

The New Vacuum Control System for the SPS

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Abstract

The Super Proton Synchrotron (SPS) accelerator at CERN was put into service in 1976. The vacuum control equipment is located mainly in six surface buildings (BA) which are at distances of about 1.5 km from each other. Maintenance and repair of major parts of the vacuum control system have become very expensive if not impossible. The paper describes the hard- and software choices which have been made to replace the existing control system, taking the limitations of the already installed control equipment into account and being based on available and proven technologies.

I. INTRODUCTION

The general data communications system for the control of the SPS accelerator is in operation since the commissioning of the SPS in 1976[1]. A new communication system, relying on the same architecture as in LEP[2] has now been installed in the SPS tunnel and will gradually replace the original system at the rate at which the control equipment is being converted to the new standards. The control equipment for the vacuum system has been developed throughout the life of the SPS under various standards. To obtain the same state of the art level of control for all equipment, it is necessary to upgrade substantially most of the control systems. The replacement of obsolete and onerously maintainable equipment is being undertaken on a building by building basis, system by system, over the years 1990 - 1993.

II. NEW CONTROL SYSTEM ARCHITECTURE

A. Accelerator Network

The system is built from three hierarchical levels which follow, where possible, widely used communications standards. The top layer (*accelerator network*) is used to link the distant buildings. Each building is equipped with a local control computer which is connected to the network and which in turn provides the necessary communications links with the control instrumentation. The totality of the equipment will be interfaced through RS 232 connections in order to obtain a uniform and versatile communications interface at the instrumentation level.

The general transmission system between SPS sites, which is already in operation, complies with the Token-Ring protocol[5]. Inside the BA buildings, this backbone network is isolated from the local communication systems, i.e. Token-Ring and Ethernet (IEEE 802.3), through gateways and bridges but which are transparent to the application software.

B. Equipment Control Computer

The presently installed NORISK frontend minicomputers (GPx) in the BA buildings are being replaced by so-called Device Stub Controllers (DSC)[6].

One *System Equipment Control Computer* (DSC) per building is connected to the general communications network and provides the X.25 links for the control of the vacuum equipment. It is the task of the DSC to supervise the control instrumentation in order to guaranty the integrity of the vacuum control. The DSC are VME based systems, running a real-time operating system (OS9). The communications protocol over the accelerator network conforms to the TCP/IP protocol suite, whereas X.25 [7] is used to exchange information with the vacuum control equipment.

C. Equipment Communications Link

At present, virtually all of the equipment is connected to the MPX system[3]. The vacuum system does not require sophisticated control strategies and algorithms. The required tasks are essentially

- the execution of user driven commands
- the surveillance of status information
- the signalling of exception conditions
- the reading and conversion of analog values
- the inhibition or resetting of commands.

This information can be transported by a "slow" communications link. The MPX system is, therefore, replaced by RS 232 point to point links which connect the equipment to RS 232 concentrator modules with 16 ports each. These are connected to the DSC via X.25 links (Fig. 1)

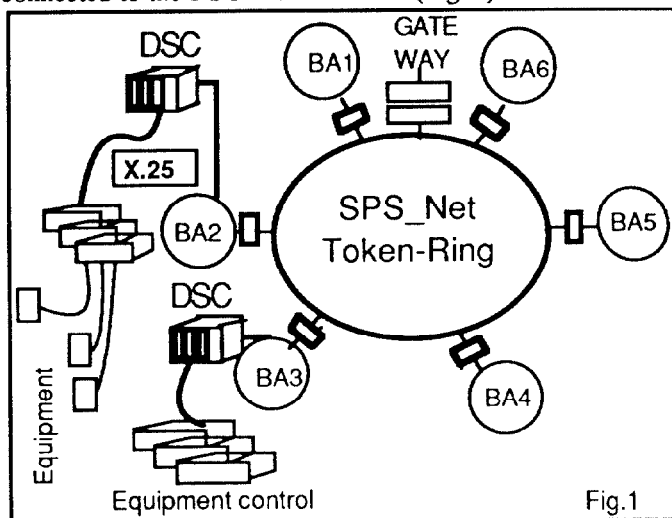


Fig.1

The architecture provides the following advantages

- a) Easy conversion of the presently installed instrumentation to the new communications system, e.g. virtually all equipment is provided with a serial interface or can be equipped with such.
- b) The unique connection standard largely simplifies modifications or configuration changes of the control system.
- c) The required hardware and communications software consists of standard tested industrial equipment and uses internationally accepted communications standards.

III. CONTROLS HARDWARE ADAPTION

A. Sputter Ion Pump Supplies

The adaption of the power supply controls to the new communication system is being undertaken in the course of a general overhaul and modification of the presently installed supplies.

The two major improvements are:

- higher precision of the pump current as a measure of the actual pressure in the beam pipe.
- simplification of the necessary controls cabling for easier maintenance and reduced costs.

In order to simplify cabling and control of the power supplies, the rearpanels of the units are replaced by a mounting which includes a small printed circuit (addressing unit)[8] and is connected to a flat cable which acts as a parallel bus. Up to 15 supply units can be connected to each of the 8 ports in a 19" G64 controller chassis.

B. Sublimation Pumps

Approximately 1300 sublimation pumps are distributed around the SPS accelerator. Groups of up to 10 pumps are chained over a single control cable which is connected to controller crates in the surface buildings.

Newly designed controller crates similar to those for the sputter ion pumps[9] are replacing the presently installed CIM-bus controller crates.

Each G64 crate can handle up to 8 chains of sublimation pumps. The functionality of the new equipment corresponds essentially to that of the CIM bus system. One important improvement is the hardware interlock to switch the 380 Volt mains off in case of malfunction of the system. They are divided into a proper interlock crate which controls the mains over a relay switch and into a watchdog circuit board in each sublimation pump controller crate which monitors the operation of the crate, each of which may be isolated from the interlock chain to allow sublimation despite the failure of this controller crate.

C. Gauges

200 new gauge control units have been received to replace the presently installed instruments. The new control units are equipped with serial interface connectors according to RS 232 and are directly connected to the RS 232 concentrators.

D. MACBUS systems

The MACBUS is a backplane bus [10], similar to G64 and has been implemented for the control of Roughing Pump stations, Vacuum Valves and the Sector Valve interlock Chain. At present, the MACBUS crates are controlled via the MPX. However, the available CPU cards, with 8 Bit microprocessors are equipped with serial line interfaces, according to RS 422 and may, consequently, be directly connected to RS 232 lines.

Those vacuum valves which are not connected to the MACBUS are readily equipped with a MPX interface connector where all the signals are provided in form of open contacts. The addressing interface which has been developed for the control of the sputter ion pump supplies is being adapted for this purpose. As a consequence, both kinds of equipment could be connected to the same parallel bus.

IV. SOFTWARE

A. Communication

Configuration data is transferred to the local control computers using TelNet. The equipment is accessed, conform to the LEP vacuum message format[11]. Requests to a DSC are sent in form of *Remote Procedure Calls* (RPC).

The replacement of the MPX by a serial link modifies largely the method of equipment control. More intelligence is close to the instrumentation, thus relieving considerably the load on the control computers. As a consequence, however, the control routines at the instrumentation level have to be modified correspondingly and the information exchange between control computers and remote equipment controllers must be added. In addition, software in the control computers is required to manage the instrumentation busses and the equipment database. The communication process between control computer and equipment is mainly of the command response type. An equipment with an outstanding message must at present wait until being polled by the control computer. File transfer is only required in case of a configuration update or rebooting of the equipment controller.

B. Database

A powerful database is one of the key requirements for efficient operation and maintenance of as large a system as the SPS vacuum control. The ORACLE database is already in widespread use at CERN (i.e. LEP vacuum system) and available on the SPS network[12].

The kind of information which is contained in the database is essentially of three types:

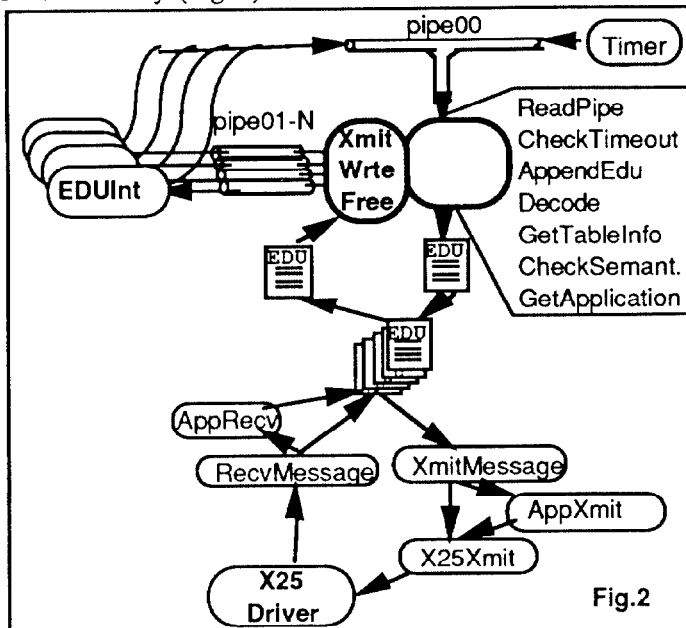
- The description of the SPS accelerator defines the physical layout of the machine, such as sector numbers and names, machine positions and such like. This information will in principle only vary in case of major modifications in the SPS tunnel.
- The description of the communications path contains the necessary correspondence tables between equipment names and positions in the accelerator as well as the absolute network address of the item. These tables are relatively dynamic, since they change as soon as equipment is being moved to other locations. The address of an item is fully described by the "family-member" which identifies equally the RS 232 port to which it is connected.
- The description of the equipment contains the static information about each kind of equipment. A "family" defines the characteristics of an equipment. Each "family" includes an Equipment Data Module (EDM) which consists of the parameters, commands and functions that this kind of equipment may recognize and execute.

The cabling list database provides the correspondence between the equipment, installed in the accelerator tunnel and the related control instrument.

The inventory database of the vacuum equipment of the SPS is linked to this list. The database is used to keep track of the movement and state of the equipment and to establish the "Family-Member" relationship.

C. Application programs

The control computer (DSC) in each building (BA) is responsible for the information routing and checking between equipment controllers and application program, e.g. interactive or batch program. The dynamic pipe-allocation for each transfer session allows multiple equipment access simultaneously (Fig. 2).



Each DSC runs a Data-Server process which is the default message handler. The Data-Server accesses the local database for address verification and checking of command and equipment type before forwarding the request to the Equipment Directory Unit (EDU). The EDU is responsible for the transmission over the X.25 Interface. Depending on the type of access, different application programs may be called before the transmission, for example to read the pressure of an entire accelerator sextant. The EDU can be directly accessed via the communications interface. In this case a pipe will be opened prior to the connection.

The Equipment Controllers interact with the equipment, such as pumps, valves, etc.. Most devices can accept messages in the standard LEP message format and execute the requested action. The CPU has full control over the equipment and exception conditions can be signalled to the DSC at any time.

Commercial instruments, e.g. vacuum gauge control units, terminals, etc., however, require a corresponding control program in the DSC.

D. User Interface

The general introduction of workstations and PC based consoles provide the tools for graphical user interfaces. Highlevel languages, like C, and multitasking operating systems are replacing the present environment, i.e. Nodal and Sintron[4]. The user access to the vacuum control system will follow the presentation which was chosen for LEP. Since the message format and the addressing scheme are similar, many of the user interface programs may be easily ported to the SPS environment.

In the first stage the user interface which has been developed on the Apollo Domain network is being used while the screen representations, written under the X11 standard, are still under development.

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