THE IUCF HIGH INTENSITY POLARIZED ION SOURCE CONTROL SYSTEM*

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ABSTRACT

A high intensity polarized ion source (HIPIOS), capable of producing 100μA of protons at 600keV with $\geq$75% polarization is presently under construction at IUCF. An overview of the control system is presented, with a brief explanation of the bakeout and vacuum subsystems. HIPIOS will utilize a control architecture new to IUCF. Implementation through the use of VME hardware and programmable logic controllers, all under control via the VAX-based Vista^{tm} graphical user interface, and results from initial bench tests will be discussed.

1. INTRODUCTION

IUCF is developing HIPIOS to improve substantially polarized beam intensity in the Cooler Ring[1]. The existing accelerator complex is controlled by PDP-11s driving DACs, ADCs and parallel I/O over a system built in-house from a long obsolete commercial standard[2]. While it is possible, for many reasons it is not prudent to further expand this system. Since HIPIOS and its associated beamline (BL1C) can be operated independently of the IUCF accelerators and other beamlines, we chose to use them as an opportunity to become familiar with new controls equipment. HIPIOS and BL1C will be controlled through VMEbus, commercial VME cards, PLCs, GPIB, workstations and a commercial software system. Figure 1 presents a schematic representation of the HIPIOS control system.

2. CONTROL SYSTEM COMPONENTS

2.1 Software

As in any computer intensive project, software costs eventually dominate, as long as manpower costs are accounted for. Recognizing this in our own control system and knowing that we could not afford to create our own graphical user interface system, we examined a number of existing systems. We chose the Vista[3] software system as best fitting our requirements and limitations. Vista provides the GUI framework and basic device access mechanisms. We need only create control displays for the operator using Vista tools and write that software which is unique to our equipment.

The distributed control system uses ethernet and fiber optics to connect data acquisition nodes to graphics generating nodes and operator X-window terminals. All operator interaction will use X-terminals, not hardwired panels. Our operations staff have insisted that knobs be included at all control stations. (They do not want to use on-screen sliders.) Our goal is to have sufficient tools on hand at commissioning that neither knobs nor sliders will be necessary.[4]

2.2 Hardware

The basic unit of the control system is a 21 slot 6U VME crate built by VERO to our specifications so that crate power supplies can be serviced from the front. Most crates contain an AEON VME300 CPU board which includes an rtVAX300, 8Mb of memory, and VMEbus and ethernet interfaces, running the VAXELN operating system. Crates operated in hostile environments, such as inside HIPIOS, are driven by Augment fiber optic backplane extenders from a ground potential station and do not contain a cpu. There will also be a reboot link between the terminal and ground which

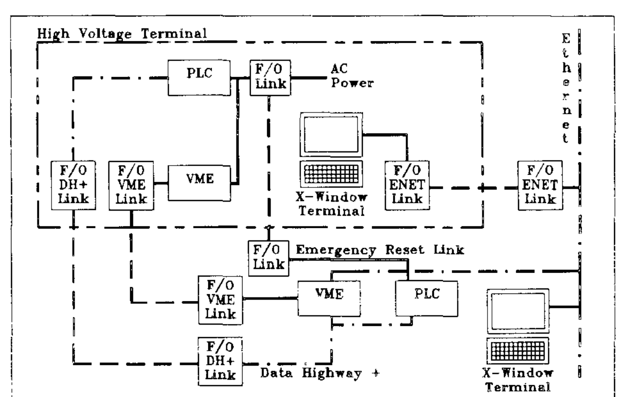

Fig. 1. Controls block diagram

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will allow the operator to reset all controls systems in the terminal.

2.2.1 PLC

The hardware in the new controls system which provides us a qualitative advance over the old system is the Programmable Logic Controller (PLC). We have decided on the Allen-Bradley PLC5/VME, a PLC5/15 equivalent in a VME form-factor. We use 32-point 24v input modules (A/B #1771-IBN) for status/interlock inputs, 32-point contact closure output modules (A/B #1771-OWNA) for device actuation outputs and 8-point thermocouple input modules (A/B #1771-IXE) for temperature readout. For spark protection, the PLC5/VME resides in the ground station VME crate and communicates with the HIPIOS high voltage platform via the fiber optic converter modules (A/B #1771-AF) and remote I/O adapter modules (A/B #1771-ASB).

On/Off control, interlocks and status for power supplies, vacuum devices, bakeout devices, RF devices and stops are handled in the PLC. Commands from the control computers are treated as requests by the PLC. If the pre-defined interlocks and conditions are satisfied, the PLC will honor the request via a contact opening or closure. All interlocks are hardwired or implemented under PLC ladder logic; controls computers do no interlock checking on their own.

Programming the PLC is done with ICOM Ladder Logistics software running on a PC. Currently a desktop PC is used, but we are ordering a laptop PC since portability will be important in diagnosing control problems in the future.

Communication between the PLC and a controls computer is provided through a block of PLC memory accessible from the VMEbus. To reduce software overhead, the device handler divides this memory into blocks for treating reads, writes and error reporting. Because obtaining a data block from the PLC is comparatively slow, the handler supports a deferred read function where execution returns to the calling program immediately after a read command is issued. The program may later execute a handler call to return the last data block read or wait until it becomes available. The handler uses multiple read blocks so that multiple programs may have simultaneously active read requests.

2.2.2 Analog I/O

In choosing components for the analog section of the control system, multi-function cards were rejected as too costly to maintain in the long run. Standard commercial components were chosen where-ever possible.

For analog acquisition we use ADAC 7000MF series ADC cards. These twelve bit (7010MF) and sixteen bit (7040MF) VME cards allow their inputs to be multiplexed through an external chassis (5305ENV) using 4012HLEX multiplexer cards. In this way one can have up to eighty analog inputs per VME slot. Inputs are differential to avoid common mode voltage problems with power supplies. Few sixteen bit inputs are needed so multiplexers are not used with the 7040MF cards.

For analog control we chose Datel's DVME-626 and DVME-628 DAC cards for fourteen bit and twelve bit resolutions, respectively. (Although the DVME-626 is a sixteen bit card, it is only monotonic to fourteen bits.) These cards were chosen primarily for their thermal stability (8ppm/°C).

2.2.3 Isolation

The DAC cards are not isolated from digital (VME) ground, while the supplies we are controlling require the outputs to be isolated from digital and frame ground. To cut costs, we decided to design and build an analog isolation subsystem ourselves; the isolator card (CYC-V01) is the only non-commercial component we are using. It is a 160x233mm Eurocard which fits into a VME crate, using it's P2 connector for power and output connections. Inputs for the CYC-V01 come through DB-25 connectors on the front panel. The CYC-V01 uses Burr Brown ISO-102 amplifiers and PWM740 DC-DC conversion components to provide eight isolated outputs per card. The bandwidth of the system is limited to 6Hz to eliminate any switching noise from the ISO-102. We implement these cards in VERO KM6 subracks to save expansion space on the VME backplane.

2.2.4 EMI Shielding

We have invested considerable thought to trying to protect expensive electronics in the hostile environment of the HIPIOS high voltage terminal. Because of the industrial ruggedness of the PLC components and the bandwidth limits and analog isolation for the DAC channels and because of costs, we shield only analog inputs, GPIB and serial lines. We are using ferrite beads, a 100 Ohm series resistor, a 1.5KE18CA transzorb and an Oxley FLT/P/5000 on each signal connection. There is a filter assembly on both signal and return connections for all signals attached to the VME crate. The filter assemblies will be mounted in the rear doors of a General Devices EMI shielded rack. Tests have been done using a proto-type which show that, by using these filter assemblies, damage to our electronics from typical discharge events should be minimized.[5]

2.2.5 Motors, GPIB and serial links

Motors will be driven by Oregon Micro Systems VME8 eight-axis controller boards interfacing to SD3 motor drivers. This combination can handle a wide variety of motors with programmable velocity and acceleration profiles.

We are using National Instruments GPIB-1014 for a GPIB interface and FORCE ISIO-2 for a serial interface supporting both RS-232 and RS-422 protocols. Both devices are serviced by separate programs rather than device handlers, even though interrupts are used to signal command completion. This does make new applications less convenient to create, but the variety in serial and GPIB devices is too great to admit a simple common service routine.

3. OPERATIONAL SYSTEMS

3.1 Bakeout

A bakeout system is needed to improve the vacuum conditions for source operation. Each chamber of HIPIOS has its own bakeout sub-system, consisting of two heaters, two thermocouples and two temperature sensing klixons. All klixons are wired in series and pass the drive voltage for the main 110 VAC contactor. When any klixon reaches 170° F, it opens, shutting off power to all heating elements, providing highly reliable protection against overheating.

The PLC is programmed to keep the temperature of each chamber within a range defined by the user. If either thermocouple reads above the high setpoint, the PLC turns off the heating elements. When both thermocouples are below the low setpoint, the PLC turns the heaters back on. This algorithm protects against driving the system to an undesired temperature should one of the thermocouples fail.

The bakeout system uses only one control display. A pair of temperature bar graphs, an ON/OFF control button, an indicator showing when the heaters are actually energized, a fault indicator and a strip chart showing temperatures vs. time form a group of controls which is repeated on the display for each of the HIPIOS chambers. There are also indicators for the emergency stop button and the klixon circuit and a fault acknowledge button. Most faults are not reset until this last button is activated to show that the user is aware of the fault. Display data is updated at 1Hz.

3.2 Vacuum

The vacuum control system must deal with a wide variety of devices, including a PLC system for on/off, interlocks and status for vacuum and water valves and flow switches, RS-422 for convectron gauge controllers[6], GPIB for cryotemp monitors (Lake Shore Cryotronics model 819), and ADCs for cold cathode ion gauge controllers (MKS Instruments series 421) and flow/ratio controllers (Vacuum General model 80-4). The convectrons have alarm setpoints and outputs (contact closures) which feed directly into the PLC system for interlocking (of cold cathode ion gauge high voltages, for example). The cryotemp monitors have alarm outputs (contact closure) fed to the PLC for interlocking of cryo gate valves.

The vacuum system uses a number of control displays, some of them arranged hierarchically showing ever finer details of the system. Valve control is performed by placing the cursor on the proper valve and clicking a mouse button. Bar graphs provide pressure readings. Special buttons are provided to open or close sets of valves which experience has shown are often used together. We intend to automate pumpdown and venting procedures via the Vista command sequencer.

4. CONCLUSIONS

To date the new control system has met our goals. We have been quite pleased with how quickly bakeout and vacuum control have been implemented, considering that it is all new technology for us.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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