VERIFICATION OF OPERATION Pt100 PLATINUM RESISTANCE THERMOMETER TO MEASURE THE ELECTRONIC ELEMENTS INSIDE TIME-OF-FLIGHT (TOF) DETECTOR*

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Every electronic system working in demanding conditions requires specific cooling system. To establish appropriate operating conditions for the TOF detector, it is necessary to measure and control the temperature. For this purpose, Pt100 resistance thermometer is used. We present one of the methods verifying functioning of the mentioned resistance thermometer.

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1. Introduction

NINO microchips as a part of Time-of-Flight (TOF) detector require to keep specific temperature throughout the operation. Therefore, controlling electronic system which prevents overheating is obligatory for proper work.

TOF detector is used for particle identification arised during heavy-ion collisions in the Nuclotron. Time measurement in TOF as well as the momentum and track length measured by the tracking detectors are used to calculate the particle mass [1]. To identify particles with high efficiency, time resolution has to be better than 100 ps.

TOF construction is based on Multigap Resistive Plate Chambers (MRPC). The mentioned construction is equipped with electronic system which amplifies and discriminates the signal simultaneously matching the measured time to resolution of the detector [2]. The main part of this structure made of NINO chips is shown in Fig. 1.

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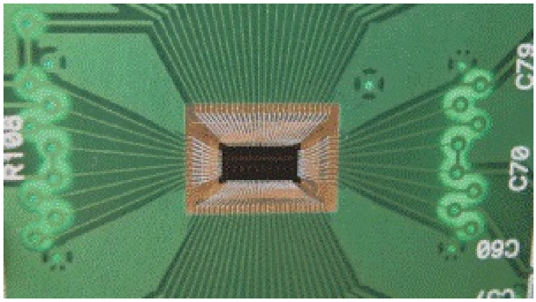

Fig. 1. Zooming of NINO chip from the TOF detector [2].

To establish appropriate operating conditions for the TOF detector, it is necessary to measure and control the temperature of detectors electronics, which affects thermodynamic properties of the gas inside the detector. One of the methods to measure the temperature is to use Pt100 resistance thermometers.

2. Method of measurement using Pt100

We proposed an alternative attitude to measure temperature using Pt100 resistance thermometers transferring the research to laboratory zone, making our work more available and understandable. We focused on designing an electronic circuit which allows testing and verifying Pt100 resistance thermometers. Proper work of this element is required in the target device to avoid detector's overheat. To carry out our research, we used National Instruments ELVIS II+ device.

ELVIS II+, shown in Fig. 2, is a modular engineering educational laboratory equipped with oscilloscope, digital multimeter, function generator, variable power supply, Bode analyzer, and other common lab instruments. Connection to computer via USB allows to create programs for a built circuits on its detachable protoboard. Device is compatible with the NI LabVIEW environment [3].

NI ELVIS II+ can be successfully used as one of the methods of examination of Pt100 proper operation.

Pt100 thermometer, Fig. 3, is a device used to measure the temperature indirectly. The principle of operation is to measure the resistance of the platinum element. Pt100 has a resistance of $100\,\Omega$ at 0° C and $138.4\,\Omega$ at 100° C [4]. The relationship between temperature and resistance is approximately linear over a small temperature range.

The relationship between temperature and resistance in platinum thermometer resistors is described by the following equations [5]:

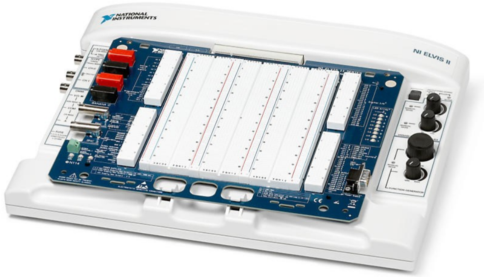

Fig. 2. NI ELVIS II+ board [6].

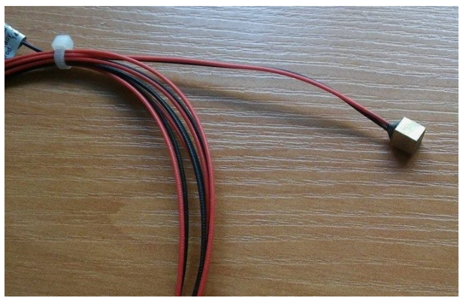

Fig. 3. Tested Pt100 platinum resistance thermometer.

— for temperature range −200–0°C,

$$R = R_0 \left[1 + AT + BT^2 + C\,(T - 100\,^\circ\mathrm{C})\right] T^3\,, \tag{1}$$

— for temperature range 0–850°C,

$$R = R_0 \left[1 + AT + BT^2\right]\,, \tag{2}$$

where R [Ω] — resistance for temperature T [°C]; R_0 [Ω] — resistance for temperature 0 [°C]; T [°C] — temperature; A, B, C — coefficients.

Very often B and C coefficients are relatively small, the resistance changes almost linearly with the temperature.

After the transformation of the positive temperature, we receive the following equation:

$$T = \frac{-A + \sqrt{A^2 - 4B(1 - R_T/R_0)}}{2B}\,. \tag{3}$$

The formula above was implemented in the LabVIEW environment.

3. Electronic circuit

One of the possibilities to verify Pt100 thermometer operation is direct connection of one proper cable to ELVIS II+ board. The second way allows to create electronic circuit on breadboard localized on ELVIS II+. We choose the first option because of limited time provided for realization. As we mentioned, we connected the cable from thermometer directly to input and output on the ELVIS II+ device. We reserved a designing protoboard for electronic alarm circuit which activates when the temperature detected by Pt100 is higher than the set threshold.

Our system has been programmed in the LabVIEW environment. The program created in this software consists of two parts. Front panel is a part visible for end users. Second part block diagram — is programer section. It is a kind of core application which covers programing logic.

Figure 4 shows hot water cooling in time. After start-up time, we can see linear relationship between temperature decrease and time. On the right side, we present measured resistance, converted temperature, and rectangle to control the threshold.

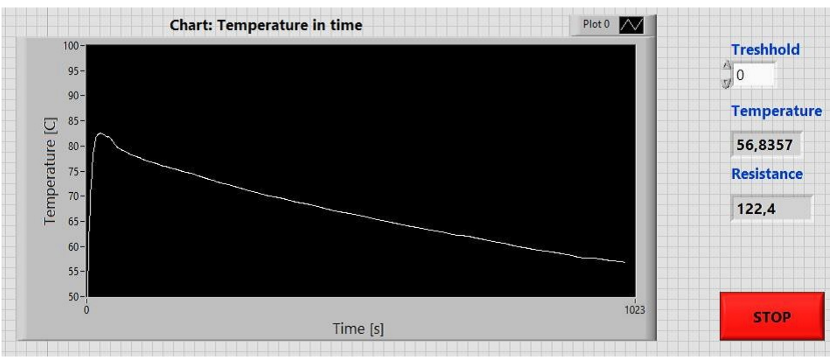

Fig. 4. Front panel of the designed system.

Block diagram given in Fig. 5 includes initialization connection with ELVIS II+ board, main loop converting resistance to temperature (implemented formula 3), and logic of alarm section with possibility to set up the value by users.

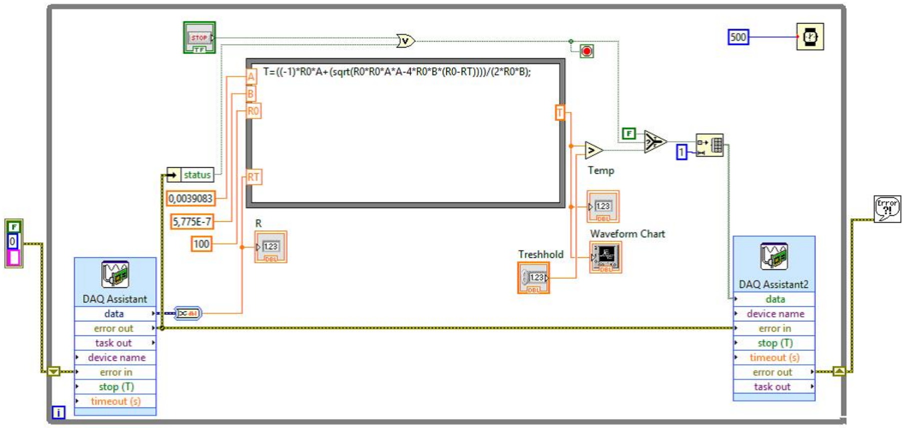

Fig. 5. Block diagram of the designed system.

4. Conclusions

The proposed system allows testing Pt100 and creating more advanced system to control and react to changing conditions. It affects safety operation of all systems. The result is a successfully designed and launched temperature measurement system. To achieve this, the applicable LabVIEW project was created. Then we performed some measurements, which were dedicated to low (0°C), medium (30°C), high (80°C) temperatures and showed that the platinum resistance thermometers are functioning properly. Moreover, the project was extended by the alarming system. When temperature is higher than the threshold set by the user it causes light-emitting diode (LED) to shine. One can see how easy it is to check the Pt100 operation. The system can be broadened allowing at the same time verifying few thermometers. Moreover, this method can be used for students to explore their knowledge and familiarize them with the Pt100 resistance thermometer.

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