

SIMULATION MODEL FOR CALCULATING THE ERROR OF THE TEMPERATURE MEASURING CHANNEL

G.G. Rannev, A.P. Tarasenko, V.M. Chernova

Abstract: The simulation model of the measuring channel (SMMC) is a LABVIEW computer model located on the desktop of a personal computer. The program part of SMMC is implemented using the principles of object-oriented programming and elements of the graphical interface of the operating systems of the Windows family. In the LABVIEW graphical programming environment, models of real technical measurement tools and simulators of additional errors, calculated values of statistical data, graphical analyzers, plotter of the laws of distribution of random variables, a table of errors of the components of the measuring channel (MC) were developed. Calculation of the additive and multiplicative components and the general error in SMMC are also performed automatically.

Keywords: measuring channel, simulation model, computer model, basic and additional error, additive and multiplicative error components, primary converter, normalizing converter, algorithm, front-end interface.

1. Introduction

The basis of any form of management, analysis, forecasting, planning, control and regulation - is reliable initial information, which can be obtained only by measuring the parameters and indicators of the required physical quantities. And only high and guaranteed accuracy of the measurement results ensures the correctness of the decisions made. Any serious measurement task implies the design of a measuring channel (MC), the quality of the result being directly dependent on how accurately we can predict and technically provide the required error of the measuring channel. But since the actual operating conditions of the production MC differ from the normalized conditions contained in the characteristics of the constituent MC components, and we do not have complete and reliable information about these changes, the problem of determining the possible components of the total MC error is quite complex.

The production cycle requires the measurement of a significant number of parameters, such as temperature, humidity, pressure, pressure difference, vibration level, noise, etc. Most of these parameters can be measured remotely by converting the current value of a signal source to an analog electrical signal that is transmitted to a meter located on the main control panel. In this connection, the issues of the correct operation of measuring instruments, the recording of operating conditions, obtaining reliable measurement information, taking into account the metrological characteristics of not only all the blocks included in the measuring channel, but also accounting for the temporary effects of the channels on each other, are acute.

The widespread distribution of personal computers, information technologies, and the creation of powerful supercomputers made computer modeling one of the most effective methods for studying various phenomena of nature, and the use of simulation modeling allows us to adjust the operating conditions of the model at various stages of the study, which allows us to obtain an almost optimal final result.

Main part

Structurally, the temperature measuring channel can be represented as consisting of three blocks (Fig. 1): a temperature sensor (S), a normalizing measuring transducer (NMT) and a secondary converter, which is an ADC. As a temperature sensor, a thermal resistance (TCM-50) or a thermocouple of the chromel-droplet type (TCA, TXA) is used; as a normalizing measuring transducer - a converter of the type PIN-900, intended for operation with thermoresistance and thermoelectric converters. Two-channel analog-digital converter AE-542 is designed for measuring electrical signals in the form of voltage and DC power with indication of measurement results in digital form.



Fig. 1. Scheme of electric structural MC

The classification, causes and correlation of errors in the MC are shown in Fig. 2. The TCM-50M sensor is characterized by the presence of a basic error, the magnitude of which is determined by the

accuracy class.

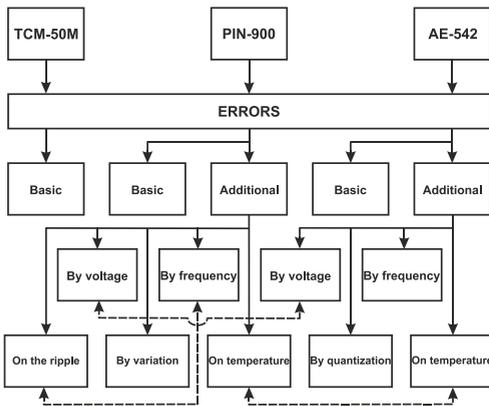


Fig. 2. Schematic of possible interference in the MC - correlated errors

Additional sensor errors are not considered, the temperature range of the MC is within the permissible temperature range of the sensor. For other transducers, both basic and additional errors that occur in real operating conditions are considered. In NTD for measuring transducers the following influencing factors are indicated: voltage and frequency variation, temperature, variation, etc.

The simulation model of the measuring channel (SMMC) is a LABVIEW computer model located on the desktop of a personal computer. When you run the program SMMC on the PC monitor screen appears the main window with the name of the system and the button "Entering the program" (Fig.3). When you press the "Login to the program" button of window №1, the window №2 "Main program menu" opens (Fig. 4).

The main menu contains two windows of theoretical information (№3 and №4) and three windows of experimental data (№5,6,7).

Window №3: "Brief theoretical information on the calculation of errors information-measuring channel": contains a description of the electrical structure of the MC, the description of the components of the error MC and the methods of calculation, the technical characteristics of the components of the MC.

Window №4; "Description of the work of the simulation model of the measuring channel" contains the purpose of SMMC and instructions for the user and administrator.

The windows of experimental data № 5 and №6

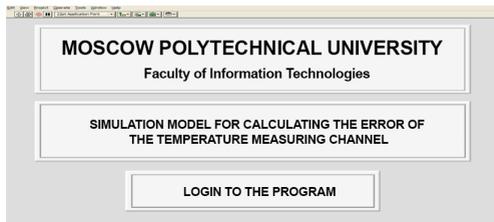


Fig. 3. Appearance of the main window №1 SMMC

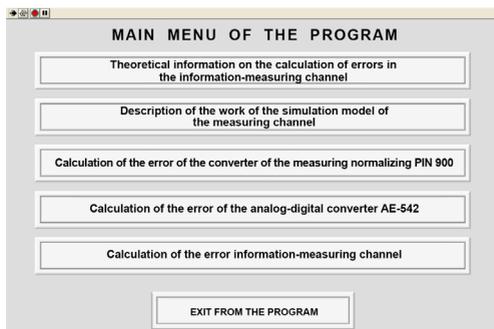


Fig. 4. Appearance of the window №2 "Main menu of the program"

contain models of virtual measuring instruments, models of additional errors simulators (voltage, frequency, temperature, variation), plotter, calibration tables and tables of values of experimental data.

The determination of the root-mean-square deviations of the error components of all elements simulating the measuring channel is performed according to the known passport data of these elements. Moreover, the division of errors into additive and multiplicative, as well as the definition of the law of error distribution, is made on the basis of an analysis of the operating principle of each MC element in window No. 7 "Calculation of the error of the information-measuring channel". MC, taking into account the correlation between individual components, is considered in tabular values, as well as the determination of the resulting laws for the distribution of total errors, their excesses (counterexcess), dispersion and other statistical data can be analyzed in the subsection "Statistical Data" of window No. 7. By specifying different values, the user can do these operations several times, at the end of the operation it is necessary to return to the main menu.

Exit the program through the "Exit the program" button in the main menu.

The front-end SMMC interface in the mode

Section IV: MEASUREMENTS IN THE INDUSTRY

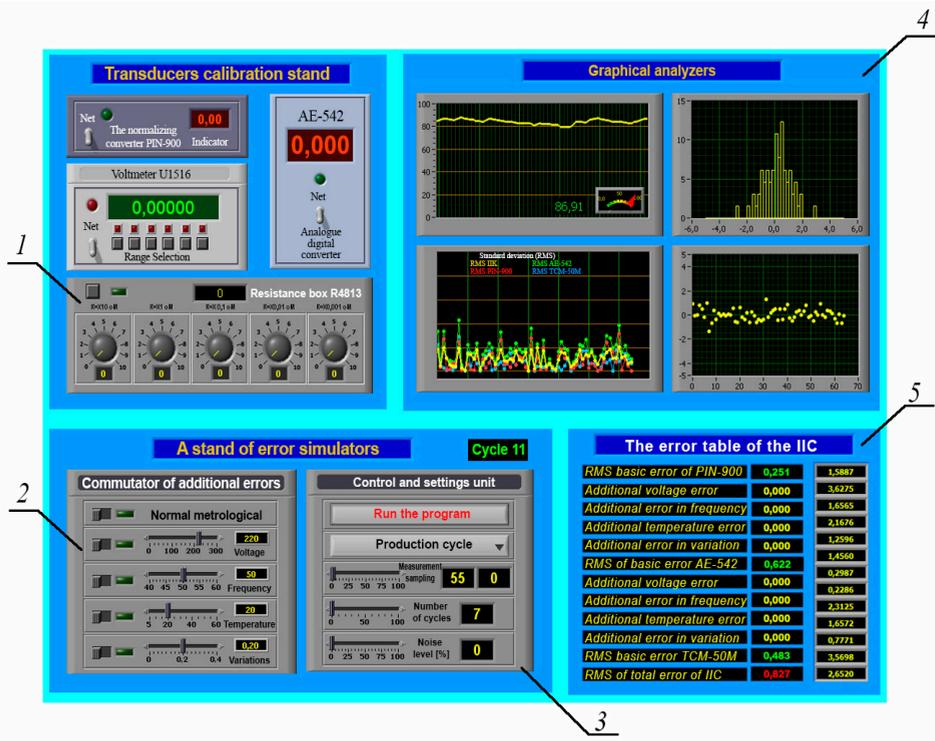


Fig. 5. Interface of the window №7

of calculating the total MC error is shown in Fig. 5.error, the magnitude of which is determined by the accuracy class.

The work on the estimation of the total MC error is carried out in the following order:

- set the corresponding value R for the primary TCM-50M sensor on the resistance store (1) on the calibration table, for example, $50.00 \Omega = 0^\circ \text{C}$ or $71.40 \Omega = 100^\circ \text{C}$;

- select the number of cycles of the specified program (for example, 70) on the control unit and the settings of the controllers (3), set the value of samples of random variables (for example, 50), set the desired processing speed for the selected cycles (for example, 100);

- switch on the "Network" switch of the converter calibration stand;

- for correct operation of the program, it is necessary to set the level of random noise in the "noise level" indicator from the PC keyboard.

To study the influence of external factors on the change in the total error of the infrared and

the determination of the values of the influencing quantities at which the MC goes beyond the maximum permissible error, it is necessary to perform the parameter setting on the front SMMC interface (2).

Investigation of the measuring channel is carried out under normal operating conditions and deviation from normal, i.e. if there are additional errors in voltage, frequency, temperature and variation alternately. The received data are automatically recorded in the corresponding table (5). A similar table is filled in for additional MC errors. Then charts are drawn in Excel and a comparative analysis of the results is carried out. Research and analysis of errors produce programs of the graphic part of SMMC (4). This part includes: graphical analyzers, plotter of the law of distribution of random variables, calculated values of statistical data, table of errors of MC. Calculation of the components of the total error in SMMC is also automatic.

The practical result of the work is the models of real technical means developed in the LABVIEW

programming environment and the simulators of additional errors based on the program of forming a random variable, which guarantees a real picture of the measurement procedure. Calculation of the total error of the MC occurs automatically, because formulas for calculating MC errors are prescribed in the block diagram of the system. Also, with the help of LABVIEW environment tools, the processing of statistical data, post-construction graphics of the normal distribution law and histograms are developed in the system functional scheme

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