smartGAS FLOW^{EVO} plus / cased

User Manual

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Revision Control file :			SG-001.2 Manual FLOW^{EVO} plus/ cased (en)		
Related :			SG-001.0 Manual FLOW^{EVO} SG-001.1 Instructions Flow^{EVO}		
Version	Date	Firmware	Author	Approved by	Comment
V1.0	2022-05-02	HW V1.0 SW V1.1 EVO V5.51/2	Andreas Hester		First Version
V1.1	2023-06-29	HW V1.0 SW V1.18 EVO V5.51/2	Niko		Manual info update
V1.2	2023-08-28	HW V1.0 SW V1.20 EVO V5.51/2	Andreas		Fully Support of smartGAS Calibration Tool New optional Analog output Interface
V1.3	2023-09-04	HW V1.0 SW V1.20 EVO V5.51/2	Andreas		Order Information added Dimension Drawings updated None Isolated analog Interface added
V1.4	2023-11-01	HW V1.0 SW V1.22 EVO V5.51/2	Andreas		Calibration Info for Analog Interface added
V 1.5	2023-11-30	HW V1.0 SW V1.24 EVO V5.51/2	Andreas		Heater Power corrected Type List updated
V1.6	2023-12-13	HW V1.0 SW V1.24 EVO V5.51/2	Andreas		Analog Interface Updated
V1.7	2024-07-24	HW V1.0 SW V1.25 EVO V5.51/2	Niko	Andreas	Analog output for 0-20mA/2V/5V/10V added
V1.8	2024-08-14	HW V2.0 SW V1.25 EVO V5.51/2	Ellie	Lia	Update communication protocol Update electrical connections Pin Configuration corrected
V 1.9	2024-08-24	HW V2.0 SW V1.25 EVO V5.51/2	Andreas		Option coding added

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1 GENERAL INFORMATION

1.1 ABOUT THIS USER MANUAL

This manual describes the construction, operation and the application areas of the **smartGAS Flow^{EVO}-plus**.
The manufacturer ensures that this equipment manual has been written in accordance with the functional and technical features of the delivered **smartGAS Flow^{EVO}-plus**.
A trouble-free and functional operation of the **smartGAS Flow^{EVO}-plus** can only be guaranteed with knowledge of this equipment manual. Please read it thoroughly before using.
Pages, tables and illustrations are numbered continuously.
The values shown as results or on the display in this manual are examples of the manufacturer.
The process-specific results must be determined by the user.

1.2 WARRANTY

Measuring cell and electronics till 12 months after delivery

Guarantee and liability claims in case of personal or instrumental damages are excluded if due to following causes:

- **Natural wear and tear**
- **None utilization of product according to order**
- **Improper placement, operation, and maintenance of product**
- **Use product with ineffective protective measures**
- **Unauthorized functional and technical alterations of product**
- **Removal of standard product part without permission of manufacturer.**
- **Installation of parts or attachments which were not supplied or approved by the manufacturer**
- **Improperly repairs or wrong operations**
- **Influences of external damage**
- **Type label is peeled off**

1.3 COPYRIGHT

1.4 SAFETY SYMBOLS

- **Symbol for direct imminent hazards**
  If these recommendations are not thoroughly observed, fatal injuries may result.

This symbol is shown with recommendations for industrial safety if a direct danger to the life and health of persons exists.	

- **Symbol for indirect imminent hazards**

  Disregard of these hints may result in damage to or destruction of the entire product or single components, other property, as well as minor injuries.

This symbol informs about situations where indirect hazards occur. Degree and intensity of the damage depends on the triggering actions and the behavior of the persons involved.	

- **Symbol for proper usage**

  If these notes aren't taken into account, it can cause damage or destruction of product or single components.

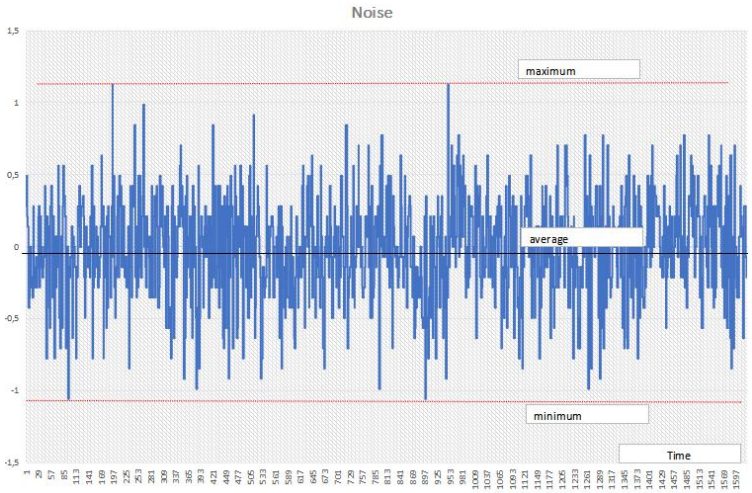
This symbol can be found where the observance of instructions, regulations, and proper order of actions/events is important.	HINT

2 DEFINITIONS

2.1 NOISE

The change of a signal output what result in an average change of zero will be defined as Noise
There are several ways of Noise Calculation what could be more or less mathematical
We use a definition of $Noise_{abs}$ which define the distance between the highest and lowest value in a specified time

In this sample the maximum value of noise is ~1.1 and the minimum ~-1.05
$Noise_{abs}$ = 1.1 - (-1.05) = 2.15
or
Noise = ± 1.075



Very often Noise will be defined based on the FS of Sensor as

Noise < ± 1.075%[FS]

Noise will be typically defined in Zero Point

Mathematically, noise can also be defined in several other ways

2.2 LINEARITY ERROR

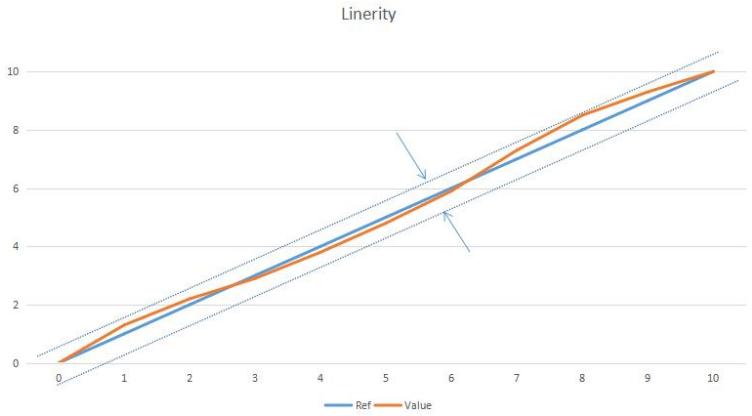
The Linearity Error is the maximal deviation of a given value to a measured one

In this sample is the max deviation at ~8

The Linearity Error will be typically given as <±X%[FS]

In special cases it will be defined as <±X%[Reading]
This requires an additional definition like
$<\pm X_{absolut}$ (what ever is higher)
It this is missing the Linearity Error must be 0 near to Zero Point what is technical not possible

In the calibration points like Zero and Span the Linearity error will be Zero right after calibration



To calculate the Linearity error it is required to know the exact value of the used Reference Gas and it's accuracy. If a Gas Mixer is used it is required to know its accuracy. These deviations will be included in the measured result what means the measured result of Linearity error is the sum of Linearity Error of the Sensor, the Gas Mixer and the deviation of used Reference Gas	HINT

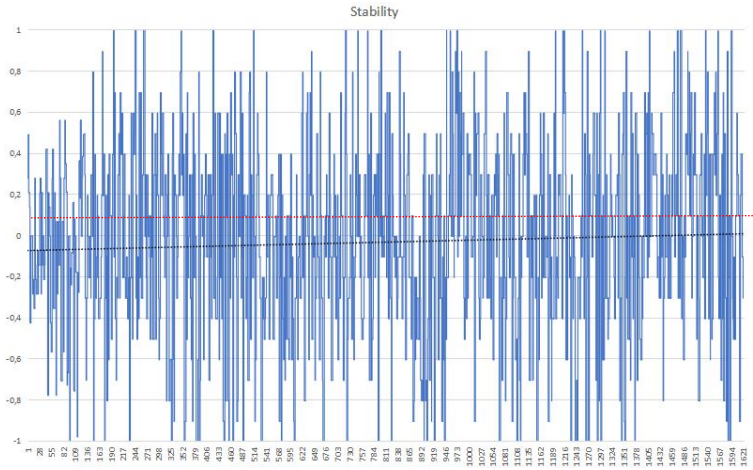
If in a Linearity measurement the Reference is given with accurate numbers like 10,20 it is obviously the person who did, ignored the dependency of Reference Gas and/or Gas mixer A bought reference gas of 10% will typically have a value somewhere in between 9.9xx and 10.0xx or worse, the exact value can be read on the QC label of Gas Cylinder	HINT

2.3 STABILITY

The Stability of Gas Sensors is a list of stabilities
Each stability is defined by itself and requires all other parameter are constant

The Stability is defined as the deviation of the average of Noise from one stable point to an other

In this example the average rise from -0,08 to 0
If we assume the value before was -0,08 and after will also be stable 0 than the Stability is 0,08



2.3.1 STABILITY OVER TIME

Defined as <±X%[FS]/time where time can be hours/days/years

Very often is is not mentioned what stability someone is talking about In this case in general it is related to stability over a time In this case it is required to hold all other parameter constant during measurement and log these data additional. There are as minimum : - Temperature of Sensor and/or Environment - Gas and/or Environment Pressure - Gas Flow Rate Also the tested Sensor is not allowed to move, tilt or flipped and there should be no convection of environment air like a fan process Otherwise the resulting Stability has no meaning	HINT

2.3.2 STABILITY OVER GAS PRESSURE CHANGE

Also named Gas Pressure Dependency
Defined as <±X%[Reading]/kPa can also be mBar or other units

The Gas Pressure Dependency is for Gas Sensor working by counting Molecules in a Volume as ppm or Vol.% different in Zero Point and all other points, this is the reason it will be defined based on reading value. By changing the Pressure the quantity of molecules in a volume change even if the concentration of the related gas did not change If we have a zero gas where no countable Molecule of interest is in, this will also not change if we rise up the pressure of this Zero Gas	HINT

Sometime the Gas Pressure Dependency is only given in Span Point as <±X%/kPa (In Span)

A Gas Sensor used in Flow Mode has generally a Pressure Difference between Gas In- and Outlet. Without this difference there will be no Gas Flow. Because of this, it is strongly recommend to compensate this pressure dependency by a cuvette pressure compensation. A compensation by environment pressure can only be done if the inner cuvette Pressure is nearly the same than environment, this means the gas sensor outlet is open to the environment	HINT

2.3.3 ...BILITY OVER TEMPERATURE CHANGE

This is mainly a combination of

1. The temperature effect on the gas we measure
   If Gas Temperature rise, the used volume rise and the countable molecules in a constant volume drop
2. The temperature effect on all analog parts of the sensor like emitter, detector, amplifier and so on

Cause the first part has no effect at zero point same as gas pressure itself, the temperature is also given typically in two values
Temperature Dependency (Z

The T_{90} Time vary extremely with the flow rate So the flow rate has to be given in any case, without this value the T_{90} Time is useless	HINT

To evaluate the T_{90} time it is essential to change the concentration in extremely short time A evaluation with a gas mixer is useless, it only gives the T_{90} time of gas mixer If T_{90} times less than 1sec shall be evaluated the switching of reference gas has to be processed by an electrical 3way valve cause even a manually turned ball calve will be to slow	HINT

Long Tubing will rise the T90 time	HINT

2.3.7 *Cross Sensitivities*

Every gas measurement has cross sensitivities in the moment we measure gas mixes and this is independent of the used technology.
A Technology without Cross sensitivities does not exist!
Because of this general dependency in gas measurement, the complete mix of gas has to b given before the usable sensor can be selected

Technology	Example of Cross Sensitivities, not complete
NDIR	CO2 to CO and SO2 and NO | H2O to a lot | SO2 to NO .....
NDUV	SO2 to NO2 | NO2 and SO2 to NO | SF6 to SO2 and NO .....
TCD	CO2 and CH4 to H2 .....

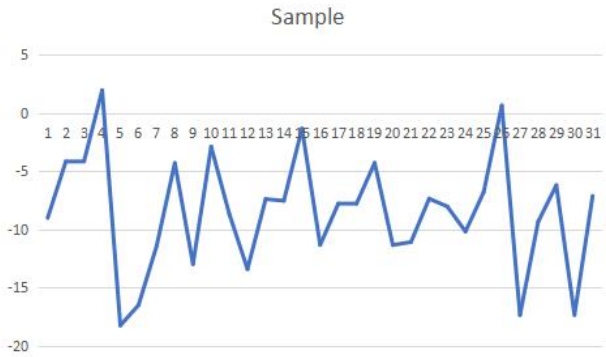
A Gas Measurement Technology without Cross sensitivities does not exist ! Different Technologies have different Cross sensitivities ! Based on the Range a gas occur in the Mix, its cross sensitivity can be ignored ! A Cross Sensitivity can be compensated but not in any mix ratios ! To suggest a gas sensor without knowing the background gas very unprofessional!	HINT

2.3.8 *LDL Lowest Detection Limit*

Defines the sensitivity of a sensor. The LDL is the lowest signal the senor can measure as different from an other signal
The LDL can be smaller than the Noise and is mainly independent of it
Often LDL will be given as Value (3σ)

LDL = 3 x STD (Standard Deviation) is called 3Sigma

In this sample the $Noise_{abs}$ is ~20
Standard Deviation is ~4.9
LDL 3σ is ~15



2.3.9 *Digital Resolution*

The digital resolution is the internal equivalent of bit related to the range of the Sensor
As example if a 0-100Vol% Sensor has internal a 16bit Analog/Digital Converter the digital resolution will be max 1/65535 or 100Vol.% or max 15.3 ppm

This is not the measuring resolution and has nothing to do with LDL or Sensitivity of the Sensor this only an internal resolution based on the accuracy of A/D Converter	HINT

2.3.10 *Output Resolution*

The output resolution (digital) is the format the resulting data will be given to the user.

As example a 0-100Vol% Sensor can have a digital output as XXX or XXX.X even with more digits as XXX.XXX or even as float value

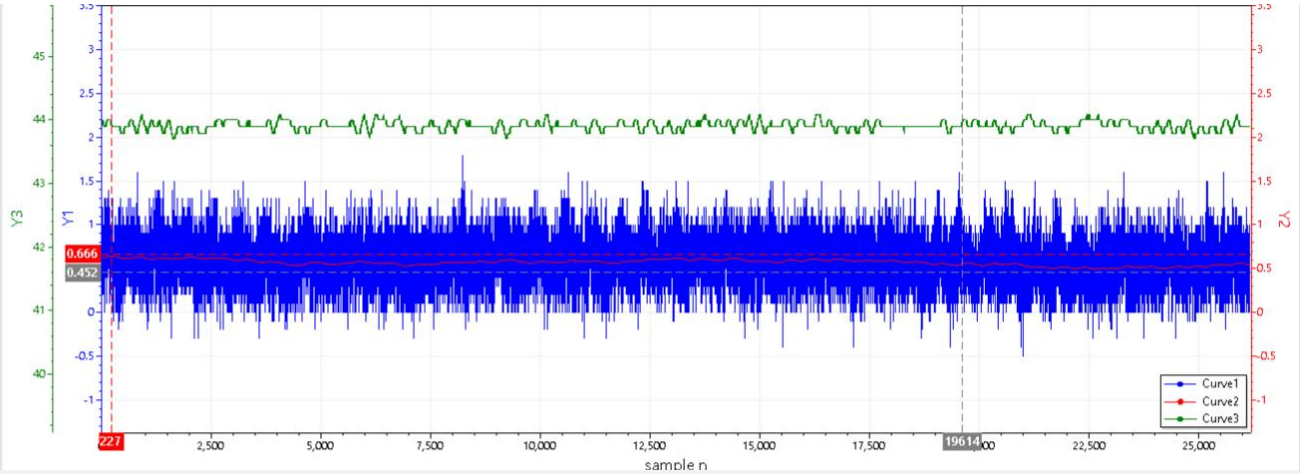
This is not the measuring resolution and has nothing to do with LDL or Sensitivity of the Sensor this is only the format the result will be presented	HINT

All Values < LDL are representing the System and mathematical Noise and have no meaning of measured result	HINT

3 BASIC DESCRIPTION

smartGAS Flow^{EVO}-plus is a combination of a **Flow^{EVO}** NDIR Gas Sensor with highly integrated **EVOPlus** Controller. Beside several interfaces and protocols the Plus Controller support high performance noise reduction algorithm and optional an integrated high precise controlled heating for optimal stability as well as a cuvette pressure compensation.

smartGAS Flow^{EVO}-plus cased is a **smartGAS Flow^{EVO}-plus** with housing and heat isolation for high performance applications.



Curve 1: Flow^{EVO} cased CO_2 100 ppm fast mode(blue)
Curve 2: smartGAS FlowEVO-plus cased CO_2 100 ppm(Red)
Curve 3: Temperauture [°C]
Y-Axis:ppm X-Axis: sample n, ts=2s

Figure 1 Sample Noise reduction performance of **smartGAS Flow^{EVO}-plus**

Basic comparison of **Flow^{EVO}** standard, fast mode, and **smartGAS Flow^{EVO}-plus**.

	Noise Level	**T_{90} time @1L/min**	**Readout cycle**	**Hardware interface**	**Constant Heated**
smartGAS Flow^{EVO} standard	±0.1%FS	<14s	Max 2.5Hz	TTL 1wire	No
smartGAS Flow^{EVO} Fast mode	±1%FS	<3s	Max 2.5Hz	TTL 1 wire	No
smartGAS Flow^{EVO}-plus **smartGAS Flow^{EVO}-plus cased**	±0.075%FS	<3s	Max 10Hz	RS232/RS485 4..20mA (optional) 2/5/10V (optional)	Yes

Figure 2 Comparison **Flow^{EVO}** and **smartGAS Flow^{EVO}-plus**

4 MEASURING PRINCIPLE

The **smartGAS FlowEVO-plus** are based on the infrared absorption technology and comply with the highest standards in accuracy, reliability and efficiency.
Due the consequent use of this optical principle the systems work without abrasion or chemical reactions and are nearly maintenance free.
As basis the IR principle uses the individual absorption spectrum of the gas to be detected and specifies the concentration by the precise quantitative analysis.
Because all measured gases absorb IR radiation in a different spectrum a so called “fingerprint” is given which ensures a selective characterization with less cross sensitivities.

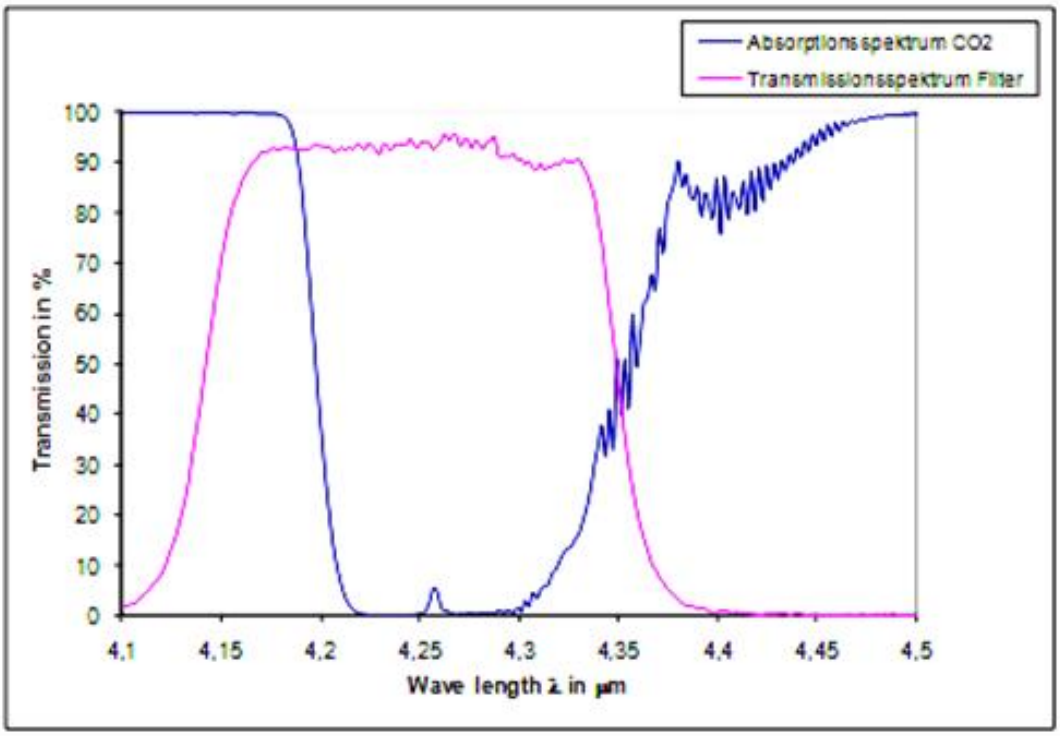


Figure 2 IR Absorption Spectrum

An integrated evaluation electronic delivers finally an easy to use concentration signal and compensates all temperature- and drift effects.

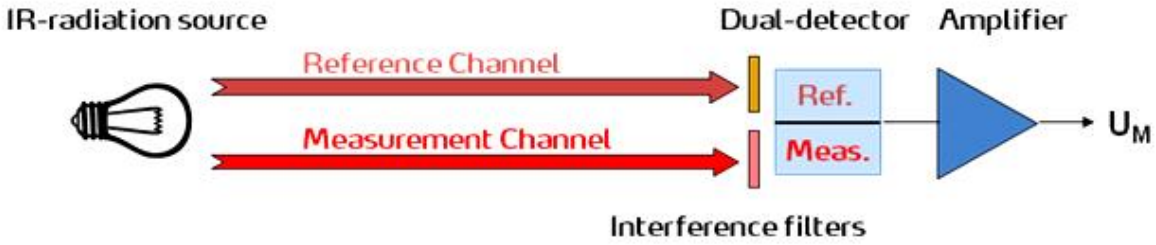


Figure 3 Dual Channel NDIR schema

5 PRODUCT PHOTO EXAMPLE

- **smartGAS Flow^{EVO}-plus** example

Figure 4 **Flow^{EVO} plus** Type I 76mm

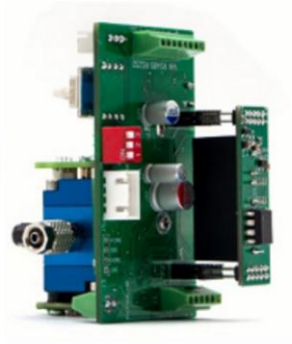


Figure 5 **Flow^{EVO} plus** Type II with isolated analog interface

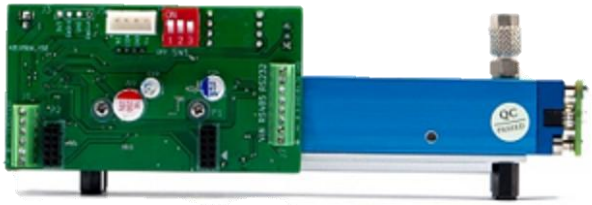


Figure 6 **Flow^{EVO} plus** Type I 156mm without analog interface

- **smartGAS Flow^{EVO}-plus cased** example

Figure 7 **smartGAS Flow^{EVO}-plus cased** for **Flow^{EVO}** Type I up to 336mm build in length

6 PRODUCT SELECTION INFORMATION

Type P3-212108	**-1xxx**	**Sample CO2 100Vol.% Type:I L=76mm** For More types refer standard type list
Heater	**-1x0** **-1x1**	**Without Heater no pressure Sensor** **With Heater no pressure Sensor** a : Heater A EVO Type II/III b : Heater B EVO Type I 76mm (Build in Space) c : Heater C EVO Type I 116mm (Build in Space) d : Heater D EVO Type I 140mm (Build in Space) e : Heater E EVO Type I 156mm (Build in Space) f : Heater F EVO Type I 236mm (Build in Space) g : Heater G EVO Type I 336mm (Build in Space) The selection of heater is based on the module
Pressure Sensor	**-1x2** **-1x3**	**With cuvette pressure sensor no Heater** **With cuvette pressure sensor and Heater**
Analog Interface	**-10x** **-11x** **-12x** **-13x**	**Without Analog Interface** **Analog Interface 1 / 4..20mA isolated** **Analog Interface 2a / 0..20mA 0-2/5/10 VDC** **Analog Interface 2b / 2..20mA 0,4-2/1-5/2-10 VDC**
Case		A : Case A 89.6x59.2x180mm B : Case B 89.6x59.2x340mm C : Case C 89.2x89.6x170mm D : Case D 89.2x89.6x340mm The selection of case is based on the module and pump
Gas Connection		6/4 or 3/5 mm Rubber Tube Fitting
Internal Pump		Internal Pump Only available for cased Version
Case **Gas Connection** **Pump**	**-1xx1** **-1xx2** **-1xx3** **-1xx4**	**Cased with 6/4 Connection** **Cased with 5/3 Gas Connection** **Cased with pump and 6/4 Connection** **Cased with pump and 5/3 Gas Connection**
Pin Config	**-1xxXA** **-1xxXB** **-1xxXC** **-1xxXD** **-1xxXE**	**Pin Configuration A** **Pin Configuration B** **Pin Configuration C** **Pin Configuration D** **Pin Configuration E** Only available for cased Version
Mode	**-1xxXX0** **-1xxXX1** **-1xxXX2** **-1xxXX3** **-1xxXX4** **-1xxXX5**	Mode **00 : (FREE ASCII)** Mode **01 : (STANDARD MODBUS ASCII)** Mode **02 : (STANDARD MODBUS RTU)** Mode **03 : (SCII MODBUS RTU)** Mode **12 : (EVO COMPATIBLE MODBUS ASCII)** Mode **23 : (EVO COMPATIBLE MODBUS RTU) (default)**
Analog Out **Connector pinning** **for Cased Version** **Refer to pin** **configuration**	**-1xxXXX1** **-1xxXXX2** **-1xxXXX3** **-1xxXXX4** **-1xxXXX5** **-1xxXXX6** **-1xxXXX7** **-1xxXXX8**	**4..20 mA** **0..20 mA** **2..10 VDC** **0..10 VDC** **1..5 VDC** **0..5 VDC** **0.4..2 VDC** **0..2 VDC**

The analog interface 1 is not available for the cased version With analog interface the high accuracy and low noise can not be reached cause of the additional noise and accuracy error effect of analog transmitting line as well as sender and receiver	HINT

The case type(size) is related to the cuvette length of the module Please refer to the related data sheet	HINT

6.1 SMARTGAS FLOWEVO-PLUS CONFIGURATION TABLE

Flow EVO Plus Configuration			
Flow EVO	Type refer data sheet	The Size defines selected heater and case	
Flow EVO Plus Controller	EVO Plus without Pressure Compensation		
	EVO Plus with Pressure Compensation		
Configuration EVO Plus	Customer Required Mode Settings	See Chapter 13Mode setting	
Analog Interface(Option)	Analog 1 4..20mA Isolated 3KV|0.2-1VDC	Not available for Cased Version	
	Analog 2 4..20mA | 0-2/5/10VDC Customer Required Mode Settings	See Chapter 14Analog Interface Setting	
Heater Element	Heater A EVO Type II/III	Ceram Heater	
	Heater B EVO Type I 76mm (Build in Space)	PTC A	
	Heater C EVO Type I 116mm (Build in Space)	PTC B	
	Heater D EVO Type I 140mm (Build in Space)	PTC C	
	Heater E EVO Type I 156mm (Build in Space)	PTC D	
	Heater F EVO Type I 236mm (Build in Space)	Silicone A and external Temp. Sensor	
	Heater G EVO Type I 336mm (Build in Space)	Silicone B and external Temp. Sensor	
Additional Configuration for Cased Versions Only			
Case without internal pump Selected by Flow^{EVO} Type	For EVO Type II and III	Case A 89.6x59.2x180mm	
	For EVO Typ I up to 156mm(Build in Space)		
	For EVO Type I 336mm(Build in Space)	Case B 89.6x59.2x340mm	
Case with internal pump Selected by Flow^{EVO} Type	For EVO Type II und III	Case A 89.6x59.2x180mm	
	For EVO Typ I up to 76mm(Build in Space)		
	For EVO Type I up to 156mm(Build in Space)	Case C 89.2x89.6x170mm	
	For EVO Type I 336mm (Build in Space)	Case D 89.2x89.6x340mm	
Internal Pump(Option)	Rotary vane pump 1,0 l/min max.: 0,09 bar		
El. Connector	Connector Weipu SP1310/S7I 1.5m cable		
	Connector Weipu SP1310/S7I		
Configuration Connector	Pin Configuration A	1 VCC 2 GND 3 RS485 A 4 RS485 B	5 RS232 RX 6 RS232 TX 7 RS232 GND
	Pin Configuration B	1 VCC 2 GND 3 analog out V+ 4 analog out V-	5 RS232 RX 6 RS232 TX 7 RS232 GND
	Pin Configuration C	1 VCC 2 GND 3 analog out 4..20mA 4 analog out 4..20mA	5 RS232 RX 6 RS232 TX 7 RS232 GND
	Pin Configuration D	1 VCC 2 GND 3 RS485 A 4 RS485 B	5 analog out V+ 6 analog out V- 7 nc
	Pin Configuration E	1 VCC 2 GND 3 RS485 A 4 RS485 B	5 analog out 4..20mA 6 analog out 4..20mA 7 nc
Gas Connections	3/5 mm Rubber Tube Fitting		
	4/6 mm Rubber Tube Fitting		

7 STANDARD TYPE LIST OF FLOW^{EVO}

Please refer to SG-001.0 Manual FlowEVO.

Please note : All standard types are calibrated based on high accurate reference gas with N_2 background. If there is any other background gas like CO_2,CH_4,SF_6.. in high concentration, please let us know ahead to offer the right solution	HINT

Please note : Generally different gases can have cross sensitivity because of overlapping spectral data For example high Vol.% CO_2 will have en effect on low ppm measurement of CO To reduce this risk of inaccurate measurement in application, please let us know the gas mix of application ahead.	HINT

8 TECHNICAL SPECIFICATION

General Information	
Product Name	**smartGAS Flow^{EVO}-plus** **smartGAS Flow^{EVO}-plus cased**
Detection Priciple	NDIR (Dual Beam)
Measuring Range	Refer order information
Gas supply	Flow
Dimension	Refer drawing
Internal Regulated temperature	45°C@24V power (PID regulator configured @24VDC)
Temperature stability	**smartGAS Flow^{EVO}-plus:** ±0.5°C @24V power with suitable isolation **smartGAS Flow^{EVO}-plus cased:** ±0.3°C @24V power @stable ambient
Warmup time	<2min cold start Typical <30min full spec. @24V power cased version @25°C
Operation temperature	0-40°C
Storage Temp	-20 °C up to 60 °C
Ambient Humidity	0%-95% rel. No condensing
Ambient Air Pressure	800 up to 1200 mbar
Gas flow	0.2-1.0 L/min (const ±0.05L/min)
Gas inlet dew-point	<5°C ±1K
Gas inlet temperature	2-40°C
Gas inlet/outlet Hose connection	**smartGAS Flow^{EVO}-plus**: 3*5mm **smartGAS Flow^{EVO}-plus cased**: 3*5mm or 4*6mm
Optional function	
Analog Interface 1 Isolated(optional) **Note : not available in cased version**	4-20mA Isolated (3kV/rms), max load 650Ω
Analog Interface 2 (optional)	Configuration A 4-20mA max load 600Ω 0-2VDC min resistance load 2kΩ 0-5VDC min resistance load 2kΩ 0-10VDC min resistance load 2kΩ Configuration B 4-20mA max load 600Ω 0.4-2VDC min resistance load 2kΩ 1-5VDC min resistance load 2kΩ 2-10VDC min resistance load 2kΩ

Gas Measurement spec.	
T_{90} time	<3s (typical) @0.7L/min constant gas flow
Noise at zero point @digital output	<±0.075% FS[1] (typical) @stable flow, pressure and temperature
Noise at zero point @analog output	<±0.075% FS plus 10mV RMS (typical) with signal transmission and receiver noise <10mV RMS @stable flow, pressure and temperature  For low noise applications it is strongly recommend to use the digital interface The signal converting to analog will add own noise as well as the reconverting on receiver sind This will result in much higher noise in sum
Detection Limit (3sigma)	Typical ≤ 0.5 % FS (Please refer to Flow^{EVO} data sheet)
Repeatability @digital output	Typical ≤±1.0 % FS (Please refer to Flow^{EVO} data sheet)
Linearity Error @digital output	Typical ≤±1.0 % FS (Please refer to Flow^{EVO} data sheet)
Linearity Error @analog output	Typical ≤±2.0 % FS
Stability (zero) @digital output	Typical ≤ 2%FS (24h) (Please refer to Flow^{EVO} data sheet)
Stability (span) @digital output	Typical ≤ 2%FS (24h) (Please refer to Flow^{EVO} data sheet)

[1] FS : Full Scale (German: MBE)

Pressure Drift	Typical 0.1% of reading per mbar without pressure comp. (Please refer to Flow^{EVO} data sheet)

Electrical Data	
Power Supply	10-26VDC, recommend 24VDC Max 1.3A @24V
Power consumption with heater	<11 W @24V for Type II/III <4 W @24V for Type I (73) <8 W @24V for Type I (113mm...153mm) <21 W @24V for Type I (233mm) <31 W @24V for Type I (333mm)
Electrical Connection	**smartGAS Flow^{EVO}-plus**: 2.54 pitch screw terminal **smartGAS Flow^{EVO}-plus cased**: Weipu SP1312/P7I Male

9 COMMUNICATION MODES

Communication	
Digital Interface	RS232, RS485
Communication Protocol	Standard or modified Modbus, refer working mode setting
Modbus address	Refer product lable Address range 0x01...0xF7 for multi module on one bus..

Standard Working Mode			
Mode	**Mode Name**	**Baudrate**	**Read/send out frequency**
Mode [0]	Free ASCII	Send out by 115200, 8, None, 1 after power on, with 2400-115200 auto baud rate, auto frame	Free send out fix @2Hz max. 10Hz Able to change by command
Mode [1]	Modbus ASCII	2400-115200 Auto baud rate, auto frame	Recommend ≤3Hz, max. 10Hz
Mode [2]	Modbus RTU	2400-115200 Auto baud rate, auto frame	Recommend ≤3Hz, max. 10Hz

FlowEVO comatible working mode, support EVO registers			
Mode	**Mode Name**	**Baudrate**	**Read/send out frequency**
Mode [12]	EVO Modbus ASCII	2400-115200 Auto baud rate, auto frame	Recommend ≤3Hz, max. 10Hz
Mode [23]	EVO Modbus RTU	2400-115200 Auto baud rate, auto frame	Recommend ≤3Hz, max. 10Hz

S-CONNECT II compatible working mode (Not support to access in standard registers, only SCII register supported)			
Mode	**Mode Name**	**Baudrate**	**Read/send out frequency**
Mode [3]	SCII Modbus RTU	9600, 8, none, 1	Recommend ≤3Hz, max. 10Hz

For data read out frequency >3Hz, the RTU mode is recommended.
Please use higher baud rate eg. 38400/57600/115200.
Low baud rate read at high frequency can cause internal error!

10 AUTO BAUDRATE AND AUTO FRAME

For all work mode the **smartGAS Flow^{EVO}-plus** (or cased) will printout internal boot information at startup via digital interface
In Mode [0] [1] [2]]12] and [23] this printout will be done in initial setting of 115200,8,N,1
In Mode [3] this printout will be done in initial setting of 9600,8,N,1

After this initial process the **smartGAS Flow^{EVO}-plus** In Mode [0] [1] [2]]12] and [23] switch to detect transmission parameter.
When receiving first user command with valid transmission parameter, the **smartGAS Flow^{EVO}-plus** switch to this frame and send out all information in this frame until reboot (repower).

10.1 SUPPORTED BAUDRATES AND FRAMES

The supported auto baud rates and auto frames:
For ASCII mode([0] [1] [12]):

Baudrate:	2400/4800/9600/19200/38400/57600/115200
data bits:	8/7
parity:	EVEN/ODD/NONE
Stop bits:	1/2

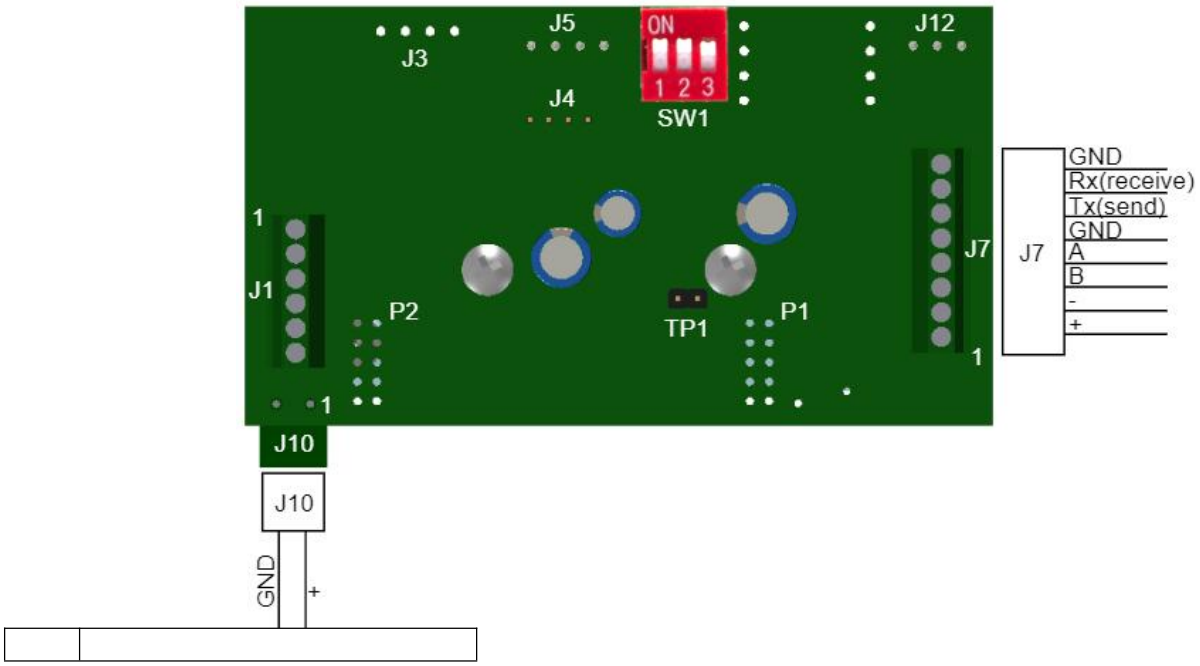
For RTU mode([2] [23]):

Baudrate:	2400/4800/9600/19200/38400/57600/115200
data bits:	8
parity:	EVEN/ODD/ NONE
Stop bits:	1/2

Mode [3] does not support auto baud rate and frame. HINT

11 ELECTRICAL CONNECTIONS

11.1 SMARTGAS FLOW^{EVO}-PLUS ELECTRICAL CONNECTIONS



J1	J1-1 GND of AO mV J1-2 AO mV J1-3 AO mA I+ J1-4 AO mA I- J1-5 Heater Power+ (10V-26V) J1-6 Heater Power- (GND)

J7	J7-1 V+ (10V-26V) J7-2 V- (GND) J7-3 RS485 B J7-4 RS485 A J7-5 GND J7-6 RS232 Tx J7-7 RS232 Rx J7-8 RS232 GND

J10	J10-1 to Heater(by factory) J10-2 to Heater(by factory)

Figure 8 Connection Overview of **smartGAS Flow^{EVO}-plus**

11.2 SMARTGAS FLOW^{EVO}-PLUS CASED ELECTRICAL CONNECTIONS (RS485+RS232)

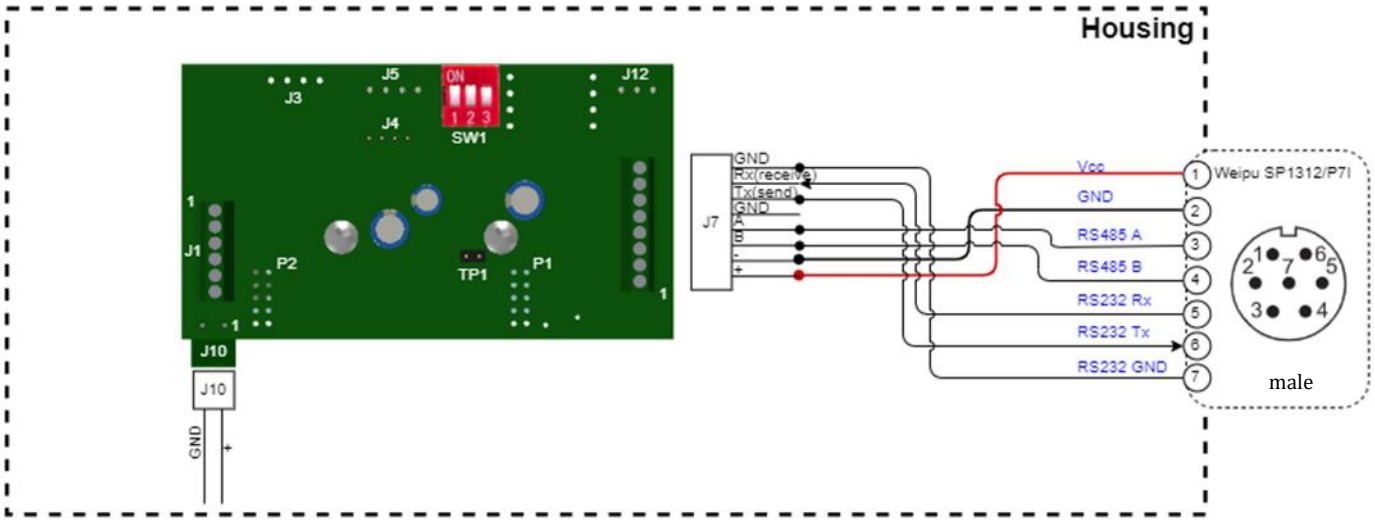
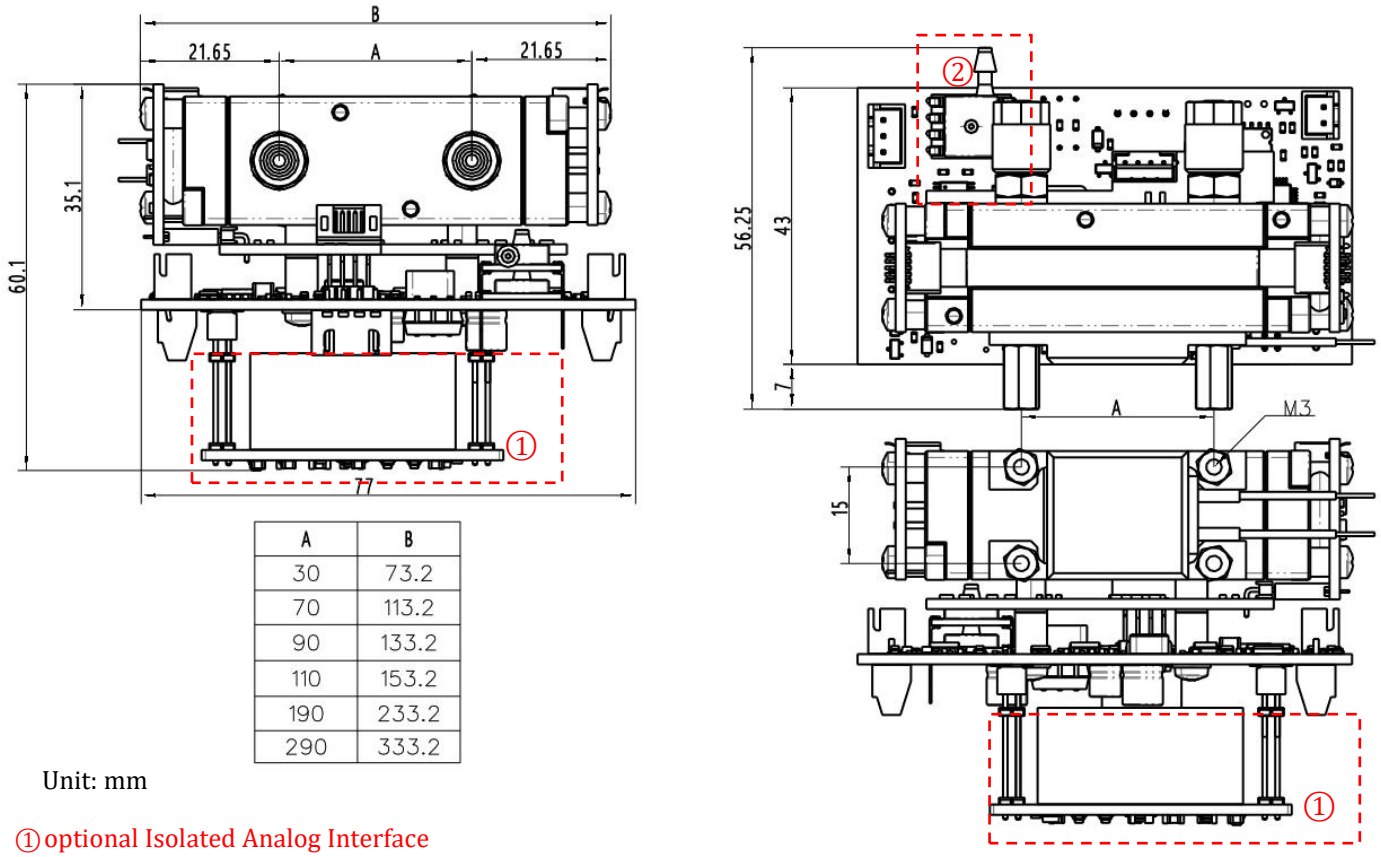


Figure 9 Connection Overview of **smartGAS Flow^{EVO}-plus cased**(RS232+RS485)

12 MECHANICAL DRAWINGS

12.1 MECHANICAL DRAWINGS SMARTGAS FLOW^{EVO}-PLUS



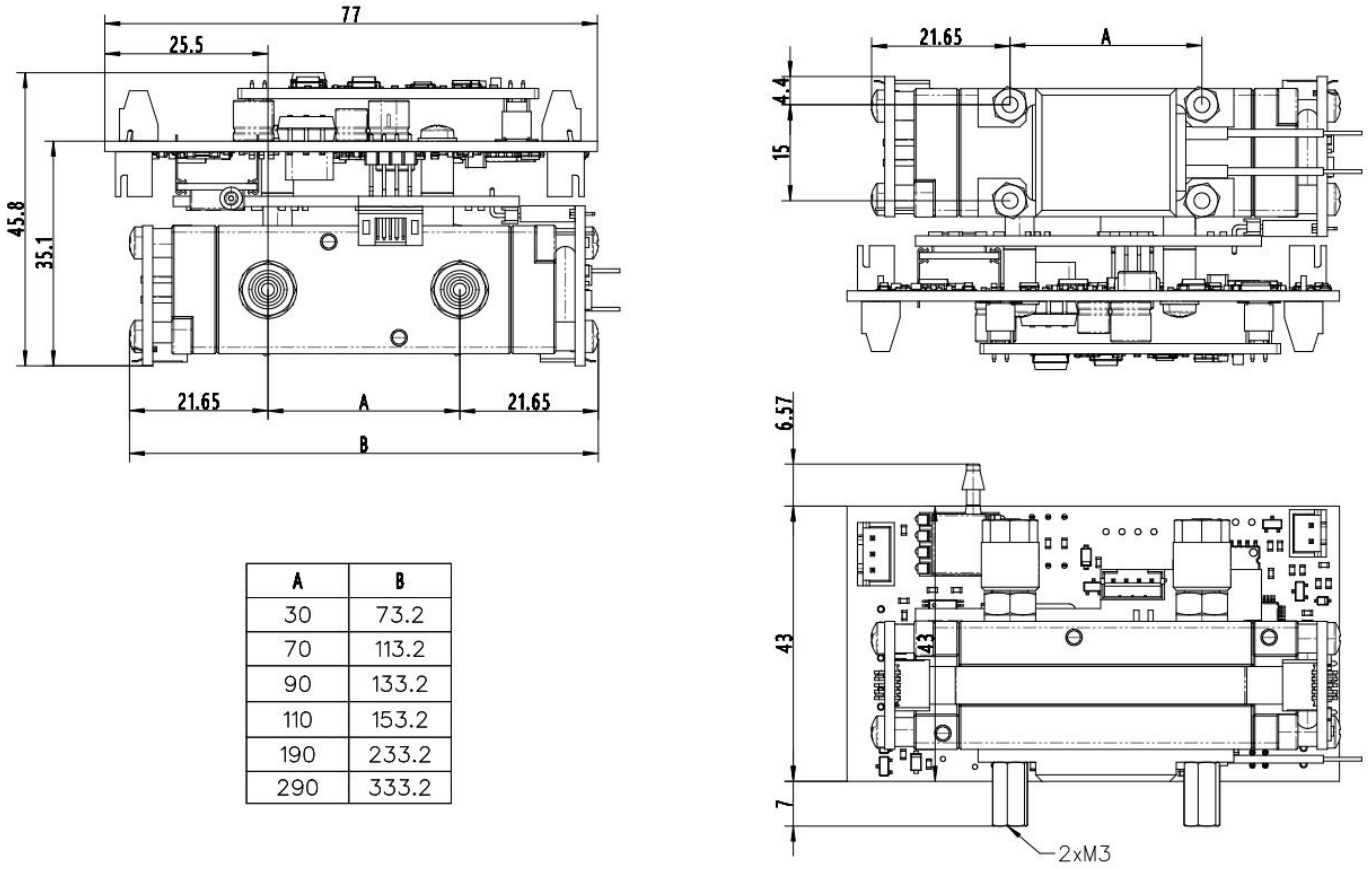
A	B
30	73.2
70	113.2
90	133.2
110	153.2
190	233.2
290	333.2

Unit: mm

①optional Isolated Analog Interface

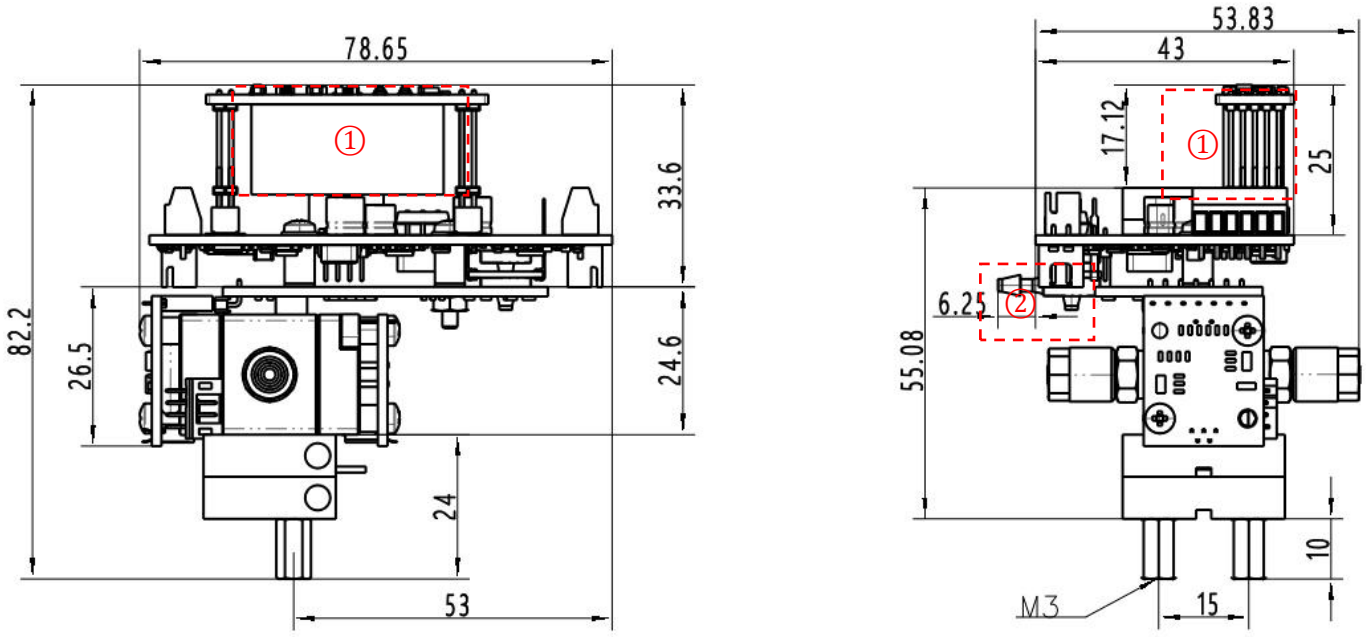
②optional Pressure Compensation Sensor

Figure 10 Mechanical dimension of **smartGAS Flow^{EVO}-plus** Type I 76 to 336mm with Analog 1 and Pressure Sensor



A	B
30	73.2
70	113.2
90	133.2
110	153.2
190	233.2
290	333.2

Figure 11 Mechanical dimension of smartGAS FlowEVO-plus Type I 76 to 336mm with Analog 2 and Pressure Sensor

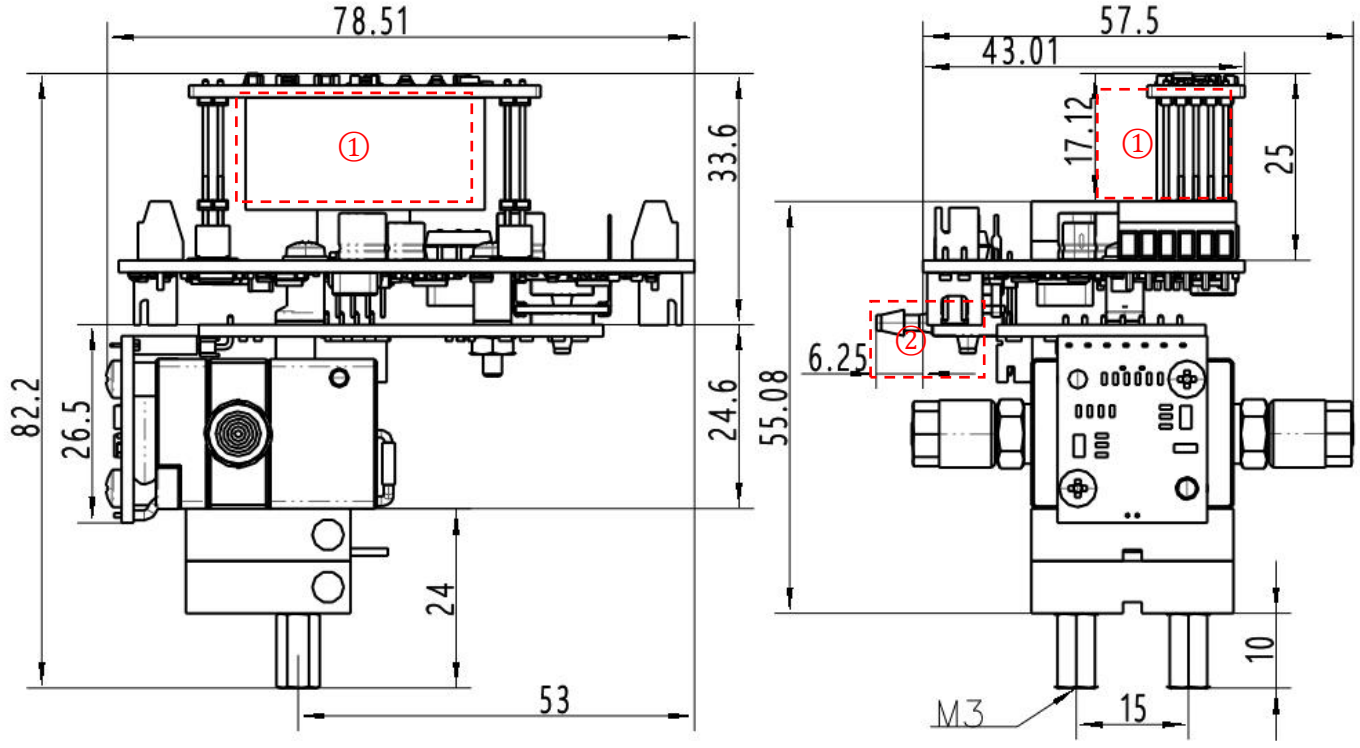


Unit: mm

①optional Isolated Analog Interface

②optional Pressure Compensation Sensor

Figure 12 Mechanical dimension of **smartGAS Flow^{EVO}-plus** Type II with Analog 1 and Pressure Sensor



Unit: mm

①optional Isolated Analog Interface

②optional Pressure Compensation Sensor

Figure 13 Mechanical dimension of **smartGAS Flow^{EVO}-plus** Type III with Analog 1 and Pressure Sensor

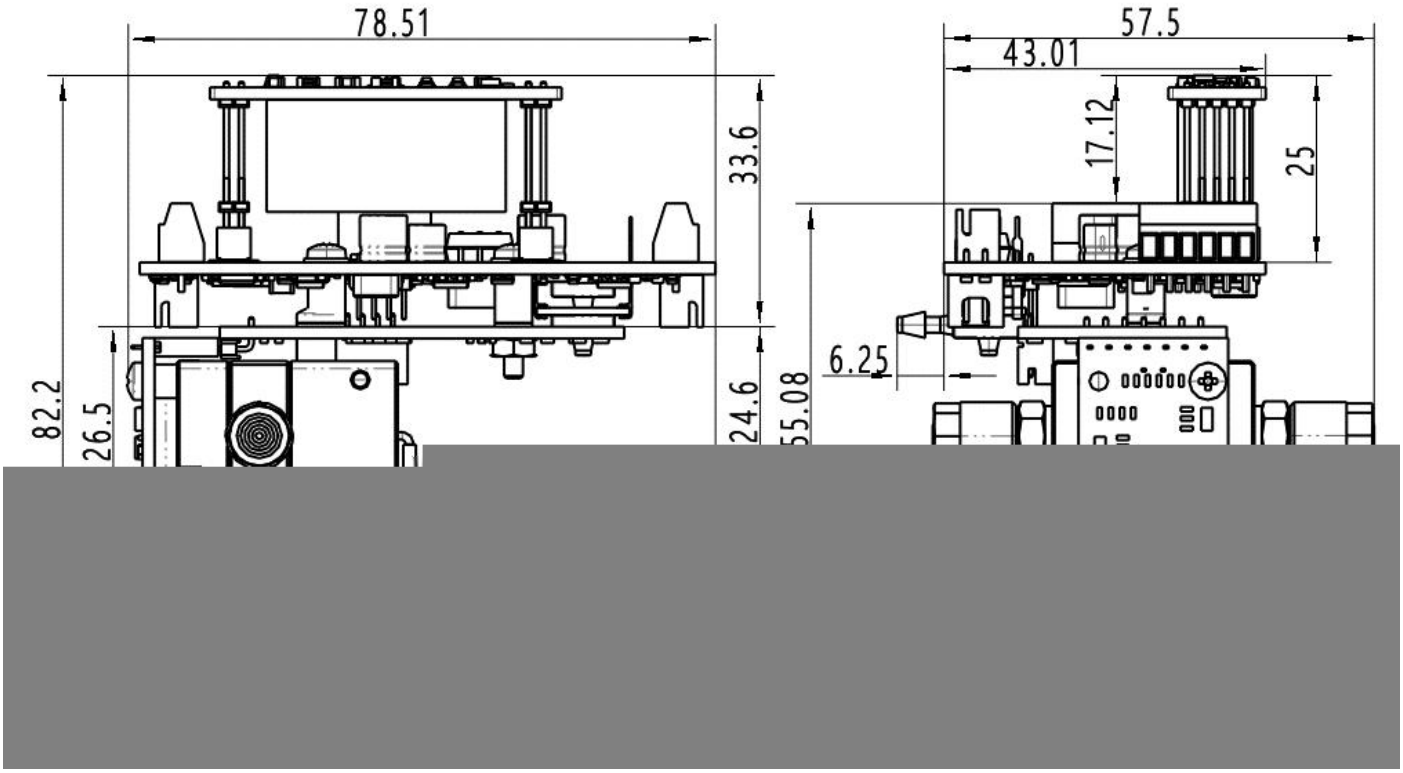


Figure 14 Mechanical dimension of FlowEVO-plus Type III with Analog1 and pressure sensor

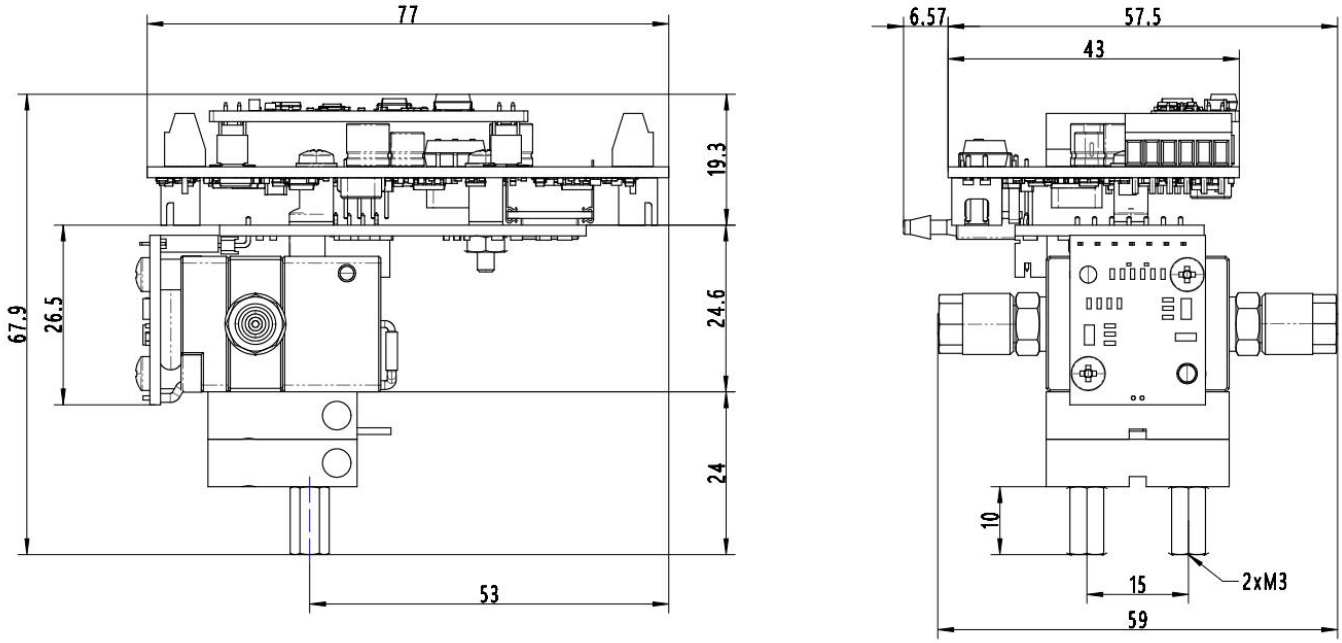
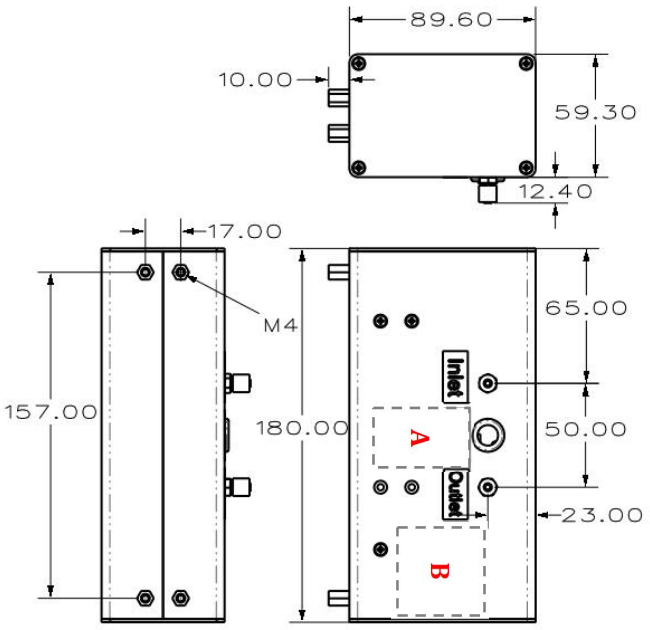


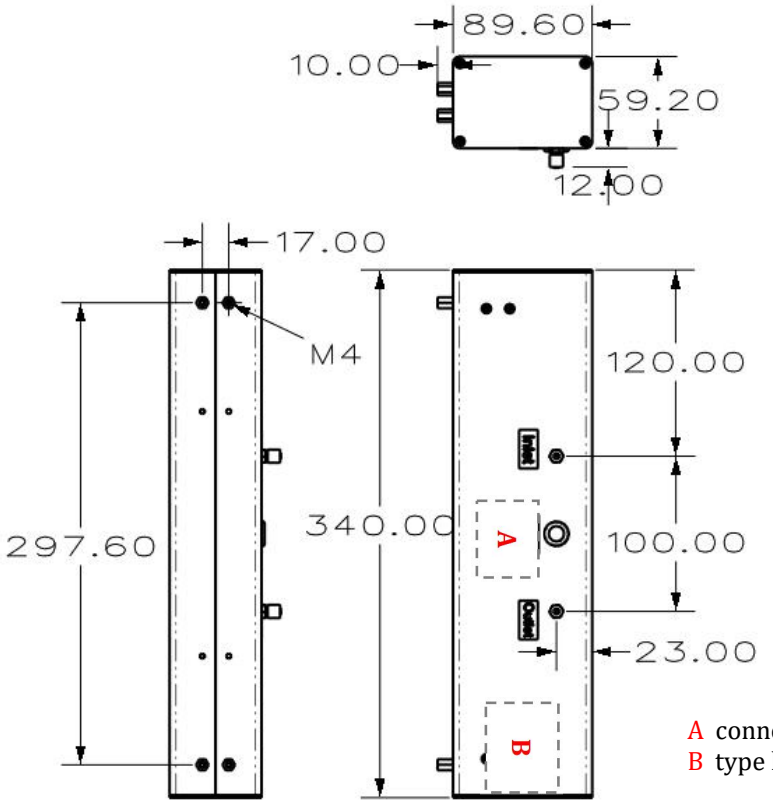
Figure 15 Mechanical dimension of FlowEVO-plus Type III with Analog2 and pressure sensor

12.2 MECHNICAL DRAWINGS SMARTGAS FLOW^{EVO}-PLUS CASED



A connection label
B type label

Figure 16 Mechanical dimension Case Type A



A connection label
B type label

Figure 17 Mechanical dimension Case Type B

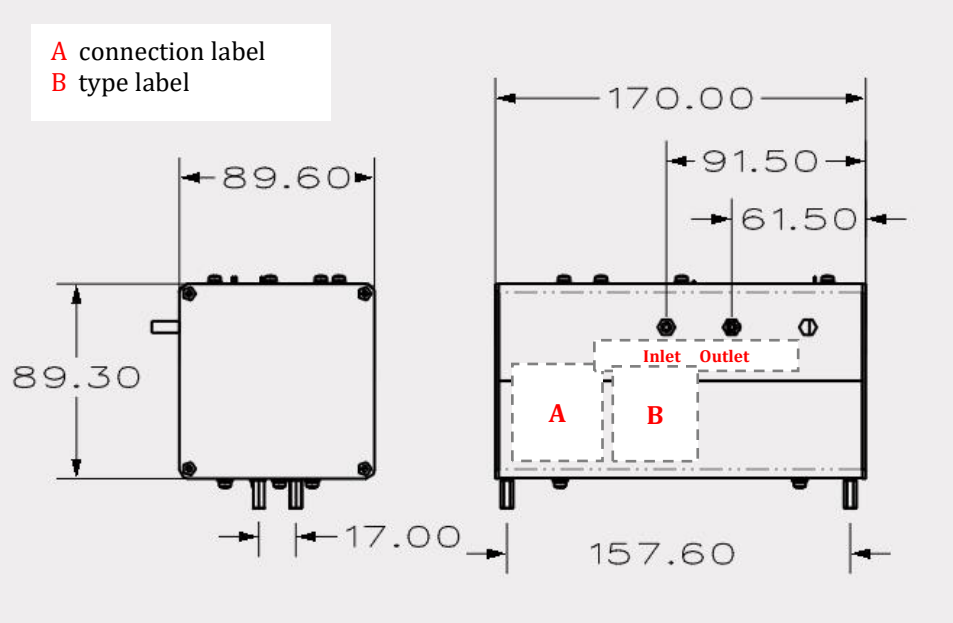


Figure 18 Mechanical dimension Case Type C

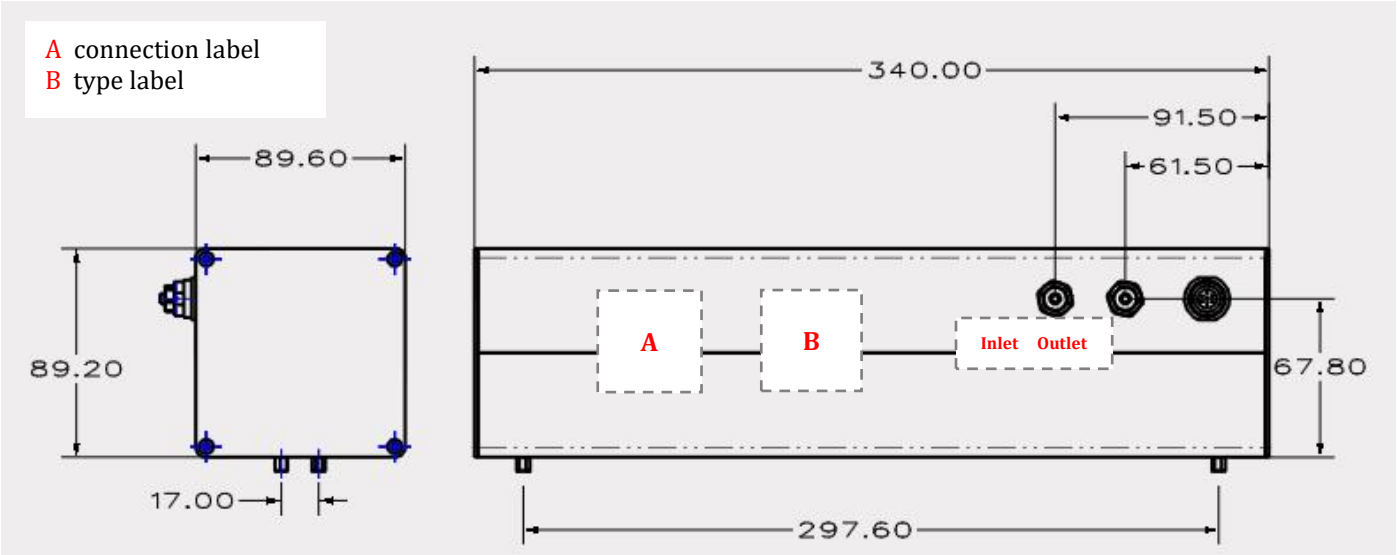


Figure 19 Mechanical dimension Case Type D

13 INDICATOR LEDS

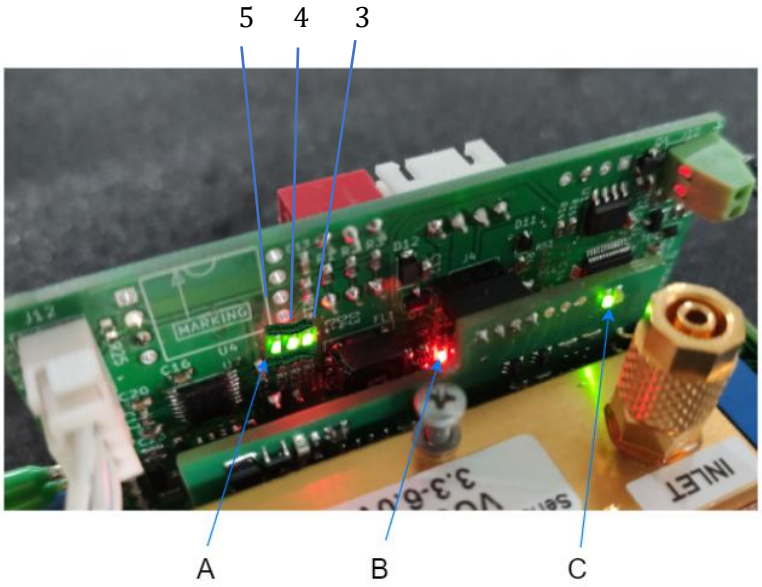


Figure 20 LED indication of **smartGAS Flow^{EVO}-plus**

LED	Description
A	smartGAS Flow^{EVO}-plus status LED（from Left to right LED5, LED4, LED3）
B	Indication of power
C	module status

LED5	LED4	LED3	Function	Action[1]	Code
OFF	OFF	OFF	initial error or initial not finish or is on going	AO=2mA/100mV	0x0000
OFF	OFF	ON	Module Error or loose connection	AO=2mA/100mV	0x0001
OFF	ON	OFF	zero or span calibration error	AO=2mA/100mV	0x0002
ON	OFF	OFF	temperature out of range	turn off heater/ AO=2mA/100mV	0x0003
ON	ON	ON	normal running	NONE	0x0007
flashing	flashing	flashing	in configuration mode（factory only）	AO=2mA/100mV	0x0008

[1] For option with analog interface, the analog output error state will be 2mA or 100mV

14 MODE SETTING

The **smartGAS Flow^{EVO}-plus** can work in several different mode.
The Mode setting has to be done by SW1 switch.

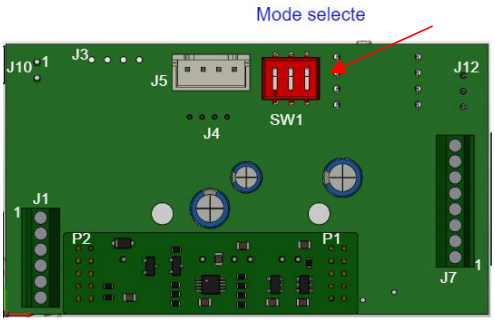


figure 3 SW1 position

After change the SW1, the **smartGAS Flow^{EVO}-plus** has to be repowered to take mode setting effect. During normal working, change the SW1 will not change the function mode until repower.	HINT

Generally, except the difference of RTU and ASCII, the difference between the modes are the register list and the commands type. **smartGAS Flow^{EVO}-plus** able to compatible to old product and lower version, for this reason there are several different working mode. But the kernal are same.	HINT

smartGAS Flow^{EVO}-plus cased has housing, typically user can not change the SW1 generally the initial mode was pre-defined in the order and set by factory.	HINT

The default working mode of **smartGAS Flow^{EVO}-plus** or **smartGAS Flow^{EVO}-plus cased** is **mode [1]**. Other modes have to be defined in order	HINT

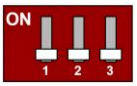
SW1	Working mode	Description	port config
	**【0】Free ASCII Print**	Print out concentration, temperature and message **automatic**. Support [1] **Standard modbus ASCII** Read 03, write 06	2400-115200 Auto baudrate Auto frame
	**【1】standard Modbus ASCII** (default mode)	**Standard modbus ASCII**, Read 03, write 06	2400-115200 Auto baudrate Auto frame
	**【2】standard Modbus RTU**	**Standard modbus RTU**, Read 0x03, write 0x06	2400-115200 Auto baudrate Auto frame
	**【3】SCII modbus RTU**	Compatible with S-CONNECT II RS485 modbus RTU. Read 0x03 or 0x04, write 0x06 or 0x10 two reg	9600，8，N，1
	**【12】EVO modbus ASCII**	EVO Modbus ASCII Compatible with FlowEVO protocol. Compatible with V1.0 cmd. Read 03, write 06.	2400-115200 Auto baudrate Auto frame
	**【23】EVO modbus RTU**	EVO Modbus RTU, compatibel to **smartGAS Calibration Tool** Compatible with FlowEVO protocol Compatible with V1.0 cmd. Read 0x03, write 0x06	2400-115200 Auto baudrate Auto frame

Figure 21 Modes of **smartGAS Flow^{EVO}-plus**

The support auto baudrate and frame types please refer „*Auto baudrate and auto frame*“.	HINT

14.1 MODE OPTION DESCRIPTION:

14.1.1 MODE 【0】 (FREE ASCII):



Set the SW1 all 0 will set to Free ASCII output.
After power on the default baud rate setting to print out string is 115200, 8, None, 1.
As soon as the right command is received, the device will automatically adapt to the user baud rate and frame.

The structure of output string:

SN of smartGAS FlowEVO-plus	Concentration	unit	temperature	degC	statusCode

Every string will start with ":" and separated by ";" and at last terminated with 0x0D 0xDA.

Example:
:2204-5610;69.2667;ppm;27.80;degC;0x0000;
:2204-5610;87.7192;ppm;27.80;degC;0x0000;

The default output frequency of string is 2Hz (500ms).
The status code details please refer chapter "*Indicator LED".*

14.1.2 MODE 【1】 (STANDARD MODBUS ASCII):

Set the SW1 as 1 will set to standard Modbus ASCII mode
In this mode user can use standard Modbus ASCII commands
The supported function codes are read 03 and write 06.

Baudrate setting: Auto baud rate auto frame.

Mode [1] General protocol description:
Read:

:	address	Function code 03	Start register	Data length	CheckSum-8N/LRC	\r	\n

Reply of read:

:	address	Function code 03	Byte length	data	CheckSum-8N/LRC	\r	\n

Example to read out the register 0x000F:
Send:
:0103000F0001EC\r\n
Reply:
:0103020000FA\r\n

Write:

:	address	Function code 06	register	Data	CheckSum-8N/LRC	\r	\n

Reply of write:

:	address	Function code 06	register	Data	CheckSum-8N/LRC	\r	\n

Example to write 1234 to register 0x000F:
Send:
:0106000F04D214\r\n
Reply:
:0106000F04D214\r\n

Available register list please refer appendix.	HINT

Min. delay between write commands is 20ms.	HINT

14.1.3 MODE【2】(STANDARD MODBUS RTU):

Set the SW1 as 2 will set to standard Modbus RTU mode
In this mode user can use standard Modbus RTU commands
The supported function codes are 0x03 and 0x06.

Baudrate setting: Auto baud rate auto frame.

Mode [2] General protocol description:
Read:

address	Function code 0x03	Start register	Data length	CRC16 Modbus

Reply of read:

address	Function code 0x03	Byte length	data	CRC16 Modbus

Example to read out the register 0x000F:
Send:
0x01 0x03 0x00 0x0F 0x00 0x01 0xB4 0x09
Reply:
0x01 0x03 0x02 0x00 0x00 0xB8 0x44

Write:

address	Function code 06	register	Data	CRC16 Modbus

Reply of write:

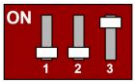
address	Function code 06	register	Data	CRC16 Modbus

Example to write 1234 to register 0x000F:
Send:
0x01 0x06 0x00 0x0F 0x04 0xD2 0x3B 0x54
Reply:
0x01 0x06 0x00 0x0F 0x04 0xD2 0x3B 0x54

Available register list of this mode please refer appendix.	HINT

Min. delay between write commands is 20ms.	HINT

14.1.4 MODE【3】(SCII MODBUS RTU):



Set the SW1 as 3 will set to SCII Modbus RTU mode.
This mode is compatible with previous S-CONNECT II RS485 Interface Modbus RTU protocol

Baudrate setting: 9600，8，None，1.
This Baud rate setting is fix

Available register list of this mode please refer appendix.	HINT

14.1.4.1 Basics

- Every Address is 2 Byte
- 30001 (4 Byte) read only — is the corresponding register of reading concentration
- 30003 (4 Byte) read only — is the corresponding register of reading the sensor temperature
- 30005 (2 Byte) read only — is the corresponding register of reading the sensor status
- 40001 (2 Byte) — is the register used for zero calibration
- 40002 (4 Byte) — is the register used for span calibration (from V1.1)
- 40004 (2 Byte) — Selector for 4 or 20mA Calibration Mode (from V1.1)
  - 0x01 4mA Calibration Mode
  - 0x02 20mA Calibration Mode
  - 0x00 Turn off calibration Mode (default after reset)
- 40007 (4 Byte) — Set concentration value regarding 4mA (from V1.1)
- 40009 (4 Byte) — Set concentration value regarding 20mA (from V1.1)
- 40013 (4 Byte) — Current Calibration value of 4/20mA (from V1.1)
- Error Codes
  - 0x86 Defined as Write Error
  - 0x84 Defined as Read Error
  - 0x90 Defined of Write Error multiple consecutive registers command
- The reading frequency is 500 ms
- Communication parameters 9600, 8, 1, None
- Equipment address 0x01
- RS485 interface communication
- Value conversion as specified by IEEE754
  https://www.h-schmidt.net/FloatConverter/IEEE754.html
  Sample :
  https://people.eecs.berkeley.edu/~wkahan/ieee754status/IEEE754.PDF
- CRC 16 ModBus
  http://www.ip33.com/crc.html
  Sample :
  https://ctlsys.com/support/how_to_compute_the_Modbus_rtu_message_crc/

14.1.4.2 Read Concentration Command

Send: 01 04 00 00 00 02 71 CB
0x01 Equipment address
0x04 Read Command
0x00 Data Address (H)
0x00 Data Address (L)
0x00 Data Byte (H)
0x02 Data Byte (L) (2 register : 4 Byte have to be read)
0x71 CRC L
0xCB CRC H

Read concentration command return

Receive 01 04 04 42 82 33 33 1B 31 (Sample use the value 65.1)
0x01 Equipment address
0x04 Read Command OK (0x84 Read Command Error)
0x04 Return Byte Count
0x42 Data Byte 1 (H) Float Value of concentration in [ppm/Vol.%/LEL..] according to IEEE754
0x82 Data Byte 2
0x33 Data Byte 3
0x33 Data Byte 4 (L)
0x1B CRC Low byte
0x31 CRC High Byte

The data bytes in this sample, 0x42 0x82 0x33 0x33 have to be converted by IEEE754 into the value of 65.1

14.1.4.3 Read Module Temperature Command

Send: 01 04 00 02 00 02 D0 0B
0x01 Equipment address
0x04 Read Command
0x00 Data Address (H)
0x02 Data Address (L)
0x00 Data Byte (H)
0x02 Data Byte (L) (Two register have to be read)
0xD0 CRC L
0x0B CRC H

Read Module Temperature command return

Receive 01 04 04 DB1 DB2 DB3 DB4 CRCL CRCH
0x01 Equipment address
0x04 Read Command OK (0x84 Read Command Error)
0x04 Return Byte Count
DB1 Data Byte 1 (H) Float Value of temperature in [°C] according to IEEE754
DB2 Data Byte 2
DB3 Data Byte 3
DB4 Data Byte 4 (L)
CRCL CRC Low byte
CRCH CRC High Byte

The current temperature has to be converted from DB1 DB2 DB3 DB4 by IEEE754 into the float value as XX.X C°

14.1.4.4 Read Module Status Command

Send: 01 04 00 04 00 01 70 0B
0x01 Equipment address
0x04 Read Command
0x00 Data Address (H)
0x04 Data Address (L)
0x00 Data Byte (H)
0x01 Data Byte (L) (One register have to be read)
0x70 CRC L
0x0B CRC H

Read Module Status command return

Receive 01 04 02 DB1 DB1 CRCL CRCH
0x01 Equipment address
0x04 Read Command OK (0x84 Read Command Error)
0x02 Return Byte Count
DB1 Data Byte 1 (H)
DB2 Data Byte 2 (L)
CRCL CRC Low byte
CRCH CRC High Byte

For the function of Status Bits in in the two bytes DB1 DB2 please refer to Flow^{EVO} Manual	HINT

14.1.4.5 Zero Calibration Command

Send: 01 06 00 00 00 01 48 0A
0x01 Equipment address
0x06 Write Command
0x00 Data Address (H)
0x00 Data Address (L)
0x01 Data Byte Count
0x48 CRC L
0x0A CRC H

Zero Calibration command return

Receive 01 06 00 00 00 01 48 0A
0x01 Equipment address
0x06 Write Command (0x86 Write Command Error)
0x00 Data Address (H)
0x00 Data Address (L)
0x01 Data Byte Count
0x48 CRC L
0x0A CRC H

After receiving the Zero Calibration return command by the host, the host shall delay 500ms ~ 1000ms until calibration completed before sending next command	HINT

14.2 Span Calibration Command

Send: 01 10 00 01 00 02 04 41 A9 00 00 26 7D (Sample use reference gas value of 200ppm)
0x01 Equipment address
0x10 Write Command multiple register
0x00 Data Address (H)
0x01 Data Address (L)
0x00 data numbers(H)
0x02 data numbers (L)
0x04 data bytes number
0x41 Data 1 Byte (H)
0xA9 Data 1 Byte (L) (The value of 200)
0x00 Data 2 Byte (H)
0x00 Data 2 Byte (L)
0x26 CRC (L)
0x7D CRC (H)

Span Calibration command return

Receive 01 10 00 01 00 02 10 08

0x01	Device address	
0x10	Write multiple consecutive registers command	(0x90 write command error)
0x00	start data address (H)	
0x01	start data address(L)	
0x00	data numbers(H)	
0x02	data numbers (L)	
0x10	CRC L	
0x08	CRC H	

After receiving the Zero Calibration return command by the host, the host shall delay 500ms ~ 1000ms until calibration completed before sending next command	HINT

14.3 SET 4..20MA INTERFACE CALIBRATION MODE COMMAND

14.3.1 SET TO 4MA CALIBRATION MODE

Send	01 06 00 03 00 01 B8 0A		Receive	01 06 00 03 00 01 B8 0A	
	0x01	device address		0x01	device address
	0x06	write command		0x06	write command (0x86 write error)
	0x00	data address (H)		0x00	data address(H)
	0x03	data address(L)		0x03	data address(L)
	0x00	data(H)		0x00	data(H)
	0x01	data (L) (1 defined as 4mA Mode)		0x01	data (L)
	0xB8	CRC L		0xB8	CRC L
	0x0A	CRC H		0x0A	CRC H

14.3.2 SET TO 20MA CALIBRATION MODE

Send	01 06 00 03 00 02 F8 0B		Receive	Receive 01 06 00 03 00 02 F8 0B	
	0x01	device address		0x01	device address
	0x06	write command		0x06	write command (0x86 write error)
	0x00	data address (H)		0x00	data address(H)
	0x03	data address(L)		0x03	data address(L)
	0x00	data(H)		0x00	data(H)
	0x02	data (L)2 defined as 20mA Mode		0x02	data (L)
	0xF8	CRC L		0xF8	CRC L
	0x0B	CRC H		0x0B	CRC H

14.3.3 RESET CALIBRATION MODE TO DEFAULT FUNCTION

Send	01 06 00 03 00 00 79 CA		Receive	Receive 01 06 00 03 00 00 79 CA	
	0x01	device address		0x01	device address
	0x06	write command		0x06	write command (0x86 write error)
	0x00	data address (H)		0x00	data address(H)
	0x03	data address(L)		0x03	data address(L)
	0x00	data(H)		0x00	data(H)
	0x00	data (L)0 definde as default		0x00	data (L)
	0x79	CRC L		0x79	CRC L
	0xCA	CRC H		0xCA	CRC H

14.3.4 MODE【12】(EVO COMPATIBLE MODBUS ASCII):

Set the SW1 as 12 will set to Flow^{EVO} compatible Modbus ASCII mode
In this mode the user can use EVO modbus ASCII commands
The supported function codes are read 03 and write06.
In this mode the user can access in the Flow^{EVO} compatible registers

Baudrate setting: Auto baudrate auto frame.

Available register list of this mode please refer appendix.	HINT

More info. about this **Flow^{EVO}** compatible Modbus ASCII protocol please refer to the **Flow^{EVO}** *M*anual	HINT

14.3.5 MODE【23】(EVO COMPATIBLE MODBUS RTU):

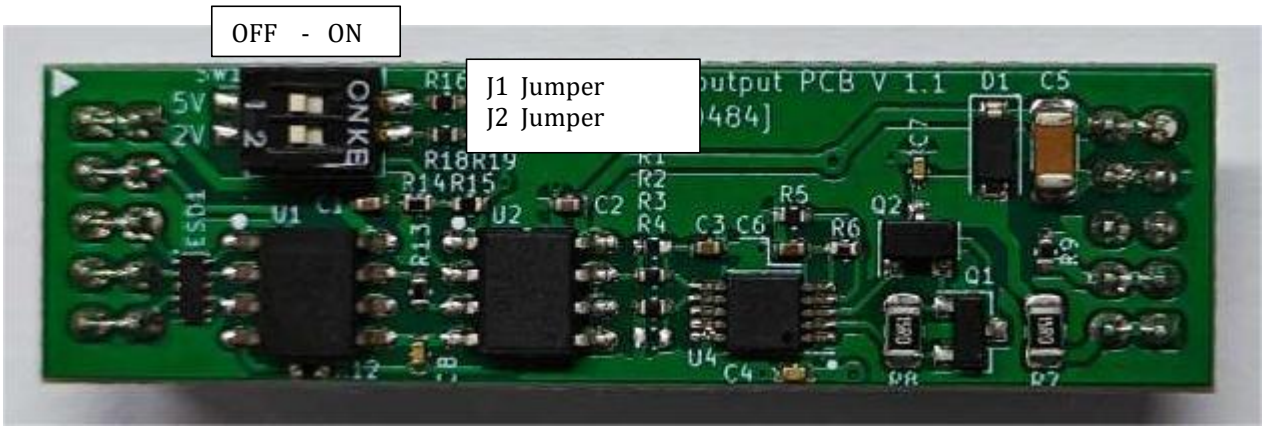
Selecting SW1 as 23 will set to Flow^{EVO} compatible Modbus RTU mode
In this mode user can use EVO modbus RTU commands
The supported function codes are read 0x03 and write 0x06.
In this mode, user can access in the Flow^{EVO} compatible registers
This mode is not supported by the **smartGAS Calibration or Service tool**.

Baudrate setting: Auto baudrate auto frame.

Available register list of this mode please refer appendix.	HINT

More info. about this Flow^{EVO} compatible Modbus RTU protocol please refer to the **Flow^{EVO}** *M*anual	HINT

15 Analog Interface Setting



J1	J2	Configuration A	Configuration B
Off	Off	0-10VDC (default)	2-10VDC default)
Off	On	0-2VDC	0.4-2VDC
On	Off	0-5VDC	1-5VDC

16 Power on and Initial

After power on, it will process several initial check and configuration and print out the info.
This initial process is same for all modes.

To receive the correct initial info, please set you receiver side interface with right baud rate refer mode.
The initial port setting is 115200,8,N,1(except mode[3] is 9600).
As soon as a right commands received, will adapt to the target port setting
The supported auto baudrate and frame please refer "*Auto baudrate and auto frame*".
The initial print out string as following text:

FlowEVO+ V1.1
SN:2230-1111
Addr: 0x04
DIPSW1: 12
Module init...
checking 0x04...0x04 ok
Module sVer:5.23
Module SN:52-1800-004
Module FS: 2500 Vol% x0.001000
Module speed fast.
KFr=0.046382
AO Data Range: 0.00 ... 2.500000
init done.

Generally the initial process need <10s if no error occurs.
Any initial problem will cause reboot or error hold and print out error log, and same time turn LED to corresponding status.

HINT

17 WARMUP

It is recommended to feed gas during power on to ensure to support the warm-up process.

The min. warm-up time is 10min.
The max. warm-up time will <30min.

The Warmup Time and Stability Result depend directly on the environment temperature, it‘s stability and the used thermal isolation Any direct temperature change has to be prevented like heating devices beside or direct fan blowing as well as high environment temperature changes	

The warmup status can be read out from register 0x0042 (mode[0][1][2]) or register 0xA042 (mode[12][23]).
if data=0 shows still in warmup
if data=1 shows warmup done by temperature
if data=2 shows warmup finish by reach max. time.

DO Not calibrate the product during warm-up period, otherwise can get a wrong calibration result.	

The PID regulator for heater was configured @24VDC. For low ambient temperature or fast warmup application, please use 24VDC power supply Lower power supply voltage will reduce the heater power	

18 EXAMPLE COMMANDS TO READ OUT THE CONCENTRATION

Read out the gas **concentration**:

Mode	Register for Concentration	Example commands to read out the concentration (Address =0x01)
Mode [0] Free print	Same as Mode [1]	The values will be printed out automatically.
Mode [1] Standard modbus ASCII	standard reg: 0x0156 float Low word 0x0157 float High word	Send→ :010301560002A3\r\n Reply← :010304FC2742D9BA\r\n The data is 0x42D9FC27 =108.992485046 ppm
Mode [2] Standard modbus RTU	standard reg: 0x0156 float Low word 0x0157 float High word	Send→ 0x01 0x03 0x01 0x56 0x00 0x02 0x25 0xE7 Reply← 0x01 0x03 0x04 0xA8 0xC8 0x42 0xE8 0x6B 0x43 The data is 0x42E8A8C8 =116.329650879 ppm
Mode [3] SCII modbus RTU	SCII reg: (30001) 0x0000 float High word 0x0001 float low word	Send→ 0x01 0x04 0x00 0x00 0x00 0x02 0x71 0xCB Reply← 0x01 0x04 0x04 0x43 0x0B 0xD8 0x47 0x85 0xF0 The data is 0x430BD847 =139.844833374 ppm Please Note: Mode [3] shall set port to 9600,8,N,1
Mode [12] EVO compatible modbus ASCII	EVO reg: 0x000A (conc. with factor)	Send→ :0103000A0001AA\r\n Reply← :01030200290F\r\n The data is 0x0029 = 41 Concentration=41/factor=0.041 Vol% The factor stored in register 0x004F. Details please refer user manual of FlowEVO.
Mode [23] EVO compatible modbus RTU	EVO reg: 0x000A (conc. with factor)	Send→ 0x01 0x03 0x00 0x0A 0x00 0x01 0xA4 0x08 Reply← 0x01 0x03 0x02 0x00 0x20 0xB9 0x9C The data is 0x0020 = 32 Concentration=32/factor=0.032 Vol% The factor stored in register 0x004F. Details please refer user manual of FlowEVO.

19 CALIBRATION

In several applications, a first calibration of the sensor is necessary after the initial operation or in periodically intervals.

19.1 ZERO-CALIBRATION

Please do only process the zero calibration
+ with the correct zero gas
+ constant gas flow
+ after at least 30min power on and warm up during zero gas flow
otherwise there will be measurement errors afterwards.

Use right command to write data 0x0001 into the zero calibration register to start the zero calibration process.
If the right command received, it will replay the same command.
Under different mode, the commands can be different, please send right command refer your working mode.

The register for zero calibration:

Mode	Register for zero cal.	Example command to calibrate zero and the reply (Address =0x01)
Mode [0] Free print	Same as Mode [1]	Same as Mode [1]
Mode [1] Standard modbus ASCII	standard reg: 0x0151	Send→ :010601510001A6\r\n Reply← :010601510001A6\r\n
Mode [2] Standard modbus RTU	standard reg: 0x0151	Send→ 0x01 0x06 0x01 0x51 0x00 0x01 0x18 0x27 Reply← 0x01 0x06 0x01 0x51 0x00 0x01 0x18 0x27
Mode [3] SCII modbus RTU	SCII reg: (40001) 0x0000	Send→ 0x01 0x06 0x00 0x00 0x00 0x01 0x48 0x0A Reply← 0x01 0x06 0x00 0x00 0x00 0x01 0x48 0x0A
Mode [12] EVO compatible modbus ASCII	EVO reg: 0x0047	Send→ :010600470001AD\r\n Reply← :010600470001AD\r\n
Mode [23] EVO compatible modbus RTU	EVO reg: 0x0047	Send→ 0x01 0x06 0x00 0x47 0x00 0x01 0xF8 0x1F Reply← 0x01 0x06 0x00 0x47 0x00 0x01 0xF8 0x1F

At mode [0], if right command received
it will pause the free print out string and switch to mode[1] for 5s
If no more commands received within 5s, it will auto switch back to free print mode.

HINT

19.2 SPAN-CALIBRATION

Please ensure the correct SPAN Gas is in use.
Please follow the span calibration requirements, otherwise there will be measurement errors afterwards.

To ensure the calibration accuracy, before span calibration, we strongly recommend to do zero calibration first in any case.

Use right command to write reference concentration to the span calibration register to start the span calibration procedure
If the correct command received, it will replay the same command.
Under different mode, the commands can be different, please send right command refer your mode setting.

The register for span calibration:

Mode	**Register for span cal.**	**Example steps and commands to calibrate span and the reply (Address =0x01)**
Mode [0] Free print	Same as Mode [1]	Same as Mode [1]
Mode [1] Standard modbus ASCII	standard reg: 0x015A float Low word 0x015B float High word	Cal. to ref. gas 100.0ppm, data=0x42C80000 (IEE754 float) Send→ :0106015A00009E\r\n Reply← :0106015A00009E\r\n Waite 20ms Send→ :0106015B42C893\r\n Reply← :0106015B42C893\r\n
Mode [2] Standard modbus RTU	standard reg: 0x015A float Low word 0x015B float High word	Cal. to ref. gas 100.0ppm, data=0x42C80000 (IEE754 float) Send→ 0x01 0x06 0x01 0x5A 0x00 0x00 0xA8 0x25 Reply← 0x01 0x06 0x01 0x5A 0x00 0x00 0xA8 0x25 Waite 20ms Send→ 0x01 0x06 0x01 0x5B 0x42 0xC8 0xC8 0xD3 Reply← 0x01 0x06 0x01 0x5B 0x42 0xC8 0xC8 0xD3
Mode [3] SCII modbus RTU	SCII reg: (40002) 0x0001 float High word 0x0002 float low word	Cal. to ref gas 100.0 ppm, data=0x42C80000 (IEE754 float) Send→ 0x01 0x10 0x00 0x01 0x00 0x02 0x04 0x42 0xC8 0x00 0x00 0xA7 0xE5 Reply← 0x01 0x10 0x00 0x01 0x00 0x02 0x10 0x08 (details please refer appendix)
Mode [12] EVO compatible modbus	EVO reg: 0xF001(ref gas conc x1)	Cal. to ref gas 100ppm, use x1 register, data=100:

ASCII	or 0xF002 (ref gas conc x10) or 0x0054(EVO span)	Send→ :0106F001006498\r\n Reply← :0106F001006498\r\n Or, cal. to ref gas 100.0ppm, use x10 register, data=1000: Send→ :0106F00203E881\r\n Reply← :0106F00203E881\r\n Handle of 0x0054 please refer manual of Flow^{EVO}.
Mode [23] EVO compatible modbus RTU	EVO reg: 0xF001(ref gas conc x1) or 0xF002 (ref gas conc x10) or 0x0054(EVO span)	Cal. to ref gas 100ppm, use x1 register, data=100: Send→ 0x01 0x06 0xF0 0x01 0x00 0x64 0xEA 0xE1 Reply← 0x01 0x06 0xF0 0x01 0x00 0x64 0xEA 0xE1 Or, cal. to ref gas 100.0ppm, use x10 register, data=1000: Send→ 0x01 0x06 0xF0 0x02 0x03 0xE8 0x1B 0xB4 Reply← 0x01 0x06 0xF0 0x02 0x03 0xE8 0x1B 0xB4 Handle of 0x0054 please refer manual of Flow^{EVO}.

At Mode [0], if right command received
It will pause the free print out string and switch to mode[1] for 5s
If no more commands received within 5s, it will auto switch back to free print Mode[0].

HINT

20 Analog Output Interface Calibration

Use mode [1] as example.

Step 1: write AO control data to register 0x00DC (mode[1])

Data	function	
0	No force out	
1	4mA	(of 4-20mA)
2	20mA	(of 4-20mA or 0-20mA)
3	0.4V	(of 0.4-2V)
4	2V	(of 0.4-2V or 0-2V)
5	1V	(of 1-5V)
6	5V	(of 1-5V or 0-5V)
7	2V	(of 2-10V)
8	10V	(of 2-10V or 0-10V)
9	Reset default	

The analog output of 0V or 0mA has not to be calibrated Only the values differ to 0zero need a calibration This means : If 0-20mA is used, only 20mA has to be calibrated	HINT

Example:
set force out 4mA, then data=1, the command is :010600DC00011C\r\n

Step 2: measure the AO output value by suitable multimeter.

Step 3: write measured value to register 0x00DD(low word) 0x00DE(high word)
these two register is the IEE754 float type.

Example:
Write 4.1mA to register, data is 0x40833333, the commands are:
:010600DD3333B6\r\n
:010600DE408358\r\n
Note: Please wait 20ms between two write commands.

Step 4: measure the AO output value by suitable multimeter.
Check if value is correct now. If not, please repeat step 2 and 3.

Step 5: write AO control data 0 to 0x00DC to exit the AO calibration force output.

For different mode, the registers can be different For details please refer register list in appendix. The calibration steps are same.	HINT

If the voltage output is selected , please convert the voltage to mA for the analog interface calibration. Typically, 1mA=50mV for analog range 4-20mA and 200-1000mV.	HINT

21 Change the concentration output range for analog value

The default output concentration range is
0 to FS for current range 4mA to 20mA
or
0 to FS for voltage range 200mV to 1000mV
user can change the default range by commands.
The related registers please refer appendix.

22 COMMUNICATION ADDRESS

The communication address can be found on product label.

In register 0x002C (mode [0][1][2]) or 0xA02C (mode [12][23]) is the communication address setting,
if the set value is 0x0000, the address value will be same as the value saved in FlowEVO register 0x00C0.
If the set value is 0x0001 to 0x00F7, the address value will be the set value.

The write change of Flow^{EVO} register 0x00C0 (mode[12] [23]) is not allowed this register is protected by smartGAS FlowEVO-plus.	HINT

23 RECOVERY TO FACTORY SETTING

smartGAS FlowEVO-plus and **smartGAS FlowEVO-plus cased** have a factory backup function
If any error or wrong setting happens, please make a recovery to factory backup setting.

Step 1: write user password 1234 (0x04D2) to register 0x000F (mode [0][1][2]) or 0xA00F (mode[12][23]).
Step 2: write control data 7(0x0007) to register 0x0011(mode [0][1][2]) or 0xA011 (mode[12][23]).
Then the string message "start recovery…" will be printed out
and the same time the recovery start, and if recovery ok it will reboot automatically.

DO NOT power off the product during the recovery! **DO NOT send other command when recovery start!**	DANGER

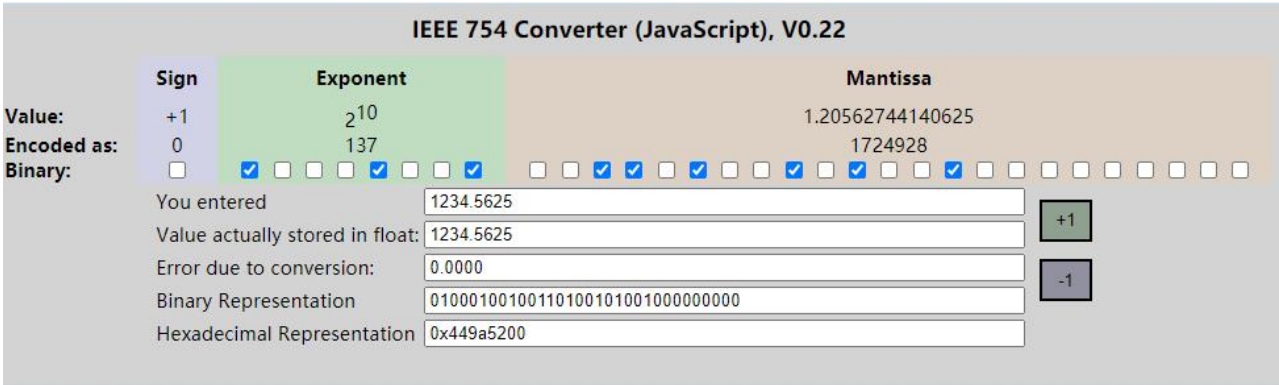
Mode [3] does not support the recovery function Please change the working mode to other mode to make recovery.	HINT

24 ABOUT THE FLOAT TYPE DATA

Under different working mode, the IEE754 float data can has different byte level sequence.
Please try to read out the reference data register of the working mode to check if your float handling is correct.

Details please refer register list in appendix.

One online tool for float data convert:
https://www.h-schmidt.net/FloatConverter/IEEE754.html



25 INDEPENDENT POWER SUPPLY FOR HEATER

The power of heater(J1-5) is internally short connected to main power supply (J7-1) by TP1(a jumper) by factory
If independent power supply to heater required, TP1 has to be disconnected.

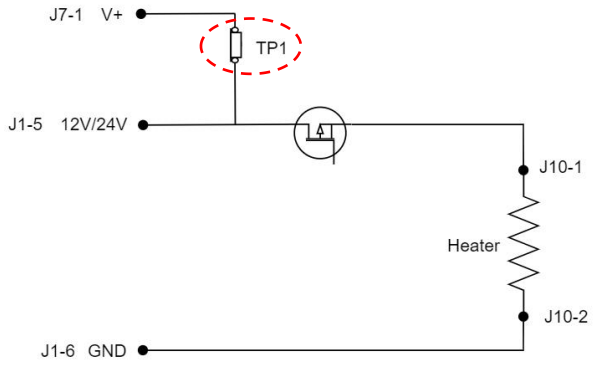
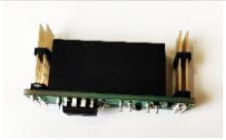


Figure 22 Independent Heater Power Configuration

26 ACCESSORY LIST

	Part name	Photo	Note
	Standard Sensor Connection Cable 1.5m Weipu SP1310/S7I w/o Clamps		For **smartGAS FlowEVO-plus** cased 1 white 2 brown 3 yellow 4 blue 5 gray or black 6 green 7 red
	Standard Sensor Connector Weipu SP1310/S7I		
	RS485/232 ConverterZLAN9223E DB9 Femal --- Screw Terminal		RS485 to RS232 converter
	USB RS232 Converter 9Pin Male HL340/Quarz 32/64bit		RS232 to USB converter
	RS232 DB9 female to screw terminal		
	EVOPlus Output Interface 4..20mA(isolated)		Analog output 4-20mA isolated 3KV module for smartGAS FlowEVO-plus This Interface can not be used inside standard cased FlowEVOPlus HINT
	EVOPlus Output Interface 4-20mA 0-2/5/10VDC		Analog output 4-20mA 0-2/5/10VDC (selectable) module for smartGAS FlowEVO-plus
	S-CONVERT RS232 / 1 Wire Modbus TTL Sub-D/PH 2.0		Need 5VDC Power Supply
	S-CONVERT RS232 / 1 Wire Modbus TTL PH2.0/PH 2.0		Need 5VDC Power Supply

27 APPENDIX

27.1 REGISTER FIELD DESCRIPTION

For different mode the register can be different, the general information about the register field access:
In mode[12] [23], to access in the standard register field, the standard RegN shall add a shift 0xA000.

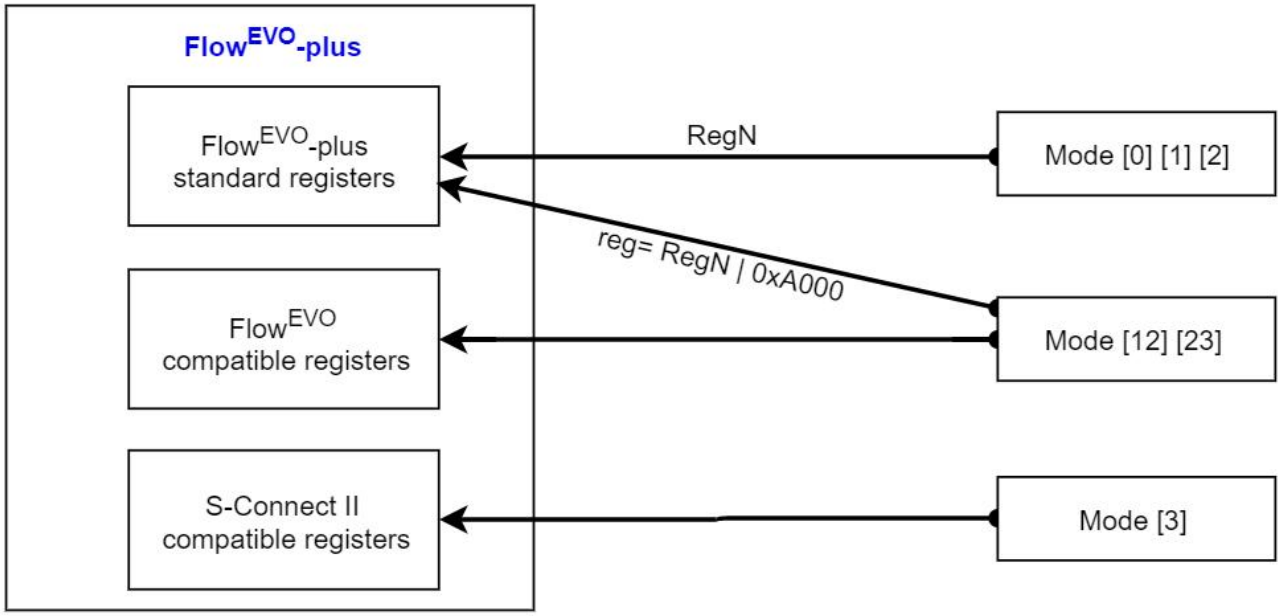


Figure 23 The register access under different mode

27.2 STANDARD REGISTER LIST OF SMARTGAS FLOWEVO-PLUS

smartGAS FlowEVO-plus standard register list							
Register index for Mode [0] [1] [2]	**Register index for Mode [12] [23]**	**Write /Read**	**Register Name**	**Description**	**Var Type**	**Var Value**	**range/value option/notes**
0x000D	0xA00D	R	B_flag1	message	uint16	0	refer LED mask, to clear the code, reboot required.
0x000F	0xA00F	W/R	B_key	Password	uint16		1234
0x0011	0xA011	W/R	B_ctr	usr control	uint16	0	0- NA 1- reboot 7- recovery from factory setting and save (password required)
0x0012	0xA012	R	B_sfr	usr control status flag This register is reboot auto clear type.	uint16	0	0x0008- rebooting… 0x0001- recovery ok.(hold state 2s, then reboot)
0x001E	0xA01E	R	B_f	test float	float Lw	1234.5625	reference float value for test
0x001F	0xA01F	R	B_f	test float	float Hw		
0x002A	0xA02A	W/R	COM_cycl	COM free printout cycle [ms]	uint16	500	time interval for mode [0] free print out range 100-10000ms
0x002C	0xA02C	W/R	COM_adr	COM address	uint16	0	communication address setting of smartGAS FlowEVO-plus Range 0x0000-0x00F7， default 0x0000 If value=0x0000, the address =FlowEVO reg 0x00C0 value.
0x0042	0xA042	R	WARM_Ready	warmup state	uint16	0	0- warmup not ready 1- warmup ok (by temperature) 2- warmup ok (by max time)
0x0052	0xA052	R	HEA_Tm	heater temp [°C]x100	int16	0	
0x0053	0xA053	R	HEA_Ts	heater set temp [°C] x100	uint16	4500	
0x0056	0xA056	R	HEA_sFlag	heater stable flag	uint16	0	0-not stable, 1- stable
0x00B6	0xA0B6	R	H_P_P	Pressure sensor p [kPa] x100	int16	0	(if pressure sensor exist)
0x00D5	0xA0D5	W/R	AO_lowC	AO low corresponding channel conc.	float Lw	0	reference concentration value for AO low default: 0
0x00D6	0xA0D6	W/R	AO_lowC	AO low corresponding channel conc.	float Hw	0	
0x00D7	0xA0D7	W/R	AO_highC	AO high corresponding channel conc.	float Lw	0	reference concentration value for AO high If value is 0 will set to FS.
0x00D8	0xA0D8	W/R	AO_highC	AO high corresponding channel conc.	float Hw	0	

0x00DC	0xA0DC	W/R	AO_CalTyp	AO1 calibration control	uint16	0	0- no action (default) 1- 4mA (of 4-20mA) 2- 20mA (of 0/4-20mA) 3- 0.4V (of 0.4-2V) 4- 2V (of 0.4-2V) 5- 1V (of 1-5V) 6- 5V (of 1-5V) 7- 2V (of 2-10V) 8- 10V (of 2-10V) 9- Clear AO cal set to no cali, state.
0x00DD	0xA0DD	W/R	AO_Calmess	AO cal measuring value [mA or V]	float Lw	0	Measured value of real AO output for calibration, value unit in mA or V.
0x00DE	0xA0DE	W/R	AO_Calmess	AO cal measuring value [mA or V]	float Hw	0	
0x0127	0xA127	R	M_Tmess	Module1 temperature [°C] x10	uint16	0	
0x012B	0xA12B	R	M_FS	Module1 concentration full scale with factor	uint16	0	The full scale of concentration *factor
0x012C	0xA12C	R	M_Unit	Module 1 unit	uint16	0	0 NA 1 ppm 2 Vol% 3 LEL%
0x012D	0xA12D	R	M_Fac	Module1 concentration factor	uint16	0	1, 10, 100, 1000, 10000…
0x012E	0xA12E	R	M_Typ	Module1 DeviceType	char duo	0	
0x012F	0xA12F	R	M_Typ	Module1 DeviceType	char duo	0	
0x0130	0xA130	R	M_Typ	Module1 DeviceType	char duo	0	
0x0131	0xA131	R	M_Typ	Module1 DeviceType	char duo	0	
0x0138	0xA138	R	M_fla	Module1 flag	uint16	0	
0x0151	0xA151	W/R	M_Cal0	zero calibration control	uint16	0	0- NA 1- cal zero
0x0155	0xA155	R	M_CalUsrEN	Module1 Cal user EN	uint16	1	1- EN, 0- OFF
0x0156	0xA156	R	M_CalUsrKonz	Concentration output	float Lw	0	the calibrated concentration(no factor)
0x0157	0xA157	R	M_CalUsrKonz	Concentration output	float Hw	0	
0x015A	0xA15A	W/R	M_UsrSPr	Module1 cal span ref	float Lw	0	span clibration reference gas concentration
0x015B	0xA15B	W/R	M_UsrSPr	Module1 cal span ref	float Hw	0	

27.3 FLOWEVO COMPATIBLE REGISTER LIST OF SMARTGAS FLOWEVO-PLUS

FlowEVO compatible register list							
Register index for Mode [0] [1] [2]	**Register index for Mode [12] [23]**	**Write /Read**	**Register Name**	**Description**	**Var type**	**Var value**	**range/value option/notes**
not support	0x0003	R	T_m	temperature [°C] x10	int16		
not support	0x0009	R	Flags	flags	uint16		
not support	0x000A	R	Conc	concentration with scaling factor	int16		
not support	0x0047	W/R	IR_4tagnew	zero point reference value	uint16		
not support	0x0059	R	Fac_zero_value	factory zero	uint16		
not support	0x004F	R	Unit	unit code and scaling factor for conc	uint16		
not support	0x0054	W/R	span	span reference vlaue	uint16		
not support	0x005A	R	Fac_span_value	factory span	uint16		
not support	0x00C0	R	adr	FlowEVO address	uint16		write not allowed by smartGAS FlowEVO-plus
not support	0xF001	W/R	spanrefx1	reference gas conc x1 for span cal	uint16		compatible to V1.0
not support	0xF002	W/R	spanrefx10	reference gas conc x10 for span cal	uint16		compatible to V1.0
	*more register of FlowEVO please refer FlowEVO manual, here not list all reg.						

27.4 S-CONNECT II RTU COMPATIBLE REGISTER LIST OF SMARTGAS FLOWEVO-PLUS

S-Connect II compatible MODBUS RTU register list						
Register index for Mode [3]	**Write /Read**	**Register Name**	**Var Description**	**Var type**	**Var value**	**Note**
0x0000	R	O_conc	mirror to 0x0157 M_CalUsrKonz	float Hw		function code 0x03
0x0001	R	O_conc	mirror to 0x0156 M_CalUsrKonz	float Lw		function code 0x03
0x0002	R	O_Tem	mirror to 0x0127 M_Tmess (cal)	float Hw		function code 0x03
0x0003	R	O_Tem	mirror to 0x0127 M_Tmess (cal)	float Lw		function code 0x03
0x0004	R	O_status	mirror to 0x0138 M_flag	uint16		function code 0x03
0x0000	W/R	O_zero	mirror to 0x0151 M_Cal0	uint16		function code 0x04,0x06,0x10
0x0001	W/R	O_span	mirror to 0x015B M_UsrSPr	float Hw		function code 0x04,0x06,0x10
0x0002	W/R	O_span	mirror to 0x015A M_UsrSPr	float Lw		function code 0x04,0x06,0x10
0x0003	W/R	O_AOctr	mirror to 0x00DC AO_CalTyp	uint16		function code 0x04,0x06,0x10
0x0006	W/R	O_AO4Var	mirror to 0x00D6 AO_lowC	float Hw		function code 0x04,0x06,0x10
0x0007	W/R	O_AO4Var	mirror to 0x00D5 AO_lowC	float Lw		function code 0x04,0x06,0x10
0x0008	W/R	O_AO20Var	mirror to 0x00D8 AO_highC	float Hw		function code 0x04,0x06,0x10
0x0009	W/R	O_AO20Var	mirror to 0x00D7 AO_highC	float Lw		function code 0x04,0x06,0x10
0x000C	W/R	O_AOcal	mirror to 0x00DE AO_Calmess	float Hw		function code 0x04,0x06,0x10
0x000D	W/R	O_AOcal	mirror to 0x00DD AO_Calmess	float Lw		function code 0x04,0x06,0x10
0x000F	W/R	O_Adr	mirror to 0x002C COM_adr	uint16		function code 0x04,0x06,0x10

28 FAQ[1]

28.1 My signal output is not stable

Make sure your power supply will drive enough current.

Please have a look if there is a limitation circuit active. The current will increase during warm up and heating.

Do not touch the PCB during operation.

Never blow directly to the sensor by a system build in fan.

Do not touch the PCB of Cuvette during operation.

Make sure the cuvette is not connected mechanical to electrical GROUND or Earth potential.

28.2 Could I leave out the LRC Checksum or CRC check

No. The correct check has to be send to the **smartGAS FlowEVO-plus** otherwise the **smartGAS FlowEVO-plus** will not accept the command.

28.3 How to clean smartGAS FlowEVO-plus inside

Never unscrew the cuvette otherwise the **smartGAS FlowEVO-plus** will be irreversible damaged.

If something like Oil is inside the cuvette please contact your local dealer to offer service.

If humidity condensed inside the **smartGAS FlowEVO-plus**, it mostly can dried by flowing with N_2 (dry) for longer(more than 1h).

If, after this procedure, the **smartGAS FlowEVO-plus** still not have stable function, please contact your local dealer to offer service.

28.4 Is there cross sensitivity to other gases

There is no cross sensitivity to N_2 and O_2 because these gases have no IR absorption in the used range.

If there is an abnormal high concentration of other gases you should give us an information to make a user calibration.

For bio gas applications please give an information to us.

These application needs special calibration

28.5 Is there EMI (Electro-Magnetic Interference) effect on smartGAS FlowEVO-plus

The **smartGAS FlowEVO-plus** includes high sensitive sensors.

It shall not placed directly beside eletrical machines, cable or transformers having a strong EMI field

The cuvette itself shall be isolated against other Ground Potential.

28.6 Can the uniformity guaranteed for each sensor

Yes, the uniformity is defined in accuracy. So, all sensors are in 1% or 2% accuracy depending on sensor Type

28.7 Will zero point Calibration influence linearity

No, it has no influence. Zero point calibration is just a shift. Did not have any effect on linearity as long as you use it in normal case

Note :

[1] FAQ : Frequently asked Questions

If you have a 0..10% sensor and make a zero calibration at 10% to get a 10% ..20% sensor than it will have an effect on linearity!

29 Additional Information

29.1 List of LEL (Lowest explosive Limit) LEL

Gas	LEL Lower Explosive Limit	UEL Upper Explosive Limit	OEL Occupational Exposure Limit
Acetylene/ C_2H_2	2,3 Vol% (24 g/m3)	82 Vol.-%	1000 ppm (1080 g/m^3)
Ammoniac / NH_3			20 ppm (14 g/m^3)
n-Butan / C_4H_{10}	1,4 Vol.-% (33 g/m^3)	9,4 Vol.-% (231 g/m^3)	800 ppm (1900 g/m^3)
Ethylene / C_2H_4	2,4 Vol.-%		10000 ppm (11500 g/m^3)
Carbon dioxide / CO_2	--	--	5000 ppm (9000g/m^3)
Carbon monoxide / CO	12 Vol.-%	75 Vol.-%	30 ppm (35 g/m^3)
Methane / CH_4	4,4 Vol.-% some Standards 5 Vol.-%	15 Vol.-%	10000 ppm (6700 g/m^3)
Propane / C_3H_8	1,7 Vol.-% some Standards 2,1 Vol.-%	10,1 Vol.-%	1000 ppm (1800 g/m^3)
Sulfur Hexafluoride / SF_6	--	--	1000 ppm (6000 g/m^3)
Ethanol / C_2H_6O	3 Vol.-%	19 Vol.-%	500 ppm (690 g/m^3)

Figure 24 List of LEL

29.2 Expressions of Terms

ppm	Parts Per Million
Vol.%	Vol.- % of Atmosphere
LEL	Lower Explosive Limit (German UEG)
UEL	Upper Explosive Limit (German OEG)
OEL	Occupational Exposure Limit (German MAK)
TTL	Transistor Transistor Logic Specification: 0 V and 0.4 V for a "low" and between 2.6 V and 5 V for a "high"
VDC	Volts - Direct Current
FAQ	Frequently asked Questions
PCB	Printed Circuit Board
N_2	Nitrogen
O_2	Oxygen

29.3 ASCII TABLE

Binary	Oct	Dec	Hex	Glyph	Binary	Oct	Dec	Hex	Glyph	Binary	Oct	Dec	Hex	Glyph
010 0000	040	32	20	␣	100 0000	100	64	40	@	110 0000	140	96	60	`
010 0001	041	33	21	!	100 0001	101	65	41	A	110 0001	141	97	61	a
010 0010	042	34	22	"	100 0010	102	66	42	B	110 0010	142	98	62	b
010 0011	043	35	23	#	100 0011	103	67	43	C	110 0011	143	99	63	c
010 0100	044	36	24	$	100 0100	104	68	44	D	110 0100	144	100	64	d
010 0101	045	37	25	%	100 0101	105	69	45	E	110 0101	145	101	65	e
010 0110	046	38	26	&	100 0110	106	70	46	F	110 0110	146	102	66	f
010 0111	047	39	27	'	100 0111	107	71	47	G	110 0111	147	103	67	g
010 1000	050	40	28	(	100 1000	110	72	48	H	110 1000	150	104	68	h
010 1001	051	41	29	)	100 1001	111	73	49	I	110 1001	151	105	69	i
010 1010	052	42	2A	*	100 1010	112	74	4A	J	110 1010	152	106	6A	j
010 1011	053	43	2B	+	100 1011	113	75	4B	K	110 1011	153	107	6B	k
010 1100	054	44	2C	,	100 1100	114	76	4C	L	110 1100	154	108	6C	l
010 1101	055	45	2D	-	100 1101	115	77	4D	M	110 1101	155	109	6D	m
010 1110	056	46	2E	.	100 1110	116	78	4E	N	110 1110	156	110	6E	n
010 1111	057	47	2F	/	100 1111	117	79	4F	O	110 1111	157	111	6F	o
011 0000	060	48	30	0	101 0000	120	80	50	P	111 0000	160	112	70	p
011 0001	061	49	31	1	101 0001	121	81	51	Q	111 0001	161	113	71	q
011 0010	062	50	32	2	101 0010	122	82	52	R	111 0010	162	114	72	r
011 0011	063	51	33	3	101 0011	123	83	53	S	111 0011	163	115	73	s
011 0100	064	52	34	4	101 0100	124	84	54	T	111 0100	164	116	74	t
011 0101	065	53	35	5	101 0101	125	85	55	U	111 0101	165	117	75	u
011 0110	066	54	36	6	101 0110	126	86	56	V	111 0110	166	118	76	v
011 0111	067	55	37	7	101 0111	127	87	57	W	111 0111	167	119	77	w
011 1000	070	56	38	8	101 1000	130	88	58	X	111 1000	170	120	78	x
011 1001	071	57	39	9	101 1001	131	89	59	Y	111 1001	171	121	79	y
011 1010	072	58	3A	:	101 1010	132	90	5A	Z	111 1010	172	122	7A	z
011 1011	073	59	3B	;	101 1011	133	91	5B	[	111 1011	173	123	7B	{
011 1100	074	60	3C	<	101 1100	134	92	5C	\	111 1100	174	124	7C	|
011 1101	075	61	3D	=	101 1101	135	93	5D	]	111 1101	175	125	7D	}
011 1110	076	62	3E	>	101 1110	136	94	5E	^	111 1110	176	126	7E	~
011 1111	077	63	3F	?	101 1111	137	95	5F	_					

Figure 25 ASCII Table