

INITIAL CONTROL OF THE H⁻ ION SOURCE AT THE SUPERCONDUCTING SUPER COLLIDER LABORATORY

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Abstract

The ion source produces a 30 mA beam of 35KeV H⁻ ions for SSC accelerators. The beam is chopped at 10 Hz into pulses of 7 to 100 μ sec. The ion source presents an opportunity to implement and exercise software tools and techniques which will be useful in future SSC control systems. TACL, a software package from the Continuous Electron Beam Accelerator Facility, forms the core of the system. TACL controls several analog channels and monitors interlocks. Emittance measurement control is now under design. In addition to TACL, components of ISTK are also used to interactively acquire and display ion beam information. The integrated system, including VXI and CAMAC acquisition modules attached to a network of heterogeneous computers, is described.

I. INTRODUCTION

The SSCL will have two H⁻ Ion Source types: a volume source to be built by Lawrence Berkeley Laboratory (LBL)[1] and a backup magnetron source built by the Texas Accelerator Center (TAC)[2]. The magnetron source, currently functioning as a prototype is discussed in this paper.

The beam current, specified at 30 mA and 35 kV, will be chopped to achieve a 7 to 100 μ sec pulse width at 10 Hz. The design goal is an emittance of 0.2π mm-mrad

The Low Energy Beam Transport (LEBT) will be one of two types. A Helical Electrostatic Quadrupole (HESQ)[3] is the main design; with an Einzel Lens for backup. Due to low cost and simplicity of fabrication, the Einzel lens is now installed in the prototype and is discussed in this paper.

Diagnostics will consist of a phosphor screen monitored by television camera for remote viewing, charge collector, slit and collector in both transverse directions, two flying wires positioned 5 and 9 cm downstream from the LEBT, and a current toroid positioned at the exit of the LEBT.

II. CONTROL SYSTEM PROTOTYPE

A. Control Block Diagram

Figure 1 indicates that the present points available for monitoring and control are few, as scientists wish to have direct control while tuning the source.

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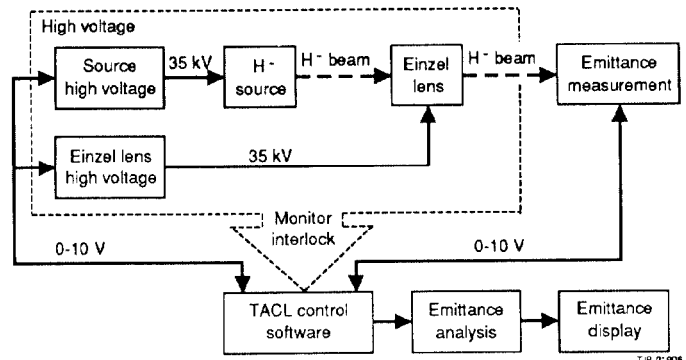


Figure 1: Control Block Diagram

The prototype control system monitors the high voltage power supply for the magnetron source, the safety interlock, and monitors and controls one of six high voltage power supplies for the einzel lens elements. Emittance measurement control is now under design.

The emittance measurement is done by independent slit and collector probes. The collector consists of 48 wires each separated by 0.254 mm, and is located 150 mm downstream from the slit. The slit width is adjustable but is nominally set at 0.1 mm. After each successful collection of data, the slit advances one slit width. Beam diameter is approximately 30 mm, which results in about 400 data points to fully traverse the beam and surrounding area. Ions not passing through the slit are collected from the slit plates and sampled. If the slit charge is not within tolerance from the expected value, the candidate data set from the collector is discarded and a new data set is taken, at the same position, on the next available pulse. Ions deposited on the collector yield intensity values for the 48 wires. It is expected that 6-10 wires will have significant values during each measurement. To ensure that all of the beam projection falls on active elements of the collector, data sets indicating excitation of wires too close to the ends of the detector are discarded and, after repositioning, a new data set is taken. An attempt is made to position the collector for each data collection so as to minimize the number of discarded data sets. Five analog-to-digital converters with 12 channels and 11 bit accuracy are used. All 60 channels are gated by the same NIM gate, which is triggered by the same master timer used to generate the beam pulse. Forty eight channels are assigned to the collector wires, while the slit, and each of the two flying wires, are assigned one channel. The width and delay of the NIM

gate is calibrated for the collector wires at midbeam. The current from the slit is attenuated by a resistive network before sampling. This allows the slit current which is much larger than the collector wire currents to be sampled in the same NIM gate interval.

B. TACL Control Software

Thaumaturgic Automated Control Logic (TACL) [4] is a hierarchical, distributed, and extensible control system. It is coded in C and operates in Unix on HP 9000 series computers. It interfaces mainly with CAMAC modules, but can be configured to interface with RS232 and GPIB instruments.

TACL has been extended at SSC to include VXI/VME interface capability. An oscilloscope in a VXI crate with an embedded processor running TACL has been used to monitor the ion source beam. Programming the oscilloscope interface was done in much the same manner as GPIB instruments have been done in the past, using ASCII string commands from within a custom user process. The beam trace data may be displayed by TACL and Kaspar, a plotting utility which will be described later. In addition, the VXI capability has been extended to register-based devices which allow memory mapping and fast backplane access to VXI devices. No custom code is required for these devices and when hardware becomes available, we expect to use this same technique to interface to VME cards in a VXI crate.

TACL uses two off-line editors to build the runtime system: a LOGIC editor and a DISPLAY editor. In the LOGIC editor, the user configures the hardware by selecting CAMAC modules from an extensible library and clicking on the desired slot on the screen icon graphically representing the CAMAC crate. Clicking on another icon displays the LOGIC screen which presents various menus and a two-dimensional grid.

In this grid, ladder logic is built which defines the control system algorithms. The elements making up the control logic may be selected from menus or custom-built "user-processes". The LOGIC array executes down the columns from left to right until the last column is executed and then starts at the beginning again. This constitutes a LOGIC cycle. CAMAC reads are automatic on each LOGIC cycle but writes can be either automatic or executed on demand.

Figure 2 shows the section of LOGIC array which controls the emittance measurement. The figure contains standard LOGIC elements plus two custom "user-processes" written in C and executed by LOGIC when triggered.

Emittance measurement begins when the momentary switch labeled "start" is closed by the operator. This initiates the user process "qkck" which does four things: validates data when available, calculates motor movement for the next data collection, triggers motor movement by setting "trig", and signals completion of "qkck" by setting the "ckrdy flag". When the motors have stopped (busy3 is low), the CAMAC LAM signals are cleared and the NIM

gate is enabled in preparation for data collection. The second user process, "cklam", is initiated which: waits for LAMS to indicate signal digitization is complete, resets "ckrdy", sets "start" to repeat the above cycle.

The operator can enable/disable data gathering by toggling the enable button on the user screen.

The cluster of LOGIC in the lower left corner of the figure initiates motor movement.

The part of the LOGIC array for bit status monitoring and control is not shown in Figure 2 but consists of assigning the binary control points to a word to be sent to CAMAC and converting the output word from CAMAC to binary monitoring points. This allows the user screen to attach toggle symbols and/or pushbuttons to every binary point if desired.

Digital values reflecting the power supply settings are made available to the user screen before and after filtering by placing a "display output" symbol for each condition in the block diagram. Bar graphs are tied to the noisy signals while digital readouts are attached to the filtered values.

On the user screen (not shown), bit status is shown on a "byte" display which displays up to 16 bits. Each bit display changes color when the system response indicates that the bit was indeed set. Clicking on the bit display will set or reset the bit. Bits 9-16 are not settable by software but are reserved for monitoring. The interlock status bit is monitored at bit 16. Bits 1 and 2 are currently used for testing. All other bits are yet to be assigned. Analog control is done at read/write boxes by a point-click-enter sequence or by assigning a knob to the read/write box. Analog monitoring is done with bar graphs and digital readouts.

III. ISTK SOFTWARE

The ISTK collaboration [5] consists of a group of scientists, engineers, computer scientists, and industry representatives working on an informal basis to produce a collection of software products for use in engineering and science. The goal of this effort is to provide a tool kit that will contain a growing and evolving collection of scientific and engineering tools connected by a high-level integration architecture (a software bus). The following ISTK components are used during the operation of the ion beam source:

1. SDS (Self-describing Data Standard) - SDS is a data discipline for storing and retrieving binary data. It is portable across different architectures and supports different storage formats such as SYBASE, a commercial database, shared and process memory and disk.
2. Kaspar - Plotting utility for viewing self-describing data.
3. Camel - A control-panel designed for interfacing to and retrieving data from CAMAC crates. It stores the data it acquires as SDS datasets.

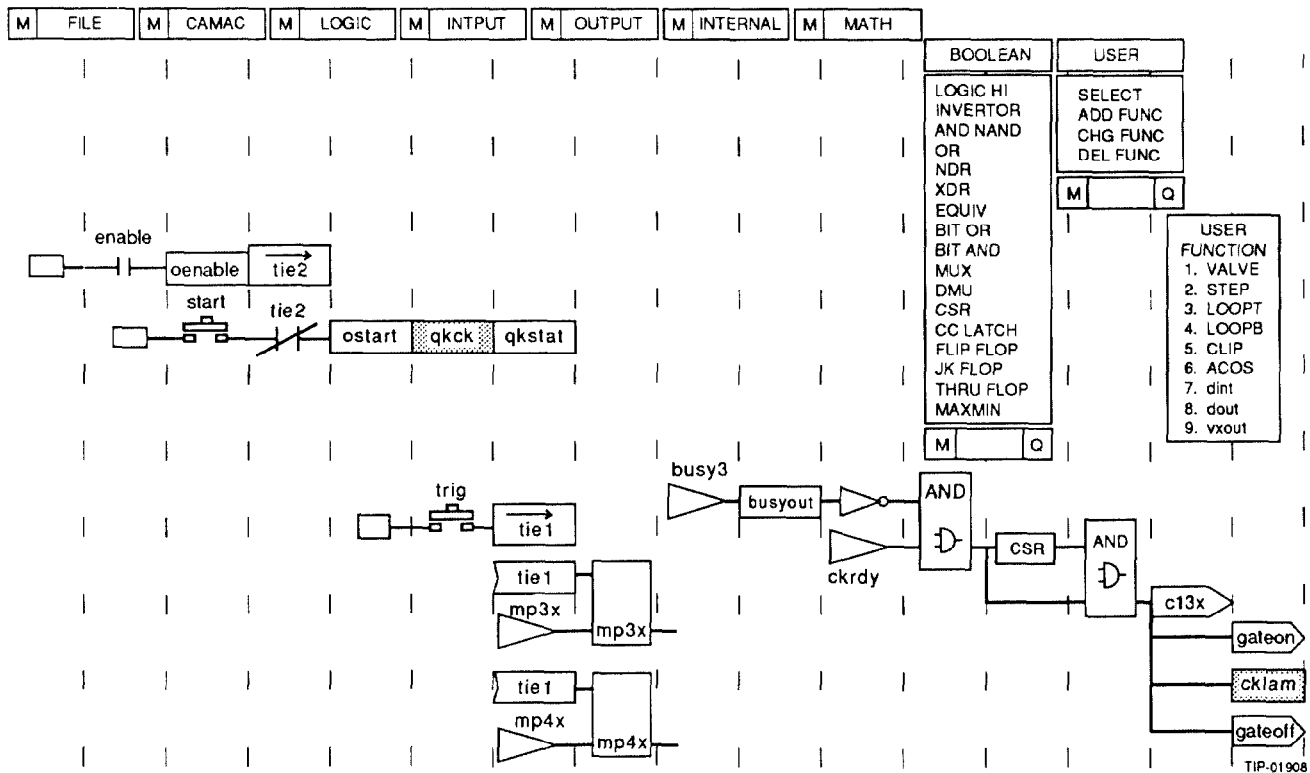


Figure 2: TACL LOGIC

The data acquisition and display sequence begins with a CAMAC data logger informing Camel that there is valid data available in its buffers. Camel retrieves this data, stores it as an SDS dataset in shared memory and informs Kaspar. Kaspar is attached to this same SDS dataset and awaits a signal from Camel. When it arrives, Kaspar retrieves the data from the dataset, replots it on-screen and the entire sequence begins anew. During the preliminary operation of the ion source, Kaspar and Camel were connected via sockets. Ultimately, glish will be used to direct the sequence and oversee the process interconnections. Glish [5], also developed as part of the ISTK collaboration, is a system for accelerator control sequencing, providing a general mechanism for processes to exchange messages and to be sequenced according to both abstract and real (hardware) events. The sequencing is rule-based and processes can be controlled across the network.

IV. FUTURE PLANS

As the machine is tuned, more monitoring and control points will be made accessible. A current list identifies 117 monitoring and control points. In many instances, the additions are typical to tried and tested control LOGIC and DISPLAY and can be quickly duplicated. This allows the system designer to concentrate on designing LOGIC and DISPLAY of the new elements.

V. CONCLUSION

The above system has functioned well within the limited scope assigned. Physicists have been pleased with the ease of use and rapid development time. The addition of

ISTK tools in parallel, allows browsing and plotting of data without interrupting operator control. The prototype has provided a valuable testbed to implement and test software tools and techniques to be used in future SSC control systems.

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