USE OF VMEBUS IN ACCELERATOR APPLICATIONS

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Introduction

VMEbus systems were introduced in our laboratory to control the Saclay Linear Accelerator in 1983. During the next 3 years many tools in software and in hardware as well were developed [1]. The experience gained with these systems, their obvious qualities and the advantages of standardization led us to use VMEbus for new applications.

One concerns the control system of the superconducting booster of the Saclay Tandem Accelerator which is now starting operation: the same kind of hardware and software components have been used to interface the operator console to the existing control system.

Another one concerns the computerization of several experimental equipments for superconducting studies undertaken in our laboratory.

The paper will describe these different applications and outline the benefits of such a standardized approach.

The Control System of the Saclay Linac

The functions of the system are distributed among 3 dedicated VME crates (see fig. 1) :

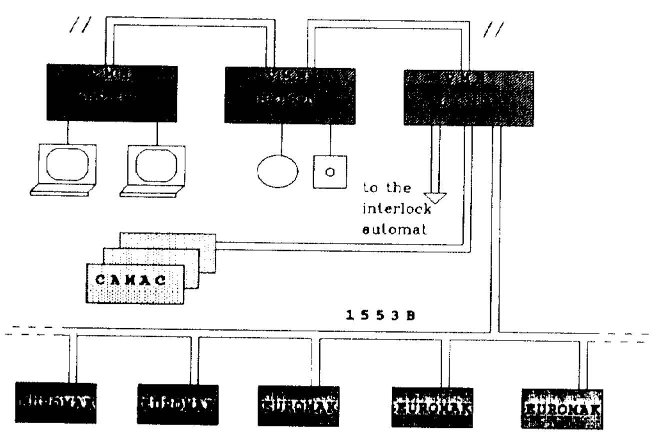

Figure 1-Block Diagram of the Saclay Linac Control System.

- the "HOST" crate with 2 MByte of memory, a 20 MByte disk drive, a floppy disk for back-up is running under the MOTOROLA VERSAdos disk-based operating system. This station is responsible for the data base management (modifications, periodic savings).

  The interactive tasks are run in this system, they are disk resident and loaded in memory on the operator demand.

- the "LINA" crate with 1 MByte of memory is running under the MOTOROLA RMS68k real-time kernel. This station is responsible for the management of the control and acquisition subsystems.

- the "OPER" crate with 1 MByte of memory and all the interfaces to the man-machine communication devices. This station is also running under RMS68k.

The LINA and OPER stations have no disk and their software is down loaded from the HOST station. The 3 stations are close enough to be interconnected with parallel links, the protocol used enables 50 kBaud data transfer rates on these links.

The acquisition and control subsystems are interconnected to the LINA crate through a MIL/STD 1553B serial link. These subsystems consist of 8/16 bit EUROMAK crates with MC6809 or MC68000 CPUs, interfaces to the equipment and RTs modules for the 1553B bus.
Twelve of these crates are located along the accelerator. The 1553B serial link is 500 meters long.

A CAMAC parallel branch is still connected to the LINA station to control the beam . It is the last surviving part of the previous control system designed during the end of the 70's. A VME-based system will replace it in the near future [2]. To connect it to the other VME micro-computers, we will use the ETHERNET network as soon as the development undertaken in the laboratory has been completed. This more modern means of networking will supplant the point to point parallel links. With the flexibility introduced, it will become straightforward to connect new VME systems.

The development tools (assemblers, compilers, editors, PROM programmer) are run in an EXORmacs development system from MOTOROLA.

The software is mainly written in FORTRAN except for some low level libraries written in assembly language and the ETHERNET software written in C. The application tasks use basic powerful software services (data base management, graphics software, intertask communication, error handling facility...). This layered structure has been valuable to write efficiently and comfortably the application software.

The hardware and software architectures give us a great flexibility for possible extensions:

- VME crates can be added where more local processing power is needed (extension for beam switchyard control and later for beam diagnostics).

- The power of an existing system can be increased by introduction of new VME compatible boards (such performance upgrading of the HOST system is planned).

- The data base system is able to handle practically all kind of data (integer 16/32 bit, real, variable length arrays, character strings, logical, hexadecimal, binary) and has built-in distributed features (this software was initially designed at SLAC and is used for the 70 micro-computers of the SLC control system).

- The communication software handle the local and the remote messages in a transparent way. Then, redistribution of the tasks among the VME systems can be done without major software modification.

The Saclay Superconducting Booster Control System

Basically this accelerator is controlled by a fully distributed system. Each piece of equipment (cryostats, power supplies, vacuum pumps and valves, beam diagnostics ...) is connected to a dedicated interface board. The local supervision is done on these boards with 6800 microprocessors. CAMAC dual ported memories enable communications between the equipment and the high level control system (see fig. 2). The CAMAC crates are linked with a KINETICS serial loop.

We have installed a VME crate for insuring the dialogue between the operator and the machine. This crate is equipped with a 40 Mbyte disk, a floppy disk, 2 Mbyte of memory, a CAMAC branch controller, and the hardware useful to manage an operator console (colour graphic screen, touch panel, shaft encoders and push buttons). This configuration is built with the same components as those used for the Saclay Linac except for the CPU and the SCSI disk interface which are of a more recent generation. A second VME crate similar to the previous one is used for software development. The communications are done by a parallel link, but it is likely that we will take advantage of the development mentioned earlier concerning the ETHERNET network. A software package has been written to make transparent access to CAMAC and to the data base, available from this system, through the VME link. Thus, it was possible to add a console to this crate without any change to the application programs.

The major part of the software services developed for the Saclay Linac were re-used: data base management system, graphics library, touch panel software, intertask and intercrate communication package, error handling facility and dynamic tasks loader. The powerful F77 compiler available on these systems was extensively used to write the application programs.

The hardware based on well-proven components allowed us to build a complete system with CAMAC interface and man-machine communication tools as soon as the proposal for such a system was accepted at the end of 1986. The systematic use of existing software services, of a familiar program development environment and operating system allowed us to complete this work quickly and easily.

At the request of the team who manages the machine, some hardware developments were undertaken: a VME module to control 4 shaft encoders and 32 bits of digital I/O and a graphics module with an interface for a mouse. It is likely that these developments will also benefit the Linac control system.

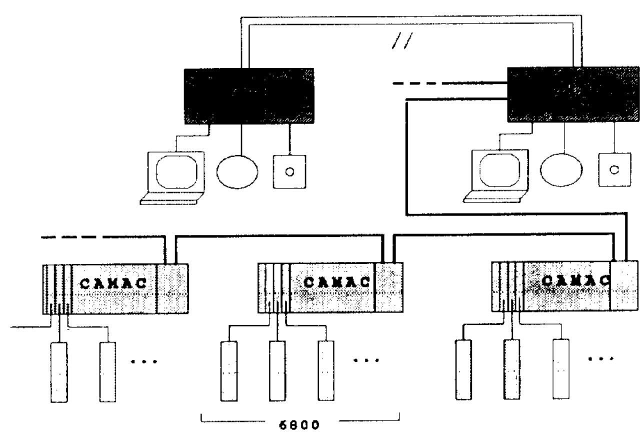

Figure 2-Block diagram of the Saclay Superconducting Booster Control System.

Use of VME for the Superconducting Cavities Laboratory

A R&D laboratory for superconducting cavities was created in Saclay two years ago [3]. It was stated at that time that all the experimental installations should be completely computerized. To insure compatibility and to minimize the development delays, VME based systems were chosen. Keeping the same options as for the two previous projects, VME micro computers manufactured by MOTOROLA and running under VERSAdos were chosen. The interface boards come mainly from the French manufacturer THOMSON. A graphic terminal is connected to each system to insure on-line graphic representations and nice interactive menus. For program development, an alphanumeric terminal is also provided.

The major part of the equipment is interfaced through the IEEE 488 link. A special purpose package has been developed to make dialog between the high level programs and the various equipment as transparent as possible. Except for this development, all the necessary basic software services were re-used: graphics (enhanced with 3D plotting capabilities), communications, error handling. The F77 compiler is always extensively used, especially in such a physicist's environment.

One system is used for room temperature field measurements. As on-line scientific calculation power was required we have used a 20 Mhz 68020 microprocessor with a 68881 coprocessor. Two other systems are used for cryogenic measurements, including the temperature mapping of the cavities. Another system is planned to manage the niobium test cryostat.

Conclusion

After almost 5 years of experience with these different applications, the original choices still appear relevant.They have proven to be adaptable to three quite different situations. The use of VMEbus gives us flexibility, versatility, reliability. The choice of VME modules commercially available is increasing and the modules are more and more powerful: at least 150 vendors product thousands of VME compatible modules. In 1983, VERSAdos was the only multi-tasking multi-user operating system available for the 68000 micro-processor and supporting a number of VME modules. VERSAdos and its associated real-time kernel have shown good qualities for program development and for real-time tasks management but it suffers mainly the lack of networking facilities. This product is now supplanted mainly by combinations of an UNIX development environment plus a real-time kernel. The universally used FORTRAN language was also appreciated by everyone involved in developing the software, especially considering the power of the ABSOFT compiler (efficiency, extensions, direct memory mapped I/O access). The standardization of the software tools was also very important in the success of these applications.

References

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[2] J.F. GOURNAY, G. GOURCY, F. GARREAU, A. GIRAUD, J. ROUAULT, "Upgrading the Control System of the Saclay Linac", presented at the "Control Systems for experimental Physics Conference" , 28 sept- 2 oct 1987, Villars/ Ollon, CH.

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