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The New Control System for the LEP Pretzel Separators

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Abstract

A Pretzel separator system has been set up recently at LEP in order to increase the luminosity of the machine by operating with a higher number of bunches. The electronics to control the separator components is largely based on industrial off-the-shelf material. The software required for equipment-level control, equipment monitoring, and fault diagnosis has been implemented using a highly configurable and thus re-usable tool kit.

I. INTRODUCTION

A Pretzel separator scheme has been set up at the e^+e^- storage ring LEP at CERN which allows the machine to be operated with twice as many e^+ and e^- bunches (8 + 8) in order to increase the luminosity [1]. It consists of 8 electrostatic separators, recuperated from the former SppbarS collider, which were installed in 4 different LEP points in 1991 and 1992. Two further separators (so called 'trim separators') have been added in two other LEP points in 1993 which allow compensation for small imperfections in the beam optics of the storage ring.

For the trim separators a new control system has been set up, which is largely based on industrial off-the-shelf components, following the principles laid down in [2]. Time considerations have meant that, until now, the other 8 separators were still controlled by old electronics recuperated together with the equipment from the SPS [3]. This is currently being replaced by the same system already in use for the trim separators. Comprehensive software for control, supervision, and diagnostics has been provided in the framework of a generic tool kit [4].

II. DESCRIPTION OF THE CONTROL SYSTEM

II.1. The equipment

The equipment to be controlled consists, in each of the 6 LEP points concerned, of high voltage generators (+/- 180 kV or +/- 300 kV, resp.), high voltage switches, and motor systems to move the separator electrodes. Auxiliary facilities like spark counters for the separator electrodes and an interface to the LEP vacuum system [5], are required for a safe operation of the separators.

II.2. The equipment controllers

For each of the components described above a separate equipment controller has been built (the controller for the electrode motor systems is currently under development). Each controller consists of a set of digital and analogue I/O modules from the range of a commercial I/O system [6] mounted in a 19" crate with a CPU module which provides a BITBUS [7, 8] connection to the next higher level of the control system. The wire connections to the equipment are made using screw terminals. The system already provides a multitude of indicator lamps, however, some local control facilities such as displays, push buttons, and potentiometers have been added where needed, to facilitate stand-alone equipment tests. Furthermore, an RS-232 interface on the CPU module allows to access the system, e.g. through a hand-held terminal.

The software running in the CPU modules was largely provided as firmware by the manufacturer, e.g. the kernel which handles the communication over the BITBUS and the access kit for the I/O modules, The addition of user specific code was much simplified through templates and a comprehensive software library. Nevertheless, such code has been kept to a strict minimum, like the decoding of commands, range checking, and the calculation of mean values. Most of the local control elements mentioned above are also handled by this software, to avoid over-complicated additional wiring. All external accesses to the controller, via the BITBUS or the RS-232 link, are channeled through the same piece of code assuring an identical functionality. All software has been written in C, cross-compiled on a PC [9], and downloaded into the controllers. Debugging facilities are included in the cross development package.

II.3. The process controllers

In the case of the present application the process controllers consist of industrial rack-mountable PCs, running the real-time multi-user / multi-tasking operating system LynxOS. These were provided, together with the uniform software infrastructure required to manage them and to access the attached equipment [10], by the CERN-SL Controls group. These PCs form the interface between the application specific electronics and controllers and the accelerator-wide controls network.

The equipment controllers are connected to the associated process controller by means of the BITBUS. For

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the proper integration with the LynxOS operating system a BITBUS driver has been developed by a company [11]. The handling of commands issued to an equipment controller and the connection with the driver level is performed, at the level of the process controller, by a process called 'message handler' [12] forming part of the software infrastructure mentioned above. There are also facilities to download new code into the equipment controllers over the network [13], once this becomes necessary. No application specific software is needed at this level.

II.4. Software to control, supervise, and diagnose the equipment

The software used to control, supervise, and diagnose the equipment has been provided in the framework of a simple generic, thus re-usable, software tool kit [4]. At present this runs on a workstation in the SPS/LEP main control room but could, in principle, run on any UNIX type computer in the network with access to the equipment.

The tool kit consists essentially of a shared data base and a set of client modules, each dealing with a specific controls task, such as data acquisition, the running of control algorithms, or the generation of alarm messages. The application specific behaviour is given through data files which are read in and interpreted at startup.

For the new Pretzel separator control system this tool kit provides the following functions:

- it translates all 'high-level actions' from the main control room into the proper sequence of equipment specific actions thus providing the desirable abstraction from the details of the equipment handling,
- it monitors continuously the equipment values, detects fault conditions, generates alarm messages and injects them into the general alarm system [14],
- it produces diagnostic files to trace back faults or to detect early a degradation of the equipment, and notifies the equipment specialists by E-mail,
- it provides an uniform interface for the equipment specialists for on-line inspection of all values and control of all parameters, and
- it provides an uniform and simple interface towards other services wishing to acquire data about the Pretzel separators or to control the Pretzel separators in the framework of the global accelerator control.

It should be noted that, apart from the tool kit itself, which is also being used in other applications [15], no further C programming was required to provide the described functionality.

III. CONCLUSION

The control for the Pretzel separators has been the first system in which the ideas presented in [1] have been thoroughly and successfully applied. After an initial learning phase the basic elements (I/O hardware system, cross software environment, controls tool kit) are now all well mastered. The massive use of pre-fabricated, resp. commercial software, and the limited production of specific code led to a rather well documented system from the very beginning and will reduce the time needed for further maintenance. The use of BITBUS as field bus opens the possibility to integrate rapidly control components from many different vendors.

The elements developed for this application by, or in collaboration with, the CERN-SL Controls group, resp. by industry (LynxOS driver, download facility), have permitted the harmonious integration of the system into the overall controls concept. As a result it has now become possible to set up similar new applications in a rather short time.

IV. ACKNOWLEDGEMENTS

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