THE OPERATOR INTERFACE IN THE CONTROL SYSTEM
FOR THE MILAN SUPERCONDUCTING CYCLOTRON

F.Aghion *, G.Cuttone ***, D.Giove **

*) Department of Physics – University of Milan
**) National Institute for Nuclear Physics – Milan
***) INFN – Laboratorio Nazionale del Sud – Catania

Abstract. – Two separated console prototypes have been designed and installed in the main control room of the Milan Superconducting Cyclotron. The paper describes the hardware and software elements, and discusses the major design features.

1. Introduction

A brief overview of the basic control system of the Milan Superconducting Cyclotron,along with the present status of the project, which are extensively described in other papers at this Conference[1,2], will be given.

The control system for the Cyclotron has been designed as a distributed set of powerful microprocessor based control stations each one performing the real time control of a section of the accelerator. A local area network,based on an optical bus with a star topology has been implemented as a high speed link (10 Mbit/sec) among the control units, in accordance with the Ethernet specifications up to the transport level. Each control station,designed to be able to operate in a stand alone configuration in case of failure of the network, makes use of plug-in boards accordingly to the IEEE 796 standard bus (Multibus I)[7].

The Cyclotron will be tested in a new building in which we decided to put under computer control all the technical plants, as the electric system, the water cooling plant,the helium liquefier and so on. Some Programmable Logic Controllers, which are well proved in the industrial environment, have been chosen for such specific tasks. They will be also used for the accelerator interlocks and easily integrated in the main control system due to their Multibus based structure.

Specific control stations have been dedicated to the man-machine interface, using distributed microcontrollers for driving programmable knobs,LCD displays and touch panels and for color graphic display generation.

For the first tests on the accelerator two console modules have been designed and are now under test. The first one is a prototype of the complete accelerator console while the second has been dedicated to the display and control of the plants.

2. Design Features

The philosophy so far adopted in the design of the console is close to that well proved in other control systems[3,4,5,6];its main objectives can be summarized in the following items:
- flexible and easy operation;
- possibility of displaying a limited number of data pre-selected by the operator and simple access to every machine parameter by means of specialized microprocessors and microcontrollers;
- modular construction and a standard interface based design which allow an easy expansion following the future needs;
- use of a multitasking operating system for applications running and applications development;
- extensive use of graphic tools and interactive devices.

3. General Description

The operator console consists of two movable, aluminum made modules,respectively dedicated to the control of the apparatus of the Cyclotron and for technical plants monitoring in the new building.

Its structure has been conceived in order to present an ergonomic design (to minimize fatigue,eyes strain and discomfort) and to allow the assembling of standard mechanical supports.

The accelerator console (fig.1) looks like a specialized workstation performing two distinct functions:
- the data display and alarm information;
- the man-machine interface function.

The display and alarm element has a 19" color graphic monitor,an alphanumeric monochrome monitor and a computer video terminal.

The color monitor displays animated synoptic diagrams representing subsets of the accelerator and alarm messages. Color is a leading feature for such an application. The coded color of an equipment in a synoptic table indicates its present status. If an apparatus is malfunctioning an alarm message is displayed in a reserved part of the screen. All the machine parameters are updated every second,but in case of a manual change an immediate update is performed. Synoptic diagrams are organized into a tree structure, in accordance with the lay-out of the accelerator, and the operator may choose the one of interest using a touch panel (TP).

The alphanumeric b/w monitor displays 20 computer generated lines of data related to selected functions of the accelerator.

The computer terminal shows programs in progress in the database computer.

Fig. 1 – The operator console in the main control room

The interaction unit consists of a touch panel, a 16 buttons numeric keyboard and 3 identical modules which are the main interactive I/O devices. The TP (FLUKE mod.1780A) has the function, in the 'decision tree', to gain access to the desired subset of the control system and to select the parameters to be changed. It is fully programmable allowing up to 60 touch sensitive areas arranged in 6 rows and 10 columns, which form a resistive switch contact matrix. Each I/O module, which is software assignable to any controlled variable of the accelerator, is composed by : a 48 characters liquid crystal display, 6 buttons and an optical shaft encoder. Use of LCD is a low cost solution that allows to give more detailed information on the selected parameters as the name of the variable to which the module is assigned, its actual value (in engineering units),the new selected value of the variable and messages related to the input operation. The knob is used as a manual input of digital or analog changes.

The console dedicated to the technical plants (fig.4) is based on a PC IBM AT. The monitoring of the various plants, performed on a high resolution color graphic monitor (Mitsubishi C-6922), follows the same rules described for the machine console. Data entry for the set points and the choice of a particular start up for each plant is possible using a 16 buttons dedicated keyboard,which is directly coupled to an I/O module of the Programmable Logic Controller.

4. Hardware Description

The machine console has been implemented as a microprocessor based station,whose structure allows an easy development. The hardware consists of commercially available Multibus I boards,and of microcontroller based boards interconnected on a BITBUS[7] multidrop lay-out (fig. 2).
The BITBUS interconnect is an INTEL proposal for a serial bus optimized for high speed transfer (up to 2.4 Mbaud) of short control messages between 8 bit and 16 bit microcontroller boards. Some key features of this

architecture are: defined high level software interface for communication and user program management, a reliable transmission protocol (SDLC), standard industrial packaging (single height,double depth Eurocard), compact software and hardware provided in high performance MCS-51 and MCS-96 families of microcontrollers. In addition, complex and expensive connections are no longer a factor because the BITBUS interconnect requires a simple twisted wire pair.

The central intelligence is provided by an INTEL iSBC 286/12 single computer board (SBC) with an 80286 8 Mhz microprocessor,an 80287 mathematics coprocessor, 1 Mbyte of on board RAM, a parallel port for a line printer and 2 RS-232 ports,used for an engineering terminal and for the touch panel.

Graphics generation is provided by a MATROX SX-900 intelligent graphic board; it provides 640 x 480 resolution and up to 16 colors by means of a graphic coprocessor (NEC 7220) and an on board 80286 microprocessor which off-loads the host CPU.

The alphanumeric monochrome monitor is driven by a MATROX MSBC-QV3 controller. The board supports four independent displays and all the video attributes are user definable programming an on board CRT controller. The standard display format used is 40 characters on 24 lines.

Operator inputs are handled by INTEL iRCB 44/10 BITBUS boards,based on the 8044 component which integrates on the chip an 8 bit 8051 microcontroller,an intelligent SDLC controller and an iRMX 51 real time executive. The iRCB 44/10 board has 24 digital I/O lines (allowing expansion capability up to 48), 64 Kbytes of memory and 2 interrupt lines. Each operator input module is controlled by an iRCB 44/10 which can execute its own control algorithms sending to the host CPU only high level messages (fig.5).

Communications between the console and the database computer are performed on a 2.0 Mbaud parallel link by a Matrox COM-1 DMA interface.

The link to the optical Ethernet network is accomplished by an IEEE 802.3 communication controller (INTEL iSBC 186/51).
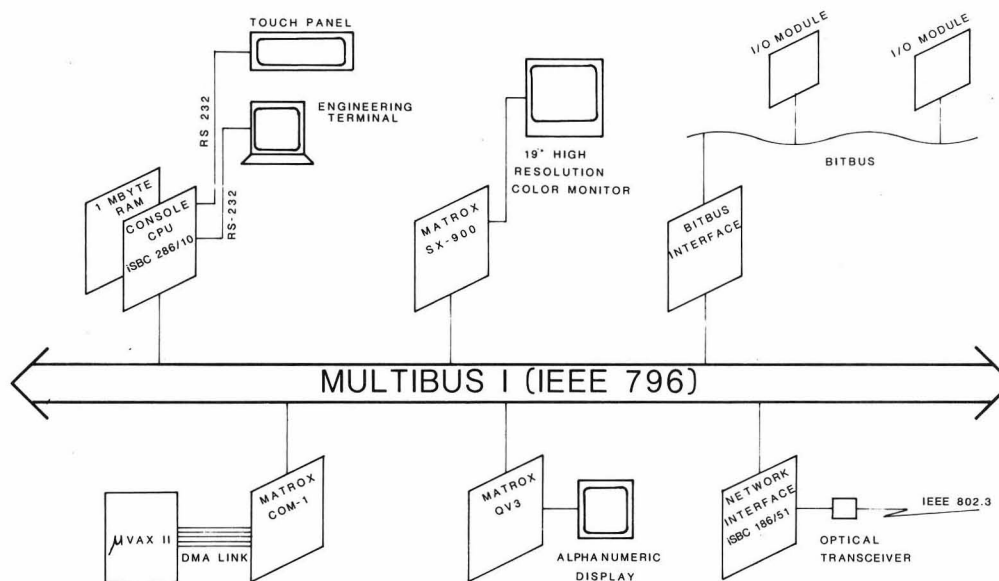

Fig. 2 - Hardware block diagram of the cyclotron console

5. Software Description

Application programs in the machine console runs as a job under the iRMX 86[7] real time operating system. A powerful console, in which software has to provide system services, to manage interrupt requests, to allocate system resources to tasks and to handle communication between them, is more like a multitasking than an interrupt driven environment. Thus a real time operating system's nucleus has been installed on EPROM in the 286/12 single board computer and in the Ethernet controller board. Programs have been written in high level language (PL/M 86) well suited for real time applications.

According to the distributed nature of the hardware so far described, the software has been structured in modules related to specific functions. The main SBC at power on runs a start up program which, after having tested all the equipment creates 5 main tasks which have the responsibility to manage network messages, database access, touch panel communication, operator inputs and display generation.
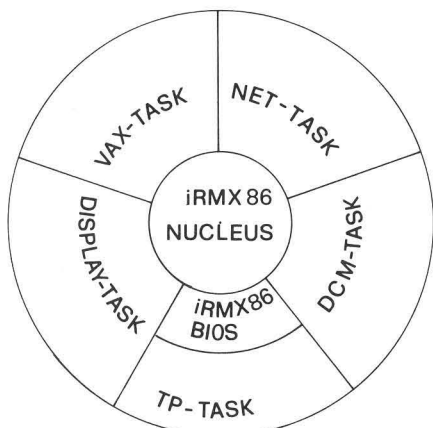A schematic layout of the software structure is shown in fig. 3.

Fig. 3 - Software block diagram of the cyclotron console

The routine NET_TASK is an interrupt driven messages interchange protocol able to send and receive requests for the Ethernet services provided by the code burned on iSBC 186/51 memory.
Access to the Cyclotron database, which resides on the DEC microVAX II, is handled by VAX_TASK. The dialogue between the two machines is governed by an home made protocol whose main features are :
- the communication starts by receiving or setting an interrupt line on the parallel link;
- the message blocks of data exchanged have a size of 1.5 Kbytes in accordance with the size of the Ethernet packets in the control network;
- an error pattern recognition has been implemented embedding control bytes in the data packet.
When driving the Cyclotron to a particular state, VAX_TASK sends a request to the microVAX II in order to receive the calculated set of values necessary for the set-up of all the equipments. During a manual operation it notifies to the DEC computer every change to update the database. A resident task on the microVAX, called INTEL_TASK, waits to insert or retrieve data from the database. The structure of the database strictly reflects the distributed nature of the control system. It consists of a set of matrix, each related to a particular state of the accelerator. Every matrix, divided in vectors, called 'station configurations', contains, in a formatted way, all the informations for a specific control station.

The primary task which sets all the input modules and the display screen for operation is the TP_TASK, which is made active by the touch panel. It allows to select the desired action to be undertaken by the operator, i.e. to prepare a graphic to be displayed or a parameter to be changed by an I/O module.
The color graphic and the alphanumeric monochrome monitors are driven by a task called DISPLAY_TASK. It generates synoptic diagrams passing the address of the memory where it stores the display code to an I/O port of the MATROX SX-900 board which then fetches the instructions and their arguments to draw the picture. The alphanumeric screen is seen by the DISPLAY_task as a memory area where the desired informations are written as ASCII codes. The values used by the DISPLAY_TASK are stored in fixed memory locations and are updated in real time by the NET_TASK.
The small BITBUS network, to which the I/O modules are interconnected, may exchange messages with the main console CPU using the services provided by the DCM_TASK. This task waits at two mailboxes to send or receive formatted messages from the programs running on the BITBUS nodes. Operator input at the I/O module is processed by tasks running on the microcontroller board which are able to understand the action to be undertaken sending to the DCM_TASK only command and numerical data to be rerouted to the NET_TASK. On the BITBUS boards we have a small executive (iDCX 51) under which runs all the resident tasks which are written in PL/M 51.
The software dedicated to the analysis and display of the informations related to the plants controlled by a PLC, is a graphic package, called CAMM, produced by CENTEC (USA) which runs under MS-DOS. CAMM presents quite a large number of functional capabilities implemented by 6 specific software modules which may be configured by the user to meet its own requirements. These tools, from a logical point of view, may be divided into two groups: those which allow sensing and recording of plant data (i.e. the communication with the PLC) and those which are used for real-time and historical analysis of plant conditions and graphic display generation. CAMM is quite easy to use because it not requires particular command languages but it operates through a series of menus and prompts.

Fig. 4 - Operation of the Cyclotron new building plants with the dedicated console

6. Conclusions

The preliminary use of the two console modules for the operation of the plants and for laboratory tests on the control units has proved that the design adopted is quite satisfactory. Minor modifications in the mechanical structure, necessary to allow an easier assembling of the internal elements and to improve the ergonomic design, have been taken into account for the final drawing. Extensive tests on the hardware and software will be carried out during the first tests on the cyclotron and the magnet field measurements.
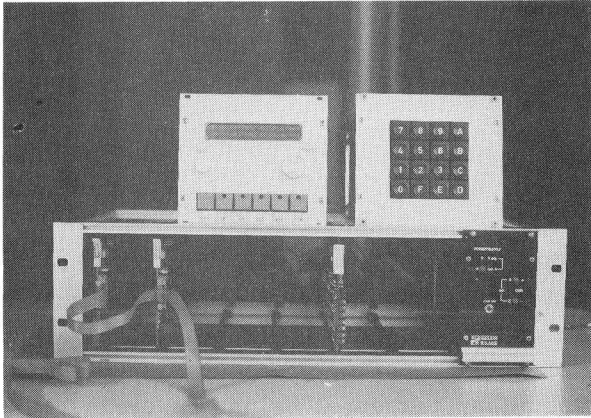

Fig. 5 – Operator interaction and display modules under Bitbus control boards

7. Acknowledgments

We would like to express our thanks to Mr. A.Amato for his skill assistance in the design of the operator interaction modules and to Miss G.Giovannetti for her work in the graphic software development.

8. References

1) – E.Acerbi et al. – Progress Report on the Milan Superconducting Cyclotron – Paper at this Conference.
2) – F.Aghion et al. – The Distributed Control System with Decentralized Access to an Optical Bus for the Milan Superconducting Cyclotron – Paper at this Conference.
3) – G.Hochweller et al. – Tools for Man Machine Communication in the Petra Control System – IEEE Transactions on Nuclear Science – Vol.NS 26,N.3, June 1979.
4) – P.Bardon et al. – The Ganil Control System as Seen from the Control Room – Proc. 9th Conf. on Cyclotrons and their Appl. Caen 1981 – Les Editions de Physique.
5) – E.Linstadt – Dissecting the Cow – IEEE Transactions on Nuclear Science – Vol.NS 32,N.5, October 1985.
6) – M.Knott et al. – Control System Features of the Argonne 6 GeV Synchrotron Light Source – IEEE Transactions on Nuclear Science – Vol.NS 32,N.5, October 1985.
7) – Multibus,Bitbus and iRMX86 are trademarks of Intel Corporation.