IEEE Transactions on Nuclear Science, Vol. NS-28, No. 3, June 1981

OPERATION-ORIENTED COMPUTER CONTROLS FOR THE CERN PS COMPLEX

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Summary

A new computer control system for the CERN PS is presently under development, with the final aim to operate all the accelerators from a unique control centre. From the start, a team of engineers experienced in machine physics and the actual control process, undertook the definition of guiding operational concepts and special characteristics for control and equipment. This included defining the control room layout, structuring the accelerators into operational subprocess, specifying in detail the interactive programs and participating in the commissioning. Using process variables reservation to prevent usage conflicts, the operation can be carried out from any one of the 5 non-dedicated consoles. This involves cycle-to-cycle programming parameters and functions with quick access to ∿ 1600 analogue signals from each console. The structured system permits analysis of process degradation and advance warning of breakdowns. Full use is made of the data handling power by means of global commands and stored optimum operating conditions.

Introduction

The PS complex presently comprises 4 accelerators and a storage ring namely, the old and new 50 MeV Linacs, the 800 MeV Booster Synchrotron (PSB), the 28 GeV Proton Synchrotron (CPS) and the 3.5 GeV Antiproton Accumulator. Up to last year, the various parts of the PS complex were controlled in various manners and from different physical locations. Of these, computer-assister controls covered about 80% of the processes but different tools and philosophies were used so that it was difficult for the operations team and machine experimenters to adjust the beams in the different machines or to discover faults.

The PS complex is continuously in expansion and its complexity is increasing, hence an additional reason to unify and homogenize the control system. It was thus decided 4 years ago to build an integrated and user-oriented control system with the final aim to operate all the accelerators from a unique control centre[1,2]. The controls conversion was divided into slices; the first package concerned the PSB and the PLS* which were transferred last autumn.

Operational Aspects Team

Already in the years 65-66, certain members of this team participated in the definition of the PS controls using an IBM 1800 computer, linked to PDS1 consoles[3]: several principles were implemented for commands, acquisitions and beam observation, and good results were obtained to control the PS with this system. These consoles were a good starting point to undertake the definition of the operational aspects for the new control system[4]. The different tasks of the team can thus be enumerated:

- General principles were used, particularly the possibility of controlling the process from any one of the non-dedicated consoles[5]. This enables the best utilization of the tools available in the control room, e.g. to be able to dedicate temporarily 2 or 3 consoles to the accelerator which is in the setting-up phase. Another important principle was the structuring of the accelerators into subprocesses in the sense of machine physics because experimenters wish to see only the actions and the behaviour of the beam[6].
- Access from the consoles to the different subprocesses was defined to permit the various phases of the operation, machine experiments and the utilization of the control system by hardware or software specialists. Process variables reservation was proposed to prevent usage conflicts and to enable operation from any one of the consoles.
- The consoles were specified in detail and the layout of the new control room was defined[7].
- For some equipment, the team also defined the hardware specifications, for example for the shared usage of multiplexed devices from different consoles.
- Interactive application programs were specified in detail, with the Application Software Section[8].
- One of the tasks of the team was to train and inform the operation crew, machine physicists and hardware specialists on the use of the new system.

Detailed specifications

The Operation consoles

The number of consoles was defined as a function of the actual size of the PS complex; 5 non-dedicated consoles are presently installed in the new PS control room and special console is allocated to the radiation safety and general information (Fig. 1).

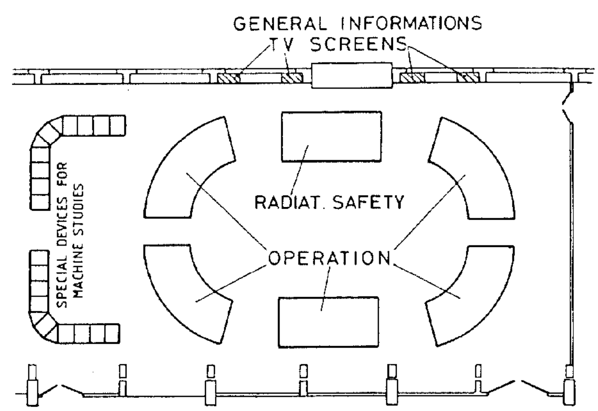

FIG 1. MAIN CONTROL ROOM LAYOUT OF CONSOLES

The hardware of the operation consoles is identical and can be divided into different operational areas (Fig. 2):
- Program selection and communication is carried out via the central part of the console. The "main touch panel"* permits the choice of the interactive programs via a tree structure while the particular program options are selected by a second TPU called "User TPU". Two big screens, the video colour screen and the graphics screen present to the operator all the information about the processes as they are defined and interpreted by the application programs.
- Interaction tools comprising 4 shaft encoders associated to incremental positioning-switches, a tracker ball, the main and user TPU's, and a keyboard.
- Two separated tree structures permit the selection of analogue and video signals: 4 black-and-white screens

* PLS: Program Lines Sequencer - See reference 9.

* Touch Panel Unit (TPU): a sensitive transparent screen with 16 TV labelled positions.

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are used to visualize video signals and 2 scopes for analogue signals.

- The alarm system large colour TV screen to display faults is situated on the right of the console together with a TPU to carry out interactions.
- The left part is normally kept free to install special devices (i.e. specific measurement equipment) which cannot be controlled by the system.

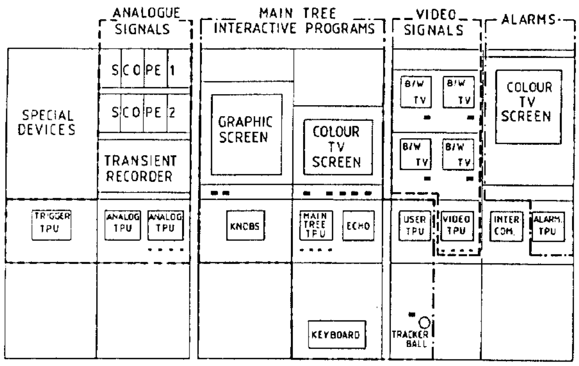

FIG. 2 OPERATION CONSOLE (Operational areas)

The main tree

The main tree gives access to all standard control and measurement programs by the main TPU. It has four levels (Fig. 3): level 1 for the choice of the accelerator, level 2 for the process (e.g. injection..), level 3 for the subprocess (e.g. focalisation) and level 4 for parameter control and acquisition. The subprocesses called at level 3 were defined to be as independent as possible; thus, two users could work on two different subprocesses of the same process without conflict. In any case, if the subsequent two subprocesses have identical parameters, then the first user has the reservation priority and the second user is appropriately notified by a message. However, it is still possible to share the same measurement and acquisition values between the consoles.

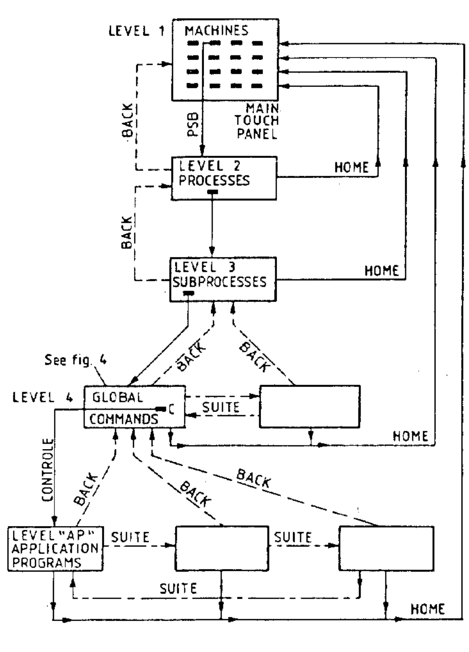

FIG. 3 MAIN TREE _ Example

Three buttons, external to the TPU are available for special displacements in the tree (Figs 3, 4): "HOME" leads back to level 1, "BACK" permits going back one level and "SUITE" gives access to side-pages at the same level. A fourth external button called "OPTIONS" permits the selection of the beam type to be adjusted: the accelerators of the PS complex are pulsed and the beam characteristics and utilization are modulated from one cycle to the next[9,10]. The "OPTION" selection permits independent tuning of any one beam but also enhances complexity of the variables reservation procedure.

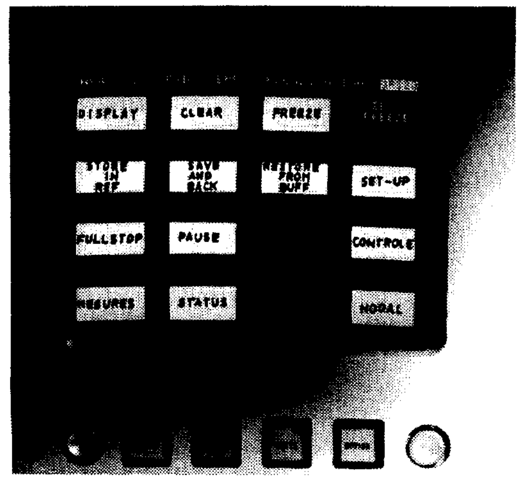

Fig. 4 MAIN TPU - Level 4

The different phases of the operation correspond to different main trees chosen at level 1 by a button called "ACCESS CONTROL": "STARTING UP" access allows one to select a set of values from archives on discs and to send it to the process after verification. This access control is used for the start-up of the accelerators after a shut-down or for important changes in the operations. "SETTING UP and MACHINE STUDIES" access is the most commonly-used phase; all the measurements and controls are employed to adjust to new situations or to study a new process. "NORMAL OPERATION" is a subset of the "SETTING UP" tree and comprises simple adjustment facilities and some standard measurements for operation supervision. Another access control called "HARDWARE SPECIALIST" gives a set of diagnostic programs, individual controls and detailed acquisition used for verification and repair.

For each access control at level 4, a standard page on the main TPU presents global commands; (see Fig. 4 for the Setting-up/MD access). The first four buttons are relative to a refreshed "display" of standard measurements and acquisition, giving a good representation of the subprocess, generally on the colour TV screen. The commands (Fig. 5) "STORE IN REFERENCE", "SAVE AND BACK" and "RESTORE FROM BUFF"

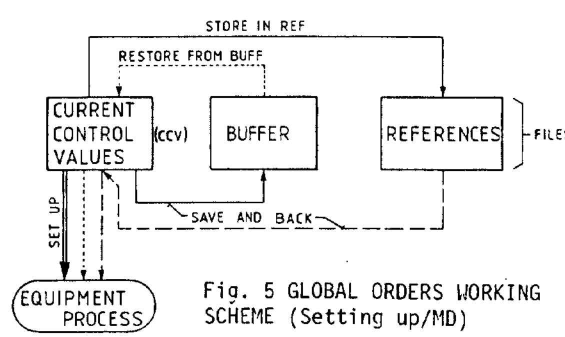

Fig. 5 GLOBAL ORDERS WORKING SCHEME (Setting up/MD)

permit handling of three files of values concerning the whole subprocess so as to try improvements of the adjustments while keeping the initial conditions in reference. "SET UP", "FULL STOP" and "PAUSE" transmit actuations and values to the hardware to restart or stop the process. "MEASUREMENTS" gives access to special measurement devices to get a better judgement of the running of the process. "CONTROL" permits access to the different application programs (AP) and individual controls, presented on the main TPU at a level called AP (Fig. 3).

Individual controls concern directly the machine parameters for which two facilities were adopted: 1) for a better understanding of the process, values are converted into normalized physical units; 2) a structured and homogeneous naming scheme for the components was devised and applied to take into account the hierarchical tree structure[11].

The "Starting up" tree has only special global commands which allow one to use or to create files of parameters corresponding to optimum situations. A simplified scheme of the file handling is given in Fig. 6. The process works with several files of current control values to permit the cycle-to-cycle modulation. A file stored in the archives can be sent to the process by three successive orders: "SELECT", "LOAD" and "INIT". Good working conditions of the process can be stored in an archives file by the order "STORE"; a new file can also be created directly from the console by the keyboard (order "CREATE").

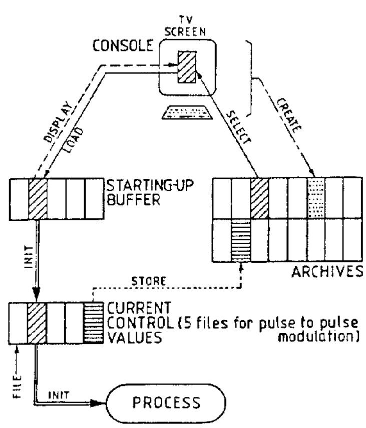

FIG. 6. FILES HANDLING IN "STARTING-UP" (Global orders at level 4) ACCESS

The Analogue Signal Observation System Tree (SOS)
Several reasons have led to the design and construction of a comprehensive system for analogue signal observation[12] e.g. real-time observation of the process, fine analysis of the behaviour of the beam, help in case of partial degradation of the control process. The tree for analogue signals is completely independent but has the same structure as the main tree. Signal selection and scope trace allocation is carried out by 2 TPU's. Two classes of signals were defined: the essential signals which can be found in any branch of the tree and the more specific signals concerning each subprocess. The computer controls the multiplexing of 40 signals (8 per console) selected from a total of $\sim$ 1600 signals. The choice of the scope trigger pulse is controlled by a special TPU and its value by two electronic positioning-switches.
The video signals tree. The black and white video signals are either coming directly from beam observation TV cameras or from process computers via character generators to display alphanumeric information in real-time. The video signals tree is simple: it permits signal selection, allocation to a small black and white screen and some adjustments on beam screens and cameras.
The alarm tree. This system provides a surveillance of the overall process independent from reservations made at the consoles. Faults on elements are displayed on a large colour TV screen. A special TPU is used to obtain more detailed information, to mask certain elements and to reset fault conditions. Surveillance programs linked to several beam monitors generate warning messages when variations from standard conditions are detected. In the future the alarm system should permit the automatic analysis of process degradation and forewarning of breakdowns.
General information in the control room. General information about the running of the accelerators is displayed on 4 large TV screens installed high at the back of the control room. Characteristic analogue waveforms like beam currents and accelerator magnet cycles are displayed. A special panel presents the visualization of the status of elements which could produce an obstacle to the beam.

Conclusion

Up to now, the Booster Synchrotron has been running for 3 months with the new control system. A large part of the original specifications by the operational aspects team has already been used successfully. The control system is still being implemented and the users will soon benefit from new powerful facilities like the starting-up tree, the alarm system, the global commands and all 5 consoles. The work of the operational aspects team continues with the general and detailed specifications of the following packages of the control project; the next package will concern the PS itself but as the PS complex is continuously expanding, new accelerators as well as beam usage must also be studied for their integration into the new control system.

Acknowledgements

We wish to thank B. Kuiper (Controls Project Leader), K.H. Reich (BR Group Leader), other colleagues of CO, BR and OP Groups, and especially P. Heymans who gave very useful contribution to our work.

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