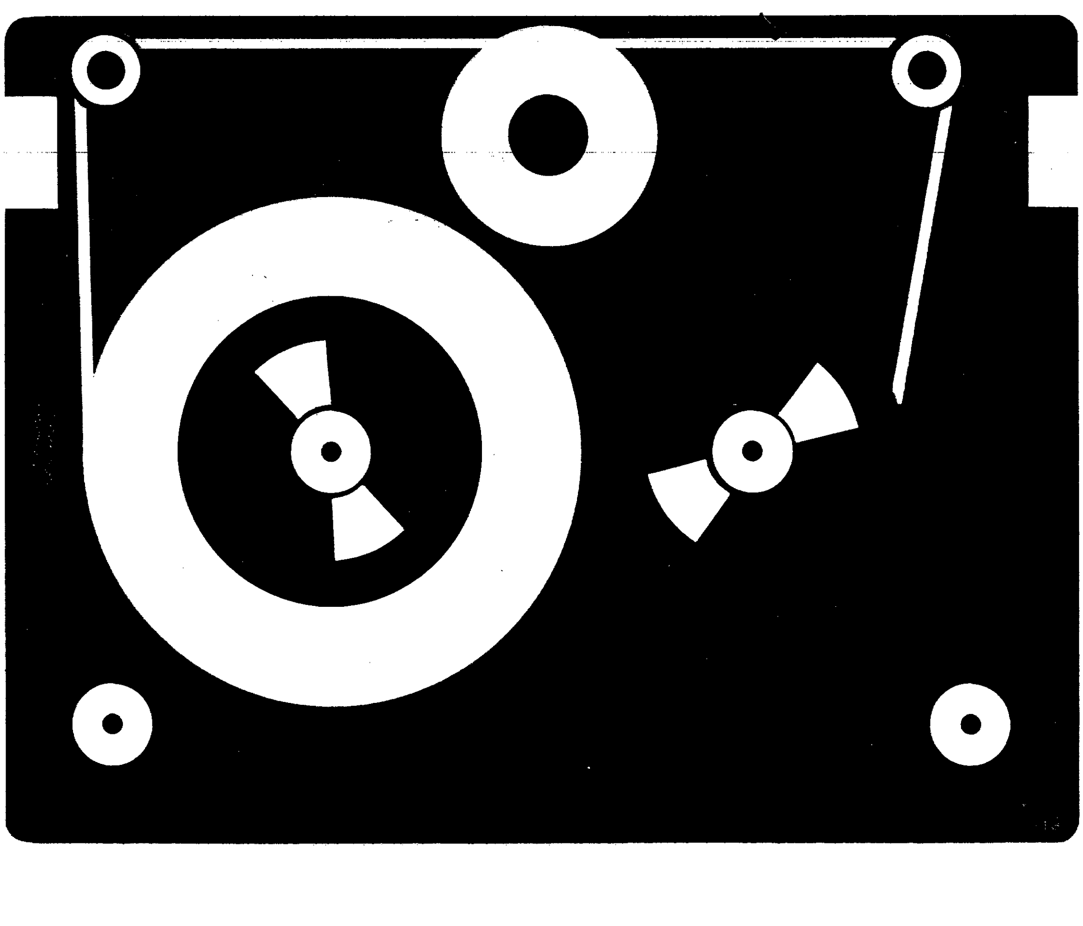
digital

TU58 DECtape II TECHNICAL MANUAL



EK-0TU58-TM-001

TU58 DECtape II Technical Manual

digital equipment corporation • maynard, massachusetts

1st Edition, September, 1979

Printed in U.S.A.

This document was set on DIGITAL's DECset-8000 computerized typesetting system.

CONTENTS

CONTENTS (Cont)

CONTENTS (Cont)

FIGURES

FIGURES (Cont)

TABLES

CHAPTER 1
INTRODUCTION

1.1 SCOPE

The TU58 DECtape II is a low-cost, mass-storage device that may be used in a wide variety of applications. This manual provides the information a user needs to install, interface, and command the operation of the tape system. (For information about the operation of the TU58 under DEC operating systems, refer to the individual system manuals.)

Chapter 1 provides a general description of the TU58 and a list of specifications including electrical and mechanical requirements. The configurations section describes the different variations of the TU58 that are available.

Chapter 2, the system operator's reference section, contains important information for day-to-day operation and routine maintenance.

Chapter 3 is the programmer's guide. It contains functional descriptions of the TU58 command set, illustrates command sequences, explains the details of the Radial Serial Protocol, and lists the system instruction codes and byte sequences.

Chapter 4 gives illustrated instructions for jumper selection; mechanical, electrical, and interface installation; and operational checkout of the tape system.

Chapter 5 has details about the optional features available in the TU58.

Chapter 6 contains a technical description of the TU58 using block diagrams and schematic references to illustrate functions.

Chapter 7 is a troubleshooting and removal and repair section, oriented to field replaceable units (FRUs).

The appendices include a list of spare parts, and a toggle-in bootstrap program for PDP-11 systems. Schematics for both parallel and serial versions of the TU58 may be found in the *Field Maintenance Print Set*. See Paragraph 1.6 for ordering information.

1.2 GENERAL DESCRIPTION

The TU58 is a random-access, fixed-length-block, mass-storage tape system. It uses preformatted tape cartridges which store 262 kilobytes of data in 512-byte blocks. There are 256 blocks on each of two tracks. They may be accessed by a program in a fashion similar to data stored on disks or DECtape, using a new, high-level instruction set. A file-oriented structure is easily implemented in an operating system by setting aside several blocks on the tape to store a directory.

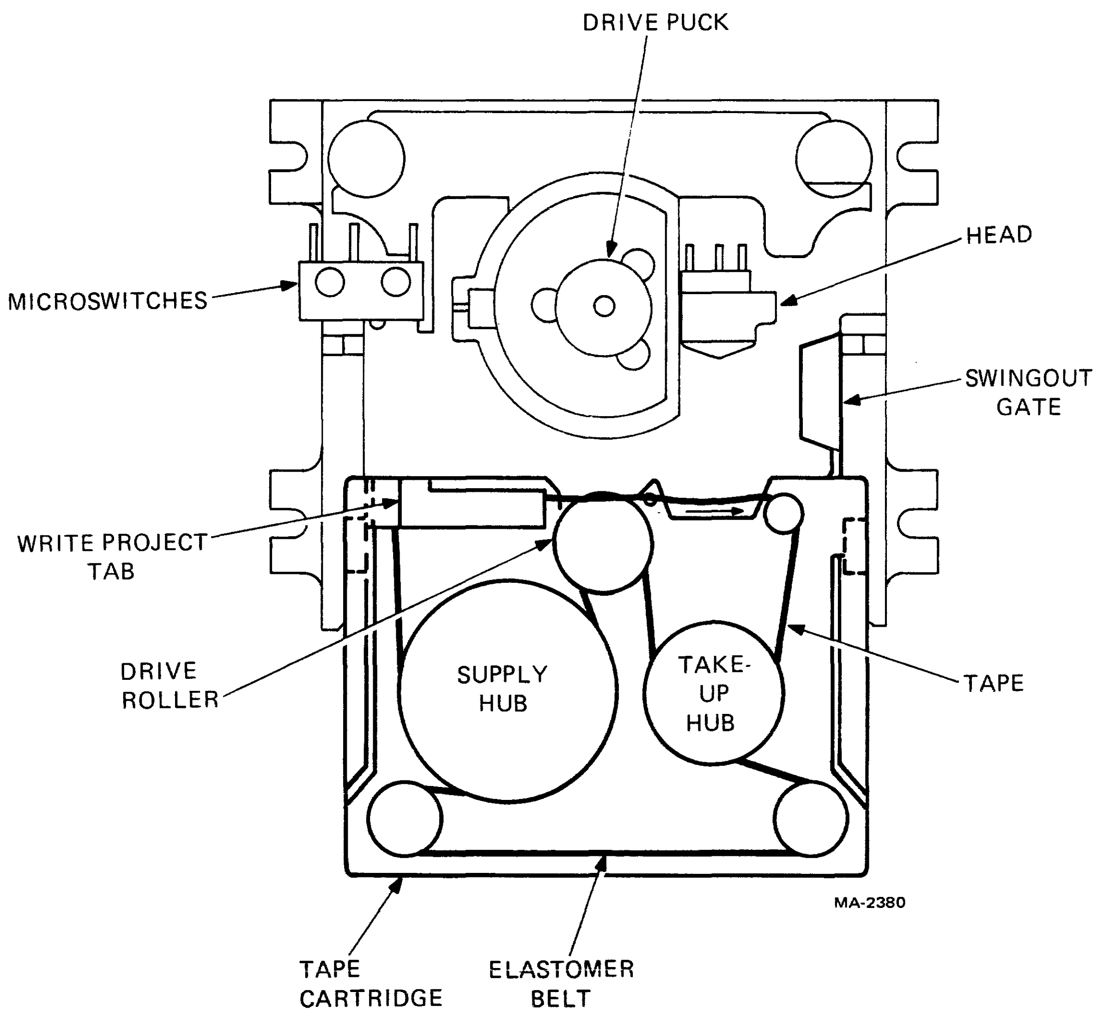


Figure 1-1 Tape Cartridge Partially Inserted into Drive (Top View)

The TU58 is compact and mechanically simple. The tape cartridges are DIGITAL-preformatted miniature reel-to-reel packages containing 42.7 m (140 ft) of 3.81 mm (0.150 in) wide tape. The tape is driven by a single puck which engages a roller which moves an elastomer drive belt in the cartridge. This belt loops around both tape spools and provides uniform tension and spill-free winding without mechanical linkages (Figure 1-1). The simple single-point drive mechanism allows high reliability for the entire system.

The control and drive circuitry of the TU58 is located on a single circuit board. The controller uses a microprocessor (μP) to reduce the tape handling and communications management load on the host system.

The motor and tape head control, driver, and switching circuits to manage two tape drives are on the printed circuit board with the μP. The controller supports one or two drives, but only one drive can operate at a time. The μP controls all of the activities of the TU58. Head and motor selection, speed and direction changes, etc., are managed by outputs from I/O ports on a peripheral IC. The mechanical actions of the drives themselves are supervised by the μP to improve the system's performance.

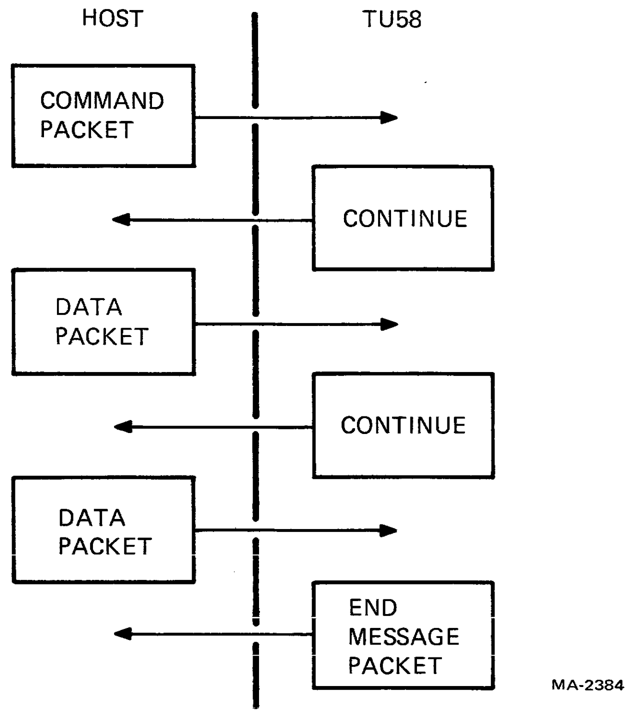


Figure 1-2 An Exchange in Radial Serial Protocol

Operational amplifiers, comparators, and logic circuits perform amplification, signal switching and conditioning, proportional control, and logic steering functions in the controller. The tape is protected by motor current limiting and an anti-runaway timer.

Because of the μP intelligence, requests from the host for data retrieval or storage need only contain simple specifications about the transfer. The controller positions the tape and performs the transfer without supervision from the host.

The host and controller communicate in a format called Radial Serial Protocol (RSP). The RSP uses two kinds of byte sequences called message packets. Both command and data packets have protocol information placed in specific locations in the byte sequence. This format is easily generated by the TU58, making host-peripheral interaction possible at a high level with low cost.

Figure 1-2 illustrates a typical RSP exchange between a host computer and the TU58. Refer to Chapter 3 for a full discussion of RSP implementation.

The serial host interface operates on full-duplex, asynchronous 4-wire lines at jumper-selectable rates from 150 to 38.4 kilobaud. The send and receive rates may be independently set with jumpers to operate in accordance with Electronic Industries Association (EIA) Standards RS-422 or RS-423. When set to RS-423, the TU58 is also compatible with devices complying with RS-232-C.

1.3 BLOCK DIAGRAM

Figure 1-3 illustrates the structure of the TU58 system. The data path is along the top of the diagram, passing to the host through the processor at the right. The drive control is at the lower left, also closely associated with the processor through the I/O ports. The ports, memory, and universal asynchronous receiver-transmitter (UART) are tied to the processor by an 8-bit-wide data/address bus.

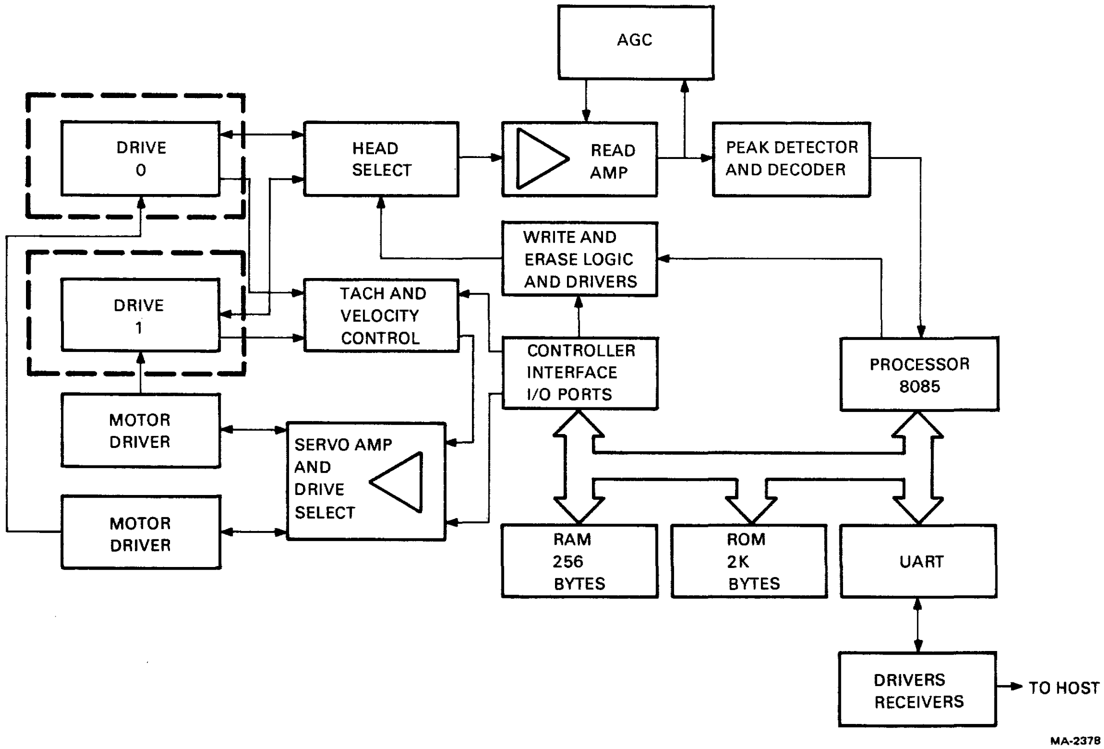


Figure 1-3 TU58 Block Diagram

1.3.1 Drive Control

The cartridge drive motors are powered by servo-regulated speed and direction circuits. These are controlled by the processor which monitors with tachometers and with signals from the tape. The heads are selected by processor-controlled switches and either feed the automatic-gain-controlled (AGC) read amplifier and decoder circuits or are driven by write currents encoded by the processor.

1.3.2 Processor

The processor consists of an 8085 processor supported by firmware in a 2-kilobyte read-only memory (ROM) and by scratchpad and data buffer memory in a 256-byte random access memory (RAM). The processor communicates with the drive control circuitry through a bidirectional I/O port. The UART exchanges data between the TU58 processor bus and the host computer via the serial line drivers and receivers.

1.4 SPECIFICATIONS

1.4.1 Performance

Capacity per cartridge	262,144 bytes, formatted in 512 blocks of 512 bytes each
Data transfer rate	
Read/write on tape	41.7 μs/data bit, 24 kbytes/s
Data buffer to interface	150 to 38.4 kbaud, jumper selected
Cartridge life	5000 typical end-to-end-and back tape passes
Data reliability	
Soft data error rate	1 in 10^7 bits read (before self-correction)
Hard error rate	1 in 10^9 bits read (unrecoverable within 8 automatic retries)
Hard error rate with write-verify and system correction	2 in 10^{11} bits read/written
Error checking	Checksum with rotation
Average access time	9.3 seconds
Maximum access time	28 seconds
Read/write tape speed	76 cm/s (30 in/s)
Search tape speed	152 cm/s (60 in/s)
Bit density	315 bits/cm (800 bits/in)
Flux reversal density	945 fr/cm (2400 fr/in)
Recording method	Ratio encoding
Medium	DECtape II cartridge with 42.7 m (140 ft) of 3.81 mm (0.150 in) tape Size: 6.1 × 8.1 × 1.3 cm (2.4 × 3.2 × 0.5 in) Order TU58-K

Track format (Figures 1-4 and 1-5)	Two tracks, each containing 1024 individually numbered, firmware-interleaved "records." Firmware manipulates 4 records at each operation to form 512-byte blocks.
Drive	Single motor, head integrally cast into molded chassis
Drives per controller	1 or 2. Only one may operate at a time.

1.4.2 Electrical

Power consumption	
Module and 1 or 2 drives	11 W, typical, drive running +5 V ±5% at 0.75 A, maximum +12 V +10% -5% at 1.2 A, peak 0.6 A average running 0.1 A idle These voltages need not stabilize simultaneously upon power-on.
Rackmount	90–128, 180–256 Vac, 47–63 Hz, 35 W maximum
Serial interface standards	In accordance with RS-422 or RS-423; compatible with RS-232-C

1.4.3 Mechanical

Drive	8.1 H × 8.3 D × 10.6 W cm (3.2 × 3.3 × 4.1 in) with 19 cm (7.5 in) cable 0.23 Kg (0.5 lb)
Board (Module)	13.2 H × 26.5 D × 3.5 W cm (5.19 × 10.44 × 1.4 in) 0.24 Kg (0.53 lb)
Rackmount cabinet	13.2 H × 38.1 D × 48.3 W cm (5.19 × 15.0 × 19.0 in) 9 Kg (20 lbs)
Power connector to module	AMP 87159-6 with 87027-3 contacts (DEC part nos. 12-12202-09, 12-12203-00)
Power connector to rackmount	European IEC standard
Interface connector to module	AMP 87133-5 with 87124-1 locking clip contacts and 87179-1 index pin (DEC part nos. 12-14268-02, 12-14267-00, 12-15418-00)

	78.7 b/cm 200 b/in	315 b/cm 800 b/in						
	INTER RECORD MARK	HEADER SYNC.	RECORD NUMBER	COMPL OF RCD. NUMBER	DATA SYNC.	DATA SPACE 128 BYTES	CHECK SUM	END SPACE ALL ZEROS
TRK1		000...01	N + 1024	$\overline{N + 1024}$	00 00 00 00....01			
TRK0		000...01	N	$\overline{N}$	00 00 00 00...01			

TU58 ARRANGES FOUR RECORDS AS ONE BLOCK

MA-2371

Figure 1-4 Single Record on Tape

128 200_8	384 600_8	129 201_8	385 601_8	130 202_8	386 602_8	131 203_8	254 376_8	510 776_8	255 377_8	511 777_8
0 0_8	256 400_8	1 1_8	257 401_8	2 2_8	258 402_8	3 3_8	126 176_8	382 576_8	127 177_8	383 577_8

BOT/EOT:BEGINNING/END OF TAPE

MA-3813

Figure 1-5 Block Locations on Tape

1.4.4 Environmental
The TU58 meets the following environmental specifications. When the TU58-AB or -BB (Paragraph 1.5) is integrated in a host device such as a terminal, convection provides adequate cooling if the interior temperature is below 50° C (122° F) dry bulb, 26° C (79° F) wet bulb.

Maximum dissipation	
TU58-CA	120 Btu/hour
TU58-AB, TU58-BB	34 Btu/hour
Temperature	
TU58-CA operating	15° C (59° F) to 32° C (90° F) ambient
TU58-CA nonoperating	-34° C (-30° F) to 60° C (140° F)
Medium operating temperature	0° C (32° F) to 50° C (122° F)
Maximum temperature difference between system ambient and TU58 module	18° C (32.4° F)
Relative Humidity, noncondensing	
TU58 operating	
Maximum wet bulb	26° C (79° F)
Minimum dew point	2° C (36° F)
Relative humidity	20% to 80%
TU58 nonoperating	5% to 98%
Medium nonoperating	10% to 80%

CAUTION

If a cartridge has been exposed to either the maximum or minimum temperature extreme, the tape should be rewound one complete cycle before using (Paragraph 2.3.5). This is done to bring the tape to the proper tension.

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

Components

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

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 V switch-selectable, detachable line cord and fuses for 110 V, two cartridges.

Additional Supplies

BC20Y-25 interface cable TU58 to DL-11 and DLV-11
BC20Z-25 interface cable TU58 to DLV-11J
TU58-K preformatted tape cartridges. Available singly or in packs of five.
TUC-01 Tape Drive Cleaning Kit.

NOTE
Order interface cable separately.

1.6 HARDWARE DOCUMENTATION ORDERING INFORMATION

The following TU58 DECtape II Tape Subsystem hardware manuals can be purchased from DIGITAL's Accessory and Supplies Group.

Part No.	Title
EK-0TU58-UG-001	TU58 DECtape II User's Guide (paper)
EK-0TU58-PG-001	TU58 DECtape II Pocket Service Guide (card)
EK-0TU58-TM-001	TU58 DECtape II Technical Manual (microfiche or paper)
EK-0TU58-IP-001	TU58 DECtape II Illustrated Parts Breakdown (paper)
MP00747	Field Maintenance Print Set

ORDERING

Purchase orders for supplies and accessories should be forwarded to:

Digital Equipment Corporation
Accessories and Supplies Group
Cotton Road
Nashua, New Hampshire 03060

Contact your local sales office or call DIGITAL Direct Catalog Sales toll-free 800-258-1710 from 8:30 a.m. to 5:00 p.m. eastern standard time (U.S. customers only). New Hampshire customers should dial (603)-884-6660. Terms and conditions include net 30 days and F.O.B. DIGITAL plant. Freight charges will be prepaid by DIGITAL and added to the invoice. Minimum order is $35.00. Minimum does not apply when full payment is submitted with an order. Checks and money orders should be made out to Digital Equipment Corporation.

CHAPTER 2
OPERATION

2.1 TU58-CA RACKMOUNT CONTROLS AND INDICATORS

2.1.1 Front Panel

The front panel (Figure 2-1) has two slots for the tape cartridges and two tape motion indicator lights for the drives. In addition, the decorative bezel has a small compartment that can be used to store up to six cartridges in their boxes.

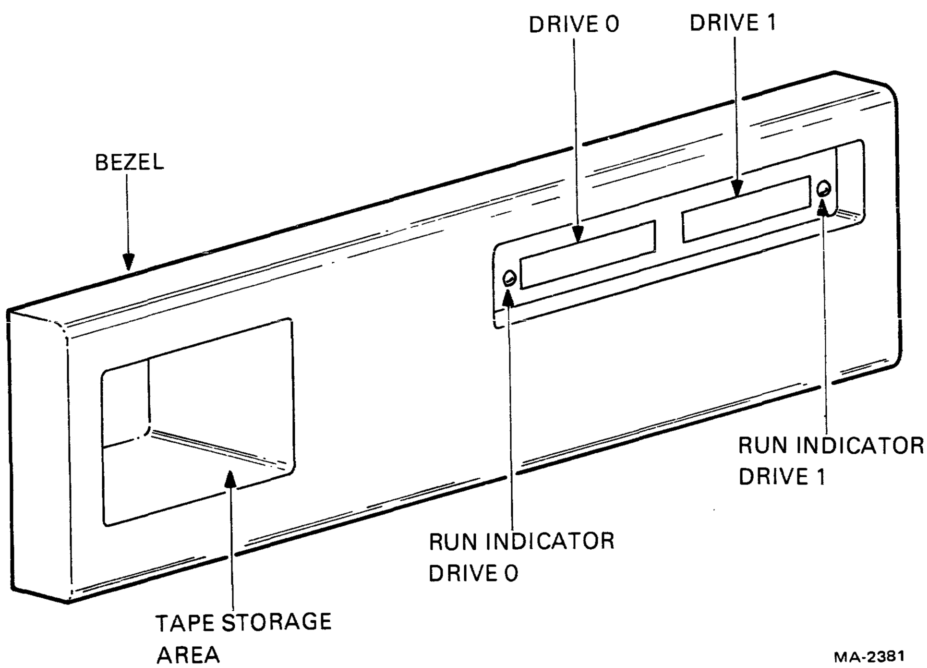


Figure 2-1 TU58-CA Rackmount Front Panel

2.1.2 Run Indicator

Each tape drive has an LED that lights to indicate tape motion. Since data loss can occur if a cartridge is removed while the tape is being written, the cartridge should not be removed if the light is on.

2.1.3 Application and Removal of Power

The TU58-CA does not have a power switch. If an outlet is available on a system power controller, the TU58 may be plugged into the controller. Otherwise, it does not need to be turned off. Its idling power consumption is less than 20 W.

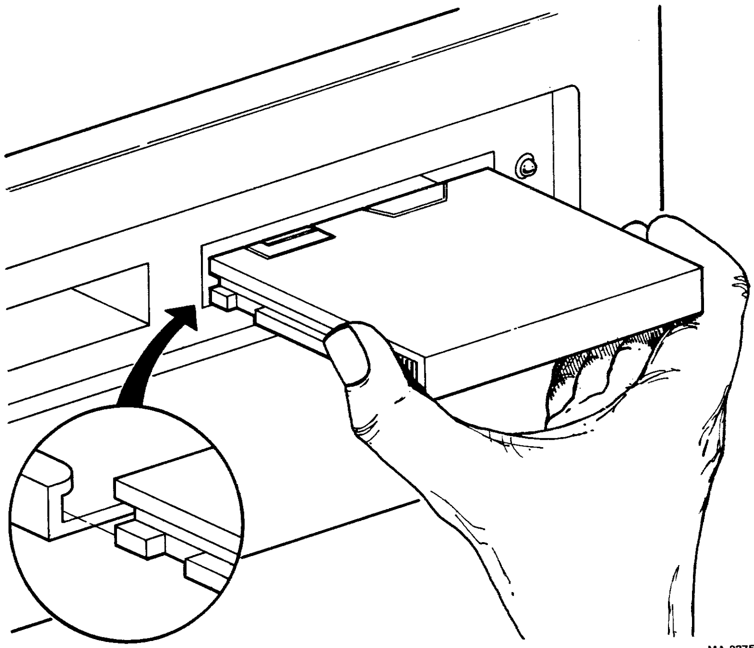


Figure 2-2 Loading a Cartridge

When power is applied, the TU58 initializes itself, performs its internal diagnostic tests, and then asks the host for an acknowledgement before it settles down to wait for instructions. Refer to Paragraph 3.2.3 for a description of the required exchange.

If power is removed while a tape is being written, data may be lost. There are no other restrictions on power removal.

2.2 TU58 COMPONENTS CONTROLS AND INDICATORS

Refer to the options section (Chapter 5) for installation and operation of OEM features.

2.2.1 Application and Removal of Power

The TU58 may be supplied with power from a host system. It is ready for operation within 1 second of voltage stabilization. It does not need to be turned off when not in use; its idling power consumption is less than 5 W.

When power is applied, the TU58 initializes itself, performs its internal diagnostic tests, and then asks the host for an acknowldgement before it settles down to wait for instructions. Refer to Paragraph 3.2.3 for a description of the required exchange.

If power is removed while a tape is being written, data may be lost. There are no other restrictions on power removal.

2.3 CARTRIDGE

2.3.1 Cartridge Loading

The TU58 drive is designed to make correct loading easy. To load the cartridge, hold it label-up, line it up with the grooves in the chassis, and slide it in with a firm push. Figure 2-2 illustrates the fit of the cartridge into the drive chassis grooves.

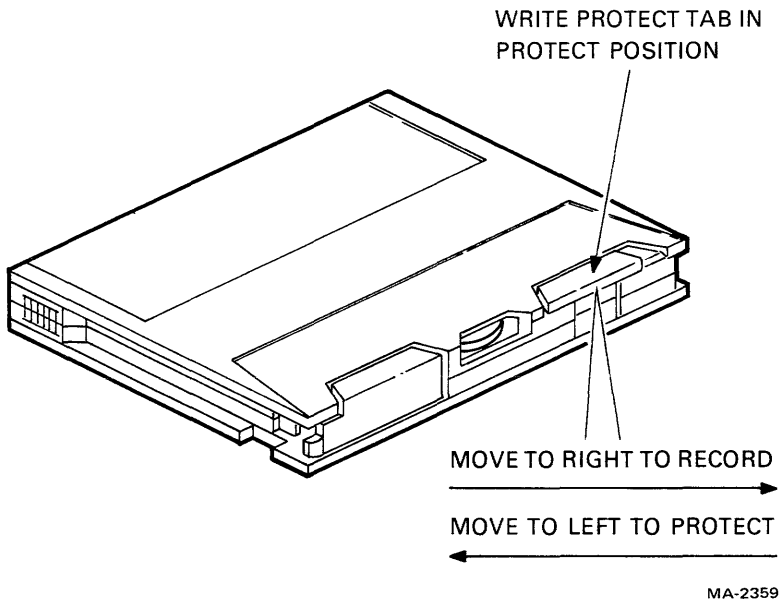


Figure 2-3 Write Protect Tab

2.3.2 Cartridge Unloading
Unloading the cartridge is as simple as loading. Just pull it straight out. It is best to wait for the tape to stop, as indicated by the run light, before removing the cartridge. The mechanism cannot be damaged by removing the cartridge while the tape is moving, but if a write is in progress, data may be lost. An error message will be sent to the host if a command is interrupted by removal of a cartridge.

2.3.3 Keeping Track of Cartridges
If the TU58 is used in a non-file-structured system, the cartridge does not have an identifying number or label recorded on the tape. If a cartridge is changed, the TU58 will not know that a different cartridge was loaded; the operator must keep track of the contents of various cartridges.

2.3.4 Write Protect Tab
Each tape cartridge has a movable tab which, when properly positioned, protects data on the tape from unintended write operations. When this Write Protect tab (Figure 2-3) is in the inner position (toward the drive roller), it locks out the write circuitry.

When the Write Protect tab is in the outer position, it closes a switch in the chassis and allows the controller to write when it is commanded to. The operator should be sure that system or program tapes are backed up with copies before loading them into the TU58 with their Write Protect tabs set to record.

The Write Protect tab can be completely removed for long-term write protection. On the metal-base cartridge, lift the protect tab with a fingernail under the protruding end. Replace it by dropping it into its slot and pressing on it until it snaps. On the plastic-base cartridge, pry up the tab from its back edge partway and then lift from the front. To replace it, drop it into its slot and press forward and down.

2.3.5 Cartridge Storage and Care
Store cartridges in their cases, away from dust and heat or direct sunlight. Do not touch the tape; there is no safe way to clean the tape and permanent errors may result. Keep tools and other ferrous or

magnetic objects away. If a tape is suspected of having been exposed to environmental extremes as listed in the specifications and if the software operating system permits, wind it all the way through with a "Newtape" (Paragraph 3.1.2) or equivalent command or by requesting positionings to blocks at each end of the tape before attempting to store data on the cartridge.

2.4 MAINTENANCE

2.4.1 Head and Puck Cleaning

After 250 hours of tape running time or semi-annually, clean the head and motor puck with a long-handled cotton applicator moistened with DEC cleaning fluid (from cleaning kit TUC-01), 95 percent isopropyl alcohol, fluorocarbon TF, 113 or equivalent (Figure 2-4). Push the puck around with the applicator to clean its entire surface. Regular cleaning minimizes tape and head wear and prevents tape damage and data errors caused by contamination. This is the only regular maintenance required by the TU58.

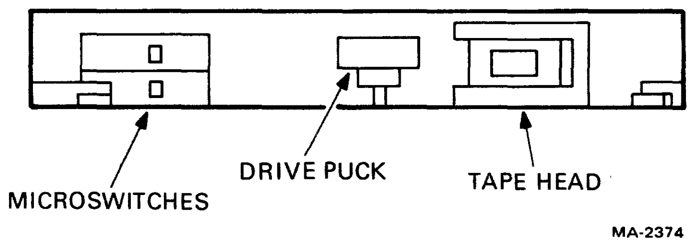


Figure 2-4 View Into Tape Drive Cartridge Slot

2.4.2 Operator Trouble Isolation

Table 2-1 lists potential problems and possible corrective actions and comments. (Some items are not applicable to components.)

Table 2-1 Operator Trouble Isolation

Symptom	Action/Comments
TU58 does not respond to host.	1. Ensure that the TU58-CA is plugged into a live ac socket (or proper dc source for components). 2. Check that the voltage selection switch is properly set. 3. Ensure that the fuse and power cord are intact and properly inserted. 4. Check that the baud rates and interface standards are the same for both the TU58 and the host interface board (Paragraph 4.3).

Table 2-1 Operator Trouble Isolation (Cont)

Symptom	Action/Comments
	5. If possible, observe the self-test indicator light on the controller module. [Remove the bezel on the rackmount version (Paragraph 4.1.1)]. When power is applied, the light should shine for half a second, go out for another half second, and then relight. This means the controller has passed its automatic self-test and is ready for operation. If the light remains off, there is some problem within the module or in the interface. Check that the interface cable is intact and properly inserted. If the serial interface is suspected and the standards are correct, try a new interface cable. An open wire in the line from the host prevents the light from coming on. Other causes require servicing.
TU58 does not write (reads okay).	1. Check that the Write Permit tab is correctly on the cartridge (Figure 2-3). 2. The trouble may be in a drive. Try writing on the other drive. Any problem except the Write Permit tab setting requires service.
Read errors (Some host operating systems may provide this or a similar message.)	1. Clean the head. Dirt and tape oxide buildup can cause errors (Paragraph 2.4.3). 2. The tape may contain errors that were written onto it. If a tape is in poor condition or if data is not verified at write-time, errors may become a permanent part of the recording. A new cartridge with format problems will produce the same error message. Try another cartridge.
TU58 sends motor-stopped error messages.	This indicates that a malfunction has occurred in the data recovery section and the runaway timer has stopped the motor. The TU58 should not be commanded to move tape more than twice under these conditions without checking the cartridge. Make sure that the tape is not getting near the end where it might come free of the hub.

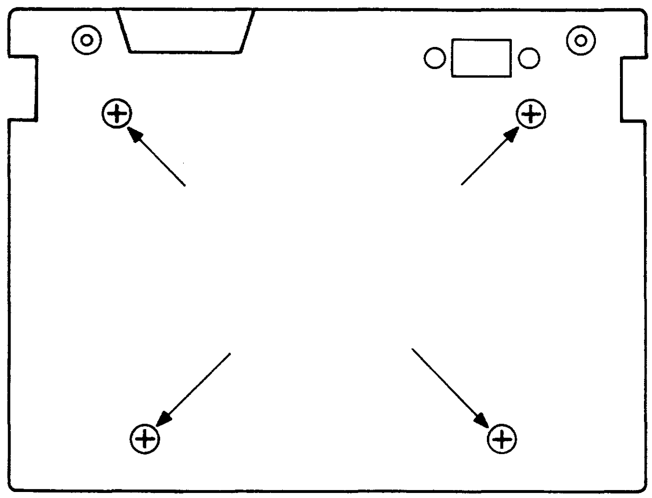


Figure 2-5 Cartridge Baseplate Screw Locations

2.4.3 Cartridge Wear

Cartridge tape is expected to last for 5000 end-to-end-and-back passes. If a cartridge is at the end of its life, a read operation may require several retries to get the data in the presence of soft errors. A soft error is a temporary data loss which is usually caused by a speck of dirt or oxide on the tape or head surface. This speck lifts the tape away from the head and causes signal loss and consequent read errors. A few extra passes of the tape past the head may knock the speck away and allow error-free reading. If it happens often, the tape is probably old and shedding oxide and should be copied and discarded as soon as possible.

2.5 CARTRIDGE REPAIR

Under unusual circumstances of controller failure or cartridge mishandling, the tape might come free of the hub. The tape is not fastened to the hub but is held in place by the elastomer belt and by the tape's wrap around itself. The procedures for looping the tape back onto the hub help the user prevent the loss of important data. They are not a substitute for the customary precautions of proper handling and backup copying. Two procedures are given here. One is for the metal-base cartridge and the other is for the plastic-base cartridge.

These are moderately difficult procedures requiring the use of small tools. Minimum tools are a no. 1 Phillips head screwdriver and a small probe (a straightened paper clip can be used). Tweezers are helpful.

NOTE

Keep magnetized tools away from the bulk of the tape and do not touch the tape surface except at the ends because fingerprints cause errors. (If staples or paper clips stick to a tool, it is magnetized.)

2.5.1 Metal-Base Cartridge Tape Rethreading Procedure

1. Open the cartridge by removing the four baseplate Phillips head screws (Figure 2-5) and set it upright on the work surface with the cover still on.

2. Lift the cover off.

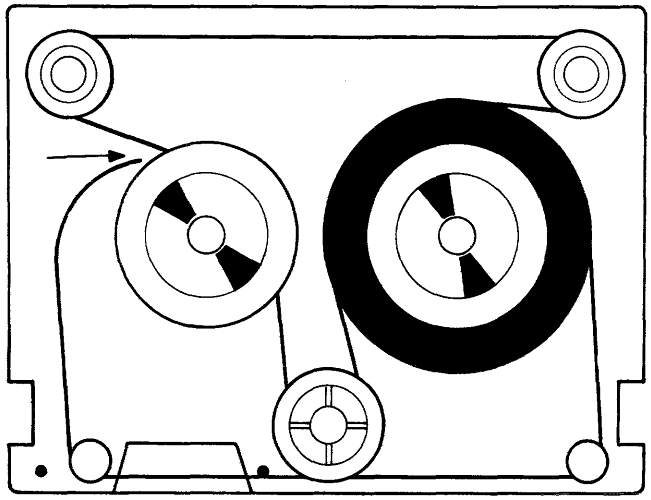


Figure 2-6 Threading the Metal-Base Cartridge

NOTE
To remove the head gate, swing it out to clear the tape before lifting it up. Its replacement is optional.

3. Thread the end of the tape around the tape guides (Figure 2-6).
4. Moisten the end of the tape with water to get it to stick to the hub.
5. With a small amount of slack at the free end, insert the end between the hub and belt and operate the drive roller with a finger to take up the tape. As soon as the tape is grabbed, keep some back tension on the tape. This will keep it feeding straight into the hub.
6. Continue to wind. Watch for the loose end as it comes around. If it separates from the hub, tuck it under the next turn of tape with the probe. (Back up if the end is too long.)
7. Continue to wind a few more turns with the drive roller while applying tension to the tape.
8. Hold the takeup hub and drive roller fixed, and rotate the supply reel to take up the slack.
9. Continue winding the tape about 20 turns before reassembling.
10. To reassemble the cartridge, reinstall the gate (if desired) by aligning the long and short ends of the spring with the long and short ends of the gate, as in Figure 2-7.
11. Drop the spring into the well in the gate. Holding the spring down with a thumbnail or probe, rotate the long end of the spring around to the slot that is at a right angle to the long dimension of the gate. Push the end of the spring into the slot; it should stay there by itself.
12. Hold the gate halfway out so that the gate and the spring end do not touch the tape. Slowly press the gate down onto its pin on the cartridge baseplate. Reach in with the probe and press the spring down. It will clear its holding slot and snap into position, closing the gate.
13. Carefully lower the cartridge cover into place and reinstall the screws.

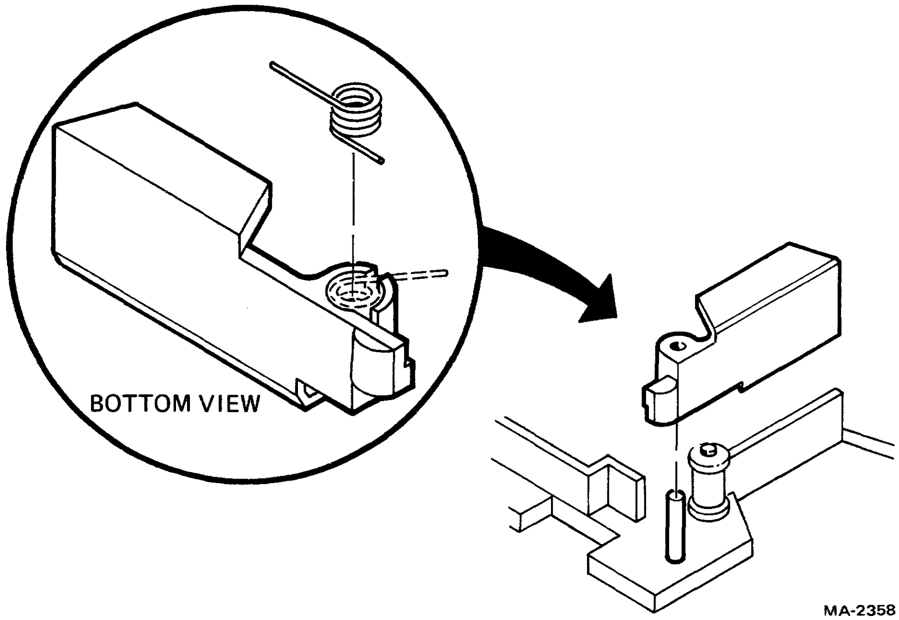


Figure 2-7 Head Gate and Spring

2.5.2 Plastic-Base Cartridge Tape Rethreading Procedure

Open the plastic-base cartridge case by removing the four baseplate Phillips head screws (Figure 2-5) and carefully remove the top.

2.5.2.1 Preparation for Threading – The four rollers and tape hubs in the plastic-base cartridge are held in their operating plane by the top and bottom of the case together. When the top is off, the various parts tend to creep out of position, and the elastomer belt can get folded under the hubs.

1. To organize the parts for threading, remove and discard the head gate and spring. Take the empty tape hub from the case and set it aside.
2. Remove the floating roller (Figure 2-8).
3. Rearrange the elastomer belt around the drive roller and the full hub.
4. Reinstall the floating roller and use it to stretch the belt tight.
5. Put the empty tape hub on its pin.
6. Using the top to hold the floating roller, belt, and loaded hub down, use a straightened paper clip or pencil to guide the elastomer belt around the hub. The hub should seat against the base with the belt around it:

2.5.2.2 Threading the Cartridge

1. Pull several centimeters (a few inches) of tape off the supply hub and through the tape guides (Figure 2-9).

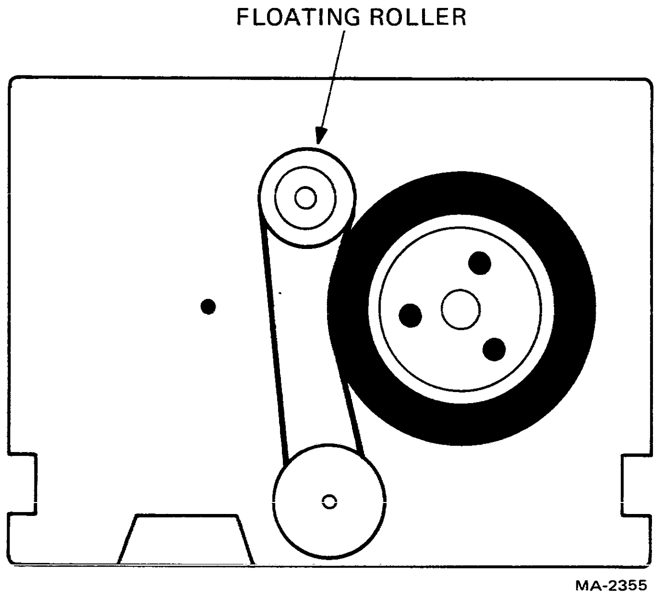


Figure 2-8 Stretch the Belt with the Floating Roller

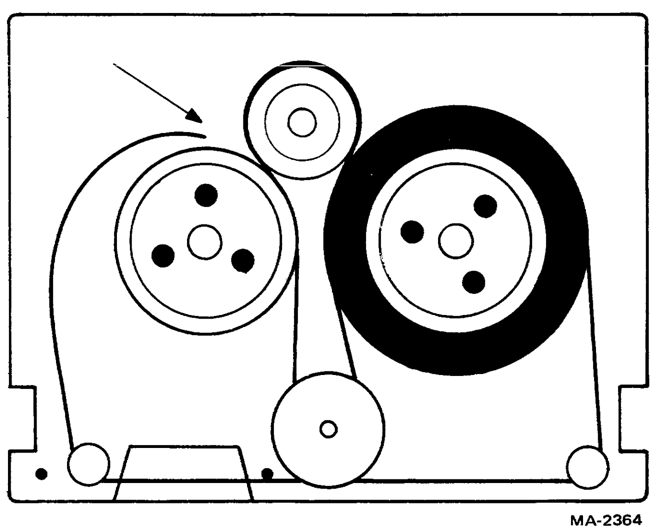


Figure 2-9 Threading the Plastic-Base Cartridge

NOTE
Hold all parts down when moving them. Otherwise, the hubs will creep up the pins and cause the belt to slip. Then the procedure must be restarted at Paragraph 2.5.2.1.

2. Moisten the end of the tape with water to get it to stick to the hub.

3. With a small amount of slack at the free end, insert the end between the hub and belt, and operate the floating roller to take up the tape.

4. As soon as the tape is grabbed, keep some back tension on the tape. This keeps the tape feeding straight into the hub.

5. Continue to wind. Watch for the loose end as it comes around. If it separates from the hub, tuck it under the next turn of tape with the paper clip. (Back up if the end is too long.)

6. Continue to wind a few more turns with the floating roller while applying tension to the tape.

7. Now hold the takeup hub, drive, and floating rollers fixed and rotate the supply hub to take up the slack.

2.5.2.3 Closing the Cartridge – Place the top back on the cartridge. Do not reinstall the head gate. The mirror window may need to be pressed in slightly to clear the bottom. Reinstall the four baseplate screws.

Now use a finger to operate the drive roller and wind the tape about 20 turns onto the takeup hub before inserting the cartridge into a drive.

NOTE
The only reason for performing this exercise is to copy the data from the injured tape as soon as possible. Discard the cartridge after copying.

CHAPTER 3
PROGRAMMING

3.1 GENERAL PRINCIPLES

The TU58 is controlled by a high-level command set that unburdens the host computer from device-related operations such as tape positioning and read retries. The TU58 firmware contains subroutines that are activated by brief strings of command bytes. The command strings contain the numerical code for the operation to be performed and the location and size of data files that are to be transferred, when applicable. They also contain various housekeeping characters that are part of the Radial Serial Protocol (RSP) under which the byte sequences are defined. The byte sequences are called message packets and are designed to be suitable for transmission by asynchronous interfaces.

3.1.1 Block Number, Byte Count, and Drive Number

The TU58 uses the block number and byte count to write or retrieve data. If all of the desired data is contained within a single 512-byte block, the byte count will be 512 or less. When the host asks for a particular block and a 512-or-less byte count, the TU58 will position the specified drive (unit) at that block and transfer the number of bytes specified. If the host asks for a block and also a byte count greater than that of the 512-byte boundary, the TU58 will read as many sequential blocks as are needed to fulfill the byte count. The same process applies to the write function. This means that the host software or an on-tape file directory need only store the number of the first block in a file and the file's byte count to read or write all the data without having to know the additional block numbers.

3.1.2 Special Handler Functions

Some device-related functions are not dealt with directly in the RSP or in the TU58 firmware.

1. A short routine (perhaps entitled "Newtape") should be included in a TU58 handler to provide a complete wind-rewind for new or environmentally stressed tape cartridges. This procedure brings the tape pack to proper operating tension levels.

2. A TU58 handler should check the success code (byte 3 of the RSP end message) for the presence of soft errors. This enables action to be taken before hard errors (permanent data losses) occur. For example, if the number of retries on a particular cartridge reaches some value, a message like "Tape Maintenance Required" could be presented to the operator. This would suggest that prompt copying of the tape and cleaning of the head is in order.

3.2 RADIAL SERIAL PROTOCOL (RSP)

3.2.1 Message Packets

All communication between the TU58 and the host is divided into message packets, which are groups of bytes arranged in fixed order. Position within the packet determines the meaning of each byte. There are three kinds of message packets: command, data, and end messages. The end message is a special case of the command packet. In addition, there are three single-byte protocol management messages: INIT, Continue, and XOFF.

Each packet begins with a flag byte, which announces its contents. 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 message 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 16-bit words and using an end-around carry from bit 15 to bit 0. The flag and byte count are included in the checksum.

3.2.2 Flag Byte Op Codes

Bits 7–5 of the op code are reserved.

01_8	00001	Data
02_8	00010	Control (command)
04_8	00100	INIT
10_8	01000	Bootstrap
20_8	10000	Continue
23_8	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 does not look for an op code to execute.

Command — The command flag informs the TU58 that a command packet follows. An instruction code will be in this packet. The flag 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. The TU58 returns Continue after completion. It is sent from the TU58 to the host to indicate that the power-up sequence has occurred. When the TU58 makes a protocol error or receives an invalid command, it reinitializes and sends INIT continuously to the host. When the host recognizes INIT, it sends Break to the TU58 to restore the protocol.

Bootstrap — A flagbyte saying Bootstrap (octal 10), followed by a byte containing a drive number, causes the TU58 to read block 0 of the selected drive. It returns the 512 bytes without radial serial packaging. This simplifies bootstrap operations. Bootstrap may be sent by the host instead of a second INIT as part of the initialization process described below.

Continue — After a message is sent from host to the 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.

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 may send XOFF. The TU58 stops transmitting immediately and waits until the host sends Continue to complete the transfer when it is ready. (Two characters may be sent by the UART to the host after the TU58 receives XOFF.)

3.2.3 Break and Initialization

Break is a unique logic entity that can be interpreted by the TU58 and the host regardless of the state of the protocol. Break is transmitted when the serial line, which normally switches between two logic states called mark and space, is kept in the "space" condition for more than one character time. This causes the TU58's UART to set its framing error bit. The TU58 will interpret the framing error as break.

Break has two applications in the TU58: one is routinely used, and the other is for special conditions. When the TU58 is powered up, it performs its internal checkout and initialization and then transmits INITs continuously to the host to inform the host that it is present. The host acknowledges the TU58 by sending break for a minimum of one character time, and then sending two INITs. The TU58 responds with Continue and enters an idle state in which it will wait for further instructions.

If communications break down, due to any transient problem, the host may restore order by sending break and INIT as outlined above. Whatever faulty operations were underway will be cancelled, and the TU58 will reinitialize itself, return Continue, and wait for instructions.

With DEC serial interfaces, the initialize sequence may be sent by the following sequence of operations. Set the break bit in the transmit control status register, then send two null characters. When the transmit ready flag is set again, remove the break bit. This will time Break to be one character time long. The second character will be discarded by the TU58 controller. Next, send two INIT characters. The first will be discarded by the TU58. The TU58 will respond to the second INIT by sending Continue. When Continue has been received, the initialize sequence is complete and any command packet may follow.

3.3 COMMAND SET

The command set for the TU58 provides the capabilities required for the performance of random-access operations. To allow for future development, certain op codes in the command set have been reserved; these commands have unpredictable results and should not be used. Op codes not listed in the command set are illegal and result in the return of an end packet with the "bad op code" success code.

A data transfer operation uses three or more message packets. The first packet is the command packet from host to the TU58. Next, the data is transferred in 128-byte packets in either direction (as required by read or write). After all data is transferred, the TU58 sends an end packet. If the TU58 encounters a failure before all data has been transferred, it sends the end packet as soon as the failure occurs.

3.3.1 Command Packets

The command packet format is shown in Table 3-1. Bytes 0, 1, 12, and 13 are the message delivery bytes. Their definitions are as follows.

Table 3-1 Command Packet Structure

Byte	Byte Contents
0	Flag = 0000 0010 (02_8)
1	Message Byte Count = 0000 1010 (12_8)
2	Op Code
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

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.

The remaining bytes are defined as follows.

2	Op Code	Operation being commanded. Refer to Table 3-2 and Paragraph 3.4 for definitions.
3	Modifier	Permits variations of commands.
4	Unit Number	Selects drive 0 or 1.
5	Switches	Selects maintenance mode.
6, 7	Sequence Number	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.

Table 3-2 Instruction Set

Op Code Decimal	Op Code Octal	Instruction
0	0	NOP
1	1	INIT
2	2	Read
3	3	Write
4	4	(Reserved)
5	5	Position
6	6	(Reserved)
7	7	Diagnose
8	10	Get Status
9	11	Set Status
10	12	(Reserved)
11	13	(Reserved)

3.3.1.1 Maintenance Mode - Setting bit 4 of the switches byte (byte 5) to 1 in a read command inhibits retries on data errors. Instead, the incorrect data is delivered to the host followed by an end packet. The success code in the end packet indicates a hard data error. Since data is transmitted in 128- byte packets, a multiple packet read progresses normally until a checksum mismatch occurs. Then the bad data packet is transmitted, followed by the end packet, and the operation terminates.

3.3.1.2 Special Address Mode – Setting the most significant bit of the modifier byte to 1 selects special address mode. In this mode all tape positioning operations are addressed by 128-byte blocks (0–2047) instead of 512-byte blocks (0–511). Zero-fill in a write operation only fills out to a 128-byte boundary in this mode.

3.3.2 Data Packets

The data packet is shown in Table 3-3. 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.

Table 3-3 Data Packets

Byte	Byte Contents
0	Flag = 0000 0001
1	Byte Count = M
2	First Data Byte
3	Data
.	.
.	.
.	.
M	Data
M+1	Last Data Byte
M+2	Checksum L
M+3	Checksum H

3.3.3 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 Table 3-4. The definition of bytes 0, 1, 12, and 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
Byte 3	Octal	Success Code
	0	– 0 = Normal Success
	1	– 1 = Success but with Retries
	377	– 1 = Failed Self-Test
	376	–2 = Partial Operation (End of Medium)
	370	–8 = Bad Unit Number
	367	–9 = No Cartridge
	365	–11 = Write Protected
	357	–17 = Data Check Error
	340	–32 = Seek Error (Block Not Found)
	337	–33 = Motor Stopped
	320	–48 = Bad Op Code
	311	–55 = Bad Block Number (i.e. > 511)

Byte 4	Unit Number 0 or 1 for Drive Number
Byte 5	Always 0
Bytes 6, 7	Sequence Number - Always 0 as in command packet
Bytes 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.
Bytes 10, 11	Summary Status

Summary Status

Byte 10	Bit 0 → 7	Reserved
Byte 11	Bit 0	Reserved
	1	Reserved
	2	Reserved
	3	Reserved
	4	Logic Error
	5	Motion Error
	6	Transfer Error
	7	Special Condition (Errors)

Table 3-4 End Packet

Byte	Byte Contents
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

3.4 THE INSTRUCTION SET

The instructions and their op codes are shown in Table 3-2. The following is a brief description and usage 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	001X	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 ready 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, and Read with Increased Threshold
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 designated 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 indicates success, success with retries, or failure of the operation. In the event of failure, the end packet is 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 causes the TU58 to read the tape with an increased threshold in the data recovery circuit. This makes 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 in Figure 3-1.

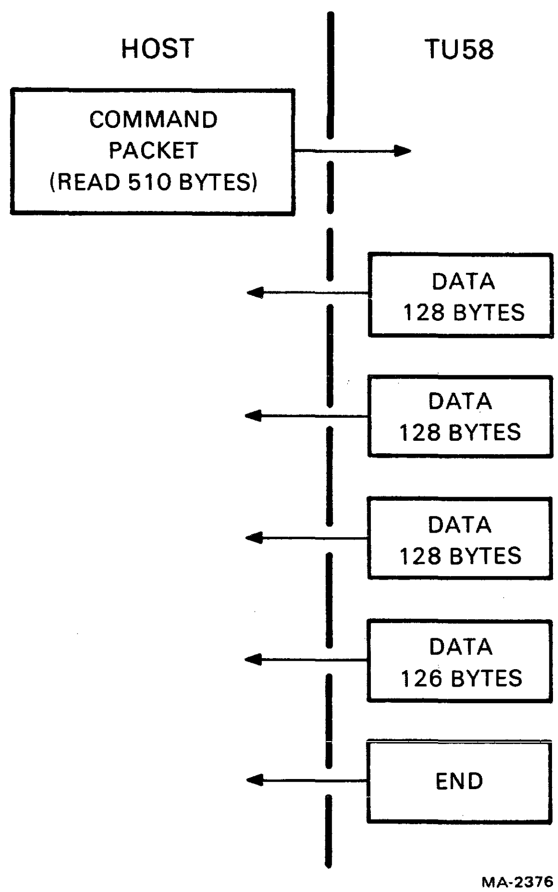


Figure 3-1 Read Command Packet Exchange

OP CODE 3 Write, and Write and Read Verify

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 automatically zero-fills any remaining bytes in an 512-byte tape block.

There is one modifier permitted with the write command. A modifier of 0000 0001 causes the TU58 to write all of the data and then back up and read the data just written with increased threshold and test the checksum of each record. If all of the checksums are correct, the TU58 sends an end packet with the success code set to 0 (or 1 if retries were necessary to read the data). Failure to read correct data results 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 in Figure 3-2.

OP CODE 4 (Reserved)

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 (Reserved)

OP CODE 7 Diagnose

This command causes the TU58 to run its internal diagnostic program which tests the processor, ROM, and RAM. Upon completion, TU58 sends an end packet with appropriate success code (0 = Pass, –1 = Fail).

OP CODE 8 Get Status

This command is treated as an NOP. The TU58 returns an end packet.

OP CODE 9 Set Status

This command is treated as an NOP because TU58 status cannot be set from the host. The TU58 returns an end packet.

OP CODE 10 (Reserved)

OP CODE 11 (Reserved)

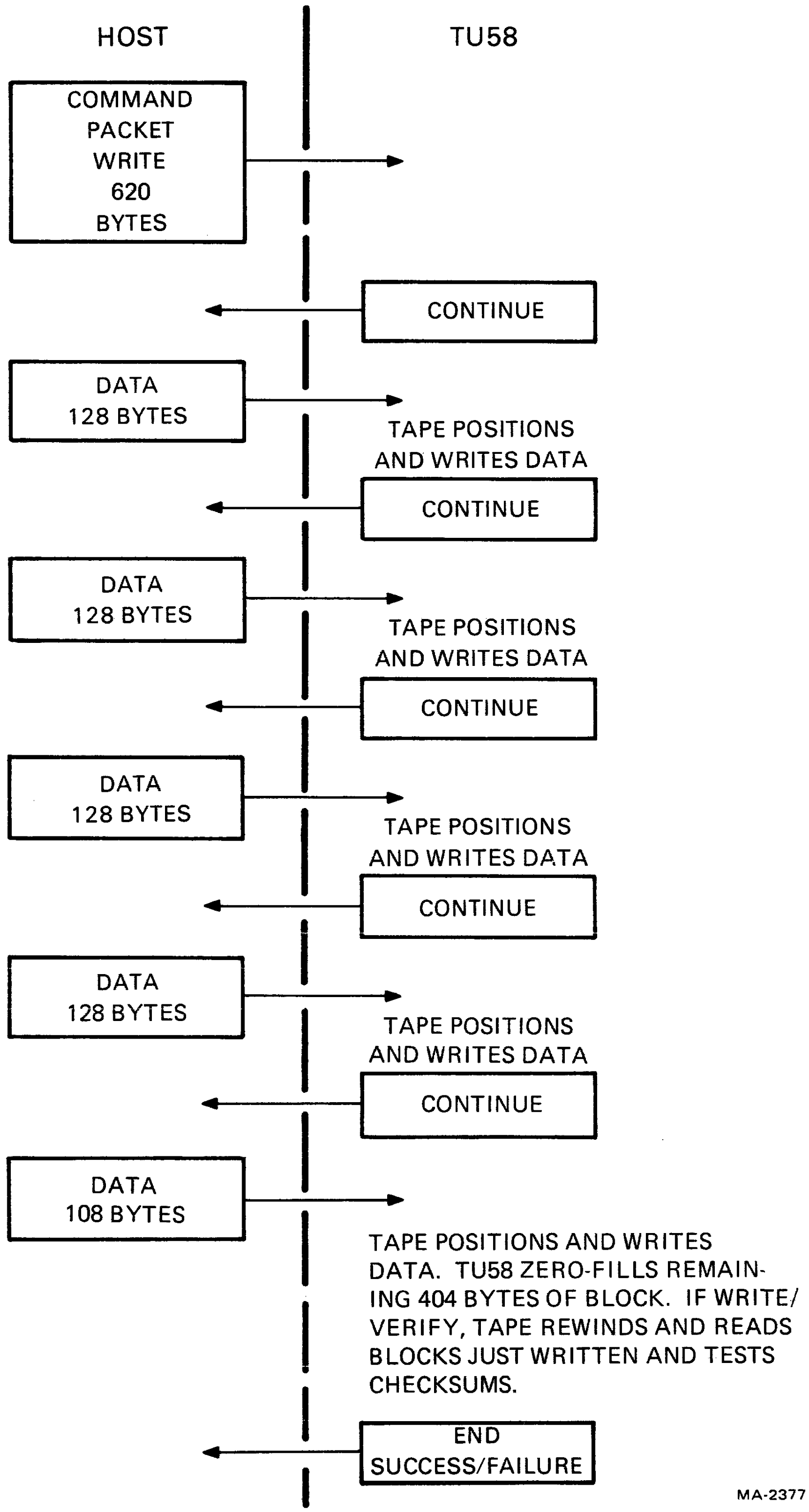


Figure 3-2 Write Command Packet Exchange

CHAPTER 4
INSTALLATION

4.1 INSTALLATION OF RACK VERSION

4.1.1 Mounting in a Rack

The TU58-CA rackmount unit mounts in 13.2 cm (5.2 in) of standard 48.3 cm (19 in) width rack. It should be located so that the 2 m (6 ft) power cord can reach a power controller outlet box such as the DEC 861 or any power outlet.

To get to the mounting holes, remove the bezel (Figure 4-1) by gripping it at the top and bottom with both hands. Rotate it out from the bottom and lift it away. (If the unit is installed in a recessed rack, the bezel may be removed by gripping it with both hands on the left edge with fingers or thumbs inside the storage well. Pull sharply out and swing the bezel away.

WARNING
Metal bezels are heavy!

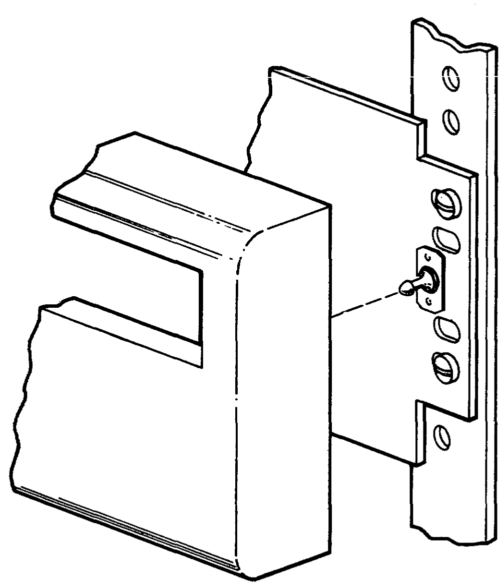


Figure 4-1 Bezel and Clip

If the rack requires them, install four speednuts at the holes spaced according to Figure 4-2. The TU58 is light enough for one person to install. Put the two bottom screws in first to avoid bending the mounting ears.

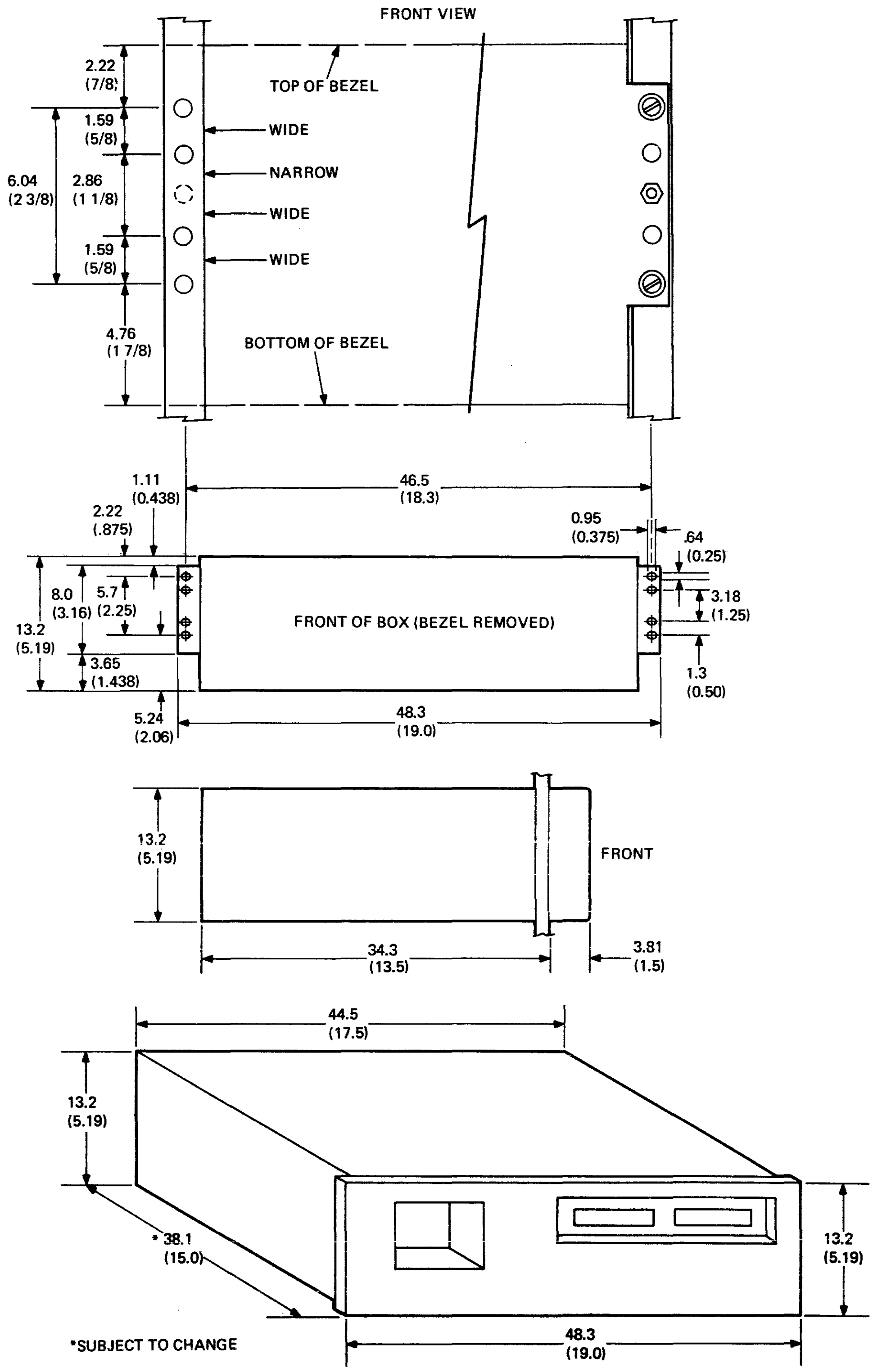


Figure 4-2 Rack Mounting the TU58-CA

4.1.2 Power Selection for the Rack Version

A line cord for 110 V and two fuses are supplied with the TU58-CA. Line cords for other voltages and standards may be purchased separately. The chassis power receptacle meets European IEC standards. A switch on the back of the rackmount cabinet selects 110 or 220 V (Figure 4-3).

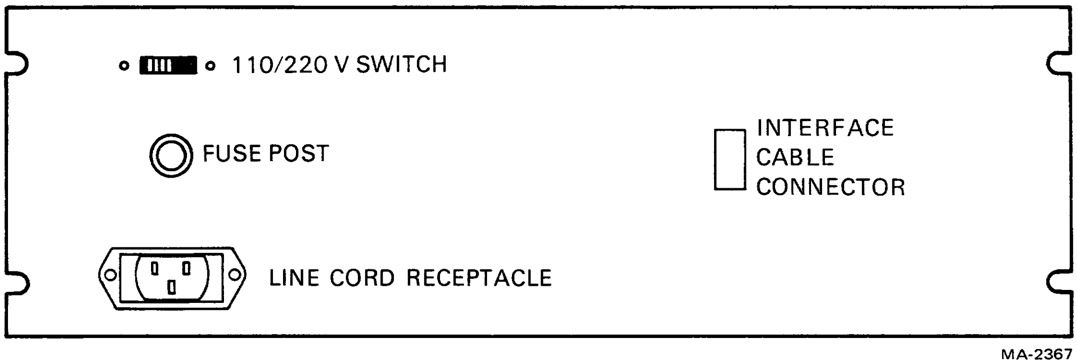


Figure 4-3 TU58-CA Rear Panel

1. Set the switch to the correct value using a small screwdriver.

CAUTION

If the unit is plugged into a 220 V circuit while set for 110 V, it may be severely damaged.

2. Install a fuse in the fuse post.

NOTE

A 3/8 A slow-blow fuse is required for 220 V, a 3/4 A slow-blow fuse for 110 V.

3. Insert the appropriate power cord into the receptacle. Do not plug it into an outlet until the installation is complete.

4.1.3 Removing Module From Chassis

The drive and module mounting cage must be pulled forward for the module to clear the bottom of the rack cabinet (Figure 4-4).

1. Unplug the power, drive, and interface connectors.

CAUTION

Be careful around the thin tachometer disk. It is easily bent (and its edge is sharp). If the disk gets bent without creasing, it might be straightened with pliers. Alignment is not critical, but it is better if the disk does not rub against the optical sensor block. It it cannot be aligned, or if it is creased, it must be replaced.

2. Lift one of the spring-metal catches at the bottom left or right edges of the cage and pull that side of the cage forward just enough to clear the catch.

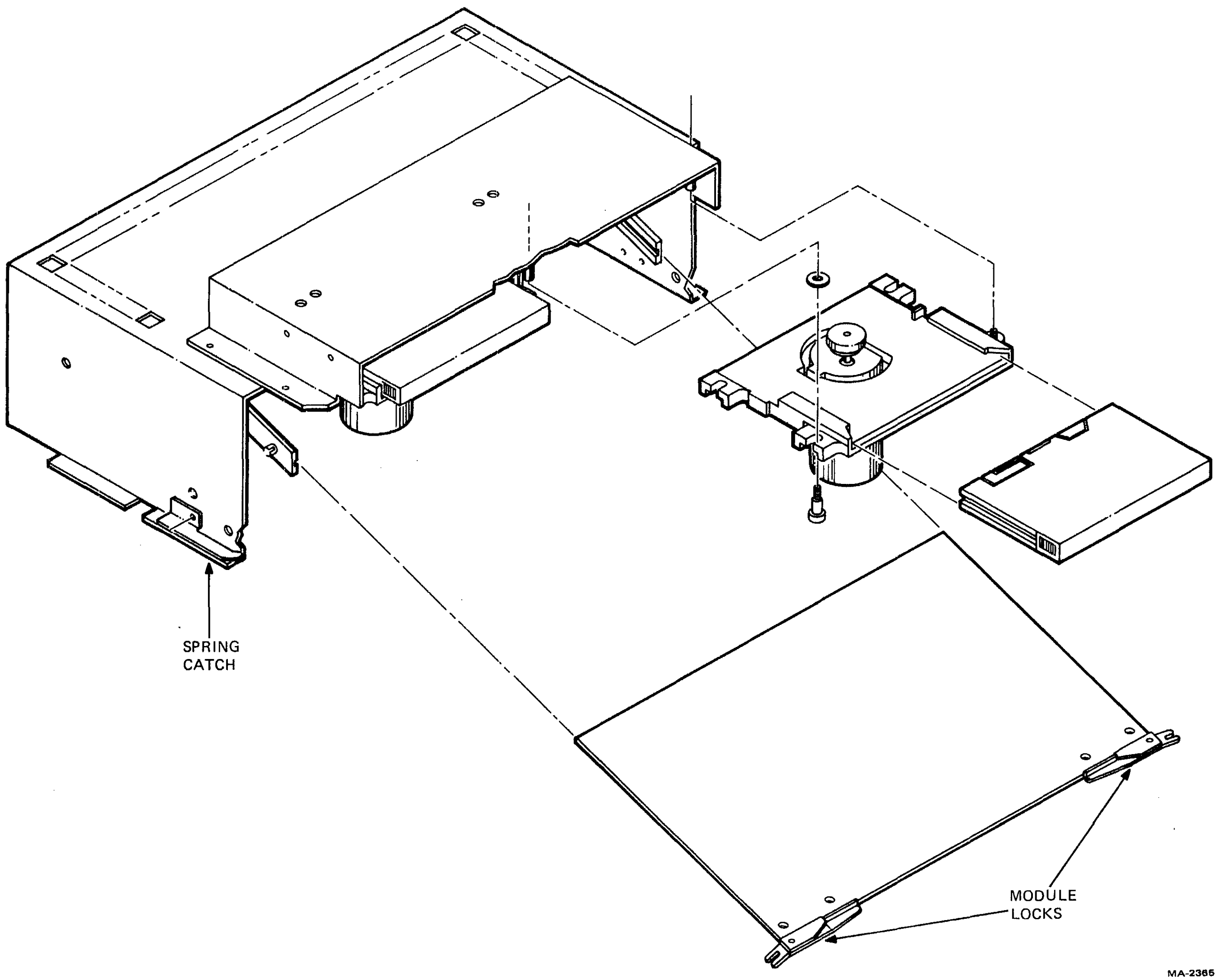


Figure 4-4 Module Removed from Chassis

3. Release the other side in the same way.

4. Slowly pull the cage forward about 5 cm (2 in).

5. Unlatch the module handle locks and pull the module out. The loose cage may be tilted to provide clearance.

4.1.4 Reinstalling the Module

1. Slide the module into the guides in the cage, lifting the drive cables out of the way. (This may be done with the cage removed from the rack.) Do not latch the module into place yet.

2. Plug the drive cables into the module headers, left drive to left header and right to right. The plugs are keyed and install with the cables attached to them from the rear of the cabinet.

3. Set the cage on the edge of the cabinet and reach behind to the power supply cable. Thread the cable into the cage over the module. The three keying fingers are on the left as the plug goes onto the power header on the module.

4. Push the module firmly into the cage and latch it into place.

5. The interface cable enters the rackmount cabinet through a connector on the back panel. Draw the flat interface cable forward under the module and cage and arrange it so that the connector can fit into the header without twisting the cable. The red stripe is on the left and the cable goes into its connector from below.

6. Dress the cable so that it is not crimped under the cage edges and line the four cage ears with the punched tabs in the cabinet bottom plate. Push the cage back into the tabs until the spring catches click.

4.2 DRIVE AND MODULE INSTALLATION (DOES NOT APPLY TO RACKMOUNT)

Figures 4-5 and 4-6 provide the mounting dimensions for the circuit board (module) and drive mechanism. The drive has a 19 cm (7.5 in) cable which plugs into the module header with the wires coming out of the plug toward the center of the module. The plug is keyed to ensure proper orientation. The cartridge extends 1.60 cm (0.62 in) from the front of the drive. If the drive is recessed in a panel, clearance must be provided around the opening for fingers to grip the cartridge. Ideally, the cartridge slot in a front panel will be somewhat larger than minimum, to allow easy insertion. The opening should be at least the dimensions of the cartridge, 1.3 cm (0.5 in) × 8.1 cm (3.2 in), located not more than 0.53 cm (0.17 in) above the bottom mounting surface (line A in Figure 4-5).

The module should be mounted on a flat surface with 3 mm (4-40) hardware and 1 cm (3/8 in) standoffs. Both the module and the drive may be mounted at any angle. For mounting to a surface above the drives, the 1.80 cm (0.71 in) clearance is required; hole spacing is given in the outline drawings. For mounting to a surface below the drives, an 8.18 cm (3.22 in) × 8.89 cm (3.50 in) chassis cutout is required, with the same mounting hole spacing.

CAUTION

The mounting surface for the drives must be flat within 0.64 cm (0.025 in).

4.3 INTERFACE STANDARDS SELECTION AND SETUP

The TU58 is shipped with factory-installed jumpers for a transmission rate of 38.4 kilobaud and the RS-423 unbalanced line interface (Figure 4-9). A variety of standards and rates may be selected by changing the jumpers on the controller module. Table 4-1 provides a list of all the pins on the board and their functions, including the wire-wrap (WW) pins, interface, and power connectors.

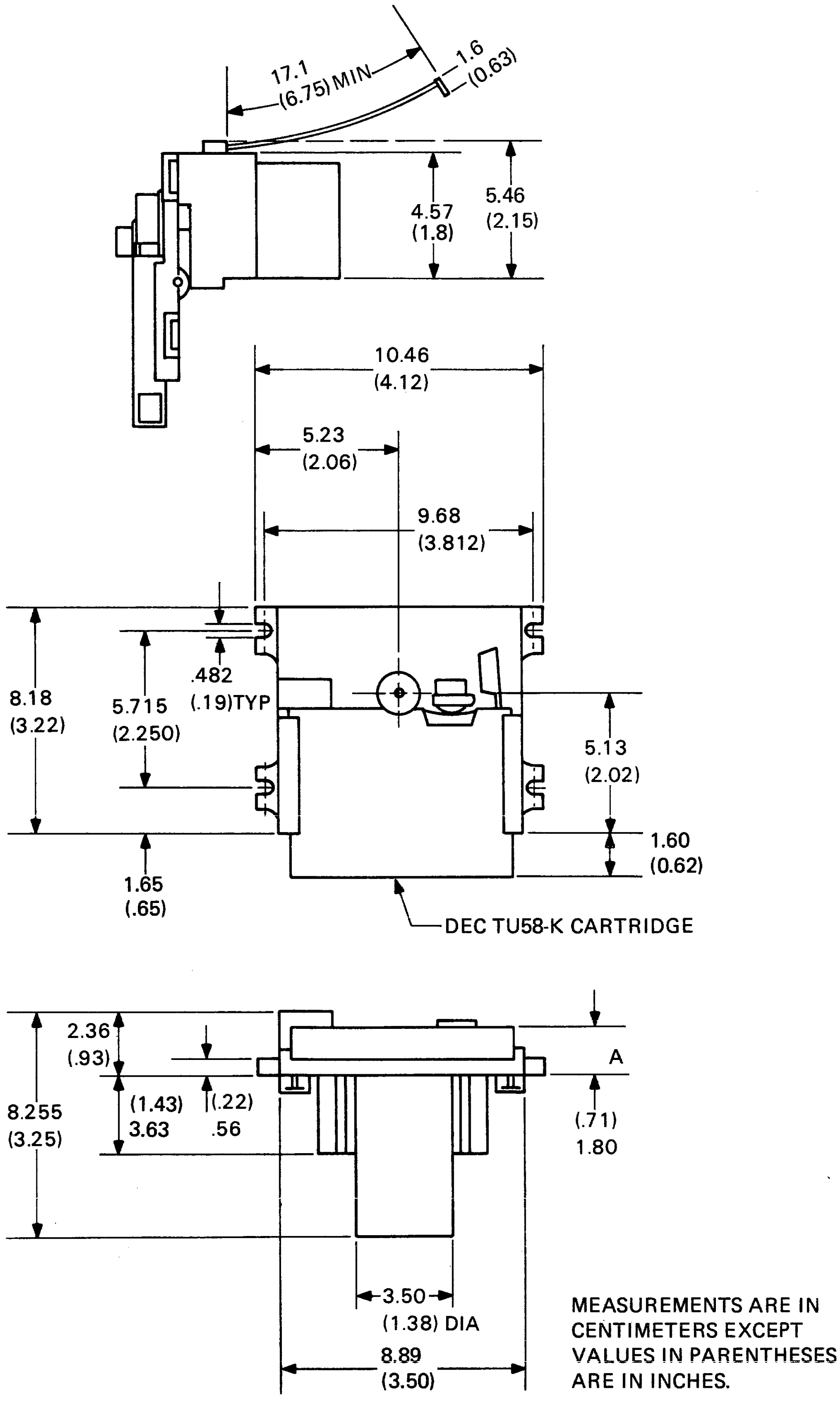
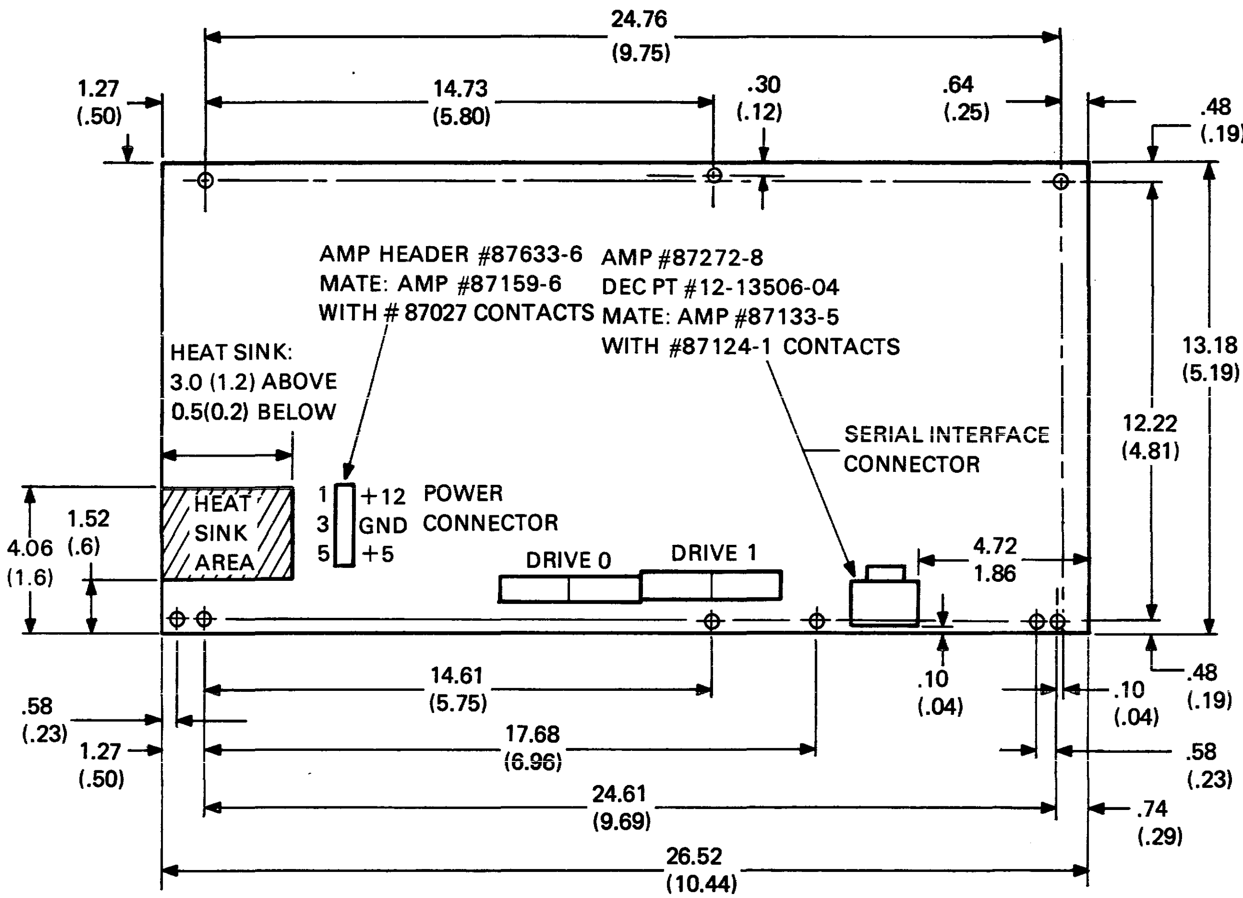


Figure 4-5 Drive Outline Drawings



MEASUREMENTS ARE IN
CENTIMETERS EXCEPT VALUES IN
PARENTHESES ARE IN INCHES
MEASUREMENTS ARE ±.013 (.005) CENTER TO
CENTER

MA-2370

Figure 4-6 Module Outline Drawing

Table 4-1 TU58 Module Connections

Wire-Wrap Pins

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

J2-10	Auxiliary B	J2-5	Ground
J2-9	Ground	J2-4	Transmit Line –
J2-8	Receive Line +	J2-3	Transmit Line +
J2-7	Receive Line –	J2-2	Ground
J2-6	Key (no connection)	J2-1	Auxiliary A

Power Input Connector

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

Drive Cable

J3,4-1	Cart L	J3,4-9	LED
J3,4-2	No Connection	J3,4-10	Head Shield Ground
J3,4-3	Permit L	J3,4-11	Erase Return
J3,4-4	Signal Ground	J3,4-12	Erase 1
J3,4-5	Motor +	J3,4-13	Erase 0
J3,4-6	Motor –	J3,4-14	Head Return
J3,4-7	+12 V	J3,4-15	Head 0
J3,4-8	Tachometer	J3,4-16	Head 1

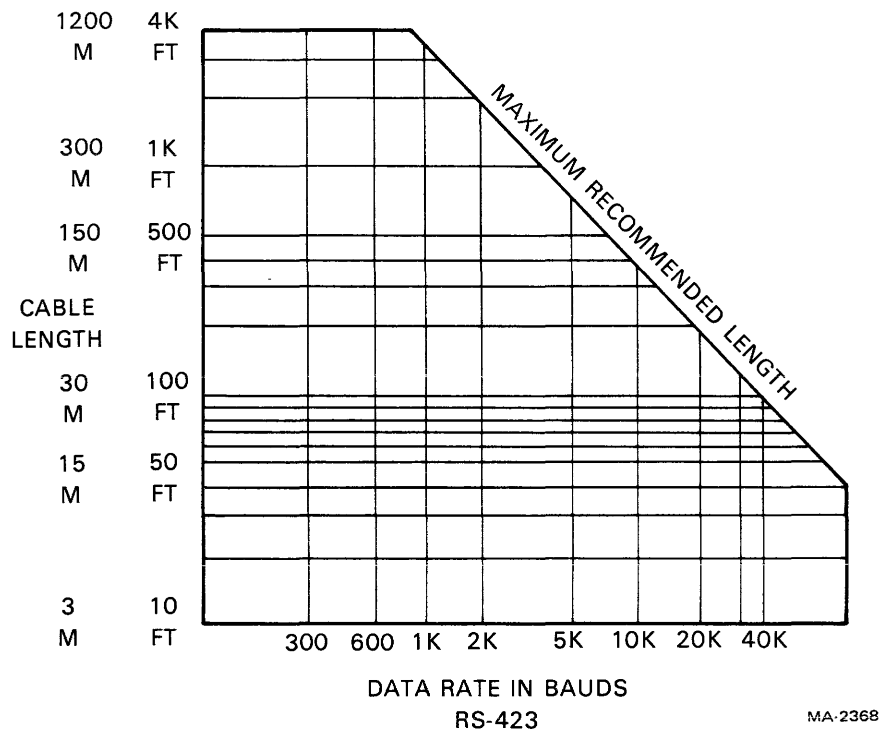


Figure 4-7 Data Rate and Cable Length for RS-423

4.3.1 Selecting Interface Standards

The serial interface operates on full-duplex, asynchronous 4-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 kilobaud 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 m (90 ft). The wire used with any installation should be no less than 24 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 m (4000 ft) at any TU58 data rate. Figure 4-7, 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.

4.3.2 Connecting Standard Jumpers

The jumper pins are standard 0.635 mm (0.025 in) wire-wrap posts which may be connected using 30 AWG wire and a hand tool. Other techniques that may be used include slip-on connectors such as DEC H821 Grip Clips, 915 patchcords, 917 daisy-chain, or soldering.

The baud rates may be set independently for transmission and reception, or both can operate at the same speed. Simply connect the pin with the desired baud value to either the XMIT or RCV pins or both. Figure 4-8 illustrates the pin locations, and Figure 4-9 shows the factory-wired configuration.

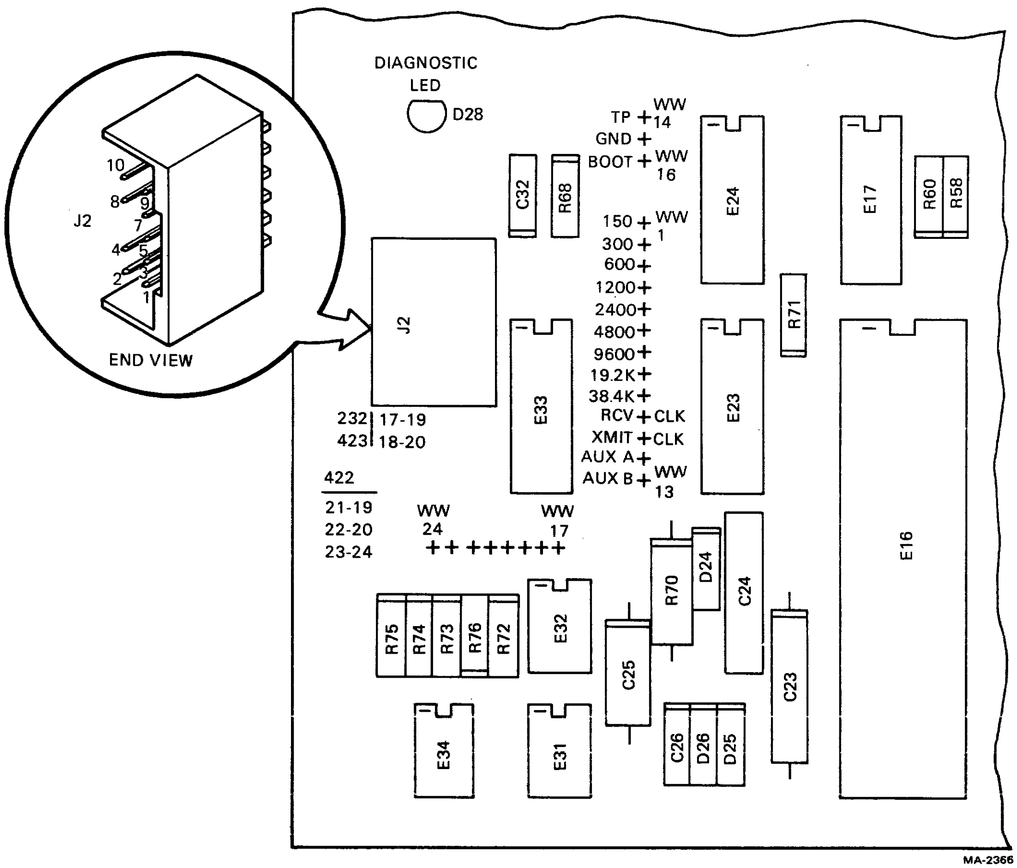


Figure 4-8 Interface Selection Jumper Pin Locations

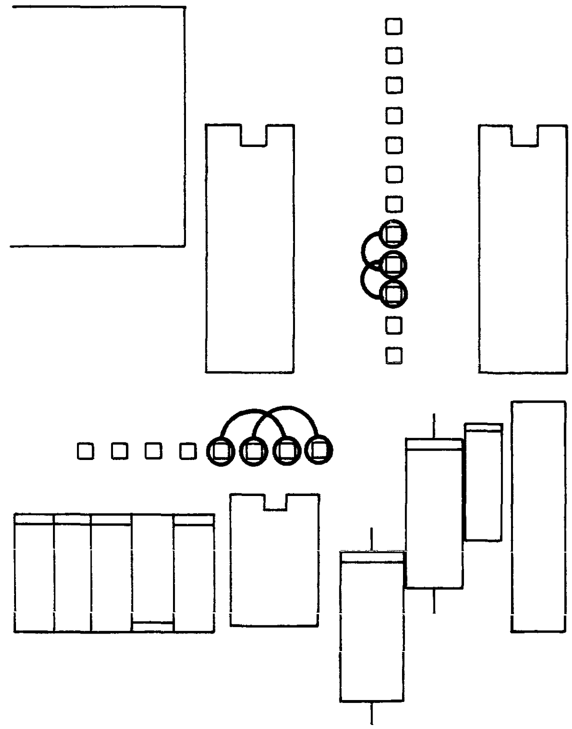


Figure 4-9 Factory Wiring

The interface standards may be selected by connecting sets of pins together. The connections are listed in abbreviated form in Figure 4-8. The group of pins 17 through 24 are the interface pins. The module is shipped prewired for RS-423 with pin 17 connected to pin 19, and pin 18 connected to pin 20. No other pins in the group are connected.

For RS-422, pin 21 should be tied to pin 19, pin 22 to pin 20, and pin 23 to pin 24. No other pins in the group are connected.

4.4 OPERATIONAL CHECKOUT

A confidence check of the operation of the newly installed TU58 may be performed through the console or keyboard console emulator of a host system without the use of an operating system device handler. The light on the TU58 module should be on, indicating a functional processor.

4.4.1 Checkout of Interface

To address the serial interface device registers with the console (consult the system manuals for address and codes), perform the following steps.

1. Set the transmit control status register to send Break to the TU58.
2. Remove the Break condition.
3. Transmit INIT: 04 (octal) to the TU58.
4. Transmit a second 04.
5. Examine the receive data buffer to find Continue: 20 (octal).

4.4.2 Checkout of RSP and Command Function

1. Insert a tape cartridge into drive 0 (left side) (The TU58 should have sent Continue (20_8) already, as in Paragraph 4.4.1).

2. Transmit the following string of octal numbers to the TU58. (Consult the programming chapter for an explanation of this format.)

Byte 1	2
Byte 2	12
Byte 3	2
Byte 4	0
Byte 5	0
Byte 6	0
Byte 7	0
Byte 8	0
Byte 9	0
Byte 10	200
Byte 11	200
Byte 12	0
Byte 13	204
Byte 14	212

The TU58 should wind to the beginning of the tape and read about half of the tape.

CHAPTER 5
OPTIONS

Options may be added to the TU58 to enhance its product performance. These additions are described in this chapter.

5.1 RUN INDICATOR

Each tape drive may be modified to have an LED which lights to indicate tape motion. Since data loss can occur if a cartridge is removed while the tape is being written, the cartridge should not be touched if the light is on.

5.1.1 Installation

The LED (which may be any device capable of handling 30 mA with a forward voltage less than 1.8 V) is wired in series with the tachometer source LED. Splice the run LED into the wire from pin 7 of the drive connector. (Count from the end with the missing pin. That pin is number 2.) The anode should be on the module side of the wire (symbol arrow pointing away from pin 7). See Figure 5-1. The LED is available from DEC as part number 11-10324, and wires with slip-on connectors are available to join the LED to the tach (cable number 70-16526) and to extend the module connector end to the LED at the front of the drive (cable number 70-16525).

5.2 BOOT SWITCH

Some applications use the TU58 as a program loader. The intelligence of the TU58 enables it to perform a seek and read operation without processor commands. Pins are available on the controller module which, when connected by the Boot switch, initiate the following actions.

1. On power-up, the TU58 checks for the presence of the closed switch. It then delays 1 second and begins the boot procedure.

2. When the TU58 is in the idle state, it monitors the Boot switch. Any switch contact open-close sequence causes a 1-second delay (to allow for contact settling or to allow the host processor to enter the halt mode), and then the TU58 begins the boot procedure.

The boot procedure positions the tape in drive 0 to block 0, sends Break to the host, and transfers ASCII characters from the tape to the host in groups of seven. Each group is separated from the adjacent groups by 15 character times (based on 9600 baud). The TU58 exits the boot mode following the transfer of the terminating character ASCII G (147_8) and enters the idle state. Because of the timing requirement, only rates of 9600, 19.2, and 38.4 kilobaud may be used with boot.

Boot is intended for use with the LSI-11. The boot tape contents are formatted to appear to the LSI-11 as output from a console (keyboard) operating under the ODT keyboard interpreter. This means that the TU58 must be located at the standard console address in the LSI-11 bus. A keyboard cannot be connected at the same time. This arrangement is useful in an unattended control system, where the TU58 can automatically load and start or reload and restart an unsupervised process controller or similar application. The Boot switch allows a reboot without powering down to cycle the automatic sequence.

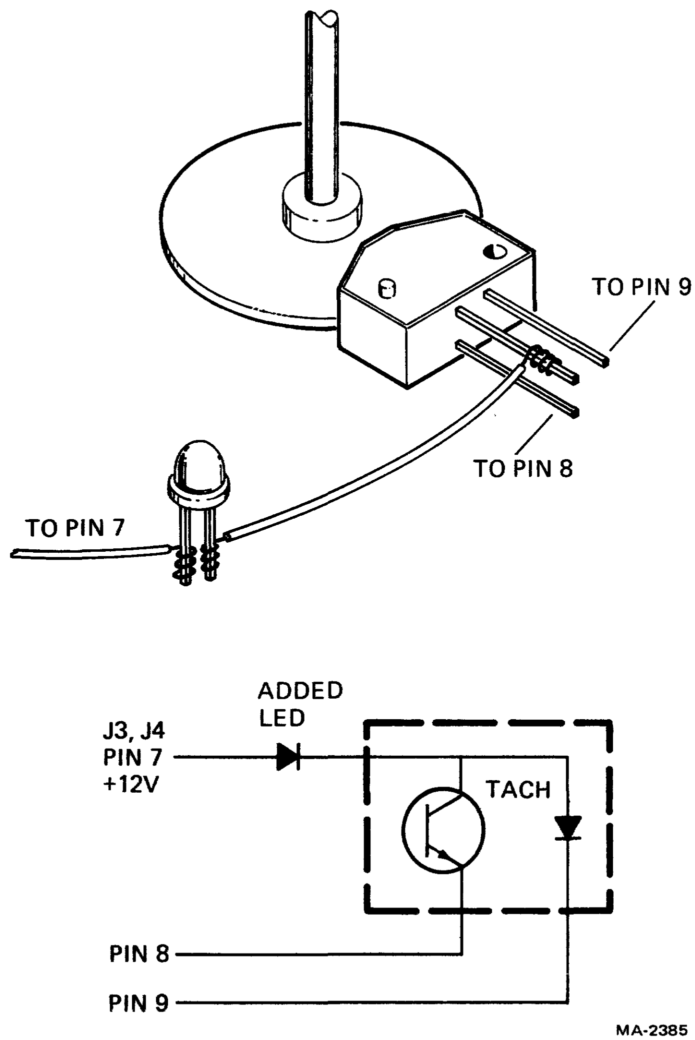


Figure 5-1 Installation of Run Indicator

A utility program running under RT-11 will be available from DEC which will take a user program that was developed under RT-11 and generate a boot tape containing that program, suitable for automatic loading.

NOTE

Boot mode does not work in any DEC operating system environment.

The boot pin on the module (WW16) may be connected to ground (WW15) through a normally closed momentary action switch (Paragraph 4.4.2). Wires may be wire-wrapped, DEC Grip-Clipped, or soldered to the pins. Placement of the switch and lead dress are not critical if adequate clearance is provided around moving parts of the drive and the heat sink and power resistors on the module.

CHAPTER 6
TECHNICAL DESCRIPTION

This chapter is designed to enable the reader to understand the TU58 drive and controller operating principles. In some sections of the text, a simplified schematic or block diagram of a circuit illustrates a concept. References to these figures are made in the text. Other parts of the text are intended to highlight circuits in the Engineering Print Set, included at the end of this manual.

6.1 BLOCK DIAGRAM

Figure 6-1 shows the signal and control paths between the various elements of the TU58 and between the TU58 and its internal microprocessor. This diagram illustrates the control the microprocessor has over activities in the TU58.

6.1.1 Data Flow, Tape to Interface

Refer to Figure 6-2. The tape track is selected by signals from the I/O ports. Recorded data passes through the selection circuits to the read amplifier. There the signal amplitude is adjusted to a standard level by the automatic gain control (AGC) action of the circuit. The Gain Reduce signal allows detection of weak recordings. The slope changes of the sinusoidal signal are sensed by the peak detector that produces a squarewave with a duty cycle similar to that of the original encoded data. The duty cycle is decoded to data bits by an integrater in the bit detector that delivers the bits to the microprocessor serial data input (SID) with a strobe signal from the peak detector.

The microprocessor deserializes the read data and stores it in the data buffer area of memory. After a 128 byte record has been stored, a checksum calculated from the read data is compared with the checksum read from the tape. If they do not match, retries are attempted. Failure is indicated to the host in an end packet. Success results in the transfer of the data, one byte at a time, to the interface. If the unit has a parallel interface, the data is transferred eight bits at a time upon receipt of a strobe from the host. If the unit has a serial interface, the data is loaded into a UART and transmitted through line drivers with one start bit and one stop bit. A charge pump supplies negative voltage for the bipolar EIA line drivers since the power supply only produces positive voltages.

6.1.2 Data Flow, Interface to Tape

Data enters the interface and is latched (parallel) or deserialized and stored in a register (serial) (Figure 6-3). The microprocessor receives a ready signal from the interface and transfers the data to a buffer area in memory. The data then reenters the microprocessor, is serialized, ratio-encoded, and sent to the write circuit through the serial data output (SOD). When the write circuit interlock is released by the cartridge-activated write permit switches on the drives, write current is delivered to the correct head gap by selection circuits under microprocessor control. The erase circuit control logic is part of this control loop.

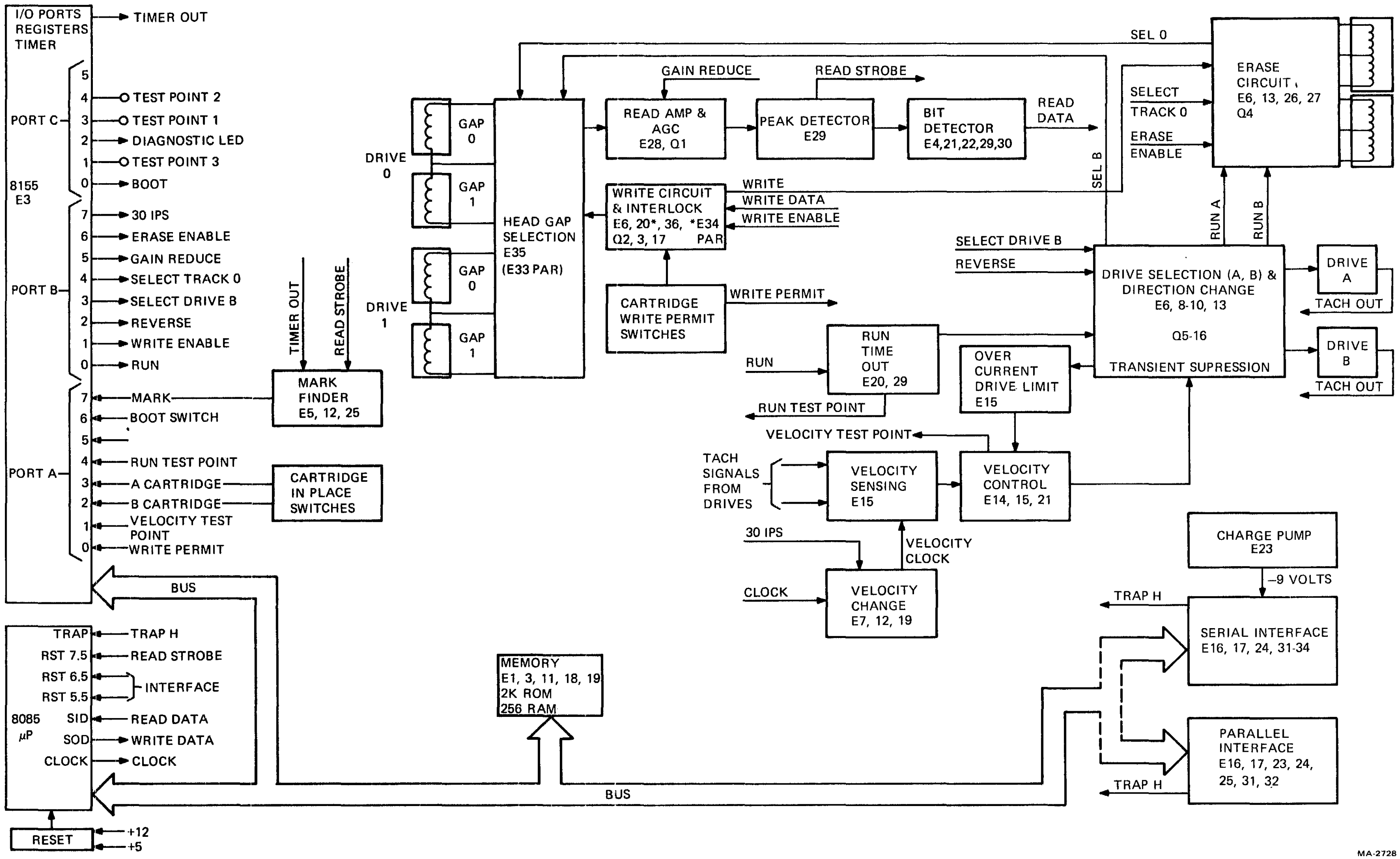


Figure 6-1 TU58 Block Diagram

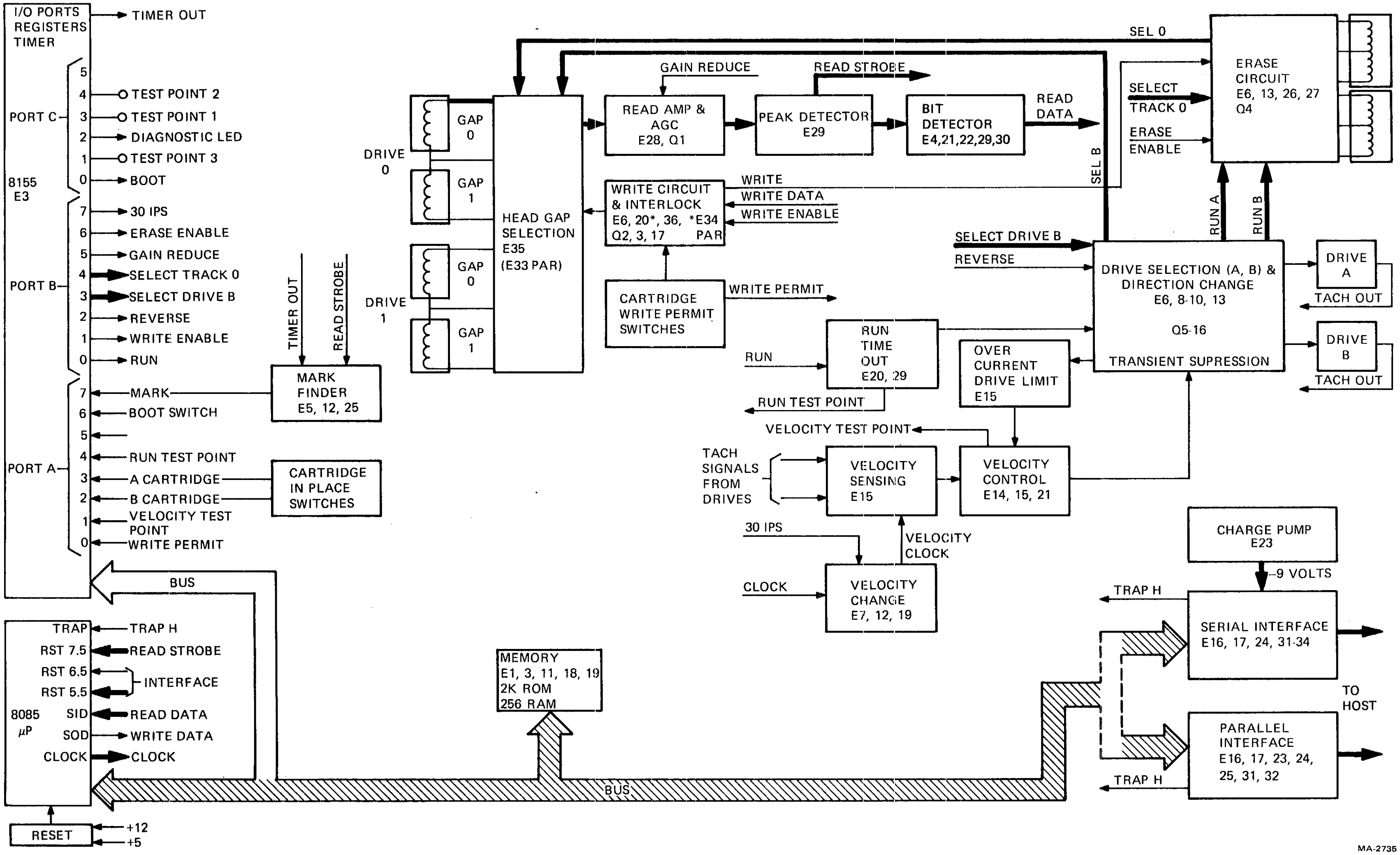


Figure 6-2 Data Flow, Tape To Interface

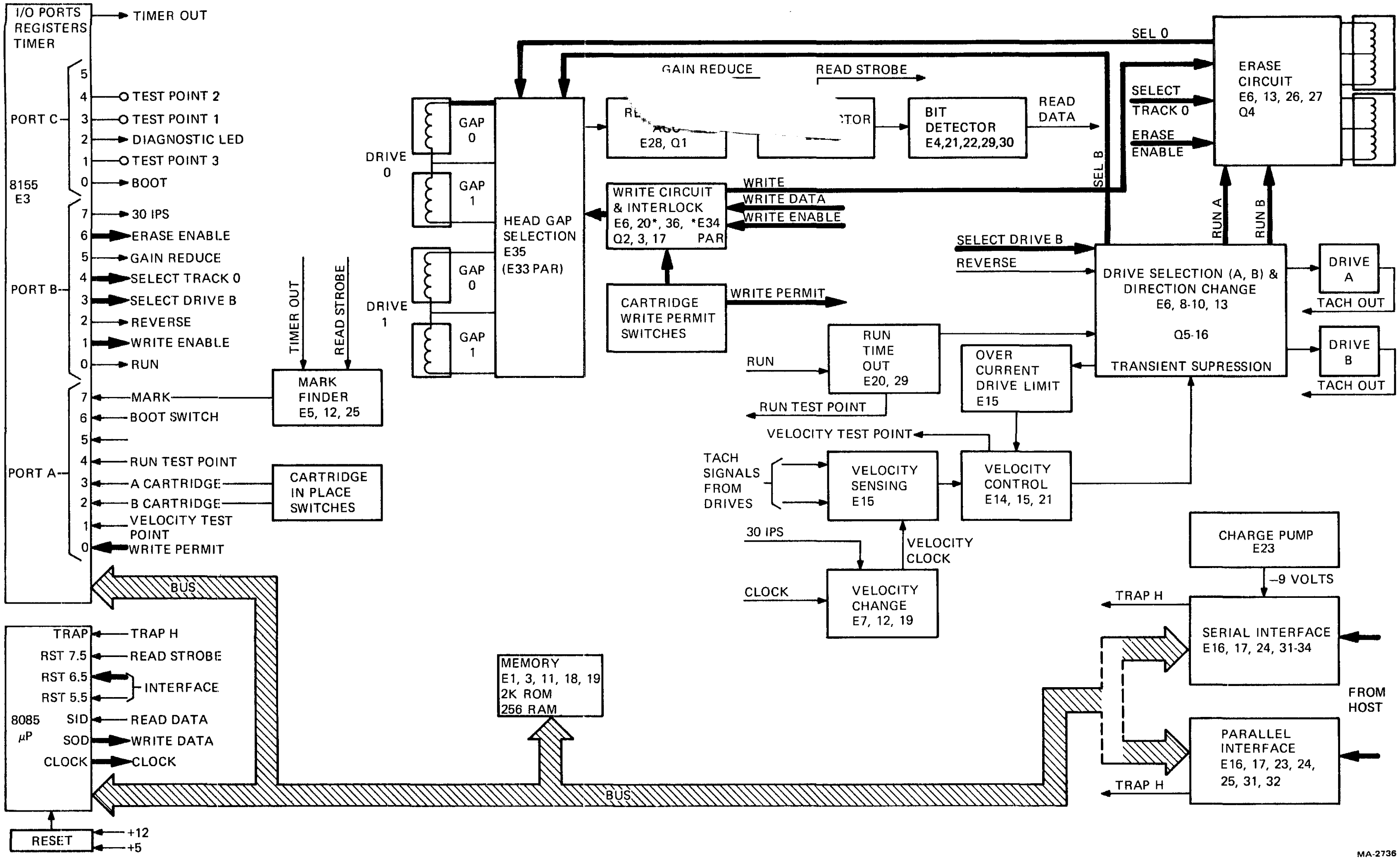


Figure 6-3 Data Flow, Interface To Tape

6.1.3 Tape Motion Control

Refer to Figure 6-4. Tape is protected from unspooling under fault conditions by a run timeout circuit. Regular RUN pulses from the microprocessor keep the run timeout disengaged. Microprocessor signals control the direction and drive selection gates to channel power to the correct drive transistors. No operations can occur unless the cartridge-in-place switch on the desired drive is engaged. The amplitude of applied motor current is regulated by a velocity control servo that senses the pulse rate from a tachometer mounted on each drive. Speeds are selected by a microprocessor-controlled velocity change circuit that controls the clock to the velocity sensing circuit. A motor over-current drive limiter keeps the maximum current to a safe value, even under stall conditions. A mark finder circuit locates specially encoded signal bursts on the tape to allow positioning of the tape at high speed. The microprocessor counts these interrecord marks as they pass by.

6.2 VELOCITY CONTROL

6.2.1 Velocity Sensing

Each motor has a LED lamp focussed on a phototransistor through a slotted disk on the motor shaft. (Only the activated drive delivers a tachometer signal.) This optical tachometer output is amplified and shaped by a comparator to produce a pulse rate proportional to the shaft speed of the motor. The buffered pulses from the optical tachometer go into an 18-bit shift register. The clock for the shift register is selected to give a quarter-period delay to the pulses at the desired shaft speed. The delayed and undelayed pulses are then exclusive-ORed to yield a pulse width modulated representation of the actual velocity. Modulation occurs because the shift-register delay, a fixed amount of time, is a different fraction of a period for different tachometer frequencies. Therefore, the amount of overlap varies between delayed and undelayed waves. The overlap is extracted by the exclusive-OR gate, averaged to a dc level by a capacitor, and buffered by an operational amplifier (op amp).

6.2.2 Velocity Servo

The quarter-period overlap at the desired shaft speed produces a 50 percent duty cycle output into the averaging capacitor. This puts the desired speed in the middle of a linear dc level versus speed curve at the op amp input. For an underspeed condition, the motor is accelerated to the correct speed, while for an overspeed, power is reduced and the motor coasts down.

6.2.3 Velocity Change

The velocity clock signal that drives the shift register is generated by a programmable divider from the microprocessor clock. A flip-flop and a gate (controlled by the 30 IPS signal from the microprocessor) produce pulses divided by 2 or 4. They receive their inputs from a fixed divider that also supplies the charge pump and UART. The resulting velocity control frequencies are 1/8 microprocessor clock for 60 in/s and 1/16 microprocessor clock for 30 in/s. The output goes to the shift register in the sensing circuit.

6.2.4 Drive Selection and Direction Change

Only two microprocessor signals are required to control drive selection and direction. When the signals are not asserted, drive A is selected in the forward direction. When RUN L, common to both drives, is asserted, SEL DRV B L signal gating directs the run signal to a pair of gate/drivers associated with the power switch section of each drive bridge. REVERSE H signal gating selects the gate/driver for the appropriate direction and also selects the paths for the velocity servo output to get to the correct motor control transistors. The simplified circuit in Figure 6-5 shows the current path for the forward direction.

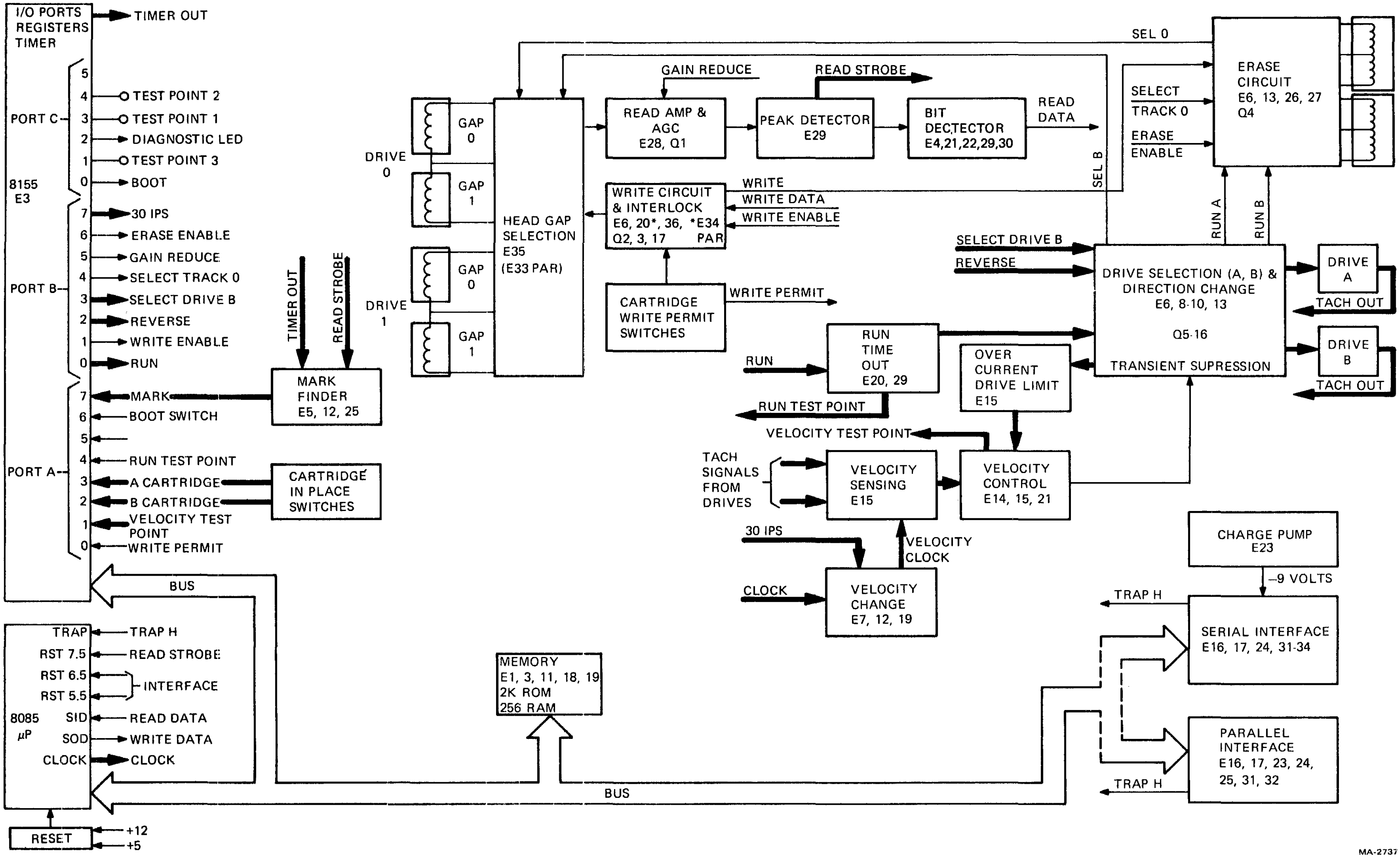


Figure 6-4 Tape Motion Control

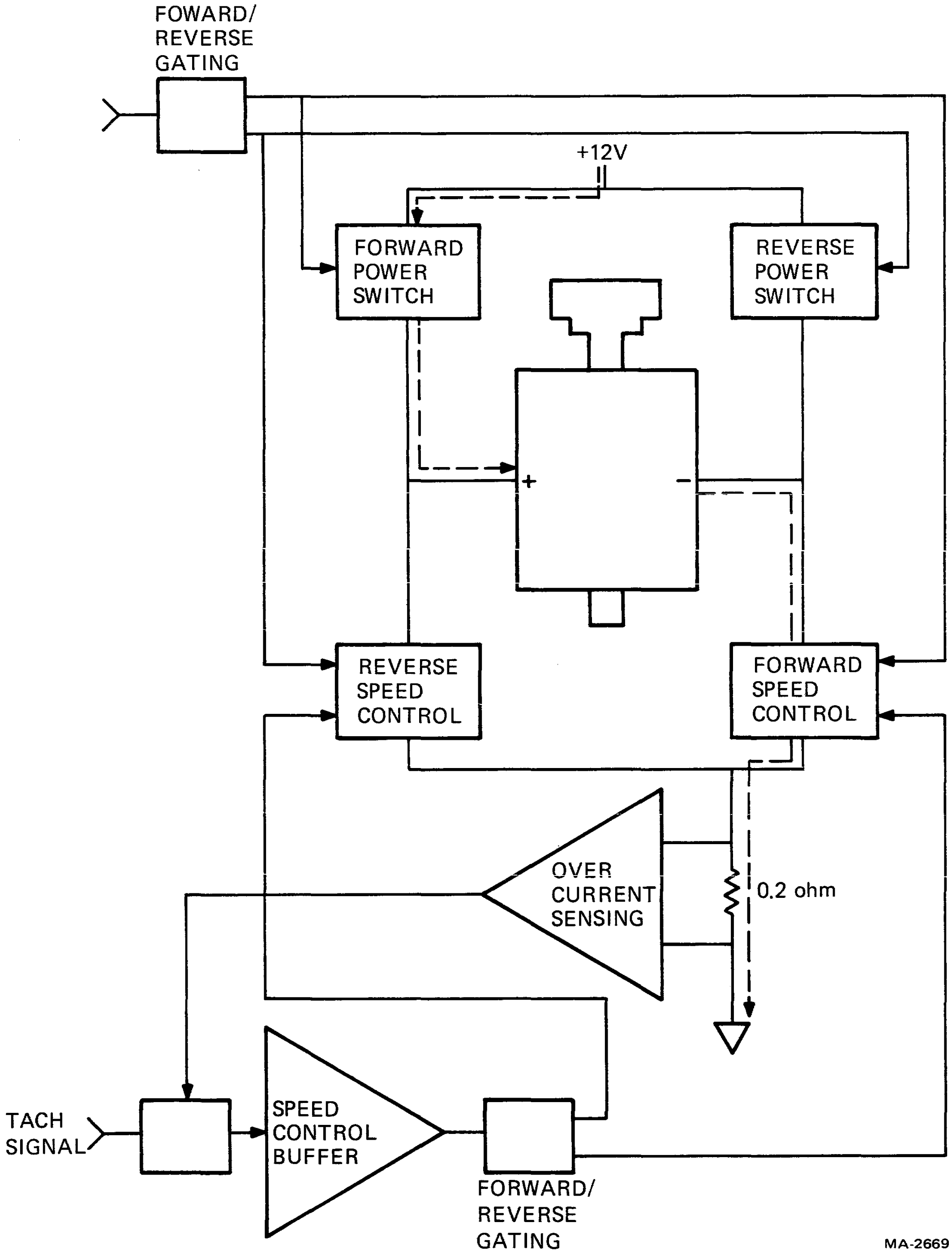


Figure 6-5 Motor Bridge

6.2.5 Microprocessor Velocity Control

Since the power supply for the motor is unipolar the motor polarity must be changed to reverse direction. The microprocessor switches the polarity of the motor in the drive bridge at appropriate times to stop or reverse the tape motion with full power. Once power to the motor has been reversed, the microprocessor monitors velocity by comparing the pulse rate from the velocity test point with an internal timing reference set by firmware. When the shaft pulse interval is longer than the reference

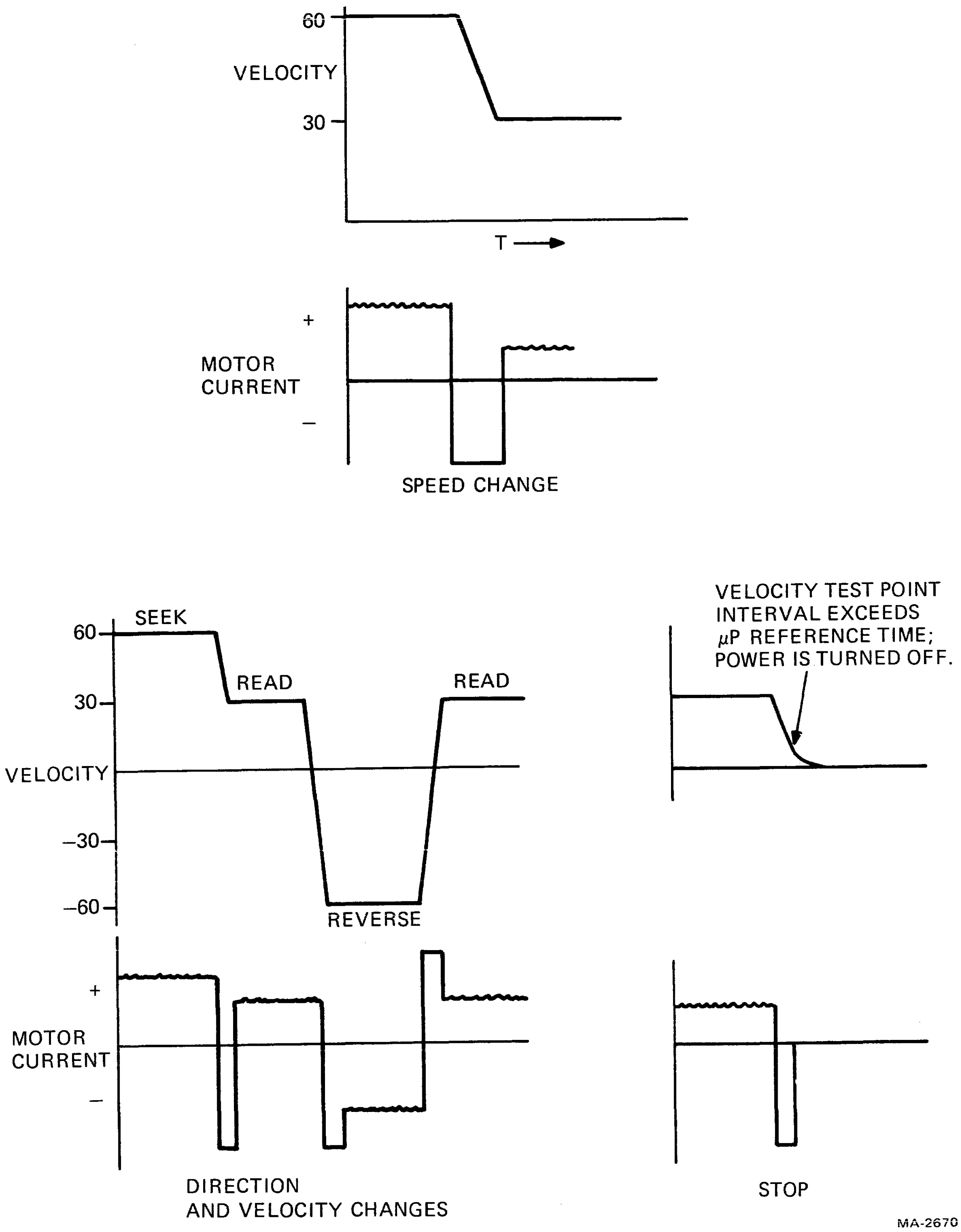


Figure 6-6 Velocity Change Waveforms

time, the microprocessor turns off the motor or changes the velocity setting. If direction change is in progress, deceleration power is first applied at the 60 in/s value until the tape is stopped. Then the tape is started forward at the 30 in/s value. The test point signal is ignored after power reduction and the servo is relied on to correct any velocity overshoot that occurs. The graphs in Figure 6-6 illustrate the drive levels at various stages during velocity changes.

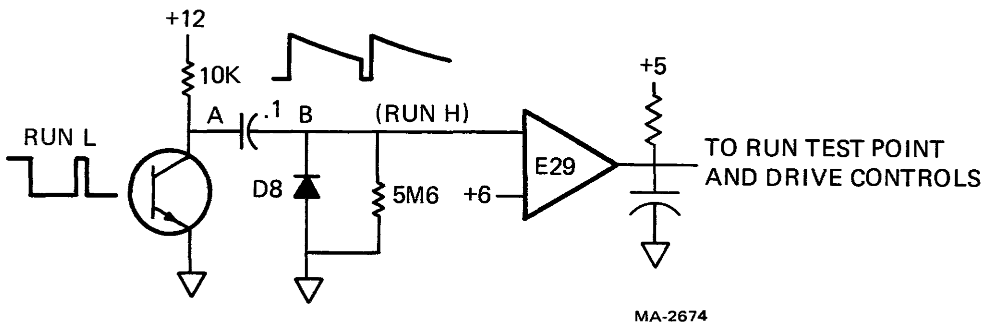


Figure 6-7 Run Timer Simplified Schematic

6.2.6 Run Timeout

The motor control circuit employs a 400 ms timeout circuit to prevent the tape from unspooling in the cartridge because of a hardware failure. The microprocessor pulses the RUN L signal high every time it sees an interrecord mark. If the RUN L signal is not pulsed for 400 ms, the timeout circuit stops the tape.

Figure 6-7 is a simplified schematic of the run timer. When the RUN signal arrives at inverter E20 containing the transistor, point A steps up to +12 V from ground. The charge at point B then wants to redistribute to accommodate the new equilibrium value. The high resistance in the B side of the circuit prevents an immediate current flow and so there is a potential present at B. Since charge has flowed into A, current wants to flow out at B; therefore the potential at B has the same polarity as A. This positive signal switches the comparator to run the motor. The charge at B slowly drains through the 5.6 megohm resistor, lowering the potential at the comparator. If a resetting pulse does not occur, point B descends to ground and the comparator switches off. The reset pulse grounds point A through the transistor in inverter E20 and grounds point B through diode D8. The bandwidth of the comparator is narrow so the reset pulse does not get through to the motor. The rising part of the reset pulse arrives quickly. This step is the same as the step at the beginning of this description.

6.2.7 Motor Overcurrent Drive Limit

A comparator senses the motor current through a 0.2 ohm resistor. While the current is less than 0.75 A, the comparator output is high, reverse-biasing D9, and has no effect. If the current exceeds 0.75 A, the comparator output goes low, forward-biasing D9 and pulling the noninverting input of the servo amplifier low. This causes the servo amplifier to reduce motor drive as if the velocity was too high.

6.2.8 Transient Suppression

Inductive spikes and surges from the motor are dumped through the diodes into the power supply. The capacitor suppresses high frequency noises caused by the motor commutators.

6.3 HEAD SELECTION

The read/write heads are selected by signals from the microprocessor. The microprocessor generates a SEL DRV B signal to choose the head. The gap for track 0 or track 1 is chosen by SEL 0 H from the microprocessor. The selected head gap is connected to the read and write circuitry through a dual 4 to 1 multiplexing analog switch IC. The IC's dual circuits are paralleled to minimize series resistance in the low impedance write driver circuit. The common taps of both heads are connected together, so only one lead per gap needs to be switched.

6.4 WRITE CIRCUIT AND INTERLOCK

The write drivers are two transistors (Q2, Q3) arranged as a constant current source and sink operating at 7.5 mA. They use tristate buffers as data-gated switches and return paths. Writing is gate-interlocked by the mechanical interlock on the cartridge in the drive being selected. Also, the microprocessor tests the mechanical switch for the Write Permit signal before turning on write current. Attempting to write while the cartridge is write-protected results in an error report to the host. The microprocessor Write Enable signal turns the write current on and off at the proper times. In the absence of write enabling, the tristate outputs become open-circuited and source and sink transistors Q2 and Q3 are biased off.

6.5 ERASE CIRCUIT
Erase gaps are selected by the same pair of signals that select read/write gaps. They are also enabled by ERASE ENA L. A 26 mA current source supplies the erase gaps in common. Current through the desired gap is passed to ground through a peripheral driver (high current capacity) gate which is part of a decoder for the control signals. A diode across each erase head winding clamps the inductive voltage spike when the erase current is turned off.

6.6 DATA ENCODING AND DETECTION

6.6.1 Encoding
Data is recorded on tape using the ratio encoding method. Each data bit is given a cell with room for three flux reversals. After an initial positive transition, only one of the remaining reversal positions is used. If the reversal occurs in the first available position, the bit is a zero. If it occurs in the second position, the bit is a one. These position shifts correspond to duty cycles or ratios of 1/3 and 2/3 (Figure 6-8a). To compensate for waveform distortion in the recording process, the actual write encoding ratio is 1/4 to 3/4.

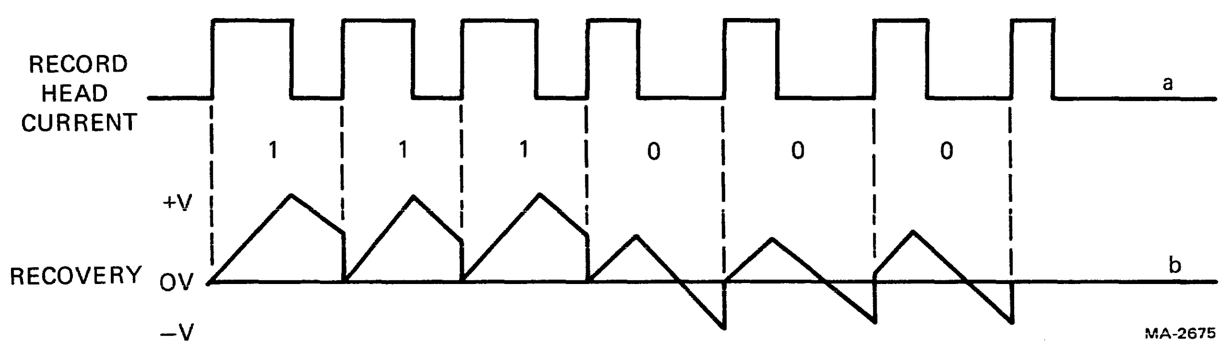


Figure 6-8 Data Encoding and Decoding

6.6.2 Detection
The beginning of a bit cell is defined by a positive peak at the read amplifier. The second flux reversal is defined by the next negative peak. The peaks are detected by a comparator.

The read amplifier output is fed to one input of the comparator. The same signal is phase-shifted and fed to the other input. The output is high for a positive slope input and low for a negative slope input. A small amount of hysteresis is added to prevent oscillation at the zero slope point.

The output of the comparator has a duty cycle similar to that of the original encoded signal. The data are recovered using an integrater as shown in Figure 6-8b. The integrater is discharged by an analog switch on the positive edge of the data waveform. The integrater is sampled by a flip-flop on the next rising edge. If the integrater is positive at sample time, the recorded bit was one. If the integrater is negative at sample time, the bit was a zero.

Decoded data is delivered to the serial data input (SID) on the 8085 microprocessor, while a strobe signal corresponding to the moment of integrater sampling triggers an interrupt to get the microprocessor to store the data bit in a register.

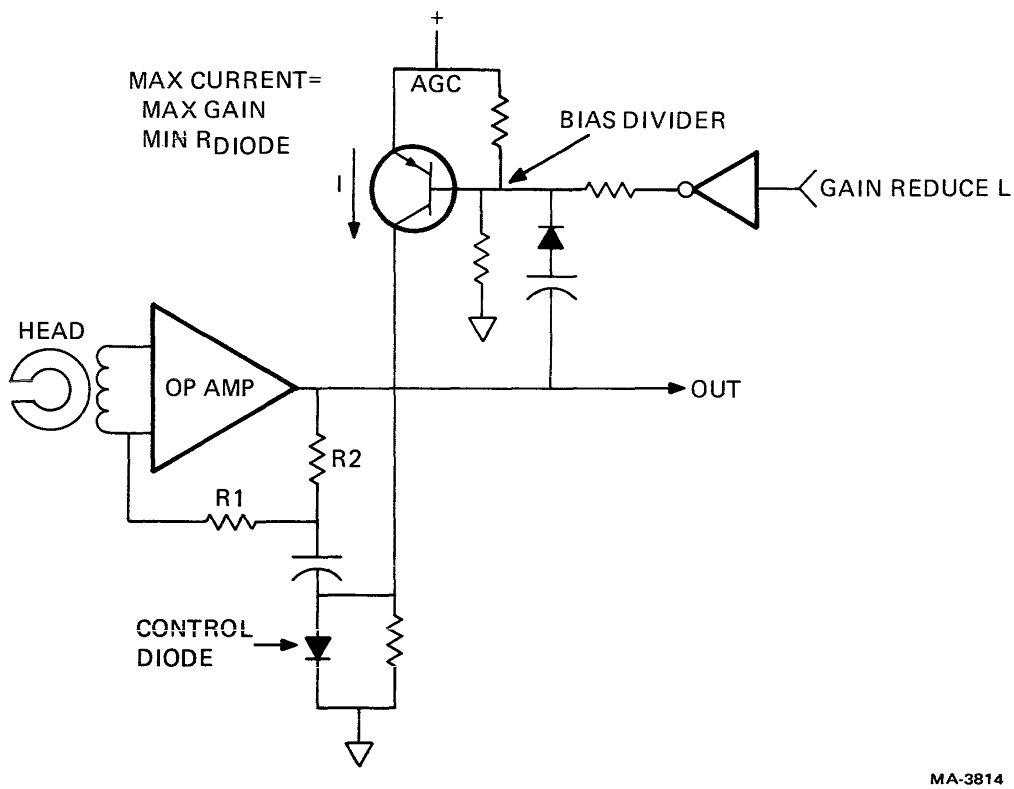


Figure 6-9 Read Amplifier and Automatic Gain Control

6.7 READ AMPLIFIER AND AUTOMATIC GAIN CONTROL

An op amp amplifies the signals coming from the selected head. Automatic gain control (AGC) maintains a constant output to following stages in the presence of large variations in output from the tape because of worn tape or recording variations (Figure 6-9).

To produce the AGC signal, a capacitor couples some of the op amp's output to a diode which rectifies the signal. The dc output from the diode, representing the read signal amplitude, controls the current through a transistor. Increasing the read signal biases off the transistor, decreasing the current. Other inputs to the transistor are: (1) a resistive divider that sets the steady-state value of bias and therefore current; and (2) the GAIN REDUCE L signal from the microprocessor. GAIN REDUCE controls an open-collector inverter that normally shorts a bias resistor to ground. GAIN REDUCE L cuts off the inverter so that the bias shifts to reduce the current through the transistor. The transistor's current is the AGC signal. If the gate switches on, shorting the resistor, the bias shifts to reduce the steady-state current through the transistor.

The op amp gain is set by a negative feedback loop composed of two resistors and a coupling capacitor, a diode, and a resistor to ground. This diode is forward-biased by the AGC current. When a small signal is applied to a forward-biased diode, the diode acts as if it is a resistor. The value of the diode's resistance is determined by the AGC current applied to it. In this circuit, the resistance of the diode forms a divider with feedback resistor 2. If the op amp output signal increases, the AGC transistor's bias and thus current decreases, the resistance of the diode increases, the feedback to the op amp increases, and thus the gain decreases to lower the output signal to the desired set point. GAIN REDUCE changes the bias on the AGC transistor to change the set point. It ensures that the data is free of dropouts.

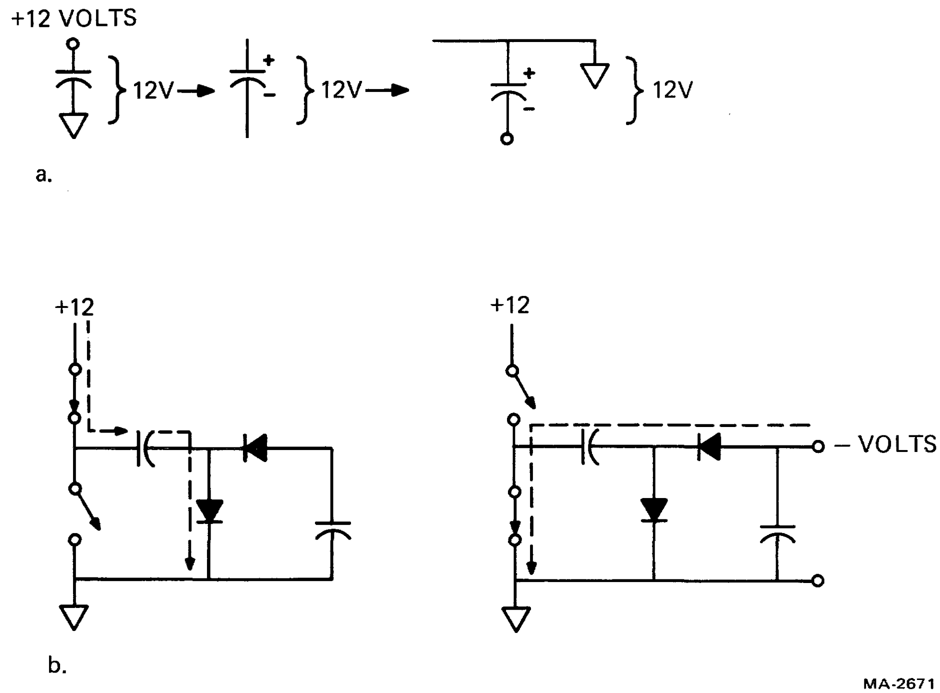


Figure 6-10 Simplified Charge Pump

6.8 CHARGE PUMP

The principle behind the operation of the charge pump is that of charge storage in a capacitor. This is illustrated by the simplified example in Figure 6-10a. Assume that a capacitor is connected between a positive charge source, e.g., +12 V and ground. Electrons will accumulate at the grounded end. If the capacitor is disconnected from the source and ground, it still has 12 V across it, because the electron charge accumulated may not move. If the original positive end is connected to ground, the 12 V extends its polarity below ground because now there is an excess of electrons relative to ground. This negative potential is available to do work at a rate subject to the charge capacity of the storage element (capacitor).

In the actual circuit (Figure 6-10b), one end of the capacitor is switched alternately from +12 V to ground through a totem pole pair of transistors in E32. The other end is switched by diodes either to ground or to a filter and the load. The transistors of E32 are driven by a 500 KHz clock from a divider in the CPU system.

6.9 MARK FINDER

A specially encoded signal is recorded on the DECtape II as part of the formatting operation. The signal is recorded at one quarter of the normal bit density and is located at the beginning and end of the tape (BOT and EOT) and also between each of the formatted records. The signal is called a mark and indicates the location of the beginning of each record header. This allows the microprocessor to count the passage of records past the head at winding speed, and alerts the microprocessor when the tape enters the BOT or EOT regions. Header marks and BOT-EOT marks are distinguished by different bit patterns. BOT is all zeros, EOT is all ones, and the header mark alternates ones and zeros. The mark is detected by a circuit that detects the lower bit density of the mark compared with normal data. The microprocessor sets up the timer in the 8155 (Paragraph 6.12) to provide a clock to the mark finder. The clock is chosen to allow the MARK H output to be set while the pulse rate coming in through the read strobe input is lower than that of the timer. MARK H appears at an input port that is examined by the mark-detecting routine in the microprocessor.

At the same time the mark is being detected because of its density, the data in it is being decoded by the data separator and delivered to the serial input on the microprocessor where its function is determined to be that of header, BOT or EOT mark. The microprocessor can detect BOT and EOT by the bit patterns alone.

6.10 INTERFACES

6.10.1 Serial Interface

Data moves within the TU58 microprocessor on an 8-bit parallel bus. Data is transferred between the TU58 and the host computer through a full duplex asynchronous serial interface that uses one signal loop (conductor pair) for each direction. The universal asynchronous receiver/transmitter (UART) performs the parallel to serial and serial to parallel conversions that make the economy of wire possible. The UART, a single IC, contains circuitry allowing wired programming of its conversion format, plus microprocessor bus protocol management, and the capability to detect conversion and timing errors.

The rate at which the bits of each data byte are sent or accepted is determined by the rate of the clock driving the transmit and receive shift register serializer/deserializers. This particular UART allows different clock rates for each function, although they are usually the same. The clock is derived from the microprocessor clock and is divided down by a series of gates in a divider IC. Each stage output from the divider is available at a pin on the module and can be tied to the RCV or TRANS pins, the UART clock inputs, to set those rates.

The UART inputs and outputs are all at TTL levels, and the serial signals need an interface to the long wires connecting the TU58 to the host. Two line driver ICs and one line receiver are available for connection to the lines. Different jumper configurations on the module allow the interface to operate in accordance with RS-422, a unipolar differential TTL signal standard, or according to RS-423, which references a $\pm$ 3 V bipolar signal to ground. RS-423 is more commonly used because it can operate (at appropriate baud rates) with devices using the older, slower RS-232-C. RS-422 is more noise-immune and can be used over very long distances at high baud rates.

The parallel side of the UART is connected to the 8-bit data/address bus. Loading and unloading the UART transmit and receive registers is performed by a set of signals from the 8085 that are timed to allow only data to be moved from or to the time-multiplexed bus. These signals are read and write control signals, plus a signal that selects between I/O (input/output) and memory, and one address bit. The I/O signal, in conjunction with the A3 address bit, allows the UART to be written or read as if it were a memory location. The address bit distinguishes the UART's I/O address from the 3-bit addresses of the 8155 ports and registers (Paragraph 6.12).

6.10.2 Parallel Interface

The parallel version of the TU58 is identical to the serial version except for the interface section. The UART, baud rate divider, and line driver ICs are replaced by a pair of 8-bit tristate latches that buffer and isolate incoming and outgoing signals from the 8085 data bus. This arrangement is intended for short distances between the TU58 and the host.

6.11 MICROPROCESSOR AND MEMORY

All TU58 activities are supervised or directly controlled by an 8085 microprocessor. The microprocessor operates with firmware stored in a 2K x 8 read only memory (ROM). Scratchpad memory for the microprocessor computations, and a 128-byte buffer for data coming from the host are located in a 256 x 8 random access memory (RAM). The RAM IC also contains other functions described in Paragraph 6.12.

6.11.1 Memory and Bus Operation

The microprocessor uses a partially multiplexed bus for the transmission of data and addresses. Sixteen address bits are used. The lower eight bits share the bus with the 8-bit data in the system. To maintain proper addressing of the memories while data is being transferred, the lower eight address bits must be latched into the memory address inputs. The ROM utilizes a separate latching IC to hold the address, and the RAM has an appropriate latch built in. Both latches are loaded when a signal from the 8085 called Address Latch Enable (ALE) appears briefly while an address is present on the bus. Once the memory is addressed, the bus is cleared of address information, and if the 8085 is reading, a read signal (RD L) is sent and a data byte is presented to the bus from the accessed location. If the 8085 is writing into memory, a write signal (WR L) is sent to the RAM and the data on the bus is stored in the accessed location.

6.11.2 Trap and Restarts

Two kinds of messages activate the performance of firmware routines in the microprocessor. One group of instructions is delivered through the data bus and is formulated according to the radial serial protocol. These instructions will be discussed later. The other messages are hardware signals that are connected directly to pins on the microprocessor IC. There are four of these signals generated by specific conditions in the TU58. They cause interrupts in the microprocessor, with program jumps to locations pointed to by vectors inherent in the microprocessor hardware.

The highest priority interrupt is made by the TRAP H signal; this comes from the framing error (FE) signal at the UART. The framing error is set when the host sends Break, and the trap interrupt is forced into action regardless of the state of the microprocessor. The trap interrupt service routine performs the initialization required for restoration and synchronization of the interface protocol.

The other three interrupt inputs on the microprocessor are called restarts (RST). (The numbers associated with the input names are related to the vectored addresses.) Each input is triggered by a particular event in the TU58. RST 5.5 is set when the UART transmit buffer is empty and ready for a new character to send. RST 6.5 informs the microprocessor that a character has been received from the host and should be read out of the receive buffer. RST 7.5 is synchronized with the tape head data decoding circuitry and causes the microprocessor to read in a single bit of data into its serial data input (SID, Paragraph 6.11.3). The restart interrupts can be individually disabled by a firmware instruction. This is done, for example, to cause the microprocessor to ignore serial data from the tape while it is counting marks in fast wind.

6.11.3 SID, SOD, and Data Encoding

Data moves on and off the tape in bit-serial form. The 8085 has ports and special instructions to transfer bits in and out of a microprocessor register that rotates the bits as a shift register. This rotation performs serialization or deserialization of data under control for firmware that is timed by the read strobe for serial input, or by timing loops for serial output. Data recorded on the tape is encoded by its high to low time ratio, so the serial data output (SOD)is set high or low for appropriate periods by the firmware loops. The SOD is high for one third of each bit time if the bit is a zero, and for two thirds of each bit time for a one (Paragraph 6.6).

6.11.4 Clock

The 8085 contains all the circuitry required to operate a clock oscillator with an external crystal. The crystal frequency was chosen, within the constraint of proper microprocessor operation, to give an output that could be evenly divided down to the values required by the UART to generate its standard baud rates. The clock output of the 8085, which is used by the velocity servo, timer, and charge pump as well as the UART, is one-half the crystal oscillator frequency.

6.11.5 Reset

Reset is a hardware function in the 8085 that sets the program counter to zero. It is implemented in the TU58 by a circuit derived from the two power supply voltages on the module. If either supply fails to come up, the microprocessor is held in the reset state. If the supplies settle normally, the capacitor at the reset input charges up a few moments later and the microprocessor is released to perform its power-up routine starting at location 0 in memory.

6.12 8155 I/O PORTS, REGISTERS, AND TIMER
The 8155 is a multipurpose IC used in the TU58 to simplify the circuit and conserve board space. Its function as a 256-byte RAM is discussed in Paragraph 6.11.1.

6.12.1 I/O Ports
The I/O ports provide most of the communication paths between the microprocessor and the TU58 hardware. Port A provides the inputs for the various status signals from the mechanism, such as cartridge present and write permit. Port B delivers control signals to the system, such as velocity and direction commands. Port C controls the self-test indicator lamp and causes the interface to the host to transmit Break as a part of the boot sequence (Paragraph 5.2).

Port C also carries three signals useful for module testing. Test Point 1 (pin 1) pulses high when the header of a sought record is successfully read (confirmed by the record number complement). Test Point 2 (pin 2) pulses high each time the header of any record is unsuccessfully read. Test Point 3 (pin 38) pulses high after a record of data is read but fails the checksum test.

6.12.2 Registers and Timer
The 8155 registers control the operation of the I/O ports and timer. The registers are addressed as I/O locations like the ports. The control/status register defines the ports as inputs or outputs and sets the timer start and stop characteristics. The timer registers define the cycle characteristics and load the value required to generate the desired pulse interval with the system clock at the timer's clock input. A 14-bit counter, parallel-loaded by the registers, provides the timer function.

6.13 FIRMWARE
The TU58 operates under control of a microprocessor whose instructions are stored in a ROM. These instructions, called firmware, define the functions and capabilities of the TU58 as an integral part of the mechanism. This section describes a few of the basic firmware sequences that are part of normal TU58 operation. No extensive coverage is attempted because firmware problems cannot be repaired in any direct way. The self-test checks for proper contents in the ROM and halts the processor if a fault is detected. The self-test checks other things as well but does not isolate the problem to a particular component. Field repair is the replacement of the module.

6.13.1 Initialization and Radial Serial Protocol
Initialization occurs at power-up, on errors, and on receipt of the Init command from the host. Figure 6-11 shows the interchange that occurs at this time. IDLE is a firmware routine that waits for incoming characters and delegates other routines to handle the data according to its contents.

The radial serial protocol (RSP), described in Chapter 3, is the system that defines the meaning of each character byte as it comes from or is sent to the host.

6.13.1.1 Flag Byte, Byte Count, and Checksum – The first character in a message packet is the flag byte that tells the microprocessor whether to store the incoming bytes in sequential, labeled command byte locations, or in the general purpose, 128-byte data buffer. The second byte, the byte count, is stored and decremented with the arrival of each successive character. Another location stores an accumulating 16-bit checksum of the bytes. When the byte count is decremented to zero, there are two bytes still to arrive from the message packet. These are the packet's checksum and are compared with the newly calculated value; a match assures that an accurate transmission occurred.

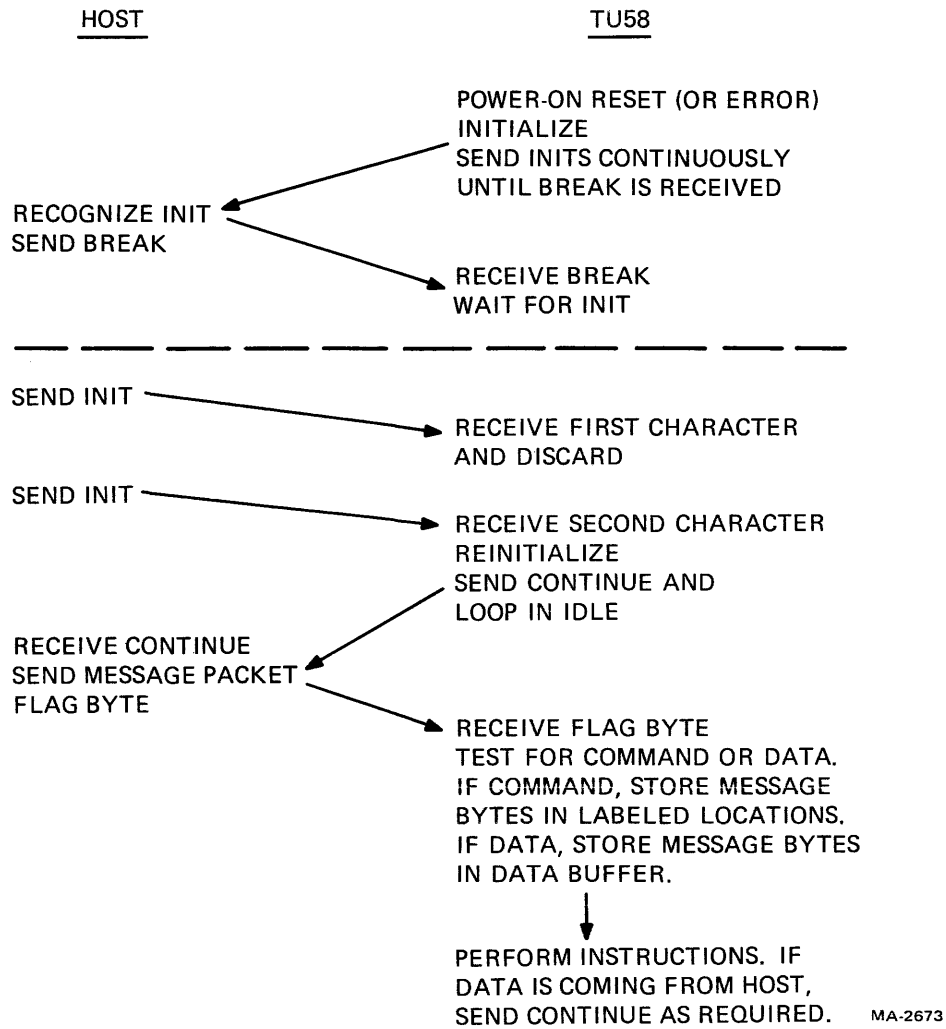


Figure 6-11 Host-TU58 Power-up Interchange

6.13.1.2 Op Code and Specifications – In an RSP command packet, the third byte to arrive is the op code (operation code). This number designates the function to be performed. The following bytes: modifier, unit (drive) number, byte count, and block number make up a complete specification of the sequence of operations to follow. The sequence number and certain op codes in the RSP are not used by the TU58. The byte count is stored and decremented to allow the TU58 to keep track of the number of bytes transferred to or from the tape during the operation.

6.13.1.3 Data Packets – If the flag byte of the message packet indicates that the contents are data, the bytes are stored in the data buffer. The byte count then indicates the last data byte before the checksum. The last two bytes are compared with a newly calculated checksum to confirm proper data transmission. (The same checking process occurs when data is read off the tape and temporarily stored in the data buffer. In that case the byte count is fixed at 128, the length of a tape record.)

6.13.2 Command Operations

The read and write commands activate the tape transport and utilize all of the TU58's systems. The position command is the basis for all tape motion and uses the read circuitry. Position is flowcharted in Figure 6-12. If the tape has already been involved in positioning operations, the current position calculates the distance to the desired block and the tape winds past the appropriate number of marks to the new location. If the tape is newly inserted, it is assumed to be at the desired location. The tape is backed up two records and the record number is read. If the position is not correct, the distance to the correct location is calculated from the current position. If the location is at one end of the tape or the other, the EOT or BOT marks will be detected while the tape is moving and the tape will be reversed and slowed to read the current position.

The read command positions the tape at the first record of the requested block and then transfers data to the buffer. After each 128-byte record, the checksum is checked. If there is a discrepancy, the tape is backed up and re-read up to eight times, until the checksums match. If there is no match, a hard data error is reported to the host and the operation is cancelled. Otherwise, reads continue on successive (interleaved) records, with record numbers checked as they go by, until the byte count is met.

The write command positions the tape at the first record of the requested block and transfers data to the interleaved records until the byte count is met. If the byte count does not fill a block, the block is zero-filled.

Diagnose, a routine automatically performed at power-up, may be run at anytime. It is a confidence check of the microprocessor system. It turns the indicator light off and checks the firmware ROM by calculating a checksum for all data in the ROM and comparing it with a stored value. The RAM is checked by having each location written in and read out with a test pattern. If the tests are passed, the light is turned back on.

The hardware reset that occurs at power-up turns the indicator light off directly at the I/O port, so if the light is on, the microprocessor is most likely operating successfully and performing its programmed functions.

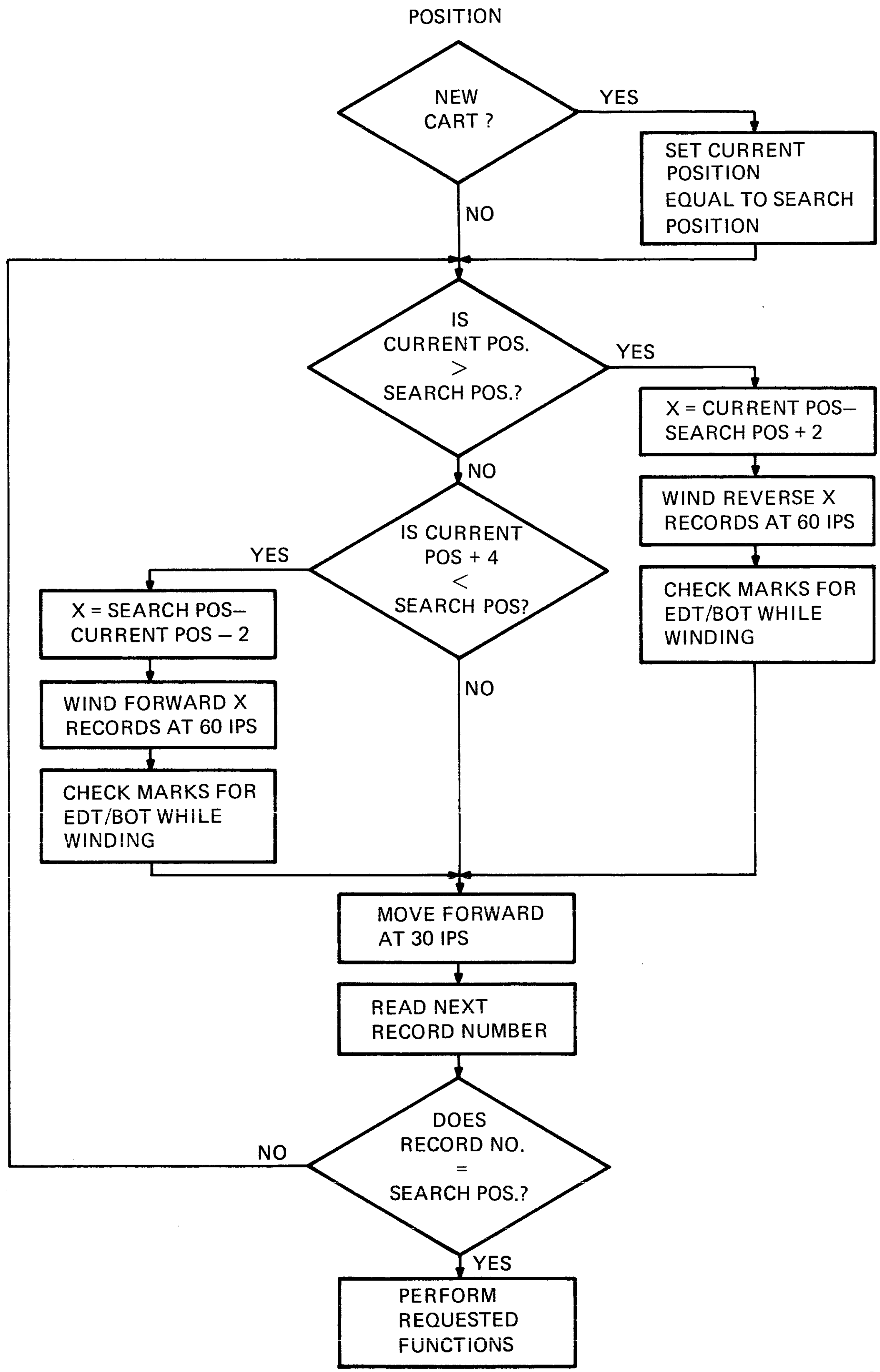


Figure 6-12 Position Flowchart

CHAPTER 7
MAINTENANCE

7.1 INTRODUCTION

This chapter contains information that enables a service technician to solve basic connection and operating problems in the TU58. The primary method of solution is the replacement of basic system units. Trouble isolation guidelines are aimed at distinguishing the faulty field-replaceable unit (FRU). A few easily found and corrected electromechanical problems are also covered.

7.2 TROUBLE ISOLATION CHART

Symptom	Action/Comments
TU58 does not respond host	1. Ensure that the TU58-CA is plugged into a live ac socket (or proper dc source for components).
	2. Voltage selection switch properly set.
	3. Fuse and power cord are intact and properly inserted.
	4. Baud rates and interface standards are the same for both the TU58 and the host interface board.
	5. Observe the self-test indicator light on the controller module. (Remove the bezel on the rackmount version.) When power is applied, the light indicator should shine for one-half second, go out for another half second, and then relight. This means the controller has passed its automatic self-test and is ready for operation. If the light remains off, there is some problem within the module or in the interface. If the light never comes on, check the power supply voltages. See Figure 7-1.

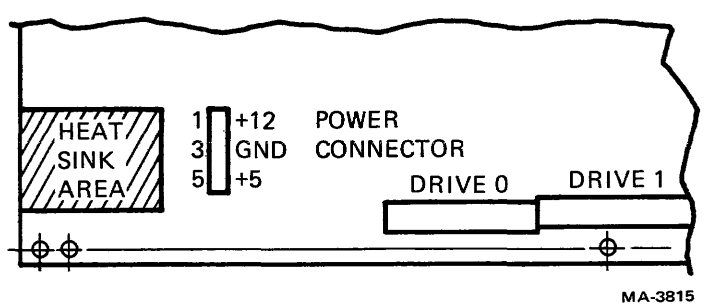


Figure 7-1 Power Connector Location

Check that the interface cable is intact and properly inserted. If the serial interface is suspected and the interface parameters are correct, try a new interface cable. An open wire in the line from the host will prevent the diagnostic test from completing. Other causes will require servicing.

TU58 will not write (reads okay)

1. Check that the Write Permit tab is set correctly on the cartridge.
2. The problem may be in a drive. If the system has two drives, try writing on the other drive to determine whether the module is okay.

Read errors (Some host operating systems may provide this or a similar message.)

1. Clean the head. Dirt and tape oxide buildup can cause errors. If a cartridge is causing errors, it may be near the end of its life, based on number of passes. As soon as possible, duplicate and discard it.
2. The tape may contain errors that were written onto it. If a tape is in poor condition, or if data is not verified at write time, errors may become a permanent part of the recording. A new cartridge with format problems will produce the same error message. Try another cartridge.
3. As the motor reaches the end of its life, soft errors will begin to occur more frequently.

TU58 sends motor-stopped error-messages

This indicates that a malfunction has occured in the data recovery section of the circuitry and the runaway timer has stopped the motor. The TU58 should not be commanded to move tape more than twice under these conditions without checking the cartridge. Make sure the tape is not getting near the end where it might come free of the hub.

TU58-CA blows fuses

1. Disconnect the power connector from the controller module. Check for fuse blowing.
    a. If the new fuse does not blow, there is a failure on the controller module. Replace it.
    b. If the fuse does blow, remove the power supply panel from the unit. Disconnect the transformer connector from the regulator circuit board and test again.
    (1) If the fuse does not blow, replace the regulator circuit board.
    (2) If it does blow, consult Digital Equipment Corporation for parts information.

7.3 REPAIRABLE DRIVE PROBLEMS

Run light goes on for a half second at a time but the tape does not move	1.	Check for loose connectors on drive.
	2.	Open motor brushes or shorted commutator. Check motor continuity. Normal resistance is approximately 10 ohms. (A good motor may run on the current from some multimeters. Stop the rotation to get an accurate resistance reading.) A shorted motor will not blow a fuse because of the current limiting circuit.
	3.	Seized motor bearings. The motor shaft should spin freely.
Run light goes on for a half second at a time but tape moves too fast and read errors are reported.	1.	Check connections to the tachometer pickup.
TU58 will not operate on a loaded drive, sends No Cartridge error messages.	1.	The bottom microswitch is bad (open).
	2.	The switch wires are mixed up.
TU58 attempts to operate on an empty drive	1.	The bottom microswitch is bad (shorted).
TU58 will not write on a write-enabled cartridge, sends Write Protected error messages.	1.	The top microswitch is bad (open).
TU58 writes on a write-protected cartridge.	1.	The top microswitch is bad (shorted).
Creased tachometer encoder wheel (or other damage to slots).	1.	If the tachometer wheel is slightly warped it may be possible to straighten it with needle-nosed pliers. Otherwise, it must be replaced.

7.4 REMOVAL AND REPLACEMENT OF DRIVE PARTS

Procedures for the removal and replacement of the module and drive may be found in Chapter 4. They must be performed before the component parts can be reached.

7.4.1 Tachometer Encoder Wheel and Pickup Housing

The encoder wheel and pickup housing are removed and replaced at the same time so that the wheel is not bent at installation.

1. Loosen the set screw in the wheel hub.

2. Remove the screw from the bottom of the pickup housing.

3. Slide the wheel and housing off the motor shaft and drive at the same time.

Reverse the procedure to install the wheel.

7.4.2 Microswitches

The switches are mounted to the drive base by two long vertical screws. If a switch is defective, replace both switches.

1. Remove the connectors from the switches.

2. Remove the two screws and the switches.

3. Install the new switches in a stack with the screws.

4. Solder a jumper to the same contacts as on the old switches.

5. Replace the connectors.

7.5 POWER SUPPLY REMOVAL AND REPLACEMENT

1. Disconnect the power input.

2. Disconnect the interface cable at the back panel connector and also at the module. The cage will have to be released for this. (See Chapter 4.)

3. Unfasten the four screws at the back corners and slide the panel out.

Reverse the procedure to reinstall the panel.

The power supply circuit board is mounted on the back panel. To remove it:

1. Disconnect all pc board connectors.

2. Remove two screws from the board corners and three screws from under the regulator heat sink.

Install a new board by reversing the procedure. Make sure that there is an even coating of thermal grease on the heat sink. Add grease if required.

APPENDIX A
TU58/PDP-11 TOGGLE IN BOOT

This boots drive 0 only.

```
1000/012701
1002/176500
1004/012702
1006/176504
1010/010100
1012/005212
1014/105712
1016/100376
1020/006300
1022/001004
1024/005012
1026/005200
1030/005761
1032/000002
1034/042700
1036/000020
1040/010062
1042/000002
1044/001363
1046/005003
1050/105711
1052/100376
1054/116123
1056/000002
1060/022703
1062/001000
1064/101371
1066/005007
```

APPENDIX B
FIELD REPLACEABLE UNIT SPARES LIST

Unit	DEC Part No.
Serial Module	54-13489
Parallel Module	54-13491
Regulator Module	54-13609
Drive	70-15510
Tachometer Encoder Wheel	74-20649
Tape Cartridge	36-15809

TU58 DECtape II
TECHNICAL MANUAL
EK-0TU58-TM-001

Reader's Comments

Your comments and suggestions will help us in our continuous effort to improve the quality and usefulness of our publications.

What is your general reaction to this manual? In your judgement is it complete, accurate, well organized, well written, etc? Is it easy to use? ____________________

What features are most useful? ____________________

What faults or errors have you found in the manual? ____________________

Does this manual satisfy the need you think it was intended to satisfy? ____________________

Does it satisfy *your* needs? __________ Why? ____________________

☐ Please send me the current copy of the *Technical Documentation Catalog*, which contains information on the remainder of DIGITAL's technical documentation.

Name ____________________
Title ____________________
Company ____________________
Department ____________________
Street ____________________
City ____________________
State/Country ____________________
Zip ____________________

Additional copies of this document are available from:

Digital Equipment Corporation
Accessories and Supplies Group
Cotton Road
Nashua, NH 03060

Attention *Documentation Products*
Telephone 1-800-258-1710

Order No. ____________________

Fold Here

Do Not Tear – Fold Here and Staple

digital

No Postage
Necessary
if Mailed in the
United States

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO.33 MAYNARD, MA.

POSTAGE WILL BE PAID BY ADDRESSEE

Digital Equipment Corporation
Educational Services Development and Publishing
129 Parker Street, PK3-1/T12
Maynard, MA 01754