EN Manual

BENDER
The Power in Electrical Safety©

ISOMETER® isoGEN523-S4-4

AC/DC

Insulation monitoring device for
unearthed AC, AC/DC and DC systems (IT systems)
up to 3(N)AC, AC 400 V, DC 400 V
Suitable for use in applications using generators
according to DIN VDE 0100-551
Software version: D0494 V1.xx

isoGEN523_D00320_04_M_XXEN/06.2018

Bender GmbH & Co. KG
P.O. Box 1161 • 35301 Gruenberg • Germany
Londorfer Str. 65 • 35305 Gruenberg • Germany
Tel.: +49 6401 807-0 • Fax: +49 6401 807-259
E-mail: info@bender.de • www.bender.de

Photos: Bender archive

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1. Important information

1.1 How to use this manual

*This manual is intended for **qualified personnel** working in electrical engineering and electronics!*

Always keep this manual within easy reach for future reference.
To make it easier for you to understand and revisit certain sections in this manual, we have used symbols to identify important instructions and information.
The meaning of these symbols is explained below:

*This signal word indicates that there is a **high** risk of danger, that **will** result in **death** or **serious injury** if not avoided.*

*This signal word indicates a **medium risk of danger** that can lead to **death** or **serious injury** if not avoided.*

*This signal word indicates a **low-level risk** that can result in minor or **moderate injury** or **damage to property** if not avoided.*

*This symbol denotes information intended to assist the user in making **optimum use** of the product.*

1.2 Technical support: service and support

For commissioning and troubleshooting Bender offers you:

1.2.1 First level support

Technical support by phone or e-mail for all Bender products

- Questions concerning specific customer applications
- Commissioning
- Troubleshooting

Telephone: +49 6401 807-760*
Fax: +49 6401 807-259
In Germany only: 0700BenderHelp (Tel. and Fax)
E-mail: support@bender-service.com

1.2.2 Repair service

Repair, calibration, update and replacement service for Bender products

- Repairing, calibrating, testing and analysing Bender products
- Hardware and software update for Bender devices
- Delivery of replacement devices in the event of faulty or incorrectly delivered Bender devices
- Extended guarantee for Bender devices, which includes an in-house repair service or replacement devices at no extra cost

Telephone: +49 6401 807-780** (technical issues)
+49 6401 807-784**, -785** (sales)
Fax: +49 6401 807-789
E-mail: repair@bender-service.com

Please send the devices for **repair** to the following address:
Bender GmbH, Repair-Service,
Londorfer Straße 65, 35305 Grünberg

1.2.3 Field service

On-site service for all Bender products

- Commissioning, parameter setting, maintenance, troubleshooting for products
- Analysis of the electrical installation in the building (power quality test, EMC test, thermography)
- Training courses for customers

Telephone: +49 6401 807-752**, -762 **(technical issues)
+49 6401 807-753** (sales)
Fax: +49 6401 807-759
E-mail: fieldservice@bender-service.com
Internet: www.bender-de.com

*Available from 7.00 a.m. to 8.00 p.m. 365 days a year (CET/UTC+1)
**Mo-Thu 7.00 a.m. - 4.00 p.m., Fr 7.00 a.m. - 1.00 p.m.

1.3 Training courses

Bender is happy to provide training regarding the use of test equipment.
The dates of training courses and workshops can be found on the Internet at www.bender-de.com -> Know-how -> Seminars.

1.4 Delivery conditions

Bender sale and delivery conditions apply.
For software products the "Softwareklausel zur Überlassung von Standard-Software als Teil von Lieferungen, Ergänzung und Änderung der Allgemeinen Lieferbedingungen für Erzeugnisse und Leistungen der Elektroindustrie" (software clause in respect of the licensing of standard software as part of deliveries, modifications and changes to general delivery conditions for products and services in the electrical industry) set out by the ZVEI (Zentralverband Elektrotechnik- und Elektronikindustrie e. V.) (German Electrical and Electronic Manufacturer's Association) also applies.
Sale and delivery conditions can be obtained from Bender in printed or electronic format.

1.5 Inspection, transport and storage

Inspect the dispatch and equipment packaging for damage, and compare the contents of the package with the delivery documents. In the event of damage in transit, please contact Bender immediately. The devices must only be stored in areas where they are protected from dust, damp, and spray and dripping water, and in which the specified storage temperatures can be ensured.

1.6 Warranty and liability

Warranty and liability claims in the event of injury to persons or damage to property are excluded if they can be attributed to one or more of the following causes:

- Improper use of the device.
- Incorrect mounting, commissioning, operation and maintenance of the device.
- Failure to observe the instructions in this operating manual regarding transport, commissioning, operation and maintenance of the device.
- Unauthorised changes to the device made by parties other than the manufacturer.
- Non-observance of technical data.
- Repairs carried out incorrectly and the use of replacement parts or accessories not approved by the manufacturer.
- Catastrophes caused by external influences and force majeure.
- Mounting and installation with device combinations not recommended by the manufacturer.

This operating manual, especially the safety instructions, must be observed by all personnel working on the device. Furthermore, the rules and regulations that apply for accident prevention at the place of use must be observed.

1.7 Disposal

Abide by the national regulations and laws governing the disposal of this device. Ask your supplier if you are not sure how to dispose of the old equipment.
The directive on waste electrical and electronic equipment (WEEE directive) and the directive on the restriction of certain hazardous substances in electrical and electronic equipment (RoHS directive) apply in the European Community. In Germany, these policies are implemented through the "Electrical and Electronic Equipment Act" (ElektroG). According to this, the following applies:

- Electrical and electronic equipment are not part of household waste.
- Batteries and accumulators are not part of household waste and must be disposed of in accordance with the regulations.
- Old electrical and electronic equipment from users other than private households which was introduced to the market after 13 August 2005 must be taken back by the manufacturer and disposed of properly.

For more information on the disposal of Bender devices, refer to our homepage at www.bender-de.com -> Service & support.

2. Safety instructions

2.1 General safety instructions

Part of the device documentation in addition to this manual is the enclosed "Safety instructions for Bender products".

2.2 Work activities on electrical installations

*Only **qualified personnel** are permitted to carry out the work necessary to install, commission and run a device or system.*

DANGER

Risk of fatal injury due to electric shock!
Touching live parts of the system carries the risk of:

- *An electric shock*
- *Damage to the electrical installation*
- *Destruction of the device*

***Before installing and connecting the device, make sure** that the **installation** has been **de-energised**. Observe the rules for working on electrical installations.*
Observe the information on nominal voltage and supply voltage specified in the technical data!

If the device is used outside the Federal Republic of Germany, the applicable local standards and regulations must be complied with. The European standard EN 50110 can be used as a guide.

2.3 Intended use

*Only **qualified personnel** are permitted to carry out the work necessary to install, commission and run a device or system.*

The ISOMETER® monitors the insulation resistance R_F of unearthed AC, AC/DC and DC systems (IT systems) with nominal system voltages of 3(N)AC, AC/DC 0…400 V or DC 0…400 V. The maximum permissible system leakage capacitance C_e is 5 µF. DC components existing in AC systems do not influence the operating characteristics, when a minimum load current of DC 10 mA flows. A separate supply voltage allows de-energised systems to be monitored, too.
In order to meet the requirements of applicable standards, customised parameter settings must be made on the equipment in order to adapt it to local equipment and operating conditions. Please heed the limits of the range of application indicated in the technical data.
Any use other than that described in this manual is regarded as improper.

To ensure that the ISOMETER® functions correctly, an internal resistance of ≤1 kΩ must exist between L1/+ and L2/- via the source (e.g. the transformer) or the load.

In the event of an alarm message of the ISOMETER®, the insulation fault should be eliminated as quickly as possible.

If the ISOMETER® is installed inside a control cabinet, the insulation fault message must be audible and/or visible to attract attention.

3. Device description

3.1 Device features

- Monitoring the insulation resistance R_F for unearthed AC/DC systems
- Measurement of the nominal system voltage U_n (true RMS) with undervoltage and overvoltage detection
- Measurement of residual voltages to earth (L1+/PE and L2-/PE)
- Two operating modes: GEn and dc
- Automatic adaptation to the system leakage capacitance C_e up to 5 µF
- Selectable start-up delay, response delay and delay on release
- Two separately adjustable response value ranges of 5…200 kΩ (Alarm 1, Alarm 2)
- Automatic device self test with connection monitoring
- Selectable N/C or N/O relay operation
- Fault memory can be activated
- RS-485 (galvanically isolated) including the following protocols:
  - BMS interface (Bender measuring device interface) for data exchange with other Bender components
  - Modbus RTU
  - IsoData (for continuous data output)

3.2 Functional description

The ISOMETER® measures the insulation resistance R_F. It features two operating modes: **GEn** and **dc**.

3.2.1 GEn mode

GEn mode is used in AC/DC or DC systems. The device complies with the maximum response time of ≤ 1s for C_e ≤ 1 µF and R_F ≤ R_{an}/2.

3.2.2 dc mode

dc mode is only used in DC systems. In this mode, the device complies with the maximum response time of ≤ 1s for C_e ≤ 2 µF and R_F ≤ R_{an}/2 in the event of asymmetrical insulation faults. In case of symmetrical insulation faults response times of ≤ 10 s for C_e ≤ 5 µF and R_F ≤ R_{an}/2 are complied with. The system leakage capacitance C_e is also measured in this mode.

3.2.3 General measuring functions

The ISOMETER® measures the RMS value of the nominal system voltage U_n between L1/+ and L2/- as well as the residual voltages U_{L1e} (between L1/+ and earth) and U_{L2e} (between L2/- and earth).

When coupled to a **DC system** , the ISOMETER® determines from a minimum value of the nominal system voltage the fault y conductor L1/+ or L2/- which shows the distribution of the insulation resistance between conductors L1/+ and L2/-. The distribution is indicated by a "+" or "-" sign preceding the insulation resistance measurement. The value range of the fault y conductor is ±100 %:

Indication	Meaning
-100 %	One-sided fault on conductor L2/-
0 %	Symmetrical fault
+100 %	One-sided fault on conductor L1/+

The partial resistances can be calculated from the total insulation resistance R_F and the fault y conductor (R %) using the following formula:

- Fault on conductor L1/+ ->R_{L1F} = (200 % * R_F)/(100 % + R %)
- Fault on conductor L2/- -> R_{L2F} = (200 % * R_F)/(100 % – R %)

When the ISOMETER® is coupled to an **AC system**, the fault y conductor can only be determined in a connected DC system and the fault is detected either on L1/+ (+100 %) or L2/- (-100 %). Calculating the fault distribution is not possible in this case.

If the values R_F or U_n reach or violate the activated response values for the period t_{on} without interruption, an alarm is signalled via the relays "K1" and "K2". If the values R_F or U_n do not reach or violate their release value (response value plus hysteresis) for the period t_{off} without interruption, the alarm relays will switch back to their initial position. If the fault memory is enabled, the alarm relays remain in the alarm state until the external test/reset button is pressed or until the supply voltage is switched off.

The device function can be tested using the external T/R button. Parameterisation of the ISOMETER® is possible via the BMS bus, for example by means of a BMS-Ethernet gateway (COM465IP) or Modbus RTU.

3.2.4 Isolation from the system to be monitored

If the device has no supply voltage or is in stop mode (see page 16), it decouples terminals L1/+ and L2/- internally from the IT system being monitored. In this case, an insulation measurement up to DC 500 V can be carried out using an insulation tester.

3.2.5 Monitoring the insulation resistance

The two parameters "R1" and "R2" monitor the insulation resistance. The value R1 can only be set higher than the value R2. If the insulation resistance R_F reaches or falls below the activated values R1 or R2, then this leads to an alarm message. If R_F exceeds the values R1 or R2 plus the hysteresis value (see table on page 23), the alarm will be cleared.

3.2.6 Undervoltage/overvoltage monitoring

The two parameters "U <" and "U >" can be activated or deactivated for monitoring the nominal system voltage U_n. The maximum undervoltage value is limited by the overvoltage value. The RMS value of the system voltage is monitored. If the nominal system voltage U_n reaches, falls below or exceeds the limit values ("U <" or "U >"), an alarm will be signalled. If the maximum permissible system voltage set for the ISOMETER® is exceeded, an alarm will be triggered even if the overvoltage limit value has been deactivated. The alarm will be deleted when the limit values plus hysteresis are no longer violated.

3.2.7 Self test/Device fault

The integrated self test function checks the function of the insulation monitoring device and the connection to earth and to the IT system to be monitored. By pressing the external test/reset button a self test is started. In the event of a fault, relay 2 ("K2") switches and the measuring function is interrupted. Internal device errors can be caused by external disturbances or internal hardware errors. After eliminating the fault, the alarm relays switch back automatically or by pressing the external T/R button (see page 16). The self test can take up to 30 s.
It can be suppressed for the duration of the device start by setting the parameter in the menu "SEt" to"S.Ct = off" (i.e. device test after device start = off). This allows the ISOMETER® to enter measurement mode quickly after connecting the supply voltage U_s.
If the error message occurs again after restarting the device or after a reset to factory settings, the device must be repaired.

Automatic self test

The device runs a self test after connecting to the supply voltage U_s and then every 24 h.

3.2.8 Malfunction

In addition to the described self test, several functions in the insulation monitoring device are continuously checked during operation. If the error occurs again after restarting the device or after restoring the factory settings, please contact Bender Service.

3.2.9 Signalling assignment of the alarm relays K1/K2

The signalling assignment of the alarm relays "K1" and "K2" is listed in the relay signalling assignment table "r1" and "r2".

3.2.10 Measuring and response times

Operating time t_{ae}

The operating time t_{ae} is the time required by the ISOMETER® to determine the measured value. It applies to the insulation measurement value R_F, the system leakage capacitance C_e, residual voltages U_{L1e} and U_{L2e} as well as the faulty conductor "R %" and is dependant on the insulation resistance R_F and the system leakage capacitance C_e of the system to be monitored. System disturbances may lead to extended measuring times. The measurement time for the system voltage U_n is independent and considerably shorter.

Response delay t_{on}

The response delay t_{on} is set uniformly for all messages, whereby each alarm message specified in the alarm assignment hast its own timer for t_{on}. This delay time can be used for interference suppression in the case of short measuring times. An alarm will only be signalled when a threshold value of the respective measuring value is violated for the period of t_{on} without interruption.

Every time the threshold value is violated within the time t_{on}, the response delay "ton" restarts once again.

Total response time t_{an}

The total response time t_{an} is the sum of the operating time t_{ae} and the response delay time t_{on}.

Delay on release t_{off}
The delay on release t_{off} can be set uniformly for all messages using the parameter "toff", whereby each alarm message specified in the alarm assignment hast its own timer for t_{off}. An alarm will continuously be signalled until the threshold value of the respective measured value is not violated (including hysteresis) for the period of t_{off} without interruption. Each time the threshold value is not violated for the period of t_{off}, the delay on release "toff" restarts once again.

Start-up delay *t*
After connection to the supply voltage U_S the alarm indication for the preset time (0…10 s) in the parameter "t" is suppressed.

3.2.11 Factory settings FAC
Activating the factory settings will reset all modified settings, with the exception of the interface parameters, to the default upon delivery.

3.2.12 External, combined test or reset button T/R
Reset= Press the external button < 1.5 s
Reset with subsequent test= Press the external button > 1.5 s
Stop mode = Press and hold the external button
Only one ISOMETER® may be controlled via an external test/reset button. A galvanic parallel connection of several test or reset inputs for testing multiple insulation monitoring devices is not allowed.

Stop mode can also be triggered via an interface command and in this case it can only be reset via the interface.

3.2.13 Fault memory
The fault memory can be activated or deactivated. When the fault memory is activated, all pending alarm messages of the relays remain available until they are deleted by using the reset button (internal/external) or the supply voltage U_s is turned off.

3.2.14 Interface/protocols

The ISOMETER® uses the serial hardware interface RS-485 with the following protocols:

- **BMS**

The BMS protocol is an essential component of the Bender measuring device interface (BMS bus protocol). Data transmission generally makes use of ASCII characters.

The isoGEN523 identifies itself on the BMS bus with the device name "isoGEN423".

- **Modbus RTU**

Modbus RTU is an application layer messaging protocol and it provides Master/Slave communication between devices that are connected altogether via bus systems and networks. Modbus RTU messages have a 16-bit CRC (Cyclic Redundant Checksum), which guarantees reliability.

The isoGEN523 identifies itself on the Modbus with the device name "isoGEN423".

- **IsoData**

The ISOMETER® continuously sends an ASCII data string with a cycle of approximately 1 s. Communication with the ISOMETER® within this mode is not possible and no additional transmitter may be connected to the RS-485 bus cable. The ASCII data string for the ISOMETER® is described on page 40.

Transmission from the isoGEN523 via the IsoData protocol can be stopped by sending the command"Adr3" during an interval.

Parameter address, baud rate and parity can be parameterised via the RS-485 interface.

The IsoData protocol is activated by setting "Adr = 0".
The parameter value "---" for the baud rate indicates the activated BMS protocol. In this case, the baud rate for the BMS protocol is set to 9,600 baud. If the baud rate is set unequal to "---", the Modbus protocol with configurable baud rate is activated.

4. Installation and connection

*Only **qualified personnel** are permitted to carry out the work necessary to install, commission and run a device or system.*

DANGER

Risk of fatal injury due to electric shock!
Touching live parts of the system carries the risk of:

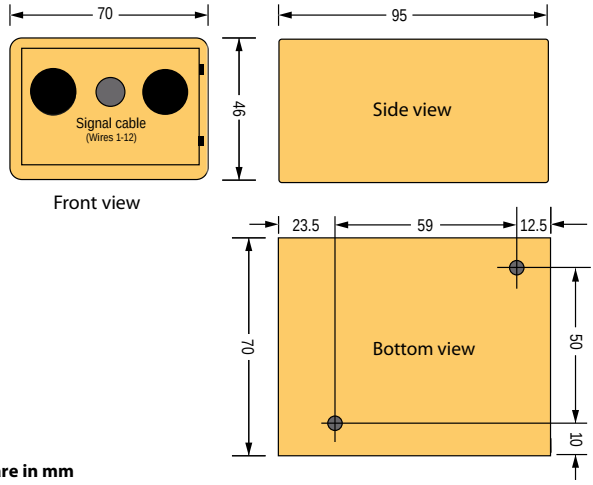
- *An electric shock*
- *Damage to the electrical installation*
- *Destruction of the device*

***Before installing and connecting the device, make sure** that the **installation** has been **de-energised**. Observe the rules for working on electrical installations.*
***Observe the information on the rated voltage and supply voltage** specified in the technical data!*

4.1 Installation

Screw mounting:

Fix the device with two M4 screws, see the following sketch.



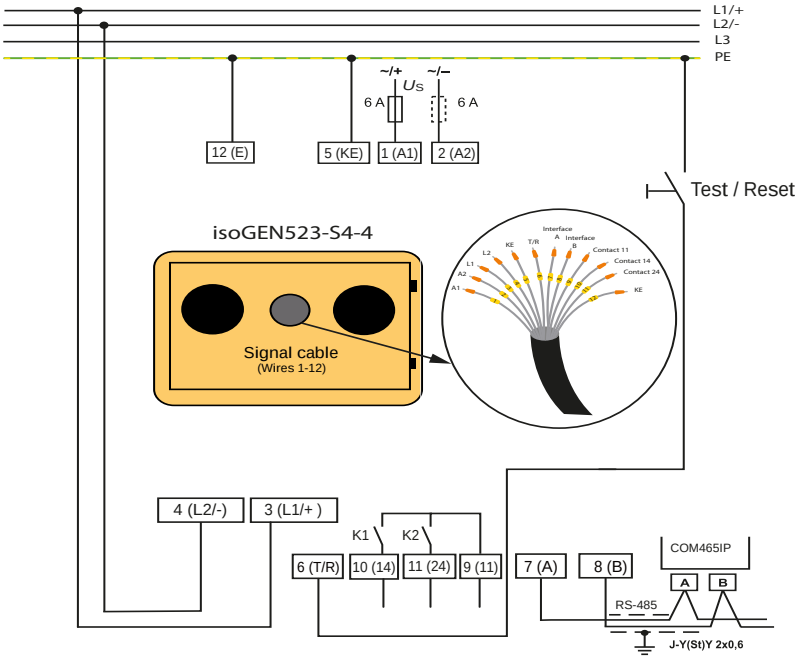
All dimensions are in mm

Abb. 4.1: Dimension diagram (front and side view, bottom view)

4.2 Connection of the device

The wires 1 and 2 ("A1" and "A2") have to be connected to the supply voltage U_s according to IEC 60364-4-43, which means, the connections have to be protected against short circuit by means of a protective device (a 6 A fuse is recommended). Devices for protection against short-circuit in conformity with IEC 60364-4-43 for the connection of terminals "L1/+"/"L2/-" to the IT system to be monitored can be omitted if the wiring is carried out in such a manner as to reduce the risk of a short-circuit to a minimum.

Only one ISOMETER® may be controlled via an external test/reset button. It is not allowed to use a parallel connection of several test or reset inputs for combined testing of ISOMETER®s.



The lower temperature range is only valid if the cable is installed permanently.

Legend for isoGEN523 wiring diagram:

Wire number	Terminal	Connections
1 2	A1 A2	Connection to the supply voltage U_s via fuse (line protection): If being supplied from an IT system, both lines have to be protected by a fuse.
3	L1	Connection to the system to be monitored
4	L2	Connection to the system to be monitored
5	KE	Connect to PE.
6	T/R	Connection for the external combined test and reset button
7 8	A B	Serial communication interface Example: Connection of a BMS Ethernet gateway COM465IP
9 10 11	11 14 24	Common connection for "K1" and "K2" Connection to alarm relay "K1" Connection to alarm relay "K2"
12	E	Connect to PE.

4.3 Commissioning

1. **Check that** the ISOMETER® is **properly connected** to the system to be monitored.
2. **Connect the supply voltage U_s to the ISOMETER®**.
   The device carries out a calibration, a self test and adjusts itself to the IT system to be monitored. This process can take up to 30 s.
3. **Start a manual self test** by pressing the external test/reset button.
4. **Check the function using a genuine insulation fault**.
   The ISOMETER® in the system being monitored has to be tested with a suitable resistance to earth.

5. Parameter overview

5.1 Response value setting

The two parameters that monitor the insulation resistance are "R1" and "R2". The value R1 can only be set higher than the value R2. If the insulation resistance R_F reaches or falls below the activated values R1 or R2, this leads to an alarm message. If R_F exceeds the values R1 or R2 plus the hysteresis value (see table below), the alarm will be cleared. The two parameters ("U <" and "U >") for monitoring the system voltage can be activated or deactivated. The maximum undervoltage value is limited by the overvoltage value.

Parameter	Activation	Setting value			Description	Available via	
	FAC	Value range	FAC	Cs		BMS	Modbus
R1	**on**	R2 … 200	**46**	kΩ	Pre-alarm value R_{an1} Hys. = 25 %/min. 1kΩ	X	X
R2	**on**	5… R1	**23**	kΩ	Alarm value R_{an2} Hys. = 25 %/min. 1kΩ	X	X
U <	**off**	10 … "U>"	**10**	V	Alarm value undervoltage RMS Hys. = 5 %/min. 5 V	X	X
U >	**off**	"U<" … 500	**500**	V	Alarm value overvoltage RMS Hys. = 5 %/min. 5 V	X	X

FAC = Factory settings; **Cs** = Customer settings

5.2 Configuration of the relay operating mode

Relay K1		Relay K2		Description	Available via	
FAC	Cs	FAC	Cs		BMS	Modbus
n.c.		**n.c.**		Operating mode of the relay n.c/n.o.	X	X

FAC = Factory settings; **Cs** = Customer settings

5.2.1 Relay signalling assignment "r1" and "r2"

In the alarm assignment, each alarm is assigned to the corresponding relay with the setting "on". If the device can assign an asymmetrical insulation fault to the corresponding conductor (L1/+ or L2/-), it will only signal the respective alarm.

K1 "r1"		K2 "r2"		Alarm description	Available via
FAC	Cs	FAC	Cs		Modbus
off		on		Device error E.xx	X
on		off		Pre-alarm R1 Fault R_F at L1/+	X
on		off		Pre-alarm R1 Fault R_F at L2/-	X
off		on		Alarm R2 Fault R_F at L1/+	X
off		on		Alarm R2 Fault R_F at L2/-	X
off		on		Alarm U_n undervoltage	X
off		on		Alarm U_n overvoltage	X
off		off		Manually started device test, test	X
off		off		Device start with alarm, S.AL	X

FAC = Factory settings; **Cs** = Customer settings

5.2.2 Fault memory configuration

FAC	Cs	Description	Available via	
			BMS	Modbus
off		Memory function for alarm messages (fault memory)	X	X

FAC = Factory settings; **Cs** = Customer settings

5.3 Interface configuration

Setting value			Description		Available via	
Value range	**FAC**	**Cs**			**BMS**	**Modbus**
0 / 3 … 90	**3**	( )	BusAdr.	Adr = 0 deactivates BMS as well as Modbus and activates isoData with continuous data output (115k2, 8E1)	X	X
--- / 1.2k … 115k	"**---**"	( )	Baud rate	"---" --> BMS bus (9k6, 7E1) "1.2k" … "115k2" --> Modbus (variable, variable)	X	X
8E1 8o1 8n1	**8E1**	( )	Modbus	**8E1** - 8 data bits even parity, 1 stop bit **8o1** - 8 data bits odd parity, 1 stop bit **8n1** - 8 data bits no parity, 1 stop bit		X

FAC = Factory settings; **Cs** = Customer settings;
( ) = User setting that is not modified by FAC.

5.4 Time configuration

Parameter	Setting value			Description	Available via	
	Value range	**FAC**	**Cs**		**BMS**	**Modbus**
t	0 … 10	**0**	**s**	Start-up delay when starting the device	X	X
ton	0 … 99	**0**	**s**	Response delay K1 and K2	X	X
toff	0 … 99	**0**	**s**	Delay on release K1 and K2	X	X
test	OFF / 1 / 24	**24**	**h**	Repetition time device test	X	X

FAC = Factory settings; **Cs** = Customer settings

5.5 Function configuration

Parameter	Activation		Setting value			Description	Available via	
	FAC	Cs	Value range	FAC	Cs		BMS	Modbus
GEn/dc			GEn/dc	**GEn**		Selection of the system to be monitored **GEn**: Generators (AC, AC with connected DC, DC) **dc**: DC system	X	X
nEt	**on**					Test of the system connection during device test	X	X
S.Ct	**on**					Device test during device start	X	X
FAC						Restore factory settings	X	X
SYS						For Bender Service only		

FAC = Factory settings; **Cs** = Customer settings

5.6 Measured value description

Description	
Insulation resistance	R_F
1 kΩ ... 2 MΩ	Resolution 1 kΩ
System leakage capacitance	C_e
1 nF ... 17 µF	Resolution 1 nF
Nominal system voltage L1 - L2	U_n
0 $V_{trueRMS}$ … 500 $V_{trueRMS}$	Resolution 1 $V_{trueRMS}$
Residual voltage L1/+ - PE	U_{L1e}
0 V_{DC} … ±500 V_{DC}	Resolution 1 V_{DC}
Residual voltage L2/- - PE	U_{L2e}
0 V_{DC} … ±500 V_{DC}	Resolution 1 V_{DC}
Fault location in %	
-100 % …+100 %	

6. Data access using the BMS protocol

The BMS protocol is an essential component of the Bender measuring device interface (BMS bus protocol). Data transmission generally makes use of ASCII characters.

BMS channel no.	Operation value	Alarm
1	R_F	Pre-alarm R1
2	R_F	Alarm R2
3	----	----
4	U_n	Undervoltage
5	U_n	Overvoltage
6	---	Connection fault earth (E.01)
7	---	Connection fault system (E.02)
8	---	All other device errors (E.xx)
9	Fault location [%]	---
10	C_e	---
11	---	---
12	Update counter	---
13	U_{L1e}	---
14	U_{L2e}	---
15	---	---

7. Data access using the Modbus RTU protocol

Requests to the ISOMETER® can be made using the function code 0x03 (read multiple registers) or the command 0x10 (write multiple registers). The ISOMETER® generates a function-related answer and sends it back.

7.1 Reading out the Modbus register from the ISOMETER®

The required Words of the process image can be read out from the "Holding registers" of the ISOMETER® using the function code 0x03. For this purpose, the start address and the number of the registers to be read out have to be entered. Up to 125 Words (0x7D) can be read with one single request.

7.1.1 Command of the master to the ISOMETER®

In the following example, the master of the ISOMETER® requests the content of the register 1003 with the address 3. The register contains the channel description of measuring channel 1.

Byte	Name	Example
Byte 0	ISOMETER® Modbus address	0x03
Byte 1	Function code	0x03
Byte 2, 3	Start address	0x03EB
Byte 4, 5	Number of registers	0x0001
Byte 6, 7	CRC16 Checksum	0xF598

7.1.2 The ISOMETER® answers the master

Byte	Name	Example
Byte 0	ISOMETER® Modbus address	0x03
Byte 1	Function code	0x03
Byte 2	Number of data bytes	0x02
Byte 3, 4	Data	0x0047
Byte 7, 8	CRC16 Checksum	0x81B6

7.2 Writing the Modbus register (parameter setting)

Registers in the device can be modified with the Modbus command 0x10 (set multiple registers). Parameter registers are available from address 3000. The content of the register is listed in the table on page 31.

7.2.1 Command of the master to the ISOMETER®

In this example, the master addresses the ISOMETER® with address 3 and requests that the content of the register with address 3003 is set to 2.

Byte	Name	Example
Byte 0	ISOMETER® Modbus address	0x03
Byte 1	Function code	0x10
Byte 2, 3	Start register	0x0BBB
Byte 4, 5	Number of registers	0x0001
Byte 6	Number of data bytes	0x02
Byte 7, 8	Data	0x0002
Byte 9, 10	CRC16 Checksum	0x9F7A

7.2.2 The ISOMETER® answers the master

Byte	Name	Example
Byte 0	ISOMETER® Modbus address	0x03
Byte 1	Function code	0x10
Byte 2, 3	Start register	0x0BBB
Byte 4, 5	Number of registers	0x0001
Byte 6, 7	CRC16 Checksum	0x722A

7.3 Exception code

If a request cannot be answered for whatever reason, the ISOMETER® will send a so-called exception code with which possible faults can be narrowed down.

Exception code	Description
0x01	Impermissible function
0x02	Impermissible data access
0x03	Impermissible data value
0x04	Internal fault
0x05	Acknowledgement of receipt (answer will be time-delayed)
0x06	Request not accepted (repeat request if necessary)

7.3.1 Structure of the exception code

Byte	Name	Example
Byte 0	ISOMETER® Modbus address	0x03
Byte 1	Function code (0x03) + 0x80	0x83
Byte 2	Data (exception code)	0x04
Byte 3, 4	CRC16 Checksum	0xE133

8. Modbus register assignment of the ISOMETER®

Depending on the device condition, the information in the registers is the measured value without alarm; the measured value with alarm 1; the measured value with alarm 2; or only the device error.

Register	Measured value			Device error
	Without alarm	**Alarm 1**	**Alarm 2**	
1000 to 1003	R_F Insulation fault (71) [no alarm]	R_F Insulation fault (1) [prewarning]	R_F Insulation fault (1) [alarm]	--- Connection earth (102) [device error]
1004 to 1007	---	---	---	---
1008 to 1011	U_n Voltage (76) [no alarm]	U_n Undervoltage (77) [alarm]	U_n Overvoltage (78) [alarm]	--- Connection to system (101) [device error]
1012 to 1015	C_e capacitance (82) [no alarm]	---	---	---
1016 to 1019	U_{L1e} Voltage (76) [no alarm]	---	---	---
1020 to 1023	U_{L2e} Voltage (76) [no alarm]	---	---	---
1024 to 1027	**Fault location in %** --- (1022) [no alarm]	---	---	---
1028 to 1031	---	---	---	---
1032 to 1035	**Measured value update counter** --- (1022) [no alarm]	---	---	--- Device error (115) [device error]

( ) = Channel description code (refer to Chapter 8.2); [ ] = Alarm type (refer to Chapter 8.1.2.2)

Regpage 31ister	Property	Description	Format	Unit	Value range
3000	RW	Reserved	---	---	---
3001	RW	Reserved	---	---	---
3002	RW	Reserved	---	---	---
3003	RW	Reserved	---	---	---
3004	RW	Reserved	---	---	---
3005	RW	Pre-alarm value resistance measurement "R1"	UINT 16	kΩ	R2 … 250
3006	RW	Reserved	---	---	---
3007	RW	Alarm value resistance measurement "R2"	UINT 16	kΩ	5 … R1
3008	RW	Activation alarm value undervoltage "U<"	UINT 16	---	0 = Inactive 1 = Active
3009	RW	Alarm value undervoltage "U<"	UINT 16	V	10 … U>
3010	RW	Activation alarm value overvoltage "U>"	UINT 16	---	0 = Inactive 1 = Active
3011	RW	Alarm value Overvoltage "U >"	UINT 16	V	U< … 500
3012	RW	Memory function for alarm messages (Fault memory) "M"	UINT 16	---	0 = Inactive 1 = Active
3013	RW	Operating mode of relay 1 "r1"	UINT 16	---	0 = n.o. 1 = n.c.
3014	RW	Operating mode of relay 2 "r2"	UINT 16	---	0 = n.o. 1 = n.c.
3015	RW	Bus address "Adr"	UINT 16	---	0 / 3 … 90
3016	RW	Baud rate "Adr 1"	UINT 16	---	0 = BMS 1 = 1.2 k 2 = 2.4 k 3 = 4.8 k 4 = 9.6 k 5 = 19.2 k 6 = 38.4 k 7 = 57.6 k 8 = 115.2 k

Regpage 31ister	Property	Description	Format	Unit	Value range
3017	RW	Parity "Adr 2"	UINT 16	---	0 = 8N1 1 = 8O1 2 = 8E1
3018	RW	Start-up delay "t" during device start	UINT 16	s	0 …10
3019	RW	Response delay "ton" for relays "K1" and "K2"	UINT 16	s	0 … 99
3020	RW	Delay on release "toff" for relays "K1" and "K2"	UINT 16	s	0 … 99
3021	RW	Repetition time "test" for automatic device test	UINT 16	---	0 = OFF 1 = 1 2 = 24 h
3022	RW	Reserved	---	---	---
3023	RW	System and function selection	UNIT 16	---	0=GEn 1 = dc 2 = CHd
3024	RW	Test of the system connection during device test "nEt"	UINT 16	---	0 = Inactive 1 = Active
3025	RW	Device test during device start "S. Ct"	UINT 16	---	0 = Inactive 1 = Active
3026	RW	Request stop mode (0 = deactivate device)	UINT 16	---	0 = Stop 1 = ---
3027	RW	Alarm assignment of relay 1 "r1"	UINT 16	---	Bit 9 … Bit 1 see Chapter 8.1.3
3028	RW	Alarm assignment of relay 2 "r2"	UINT 16	---	Bit 9 … Bit 1 see Chapter 8.1.3
8003	WO	Factory settings for all parameters	UINT 16	---	0x6661 "fa"
8004	WO	Factory setting only for parameters resettable by FAC	UINT 16	---	0x4653 "FS"
8005	WO	Start device test	UINT 16	---	0x5445 "TE"
8006	WO	Clear fault memory	UINT 16	---	0x434C "CL"

Regpage 31ister	Property	Description	Format	Unit	Value range
9800 to 9809	RO	Device name	UNIT 16 (ASCII) - refer to Chapter 8 .1.1	---	---
9820	RO	Software ID number	UINT 16	---	Software D number
9821	RO	Software version number	UINT 16	---	Software version
9822	RO	Software version: Year	UINT 16		
9823	RO	Software version: Month	UINT 16		
9824	RO	Software version: Day	UINT 16		
9825	RO	Modbus driver version	UINT 16		

RW = Read/Write; **RO** = Read only; **WO** = Write only

8.1 Device-specific data type of the ISOMETER®

8.1.1 Device name

The data format of the device name is specified below.

Word 0x00	0x01	0x02	0x03	----------	0x08	0x09
10 Words in total Each Word contains two ASCII characters						

8.1.2 Measured values

Each measured value is available as a channel and consists of 8 bytes (4 registers). The first measured value register address is 1000. The structure of a channel is always identical. Content and number depend on the device. The structure of a channel is shown with the example of channel 1:

1000		1001		1002		1003	
HiByte	LoByte	HiByte	LoByte	HiByte	LoByte	HiByte	LoByte
Floating point value (Float)				Alarm type and test type (AT&T)	Range and unit (R&U)	Channel description	

8.1.2.1 Float = Floating point value of the channels

Word	0x00																0x01															
Byte	HiByte								LoByte								HiByte								LoByte							
Bit	31	30						24	23	22						16	15							8	7							0
	S	E	E	E	E	E	E	E	E	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M

Representation of the bit order for processing analogue measured values according to IEEE 754
S = Sign; **E** = Exponent; **M** = Mantissa

8.1.2.2 AT&T = Alarm type and test type (internal/external)

Bit	7	6	5	4	3	2	1	0	Meaning
	Test external	Test internal	Reserved	Reserved	Reserved	Alarm	Fault		
Alarm type	X	X	X	X	X	0	0	0	No alarm
	X	X	X	X	X	0	0	1	Prewarning
	0	0	X	X	X	0	1	0	Device error
	X	X	X	X	X	0	1	1	Reserved
	X	X	X	X	X	1	0	0	Warning
	X	X	X	X	X	1	0	1	Alarm
	X	X	X	X	X	1	1	0	Reserved
	X	X	X	X	X	…	…	…	Reserved
	X	X	X	X	X	1	1	1	Reserved
Test	0	0	X	X	X	X	X	X	No test
	0	1	X	X	X	X	X	X	Internal test
	1	0	X	X	X	X	X	X	External test

The alarm type is coded by the bits 0 to 2. Bits 3, 4 and 5 are reserved and always have the value 0. Bit 6 or 7 is usually set when an internal or external test has been completed. Other values are reserved. The complete byte is calculated from the sum of the alarm type and the test type.

8.1.2.3 R&U = Range and unit

Bit	7	6	5	4	3	2	1	0	Meaning
Unit	-	-	-	0	0	0	0	0	Invalid (init)
	-	-	-	0	0	0	0	1	No unit
	-	-	-	0	0	0	1	0	Ω
	-	-	-	0	0	0	1	1	A
	-	-	-	0	0	1	0	0	V
	-	-	-	0	0	1	0	1	%
	-	-	-	0	0	1	1	0	Hz
	-	-	-	0	0	1	1	1	Baud
	-	-	-	0	1	0	0	0	F
	-	-	-	0	1	0	0	1	H
	-	-	-	0	1	0	1	0	°C
	-	-	-	0	1	0	1	1	°F
	-	-	-	0	1	1	0	0	Second
	-	-	-	0	1	1	0	1	Minute
	-	-	-	0	1	1	1	0	Hour
	-	-	-	0	1	1	1	1	Day
	-	-	-	1	0	0	0	0	Month
Range of validity	0	0	X	X	X	X	X	X	Actual value
	0	1	X	X	X	X	X	X	The actual value is lower
	1	0	X	X	X	X	X	X	The actual value is higher
	1	1	X	X	X	X	X	X	Invalid value

- The units of the bits 0 to 4 are coded.
- Bits 6 and 7 describe the validity range of a value.
- Bit 5 is reserved.

The complete byte is calculated from the sum of the unit and the range of validity.

8.1.3 Alarm assignment of the relays

Several alarms can be assigned to each relay. For the assignment of each relay, a 16-bit register is used with the bits described below. The following table applies to relay 1 and relay 2, in which "x" stands for the relay number. A set bit activates the specified function.

Bit	Display indication	Meaning
0	Reserved	When reading, always 0 When writing, any value
1	x Err	Device error E.xx
2	rx +R1 < Ω	Pre-alarm R1 - fault R_F at L1/+
3	rx -R1 < Ω	Pre-alarm R1 - fault R_F at L2/-
4	rx +R2 < Ω	Alarm R2 - fault R_F at L1/+
5	rx -R2 < Ω	Alarm R2 - fault R_F at L2/-
6	rx U < V	Alarm message U_n - undervoltage
7	rx U > V	Alarm message U_n - overvoltage
8	rx test	Manually started self test
9	rx S.AL	Device start with alarm
10	Reserved	When reading, always 0 When writing, any value
11	Reserved	When reading, always 0 When writing, any value
12	Reserved	When reading, always 0 When writing, any value
13	Reserved	When reading, always 0 When writing, any value
14	Reserved	When reading, always 0 When writing, any value
15	Reserved	When reading, always 0 When writing, any value

8.2 Channel description

Value	Measured value description/alarm message operating message	Comments
0		
1 (0x01)	Insulation fault	
71 (0x47)	Insulation fault	Insulation resistance R_F in Ω
76 (0x4C)	Voltage	Measured value in V
77 (0x4D)	Undervoltage	
78 (0x4E)	Overvoltage	
82 (0x52)	Capacitance	Measured value in F
86 (0x56)	Insulation fault	Impedance Z_i
101 (0x65)	System connection	
102 (0x66)	Connection earth	
115 (0x73)	Device error	Fault ISOMETER®
129 (0x81)	Device error	
145 (0x91)	Own address	

To convert parameter data, data type descriptions are required. Text representation is not necessary in this case.

Value	Description of parameters
1023 (0x3FF)	Parameter/measured value invalid. The menu item of this parameter is not displayed.
1022 (0x3FE)	No measured value/no message
1021 (0x3FD)	Measured value/parameter inactive
1020 (0x3FC)	Measured value/parameter only temporarily inactive (e.g. while transmitting a new parameter).
1019 (0x3FB)	Parameter/measured value (value) unit not displayed
1018 (0x3FA)	Parameter (code selection menu) unit not displayed
1017 (0x3F9)	String max. 18 characters (e.g. device type, device variant, …)
1016 (0x3F8)	
1015 (0x3F7)	Time
1014 (0x3F6)	Date: Day
1013 (0x3F5)	Date: Month
1012 (0x3F4)	Date: Year
1011 (0x3F3)	Register address unit not displayed
1010 (0x3F2)	Time
1009 (0x3F1)	Factor multiplication [*]
1008 (0x3F0)	Factor division [/]
1007 (0x3EF)	Baud rate
1022 (0x3FE)	
1023 (0x3FF)	Invalid

9. IsoData data string

In IsoData mode, the ISOMETER® continuously sends the whole data string with a cycle time of approximately 1 second. Communication with the ISOMETER® in this mode is not possible and no additional sender may be connected via the RS-485 bus cable. IsoData is activated when the menu item is set to Adr = 0.

Transmission from the ISOMETER® via the IsoData protocol can be stopped by sending the command "Adr3" during an interval.

String	Description
!;	Start symbol
v;	Insulation fault location ' '/'+'/'-'
1234, 5;	Insulation resistance R_F [kΩ]
12345;	System leakage capacitance C_e [nF] (only with setting "GEn")
123456;	Reserved
+1234;	Nominal system voltage U_n [$V_{trueRMS}$] Nominal system voltage type: AC or unknown: ' ' DC: '+'/'-'
+1234;	Residual voltage U_{L1e} [V_{DC}]
+1234;	Residual voltage U_{L2e} [V_{DC}]
+123;	Insulation fault location -100 … +100 [%]
123456;	Reserved
1234;	Alarm message [hexadecimal] (without leading "0x") The alarms are included in this value with the OR function. Assignment of the alarms: 0x0002 Device error 0x0004 Prewarning insulation resistance R_F at L1/+ 0x0008 Prewarning insulation resistance R_F at L2/- 0x000C Prewarning insulation resistance R_F symmetrical 0x0010 Alarm insulation resistance R_F at L1/+ 0x0020 Alarm insulation resistance R_F at L2/- 0x0030 Alarm insulation resistance R_F symmetrical 0x0040 Alarm undervoltage U_n 0x0080 Alarm overvoltage U_n 0x0100 Message system test 0x0200 Device start with alarm
12	Update counter, consecutively counts from 0 to 99. It increases with the update of the insulation resistance value.
<CR><LF>	String end

10. Technical data

10.1 Tabular representation

( )* = Factory settings

Insulation coordination acc. to IEC 60664-1/IEC 60664-3

Definitions:

Measuring circuit (IC1) ..... 3 (L1/+), 4 (L2/-)
Supply circuit (IC2) ..... 1(A1), 2 (A2)
Output circuit (IC3) 9 (11), 10 (14), 11 (24)
Control circuit (IC4) ..... 12 (E), 5 (KE), 6 (T/R), 7 (A), 8 (B)
Rated voltage ..... 400 V
Overvoltage category III

Rated impulse voltage:

IC1/(IC2-4) ..... 6 kV
IC2/(IC3-4) ..... 4 kV
IC3/IC4 ..... 4 kV

Rated insulation voltage:

IC1/(IC2-4) ..... 400 V
IC2/(IC3-4) ..... 250 V
IC3/IC4 ..... 250 V
Pollution degree 3

Safe isolation (reinforced insulation) between:

IC1/(IC2-4) ..... Overvoltage category III, 600 V
IC2/(IC3-4) ..... Overvoltage category III, 300 V
IC 3/IC4 ..... Overvoltage category III, 300 V

Voltage tests (routine test) acc. to IEC 61010-1:

IC2/(IC3-4) ..... AC 2.2 kV
IC 3/IC4 ..... AC 2.2 kV

Supply voltage

Supply voltage U_s ..... AC 100 . . . 240 V/DC 24 . . . 240 V
Tolerance of U_s ..... -30 . . . +15 %
Frequency range U_s ..... 47 . . . 63 Hz
Power consumption ..... ≤ 3 W, ≤ 9 VA

Monitored IT system

Nominal system voltage U_n ..... 3(N)AC, AC 0...400 V/DC 0...400 V
Tolerance of U_n ..... +25 %
Frequency range of U_n ..... DC, 35...460 Hz

Measuring circuit

Measuring voltage U_m ..... ±12 V
Measuring current I_m at R_F, $Z_F = 0$ ..... ≤ 110 µA
Internal resistance R_i, Z_i ..... ≥ 115 kΩ
Permissible system leakage capacitance C_e ..... ≤ 5 µF
Permissible extraneous DC voltage U_{fg} ..... ≤ 700 V

Response values

Response value R_{an1} ..... R_{an2}...200 kΩ (46 kΩ)*
Response value R_{an2} ..... 5 kΩ...R_{an1} (23 kΩ)*
Relative uncertainty R_{an} ..... ±15 %, at least ±2 kΩ
Hysteresis R_{an} ..... 25 %, at least 1 kΩ
Undervoltage detection $U<$ ..... 10 V...U> (off/10 V)*
Overvoltage detection $U>$ ..... U<...500 V (off/500 V)*
Relative uncertainty U ..... ± 5 %, at least ± 5 V
Relative uncertainty depending on the frequency ≥400 Hz ..... -0.015 %/Hz
Hysteresis U ..... 5 %, at least 5 V

Time response

Response time t_{an} at $R_F = 0.5 \times R_{an}$ and C_e=1 µF acc. to IEC 61557-8 ..... ≤ 1 s
Start-up delay t ..... 0...10 s (0 s)*
Response delay t_{on} ..... 0...99 s (0 s)*
Delay on release t_{off} ..... 0...99 s (0 s)*

Measured values, storage

Measured value insulation resistance (R_F) ..... 1 kΩ...2 MΩ
Operating uncertainty ..... ±15 %, at least ±2 kΩ
Measured value nominal system voltage (U_n) ..... 0...500 V_{RMS}
Operating uncertainty ..... ±5 %, at least ±5 V
Measured value system leakage capacitance at R_F > 10 kΩ ("dc" mode only) ..... 0...17 µF
Operating uncertainty at R_F ≥ 20 kΩ and C_e ≤ 5 µF ..... ±5 %, at least ±0.1 µF
Password ..... off/0...999 (0, off)*
Fault memory alarm messages ..... on/(off)*

Interface

Interface/protocol ..... RS-485/BMS, Modbus RTU, isoData
Baud rate ..... BMS (9.6 kbit/s), Modbus RTU (selectable), isoData (115.2 kbits/s)

Cable length (9.6 kbits/s) ..... ≤ 1200 m
Cable: twisted pair, shield connected to PE on one side ..... min. J-Y(St)Y 2 x 0.6
Terminating resistor ..... 120 Ω (0.25 W), external
Device address, BMS bus, Modbus RTU ..... 3 . . . 90 (3)*

Switching elements

Switching elements ..... 2 x 1 N/O contacts, common terminal 11
Operating principle ..... N/C operation/N/O operation (N/O operation)*
Electrical endurance, number of cycles 10,000

Contact data acc. to IEC 60947-5-1:

Utilisation category	AC-12	AC-14	DC-12	DC-12	DC-12
Rated operational voltage	230 V	230 V	24 V	110 V	220 V
Rated operational current	5 A	2 A	1 A	0.2 A	0.1 A

Minimum contact rating ..... 1 mA at AC/DC ≥10 V

Environment/EMC

EMC ..... IEC 61326-2-4

Ambient temperatures:

Operation ..... -40 . . . +70 °C
Transport ..... -40 . . . +85 °C
Storage ..... -40 . . . +70 °C

Classification of climatic conditions acc. to IEC 60721:

Stationary use (IEC 60721-3-3) 3K8
Transport (IEC 60721-3-2) 2K4
Long-term storage (IEC 60721-3-1) 1K6

Classification of mechanical conditions acc. to IEC 60721:

Stationary use (IEC 60721-3-3) 3M7
Transport (IEC 60721-3-2) 2M2
Long-term storage (IEC 60721-3-1) 1M3

Connection type

Connection type ..... 0.8 m connecting wire
Minimum bending radius of the connecting cable ..... > 40 mm

Other

Operating mode ..... continuous operation
Degree of protection, built-in components (DIN EN 60529) IP65
Enclosure material ..... polycarbonate (filled with Wevo PUR403FL)
Screw mounting ..... 2 x M4
Tightening torque ..... max. 3 Nm (26 lb-in)
Weight ..... ≤ 600 g

10.2 Standards and certifications

The ISOMETER® has been developed in compliance with the following standards:

- DIN EN 61557-8 (VDE 0413-8): 2015-12/Ber1: 2016-12
- IEC 61557-8:2014/COR1: 2016
- DIN VDE 0100-551: 2017-02

Subject to change! The specified standards take into account the edition valid until 06.2018 unless otherwise indicated.

10.3 Ordering details

Type	Version	Article number
isoGEN523-S4-4	Digital interface	B91016330

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Bender GmbH & Co. KG
P.O. Box 1161 • 35301 Gruenberg • Germany
Londorfer Str. 65 • 35305 Gruenberg • Germany
Tel.: +49 6401 807-0 • Fax: +49 6401 807-259
E-mail: info@bender.de • www.bender.de

Photos: Bender archive

BENDER Group