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Floppy-Disk System for Punched-Tape Reader Emulation

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J. E. Hopwood

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FLOPPY-DISK SYSTEM FOR PUNCHED-TAPE
READER EMULATION

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ABSTRACT

This report describes the application of minifloppy disk systems to numerically-controlled machine tools at Sandia, Livermore, as an alternative to time-consuming and unreliable punched-tape readers.

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FLOPPY DISK SYSTEM FOR PUNCHED TAPE READER EMULATOR

Introduction

For several years Sandia National Laboratories, Livermore (SNLL), has been seeking alternatives to punched-tape readers on numerically-controlled (NC) machine tools. SNLL possesses every generation of NC equipment, from a 1960 vintage GE 100S control using a Tally mechanical tape reader to a Kearny and Trecker Model 180 CNC with a 300-cps photoelectric reader. The readers are the primary source for malfunctions. A system had been developed previously that read part description data from a cartridge to an Ampex Core Memory. The NC equipment then read the memory in a similar manner to reading punched tape. The new system performed well but had a small program capacity. Other commercial storage systems were rejected on the basis of cost-effectiveness and lack of versatility.

Recent advances in mass data storage devices has made possible a low-cost minifloppy disk system with a self-contained 5.25-inch floppy disk drive, power supply, microprocessor-based controller, and RS232C interface. This system was manufactured by GUC Products in San Diego, California.

Minifloppy Disk System

SNLL worked with GUC to develop the interface electronics to the numerical controls. The interface, incorporated on a single printed wiring board (PWB), is adaptable to any model of NC equipment by simply setting miniature switches on the board. After debugging the system, it was successfully demonstrated on three NC machines, a Gerber photoplotter, and a Gerber coordinate digitizer.

Before equipping the SNLL NC machine tools with a minifloppy disk drive, it was first necessary to obtain disk writing capability. This was accomplished several months prior to installation. Once installed, the minifloppy disk system was used to store part description data that had been sent from a CDC 6600 computer through a modem to a tape punching machine.

Using the tape puncher was a slow process (600 bits per second (bps)), requiring 45 minutes to complete a 600-foot tape. Occasionally, the computer failed during this operation, and it had to be repeated. The mini-

floppy disk system can send data at 9600 baud, a three-minute task. After storage, the disk system is taken off-line and the baud rate changed to 600 bps and read to the tape puncher. This gives the disk system a dual purpose: recording data on a disk for direct use on NC equipment, or being used for off-line tape-punching.

Data Flow

The following briefly describes the flow of the part description data being written to the minifloppy disk system. Refer to Figure 1.

After the programmers text file has been processed by the CDC 6600 APT program, and the appropriate post-processor invoked, the part description data is stored in a batch file within the computer. By commands entered through the terminal, the permanent file is transmitted at a baud rate of 9600 bps across signal lines in an asynchronous, serial-EIA format to the modem (the voltage levels conform to RS232C specifications). Immediately prior to valid data transmission, a ASCII control character (DC-2) is inserted by the computer program. The minifloppy disk systems, which is constantly testing the data string, senses the DC-2 and begins to store every transmitted character until sensing a DC-4 character, which is transmitted at the conclusion of the permanent file. At this point, the disk is delivered to the NC machine tool.

If the machine had not yet been equipped with a minifloppy disk drive, a punched tape was generated. To do this, the minifloppy baud rate is changed, via the front panel keypad, from 9600 to 600 bps. After selecting the disk file number to be punched, the entire file is transmitted to the tape punch machine. The punched tape is then delivered to the NC machine tool. Figure 2 shows the read-write minifloppy disk drive, HP 2640 terminal, Tektronix 4631 hard-copy machine, and DSI tape puncher. This equipment is located in the programmer's office.

The minifloppy disk drive at the NC machine is a read-only tape reader emulator. The outputs are: eight-bit parallel data synchronous to the Tape Forward Command (TFC) issued by the NC machine, and Sprocket Clock that the NC machine tool uses to sense that a valid character is present. By means of miniature slide switches internal to the disk drive, the signal level, logic state, and transfer rate are selectable for each NC machine model. The capacity of the minifloppy disk is 179,000 bytes, equivalent to 1488 feet of punched tape. The punched tape reader is still used in a back-up role. To reinsert the tape reader into the data input circuitry, an adapter connector is installed in place of the emulator.

Another application of the minifloppy system outside of the NC machine tool area involved a Gerber Model GCD-1 Coordinate Digitizer. An interface was developed to properly format the digitized data, convert to RS232C voltage levels, and transmit it to a file in the CDC 6600 computer. Because the computer frequently breaks down during the long digitizing process, data which was assumed to be going into file would be lost. To prevent this condition, the minifloppy disk drive is placed in parallel with the modem, as

Figure 1. Flow of Part Description Data to Disk System

Figure 2. Minifloppy Disk System

shown in Figure 3. Now, if a failure occurs without the operator's knowledge, the data is saved on the disk and can later be transmitted to the computer.

Advantages of Floppy Disks

1. Elimination of paper-tape punching.

A 600-foot tape takes about 45 minutes to punch. The same data written to disk takes approximately three minutes. Historically, the punch mechanism has been troublesome.

2. Cost Saving.

Mylar tape currently costs \$50.00 per 1,000-foot roll. Floppy disks cost approximately \$5.00 each and are reusable for an indefinite length of time. Each disk will hold 1,488 feet of punched tape data. At four rolls per week, the savings amount to \$200 per week, or \$10,400 per year. The cost of the minifloppy disk system is approximately \$2,000.

3. Greater data transfer speed.

The speed of data transfer from the CDC 6600 is 9600 bps versus 600 bps when tape-punching is required.

4. Greater reliability.

With the faster transfer rate, there is less chance of the computer failing in the middle of data transfer.

5. More efficient use of data terminals.

When punching tape, the data terminal is on-line making it unavailable for normal programming use. The fast recording time increases use time.

6. Storage space reduced.

The amount of storage space is reduced by no longer having to save punched tape.

7. Tape handling is completely eliminated.

With the disk system, the operator inserts the disk and then simply selects the file to be read. Installing and threading punched tape is more complex.

Figure 3. Minifloppy Disk System with Computer Interface

8. Greater program storage capability.

Punched tape reels will hold only 600 feet of tape. The disk will contain program storage equivalent to 1,488 feet of tape.

9. Multiple-program storage on a single disk.

Each disk contains 26 programs. The operator selects the desired program via keyboard.

10. Lower initial cost than tape reader.

The price difference between a tape reader and a minifloppy disk system is approximately \$1,000.

11. Less maintenance.

The minifloppy disk drive requires only periodic cleaning of the disk heads.

12. Impact of floppy disks.

The GUC floppy disk drive system has had a large impact on the programmer:

- a. The amount of time necessary to get changes onto the shop floor has been reduced dramatically. The main reason is that a tape punching machine takes almost an hour, while the same data on floppy disk only requires minutes (two or three minutes at most).
- b. On machines without sequence search facilities, each tool change or other convenient breaking-point can be set up as a separate file on the floppy disk. This has several advantages:
 - (1) It allows the machine tool operator to run a section of the data over without having to start the data at the beginning and running through to the area to be remachined (useful for tool wear or breakage).
 - (2) It allows the machine tool to be shut down and restarted without having to run the entire job again.
 - (3) On the DAC printed circuit drill and router, when using paper tape, it was necessary to punch individual tapes for each hole size. When routing the board, the tapes had to be broken into 300-foot lengths. Since the machine does not have circular or linear interpolation, this tape length is reached very quickly because all nonaxis movements must be broken down to 0.001 of an inch. With the advent of the floppy disk, the entire job is stored on one disk and separated into various files:

File #1 - S and T hole.

File #2 - First hole size.

File #3 - Next hole size.

.

.

.

File #N - File contains router information.

- c. On CNC machines, minor corrections can now be made in the main program without the operator having to edit data, thereby keeping the APT program current at all times.
- d. Reliability of data transfer is much better (no punch hangs or mis-punches in tape).
- e. Floppy disks are an easier and more compact data storage medium.
- f. Operators have accepted the minifloppy disk system and have expressed the following comments:
 - (1) No tape handling.
 - (2) No threading of machine.
 - (3) Easier storage.
 - (4) More data on floppy disks than possible on tape.
 - (5) No waiting for rewinding.
 - (6) Easier search facility.
- g. There are no significant changes in the programmer's routine. The floppy disk setup routine is similar to paper tape.

Information on the Disk Drive and Emulator

Figure 4 shows the minifloppy disk drive. A latching access door provides for the disk inserting and removal. The purpose of the indicators and controls are as follows:

Activity	- This indicator flashes when activity is detected on the transmit or receive interface lines.
Status	- This indicator identifies the three-digit numeric display as an error code or status code.

Figure 4. Minifloppy Disk Drive

- File Open - This indicator flashes when a file is selected for reading or writing.
- Numeric Display - System status and error information is communicated to the operator by means of a three-digit, seven-segment numeric display. (The status codes and error messages will be explained later in this report). Through this display, the operator may obtain additional information on command such as the contents of the directory and free space available.
- Keyboard - The entire file management is in firmware. Control of all the file management functions is available to the operator by means of a keyboard. The entry sequence for the functions will be explained later.

Figure 5 lists the specifications for the read-write minifloppy disk system, and Figure 6 lists the file management commands. Figure 7 lists the specifications for the read-only punched emulator, and Figure 8 lists its file management commands. In order to aid the machine tool operator in selecting a file (part description program) the 2 key, and the * key and # key are imprinted with the words RUN-FILE and ENTER, respectively.

CAPACITY	179,000 BYTES NET, DOUBLE SIDED EQUIVALENT TO 1488 FEET OF PUNCHED TAPE
MAXIMUM FILES	26
INTERFACE	SERIAL, ASYNCHRONOUS, RS232C LEVELS 8 BIT DATA 1 START BIT 2 STOP BITS
BAUD RATES	50, 75, 110, 135, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, 9600
PACKAGE	PORTABLE WITH CARRYING HANDLE 5-1/4" H x 10" W X 10-1/2" D
RECORDING FORMAT	160 BYTES/SECTOR NET 16 SECTORS/TRACK 35 TRACKS/SURFACE 2 SURFACES
RECORDING MEDIUM	5-1/4" FLOPPY DISKETTE, 16 SECTOR SUGART SA155 OR EQUIVALENT
HARD ERRORS	1 IN 100 BILLION BITS
SOFT ERRORS	HANDLED INTERNALLY AND LOGGED
COST	APPROXIMATELY \$2,000

Figure 5. Minifloppy Disk System Specifications

1*N#	DEFINE FILE
2*N#	SELECT FILE
3#	CLOSE FILE
4#	FREE BLOCKS
5#	DIRECTORY
13*N#	SET BAUD RATE
14*N#	SYNC MODE SELECT
73#	RESET
91#	FORMAT
92#	INITIALIZE DIRECTORY
96#	VERIFY DISKETTE
97#	COMPRESS DISKETTE
98*N#	DELETE FILE

Figure 6. Minifloppy Disk System File Management Commands

FUNCTION	READ ONLY PAPER TAPE READER EMULATION
CAPACITY	178,560 BYTES NET OR 1488 FT. OF PAPER TAPE
INTERFACE - INPUTS	TAPE FORWARD COMMAND (TFC) LEVEL OR EDGE TRIGGERED
OUTPUTS	8 BIT PARALLEL DATA SYNCHRONOUS TO TFC SPROCKET CLOCK TAPE/READY TAPE FORWARD ACKNOWLEDGE
SIGNAL LEVELS	INTERNALLY OR EXTERNALLY SOURCED 0V/5V, 0V/6V, 0V/12V
LOGIC STATE	SELECTABLE FOR EACH INPUT AND OUTPUT
TRANSFER RATE	60 CPS TO 1000 CPS
FORMAT	160 BYTES/SECTOR NET 16 SECTORS/TRACK 35 TRACKS/SURFACE 2 SURFACES
MEDIA	5-1/4" FLOPPY DISKETTE, 16 SECTOR SUGART SA155 OR EQUIVALENT
HARD ERRORS	1 IN 100 BILLION BITS
SOFT ERRORS	HANDLED INTERNALLY AND LOGGED

Figure 7. Read-only Punched Emulator Specifications

2*N#	SELECT FILE (RUN-FILE-N-ENTER)
3#	CLOSE FILE
4#	FREE BLOCKS
5#	DIRECTORY
12#	DISPLAY ERROR COUNT
73#	RESET
96#	VERIFY DISKETTE

Figure 8. Emulator File Management Commands

APPENDIX A--NC MACHINE TOOLS CONVERTED TO MINIFLOPPY DISK SYSTEM

The following figures show NC machine tools that have been converted to minifloppy disk systems.

Figure A-1. Keary & Trecker Model 180 Milling Machine with
a K & T Modified DEC PDP-8A Computer

Figure A-2. Kearny & Trecker Model Eb Milling Machine with GE Model 7500 Control

Figure A-3. Monarch Lathe with GE Model 100 Control

Figure A-4. Monarch Lathe Series 10 with GE 550 TX Control

Figure A-5. Cincinnati Three-axis Milling Machine (not shown) with GE Model 100 Control

Figure A-6. Control for Gerber Photoplotter Model 2000
with Honeywell Computer

Figure A-7. DAC Drilling and Routing Machine

APPENDIX B--WIRING DIAGRAM OF DATA INPUT CIRCUITRY FOR
EACH NC MACHINE TOOL

The following figures are wiring diagrams of the data input circuitry for each NC machine tool.

Figure B-1. Wiring Diagram for Data Input to K and T Model 180 CNC Milling Machine

Figure B-2. Wiring Diagram for Data Input to K and T Model EB Milling Machine

Figure B-3. Wiring Diagram for Data Input to GE Model 100 Monarch Lathe

Figure B-4. Wiring Diagram for Data Input to GE Model 550 TX Monarch Series 10 Lathe

Figure B-5. Wiring Diagram for Data Input to GE Model 100 Cincinnati Three-axis Milling Machine

Figure B-6. Wiring Diagram for Data Input to Gerber Photoplotter Model 2000

Figure B-7. Wiring Diagram for Data Input to DAC Drilling Machine

APPENDIX C--FILE MANAGEMENT COMMANDS

This appendix contains explanations of the file management commands, system status information, switch selectable options, and information on the tape emulator.

File Management Commands

1*N# DEFINE FILE

This command is for creating a file and enables writing on the diskette beginning at the first available sector. The entry N is a one or two-digit number (1 - 99) that is entered into the directory. Future access to the file is identified by that number. Data transmitted to the minifile are recorded in blocks of 160 bytes. The Close File command, which terminates this operation, causes any partial blocks to be recorded, and a final entry is made in the directory.

2*N# SELECT FILE

This command selects for reading the file N that was previously generated by a Define File command. The directory is searched for the entry N and the beginning of that file is obtained. The data recorded in that file are transmitted to the host or receiving device until the end of the file is detected or a Close File command is entered.

3# CLOSE FILE

The Close File command is entered by the operator to mark the completion of a Define File or Select File operation. In most applications, it is only necessary when all the data for a given file are transmitted to the minifile. Select file operations automatically close the file when the end of the file is detected.

5# DIRECTORY

The Directory command displays the file ID numbers recorded in the directory beginning with the first entry. Depressing the # key causes successive entries in the directory to be displayed.

6# ENABLE DC2/DC4 DETECTION

This command is provided with the (-SP5) firmware option. When enabled, the minifile begins recording data following the first DC2 character and stops recording when DC4 is detected.

7# DISABLE DC2/DC4 DETECTION

This command is provided with the (-SP5) firmware option and disables the DC2/DC4 detection mechanism earlier described.

12# DISPLAY ERROR COUNT

This command displays a number maintained by the minifile firmware that is an accumulation of errors detected when reading or writing on a diskette. This command is provided to enable the operator to note marginal or deteriorating diskettes before they become unusable. The error count is initialized to zero when power is applied or when the Reset command is entered.

13*N# SET BAUD RATE

The Set BAUD Rate command provides a convenient method of changing the BAUD rate at the RS232C interface; thus overriding the switch settings that are only accessible by removing the cover. Entering a Reset command will set the BAUD rate back to that of the switch settings.

14*N# SYNC MODE SELECT

This command specifies a mode for synchronizing data transmitted by the minifile to the receiving device. It is useful in that in many applications the receiving device will be unable to maintain the full rate of transfer. The modes specified by parameter N are as follows:

- 0 - No synchronization. This is the default mode when power is applied or when a Reset command is entered.
- 1 - Character sync mode. The minifile transmits one byte for each byte received from the host device. The value sent by the host has no significance.
- 2 - X-ON/X-OFF. The minifile transmits data until X-OFF character is received from the host device. Data transmission is resumed when X-ON character is received.

73# RESET

The Reset command causes the minifile to reinitialize in the same manner as if power is applied. Any data in a write file that was not closed by the Close File command is lost.

91# FORMAT

This command is required when a diskette is placed into service for the first time. The Format command writes all blocks, initializes the directory, and verifies the diskette.

92# INITIALIZE DIRECTORY

The Initialize Directory command deletes all files from the diskette.

96# VERIFY DISKETTE

The Verify Diskette command performs a read check on all the blocks on the diskette. Failures are reported on the front panel numeric display.

97# COMPRESS DISKETTE

The minifile system uses a file structure in which all the blocks on a diskette are allocated sequentially. The deletion of a file creates an unavailable area on the diskette unless the deleted file happened to be the last file defined. This command repacks the files and reclaims any space on the diskette that was unavailable due to the file deletion. The execution time is dependent on the number of deleted files, their sizes, and relative positions. In most cases, this time will not exceed three minutes.

4# DISPLAY FREE BLOCKS

The Display Free Blocks command displays the available space on the diskette.

System Status Information

System status is presented in the form of a numeric code on the front panel three-digit display. This code is identified as status by the STATUS indicator and pertains to improper operating procedures or some form of condition or malfunction detected by the minifile.

Listed below are the status codes presented by the minifile and a description for each of the codes.

002	FILE ALREADY EXISTS	An attempt was made to define a file with a ID number that is currently defined in the directory.
003	FILE DOES NOT EXIST	The file selected for reading or deletion cannot be found in the directory.
004	ILLEGAL COMMAND	The command issued is not recognized by the minifile.
005	DISKETTE FULL	The diskette does not have room for the data transmitted or the directory has no room for an additional entry.
006	END OF FILE	The minifile transmitted all the data in the selected file.

007	INITIALIZE ERROR	Data errors were encountered during Initialize or Format operation. The minifile makes 16 attempts to recover prior to reporting this error.
008	FILE ALREADY OPEN	An attempt was made to define or select a file with one currently defined or selected, respectively. The Close File command must be issued to avoid this condition.
009	COMMUNICATION ERROR	This error is a signal to indicate some error condition was detected during communication with the host device. The error condition can sometimes be attributed to improper BAUD rate or STOP bit selection.
100	DIRECTORY READ ERROR	The minifile was unable to read the directory without an error. This usually indicates an unformatted diskette.
101	BLOCK CHECK ERROR	A block on the diskette could not be read without error within 16 attempts.
103	SEEK ERROR	The minifile was unable to verify the track position on the diskette before reading or writing a block of data.
104	DISK TIME OUT	This error indicates a disk I/O operation did not complete within two seconds. It is normally as a result of initiating a command without a diskette in the drive.
105	WRITE PROTECT VIOLATION	The diskette in the disk drive is write protected and the minifile attempted to write on it.

Switch Selectable Options

The FDS-100 Minifile offers a variety of switch selectable options that are set in accordance with the desired mode of operation. These options pertain to BAUD rate, number of STOP bits, hardware synchronization, and selection of features provided for some custom applications. By removing the top cover from the minifile, two eight-position DIP switches are exposed

(D1 and D2). These switches are mounted on the serial interface card inserted at the top of the unit. The switch closest to the circuit card edge is D2.

Two switches allow a selection of features desirable in some applications. They are somewhat related and described below.

SWITCH D2-7: when this switch is open the minifile will not send data until requested by a false to true transition of the Data Terminal Ready signal at the RS232C interface (Table A-1). This option allows the host device to strobe the data from the minifile. Switch D2-8 must be closed when this option is selected.

SWITCH D2-8: when this switch is closed, the minifile ignores the state of the input signals Data Terminal Ready and Request to Send at the RS232C interface. When this switch is open, switch D2-7 must be closed and Data Terminal Ready and Request to Send must be true for the minifile to accept data from the host device.

Tape Emulator

This section is devoted to the FDS-100 Paper Tape Emulator, herein referred to as the tape emulator. The user should review this section carefully before attempting to interface the tape emulator with other equipment.

The tape emulator is an offspring of the FDS-100 Minifile used to record and retrieve data via an RS232C serial interface. Data are maintained by a file management technique common to the minifile and the tape emulator. The operator gains entry to the file management system via a front panel keyboard. Commands available to the tape emulator are a subset of those in the minifile. Primarily, only those commands that pertain to read functions are recognized.

The interface is eight-bit parallel data and provides the signals necessary to emulate paper tape readers. A number of switch and strap selectable options on the interface card are provided to alter the signals levels, polarity, and timing.

Operation

The tape emulator is operated in the same manner as the minifile. Commands are entered by the operator via the front panel keyboard. Operational status is provided by a three-digit numeric display. The following are the commands and numerical status codes offered by the tape emulator.

TABLE A-1

RS232C INTERFACE CONNECTOR (DB25S) PIN ASSIGNMENTS

PIN	SIGNAL	DIRECTION	COMMENT
1	PROTECTIVE GROUND		DC COMMON
2	TRANSMIT DATA	INPUT	
3	RECEIVE DATA	OUTPUT	
4	REQUEST TO SEND	INPUT	MUST BE TRUE *
5	CLEAR TO SEND	OUTPUT	TRUE WHEN FILE OPEN
6	DATA SET READY	OUTPUT	TRUE WHEN FILE OPEN
7	SIGNAL GROUND		DC COMMON
8	DATA CARRIER DETECT	OUTPUT	ALWAYS TRUE
20	DATA TERMINAL READY	INPUT	MUST BE TRUE *

* SIGNAL IS IGNORED WHEN SWITCH POSITION D2-8 IS CLOSED

Entry Sequence	Command
2*N#	SELECT FILE
3#	CLOSE FILE
4#	DISPLAY FREE BLOCKS
5#	DIRECTORY
12#	DISPLAY ERROR COUNT
73#	RESET
96#	VERIFY DISKETTE

Status Code	Meaning
003	FILE DOES NOT EXIST
004	ILLEGAL COMMAND
006	END OF FILE
008	FILE ALREADY OPEN
009	COMMUNICATION ERROR
100	DIRECTORY READ ERROR
101	BLOCK CHECK ERROR
103	SEEK ERROR
104	DISK TIME OUT

Parallel Interface

The parallel interface is eight-bit parallel data with handshaking signals to synchronize communication with the host machine. Input and output signals are programmable for signal voltage level, active stage, and timing. Table A-2 shows the programmable features at the interface card. For the purpose of simplifying the interface description, the active status are assumed 0 volts. Timing relationships are proportional to the character rate which is an adjustable feature on the interface card.

Table A-3 shows the connector assignments for each of the input and output signals. The following is a description for each of the signals shown at the interface connector.

TABLE A-2

PROGRAMMABLE FEATURES AT THE INTERFACE CARD

S1 SWITCH	OPEN / OFF	CLOSED / ON
S1-1	HIGH SPEED TRANSFER 200 - 500 CPS	LOW SPEED TRANSFER Less than 200 CPS
S1-2	DATA +	DATA -
S1-3	OUTPUT DATA REGISTER REMAINS VALID FOR THE DURATION OF THE READ CYCLE.	OUTPUT DATA REGISTER IS CLEARED AT THE END OF THE READ CYCLE (SEE READ TIMING DIAGRAMS). USED WITH NEGATIVE TRUE LOGIC ONLY.
S1-4	TFC - (input signal)	TFC + (input signal)
S1-5	SPARE	SPARE
S1-6	TFA +	TFA -
S1-7	RDY + / TAPE LOW -	RDY - / TAPE LOW +
S1-8	SPARE	SPARE

JUMPER SELECTION	DESCRIPTION
E1 - E2	SPRK -
E1 - E3	SPRK +
E4 - E5	TFC LEVEL TRIGGER (SLEW MODE)
E4 - E6	TFC EDGE TRIGGER (STEP MODE / SINGLE CHARACTER
E9 - E8	TAPE LOW ON PIN 15 OF I/O CONNECTOR
E7 - E9	READY ON PIN 15 OF I/O CONNECTOR
E10- E11	SIGNAL LEVELS 0 - 12V
E10- E12	SIGNAL LEVELS DERIVED FROM SIGNAL SOURCE VOLTAGE
E10- E13	SIGNAL LEVELS 0 - 5V

TABLE A-3
READER INTERFACE I/O CONNECTOR

PIN	SIGNAL	MNEMONIC
1	GND	
14	TAPE FORWARD COMMAND	TFC
2	GND	
15	TAPE LOW / READY	RDY
3	GND	
16	CHANNEL 1	TBIT 1
4	GND	
17	CHANNEL 2	TBIT 2
5	GND	
18	CHANNEL 3	TBIT 3
6	GND	
19	CHANNEL 4	TBIT 4
7	GND	
20	CHANNEL 5	TBIT 5
8	GND	
21	CHANNEL 6	TBIT 6
9	GND	
22	CHANNEL 7	TBIT 7
10	GND	
23	CHANNEL 8	TBIT 8
11	GND	
24	SPROCKET CLOCK	SPRK
12	GND	
25	SIGNAL SOURCE VOLTAGE	+5VDC - +12VDC
13	TAPE FORWARD ACKN	TFA

TFC	TAPE FORWARD COMMAND. The tape forward command is generated by the host machine and causes the tape emulator to advance characters (i.e., step forward). The TFC input is strap selectable on the parallel interface card for either step mode or slew mode operation. In the step mode of operation, the tape emulator advances on character for each leading edge transistion of the TFC signal. In the slew mode of operation, the tape emulator advances one or more characters depending on the duration TFC is held active.
TFA	TAPE FORWARD ACKNOWLEDGE. Tape forward acknowledge is transmitted in response to TFC. It is not always required to use this signal for proper operation of the interface. It is provided for some controllers or host devices that utilize this signal to cause a release of TFC.
RDY	READY/TAPE LOW. This signal is strap selectable to one of two meanings. If strapped as a READY signal, it provides to the host device the indication the tape emulator is in a read or step forward cycle. It is not required to utilize this signal providing the timing requirements are met. If strapped as a tape low indicator, this signal will remain active until a file is selected by the operator.
TBIT 1-8	TRANSMIT BITS/CHANNELS 1-8. These outputs are the eight data bits as would be provided by a paper tape reader. One switch selectable option is available with 0-volt TRUE convention. With the S1-3 switch position closed, the outputs are forced to logic zero at the end of a given step forward cycle, thus simulating the GAP between characters on paper tape.
SPRK	SPROCKET CLOCK. The sprocket clock is provided for the host machine to strobe the eight bits of data to its internal register. The leading and trailing edge of SPRK are valid.
+5VDC to +12VDC	SIGNAL SOURCE VOLTAGE. This input allows the signal levels to be defined at the interface. This is especially valuable when the logic levels needed are something other than 0-5 or 0-12 volts.

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