment be regularly serviced.

The oxygen sensor and its accessories are subjected to thorough quality control in accordance with DIN ISO 9001 in the course of their manufacture and testing.
They must only be installed and used in compliance with all applicable local and special regulations, particularly the VDE and DVGW standards that apply in Germany.
The measurement accuracy and effective function of the measurement device will need to be checked at intervals whose frequency will depend on the application concerned. Such a check must be effected in the course of a calibration and examination check on the equipment being first put into operation.

Figure: Oxygen Measuring Module Type U15-Digital

This description is valid for the versions listed here				
Versions of U15-Digital				
Designation	**Sensor**	**Output**	**Alarm**	**Supply**
U15-Digital	Extractive	1	2	230VAC
U15-Digital-2	Extractive	2	2	230VAC
U15-Digital-24	Extractive	1	2	24VDC
U15-Digital-224	Extractive	2	2	24VDC
U15-Digital-C24	Inline	1	2	24VDC
U15-Digital-2C24	Inline	2	2	24VDC

3 Introduction

3.1 Measuring Principle

Oxygen measurement units are designed to process signals transmitted from an oxygen sensor constructed of stabilized zirconium oxide. Zirconium oxide, a ceramic material that is also spoken of as a solid-state electrolyte, acts as an excellent oxygen-ion conductor when at a high temperature.
Within certain temperature limits, that depend on the properties of the material concerned, such ion conductors are able to fill empty spaces in their crystal lattice with oxygen ions. The oxygen ions occur against an electrically conductive surface that is generally of platinum.
The concentration of oxygen in a measurement gas is thus decisive for the extent of oxygen activity, and thus for the number of oxygen ions.
An oxygen sensor consists essentially of a solid-state electrolyte with a contact surface on both sides.
One side of the electrolyte is in contact with a reference gas such as air, and the other with the gas whose oxygen content is to be measured. The mechanical construction of the sensor prevents contact between the two gases so that there is no risk of their being intermixed.
Depending on the application concerned, heated or unheated sensors are used. Unheated sensors are generally used in furnaces while heated sensors are used for applications where the gas to be measured is at a temperature of less than around 600 degrees Celsius (the measurement principle necessitates the sensor being maintained at a temperature of not less than 500 - 650 degrees Celsius).
Heated sensors are maintained at a set temperature by an electronic temperature regulator that forms part of the electronic control unit. The temperature of heated and unheated sensors is measured by the electronics and is significantly included in the calculation of the oxygen content (oxygen partial pressure).
The calculation is based on the formula:

$$EMF = \frac{R \cdot T}{4 \cdot F} \cdot \ln(\frac{P_1}{P_2})$$

where this applies:

R	=	8.31J/mol K
T	=	Temperature in Kelvin
F	=	96493 As/mol
P1	=	Oxygen partial pressure on the reference side with 0.20946 bar
P2	=	Oxygen partial pressure on the measurement gas side
EMF	=	Electromotive force in Volt

3.2 Measuring Module

The U15-DIGITAL series measuring module includes the following functions:

- Measures the oxygen partial pressure in connection with a separate series A or C sensor
- Output of measured value 0/4 to 20 mA.
- Generation of alarms

The module is parameterized after the installation, if necessary, and will operate permanently with these settings.

Note:
In order to implement extensive changes and to display measured values, the "METROTEC App" for Android" or *"METROTEC App for Windows" is required.*

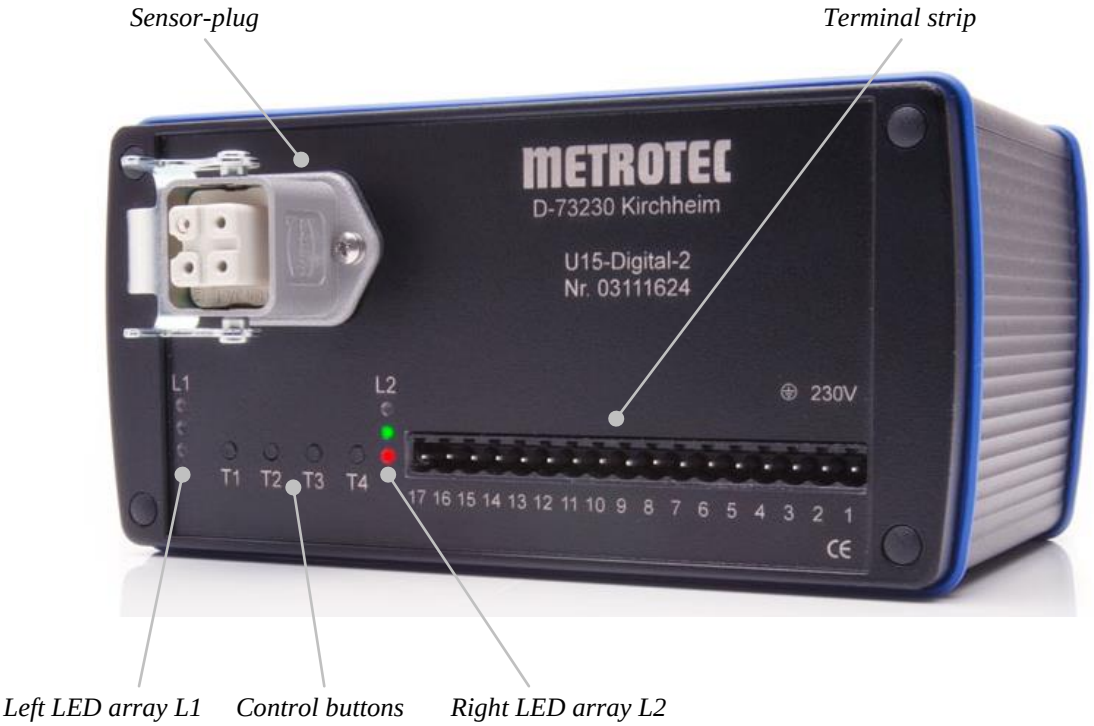
3.3 Sensor

The measuring module requires a separate extractive oxygen sensor or an inline sensor to carry out its functions.
Connecting the sensor: See section "Connection Diagram" as well as separate operating instructions of the sensor.

4 General Layout

4.1 Measuring Electronics

The front is divided into several areas representing key panel and display.



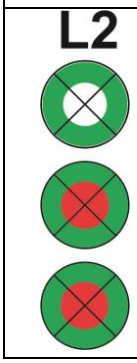
5 Device Start-up

5.1 Start Measuring Module

The measuring module is wired up in accordance with the wiring diagram. The module is ready to start when the supply voltage is applied.

The LED status in array L2 is flashing green. See Table 1
After the heat-up phase of the sensor, readiness is indicated by the green LED status in array L2. See Table 1
From the readiness status, the measurement module provides the current measured value at the mA output.

Table 1: Status display of LED array L2

LED	Status	Description
	Off	Bluetooth switched off
	Green flash	Bluetooth switched on
	Green	Bluetooth connected
	Green flash	Status warm-up phase
	Green	Status readiness
	Red flash	Status malfunction cable break/over-/under-temperature
	Off	Alarm off
	Green	Alarm limit value OK
	Red	Alarm limit value too high

5.2 Measurement

After the starting routine the device is ready for use and can determine the oxygen content in gases. This requires supplying the sample gas according to the sensor type. Alternatively the sample gas contains the sensor. See the operating instructions of the respective sensor.

5.3 Stop Measuring Module

It is advisable to keep the device in operation continuously. This will avoid the condensation of steam in heated sensors which may cause corrosion.
Should the unit need to be switched off, the energy supply of the measuring module will be interrupted. See the operating instructions of the respective sensor.

6 Value Output

The measuring module can output the measured value in linear or logarithmic mode. The standard setting is "linear". This setting can be changed with *„METROTEC App“*. See section "Definition of analog outputs".

6.1 LIN Measured Value Output

The linear output of measured values implicates the assignment of the measured values to either the 0 to 20 mA or the 4 to 20 mA output in linear mode. This assignment is permanent and can only be changed by means of the *„METROTEC App“*.

6.2 LOG Measured Value Output

The logarithmic output of measured values implicates the assignment of the measured values to either the 0 to 20 mA or the 4 to 20 mA output in logarithmic mode. This assignment is permanent and can only be changed by means of the *„METROTEC App.*
The output can take on values between 10^{0} and 10^{-30}. The values represent the logarithm of the oxygen partial pressure. This presentation helps to output values stretching over many powers of ten.

Conversion				
%	**bar**	**ppm**	**log (x)**	**10^{x}**
100	1	1000000	0,00	10^{0}
10	0,1	100000	-1,00	10^{-1}
1	0,01	10000	-2,00	10^{-2}
0,1	0,001	1000	-3,00	10^{-3}
0,01	0,0001	100	-4,00	10^{-4}
0,001	0,00001	10	-5,00	10^{-5}
0,0001	0,000001	1	-6,00	10^{-6}
0,00001	0,0000001	0,1	-7,00	10^{-7}
0,000001	0,00000001	0,01	-8,00	10^{-8}

The measurement module can process values between 10^{0} and 10^{-30}.

7 Configuration

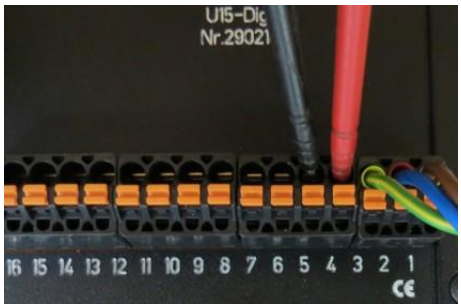
Measurement value comparison and limit value definition can be performed directly on the device.

Note:

In order to implement extensive changes and to display measured values, the "METROTEC App" for Android" or *"METROTEC App for Windows" is required.*

7.1 Practical Approach

In many cases the visualization of the mA signal is not in visible proximity to the measuring module. It is therefore suggested to disconnect the mA connection from terminals 4 and 5 and replace it with a commercially available, portable mA measuring instrument.



The adjustments and settings described below can now be made. After completing the settings, the previously disconnected connections are restored.

7.2 Configuration

Note!
In the "Configuration" mode, important setting values can be changed. so that the originally intended function is no longer guaranteed!
It must therefore be clarified beforehand for what purpose this mode is selected. The following actions can be configured:
1. Checking / adjusting the measured value at 20.94% oxygen. (Reference point)
2. Checking / comparing a measured value with test gas. (Operating point)
3. Checking / setting the switching point for the limit value relay
In particular, the checking / adjustment of the measured value at 20.94% oxygen must be carried out with the greatest care. The adjustment influences the displayed measured value when the sensor is again flowed through with sample gas.
Important!
The set configurations are used at the same time for the optionally available 2nd measuring range.

The configuration will be enabled by pressing "T1" until the LED configuration reference point of the LED array L1 lights up. See Table 2
See also sections "Correction of Measured Values" and "Limit Value Setting"

Table 2: Status display of LED array L1

LED	Status	Description
L1	Off	Configuration limit value off
	Red	Configuration limit value on
	Red flash	Limit value is changed
	Off	Configuration operating point off
	Red	Configuration operating point on
	Red flash	Operating point is changed
	Off	Configuration reference point off
	Red	Configuration reference point on
	Red flash	Reference point is changed

7.3 Value corrections

Important note:
There is a reference point and a operating point. The reference point refers to air with 20.94% oxygen. The operating point relates to a current measured value that is smaller than the reference value. The sequence of an adjustment must start with the reference point. Adjusting the measured value with the reference point leads to a shift in the measurement curve and to measurement deviations with different oxygen concentrations.

If necessary, the current measured value can be corrected. It is advisable to carry out the adjustment only when the measurement is stable and any other measurement errors have been excluded.

7.3.1 Reference Point

The adjustment reference point is started by pressing the "T1" button until the LED configuration reference point of the LED array L1 lights up. See Table 2
The measuring module has now switched the reference point to the measuring output. If necessary, this is set to the middle of the range of the measurement output. With the configuration 0 to 20 mA this is 10 mA and with the configuration 4 to 20 mA this is 12 mA.
A comparison should only be carried out if the following requirement is met:
1. The sensor must be at operating temperature
2. The sensor must be purged with clean air, 20.94% oxygen

The adjustment is carried out with the key "T3" for MINUS and "T4" for PLUS. Continuous pressing of the button speeds up the steps, during which the LED flashes.

Save the setting
After completion, the setting is saved with the "T2" button and the calibration menu is exited at the same time. All LEDs in the LED array L1 go dark. See Table 2

7.3.2 Operating Point

The adjustment operating point is started by pressing the "T1" button until the LED configuration reference point of the LED array L1 lights up. See Table 2
Pressing the "T1" button again switches the LED array L1 one level further to configuration operating point. See Table 2
The measuring module has now switched the actual measured value to the measuring output. The measuring output, 0/4 - 20 mA, corresponds to the range specified on the *FACTORY CALIBRATION CERTIFICATE* or set by *"METROTEC App"*. If necessary, this is set to the expected measured value.
An adjustment should only be carried out if the following requirement is met:

1. The sensor must be at operating temperature
2. The sensor must be purged with a known measuring gas or test gas, whereby this gas must be within the measuring range. (Otherwise 0/4 or 20 mA is displayed and an adjustment does not make sense)
3. The measuring gas or test gas must not contain 20.94% oxygen! An oxygen concentration less (or greater) than 20.94% oxygen is to be used, depending on the measuring range.

The adjustment is carried out with the key "T3" for MINUS and "T4" for PLUS. Continuous pressing of the button speeds up the steps, during which the LED flashes.

Save the setting
After completion, the setting is saved with the "T2" button and the calibration menu is exited at the same time. All LEDs in the LED array L1 go dark. See Table 2

7.3.3 Limit Value

The limit value switches when the current measured value exceeds the set limit value. The limit value is within the programmed measuring range. An alarm condition is signaled by the

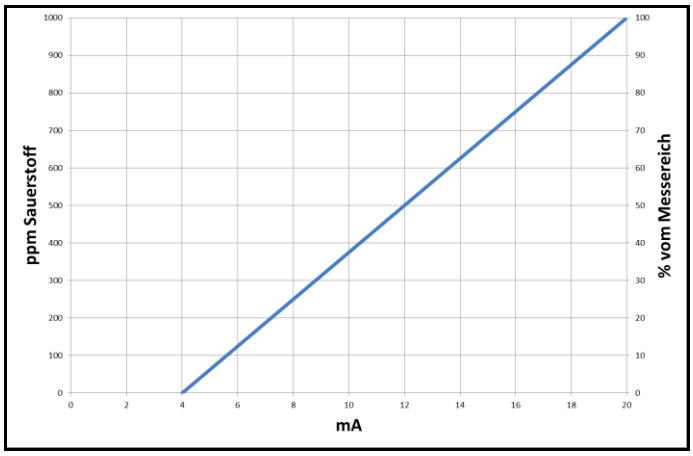
LED array L2. See Table 1. At the same time, the semiconductor relay, whose contact is connected to the connection terminal strip, terminals 10 and 11, switches.

The adjustment of the limit value is started by pressing the "T1" button until the LED configuration reference point of the LED array L1 lights up. See Table 2
Pressing the "T1" button two times again switches the LED array L1 further to configuration limit value. See Table 2

The measuring module has now converted the limit value into a measured value and switched to the measuring output.

The new setting is made with the "T3" button for PLUS and "T4" for MINUS. Continuous pressing of the button speeds up the steps, during which the LED flashes.

Example:
The measuring range is 0-1000 ppm oxygen with a 4-20 mA output.



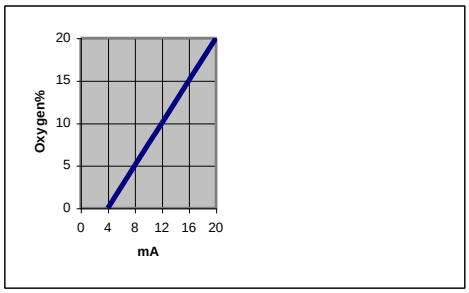
If the limit value is to switch at 500 ppm oxygen, the mA output must be set to 12 mA as described above.

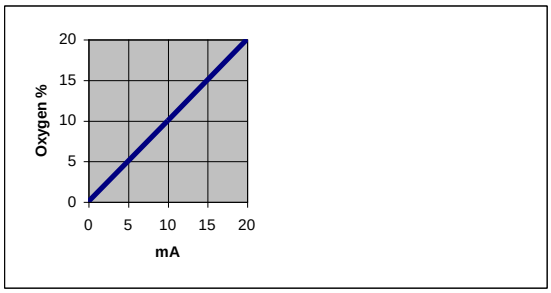
Save the setting
After completion, the setting is saved with the "T2" button and the calibration menu is exited at the same time. All LEDs in the LED array L1 go dark. See Table 2

7.4 Definition of Analog Outputs

Switching the analogue output from 4 to 20 mA to 0 to 20 mA occurs by *"METROTEC App"*. Should there be a 2nd analog output, it will also be switched over in the process.

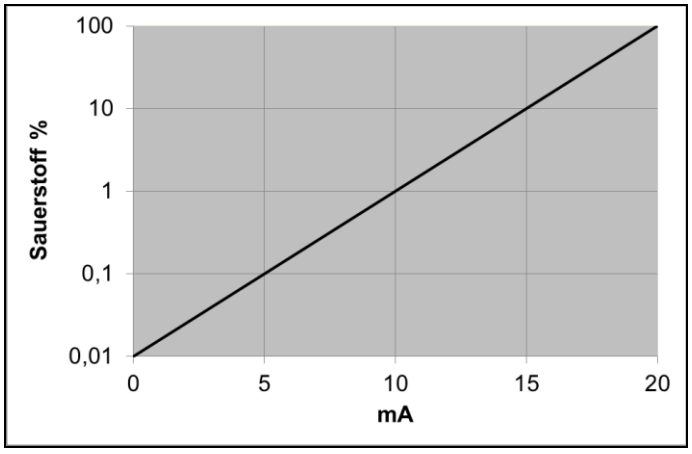
Example for 0 to 20 mA and for 4 –20 mA at 0-20% oxygen.





Switching the analog output to linear / logarithmic occurs by *"METROTEC App"*. Should there be a 2nd analog output, it will also be switched over in the process.

Example for logarithmic output 0 to 20 mA at 0.01-100% oxygen.



8 Interfaces

8.1 Analog Interfaces

There are 1 or optionally 2 analog 0/4-20 mA interfaces. These can be used at the same time.

8.2 Digital Interfaces

Semiconductor relay for oxygen limit value
Semiconductor relay for readiness

9 METROTEC App for Windows

The *"METROTEC App for Windows"* enables you to look at measuring values and change configuration settings. First the Bluetooth interface of the measuring module must be activated.
Activation is effected by pressing the button “T2”. The green flashing Bluetooth LED in array L2 indicates the readiness for a Bluetooth connection. See Table 1
Now a connection can be established. As soon as a connection is active, the Bluetooth LED in array L2 lights up permanently. Pressing the “T2” button again switches off the Bluetooth connection and the Bluetooth LED in array L2.
An exact description is available in the *"METROTEC App for Windows"* operating instructions.

10 METROTEC App for Android

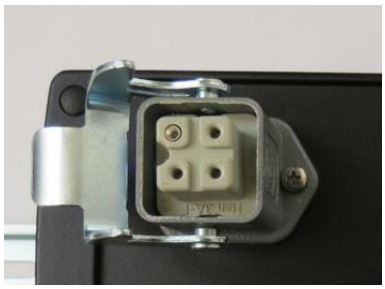
The *"METROTEC App for Android"* enables you to look at measuring values and change configuration settings. First the Bluetooth interface of the measuring module must be activated.
Activation is effected by pressing the button “T2”. The green flashing Bluetooth LED in array L2 indicates the readiness for a Bluetooth connection. See Table 1
Now a connection can be established. As soon as a connection is active, the Bluetooth LED in array L2 lights up permanently. Pressing the “T2” button again switches off the Bluetooth connection and the Bluetooth LED in array L2.
An exact description is available in the *"METROTEC App for Android"* operating instructions.

11 Technical Specifications

Measuring range	100 % to 10^{-35} bar O_2
Ambient temperature	0 to 45 degrees Celsius
Measuring accuracy	+/- 0.3 mV of the sensor e.m.f. +/- 2 degrees Celsius +/- 2% of the mA output +/- 2% of the log oxygen partial pressure
Dimensions	ca. 150 x 180 x 90 mm (HxWxD)
Weight	ca. 1.5 kg
Supply voltage	230 VAC, 24 VDC Observe type plate! Wrong power supply can destroy the module!
Output	Acc. to sensor type, ca. 100 VA max.
1 (optionally 2) analog output(s)	0/4 – 20 mA configurable, floating
2 Relay outputs	configurable for alarms, 1A, 24 V (ohmic)

12 Connection Diagrams

Note:
Digital outputs are floating semiconductor contacts (1A, 24V)
mA Output 1 and 2 are electrically isolated from one another.



Connecting sensors

Note: Please refer to the operating instructions of the respective sensor.

Extraktive sensors	
Pin	**Function**
1	Heating
2	Heating
3	Sensor +
4	Sensor -

Inline-sensors	
Pin	**Function**
1	Thermocouple +
2	Thermocouple -
3	Sensor +
4	Sensor -

U15-Digital		
Terminal	Function	Definition
1	230 VAC	Supply
2	230 VAC	Supply
3	PE (Protective Earth)	Protective Earth
4	mA+	Measured value output 1 +
5	mA-	Measured value output 1 -
6	n.c.	
7	n.c.	
8	Semiconductor relay	Readiness 60VAC-DC, 1A
9	Semiconductor relay	Readiness 60VAC-DC, 1A
10	Semiconductor relay	Limit value 60VAC-DC, 1A
11	Semiconductor relay	Limit value 60VAC-DC, 1A
12	n.c.	
13	n.c.	
14	Test	Test output for factory setting
15	Test	Test output for factory setting

16	n.c.	
17	n.c.	

U15-Digital-2		
Terminal	Function	Definition
1	230 VAC	Supply
2	230 VAC	Supply
3	PE (Protective Earth)	Protective Earth
4	mA+	Measured value output 1 +
5	mA-	Measured value output 1 -
6	mA+	Measured value output 2 +
7	mA-	Measured value output 2 -
8	Semiconductor relay	Readiness 60VAC-DC, 1A
9	Semiconductor relay	Readiness 60VAC-DC, 1A
10	Semiconductor relay	Limit value 60VAC-DC, 1A
11	Semiconductor relay	Limit value 60VAC-DC, 1A
12	n.c.	
13	n.c.	
14	Test	Test output for factory setting
15	Test	Test output for factory setting
16	n.c.	
17	n.c.	

U15-Digital-24		
Terminal	Function	Definition
1	24 VDC +	Supply
2	24 VDC -	Supply
3	PE (Protective Earth)	Protective Earth
4	mA+	Measured value output 1 +
5	mA-	Measured value output 1 -
6	n.c.	
7	n.c.	
8	Semiconductor relay	Readiness 60VAC-DC, 1A
9	Semiconductor relay	Readiness 60VAC-DC, 1A
10	Semiconductor relay	Limit value 60VAC-DC, 1A
11	Semiconductor relay	Limit value 60VAC-DC, 1A
12	n.c.	
13	n.c.	
14	Test	Test output for factory setting
15	Test	Test output for factory setting

16	n.c.	
17	n.c.	

U15-Digital-224		
Terminal	Function	Definition
1	24 VDC +	Supply
2	24 VDC -	Supply
3	PE (Protective Earth)	Protective Earth
4	mA+	Measured value output 1 +
5	mA-	Measured value output 1 -
6	mA+	Measured value output 2 +
7	mA-	Measured value output 2 -
8	Semiconductor relay	Readiness 60VAC-DC, 1A
9	Semiconductor relay	Readiness 60VAC-DC, 1A
10	Semiconductor relay	Limit value 60VAC-DC, 1A
11	Semiconductor relay	Limit value 60VAC-DC, 1A
12	n.c.	
13	n.c.	
14	Test	Test output for factory setting
15	Test	Test output for factory setting
16	n.c.	
17	n.c.	

U15-Digital-C24		
Terminal	Function	Definition
1	24 VDC +	Supply
2	24 VDC -	Supply
3	PE (Protective Earth)	Protective Earth
4	mA+	Measured value output 1 +
5	mA-	Measured value output 1 -
6	n.c.	
7	n.c.	
8	Semiconductor relay	Readiness 60VAC-DC, 1A
9	Semiconductor relay	Readiness 60VAC-DC, 1A
10	Semiconductor relay	Limit value 60VAC-DC, 1A
11	Semiconductor relay	Limit value 60VAC-DC, 1A
12	n.c.	
13	n.c.	
14	Test	Test output for factory setting
15	Test	Test output for factory setting
16	n.c.	
17	n.c.	

U15-Digital-2C24		
Terminal	Function	Definition
1	24 VDC +	Supply
2	24 VDC -	Supply
3	PE (Protective Earth)	Protective Earth
4	mA+	Measured value output 1 +
5	mA-	Measured value output 1 -
6	mA+	Measured value output 2 +
7	mA-	Measured value output 2 -
8	Semiconductor relay	Readiness 60VAC-DC, 1A
9	Semiconductor relay	Readiness 60VAC-DC, 1A
10	Semiconductor relay	Limit value 60VAC-DC, 1A
11	Semiconductor relay	Limit value 60VAC-DC, 1A
12	n.c.	
13	n.c.	
14	Test	Test output for factory setting
15	Test	Test output for factory setting
16	n.c.	
17	n.c.	