

RFQ1 CONTROL AND DATA ACQUISITION SYSTEM*

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Abstract

The RFQ1 control and data acquisition system uses an IBM PC-AT personal computer controlling a special purpose computer built by Taurus Computer Products Inc. which contains the input-output interface boards. The special purpose computer maintains a real time data table, drives the output lines, and completes control loops. The PC provides the user interface to adjust variable set points, monitor system activity and perform data logging functions. System control and data logging may continue as a background task while the PC runs other user programs. A description of the control system will be given with details of operation with the RFQ1 injector system.

Description of RFQ1

RFQ1¹ is a 0.6 MeV cw test radiofrequency quadrupole (RFQ) accelerator consisting of an injector^{2,3} with a 50 kV ion source and charge state selector, and the RFQ accelerating structure with its rf system. It is proposed to subdivide the control and data logging system into two units - one for the injector, the other for the RFQ - each with 100 to 120 data channels. Interaction between the two control units is limited to a few signals. At the time of writing this paper, the hardware for the injector data logging system has been installed and the injector is being commissioned. The equipment is shown in Fig. 1 adjacent to the RFQ1 injector.

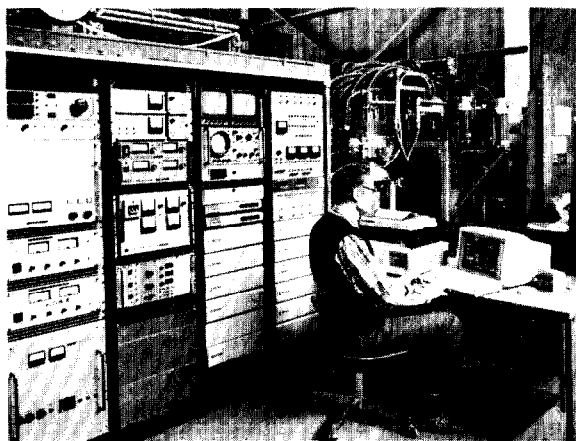


Fig. 1 RFQ1 injector, instrument racks, and control computer.

Purpose of System

The system will read all significant parameters of the injector and provide a visible display and a permanent record of selected parameters, with alarms to alert operators to abnormal conditions. It will generate outputs for remote operation based on the monitored inputs (i.e., feedback or interlock loops) or on user input.

Requirements

To satisfy the above purposes all inputs must be scanned in a period short relative to the desired control loop response times. This implies that the scan process must not halt for operator communication.

The control functions are restricted to those for which action may be delayed a few seconds. This is adequate for operator adjustments, cooling system related signals, thermal protection, and programmed run-up of parameters. It is not suitable for protection of equipment against electrical transients or high voltage breakdowns.

General Description of System

Although a general purpose microcomputer can accept I-O boards, to accommodate a large number of data channels it is more practical to use an external multiplexor or special purpose microcomputer dedicated to I-O operations. The system selected uses a special computer built by Taurus Computer Products Inc. to communicate with external devices and maintain a real time data table, and a general purpose IBM PC-AT data table to display, analyze and print the data and interact with the operator.

The software package for the system is being written by Taurus and is scheduled for completion in September 1987. As an interim measure a preliminary package is being used which contains the fundamental I-O programs for the Taurus microcomputer on a ROM chip, and a user oriented display program for the IBM written in compiled BASIC (Microsoft quickBASIC). This preliminary package will allow injector operation and permit us to assess the usefulness of various display and control options which can be transferred to the final package. The final software package is being delivered as the various program modules are completed but at the time of writing only the preliminary package has been used during RFQ injector operation.

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Hardware

User Microprocessor

IBM PC-AT with 80287 numeric processor
EGA graphics and colour monitor
2.5 Mb RAM
dot matrix printer
8 colour X-Y plotter

I-O Microprocessor

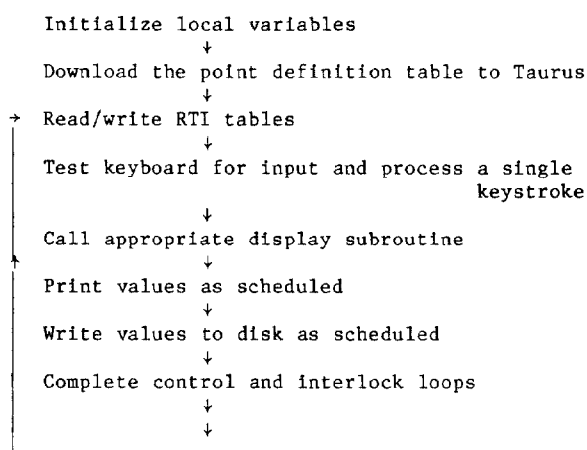
TAURUS TWO with 80186 cpu and 8087 numeric processor
ROM BIOS
64 Kb RAM
boards for 64 single ended analog inputs
64 differential analog inputs
16 analog outputs
32 digital inputs
32 digital outputs
7 event counters
appropriate terminal panels

Software (Preliminary)

The Taurus computer has a program stored in ROM to permit communications via an RS232 serial line, to set up a real time interface table (RTI), and to read or write the data lines via the I-O boards. It executes a loop which reads all of the input lines as defined in its point definition table and stores the values in the RTI, and writes each output line with the current value of the related parameter in the RTI. If it is interrupted by the RS232 line it takes appropriate action and sends an acknowledgement but it does not initiate a dialog.

The IBM PC has a compiled basic program which communicates via the RS232 line to maintain its own copy of the RTI table, controls the display, and provides a user interface.

The flow chart of the host program is as follows:



In this mode of operation the Taurus computer executes its loop quickly, and the IBM will interrupt it infrequently to read or write a value in the RTI table. The IBM runs in a slower loop (requiring 1 to 2 seconds) to update the display, print or save values as scheduled, complete control and interlock loops, and accept keyboard entries. Note that keyboard input must be done in a manner which does not halt the IBM computer or the control and interlock loops will not continue to operate.

Displays

Seven displays can be selected via Function or Shift-Function keys - a graphic display, a bar chart display, and 5 text displays. Examples are shown in Fig. 2, 3 and 4. The graph and bar charts are general purpose menu selectable displays which can show any of the parameters, but the text displays are written into the code and require recompilation of the BASIC program to change them. The text displays show

1. Ion Source Parameters (20 values)
2. Injector Cooling System (34 values)
3. Injector Parameters (15 values)
4. Beam Currents (11 values)
5. Control Interlock Status Table

ION SOURCE				
FILAMENT	-310 V	4.7 A	ISPC 0.000	
COIL	-5.6 V	-0.2 A	ISCC 0.000	
WCC	-5.3 V	-0.79 A	ISWC 0.000	
PLASMA APERTURE	0.00 V			
INTERMEDIATE ELECTRODE	0.05 V			
HIGH VOLTAGE	1-98.332 KV	0.0 mA		
MODEL SUPPLY	-0.003 KV	0.000 mA		
Gas Flow	Ar	-0.21 SCC/M	ISG1 0.000 (V-1)	
	H2	-2.15 SCC/M	ISG2 0.000 (V-2)	
STRAIGHT THROUGH CURRENT	0.0 mA			
INTERMEDIATE PORT SOLENOID	0.0 mA			
SOLENOID BEAM PLATE	0.0 mA			
DISPL 1				
10:12	0	RPQ1 Injector Test	ISPC - 0.000	ADJ
03-03-1987				
1 HELP 2 CRPH 3 DSPL 4 CNTL 5 LOC 6 ARCH 7 RESET 8 MOD 9 ADJ 10 QUIT				

Fig. 2 Ion source display screen.

Injector Cooling System				
	Flow L/s	T °C	P psi	
INLET				
MAIN BEAM STOP (MBS)	0.972	18.8	117.3	
H2 H3 STOP (H2H3)	12.207	20.4	16.8	
PLUNGING BEAM STOP (PBS)	-0.009	17.3	102.9	
STRAIGHT THROUGH STOP (STBS)	0.112	19.3	54.5	
MAIN RETURN	16.661	21.2	76.4	
FLOW SWITCHES				
Solenoid				
Beam Stop Plate				
Beam Stop Coil				
Diagnostic Box Flange				
Plunging Beam Stop Box				
Side Plate				
Source, Beam, Global				
Belloes				
Fractional Beam Plate				
H2 H3 Beam Plate				
Solenoid Beam				
Straight Through Plate				
Solenoid				
Purification Loop				
DISPL 2				
10:13	0	RPQ1 Injector Test	ISPC - 0.000	ADJ
03-03-1987				
1 HELP 2 CRPH 3 DSPL 4 CNTL 5 LOC 6 ARCH 7 RESET 8 MOD 9 ADJ 10 QUIT				

Fig. 3 Cooling system display screen.

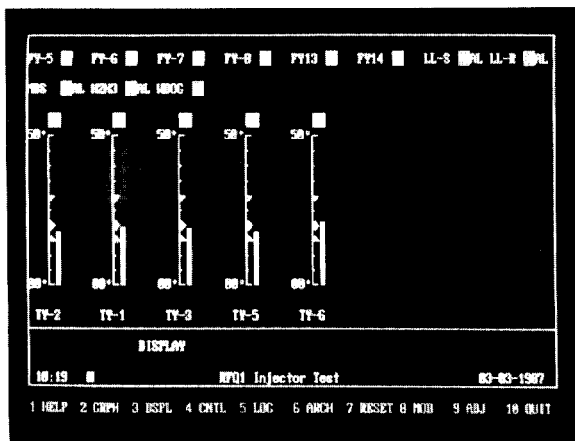


Fig. 4 General purpose bar chart display.

Help Displays

Help displays have been added to make the system as user-friendly as possible. The help file is an external file maintained by a text editor which can be updated without program modification. In addition to brief operating instructions, the help file also contains tables of external connections, descriptions to clarify the parameter identification mnemonics, and up-to-date information on which external lines are connected to the computer and which are disconnected or not yet operable. During the construction phase this has been a convenient notepad.

Printer Output

Any of the variables can be automatically printed at individually specified intervals. In addition a monochrome version of the text displays can be printed on request via the Alt-Function keys.

Data Logging

Any of the variables can be selected to be written to a disk file at selected intervals. This disk file could be used for off-line analysis or as a permanent operating record.

Programmable Knob

A programmable knob panel was built incorporating 2 continuous-turn pots and 4 momentary-contact buttons. It is connected to the games port of the PC and is read as a "joystick". The knobs can be assigned by the program to control any of the output lines. They behave as multi-turn pots which assume the present value of variable when they are assigned.

Software (Final)

The target software under development will operate on the IBM under the QNX operating system. This is a multi-tasking operating environment developed by Quantum Software Systems Ltd. which will permit tasks like the RTI update program to be run in the background, unaffected by foreground display or user input programs. In addition to running several jobs simultaneously, QNX can also run one DOS job on a time

shared basis. The DOS job might be a data analysis program or even a completely unrelated program such as a word processor. The system programs under QNX will be written in C for maximum efficiency and because they will be independent modules, should not require user modifications. Screen data can be prepared by a graphics editor program which can prepare displays which show graphic and text animated by data in the RTI table. Multiple display tasks can be stored and the appropriate one selected by a single keystroke. As a first step, displays could be written identical to the ones embedded in the BASIC program.

The Taurus computer has an 80186 microprocessor and 64 Kb of RAM into which binary code can be downloaded from the IBM. The programs for the Taurus will be written in C and compiled on the IBM with suitable precautions because the Taurus does not contain a DOS or QNX operating system. To reduce traffic over the relatively slow RS232 serial link it is planned to download a program to transmit only changed RTI entries rather than reading the entire table each cycle. A program could be downloaded to complete control and interlock loops locally but although this would improve response time, it might detract from the simplicity of the system by allowing user oriented programs to leave the IBM.

Preliminary Evaluation

The most significant feature of the system has been the ease of making changes to the operating parameters and the displays. Most of the logic resides in the IBM PC which is familiar to all of the operators and is written in a high level language. Temporary changes or customized displays can easily be developed and saved on disk for future use without disturbing the normal operating system.

This flexibility is proving very useful because, in a developing system, parameters which appear to be vital during the construction stage often become uninteresting at a later date, with the emphasis shifting to other parameters.

In conclusion it is noted that commercial "Home Computer" hardware and software represents a very good value for money. Commercial systems have reached the level where only a modest software effort (including learning time) is required for a specific facility to be implemented.

Acknowledgments

We would like to acknowledge the help of systems engineers at Taurus Computer Products.

Trade Names

TAURUS	- Taurus Computer Products Inc., Ottawa, Canada.
IBM, PC-AT, DOS	- International Business Machines Inc.
QNX	- Quantum Systems Ltd., Ottawa, Canada.
quickBASIC	- Microsoft Inc.