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 the 80s based on an 8-bit microprocessor, SUMMA hardware and a home made serial communication link. Because of 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 console level – Sun SPARC Station (Solaris 2.5.1) and PC (Linux, Windows NT, eXceed);
- at the front-end level – VME crates with MVME 167 CPUS running VxWorks and microcontroller based VME modules;
- at the application level – the process control and data acquisition toolkit EPICS.

The architecture of the 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 80s and still in use the diagnostic system of the transfer lines of ejected beams [1,2] provides the measurement of:

- Profiles and position of beams in both fast and slow ejection modes. Profilometers are placed in 20 locations of the beams complex, have 16 channels in each of two orthogonal planes with a space resolution of 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 proton beam losses around the transfer lines in a dynamic range of 10^{7}–10^{5} protons/cycle for both the fast and slow ejection modes. Totally 16 detectors were installed on beam transfer lines (BTLs).

The system included 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 a separate crate.

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

2 VME MODULES

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

All mentioned modules share a common architecture, a 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 on the MVME 167. The address space of the modules has three logical areas: 1) The control area used for reading from and writing to the CSR and interrupt vector registers, 2) the parameter area containing the operational parameters of modules, and 3) the data area storing the data acquired by the boards. The definition of the module's operational mode and reading of the results is realized through the DPM, while the operational control of modules is carried out through the CSR register.
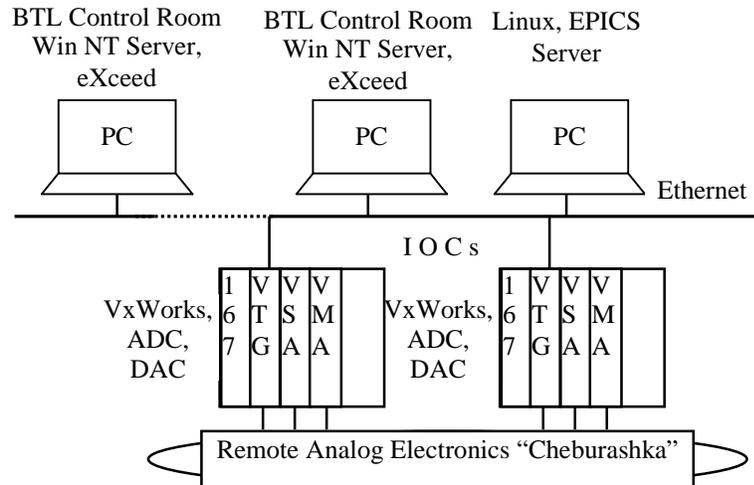
Figure 1: General view of the hardware/software structure of the beam transfer lines (BTL) diagnostic system

The module software reuses common subroutines for all types of modules, namely INIT (initializing of hardware), CONFIG (updating all controlled parameters), and MAIN (event queuing). The other subroutine – EXECUTE – is module specific and treats events from the queue. Such approach facilitates simplicity of software maintenance and future developments for new modules.

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

The VSA and VMA modules are normally looping in waiting for 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. An incoming stop pulse breaks the modules out of this loop, allowing the host processor to extract data from the DPM.

3 IOC SOFTWARE

The software of an input-output controller (IOC) in the diagnostic system is based on the EPICS package [5,6] and is running under VxWorks [7]. A corresponding driver has been developed to support all types of modules used. A number of EPICS record types are involved including analog input (**ai** class), analog 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 the current state of modules in the system. The beam profile data is represented by records of **waveform** type.

The driver developed ensures the continuity of profile and intensity measurement. It handles interrupts from the VTG board, keeps all acquired data and finally prepares the signals and zero level measurements in the next accelerator cycle. It supports all used hardware modules because of their tight interdependency. For example, obtaining the interrupt from VTG, it scans all ADC units in the system, reads their data, loads a new configuration and starts all modules. The execution of such time consuming procedure would be much less efficient when running different drivers in the same IOC.

4 DATA REPRESENTATION

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

A hierarchy of displays has been developed for representing 1) the general map of U-70 beam transfer lines, 2) a selected beam transfer line with a set of profilometers installed on it, 3) an arbitrary selection of one or several profilometers. Profilometer data contains the distribution of beam profiles in two directions, the position of the beam's center of gravity, the full charge accumulated by the profilometer, and the beam width satisfying to controlable threshold condition. Some MEDM displays are shown in the figures 2, 3.
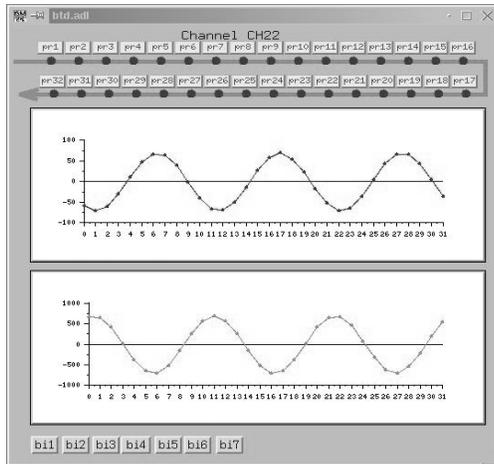
Figure 2: Data displays of BTLs
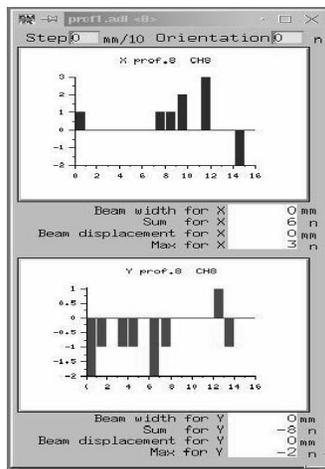
Fig.3: Profilometer display

5 CONCLUSION

The 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 the 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 the extracted beam control system.

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