INFORMATION SYSTEM TO AUTOMATE THE ACQUISITION AND ANALYSIS OF DATA FROM TRANSDUCERS OF PHYSICAL QUANTITIES

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Abstract

This study concerns the important and urgent scientific problem of automated calibration and analysis of sensor data. The study focuses on comprehensive data visualization, which provides an accurate description of the characteristics of the calibrated devices.

1. Introduction

Scientific and technical thought rapidly develops advancing beyond technology; this brings technological works to the forefront. However, there is an extensive area of scientific and technological activities in which we can get a lot of answers to the question "How should we do this?"; most of these answers will be nonoptimal and sometimes even incorrect. This area is experimental laboratory practice, which is mostly concentrated in the application-oriented laboratories of higher education institutions, academic institutions, and other research and development organizations.

Experiment (*experimentum is Latin for test*, *trial*) is a general scientific method for studying a certain phenomenon under controlled conditions. To penetrate further into the nature of the phenomenon, modern experimental physics uses the finest methods and sophisticated instruments, the development of which involves the activities of entire institutions. The technique of physical experiments and laboratory works, which has reached a high level to date, requires that the researcher has a wide range of knowledge on various aspects of science and technology and highly diverse skills.

Automation of experiment is a set of tools and techniques to speed up the acquisition and processing of experimental data, to intensify the use of experimental facilities, and to improve the efficiency of research. Automation of experiment accelerates the rates of research and development works, which makes the implementation of scientific achievements more efficient.

This study concerns the development of a system for the automation of experiment. The novelty and singularity of the study lie in both the development of a universal platform for designing modules for the acquisition and analysis of data from transducers of physical quantities and the implementation of a software module based on this platform for the automation of the calibration of pressure transducers with the ability to completely control the test parameters using laboratory equipment.

The developed measuring information system can significantly increase the speed and quality of work of the researches and thereby helps them to focus entirely on the analysis of the results of observation. The system has been implemented and actively used in the laboratory "Criogenia" at our institute.

2. System Description

The static pressure transducers with digital and analog output are being developed at the Ghitu Institute of Electronic Engineering and Nanotechnologies for a long time. Data acquisition was often performed manually via recording the readings of voltmeters or with a minimal aid of a computer (the data for processing were typed using a keyboard).

A review of available sources of information about developed PC based automated systems for scientific research and, in particular, systems for the automation of experiment in developing pressure transducers, showed that these systems not fully meet the laboratory requirements, such as:

- modularity of the information system;
- intuitive visualization of data analysis results;
- possibility to extend the list of supported devices;
- easiness of the developed software support;
- low price of the software platform.

On this basis, it was decided to develop an information system to automate the acquisition, processing, and analysis of data from both pressure transducers with analog or digital output and other transducers of physical quantities (temperature, humidity, etc.).

The infrastructure of the developed system consists of hardware and software parts. The hardware part consists of the following components:

- environment pressure controller;
- device for temperature control as well as for humidity and absolute pressure monitoring;
- digital multimeters for conversion of analog signal into digital information;
- precise pressure digital sensors acting as a calibrating device.

The software part consists of the following components:

- .NET software framework;
- device drivers;
- data visualization components.

A special panel for the automation of pressure sensor calibration has been developed (see Fig. 1). The following components are located on it:

- field set for data from a pressure sensor acting as a calibrating device;
- field set for data from a thermostat;
- table consisting of information about calibration process;
- reduced error diagram of calibrated device.

The first three components are visualization elements, which play the role of a slot. This slot is required for connecting to the respective driver and further processing of data from the devices. This table is filled with calibration data which have been received. The table shows columns characteristics of a selected pressure transducer pair. The table widget allows saving the data in XML format, loading previous processing results for its analysis, sorting data by various columns, and writing a comment for each record. Upon a change in the cell value, an auto-recalculation of dependent cells takes place. For example, upon a change in the main units of pressure value, the dependent secondary units of pressure value will change and the absolute error and reduced error will be also recalculated.

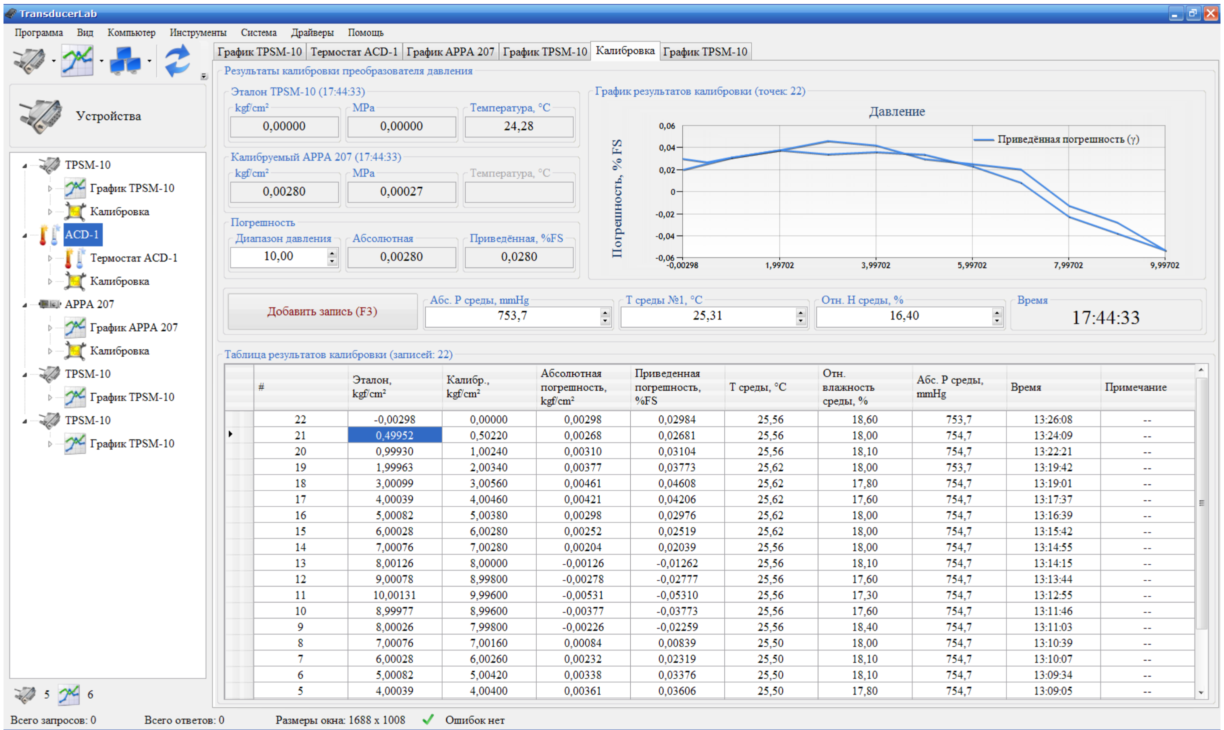

Fig. 1. TransducerLab main window.

In order to display data from pressure transducers, a special module as a line chart was developed (see Fig. 2).

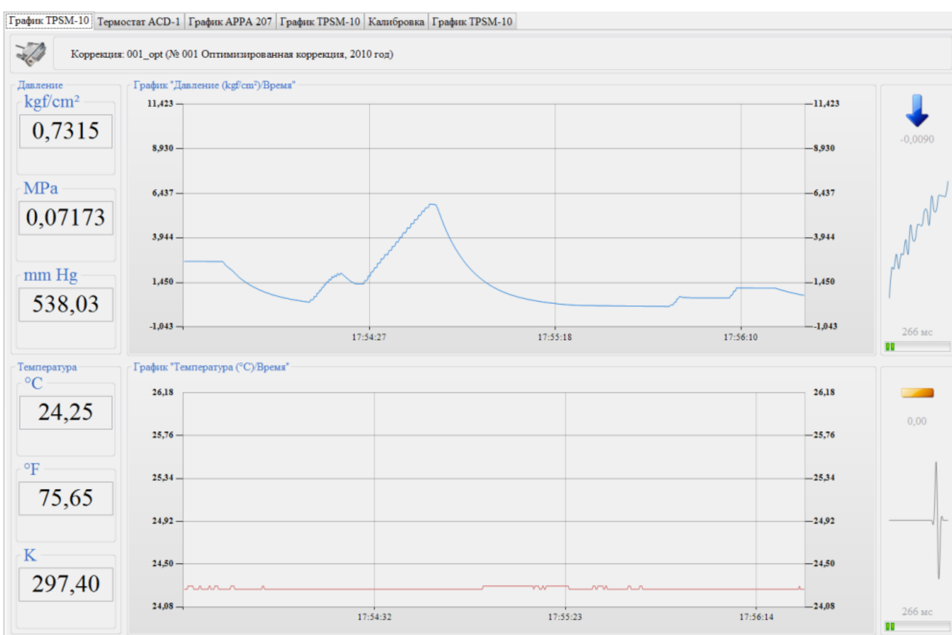

Fig. 2. Visual representation of data.

For each device driver, there is a possibility to develop user defined algorithms for correcting the received data. To this end, a special code editor of data processing DLL has been developed. The ability to define the data processing algorithm allows the researcher to change this algorithm (without program exit) and develop algorithms of linearization of the output characteristics for their further use by MCU of the digital transducer. This allows increasing the transducer's precision.

To automate the control of calibration medium, a special panel to control a laboratory thermostat has been developed (see Fig. 3). It allows controlling the temperature in the medium and makes it possible to display data on the absolute pressure and relative humidity in the calibration medium.

Fig. 3. ACD-1 thermostat control panel.

The system has been tested and is actively used in "Criogenics" laboratory of the Ghitu Institute of Electronic Engineering and Nanotechnologies. In particular, it was used in the diagnostics, adjustment, calibration, and estimation of linearity characteristics in repairing some Sapfir and Korund transducers of CHIŞINĂU-GAZ SRL.

The developed informational system has the following features:

- Serial port data acquisition;
- Data analysis using chart display and tables;
- Ability to save data in the widely used formats:
  - figures in PNG, JPG and BMP;
  - tables in CSV and XML;
- Calibration process visualization;

- Embedded converter of digitized analog signal into corresponding physical values and its units of measure;
- ACD-1 thermostat control panel visualization;
- Scripting data processing algorithms in C# language and, as the result of it, possibility to make additional linearization and correction of transducer's characteristics;
- Support of industrial computer network protocols, such as Modbus RTU and Modbus ASCII;
- Possibility to save/load processing results and, as the result of it, possibility to continue experiment in the future.

3. Conclusions

The rapid development of computers opens up new possibilities for modern engineers, who are increasingly faced with the difficulties of acquisition, processing, and analysis of large amounts of information. To sum up, it should be emphasized that comprehensive implementation of information technology to science is an inevitable necessity, because it allows increasing the speed and quality of work of the researchers and thereby helps them to focus entirely on the analysis of the results of observation.

Based on this, we can conclude that this theme, which is of scientific and practical significance, is in line with the state-of-the-art of science and its prospects for the development. As regards the relevance of this study, the results of the development have been used in practice in implementing the institutional research and contract works.

During the use of the program, a large amount of data was received and processed; the analysis of these data has made a significant contribution to the design of the next generation of pressure transducers with high metrological and operational parameters.

The system was developed with allowance for the rapid future integration of drivers for new devices (transducers of physical quantities) and data visualization components, which would take into account the specific characteristics and requirements for experimental conditions.

To sum up, it should be emphasized that the level of development of modern systems for the automation of experiment in the domain of pressure transducers is still far from perfect and there are still many directions of research and innovation in this domain.

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