Integrated system for conducting a full-scale experiment in a workshop on robotics and electronics

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Abstract. An integrated information and measurement system is presented, including a personal computer, special software, a set of sensors, and an ADC-DAC. Some possibilities of using modern information technologies in the workshop on robotics and electronics are shown. Several experiments were carried out using a traditional installation and a modified one using modern information technologies.

1. Introduction

In the modern world, information technologies are experiencing a particular era, gradually being introduced into absolutely all spheres of our life: education [1-3], industry [4-6], agriculture [7], electronics [8-10], basic sciences [11-14], and others. A new approach to full-scale experiments plays a vital role in this period, particularly in physics. This approach is based on the use of modern information technologies and the development of digital research methods.

The analysis of the vector of development of the use of information technologies in education, in particular in the physical block of the taught disciplines, allows us to identify the main principles laid down in digital research methods:

1. The basis of the measuring system is a personal computer.
2. To communicate with the object under study, the following sensors are used: a set of sensors; analog-to-digital (ADC) and digital-to-analog (DAC) converters combined in one module; the corresponding software (software).
3. As the simplest example of providing a full-scale experiment with digital methods, we can use the sound card of a personal computer as an ADC-DAC converter. The computer's sound card can be used as analog-to-digital and digital-to-analog converters with extensive data processing capabilities. In addition, a computer with such a card can be used as an oscilloscope, generator, or signal analyzer.
2. Materials and methods
To date, the most popular program for analyzing a digital signal based on a sound card is the program "SpectraLab", developed by the company "Sound Technology" [14]. The PC sound card performs digitization of the analog signal, and the conversion from the time domain to the frequency domain is performed by the PC CPU using the fast Fourier transform – FFT algorithm. "SpectraLab" includes the following elements of sound analysis: a spectral analyzer, an oscilloscope, a phase meter. It is possible to compare the frequency response graphs by superimposing several curves on one chart. The analog of "SpectraLab" is the freely distributed program "Spectrum Laboratory", developed by the German radio amateur Wolfgang Busher.

Separate autonomous modules, including ADC/DAC converters, provide more extensive opportunities for delivering a physical experiment using digital approaches. The "ZET" device [14] was considered an example of such modules, including ADC / DAC converters, and providing mutual communication between the computer, sensors, and the object under study. The block diagram of the module is shown in Fig. 1.

![Figure 1. Block diagram of the module](image)

The ZET ADC/DAC module allows you to connect and process heterogeneous signal sources with different frequency ranges and conduct their comparative analysis. The digital input/output is used for monitoring and controlling discrete elements: relays, switches, end sensors. In addition, the module can be used independently as a controller for signal acquisition and processing systems, control of various devices and actuators.

There are three ways to connect the module to a computer: connecting the module via USB 2.0 (Fig. 2), connecting the module via the Bluetooth interface (Fig. 3), connecting the module via WI-FI (Fig. 4)
Figure 2. Connecting the module via USB 2.0

Figure 3. Connecting the module via the Bluetooth interface

Figure 4. Connecting the module via WI-FI

The wireless interface allows for complete galvanic isolation of the measuring circuits and the digital circuits of the computer. In addition, it becomes possible to measure movable structural elements. Connecting the module via WI-FI allows you to take measurements at long distances, up to 10 km within the operator's line of sight. In this case, the cost of the measurement system is reduced due to the absence of a communication cable.

To register, process, and visually obtain information about the object under study on a computer, you need software that provides communication, a connection of the thing under investigation, and the ADC/DAC module "ZET" to the computer. The essential ZETLab software includes: AC and DC voltmeters, a multi-channel oscilloscope, a signal generator of various shapes, a frequency meter, a phase meter, a tachometer, an encoder, thermal measurement programs, an XYZ oscilloscope, a program for viewing measurement results, a signal filtering program, a program for performing algebraic operations on signals, a driver and a description of functions for working with it, programs for recording and reproducing signals, development tools.

The following equipment was manufactured as the objects under study: a combined voltage converter, a rectangular pulse generator, a magnetic hysteresis module, operational amplifier chips in the input signal repeater mode (Fig. 5,6).
Computer modeling of the manufactured research objects was carried out in the Multisim 10.1 software package of the Electronics Workbench company. The apparatus for studying electronic circuits used in the Multisim program includes all modern methods and is quite extensive.

Experimental work has been carried out to study physical phenomena and processes occurring in manufactured objects traditionally, using modern information technologies.

Figure 7 shows the curve obtained using a traditional setup (study of the hysteresis loop of ferromagnets). Figure 8 shows the curve obtained using the ZET technology. Finally, figure 9 shows an analysis of a board based on K554CA3 chips using digital methods.
Figure 7. The curve obtained using the traditional setup

Figure 8. The curve obtained through the use of ZET technology

Figure 9. The signal frequency is 5 kHz, the voltage is 5 V
3. Conclusion

Among the advantages of studying physical objects by digital methods, it is worth noting the following. The use of ADC-DAC modules makes the experiment visual, allows you to make measurements quickly, and training is easier to perceive and enjoyable. The researcher can simultaneously observe and analyze the system of objects without using additional equipment. It is worth noting the higher accuracy of the experiments. In addition, the use of digital methods also allows you to significantly save money on the modernization of laboratories since the cost of ADC-DAC modules compatible with a PC is considerably lower than a set of standard measuring devices. Such complexes are more compact.

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