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Optimization of the laboratory practice by means of information and communication technologies

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Abstract

In the work it was analysed the technical solutions to expand the capabilities of the laboratory stands for a practical development of the microcontroller control systems, which allows them to be used not only as a microcontroller kit, but also as a visual demonstration tool. The design of the laboratory stand and its element base were selected. The using of Arduino Uno microcontroller control board was justified. The combination of electronic components, analog and digital sensors, booth peripherals and the means of the connecting them was selected. The Arduino IDE product was used to develop the stand software. The laboratory stand refers to the training tools and allows you to carry out works related to the study of the sensors control systems, indicators and devices of power electronics.

Keywords:	*Schlüsselwörter:*
laboratory stand	…
information and measuring systems	…
controlled electric drives	

1 Introduction

Modern information and communication technology is the current focus of scientific and technological progress, combining expertise in software, microelectronics, digital electronics and artificial intelligence. Directions cover a broad class of systems from automated industrial lines to consumer devices for general purposes. On this basis it is also possible to build information-measuring systems and intelligent electric control systems that will be effective in laboratory experiment and demonstration.

Active promotion of the future specialist's creativity in the field of technical design is an especially urgent problem. Students of modern engineering specialties need the laboratory equipment that will perform the work related to the design and development of control systems for electric, measuring sensors, indicators and power electronics devices. The existing universities microcontroller hardware i are out of date in the whole and should be modernized or replaced by the modern one.

The modern electric drive is a combination of the electric machines and their systems for management. It is the main consumer of electricity (to 60%) and the main source of mechanical energy in the industry. The devices of such a type conclude electric motors, electric and pneumatic or hydraulic actuators, relay devices, electrostatic motors, mechanical parts of robots, drives of the moving parts, including solenoid actuators and voice coil motors and many other devices.

Based on the design features of intelligent control systems and information measuring systems, the laboratory stands, designed for the equipment learning, should be capable of building and debugging the hardware and software components. To achieve this it must be ensured interaction of the stands with the PC, the presence of signal sources, input and output devices and the possibility to carry out switching between the devices and the microcontroller.

We know the laboratory stand for the practical development of microprocessor control systems (declarative patent of Ukraine №79652, G09B 23/18, G09B 23/00, 2007)., which includes the microcontroller

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installed on the mounting plate, PC, with the 12-button keyboard, digital indicator and piezo dynamic speaker, temperature sensor and real-time counter, LED display unit, graphic display and storage unit. The disadvantages of the device conclude the lack of visibility of the internal construction, the absence of real sensors, potentiometers for the impact on system parameters, electromagnetic relays and the absence of the possibility to change the electrical circuit system.

As the similar laboratory stand there is also the Ukrainian Patent for the utility model №83533 (computerized laboratory complex digital systems for study of the DC commutator motors IPC G09B 19/25, publ. 09.10.2013), which comprises of the two low power electrical machines, semiconductor convertor with the module connector for analog and discrete input/ output by means of which the connection with a personal computer is fulfilled as well as sensors for measurement and control of electrical and mechanical parameters of the engines. The Patent differs in that its laboratory complex is additionally equipped with the manual control of the electric drive . The disadvantages of this device are the low operating frequency range, large size, high cost of implementation, which is due to the need of connecting to the dedicated PC set.

So the task of expanding the functional capabilities and combinatorial laboratory equipment for the practical development of microcontroller information and measurement systems is important that allow the use of equipment not only as a microcontroller kit, but as a visual demonstration tool.

The purpose of this research is to develop of the hardware, software and methodological support for two laboratory stands by means of which the future engineers will acquire practical skills in the information-measuring and intelligent control systems based on the microcontrollers.

2 Statement of the material

2.1 Mounting diagrams of laboratory stands

In recent years the platform Arduino (the line of microcontroller hardware and software products) has been widespread among the designers. Arduino is used for creating electronic devices with the ability to receive signals from digital and analog sensors of technological devices.

To achieve a correct working process of the laboratory stand, the microcontroller board must have at least 32 KB of memory, 10 digital outputs and inputs pins with support for the pulse-width modulation power from the USB-bus. These specifications are satisfied to several boards, including the most popular Arduino Uno. It is based on the processor Atmega328R, which comprises 14 digital pins, 6 analog inputs, USB-slot bus and external power. For the development and debugging of programs, the integrated environment Arduino IDE is used which includes a code editor, a compiler and a module firmware.

To optimize the laboratory practice in "Intelligent control of electrical drive systems" it was developed two laboratory stands, by means of which students can learn the technology of designing and developing the modern control systems.

Each student has the opportunity to develop and debug the control programs (sketches) using Arduino IDE, which includes a code editor, a compiler and a transmission module of firmware in charge.

For developing the mounting diagram and the mock-up prototype of the stands the Fritzing free software application is used which facilitates the process of prototyping projects to a developer. The Fritzing library contains a huge amount of the virtual platforms models, components and modules that can be placed on the working field and connected to the breadboard, creating a schematic diagram of the future device. The library contains mock-up application components and circuit boards, a set of analog and digital circuits, radio, motors, rangefinders, speakers, drives, LCD-indicators and many other things.

The analysis of the existing laboratory stands allowed to choose a combination of hardware wireless devices, analog and digital sensors, peripherals, electric elements, as it is shown in fig. 1 and 3.

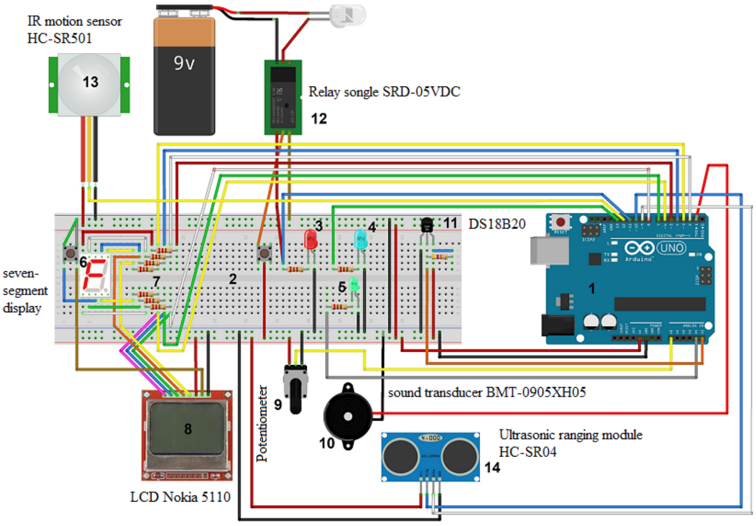

Fig. 1: Mounting diagram of the laboratory stand №1 for studying the information and measurement systems.

On the wiring diagram shows a microcontroller Arduino Uno (1) and a group of switching and indicator devices. Opportunities provided Combinatorial booth presence breadboard MB-102 to 830 contact points (2), of which one group of terminals connected to the conclusions of the microcontroller and other groups associated terminals and peripheral devices. Conclusions are made with providing connectivity between them in the specified combinations using removable conductive jumpers and connect to the contact probes external instrumentation. Indicator devices consist of monochrome graphic LCD Nokia 5110 (8), seven-segment display (6), colored LEDs (3-5), sound transducer BMT-0905XH05 (10). Peripherals consist of a single-channel electromagnetic relay Songle SRD-05VDC (12), ultrasonic ranging module HC-SR04 14, infrared motion sensor HC-SR501 (13), analog potentiometer (9), digital temperature sensor Dallas 18B20 (11).

The laboratory stand consists of two floors, thus giving the possibility to build additional floors above and below the stand, as it is shown in fig. 2.

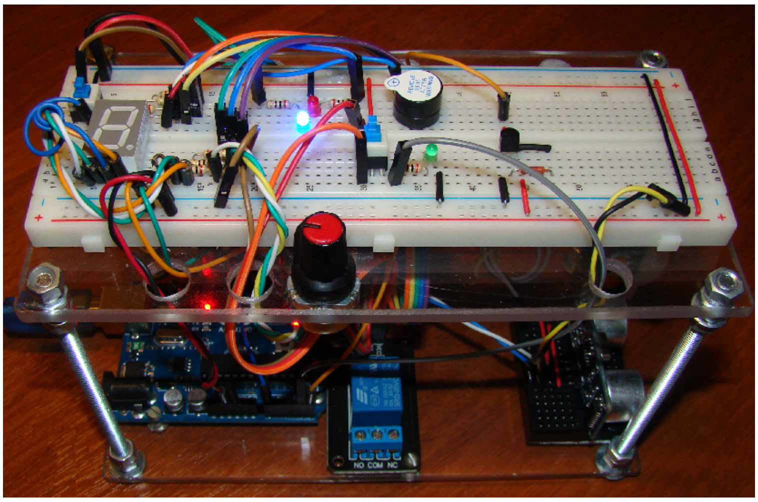
Fig. 1: View of laboratory stand №1.

The floors are made of transparent acrylic organic glass. The technological holes are drilled in them for laying the connecting cables. The lower floor houses the microcontroller board Arduino Uno, a small breadboard, LCD display, electromagnetic switches, an ultrasonic ranging), an infrared motion sensor and a self-contained battery. The upper floor houses the breadboard that allows to build electric circuits without soldering and the analog potentiometer. The segment LED, 220 ohm resistors, multicolored LEDs, switches, buttons, the temperature sensor and the acoustic device are mounted on the breadboard.

The laboratory stand №2 has a modular design (Fig. 4) and consists of two floors, giving the possibility to build additional floors as well as above and below the stand. The upper floor of the stand houses DC motors, two 5V DC collector motors, unipolar stepper motor DYJ48-28, a miniature servomotor SG-90 and an analog potentiometer for adjusting the rotation speed of the stepper motor or for controlling the rotation angle of the servomotor. All items have special connector leaders, prepared for a quick connection to the control elements.

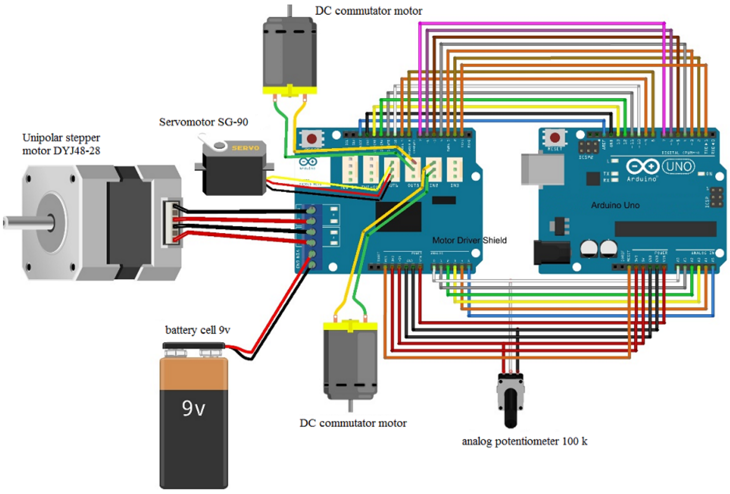

Fig. 3: Mounting diagram №2 laboratory stand for studying the Intelligent control of electrical drive systems.

The strength of current in typical circuits does not exceed 10-20 mA. But even small engines require the voltage of 5.6 V and the strength of current up to hundreds of mA. However, at the time of the engine starting it passes through the current with the strength of more than one ampere. This charge will inevitably destroy any microcontroller. For solving this problem special devices are used, they are known as the regulators of the engines move or drivers. Such devices can transmit more current into a powerful engine under the running by a low-power microcontroller.

Using laboratory stands electromechanical engineers have the opportunity to learn the technology for designing and developing the modern management systems and gaining the practical skills of the control programs for Arduino Uno and the connection of the electronic components to the microcontroller.

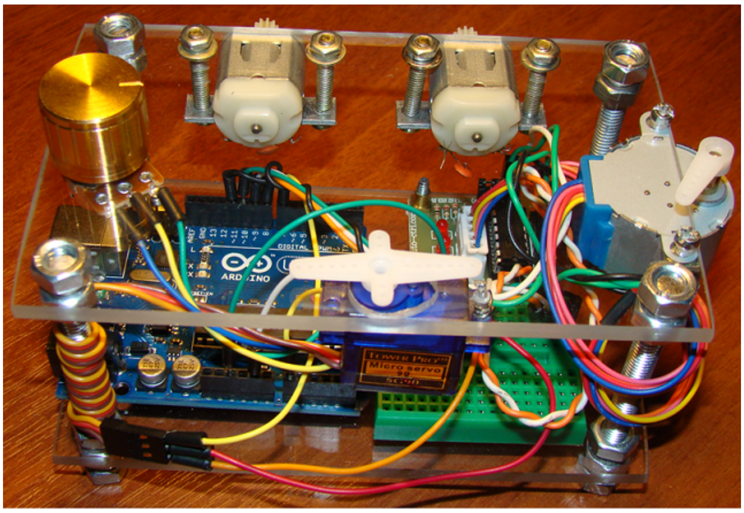

Fig. 4: View of laboratory stand №2.

2.2 Description of the laboratory practice

Then follows the description of the work that can be performed using the stand №1 and its hardware and software.

1. LED control.

The simplest indicator used in the laboratory work is called the ‘light-emitting diode’. It is important to note that the LED supply voltage ranges from 1.85 to 2.5 volts with the recommended amperage 20 mA. For proper operation of the device in the chain the limiting resistor (from 200 Om to 500 Om) should be added.

To activate two LEDs at once, the students should read the scheme of their connection to the digital output Arduino Uno and make the management program. The correct result of the work is if after the start the both LEDs begin to blink. The used components are 2 LEDs and 2 resistors of 220 Om.

2. Control of the acoustic device.

Of course, a special acoustic device (called sound transducer), designed to generate a sound wave of a certain frequency, is used for sound indication. To obtain different frequencies of sound, a special 'tone' feature must be used, thereby enabling to change the frequency of the sound of the buzzer.

After starting the program, the sound transducer begins to generate notes continuously in the given sequence. The used component is one buzzer BMT-0905XH05.

3. Seven-segment display control.

This device is a set of conventional LEDs arranged so that they together create the outlines of the numbers. The LEDs with the common cathode inside the indicator are connected together by their cathodes and their anodes are connected to the separate contacts.

To perform the work for outputting numbers on the indicator, the students must learn the indicator wiring scheme to the digital output of the Arduino Uno and make the management program. After starting the program values from the potentiometer are read, then translated into a number and highlighted on the display. The used components are one LED, 7 resistors (200 Om), 1 potentiometer (10 Om).

4. Control of LCD display.

The most informative and yet the most difficult type of indicators is a Liquid Crystal Display. The LCD displays are able to clearly report the measurable value in the form of numbers or graphics. The laboratory stand use the monochrome graphic LCD Nokia 5110, which has a resolution of 84x48 pixels, the diagonal of 1.6 inches and the blue lights.

After starting the program the initial settings of the LCD are fulfilled, then the text, integer and real data are displayed and the mode of inverse/non-inverse output is changed. The used component is one LCD Nokia 5110.

5. Control of temperature by the sensor.

In modern electronic measuring systems the temperature sensors with built-in analog-to-digital converter (ADC) are increasingly used. These sensors independently digitizes the temperature of its body and transmits the information in digital code from a standard interface. Each sensor has a unique number, this makes it possible to connect about 256 sensors to a line. The sensor provides the ability to work without the external power.

After running the software, the ambient temperature is sent each second to the LCD. The used components are the temperature sensor DS18B20, the resistor (4.7 Om) and the LCD Nokia 5110.

6. Control of the electromagnetic relays and the motion sensor.

With the help of electromagnetic relays, motion sensors, range finders and the Arduino Uno board, the students are able to develop projects for the control of environmental parameters, for a example an auto backlight system.

The stand houses the single-channel electromagnetic relay Songle SRD-05VDC. It is operated by 5V voltage and can commutate up to 10A AC of 30V voltage and 10A DC of 250V voltage. The relay has three contacts: COM (common), NC (normally closed) and NO (normally open-circuited). When the relay is turned off, the COM connects to the NC, and when it is turned on, the COM connects to NO. To connect an incandescent to the relay the last one should be put in the break of a wire.

Infrared motion sensor HC-SR501 is used to detect a motion in the area of objects that emit the infrared radiation. The sensor is a module consisting of a PIR-sensor and the control circuit. The principle of the sensor working is based on the ability to generate the field under irradiating the material with infrared rays.

After starting the program we perform the motion sensor calibration, during which diode will be flashing. If the motion is detected, we turn on the relay and withstand a pause of 5 seconds. After that the motion is considered to be complete and we can turn off the relay. Used components are the relay SRD-05VDC, the infrared motion sensor HC-SR501, the energy saving lamp Maxus 1-ESL-020.

7. Work with ultrasonic ranging module.

The principle of a sonar operation is based on the ultrasound radiation and its reflections from the objects. The ultrasonic ranging module HC-SR04 is capable of measuring distance within the range of 2 to 450 centimeters. After running the LCD each second the value of the distance from the rangefinder to the obstacle in front of the stand is sent. If the distance is less than 30 centimeters, we turn on the built-in LED.
The used components are the ultrasonic ranging module HC-SR04, the LCD Nokia 5110.

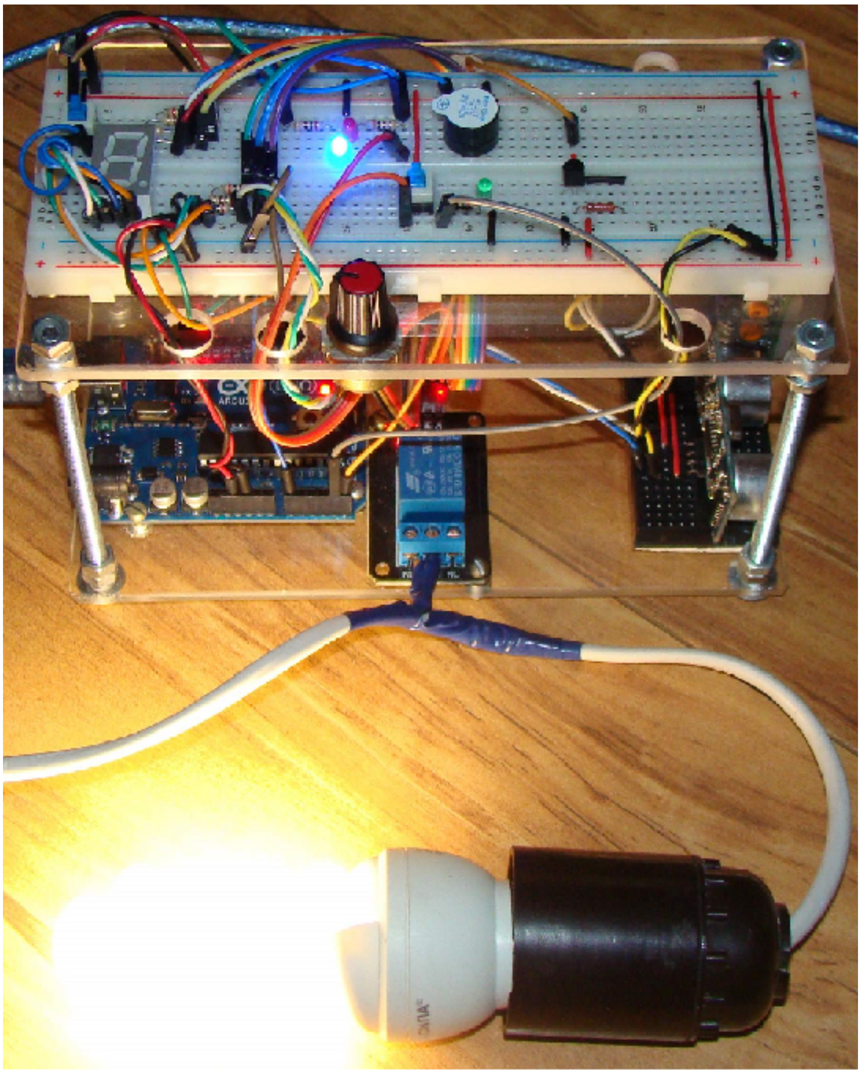

Fig 5: Example of the auto backlight

For laboratory stand №2 on studying the Arduino opportunities in managing the electric drives a methodological support is developed. It contains two works about the control of the DC stepper motor and about the servomotor control with the help of a potentiometer.

For stand №2 the software I developed that allows to control a stepper motor and forces it to rotate the shaft for the given number of steps and microsteps.

To control the servomotor the PWM signal is applied that sets no speed but an angle.
To control the change in the position of the servo drive the potentiometer is used which causes the servo motor to rotate within 0÷180 degrees depending on the position of the handle.

3 Conclusions

The paper presents an attempt to optimize laboratory workshop by using the modern information and communication technologies, including the Arduino Uno platforms and the popular wireless devices. The analysis made during the study revealed empower of the microcontroller managing systems, which allows to use them not only as laboratory stands, but as a visual demonstration tool. The construction of two laboratory stands was chosen as well as their basic elements. The combination of the radio engineering devices, analog and digital sensors, the stand peripherals and the means of their connection was selected too. The Arduino IDE was used for developing the software.

The laboratory stand №1 makes it possible to implement the works related to learning the management systems of the gauging sensors, indicators and power electronics devices. Laboratory stand №2 makes it possible to implement the works related to the computer systems management of the electric drive. The application of the laboratory workshop stands will make it possible for the students to improve their work quality as the designers of the electromechanical systems and make perfect their training as the future engineers.

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