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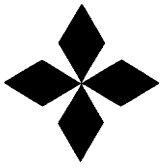
PC — LINK
HISTORICAL DATA BASE SYSTEM MODCOMP/IBM AT LINK FOR NEUTRAL PARTICLE BEAM OPERATION

by
PAUL THURGOOD

DECEMBER 1989



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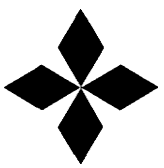

GENERAL ATOMICS

PC — LINK
HISTORICAL DATA BASE SYSTEM
MODCOMP/IBM AT LINK FOR NEUTRAL PARTICLE BEAM OPERATION

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Abstract: "PC-Link" is a combination of hardware and software that connects an IBM PC/AT to a MODCOMP minicomputer. It is designed as an aid to the Neutral Beam operations coordinator during injection into the DIII–D tokamak project. An IBM PC/AT is linked to 4 MODCOMP "realtime" acquisition systems, each of which controls 2 neutral particle beam sources. At various points in the shot sequence, data is sent to the IBM PC/AT. This data can then be integrated with the data from the other sources into tables or graphics displays for use by the Beam Coordinator. In this way, the coordinator gets realtime feedback on the relative settings and performance of the sources and can observe trends within a particular source at one location. The PC-Link is used for observing relative timing information and for post shot historical archiving. The concept of the PC-Link was originally proposed several years ago. In April 1988, in-house implementation of the link software was begun.

The PC-Link receives approximately 2 Kbytes of data per source per shot. This data is converted from MODCOMP format to IBM PC format and archived to disk. The last 280 shots per source are stored to disk to observe trends. The data can be displayed in a number of formats depending upon the situation. For example, prior to a shot, the beam MODCOMPs are sent timing information from the DIII–D tokamak control system. This data is echoed on the PC in a graphical representation displaying all 8 sources. At the end of the shot, the actual running times are displayed along with the requested settings. Any subset of the Historical data may be displayed either graphically or in tables for realtime comparisons between sources. This system is designed for realtime use, not for complete archiving purposes. This same data is also sent to a VAX computer for full integration into the archive database. This system is easily upgradable and extremely versatile.

Introduction

The General Atomics DIII–D Neutral Particle Beam Injection system consists of 8 beam sources, run by 4 MODCOMP minicomputers. With 8 sources, it is often difficult, during synchronous Neutral Beam Injection ("D3SYNC"), to keep the overall operation in perspective. Parameters such as power injected, run time, etc., must be quickly available. The PC-Link "Coordinator's Console" is an IBM PC/AT designed to aid the Neutral Beam Coordinator during beam injection into the DIII–D Tokamak. As one of its functions, the IBM receives data from the 4 MODCOMP computers and gives "real time" feedback on the operation of each source and the requested settings from Tokamak Control system during injection. This paper is a detailed description of the hardware and software associated with the PC-Link system.

As the beams are preparing for a shot (GETREADY), data is sent to the IBM PC/AT by each MODCOMP computer. The PC collects and processes this data into an easy to read graphic display of relevant timing information. As data is received from each computer, the display is updated dynamically. In the post shot phase, this data is updated with the actual running times of each source overlaid above the requested. From this display, the coordinator gets a comprehensive summary of the timing setup. This often points out errors in the setup of one or more of the beams.

In addition to the dynamic timing display, the operator may also call up a summary page listing selected point names from each source or review data from a previous shot in one of several formats. Items such as power shinethrough, power injected, thermocouple temperatures, etc., can be viewed side by side for all sources. The operator can also view any system errors that may have occurred during the session. The IBM is also connected to a Macintosh (Apple Computers Inc.) network, enabling many other diagnostics to gain access to the MODCOMP's data more easily and quickly than would otherwise be possible.

Design

During the shot sequence, each of the 4 MODCOMPs accumulate and store shot data in the "Historical Log." These shot logs can contain up to 512 entries which are determined by the historical "structure." The "structure" is a set of parameters defining the physical Name, Units, and numerical Type of each log entry. Each entry is 32 bits long, so consequently a shot log requires 1024, 16 bit words. The shot log resides in a common area during the shot and is archived into the Historical Log when the shot is complete. The Historical Log is a 50 Mbyte disk file capable of holding 24000 shot logs (12000 per source).

These logs are also sent to the IBM PC/AT. At present the PC stores the most recent 280 shot logs for each source. This is usually sufficient for trend curves or to lookup recent history. At 50-60 shots per day, about a week's worth of data is stored. This system is designed for quick access to the most recent data. It is not designed for use as a major data base. At the end of each operating day, the day's shot logs are sent to a VAX (Digital Equipment Corp.) for integration into a relational data base. If, however, it should be deemed necessary, the capacity of the IBM can be increased to the limit of available disk space. There are a number of features to this system and it is upgradable to user designs.

During a D3SYNC shot, beam timing control is handled remotely from the Tokamak Control computer. Parameters such as SKEW (start time) and maximum ONTIME (run time) can be set by the operator. If the beam computers are setup to run SYNChronously with DIII–D and are set in DIII–D Heating MODE (injection into Plasma), the "Control" computer controls the source timing within the guidelines set by the beam operator. When in SYNC, the Beam computer will take the SKEW from the Control computer and will select the lower of the two ONTIMEs.

The main summary page on the PC is a graphical representation of this timing information (see Fig. 1). During GETREADY, the MODCOMPs send the planned timing data

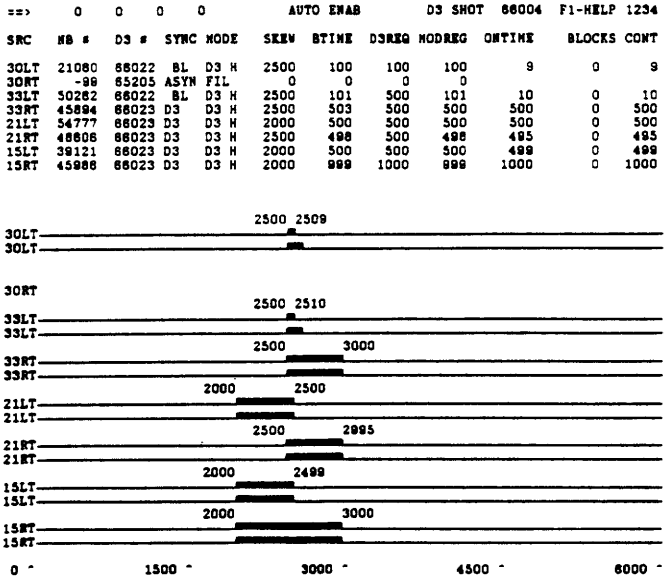

Fig. 1. Timing screen.

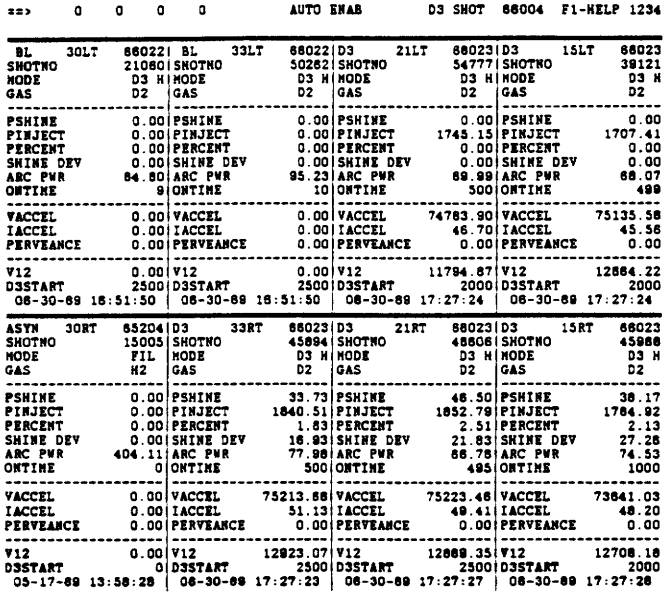

Fig. 2. Post shot summary page.

for each source to the PC. The timing display shows both the the DIII–D Control's timing requests and those set by the beam operators. The timing schedule selected (based on SYNC and MODE) is displayed under the "MODREG" heading. When the shot is complete, the MODCOMP's send a copy of the historical log to the IBM PC/AT. In addition to being archived to the PC disk, the information is also used to update the timing display with the actual time that the beam ran.

The actual beam duration is overlaid on the requested duration for a good view of requested versus actual operation. This can be used by the coordinator to monitor the overall timing picture. The top line of the display shows the status of the four data buffers from the MODCOMPs and what the current D3SYNC shot number is.

The coordinator also has the option to view a summary page of selected point names (see Fig. 2). The summary page has a separate block for each of the eight sources. The top line

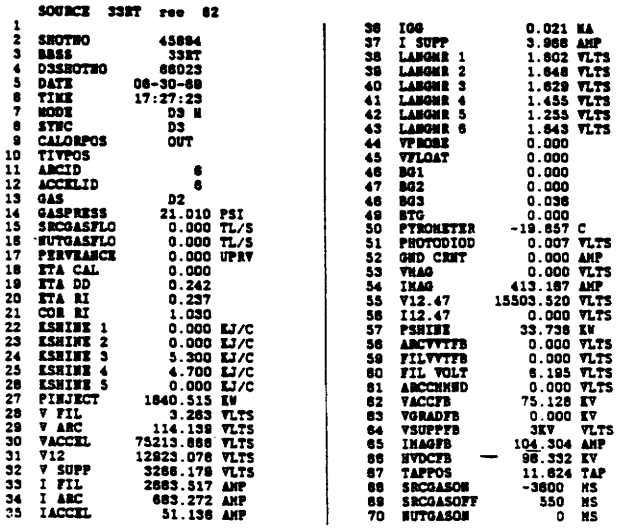

Fig. 3. Historical log display page.

of the block displays the MODE, SOURCE designation, and the D3SYNC shot number it was run under. the bottom line displays the time and date the shot was run. The other 16 lines contain user-defined points that may vary from source to source. The top right block, for example, is the summary of the left SOURCE at the 150° point in the tokamak (15LT). It shows the MODE (Synchronous Plasma Heating), the gas used, the power injected into the plasma (PINJECT), the run time of the source (ONTIME), etc. The units for each value are understood by the user, but can be viewed in the more detailed listing discussed below (see Fig. 3).

This listing allows the operator to view any point in any of the data files stored on disk. These files are indexed and referenced by shot number for easy access. If desired, the display can be split so that two records may be examined together for comparisons. These records may be from different sources, different shots, or different sections of the same log.

A subset of this data is also sent to the Macintosh network disk after each shot. This can be used by other diagnostics experiments on the network, such as Water Flow Calorimetry.

Technical Discussion

On the IBM PC/AT:

The PC-Link is a 6 MHz IBM PC/AT connected through half duplex async communication lines to the 4 MODCOMP minicomputers (see Fig. 4).

This system is designed to work with minimal overhead. It requires no Xon/Xoff protocol or other handshaking, but will make use of it if it is available. Consequently, the IBM PC/AT must be ready to receive data at all times. To accommodate this, a COMM+4, 4 Channel async communication board, supplied by Sealevel Systems Inc., is required to receive the data. The COMM+4 async ports are buffered to improve system performance. These buffers are, in turn, read by a memory resident program that translates and archives the data. Since the communications routines are memory resident, the foreground is left free for the dynamic timing display program discussed above (dispCOMM) or any software one chooses to run such as spread sheets or plotting packages.

The communication ports/buffers are interrupt driven and reside in a fixed location in memory. System drivers from

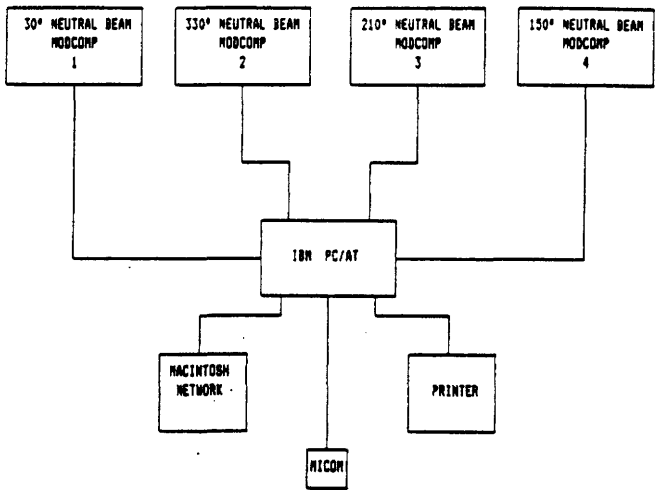

Fig. 4. PC-LINK configuration.

Commtech Inc. allow access of up to 10 communication ports simultaneously. Currently, com1: is used for a printer port or for the micom and data is taken from com3: through com6:. Only ports 3 - 6 are buffered, thus buffer 1 is com3: and buffer 4 is com6:. The index counter for each is stored in the last 2 bytes of the buffer. So, effectively, each buffer is actually only 4094 bytes long. The memory locations for com2: are being used by the Apple Talk Network Board for communication with the Macintosh network. "Apple Share" (Apple Computer Corp.) is used to interface with the server.

Since there is only 256 Kbytes on the mother board of the PC/AT, a 2 Mbyte RAMPAGE extended memory board is used to expand the memory capacity. This requires however, that the memory locations used by the ram buffers be explicitly excluded from the RAMPAGE mapping drivers. Since only com3: through com6: are buffered, 4 buffers are used and only 16K of memory is needed.

"ResCOMM" is a memory resident background program written in TURBO PASCAL 5.0 [TURBO PASCAL is a trademark of Borland International Inc. resCOMM supports the TesSeRact (tm) Development Team standard for memory resident software]. It is loaded at boot time from the AUTOEXEC.BAT file and scans the memory resident comm buffers for incoming data. When there is incoming data, resCOMM checks the datablock for size and header flag. If these match the specifications it is expecting, the data is converted appropriately and saved to disk. If there is not a match, then resCOMM loops and checks for a static index counter. If the counter is static for more than 1 second, the buffer is cleared and an error message is logged. If the Macintosh server on com2: is operating, resCOMM also sends data to its disk. At GETREADY and at the end of the shot, when data is received, resCOMM sends a signal to dispCOMM to display the latest timing information. This signal is sent only if dispCOMM has been loaded and only if AUTODISPLAY mode is enabled within dispCOMM. When dispCOMM receives this signal, it displays the timing graph that was derived from resCOMM's internal data table.

DispCOMM (see Fig. 2) displays data in Enhanced Graphics (EGA) 43 line mode to allow for a greater display area. When it is loaded, dispCOMM communicates with resCOMM and gets the addresses of resCOMM's internal data tables and tells resCOMM that it is ready to display data. In the upper left corner dispCOMM displays the status of the four data buffers. These indicate the amount of data received (in bytes) since the buffer was last read. In the upper right corner, the current DIII-D shot number is displayed (updated only by DIII-D shots) along with resCOMM's 4 buffer status flags. The second line in the display region is used for informational messages and the status of the keyboard buffer. This buffer holds any alphanumeric characters entered and is not cleared by hitting function keys. The bottom line of the display is for independent processes, such as disk access routines, to display their current status. The center of the screen may be used to display the timing page, summary page, a trend plot, or to display the data from a previous shot.

There are a number of commands available to the operator within dispCOMM. Commands can be entered from the keyboard, using single keystrokes (hot keys) or by using their 4 character alphanumeric commands.

If errors or significant incidents occur during operation, resCOMM and dispCOMM log them to a disk file. This file can be read from dispCOMM at any time.

There are also several stand alone routines available to the operator. These include:

STRUCTUR	:	Receives Historical Structure record from the MODCOMP and writes it to a disk file for use by resCOMM and dispCOMM.
BUILDER	:	Builds tab separated datafiles from shots on disk. BUILDER reads a list of historical entry numbers from a file and puts the corresponding values from a set of shots in a file for use by other routines such as spreadsheets. If the file exists, then the new data is appended to the end.
WF	:	Water Flow Calorimetry specific version of BUILDER.
PLOTIT	:	Plots user defined points from a given shot range. Operation is similar to that of BUILDER, but the result is a plot.

MODCOMP Routines:

There are only 3 routines used on the MODCOMPs as part of the PC-Link. One is an overlay used to transmit the historical log's structure to the PC. This allows the PC to receive the structure modifications without re-entering them. The other 2 are subroutines called from system tasks at appropriate points in the shot cycle. One transmits the timing information during GETREADY, at the beginning of the shot, and the other reads the shot log from memory at the end of the shot. The transmission tasks use non-standard, binary, quick return writes across async comm lines. At present, the only error checking done is size and header flags. Although this system resides in a high noise environment, there has been no trouble with data

loss to this point. For the future, however, we expect to make the transmission lines full duplex and add checksumming and/or other forms of error correction.

Conclusion

PC-Link is designed with real time acquisition in mind. It processes approximately 1 Mbyte of data per day and can produce trend plots, tables, summary tables, etc., on the spot. This system has vast capabilities and is relatively inexpensive as it requires no additional hardware on the MODCOMPs. It can easily be tailored to the individual needs of the operator and can be used in many different environments. The IBM makes an efficient and convenient data collection node requiring very little expense. The Coordinators Console has proven useful during multiple sources operations. The coordinator can now obtain a comprehensive overview of each beam's performance from a single source in a variety of formats.

Acknowledgment

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