UCRL- 86064
PREPRINT
CONF-811040--2

TOOLS AND METHODS FOR IMPLEMENTING THE CONTROL SYSTEMS ON THE MIRROR FUSION TEST FACILITY

Earl G. Minor
William G. Labiak

MASTER

This paper was prepared for submittal to
9th Symposium on Engineering Problems
of Fusion Research
Palmer House
Chicago, Illinois

October 26-29, 1981

September 29, 1981

Lawrence Livermore Laboratory

Unclassified

TOOLS AND METHODS FOR IMPLEMENTING THE CONTROL SYSTEMS ON THE MIRROR FUSION TEST FACILITY

Earl G. Minor and William G. Labiak
Lawrence Livermore National Laboratory
P.O. Box 5511, L-634
Livermore, CA 94550

Summary

Installation of the major hardware subsystems for MFTF is nearing completion. These subsystems include the Fusion Chamber System, the eighty KV Neutral Beam System, the Superconducting Magnet System, and the Personnel Safety System. The Local Controls group has undertaken a uniform approach to implementing the control systems for all of these hardware subsystems. This approach has two major aspects: (1) to provide a stand-alone computer control system with a remote, portable terminal so that computer control can be provided at the site of the hardware for initial testing, (2) to provide hardware simulators so that the complicated MFTF computer control system can be tested independent of the hardware. The software and hardware tools which were developed to carry out this plan will be described. Our experiences with bringing up subsystems containing up to 900 separate channels of control and status will also be described.

"Work performed by LLNL for USDOE under contract number W-7405-ENG-48."

Introduction

The Mirror Fusion Test Facility (MFTF) being constructed at Lawrence Livermore National Laboratory (LLNL) is nearing completion and will soon be ready for a technology demonstration. The MFTF technology demonstration will consist of using the major MFTF subsystems; four eighty kV neutral beams, the superconducting magnets, the vacuum and cryogenic systems, and the personnel safety system. All of these subsystems as well as the systems to be added for the MFTF-B are to be computer controlled.

This computer control system consists of three levels and is shown in Figure 1. The top level of the system is the Supervisory Control and Diagnostic System (SCDS) which is made up of nine Perkin-Elmer 32-bit computers. These nine computers are connected through a shared memory to form a network. The purpose of the SCDS is to provide the operator interface to the experiment. Commands are accepted from and information is displayed to the operators by SCDS. SCDS sends these commands and receives data from the next level of the control system; the Local Controls and Instrumentation System (LCIS).

The LCIS has the Local Control Computers (LCC) and the two instrumentation systems that connect directly to MFTF. The LCC's are LSI-11 16-bit computers connected to the supervisor with RS232-C serial lines. About ten LCC's will be used for technology demonstration. There will be over one hundred in the MFTF-B configuration. All of the LCC's run essentially identical software to reduce complexity and improve maintainability. The LCC's have no discs or other mass storage peripherals. Each LCC controls part of the MFTF through CAMAC systems or, in a few cases, Modicon programmable controllers.

The purpose of the LCIS is to execute commands from the supervisor to control the experiment, and to monitor the experiment continuously and report any significant changes in equipment status to the supervisor. The LCC's allow the SCDS to have a uniform interface to control and monitor the different devices connected through the instrumentation systems.

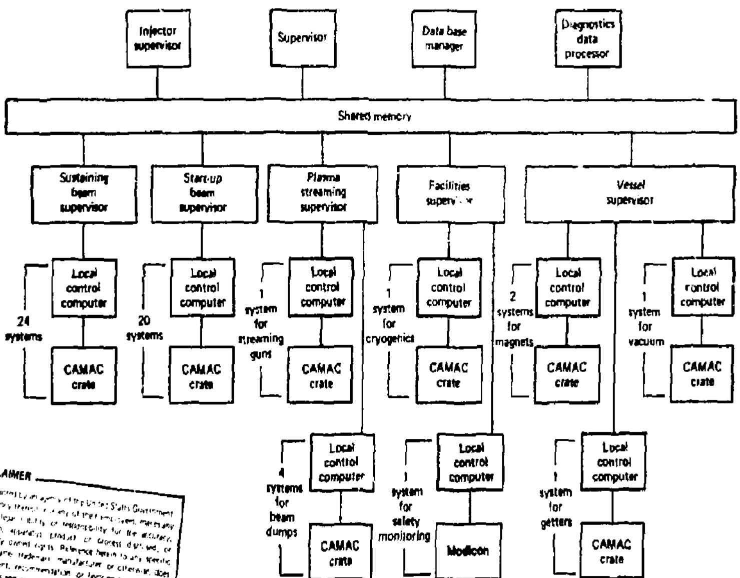

Figure. 1. Computer Control System For MFTF

The multi-level computer control system of MFTF presents significant problems during the startup and checkout phases. One solution to this problem is to complete each level of the system before working on the next. This guarantees that each new level developed will meet the requirements of previous levels. This approach is very time consuming because all are done in series. There is also a potential for great problems if a detail discovered in the last level cannot be easily integrated into the whole system. Parallel development of all levels of the system relieves these problems but can make integration and startup difficult. If the interfaces between the different levels of the system are defined early in the design, it is possible to develop effective simulators which simulate one side of the interface. This in fact allows testing of one level to start before another level is finished. The MFTF computer control system used the simulation of both hardware and software at the different levels of the control system to help overcome the system integration problems.

The local controls group has developed simulators for hardware systems to check out the software for both local and supervisory controls and a simulator of the supervisory system to test the actual hardware systems which are used on MFTF.

Stand Alone System

To simulate a supervisory computer, an LSI-11 computer was used. This machine is connected to an LCC with the same serial link that is used for communication with the supervisor as shown in Figure 2. The simulator computer has a disc for program storage and a terminal for user I/O. The terminal may be connected to the simulator through a telephone modem. This allows the terminal to be moved to different locations in the experiment area. The operator can work right next to the equipment being tested and see the responses to computer commands. This allows one person to do the complete checkout of wiring, contacts, and hardware interfaces. The software consists of the LCC communications procedures (these are identical to the procedures used in the SCDS), an operator input procedure which maps command mnemonics into command tokens, a display procedure to present messages from the LCC to the operator on the terminal, and a procedure to log large data vectors into disc files.

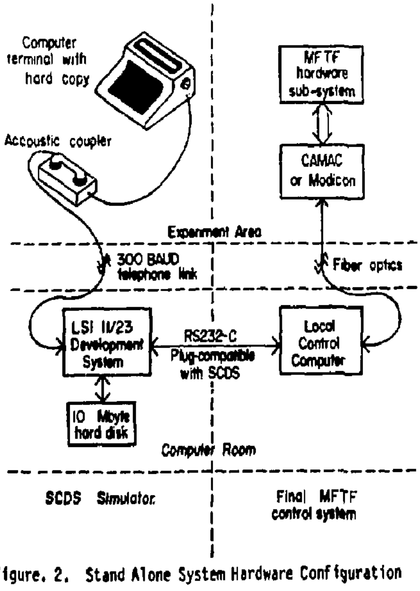

Figure. 2. Stand Alone System Hardware Configuration

The commands communicated from the supervisory computer to the LCC are encoded into numbers to keep the messages short. It would be difficult for an operator to use number codes so the operator input procedure converts meaningful mnemonics into numbers.

The mnemonics are stored in a file to make it easy to add, change, and remove them. A command entered by the operator may be longer than one line so a period is used to indicate the end of the command. Whenever a command is terminated, it is sent to the LCC immediately. The following command would set the arc voltage to 50 volts.

SET ARCV 50.

The simulator converts this line into a command and sends it to the LCC. If a mnemonic is not defined, no number is put in for it. This could lead to confusing results so just before the command is sent to the LCC, the numbers forming the command are displayed on the terminal. This allows an easy check for correct mnemonic definitions. A malformed command sent to an LCC will not be executed because of extensive internal checking in the LCC software. After the command is executed by the LCC a reply is sent to the simulator (or supervisor).

A reply from an LCC is contained in a data structure called the kernel. The kernel contains information such as the value that was read from an interface, the interface being accessed, the time when the reply was sent, and error flags indicating any errors detected during command execution. This kernel is displayed on the terminal when it is received. Errors are printed by name, and numbers are displayed in base 10 if the are 16-bits or less in size. Otherwise they are displayed in base 8. This is beause very few hardware units return a number larger than 16-bits. Those that do use 24 and 32-bit numbers are usually interpreted as individual bits. If a number in the kernel is zero it is not printed to keep the display as simple as possible.

Any operations that can be done from the supervisor can be done from the simulator on an individual LCC. The supervisor has superior data logging and display capabilities as well as the ability to handle many LCC's simultaneously. Sometimes the number of commands to do an operation is quite large, especially for initialization where fifty or more commands may be needed. A facility to read commands from a file is available in the system. A special mnemonic, USE, indicates that a file name follows. The files are created using a text editor. This allows checkout of complicated sequences with the operator being close to the equipment under test. In fact the details of control sequences can be worked out very quickly this way and the debugging time with the supervisor is reduced.

The vacuum and cryogenic systems of the fusion chamber system were checked out using a portable terminal and the SCDS simulator computer. This is a large system with hundreds of individual devices to control and monitor, and the CAMAC crates which interface to them are located throughout the experiment's building. The operator being able to directly observe the equipment and CAMAC interfaces was able to determine not only improper operation but exactly where the fault occurred. This simulation method identified many errors in the wiring of the equipment after it was installed but, before it was put into operation.

Hardware Simulation

To check out the SCDS, it was decided to simulate, as much as possible, in the control room, the MFTF subsystems. This has several advantages. One is that the testing can be done without tying up the equipment on the experiment which is being installed. Another advantage is that errors in the control hardware and software can be eliminated before being connected to the experiment. This helps prevent damage to equipment and the creation of hazards. The close proximity of the simulation hardware to the control computers makes checkout much easier. There is no need for telephones, walkie-talkies, and extra observers.

The simulation hardware is usually quite simple. CAMAC switch register modules and dataway displays can simulate binary devices. The analog modules can be driven by voltage sources and function generators. As much as possible, the actual hardware to be used to inferface equipment to the LCIS is used. This will give a better understanding of how the control system works, system response time and builds confidence in the hardware and software.

In the case of the neutral beam power supply systems, simulators of all the power supplies were provided by the vendor. These have proved very useful in developing correct sequences to set power supply setpoints and observe the behavior of the system when simulated shots are fired. This allowed all of the software and hardware in the system to be tested before installation of the power supply was complete.

Conclusion

Large multi-level computer control networks can prove difficult to test and debug. By providing simulators for each interface level of the network, the control system can be tested in manageable parts without damaging equipment or creating personnel hazards. Having the personnel conducting the tests be close to the equipment or simulation hardware under test saves time and improves understanding of system responses. The use of simulation tools speeds up testing and brings about a greater level of confidence in the control system which is important for operations.