THE PRECISION CONTROL OF TEMPERATURE VEPP-4M ACCELERATOR FACILITY

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Abstract

This work offers the temperature control system of distillate in various working elements of complex VEPP-4M, as the RF cavities and the dipole magnets.

The basis of the monitoring system is 32 channel controller of temperature using digital probes of temperature measurements DS 1621 « Digital Thermometer and Thermostat ».

The represented system allows to measure temperature in the range from -55 up to +125 degrees with the time resolution one minute and accuracy $1\bullet10^{-2}$ degrees centigrade.

INTRODUCTION

VEPP-4M is the collider with the high energy beams of electrons and positrons [1]. The VEPP-4M accelerator facility consists of the electron-positron collider VEPP-4M at an energy up to 6000 MeV, a synchrotron at an energy of 350 MeV, and linear accelerator which enables the obtaining of 7 MeV electrons or positrons. Both the storage ring VEPP-3 and the VEPP-4M collider are used in experimental studies. These installations have rooms specially equipped for the operation with SR beams. At the VEPP-4M there is the ROKK-1M installation (Backward Scattered Compton Quanta), producing the polarized tagged gamma-quanta within the energy range from 50 to 1600 MeV, obtained with the method of the backward Compton scattering of the laser light on the VEPP-4M electron beam. The scheme of VEPP4M is shown in Figure1.

One of major factors influencing stability of average energy of particles of beams in the VEPP-4M collider , is temperature of dipole magnets. The magnetic field created by magnets, directly depends on the sizes of magnets, and the sizes in turn have complex dependence of temperature. Thus, for the control of energy of particles it is necessary rather precisely to measure the temperature of elements of magnetic system, and, in an ideal case to ensure steady thermal stability of all magnets.

As, the control of temperature of RF cavities is required, as the change of their sizes results in excitation of undesirable modes of electromagnetic oscillations, which raise phase oscillations of particles of a beams. That results in increase of the beam of a bunch and life time decrease. The similar problems arise during the laser operation. The laser is used for the backward Compton scattering of the laser light on the VEPP-4M electron beam With this purpose the new system of measurement of temperature was developed.

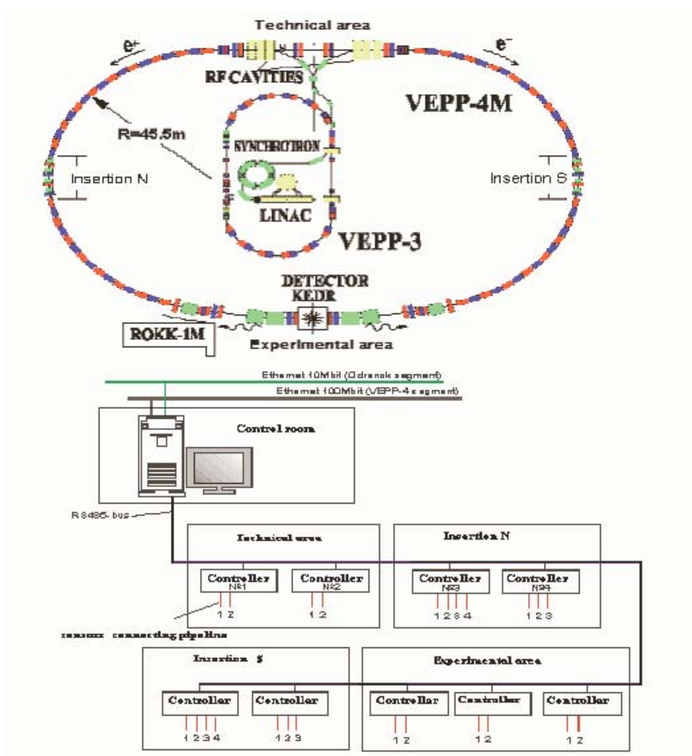

Figure 1: Scheme of VEPP4M.

TEMPERATURE PROBES

We choosed as the probes DS 1621 « Digital Thermometer and Thermostat **».**

Its main feature is:

- Temperature measurements require no external components
- Measures temperatures from –55°C to +125°C in 0.5°C increments
- Temperature is read as a 9–bit value (2- byte transfer)
- Wide power supply range (2.7V to 5.5V)
- Converts temperature to digital word in 1 second
- Thermostatic settings are user definable and nonvolatile
- Data is read from/written via a two–wire serial interface (open drain I/O lines)

The DS1621 Digital Thermometer and Thermostat provides 9–bit temperature readings which indicate the temperature of the device. The thermal alarm output, TOUT, is active when the temperature of the device exceeds a user–defined temperature TH. The output remains active until the temperature drops below user defined temperature TL, allowing for any hysteresis necessary. User-defined temperature settings are stored in nonvolatile memory so parts may be programmed prior to insertion in a system. Temperature settings and temperature readings are all communicated to/from the DS1621 over a simple two–wire serial interface.

The DS1621 measures temperature by counting the number of clock cycles that an oscillator with a low temperature coefficient goes through during a gate period determined by a high temperature coefficient oscillator. The counter is preset with a base count that corresponds to –55 °C. If the counter reaches 0 before the gate period is over the temperature register, which is also preset to the –55 °C value, is incremented indicating that the temperature is higher than –55 °C. At the same time, the counter is preset with a value determined by the slope accumulator circuitry. This circuitry is needed to compensate for the parabolic behavior of the oscillators over temperature. The counter is then clocked again until it reaches 0. If the gate period is still not finished, then this process repeats.

The slope accumulator is used to compensate for the nonlinear behavior of the oscillators over temperature, yielding a high resolution temperature measurement. This is done by changing the number of counts necessary for the counter to go through for each incremental degree in temperature. To obtain the desired resolution, both the value of the counter and the number of counts per °C (the value of the slope accumulator) at a given temperature must be known. This calculation is done inside the DS1621 to provide 0.5 °C resolution. The temperature reading is provided in a 9–bit, two's complement reading by issuing the READ TEMPERATURE command. The data is transmitted through the 2–wire serial interface, MSB first. The DS1621 can measure temperature over the range of –55 °C to +125 °C in 0.5 °C increments. Since data is transmitted over the 2–wire bus MSB first, temperature data may be written to/read from the DS1621 as either a single byte (with temperature resolution of 1 °C) or as two bytes. The second byte would contain the value of the least significant (0.5 °C) bit of the temperature. Note that the remaining 7 bits of this byte are set to all "0"s.

Higher resolutions may be obtained by reading the temperature and truncating the 0.5 °C bit from the read value. This value is TEMP_READ. The value left in the counter may then be read by issuing a READ COUNTER command. This value is the count remaining (COUNT_REMAIN) after the gate period has ceased. By loading the value of the slope accumulator into the count register (using the READ SLOPE command), this value may then be read, yielding the number of counts per degree C (COUNT_PER_C) at that temperature.

The actual temperature may be then be calculated by the user using the following:

$$\mathrm{TEMPERATURE} = TEMP\_READ - 0.25 + \frac{(\mathrm{COUNT\_PER\_\ -\ COUNTREMAIN})}{\mathrm{COUNT\_PER\_C\,COUNT}}$$

MULTICHANNEL CONTROLLER OF TEMPERATURE SENSORS

But it is possible to connect only eight DS1621 Digital Thermometer per line. To the present time in institute was developed modern 8- digit multichannel controller of temperature sensors. The given controller can work with gauges on four consecutive channels of connection. It is possible to connect to each channel up to 8 temperature sensors and up to 32 temperature sensors to controller. The data in the controller are submitted as the table consisting of 6 banks (0-5), size till 64 bytes.

In 0 bank the summary table of the current meanings of temperature from all of the 32-nd sensors contains.

0 - LSB 1 - MSB = temperature 1-st sensor 1-st chanel
2-LSB 3-MSB = temperature 2-nd sensor 1-го chanel
……
62-LSB 63-MSB = temperature 8-rd sensor 4-rd chanel

В MSB contain the temperature from -55 to +125 градусов. Senior bit contain the sign.

В LSB contain the fractional part of temperature 1/256 of degree.

The banks with 1 on 4, stored in the read - only STORAGE of the controller, are intended for management of sensors 1-4 channels accordingly.

0 TWLL - first lower level of temperature
1 SWLL - number interlocking relay for TWLL
2 TWHL - first upper level of temperature
3 SWHL - number interlocking relay for TWHL
4 TBL1 - second lower level of temperature
5 SBL1 - number interlocking relay for TBL1
6 TBL2 - second upper level of temperature
7 SBL2 - number interlocking relay for TBL2

The fifth bank stores the information on a condition of channels of measurement of temperature and condition of relay contacts.

0-31 bytes stores the information on a condition of channels of measurement

0 bit - exceeding level TWLL
1 bit - exceeding level TWHL
2 bit - exceeding level TBL1
3 bit - exceeding level TBL2
4..7 bits is unused (set 0).

32-47 bytes are keeped in reserve

48-58 bytes stores the information on condition of relay contacts

7 bit (1 - switch off, 0 - switch on)
0..6 bits stores number temperature sensor (1..32), that switched on relay contact.

The data 7Fh is used for relay control from computer. This bytes are available for write from computer. If computer send 00h, relay is switched off and controller can switch on it. If computer send 7fh, relay is switched off and controller cannot switch on it. If computer send ffh, relay is switched on

59..62 bytes are keeped in reserve.

63 byte stores controller address (1-30).

For an exchange given between controllers of temperatures (they consistently can be connected up to 30 pieces) and the COMPUTER is used the interface RS-485 (RS-232) and special protocol of communication. The transfer is carried out by packages from any number of any bytes. Each package begins in special byte START for which byte of the address of the controller of temperatures follows. The package by the control sum and special byte STOP is finished. The check sum is excluding OR all bytes of a package except for START and STOP, that is XOR of all bytes, including the control sum, should be equal to zero. Care of the bytes conterminous to the allocated bytes START and STOP, one more allocated byte SHIFT serves. Thus, if inside a package there should be a byte BYTE, conterminous with meaning START, STOP or SHIFT, this byte is replaced with a sequence <SHIFT> <BYTE-START>. This replacement after calculation of the control sum is done(made) by transfer. Accordingly at reception SHIFT is thrown out, and to byte, following it, the meaning START increases.

The temperature measurements results are saved to data servers for VEPP-4M and for KEDR data bases. The temperature sensor and controller are presented on Figure 2. The length from control room to the lust controller up to 500 meters. The length from controller to the lust csensor up to 20 meters.

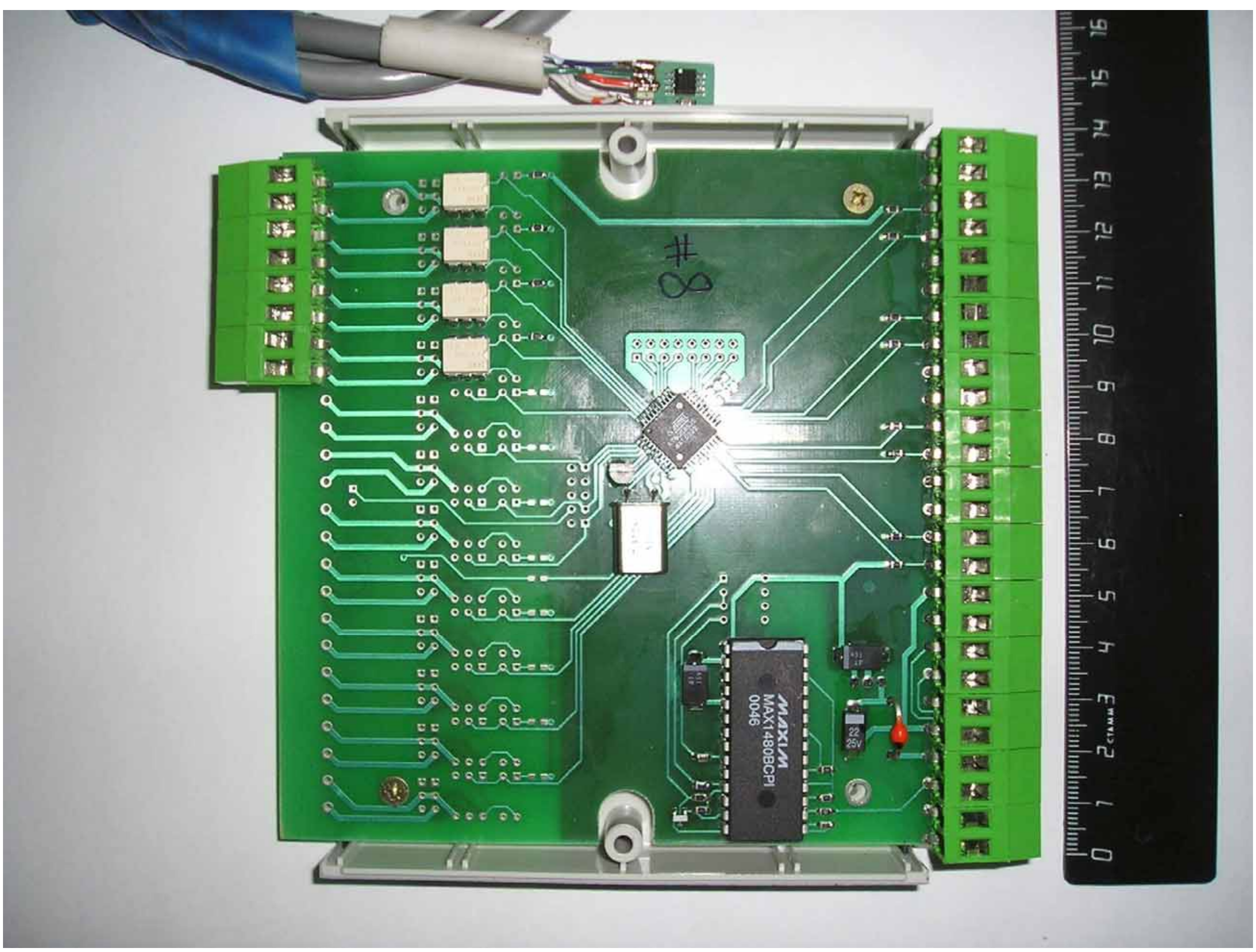

Figure 2: Temperature sensor and controller.

The typical temperature time dependence is presented on Figure 3.

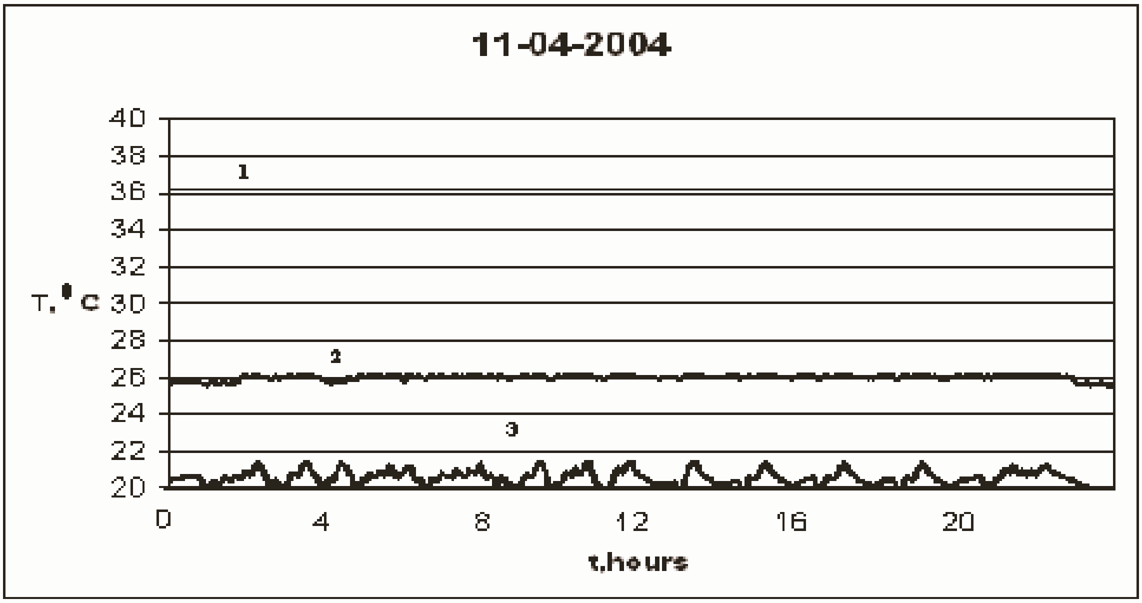

Figure 3: The typical temperature time dependence during the one day.

1- magnet temperature.

2- 3-rd RF cavitie temperature.

3- 4-rd RF cavitie temperature.

REFERENCES

[1] E.Levichev, A.Bogomyagkov, V.Kiselev, O.Meshkov, N.Muchnoi, A.Naumenkov, S.Nikitin, D.Shatilov, E.Simonov, A.Skrinsky, V.Smaliuk, G.Tumaikin . VEPP-4M Operation at Low Energy The 3rd Asian Particle Accelerator conference, Hotel Hyundai, Gyeongju, Korea, March 22-26, 2004. THM-.

[2] A.V. Bogomyagkov, S.E. Karnaev, V.A. Kiselev, B.V. Levichev, E.B. Levichev, A.I. Naumenkov, S.A.Nikitin, I.B. Nikolaev, I.Ya. Protopopov, D.N. Shatilov, E.A. Simonov, G.M. Tumaikin. STUDY OF THE ENERGY STABILITY IN THE VEPP-4M STORAGE RING Proceedings of EPAC 2002, pp.386-388, 2002.