CONTROL SYSTEM BY THE TECHNOLOGICAL ELECTRON LINAC KUT-20

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The high-power technological electron linac KUT-20 was developed at the Science Research Complex “Accelerator” of NSC KIPT. The linac consists of two 1.2 m length accelerating structures with a variable geometry and an injector. The latter comprises a diode electron gun, a klystron type buncher and an accelerating cavity. With a RF supply power at accelerating structure entries of 11 MW and with a current at the accelerator exit of 1 A, the beam energy will be up to 20 MeV. An average beam power is planned to be 20 kW [1].

All systems of the accelerator are controlled by a computerised control system. The program & technical complex consist of PC equipped with fast ADC, control console, synchronization unit, microprocessor-operated complexes.

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1 AUTOMATIC CONTROL SYSTEM

A special system has been developed for linac control [3, 5]. It controls the electron beam current, the energy and the position, defends accelerating and scanning systems from damage caused by the beam; blocks the modulator and the klystron amplifier in the case of intolerable operation modes; regulates the phase and power of HF signals in the injecting system and also regulates the source power currents in the magnetic system. Also the radiation dose of technological samples is controlled and the target devices are operated. The program & technical complex consists of PC equipped with two fast channels ADC (Fig. 1), synchronization unit (S), microprocessor-operated complexes (MC) to monitor the klystron amplifier operation, the thermostating system (t°C), magnet power supplies (MPS), the target equipment (TE).

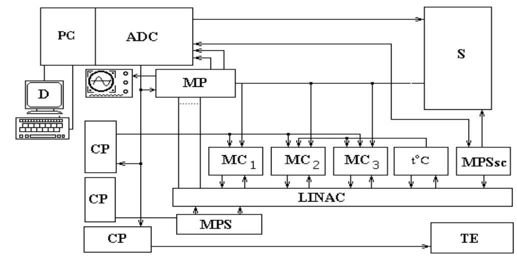

Fig. 1. Functional schematic diagram of the KUT-20 linac control system.

The specially developed supple source (MFSsc) with digital control [2] shapes the excitation current of the scanator-magnet at KUT-20 exit. The multiplexer (MP) and the analog-to-digital converters (ADC) with 8 digits receive the signal from the analog pulse sensors with the 50 or 100 nsec discreteness by 2 (from 32) switching channels simultaneously. The information of the linac system state and the beam parameters are shown on the local unit terminals (CP) and on the color graphics display (D) in the form of the triple-screen control panel (Fig. 2). The operator can monitor the linac work from the PC keyboard and from the local control panels. The program units can provide the momentary or repeated control of system parameters or give operating commands. Simultaneously the parameters of several systems can be controlled and only one of them regulated.

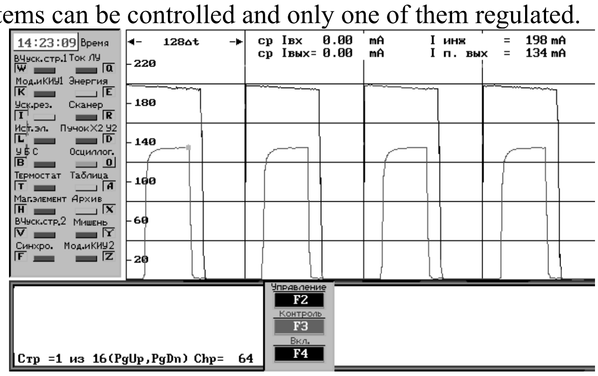

Fig. 2. Videogram of the calibration process of the magneto-induction beam current transducer on the linac KUT-20.

2 OPERATIVE CONTROL OF CURRENT, POSITION AND ENERGY OF THE ELECTRON BEAM

The linac is equipped with magnetoinductance transducers established at an input and an output of accelerating structures for measurement of the value and the form of the beam pulse current [7, 8]. The signals from transducers are used in the control system for a rating amplitude and average current value (Fig. 2). The calibration of sensors is carried out periodically with the test pulse trains from a special current generator [9].

The linac exit also is equipped with four winding position sensors [11]. These sensors admit the center beam position measurement with a 0.5 mm error.

The wide-aperture (50 x 200mm) one-coordinate magneto-induction position transducer [6] and beam profile monitor [12] are used for the energy and position control of the sweeped electron beam at the linac exit. One of the program modules provides simultaneous measurement of the value of the scanning magnet excitation current and the signal from the sensor winding (Fig. 3).

It is shown in [4, 6] that the scanning electromagnet equipped with a beam position sensor can be used for the on-line control of the electron energy (*E*). With an inductive transduser or profile monitor the beam center deviation from the axis *(R)* is evaluated, the amplitude of the electromagnet excitation current (*I)* is determined at the same time, and then the value *E=f (I, R)* [4] is calculated with an error of about 5%.

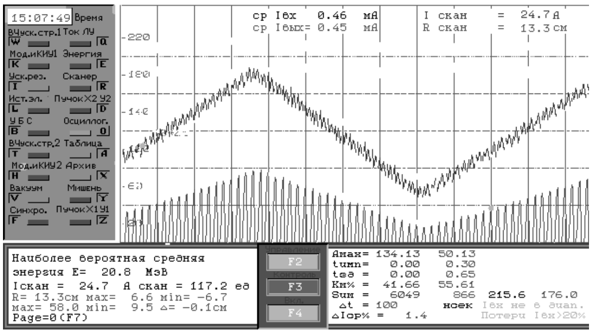

Fig. 3. Videogram of testing the electromagnet excitation current of the scanator-magnet on the linac KUT-20.

3 SYNCHRONIZING SYSTEMS

A synchronizing system of the technological accelerator complex KYT-20 forms the frequency scale of the pedestal pulses $f_0 = 600/n$, where *n=1, 2, 3, 4, 6, 12, 24 (25 – 600 Hz)*. The operation startup frequency of EGM and KPA modulator are f_0. A lower operation frequency of EGM may be equal *6.25, 3.125 or 1.562 Hz*. The synchronizer has *10* channels. The pulse amplitude is no more than 15 V, the pulse width is $2.5 \pm 0.5 \mu s$, the delay range is from 0 *to* $10\ \mu s$ with the step $0.1\ \mu s$. When alarm signals "Beam switching off" from the accelerator systems are received the electron beam turns off with the additional delay of EGM startup pulses on $11 \mu s$. Pulses with a frequency of f_0 are synchronous with the frequency of supply line (50 ±0.5 *Hz*) and can be fixed in phase from 0 to 990 μs.

4 TERMOSTABILIZATION SYSTEM

A thermostabilization system of the accelerator KUT ensures the termostabilization of two accelerating structures, injector and an accelerating cavity. The thermostabilization system consists of 19 detectors for temperature measurement, 23 detectors in the water-cooling system, 6 water pressure detectors, 2 water discharge detectors and 1 water level detector. The 60-channel measuring transformer analyzes the detector signals and for the temperature stabilization regulative programmable microprocessor devices are used.

The information from the tested devices through the RS-232 interface is transmitted to the control PC; the lock signals by 10 channels come in the alarm system.

5 ALARM SYSTEM

An alarm system tests more than 60 discrete state signals of the accelerator systems. It allows turning on the high supply voltage for the injector and two modulators. The local control is conducted from the klystron room and the remote control from the local control panel. The information about the system is represented on the local control panel [13] and is transmitted to the microprocessor complex [11].

6 TARGET DEVICE OPERATION

Special target devices will be set up in the accelerator bunker for transfer of irradiated samples. There are manual and automatic modes of its operation. The technological file is created for each sample; target position number and corresponding exposure doze are written there. The microprocessor complex changes the irradiated sample position with an electromotor if a PC command passes. When the sample gets the required doze the operator is informed about it.

REFERENCES

1. K.I.Antipov, M.I.Ayzatsky, I.Yu.Akchurin et al. High-Power Electron Linac for Irradiation Applications // *Proc. PAC'01*, Chicago, 2001.
2. A.N.Dovbnya et al. The Output Beam Scanning and Forming in the Multipurpose Electron Accelerators of KIPT // *Problems of Atomic Science and Technology. Issue: Nuclear-Physics Research* (28). 1997, v. 1, p. 114-121 (in Russian).
3. V.N.Boriskin et al. Control System for a Linear Resonance Accelerator of Intense Electron Beams // *Nucl. Instr. and Meth. in Phys. Res*. 1994, A 352, p. 61-62.
4. V.N.Boriskin, A.E.Tolstoy, V.L.Uvarov et al. Automatic Control of the Electron Energy in the Technological Linear Electron Accelerators // *Proc. of the XIV Meeting on the Accelerated Particles*, Protvino, Russia, 1994, v. 2, p. 97-98.
5. V.Boriskin. Control System for Technological Linacs // *Proc.EPAC98*, Stockholm, 1998.
6. V.N.Boriskin, A.N.Savchenko, V.I.Tatanov. Monitoring of the Electron Beam Position in Industrial Linacs // *Proc. PAC'99*, NY, 1999.
7. V.N.Boriskin, V.A.Vishnyakov, V.A.Gurin et al. Measuring system of beam parameters at LUE-2000 // *Proc. of the XI Meeting on the Acceleratores*, Dubna, Russia, 1989, v. 1, p. 61-63.
8. Yu.V.Avdeev, V.N.Boriskin, et al. *Metrological Research of Measurement Facility Parameters of Electron Radiation LU-10 u LU-40 KIPT*. Pre-print KIPT 91-6, Kharkov, 1991.
9. V.L.Uvarov et al. A Beam Monitoring & Calibration System for High-Power Electron Linacs // *Bulletin of the American Physical Society*, May 1997, v. 42, No. 3, p. 1367.
10. V.N.Boriskin, V.A.Gurin, L.V.Reprintsev et al. Channel of the Control of the Beam Position in the High-Current LEA // *Proc. of the XV Meeting on the Accelerated Particles*, Dubna, Russia, 1996.
11. Yu.I.Akchurin et al. Linac failure diagnostic // *Problems of Atomic Science and Technology. Issue: Nuclear-Physics Research* (35). 1999, v. 4, p. 40-41.
12. V.N.Boriskin, V.A.Gurin, V.A.Popenko, et al. Monitoring Channel of the Technological Linac Beam Cross-Section // *Problems of Atomic Science and Technology. Issue: Nuclear-Physics Research* (39). 2001, v. 5, p. 147-149.
13. Yu.I.Akchurin. Experience of centralization of LUE 2 GeV operating // *Problems of Atomic Science and Technology. Issue: Automation of Physi-*

cal Experiment. 1973, p. 30. (in Russian).