Chapter 7
Reference Information

7.1 Introduction

This chapter contains HP 110 reference information and additional service information.

- 7.2 Diagnostic Test Results.
- 7.3 Signal Names.
- 7.4 Descriptions of Diagnostic Tests.
- 7.5 Service References.
- 7.6 Service Equipment.

7.2 Diagnostic Test Results

Use the information in table 7-1 to interpret the results of built-in, disc-based, and service EPROM diagnostic tests. (This information is repeated from table 4-2 in chapter 4.)

For assembly-level repair, replace the assembly indicated in the "assembly-level" column (or take the steps listed).

For component-level repair, replace the component indicated in the "component-level" column (or take the steps listed); when directed, use signature analysis (S/A) according to the reference in the last column to the signature analysis supplement.

> **Note:** If you're equipped to perform signature analysis, you can verify that the address, data, and control lines are good before replacing a component. You should do this if you're not reasonably certain that the indicated component is bad. Refer to the signature analysis supplement for information about performing signature analysis.

Table 7-1. Diagnostic Test Results

Test Result	Assembly-Level Replacement	Component-Level Replacement	Signature Analysis Reference
Failure Codes:			
101	System PCA.*	Replace A1U1 (CPU).	"Analyzing the CPU"
120–127	System PCA.*	If only one or two RAMs indicated, replace individual A1U20–U27 (RAM).	"Analyzing System RAM"
		If more than two RAMs indicated, latch or transceiver suspected. Trace using S/A.	
128–151	System PCA.*	If only one or two RAMs indicated, replace individual A1U28–U51 (RAM).	"Analyzing Mass Storage RAM"
		If more than two RAMs indicated, latch or transceiver suspected. Trace using S/A.	
152–163	If only one or two ROMs indicated, replace individual A1U52–U63 (ROM).*	If only one or two ROMs indicated, replace individual A1U52–U63 (ROM).*	"Analyzing System ROM"
	If more than two ROMs indicated, replace system PCA.*	If more than two ROMs indicated, latch or transceiver suspected. Trace using S/A.	
166–167	System PCA.*	If only one or two RAMs indicated, replace individual A1U66–U67 (RAM).	"Analyzing System RAM"
		If more than two RAMs indicated, latch or transceiver suspected. Trace using S/A.	
201	I/O PCA.†	Trace using S/A; replace A2U1 (PPU).	"Analyzing the PPU"
202	I/O PCA.†	Replace A2U2 (multicontroller).	"Analyzing the Keyboard Circuit"

Table 7-1. Diagnostic Test Results (Continued)

Test Result	Assembly-Level Replacement	Component-Level Replacement	Signature Analysis Reference
203	I/O PCA.†	Replace A2U3 (LCD controller).	"Analyzing the Display Controller"
204	I/O PCA.†	If occurs during HP-IL test, check HP-IL components using S/A; replace A2U4 (HP-IL controller). If occurs during RS-232 test, replace A2U4 (HP-IL controller).	"Analyzing the HP-IL Circuit"
205	I/O PCA.†	Verify using S/A; replace A2U5 (display RAM); replace A2U3.	"Analyzing Display RAM"
228	Replace A2U28 (EPROM)—burn new EPROM IC before installing (section 4.3)	Replace A2U28 (EPROM)—burn new EPROM IC before installing (section 4.3)	"Analyzing the Configuration EPROM"
331‡	Check modem PCA connection; swap modem PCA and retry; replace modem PCA or I/O PCA†, as indicated.	Check modem circuit according to table 4-10, "Repairing the Modem" (may not be A3U31).	
332‡	Check modem PCA connection; swap modem PCA and retry; replace modem PCA or I/O PCA, as indicated.	Check modem circuit according to table 4-10, "Repairing the Modem" (may not be A3U32).	
4*rcc* (*r* is row number) (*cc* is column number)	Swap top case (if possible) or swap keyboard module, then retry. If fixed, replace keyswitch (or keyboard module) after checking continuity; if not fixed, replace I/O PCA.†	Swap top case (if possible) or swap keyboard module, then retry. If fixed, replace keyswitch (or keyboard module) after checking continuity; if not fixed, replace A2U2 (multi-controller).	

Table 7-1. Diagnostic Test Results (Continued)

Test Result	Assembly-Level Replacement	Component-Level Replacement	Signature Analysis Reference
Messages:			
Broken loop	Try new cable; check connections; check I/O plate (or swap and retry); replace I/O PCA.†	Try new cable; check connections; inspect internal connections to I/O plate assembly (or swap assembly and retry); check continuity of HP-IL interface circuit (see schematic); replace A2U4 (HP-IL controller).	"Analyzing the HP-IL Circuit"
Loop error, data not received as sent	Remove peripherals and run "no devices" test; try new cable; check connections; bad HP-IL peripheral; check I/O plate (or swap and retry); replace I/O PCA.†	Remove peripherals and run "no devices" test; try new cable; check connections; bad HP-IL peripheral; check I/O plate (or swap and retry); check HP-IL components using S/A; replace A2U4 (HP-IL controller).	"Analyzing the HP-IL Circuit"
Number of devices on HP-IL loop= *wrong number*	Check connections; bad HP-IL peripheral; if occurs for every peripheral, replace I/O PCA.†	Check connections; bad HP-IL peripheral; if occurs for every peripheral, replace A2U4 (HP-IL controller).	
Transmitted or Rcvd. Data line(s) bad	Check test connector; replace I/O PCA.†	Check test connector; trace signals using scope routine.	
CTS line bad DSR line bad DTR line bad RTS line bad Carrier Det line bad	Check test connector; replace I/O PCA.†	Check test connector; check serial interface according to table 4-9, "Repairing the Serial Interface."	
Ring Det line bad	Check modem PCA connection; swap modem PCA and retry; replace modem PCA or I/O PCA†, as indicated.	Check modem PCA connection; check test connector; check serial interface according to table 4-9, "Repairing the Serial Interface."	

Table 7-1. Diagnostic Test Results (Continued)

Test Result	Assembly-Level Replacement	Component-Level Replacement	Signature Analysis Reference
Pwr Supply Stuck On	I/O PCA.†	Trace power supply signals according to table 4-9, "Repairing the Serial Interface."	
Display Test Observations:			
Display doesn't scroll properly	I/O PCA.†	Replace A2U3 (LCD controller).	
Border line improper	Display assembly.	Display assembly.	
Extra or missing pixels	Swap top case assembly and retry; replace display assembly or I/O PCA†, as indicated.	Check VCC2 at A2U3 pin 1; swap top case assembly and retry; check display circuit using S/A or replace display assembly, as indicated.	"Analyzing the Display Controller"
Row (or column) dark or light	Display assembly.	Display assembly.	
Blinking or inverse display improper	Display assembly.	Display assembly.	
12- or 16-line display format improper	I/O PCA.†	A2U3 (LCD controller).	
Two cursors improper	I/O PCA.†	A2U3 (LCD controller).	
Quadrant bad	Check continuity between A2U3 and display assembly; swap I/O PCA or top case assembly, then retry; replace display assembly or I/O PCA†, as indicated.	Check continuity between A2U3 and display assembly; use scope to check for toggling signals at A2U3 pins 9–16; replace display assembly or A2U3 (LCD controller), as indicated.	
Adjacent rows (or columns) duplicated	Display assembly.	Display assembly.	
Modem Observations:			
During optional pulse dialing test, telephone doesn't ring	Check modem connections; check phone number; check modem PCA connection; swap modem PCA and retry; replace modem PCA or I/O PCA†, as indicated.	Check modem connections; check phone number; verify circuit using standard modem test; check modem circuit according to table 4-10, "Repairing the Modem."	

Table 7-1. Diagnostic Test Results (Continued)

Test Result	Assembly-Level Replacement	Component-Level Replacement	Signature Analysis Reference
During optional tone dialing test, telephone doesn't ring	Check modem connections; check phone number; check modem PCA connection; swap modem PCA and retry; replace modem PCA or I/O PCA†, as indicated.	Check modem connections; check phone number; verify circuit using standard modem test; check modem circuit according to table 4-10, "Repairing the Modem."	
During optional ring-detect test, HP 110 doesn't beep or indicate call received	Check modem connections; check phone number; check modem PCA connection; swap modem PCA and retry; replace modem PCA or I/O PCA†, as indicated.	Check modem connections; check phone number; verify circuit using standard modem test; check modem circuit according to table 4-10, "Repairing the Modem."	

* Whenever you replace system ROMs, you must ensure that the configuration EPROM (A2U28) matches the system ROMs (contains the proper ROM checksum values). (Refer to tables 6-8 and 6-9.)

- If the *same-revision ROMs* are installed, leave the original configuration EPROM in the I/O PCA.
- If *new-revision ROMs* are installed, burn a new configuration EPROM (section 4.3), then install it in the I/O PCA.

† Whenever you replace the I/O PCA, remove the configuration EPROM (A2U28) from the old PCA and install it in the new PCA. (This does not apply if you install new-revision ROMs or if you suspect that the configuration EPROM itself is bad.)

‡ Ignore this result for all B versions. These units don't have modems.

7.3 Signal Names

Table 7-2 lists the names, descriptions, and sources of the primary signals used by the HP 110.

Table 7-2. Signal Names

Name*	Description	Source
1MHZ	1-MHz Clock	Counter A2U20
2MHZ	2-MHz Clock	Counter A2U20
A0–A15	Main Address Bus	CPU (via A2U8, A2U9)
A16–A19	Auxiliary CPU Address	CPU
AD0–AD15	CPU Address/Data Bus	CPU
ADD	Latch CPU Address	LCD controller
ALE	Address Latch Enable	CPU (via A1U2)
BA0–BA13	RAM/ROM Address Bus	CPU (via A1U4, A1U5)
BATDOWN	Battery Voltage Down	Charger A2U27D
BD0–BD15	RAM/ROM Data Bus	CPU (via A1U8, A1U9), A1U20–A1U27, A1U52–A1U63
BEEP	Beep	PPU

Table 7-2. Signal Names (Continued)

Name*	Description	Source
BUSY	Busy PPU	PPU
C1–C13	Keyboard Columns	Keyboard
CARRIER	Carrier Interrupt	Multiplexer A2U41
CHARGE	AC Charge Indicator	Charger A2Q5
CHGREF	Charger Reference	Regulator A2VR3 (via A2R22)
CL1	Clock (LCD Rows)	LCD controller
CL2	Clock (LCD Quadrants)	LCD controller
CLK	CPU Clock (5.33 MHz)	Clock A2U19 (via A2R121)
CRESET	CPU Reset	Clock A2U19
CTS	Clear To Send	(External)
D0–D15	Main Data Bus	(Shared)
DATACLK	PPU Serial Data Clock	PPU
DSR	Data Set Ready	(External)
DT	Direction Transmit	CPU (via A1U2)
DTR	Data Terminal Ready	PPU (via A2U39C)
FAST	Fast Charge	PPU
FLM	Frame Clock (LCD Refresh)	LCD controller
HB	High Dial Signal	Tone-dial generator A2U33
HPILCLK	HP-IL Clock	Counter A2U20 (via A2U25C)
HPILCS	HP-IL Select	CPU (via A2U22)
HPILIRQ	HP-IL Interrupt	HP-IL controller
INH	Input High Data (to LCD RAM)	LCD controller
INL	Input Low Data (to LCD RAM)	LCD controller
INTA	Interrupt Acknowledge	CPU
INTR	Interrupt CPU	PPU, multi-controller (via A2U23A)
IOEN	I/O Enable	CPU (via A1U19)
KEYCLK	Keyboard Clock (2.67 MHz)	Clock U19
KEYCS	Keyboard Select	CPU (via A2U22)
KEYIRQ	Keyboard Interrupt	PPU, multi-controller
KEYRDY	Keyboard Ready	Multi-controller
LAH	Latch High Data (from LCD RAM)	LCD controller
LAL	Latch Low Data (from LCD RAM)	LCD controller
LB	Low Dial Signal	Tone-dial generator A2U33

Table 7-2. Signal Names (Continued)

Name*	Description	Source
LBHE	Latch Bus High Enable	CPU (via A1U3)
LCDEN	LCD Enable	PPU
LCDMCS	LCD Memory Select	CPU (via A1U12)
LCDNEG	LCD Negative Supply	LCD supply A2Q28
LCDRCS	LCD Registers Select	CPU (via A2U22)
LCDRDY	LCD Ready	LCD controller
LD0–LD7	LCD Data Bus	CPU (via A2U12, A2U13), LCD controller
LEN	Low Memory Enable	CPU (via A1U19)
LM	Latch Main Memory	CPU (via A1U3)
LOBAT	Low Battery Voltage	Regulator A2Q34
LS0–LS2	Latch Select	CPU (via A1U17)
M	Multiplex Clock (Alt. Refresh)	LCD controller
M/IO	Main/IO Memory Select	CPU
MA1–MA13	Mass Storage Address Bus	CPU (via A1U6, A1U7)
MC1–MC3	Modem Key Column	PPU
MD0–MD15	Mass Storage Data Bus	CPU (via A1U10, A1U11), A1U28–A1U51, A1U66, A1U67
MODEMCARRIER	Modem Carrier	Carrier detector A3U35D
MODEMEN	Modem Enable	PPU
MODEMON	Modem On	PPU
MODEMSIN	Modem Serial Data In	Modem IC A3U32 (via A3U37D)
MPWR	Modem Power	Modem power switch A3Q32
MR1–MR4	Modem Key Row	PPU
MSEN	MS RAM Enable	CPU (via A1U19)
MSSEL	MS RAM Address Select	CPU (via A1U18)
OFFHOOK	Modem Off Hook	PPU
ORIG	Modem Originate Mode	PPU (via A2U41)
OSC	Master Oscillator	Clock A2U19
OUT	Output Data Enable	LCD controller
PPUBUSY	PPU Busy Interrupt	PPU (via A2U23D)
PWO	Power-On Reset	PPU
R1–R8	Keyboard Rows	Keyboard
RA0–RA12	LCD RAM Address Bus	CPU (via A2U14, A2U15), LCD controller
RAMCS	LCD RAM Select	LCD controller
RAMOE	LCD RAM Output Enable	LCD controller

Table 7-2. Signal Names (Continued)

Name*	Description	Source
RAMRW	LCD RAM Write	LCD controller
RD1	Read 1 Strobe (ROM)	CPU (via A1U2)
RD2	Read 2 Strobe (MS)	CPU (via A1U2)
RD3	Read 3 Strobe (I/O)	CPU (via A1U2)
RDx0, RDx1	HP-IL Receive Data	(External)
READY	Ready	Clock A2U19
RESET	Reset	PPU
RING/RxCAR	Ring/Carrier Interrupt	Modem limiter A3U35B
ROMCS	EPROM Select	CPU (via A2U21)
RS232CARRIER	Serial Carrier	(External)
RS232PWR	Serial Power	PPU (via A2U41)
RS232RING	Serial Ring	(External)
RTS	Request To Send	PPU (via A2U39B)
RxD	Received Data	(External)
SA–SF	ROM Select	CPU (via A1U12)
SA14–SA19	Select Address	CPU (via A1U3)
SD1–SD4	Serial Data for Quadrants	LCD controller
SDATIN	PPU Serial Data In	CPU (via A2U18B)
SDATOUT	PPU Serial Data Out	PPU
SELFTEST	Modem Self-Test	PPU (via A2U42)
SHUTDOWN	Shutdown Battery Voltage	Regulator A2Q35
SIGNAL	Phone Signal	Protective interface A2T2, filter A3U34B (via A3R84)
SIN	Serial Data Input	Multiplexer A2U41
SLEEP	Sleep	PPU
SOUT	Serial Data Output	Multi-controller
STEP1,2,4,8	Contrast Step	PPU
SYS	PPU Select	CPU (via A2U22)
SYSEN	System RAM/ROM Enable	CPU (via A1U19)
SYSRD	PPU Read	CPU (via A2U21)
SYSWR	PPU Write	CPU (via A2U21)
TDx0, TDx1	HP-IL Transmit Data	HP-IL controller
TRANSEN	Transmit Enable	PPU
TxD	Transmitted Data	Multi-controller (via A2U39A)
VAG	Analog Reference Voltage	Filter A3U31

Table 7-2. Signal Names (Continued)

Name*	Description	Source
VBAT	Battery Supply Voltage	Battery, charger A2Q4
VCC1	+5V Unswitched	Regulator A2Q13
VCC2	+5V Switched	Regulator A2Q20
WR1	Write 1 Strobe (I/O)	CPU (via A1U2)
WR2	Write 2 Strobe (MS)	CPU (via A1U2)

* The signal names don't include the logic sense of the signal (bars aren't included over signal names) because some signals are present in the HP 110 with both logical senses.

7.4 Descriptions of Diagnostic Tests

The following paragraphs summarize the operation of the built-in, disc-based, and EPROM diagnostic tests. This information may be useful for interpreting unusual test results.

In order for the test program to run and display its menu, certain functions of the HP 110 must operate, either partially or entirely. These functions include:

- Display.
- Display controller.
- Display RAM.
- Latches, buffers, and decoders for the CPU circuit, display circuit, and address/control circuit.
- Clock circuit.
- PPU.
- Power supply.
- Configuration EPROM.
- Keyboard (key not stuck).
- Certain ROM ICs (several for disc-based test; highest two for built-in and EPROM tests).
- Multi-controller (for disc-based test).

The built-in test checks part of the CPU and display RAM during its startup routine.

7.4.1 System Test

The System test includes all of the tests described below except for the Sleep test.

7.4.2 CPU Test

The CPU test checks about 90 percent of the CPU functionality, including tests of its registers, addressing, and stack operations.

7.4.3 ROM Test

The ROM test computes the checksum for each system ROM IC (plus the configuration EPROM) by stepping through the address space sequentially; then it compares the value with the proper value stored in the configuration EPROM. The test further computes the checksum for each system ROM IC by cycling through the address space in 16-byte steps; then it compares the value with the proper value from the configuration EPROM.

7.4.4 RAM Test

The EPROM-based RAM test clears memory; the disc-based RAM test preserves memory. This test checks system RAM and mass storage RAM, but it *doesn't* check the display RAM.

The RAM test checks the RAM select circuit, RAM address latches, and transceivers by sending one byte to each of the RAM ICs, then reading those bytes back from all ICs. It repeats this cycle starting at each RAM IC.

The test checks data retention by storing 0's at all addresses, waiting 4 seconds, then reading from all addresses. This cycle is repeated using 1's.

The test checks internal addressing of the RAM ICs by repeating a read-store cycle four times, using 0's (then 1's) and working from low to high addresses (then high to low). The test further checks the internal addressing by storing at each address the lower eight bits of that address, then reading them back; it then repeats this cycle using the upper eight bits of the address.

7.4.5 LCD Test

The LCD test checks the LCD controller registers by writing to and reading from them.

The test checks the LCD controller and display module using messages and visual patterns. The visual test includes scrolling (in alpha and graphics modes), border lines, horizontal and vertical lines, blinking and inverse characters, 12- and 16-line alpha displays, and dual cursors.

The test checks the display RAM using all of the RAM tests described above for the RAM test. While this test is executing, the display reflects the patterns caused by the bytes stored in display RAM.

7.4.6 Keyboard Test

The Keyboard test displays the keyboard layout derived from the configuration EPROM and prompts the operator to press each key in sequence. The test provides no key roll-over (unlike normal keyboard operation). As each key is pressed, the test checks the operation of the interrupt register, row/column registers, and the debounce function in the multi-controller.

7.4.7 HP-IL Test

The HP-IL test checks the operation of the HP-IL interface using two tests.

The "no devices" test requires that one HP-IL cable be connected between the HP 110 IN and OUT receptacles. (No peripheral devices should be connected.) This test checks the continuity of the HP-IL circuit by sending an End Of Transmission message on the loop.

The "devices" test requires that the HP 110 and one or more peripheral devices be connected in a loop. This test checks the continuity of the HP-IL circuit by sending an End Of Transmission message. It also checks that each connected peripheral device is operating—it does this by sending an Auto Address message, which assigns an address to each peripheral device. The test displays the number of peripheral devices based upon the modified HP-IL addressing message that returns to the HP 110.

Both of these tests then check the controller functions and scratch pad of the HP-IL controller IC.

7.4.8 Modem Test

The Modem test puts the multi-controller UART (universal asynchronous receiver-transmitter) function in its self-test mode, then sends and receives 256 bytes of data at 9600 baud to check its operation. During the data transfer, the test checks the UART control and status registers and the interrupt function.

The test checks the operation of the modem circuit and PPU by setting the modem IC and active filter IC to their self-test modes, then sending and receiving data at 300 baud. This is done in both Originate and Answer modes.

The optional tone-dialer part of the test exercises the tone-dial generator IC, PPU, and related circuitry. The test requires that the HP 110 be connected to a phone line; it dials the phone number entered by the user.

The optional pulse-dialer part of the test exercises the PPU and related circuitry. The test requires that the HP 110 be connected to a phone line; it dials the phone number entered by the user.

The optional ring-detect part of the test exercises the PPU and related circuitry. The test requires that the HP 110 be connected to a phone line and that its number be dialed from another phone; it beeps and displays a message when it detects a ring signal.

7.4.9 RS-232 Test

The RS-232 test checks the serial interface. The test requires that the RS-232 test connector be installed at the serial receptacle. This connector provides a path for output signals to be fed back to input lines.

The test toggles the output (control) lines and checks the status of the input (status) lines. This checks the operation of the PPU, HP-IL controller, and serial interface circuit.

The test then checks the data path by sending and receiving 256 bytes of data on the transmit and receive lines. If an error occurs, the test checks the multi-controller by setting the multi-controller UART to its self-test mode, then sending and receiving data at two baud rates.

7.4.10 Beeper Test

The Beeper test checks the PPU and beeper (transducer) by sounding three normal beeps.

7.4.11 Timer Test

The Timer test first checks the real-time clock in the PPU by writing to and reading from its clock registers.

The test then checks the count-down timer in the multi-controller by writing to and reading from its registers, and by starting and stopping the timer at different values. The test also checks the CPU-interrupt function of the multi-controller.

7.43.12 Sleep Test

The Sleep test checks that the CPU and PPU can power-down the system.

7.5 Service References

The following references provide additional information about the HP 110 and about components used in the HP 110.

Hewlett-Packard Company. *HP 110 Owner's Manual.* HP reorder number 00090-90004, ©1984.

Intel Corporation. *Microsystem Components Handbook,* Volume I. ©1984.

Kane, Gerry, et al. *The HP-IL System: An Introductory Guide to the Hewlett-Packard Interface Loop.* Osborne/McGraw-Hill, Berkeley, California, ©1982.

McNamara, John E. *Technical Aspects of Data Communication.* Digital Equipment Corporation, Bedford, Massachusetts, ©1977.

7.6 Service Equipment

7.6.1 RS-232 Test Connector

Figure 7-1 shows the wiring for the RS-232 test connector.

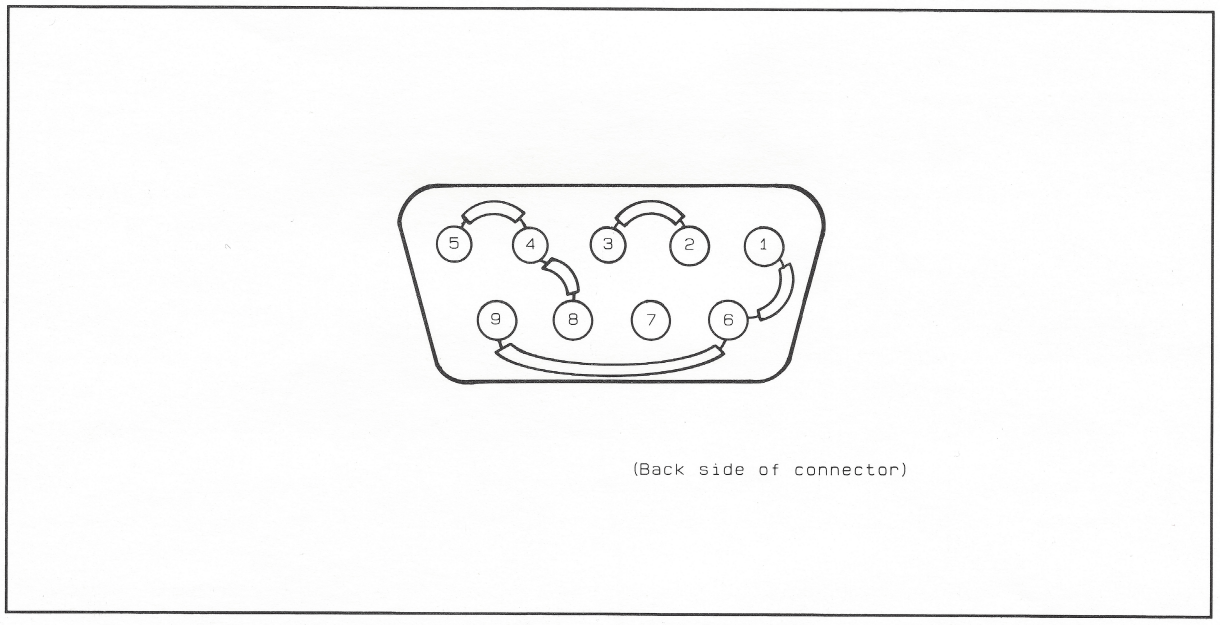

Figure 7-1. RS-232 Connector Wiring Diagram

7.6.2 Diagnostic Module

The diagnostic module is used while the HP 110 is dissassembled. The module connects in parallel with the 50 lines that connect the system and I/O PCAs. The module (figure 7-2) contains circuitry to provide the control signals for signature analysis, circuitry to burn configuration EPROMs for the HP 110, and two 8K-byte EPROMs that contain the diagnostic tests. The code located in the diagnostic EPROM provides the software for system testing, EPROM burning, and signature analysis.

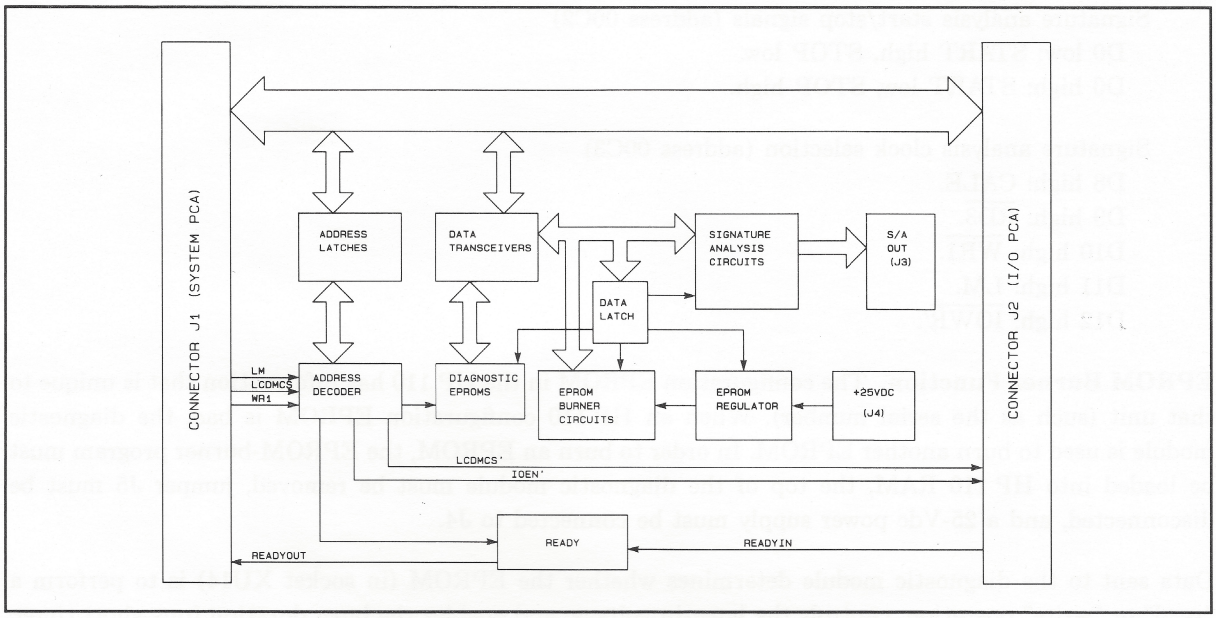

Figure 7-2. Diagnostic Module Block Diagram

The diagnostic module is contained on one PCA. The PCA contains all circuits necessary to communicate with the HP 110. (Table 7-3 lists the replaceable parts for the diagnostic module. Figures 7-4 and 7-5 show its component location diagram and schematic diagram.)

The diagnostic module latches the addresses and data sent on the CPU bus by HP 110 circuits. The addresses are decoded to determine what function the module should perform. The HP 110 must write data to I/O address 00C3 and then either read an EPROM address (for diagnostic testing), or write data to addresses (for EPROM burning or for controlling the signature analysis control lines).

EPROM Diagnostic Test Function. The diagnostic EPROM is located in the last 16K bytes of display RAM (addresses 8C000 through 8FFFF). When the module is connected to the HP 110 and jumper J5 is installed, the diagnostics are run at power-up. At power-up the CPU checks for "55" at address 8C000. If "55" is present, the CPU jumps to and excutes the code in the diagnostic EPROMs (U5 for odd addresses, U10 for even addresses). If "55" is not present, the CPU follows its normal power-up routine.

HP 110 data is transferred through tristate transceivers U3 and U4.

Signature Analysis Function. Software located in the diagnostic EPROMs provides the necessary routines that generate the control signals for signature analysis and provide the stimulus (signal patterns on the bus). When data is sent on D0 to I/O address 00C2, the module toggles the START and STOP outputs for signature analysis. The signature analysis clock is driven from one of several signals (CALE, $\overline{WR1}$, LM, or $\overline{RD3}$), according to data sent on D8 through D13 to I/O address 00C3. This provides a reliable clock signal for the signature analyzer.

Signature analysis start/stop signals (address 00C2)
D0 low: START high, STOP low.
D0 high: START low, STOP high.

Signature analysis clock selection (address 00C3)
D8 high: CALE.
D9 high: $\overline{RD3}$.
D10 high: $\overline{WR1}$.
D11 high: LM.
D12 high: $\overline{IOWR'}$.

EPROM Burner Function. The configuration EPROM in the HP 110 has information that is unique to that unit (such as the serial number). When an HP 110 configuration EPROM is bad, the diagnostic module is used to burn another EPROM. In order to burn an EPROM, the EPROM-burner program must be loaded into HP 110 RAM, the top of the diagnostic module must be removed, jumper J5 must be disconnected, and a 25-Vdc power supply must be connected to J4.

Data sent to the diagnostic module determines whether the EPROM (in socket XU14) is to perform a "read" or "write" operation, controls the burn-in voltage, and enables the burn duration (one-shot) timer.

Circuit Description. Connector J1 is the connection to the HP 110 system PCA; connector J2 connects to the HP 110 I/O PCA. Address latches U1 and U2 capture the 16-bit address on the HP 110 CPU bus when ALE goes high.

Tristate data transceivers U3 and U4 control the transfer of data between the diagnostic module and the HP 110. The DT line controls the direction of the data transfer; the $\overline{IOEN}$ line enables the data transfer.

EPROM U5 contains the odd-address memory; EPROM U10 contains the even-address memory.

Data latch U6 is enabled at I/O address 00C3. A high data line D15 turns on EPROM U14 (an HP 110 configuration EPROM). When D14 and $\overline{WRT}$ are asserted, the "clear" input to multivibrator U15 is also asserted. When D13 is high, Q1 turns on. This lowers the output voltage from regulator U7, causing the U14 programming voltage to drop from approximatly 21 Vdc to about 5 Vdc. D12 determines the $\overline{IOWR'}$ (I/O write') state, D11 determines the $\overline{IORD'}$ (I/O read') state, D10 determines the $\overline{WR'}$ (write') state, D9 determines the $\overline{RD'}$ (read') state, and D8 determines the ALE' (address latch enable') state. When U6 is enabled, data on lines D12 through D8 are ANDed with their system signals to provide the clocking pulses for the signature analyzer clock (for example, D10 $\overline{WR'}$ is ANDed with $\overline{WR1}$).

Eight-bit comparator U8 enables the data latch (U6) when I/O address 00C3 is on the CPU bus and $\overline{WR1}$ is asserted.

Half of 2-to-4 line decoder U9 enables U8 and U13 when address line A15 is low, LM is low, and $\overline{WR1}$ is asserted. The second half of U9 has two functions: to enable the module's EPROMs and provide the address portion to trigger U15 (when lines A15 and A14 are high and $\overline{LCDMCS}$ is asserted); and to determine when the LCD memory should be accessed. The first 16K bytes of display RAM contains the display data and is enabled when A15 and A14 are low and $\overline{LCDMCS}$ is asserted.

D-type flip-flops U11 and U12 and comparator U13 provide the start and stop signals for signature analysis. Comparator U13 is enabled when the CPU writes to I/O address 00C2 (refer to previous paragraph). The output from U13 clocks both flip-flops in U11. Data line D0 triggers both D inputs for U11. The output of the first flip-flop clears and triggers the second flip-flop in U12 to generate the "stop" signal. The output of the second flip-flop in U11 triggers and clears the first flip-flop in U12 to generate the "start" signal for signature analysis. The signature analysis "clock" signal clocks both flip-flops in U12.

U15 is a dual-trigger monostable multivibrator. It determines the EPROM burn time for data at each address. Typically, this time is about 55 milliseconds. U15 is triggered when the address on the bus is above C000 (A15 and A14 are high; refer to second paragraph above) and $\overline{WR1}$ is asserted. (The second multivibrator isn't used.)

D-type filp-flop U23 is synchronized with the system clock and generates a READYout signal. The flip-flop is triggered when U15 asserts the $\overline{Q}$ line; the flip-flop is clocked by the $\overline{IOEN}$ line. The output of the flip-flop is ANDed with the READYIN line from J2 to form the READYOUT signal.

Checking the Signature Analysis Circuit. Use the following procedure to check the signature analysis circuit of the diagnostic module:

1. Remove the battery, separate the case, and remove the I/O and system PCAs from the HP 110 (procedures 5.2, 5.3, and 5.4).
2. Open the module case and remove jumper H2 from J5 near the I/O PCA end of the module. (You can store the jumper by placing it on only one of the pins.)
3. Connect the I/O PCA to the cable extending from the module. Connect the system PCA cable to the receptacle on the module. Connect the keyboard to the I/O PCA using a keyboard extension cable (00090-60910). Check that the connectors are aligned properly. (See figure 7-3.)

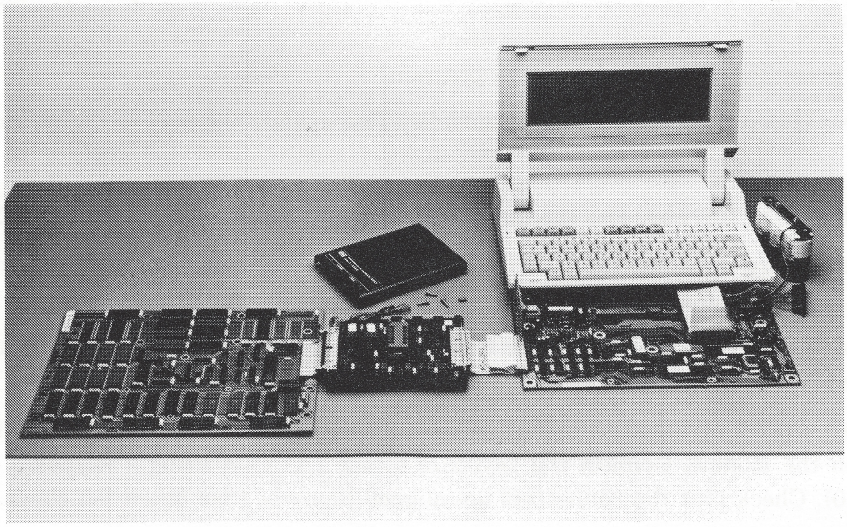

Figure 7-3. Checking the Diagnostic Module

4. Connect a recharger to the HP 110—it isn't necessary to connect the battery. (However, you *can* use a service battery assembly rather than the recharger if it's more convenient.)
5. Connect the HP 110 to an HP 9114 Disc Drive using two HP-IL cables. Turn on the disc drive and insert the service disc.
6. Turn on the HP 110 and configure it for one disc drive. Press (f6) (System Config) in the main P.A.M. screen. Use the tab or cursor keys to select the "External disc drives" field, then use the "Next Choice" and "Previous Choice" function keys to select one drive. Use the "Exit Config" function key to return to the main P.A.M. screen.
7. Type **C:DEBUG** and press (Return).
8. Type **o c3 00** and press (Return). This clears latch U6. Measure the voltage at U6 pins 12–19. All pins should measure low (about 0 Vdc).
9. Type **o c3 01** and press (Return). The voltage at U6 pin 19 should measure high (about 5 Vdc); U6 pins 12–18 should measure low.
10. Type **o c3 02** and press (Return). The voltage at U6 pin 18 should measure high; U6 pins 12–17 and 19 should measure low.
11. Type **o c3 04** and press (Return). The voltage at U6 pin 17 should measure high; U6 pins 12–16 and 18–19 should measure low.
12. Type **o c3 08** and press (Return). The voltage at U6 pin 16 should measure high; U6 pins 12–15 and 17–19 should measure low.
13. Type **o c3 10** and press (Return). The voltage at U6 pin 15 should measure high; U6 pins 12–14 and 16–19 should measure low.
14. Type **o c3 1f** and press (Return). Probe connector J3 pin 4. The signature analysis "Clock" signal should be present. (Pressing any key will increase the clock frequency.)
15. Probe connector J3 pin 1 to observe the effects of the "start/stop bit." Type **o c2 00** and press (Return); the START signal at pin 1 should then be high. Type **o c2 ff** and press (Return); the signal at pin 1 should go low.
16. Probe connector J3 pin 2 to observe the effects of the "start/stop bit." Type **o c2 00** and press (Return); the STOP signal at pin 2 should then be low. Type **o c2 ff** and press (Return); the signal at pin 2 should go high.
17. Type **q** and press (Return) to terminate the program.
18. Install jumper H2 on J5 in the diagnostic module. (This enables the module to perform its diagnostic function.)

Checking the EPROM Burner. Use the following procedure to calibrate and test the EPROM burner:

1. Remove the battery, separate the case, and remove the I/O and system PCAs from the HP 110 (procedures 5.2, 5.3, and 5.4).
2. Open the module case and remove jumper H2 from J5 near the I/O PCA end of the module. (You can store the jumper by placing it on only one of the pins.)
3. Connect the I/O PCA to the cable extending from the module. Connect the system PCA cable to the receptacle on the module. Connect the keyboard to the I/O PCA using a keyboard extension cable (00090-60910). Check that the connectors are aligned properly. (See figure 7-3 above.)
4. Connect a recharger to the HP 110—it isn't necessary to connect the battery. (However, you *can* use a service battery assembly rather than the recharger if it's more convenient.)

5. Connect a 25-Vdc power supply to the red and black wires at the two-pin power connector J4 at the system PCA end of the module: RED (+25 Vdc) and BLACK (Ground and Common, if present).
6. Connect the HP 110 to an HP 9114 Disc Drive using two HP-IL cables. Turn on the disc drive and insert the service disc.
7. Turn on the HP 110 and configure it for one disc drive. Press (f6) (System Config) in the main P.A.M. screen. Use the tab or cursor keys to select the "External disc drives" field, then use the "Next Choice" and "Previous Choice" function keys to select one drive. Use the "Exit Config" function key to return to the main P.A.M. screen.
8. Type **C:DEBUG** and press (Return).
9. Type **o c3 80** and press (Return). This activates the EPROM-burner power supply.
10. Calibrate the power supply. Measure the voltage at U7 pin 2 and UX14 pin 27. The voltage should be between 20.5 and 21.5 Vdc. If the voltage is higher, clip out resistor R6; if the voltage is lower, install resistor R6 (if removed) or decrease its resistance.
11. Type **o c3 a0** and press (Return). Measure the voltage at U7 pin 2 and UX14 pin 27. The voltage should be between 4.5 and 5.5 Vdc (from the HP 110 power supply).
12. Disconnect the 25V power supply.
13. Type **q** and press (Return) to terminate the program.
14. Connect a good HP 9114 Disc Drive using two good HP-IL cables. Then turn it on.
15. Insert the service disc in the disc drive.
16. Type **C:ETSTROBE.EXE** and press (Return).
17. Calibrate the EPROM-burner timer. Probe UX14 pin 27 and adjust potentiometer R8 until the width between pulses is between 50 and 52 milliseconds.
18. Turn off and disconnect the power supply. Carefully wrap and store the wires inside the module.
19. Disconnect power from the HP 110.
20. Install jumper H2 on J5 in the diagnostic module. (This enables the module to perform its diagnostic function.)

Table 7-3. Diagnostic Module Replaceable Parts

Reference Designation*	HP Part Number	Description	Quantity
C1, C3–C5, C8–C11, C13, C15, C17–C22	0160-5941	CAPACITOR, 0.047 μF	16
C7	0180-0269	CAPACITOR, 1 μF	1
C23	0180-2904	CAPACITOR, 0.1 μF	1
C24	0180-0291	CAPACITOR, 1 μF	1
C25	0160-4807	CAPACITOR, 33 pF	1
CR1	1901-1098	DIODE, 1N4150	1
H1	1251-5751	JUMPER, 2 pin	1
H2	1258-0189	JUMPER, 2 pin	1
J1	1251-8465	CONNECTOR, 50 pin	1
J2	1251-8832	CONNECTOR, 50 pin	1
J3	1252-0257	CONNECTOR, 4 pin	1
J4, J5	1251-6978	CONNECTOR, 2 pin	2
Q1	1854-0477	TRANSISTOR, 2N2222A	1
Q2, Q3	1853-0036	TRANSISTOR, 2N3906	2
Q4	1854-0215	TRANSISTOR, 2N3904	1
R1	0757-0394	RESISTOR, 51.1 ohm, 1%, ¼W	1
R2	0699-0208	RESISTOR, 1 ohm, 5%, ¼W	1
R3	0698-3440	RESISTOR, 196 ohm, 1%, ¼W	1
R4, R7, R10–R12	0683-2235	RESISTOR, 22 kΩ, 5%, ¼W	5
R5	0757-0421	RESISTOR, 825 ohm, 1%, ¼W	1
R6	0683-2225	RESISTOR, 2.2 kΩ, 5%, ¼W	1
R8	2100-3253	RESISTOR, variable, 50 kΩ	1
R9	0683-3935	RESISTOR, 39 kΩ, 5%, ¼W	1
U1, U2, U6	1820-3486	INTEGRATED CIRCUIT, 82C82	3
U3, U4	1820-3330	INTEGRATED CIRCUIT, 74HC245	2
U5	00090-60922	INTEGRATED CIRCUIT, service, odd	1
U7	1826-0772	INTEGRATED CIRCUIT, LM317L	1
U8, U13	1820-3209	INTEGRATED CIRCUIT, 74HC688	2
U9	1820-3014	INTEGRATED CIRCUIT, 74HC139	1
U10	00090-60923	INTEGRATED CIRCUIT, service, even	1
U11, U12, U23	1820-3081	INTEGRATED CIRCUIT, 74HC74	3
U15	1820-3673	INTEGRATED CIRCUIT, 74HC123	1
U16, U20	1820-3298	INTEGRATED CIRCUIT, 74HC32	2

Table 7-3. Diagnostic Module Replaceable Parts (Continued)

Reference Designation*	HP Part Number	Description	Quantity
U17, U18	1820-3097	INTEGRATED CIRCUIT, 74HC08	2
U19, U21	1820-2924	INTEGRATED CIRCUIT, 74HC02	2
U22	1820-2921	INTEGRATED CIRCUIT, 74HC04	1
XU5, XU10	1200-0567	SOCKET, 28 pin	2
XU14	1200-0870	SOCKET, 28 pin, EPROM burner	1
	00090-60911	CABLE, I/O	1
	5041-4110	CASE, bottom	1
	5041-4111	CASE, top	1
	5040-9207	FOOT	4
	00090-80038	LABEL, connector	1
	00090-80039	LABEL, instruction	1
	00090-80037	LABEL, top	1
	00090-80040	PLATE, I/O end	1
	00090-80041	PLATE, system end	1
	0624-0400	SCREW, self-tapping, 6-19 x 0.5 inch	3

* Use the prefix "Diagnostic Module" with reference designations for parts of the diagnostic module (part number 00090-60904). This will help avoid confusion with parts for the HP 110.

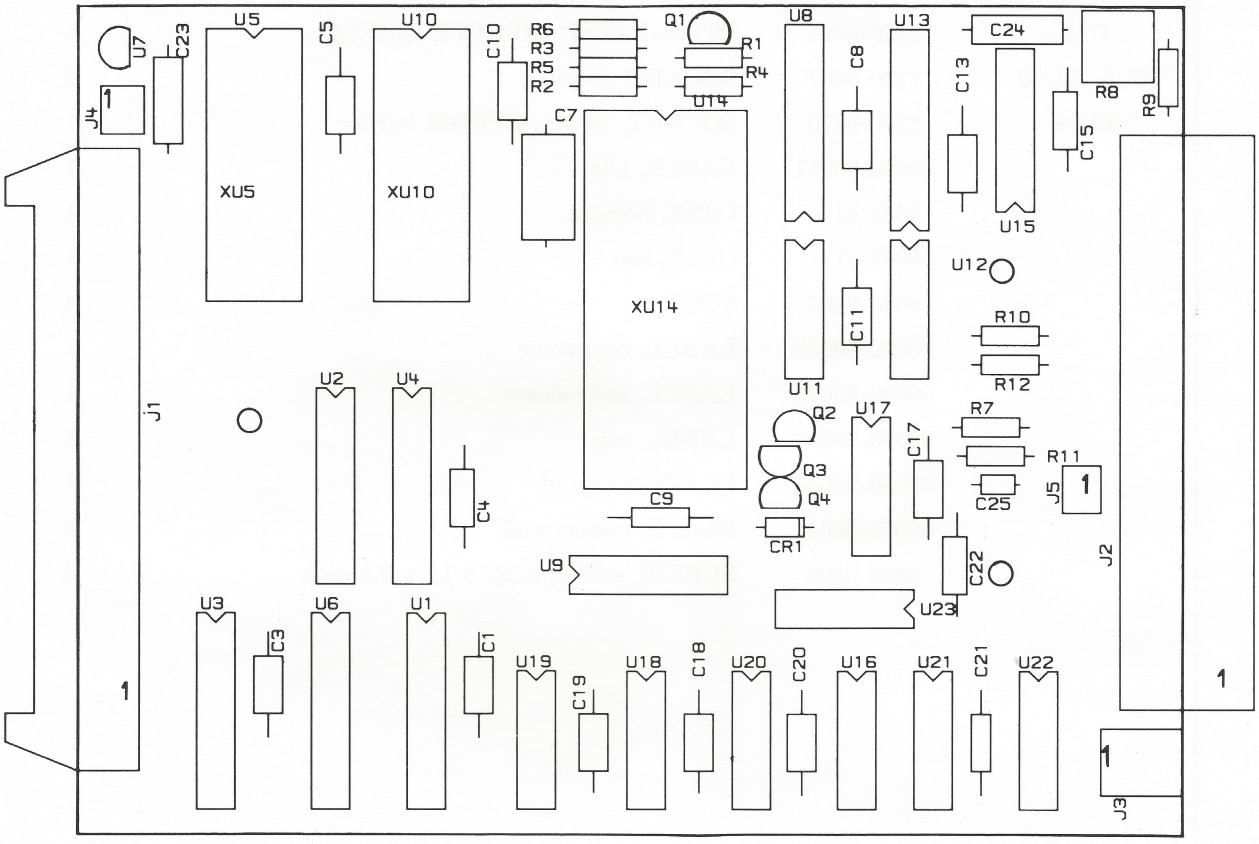

Figure 7-4. Diagnostic Module Component Location Diagram

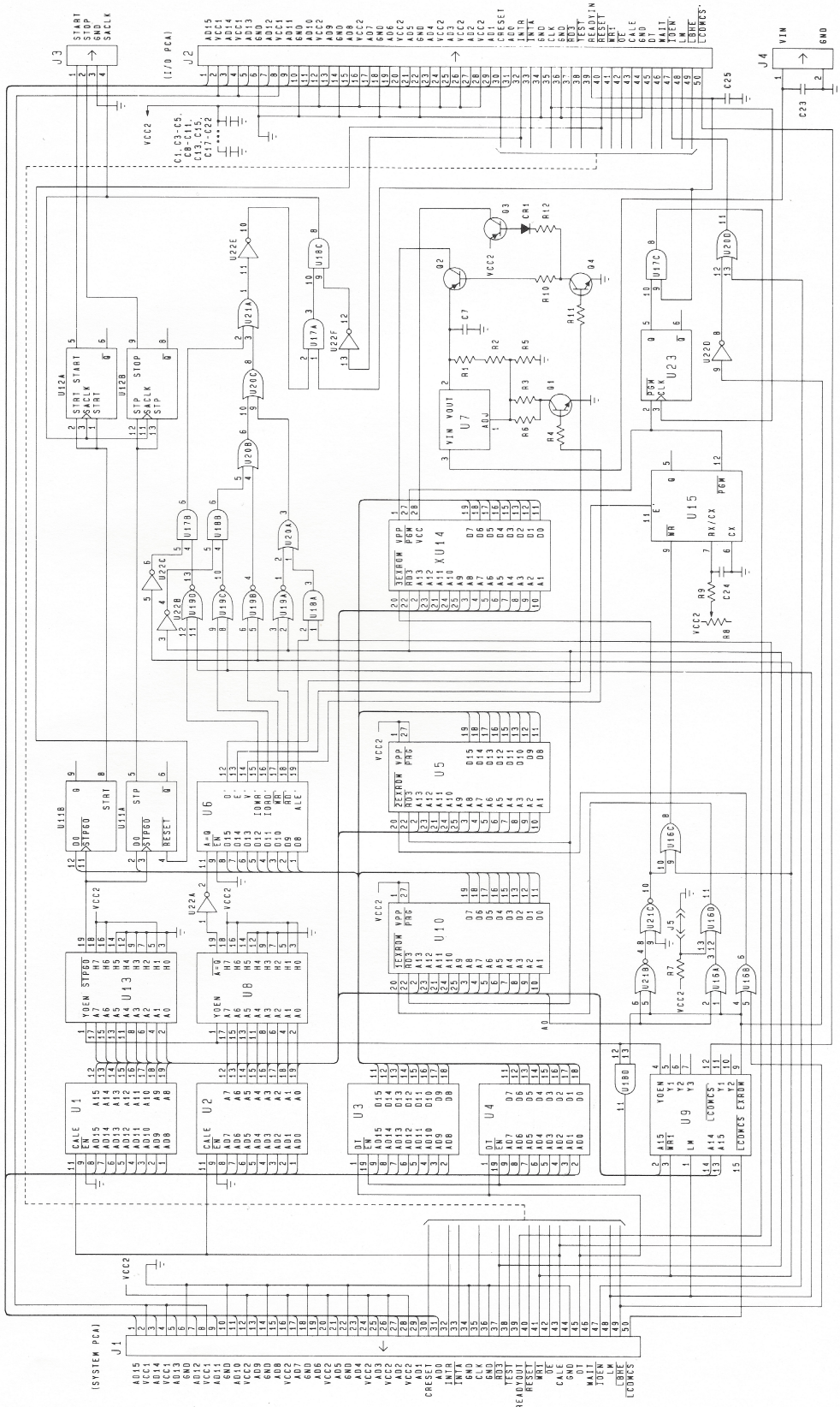

Figure 7-5. Diagnostic Module Schematic Diagram