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VACUUM AND BEAM DIAGNOSTIC CONTROLS FOR ORIC BEAM LINES

B. A. TATUM

Oak Ridge National Laboratory*
Oak Ridge, TN 37831-6368

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ABSTRACT

Vacuum and beam diagnostic equipment on beam lines from the Oak Ridge Isochronous Cyclotron, ORIC, is now controlled by a new dedicated system. The new system is based on an industrial programmable logic controller with an IBM AT personal computer providing control room operator interface. Expansion of this system requires minimal reconfiguration and programming, thus facilitating the construction of additional beam lines. Details of the implementation, operation, and performance of the system are discussed.

INTRODUCTION

Beam lines from the Oak Ridge Isochronous Cyclotron, ORIC,[1,2] contain numerous components related to vacuum and beam diagnostics. A new system for controlling these components and monitoring beam line vacuum has been implemented. It provides capabilities which did not previously exist, standardizes those which did exist, and facilitates expansion associated with new beam lines. An industrial programmable logic controller is the basis of the system, which is a deviation from the more traditional hardware platforms used in accelerator facilities, such as CAMAC. The system is dedicated in that it is not interfaced to a host computer and is used solely for the purpose of vacuum and beam diagnostic control.

SYSTEM HARDWARE

From a hardware standpoint, the system consists of an industrial programmable logic controller (PLC), a personal computer (PC), digital vacuum gauge controllers (DGCs), vacuum gauges, valves, and beam viewers. Figure 1 shows a block diagram of the system.

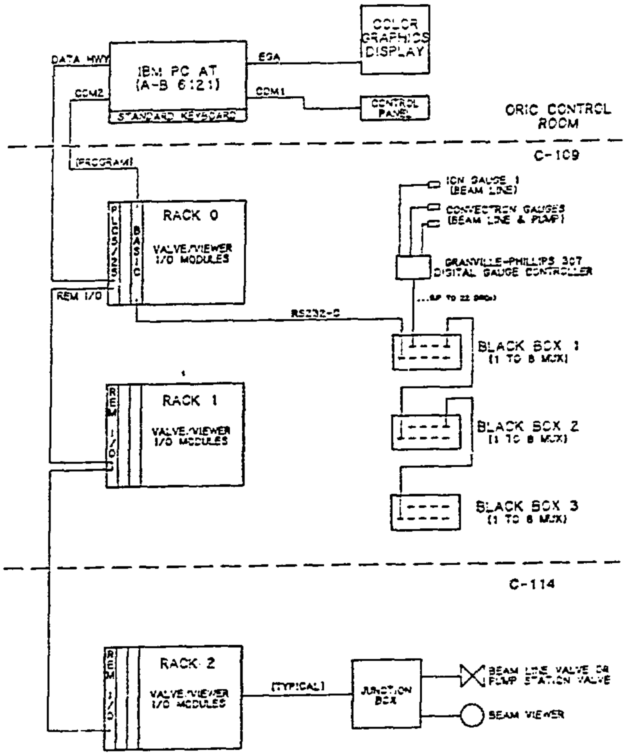

Fig. 1. Vacuum and beam diagnostic controls block diagram.

An Allen-Bradley (A-B) PLC 5/25 processor provides the logic handling capability of the system. The processor resides in a chassis containing I/O modules through which the beam line valves, pump station valves, and beam viewers are interfaced. Granville-Phillips (G-P) 307 DGCs are interfaced through a BASIC module which resides in the A-B chassis and transfers information to the PLC. Each DGC operates one Bayard-Alpert ionization gauge and two G-P Convectron gauges. Additional I/O chassis are networked to the processor chassis via the A-B Remote I/O Link operating at a 57-kbaud transmission rate.

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DISCLAIMER

A distinct advantage of the PLC is the ease in which the valves and viewers are interfaced to the modules. Wiring is connected to terminal strips which swing out of the way for easy module removal. Thus complicated interface boxes and connectors are not required.

Operator interface to the PLC network is provided through a dedicated IBM AT Personal Computer located in the ORIC control room. The A-B Advisor PC Color Graphic System is utilized to provide color graphics displays of the beam lines. Pages may be selected to show overviews of the beam lines with beam line valve or beam viewer status shown by the color of the respective symbols; this is OPEN/CLOSED for valves and WITHDRAWN/INSERTED for viewers. A red symbol refers to a device positioned to block beam passage, and green represents an OPEN or WITHDRAWN state. Additional vacuum pages may be selected to show elevation views of sectors of the beam lines. A typical sector, as shown in Fig. 2,

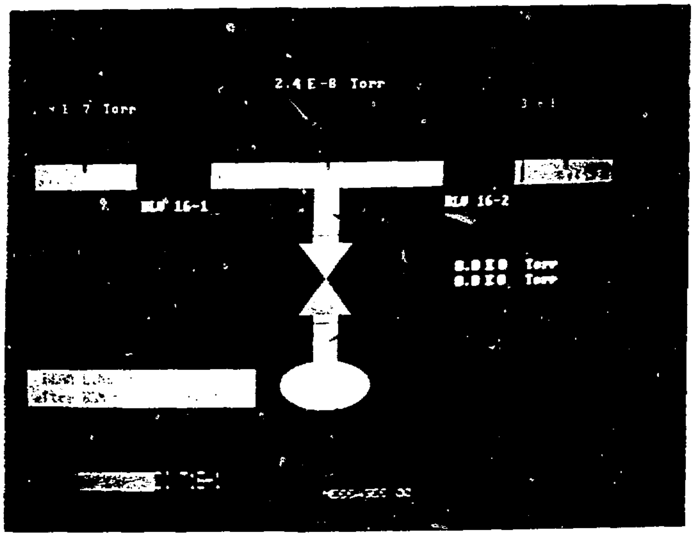

Fig. 2. Typical beam line sector.

consists of a pump station, a pump valve, and two beam line valves to isolate the pump station. These views provide beam line and pump station valve status, pressure readout, and the capability to control valves and ionization gauges in the displayed sector using a programmable A-B keyboard. Available ionization gauge controls are ON/OFF and electron bombardment DEGAS. The keyboard sector select keys are arranged so that an operator can sequentially step down any given beam line to a target station. Valve, viewer, and DGC control keys are also conveniently grouped. Individual components do not have separate keys. Instead, an operator selects the device he wishes to operate and presses the appropriate operation key.

SOFTWARE

Software for the system is divided into three major segments: PLC ladder logic for valve/viewer handling, a BASIC program for DGC handling, and operator interface configuration.

Communication to the PLC is accomplished via A-B PLC-5 programming software running on the control room PC. All of the PLC code is written in relay, or ladder logic. There exist different subroutines for each available operator interface display. The subroutines differ primarily in the block transfers to the BASIC module. To improve the update time of pressure readings, only the DGCs associated with a given sector display are scanned, thus block lengths vary. The block transfers are synchronized in read-write pairs. For simplicity, all valves are scanned within the main program. Viewers are only scanned when the single viewer display is selected.

The purpose of the BASIC module is to provide ASCII communication to the DGCs and to convert ASCII pressure readings to a PLC compatible data format. It is possible to communicate directly with the BASIC module from the control room PC via a terminal emulator. This permits easy program modifications, diagnostics, or uploading and downloading of program code. The BASIC program resides in the 16-kB battery backed RAM of the module. If expansion of the program to more than 16 kB becomes necessary, a 32-kB EPROM is also available.

Operator interface configuration takes on several aspects. Graphics displays are created with a mouse graphics package in which tags are applied to different symbols, e.g. valves, viewers, or pressure readout boxes. Information related to these tags is stored in a database. For example, each valve in the system has an associated tag which contains the PLC status and control bits pertaining to that valve. Thus a tag may be referenced by more than one display. Each graphics display has a corresponding background program which informs the PLC and BASIC module of the current display. The viewer page background program also saves the selected viewer such that if an operator leaves and returns to the page he will not have to restep through the control list. Graphics screens are preloaded into RAM when the system is booted to facilitate rapid screen drawing. The programmable membrane keyboard is easily defined in a database and a single communications table is used to define each of the communication links.

The software operates in the following way:

Advisor PC informs the PLC and BASIC module which display page is active and scans the PLC data tables. Additionally, it writes to the data tables if an operator has requested toggling of a valve, viewer, or ionization gauge state. The PLC and BASIC module branch to subroutines relevant to that page, with the BASIC module transferring DGC pressure readings to the PLC data tables and toggling ionization gauge status as necessary. BASIC module communications to the DGCs is via RS-232C. Switch codes are sent to three Black Box 1-to-8 RS-232C multiplexer boxes which are daisy-chained together and to which the DGCs are connected. The Black Box switches are located adjacent to the DGCs.

In the event of a power failure, the entire system will restart itself. The system is designed to operate in the "fail-safe" mode. If a power failure occurs, valves close, viewers withdraw, and they remain de-energized after power is restored until an operator changes their state.

SYSTEM PERFORMANCE

Programmable logic controllers are traditionally not known for high speed data transfers and there were initially a few problems with moderately slow pressure update rates. However, accelerator beam line vacuum monitoring does not require millisecond updates. What an operator needs is to know the vacuum scale and to be able to see changes in vacuum. Nevertheless, the pressure update rate has been enhanced to about twice per second, which is more than adequate for normal operation. This was accomplished by some programming adjustments and a direct 57-kbaud A-B Data Highway interface between the PC and PLC. Previously an RS-232C 19.2-kbaud link was used. Presently, the slowest aspects of the system are communications between the BASIC module and the G-P DGCs (limited to 9600 baud), and the fact that the BASIC program is interpreted rather than compiled.

An early problem which had to be overcome was the use of a color CRT in the ORIC control room in which there may be up to a 20 gauss magnetic field when ORIC is operating. Several different types and sizes of CRT were tested. It was apparent that Trinitron technology showed the least distortion. However, some shielding was still necessary. A mu-metal shield and a protective aluminum box were fabricated to house a 13" Sony Trinitron monitor. The assembly was mounted on a tiltable, swivel base and bolted to the top of the ORIC console. Operationally, there have been been no complaints except that it slightly obstructs the view of a portion of the ORIC main panel.

Operators are pleased with the improved information that the system provides. They have contributed numerous ideas to make the system as user-friendly as possible. This is the first color graphics based control system for the Holifield accelerators. Thus there were the usual ergonomic discussions on colors, glare, page layout, symbols, and location. At present, the operator's primary enhancement request is for the replacement of the programmable keyboard with a trackball. The Holifield tandem accelerator control system presently utilizes a trackball. This was not an option with earlier versions of the operator interface software but it is now available and the possibility of such a conversion is being studied.

Portions of the system have been in operation for more than a year and a half and the only hardware failure was, oddly enough, with a defective PLC chassis. Otherwise, the only maintenance required has been the routine replacement of burned out ionization gauge filaments.

The system has proven to be easy to expand. Originally, the beam viewers were not to be part of the system. However, they operate exactly like a valve and thus became a logical addition to the system. Their inclusion was basically as simple as creating a graphics screen, adding them to the database, and wiring them to new modules. Other chassis and modules may also be added with ease. This is attractive for further expansion of Holifield beam lines.

SUMMARY

Vacuum and beam diagnostic equipment on beam lines from the ORIC is now controlled via a new system based on an industrial programmable logic controller with a personal computer operator interface. It has proven to be a viable alternative to the more traditional hardware implementations. PLCs offer simple interfacing, reasonable cost, and they fit very nicely into modular control systems. As PLCs continue to improve in the areas of data transfer and number crunching, they will likely be used in ever increasing areas of accelerator control.

REFERENCES

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