GA-A--19758

DE90 004091

DESIGN AND IMPLEMENTATION OF A USER-FRIENDLY INTERFACE FOR DIII–D NEUTRAL BEAM AUTOMATED OPERATION

by

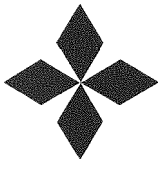
J. PHILLIPS, A.P. COLLERAINE, R. HONG

J. KIM, R.L. LEE, AND J.J. WIGHT

This is a preprint of a paper to be presented at the 13th Symposium on Fusion Engineering, October 2–6, 1989, Knoxville, Tennessee, and to be printed in the *Proceedings*.

Work supported by
Department of Energy
Contract DE-AC03-89ER51114

GENERAL ATOMICS PROJECT 3466
DECEMBER 1989



GENERAL ATOMICS

DESIGN AND IMPLEMENTATION OF A USER-FRIENDLY INTERFACE FOR DIII-D NEUTRAL BEAM AUTOMATED OPERATION

J. Phillips, A.P. Colleraine, R. Hong,
J. Kim, R.L. Lee, and J.J. Wight

General Atomics, P.O. Box 85608
San Diego, California 92138-5608

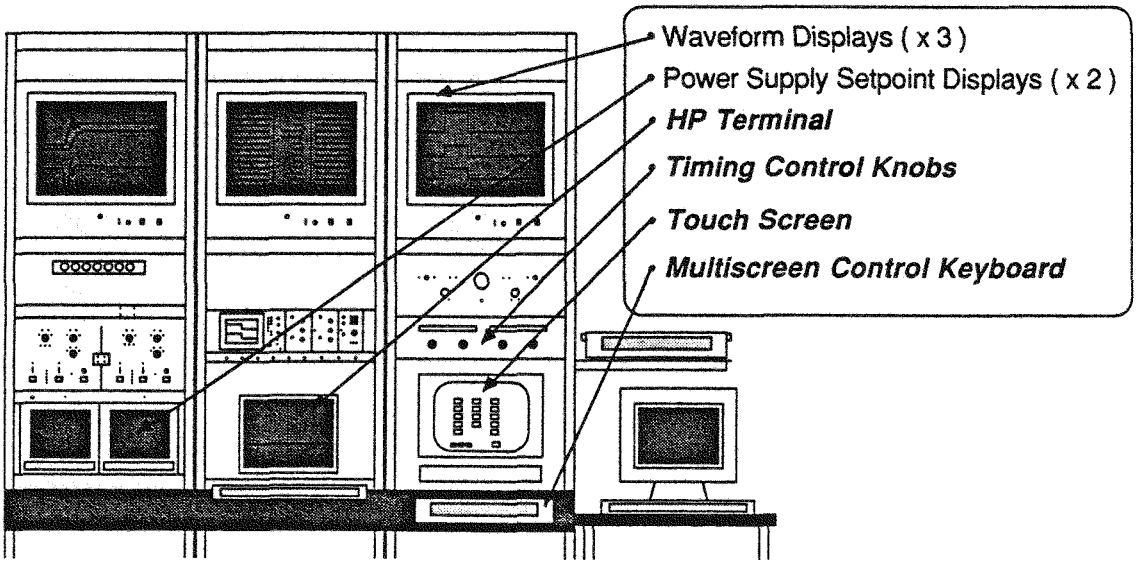
Abstract: The operational interface to the DIII-D neutral beam system, in use for the past 10 years, consisted of several interactive devices that the operator used to sequence neutral beam conditioning and plasma heating shots. Each of four independent MODCOMP Classic control computers (for four DIII-D beamlines) included a touch screen, rotary knobs, an interactive dual port terminal, and a keyboard to selectively address each of five display screens. Most of the hardware had become obsolete and repair was becoming increasingly expensive. It was clear that the hardware could be replaced with current equipment, while improving the ergonomics of control.

Combined with an ongoing effort to increase the degree of automated operation and its reliability, a single microcomputer-based interface for each of the four neutral beam MODCOMP Classic control computers was developed, effectively replacing some twenty pieces of hardware. Macintosh II microcomputers were selected, with 1 megabyte of RAM and "off-the-shelf" input/output (I/O) consisting of a mouse, serial ports, and two monochrome high-resolution video monitors. The software is written in PASCAL and adopts standard Macintosh "window" techniques. From the Macintosh interface to the MODCOMP Classic, the operator can control the power supply setpoints, adjust ion source timing and synchronization, call up waveform displays on the Grinnell color display system, view the sequencing of procedures to ready a neutral beam shot, and add operator comments to an automated shot logging system.

The new Macintosh interface also provides a springboard for increased levels of automation of the neutral beam control system, within the framework of a cost-effective and standardized software environment. The built-in Macintosh local area network (LAN) makes communication and record keeping very easy, and will provide the capability for supervisory instructions to be communicated to the operator interface. Future plans call for all four operator consoles to be controlled from one location via the LAN.

Introduction

The main goal of this project was to modernize and condense the operator interface to the neutral beam control systems, while providing additional communication and automation capabilities. Whereas, previously, an operator used several distinct I/O devices to effect changes in ion source timing, power supply setpoints, waveform display, and interaction with the sequencing procedures [1], a single interactive device now handles routine operator interaction with the MODCOMP Classic control computers. Each of the I/O devices previously used had its own peculiar characteristics (Fig. 1). The touch screen, used to pick waveforms for display by means of hierarchical menus, had developed dead spots. The rotary knobs used to advance and retard various timing channels (for the diagnostic, ion source gas, filament, arc, and high-voltage supplies) were cumbersome, often taking hundreds of turns of the knob to implement a timing change. The keyboard, used for addressing power supply setpoints and display pages, was an obsolete piece of hardware with failing key contacts. None of the I/O hardware in use was commercially available anymore. In order to perform a sequence of tasks, the operator had to shift attention from one of these very different devices to another. With the introduction of a single interface, the "modality" of the system has been decreased.



Items Described in Bold are Replaced by the Macintosh Interface.

Fig. 1. The DIII-D Neutral Beam Operator's Console 1976 to 1988 (one of four).

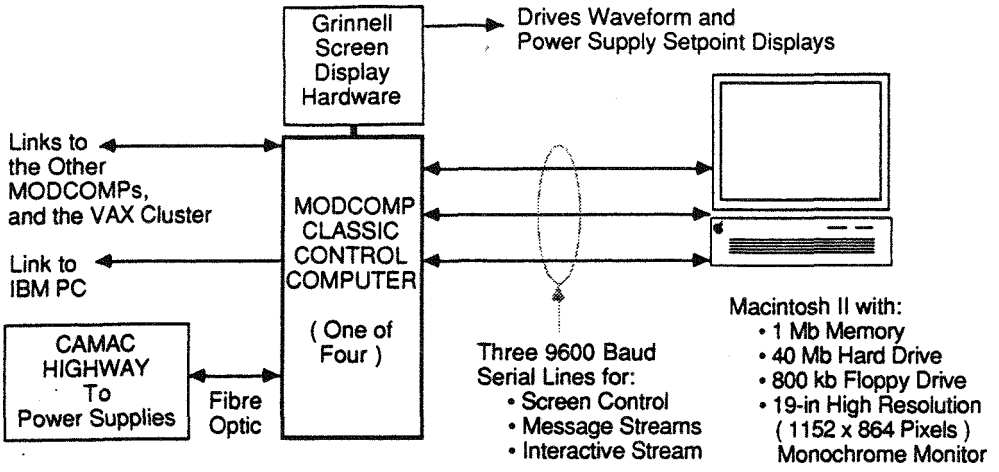


Fig. 2. Macintosh/MODCOMP hardware interconnection.

Design Philosophy and Challenges

A prime concern bearing on the design of the interface was the need to provide continued availability of the neutral beam injector systems, with only occasional one-week maintenance periods available for development work. This, combined with the expense and difficulty involved with any extensive modifications to the software written for the MODCOMP, lead to the decision not to alter the way in which the MODCOMP communicated with its I/O devices. Instead, the Macintosh was to emulate these devices as far as possible. Thus, during the development phase, it was possible to switch back and forth between the old and new hardware. As an example of this emulation, the Hewlett Packard (HP) four-window terminal, which provided the stream-of-shot sequence status messages, had the ability to play a musical sequence controlled by specific escape sequences sent by the MODCOMP. When the neutral beam shot is ready to fire, a special sequence is sounded. The operators have come to find this auditory cue very useful, so the Macintosh interface application was programmed to play these musical sequences using the HP escape character sequences. Similarly, the HP terminal had the ability to resize its working window when using the text editor, so the Macintosh application uses these same escape sequences to resize its windows automatically.

Hardware

The hardware selected for this operator interface is a Macintosh II 32 bit personal computer with 1 megabyte of memory, a 40 megabyte hard disk drive, extended keyboard, mouse, and 19–in diagonal measure high-resolution monochrome monitor (Fig. 2). The Macintosh was selected for two primary reasons:

1. The built-in system routines for presenting I/O give a consistent user-friendly "feel" to applications that are developed.
2. The availability of personnel capable of writing PASCAL routines for the Macintosh.

The hardware selected is standard and off the shelf. The software written for the operator interface will run on any member of the Macintosh family (Macintosh Plus, SE, SE30, or IIcx). Thus, in the event of a hardware failure, any available Macintosh could be substituted in short order. Communication between the Macintosh and the MODCOMP Classic is done with three serial lines operating at 9600 baud. One is used for screen control and two for interactive communication and messages.

Software

The software providing emulation of the older I/O devices is written in PASCAL using Think Technologies' Lightspeed PASCAL compiler. Currently, the application is 2500 lines of code, and development time was about three man-months. The development environment is extremely user friendly, with a debugging routine that allows for the examination of any set of variables during actual execution of the code. We feel that the extensive debugging tools available contributed to the relatively short development time. The code uses calls to the standard Macintosh "tool box," which perform most of the detailed tasks such as creating, maintaining, and updating the "windows" for various functions and displays. In fact, most of the code consists of calls to these lower level built-in routines.

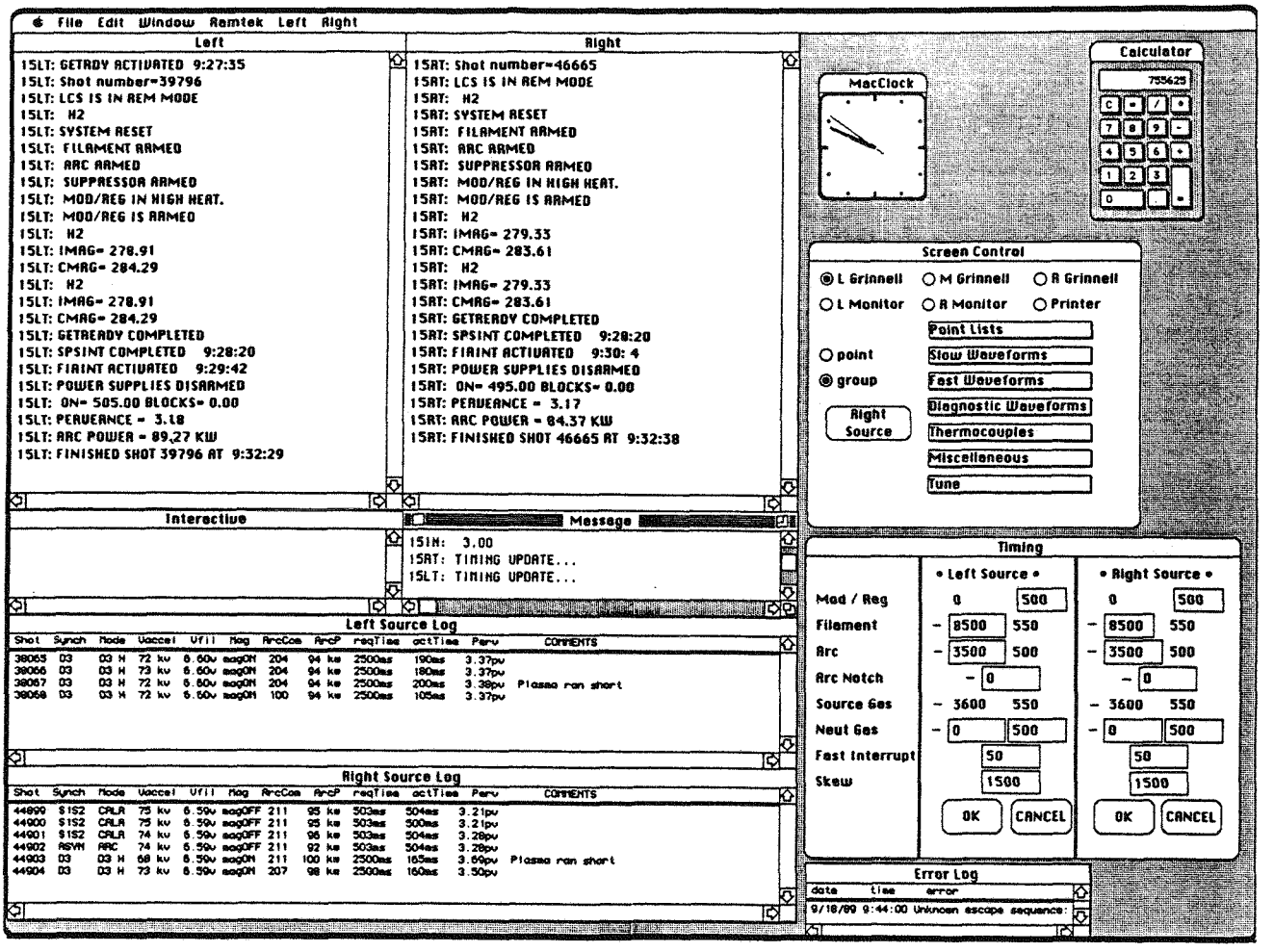
Function

From the Macintosh interface, the operator can use the mouse and keyboard for the following:

1. Set ion source timing.
2. Call for the display of waveforms on the MODCOMP's three-screen Grinnell display system.
3. Add comments to the automatically generated log.
4. Observe the status messages displayed by the shot sequencing procedures.

In many cases, there are keyboard equivalents for mouse operations, so that the operator can use whichever they please. Windows performing these various functions can be simultaneously viewed on the screen (Fig. 3), and although they have default positions on the screen, the operator can place them wherever they like. Message and logging windows can be resized by the operator. An error log window reports any uninterpretable strings received by the communication ports. In addition to the windows provided by the interface application, the operator has use of the standard array of Macintosh "desk accessories," applications that run concurrently and are always available. These include a clock and a calculator.

A considerable advantage associated with the use of the Macintosh (as opposed to the HP terminal) for the display of shot sequencing status messages, is that the messages are not lost when they scroll off the page. One can look back over several days by use of the vertical "scroll bars" associated with the



The operator's view of the new Macintosh/MODCOMP interface.

Macintosh window. The contents of the windows are archived to hard disk, so there is a continuous historical record kept of the sequence of events.

Focus for Automation

Through use of the mouse and pull-down menus, operations that previously required typing long strings of characters by the operators can be condensed into single motions. For example, pulling down the LEFT menu and highlighting INJECT, issuing the characters "INJECT LT" to the MODCOMP, causing the calorimeter to be moved out of position, the ion bending magnet to be energized, and beam timing to be set to 50 ms for the first shot of the day. Although this could have been achieved by the operator typing "INJECT LT," we have found that the operators have avoided typing commands for the most part, as errors in typing produced unpredictable results with the MODCOMP command language procedures. The mouse gives them a predictable, reliable substitute for typing. These menu commands (and their keyboard equivalents) can easily be added to the Macintosh application without changes to the PASCAL code by editing resource files that the application uses. It is envisioned that when further automation work is done using the MODCOMP control computer, the Macintosh interface will be able to direct ion source operation with less operator intervention required. Through use of the LAN, a single concentrated operator console will be able to control routine operations for eight ion sources.

Future Plans

Development work is planned in two primary areas: (1) communication with the MODCOMP Classic, and (2) communication over the LAN.

Communication between the Macintosh and the MODCOMP Classic is currently done with three 9600–baud serial lines and relies on the "parsing" of ASCII strings. Generally, there are no problems with this method, but extraneous characters or garbage can result in very occasional glitches. Future plans call for the development of a Small Computer System Interface (SCSI) standard for the Macintosh and available for the MODCOMP. This will allow for access at the file level, making the Macintosh an integrated part of the MODCOMP control system. The high-speed communications that would result, will allow for the transfer of waveforms as well as control information.

The Macintosh has built-in hardware and software for communication over a LAN. The current design of the Macintosh interface uses all available serial ports for communication with the MODCOMP, leaving none for the LAN. This will be remedied in the fall of 1989, when Apple's operating system software enhancements are released allowing for additional serial communication cards to be recognized by the system. The

LAN is becoming an increasingly important part of the neutral beam operating environment. Currently an IBM PC communicates neutral beam operating parameters over the LAN to the Macintosh-based waterflow calorimetry (WFC) diagnostic [2,3].

The use of the Macintosh interface will allow the reduction of the rack space required for a neutral beam operator's console by 30% to 40%, through the removal of the touch screen, timing knobs, and screen control keyboard (Fig. 1). Currently, the console consists of three 19–in racks, each 7–ft tall, repeated for each of four systems. The reduction will probably occur in the vertical height used, bringing everything closer to the operator's level and "opening up" the control room.

Conclusion

The Macintosh front end to the DIII–D MODCOMP neutral beam control computers has provided a unified operator interface at a comparatively low cost both in terms of hardware and, more importantly, software development time. The hardware chosen is universally available and repairable. In addition, it is providing an exciting platform for increasing the level of automation of routine neutral beam operation tasks, such as execution of command functions and logging.

Acknowledgment

Sincere thanks are due to Matt Madruga and to all the neutral beam operating staff for their ideas, enthusiasm, and contributions during the period of design and debugging.

This work was sponsored by the U.S. Department of Energy under Contract No. DE-AC03-89ER51114.

References

[1] A. S. Glad, "A Structured Multi-Stream Command Language," GA Report GA–A16890, *Proceedings of the 8th MUSE Conference*, Fort Lauderdale, Florida, December 1982.

[2] J. Wight, "Design and Implementation of a Macintosh-CAMAC Based System for Neutral Beam Diagnostics," IEEE Poster Session No. 05-P-30, to be presented at the *13th Symposium on Fusion Engineering*, October 2–6, 1989, Knoxville, Tennessee.

[3] P. Thurgood, "PC-Link MODCOMP/IBM a Link for Neutral Particle Beam Operation," IEEE Poster Session No. 29-P-30, to be presented at the *13 th Symposium on Fusion Engineering*, October 2–6, 1989, Knoxville, Tennessee.