Control System of the Synchrotron Radiation Source SIBERIA-2.

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SIBERIA-2 is synchrotron radiation source at electron beam energy 2.5 GeV. The SIBERIA control system can be classed into three levels-- console, networking and data acquisition. This paper describes control hardware for magnet, RF and injection system; timing system; temperature and vacuum monitoring system; basic software. Control hardware consists of 36 CAMAC crates. The special software for automatic processes--beam accumulating, energy ramping were developed. Control systems are used in commissioning of accelerator complex.

1. INTRODUCTION

The control system is separated by 3 level schematically. The PC-network is presented upper-level for usage in the control rooms. The consoles are IBM PC 486 computers. 4 main control room computers are equipped with 19" color monitors and 8 Mbytes RAM. PCs run "MS-Windows for WorkGroups 3.11". Network Dynamic Data Exchange (NetDDE) between any tasks in several computers may be used. The single PC makes available the interconnection between the console network and the second level real-time control.

24-bit CAMAC-oriented computers use in the second real-time level of the control system [2]. At this level we have 8 computers in service. Each computer controls the specific part of accelerator complex (injection, main ring) or specific system (vacuum, beam diagnostic, termomonitoring, etc.). Switching center computer is equipped with 50 Mb HDD and provides communications to console network. Diskless peripheral computers connect to center by serial data links with 1 Mbit/sec physical rate. Real time computers are equipped with CAMAC system modules set: RS232 interface for local terminals, RAM, network interface, graphic adapter, peripheral crates driver. These run real-time multitasking "ODOS" operating system [3].

The I/O data acquisition and controlling CAMAC hardware is presented the low level of the control system. The peripheral crates are placed near the power supplies, RF, vacuum equipment and connected to control computers by serial data links. The distance between crates is 50-100 m. The coaxial cables used for convenience 1 Mbit/sec transmission rate. Total number of CAMAC crates is 36.

2.HARDWARE SOLUTIONS

2.1. General description

All CAMAC equipment for control system is designed and manufactured in the Budker INP (Novosibirsk). Control 24 bit computer is intellectual CAMAC crate controller. Architecture is suitable for width of CAMAC data bus and number of peripheral modules in crate. The LAM manager and instruction for single/vector CAMAC exchanges are realized in firmware. Computer is equipped internal 64 kW RAM and used the CAMAC-bus in the capacity of I/O bus. The effective dedicated system software is designed in the Budker INP for real-time CAMAC applications. This computer allows to employ very simplify peripheral crate controllers and CPU-less CAMAC modules. The total number of CAMAC modules is more than 350.The set of modules includes the standard complex of ADC, DAC, input-output registers, timing generators.

2.2. Timing, synchronization and RF control

The synchronization system supports interprocess communications, automatic operations of accelerator; - and timing control for the slow pulsed elements and fast devices such as kickers and inflectors. In most cases we applied digital delay 8 channel 16 bit CAMAC module with programmable resolution 100 nsec - 12.8 microsec (maximum delay 6.5 msec- 828 msec). Main clocks for injection and acceleration processes are generated by slow digital timers with 20 msec resolution..

The special part is the synchronization between RF of main ring, RF of booster and fast inflectors in the injection process in main ring. The multi channel CAMAC programmable timing generators with the 0.4 ns resolution and 5.12 microsec maximum delay are used. The special programmable modules used for frequency matching and selection the number of bunch. Operator can select the number of bunch and control the phase of injection. The fast synchronization system allows to measure the time delay with 0.6 ns accuracy. The RF control includes 16 DAC channels for cavity voltage control, fider current setting and revolution frequency control

2.3. Power supplies control and measurement

Few types of power supplies are used for magnet elements: 1 (I max =7200 A) for bending magnets of main ring; 6 (Imax = 1000 A) for quadrupole lenses of main ring; 8 (Imax = 25 A) for sextupole, octupole lenses of main ring ; 168 (Imax = 5 A) for all correctors of main ring. Different DAC and ADC modules are employed, corresponding with the requirements of setting accuracy and stability. 20 bit DACs are used for main ring bending and quadrupole, these have the external synchronization input for ramping process realization. The integrated ADC with programmable resolution/conversion time is used for measurement main parameters of power supplies. This ADC has 1 input and controls the analog CAMAC mix for connection up to 256 channels. The most commonly used mode is the measurement of selected channels and stored these into onboard ADC RAM, than information block can be reading by control computer. We employ the 14 bit/ 5 msec mode for correctors' power supplies measurement and connected to one ADC up to 128 channels (2 cabinets) and 16 bit/ 20 msec mode for high accuracy power supplies - up to 32 channels. Thus we can update information every 1 sec cycle. The 20 bit / 320 msec mode with stored up to 1024 samples may be applied for detailed investigation of selected power supply.

2.4. Temperature and vacuum monitoring

The building principles of monitoring systems are identical. Main functions are:

- all channel data acceptation with 1-5 sec working cycle;
- data handling - comparison with preventive and alarm levels, stored status and value information;
- control alarm devices and interlocks (adding to direct hardware control);
- graphic presentation- general status, history of selected channels.

The control computer supplies the feedback function of control except the termomonitoring system. This is based on intellectual ADC module, contained CPU, program ROM, RAM with warning limits. Module has 4 relay output for interlock communications. The interlocks used for power supplies alarm control.

2.5. Beam diagnostics

The DCCTs are used for beam current measurement in main ring. Signals after analog processing are accepted by integrated ADC, current history plotted at the color graphic monitor. The lifetime constant automatically displayed from the slope of decay. The set of 12 moveable scintillation probes is used for first turn diagnostic. Position of each probe is measurement using ADC with accuracy 0.2 mm. 24 horizontal and 24 vertical BPM are equipped in main ring. CAMAC set includes timer, integrated ADC and amplifier/filter dedicated modules. The 4 pickups and 4 fast ADC (internal RAM 1Kb, 8 bit, 1 sample /turn = 400 nsec) applied in the data handling system for diagnostic first 1000 turns. This system allows to optimize injection to main ring.

3. SOFTWARE

The applied software for control system includes the man-machine interface, intertask communications system, control of facility systems, beam diagnostics' programs. This software allows to achieve the working mode for booster and to start main ring operations.

Information about logical channel is stored in data-base, it includes : 1) logical channel name, dimension of value, limit of value, value-code factor; 2) name, address of corresponding CAMAC module, number of its channel, address of CAMAC crate; 3) comment for man-machine interface.

Applied software structure for control system of injection complex is shown in Fig1.

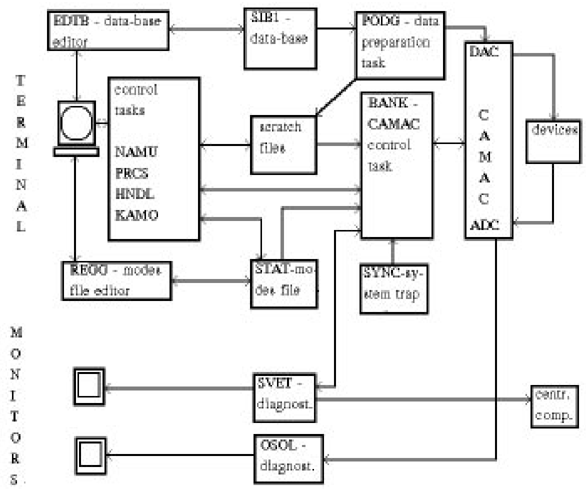

Fig. 1. Software structure for SIBERIA control.

Logical channels associated to same system integrate into logical elements and systems. There are following logical systems : linac, booster, beam transport line to main ring, pulsed system, magnet system. Their contents can intersect. The same data-base has a list of CAMAC crates and associated modules.

The data preparation program (named PODG) starts control system work cycle. It checks capability of channels, described in data-base, starts CAMAC modules, opens the scratch files. Than start a control program BANK, which executes command for CAMAC control.. This program receives a synchronous system trap generated by program SYNC with period 100 msec for injection facility and 300 msec for main ring. A code generated by control program is written in DAC with this period. The writing time for one channel is equal to 0.5 msec. The number of DAC-channels is equal 125 for injection facility and 250 for main ring respectively. Tact period is chosen so that BANK can write all DAC-channels in a time of period and some time remains for other programs. In each moment the program BANK executes only one inquires for control. Hence, when the program executes a long inquire, it does not control logical channels are absent in inquire. When the program of control receives a command to write a new code for a few channels in a few steps, BANK does a linear interpolation for each channel between current and wanted values, then writes all channels synchronous step by step. This process has the highest priority because non uniformity of the execution rules a beam loss (for example in acceleration). If the program BANK does not write by steps, it reads channels of measurements of all ADC at each 10-th tact.

Main control program NAMU forms a command, transmitted to BANK task for execution. There are following functions of program NAMU : controlling one or a group of channels; saving a present mode of CAMAC-modules in machine file named STAT and reading and listing of machine file; working with buffer. A user changes a wanted logical channel in the element and writes required value both a dimensional form and a shift of current value form or percentage. The setting value transforms to code, transmitted to BANK program for execution.. Inside logical element one can change a few channels simultaneously with any mutual coefficient. At each second the NAMU program updates values measured by ADC.

Program PRCS controls real-time process of changing of facility mode (for example beam accelerating). This program includes following functions : setting time expectation; external trap excitation and checking; setting the facility mode in desired number of steps. PRCS task gives a command to BANK program for execution. Now there are the following working cycle of accelerator facility: 1) injection in SIBERIA-1 and beam storing, 2) acceleration to 140 MeV in 50 steps, 3) acceleration to 240 MeV in 100 steps, 4) acceleration to 350 MeV in 100 steps, 5) beam transmission to SIBERIA-2, 6) return to the injection mode in 300 steps.

The status of facility systems is shown in control room monitors by special programs. One can see for example following two programs. Program SVET checks a magnet power supply. If difference between setting and reading values is more then tolerant value, associated symbol on the screen changes your color from green to yellow than red. The program shows three types of pictures : facility status, status of one of system, status of any fore channels. Program OSOL checks RF-power supply by 4-th channels CAMAC based digital oscilloscope. The program reads ADC, shows RF pulsed signals (screen copies see Fig. 2), saves 80 recent pictures. There are programs of control for pulsed power supply, vacuum monitoring, temperature and radiation checking system, which transmit the information to control room monitors.

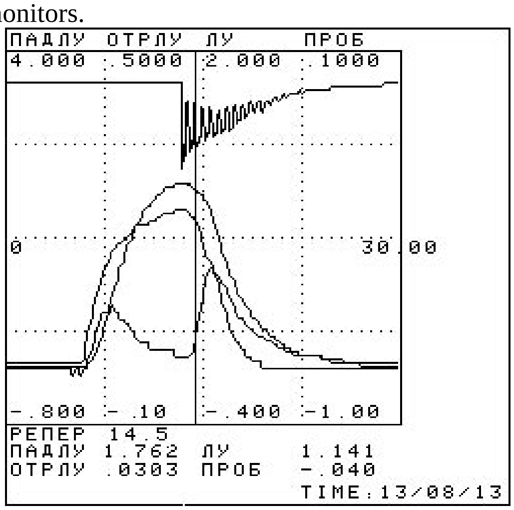

Fig.2. RF generator control program screen copy.

There are few programs for automatically measurement of beam parameters. In injection and booster facility are following: RIPP - beam position in transport line to main ring by second emission monitors, TOMN - stored current measurements by DCCT. In main ring are following:, TOBN - stored current measurements by DCCT. One can see for example following two programs. Program RIPP reads CAMAC module of beam position monitor in transport line to SIBERIA-1 and shows to screen (see Fig. 3) transverse distribution, center-of-mass and width of beam.

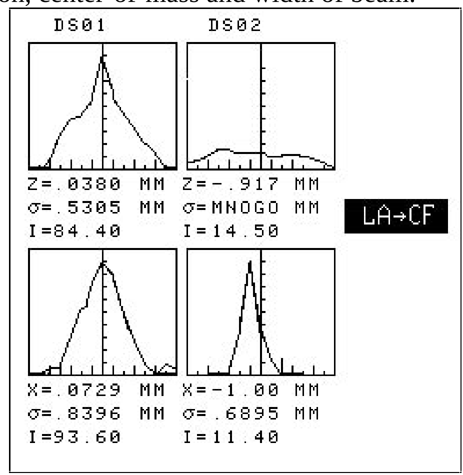

Fig.3. Beam position monitor program screen copy.

Program TOMN reads beam current monitor in SIBERIA-1, and shows (see Fig. 4) current value of stored beam, life time, beam energy and summary number of ampere * hour.

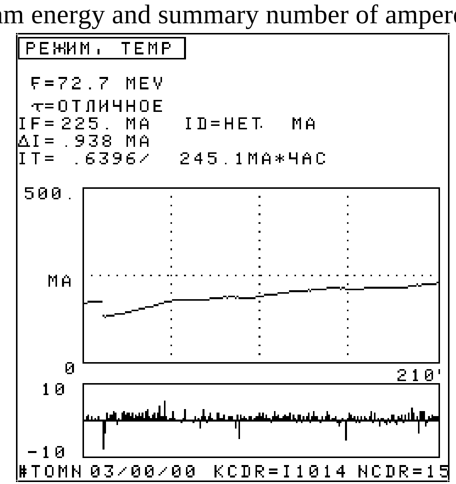

Fig.4. Beam current measurements screen copy.

4. REFERENCES

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