

# PORTABLE LABORATORY pH – METER

**C – 03 / T**



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USER'S MANUAL

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## TABLE OF CONTENTS

1. INTRODUCTION .....	3
2. DEVICE STRUCTURE .....	3
3. OPERATING MODES .....	4
3.1. Choosing operating language .....	5
3.2. Millivolt or pH readings .....	5
3.3. Automatic or manual temperature compensation of pH readings .....	6
3.4. Calibration of pH electrodes .....	6
3.4.1. Single Point Calibration .....	7
3.4.2. Double Point Calibration .....	7
3.4.3. Cancelling calibration procedure .....	8
3.5. Recharging battery power supply .....	8
3.6. Turn to one-row (large font) display mode .....	9
4. DEVICE SETTINGS ADJUSTMENT .....	10
4.1. General principles .....	10
4.2. Temperature for manual compensation .....	10
4.3. Offset of pH electrode .....	10
4.4. Slope of pH electrode .....	10
4.5. Buffer S .....	11
4.6. Buffer A .....	11
4.7. Buffer B .....	11
5. DEVICE CALIBRATION PROCESS (PHYSICAL ADJUSTMENT) .....	12
6. TECHNICAL DATA .....	14

## 1. INTRODUCTION

The portable laboratory pH meter C-03/T is suitable for pH and millivolt measurement, regardless of presence or absence of power supply voltage 220V 50Hz. The device can be used for all *potentiometric* measurements (ion-selective, ORP, etc.), where very high input resistance (impedance) is needed. Except pH and mV the device measures also temperature through the outer RTD Pt1000. The temperature measurement is used for temperature compensation of measured pH value.

## 2. DEVICE STRUCTURE

The portable laboratory pH meter C-03/T consists of the following main parts:

- power supply module;
- microcomputer;
- input convertors;
- keypad;
- display.

The power supply module is an accumulator and a built-in charger, which ensure high independence of the pH meter. The microcomputer part realizes all pH meter functions and keeps in memory all needed settings. The input convertors ensure high input resistance of pH/mV input and the connection of RTD Pt1000 on the temperature measurement input. The keypad consists of eight buttons and their functions are described further (*see paragraph 3*). The buttons have two different meanings - the first one in measurement mode and a second one - in adjustment mode. The two different meanings of these buttons are written separated with horizontal line. The upper meaning is valid in measurement mode and the lower one is valid in adjustment mode. The two meanings are coloured in different colours. The portable laboratory pH meter C-03/T has a graphics LCD (Liquid Crystal Display) – 122 x 32 dots, which displays all messages, and in main work mode (measurement mode) – all measured values. There are two modes of information presentation – two-rows (small font) and one-row (large font). All messages, settings and the calibration of device are displaying in two-rows (small font) mode. Only measured values for temperature, mV and pH can be displayed in one-row (large font) mode.

In two-rows (small font) mode the upper row visualizes chosen pH or mV values with relevant dimension and the lower row displays temperature, used for pH compensation with its dimension in degrees centigrade - °C. The letter **a** in the first position of second row indicates that the device is in automatic temperature compensation (ATC) mode. The letter **m** in the same position indicates that the device is in manual temperature compensation (MTC) mode.

The first position of first row at normal work mode is empty. The letter **S** in this position indicates that the device enters single point calibration mode and the pH electrode has to be immersed in the corresponding pH buffer **S**. Letters **A** and **B** indicate, that the device enters double point calibration mode and the pH electrode has to be immersed in pH buffer **A** or pH buffer **B**.

In one-row (large font) mode on the whole display is visualizing only one of measured value – pH, mV or temperature with its dimension in right side written in small font. For the temperature the relevant character **a** or **m** is written also.

Front panel view of portable pH meter C-03/T is shown on fig. 1.

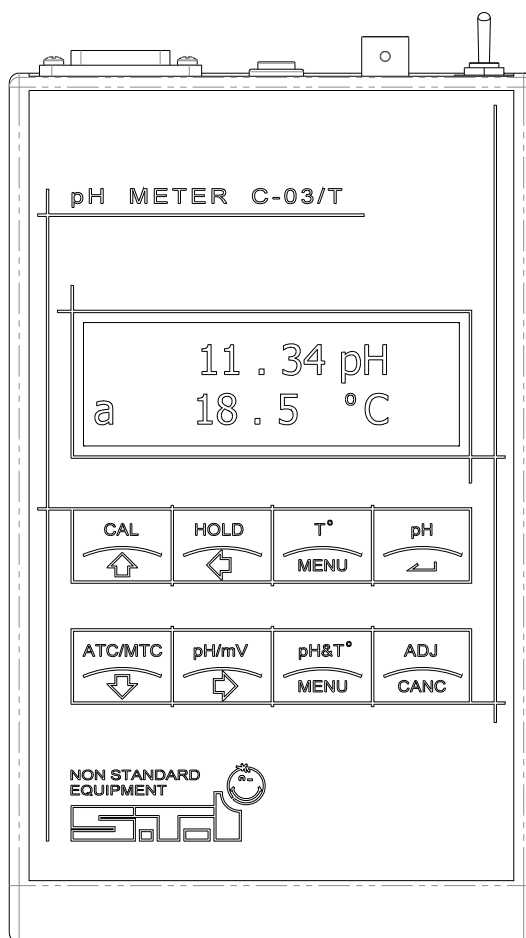


fig.1

### 3. OPERATING MODES

Before the pH meter will be turned on a pH electrode has to be connected to it. The pH electrode's socket is BNC type and is mounted to the rear panel. There is also a terminal for temperature sensor ( RTD Pt1000).

The power supply voltage can be turned on or off by an ON/OFF switch. This switch is mounted to the rear panel too. Rear panel view of portable pH meter C-03/T is shown on fig. 2.

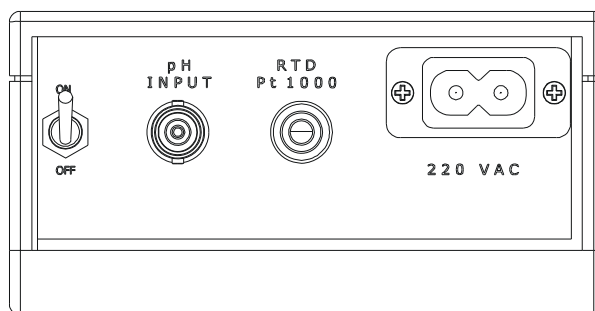



fig. 2

### 3.1. Choosing operating language

The device has two operating languages - Bulgarian and English.

When the device is turning on, the user could select English or Bulgarian language for system messages. If the power supply is turned on when the button  (**ENTER**) is pressed, all system messages will be on Bulgarian. If the power supply is turned on when the button **ADJ** is pressed, all system messages will be on English. When the power supply is turned on and no button is pressed, the system messages will be on the last language, which has been used. In this User's Manual all messages are given in English.

When the power supply is turned on, the following message appears on LCD: manufacturer's company logo, company name **S.T.INNOVATORS**, and then the type of device - **PORTABLE pH-METER**. Then one of the following messages appears:

- **ADJUST O'K** - all physical settings have been entered with right values (the device has been calibrated);

or

- **ADJUST ERROR = N** - where N stays for error's number and this means the device has to be calibrated (see paragraph 5). After that follows the message:

- **MEMORY O'K** - the microprocessor flash memory is O'K and all device settings have the last entered values;

or

- **MEMORY ERROR** - the microprocessor flash memory is damaged and all device settings have the default values (see paragraph 4);

After these messages the device enters pH or mV measurement mode. The LCD is in two-rows (small font) mode.

### 3.2. Millivolt or pH readings

By pressing of **pH/mV** button the measured pH value or the input voltage appear on LCD. Every pressing of **pH/mV** button changes the readings on the LCD between pH and mV. If the measuring unit is **mV** than the device reading is the input voltage. If the measuring unit is **pH** than the pH electrode's voltage will be converted to the equivalent pH value, considering the pH electrode's slope and offset and the temperature compensation value. The reading mode (**pH** or **mV**) is a device setting, which doesn't change when the pH meter has been turned off. If the input voltage is above or under the device physical range than **PHOL** (**PH**ysical **O**ver **L**imit) or **PHUL** (**PH**ysical **U**nder **L**imit) message appear on LCD in two-rows (small font) display mode. In one-row (large font) display mode input overlimiting is displayed with five minuses (-----).

### 3.3. Automatic or manual temperature compensation of pH readings

As the pH measurement is temperature dependent, there is manual or automatic temperature compensation mode in the pH meter. The pH readings are given under standard temperature - 25 °C that means pH readings when sample temperature is 25 °C. By pressing of **ATC/MTC** button the user can change the temperature compensation mode - ATC - automatic (only when RTD Pt1000 is connected to the meter) or MTC - manual (temperature value is entered by the operator). On LCD appears the corresponding letter **a** or **m** for automatic or for manual temperature compensation. The temperature compensation mode (**a** or **m**) is a device setting, which doesn't change when the pH meter has been turned off. If the temperature sensor is not connected to the device or it has been damaged, ATC mode couldn't be selected. The sample temperature for compensation (automatic or manual) is indicated on LCD.

### 3.4. Calibration of pH electrodes

Because of fact that pH electrodes haven't the same characteristics and they have been changed during their work calibration procedures must be done at regular intervals. The calibration is obligatory when a pH electrode is connected for the first time to the pH meter. The calibration interval should be chosen as a compromise between two conflicting requirements - pH measurement accuracy and calibration expenses (price). In any case pH electrode with actual characteristics (stored in the pH meter's memory), meeting the accuracy requirements, must be used. It is desirable pH electrode's calibration to be done with buffers which pH is close to the pH value of measured sample.

It is accepted that pH electrode's characteristic is a line in a orthogonal system where X-axis is pH (pH units) and Y-axis is voltage (mV). The starting point co-ordinates are (pH=7, mV=0). The acid solutions (pH < 7) have positive millivolts and the alkaline solutions (pH > 7) have negative millivolts (see fig.3).

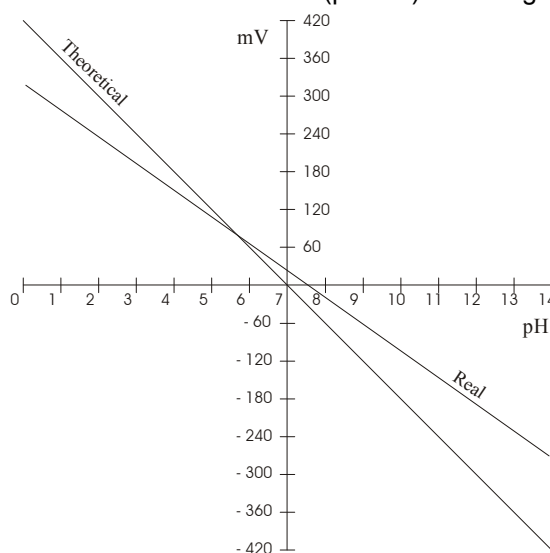


fig. 3

The pH electrode's characteristic is determined by two parameters - SLOPE and OFFSET. SLOPE is the voltage difference corresponding to sample pH change with 1 unit (pH). OFFSET is the voltage corresponding to sample pH = 7. Theoretically an ideal pH electrode at 25 °C has SLOPE = 59.16 mV/pH and OFFSET = 0 mV. Practically a real pH electrode has SLOPE and OFFSET different than in theory. The aim of calibration is to define SLOPE and OFFSET of specific electrode and store them in the pH meter's memory. If these parameters have unacceptable values (e.g. very small SLOPE or very big OFFSET) it's considered the pH electrode is damaged and must be replaced.

### 3.4.1. Single Point Calibration

Single point calibration determines pH electrode's OFFSET and SLOPE is set equal to theoretical (59.16 mV/pH). Single point calibration is not accurate in large pH range and has to be used when pH of the measured sample is close to calibratoin buffer. Single point calibration is cheaper than two point calibration because of using only one buffer.

Below is given single point calibration procedure.

- Connect pH electrode to pH meter C-03/T. Press **ADJ** button to enter adjustment mode and set buffer **S** value, which most closely approximates the expected sample pH (see 4.1. and 4.5.);
- Press **CAL** button. The LCD goes in two-rows (small font) mode and the letter **S** appears in the first upper row position on LCD;
- Rinse pH electrode in water and dry it with soft paper or clothe;
- Place pH electrode into buffer **S** tempered to 25 °C;
- Wait for a stable pH reading
- Press **HOLD** button.

Then letter **S** disappears from the first upper row position on LCD and device enters measurement mode. Single point calibration is finished and pH electrode's OFFSET is stored in device memory. The theoretical value of pH electrode's SLOPE = 59.16 mV/pH is stored in device memory. If the OFFSET is out of acceptable limits an error message " **CALIBRATION ERROR** " appears and the values from the last successful calibration remain in device memory. Then single point calibration procedure must be repeated. If a calibration error occurs again the pH electrode must be regenerated or replaced.

### 3.4.2. Double Point Calibration

Double point calibration determines simultaneously pH electrode's OFFSET and SLOPE. Double point calibration gives good accuracy in large pH range and has to be preferred than the single point calibration. Double point calibration is more expensive than single point calibration (two buffers).

Below is given double point calibration procedure.

- Connect pH electrode to pH meter C-03/T. Press **ADJ** button to enter adjustment mode and set buffer **A** and buffer **B** values. It is recommended that values of buffers **A** and **B** bracket the expected sample range. (see 4.1., 4.6. and 4.7.);
- Press twice **CAL** button. The LCD goes in two-rows (small font) mode and letter **A** appears in the first upper row position on LCD;
- Rinse pH electrode in water and dry it with soft paper or clothe;
- Place pH electrode into buffer **A** tempered to 25 °C;
- Wait for a stable pH reading and press **HOLD** button. Letter **B** appears in the first upper row position on LCD;
- Rinse pH electrode in water and dry it with soft paper or clothe;
- Place pH electrode into buffer **B** tempered to 25 °C;
- Wait for a stable pH reading;
- Press **HOLD** button.

Then letter **B** disappears from the first upper row position on LCD and device enters measurement mode. Double point calibration is finished and pH electrode's SLOPE and OFFSET are stored in device memory. If they are out of acceptable limits an error message " **CALIBR. ERROR** " appears and values from the last successful calibration remain in device memory. Then double point calibration procedure must be repeated. If a calibration error occurs again the pH electrode must be regenerated or replaced.

It should be mentioned that placing the electrode first in buffer **B** and then in buffer **A** wouldn't spoil the calibration. The meter automatically assigns the input signal (mV) to the corresponding buffer value and calculates SLOPE and OFFSET correctly.

### 3.4.3. Cancelling calibration procedure

By pressing button **CAL** once single point calibration mode will be entered (letter **S**). By pressing button **CAL** twice double point calibration mode will be entered (letter **A**). By pressing button **CAL** three times double point calibration mode will be cancelled and device will enter measurement mode. Pressing button **CAL** makes LCD to go in two-rows (small font) mode. Button **CAL** is always active in measurement and calibration and pressing **CAL** always work in described manner, even if the device is on the half way of double point calibration procedure after first pressing of **HOLD** button.

### 3.5. Recharging battery power supply

Portable pH meter C-03/T has an independent power supply. It is an accumulator, which must be recharged when a "**BATTERY LOW**" message appears on LCD. There is a built-in charger, which will start to work when a power supply cable from the power network 220V/50Hz will be connected to the meter. The battery recharging occurs regardless whether the meter is switched on or off. If pH meter has been switched on and battery charge has reached the working level then "**BATTERY LOW**" message disappears and the meter starts its normal work. The device can work or stay connected to the power network without danger of overcharging the battery.



### 3.6. Turn to one-row (large font) display mode

As was mentioned above the portable pH meter has ability to display readings in large font size. The purpose is visualization improvement from long distances. By pressing **pH** button the device turn to one-row (large font) display mode and displays measured value on the voltage input – pH or mV. Measured pH value is in the form: sign, two digits (integer), decimal point, two digits (broken number part), represented in large font and pH dimension represented in small font. Measured mV value is in the form: sign, three digits (integer), decimal point, one digit (broken number part), represented in large font and mV dimension represented in small font. The turn between both pH and mV values realizes as in two-rows (small font) mode by pressing the **pH/mV** button. If the input voltage is above or under the device physical range than five minuses (-----) are displayed. Pressing the **T°** button turns display to large font mode for temperature compensation value. The value is in the form: sign, three digits (integer), decimal point, one digit (broken number part), represented in large font and °C dimension represented in small font. In case of ATC (only when RTD Pt1000 is connected to the meter) small font letter **a** is displayed above dimension. In case of MTC letter **m** is displayed.

Pressing the **pH & T°** button turns display to two-row (small font) mode. Also pressing **CAL** button (starting calibration) turns display to two-row (small font) mode because during calibration process it is necessary to watch both values.

## 4. DEVICE SETTINGS ADJUSTMENT

There are few device settings connected with pH meter's work. Their values could be adjusted by the operator.

### 4.1. General principles

By pressing **ADJ** button the portable pH meter enters adjustment mode. On LCD appears the first device setting, its current value and its dimension. By pressing of either **MENU UP** or **MENU DOWN** button all device settings and their current values and dimensions can be displayed. The cursor appears in the value field under the decimal digit that will be adjusted. By **↑ (up arrow)** and **↓ (down arrow)** buttons (representing increment and decrement) the adjustment of setting value can be done. By **← (left arrow)** and **→ (right arrow)** buttons the wanted value digit can be reached (the cursor moves on left or right). All setting adjustments could be confirmed by pressing **↵ (ENTER)** button or cancelled by pressing **CANC** button. In the last case the last entered or default device settings (if no adjustment has been done before) remain in system memory. In both cases (when either **↵ (ENTER)** or **CANC** button has been pressed) pH meter enters measurement mode.

Below all device settings will be described in the same order as they appear on LCD.

### 4.2. Temperature for manual compensation

The device setting "**MANUAL TMP.**" is used for manual temperature compensation of measured pH sample. It represents the temperature of measured sample in degrees centigrade. When it's no possible to use RTD Pt 1000 for ATC or the sample temperature is known from another thermometer, the temperature is entered by the operator and serves for temperature compensation in MTC mode (see 3.3.). Default value of this setting is 25 °C.

### 4.3. Offset of pH electrode

The device setting "**OFFSET**" is the one from the two components of pH electrode's characteristic (see 3.4.). **OFFSET** is the voltage corresponding to sample pH = 7. It serves for calculating pH of the measured sample from the input millivolt signal. The device sets it up automatically after pH electrode's calibration. Manual adjustment is also available and it is used when a pH electrode has been calibrated with another pH meter and its current settings are known. Default **OFFSET** value is 0 mV.

### 4.4. Slope of pH electrode

The device setting "**SLOPE**" is the one from the two components of pH electrode's characteristic (see 3.4.). **SLOPE** is the voltage difference corresponding to sample pH change with 1 unit (pH). It serves for calculating pH of the measured sample from the input millivolt signal. The device sets it up automatically

after pH electrode's calibration. Manual adjustment is also available and it is used when a pH electrode has been calibrated with another pH meter and its current settings are known. Default SLOPE value is 59.16 mV/pH.

#### **4.5. Buffer S**

The device setting " **BUFFER S** " represents pH value of buffer solution used for single point calibration at temperature 25 °C (see 3.4.1.). Default value of buffer S is 7.00 pH.

#### **4.6. Buffer A**

The device setting " **BUFFER A** " represents pH value of the first buffer solution used for double point calibration at temperature 25 °C (see 3.4.2.). Default value of buffer A is 4.00 pH.

#### **4.7. Buffer B**



The device setting " **BUFFER B** " represents pH value of the second buffer solution used for double point calibration at temperature 25 °C (see 3.4.2.). Default value of buffer B is 10.00.

## 5. DEVICE CALIBRATION PROCESS (PHYSICAL ADJUSTMENT)


As any type of measurement device the portable pH meter must be calibrated to adjust its analog inputs. This adjustment is done from manufacturer, but it is possible to be repeated always when it is necessary. **It is obligatory to make calibration in laboratory conditions from competent persons. DC voltage calibrator and a standard resistance with precision grade 0.05 or better are necessary for calibration.**

Calibration procedure is given below:

- Place the device in a laboratory in normal working conditions;
- Connect the device to power supply conforming specified requirements and turn on;
- Leave device to work at least one hour;
- Turn off the device for a moment and turn it on while pressing both **MENU UP** and **MENU DOWN** buttons;
- After usual starting, message "**ADJUSTMENT**" appears on LCD for a moment, and device enters calibration mode.

On the display appear the parameter that has to be adjusted and the measured value in corresponding input in this moment. Pressing **MENU UP** or **MENU DOWN** buttons selects parameters for adjustment. Connect the necessary standard input signal to corresponding input. After stabilizing of the reading press  (**ENTER**) button. If the calibration of displayed parameter is successful on LCD appears message "**ADJUSTMENT O'K**" and the parameter's value is saved in device memory. If the calibration fault on display appears message "**OUT OF LIMITS**". In this case the calibration **must** be repeated. After calibration of all parameters the device can be turned off or switched to normal work mode by pressing combination of buttons: press and hold **CANC (ADJ)** button and then together with it press  (**ENTER**)(**pH**) button. On LCD for a moment appears "**ADJUSTMENT END**" and the device turn to normal measurement mode.

Below an example of the calibration process (physical adjustment) is given:

1. Prepare and connect proper cables between the pH meter and the calibrator and the standard resistance;
2. Turn on and prepare for work the voltage calibrator and the standard resistance, according their technical instruction for exploitation;
3. Turn on the portable pH meter and leave it to work at least one hour;
4. Turn off the device for a moment and turn it on while pressing both **MENU UP** and **MENU DOWN** buttons;
5. After usual starting, message "**ADJUSTMENT**" appears on LCD for a moment, and device enters calibration mode. The first calibration parameter appears:  
 " **INP.= +500mV** "  
 0.0 mV
6. From the DC voltage calibrator apply input signal +500 mV to pH meter's pH/mV input;
7. Wait for a stable reading, for example:  
 " **INP.= +500mV** "  
 489.0 mV;
8. Press  (**ENTER**) button. On the display appears:  
 " **ADJUSTMENT O'K** ", after that  
 " **INP.= +500mV** "  
 500.0 mV
9. Press **MENU UP** button. On the display appears the second calibration parameter:

- " INP.= -500mV "  
500.0 mV;
10. If now press **↵** (**ENTER**), the message:  
" **OUT OF LIMITS** " appears, because the input voltage is +500mV. After that on LCD is:  
" INP.= -500mV "  
500.0 mV ;
11. From the DC voltage calibrator apply input signal -500 mV to pH meter's pH/mV input;
12. Wait for a stable reading, for example:  
" INP.= -500mV "  
- 486.3 mV;
13. Press **↵** (**ENTER**) button. On the display appears:  
" **ADJUSTMENT O'K** ", after that  
" INP.= -500mV "  
-500.0 mV;
14. Press **MENU UP** button. On the display appears the third calibration parameter:  
"RTD = 1385 om"  
1554 om;
15. Connect a standard resistance with value of 1385 ohms to pH meter's RTD input;
16. Wait for a stable reading, for example:  
"RTD = 1385 om"  
1382 om ;
17. Press **↵** (**ENTER**) button. On the display appears:  
" **ADJUSTMENT O'K** ", after that  
"RTD = 1385 om"  
1385 om.
18. Calibration and of the three parameters is complete successfully. The device can be turned off or switched to normal work mode by pressing combination of buttons: press and hold **CANC (ADJ)** button and then together with it press **↵** (**ENTER**)(**pH**) button. On the display for a moment appears " **ADJUSTMENT END** " and the device turn to normal measurement mode.

**It is not recommended to CALIBRATE (ADJUST PHISICALLY) THE DEVICE in follow cases:**

- **When the calibration is not completely necessary;**
- **From incompetent persons;**
- **Useing equipment with unsuitable accuracy grade;**
- **Inobservance of the algorithm, mentioned above.**

## 6. TECHNICAL DATA

### 6.1. Power Supply

- Network power supply: 220V  $\pm$ 10% , 50 Hz. Built-in charger;
- Built-in Ni-MH accumulator batteries power supply: operating time 24 hours.

**6.2. pH/mV input type:** single, BNC connector

**6.3. Input impedance of pH/mV input:**  $> 10^{13} \Omega$

**6.4. Measurement range of pH/mV input:** 0  $\div$  14 pH; -600  $\div$  +600 mV

**6.5. Resolution:** 0.01 pH; 0.3 mV

**6.6. Temperature measurement:**

- External RTD Pt1000: 2 wire connection;
- Range: 0  $\div$  140 °C;
- Resolution: 0.1 °C;

**6.7. Accuracy:** 0.2% full scale  $\pm$  1LSB.

**6.8. Adjustable settings:**

- pH buffer solutions value: to 0.01pH;
- pH electrode's slope: to 0.01mV/pH;
- pH electrode's offset: to 0.1mV;
- Manual temperature compensation value: to 0.1 °C.

**6.9. Display:** graphics LCD (Liquid Crystal Display) – 122 x 32 dots

**6.10. Keypad:** Micro switch - dry contact

**6.11. Microprocessor:** Texas Instruments MSP430F149.

**6.12. Memory type:** Flash EEPROM

**6.13. Enclosure:** BOPLA BP 810 - IP 40.

**6.14. Operating conditions:**

- Ambient temperature: 5  $\div$  45 °C;
- RH (relative humidity): up to 90% at 30 °C;
- Atmospheric pressure: 61  $\div$  107 kPa;
- Shock and vibration: up to 10g.

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