DIAGNOSTIC AND CONTROL SYSTEM FOR THE LISA PROJECT

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Abstract.

The control and diagnostic system for LISA is presented. Industry standard graphical workstations and the VME data acquisition system have been used. A strict hierarchical structure has been designed into the system for reliability and flexibility.

Introduction.

LISA is a low energy (25 MeV) superconducting electron linac under construction at the INFN Frascati Laboratories.

The aim of the project is to study the problems of superconducting RF cavities for high energy linac colliders and to build an infrared Free Electron Laser. Peculiar features of the machine will be the beam energy recovery after the FEL interaction to increase the total conversion efficiency, and a recirculation transport channel to double the beam energy. The injection system and the transport channel have been carefully designed to obtain high peak gain in the FEL interaction and complete control of the beam parameters within the undulator. Detailed information about machine layout and parameters can be found in Ref.1.

The experimental nature of this machine as well as the different operating regimes which are foreseen in the project call for a powerful and flexible diagnostic and control system.

This system must be developed along with the machine construction (preliminary test of single machine components, injection system, RF phase adjustment etc.) to reach the parameter optimization necessary to run the whole machine in FEL experiments.

A modular structure [2-6], both hardware and software, is the most suitable for our purposes.

The man-machine interface (machine consoles), is implemented using cheap workstations with good graphic support and easy to use interactive capabilities. Powerful low cost single board computers allow to build a distributed intelligence system where every task is carried out by a different CPU module. Furthermore network compatibility with Laboratory LANs is required.

Control System General Description.

A system architecture with three processor levels and a well defined hierarchical structure has been chosen.

The first level is operator oriented and performs interactive procedures on a small number of graphic consoles. Each console has full control capability over the whole system, i.e. no privileged functions on specific machine subsystem are provided for any of them. At this level all variables are shown, as far as possible, in the form of machine parameters as used by accelerator physicists.

The second level is the heart of the control system. A supervisor CPU continuously monitors, using a round robin mechanism, the lower level subsystems. All the data describing the machine status are transferred to a large RAM memory accessible by the consoles. At the same time, commands or series of commands from the consoles are interpreted and transferred to the appropriate third level units for execution (e.g. emittance measurement, beam steering etc.).

The last level is constituted by at least one CPU per crate, performing on-line control and/or monitoring functions on any special purpose accelerator hardware equipment. These CPU's handle suitable I/O modules used as interface to hardware equipment (magnet power supplies, pump readout, RF phase and amplitude controls, beam monitors etc.).

The complete layout of the control system is schematically shown in fig. 1.

Hardware and software environment

LISA is a new project, with no link to preexisting machines. This allowed us to design our control system without any constraints.

HARDWARE

The VME bus standard was an obvious choice for the second and third levels of our system. This standard is at present the most powerful and widespread multiprocessor bus system, and its wide industrial support has helped its diffusion in several Physics Laboratories.

The Macintosh II was chosen to be the console system for LISA for its extremely good performance/price ratio. In particular, the use of the same CPU (68020) of the VME standard makes the interconnections particularly easy. It is also possible, on the Mac II, to install more than one display unit without any modification of the operating system, thus simplifying the display of the machine status.

For the interconnection between Macintosh and the supervisor VME crate we have chosen to use the MacVEE system, implemented at CERN [7-8]. This system allows simple and fast connection between the user and the VME hardware, mapping up to eight VME crates in the memory space of the Macintosh CPU. This allows to access directly a module installed in a crate as an absolute memory address.

For the interconnection between the VME crates (second and third level) we decided on the VMV (VME Vertical Bus) [9]. This bus allows window mode access to other crates (a memory window is opened in the memory space of a different crate), as well as DMA transfer up to 6.5 MBytes/sec between crates. The bus also allows multi-master operation, which could be useful in future, more demanding implementations.

The third level crates provide interfaces to general purpose instrument busses (GP-IB through Motorola MVME-300, and CAMAC through the Mac-CC interface [7] so that equipment, largely used in accelerator measurements, can be easily interfaced. Due to machine requirements, we are not planning to use less sophisticate links, like MIL-1553-B or G-64.

The VME processor chosen for the lower levels is the Motorola MVME 133A (68020 CPU, 68881 mathematical coprocessor 1 MByte on-board RAM) that seems the best choice in term of both performances and cost.

SOFTWARE

As far as the software environment is concerned, we chose the MacSYS system, developed at CERN [10]. This system offers several advantages to the machine physics user:

Use of the MacVEE hardware for simple, memory mapped access to the VME hardware;

Easy access from FORTRAN to the Macintosh Toolbox routines, which give a very efficient interface to graphics and mouse;

Complete programming and debugging environment offering the easy and well established Macintosh tools (windows, mouse, graphics, etc.);

Use of the RTF Real Time FORTRAN compiler, developed at CERN [11].

This compiler has been designed with Real Time, data acquisition and process control applications in mind. It offers some very powerful tools to simplify programming and debugging of a real time system, such as: compatibility with VAX-11 FORTRAN, memory-mapped I/O without the necessity to use assembler language subroutines, access to Macintosh Toolbox routines and to a large number of standard subroutine packages (subset of CERN library, mini GD3 graphics, etc.)

A big advantage of this system is that it is also ideally suited to small, laboratory scale systems using smaller Macintosh machines. This allows different subgroups to have a private laboratory system to develop different sections of the machine using the same hardware and software of the final control system, with obvious savings in terms of time and program portability.

MacSys provides an integrated working environment, with a command language developed using the Macintosh interface system and a Linker capable to link and load RTF programs and libraries. It is also possible to download and run programs into VME CPU's, using an EPROM resident monitor developed at CERN. The UA1 group adapted their monitor [12] to the Motorola MVME133 CPU.

No crosscompiling in more powerful computer is necessary in this configuration, although it is generally possible using RTF; the software environment provided by MacSYS helps very much in editing, testing/debugging and running programs directly in the target processors.

A MicroVAX running VMS, linked to the machine consoles through Ethernet, can support on-line modeling and simulation features, as well as other services such as large data bases, machine logs and external links to the INFNET network.

Network implementation

The connection between the top level and the second one consists of MICRON interfaces (MacVEE Interface Card Resident On NuBus) assuring for each console the link to the lower level supervisor CPU. The message exchange is obtained through a "mailbox" mechanism, where a buffer in the supervisor crate RAM is loaded by the consoles with the information to be sent to the lower levels, while the operators have fast and direct access from each console to the Data-base RAM memory banks in which the current status of the machine is continuously updated.

The second link, connecting the supervisor to each local CPU of the third level, has been developed using the VMV (VME Vertical bus system). This choice has been necessary to provide direct communication between two crates, which in the MacVEE hardware scheme is not possible without the help of the leading Macintosh processor. This way complete access of the supervisor to the local memory, in which the last readouts are currently updated, is provided. If necessary horizontal dedicated links between two crates are possible using VMV.

Acknowledgments

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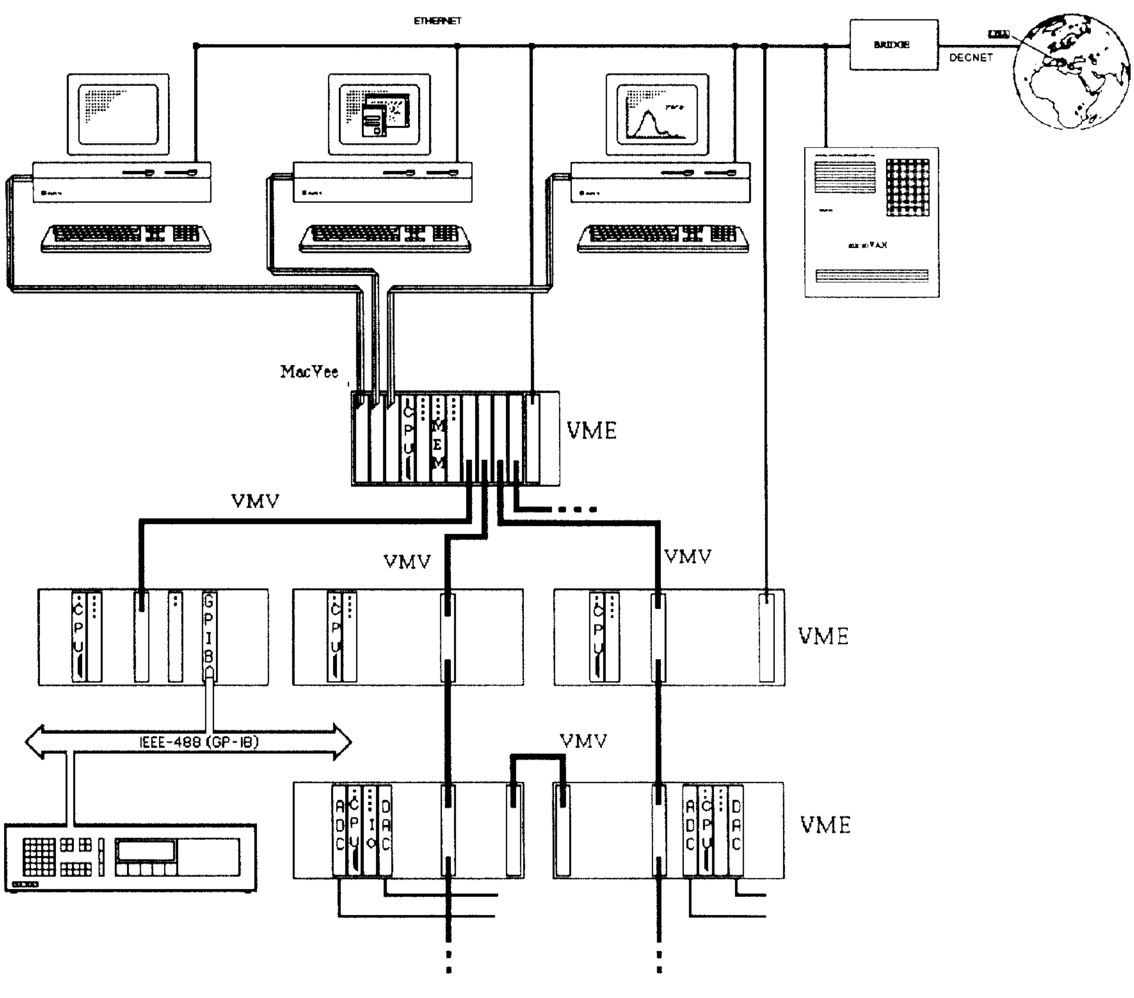

Fig. 1: LISA control system configuration.

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