" IGM-DETECTOR " CO. LTD.

IGM-12
GAS DETECTOR

USER MANUAL

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Introduction

This document, hereafter User manual (UM), provides technical information, description of operation principles and service recommendations for IGM-12 gas detector (hereafter IGM-12).

Ensure that this UM is read and understood before installing / operating / maintaining the equipment. Pay particular attention to Warnings and Cautions are listed here and repeated where appropriate at the start of the relevant sections of this UM.

This manual is provided for informational purposes only. The information contained in this manual could include technical inaccuracies or typographical errors. Changes are periodically made to the information within this UM and incorporated without notice into subsequent revisions of the manual

Glossary:

CGM – calibration gas mixture

UM – User Manual

DU – Detection Unit

IS - intrinsically-safe

VDC - Volts of Direct Current

LED – Light Emission Diode

PCB – Printed Circuit Board

MCU – Microprocessor Control Unit

PSU – Power Supply Unit

1. Device description

IGM-12 is designed for automatic continuous measurement of the concentration of explosive hydrocarbon gases or carbon dioxide in the surrounding atmosphere.

Application area is explosive zones and zones near external technological installations with possible formation of explosive mixtures of gases and vapors.

Main features:

- Easy mounting and wiring.
- Bright four digit seven-segments LED display and 4 LED for status indication.
- Wide temperature range of operations.
- Wide range of output signals: RS-485/ 3 Relays/4-20 current loop/ HART
- Easy magnet calibration
- Microprocessor based transmitter and detection unit
- Self-diagnostics algorithm firmware.
- Stable optcal sensors technology.
- IP67 full resistance.
- Explosion proof type “d”.
- Power and cost effective solution.

IGM-12 is intended for stand-alone installation and provides transmitting of gas concentration readings by RS-485 MODBUS® digital output (see Appendix F for exchange protocol) as well as current loop output and HART output.

Current loop 4-20 mA output of IGM-12 meets the requirements of IEC 62056-21 / DIN 66258 standards with respect to the following parameters:

· Galvanic interface insulation;
· Max. current loop output load must be not more than 500 Ohm;
· Current loop output range is from 0.5 to 22±1 mA.

Current loop setup and readings are described in Appendix D.

NOTE: ***Only digital interfaces (RS-485 and HART) provides concentration readings without distortion, with precision according to Appendix A. For current loop signals has specified additional error that should not exceed 1% relative accuracy.***

IGM-12has three independent relays with the load capacity of (30V, 1A), switching over when alerting and alarm limits are exceeded as well as when some failure appears. RS-485 interface can adjust the concentration limits of relay switching.

IGM-12 has two magnetic setup, that allows to set up «0» and to scale up directly in the explosion hazardous area (See procedure in the appendix I).

The gas detector also has indicating light to show power supply voltage, excess of the range of measurement and self-diagnostic results according to the table 1.

Table 1 IGM-12 indication and output status

Mode	LEDs				LED display	Current output (mA)	Relay contacts		
	Green	Red	Yellow	Blue			«FAILURE»	«ALARM1»	«ALARM2»
1. No supply voltage	-	-	-	-	-	-	NO	NO	NO
2. Stand-by mode (measuring concentration)	on	off	off	…	concentration reading	4 ÷ 20	NC	NO	NO
3. Concentration is over alarm1 threshold	on	on	off	…	concentration reading	4 ÷ 20	NC	NC	NO
4. Concentration is over alarm2 threshold	on	blinks	off	…	concentration reading	4 ÷ 20	NC	NC	NC
5. Concentration is over 100% of measuring range	blinks	blinks	off	…	Concentration blinking (over 100% LEL readings)	22 ÷ 24	NC	NC	NC
6. Indication test	on	on	on	on	«8888» is highlightted	2	NO	NO	NO
7.Firmware information	on	blinks	off	off	Firmware version and CRC	2	NO	NO	NO
8. Warm-up	on	off	Blinks (Security Off)		«----» blimks	2	NC	NO	NO
9. Fault	off	off	on (disabled proofing)	…	Error code after E-symbol	3	NO	NO	NO

10. Fault 0x08 (in-trenal indica-tion net mulfunction)	off	off	on (disabled proofing)	…	«E08H» is highlighted	…	NO	NO	NO
11 RS-485 interconnection	…	…	…	on	…	…	…	…	…
12. Sensitivity to magnet	Off (on, in case of fault)	…	…	…	…	…	…	…	…
13. Режим градуировки и установки 0 с помо-щью магни-та	on	…	Blinks (Secu-rity Off)	…	«SPEC» is highlighted during 1 s 2. concentration reading	2	NC	NO	NO

2. Technical specification

General	**Gas sampling method:**	Diffusion
	Operating principle:	Non-Dispersive Infra-Red (NDIR)
	Target gas	CH_4
		C_3H_8
		C_2H_6
		C_nH_m (heavy hydrocarbons)
		$C0_2$
	Operating conditions:	
	Relative humidity	up to 98%
	Atmospheric pressure	80-120 kPa
	Temperature range	-60... +60 °C
	Storage and transportation conditions:	
	Relative humidity	up to 96%
	Atmospheric pressure	80-120 kPa
	Temperature range	-65... +60 °C
	Overall dimensions	240×200×130
	Weight	2,5 kg (AL)
		3,5 kg (AISI 316)
	Ingress Protection Rating	IP67 acc. IEC60529
	Housing	Aluminium
		Stainless steel (optional)
	Calibration	Digital RS485/ Front panel magnets
	Free fall	*IEC 68-2-32, 1000 mm*
	Vibration - sin	IEC 60068-2-6
	MTBF	10 000 hours
	Lifetime	15 years
Measurement	**Measurement range**	100%Vol (CH4 only)
		100%LEL
		2.5%Vol (C02)
	Accuracy	±0.1 % Vol or ±5 % of indication
		±3 % LEL or ±5% of indication
	Response time, $T_{0.9}$	10s
		30s
		60s
	Temperature performance	IEC 60079-29-1
	Pressure performance	

	Humidity performance	
Electrical	**Supply Voltage Range:**	12 ...32 VDC
	Indication:	4 LEDs front panel , 4 digit seven-segments LED display
	Output signals :	RS-485 Modbus RTU, 4-20 mA, 3 Relay output
	Power consumption:	<1 W (Temp>40 ºC), <11 W (Temp<40 ºC)
	Warm-up time:	not more than 60 s
	EMC	Severity level 2 EN/IEC 61000-4-6, EN/IEC 61000-4-11
Marking and standards		1Exd IIB T4 acc. to IEC60079-0, IEC60079-1, IEC60079-11

3. Delivery set

Table 2 Standard delivery set

Denomination	Quantity, pcs.
IGM-12 -X-X Gas detector	1
Ex-proof cable gland [1)]	1
Ex-proof cable plug	1
Package	1
IGM-12 Datasheet	1
IGM-12 User Manual [2)]	1
CGM Adapter [2)]	1
Magnet for calibration [2)]	1

[1)] Standard package. 2 cable glands in delivery available upon request.
[2)] In accordance to client request for group supply at the same address.

4. Description and operation

4.1 Principle of operation

The principle of sensor operation is based on NDIR technology.

Infrared radiation of the LED passed through the measuring gas diffusion cell and reaches the two of photodetectors, one of which detects radiation in the wavelength range of 3.25 to 3.45 um only, while the other one detects radiation in the wavelength range of 3.45 to 3.7 um. The analyzed gas that is present in the measuring cell absorbs radiation of the operating wavelength (λo) and does not affect radiation of the reference operating wavelength (λr)

. The amplitude *Io* of the light sensitive cell operating signal changes upon changing concentration in accordance with equation:

$$Ip/ Io = exp (- [K(\lambda o) - K (\lambda r)] CL); \quad (1)$$

where:

$K (\lambda)$ - coefficient of absorption at a given wavelength;
L - optical length of cell;
C - measured concentration of gas;
Ip, Io - amplitude of signals at light-sensitive cell.

The concentration of gas is:

$$C = -Ln (Ip/Io) /(L [K (\lambda r) - K (\lambda o)]); \quad (2)$$

Using differential dual wavelength method of registration allows eliminating influence of water steam, contamination of optical elements and other non-selective hindrances affecting both channels similarly.

4.2 Structure and functioning

The gas detector has the metal cylindrical housing, the cable glands for connecting external circuits and the optic sensor module are situated on the downside of this housing. The gas detector has LED lights indication of status and four digit seven-segments LED display.

The outline drawing of the gas detector is shown in the Appendix G.

Connection diagram is shown on the figure B.1 of the appendix B and is described in the chapter 9 of the present UM.

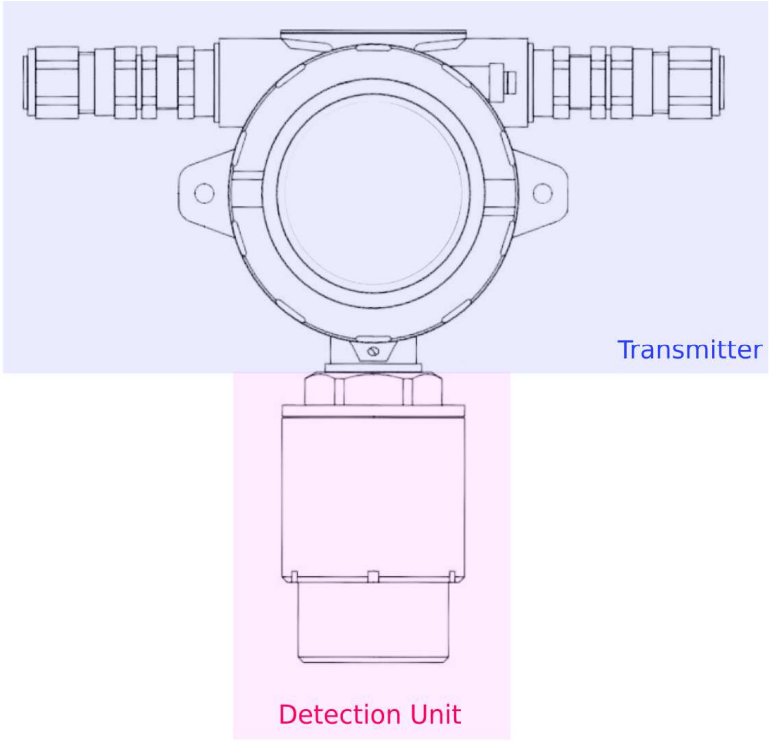


Fig. 1 IGM-12 construction parts.

DU comprise optical sensor and PCBs for converting UART digital input from sensor to current loop, RS-485 HART digital signals. DU contains MCU that reads data from sensor, stores calibration coefficients in flash memory and transfers obtained data to Transmitter.

Transmitter also consist MCU and provides indication of gas concentration on LED display and 4 status LEDs, converts data to RS-485 MODBUS RTU (see Appendix E for MODBUS-protocol description), controls supply voltage and relay output states.

IGM-12 has ability to connect HART-communication device to get the reading of concentration and basic controls of device (see Appendix E for HART-protocol description).

Current loop 4-20 mA output of IGM-12 meets the requirements of IEC 62056-21 / DIN 66258 standards with respect to the following parameters:

· Galvanic interface insulation;
· Max. current loop output load must be not more than 500 Ohm;
· Current loop output range is from 0.5 to 22±1 mA.

Current loop setup and readings are described in Appendix D.

NOTE: ***Only digital interfaces (RS-485 and HART) provides concentration readings without distortion, with precision according to Appendix A. For current loop signals has specified additional error that should not exceed 1% relative accuracy.***

5. Explosion proof

5.1 The gas detector has the following types of explosion protection: explosion-proof enclosure and ib-type intrinsically-safe electrical circuit sensor connection.
The explosion-proof marking is 1Exd IIB T4 acc. IEC 60079-0.
Explosion proof drawing of IGM-12 enclosure has shown in in Appendix C.

5.2 The gas detector explosion protection is achieved by:

- encasement of electronicparts in the flameproof enclosure with a slit field of explosion-proof coupling of parts and assemblies of the flameproof enclosure that can withstand explosion pressure and avoid the transmission of the explosion to the surrounding explosive atmosphere. The assembling of parts are noted in the drawing as "Grease" with acceptable parameters of explosion protection for flameproof screw joints: the number of complete turns of screw thread intact, axial length and thread pitch according to the requirements of IEC 60079-1-2011;
- Sealing the interface with the optic sensor according to requirements of IEC 60079-1;
- The explosion-proof cable glands for connecting to the external circuits;
- Protection from self-unfastening of all the elements fixing details that ensure explosion-protection of the gas detector;
- Mechanical strength of the gas detector encasement complying with the requirements of IEC 60079–0;
- Corrosion protection with the consistant lubricant of all surfaces sepcified as “Grease”;
- Limitation of heating temperature of all the gas detector external parts (100 ^{0}C);
- Intrinsically current circuit is acheaved by the limitation of current circuit parameters of the IS barrier of the power module and in the sensor interface to the intrinsic safe values according to IEC 60079-11;
- Providing with the necessary clearances and creepage paths as per IEC 60079-11;
- The caution plate on the gas detector housing "Do not open in the hazardous areas!"

X sign standing after the explosion-proof marking means that that the operation of the gas detector must comply with specific conditions.

6. Marking and sealing

Marking of the gas detector comprises:

- name and trademark of the manufacturer;
- name and designation of the gas detector;
- month and year of manufacture;
- gas detector number in the numbering system of the manufacturer;
- identification of technical specifications;
- measuring range;
- basic measurement error;
- designation of protection;
- warning notice "intrinsically safe";
- warning inscription "Do not open in hazardous areas!";
- IP code;
- operating temperature range;
- supply voltage parameters;
- power consumption;
- name of the certification body and the certificate number;
- GND sign.

7. Package

7.1 The gas detector and the operating documentation are packaged in a cardboard box. The cardboard box is glued over with the plastic tape with adhesive layer.

7.2 The overall dimensions of the package, mm – 300x250x180.

7.3 Represervation storage time:1 year.

8. Safety precautions

- Inspection and maintenance of the gas detector should be carried out by suitably trained personnel in accordance with the applicable code of practice (e.g. EN 60079-17).
- Any person who have studied this UM, have been briefed on safety precautions when operating electrical equipment intended for operation in the explosion-hazardous zones in the established order, is admitted to operate the gas detector.
- Repairing of the gas detector must be carried out only by the manufacturer's personnel or persons authorized by the manufacturer for repairs.
- Before switching on the gas detector, check the absence of external defects, safety of the seals, presence of all fasteners. It is prohibited to operate the gas detector when its housing is mechanically damaged and the seal is broken.
- The gas detector housing must be grounded. The ground bolt is foreseen to earth the gas detector.
- It is strongly prohibited to discharge the control gas mixture (CGM) to the atmosphere during the gas detector calibration and verification.

9. Special conditions of use

The special operation conditions marked with the sign X after explosion-proof marking include the following requirements:

- The gas detector operation and installation must be carried out by persons are informed of operation rules of electrical equipment in hazardous areas, who have studied the user manual, certified and authorized by the administration order for working with these products;
- Cabling in hazardous areas in accordance with the Installation Operating Procedures;
- During the operation the gas detector should be protected against bumps and falls;
- It is prohibited to use gas detector with damaged housing or sealing;
- Gas detector installation and connection must be carried out without power supply;
- Connecting of the power circuits of the interface must be performed according to fig. B.1 of Appendix B, the voltage must not exceed the values U_m:
  - for supply circuits U_m= 32 VDC
  - for interface circuits RS-485 MODBUS U_m= 12VDC.

The temperature at the entrance point can be upper than +100ºC at the maximum operating ambient temperature, so that you must apply the cable glands types such as E1FW, E1FX (or similar type). The cable to connect should be adopted to the acceptable temperature of his utilization, but not less than +120ºC.

10. Installation and Operation

10.1 Prepare to use

10.1.1. If the gas detector has been kept in the transportation package at temperature lower than 0^0C, hold it at the temperature of (10–35) ^{0}C for at least one hour.

10.1.2. Unpack gas detector. Check completeness, presence of the seals, the explosion-proof marking, ensure absence of mechanical injuries.

10.2 Operation procedure

The gas detector must have an external grounding.

The power and interface circuits should be connected according to the fig.B.1. of the Appendix B.

The connection should be carried out according to the instruction of the Appendix H.

NOTE:

The gas detector is supplied with wires to check the functionality before installation.

After the supply of external power to the gas detector the current of 4 mA is on its analog output (when using an analog output) or 0 concentration value when using a digital interface. After 2 minutes the gas detector automatically controls the content of combustible gases in the working area and its output displays the concentration in accordance with Appendix E or F

When combustible gas concentration achieves limit values, the gas detector performs indication and signalization according to the Table 1.

10.3 Maintenance

The technical maintenance is performed to ensure the normal operation of the gas detector during its operating life.

Recommended service types:

The technical maintenance reduces to the periodic exterior examination and to the zeroing of the gas detector.

The exterior examination aims to verify if there is any dust and impurities in the operation area of the gas detector, any mechanical damages of its structure as well as of the tie cables.

The cleaning of the gas detector body and metalceramic filter – once per year.

Control of normal operation is carried out automatically, the main faults are displayed in accordance with Table 1.

ATTENTION! To take off the gas detector in the zeroing mode and calibrate it the magnet "Setup 0" shall be kept during at least 2 sec. Yellow LED indicator should blink once in the mode of setup 0.

Zeroing and calibration of the gas detector are fullfiled once per two years when preparing to the control. Zeroing and the calibration are fullfiled according to the method (see appendix I). It is very important to carry out zeroing just after assembling the gas detector on the plant before putting into operation.

11. Transportation and storage

The transportation of the gas detectors should be performed by all means of transportation incovered transportation vehicles as well as in the heated pressurized plane compartments in accordance with the rules of cargoes transportation effective for the respective type of transportation.
The gas detectors in the Manufacturer's package should be kept in the Supplier's and Customer's storages under storage conditions pointed in Table 1. The atmosphere of storage premises should be free from harmful admixtures provoking corrosion.

12. WARRANTY

The Manufacturer guarantees compliance of the gas detector with specifications and requirements stated in this UM if Customer meets conditions of operation, transportation and storage.

During the warranty period, Customer has the right to get replace or repair of all the products that, according to its unquestionable valuation, are found to be defective, if defect is due to a fault of Manufacturer.

The warranty period is 24 months since the date of sensor shipment to a Customer.

Manufacturer is not responsible for the gas detector failure and warranty is void in case of:

- violations of conditions of operation, transportation and storage stated in UM;
- gas detector has marks of unauthorized repair;
- mechanical damages, appeared after handover the gas detector to Customer, effect of temperature and pressure beyond conditions, chemical erosion, ingress of foreign substances inside the body of the sensor;
- defects due to electrical interface unspecified by UM and other documentation conveyed to the Customer;
- defects due to force majeure circumstances, disastrous occurrences, intended or reckless act of Customer or third party;
- defect or failure due to installing, damaging, changing or erasing of gas detector firmware or changing gas detector settings because of misuse of service codes via RS-485.

Replacement or repair of defective gas detectors does not lead to setting a new warranty period.

The Manufacturer is not responsible for possible damages, direct or indirect inflicted to people or properties if this is happened in case of repair, storage and transportation rules violation or due to purport or reckless act of Customer or third party. The Manufacturer does not respond as well for possible damages, direct or indirect inflict to appropriate equipment as the result of change, damage or data loss.

The warranty repair or replacement is effecting in site of Manufacturer or designated representative.

Every shipping and packaging charge and any other incidental expenses if the products must be returned to Manufacturer will be at the Customer’s own risk and charged to them.

Appendix A

IGM-12 gas detectors types and characteristics configuration:

IGM-12– 01 A

a b c

a –Model name and number;

b –Part number as per target gas according to table A.1.

c- Housing material:

A – Aluminum enclosure;

S – Stainless steel enclosure.

Table A.1 – IGM-12 types, range and accuracy.

Gas detector part number	**Target gas**	**Full range (indication)**	**Measurement range**	**Accuracy**	
				Abs.	**Rel.**
IGM-12-01-X	methane (CH_4)	from 0 to 5% (from 0 to 100 % LEL)	from 0 to 2,5 % incl. (from 0 to 50 % LEL)	± 3 % LEL	-
			From 2,5 to 5 % (from 50 to 100 %LEL)	-	± 5 %
IGM-12-02-X	propane (C_3H_8)	from 0 to 1,7 % (from 0 to 100 % LEL)	from 0 to 0,85 % incl. (from 0 to 50 % LEL)	± 3 % LEL	-
			From 0,85 to 1,7 % (from 50 to 100 % LEL)	-	±5 %
IGM-12-03-X	n-hexane (C_6H_{14})	from 0 to 1,0 % (from 0 to 100 % LEL)	From 0 to 0,5 % (from 0 to 50 % LEL)	± 5 % LEL	-

IGM-12-04-X	carbon di-oxide (CO_2)	from 0 to 2,5 %	from 0 to 2,5 %	± 0,15 %	-
IGM-12-05-X	ethane (C_2H_6)	from 0 to 2,5 % (from 0 to 100 % LEL)	from 0 to 1,25 % (from 0 to 50 % LEL)	± 5 % LEL	-
IGM-12-06-X	n-butane (C_4H_{10})	from 0 to 1,4 % (from 0 to 100 % LEL)	from 0 to 0,7 % (from 0 to 50 % LEL)	± 5 % LEL	-
IGM-12-07-X	i-butane (i-C_4H_{10})	from 0 to 1,3 % (from 0 to 50 % LEL)	from 0 to 1,3 % (from 0 to 50 % LEL)	± 5 % LEL	-
IGM-12-08-X	pentan (C_5H_{12})	from 0 to 1,4 % (from 0 to 100 % LEL)	from 0 to 0,7 % (from 0 to 50 % LEL)	± 5 % LEL	-
IGM-12-09-X	ethylene (C_2H_4)	from 0 to 2,3 % (from 0 to 100 % LEL)	from 0 to 1,15 % (from 0 to 50 % LEL)	± 5 % LEL	-
IGM-12-10-X	propylene (C_3H_6)	from 0 to 2,0 % (from 0 to 100 % LEL)	from 0 to 1,0 % (from 0 to 50 % LEL)	± 5 % LEL	-
IGM-12-11-X	benzol (C_6H_6)	from 0 to 1,2 % (from 0 to 100 % LEL)	from 0 to 0,6 % (from 0 to 50 % LEL)	± 5 % LEL	-
IGM-12-12-X	acetone ($(CH_3)_2CO$)	from 0 to 2,5 % (from 0 to 100 % LEL)	from 0 to 1,25 % (from 0 to 50 % LEL)	± 5 % LEL	-

/ IGM-12-13-X	methanol (CH_3OH)	from 0 to 5,5 % (from 0 to 100 % LEL)	from 0 to 2,25 % (from 0 to 50 % LEL)	± 5 % LEL	-
IGM-12-14-X	methane (CH_4)	from 0 to 100 %	from 0 to 2,5 % incl.	± 0,1 %	-
			from 2,5 to 100 %	-	± 5 %

Table A.2 – Temperature performance

Gas detector part number	**Measurement range**	**Additional error limits in temperature range**		
		From -10ºC to 15ºC and from 25ºC to 40ºC	**From -40ºC to -10ºC and from 40ºC to 60ºC**	**From -60 ºC to -40ºC**
IGM-12-01-X … IGM-12-03-X and IGM-12-05-X…IGM-12-14-X (CnHm)	From 0 to 50 % LEL	± 5 % LEL	± 10 % LEL	± 15 % LEL
	From 50 to 100 % LEL	±10% Rel.	±20% Rel.	±30% Rel.
IGM 13 -04-X (CO_2)	From 0 to 2,0 % Vol..	± 0,2 % Vol..	Unspecified	Unspecified
	From 2,0 to 2,5 % Vol.	±10% Rel.		

Appendix B

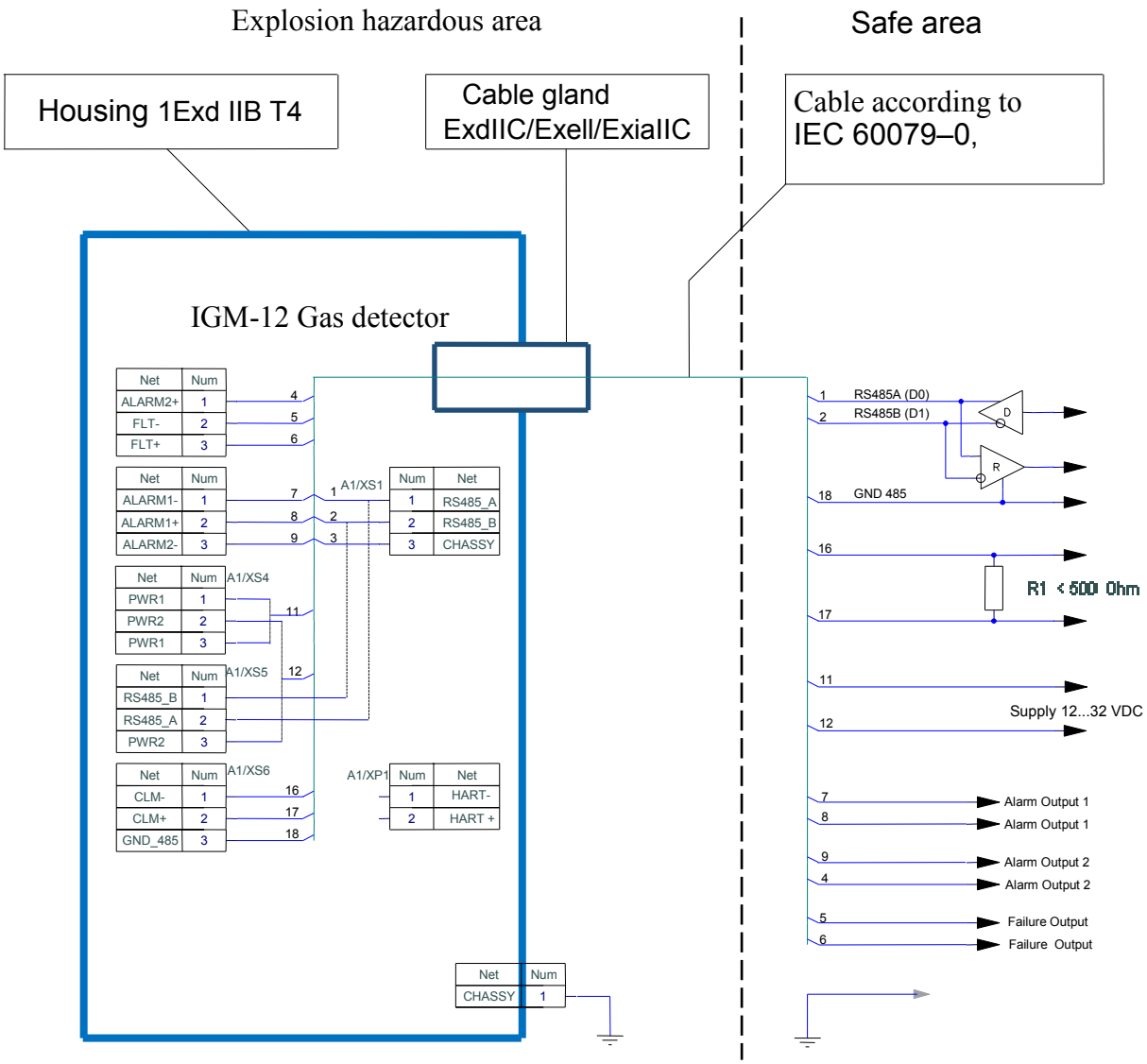
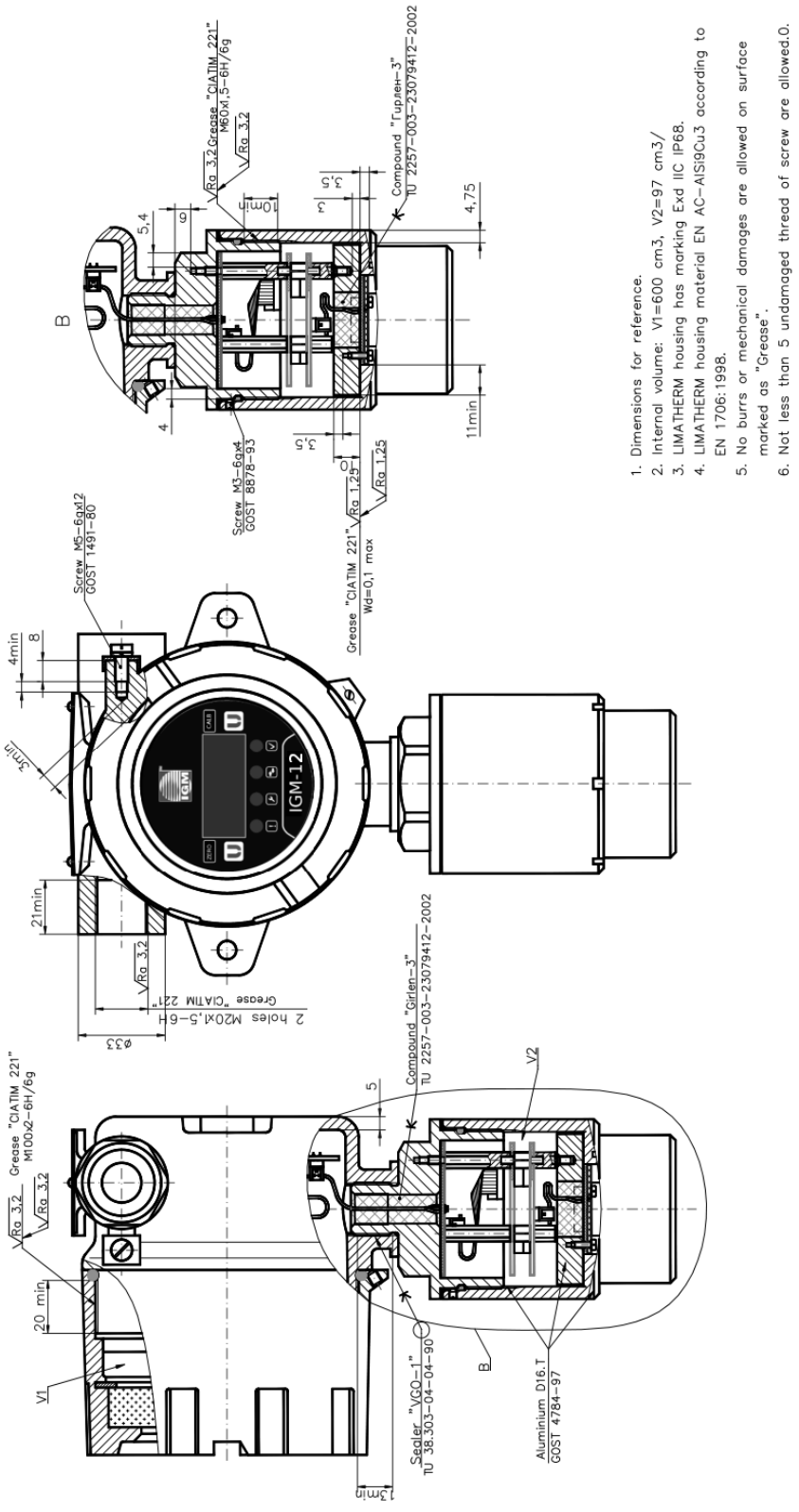


Figure B.1 – The connection diagram of IGM-12

NOTES:
1.External circuits assembling according to local norms and standards.
2. Plug pins 3 A1/XS4 and A1/XS5 are made for the standby power supply. With the same purpose than pins 1 and 2 A1/XS4
3. Plug pins 1 and 2 A1/XS5 are reserved for RS485 interface lines. With the same purpose than pins 2 and 1 A1/XS1
4. For RS485 load matching there is onboard termination resistor on PCB (see appendix G for details).
5. Plug pin A1/XP1 is used to connect the external HART-communicator. The HART-adaptor to make connection in the explosion hazardous area is supplied apart

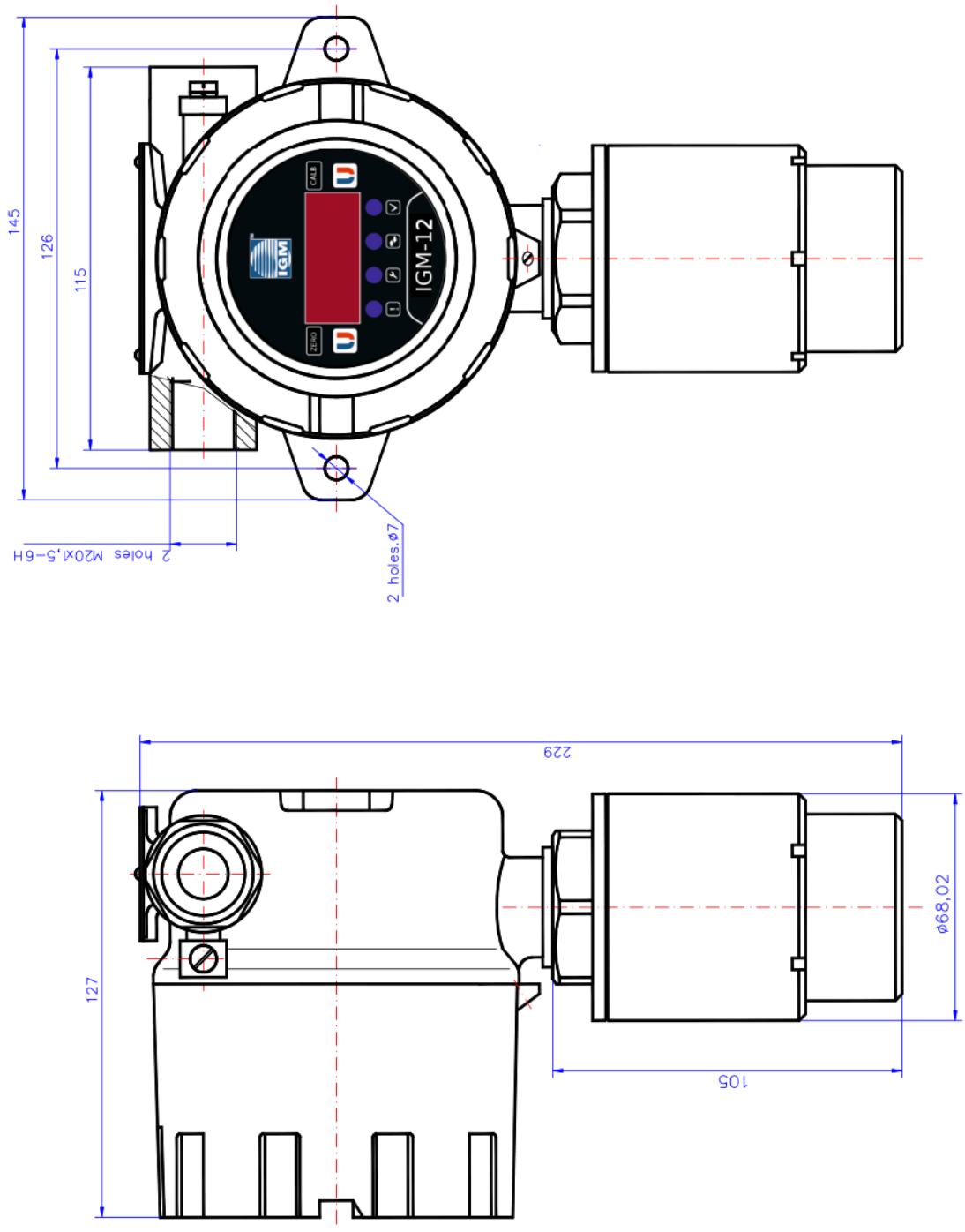
Appendix C

Figure C.1 –Explosion proof drawing of IGM-12 gas detector.



Appendix D

Figure D.1 - Overall dimension plan of IGM-12.



Appendix E

Current loop readings

Current loop output is dependence of electric current from the concentration of the measured component in accordance with:

$$I_{out} = 16 \cdot \frac{C_i}{C_{\max}} + 4; \quad \text{(E.1)}$$

where

I_{out} – output current, mA

C_i – measured concentration, %vol.

C_{max} – upper value of measuremet range in %vol corresponding to the 20 mA output current.

Gas concentration could be found as:

$$C = \frac{|I_j - I_0|}{\kappa}; \quad \text{(E.2)}$$

Where:

I_j –output current at the test point (mA);

I_0 – initial output current, 4 mA

κ – conversion factor:

$$\kappa = \frac{16mA}{C_{max} - C_{min}}; \quad \text{(E.3)}$$

Where:

C_{max} – maximal concentration of the measurement range as per table A.1 of appendix A;

$C_{min} = 0$ – minimal concentration of the measurement range (table A.1 of the appendix A).

Current loop MODBUS RTU setup

Equipment:

- PC with the USB / RS-485 interface (USB-RS485 adapter).
- Power supply unit (PSU).
- Multimeter.

Tools:

- Software with the MODBUS protocol options for PC.

Procedure:

1) Connect PSU to gas detector.
2) Connect RS-485 output to the appropriate PC port. Connect the current output – to the load.
3) Run Modbus software on PC. Find the device's address.
4) Switch gas detector to "emulation mode" by saving the value 0x0200 in the register №4. Indicated concentration value = 0.
5) Measure the indicated values of current loop. Save this value (in mcA*10) in the register №18 (for example, 4,15mA corresponds to the number 0415). The indicated values of current loop should be equal to 4mA.
6) Save the value corresponding to the upper-range concentration measure in the register №6. The indicated concentration values 0999.

7) Measure the indicated values of current loop. Save this value in the register №18 (for example, 20,10mA corresponds to the number 2010). The indicated values of TB should be equal to 20mA.
8) Switch over gas detector to the “stand-by” mode saving the value 0x0000 in the register №4.

Appendix F

MODBUS protocol

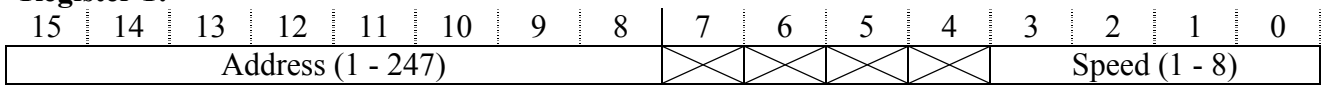
Interface: RS-485 (19200, 8-E-1).

Protocol: MODBUS RTU with following commands support:
- Reading from the gas detector. Command code: 03 (Read Holding Registers - Rd),
- Recording of a word in the gas detector. Command code: 06 (Write Single Register - Rc).

Registers of the gas detector (all 16-bit):

Register №	Register address	Description	Access	Type
1	0	Gas detector address / Interface settings	Rd/Rc	word
2	1	Serial № of the gas detector (high- low-order)	Rd	word
3	2	Serial № of the gas detector (low- high-order)	Rd	word
4	3	Gas type	Rd	word
5	4	Settings / Gas detector state	Rd/Rc	word
6	5	Gas detector failure code	Rd	word
7	6	Gas concentration,	Rd/Rc	word
8	7	Temperature, °C	Rd	word
9	8	Concentration values range	Rd/Rc	word
10	9	The first alarm concentration threshold	Rd/Rc	word
11	10	The second alarm concentration threshold	Rd/Rc	word
12	11	Concentration for magnetic calibration	Rd/Rc	word
13	12	Hysteresis of indicated values, %	Rd/Rc	word
14	13	Range of the resetting to zero of concentration values, %	Rd/Rc	word
15	14	Working time in seconds (high-order)	Rd	word
16	15	Working time in seconds (low-order)	Rd	word
19	18	Current value	Rc	word
101	100	Service register of the protocol switching	Rc	word

Register 1:



- Exchange rate via RS-485:
  - 1 - 1200 baud
  - 2 - 2400 baud
  - 3 - 4800 baud
  - 4 - 9600 baud
  - 5 - 19200 baud
  - 6 - 38400 baud
  - 7 - 57600 baud

- Parity rate:
  0 – none
  1 – odd parity
  2 – even parity

- Amount of stop-bits:
  1- 1
  2- 2
  3- 1,5

To change the gas detector address or exchange rate the user needs to record the new values into the appropriate fields of the register. The record of the values different from the specified does not lead to a change in the contents of the corresponding fields of the register.

(For example, sending 0x01 0x06 0x00 0x00 0x01 0x45 0x49 0xA9 for the device with the network address 1 keeps its network address and sets up the communication speed of 19200 baud, without parity verification, 1 stop-bit)

After power down the interface setting are saved.
The following settings are applying at the initial start-up of the device: 19200 baud, None, 1 stop-bit.

Register 2:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
№ of the gas detector (low-order), ASCII															

Register 3:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
№ of the gas detector (high-order), ASCII															

Register 4:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Gas															

Gas type:

0	Methane (100 % vol.)	11	Ethylene	22	Isopropanol
1	Methane (100 % LFL)	12	Methanol	23	Oxygen
2	Propane	13	Heptane	24	Carbonic oxyde
3	Carbonic dioxide	14	Propylene	25	Hydrogen sulfide
4	Ethane	15	Ethanol	26	Sulfur dioxide
5	Butane	16	Toluene	27	Nitrogen dioxide
6	Iso-butane	17	Benzol	28	Chlorine
7	Pentane	18	Ethyl benzene	29	Ammonia
8	Cyclopentane	19	Acetone	30	Nitrogen oxide
9	Hexane	20	P-xylene		
10	Cyclohexane	21	O-xylene		

Register 5:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
X	X	X	DIAG	RAL2	RAL1	Test	Un-block	SS	CL	Block	WU	Over	AL2	AL1	FL

State flags:

FL	1 – device failure / 0 – no
AL1	1 - first concentration threshold ALARM1 is exceeded / 0 – no
AL2	1 - second concentration threshold ALARM2 is exceeded / 0 – no
Over	1 - measurement range is exceeded / 0 - norm
WU	1 - gas detector warm-up/ 0 – stand-by mode
Error	1 - gas detector failure / 0 – no
Block	1 - gas detector settings are locked / 0 – no
CL	1 – current loop readings fixed on values / 0 – no
SS	1 – special state / 0 – no
Unblock	1 - manual value unblocking / 0 – automatic
Test	1 – gas detector in emulation (test) mode / 0 - stand-by mode
RAL1	1 – alarm 1 relay is NC/ 0 – NO
RAL2	1 – alarm 2 relay is NC/ 0 – NO
DIAG	1 – Failure relay is NC/ 0 - NO

Writing:

Bit 8 = 0 / 1 (0x0000 / 0x0100) - manual value unblocking on / automatic on
Bit 9 = 0 / 1 (0x0000 / 0x0200) - working modes switching
Bit 10 = 0 / 1 (0x0000 / 0x0400) - switching alarm 1 relay settings
Bit 11 = 0 / 1 (0x0000 / 0x0800) - switching alarm 2 relay settings
Bit 12 = 0 / 1 (0x0000 / 0x1000) - switching failure relay settings

Register 6:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									EPR	MEM	RAM	CRL	OPT	HWF	~~PWF~~

Gas detector failure flags:

PWF	1 – the gas detector failure (reduced power supply) / 0 – norm
HWF	1 - the gas detector failure (hardware error) / 0 – norm
OPT	1 - the gas detector failure (sensor optics is dirty) / 0 – norm
CRL	1 – current output failure / 0 – norm
RAM	1 – MCU failure in RAM memory / 0 – norm
MEM	1 – MCU failure in main program memory / 0 – norm
EPR	1 – MCU failure in EEPROM memory / 0 – norm

Register 6:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
X	X	X	X	X	X	F2	F1	MEM	RAM	Flash	CLS	HWF2	OPT	HWF1	PWF

Gas detector failure flags:

PWF	1 – the gas detector failure (reduced power supply) / 0 – norm
HWF1	1 – sensor interconnection failure (hardware error) / 0 – norm
OPT	1 - the gas detector failure (sensor optics is dirty) / 0 – norm
HWF2	1 – indication pcb interconnection failure (hardware error) / 0 – norm
CLS	1 – current loop needs setup / 0 – norm
Flash	1 – MCU failure in flash memory / 0 – norm
RAM	1 – MCU failure in RAM memory / 0 – norm
MEM	1 – MCU failure in main program memory / 0 – norm
F1	1 – sensor data is incorrect/ 0 – no
F2	1 - indication interconnection data failure/ 0 - no

Register 7:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Concentration % LEL * 10 , %Vol * 100 , ppm															

Writing:
0xAAAA - setup of the factory default scaling (calibration) values.
0xBBBB - zeroing of the gas detector.

Register 8:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Temp.sign	Temperature * 100, °C														

Register 9:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Measurement range, %vol * 100															

Modifies the measurement range by saving a new value to register (in % rel. * 10).

Register 10:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Alarm1 concentration threshold * 10 (≤ Alarm threshold 2), % LEL															

Register 11:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Alarm2 concentration threshold * 10 (≤ Measurement range), % LEL															

Register 12:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Concentration point for the magnetic scaling, % rel * 10															

Register 13:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Alarms value hysteresis (≤ 3,0) , % rel* 10															

Register 14:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Below this threshold, concentration values will be equal to zero, % relat. * 10															

Register 15:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Working time (high-order), seconds															

Register 16:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Working time (low order), seconds

Register 101:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Service register															

Saving:
0xABCD – switching to IGM service protocol.

CAUTION!
The registers have the limited number of the saving cycles (300000).
The device returns the standard error codes corresponding to the protocol specification MODBUS v1.1b.

HART Communication protocol

The gas detector uses the analog output of 4-20 mA and the onboard signal modem Bell 202B to ensure the information output via the protocol HART.

Interface: Bell 202 Current (1200, 8-Odd-1).
Protocol: HART 6.

The detailed description is shown in the following specification:
http://ru.hartcomm.org/hcf/org_mbr/documents/documents_spec_list.html.
The realized commands are shown in the Table F.2. The protocol allows to read out two dynamic variables, for the description see the table F.3.

The procedure of the data treatment eHartPoll carries out the following acts:

1) Check if there is any event in eQueuedEvent.
2) If there is the event EV_FRAME_RECEIVED, the packet analysis is carrying for the destination address. If the address (short or long) coincides with the gas detector address, the packet analysis is carrying for the check sum and length errors with the error code generation. If there is no errors, the EV_EXECUTE event will be created. If the addresses do not coincide, the packet is ignored.
3) If there is the EV_EXECUTE event, the coincidences are researched by the function code from the packet of the allowed values array HartFunctions. If there are no coincidences, the wrong function error will be created.
4) The command handler body analyses the number of the data and of its values, if these values are wrong, the appropriate error message is created.
5) The response with the error data or code is created and transmitted.

Table F.2. HART-protocol command list

List of commands

Command number	Command description
Universal commands	
0	Reading of the device identifier
1	Reading the main variable
2	Reading the current output value
3	Reading the current output value and four variables

6	Saving the short address
7	Reading the current output configuration
8	Reading dynamic variables class
9	Reading variables with their status
11	Reading device identifier attached to the tag
12	Reading messages
13	Reading tag, tag and date description
14	Reading main variable data
15	Reading data about the device
16	Reading final unitized number
17	Saving message
18	Saving tag, description, date
19	Saving unitized number
20	Reading long tag
21	Reading device identifier attached to the long tag
22	Saving long tag
Common commands	
33	Reading device variables
38	Reset of reconfiguration flag
40	Enter / exit of the fixed current mode
42	Restart device micro controller
43	Setup main variable zero (0 values)
59	Setup the number of the response preamble
60	Reading analog channel and range percent
62	Reading analog channels
63	Reading data on analog channel
66	Enter / exit of the fixed analog output mode
76	Reading bit for device lock
80	Reading calibration points
81	Reading acceptable calibration ranges
82	Setup of the calibration points (value calibration)
83	Reset of the calibration point (calibration reset)

Table F.3 Dynamic variables

№	Measured parameter	Dimension
Main	Measured gas concentration	%
Secondary	Optic sensor temperature	°C

Appendix G

Electrical connection instructions

- Unscrew the locking screw on the windowed cover of the gas detector;
- Unscrew the windowed cover;
- Unscrew the screws on faceplate. Unmount the faceplate and then you will have an access to terminal blocks situated on PCB.
- Connect cable in accordance with marking on PCB and fig. B.1 of the Appendix B

Additionally, when connecting RS-485 lines you could switch XN1 jumper:

- ON to connect the internal terminator load 120 Ohm, if gas detector installed at the end of the RS-485 line.
- OFF to disable the load of 120 Ohm

After the checking commutation with gas detector, reassemble it in reverse order

- Mount the faceplate
- Screw the faceplate
- Screw the windowed cover;
- Screw back the locking screw

Appendix H

Zeroing and calibration procedure

ATTENTION!

- **To zero the gas detector and to calibrate it the magnet "Setup 0" shall be kept during at least 2 sec. Yellow LED light should twinkle.**
- **For calibration mode the magnet "Setup 0" shall be kept during at least 5 sec. Auto logout of the mode – if the magnet sensors do not respond during sixty seconds.**
- **Inspection and maintenance of the sensor should be carried out by suitably trained personnel in accordance with the applicable code of practice (e.g. EN 60079-17).**
- **Any person who have studied this UM, have been briefed on safety precautions when-operating electrical equipment intended for operation in the explosion-hazardous zones in the established order, is admitted to operate the sensor.**

NOTES:

1. Zeroing and calibration of the gas detector is performed annually when preparing for the verification. Zeroing is also performed directly after installation on site before commissioning.
2. Equipment shown in Figure H.1 and in the list of GCM should be used during zeroing and calibration procedure

Procuder order:

- Install the CGM adapter on the gas detector. Establish the test set-up shown in Figure H.
- ZEROING: Feed gas detector with CGM №1 (Zero gas) during at least 1 min. Bring in 1 min the calibration magnet to the zone marked as "ZERO". The sensor magnet response is confirmed by the short blink green LED indicator.
- CALIBRATION: Feed gas detector with CGM №2 and in 1 min Bring in 1 min the calibration magnet to the zone marked as "CALB".. When the magnet sensor will respond you will see the short blink of green LED indicator.
- VERIFICATION: Feed gas detector with CGM №3 and verify the gas detector readings by the current loop output according to the appendix E or by the digital serial interface RS-485 MODBUS® according to the appendix F.

If the gas detector reading does not coincide to the concentration value of the CGM №3 the zeroing and the calibration procedure should be repeated. At the second non-coincidence of values, the gas detector should be replaced and forwarded to the manufacturer for repair.

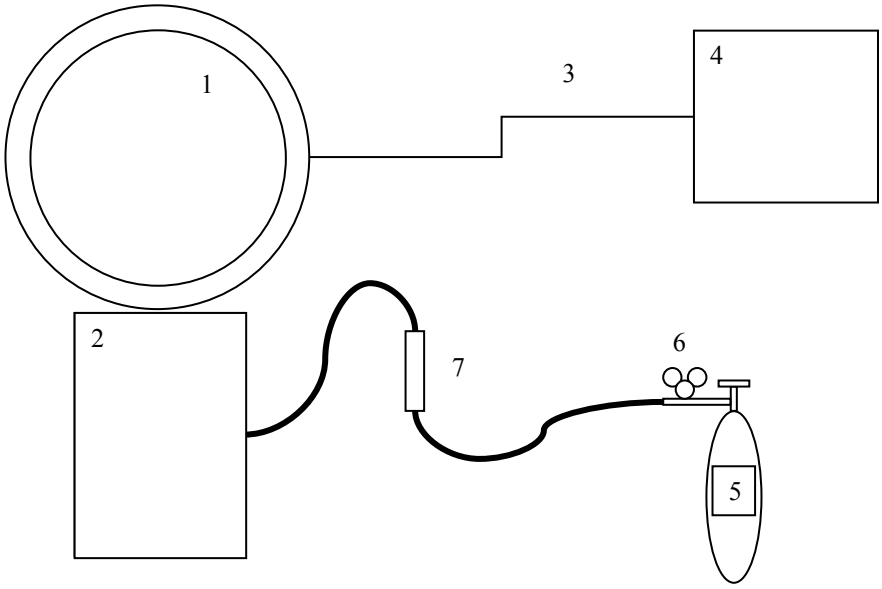


Figure H.1 Typical scheme used for zeroing and calibration

1. Gas detector IGM-12	5. CGM
2. CGM adapter for IGM-12	6. Gas regulator
3. Electrical cable	7. Flow meter
4. Power supply	

The gas detector circuits should be connected according to the Appendix B.

Appendix I

Table I.1 Technical specification of recommended CGM

Target gas	Measurement range	Recommended CGM concentration values for calibration, zeroing and verifying				Acceptable accuracy
		CGM№ 1	CGM№ 2	CGM№ 3		
methane (CH_4)	From 0 to 100 %Vol	N2				-
			2,5 % ± 5 % rel.			
				50 % ± 5 % rel.		
						95 % ± 1,5 % rel.
	From 0 to 100 % LEL (from 0 to 5 % Vol..)	N2				-
			2,5 % ± 5 % rel.	4,8 % ± 5 % rel.		-
propane (C3H8)	0÷100 % LEL (0÷1,7 % Vol..)	N2				
			0,85 % ± 5 % rel.	1,6 % ± 5 % rel.		± 1,5 % rel.
n-hexane (C6H14)	0÷50 % LEL (0÷0,5 % Vol..)	N2				
			0,25±5% rel.	0,5 ±5% rel.		± 0,01 % (Vol..)
ethane C2H6	0- 50 % LEL (From 0 to 1,25% Vol..)	N2				

			0,6 % ± 5 % rel.	1,15 % ± 5 % rel.		± 1,5 % rel.
	0÷50 % LEL	N2				
n-butane (C4H10)	(0÷0,7 % Vol..)		0,35±5% rel.	0,7 ±5% rel.		± (-0.046X+1.523) % rel.
i-butane (i-C4H10)	0÷50 % LEL (0÷0,65 % Vol..)	air				
			0,3±0,1	0,55±0,1		± 0,03
	0÷50 % LEL	N2				
pentan (C5H12)	(0÷1,4 % Vol..)		0,7 ±5% rel.	1,33 ±5% rel.		± 1,5 % rel.
Ethylene C2H4	0- 50 % LEL (From 0 to 1,15% Vol..)	N2				
			0,57 % ± ±5 % rel.	1,15 % ± 5 % rel.		± (-0,046X + 1,523) % rel.
	0÷50 % LEL	N2				
propylene (C3H6)	(0÷2,0 % Vol..)		1,0 ±5% rel.	1,8 ±5% rel.		± (-0.046X+1.523) % rel.
benzol (C6H6)	0÷50 % LEL (0÷0,6 % Vol..)	N2				
			0,3 ± 5 % rel.	0,55 ± 5 % rel.		± 1,5 % rel.
acetone (CH3COCH3)	0÷50 % LEL (0÷1,25 % Vol..)	air				
			0,63 ±5 % rel.	1,19 ±5 % rel.		± 1,5 % rel.

methanol (CH_3OH)	0÷50 % LEL (0÷2,75 % Vol..)	N2				
			1,38 ± 10 % rel.	2,47 ± 10 % rel.		(-1.111X+2.611) % rel.
carbon dioxide (CO_2)	From 0 to 2,5 %	N2				
			1,25 % ± 5 % rel.	2,38 % ± 5 % rel.		(-0,046X + 1,523) % rel.