Upgrading of Vacuum Control Systems
for Linac2, Linac3 and the PS Booster

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Abstract

Since the beginning of 1993 a new vacuum control system for the PS accelerators has been partly installed. The purpose is on one hand to be compatible with the new global control system of the PS complex, and, on the other hand, to integrate the system into a coherent standard vacuum control system at CERN.

For each accelerator the new hardware architecture is composed of two layers. The upper layer consists of a VME crate (DSC) dealing with communication and data collection. The lower layer consists of G64 chassis and industrial equipment (gauges, pumps, gas controllers). The purpose of this lower layer is to perform raw data acquisitions and to execute commands.

The emphasis is to make a standard software interface for all vacuum equipment at CERN. This includes protocols, databases, equipment directory unit, servers and user interfaces. This paper gives a summary of the standard hardware and software architecture which has been employed for this project.

1. INTRODUCTION

The aim of a vacuum control system is to allow local and remote control of all equipment used to achieve ultra high vacuum of the accelerator.

Typical devices to be controlled are Pirani, Penning and Bayard-Alpert gauges, turbo-molecular, ion and sublimation pumps, valves, gas analysers, ...

This system is a small part of the whole control of the accelerator [1] and for this reason it must be completely compatible (hardware and software) with it, but also with a clearly defined limit of responsibility.

The VME crate, called DSC (Device Stub Controller) and some VME cards (CPU, SAC, ...) are provided and maintained by the PS-Controls group as well as the software environment (Lynx OS, Equipment modules, ...). All other parts are under the responsibility of the AT-Vacuum group.

The choice of our hardware is based on the following points :
-   To use, as widely as possible, industry standards (VME, G64, X25, RS232,...).
-   To use, whenever it is possible, industrial vacuum equipment.
-   To minimise the number of different specific interface chassis.

The number of channels to be controlled is from around 70 for the Linac 2 up to more then 200 for the PS Booster.

2. HARDWARE DESCRIPTION

The hardware architecture is exactly the same for each accelerator. It is composed of two layers:

-   The upper layer consists of one VME crate (DSC), dedicated to the vacuum system, and used for the communication and data acquisition. This DSC is connected to the software server and to the workstations via an Ethernet link.
-   The lower layer consists of many G64 specific chassis and industrial equipment used to control all the vacuum equipment (gauges, valves, pumps, ...).

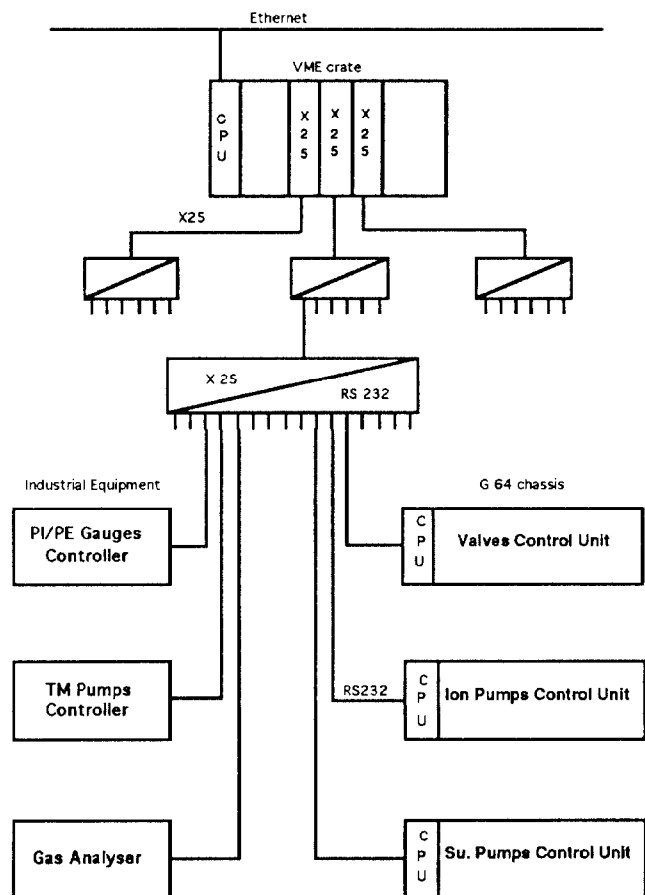The link between the two layers is made by a point to point X25 link driving RS232 terminal servers.

Figure 1. Overall Layout

2.1 DSC

The DSC consists of a 6 slots, diskless, VME crate with at least the following VME cards:

- The CPU unit, type Motorola MVME147, with eight Mbytes of memory and an Ethernet interface.
- The SAC unit for remote reset and supervision.
- The X25 interface unit(s), type Motorola MVME336, with six 1 Mbyte/s full duplex data link ports.

2.2 X25 Point to point link

Each X25 VME card is connected, via a hub module, to six remote terminal servers, each server providing up to sixteen RS232 full duplex lines.

Therefore, one VME board allows to control up to 96 RS232 channels. This choice implies that all vacuum equipment have an RS232 interface. This is the case, now, for the majority of industrial controllers.

2.3 G64 Chassis

Only three specific chassis with their cards have been developed for the control of the valves (VCU), ion-pumps (PCU) and for sublimation pumps or ion gauges (SCU). These chassis are based on a G64 bus in an Europa 3U frame. They accept 160 and 220 mm long G64 cards.

The processor unit (MC6809E) includes RAM and EPROM memories, a Real Time Clock circuit and two RS232 interfaces. The control program and device parameters are stored in EPROM. The first RS232 port is used for the communication with the DSC while the second can be connected to a dumb terminal to execute local controls and tests of the G64 chassis.

- The VCU (Valves Control Unit) chassis provides the local and remote control of up to 8 valves of any types used at CERN. It can also be used to drive special industrial valve controllers.

- The PCU (Pumps Control Unit) chassis allows for the remote control, status and pressure acquisition of up to 8 Ion pump power supplies of any type.

- The SCU (Sublimation Control Unit) chassis can drives up to 16 Sublimation pump power supplies. The same card can be used with 8 Ion gauge controllers.

2.4 Industrial Equipment

More and more industrial equipment, from different vacuum manufacturers, are integrated in our systems :

Pirani & Penning gauges controllers, Turbo-molecular pump controllers, Gas analysers, ...

The integration of new equipment is facilitated by the choice of the standard RS232 interface.

3. SOFTWARE ARCHITECTURE

In the PS accelerator complex, the application level software (User interface [2], ...) and the DSC software environment (Lynx OS, Equipment modules [3], ...) are under the responsibility of the PS controls group. Only the specific equipment software in under the responsibility of AT vacuum group.

This software is based on the operational protocol for vacuum systems [4] and applies the principle of distributed intelligence. At the higher level, DSC crates provide for data collection, routing and interfacing to the main control system of the accelerator and at the low level, G64 chassis or industrial controllers handle autonomously the vacuum equipment.
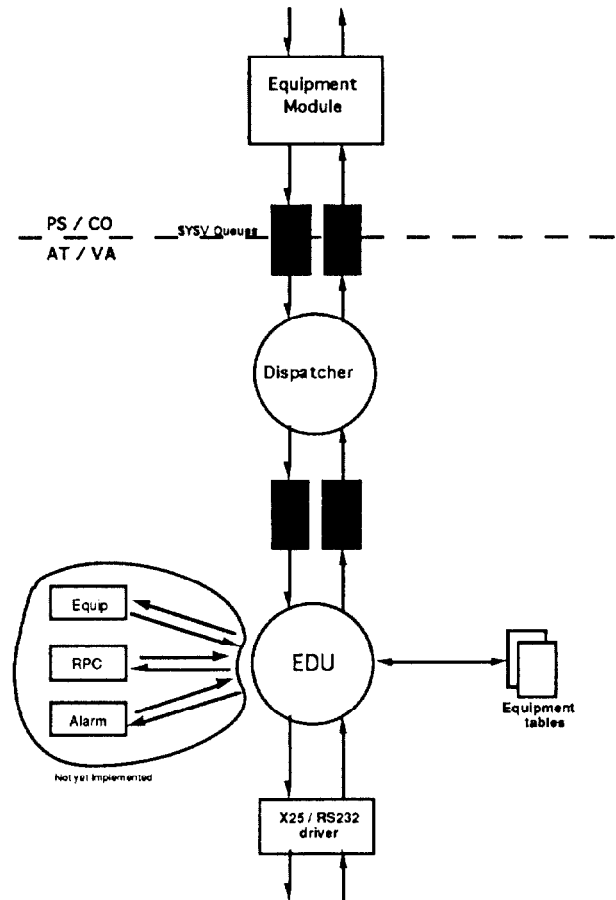

Figure 2. Software Architecture

3.1 DSC Level

The software running under Lynx OS, a real-time operating system, has the purpose of:
- protocol dispatching
- general message routing and communication support.

3.1.1 Protocol dispatching

An interface has been specified based on SYS V Queues in which a CERN standard protocol called USAP, Uniformisation of Software Access Procedures [5], is used for message passing from the application software layers to the equipment layer.

The most important characteristic of USAP is its intended independence of the different control groups at CERN. Attributes of equipment such as 'ON', 'OFF', 'START', 'STOP', etc. are standardised and only few equipment specific attributes must be defined by the controls group.

The control and data collection is done through asynchronous or synchronous control and acquisition messages dispatched through a standard header which also includes information, such as an equipment identifier. A number of fields has been laid out for each type of message with well defined types. These fields can then be used by the controls group to pass their attributes.

The incoming USAP message is either dispatched to a special protocol used internally within the vacuum group, between DSc's and G64 chassis, or to industrial protocols for access to equipment directly connected to the DSC.

The design of the vacuum protocol is based around the same principles as USAP, but has the important advantage of overhead reduction. A field in the header is reserved for information about the control fields. This allows for a variable length of the message, determined at runtime, which reduces greatly the transmission time. Furthermore the message is coded in a readable ASCII string before transmission, mainly to insure compatibility with the XON/XOFF protocol over the RS232 link.

3.1.2 General message routing and communication support

For the equipment access layer the software was already developed for the SPS accelerator [6] and could be reused without any changes. This software layer consists of the communication driver for the X.25/RS232 Terminal Server and an Equipment Directory Unit (EDU).

The EDU is the engine providing the message routing and handles the X.25/RS232 communication driver. Like for LEP and SPS, the EDU is based on a data driven concept, integrating data tables created from the central Oracle database. The EDU provides for multiple interfaces which enables independent servers (alarm, equip, rpc, ...) in simultaneous access. This facility is currently only used in SPS.

3.2 G64 Level

The software structure is exactly the same, whatever the type of G64 chassis, and uses a completely data-driven concept.

The embedded program, written in Pascal and Assembler, is composed of 4 main parts :

- The Real Time part which controls the vacuum devices (actuations, data and status acquisitions). It is the only specific part of the program.
- The Data Tables which contains all the information about the vacuum devices (number, type, parameters, ..).
- The Communication Handler which receives and sends back messages from and to the DSC. The structure of the messages is compatible with the USAP frame but is adapted to our specific needs, as explained earlier.

The Local Control and Tests program which is a set of facilities, easy to use by the specialist, for a direct access to the equipment.

4. CONCLUSION

After one and half year of operation on the Linac 2 and six months on the Linac 3 and on the PS Booster this new system meets our initial requirements. Some software parts still have to be written or improved to provide a completely operational system. The next step will be the upgrade of the PS accelerator and its transfer lines. It will be done during the 1995 shutdown.

5. REFERENCES

[1] F. Perriollat, The new CERN PS Control System - Status and Overview, ICALEPCS'93 Berlin.
[2] F. Di Maio et all, The operator interface to the equipment of the CERN PS accelerators, ICALEPCS'93 Berlin.
[3] A. Rosenstedt, Control System Software for the vacuum system, CERN/PS, Note 92-21, 1992.
[4] P. Strubin et all, Operational protocol for vacuum system, CERN/AT-VA 91-6, 1991.
[5] G. Benincasa et all, Final report on the uniform equipment access at CERN, CERN/PS 93-16, 1993.
[6] W. Koelemeijer et all, Upgrading the Controls of the SPS Vacuum System, EPAC 92, Berlin.