საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 14, №2, 2020
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 14, no. 2, 2020

Engineering

Virtual Liquid Nitrogen Level and Cryotemperatures Meter

Bezhan Bendeliani[*,], Guram Dgebuadze[*], Zaal Azmaiparashvili[**], Guram Bokuchava[*], Ioseb Metskhvarishvili[*,**]**

[*] *Laboratory of Cryogenic Technique and Technologies, Ilia Vekua Sukhumi Institute of Physics and Technology, Tbilisi, Georgia*
[**] *Department of microprocessor and measurement systems, Georgian Technical University, Tbilisi, Georgia*

(Presented by Academy Member Tamaz Natriashvili)

One of the latest trends in the development of measurement technology is the implementation of digital methods of measurement, conversion, registration and analysis of data, automation and increasing the level of intelligence of measuring devices. The recently popular Virtual Instruments (VI) provides all these features. Measuring systems based on them are much more flexible than standard laboratory devices, as they use the broad capabilities of modern software. A good example of a complete measurement system is a computer with a VI, equipped with measurement and control equipment. The present article is devoted to the making of a LabVIEW-based virtual device with measurement equipment for measure cryotemperatures (77÷300 K) and liquid nitrogen level in a vessel of any design. In contrast to available commercial devices, a new measurement approach proposed by us makes it possible to measure and constantly control the liquid nitrogen level in a small-size cryostat nitrogen vessel of an investigation designation. The working principle of the device is based on the temperature gradient in liquid nitrogen and outside it. *2020 Bull. Georg. Natl. Acad. Sci.*

Cryotemperature, liquid nitrogen level, sensors, virtual device, LabVIEW

To obtain reliable experimental data in the process of testing different materials at low temperatures, it is necessary to control the environment in which the test specimens are found. Therefore, together with an accurate temperature measurement, another principal condition is the specimen's thermal balance, which, from an experimental viewpoint, is equivalent to the following two requirements: a rather low temperature gradient and high degree of thermal stabilization.

In line with these requireents, the investigation of specimens takes place in a special device – cryostat [1-2]. The temperature range of a compact cryostat used thereby is 77-300 K. The constant control of liquid nitrogen is of importance for the normal functioning of our device, because its shortage would lead to dysfunction of the cryostat and accordingly of the whole measurement process.

To date, a peculiarity of the measuring equipment development is the automation of information retrieval, processing and recording. The substitution of real devices with the software-formed so-called virtual instruments has been

successfully implemented in different experiments [3-6]. A leading position in making such devices is occupied by the graphical diagrams to create virtual devices of the LabView software – product of an American company National Instruments [7-9]. In aggregation with the multifunctional data I/O devices of the same company, a best opportunity for substituting the real devices with their software analogs is produced.

Methods. A flowchart of the temperature and liquid nitrogen level measurement system is given in Fig. 1. Platinum thin-film thermal resistors PT100-C220 of the German company Heraeus are selected as the temperature sensor elements, the range of measurement of which is -196÷150^{0}C. Such kind of sensors are noted for a long-term stability, minimal deviations from standard indicators and for hesteresis effect absence. To improve the accuracy of measurement, a four-wire circuit is used. To preserve the thermistor's thermal stability, an additional resistor element is hooked up in the circuit in succession on R_{add}>>R_{RTD} terms. Hence, the current flowing in the thermistor does not practically change, in contrast to its resistance and correspondingly removed load. This load/voltage is supplied to the I/O device NI6210 and then to the temperature and liquid nitrogen level meter created in the virtual environment of the graphical diagrams of the LabVIEW software.

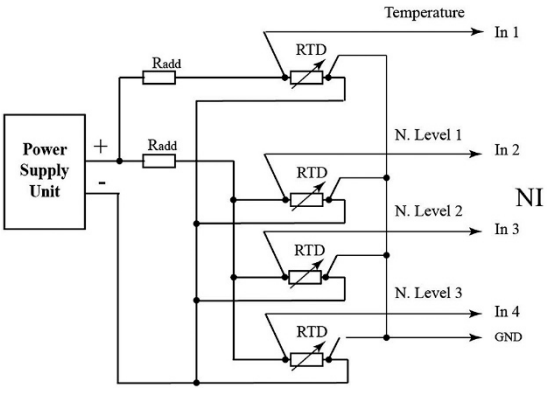

Fig. 1. A flowchart of the liquid nitrogen level and temperature measurement system.

Fig. 2 depicts the flowchart of the virtual device created in the LabVIEW. It composed of two parts: a temperature meter and a liquid nitrogen level meter.

Temperature meter. In order to reduce the measurement error, an arithmetic mean of 1,000 values measured per second is taken. The dependence of the actual temperature and the input voltage obtained by a digital analysis program was written in the Formula block. The calculated here Celsius and Kelvin temperatures are presented digitally on the front panel of the virtual device (Fig. 3). Additionally, during the whole experiment temperature changes could be controlled and memoraized in a PC on-line.

Liquid nitrogen level meter. A wide choice of liquid-level gauges is available today, which are based on the different operation principle: volumeter, hydrostatic, float-type, optical, ultrasound, etc. Finally, selection of a sensor is determined by the technological process parameters, the physical-chemical characterictics of the liquid, and a possibility of the sensor's proper location. The majority of available liquid level sensors is nor designated for operation under cryotemperatures, whereas dimensions of the rest exclude the possibility of their placement in a small-size cryostat.

Hence, the liquid nitrogen level meter of an orginal design, the principle of operation of which is based on the temperature gradient inside and outside the liquid nitrogen, is being practically realized as follows. A thin getinax stem has cut grooves that locate 3 equally distanced sensors. The voltage removed from the platinum sensor C220 at the liquid nitrogen temperature is ≈20 millivolts (±0.5). If the removed voltage exceeds this value, the sensor is outside the liquid nitrogen. As a result of comparison, all the three indicators on the front panel of the device are either switched off (the

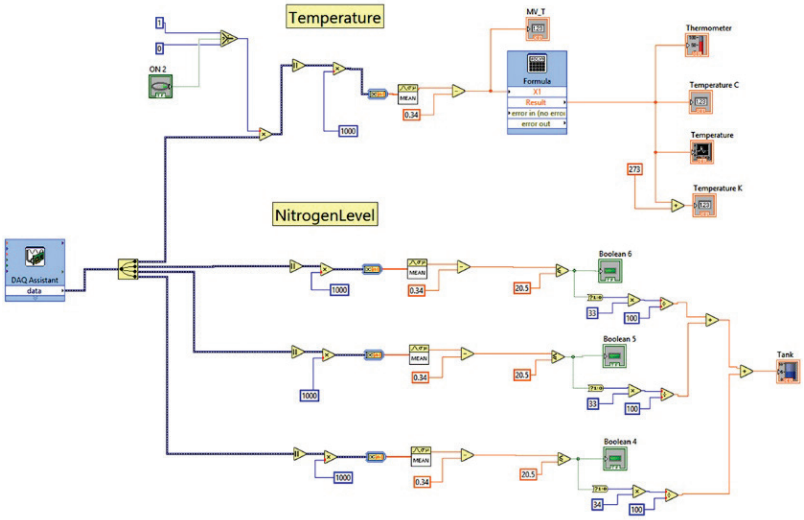

Fig. 2. A flowchart of the virtual device created in the LabVIEW.

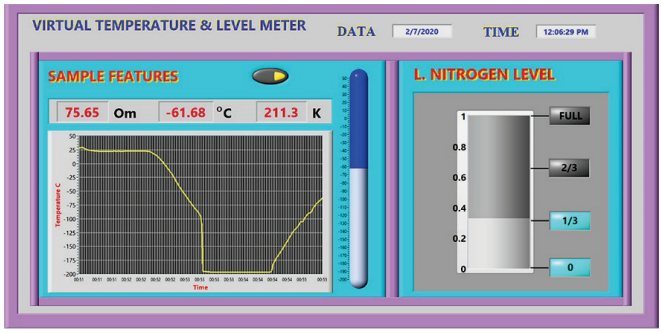

Fig. 3. Front panel of the virtual device.

nitrogen vessel is empty), or one, two or three of them will be lighted and we are thus informed about the nitrogen level in the vessel (is full by a third, two-thirds or completely). In case of need, a more complete picture can also be obtained by increasing a number of sensors (the NI6210 unit has 16 inlets).

Conclusions. Virtual instrument for measuring the liquid nitrogen level and cryotemperatures has been designed and manufactured. By means of a Heraeus C220 platinum thermal resistor the temperature within the range of 196÷20°C is measured with a 0.5-degree accuracy. An innovative approach toward the liquid nitrogen measurement in small-size cryostats, the principle of operation of which is based on the temperature gradient inside and outside the liquid nitrogen has been realized. The measured parameters are indicated on the front panel of a virtual device created on the basis of LabVIEW graphical environment.

The work was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSF), Grant number: 217524, Project title: Influence of the polymerization and various dopants on the Hg–1223 superconductive properties.

საინჟინრო მეცნიერება

თხევადი აზოტის დონისა და კრიოტემპერატურების მზომი ვირტუალური ხელსაწყო

ბ. ბენდელიანი[*,**], გ. დგებუაძე[*], ზ. აზმაიფარაშვილი[**], გ. ბოკუჩავა[*], ი. მეცხვარიშვილი[*,**]

[*] *სოხუმის ილია ვეკუას ფიზიკა-ტექნიკის ინსტიტუტი, კრიოგენული ტექნიკისა და ტექნოლოგიების ლაბორატორია, თბილისი, საქართველო*

[**] *საქართველოს ტექნიკური უნივერსიტეტი, მიკროპროცესორული და საზომი სისტემების დეპარტამენტი, თბილისი, საქართველო*

(წარმოდგენილია აკადემიის წევრის თ. ნატრიაშვილის მიერ)

გაზომვის ტექნოლოგიების განვითარების ერთ-ერთ ბოლო ტენდენციას წარმოადგენს მონაცემთა გაზომვის, გარდაქმნის, რეგისტრაციისა და ანალიზის ციფრული მეთოდების გამოყენება, გამზომი მოწყობილობების ავტომატიზაციისა და ინტელექტუალური დონის ამაღლება. ამ მოთხოვნებს სრულად უზრუნველყოფს ბოლო დროს პოპულარული ვირტუალური ინსტრუმენტები (ვი). ვირტუალურ ინსტრუმენტებზე აგებული გამზომი სისტემები არის გაცილებით უფრო მოქნილი, ვიდრე სტანდარტული ლაბორატორიული ხელსაწყოები, ვინაიდან იყენებენ თანამედროვე პროგრამული უზრუნველყოფის ფართო შესაძლებლობებს. დასრულებული გამზომი სისტემის კარგი მაგალითია კომპიუტერი, მასში შექმნილი ვირტუალური ხელსაწყოთი, აღჭურვილი გაზომვისა და მართვის მოწყობილობებით. წარმოდგენილი სტატია ეძღვნება **LabVIEW**-ბაზაზე ნებისმიერი კონსტრუქციის ჭურჭელში თხევადი აზოტის დონისა და 77÷300 K დიაპაზონში ტემპერატურის მზომი ვირტუალური ხელსაწყოს შექმნას. არსებული კომერციული მოწყობილობებისაგან განსხვავებით, ჩვენ მიერ შემოთავაზებული გაზომვის ახალი მიდგომა საშუალებას გვაძლევს, ვზომოთ და უწყვეტად ვაკონტროლოთ თხევადი აზოტის დონე კვლევითი დანიშნულების, მცირე ზომის მქონე კრიოსტატის აზოტის ჭურჭელში.

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Received January, 2020