GT40/GT42 user's guide

digital

DEC-11-HGTGA-B-D

GT40/GT42
user's guide

digital equipment corporation · maynard. massachusetts

1st Edition, June 1973
2nd Printing, September 1973
3rd Printing (Rev), November 1974

The material in this manual is for informational purposes and is subject to change without notice.

Digital Equipment Corporation assumes no responsibility for any errors which may appear in this manual.

Printed in U.S.A.

CONTENTS

CONTENTS (Cont)

Page

ILLUSTRATIONS

Figure No. Title Page

ILLUSTRATIONS (Cont)

TABLES

GT40/GT42 GRAPHIC DISPLAY TERMINAL

1.1 PURPOSE AND SCOPE

This guide describes the operation of the GT40 and GT42 Graphic Display Terminals. The following information is included: start-up procedures, equipment specifications, programming techniques, interfacing, and a description of the ROM Bootstrap.

1.2 GENERAL DESCRIPTION

The GT40/42 Graphic Display Terminal (Figures 1 through 5) is a high performance graphic display system that operates through a PDP-11/10 computer. The GT40/42 is designed for applications that require both a visual display, and a computation capability. The system can display either alphanumeric information, graphic data such as drawings, diagrams, and patterns, or any combination of these. It is particularly valuable for displaying dynamic, fast-changing data such as waveforms. The GT40/42 can function as a general purpose computer when not performing as a display terminal. In this nondisplay mode of operation, it can operate as a stand-alone system or initiate communications with a host computer as part of a computer network.

1.3 SYSTEM ORGANIZATION

The GT40/42 consists of eight basic components organized to form the system described above. These components are:

- Central Processor Unit (CPU)
- Display Processor Unit (DPU) in which is included the Bootstrap Read Only Memory (ROM)
- Communications Interface Module
- Memory
- Keyboard
- Cathode Ray Tube (CRT) Monitor
- Light Pen
- Power Supply

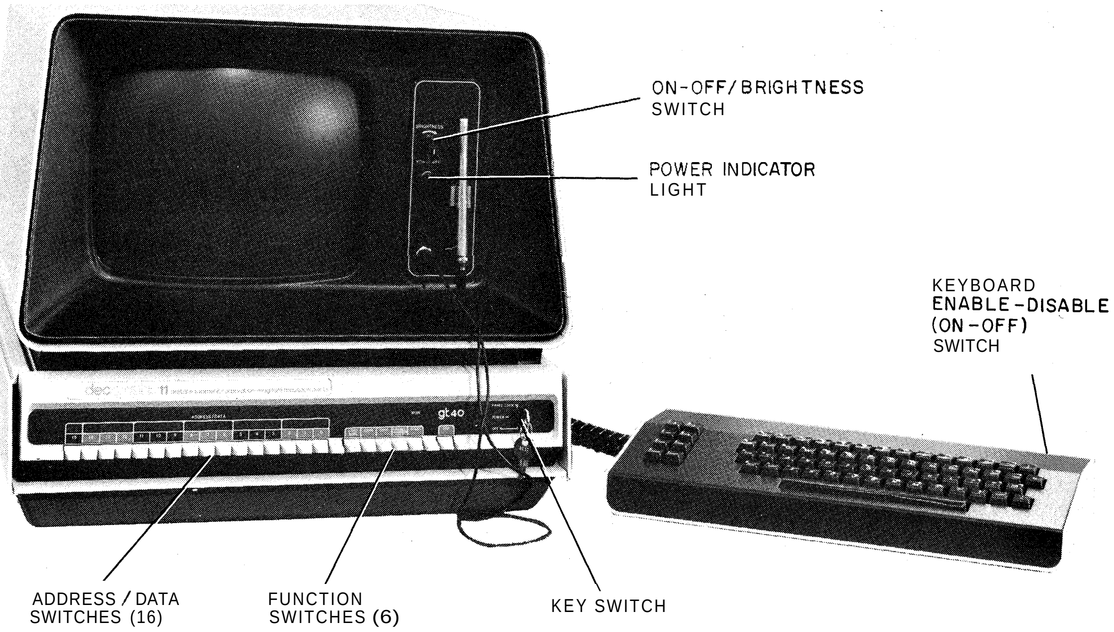


Figure 1 GT40 Graphic Display Terminal

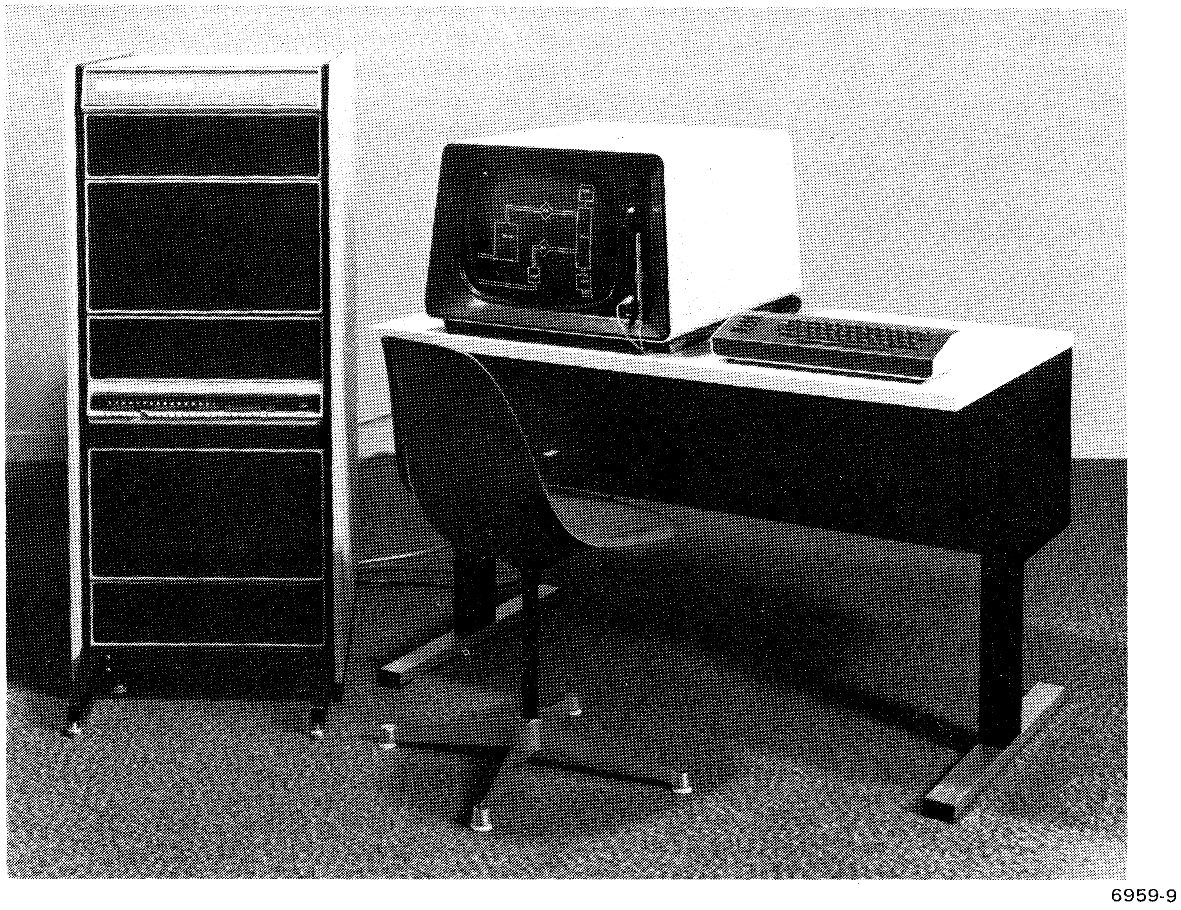


Figure 2 GT42 Graphic Display Terminal

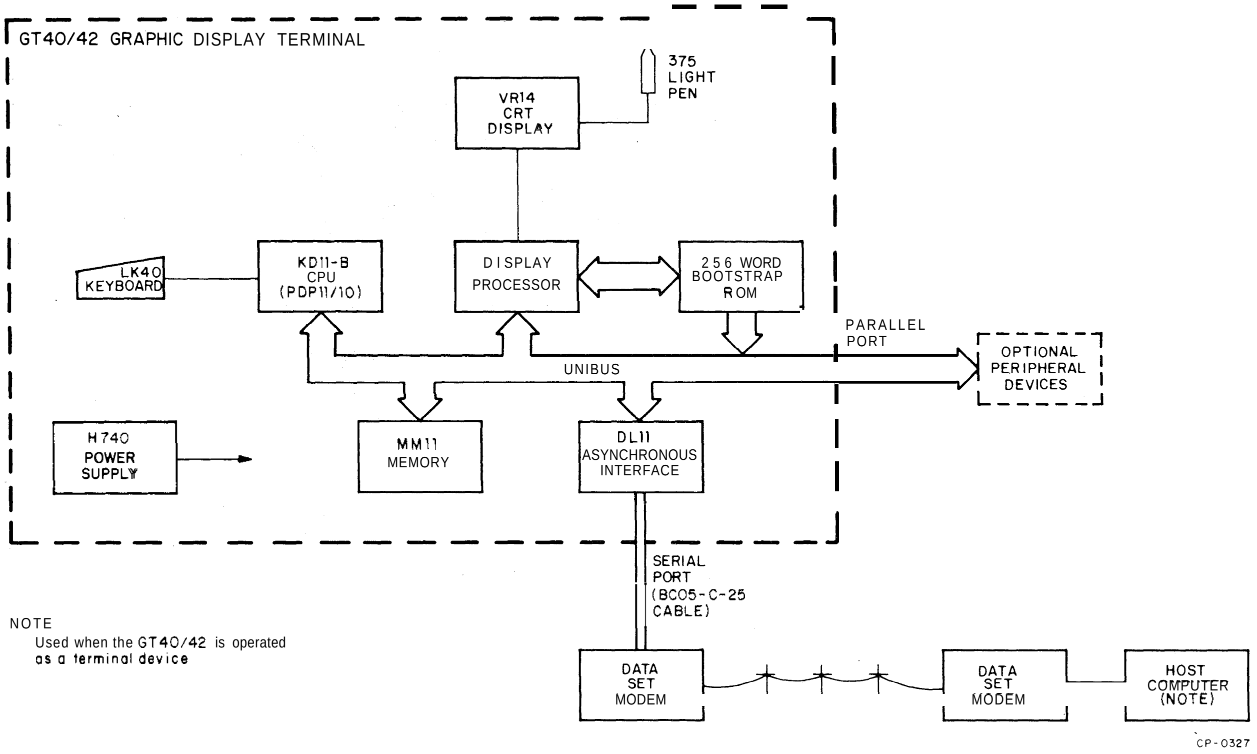


Figure 3 GT40/42 Graphic Display Terminal, Block Diagram

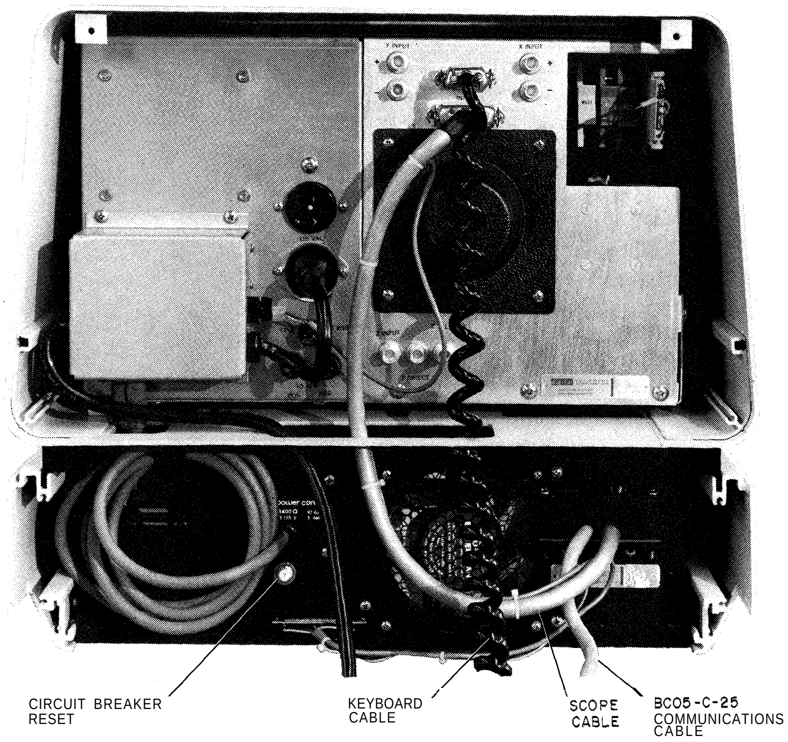


Figure 4 GT40, Rear View

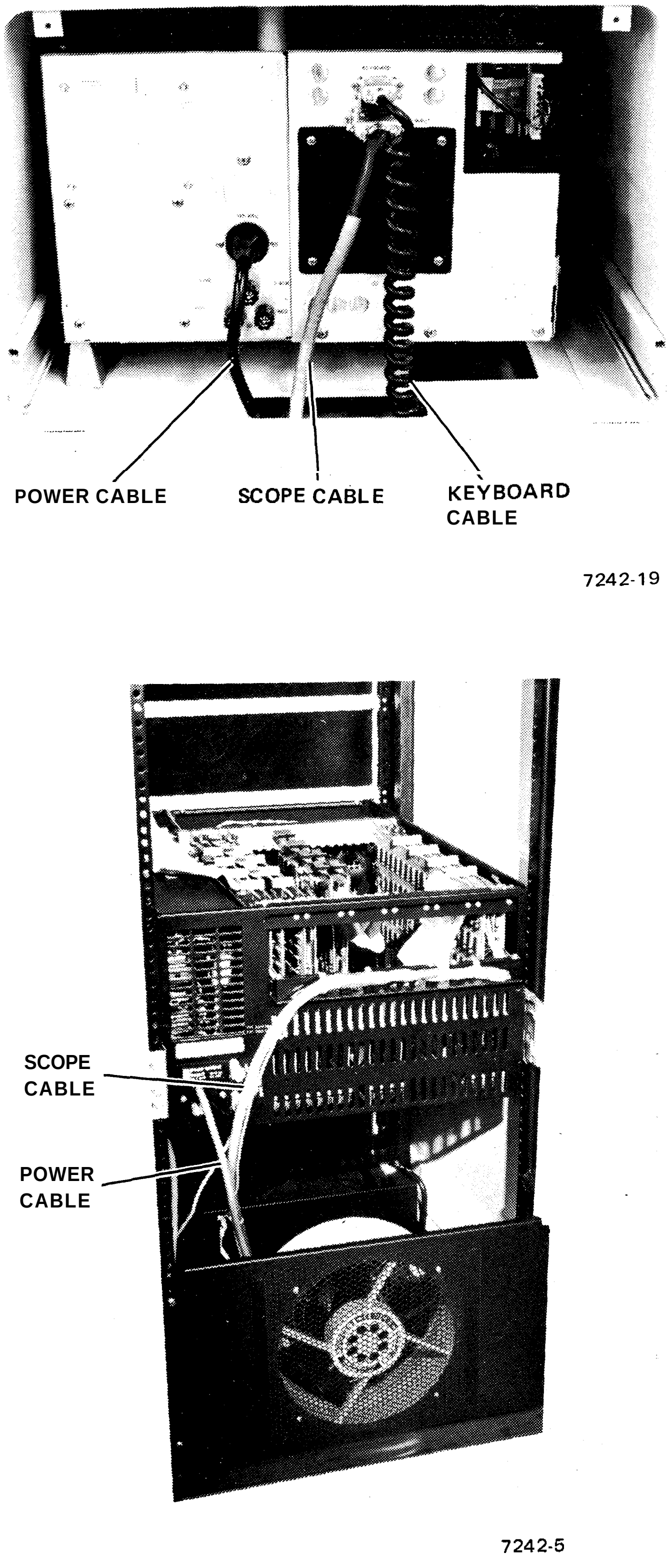


Figure 5 GT42, Rear View

1.4 SYSTEM OPERATION

The GT40/42 is a stable system that requires only minimum adjustments because it employs a combination of digital and analog techniques as opposed to analog circuits alone. The vector function operates efficiently, providing a good compromise of speed and accuracy and assuring a precise digital vector calculation. The presentation and accumulation of vectors means that every point of a vector is available in digital form.

During plotting, the end-point position is automatically retained, preventing accumulated errors or drift. Four different vector types – solid, long dash, short dash, and dot dash – are possible through standard hardware.

The GT40/42 character generator has both upper and lower case capability with a large repertoire of displayable characters. The display is the automatically refreshing type rather than the storage type so that a bright, continuous image, with excellent contrast ratio, is provided during motion or while changes are being made in the elements of the picture. A hardware blink feature is applicable to any characters or graphics drawn on the screen. A separate line clock in the display permits the GT40/42 to be synchronized to the line frequency. Scope resolution is precise enough to allow overprinting.

The terminal includes logic for descender characters such as "p" and "g," positioning them correctly with respect to the text line. In addition to the 96 ASCII printing characters, 31 special characters are included which are addressed through the shift-idshift-out control codes. These special characters include some Greek letters, architectural symbols, and math symbols. Characters can be drawn in italics simply by selecting the feature through the status instruction bit. Brightness and contrast are such that the scope can be viewed in a normally lighted room.

The instruction set consists of four control-state instructions and five data-state formats. The control instructions set the mode of data interpretation, set the parameters of the displayed image, and allow branching of the instruction flow. Data can be interpreted in any of five different formats, allowing tasks to be accomplished efficiently from both a core usage and time standpoint. The graph/plot feature of the GT40/42 automatically plots the x or y values according to preset distances as values for the opposite axis are recorded.

1.5 EQUIPMENT SPECIFICATIONS

The GT40/42 Graphic Display Terminal operating requirements and physical characteristics are listed by component in the following paragraphs. Refer to Volume 2 of the *GT40 Graphic Display Terminal Maintenance Manual* for the specifications pertaining to the KD11-B Processor (PDP-11/10).

Display Processor

Instruction Word Length	16 bits
Raster Definition	10 bits

Viewable Area	x = 1024 raster unit (1777_8)
	y = 768 raster units (1377_8)

Paper Size	12 bits
Hardware Blink	Programmable
Hardware Intensity Levels	8
Line Frequency Synchronization	Hardware programmable
Character Font	6 X 8 dot matrix
Characters/Line	73

Number of Lines	31
Character Set	96 ASCII – upper and lower case plus 31 specials (Greek letters, math symbols, etc.) (Refer to the appendix)
Control Characters	Carriage return Line feed Backspace
Bell Tone	Programmable
Italics	Hardware programmable
Line Type	Solid Long dash Short dash Dot dash
Data formats	Character (2 char/word) Short Vector (1 word) Long Vector (2 words) Point (2 words) Relative Point (1 word) Graphplot x/y (1 word/pt)
DPU Instructions	Set Graphic Modes Jump No operation (NOP) Load Status Register A Load Status Register B

DL11 Communications Interface Operating Specifications

Data Input and Output	Serial data, EIA and CCITT specifications compatible with Bell 103 and 202 Data Sets
Data Format	1 start bit 5, 6, 7, 8 data bits 1, 1.5, or 2 stop bits, odd, even or no parity.
Power Required	1.8A @ +5V 0.150A @ –15V 0.050A @ +9 to +15V
Cable iength EIA	All baud rates: 50 ft (15.24m)
Noise Margin EIA	5V

MM11 Core Memory (refer also to Volume 2 of the GT40 Graphic Display Terminal Maintenance Manual).

Type	Magnetic core, read/write, coincident current, random access
Organization Capacity	Planar, 3D, 3-wire

Access Time

DATI	400 ns
DATIP	400 ns
DATO, DATOB	200 ns

Cycle Time

DATI	900 ns
DATIP	450 ns
DATO, DATOB (PAUSE L)	900 ns
DATO, DATOB (PAUSE H)	450 ns

LK40 Keyboard

Number of Keystations	58 (Major board) 8 (Minor board)
Encoding Format	1968 USASCII
Number of Codes	Either 96 or 128 codes (internal switch controllable,
Output Data Format	8-bit ASCII 1 start bit 7 data bits 2 stop bits
Baud Rate	Approximately 150 baud
Output Signal	20-mA current loop
Bell	Tone generator
Controls	Enable/Disable transmit

CRT Monitor

Viewable Area	
GT40	6.75 X 9 in. (17.145 X 22.86 cm)
GT42	8.5 X 11 in. (21.590 X 27.940 cm)
Brightness	> 30 fL (measured using a shrinking raster technique)
Contrast Ratio	> 10:1
Phosphor Type	P39 doped with IR
Pincushion	±1% of full scale to best fit line
Spot Size	< 20 mils inside the usable screen area at a brightness of 30 fL [Full Width at Half Maximum (FWHM)]

	< ±1/2 spot diameter
Repeatability	< ±1 spot diameter (repeatability is the deviation from the nominal location of any given spot)
Gain Change	From a fixed point on the screen, less than ±0.3% gain change for each ±1% line voltage variation
Temperature Range	0° to 50°C (operating)
Relative Humidity	10 to 90% (noncondensing)
Linearity	Maximum deviation of any straight line will be < 1% of the line length measured perpendicular to a best-fit straight line
Deflection Method	Magnetic (70° diagonal deflection angle)
Focus Method	Electrostatic
High Voltage	10.5 kV dc nominal (voltage proportional to input line voltage). Supply is self-contained and equipped with a bleeder resister.
Shielding	CRT is fully enclosed in a magnetic shield.
Overload Protection	Unit is protected against fan failure or air blockage by thermal cutouts. Power supply and amplifiers are current limited. Phosphor protection is provided against fault conditions.

Light Pen

Length	5.0 in. (12.7 cm)
Diameter	0.45 in. (tapered to 0.35 in.) (1.143 cm) (0.889 cm)
Light Sensing	Phototransistor
Connector	Phono Plug
Signal Amplification	G840 Light Pen Amplifier module in VR14 CRT Display

Power **Supply**

Refer to Volume 2 of the *GT40 Graphic Display Terminal Maintenance Manual* for a detailed list of power supply specifications.

Environmental

Shock, Nonoperating	DEC STD 102, 205 at 30 ± 10 ms half-sine
Vibration, Nonoperating	DEC STD 102, Vertical 1.89 G rms 10 – 300 Hz
Operating Ambient Temperature	DEC STD 102, Class A, 60° – 95°F (16° – 35°C)
Relative Humidity (noncondensing)	DEC STD 102, Class 2, 20 – 80%

Physical

Weight

	GT40	GT42
CRT Monitor	80 lb (36.24 kg)	85 lb (38.55 kg)
Processor Cabinet	60 lb (27.18 kg)	275 lb (124.74 kg)
Keyboard	6.25 lb (2.83 kg)	6.25 lb (2.83 kg)

GT40 Size

	Height	Width	Depth
CRT Monitor	12.5 in. (31.75 cm)	19.75 in. (50.165 cm)	22.25 in. (56.515 cm)
Processor Cabinet	5.25 in. (13.335 cm)	19.75 in. (50.165 cm)	23.25 in. (59.055 cm)
Keyboard	3.0 in. (7.62 cm)	15.625 in. (42.227 cm)	6.625 in. (16.827 cm)

GT42 Size

	Height	Width	Depth
CRT Monitor	15 in. (38.10 cm)	21.5 in. (54.61 cm)	27 in. (68.58 cm)
Processor Cabinet	50 in. (127.00 cm)	21 in. (53.34 cm)	38 in. (96.52 cm)
Keyboard	3 in. (7.62 cm)	16.625 in. (42.227 cm)	6.625 in. (16.827 cm)

2.1 GT40/GT42 START-UP PROCEDURES

The procedure used to start the GT40/GT42 Graphic Display Terminal is determined by the system configuration. A GT40/GT42 that operates as a terminal in a larger system is started differently than a GT40/GT42 that functions as a stand-alone device. Four procedures are presented in the following paragraphs: GT40/GT42 Terminal Systems, GT42 Paper Tape Systems, GT40 Paper Tape Systems, and GT42 Bootstraps for Other Devices.

2.1.1 GT40/GT42 Terminal Systems

The following procedure is used to initiate the ROM Bootstrap from the PDP-11/10 console on the GT40/42.

1. Determine that the GT40/42 power cord is connected to an appropriate electrical outlet.

2. Turn the console key switch (Figure 1) to the POWER position.

3. Turn the front panel ON-OFFIBRIGHTNESS switch fully counterclockwise and then 3/4 of the way in the clockwise direction. The red power indicator light just below the switch should be on at this time.

4. Press the console ENABLE/HALT switch down to halt the computer.

5. Press the spring-loaded START switch twice; this resets the computer.

6. Place 166000_8 in the Switch register (SR). This is the starting address for the Bootstrap program in the Read-Only Memory (ROM) (Figure 20).

7. Press LOAD ADDRESS to load the address into the computer.

8. Return the ENABLEIHALT switch to the up-most position.

9. Press the START switch. The RUN indicator light should be on at this time.

10. Ensure that the LK40 keyboard ENABLE/DISABLE (On-Off) switch is in the ON position (Figure 6).

11. The GT40/42 is now ready to transmit data to and receive data from the host computer via the DL11 Asynchronous Interface module.

NOTE

A detailed description of the ROM Bootstrap and the loading procedure from a host computer are contained in Paragraph **5.1.**

2.1.2 GT42 Paper Tape Systems

The following procedure is used to initiate the ROM Bootstrap from the PDP-11/10 console on the GT42.

1. Determine that the GT42 power cord is connected to an appropriate electrical outlet.

2. Turn the console key switch (Figure 2) to the POWER position.

3. Turn the front panel ON-OFFIBRIGHTNESS switch fully counterclockwise and then 3/4 of the way in the clockwise direction. The red power indicator light just below the switch should be on at this time.

4. Press the console ENABLEIHALT switch down to halt the computer.

5. Press the spring-loaded START switch twice; this resets the computer

6. Place 167400_8 in the Switch register (SR). This is the starting address for the paper tape Bootstrap program in the Read Only Memory (ROM).

7. Press LOAD ADDRESS to load the address into the computer.

8. Return the ENABLEIHALT switch to the up-most position.

9. Place the Absolute Loader in the specified reader with the special bootstrap leader code over the reader sensors (under the reader station).

10. Press START. The Absolute Loader tape will pass through the reader as data is being loaded into core.

11. The tape stops after the last frame of data has been read into core. The Absolute Loader is now in core. If the Absolute Loader tape does not read in immediately after depressing the START switch, perform steps 26 and 27 of Paragraph 2.1.3.

2.1.3 GT40 Paper Tape Systems

1. Determine that the GT40 power cord is connected to an appropriate electrical outlet.

2. Turn the console key switch (Figure 1) to the POWER position.

3. Turn the front panel ON-OFFIBRIGHTNESS switch fully counterclockwise and then 314 of the way in the clockwise direction. The red power indicator light just below the switch should be on at this time.

4. Press the console ENABLEIHALT switch down to halt the computer

5. Press the spring-loaded START switch twice; this resets the computer.

6. The Bootstrap Loader will now be loaded (toggled) into the highest core memory bank. The locations and corresponding instructions of the Bootstrap Loader are listed in Table 1.

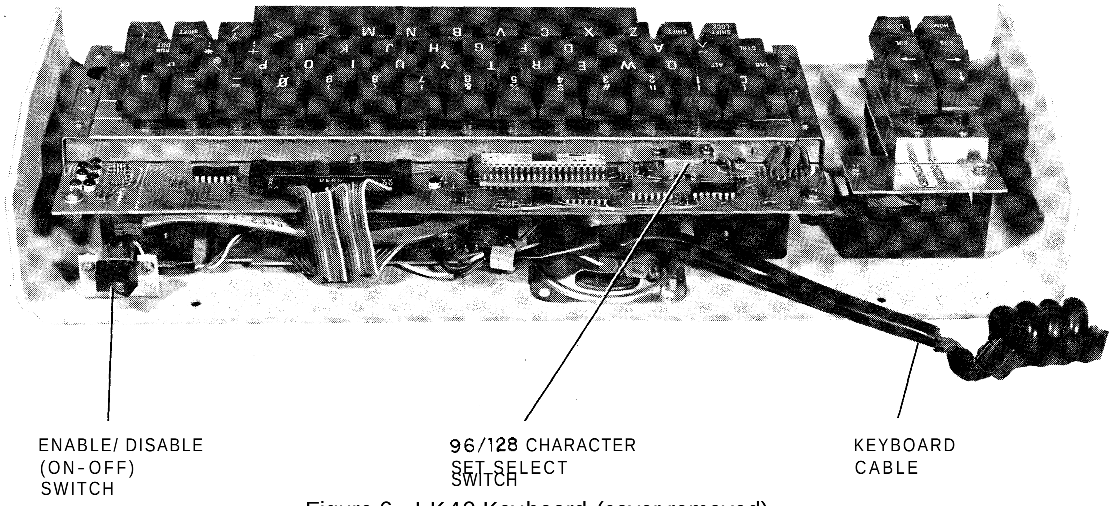

ENABLE/ DISABLE (ON-OFF) SWITCH
96/128 CHARACTER SET SELECT SWITCH
KEYBOARD CABLE

Figure 6 LK40 Keyboard (cover removed)

The Bootstrap Loader program instructs the computer to accept and store in core memory data that is punched on paper tape in bootstrap format. The Bootstrap Loader is used to load very short paper tape programs of 162_8 16-bit words or less (primarily the Absolute Loader and Memory Dump programs). Programs longer than this must be assembled into absolute binary format using the PAL-11A Assembler and loaded into memory using the Absolute Loader (step 19).

Table 1
Bootstrap Loader Instructions

Location	Instruction
xx7744	016701
xx7746	000026
xx7750	012702
xx7752	000352
xx7754	005211
xx7756	105711
xx7760	100376
xx7762	116162
xx7764	000002
xx7766	xx7400
xx7770	005267
xx7772	177756
xx7774	000765
xx7776	YYYYYY

In Table 1, xx represents the highest available memory bank. For example, the first location of the loader would be 037744_8 if the system contained an 8K memory. Table 2 lists the locations for the first Bootstrap Loader instruction as determined by the memory size. All other locations, for a given memory, are prefixed with the same two digits.

Table **2**
First Bootstrap Loader
Instruction Locations

Location	Memory Bank	Memory Size
017744	0	4K
037744	1	8K
057744	2	12K
077744	3	16K
117744	4	20K
137744	5	24K
157744	6	28K

The contents of location xx7776 (YYYYYY in the instruction column of Table 1) should contain the device status register address of the paper tape reader to be used when loading the bootstrap formatted tapes. Either paper tape reader may be used; their respective addresses are:

Teletype Paper Tape Reader – 177560
High Speed Paper Tape Reader – 177550

7. Set xx7744 in the Switch register (SR) and press the LOAD ADDRess switch (xx7744 will be displayed in the address register).

8. Set the first instruction, 016701, in the SR and lift the DEPosit switch (016701 will be displayed in the data register).

NOTE

When DEPositing data into consecutive words, the DEPosit automatically increments the address register to the next word.

9. Set the next instruction, 000026, in the SR and lift DEPosit (000026 will be displayed in the data register).

10. Set the next instruction in the SR and press the DEPosit switch. Continue depositing subsequent instructions until 000765 is stored in location xx7774.

11. Deposit the desired device status register address in location xx7776, the last location of the Bootstrap Loader.

12. Good programming procedure requires the verification of data that has been stored.

13. Set xx7744 in the SR and press the LOAD ADDRess switch.

14. Press the EXAMine switch. The octal instruction in location xx7744 will be displayed so that it can be compared with the correct instruction: 016701. If the instruction is correct, proceed to step 15, otherwise go to step 17.

15. Press the EXAMine switch. When the switch is held depressed, the ADDRESSIDATA indicators display the memory address. On releasing the switch, the instruction at that address is displayed. Compare the indicator display with the required instruction (Table 1). (The EXAMine switch automatically increments the address register.)

16. Repeat step 15 until all instructions have been verified or go to step 17 whenever the correct instruction is not displayed.

NOTE

Whenever an incorrect instruction is displayed, **it** can **be** corrected by performing steps **17** and **18.**

17. When an incorrect instruction is displayed in the ADDRESSIDATA indicators, set the correct instruction in the SR and lift the DEPosit switch.

18. Press and release the EXAMine switch to verify that the correct instruction has been deposited. Continue the checking (step 15) until all the instructions have been verified.

19. The Absolute Loader program will be loaded into core memory at this time. The Absolute Loader is a system program which, after being loaded into memory, allows the operator to load, into any core memory bank, data punched on paper tape in absolute binary format. It is used primarily to load the paper tape system software (excluding certain subprograms) and the user's object programs assembled with PAL-11A. The major features of the Absolute Loader include:

    Testing of the checksum on the input tape to ensure complete, accurate loads.

    - Starting the loaded program upon completion of loading without additional user action, as specified by the .END in the program just loaded.

    - Specifying the load address of position independent programs at load time rather than at assembly time, by using the desired loader switch register option.

With the Bootstrap Loader in core memory, the Absolute Loader is loaded into memory starting anywhere between locations xx7500 and xx7742, i.e., 162_{10} words. The paper tape input device used is specified in location xx7776 (step 11). The Absolute Loader tape begins with about two feet of special bootstrap leader code (ASCII code 351), not blank leader tape.

20. Set the ENABLE/HALT switch to HALT.

21. Place the Absolute Loader in the specified reader with the special bootstrap leader code over the reader sensors (under the reader station).

22. Set the SR to xx7744 (the starting address of the Bootstrap Loader) and press LOAD ADDRess.

23. Set the ENABLEIHALT switch to ENABLE.

24. Press START. The Absolute Loader tape will pass through the reader as data is being loaded into core.

25. The tape stops after the last frame of data has been read into core. The Absolute Loader is now in core.

26. If the Absolute Loader tape does not read in immediately after depressing the START switch (step 24), it is due to one of the following causes:

- Bootstrap Loader not correctly loaded.
- The wrong input device was used.
- Code 351_8 was not directly over the reader sensors.
- The Absolute Loader tape was not properly positioned in the reader.

27. Any paper tape punched in absolute binary format is referred to as an absolute tape, and is loaded into memory using the Absolute Loader. When using the Absolute Loader, there are two methods of loading available: normal and relocated.

    A normal load occurs when the data is loaded and placed in core according to the load addresses on the object tape. It is specified by setting bit 0 of the Switch register to zero immediately before starting the load.

There are two types of relocated loads.

·a. Loading to continue from where the loader left off after the previous load. This is used, for example, when the object program being loaded is contained on more than one tape. It is specified by setting the Switch register to 000001 immediately before starting the load.

b. Loading into a specific area of core. This is normally used when loading position independent programs. A position independent program is one that can be loaded and run anywhere in available core. The program is written using the position independent instruction format. This type of load is specified by setting the Switch register to the load address and adding 1 to it, i.e., setting bit 0 to 1.

Optional Switch register settings for the three types of loads are listed in Table 3.

Table 3
Switch Register Configuration for Loading

Type **of Load**	**Switch Register**	
	Bits 1–14	**Bit 0**
Normal	(ignored)	0
Relocated – continue loading where left off	0	1
Relocated – load in specified area of core	nnnnn (specified address)	1

The absolute tape is now loaded using either of the paper tape readers. The desired reader is specified in the last word of available core memory (xx7776), the input device status word, as explained in step 6. The input device status word can be changed at any time prior to loading the absolute tape.

28. Set the ENABLE/HALT switch to HALT

To use an input device different from that used when loading the Absolute Loader, change the address of the device status word (in location xx7776) to reflect the desired device, i.e., 177560 for the Teletype® reader or 177550 for the high speed reader.

29. Set the SR to xx7500 and press LOAD ADDR.

30. Set the SR to reflect the desired type of load.

31. Place the absolute tape in the proper reader with blank leader tape directly over the reader sensors.

32. Set ENABLE/HALT to ENABLE.

33. Press START. The absolute tape will begin passing through the reader station as data is being loaded into core.

34. The Absolute Loader was not correctly stored in memory if the absolute tape does not begin passing through the reader station. If this occurs, reload the loader (steps 20–25) and then the absolute tape (starting at step 28).

If the absolute tape halts in the middle of the tape, a checksum error occurred in the last block of data read. Normally, the absolute tape will stop passing through the reader station when it encounters the transfer address as generated by the .END statement, denoting the end of a program. If the system halts after loading, check that the low byte of the data register is zero. If so, the tape is correctly loaded. If not zero, a checksum error has occurred in the block of data just loaded, indicating that some data was not correctly loaded. Thus, the tape should be reloaded starting at step 1.

When loading a continuous relocated load, subsequent blocks of data are loaded by placing the next tape in the appropriate reader and pressing the CONTinue switch.

35. The Absolute Loader may be restarted at any time by starting at step 1.

2.1.4 GT42 Bootstraps For Other Devices

The GT42 contains bootstrap programs for the following devices:

Device	Starting Address (Octal)
TA11 Cassette	167500
RF11 Fixed Head Disk	167600
RC11 Fixed Head Disk	167720
RK11 Disk Cartridge	167610
RP11 Disk Pack	167654
TC11 DECtape	167620
TM11 Magnetic Tape	167636

The following procedure is used to initiate one of the above devices from the PDP-11/10 console of the GT42.

1. Determine that the GT42 power cord is connected to an appropriate electrical outlet.

2. Turn the console key switch to the POWER position.

3. Press the console ENABLE/HALT switch down to halt the computer.

®Teletype is a registered trademark of Teletype Corporation.

4. Press the spring-loaded START switch twice; this resets the computer

5. Place the address of the device to be started into the Switch register. The device starting addresses are listed above.

6. Press the LOAD ADDRESS switch to load the address into the computer.

7. Return the ENABLE/HALT switch to the up-most position.

8. Press the START switch.

2.1.5 GT42 Graphics Test

The GT42 contains a short program which tests the fundamental graphic capabilities of the display processor. The program, which starts at octal address 167204, displays several lines and points on the CRT.

2.2 GT40/42 FAILURE PROCEDURES

The following procedures should be followed in the event the GT40/42 fails to operate properly. If, after performing these checks, equipment operation is still unsatisfactory, the user should notify the DEC Field Service Office of the problem.

If the GT40/42 is completely inoperative:

1. Check the circuit breaker on the rear panel of the GT40 (Figure 4) or in the cabinet of the GT42. Press the button to reset the circuit breaker.

2. Check the power cord to the wall receptacle. It should be properly seated.

3. Determine that the required power (115 or 230 Vac) is present at the wall receptacle.

If the display scope fails to turn on:

1. Check the keyboard cable connector on the GT40/42 rear panel for proper seating.

2. Check the power plugs on the rear panel and the power control box for proper seating.

3. Determine that the front panel ON-OFFIBRIGHTNESS switch is in the ON position (clockwise).

4. Check the following fuses on the rear panel and the power control box:

    - 5A SB (115 V system)
      (or 3A SB for 230 V systems)

    - 10A (115 V systems)
      (or 5A for 230 V systems)

If the keyboard is incapable of transmitting data:

1. Check the ON/OFF switch on the rear of the keyboard (Figure 6). Place it in the ON position.

2. Check the cable connectors on the GT40/42 rear panel (particularly the keyboard cable) for proper seating.

3.1 GT40/42 INTERFACES

Transferral of information between GT40/42 components and devices external to the basic system requires a means for connecting or interfacing an extended system. The interface can be considered to be the physical boundary between the GT40/42 and attached units; it provides the communication link between the display terminal and associated devices such as a host computer or additional memory units.

3.2 PARALLEL PORT

The GT40/42 possesses two interfaces. One, called the ***parallel port,*** uses conventional Unibus signals and connections to transfer data in parallel format. The other interface is employed in the transfer of asynchronous data, in a serial format, over a longer communications line. The two interfaces and their relation to the GT40/42 are shown in Figure 7.

The parallel port is used typically to interface local high speed peripheral devices such as additional core memory, disk storage units, etc. The parallel port is basically an extension of the PDP-11 family Unibus.

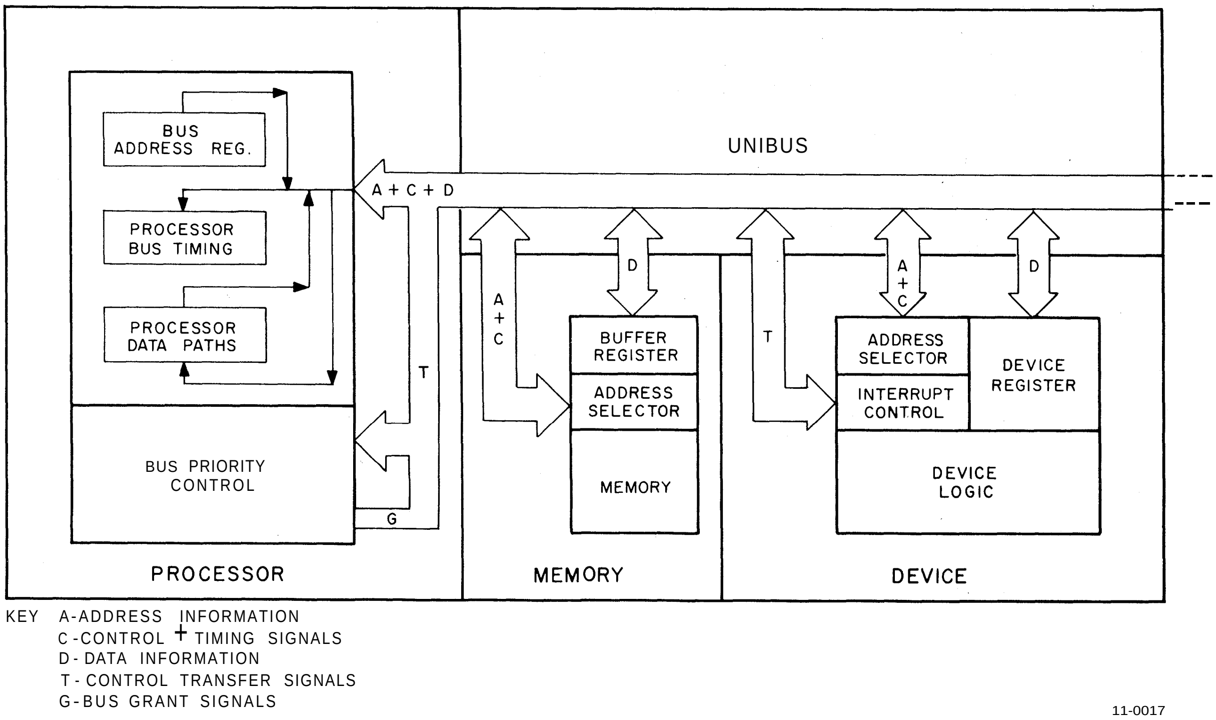


Figure 7 Unibus Interface Block Diagram

3.2.1 Unibus Structure

The Unibus is a single common path that connects the processor, memory, and all peripherals. Addresses, data, and control information are transmitted along the 56 lines of the bus. All 56 signals and their functions are listed in Table 4.

Every device on the Unibus employs the same form of communication; thus, the processor uses the same set of signals to communicate with memory and with peripheral devices. Peripheral devices also communicate with the processor, memory, or other peripheral devices via the same set of signals.

All instructions applied to data in memory can be applied equally well to data in peripheral device registers, enabling peripheral device registers to be manipulated by the processor with the same flexibility as memory. This feature is especially powerful, considering the capability of PDP-11 instructions to process data in any memory location as though it were an accumulator.

Table 4
Unibus Signals

Name	Mnemonic	Source	Destination	Timing	Function
Data Transfer Signals (For transfer of data to or from master)					
Address	A(17:00)	Master	All	MSYN	Selects slave device
Data	D(15:00)	Master Slave	Slave Master	MSYN (DATO, DATOB) SSYN (DATI, DATIP)	
Control	C(1:0)	Master	Slave	MSYN	Selects transfer operation
Master Sync	MSYN	Master	Slave	Beginning of transfer	Initiates operation and gates A, C, and D signals
Slave Sync	SSYN	Slave	Master	Data accepted (DATO, DATOB) Data Available (DATI, DATIP)	Response to MSYN
Parity Bit Low	PA	Master	Slave	Same as Data	Transmits parity bit, low byte
Parity Bit High	PB	Master	Slave	Same as Data	Transmits parity bit, high byte
Priority Transfer Signals (For transfer of bus control to a priority-selected master)					
Non-Processor Request	NPR	Any	Processor	Asynchronous	Highest priority bus request
Bus Request	BR(7:4)	Any	Processor	Asynchronous	Requests bus mastership
Non-Processor Grant	NPG	Processor	Next master	In parallel with data transfer	Transfers bus control
Bus Grant	BG(7:4)	Processor	Next master	After instruction	Transfers bus control
Selection Acknowledge	SACK	Next Master	Processor	Response to NPG or BG	Acknowledges grant & inhibits further grants
Bus Busy	BBSY	Master	All	except during transfer of control	Asserts bus mastership

Table 4 (Cont)
Unibus Signals

Name	Mnemonic	Source	Destination	Timing	Function
Interrupt	INTR	Master	Processor	After asserting BBSY (not after NPR), device may perform several transfers before asserting INTR.	Transfers bus control to handling routine ın processor
Miscellaneous Signals					
Initialize	INIT	Processor	All	Asynchronous	Clear and reset signal
AC Low	AC LO	Power	All	Asynchronous	Indicates impending power failure
DC Low	DC LO				Indicates dc voltages out of tolerance, and system operation must be suspended.

NOTE
Signals on the Unibus are asserted when low (except for the unidirectional bus grant lines).

3.2.1.1 Bidirectional Lines – Most Unibus lines are bidirectional, allowing input lines to also be driven as output lines. This is significant in that a peripheral device register can be either read or used for transfer operations. Thus, the same register can be used for both input and output functions.

3.2.1.2 Master/Slave Relationship – Communication between two devices on the bus is based on a master/slave relationship. During any bus operation, one device, referred to as the bus master, has control of the bus when communicating with another device, the slave. A typical example of this relationship is the processor (master) transferring data to memory (slave). Master/slave relationships are dynamic. The processor, for example, passes bus control to a disk; the disk, as master, then communicates with a slave memory.

The Unibus is used by the processor and all I/O devices; thus, a priority structure determines which device gains control of the bus. Consequently, every device on the Unibus capable of becoming bus master has an assigned priority. When two devices capable of becoming bus master have identical priority values and simultaneously request use of the bus, the device that is electrically closest to the bus receives control.

3.2.1.3 Interlocked Communication – Communication on the Unibus is interlocked between devices. Each control signal issued by the master device must be acknowledged by a response from the slave to complete the transfer. Consequently, communication is independent of the physical bus length and the response time of the master and slave devices. The maximum transfer rate on the Unibus, with optimum device design, is one 16-bit word every 400 ns or 2.5 million 16-bit words per second.

3.2.2 Peripheral Device Organization and Control

Peripheral device registers are assigned addresses similar to memory; thus, all PDP-11 instructions that address memory locations can become I/O instructions, enabling data registers in peripheral devices to take advantage of all the arithmetic power of the processor.

The PDP-11 controls devices differently than most computer systems. Control functions are assigned to a register address, and then the individual bits within that register can cause control operations to occur. For example, the command to make the paper tape reader read a frame of tape is provided by setting a bit (the reader enable bit) in the control register of the device. Instructions such as MOV and BIS may be used for this purpose. Status conditions are also handled by the assignment of bits within this register, and the status is checked with TST, BIT, and CMP instructions.

3.2.3 Unibus Control Arbitration

The Unibus is capable of performing two basic and parallel tasks in order to allow transfers by multiple peripherals at maximum speed. The first is the actual transfer of data between the current bus master and its addressed slave. The second is the selection of the next bus master, the peripheral which will be allowed to assert control as soon as the bus becomes free. It is important to note that the granting of future mastership is in no way influenced by either the current master or its method of obtaining the bus. It is this fact which allows these functions to be performed in parallel and allows transfers on the bus at a maximum rate.

3.2.3.1 Priority Transfer Requests – To gain mastership of the Unibus, a peripheral must first make a request to the processor for the bus and then wait for its selection. The processor contains the logic necessary to arbitrate these requests because normally there are several requests pending at any given time.

There are two classes of requests: bus requests and non-processor requests. A bus request (BR) is simply a request by a peripheral to obtain control of the Unibus with the understanding by the processor that the peripheral may end its use of the bus with a processor interrupt. An interrupt is a command to the processor to begin executing a new routine pointed to by a location selected by a device. A non-processor request (NPR) is similarly a request for the bus, but with the exception that it may not interrupt the processor. Since the granting of an NPR cannot affect the execution of the processor, it can occur during or between instructions. BRs, however, by possibly causing execution to be diverted to a totally new routine, can only be granted between instructions. In this way, NPRs are assigned priority over any BR.

Between bus requests, there are four levels of priority created by four separate request lines. They are assigned priority levels 4 through 7; BR4 is the lowest and BR7 is the highest. These levels are associated with the program controlled priority level of the processor, controlled by bits 7, 6, and 5 of the processor status register. Only BRs on a priority level higher than the level of the processor are eligible for receiving a bus grant. Thus, during high priority program tasks, all or selected Unibus requests (hence interrupts) can be inhibited by raising the level of the processor priority.

Another form of priority arbitration occurs through the system configuration. When the processor grants a request, the grant travels along the bus until it reaches the first requesting device which terminates the grant. Therefore, along the same grant line, the device electrically nearest the processor has the highest priority. Also note that in the KD11-B, the internal line clock is logically the last device on BR6, and the keyboard or Teletype interface is logically the last device on BR4.

The GT40/42 relationship to this priority scheme is indicated in Table 5.

After a requesting device receives a bus grant it asserts its selection as next bus master until the bus is free, thus inhibiting other requests from being granted. When the bus becomes free, the selected device asserts control of the bus and relinquishes its selection as next bus master so that the priority arbitration among pending requests may continue.

Table 5
GT40/42 Priority

GT40/42 Component	Priority Level	Relative Physical Position from the CPU
DL11 Asynchronous Interface	BR5	2
Display Processor	BR4	1
Unibus Output Slot (Parallel Port)	–	3

NOTE: The MM11 memory is not shown as an active device because it always functions as a slave, never asserting a bus request itself.

3.2.3.2 Processor interrupts – After gaining control of the bus through a BR, a device can perform one or more transfers on the bus and/or request a processor interrupt. This is typically requested after a device has completed a given task, e.g., typing a character or completing a block data transfer through NPRs. If a peripheral wishes to interrupt the processor, it must assert the interrupt after gaining control of the bus but before relinquishing its selection as next bus master. Thus the processor knows that it may not fetch the next instruction, but must wait for the interrupt to be completed. Along with asserting the interrupt, the device asserts the unique memory address, known as the interrupt vector address, containing the starting address of the device service routine. Address vector +2 contains the new processor status word (PSW) to be used by the processor when beginning the service routine. After recognizing the interrupt, the processor reads the vector address and saves it in an internal register. It then pushes the current PSW and program counter onto the stack and loads the new program counter (PC) and PSW from the vector address specified. The service routine is then executed.

NOTE
These operations are performed automatically and no device polling is required to determine which routine to execute.

The device service routine can cause the processor to resume the interrupted process by executing the return from interrupt (RTI) instruction which pops the top two words from the processor stack and transfers them back to the PC and PS registers.

3.2.3.3 **Data** Transfers – After asserting control of the Unibus, the device does not release control until it has completed either one or more data transfers or an interrupt. Typically, only one transfer is completed each time the device gains control of the bus because few single devices can give or receive information at the maximum Unibus rate. Holding the bus for multiple transfers inhibits other devices from using the bus.

A transfer is initiated by the master device asserting a slave address and control signals on the bus and a master or address validity signal. The appropriate slave recognizes the valid address, reads or writes the data, and responds with a transfer complete signal. The master recognizes the transfer complete, sends or accepts data, and drops the address validating signal. It can then assert a new address and repeat the process or release control of the bus completely.

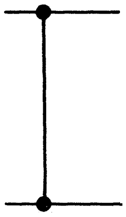
The importance of this type of structure is that it enables direct device-to-device transfers without any interaction from the central processor. An NPR device, such as the high speed CRT display, can gain fast access to the bus and transfer data at high rates while refreshing itself from memory without slowing down the processor.

For a more detailed description of the Unibus and its function, refer to the *GT40 Graphic Display Terminal Maintenance Manual,* Volume 2 or to the *PDP-11 Peripherals Handbook.*

3.3 SERIAL PORT

The serial port is the primary means of interfacing the GT40/42 with a host or remote computer. Access to this port is through the DL11 Asynchronous Interface module and the 25-ft BC05-C-25 cable which terminates in a 25-pin, RS232-defined connector at a data set modem (Figure 3 and Table 6).

Table 6
BC05-C-25 Cable Output Connections

CINCH Connector Pin No. (to modem)	Signal
1 	Ground
2	Transmitted Data
3	Received Data
4	Request to Send
5	Clear to Send
6	Data Set Ready
7	Ground
8	Carrier
9	+ Power
10	- Power
11	202 Secondary Transmit
12	202 Secondary Receive
13	Secondary Clear to Send
14	EIA Secondary Transmit
15	Serial Clock Transmit
16	EIA Secondary Receive
17	Serial Clock Receive
18	Unassigned
19	Secondary Request to Send
20	Data Terminal Ready
21	Signal Quality
22	Ring
23	Signal Rate
24	External Clock
25	Force Busy

3.4 DL11 PROGRAMMING

All software control of the DL11 Asynchronous Line Interface is performed by means of four device registers. These registers have been assigned bus addresses and can be read or loaded (with the exceptions noted) using any PDP-11 instruction referring to their addresses. Address assignments can be changed by altering jumpers on the address selection logic to correspond to any address within the range of 174000 to 177777. However, register addresses for the DL11 in the GT40/42 fall within the range of 175610 to 175616.

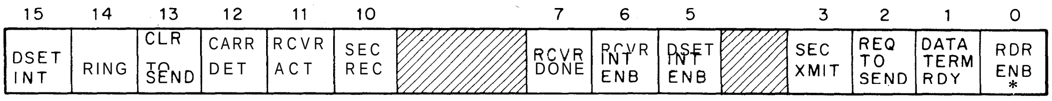
The four device registers and associated DL11 addresses are listed in Table 7.

Table **7**
Standard **DL11** Register Assignments for the **GT40/42**

Register	Mnemonic	Address
Receiver Status Register	RCSR	175610
Receiver Buffer Register	RBUF	175612
Transmitter Status Register	XCSR	175614
Transmitter Buffer Register	XBUF	175616

Figures 8 through 11 show the bit assignments for the four device registers. The unused and load-only bits are always read as 0s. Loading unused or read-only bits has no effect on the bit position. The mnemonic INIT refers to the initialization signal issued by the processor. Initialization is caused by one of the following: issuing a programmed RESET instruction; depressing the START switch on the processor console; or the occurrence of a power-up or power-down condition of the processor power supply.

In the following descriptions, *transmitter* refers to those registers and bits involved in accepting a parallel character from the Unibus for serial transmission to the external device; *receiver* refers to those registers and bits involved with receiving serial information from the external device for parallel transfer to the Unibus.



RCSR = 175610 * **Not used for data operations.**

Figure 8 Receiver Status Register (RCSR) – Bit Assignments

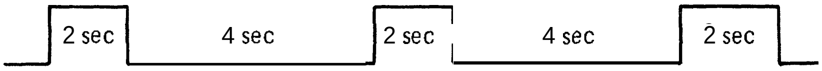
3.4.1 Receiver Status Register

Bit	Name	Meaning and Operation
15	DATASET INT (Dataset Interrupt)	This bit initiates an interrupt sequence provided the DATASET INT ENB bit (05) is also set. This bit is set whenever CAR DET, RCVR ACT, or SEC REC changes state, i.e., on a 0 to 1 or 1 to 0 transition of any one of these bits. It is also set when RING changes from 0 to 1.

Cleared by INIT or by reading the RCSR. Because reading the register clears the bit, it is, in effect, a "read-once" bit.

14 RING

When set, indicates that a RINGING signal is being received from the dataset. Note that the RINGING signal is not a level but an EIA control signal with the cycle time as shown below:



Read-only bit

13 CLR TO SEND (Clear to Send)

The state of this bit is dependent on the state of the CLEAR TO SEND signal from the dataset. When set, this bit indicates an ON condition; when clear, it indicates an OFF condition.

Read-only bit.

12 CAR DET (Carrier Detect)

This bit is set when the data carrier is received. When clear, it indicates either the end of the current transmission activity or an error condition.

Read-only bit.

11 RCVR ACT (Receiver Active)

When set, this bit indicates that the DL11 interface receiver is active. The bit is set at the center of the START bit which is the beginning of the input serial data from the device and is cleared by the leading edge of RCVR DONE.

Read-only bit; cleared by INIT or by RCVR DONE (bit 07).

10 SEC REC (Secondary Receive or Supervisory Received Data)

This bit provides a receive capability for the reverse channel of a remote station. A space (+6V) is read as a 1. (A transmit capability is provided by bit 03.)

Read-only bit; cleared by INIT.

9–8 Unused

Not applicable.

07 RCVR DONE (Receiver Done)

This bit is set when an entire character has been received and is ready for transfer to the Unibus. When set, initiates an interrupt sequence provided RCVR INT ENB (bit 06) is also set.

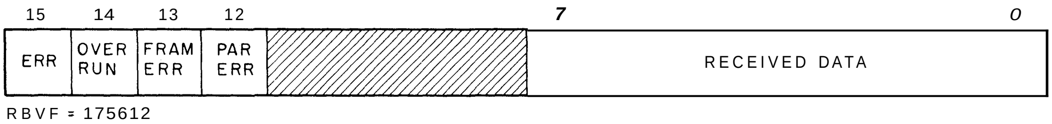
Cleared whenever the receiver buffer (RBUF) is addressed or whenever RDR ENB (bit 00) is set. Also cleared by INIT.

Read-only bit.

Bit	Name	Meaning and Operation
06	RCVR INT ENB (Receiver Interrupt Enable)	When set, allows an interrupt sequence to start when RCVR DONE (bit 07) sets. Readlwrite bit; cleared by INIT.
05	DATASET INT ENB (Dataset Interrupt Enable)	When set, allows an interrupt sequence to start when DATASET INT (bit 15) sets. Readlwrite bit; cleared by INIT.
04	Unused	Not applicable.
03	SEC XMIT (Secondary Transmit or Supervisory Transmitted Data)	This bit provides a transmit capability for a reverse channel of a remote station. When set, transmits a space (+6V). (A receive capability is provided by bit 10.) Readlwrite bit; cleared by INIT.
02	REQ TO SEND (Request to Send)	A control lead to the dataset which is required to transmission. A jumper ties this bit to REQ TO SEND or FORCE BUSY in the dataset. Readlwrite bit; cleared by INIT
01	DTR (Data Terminal Ready)	A control lead for the dataset communication channel. When set, permits connection to the channel. When clear, disconnects the interface from the channel. Readlwrite bit; must be cleared by the program, is not cleared by INIT.

NOTE
The state of this bit is not defined after power-up.

Bit	Name	Meaning and Operation
00	RDR ENB (Reader Enable)	When set, this bit advances the paper-tape reader in ASR Teletype units and clears the RCVR DONE bit (bit 07). This bit is cleared at the middle of a START bit which is the beginning of the serial input from an external device. Also cleared by INIT. Write-only bit. Not used in dataset configurations.



RBVF = 175612

Figure 9 Receiver Buffer Register (RBUF) – Bit Assignments

3.4.2 Receiver Buffer Register

Bit	Name	Meaning and Operation
15	ERROR (Error)	Used to indicate that an error condition is present. This bit is the logical OR of OR ERR, FR ERR, and P ERR (bits 14, 13, and 12, respectively). Whenever one of these bits is set, it causes ERROR to set. This bit is not connected to the interrupt logic. Read-only bit; cleared by removing the error-producing condition.

NOTE

Error indications remain present until the next character is received, at which time the error bits are updated. INIT does not necessarily clear the error bits.

Bit	Name	Meaning and Operation
14	OR ERR (Overrun Error)	When set, indicates that reading of the previously received character was not completed (RCVR DONE not cleared) prior to receiving a new character. Read-only bit; cleared in the same manner as ERROR (bit 15).
13	FR ERR (Framing Error)	When set, indicates that the character that was read had no valid STOP bit. Read-only bit; cleared in the same manner as ERROR (bit 15).
12	P ERR (Parity Error)	When set, indicates that the parity received does not agree with the expected parity. This bit is always 0 if no parity is selected. Read-only bit; cleared in the same manner as ERROR (bit 15).
11–08	Unused	Not applicable
07–00	RECEIVED DATA BITS	Holds the character just read. If less than eight bits are selected, then the buffer is right-justified into the least significant bit positions. In this case, the higher unused bit or bits read as 0s. Read-only bits; not cleared by INIT

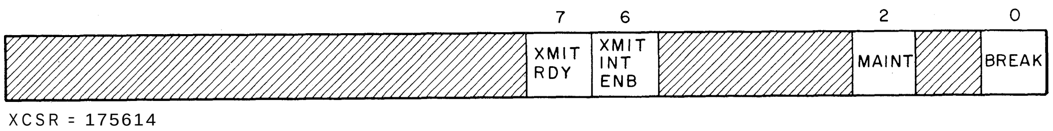


Figure 10 Transmitter Status Register (XCSR) – Bit Assignments

3.4.3 Transmitter Status Register

Bit	Name	Meaning and Operation
15–08	Unused	Not applicable.
07	XMIT RDY (Transmitter Ready)	This bit is set when the transmitter buffer (XBUF) can accept another character. When set, it initiates an interrupt sequence provided XMIT INT ENB (bit 06) is also set. Read-only bit. Set by INIT. Cleared by loading the transmitter buffer.
06	XMIT INT ENB (Transmitter Interrupt Enable)	When set, allows an interrupt sequence to start when XMIT RDY (bit 07) sets.
05–03	Unused	Not applicable.
02	MAINT (Maintenance)	Used for maintenance function. When set, disables the serial line input to the receiver and connects the transmitter output to the receiver input which disconnects the external device input. It also forces the receiver to run at transmitter speed. Read/write bit; cleared by INIT.
01	Unused	Not applicable.
00	BREAK	When set, transmits a continuous space to the external device. Read/write bit; cleared by INIT.

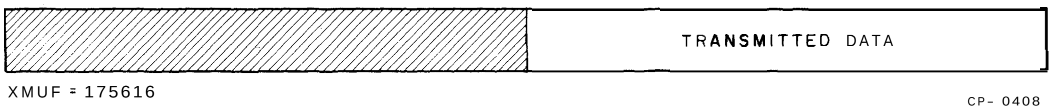


Figure 11 Transmitter Buffer Register (XBUF) – Bit Assignments

3.4.4 Transmitter Buffer Register

Bit	Name	Meaning and Operation
15–08	Unused	Not applicable.
07–00	TRANSMITTER DATA BUFFER	Holds the character to be transferred to the external device. If less than eight bits are used, the character must be loaded so that it is right-justified into the least significant bits. Write-only bits.

3.4.5 Interrupts

The DL11 interface uses BR interrupts to gain control of the bus to perform a vectored interrupt, thereby causing a branch to a handling routine. The DL11 has two interrupt channels: one for the receiver section and one for the transmitter section. These two channels operate independently; however, if simultaneous interrupt requests occur, the receiver has priority. The receiver section is capable of handling multiple source interrupts.

A transmitter interrupt can occur only if the interrupt enable bit (XMIT INT ENB) in the transmitter status register is set. With XMIT INT ENB set, setting the transmitter ready (XMIT RDY) bit initiates an interrupt request. When XMIT RDY is set, it indicates that the transmitter buffer is empty and ready to accept another character from the bus for transfer to the external device.

A receiver data interrupt can occur only if the interrupt enable (RCVR INT ENB) bit in the receiver status register is set. With RCVR INT ENB set, setting the receiver done (RCVR DONE) bit initiates an interrupt request. When RCVR DONE is set, it indicates that an entire character has been received and is ready for transfer to the bus. The additional interrupt request sources for the DL11 option are discussed in the following paragraphs.

The receiver portion of the DL11 in the GT40/42 dataset configuration can service multiple source interrupts. One of the receiver interrupt circuits is activated by RCVR INT ENB and RCVR DONE. The additional interrupt circuit can cause an interrupt only if the dataset interrupt enable bit (bit 05, DATASET INT ENB) in the receiver status register is set. With DATASET INT ENB set, setting the DATASET INT bit initiates an interrupt request. The DATASET INT bit can be set by one of four other bits: CAR DET, CLR TO SEND, SEC REC, or RING.

When servicing an interrupt for one condition, if a second interrupt condition develops, a unique second interrupt, as well as all subsequent interrupts, may not occur. To prevent this, either all possible interrupt conditions should be checked after servicing one condition or both interrupt enable bits (bits 05 and 06) should be cleared upon entry to the service routine for vector XXO and then set again at the end of service.

The interrupt priority level is 5 with the receiver having a slightly higher priority than the transmitter in all cases. Note that the priority level can be changed with a priority plug.

Any DEC programs or other software referring to the standard BR level or vector addresses must also be changed if the priority plug or vector address is changed.

3.4.6 Timing Considerations

When programming the DL11 Asynchronous Line Interface, it is important to consider timing of certain functions in order to use the system in the most efficient manner. Timing considerations for the receiver transmitter, and break generation logic are discussed in the following paragraphs.

3.4.6.1 Receiver – The RCVR DONE flag (bit 07 in the RCSR) sets when the Universal Asynchronous Receiver/Transmitter (UART) has assembled a full character. This occurs at the middle of the first STOP bit. Because the UART is double buffered, data remains valid until the next character is received and assembled. This permits one full character time for servicing the RCVR DONE flag.

3.4.6.2 Transmitter – The transmitter section of the UART is also double buffered. The XMIT RDY flag (bit 07 in the XCSR) is set after initialization. When the buffer (XBUF) is loaded with the first character from the bus, the flag clears but then sets again within a fraction of a bit time. A second character can then be loaded, which clears the flag again. The flag then remains cleared for nearly one full character time.

3.4.6.3 Break Generation Logic – When the BREAK bit (bit 00 in the XCSR) is set, it causes transmission of a continuous space. Because the XMIT RDY flag continues to function normally, the duration of a break can be timed by the pseudo-transmission of a number of characters. However, because the transmitter section of the UART is double buffered, a null character (all 0s) should precede transmission of the break to ensure that the previous character clears the line. In a similar manner, the final pseudo-transmitted character in the break should be null.

3.4.7 Program Notes

The following notes pertain to programming the DL11 interface and contain information that may be useful to the programmer. More detailed programming information is given in the *Paper Tape Software Programming Handbook,* DEC-11-GGPC-D and in the individual program listings.

a. Character Format – The character format for the DL11 consists of a START bit, five to eight DATA bits, 1, 1.5, or 2 STOP bits and the option of PARITY (odd or even) or no parity. This is illustrated in Figure 12. Note that when less than eight DATA bits are used, the character must be right-justified to the least significant bit. The character format pertains to both the receiver and the transmitter.

b. Maintenance Mode – The maintenance mode is selected by setting the MAINT bit (bit 02) in the XCSR. In this mode, the interface disables the normal input to the receiver and replaces it with the output of the transmitter. The programmer can then load various bits into the transmitter and read them back from the receiver to verify proper operation of the DL11 logic circuits.

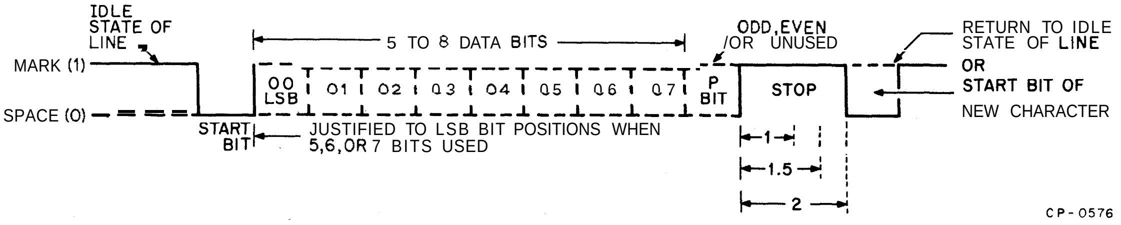


Figure 12 Serial Character Format

3.4.8 Program Example

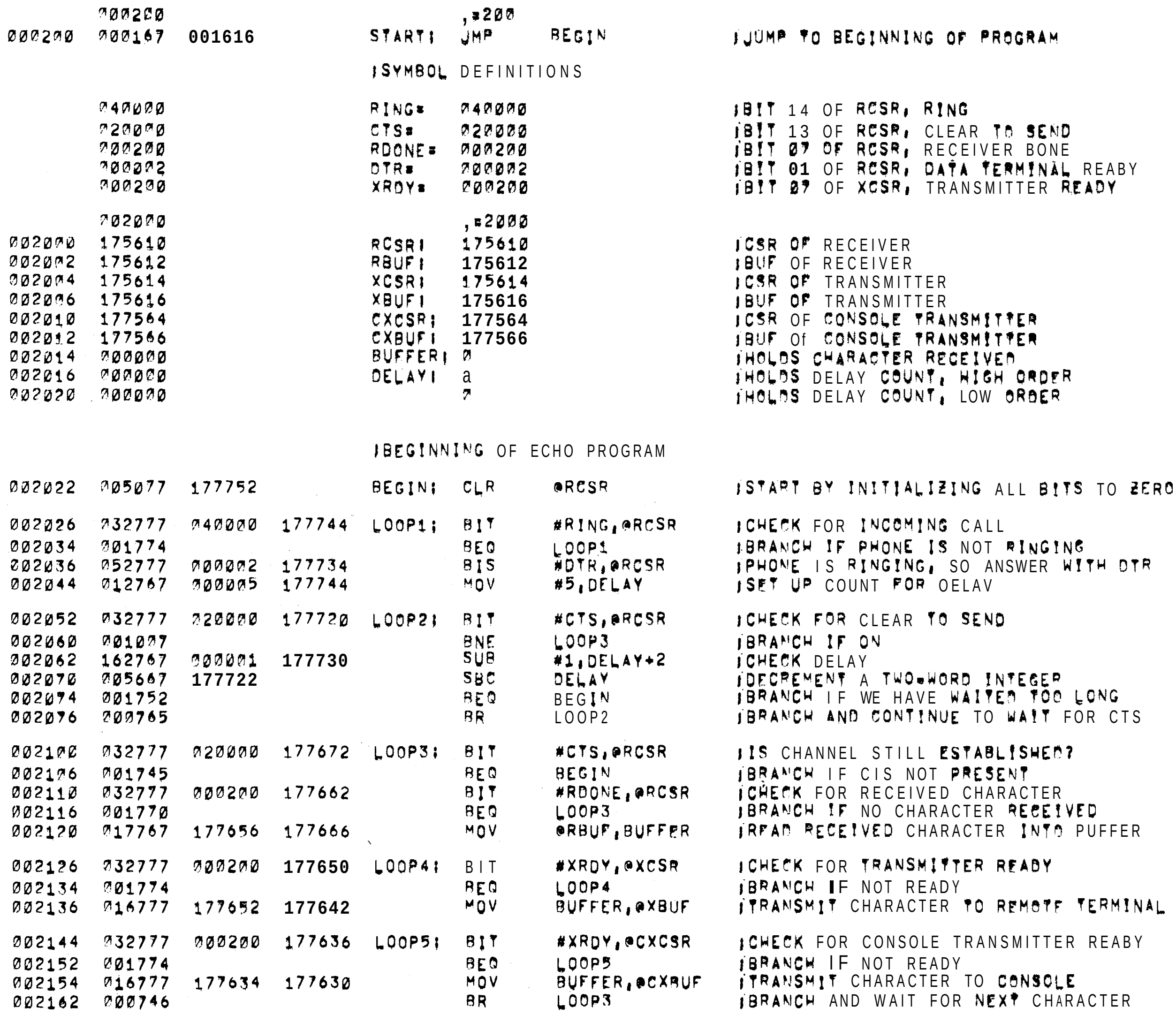
Figure 13 is an example of a typical program that can be used as an echo program for a Type 103 dataset. When a remote terminal dials in, this program answers the call and provides a character-by-character echo. Characters are also copied onto the console device.

4.1 PROGRAMMING THE GT40/42

4.2 PROGRAMMING CONCEPT

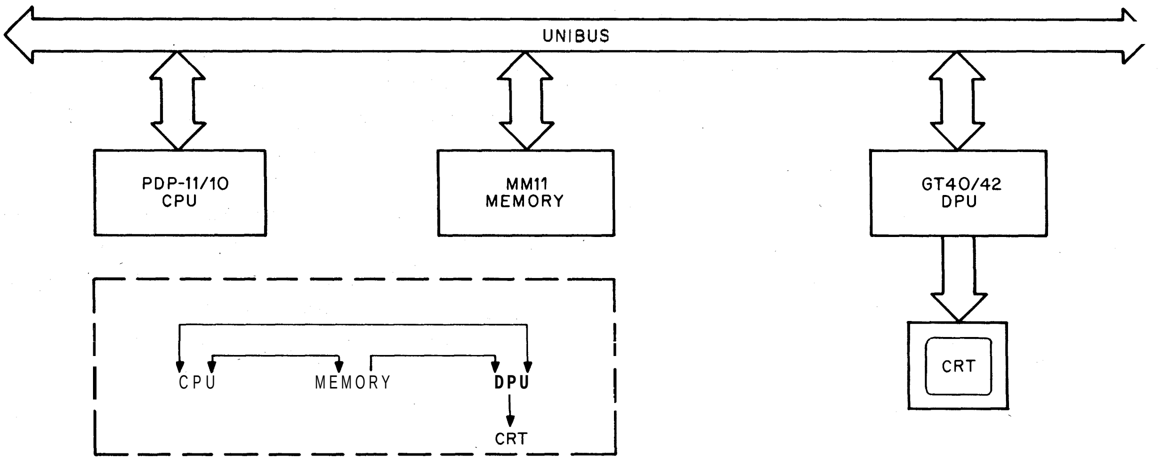
The user should view the GT40/42 Graphic Display Terminal as two separate, programmed processors: a PDP-11/10 computer (CPU) and a special display processor (DPU). The PDP-11/10 is programmed to initiate the display, and is then free to execute its own program. All instructions available on the PDP-11/10 are executable in the GT40/42. Figure 14 shows the relationship of the GT40/42 components to the Unibus (the inset illustrates specific GT40/42 data flow via the Unibus).

The DPU communicates directly with the MM11 memory by way of non-processor requests (NPR), i.e., DMA requests. The PDP-11/10, connected in parallel, also uses the MM11 memory for executing its own PDP-11 code. The DPU executes display instructions stored in semi-contiguous memory locations called display lists. A memory layout example is shown in Figure 15. The Display Program Counter (DPC) in the DPU is addressed by the CPU, via the Unibus, and the data MOVed to the DPC becomes the starting address of the display list. All addresses placed on the Unibus are even numbers, i.e., word addresses.



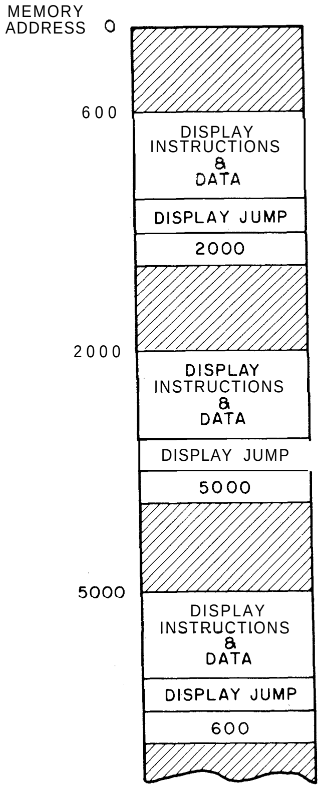
```
        ØØØ2ØØ                                 .=2ØØ
ØØØ2ØØ  ØØØ167  001616            START:  JMP     BEGIN          ;JUMP TO BEGINNING OF PROGRAM

                                  ;SYMBOL DEFINITIONS

        Ø4ØØØØ                    RING=   Ø4ØØØØ                 ;BIT 14 OF RCSR, RING
        Ø2ØØØØ                    CTS=    Ø2ØØØØ                 ;BIT 13 OF RCSR, CLEAR TO SEND
        ØØØ2ØØ                    RDONE=  ØØØ2ØØ                 ;BIT Ø7 OF RCSR, RECEIVER BONE
        ØØØØØ2                    DTR=    ØØØØØ2                 ;BIT 01 OF RCSR, DATA TERMINAL REABY
        ØØØ2ØØ                    XRDY=   ØØØ2ØØ                 ;BIT Ø7 OF XCSR, TRANSMITTER READY

        ØØ2ØØØ                            .=2ØØØ
ØØ2ØØØ  17561Ø                    RCSR:   17561Ø                 ;CSR OF RECEIVER
ØØ2ØØ2  175612                    RBUF:   175612                 ;BUF OF RECEIVER
ØØ2ØØ4  175614                    XCSR:   175614                 ;CSR OF TRANSMITTER
ØØ2ØØ6  175616                    XBUF:   175616                 ;BUF OF TRANSMITTER
ØØ2Ø1Ø  177564                    CXCSR:  177564                 ;CSR OF CONSOLE TRANSMITTER
ØØ2Ø12  177566                    CXBUF:  177566                 ;BUF Of CONSOLE TRANSMITTER
ØØ2Ø14  ØØØØØØ                    BUFFER: Ø                      ;HOLDS CHARACTER RECEIVED
ØØ2Ø16  ØØØØØØ                    DELAY:  a                      ;HOLDS DELAY COUNT, HIGH ORDER
ØØ2Ø2Ø  ØØØØØØ                            Ø                      ;HOLDS DELAY COUNT, LOW ORDER

                                  ;BEGINNING OF ECHO PROGRAM

ØØ2Ø22  ØØ5Ø77  177752            BEGIN:  CLR     @RCSR          ;START BY INITIALIZING ALL BITS TO ZERO

ØØ2Ø26  Ø32777  Ø4ØØØØ  177744    LOOP1:  BIT     #RING,@RCSR    ;CHECK FOR INCOMING CALL
ØØ2Ø34  ØØ1774                            BEQ     LOOP1          ;BRANCH IF PHONE IS NOT RINGING
ØØ2Ø36  Ø52777  ØØØØØ2  177734            BIS     #DTR,@RCSR     ;PHONE IS RINGING, SO ANSWER WITH DTR
ØØ2Ø44  Ø12767  ØØØØØ5  177744            MOV     #5,DELAY       ;SET UP COUNT FOR OELAV

ØØ2Ø52  Ø32777  Ø2ØØØØ  17772Ø    LOOP2:  BIT     #CTS,@RCSR     ;CHECK FOR CLEAR TO SEND
ØØ2Ø6Ø  ØØ1ØØ7                            BNE     LOOP3          ;BRANCH IF ON
ØØ2Ø62  162767  ØØØØØ1  177730            SUB     #1,DELAY+2     ;CHECK DELAY
ØØ2Ø7Ø  ØØ5667  177722                    SBC     DELAY          ;DECREMENT A TWO-WORD INTEGER
ØØ2Ø74  ØØ1752                            BEQ     BEGIN          ;BRANCH IF WE HAVE WAITED TOO LONG
ØØ2Ø76  ØØØ765                            BR      LOOP2          ;BRANCH AND CONTINUE TO WAIT FOR CTS

ØØ21ØØ  Ø32777  Ø2ØØØØ  177672    LOOP3:  BIT     #CTS,@RCSR     ;IS CHANNEL STILL ESTABLISHED?
ØØ21Ø6  ØØ1745                            BEQ     BEGIN          ;BRANCH IF CIS NOT PRESENT
ØØ211Ø  Ø32777  ØØØ2ØØ  177662            BIT     #RDONE,@RCSR   ;CHECK FOR RECEIVED CHARACTER
ØØ2116  ØØ177Ø                            BEQ     LOOP3          ;BRANCH IF NO CHARACTER RECEIVED
ØØ212Ø  Ø17767  177656  177666            MOV     @RBUF,BUFFER   ;READ RECEIVED CHARACTER INTO PUFFER

ØØ2126  Ø32777  ØØØ2ØØ  177650    LOOP4:  BIT     #XRDY,@XCSR    ;CHECK FOR TRANSMITTER READY
ØØ2134  ØØ1774                            BEQ     LOOP4          ;BRANCH IF NOT READY
ØØ2136  Ø16777  177652  177642            MOV     BUFFER,@XBUF   ;TRANSMIT CHARACTER TO REMOTF TERMINAL

ØØ2144  Ø32777  ØØØ2ØØ  177636    LOOP5:  BIT     #XRDY,@CXCSR   ;CHECK FOR CONSOLE TRANSMITTER REABY
ØØ2152  ØØ1774                            BEQ     LOOP5          ;BRANCH IF NOT READY
ØØ2154  Ø16777  177634  17763Ø            MOV     BUFFER,@CXBUF  ;TRANSMIT CHARACTER TO CONSOLE
ØØ2162  ØØØ746                            BR      LOOP3          ;BRANCH AND WAIT FOR NEXT CHARACTER
```

Figure 13 Program Example



CP-0654

Figure 14 GT40/42 Data Paths


MEMORY ADDRESS 0
600
DISPLAY INSTRUCTIONS & DATA
DISPLAY JUMP
2000
2000
DISPLAY INSTRUCTIONS & DATA
DISPLAY JUMP
5000
5000
DISPLAY INSTRUCTIONS & DATA
DISPLAY JUMP
600

Shown are three "lists" of display instructions and data chained together by Display Jump instructions into one, closed display file. The shaded memory areas can be used by the CPU for PDP-11 code, data, buffer registers, etc.

CP-0653

Figure 15 Memory Layout Example

4.3 IMPORTANT REGISTERS (all addresses are in octal)

Display Addresses:

Display Program Counter (DPC) = 172000 (Read/Write)
Resume Address (RA) = 172000 (Write)

(To resume a display, for example after a light pen hit, bit 0 (LSB) = 1 should be MOVed to the RA, i.e., MOV #1, RA.)

Display Status Register = 172002 (Read/Write)

Contents (Read):

Stop Flag	Bit	(15) (MSB)
Mode		(14:11)
Intensity		(10:8)
Light Pen Flag		(7)
Shift Out		(6)
Edge Indicator		(5)
Italics		(4)
Blink		(3)
Spare (Not Used)		(2)
Line		(1:0)

(If an attempt is made to write to address 172002, the effect is to ring the BELL in the GT40/42, e.g., MOV #2, 172002.)

X Status Register = 172004 (Read only)

Contents:

X Position	Bits	(9:0)
Graphplot Increment		(15:10)

Y Status Register = 172006 (Read only)

Contents:

Y Position	Bits	(9:0)
Character Register		(15:10)

(Note: When in the SHIFTED OUT character mode, and an illegal code (040 → 137_8) is fetched, the program is interrupted. The Character Register can then be read to find the dispatch to a user routine that is used to draw some special character.)

Display Interrupt Vector Addresses:

Stop Interrupt = 3201322
Light Pen Interrupt = 3241326
Time Out and Shift Out Interrupt = 3301332
(All display interrupts are requested at level BR4.)

DL11 Communications Interface Addresses:

Receive Status Register (RCSR) = 175610
Receive Buffer (RBUF) = 175612
Transmitter Status Register (XCSR) = 175614
Transmitter Buffer (XBUF) = 175616
(Additional DL11 programming information is included in Paragraph 3.1.)

DL11 Interrupt Vector Addresses:

Receiver Interrupt = 3001302
Transmitter Interrupt = 3041306
(DL11 interrupts are requested on level BR5.)

Miscellaneous Addresses:

CPU General Register	R0 = 177700
(only console addressable)	R7 = 177707

CPU Console Switches SWR = 177570
(console and CPU addressable)

CPU Status PS = 177776
(console and CPU addressable)

Keyboard Command and Status (KCSR) = 177560

Keyboard Data Buffer (KDBR) = 177562

Keyboard Interrupt Vector = 60162

Line Frequency Clock (KW11-L) = 177546

ROM Bootstrap Memory = 166000
(Starting Address)

4.4 PDP-11 INSTRUCTION SET

A detailed description of the PDP-11 instruction set can be found in *GT40 Graphic Display Terminal, Volume 2* (DEC-11-HGTMA-A-D). This manual assumes the reader is familiar with the instruction set and general operation of the PDP-11/10.

4.5 GT40/42 DISPLAY PROCESSOR INSTRUCTION SET

The display processor instruction set consists of five basic instructions: Set Graphic Mode, Jump, No-op, Load Status Register A, and Load Status Register B. Figure 16 shows the breakdown, by bit position, of each instruction. Figure 17 provides similar information for the data words that accompany the instructions.

NOTE

The user should not insert I-bits into those positions indicated as spare or unused.

4.6 PROGRAMMING EXAMPLES

The following programming examples are meant to provide the user with a basic introduction to GT40/42 programming technique. They have been kept brief in order that the points being illustrated not be lost as would be the case if larger, operational program examples were used.

Table 8 is a list of suggested mnemonics for GT40/42 operation.

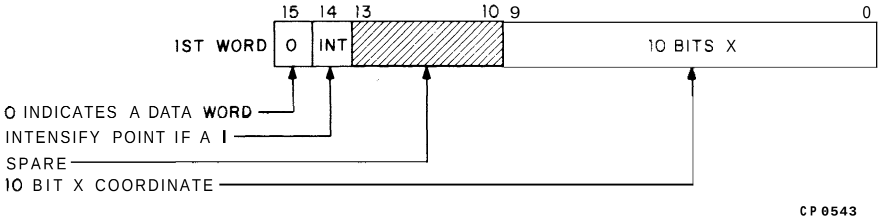
4.6.1 Initializing the Display Processor

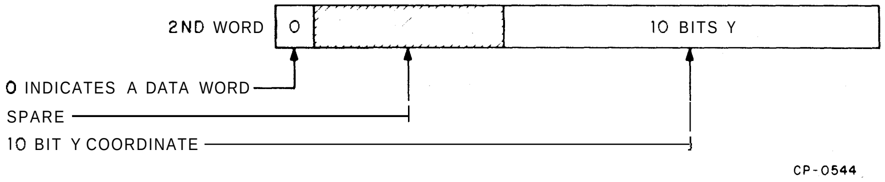
To start the DPU, the CPU executes a short program that loads the Display (processor) Program Counter (DPC) with the starting address (SA) of the display file. The Stack Pointer must also be initialized to an address above 400_8 to prevent a stack overflow if an interrupt occurs.

The following program performs these two operations.

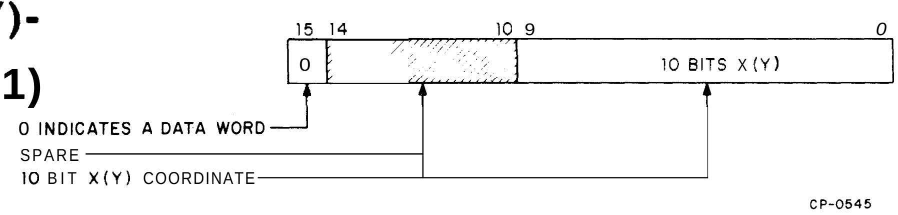
Address	Instruction/Data	Mnemonic	Comment
1000	012706	MOV #500, R6	Initialize the
1002	500		stack pointer
1004	012737	MOV #SA, @ #DPC	Load the DPC
1006	2000		with SA = 2000
1010	172000		
1012	00001	WAIT	Wait (or other
			PDP-11 code)

POINT DATA MODE- Mode 0011





GRAPHPLOT X(Y)- Mode 0100 (0101)



RELATIVE POINT MODE- Mode 0110

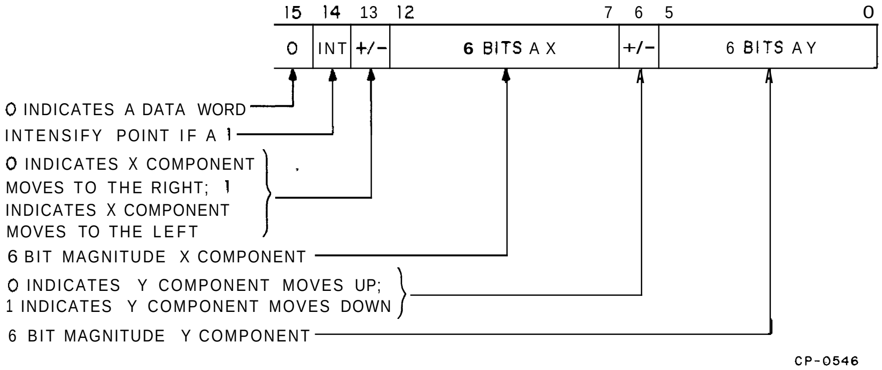

15
14
13
12
7
6
5
0
0
INT
+/-
6 BITS A X
+/-
6 BITS A Y
0 INDICATES A DATA WORD
INTENSIFY POINT IF A 1
0 INDICATES X COMPONENT MOVES TO THE RIGHT; 1 INDICATES X COMPONENT MOVES TO THE LEFT
6 BIT MAGNITUDE X COMPONENT
0 INDICATES Y COMPONENT MOVES UP; 1 INDICATES Y COMPONENT MOVES DOWN
6 BIT MAGNITUDE Y COMPONENT
CP-0546

Figure 17 Data Word Formats (Sheet 2 of 2)

Table 8
Recommended GT40/42 Mnemonics

	Mnemonic = Value			Function
Group 1				
	CHAR	=	100000	Character Mode
	SHORTV	=	104000	Short Vector Mode
	LONGV	=	110000	Long Vector Mode
	POINT	=	114000	Point Mode
	GRAPHX	=	120000	Graphplot X Mode
	GRAPHY	=	124000	Graphplot Y Mode
	RELATV	=	130000	Relative Point Mode
	INTO	=	2000	Intensity 0 (Dimmest)
	INT1	=	2200	Intensity 1
	INT2	=	2400	Intensity 2
	INT3	=	2600	Intensity 3
	INT4	=	3000	Intensity 4
	INT5	=	3200	Intensity 5
	INT6	=	3400	Intensity 6
	INT7	=	3600	Intensity 7 (Brightest)
	LPOFF	=	100	Light Pen Off
	LPON	=	140	Light Pen On
	BLKOFF	=	20	Blink Off
	BLKON	=	30	Blink On
	LINE0	=	4	Solid Line
	LINE1	=	5	Long Dash
	LINE2	=	6	Short Dash
	LINE3	=	7	Dot Dash
Group 2				
	DJMP	=	160000	Display Jump
Group 3				
	DNOP	=	164000	Display No Operation
Group 4				
	STATSA	=	170000	Load Status A Instruction
	DSTOP	=	173400	Display Stop and Interrupt
	SINON	=	1400	Stop Interrupt On
	SINOF	=	1000	Stop Interrupt Off

Table 8 (Cont)
Recommended GT40/42 Mnemonics

Mnemonic	=	Value	Function
LPLITE	=	200	Light Pen Hit On
LPDARK	=	300	Light Pen Hit Off
ITAL0	=	40	Italics Off
ITAL1	=	60	Italics On
SYNC	=	4	Halt and Resume in Sync
Group **5**			
STATSB	=	174000	Load Status B Instruction
INCR	=	100	Graphplot Increment
Group 6 (Vector/Point Mode)			
INTX	=	40000	Intensify Vector or Point
MAXX	=	1777	Maximum A X Component
MAXY	=	1377	Maximum A Y Component
MINUSX	=	20000	Negative A X Component
MINUSY	=	20000	Negative A Y Component
Group **7** (Short Vector Mode)			
MAXSX	=	17600	Maximum Δ X Component
MAXSY	=	77	Maximum A Y Component
MISVX	=	20000	Negative A X Component
MISVY	=	100	Negative A Y Component

4.6.2 Display File

The following program causes a 200_8 unit box to be drawn with the lower left corner at screen location $500{,}500_8$. Initially, the DPC is loaded with the starting address. Then the display parameters, e.g., intensity, are established and the mode set to Point. The four vectors are drawn after the Point is executed and, to conclude the file, the last commands reload the DPC with the display file starting address. This results in the display file being re-executed; the CRT display is refreshed.

Address	Instruction/Data	Mnemonic	Comment
		.= 100	
100	012706	MOV #500, R6	Initialize the
102	500		stack pointer
104	012737	MOV #2000, @ #DPC	Load the DPC
106	2000		with SA = 2000
110	172000		
112	000001	WAIT ,	Wait
2000	117124	.=2000	Point mode, intensity
		POINT+INT4+LPOFF	4, no light pen, no
		+BLKOFF+LINED	blink, solid lines.
2002	500	500	Unintensified point
2004	500	500	at X = 500, Y = 500
2006	110000	LONGV	Long vector mode
2010	40200	200+INTX	a X = 200, a Y = 0,
2012	0	0	intensified
2014	40000	0+INTX	Δ X = 0, a Y = 200,
2016	200	200	intensified
2020	60200	200+INTX+MINUS	Δ X = -200, Δ Y = 0,
2022	0	0	intensified
2024	40000	0+1NTX	a X = 0, Δ Y = -200,
2026	20200	200+MINUS	intensified
2030	160000	DJMP	Jump to start of
2032	2000	2000	display file.

Note that since the parameters (intensity level, no blink, and line type) are specified in the point instruction, they need not be re-specified in the long vector instruction (2006) because they will not change unless the appropriate enable bits are set. The enable bits also allow the user to change, for example, the line type but not the intensity. In this case, only the line type enable bit is changed, not the intensity enable bit. This retention of current, not-to-be-changed, values saves both execution time and memory storage space.

4.6.3 Application of the Stop Interrupt

The Stop Interrupt provides close interaction between the CPU and the DPU. The following program restarts the display after the halt and interrupt sequence. This occurs at the end of each pass.

Address	Instruction/Data	Mnemonic	Comment
		. = 100	
100	012706	MOV #500, R6	Initialize the
102	500		stack pointer
104	012737	MOV #2000, @ #DPC	Load the DPC with
106	2000		SA = 2000
110	172000		
112	000001	WAIT	Wait for interrupt
114	776	BR.- 2	Jump back one
		. = 320	instruction
320	400	400	Address of next
			instruction to be
			executed after a
			Stop interrupt
322	200	200	Processor status
		. = 400	(BR level 4)
400	012737	MOV #1, @ #DPC	Resume the display

```
Address   Instruction/Data   Mnemonic              Comment

 402            01
 404        172000
 406            02           RTI                   Return from interrupt
2000        117124           .=2000                Point mode, intensity
                             POINT+INT4+LPOFF      4, no light pen, no
                             +BLKOFF+LINED         blink, solid lines.
2002           500           500                   Unintensified point
2004           500           500                   at X = 500, Y = 500
2006        110000           LONGV                 Long vector mode
2010         40200           200+INTX              Δ X = 200, Δ Y = 0,
2012             0           0                     intensified
2014         40000           0+INTX                A X = 0, A Y = 200,
2016           200           200                   intensified
2020         60200           200+INTX+MINUS        Δ X = -200, Δ Y = 0,
2022             0           0                     intensified
2024         40000           0+1NTX                Δ X = 0, Δ Y = -200
2026         20200           200+MINUS             intensified
2030        173400           DSTOP                 Enable Stop interrupt,
                                                   Stop
2032        160000           DJMP                  Jump to start of
2034          2000           2000                  display file after
                                                   a Resume
```

After initializing the DPU, the CPU WAITs for an interrupt. The DPU executes the display file, eventually performing the STOP with interrupt enabled. This causes a vectored interrupt to address 320_8.

Since the Stack Pointer was initialized to 500_8, the CPU stores its processor status and program counter in location 500_8 and 476_8 respectively; it pushes them on the "stack." Once stored, the CPU goes to location 320_8 and uses its contents as the address of the interrupt routine. The CPU takes the contents of location 322_8 as its new processor status. In this example, location 400_8 is the address of the interrupt handler and the CPU proceeds to that location.

The interrupt handler simply MOVes the number 1 to the DPC which is interpreted as a RESUME by the DPU. As the DPU resumes operation, it will fetch and interpret the next instruction after stopping, in this case a DJMP, back to the start of the display file. The final instruction of the interrupt handler is a Return from Interrupt (RTI), restoring the CPU to the status and location present before the interrupt, i.e., it pops two words off the stack. A computer branch back one instruction is executed, thus placing the CPU in a WAIT condition again.

4.7 PROGRAMMING RESTRICTIONS

As with any complex system, certain restrictions must be observed by the user if trouble-free operation is to be expected. In the case of the GT40/42, the programmer should be aware of certain programming limitations so that the hardware may be exercised more proficiently without violating hardware rules.

4.7.1 Stop and Sync, Microcoding

Stop and Sync appear in the Load Status A instruction. However, selection of both conditions in any given Load Status A instruction should be avoided. Priorities have been built into the GT40/42 hardware concerning the action on the microcoding of these bits. The rules are as follows:

1. Sync and Stop
   Sync will override Stop. The display will stop but will resume in sync with the line frequency.

2. Stop and Sync with Stop Interrupt Enabled
   Setting Stop with the Stop Interrupt enabled and Sync must be avoided. Under these conditions, the DPU will stop, post an interrupt, and restart automatically in sync with the line frequency. Since the Sync resume happens rather randomly with respect to the interrupt, the effect of this microcoding is undetermined.

4.7.2 Display File Changes

Restarting a Running Display – Restarting the DPU while the DPU is running should be avoided. It is possible to "catch" the DPU in the middle of a bus operation causing inconsistent or undetermined operation.

It is recommended that the DPU be halted with a Stop instruction before restarting it again.

Modification of the File – Dynamic modification of the display file should be avoided when possible. Normally the file can be modified dynamically without consequence. However, it is possible to cause problems when modifying two word instructions such as a Display Jump. For example, if the DPU fetched the first part of a DJMP while the CPU modified the second word, the DPU will process the DJMP order code and will take the modified second word as a correct address, causing the DPU to branch to a non-intended address. It is recommended that the DPU be halted before modifying the display file and that care be exercised in selecting the sequence of commands used to modify the file.

4.7.3 Non-Flicker Display

The quality of the image displayed on the screen is determined by many factors. Primarily, the display is controlled by internal adjustments (contrast, focus, etc.) and the external BRIGHTNESS control on the front panel. However, programming is also instrumental in producing better image quality. The selectable brightness feature, one of the display parameters controlled by the Set Graphic Mode instruction, is one example of the role that programming plays. Another is the control of image flicker, the repetitive dimming and brightening of all vectors and characters on the screen. Flicker, in this case, is caused by a relatively long program execution time, i.e., the time from the beginning of the display frame until the program recycles and the display is repeated. If this time is longer than about 1/30 of a second the screen fluorescence will decay (the image will become dimmer), and then brighten when the next frame begins, to the point where flicker is apparent. When the program time is less than 1/30 second, the display is reintensified before the image dims noticeably and there is no apparent flicker. Consequently, the objective, from a programming standpoint, is not to exceed this (1/30 second) execution period when designing a display program.

Program time, as defined above, and where vectors make up most of the display, is primarily determined by two factors: vector magnitude or length, and the number of vectors in the display frame. The longer the vectors and the greater the number of vectors the longer the display frame will be. Figure 18 shows the allowable limits, considering these two factors, for a flickerless display, defined here as display frames $\leqslant$ 32 ms (about 1/30 second). Note that a third factor is also present: the vector to mode word ratio. If this is a 1:1 ratio, then fewer vectors are allowed because the mode word itself requires time to be decoded – time that must be subtracted from the 32 ms period. However, this time is more efficiently used when the ratio increases, i.e., when a mode word is accompanied by a number of vectors; the total number of allowable vectors is increased. This is shown in Figure 18 as the shaded area for each vector length with the top line being the practical limit. If vector lengths vary, as is usually the case, the total number of each length must be taken into account; the aggregate must not cause the frame time to exceed 32 ms.

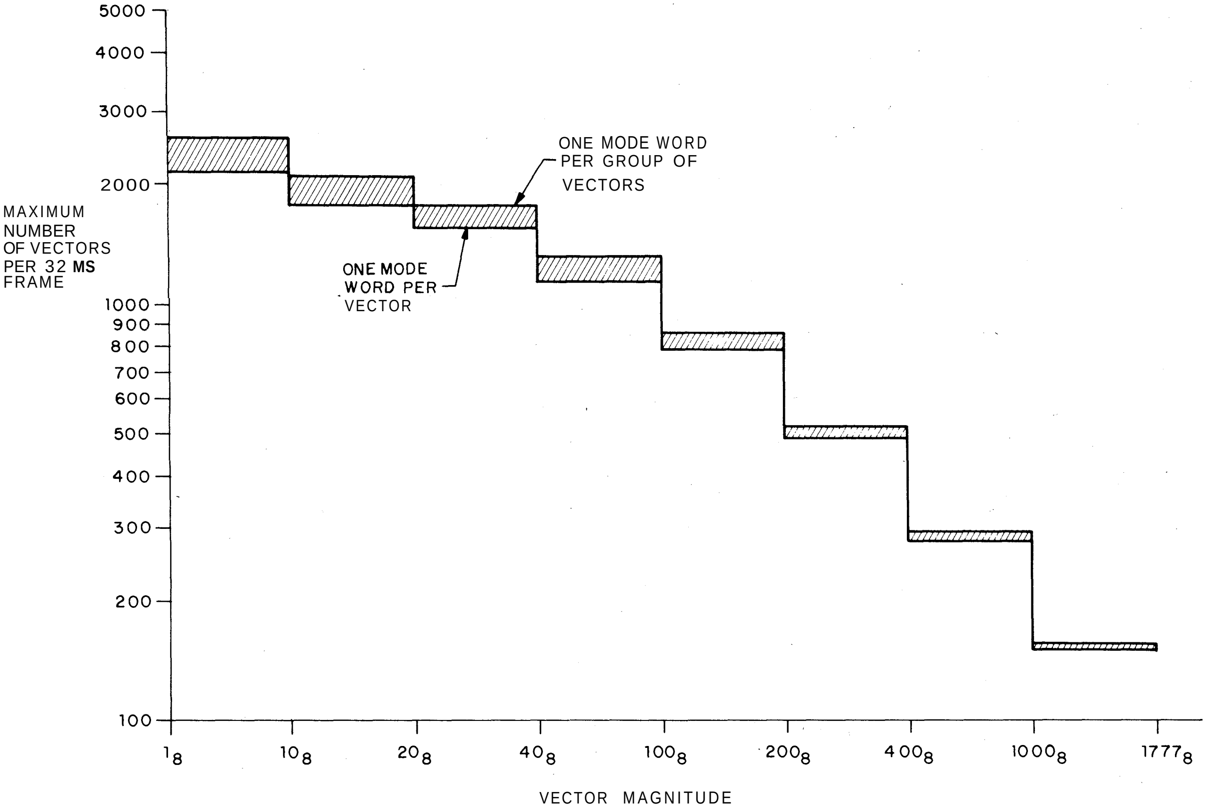


Figure 18 Non-Flicker Display as Determined by Vector Quantity and Magnitude

4.8 ADVANCED PROGRAMMING TECHNIQUES

4.8.1 Subroutines

This programming method is used when a section of display code is repeated a number of times during the execution of a display file. It precludes the need to store multiple copies of the routine in memory and therefore makes more efficient use of available storage space. Writing effective display subroutines is accomplished through use of the stop interrupt instruction (DSTOP) followed by an identifier that informs the interrupt service routine what to do or where to go. Figure 19 shows an example of how a display subroutine can be repeatedly called by the main display file. An example of an interrupt service routine is shown below. It is assumed that register **R5** is used for the subroutine stack. STKST is the starting location for the subroutine stack.

```
                 Mnemonic                   Comment

STPINT:     TST @ DPC               Test the DPC

            BEQ STOPO        If it contains a valid, non-zero address go to the next
                             instruction; if not go to STOPO

            MOV DPC,-(R5)    Push current DPC on stack

            ADD #2, @R5      The stack now contains the return address from the
                             subroutine.
```

```
              Mnemonic                 Comment


              MOV @ DPC, DPC           Move address pointed to by DPC into the
                                       DPC, i.e., go to the subroutine.

              RTI                      Exit

STOPO:        CMP R5, STKST            Is the subroutine stack empty?

              BEQ TOP                  Yes, go to top of file

              MOV (R5)+,DPC            No, pop off a word and go there

              RTI                      Exit

TOP:          MOV#START,DPC            Restart at TOP
              RTI                      and exit
```

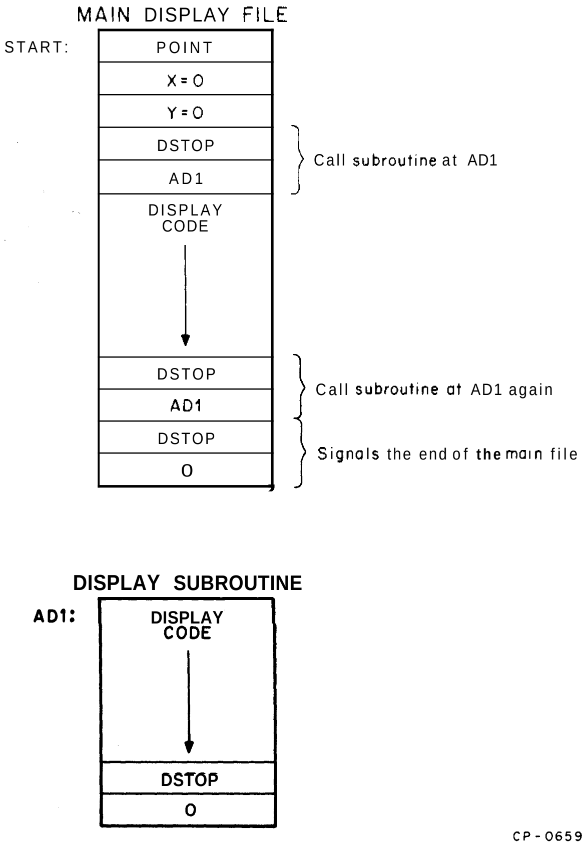


Figure **19** Subroutining **Example**

4.8.2 Light Pen Interaction

The DPU is stopped when a light pen "hit" occurs during the display of a vector, character, or point, provided light pen interrupts are permitted (bits 5 and 6 of the Set Graphic Mode word must both be true to enable the LP interrupt function).

Priorities permitting, the LP hit interrupts the PDP-11. The interrupt service routine that is called in as a result of the LP interrupt has access to three data in the DPU (the data can be read by specifying the addresses indicated):

- Display Program Counter (DPC) Addr = 172000. Points to the instruction/data word following the data word on which the LP hit occurred.
- The X position of the display at the time the DPU stopped, Addr = 172004. A 10-bit absolute number.
- The Y position of the display at the time the DPU stopped, Addr = 172006. A 10-bit absolute number.

The service routine can respond to the LP interrupt by restarting the display in one of two ways:

- Resume the display – the operation in progress at the time of the interrupt is allowed to continue. Program example: MOV #1, DPC
- Restart the display – the operation in progress at the time of the interrupt is abandoned and a new display program routine is initiated. Program example: MOV #SA, DPC

4.8.3 Special Characters

The 31 special characters in the GT40/42 display character set are addressed through use of ASCII codes Shift Out (016_8) and Shift In (017_8).

When the DPU detects the character code 016_8, the hardware enters the shift mode. In this mode codes 000 through 037_8 are decoded as special characters. (Appendix C contains a list of GT40/42 character codes.) Note that when the DPU is in the shift mode, the Shift Out code (016_8) itself is a legitimate printing character. The DPU is returned to the non-special character ASCII set (non-shift mode) when Shift In is decoded. Unlike the Shift Out code, the Shift In code (017_8) does not cause a special character to be displayed. If, when in the shift mode, the DPU detects a code $\geqslant 040_8$, the PDP-11 is interrupted by a Shift In/Time Out interrupt vector. This is because only the special characters (codes 000 through 037_8) are legal when in the shift mode. The PDP-11 now has access to the 6 low order bits of the 7-bit illegal code. These 6 bits could be used, for example, as an index to a table of software generated characters.

4.8.4 Edge Violations

An edge violation occurs if either the X or Y coordinate indicated for a relative display causes the display to go outside the physical limits of the CRT face. (Vectors, relative points, characters, and Graphplots are classified as relative type displays.) In the event of an edge violation, the edge flag in the status word is set and the display is clipped (terminated) at the edge of the screen; wrap-around does not take place. However, there is one exception in which wrap-around can occur. The GT40/42 hardware is capable of counting only up to 4095_{10}, i.e., 12 bits. Therefore, if the vector position exceeds this 12-bit limit, the count overflows to 0 and wrap-around occurs. For example, if four consecutive vectors with the same coordinates (Δ X = 1023, Δ Y = 1) are read, only the first vector is displayed; it is the only one that can be displayed within the physical address space. The other three vectors cause the count to legally exceed the 12-bit field. If a fifth vector, with the coordinates of Δ X = 10 and Δ Y = 0, is decoded, the vector will appear on the left of the display; the hardware has caused the display to wrap around. This relative X and Y counting is performed in a 12-bit circular fashion. Absolute points are limited to 10-bit addressing.

5.1 COMMUNICATIONS BOOTSTRAP READ-ONLY MEMORY (ROM)

The communications bootstrap ROM in the GT40 and the GT42 connects the Graphic Display Terminal to a host computer by way of the DL11 Asynchronous Line Interface. Two functions are performed:

1. The program allows ASCII dialogue with the host computer in order to perform such functions as logging in, etc., which presumably leads to

2. The ability to load the Graphic Display Terminal's core memory with an absolute PDP-11 program. This function is typically called a down-line load.

The ROM Bootstrap program is stored in a bipolar ROM contained in the display processor (M7014 module). The memory is assigned addresses starting at 166000_8 and is accessed via the Unibus and the display processor addressing hardware. Although physically located in the display processor, the communications ROM should be considered a separate, Unibus connected, memory device. In the GT40, the ROM contains 256 words; in the GT42, the ROM contains 512 words.

Appendix D contains a program listing of the ROM Bootstrap for the GT40 and Figure D-1 is a flow diagram for the program. Appendix E contains a program listing of the ROM Bootstrap for the GT42 and Figure E-1 is a flow diagram for the program.

5.1.1 Bootstrap Loader

The communications down-line loader portion of the Bootstrap allows loading programs in all memory locations except for the absolute addresses 15700 through 15776_8, which are used by the loader itself. If the user finds this restriction unacceptable, it is possible to reassemble a copy of the Bootstrap program with the tag COREND equal to the highest address in the user's memory, e.g., COREND = 57776_8 for a 12K memory. The procedure then is to load this modified Bootstrap first and then the user's program.

The loader will accept properly encoded ASCII strings and effect the loading of a PDP-11 absolute program. The encoding and decoding scheme is shown pictorially in Figure 20.

The loading procedure, from the host computer, is presented below in brief terms:

1. Initiate the Bootstrap by placing 166000 in the SR switches; press LOAD ADDRESS and START.

2. Transmit) (175_8) and then R (122_8) to reset the Bootstrap.

3. Transmit } (175_8) and then L (114_8) to start the Loader.

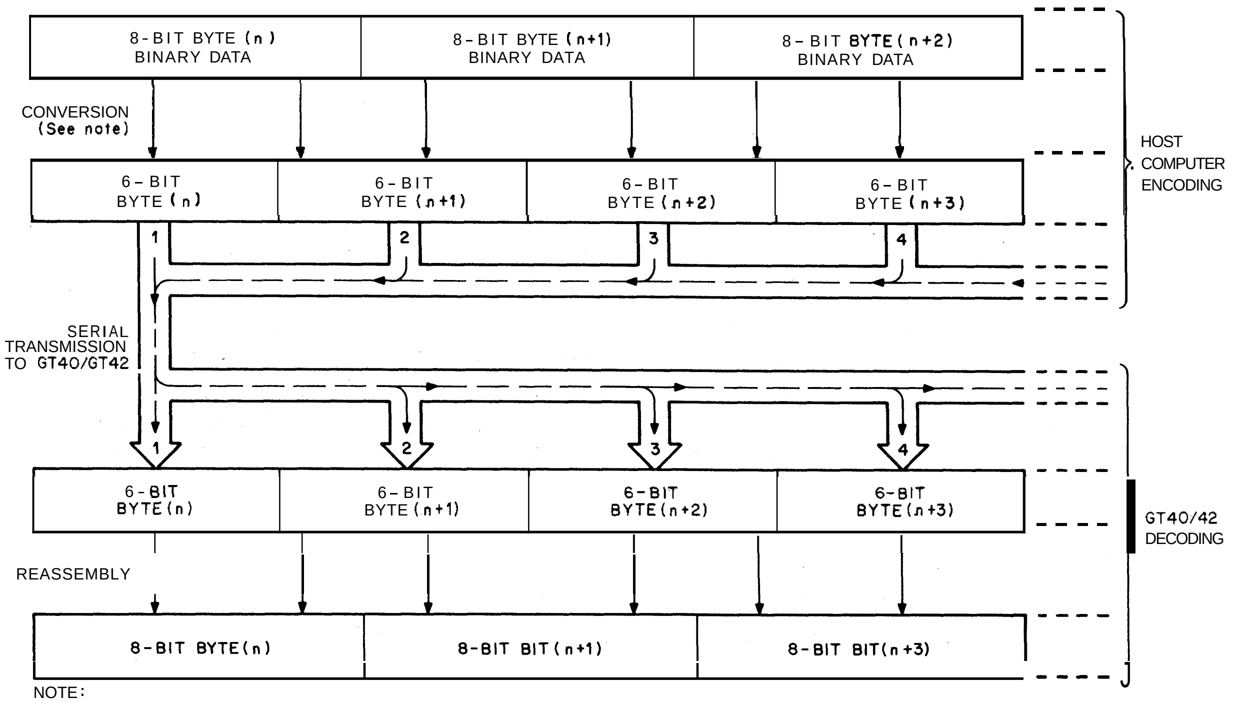
4. Transmit encoded characters representing the binary program to be loaded.

5. If a checksum error occurs during a load, B (102_8) and } (175,) will be returned.

6. If the program loads but does not self-start, G (107_8) and) (175_8) are returned.

7. There is no return if the program is properly loaded and started.

To enable synchronization of the loader at high transfer rates, the host computer should transmit filler characters after step 3 above. These fillers should be nulls in multiples of three, as indicated in Figure 21. The @ symbol (100_8) is transmitted because 100_8 is added to all characters less than 040_8; therefore, null (000) + 100_8 = 100_8. The filler requirement is satisfied by six nulls, i.e., eight @ symbols.



NOTE:
If 6-Bit number x $<40_8$ then $x=x+100_8$; if 6-Bit number $x \geqslant 40_8$ then $x=x$. The resulting 6-Bit codes are 040_8 through 137_8; all are printable characters and symbols. They are serially transmitted in sequential order, until the end of the PDP-11 program, to the GT40 where they are reassembled into their 8-Bit binary format.

CP-0650

Figure 20 Encoding and Decoding of Serial Data

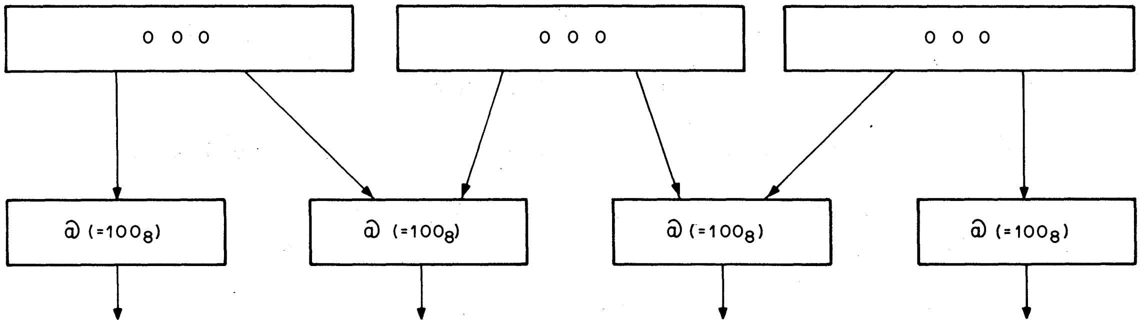


Figure 21 Filler Character Transmission to the GT40/42

It is necessary to preface the first "one" byte in the absolute program with a "zero" byte in order to save Bootstrap code. A normal absolute program, in octal, before encoding into the 6-bit tape format, is transmitted in the order shown in Figure 22. An example of a short program (in octal) and the resultant encoded characters transmitted are shown in Figure 23.

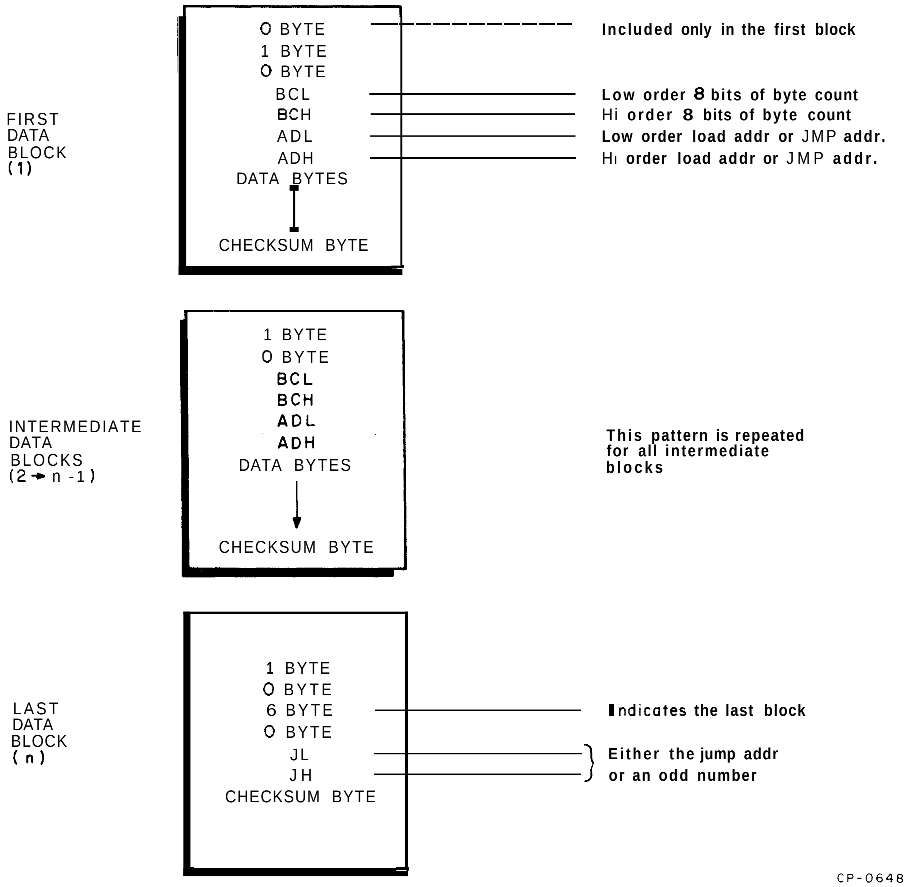

FIRST
DATA
BLOCK
(1)
O BYTE
1 BYTE
O BYTE
BCL
BCH
ADL
ADH
DATA BYTES
CHECKSUM BYTE
Included only in the first block
Low order 8 bits of byte count
Hi order 8 bits of byte count
Low order load addr or JMP addr.
Hi order load addr or JMP addr.
INTERMEDIATE
DATA
BLOCKS
(2→n-1)
1 BYTE
O BYTE
BCL
BCH
ADL
ADH
DATA BYTES
CHECKSUM BYTE
This pattern is repeated for all intermediate blocks
LAST
DATA
BLOCK
(n)
1 BYTE
O BYTE
6 BYTE
O BYTE
JL
JH
CHECKSUM BYTE
Indicates the last block
Either the jump addr or an odd number
CP-0648

Figure 22 Absolute Program, Octal Format

5.1.2 Character Echoing

When not running in the LOADER mode, the Bootstrap allows the GT40/42 to communicate with the host computer in ASCII. Depressing a key on the LK40 keyboard at this time causes the ASCII character for that key to be sent to the host computer. If the host computer echoes the character, it will appear on the GT40/42 display (providing it is printable).

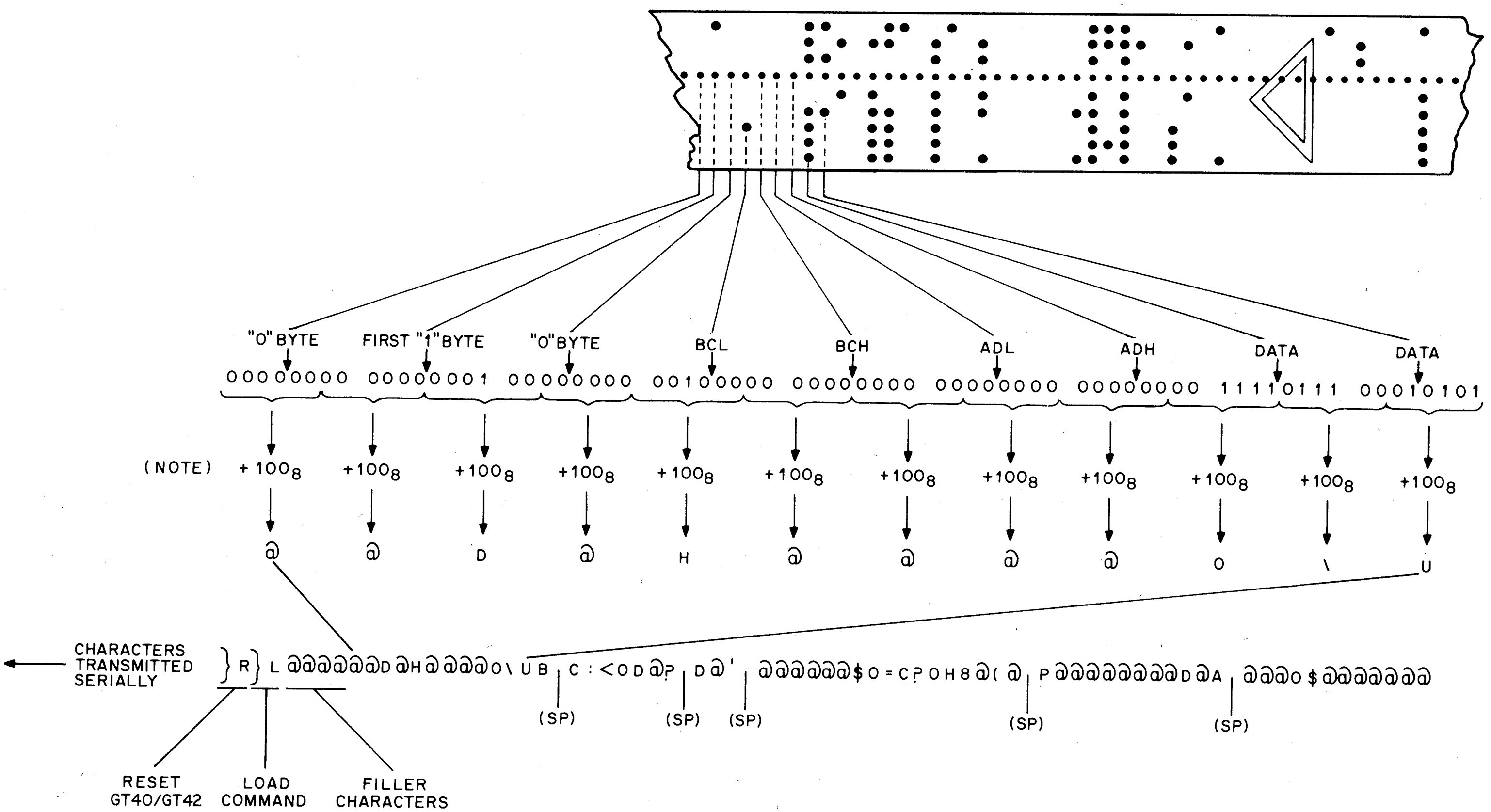
In reference to this type of display, several characteristics should be noted:

- The GT40 Bootstrap does not scroll. If the initial dialogue runs off the bottom of the screen, the operator must again depress START; the dialogue will then return to the top of the screen. In the GT42, the dialogue appears at the bottom of the screen and scrolls off the top when the screen is full.

- With the exception of 175_8 characters with codes of from 040_8 through 176_8 will be displayed on the screen. Code 175_8 is used to initiate restarting and loading of the GT40/42.

- In the GT40 the only control characters which affect the display are CARRIAGE RETURN, LINE FEED, and BACKSPACE. TAB, FORM FEED, etc. are not understood. In the GT42, TAB and FORM FEED characters are understood.

- The host computer should not send SHIFT OUT (016_8) because this character causes the GT40/42 hardware to generate a special character set. (This restriction applies only to the Bootstrap because of space limitations in this program. Normally the software would monitor all characters before inserting them into the display file.)



NOTE:
All the characters shown are originally <40₈ and must be incremented by 100₈; this is not done when characters are ⩾ 40₈.

CP-0647

Figure 23 Absolute Program Conversion and Transmission

APPENDIX A
KEY BOARD LAYOUT

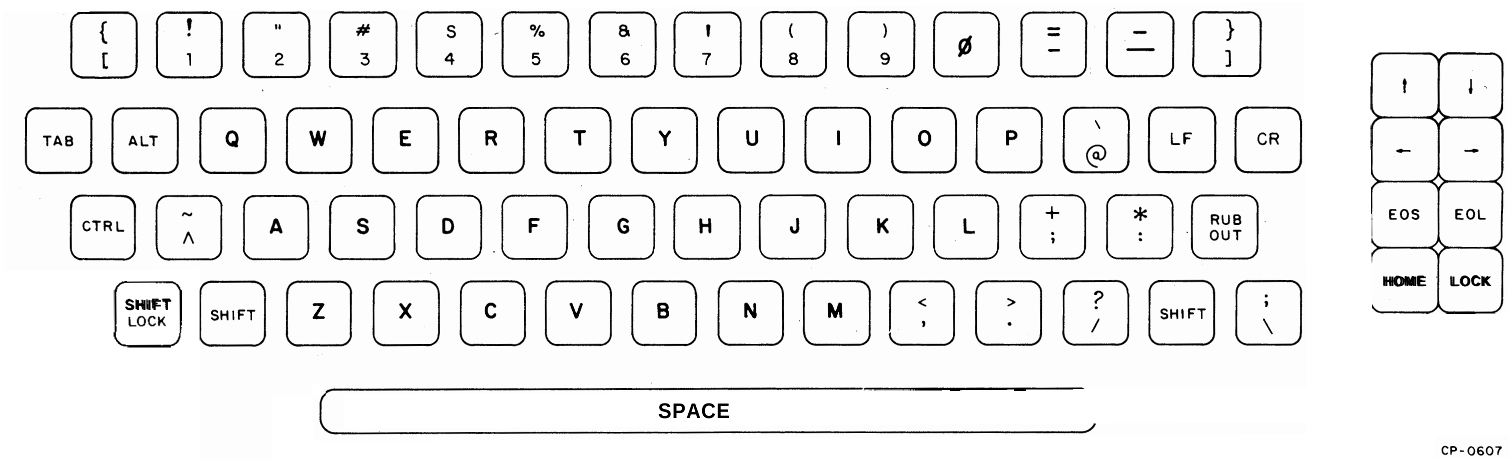


Figure A-1 Keyboard Key Configuration

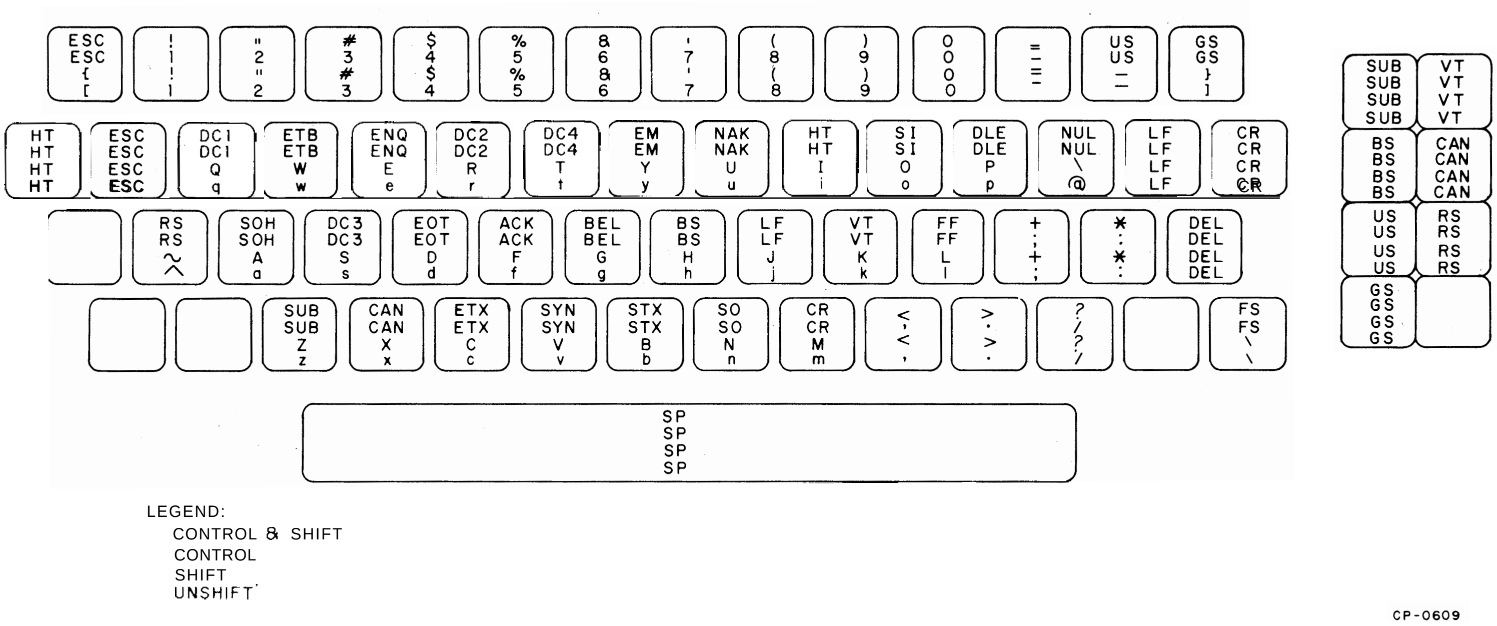


Figure A-2 128-Character Keyboard (Position 1)

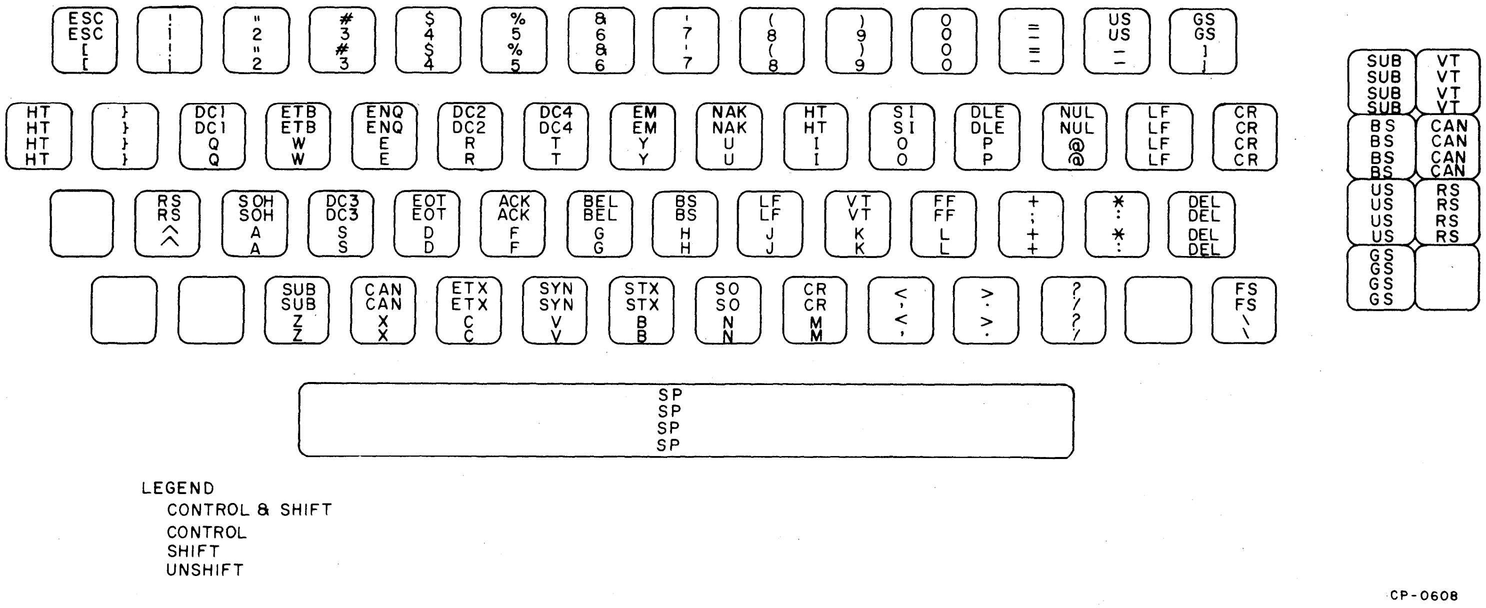


Figure A-3 64-Character Keyboard (Position 2)

APPENDIX B
ADDRESS MAPPING

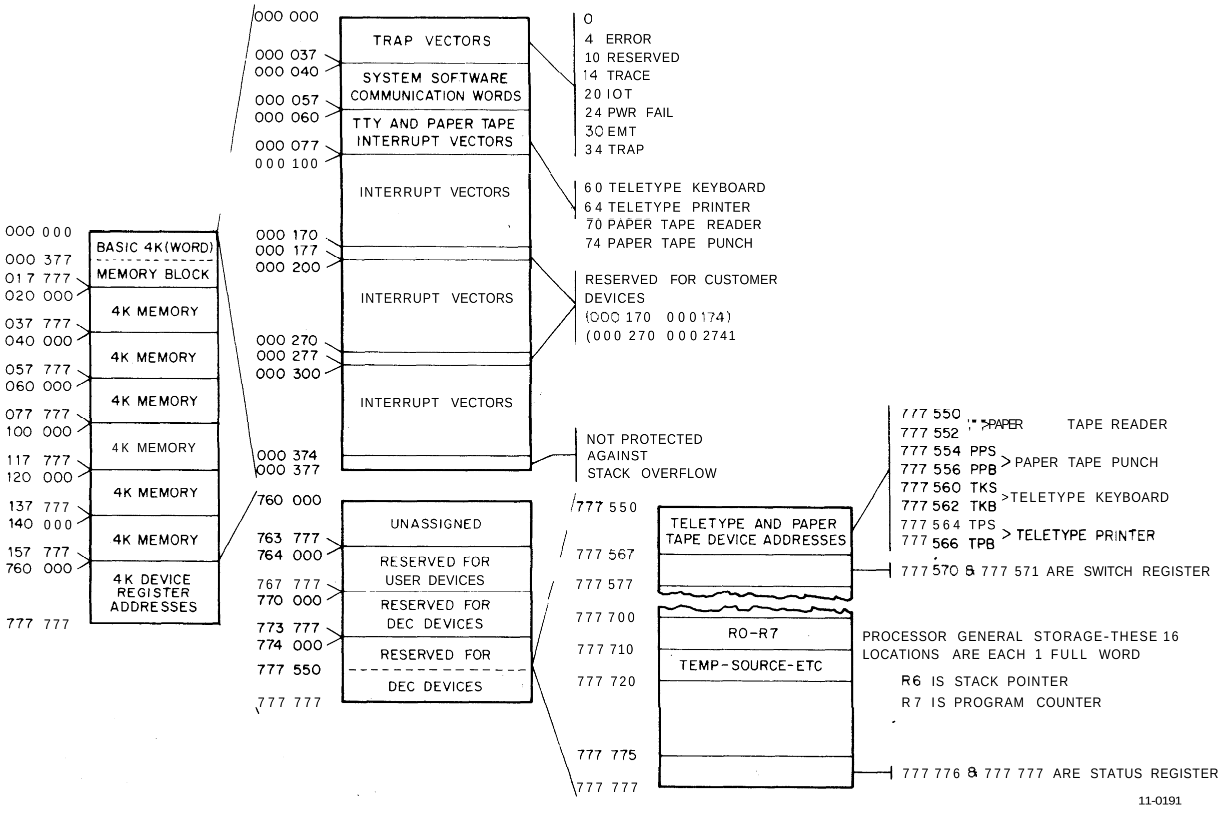


Figure B-1 Address Mapping

APPENDIX C
CHARACTER CODES

7 Bit (octal)	ASCII Representation	Keyboard	GT40/42 Printing	GT40/42 Printing When Preceded By Shift-Out = 016
000	NUL	CTRL @		λ
001	SOH	CTRL A		α
002	STX	CTRL B		ϕ
003	ETX	CTRL C		Σ
004	EOT	CTRL D		δ
005	ENQ	CTRL E		A
006	ACK	CTRL F		∿
007	BEL	CTRL G		a
010	BS	CTRL H	Backspace	∩
011	HT	CTRL I (TAB)		ψ
012	LF	CTRL J (LF)	Line Feed	−
013	VT	CTRL K		o
014	FF	CTRL L		
015	CR	CTRL M (CR)	Carriage Return	μ
016	SO	CTRL N		£
017	SI	CTRL O		Shift In
020	DLE	CTRL P		π
021	DC1	CTRL Q		‖
022	DC2	CTRL R		Ω
023	DC3	CTRL S		σ
024	DC4	CTRL T		ϒ
025	NAK	CTRL U		ϵ
026	SYN	CTRL V		←
027	ETB	CTRL W		→
030	CAN	CTRL X		↑
031	EM	CTRL Y		↓
032	SUM	CTRL Z		r
033	ESC	CTRL [(ALT)		⊥
034	FS	CTRL \		≠
035	GS	CTRL]		≈
036	RS	CTRL~		∨
037	US	CTRL –		□
40	SP	SPACE BAR ´	Space 1 character	
41	!	SHIFT 1	!	
42	“	SHIFT 2	“	
43	#	SHIFT 3	#	

7 Bit (octal)	ASCII Representation	Keyboard	GT40/42 Printing	GT40/42 Printing When Preceded By Shift-Out = 016
44	$	SHIFT 4	$	
45	%	SHIFT 5	%	
46	&	SHIFT 6	&	
47		SHIFT 7		
50	(	SHIFT 8	(	
51	)	SHIFT 9	)	
52	*	SHIFT :	*	
53	t	SHIFT ;	t	
54			,	
55	- (minus)	-	-	
56				
57	/	/	/	
60	0	0	0	
61	1	1	1	
62	2	2	2	
63	3	3	3	
64	4	4	4	
65	5	5	5	
66	6	6	6	
67	7	7	7	
70	8	8	8	
71	9	9	9	
72				
73				
74	<	SHIFT ,	<	
75	=	SHIFT -	–	
76	>	SHIFT .	>	
77	?	SHIFT /	?	
100	@	@	@	
101	**A**	SHIFT **A**	**A**	
102	B	SHIFT B	B	
103	C	SHIFT C	C	
104	D	SHIFT D	D	
105	E	SHIFT E	E	
106	F	SHIFT F	F	
107	G	SHIFT G	G	
110	H	SHIFT H	H	
111	I	SHIFT I	I	
112	J	SHIFT J	J	
113	K	SHIFT K	K	
114	L	SHIFT L	L	
115	M	SHIFT M	M	
116	N	SHIFT N	N	
117	*O*	SHIFT O	*O*	
120	P	SHIFT P	P	
121	Q	SHIFT Q	Q	
122	R	SHIFT R	R	
123	S	SHIFT S	S	
124	T	SHIFT T	T	

7 Bit (octal)	ASCII Representation	Keyboard	GT40/42 Printing	GT40/42 Printing When Preceded By Shift-Out = 016
125	U	SHIFT U	U	
126	V	SHIFT V	V	
127	W	SHIFT W	W	
130	X	SHIFT X	X	
131	Y	SHIFT Y	Y	
132	Z	SHIFT Z	Z	
133	[	[	[	
134	\	\	\	
135	]	]	]	
136	^	A	^	
137	-		-	
140	`	SHIFT @	`	
141	a	A	a	
142	b	B	b	
143	c	C	c	
144	d	D	d	
145	e	E	e	
146	f	F	f	
147	g	G	g	
150	h	H	h	
151	i	I	i	
152	j	J	j	
153	k	K	k	
154	l	L	l	
155	m	M	m	
156	n	N	n	
157	o	O	o	
160	p	P	p	
161	q	Q	q	
162	r	R	r	
163	s	S	s	
164	t	T	t	
165	u	**U**	u	
166	v	**V**	v	
167	w	**W**	w	
170	**x**	**X**	x	
171	Y	Y	y	
172	z	Z	z	
173		SHIFT [	{	
174		SHIFT \	¦	
175		SHIFT]	}	
176	~	SHIFT A	~	
177	**RUB OUT**	**R.O.**	■	

Function Key Codes

← 10	↑ 32	. Home 35	EOS 37
→ 30	↓ 33	**EOL** 36	

APPENDIX D
ROM BOOTSTRAP LOADER PROGRAM - GT40

```
                    ;BOOTVT.SØ9  5/2/72

                            VT-4Ø BOOTSTRAP LOADER,  VERSION SØ9, RELEASE RØ1, 5/2/72

                    ;       COPYRIGHT 1972, DIGITAL EQUIPMENT CORPORATION.
                    ;       146 MAIN STREET
                    ;       MAYNARD, MASSACHUSSETTS
                    ;                                01754

                            WRITTEN BY JACK BURNESS, SENIOR SYSTEMS ARCHITECT!


                            THIS ROUTINE IS INTENDED TO BE LOADED IN THE ROM PORTION OF THE VT-4Ø.

                    ;       REGISTER DEFINITIONS:

        ØØØØØØ              RØ=%Ø
        ØØØØØ1              R1=%1
        ØØØØØ2              R2=%2
        ØØØØØ3              R3=%3
        ØØØØØ4              R4=%4
        ØØØØØ5              R5=%5
        ØØØØØ6              R6=%6
        ØØØØØ7              R7=%7

        ØØØØØ6              SP=R6
        ØØØØØ7              PC=R7

        ØØØØØØ              RET1=RØ                         ;RETURN OF VALUE REGISTER.
        ØØØØØ1              INP1=R1                         ;ARGUMENT FOR CALLED FUNCTION
        ØØØØØ2              INP2=R2                         ;SECOND ARGUMENT.
        ØØØØØ3              WORK1=R3                        ;FIRST WORK REGISTER.
        ØØØØØ4              WORK2=R4                        ;SECOND WORKING REGISTER.
        ØØØØØ5              SCR1=R5                         ;SCRATCH REGISTER,

        ØØØØØ3              L.CKSM=WORK1                    ;OVERLAPPING DEFINITIONS FOR LOADER PORTION.
        ØØØØØØ              L.BYT=RET1
        ØØØØØ5              L.BC=SCR1
        ØØØØØ1              L.ADR=INP1


        Ø16ØØØ              COREND=16ØØØ                    ;FIRST LOCATION OF NON-CORE.
        166ØØØ              ROMORG=166ØØØ                   ;WHERE THE ROM PROGRAM SHOULD GO.

        ØØØØØØ              STARTX=Ø                        ;WHERE TO START DISPLAYING THE X POSITIONS.
        ØØ136Ø              STARTY=136Ø                     ;WHERE TO START DISPLAYING THE Y.
```

```
         172ØØØ                             VT4ØPC=172ØØØ                 ;VT4Ø PROGRAM COUNTER.
         17756Ø                             KBDIS=17756Ø                  ;TTY INPUT STATUS.
         175614                             P1ØOS=175614                  ;PDP-1Ø OUTPUT STATUS.
         17561Ø                             P1ØIS=17561Ø                  ;PDP-1Ø INPUT STATUS.

         177562                             KBDIB=KBDIS+2                 ;TTY INPUT BUFFER.
         175612                             P1ØIB=P1ØIS+2                 ;PDP-1Ø INPUT CHARACTER.
         175616                             P1ØOB=P1ØOS+2                 ;PDP-1Ø OUTPUT BUFFER.


         Ø15776                             P1ØOC=COREND-2                ;CHARACTER TO BE SENT TO THE PDP-1Ø
         Ø15772                             P1ØIC=P1ØOC-4                 ;INPUT CHARACTER FROM 1Ø PLUS ONE SAVE CHARACTER
         Ø1577Ø                             STKSRT=P1ØIC-2                ;FIRST LOCATION OF STACK.


         16ØØØØ                             JMPDIS=16ØØØØ                 ;THE VT-4Ø DISPLAY JUMP INSTRUCTION.


         ØØØØ24                             PWRFAL=24                     ;POWER FAIL RESTART LOCATION.


         166ØØØ                             .=ROMORG                      ;SET THE ORIGIN NOW!!!!

166ØØØ   Ø127Ø5   ØØØØ26          START:    MOV     #PWRFAL+2,SCR1        ;PICK UP POINTER TO P.F. STATUS.
166ØØ4   ØØ5Ø15                             CLR     @SCR1                 ;CLEAR IT OUT TO BE SURE.
166ØØ6   Ø1Ø745                             MOV     PC,-(SCR1)            ;SET UP THE RESTART LOCATION.

166Ø1Ø   ØØØØØ5                             RESET                         ;RESET THE BUS.

166Ø12   Ø12767   ØØØØØ7   ØØ757Ø           MOV     #7,P1ØIS              ;INITIALIZE PDP-1Ø INPUT
166Ø2Ø   Ø12767   ØØØØØ1   Ø11532           MOV     #1,KBDIS              ;INITIALIZE TTY INPUT.
166Ø26   Ø12767   ØØØ2Ø1   ØØ756Ø           MOV     #2Ø1,P1ØOS            ;INITIALIZE PDP-1Ø OUTPUT.


166Ø34   Ø127Ø6   Ø1577Ø          RESTRT:   MOV     #STKSRT,SP            ;SET UP THE STACK NOW!
166Ø4Ø   ØØ5ØØ1                             CLR     L.ADR                 ;CLEAR ADDRESS POINTER.
166Ø42   Ø127Ø2   16ØØØØ                    MOV     #JMPDIS,INP2          ;PLACE A DISPLAY JUMP INSTRUCTION IN A REGISTER.


166Ø46   Ø1Ø221                             MOV     INP2,(L.ADR)+         ;MOVE IT TO LOCATION Ø.
166Ø5Ø   Ø12711   166756                    MOV     #DISPRG,(L.ADR)       ;MOVE ADDRESS POINTER INTO 2.
166Ø54   Ø127Ø1   ØØØØ3Ø                    MOV     #PWRFAL+4,L.ADR       ;SET UP WHERE WE WILL STORE CHARACTERS.
166Ø6Ø   ØØ5ØØØ                             CLR     RET1                  ;PREPARE TO INSERT A ZERO CHARACTER.
166Ø62   ØØ4767   ØØØØ22                    JSR     PC,DOCHAR             ;INSERT IT NOW.
166Ø66   ØØ5Ø67   ØØ37Ø6                    CLR     VT4ØPC                ;CLEAR THE DISPLAY PROGRAM COUNTER AND START.

166Ø72   ØØ4767   ØØØ21Ø          MAJOR:    JSR     PC,GETCHR             ;GET A CHARACTER NOW.
166Ø76   ØØØ24Ø                             NOP
1661ØØ   ØØØ24Ø                             NOP
1661Ø2   ØØØ24Ø                             NOP
1661Ø4   Ø12746   166Ø72                    MOV     #MAJOR,-(SP)          ;INSERT IN DISPLAY BUFFER NOW.
```

```
166110  010105              DOCHAR: MOV     L,ADR,SCR1              ;GET CURRENT BUUFER POSITION NOW.
166112  022525                      CMP     (SCR1)+,(SCR1)+         ;BYPASS CURRENT DISPLAY JUMP.
166114  005025                      CLR     (SCR1)+                 ;CLEAR FUTURE ADDRESS FOR JUMP.
166116  010225                      MOV     INP2,(SCR1)+            ;STICK IN TEMPORARY JUMP WHILE WE REPLACE CURRE
166120  005015                      CLR     (SCR1)                  ;A DISPLAY JUMP TO ZERO.
166122  005011                      CLR     (L.ADR)                 ;NOW REPLACE CURRENT DISPLAY JUMP BY THE CHARAC
166124  050021                      BIS     RET1,(L.ADR)+           ;IT'S DONE THIS WAY TO WASTE 2 CYCLES.
166126  010211                      MOV     INP2,(L.ADR)            ;TO AVOID TIMING PROBLEMS WITH THE VT40.
166130  000207                      RTS     PC                      ;AND FINALLY RETURN.

166132  004767  000124      GET8:   JSR     PC,GETSIX               ;GET SIX BITS NOW.
166136  010046                      MOV     RET1,-(SP)              ;SAVE T_E CHARACTED NOW.
166140  000401                      BR      GETP84                  ;BYPASS TH≤ 8'ER
166142  005002              GET84:  CLR     INP2                    ;RESET THE MAGIC R≤GIST≤R NOW
166144  005722              GETP84: TST     (INP2)+                 ;INCREMENT WHERE TO GO.
166146  066207  166250              ADD     GET8TB(INP2),PC         ;UPDATE PC NOW.

        166152              GET8P=.

16  52  004767  000104      GET81:  JSR     PC,GETSIX               ;GET A CHARACTER NOW.
16  56  010004                      MOV     RET1,WORK2              ;SAVE FOR A SECOND.
16  60  006300                      ASL     RET1
16  62  006300                      ASL     RET1                    ;SHIFT TO LEFT OF BYTE
16  64  106300                      ASL3    RET1
16  66  106116                      ROL3    @SP                     ;PACK THEM IN.
16  70  106300                      ASL3    RET1


166172  106116                      ROLB    @SP                     ;A GOOD 8 BIT THING.
166174  012600                      MOV     (SØ)+,RET1              ;POP AND RETURN NOW.
166176  000207                      RTS     PC

166Z00  006300              GET82:  ASL     RET1                    ;WORST CASE. SHIFT 4
166Z02  006300                      ASL     RET1
166Z04  106300                      ASL3    RET1
166Z06  106104                      ROL3    WORKZ
166§10  106300                      ASL3    RET1
166Z12  106104                      ROL3    WORKZ
166Z14  106300                      ASL3    RET1
166Z16  106104                      ROL3    WORK2
166Z20  106300                      ASL3    RET1
166Z22  106104                      ROL3    WORK2
166Z24  010400                      MOV     WORK2,RET1
166Z26  012604                      MOV     (SP)+,WORK2
166Z30  000207                      RTS     PC

166Z32  006100              GET83:  ROL     RET1
166Z34  006100                      ROL     RET1
166Z36  006004                      ROR     WORK2
166Z40  106000                      ROR3    RET1
166Z42  006004                      ROR     WORK2
166Z44  106000                      ROR3    RET1                     FINAL CHARACTER ASSEMBLED.
166Z46  005726                      TST     (SP)+                    FUDGE STACK.
166Z50  000207                      RTS     PC                       AND RETURN NOW.
```

```
        166250                  GET8TB  =       .-2                     ;PUSH ZERO CONDITION BACK INTO NEVER-NEVER LAND.

166252  000000                          .WORD   GET81-GET8P
166254  000026                          .WORD   GET82-GET8P
166256  000060                          .WORD   GET83-GET8P
166260  177770                          .WORD   GET84-GET8P


166262  004767  000020          GETSIX: JSR     PC,GETCHR
166266  020027  000040                  CMP     RET1,#40
166272  002546                          BLT     L,BAD
166274  020027  000137                  CMP     RET1,#137
166300  003143                          BGT     L,BAD
166302  000207                          RTS     PC


166304  005726                  GETCHP: TST     (SP)+                   ;UPDATE THE STACK.

166306  012700  015772          GETCHR: MOV     #P10IC,RET1             ;SET UP POINTER TO THE INPUT CHARACTER.
166312  004767  000064          GETCHL: JSR     PC,CHECK
166316  005710                          TST     @RET1                   ;ANY CHARACTERS THERE?
166320  001774                          BEQ     GETCHL
166322  011046                          MOV     @RET1,-(SP)             ;PUSH THE CHAR ON THE STACK.
166324  005020                          CLR     (RET1)+                 ;CLEAR THE CHAR GOT FLAG NOW.
166326  042716  177600                  BIC     #-200,(SP)              ;CLEAR AWAY PARITY NOW.
166332  001764                          BEQ     GETCHP                  ;IF ZERO, GET ANOTHER


166334  022716  000177                  CMP     #177,(SP)
166340  001761                          BEQ     GETCHP                  ;ALSO IGNORE RUBOUTS.
166342  022710  000175                  CMP     #175,@RET1              ;WAS IT A "175"
166346  001007                          BNE     GETNP                   ;NOPE.
166350  011610                          MOV     (SP),@RET1              ;YEP. RESET IN CASE OF ABORT.
166352  021027  000122                  CMP     @RET1,#122              ;IS IT AN R
166356  001626                          BEQ     RESTRT                  ;YEP. RESTART
166360  021027  000114                  CMP     @RET1,#114              ;IS IT AN L
166364  001455                          BEQ     LOAD                    ;YEP. LOAD.

166366  011610                  GETNP:  MOV     (SP),@RET1              ;NOW DO THE FDUGING.
166370  012600                          MOV     (SP)+,RET1
166372  020027  000175                  CMP     RET1,#175
166376  001743                          BEQ     GETCHR                  ;IF ALTMODE, LOOP
166400  000207                          RTS     PC


166402  005767  027370          CHECK:  TST     P10OC                   ;DO WE WANT TO OUTPUT?
166406  001410                          BEQ     CHECK1                  ;NO.
166410  105767  007200                  TSTB    P10OS                   ;WE DO. IS THE 10 READY?
166414  100005                          BPL     CHECK1                  ;NOT QUITE.
166416  016767  027354  007172          MOV     P10OC,P10OB             ;IT'S READY. SEND THE CHARACTER.
166424  005067  027346                  CLR     P10OC                   ;AND THE SAVED CHARACTER.

166430  105767  011124          CHECK1: TSTB    KBDIS                   ;HEY, IS THE KEYBOARD READY?
166434  100014                          BPL     CHECK3                  ;NOPE. NO LUCK.
```

```
166436  116746  011120                     MOVB    <BDIB,-(SP)          ;YEP.  SAVE THE CHARACTER NOW.
166442  012767  000001  011110             MOV     #1,KBDIS             ;AND REENABLE THE COMMUNICATIONS DEVICE.

166450  004767  177726          CHECK2:    JSR     PC,CHECK             ;IS THE OUTPUT READY?
166454  005767  027316                     TST     P100C
166460  001373                             BNE     CHECK2               ;IF NOT, WAIT TILL DONE.
166462  012667  007130                     MOV     (SP)+,P100B          ;AND THEN SEND OUT THE CHARACTER.


166466  105767  007116          CHECK3:    TSTB    P10IS                ;IS THE 10 TALKING TO ME.
166472  100011                             BPL     CHECK4               ;NOPE. EXIT.
166474  116767  007112  027270             MOVB    P10IB,P10IC          ;GET THE CHARACTER NOW.
166502  052767  177400  027262             BIS     #-400,P10IC          ;MAKE SURE IT'S NONE ZERO.
166510  0112767 000007  007072             MOV     #7,P10IS             ;REINITIALIZE COMMUNICATION LINE.

166516  000207                  CHECK4:    RTS     PC                   ;AND RETURN.


                                ;          THE     L O A D E R

166520  005002                  LOAD:      CLR     INP2                 ;RESET TO FIRST 8 BIT CHARACTER.
166522  012712  172000                     MOV     #172000,(INP2)       ;AND ALSO CLEVERLY STOP THE VT40.
166526  012706  015770                     MOV     #STKSRT,SP           :RESET STACK POINTER NOW.

166532  005003                  _.LD2:     CLR     L.CKSM               ;CLEAR THE CHECKSUM
166534  004767  000070                     JSR     PC,L.PTR             ;GET A BYTE NOW.
166540  105300                             DECB    L.BYT                ;IS IT ONE?
166542  001373                             BNE     L,LD2                ;NOPE. WAIT AWHILE
166544  004767  000060                     JSR     PC,L.PTR             ;YEP. GET NEXT CHARACTER.

166550  004767  000072                     JSR     PC,L.GWRD            ;GET A WORD.
166554  010005                             MOV     _,BYT,L.BC           ;GET THE COUNTER NOW.
166556  162705  000004                     SUB     #4,L.BC              ;CHOP OFF EXTRA STUFF.
166562  022705  000002                     CMP     #2,L.BC              ;NULL?
166566  001437                             BEQ     L.JMP                ;YEP. MUST BE END,
166570  004767  000052                     JSR     PC,L.GWRD            ;NOPE. GET THE ADDRESS.
166574  010001                             MOV     _,BYT,L.ADR          ;AND REMEMBER FOR OLD TIMES SAKE.

166576  004767  000026          L.LD3:     JSR     PC, L.PTR            ;GET A BYTE (DATA)
166602  002010                             BGE     L,_D4                ;ALL DONE WITH THE COUNTER?
166604  105703                             TSTB    L.CKSM               ;YEP. GOOD CHECK SUM?
166606  001751                             BEQ     L,LD2                ;NOPE. LOAD ERROR,

166610  012700                  L.BAD:     MOV     (PC)+,RET1           ;SEND OUT SOME CHARACTERS NOW.
166612     175     102                     ,BYTE   175,102              ;"CTRL BAD"
166614  004767  000110                     JSR     PC,SENDIT
166620  000167  177210                     JMP     RESTRT

166624  110021                  L.LD4:     MOVB    L,BYT,(L.ADR)+       ;PLACE THE BYTE IN CORE.
166626  000763                             BR      L.LD3                :GET ANOTHER ONE,

166630  004767  177276          L.PTR:     JSR     PC,GET8              ;GET 8 BITS NOW.
166634  060003                             ADD     L.BYT,L.CKSM         ;UPDATE CHECKSUM
166636  042700  177400                     BIC     #177400,L,BYT        ;CLEAN UP THE BYTE NOW.
166642  005305                             OEC     L,BC                 ;UPDATE THE COUNTER.
166644  000207                             RTS     PC                   ;RETURN NOW.
```

```
166646  ØØ4767  177756              JSR     PC,L.PTR                ;GET A CHARACTER.
166652  Ø1ØØ46                      MOV     L,BYT,-(SP)             ;SAVE FOR A SECOND.
166654  ØØ4767  17775Ø              JSR     PC,L.PTR                ;GET ANOTHER CHARACTER.
16666Ø  ØØØ3ØØ                      SWAB    L,BYT                   ;NOW ASSEMBLE THE WORD.
166662  Ø526ØØ                      BIS     (SP)+,L.BYT             ;AND RETURN WITH A 16 BITER.

166664  ØØØ2Ø7                      RTS     PC

166666  ØØ4767  177754      L.JMP:  JSR     PC,L.GWRD               ;GET A WORD
166672  Ø1ØØ46                      MOV     L,BYT,-(SP)             ;SAVE ON THE STACK.
166674  ØØ4767  17773Ø              JSR     PC,L.PTR                ;GET A CHARCTER.
1667ØØ  1Ø57Ø3                      TSTB    L,CKSM                  ;IS IT ZERO?
1667Ø2  ØØ1342                      BNE     L,BAD                   ;YEP. WHAT CRAP.
1667Ø4  Ø32716  ØØØØØ1              BIT     #1,(SP)                 ;IS IT ODD?
16671Ø  ØØ14Ø6                      BEQ     L,JMP1                  ;YEP. START PROGRAM GOING NOW.
166712  Ø127ØØ                      MOV     (PC)+,RET1              ;TELL PDP-1Ø WE'VE LOADED OK.
166714     175     1Ø7              .BYTE   175,1Ø7
166716  ØØ4767  ØØØØØ6              JSR     PC,SENDIT
166722  ØØØØØØ                      HALT
166724  ØØØ776                      BR      .-2

166726  ØØØ136              L.JMP1: JMP     @(SP)+                  ;AND AWAY WE GO.

16673Ø  ØØ4767  177446      SENDIT: JSR     PC,CXECK                ;POLL THE OUTPUT DEVICE NOW.
166734  ØØ5767  Ø27Ø36              TST     P1ØØC                   ;OUTPUT CLEAR?
16674Ø  ØØ1373                      BNE     SENDIT                  ;NOPE. LOOP AWHILE LONGER.
166742  Ø1ØØ67  ØØ665Ø              MOV     RET1,P1ØØB              ;SEND OUT THE CHARACTER.
166746  1Ø5ØØØ                      CLRB    RET1                    ;CLEAR THE BYTE.
16675Ø  ØØØ3ØØ                      SWAB    RET1                    ;AND SWAP THEM NOW.
166752  ØØ1366                      BNE     SENDIT                  ;IF NOT EQUAL, REPEAT.
166754  ØØØ2Ø7                      RTS     PC

                            ;               THIS IS THE INITIALIZING VT4Ø PROGRAM WHICH WILL
                            ;               JUMP TO THE PROGRAM AFTER THE POWER FAIL LOCATIONS
                            ;               WHICH WILL JUMP TO ZERO WHICH WILL JUMP BACK TO HERE


166756  17Ø256              DISPRG: .WORD   17Ø256                  ;LOAD STATUS REGISTER FOR NORMAL OPERATION.
16676Ø  115124                      .WORD   115124                  ;SET POINT MODE, "NORMAL".
166762  ØØØØØØ                      .WORD   STARTX                  ;X COORDINATE
166764  ØØ136Ø                      .WORD   STARTY                  ;Y COORDINATE
166766  1ØØØØØ                      .WORD   1ØØØØØ                  ;SET CHARACTER MODE.
16677Ø  16ØØØØ                      .WORD   JMPDIS                  ;THEN JUMP TO THE POWERFAIL LOCATION.
166772  ØØØØ3Ø                      .WORD   PWRFAL+4                ;TO DISPLAY USERS CHARACTERS.

        ØØØØØ1                      END
```

```
                  SYMBOL TABLE

CHECK     166402         CHECK1    166430         CHECK2    166450         CHECK3    166466
CHECK4    166516         COREND  = Ø16ØØØ         DISPRG    166756         DOCHAR    16611Ø
GETCHL    166312         GETCHP    1663Ø4         GETCHR    1663Ø6         GETNP     166366
GETP84    166144         GETSIX    166262         GET8      166132         GET8P   = 166152
GET8TB  = 16625Ø         GET81     166152         GET82     1662ØØ         GET83     166232
GET84     166142         INP1    =%ØØØØØ1         INP2    =%ØØØØØ2         JMPDIS  = 16ØØØØ
KBDIB   = 177562         KBDIS   = 17756Ø         LOAD      16652Ø         L.ADR   =%ØØØØØ1
L.BAD     16661Ø         L.BC    =%ØØØØØ5         L.BYT   =%ØØØØØØ         L.CKSM  =%ØØØØØ3
L.GWRD    166646         L.JMP     166666         L.JMP1    166726         L.LD2     166532
L.LD3     166576         L.LD4     166624         L.PTR     16663Ø         MAJOR     166Ø72
PC      =%ØØØØØ7         PWRFAL  = ØØØØ24         P1ØIB   = 175612         P1ØIC   = Ø15772
P1ØIS   = 17561Ø         P1ØOB   = 175616         P1ØOC   = Ø15776         P1ØOS   = 175614
RESTRT    166Ø34         RET1    =%ØØØØØØ         ROMORG  = 166ØØØ         RØ      =%ØØØØØØ
R1      =%ØØØØØ1         R2      =%ØØØØØ2         R3      =%ØØØØØ3         R4      =%ØØØØØ4
R5      =%ØØØØØ5         R6      =%ØØØØØ6         R7      =%ØØØØØ7         SCR1    =%ØØØØØ5
SENDIT    16673Ø         SP      =%ØØØØØ6         START     166ØØØ         STARTX  = ØØØØØØ
STARTY  = ØØ136Ø         STKSRT  = Ø1577Ø         VT4ØPC  = 172ØØØ         WORK1   =%ØØØØØ3
WORK2   =%ØØØØØ4         .       = 166774
```

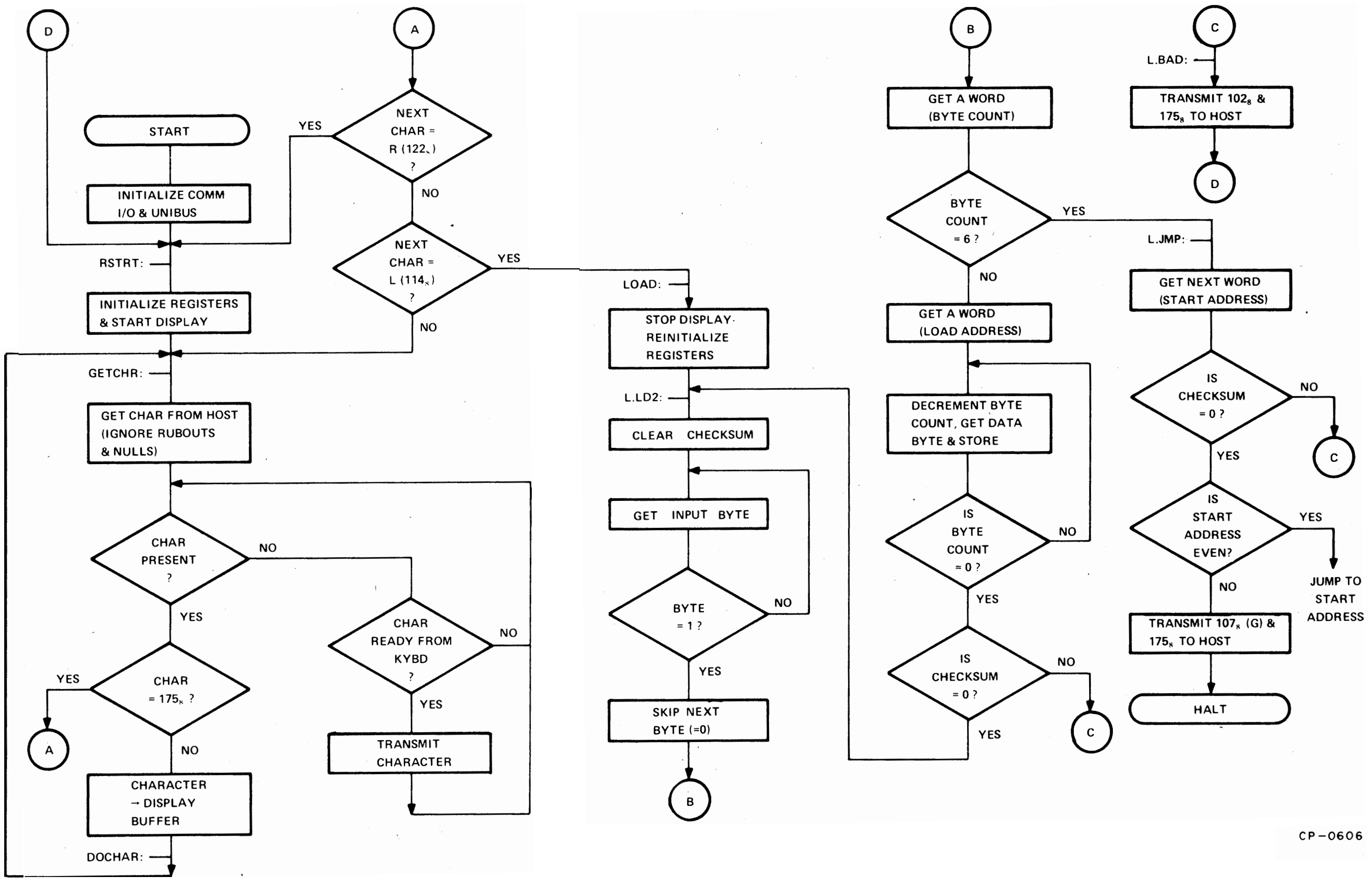

D
A
START
YES
NEXT CHAR = R (122_8) ?
NO
INITIALIZE COMM I/O & UNIBUS
NEXT CHAR = L (114_8) ?
YES
RSTRT:
INITIALIZE REGISTERS & START DISPLAY
NO
GETCHR:
GET CHAR FROM HOST (IGNORE RUBOUTS & NULLS)
CHAR PRESENT ?
NO
YES
CHAR READY FROM KYBD ?
NO
YES
CHAR = 175_8 ?
A
YES
NO
TRANSMIT CHARACTER
CHARACTER → DISPLAY BUFFER
DOCHAR:
LOAD:
STOP DISPLAY. REINITIALIZE REGISTERS
L.LD2:
CLEAR CHECKSUM
GET INPUT BYTE
BYTE = 1 ?
NO
YES
SKIP NEXT BYTE (=0)
B
B
GET A WORD (BYTE COUNT)
BYTE COUNT = 6 ?
YES
NO
GET A WORD (LOAD ADDRESS)
DECREMENT BYTE COUNT, GET DATA BYTE & STORE
IS BYTE COUNT = 0 ?
NO
YES
IS CHECKSUM = 0 ?
NO
YES
C
C
L.BAD:
TRANSMIT 102_8 & 175_8 TO HOST
D
L.JMP:
GET NEXT WORD (START ADDRESS)
IS CHECKSUM = 0 ?
NO
C
YES
IS START ADDRESS EVEN?
YES
JUMP TO START ADDRESS
NO
TRANSMIT 107_8 (G) & 175_8 TO HOST
HALT
CP–0606

Figure D-1 Communications Bootstrap Loader Diagram

APPENDIX E

SCROLLING ROM BOOTSTRAP LOADER PROGRAM - GT42

```



                                ;                       REGISTER DEFINITIONS
                                ;                       -------- -----------



                                ;               BASIC DEFINTIONS
                                ;               ----- ----------


         000000                      R0=%0                            ;DEFINE STANDARD VALUES.
         000001                      R1=%1
         000002                      R2=%2
         000003                      R3=%3
         000004                      R4=%4
         000005                      R5=%5
         000006                      SP=%6
         000007                      PC=%7



                                ;               GT40 DEFINTIONS
                                ;               ---- ----------


         000000                      CHAR=R0                          ;CONTAINS THE INPUT CHARACTER.
         000001                      POINTR=R1                        ;POINTS TO NEXT INSERTION BYTE IN DISPLAY BUFFER
         000002                      TABCNT=R2                        ;CHARACTER COUNTER FOR THE "TAB" FEATURE.
         000003                      SCAN=R3                          ;GENERALLY CONTAINS A POINTER WHICH
                                                                      ;IS USED WHEN SCANNING MEMORY FOR SOMETHING.
         000004                      HOLD=R4                          ;TYPICALLY A TEMPORARY WHICH IS USED TO RETAIN
                                                                      ;A VALUE FOR A SHORT TIME.
         000005                      COUNTR=R5                        ;TYPICALLY USED AS A COUNTER.





                                ;               LOADER DEFINITIONS
                                ;               ------ -----------





         000000                      L.BYT=CHAR                       ;CHARACTER INPUT FOR THE LOADER.
         000001                      L.ADR=POINTR                     ;CURRENT MEMORY ADDRESS TO BE LOADED.
         000002                      L.BC=TABCNT                      ;NUMBER OF DATA ITEMS TO LOAD.
         000005                      L.CKSM=COUNTR                    ;CHECKSUM ON THE INPUT DATA.
         000003                      INDEX=SCAN                       ;INDICATES HOW TO ASSEMBLE THE 8 BIT CHARACTER.


```

```


                                  ;                   MAJOR SYSTEM DEFINITIONS
                                  ;                   ----- ------ -----------



        166000                  ORIGIN=166000                 ;ORIGIN OF THE BOOTSTRAP.

        175610                  DL11IS=175610                 ;INPUT STATUS REGISTER OF DL11
        175612                  DL11IB=DL11IS+2               ;INPUT CHARACTER FROM DL11
        175614                  DL11OS=DL11IB+2               ;OUTPUT STATUS OF THE DL11
        175616                  DL11OB=DL11OS+2               ;OUTPUT CHARACTER TO THE DL11

        177560                  KBDIS=177560                  ;KEYBOARD INPUT STATUS
        177562                  KBDIB=KBDIS+2                 ;CURRENT CHARACTER FROM KEYBOARD.

        172000                  GT40PC=172000                 ;GT40 PROGRAM COUNTER.
        172002                  GT40SR=GT40PC+2               ;GT40 STATUS REGISTER ADDRESS.


        001000                  BSTART=1000                   ;START OF THE DISPLAY BUFFER
        007000                  BLIMIT=7000                   ;APPROXIMATE END OF THE DISPLAY BUFFER.
        007776                  TMPEND=7776                   ;LOCATION OF INITIALIZATION STACK.
        000004                  CORSTR=4                      ;LOCATION OF PDP-11 TRAP VECTOR.
        007012                  JMPADD=BLIMIT+10.             ;WHERE THE POINTER IS TO FIRST CHAR ON SCREEN
        000040                  NUMLIN=32.                    ;NUMBER OF LINES ON TEXT TO SHOW ON THE SCREEN

        005015                  CRLF=5015                     ;CARRIAGE RETURN - LINE FEED
        000175                  ALTMOD=175                    ;THE "KEY" CHARACTER [I.E. ALTMODE].

        160000                  DISJMP=160000                 ;THE GT40 JMP INSTRUCTION
        173000                  DISTOP=173000                 ;THE GT40 STOP DISPLAY INSTRUCTION.



















                                .SBTTL  INITIALIZATION AND RESTART CODE
```

```



                                          ;             GT42 BOOTSTRAP CODE
                                          ;             ---- --------- ----




          166ØØØ                                 .=ORIGIN                         ;DEFINE ORIGIN OF THE BOOTSTRAP.






                                          ;             COLD INITIALIZATION CODE
                                          ;             ---- -------------- ----



  166ØØØ  ØØØØØ5                          START: RESET                            ;RESET ALL HARDWARE NOW.
  166ØØ2  Ø12737  ØØØØØ7  17561Ø                 MOV    #7,DL11IS                 ;INITIALIZE DL-11 INPUT NOW.
  166Ø1Ø  Ø127Ø6  ØØ7776                         MOV    #TMPEND,SP                ;A GOOD TEMPORARY STACK
  166Ø14  ØØ5237  175614                         INC    DL11OS          ;SET BREAK BIT
  166Ø2Ø  ØØ4337  166652                         JSR    SCAN,OUTLIT               ;FOR 2 CHARACTER TIMES
  166Ø24  ØØØØØØ                                 .WORD Ø                          ;SNED TWO ZERO'S

  166Ø26  Ø127Ø3  ØØØØ44                         MOV    #CORSTR,SCAN              ;GET ADDRESS OF BAD CORE TRAP VECTOR.
  166Ø32  Ø12723  166Ø42                         MOV    #NOTHERE,(SCAN)+          ;AND INSERT A POINTER TO US THERE.

  166Ø36  ØØ5Ø23                          ENDCOR: CLR   (SCAN)+                   ;NOW CLEAR ALL OF MEMORY BEYOND THE POINTER.
  166Ø4Ø  ØØØ776                                 BR     ENDCOR                    ;UNTIL WE RUN OUT OF MEMORY AND TRAP.


  166Ø42  ØØ5743                          NOTHER: TST   -(SCAN)                   ;WHEN WE TRAP OUT, WE COME HERE.
                                                                                  ;WE BACK UP POINTER TO GOOD CORE.
                                                                                  ;NOTE THAT IF WE TRAP OUT AGAIN, IT
                                                                                  ;IS STILL OK, BECAUSE WE WILL LOOP
                                                                                  ;UNTIL WE GET A GOOD CORE ADDRESS.
  166Ø44  Ø1Ø3Ø6                                 MOV    SCAN,SP                   ;WHEN WE GET ONE, THAT IS LAST LOCATION
                                                                                  ;IN THE MACHINE, AND HENCE OUR SP.
  166Ø46  1Ø5737  175614                  1$:    TSTB   DL11OS                    ;SEE IF BREAK IS DONE
  166Ø52  1ØØ375                                 BPL    1$                        ;NO GO BACK
  166Ø54  ØØ5Ø37  175614                         CLR    DL11OS                    ;CLEAR BREAK BIT






                                          ;             RESTART INITIALIZATION CODE WHEN COMMUNICATIONS IS WORKING.
                                          ;             ------- -------------- ---- ---- -------------- -- --------
```

```
                                                       ------- -------------- ---- ---- -------------- -- -------



 166Ø6Ø  Ø527Ø6  ØØ7776      RESTRT: BIS     #TMPEND,SP              ;FORCE THE SP TO LIMIT OF EXISTING CORE.


 166Ø64  Ø127Ø3  ØØ67ØØ              MOV     #BLIMIT-NUMLIN-NUMLIN,SCAN      ;NOW WE WILL FILL THE KEY AREAS OF THE
 166Ø7Ø  Ø127Ø2  ØØØØ4Ø              MOV     #NUMLIN,TABCNT          ;DISPLAY BUFFER WITH INITIAL CR-LF'S.

 166Ø74  Ø12723  ØØ5Ø15      SETLP1: MOV     #CRLF,(SCAN)+           ;INSERT A CRLF NOW.
 1661ØØ  ØØ53Ø2                      DEC     TABCNT                  ;AND LOOP UNTIL DONE.
 1661Ø2  ØØ3374                      BGT     SETLP1                  ;THUS DISPLAY CORE IS ALMOST CORRECT.


 1661Ø4  Ø127Ø3  166432              MOV     #SETUP,SCAN             ;NOW WE WILL INITALIZE CORE FOR THE
                                                                     ;DISPLAY, PICK UP POINTER TO LIST.

 16611Ø  Ø123Ø2              SETLP2: MOV     (SCAN)+,TABCNT          ;GET NUMBER OF ITEMS TO INSERT.
 166112  ØØ14Ø5                      BEQ     SETDUN                  ;IF ZERO, WE ARE DONE.
 166114  Ø123Ø1                      MOV     (SCAN)+,POINTR          ;PICK UP FIRST CORE ADDRESS POINTER.

 166116  Ø12321              SETLP3: MOV     (SCAN)+,(POINTR)+       ;MOVE OVER A DATA ITEM NOW.
 16612Ø  ØØ53Ø2                      DEC     TABCNT                  ;ALL DONE?
 166122  ØØ3375                      BGT     SETLP3                  ;NOPE. MOVE OVER THE NEXT.
 166124  ØØØ771                      BR      SETLP2                  ;YES. GET NEXT MAJOR LIST TO INSERT.


 166126  Ø127Ø1  ØØ6776      SETDUN: MOV     #BLIMIT-2,POINTR        ;ESTABLISH THE BUFFER POINTER NOW











                                     SBT     VTØ5 SIMULATOR
```

```



                                          ;        VTØ5 (SCROLLING) PORTION OF THE BOOTSTRAP
                                          ;        ---- ----------- ------- -- --- ---------



 166132  ØØ4737  166564      NXTCHR: JSR     PC,GETCHR          ;GET A CHARACTER NOW .
 166136  Ø2ØØ27  ØØØ177              CMP     CHAR,#177          ;IS IT OUT OF RANGE?
 166142  ØØ2373                      BGE     NXTCHR             ;YEP, GET ANOTHER ONE.
 166144  Ø2ØØ27  ØØØØ4Ø              CMP     CHAR,#4Ø           ;IS IT A PRINTING CHARACTER?
 16615Ø  ØØ2Ø2Ø                      BGE     NORMAL             ;YES, IT 'S A NORMAL PRINTING CHARACTER
 166152  Ø1ØØØ3                      MOV     CHAR,SCAN          ;MOVE IT OVER SO WE CAN PLAY WITH IT.
 166154  1627Ø3  ØØØØØ7              SUB     #7,SCAN            ;BIAS SO THAT BELL [7] IS ZERO.
 16616Ø  Ø2Ø327  ØØØØØ7              CMP     SCAN,#7            ;IF CHARACTER IS LESS THEN BELL OR
 166164  1Ø3362                      BHIS    NXTCHR             ;GREATER THEN CR, THEN IGNORE .
 166166  ØØ63Ø3                      ASL     SCAN               ;IF GOOD, MAKE IT WORD INDEX.
 16617Ø  Ø6Ø3Ø7                      ADD     SCAN,PC            ;AND GO TO THE CORRECT ROUTINE.

 166172  ØØØ426                      BR      BELL               ;7=BELL
 166174  ØØØ4Ø6                      BR      NORMAL             ;1Ø=BACKSPACE
 166176  ØØØ411                      BR      TAB                ;11=TAB
 1662ØØ  ØØØ437                      BR      LF                 ;12=LINE FEED [LF]
 1662Ø2  ØØØ42Ø                      BR      VT                 ;13=VERT ICAL TAB [VT]
 1662Ø4  ØØØ424                      BR      FF                 ;14=FORM FEED [FF]
                                                                ;15=CARRIAGE RETURN [CR]



 1662Ø6  Ø127Ø2  177777      CR:     MOV     #-1,TABCNT         ;RESET TAB POSITION ON A CR, AND
                                                                ;FALL THROUGH TO INSERT THE CHARACTER.


 166212  ØØ4737  16635Ø      NORMAL: JSR     PC,INSERT          ;INSERT THE CHARACTER IN THE BUFFER.
 166216  ØØ52Ø2                      INC     TABCNT             ;UPDATE TAB POSITION NOW.
 16622Ø  ØØØ744                      BR      NXTCHR             ;AND GET NEXT CHARACTER.




 166222  Ø127ØØ  ØØØØ4Ø       AB:    MOV     #4Ø,CHAR           ;ON A TAB, INSERT BLANKS UNTIL THE
 166226  ØØ4737  16635Ø              JSR     PC,INSERT          ;NEXT CHARACTER POSITION IS A MULTIPLE
 166232  ØØ5222                      INC     TABCNT             ;OF 8.
 166234  Ø32722  ØØØØØ7              BIT     #7,TABCNT          ;ARE WE DONE YET?
 16624Ø  ØØ137Ø                      BNE     TAB                ;NOPE.
 166242  ØØØ733                      BR      NXTCHR             ;YES.


 166244  1117Ø5              VT:     MOVB    (PC),COUNTR        ;THIS PUTS THE LOW BYTE OF THE
                                                                ;BRANCH CODE IN COUNTR-SAVE A WORD
 166246  ØØØ425                      BR      FFLOOP
                                                                ;
 16625Ø  ØØ5Ø37  172ØØ2      BELL:   CLR     GT4ØSR             ;RING BELL -WRITE IN GT4ØSR
 166254  ØØØ726                      BR      NXTCHR             ;AND LOOP BACK
```

```

166256  Ø12705  ØØØØ4Ø      FF:     MOV     #NUMLIN,COUNTR         ;FORM FEED IS DONE BY INSERTING LF'S,

166262  Ø127ØØ  ØØØØ12      FFLOOP: MOV     #12,CHAR               ;MAKE THE CHARACTER A LINEFEED,
166260  ØØ4737  1663Ø4              JSR     PC,LFSUB               ;DO A LINEFEED,
166272  ØØ53Ø5                      DEC     COUNTR                 ;DONE?
166274  ØØ3372                      BGT     FFLOOP                 ;NOPE, KEEP SENDING THEM,
166276  ØØØ715                      BR      NXTCHR                 ;YES, NOW RETURN, DO NOT FALL THROUGH


1663ØØ  Ø12746  166132      LF:     MOV     #NXTCHR,-(SP)          ;RETURN TO NXTCHR AFTER PROCESSINO
                                                                   ;THE LF BY FAKING A JSR,

1663Ø4  Ø137Ø3  ØØ7Ø12      LFSUB:  MOV     JMPADD,SCAN            ;GET POINTER TO FIRST CHAR ON SCREEN

16631Ø  1223ØØ              LFLOOP: CMPB    (SCAN)+,CHAR           ;AND LOOK FOR A LINEFEED,
166312  ØØ14Ø6                      BEQ     LFOUND                 ;GOT IT, SEARCH HAS ENDED,
166314  Ø2Ø327  ØØ7ØØØ              CMP     SCAN,#BLIMIT           ;ARE WE AT END OF BUFFER?
16632Ø  1Ø3773                      BLO     LFLOOP                 ;NOPE, KEEP ON LOOKING,
166322  Ø127Ø3  ØØ1ØØØ              MOV     #BSTART,SCAN           ;IF AT TOP, RESET TO BOTTOM OF BUFFER
166326  ØØØ77Ø                      BR      LFLOOP                 ;AND KEEP ON LOOKINO .

16633Ø  ØØ52Ø3              LFOUND: INC     SCAN                   ;WE'VE GOT THE LINE FEED, STOP SHOWING
166332  Ø427Ø3  ØØØØØ1              BIC     #1,SCAN                ;FIRST LINE BY CHANGING THE "DISJMP"
166336  Ø1Ø337  ØØ7Ø12              MOV     SCAN,JMPADD            ;INSTRUCTION TO FIRST CHAR BEYOND LF,
166342  ØØ4737  16635Ø              JSR     PC,INSERT              ;INSERT THE LF IN THE BUFFER,
166346  ØØ5ØØØ                      CLR     CHAR                   ;AND THEN INSERT ONE NULL CHARACTER BECAUSE
                                                                   ;THE "DISJMP" ADDRESS MUST BE EVEN, AND
                                                                   ;THIS GUARANTEES WE WILL NOT LOSE A
                                                                   ;A GOOD DATA CHARACTER, WE FALL THROUGH
                                                                   ;TO INSERT THE NULL IN THE BUFFER,


16635Ø  11ØØ21              INSERT: MOVB    CHAR,(POINTR)+         ;JET EK IN THE CHARACTED NOW,
166352  Ø327Ø1  ØØØØØ1              BIT     #1,POINTR              ;IS NEXT POSITION EVEN OR ODD?
166356  ØØ1Ø21                      BNE     INSRTX                 ;ODD, NO PROBLEMS, SPACE IS ALLOCATED,
16636Ø  Ø2Ø127  ØØ7ØØØ              CMP     POINTR,#BLIMIT         ;EVEN, ARE WE AT THE END OF THE BUFFER?
166364  1Ø341Ø                      BLO     INSRTL                 ;NO, JUST MAKE ROOM FOR ANOTHER WORD,
166366  Ø1Ø1Ø3                      MOV     POINTR,SCAN            ;AT THE END, MOVE THE STUFF TO THE
16637Ø  Ø127Ø1  ØØ1ØØØ              MOV     #BSTART,POINTR         ;BEGINNING OF THE BUFFER,
166374  ØØ4737  1664Ø6              JSR     PC,INSRTL              ;CALL THE ROUTINE TO SAVE SPACE,
1664ØØ  ØØ5Ø23                      CLR     (SCAN)+                ;AND CLEAR UP THE INSTRUCTIONS AT THE
1664Ø2  ØØ5Ø13                      CLR     (SCAN)                 ;END OF THE BUFFER,
1664Ø4  ØØØ2Ø7                      RTS     PC                     ;AND THEN RETURN,

1664Ø6  Ø22121              INSRTL: CMP     (POINTR)+,(POINTR)+    ;BYPASS THE "DISJMP" BY ADDING 4 TO POINTR,
16641Ø  Ø12711  1Ø6474              MOV     #HEADER,(POINTR)       ;NOW INSERT THE DISJMP INSTRUCTION TO OUR HEADER
166414  Ø12741  16ØØØØ              MOV     #DISJMP,-(POINTR)      ;AND IT'S ADDRESS  PUT THEM IN BACKWARDS),
16642Ø  ØØ5Ø41                      CLR     -(POINTR)              ;MAKE AVAILABLE A NEW CHARACTER SPOT,

166422  ØØØ2Ø7              INSRTX: RTS     PC                     ;FINALLY RETURN TO THE CALLER ,





 166424  012737  001000  172000  GTBUSE! MOV     #BSTART,GT40PC          !ON A BUS ERROR, WE MERELY RESTART THE GT40 AT

                                                                         !THE RTI FOR THIS ROUTINE
                                                                         !IS THE FIRST WORD OF THE TABLE
                                                                         !BELOW-IT SAVES A WORD!











                                         !                 INITIALIZATION TABLE FOR THE SCROLLER
                                         !                 -------------- ----- --- ---



 166432  000002                  SETUP!  ,WORD   2                       !INITIALIZE 2 WORDS,--ALSO RTI FROM ABOVE
 166434  000330                          ,WORD   330                     !STARTING AT LOCATION 33P
 166436  166424                          ,WORD   GTBUSE                  !FIRST WORD IS POINTER TO BUS ERROR ROUTINE,
 166440  000200                          ,WORD   200                     !SECOND WORD IS NEW STATUS WORD ON INTERUPT,

 166442  000007                          ,WORD   7                       !INITIALIZE THE END OF THE BUFFER TO
 166444  006776                          ,WORD   BLIMIT-2                !A CLEAR SPACE TO INSERT THE CHARACTER,
 166446  000000                          ,WORD   0                       !THIS IS THE "RUNNING" START, THIS IS
 166450  160002  166474                  ,WORD   DISJMP,HEADER           !FOLLOWED BY A DISJMP TO OUR HEADER BLOCK
 166454  160000  001000                  ,WORD   DISJMP,BSTART           !AND THEN A DISJMP TO THE START OF THE BUFFER
 166460  160000  006700                  ,WORD   DISJMP,BLIMIT-NUMLIN-NUMLIN     !AND A DISJMP TO THE FIRST CHAR ON SCREE

 166464  000001                          ,WORD   1                       !FINALLY START THE GT40 GOING AT
 166466  172000                          ,WORD   GT40PC                  !THE POSITION INSTRUCTION IN THE
 166470  166474                          ,WORD   HEADER                  !HEADER BLOCK,

 166472  000000                          ,WORD   0                       !END OF INIT CODE
                                 !
                                 !               HEADER BLOCK FOR THE SCROLLER

 166474  103334                  HEADER! ,WORD   103534                  !ENABL CHAR MODE,BLINKING
 166476  000177                          ,WORD   177                     !A BLINKING BOX-RUB OUT!
 166500  116124                          ,WORD   116124                  !GO TO POINT MODE
 166502  171340                          ,WORD   171340                  !LOAD STATUS REGISTER
 166504  000000  001352                  ,WORD   0,1352                  !POINT TO UPPER LEFT
 166510  103324                          ,WORD   103324                  !BACK TO CHAR MODE
 166512  160000  007010                  ,WORD   DISJMP,JMPADD-2         !AND TO THE CHANCING JMP INST,




   421
   422
   423
   424
   425                                              SBTTL  COMMUNICATIONS AND MISC. SUPPORT ROUTINES
```

```



                                        ;                       COMMUNICATIONS HANDLING ROUTINES
                                        ;                       -------------- -------- --------






                                        ;               THE DL-11 HANDLER
                                        ;               --- ----- -------



166516  1Ø5737  17561Ø          GETDL:  TSTB    DL11IS                  ;CHECK THE HOST INPUT STATUS,
166522  1ØØØ11                          BPL     GETDL1                  ;HOST DID NOT SEND ANYTHING, YET,
166524  1137ØØ  175612                  MOVB    DL11IB,CHAR             ;HOST SENT US A CHARACTER, PROCESS IT,
16653Ø  Ø12737  ØØØØØ7  17561Ø          MOV     #7,DL11IS               ;REENABLE THE HOST TELECOMMUNICATIONS,
166536  Ø427ØØ  1776ØØ                  BIC     #-2ØØ,CHAR              ;MAKE CHARACTER JUST SEVEN BITS,
166542  ØØ1765                          BEQ     GETDL                   ;IF NULL, IGNORE I ,
166544  ØØØ2Ø7                          RTS     PC                      ;ELSE RETURN NOW .

166546  1Ø5737  17756Ø          GETDL1: TSTB    KBDIS                   ;DID USER TYPE A CHARACTER?
166552  1ØØ361                          BPL     GETDL                   ;NO, GO BACK AND CHECK HOST MACHINE
166554  113737  177562  175616          MOVB    KBDIB,DL11OB            ;MOVE THE CHARACTER TO THE HOST,
166562  ØØØ755                          BR      GETDL                   ;AND CHECK AGAIN FOR INPUT,





                                        ;               THE "GET CHARACTER" ROUTINE
                                        ;               --- --- ---------  -------



166564  ØØ4737  166516          GETCHR: JSR     PC,GETDL                ;GET A CHARACTER FROM THE HOST NOW,
16657Ø  Ø2ØØ27  ØØØ175                  CMP     CHAR,#ALTMOD            ;IS IT AN "ALTMODE"
166574  ØØ1Ø25                          BNE     GETEXT                  ;NO, EXIT NOW,

166576  ØØ4737  166516                  JSR     PC,GETDL                ;YES, GET ANOTHER ONE NOW,
1666Ø2  Ø2ØØ27  ØØØ114                  CMP     CHAR,#'L                ;IS IT AN "L"
1666Ø6  ØØ15Ø1                          BEQ     LOADER                  ;YES, START LOADING NOW,
16661Ø  Ø2ØØ27  ØØØ122                  CMP     CHAR,#'R                ;IS IT AN "R"
166614  ØØ1Ø15                          BNE     GETEXT                  ;NO, IGNORE THE ALTMODE AND JUST RETURN THE CHAR

166616  Ø12737  173ØØØ  ØØ7Ø1Ø          MOV     #DISTOP,JMPADD-2        ;YES, RESEØ, STOP DISPLAY BY INSERTING a "DISTOP
166624  ØØØ137  166Ø6Ø          PRESTR: JMP     RESTRT                  ;INSTRUCTION IN THE BUFFER, AND RESTA?Ø,





                                          ;            THE "GET A SIX BIT CHARACTER" ROUTINE
                                          ;            --- --- - --- --- ---------  -------



 166630  004737  166564           GETSIX: JSR      PC,GETCHR                    ;GET A CHARACTER NOW.
 166634  020027  000040                   CMP      CHAR,#40                     ;IS IT A LEGAL PRINTING CHARACTER?
 166640  002517                           BLT      .,BAD                        ;NOPE, ABORT
 166642  020027  000137                   CMP      CHAR,#137                    ;IT'S BIG ENOUGH, IS IT TOO BIG?
 166646  003114                           BGT      .,BAD                        ;YEP, ABORT.

 166650  000207                   GETEXT: RTS      PC                           ;RETURN TO THE CALLER.


                                          ;            THIS OUTPUTS TWO CHARACTERS VIA A
                                          ;            JSR SCAN,OUTLIT
                                          ;            'TWO CHARACTERS'

 166652  112337  175616           OUTLIT: MOVB     (SCAN)+,DL11OB
 166656  112337  175616                   MOVB     (SCAN)+,DL11OB               ;DOUBLE BUFFERED
 166662  000203                           RTS      SCAN                         ;RETURN







                                          ;            THE "GET AN EIGHT BIT CHARACTER" ROUTINE
                                          ;            --- --- -- ----- --- ---------




                                          ;                             THIS ROUTINE DIFFERS FROM THE PREVIOUS ROUTINES
                                          ;                     IN THAT IT WILL TAKE SIX BIT CHARACTERS AND ASSEMBLE
                                          ;                     THEM FOR THE LOADER TO USE. NOTE THAT FROM THIS POINT
                                          ;                     ON WE WILL SWITCH TO THE LOADER DEFINITIONS OF THE
                                          ;                     REGISTERS. THUS THE CHARACTER IS RETURNED IN
                                          ;                     REGISTER "L.BYT" RATHER THAN CHAR (THOUGH THEY ARE
                                          ;                     PHYSICALLY THE SAME).



 166664  004737  166630           GET8:   JSR      PC,GETSIX                    ;GET A SIXBIT CHARACTER.
 166670  010046                           MOV      .,BYT,-(SP)                  ;SAVE IT ON THE STACK.
 166672  005723                           TST      (INDEX)+                     ;UPDATE INDEX TO NEXT ITEM (ALL ARE *2)
 166674  000163  166676                   JMP      GET8TB-2(INDEX)              ;AND DISPATCH ACCORDING TO THE INDEX.

 166700  000404                   GET8TB: BR       GET81                        ;INDEX=2: ASSEMBLE FIRST CHAR
 166702  000416                           BR       GET82                        ;INDEX=4: ASSEMBLE SECOND CHAR
 166704  000432                           BR       GET83                        ;INDEX=6: ASSEMBLE THIRD AND LAST CHAR
                                                                                ;INDEX=8: RESET INDEX TO 0 [2] AND RETRY.
```

```

166706  Ø127Ø3  ØØØØØ2          GET84:  MOV     #2,INDEX        ;THE FOURTH INDEX IS THE SAME AS THE FIRST
                                                                ;INDEX, JUST RESET IT AND FALL THROUGH.


166712  ØØ4737  16663Ø          GET81:  JSR     PC,GETSIX       ;GET ANOTHER CHARACTER NOW.
166716  Ø1ØØØ4                          MOV     L.BYT,HOLD      ;AND PRESERVE IT FOR NEXT TIME THROUGH.
16672Ø  ØØ63ØØ                          ASL     L.BYT           ;NOW THROW AWAY LEFT MOST BITS OF
166722  ØØ63ØØ                          ASL     L.BYT           ;THE 8 BIT CHARACTER. NOW MERGE IN
166724  1Ø63ØØ                          ASLB    L.BYT           ;THE LEFT TWO BITS OF THE
166726  1Ø6116                          ROLB    (SP)            ;NEW SIX BIT CHARACTER WITH THE SIX
16673Ø  1Ø63ØØ                          ASLB    L.BYT           ;BITS FROM THE CHARACTER ON THE
166732  1Ø6116                          ROLB    (SP)            ;STACK. 1ST CHARACTER IS NOW ASSEMBLED.
166734  Ø126ØØ                          MOV     (SP)+,L.BYT     ;SO WE'LL RETURN IT TO THE USER.
166736  ØØØ2Ø7                          RTS     PC              ;AND THEN WE SHALL RETURN TO HIM.


16674Ø  ØØ63ØØ                  GET82:  ASL     L.BYT           ;THE SECOND CHARACTER IS CREATED FROM
166742  ØØ63ØØ                          ASL     L.BYT           ;THE 4 RIGHT BITS OF THE PREVIOUS CHARACTER
166744  1Ø63ØØ                          ASLB    L.BYT           ;AND THE FOUR MIDDLE BITS OF THE PRESENT
166746  1Ø61Ø4                          ROLB    HOLD            ;8 BIT CHARACTER.
16675Ø  1Ø63ØØ                          ASLB    L.BYT           ;WE WILL CREATE THE NEW 8 BIT
166752  1Ø61Ø4                          ROLB    HOLD            ;IN THIS REGISTER, SINCE IT
166754  1Ø63ØØ                          ASLB    L.BYT           ;MORE CONVIENT. WE WILL MOVE OVER THE
166756  1Ø61Ø4                          ROLB    HOLD            ;ANSWER AT THE END.
16676Ø  1Ø63ØØ                          ASLB    L.BYT           ;ONE MORE TO GO
166762  1Ø61Ø4                          ROLB    HOLD            ;DONE.
166764  Ø1Ø4ØØ                          MOV     HOLD,L.BYT      ;BRING OVER THE VALUE.
166766  Ø126Ø4                          MOV     (SP)+,HOLD      ;AND REMEMBER THE LAST CHARACTER WE RECEIVED.
16677Ø  ØØØ2Ø7                          RTS     PC              ;AND RETURN TO THE CALLER.


166772  ØØ61ØØ                  GET83:  ROL     L.BYT           ;FINAL CHARACTER IS EASY. JUST A
166774  1Ø61ØØ                          ROLB    L.BYT           ;SIMPLE MERGER OF LEFT TWO BITS OF
166776  ØØ6ØØ4                          ROR     HOLD            ;PREVIOUS VALUE WITH RIGHT SIX BITS
167ØØØ  1Ø6ØØØ                          RORB    L.BYT           ;OF LAST (4TH) CHARACTER RECEIVED.
167ØØ2  ØØ6ØØ4                          ROR     HOLD
167ØØ4  1Ø6ØØØ                          RORB    L.BYT           ;AND WE ARE DONE.
167ØØ6  ØØ5726                          TST     (SP)+           ;FINALLY THROW AWAY STACK.
167Ø1Ø  ØØØ2Ø7                          RTS     PC              ;AND RETURN TO THE CALLER.
```

```
                                        .SBTTL  THE LOADER



                                        ;               THE LOADER
                                        ;               --- ------




167012  012737  173000  007010  LOADER: MOV     #DISTOP,JMPADD-2        ;STOP THE GT40 BY INSERTING A "DISTOP" IN THE LI

167020  005003                          CLR     INDEX                   ;RESET THE 8 BIT ASSEMBLER TO THE FIRST CHAR


167022  005005                  L.LD2:  CLR     L.CKSM                  ;CLEAR THE CHECKSUM
167024  004737  167114                  JSR     PC,L.PTR                ;GET A BYTE NOW.
167030  105300                          DECB    L.BYT                   ;IS IT A ONE (HEADER)?
167032  001373                          BNE     L.LD2                   ;NO, WAIT FOR THE ONE.

167034  004737  167114                  JSR     PC,L.PTR                ;YES, SKIP OVER THE NEXT CHARACTER NOW.

167040  004737  167126                  JSR     PC,L.GWRD               ;ASSEMBLE A WORD NOW.
167044  010002                          MOV     L.BYT,L.BC              ;MOVE OVER TO THE COUNTER.
167046  162702  000004                  SUB     #4,L.BC                 ;REDUCE TO ACTUAL DATA COUNT.
167052  022702  000002                  CMP     #2,L.BC                 ;ANY DATA AT ALL?
167056  001433                          BEQ     L.JMP                   ;NO, MUST BE END
167060  004737  167126                  JSR     PC,L.GWRD               ;YES, ASSEMBLE A DATA WORD NOW.
167064  010001                          MOV     L.BYT,L.ADR             ;AND THIS MUST BE THE FIRST ADDRESS.


167066  004737  167114          L.LD3:  JSR     PC,L.PTR                ;GET A BYTE OF DATA NOW.
167072  002006                          BGE     L.LD4                   ;ALL DONE?
167074  105705                          TSTB    L.CKSM                  ;YEP, COUNTER IS MINUS, CHECK CHECKSUM.
167076  001751                          BEQ     L.LD2                   ;CHECKSUM GOOD, GET NEXT COMMAND.


167100  004337  166652          L.BAD:  JSR     SCAN,OUTLIT     ;BAD LOAD INFORM HOST
167104     175     102                  .BYTE   ALTMOD,'B               ;SEND ALTMODE B
167106  000646                          BR      PRESTRT                 ;AND RESTART THE DISPLAY.


167110  110021                  L.LD4:  MOVB    L.BYT,(L.ADR)+          ;INSERT BYTE INTO MEMORY.
167112  000765                          BR      L.LD3                   ;AND GET THE NEXT BYTE.



167114  004737  166664          L.PTR:  JSR     PC,GET8                 ;ASSEMBLE AN 8 BIT CHARACTER NOW.
167120  060005                          ADD     L.BYT,L.CKSM            ;UPDATE THE CHECKSUM NOW.
167122  005302                          DEC     L.BC                    ;DECREMENT THE CHARACTER COUNTER.
167124  000207                          RTS     PC                      ;AND RETURN TO THE CALLER NOW.



167126  004737  167114          L.GWRD: JSR     PC,L.PTR                ;ASSEMBLE A WORD, FIRST GET A CHARACTER
```

```
167132  010046                        MOV     L.BYT,-(SP)             ;AND SAVE IT.
167134  004737  167114                JSR     PC,L.PTR                ;AND THEN GET ANOTHER ONE.
167140  000300                        SWAB    L.BYT                   ;AND THEN REASSEMBLE THE MESS.
167142  052600                        BIS     (SP)+,L.BYT             ;WITH THE FEARSOME POWER OF THE 11.
167144  000207                        RTS     PC                      ;AND RETURN TO THE CALLER.




167146  004737  167126        L.JMP:  JSR     PC,L.GWRD               ;ALL DONE WITH THE LOAD. ASSEMBLE
167152  010046                        MOV     L.BYT,-(SP)             ;THE STARTING ADDRESS NOW.
167154  004737  167114                JSR     PC,L.PTR                ;AND DON'T FORGET TO CHECKSUM IT.
167160  105705                        TSTB    L.CKSM
167162  001346                        BNE     L.BAD                   ;A BAD CHECKSUM. ALL IS EVIL.

167164  004337  166652                JSR     SCAN,OUTLIT             ;GOOD CHKSUM,INFORM HOST
167170     175     107                .BYTE   ALTMOD,'G               ;WITH ALTMOD G

167172  032716  000001                BIT     #1,(SP)                 ;DO WE WANT TO START EXECUTION?
167176  001401                        BEQ     L.JMP1                  ;YES. AWAY WE GO.

167200  000000                L.HALT: HALT                            ;IF NOT, HALT.

167202  000136                L.JMP1: JMP     @(SP)+                  ;IF GO, THEN GO ALREADY, WHEEEE!
```

```
                                                                 ;THIS IS GT40 QUICK TEST
                                                                      ;GIVES QUICK VISUAL TEST
                                                                      ;OF CONDITION OF MACHINE
                                                                      ;WITHOUT READING IN DIAG.
          100000           CHAR=100000
          104000           SHORTV=104000
          110000           LONGV=110000
          114000           POINT=114000
          120000           GRAPHX=120000
          124000           GRAPHY=124000
          130000           RELATV=130000

          002000           INT0=2000
          002200           INT1=2200
          002400           INT2=2400
          002600           INT3=2600
          003000           INT4=3000
          003200           INT5=3200
          003400           INT6=3400
          003600           INT7=3600                                  ;BRIGHTEST

          000100           LPOFF=100
          000140           LPON=140
          000020           BLKOFF=20
          000030           BLKON=30

          000004           LINE0=4
          000005           LINE1=5
          000006           LINE2=6
          000007           LINE3=7

          160000           DJMP=160000
          164000           DNOP=164000
          170000           STATSA=170000
          173400           DSTOP=173400                               ;STOP INTERRUPT

          000300           LPLITE=300
          000200           LPDARK=200
          000040           ITAL0=40                                   ;ITALICS OFF
          000060           ITAL1=60                                   ;"       ON
          000004           SYNON=4                                    ;SYNC ON


          174000           STATSB=174000

          000100           INCR=100                                   ;LOAD GRAPH INCR
          040000           INTX=40000                                 ;INTENSIFY BIT
          001777           MAXX=1777                                  ;BIGGEST X VECTOR
          001377           MAXY=1377                                  ;BIGGEST Y VECTOR
          020000           MINUSX=20000                               ;THE MINUS BIT
          020000           MINUSY=MINUSX
          017600           MAXSX=17600                                ;BIGGEST X IN SHOR VEC
          000077           MAXSY=77                                   ;  "     Y IN  "
          000100           MINSUY=100                                 ;MINUS BIT FOR Y IN SHORTVEC
```

```
SCROLLING ROM BOOTSTRAP FOR THE GT40    MACDLX 622(622)-1  26-JUN-73  16:11   AGE 1-16
BOOT.T15          THE LOADER


 167204  012737  167214  172000           MOV     #FILE0,GT40PC             ;START THE GT40
 167212  000001                           WAIT                              ;AND WAIT

 167214  114020                   FILE0:  POINT!BLKOFF                      ;POINT--INVISIBLE
 167216  000000                           0
 167220  001377                           MAXY

 167222  112004                           LONGV!INT0!LINE0                  ;DRAW TOP LINE
 167224  041777                           INTX!MAXX
 167226  000000                           0

 167230  112405                           LONGV!INT2!LINE1
 167232  040000                           INTX                              ;DRAW LINE TO RIGH
 167234  021377                           MINUSX!MAXY

 167236  113006                           LONGV!INT4!LINE2
 167240  061777                           INTX!MINUSX!MAXX                  ;DRAW BOTTOM LINE
 167242  000000                           0

 167244  113407                           LONGV!INT6!LINE3
 167246  040000                           INTX
 167250  001377                           MAXY                              ;DRAW LINE TO LEFT

 167252  114000                           POINT
 167254  000400                           400
 167256  000500                           500
 167260  106200                           SHORTV!INT1
 167262  057677                           57677                             ;+X+Y
 167264  106600                           SHORTV!INT3
 167266  077677                           77677                             ;+X-Y
 167270  107200                           SHORTV!INT5
 167272  077777                           77777                             ;-X-Y
 167274  107600                           SHORTV!INT7
 167276  057777                           57777                             ;-X+Y

 167300  114000                           POINT
 167302  001400                           1400
 167304  000500                           500
 167306  133030                           RELATV!INT4!BLKON
 167310  057677                           57677                             ;+X+Y
 167312  077677                           77677                             ;+X-Y
 167314  077777                           77777                             ;-X-Y
 167316  057777                           57777                             ;-X+Y

 167320  114000                           POINT
 167322  000400                           400
 167324  000100                           100
 167326  174120                           STATSB!INCR+20                    ;TRY GRAPH MODES
 167330  114000                           POINT
 167332  001000                           1000
 167334  000200                           200

```

```
SCROLLING ROM BOOTSTRAP FOR THE GT4Ø    MACDLX 622(622)-1  26-JUN-73  16:11   AGE 1-1
BOOT.T15         THE LOADER

   799  167336  12ØØØØ                                   GRAPHX
   8ØØ  16734Ø  ØØ1Ø1Ø                                   1Ø1Ø
   8Ø1  167342  ØØ1Ø2Ø                                   1Ø2Ø
   8Ø2  167344  ØØ1Ø3Ø                                   1Ø3Ø
   8Ø3  167346  ØØ1Ø4Ø                                   1Ø4Ø
   8Ø4  16735Ø  ØØ1Ø5Ø                                   1Ø5Ø
   8Ø5
   8Ø6  167352  114ØØØ                                   POINT
   8Ø7  167354  ØØ1ØØØ                                   1ØØØ
   8Ø8  167356  ØØ12ØØ                                   12ØØ
   8Ø9
   81Ø  16736Ø  124ØØØ                                   GRAPHY
   811  167362  ØØ1Ø2Ø                                   1Ø2Ø
   812  167364  ØØ1Ø3Ø                                   1Ø3Ø
   813  167366  ØØ1Ø4Ø                                   1Ø4Ø
   814  16737Ø  ØØ1Ø5Ø                                   1Ø5Ø
   815  167372  ØØ1Ø6Ø                                   1Ø6Ø
   816
   817  167374  16ØØØØ                                   DJMP
   818  167376  167214                                   FILEØ
   819
   82Ø
```

```
   849                                ;
   85Ø                                ; PAPER TAPE BOOT
   851                                ;
   852          177550                HSR=17755Ø                          ;HIGH SPEED READER ADDRESS
   853          17756Ø                LSR=17756Ø                          ;LOW SPEED READER ADDRESS
   854          1674ØØ                .=ORIGIN+14ØØ
   855                                ;
   856  1674ØØ  Ø127Ø1  16ØØØØ        PTBOOT: MOV     #16ØØØØ,R1          ;SET MEMORY CHECK LIMITS
   857  1674Ø4  Ø127Ø2  ØØØØØ4                MOV     #4,R2               ;TRAP ADDRESS IS LOC. 4
   858  16741Ø  Ø127Ø3  1675ØØ                MOV     #DEV+4,R3           ;POINTER TO DEVICE ADDRESSES
   859  167414  Ø1Ø712                        MOV     PC,@R2              ;PRESET TRAP ADDRESS IN LOC. 4
   86Ø  167416  Ø127Ø6  ØØØØ24                MOV     #24,SP              ;STACK SET UP AT SPECIAL ADDRESS
   861  167422  Ø143Ø4                DEV1:   MOV     -(R3),R4            ;GET DEVICE ADDRESS
   862  167424  ØØ5714                        TST     @R4                 ;CHECK AVAILABILITY OF DEVICE
   863  167426  1ØØ775                        BMI     DEV1                ;CHECK DEVICE FOR ERRORS
   864  16743Ø  Ø1Ø712                        MOV     PC,@R2              ;RESET TRAP ADDRESS AT LOC. 4
   865  167432  Ø127Ø6  ØØØØ24                MOV     #24,SP              ;SPECIAL ADDRESS USED AS MASK LATER
   866  167436  Ø1Ø441                        MOV     R4,(R1)             ;DO MEM CHK:READER STATUS ADDRESS
   867                                                                    ;IS MOVED
   868  16744Ø  Ø4Ø6Ø1                        BIC     SP,R1               ;SET R1=X7752,MASK IN SP=24
   869  167442  Ø1Ø111                        MOV     R1,@R1              ;STORE OWN ADDRESS IN POINTER
   87Ø  167444  Ø111Ø2                LOOP:   MOV     @R1,R2              ;GET BYTE POINTER
   871  167446  ØØ5214                        INC     @R4                 ;ENABLE READER
   872  16745Ø  1Ø5714                        TSTB    @R4                 ;TEST DONE BIT
   873  167452  1ØØ376                        BPL     .-2                 ;WAIT UNTIL READY
   874  167454  116412  ØØØØØ2                MOVB    2(R4),@R2           ;THEN PICK IT UP AND STORE IT
   875  16746Ø  ØØ5211                        INC     @R1                 ;BUMP POINTER
   876  167462  12Ø227  ØØØ375                CMPB    R2,*375             ;STORED JUMP OFFSET?
   877  167466  ØØ1366                        BNE     LOOP                ;NOT YET
   878  16747Ø  1Ø5222                        INCB    (R2)+               ;YES,ALL DONE
   879  167472  ØØØ142                        JMP     -(R2)               ;GO EXECUTE AS BRANCH
   88Ø                                ;
   881                                ; DEVICE ADDRESSES FOLLOW - DO NOT CHANGE THE ORDER
   882                                ;
   883  167474  17756Ø                DEV:    LSR                         ;LOW SPEED READER
   884  167476  17755Ø                        HSR                         ;HIGH SPEED READER
```

```
SCROLLING ROM BOOTSTRAP FOR THE GT4Ø    MACDLX 622(62  -1  26-JUN-73  16:
BOOT.T15         THE LOADER

  887                                   ;
  888                                   ; CASSETTE BOO
  889                                   ;
  89Ø          1775ØØ                   TACS=1775ØØ                         ;TA-11 CONTROL AND STATUS REGISTER
  891          1675ØØ                   .=ORIGIN+15ØØ
  892  1675ØØ  Ø127ØØ  1775ØØ           TABOOT: MOV     #TACS,RØ
  893  1675Ø4  ØØ5Ø1Ø                           CLR     (RØ)                ;SELECT UNIT #Ø
  894  1675Ø6  Ø1Ø7Ø1                   RES:    MOV     PC,R1               ;USE FOR P C
  895  16751Ø  Ø627Ø1  ØØØØ52                   ADD     #TABLE-.,R1         ;R1 HOLDS  DOR. OF COMMANO TABLE
  896  167514  Ø127Ø2  ØØØ375                   MOV     #375,R2             ;MEMORY PT  ,AND DATA FLAG
  897  16752Ø  1121Ø3                           MOVB    (R1)+,R3            ;TEST BITS
  898                                   ;
  899  167522  11211Ø                   LOOP1:  MOVB    (R1)+,(RØ)          ;COMMAND FROM TABLE TO THCS
  9ØØ  167524  1ØØ413                           BMI     DONE                ;WHEN COMM -D CODE NEO., QUIT
  9Ø1  167526  13Ø31Ø                   LOOP2:  BITB    R3,(RØ)             ;TEST READ  AND T-REQ BITS IN TACS
  9Ø2  16753Ø  ØØ1776                           BEQ     LOOP2               ;LOOP 'TIL SOMETHING COMES UP
  9Ø3  167532  1Ø52Ø2                           INCB    R2                  ;ADVANCE MEMORY POINTER
  9Ø4  167534  1ØØ772                           BMI     LOOP1               ;IF MINUS, TRY NEXT COMMAND
  9Ø5  167536  116Ø12  ØØØØØ2                   MOVB    2(RØ),(R2)          ;READ DATA INTO MEMORY
  9Ø6  167542  123337  ØØØØØØ                   CMPB    R3,@#Ø              ;FIRST BYTE READ SHOULD BE '24Ø'
  9Ø7  167546  ØØ1767                           BEQ     LOOP2               ;IF O K., GO READ ANOTHER BYTE
  9Ø8  16755Ø  ØØØØØØ                   STOP:   HALT                        ;HALT ON ERROR
  9Ø9  167552  ØØØ755                           BR      RES                 ;RESTART ON CONTINUE
  91Ø                                   ;
  911  167554  ØØ571Ø                   DONE:   TST     (RØ)                ;CHECK FOR ERROR
  912  167556  1ØØ774                           BMI     STOP                ;HALT ON ERROR
  913  16756Ø  ØØ5ØØ7                           CLR     PC                  ;= 'JMP @#Ø'
  914                                   ;
  915  167562  Ø1764Ø                   TABLE   .WORD   1764Ø               ; BYTE 24Ø: READY+T-REQ.
  916                                                                       ; BYTE 37:  ILBS+READY+GO
  917  167564  ØØ2415                           .WORD   2415                ; BYTE  15: SFB+GO
  918                                                                       ; BYTE   5: READ+GO
  919  167566  112Ø24                           .WORD   112Ø24              ; BYTE  24: READ+ILBS
  92Ø                                                                       ;.BYTE 224: READ+ILBS+E.O.TABLE
  921  16757Ø  ØØØØØØ  ØØØØØØ                   .WORD   Ø,Ø                 ;THESE ARE FILLER WORDS
  922  167574  1675ØØ                           .WORD   TABOOT              ;POWER UP VECTOR AND PRIORITY
  923  167576  ØØØ34Ø                           .WORD   34Ø                 ;
```

```
                                ;MR11-DB BULK STORAGE PROGRAM LOADER LISTING

               167600           .=ORIGIN+1600                   ;KEEP TRACK OF ORIGIN

       167600  010702           RF11:   MOV PC,R2               ;FIXED HEAD DISK (256 KW)
       167602  000451                   BR OTHER
       167604  177462                   177462
       167606  000005                   5

       167610  010702           RK11:   MOV PC,R2               ;MOVING HEAD DISK (CARTRIDGE)
       167612  000445                   BR OTHER
       167614  177406                   177406
       167616  000005                   5


       167620  010702           TC11:   MOV PC,R2
       167622  000417                   BR TAPES
       167624  177344                   177344                  ;ADDRESS OF WORD COUNT
       167626  000005                   5                       ;LAST COMMAND
       167630  004003                   4003                    ;FIRST COMMAND
       167632  100000                   100000                  ;DONE MASK
       167634  024000                   24000                   ;ERROR MASK


       167636  010702           TM11:   MOV PC,R2
       167640  000410                   BR TAPES
       167642  172524                   172524                  ;ADDRESS OF BYTE COUNT
       167644  060003                   60003                   ;LAST COMMAND
       167646  060011                   60011                   ;FIRST COMMAND
       167650  000200                   200                     ;DONE MASK
       167652  100000                   100000                  ;ERROR MASK


       167654  010702           RP11:   MOV PC,R2               ;MOVING HEAD DISK (PACK)
       167656  000423                   BR OTHER
       167660  176716                   176716


       167662  000005           TAPES:  RESET
       167664  010200                   MOV R2,R0               ;GET THE ADDRESS OF THE BRANCH
       167666  005720                   TST (0)+                ;R0 TO POINT AT LAST COMMAND
       167670  012001                   MOV (0)+,R1             ;GET THE WORD COUNT ADDRESS
       167672  005311                   DEC (1)                 ;SET UP FOR ADVANCE 1 RECORD
       167674  005720                   TST (0)+                ;MOVE R0 TO FIRST COMMAND
       167676  012041                   MOV (0)+,-(1)           ;COMMAND WORD TO COMMAND REG.
       167700  031011                   BIT (0),(1)             ;LOOK FOR DONE INDICATORS
       167702  001776                   BEQ .-2                 ;NONE SET, TRY AGAIN
       167704  005720                   TST (0)+                ;DONE FIRST COMMAND, CHECK FOR ERROR
       167706  031041                   BIT (0),-(1)            ;LOOK FOR SET ERROR BITS
       167710  001406                   BEQ OTHER               ;NO ERRORS - TRY THE READ
       167712  000112           AGAIN:  JMP (2)                 ;RERUN FOR ERRORS


       167714  167600           RFVEC:  RF11                    ;RF11 POWER UP VECTOR
```

```
167716  000340                            340

167720  010702               RC11:      MOV PC,R2                 ;FIXED HEAD DISK (64KW)
167722  000401                          BR OTHER
167724  177450                          177450                    ;ADRS OF WORD COUNT (COMMAND+2)
                                                                  ;COMMAND WORD (5) IS THE RESET

167726  000005               OTHER:     RESET
167730  010200                          MOV R2,R0                 ;R0 TO POINT AT WORD COUNT ADRS
167732  005720                          TST (0)+                  ;POINT TO ADDRESS
167734  012001                          MOV (0)+,R1               ;WORD COUNT ADDRESS TO R1
167736  012711  177000                  MOV #-1000,(1)            ;LOAD WORD COUNT
167742  011041                          MOV (0),-(1)              ;COMMAND TO COMMAND REGISTER
167744  032711  100200                  BIT #100200,(1)           ;CHECK FOR ERROR OR DONE
167750  001775                          BEQ .-4                   ;IF NEITHER, KEEP LOOKING
167752  100757                          BMI AGAIN                 ;ERROR, TRY AGAIN
167754  005007                          CLR PC

167756  000000                          0                         ;FILLER
167760  167610               RKVEC:     RK11                      ;RK POWER UP VECTOR
167762  000340                          340
167764  167720               RCVEC:     RC11                      ;RC POWER UP VECTOR
167766  000340                          340
167770  167654               RPVEC:     RP11                      ;RP POWER UP VECTOR
167772  000340                          340
167774  167620               TCVEC:     TC11                      ;TC11 POWER UP VECTOR
167776  000340                          340
```

```
SCROLLING ROM BOOTSTRAP FOR                         622(622)-1
BOOT.T15        THE LOADER

  1ØØ8          ØØØØØ1                               .END
```

```
SCROLLING ROM BOOTSTRAP FOR THE GT40    MACY11,624  16-JUL-73  10:04  PAGE 6-1
BOOT,T16          CROSS REFERENCE TABLE

AGAIN     167712              974#    993
ALTMOD  = 000175              139#    465     633     666
BELL      166250              278     310#
BLIMIT  = 007000              132#    135     223     244     329     348     395     399
BLKOFF  = 000020              713#    749
BLKON   = 000030              714#    784
BSTART  = 001000              131#    331     351     368     398
CHAR    = 100700               82#    102     267     269     271     298*    315*    327     338*    345     444*    446*    465
                              469     471     487     489     694#
CORSTR  = 200204              134#    192
COUNTR =%000005                89#    105     306*    313*    317*
CR        166266              267#
CRLF    = 005015              138#    226
DEV       167474              857     882#
DEV1      167422              860#    862
DISJMP  = 160000              141#    359     397     398     399     415
DISTOP  = 173000              142#    474     605
DJMP    = 160000              721#    816
DL11IB  = 175612              120#    121     444
DL11IS  = 175610              119#    120     186*    442     445*
DL11OB  = 175616              122#    452*    499*    520*
DL11OS  = 175614              121#    122     188*    226     228*
DNOP    = 164000              722#
DONE      167554              899     910#
DSTOP   = 173400              724#
ENDCOR    166236              195#    196
FF        166256              283     313#
FFLOOP    166262              308     315#    318
FILE0     167214              746     749#    817
GETCHR    166564              266     464#    486
GETDL     166516              442#    447     451     453     464     468
GETDL1    166546              443     450#
GETEXT    166650              466     472     492#
GETSIX    166630              486#    524     539
GET8      166664              524#    642
GET8TB    166700              527     529#
GET81     166712              529     539#
GET82     166740              530     551#
GET83     166772              531     566#
GET84     166706              535#
GRAPHX  = 120000              698#    798
GRAPHY  = 124000              699#    809
GTBUSE    166424              368#    391
GT40PC  = 172000              127#    128     368*    402     746*
GT40SR  = 172002              128#    310*
HEADER    166474              358     397     403     409#
HOLD   =%000004                87#    540*    554*    556*    558*    560*    561     562*    568*    570*
HSR     = 177550              851#    883
INCR    = 000100              735#    793
INDEX  =%000003               106#    526     527     535*    607*
INSERT    166350              291     299     337     345#
INSRTL    166406              349     352     357#
INSRTX    166422              347     362#
INTX    = 040000              736#    754     758     762     766
```

E-26

```
BOOT,T16          CROSS REFERENCE TABLE

INTØ    = ØØ2ØØØ             7Ø2#     753
INT1    = ØØ22ØØ             7Ø3#     772
INT2    = ØØ24ØØ             7Ø4#     757
INT3    = ØØ26ØØ             7Ø5#     774
INT4    = ØØ3ØØØ             7Ø6#     761      784
INT5    = ØØ32ØØ             7Ø7#     776
INT6    = ØØ34ØØ             7Ø8#     765
INT7    = ØØ36ØØ             7Ø9#     778
ITALØ   = ØØØØ4Ø             728#
ITAL1   = ØØØØ6Ø             729#
JMPADD  = ØØ7Ø12             135#     325      336*     415      474*     6Ø5*
KBDIB   = 177562             125#     452
KBDIS   = 17756Ø             124#     125      45Ø
LF        1663ØØ             281      322#
LFLOOP    16631Ø             327#     33Ø      332
LFOUND    16633Ø             328      334#
LFSUB     1663Ø4             316      325#
LINEØ   = ØØØØØ4             716#     753
LINE1   = ØØØØØ5             717#     757
LINE2   = ØØØØØ6             718#     761
LINE3   = ØØØØØ7             719#     765
LOADER    167Ø12             47Ø      6Ø5#
LONGV   = 11ØØØØ             696#     753      757      761      765
LOOP      167444             869#     876
LOOP1     167522             898#     9Ø3
LOOP2     167526             9ØØ#     9Ø1      9Ø6
LPDARK  = ØØØ2ØØ             727#
LPLITE  = ØØØ3ØØ             726#
LPOFF   = ØØØ1ØØ             711#
LPON    = ØØØ14Ø             712#
LSR     = 17756Ø             852#     882
L,ADR   =%ØØØØØ1             1Ø3#     623*     637*
L,BAD     1671ØØ             488      49Ø      632#     663
L,BC    =%ØØØØØ2             1Ø4#     618*     619*     62Ø      644*
L,BYT   =%ØØØØØØ             1Ø2#     525      54Ø      541*     542*     543*     545*     547*     551*     552*     553*     555*     557*
                             559*     561*     566*     567*     569*     571*     612*     618      623      637      643      65Ø      652*
                             653*     66Ø
L,CKSM  =%ØØØØØ5             1Ø5#     61Ø*     628      643*     462
L,GWRD    167126             617      622      649#     659
L,HALT    1672ØØ             671#
L,JMP     167146             621      659#
L,JMP1    1672Ø2             669      673#
L,LD2     167Ø22             61Ø#     613      629
L,LD3     167Ø66             626#     638
L,LD4     16711Ø             627      637#
L,PTR     167114             611      615      626      642#     649      651      661
MAXSX   = Ø176ØØ             741#
MAXSY   = ØØØ377             742#
MAXX    = ØØ1777             737#     754      762
MAXY    = ØØ1377             738#     751      759      767
MINSUY  = ØØØ1ØØ             743#
MINUSX  = Ø2ØØØØ             739#     74Ø      759      762
MINUSY  = Ø2ØØØØ             74Ø#
NORMAL    166212             27Ø      279      291#
```

```
SCOOLLING ROM BOOTSTRAP FOR THE GT40    MACY11.624  16-JUL-73  10:04  PAGE 6-3
BOOT .T16          CROSS REFERENCE TABLE

NOTHER    166042          193    199#
NUMLIN  = 000040          136#   223    224    313    399
NXTCHR    166132          266#   268    274    293    303    311    319    322
ORIGIN  = 166000          117#   173    853    890    926
OTHER     167726          929    934    958    973    981    985#
OUTLIT    166652          189    499#   632    665
PC       =%000007          74#   266*   276*   291*   299*   306    316*   337*   352*   355*   362*   448*   464*
                          468*   486*   492*   524*   539*   548*   563*   573*   611*   615*   617*   622*   626*
                          642*   645*   649*   651*   654*   659*   661*   858    863    893    912*   928    933
                          939    948    957    980    994*
POINT   = 114000          697#   749    769    781    790    794    805
POINTR  =%000001           83#   103    236*   238*   244*   345*   346    348    350    351*   357    358*   359*
                          362*
PRESTR    166624          475#   634
PTBOOT    167400          855#
RCVEC     167764          999#
RC11      167720          980#   999
RELATV  = 130000          700#   784
RES       167506          893#   908
RESTRT    166560          220#   475
RFVEC     167714          977#
RF11      167600          928#   977
RKVEC     167760          997#
RK11      167510          933#   997
RPVEC     167770         1001#
RP11      167654          957#  1001
R0       =%000000          67#    82    891*   892*   898*   900    904    910    963*   986*
R1       =%000001          68#    83    855*   865*   867*   868*   869    874*   893*   894*   896    898    965*
                          988*
R2       =%000002          69#    84    856*   858*   863*   869*   873*   875    877*   878    895*   902*   904*
                          928*   933*   939*   948*   957*   963    980*   986
R3       =%000003          70#    85    857*   860    866*   900    905
R4       =%000004          71#    87    860*   861    865    870*   871    873
R5       =%000005          72#    89
SCA      =%000003          85#   106    189*   192*   193*   195*   199    204    223*   226*   231*   234    236
                          238    271*   272*   273    275*   276    325*   327    329    331*   334*   335*   336
                          350*   353*   354*   499    500    501*   632*   665*
SETDUN    166126          235    244#
SETLP1    166074          226#   228
SETLP2    166110          234#   241
SETLP3    166116          238#   240
SETUP     166432          231    389#
SHORTV  = 124000          695#   772    774    776    778
SP       =%000006          73#   187*   204*   220*   522*   525*   544*   546*   547    562    572    650*   653
                          660*   668    673    859*   864*   867
START     166000          185#
STATSA  = 170000          723#
STATSB  = 174000          733#   793
STOP      167550          907#   911
SYNON   = 000004          730#
TAB       166222          280    298#   302
TABCNT   =%000002          84#   104    224*   227*   234*   239*   287*   292*   300*   301
TABLE     167562          894    914#
TABOOT    167500          891#   921
```

```
SCROLLING ROM BOOTSTRAP FOR THE GT4Ø
BOOT.T16          CROSS REFERENCE TABLE

TACS    = 1775ØØ              889#      891
TAPES     167662              94Ø       949      962#
TCVEC     167774             1ØØ3#
TC11      16762Ø              939#     1ØØ3
TMPEND  = ØØ7776              133#      187      22Ø
TM11      167636              948#
VT        166244              282       3Ø6#
.       = 17ØØØØ              173#      853#     872      89Ø#     894      926#     97Ø      992
```

```
SCROLLING ROM BOOTSTRAP FOR THE GT4Ø    MACY11,624  16-JUL-73  1Ø:Ø4  PAGE 6-5
BOOT,T16           CROSS REFERENCE TABLE

ADD        276     643     894
ASL        275     541     542     551     552
ASLB       543     545     553     555     557     559
BEQ        235     328     447     47Ø     621     629     !69     9Ø1     9Ø6     97Ø     973     992
BGE        268     27Ø     627
BGT        226     24Ø     318     49Ø
BHIS       274
BIC        335     446     867
BIS        22Ø     653
BIT        3Ø1     346     668     969     972     991
BITB       9ØØ
BLO        33Ø     349
BLT        468
BMI        862     899     9Ø3     911     993
BNE        3Ø2     347     466     472     613     663     !76
BPL        2Ø7     443     451     872
BR         196     241     278     279     28Ø     281     !82     283     293     3Ø3     3Ø8     311     319     332     453
           529     53Ø     531     634     638     9Ø8     929     934     94Ø     949     958     981
CLR        195     2ØØ     31Ø     338     353     354     36Ø     6Ø7     61Ø     892     912     994
CMP        267     269     273     329     348     357     465     469     471     487     489     62Ø
CMPB       327     875     9Ø5
DEC        227     239     317     644     966
DECB       612
HALT       671     9Ø7
INC        188     292     3ØØ     334     87Ø     874
INCB       877     9Ø2
JMP        475     527     673     878     974
JSR        189     266     291     299     316     337     !52     464     468     486     524     539     611     615     617
           622     626     632     642     649     651     !59     661     665
MOV        186     187     192     193     2Ø4     223     !24     226     231     234     236     238     244     271     287
           298     313     315     322     325     331     !36     35Ø     351     358     359     368     445     474     525
           535     54Ø     547     561     562     6Ø5     !18     623     65Ø     66Ø     746     855     856     857     858
           859     86Ø     863     864     865     868     !69     891     893     895     928     933     939     948     957
           963     965     968     98Ø     986     988     '89     99Ø
MOVB       3Ø6     345     444     452     499     5ØØ     (37     873     896     898     9Ø4
RESET      185     962     965
ROL        566
ROLB       544     545     554     556     558     56Ø     !67
ROR        568     57Ø
RORB       569     571
RTS        355     362     448     492     5Ø1     548     !63     573     645     654
SUB        272     619
SWAB       652
TST        199     526     572     861     91Ø     964     967     971     987
TSTB       2Ø6     442     45Ø     628     662     871
WAIT       747
,BYTE      633     666
,ENABL      36
,END      1ØØ7
,PAGE       55     1Ø9     162     257     425     595     !89     82Ø
,SBTTL      54     161     256     424     594
,TITLE       2
,WORD      19Ø     389     39Ø     391     392     394     395     396     397     398     399     4Ø1     4Ø2     4Ø3     4Ø5
           4Ø9     41Ø     411     412     413     414     415     914     916     918     92Ø     921     922
```

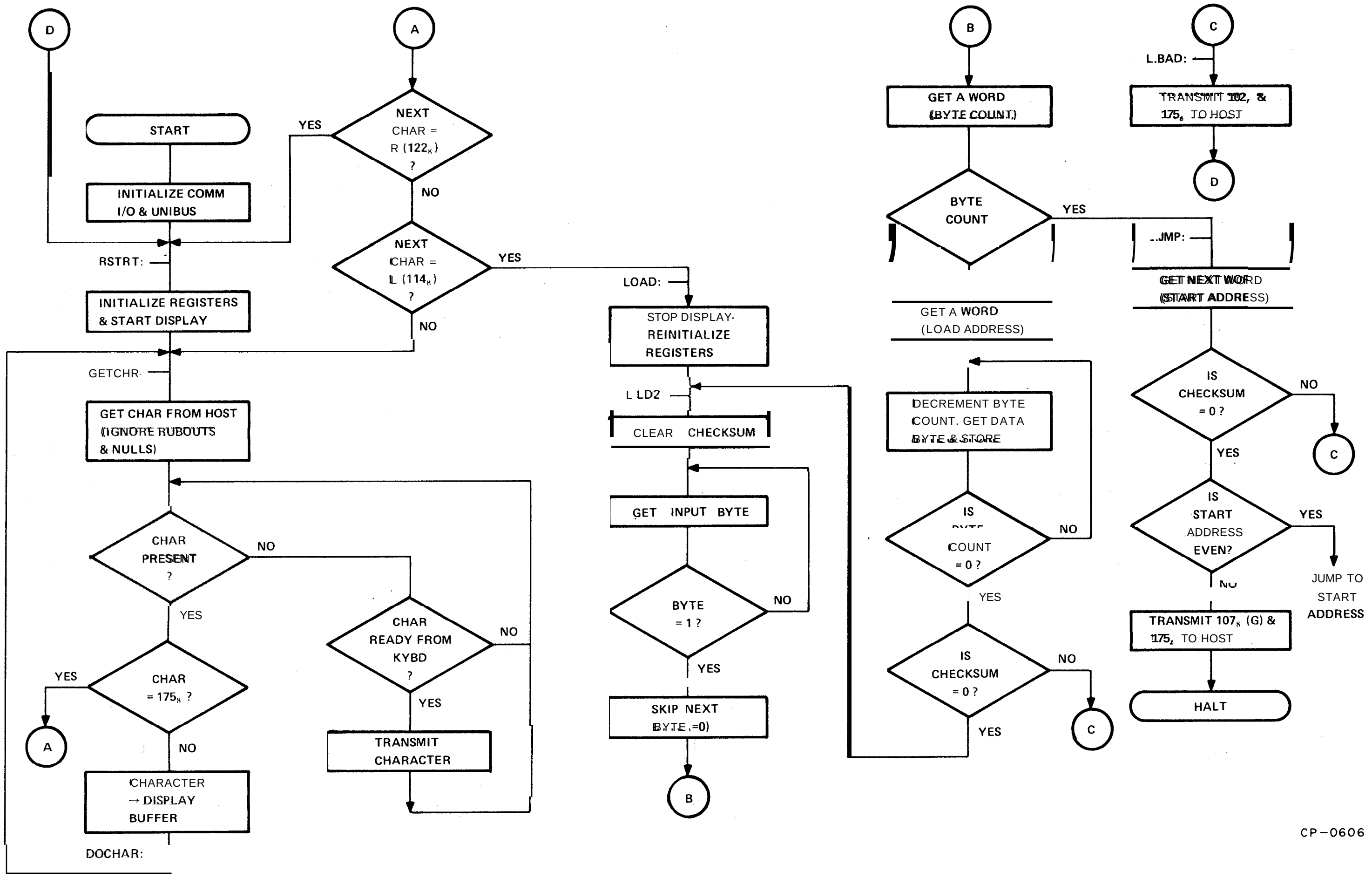

D
START
INITIALIZE COMM I/O & UNIBUS
RSTRT:
INITIALIZE REGISTERS & START DISPLAY
GETCHR
GET CHAR FROM HOST (IGNORE RUBOUTS & NULLS)
CHAR PRESENT ?
YES
NO
CHAR = 175_8 ?
YES
A
NO
CHARACTER → DISPLAY BUFFER
DOCHAR:
A
NEXT CHAR = R (122_8) ?
YES
NO
NEXT CHAR = L (114_8) ?
YES
NO
CHAR READY FROM KYBD ?
NO
YES
TRANSMIT CHARACTER
LOAD:
STOP DISPLAY· REINITIALIZE REGISTERS
L LD2
CLEAR CHECKSUM
GET INPUT BYTE
BYTE = 1 ?
NO
YES
SKIP NEXT BYTE (=0)
B
B
GET A WORD (BYTE COUNT)
BYTE COUNT
YES
GET A WORD (LOAD ADDRESS)
DECREMENT BYTE COUNT. GET DATA BYTE & STORE
IS BYTE COUNT = 0 ?
NO
YES
IS CHECKSUM = 0 ?
NO
C
YES
C
L.BAD:
TRANSMIT 102_8 & 175_8 TO HOST
D
L.JMP:
GET NEXT WORD (START ADDRESS)
IS CHECKSUM = 0 ?
NO
C
YES
IS START ADDRESS EVEN?
YES
JUMP TO START ADDRESS
NO
TRANSMIT 107_8 (G) & 175_8 TO HOST
HALT
CP–0606

Figure E-1 Communications Bootstrap Loader Flow Diagram

Reader's Comments

GT40/42 USER'S GUIDE
DEC-11-HGTGA-B-D

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 judgment is it complete, accurate, well organized, well written, etc.? Is it easy to use? ______________________________

____

____

____

What features are most useful? ______________________________

____

____

____

What faults do you find with the manual? ______________________________

____

____

____

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

Does it satisfy *your* needs? ______________ Why? ______________

____

____

____

Would you please indicate any factual errors you have found. ______________

____

____

____

Please describe your position. ______________________________

Name ______________ Organization ______________

Street ______________ Department ______________

City ______________ State ______________ Zip or Country ______________

— — — — — — — — — — Fold Here — — — — — — — — — —

— — — — — — — — — Do Not Tear - Fold Here and Staple — — — — — — — —

Digital Equipment Corporation
Technical Documentation Department
146 Main Street
Maynard, Massachusetts 01754

Digital Equipment Corporation
Maynard, Massachusetts

digital

printed in U.S.A