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TOOLS FOR MAN MACHINE COMMUNICATION IN THE PETRA CONTROL SYSTEM

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Summary

A standardized control console for man machine communication in computerized processes has been developed. Four identical setups of this type are used for the control and operation of PETRA. A description of the selected interactive communication devices and the electrical and mechanical design objectives are given. Details of the PADAC interface standard and the graphic color video system designed for the PETRA controls are described.

Introduction

In the early stage of the discussion about the PETRA control system the following decisions were made:

- All control tasks have to be executed by means of computers, no 'manual override' features will exist.
- The control room will be equipped with several (3..4) identical operator consoles.
- All parts of the system have to use the same devices to present data to the operator, no dedicated LEDs, displays, panel meters, etc. will exist.
- All operator interventions have to be performed using a small number of standardized operating devices, no dedicated switches, knobs, etc. will be installed.

This concept led to some important consequences: The absence of dedicated data displays requires a data presentation system with a high degree of flexibility and responsiveness. The operator has to deal with computer generated information rather than the original data delivered by the hardware. Therefore the programs which serve as a filter for the data have to be very carefully designed to come as close as possible to the ideal version: to present all information which may help the operator and to suppress all data which are of no importance for the given question.

The operator console

Influenced by the CERN SPS control system[1], we chose the following setup for our standardized operator console:

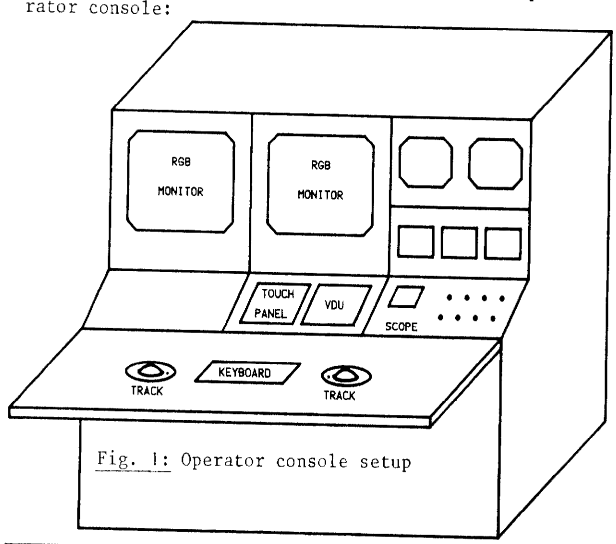

Fig. 1: Operator console setup

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Besides some b/w TV monitors used for the display of camera pictures (beam position, access control, etc.) and an oscilloscope for the display of real time signals, the console contains the following instrumentation:

KEYBOARD and VDU for the basic communication with the computer operating system, typing of program code, entering of numerical information, etc.

The TOUCH PANEL is basically a set of 16 transparent touch button switches whose lettering is done from the rear by a TV monitor under program control. The first set of touch panels we put to use were an exact copy of the CERN development[2]. Currently, we are installing a revised version which makes use of more up-to-date sensor circuits that require less adjustment. The touch panel is a very convenient I/O-device for all those cases where the operator has to do a multiple choice decision. Typical applications are the 'decision trees' to gain access to the desired part of the control system (rather than typing in a program name at the keyboard).

The TRACKER BALLs together with a cursor generator for the video display system represent the main interactive I/O-device. Rotating the balls moves the cursor to the desired area on the video screen; an additional touch button on the tracker ball device starts the programmed action via a computer interrupt. Two modes of operation are possible:

(1) The cursor position registers, which are designed as up/down counters, are hardware coupled to the tracker ball movements.
(2) The tracker ball is employed as an independent device which generates different interrupts when turned into different directions. In this mode, the usage of the tracker ball is not only limited to cursor movements, but it is also possible to count up/down numeric values, generate clock pulse chains, etc.

The tracker ball devices themselves are commercial products.

Two COLOR VIDEO SCREENS are the output devices for the presentation of information to the operator. The specific usage of the two screens is fully up to the programmer. A typical way is to use one screen for the interaction with the operator by means of cursor and tracker ball, while the results of his actions upon the controlled process are presented on the second screen. Another common way to utilize the two displays is to present an overall view on one and zoom in on the area of special interest with the other screen (see 3) for detailed examples).

The interface system

For the interfacing of the man machine communication and data acquisition devices we required a system with the following properties:

- modularity: Each part of the interface should be a pluggable module using a standardized (computer independent) bus within the interface crate;
- ruggedized mechanical construction: It should be possible to plug in and out a module very often without getting problems with the bus connectors.
- Modules may be changed in a powered crate without affecting the other modules or causing trouble with the power itself.
- The front space of the modules should be reserved for maintenance purposes (LEDs, test points) only;

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all I/O-signals should use a rear connector to enable replacing of a module without disconnecting the I/O-cables.
- The interface crates are located within the consoles; since blowers are ruled out for noise level reasons the package density has to be low enough to permit convection cooling.
- The address of the module should be position independent; rearranging of modules within a crate should have no consequences for the programs.
- The adaptation of modules to the bus should be possible with a minimum number of circuits, i.e. only the basic read/write functions should be implemented to keep down the bus interface overhead.
- The standard crate controller should contain all necessary circuits to allow interrupt and DMA from all slots within the crate.
- Since the interface system will also be used in most of the experiment control computers at DESY, the long term total number of crates to be installed will be close to 100. Therefore the price of a crate (including the 5V power supply) should not exceed DM 1500.

Since all of the commercially available interface systems (including CAMAC) do not meet most of the above objectives, we decided to design and build PADAC (PArallel Data Acquisition and Control system).

Mechanical Specification

The PADAC crate is basically a NIM-type crate (8 units high) which accomodates 12 single width modules. Since one slot is used for the crate controller, up to 11 interface modules may be plugged into one crate. Each module connects to the crate via up to three connectors of the DIN 41612 (IEC 130/14) type.

B - bus connector, 96 pins, 64 of which are used for the PADAC bus, some of the remaining for the discrete interrupt and DMA request and grant signals
I - I/O-connector, used for the I/O-signals to and from the peripheral device
N - not specified, used for additional I/O-signals or module-module-interconnections.

The bus itself is realized as a 64 line ribbon cable with 12 mass termination connectors of the type 3M-3332, which are plugged onto the wire wrap poles of the crate mounted bus connectors. Compared to a printed circuit backplane this has several advantages:
- no soldering necessary
- lower price
- very short assembly time
- possibility to replace a single bus connector without difficulty.

However, using such a simple bus construction, cross talk between different signal lines cannot be avoided. By a reasonable definition of the bus signals and carefully designed receiver circuits within the modules noise immunity can be achieved.

Bus Specification

The PADAC bus is a bidirectional tristate bus which connects the crate controller (CC) to all the user modules (UM). It consists of the following signal lines:

D0...D15	16 data lines, bidirectional CC → UM for output, CC ← UM for input
A0...A17	18 address lines, bidirectional CC → UM for programmed transfer, CC ← UM for DMA
INP	transfer direction, bidirectional CC → UM for programmed transfer, CC ← UM for DMA
SEL+ SEL-	differential strobe signal for programmed Transfer, CC → UM (=address/data valid)
CON	hand shake signal generated by the addressed UM (= data ready/request for new data)
PC+ PC-	differential power clear signal, CC → UM
DRY+ DRY-	differential data ready signal, used with DMA only

Besides those bus signals, two pairs of wrapped wires exist between the CC and each UM for the execution of interrupt and DMA requests.

This set of signals provides a straightforward interface which needs only a very few circuits for adaptation within each module. To overcome the inherent bus cross talk two points are very important:
- The signals which must be regarded as pulses rather than levels because they cause action with their rising or falling edges (SEL, PC, DRY) have to be distributed as differential signals and to be received by a differential line receiver with a good common mode rejection within each UM.
- The address information has to be latched within the UM to avoid the generation of spikes on strobe pulse lines by cross talk distortions. This can be accomplished without additional circuits by the use of comparators and decoders with latched inputs.

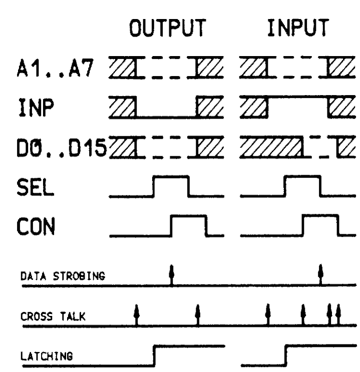

Fig. 2: Basic PADAC timing

The color video system

The color video system has been developed under the following design objectives:
- 8 colors using RGB monitors
- for economic reasons limitation to the standard TV bandwidth (50 Hz, 625 lines)
- no picture interleaving to minimize flickering
- possibility to overlay pictures from different sources
- no load for the computer memory, i.e. refresh memories within the interface modules
- realization as modules within the PADAC system.

The basic clock frequency in the video system is 10 MHz; this leads to a resolution of 256 lines of 512 dots each. A central timing module generates the line and dot addresses, the sync pulses and the timing information for the picture refresh memories. These video timing signals are distributed via a private bus using the third (N) connector of the PADAC modules.

Each picture source module generates a 4 bit output information (R, G, B, BLINK) which is fed to all video selector modules via a set of wrapped wires on the I-connectors. One selector module is needed for each screen. A programmable mask register within each selector module defines which of the up to 16 picture sources are overlayed on the screen. The overlay itself is done on the digital side. For each dot - every 100 ns - the selector compares the information offered by the enabled picture source modules and switches the one with the highest priority and a color different from zero (= black) onto the video output lines. The priority is given by the position within the crate. This 'digital' picture overlay method produces better pictures and cleaner colors than overlaying by mixing of analog video signals.

Three different picture source modules are used in the control system:

(1) Cursor generator - generates different types of cursors and has normally the highest priority. Cursor type, position and color are under program control.
(2) Full graphic buffer - each of the 512 by 256 dots is individually programmable with a 3 bit color information. This module type is the most universal one, but requires a rather large memory (384 Kbits).
(3) Semigraphic buffer - this module type works with a smaller memory, but its graphic capabilities are more limited. The screen is divided into 2048 areas of 8 by 8 dots, each of which can show one of 512 different (programmable) symbols. This kind of picture source is ideally suited for the display of alphanumeric symbols and seldom changing background information.

A typical control system display overlays picture from all three sources: On the lowest priority a semigraphic buffer generates a coordinate system including lettering and background color. Upon this a full graphic buffer superimposes a graphic presentation of measured values. Changes in the measured data require only the updating of the full graphic buffer, the bulk background information requires no attention. For operator intervention enabling of a cursor module overlays a nondestructive cursor at the highest priority.

Conclusions

The PETRA control man machine communication system has been operational for more than a year. Getting PETRA on the air was a comprehensive test for the control system under worst case conditions. It was demonstrated that the instrumentation of the consoles provides a tool for the operator, which is well managable and powerful enough for control tasks of this kind.

Evidently, the use of such consoles is not limited to accelerator control; similar equipped versions are currently being installed in most of the PETRA experiments.

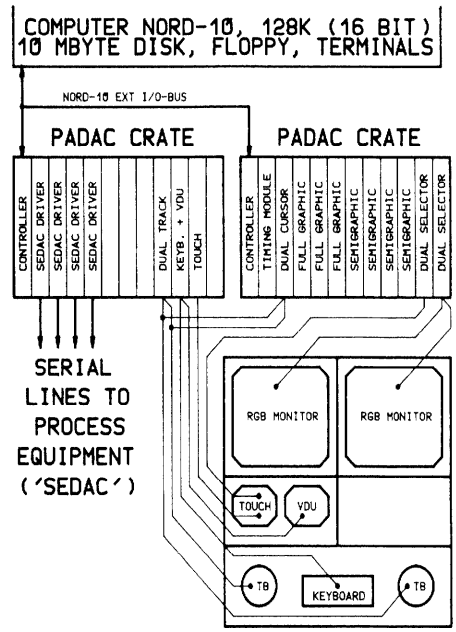

Fig. 3: Console interface

References

1) M.C. Crowley-Milling, The Design of the Control System for the SPS, CERN75-20, 1975

2) F. Beck, The Design and Construction of a Control Centre for the CERN SPS Accelerator, CERN SPS-CO/76-1, 1976

3) H. Frese et al., First Experience with the PETRA Control System, in these proceedings.