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Upgrading of the beam diagnostic system of U-70 beam transfer lines

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Abstract

The beam diagnostic system of U-70 beam transfer lines (beam profiles, intensity and beam losses measurements) was designed in the beginning of 80-th on the base of 8-bit microprocessor, SUMMA hardware and home made serial communication link. Because of the maintenance problems the decision was taken to upgrade the hardware and software parts of the system.

The main implemented features of the modernized system are:

- at the level of consoles - Sun SPARK Station (Solaris 2.5.1) and PC (Linux, Windows NT, eXceed);
- at the front-end level - VME crates with processor MVME 167 (VxWorks) and microcontroller?s based VME modules;
- at the application level - the process control and data acquisition toolkit EPICS.

The architecture of upgraded system, the first experience of its usage in U-70 accelerator run and possibility of integration the beam diagnostics into the common beam lines controls are discussed.

1 INTRODUCTION

Created in the beginning of the 80-th years and used till now the diagnostic system of the transfer lines of ejected beams [1, 2] provides the measurement of:

- Profiles and position of beams in the both fast and slow ejection modes. Profilometers are placed in 20 locations of beams complex, have 16 channels in each of two orthogonal planes with space resolution 1, 2.5, 5, 8 and 10 mm;
- Intensities in the range of 10^{10} - 10^{13} protons/cycle for fast ejection and in the range of 10^{7} - 10^{13} protons/cycle for slow ejection with accuracy of several percents in three cuts;
- Relative allocation of protons beam losses around of transfer lines in a dynamic range 10^{7} - 10^{5} protons/cycle for the both fast and slow ejections modes. Totally 16 detectors were installed on beam transfer lines (BTLs).

The system included the PDP-11/40 (RSX-11M) compatible support computers and home made CAMAC-like crates, housing programmable controllers and a set of I/O modules, connected with the specialized analog electronics placed close to appropriate detectors [1, 3]. Remote access to diagnostic information was implemented by communication boards placed in separate crate.

The structure of upgraded diagnostic system of BTL is shown in Fig. 1. It is based on the personal computers with OS Linux, VME crate controllers MVME-167 with OS VxWorks, set of microprocessor I/O modules and the software tools EPICS, distributed over the network.. Such a package as eXceed running under Windows on PCs could allow to PC consoles users to access the beams diagnostics information stored and represented in the different forms by EPICS graphical applications. Sun Station (Solaris 2.5.1), not shown in Fig. 1, is used for development of different software (drivers and so on) for MVME-167 IOCs. The modification does not affect a specialized analogue electronics.

2 VME MODULES

The application of the VME standard has caused in development of microprocessor based boards such as the timing generator VTG, fast scanning 12-bit ADC VSA and 16-bit ADC VMA [4], aimed to solve real time tasks of beam profile and intensity measurements.

All mentioned modules share common architecture, standard map of address space and uniform assignment of bits of the status and control register (CSR). They are based on the microprocessor chip DS80C320 and have 64 Kb of dual port memory (DPM) allowing access from both the microprocessor and host processor in MVME-167. The address space of modules has three logical areas: 1) control area aimed for reading from and writing to CSR and interrupt vector register, 2) parameters area maintaining the operational parameters of modules, and 3) data area storing the data acquired by boards. The definition of operational mode of the module and reading of the results is realized through the DPM, while the operational control of modules is carried out through register CSR.

Programs in modules reuse common subroutines for all types of modules, namely, INIT (initializing of a hardware), CONFIG (updating all controlled parameters), MAIN (events queuing). The other subroutine - EXECUTE - is module specific, it treats events from the queue. Such approach facilitates in simplicity of software maintenance and future development for new modules.

The timing generator module - VTG - executes main management and synchronization functions in the system dealing with the measurement of beams profiles and intensities. By receiving the clock pulse, it implements hard-coded sequence of operations such as permit or disable the integration, control of channel multiplexor, start and stop analogue-to-digital conversions.

The VSA and VMA modules normally are looping in waiting the external trigger, handling the single measurement of input signals for all their channels (16 per VSA, 32 per VMA), and archiving data in their own DPM. Incoming stop pulse breaks modules out this loop, allowing the host processor to extract data from DPM.

3 IOCs SOFTWARE

The software of an input-output controller (IOC) in the diagnostic system is based on EPICS package [5, 6] and is running under OS VxWorks [7]. Corresponding driver has been developed to support all types of modules used. A number of EPICS record types were involved including analogue input (**ai** class), analogue output (**ao** class) and data array input (**waveform** class) [8, 9]. The records of **ao** type are used to specify the parameters of the VTG module, whereas the records of **ai** class ensure reading a current state of modules in the system. The beam profiles data are represented by records of **waveform** type.

The driver developed ensures the continuity of profiles and intensity measurement. It handles interrupts from VTG board, keeps all the data acquired and finally prepares the signals and zero levels measurements in the next accelerator cycle. It supports all hardware modules used because of their tight interdependency. For example, obtaining the interrupt from VTG, it obliges to scan all live in the system ADC units, read their data, load a new configuration and start all modules. The execution of such time consumption procedure would be much less efficient in the case of running different drivers in the same IOC.

4 DATA REPRESENTATION

The EPICS package includes graphical applications [7] implementing man-machine interface in control systems. We use MEDM as well as DM2K which are graphical builders and real time managers of interfaces, or displays. StripTool program is also rather usefull, it permits to watch data of arbitrary selected groups of records with the possibility of historical data review.

The hierarchy of displays has been developed for representation 1) of the general map of U-70 beam transfer lines, 2) of beam transfer line selected with a set of profilometers installed on it, 3) of arbitrary selected one or several profilometers. Profilometer?s data contain the distribution of a beam profiles in two directions, a position of beam?s center of gravity, full charge accumulated by the profilometer, and the beam width satisfying to controlable threshold condition. Some of MEDM displays are shown in the figures 2, 3.

5 CONCLUSION

Upgraded diagnostic system of U-70 BTLs supports measurement and visualization of beam profiles and their intensities for two channels. The software for diagnostics operates within the framework of EPICS tools.

Further extension of diagnostic system will also include measurements of beam losses. All the equipment needed for this project is underway.

Next year the diagnostic system will be integrated with extracted beam control system.

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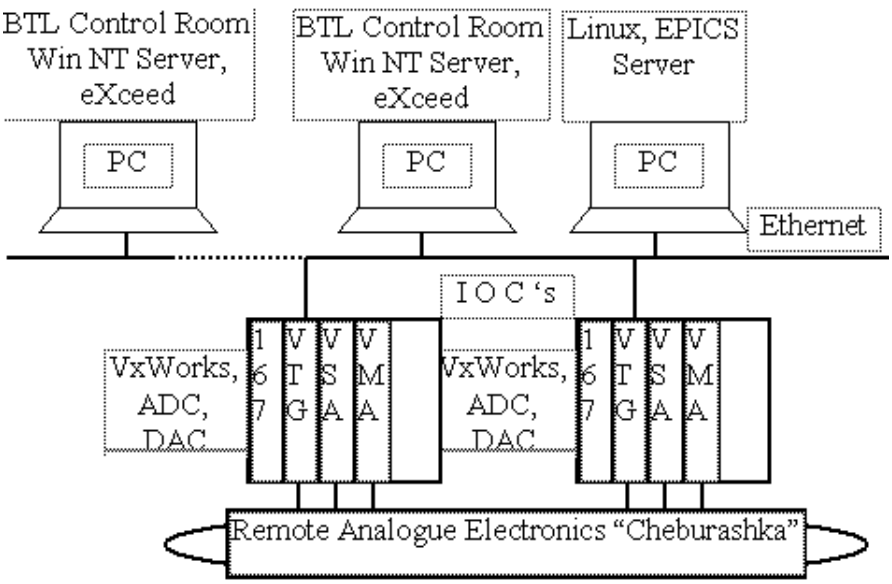

Figure 1: General view of the hardware/software structure of the beam transfer lines (BTL) diagnostic system.

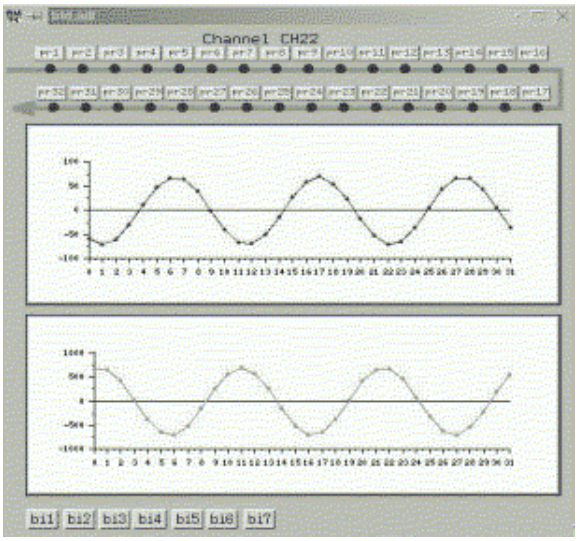

Figure 2: Data displays of BTLs.

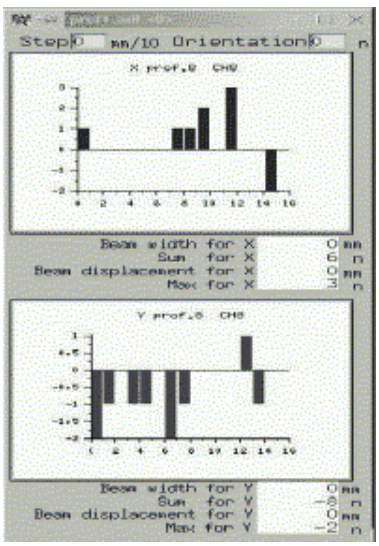

Figure 3: Profilometer display.