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AUTOMATYZACJA MONITORINGU POMIARÓW METROLOGICZNYCH

Streszczenie: W pracy przeanalizowano metody i środki oceny warunków pracy w laboratoriach kalibracyjnych, testowych i weryfikacyjnych. Oferowane są konkretne rozwiązania techniczne dla zautomatyzowanego systemu monitorowania, odpowiedniego oprogramowania i metody kalibracji systemu pomiarowego. Przedstawiono przykład zastosowania wraz ze schematem blokowym programu.

Słowa kluczowe: monitorowanie, wielkość wpływu, system automatyczny, kalibracja, testowanie, kalibracja.

AUTOMATIZATION OF MONITORING OF CONDITIONS FOR METROLOGICAL WORKS

Summary: The paper analyzes the methods and means of measuring the conditions in the calibration, testing and verification laboratories. The specific technical solutions for the automated monitoring system, the corresponding software product and the method of calibration of the measuring system of the system are offered. A functioning model based on industrial converters and software code is developed.

Keywords: monitoring, influence quantity, automated system, calibration, test, verification.

1. Introduction

Today, more and more gauge and testing laboratories are undergoing accreditation, as with positive results the customer's trust in the results of work increases. This is especially important for domestic enterprises entering the international market.
During this process there is a comprehensive review of the laboratory. One aspect that is considered separately is monitoring (control) of the conditions for carrying out metrological works. The issue of monitoring the conditions is relevant, since, without affecting the direct activity of the laboratory (measuring at calibration or testing), on

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the one hand, it can affect the results, and on the other hand, it is part of the overhead, which must be reduced for competitiveness in the provision of services.

All of the above applies to laboratories authorized to carry out verifications of legally regulated measuring instruments.

Analysis of publications. The control of the conditions for metrological works is an integral part of the methods developed in accordance with [1-2]. However, the description of the procedure is usually absent or insufficient, which may affect the measurement results.

At first glance, there is no difficulty visually removing the impressions from the means of controlling the conditions (thermometer, voltmeter, etc.), but in that case, the continuity of control over time during the measurement is left out of sight. In certain cases, there is a need for continuous monitoring of conditions during preparation for work, in particular, if there are requirements for the long stay of an object in normal ranges of influencing quantities or in the normalization of the limiting rate of changing conditions for a long time, for example: in [3] the marginal rates of change are normalized temperature (± 0.5 ° C for 12 hours before calibration) and relative humidity (± 5% for 4 hours before calibration weight).

The purpose of the article is to analyze the process of monitoring the conditions when performing metrological works (hereinafter - monitoring) and its improvement in terms of increasing the reliability.

Setting objectives. It is necessary to determine the requirements for monitoring tasks and an effective method for their solution, ensuring the automation of the process.

Most often, when performing measurements, the power supply parameters (voltage, frequency of the power supply and THD) and the climatic conditions (temperature, relative humidity and atmospheric pressure) are normalized.

To measure the frequency, it is expedient to use only one measuring transducer, located anywhere inside the building, because the frequency of the voltage is the same for the entire network. However, it is most expedient to measure it simultaneously with the THD at the electric input to the building (usually the main distribution shield (MDB)) or on the low side of the transformer substation (TP).

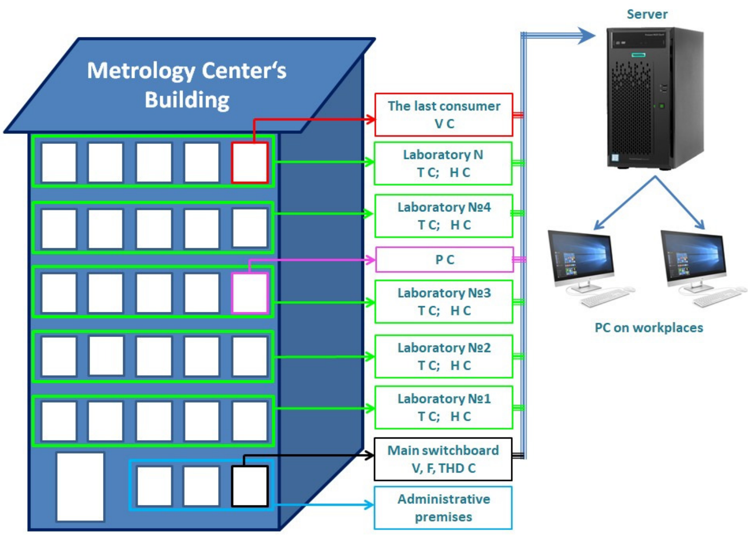
The voltage of the supply varies with respect to the jobs due to voltage losses in the conductors, and therefore it is advisable to install voltage converters for a limited number of jobs, for example, on the panel of circuit breakers of each of the premises. In the presence of insignificant voltage losses (correctly calculated for voltage losses of internal conducting) it is enough to measure the voltage only twice, regardless of the number of jobs: on the MDB or the TP (the highest value of voltage) and on the most remote consumer (the lowest voltage). In this case, as the primary converters, it is expedient to use meters of electricity quality. Such an option seems more costly on the economic side, but much easier to implement in practice due to ready-made technical solutions. For example, the multifunctional power quality analyzer DIRIS A40 (manufacturer - Socomec) allows simultaneous measurement of all the above parameters (voltage, THD and frequency) in single-phase and three-phase modes.

It is expedient to measure atmospheric pressure only in one specific place, because its area of normal values has a wide range in comparison with its changes from height. In addition, a wide range of normalized values does not require high metrological characteristics of the measuring transducer.

Usually this does not apply to certain types of work, such as calibration or testing of weights and static weights, in which uncertainty of measurement of pressure is a component of uncertainty [3], [5].
The latter also relates to the measurement of relative humidity to a certain extent. However, the relative humidity is advisable to control in each room, taking into account its constant change over the duration of work.
The temperature measurement is significantly different from the measurement of the previous parameters, first of all, by the narrow range of the normal region and, in certain cases, the normalization of the boundary changes within the normal region. This leads to the need to measure it with a relatively high accuracy, and the number of measuring transducers depends on the size of the concrete premises (the unevenness of the temperature in the room does not need to be proved, since even in the thermocouples the achievement of the unevenness of 0.2 ° C from the average temperature is a good result).
In some cases, measuring transducers can be installed on individual workplaces. The most suitable for temperature monitoring are digital measuring transducers, which can be installed in the workplaces or sectors of the premises, and used in compact thermometers that will be connected to personal computers.

2. Automated monitoring system

To automate the monitoring process, it is expedient to implement a measuring system, the structural-logical scheme of which is shown in Pic. 1 [4].



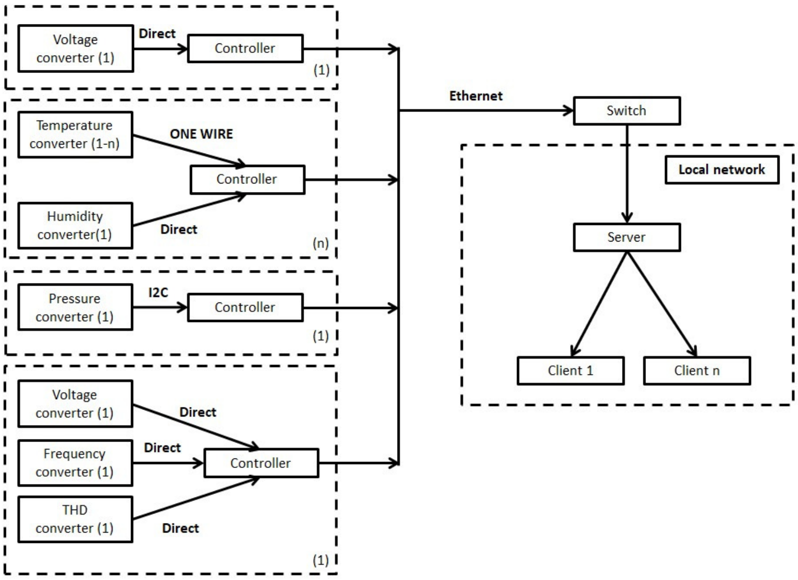
Picture 1 - Structural-logical scheme of the automated monitoring system: C - converter of the corresponding value (T - temperature, H - humidity, P - atmospheric pressure, F - frequency, THD - coefficient of total harmonic distortions, V - voltage)

The primary data of the measured parameters of the influencing values is formed by the converters and digitally through the data bus or by the radio modem transmitted to the server. The rational number of such converters in a particular room or in certain areas of such premises (adjacent areas in which incompatible works can be carried out must be reliably isolated from each other [2]) is determined taking into account the above analysis.

The received data is adjusted, stored and finally transmitted to PC workplaces. All data stored on the server is not available to laboratory personnel, which excludes the possibility of their distortion. In the workplace, information is available for relevant inquiries, for example: current parameter data or their limit values during preparation and / or measurements.

Such system allows to automate not only the monitoring process, but also to improve the process of checking the system itself (according to [1] auxiliary equipment is subject to calibration or verification).

One of the possible options for the implementation of the structural-logical scheme, shown in Pic. 1, is the following scheme (Pic. 2):



Picture 2 - The block diagram of an automated monitoring system

In the presented structural scheme data in controllers are transmitted:

- directly to the ADC or to digital inputs from converters of electrical quantities (2 voltage converters and one for frequency and THD and one humidity converters at workstations);

- on the interface I2C from a single converter of atmospheric pressure;

- with the ONE-WIRE protocol from the temperature converters according to the number of jobs in n workstations.

Data from Ethernet bus controllers is transferred to the server.

The server features are described above.

Information on PC workstations is transmitted over the company's local network.

Unlike the calibration of all meters, in this case it is necessary to calibrate only one reference for each measuring parameter in a limited range of measurements. For example, if it is known that the room temperature is maintained in the range from 18° C to 22 ° C, then there is no sense to calibrate the standard in the wider range, regardless of its real possibilities.

Standards with known calibration curves are connected along with working converters and similarly transmit to the server information about the measured parameter, after which the correction of the current converter is calculated p_x by the formula:

$$p_x = X_B + p_B - X \tag{1}$$

where: X_B and X are indications of the standard and working converter;

p_B correction to the standard obtained from the calibration certificate.

Accordingly, the final result is determined by the formula:

$$X_B = X + p_X \tag{2}$$

The value of the correction is constant during the intercalibration interval of the reference converter.

Such a method allows to reduce the economic burden on the laboratory with the metrological provision of monitoring.

3. Test sample

To test the feasibility of implementing such method, it is planned to develop a model with a number of similar temperature transducers, relative humidity and atmospheric pressure converter, and corresponding software.

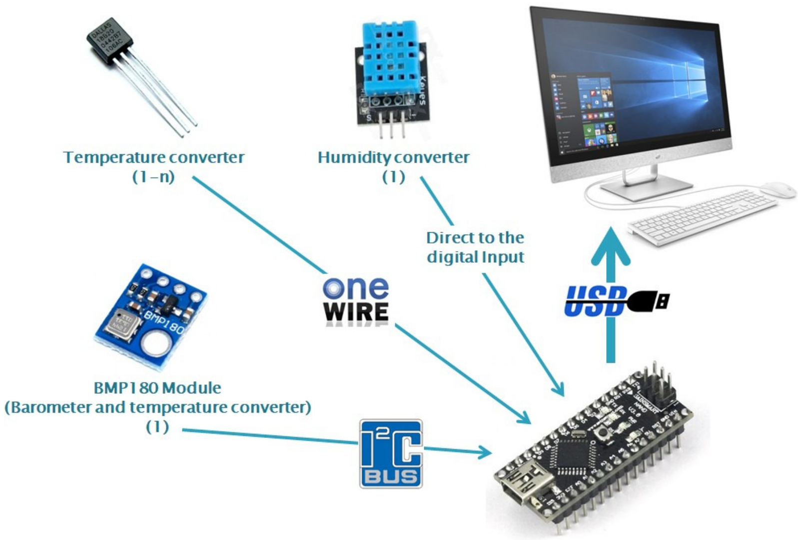
The demonstration scheme of such model is presented in Pic. 3.

In this model information from the primary converters of temperature, pressure and relative humidity is transmitted to the microcontroller (MCU), respectively, via the ONE WIRE, I2C bus and directly to the digital input of microcontroller.

The microcontroller coordinates the received data and passes them through USB (virtual COM port) to the PC, where the visualization of the received values and their processing according to the given algorithms is carried out.

Experimental studies of such model will be aimed at identifying the non-excluded components of the total error (or uncertainty) that arise due to the scan synchronization of measurements and the non-identity of the metrological characteristics of the reference converter and system transducers.

After the data on the non-identity of the characteristics of the calibrator converters will be obtained, the system will be set onto the automated mode, since all components of the total uncertainty will be known.



Picture 3 - Model of monitoring system

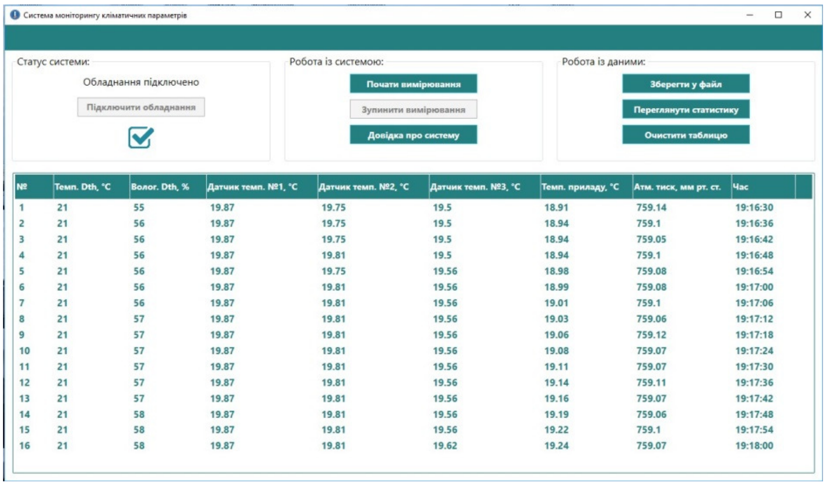
In accordance with the developed system a fully functioning research sample, the appearance of which is shown in Pic. 4, was developed.

Picture 4 - Appearance of the prototype (without PC): from the upper left corner clockwise: a microcontroller with a module of pressure and temperature converter (this converter shows the temperature of the device), temperature converter (3 units) with adapters (10m), humidity converter with connecting conductor (5m).

During the constructing are used:

- temperature converters - DS18b20 [6];
- converter of atmospheric pressure and temperature - BMP180 [7];
- relative humidity converter - DTH11 [8];
- microcontroller (MCU) - ATMEL MEGA 328.

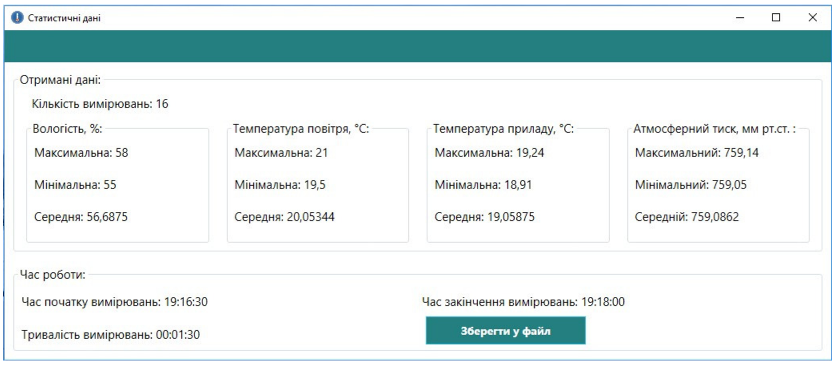
Connecting the converter to the MCU exactly matches the structure shown in Pic. 3. The obtained values are shown in the following form (Pic. 5).



№	Темп. Dth, °C	Волог. Dth, %	Датчик темп. №1, °C	Датчик темп. №2, °C	Датчик темп. №3, °C	Темп. приладу, °C	Атм. тиск, мм рт. ст.	Час
1	21	55	19.87	19.75	19.5	18.91	759.14	19:16:30
2	21	56	19.87	19.75	19.5	18.94	759.1	19:16:36
3	21	56	19.87	19.75	19.5	18.94	759.05	19:16:42
4	21	56	19.87	19.81	19.5	18.94	759.1	19:16:48
5	21	56	19.87	19.75	19.56	18.98	759.08	19:16:54
6	21	56	19.87	19.81	19.56	18.99	759.08	19:17:00
7	21	56	19.87	19.81	19.56	19.01	759.1	19:17:06
8	21	57	19.87	19.81	19.56	19.03	759.06	19:17:12
9	21	57	19.87	19.81	19.56	19.06	759.12	19:17:18
10	21	57	19.87	19.81	19.56	19.08	759.07	19:17:24
11	21	57	19.87	19.81	19.56	19.11	759.07	19:17:30
12	21	57	19.87	19.81	19.56	19.14	759.11	19:17:36
13	21	57	19.87	19.81	19.56	19.16	759.07	19:17:42
14	21	58	19.87	19.81	19.56	19.19	759.06	19:17:48
15	21	58	19.87	19.81	19.56	19.22	759.1	19:17:54
16	21	58	19.87	19.81	19.62	19.24	759.07	19:18:00

Picture 5 - The output window

At the user level, it is possible to determine the maximum and minimum values of the parameters for any arbitrary time (Pic. 6).



Picture 6 - Dialog Box

Conclusions

In the present scientific work certain tasks of metrological maintenance of monitoring of the conditions of metrological works have been solved.

- Projects of national standards for verification contain requirements on the extreme changes in terms of work, which requires their continuous monitoring (monitoring).
- Traditional means of measurement are not capable of ensuring the continuity of monitoring during preparation and during calibration or testing, nor does it guarantee the exclusion of the possibility of deliberate distortion of its results.
- The developed automated system eliminates the specified shortcomings.
- Implementation of the system does not create additional economic burden on the laboratory. It is provided with the optimal component selection and advanced calibration.

- The efficiency of the system is proved by its functioning model, the development of which is brought to the level of the prototype.
- The model is suitable for monitoring of temperature, relative humidity and atmospheric pressure.

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