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4051 Option 1
DATA COMMUNICATION INTERFACE

OPERATOR'S MANUAL

Tektronix, Inc.
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Beaverton, Oregon 97077

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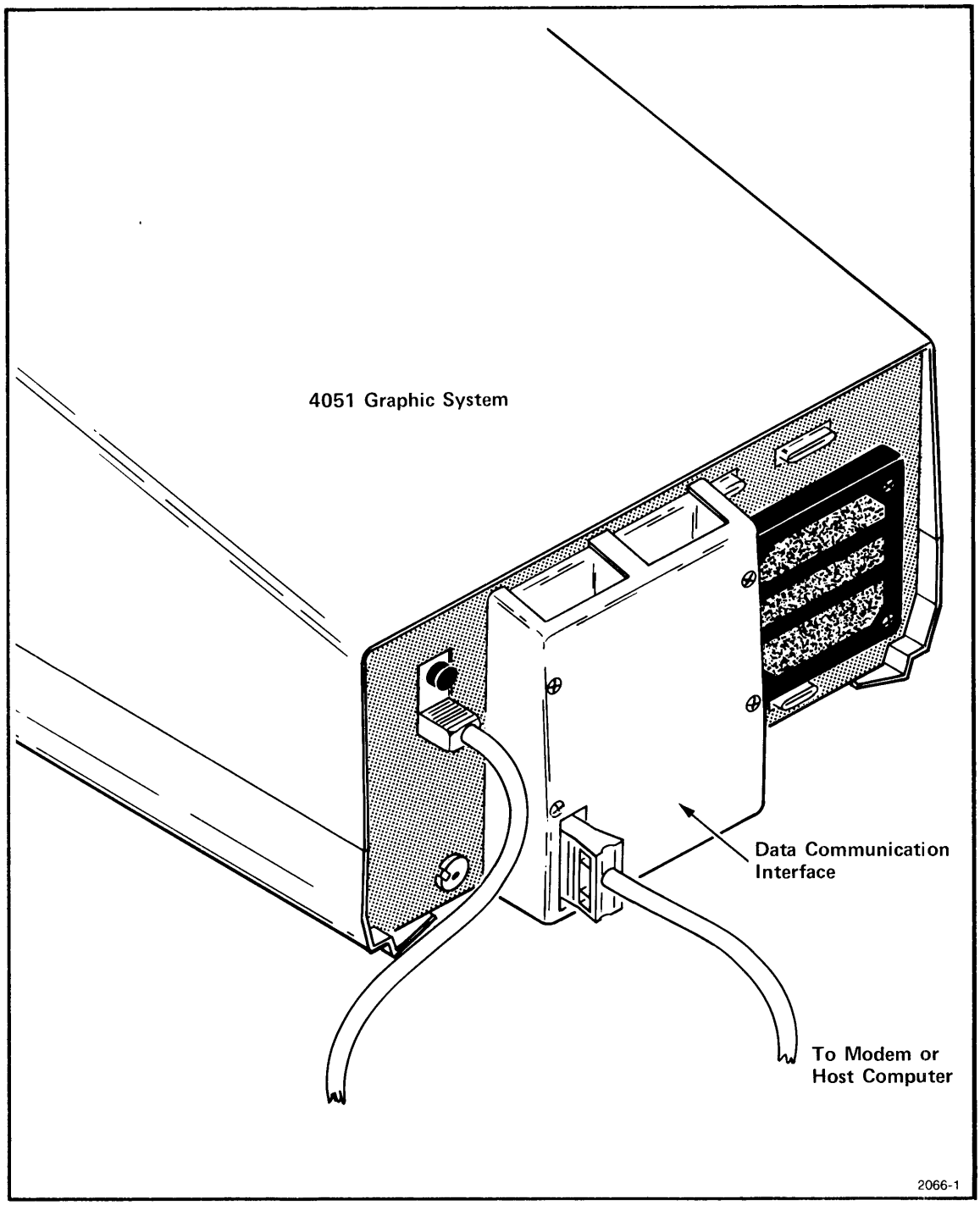

Fig. 1-1. 4051 with Data Communication Interface Installed.

Section 1

GENERAL DESCRIPTION

DOCUMENTATION NOTE

This manual is a standard accessory to the 4051 Data Communication Interface and documents all the operational characteristics of the interface.

WHAT IS THE 4051 DATA COMMUNICATION INTERFACE?

The TEKTRONIX 4051 Data Communications Interface (Fig. 1-1) is designed for use with 4050-Series Graphics Systems. When ordered with a 4051 Graphic System, the interface is described as a 4051 Option 1 Data Communication Interface. When ordered separately, the interface is referred to as a 021-0188-00 Data Communication Interface. In this manual, the terms "interface," "serial interface," and "port" are used to refer to the 4051 Data Communication Interface.

The interface mounts to the rear edge-board connector of the 4051 mainframe and replaces the standard firmware backpack.

The data communication interface gains direct access to the Graphic System Microprocessor via the J5 connector. This facility allows the interface to modify the system's operational appearance to the user. Also, as a consequence, the interface is able to directly tap the 4051 power supplies.

Being an interface, and specifically an RS-232 compatible interface, requires a bit-serial data path in compliance with the EIA standard RS-232.[1] The 25-pin connector on the rear port housing fulfills this requirement.

INTERFACE MODES OF OPERATION

The 4051 Data Communications Interface behaves as a data port between the 4051 and an RS-232 compatible device (modem, terminal, line printer, mass storage, etc.). Communication occurs over a cable which ties the interface connector at one end to an external peripheral device on the other.

Information travels back and forth in the cable as a series of pulses. Depending on the polarity of the pulse, the pulse may represent either a binary "0" or binary "1." A character is sent as 7 bits in a sequence; the possible combinations of 1's and 0's in this "bit-train" can specify any of the 128 ASCII[2] characters.

[1] **This standard is described in detail in Section 2.**

[2] **"ASCII" refers to a code (American Standard Code for Information Interchange) developed by the American Standards Association. See Section 2 for details.**

The interface acts as a doorway, allowing streams of characters to flow to and from the Graphic System. The rate of flow may approach 300 characters per second, as specified by the user.

Inside the Graphic System, there are four peripherals which have access to the data stream: the keyboard/joystick, the display, the magnetic tape unit, and semiconductor memory (RAM).

When enabled, the data communication port must operate in one of three modes. The mode is determined by which of the previously mentioned internal peripherals is an active talker or listener. These modes are: BASIC I/O mode, Terminal mode, and Tape Communication mode.

BASIC I/O MODE

If the 4051 end of the ASCII data link is driven and also received by the user-accessible system memory, BASIC I/O mode is active. Any of the seven BASIC statements dealing with ASCII character movement may be used: INPUT, PRINT, OLD, APPEND, SAVE, LIST, or TLIST.

An I/O address of 40 must be entered after the BASIC keyword to specify the data communications port rather than the internal magnetic tape, a GPIB peripheral, etc.

BASIC I/O, as with most BASIC keywords, may be executed directly from the keyboard or under program control.

TERMINAL MODE

In Terminal mode, the Graphic System becomes an interactive computer display terminal. It has the main characteristics of the TEKTRONIX 4012 terminal, in that three submodes are allowed: Alpha, Graph, and GIN (Graphic Input). During Terminal mode, the keyboard is a character transmitter for the interface port. The processor no longer interprets the keyboard entries as BASIC language statements. The storage display is the principle receptor for characters entering the port.

In Terminal mode, all system peripherals except for the keyboard/joystick and display are disabled.

ALPHA Submode

Incoming characters are displayed and stored on the screen as lines of text. The user may send all of the 128 ASCII characters directly from the 4051 keyboard.

GRAPH Submode

Incoming characters are decoded as screen locations. Subsequent locations, or "points" are linked together with lines (vectors), allowing pictures to be drawn on the screen. The keyboard may be used after one display presentation to prepare the system for the next.

GIN Submode

By a keyboard command, the user may cause a screen point address to be sent out the data communications port. The address location is indicated by a pointer which appears on the display. The pointer may be moved in four directions by keyboard commands. Alternately, the pointer may be manipulated by a joystick (specifically, the TEKTRONIX 4952).

The address sent by the user from the keyboard may be the address of the lower-left corner of the alpha cursor, or the current vector-tip.

TAPE COMMUNICATIONS MODE

In Tape Communications mode, ASCII characters pass through the interface and are either originated by or stored on the Graphic System internal magnetic tape. When the tape is receiving and storing ASCII strings arriving through the interface, the Tape Communications Data-Receive submode is active. When the tape is reading out through the interface, the Tape Communications-Data Send submode is active.

MEMORY REQUIREMENTS

When the Data Communications Interface is installed in a 4051, an additional 800 bytes of read/write memory is allocated for storing the Data Communication parameters. This occurs automatically when the system is powered up. When the interface is activated with a CALL "TERMIN" statement, a CALL "DTSEND" statement, or a CALL "DTRECV" statement, 1000 bytes of additional memory must be available for temporary buffer allocation. This memory is returned to the system as "free" space when control is returned to the BASIC program.

SUMMARY

The 4051 Data Communications Interface is an option to the 4051 Graphic System that allows the system to communicate over a standard RS-232 channel. The interface mounts to the J5 connector at the rear of the 4051 main chassis and draws all its power from the 4051.

The interface can operate in three modes. In BASIC I/O mode, the interface may be addressed with PRINT, INPUT, OLD, APPEND, SAVE, LIST, and TLIST, either directly from the keyboard or under program control. In Terminal mode, the Graphic System is made to appear as a TEKTRONIX 4012 Computer Display Terminal; the 4051's ability to understand BASIC is inhibited. In Tape Communications mode, data may be sent to and from the internal magnetic tape via the interface port.

NOTES

Section 2

DATA COMMUNICATION TERMS

INTRODUCTION

This section defines commonly used data communication ideas and terms, beginning with a historical perspective. Readers already familiar with the meaning of "baud," "duplex," "ASCII," etc. can turn to Section 3 without loss of continuity.

WHAT IS DATA COMMUNICATION?

The term data communication refers to conversation between machines using coded messages.

In this definition, a machine is an electrical network made of ON-OFF switches. The language of machines is called "binary," because there are only two elements: ON or OFF, corresponding to a switch being open or closed.

Data communication occurs when one machine talks to another, using messages coded in binary. The message path is called the "communication channel."

TERMINAL AND HOST COMPUTER

A computing system may contain many components interconnected by various communication channels. The component through which we gain access to the central computer is called a "terminal."

Computers which are programmed to support multiple terminals are called "hosts" in a "time-share" system. The host services all of the terminals in sequence. Each terminal user is able to make inputs to the computer, often using a typewriter-like keyboard.

Computer messages to the terminal are converted into a display of some kind; cathode-ray tubes, storage displays, and line printers are common examples of displays.

ON-LINE AND OFF-LINE

A terminal allows you to be in touch with a sometimes distant and usually expensive host computer. You can input a command from a keyboard, and usually see the host's response displayed within a few seconds. This is called "interactive" or "direct" communication.

Direct communication is ideal for interactive needs, but it is expensive. If an application requires sending large amounts of data to the host, it is advantageous to "buffer" the keyboard messages (e.g., store them on magnetic tape while disconnected from the host). While disconnected from the host, the terminal is "off-line." Later, the communication channel to the host can be reopened (terminal "on-line") and the tape quickly read to the computer.

A terminal display can use buffering to advantage too, although the display has an easier time keeping up with the computer than does a keyboard. If numerous pages of data are sent by the host, the terminal time-share bill can be reduced by receiving the data into intermediate, buffered storage like magnetic tape storage. Later, with the host "off-line," the data can be replayed and analyzed.

KINDS OF CHANNELS

Data communication occurs over a channel between two machines. Messages travelling over the channel are encoded as electrical signals.

For example, a telegraph wire either carries current or it doesn't, corresponding to the two states ON-OFF. The telegraph line can normally carry messages in only one direction at a time, because the type of signal output from each sender is the same: ON and OFF. If both ends choose to send at the same time, it is impossible to distinguish one sender's message from the other.

To get around this problem, a true two-way channel separates messages, so that information travelling in one direction does not interfere with information travelling in the other direction. This is usually done by assigning the ON and OFF states for each device to different frequencies. Two audible frequencies are assigned to the device on one end and two different frequencies are assigned to the device on the other end. The device which does this frequency conversion is called a "modulator." Each end also has a "demodulator" which converts the frequencies from the distant sender back into the ON-OFF machine language. In this way, data can travel in both directions over a regular telephone line at the same time.

FULL DUPLEX

The preceding paragraph describes a typical "full-duplex" data communication channel. A modulator and demodulator are packaged in one unit, a "modem" such as the Bell 103 series modem.

Although a full duplex channel allows two simultaneous talkers, such an occurrence is usually pure chaos. Even the most sophisticated host computer is not able to really talk and listen simultaneously. At best, the host buffers (temporarily stores) received data while it is talking, and then acts on the buffered information afterwards. This ability is called "type-ahead."

HALF DUPLEX

In a half-duplex channel such as a simple telegraph line, senders must take turns. This is usually a small sacrifice, because ordinary conversation occurs this way. In half duplex communication, a sender must tell the other party when he is finished talking and ready to listen, either by his silence or by means of a special closing message. Extra parts and delays are required to initiate the switch in line direction, called "turn-around."

The advantage acquired in half-duplex is speed. The entire band of frequencies of a modem-to-modem channel can be dedicated to a single direction; even with the drawbacks of turn-around delay, half-duplex operation allows an increase in data rate over full-duplex.

HALF DUPLEX WITH REVERSE CHANNEL

Some modems, (e.g., Bell 202C) provide a reverse channel option. This amounts to a compromise between full-duplex, with simultaneous two-way data flow, and half-duplex, where data flow is restricted to one direction at a time.

The reverse channel is a low-data rate control channel which is directed opposite the principal half-duplex data path. The reverse channel can be used by the terminal to tell the host to stop transmitting data (a "break" function, in response to a keyboard BREAK key or a display screen full condition). The host can use the reverse channel to control line turn-around, eliminating the use of special messages to accomplish this. Because of the low-data rate of the reverse channel, it is not useful for data transmission.

Some host systems will not break a transmission without receiving a special character from the terminal (e.g., a PDP-11 computer requires an ASCII Control Character ETX). The host might require a further message from the terminal before it resumes sending data, depending on the system. A full-duplex channel is necessary for this kind of "break message."

BITS AND ASCII CODE

Information flowing over a data communication channel is in the form of coded messages, where the code has only two elements: ON and OFF. A string of these elements ("bits"), are arranged in a particular sequence to represent a message.

Bits are elements of data communication and of machine language as well. The two kinds of bits (ON-OFF) are usually called "1" and "0" in machine language. "MARK" and "SPACE" are also bit names sometimes encountered.

Bits are usually sent single-file over a channel. This is called a "bit-serial" transmission. A sequence of bits has a particular meaning, depending on the code used. One code in common use is that developed by the American Standards Association, known as "ASCII." In ASCII, seven bits represent a character, which may be alphabetic, numeric, a special symbol or a control message not usually displayed on a terminal.

The ASCII code chart (Table 2-1) shows how a sequence of bits, represented as b_7 b_6 b_5 b_4 b_3 b_2 b_1, stand for a particular character. Control characters (those with $b_6 = b_7 = 0$) are represented with abbreviations, and occupy the first two columns of the chart.

Standards have been developed to define the meanings of the control characters[1]. Carriage Return (CR) is a commonly-used separator between data items. Back Space (BS), Horizontal Tab (HT), Vertical Tab (VT), and Line Feed (LF) have formatting functions implicit in their names. Section 6 discusses the effects control characters have on 4051 communications.

SYNCHRONOUS AND ASYNCHRONOUS MODES

One measure of data rate is the number of ASCII characters transferred per second. Characters travel as 7-bit strings. If characters were packed together as closely as possible, it would be possible to multiply the number of characters per second by 7, and obtain the number of bits per second (bps).

Such efficient packing occurs only when the host computer has tight control over the communication channel, to the point of being able to tell the receiver when to look at a particular data bit. This situation occurs in synchronous communications and is not supported by the 4051 Data Communication Interface.

Synchronous comunications have the advantage of efficiency and therefore speed. The disadvantages include the need to transmit a clock signal from the host, in a supplemental channel parallel to that used by data; also, the terminal receiver assumes the burden of counting data bits, to tell when one character ends and the next begins.

Asynchronous communications eliminates the need for a host clock to be sent to the terminal. Instead, the terminal provides its own timing. Both host and terminal clocks are set to run at approximately the same rate, but they are not synchronized.

The job of synchronizing the receiver's clock to the sender's is performed by adding a "start bit" before each character. The start bit warns the receiver to prepare for data, and gives it a reference for clock synchronization. Also, one or two "stop bits" are added to the end of the character, allowing the receiver time to recover before the next character arrives.

Characters are less efficiently packed in asynchronous communications than in synchronous. Extra bits (start and stop) bracket each character. The data rate for asynchronous transmission is determined by figuring the total bits per character, including start and stop bits, and multiplying by the number of characters per second.

[1] **USAS x3.4-1968 and ANSI x3.28-1971.**

Table 2-1
ASCII CODE CHART

BITS B4 B3 B2 B1	B7 B6 B5 = Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
	CONTROL		HIGH X & Y GRAPHIC INPUT		LOW X		LOW Y	
Ø Ø Ø Ø	NUL 0	DLE 16	SP 32	0 48	@ 64	P 80	\ 96	p 112
Ø Ø Ø 1	SOH 1	DC1 17	! 33	1 49	A 65	Q 81	a 97	q 113
Ø Ø 1 Ø	STX 2	DC2 18	" 34	2 50	B 66	R 82	b 98	r 114
Ø Ø 1 1	ETX 3	DC3 19	# 35	3 51	C 67	S 83	c 99	s 115
Ø 1 Ø Ø	EOT 4	DC4 20	$ 36	4 52	D 68	T 84	d 100	t 116
Ø 1 Ø 1	ENQ 5	NAK 21	% 37	5 53	E 69	U 85	e 101	u 117
Ø 1 1 Ø	ACK 6	SYN 22	& 38	6 54	F 70	V 86	f 102	v 118
Ø 1 1 1	BEL 7	ETB 23	' 39	7 55	G 71	W 87	g 103	w 119
1 Ø Ø Ø	BS 8	CAN 24	(40	8 56	H 72	X 88	h 104	x 120
1 Ø Ø 1	HT 9	EM 25	) 41	9 57	I 73	Y 89	i 105	y 121
1 Ø 1 Ø	LF 10	SUB 26	* 42	: 58	J 74	Z 90	j 106	z 122
1 Ø 1 1	VT 11	ESC 27	+ 43	; 59	K 75	[91	k 107	{ 123
1 1 Ø Ø	FF 12	FS 28	, 44	< 60	L 76	\ 92	l 108	¦ 124
1 1 Ø 1	CR 13	GS 29	- 45	= 61	M 77	] 93	m 109	} 125
1 1 1 Ø	SO 14	RS 30	. 46	> 62	N 78	^ 94	n 110	~ 126
1 1 1 1	SI 15	US 31	/ 47	? 63	O 79	_ 95	o 111	RUBOUT (DEL) 127

PARITY

An eighth bit, called a parity bit, is sometimes used in each character to detect errors in transmission between the sender and the receiver. There are two methods used to check parity; the even method and the odd method. When the even method is used, the sender counts the number of 1 bits in each 7-bit ASCII character before the character is transmitted. If the total number of 1 bits is even (0, 2, 4, or 6), the eighth bit is made equal to a binary 0 to keep the total number even. If the 7-bit total is odd (1, 3, 5, or 7), the eighth bit is set to a binary 1 to make the total even. The opposite is true when odd parity is used. The sender makes the eighth bit in each character even or odd in order to keep the total number of 1 bits odd.

The receiver performs the same addition. If no errors in transmission occur, the receiver should calculate the same value of parity.

If an error occurs that causes the number of 1's to switch from odd to even (or vice versa), the calculated parity will differ from received parity, and the error can be detected.

Terminals and hosts can be set for even or odd parity, meaning the parity bit is a 1 for an even or odd total of 1's, respectively.

The host and many terminals are able to respond to parity errors in various ways; the errors can be ignored, they can be counted, or the data transfer can be aborted.

DATA RATE (BAUD)

The Data Rate or "Baud Rate" of a communication channel refers to the bit transfer rate it accommodates. All components of the channel must operate at the same data rate, including the terminal, the host, and the modem for each.

Baud is a measure of bits per second on a data communication channel[2]. Baud can be related to characters per second by dividing Baud by the number of bits per character. In many systems, a character is encoded as 1 Start bit + 7 data bits +1 parity +2 stop bits = 11 bits/character. Therefore 110 Baud = 10 characters/second.

The common baud rates are 110, 150, 300, 600, 1200, 2400, 4800, and 9600. The higher rates are more common on a half-duplex channel. The 4052 and 4054 support the 4800 and 9600 baud rates, but won't receive continuously at 9600 baud without overrunning the system.

ECHO

Terminal users often require a copy of their transmission to the host, and implement an "echo" of the keyboard data back to the display.

[2]**Technically, Baud is a measure of a signal-events per second on the channel.**

The echo can occur at the terminal, at the modem, or at the host (in the case of a full-duplex channel). The latter situation, termed a "computer echo," is the most ideal, allowing software in the computer (its program) to selectively echo only the information necessary to the user.

"Local echo," an echo occurring at the terminal or modem, is usually done in off-line or half-duplex situations where a computer echo is not available.

WHAT AN RS-232 CHANNEL IS

All RS-232 channels must comply with a standard developed by the Electronic Industries association. The channel assumes that the "data terminal equipment" is at one end and the "data communications equipment" (i.e., modem) at the other end. By this restriction, the host computer is considered to be a "terminal."

The RS-232 specifies that the communication channel must be a group of 25 electrical wires in a cable, each with a specific name and purpose. The electrical characteristics of the transmitters and receivers at each end of the cable are also specified. Each wire can convey one of two voltages from transmitter to receiver: positive or negative. The allowed voltages are +3 V to +25 V for a binary "ON" condition and −3 V to −25 V for a binary "OFF" condition (see Table 2-2).

Table 2-2
RS-232 SIGNAL LEVELS

Binary Value	Voltage Range
ON, 0, SPACE	+3 to +25 V
OFF, 1, MARK	−3 to −25 V

The standard then defines the dedicated use and direction of each of the 25 wires in a cable.

In practical systems, only a few wires are used. Most asynchronous systems use a standard set, described in Table 2-3. For half-duplex operation, the same lines are used; the line "turn-around" mechanism is housed within the terminal. If a reverse interrupt channel is implemented, the supplementary lines described in Table 2-4 are usually required.

Table 2-3
COMMONLY-USED RS-232 SIGNALS

Signal Name	Mnemonic	Pin	Use
Protective Ground	GND	1	A connection to the terminals metal chassis.
Transmitted Data	TDATA	2	Outgoing data path from the terminals point of view.
Received Data	RDATA	3	Incoming data path from the terminals point of view.
Request to Send	RTS	4	Activated by the terminal to tell the modem to prepare to receive data from the terminal.
Clear to Send	CTS	5	Activated by the modem to tell the terminal that it is ready to receive data from the terminal.
Signal Ground	SGND	7	Return path for all other signals on the bus.
Received Line Signal Detector	RLSD	8	Activated by the modem to tell the terminal that the modem has made contact with the computer and can sense the carrier.
Data Terminal Ready	DTR	20	Activated by the terminal to tell the modem that the terminal is operational.

Table 2-4
COMMONLY-USED SUPERVISORY (REVERSE CHANNEL) RS-232 SIGNALS

Signal Name	Mnemonic	Pin	Use
Secondary Received Line Signal Detect (Supervisory Transmit)	SRX	12	A courtesy signal from the terminal telling the modem (and the computer) that it's OK to transmit data. The loss of this signal tells the computer that the terminal wants to break the data transmission.
Secondary Request to Send	STX	19	A courtesy signal from the modem (and the computer) telling the terminal that it's OK to transmit data. The loss of this signal tells the terminal that the computer wants to break the data transmission.

NOTE: In the first revision of the Standard, RS-232-A, the supervisory transmit signal was assigned to pin 11; pin 19 was not used.

WHAT AN RS-232 CHANNEL ISN'T

Two devices, each compatible with the same version of the RS-232 standard, may still be unable to communicate. This can happen because timing and format variables are not covered by the standard, and they can be different for each "compatible" device.

Fortunately, most RS-232 devices comply with the signal definitions and asynchronous data formats previously described. Most devices transmit ASCII code. Many have agreement as to the use of certain control characters (CR, LF, for example).

Because compliance with the RS-232 standard does not guarantee compatibility between two devices, it is necessary to make a point-by-point comparison of their specifications before ever connecting them. The specifications of the 4051 Data Communication Interface are described in Section 3.

NOTES

Section 3

HARDWARE SPECIFICATIONS

GENERAL

The 4051 Data Communications Interface mounts on the rear of the 4051 in place of the standard backpack fixture, and accepts a male connector from a RS-232 compatible device. All standard backpack functions are implemented in the interface; both accept extended function ROM Packs and ROM Pack-like interfaces.

The Data Communication Interface allows communication between the 4051 and an external device which conforms to the RS-232 standard (e.g., teletypes, paper tapes, line printers, terminals or other terminal-like equipment). These devices typically provide the required cable and male connector which attach to the interface connector. The 4051 appears like a modem to the external device; i.e., it has a female connector.

The 4051 can be used as an "intelligent" terminal (a terminal with data processing power) and communicate with a host computer. In order to "drive" a modem, the 4051 must appear to be a terminal to the host; this requires a special cable and male connector. Such a cable is provided as a standard accessory.

PHYSICAL AND ENVIRONMENTAL SPECIFICATIONS

Weight: 1.125 pounds, 0.5103 kilogram

Temperature: +10° C to +40° C operating; −40° C to +60° C non-operating.

Humidity: F 95% non-condensing.

ELECTRICAL SPECIFICATIONS

Power Consumption: +5 Vdc at 250 mA; +12 Vdc at 75 mA; −12 Vdc at 25 mA.

Power dissipation: 2.45 W.

Connectors. The interface has four connectors:

1. A 50-contact edge-board receptor (J5), which connects to the 4051 through the rear slot marked J5. TTL levels and +12 V, −12 V, +5 V, 0 V.
2. Two 44-contact edge-board receptors designed to accommodate ROM Packs or ROM Pack-like interfaces. These connectors are designated J91 and J92; they are electrically identical. TTL levels are +12 V, −12 V, +5 V, 0 V.

3. A 25-contact RS-232 type female connector (J93); identical to the kind used on most modem equipment. RS-232 levels: ON , +3 to +12 V; OFF, −3 to −12 V; and 0 V reference.

RS-232 SPECIFICATIONS

Compatible to Standards: RS-232-A, RS-232-B, and RS-232-C.

Data Rates: 110, 150, 300, 600, 1200, 2400 Baud.

Code: 7 bit ASCII (128 characters; see Table 2-1).

Start Bit: Yes.

Data Bits: 7 or 8[1].

Parity: Odd, even, or absent.

Stop Bits: 1 or 2.

Error Detection: Programmable; error in parity or framing[2] has no effect, causes a halt in communication, or is counted.

Local Echo: Programmable.

Channel Options: Full Duplex, Half Duplex-Normal, Half Duplex with Reverse Channel.

FULL DUPLEX

Compatible with Bell 103-type modem equipment. The break function is available with programmable options. This means that a break condition, caused by either pressing the BREAK key on the GS keyboard, or by a display screenfull condition, can have the following effects:

1. A break signal can be transmitted as a pulse on the RS-232 line Transmitted Data, 0—350 ms in duration.[3]
2. From zero to ten characters (BKSTG 1) can be sent to the host to signal a break condition.
3. Another character string of up to ten characters called (BKSTG 2), can be sent to the host when the user either pages the display or returns the cursor to the home position, following a page-full condition.

[1]If 8 data bits are selected, the most significant bit (bit 8) is transmitted as a zero and ignored when received.

[2]A framing error is caused by the absence of the first stop bit, which in turn is the result of a synchronization or transmitter problem, or else a BREAK condition.

[3]Two 350 ms pulses separated by 1 second can be enabled for use on certain Honeywell computers.

4. A hard copy can be automatically made with a compatible unit (e.g., TEKTRONIX 4631 or 4610); the screen is then automatically paged. This is called the Hard Copy and Auto Page feature.

Certain combinations of these four responses to the break condition are user-programmable. These combinations are listed in Section 8 under the topic CALL "BREAK."

HALF DUPLEX

The break function is available here as it is in full duplex communication, but without the BKSTG feature.

Turn-around delays required in Half Duplex with Reverse Channel (also called Supervisory, referring to the computer's complete control of line direction) are as follows:

1. A delay from the time the computer requests the line until the time it may be acquired by the terminal (DELAY1). Default value: 200 ms.
2. A minimum time that the terminal must hold onto the line, once it has been relinquished by the host (DELAY2). Default value: 1 second.

Both delays can be programmed from 0 to 65,535 ms.

A blanking feature is also available, as described in the following:

Half Duplex with Blanking: The blanking option permits the user to specify three ASCII characters, which, when received from the host via half-duplex communications, have the following effect:

1. Normally before the computer message, the first character received enables the display or tape to receive data. This character is called the unblanking character.
2. A second character, generally following a line sent from the host and often identical to the turn-around character in Half Duplex Normal mode, turns off the interface receiver. It remains off until an unblanking character is received.
3. A third character at the end of Computer communication has the same effect on the interface as the blanking character.

The second character can be omitted for faster operation or where a terminator is needed for proper formatting.

HALF DUPLEX NORMAL

Compatible with Bell 202C-type modem equipment. The 4051 defaults to a receiver state. The transmit state is entered (i.e., signal Request to Send is raised) and a transmit data function is executed. A programmable character follows the data (EOL character) which causes the 4051 to return to receive mode.

The break function is inactive; transmissions from the host computer cannot be interrupted by the 4051.

A blanking option is available, as described in Section 8 under the topic CALL "BLKCHR."

HALF DUPLEX WITH REVERSE CHANNEL

Compatible with Bell 202C-type modem equipment. The 4051 transmits and receives as directed by the host computer.

The break function is active, with the break signal being a lowering of the reverse channel. This occurs in response to the BREAK key, or a pagefull condition as selected by the user option BREAK.

A blanking option is available, as described under the topic CALL "BLKCHR" in Section 8.

KNOWN EXCEPTIONS TO 4012 EMULATION

1. There isn't an independent data rate for transmit and receive as in the 4012.

2. The TTY LOCK key allows the following keycodes to be transmitted: ` | ~ {.

3. The following keys are not available on the 4051 keyboard as they are on the 4012 keyboard.

   CTRL SHIFT P for NULL
   CTRL SHIFT K for ESC
   CTRL SHIFT L for FS
   CTRL SHIFT M for GS
   CTRL SHIFT N for US

   The keycodes are available in the following alternative manner.

   CTRL SHIFT P as CTRL @
   CTRL SHIFT K as CTRL [
   CTRL SHIFT L as CTRL /
   CTRL SHIFT M as CTRL]
   CTRL SHIFT N as CTRL (space)
   CTRL SHIFT O as CTRL RUBOUT

4. The following keys do not respond the same as a 4012 when the key is pressed in conjunction with the CTRL key:

Key	4051	4012
1!	!	1
2"	"	2
3#	#	3
4$	$	4
5%	%	5
6&	&	6
7'	'	7
8(	(	8
9)	)	9
:*	*	:
−=	=	−
;+	+	;
,<	<	,
.>	>	.
/?	?	/
RUBOUT_	_	RUBOUT

5. Using the user-definable keys to move the pointer for Graphic Input operations results in a digital movement of the pointer which is different than a separate and independent analog joystick movement.

STANDARD ACCESSORIES

Quantity	Description	Part Number
1	Operators Manual	070-2066-01
5	Communications Overlay	334-2788-00
1	Self Test Adapter	013-0173-01
1	Interconnect Cable	012-0689-00

FIELD INSTALLATION

If a 4051 and the 4051 Data Communication Interface are ordered at the same time from the factory, the 4051 will be delivered with the Data Communication Interface installed. If this is the case, read the NOTE below then skip to the next topic.

If a 4051 Data Communication Interface is ordered separately after you receive your 4051, then follow the installation guidelines below starting with step 1.

1. Flip the 4051 power switch to the OFF position.

2. Use a phillips-type screwdriver to remove the four screws which hold the firmware backpack to the rear panel of the 4051 main chassis. (See Fig. 3-1.)

3. Gently pull the backpack away from the main chassis until the J5 connectors disengage; set the firmware backpack aside.

4. Remove the packaging material from the 4051 Data Communication Interface and check the position of the two-pin harmonica connector as shown in Fig. 3-2. If your data communication application conforms to the RS-232-A standard, the two-pin harmonica connector should be positioned over pin A and the center pin. If your data communication application conforms to the RS-232-C standard, then the two-pin harmonica connector should be positioned over pin C and the center pin.

NOTE

Data Communication Interfaces installed at the factory are strapped to conform to the RS-232-C standard. If your application involves the RS-232-A standard, then it will be necessary to remove the interface, change the harmonica connector to the "A" configuration, then re-install the interface.

5. Use the same mounting screws to install the Data Communication Interface to the rear panel of the 4051. Note that the top screws are shorter than the bottom screws (see Fig. 3-1).

6. When the interface is installed, turn the power switch ON and follow the "CMTEST" instructions as outlined in Section 8. If the results of the self-test are satisfactory, the interface is ready for use.

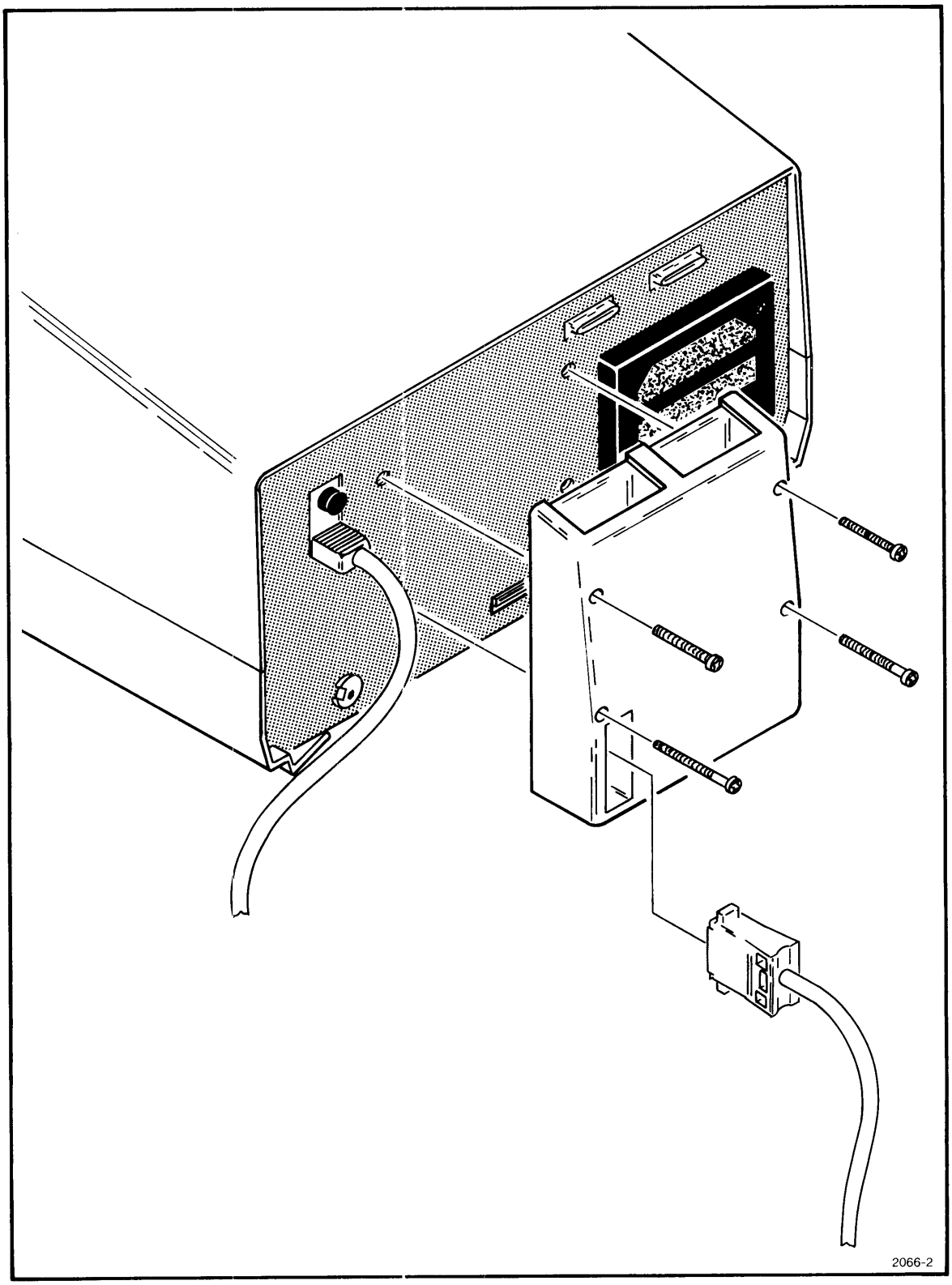

Fig. 3-1. Installing the Data Communication Interface on the Rear Panel of the 4051.

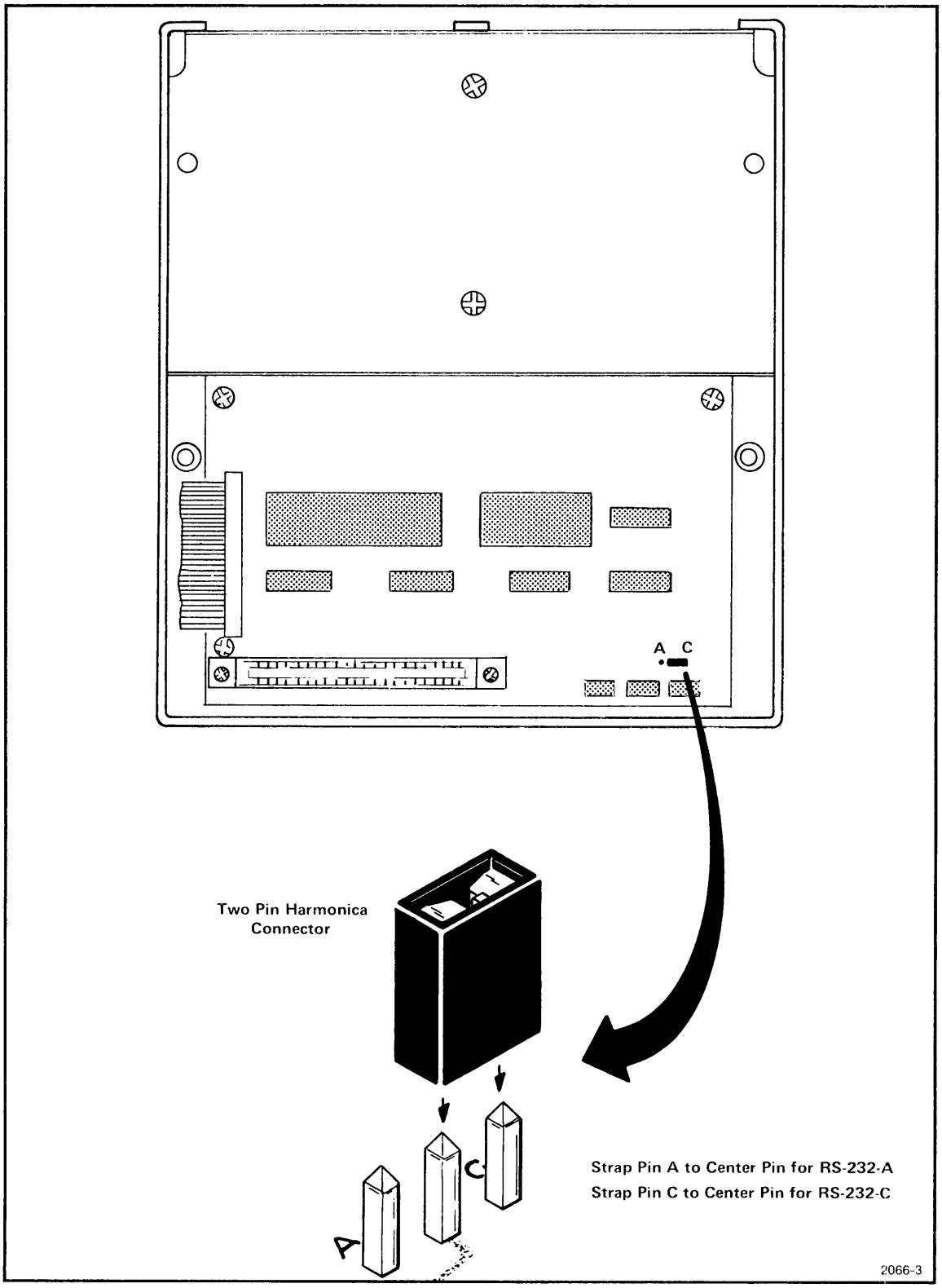

Fig. 3-2. RS-232 Strap Option. Strap Pin A to Center Pin for RS-232-A Configuration. Strap Pin C to Center Pin for RS-232-C Configuration.

CONNECTING THE INTERFACE TO A TERMINAL

If you are connecting the Data Communication Interface directly to terminal-type equipment (a line printer, for example), the terminal equipment must provide its own cable and male connector. Check to make sure that the pin arrangements on the connectors are compatible. Due to the general nature of the RS-232 standard, some RS-232 connectors may not be pin-to-pin compatible and it may be necessary to construct a special adapter plug or re-arrange the wiring scheme inside the male connector to obtain the proper match.

NOTE

If the 4051 is turned on with the Data Communication Interface installed, and a communications I/O operation is executed, and the RS-232 connector (J93) is not connected to an active modem or terminal-type piece of equipment, then the front panel BUSY light and I/O light alternately flash back and forth. The flashing lights indicate that the 4051 is unable to establish a proper hardware data communication link with the device connected to the J93 connector. The lights stop flashing as soon as a communication link is established.

CONNECTING THE INTERFACE TO A MODEM

If you are connecting the Option 1 interface to a modem, it will be necessary to use the special Option 1 interconnect cable between the 4051 Option 1 J93 connector and the modem RS-232 connector. This special interconnect cable reverses the wiring on the 4051 RS-232 connector so that the 4051 appears to be a terminal to the modem and the host computer. The special interconnect cable comes as a standard accessory to the Option 1 Interface and is part numbered 012-0689-00.

The 4051 Option 1 is designed to be used with Bell 103-compatible modems for full duplex operation and Bell 202C compatible modems for half duplex operation. Most other modems are compatible with one of these and will support a communication link with the 4051 and a host computer.

If communications are to be half-duplex supervisory (sometimes called half duplex with reverse channel), then it must be determined whether the half-duplex modem complies to version RS-232-A or RS-232-C. The "A" version is older and most half-duplex modems now comply to the newer RS-232-C version. Follow the instructions in step 4 of the installation procedure just described and make sure that the 4051 conforms to the modem standard.

MAKING CONTACT WITH A HOST COMPUTER OVER TELEPHONE LINES

General Procedure

If the 4051 is to be used as a terminal to talk to a host computer over telephone lines, the following guidelines are normally followed. First, the necessary hardware connections are made. The 4051 is connected to the modem with the special interconnect cable provided, and the modem is connected to the telephone service. Next, the 4051 is turned on, and a BASIC program is created in memory to set the data communications parameters in the 4051. (Examples of such programs are found at the end of this section.) The BASIC program is normally saved on tape in file 1. Pressing AUTO LOAD then loads the BASIC program back into memory and the program is executed automatically. The program sets the 4051 data communications parameters to match the timeshare telephone line parameters.

Normally, the last statement in the BASIC program is a CALL "TERMIN" statement. This statement switches the 4051 into Terminal mode. Since the computer hasn't been dialed yet, the 4051 I/O light and BUSY light alternately flash back and forth. At this point, the computer telephone number is dialed. When the computer answers with a continuous tone, the modem button is pushed, and the 4051 makes contact with the computer. Contact is verified when the 4051 I/O light and BUSY light stop flashing. At this point, it is OK for the 4051 keyboard operator to log on to the computer system.

Step by Step Procedure

1. Install the Option 1 Backpack on your 4051 as outlined in the Field Installation Instructions.

2. Go through CMTEST procedure as outlined in Section 8 to verify the operation of the Option 1 interface.

3. Connect the modem to Option 1 with the special interconnect cable provided.

4. Turn the 4051 ON.

5. Turn the modem ON.

6. If applicable, set the modem switches to conform to the protocol you select (i.e., full duplex, half duplex, or half duplex with reverse channel).

7. Set the 4051 protocol to match the line protocol with a CALL "MARGIN" statement in BASIC. (See CALL "MARGIN" in Section 8.)

8. Set 4051 baud rate to match the line baud rate with a CALL "RATE" statement in BASIC. (See CALL "RATE" in Section 8.)

9. Enter CALL "TERMIN" from the 4051 keyboard and press RETURN. The I/O and BUSY lights should alternately flash back and forth.

10. Pick up the modem receiver and dial the computer. (Get the number from your timeshare instruction sheet.)

11. The computer should answer with a continuous high pitched tone. Press the button on your modem, if the modem is the direct coupled DATASET type, or press the phone receiver into the cups, if the modem is the acoustic coupled type.

12. The 4051 I/O and BUSY lights should stop flashing. This means that the 4051 has made contact with the computer.

13. Attempt to log on. Any 4051 keyboard activity should cause the computer to send a log-on prompt question to you.

14. If unrecognizable characters appear on the 4051 screen, it means the 4051 baud rate does not match the line baud rate. Check the timeshare instruction sheet for the baud rate of the telephone line you selected. Press user-definable key number 14 (labeled PARAMETER LIST on the overlay) to list the Data Communication parameters on the 4051 screen. Compare the first parameter in the RATE environmental routine to see if the parameter matches the line baud rate. If it doesn't, press user-definable key number 5 to return to BASIC, execute a CALL "RATE" statement to match the 4051 baud rate to the line baud rate, then execute a CALL "TERMIN" statement again.

15. If the computer is still on the line, step 14 should correct the unrecognizable character problem. Proceed with the log on procedure as outlined in your timeshare instruction sheet. If the computer appears to be gone, repeat steps 12 through 13. In most systems, the log on procedure must be completed in a short time period, or the computer will hang up.

16. After logging on, refer to the timeshare instruction manual for information on the monitor command language. Other timeshare manuals should also be available on high level computer languages like BASIC and FORTRAN.

17. If at any time you wish to change the 4051 Options 1 environmental parameters to smooth out the interchange between you and the computer, press user-definable key 5 to return to 4051 BASIC. Change a parameter with the correct CALL statement, execute a CALL "CMSET" statement, then a CALL "TERMIN" statement. This procedure should return you to TERMINAL status. If for any reason you have lost contact with the computer, it will be necessary to log on again.

SETTING UP FOR TAPE TRANSFERS

General Procedure

After you have made contact with the host computer and logged on, you may want to transfer data files from the host computer to the 4051 internal tape and vice versa. Before you go any further, scan the text in Section 7 which explains Data Send and Data Receive mode. Get a good idea of how it works before going on.

In most cases, follow the guidelines below to get Data Receive mode working properly.

1. First determine the file name of the file you wish to transfer to tape. For illustrative purposes, assume the file name is TRACY.

2. Bring the file into local storage. A typical monitor command for doing this is GET, TRACY (RETURN). (Consult your timeshare manual to find out for sure.)

3. Press user-definable key 11 (marked PRINTED CONTROL CHARACTERS on the 4051 Data Communications Overlay). This causes all the control characters received from the computer to be printed on the 4051 display along with the normal ASCII character set (except for CR which is executed as a carriage return/linefeed).

4. Transfer the file to the 4051 display screen. A common monitor command for this action might be XFER,TRACY.

5. The file contents, along with all the embedded control characters should be displayed on the 4051 screen. Assume for illustrative purposes that the file TRACY contains two graphic subroutines in FORTRAN and appears on the 4051 screen as follows:

```
GET,TRACY
XFER,TRACY
J
J@@.75)
J@@          SUBROUTINE TRIANG(IX,IY)
J@@          CALL MOVED(IX,IY)
J@@          CALL DRAW(200,0)
J@@          CALL DRAW(0,200)
J@@          CALL DRAW(-200,-200)
J@@          RETURN
J@@          END
J@@          SUBROUTINE BOX(IX,IY)
J@@          CALL MOVED (IX,IY)
J@@          CALL DRAW(200,0)
J@@          CALL DRAW(0,200)
J@@          CALL DRAW(-200,0)
J@@          CALL DRAW(0,-200)
J@@          RETURN
J@@          END
J@@>
```

6. Look for a common character (or characters) that precede each line of text; and look for a common character (or characters) that follow each line of text. Also look for a unique character that follows the entire data file. In this case, each program line starts with two NULL characters ("@@"). At the end of each line, the computer sends carriage return/line feed. The 4051 executes the CR as a CR/LF, then prints the line feed character as J. Since the computer sends the prompt character ">" after the file is transferred, this character can serve as the ending character for the data receive operation.

7. The next step is to set the RSTRING parameters to these opening, closing, and ending characters. It can be done manually from the 4051 keyboard by executing a CALL "RSTRING" statement in immediate execute mode, or the CALL "RSTRING" statement can be made part of the data communications BASIC program and executed when the data communications parameters are loaded from tape and set under program control. Here is the appropriate RSTRING statement for this example:

   160 CALL "RSTRING","@@","J",">"

8. With the RSTRING parameters set as specified above, the file can now be transferred to the 4051 internal tape. First, get back to Terminal mode by executing a CALL "TERMIN" statement in BASIC.

9. While in Terminal mode, press user-definable key 13 (marked FIND FILE on the overlay), enter the 4051 tape file number of the file you wish to store the data in, then press RETURN. The 4051 should locate the tape file and open the file for access.

10. Now enter the computer command XFER,TRACY to tell the computer to send the data file named TRACY. DON'T PRESS RETURN. Instead, press the Data Receive key (user-definable key 3) on the 4051 keyboard. Since the SNGSTG parameter is set to CR by default, the first action the 4051 takes is to send CR to the computer. This has the same effect as pressing RETURN on the 4051 keyboard and tells the computer to execute the command XFER,TRACY. The computer responds by sending the contents of the data file to the 4051. Because the DATA RECEIVE key was pressed, the 4051 is now in Data Receive submode, so the 4051 stores the incoming information on the internal tape.

11. When the computer is finished, the computer sends the prompt character ">" and the Data Receive operation is terminated. The tape file is automatically closed and control is returned to 4051 in Terminal mode.

At this point, several options are available. If an EDITOR ROM Pack is installed on the 4051, the FORTRAN program can be loaded into memory, edited, placed back on tape, then sent back to the computer. Or, the FORTRAN program could be processed by an editor written in 4051 BASIC. Or, the FORTRAN subroutines can be saved on tape for later insertion into a larger FORTRAN program.

A FEW WORDS ABOUT HALF DUPLEX WITH BLANKING

What is Half Duplex with Blanking?

Blanking is a feature which allows a host computer to turn the 4051 data communications receiver ON and OFF during half duplex operations. The computer does this by sending a special ASCII character to turn the 4051 data communications receiver ON just before a message is transmitted. After the message is transmitted, the computer sends a different ASCII character to the 4051 to turn the data communications receiver OFF.

Why is Blanking Sometimes Necessary During Half Duplex Operations?

When line turn-around periods occur in half duplex operations, spurious noise can be generated on the RS-232 line. If the 4051 data communications receiver is ON during this time, this noise may be picked up and interpreted as ASCII characters. The blanking feature in the data communications interface makes sure that the 4051 data communications receiver is "turned off" during these periods of communications inactivity, and ensures that the 4051 only receives valid information over the RS-232 line.

Do I Need to Set Up the Blanking Feature Before I Talk to a Host Computer in Half-Duplex?

Normally, the answer is no. Most timeshare environments today don't support the half-duplex blanking feature. And most modem manufacturers today have conquered and eliminated the half duplex line turn-around noise problem; this makes the blanking feature virtually obsolete.

Why Then is the Blanking Feature Supported in the 4051?

The blanking feature is supported in the 4051 to make the 4051 compatible with older type modems and timeshare environments which require blanking.

How do I find out if my Timeshare Service Supports Half-Duplex with Blanking?

Ask your timeshare service. (There should be a "service" phone number that you can call to find out.) If your timeshare service does support half duplex with blanking, ask which unblanking and blanking characters are used. You'll need to know this information when you set the CALL "BLKCHR" parameters. Typically, the start of text character is the ASCII control character SOH or STX and the end of text character is ETX. The end of transmission character is normally EOT, if one is used by the computer.

HALF DUPLEX WITH BLANKING

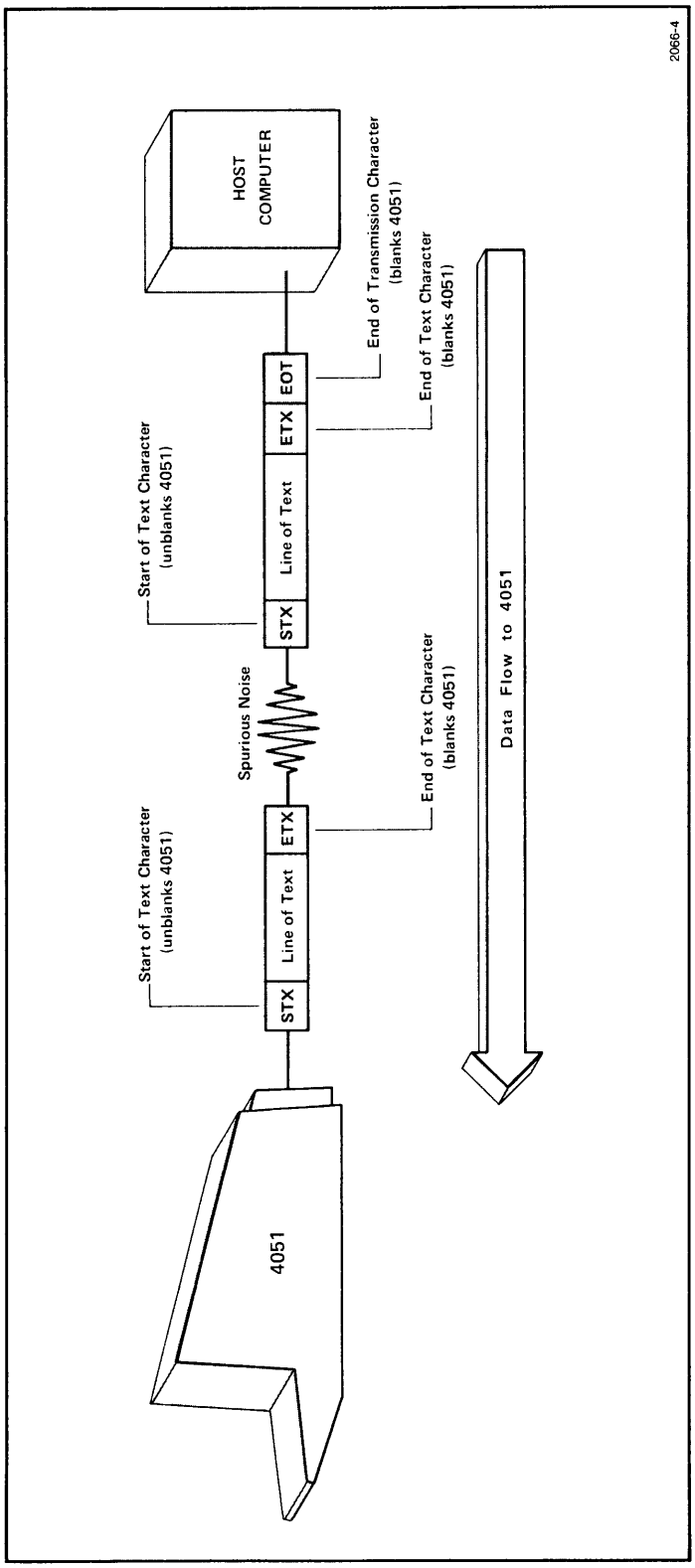

Fig. 3-3. 4051 Option 1 Half-Duplex with Blanking.

How does Blanking Work so I know for sure what's Happening?

Fig. 3-3 illustrates what half duplex with blanking is all about. First, the blanking feature only works with transmissions from the computer to the 4051 in half duplex. This applies to both Terminal mode and Data Receive tape operations. If blanking is specified with the parameter BLANKE=1, then entering Terminal mode or Data Receive mode turns the 4051 data communications receiver OFF. To start the 4051 receiving, the computer must send the specified start of text character over the RS-232 channel. All characters that precede the start of text character are received by the 4051, but the 4051 does not retain them. After the start of text character is received, the 4051 data communications receiver is "turned on" and all characters received after that are either sent to the screen (Terminal mode) or to the internal tape (Data Receive mode).

When the computer has finished sending a line of text or a logical record, the computer sends an end of text character (normally ETX). This turns the 4051 data communications receiver OFF. The receiver then stays OFF until another STX character turns it on, usually just before the computer transmits another line of text.

At the end of a computer transmission, the computer has the option to send an end of text character, an end of transmission character, or both. The result is the same in either case; the 4051 data communications receiver is turned OFF (blanked).

How do I specify the Blanking and Unblanking Characters in the Option 1?

The default values established for blanking mode are as follows:

Start of Text Character = STX (decimal 2)
End of Text Character = ETX (decimal 3)
End of Transmission = EOT (decimal 4)

If your host system does not use these characters, then you'll have to change the blanking parameters to the correct characters with a CALL "BLKCHR" statement in BASIC. The syntax for the statement is as follows:

[Line number] CALL "BLKCHR", STXCHR, ETXCHR, EOTCHR
STXCHR = Start of Text Character (Default Value is STX decimal 2)
ETXCHR = End of Text Character (Default Value is ETX decimal 3)
EOTCHR = End of Transmission Character (Default Value is EOT decimal 4)

Assume that your host system uses the ASCII control character SOH (decimal 1) to start each line of text and carriage return (CR) decimal 13 to end each line of text. Assume also that the computer does not send an EOT (End of Transmission) character, but instead relies on the last CR transmitted to blank the screen. Here's how to set the blanking and unblanking characters for this situation in the 4051 data communications interface:

```
CALL "BLKCHR",1,13,13
```

With the 4051 in the BASIC language mode, typing this statement into the 4051 and pressing RETURN causes the Start of Text character to be set to SOH (decimal 1), and the End of Text character to CR (decimal 13).

Because all three parameters must be specified, setting the End of Text character to CR (decimal 13) is just as good as leaving it set to EOT (decimal 4). It doesn't matter what it is in this case, because the computer doesn't send a special EOT character.

Once the Blanking Characters are Set, How is the Blanking Feature Enabled?

The 4051 powers up with the blanking feature disabled. To turn the blanking feature on, a special CALL statement must be executed in BASIC as follows:

```
CALL "EOLCHR",13,"@",1
```

The third parameter in this CALL statement is the BLANKE (Blank Enable) parameter which controls the ready state of the blanking feature. If the third parameter is Ø, blanking is disabled. If the third parameter is 1, blanking is made active (as shown above).

EXAMPLE PROGRAMS

Introduction

The following program listings illustrate how to set the 4051 data communication parameters under BASIC program control. The first program sets the 4051 Option 1 parameters so that they are compatible with a General Electric Mark III Timeshare Computer. The telephone line selected operates in half duplex supervisory at 1200 baud. The second program sets the 4051 Option 1 parameters to be compatible with Half Duplex Normal protocol at 1200 baud. In this example, prompt mode is used during Data Send operations and the Option 1 parameters are set accordingly.

Since half duplex protocols appear to give beginners the most trouble, these examples are centered around half duplex. Full duplex protocol is, however, the most common in use and BASIC programs written for full duplex follow a similar pattern, except that they are much simpler. Many of the default settings for the option 1 parameters conform to full duplex requirements and don't have to be changed.

The program listings that follow are filled with REMARK statements to explain how the parameters are set. The programs are mostly self-explanatory, so study the listings carefully. As you come to each CALL statement, turn to the explanation of that CALL statement in Section 8 to find out what the parameter selections mean.

Example 1

```
100 REMARK ** GENERAL ELECTRIC MARK III TIME SHARE
110 REMARK ** 1200 BAUD - HALF DUPLEX - SUPERVISORY
120 REMARK
130 PRINT "GENERAL ELECTRIC MARK III TIME SHARE"
140 REMARK ** Assign "RUBOUT" to D$
150 D$=CHR(127)
160 REMARK ** Assign Carriage Return (CR) to M$
170 M$=CHR(13)
180 REMARK ** Add CR to the end of "LIST"
190 L$="LIST"&M$
200 REMARK ** Add CR to the end of "ACT"
210 A$="ACT"&M$
220 REMARK ** Initialize Comm Parameters for Good Measure
230 CALL "CMINIT"
240 REMARK** Data Rate =1200 baud, 7 data bits, 2 stop bits, even parity
250 REMARK ** Count errors and continue transmission
260 CALL "RATE",1200,0,2
270 REMARK ** TOPEN = zip!, TCLOSE = CR, TEND = "LIST(CR)"
280 CALL "TSTRING","",M$,L$
290 REMARK ** ROPEN = "RUBOUT", RCLOSE = CR, REND = zip!
300 CALL "RSTRING",D$,M$,""
310 REMARK ** Delimiters going out: CR=CR, LF=LF, No local Line Feed
320 CALL "TCRLF",1,2,0
330 REMARK ** Delimiters coming in: CR=CR/LF, suppress LF
340 REMARK ** Don't print control characters - execute them.
350 CALL "RCRLF",3,0,0
360 REMARK ** Use Default Margin, Half Duplex Supervisory, No local echo
370 CALL "MARGIN",0,1,0
380 REMARK ** Disable PROMPT mode, prompt delay=0, prompt chara. = zip!
390 CALL "PROMPT",0,0,""
400 REMARK ** Use break action no. 2, send special "GE" break sequence
410 REMARK ** Send "ACT(CR)" tc the computer to resume the transmission
420 CALL "BREAK",2,"GE",A$
430 REMARK ** Exit GIN mode when "CR" is echoed, use joystick for GIN
440 REMARK ** A hard copy unit is present
450 CALL "GRAFIN",M$,1,1
460 REMARK ** CR=4051 end of line, CR=send string, disable blanking
470 CALL "EOLCHR",13,M$,0
480 REMARK ** Enter Terminal Mode from BASIC
490 CALL "TERMIN"
500 REMARK ** We have returned from Terminal Mode.
510 REMARK ** User Key 5 was pressed or the sequence ESC ESC was
520 REMARK ** received from the computer.
530 END
```

NOTE

This program is for illustrative purposes only. Some parameters may have to be changed before the program will work in your half-duplex environment.

Example 2

```
1 GO TO 100
7 REMARK ** Enter Terminal Mode by pressing user key labeled "ON LINE"
8 CALL "TERMIN"
9 RETURN
54 REMARK ** Display parameter list by pressing user key labeled
55 REMARK ** "PARAMETER LIST"
56 CALL "PRLIST"
57 RETURN
100 REMARK ** U.S. ARMY CORP OF ENGINEERS
110 REMARK ** 1200 BAUD - HALF DUPLEX - NORMAL
120 REMARK ** PROMPT MODE ACTIVE IN DATA SEND SUBMODE
130 REMARK
140 INIT
150 REMARK ** Initialize Comm Parameters for Good Measure
160 CALL "CMINIT"
170 PRINT "U.S. ARMY CORPS OF ENGINEERS."
180 REMARK ** Assign Carriage Return (CR) to M$
190 M$=CHR(13)
200 REMARK ** Add CR to the end of "LIST"
210 L$="LIST"&M$
220 REMARK** Data Rate =1200 baud, 7 data bits, 2 stop bits, even parity
230 REMARK ** Count the errors and continue the transmission
240 CALL "RATE",1200,0,2
250 REMARK ** Use Default Margin, Half Duplex Supervisory, No local echo
260 CALL "MARGIN",0,1,0
270 REMARK ** TOPEN = zip!, TCLOSE = zip!, TEND = EOT (Control D)
280 CALL "TSTRING","","","D"
290 REMARK ** ROPEN = zip!, RCLOSE = zip!, REND = "END OF D"
300 CALL "RSTRING","","","END OF D"
310 REMARK ** Delimiters going out: CR=CR, LF=LF, Local Line Feed PLease
320 CALL "TCRLF",1,2,1
330 REMARK ** Delimiters coming in: CR=CR/LF, suppress LF
340 REMARK ** Don't print control characters - execute them.
350 CALL "RCRLF",3,0,0
360 REMARK ** Enable PROMPT mode, prompt delay=1000
370 REMARK ** Prompt Character = Line Feed (↓)
380 CALL "PROMPT",1,1000,"↓"
390 REMARK ** CR=4051 end of line, CR=send string, disable blanking
400 CALL "EOLCHR",13,L$,0
410 REMARK ** Enter Terminal Mode from BASIC
420 CALL "TERMIN"
430 REMARK ** We have returned from Terminal Mode.
440 REMARK ** User Key 5 was pressed or the sequence ESC ESC was
450 REMARK ** received from the computer.
460 END
```

NOTE

This program is for illustrative purposes only. Some parameters may have to be changed before the program will work in your half-duplex environment.

Additional Comments

In addition to the REMARK statements in the program listings, a few additional comments are in order:

1. In some cases, it is desirable to set a parameter equal to CR (carriage return). If the parameter calls for the decimal equivalent of an ASCII character, then 13 may be specified to indicate CR. If the parameter calls for a string constant in quotation marks or a string variable, then extra measures must be taken to specify CR. Lines 170 and 280 in the first program illustrate how to specify CR as a character string. First, the CHR function must be used to assign CR to a string variable, as shown in line 170. The string variable is then specified where a parameter calls for a string constant, as shown in line 280.

2. Specifying a computer command (with a CR added to the end) allows the 4051 to automatically send commands to the computer. In the first example program, lines 170, 190, and 280 illustrate this technique. In line 170, a carriage return character is assigned to M$. In line 190, the CR is added to the character string "LIST" and assigned to L$. This string is then specified as the TEND parameter in line 280. When the 4051 finishes a tape transmission to the computer, the 4051 sends the TEND string to end the transmission. Since LIST(CR) tells the computer to send a copy of the program back to the 4051, the copy of the just transmitted 4051 program is sent back to the 4051 screen where the 4051 operator can check to make sure that the computer received the program correctly during the Data Send operation.

NOTES

Section 4

MODE CHANGES

INTRODUCTION

A 4051 equipped with the RS-232-C Data Communication Interface is capable of four primary modes of operation. These modes are the BASIC language mode, the BASIC I/O mode, Terminal mode, and Tape Communication mode. Each mode gives the Graphic System special characteristics which allow the system to handle different and varying communication tasks.

When power is applied to the Graphic System, the system enters the BASIC language mode. The Data Communication Interface may be used as a data port by specifying the primary address 40 after the BASIC keywords PRINT, LIST, SAVE, TLIST, INPUT, OLD, and APPEND. For example, executing the statement PRINT @40:"HI" causes the message HI to be transmitted out the RS-232 port to the host computer or printing device. This mode only works with the full duplex protocol. In this manual, the term BASIC I/O is used to describe data transfers through the Data Communication port by using the primary address 40 in BASIC statements.

BASIC I/O MODE

Figure 4-1 illustrates the BASIC language mode as a circle. Data are transferred from the 4051 memory via the Data Communication Interface whenever the primary address 40 is specified in the previously mentioned BASIC statements. For this reason, an arrow is drawn from the circle representing the BASIC language mode to the BASIC I/O mode and labeled "Primary Address 40" to indicate how this mode transition is achieved. After the BASIC I/O operation is completed, the Graphic System automatically returns to the BASIC language mode. This is indicated by the arrow which begins at the BASIC I/O circle and points to the BASIC circle. The arrow is labeled "Execution Completed," meaning that this transition back to BASIC occurs automatically as soon as the statement using primary address 40 is finished executing.

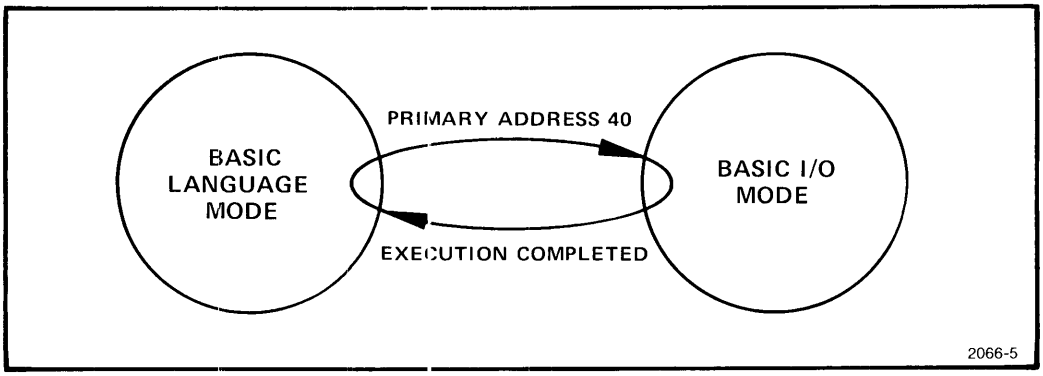

Fig. 4-1. Mode Transition between BASIC and BASIC I/O (full duplex only).

ENTRY INTO TERMINAL MODE

Whenever the system is in the BASIC language mode, Terminal mode can be entered by executing the BASIC statement CALL "TERMIN." Once in Terminal mode, the Graphic System operating features have little resemblance to a stand-along system operating under the BASIC language. The 4051 emulates a TEKTRONIX 4012 Graphic Terminal. Data entries from the keyboard are transmitted directly to the host computer via the Data Communication Interface.

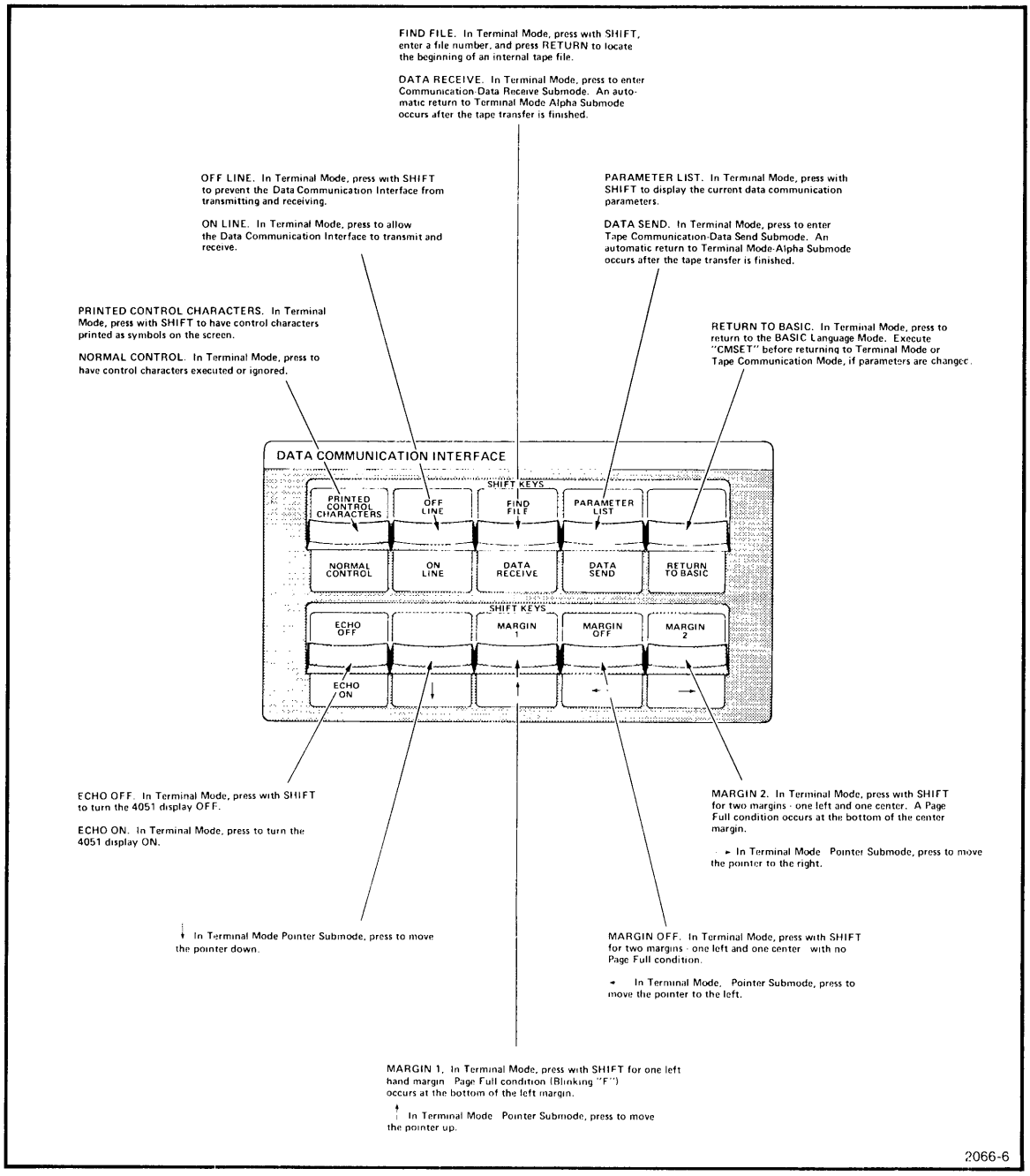

Fig. 4-2. Data Communication Interface Overlay.

Incoming data from the computer are displayed on the 4051 screen as soon as they arrive from the host computer. The data can be displayed as written text on the screen or as graphic vectors. In Terminal mode, the 4051 internal magnetic tape and the General Purpose Interface Bus (GPIB) are not accessible from the keyboard.

SPECIAL FUNCTION KEYS

Once in Terminal mode, the user-definable keys in the upper-left corner of the keyboard assume special dedicated functions and are no longer "user-definable." The function of each key is identified by placing the Data Communication Overlay over the user-definable keys as shown in Fig. 4-2.

RETURN TO BASIC

After completing operations in Terminal mode, the system is restored to BASIC language control by pressing user-definable key 5, labeled RETURN TO BASIC. Or, on interfaces with identification number B02000 or above, receiving the character sequence ESC ESC from the computer returns the system to BASIC.

Figure 4-3 illustrates the transition to Terminal mode when the statement CALL "TERMIN" is executed and user-definable key 5 is pressed (RETURN TO BASIC). This figure is an extension of Fig. 4-1, showing how Terminal mode relates to the BASIC language mode and the BASIC I/O mode previously discussed.

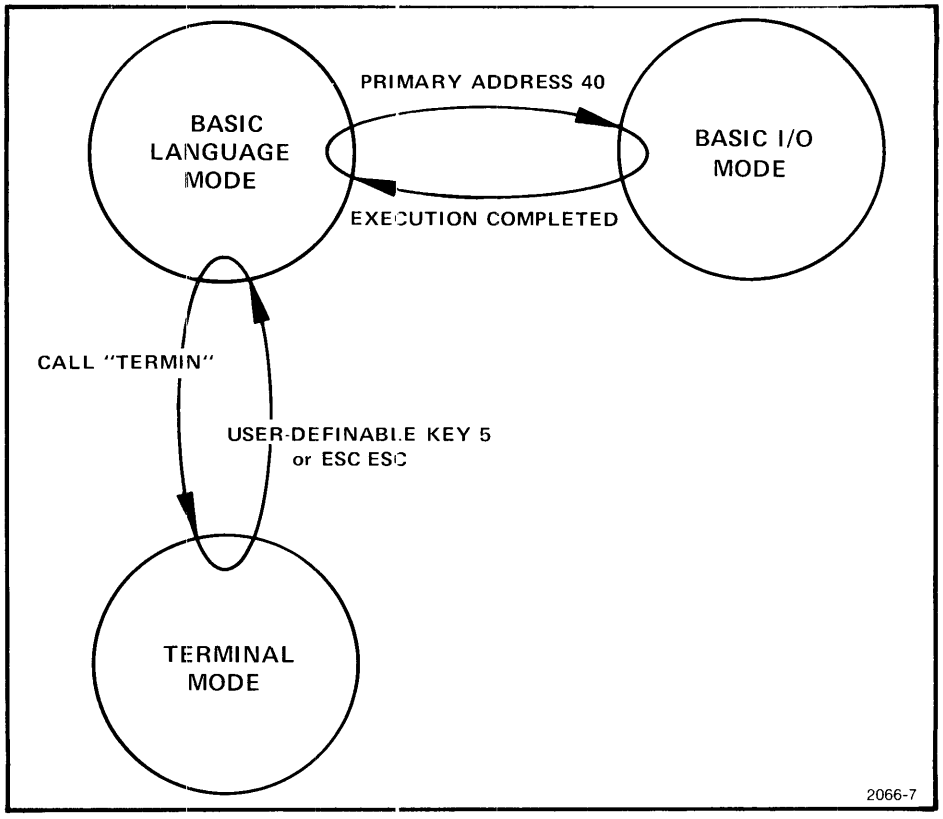

Fig. 4-3. Transition between BASIC, BASIC I/O, and Terminal modes.

ENTRY INTO TAPE COMMUNICATION MODE

Exploring mode changes further, assume that Terminal mode is now active. When user-definable key 13 is pressed (marked FIND FILE on the overlay), the word "File?" is printed on the screen. The user enters an internal file number of a previously marked file, and presses RETURN. The internal tape is then positioned to the specified file.

Now, by pressing either user-definable key 3 or key 4 (DATA RECEIVE or DATA SEND), the system enters Tape Communication mode. At this time, the 4051 exchanges data between the internal tape cartridge and an external device, via the Data Communication Interface. This process occurs under machine control, and the keyboard operator need not be involved.

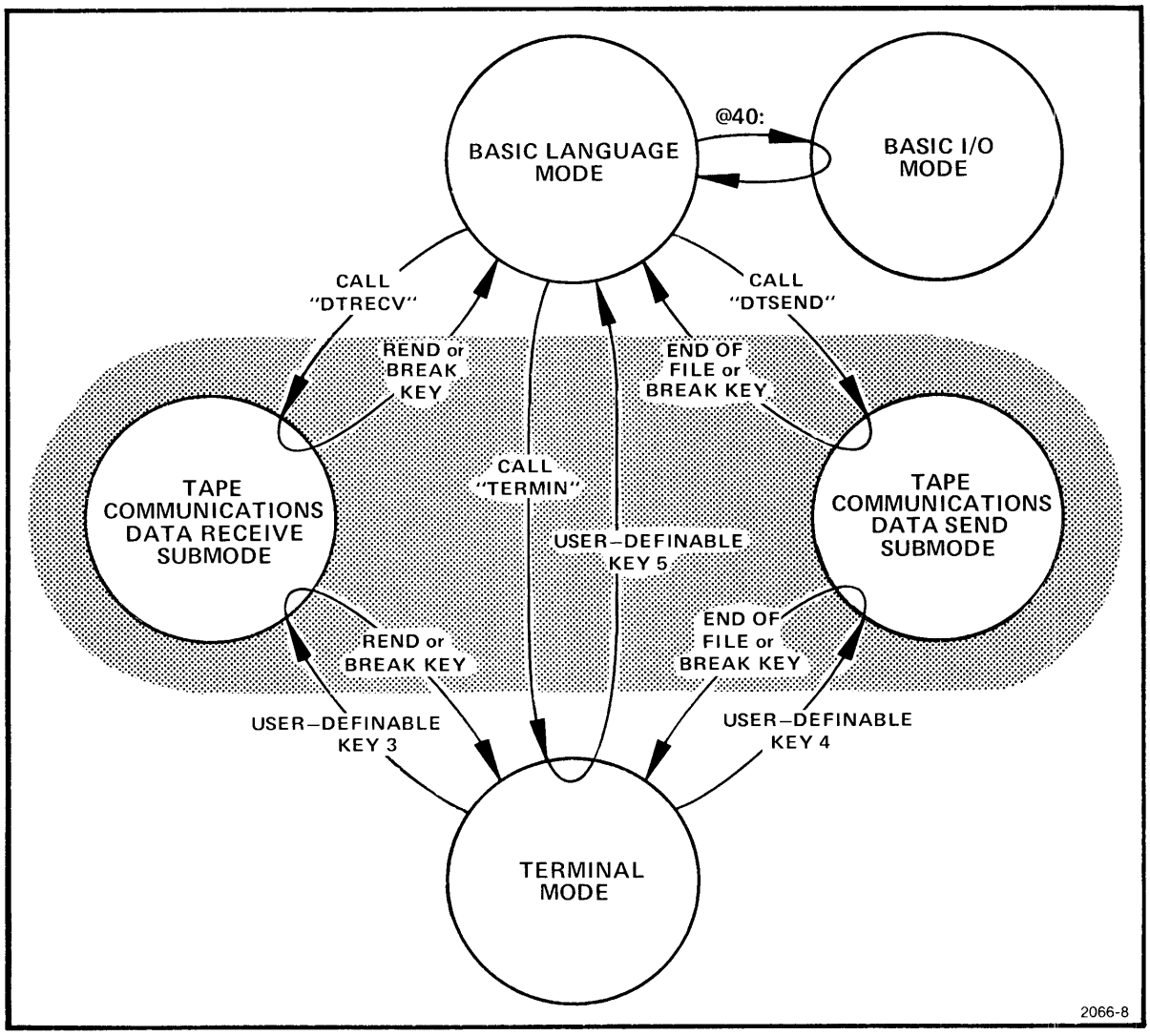

Fig. 4-4. Detailed mode change diagram.

After the file is transferred, the system automatically returns to Terminal mode, unless ESC ESC is received, in which case a return is made to the BASIC language mode. Refer now to Fig. 4-4, where Tape Communications mode is illustrated. The illustration shows the four modes of operation, and the normal process by which the mode changes are made. Note that Tape Communications mode may be entered directly from BASIC, using the statement CALL "DTRECV" or CALL "DTSEND". The arrow which shows this change loops through the circle labeled TAPE COMMUNICATIONS, and returns to BASIC upon completion of Tape Communications. If Tape Communications are called from Terminal mode, by pressing user-definable key 3 or key 4, Terminal moce is re-entered afterwards.

NOTES

Section 5

BASIC I/O MODE (FULL DUPLEX ONLY)

INTRODUCTION

The default (power-up) mode of the 4051 is the BASIC language mode. Adding the Data Communications interface enables the 4051 to execute the following BASIC statements as part of the standard group. An additional statement, CALL, is discussed in detail in Section 8 on CALL Routines.

Table 5-1
BASIC I/O KEYWORDS AND THEIR USE

Keyword	Effect
PRINT @40:A$	The data following the colon (e.g., A$) are sent out the interface in ASCII format.
SAVE @40:	The current BASIC program in memory is transmitted by the interface as an ASCII data stream. Control characters are sent unmodified. Starting and ending line numbers can follow the colon to SAVE a program segment.
LIST @40:	The current BASIC program in memory is transmitted by the interface as an ASCII data stream. Control characters are modified as shown in Table 5-2. Starting and ending line numbers can follow the colon to LIST a program segment.
TLIST @40:	The status of all internal tape files is sent by the interface in the form File Number, File Contents, File Size. Particulars on this format are found in the Graphic System Reference manual.
INPUT @40:A$	When executing these statements, ASCII data received by the interface are assigned to the target variable (A$ in this example). The assignment ends when a CR character is received. The %40 form allows termination on the receipt of an alternate delimiter (see INPUT in the Graphic System Reference manual).
OLD @40:	An ASCII program may be read in through the interface, assuming it is in the correct format. The program then resides in memory.
APPEND @40:500	An ASCII program may be read in through the interface, assuming it is in the correct format The colon must be followed by a starting target line number. The first program line coming in overwrites the target line number.

Table 5-1 (cont)

Keyword	Effect
PRINT @40,30:	This statement enables, resets, and clears the interface INPUT buffer. This buffer allows up to 255 characters to be received over the RS-232 channel, prior to and during INPUT operations in BASIC. If more than 255 characters are received by the buffer at any time, an overflow condition occurs; data in the buffer and all data received after an overflow condition is lost. A printed indication of overflow is not given until an INPUT @40: statement is executed, or a PRINT @40,30: statement is executed. *NOTE* *Any attempt to INPUT and PRINT data from the interface buffer after an overflow condition without executing a PRINT @40,30: statement first, produces random results.*
PRINT @40,31:	This statement disables the 255 character INPUT buffer. All data received by the interface prior to, and sometimes during, the execution of an INPUT @40: statement is lost. Normally, this statement is used only to prevent the buffer from overflowing when unwanted character strings are transmitted from the computer. Executing a PRINT @40,30: statement enables the buffer to receive valid data again.
INPUT @40,0:A	This statement assigns the number of CR (Carriage Return) characters stored in the INPUT buffer to the specified numeric variable. It is normally used to find out how many logical records are in the buffer, before the records are input into memory with an INPUT statement.

Table 5-2
PRINTED CONTROL CHARACTERS

ASCII control characters are listed by the following symbols:

Control Character	How Printed (CTLDSP=1)	Control Character	How Printed (CTLDSP=1)
NUL	@	DLE	P
SOH	A	DC1	Q
STX	B	DC2	R
ETX	C	DC3	S
EOT	D	DC4	T
ENQ	E	NAK	U
ACK	F	SYN	V
BEL	G	ETB	W
BS	H	CAN	X
HT	I	EM	Y
LF	J	SUB	Z
LT	K	ESC	[
FF	L	FS	/
CR	M	GS	]
SO	N	RS	_
SI	O	US	_

NOTE: BASIC I/O MODE will not work in half duplex.

Fig. 5-1 illustrates which environmental parameters have an effect on BASIC I/O operations and where in the data path the effect occurs.

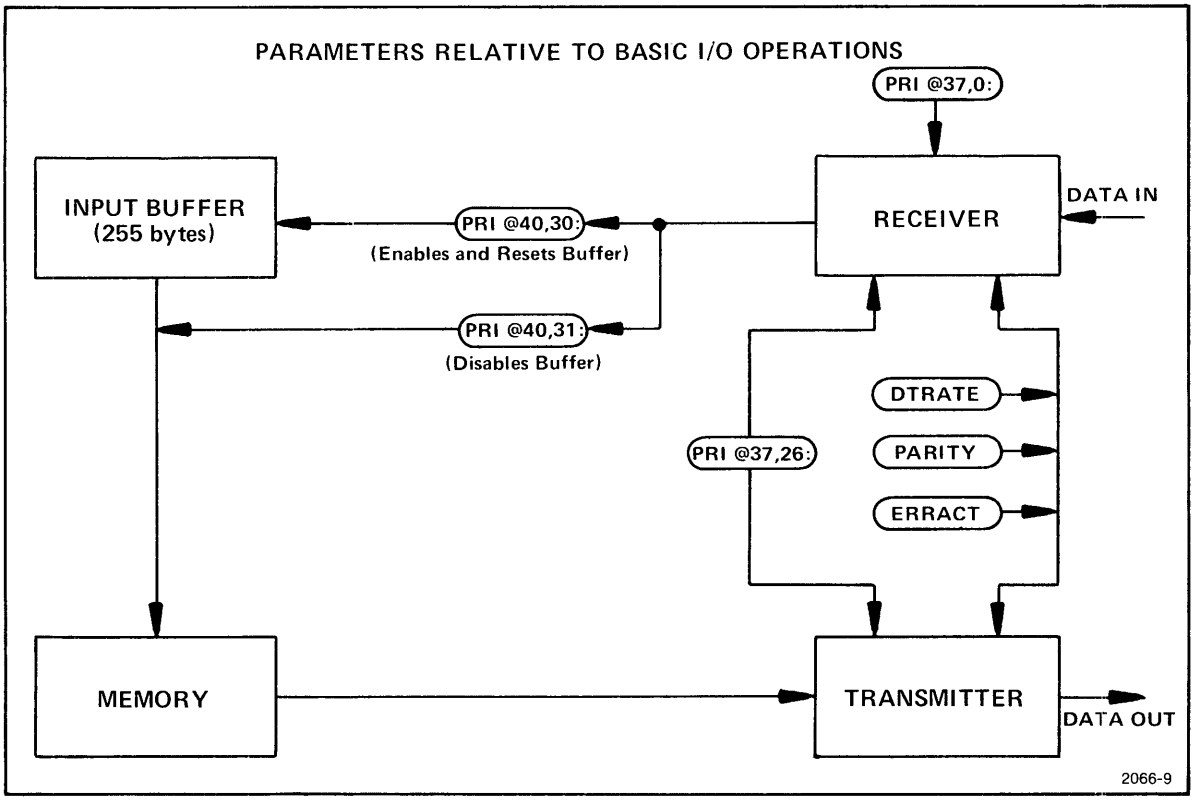

Fig. 5-1. BASIC I/O Mode characteristics.

Section 6

TERMINAL MODE

INTRODUCTION

When the BASIC statement CALL "TERMIN" is executed, the 4051 Data Communication Interface enters Terminal mode. The 4051's behavior in Terminal mode resembles a Tektronix 4012 Graphic Terminal.

Terminal mode is useful when communicating interactively with a host computer via a modem, or with any RS-232 compatible device connected to the 4051 Data Communications Interface port. The principal characteristic which is absent from the 4051 in Terminal mode is the BASIC language ability; the 4051 becomes a direct transmitter and receiver interacting with the device connected to the interface. Many Terminal mode functions can be accomplished in the BASIC I/O mode previously discussed; Terminal mode, however, allows these functions to be performed more easily without BASIC language programming. In addition, Terminal mode allows the 4051 to operate with current 4012 Software.

The TEKTRONIX 4012 terminal itself is capable of several "modes" of operation, and these modes are simulated by the 4051 while in Terminal mode. The 4012 modes are therefore "submodes" to the 4051 Terminal mode. These submodes include Alpha, Graph, and GIN (Graphic Input).

These submodes within Terminal mode are now discussed in terms of their individual characteristics and data paths. These discussions, accompanied with the information in Section 8 on CALL routines, should provide a clear picture on how the system operates in Terminal mode.

ALPHA SUBMODE

The 4051 enters the Alpha submode of Terminal mode when the BASIC statement CALL "TERMIN" is executed from the 4051 keyboard or under BASIC program control. The 4051 BASIC language capability momentarily goes away and the 4051 operating characteristics appear to be similar to a TEKTRONIX 4012 Display Terminal. Fig. 6-1 is a conceptual diagram which illustrates the ASCII data paths while the 4051 is in the Alpha submode of Terminal mode.

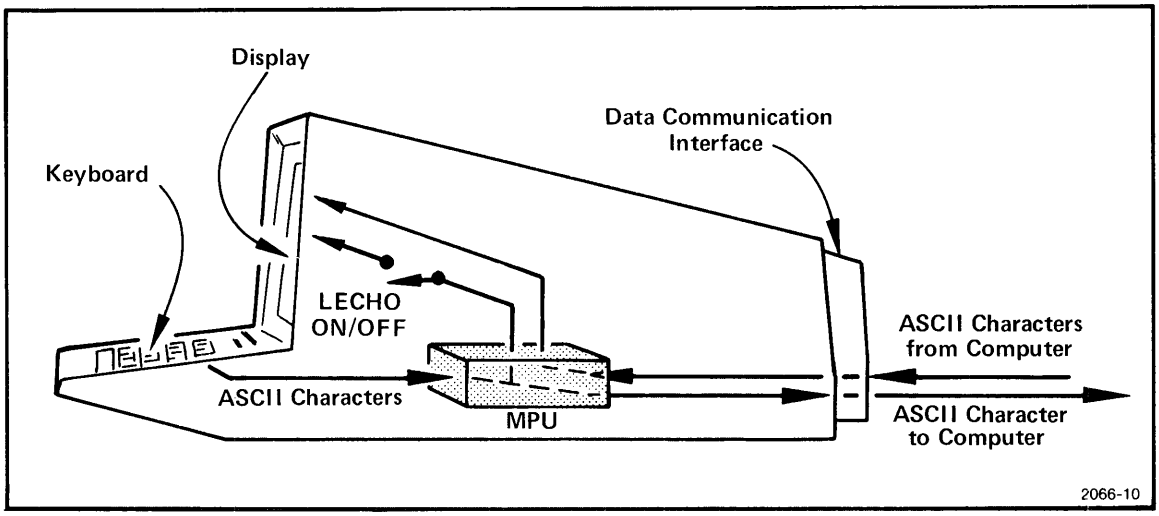

Fig. 6-1. ASCII data paths in Terminal mode — Alpha submode.

Entries from the 4051 keyboard are transmitted through the Microprocessor Unit (MPU) to the Data Communication Interface, then out the RS-232 port to the host computer or modem. Normally, the keyboard entries are echoed to the 4051 display, because the default setting for the LECHO parameter is 1 (ON). If the LECHO parameter is previously set to 0 (OFF) with a CALL "MARGIN" statement before entering Terminal mode, then all entries from the keyboard are transmitted directly to the interface and are not echoed to the display. User-definable key 6/16 can be used to reset this parameter if need be. Pressing this key (marked ECHO ON on the Data Communication overlay) restores the echo to the display. Pressing this same key in combination with the SHIFT key returns the display to the ECHO OFF status.

ASCII data coming back from the host computer or modem is received by the interface and transmitted to the 4051 display via the MPU.

There are many 4051 environmental parameters which have an effect on the way ASCII data is handled and processed in the Alpha submode. These parameters are usually set up by executing BASIC CALL statements before Terminal mode is entered. In most cases, the default (power-up) states of these parameters will be compatible with your computer application. The two parameters MODE and DTRATE should be checked, however, before entering Terminal mode. The MODE parameter determines half or full duplex operation, and the DTRATE parameter deterimes the baud rate. The default states of these parameters are full duplex and 300 baud, respectively. Once these parameters are checked and correctly set, Terminal mode can be entered with a CALL "TERMIN" statement and you should be able to communicate with the computer assuming the hardware connections are correct. After initial contact is made with the computer, additional environmental parameters can be changed to enhance the data-communication performance. Pressing the RETURN TO BASIC key (key 5 on the user-definable key pad) returns the 4051 to the BASIC language mode. CALL statements can then

be executed to change the required environmental parameters. Terminal mode can then be re-entered with a CALL "TERMIN" statement. A little experimentation will be required to find the most desirable settings for the environmental parameters.

The following paragraphs now cover the specifics on 4051 keyboard transmission and ASCII data receptions in the Alpha submode.

KEYBOARD OUTPUT IN ALPHA SUBMODE

ASCII Keys

When the 4051 enters Terminal mode, the 4051 keyboard is capable of sending all 128 ASCII keycodes to an external device via the RS-232 port. The keys controlling the transmission of these characters are shown in Fig. 6-2

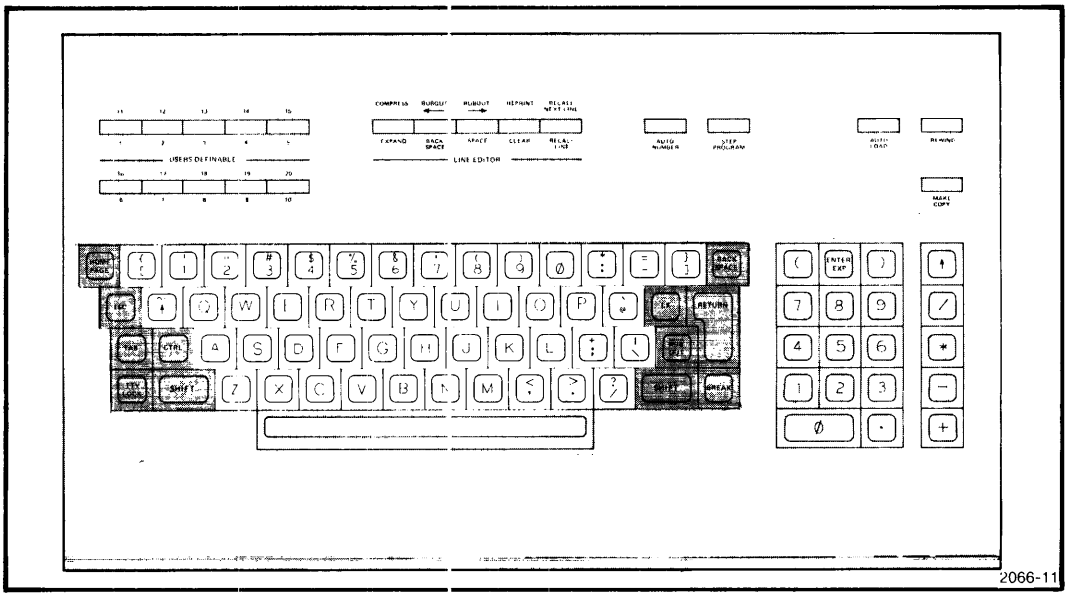

Fig. 6-2. 4051 Keyboard.

The center keys on the ASCII keyboard each represent two ASCII characters. The lower character is sent out the interface when the key is pressed directly. The upper character is sent out when the key is pressed in combination with the SHIFT key. The dark gray keys on each side are used to either modify the characters transmitted by the center keys or they cause direct control functions to be executed.

The shaded keys in the illustration marked SHIFT, CTRL, and TTY LOCK modify the uses of the center ASCII keys. With SHIFT and CTRL, this modification occurs when pressing one of these special keys simultaneously with another ASCII key in the center. In the case of TTY LOCK, the key locks into the down position when pressed once. Pressing the TTY LOCK key again releases it, and deactivates the TTY lock modification. Table 6-1 lists the ASCII keyboard keys and the characters sent out when they are pressed. The effects of the modifier keys SHIFT, CTRL, and TTY LOCK are shown as different columns in this table. The other shaded keys on the ASCII keyboard illustration are discussed following this table.

Table 6-1
ASCII CHARACTERS ISSUED FROM THE 4051 KEYBOARD

Key Pressed	Character Issued				
	Normal	With SHIFT	With CTRL	With TTY	With TTY and SHIFT
Space Bar	SP	SP	SP	SP	SP
Ø	Ø	Ø	Ø	Ø	Ø
1 !	1	!	1	!	!
2 "	2	"	2	"	"
3 #	3	#	3	#	#
4 $	4	$	4	$	$
5 %	5	%	5	%	%
6 &	6	&	6	&	&
7 '	7	'	7	'	'
8 (	8	(	8	(	(
9)	9	)	9	)	)
: *	:	*	:	*	*
; +	;	+	;	+	+
, <	,	<	,	<	<
- =	-	=	-	=	=
. >	.	>	.	>	>
/ ?	/	?	/	?	?
A	a	A	SOH	A	A
B	b	B	STX	B	B
C	c	C	ETX	C	C
D	d	D	EOT	D	D
E	e	E	ENQ	E	E
F	f	F	ACK	F	F
G	g	G	BEL	G	G
H	h	H	BS	H	H
I	i	I	HT	I	I
J	j	J	LF	J	J
K	k	K	VT	K	K

Table 6-1 (cont)

Key Pressed	Character Issued				
	Normal	With SHIFT	With CTRL	With TTY	With TTY and SHIFT
L	l	L	FF	L	L
M	m	M	CR	M	M
N	n	N	SO	N	N
O	o	O	SI	O	O
P	p	P	DLE	P	P
Q	q	Q	DC1	Q	Q
R	r	R	DC2	R	R
S	s	S	DC3	S	S
T	t	T	DC4	T	T
U	u	U	NAK	U	U
V	v	V	SYN	V	V
W	w	W	ETB	W	W
X	x	X	CAN	X	X
Y	y	Y	EM	Y	Y
Z	z	Z	SUB	Z	Z
[{	[	{	ESC	[	{
\ |	\	|	FS	\	|
] }	]	}	GS	]	}
↑ ~	↑	~	RS	↑	~
RUBOUT _	DEL	_	US	DEL	_
@ `	@	`	NUL	@	`

Other 4051 Keyboard Keys

Table 6-1 defines the functions of the regular ASCII keys. The remaining ASCII keys are modifiers (CTRL, SHIFT, TTY LOCK) or special purpose keys which allow abbreviated ASCII Control Character transmissions. These keys are defined in Table 6-2.

Table 6-2
DIRECT CONTROL CHARACTER KEYS

Key	Control Character Sent
ESC	ESC (Escape)
BACKSPACE	BS (Backspace
TAB	HT (Horizontal Tab)
LF	LF (Line Feed)
RETURN	CR (Carriage Return)

The PAGE/RESET key and BREAK key have special functions which will be discussed later.

DISPLAY RESPONSE IN ALPHA SUBMODE

Received data from the computer or modem are routed directly to the display. If local echo is set (see CALL "MARGIN"), then transmitted data is also viewed on the 4051 display.

The 4051 display in Alpha submode is capable of printing 35 lines of ASCII characters, each with a maximum length of 74 characters. A pulsating dot matrix, which does not store, marks the current display location and is called the Alpha cursor.

Upon display initialization (pressing the PAGE/HOME key), the Alpha cursor is positioned at the upper-left corner of the screen. As characters are received by the display, they are printed at the current Alpha cursor position, and the cursor then moves one character space to the right, ready for the next character.

When the end of a line is reached, or upon receipt of a CR (Carriage Return) character, the Alpha cursor returns to the left margin of the screen, moves down to the next line (if LCLLF is set to 1), and continues to indicate where the next character will be printed.

Margin Control

The margin control feature of the 4051 Data Communication Interface in Alpha mode is analogous to the margin switch on a TEKTRONIX 4014 terminal, and is not available on a 4012 terminal. The margin control is set by the CALL "MARGIN" statement during BASIC operation, before entering Terminal mode. The margin control can also be set by pressing the user-definable keys 18, 19, and 20 when in Terminal mode, as will be described later in this section. The possible margin settings are Ø, 1, and 2.

If the margin is set to Ø or 2, then after the 35th line is filled or terminated with a CR, the cursor is positioned on the top of the screen approximately half-way across. This mid-screen margin is then effective for the next 35 lines and a CR or line which extends beyond the right of the screen causes the cursor to position back to the mid-screen margin and down to the beginning of the next line.

At the end of the last line with the mid-screen margin, two things happen depending on whether the MARGIN is set to 0 or 2. If the MARGIN is set to 0, the cursor returns to the initial position (upper-left corner) and the screen-filling process is repeated. Previously written characters are overwritten, and the MARGIN successively alternates between the left screen and mid-screen position with each 35 lines.

If the margin is set to 2, then after the 34 lines at the mid-screen margin, the cursor exits the lower-right corner of the display, and a Pagefull condition occurs. If the margin is set to 1, then a Pagefull condition occurs after the first 35 lines of left margin printing.

Pagefull

The Pagefull busy condition can have varied effects, depending on a parameter previously set by the CALL "BREAK" statement. A BREAK signal may be sent to the external device via the RS-232 port as a 350 ms pulse. The BREAK pulse, however, is not possible with Half Duplex Normal operation until after the external device is through sending data and indicates this by sending a Line Turn-Around character as defined by the CALL "EOLCHR" statement. Alternately, the 4051 Data Communication Interface may send a character string to indicate "stop sending, my display is filled"; this is BKSTG1 defined with the CALL "BREAK" statement. Once again, this string cannot be sent in Half Duplex Normal communications until after the external device has relinquished the line.

The Pagefull busy condition is cleared manually by pressing PAGE or HOME (PAGE/HOME key with SHIFT key). An added option which is set by CALL "BREAK" causes the interface to send a "resume transmission" string at this time (BKSTG2). A further option set by CALL "BREAK" allows a Pagefull busy condition to be cleared automatically when it occurs. The display is PAGED (erased), and a hard copy of the display is automatically made (if the hard copy unit is present); the "resume transmission" string BKSTG2 can be sent after the hard copy process is completed, if it is so specified.

Alternate Character Set

The character set displayed in Alpha mode is also active during the BASIC language mode, before the CALL "TERMIN" statement is executed. For a detailed explanation about the selection of alternate characters, see the 4051 Graphic System Reference Manual. The following summarizes how the selection is made:

1. Select a character set from the following, and find its associated number n:

CHARACTER FONT	n
English	Ø
Scandanavian	1
German	2
General European (French, British, Italian)	3
Spanish	4
Graphic Symbols	5

2. Execute the statement PRINT@32,"8:n, where n is the number from Step 1.

Printed Control Characters

The display responds to received ASCII non-Control Characters by printing them directly in the position of the Alpha cursor. Control Characters may be either decoded as commands, as in the 4012, or printed as special symbols and not decoded. The choice is made by the CALL "RCRLF" statement CTLDSP parameter during the BASIC language mode. During Terminal mode Alpha operation, the CTLDSP parameter is directly set by pressing the upper-left user-definable key, as indicated by the Data Communication Overlay.

When printing Control Characters (CTLDSP=1), an ASCII Line Feed appears as a J, relating to the fact that a Line Feed is generated by pressing the CTRL and J keys simultaneously. The underlined J results from a Backspace BS followed by the underscore. If the Alpha cursor happens to be at the extreme right margin when a Control Character is received, the underscore follows the character at the beginning of the next line. Table 6-3 illustrates the way each ASCII Control Character appears when printed.

Alternately, Control Characters may be decoded as commands much like in the 4012 terminal. In this case, nothing is printed on the display. The effect of the Control Characters is discussed in Table 6-3.

Table 6-3
4051 DISPLAY RESPONSE TO CONTROL CHARACTERS IN ALPHA SUBMODE

Control Character	4051 Keyboard Entry	Displayed Character	4051 Display Response
NUL	CTRL @	@	None.
SOH	CTRL A	A	None.
STX	CTRL B	B	None.
ETX	CTRL C	C	None.
EOT	CTRL D	D	None.
ENQ	CTRL E	E	As the second character in a ESC ENQ sequence, ENQ causes echoplex suppression and creates one of the following GIN submode situations: 1) Causes the 4051 terminal status and the address of the lower-left corner of the Alpha cursor to be sent to the computer if received while the 4051 is in the Alpha submode. 2) Causes the 4051 terminal status and the address of the display beam to be sent to the computer if received while the 4051 is in Graph submode. 3) Causes the address of the Pointer to be sent to the computer if received while the pointer is being displayed.
ACK	CTRL F	F	None.
BEL	CTRL G	G	Rings bell for approximately 200 ms; clears echoplex suppression.
BS	CTRL H or BACKSPACE Key	H	Backspaces the cursor one character position. Wrap around occurs at the left margin. Clears echoplex suppression.
HT	CTRL I or TAB Key	I	Spaces one space to the right. Also clears echoplex suppression.

Table 6-3 (cont)

Control Character	4051 Keyboard Entry	Displayed Character	4051 Display Response
LF	CTRL J or LF Key	J	Cursor moves down one line; if cursor moves past the bottom of the display, it "wraps" around and appears at the top of the display, selecting the alternate margin. Also clears echoplex suppression, if PAGE FULL is not set.
VT	CTRL K	K	Causes the cursor to move up one line. Clears echoplex suppression.
FF	CTRL L	L	As second character in ESC FF sequence, it erases the screen, selects Alpha submode, sets the cursor to home position, sets Margin 0, and clears echoplex suppression.
CR	CTRL M or RETURN Key	No Printed Character	Carriage return; resets 4051 from Graph to Alpha submode; cancels the pointer setting Alpha submode but leaving the 4051 in an undefined margin (page full) status clears echoplex suppression.
SO	CTRL N	N	None.
SI	CTRL O	O	None.
DLE	CTRL P	P	None.
DC1	CTRL Q	Q	None.
DC2	CTRL R	R	None.
DC3	CTRL S	S	None.
DC4	CTRL T	T	None.
NAK	CTRL U	U	None.
SYN	CTRL V	V	None.
ETB	CTRL W	W	As second character in ESC ETB sequence, it creates a Make Copy signal, which causes a hard copy of the display to be made if an energized Hard Copy Unit is connected. ESC ETB also clears echoplex suppression. Not effective while pointer is displayed.
CAN	CTRL X	X	None.
EM	CTRL Y	Y	None.
SUB	CTRL Z	Z	As the second character in a ESC SUB sequence, SUB sets GIN submode and displays the pointer arrow. Echoplex suppression is activated.
ESC	CTRL [or ESC Key	[	4051 "arming" character which makes the 4051 sensitive to certain control characters received immediately after ESC, see ENQ, ETB, FF, SUB. Other characters may be used in sequence with ESC in control accessory devices. ESC ESC returns the system to BASIC.
FS	CTRL /	/	None.

Table 6-3 (cont)

Control Character	4051 Keyboard Entry	Displayed Character	4051 Display Response
GS	CTRL]	]	Sets 4051 to Graph submode; sets circuitry for dark vector. Should not be used while pointer arrow is displayed.
RS	CTRL ↑	↑	None.
US	CTRL _ or CTRL RUBOUT	_	Resets 4051 from Graph to Alpha submode; clears echoplex suppression.

Table 6-4 summarizes the operating characteristics of the 4051 while operating in Terminal mode—Alpha submode.

Table 6-4
ALPHA SUBMODE CHARACTERISTICS

Keyboard	ASCII keys	All 128 ASCII characters can be transmitted from the keyboard. The TTY LOCK key restricts the set to 96 characters.
	BREAK key	Causes the interface to send a BREAK pulse or BREAK string. (See CALL "BREAK").
	Numeric Pad	Equivalent to the corresponding ASCII symbol keys. ENTER EXP key is the same as an ASCII E.
	User-Definable keys	#1 NORMAL CONTROL. Control characters are decoded as specified in Table 6-3. #2 ON LINE. The Data Communication Interface is enabled. #3 DATA RECEIVE. Causes a transition to Tape Communications — Data Receive submode. Equivalent to CALL "DTRECV" in BASIC. Returns to Alpha submode upon completion. #4 DATA SEND. Causes a transition to Tape Communications — Data Send submode. Equivalent to CALL "DTSEND" in BASIC. Returns to Alpha submode upon completion. #5 RETURN TO BASIC. Causes a return to the BASIC language mode. The cursor executes a Carriage Return/Line Feed.

Table 6-4 (cont)

Keyboard (cont)	User-Definable (cont)	#6 ECHO ON. Local Echo ON. Characters transmitted from the 4051 keyboard are seen on the 4051 display. #7 Not used. #8 Not used. #9 Not used. #10 Not used.
	User-Definable keys with SHIFT	#11 PRINTED CONTROL CHARACTERS. All ASCII characters, including control characters, are printed on the display instead of being interpreted as specified in Table 6-3. #12 OFF LINE. The Data Communication Interface is inhibited from transmitting or receiving. #13 FIND FILE. Prints the message "File?" on the screen. When a file number is entered and RETURN is pressed, the file is located on the internal magnetic tape. A return to Alpha submode is then executed. #14 PARAMETER LIST. Prints a Data Communication Parameter list on the 4051 Display, then returns to Alpha submode. #15 Not used. #16 ECHO OFF. Changes the LECHO parameter to 0 and disables the Local Echo function. Alphanumerics are not displayed on the 4051 screen. #17 Not used. #18 MARGIN 1. Changes the MARG parameter to 1, then returns to Alpha submode. (See CALL "MARGIN"). #19 MARGIN/OFF. Changes the MARG parameter to 0, then returns to Alpha submode. (See CALL "MARGIN"). #20 MARGIN 2. Changes the MARG parameter to 2, then returns to Alpha submode. (See CALL "MARGIN").
	LINE EDITOR keys	Used only following user-definable key 13 to alter the FIND FILE entry. RECALL LINE and RECALL NEXT LINE are not used.

Table 6-4 (cont)

Keyboard (cont)	AUTO NUMBER key	Not used.
	STEP PROGRAM key	Not used.
	AUTO LOAD key	Not used.
	REWIND key	Causes the internal tape cartridge to rewind to the beginning.
	MAKE COPY key	Causes a hard copy, if a Hard Copy Unit is connected.
Display	Type	Direct View Storage. ASCII characters are displayed.
	Writing Area	8 inches (20.32 cm) horizontal; 6 inches (15.24 cm) vertical.
	ASCII display	35 lines with 74 characters/line (with MARG 0 or 2). Twin columns of 35 lines with 36 characters/line (with MARG 1).
	Character Set	5 character sets are possible.
	Control Character effect	During Normal Control, decoded as in Table 6-3. During Print Control Characters, printed as in Table 6-3.
	Writing Position	Indicated by non-stored 5X8 dot matrix .087" wide (0.22 cm) by 0.016" high (0.27 cm).
	Writing Rate	4800 Baud maximum. 50 characters per second.
	Hold & Auto Erase	After 90 seconds of inactivity, the display intensity is reduced to increase the display life. Approximately 30 minutes more of inactivity results in an automatic PAGE. Hold (dim) is released by pressing any ASCII key or SHIFT key.
Indicators	I/O	Indicates that the Data Communication Interface is active.
	BUSY	Indicates that data is being transferred.

GRAPH SUBMODE

In Graph submode, the 4051 display responds to ASCII characters by drawing straight lines (called "vectors") on the high-resolution storage screen. The transition from Alpha submode to Graph submode happens when the ASCII control character GS is received from the Data Communication Interface or when CTRL] is entered manually from the 4051 keyboard. When the system enters the Graph submode, the Alpha cursor goes away and the system prepares to interpret ASCII characters as coordinates for drawing graphic vectors.

For addressing purposes, the 4051 display represents the first quadrant in a cartesian coordinate system as shown in Fig. 6-3.

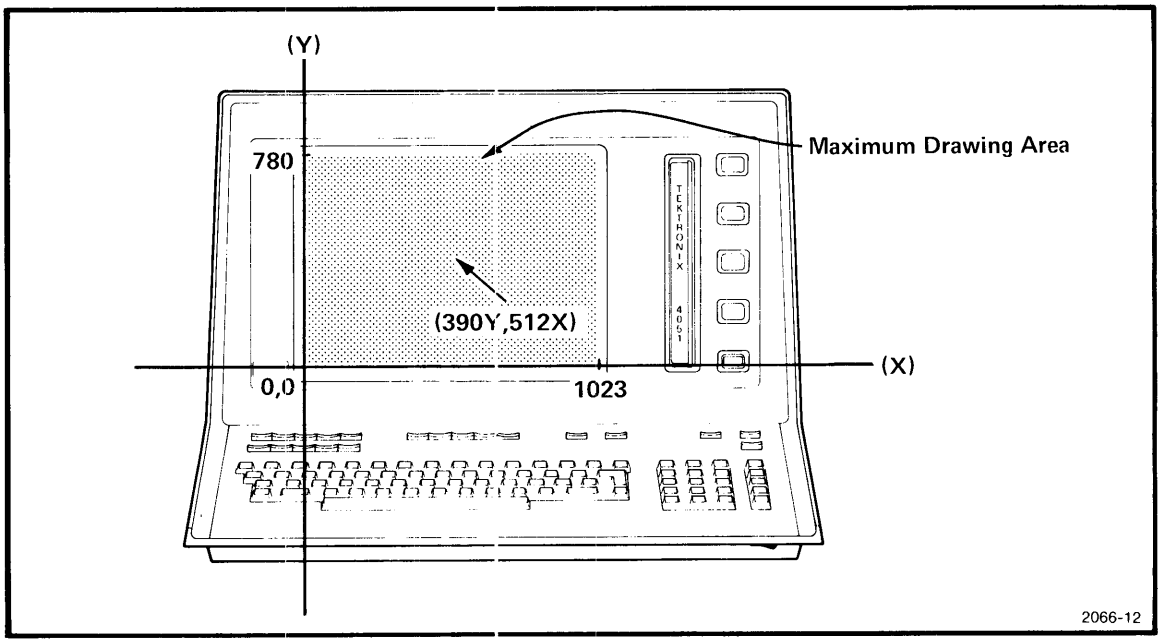

Fig. 6-3. How the 4051 Display relates to a cartesian coordinate system in Graph submode.

The lower-left corner of the display is the point of origin (0,0). Internally, the X (horizontal) axis is divided into 1023 increments and the Y (vertical) axis is divided into 780 increments. Points on the screen are addressed by specifying coordinate pairs which represent the vertical and horizontal distance from the point of origin (lower-left corner). For example, the center point on the screen is represented by the coordinates (390,512) as shown in Fig. 6-3. The vertical distance (Y) from the point of origin is specified first (390), followed by the horizontal distance X (512). Notice that this method of specifying coordinates is opposite from the (X,Y) method used to specify coordinates in the 4051 BASIC language.

While the system is in the Graph submode, each coordinate pair must be encoded as four ASCII characters. The first two characters in a four-character sequence represent the Y coordinate and the second two characters represent the X coordinate. The details of this addressing scheme will be discussed in a moment.

The first four ASCII characters are sent to the display after a GS control character moves the graphic point to a location on the screen. This is analogous to executing a MOVE statement in BASIC and positions the beam to the starting point of the first graphic vector. The next four ASCII characters sent to the display are interpreted as the ending point of the first vector and a vector is immediately drawn to that point on the screen. Each four ASCII characters sent to the display after that represent the end point for a new vector and the vector is drawn immediately after the fourth character is received. In each case, the end point of one vector marks the beginning of the next. This is analogous to executing a series of DRAW statements in BASIC or executing a matrix DRAW.

To break the sequence and move the writing beam to a new location on the screen without drawing a vector, a GS control character must be sent to the display, followed by four ASCII characters representing the coordinates of the new destination point. ASCII characters received after that are then interpreted as the coordinates for a new series of vectors. After the graphics operations are completed, a return to the Alpha submode is accomplished by sending one of the following ASCII characters to the display either from the 4051 keyboard or the Data Communication Interface: CR (CTRL M), US (CTRL RUBOUT or CTRL SHIFT _), or ESC (CTRL [or ESC key) followed by FF (CTRL L).

ADDRESSING POINTS ON THE SCREEN USING ASCII CHARACTERS

As previously stated, each point on the screen is represented by a (Y,X) coordinate pair which is encoded as four ASCII characters, two for the Y coordinate and two for the X coordinate. The ASCII character sequence takes the following form:

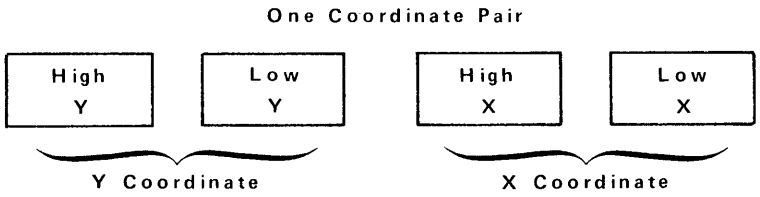

Table 6-5 is a conversion chart which illustrates how to encode a coordinate value into ASCII characters. Assume that you want to address a point on the screen with the coordinates (173,951). The body of the chart contains coordinate values from 0 through 1023. Find the Y value (173) first. It's on the first page of the chart, sixth column (main body), 14th number down. Put your finter on it, then follow the column down to the bottom of the page and note the ASCII character %. This character must be used as the HIGH Y character. Find the number 173 again in the center of the chart, put your finger on it, then follow the row over to the right side of the page. Note the ASCII character m. This character must be used to represent LOW Y.

The X coordinate is next. Look for the number 951 in the main body of the chart (HINT: fourth page, sixth column, 24th number down). Follow the column on down to the bottom of the page and note the ASCII character =. This is the HIGH X character, the third character in the sequence. Find 951 again, follow the row to the left side of the page and note the ASCII character W. This is the LOW X character, the last in the series. The ASCII character equivalent of the coordinates (173, 951) are %m=W, in that order.

Table 6-5
COORDINATE CONVERSION CHART

One Coordinate Pair

High Y	Low Y	High X	Low X
Y Coordinate		X Coordinate	

Low Order X		X or Y Coordinate								Low Order Y	
ASCII	DEC.									DEC.	ASCII
@	64	0	32	64	96	128	160	192	224	96	`
A	65	1	33	65	97	129	161	193	225	97	a
B	66	2	34	66	98	130	162	194	226	98	b
C	67	3	35	67	99	131	163	195	227	99	c
D	68	4	36	68	100	132	164	196	228	100	d
E	69	5	37	69	101	133	165	197	229	101	e
F	70	6	38	70	102	134	166	198	230	102	f
G	71	7	39	71	103	135	167	199	231	103	g
H	72	8	40	72	104	136	168	200	232	104	h
I	73	9	41	73	105	137	169	201	233	105	i
J	74	10	42	74	106	138	170	202	234	106	j
K	75	11	43	75	107	139	171	203	235	107	k
L	76	12	44	76	108	140	172	204	236	108	l
M	77	13	45	77	109	141	173	205	237	109	m
N	78	14	46	78	110	142	174	206	238	110	n
O	79	15	47	79	111	143	175	207	239	111	o
P	80	16	48	80	112	144	176	208	240	112	p
Q	81	17	49	81	113	145	177	209	241	113	q
R	82	18	50	82	114	146	178	210	242	114	r
S	83	19	51	83	115	147	179	211	243	115	s
T	84	20	52	84	116	148	180	212	244	116	t
U	85	21	53	85	117	149	181	213	245	117	u
V	86	22	54	86	118	150	182	214	246	118	v
W	87	23	55	87	119	151	183	215	247	119	w
X	88	24	56	88	120	152	184	216	248	120	x
Y	89	25	57	89	121	153	185	217	249	121	y
Z	90	26	58	90	122	154	186	218	250	122	z
[	91	27	59	91	123	155	187	219	251	123	{
\	92	28	60	92	124	156	188	220	252	124	¦
]	93	29	61	93	125	157	189	221	253	125	}
^	94	30	62	94	126	158	190	220	254	126	~
_	95	31	63	95	127	159	191	223	255	127	RUBOUT (DEL)
DEC. →		32	33	34	35	36	37	38	39		
ASCII →		SP	!	"	#	$	%	&	'		
		High Order X & Y									

Coordinate conversion chart, part 1 of 4. INSTRUCTIONS: Find coordinate value in body of chart; follow that column to bottom of chart to find decimal value or ASCII character which represents the High Y or High X byte; go to the right in the row containing the coordinate value to find the Low Y byte, or go to the left to find the Low X byte. EXAMPLE: 200Y, 48X equals 38 104 33 80 in decimal code, and equals & h ! P in ASCII code.

Table 6-5 (cont)

One Coordinate Pair

High Y	Low Y	High X	Low X
Y Coordinate		X Coordinate	

Low Order X		X or Y Coordinate								Low Order Y	
ASCII	DEC.									DEC.	ASCII
@	64	256	288	320	352	384	416	448	480	96	`
A	65	257	289	321	353	385	417	449	481	97	a
B	66	258	290	322	354	386	418	450	482	98	b
C	67	259	291	323	355	387	419	451	483	99	c
D	68	260	292	324	356	388	420	452	484	100	d
E	69	261	293	325	357	389	421	453	485	101	e
F	70	262	294	326	358	390	422	454	486	102	f
G	71	263	295	327	359	391	423	455	487	103	g
H	72	264	296	328	360	392	424	456	488	104	h
I	73	265	297	329	361	393	425	457	489	105	i
J	74	266	298	330	362	394	426	458	490	106	j
K	75	267	299	331	363	395	427	459	491	107	k
L	76	268	300	332	364	396	428	460	492	108	l
M	77	269	301	333	365	397	429	461	493	109	m
N	78	270	302	334	366	398	430	462	494	110	n
O	79	271	303	335	367	399	431	463	495	111	o
P	80	272	304	336	368	400	432	464	496	112	p
Q	81	273	305	337	369	401	433	465	497	113	q
R	82	274	306	338	370	402	434	466	498	114	r
S	83	275	307	339	371	403	435	467	499	115	s
T	84	276	308	340	372	404	436	468	500	116	t
U	85	277	309	341	373	405	437	469	501	117	u
V	86	278	310	342	374	406	438	470	502	118	v
W	87	279	311	343	375	407	439	471	503	119	w
X	88	280	312	344	376	408	440	472	504	120	x
Y	89	281	313	345	377	409	441	473	505	121	y
Z	90	282	314	346	378	410	442	474	506	122	z
[	91	283	315	347	379	411	443	475	507	123	{
\	92	284	316	348	380	412	444	476	508	124	¦
]	93	285	317	349	381	413	445	477	509	125	}
^	94	286	318	350	382	414	446	478	510	126	~
_	95	287	319	351	383	415	447	479	511	127	RUBOUT (DEL)
DEC. →		40	41	42	43	44	45	46	47		
ASCII →		(	)	*	+	,	—	.	/		
		High Order X & Y									

Coordinate conversion chart, part 2 of 4. (Refer to part 1 for interpretation instructions.)

Table 6-5 (cont)

One Coordinate Pair

High Y	Low Y	High X	Low X
	Y Coordinate		X Coordinate

Low Order X		X or Y Coordinate								Low Order Y	
ASCII	DEC.									ASCII	DEC.
@	64	512	544	576	608	640	672	704	736	`	96
A	65	513	545	577	609	641	673	705	737	a	97
B	66	514	546	578	610	642	674	706	738	b	98
C	67	515	547	579	611	643	675	707	739	c	99
D	68	516	548	580	612	644	676	708	740	d	100
E	69	517	649	581	613	645	677	709	741	e	101
F	70	518	550	582	614	646	678	710	742	f	102
G	71	519	551	583	615	647	679	711	743	g	103
H	72	520	552	584	616	648	680	712	744	h	104
I	73	521	553	585	617	649	681	713	745	i	105
J	74	522	554	586	618	650	682	714	746	j	106
K	75	523	555	587	619	651	683	715	747	k	107
L	76	524	556	588	620	652	684	716	748	l	108
M	77	525	557	589	621	653	685	717	749	m	109
N	78	526	558	590	622	654	686	718	750	n	110
O	79	527	559	591	623	655	687	719	751	o	111
P	80	528	560	592	624	656	688	720	752	p	112
Q	81	529	561	593	625	657	689	721	753	q	113
R	82	530	562	594	626	658	690	722	754	r	114
S	83	531	563	595	627	659	691	723	755	s	115
T	84	532	564	596	628	660	692	724	756	t	116
U	85	533	565	597	629	661	693	725	757	u	117
V	86	534	566	598	630	662	694	726	758	v	118
W	87	535	567	599	631	663	695	727	759	w	119
X	88	536	568	600	632	664	696	728	760	x	120
Y	89	537	569	601	633	665	697	729	761	y	121
Z	90	538	570	602	634	666	698	730	762	z	122
[	91	539	571	603	635	667	699	731	763	{	123
\	92	540	572	604	636	668	700	732	764	|	124
]	93	541	573	605	637	669	701	733	765	}	125
^	94	542	574	606	638	670	702	734	766	~	126
_	95	543	755	607	639	671	703	735	767	RUBOUT (DEL)	127
DEC →		48	49	50	51	52	53	54	55		
ASCII →		0	1	2	3	4	5	6	7		
		High Order X & Y									

Coordinate conversion chart, part 3 of 4. (Refer to part 1 for interpretation instructions.)

Table 6-5 (cont)

One Coordinate Pair

High Y	Low Y	High X	Low X
Y Coordinate		X Coordinate	

Low Order X		X or Y Coordinate								Low Order Y	
ASCII	DEC.									DEC.	ASCII
@	64	768	800	832	864	896	928	960	992	96	`
A	65	769	801	833	865	897	929	961	993	97	a
B	66	770	802	834	866	898	930	962	994	98	b
C	67	771	803	835	867	899	931	963	995	99	c
D	68	772	804	836	868	900	932	964	996	100	d
E	69	773	805	837	869	901	933	965	997	101	e
F	70	774	806	838	870	902	934	966	998	102	f
G	71	775	807	839	871	903	935	967	999	103	g
H	72	776	808	840	872	904	936	968	1000	104	h
I	73	777	809	841	873	905	937	969	1001	105	i
J	74	778	810	842	874	906	938	970	1002	106	j
K	75	779	811	843	875	907	939	971	1003	107	k
L	76	780	812	844	876	908	940	972	1004	108	l
M	77	781	813	845	877	909	941	973	1005	109	m
N	78	782	814	846	878	910	942	974	1006	110	n
O	79	783	815	847	879	911	943	975	1007	111	o
P	80	784	816	848	880	912	944	976	1008	112	p
Q	81	785	817	849	881	913	945	977	1009	113	q
R	82	786	818	850	882	914	946	978	1010	114	r
S	83	787	819	851	883	915	947	979	1011	115	s
T	84	788	820	852	884	916	948	980	1012	116	t
U	85	789	821	853	885	917	949	981	1013	117	u
V	86	790	822	854	886	918	950	982	1014	118	v
W	87	791	823	855	887	919	951	983	1015	119	w
X	88	792	824	856	888	920	952	984	1016	120	x
Y	89	793	825	857	889	921	953	985	1017	121	y
Z	90	794	826	858	890	922	954	986	1018	122	z
[	91	795	827	859	891	923	955	987	1019	123	{
\	92	796	828	860	892	924	956	988	1020	124	¦
]	93	797	829	861	893	825	957	989	1021	125	}
^	94	798	830	862	894	926	958	990	1022	126	~
_	95	799	831	863	895	927	959	991	1023	127	RUBOUT (DEL)
DEC →		56	57	58	59	60	61	62	63		
ASCII →		8	9	:	;	<	=	>	?		
		High Order X & Y									

Coordinate conversion chart, part 4 of 4. (Refer to part 1 for interpretation instructions.)

Normally, graphs are generated by using a computer to send a whole string of ASCII characters to the display via the Data Communication Interface at high speed. It is very impractical to generate a graph by entering ASCII characters from the 4051 keyboard while the system is in the Graphic submode, however, it can be done. Fig. 6-4 shows how a simple graph can be generated by entering ASCII characters from the 4051 keyboard. Study the coordinate values on the display and compare them with the conversion chart to see how they were encoded into ASCII characters. Then, just for fun, enter the ASCII characters from the 4051 keyboard starting with CTRL] as shown in the table below the display diagram, and generate the simple graph. This will give you a feel for how the display responds to ASCII characters in the Graph submode.

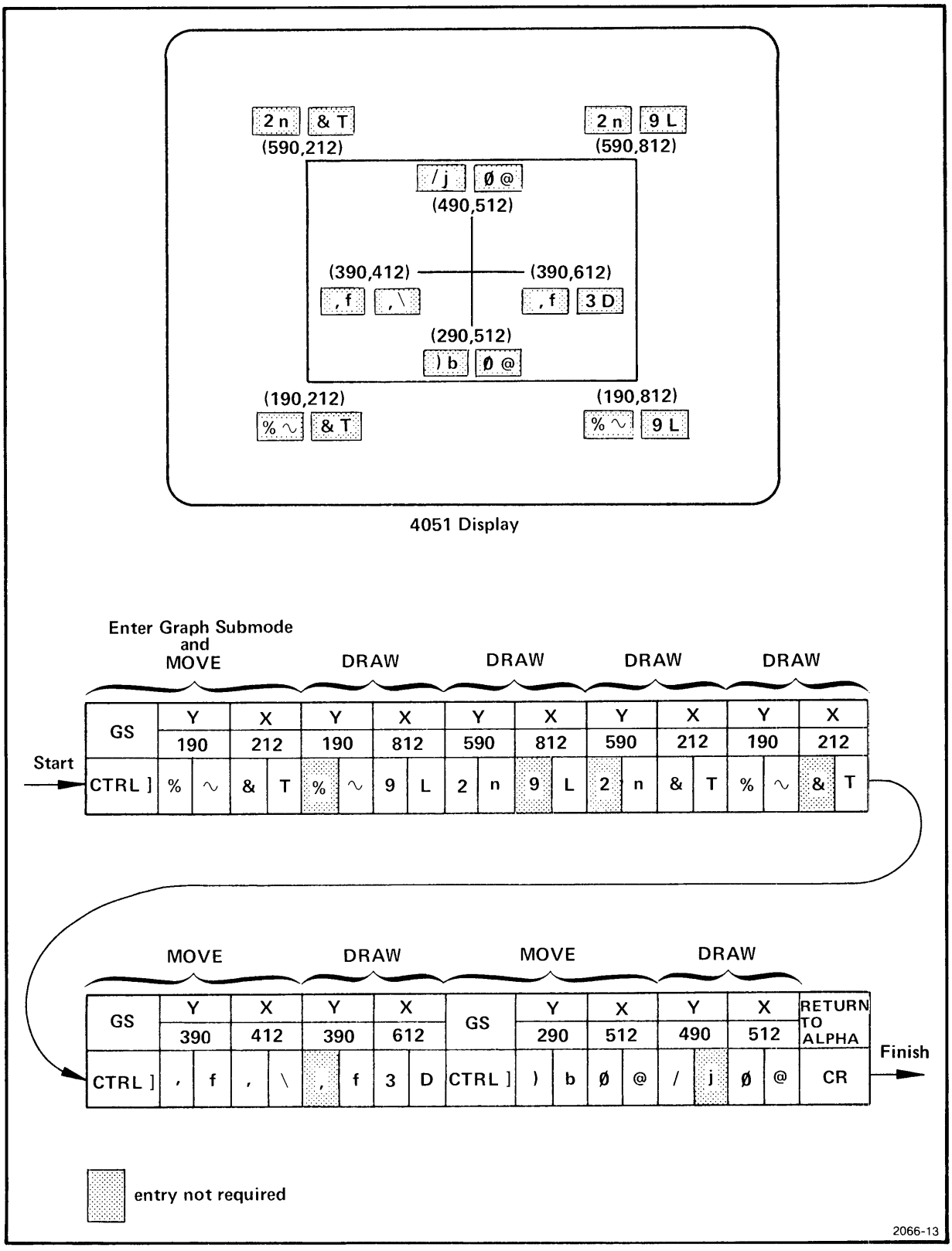

Fig. 6-4. Graph submode example. Enter the ASCII characters in sequential order from the 4051 keyboard to reproduce the graph.

SHORT FORM ADDRESSING

After the first GS command, the initial four bytes of the first address must be sent to the display to specify the starting point for the first vector. Once the starting point is established, some of the characters in the second address do not have to be specified if they do not change. The following rules apply:

1. If LOW X changes, then LOW X needs to be specified in the new address.

2. If HIGH X changes, then LOW Y, HIGH X, and LOW X must be specified in the new address; HIGH Y does not have to be respecified unless it changes.

3. If LOW Y changes, then LOW Y and LOW X must be specified in the new address; HIGH Y and HIGH X do not have to be respecified, unless they change.

4. If HIGH Y changes, then HIGH Y and LOW X must be specified in the new address; LOW Y and HIGH X do not have to be respecified, unless they change.

Fig. 6-5 summarizes these rules.

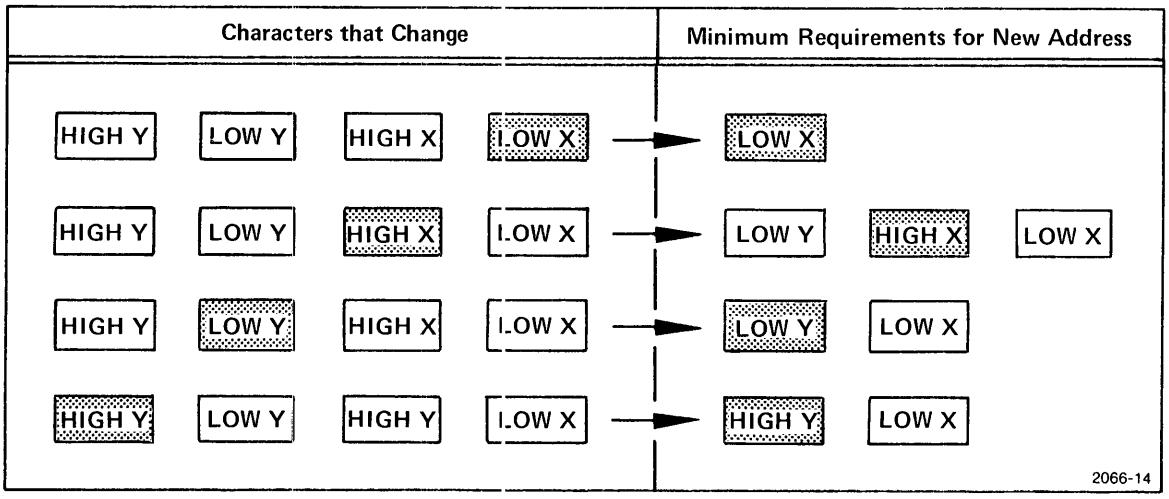

Fig. 6-5. Characters required for Graphic Addressing.

COORDINATE VALUES AND THE CORRESPONDING ASCII CHARACTERS

There is a direct relationship between the decimal value of a graphic coordinate, its binary equivalent, and the ASCII characters used to represent the value. Fig. 6-6 illustrates how the four ASCII characters SPACE RUBOUT SPACE @ are interpreted as the coordinate pair (31,0).

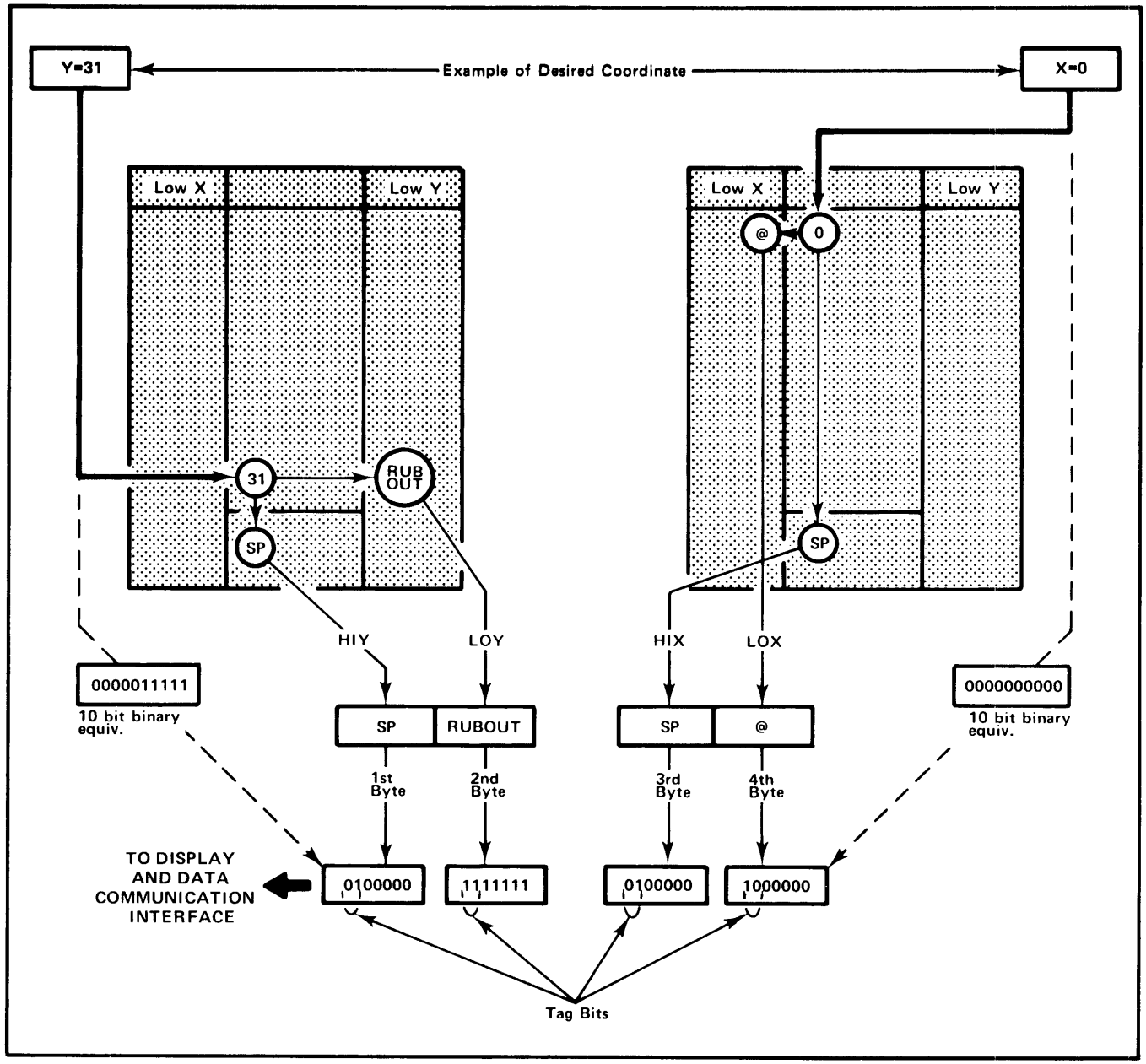

Fig. 6-6. How coordinate values are encoded in ASCII.

Looking first at the Y coordinate 31, the ASCII characters SP (SPACE) and RUBOUT are used to represent this value. The binary numbers representing each character are placed side by side and the two high order bits of each character are stripped off. The 10 bit binary number left over is equivalent to the coordinate value. In this case, the number 0000011111 base 2 is equivalent to 31 base ten. The high order bits in each byte identify the byte. The high order bits in the first byte (01) tell the display that the byte represents the most significant part of the binary number (HIGH Y in this case). The high order bits in the second byte (11) tell the display

that the byte represents the least significant part of the Y coordinate (LOW Y). Looking at the two bytes representing the X coordinate. the high order tag bits are 01 and 10. Even though the tag bits of the third byte are 01 (the same as the first byte) the 4051 knows that this is the HIGH X byte because it follows the LOW Y byte with the tag bits 11. The tag bits for the LOW X byte are unique, however, (10) and the 4051 easily identifies this byte as the LOW X byte. The ASCII characters SPACE and @ are used to represent the coordinate Ø. The tag bits are stripped off and the lower 5 bits of each byte are combined to form one 10 bit binary number. The decimal equivalent of this binary number is the same as the coordinate value Ø, in this case 0000000000_2 is equivalent to $Ø_{10}$.

SUMMARY OF GRAPH SUBMODE CHARACTERISTICS

Table 6-6 summarizes the operating characteristics of the 4051 while operating in Terminal mode — Graph submode.

Table 6-6
GRAPH SUBMODE CHARACTERISTICS

Keyboard	ASCII keys	All 128 ASCII characters can be transmitted from the keyboard and are decoded as graphic coordinates. The TTY LOCK key restricts the set to 96 characters.
	BREAK key	Causes the interface to send a BREAK pulse or BREAK string. (See CALL "BREAK").
	Numeric Pad	Equivalent to the corresponding ASCII symbol keys. ENTER EXP key is the same as an ASCII E.
	User-Definable	#1 NORMAL CONTROL. Control characters are executed or interpreted as Graphic coordinates. #2 ON LINE. The Data Communication Interface is enabled. #3 DATA RECEIVE. Causes a transition to Tape Communications — Data Receive submode. Equivalent to CALL "DTRECV" in BASIC. Returns to Alpha submode upon completion. #4 DATA SEND. Causes a transition to Tape Communications — Data Send submode. Equivalent to CALL "DTSEND" in BASIC. Returns to Alpha submode upon completion.

Table 6-6 (cont)

Keyboard (cont)	User-Definable (cont)	#5 RETURN TO BASIC. Causes a return to the BASIC language mode. The cursor executes a Carriage Return/Line Feed. #6 ECHO ON. Local Echo ON. Characters transmitted from the 4051 keyboard are seen on the 4051 display. #7 Not used. #8 Not used. #9 Not used. #10 Not used.
	User-Definable keys with SHIFT	#11 PRINTED CONTROL CHARACTERS. All ASCII characters, including control characters, are printed on the display instead of being interpreted as graphic coordinates. #12 OFF LINE. The Data Communication Interface is inhibited from transmitting or receiving. (Host computer still connected). #13 FIND FILE. Prints the message "File?" on the screen. When a file number is entered and RETURN is pressed, the file is located on the internal magnetic tape. A return to Graph submode is then executed. #14 PARAMETER LIST. Prints a Data Communication Parameter list on the 4051 Display, then returns to Graph submode. #15 Not used. #16 ECHO OFF. Changes the LECHO parameter to 0 and disables the Local Echo function. Graphics are not displayed on the 4051 screen. #17 Not used. #18 MARGIN 1. Changes the MARG parameter to 1, then returns to Graph submode. (See CALL "MARGIN"). #19 MARGIN/OFF. Changes the MARG parameter to 0, then returns to Graph submode. (See CALL "MARGIN").

Table 6-6 (cont)

Keyboard (cont)	User-Definable keys with SHIFT (cont)	#20 MARGIN 2. Changes the MARG parameter to 2, then returns to Graph submode. (See CALL "MARGIN").
	LINE EDITOR keys	Used only following user-definable key 13 to alter the FIND FILE entry. RECALL LINE and RECALL NEXT LINE are not used.
	AUTO NUMBER key	Not used.
	STEP PROGRAM key	Not used.
	AUTO LOAD key	Not used.
	REWIND key	Causes the internal tape cartridge to rewind to the beginning.
	MAKE COPY key	Causes a hard copy, if a Hard Copy Unit is connected.
Display	Type	Direct View Storage. Straight lines are displayed (vectors). Single intensity.
	Writing Area	7.88 inches (20.02 cm) horizontal; 6 inches (15.24 cm) vertical.
	Addressing	Coordinates are received as a sequence of 4 ASCII characters: High Order Y, Low Order Y, High Order X, Low Order X. Abbreviated addressing possible. Successive points connected by vectors until ASCII GS is received. Points which follow are connected, but disconnected from the previous vector group.
	Resolution	1023 horizontal (X) points by 780 vertical (Y) points. Additional Y points, to 1023, may be addressed but are not seen. Approximately .0077" between successive points (0.2 mm).
	Writing Rate	2.6 ms/vector. 385 vectors/second. Worst case requires 9 characters per vector (GS, 4 characters to specify start of vector, 4 characters to specify end of vector).
	Vector Length Error	$\leq$1% of vector length.
	Vector Geometry	Deviation from prescribed straight line $\leq$1.5% of line length. This is exclusive of the 0.5% Line Straightness specification of the display circuits.

Table 6-6 (cont)

Display (cont)	Dark Vectors	First vector to follow GS is unwritten. GS can be repeated at any time. Second vector and all subsequent vectors following GS are written.	
	Hold & Auto Erase	No hold function, screen retains display at full intensity. The user should return to Alpha by means of RESET or US to re-enable Hold if the display is to be viewed for more than 15 minutes. With no activity for 30 minutes, the screen is PAGED (erased) automatically.	
	Control Character Effect	US or CTRL RUBOUT	A return to Alpha submode is executed. The cursor appears at the current vector coordinates.
		CR RETURN key or CTRL M	A return to Alpha submode is executed. The cursor appears at the left margin, at the current Y coordinate position.
		FF PAGE key or ESC CTRL L	A return to the Alpha submode is executed. Equivalent to a keyboard PAGE.
		ESC SUB or ESC CTRL Z	Causes a transition to the Pointer submode.
		ESC ETB or ESC CTRL W	Causes a hard copy to be taken of the display, if a Hard Copy Unit is connected.
		ESC ENQ or ESC CTRL E	Causes the coordinates of the current beam position to be transmitted.
		Others	No effect.
Indicators	I/O	Indicates that the Data Communication Interface is active.	
	BUSY	Indicates that data is being transferred.	

GIN (Graphic Input) SUBMODE

INTRODUCTION

The GIN submode of Terminal mode allows a host computer to interrogate the 4051 to find out where the graphic point or Alpha cursor is located on the screen. If a GIN operation is performed while the 4051 is in Alpha mode, the coordinates of the lower-left corner of the Alpha cursor are sent to the computer. If a GIN operation is performed while the 4051 is in the Graph submode, then the coordinates of the graphic point are sent to the computer.

Two types of graphic input operations can be performed; pointer input operations and terminal status input operations. Both operations can be executed from either the Alpha submode or the Graph submode.

POINTER INPUT OPERATIONS

If the 4051 is in Alpha submode or Graph submode and the host computer sends the control character sequence ESC SUB, the 4051 enters GIN submode and displays a blinking arrow on the screen. If GINSW = 2 while the pointer is displayed, the keyboard operator has the freedom to move the pointer to any location on the screen by pressing user-definable keys 7, 8, 9, and 10. If GINSW = 1, then rotating a 4952 Joystick positions the pointer. (The Joystick is an optional peripheral device connected to the J40 connector on the 4051 rear panel). After the pointer is positioned to the desired screen location, pressing a keyboard key causes the coordinates of the pointer tip to be transmitted to the host computer. The ASCII character representing the key symbol of the pressed key is sent first, then followed by the coordinates HIGH X, LOW X, HIGH Y, LOW Y, followed by the character string GINTRM as defined in the CALL "GRAFIN" statement. Notice that unlike Graph submode operations, the X coordinates are sent first followed by the Y coordinates.

TERMINAL STATUS OPERATIONS

The other kind of graphic input causes the 4051 to transmit a terminal status byte, followed by the screen coordinates of the graphic point (or the Alpha cursor), followed by the GINTRM character string. This information is transmitted immediately when the 4051 receives the control character sequence ESC ENQ.

Normally the ESC ENQ sequence is transmitted by the host computer to locate the position of the graphic point and to check on the terminal status. This can occur at any time in either Graph submode or Alpha submode. ESC ENQ can also be keyed in from the 4051 keyboard while the 4051 is in Alpha mode to send the terminal status to the computer, but ESC ENQ should not be entered from the 4051 keyboard while the system is in Graph submode, because the ESC ENQ in Graph submode is interpreted as graphic coordinates.

The terminal status byte contains seven bits. Each bit has a pre-defined meaning as outlined in Table 6-7. Normally, the host computer checks each bit to see if the bit is a 0 or a 1, then determines the terminal status on that basis.

Table 6-7
STATUS CHARACTER BIT MEANINGS

Bit	Meaning
7	always 0
6	always 1
5	0 if HCOPY=1 and copier is ready. 1 if HCOPY=0 or copier is not ready.
4	0 if not ready for a Graphic vector. 1 if ready for a Graphic vector.
3	0 if Graph submode is active. 1 if Graph submode is not active.
2	0 if Margin 0 is active. 1 if Margin 1 is active.
1	always 1

If the status byte (and accompanying graphic coordinates) are sent to a line printer, for example, rather than to a host computer, the status byte is printed as an ASCII character. By looking up the ASCII character in an ASCII code chart, the exact bit pattern of the screen byte can be examined and analyzed by a human.

ECHOPLEX SUPPRESSION

Each time the 4051 enters the GIN submode, the 4051 display is prevented from printing data, either graphic or alphanumeric. This feature is called "echoplex suppression" and is implemented to prevent the transmitted screen coordinates from being echoed to the screen where they might spoil the appearance of a graph.

Clearing Echoplex Suppression after a Pointer Operation

When the control character sequence ESC SUB is received from the computer or the 4051 keyboard, the blinking pointer appears on the screen and echoplex suppression is activated. Once the echoplex suppression feature is made active, one of the following control characters must be received by the display to clear the suppression feature:

CR, BELL, HT, VT, US, ESC ETB, or ESC FF

Pressing a keyboard key terminates the pointer operation and the pointer coordinates and the GINTRN string are sent to the host computer. If the pressed key is not one of the above control characters, then echoplex suppression is not cleared unless one of the above control

characters is part of the GINTRM string. To clear echoplex suppression from the keyboard, one of the above control character keys must be pressed; the RETURN key or the TAB key, for example.

Clearing Echoplex Suppression after a Terminal Status Operation

As soon as a host computer sends the control character sequence ESC ENQ to the 4051, echoplex suppression is activated and the 4051 display is prevented from printing additional data. Like a pointer operation, echoplex suppression is not cleared until the display receives a CR, BELL, HT, VT, US, ESC ETB, or ESC FF control character. One of these control characters can be transmitted from the 4051 keyboard after the status request, or if LECHO = 1, one of the above control characters can be embedded in the GINTRM string to clear the echoplex suppression.

NOTE

If CR is embedded in the GINTRM character string and a Graphic Input operation is executed while the 4051 is in Graph submode with LECHO = 1, then an automatic return to Alpha submode occurs when the CR is transmitted to the computer. Echoplex suppression is also cleared when the CR is transmitted.

GRAPHIC INPUT SUBMODE CHARACTERISTICS SUMMARIZED

Table 6-8 summarizes the operating characteristics of the 4051 while operating in Terminal Mode — Graphic Input submode.

Table 6-8
GRAPHIC INPUT SUBMODE CHARACTERISTICS

Keyboard	ASCII keys	Any key pressed causes the coordinates of the pointer to be sent. The coordinates are sent following the character symbol.
	PAGE/RESET key	Causes the screen to be erased and to return to Alpha. With SHIFT, a return to Alpha is executed and the screen is not erased.
	BREAK key	Causes a BREAK pulse or BREAK string to be sent.
	Numeric Pad	Equivalent to the corresponding ASCII symbol keys. ENTER EXP key is the same as an ASCII E.

Table 6-8 (cont)

Keyboard (cont)	User-Definable keys	#1 NORMAL CONTROL. Not used. #2 ON LINE. The Data Communication port is enabled. A return to Alpha submode is executed. #3 DATA RECEIVE. Causes a transition to Tape Communications — Data Receive submode. Equivalent to CALL "DTRECV" in BASIC. Returns to Alpha submode upon completion. #4 DATA SEND. Causes a transition to Tape Communications — Data Send submode. Equivalent to CALL "DTSEND" in BASIC. Returns to Alpha submode upon completion. #5 RETURN TO BASIC. Causes a return to BASIC. The cursor appears at the left margin, one line down from the last pointer coordinates. #6 ECHO ON. Not used. The coordinates sent are not echoed anyway. #7 Advances the pointer down. Wrap around occurs at the bottom of the display. #8 Advances the pointer up. Wrap around occurs at the top of the display. #9 Advances the pointer left. Wrap around occurs at the left margin. #10 Advances the pointer right. Wrap around occurs at the right edge of the display.
	User-Definable keys with SHIFT	#11 PRINTED CONTROL CHARACTERS. Not used. #12 OFF LINE. The Data Communication port is disabled and a return to Alpha submode is executed. (The host computer is still connected.) #13 FIND FILE. Prints the message "File?" on the screen. When a file number is entered and RETURN is pressed, the file is located on the internal magnetic tape. A return to pointer submode is then executed.

Table 6-8 (cont)

Keyboard (cont)	User-Definable keys with SHIFT (cont)	#14 PARAMETER LIST. Causes a listing of all parameter values on the screen. Equivalent to CALL "PRLIST" in BASIC. #15 Not used. #16 ECHO OFF. Not used. The pointer co-ordinates are not echoed anyway. #17 Not used. #18 Not used. #19 Not used. #20 Not used.
	LINE EDITOR	Not used. A return to Alpha submode is advisable to use the FIND FILE feature, when these keys have an effect.
	AUTO NUMBER key	Not used.
	STOP PROGRAM key	Not used.
	AUTO LOAD key	Not used.
	REWIND key	Causes the internal tape cartridge to rewind to the beginning. A return to pointer submode is then executed.
	MAKE COPY key	Causes a hard copy, if a Hard Copy Unit is connected. A return to Alpha submode is executed after the hard copy scan.
Display	Type	Direct View Storage. The pointer appears as a non-storing arrow within the 5X8 Alpha matrix dimensions.
	Pointer Area of Movement	Pointer can be manipulated within the Graph area of 7.88 inches (20.02 cm) horizontal by 6 inches (15.24 cm) vertical, either with a Joyswitch or the user-definable keys.
	Pointer Movement	Controlled by user-definable keys 7, 8, 9, and 10. Alternately controlled by TEKTRONIX 4952 Joyswitch if connected and the GINSW parameter = 1.
	Pointer Accuracy	Coordinates sent are within 0.0077" (0.2 mm) of the pointer tip location.
	Echoplex Suppression	Coordinates sent are suppressed from the 4051 display.
	Control Character Effect	BEL Causes a return to Alpha submode. BS Causes a return to Alpha submode.

Table 6-8 (cont)

Display (cont)	Control Character Effect (cont)	CR	Causes a return to Alpha submode.
		HT	Causes a return to Alpha submode.
		LF	Causes a return to Alpha submode.
		US	Causes a return to Alpha submode.
		VT	Causes a return to Alpha submode.
		ESC FF	Causes a return to Alpha submode.
		ESC ETB	Causes a hard copy, if a Hard Copy unit is connected. A return to Alpha submode is then executed.
		ESC ENQ	Causes the transmission of the Status Character and pointer coordinates (High Order X, Low Order X, High Order Y, Low Order Y) followed by the character string GINTRM. A computer echo of this message should not occur, for the GINTRM string normally is set to restore Alpha. This ESC ENQ sequence should not occur sooner than 20 ms after ESC SUB unless: 1. Only the Y address is required. 2. If the Y address is set prior to receiving the ESC SUB.
		Others	No effect.
Indicators	I/O	Indicates that the Data Communication Interface is active.	
	BUSY	Indicates that a data transfer is in progress.	

PARAMETERS RELATIVE TO TERMINAL MODE

Fig. 6-7 illustrates which environmental parameters have an effect on Terminal mode, and where in the data path the effect occurs.

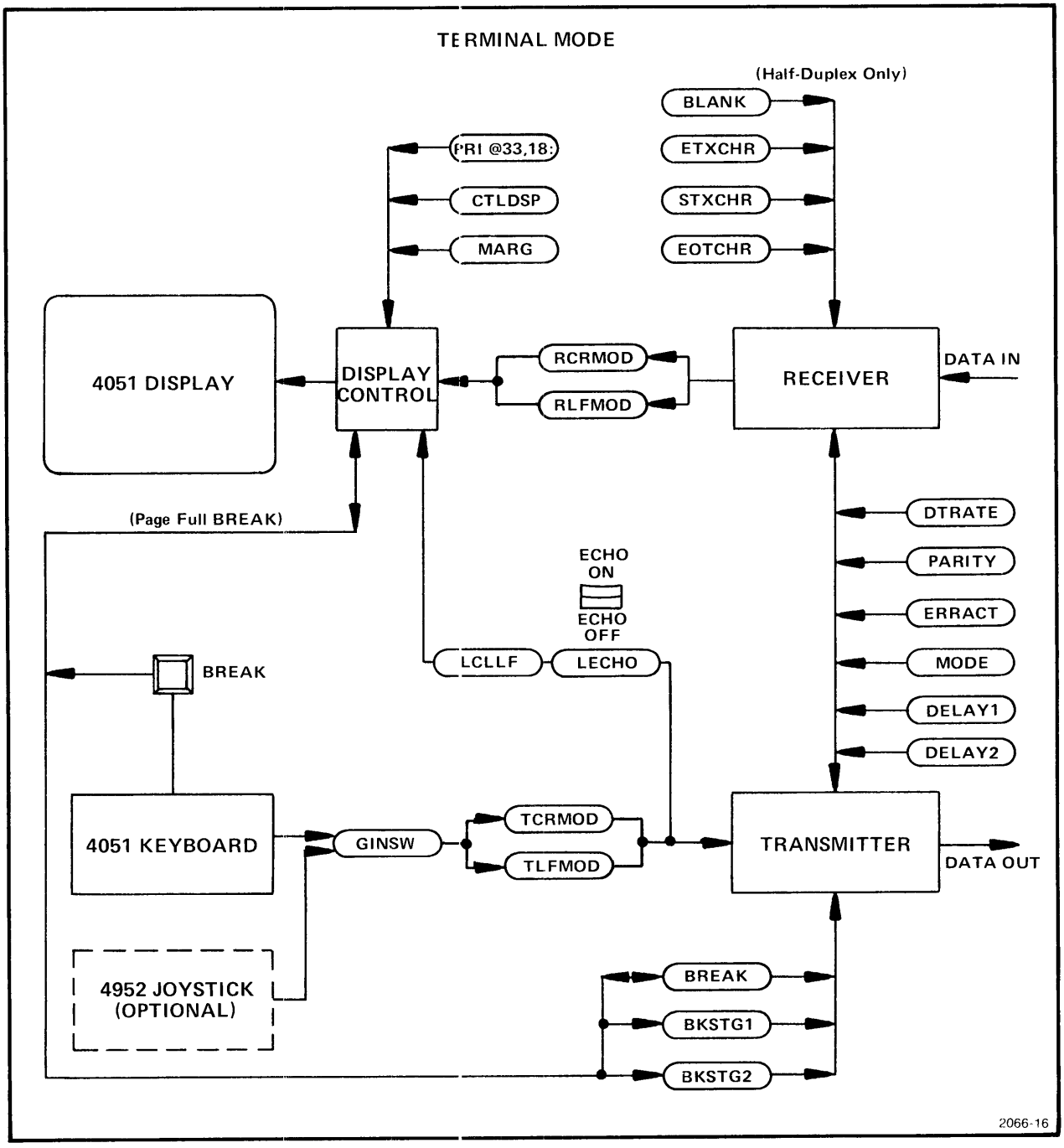

Fig. 6-7. Parameters relative to Terminal mode.

NOTES

Section 7

TAPE COMMUNICATIONS MODE

INTRODUCTION

Entering Tape Communications mode allows data to be transferred between the 4051 internal tape cartridge and an external device via the Data Communication Interface. In this mode, the ASCII keyboard has no effect on operations, except the BREAK key which will be described later. The 4051 display monitors the data flow, but is not useful in this mode except to indicate communication activity.

There are two submodes to Tape Communications, depending on the direction of data flow. In Data Receive submode, incoming data from the external device are recorded on the 4051 internal tape cartridge. In Data Send submode, data are transferred from the tape cartridge to the external device.

DATA RECEIVE SUBMODE

The Data Receive submode is entered from the BASIC Language mode by executing the statement CALL "DTRECV", or from Terminal mode by pressing user-definable key 3 (marked DATA RECEIVE on the overlay). A tape file must be selected prior to entering the Data Receive submode by executing a FIND statement in BASIC or by pressing user-definable key 13 (marked FIND FILE on the overlay) in Terminal mode. (The use of key 13 is described later.)

The flowchart in Fig. 7-1 illustrates the events which occur following an entry into the Data Receive submode.

The 4051 starts the Data Receive operation by transmitting the SNDSTG character string to the external device connected to the data communication line. This character string must be predefined in a CALL "EOLCHR" statement before entering the Data Receive submode and must mean "start sending logical records" to the external device. The external device responds by sending ROPEN which is a character string predefined in the CALL "RSTRING" routine. ROPEN tells the 4051 to prepare to receive an ASCII logical record and to store the record on the internal magnetic tape starting at the present position of the read/write head. (NOTE: ROPEN is "swallowed" by the interface and is not recorded on the tape. The only purpose of ROPEN is to alert the 4051 that a logical record containing valid data is coming over the communication channel next.)

After sending ROPEN, the external device sends the first logical record to the 4051. The 4051 receives the record and places it on the internal tape. The external device then sends the predefined character string RCLOSE (see CALL "RSTRING") to tell the 4051 that the end of the logical record has been reached. The 4051 swallows RCLOSE, then closes the record on the magnetic tape file.

DATA RECEIVE SUBMODE

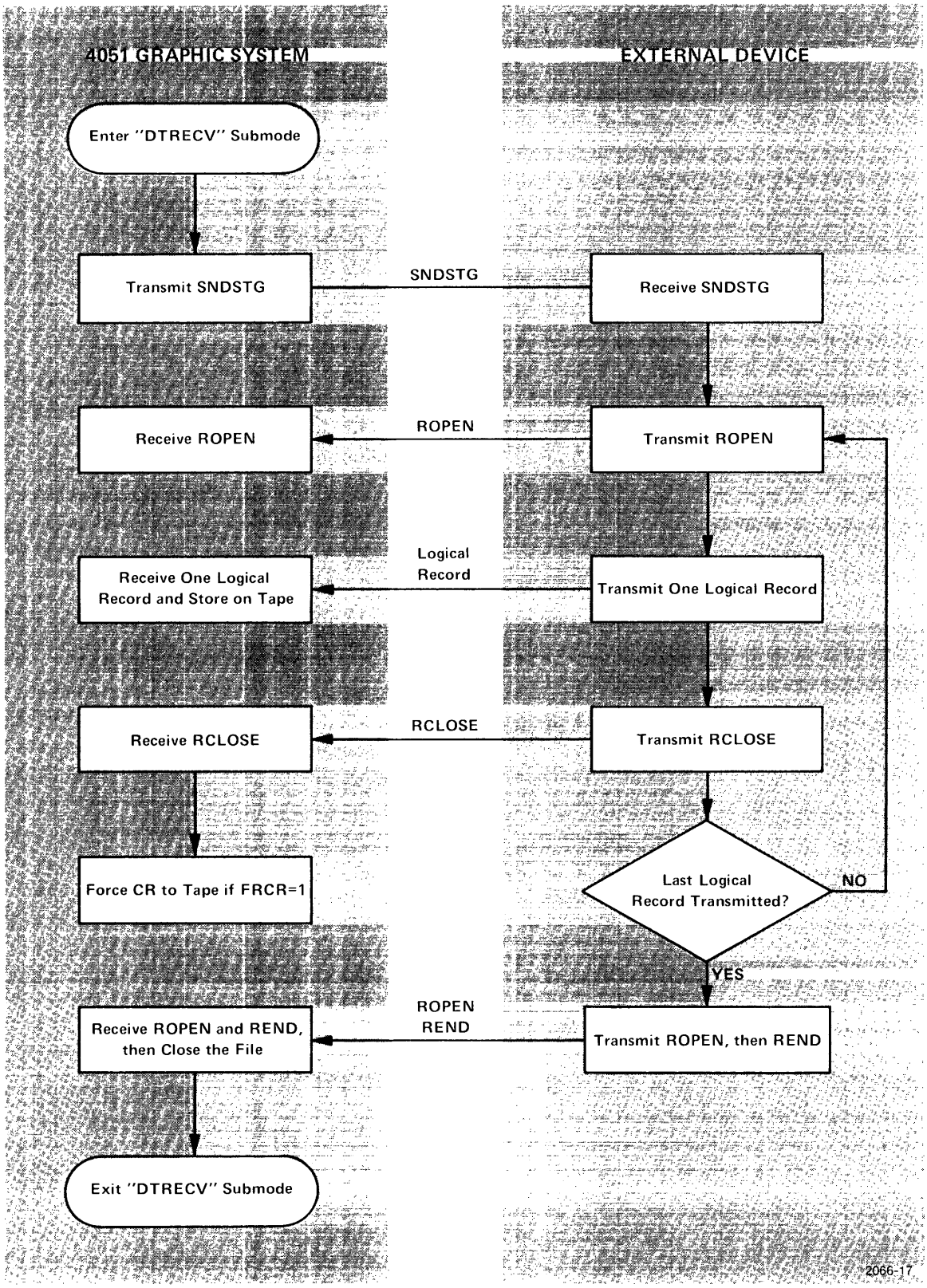

Fig. 7-1. Data Receive submode flow chart.

At this point, the external device can send more logical records to the 4051, or it can terminate the operation by sending the character strings ROPEN and REND, in that order. If more logical records are to be transferred, each record must be preceded by ROPEN and followed by RCLOSE. When all the records are transferred, the sequence ROPEN-REND causes the 4051 to close the magnetic tape file.

NOTE

If RCLOSE=REND, the 4051 does not recognize the ROPEN-REND sequence and the Data Receive operation cannot be terminated without pressing the BREAK key.

Once the file is closed, Tape Communications Data Receive submode is exited. The data stored on the tape may be input during the BASIC language mode via the INPUT statement. If the received data are formatted as a BASIC program, with a line number preceding each record, the OLD statement or APPEND statement can be used to read the program into memory.

Relevant parameters to the Data Receive submode are ROPEN, RCLOSE, REND, FRCR and RCRLF.

THE FRCR PARAMETER

If the FRCR parameter is set to 1 with a CALL "DELAYS" statement, then a CR (Carriage Return) character is written on the tape upon receipt of an RCLOSE string. This is useful in the following case. Suppose the external device sends lines of data, each ending in a CR. If RCLOSE is set to CR, the incoming CR is "swallowed" and a CR is not written on the tape to delimit the logical record. The FRCR parameter allows logical record delimiting by writing a CR to the tape upon receipt of RCLOSE. REND is typically set to a string which is sent by the external device to indicate it is through sending data. FRCR does not write a CR to the tape when REND is sent, however, REND causes the file to be closed by writing the End of File bit pattern (hexidecimal FF) to the tape.

PARAMETERS RELATIVE TO DATA RECEIVE SUBMODE

Fig. 7-2 illustrates which environmental parameters have an effect on a Data Receive operation and where in the data path the effect occurs.

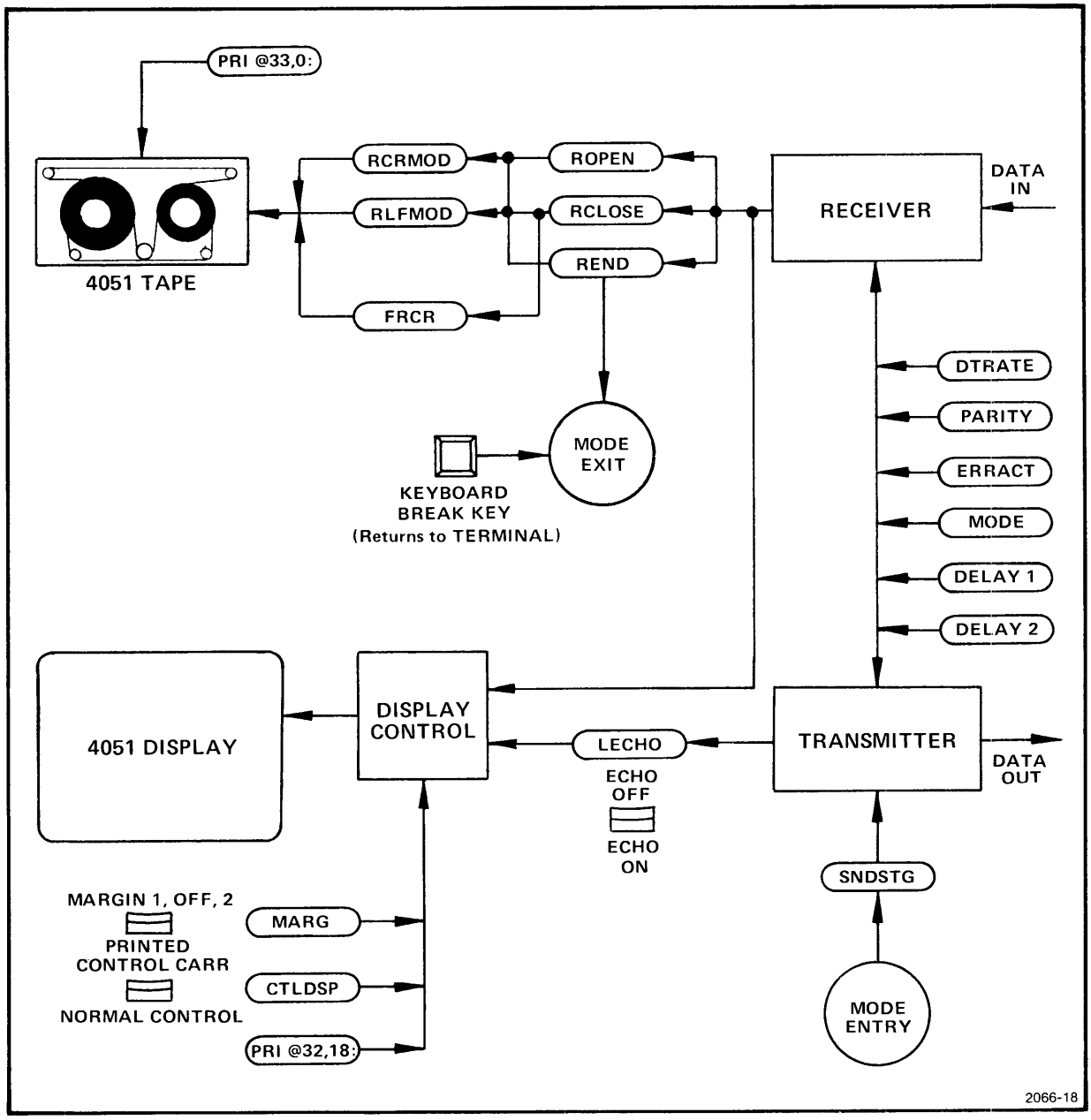

Fig. 7-2. Data Receive submode parameters.

DATA SEND SUBMODE

The Data Send submode is entered from the BASIC language mode by executing the statement CALL "DTSEND", or from Terminal mode by pressing user-definable key 4 (marked DATA SEND on the overlay). As with Data Receive, a tape file on the internal tape cartridge is found first by executing a FIND statement in BASIC, or by pressing user-definable key 13 in Terminal mode (marked FIND FILE on the overlay). The sequence of events outlined in the flowchart (Fig. 7-3) occurs upon entry into the Data Send submode.

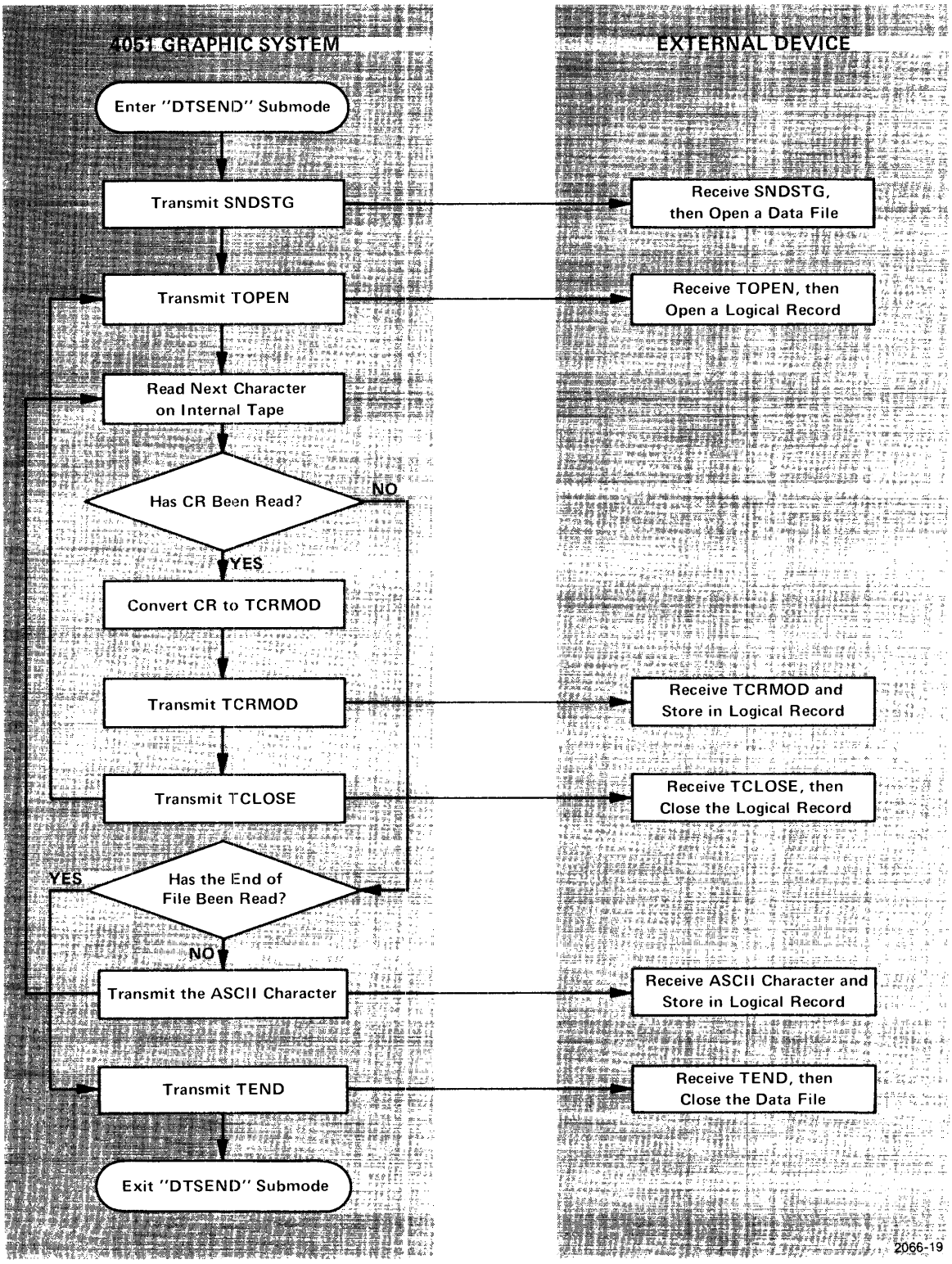

Fig. 7-3. Data Send submode flow chart.

Like Data Receive, the 4051 starts the Data Send operation by sending a predefined character string called SNDSTG to the external device. The external device should interpret this string as meaning "open a data file and prepare to receive logical records containing valid data." Next, the 4051 transmits the character string TOPEN, as defined in a previous CALL "TSTRIN" statement. The external device should interpret TOPEN as "open the first logical record in the current data file and prepare to receive valid data over the RS-232 channel." Immediately following TOPEN, the 4051 starts transmitting the ASCII characters found in the internal magnetic tape file. The characters are transmitted one after another, until a CR character is found. CR is used as the ASCII logical record delimiter, and is treated in the following special way. The CR is either left alone, suppressed, or converted to LF or CR/LF, whichever is specified by the TCRLF parameter, then transmitted to the external device. The 4051 follows this action by transmitting TCLOSE which should be interpreted by the external device as meaning "close the current logical record." The 4051 then transmits TOPEN to open the next logical record on the external data file and the above process is repeated. When the end of the internal tape file is reached, the EOF (End of File) mark on the tape is read, and the 4051 transmits TOPEN, followed by TEND. The external device should interpret this sequence as meaning "close the data file and terminate the data transfer operation." After TOPEN, TEND is transmitted, the 4051 returns to the mode in which it was operating before it entered the Data Send submode.

PROMPTED DATA SEND OPERATIONS

If a Prompted Data Send operation is selected by setting the PMODE parameter to 1 with a CALL "PROMPT" routine, then prompt character(s) are required from the external device (usually from the host computer) to cue the transmission of each logical record from the internal tape. A good example of the prompt operation requirement is the IBM 370 computer in Edit mode. The computer sends a line number and then waits for a line of text from the terminal. This process is repeated over and over for each line of text sent to the computer. The Control Data 6000 series computers typically send a question mark to the terminal to cue the operator for a keyboard entry.

Before using the prompt feature, you should first determine what kind of prompt character (or characters) the computer sends and then set the PCHAR parameter to equal these characters with a CALL "PROMPT" statement. If the computer sends meaningless characters, like NULL characters, before the prompt character(s), then setting ROPEN equal to these characters causes the 4051 to swallow these characters following the prompt sequence. ROPEN and RCLOSE can be set to 10 characters each with a CALL "RSTRIN" statement.

Fig. 7-4 illustrates the sequence of events that occur when the 4051 enters the Prompted Data Send submode. An explanation of these events follow the figure.

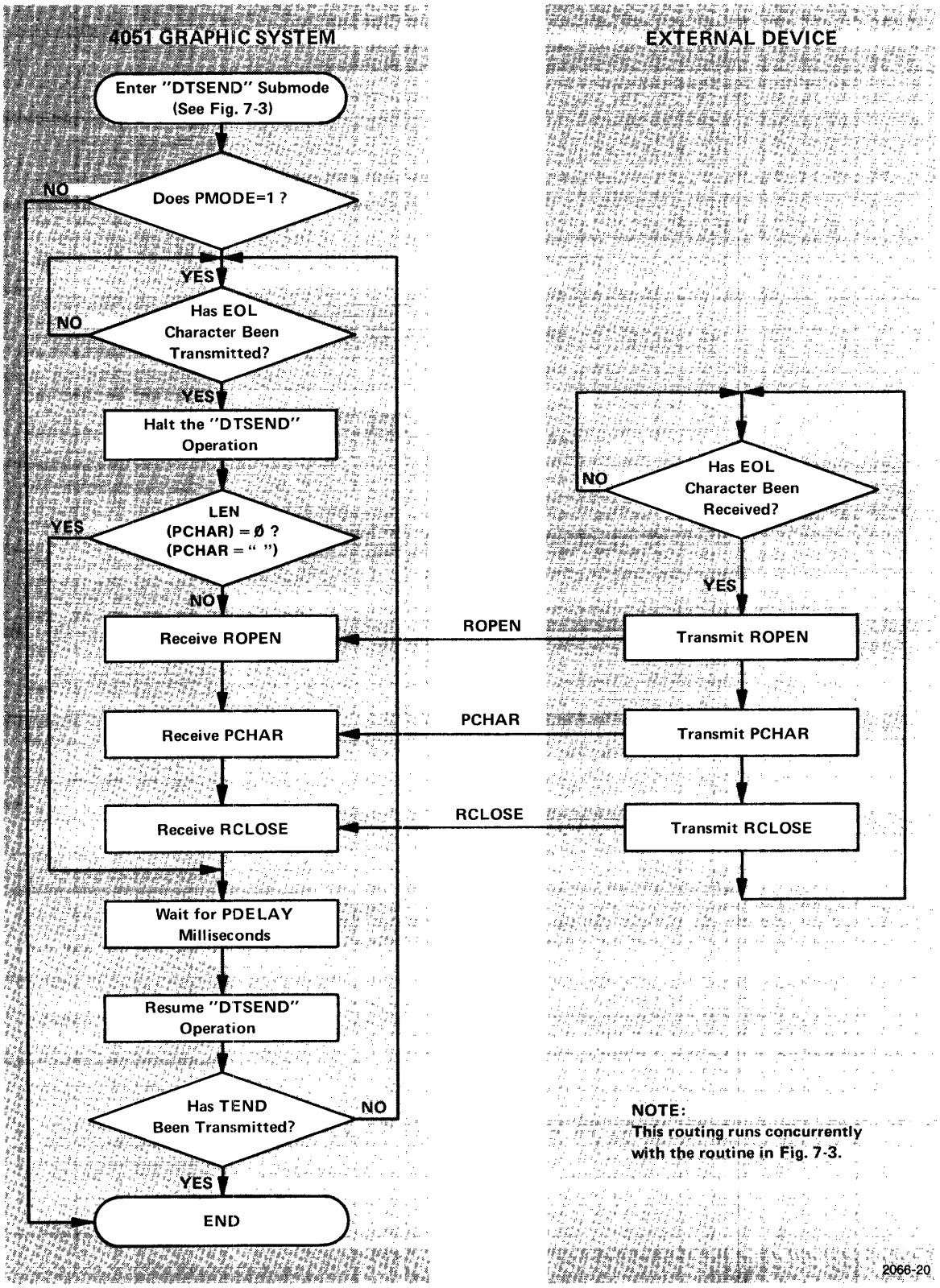

Fig. 7-4. Data Send submode PROMPT routine flow chart.

PROMPTED DATA SEND OPERATIONS

Each time the 4051 enters the Data Send submode, it checks to see if the PMODE parameter is set to 1. If PMODE is set to 1, the prompt routine is activated as shown in Fig. 7-4. If PMODE is set to Ø, the prompt routine is made inactive. It is important to realize that the prompt mode routine runs concurrently with the DTSEND routine shown in Fig. 7-3. They run side-by-side and do not intermingle with each other.

The key to the prompt routine is the transmission of the EOL control character which is specified in a CALL "EOLCHR" statement. As soon as the 4051 enters the Data Send submode and the prompt routine is activated, the prompt routine monitors the data flow for this control character. Each time the EOL character is transmitted by the 4051, the prompt routine halts the Data Send operation and the prompt sequence is started.

Normally, the EOL control character is set equal to CR (decimal 13). This causes the prompt sequence to be executed at the end of each logical record, because CR is used as the logical record delimiter on the internal magnetic tape. The purpose of the prompt feature is to give the external device the time it needs to receive and process a logical record. When it is ready for another logical record, the external device transmits the prompt character(s) back to the 4051, which cues the 4051 to transmit another logical record from the internal tape.

As shown in the flow chart in Fig. 7-4, the Data Send operation stops after the EOL character is transmitted by the 4051. The 4051 then waits for the external device to send ROPEN, followed by PCHAR, followed by RCLOSE, in that order. It is up to the external device to recognize the EOL character as the logical record delimiter and to transmit the ROPEN-PCHAR-RCLOSE character strings as soon as it is ready to receive another logical record. When the 4051 receives RCLOSE, a time period of PDELAY milliseconds is allowed to elapse before the Data Send operation resumes. The PDELAY parameter is specified in a CALL "PROMPT" statement in BASIC before the Data Send submode is entered.

If the external device is unable to transmit a character string before and after the prompt character(s), the ROPEN and RCLOSE strings can be specified as having zero length (i.e., A$=""), and the ROPEN and RCLOSE requirement is eliminated.

Normally, EOL control characters are positioned at the end of each logical record on the tape to cue the prompt sequence after the transmission of logical records. However, it is important to note that the prompt sequence occurs anytime the EOL character is transmitted by the 4051 in the Data Send submode, even if the EOL character appears in the SNDSTG string, the TOPEN string, the TCLOSE string, the TEND string, or in the middle of a logical record.

It is also important to note that no characters are lost from the data stream while operating in prompt mode. The prompt sequence is started immediately after the EOL character is transmitted to the external device. As soon as the prompt requirement is fulfilled, the character immediately following the EOL character in the data stream is the first character transmitted when the Data Send operation resumes.

STARTING THE PROMPT SEQUENCE WITH SNDSTG

Normally, CR (Carriage Return) is the logical record delimiter on the internal tape and the default for EOL and SNDSTG is CR, so the prompt sequence starts as soon as SNDSTG is transmitted to the external device. In some cases, it is necessary to change the SNDSTG string and if a prompt sequence is still desired after the SNDSTG transmission, then it is necessary to concatenate a Carriage Return onto the end of the SNDSTG string before it is specified in a CALL "EOLCHR" statement. For example, the following program changes the SNDSTG string to "OPEN FILEM" while leaving the EOL character and the logical record delimiter set to CR. The CR character at the end of SNDSTG string (represented by the M symbol) causes the first prompt sequence to occur immediately after SNDSTG is transmitted by the 4051.

```
100 INIT
110 A$ =CHR (13)
120 B$="OPEN FILE"
130 C$=B$&A$
140 CALL "EOLCHR" ,13,C$,Ø
150 FIND 2
160 CALL "DTSEND"
170 END
```

PARAMETERS RELATIVE TO THE DATA SEND SUBMODE

Fig. 7-5 illustrates which environmental parameters have an effect on the Data Send operation and where in the data path the effect occurs.

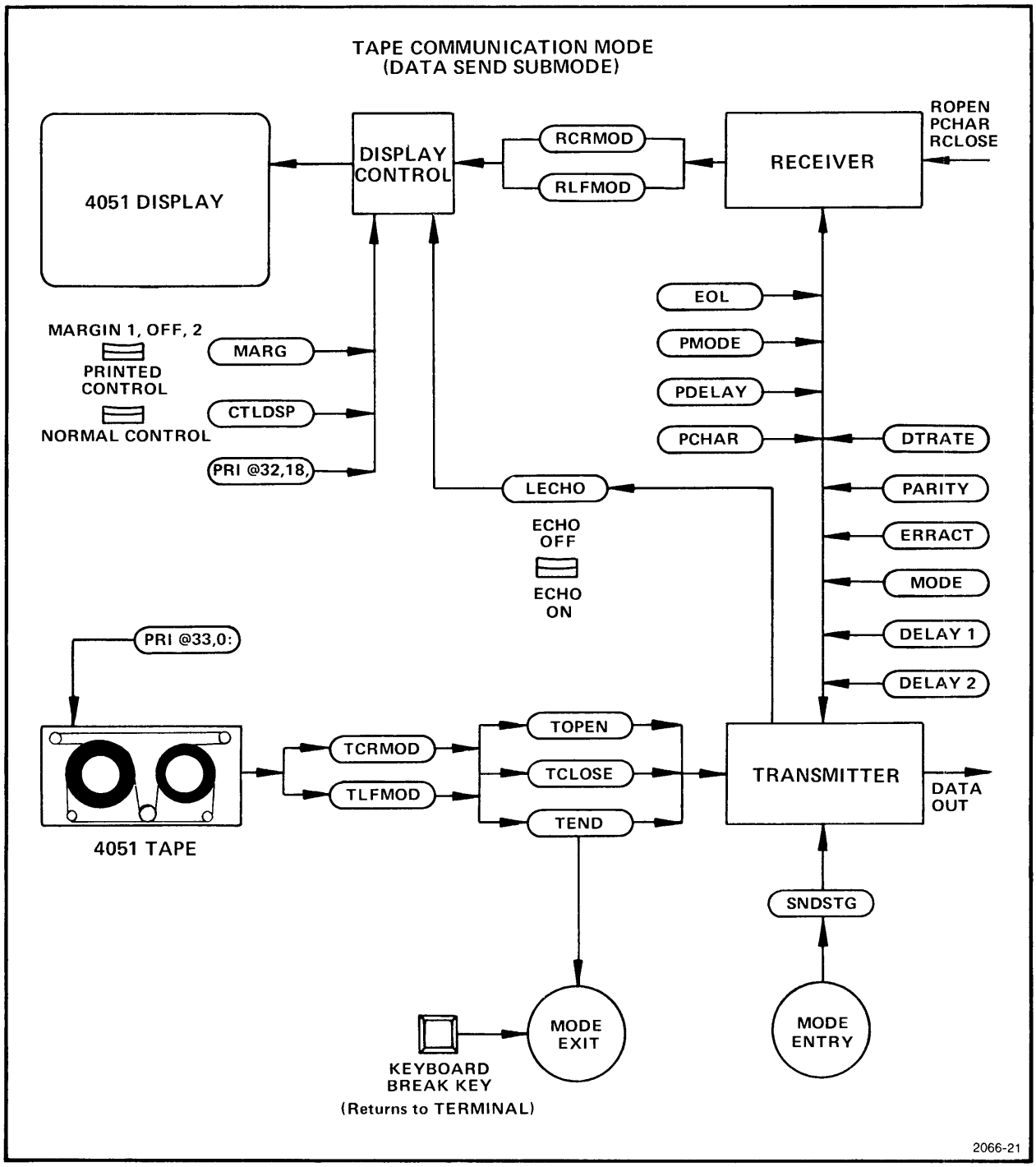

Fig. 7-5. Data Send submode parameters.

TAPE COMMUNICATION MODE CHARACTERISTICS

Table 7-1 summarizes the operating characteristics of the 4051 while in Tape Communications mode.

Table 7-1
TAPE COMMUNICATIONS MODE CHARACTERISTICS

Keyboard	ASCII keys	Not used except for the BREAK key which returns the system to Terminal mode—Alpha submode.
	Other keys	Not used.
Display	Use	Not useful in this mode, except to monitor communicating activity.
Indicators	I/O	Indicates that the Data Communication Interface is active.
	BUSY	Indicates that a data transfer is occurring.
Tape	Type	A 4051 internal tape cartridge, with all normal specifications: 250,000 ASCII character capacity, file format subdivided into logical records, each record terminated by a CR. The file is terminated by a hexidecimal FF.
	Setup	A tape file must be located before entering Tape Communications mode. This is done from BASIC with the FIND statement, or from Terminal mode with user-definable key 13 (marked FIND FILE on the overlay).

NOTES

Section 8

CALL ROUTINES

INTRODUCTION

The CALL statement is a general purpose control statement in the 4051 BASIC language which transfers control to specialized firmware routines not normally found in the standard 4051 operating system. There are 23 special Data Communication Interface routines physically housed in the Data Communication Backpack. These routines are made available to the 4051 operating system when the backpack is installed on the rear panel of the 4051 main chassis. These routines remain inactive, however, until "called" by the CALL statement.

The data communication routines are divided into two groups. The first group contains 11 routines called "utilities." These utilities cause specific interface actions to occur. For example, the "PRLIST" (Parameter List) utility causes the current state of all the interface environmental parameters to be printed on the 4051 display; the "CMINIT" (Communication Initialization) utility returns all the interface environmental parameters to their default power-up values; and the "CMTEST" (Communication Test) utility causes the interface to perform a "self-test." Some routines in the utility group cause dramatic changes in the operating features of the 4051. For example, the "TERMIN" (Terminal) routine causes the 4051 to start acting like a Tektronix 4012 graphic terminal. The 4051's ability to execute BASIC momentarily goes away and doesn't return until the keyboard operator presses user-definable key 5 on the 4051 keyboard.

The second group contains 12 routines which control 36 interface environmental parameters. Each routine controls three parameters. For example, the "RATE" routine controls the data rate parameter (DTRATE), the parity parameter (PARITY), and the communication error action parameter (ERRACT). When the RATE routine is "called" with a CALL statement, these three parameters are set to the values specified in the CALL statement; control is then returned to the 4051 BASIC interpreter. No apparent action may be visible; however the parameter changes do affect all communications operations from that point on. Many times, the only way the keyboard operator can confirm a parameter change is to execute the "PRLIST" (Parameter List) utility which prints the current state of all data communication parameters on the 4051 display.

RULES FOR CALLING UTILITIES

The eleven utility routines in the Data Communication Interface are executed by specifying the "routine name" in a CALL statement as follows:

[Line number] CALL "routine name"

LINE NUMBER

The line number in a CALL statement is an optional entry. If a CALL statement is entered from the 4051 keyboard without a line number and the RETURN key is pressed, the statement is executed immediately. The BASIC interpreter evaluates the statement, then passes control to the specified routine and waits for the routine to finish executing. When the routine is finished executing, control is passed back to the BASIC interpreter, which then monitors the 4051 keyboard for further input. In some cases, the keyboard operator is required to press a key before control is returned to the BASIC interpreter. These special cases are noted in the documentation for that routine.

If a CALL statement is entered with a line number and the RETURN key is pressed, the BASIC interpreter stores the statement in memory as part of the current BASIC program. When the system is placed under program control with a RUN statement, the program is executed starting with the lowest line number in memory. When a CALL statement is found, the BASIC interpreter passes control to the specified data communication routine and waits for the routine to execute. When the routine is finished, control is passed back to the BASIC interpreter, and then to the next statement in the BASIC program.

ROUTINE NAME

The "routine name" in a CALL statement is a label Tektronix has preassigned to each routine in the Data Communication Interface. The routine name is a character string from zero to six characters in length and must be specified exactly as shown in this manual. The only exception to this rule is that lowercase letters can be substituted for upper-case letters. For example, CALL "PRLIST", CALL "prlist", and CALL "PrLiSt" all appear to be the same to the BASIC interpreter.

A routine name can be specified as a string constant enclosed in quotation marks after the keyword CALL, or assigned to a string variable and specified as a string variable after the keyword CALL. For example:

```
100 CALL "CMINIT"
110 PAGE
120 A$="PRLIST"
130 CALL A$
```

Line 100 illustrates how the routine called CMINIT (Communication Initialization) is specified as a string constant in a CALL statement and executed under program control. When CMINIT finishes executing, control is returned to the BASIC interpreter, which then executes the PAGE command in line 110, then assigns the routine name "PRLIST" to A$ is line 120. The BASIC interpreter then executes the CALL statement in line 130 and passes control to the PRLIST (Parameter List) routine. When PRLIST is finished executing, control is returned to the BASIC interpreter and the program is ended. Lines 120 and 130 illustrate how a routine name can be assigned to a string variable and specified as a string variable in a CALL statement.

Table 8-1 is a list of all the utilities in the Data Communication Interface and how they are specified in a CALL statement. The meaning of mnemonic used for the routine name is given in Table 8-3.

RULES FOR CALLING ENVIRONMENTAL PARAMETER ROUTINES

Environmental parameter routines are called the same as utility routines except that three environmental parameters must be specified after the routine name. The following form illustrates the syntax to be used when calling an environmental parameter routine:

[Line Number] CALL "routine name", parameter 1, parameter 2, parameter 3

Each environmental parameter is specified as either a character string or a numeric expression, depending on the nature of the routine. The routine name and the parameters are all separated by commas, as shown in the syntax form. In general, parameters which are specified as a character string must be from zero to ten characters in length and can be specified as a string constant enclosed in quotation marks or assigned to a string variable and specified as a string variable. Parameters which are specified as numeric expressions must be specified in such a way that they can be reduced to a numeric constant and rounded to an integer within a given range (normally between 0 and 7). Each integer within the range represents a parameter choice. The exact meaning of an integer varies from routine to routine and is defined in the explanation section for each particular routine following this introduction.

Table 8-1
CALL STATEMENT UTILITIES

UTILITY	CALL STATEMENT	PURPOSE
Communication Initialization	CALL "CMINIT"	Returns all interface environmental parameters to their default "power-up" values.
Communications Set	CALL "CMSET"	Sets up conditions which prepare the interface for a mode change after one or more environmental parameters are changed with a CALL statement.
Communication Test	CALL "CMTEST"	Causes the interface to perform a "self-test." A special plug adapter and cable is required.

Table 8-1 (cont)

Communication Error	CALL "COMERR",A	Records the number of communication errors which occur during a transmission and assigns the total to A.
Data Receive Submode	CALL "DTRECV"	Places the interface into the Data Receive submode of Tape Communication Mode.
Data Send Submode	CALL "DTSEND"	Places the interface into the Data Send submode of Tape Communication Mode.
Parameter List	CALL "PRLIST"	Prints the current value of all interface parameters on the 4051 display.
Terminal Mode	CALL "TERMIN"	Places the interface in Terminal Mode.

NOTE: The three utilities ECHO, FIND, and LINE are executed by pressing user-definable keys. Refer to the Data Communication Overlay explanation.

SPECIAL PARAMETER MNEMONICS USED IN THIS MANUAL

To simplify references to environmental parameters in this manual, each parameter has been assigned a special mnemonic name from four to six characters in length. These mnemonic names are similar to routine names; however, they are not enclosed in quotation marks, and thus they can be distinguished from routine names. For example:

[Line number] CALL "RATE", DTRATE, PARITY, ERRACT

This is the syntax description for the "RATE" routine when it is specified in a CALL statement. The first parameter controls the data rate for communications over the RS-232 line and is appropriately labeled DTRATE, meaning Data Rate. The second parameter controls the data format which is used by the interface during a transmission. Eight format selections are available which determine even or odd parity (among other things); therefore, this parameter is referred to as the PARITY parameter. The third parameter determines what action the interface takes when a communication error occurs during a transmission. This parameter is called the ERRACT (Error Action) parameter.

It is important to remember that these parameter mnemonic names are for reference use only in this manual, and should never be entered into the 4051 as part of a CALL statement. In the above example, the DTRATE (Data Rate) parameter must be specified as 110, 150, 300, 600, 1200, or 2400 (baud). The PARITY parameter must be specified as an integer from 0 through 7, and the ERRACT (Error Action) parameter must be specified as an integer from 0 through 2. Each integer represents a separate data format or a separate action the interface can take when communication errors occur during a transmission. Again, the details on what each integer means for a particular parameter are given in the explanation of the CALL routine following this introduction.

ALL THREE PARAMETERS MUST BE SPECIFIED IN A CALL STATEMENT

In most cases, you'll want to change only one or two parameters at a time with a particular CALL statment. Each environmental routine, however, controls three environmental parameters and all three parameters must be specified in the CALL statement, whether they are changed or not. For example, assume that you want to change the data rate (DTRATE) from 300 to 2400 baud and you want to leave the PARITY parameter and the ERRACT parameter the same. In the CALL statement, the PARITY parameter and the ERRACT parameter must still be restated using the current values. If you don't know the current values, execute a CALL "PRLIST" statement and the values will be displayed on the 4051 display.

Assuming that the PARITY parameter is currently 0 and the ERRACT parameter is 2, the following is the appropriate CALL statement to change the data rate from 300 to 2400 baud:

```
CALL "RATE", 2400,0,2
```

After this statement is executed, either directly from the 4051 keyboard or under program control, the data rate is changed to 2400 baud; the PARITY and ERRACT parameters remain the same, and control is returned to the BASIC interpreter. If a return from Terminal Mode was just executed in order to make this change, a CALL "CMSET" statement must be executed before re-entering Terminal Mode.

Table 8-2 is an alphabetical list of the environmental routines and the parameters they control. The meaning of each parameter mnemonic is given in Table 8-3. The values which can be specified for each parameter are given in the routine explanations which follow Table 8-3.

Table 8-2

ENVIRONMENTAL PARAMETER ROUTINES

[Line number] CALL "BLKCHR",	STXCHR,	ETXCHR,	EOTCHR
[Line number] CALL "BREAK",	BKACT,	BKSTG1,	BKSTG2
[Line number] CALL "DELAYS",	DELAY1,	DELAY2,	FRCR
[Line number] CALL "EOLCHR",	EOL,	SNDSTG,	BLANKE
[Line number] CALL "GRAFIN",	GINTRM,	GINSW,	HCOPY
[Line number] CALL "MARGIN",	MARG,	MODE,	LECHO
[Line number] CALL "PROMPT",	PMODE,	PDELAY,	PCHAR
[Line number] CALL "RATE",	DTRATE,	PARITY,	ERRACT
[Line number] CALL "RCRLF",	RCRMOD,	RLFMOD,	CTLDSP
[Line number] CALL "RSTRIN",	ROPEN,	RCLOSE,	REND
[Line number] CALL "TCRLF",	TCRMOD,	TLFMOD,	LCLLF
[Line number] CALL "TSTRIN",	TOPEN,	TCLOSE,	TEND

Table 8-3

MNEMONICS LIST

MNEMONIC	MEANING
BAUD	Baud Rate Parameter
BKSTG1	Break String Number 1 Parameter
BKSTG2	Break String Number 2 Parameter
BKACT	Break Action Parameter
BLANKE	Blank Enable Parameter
"BLKCHR"	Blanking Characters Routine
"BREAK"	Break Action Routine
"CMINIT"	Communication Initialization Utility
"CMSET"	Communications Set Utility
"CMTEST"	Communications Test Utility
"COMERR"	Communications Error Utility
CTLDSP	Control Characters Displayed Parameter
"DELAYS"	Delays Routine
DELAY1	Delay Number 1 Parameter
DELAY2	Delay Number 2 Parameter
"DTRECV"	Data Receive Submode Utility
"DTSEND"	Data Send Submode Utility
ECHO	Echo Utility
EOL	End of Line Character Parameter
"EOLCHR"	End of Line Character Routine
EOTCHR	End of Transmission Character Parameter

Table 8-3 (cont)

MNEMONIC	MEANING
ERRACT	Error Action Parameter
ETXCHR	End of Text Character Parameter
FIND	Find Tape File Utility
FRCR	Force Carriage Return to Tape Parameter
GINTRM	Graphic Input Terminator Parameter
GINSW	Graphic Input Switch Parameter
"GRAFIN"	Graphic Input Routine
HCOPY	Hard Copy Unit Parameter
LCLLF	Local Line Feed Parameter
LECHO	Local Echo Parameter
LINE	Line Utility
"MARGIN"	Margin Routine
MARG	Margin Location Parameter
MODE	Communications Mode Parameter
PARITY	Parity Parameter
PCHAR	Prompt Character Parameter
PDELAY	Prompt Delay Parameter
PMODE	Prompt Mode Parameter
"PRLIST"	Parameter List Utility
"PROMPT"	Prompt Routine
"RATE"	Baud Rate and Data Format Routine
RCLOSE	Receive Close String Parameter
"RCRLF"	Receive Carriage Return and Line Feed Routine
RCRMOD	Receive Carriage Return Modification Parameter
REND	Receive End String Parameter
RLFMOD	Receive Line Feed Modification Parameter
ROPEN	Receive Open String Parameter
"RSTRIN"	Receive String Routine
SNDSTG	Send String Parameter
STXCHR	Start of Text Character Parameter
TCLOSE	Transmit Close String Parameter
"TCRLF"	Transmit Carriage Return and Line Feed Routine
TCRMOD	Transmit Carriage Return Modification Parameter
TEND	Transmit End String Parameter
"TERMIN"	Terminal Mode Utility
TLFMOD	Transmit Line Feed Modification Parameter
TOPEN	Transmit Open String Parameter
"TSTRIN"	Transmit String Routine

RULES FOR CALLING ENVIRONMENTAL PARAMETER ROUTINES

CALL "BLKCHR"

Syntax: [Line number] CALL "BLKCHR", STXCHR, ETXCHR, EOTCHR

STXCHR (Start of Text Character)

Comm. Modes:	Half Duplex with Blanking.
Interface Modes:	Terminal.
Parameter Values:	0 to 127
Meaning:	This parameter specifies the ASCII decimal equivalent of a character which when received with blanking set, (see CALL "EOLCHR") enables the 4051 Data Comm. receiver to receive data from the RS-232 channel. Initially, the receiver is disabled.
Default Value:	2

ETXCHR (End of Text Character)

Comm. Mode:	Half Duplex with Blanking.
Interface Modes:	Terminal.
Parameter Values:	0 to 127
Meaning:	This parameter specifies the ASCII decimal equivalent of a character which when received with blanking set, disables the 4051 Data Comm. Receiver.
Default Value:	3

EOTCHR (End of Transmission Character)

Comm. Modes:	Half Duplex with Blanking.
Interface Modes:	Terminal.
Parameter Values:	0 to 127
Meaning:	Same as EXTCHR; used as an alternate End of Text Character.
Default Value:	4

CALL "BLKCHR"

CALL "BREAK"

Syntax: [Line number] CALL "BREAK", BKACT, BKSTG1, BKSTG2

BKACT (Break Action)

Comm. Modes: All (limited in Half Duplex).
Interface Modes: Terminal.
Parameter Values: 0,1,2,3,4,5,6,7
Meaning: A BREAK condition can be initiated by a pageful condition (i.e. more than 35 lines with MARG=1 or more than 70 lines with MARG=2). or by pressing the keyboard BREAK key. The BKACT parameter determines the effect a BREAK condition has on the system. A BREAK signal can be sent as a 350 msec spacing pulse on the RS-232 Transmitted Data signal line. This can occur only in Full Duplex communication. Alternatively, but also only in Full Duplex mode, a character string can be sent as specified by the second parameter "BKSTG1". When the BREAK is caused by a screen pageful condition, a second string "BKSTG2" can be sent after the screen is paged (erased) or after the cursor is reset (keyboard PAGE). Unless Local Echo is disabled, both BKSTG1 and BKSTG2 are echoed to the display. Finally, a hard copy may be made of the screen contents and then an automatic PAGE is performed. This function, Hard Copy and Auto Page, can occur only when a Tektronix 4631 or 4610 Hard Copy Unit is connected to the 4051 and its' presence indicated with the CALL "GRAFIN" statement.

Value	Effect			
	BREAK Signal as 350 msec pulse?	"BKSTG1" Sent?	"BKSTG2" Sent?	Hard Copy & Auto Page?
0	no	no	no	yes
1	yes	no	no	no
2	yes	no	no	yes
3	yes	no	yes	no
4	yes	no	yes	yes
5	no	yes	yes	no
6	no	yes	yes	yes
7	no	no	no	no

Default Value: 1

BKSTG1 (Break String 1)

Comm. Modes:	Full Duplex.
Interface Modes:	Terminal.
Parameter Values:	This parameter specifies an ASCII character string from zero to ten characters in length.
Meaning:	The specified character string is sent when a BREAK condition occurs and BKACT is enabled. The character string should be acknowledged by the computer as a command to interrupt the transmission. As a special feature, when "BKSTG1" = "GE", and BKACT = 1,2,3, or 4, then a BREAK condition causes two BREAK signals to be transmitted separated by 1 second. This is a requirement for interrupting the transmission on GE (Honeywell) 6000-Series computers.
Default Value:	@ (NUL)

BKSTG2 (Break String 2)

Comm. Mode:	All.
Interface Modes:	Terminal
Parameter Values:	An ASCII character string from zero to ten characters in length.
Meaning:	The character string is sent after a pagefull break is cleared by a PAGE or RESET command, or after an Auto Page is performed. This parameter is enabled only when BKACT is set to 3,4,5 or 6. This character string should tell the computer to resume the transmission.
Default Value:	@ (NUL)

CALL "CMINIT"

Syntax: [Line number] CALL "CMINIT"

This utility causes all communication parameters to be set to their default (power-up) values as shown below:

ROUTINE	PARAMETER	VALUE
"RATE"	BAUD	300 (Baud)
	PARITY	0 (7+even+1)
	ERRACT	2 (count)
"TSTRIN"	TOPEN	@ (NUL)
	TCLOSE	S (DC3)
	TEND	D (EOT)
"RSTRIN"	ROPEN	R (DC2)
	RCLOSE	T (DC4)
	REND	D (EOT)
"TCRLF"	TCRMOD	1 (CR→CR)
	TLFMOD	2 (LF→LF)
	LCLLF	0 (no local LF)
"RCRLF"	RCRMOD	1 (CR→CR)
	RLFMOD	2 (LF→LF)
	CTLDSP	0 (act on ctrl chars)
"MARGIN"	MARG	0 (far left, no pagefull)
	MODE	0 (full duplex)
	LECHO	1 (echo on)

ROUTINE	PARAMETER	VALUE
"PROMPT"	PMODE	0 (disable)
	PDELAY	200 (msec)
	PCHAR	Q (DC1)
"BREAK"	BKACT	1 (signal only)
	BKSTG1	@ (NUL)
	BKSTG2	@ (NUL)
"GRAFIN"	GINTRM	MD (CR,EOT)
	GINSW	2 (keys)
	HCOPY	1 (HCU present)
"DELAYS"	DELAY1	200 (msec)
	DELAY2	1000 (1 sec)
	FRCR	1 (CR forced)
"EOLCHR"	EOL	13 (CR)
	SNDSTG	M (CR)
	BLANK	0 (none)
"BLKCHR"	STXCHR	2 (STX)
	ETXCHR	3 (ETX)
	EOTCHR	4 (EOT)

CALL "CMSET"

Syntax: [Line number] CALL "CMSET"

This utility sets communication parameters and is used always before BASIC I/O operations (e.g. PRINT @40:A$) and after a change in one or more parameters in all interface modes.

CALL "CMTEST"

Syntax: [Line number] CALL "CMTEST"

The "CMTEST" utility causes a self-test to be performed on the Data Communication Interface and the modem interconnect cable when the self-test adapter is plugged into the modem cable. The other end of the modem cable must be plugged into the J93 connector on the rear panel of the data communication housing. The self-test adapter is included as a standard accessory to the interface and looks like an RS-232-C connector plug without a cable. The modem interconnect cable is also included as a standard accessory and is part numbered 012-0689-00.

SELF-TEST INSTRUCTIONS

1. Remove the RS-232 connector and cable (if any) from the J93 connector on the Data Communication Interface housing.

2. Plug one end of the modem interconnect cable (012-0689-00) into the J93 connector on the Option 1 housing.

3. Plug the self-test adapter onto the other end of the modem cable.

4. Apply power to the 4051 (if power is not already applied) and place the system in the BASIC language mode of operation.

5. Enter the BASIC statement CALL "CMTEST" from the 4051 keyboard and press RETURN.

EXPECTED RESULTS

(a) There are three parts to the test. In the first part, the RS-232 control lines are tested for proper operation. The 4051 screen pages (erases) and the message "Control Line" is printed in the upper-left corner of the screen as shown in Fig. 8-1. The interface is now performing a test on the RS-232 control lines. If an error occurs in the test, the test data will be printed on the screen along with the word ERROR. (Only qualified Tektronix Personnel can interpret the data to find the source of the error). The RETURN key must be pressed to continue the test.

(b) After the Control Line test is finished, the Data Line (pin 3) is tested. The message "Data Line" is printed on the screen underneath the message "Control Line", and the test is started.

To test the Data Line, all 128 ASCII characters are transmitted starting with NULL (Decimal 0) an ending with RUBOUT (Decimal 127). The characters are transmitted to the self-test adapter and are returned to the 4051 display. Every character symbol is printed except for CR (Carriage Return) which is executed instead of printed. The results are shown in Fig. 8-1.

If a transmission error occurs during the test, the word ERROR is printed on the screen and the system goes on to the baud rate calibration test.

(c) The third part of the self-test allows the baud rate to be checked on pin 3 of the RS-232 connector. The message "pin#3 for (BAUD RATE)/2" is printed on the screen. The interface then generates a 50% duty cycle square wave on pin 3 of the J93 connector. The frequency of the square wave is 1/2 the selected baud rate. For example, if the baud rate is set to 2400 with a CALL "RATE" statement, then the square wave frequency should be 1200 Hz. If the frequency is not 1200 Hz, then the calibration trim pot on the bottom of the interface housing should be adjusted until the frequency is 1200 Hz.

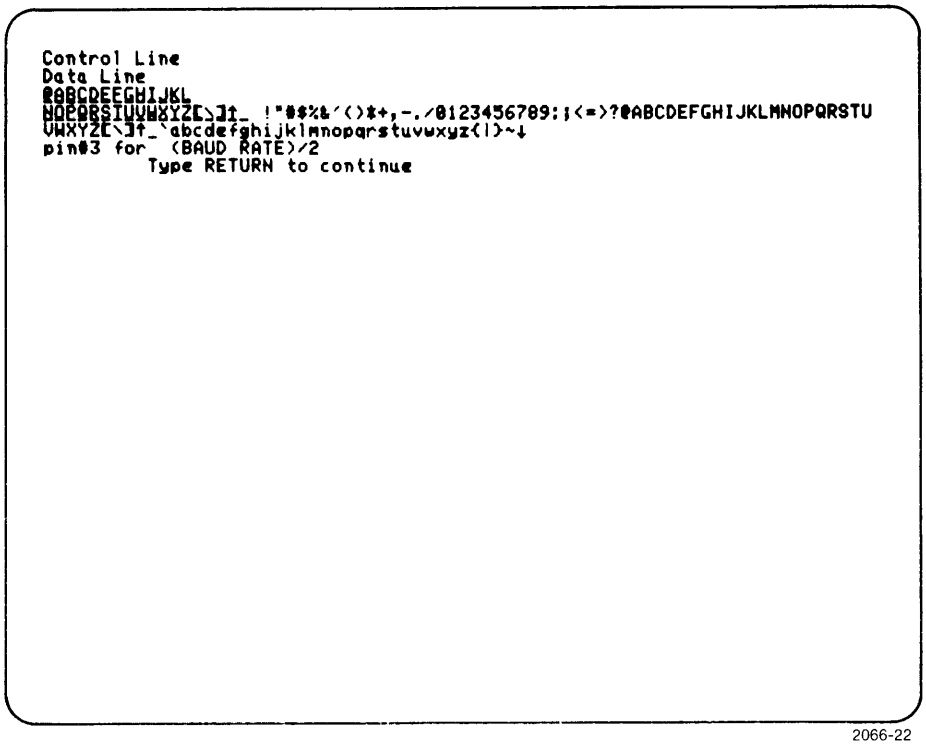

Fig. 8-1. Self-Test Results When No Errors Occur.

BAUD RATE ADJUSTMENT PROCEDURE

It is important that the baud rate accuracy be within 1% of the DTRATE parameter selection. The interface is calibrated when it leaves the factory and should not have to be recalibrated under normal circumstances. However, in those cases when recalibration is necessary, the following calibration guidelines shoulc be followed.

If you are having trouble with the interface, check everything else before you check the calibration. The baud rate calibration is the least likely source of trouble. Never turn the calibration trim pot at random, just to see what happens. And never attempt to calibrate the baud rate without the proper test equipment.

Calibrating the interface at 2400 baud also calibrates the 150,300, and 1200 baud selections. All of these baud rate frequencies track together because they are even multiples of each other. The 110 baud selection will generally be within the 2% tolerance when the interface is calibrated at 2400, however, when the interface is totally dedicated to 110 baud application, it is best to recalibrate the interface with the DTRATE parameter set to 110.

The calibration procedure is performed by adjusting the calibration trim pot on the bottom of the interface housing until a square wave on pin 3 of the RS-232 connector is 1/2 the desired baud rate frequency. See Fig. 8-2. The square wave frequency can be measured with a frequency counter, such as a Tektronix DC 503 counter/timer, or a 10 MHz oscilloscope. A frequency counter is recommended for more accurate readings.

If using a frequency counter, place the input probe on pin 3 of the RS-232 connector as shown in Fig. 8-2 and adjust the counter to display the calibration frequency. If using an oscilloscope, place the input probe on pin 3 of the RS-232 connector. Refer to Table 8-4 for the proper VOLTS/DIV and TIME/DIV settings. Adjust the oscilloscope dials as needed (TRIG SOURCE, HORZ POS etc.) until the calibration square wave is displayed.

TABLE 8-4
Calibration Data

Baud Rate	Cal Square Wave		Frequency Counter Gate Time	Oscilloscope	
	Freq.	Cycle Time		Volts/Div*	Time/Div
2400	1200	833.3 μs	1 s	5 V	.2 ms
1200	600	1.667 ms	1 s	5 V	.2 ms
300	150	6.667 ms	1 s	5 V	2 ms
150	75	13.33 ms	1 s	5 V	2 ms
110	55	18.18 ms	1 s	5 V	2 ms

*assumes a X10 probe is used.

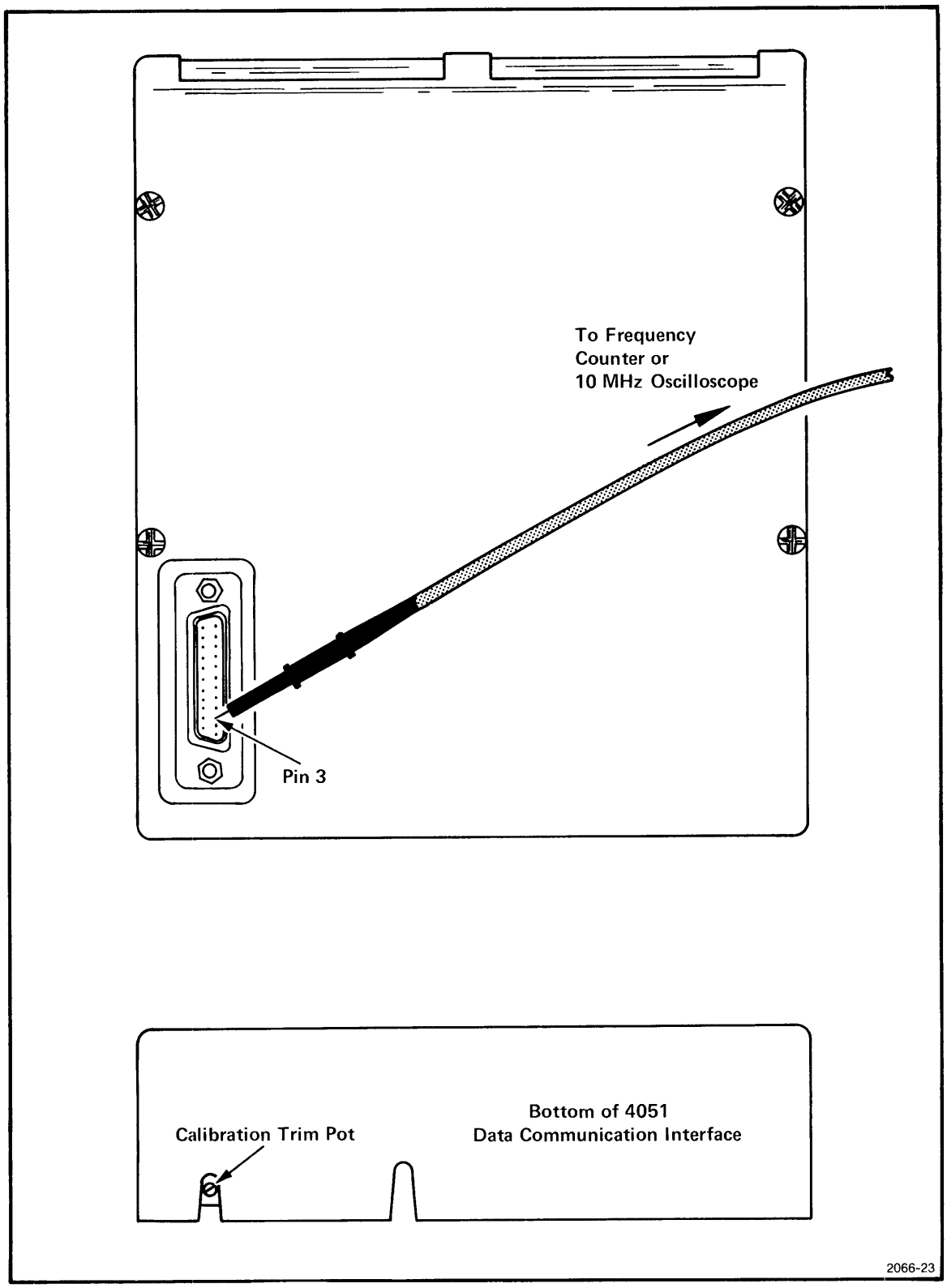

Fig. 8-2. Calibrating the Baud Rate.

Using a blade-type screwdriver, rotate the calibration trim pot first one way, then back the other until the square wave frequency is 1/2 the baud rate selection. Refer to Table 8-4 for the proper frequency and cycle time for each baud rate.

After the frequency is adjusted, press RETURN to exit the baud rate calibration mode and terminate the self-test.

IF THINGS GO WRONG

If during the course of the self-test the message—ERROR—is printed on the screen, then an error has occurred during the interface check-out procedure. Repeat the self-test several times to make sure that the error is persistant, then call you nearest Tektronix representative for assistance.

Fig. 8-3 illustrates the test results which are printed on the screen when the "CMTEST" utility is executed with the self-test adapter removed. This situation represents a "worst case" condition as far as the hardware checkout is concerned, because all the data lines are left open. The illustration is provided here to give you an idea of what the screen messages can look like if an error occurs during the self-test. Normally, the screen print out will be some where in-between Fig. 8-1 and Fig. 8-3, if an error occurs.

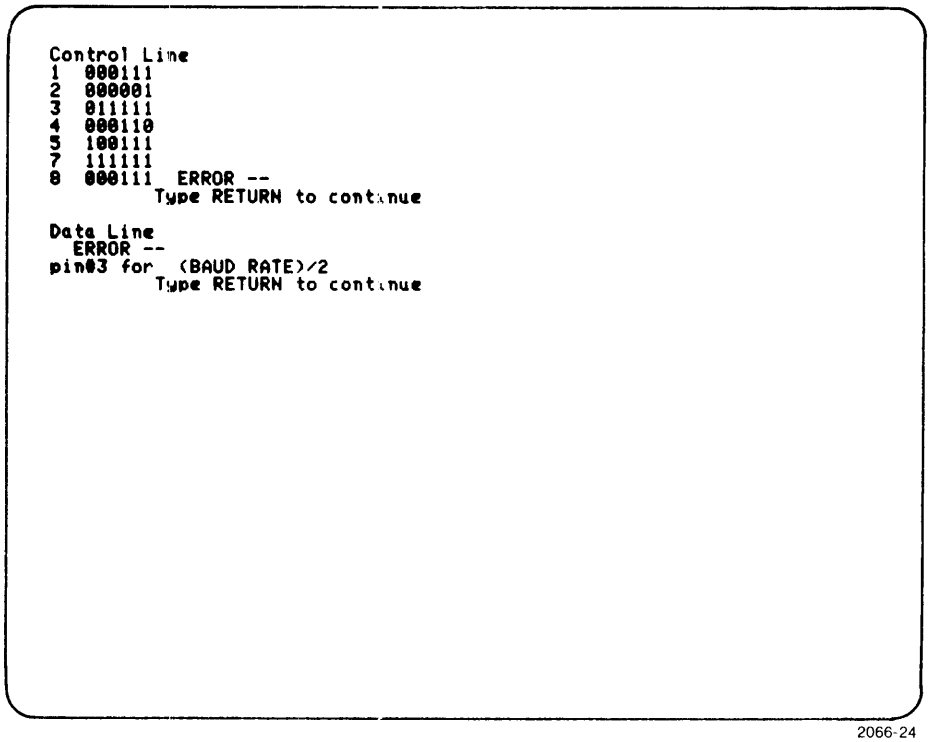

Fig. 8-3. Self-Test Results When the Self-Test Adapter is Removed.

CALL "CMTEST"

CALL "COMERR"

Syntax: [Line number] CALL "COMERR", numeric variable

When the interface is programmed to count communication errors (by executing a CALL "RATE" statement), this utility records the number of errors that occur during the transmission.

The numeric variable which follows CALL "COMERR", can be any BASIC language numeric variable. The value assigned to the variable is equal to the number of communication errors which occur during the last transmission.

CALL "DELAYS"

Syntax: [Line number] CALL "DELAYS", DELAY1, DELAY2, FRCR

DELAY1

Comm. Modes: Half Duplex with Reverse Channel.
Interface Modes: Terminal, Tape Communications.
Parameter Values: 0 to 65535
Meaning: This parameter specifies the minimum delay in milliseconds from the time the computer stops transmitting until the 4051 can start transmitting.
Default Value: 200

DELAY2

Comm. Modes: Half Duplex with Reverse Channel.
Interface Modes: Terminal, Tape Communications.
Parameter Values: 0 to 65535
Meaning: This parameter specifies the minimum delay in milliseconds between the time the computer relinquishes the transmission line and the time it can again request the line.
Default Value: 1000

FRCR (Force CR to Tape)

Comm. Modes: All.
Interface Modes: Tape Communications (receive direction).
Parameter Values: 0,1
Meaning:

Value	Meaning
0	No action. Tape receive occurs as usual.
1	Tape receive occurs as usual, but upon receiving a string RCLOSE or REND, a CR is sent to the tape. This is a useful feature when CR is the line delimiter in incoming data, and REND and possibly RCLOSE are set to CR. REND and RCLOSE are swallowed by the 4051, and if FRCR is set to zero, then no CR is recorded on the tape between lines of data. This parameter forces the 4051 to write a CR to the tape when set to 1.

Default Value: 1

CALL "DTRECV"

Syntax: [Line number] CALL "DTRECV"

This utility causes a transition from the BASIC language mode to Tape Communications Receive mode. The interface sends out a "start transmit" request (SNDSTG) and then records incoming ASCII data on the current magnetic tape file. Relevant parameters are ROPEN, RCLOSE, REND, FRCR, and RCRLF.

CALL "DTSEND"

Syntax: [Line number] CALL "DTSEND"

This utility causes a transition from the BASIC language mode to Tape Communications Send mode. The interface sends out a "start receive" command (SNDSTG) followed by formatted ASCII data from the current magnetic tape file. Relevant parameters are TOPEN, TCLOSE, TEND, TCRMOD, LCLLF, and the CALL "PROMPT" routine.

CALL "EOLCHR"

Syntax: [Line number] CALL "EOLCHR", EOL, SNDSTG, BLANKE

EOL (End of Line Character)

Comm. Modes:	Half Duplex (Full Duplex in Prompted Data Send)
Interface Modes:	Terminal, Tape Communications.
Parameter Values:	0 to 31
Meaning:	This parameter specifies the ASCII decimal equivalent of a control character selected as the half duplex line turn around character. When this character is sent from the keyboard or tape, it causes the 4051 to stop transmitting and begin receiving. When in Data Send Prompt Submode, transmitting this character triggers the prompt sequence.
Default Value:	13 (CR)

SNDSTG (Send String)

Comm. Modes:	All
Interface Modes:	Tape Communications
Parameter Values:	ASCII character string from zero to ten characters in length.
Meaning:	This parameter specifies the character string to be transmitted after entering the Tape Communications mode.
Default Value:	M (CR)

BLANKE (Blanking Enable)

Comm. Modes:	Half Duplex
Interface Modes:	Terminal
Parameter Values:	0, 1
Meaning:	When BLANKE=0, no unusual action occurs. When BLANKE=1, then the characters defined in the CALL "BLKCHR" statement are decoded to turn the data comm. receiver OFF and ON by computer control. This may be desirable in some cases to prevent spurious noise from appearing on the screen.
Default Value:	0

CALL "EOLCHR"

CALL "GRAFIN"

Syntax: [Line number] CALL "GRAFIN", GINTRM, GINSW, HCOPY

GINTRM (Graphic Input Terminator)

Comm. Modes: All.
Interface Modes: Terminal (GIN Submode).
Parameter Values: ASCII string, from zero to ten characters in length.
Meaning: As described in the Graphic Input specifications, the 4051 can send screen coordinate locations after receiving ESC SUB or ESC ENQ sequences from the computer. The coordinates are followed by the character string specified by "GINTRM", and normally this string contains a CR which is then echoed by the computer or a Local Echo to cause a GIN mode exit.
Default Value: M D (CR, EOT)

GINSW (Graphic Input Switch)

Comm. Modes: All.
Interface Modes: Terminal (GIN Submode).
Parameter Values: 0, 1, 2.
Meaning:

Value	Effect
0	Graphic Input is not allowed.
1	The Joyswitch controls the pointer location.
2	The User-Definable keys control the pointer location.

Default Value: 2

HCOPY (Hard Copy Unit Present)

Comm. Modes: All.
Interface Modes: Terminal.
Parameter Values: 0, 1.
Meaning:

Value	Effect
0	Hard Copy Unit is not present; BREAK Hard Copy and Auto Page are not allowed. The GIN Status character has the HCU status bit set equal to 0.
1	Hard Copy Unit present. BREAK Hard Copy and Auto Page possible (see CALL "BREAK"). The GIN status character has the HCU Status bit set equal to 1.

Default Value: 0

CALL"MARGIN"

Syntax: [Line number] CALL "MARGIN", MARG, MODE, LECHO

MARG (Margin Location)

Comm. Modes: All.
Interface Modes: Terminal (Alpha Submode)
Parameter Values: 0, 1, 2.
Meaning:

Value	Effect
0	Continuous writing. CR causes the cursor to return to the extreme left margin until the bottom of the screen is reached (line 35). The next 35 lines continue printing with the margin at the mid-screen position. Line lengths must be 37 characters or less to prevent overwriting. No pagefull busy occurs, and with each 35 lines, the margin alternates between the left-screen position and the mid-screen position.
1	Page fills with 35 lines of characters, and a BREAK can be sent to the transmitting device (see CALL "BREAK"). The margin is set at the left-screen position.
2	Writing occurs as with MARG=0, but a pagefull condition occurs after two columns (70 half-length lines) fill the display. The effect of pagefull is determined by the CALL "BREAK" parameters.

In all MARG settings, the left-screen margin is reset on a PAGE command (keyboard PAGE or ESC followed by CTRL and L keys, or ESC FF from the transmitting device.) Margin is also reset by pressing the SHIFT and PAGE keys (RESET command), although in this case, screen data are not erased.

Default Value: 0

MODE (Communications Mode)

Comm. Modes: Determined by this parameter.
Interface Modes: All.
Parameter Values: 0, 1, 2.
Meaning:

Value	Effect
0	Full Duplex.
1	Half Duplex with Reverse Channel.
2	Half Duplex Normal.

Default Value: 0

LECHO (Local Echo)

Comm. Modes: All.
Interface Modes: Terminal, Tape Communications (send directions).
Parameter Values: 0, 1.
Meaning:

Value	Effect
0	No Local Echo. Transmitted data are not displayed.
1	Local Echo. Transmitted data are simultaneously sent to the computer and the 4051 display.

Default Value: 1

CALL "PRLIST"

Syntax: [Line number] CALL "PRLIST"

This utility routine causes all programmable communciation parameters to be listed with a row for each routine and a column for each of the three prameters (arguments) associated with that routine.

In the parameter list (shown below), string parameters are delimited by forward slash marks rather than quotation marks. All control characters are underlined. This list can be also displayed by pressing User Definable key #14 while in Terminal Mode.

```
CALL "PRLIST"
RATE              300              0              2
TSTRIN           /@/             /S/            /D/
RSTRIN           /R/             /I/            /D/
TCRLF               1               2              0
RCRLF               1               2              0
MARGIN              0               0              1
PROMPT              0             200            /R/
BREAK               1              //             //
GRAFIN           /ND/               2              0
DELAYS            200            1000              1
EOLCHR             13             /M/              0
BLKCHR              2               3              4
```

CALL "PROMPT"

Syntax: [Line number] CALL "PROMPT", PMODE, PDELAY, PCHAR

PMODE (Prompt Mode)

Comm. Modes: All.
Interface Modes: Tape Communications (send direction).
Parameter Values: 0, 1.
Meaning:

VALUE	EFFECT
0	**No Prompt Mode.** Tape data is sent without interference from the external receiving device.
1	**Prompt Mode Set.** Tape file data is transmitted the same as in a normal tape send mode, except that a prompt character must be received by the 4051 before a logical record is transmitted. The exact protocol for prompt mode communications is described in the flow chart in Fig. 7-1.

Default Value: 0

PDELAY (Prompt Delay)

Comm. Modes: All.
Interface Modes: Tape Communications (send direction).
Parameter Values: 0 to 65535
Meaning: The value of PDELAY specifies the delay in milliseconds from the time when PCHAR and RCLOSE are received to the time when the Data Send Operation resumes.
Default Value: 200

PCHAR (Prompt Characters)

Comm. Modes: All.
Interface Modes: Tape Communications (send direction).
Parameter Values: An ASCII string from zero to six characters in length.
Meaning: PCHAR defines the prompt character string which when received, causes the next tape record to be sent. Details are provided in Section 7.
Default Value: R (DC2)

CALL "RATE"

Syntax: [Line number] CALL "RATE", DTRATE, PARITY, ERRACT

DTRATE (Data Rate)

Comm. Modes: All (Half and Full Duplex).
Interface Modes: All (BASIC I/O, Terminal, Tape Communications).
Parameter Values: 110, 150, 300, 600, 1200, 2400, 4800 (4052 and 4054 only), 9600 (4052 and 4054 only).
Meaning: Data Transfer baud rate (bits per second), refer to received and transmitted data rates.
Default Value: 300

PARITY (Parity, Data bit, and Stop bit specification)

Comm. Modes: All.
Interface Modes: All.
Parameter Values: 0, 1, 2, 3, 4, 5, 6, 7
Meaning:

PARAMETER VALUE	DATA BITS	STOP BITS	PARITY
0	7	2	even
1	7	2	odd
2	7	1	even
3	7	1	odd
4	8*	2	none
5	8*	1	none
6	8*	1	even
7	8*	1	odd

***If 8 data bits are specified, bit 8 is always set to binary zero and ignored when received.**

Default Value: 0

ERRACT (Error Action, on received parity and framing errors)

Comm. Modes: All.
Interface Modes: All.
Parameter Values: 0, 1, 2
Meaning:

VALUE	MEANING
0	No action—ignore errors.
1	Stop on error and display a communication interface error message.
2	Count the errors and do not stop. Assign the number of errors to the variable specified in the utility statement CALL "COMERR".

Default Value: 2

CALL "RCRLF"

Syntax: [Line number] CALL "RCRLF", RCRMOD, RLFMOD, CTLDSP

RCRMOD (Receive Carriage Return Modification)

Comm. Modes: All.
Interface Modes: Terminal, Tape (receive only).
Parameter Values: 0, 1, 2, 3
Meaning: When a Carriage Return (CR) is received, this routine suppresses the CR and substitutes a character in its place as follows:

VALUE	SUBSTITUTED CHARACTER
0	none (suppress CR)
1	CR
2	LF (Line-Feed)
3	CR and LF

Default Value: 1

RLFMOD (Receive Line Feed Modification)

Comm. Modes: All.
Interface Modes: Terminal, Tape (receive only).
Parameter Values: 0, 1, 2, 3
Meaning: If a Line Feed (LF) is received, this routine suppresses the LF and substitutes a character in its place as follows:

VALUE	SUBSTITUTED CHARACTER
0	none (suppress LF)
1	CR
2	LF
3	CR & LF

Default Value: 2

CTLDSP (Control Characters Displayed)

Comm. Modes: All.

Interface Modes: Terminal, Tape Communications.

Parameter Values: 0, 1

Meaning: CTLDSP determines the effect that ASCII Control Characters have on the Graphic System display. Characters are sent to the display as data received from the external RS-232 device. Even in Tape Communications mode, a copy of the information recorded on the tape is also sent to the display.

Data are also sent to the display when the interface is transmitting, providing the Local Echo parameter is set by executing a CALL "MARGIN" command.

With CTLDSP=0, Control Characters received by the display are decoded and executed (in Terminal mode) or ignored (in Tape Communications mode). The decoding performed in Terminal Mode is described later.

When CTLDSP=1, Control Characters are printed as an upper-case ASCII alpha character followed by a BS (Backspace) and an underscore. The result is an underlined character.

Carriage Return Exception. The ASCII Control Character CR, generated from the keyboard by either pressing the RETURN key or simultaneously pressing the CTRL key and the M key, is given special treatment. Regardless of the setting of the CTLDSP parameter, when the display receives a CR, the alpha cursor returns to the current left-hand margin and then moves down one line. This prevents overwriting the display, even if other Control Characters are displayed. CR causes the system to exit the Graph and GIN submodes of Terminal mode, and return to the Alpha Submode.

Default Value: 0

NOTE: The data displayed on the screen may lag behind, or otherwise be an inaccurate reflection of what is actually stored on the tape cartridge.

CALL "RSTRIN"

Syntax: [Line number] CALL "RSTRIN", ROPEN, RCLOSE, REND

ROPEN (Receive Open String)

Comm. Modes:	All.
Interface Modes:	Tape Receive and Prompt Tape Send.
Parameter Values:	From zero to ten characters, chosen from the ASCII code chart.
Meaning:	This parameter specifies the data string which is received and then suppressed by the interface before it can begin recording a tape record. In Prompt mode, ROPEN must be received before a prompt character can be searched for, and RCLOSE or REND must follow the prompt character before the character can be decoded.
Default Value:	R (DC2)

RCLOSE (Receive Close String)

Comm. Modes:	All.
Interface Modes:	Tape Receive and Prompt Tape Send.
Parameter Value:	From zero to ten characters, chosen from the ASCII code chart.
Meaning:	This parameter specifies the data string which is received, then suppressed, and then causes the current tape file to be terminated. In Prompt mode, RCLOSE or REND must follow the prompt character in order for it to have any effect.
Default Value:	T (DC4)

REND (Receive End String)

Comm. Modes:	All.
Interface Modes:	Tape Receive and Prompt Tape Send.
Parameter Values:	From zero to ten characters, selected from the ASCII code chart.
Meaning:	This parameter specifies the data string which when received, following ROPEN, is suppressed and causes the tape file to be terminated. In Prompt mode, RCLOSE or REND must follow the prompt character in order for it to have any effect.
Default Value:	D (EOT)

CALL "TCRLF"

Syntax: [Line number] CALL "TCRLF", TCRMOD, TLFMOD, LCLLF

TCRMOD (Transmit Carriage Return Modification)

Comm. Modes: All.
Interface Modes: Terminal, Tape (send only)
Parameter Values: 0, 1, 2, 3
Meaning: If a carriage return (CR) is sent, either from keyboard or tape, this routine suppresses the CR and substitutes a character in its place as follows:

VALUE	SUBSTITUTED CHARACTER
0	none
1	CR
2	LF (line-feed)
3	CR and LF

Default Value: 1

TLFMOD (Transmit Line Feed Modification)

Comm. Modes: All.
Interface Modes: Terminal, tape (send only).
Parameter Values: 0, 1, 2, 3
Meaning: If a Line Feed (LF) is sent, either from keyboard or tape this routine suppresses the LF and substitutes a character in its place as follows:

VALUE	SUBSTITUTED CHARACTER
0	none
1	CR
2	LF
3	CR and LF

Default Value: 2

LCLLF (Local Line Feed)

Comm. Modes: All.

Interface Modes: Terminal, Tape (send only).

Parameter Value: 0, 1

VALUE	MEANING
0	No Local Line Feed.
1	Local Line Feed.

Meaning: When LCLLF is set to 1 and a CR is sent from the tape or keyboard, and the CR is not inhibited by the TCRMOD value specified above, and a local echo to the screen is set, a LF accompanies the CR to the display. The CR does not cause a LF to be transmitted unless TCRMOD is set to 2 or 3.

NOTE: Setting TCRMOD to Local LF is useful in Tape Send mode when data is echoed to the GS display. If local LF is not set, data is continually overwritten in the same place on the screen. This action may eventually shorten the tube life.

Default Value: 0

CALL "TERMIN"

Syntax: [Line number] CALL "TERMIN"

This CALL statement causes the system to enter Terminal mode—Alpha submode. A return to BASIC is executed by pressing User Definable Key #5, or pressing ESC twice, or receiving ESC ESC over the RS-232 channel.

Besides returning to BASIC, one can go directly to Tape Communications mode by pressing User Definable Key #3 (Receive to Tape) or Key #4 (Transmit from Tape). After the tape operation is complete, a return to the original mode occurs automatically.

CALL "TSTRIN"

Syntax: [Line number] CALL "TSTRIN", TOPEN, TCLOSE, TEND

TOPEN (Transmit Open String)

Comm. Modes:	All.
Interface Modes:	Tape Send, including Prompt.
Parameter Values:	From zero to ten characters, chosen from the ASCII code chart.
Meaning:	This parameter specifies the data string to be sent before each tape record is transferred.
Default Value:	@ (NUL)

TCLOSE (Transmit Close String)

Comm. Modes:	All.
Interface Modes:	Tape Send, including Prompt.
Parameter Value:	From zero to ten characters, chosen from any in the ASCII code chart.
Meaning:	This parameter specifies the data string to be sent after each tape record.
Default Value:	S (DC3)

TEND (Transmit End String)

Comm. Mode:	All.
Interface Modes:	Tape Send, including Prompt.
Parameter Values:	From zero to ten characters, chosen from any in the ASCII code chart.
Meaning:	This parameter specifies the data string to be sent after the last record in the specified tape file. TEND is sent preceded by TOPEN.
Default Value:	D (EOT)

Appendix A

COMMUNICATION ERROR MESSAGES

129—Comm. Error: Interface error. When the programmer set ERRACT=1, the RS232 interface either received an illegal condition (parity, overrun, or framing) or attempted to output with the 8th bit=1.

130—Line Loss: Hardware error. An unexpected loss of one, or more, RS232 signal lines occurred. One must re-enter from BASIC.

131—Illegal Arg: Programmer's error. The "CALL" statement does not have the correct argument type (string or numeric) or does not have the correct number of arguments.

134, 135, 136, 137—Overflow: Internal Queue Overflow. Information awaiting dataports has exceeded the buffer length and has been lost.

Mode	134	135	136	137
Terminal	KEYBOARD	RS232/IN	CRT	RS232/OUT
DTRECV	RS232/IN	CRT	RS232/OUT	Mag Tape
DTSEND	——	CRT	RS232/IN	RS232/OUT
BASIC I/O	RS232/IN	——	——	——

140—I/O Mode: Programer's error. An attempt has been made to use device 40 from BASIC when in half-duplex mode. Or, BREAK=5 or 6 when in half-duplex.

141—I/O Function: Programmer's error. Attempt at BASIC I/O with device 40 with incorrect secondary address. Input from 40 is only correct when secondary address=4(OLD), 13(INPUT), and 0(STATUS). Output correct when secondary address=1(SAVE), 12(PRINT), 19(LIST), 30(ON), and 31(OFF).

142—Mem Full: Internal error. There was not enough free memory upon entry. A BASIC "MEM" may correct the situation without deleting BASIC variables or program lines from memory.

143, 144, 145—MT file: Programmer's error. An attempt was made to incorrectly use a mag tape file. 143, DTSEND, file header was Secret, Binary, or New; or file was not at the beginning. 144, DTRECV, file was not at the beginning. 145, FIND FILE, incorrect input from keyboard.

146—MT at EOF: Programmer's error. An attempt was made to write or read past the physical End Of File on the magnetic tape.

147—Comm Aborted: Programmer's action. BREAK was pressed while in DTSEND or DTRECV which aborted the operation to terminal mode. A return to BASIC (pressing user-definable key number 5) may be necessary if this message appears after a line loss error message.)

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MANUAL CHANGE INFORMATION

PRODUCT 4051 Option 1
070-2066-01

CHANGE REFERENCE C2/679
DATE 6-8-79

CHANGE:	DESCRIPTION

4054 GRAPHIC COMPUTING SYSTEM EMULATION OF THE TEKTRONIX 4014-1 COMPUTER DISPLAY TERMINAL

GENERAL INFORMATION

The 4054 Graphic Computing System with the Data Communications Interface (Option 1 or Option 3) includes all of the 4012 Computer Display Terminal features that are emulated by the 4051 and 4052 Graphic Computing Systems. It also emulates many features of the 4014-1 Computer Display Terminal equipped with the Enhanced Graphics Module. These features include:

- Nineteen-inch screen (48.26 cm)
- Twelve-bit graphic resolution (4096X by 4096Y addressable points with 4096X by 3120Y viewable points)
- Four character sizes
- Four dot-dash vectors
- Focus/defocus
- Thumbwheel control of crosshair cursor position

Known exceptions to 4054 emulation of the 4014-1 with the Enhanced Graphics Module include those listed on Pages 3-4 and 3-5 of this manual and the following:

- Point Plot mode, Special Point Plot mode, and Incremental Plot mode are not emulated.
- Write-Thru mode is not emulated.
- The 4054 displays only stroke characters (instead of dot matrix characters).
- The default condition for all character sizes is normal focus.

The 4054 Graphic Computing System must be in Terminal mode to emulate a 4014-1 Computer Display Terminal. See Section 6 of this manual for Terminal mode instructions.

CHARACTER SIZE SELECTION

Table C-1 shows the ASCII character sequences that select the four available character sizes. The default size is the largest. Each sequence consists of the ASCII control character ESC followed by a specific character that is not a control character. The ESC character may be sent by pressing the ESC key or by pressing CTRL [.

Table C-1
CHARACTER SIZE SELECTION

ASCII Character Sequence	Characters Per Line	Lines Per Page	Characters Per Page
ESC 8	74	35	2590
ESC 9	81	38	3078
ESC :	121	58	7018
ESC ;	133	64	8512

VECTOR SELECTION

The following vectors are selectable: solid, dotted, dot-dashed, short dashed, and long dashed. The default vector is the solid vector. All vector writing begins with the longest element of the vector pattern; for example, the dot-dash pattern always starts with the dash. Vector type has no impact on plotting time.

Table C-2 shows the ASCII character sequence for each vector type combined with normal focus or defocus. Each sequence consists of the ASCII control character ESC followed by a specific lower case character. The ESC character may be sent by pressing the ESC key or by pressing CTRL [.

Table C-3 shows the bit pattern for each of the vector types.

Table C-2
VECTOR TYPE AND FOCUS/DEFOCUS SELECTION

ASCII Character Sequence	ASCII Decimal Equivalent	Vector	Focus/Defocus
ESC `	96	Solid vector	Normal focus
ESC a	97	Dotted vector	Normal focus
ESC b	98	Dot-dashed vector	Normal focus
ESC c	99	Short dashed vector	Normal focus
ESC d	100	Long dashed vector	Normal focus
ESC h	104	Solid vector	Defocus
ESC i	105	Dotted vector	Defocus
ESC j	106	Dot-dashed vector	Defocus
ESC k	107	Short dashed vector	Defocus
ESC l	108	Long dashed vector	Defocus

Table C-3
VECTOR TYPE AND FOCUS/DEFOCUS BIT PATTERN

Desired Status	Required Bit Configuration						
	B7	B6	B5	B4	B3	B2	B1
Normal focus	1	1	0	0			
Defocus	1	1	0	1			
Solid vector[a]	1	1			0	0	0
Dotted vector[a]	1	1			0	0	1
Dot-dashed vector[a]	1	1			0	1	0
Short dashed vector[a]	1	1			0	1	1
Long dashed vector[a]	1	1			1	0	0

[a]Graph mode only

FOCUS/DEFOCUS

Focus/defocus affects the width of the lines drawn on the display. Normal focus is the default condition. The defocus condition displays a wider line and is normally used only for drawing vectors.

Table C-2 shows the ASCII character sequences for normal focus and defocus in combination with vector types. Each sequence consists of the ASCII control character ESC followed by a specific lower case character. The ESC character may be sent by pressing the ESC key or by pressing CTRL [.

Table C-3 shows the focus/defocus bit pattern.

THE THUMBWHEELS

The thumbwheels, located at the right of the keyboard, control the position of the GIN mode crosshair cursor (unless you are using the optional Joystick). Moving the thumbwheels as indicated by the arrows on the keyboard moves the graphic cursor left, right, up, and down. The intersection of the crosshairs shows the present position of the graphic point. For additional information about GIN mode, refer to Section 6 of this manual.

CHANGE:	070-2066-01	DESCRIPTION

4096X BY 4096Y ADDRESSING

An address on a 4096X by 4096Y grid (4096X by 3120Y viewable points) requires 12 bits of X and 12 bits of Y data. This requires an EXTRA 7-bit byte in the address; five data bytes are sent for 12-bit addressing instead of four as in 10-bit addressing. To form the address, first convert the X and Y addresses each to a binary number. Then see Table C-4 for byte configuration and transmission order. Figure C-1 shows the formation of the address for Y=2500, X=1595.

Table C-4
BYTE COUNT AND TRANSMISSION ORDER

Order of Byte Transmission	Byte Configuration 7-Bit ASCII Character						
Byte Name	Tag Bits		Address Bits				
	7	6	5	4	3	2	1
HIGH Y	0	1	5 Most Significant Bits of Y address				
EXTRA[a]	1	1	Unused	Y2	Y1	X2	X1
LOW Y	1	1	5 intermediate bits of Y address				
HIGH X	0	1	5 Most Significant Bits of X address				
LOW X	1	0	5 intermediate bits of X address				

[a]Bits 7 and 6 of the EXTRA byte must be ones. Bit 5 is not used. Bits 4 and 3 contain the two Least Significant Bits of the 12-bit Y address, and bits 2 and 1 contain the two Least Significant Bits of the 12-bit X address.

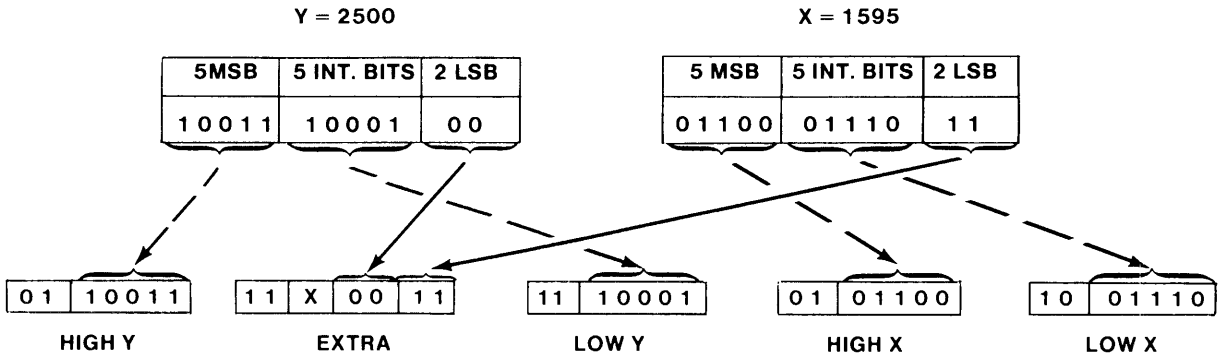

Figure C-1. Formation of vector address for Y=2500, X=1595.

As with 10-bit addressing, it is not always necessary to transmit every byte. However, whenever the EXTRA byte is sent, the LOW Y byte and the LOW X byte must be sent. Table C-5 shows the minimum bytes that must be sent for shortened address transmission.

The holding register for the EXTRA byte always clears to 0 when power is turned on. It is also cleared by PAGE and ESC FF. CR resets only the two Least Significant Bits of the EXTRA byte (the two Least Significant Bits of the X address).

Table C-5
SHORTENED ADDRESSING

Bytes Which Change	Bytes Required to be Sent				
	HIGH Y	EXTRA	LOW Y	HIGH X	LOW X
HIGH Y	#				#
EXTRA		#	#		#
LOW Y			#		#
HIGH X			#	#	#
LOW X					#

Upward and Downward Compatibility

The 12-bit system of addressing is upward and downward compatible with the 4010 Series Computer Display Terminal 10-bit addressability software. If a 4054 Graphic Computing System is driven from a program written for a 4012, for example, the 4054 will enlarge the plot proportionally to fill the larger screen. If a 4051/4052 Graphic Computing System is driven from a program written for a 4014 Computer Display Terminal with the Enhanced Graphics Module, for example, the EXTRA byte is ignored, and the plot is reduced proportionally to fit the smaller screen.