Advanced potentiometric converter MPH 71

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Function description

Intelligent potentiometric converter MPH71 is composed from several important parts. Signal digitalization is done by 24-bit A/D converter. Then follows microprocessor controlled data processing and then is output send via optical barrier to current loop, where data is converted to analogue form by 16-bit D/A converter.

Technical parameters

- Input impedance: 10^{12} Ohm
- Power supply: adaptor 9V/300mA or 9 – 12V DC
- Displaying of actual value: 3,5-digit LED display
- Units : concentration, pH with temperature correction, mV
- 3-point calibration of pH and concentration
- Output: isolated current loop 4-20mA working in series with external power supply 12-48VDC
- galvanically separated RS-232 interface for converter set-up and eventual data collection.

Ranges

pH	range	0-14
	resolution	0.002
	precision	0.01
voltage	range	+/- 2.3V
	resolution	0.1 mV
	precision	1 mV
concentration	range	1.10^{-9} – 1.10^{9} ($g.l^{-1}$ or $mol.l^{-1}$)
	resolution	Third valid digit
	precision	Second valid digit
temperature	range	-5 – 120 °C
	resolution	0.1 °C
	precision	1° C

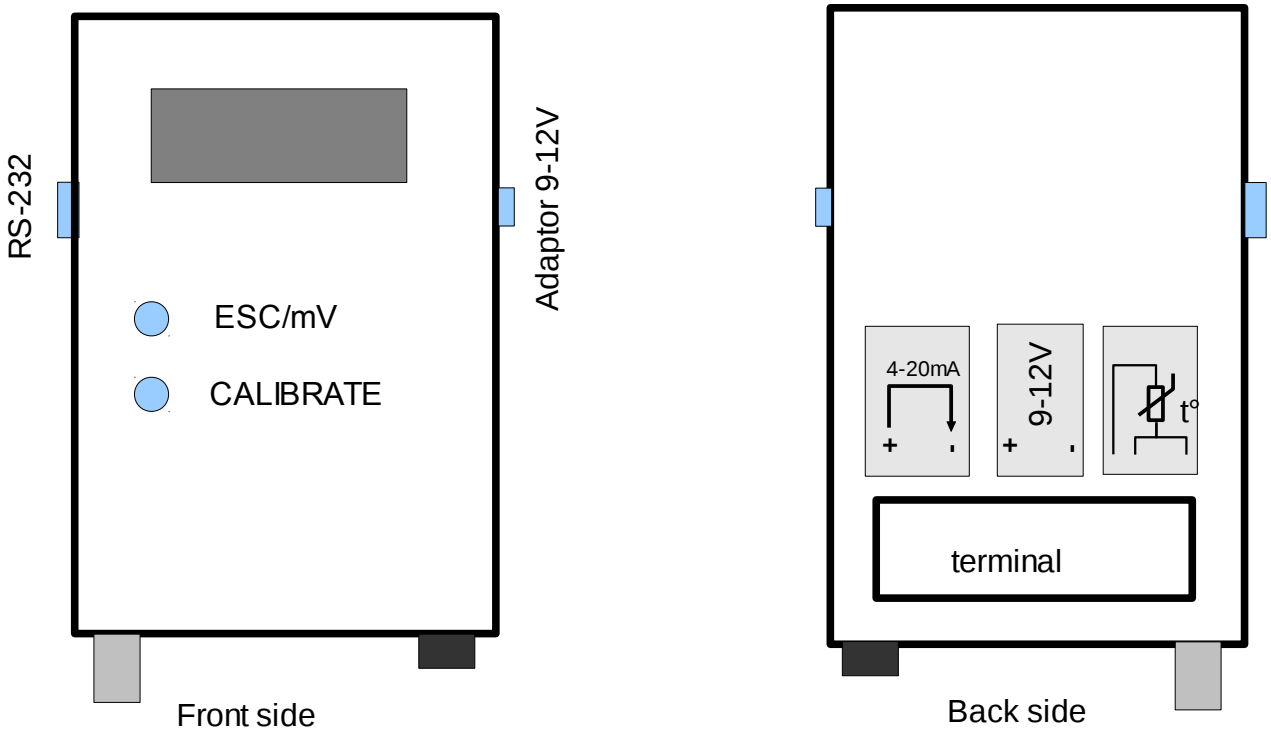
Description of working modes

The instrument allows three modes. The most simple is common milivoltmeter. In this mode, the instrument displays milivolts on display. Second mode is measuring pH. For this mode we have to set up calibration points – buffers – which we will use for calibration and set it by serial port. Then we make calibration of instrument by method described bellow. After successfull calibration shall

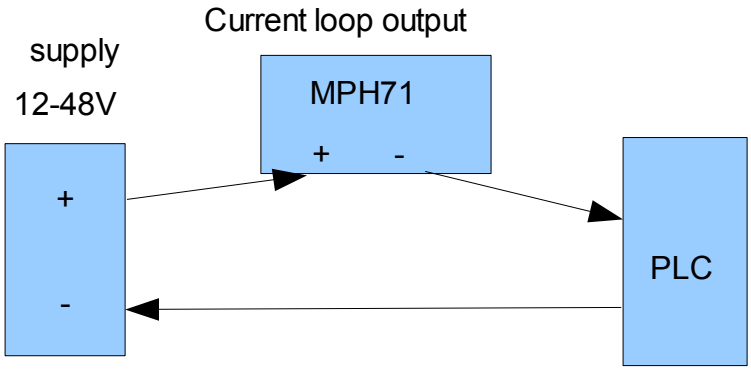
instrument display actual pH on display. Third mode is ionmeter. For ionmeter, same as for pH-meter, we have to set-up calibration points. They will be displayed during calibration and measuring in logaritmic scale. They are send in linearised form to RS-232 and to current loop.

Instrument connection

For laboratory we can use connectors on the instrument. Supply connector is placed on right side, on the left side is serial port (RS-232) and on the bottom are connectors for electrodes (grey – BNC – for indication electrode, black – banana – for reference electrode). As the indication and reference electrode you can use anyone from our assortment depending on their suitability for the application.



For the usage in switchboard on the DIN bar is suitable to use terminal which is on the back side. This terminal contains outputs for current loop (which should be used in series with suitable power supply), temperature sensor and power supply input. As the temperature sensor, device KTY-81/210 is used. We can supply it with proper wiring and in chemically resistant body. Polarity of the inputs and outputs must be corrent. If other than supplied power source is used (ie. DC-DC converter), it is necessary that output of power supply will be isolated from input and ground. In other case the presence of ground loops can lead to unpredictable results. Current loop should be supplied from suitable power supply (linear stabilized power supply is ideal) with voltage from 12 to 48V.



Calibration description

For starting calibration we press the **CALIBRATE** button. Then will show CAL on display followed by value of pH buffer or logarithmic concentration. Then we put electrode to buffer and wait for potential stabilization. If the potential is stable enough, we press **CALIBRATE** button again. Display shows next value of the standard and then current potential. Then we insert electrodes to correct standard and wait for stable potential. After it we press **CALIBRATE** button again. If there is set third calibration point, then we must insert correct buffer, wait for stable potential and press **CALIBRATE** once again. If there are set only two points, calibration is finished. At the end, display will show firstly SLP1 and then slope for a moment, then SLP2 and second slope if 3rd calibration point is set, and store data to memory.

Doing calibration over serial port

After insertion of standard we let to stable potential and send command **CALIB n** (n depends on sequence 1 to 3). For final storing calibration points to memory, send command **CAL_CALC**.

Calibration point setup and D/A parameters setup

Setup of all parameters (calibration points, transformation parameters for conversion to current etc.) is done via serial port.

Conversion of units to current

The range of output current is 4 to 20 mA and cannot be set out of this range. The converter allows three measuring modes – concentration (logarithmic scale), pH – linear scale with temperature compensation and direct recalculation of milivolts. This modes covers most probable usage of the converter for measuring potentiometry. Recalculation is always applied to units, that means for **TR_SLOPE** = 1 it is 1 mA to 1 pH, 1mA to 1mV a 1 mA to 1 C (mol/dm^3, g/l – depends on standards). **TR_Y** is defined as value which will be substracted from the quantity before multiplying by **TR_SLOPE** (ie., if pH = 7, **TR_Y** = 4, **TR_SLOPE**=1, result is +3 mA)

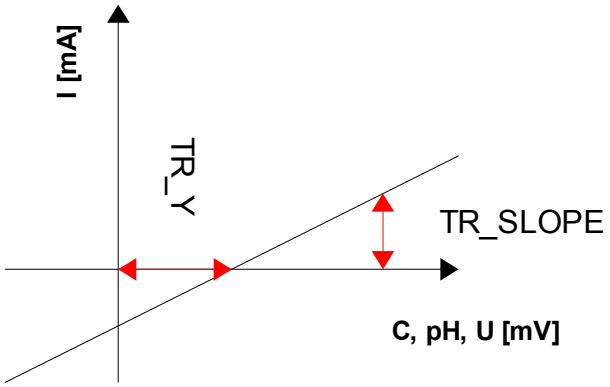


Fig 3: graphical scheme of dependence I, TR_Y, TR_SLOPE and quantity.

The communication protocol

The instrument is set-up for 9600 bits 1 stop bit, 8 bits word, without parity. It is necessary to keep caps size because **protocol is case sensitive**. Every command has following form: (\n is C language notation for 0x0A hex char, line feed):

COMMAND\n

or for command and parameter separated by space (32 decimally):

COMMAND parameter\n

After every command is processed, converter returns a status or value:

STATUS\n

It could happen that blank line will be returned.

List of commands:

- **CAL1?** - returns value of first calibration point, number in range -32.767 to +32.767 for pH or 9.99e-9 to 9.99e9 for measuring concentration. If measure type is **MV**, returns **NA**.
- **CAL1: number** – set first calibration point to value number. It should be in range -32.767 to +32.767. After successful processing it returns **OK**. Else returns **NA** (if measuring type is **MV**). Values of calibration points must be sorted from low to high for pH (ie. pH: 4.01, 6.86) and from hight to low for concentration (ie. 6.2e-2, 9.6e-3 etc.).
  NOTICE: All calibration results and recalculations(TR_Y, SLOPE) are kept after reseting calibration point.
- **CAL2?** - returns value of 2nd calibration point. For details see **CAL1?**.
- **CAL2: number** – set second calibration point to value number. For details see **CAL1:**.
- **CAL3?** - returns value of 3rd calibration point. For details see **CAL1?**. If value of 3rd calibration is **NA**, 3rd will not be used.
- **CAL3: number** – set third calibration point to value number. For details see **CAL1:**. If value is set to **NA**, this point is no longer used.
  NOTE: if you set this point to NA, the second slope is no longer used (between points

CAL2 and CAL3) and for calculations only one point calibration (CAL1, CAL2) will be used.

- **CALIB number** – store measured value for calibration point number (1 to 3) to temporary memory. If invalid number is entered (> 3 or <1), returns **FAIL**.
- **CAL_CALC** – calculate calibration from temporary values.
- **DEV** point – returns point of calibration curve:
  - **CAL1** – returns first point of curve (in milivolt)
  - **SLOPE1** – returns slope of the first curve (milivolt/order)
  - **CAL2** – returns point of second curve (in milivolt)
  - **SLOPE2** – returns slope of the second curve (milivolt/order)
  - if unknown parameter is provided, returns **FAIL**.
- **ISO?** - returns isoelectric point for pH electrode. This point is not used for measuring concentration or milivolts. For number formatting see **CAL1?**. For measuring type **MV** returns **NA**.
- **ISO:** - sets the value of isoelectric point of pH electrode. If mode **MV** is set, returns **NA**, elsewhere returns **OK**.
- **MEAS** – measures actual value. Number format is 99.999 for pH or 9.99e-9 for concentration or 9999.9 for milivolts.
- **MODE?** - returns measuring mode. If returns **NA**, it means that converter wan never been configured. In other case returns one of these options:
  - **CONC** – neasuer concentration
  - **MV** – measure milivolts
  - **PH** – measure pH
- **MODE: mode** - sets mode according to parameter. Usable parameters are above (command **MODE?**). If unknown mode is requested, returns **FAIL**.
- **MV** – returns actual value of milivolts (without conversion).
- **PING** – returns **OK**. Suitable for cable checking.
- **TEMP** – returns temperature in Kelvins.
- **TR_SLOPE?** - returns conversion value of slope for D/A converter in miliamps per unit. See conversion units to current. Number format is in floating point form (9.99e-9). Returns NA, if measuring type is not configured.
- **TR_SLOPE:** - sets slope parameter for D/A. Details are above.
- **TR_Y?** – returns value to substract from measured before conversion on D/A. See conversion units to current. Number format is in floating point form (9.99e-9). Returns NA, if measuring type is not configured.

- **TR_Y:** - sets value to substract. See above.

Software tools

Serial port setup on unix can be easily done by stty command:

stty -F /dev/ttyS0 9600 raw -echoe -echo

After this setup it is possible to simply send commands to device ie. by echo and read them ie. by cat. For more comfort reading/writing there is there small piece of software written in C which can be compiled by following command:

gcc main.c unix-serial.c -o serial

Compiled program serial allows easy reading/writing by standard input and standard output respectively without additional serial port setup. For windows, there is precompiled binary serial.exe

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