DEVELOPMENT OF TECHNOLOGICAL LINAC CONTROL SYSTEM WITH USE OF LPT PORT*

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Abstract

A possibility is demonstrated for a simple extension of a P?-aided control system through the use of a printer LPT port. Its standard is supported by all IBM-compatible computers and does not require any creation of an additional interface. With the use of digital and analog element base with a serial data transfer this channel provides the data rate up to 120 kbauds, this being sufficient for the control systems of moderate setups (e.g., technological accelerators). At the same time, the transition to the bidirectional bus in the current LPT standard provides a one more order-of-magnitude increase in the rate of exchange. The proposed approach has been used in the development of subsystems for formation of the technological-accelerator radiation field and its monitoring. The subsystem drivers are written in the high-level Turbo-Pascal language; this simplifies the program preparation and maintains a high performance of the accelerator control system.

1 INTRODUCTION

To control one- and two-section electron linacs used in technological processes (sterilization, modification of materials, isotope production, activation analysis, etc.), it is sufficient to have a two-level PC-controlled system (e.g., see ref. [1]). At the same time, should the need arise to extend the number of control channels or to create additional subsystems, there arises the problem associated with a restricted number of connection lines built into the PC. The solution of this problem by applying the known standards (IEEE-488, CAMAC, et al.) appears somewhat costly and not always justified.

As an alternative variant of a simple extension of the technological-linac control system, we propose here to use a printer port (LPT). Its standard is supported by all IBM-compatible computers and requires no additional interfaces. To exemplify practical realization of this approach, we describe here the LPT port-based subsystems of metrological support of radiation processes with the use of electron and braking radiation.

2 SPECIAL FEATURES OF EXTENDING THE CONTROL SYSTEM THROUGH THE USE OF LPT

As it is known, the printer port in a computer is presented in the form of three registers, the signals from which go to the LPT port plug (Fig. 1). In this case, 12 lines are involved to transfer the data and to control the printer, and 5 lines are devised for data transfer to the computer. All output signals are generated by the software, all input signals arrive in the real-time mode (are not gated). This quantity of lines is sufficient for controlling a simple measuring system and for receiving information from it.

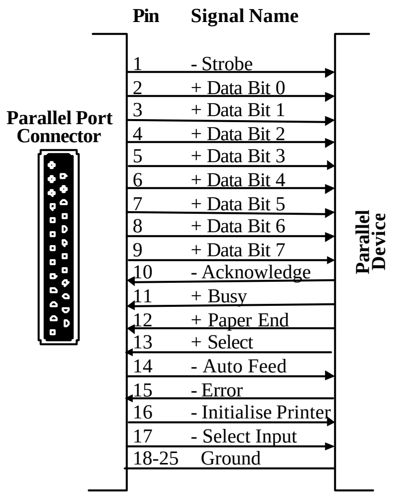

Fig. 1 Diagrammatic sketch of the LPT port

By way of example, we can mention here the logic of LPT compatibility with the linear commutator and a sequential-type analog-digital converter (ADC). So, the logic of operation with the ADC is as follows. By the ALF signal (pin 14), the ADC is activated. In this case, the state of the SELECT signal (pin 13) is analyzed. The appearance of “1” at the output means that the “analog-digit” conversion is completed. The data are read out via the P. OUT line (pin 12), and their gating is realized with the STROBE line (pin 1).

After the data are read out, the cycle is repeated. The data record into the spool register of the linear commutator is performed via the lines D0, D1and D2 (pins 2, 3, 4), and the data gating is done with the SELECT INPUT line (pin 17).

3 THE USE OF LPT IN THE CALIBRATION SUBSYSTEM OF ELECTRON RADIATION CONTROL CHANNELS

The technological processes carried out with the electron accelerator periodically call for calibration of its control system (e.g., see ref. [2]) in the principal parameters of radiation such as the average beam current and its power, the average electron energy. To perform this calibration, a working standard was elaborated on the basis of the combined charge-calorimetric sensor (CCS), ref. [3]. This standard can easily be integrated via the LPT

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port into the accelerator control system as its subsystem.

The standard presents the measuring channel (see Fig. 2), where the CCS provides the basis for two measuring circuits: for absorbed charge and the electron radiation energy.

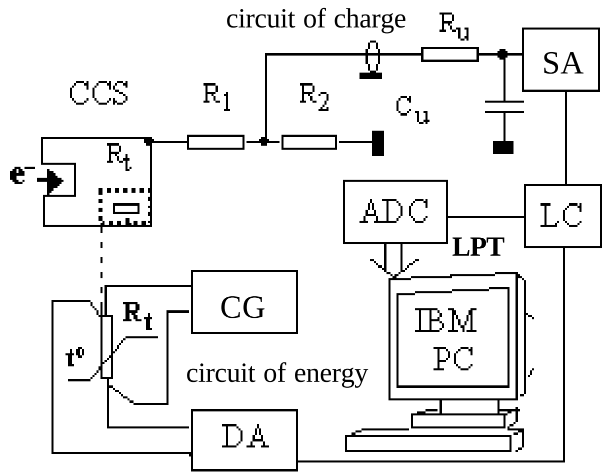

Fig. 2: Diagram of the measuring channel based on the CCS

The charge measuring circuit includes a precision ohmic divider R1, R2 arranged directly on the CCS. The signal from the divider is supplied via a coaxial cable to the passive integrator R_i, C_i with a time constant of ~20 s. The integrated signal is fed to the spool amplifier SA providing the match between a high output resistance of the integrator and a low (~1 k?) of the input resistance of the ADC. The integrator and the SA are designed as an individual hermetically sealed unit enclosed in a constant-temperature vessel. The transfer coefficient of the BA is ~1. The capacity of the ADC is 12 bits, the conversion frequency (including the reception by the computer) is about 10 kHz.

The energy measuring circuit comprises a thermistor R_t as a primary sensor. It is built into the CCS and is in thermal contact with the latter. The thermistor is connected to the measuring circuit by a four-line scheme. This provides a significant reduction in errors occurring due to the influence of leads and electromagnetic noise.

The current generator (CG) feeds a 50 ?A current to the thermistor at a stability no worse than 10^{-5}. Such a small value permits one to neglect the variations in thermoresistance associated with this current. The thus generated voltage across the thermistor is supplied to the direct-current differential amplifier DA and to the ADC. The DA is set up by the scheme providing a small intrinsic temperature drift (< 1?V/C$^?$). Its amplification coefficient is found to be ~10^3, the input resistance being 100 k? .

The system is made using the Analog Devices components. A twelve-bit bipolar AD 7895 was chosen as an ADC. The overall dimensions of the electronic unit are 250x200x80 mm^3, the weight is less than 0.5 kg.

The device is operated with the following algorithm. With the beam being off, the system measures the initial temperature of the CCS absorber and the noise signal level in the temperature and charge circuits. Then, by the computer signal, the linac beam is turned on for the given exposure time. In this case, both the charge and temperature are being measured. After the exposure is over, the system switches off the beam and measures the exact exposure time by the computer timer. Then the temperature variations in the sensitive volume (beam absorber) of the CCS are determined. The measurements are terminated after the maximum in the temperature dependence is reached. All the measured data (time dependences) are saved in the symbolic form in the corresponding files. In the course of measurements the temperature dependence of the CCS is put out as a plot in the real-time mode. The result of the system operation lies in the determination of charge and average beam energy absorbed by the CCS during the exposure. Based on these data, the average electron energy and the average beam current are determined. The data obtained are communicated to the upper level of the control system of the linac for calibration of technological measuring channels.

4 LPT INTERFACE IN THE BRAKING RADIATION CONTROL SUBSYSTEM

A subsystem of continuous monitoring of braking radiation on the target with the use of a thin-walled ionization chamber as a sensor can serve as another example of the subsystem that can be easily integrated into the control system of the accelerator by means of the LPT interface. This measuring channel is required in a number of applied programs such as activation analysis, isotope production, radiation tests of materials, etc. (e.g., see refs. [4, 5]).

Figure 3 shows a variant of the target device combined with the ionization chamber for simulating irradiation of material specimens in the braking radiation field of a high-current electron linac. It is used to investigate the behavior and to select materials used in the radioactive waste disposal at strong radiation field conditions.

The device has a form of parallelepiped and consists of three chambers (Fig. 3).

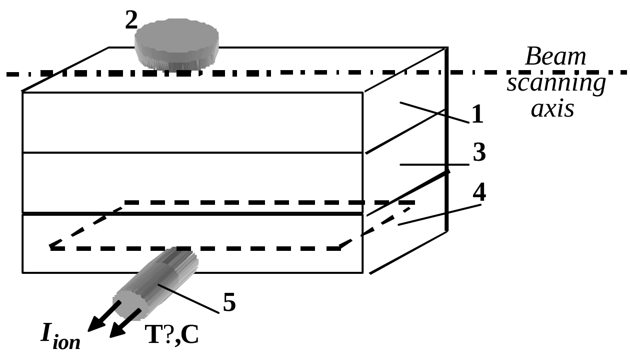

Fig. 3: Structure of target device for radiation tests of specimens

The upper hermetically sealed chamber 1 is intended for accommodating the specimens irradiated in a liquid (specimens are charged through neck 2), while the central chamber 3 houses the specimens irradiated in air. Volume 4 accommodates a free-air ionization chamber (IC-1) for continuous monitoring of the photon flux passing through the specimens. The IC-1 power supply channel as well as signal cables are installed in a ceramic insulator through pipe 5.

The measuring channel (Fig. 4) developed for the target unit is devised for monitoring (real-time conditions) the photon radiation absorbed dose in the specimens, and also their temperature in the process of computer-controlled radiation tests.

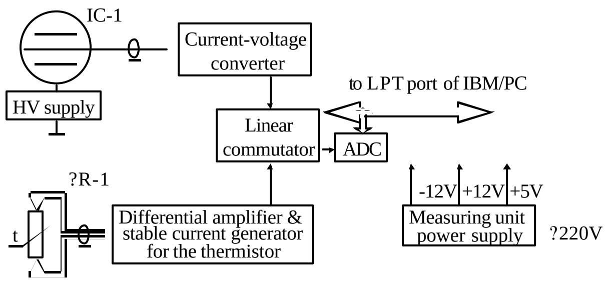

Fig. 4: Subsystem to control specimen irradiation conditions

The IC-1 is used as a primary probe in the circuit for measuring the photon radiation parameters, and a copper thermoresistor TR-1 is used to measure the specimen temperature.

The ionization chamber is power supplied from a high-voltage source (U ~300 V, instability less than 0.1%).

The signal from the ionization chamber arrives at the input of the current-voltage converter (CVC). At the CVC output, the voltage is generated with the amplitude proportional to the input current. The conversion coefficient of the CVC is equal to 500 nA/V. The integration time constant is about 10 s. This provides both the suppression of a high-frequency noise and the effect of electron beam scanning over the surface of the bremsstrahlung converter. Then the signal goes via the linear commutator to the input of the ADC.

The temperature channel is made by the same scheme as that used for the CCS, and it has similar characteristics.

The information coming from the target device comes to the computer, where it is processed and is displayed as a plot in the real-time mode. The operator can see the temperature of the specimen and the dose rate of photon radiation. The separate window shows the value of dose absorbed by the specimen for the whole time of irradiation. In the case when the absorbed dose has reached the assigned value, the computer sounds a signal and the process of irradiation ceases.

All the information obtained during irradiation is spooled and can be used in further processing.

5 CONCLUSIONS

The use of LPT port provides the possibility of extending easily the control system without involving additional interface devices.

The application of a series ADC of AD7895 type provides the data reception at a rate of 120 kbauds, this being sufficient for systems with low and moderate information flows (e.g., control systems of technological linacs). It should be also noted that the present-day printer port standard implies the use of a two-directional data bus. This, in its turn, makes it possible to use parallel ADC and to increase the rate of exchange by nearly an order of magnitude.

Writing the processing and system control programs in the high-level Turbo-Pascal language makes the development of the control system much easier without loosing of high performance.

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