DIGITAL EQUIPMENT CORPORATION

MAYNARD, MASSACHUSETTS

ENGINEERING SPECIFICATION

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TITLE TU58 ENGINEERING SPECIFICATION

REVISIONS

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A	UPDATE			Aug 1,78	M Fen	Aug 1,78

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R. Rose / M. Leis	M Fen Aug 1, 1978	A	SP	TU58-0-0	A

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1.0 GENERAL DESCRIPTION

The TU58 is a low cost mass memory device using the 3M DC-100A cartridge. The cartridge is preformatted to store 2048 records each containing 128 bytes. The controller provides random access to any record. The average search time to any record is ten (10) seconds. All data transfers between the TU58 and the host are in 512-byte blocks. The TU58 manipulates four 128-byte records to accomplish this. The control and read/write electronics will support two drives, but only one drive can operate at a time. Two controller modules are available. One has a parallel interface for use inside a terminal. The other is designed for use with an asynchronous serial interface. Baud rates for the serial interface are jumper selectable from 150 baud up to 38.4K baud.

The TU58 consists of one or two cartridge drives and a module containing read/write circuits, motor speed, control, and a firmware programmed control module. Power may be provided by an external power supply or from an existing power supply in devices with which it is integrated.

The TU58 may be maintained in the field by sub unit swaps. The sub units are:

TU58-XA	Drive and Cable
TU58-XB	Serial Controller Module
TU58-XC	Parallel Controller Module

1.1 OPERATION

1.1.1 FEATURES

The TU58 uses cartridges that have been factory preformatted to have 2048 headers to identify each record number. The TU58 searches at 60 IPS to find the file requested then reads the file at 30 IPS. Data read from the tape are verified via check sums at the end of each record or header. Data are recorded on two tracks and both tracks are recorded in the forward direction.

1.1.2 INTERFACE OPERATION

1.1.2.1 PARALLEL INTERFACE

The Parallel Interface is used in terminals where the interconnect distance is one foot or less. It permits the TU58 to be wired directly to the terminal processor bus. The terminal processor controls data transfers between itself and the TU58 via the series of commands defined for the serial radial bus protocol. Each byte is processed by interrupt service routines.

1.1.2.2 SERIAL INTERFACE

The Serial Interface is an RX-232, RS-422 and RS-423 compatible asynchronous full duplex serial line which permits operation of the TU58 through DL-11, DLV-11 or M8650 interface modules. Control commands are distinguished from binary data via the serial radial bus protocol. Transmit and receive baud rates may be different. The appropriate interface standard and baud rates are selected by jumpers on the module. Table 1.1 shows the baud rates obtainable and the resulting average data transfer rate.

TABLE 1.1

BAUD RATES AVAILABLE	AVERAGE DATA TRANSFER RATE (BYTES/SEC.)
38.4K BAUD	1280
19.2K BAUD	750
9600 BAUD	520
4800 BAUD	330
2400 BAUD	190
1200 BAUD	100
600 BAUD	50
300 BAUD	25
150 BAUD	12.5

1.1.3 POWER

The TU58 requires the following power inputs:

+5V ±5% @ .75A

+12V -5% @1.2A peak (60ms)
+10% .6A average running
.1A idle

1.2 CONFIGURATION

See Figure 1 for configuration with the parallel interface and Figure 2 for configuration with the serial interface.

Component Designations

TU58-XA Drive and Cable
TU58-XB Serial Controller Module 5413489
TU58-XC Parallel Controller Module 5413491
DL-11-D Serial Interface Module
DLV-11-J Serial Interface Module
M8650 Serial Interface Module
DLV-11 Serial Interface Module

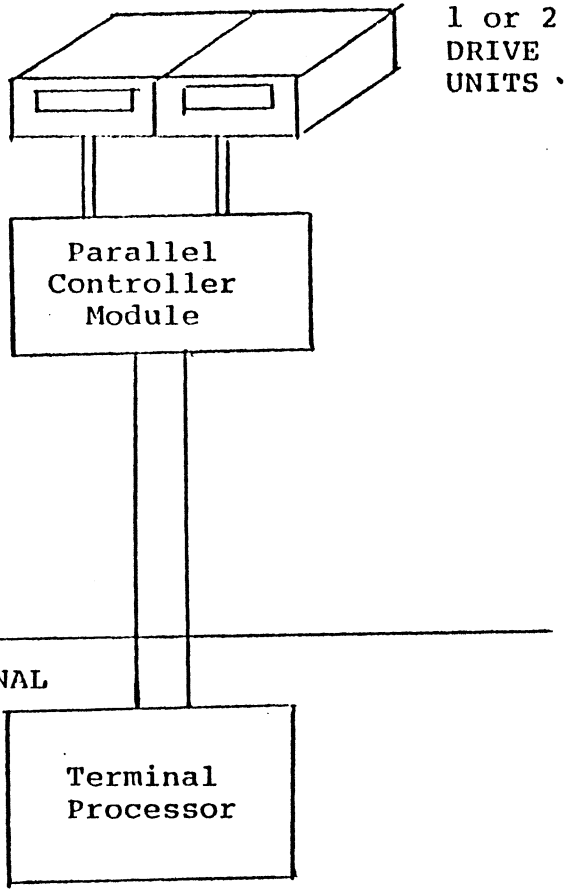


Figure 1

TU58 Configuration with

Parallel Interface

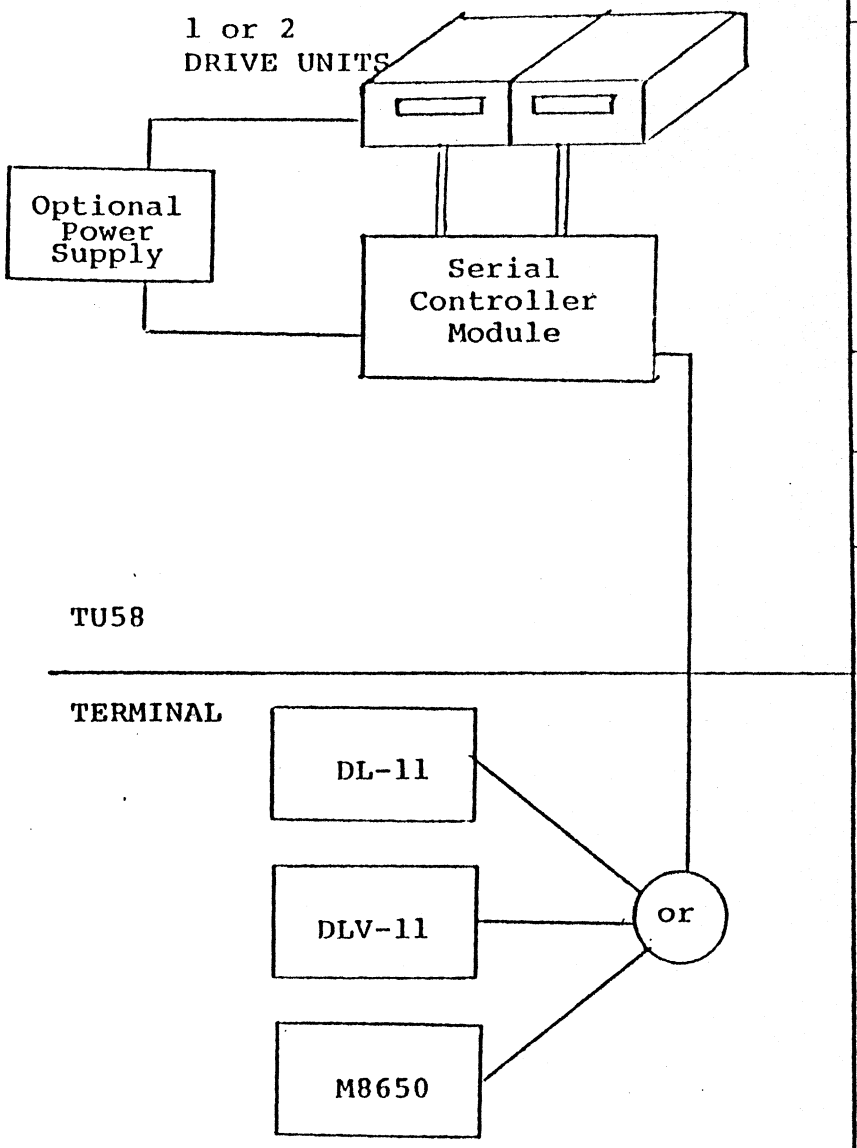


Figure 2

TU58 Configuration with Serial

Interface

1.2.1 MECHANICAL CONFIGURATION

The unit may be configured with one or two drives. The module is mounted under the drives. This package may be integrated as is into a terminal or host processor, or it may be mounted in a box with power supply as a stand-alone or rack mount unit.

1.2.2 OPTIONS AND INDICATORS

An LED may be added to each drive at time of manufacture to indicate tape in motion. The unit may have either a parallel or serial interface. The cartridges may be removed at any time but if a cartridge is removed during a read or write operation, an error will be indicated to a host processor. A switch may be added to initiate boot.

1.2.3 SUBSYSTEM DESIGNATION PLAN

The TU58 is available in the following configurations with accompanying designations.

Components

TU58-AA Parallel interface controller module, surface mounting, with one drive.

TU58-AB Serial interface controller module, surface mounting, with one drive.

TU58-BA Parallel interface controller module, surface mounting, with two drives.

TU58-BB Serial interface controller module, surface mounting, with two drives.

Subsystems

TU58-CA Rackmount, two drives, serial interface controller module, power supply 110/220 volts switch-selectable, detachable line cords and fuses for both voltages, two cartridges.

Additional Supplies

BC20M-5 Interface cable TU58 to DLV-11J, 5 feet

BC20M-50 Interface cable TU58 to DLV-11J, 50 feet

Preformatted data cartridges, DEC #TU58K

1.3 INTERCHANGE COMPATIBILITY

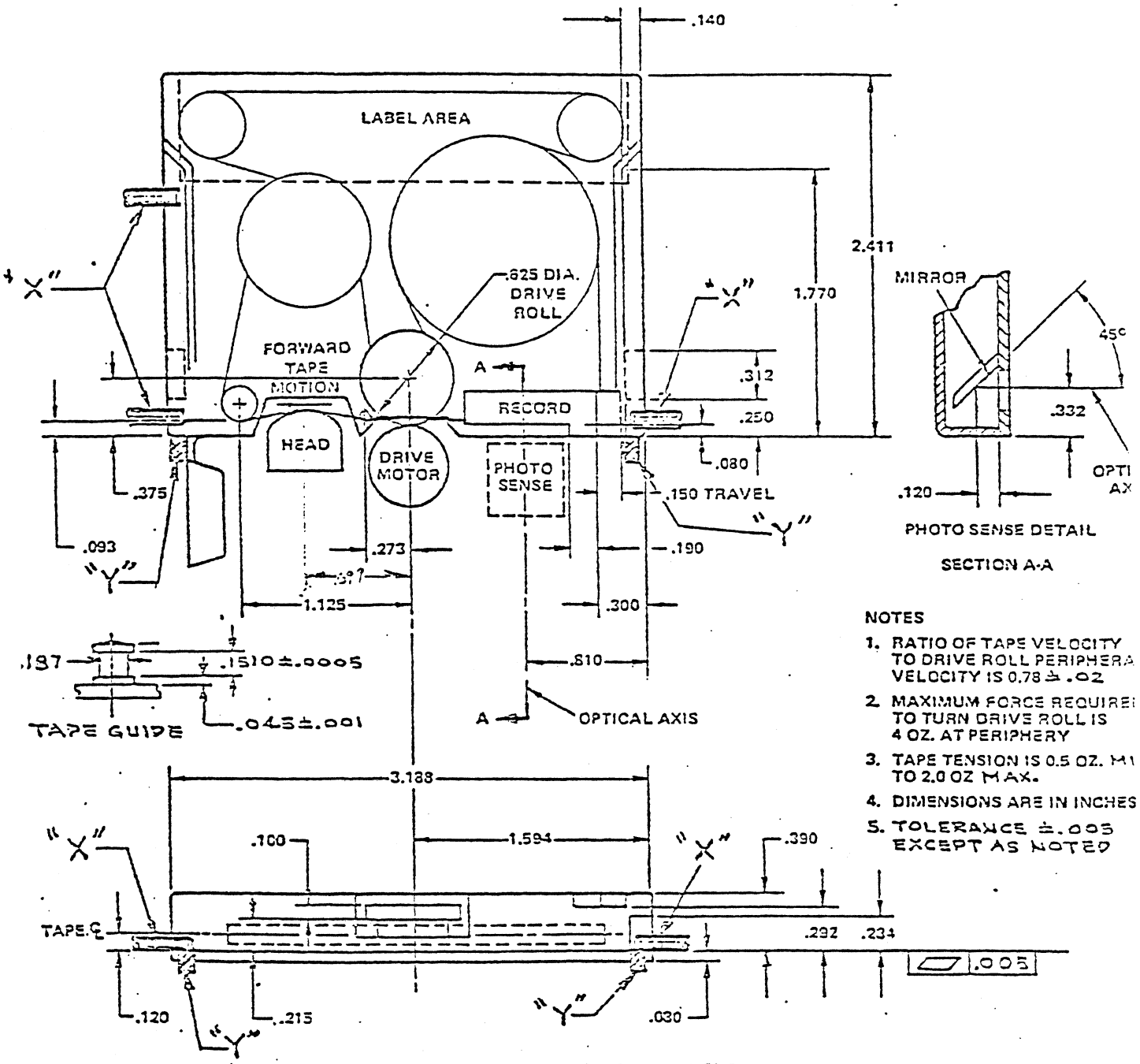
This section describes the medium, logical format and structure of headers and data.

1.3.1 MEDIUM

The 3M DC-100A was designed as a second generation version of the DC-300 data cartridge unit. It contains 140 feet of 0.15 inch tape in a package measuring 2.4 X 3.2 X 0.5 inches. The outline drawing of the cartridge is shown in Figure 3.

1.3.2 RECORDING SCHEME

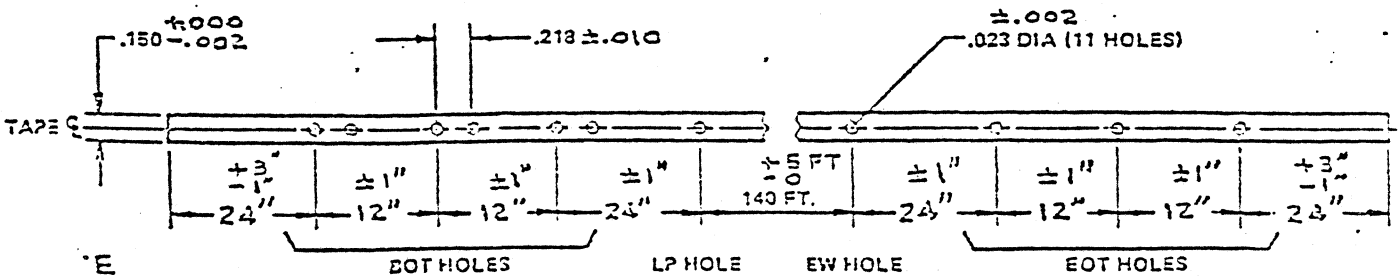
The data are recorded with ratio encoding using a 1/3 duty cycle pulse for zeros and a 2/3 duty cycle pulse for ones. The recording density is 800 bits per inch. Each bit requires three flux reversal positions although only two will actually contain flux reversals. The density is, therefore, 2400 flux reversals per inch. The record head current wave forms are shown in Figure 4.



NOTES

1. RATIO OF TAPE VELOCITY TO DRIVE ROLL PERIPHERA VELOCITY IS 0.78 ± .02
2. MAXIMUM FORCE REQUIRE TO TURN DRIVE ROLL IS 4 OZ. AT PERIPHERY
3. TAPE TENSION IS 0.5 OZ. MI TO 2.0 OZ MAX.
4. DIMENSIONS ARE IN INCHES
5. TOLERANCE ±.005 EXCEPT AS NOTED

MAGNETIC TAPE DIMENSIONS



"E" INDICATES CARTRIDGE PLANE LOCATERS
"D" INDICATES CARTRIDGE STOPS

"SCOTCH" IS A REGISTERED TRADEMARK OF 3M COMPA

REVISED

FIGURE 3

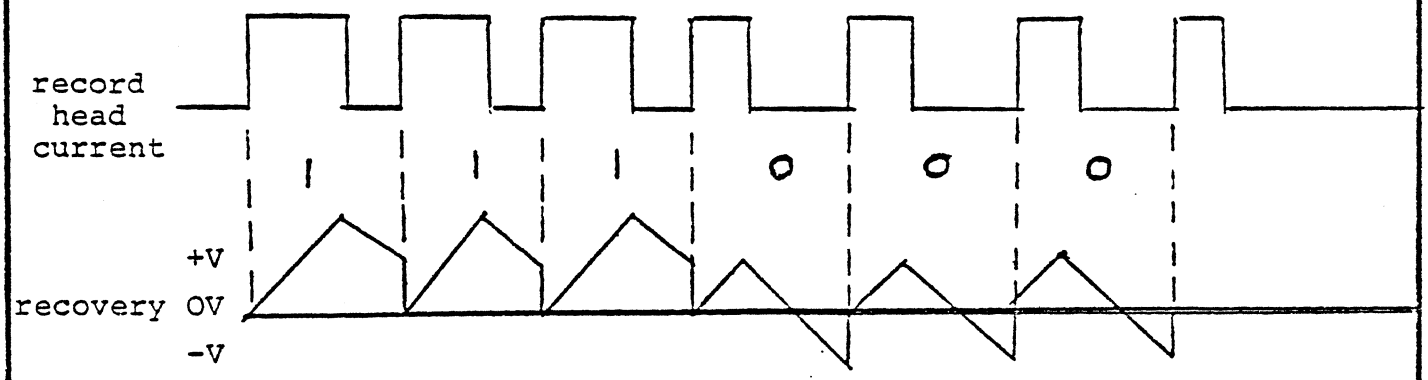


Figure 4

Data are recovered using an integrater as shown in Figure 4. The integrater is dumped on the positive edge of the data waveform. The data waveform is then integrated. The integrater output is sampled on the next positive edge. If the integrater output is positive at sample time, the recorded bit was a one. If the integrater was negative at sample time, the bit was a zero. The time between bits is 1/(800 bits per inch) (30 ips) = 41.7 μs.

1.3.3 LOGICAL FORMAT

Data are recorded on two tracks. Each track contains 1024 records of 128 bytes. To accommodate the orientation of the record and erase head gaps, both tracks are recorded in the same direction. The positioning of the tracks is shown in Figure 5. To accommodate standard mass storage blocks of 512 bytes, the controller groups four 128 byte records together. All addressing from the host is done by block numbers.

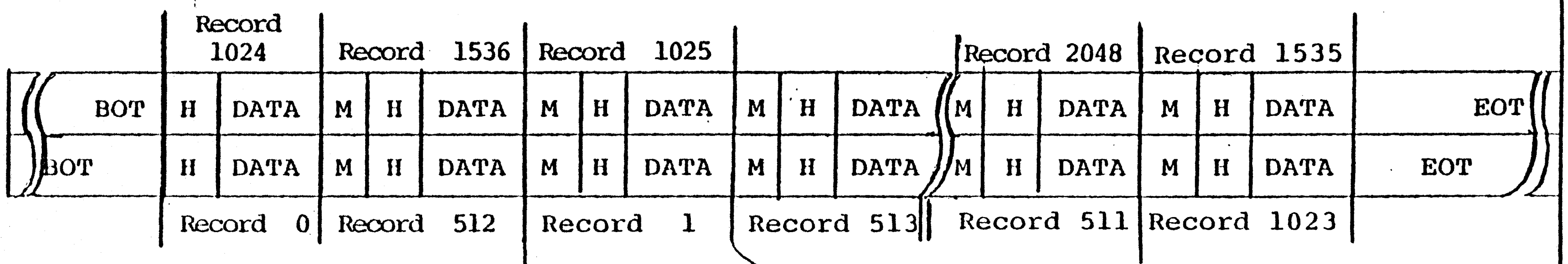


FIGURE 6A TAPE FORMAT

M = Interrecord Mark

H = Header

No mark for records 0, 1024

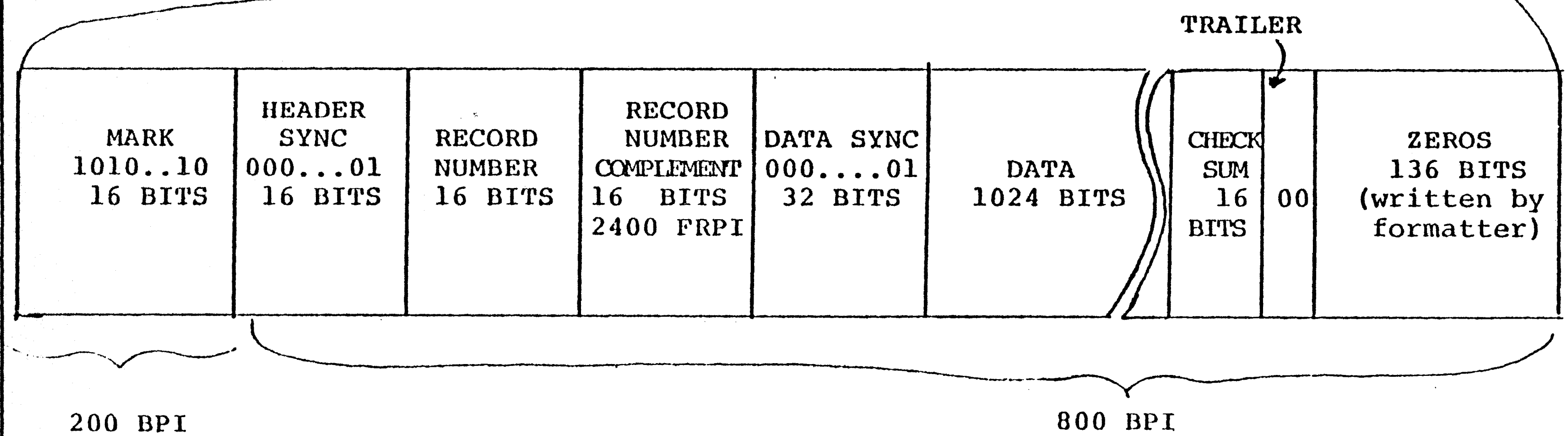


FIGURE 6B RECORD AND HEADER FORMAT

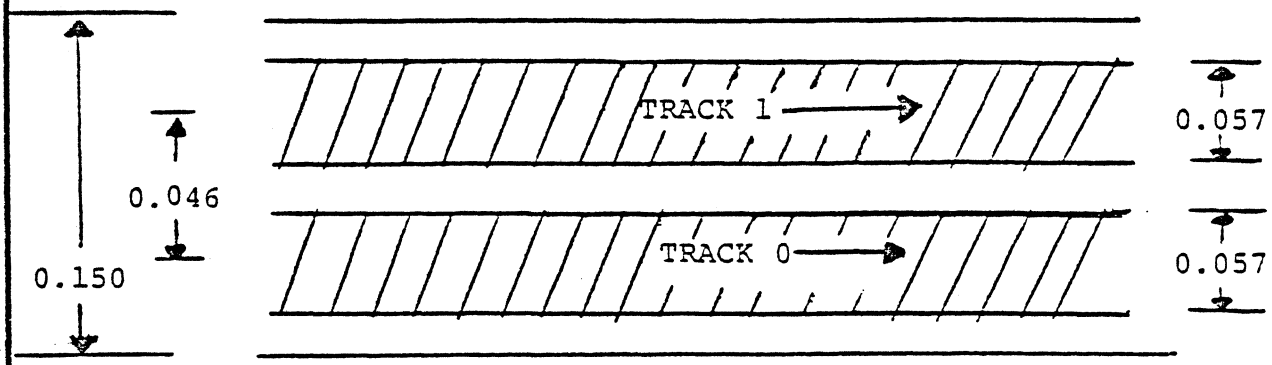


Figure 5

1.3.3.1 BOT, EOT, AND INTER RECORD MARKS

Special marks are recorded during tape formatting to indicate beginning and end of tape as well as beginning of record. These marks are recorded at one fourth the bit density of data (600 FRPI). The lower frequency is detected by the controller. The encoding method used is not sensitive to tape speed, so that ones and zeros may be recovered at the lower frequency with no change in hardware. The BOT, EOT, and IRM (Inter Record Marks) are distinguished from one another as follows:

A. BOT is recorded as all zeros.
B. EOT is recorded as all ones.
C. IRM's are recorded as alternate ones and zeros.

1.3.3.2 HEADER DESCRIPTION

The header and data fields are shown in Figure 6. The header contains the following components:

A. Inter Record Marks - Sixteen bits recorded at 200 BPI and having a data pattern of 1010101010101010. During search, the controller finds records by starting from a known position and counting the inter record marks as they go by at 60 IPS. When it reaches the record before the record being searched for, it slows the tape down to 30 IPS and reads the next header. If the header number read agrees with the header

number expected, the controller continues with the read or write operation. Otherwise, it corrects the current position and initiates a new search.

B. Pre-Amble - (All of the following bits are recorded at 800 BPI.) It consists of 15 zeros followed by a one. The controller looks for the one and then begins to accept the record number.

C. Record Number - 16 bits (0 to 2041)

D. Record Number Complement - The controller tests this number to insure that the header was read with no errors.

E. Trailer - 31 zeros and a one. During a write operation, the controller reads the first four zeros then switches to write mode and writes the remaining zeros and one. The glitches caused by switching on the write current are then confined to a narrow space which the controller blanks out during read operations. After a fixed duration blank (controller ignores tape output) the controller begins to search for the one at the end of the trailer. When it finds the one it begins reading the data field.

1.3.4 DATA FIELD DESCRIPTION

The data field is shown in Figure 6 and consists of the following components:

A. Data field - the next 1024 bits of data are stored in the data buffer in the controller.

B. Checksum - The checksum contains 16 bits and is used to find errors in the read data. During read, each pair of bytes is summed in a 16 bit add. The remainder is added to the checksum and the result should be zero. If the result is not zero, the record is re-read up to eight tries. If the correct data cannot be read after eight tries, a hard error is indicated to the host processor.

C. Trailer - This field is two zeros and is used to prevent noise from influencing the last bit of data.

D. Post record zeros - When the tape is formatted, an additional 136 zeros are written to allow for 10% tolerance in motor speed. These zeros are never rewritten or read in normal operation. Their purpose is only to provide flux reversals where gaps might be left from normal system operations.

1.3.5 RECORD USAGE

The TU58 controller will treat all records as data records. Any records may be used for directories, error logs, etc., but these functions must be accomplished via user software.

1.4 SYSTEM PERFORMANCE

1.4.1 WEAR

The TU58 read and write operations are performed by a contact process resulting in wear at the head/tape interface. The DC-100A cartridge maintains contact between the tape and record/play back head whenever the cartridge is inserted in the drive. This results in wear during search and rewind operations as well as read/write operations. The wear is, thus, a function of total tape motion and not just read/write tape motion.

1.4.2 SYSTEM RELIABILITY

Minimum number of tape passes beginning to end to beginning	
Search error rate**	1 in 10^4 searches
Soft data error rate**	1 in 10^7 bits read or written
Hard data error rate	1 in 10^9 bits read or written
MTBF System*	1000 hours at 100% duty cycle
MTTR System	Less than .5 hour, module swap

* With expected 10% usage, MTBF will be 10,000 hours.

** These errors will be recovered by the TU58 controller.

**Continued
Search errors and soft data errors are usually attributed to effects such as electrical noise, dust, or wear in the medium. If the error can be recovered in eight tries, it is a soft error. The errors that cannot be recovered after eight tries are hard errors. The host will be notified that retries occurred.

1.4.3 DRIVE PERFORMANCE

Capacity

per cartridge	262,144 bytes (2048 records X 128bytes)
per track	131,072 bytes
per record	128 bytes

Data Transfer Rate

read/write on tape	41.7 μsec/data bit
data buffer to interface	150 to 38.4K baud, jumper selected
parallel interface	30 μs per data byte, min.
average access time	9.3 sec.
maximum access time	28 sec.
read/write tape speed	30 ips
search tape speed	60 ips
bit density	800 bpi
flux reversal density	2400 frpi

1.4.4 ENVIRONMENTAL CHARACTERISTICS

The TU58 will meet DEC STD 102 for class A devices. When the TU58 is integrated in a host device such as a terminal, the maximum temperature rise above ambient inside the device must be restricted to 18°C.

(Performance limits under Class B to be defined.)

Temperature

TU58 operating 15°C (59°F) to 32°C (90°F) ambient
TU58 non-operating -30°F to 140°F (-34°C to 60°C)
Medium operating 0°C (32°F) to 50°C (122°F)
Max temperature gradient between system ambient and TU58 ambient 18°C (32.4°F)

Relative Humidity

TU58 operating
Maximum wet bulb 25°C (77°F)
Minimum dew point 2°C (36°F)
Relative humidity 20% to 80% RH
TU58 non-operating 5% to 98% RH } non-condensing
Medium non-operating 10% to 80% RH

Magnetic field

NOTE: It is recommended that if the recipient of a data cartridge knows or suspects that the cartridge has been exposed to either the maximum or minimum temperature extreme, the tape should be rewound one complete cycle before using.

EMI

1.4.5 ELECTRICAL

Power Requirements

Module and Drive

5V ± 5% @ .75A
12V - 5%, + 10% @ 1.2 A peak (60ms)
.6 A average running
.1 A idle

Rack Mount

110,220 VAC
50, 60 Hz
50 watts max.

Interface Levels

Parallel Interface - TTL levels

Serial Interface - In accordance with RS-422, or RS-423, jumper selectable. Compatible with RS-232-C when set for RS-423.

The serial interface operates on half-duplex, asynchronous four-wire lines at rates from 150 baud to 38.4 kilobaud. The transmit and receive rates may be independently set. Each 8-bit byte is transmitted with one start bit, one stop bit and no parity. The line driver and receiver may be set to operate in accordance with EIA RS-422 balanced or RS-423 unbalanced signal standards. When set to RS-423, the TU58 is compatible with devices complying with RS-232-C.

The TU58 is shipped prewired for operation at 38.4 kbaud transmit and receive on RS-423. The maximum wire length that may be used at that data rate in an electrically quiet environment like an office is approximately 27 meters (90 feet). The wire used with any installation should be no less than 23 AWG diameter.

Longer wire runs may be made if data rates are reduced. RS-422 is considerably more noise-immune than RS-423 and can be used over at least 1200 meters (4000 feet) at any TU58 data rate. The following chart, figure 4-10, derived from the EIA standards, illustrates the variations in distance needed by RS-423 for different data rates. For more information, consult the standards for RS-422 and RS-423 published by the Electronic Industries Association.

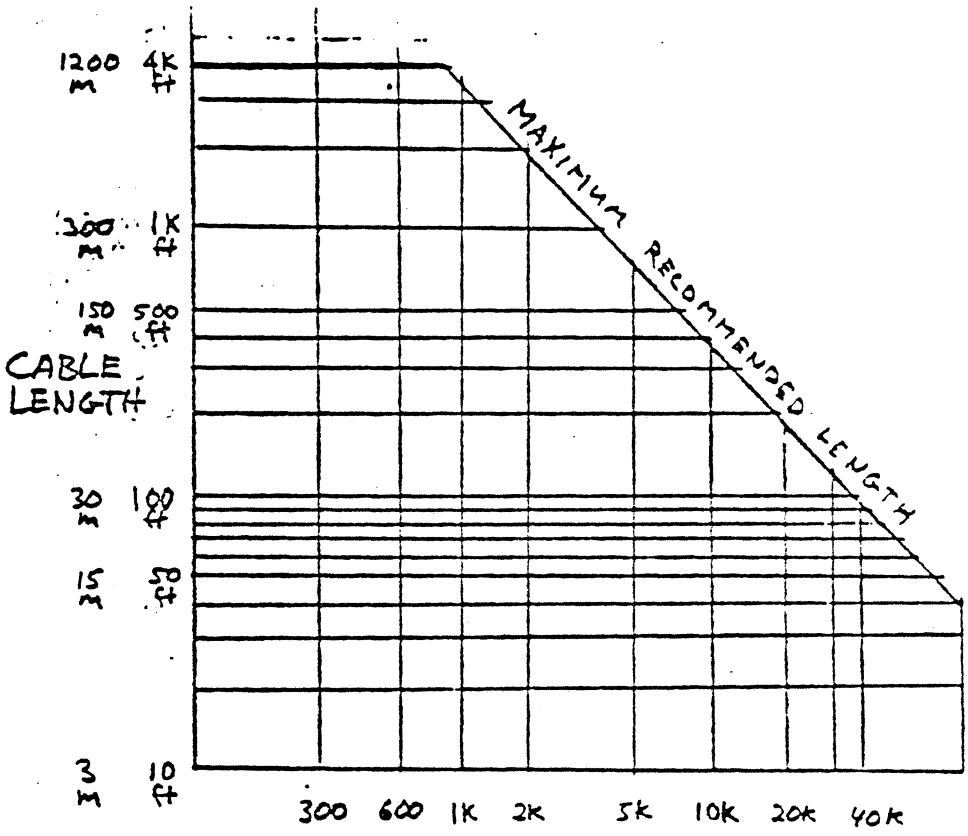


Figure Data Rate and Cable Length for RS-423

TU58 MODULE CONNECTIONS

WW1	150 Baud
WW2	300 Baud
WW3	600 Baud
WW4	1200 Baud
WW5	2400 Baud
WW6	4800 Baud
WW7	9600 Baud
WW8	19200 Baud
WW9	38400 Baud
WW10	UART Receive Clock
WW11	UART Transmit Clock
WW12	Auxiliary A (To interface connector pin L)
WW13	Auxiliary B (To interface connector pin A)
WW14	Factory Test Point
WW15	Ground } Connect together for auto-boot on power-up.
WW16	Boot }
WW17	RS-423 Driver
WW18	RS-423 Common (Ground)
WW19	Transmit Line +
WW20	Transmit Line -
WW21	RS-422 Driver +
WW22	RS-422 Driver -
WW23	Receiver Series Resistor
WW24	(Jump for RS-422)

Serial Interface Connector

J2-A	Auxiliary B	H	Transmit Line -
B	Ground	J	Transmit Line +
C	Receive Line +	K	Ground
D	Receive Line -	L	Auxiliary A
F	Ground		

Power Input Connector

J1-1	+12 volts
3	Ground
5	+5 volts
6	Ground

Drive Cable

J3,4-1	Cart L	9	LED
2	n/c	10	H Ground
3	Permit L	11	Erase Return
4	Signal Ground	12	Erase 1
5	Motor +	13	Erase Ø
6	Motor -	14	Head Return
7	+12 volts	15	Head Ø
8	Tach	16	Head 1

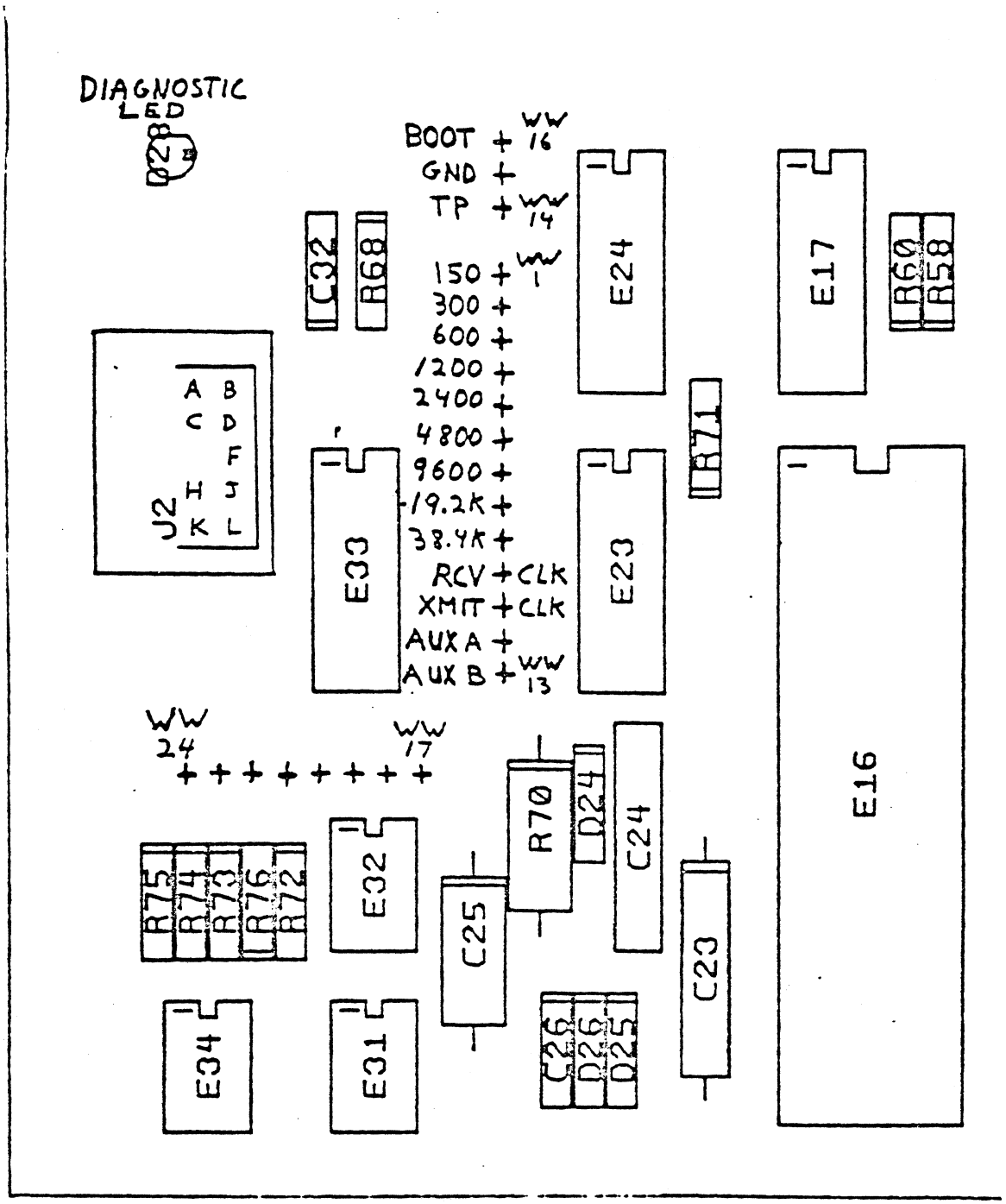


Figure Interface Selection Jumper Pin Locations.

Jumper Table

232 / 423	17-19
	18-20
422	21-19
	22-20
	23-24

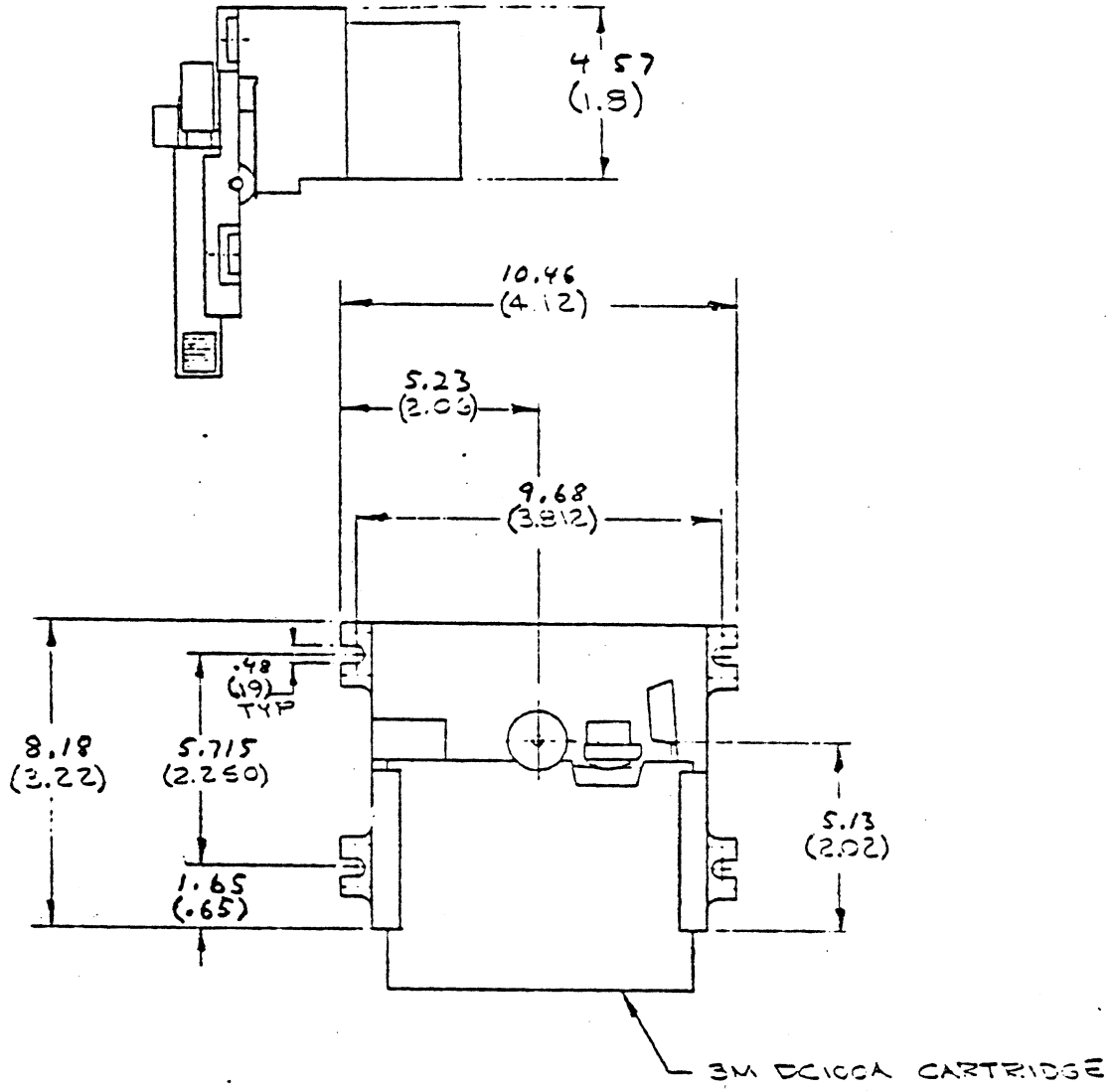
1.5 DIMENSIONS

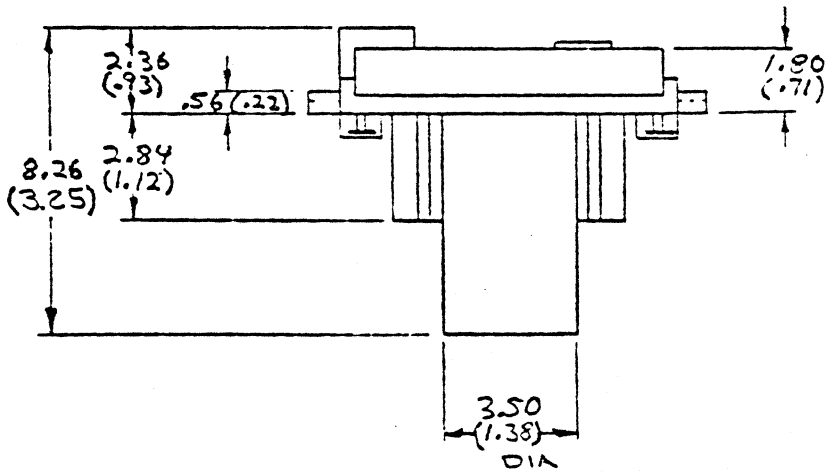
1.5.1 Controller Board 5.187 X 10.44 in.
13.2 X 26.5 cm.

1.5.2 Drive Module 3.2H X 3.3D X 4.1W in.
8.1 8.3 10.6 cm.

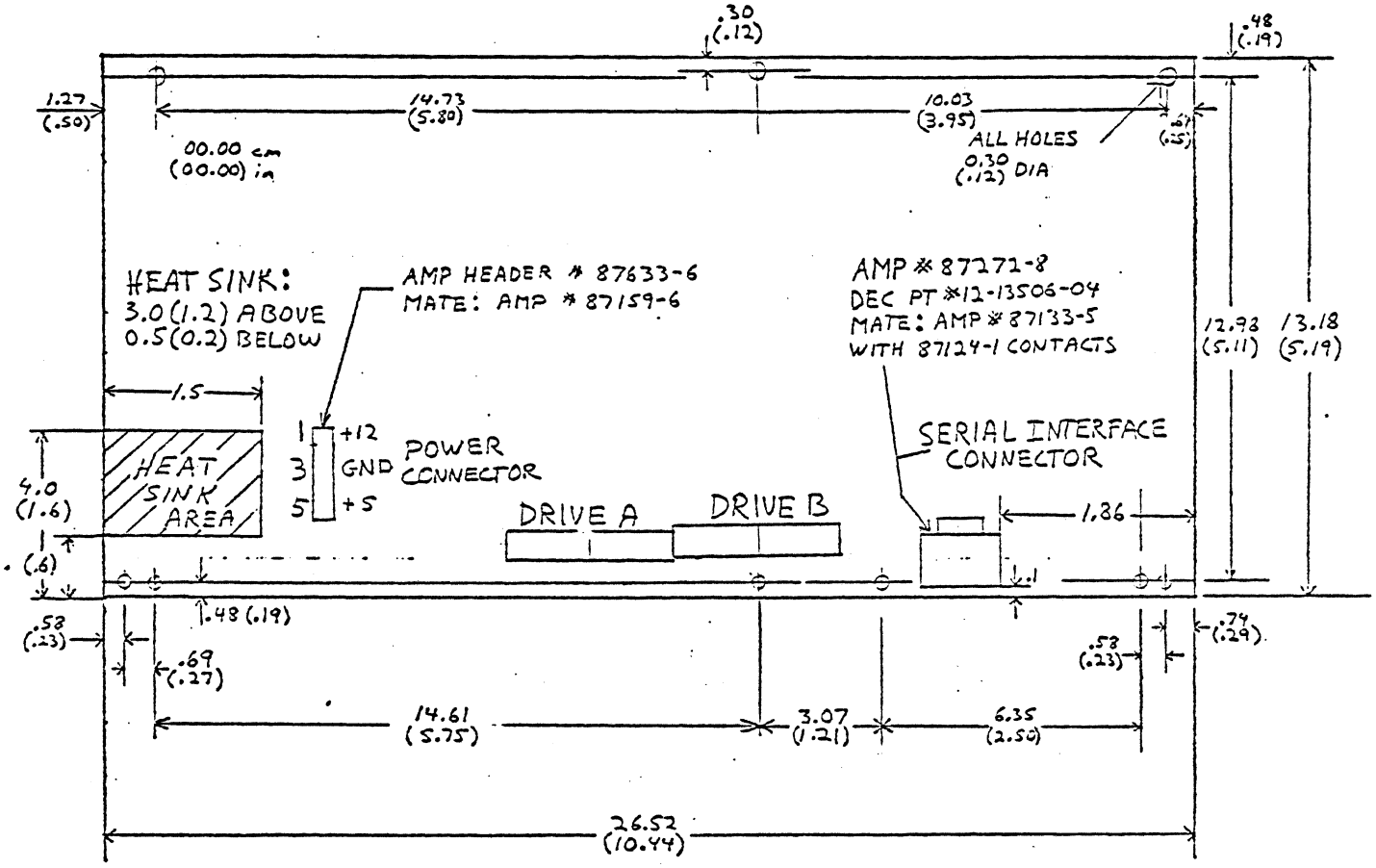
1.5.3 Cage 4.2H X 7.2D X 11.4W (including mounting tabs) in.
10.7 18.5 29.1 cm.

1.5.4 Rackmount Unit 5.2H X 13.6D X 19.0W in.
(mounts on 18.3" centers)
13.3cm X 34.9 X 48.7cm.


4.57
(1.8)
10.46
(4.12)
5.23
(2.06)
9.68
(3.812)
.48
(.19)
TYP
8.18
(3.22)
5.715
(2.250)
1.65
(.65)
5.13
(2.02)
3M DC1000 CARTRIDGE


2.36
(.93)
.56 (.22)
1.90
(.71)
8.26
(3.25)
2.84
(1.12)
3.50
(1.38)
DIA

0.00 cm
(0.00) in


.30 (.12)
.48 (.19)
1.27 (.50)
14.73 (5.80)
10.03 (3.95)
.51 (.15)
00.00 cm (00.00) in
ALL HOLES 0.30 (.12) DIA
HEAT SINK:
3.0 (1.2) ABOVE
0.5 (0.2) BELOW
AMP HEADER # 87633-6
MATE: AMP # 87159-6
AMP # 87271-8
DEC PT # 12-13506-04
MATE: AMP # 87133-5
WITH 87124-1 CONTACTS
12.98 (5.11)
13.18 (5.19)
1.5
HEAT SINK AREA
4.0 (1.6)
1 +12
3 GND
5 +5
POWER CONNECTOR
SERIAL INTERFACE CONNECTOR
DRIVE A
DRIVE B
1.86
.1
(.6)
.48 (.19)
.58 (.23)
.69 (.27)
.58 (.23)
.74 (.29)
14.61 (5.75)
3.07 (1.21)
6.35 (2.50)
26.52 (10.44)

2.0 SOFTWARE INTERFACE

2.1 GENERAL DESCRIPTION

The TU58 is controlled by a high level command set that unburdens the host from device-related operations such as tape positioning, read retries, etc. The commands are implemented by the Radial Serial Protocol which arranges commands and data in separate message packets. These are byte sequences suitable for transmission by asynchronous serial or parallel interfaces.

2.2 RADIAL SERIAL PROTOCOL (RSP)

The full spec for radial serial protocol is included in Appendix A. This section provides an introduction to the major features.

2.2.1 MESSAGE PACKETS

All communication between TU58 and host is broken up into message packets. Each packet begins with the flag byte. This byte is defined as follows:

BITS 7-5 = RESERVED

BITS 4-0 = OP CODE

The next byte in a message packet is the byte count. This is the number of message characters in the packet, excluding the flag, byte count, and checksum. Up to 128 bytes may be in each packet. Larger blocks of data are sent with multiple packets. The last two bytes of the message packet are a 16 bit checksum. The checksum is formed by summing successive byte pairs taken as sixteen bit words and using an end around carry from bit 15 to bit 0. The flag and byte count are included in the checksum.

2.2.2 FLAG BYTE OP CODES

00001 DATA
00010 CONTROL (COMMAND)
00100 INIT
10000 CONTINUE
10011 XOFF

DATA: This flag informs the receiver that data rather than commands are arriving. The receiver loads the incoming bytes into a buffer area in memory. It doesn't look for an op code to execute.

COMMAND: The COMMAND flag informs the TU58 that a command packet follows. This is particularly important when the TU58 encounters an error condition. In this case it sends an end packet before data transfer is complete. The host knows that the end packet has been sent because the packet received has a COMMAND flag instead of a DATA flag.

INIT: This op code is sent from the host to the TU58 to cause it to execute its power-up sequence. It is sent from the peripheral to the host to tell the host that the initialize sequence has occurred. When the TU58 makes a protocol error or receives an invalid command, it reinitializes and sends INIT to the host. The TU58 must send up to 261 INITs in this case because the host may think it is receiving a message packet and will not interpret the INIT until the message packet is complete.

CONTINUE: After a message is sent from host to TU58, the host must wait until the TU58 sends CONTINUE before any more messages can be sent. This permits the TU58 to control the flow of data. CONTINUE means that the tape is in position and ready for data.

XOFF: Ordinarily, the TU58 does not have to wait between messages to the host. However, if the host is unable to receive all of a message from the peripheral at once, it sends XOFF. The TU58 stops transmitting immediately and waits until the host sends continue to complete the transfer when it is ready.

2.2.3 SIGNAL

Signal is defined in the RSP spec as a unique logic entity that can be interpreted as signal regardless of the state of the protocol. Its implementation for the TU58 is the BREAK condition on the serial line. Break

is interpreted when the serial line is kept in the space condition for more than one character time. This causes the UART to set its framing error bit. The TU58 will interpret the framing error as signal.

2.3 COMMAND SET

The command set is designed to be compatible with the device handlers for any random access mass storage devices. Since the full scale handlers are used with large disk systems, the TU58 implements only a subset of the commands available to higher performance devices. The TU58 commands meet the minimum requirements for a device handler; the differences are in characteristic and status flexibility in large systems.

A data transfer operation uses three or more message packets. The first packet is the command packet from host to peripheral. Next, the data is transferred in 128 byte packets in either direction (as required by read or write). After all data is transferred, the peripheral sends an end packet. If the peripheral encounters a failure before all data has been transferred, it sends the end packet as soon as the failure occurs.

2.3.1 COMMAND PACKETS

The command packet format is shown in Figure 2.1 Bytes 0, 1, 12, 13 are the message delivery bytes. Their definition is as follows:

0	FLAG	This byte is set to 00000010 to indicate that the packet is a command packet.
1	MESSAGE BYTE COUNT	Number of bytes in the packet excluding the four message delivery bytes. This is decimal 10 for all command packets.
12,13	CHECKSUM	The 16 bit checksum of bytes 0 through 11. The checksum is formed by treating each pair of bytes as a word and summing words with end around carry.

Figure 2.1

COMMAND PACKET STRUCTURE

BYTE		
0	FLAG = 0000 0010	
1	MESSAGE BYTE COUNT = 0000 1010	
2	OP CODE	DATA
3	MODIFIER	
4	UNIT NUMBER	
5	SWITCHES	
6	SEQUENCE NUMBER - LOW	
7	SEQUENCE NUMBER - HIGH	
8	BYTE COUNT - LOW	
9	BYTE COUNT - HIGH	
10	BLOCK NUMBER - LOW	
11	BLOCK NUMBER - HIGH	
12	CHECKSUM - LOW	
13	CHECKSUM - HIGH	

Figure 2.2

INSTRUCTION SET

OP CODE	
0	NOP
1	INIT
2	READ
3	WRITE
4	COMPARE
5	POSITION
6	ABORT
7	DIAGNOSE
8	GET STATUS
9	SET STATUS
10	GET CHARACTERISTICS
11	SET CHARACTERISTICS

The remaining bytes are defined as follows:

2	OP CODE	Operation being commanded. See Figure 2.2
3	MODIFIER	Permits variations of commands.
4	UNIT NUMBER	Selects drive 0 or 1.
5	SWITCHES	Not used by TU58.
6,7	SEQUENCE NUMBER	Used with devices that can handle more than one outstanding operation. Always zero for TU58.
8,9	BYTE COUNT	Number of bytes to be transferred by a read or write command. Ignored by other commands.
10,11	BLOCK NUMBER	The block number to be used by commands requiring tape positioning.

2.3.2 DATA PACKETS

The data packet is shown in Figure 2.3. The flag byte is set to 00000001. The number of data bytes may be between 1 and 128 bytes. For data transfers larger than 128 bytes, the transaction is broken up and sent 128 bytes at a time. The host is assumed to have enough buffer capacity to accept the entire transaction, whereas the TU58 only has 128 bytes of buffer space. For write commands the host must wait between message packets for the TU58 to send the Continue flag (00010000) before sending the next packet. Since the host has enough buffer space, the TU58 does not wait for a continue flag between message packets when it sends back read data.

2.3.3 END PACKETS

The end packet is sent to the host by the TU58 after completion or termination of an operation or on an error. The end packet is shown in Figure 2.4. The definition of bytes 0, 1, 12, 13 are the same as for the command packet. The remaining bytes are defined as follows:

BYTE 2 OP CODE - 0100 0000 for end packet.

Figure 2.3

DATA PACKETS

BYTE	
0	FLAG = 0000 0001
1	BYTE COUNT = M
2	FIRST DATA BYTE
3	DATA
"	"
"	"
"	"
"	"
M+1	LAST DATA BYTE
M+2	CHECKSUM L
M+3	CHECKSUM H

Figure 2.4

END PACKET

BYTE	
0	FLAG = 0000 0010
1	BYTE COUNT = 0000 1010
2	OP CODE = 0100 0000
3	SUCCESS CODE
4	UNIT
5	NOT USED
6	SEQUENCE NO. L
7	SEQUENCE NO. H
8	ACTUAL BYTE COUNT L
9	ACTUAL BYTE COUNT H
10	SUMMARY STATUS L
11	SUMMARY STATUS H
12	CHECKSUM L
13	CHECKSUM H

BYTE 3 SUCCESS CODE
- 0 = NORMAL SUCCESS
- 1 = SUCCESS BUT WITH RETRIES
- -1 = READ ERROR
- -8 = WRITE ERROR
- -15 = SEEK ERROR
- -16 = COMMAND ERROR
- -32 = NO CARTRIDGE
- -33 = NON-EXISTANT UNIT
- -34 = WRITE LOCKED
- -35 = ABORTED
- -36 = PARTIAL OPERATION (End of Medium)

BYTE 4 UNIT NUMBER 0 or 1 FOR DRIVE NUMBER

BYTE 5 NOT USED

BYTE 6,7 SEQUENCE NUMBER - ALWAYS 0 AS IN COMMAND PACKET

BYTE 8,9 ACTUAL BYTE COUNT - NUMBER OF BYTES HANDLED IN TRANSACTION. IN A GOOD OPERATION, THIS WILL BE THE SAME AS THE DATA BYTE COUNT IN THE COMMAND PACKET.

BYTE 10,11 SUMMARY STATUS

BYTE 10
Bit 0 ↓ 7
BYTE 11
Bit 0 1 2 3 RESERVED

Bit
- 4 LOGIC ERROR
- 5 MOTION ERROR
- 6 TRANSFER ERROR
- 7 SPECIAL CONDITON (Errors)

2.3.4 THE INSTRUCTION SET

The instructions and their op codes are shown in Figure 2.2 The following is a brief description and usuage example of each.

OP CODE 0 NOP

This instruction causes the TU58 to return an end packet. There are no modifiers to NOP. The NOP packet is shown below.

BYTE			
0	0000 0010	FLAG	
1	0000 1010	MESSAGE BYTE CNT	
2	0000 0000	OP CODE	
3	0000 0000	MODIFIER	
4	0000 000X	UNIT NUMBER (IGNORED)	
5	0000 0000	SWITCHES (NOT USED)	
6	0000 0000	SEQ NO.	NOT USED
7	0000 0000	SEQ NO.	
8	0000 0000	BYTE COUNT L	NO DATA
9	0000 0000	BYTE COUNT H	INVOLVED
10	0000 0000	BLOCK NO. L	NO TAPE
11	0000 0000	BLOCK NO. H	POSITION
12	0000 101X	CHECKSUM L	
13	0000 1010	CHECKSUM H	

The TU58 returns the following end packet:

0	0000 0010	FLAG	
1	0000 1010	MESSAGE BYTE CNT	
2	0100 0000	OP CODE	
3	0000 0000	SUCCESS CODE	
4	0000 000X	UNIT (IGNORED)	
5	0000 0000	NOT USED	
6	0000 0000	SEQ. L	NOT USED
7	0000 0000	SEQ. H	
8	0000 0000	ACTUAL BYTE CNT L	NO DATA
9	0000 0000	ACTUAL BYTE CNT H	INVOLVED
10	0000 0000	SUMMARY STATUS L	
11	XXXX XXXX	SUMMARY STATUS H	
12	000X XXXX	CHECKSUM L	
13	XXXX XXXX	CHECKSUM H	

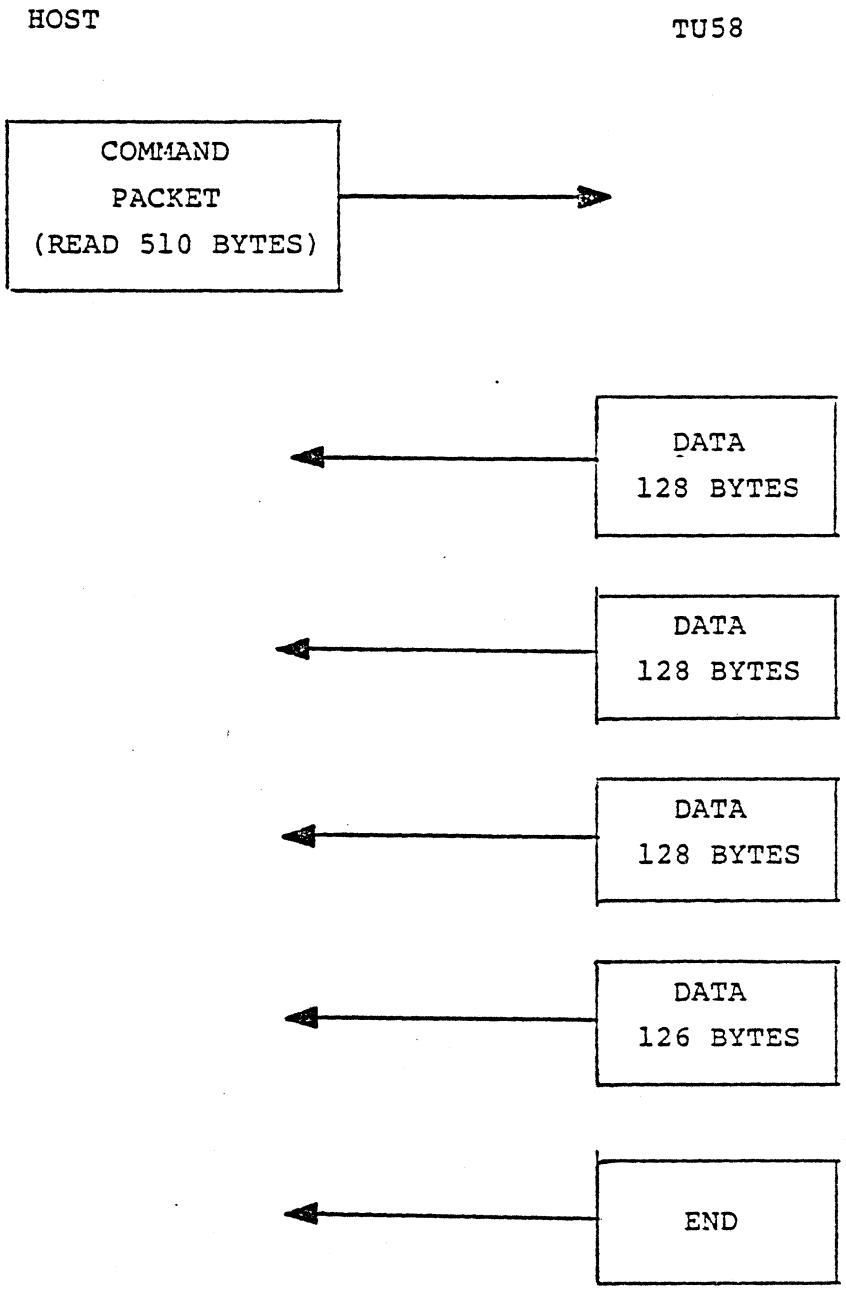
OP CODE 1 INIT

This instruction causes the TU58 controller to reset itself to a known state. No tape positioning results from this operation. The command packet is the same as for NOP except for the OP CODE and the resultant change to the low order checksum byte. The TU58 sends the same end packet as for NOP after reinitializing itself. There are no modifiers to Init.

OP CODE 2 READ

This instruction causes the TU58 to position the tape in the drive selected by UNIT NO. to the block designated by the block number bytes. It reads data starting at the first block and continues reading until the byte count (command bytes 8 and 9) is satisfied. After data has been sent the TU58 sends an end packet. Byte 3 will indicate success, success with retries, or failure of the operation. In the event of failure, the end packet will be sent at the time of failure without filling up the data count. The end packet will be recognized by the host by the flag byte. The host will see a command flag (0000 0010) instead of a data flag (0000 0001).

There is one modifier to the read command. A modifier of 0000 0001 will cause the TU58 to read the tape with an increased threshold in the data recovery circuit. This will make the tape drop bits if any weak spots are present. Thus, if the TU58 can read error free in this mode, the data is healthy. The read transaction between TU58 and host is shown on the next page.


HOST
TU58
COMMAND PACKET (READ 510 BYTES)
DATA 128 BYTES
DATA 128 BYTES
DATA 128 BYTES
DATA 126 BYTES
END

OP CODE 3 WRITE

This OP CODE causes the TU58 to position the tape in the selected drive to the block specified by the number in bytes 10, 11 of the command packet and write data from the first data packet into that block. It writes data from subsequent data packets into one or more blocks until the byte count called out in bytes 8, 9 of the command packet has been satisfied.

The controller will automatically zero-fill any remaining bytes in a 512 byte tape block.

There is one modifier permitted with the write command. A modifier of 0000 0001 will cause the TU58 to write all of the data and then back up and read the data just written and test the checksum of each record. If all of the checksums are correct, the TU58 will send an end packet with the success code set to zero (or 1 if retries were necessary to read the data). Failure to read correct data will result in a success code of -6 (1111 1010) to indicate a hard read error.

The write operation has to cope with the fact that the TU58 only has 128 bytes of buffer space. It is necessary for the host to send a data packet and wait for the TU58 to write it before sending the next data packet. This is accomplished using the continue flag. The continue flag is a single byte response of 0001 0000 from TU58 to host. The write operation is shown for both write and write/verify operations. (Figure

OP CODE 4 COMPARE

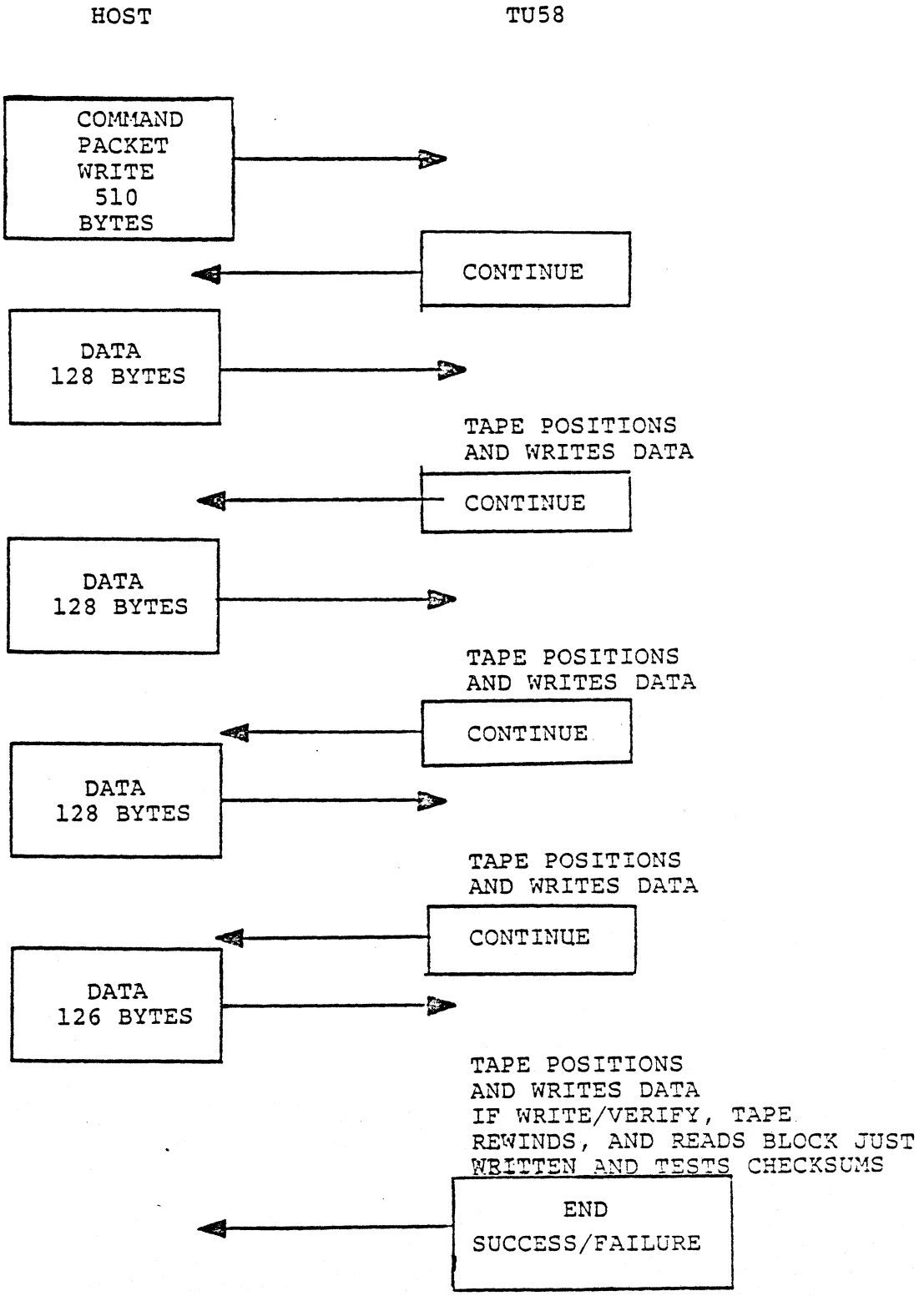
Treated as a NOP.

OP CODE 5 POSITION

This command causes the TU58 to position tape on the selected drive to the block designated by bytes 10, 11. After reaching the selected block, it sends an end packet. No modifiers are used.

OP CODE 6 ABORT

This command is treated as a NOP. Its use is intended for devices with multiple outstanding operations. The TU58 returns an end packet.


HOST
TU58
COMMAND PACKET WRITE 510 BYTES
CONTINUE
DATA 128 BYTES
TAPE POSITIONS AND WRITES DATA
CONTINUE
DATA 128 BYTES
TAPE POSITIONS AND WRITES DATA
CONTINUE
DATA 128 BYTES
TAPE POSITIONS AND WRITES DATA
CONTINUE
DATA 126 BYTES
TAPE POSITIONS AND WRITES DATA IF WRITE/VERIFY, TAPE REWINDS, AND READS BLOCK JUST WRITTEN AND TESTS CHECKSUMS
END SUCCESS/FAILURE

OP CODE 7 DIAGNOSE

This command causes the TU58 to run its internal diagnostic program. Upon completion TU58 sends an end packet with appropriate success code.

OP CODE 8 GET STATUS

OP CODE 9 SET STATUS

Treated as a NOP because TU58 status cannot be set from the host. The TU58 returns an end packet.

OP CODE 10 GET CHARACTERISTICS

This command causes the TU58 to send a data message to the host containing its operating parameters. The format of these parameters is not defined yet.

OP CODE 11 SET CHARACTERISTICS

The TU58 characteristics cannot be changed so this command is treated like a NOP.