SURVEILLANCE AND DIAGNOSTIC TOOLS FOR THE LEP BEAM SEPARATION SYSTEM

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Abstract: - In the LEP collider, electrostatic separators serve to keep the e+/e- bunches apart during injection and acceleration and to adjust them during collision. After a brief overview on the separator equipment and its associated control system the article will focus on software issues. A number of structures and utilities has been developed to allow an efficient surveillance of the equipment, the diagnostic of fault conditions, and the analysis of the past and present performance. The system is essentially based on PCs running under XENIX. The application programs are written in C. The user access is based on menus, graphics software is used to visualize the results. The user interface will be illustrated.

Introduction

In each of the eight collision points of the LEP collider, four electrostatic separators [1] are used to keep the e+ and e- bunches apart during injection and acceleration in order to allow the accumulation of sufficiently high beam currents at injection energy (about 20 GeV).

After the acceleration and the tuning of the low-beta insertions the beams are simultaneously brought into collision in the four experimental areas by rapidly discharging the separator electrodes by means of synchronous discharge switches [2,3]. Small collision imperfections in the vertical plane can be compensated by a vernier adjustment including a polarity reversal of the electric fields.

In the following, firstly a short overview on the control system is given. Afterwards, the article will focus on the software structures and tools which have been developed by and for the equipment specialists for the surveillance, the fault diagnostics in the equipment and the control system as well as for the performance analysis of the equipment. The user interface will be illustrated using a few examples. Finally, the experience gained with the software is reported.

Aspects related to the control of the separators in the framework of the overall accelerator operation are not covered within this context. A discussion of the LEP control system in general can be found e.g. in [4].

The Control System

Figure 1 gives a schematic overview on the hardware of the LEP control system (only part of the separator control system of one collision point is shown). The part above and including the VME crates has been provided within the general LEP control system [4]. All involved Apollos and PCs as well as the file server are running UNIX type operating systems.

All separator equipment is handled by a number of embedded microcomputers (equipment controllers) housed in G-64 chassis. Each controller contains a CPU card based on a M6809 microprocessor, a MIL-1553B bus interface, and, varying with the attached equipment, digital and/or analogue input/output cards and/or servo amplifiers. Each major device (e.g. every HV generator, the synchronous discharge switch) has been attributed a separate controller. In total, there are 64 units distributed over the 8 collision points. A more thorough discussion of the separator control system can be found in [5].

In each point, a PC (local console) has been installed to allow local tests and a visualization of the status of the equipment and their controllers near the equipment.

All equipment controllers of a collision point

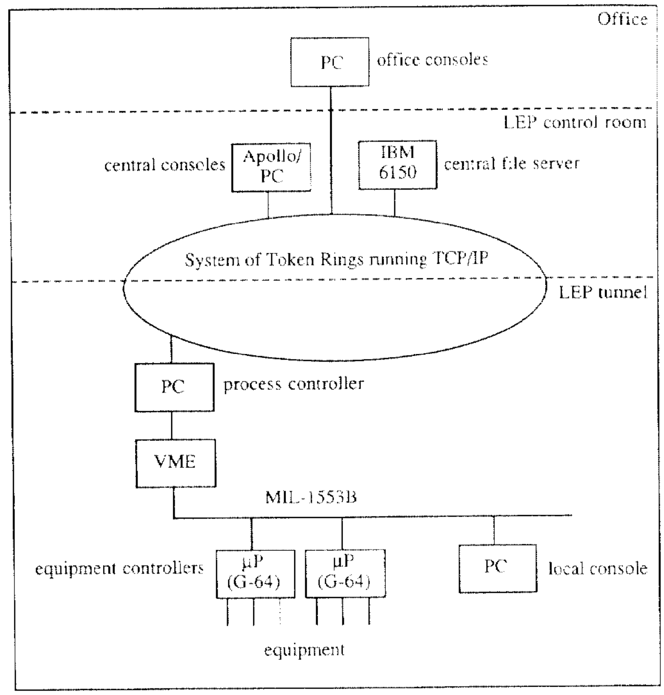

Fig. 1 Layout of the LEP control system

are linked to a process controller which bridges the local bus to the Token Ring and which translates arriving requests into commands to the equipment controllers (using 'Remote procedure calls' to a 'server program'). Besides that, it performs also surveillance tasks. The process controllers are being shared with other users.

By the nature of the equipment the whole process control can be slow. The involved command rates and data rates are low. Critical timing signals necessary for the proper functioning of the equipment or protection interlocks are hard-wired. Less critical interlocks have been implemented using a broadcast mechanism between all equipment controllers. Information about short-timed processes (e.g. an operation of the synchronous discharge switch) are stored temporarily in the equipment controllers for later retrieval ('post-mortem information'). The access to the equipment is based on commands like 'generator on', 'read status', or 'read post mortem'. Errors occurring during the communication or the execution of the command are signalled to the general LEP error reporting software for logging.

Diagnostic Tools and Structures

A number of software tools and mechanisms have been developed to allow the surveillance of the equipment, the detection of current or previous fault states, the access for test purposes, and the performance analysis. All involved programs have been written in C.

The surveillance of the equipment and its control system is based on a program running in the process controller. This program retrieves the status of all equipment controllers every 5 s and performs all necessary checks. In case of failures it generates an alarm, which is fed in the general LEP alarm chain for logging and display in the control room.

The same program is used to acquire a subset of all arising information for off-line diagnostics and performance analyses: Once per 5 minutes, the complete status information of all equipment controllers is sent to the central file server ('short-term history data'), together with all new alarms and post mortem data. In addition, once per 10 minutes a compressed status and once per hour again a complete status is sent ('long-term history data'). The data are received by a server program and put into a file structure. Simultaneously, the file server takes care of the storage of machine parameters (e.g. beam currents). The short-term information (about 1.5 MB/day for all collision points together) is kept for four days and then deleted automatically. The long-term information (about 350 kB/day for all collision points together) is kept on disc within the limits of the reserved partition (about 4 months). A tape backup mechanism can then be used to save this information further.

As the key tool a comprehensive software package has been developed to allow to visualize the history data stored on the file server (for off-line exploitation and diagnostics) and to access directly the equipment (for on-line control and diagnostics). This main application program amounts to about 41000 lines of source code or about 750 kB of executable code. CGI (Computer Graphics Interface) is used as graphics package. This program can run on all PC consoles in the LEP control room and the offices, and all PC process controllers in the LEP tunnel and the local PC consoles.

The selection of the collision points, the items to be displayed, or the desired actions to be performed is made via the keyboard from a tree of menus. It is foreseen to include also input from a mouse or a trackball. Besides the possibility to provoke any possible command singly, there are a number of useful command sequences already pre-programmed.

There are slight differences between the implementation on the local consoles and the other machines: The functionality on the local consoles is restricted to the immediate access to the equipment in the local collision point, whereas all other PCs allow the immediate access to all collision point and to the history data on the file server. On the other hand, on the local consoles the displays are automatically updated with the incoming broadcast information, whereas on the other PCs each update has to be requested explicitly to reduce the traffic on the global network.

Examples for the User Interface

In the following, the versatility of the program and its user interface will be illustrated by a number of examples.

Figure 2 shows an image of the 'broadcast display page'. This page gives a 'quasi-synoptic' overview of the equipment in one collision point and allows a quick check of the most important parameters (e.g. tensions and currents of all HV generators).

The 'single commands menu' of a particular equipment, in this case one of the main HV generators, is given in figure 3. The left part visualizes again the actual state of some of the most important parameters, whereas the right part permits to select the desired command. According to the type of the command, the selection is followed either by the pure action (e.g. 'generator on'), by another sub-menu to enter data (e.g. 'write operation mode'), or by the display of the requested data. An example of the latter is given in figure 4, resulting from the action 'read general status which displays the complete status information of this generator.

Figure 5 gives a synoptic view of the separator electrodes of the selected collision point and the associated spark counts and rates since the last reset. The displayed information is derived from a table contained in one of the equipment controllers.

During each operation of the synchronous discharge switch, information about this short-timed

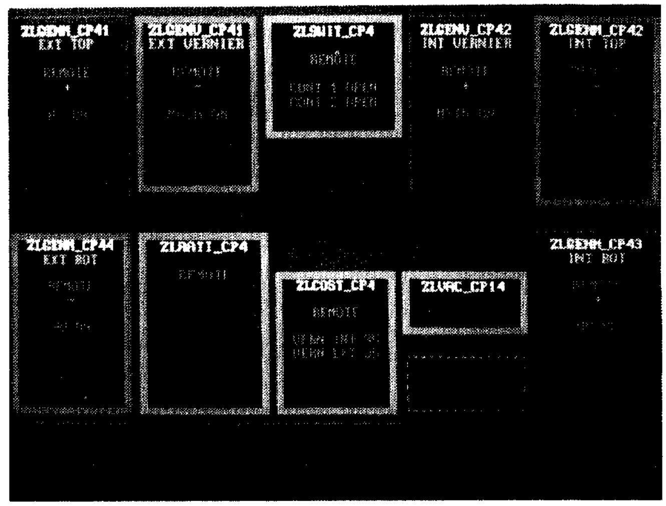

Fig. 2 The broadcast display page

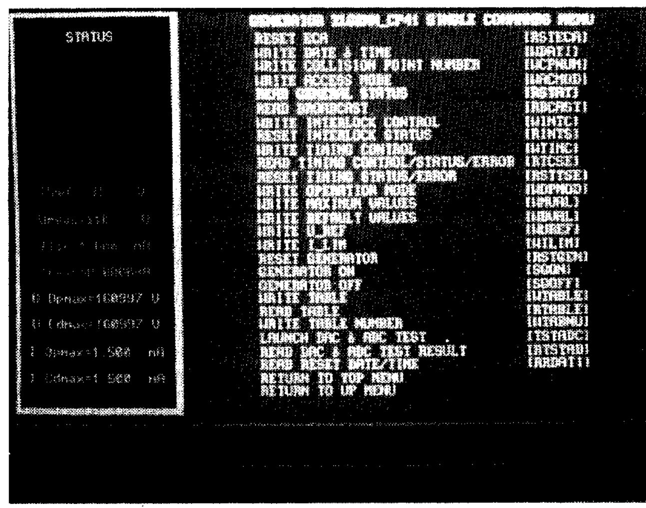

Fig. 3 Example for a 'single commands menu' page

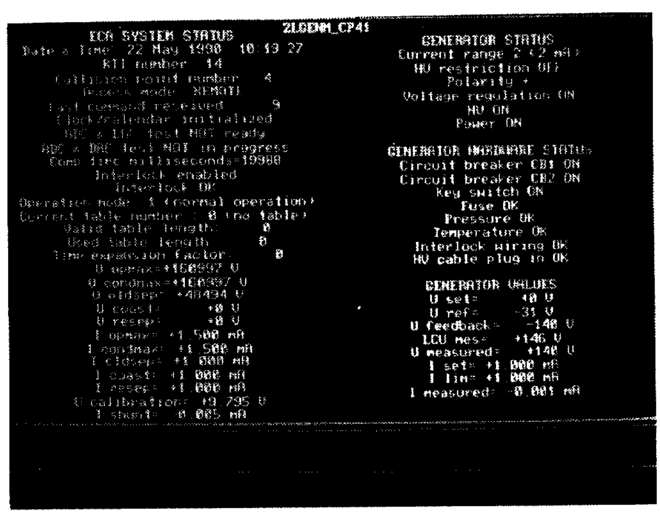

Fig. 4 Display resulting from the action 'read general status

process (duration about 300 ms) is stored in the equipment controller of this device ('post-mortem information'). A graphical representation of these data is given in figure 6. It may be interesting to

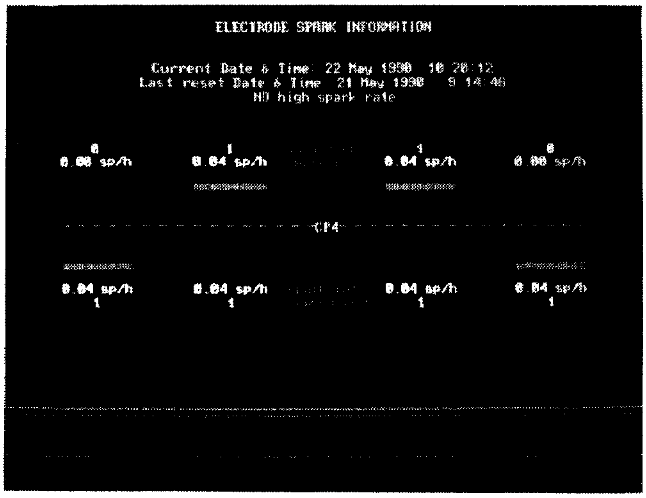

Fig. 5 Display of the electrode spark information

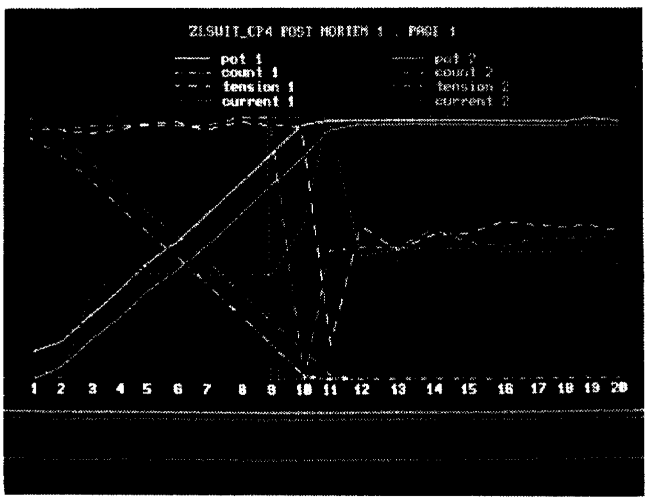

Fig. 6 Display of the post-mortem information of the synchronous discharge switch

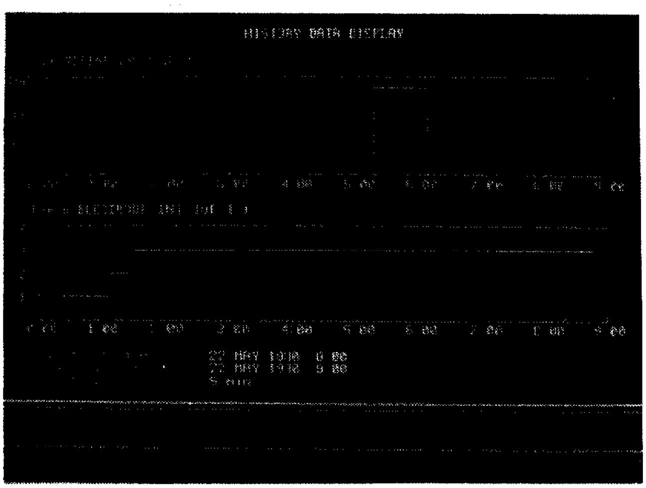

Fig. 7 Example for the display of history data

compare the graphs with those of figure 5 in [3].

Finally, figure 7 gives an example for the replay of information previously stored on the file server. For this image, two parameters - the tension of a high voltage generator and the spark count on one of the associated electrodes - have been selected and displayed for the desired period and with the desired resolution. For the near future it is foreseen to include also the display of correlations between parameters.

For documentation or communication purposes, every image displayed on the screen can be stored on a floppy disk and replayed later on elsewhere. In the longer term, it is envisaged to implement a hardcopy facility.

Experience

The installed diagnostic software runs very reliably. Most of the presented tools have already been very useful during the running-in of the control system. A few improvements have been carried out since then. Today, the installed structures and tools are successfully used by a number of persons for the fault finding in the equipment and its control system as well as for the supervision of the performance of the equipment. The way in which the human interface is designed and implemented is well appreciated.

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