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ELECTRONIC RECORDER OF SIGNALS FROM HUMAN HEAT FLUX SENSORS

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- This paper presents the results of development of an electronic recorder of signals intended for contact measurement of human temperature and heat flux density. Its design peculiarities, specifications, electronic circuit diagram and flowchart, operating modes and functional capabilities are shown.

Introduction

General characterization of the problem. Thermoelectric heat meters (heat flux sensors) are used in various branches of medicine, in particular, in diagnostics, traumatic surgery, oncology, etc. An important aspect in the investigation of human heat fluxes using such heat meters is high precision and speed of recording a signal from thermoelectric sensors.

Analysis of the literature. The need in high precision and speed of measurement motivates schematic complication and enlargement of measuring device dimensions. Thus, the early developments of this class of devices [1-4] have a relatively high measurement error, large dimensions and a low speed and give no way for control of measurement time interval. Their main disadvantage is impossibility of storing measurement data and a demand for external power supply [5-7]. Therefore, it is of immediate interest to develop an electronic recorder of signals which is characterized by improved precision of measuring signals from sensors, high speed of processing the results and capability of simultaneous construction of plots of human heat release versus time.

The purpose of the work is development of an electronic recorder of signals from human heat flux sensors which is intended for the diagnostics of various diseases by simultaneous measurement of the heat flux and temperature of the respective portion of human body.

Description of development results

Electronic measurement unit is a measurement analog to digital multichannel system (Fig.1) which converts, analyzes and stores primary analog signals in a digital form.

The device flowchart comprises (Fig. 1):

- thermocouple signal amplifier (TSA) with embedded zero sensor which receives a signal from the thermocouple (TC);
- analog-to-digital converter (ADC) which receives a signal from thermoelectric sensor (TES);
- microcontroller;
- program (firmware);
- display;
- output for personal computer connection (PC).

The device is based on a microcontroller that has 32 Kb of internal memory, frequency 20 MHz, assuring high-speed performance. It has 4 channels for information input-output and supports data transfer interface I²C which is necessary for information read-out from analog-to-digital converters;

16-digit analog-to-digital converter is used to convert analog signals into a digital code and passes them alternately to microcontroller input, allowing to do without a cascade of preamplifiers which simplifies the circuit and improves the accuracy of measurement. The microcontroller is programmed by means of personal computer. The program according to algorithm controls the work of all internal units of device and battery charging, information display and data read-in.

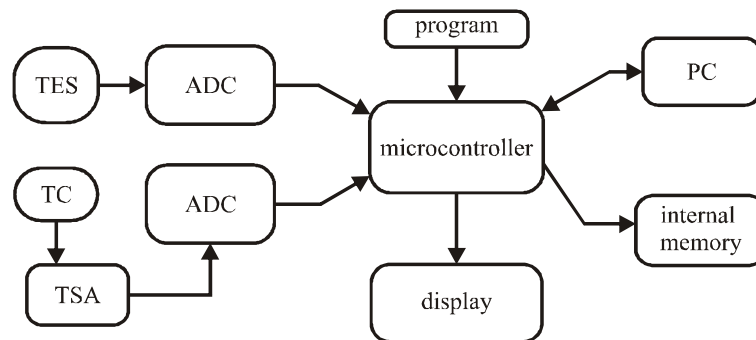


Fig. 1. Device flowchart.

The device employs a monochrome display with a resolution 128×64 pixel, which is quite sufficient for information display during 8 hours of heat flux measurement, as well as the real-time analysis of measurements and storage of measurement results.

Device is powered from lithium-ion battery of capacity 1000 mA/h which is enough for 10 hours of device autonomous operation. As long as power supply to main schematic units requires 3.3 – 5 V, the device schematic employs voltage stabilizer.

Engineering development had been preceded by computer design and optimization calculations of printed circuit board and electrical schematic (Fig. 2).

Fig. 2 shows an electrical schematic with electrical connections of all device units. Computer design of the electrical schematic allowed optimal arrangement of elements on the board taking into account loading and electrical characteristics. The design and analysis made it possible to improve the device efficiency and to reduce its overall dimensions.

Table
Specifications of electronic signals recorder

№	Device specifications	Parameter values
1.	Operating temperature range of thermoelectric sensors	$(0 \div +50)^{\circ}\text{C}$
2.	Dwell time of the established value of thermoelectric sensor heat flux	$(100 \div 300)$ s
3.	Accuracy of temperature measurement	$\pm 0.1^{\circ}\text{C}$
4.	Device supply voltage	(5.0 ± 0.3) V
5.	Device power consumption	~ 100 mW
6.	Measuring unit dimensions	$(90 \times 58 \times 24)$ mm
7.	Device weight	0.14 kg
8.	Device running time	8 – 10 h

Fig. 3 a, b shows a general view of an electronic recorder of signals from human heat flux sensors. Thermoelectric sensor (Fig. 1 b) is connected to measuring unit with the aid of a suitable matched connector, which creates additional convenience of device operation and makes it possible to change thermoelectric sensors depending on the specific nature of research. The left lateral wall accommodates a

thermoelectric sensor connector, a switch button and a connector for battery charging. The display shows the values of heat flux of the respective portion of human body in millivolts (mV) and the values of temperature in degrees Centigrade (°C). 5 mV of thermoelectric sensor's electromotive force (EMF) correspond to one pixel of display screen. Thus, by means of display one can analyze previous results of measurements directly from the plot which is displayed on the screen.

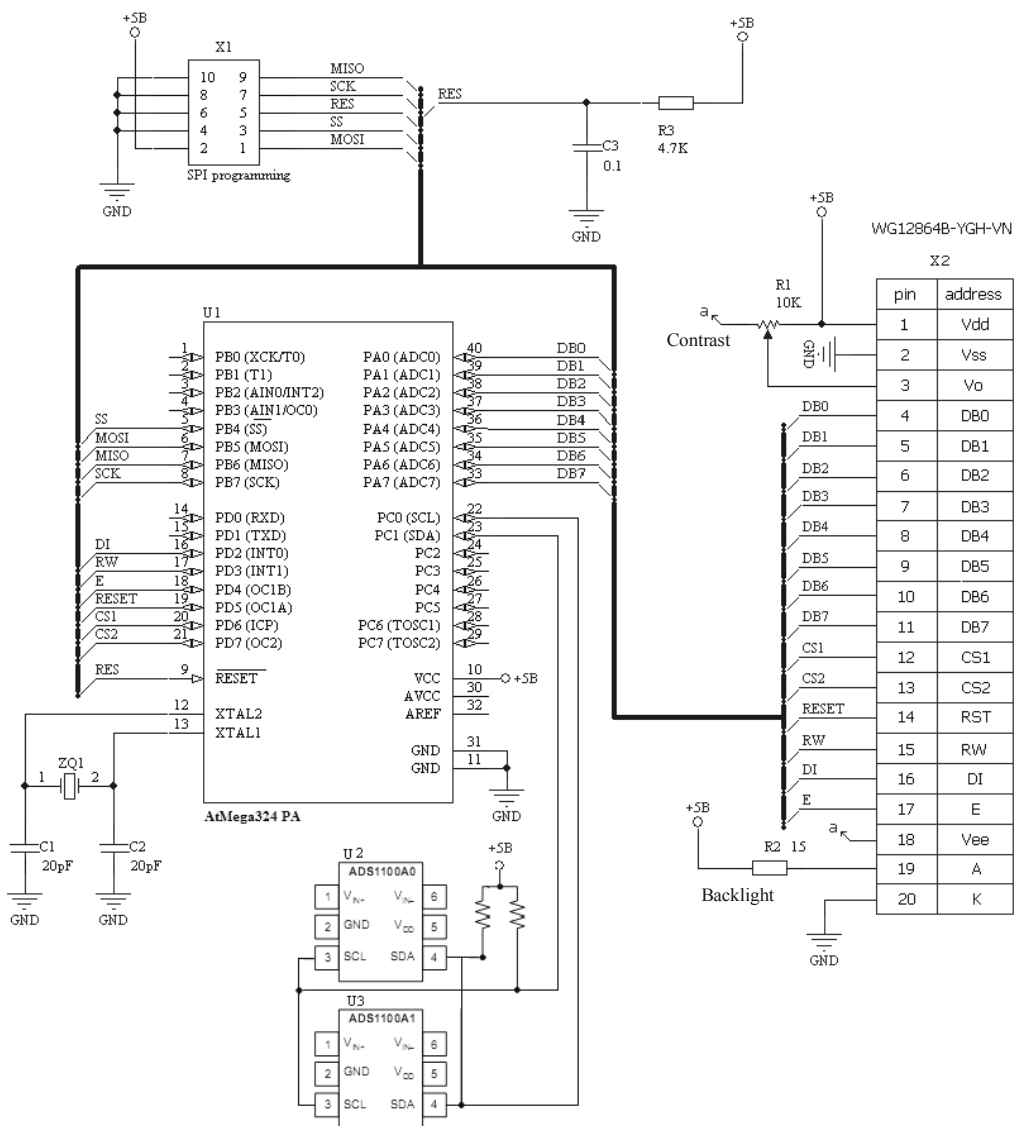


Fig. 2. Electrical schematic.



a) measuring unit appearance, b) heat flux thermoelectric sensor appearance.

Conclusions

- A design of electronic recorder of signals from human heat flux sensors is developed, assuring the speed of 1 measurement per second, with the error of heat flux measurement 3 – 4%, the accuracy of temperature measurement ± 0.1 °C. The device allows read-in and real-time information display on personal computer.
- The elaborated electronic signal recorder can be used in the diagnostics of various diseases by simultaneous measurement of the heat flux and temperature of the respective portion of human body.

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