Portable gas analyzer

POLARIS

1011 series "Methane-CH4"

User manual

KDYUSH.413327.017-01 UM

IGM Instruments
Saint-Petersburg
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Introduction

This User manual is designed to study the arrangement, design and operation of a portable gas analyzer "POLARIS" 1011 series "Methane CH4" (hereinafter, gas analyzer or GA).

The User manual contains the basic technical data and characteristics of GA, recommendations on maintenance, as well as other information necessary for the proper operations.

Example entries in order and documentation of other products: "Portable gas analyzer "POLARIS" 1011 series" Methane CH4 "KDYUSH. 413327.017 TU. "

The changes can be made in electronic circuit and construction design of GA during the manufacturing process without affecting technical and metrological characteristics of device. The manufacturer reserves the right to not include these changes in User manual.

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1 Description

1.1 Application notes

Main features:

- GA has built-in sensor and internal rechargeable battery.
- GA is designed for:
  - measuring the volume fraction of methane at the approximately safe level of impact (ASLI) in the ambient air of populated areas;
  - detecting of methane leaks and output alarms in excess of the measured the value of the threshold.
- Main application of GA is mobile environmental laboratories. The gas analyzer is designed to be used in non-hazardous areas.
- Information about the measured values of methane molume fraction displays on:
  - digital LCD with up to 0.1 ppm resolution.
  - green and red LED bar graphs;
  - external PC via RS-232C serial interface (additionally).

1.2 Specification

1.2.1 Common specification

1) Outline dimensions H × W × L, mm, not more than: 140 × 120 × 280
2) Weight, kg, not more than: 4
3) Index of protection acc. IEC 529-89: IP 32
4) Supply is carried by embedded rechargeable battery.
5) Average life time 5 years.
6) MTBF, without regard to batteries replacements, hours, not less than: 10 000

Operating principle: Optical (IR)

Categories, operating, storage and transportation conditions as to environment climatic aspects influence: NF 3.1 category according to GOST 15150. GA is portable device, recoverable under the manufacturer's territory.

Operating conditions:

- Temperature range, ^{0}C - 10 ... 40
- Relative humidity at 25 0C, % 45 ... 95
- Atmospheric pressure: 84,0 ÷ 107 kPa (630 ÷ 800 mmhg)

Composition of test environments:

Air environment component.	*Concentration values of components under operation conditions*
1 Oxygen	21 % Vol.
2 Nitrogen	78 % Vol.
3 Carbon dioxide	0 % Vol. ... 1,0 % Vol.
4 Carbonic oxide	0 ppm ... 100 ppm
5 Methane	0 ppm ... 10000 ppm
6 CnHm heavy hydrocarbons (propane cross sensitivity)	0 ppm ... 1000 ppm
7 Dust	0 mg/m³ ... 2,0 mg/m³
8 Sulfur vapor	0 mg/m³ .... 0,31 mg/m³

1.2.2 Performance

1) Gas sampling method:	Forced-feed (gas pump)
2) Gas feeding. Flow rate, l/min, not less than:	2
3) Measuring range of methane volume fraction, ppm:	0 ÷ 2000
4) Indication range of methane volume fraction, ppm:	0 ÷ 9999
5) LCD resolution, methane volume fraction, ppm:	0.1
6) Display update time, sec:	
upper scale (slow output)	4
lower scale (high output)	0.25
7) Accuracy Δ_o, methane volume fraction, ppm:	$\pm (5 + 0{,}05 \cdot C_{IN})$

Where C_{IN} – GA input methane volume fraction.

8) GA has sound and light alarm indication with threshold setup:	
- by manufacturer, methane volume fraction, ppm:	100
- by user, in range, methane volume fraction, ppm:	0 ÷ 2000
9) Alarm operation accuracy, methane volume fraction, ppm:	$\pm$ 5
10) Additional temperature error, on each 10 ^{o}C:	$0{,}5 \cdot \Delta_o$
11) Additional error by impact of non-measured components in air environment	$0{,}5 \cdot \Delta_o$
12) Additional pressure error, on each 3.3 kPa:	$0{,}5 \cdot \Delta_o$
13) The period of the serial interface data output, sec:	0.25
14) Time of response (T_{90}), sec, not more than:	
With detectability 0.1 ppm	4
With detectability 0.5 ppm	0,25
15) Operating period without requalification, month , not more than:	6
16) Recovery time to gas overload impact (up to 100% of methane concentration during 10 min with continuous gas feeding), sec, not more than:	20
17) Warm-up time, min, not more than:	5

1.2.3 Supply

1) Internal rechargeable battery output voltage, V	10.6±0.6
2) Minimum working time on fully charged battery (battery supplied from the charger connected to the 220 V 50 Hz during 16 hours) , hours, not less than:	4

1.2.4 Data output

Measured valued of methane concentration is displayed:

- On LCD with 0.1 ppm resolution for 0.1…99.9 ppm range and with 1 ppm resolution for 100…9999 ppm range.
- On green LED bar graph in range 0…2000 ppm with regard to scale coefficient.
- On red LED bar graph in range 0…2000 ppm with regard to alarm threshold settings.

GA provides data on the serial digital interface RS-232C. Communication protocol and transmission parameters are given in Appendix B.

During operation, GA may provide additional light and sound signals: LEDs glow red bar-graph LED and buzzer - methane concentration above the threshold level (100 ppm - the default factory setting)

NOTES: On red LED bar graph displays the readings of methane concentration in the same manner as in the green LED bar graph - see article 2.2.1.5.

1.3 Delivery set

Table 1 Delivery set

Name	*Designator*	*QTY, pcs*
Portable gas analyzer "POLARIS" 1011 series" Methane CH4 "	KDYUSH. 413327.017 -01	1
RS-232 serial cable	-	1
User manual	KDYUSH. 413327.017-01 UM	1

1.4 Description and operation

1.4.1 Gas analyzer principle

The principle of GA operation is based on selective absorption of infrared radiation methane molecules in the wavelength 3.2-3.4 um region.

Infrared radiation of source (black body) passes through the measuring gas cell, which is pumped by sample gas. Than the IR light gets into electrically controlled spectral filter, which transmission spectrum is matched to the absorption spectrum of the measured gas, and then enters a photodetector (receiver), stabilized in sensitivity to temperature by thermoelectric battery (Peltier element).

The transition of a spectral filter according to an applied electrical control signal either superimposed or not coincide with the absorption spectra of methane. Thus, at the receiver, a signal with a frequency modulation control appears, and its modulation amplitude is described in accordance with equation:

$$Ip - Io / 0.5*(Ip + Io) = 1-\exp \{ - [K(\lambda p) - K (\lambda o)]CL \}, \quad (1)$$

where:

K (λ) - absorption coefficient at a given wavelength;

L - optical length of the cell;

C - the measured concentration of gas;

Ip - the amplitude of the signal on receiver at the moment of matching electrically controlled spectral filter with the spectral absorption region of methane.

Io - the amplitude of the signal on receiver at the moment of mismatching electrically controlled spectral filter with the spectral absorption region of methane..

Unknown concentration of the gas is given by:

$$C = -Ln[1-((Ip – Io) / 0.5*(Ip + Io))] /(L [K (\lambda p) - K (\lambda o)]), \quad (2)$$

As used spectral correlation registration technique eliminates the influence of water vapor, dirt and other elements of optical nonselective influences (including other hydrocarbon compounds) as well as the instability associated with the optoelectronic elements of GA itself.

Functional structure is shown on Fig.1

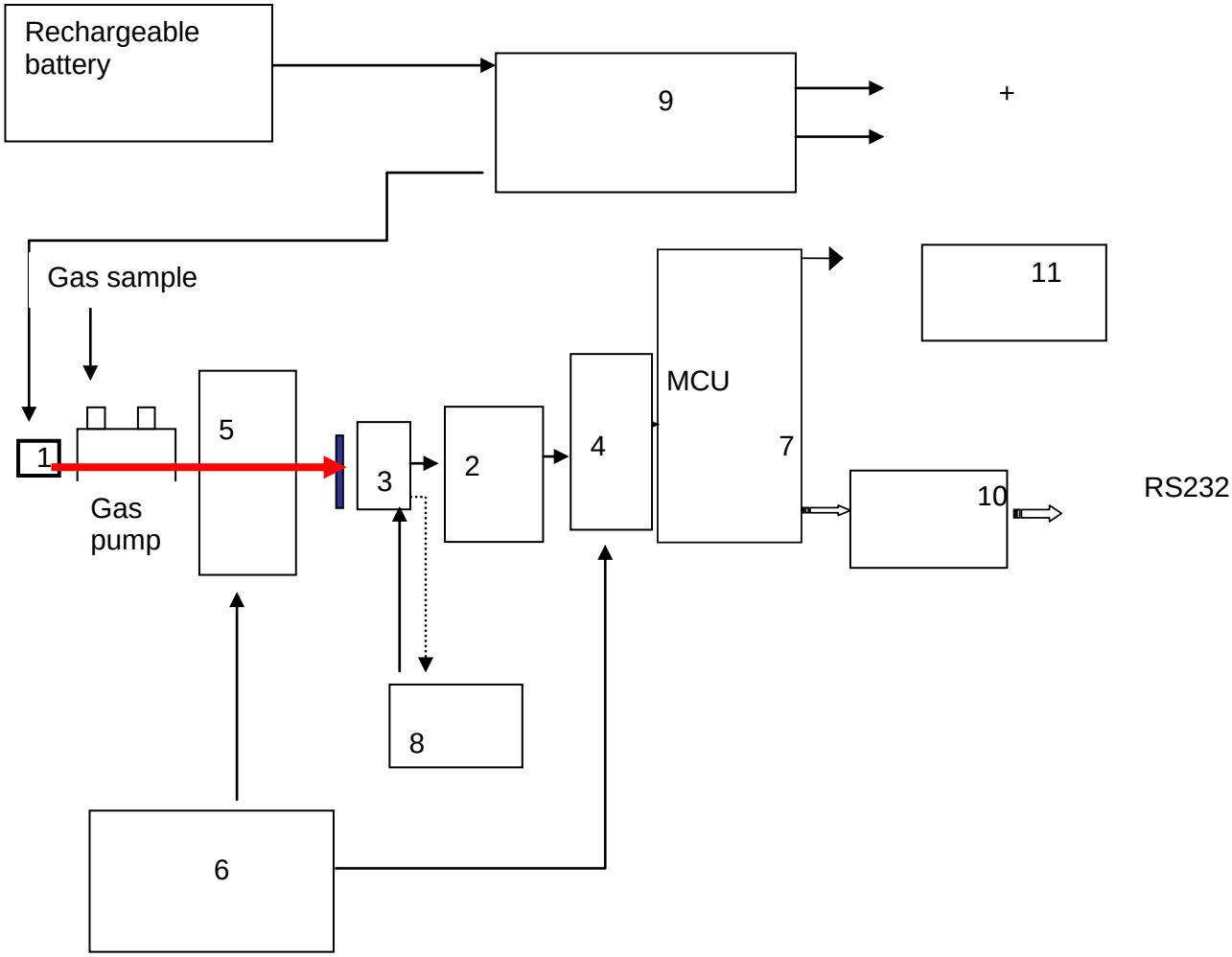

Fig.1 GA principles

Operation is controlled by a microprocessor unit (7) MCU, which generates a clock pulse sequence to control the master oscillator (6). MCU digitalizes the amplitudes of signals coming from the synchronous detector unit (4). The clock generator (6) enables the formation of a control voltage to the electrically controlled spectral filter (5), and a synchronous timing detector (4) .

Infrared source (1) is energized by stabilized current from the power supply voltage unit (9). The infrared source emits in the band, that overlaps desired and reference signal wavelengths. Reciever (2) passes radiation in the band in the bandwidth 3.2-3.6 um, provided by interference filter, which is directly mounted to the housing of photodetector. Temperature stabilization (3) by Peltier element is integrated and controlled by current going from thermal stabilization unit (8). The thermal stabilization control signal goes from thermistor mounted inside of photodetector.

MCU produces mathematical processing and calculates concentration of the target gas in accordance with the equation given above. Information about the concentration outputs on the serial port (10) (MAX 242 chip) in the standard RS-232 protocol (see Appendix 1).

Information about the measured concentration is displayed on indication unit (11), consisting of a matrix LCD and two LED bar indicators - green and red.

The LCD can display information about the operability of GA, based on measurements of additional signals and the operating voltage.

Power supply unit (9) provides GA with an input voltage +(10.6±0.6) VDC from the battery.

1.4.2 Construction design

GA has design as it shown on Fig. 2.

Following parts are located in front side of gas analyzer:

- LCD display with backlighting
- Bar graph LEDs (red and green)
- LEDs for indication of embedded gas pump and audible alarm
- LEDs for indication of current “2.0”, “20.0”, “200.0 ppm”.
- The keyboard with following buttons:

- on-off power
- on-off pump

- on-off buzzer -
- save set up values - "ВВОД"
- set up zero - > 0 <
- setting up alarm threshold - "ПОРОГ"
- values selection - △ ▽
- connector for the charger and serial RS-232 plug.

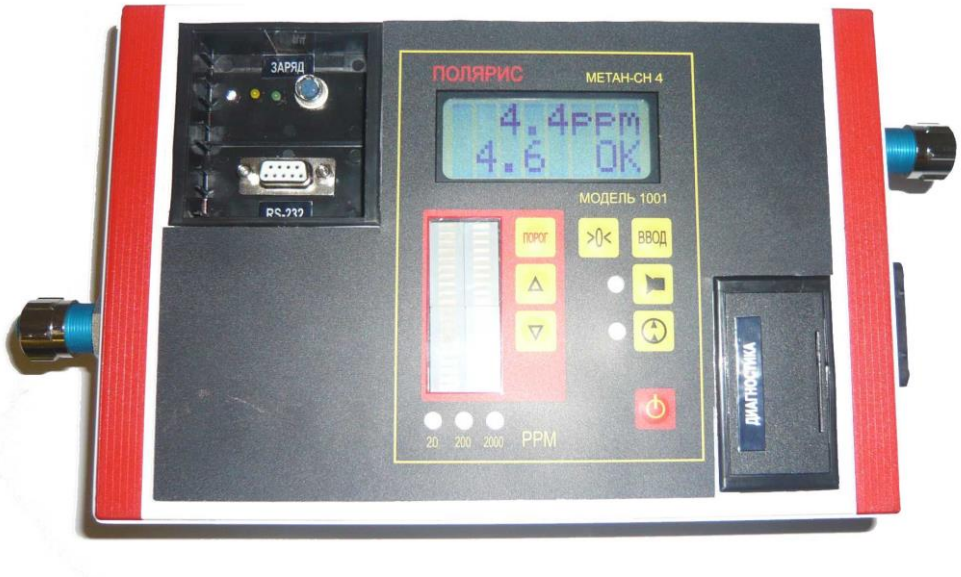

Fig 2 GA design.

Input and output fittings are located on the side face of GA

Gas sampling device with probe connects to quick-detachable input fitting.

To replace the battery the bottom cover can be dismounted by removing the two bars and unscrewing four fixing screws.

1.5 Marking and sealing

Face side marking:

- Device name;
- Manufacturer trademark.

Side face marking:

- Serial number and production date

Device is sealed by the manufacturer.

1.6 Package

GA is packed in a bag, then in carton box. In the box with the GA keeps technical documentation in a plastic bag and charger. The box fits in an additional polyethylene bag for transportation.

2 Using of gas analyzer

2.1 Preparation for use

2.1.1 Precautions

Using of GA are allowed only for persons who are appropriately trained on safety, *who have studied this UM* and have qualification group on electrical safety.

When working with the gas mixture in vessels under pressure it must be proceed with full compliance to gas process, pipeline and transportations requirements.

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2.1.2 Preparations

2.1.2.1. Unpack the GA.
2.1.2.2. Charge the battery by charger, which comes in delivery set, with the following instructions:
- Remove the cover on the front of the charger
- Connect the charger connector (connector has a key and admits a unique ability to connect).
- Connect the charger to power line 220 VAC 50 Hz, then press the power button on the charger.

The GA should be lit yellow LED (REM charge) in the area of the charge connector, and then during the charging process, the yellow LED goes off and the green. Both LEDs are extinguished when the battery is fully charged.
The yellow LED should be highlighted (rapid charge stage). During the charging process, the yellow LED goes off and the green LED lights. Both LEDs are off when the battery is fully charged.
Lighting of red LED indicates malfunction of the battery or open circuit of charge.
Battery charging time is according to the instructions to the charger
2.1.2.3. Turn off the charger and disconnect it from power line 220 VAC 50 Hz, then disconnect the charge from GA.

2.2 Proper use

2.2.1 Turning on and measuring

2.2.1.1. Turn on GA by pressing the button ⏻
In LCD screen it displays “CH4 Working” during 20 sec. Then “WARM UP” appears in upper raw and during this time squares sequence from 1 to 8 is displaying on lower raw.
After that measured concentration readings displays in upper raw (1-5 digits with “ppm” symbol)
In lower raw GA indicates operation information about the checkup results.

Example:

XXX.X ppm
XX.X OK

Where:
XXXXX ppm - measured methane concentration value in two raws:
- in upper raw – with 2.5 sec accumulation and update time
- in lower raw - with 0.2 sec accumulation and update time

OK - electrical circuit functionality test is successfully completed and battery voltage is valid.

NOTE: The symbol sequence listed above indicates that GA is working properly. See for troubleshooting list in article 2.3.4 if other symbols appears in right down corner.

2.2.1.2. Complete warm-up time is 5 min.

NOTE: Before starting up the first measuring that is recommended to follow zeroing procedure, see section 2.3.3 for details.

2.2.1.3. Move the end of the rubber tube running from the inlet fitting of the gas cell, to a controlled point of the air volume.

2.2.1.4. Feed the gas cell of GA with 2 l/min flow of analyzed air by turning on the embedded gas pump. To do this requires to press button. When gas pump starts to work, red LED near the button is lighting. Press again to turn off the gas pump when it's necessary, that will off the red LED as well.

2.2.1.5. Check the measured value of methane concentration of on LCD screen of GA.

On the green LED bar graph GA displays concentration with the number of lighting segments proportional to volume fraction of methane with regard to scale coefficent. Full scale is indicated by highlighting one of three green LEDs marked as "**2.0 ppm**", "**20.0 ppm**", "**200.0 ppm**".

On the red LED bar graph GA displays concentration the same ways as on greed LED bar graph, but the scale is specified by alarm threshold settings. The threshold of alarm is always as half scale of red LED bar and the median segment is constantly highlighted.

By default, a setting of alarm threshold is 100 ppm, thus the full scale for the red LED bar graph is 200 ppm.

The delay time of displaying information on red LED bar is 0.2 sec.

2.2.1.6 Working time on fully charged battery without recharging is 6 hours.

When the level of methane alarm concentration (alarm threshold settings) is reached, the buzzer starts to sound and the number of highlighted red segments exceeds half of scale (middle segment of the scale at the same time goes off). The audio signal can be switched off if it's necessary by pressing the button , then the LED nearest to the sound button (which lights up when you turn on GA) goes off.

2.2.2 Reading data on PC

2.2.2.1 Connect GA to compatible PC with RS-232 cable.

2.2.2.2 To work with GA you can use any software with ASCII charset and keyboard input.

2.2.2.3 PC comport settings:

- 9600 baud rate
- 8-bit message,
- 1 stop bit, no parity,
- Communication protocol -see Appendix B.

2.3 Maintenance

2.3.1 General notes

Maintenance should be performed in order to ensure the normal operation of GA during its lifetime. Recommended types and dates of service:

- Visual inspection of the GA (article 2.3.2) - every 6 months;
- Zeroing and span gas calibration (article 2.3.3) - every 6 months;
- Cleaning the enclosure from dust and dirt - every 6 months;

2.3.2 Visual inspection

Check the enclosure of GA for cracks. Check the connectors.

2.3.3 Zeroing and span gas calibration

2.3.3.1. Prepare GA for operations according article 2.2.1.1

2.3.3.2. Connect GA to gas feeding according to diagram shown in Appendix C.

2.3.3.3. Feed the GA with zero gas (nitrogen, CGM №1 see Appendix A). Flow rate is 0.5 l / min. duration - one minute.

2.3.3.4. GA zeroing:

- Hold “>0<” button during 1 sec. в течение 1 сек, на индикаторе высветятся символы The LCD lights the symbols "ZERO?".
- Press "ВВОД" button to confirm zeroing. The new value of the zero state is written to flash memory.

  NOTE Set to zero can also be submitting from PC by sending "ZERO" command.

2.3.3.5. Connect GA to PC and feed the GA with span gas (CGM №2 or 3 see Appendix A). Flow rate is 0.5 l / min. duration - one minute.

2.3.3.6 Calibrate the GA by sending command "CALB XXXX" from PC, where XXXX is the numerical value which is strongly corresponds to the concentration of CGM applied.

2.3.3.7. Setting up alarm thresholds.

To setup alarm threshold push the button "ПОРОГ" and press ▽ or △ to choose desirable value, which is displaying on the bottom line in the left corner of LCD. " Press “ВВОД” to store chosen alarm threshold in the memory. This will automatically change the scale of the red bar indicator. The new alarm threshold value corresponds to half of indication scale.

3 Troubleshooting

Table 3 Troubleshooting list

Fault event	**Possible reason**	**Recommendations**
BATT symbols lights on LCD screen.	Low battery.	Charge the battery.
Fail symbols lights on LCD screen.	Electrical circuit malfunction, detected by the system self-test	Enter the command **FULV?** from PC to check to possible malfunction reasons (see article 3.2 or Appendix B) Save response log and send this information to manufacturer for problem solving.
No symbols on LCD screen.	Completely discharged battery	Try to charge or replace the battery.
OPT symbols lights in right down corner of LCD screen.	Optics in gas cell is dirty	Enter the command **FULV?** from PC to check to possible malfunction reasons (see article 3.2 or Appendix B) Save response log and send this information to manufacturer for problem solving.
Red LED lighting during the battery charging.	Battery fail	Replace the battery.
EHT symbols lights in right down corner of LCD screen.	Low temperature	Additional heating of GA required achieving proper performance. After the heating the using of the GA is possible when warm-up process done and device displays OK symbols in right down corner.

NOTE: Any malfunctions requires breaking GA sealing must be fixed by manufacturer authorized personal only.

3.1 Malfunction self-test

GA has the ability to output data to PC in self-test mode. Send **FULV?** command to identify possible problems. See Appendix B for details about command format. Contact to manufacturer for more information.

4 Storage

- GA should be stored in a heated place at a temperature of from 5 to 40 ° C and relative humidity of 80% at 25 ° C.
- Device should be stored in the factory packing.
- Storage time is 3 months.
- Amount of dust, vapors of acids and alkalis, corrosive gases and other substances that may cause corrosion in storage places should not exceed the values of its content required of type 1 according to GOST 15150-69 (IEC 721-2-1 , IEC 721-3-1 IEC 721-3-7 , IEC 68-1).

5 Transportation

Transportation of GA should be done in consumer packaging, transport box (wooden or cardboard).

GA for transportation must be packed in the transport box.

Transportation is possible if:

1) ambient temperature from minus 30 to plus 50 ° C;

2) maximum relative humidity of 98% at 35 ° C.

GA can be transported by all types of transport, including air transport, in heated and sealed places with protection from direct exposure to rain and dust.

6 Warranty

The manufacturer guarantees compliance with all the requirements of the GA technical conditions if the Customer observes operation, transportation and storage within the warranty period - 12 months from the date of take into operation.

The starting point for calculating the warranty period is the date of sale to the Consumer

Warranty repair or replacement shall be subject to the GA of improper use, transportation and storage.

The warranty period is extended for repeating time till the Consumer put in use repaired device.

7 Repairing

In case of GA failure, as well as the detection of incompleteness of its delivery set, the Consumer must return device to the Manufacturer with the following notice:

- Model of gas analyzer, serial number, production date and date of sale;
- Information about availability of factory seals;
- Defect (or incompleteness) description.

Appendix A List of CGM used for checking POLARIS gas analyzer

CGM Nos according to text	Component composition	Composition of measured component, vol. %	Permissible deviation limits, vol. %, ppm	Limits of permissible error of qualification	Number as per State Register or Standard designation
1	N_2	100	-	-	GOST 9392-74
2	$CH_4 – N_2$	950 ppm	±50	±2 % relative accuracy	3865-87
3	$CH_4 – N_2$	1900 ppm	±100	±40 ppm	3868-87

Appendix B RS-232 communication protocol

Communication parameters:

- *9600 baud rate*
- *8-bit message,*
- *1 stop bit, no parity,*
- *ASCII*

Commands:

1. Commands with multiple (continues) outputting of data responses:

CDAT? – requests concentration slow output. Response format is **AAAAA 0DH** every 2.5 sec.

XDAT? - requests concentration fast output Response format is **AAAAA 0DH** every 0.25 sec.

AAAAA is methane concentration in ppm*10 with regard to scale coefficient set.

FULV? — requests **self-test results. Response is in format:**

AAAAA 09H BBBBB 09H CCCCC 09H DDDDD 09H EEEEE 09H FFFFF 09H GGGGG 09H HHHHH 09H IIIII 09H JJJJJ 09H KKKKK 0DH

Where:

AAAAA	T amb – ambient temperature of GA
BBBBB	Signal value of measuring channel (Umeas) , accumulation period - 4 sec
CCCCC	Signal value of reference channel (Uref) , structurally stable scale
DDDDD	U const – constant component - the light intensity
EEEEE	T eth – reference temperature
FFFFF	T PD – photodetector temperature
GGGGG	Ua – battery voltage control
HHHHH	U gen –clock generator voltage control
IIIII	Concentration calculated from table in ppm*10
JJJJJ	Concentration with regard to scale coefficient (see CALB XXXXX) in ppm*10
KKKKKKKK	GA serial number

2 Commands with single response:

DATA? — requests concentration output прибор выдает однократно в последовательный порт

AAAAA is methane concentration in ppm*10 with regard to scale coefficient set.

SRAL? – serial number request.

INIT – reset device to factory settings.

ZERO – zeroing the GA.

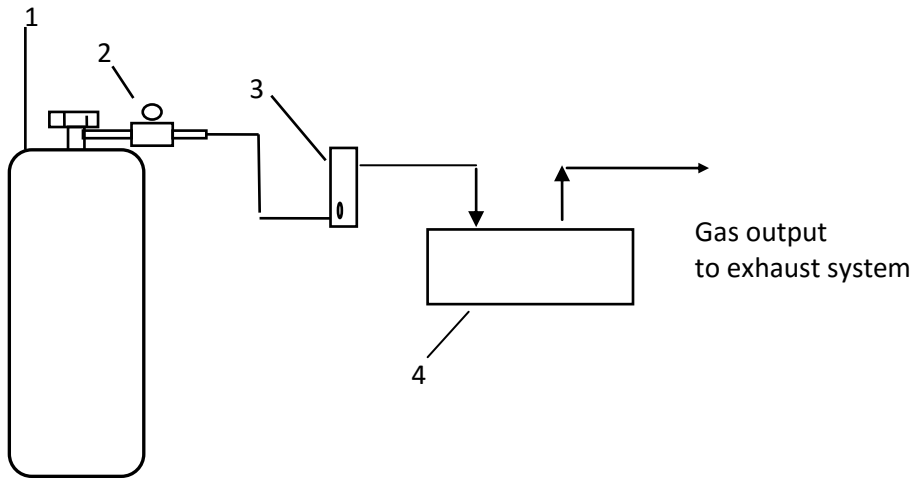
CALB XXXXX – save the scale (calibration) coefficient. **XXXXX** is applied concentration in ppm*10.

3 Alarm settings

ALARM? — requests alarm threshold.

ALARM XXXXX— set up alarm threshold. XXXXX - concentration in ppm*10.

Appendix C Gas feeding diagram required for zeroing and span gas calibration



1 - Control Gas Mixture (CGM) vessel under pressure;
2 - fine control gas vent;
3 - flow meter;
4 – GA