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DESIGN OF THE CONTROL SYSTEM FOR REHABILITATION DEVICE OF UPPER ARM

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Abstract: *The article deals with a design of the control system for rehabilitation device of upper arm based on artificial muscles. The main part is devoted to a description of main control unit with MCU ATMEGA128L and its using with several input/output devices. The Control system is including different sensors and output switching elements for controlling pneumatic muscle system of a rehabilitation device. The sensorial system consists mainly from MEMS sensors, pressure and body temperature sensors. With small keypad and LCD display is possible to set several types of rehabilitation practices. Simply describes the algorithm for control of pneumatic muscles.*

Keywords: ***Rehabilitation device, microcontroller, sensors.***

1. Introduction

For a rehabilitation of upper limb of the human body with the help of rehabilitation device is necessary that this device should to have reliable control system. This control system must perform three basic mainly functions as:

a) regulate action of the pneumatic muscles on the basis of information from the sensors and the kind of practices,

b) protect the patient's health in case of detection dangerous acceleration or other malfunctions,

c) display information on a display of device with the option to select a different rehabilitation practices and possibility to connect control system with a PC (Piteľ & Balara, 2009).

The base is 8-bit microcontroller ATMEGA128L which using an algorithm and using information from sensors is capable to switch electromagnetic valves. Triggering of this valve is getting pressure to the pneumatic muscle and this muscle shrinks and then carries out the movement of rehabilitation arm. The control system should be controllable by the PC, where it would be possible to logging data about the practice on the rehabilitation of devices and on this basis, further modify and improve rehabilitation practices (Tao et al., 2009).

2. Design of the control part

Most commercially available sensors which are used for sensing are supplying from 3.3 V voltages, and from this is clear that the main control part (ATMEGA128L microcontroller) must be able to cooperate with these sensors. Therefore the supply voltage is equal to most sensors. It brings some limitations which microcontroller is able to operate at a frequency of only to 8 MHz, but for the control of pneumatic muscle it is enough.

On 10-bit analog/digital input of microcontroller is connected a pressure sensor in a pneumatic system, gyroscope and pressure sensor from limb (it senses pressure between limbs and rehabilitation arm), which by means of operational amplifier gives on the output voltage. Furthermore, on the I2C bus is connected to an accelerometer and temperature sensor of the human body. As the last sensor is connected incremental encoder to sense speed and position of arm and by means of a simple voltage divider, its output voltage is reduced from 5 to 3.3 V.

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The main output part for switching the electromagnetic valves is integrated transistor array, which is directly connected to the microcontroller output. For viewing process of the rehabilitation is necessary a display and for choosing the various practices in the rehabilitation, including buttons Start, Stop, Total stop is necessary a simple keypad. For communication Microcontroller with a PC is routed a serial link and by means of USART to USB converter is possible to connect device to any PC.

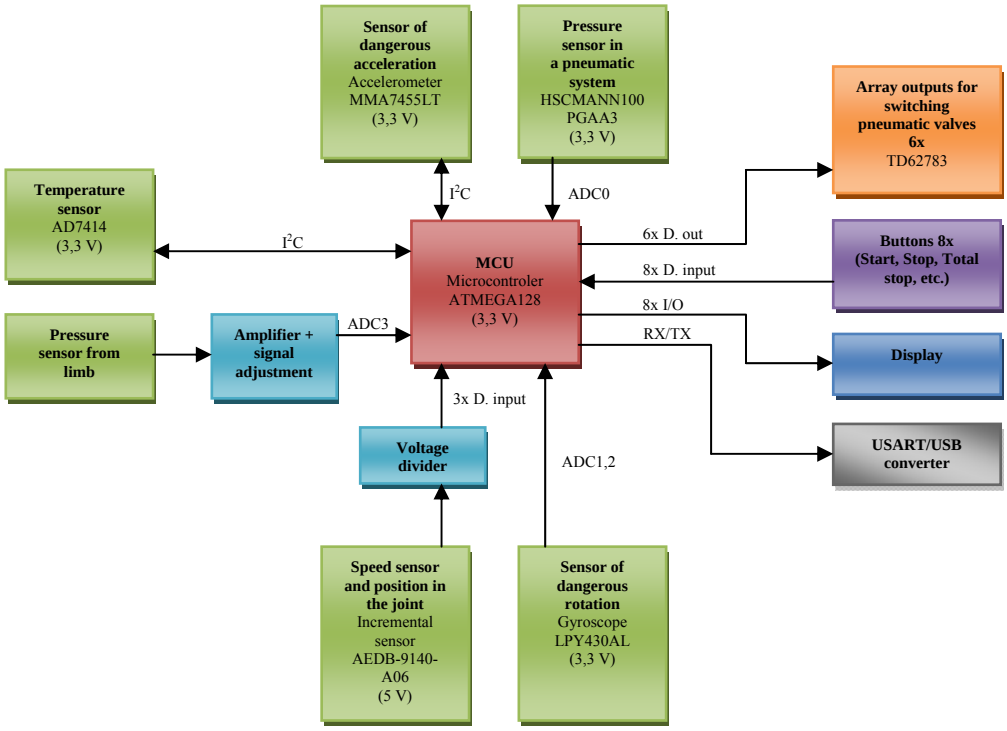

Fig. 1: Block diagram of control part.

3. Description of the control module

The schematic diagram is shown in Fig. 2 and is created in Eagle layout editor. Most of the sensors is placed on the printed circuit board, but by using connectors are attached to it. Two types of sensors to give output voltage without adjustment or have their output connected to the I^2C bus. To obtain information from the incremental encoder is needed using a simple voltage divider to reduce output voltage because, to avoid damage to the microcontroller input (it is because of differences between the microcontroller supply voltage and incremental encoder). Therefore the pressure sensor from limb only works on the concept of change of electrical resistance relative to the pressure exerted on his surface, it must be connected with a simple converter including an amplifier. This feature provides an operational amplifier with non inverting input.

Change the program in the microcontroller is possible with using the ISP programming interface. It is possible to change the program through the serial link, because in the program of microcontroller is implemented a bootloader that makes this possible.

To supply individual components are needed three DC stabilized power supply voltages (+3.3 V, +5 V, +24 V). The microcontroller operates at a frequency of 7.3728 MHz, and because of the minimal errors of a serial link.

As the display unit is used a simple 16 character two line display, which displays information about the behavior and status of the rehabilitation process, as well as information from the sensors.

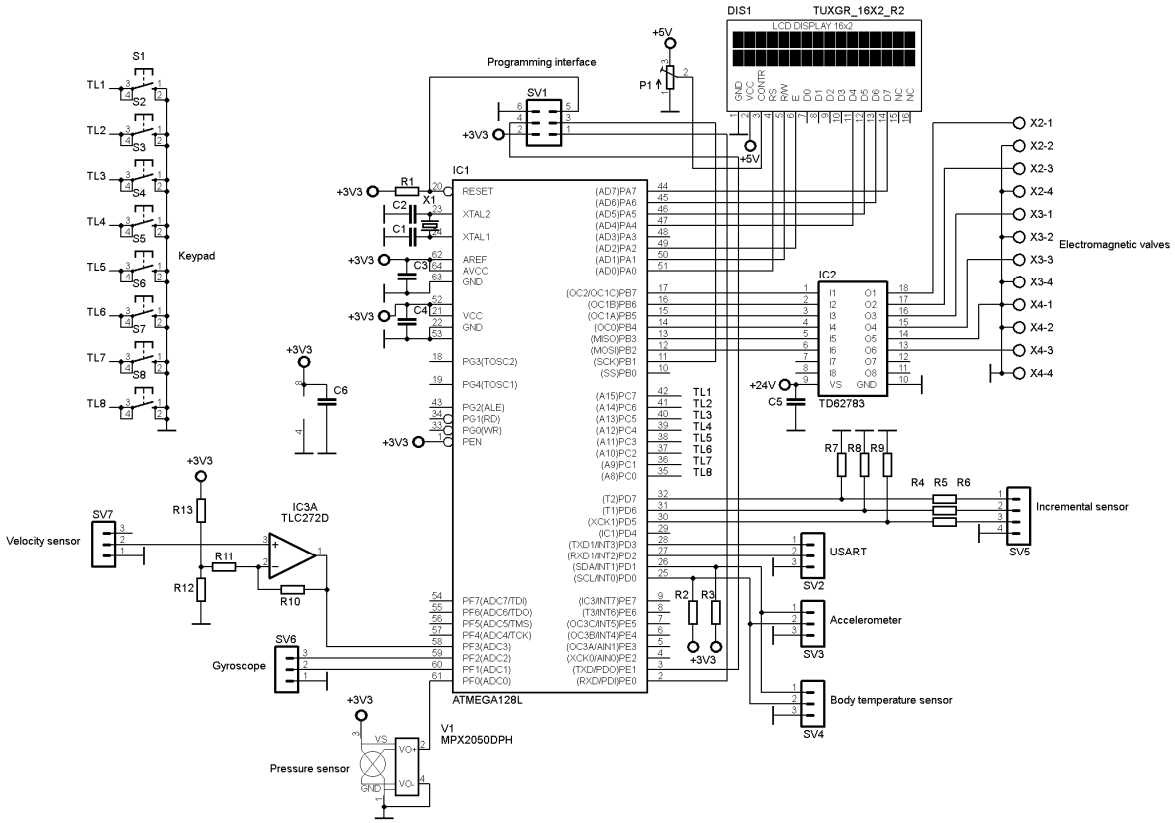

Fig. 2: Schematic diagram of the control module a rehabilitation device.

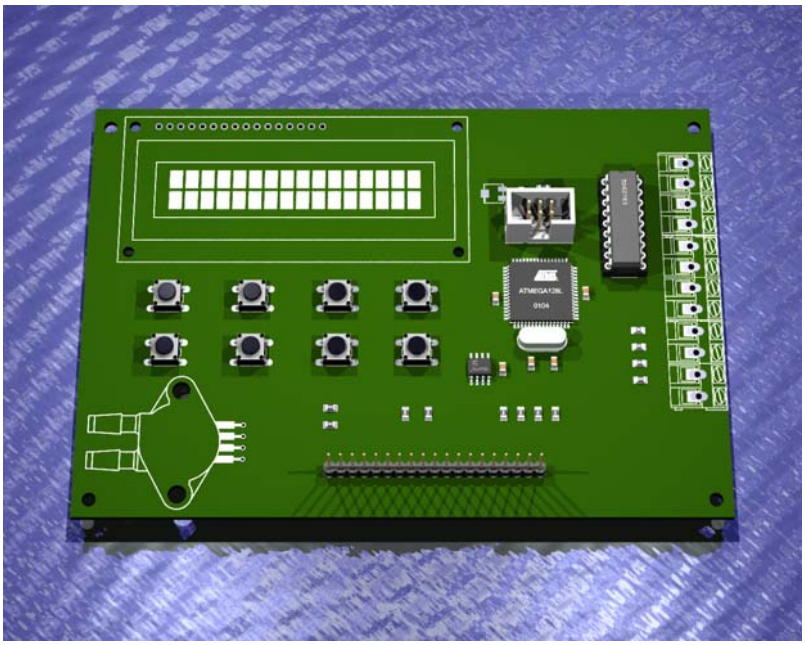

Fig. 3: Printed circuit board of control module rendered in Eagle 3D software.

4. Basic algorithm for control of rehabilitation process

The basic control algorithm for the control of the rehabilitation process consists of three parts:

a) regulatory part,
b) protective part,
c) user part.

The regulatory part of the algorithm ensures that the required rehabilitation practices conducted for the patient. An important feature for controlling the rehabilitation is pressure sensing of arm rehabilitation

from limbs. Based on this property we can achieve a suitable speed of shoulder rehabilitation practices in the prescribed mode.

The protective part of the algorithm is designed to ensure safety of the patient with rehabilitation practices, where for example: in detecting accelerations above a certain threshold to stop the movement of limbs rehabilitated within a few milliseconds. The important elements for detection is included acceleration sensor, gyroscope and temperature sensor of human body (to avoid overheating of the muscles during practice).

The user part of the algorithm ensures communication between the user and the microcontroller. By means of eight buttons you can choose several types of rehabilitation practices with various parameters. All data during practice are displayed on the display unit. Since the display that is not able to display all values at once, so individual information rotated cyclically in a time loop (Sun et al., 2007).

5. Conclusion

The main reason was to design the control electronics for control of artificial muscle of rehabilitation device. The base is ATMEGA128L microcontroller with control algorithm, which by means of a simple transistor array directly controls the electromagnetic valves and pneumatic muscles. Very important part is the sensorial system, without which it would be impossible to carry out control. The basic algorithm for control of the pneumatic artificial muscle consists of control, protection and user part, which is provided practically all the functionality of a rehabilitation device.

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