TEKTRONIX®

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ROMULAN LOADER

INSTRUCTION MANUAL

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WARNING

The remaining portion of this Table of Contents lists servicing instructions that expose personnel to hazardous voltages. These instructions are for qualified service personnel only.

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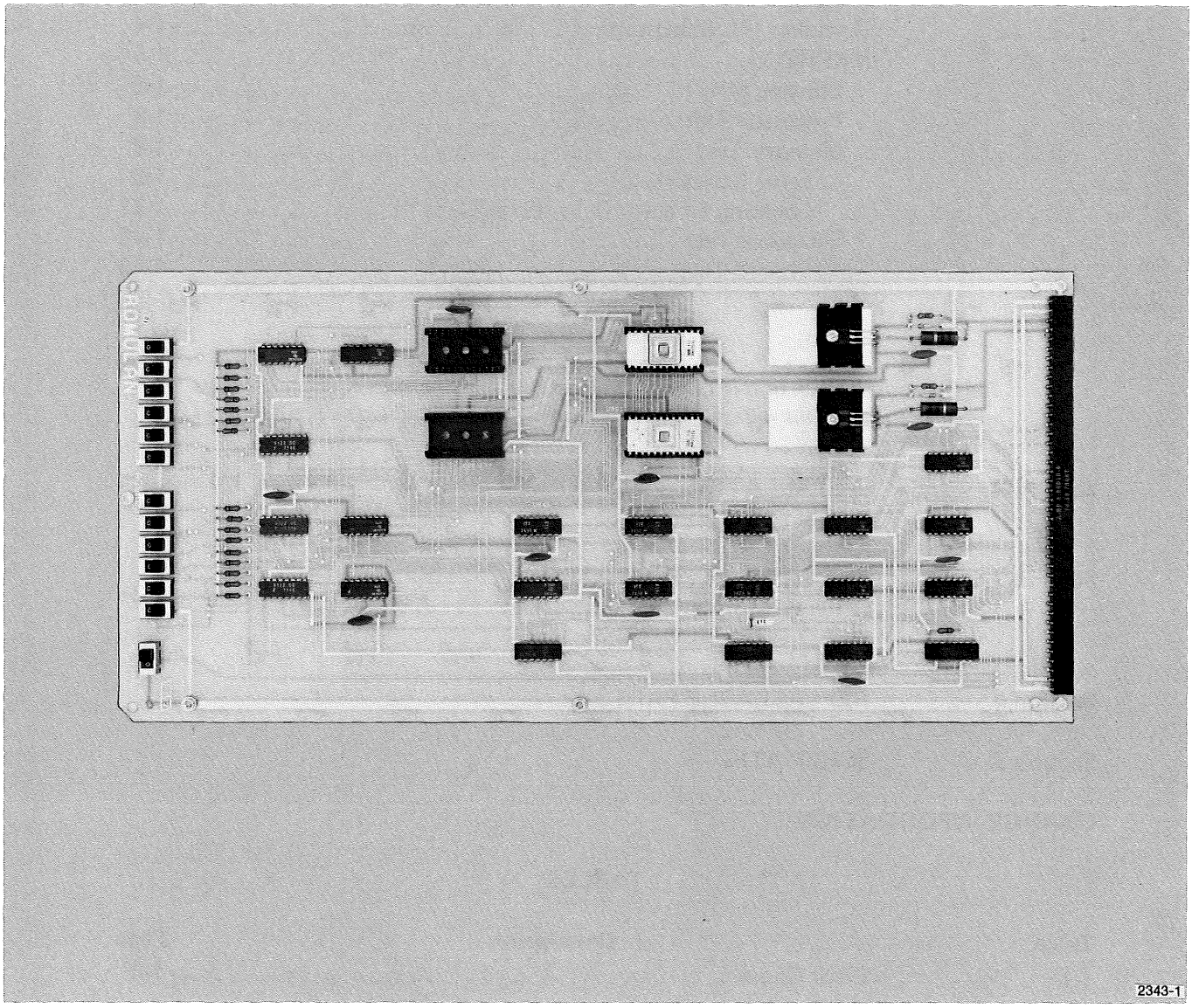


Fig. 1-1. The Romulan Card.

Section 1

OPERATION

GENERAL INFORMATION

The 067-0794-00 Romulan Loader card (Fig. 1-1) is a special purpose circuit card that plugs into the card cabinet of the 4081 Graphic System; it loads programs or data into the 4081 System's Memory. Romulan is equipped with four sockets for mounting Programmable Read-Only Memory (PROM) devices which permanently store the program to be loaded.

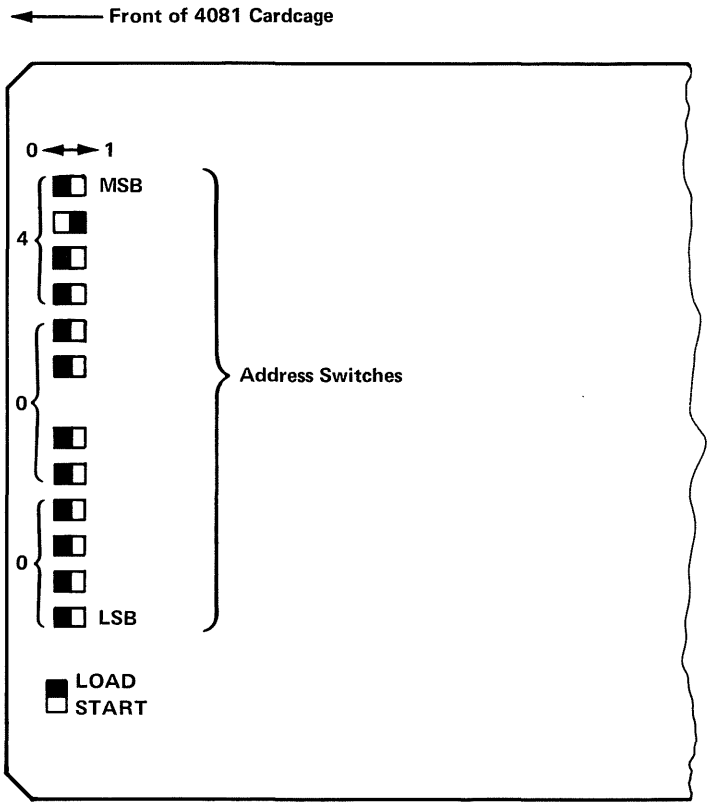
Two PROMs are furnished with the Romulan card. The IPL (Initial Program Load) PROM contains a bootstrap program which, when started, locates the 4081's main program (operating system) wherever it resides in disc memory, and loads it into the 4081's Memory. The other PROM contains MKPHT—Memory, Keyboard, Processor, and Hexpanel Test—a diagnostic program which tests the basic 4081 System, except for the Display Controller, Communications Interface, and the Cartridge Tape Unit. MKPHT sequentially exercises the Memory, the Keyboard, the Processor, and the 067-0772-00 Hexadecimal Display Panel (Hexpanel). It is a sophisticated program which should generally be operated only by someone familiar with the System and its theory of operation. The Hexpanel is used to diagnose memory problems.

The Romulan card may also be used with custom-programmed PROMs. The card, as shown in Fig. 1-1, has four sockets for PROMs, labelled U351, U151, U131, and U331.

Referring again to Fig. 1-1, notice that there are 13 slide switches at the left side of the Romulan card as it is viewed in the illustration. The bottom one is the Load/Start switch, which is normally left in the up (Load) position. When Load/Start is in the Start position, Romulan is effectively removed from the system.

The other 12 slide switches are Address Switches. They are set to manually address a PROM plugged into one of the four sockets on the Romulan card. As indicated in Fig. 1-2, a switch in the left position enters a "0" character in the address, and in the right position it enters a "1". Starting addresses (digits enclosed in quotes and preceded by "X" are hexadecimal notation) of the PROM sockets are as follows:

U351 is X'000' (Switches set to 0000 0000 0000)
U151 is X'400' (Switches set to 0100 0000 0000)
U131 is X'800' (Switches set to 1000 0000 0000)
U331 is X'C00' (Switches set to 1100 0000 0000)



Address Switches Set to X'400'
LOAD/START Switch Set to LOAD

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Fig. 1-2. Romulan Address Switches.

Loading A Program with Romulan

There are several methods for loading a program that is stored in Romulan into the System's Main Memory. After the program is loaded, the 4081 begins executing the program. Steps A and B of the first method (INIT) are common to all methods.

1. INIT Button.

A. With the Romulan card plugged into the 4081, set the Address switches on Romulan to the starting address of the IPL PROM. For example, if IPL is plugged into the U151 socket, the switches should be exactly as shown in Fig. 1-2, to address X'400'.
B. Check that the Load/Start switch on Romulan is set to Load.
C. Press the **INIT** button on the Hexpanel's keyboard. The IPL Software will load from disc into Memory.

2. Warm Start.

A. Check that the WARM START strap on the Keyboard Controller is set to IN.
B. Simultaneously press the **SHIFT** and **RESET** keys on the 4081 keyboard.

3. Without Hexpanel.

A. Mount any tape in the Cartridge Tape Unit.
B. Push the IPL button on the Cartridge Tape Unit.
C. The tape will rewind to the load point, run forward a short distance, and stop briefly. Remove the tape from the unit, and the System will load from disc.

4. Power Up Load.

If the Power-Up switch on the Tape Interface card is on (down position), the loading sequence will automatically start when the 4081's Power swtich is turned on. There must be a tape in the Cartridge Tape Unit for the loading process to complete itself. Wait for the tape to rewind, move forward, and stop briefly. Then remove the tape from the drive, and the operating system will load from disc.

NOTE

Power-Up Bootstrap loading will not work from a hard disc if the hard disc is not ready (up to speed) at the moment the 4081's power is turned on.

PROGRAMMED OPERATION

A program running on the 4081 may access data or a subroutine stored in a PROM on the Romulan card. The program first must send the starting 12-bit PROM address to Romulan. A Write Halfword instruction sent to device X'05' (Romulan) sets the starting address (12 least-significant bits of the data halfword). Subsequent Read Data instructions (or a Read Block instruction) retrieves the data from sequential locations in the 1024-byte PROM. Starting addresses related to PROM locations in the Romulan sockets are discussed under "General Information "earlier in this section. The Address switches are not used for program operation, but the Load/Start switch must be in the Load (up) position. A Sense Status instruction will normally result in a status byte with all bits reset. If the device is not installed, or the Load/Start switch is in Start position, the Examine bit of the status byte will be set. Other common input/output instructions (e.g., Output Command) have no effect on Romulan. Interrupt-driven operations are not possible with Romulan. Refer to the Plot 80: Assembly Language Programming Manual for general 4081 programming information.

ROMULAN IPL BOOTSTRAP

The IPL Bootstrap program is approximately 800 bytes in length, and is contained on one PROM. To run the program, Romulan must be installed in the 4081 card cabinet. Start the IPL Bootstrap program by following the procedure described under "Loading A Program With Romulan". As soon as this is done, the Bootstrap program begins its search for a file titled ???IPL.SYS (the question marks represent any characters describing the operating system in use—for example, GOS or IGT). The Bootstrap first searches hard disc locations DK0 through DK7, then runs through floppy disc locations FD0 through FD3. Each device's primary directory is searched for a file bearing the proper name. When ???IPL.SYS is located, the Bootstrap loads it into Memory, ???IPL.SYS then becomes the 4081's operating system.

If a device is unavailable, or the file cannot be found, the next device in sequence is searched. If the file can't be found on any of the devices, or if there is an error on all devices, the keyboard lights are lighted and the program loops. If the proper media is mounted and **INIT** is pressed again at this point, a valid program load should result. If a hard disc is used, wait for its Ready light to go on before attempting to use the IPL Bootstrap.

MKPHT

This diagnostic program checks out the basic 4081 System, except for the Display Controller, Communications Interface, and the Cartridge Tape Unit. It provides testing capabilities for the Processor, Memory, Keyboard, and Hexadecimal Display Panel. It is used when the 4081 fails to perform properly, and also can serve to isolate trouble to the Cartridge Tape Unit or the Display Controller by demonstrating that other devices in the System are operating correctly.

CAUTION

MKPHT is a complex program which requires considerable knowledge of the System in order to interpret results. It should not be used except by Tektronix Service Specialists, or others with equivalent experience.

Starting MKPHT

Use of MKPHT in a 4081 System requires installation of the Romulan card with a MKPHT PROM, and also requires a Hexadecimal Display Panel. The following series of steps starts the program:

1. Set the 12 Address switches on the Romulan card to the beginning address that corresponds to the location of MKPHT PROM.
2. Set the Load/Start switch to Load (Up) position.
3. Initiate the program by one of the methods described under "Loading A Program With Romulan" in this section (1).

Processor Test

As soon as MKPHT is initiated by any of the means described in Step 3 above, the Processor Test begins. This test is not a complete check of the Processor's instruction set. It does, however, test the capability of the Processor to control peripheral devices in both interrupt and non-interrupt modes. The sequence of events in the Processor Test is as follows:

1. Turns on the Four Keyboard Prompt Lights.
2. Sounds the audible indicator.
3. Turns off the Keyboard Prompt lights.
4. Sounds the audible indicator.
5. Sets the Processor's Program Status Word to X'6800'.
6. At this point, the Memory Test is entered automatically. During the Memory Test, pressing any key on the 4081's Keyboard will cause its ASCII code to be displayed in Hexpanel Register R2 (LEDs D3 and D4). For example, pressing the **G** key will cause "7" to appear in D3, and "4" to appear in D4. Figure 1-3 is a chart showing ASCII codes and their hexadecimal equivalents.

NOTE

During the running of MKPHT, some 4081 keys have special functions. Pressing capital **K** *causes the program to enter the Keyboard Test. Striking the Spacebar or capital* **P** *causes the program to restart at the Processor Test (which is also the only way to restart the Memory Test, since Processor Test takes only a moment), and the program then automatically moves directly into the Memory Test. When either the Processor Test or the Memory Test is executing (but not during Keyboard Test), Hexpanel Test can be entered by depressing the* **FN** *key, followed by* **0** *on the Hexpanel's keyboard.*

ASCII CODE CHART

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

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Fig. 1-3. ASCII Code Chart With Hexadecimal Equivalents (lower left corner of each block).

Memory Test

If none of the special-purpose keys are pressed during or immediately after the Processor Test, MKPHT automatically enters the Memory Test. This test checks for three different failure modes:

1. Address decoding or crosstalk.
2. Pattern sensitivity (defective memory chip).
3. Clear parity bit test. If the System under test does not have parity chips, this test has no effect.

Verification that the Memory Test is running is provided by the fact that the display in Hexpanel LED D1 continually decrements from X'F' toward 0 at a rate of about one digit every 10 seconds, as the test cycles through memory. If no errors occur, the Memory Test automatically repeats until another test is started.

When a failure in Memory is detected, the program stops; the WAIT light on the Hexpanel illuminates, and an error code appears in Hexpanel LED Display D9 (Fig. 1-4). Table 1-1 shows error codes with address and data information as they appear in Hexpanel displays. Following Table 1-1 are explanations of the various error codes, describing the probable indications. Following these comments, the information titled "Locating a Faulty Chip" gives details on localizing troubles indicated by an error code 4.

NOTE

When the Memory Test is run, it automatically erases the operating system from Memory. After completion of the Memory Test, the 4081's operating system must be reloaded.

Table 1-1
ERROR CODES

Hexpanel LED Displays (Fig. 1-4)		
D9 Error Code	**D8, D7, D6, D5 Address Display**	**D4, D3, D2, D1 Data Display**
1	Failing Address	Data
2	Failing Address	Data
3	Failing Address	Data
4	Failing Address	W X Y Z[1]
5	Failing Address	W X Y Z[1]

[1]**WXYZ represents the actual data portion of the Hexpanel display, appearing in LEDs D4 through D1. The actual display in each of these LEDs is a hexadecimal character resulting from the contents of one of the four data blocks shown as W, X, Y, and Z on the Memory card in Fig. 1-5.**

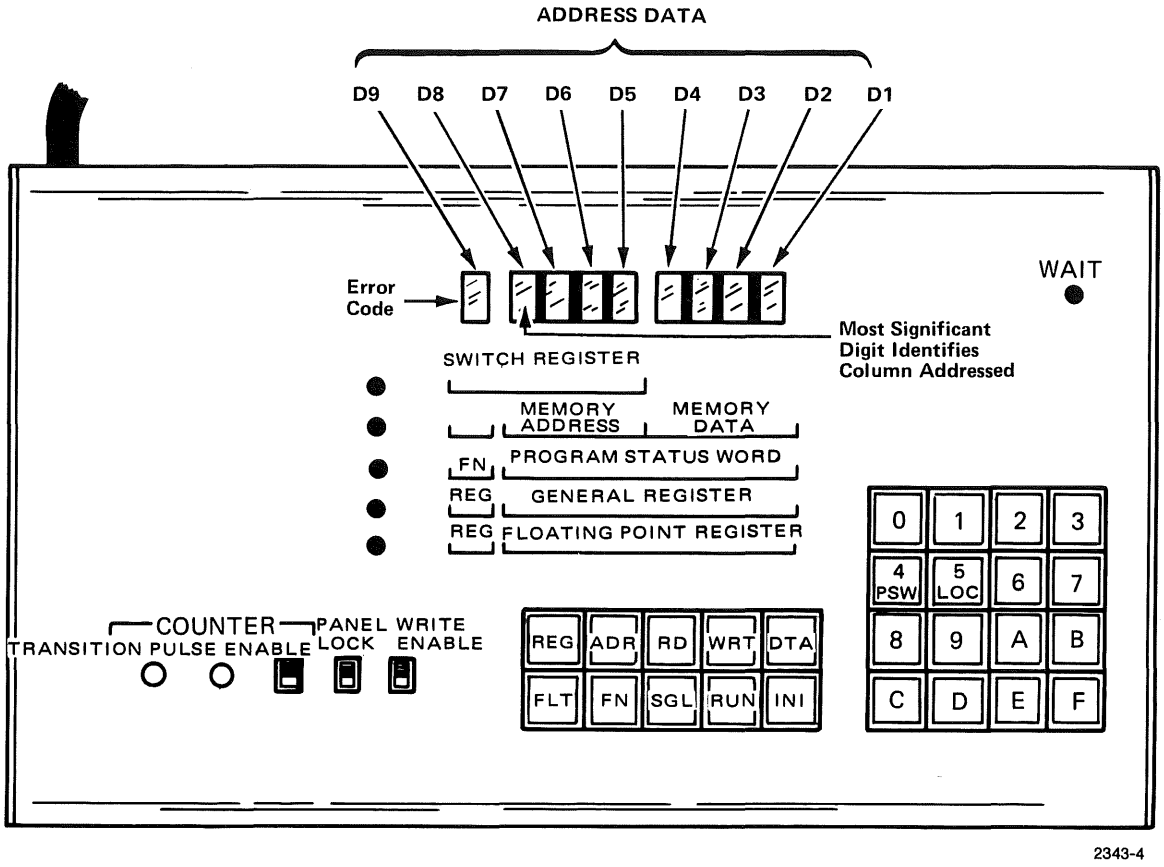


Fig. 1-4. Hexpanel Display Indications For Faulty Chip Location.

Error Code 1. This error occurs infrequently, but usually decodes similarly to an an error code 4. In the Memory Test, a correct reading in the Data Display section usually shows the same four hexadecimal characters in each Data Display LED (e.g., 0000). An error code 1 display will have one dissimilar character (e.g., 0040). Compare these two readings in the manner described under "Locating a Faulty Chip", but do not use Register 9.

Error Code 2. Press Hexpanel keys **REG 9.** If the data in Register 9 is the same as the failing data shown in error code 2, the parity chip at the failing address location is faulty. If the failing data and the data shown in Register 9 are different, use the same comparison test described in Error Code 4 and under "Locating a Faulty Chip".

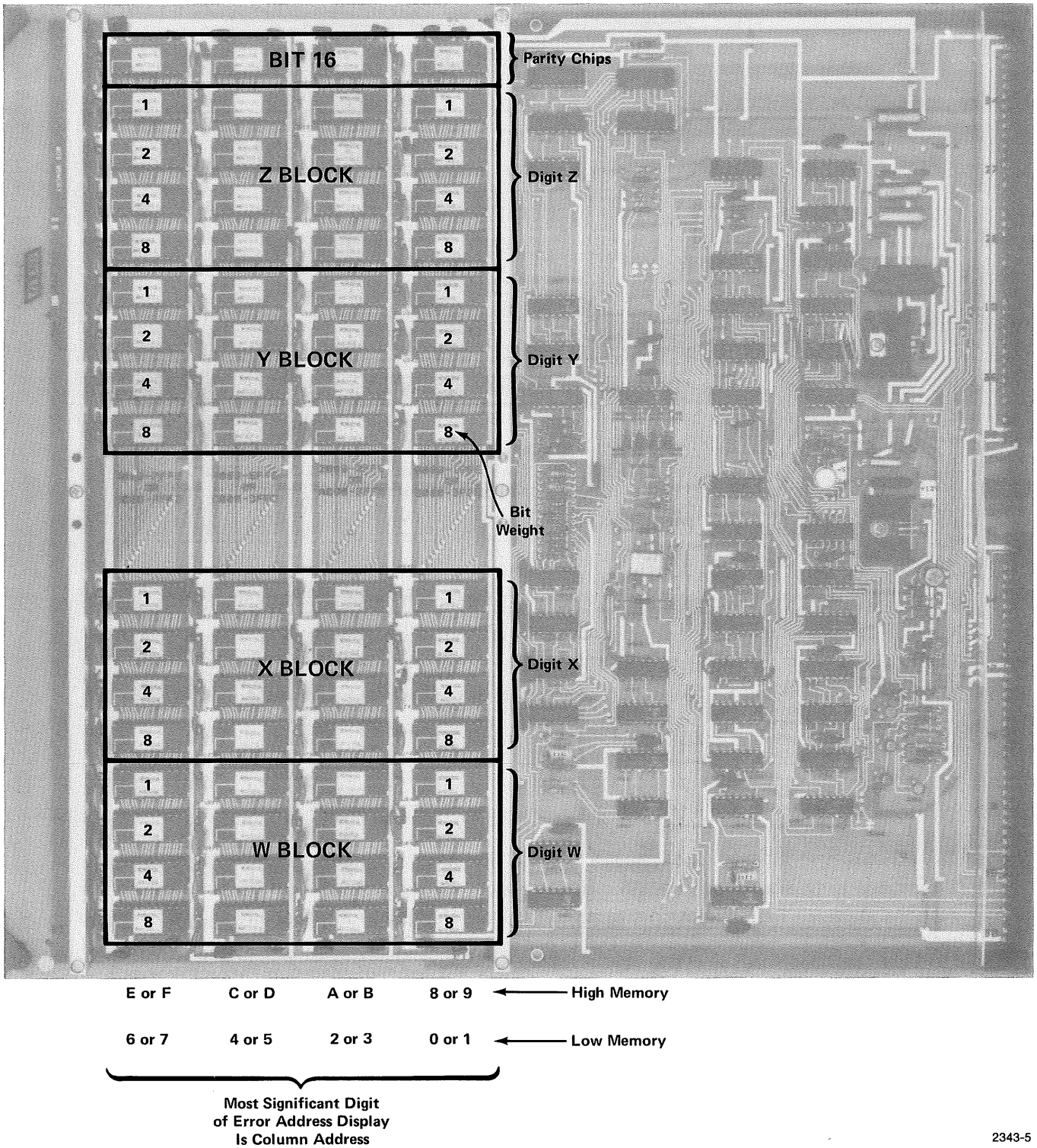


Fig. 1-5. Memory Card Bit Locations.

Error Code 3. This error code indicates an illegal instruction. Examine Memory location X'32' to obtain the instruction address. This error can occur when the area of Memory occupied by MKPHT is faulty. By comparing the data from the faulty address to the correct data (obtained by examining the same address with MKPHT loaded into a known good Memory), the faulty location is found using the Error Code 4 procedure.

Error Codes 4 and 5. The data shown in the LED display should be compared against the data displayed when **REG 9** is pressed on the Hexpanel keyboard. If only a single binary bit differs in the two displays, a faulty RAM chip is indicated. Then the procedure described under "Locating the Faulty RAM Chip" should be carried out to find the fault. When more than one binary bit differs between the error code 4 or 5 display and the REG 9 display, the indication is a pair of shorted address lines. Error code 5 usually indicates a set of shorted address lines. Re-running the test in this case generally produces different failing addresses and different data displays. At this point, the shorted lines can be located quickly and accurately by the use of an oscilloscope to examine the waveforms on the suspected lines while a program is running and using memory. The crosstalk from shorted-together address lines appears as lower amplitude noise on the lines. Normal address line waveforms appear as a clean pulse train without "fuzz".

Locating a Faulty Chip (Error Code 4). When repetitions of the Memory test continue to show an error code 4 and the comparison of the Register 9 data to error code data shows that only one binary bit differs, the indication is a faulty RAM chip. Locate the exact chip causing the problem, using the following procedure.

Observe the address section of the Hexpanel display (LEDs D8, D7, D6, D5 produced by the error); the most significant bit (D8 display) shows the column address of the chip of the Memory card (see Fig. 1-5). If there are two memory cards in the System, the column address also identifies the card that contains the faulty device. Hexadecimal digits of larger value (8 through X'F') are high memory, and smaller-value digits (0 through 7) are low memory. The address straps on the memory cards identify which card is low and which is high.

The display contained in LEDs D4, D3, D2, and D1 is the data that includes the error. Write down the four hexadecimal characters shown in these four LEDs. Then press **REG** and **9** on the Hexpanel keyboard, and the data portion of the display will show the correct data that should have been written into the memory chips.

Comparing the four hexadecimal characters displayed by pressing **REG 9** with the four just written down will reveal a difference in digit W, X, Y, or Z. The digit in which the discrepancy occurs is the Memory card block in which the fault has occurred (Fig. 1-5). Now the fault has been traced to a particular column on the card, and to the block of 4 bits in which it occurred. The actual bit and associated memory chip are isolated by comparing the binary makeup of the correct Hexpanel character with that of the erroneous one, as shown in the following example:

Hexpanel Display

D4	D3	D2	D1	
W	X	Y	Z	Memory Chip Block
F	F	F	F	Correct Display (REG 9)
F	F	E	F	Erroneous Display

faulty block is Y

Comparing the binary structures of the two differing hexadecimal characters:

8	4	2	1	Row
1	1	1	1	Hexadecimal F
1	1	1	0	Hexadecimal E

faulty bit in row 1

Referring again to Fig. 1-5, we see that the error has occurred in the 4-row block "Y", row "1" of the column that is indicated in D8 of the Address Data display. If the column digit is, for example, E or F, U212 is the faulty device.

Hexpanel Test

To enter the Hexpanel Test from either the Processor Test or the Memory Test, press the **FN** and **0** keys on the Hexpanel keyboard. The Hexpanel Test will then generate an interrupt and be serviced. The Processor enters a Wait state, turning on the WAIT Light on the Hexpanel and the four prompt lights on the 4081 Keyboard. To display the Processor's Program Status Word of X'8000' on Hexpanel LEDs D1 through D4, press, in order, Hexpanel keys **FN, 4, FN, 4.** To continue with MKPHT, starting over with the Processor Test, press the Hexpanel **RUN** key or press **FN 0** again.

Keyboard Test

The Keyboard Test is entered by pressing **K** on the 4081 keyboard. The Keyboard Test exercises the Real-time Clock first. If an interrupt is received from the Real-time Clock, "Fb" appears on Hexpanel LEDs D1 and D2 (X'FB' is the address of the Real-time Clock on the Keyboard Controller). At this time, pressing any function key on the 4081 keyboard, or moving the Joyswitch in any direction will cause a digit that corresponds to the pressed key's relative bit position in a 16-bit halfword to be displayed on Hexpanel LEDs D1 through D4 in the arrangement shown in Fig. 1-6. To exit the Keyboard Test and return to the beginning of the Processor Test, press capital **P** or hit the Spacebar on the 4081.

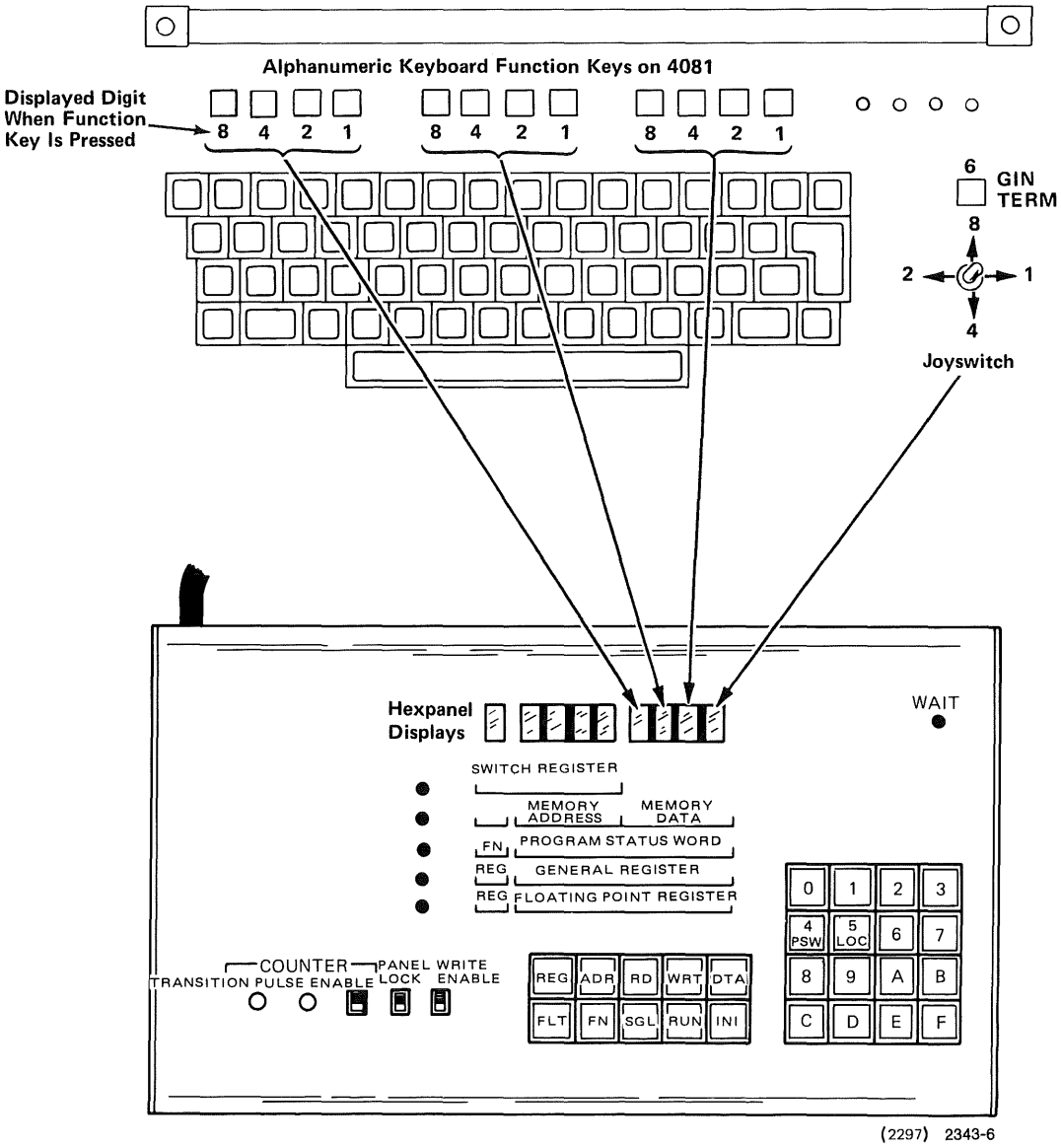


Fig. 1-6. Hexpanel Display Of Function Keys During Keyboard Test.

Section 2

INSTALLATION

INSTALLATION PROCEDURE

The Romulan card is a half-size card that plugs into the 4081 Graphic System's backplane; it must be physically braced by being connected with another half-size card to make an assembly equivalent to a full-size card, before it can be plugged into the 4081 card cabinet. Three connecting bars are used to tie the two half-cards together. If a second half-size card is not already available in the card cabinet, a blank dummy half-board (Part No. 670-4627-00) is provided to fill out the assembly. Once installed in the system, the Romulan card is normally left permanently in place.

The PROMs for the Romulan card are labelled IPL or MKPHT. Before you install Romulan into the 4081, plug the appropriate PROM into the socket in which it will be used, or verify which socket it is plugged into.

CAUTION

Be sure power has been removed from the System before starting to install or remove any circuit cards from the 4081 to prevent damage to the circuit cards.

To mount the Romulan card in the 4081 card cabinet:

1. Remove the four screws on the front of the card cabinet. Remove the cover and set it aside.
2. Attach the Romulan card to another half-size card with the connecting bars and screws.
3. Select a slot in the card cabinet for the Romulan card. Any unused slot is suitable. Slide the circuit card assembly into the slot until the front edge of the card is flush with the other cards in the cabinet. Make desired switch settings, and replace cover.

To remove the Romulan card from the 4081 card cabinet, reverse the procedure just described.

Section 3

THEORY OF OPERATION

GENERAL INFORMATION

The Romulan card is a ROM (Read-Only Memory) loader storage unit. It is a 4081 accessory which loads data from a disc unit into Memory, or loads diagnostic programs which check out various parts of the 4081 System. Programmable Read Only Memory chips store the data or programs even when system power is off.

One of the primary uses of the Romulan card is Initial Program Loading (IPL) of the Graphic Operating System (or other applicable operating systems) from disc memory into System Memory. The IPL instructions are contained in the IPL PROM. Another function of the Romulan card is the loading of MKPHT, a diagnostic program for checkout of various facilities of the 4081 System.

There are four PROM sockets on the Romulan card which are designated U131, U151, U331, and U351. Twelve binary switches, which are at the front edge of the Romulan card, address the socket and PROM from which information is to be loaded. Instead of manually selecting a starting address, a running program can send a halfword of data to Romulan (device address X'05'). Romulan uses the 12 least significant bits of the halfword as the starting address for a load operation. Data is transmitted from the addressed PROM to the Processor via the 4081's Multiplexer (Mux) Bus in 8-bit bytes, each byte containing 8 parallel bits.

ROMULAN CIRCUIT OPERATION

Refer to the Romulan Schematic at the back of this manual during the following description. The schematic shows the major component blocks outlined and labelled.

Address information is loaded into the Romulan card by one of two methods—under program control via data lines D040 through D150, or manually by way of the Address switches on the Romulan card. If, via the latter method, the sequence of operation is as follows:

1. Set the Load/Start switch on the Romulan card to Load.
2. Enter the starting address on the 12 switches (the address for each ROM socket is labeled on the Romulan card alongside the socket).
3. Press the IPL button, the INIT button on the Hexpanel, or (if Warm Start operation is enabled) the SHIFT and RESET keys on the 4081 keyboard. This action starts the Processor's initialization procedure by activating the Power Fail Detect Line to the Processor.

At this point, the Processor activates the ADRS0 line and places Romulan's fixed address (X'05') on the D08—D15 data lines. An address match results through the Address Decoder, which enables the Control Decoder. The Romulan card is now addressed and ready to accept control signals from the Processor.

PROM address information is sent to the appropriate PROM from the 12 data lines (D04—D15) or the 12 Address switches via the PROM Address Selector. The Data Available (DA) signal selects the D04—D15 inputs and loads the Address Counter. At initialization the System Clear (SCLR) signal loads the switch-selected data into the Address Counter. Each subsequent Data Request (DR) gates a data byte from the addressed PROM location onto the Multiplexer Bus (D08—D15). The trailing edge of DR increments the Address Counter to the next PROM location. The control lines Command (CMD) and Status Request (SR) have no effect of Romulan. However, all control signals are acknowledged by the SYN (synchronize) signals if the Control Decoder is enabled by the Address Decoder. The System Clear (SCLR) signal, or addressing another device on the Multiplexer Bus, disables the Control Decoder. The Address Decoder cannot enable the Control Decoder if the Load/Start switch is set to start.

Two zener diode-regulated power supplies on the card provide +12 and −5 V power to the PROMs.

Section 4

REPLACEABLE PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

1 2 3 4 5 Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
\- - - * - - -
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
\- - - * - - -
Parts of Detail Part
Attaching parts for Parts of Detail Part
\- - - * - - -

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol - - - * - - - indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

"	INCH
#	NUMBER SIZE
ACTR	ACTUATOR
ADPTR	ADAPTER
ALIGN	ALIGNMENT
AL	ALUMINUM
ASSEM	ASSEMBLED
ASSY	ASSEMBLY
ATTEN	ATTENUATOR
AWG	AMERICAN WIRE GAGE
BD	BOARD
BRKT	BRACKET
BRS	BRASS
BRZ	BRONZE
BSHG	BUSHING
CAB	CABINET
CAP	CAPACITOR
CER	CERAMIC
CHAS	CHASSIS
CKT	CIRCUIT
COMP	COMPOSITION
CONN	CONNECTOR
COV	COVER
CPLG	COUPLING
CRT	CATHODE RAY TUBE
DEG	DEGREE
DWR	DRAWER
ELCTRN	ELECTRON
ELEC	ELECTRICAL
ELCTLT	ELECTROLYTIC
ELEM	ELEMENT
EPL	ELECTRICAL PARTS LIST
EQPT	EQUIPMENT
EXT	EXTERNAL
FIL	FILLISTER HEAD
FLEX	FLEXIBLE
FLH	FLAT HEAD
FLTR	FILTER
FR	FRAME or FRONT
FSTNR	FASTENER
FT	FOOT
FXD	FIXED
GSKT	GASKET
HDL	HANDLE
HEX	HEXAGON
HEX HD	HEXAGONAL HEAD
HEX SOC	HEXAGONAL SOCKET
HLCPS	HELICAL COMPRESSION
HLEXT	HELICAL EXTENSION
HV	HIGH VOLTAGE
IC	INTEGRATED CIRCUIT
ID	INSIDE DIAMETER
IDENT	IDENTIFICATION
IMPLR	IMPELLER
IN	INCH
INCAND	INCANDESCENT
INSUL	INSULATOR
INTL	INTERNAL
LPHLDR	LAMPHOLDER
MACH	MACHINE
MECH	MECHANICAL
MTG	MOUNTING
NIP	NIPPLE
NON WIRE	NOT WIRE WOUND
OBD	ORDER BY DESCRIPTION
OD	OUTSIDE DIAMETER
OVH	OVAL HEAD
PH BRZ	PHOSPHOR BRONZE
PL	PLAIN or PLATE
PLSTC	PLASTIC
PN	PART NUMBER
PNH	PAN HEAD
PWR	POWER
RCPT	RECEPTACLE
RES	RESISTOR
RGD	RIGID
RLF	RELIEF
RTNR	RETAINER
SCH	SOCKET HEAD
SCOPE	OSCILLOSCOPE
SCR	SCREW
SE	SINGLE END
SECT	SECTION
SEMICOND	SEMICONDUCTOR
SHLD	SHIELD
SHLDR	SHOULDERED
SKT	SOCKET
SL	SLIDE
SLFLKG	SELF-LOCKING
SLVG	SLEEVING
SPR	SPRING
SQ	SQUARE
SST	STAINLESS STEEL
STL	STEEL
SW	SWITCH
T	TUBE
TERM	TERMINAL
THD	THREAD
THK	THICK
TNSN	TENSION
TPG	TAPPING
TRH	TRUSS HEAD
V	VOLTAGE
VAR	VARIABLE
W/	WITH
WSHR	WASHER
XFMR	TRANSFORMER
XSTR	TRANSISTOR

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
00779	AMP, INC.	P O BOX 3608	HARRISBURG, PA 17105
01121	ALLEN-BRADLEY COMPANY	1201 2ND STREET SOUTH	MILWAUKEE, WI 53204
01295	TEXAS INSTRUMENTS, INC., SEMICONDUCTOR GROUP	P O BOX 5012, 13500 N CENTRAL EXPRESSWAY	DALLAS, TX 75222
10389	CHICAGO SWITCH, INC.	2035 WABANSIA AVE.	CHICAGO, IL 60647
13103	THERMALLOY COMPANY, INC.	2021 W VALLEY VIEW LANE P O BOX 34829	DALLAS, TEXAS 75234
27014	NATIONAL SEMICONDUCTOR CORP.	2900 SEMICONDUCTOR DR.	SANTA CLARA, CA 95051
71785	TRW, CINCH CONNECTORS	1501 MORSE AVENUE	ELK GROVE VILLAGE, IL 60007
72982	ERIE TECHNOLOGICAL PRODUCTS, INC.	644 W. 12TH ST.	ERIE, PA 16512
78189	ILLINOIS TOOL WORKS, INC. SHAKEPROOF DIVISION	ST. CHARLES ROAD	ELGIN, IL 60120
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
83385	CENTRAL SCREW CO.	2530 CRESCENT DR.	BROADVIEW, IL 60153

Electrical

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
	670-4173-00			CKT BOARD ASSY:ROMULAN	80009	670-4173-00
	670-4173-01			CKT BOARD ASSY:ROMULAN	80009	670-4173-01
C31	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C186	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C287	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C351	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C411	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C641	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C661	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C821	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C851	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C975	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
Q185	151-0334-00			TRANSISTOR:SILICON,NPN	80009	151-0334-00
Q285	151-0335-00			TRANSISTOR:SILICON,PNP	80009	151-0335-00
R101	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R103	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R181	315-0821-00			RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R185	303-0100-00			RES.,FXD,CMPSN:10 OHM,5%,1W	01121	GB1005
R201	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R203	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R205	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R207	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R281	315-0821-00			RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R285	303-0100-00			RES.,FXD,CMPSN:10 OHM,5%,1W	01121	GB1005
R301	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R501	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R502	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R504	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R505	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R601	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R602	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R701	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R703	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R705	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R981	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
S1	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S102	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S202	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S205	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S302	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S311	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S501	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S505	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S601	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S605	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S701	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S705	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
S901	260-0960-01			SWITCH,SLIDE:0.5A,120VDC,CKT CD MT	10389	23-021-043
U111	156-0142-00			MICROCIRCUIT,DI:50 MHZ PRESETTABLE BIN CNTR	80009	156-0142-00
U121	156-0110-00			MICROCIRCUIT,DI:DUAL 2 - 4 LINE DCDR DEMUX	01295	SN74155N
U131	156-0708-00			MICROCIRCUIT,DI:STATIC ERASEABLE PROM	80009	156-0708-00

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
U151	156-0708-15			MICROCIRCUIT,DI:PROM,IPL	80009	156-0708-15
U311	156-0125-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BFR	01295	SN74157N
U331	156-0708-00			MICROCIRCUIT,DI:STATIC ERASEABLE PROM	80009	156-0708-00
U351	156-0708-16			MICROCIRCUIT,DI:PROM,MKPHT	80009	156-0708-16
U381	156-0058-00			MICROCIRCUIT,DI:HEX.INVERTER	01295	SN7404N
U511	156-0125-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BFR	01295	SN74157N
U521	156-0142-00			MICROCIRCUIT,DI:50 MHZ PRESETTABLE BIN CNTR	80009	156-0142-00
U541	156-0145-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BFR	01295	SN7438N
U551	156-0145-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BFR	01295	SN7438N
U561	156-0030-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U571	156-0058-00			MICROCIRCUIT,DI:HEX.INVERTER	01295	SN7404N
U581	156-0058-00			MICROCIRCUIT,DI:HEX.INVERTER	01295	SN7404N
U711	156-0125-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BFR	01295	SN74157N
U721	156-0142-00			MICROCIRCUIT,DI:50 MHZ PRESETTABLE BIN CNTR	80009	156-0142-00
U741	156-0129-00			MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U751	156-0145-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BFR	01295	SN7438N
U761	156-0039-00			MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	01295	SN7473N
U771	156-0058-00			MICROCIRCUIT,DI:HEX.INVERTER	01295	SN7404N
U781	156-0058-00			MICROCIRCUIT,DI:HEX.INVERTER	01295	SN7404N
U441	156-0041-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U961	156-0034-00			MICROCIRCUIT,DI:DUAL 4-INPUT NAND GATE	80009	156-0034-00
U971	156-0030-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U981	156-0539-00			MICROCIRCUIT,DI:BUS COMPTR	27014	DM8136N
VR183	152-0508-00			SEMICOND DEVICE:ZENER,0.4W,12.6V,5%	80009	152-0508-00
VR283	152-0175-00			SEMICOND DEVICE:ZENER,0.4W,5.6V,5%	80009	152-0175-00

Mechanical

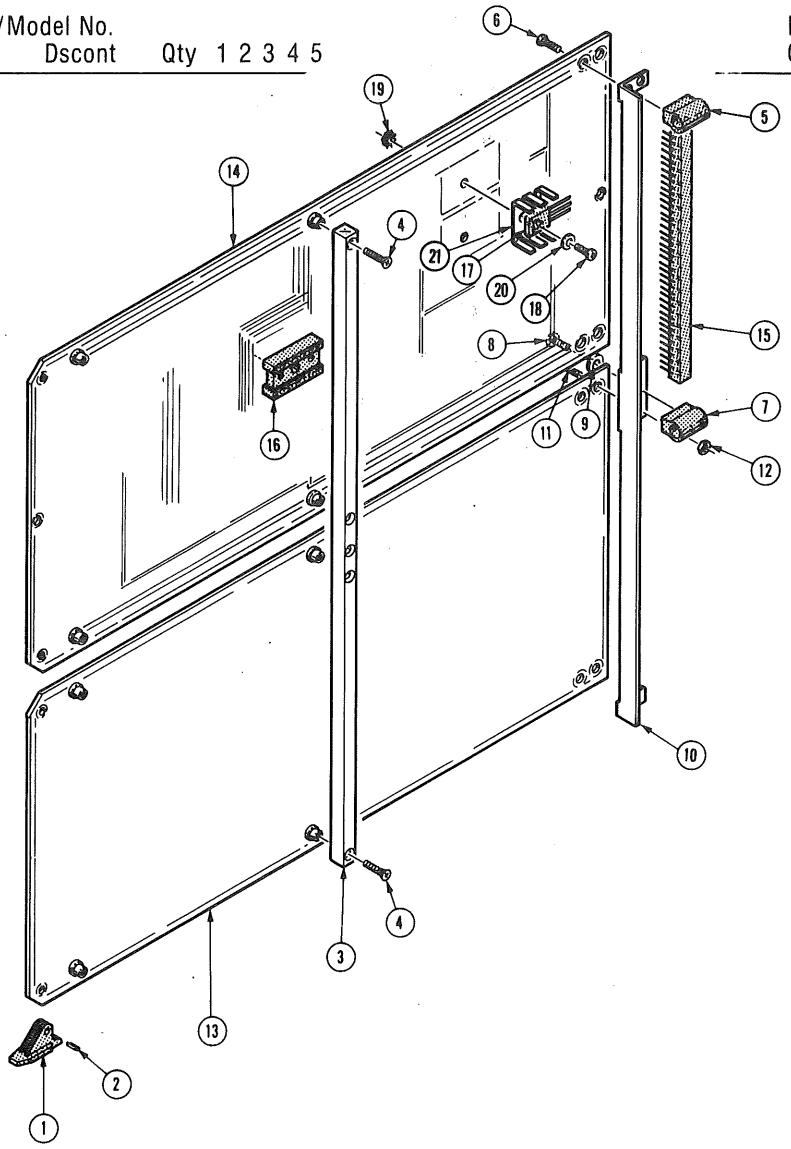


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
-1	105-0160-03			2		EJECTOR,CKT CD:GRAY PLASTIC	80009	105-0160-03
						(ATTACHING PARTS FOR EACH)		
-2	214-1337-00			1		PIN,SPRING:0.10 OD X 0.25 INCH L,STL	80009	214-1337-00
						- - - * - - -		
-3	386-3395-00			2		STIF,CKT CARD:	80009	386-3395-00
						(ATTACHING PARTS FOR EACH)		
-4	211-0016-00			4		SCREW,MACHINE:4-40 X 0.625 INCH,PNH STL	83385	OBD
						- - - * - - -		
-5	351-0460-00			2		GUIDE,CKT CARD:	80009	351-0460-00
						(ATTACHING PARTS FOR EACH)		
-6	213-0088-00			2		SCR,TPG,THD CTG:4-24 X 0.25 INCH,PNH STL	83385	OBD
						- - - * - - -		
-7	351-0460-00			1		GUIDE,CKT CARD:	80009	351-0460-00
						(ATTACHING PARTS)		
-8	213-0088-00			2		SCR,TPG,THD CTG:4-24 X 0.25 INCH,PNH STL	83385	OBD
-9	210-0054-00			2		WASHER,LOCK:SPLIT,0.118 ID X 0.212"OD STL	83385	OBD
						- - - * - - -		

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
-10	407-1718-00			1		BRACKET,CKT CD:DUAL	80009	407-1718-00
						(ATTACHING PARTS)		
-11	211-0097-00			4		SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL	83385	OBD
-12	210-0586-00			4		NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL	78189	OBD
						- - - * - - -		
-13	670-4627-00			1		CKT BOARD ASSY:BLANK	80009	670-4627-00
-14	----- -----			1		CKT BOARD ASSY:ROMULAN(SEE EPL)		
-15	131-1717-00			1		. CONNECTOR,RCPT,CKT CARD,42/84 FEM CONN	00779	3-86018-4
-16	136-0432-00			4		. SOCKET,PLUG-IN:24 CONTACT	71785	133-59-02-011
-17	----- -----			2		. TRANSISTORS:(SEE Q185,Q285 EPL)		
						(ATTACHING PARTS FOR EACH)		
-18	211-0012-00			1		. SCREW,MACHINE:4-40 X 0.375 INCH,PNH STL	83385	OBD
-19	210-0586-00			1		. NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL	78189	OBD
-20	210-1122-00			1		. WASHER,LOCK:0.228 ID X 0.375 INCH OD,STL	78189	4704-04-02
						- - - * - - -		
-21	214-1967-00			2		. HEAT SINK,DIODE:FINGER TYPE	13103	6107B-14
						ACCESSORIES		
	119-0848-02			1		FLEX MAG DISC:GOS,IPL,MAX	80009	119-0848-02

Section 5
SCHEMATIC

Symbols and Reference Designators

Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors = Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).

Resistors = Ohms (Ω).

Graphic symbols and class designation letters are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

Abbreviations are based on ANSI Y1.1-1972.

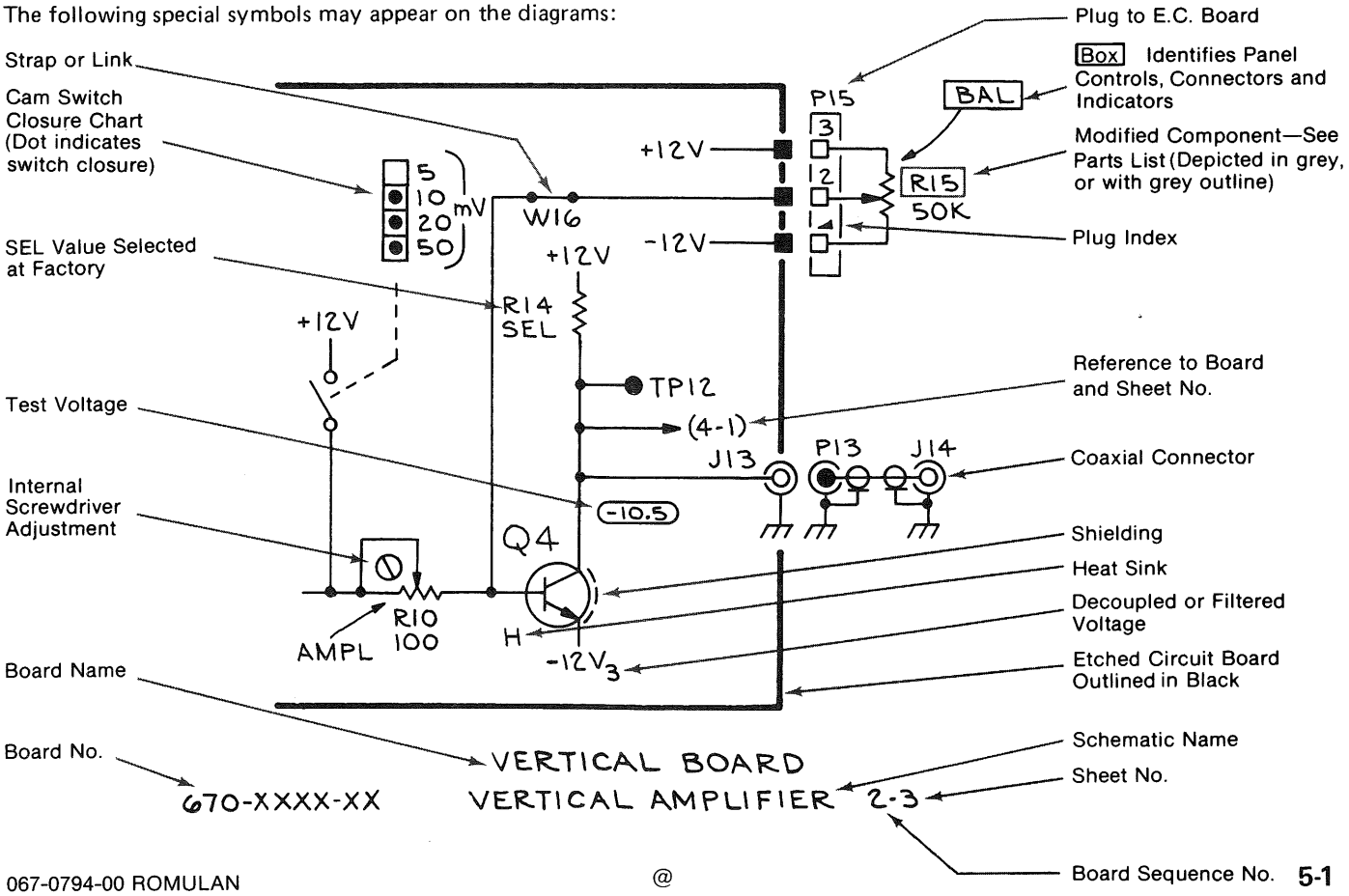
Other ANSI standards that are used in the preparation of diagrams by Tektronix, Inc. are:

Y14.15, 1966	Drafting Practices.
Y14.2, 1973	Line Conventions and Lettering.
Y10.5, 1968	Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

A	Assembly, separable or repairable (circuit board, etc)	H	Heat dissipating device (heat sink, heat radiator, etc)	S	Switch or contactor
AT	Attenuator, fixed or variable	HR	Heater	T	Transformer
B	Motor	HY	Hybrid circuit	TC	Thermocouple
BT	Battery	J	Connector, stationary portion	TP	Test point
C	Capacitor, fixed or variable	K	Relay	U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
CB	Circuit breaker	L	Inductor, fixed or variable	V	Electron tube
CR	Diode, signal or rectifier	M	Meter	VR	Voltage regulator (zener diode, etc.)
DL	Delay line	P	Connector, movable portion	W	Wirestrap or cable
DS	Indicating device (lamp)	Q	Transistor or silicon-controlled rectifier	Y	Crystal
E	Spark Gap, Ferrite bead	R	Resistor, fixed or variable	Z	Phase shifter
F	Fuse	RT	Thermistor		
FL	Filter				

The following special symbols may appear on the diagrams:



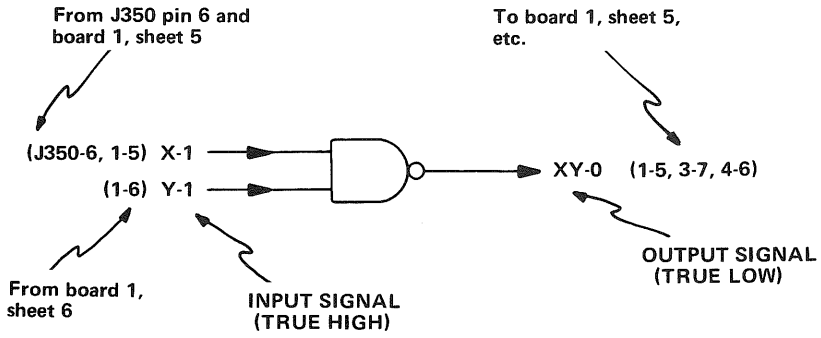
1. TRUE HIGH and TRUE LOW Signals

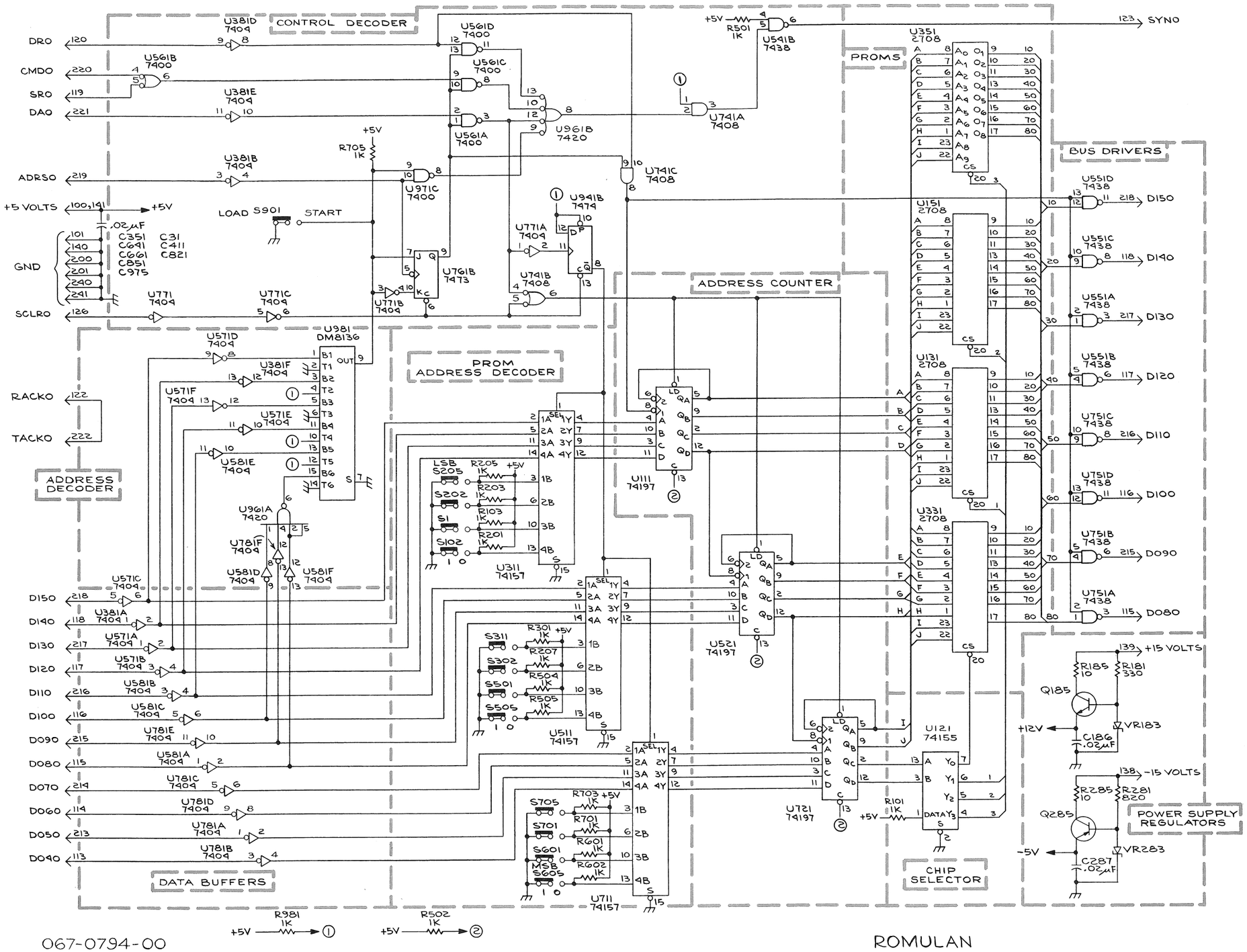
Signal names on the schematics are followed by −1 or −0. A TRUE HIGH signal is indicated by −1, and a TRUE LOW signal is indicated by −0.

SIGNAL−1 = TRUE HIGH
SIGNAL−0 = TRUE LOW

2. Cross-References

Schematic cross-references (from/to information) are included on the schematics. The "from" reference only indicates the signal "source," and the "to" reference lists all loads where the signal is used. All from/to information will be enclosed in parenthesis.





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ROMULAN

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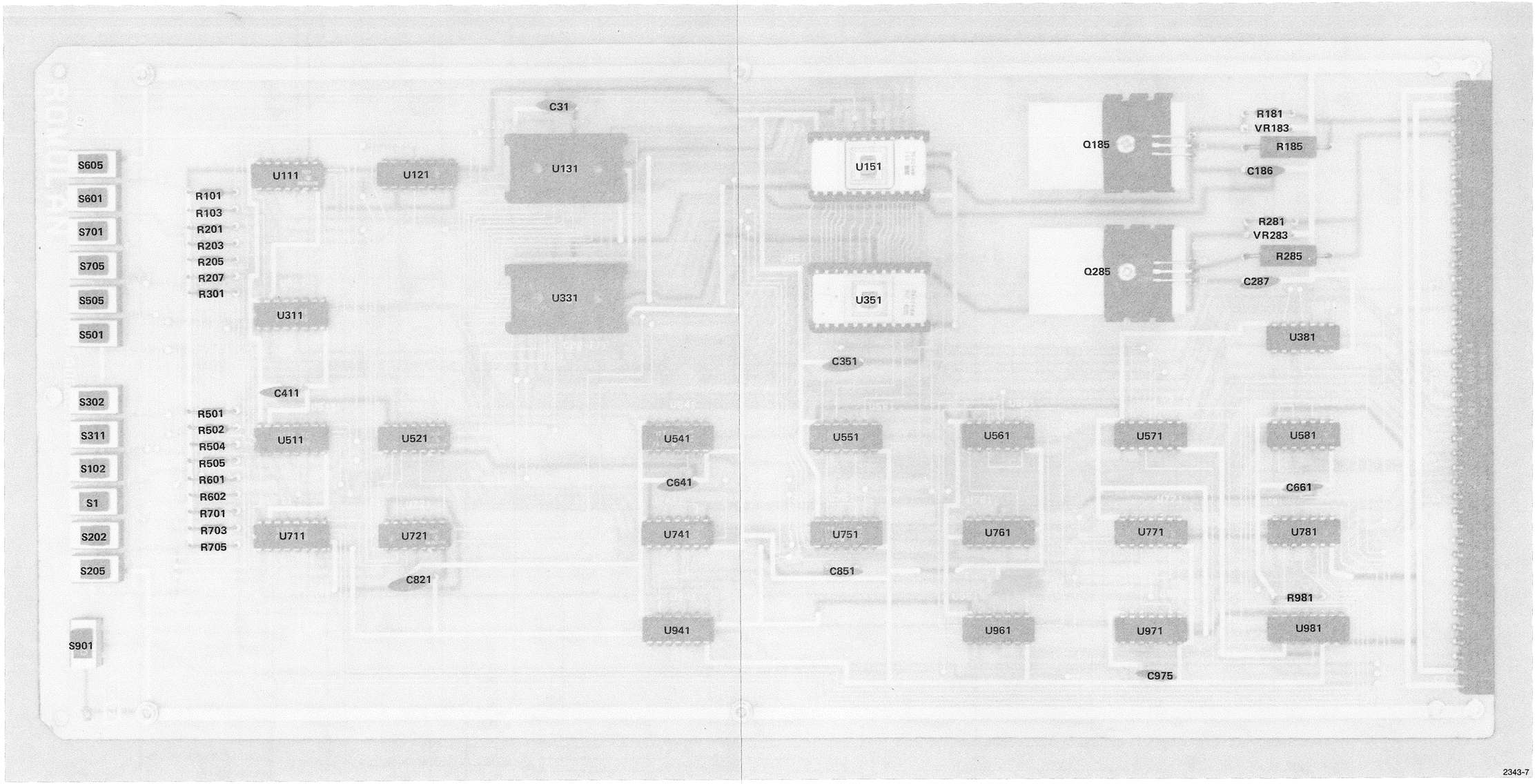
ROMULAN



Romulan Component Locations.