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VERIFICATION OF Pt100 PLATINUM RESISTANCE THERMOMETER OPERATION TO MEASURE THE ELECTRONIC ELEMENTS INSIDE THE **TOF** DETECTOR

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Треихель З. и др. E13-2017-82
Улучшение работы термометра сопротивления Pt100 для измерения электронных элементов внутри TOF-детектора

Каждая электронная система, работающая в жестких условиях, требует специальной системы охлаждения. Чтобы создать соответствующие условия работы для TOF-детектора, необходимо измерять и контролировать температуру. Для этой цели используется термометр сопротивления Pt100. Представлен один из методов проверки функционирования данного прибора.

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Verification of Pt100 Platinum Resistance Thermometer Operation to Measure the Electronic Elements inside the TOF Detector

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 to verify functioning of the mentioned device.

The investigation has been performed at the Veksler and Baldin Laboratory of High Energy Physics, JINR.

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INTRODUCTION

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

TOF detector is to be 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, is 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 is made of NINO chips (see Fig. 1).

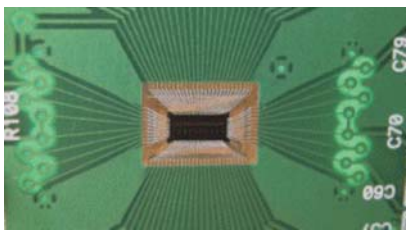

Fig. 1. Zooming of NINO chip from the TOF detector [2]

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

1. 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 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

Fig. 2. NI ELVIS II+ board [4]

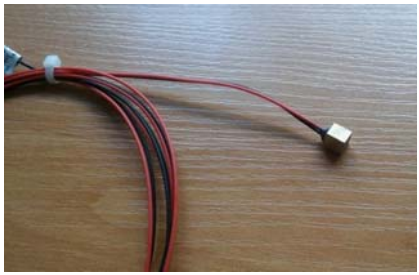

Fig. 3. Tested Pt100 platinum resistance thermometer

supply, Bode analyzer, and other common lab instruments. Connection to computer via USB allows one to create programs for built circuits on its detachable protoboard. The device is compatible with 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 Ω at 0 °C and 138.4 Ω at 100 °C [5]. 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 [6]:
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,

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

where R — resistance for temperature T; R_0 — resistance for temperature 0 °C; T — 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 LabVIEW environment.

2. ELECTRONIC CIRCUIT

One of the possibilities to verify Pt100 thermometer operation is direct connection through proper cable to ELVIS II+ board. The second way allows one 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 the thermometer directly to input and output on 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 programed in LabVIEW environment. Program created in this software consists of two parts. Front panel is a part visible for end users. The second part — block diagram — is a programer section. It is a kind of core application which covers programing logic.

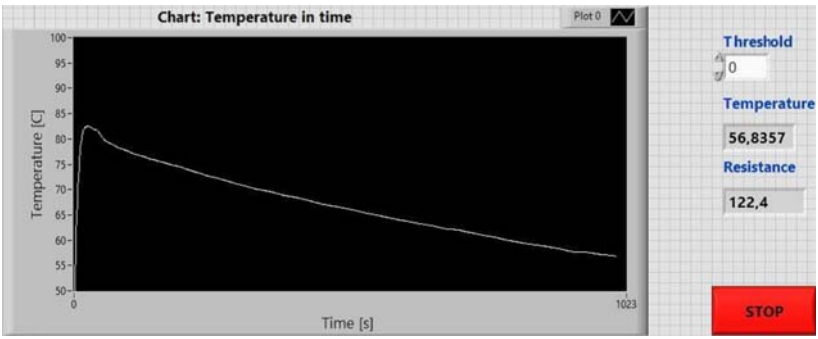

Fig. 4. Front panel of the designed system

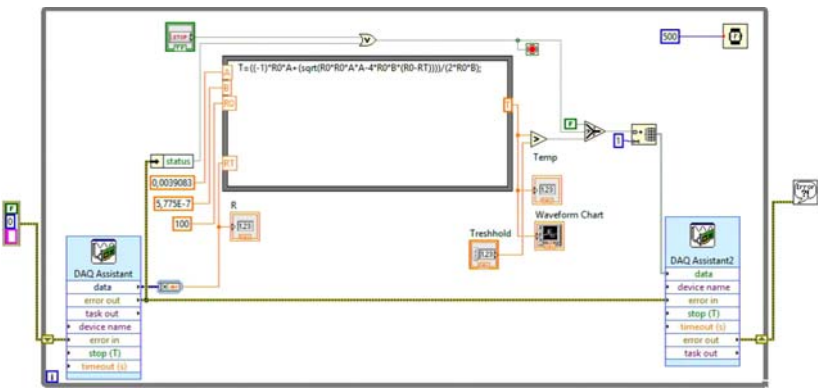

Fig. 5. Block diagram of the designed system

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.

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 value by users.

CONCLUSIONS

The proposed system allows testing Pt100 and creating more advanced system to control and react to changing conditions. It affects the 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. The temperature higher than the threshold set by the user causes light-emitting diode (LED) to shine. One can see how easy it is to check Pt100 operation. System can be broadened allowing at the same time verifying few thermometers. Also, this method can be used for students to expand their knowledge and familiarize them with Pt100 resistance thermometer.

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