The System for measurement using a computer in the school laboratory as a platform for measuring temperatures during the water heating

Radek Nemec, Stepan Hubalovsky

***Abstract*—** The system for measurement using a computer in the school science laboratory is low-cost platform used for many measuring. One of these is measuring temperatures during the water heating. This is important to explanation for temperatures during the water heating. It is used to justify the differences in dependency of the temperature during the heating. To facilitate understanding of the dependency we suggest using of a graphical representation. The system allows showing the dependency in real time by graphical representation.

***Keywords*—**Experiments supported by ICT, temperature sensor, the system SMPSL.

I. Introduction

FOR the real display of temperature dependency during heating the systems for measurement using a computer are used. These systems are usually very expensive. As an alternative system was created SMPSL (http://smpsl.radeknemec.cz). The SMPSL (Measurement System Using a Computer in School Lab) enables using sensors connected to the hardware of the system via a USB connection to a PC evaluation program. The evaluation is created using a graphical representation of values from the computer. It enables control and measure - see Figure 1. By constructing the hardware part from programmed microcontroller and using of a few components (Figure 2), USB connection (Figure 3) a free program available SMPSL such a system can take just a few euros. The system can be connected to commercial sensors or the sensors can be developed in the same ideology as the system itself, i.e. the most acceptable options - both financial and material. [1], [2], [3]

One of the presented sensors is sensor for temperature measurement.

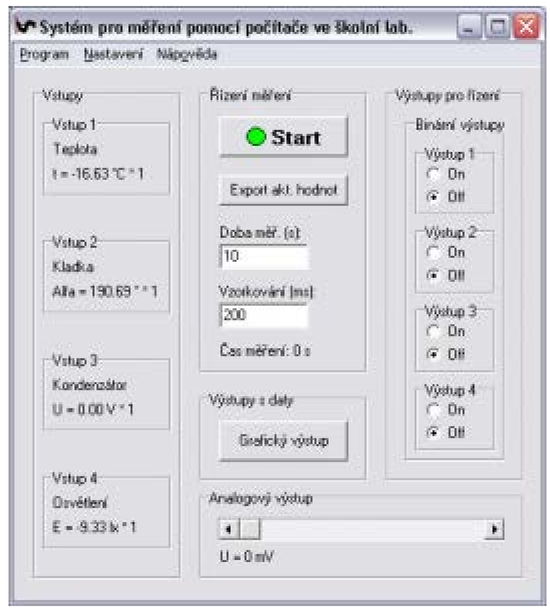

Fig. 1 System SMPSL

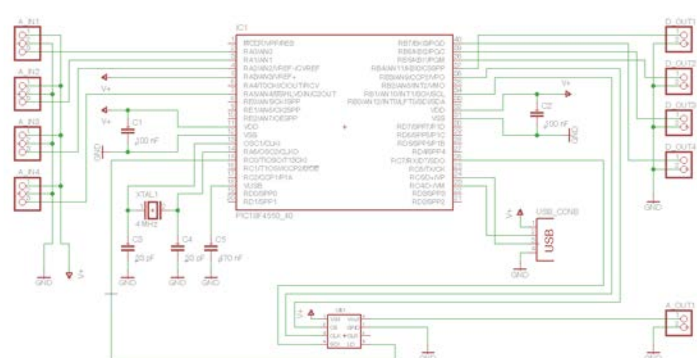

Fig. 2 System SMPSL – connection diagram

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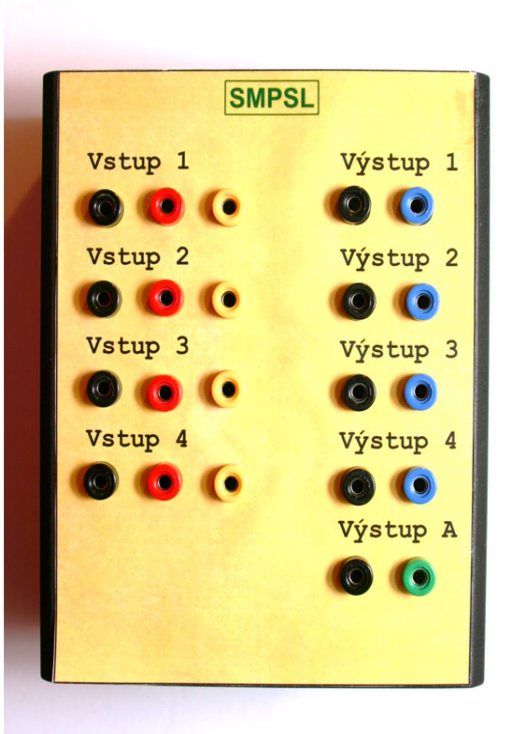

Fig. 3 System SMPSL

Fig. 4 System SMPSL - inside

II. . SYSTEM SMPSL

SMPSL system is based on platform eProDas created at University of Ljubljana.

Hardware based part of the SMPSL system is microprocessor connected via USB interface. The system is designed so that it can be used at all levels of education, from primary school to high school. An important feature of the system is the ability to produce it yourself, both due to the very low price, thanks to freely available libraries and documentation.

Hardware-based microcontroller is a Microchip PIC series. With affordable price and sufficient properties was selected the PIC18F4550 (Figure 5).

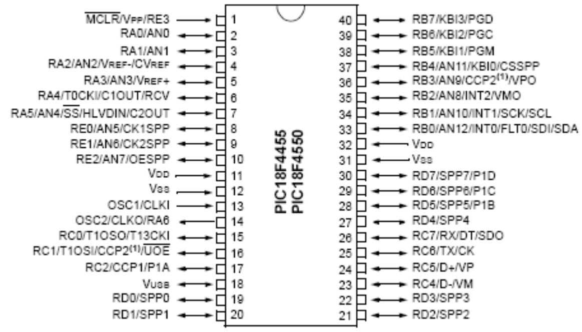

Fig 5 Microcontroller Microchip PIC18F4550

This microcontroller allows full speed (12 megabytes/s) USB connection, 32 KB program RAM, 2 KB of data RAM and 256 B integrated EEPROM. It offers 10-bit AD converter, 13 multiplexed input channels, two voltage comparators, 4 timers. PWM module is used to control the power, SPI and I2C communication. USART module has 31 general purpose digital I/O ports. Connection with other devices is mainly done through SPI interface allows connection to 12-bit AD and DA converters. [4]

The resulting hardware part consists of the chassis described by color-coded banana connectors for connecting the sensors - inputs and devices - outputs. It contains 4 analog inputs, 4 digital outputs and 1 analog output – see figure 3, 4. The interior of the hardware has been implemented on a printed circuit board with cable management to banana jacks on the top of the chassis.

Software part of the SMPSL system allows the connection of hardware to computer via programming interface (API) in C / C + +, created in Delphi or Visual Basic. Software included in the libraries of eProDas can be divided into two parts. First part is firmware that is installed in the memory of the microcomputer; second part is installed on the PC. On the PC it is needed install the communication driver and library functions.

SMPLS system has also created User Interface part that allows using the system for ICT experiment in the school laboratories. User interface of SMPLS consists of several parts:

- **The main window**, which consist part for display of input variables, part for control of analog and dialog outputs and part for setting of the measurement – see figure 4.
- **Graphical output window**, where measured data are shown in graphical and numerical form – see figure 4.
- **Display window** where graphical display is configured.
- **Inputs window** where are configured inputs of measurements, OS settings and calibration.

III. Science Experiment

Science experiment offers a way to observe, document, set hypotheses, draw conclusions and finally gain knowledge about a phenomenon. It is a way how to actively acquire knowledge.

When carrying out science experiments the observations and experiments themselves are conducted. This will enrich all science learning and work of pupils and students in the classroom is activated. They will get practical skills for understanding the natural aspects of the world. At the same time scientific observation and experiment is strong motivator of teaching and it strongly contributes to the development of science pupils' interests.

Natural-science experiment unlike mere demonstration experiment is not only demonstration of already known phenomena, but pupils and students based on their hypotheses verified phenomenon itself [5].

IV. Natural science experiments using ICT

The above mentioned aspects of the science observation and experiment can be realized also by means of computer. For such experiments and measurement systems are used for measurement using a computer in a school science lab. Systems for measurement using the computer are systems that enable collection, management and processing of data obtained with the measuring device that is connected to the computer. Such experiments are also called computer-aided experiments.

There are many reasons why a measurement is carried out using computer. The main reason is the possibility of obtaining large amounts of data without manual recording, which is done by connected computer. The processing may be immediately performed on the computer without overwriting previous readings.

Measurement, processing and control by computer has existed for a long time. High extension of these systems in the school laboratories occurs currently, mainly due to the lower cost and the opportunity to assemble system yourself.

Thanks systems for measurement using the computer, the above described observations and experiments can be carried out with the use of ICT, which is a major advantage in the rapid collection of large amounts of data and real processing in the form of graphs. Graphical representation helps for easier understanding of a phenomenon, which is our purpose. [6], [7], [8], [9].

V. Experiment explaining the course of temperature in heating water

In science subjects (e.g. physycs) during the teaching of the temperatures it is needed to justify the difference in heating of water with free surface and covered surface.

The graphic representation is used to help to understand this phenomenon. Let’s present demonstration of this phenomenon using for computer measurement in the school science laboratory. The experiment requires a computer system for measuring a temperature sensor.

In addition to heating the water with free and covered cover surface the experiment with heated ice will be presented too.

A. Temperature Sensor

Temperature sensor is simple sensor consisting of a sensor adapted directly to the low voltage output with a suitable voltage (power and output) for system SMPSL with linear characteristic 10mV/°C. The range of temperature is from –40°C to +125°C. The sensor should be placed to a suitable case (e.g. steel tube with thermally conductive paste for better transmission of the heating from the surrounding) and provide appropriate cables with connectors for connection to the system SMPSL (Fig. 7). The total price of self-produced sensor is tenths of price of commercial sensor.

Fig. 6 Temperature sensor

Fig. 7 Self-produces sensor with cables and case

In addition to monitoring and clarification of process of heating water, the temperature sensor can be used, for example in the following experiments:

• Spontaneous cooling of sensor (dry / wet, with / without flapping)

• Dissolution of ice cubes in fresh and saltwater

• Water cooling rate of water

• How to change the temperature in the freezer or refrigerator during the day

• How the temperature changes at a particular point during the day and night.

B. Experiment realization

For experiment realization, in addition to already mentioned computer system for measurement and temperature sensor is need a container with a lid and heating source. For comparison between temperature curve with free surface and covered surface covered would be ideal to have two containers (one with a lid, second without), two sources of heating and two temperature sensors. The current realization of the experiment would guarantee the same conditions under which the experiment will be carried out (ambient air temperature, pressure). For demonstration experiment is carried out first one and then the other measurements – see Figure 8.

Fig. 8 Set for measuring

Before performing the experiment, it is first necessary calibrate the temperature sensor (Fig. 9). It is advisable to calibrate it before the lessons.

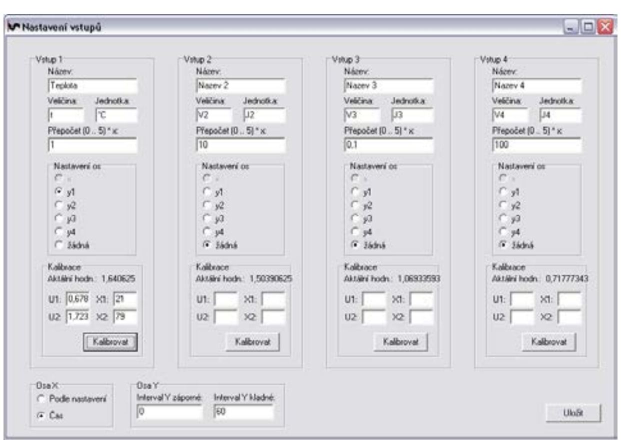

Fig. 9 Calibration

The resulting temperature dependence of heating of water with free surface is shown in Figure 10.

The resulting temperature dependence of heating of water with covered surface is shown in Figure 11.

The resulting temperature dependence of heating of water with free and covered surface is shown in Figure 12.

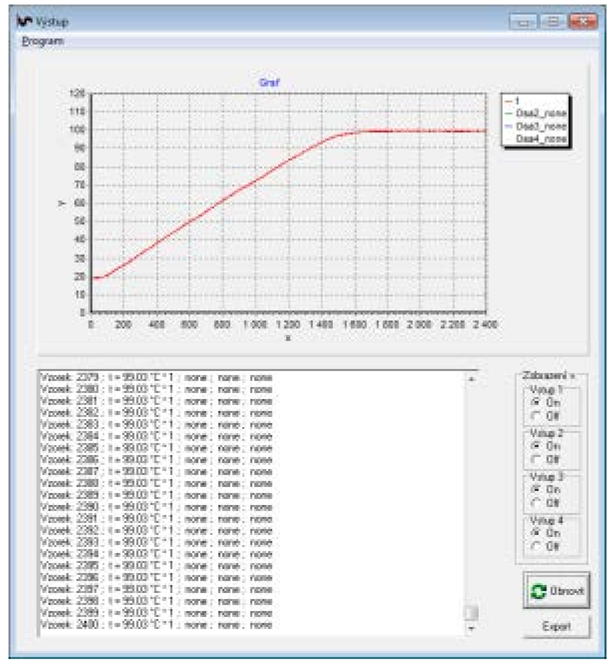

Fig. 10 Heating of water with free surface

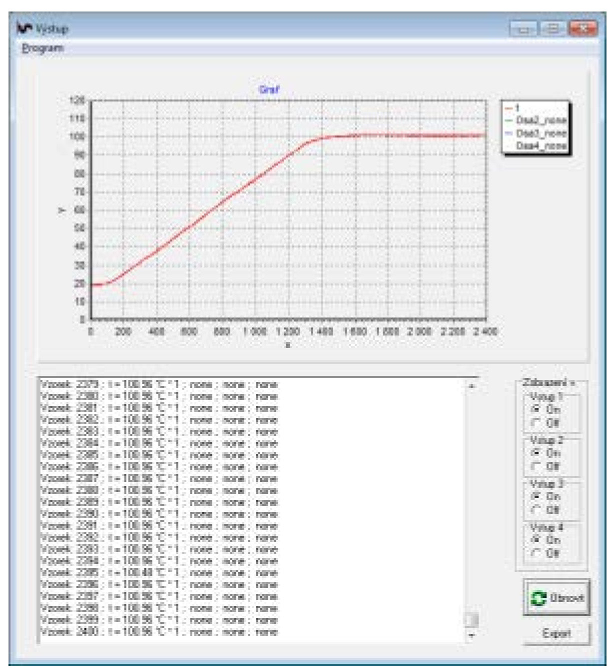

Fig. 11 Heating of water with covered surface

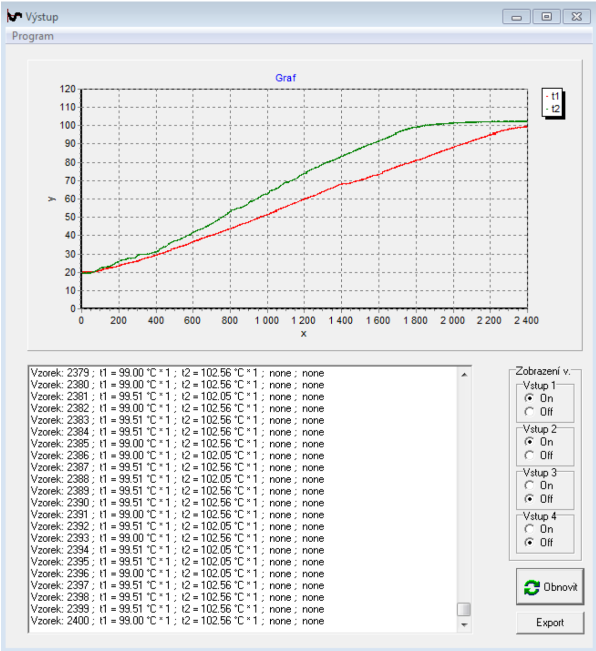

Fig. 12 Heating of water with free and covered surface

Heating of ice is shown on the Figure 13 and 14. In this case the solid state (ice) we get to the boiling point. For this measurement to SMPSL the temperature sensor is connected to thermometer and two beakers with hot and cold water to calibrate and set the input.

The measurement is carried out by immersing the calibrated sensor into ice, by setting the measurement time, and initiating a measurement.

Fig. 13 Measurement of heating of ice

Fig. 14 Measurement of heating of ice

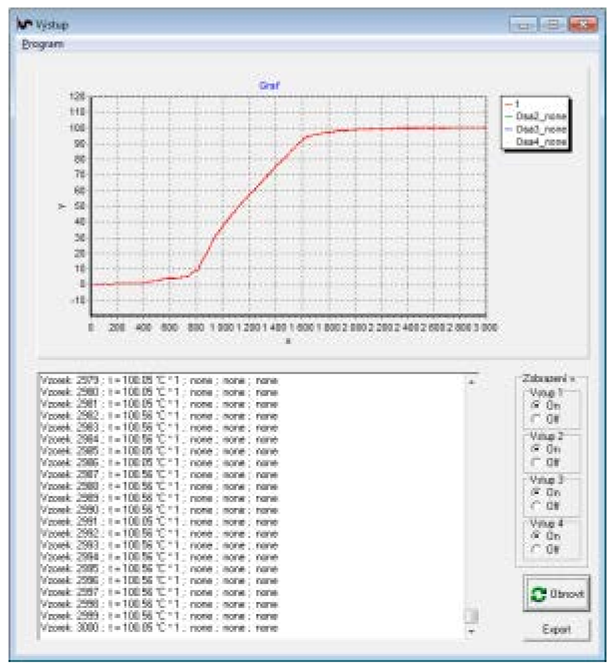

Fig. 15 Heating of ice

When this measurement demonstrates known phenomenon in which the first heat the entire volume of the container and then starts to increase until the temperature. The same thing happens then is shown on the Figure 15.

C. Bonus experiment

In the case that we have sufficient time the experiment can be proceed spontaneously. It can be demonstrated cooling liquid of the water with free surface and covered surface. This experiment is, however, very time consuming, so it is appropriate to include heating in the beginning. In the time the student will evaluate the heating dependencies it can in the background provided this bonus experiment.

VI. CONCLUSION

The important rule, as described above, is that natural science experiment has to fulfill its sense, therefore, test hypotheses and conclude it. Without this they are only mere experiments in which the pupils and students only saw a demonstration of various phenomena. They should enrichment their knowledge by visual demonstration, establishing and verifying hypotheses, and by better understand the science principles. [11].

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