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BEAM EXTRACTION CONTROL SYSTEMS OF THE FAST-CYCLING SYNCHROTRON

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Abstract

A compact system controlling the extraction of different beams (gamma, electron, synchrotron radiation) in single and simultaneous operation modes at high electromagnetic disturbances level based on using one computer of IBM PC/AT type is described.

Introduction

Physical research program at the Yerevan synchrotron pursues the realization of the experiments generally with the use of the slow extraction of primary and secondary beams in single and simultaneous operation modes at 4.5 GeV energy with the 4-8 μs magnetic field top. The most complicated process of the extraction, requiring the precision tuning of the beam extraction devices and not having analog in the world is the mode of simultaneous beam guidance to the two internal targets, one of which is a thin crystal, the other one is of thick tungsten and is put in the neighbouring focusing interval of the synchrotron. At the same time it is necessary to provide a significant decrease of the beam pass factor through the thin target by screening from the particles, once passed through it by means of the thin target [1].

Due to the developed and described below the control system of the synchrotron extraction devices it was managed to increase the ratio of the pick of coherent bremsstrahlung radiation from the thin crystal target to the amorphous part almost 2.5-3 times with keeping unchanged the common requirements to the extracted beam parameters, that is to say to the stable uniformity and duration of the extraction, effectiveness of the extraction and so on.

Secondary beam extraction of the Yerevan synchrotron is based on the local disturbance of the orbit with using the additional electromagnetic coils of the guiding magnetic field. At the beam guidance simultaneously onto two internal targets there is also used a system of changing the betatron oscillation frequencies of the circulating particles with the help of the lenses set on the orbit. To realize the slow extraction of the primary beams to the vicinity of the nonlinear resonance of the third order the conventional system of magnetic elements (quadrupole and sextupole lenses, septum and bending magnets) is used. Magnetic elements and additional coils of the electromagnet are supplied by the current pulses of the complicated shape, produced by the resonance forming lines with the use of the thyristor switches. The tuning of the form and amplitude of the current pulses is realized by means of the face control of thyristor switches with the use of the synchronizing pulses from the synchrotron timer device. The control of the current pulse form and the intensity changes during the beam extraction is carried out by many pickups.

1. Architecture and the control system construction principles

The first control system of the synchrotron extraction device was based on the control computers EC1010 and EC1011 (Videoton firm, Hungary) [2]. But the lack of reliability in their work and the relatively expensive maintenance showed the necessity of replacing them by the modern computers. The computer PC/AT was chosen for that. It determined the architecture of the control system from the one hand and from the other the requirements of reliability and flexibility at high level of the electromagnetic noises were satisfied by having an intensive information flow, a large number of the control parameters and so on. That's why a mixed 3-level architecture of

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the computing systems was chosen (fig.1).

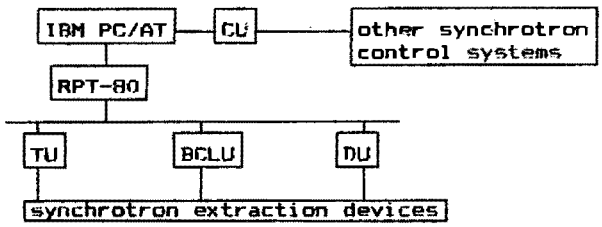

Fig. 1

A set of specialized microprocessor modules of KP580BM80 type, allowing to solve the following tasks was developed for operation at the low level:

- continuous measuring, tolerance parameters control and formation of the actions for controlling accelerator extraction devices;
- buffering, preliminary processing, information conversion and transmission to the computer of the higher level;
- synchronization of measurement and control processes with the synchrotron cycles.

The wish to minimize and get less expensive apparatours from the one hand and to achieve the sufficient universality of its functional possibilities from the other - was the main reason of the development of these modules and of not using the nucleus electronics apparatours.

The microcomputer RPT-80 (Hungary) used on the middle level with the processor of INTEL 8080 type runs system terminal functions in the separate control subsystems at its off line work and as a peripheral processor at the controlling through the higher level. In the first case it solves the user tasks providing a standard interface to all the modules of the low level and in the second one it solves the same problems as well as the other ones but under the control of the computer higher level.

At the higher level a personal computer IBM PC/AT is used, the main functions of which are the following:

- creation and maintenance of the parameter data base of the main operation modes of the beam extraction devices;
- realization o the local control algorithms with the feedback;
- statistic processing of measurement results at the normal system operation;
- information exchange with the other synchrotron control system.

For information exchange with the other synchrotron control systems, specially with rf systems, electromagnet supply system and others, the second serial port of IBM PC/AT is used, as well as a non-standard communication unit (CU).

1.1. Timer Unit (TU)

The timer unit is developed on the base of the microprocessors and is used for synchronization of all the extraction devices and equipment of physics-experimenters with the synchrotron acceleration cycles and carries out the following functions:

- control of the synchronization main pulse and its selection on the false signals background measurement and tolerance control of frequency; in case of mode violation of the main pulse forming timer unit automatically switches off the controlling of the extracted beam channels for elimination of the break-downs in the thyristor devices;
- program distribution of the synchronization main pulse in the devices of different extraction beam lines depending on the operator given sequence;
- time pulse delay formation in the given devices for running the phase control.

Main technical features

- pulse distribution channels number - 8;
- the range of the programmed pulse time delay is within 0.5 μs - 32 μs;
- pulse distribution periodicity in the beam lines is arbitrary - up to 256 cycles.

1.2. Beam lines control units (BLCU)

Eight units of the beam control lines are based on the unified microprocessors for control all the parameters of the magnet extraction devices and have the following functions:

- measuring with the help of the different ADC - the current control pulse in the magnets and beam intensity signal from the

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scintillator pickup and realization of their tolerance control (the number of sampling points at analog signals measurements is up to 256, sampling step is 50 μs, measurement accuracy is 12 digits);
- the phase control of the amplitude and shape of the control current in the magnets by means of the 6 control time intervals for each forming current pulse;
- measuring and tolerance control of time intervals between synchronization and controlling pulses (up to 16 time intervals);
- information exchange with the higher level computer.

1.3. Diagnostics unit of the relay signals (DU)

This unit realizes registration, control, diagnostics of the state signals of the "switch on - switch off" type (number of channels -64, block time response to the state change - not more than 100 μs).

1.4. Software

The low level microprocessor units software is based on the program-monitor, realizing the main cycle of unit operation and organizing communications with the subprograms as well as on the asynchronous lines, drivers including subroutines of the data exchange, control words receive determining equipment operation mode and status-words transmission programs of the corresponding unit.

Middle level software [3] realized in RPT-80 consists of command monitor, global control table and command table, input-output dispatcher of the driver external devices, manager of the asynchronous communication lines and the interrupt handlers.

Command monitor realizes the direct interaction with the operator through menu, which gives the list of all available tasks and the ways of access to them. Monitor also supports the global control table and the command table.

The information of the external device operation mode, the interrupt bytes and also the pointer to system area, which is given to each external device, are kept in the control table. Command table contains the addresses of the functional tasks.

The input-output dispatcher is created for a common access to different external devices.

Manager of asynchronous communication lines gives an alternative command input source which realizes the information exchange between the computers.

The described software is written in the assembly language in the CP/M OS environment and occupies 2 kB of ROM.

Conclusions

The created system realizes the following possibilities:
- continuous control of the extraction devices state;
- measuring and display of the current values of all the measured parameters in the digital and graphical form;
- monitoring the extraction beam quality and fault diagnostics;
- manual and automized control of the extraction devices through the computer while tuning the extraction modes and stabilization of their parameters.

More than one year operation of the system proved the reliability of its work and the convenient maintenance.

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