# TEMPERATURE CONTROL SYSTEM OF TWO SECTION ELECTRON LINAC-40

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The temperature control system of the accelerator provides thermal stabilization of the two accelerating sections and the injector. The system consists of 7 temperature-sensitive elements, up to 8 transducers of water flow through the objects being cooled and the detector of the water level in the tank. The microprocessor complex ADAM 5511 and the commercial thyristor controllers are used for analysis of signals from the transducers and for temperature control. Information of the process parameters is displayed on the local control desk, as well as, via the RS-485 port is transferred to the accelerator control room.

*PACS:* 29.17.+w

The LU-40 temperature control system (Fig.1) is made for the stabilization of the accelerated section optimal size. Unlike the previous developments, the described system is able to accumulate data and to carry out the control action using the consistent with personal computer (PC) ADAM5511 controller. The MERA6052 terminal is used for the data representation and for the thermostatic system regime change. There are 7 temperature-sensitive elements, 3 transducers of water flow through the objects being cooled and the detector of the water level in the tank.

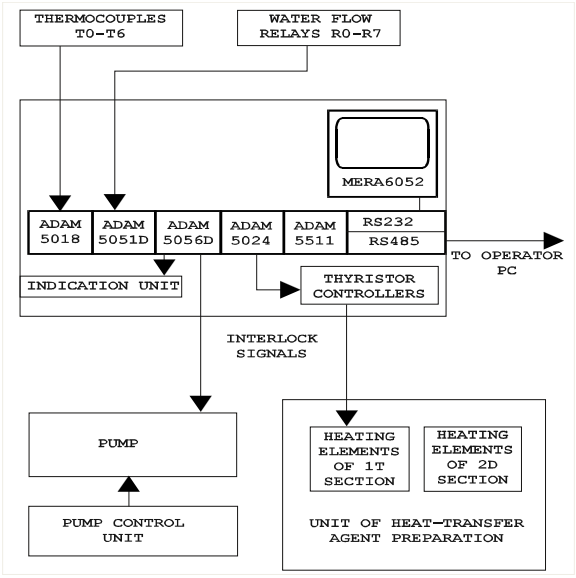


*Fig.1. Thermostatic system functional diagram of the LU-40 accelerator*

The system hydraulic block diagram is presented in Fig.2.

During temperature control the proportional integro-differential (PID) law is used to maintain the optimal sizes of the accelerated sections. This enables to maintain accelerated section temperature accurate to ±0.5 degree when linac operation regime changes stepwise. Under slow disturbance accelerated section temperature is kept accurate to ±0.2 degree. After accelerator is turn on, the operating conditions of the thermostatic system are set within 15 minutes.

The mode conditions of the LU-40 thermostatic system are completely automatic without operator participation and a blocking signal is sent to other accelerator systems if a malfunction occurs. The accelerator operator can change the work regime of the thermostatic system using the local console (the MERA6052 terminal) or the central control board of the accelerator. To do this operator's PC is connected to the RS-485 serial port of the controller. For the information transmission between the thermostatic system and operator's PC MODBUS standard protocol is used.

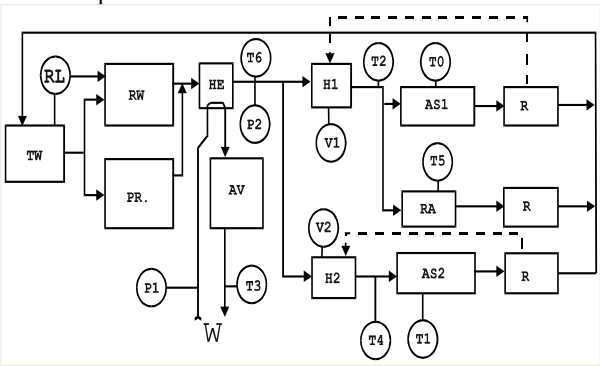


*Fig.2. Thermostatic system hydraulic diagram of the LU-40 accelerator. R – water flow relay; RL – water level relay; P1,P2 – manometers; T0…T6 – thermocouples; AS1,AS2 – accelerating sections; TW – tank with water; W – external cooling water; PW – main pump; RW – stand-by pump; HE – heat exchanger; AV – actuator valve; H1,H2 – heaters; V1,V2 – voltmeters; RA – accelerating resonator*

The system service routine is written in C++ language. It starts to run automatically when electric power is turned on. Then the starting routine checks and performs an initialization of peripherals of the ADAM5511 controller (modules of 5000 series, RS-232 serial port, RS-485 serial port, etc.). If an emergency event is determined, the program execution is suspended if the occurring equipment malfunction can be removed on-line; otherwise it exits. If the check and the initialization are executed successfully, there exists an opportunity to perform the following procedures: analog date reading from the module of 5000 series, discrete date reading from the module of 5000 series, output data forming from the module of 5000 series for the control of the execute analog devices, output data forming from the module of 5000 series for the control of the execute dis-

crete devices, the communication between the controller and MERA6052 terminal or emulator computer terminal through RS-232 port for the thermostatic system control and for operation mode display (by symbol-by-symbol swapping), the communication between the controller and PC or other peripherals for the thermostatic system control and for operation mode display (by network MODBUS protocol).

For PID algorithm realization the following formula [2] is applied:

$$CO = KP*((TP - SP) + (Sn\_O + (1/Ti)*(TP - SP)*Ts) + KD*(TP - PV\_O)/Ts),$$

where *KP* is a proportional factor; *KD* is a derivative factor; *Ti* is a time interval of integration; *TP* is measured temperature; *SP* is a temperature setting; *Ts* is sampling time; *Sn_O* is a integral component value for preceding step; *PV_O* – the temperature value for preceding step.

Below is the code fragment using this formula, it ensures the stable work under changes of input and output signal value.

```
ER=TP-SP;
Sn=Sn_0+ER*Ts* (KP*(1/Ti));
if (Sn > 4095) Sn=4095;
if (Sn < 0) Sn=0;
if (Ts == 0.0) Ts=0.1;
DPV= (TP-PV_0)/Ts;
if (Ti == 0) Ti = 10;
CO=KP*ER + Sn + KP*KD*DPV;
Sn_0=Sn;
PV_0=TP;
if (CO >= 4095) CO=4095;
if (CO <= 0) CO=0;
out5024=CO.
```

There also exists an opportunity to accumulate data of the controlled object temperature change on the operator's PC. An example of the temperature change at the accelerator turning on is shown in Fig.3. The thermostatic system has been operating successfully for more than year.

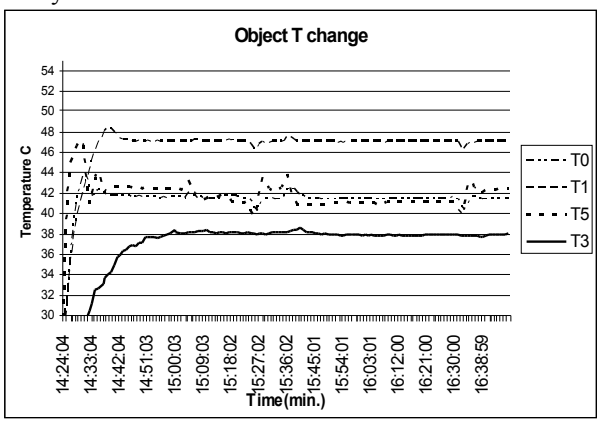


*Fig.3. Temperature change diagram for the accelerating sections (T0,T1), for the accelerating resonator (T5), and for water at heat exchanger exit (T3) during turn on of the LU-40 accelerator*

Authors are grateful to V.A. Kushnir and V.V. Mitrochenko for advice and discussion of the results obtained.

## REFERENCES

1 K.I. Antipov, M.I. Ayzatsky,Yu.I. Akchurin et al. S-Band Electron Linac with Beam Energy of 30… 100 MeV *// Problems of Atomic Science and Technology, Series: Nuclear Physics Investigation.* 2004, №5(46), p.135-138.

2 www.geocities.com/oleg_kaliberda/pid_sim1/pid_sim1R.htm

## СИСТЕМА ТЕРМОСТАТИРОВАНИЯ ДВУХСЕКЦИОННОГО ЛУЭ-40

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Система термостатирования ускорителя ЛУЭ-40, обеспечивает термостабилизацию двух ускоряющих секций и инжектора. В системе термостатирования имеется 7 датчиков измерения температуры, до 8 датчиков протока воды через охлаждаемые объекты и датчик уровня воды в баке. Для анализа сигналов от датчиков и регулирования температуры используется микропроцессорный комплекс АДАМ 5511 и тиристорные регуляторы РОТ-63. Информация о параметрах процессов выдается на местный пульт управления, а также через порт RS-485 в РС оператора ускорителя.

## СИСТЕМА ТЕРМОСТАТУВАННЯ ДВОХСЕКЦІЙНОГО ЛПЕ-40

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Система термостатування прискорювача ЛПЕ-40, забезпечує термостабілізацію двох прискорюючих секцій та інжектора. У системі термостатування є 7 датчиків вимірювання температури, до 8 датчиків протоку води крізь охолоджувані об'єкти та датчик рівня води у баці. Для аналізу сигналів від датчиків та регулювання температури використовується мікропроцесорний комплекс АДАМ 5511 та тиристорні регулятори РОТ-63. Інформація о параметрах процесів видається на локальний пульт управління, а також через порт RS-485 у РС оператора прискорювача.