THE TOTAL-TEMPERATURE MEASUREMENTS AND INTERLOCK SYSTEM AT THE VEPP-4M COLLIDER

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Abstract

Temperature conditions affect the circulating bunches parameters in colliders. So, the permanent temperature measurements are very important for the estimation of the beam energy during the experiments with colliding beams.

The temperature measurement system [1] is implemented at the VEPP-4 facility [2] for permanent and precise temperature measurement in a lot of points (about 500) of the facility: on magnet yokes, coils, and electrical power connections, air in the tunnel, cooling water of RF cavities, water cooling system. Also, the system provides the interlock functions. In the case of overheating in measuring points the system switch off the corresponding power supplies.

The system is based on using of DS1631Z Accuracy Digital Thermometers and 32-channel home-developed controller. The controllers are connected to PC via serial interface. Temperature values are renewed automatically for the all channels in each controller in 0.75 second.

The program running in PC reads the data from the all controllers and transfers the temperature data to PostgreSQL database every minute. The graphic interface provides browsing of the temperature diagrams for the selected thermometers for any period of time. All the programs run under Linux.

INTRODUCTION

The high-energy physics experiments performed at the VEPP-4M collider require a high-precision beam energy measurement. Beam energy is proportional to the dipole magnetic field integral. On-line monitoring of the magnetic field with 10^{-6} accuracy is realized by nuclear magnetic resonance (NMR) method. But the beam energy also depends on thermal changing of the magnets and tunnel dimensions. For accurate estimation of the beam energy between resonance depolarization calibrations it is necessary to measure precisely temperature in a lot of locations of the VEPP-4M facility. The control of the temperature of the RF cavities is required also. The RF cavities dimensions variation results in excitation of undesirable modes of oscillations, which excite coherent oscillations of the beams particles during the experiment.

The new system of temperature monitoring was developed in order to provide total precise permanent measurements [2]. The second function of the system is interlock function.

This paper describes the Total-Temperature Measurements and Interlock System at the VEPP-4M Collider.

HARDWARE AND CONNECTIONS

The VEPP-4M temperature measurement system bases on BINP developed 32 channel temperature controllers (see Fig. 1) using High-Precision Digital Thermometers DS1631 with the resolution 0.0625ºC [3] and relay contacts for connection/disconnection of electric circuits.

High-Precision Digital Thermometers DS1631

DS1631 is produced by MAXIM/DALLAS Company. Sensor's principal features are:

- DS1631 provides ±0.5° C accuracy within 0° C up to +70° C range
- Operating temperature range: –55°C to +125° C
- Temperature measurements require no external components
- Output resolution is user-selectable to 9, 10, 11 or 12 bits (12 bits resolution corresponds 0.0625° C)
- Wide power supply range (2.7V to 5.5V)
- Converts temperature to digital word in 750 ms (max)

Data are read/written through two–wire serial interface

32 channel Temperature Controller

32 channel Temperature Controller was developed in BINP. The scheme of the controller is shown in Figure 2.

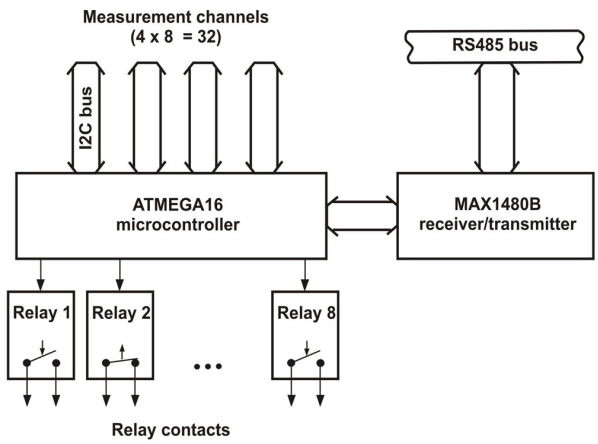

Figure 1: Scheme of the temperature controller.

Controller's functions and features are:

- temperatures are read from the temperature sensors every second and is written to the memory of the controller,
- automatic checking of the temperature value of each sensor to be inside the specified temperature range,
- switching on the relay interlock if the temperature is out of the specified range,
- two interlock levels for each sensor,

- switching of the relay by PC or by controller,
- wide feeding voltage range (8 - 12 V).

Controller is connected with sensors through four-wire multi-drop serial lines. It is possible to connect up to eight sensors in one line with wire of twenty meters length. Temperature values are renewed for the all sensors of each controller and stored to the memory every second automatically.

If the temperature value is out of the specified temperature limits, then specified relay contact is changed automatically. Relay interlock is used for switching off the power supplies of the VEPP-4M magnetic elements in the case of overheating. There are up to 8 solid-state relays in one controller. Program running in PC reads from (or writes to) controller the specifications for relay contact changing. Controller can close relay contacts but can't open. Program in PC can close and open relay contacts in accordance the operation logic.

Connection of Temperature Controllers to PC

The controllers are connected to PC via industrial RS485 bus. This line can be attached to PC via USB or COM port using protocol converter "RS485-USB" or "RS485-COM". The scheme of the connection is shown in Figure 2.

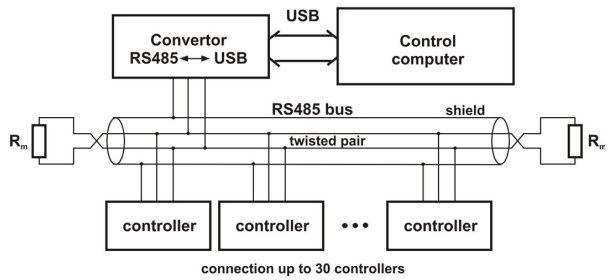

Figure 2: Temperature controller connections.

Thirty controllers can be connected in parallel via the bus. The length of bus can be up to 1200 meters.

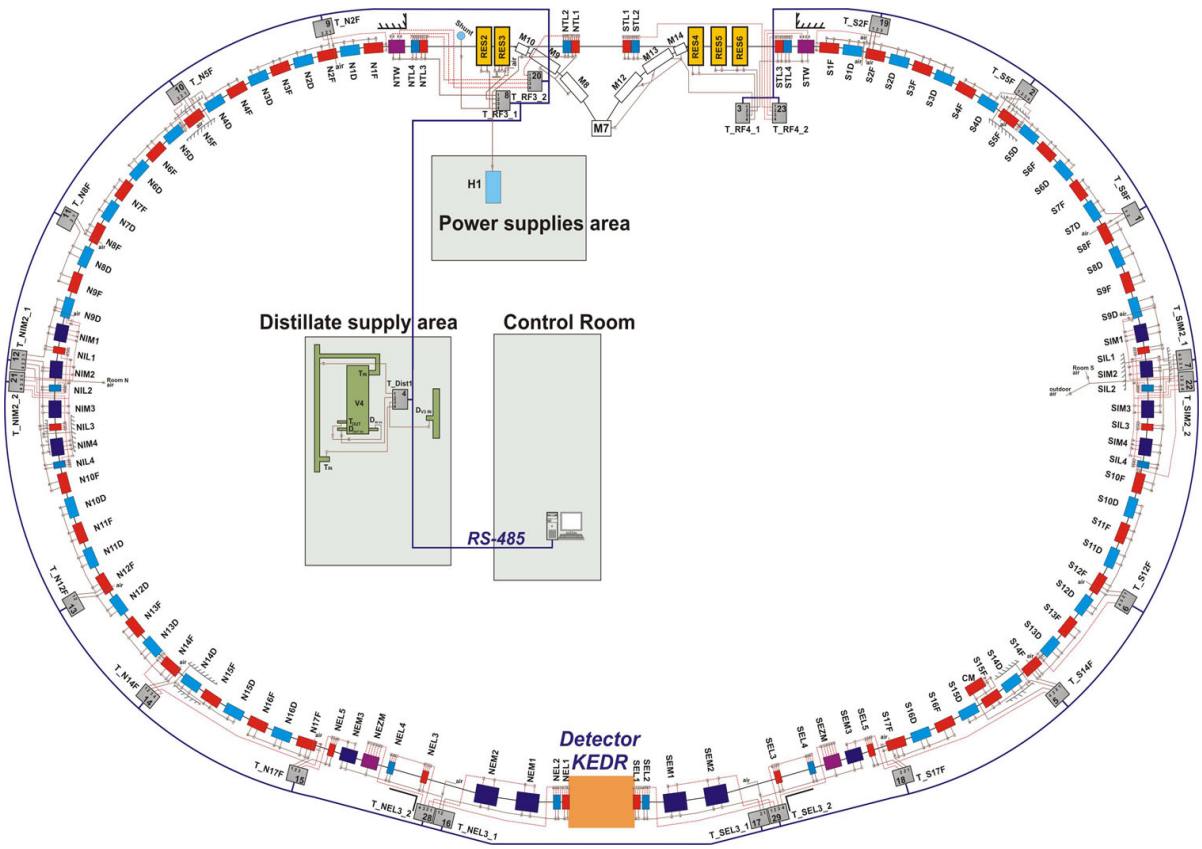

Figure 3: Temperature measurement system layout.

REALIZATION OF THE SYSTEM

The layout of the VEPP-4 temperature measurement system is shown in Figure 3. The system comprises 25 controllers and almost 500 sensors.

The temperature measurement system is used for two purposes:

- temperature measurements for the beam energy estimation during the experiments with colliding beams,
- temperature measurements for the prevention of the magnets overheating

For the first purpose the air and the tunnel walls temperatures are measured in several points. Also the temperature of each magnet is measured in two points: on

upper and down parts of the yoke. Almost three hundred sensors are used for these measurements. For the second purpose the temperatures of magnetic coils and the temperatures of magnet commutations are measured. Number of sensors the interlock group is about two hundred. For the each interlock sensor the range of working temperatures is set in memory of the controller. The each sensor has two blocking levels: warning level and power supply switching off level.

SOFTWARE

The full description of the controllers and sensors configuration is contained in the VEPP-4 database. The resident program works with controllers and periodically reads the configuration data from the database for the case of renewing of the temperature measurement cannels configuration. It provides permanent temperature measurements and storing of the temperature measurements even if the measurement channel configuration is modified.

The program reads the data from the all controllers and writes measurements to database once per minute.

The database graphic observation program provides browsing of the temperature diagrams of the selected sensors for any period of time in any scale. Also, the graphic interface allows temperature monitoring. The typical temperature diagrams are presented in Figure 4. The diagrams of input and output cooling water temperatures, and input circulating distillate temperature is shown in the picture.

The resident program runs under Linux. The observation program can run in any Control Room machine [4].

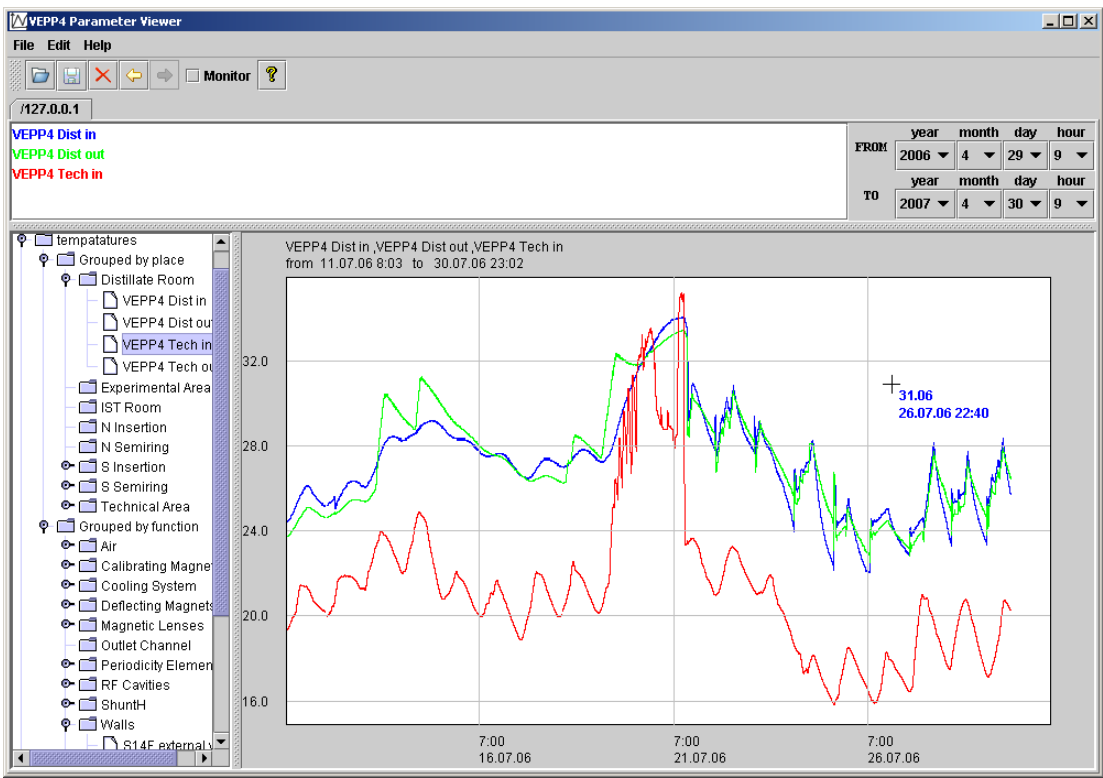

Figure 4: An example of temperature diagrams.

CONCLUSION

The temperature measurement system started its work in 2006/2007 operating season. Installation of sensors and controllers in the tunnel and on the magnetic elements of the VEPP-3 – VEPP-4M transfer channel now are completed. Since 2006 the measurement system has been showing very good reliability.

The temperature measurements were used for the permanent beam energy reconstruction, for the diagnostic of state of the cooling and magnetic systems of the VEPP-4M collider.

The next step is the implementation of the system at the VEPP-3 storage ring.

REFERENCES

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[4] A. Aleshaev, et al., " Integration of PCs into the VEPP-4 Control System", PCaPAC2005, 22-25 march 2005, GUAS (Hayama), Japan.