Automatic High Voltage Conditioning of the Electrostatic LEP Separators without Conventional Programming

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Abstract

The TS Tool Kit is a generic, fully data-driven and user-configurable software system developed at CERN for supervisory, control and data acquisition applications. It provides a comprehensive framework to solve fairly complex process control problems requiring response times of the order of a second, without any need for conventional programming. The characteristics and benefits of this approach are discussed in the context of the new high voltage conditioning process for the electrostatic LEP separators.

1. EQUIPMENT

Separation of the e+e- beams in LEP is achieved by a vertical electrostatic separation system comprising 40 bipolar separator units, arranged to provide local vertical separation bumps at all eight LEP interaction points. Each separator consists of a vacuum tank of 50 cm diameter and 4,5 m length and contains two high-voltage electrodes mounted on two insulating supports as shown in figure 1. Each electrode is connected via an alumina feedthrough to a high-voltage (HV) generator (± 175 kV DC). The gap width can be varied between 6 and 16 cm [1].

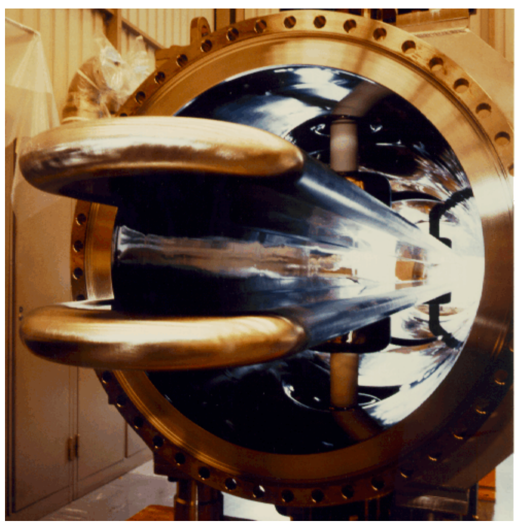

Fig 1. Separator tank with electrodes.

In order to improve the HV behaviour at the nominal field (15 - 30 kV/cm) after assembly, loss of vacuum, or polarity change, a separator is (re-)conditioned by increasing the voltage slowly to the maximum field (56 kV/cm). The maximum speed of voltage increase is determined by two parameters: the spark rate and the vacuum pressure in the tank. After the maximum field has been reached and maintained during several hours for consolidation, the field is reduced to 50 kV/cm for a total of 72 hours, during which the tank is checked for a low spark rate.

2. PROJECT OVERVIEW

To speed up the procedure and to save manpower a software regulation process has been used for many years to perform the HV conditioning automatically. Its original implementation was a stand-alone C program [2] designed to run on the local process controllers (PCs under SCO XENIX) widely used for LEP control. For screen handling, user input, and display of historical and trending curves the program made abundant use of the CGI (Computer Graphics Interface) graphics package, conveniently available under XENIX. Many of the parameters needed during the conditioning, like maximum voltages, flat-top timeout interval, etc., were hard-coded, as the program was only foreseen to be used with the initial separator setup [1]. As it was conceived, this program could also run only locally and not be interrogated or influenced over the network. Therefore, its use necessitated a lot of travel between the equipment specialists' offices and the various LEP interaction points.

The recent migration from XENIX to LynxOS [3] (which no longer offers CGI) as operating system in the process controllers, the evolution of the separator layout over the years (e.g. for the 'LEP bunch train scheme' [4] or LEP2) has rendered this old implementation of the automatic conditioning obsolete. Therefore a new solution has been recently conceived and realised.

3. CHARACTERISTICS

The new automatic conditioning process has been developed in the framework of the fully configurable, event and data driven 'TS Tool Kit' described already elsewhere [5, 6]. This provided:

- No need for conventional (e.g. C) programming;
- Portability (runs so far on HP-UX, ULTRIX, and LynxOS) (applications are platform-independent);
- Full on-line remote control;
- Separation between algorithm and user interface;
- Equipment independence (can be used for all types of LEP separators but also other equipment, e.g. the SPS extraction electrostatic septa).

In particular the suppression of conventional programming has allowed one to set up the new system in a remarkably short time, permitting concentration on the proper implementation of the conditioning algorithm. It largely favoured a clear communication between users and developers, resulting in a successful transfer of the desired functionality into the final product. The user interface was largely conceived by non-software specialists, using functions of the TS Tool Kit together with other easily configurable tools [7]. Non-software specialists will also be able to perform most of the future upgrade work in case the applications evolve.

4. TS TOOL KIT

The core of the TS Tool Kit [5, 6] is a shared database to which the access is handled by a client/server mechanism. This database is the run-time repository for all the data needed to run the application. It is surrounded with a set of client modules, each dealing with a specific control task, like data acquisition, running control algorithms, or user interaction. The general application behaviour is given through flat data files which are read in and interpreted at startup. The TS Tool Kit configuration needed to implement the automatic conditioning process is shown in figure 2.

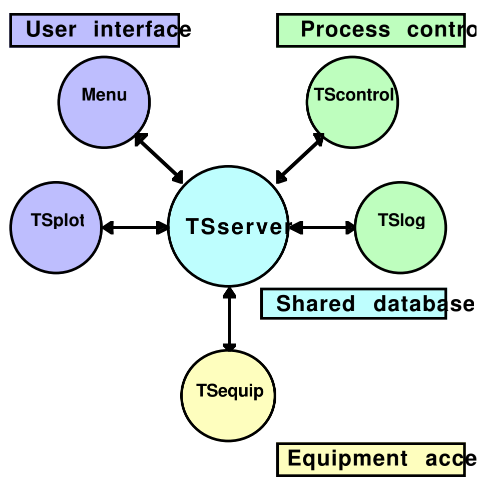

Fig 2. Software layout.

The various modules perform the following functions:

TSserver: shared database.
TScontrol: runs control and supervision algorithms specified in 'rules'.
TSlog: stores, at definable time intervals or on change, any set of data in the shared database onto files or onto a remote Oracle database.
TSequip: sends commands to, and reads data from, the equipment.
TSplot: writes selected data onto files in a format understandable by 'gnuplot' to provide trending curves.
Menu: generic alphanumeric user interface which permits, based on simple text files, the organization of operating system commands or calls to user-written programs into a tree of menus, to display the menus, to move in the menu tree and to invoke commands by single-key actions [7].

Several auxiliary modules (not shown here) are used from within Menu, for user access to the shared database for information and run-time control of the application.

5. SCENARIO and ALGORITHM

The automatic conditioning procedure is determined through ‘scenarios’, made up from a set of parameters and ‘rules’, executed by the TScontrol module. Various scenarios are available for positive, negative, or bipolar conditioning, selectable from Menu. Likewise, parameters are pre-set as appropriate for the chosen scenario, but can be modified dynamically at run-time to influence the procedure.

The rules are formulated as conditions and subsequent actions in term of data in the shared database, and specified in a simple “controls language” [8]. These rules are read from a text file at start-up and continuously evaluated at run-time. All rules are executed completely asynchronously when their respective conditions (WHEN ...) are evaluated as ‘TRUE’.

A largely simplified version of the rules constituting the automatic conditioning algorithm is shown in figure 3.

The overall process regulation loop is made up of three parts: hardware acquisition, algorithm checking, and hardware setting modification. A frequency of 1 Hz has been chosen for the acquisition providing a sufficiently fast reaction time in case of vacuum degradation or sparks (spark bursts are interlocked by software in the HV generators itself). It is noteworthy that the TS Tool Kit is able to provide considerable shorter reaction times if run on sufficiently performant hosts. Separator conditioning for the whole of LEP is presently run from a central HP workstation, even when several tanks need to be conditioned in parallel. Due to the full platform independence of TS Tool Kit applications, individual processes could be also be run locally or separately for each interaction point, without any modification.

```
WHEN Maximum electrical field reached
   DO
      IF First time
         THEN
            Double charging current
         ELSE
            Check spark rate
      ENDIF
   ENDDO

WHEN Poor vacuum
   DO
      Decrement charging current
   ENDDO

WHEN Sparks
   DO
      Decrement charging current
   ENDDO

WHEN Conditioning rate too low
   DO
      Increment charging current
   ENDDO

WHEN Conditioning rate too high
   DO
      Decrement charging current
ENDDO
```

Fig 3. Set of TScontrol rules constituting the main conditioning algorithm (largely simplified).

In terms of numbers the new algorithm comprises 25 rules with a total of 500 lines. In comparison, the previous implementation comprised about 6500 lines of C code and some minor parts in assembler.

6. CONCLUSION

Despite its considerable advantages in flexibility and user-friendliness over the previous solution, the new automatic conditioning of the LEP separators has been realised, using the TS Tool Kit software package, in a much shorter time scale (ca. 2 man-months counted from after the user specification phase compared to ca. 1.5 man-years for the old process). All tests have so far been successfully achieved. The process will be intensively used during the coming LEP shutdown.

The new solution will be much easier to maintain and adapt to new needs if necessary, even outside its original LEP applications.

As the TS Tool Kit is nicely integrated into the CERN SL accelerator control system (offering interfaces to the X user interface, the general CERN alarm system, and Oracle on-line databases) further extensions of the automatic conditioning, like alarm generation and forwarding or graphical user interfaces are quite straightforward.

ACKNOWLEDGEMENTS

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