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Disk Controller Unburdens Real Time Applications

Computers are currently being used in real time applications more than ever. Equipment used in industrial automation, telecommunications and medicine relies on processors to provide intelligent control and data processing ability in real time situations.

Many applications require storage and retrieval of large amounts of data from one or more data bases. The processing overhead required to efficiently organize this data into files can be quite large. Because of the time constraints associated with real time applications, this function often cannot be performed by the same processor that performs real time control. File management software also requires significant amounts of memory space, further limiting the resources available to real time tasks. Because of the large amount of memory and processing resources used by file management systems, data storage and retrieval is often accomplished by downloading to an external computer or limited to simple direct sector data dumps onto disk storage devices.

A New Solution

Providing real time equipment with the file management power previously limited to much larger computing systems was the aim behind the PM-3001 disk controller. In addition to disk control circuitry, it contains 32 Kbits of cache RAM and PFMS, a ROM based file management system designed for maximum efficiency in real time applications. PFMS (which stands for Paged File Management System) is executed by a μP located on the PM-3001. PFMS performs all file manipulation by responding to simple high level commands issued by the host system.

Commands are issued to the PM-3001 by using host command blocks. A host command block is a buffer in the host computer's memory containing a one byte operation code followed by the parameters for that command.

To initiate action by the PM-3001, the following steps must be taken by the host processor. The host command block is assembled in the host memory. This may be done in real time by the host processor or may be loaded into the host memory along with the host program. The address of the first byte in the host command block is written into a register in the PM-3001 by the host processor. This initiates command execution by the PM-3001. The host processor may now spend its time servicing real time tasks. The PM-3001 reads the host command block using Direct Memory Access (DMA). All data transfers to or from disk are handled by the PM-3001 without any host processor intervention.

When command execution is completed, the PM-3001 transfers a result code to the specified location in host memory. A request for interrupt is then issued to the host processor by the PM-3001.

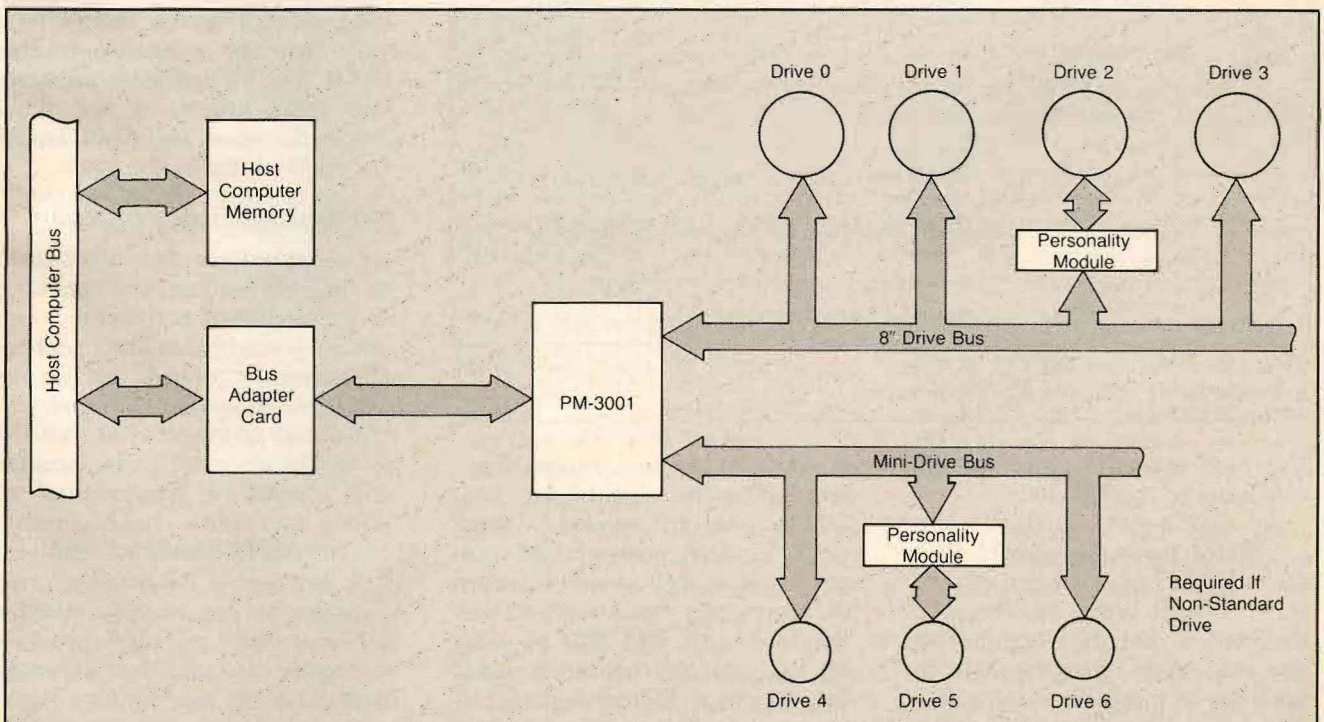

Figure 1: PM-3001 Floppy Disk Controller configuration: with an appropriate computer bus adapter card, it can control up to four 8" drives plus three mini-drives.

COMMAND	DESCRIPTION
READ SEGMENT	Transfers the specified number of bytes from a diskette file to the host computer memory.
WRITE SEGMENT	Transfers the specified number of bytes to a diskette file from the host computer memory.
CREATE FILE	Creates a PFMS file.
DELETE FILE	Deletes the specified file(s) from the diskette and frees the occupied disk space. Wild card file specifications are supported.
COPY FILE	Copies the specified source file(s) into the specified destination file(s). Wild card file specifications are supported.
VERIFY FILE	Compares the specified files and determines whether the data contained in the two files is identical.
RENAME FILE	Assigns a new name to an existing file. Wild card file specifications are supported.
COMMENT FILE	Allows the user to specify a 38-byte comment field to be displayed in the directory listing, for any PFMS file.
MAP FILE	Returns a formatted ASCII sector allocation map for the specified PFMS file.
FORMAT DISKETTE	Writes new track and sector boundries onto soft sectored floppy disk media.
SET VOLUME NUMBER	Allows the user to specify a 10-byte diskette volume number to be displayed in the directory listing, for any PFMS diskette.
COMMENT DISKETTE	Allows the user to specify an 80-byte directory comment field to be displayed in the directory listing, for any PFMS diskette.
COPY DISKETTE	Copies block for block the image of one diskette to another.
DIRECTORY	Returns the diskette directory in formatted ASCII or unformatted binary modes.
MAP DISK	Returns a formatted ASCII sector allocation map for the specified diskette.
READ SECTOR	Allows direct sector access of non-PFMS diskettes.
WRITE SECTOR	Allows direct sector access of non-PFMS diskettes.
DISKETTE TYPE	Returns the media format of the diskette in the specified drive.
SET SYSTEM DATE	Sets the PFMS system date.
VERSION	Returns the PM-3001 version number.
DIAGNOSTICS	Causes the PM-3001 to execute a self-test routine.
UNLOCK DRIVE	Sends an unlock signal to the specified drive.
CONTINUE	Instructs the PM-3001 to transmit another 80 character display line.
PROCEED/SKIP	Used in conjunction with any command which requires confirmation for an action to take place.
TERMINATE	Causes the command currently executing to abort.
RESET	Causes a PM-3001 system reset.

Figure 2: The Command List includes a complete set of file management functions, including wild card file specifications.

The host may now issue another command to the PM-3001.

All disk control circuitry, plus μP, ROM firmware and 32 Kbit cache RAM are contained on one 9″ × 11″ logic board which can be mounted in the same cabinet as the disk drives. This board connects via 40 pair ribbon cable to a host bus adapter card (**Figure 1**). The bus adapter card presents the proper pin-out configuration for interface to the host computer bus and generates signals for host DMA, interrupt, and I/O functions. Virtually any standard computer bus as well as non-standard or proprietary bus structures can interface to the PM-3001 by using off the shelf or custom designed bus adapters. Optional personality modules allow non-standard drives to be intermixed using one PM-3001. Step rates and head settle times are automatically varied to suit each drive's requirements.

File Management System

The PFMS file management system simplifies real time application programming by providing a unique file access method. Data is transferred to and from PFMS disk files much as data would be transferred between host memory and an external memory bank. Each file appears to the host computer as 2 Mbytes of virtual RAM. This means that any byte address from 0 to 2,097,151 may be accessed in a PFMS file regardless of the history of that file.

File space allocation and de-allocation is handled automatically by PFMS during and between disk accesses. When a disk file is created, only one disk sector is initially allocated to that file. All 2,097,151 bytes of the file will contain zeros. As data is written into the file by the host computer, sectors are allocated when necessary to hold non-zero data. Whenever a sector is found to contain all zero data, PFMS de-allocates that sector and places it back into the pool of available sectors so it may then be used in another PFMS file. This scheme increases disk space utilization and eliminates the need for fixed length record blocking by the host.

Unburdens Host Processor

One application for which offloading file management functions to an intelligent peripheral is important would be an intelligent environmental control or energy management system. In such applications, processor time must be strictly allocated to the monitor and control of temperature set points and other environmental conditions. In addition to this real time function it is also frequently desirable to log these conditions for future reference. If floppy disk storage is used, the data files may then be easily archived or transported to other computer sites for analysis.

Conventional floppy disk con-

trollers require that the system processor halt its real time tasks when data is to be logged so that file management code can be executed. If this code is not memory resident, additional time must be taken to "page in" file management code and to later page process control code back in. Disk writes may also take considerable time due to track seeks and rotational latency within the drive.

Access times for page-resident data for this disk controller, 8" and 5¼" floppy disk drives are shown in **Figure 3**. 256–byte sectors are assumed. Best and worst access times using the PM-3001 converge for data transfers greater than 4.5 Kbits. Note that in the same time it takes to transfer 2 Kbits on a 5¼" drive or 4 Kbits on an 8" drive, 24 Kbits can be transferred from the PM-3001 paging memory. On the average, 18 Kbits of page-resident data can be transferred before a single byte of disk data can be accessed.

The PM-3001 greatly simplifies the task of data logging since no file management code need be held in system memory or executed by the system processor. In addition, disk writes occur in much less time because of the cache memory on board.

In the case of disk write operations, the cache memory acts like a 32–Kbit write buffer. As data is transferred to the board it is partitioned into 256–byte segments and stored in cache. Although it may take up to one half second for some disk drives to seek the proper track and sector, the PM-3001 allows the host to resume execution of real time tasks as soon as all the data has been transferred into cache. This normally occurs within a few milliseconds.

Program Segmenting

Another common use of disk storage in real time systems is for program segmenting or paging. As an example, consider a computer controlled telephone system such as a PBX or "Private Branch Exchange." In such systems, a large control program is often broken up into smaller segments which are read into memory as needed from floppy disk storage. Program segments to control commonly used telephone functions may always be kept resident in system memory. Program segments that contain code for less frequently used functions might be kept on disk storage until needed. At that time the processor must temporarily suspend the execution of real time tasks in order to supervise the paging in of the desired program segment.

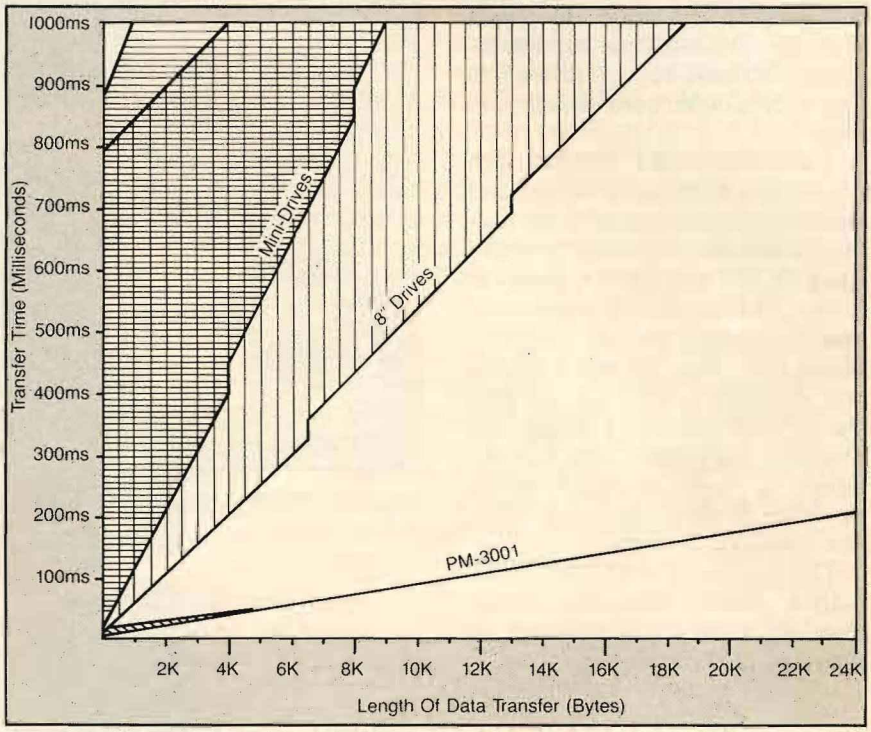

Figure 3: Comparison of best and worst case access plus transfer times for page-resident data using the PM-3001 versus sequentially stored data on 8" and 5¼" floppy disk drives.

The PM-3001 cache memory greatly facilitates program segmenting not only because of its additional speed but because of its unique paging algorithm. The most frequently used disk data has the best chance of being found in cache. This means that commonly used program segments which are paged into cache most often will have the shortest access times. Program segments that are seldom accessed will more likely be moved out of cache by the PM-3001 to make room for other data.

The designer of telephone system software is not forced to guess which features will be used most often by telephone customers. The PM-3001 monitors disk data usage in real time and adjusts cache resident data for the quickest overall response times, increasing overall system throughput.

One Package

Since the PM-3001 incorporates disk control, file management and cache memory in one package, the design of real time systems is simplified and overall system throughout improved. Because the host processor need not execute file management code, it can handle more real time tasks with a subsequent increase in total system performance.

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