Device for Hypothermic Therapy

[1,2]Victor COJOCARU, [1]Vladimir MARDARI, [1]Iurie NICA

vcojocaru@nano.asm.md
mardari@nano.asm.md
tehmed@nano.asm.md
[1]D. Ghitu Institute of the Electronic Engineering and Nanotechnologies of the Moldavian Academy Science, Chisinau, Moldova
[2]Technical University of Moldova

***Abstract* — In the present paper the authors propose a device which use therapeutic hypothermia implemented due Peltier elements which are controlled by a microcontroller, operated by guided user interface**

***Index Terms* — Hypothermia, Peltier elements, temperature sensors, microcontroller**

I. INTRODUCTION

Hypothermia for therapeutic purposes is used for its cooling effect on some areas of patient's body, in order to reduce the risk of ischemic tissue trauma after a period of insufficient blood supply [1]. Period of insufficient supply with blood may be caused by heart failure or blockage of arteries when an embolism occurs, as it is usually happens after a stroke.

Studies have shown that patients under risk for ischemic brain injury present better results using hypothermic methods of treatment [2]. This studies where focused on researching ischemic accidents that unlike usual strokes reduces coagulation threshold. This researches shown that hypothermia used in therapeutical purposes has a neuroprotective effect [3]. Studies showed as well that use of therapeutic hypothermia in order to control intracranial pressure (ICP) after an ischemic stroke is a safe and feasible procedure [4].

Medical therapeutic hypothermia may be implemented using invasive techniques, where heat transportation is directed by a catheter inserted into femoral vein, or through noninvasive methods when usually is used water/ice. To achieve the required temperature, patient's torsos are covered with specific applications or with sheets soaked with water which are in direct contact with patient's skin.

II. METHODS

In specialty literature authors propose construction and testing of a special device which use hypothermia for medical purposes, in order to control cooling of specific areas and tissues on head. In fig.1 researchers present us a sketch of this device which uses cooling elements with sensors. For primary experiments are used 4 cooling elements and further their number increase to 20 which should be enough to cool the blood flow. For control of temperature we will use sensors placed near ears, neck and nose (fig1). Routing algorithms will be based on Fuzzy logic rules [6] which in present are developed in collaboration with medical officers from their specific domain. Fuzzy logic rules will allow smart routing of temperature reducing inertia of reaction system [5].

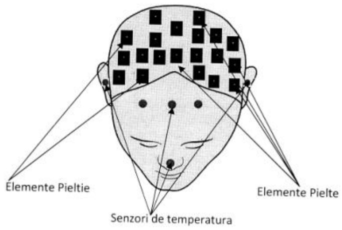

Figure 1. Localization scheme of temperature sensors and cooling elements

III. CIRCUIT DESIGN

Block diagram of the hypothermal therapy device (fig. 2) consists of cooling module, collector module and temperature processing, automatic guidance module, PC interface module and the UI Graphical interface on the PC.

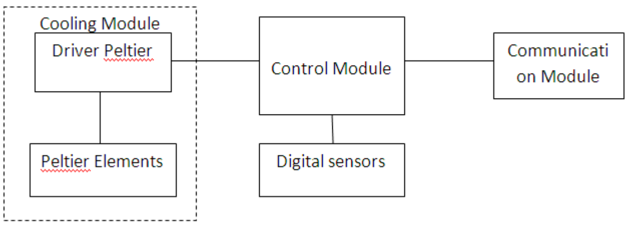

Figure 2. Block diagram of the device

Cooling module consists of 4 Peltier elements with power supply driver. As cooling elements the Peltier elements are used because they are small, which permits the creation of managed cooling surpasses and will end up with an area with non-uniform temperatures.

Drivers based on power MOS-FET transistors (IRF3808) used for controlling of the Peltier elements. Modification of the duty-cycle (PWM) is used as a controlling algorithm.

Four digital sensors [8] (DS18B20) are used for temperature monitoring. They measure the temperature with a resolution of 12 bits, witch a delta error of 0.1^0C which is sufficient for measuring dynamically low biological signals. Temperature sensors are connected to the 1-Wire protocol (fig. 3) on the microcontroller data-bus. The 1-Wire protocol has been implemented on the software level.

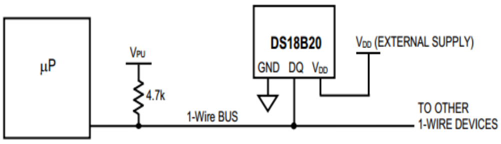

Figure 3. Sensors connection with 1-Wire protocol

Atmega16 microcontroller [9] is used. It has a 14.7456 MHz working frequency. This microcontroller was chosen because of the fact that a cheap microcontroller is used to check the preceding algorisms and the management of the cooling elements and also for checking and creation of the temperature filed.

To generate 4 PWM signals, 3 Timer Modules are used, which are working at a 115.2 kHz frequency. To obtain a SMART control of Peltier elements we use a proportional PWM signal obtained by using Fuzzy control algorithms [7].

UASRT module for hypodermic and computing communication is used to modify and control the necessary parameters and also for visualization of the sensor's temperature filed figures. UASRT module allows a 250kbps data exchange speed. Data package is formed of 4 bits of data and the control sum, so the integrity of date is guaranteed.

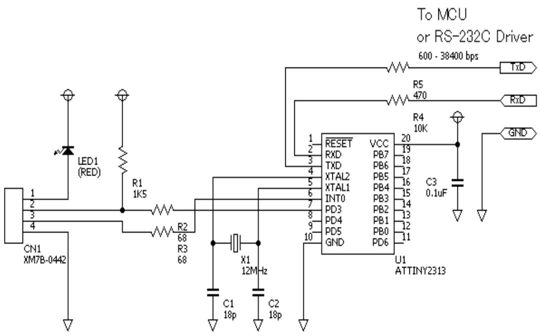

Figure 4. USB-UART converter

USB-UART converter (Fig. 4) is assembled according to a scheme based on ATTINY2313 controller [10]. We used the converter due to low price and acceptable functionality. Reason of this choice was intention to elaborate a device at a low cost.

Therapeutic hypothermia device operates autonomously. In case that there is a need of changing the treatment program, there can be made some changes to initial soft program which can be used from any working computer with an USB port. In order to connect this device there was made an user guide interface that allows to display temperature of monitored areas.

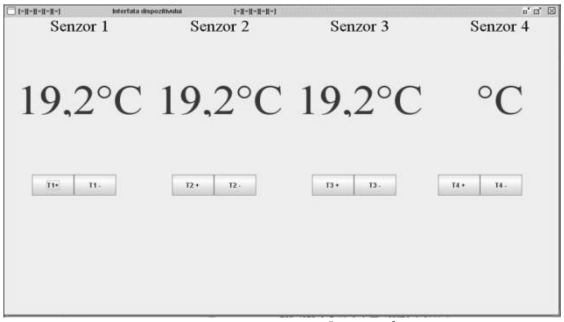

Figure 5. User guide interface

IV. CONCLUSION

Authors build a sample of a device for therapeutics with hypothermia used in medical purposes for directed cooling of specific tissues using Peltier, elements. Peltier cooling elements allow elaboration of a small mobile device that can be operated in emergency medical service, in this way reducing the risk of ischemic tissue trauma after heart failure or blockage of arteries to embolism.

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