Upgrading the Controls of the SPS Vacuum System

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Abstract

As a consequence of the rejuvenation of the SPS control system, the controls for the vacuum system have to be modified. This is a unique opportunity to have them converge with those of LEP, a feature even more appreciated since there is a single vacuum group that maintains both vacuum systems and one operation group that runs both accelerators.

The new controls for the SPS vacuum system closely follow the guide-lines of the CERN wide accelerator control convergence project.

Four levels can be identified in the new control system which are, from bottom up: the existing pump power supplies or new industrial gauge power supplies and the existing valve control units, G-64 chassis controlling these items and unifying their access methods, VME chassis acting as data concentrators and Apollo workstations used for the man-machine interface. RS-232 interfaces have been chosen for the G-64 chassis and for the industrial gauge power supplies. The physical RS-232 lines are multiplexed through concentrator boxes based on X.25 protocol to connect them to the VME chassis. The VME chassis and the Apollo workstations are connected onto the main LEP/SPS Ethernet and Token Ring network.

As for LEP, the software for the SPS vacuum controls has been designed to be as much data driven as possible. CERN standards have been used for communication, that is the LEP message format is used between G-64 and VME and Remote Procedure Calls are used between the VME chassis and the Apollo workstations. Finally a uniform graphical interface based on an expert system is used for the man-machine interface.

1. INTRODUCTION

The SPS vacuum controls were based on CAMAC and the CERN Multiplex addressing and acquisition system. The equipment did not have any data processing potential and all the data handling was done in Norsk-Data computers, running NODAL programs.

Because the Norsk-Data computers are now obsolete, the decision was made to replace them by a more modern hardware. At the same time, the opportunity was there to have the SPS controls converge with those of LEP [1] and of the PS complex.

The three level architecture which has been chosen to be the foundation of all future CERN control systems is also used for the vacuum system. Hardware is driven by G-64 chassis connected to VME chassis which concentrate the data and make it accessible to the remote workstations where the man-machine interface and applications are run [2].

The new controls for the vacuum system had to take into account the existing hardware, as well as some recently installed industrial gauge controllers. Mainly because of the latter, RS-232 standard rather than the proposed MIL-1553 standard has been chosen to communicate between the G-64 or the industrial equipment and the VME chassis. Figure 1 pictures the overall layout used for the vacuum controls.

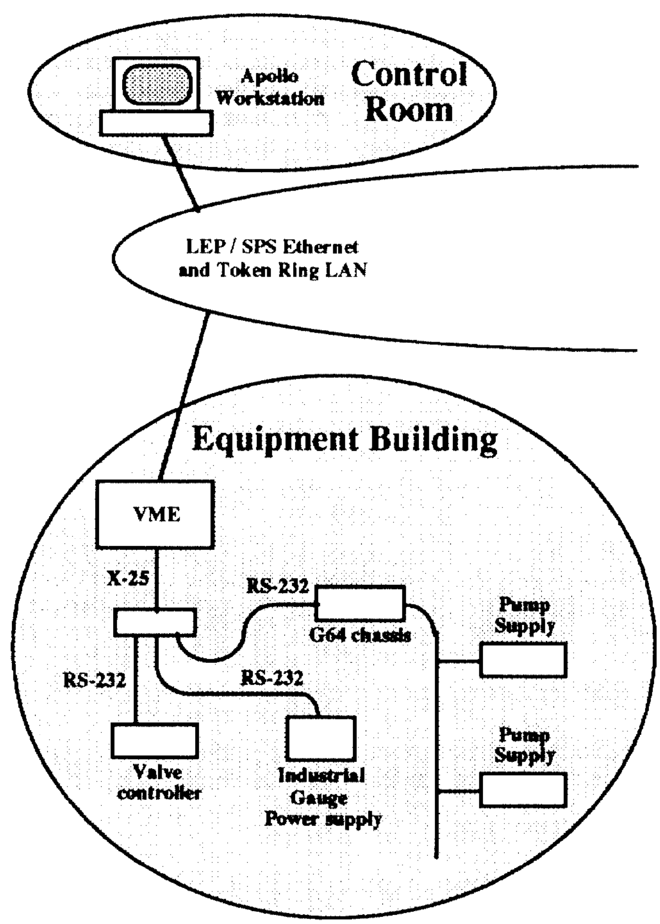

Fig. 1, overall layout

2. G-64 AND INDUSTRIAL EQUIPMENT

2.1 *Boundary conditions*

For obvious cost reasons, it was required to minimize the modifications made to the existing power supplies and to keep the cabling between the power supplies or the control units and the pumps, gauges, valves and other items as it was. The G-64 standard for low cost micro-processor controlled chassis was chosen for its wide availability within CERN. Whenever possible, G-64 boards have been bought from industry.

2.2 *Ion Pumps*

The existing ion pump power supplies have been equiped with an additional board, mounted on their rear panel, allowing to read and control them by multiplexing up to 10 pump power supplies on a same flat cable. Up to eight of these chains of power supplies are connected to a G-64 chassis, which runs the supervision and access program.

The programs are written in PASCAL, with some small assembler support for interrupt handling. The G-64 chassis communicate with the VME chassis over RS-232 lines, using the LEP message format [3]. The messages are defined in the central data base (ORACLE) and a data driven decoder interprets them [4]. Command/response mode is exclusively used for access. Because of hardware restrictions, access time is poor, in the order of 500 ms per power supply, requiring that data be updated in tables which can be instantly accessed by the VME chassis.

2.3 *Sublimation pumps*

New G-64 chassis have replaced the previous CIM-bus based hardware, keeping all the cabling and pump power supply as they were, however. Here again, RS-232 interfaces and the LEP message format and decoder have been used to communicate with the VME chassis and the programs have been written in PASCAL.

2.4 *Sector valves and pumping stations*

For most of the valves and all of the pumping stations, the existing control equipment was already based on a proprietary control bus. It was therefore only needed to add a processor card running the control programs and communicating with the VME chassis using an RS-232 line. Unlike the previous items, it is possible to control the valves and pumping stations both from the old Multiplex system and via the new processor card. The remaining valves are connected to G-64 chassis. Once again, the LEP message format and decoder have been used and the programs have been written in PASCAL.

2.5 *Industrial gauge controllers*

The Pirani and Penning gauges have been bought with their matching power supplies from Balzers. These power supplies come with an RS-232 interface. However, the message format is proprietary to Balzers. It was therefore required to add a control program which accepts standard LEP messages and issues the appropriate control sequences to the gauge power supplies. This control and access program has been installed in the VME chassis rather than in an additional G-64 chassis, for cost reasons.

2.6 *Use of operational protocols*

A significant effort is under way at CERN to define operational protocols in various fields, like power converters, instrumentation and vacuum [5]. These guide-lines have been largely used in the definition of the messages to the equipment.

3. VME CHASSIS (DSC)

3.1 *Hardware*

Standard Motorola VME chassis with a MVM147 CPU board are installed in the equipment buildings. They are referred to as Device Stub Controllers (DSC). The CPU board includes all RAM and ROM, RS-232 lines for the console and an Ethernet interface.

The decision to use RS-232 as transmission protocol to the micro controller equipment requires a great number of RS-232 ports for each DSC. This problem has been solved by using Motorola MVME336 modules, which support up to six X.25 point to point links. The other end of each X.25 link is connected to a SYS336 RS-232 concentrator box, with up to sixteen RS-232 ports. The maximum capacity for this system is thus 96 RS-232 ports, which has until now been enough for each SPS access point (BA2, BA3).

A real benefit gained by employing this approach is the fact that the RS-232 concentrator boxes can be distributed via X.25 lines in the machine, limiting the length of the RS-232 flat cables, and thereby reducing the bit-error-rate introduced by the noisy electromagnetic environment.

3.1 *Software*

The first implementation of the new vacuum control software has been written using the OS-9 operating system and is currently operational. Driven by a decision of using LynxOS, a UNIX like realtime operating system, on a CERN wide basis for the accelerator controls, a second version is being worked on.

The vacuum control system is implemented in a distributed processing concept, over two main threads - command/send - response/receive. An event driven intercommunication has been chosen using POSIX semaphores, propritary message queues implemented in shared memory and Remote Procedure Calls (RPC). All the programs have been written in the C language, but C++ might be introduced in the near future.

The purpose of the vacuum control software in the VME crate, is to handle the routing and demultiplexing of complex equipment calls arriving from the CERN wide network, in the form of RPC. The software provides thus the possibility of several simultaneous connections from Eg. the main control room, individual offices, remote consoles in the machine etc.

To speed up the response time for cluster commands asking for pressures or status on, for instance, a sector basis, a background program runs continually to acquire data from all equipment supervised by the VME chassis. Every 15 minutes a table is updated with all status information given for the different equipment classes together with a corresponding timestamp. For the purpose of vacuum surveillance 15 minutes old data is normally acceptable. However, as soon as some particular information is read out from the table, the concerned equipment is flagged as requiring an immediate update, so as to insure that the next readout obtains recent data.

Complex equipment calls like "give me the pressures in sector 310" are demultiplexed into single equipment calls, Eg. "give me the pressure for equipment_class, equipment_identifier". All the single equipment calls can be distributed in parallel asynchronously, hereby saving the overhead of the synchronous command/response concept. An obvious advantage of this concept is that it is possible to close all sector valves at the same time or to get instantaneously the pressure distribution over a complete sextant. All answers from the individual equipment are collected and put sequentially into a proprietary response structure, which is returned to the requesting user.

The handling of the equipment calls is using a completely data-driven concept, that means: the relations between sector number and equipment identifier, the appropriate path and communication parameters for the equipment call, etc... are retrieved from data tables, which are derived from the central data base engine, a VAX running the ORACLE relational data base management system.

Before sent on the X.25 lines, the equipment calls are converted into messages with the standard LEP format. These messages are checked for their consistency before being sent either to the appropriate RS-232 port (via the X.25 driver) or to an internal application like the gauge control.

The vacuum control software in the VME crate also provides a way of directly issuing calls using the LEP message format. This is mainly intended for diagnostic and debugging.

Last but not least, the messages are sent on the communication media (X.25/RS-232) and a time-to-live is established for each message for eventually issuing a timeout later.

4. VACUUM SUPERVISION PROGRAMS

At the time of writing the vacuum supervision program is run on Apollo workstations. It is based on an commercial drawing packet and a CERN based unified man-machine interface [6]. Because of the latter, it is possible to run the vacuum supervision program as an X11 client, which can be accessed from any X11 server, hence opening its use to a large variety of platforms.

The functionality of the supervision program includes overviews of complete sextants and of sectors, including the valves, interlocks, pumps and gauges. Commands are entered by pointing and clicking on pre-defined objects on the screen.

It is important to note that this program is essentially the same as the one used for LEP [7], hence minimising the maintenance overhead.

5. STATUS

At the time of writing, two sextant of the SPS have been upgraded to the new control system. Whilst OS-9 is still running in the VME chassis, we intend to move to Lynx-OS in the next few months. If money permits, we shall install a third sextant during this year and we aim at finishing the project during the 1993 long shut-down.

[1] P. Strubin, Controls for the vacuum system of LEP, J Vac Sci Technol,A5(4), Jul/Aug 1987
[2] D. Swoboda, the new vacuum control system for the SPS, IEEE Particle Accelerator Conference, San-Francisco, 1991, p.1516
[3] LEP-SPS Controls Group, LEP Controls Note 54, 1986
[4] P. Strubin, Automatic decoding of the control messages for the LEP Vacuum System, 8th European ORACLE User Group Conference, Madrid, 1990
[5] P. Strubin at all., Operational Protocols for Vacuum Systems, AT-VA-91-6 (1991)
[6] P. Ninin, J.-P. Regin, P. Sollander and M. Vanden Eynden, Uniform Man Machine model for the control of industrial equipment, CERN-SL/90-94 (OP), 1990
[7] S. Vossiniotis and P. Strubin, Accessing the vacuum equipment of the LEP collider from the Main Control Room, CERN LEP Controls Note 99 (1989)