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THE COMPUTER CONTROL AND DATA ACQUISITION SYSTEM FOR THE R. F. TEST FACILITY*

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ABSTRACT

The Radio Frequency Test Facility (RFTF) at Oak Ridge National Laboratory, used to test and evaluate high-power ion cyclotron resonance heating (ICRH) systems and components, is monitored and controlled by a multicomponent computer system. This data acquisition and control system consists of three major hardware elements, (1) an Allen-Bradley PLC-3 programmable controller, (2) a VAX 11/780 computer, and (3) a CAMAC serial highway interface. Operating in LOCAL as well as REMOTE mode, the programmable logic controller (PLC) performs all the control functions of the test facility. The VAX computer acts as the operator's interface to the test facility by providing color mimic panel displays and allowing input via a trackball device. The VAX also provides archiving of trend data acquired by the PLC. Communications between the PLC and the VAX are via the CAMAC serial highway. Details of the hardware, software, and the operation of the system are presented in this paper.

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I. INTRODUCTION

The radio frequency test facility (RFTF) at ORNL provides a national facility for the testing and evaluation of rf antennas and components for fusion devices. The facility consists of a vacuum vessel and two fully tested superconducting development magnets arranged in a simple mirror configuration. Fig. 1 shows a cutaway perspective of the facility. The key features of the facility are the presence of a steady-state plasma load and the availablity of cw, high-power rf sources over a wide range of frequencies.[1] RFTF comprises several subsystems; cryogenics, vacuum vessel, magnets, interlocks, vessel pumping, electron cyclotron heating (ECH) and ion cyclotron heating (ICH) systems.

The control and data acquisition system for the RFTF was based on the Repeating Pneumatic Injector (RPI) control and data acquistion system developed at Oak Ridge National Laboratory (ORNL). This system required fewer modifications and was less expensive than alternative systems considered. Development time was a major factor in the decision since RFTF was to be operational within two months.

II. HARDWARE

The RFTF control and data acquisition system consists of three major hardware components; the programmable logic controller (PLC), the VAX computer, and the CAMAC serial highway. A block diagram of the system is shown in Fig. 2. All the control and monitoring functions for RFTF are performed by the Allen Bradley PLC-3. The PLC is interfaced to the VAX using RS-232 devices. Local operation of the test facility is provided by a touch panel and keyboard with display at the PLC. Remote operations are provided by mimic panel displays controlled by the VAX-780.

A. PLC

The PLC is an Allen-Bradley PLC-3 with 32K bytes of memory and 5 I/O racks containing both analog and discrete modules. The PLC program is written in relay ladder logic. The PLC does virtually all the data acquisition for monitoring the state of the machine, but at present, it performs control functions such as closing valves only under operator instruction.

The PLC includes a GA module, an RS232 device which is programmable in BASIC. The GA module, having access to the PLC memory, can collect and format information for transmission to the VAX (via a CAMAC RS232 module, the Kinetic Systems 3340-D1B). The link between the two systems is 9600 baud; traffic uses about half the available bandwidth.

B. CAMAC

The CAMAC component of the system consists of a byte serial highway interface connecting a CAMAC crate containing a Kinetic Systems (K.S.) 3952 L-2 crate controller, K.S. 3934 look-at-me (LAM) encoder, K.S. 3291 dataway display module, K.S. 3242 color display driver, and a K.S. 3340 communications module to the VAX computer. This highway is used for PLC to VAX communications and color graphics status display.

The color graphics status displays are provided by the K.S. 3242 programmable color display driver used to drive a standard raster-scan color monitor. This module produces ASCII characters as well as computer generated graphics to provide RFTF with mimic-panel displays for each subsystem. These displays can be updated at CAMAC speed (2 microseconds per character) giving a real-time effect. This module also provides a signal to drive a trackball device. The trackball, along with a push button connected to a LAM module, allows the operator to control the testing process from the workstation.

C. VAX

The third hardware component, the VAX 11/780, is a 32-bit, multitasking, timesharing machine with four MBytes of memory, 2 RL02 disk drives, one magnetic tape unit, and several terminal ports. RFTF shares this computer with other projects thoughout ORNL. The primary function of the VAX for RFTF is to allow the operator to control the testing process from a single location, remote from the testing facility, easily and quickly with minimum errors. The operator's workstation consists of a VT100 terminal, a color monitor, and a trackball with a pushbutton device.

III. SOFTWARE

The VAX executes four software programs or tasks that monitor and control RFTF. They execute as detached tasks with all I/O directed to specific disk files or devices. These tasks communicate with one another primarily through two sharable common memory areas, RFTFSTATUS and RFTFCONTROL. Fig. 3 is a block diagram of the software architecture for RFTF.

A. Communication Task

The communication task, COMM, handles the communications link by reading from and writing to the K.S. 3340 module. This task also dissects the strings received from the PLC and constructs the strings to be sent to the PLC as command requests. In the inbound case, status information received from the PLC is converted to Boolean, integers, or real form and stored in RFTFSTATUS common. This information is available to all the other VAX tasks.

In the outbound case, command requests entered via the control task are stored in RFTFCONTROL common. These requests are Boolean type since there is no need for integer or real data. The COMM task structures an ASCII string containing the request and writes it to the 3340 module for transmission to the PLC. The string contains two copies of the data, so that upon receipt the PLC can check validity by an exclusive-or operation on the two copies. If the PLC detects a difference in the two copies, it ignores the request.[2]

B. Mimic Task

It is the mimic task's responsibility to display the current information from the PLC as stored in RFTFSTATUS. The mimic task displays a choice of eight mimic panels, each representing a subsystem of RFTF. Each panel contains a one-line header with the current time, date and the title of the display. Eight push buttons on the left of each display allow the operator to switch displays as well as serve as subsystem status indicators. Each button is color coded to indicate the status of the system it represents. The following color scheme is used thoughout the displays: blue indicates an inactive condition, green indicates active and normal, yellow is caution, and red indicates an alarm or error condition. The valves and pumps are represented by symbols and labels.

The mimic task updates these displays by reading information from the common memory area, converting the values and statuses to a display format, combining this information with the static part of the display, and sending the displays to the Kinetics System display driver.[3] The module then updates the color monitor screen.

C. Control Task

Operator control is provided by a trackball and push-button combination. The operator selects a new display or changes a valve setting by moving the screen cursor to the selected location and depressing the trackball button. This action activates the control task, which sends information about the selected element to the communications task to be acted upon by the PLC.

D. Trend Task

The trend task is responsible for periodically archiving the data stored in the shared common area. The task, automatically activated every ten minutes, stores the common data in disk files that are later used to analyze RFTF's performance.

VI. ACKNOWLEDGMENTS

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FIGURE CAPTIONS

Fig. 1. Artist's cutaway perspective of the RF Test Facility.

Fig. 2. RFTF hardware layout.

Fig. 3. RFTF software architecture.

ARTIST'S CUTAWAY PERSPECTIVE OF THE RF TEST FACILITY

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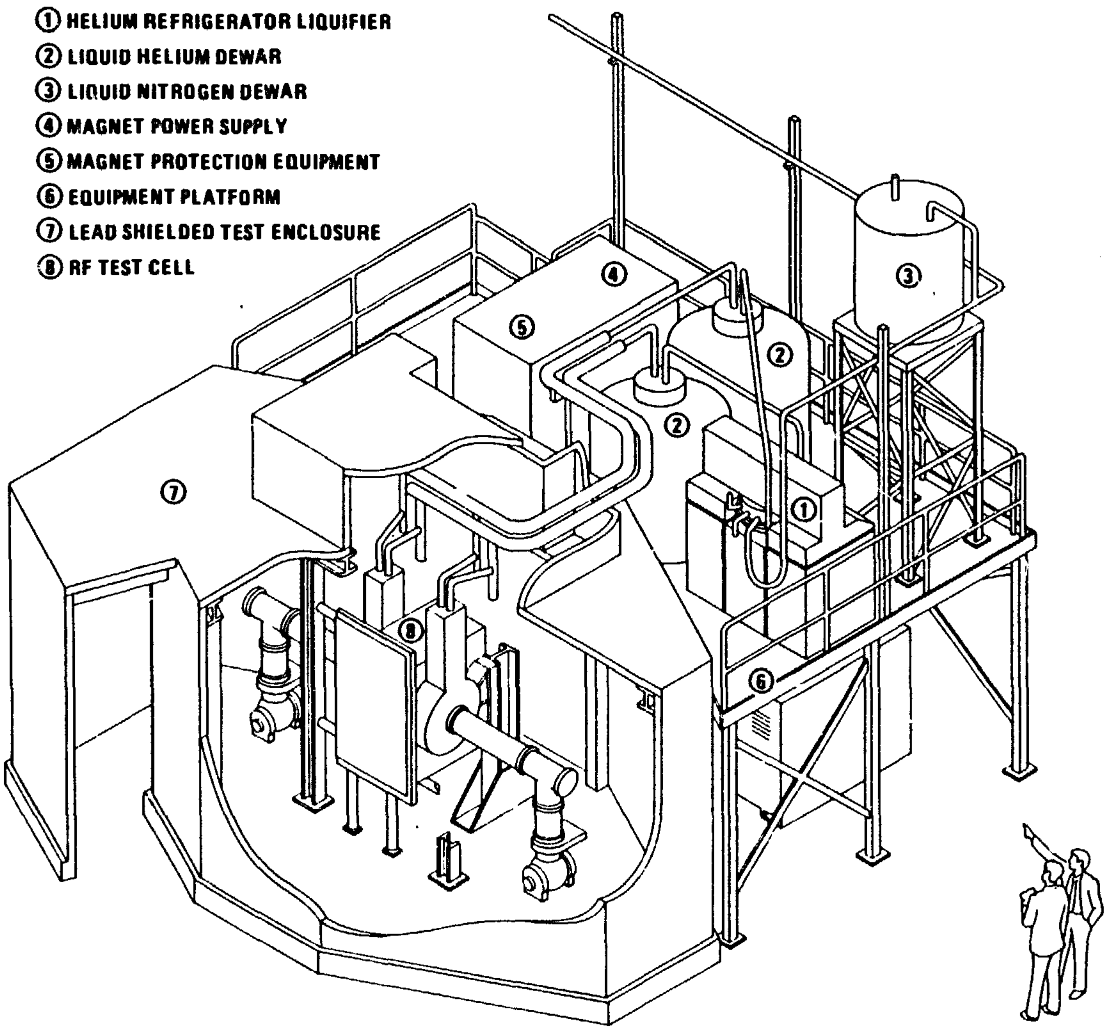

RFTF HARDWARE LAYOUT

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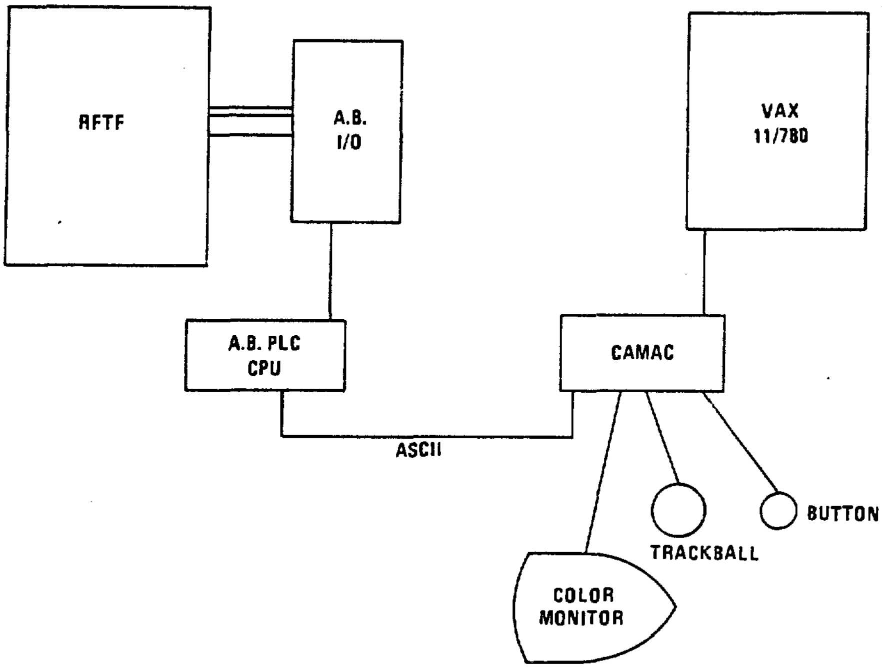

RFTF SOFTWARE ARCHITECTURE

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