SAND-77-0750C

CONF-771023--1

# DATA ACQUISITION AND PROCESSING ON ELECTRON BEAM FUSION ACCELERATORS*

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## ABSTRACT

This report briefly describes the hardware and software components of the custom data acquisition facility developed for the Sandia electron beam fusion research program. The facility contains a Modcomp II minicomputer system, Tektronix transient digitizers, conventional oscilloscopes, and an image digitizer. Commercial equipment is utilized as much as possible. Careful cable shielding techniques are used to overcome the severe noise environments. The powerful capabilities of the Modcomp multi-task operating system allow two simultaneous users. Special applications programs developed for data acquisition and reduction are described. The facility is currently operational and has met design goals. A duplicate of this system will be built to support the next generation accelerator EBFA (Electron Beam Fusion Accelerator).



*This work was supported by the U.S. Energy Research and Development Administration, under Contract AT(29-1)-789.

## DISCLAIMER

A special data acquisition and processing facility has been developed for the Sandia electron beam fusion research accelerators Hydra, Proto I and Proto II. Like the accelerators, the data acquisition facility is a prototype for a future system to support the next generation accelerator EBFA (Electron Beam Fusion Accelerator). Many of the diagnostic signals from these machines and associated experiments must be digitially processed for meaningful evaluation. The main objective in designing the facility was to get this processed data back to users within minutes after each shot. This rapid turnaround is necessary to enable proper adjustment of experimental parameters for the next shot.

Many data signals are fast pulses of 20-100 ns duration. These signals required on-line data acquisition devices to meet the rapid turn-around requirements. The only device available is the Tektronix 7912 Transient Digitizer. Other data is recorded off-line in photographic form. The photographs are either conventional oscillograms or transparency images. This data must also be digitally processed. Oscillogram data sometimes must be reduced in conjunction with the 7912 data. The digitizing is done on a Colorado Video 270 Video Digitizer incorporated into a high resolution closed circuit television system.

Several factors dictated the development of a special system as opposed to the purchase of a commercial off-the-shelf one. Both on-line and off-line fast transient data had to be digitized and collectively processed. Multiple simultaneous users had to be accommodated. And finally, anticipated software requirements were incompatible with available packages.

Hardware

The computer system itself consists of a Modcomp II CPU with standard peripherals. A block diagram is shown in Fig. 1. A special hardware interface had to be designed to mate the 7912's to the Modcomp since none existed. This interface consists of controller card in the CPU and a multiplexer chassis located in the 7912 racks. The controller supports all the functions of the 7912's. The interface is compatible with the Tektronix CP Bus Interface card. However, the controller logic was designed to overcome some of the timing errors that can occur with the CP Bus. The multiplexer can handle 4 bus lines with 8 digitizers per line. We currently have 15 7912's on line. Another 14 units will be added soon.

A second custom interface was required for the Video Digitizer. This interface also supports all the functions of the device. In addition, it contains optional logic to automatically scan a picture, thus relieving software of this job.

Part of the data acquisition facility development was the low noise cabling system from the facility to the accelerator diagnostics. The accelerators can produce voltage and current risetimes of $10^{14}$ volts and amps per second. This creates an extreme noise environment. High quality RG 214 and RG 331 cabling is used in all runs. All cable runs are shielded by either thick walled rigid conduit or flexible tubing. Rf-tight junction boxes are used to interface different runs and to bleed off shield noise currents to ground. All the electronic equipment is housed in a high-quality double-shielded enclosure.

Software

The real time multi-task capabilities of the Modcomp MAX III operating system are used extensively. Device handler tasks compatible with the executive were written for both the 7912 and Video Digitizer interfaces. The core partitioning features of MAX III are used to load applications programs into fixed areas of core. This eliminates the need for dynamic core allocation. A user oriented operator communications task was developed to allow easy selection of applications programs. Most applications programs are interactive to some extent. The operator communications task automatically assigns local program communications to the proper terminal. Applications programs were designed to optimize the tradeoff between automation and operator control. These programs include a data acquisition task, an automatic data reduction task for accelerator diode parameters, and various interactive manual data reduction tasks. The operating system allows two copies of the same program to be active simultaneously.

The manual data reduction tasks all use the text interpretation services in the MAX III operating system to process input mnemonic command sentences. A main program uses the interpreted data to call different subprograms which then actually perform the operation requested in the command. This approach has proven very versatile. The same code is used in several main programs in nearly identical form. Adding or modifying subprograms is easily accomplished. The manual reduction programs have virtually eliminated the need for users to write their own custom software.

Extensive processing of digitized signals is done after data acquisition. One element in the signal conditioning process is cable compensation. Signals sent from the machines suffer high frequency

attenuation from the long cable runs. The high frequency components are restored by convolving the data with special cable compensation filters. Typically, the signal bandwidth can be restored from about 70 MHz on input to about 250 MHz on output. An example of cable compensation is shown in Fig. 2.

## Conclusion

The data acquisition facility described above is operational and has met the design objectives. Fully processed data is available to experimenters within minutes after a shot. The dual user capability has generally eliminated computer delays in getting shots off. The system hardware and software will be duplicated for EBFA.

## Figure Captions

Figure No.

1 Block Diagram of Sandia e-beam fusion data acquisition facility.

2 DI/DT signal from Proto I with and without software cable compensation filter.

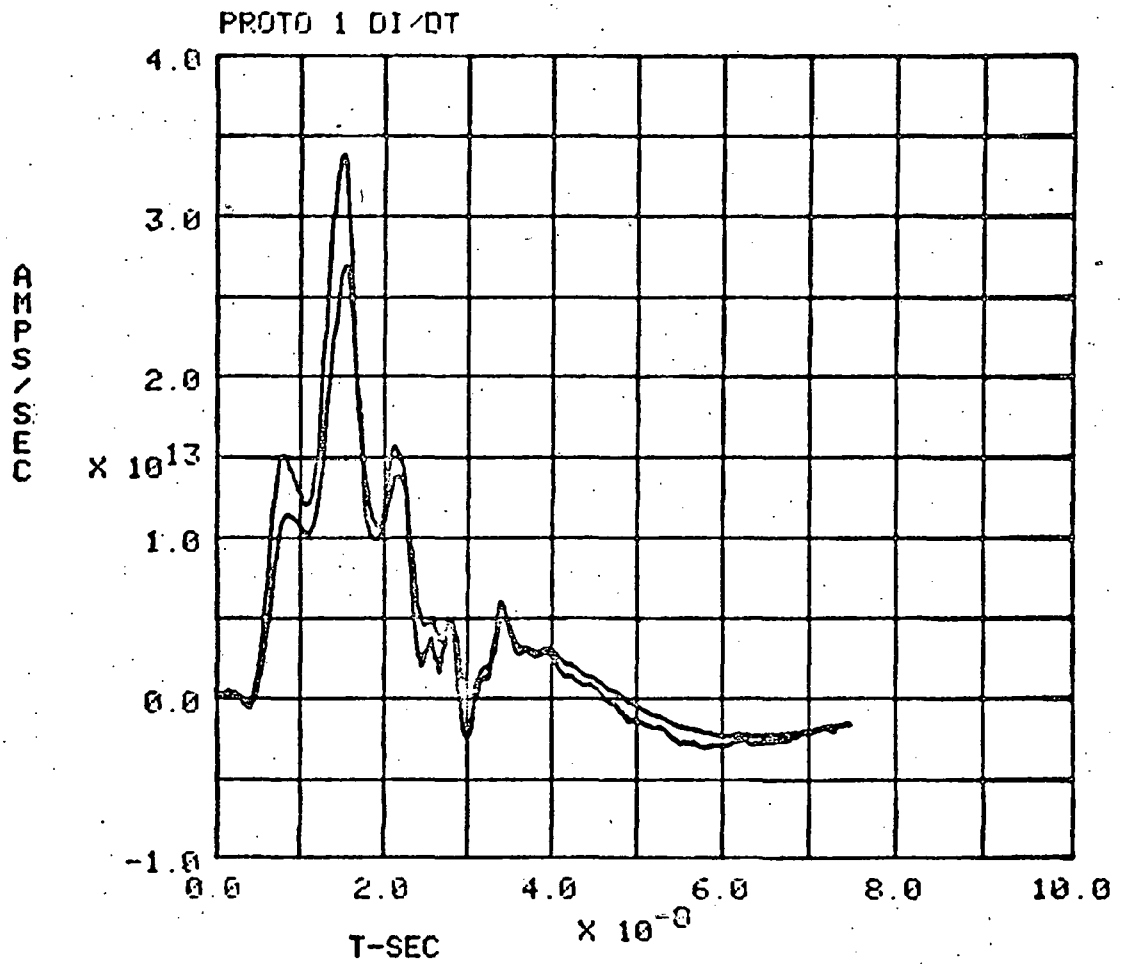


FIGURE 2

DI/DT signal from Proto I with and without software cable compensation filter

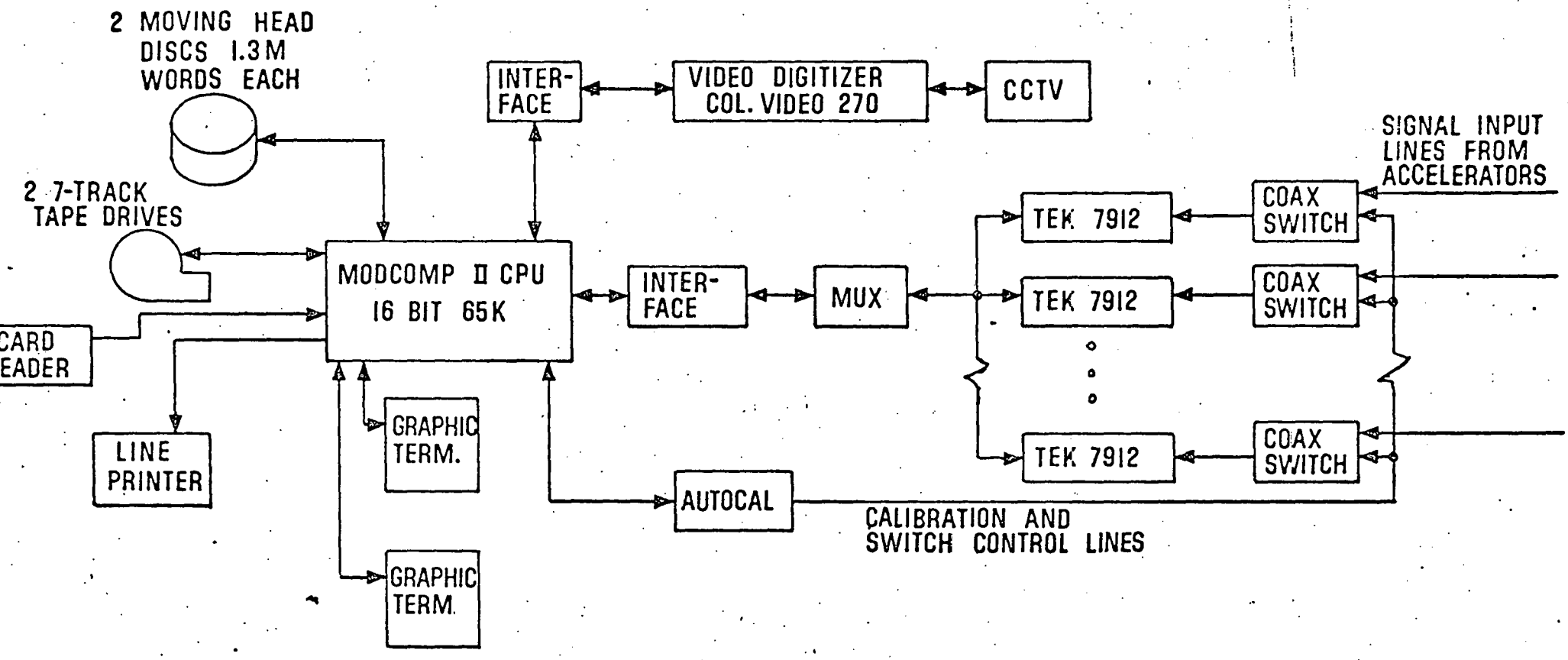


FIG 1

BLOCK DIAGRAM OF SANDIA E-BEAM FUSION DATA ACQUISITION FACILITY