Experience with the Use of "Macintrotte" for Commissioning Process Equipment of the LEP Pre-injector.

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Introduction

"Macintrotte" is a CAMAC control system which is composed of a Macintosh computer and a dedicated software package. The purpose of this system is to be a versatile and user-friendly tool in the field of equipment commissioning or local interaction. The CERN interpreter Nodal has been implemented as the programming language and integrated into the Macintosh environment.

The primary function of Macintrotte is to provide a stand-alone CAMAC control system with a high-level user interface for programmers and end users. In this kind of application, a CERN-made CAMAC interface is used. This has been the main use of the system during the early phase of the LPI commissioning. A secondary function of Macintrotte is to act as a front-end computer for the SMACC, a 68000-based auxiliary crate controller used in the PS central control network. In this configuration, the Macintosh is connected as a terminal to the SMACC to provide local access, basic input / output and autonomous computational facilities. This is currently used for LPI equipment which is interfaced with the main control system. A third function of the system is to interconnect, in a LAN (local area network), SMACCs and Macintoshes in order to provide high-level local control facilities for machine development and to extend the functionality of the main consoles. This is still experimental and has not yet been used in operation.

This paper gives an overview of the system and describes its use for the commissioning of the LPI equipment and the experience we have gained from this application.

Software Overview

A software package, "MacNodal" is provided for the first two functions of Macintrotte (stand-alone CAMAC control and SMACC front-end). It is mainly composed of :

- MacNodal, a customized version of Nodal 68000 for the Macintosh,
- a driver for CAMAC communications,
- a graphics package.

The 68000 version of Nodal has been developed at the CERN SPS division. It has been implemented as a Macintosh application and extended to include the Macintosh user interface, the CAMAC driver and the graphics package.

Macintosh User Interface

The programmer can integrate in his programs the Macintosh high-level user interface consisting of pull-down menus, dialog boxes and a speech synthesizer.

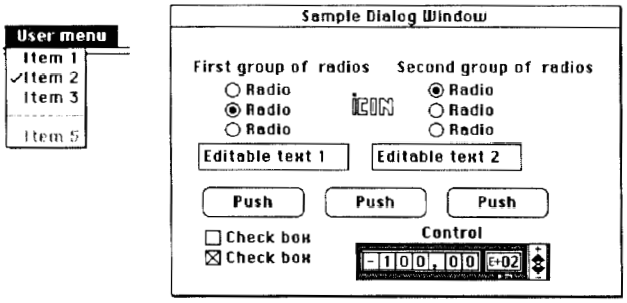

Fig 1 - Sample user interface

These extensions to the original 68000 Nodal interpreter make interactive programs more system-dependent, but it is probably better to have a specific part of a program for the user interaction which benefits from the computer facilities than to have purely compatible programs with poor user interaction.

CAMAC Driver

A CAMAC driver which controls the CAMAC interface has been implemented as a Macintosh "desk accessory". This provides both a dialog box for direct interaction and an interface for the programming languages. The driver does not handle demand messages (generated by LAM). A CAMAC command-reply transaction is executed in about 5 ms. The execution time of a simple Nodal CAMAC function is about 10 ms and the data rate for block transfers is about 6 ms per 16 bit word.

Graphics Package

An emulator of a CERN CAMAC display controller, the SPS DiCo-DiMe pair (Display Controller - Display Memory), has been implemented as a graphics window. The MacNodal graphic functions can address either this Macintosh window or external VDUs controlled by DiCo-DiMe modules. This allows Macintrotte programs to display information either on a Macintosh B/W window or on external B/W or colour displays. The Macintosh window image can be printed or copied to disk. Graphics can also be saved in display files. The mouse may also be used as a pointing device in the Macintosh window. This has been used, for instance, for graphics editing or for the selection of a frequency in a spectrum representation.

Remote Computer Driver

A dedicated terminal emulator has been implemented as a Macintosh "desk accessory" . The main function of this driver is to provide a window on a Nodal task in the SMACC with input / output service using a Kermit-like protocol.

Since the driver has been implemented as a desk accessory, the user can alternate the use of the two computers by selecting one of two overlapping windows on the screen. Nevertheless, because the CAMAC interface and the SMACC link use the same Macintosh serial port, the Remote Computer driver and the CAMAC driver are incompatible. This results from a choice made to leave the printer port available for the Appletalk network and is justified by the fact that in our context, when the Macintosh is connected to a SMACC, it does not need to have direct control of CAMAC.

The Nodal task in the SMACC and the one in the Macintosh share the same floppy files. Therefore, the Macintosh Nodal may be used to edit Nodal programs or data and the task in the SMACC may be used to load them.

Stand-alone CAMAC Control System

In this mode of operation, a Macintosh controls a standard CAMAC serial highway (ESONE/SH/01) operated in bit-serial mode with 250 Kbits/s. The CAMAC interface plugs into one of the Macintosh serial ports and requires no modification of the computer. The Macintrotte can control up to 62 CAMAC crates through type L2 Serial Crate Controllers.

The crates may be interconnected in two ways. The serial link may consist of direct connections (4 pairs or flat cables) between SCC D-ports with the first SCC connected to the Macintosh interface. The serial link may also be built with 2 pairs using biphase modulation, with each SCC connected to a U-port adapter module.

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In the second case, the Macintosh interface is connected to a dedicated U-port adapter or to a D-port of one of the SCCs. These two kinds of highways may be mixed and they have both been used for the LPI equipment, depending on distance, noise and final layout.

All the control programs have been written in MacNodal (the customized version of Nodal for the Macintosh) because Nodal is a CERN-wide known language and is implemented in every computer used for PS control. The programming languages with access to the Macintosh operating system (Assembler, Pascal, C, Fortran ...) could also have been used to write CAMAC control programs.

During the LPI running-in, Macintrottes have been used to control equipment for which the main control system was not yet available. The layout of the interface to the equipment has been approximately the same as that for central control. The systems developed were :

- klystron modulator monitoring (still in operation),
- LIL phase control (still in operation),
- instrumentation control (replaced),
- timing control (replaced).

Some equipment has also been tested in lab and installed using Macintrottes, the test programs being transferred from the lab Macintrottes to the front-end computers. This is the case, for instance, for the kickers and septa of the injection and ejection of the EPA ring. For machine studies, some control / acquisition units based on Macintrottes are also in operation. Such units are used for the measurement of the beam oscillations and for the analysis of the residual gas.

The following is a short presentation of some of the systems.

Klystron Modulator Monitoring.

The electronic equipment of each modulator of the Linacs is monitored by a Macintrotte system which displays its current status on 3 video display units close to the modulator. This system is developed and maintained by the modulators' specialists.

The 6 Macintrottes used for the 6 modulators are installed in the klystron gallery and operate continuously during every running period. Therefore, these systems are the most likely to fail and there have been some failures, especially during summer. Nevertheless, due to the portability and exchangeability of the systems, these failures are not critical because office or lab computers may be used as spare parts during the repair.

LIL Phase Control

A Macintrotte has been installed in the LPI control room to control the phase of the Linacs' klystrons. The program provides a high-level user interface to let the operators tune the phase using only Macintosh dialog windows and menus.

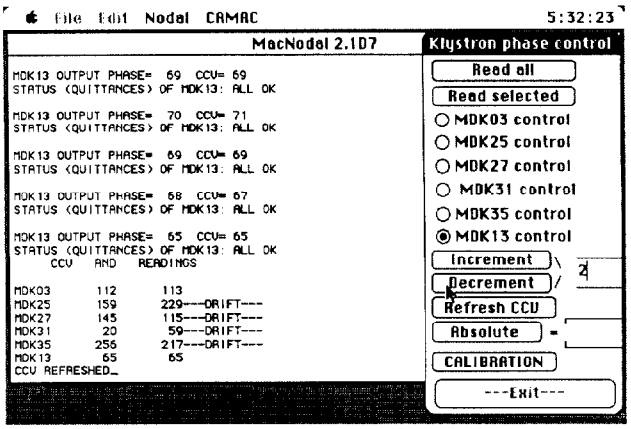

Fig 2 - Klystron phase control

This system is temporary and the software will not be transported to the main control system as it is. But it is directly maintained by the hardware and machine engineers who may easily modify their system when needed.

Instrumentation Control

For the early phase of the LPI running-in, one SEM-grid and 5 wire beam scanners were controlled by a Macintrotte enhanced with an external VDU [2].

The system was developed and maintained by the engineer in charge of the interface and used by machine specialists. This kind of system requires great flexibility to cope with the modifications of the hardware and is usually implemented as a Nodal program running in a front-end computer and controlled from a terminal. Compared to that approach, a system like the Macintrotte simplifies the hardware connection and enables the programmer to provide the end users with a more efficient tool. From the programmer's point of view, the design of a clean user interface is no more difficult than implementing standard menus and a tree structure, but lowers the amount of documentation and support which are necessary for the final use.

Beam Oscillations Measurements

A test unit made of a Macintrotte controlling fast digitizers connected to pick-up signals has been developed by machine specialists to study the beam oscillations and to analyse its spectrum.

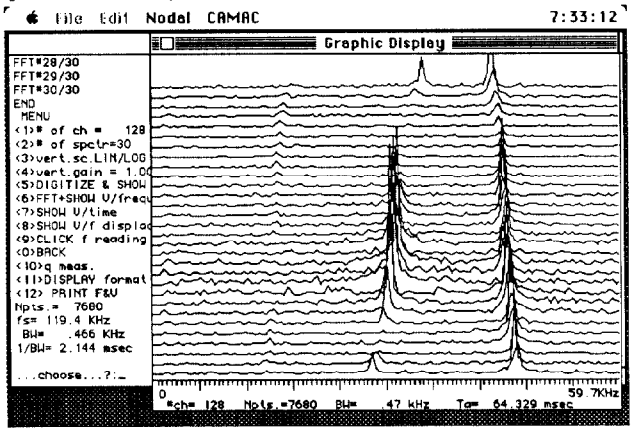

Fig 3 - Onset of betatron e- beam instabilities

As an example, when analysing the beam spectrum, using 8192 samples, the Macintrotte program must read the 8 KWords of acquisition from the digitizer, operate a FFT on the values and plot the result. This is done in about 2 minutes, it is still in the range of what a user is able to wait for without damaging the keyboard, but it is poor, of course, compared with the speed of a more expensive configuration using floating-point or FFT co-processors and with direct bus access to CAMAC modules.

Residual Gas Analysis

A mobile test unit assembled on a trolley composed of a Macintrotte, a SMACC and CAMAC interface modules has been developed by vacuum specialists [3] for the remote control of mass spectrometers and for on-line analysis and presentation of the acquisition.

A SMACC has been used in this configuration to handle synchronous acquisitions. The Nodal program running in the SMACC is down-loaded from the Macintosh. Then, the Macintosh is switched to the Serial Crate Controller. The user program in the Macintosh communicates with the one in the SMACC via CAMAC DMA. It presents a virtual front panel of the analyser and handles the acquisition treatment and presentation.

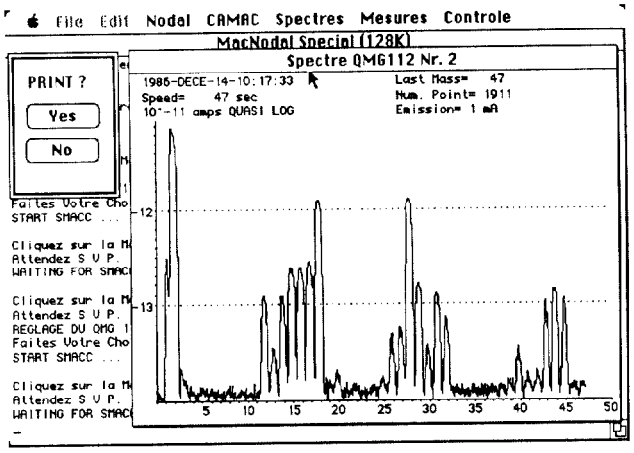

Fig 4 - Spectral gas analysis

SMACC Front-end

For LPI equipment interfaced to the central control network : SMACCs, front-end computers (ND100) and main consoles, the Macintrotte is used as a local terminal of the SMACC and as an input / output server for floppy files, printer, graphics window or speech synthesizer. For this operation, the Macintrotte does not have direct control of the crate but is linked with the SMACC through serial ports. This system is currently used for the instrumentation and for one part of the timing. For these two applications, it is used as the system terminal of the SMACC, a mass storage device and as a data editor.

An important part of the instrumentation of the LPI [4], pick-ups, SEM-grids and wire beam scanners is now controlled using SMACCs with standard application software [5]. Six of these SMACCs are linked to two Macintrottes which are used during software installation or testing and during the machine start-up. The Macintrottes are used to communicate with the SMACC's operating system (RMS68K) via Nodal, to test installed software or to load Nodal programs. They are also used to edit off-line the layout of the local displays of the instrumentation using a graphics editor written in MacNodal and then to load the data files into the SMACC during machine start-up. In operation, the acquisition and refresh of these displays are handled by a set of RT tasks in the SMACC and the Macintosh is only used by the error logging task. This system is not final yet but it is the first implementation of the local facility to edit and activate repetitive displays of the machine parameters using a single console.

LAN Connection

An experimental system using the Appletalk LAN is being implemented to extend the facilities of the former system and to study new solutions for the main consoles.

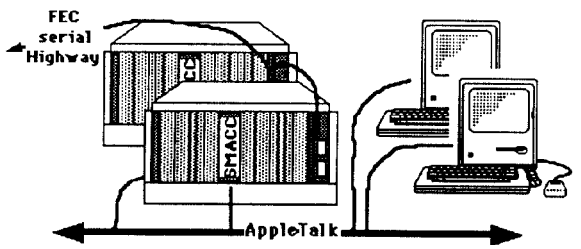

Fig 5 - Local area network

The Appletalk network is already used to share peripheral devices between the Macintrottes. The link layer protocols of Appletalk have been implemented in the SMACC which are connected to that network. Communications between the SMACC tasks and the Macintoshes are based on remote procedure calls.

This system should be used to provide local interaction facilities, with one (or more) Macintoshes being able to communicate with all the SMACCs of a given sub-process (such as the instrumentation or the klystron modulators monitoring). This will increase the performance of the current serial connection and replace the serial links and multiplexers with a multi-drop network. It could also be used as a stand-alone control facility for tests or machine development programs integrating a high-level user interface .

Conclusion

The use of the Macintrotte system for the LPI commissioning illustrates the validity and restrictions of such a solution.

The main asset of such a device is that machine or hardware specialists can assemble quite easily and quickly simple control systems with a good user interface. A good user interface enhances the efficiency at each level of user : the system programmers, the application program writers and the end users. Another important point is that such a system is inexpensive compared to the average price of accelerator equipment and that it is transportable.

The performance of the Macintrotte is limited, it cannot compete with a central control system such as the one of the PS complex. As an illustration, an assembly language call to execute a commmand-reply transaction takes about 5 ms in a Macintrotte and about 25µs in the SMACC (8 MHz 68000 version), optimisation could probably not reduce that time under 1 ms. This is why the use of the Macintosh tends to be more and more integrated with the main control system. Another problem (but is it really one?) with these systems is that they tend to make the users lazy to use manuals and harder to please.

The experience of using an "inexpensive workstation" for process equipment commissioning showed that these devices can provide the operators with a very good interface for a price much lower than that of an assembly of interaction modules on a process computer. The crucial point in such a system is the availablility of reliable and high-performance communication channels. In addition, in order to be able to benefit from new developments, these communication channels should be as standard as possible. In our context, the control bus, CAMAC, cannot be controlled by more than one master and the use of other control buses (VME or G64) should also be considered.

For these reasons, the LAN connection of the Macintrotte is also intended to be a prototype implementation of the structure "Workstation-LAN-Process computer". Besides its applications for the commissioning and operation of the LPI, this system is intended to be a workbench for prototyping new concepts in the fields of user interaction and communication protocols. As an example, object-oriented user interfaces [6] and remote method calls are concepts that could be studied with that configuration.

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