

UPGRADING THE CONTROL SYSTEM AT THE WEIZMANN INSTITUTE ACCELERATOR LABORATORY

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Abstract

A major upgrade of the control system at the Accelerator Laboratory at the Weizmann Institute of Science has been performed recently. The control hardware is based on GROUP3 CONTROL system using fibre optic communication loops between local I/O device interfaces and few special independent communication PC cards. The software was upgraded to LabVIEW 6.1 with Datalogging and Supervisory Control (DSC) module. The hardware is controlled by special servers on dedicated computers. Each I/O point is represented by a tag that can be controlled by clients via network communication. Security, data log and alarms were also added to the system. The need for computer control at the accelerator laboratory was in large part driven by the program of accelerator mass spectrometry (AMS) measurements, where frequent and repeated command sequences are performed. A script utility program was written for easy user interface so that changes of the experimental setup can be carried out routinely and rapidly.

1 INTRODUCTION

The accelerator laboratory of the Weizmann Institute of Science includes two accelerators. The first accelerator is a 3MV Van de Graff (VDG) and the second one is a 14 UD Pelletron accelerator. Additional facility is the new molecular physics laboratory which includes a low energy ion beam facility and electrostatic ion traps. The accelerators were built 45 and 27 years ago respectively, with no computer control systems. The decision to convert the accelerators control to computerized one was taken in 1994. This process required a long time since both the hardware and software installation took place without interruption of the scientific activities. The basic hardware for the control system is the Group3 Control which is widely used in electrostatic accelerators due to its built-in fibre optic communication. The software was developed under LabVIEW 3.1 originally running with Windows 3.1. Several software upgrades were performed to adapt the system Windows and LabVIEW versions. During these years the control system has also increased rapidly as more and more manual controls were converted to computer control, and users request for new features were included. However, the heavy load on the control computer, which included both hardware and user

interfaces became too large, causing the system to crash too often.

A major upgrade was then performed, based on a radical change on the control concept. The hardware control and the user interface were separated and the server-client scheme solution was adapted to the system.

In the next Section, a more detailed description of the hardware is given. Section 3 contains the basic software concepts of the server client solution and a special script utility. The conclusions and the present status of the system are described in Section 4.

2 CONTROL HARDWARE

The basic hardware for the control system is the Group3 Control. Additional hardware consists of DAQ cards for timing control and GPIB communication for some instruments. Instruments that are using RS232 serial communication are part of the Group3 Control hardware. A schematic view of the Group3 Control is given in Figure 1.

The control computer contains a communication card that is called Loop Controller (LC). The old Loop Controller (ISA) cards used in the system were all changed to PCI Loop Controllers, to fit the computers available on the market. Each LC card is communicating through a fibre optic loop with its own dual port and on board processor. All the communication and the control data are located on a 2 Kbytes memory, which is shared by the host computer. The communication with the instruments in the loop is done with no overhead to the computer CPU. In each LC card there are either one or three independent loops; few LC cards can be located in the same computer (up to 16 loops in a single PC).

In each loop, up to 16 (addressed 0-15) device interfaces (DI) can be connected. Input and output plastic fibres are connected to each DI to close the communication loop. Each DI includes a mother board with its own processor for communication, data handling, setups, watchdog signals and local diagnostic. A DI can control up to three DAQ cards (addressed 1-3). A variety of DAQ cards are available and the most common used one in this system are: 24 digital I/O, 8 ADC 16 bit input, 8 DAC 14 bit output, 2 RS232 serial ports and 4 encoders boards.

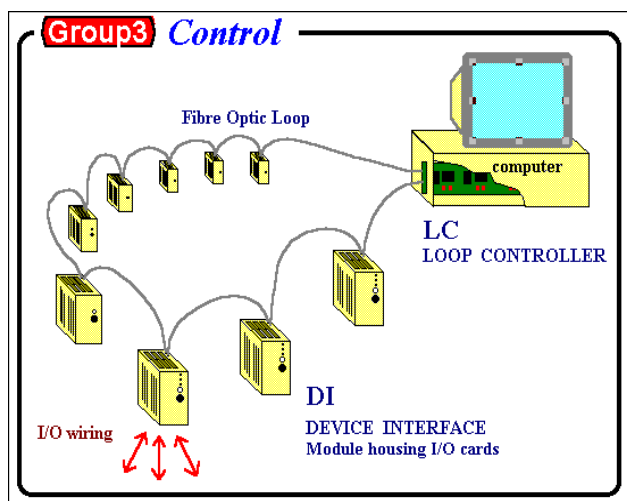


Figure 1: Schematic layout of a single control loop.

A single I/O channel is updated in 0.8 millisecond and 32,000 I/O channels are scanned in a second, in each loop. The currently active loops, DI's and host computers are listed in Table 1.

Table 1: I/O hardware and computers

LOOP NAME	DI	HOST COMPUTER – TYPE and OPERATING SYSTEM
Control Room	5	Pelletron Server, Pentium 3, Win2000
Beam Tunnel+ Target Room	4	As above
Ion Sources+ Pre-injection	6	As above
Tank	0	As above
VDG	2	VDG Server, Pentium 2, Win98
Molecular Physics Lab	7	Ion Trap Server, Pentium 4, Win2000
Radiation monitor	PLC – RS485	Radiation Server, Pentium 3, Win2000

The Pelletron server is connected to about 600 I/O in the loops as well as a GPIB instrument. The VDG server is connected to 40 I/O. The Ion Trap server is connected to about 200 I/O in the loop plus several RS232 instruments that are not included in the loop, and an additional timer card. The radiation server is connected to 19 PLC's via RS485 communication.

A special hybrid infrared(IR)-fibre optics communication system was built to operate and control the AMS ion source on a high-voltage (150 kV) platform. Control values for current and voltage power supplies are set through an IR-link operated either manually or via a

PC-IR interface. P/S monitor values are read-out by the Group 3 hardware and communicated to ground by fibre-optics. The hybrid system enables local (manual) operation concurrently with computer-control together with enhanced reliability.

3 SOFTWARE AND SCRIPT UTILITY

The software used for the control system is based on LabVIEW. The major upgrade of the software, beside the conversion to version 6.1 was to implement the Datalogging and Supervisory Control (DSC) Module to the previous control software. The basic concept in the old version was to separate the hardware control from the user interface by running two software processes in parallel. The first process operation was to put the hardware data in and out from the computer memory to global variables. The second one was the user interface software process that was interfacing only with the global variables and not directly with the hardware memory. These two processes were running independently and asynchronously.

The first software process was moved to a separate computer with a built-in new written server. The server is using the DSC module. In this module many data servers can be operated, in each one there are many devices and each device has many items. An item is a name for a real I/O point in the hardware. In this upgraded system, a server is one or few Group3 loops; a device is a board in one of the DI's and an item is a real I/O point in such a board. The server action is to read or write data from or to a built-in Queue. The data is coming from or to the computer memory at the hardware loop location.

In order to allow any user to write or read from the Queue, a tag engine that is built in the DSC module is used. In this tag engine, any I/O item of the server, can be defined and be used for further programming. Therefore the above second programming process was changed so that each global variable was replaced by a tag. Each tag is more than just a data variable number; it is a fully programmable variable. It has built-in scaling, alarms, update mechanism, logging options and security.

Each tag (all of them or any part) can be imported through the network. A user on a client computer can use such a network tag to send or get data to the Queue on the server. A client can import tags from few different servers on different computers and control all of them using the client program. In order to minimize the communication over the network only changes are updated with event driven mechanism.

Another available option is to define a memory tag. Such a tag is not a real I/O item; but rather a virtual I/O point that is used in few instances. For example, when an instrument is sending ASCII characters, which after checks and manipulation, result in a numeric value. This value is defined as a memory tag so that all clients do not need to manipulate the real tag again to get its value. Another example is when a client wants to control an item

with a manual encoder. In such an encoder, increment or decrement of a certain tag value is needed. The client user clicks on the wanted control and the name of the required controlled tag is entered to a special memory tag. Hence a unique assignment is given to the encoder enabling it to change the tag value. The DSC module has built-in options for data logger, alarms and security. Data files containing the set-up of all major ion-optical elements of the machine and corresponding to a given ion-energy condition can be saved and reloaded.

The AMS measurements demand repeated sequences of operations in order to set the 14UD Pelletron accelerator for different ions (usually a rare and abundant isotope of a given element), measure currents in a number of Faraday cups and eventually calculate an isotopic ratio (in a range down to 10^{-15}). A special script macro language was developed in LabVIEW in order to give the user the possibility to define an *ad-hoc* sequence of commands (up to 100 at present). Commands are composed of ion-optical setup (data file loading), single elements operation (e.g. Faraday cups), current or integrated current measurements, arithmetical operations etc. All commands are executed sequentially either in a continuous "auto" mode or prompted "manually" by the user. Options to stop

the sequence and restart it from any command are available.

4 CONCLUSIONS

The major upgrade of the Weizmann Institute Accelerator laboratory computer control system has been done successfully. Several computer servers operate with hardware communication cards. The servers are getting the data in and out to a Queue. Clients are connected through the local network to the Queue using tag engine facility of the LabVIEW DSC module. The server client scheme with different server computers enables the user to have more reliable controls with no interruptions to the routine accelerator operation.

Further development includes an additional loop for the accelerator tank where the high voltage (14 MV) and high pressure (5 atmosphere of SF₆) require special considerations. Additional boards (called CAN with built in PID's) which can be operated in such harsh environment will be added. Another control system is under development using National Instrument FieldPoint with Real Time capabilities.