

Anna GOLIJANEK-JĘDRZEJCZYK*
Dariusz JĘDRZEJCZYK*
Ludwik REFEROWSKI*
Dariusz ŚWISULSKI*

EDUCATIONAL LABORATORY STAND FOR REMOTE MEASUREMENT SENSORS' DYNAMIC CHARACTERISTICS

This article presents a laboratory stand that enables one to test properties of temperature sensors over Internet. The measuring system lets determine dynamic characteristics of the sensor. It was designed for didactic applications, which can be used by extra-mural or ill students although some solutions may be used by industry.

Keywords: education, laboratory, measurements.

1. INTRODUCTION

The remote laboratory offers students new way to teach and learn important concepts. What is more, students can access to remote laboratory from home over Internet. This kind of laboratory has many advantages. One of them is the fact that one might attend extramural studies over Internet. Another advantage is that an ill student is able to realize his experiments at home [1].

The remote laboratory consists of: the computer situated in the laboratory, clients computers and suitable software. Every computer should be connected to the Internet.

* Technical University of Gdańsk, Electrical and Control Engineering Faculty, Narutowicza 11 str., 80-952 Gdańsk, Poland, e-mail: agol@ely.pg.gda.pl

2. STRUCTURE OF THE SYSTEM

The presented measuring system enables estimating dynamic characteristics and properties of various types of temperature sensors. Simultaneously, there can be tested three sensors: resistant Pt100, thermocouple type K and semiconductor LM35DZ [2]. Laboratory stand service can be realized directly at laboratory and remote from any computer with access to Internet.

Structure of this measuring system was shown in the Fig. 1.

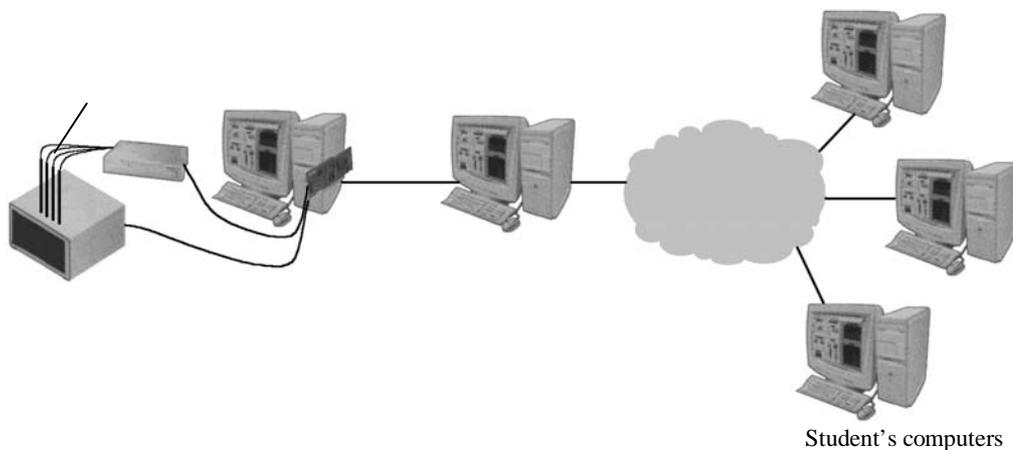


Fig. 1. Structure of measuring system

This system consists of: measuring circuits testing temperature sensors and system for control of heating and cooling processes, cooling fan and electric heater.

Measuring system of resistant sensors consists of stabilized DC source, controllable current generator, measuring bridge and measuring amplifier. Whereas measuring system of thermocouple type K consists of stabilized DC source and special chip AD595AQ Analog Devices. System for control of heating and cooling temperature sensors is based on contact switching elements.

Personal computer is responsible for control measuring system. This computer is equipped in measuring card and network card. Data acquisition card (DAQ) converts signals from measuring temperature to digital signals and save them in computer memory. This card has discrete outputs which are used to control operation of cooling fan and electric heater.

Software is an integral part of this system. This laboratory stand application and customer application were made in integrated software environment – LabVIEW.

Measuring and control data are not directly sent from computer situated in the laboratory to customer's computer but by means of the computer with installed *Data-socket server*.

DataSocket server uses protocol DSTP (*DataSocket Transfer Protocol*) for sending data, which is based on TCP/IP protocol. But, as opposed to protocol TCP/IP, where data first must be converted in a suitable string and then send, DSTP lets send any sequences of data and conversion to a form which can be send is invisible for a customer [3].

3. SYSTEM SOFTWARE

System software was designed on the basis of the following system: customer's application – *DataSocket server* – application in the measuring stand.

Computer in the laboratory has installed application, which was designed and made at software environment LabVIEW [4]. This application lets not only elaborate and display measuring results on the computer screen but also publish them over Internet.

In order to it can be possible customer has to have client version of this application installed on his computer.

3.1. APPLICATION OF THE LABORATORY STAND

Application of measuring laboratory stand consists of:

- application responsible for measuring, control heating and cooling processes and also for accessing laboratory stand over Internet,
- application saving panel view to file as a JPG file,
- text file – where is saved information about users (logins and comply with passwords), who have access to laboratory stand over Internet.

Panel view of main application was shown as a Fig. 2.

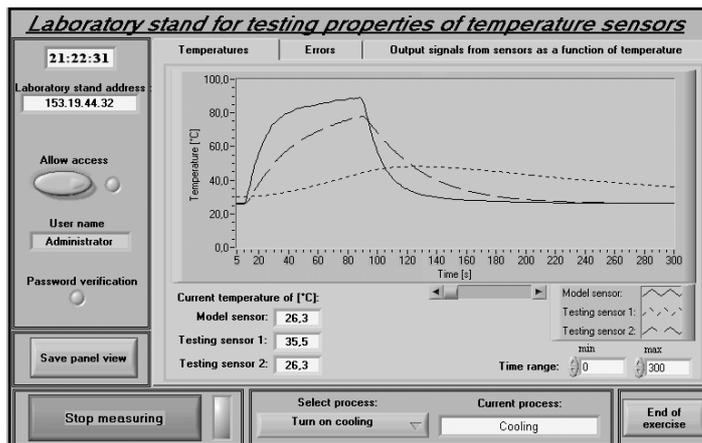


Fig. 2. Panel view of application on laboratory stand

There is a clock at the panel, which shows current system time, address measuring stand (filling this record is necessary to access this stand over Internet) and information about the user.

The administrator is a default user and this name is evidently in the Fig. 2. Whereas, when laboratory stand is accessed, the user's name is visible in this record.

Measuring results are shown in graphical and numerical form at the panel on *Temperature* overlap. The overlap *Characteristics of output sensors signals as a function temperature* shows output signals from resistant and semiconductor signals as a function temperature. At *Errors* overlap are shown relative errors in graphical and numerical form and also different temperature among testing and standard sensors.

When *Access laboratory stand over Internet* button will be pressed then laboratory stand will be accessed and information about password will also appear. Application will wait for notify a remote customer. When verification is positive then it is possible to realize testing sensors by a remote user. Measuring results are sent to *DataSocket server* where are drawn to user application from.

Those results and every action made by the remote user (start and stop measuring, changing processes) are being saved at suitable files in both computer situated in laboratory and customer computer.

Because quite often one does not have access to the printer thus one cannot print current views of panel, that is why there is a more universal and comfortable option of saving to file.

3.2. CUSTOMER'S APPLICATION

Customer's application is a file compiled to executive form. After filling stand address, there will be visible information about if laboratory stand is in readiness for measuring by a new user (only one customer can do measure at the same moment).

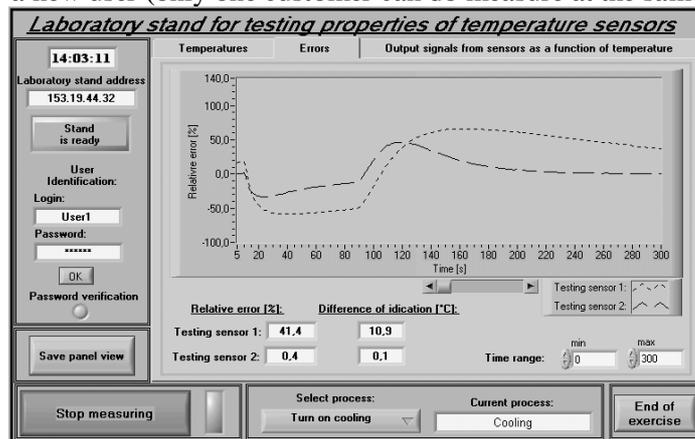


Fig. 3. Panel view of users' application

The user should write in suitable records his login and password knows only to himself and then press button *OK*. Then, those information will be sent by *DataSocket server* to the computer situated in the laboratory, which will verify a client. If verification succeeds an indicator below inscription *Password verification* changes colour to green and from this moment the user can carry through measuring.

Customer does measuring in the same way as a user in the laboratory. Panel view of user's application was shown in the Fig. 3.

At the suitable overlaps were shown temperature course, errors and characteristics of output signals from testing and standard sensors as a function temperature.

3.3. SOFTWARE PROTECTION

This practise in one moment can be realized by only one user, whose login and password were saved in the computer situated in the laboratory. In order to increase safety, users do not connect directly with the computer situated in the laboratory, but they use *DataSocket server*. This server can be configured that access have only users with specified IP number.

What is more, when application in the computer situated in the laboratory is running there is created a folder, which name is current data. There are formed automatically files in this folder including: information about processes with user's name who started specified action and time of stating action, time stating of application, measuring results with time and measuring errors of testing sensors. Those information let restore history of activity of this laboratory stand.

There is also created folder in the user's computer, in which there are files with data, which lets trace activity in the user's computer.

4. RESULTS RECEIVED WHEN LABORATORY STAND RAN

Example testing was made on heating the following sensors: Pt100, K and LM35DZ from temperature 25°C to 90°C. Memory buffer size and DAQ samples frequency select to get one second delay between in turn measuring results.

Errors of testing of sensors were calculated on the basis of standard sensor indication.

When one has results of heating and cooling tested sensors one can estimate the value of time constants of heating and cooling. One can made this in three ways:

- 1) graphical – drawing tangent to curve of temperature – determine time between contact place of tangent with curve and intersection of this tangent maximum value of temperature,

- 2) determine time after which the value of temperature will attain 0,632 maximum of value – this time is equal to the value of time constant this sensor,
- 3) determine time $t_{0,5}$ – time, in which the value of temperature is equal a half of maximum value of temperature. Then, the value of time constant sensor should be calculated from the pattern 1:

$$\tau = \frac{t_{0,5}}{\ln 2} \quad (1)$$

Saved measuring results let determine the value of time constant of temperature with a good accuracy for every sensor – the second and third way. The first way is rarely used because is less accurate.

AD595AQ lets measuring temperature with 1°C accuracy. Whereas maximum of measure error by sensor LM35DZ is equal to 1,5°C. The accuracy of measuring of temperature resistant sensor Pt100 depends on the accuracy of determining characteristics of the convert system. At the beginning and the end of measurement temperature difference between thermocouple and resistant sensor is equal about. 1°C. But this value is not constant and not influential in the considerable degree. It was confirmed by heating and cooling sensors many times.

5. CONCLUSION

Measuring systems, system for control of heating and cooling sensors and also software applications let carry through testing, both in the laboratory and via Internet with simultaneously saving of measuring results and processes to files. It lets analyse them later and lets determine parameters of testing sensors and also restore history of activity of this laboratory stand.

REFERENCES

- [1] REFEROWSKI L., ROSKOSZ R., ŚWISULSKI D., *Internet students laboratory*, Proceedings of 10th International Scientific Conference „Communications on the Edge of the Millenniums”, Zilina, 9-11 September 1998, 65-68.
- [2] MICHALSKI L., ECKERSDORF K., KUCHARSKI J., *Termometria przyrządy i metody*, Łódź, Wydawnictwo Politechniki Łódzkiej, 1998.
- [3] REFEROWSKI L., ROSKOSZ R., ŚWISULSKI D., *Transmission of measurement's results using DataSocket Technology*, Proceedings of 12th International Conference EAEEIE, Nancy, 14-16 May 2001, 275-280.
- [4] TRAVIS J., *Using LabVIEW for remote virtual instrumentation via the internet: an overview*, Distance Learning Solutions Guide, National Instruments Corporation., 2000, 2-5.