Concept and Status of the Control System for the VICKSI Accelerators at HMI-Berlin

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Abstract

The VICKSI accelerator and beam line systems which combine the existing 6 MV Van de Graaff with a new split pole cyclotron will be computer controlled. In its first stage the control system allows direct operator access to all system components. Operator interaction and maintenance are supported by the computer through the main control desk as well as various mobile consoles. For standard operations or tests the computer displays to the operator the choice of facilities available. For accelerator studies an interpreter allows any kind of observations. The main back up of the system is a database as a software image of the accelerator and beam line status. Control and data acquisition is routed through a CAMAC-Serial-Highway System to various CAMAC modules which control the actual devices. Five standard types of modules have been specified in such a way that one module completely controls one device thus allowing a simple and comprehensive addressing scheme as well as simple system software. Nearly all the hardware has been delivered and tested. The software is under development, a preliminary version is being checked on a test beam line section with a Van de Graaff beam.

Introduction

The heavy ion accelerator combination VICKSI being built at the Hahn-Meitner-Institut in Berlin consists of a 6 MV single stage Van de Graaff accelerator injecting into a 4 sector split pole cyclotron. The injection part will include a stripper and two bunchers which adapt the Van de Graaff beam to the requirements of the cyclotron injection, after extraction from the cyclotron the ion beam may be sent along the postaccelerator transport system to about 12 different target areas one of which will be a high resolution spectrometer. More details may be taken from a separate contribution[1] to this conference.

As the number of controls would be exceeding the amount which could be easily controlled manually it was decided in an early state of planning that a computer assisted control system should be installed. Although the design of this system should not limit its application and further improvement the layout and the feasibility had to comply with the potential available at the Hahn-Meitner-Institute. The design aims and the resulting decisions have already been outlined in an earlier publication[2]. Therefore we shall only summarize here the main points leading to our present configuration.

1. Normal operation is done in a main control room through a main control console allowing independent interaction for at least two operators.
2. Remote or mobile consoles have to be provided to access the control system at the place of the actual devices for local diagnostic purposes.
3. The design of all accelerator and beam line components must allow the access of any information which is available on the hardware status (analog and digital) as well as the access of all controls which take part in the acceleration and beam transport process. Interlocks have to be hardwired and must only feed status information to the control system.
4. The ports between the actual devices and the control system are to be specified in such a way that simple interfacing through standardized modules can be done.
5. The general interface is the CAMAC[3] system because it is well known to many manufacturers. It simplifies module specifications and offers a greater flexibility than really needed. On the other hand this flexibility has to be duly reduced to the actual requirements in order to simplify system software.
6. An interpreter has to be provided which has the power of BASIC or FOCAL but which is especially adapted to the needs of accelerator control like NODAL[4] which is used at CERN Lab II. It will be used for device test and maintenance routines as well as for machine physics. It must be available as soon as possible.
7. The rest of the system software has to be made available in several stages. In its first version it must provide access to all system components with regard to control and data acquisition as well as the simplest form of assistance to the operator such as data logging and hardware supervision. It should however be open to further extension like closed loop control in the long run.

System Lay Out

The schematic layout of the VICKSI computer control system is given in fig. 1. A PDP-11/40 computer is used with a CAMAC-Parallel-Highway[3] providing the interface to the operator's Main Console, to a system maintenance area and to a CAMAC-Serial-Highway[4] driver.

All the accelerator and beam line components will be controlled via the single loop CAMAC-Serial-Highway System. As the equipment under control is distributed almost equally along the beam transport path the Serial Highway will be of about 300 m of total length interfacing 35 crates with about 550 module ports.

Operator interaction with the actual accelerator and beam line components is basically routed through the CAMAC Highway System with the computer inducing and checking the appropriate transfers, and providing data backup as well as assistance to the operator.

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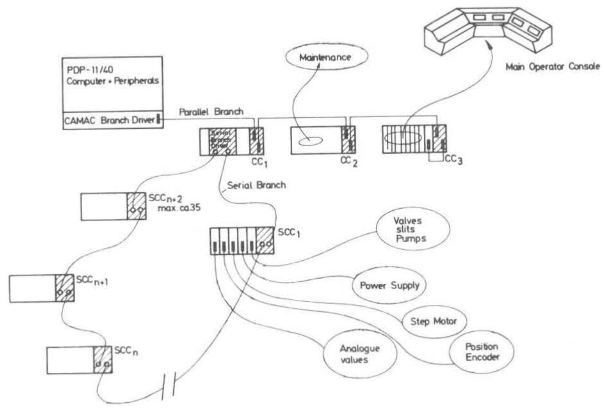

Fig. 1 Schematic View of the VICKSI Control System

CAMAC Interface

As stated above the interface between the computer and the beam handling components is based on the CAMAC Parallel and Serial Highway System. While the parallel system is explicitly specified since 1972 and hardware is available from various manufacturers the serial system still only exists as a recommendation. Nevertheless hardware can be purchased from two manufacturers since last year. We took the risk to buy this hardware although it might not comply with the final specification. Our serial system is operational since the end of last year with good results if operating speeds are adapted to the length of the serial loop, the number of crate controllers involved and of course to the quality of the transmission cable.

The final operation envisaged in our system is the byte serial transfer mode at a speed of 2.5 to 5 MHz. This however requires the addition of resynchronization and signal fresh up at the place of each crate controller. As a bypass unit is necessary for each serial crate controller to prevent the system from being incapacitated by local power failures we have ordered units which imply resynchronization signal fresh up, optical isolation and crate power monitoring at the same time. These units will be ready for delivery in September 75.

CAMAC Modules

In principal there are three types of operations which are routed through the CAMAC System. These are

- monitoring of status information of all process components within the accelerator system (e.g. status of power supplies, valves and interlocks, slit position)
- control of these components (e.g. switching power, setting of magnetic fields, positioning of slits)
- reading of analogue values (e.g. magnetic fields, current and voltage of power supplies or beam observation equipment)

The list reduces the number of necessary data transfers through the module ports to

- ON/OFF control
- 16 bit DATA OUT
- 16 bit DATA IN
- ANALOGUE data in

It follows that the major part of operations can be induced by a small set of CAMAC functions F:

- F(25) for pulse output
- F(16) for data transfers to a module
- F(0) for data transfer from a module
- F(27) to test the external device

The use of the latter function was introduced to simplify status monitoring. The bit tested by F (27) should be "TRUE" for the "normal operating condition" of the tested beam handling component combining all status bits defining this condition. When a device has been set up to its "normal operating status" the status word itself will only be acquired if the test by F(27) is "negative".

We have chosen this polling procedure instead of an interrupt facility (DEMAND or LAM on status change) because mechanical displacements which are involved in various control actions may possibly not come to their correct stop thus refraining from interrupting the system. This means that a recheck of the supposed status would have to be made after a certain time.

It was possible to specify five types of standardized CAMAC modules[2] which combine the selected CAMAC functions mentioned above in such a way that one module entirely controls one beam handling component which in return may be connected to the module by one standard cable. For analogue measurements there is an additional bus ending in an analogue-to-digital converter or a digital multimeter. Analogue sources are switched onto this bus by selection of a multiplexer channel.

The major part (95 %) of the control system may be interfaced by these modules. The rest which comprises very special devices like display controllers will be interfaced via commonly offered controllers from various manufacturers.

The high voltage terminal of the Van de Graaff accelerator will require a special solution which is presently under design. The control will basically consist of a memory storing all the information which has to be transferred to and from the terminal via an optical link. The memory will be interfaced to the CAMAC system in such a way that the addressing scheme outlined above will also apply to the terminal components.

Test and Maintenance Equipment

As there is a large amount of modules and cables to be tested on delivery or to be checked on system failures we decided to have test modules for each type of CAMAC module as well as the standard interface cables in order to do automatic testing by the computer.

On the other hand module simulators which substitute a specific standard control module have been made available to test the external equipment at its control port before branching it to the control system.

In this way we are able to use only such devices for final installations which have been tested and decided to be operational. The same test equipment may be used for quick rechecks or for maintenance purposes.

Consoles

In general operators may interact with the control system via a number of different consoles. There will be one Main Control Console set up in the Main Control Room. Small Mobile Consoles may be branched to the control system through any CAMAC crate along the Serial Loop. In general interaction with the control system may be done in parallel from all consoles. The setting of a control variable will however be reserved to the first user requesting it.

Main Control Console

A schematic view of the Main Control Desk is given in fig. 2. Its design is adopted almost completely from the CERN Lab II solution[6].

The bays of type II will be general purpose bays allowing system access via large colour TV-screens displaying any kind of system information and touch panels and/or a tracker ball for interaction with the system. The touch panels consist of a BW-TV monitor under a transparent screen with 16 touch-sensitive areas for program requests, program-option selection, device-to-knob assignments or device-to-display assignments. A knob is provided for the variation of control variables once the assignment has been made.

The bay of type III will be dedicated to general purpose graphics . The graphic displays provided at present are Tektronix type 611 scopes driven by a CAMAC storage scope driver. These scopes might be replaced by plasma-displays in the future when appropriate CAMAC interfaces are available commercially. A touch panel will allow program selection or interaction with these programs when they are running.

The bay of type IV will be reserved to permanent displays of information on critical control variables. The set up is not fixed. The operator may select and group critical variables at his choice.

The additional bays will be dedicated to the observation of analogue signals. The layout of these bays is dependent on requirements of the Van de Graaff, cyclotron and beam line groups, and is still not specified at present.

The final control desk has been delivered some time ago and is ready for installation. The design of the interaction elements is finished, all parts have been ordered and will be delivered during the next few weeks. Installation and tests will hopefully be finished by the end of the year including the operating software. The final installation of the whole console cannot be done until January 76 because the installation site still undergoes constructional changes which will not be finished until then.

Mobile Consoles

A mobile console may be any movable computer terminal, e. g. typewriters, alphanumeric display terminals or even graphic display terminals allowing the use of "remote graphics". All these terminals will be branched to the control system via CAMAC Communications interfaces. With the exception of graphics this system will be operational by the end of 75.

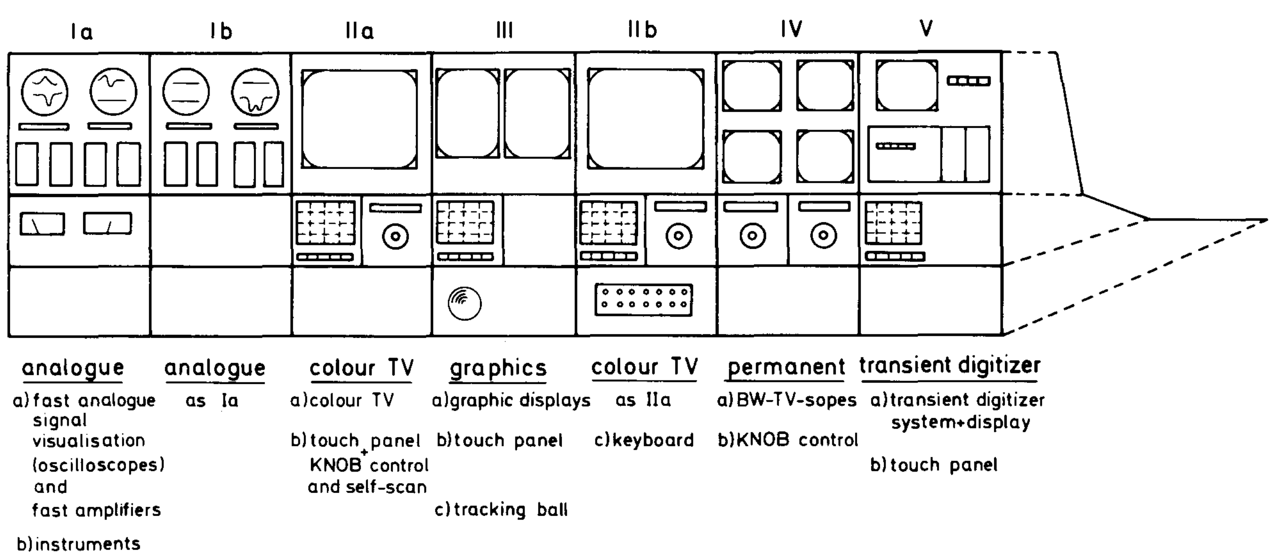

Fig. 2 Schematic view of the Main Control Console

Control Software

The control software runs under the RSX-11D operating system supplied by the Digital Equipment Corporation for their PDP-11 computers. Software is generally written in machine assembler code (MACRO-11) for time critical routines or handlers. All application programs are written in FORTRAN IV as a high level language. These resources were operational when the computer arrived in Febr. 74.

As a result of our studies of other existing accelerator control systems and especially as a consequence of CERN LAB II experience we decided to have an interpretive language available from the very beginning of system development. As a start we used a version of DEC-BASIC modified to run under RSX-11D and to drive our CAMAC interface. At the same time the HMI Data Division accepted to develop a multi-user/multi-task interpreter (MUMTI) on the basis of the CERN-Lab II NODAL proposal[5]. The first version was ready for implementation at the end of 74 and BASIC was exchanged versus the more powerful MUMTI interpreter.

The use of the interpreter was helpful for any computer assisted service that was needed for tests and check out of hardware or similar actions. No additional assembler programming was needed in this respect.

As a consequence our software group could develop the control system software without having to service early software requests from other groups.

The central back up for the accelerator and beam line setting is a sort of data base which combines all the information on the accelerator system components. The tables describing a device contain interface addresses, hardware status, present or buffered values, etc. These tables will be constantly updated and their sum will be the image of the process in the computer so that all programs can operate in up-to-date initial conditions. These data tables allow a central management facility of the control hardware and provide standard control facilities for all application programs by the use of symbolic device names. The actual hardware implications are transparent to these programs. Last not least they will prevent conflicting control in our multi-user environment and ensure a rapid recovery from mains failure, computer crashes or similar.

Operation

Interaction with the control system will normally be done by the use of touch panels and knobs. The operator will actually choose among the facilities displayed by the computer (program selection, parameter assignment, displays, etc.). The use of the keyboard should be the exception. It will be used to communicate with the interpreter for operations which are not implemented as standard operating programs, for machine-studies, error detection or similar operations which cannot be foreseen.

A preliminary version of the software system as well as interaction elements are presently being tested on a beam line test section with a Van de Graaff beam. No major problems have shown up so far in the hardware which consists of a 250 m CAMAC Serial Loop driving standard interface modules since about two months. The tests will be run for another month. Afterwards the site will be prepared for the final installation of the injection path to the cyclotron.

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