LL

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

31

CERN - PS DIVISION

/ CERN/PS 94-04 (CO)

Sw 9410

PRESENT STATUS OF THE UNK CONTROL SYSTEM AT IHEP

Reported by A. Sytin for the UNK Controls Staff

Abstract

The design of the UNK control system has been published in the proceedings of ICALEPCS'91 at Tsukuba. That is still a valid statement of our plans. Unfortunately the UNK accelerator project has been stagnating since then, due to funding problems resulting from the economic situation in Russia. Nevertheless, some significant progress has been made on the controls side. On the one hand a preliminary control system has been implemented for the forthcoming milestone of sending a first beam down the transfer line (BTL) between the injector synchrotron U70 and UNK. This is close to completion. On the other hand a prototype of the control system for the UNK proper (a "Vertical Slice" from console to process) has been built up, incorporating most of the published design features, hardware and software. For a second milestone, we now plan to connect this Vertical Slice to the beam transfer line, with the aim of exercising our prototype with actual process equipment and beam. The paper reports on these two lines of work.

IHEP, Moscow Region

International Conference on Accelerator and Large Experimental Control Systems,
Berlin, Germany, October 18-22, 1993

Geneva, Switzerland
28/2/94

**Information to SIS about
CERN Publication or Divisional Report**

From : E. Durieu PS Division

Date: 1/3/94

To : Mme Dutour, Main Library

The following paper has been authorized by the Division Leader. Six copies are attached.

Title **Present Status of the UNK Control System at IHEP**

First author: **A. Sytin**

Reference: **CERN/PS 94-04 (CO)**

No. of manuscript pages: 11

☒ This paper is **submitted to a conference** (*please give exact title, place and dates*):

International Conference on Accelerator and Large
Experimental Control Systems, Berlin, Germany,
October 18-22, 1993

☐ It will be published in the **Proceedings**, as noted below :

☐ This paper is **to be published** (*please give details indicated as far as possible*) in a :

☐ **Periodical** (*title, vol.*) :

☐ **Book** (*title, editor, publisher, date*) :

☐ This paper is a Divisional report **not to be published**.

☐ No further copies are available for distribution.

Signature :

Signature Division Leader :

d. Finow
1.3.1994

PRESENT STATUS OF THE UNK CONTROL SYSTEM AT IHEP

Reported by A.Sytin for the UNK Controls Staff,
IHEP, Moscow region, Russia,

The design of the UNK control system has been published in the proceedings of ICALEPCS'91 at Tsukuba [1]. That is still a valid statement of our plans. Unfortunately the UNK accelerator project has been stagnating since then, due to funding problems resulting from the economic situation in Russia. Nevertheless, some significant progress has been made on the controls side. On the one hand a preliminary control system has been implemented for the forthcoming milestone of sending a first beam down the transfer line (BTL) between the injector synchrotron U70 and UNK. This is close to completed. On the other hand a prototype of the control system for the UNK proper (a "Vertical Slice" from Console to process) has been built up, incorporating most of the published design features, hardware and software. For a second milestone we now plan to connect this Vertical Slice to the beam transfer line, with the aim of exercising our prototype with actual process equipment and beam. The paper reports on these two lines of work.

Temporary BTL Controls.

The beam transfer line (BTL) is a substantial fraction of the total UNK electrophysical installations and a first essential part of the UNK. Quadrupole magnets and bending magnets are situated in the tunnel of 3.5 km length (fig. 1) and are fed from hundred pulsed power supplies placed in nearby surface buildings 1003, 1004 and 1005, separated from each other by distances of around 1 km. About 100 beam detectors, 85 crates of signal amplifiers (FEE) and 45 crates of drivers for the beam profile monitor actuators are being installed along the BTL tunnel.

According to the latest plan, in December of the current year the first pilot bunches will be ejected from U70, guided through the BTL and dumped on a beam absorber, installed at the end of the intermediate bend of the BTL. Thus the first part of the BTL, representing about 2/3 of the total volume of its equipment, will be put in operation.

The temporary variant of the BTL control system design aims, on the one hand, at providing enough autonomy for various groups of specialists for commissioning their process equipment and, on the other hand, at providing the controls and monitoring functionality for the operations staff to control beam ejection and transportation processes when exercising through all aspects of tuning and running the BTL. The techniques used for the temporary controls are derived from experience in solving similar problems for the beam ejection and transportation systems of U70 [2].

BTL Controls Layout

In order to achieve the aim mentioned above, the BTL controls were divided in three subsystems: power supply (PS) control, beam diagnostics (BD) control and vacuum (VAC) control. The structure of the temporary BTL control system is shown in fig. 2. It is based on the IBM PC compatible computers, interconnected by simple point to point links.

For the communications inside the mentioned surface buildings, the RS232 interface is used directly whereas between buildings, RS232/current loop (and vise-versa) converters are inserted in the communication lines. Such a communication line of 1.5 km length, terminated by the converters, was tested and worked correctly.

In each building every control subsystem (power supplies, beam diagnostics, vacuum, etc.) has one dedicated "local" PC which serves the process equipment belonging to this location. One serial port of that PC connects via a multiplexer (MPX) to the subsystem's Equipment Controllers (EC) which latter provide the necessary I/O functions for the relevant process equipment. The second serial port connects to the subsystem's "console" computer in building 1003. There are thus "console" PCs dedicated to Power supplies, beam diagnostics, Vacuum, etc. Each of these can supervise all process equipment of one subsystem. The "console" computers of the three subsystems, in turn, are linked by Ethernet to a VAXstation 3000, running the controls software package Vsystem [3] and it is functioning as the main operator console during the BTL commissioning.

Hardware

Each EC for the pulsed power supplies has a set of modules in an Euromechanics crate with the AMS (Bus-1) backplane (Siemens, like Multibus I): one single board computer, using the 1801BM1 microprocessor (like LSI-11), one link module and two I/O modules. Regulation electronics for the pulsed power supply is situated in the same crate. The crate is galvanically insulated from the communication line. The EC for beam diagnostics is constructed in the CAMAC standard [8]. It includes one Autonomous Crate Controller (ACC) using the 580BM80 microprocessor (like Intel 8080) and a set of data acquisition and processing modules.

The EC for the vacuum system uses the 1816BE35 microcontroller (like Intel 8035). It is inserted as a general purpose unit in each vacuum control rack. Since the vacuum system is delivered by industry with its autonomous controls, the EC accesses and interfaces their control and status registers in the relevant vacuum rack. The multiplexer is composed of commutators, one 1801BM1 single board computer and one link module, placed in the Euromechanics crate with the Bus-1 backplane.

For the temporary BTL controls, 95 Euromechanics crates with Bus-1 modules and 12 crates with CAMAC modules were developed and produced in the Institute.

Timing, Synchronization and Dynamic Interlock

Time control (fig 2) of the processes in the BTL (timing of the pulsed power supplies, synchronization of the beam monitoring and the kicker magnet triggering with the U70 beam structure) is based on the synchro train (ST), which consists of two parts: "rough" (10 ms resolution) and "fine" (1.01 MHz pulse sequence related to the beam structure). The synchro train generator (STG) is triggered by the U70 start pulse and outputs 500 "rough" clock pulses. Then the STG, triggered by an event 15 ms before beam transfer, emits 30 000 "fine" pulses, derived from the RF train linked to the U70 beam structure. The moment of the fast ejection and transfer of the U70 beam corresponds to a pulse in the middle of the "fine" pulse sequence, thus allowing to select pre- and post pulses for the synchronization with the beam structure.

The ST distribution network has a multistar line topology. The synchro train is transferred from building 175 (control room of injector synchrotron U70) to the BTL surface buildings by means of re-transmission stations which also distribute the synchro pulses inside the buildings between the corresponding equipment controllers. The retransmission station is a set of repeaters placed in the Euromechanics crate. The synchro train is monitored in each station by dedicated counters and 1801BM1 single board computer, incorporated in the station crate.

The dynamic interlock hardware, using window discriminators with programmable limits, constantly monitors the pulsed magnet currents and inhibits the injection of the U70 beam into the BTL if any of the currents is out of the preset range at the ejection moment. All interlock signals (IS) are gathered by the concentrator modules placed in the retransmission station crate. The chain of these modules processes the IS's and strobes the kicker magnet (KM) trigger pulse in the STG crate. The IS processing is executed by hardware because a fast reaction and reliability are necessary.

In every cycle, the time position of each IS permission state is registered with a 1 microsec resolution in a buffer memory of the concentrators. This information is analyzed by PC and allows to reveal a weak and unreliable component in the BTL power supply chain and to give a warning. The IS time position data are also used for tuning of the power supply timing to synchronize all the pulse magnet current maximums with the beam transfer moment. The PCs level structure of the IS analysis subsystem is identical with the ones of the control subsystems, described above.

Software

A central item of each EC is a data table, describing dynamic and static parameters of controlled equipment. Updating of the table contents is done by a real time routine, placed in ROM and synchronized with the events of the BTL cycle. All data tables of each subsystem compose a distributed on-line data base which is reflected in the corresponding PC memory. The EC software is written in either PL-11 [4] or assembler language.

The software of each PC consists of two functional levels. The first level provides an access to the EC data tables and processes the incoming information. It represents a kernel of the control software working with the BTL cycle rate. The second level is a

shell of the control software which contains an expandable set of application programs with convenient graphic interfaces. PCs run under MS DOS 5.0 and their software is written in C. The necessary multitask function is provided by specially developed resident programs, activated by external interrupts.

The data are transmitted through the point to point network by packages. The data transfer from any network node to another one is foreseen. This allows to link easily the console PC with the corresponding EC through the local PC. The interaction between PC and EC is organised in a two stage mode. An executing stage is alternating with a listening one in each BTL cycle. During the first stage the EC automatically executes the PC last order for data exchange synchronously with the BTL events. In the listening stage the EC waits for the new order from the PC.

The local PCs of the power supplies control subsystem carry out an important application task of automatic correction of the magnet pulsed current drift [5].

The console PCs on the operator working place have a set of application programs which allow the different groups of specialists the commissioning , testing and trouble shooting of the respective subsystem equipment from the whole BTL area. The Vsystem software package is installed on the VAXstation 3000 and will be used as the main console for operators. This is a user friendly graphic oriented real time control package, allowing application development by operational staff, without considerable help of the professional programmers. The workstation programs logically link to the distributed PC data base by means of PC resident program which converts the UDP package format into a suitable one for communication with the console PCs.

The UNK Control System Prototype

Development and production of the preliminary BTL control hardware and software, described in the preceding sections, had begun before the final variant of the UNK control system was decided on. After the forthcoming milestone of start-up and first commissioning of the BTL, its preliminary control system, described above, will be gradually converted to the architecture which has in the meantime been adopted for the entire UNK control system. It is planned to first modify the BTL control computer level and then the lower equipment controller layer.

Implementation of the first part of this conversion plan is a natural continuation of the work which was done during the last two years in the framework of the IHEP-CERN collaboration in which IHEP controls teams in Protvino and at CERN accomplished four milestones: (a) a conceptual design study was made, a summary of which [1] was then presented at ICALEPCS'91; (b) a powerful computer platform was set up for software development by the UNK controls team ; (c) a "Vertical Slice" prototype of the UNK control system (hardware and software) was then implemented as a design support and test bench for the UNK controls architecture, including the important aspect of the equipment access; (d) the developed solutions were then successfully applied to the vacuum system of the PS linac at CERN. Although vacuum is a simple and static functionality, this was the first test of the prototype UNK high level software on a live accelerator process.

The next milestone, following on the forthcoming startup of the BTL, involves grafting the solutions of the "Vertical Slice" prototype on the lower level of the present BTL controls. On the one hand this will give the UNK controls specialists an opportunity to exercise their solutions under the real working conditions on a wide range of functionalities. On the other hand it will involve setting up a first modest prototype of a UNK Main Control Room, which will allow the operator's team, as the main users, to familiarise themselves with these solutions and possibly make contributions to defining detailed functionality and style of the operator's interface. .

Hardware

The hardware structure of the "Vertical Slice" prototype grafted upon the lower level of the temporary BTL controls is shown in fig. 3. The "operator console", located in the building 1003, is equipped with two DECstations 5000 and two X-Terminals. The front end computer (FEC) is implemented in a VME crate which houses a MVME147 computer board using an MC68030 microprocessor (with Ethernet interface) and a set of MIL1553 bus controllers. In each of the buildings 1003 and 1004 one FEC is linked to the MPXs via MIL1553 field bus. To implement such a communication, the MIL1553 remote terminal in the Bus-1 standard will be inserted in each MPX of the temporary BTL controls [6].

All the workstations, X-Terminals and FECs are linked by Ethernet to each other. For the long distances between the buildings, the Ethernet segment will be extended by an optical cable installed in the BTL tunnel. The radiation level in the channel is not expected to affect the cable's performance and it will be an opportunity to monitor its behavior under such conditions.

Software

The software structure is shown in fig. 4. The software running at the workstation level carries out the following application tasks: power supply control, beam diagnostics and vacuum equipment control. The application development environment on the workstation level includes the standard system components (Ultrix, TCP/IP, X-Windows, Motif tool kit, ORACLE RDBMS) as well as a set of home made libraries for operator interface and equipment access programming [7].

The FECs are running under the LynxOS operating system. The interaction with the workstations is provided by the CERN version of RPC. The main components of the FEC software are message handler and equipment servers. The first component routes messages from workstations to the equipment servers. The latter decodes the messages and forms Quick Data packages for MIL1553 communications [6].

The software of the 1801BM1 single board computer in the MPX provides interaction either with the MIL1553 remote terminal or with the dedicated local PC. Thus the possibility remains to switch back to the temporary PC based BTL controls if that necessity arises.

Acknowledgements

We are grateful for the hospitality which our controls teams have enjoyed at CERN and for active help received from CERN staff.

References

- [1] V.N.Alferov et al., "The UNK control system", Proc. ICALEPCS'91, November 1991, Tsukuba, Japan, pp. 134-139.
- [2] B.B.Dilmukhamedov et al., "Distributed data processing in the microcomputers based control system", Proc. Europhysics Conference on Control Systems for Experimental Physics, September 1987, Villars-sur-Ollon, CERN 90-08, pp.131-132.
- [3] Vsystem, by Vista Control Systems, Inc., Los Alamos, New Mexico, USA
A new generation of Laboratory Automation
- [4] R.D.Russel, "PL-11: A Programming Language for the DEC PDP-11 computer", CERN 74-24 Rev., Geneva, 1978.
- [5] B.B.Dilmukhamedov et al., "High precision digital loop for stabilization of UNK pulsed magnet excitation", Proc. Europhysics Conference on Control Systems for Experimental Physics, September 1987, Villars-sur-Ollon, CERN 90-08, pp. 191-193.
- [6] A. Elin et al., "Control Protocols for the UNK Control System", paper in these proceedings.
- [7] L. Kopylov et al., "Tools for Man-machine Interface Development in Accelerator Control Applications", paper in these proceedings.
- [8] V. Gotsev et al., "The Control and Operation of the Beam Diagnostics of the UNK", paper in these proceedings.

Figure captions

Fig. 1 : BTL general layout

Fig. 2 : BTL controls structure

Fig. 3: UNK control system prototype hardware structure

Fig. 4 : UNK control system prototype software structure

Fig. 1

Fig.2

Fig. 3

Fig. 4