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SECTION 12.
AUTOMATION AND APPLIANCES MAKING

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SOME ASPECTS OF THE DEVELOPMENT OF THE BEAM ROBOT CONTROL SCHEME

BEAM (Biology, Electronics, Aesthetics, and Mechanics) robots are a special class of robots that differ from classic mobile robots in several key aspects. They were designed using biological principles and strive to imitate natural processes. Here are a few differences between BEAM robots and classic mobile robots [1-3]:

- inspired by nature: BEAM robots are inspired by observations of wildlife. Their design and behavior model biological systems such as insects. This is different from classic mobile robots, which are often designed based on engineering principles and mechanical solutions;

- Sophistication and Efficiency: BEAM robots are often simpler and more efficient at performing specific tasks. They can avoid obstacles and find light sources using a minimum number of sensors and components. While classic mobile robots may have more sophisticated sensors, software and processing power to perform a variety of tasks;

- self-organization: BEAM robots usually focus on the concept of self-organization, which allows them to adapt to changing environmental conditions. They can change their behavior in real time based on external influences, while classic mobile robots usually depend on pre-programming and operator control;

- Energy efficiency: BEAM robots, because they often mimic efficient natural systems, can be more energy efficient than classic mobile robots. They can be powered by solar energy or other alternative energy sources, making them more environmentally sustainable.

Overall, BEAM robots represent a unique approach to robot creation, focusing on minimalism, biological inspiration and self-organization. This approach can be useful in various fields such as exploration and problem solving in environments with limited resources and unpredictable conditions. What makes this type of research in the field of robotics very promising for solving the problems of developing autonomous mobile devices [4-6].

One of the main principles of BEAM robotics is minimalism and efficiency: BEAM robots strive for minimalism in design and control. Control circuits are designed to use a minimum number of components and energy, making them more efficient and economical. Based on this principle, the following control scheme is proposed, which makes it possible to implement the possibility of a sensor system in the form of avoiding obstacles, without using classical approaches in the form of sensors and sensors [7].

The operating principle will be based on the following effect: when the robot hits an obstacle, its wheels encounter resistance and begin to brake. At the same time, the motors try to rotate the wheels and experience an increase in load. The load causes an increase in current consumption by electric motors. A voltage drop occurs in the robot's electrical circuit due to an increase in current consumption by the electric motors.

Having encountered an obstacle on its way, the robot will “feel” an increase in the load on the motors. The algorithm for its movement in this case will be quite simple: the robot will move back a little, turn and move forward again, thus trying to avoid the obstacle it encounters.

In order to measure the voltage on the motors, it is planned to use an ADC (Analog-to-digital converter), which converts the input signal into a numerical representation. ADC in Atmega8 is ten-bit, that is, the value of the measured voltage will range from 0 to 1023 in numerical terms [8].

To operate, the ADC requires a reference voltage source, against which the ADC makes measurements. The voltage that is converted by the ADC must be less than the reference voltage. The reference voltage can be applied to a special AREF pin of the microcontroller. You can also use the internal 2.56 volt reference or use the supply voltage. In addition, the Atmega8 has separate pins for ADC power: AVCC (analog power) and AGND (analog ground). Connect AVCC and AREF to the positive pole of the power supply, and AGND to common ground. It should be noted that the accuracy of the ADC may be affected by interference and interference. A diagram of the obstacle-avoiding robot developed by BEAM is shown in Figure 1.

We will use the PC0 (ADC0 ADC channel) and PC1 (ADC1 ADC channel) pins to measure voltage. Let's connect them through limiting resistors with a nominal value of 150-220 Ohms to those terminals of the electric motors that provide forward movement when a positive voltage is applied to them. To avoid too large voltage drops, leading to accidental reboot of the microcontroller, we connect electrolytic capacitors with a nominal value of about 470 μF to the power pins of the microcircuits.

For indication, we use two LEDs, which we connect through limiting resistors, for example, to pins PD6 and PD7. We use pins PC2 and PC3 to control motor M1, and pins PB1 and PB2 to control motor M2.

The PC4 and PC5 pins are left unused so that when the design is improved in the future, at least two free ADC channels (ADC4 and ADC5) will be available.

In general, the operating algorithm of the program for the BEAM robot will look like this:

- turn on the motors to move forward;
- wait a little until the voltage surge caused by the start of the motors subsides;
- while the robot has not yet encountered any obstacles, we make a series of ADC polls to find the minimum and maximum voltage values;
- in each series we will determine the voltages on motors M1 and M2 repeatedly to find their average values. The search for average values is necessary to level out interference;
- the threshold should be slightly greater than the average minimum voltage value. Let's calculate it using the following formula:

$$threshold = min + (max - min) / 20$$

It should be noted that the value by which the delta between max and min is divided may not be 20, but, for example, 10 or 15. This value depends on the specific motors that will be used in the design of the robot and is selected empirically. The robot's sensitivity to obstacles will depend on this value.

Conclusions: The proposed obstacle detection solution described in this work does not call for replacing standard sensors, but can be used in parallel with them. This will be a useful addition to the robot's "feelings", especially in those moments when an obstacle falls into the "blind spot" of the main sensors, and also increases the survivability of the robot's BEAM.

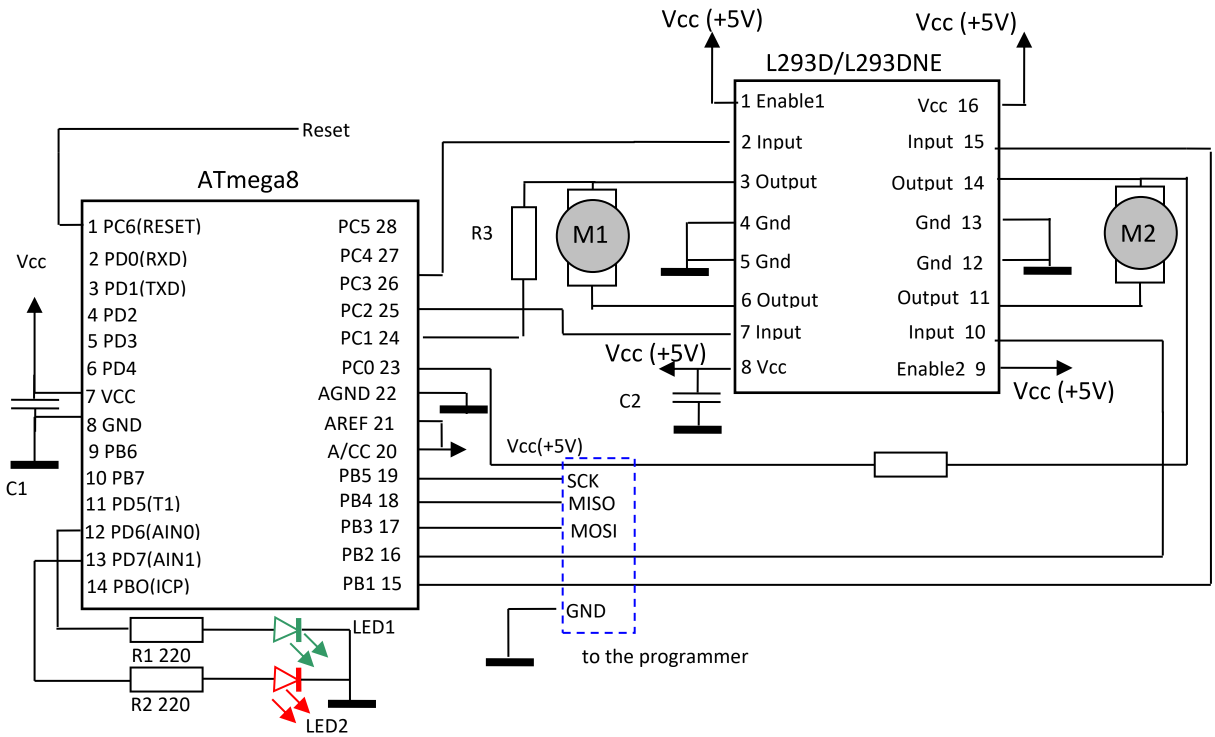

Fig. 1. **Control diagram of a BEAM robot avoiding obstacles (without sensors)**

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