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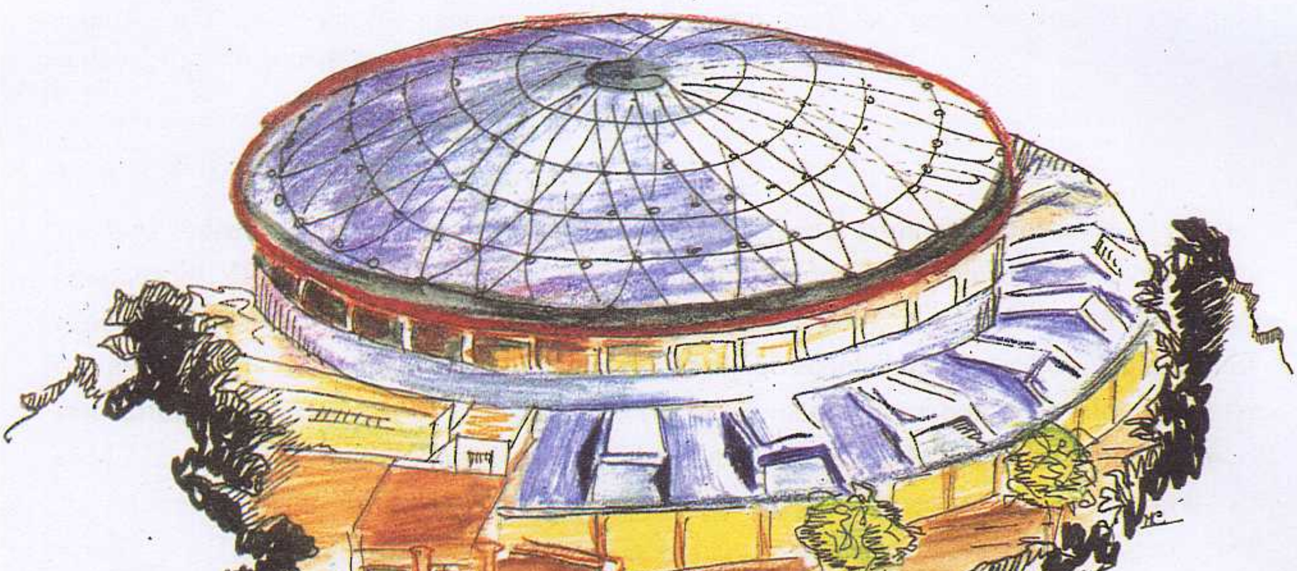

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DATA EXCHANGE BETWEEN A PS/2 AND A MACINTOSH-IICX DURING DATA ACQUISITION BY AN X-RAY POWDER DIFFRACTION STATION

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ABSTRACT

Data transfer between two entirely incompatible computers is always a difficult problem to solve. If some time-delay can be accepted in the data transfer, it is possible to port files between a Macintosh and an IBM PC, using a special software package, like LapLink Mac III(1). Here, we present a successful solution of a real-time information exchange between a PS/2 and a Macintosh IIcx. The PS/2, which controls an X-ray powder diffractometer through its manager program, by means of a resident routine seizes the interrupts from the data acquisition units, reads the data and transfers them to the Macintosh. On the Macintosh, a simple program is responsible for the data receipt, display, and save.

1. INTRODUCTION

At present, two entirely different families of personal computers are used in physics laboratories: IBM PC (or PS/2 as its successor) and Macintosh. From the viewpoint of an experimenter, the computers of the first family are very good for equipment control and data acquisition (they have higher efficiency and can easily be coupled with an experimental setup). In addition, the major part of software used for experiment automation is developed for the IBM PC and successive models. However, the computers of the Macintosh family are more convenient for data processing because of the user-friendly interface and richer graphics capabilities. Therefore, there appears a problem of integrating a Macintosh into the experimental environment. Several approaches to the solution of this problem exist, the most convenient and self-consistent among them being the organization of real-time data exchange between an IBM PC (which manages the experiment) and a Macintosh which can perform primary data processing during acquisition. The present paper reports an example of the realization of such an approach.

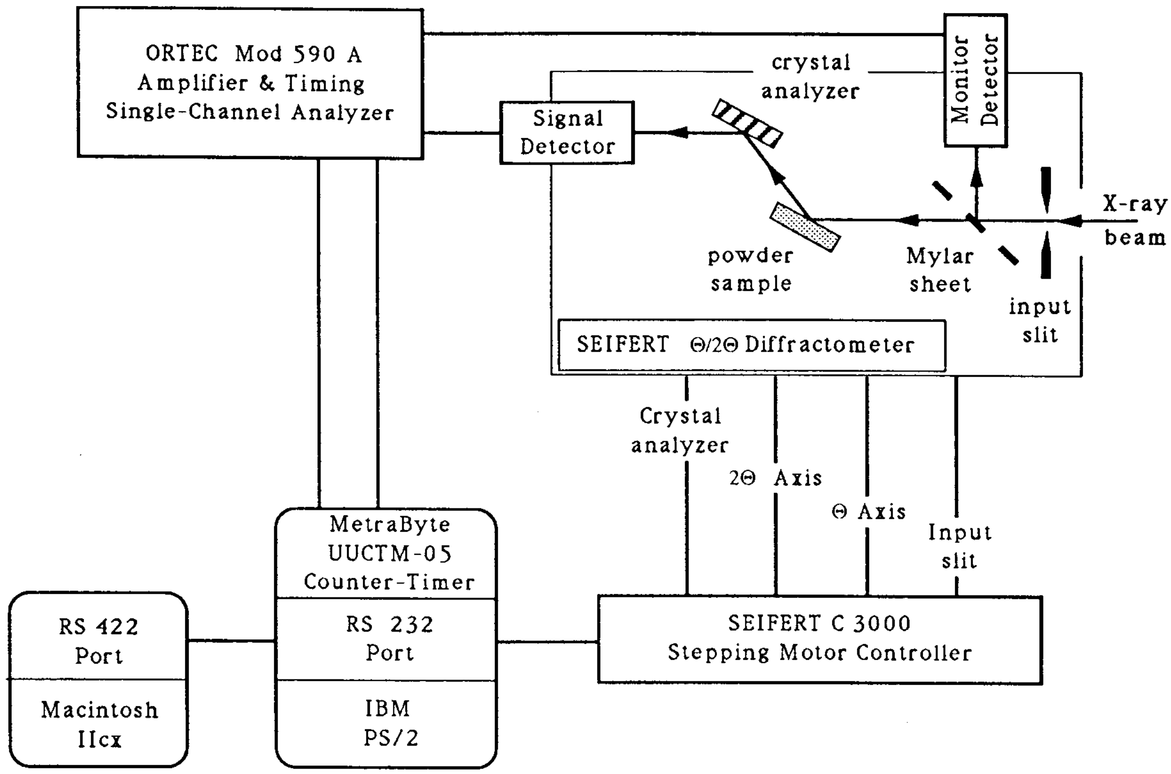

FIG. 1 – *A schematic representation of the high-resolution powder diffraction station and of the control and data acquisition electronics.*

The work has been performed within the framework of the PO.DI.STA. project. According to this, at the beginning of 1991, a high-resolution powder diffraction station, which utilizes the synchrotron radiation as X-ray source, was put into operation on the Adone storage ring at Frascati[2,3]. The station consists of a Θ/2Θ goniometer with a flat crystal analyzer on the 2Θ arm to improve the spectral resolution. Typically, an X-ray diffraction experiment consists of a series of stepwise sample rotations to a customized angle with a customized step. The sample is exposed to an X-ray beam. On each angular step the sample is stopped for a preset time and the intensity of the X-ray beam diffracted by the sample is measured. The specific feature of X-ray diffraction experiments with synchrotron radiation is that the intensity of the incident beam decreases exponentially. Thus, the equipment should provide the possibility to monitor the incident beam, which in this installation is done using a scintillation counter with a 45° Mylar deflecting sheet. The second detector registers the diffracted signal (see Fig. 1). All station operations are remote-controlled by a PS/2 computer, while a Macintosh IIcx is used for the subsequent data processing and interpretation through the program named "MacDust"[2]. This prompted us to make an attempt to collect data simultaneously on both machines, with the PS/2 performing all necessary manipulations with the diffractometer and measuring the intensity. The Macintosh was to receive the results of the measurements in real time and carry out some preliminary operations on the data.

2. – SOFTWARE

The work of the station is normally managed by a dedicated PS/2 program purchased from the Seifert company[4]. This huge piece of software incorporates many different functions, including preliminary adjustment of the equipment, customizing the parameters of measurements, performing the measurements and processing the data. The program, however, has several drawbacks, among which the most important, from our point of view, is that it treats the signals from the counter of the reflected beam and from the beam monitor as two entirely independent sets of data. At the same time, it would be very convenient to obtain a normalized diffraction curve during the experiment, so as to be able to correct the data acquisition parameters in the interactive mode.

In order to solve this problem we developed, by using Turbo Pascal 5.0[5] a TSR (terminate-and-state resident) program for the PS/2, which seizes the interrupts from the counters, reads the counters, and transfers data to the Macintosh; where, in turn, a simple program written in QuickBASIC[6], is responsible for data receipt, display, and save.

A. Hardware

The following hardware is involved in the process: counting is performed by two AMD9513-based plug-in boards[7] (one for the diffracted beam, one for the monitor); while for the data transfer a standard RS232 serial port on the PC is used, with the cable providing the compatibility between this port and the RS422, installed on the Macintosh. Information about the link cable can be found in Ref. (8).

B. Main program

Actually, the task of servicing the real-time data transfer is not very complicated and can be implemented in a straightforward way. However, the main problem to be coped with is that the manager program[4], PMEAS, has an interactive menu (see the bottom of Fig. 2), which can be invoked during measurement, thus providing the user with the possibility to change the flow of the experiment.

To activate the menu, the user must press Ctrl-A, then issue one of the prompted commands; the meaning of the commands is obvious [We wish to note that the implementation of one of the commands, namely, User_communication, contains some bugs, so we preferred to switch off this option via our TSR program]. When the user interface menu is invoked, the measurement process is suspended, and may be resumed after receiving the appropriate command. These commands should also be processed by the TSR program, to keep the Macintosh aware of what is going on at the PS/2. In order to "poke into" the user interface, the

TSR program hooks the hardware keyboard interrupt. (As we were not sure whether the main program uses BIOS functions for keyboard input, we had to intercept hardware interrupts).

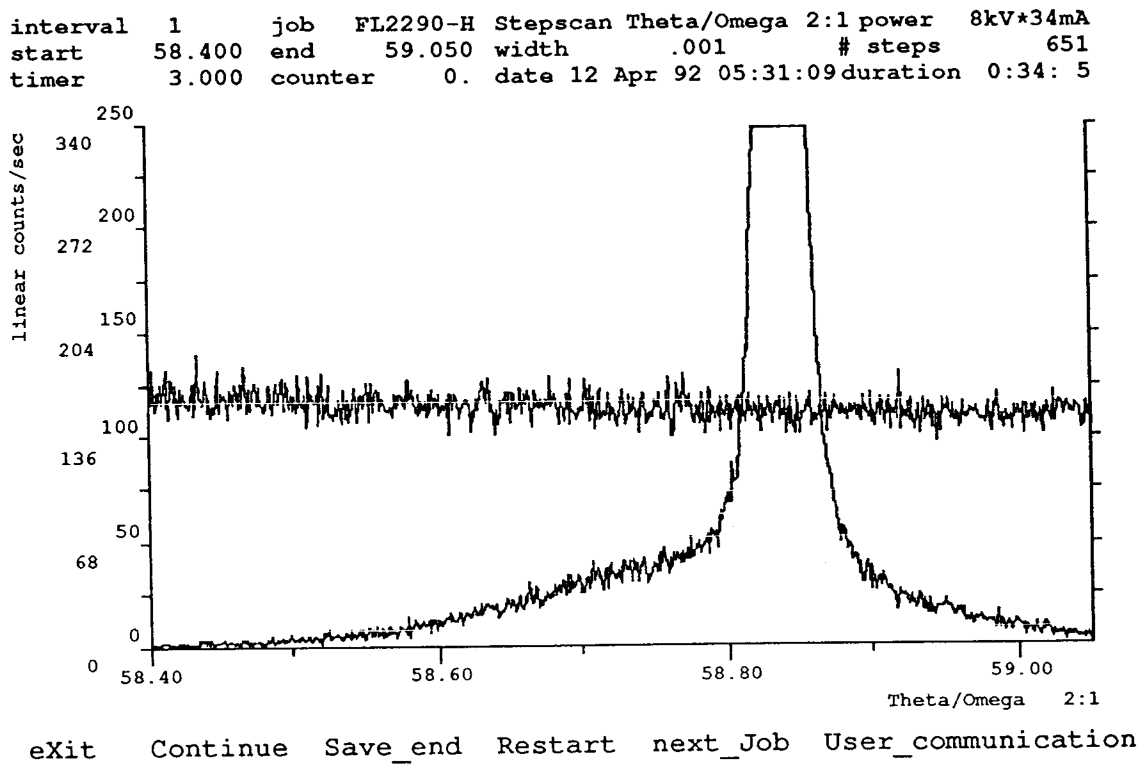

FIG. 2 – *Hardcopy of the monitor screen during data acquisition. The upper curve is the monitor signal, the lower the diffracted beam. The interactive menu commands are at the bottom.*

C. Interrupt

In order to provide internal synchronization of the routines servicing the counter and keyboard interrupts, a system of flags has been used. This enables the counter interrupt routine to be informed about the suspending of the measurement process, while the keyboard interrupt routine was informed whether the counter data were ready for transfer (this was necessary to process the commands which require data exchange).

Both keyboard input and counter data were buffered (for keyboard, we used a single-character buffer, all ahead-typed commands were ignored) for further processing by the data transfer routine, which can be invoked either by keyboard or counter interrupt, depending upon the sequence of their arrivals. In the Appendix we report the general flowchart of the program.

D. Data exchange protocol

The data transfer program can send to the Macintosh messages belonging to one of three types: header, binary data, and commands. Each angular scan of the diffractometer is started with the header transfer and terminated by a command. Header is a string which contains all the parameters of the current angular scan, which are displayed on the screen. The parameters are read from the videomemory when the first interrupt of the scan occurs (cf.Appendix). The header is transferred in ASCII format, as read from the videomemory. The data are transferred in binary format, each measurement requiring the transfer of eight bytes: four for the diffracted beam, four for the monitor. Since commands may interrupt the angular scan at any moment, it is necessary to distinguish them from data. This is done using the most significant bit of the transferred bytes: the data bytes have this bit reset, the command bytes-set. Therefore, eight-bit binary data should be encoded into seven-bit format, thus requiring that ten bytes be sent for each data message. Two commands are involved in the process: SAVE and RESET. SAVE means save current scan and start a new one, RESET means start a new scan without saving. The SAVE command is accompanied by the actual number of measurements executed in the current actual angular scan. This can be used for an additional data consistency check. The SAVE command is issued on completion of the current angular scan or on receiving the "Save" command from the user menu. The RESET command is issued when the user cancels the current measurement by selecting Restart, Exit, or New_Job options on the menu.

E. Macintosh IIcx

The Macintosh operates in a purely slave regime. It executes a loop, which consists of receiving the header followed by the reception of data. The latter continues until a command arrives from the PS/2. The data messages received in the current angular scan are counted, their number being afterwards compared with the actual number of measurements, which is sent by the PS/2 together with the SAVE command. Received data are displayed on the screen and saved, if required, into three different ASCII files: one for the diffracted beam, one for the monitor, and one for the normalized data. After the data pertaining to an angular scan have been received, the Macintosh program starts again to wait for the arrival of a header.

3 - CONCLUSION

The program developed opens new opportunities for intervening in the measurement process. This approach frees the user from the sometimes strict limitations imposed by the software manufacturer, without his having to rewrite the entire program. Such decoupling provides great flexibility in the use of purchased programs.

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APPENDIX

The general flowchart of the communication program is given below. All low-level routines and some minor details of the timing algorithm are omitted.

```
PROCEDURE MyKeyboard;interrupt;
BEGIN
  read_command;
  if buffer_full then set ignore_key
  else begin
    reset ignore_key;
    case_command of
      start_measurements:
        enable counter interrupt;
        initialize flags;
        interrupt_number:=0;
      invoke_menu:
        set menu_flag;
      user_comm:
        set ignore_key;
      _exit:
        disable counter interrupt;
        RESET to MAC;
        reset flags;
      other commands:
        command_buffer:=_command;
        reset menu_flag;
        set buffer_full;
        if measurement_ready then Transfer;
    end case;
  end;
  if not ignore_key then chain to system
  else clear keyboard interrupt status;
END MyKeyboard;

PROCEDURE MyCounter;interrupt;
BEGIN
  interruptsoff;
  read data to data_buffer;
  set measurement_ready;
  if not menu_flag then Transfer;
  interruptson;
END MyCounter;
```

```
PROCEDURE Transfer;
BEGIN
  reset measurement_ready;
  if buffer_full then begin
    reset buffer_full;
    case command_buffer of
      _continue:  nothing;
      _reset, new_job:
        RESET to MAC;
        interrupt_number:=0;
        set ignore_meas;
      _save:
        required_number_of_measurements:=interrupt_number+1;
    end case;
  end if;
  if not ignore_meas then TransferService;
END;

PROCEDURE TransferService;
BEGIN
  interrupt_number:=interrupt_number+1;
  if interrupt_number=1 then begin
    read parameters;
    transfer header;
  end if;
  transfer data_buffer;
  if required_number_of_measurements=interrupt_number then begin
    SAVE to MAC;
    transfer interrupt_number;
    disable counter interrupt;
    reset flags;
  end if;
END;
```

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