The New Vacuum Control System of the CERN PS Complex

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Between 1992 and 1995, a new vacuum control system has been installed step-by-step on the different accelerators of the CERN PS Complex (Linac2, Linac3, PS Booster and PS) as well as on the related beam transfer lines. This project has been carried out in parallel with the installation of the new main control system of the CERN PS accelerators.

The initial goal was, on one hand, to rejuvenate old equipment whose technology was very difficult to adapt to the new control methods, and on the other hand, for obvious compatibility and maintenance reasons, to standardise the hardware and software of these different systems. The hardware's two level architecture fits in very well with our needs of distributed control. Standardised and industrial equipment (VME and G64 boards and chassis, RS232 and X25 field buses, etc.) has been used where ever possible. The software is structured in two layers to obtain a standard interface to all the vacuum equipment for each of the different accelerators. This presentation describes the hardware and software architecture of this project as well as the different equipment used.

1 INTRODUCTION

The CERN PS complex is a set of inter-connected accelerators which can accelerate different types of particles and send them on to other accelerators (AAC, LEAR, SPS and LEP) or directly to experimental areas. It consists of the following accelerators: LINAC2 (Proton Linac), LINAC3 (Heavy Ion Linac), PS (Proton Synchroton), PSB (PS Booster), LIL (Lep Injector Linac), EPA (Electron Positron Accumulator) and all the transfer lines between these different accelerators.

In 1992 the controls group of the PS division started the important project of rejuvenating, step by step, the main control system of these different accelerators [1]. At the same time the vacuum group of the AT division took a similar action to install its new control system. The main goal was to rejuvenate old equipment which did not adapt well to the new control methods, and also to standardise the hardware and software of all these accelerators using standardised and industrial equipment where ever possible.

The new vacuum control system became operational on the accelerators as follows: in 1993 LINAC2, in 1994 LINAC3 and PSB, in 1995 PS and the transfer lines. At the current time, this represents about 700 pieces of vacuum equipment (pumps, gauges, valves, etc.) accessible via the new control system.

This paper gives an overview of the new vacuum control system and describes the different equipment and software architecture used.

2 HARDWARE LAYOUT

The vacuum level on the different accelerators and transfer lines ranges from 10^{-6} to 10^{-12} mbar. This requires a large variety of measuring and pumping equipment, the main types being :

- Gauges (Pirani, Penning, etc.) ≈ 180 units.
- Ion pumps (from 50l/s to 1000l/s) ≈ 300 units.
- Sublimation pumps ≈ 130 units.
- Sector valves ≈ 60 units.
- Gas analysers ≈ 10 units.
- Pumping stations ≈ 80 units.

At the present time each set or piece of equipment on the control system has its own chassis for local control plus an RS232 port for remote control. The pumping stations only run in stand-alone mode. The RS232 interface has been selected because it is a widely used standard which allows us to easily integrate equipment from different sources (CERN, industrial manufacturers, etc).

The general layout of the system is exactly the same for each machine (fig. 1). It is an architecture with two layers which are connected together by a local network based on X25/RS232. The upper layer is composed of a VME crate (called DSC) used for data acquisition and communication with the main control system of the accelerator. The lower layer consists of all the G64 control chassis and industrial equipment.

2.1 VME Chassis (DSC)

This chassis, provided and maintained by the PS-CO group, is used for the acquisition of all the vacuum data (pressures, status, etc.). The connection with the upper level of the main control system of the accelerator is made via an Ethernet network. The DSC consists of a 6 slot, diskless VME chassis with at least the following cards:

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

2.2 X25/RS232 Local Network

The X25 local network is used to multiplex data from many RS232 channels. It transfers data over distances up to 300 meters. One VME module allows us to connect, via a hub module, up to six remote terminal servers providing 16 full duplex RS232 lines each, that is to say 96 lines per VME card.

2.3 G64 Chassis

The old vacuum control system used many specific chassis, different from one machine to another, and from different technologies. The rejuvenation of the system has allowed us to limit the number of specific chassis to only 3 different types. These chassis, developed at CERN, use a 3U Europa frame and a G64 bus partially modified to get a direct access, via the bus connector to the inputs/outputs. One chassis accepts up to 4 standard G64 cards and up to 8 specific cards (160 or 220 mm length).

Each chassis has a CPU card (2Mhz MC6809E) with 32 kB of RAM and EPROM memory, a Real Time Clock circuit and two RS232 interfaces. The first one is used for communicating with the DSC, while the second can be used locally with a terminal to execute tests and local control.

The 3 types of chassis are the following:

- The Valves Control Unit (VCU) provides local and remote control for up to 8 valves of any type used at CERN. It can also be used to drive industrial valve controllers. In addition it handles all the safety interlocks used to close the valves in case of abnormal conditions (leaks, power-off, etc.).

- The Pumps Control Unit (PCU) is used for the remote control, status and pressure acquisition of up to 8 Ion pump power supplies of any type. In particular it allows us to switch on the selected pumps in sequence to avoid overloading.

- The Sublimation Control Unit (SCU) drives up to 16 Sublimation pump power supplies. It can store in local memory all the pump parameters (e.g. number of sublimations on each filament). It can also start and handle sublimation cycles for each pump individually. The same chassis can be also used to control 8 Ion gauge power supplies.

2.4 Industrial Equipment

At the present time the trend is to use more and more industrial equipment from the vacuum industry and to decrease the number of specific chassis developed at CERN.

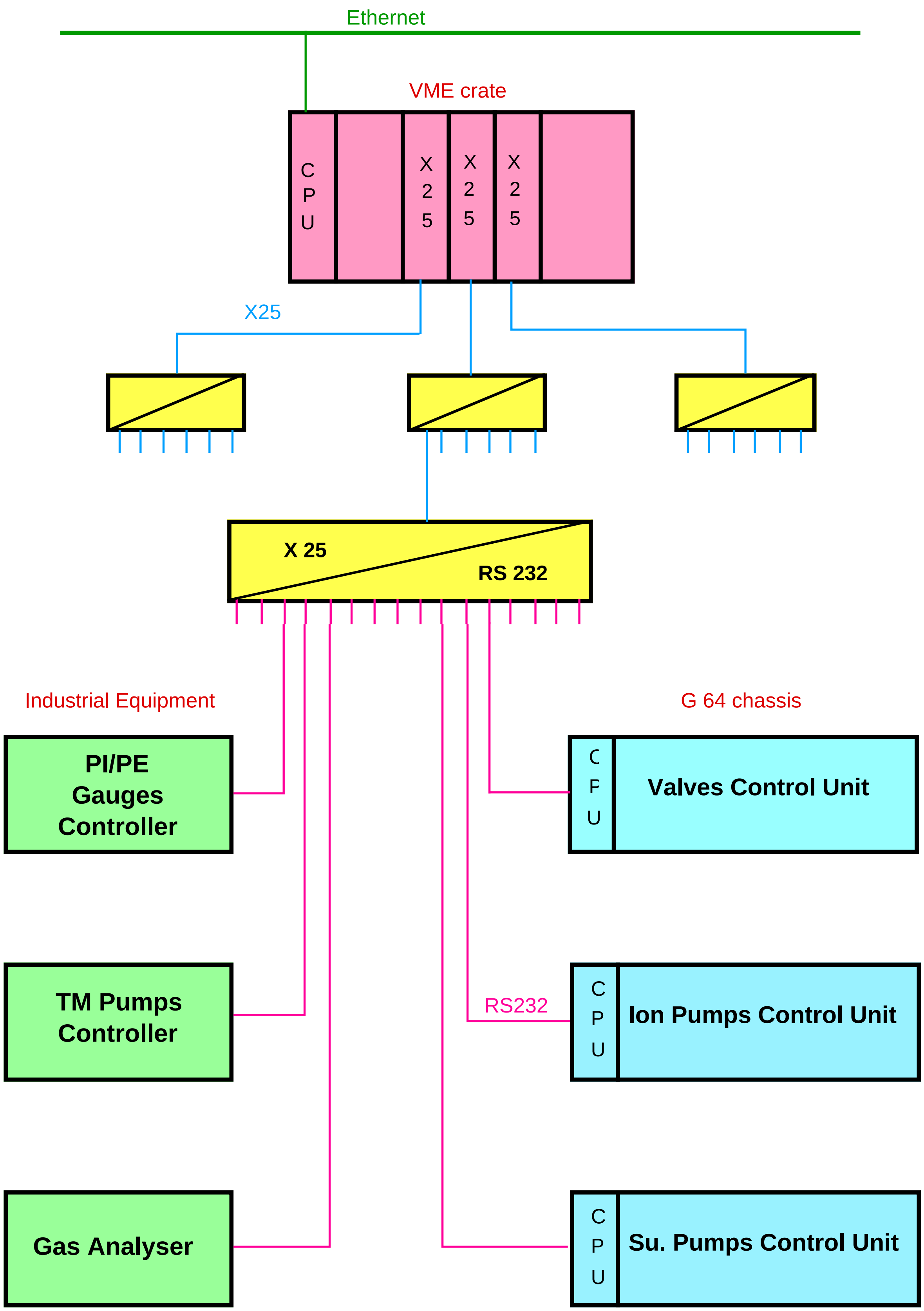

Fig. 1. Overall Layout

The most frequently used industrial components are:

- Pirani , Penning, Bayard-Alpert, etc. gauge controllers.
- Turbo-molecular and ion pump power supplies.
- Gas analysers.

Each piece of equipment has, as standard or as an option, an RS232 interface which allows easy integration into our control system.

3 SOFTWARE ARCHITECTURE

The main control system for the accelerators in the CERN PS complex uses a 3 layer software architecture:

- The upper layer, running at the work-stations level, includes all the application programmes [2], the logging, the archiving of the data and the databases.

- The middle layer includes all the programmes in the DSC. This layer is split into two parts :

  * Part 1: the interface with the upper layer (servers, equipment modules, etc.).
  * Part 2: the specific software, the interface and the drivers which communicate with the lower layer.

- The lower layer running in the specific and industrial equipment.

The software for part 1 and the upper layer is the responsibility of the PS-CO group, while the rest of the software, part 2 and below, is the responsibility of the user groups (e.g. vacuum).

Therefore, at the vacuum system level, we find a two layer structure (DSC level and G64 level) which uses all the local processing properties (distributed intelligence) of our equipment.The software uses an operational protocol for the vacuum systems based on the use of standard models of our equipment (one model per equipment family: gauges, valves, pumps, etc.) [3], [4].

3.1 Specific Software in the DSC

The programme running under the operating system Lynx OS has the following functions:

- Interface with the main control system.
- Message handling.
- Communication with vacuum equipment.

3.1.1 Interface with the Main Control System

The interface with the main control system is made through a queue mechanism (Sys V queues) in which a CERN standard protocol called USAP, Uniformisation of Software Access Procedures [5], is used for message passing from the equipment modules to the specific software. The acquisition and control messages can be passed synchronously or asynchronously.

3.1.2 Message Handling

The received messages are checked, compacted and formatted to be sent to the specified equipment. There are two different cases:

- The equipment is controlled by a G64 chassis. In this case the message is sent directly.
- The equipment is of an industrial type. In this case the message is adapted to support the specific protocol of the manufacturer.

The answers to these messages are handled in the same way before they are sent to the upper layer.The use of a local database, downloaded at the boot of the DSC and which stores all the parameters of the equipment, allows us to have entirely data-driven programmes.

3.1.3 Communication with Vacuum Equipment

A programme is used for the transmission of all these messages via a unique X25 driver. It handles the synchronisation, error detection, time-out handling, etc.

3.2 Software in the G64 Chassis

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 contain all the information about the vacuum devices (number, type, parameters, etc.).
- 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.
- The Local Control and Test program which is a set of facilities, easy to use by the specialist, for a direct access to the equipment.

4 CONCLUSION

After three years of use, this new vacuum control system gives full satisfaction. Its modularity, hardware and software, allows us to cope easily with modifications to or replacement of equipment. Furthermore, the limited number of types of chassis and their compatibility on all the CERN PS accelerators, make the maintenance easier.

The next and last step will be the installation, in the beginning of 1996, of this new vacuum control system on the LIL and EPA accelerators. This will raise the number of pieces of vacuum equipment accessible through the system to about 1000.

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REFERENCES

[1] F. Perriollat and C. Serre, The new CERN PS control system overview and status, ICALEPS'93 Berlin.

[2] J. Cuperus, F. Di Maio, C.H. Sicard, The operator interface to the equipment of the CERN PS accelerators, ICALEPCS'93 Berlin.

[3] P. Strubin et all, Operational protocol for vacuum system, CERN / AT-VA 91-6.

[4] R. Gavaggio, M. Steffensen, P. Strubin, Using models to allow for object oriented programming of the vacuum control systems, EPAC'94 London.

[5] G. Benincasa et all, Final report on the uniform equipment access at CERN, CERN / PS 93-16.