THE CONTROL SYSTEM OF JYVÄSKYLÄ K130 CYCLOTRON

P. Taskinen, J. Lampinen, K. Loberg

University of Jyväskylä,
Department of Physics,
Seminaarinkatu15, SF-40100 Jyväskylä, Finland

ABSTRACT

The operation of the K130 cyclotron to be built in Jyväskylä 1988-1992 will be controlled with a system based on distributed processors. The limited manpower available for inhouse development and programming guided us to look for other possibilities to satisfy the needs of the K130-cyclotron control task. After a careful comparison of possible commercially available control systems and those used in existing cyclotrons, it was decided to adopt a commercially distributed system used extensively in process industry. The final choice is Alcont system[1)] designed and produced by a Finnish company Altim Control Ltd. We believe this system to be an effective, flexible, and economic way to control the K130 cyclotron. The main features of the system will be described.

INTRODUCTION

The status of Jyväskylä K130 cyclotron and the project is described elsewhere in these proceedings by E. Liukkonen[2)]. The cyclotron is commercially produced. Most of the control I/O-signals are 24 V relay signals and 10 V analog voltage signals for set and read values. The most critical interlocks in the RF-system and magnets are wired and provided by the cyclotron manufacturer as well as 16-bit ADC in the main magnet power supply.

The commercial control system chosen for Jyväskylä K130 cyclotron control is frequently used in process industry and is designed especially for operation in difficult and noisy industrial conditions. In this system the operational functions are distributed to independent microprocessors which communicate trough a MAP-based highway and with I/O-units in the various cyclotron subsystems. Due to the effective and user-friendly programming tools the system configuration is flexible and rapid to carry out. This is often necessary in laboratory applications.

The system expansion necessary to satisfy equipment development and system enlargement in the future is simply carried out by addition of modules without disrupting the system running simultaneously. System includes powerful graphic display units as well as a number of library functions for graphics displays and control tasks. Existing interface units and communication protocols allow connections to other computer networks and to separate intelligent equipment without difficulty. The accuracy of the I/O-units and the number of bits available as well as the speed of the system is sufficient for the cyclotron control. The facts mentioned above reduce remarkable the inhouse programming and manpower to be used for system development.

The control system is estimated to involve about 220 analog I/O signals and 770 digital I/O signals. These numbers include magnets, RF, extraction, ECR, diagnostics, vacuum and radiation security system but do not include the control signals related to beam lines and experimental equipment.

Altim Control Ltd. will deliver the control system in spring 1990, at the same time as the cyclotron installation will start. The design and system configuration can begin already in August 1989 with the design module delivered before hardware.

GENERAL DESCRIPTION OF CONTROL SYSTEM

The functions of the Alcont system are distributed between independently operating Intel 8086 (+8087) and 8088 (8 MHZ) microprocessors that intercommunicate by means of a fast Upnet highway. The architecture of the control system is shown in figure 1.

The Upnet highway is a fast MAP 3.0 standard (miniMAP, 5 Mbit/s) serial highway between micro-processors, called system modules. Upnet is composed of duplex coaxial cables and an independent highway communication unit for every module. In the case of line failure the error is detected, an alarm to operator console is given and all communication is switched over to another line.

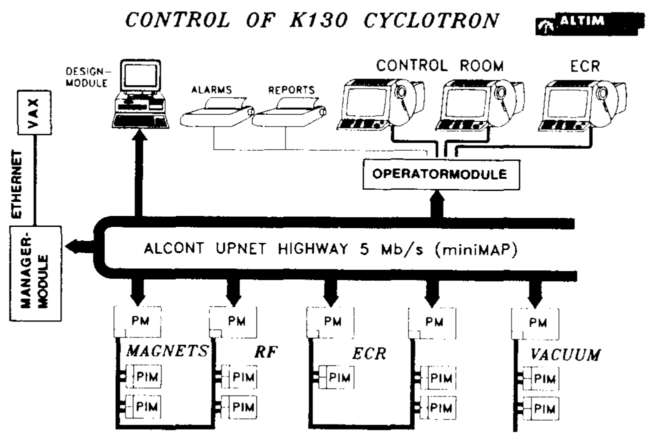

Figure 1. The architecture of Jyväskylä K130 cyclotron control system.

Token passing protocol is used. Maximum length of Upnet is 1000 m and maximum number of modules is 32.

The process modules (PM) control the process independently. They perform all measurements, regulatory control, logic, sequence and control functions, data conversion, and include versatile calculations and data processing software. The tasks are distributed to the process modules according to the structure and needs of the cyclotron subsystems (magnets, RF, ECR, vacuum, etc.).

The process interface modules (PIM) connect the system with I/O cards to the cyclotron subsystems. Every PIM unit has an independent processor capable to handle I/O card functions and communication with other modules. PIM units will be distributed close to the subsystems to be controlled. Due to the distribution of functions, PIM units significantly decrease the number of field cables necessary. This simplifies cabling and installation work. The PIM units are connected through the Upline highways to the process modules of the system and to each others. Each PIM unit can handle up to sixteen I/O cards.

The Upline highway connect PIM units to each other as well as to PM units. Upnet is composed of duplex coaxial cables and an independent highway communication unit for every module. The protocol used is HDLC with the speed of 250 kbit/s at this moment. The maximum length of Upline is 5 km and addressing allow sixteen stations in one Upline highway. Practical limit due to the speed of Upline at this moment is 4-6 stations depending on the needs of the application.

The operator module is in charge of the functions required by the operator as well as managing the display information. It is connected to the equipment needed in the control room, including monitors, keyboards, finger-touch units and hard copy devices.

The operator interface modules (OPI) are used to distribute the control functions to several workstations. A monitor, a keyboard, and a finger-touch unit are connected to each operator interface module. The Upline connects the operator interface modules with each other and with the operator modules.

The workstation for operator interface is a special Alcont finger-touch unit with full-graphics. Flickering of the screen has been removed by using a high 69 Hz scanning frequency. The screen display consists of 640x480 dots, each 0.625 mm across. As additions to the keypad are the wheel and the switch. The wheel is used for changing the set-point and control values and stepless scanning of trend values. The switch is used to control on-off functions.

The manager module is connected directly to the Alcont system highway and is fully integrated with the basic system. Typical tasks performed by the manager module are the optimizing, calculation of the set values used in start-up, data manipulation of diagnostic measurements, and also connection to Ethernet highway will be via this module.

The design module is a PC/AT workstation directly connected to the system highway. It is used to carry out the application definitions, the testing and the documentation. Design module can be used in off-line system simulation when testing configurations and developing new control sequences. This allows the system configuration to be started before hardware installation and ensures that application blocks are functioning correctly prior to start-up.

The application design and configuration as well as display graphics design is carried out by means of a mouse and pull-down menus under Microsoft Windows in PC/AT. The design module prints out all the definitions without separate time-consuming manual stages, so the documentation is always up to date.

SOFTWARE IN ALTIM SYSTEM PROCESSORS

Every processor called UPR (Universal Processor) in process modules (PM) have system software called VSYS (Virtual System). VSYS is a multitasking realtime system package developed specially for control tasks. It consists of packets which can be loaded to support the fixed kernel depending on the needs of the application in different processor modules. A subset of VSYS is used also in PIM processors.

The application independent lowest level kernel of the system is Distributed Altim Exicutive (DAX). This consists of:
1) Altim Executive (AX) which is a realtime multitasking

system.
2) DAX Monitor for testing the system operation.
3) LOADER for loading programs in start-up or for changing the programs during the run.
4) Interface Memory Communication (IMEMU) creates the connection between slave processors in station and UPR.
5) Altim Network Architecture (ANA) is for file transfer between processors in network. This allows all processor units to be known by a symbolic name in the network.
6) Distributed File Control (DFC) allows all distributed memory devices, and files in those, to be called by name.
Virtual Operating System (VOX) is next level over DAX. It may consist of:
1) Distributed Data Management (DDM) which allow physically distributed files to be seen as a unit for the user.
2) Distributed Data Transfer (DDT) supports the application related data transfer, for example the data transfer to display units.
3) One very important service is Distributed Alarm Management (DAM). The time and the source of an alarm is always recorded, and different types of alarm messages are displayed on the operator screen.

APPLICATION DESIGN AND PROGRAMMING

The design module is a PC/AT workstation directly connected to the system highway as mentioned before. The application design, debugging and testing with simulation run is done in PC/AT under Microsoft Windows system and down loaded to PM and PIM memories. The application design and definitions are made with special tools for control system design on the workstation screen using mouse and pull-down menus. In the design module there is one back-up always for application programs.

All application definitions, controls, logic, sequences, calculations, recipes and all other parts of the overall system connected to control are called blocks. The functions consist of nesting blocks, connected to each others by wires at the input and output connectors of the blocks. Block names and the three letter abbreviations of the connectors identify their functional content. The application definition can also be made by copying the blocks from the model library. Great number of different sequences and device control loop blocks as well as blocks for graphics can be found in the libraries. Anyway, in the case of cyclotron there is a need for a special software, not earlier used in commercial applications by Altim. These special applications can be made as blocks using high-level programming language. For example, some protocols for equipment connected via serial lines to control system or special graphics and data manipulation for diagnostics will be done using Pascal.

RELIABILITY OF THE ALCONT SYSTEM

Self-diagnostics supervises the system operation. The system keeps continuously track of its own condition and performance. It includes self-diagnostic functions to locate and report its own faults and can correct many situations by itself.

A disturbance in one part of the system will not affect the functions of the other parts. All modules in the system are independent and all the most important parts can be duplicated. Two sets of back-up application programs are distributed and are always available in PM and PIM units. In the case of failure each subsystem is automatically reloaded and restarted from its back-up memory.

The Upnet and Upline highways of the Alcont system are always duplicated. The diagnostic system is continuously monitoring the data highway. If any disturbance is found, the traffic is switched over to another highway. The application definitions of the system are always recorded on two semiconductor mass storage device.

BINARY AND ANALOG I/O DEVICES

The Alcont control system is connected to the cyclotron using interface cards. The cards are located physically in the same racks as PIM units. Each rack has the PIM unit and up to 16 I/O cards. The range of cards available covers all typical automation applications. The selection of the I/O cards is: Binary input/output, analog input/output, frequency inputs and serial interfaces. Many cards for special applications are also available: For example temperature measurements and data collection interface, etc.. Process interfaces used for cyclotron control are:

Binary inputs:
- 16-channel switch input, 24 V, isolated channels.

Binary output:
- 16-channel, 24 V.
- 8-channel, 230/115 V a.c.

Analog inputs:
- 10-channel, 12-bit, current signal 0/4-20 mA or voltage signal 0-1, 5 or 10 V.
- 4-channel, 12-bit, current signal 0/4-20 mA or voltage signal 0-1, 5 or 10 V. All channels floating also in respect to each others.

Analog outputs:
- 4-channel current signal, 16-bit, 0/4-20 mA, floating channels.

Serial interfaces:

8-channel current loop.

2-channel multi-protocol interface, RS232C/RS422.

Serial interfaces:

8-channel frequency or pulse count measurement, 5-24V, 100 kHz.

4-channel pulse length and interval measurement.

2-channel control, based on pulse count.

Data collection interface:

14 analog inputs, 14 synchronize inputs. Sample frequency 100 kHz. Internal processor and memory to handle 32 k * 64 bit of information.

CONCLUSIONS

In this paper we give a short description of the Alcont system which is chosen to be the control system of the Jyväskylä K130 cyclotron. Due to the late delivery of our control system for K130 cyclotron, the control system development done by Altim Control Ltd. during the year 1989 may give us some new interesting features and devices for the cyclotron control.

The main disadvantage seen in the system at this moment is rather slow (20 ms) looping of each I/O rack. If faster response is needed, it means that some special and probably Altim independent solution has to be developed. Due to the miniMAP standard highway or Ethernet connection these solutions are easy to integrate to Altim system.

In the case of beam diagnostics we believe that the special cards available will solve the problems. It seems to us that this system is able to control and fullfill all needs of the cyclotron control system.

References

1) Alcont system is a product of ALTIM CONTROL Ltd., Box 168, SF-78201 Varkaus, Finland.
2) E. Liukkonen, The Jyväskylä K130 Cyclotron Project, in these proceedings.