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DISTRIBUTED CONTROL SYSTEM FOR THE FMIT*

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Summary

The control system for the Fusion Materials Irradiation Test (FMIT) Facility will provide the primary data acquisition, control and interface components that integrate all of the individual FMIT systems into a functional facility. The control system consists of a distributed computer network, control consoles and instrumentation subsystems.

The FMIT Facility will be started, operated and secured from a Central Control Room. All FMIT systems and experimental functions will be monitored from the Central Control Room. The data acquisition and control signals will be handled by a data communications network, which connects dual computers in the Central Control Room to the microcomputers in CAMAC crates near the various subsystems of the facility.

Introduction

The FMIT Facility will contain a 100-mA continuous-beam deuteron accelerator and lithium target that will be used to produce 14-MeV neutrons for materials research,[1,2] and will be directed toward the development of containment materials for use in a controlled thermonuclear fusion reactor. The facility will be built at Richland, Washington, and will be operated by the Hanford Engineering Development Laboratory (HEDL). In addition to doing the FMIT accelerator design, the Accelerator Technology Division of the Los Alamos Scientific Laboratory (LASL) will build a prototype of the front end of the accelerator at LASL. The primary purpose of the prototype construction is to permit the development of a suitable injector, appropriate beam-diagnostics devices and to prove the radio-frequency quadrupole (RFQ) concept for this application.[3,4,5]

System Design

A layout of the proposed accelerator showing where the control system will connect to the various facility subsystems is depicted in Fig. 1. The control system consists of a distributed computer network, control consoles and several Instrumentation Subsystems (ISS). The FMIT facility will be started, operated and secured from a Central Control Room (CCR). All

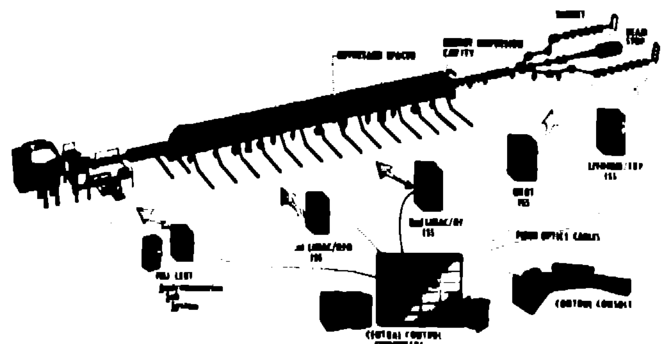

Fig. 1. The FMIT Accelerator Showing Facility Control System Connections.

system functions will be monitored from the CCR; all data acquisition and control signals will be transmitted over a communications network that connects the main computer system in the CCR to microcomputers that are located in CAMAC[6] crates near the various subsystems of the accelerator. A block diagram of the distributed control system is contained in Fig. 2.

The main computer system consists of dual mid-to-large capacity minicomputers (PDP-11/60s for the prototype, PDP-11/70s for the FMIT facility). Two large, dual-ported disks, with a 176-million byte (67 million byte, for the prototype) storage capacity will be connected to the main computers. The operator will interact with the facility through the control consoles, the primary control computer and (via a communications network) to LSI-11 computers with CAMAC hardware at the local level.

The FMIT facility will have two system consoles, each consisting of a 19-inch raster-scan, color-graphics display scope, with touch-panel, track ball and keyboard. Two control knobs with plasma and touch panels, and a small black/white "menu" touch-panel/CRT complete the console. The knob, touch-panel and display will be used to connect control variables to the knobs and input variables to the application codes. The color scope will be used primarily to display summary or detailed system diagrams with current status of data channels associated with that system. Plots of the results of emittance calculations or of other data-reduction codes can also be displayed on the color scope. Finally, a high-resolution storage CRT will be

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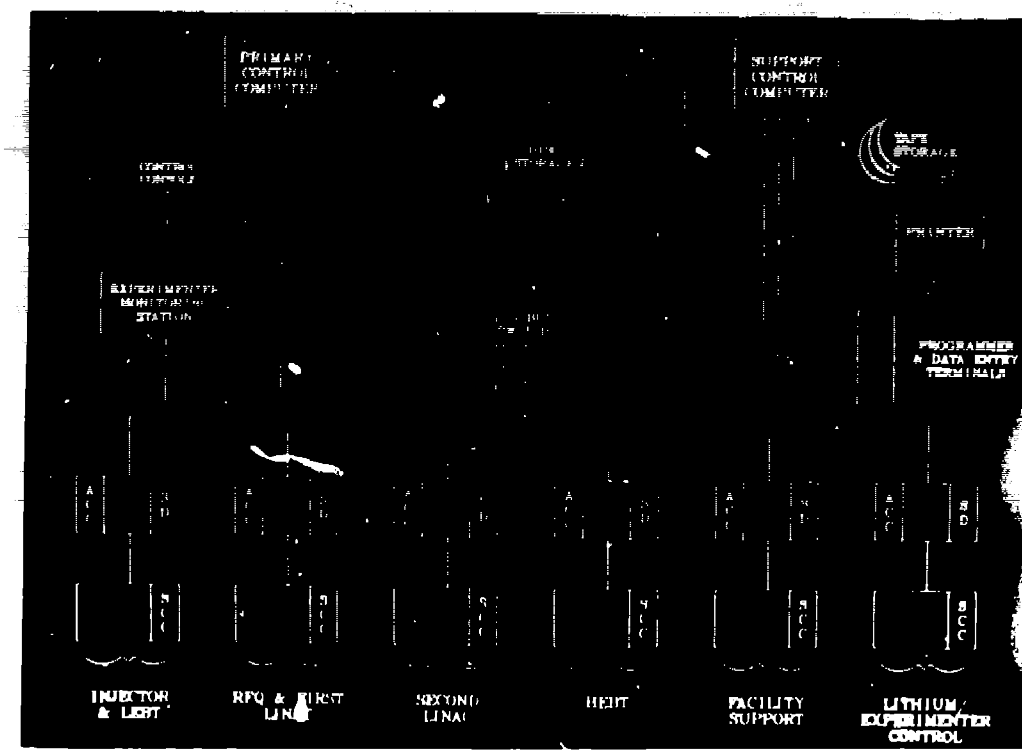

Fig. 2. Block Diagram of the FMIT Facility Control System.

included for display of information requiring 10-bit by 10-bit resolution.

The support computer will be used for software development, data-base maintenance, operator training, data analysis and as a back-up for the primary computer.

The concept of a support computer has the advantage of making significant computer time available for software development without conflicting with facility operation. In a developmental or experimental environment, software development is not permitted on a process control computer for several reasons: A system crash caused by an error in a program under development is probably the main reason for this restriction; overloading of the control computer can be another significant factor. Functions that do not fit well within real-time control contraints can easily be accomplished on the support computer. These include updating database files (which requires manual input); retrieving data from the data base (which requires a large number of disk accesses); and generating reports and operational logs. Large data-analysis codes, requiring significant computer time to run, would be included in these functions; the support computer has the peripheral equipment required to accomplish these tasks. These peripherals include program and data entry terminals, line printer, magnetic tape drives and access to the dual-ported disks. The primary computer is linked to the console, the dual-ported disks and through the data communications network to the Instrumentation Subsystem microcomputer nodes.

Interfaces Hardware

There will be at least six Instrumentation Subsystems, each of which will consist of one or more CAMAC crates and modules to interface FMIT Systems to the Control System. In each ISS, the node, or primary crate will contain an LSI-11 based Auxiliary Controller[7] (ACC) to serve as a communications controller for the Digital Equipment Corporation Network Software (DECNET). This ACC will also control a number of interface modules in the node crate. When the required number of CAMAC modules for a subsystem exceeds the number of slots available in the node CAMAC crate, a CAMAC Serial Highway[8] driver will be added to connect additional crates via the Serial Highway and Serial Crate Controller. It will also be possible to install additional ACCs in these added crates to provide dedicated processing capabilities at a specific area.

Software Design

The software is designed to be structured, modular and data-base driven.[9] The software requirements indicate the need for a layered structure that consists of a set of modules that interact with the console to interpret the operator instructions and to control the displays. There will be a number of modules

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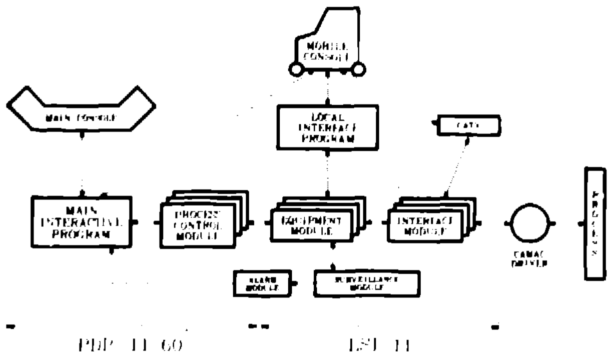

Fig. 3. Simplified Software Organization.

that will do the process control. A set of Equipment Modules (EM) will interact with the different equipment types. The lowest layer will contain hardware Interface Modules (IM), one for each type of CAMAC module used in the system. A block diagram of the software structure for the FMIT Control System is shown in Fig. 3.

There will be an executive task that is running at all times. This task is data driven and checks, interprets and calls the required Operator Interaction Module (OIM). The OIM will complete the interpretation of an operator command and call the proper display module (if one is required). After the required Process Control Module (PCM) is called, the OIM will transfer the commands to the PCM. The PCM contains the intelligence to progress through a sequence of EM commands to perform the required task. There will be no "wait" in the EM so that the system will not be required to wait until the response to the given command is received. Thus, commands to various EMs can be given in sequence, and other tasks can be performed before returning to insure that the proper responses have been obtained. The EM has access to a data base that contains, for example, the information to convert command settings to raw units; i.e., volts, milliamps, etc.; and to convert data from raw units to engineering units. The CAMAC addresses of the appropriate channels will also be contained in the data base.

Finally, the commands to the hardware are delivered to the Interface Module (IM) that interacts with the CAMAC hardware to complete the required functions.

The OIM and the Interactive Display Modules (IDM) must reside in the primary control computer so that operator response is acceptable. In addition, the primary control computer will make use of the disk for storing the large number of Process Control Modules that will be required, and the large files required to drive the color-graphics scope. The EMs will be located in the LSI-11 microcomputers if memory constraints permit. Certainly the IMs will reside in the LSI-11 memory. The LSI-11 must also have a Surveillance Module (SM) that will check selected data channels in each subsystem and notify the operator if any channel drifts out of preset limits.

The SM will be table driven with scan rates set according to the response time of the process being monitored. A requirement to support a local terminal for equipment check-out and stand-alone operation can be satisfied by a Local Interface Module (LIM). This module will convert commands from the local operator into appropriate commands to the EM. In addition, the interpretative language, CATY,[10] will be available to test, or to exercise, the hardware and requires only a knowledge of the various CAMAC addresses.

Network Communications

Communication with the various Instrumentation Subsystems will be accomplished through the utilization of DECNET or a subset of DECNET. The DECNET software will be used between the main computers (primary and support) and between the primary computer and the LSI-11s located in the CAMAC crates. Any other LSI-11s that are needed, other than the node computers, will be used to perform a specific task and will communicate with the node computers over the CAMAC Serial Highway.

Conclusions

The control system for the FMIT Facility is a distributed, modular system in both the hardware and software. The computer hardware will be purchased from a single computer manufacturer. The primary and support computers will be identically configured, will use the same operating system, and the microcomputers will be of the same computer family. The microcomputer operating system will be a memory-resident subset of the operating system used in the main computers. The software will be structured and modular, and the same high-level language will be used for all of the application software. The software will be distributed, with the portion supporting the operator located in the primary computer and the portion interacting with the hardware located in the LSI-11 Auxiliary Controller. The data base will be distributed in the same way.

This approach should provide a control system for the FMIT that will be flexible, easy to maintain, and one that can easily be extended.

Acknowledgments

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