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AUTOMATION OF AMS MEASUREMENTS IN UTRECHT

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This article describes the automation of AMS measurements by means of a MicroVAX I computer connected to a fiber optic data acquisition system. The hardware architecture allows a gradual change from manual to computerised control of the tandem accelerator.

1. Introduction

The precision of AMS measurements depends strongly on the performance of the accelerator, the ion source and on the beam transport system. Many parameters are involved. Continuous control on a real time basis allows quick adjustment of these parameters. Moreover, special features such as measurements in which the samples are continuously scanned, or measurements of large series of samples can be carried out.

At the beginning of the automation project the choice was made for a gradual change from manual to computerized control. Firstly the computer will be used only for data logging. Then gradually more parameter settings will be controlled by computer. During this test phase the return to manual control is always guaranteed, so that a breakdown will not influence the time-schedule for the experiments.

2. Main setup

Fig. 1 shows a diagram of the main setup. The hardware which controls the beam source is situated at 3 different voltage-levels: −120 kV (ion-source station), −100 kV (injector station) and ground level (LE station).

On each level there is a control station with a transmitter and a receiver, capable of 32 16-bit input and output channels. Fiber optics links are used for communication with the control room; data transmission is in serial form.

A transmitter in the control room sends the manual or auto-adjusted data to the stations. Three receivers in the control room are connected with the three stations, the measured data are shown on display panels in the control room.

To interface the data to a MicroVAX I computer, a bus has been designed (CO-bus) to which all hardware devices in the control room are attached. This bus is connected to one port of a dual ported RAM (DPR). An interface connects the other port of the DPR to the MicroVAX I in such a way that it can be considered as an extension of its main memory.

All receivers in the control room are interfaced with the CO-bus, and write their data to the DPR. The transmitter reads its data from the DPR and sends it to the experimental setup.

Manual control data, which can be used in parallel with computer controlled data, are transported via a microprocessor (Mproc1) into the DPR. This Mproc1 is also active in formatting the data to MicroVAX I format, and in communication between the separate stations. The priority scheduling of requests for CO-bus access is done by a supervisor module.

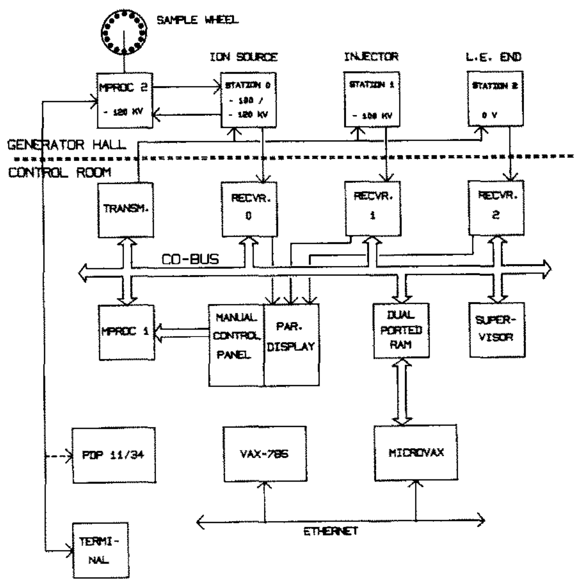

Fig. 1. Block diagram AMS automation.

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The software of the MicroVAX I is developed on a VAX/785 (VAX-ELN Pascal) and downline loaded via the Ethernet link into the MicroVAX I. Logged data is also transported via Ethernet from the MicroVAX I to the VAX/785.

A second microprocessor (Mproc2) controls a 16-position sample-wheel, which is at −120 kV. Communication from the control room is made via an RS-232 fiber-link. Construction of a link between the PDP 11/34 computer for on-line measurement and Mproc 2 is underway, so that the sample can be selected automatically. Before changing the sample, station 0 receives the command to remove the −20 kV extraction-voltage. This communication is also done via a fiber-link.

3. The dual ported RAM (DPR)

The DPR is interpreted by the MicroVAX I as a standard extension of its main memory. Access from the CO-bus takes place without occupying the Q-bus. Because of the high data refresh rate, Direct Memory Access (DMA) is not possible in order not to overload the Q-bus. The Q-bus has a higher priority than the CO-bus when accessing the DPR.

Address map: Each hardware-device has its area in the DPR:
- Receiver data: the 3 receivers write the measured data in this block, each with its own clock of about 30000 write-accesses per second;
- Manual settings: all changes on the control-panel are registered here by Mproc1.
- Auto settings: the transmitter reads the adjusted data from this block and sends it to the stations with a refresh cycle time of 4 ms;
- Communication: this block is reserved for exchange of messages between MicroVAX I and Mproc1. To synchronize this communication the highest address in the DPR is a hardware semaphore.

4. Data acquisition

The settings of the experimental setup can be changed in manual mode via up/down buttons and switches on the control panel or in automatic mode by the software of the MicroVAX I. In both modes the auto settings area in the DPR is updated.

The data for each station (fig. 1) is packed in 32 16-bit words. Each 16 bit word is composed of 12 bits representing an analog value and 4 binary bits. The analog information is used to define the voltages and currents for magnets, steerers, lenses, sputter sources etc. Binary information is used for on/off- and polarity-switching, cups in/out, scaling information, etc. Analog settings which require more than 12 bits are multiplexed over consecutive binary nibbles.

The transmitter in the control room sends a continuous sequence of serial data-words, each word containing a 2 bit station address, a 5 bit parameter address and 16 data-bits. Because of the 1 MHz clock frequency of the fiber-link a sequence of all 128 channels is sent each 4 ms.

The measured analog and binary data from the generator hall is sent to the control room in the same format as described above. The data refresh time is 1 ms, because there are 32 channels.

In automatic mode the response time of the whole system is determined by the refresh-time of the data transport system (4 + 1 ms) and the response time of the parameter involved. In manual mode Mproc1 needs up to 100 ms for updating and formatting of the control-panel changes.

At the moment about 100 analog values and 200 binary bits, distributed over the 3 stations, are in use. In the future the parameters of the high energy end of the accelerator will also be connected to the system.

5. Change from manual to automatic control

The setup can be fully manual controlled when Mproc1 updates the auto-setting area. In the automatic mode the MicroVAX I determines which data is present in the auto-setting area of the DPR. By bringing the settings gradually under control of the MicroVAX I, automation can be completed gradually.

6. The sample manipulator

Two stepping motors control a 16-position sample wheel. The *X*-axis motor produces a rotation and is used for sample changing. The surface of the sample can also be scanned in the *X*-direction by this motor. With the second motor the whole wheel can be moved in the *Y*-direction. With both motors the complete are of a sample can thus be scanned. Both motors have a feedback of the actual position. For the *X*-direction this is done by an Absolute Angle Encoder, the *Y*-direction uses a linear potentiometer. Control of the motors can be made in manual mode as well as in auto mode (via Mproc2). In manual mode the manipulator is set in the centre of sample 1, the zero position; in auto mode this position is used as a reference.

During the experiment the sample can be held in any position. It is also possible to scan the area of a sample, in which the speed (0.1–1) mm/s and scan-radius (0.1–3) mm etc can be chosen.

Because the high-voltage environment of Mproc2 (−120 kV) and the possibility of electric discharges, especially during start-up of the ion-source, much attention is paid to shielding and protection of the inputs and outputs of Mproc2.

7. Microprocessors

The microprocessors are dedicated systems, built with GESPAC G64 Eurocards with a Motorola 6809 type processor, and have no external memory. The software for these systems is written in FORTH on an OS/9 GESPAC system, and downline loaded to Mproc1 and Mproc2. In such an environment FORTH has the advantage that it is an interpreter mode language with the possibility of adding new (test) routines in memory, without intervention of the host OS/9 system.

8. Conclusion

The automation system described is based on a MicroVAX I computer. Microprocessors act as a local intelligence for sample scanning procedures or as a medium for parameter storage. During the test period no deadlock problems were encountered in the interface communication.

After installation the system works well and further progress is being made in developing the MicroVAX I software.

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