Communication Protocol

RS232 / RS485

for the Trigon® family

Trigon® BAG500, BAG552

Bayard-Alpert SingleGauge

Trigon® BPG500, BPG552

Bayard-Alpert Pirani DualGauge

Trigon® BCG552

Bayard-Alpert Pirani Capacitance Diaphragm TripleGauge®

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For cross-references within this document, the symbol (→ 🗎 XY) is used, for cross-references to further documents and data sources, the symbol (→ 🕮 [Z]).

1 General

1.1 General Information

The serial Interface allows the communication of the digital INFICON Bayard-Alpert Gauges BAG500, BAG552, BPG500, BPG552 and BCG552 with

- an INFICON Vacuum Gauge Controller (VGC50x series, firmware version V1.09 or higher) or with
- another appropriate controller.

For INFICON Vacuum Gauge Controller with older firmware versions, a firmware update must be performed before operation.

The RS232 or RS485 interface integrated in the gauge allows to digitally transmit measurement values and information on the gauge status as well as to make parameter settings.

The diagnostic port is intended to provide a digital interface in a fixed installation where the D-sub connector is not accessible.

Caution

Data transmission errors

Any attempt to simultaneously operate the gauge via the RS232/485 interface and a fieldbus interface (e.g. EtherCAT®, PROFINET) or the diagnostic port may result in incorrect data and data transmission errors.

Therefore, it is inadmissible to simultaneously operate the gauge via the RS232/RS485 and a fieldbus interface or diagnostic port.

Terms RS232, RS485

The term RS232 is used in this document as an abbreviation for the standard ANSI/EIA/TIA-232-F.

The term RS485 is used in this document as an abbreviation for the standard ANSI/TIA/EIA-485-A-98.

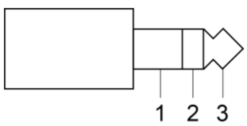
Trademarks

Trigon®	INFICON Holding AG
TripleGauge®	INFICON Holding AG
EtherCAT®	EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

1.2 Electrical Connection

Diagnostic Port (RS232)

Phone jack 2.5 mm

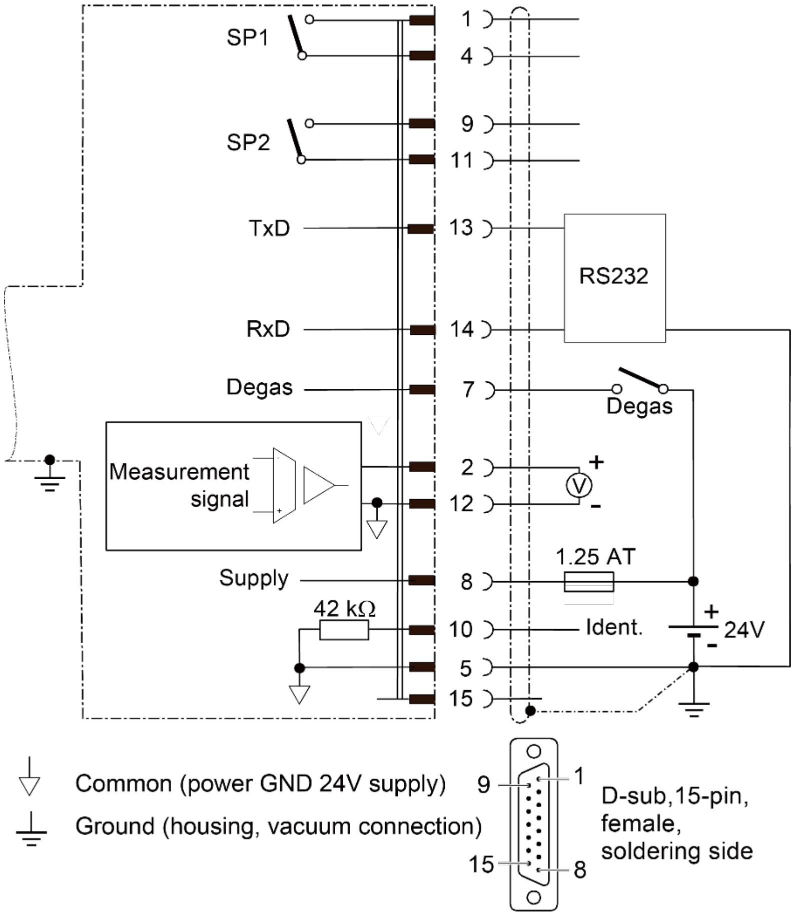


Pin 1	Supply common
Pin 2	RS232, RxD
Pin 3	RS232, TxD

RS232 – D-sub, 15-pin

If no sensor cable is available, make one according to the following diagram. Connect the sensor cable to the gauge.

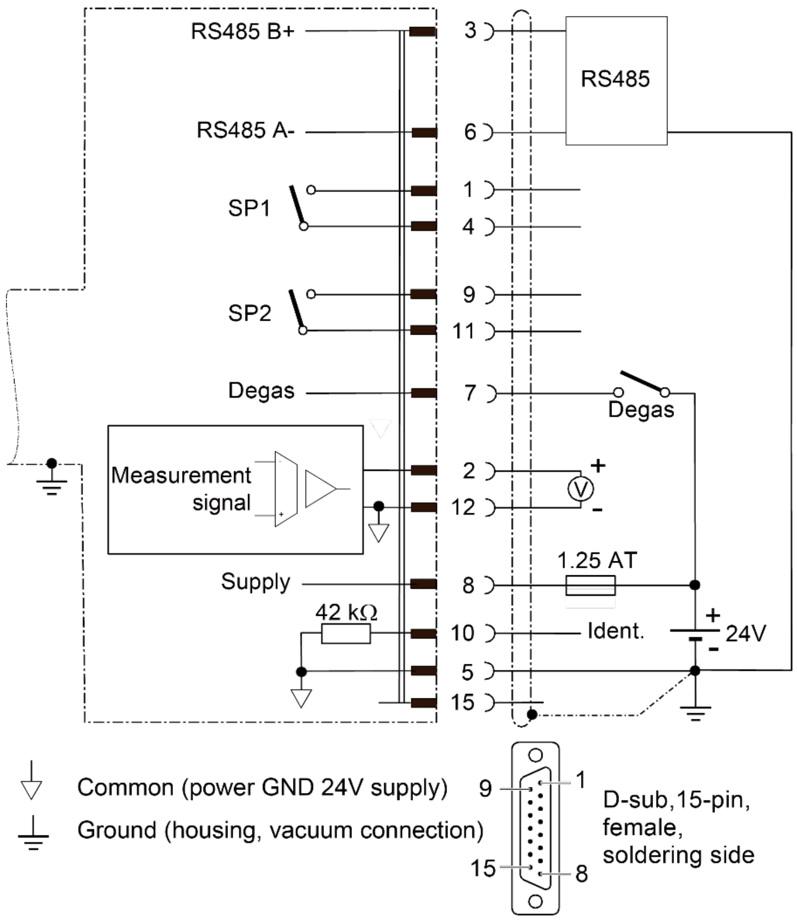
Corresponding sensor cables for VGC50x Vacuum Gauge Controller
→ www.inficon.com.



Pin 1	Relay switching function SP1, common	
Pin 2	Measurement signal output	0 … +10.13 V
Pin 3	Do not connect	
Pin 4	Relay switching function SP1, NO	
Pin 5	Supply common	0 V
Pin 6	Do not connect	
Pin 7	Degas on, active high	0 V/+24 V
Pin 8	Supply	+24 V
Pin 9	Relay switching function SP2, common	
Pin 10	Gauge identification	
Pin 11	Relay switching function SP2, NO	
Pin 12	Measurement signal common	
Pin 13	RS232 TxD	
Pin 14	RS232 RxD	
Pin 15	Do not connect	

RS485 – D-sub, 15-pin

If no sensor cable is available, make one according to the following diagram. Connect the sensor cable to the gauge.



Pin	1	Relay switching function SP1, common	
Pin	2	Measurement signal output	0 … +10.13 V
Pin	3	RS485 B+	
Pin	4	Relay switching function SP1, NO	
Pin	5	Supply common	0 V
Pin	6	RS485 A-	
Pin	7	Degas on, active high	0 V/+24 V
Pin	8	Supply	+24 V
Pin	9	Relay switching function SP2, common	
Pin	10	Gauge identification	
Pin	11	Relay switching function SP2, NO	
Pin	12	Measurement signal common	
Pin	13	Do not connect	
Pin	14	Do not connect	
Pin	15	Do not connect	

2 RS232 / RS485 INFICON Protocol

The protocols of the RS232 and RS485 interfaces are identical except that in the RS485 protocol, the address is used.

The protocol follows the Master-Slave principle. Without a corresponding request from the Master, the device does not transmit any data.

Instructions to the gauge are transmitted via binary protocol.

The data link layer uses the following terminology:

- A request (Req) is an instruction (to read / or write) transmitted by the Master.
- A response (RS) is an answer from the Slave to the Master.

Data format

- binary
- 8 data bits
- 1 stop bit
- no parity bit
- no handshake

Transmission rate (baud rate)

The transmission rate (baud rate, default: 57600) can be set with parameter PID 190 (→ 🗎 10).

RS232 address

The address of the RS232 interface is always set to zero.

RS485 address

The node address is an unambiguous device address in the RS485 network. The gauge can only communicate with the network if the node address setting is set correctly. Valid address range: 0 … 253 in decimal form.

The node address (default: 0) can be set with parameter PID 191 (→ 🗎 10).

If the node address is modified during operation, it is taken over immediately.

Addresses 254 and 255 have a special function:

254	This is a global address. The gauge processes and responds to requests with this address in addition to the set node address. This address can be used to determine the currently set node address. For this it is necessary that only one device is active on the RS485 bus.
255	This is a broadcast address. A request sent to a broadcast address is processed by all gauges on the bus, but they do not respond. With this address, for example, the Pirani-ATM adjustment can be carried out on all devices on the bus.

RS485 termination

In case of communication problems: A 120 Ohms termination resistor between B+ and A- line is recommended at the last device of the bus.

Protocol Frame

Every protocol layer of the communication protocol is represented in a protocol frame. The maximum length per frame is 68 bytes. The data field of the data link layer consists of

- a command Cmd (8 bits, unsigned integer)
- a parameter identifier PID (16 bits, unsigned integer)
- an index IDX (16 bits, unsigned integer)
- the data field Data.

APDU part of the frame (Application Protocol Data Unit):

7	8	9	10	11	12	13	14
Cmd	MSB [15...8] PID	LSB [7...0] PID	MSB [15...8] IDX	LSB [7...0] IDX	0	1	Data (n bytes)

The command determines whether the data transmitted are read or write requests.

Command (Cmd)

There are four different command types:

Cmd = 1 Read request from the Master
Cmd = 2 Read response from the gauge to a read request
Cmd = 3 Write request
Cmd = 4 Write response from the gauge to a write request

Parameter Identifier (PID)

The parameter identifier (PID) addresses a defined parameter of the device.

Index (IDX)

The index (IDX) addresses the elements of a specific field parameter. By default, the index is zero.

Data field (Data)

The data field contains the data of a request. In the case of a write request it contains the data transmitted from the Master to the gauge, in the case of a read request it contains the data to be transmitted from the gauge to the Master. Data are transmitted in Big Endian, i.e. the most significant byte is transmitted first (e.g. 0x46 0xD2 corresponds to 18130 decimal).

Medium Access Layer

The medium access layer contains the following data fields:

- RS485 address (for RS232 the address is 0)
- Device-ID (Master = 0, BxG5xx = 8)
- Header (yellow) with Version / ACK and Message Length (see "Message Length")
- 16 bit CRC (example → 🗎 16)

The ACK flag is always zero from Master to Slave, and always one from Slave to Master.

Message Length

All APDU data (brown) are counted. Amount of Data plus 7 bytes (Cmd, PID, IDX, and two reserved bytes).

APDU part of the frame (Application Protocol Data Unit):

7	8	9	10	11	12	13	14
Cmd	MSB [15...8] PID	LSB [7...0] PID	MSB [15...8] IDX	LSB [7...0] IDX	0	1	Data (n bytes)

Communication Error

If a communication error occurs during transmission the PID is set to 0xFFFF and a data byte with the error information is added.

Data byte 0, error messages:

Value	Description
1	No rights
2	Out of range
3	Wrong PID
4	Wrong length
6	Fail non-volatile memory
9	Unknown request
10	Wrong request
11	Wrong index
12	No sense
15	Procedure error

Read request from the Master:

0	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15
		Bit [7...4]	Bit [0]						MSB [15...8]	LSB [7...0]	MSB [15...8]	LSB [7...0]			LSB [7...0]	MSB [15...8]
Address	Device-ID = 0	3	0	0	MsgLength	0	0	Cmd = 1	PID	PID	IDX	IDX	0	1	CRC	CRC

Response from the gauge to a read request:

0	1	2		3	4	5	6	7	8	9	10	11	12	13	14	14 + n	15 + n
		Bit [7...4]	Bit [0]						MSB [15...8]	LSB [7...0]	MSB [15...8]	LSB [7...0]				LSB [7...0]	MSB [15...8]
Address	Device-ID = 8	3	1	0	MsgLength	0	0	Cmd = 2	PID	PID	IDX	IDX	0	1	Data (n bytes)	CRC	CRC

Write request from a Master:

0	1	2		3	4	5	6	7	8	9	10	11	12	13	14	14 + n	15 + n
		Bit [7...4]	Bit [0]						MSB [15...8]	LSB [7...0]	MSB [15...8]	LSB [7...0]				LSB [7...0]	MSB [15...8]
Address	Device-ID = 0	3	0	0	MsgLength	0	0	Cmd = 3	PID	PID	IDX	IDX	0	1	Data (n bytes)	CRC	CRC

Response from the gauge to a successful write request:

0	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15
		Bit [7...4]	Bit [0]						MSB [15...8]	LSB [7...0]	MSB [15...8]	LSB [7...0]			LSB [7...0]	MSB [15...8]
Address	Device-ID = 8	3	1	0	MsgLength	0	0	Cmd = 4	PID	PID	IDX	IDX	0	1	CRC	CRC

Error case: Response from the gauge to a unsuccessful write request:

0	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Bit [7...4]	Bit [0]						MSB [15...8]	LSB [7...0]	MSB [15...8]	LSB [7...0]				LSB [7...0]	MSB [15...8]
Address	Device-ID = 8	3	1	0	MsgLength	0	0	Cmd = 4	PID = 0xFF	PID = 0xFF	IDX	IDX	0	1	Error-Byte	CRC	CRC

Legend: yellow ... Header brown ... APDU (Application Protocol Data Unit)

2.1 Protocol Description

Abbreviations

Abbreviation	Explanation
ADC	Analogue Digital Converter
ATM	Atmosphere
CDG	Capacitive Diaphragm Gauge
CPU	Central Processing Unit
HIG	Hot Ionization Gauge
HV	High Vacuum
PID	Parameter Identification
RO	Read Only Access
WO	Write Only Access
RW	Read/Write Access
NV	Non Volatile

The following parameters can be accessed via a serial interface.

Output pressure

PID	Name	Description	NV	Access	Factory setting	Min.	Max.	Type
221	Pressure (integer)	Pressure in vacuum chamber in integer format. Formula for pressure in hPa: p_hPa = 10^(PID221 / 4000 -12.5)		RO				Uint16
222	Pressure	Pressure in vacuum chamber in Real format. Pressure unit depends on the PID 224 setting.		RO				Real32
264	ATM Pressure (integer) *)	Ambient pressure in vacuum chamber in integer format. Formula for pressure in hPa: p_hPa = 10^(PID221 / 4000 -12.5)		RO				Uint16
265	ATM Pressure *)	Ambient pressure in real format. Pressure unit depends on the PID 224 setting.		RO				Real32
466	Differential Pressure *)	Differential pressure outside and inside vacuum chamber. Pressure unit depends on the PID 224 setting.		RO				Real32
224	Data Unit	Changes the pressure unit of all Real32 pressures. 0 mbar 1 Torr 2 Pascal 3 micron 4 Counts 5 hPa	x	RW	0	0	5	Uint8

*) Parameter available for BCG55x gauges only.

Error

PID	Name	Description	NV	Access	Factory setting	Min.	Max.	Type
228	Device Exception	0 No error 1 CPU board memory error 3 CPU board memory record error 4 Pirani sensor error 5 Pirani electronic error 6 CDG sensor error 7 CDG electronic error 8 ATM sensor error 9 ATM electronic error 14 HIG sensor error 15 HIG electronic error 16 Power electronic memory error 17 Calibration memory error 18 Base board memory error 19 Power electronic board temperature sensor 20 Base board temperature sensor 21 Power electronic memory record error 22 Calibration memory record error 23 Base board memory record error 24 ADC electronic error 25 Low power supply voltage 26 Communication to fieldbus failed 27 Wrong replacement sensor		RO	0			Uint8

The first error that occurred is displayed.

General information

PID	Name	Description	NV	Access	Factory setting	Min.	Max.	Type
103	Reset	Write zero (0) to this parameter: The sensor carries out a reset		WO				Uint8
104	Factory Reset	Write zero (0) to this parameter: The sensor resets all parameters to their factory settings		WO				Uint8
178	Run Hours	Operating hours [one unit is equal to 0.25 h]	x	RO				Uint32
207	Serial Number	Serial number	x	RO			4294967295	Uint32
208	Product Name	Product name	x	RO	eg. BCG552			String
209	Manufacturers Name	Name of manufacturer	x	RO	INFICON AG			String
210	Manufacturers Model Number	Model number	x	RO				String
218	Software Version	Software version	x	RO				String
190	RS232/RS485 Baud Rate	9600, 19200, 38400, 57600	x	RW	57600	9600	57600	Uint32
191	RS485 Address	Address of the gauge (for RS485 only)	x	RW	0	0	253	Uint16
800	Display Rotation	Display rotation 0 None 1 90° 2 180° 3 270°	x	RW	0	0	3	Uint8

Sensor details

PID	Name	Description	NV	Access	Factory setting	Min.	Max.	Type
577	Emission Control Mode	Manual / automatic HIG control (BPG5xx and BCG55x gauges) 2 Automatic 4 Manual	x	RW	2			Uint8
576	Emission on / off	Emission on / off in manual mode 0 Emission off 1 Emission on		RW	0	0	1	Uint8
578	Degas on / off	Degas on / off (switches off automatically after 3 minutes) 0 Emission off 1 Emission on		RW	0	0	1	Uint8
580	Filament Control Mode	Manual / automatic filament control (gauges with two filaments) 0 Automatic 1 Manual	x	RW	0	0	1	Uint8
583	Filament Selection	Select filament (gauges with two fila-ments) 1 Filament 1 2 Filament 2	x	RW		1	2	Uint8
582	Filament Status	Filament status (gauges with two fila-ments) 0 Both filaments ok 1 Filament 1 broken 2 Filament 2 broken 3 Both filaments broken		RO				Uint8
584	Emission Status	HIG Emission Status 0 Emission off 1 Emission 25 µA 2 Emission 5 mA 3 Degas		RO				Uint8
223	Active Instance Number	Current sensor 1 HIG sensor active 2 Pirani sensor active 3 Mixed signal range HIG and Pirani sensor active 4 CDG sensor active 5 Mixed signal range CDG and Pirani sensor active		RO				Uint8
255	Safe State	Pressure output in case of an error (unit acc. to PID 224) 0 0.0 1 Full scale value is output (depending on gauge) 2 The last valid value is retained. 3 The Safe State value PID 256 is output.	x	RW	0	0	3	Uint8
256	Safe State Value	Pressure output in case of an error (unit acc. to PID 224. PID 255 must be set to 3)	x	RW	5E-10 mbar	5E-10 mbar	1500 mbar	Real32
572	CDG Full Scale	CDG full scale (BCG55x only) (unit acc. to PID 224)	x	RO	1050 mbar			Real32
1000	Pirani Full Scale	Pirani full scale (BPG5xx only) (unit acc. to PID 224)	x	RO	1000 mbar			Real32
502	HIG Full Scale	HIG full scale (BAG5xx only) (unit acc. to PID 224)	x	RO	2.0E-2 mbar			Real32

(continued)

Table "Sensor details" concluded

PID	Name	Description	NV	Access	Factory setting	Min.	Max.	Type
418	Pirani Adjust Flag **)	Executes a manual Pirani sensor adjustment. Set the value to "1" to carry out the adjustment		RW	0			Uint8
419	Pirani Adjust Status **)	Returns the status of the Pirani adjustment that was carried out 2 ATM adjustment was successfully 8 HV adjustment was successfully 32 Adjustment was not carried out (wrong pressure range)		RO				Uint8
571	CDG Status Extension *)	Status CDG sensor Bit 2 Underrange Exceeded Bit 1 Overrange Exceeded Bit 0 Reading invalid		RO				Uint8
245	Pirani Status Extension **)	Status Pirani sensor Bit 2 Underrange Exceeded Bit 1 Overrange Exceeded Bit 0 Reading invalid		RO				Uint8
501	HIG Status Extension	Status HIG sensor Bit 2 Underrange Exceeded Bit 1 Overrange Exceeded Bit 0 Reading invalid		RO				Uint8
274	ATM Status Extension *)	Status ATM sensor Bit 0 Reading invalid		RO				Uint8
268	ATM Adjust Flag *)	Adjustment of atmospheric pressure sensor Set the value to "1" in order for the adjustment to be executed. The adjustment has to be carried out while the vacuum chamber is at atmospheric pressure. Then, the atmospheric pressure sensor is adjusted to the CDG pressure sensor.		RW	0			Uint8
270	ATM Adjust Status *)	Returns the status of the ATM adjustment that was carried out 1 ATM adjustment was successfully 2 Adjustment was not carried out		RO				Uint8

*) Parameter available for BCG55x gauges only.

**) Parameter not available for BAG5xx gauges.

Setpoints

☞ Pressure values depend on the setting under PID 224 (Pressure Value).

The specified min. / max. / factory setting values apply to mbar.

PID	Name	Description	NV	Access	Factory setting	Min.	Max.	Type
320	Setpoint 1 High Trip Point	Setpoint High Trip Point in pressure unit	x	RW	1501	4.00E-10	1501	Real32
324	Setpoint 1 High Trip Point Enable	0 Off 1 On	x	RW	0	0	1	Uint8
322	High Trip Point 1 Hysteresis	Hysteresis High Trip Point 1 in pressure unit	x	RW	150.1	4.00E-11	1501	Real32
326	Setpoint 1 High Trip Point ATM Factor	Factor for High Trip Point ATM setpoint The atmospheric pressure is multiplied by this factor and used as Setpoint 1. To activate the ATM mode select the Setpoint 1 mode	x	RW	0.99	0.01	2	Real32
321	Setpoint 1 Low Trip Point	Setpoint Low Trip Point in pressure unit	x	RW	4.00E-10	4.00E-10	1501	Real32
325	Setpoint 1 Low Trip Point Enable	0 Off 1 On	X	RW	1	0	1	Uint8
323	Low Trip Point 1 Hysteresis	Hysteresis Low Trip Point 1 in pressure unit	x	RW	4.00E-11	4.00E-11	1501	Real32
327	Setpoint 1 Low Trip Point ATM Factor	Factor for Low Trip Point ATM setpoint The atmospheric pressure is multiplied by this factor and used as Setpoint 1. To activate the ATM mode select the Setpoint 1 mode	x	RW	0.99	0.01	2	Real32
330	Setpoint 1 Mode	Setpoint mode 0 Setpoint (Low / High Trip mode) 1 The Low Trip Point is in ATM mode 2 The High Trip Point is in ATM mode 3 The Low and High Trip Points are in ATM mode	x	RW	0	0	3	Uint8
331	Setpoint 1 Status	Status of Relay 1 0 Open 1 Closed		RO	0			Uint8
332	Setpoint 1 Extended Status	Extended status of Setpoint 1 0 Not active 1 Low Trip Point active 2 High Trip Point active 3 High and Low Trip Point active		RO	0			Uint8
333	Setpoint 1 High Trip Point ATM Level	Calculated high trip point level depends on the current value of the atmospheric pressure sensor		RO	0.0			Real32
334	Setpoint 1 Low Trip Point ATM Level	Calculated low trip point level depends on the current value of the atmospheric pressure sensor		RO	0.0			Real32
340	Setpoint 2 High Trip Point	Setpoint High Trip Point in pressure unit	x	RW	1501	4.00E-10	1501	Real32
344	Setpoint 2 High Trip Point Enable	0 Off 1 On	x	RW	0	0	1	Uint8
342	High Trip Point 2 Hysteresis	Hysteresis High Trip Point 2 in pressure unit	x	RW	150.1	4.00E-11	1501	Real32
346	Setpoint 2 High Trip Point ATM Factor	Factor for High Trip Point ATM setpoint The atmospheric pressure is multiplied by this factor and used as Setpoint 2. To activate the ATM mode select the Setpoint 2 mode	x	RW	0.99	0.01	2	Real32
341	Setpoint 2 Low Trip Point	Setpoint Low Trip Point in pressure unit	x	RW	4.00E-10	4.00E-10	1501	Real32
345	Setpoint 2 Low Trip Point Enable	0 Off 1 On	X	RW	1	0	1	Uint8
343	Low Trip Point 2 Hysteresis	Hysteresis Low Trip Point 2 in pressure unit	x	RW	4.00E-11	4.00E-11	1501	Real32

(continued)

Table "Setpoints" concluded

PID	Name	Description	NV	Access	Factory setting	Min.	Max.	Type
347	Setpoint 2 Low Trip Point ATM Factor	Factor for Low Trip Point ATM setpoint The atmospheric pressure is multiplied by this factor and used as Setpoint 2. To activate the ATM mode select the Setpoint 2 mode	x	RW	0.99	0.01	2	Real32
350	Setpoint 2 Mode	Setpoint mode 0 Setpoint (Low / High Trip mode) 1 The Low Trip Point is in ATM mode 2 The High Trip Point is in ATM mode 3 The Low and High Trip Points are in ATM mode	x	RW	0	0	3	Uint8
351	Setpoint 2 Status	Status of Relay 2 0 Open 1 Closed		RO	0			Uint8
352	Setpoint 2 Extended Status	Extended status of Setpoint 2 0 Not active 1 Low Trip Point active 2 High Trip Point active 3 High and Low Trip Point active		RO	0			Uint8
353	Setpoint 2 High Trip Point ATM Level	Calculated high trip point level depends on the current value of the atmospheric pressure sensor		RO	0.0			Real32
354	Setpoint 2 Low Trip Point ATM Level	Calculated low trip point level depends on the current value of the atmospheric pressure sensor		RO	0.0			Real32

2.2 Examples Setting Setpoints

☞ Setpoint pressure values are formatted in data unit (mbar, Torr, …). Check with PID224 "Data Unit" your current settings.

Setting SP1 (Low Trip Point)

Setpoint 1 will be closed if the chamber pressure is below 5.5*10^-3 mbar.

1 Activate the standard setpoint mode: write 0 to PID330 (Setpoint 1 Mode).

2 Set the pressure level: write 5.5*10^-3 to PID321 (Setpoint 1 Low Trip Point).

3 Select a hysteresis for the setpoint (a common value is 10% from the pressure value: 0.1 * 5.5*10^-3 = 5.5*10^-4): write 5.5*10^-4 to PID323 (Low Trip Point 1 Hysteresis).

4 Disable the high trip point function: write 0 to PID324 (Setpoint 1 High Trip Point Enable).

5 Activate the low trip point function: write 1 to PID325 (Setpoint 1 Low Trip Point Enable).

The configured setpoint switches on if the chamber pressure goes below 5.5*10^-3 mbar. It opens again if the chamber pressure exceeds 6.05*10^-3mbar.

The status of the relay 1 can be monitored with PID331 (Setpoint 1 Status) or PID332 (Setpoint 1 Extended Status).

Setting SP2 (High Trip Point)

Setpoint 2 will be closed if the chamber pressure exceeds 5.5*10^-3 mbar.

1. Activate the standard setpoint mode: write 0 to PID350 (Setpoint 2 Mode).
2. Set the pressure level: write 5.5*10^-3 to PID340 (Setpoint 2 High Trip Point).
3. Select a hysteresis for the setpoint (a common value is 10% from the pressure value: 0.1 * 5.5*10^-3 = 5.5*10^-4): write 5.5*10^-4 to PID342 (High Trip Point 2 Hysteresis).
4. Disable the low trip point function: write 0 to PID345 (Setpoint 2 Low Trip Point Enable).
5. Activate the high trip point function: write 1 to PID344 (Setpoint 2 High Trip Point Enable).

The configured setpoint switches on if the chamber pressure exceeds 5.5*10^-3 mbar. It opens again if the chamber pressure falls below 4.95*10^-3mbar.

The status of the relay 2 can be monitored with PID351 (Setpoint 2 Status) or PID352 (Setpoint 2 Extended Status).

Setting ATM sensor (SP1, High Trip Point)

BCG552 only.

Atmosphere setpoint 1 will be closed if the chamber pressure exceeds 90% of the atmosphere pressure.

1. Activate the high trip point atmosphere mode: write 2 to PID330 (Setpoint 1 Mode).
2. Set the factor for the switching point: write 0.9 to PID326 (Setpoint 1 High Trip Point ATM Factor).
3. Select a hysteresis for the setpoint (e.g. 20 mbar): write 20.0 to PID322 (High Trip Point 1 Hysteresis).
4. Disable the low trip point function: write 0 to PID325 (Setpoint 1 Low Trip Point Enable).
5. Activate the high trip point function: write 1 to PID324 (Setpoint 1 High Trip Point Enable).

The calculated high trip point level depends on the current value of the atmospheric pressure sensor. The currently active level can be read out with PID333 (Setpoint 1 High Trip Point ATM Level).

An atmosphere pressure of 955 mbar is assumed. The calculated high trip point level is 955*0.9 = 859.5 mbar.

So, the configured setpoint switches on if the chamber pressure exceeds 859.5 mbar. It opens again if the chamber pressure falls below 839.5 mbar.

The status of the relay 1 can be monitored with PID331 (Setpoint 1 Status) or PID332 (Setpoint 1 Extended Status).

2.3 Data Format

Real32

Use, for example, the following link for the conversion of a value in Real32 format into a binary 32 IEEE 754 format:

- https://www.h-schmidt.net/FloatConverter/IEEE754.html
  (e.g. 0x44 0x6B 0xBA 0x4D corresponds to 942.9 mbar)

2.4 Examples Read and Write Requests

The following examples show how read and write requests are made.

Read request (reading the pressure in the vacuum chamber): The required parameter has the PID 222.

From Master to BxG5xx:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Address	Device-ID	Vers ACK	Reserved	MsgLength	Reserved	Reserved	Cmd	PID	PID	IDX	IDX	Reserved	Reserved	CRC	CRC
0x00	0x00	0x30	0x00	0x07	0x00	0x00	0x01	0x00	0xDE	0x00	0x00	0x00	0x01	0xDB	0xBC

Read response: In this example the pressure value is 1000 mbar.

From BxG5xx to Master:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Address	Device-ID	Vers ACK	Reserved	MsgLength	Reserved	Reserved	Cmd	PID	PID	IDX	IDX	Reserved	Reserved	Data	Data	Data	Data	CRC	CRC
0x00	0x08	0x31	0x00	0x0B	0x00	0x00	0x02	0x00	0xDE	0x00	0x00	0x00	0x01	0x44	0x7A	0x00	0x00	0x74	0x6C

Write request (setting the data unit): The required parameter has PID 224. To set the unit to Torr, 1 must be written.

From Master to BxG5xx:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Address	Device-ID	Vers ACK	Reserved	MsgLength	Reserved	Reserved	Cmd	PID	PID	IDX	IDX	Reserved	Reserved	Data	CRC	CRC
0x00	0x00	0x30	0x00	0x08	0x00	0x00	0x03	0x00	0xE0	0x00	0x00	0x00	0x01	0x01	0x3A	0x90

Write response: The write operation is confirmed as succsessful.

From BxG5xx to Master:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Address	Device-ID	Vers ACK	Reserved	MsgLength	Reserved	Reserved	Cmd	PID	PID	IDX	IDX	Reserved	Reserved	CRC	CRC
0x00	0x08	0x31	0x00	0x07	0x00	0x00	0x04	0x00	0xE0	0x00	0x00	0x00	0x01	0x2C	0x51

2.5 Calculating CRC

The data packages are secured with CRC16-MCRF4XX in the byte order Crc[7…0], Crc[15…8].

CRC polynominal	0x1021
CRC initial value	0xFFFF

For settings and troubleshooting the CRC value can be calculated with the following online calculator:

- http://www.sunshine2k.de/coding/javascript/crc/crc_js.html

2.6 CRC Example Code

For the code integration of a CRC calculation, an example code of implementation in C# is given below.

```
using System;

class Program
{
    static void Main()
    {
    // the following test array is a valid pcg5xx frame with crc16 at the end
    byte[] arr = new byte[] { 0x00, 0x00, 0x00, 0x05, 0x01, 0x00, 0xDD, 0x00, 0x00, 0xAB, 0x21};
    UInt16 crc;
    Boolean b;
    // Calculate the crc of the test array arr, of course without crc (therefore length minus 2)
    crc = Crc16.Create(arr, (Byte)(arr.Length - 2));
    // Check, if the test array has a correct crc at the end (it is correct, therefore the returnvalue is
true)
    b = Crc16.Check(arr, (Byte)arr.Length);
    }
}

public class Crc16
{
    // initial value for crc16
    public static UInt16 inital = 0xFFFF;

    // function to create a crc16
    public static UInt16 Create(Byte[] buffer, Byte length)
    {
        UInt16 crc16 = new UInt16();
        UInt16 i = 0;

        // Initial Value for CRC calculation
        crc16 = Crc16.inital;

        while (i < length)
        {
            crc16 = (UInt16)((Crc16.crc16Tab[(crc16 ^ buffer[i++]) & (Byte)0xFF]) ^ (crc16 >> 8));
        }
        return crc16;
    }

    // function to check a buffer with a crc16 at the end
    public static Boolean Check(Byte[] buffer, Byte length)
    {
        UInt16 crc16 = Crc16.inital;
        UInt16 i = 0;
        // calculate crc for the buffer without crc
        while (i < length)
        {
            crc16 = (UInt16)((Crc16.crc16Tab[(crc16 ^ buffer[i++]) & (Byte)0xFF]) ^ (crc16 >> 8));
        }
        if (crc16 == 0)
        {
            return true;
        }
        return false;
    }
    // crc array
    public static UInt16[] crc16Tab =
    {
        0x0000, 0x1189, 0x2312, 0x329B, 0x4624, 0x57AD, 0x6536, 0x74BF,
        0x8C48, 0x9DC1, 0xAF5A, 0xBED3, 0xCA6C, 0xDBE5, 0xE97E, 0xF8F7,
        0x1081, 0x0108, 0x3393, 0x221A, 0x56A5, 0x472C, 0x75B7, 0x643E,
        0x9CC9, 0x8D40, 0xBFDB, 0xAE52, 0xDAED, 0xCB64, 0xF9FF, 0xE876,
        0x2102, 0x308B, 0x0210, 0x1399, 0x6726, 0x76AF, 0x4434, 0x55BD,
        0xAD4A, 0xBCC3, 0x8E58, 0x9FD1, 0xEB6E, 0xFAE7, 0xC87C, 0xD9F5,
        0x3183, 0x200A, 0x1291, 0x0318, 0x77A7, 0x662E, 0x54B5, 0x453C,
        0xBDCB, 0xAC42, 0x9ED9, 0x8F50, 0xFBEF, 0xEA66, 0xD8FD, 0xC974,
        0x4204, 0x538D, 0x6116, 0x709F, 0x0420, 0x15A9, 0x2732, 0x36BB,
        0xCE4C, 0xDFC5, 0xED5E, 0xFCD7, 0x8868, 0x99E1, 0xAB7A, 0xBAF3,
        0x5285, 0x430C, 0x7197, 0x601E, 0x14A1, 0x0528, 0x37B3, 0x263A,
        0xDECD, 0xCF44, 0xFDDF, 0xEC56, 0x98E9, 0x8960, 0xBBFB, 0xAA72,
       0x6306, 0x728F, 0x4014, 0x519D, 0x2522, 0x34AB, 0x0630, 0x17B9,
       0xEF4E, 0xFEC7, 0xCC5C, 0xDDD5, 0xA96A, 0xB8E3, 0x8A78, 0x9BF1,
       0x7387, 0x620E, 0x5095, 0x411C, 0x35A3, 0x242A, 0x16B1, 0x0738,
       0xFFCF, 0xEE46, 0xDCDD, 0xCD54, 0xB9EB, 0xA862, 0x9AF9, 0x8B70,
       0x8408, 0x9581, 0xA71A, 0xB693, 0xC22C, 0xD3A5, 0xE13E, 0xF0B7,
       0x0840, 0x19C9, 0x2B52, 0x3ADB, 0x4E64, 0x5FED, 0x6D76, 0x7CFF,
       0x9489, 0x8500, 0xB79B, 0xA612, 0xD2AD, 0xC324, 0xF1BF, 0xE036,
```

```
        0x18C1, 0x0948, 0x3BD3, 0x2A5A, 0x5EE5, 0x4F6C, 0x7DF7, 0x6C7E,
        0xA50A, 0xB483, 0x8618, 0x9791, 0xE32E, 0xF2A7, 0xC03C, 0xD1B5,
        0x2942, 0x38CB, 0x0A50, 0x1BD9, 0x6F66, 0x7EEF, 0x4C74, 0x5DFD,
        0xB58B, 0xA402, 0x9699, 0x8710, 0xF3AF, 0xE226, 0xD0BD, 0xC134,
        0x39C3, 0x284A, 0x1AD1, 0x0B58, 0x7FE7, 0x6E6E, 0x5CF5, 0x4D7C,
        0xC60C, 0xD785, 0xE51E, 0xF497, 0x8028, 0x91A1, 0xA33A, 0xB2B3,
        0x4A44, 0x5BCD, 0x6956, 0x78DF, 0x0C60, 0x1DE9, 0x2F72, 0x3EFB,
        0xD68D, 0xC704, 0xF59F, 0xE416, 0x90A9, 0x8120, 0xB3BB, 0xA232,
        0x5AC5, 0x4B4C, 0x79D7, 0x685E, 0x1CE1, 0x0D68, 0x3FF3, 0x2E7A,
        0xE70E, 0xF687, 0xC41C, 0xD595, 0xA12A, 0xB0A3, 0x8238, 0x93B1,
        0x6B46, 0x7ACF, 0x4854, 0x59DD, 0x2D62, 0x3CEB, 0x0E70, 0x1FF9,
        0xF78F, 0xE606, 0xD49D, 0xC514, 0xB1AB, 0xA022, 0x92B9, 0x8330,
        0x7BC7, 0x6A4E, 0x58D5, 0x495C, 0x3DE3, 0x2C6A, 0x1EF1, 0x0F78
    };
}
```

3 RS232 Legacy Protocol

This protocol is not recommended for new implementations. It is only available on request.

The built-in RS232 interface allows transmission of digital measurement data and instrument conditions as well as the setting of instrument parameters.

Caution

Data transmission errors

Any attempt to simultaneously operate the gauge via the RS232/485 interface and a fieldbus interface (e.g. EtherCAT®, PROFINET) or the diagnostic port may result in incorrect data and data transmission errors.

Therefore, it is inadmissible to simultaneously operate the gauge via the RS232/RS485 and a fieldbus interface or diagnostic port.

The interface works in duplex mode. A nine byte string is sent continuously without a request approx. every 16 ms. Commands are transmitted to the gauge in a five byte input (receive) string.

Operational parameters

- Data rate 9600 Baud
- Byte 8 data bits
  1 stop bit
- handshake no
- parity bit no

Electrical connections

→ 🗎 4, "RS232 – D-sub, 15-pin"

3.1 Output String (Transmit)

The complete output string (frame) is nine bytes (byte 0 … 8). The data string is seven bytes (byte 1 … 7).

Format of the output string

Byte No.	Function	Value	Comment
0	Length of data string	7	
1	Page number	5	for hot cathode gauges
2	Status		→ Status byte
3	Error		→ Error byte
4	Measurement high byte	0 … 255	→ Calculation of pressure value
5	Measurement low byte	0 … 255	→ Calculation of pressure value
6	Software version	0 … 255	→ Software version
7	Response value	10	for BPG500
		12	for BPG552
		13	for BCG552
		14	for BAG552
		15	for BAG500
8	Check sum	0 … 255	→ Synchronization

Synchronization

Synchronization of the master is achieved by testing three bytes:

Byte No.	Function	Value	Comment
0	Length of data string	7	
1	Page number	5	for hot cathode gauges
8	Check sum of bytes 1 … 7	0 … 255	Low byte of check sum [1)]

[1)] High order bytes are ignored in the check sum.

Status byte

Bit 1	Bit 0	Definition
0	0	emission off
0	1	emission 25 µA
1	0	emission 5 mA
1	1	degas

Bit 2	Definition
x	reserved for future use

Bit 3	Definition
0 ⇔ 1	toggle bit, changes with every string received correctly

Bit 5	Bit 4	Definition
0	0	current pressure unit mbar
0	1	current pressure unit Torr
1	0	current pressure unit Pa

for BAG552, BPG552, BCG552

Bit 6	Definition
0	filament 1 active
1	filament 2 active

for BAG500, BPG500

Bit 6	Definition
x	reserved for future use

Bit 7	Definition
x	reserved for future use

Error byte BCG552

Bit No.	Definition
0	diaphragm sensor error
1	reserved for future use
2	Pirani sensor error
3	reserved for future use
4	BA sensor error
5	reserved for future use
6	hardware failure, EEPROM failure
7	reserved for future use

Error byte BPG552

Bit No.	Definition
0	reserved for future use
1	reserved for future use
2	Pirani sensor error
3	reserved for future use
4	BA sensor error
5	reserved for future use
6	hardware failure, EEPROM failure
7	reserved for future use

Error byte BAG552, BAG500

Bit No.	Definition
0	reserved for future use
1	reserved for future use
2	reserved for future use
3	reserved for future use
4	BA sensor error
5	reserved for future use
6	hardware failure, EEPROM failure
7	reserved for future use

Error byte BPG500

Bit 3	Bit 2	Bit 1	Bit 0	Definition
x	x	x	x	reserved for future use

Bit 7	Bit 6	Bit 5	Bit 4	Definition
1	0	0	0	BA sensor error
1	0	0	1	Pirani sensor error

Software version

The software version of the gauge can be calculated from the response value of byte 6 of the transmitted string according to the following rule:

$$\text{Version No} = \text{Value}_{\text{Byte 6}} / 20$$

(Example: $\text{Value}_{\text{Byte 6}}$ of 32 means software version 1.6)

Calculation of the pressure value

The pressure can be calculated from bytes 4 and 5 of the transmitted string. Depending on the currently selected pressure unit (→ byte 2, bits 4 and 5), the appropriate rule must be applied.

As result, the pressure value results in the usual decimal format.

$$p_{mbar} = 10^{((\text{high byte} \times 256 + \text{low byte}) / 4000 - 12.5)}$$

$$p_{Torr} = 10^{((\text{high byte} \times 256 + \text{low byte}) / 4000 - 12.625)}$$

$$p_{Pa} = 10^{((\text{high byte} \times 256 + \text{low byte}) / 4000 - 10.5)}$$

Example BCG552

The example is based on the following output string:

Byte No.	0	1	2	3	4	5	6	7	8
Value	7	5	0	0	242	48	20	13	72

The instrument or controller (receiver) interprets this string as follows:

Byte No.	Function	Value	Comment
0	Length of data string	7	
1	Page number	5	for hot cathode gauges
2	Status	0	Emission = off Pressure unit = mbar
3	Error	0	No error
	Measurement		
4	High byte	242	Calculation of the pressure:
5	Low byte	48	$p = 10^{((242 \times 256 + 48) / 4000 - 12.5)} = 1000$ mbar
6	Software version	20	Software version = 20 / 20 = 1.0
7	Sensor type	13	BCG552
8	Check sum	72	5 + 0 + 0 + 242 + 48 + 20 + 13 = 328_{dec} = 01 48_{hex} High order byte is ignored ⇒ Check sum = 48_{hex} = 72_{dec}

3.2 Input String (Receive)

For transmission of the commands to the gauge, a string (frame) of five bytes is sent (without <CR>). Byte 1 to byte 3 form the data string.

Format of the input string

Byte No	Function	Value	Comment
0	Length of data string	3	
1	Data		→ admissible input strings
2	Data		→ admissible input strings
3	Data		→ admissible input strings
4	Check sum (of bytes No 1 … 3)	0 … 255	(low byte of sum) [1]

1) High order bytes are ignored in the check sum.

Admissible input strings BCG552, BPG552

For commands to the gauge, following defined strings are used:

Command:	Byte No. 0	1	2	3	4 [2]
Set the unit mbar on the display [1]	3	0x10	0x8E	0	0x9E
Set the unit Torr on the display [1]	3	0x10	0x8E	1	0x9F
Set the unit Pa on the display [1]	3	0x10	0x8E	2	0xA0
Switch degas on (switches itself off after 3 min)	3	0x10	0xC4	1	0xD5
Switch degas off	3	0x10	0xC4	0	0xD4
Read software version [3]	3	0x00	0xD1	0	0xD1
Reset	3	0x40	0	0	0x40
Switch emission on [4]	3	0x40	0x10	1	0x51
Switch emission off [4]	3	0x40	0x10	0	0x50
Emission Control Mode automatic (AUTO) [5]	3	0x10	0x8A	1	0x9B
Emission Control Mode manual (MAN) [5]	3	0x10	0x8A	0	0x9A
Filament Control Mode automatic (AUTO) [6]	3	0x10	0xD3	0	0xE3
Filament Control Mode manual (MAN) [6]	3	0x10	0xD3	1	0xE4
Select filament 1 [7]	3	0x10	0xD2	0	0xE2
Select filament 2 [7]	3	0x10	0xD2	1	0xE3
Read filament status	3	0x00	0xD4	0	0xD4

1) Only required for gauges with display. Transmitted data is not affected by this setting.

2) Only low order byte of sum (high order byte is ignored).

3) Response value in byte no. 6 of transmitted string.

4) Observe switch on/off requirements.

5) Defines the "Emission Control Mode":
AUTO = emission on/off automatically controlled by the gauge.
MAN = emission on/off controlled via interfaces.

6) Defines the "Filament Control Mode":
AUTO = selection of filament automatically controlled by the gauge.
MAN = selection of filament controlled via interfaces.

7) The "Select filament x" command can be sent any time but is only executed if the gauge is in the "Emission OFF" state.

Admissible input strings BAG552

For commands to the gauge, following defined strings are used:

	Byte No.				
Command:	0	1	2	3	4 [2)]
Set the unit mbar on the display [1)]	3	0x10	0x8E	0	0x9E
Set the unit Torr on the display [1)]	3	0x10	0x8E	1	0x9F
Set the unit Pa on the display [1)]	3	0x10	0x8E	2	0xA0
Switch degas on (switches itself off after 3 min)	3	0x10	0xC4	1	0xD5
Switch degas off	3	0x10	0xC4	0	0xD4
Read software version [3)]	3	0x00	0xD1	0	0xD1
Reset	3	0x40	0	0	0x40
Switch emission on [4)]	3	0x40	0x10	1	0x51
Switch emission off [4)]	3	0x40	0x10	0	0x50
Filament Control Mode automatic (AUTO) [5)]	3	0x10	0xD3	0	0xE3
Filament Control Mode manual (MAN) [5)]	3	0x10	0xD3	1	0xE4
Select filament 1 [6)]	3	0x10	0xD2	0	0xE2
Select filament 2 [6)]	3	0x10	0xD2	1	0xE3
Read filament status	3	0x00	0xD4	0	0xD4

1) Only required for gauges with display. Transmitted data is not affected by this setting.

2) Only low order byte of sum (high order byte is ignored).

3) Response value in byte no. 6 of transmitted string.

4) Observe switch on/off requirements.

5) Defines the "Filament Control Mode":
AUTO = selection of filament automatically controlled by the gauge.
MAN = selection of filament controlled via interfaces.

6) The "Select filament x" command can be sent any time but is only executed if the gauge is in the "Emission OFF" state.

Admissible input strings BPG500, BAG500

For commands to the gauge, following defined strings are used:

	Byte No.				
Command:	0	1	2	3	4 [1)]
Switch degas on (switches itself off after 3 min)	3	0x10	0x5D	0x94	0x01
Switch degas off	3	0x10	0x5D	0x69	0xD6

1) High order bytes are ignored in the check sum.

4 Appendix

4.1 Conversion Table

	mbar	bar	Pa	hPa	kPa	Micron	Torr mm Hg
mbar	1	1×10^{-3}	100	1	0.1	750	0.75
bar	1000	1	1×10^{5}	1000	100	7.5×10^{5}	750
Pa	0.01	1×10^{-5}	1	0.01	1×10^{-3}	7.5	7.5×10^{-3}
hPa	1	1×10^{-3}	100	1	0.1	750	0.75
kPa	10	0.01	1000	10	1	7.5×10^{3}	7.5
Micron	1.33×10^{-3}	1.33×10^{-6}	0.133	1.33×10^{-3}	1.33×10^{-4}	1	1×10^{-3}
Torr mm Hg	1.33	1.33×10^{-3}	133.32	1.33	0.133	1000	1
1 Pa = 1 N/m^2							

4.2 Literature

📖 [1] Operating Manual
Trigon® BAG500
Bayard-Alpert SingleGauge
tinb98e1
INFICON AG, LI–9496 Balzers, Liechtenstein

📖 [2] Operating Manual
Trigon® BAG552
Bayard-Alpert SingleGauge
tinb87e1
INFICON AG, LI–9496 Balzers, Liechtenstein

📖 [3] Operating Manual
Trigon® BPG500
Bayard-Alpert Pirani DualGauge
tinb96e1
INFICON AG, LI–9496 Balzers, Liechtenstein

📖 [4] Operating Manual
Trigon® BPG552
Bayard-Alpert Pirani DualGauge
tinb80e1
INFICON AG, LI–9496 Balzers, Liechtenstein

📖 [5] Operating Manual
Trigon® BCG552
Bayard-Alpert Capacitance Pirani TripleGauge®
tinb80e1
INFICON AG, LI–9496 Balzers, Liechtenstein

📖 [6] Operating Manual
VGC501, VGC502, VGC503
Single-Channel, Two-Channel & Three-Channel Control Units
tinb80e1
INFICON AG, LI–9496 Balzers, Liechtenstein

Notes

INFICON
LI–9496 Balzers
Liechtenstein
Tel +423 / 388 3111
Fax +423 / 388 3700
reachus@inficon.com

www.inficon.com

Original: English
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