CE 54

2631/35 PRINTING TERMINALS INDEPENDENT STUDY

Computer Support Division
19310 Pruneridge Avenue
Cupertino, CA 95014

MAY, 1980
P/N 5955-6103

INTRODUCTION

This manual is designed to be a self instructional guide to servicing the HP 263X family of printers/terminals.

The overall objective of this manual is to provide you with the knowledge and experience necessary to solve 80% of all service problems associated with the HP 263X product family. The areas to which this manual will address its attention will be the following:

a) Theory
b) Assembly, Removal and Replacement
c) Alignments/Adjustments
d) Troubleshooting

It will be necessary to acquire the resources found on page iv in order to complete this course of study. It is also recommended that you review the service notes published to date on those products. However, a recap of the service notes is in Appendix D. A check list has been provided for tracking your progress and should be reviewed and signed by your District Manager upon completion. This checklist will need to be furnished to your Class Manager upon entry into the SCE 100 Level Program.

Remember -- To use this manual properly, you will need the resources listed on the next page.

The learning approach used in this text will be to study the Learning Resources while developing the knowledge and/or skills outlined in the objectives for each module. After the objectives have been satisfied, you should proceed to test your understanding in the Evaluation section. If your results in the Evaluation section are less than 90%, review the Learning Resources looking for the answers found in the Evaluation Key (Self-Test Answers). All evaluations can be taken using any of the Resource lists for this text as a reference.

Do not proceed to the next module until you have thoroughly understood the concepts of the current module,

The process will work best if you have all of the required materials before beginning the course. If you have difficulty securing same, do not hesitate to contact your manager.

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________________________ Student

________________________ District Manager

____________ Date

____________ Date

Tear out this page and bring with you to the Training Center when you attend the SCE residency program.

LIST OF REQUIRED RESOURCES

REFERENCE MATERIAL:

HP 2630 family Reference Manual	02635-90905
HP 2630 family Service Manual	02631-90910
HP 2631A Operators Manual	02631-90801
HP 2631G Operators Manual	02631-90809
HP 263XB family Reference Manual	02631-90818
HP 263XB family Service Manual	02631-90819
Static	APPENDIX A
Common Symptoms and Possible Causes	APPENDIX B
HP 263XB	APPENDIX C
Service Note 263X family	APPENDIX D
Hewlett-Packard Journal - November, 1978	APPENDIX E
*2631/35 Replacement and Alignment Sound-On-Slide Program	

EQUIPMENT:

Oscilloscope, dual trace, minimum 10MHZ
Digital Voltmeter
HP 263X family Printer/Terminal

TOOLS:

Pozi drive #1 and #2
Phillip's Screwdriver #1
Pliers, Needle Nose
Screwdriver, flat blade
Wrench, hex-head, right angle 3mm
Driver set, hex-head

*The Sound-On-Slide program and the appropriate projecting equipment is usually available in most Area offices. The contact person is your Technical Support Manager.

Return to:
Hewlett-Packard
Computer Marketing Group
Attn: Development, 49B
19320 Pruneridge Avenue
Cupertino, California 95014

Computer Museum

READER'S COMMENT FORM

TITLE: CE 54 HP 2631/35

Part Number:

Dated:

This form may be used to convey your views about the content, style, and usefulness of this independent study course.

They will be evaluated by the author for review and action, if any, as appropriate.

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COURSE OBJECTIVES

1. To become acquainted with the features and options of the HP 263X family of printers/terminals.

2. Be able to relate Block Diagram level theory of operation to the troubleshooting process.

3. Be able to relate the functions performed on each Printed Circuit Board (PCB).

4. Be able to remove and replace major assemblies.

5. Be able to perform all alignments and adjustments.

6. Be able to understand the functions performed by self-test and how they can be used to assist the troubleshooting process.

MODULE 1

263X Family Overview

Overview:

Before getting into the in-depth study of the operation of the printer/terminal, it is necessary to have a basic understanding of how the product interfaces with the user and its internal microprocessor. In order to do this, you must know what your configuration consists of and the installed options. It is also important to the overall service process to know what options are currently supported on certain applications since these periodically change. These changes can be determined by the most current version of the Corporate Price List (CPL).

Objective:

After completing this Module, you should be able to:

a. Identify the model number, serial number and installed options in any 263X family product.

b. Identify date codes on all boards installed in the product.

c. Determine what accessories are supplied or available with each unit.

d. Determine what manuals relate to this product family.

e. Determine what configurations are supported by the manufacturing division.

f. Determine the functions of each of the switches on the operator panel/keyboard.

g. Determine Product Preventative Maintenance Requirements.

h. Give an overview of the theory of operation.

Approximate time for completion: ______________________________

Learning Activities:

Study carefully the following manual sections, looking for answers to satisfy the objectives in this Module. Re-read the sections until you have a thorough understanding as this material will be the foundation for the remaining modules.

a. HP 2630 family Service Manual — Section I: 1-2, 1-5, 1-6, 1-7

b. HP 2630 family Reference Manual — Section 1

c. HP 2631A Operators Manual — Sections 4, 5

d. HP 2631G Operators Manual — Section 4

Evaluation:

Check your understanding of the resource material by taking the Self-Test on the next page.

1. Where can you find the model and serial numbers of a HP 263X family product as well as a listing of all installed options?

2. Given the Printed Circuit Board (PCB) identifier A-1716-46, what does each of the elements of the identifier stand for?

3. Are all interrupts to the processor serviced when the interrupt occurs?

4. How frequently is the mainline firmware routine executed?

5. What is the difference between RAM and ROM?

6. Can a form feed be issued from the control panel push button if the printer/terminal is on-line?

7. Does changing the Print Switch from normal mode (10 CPI) to expanded mode (5 CPI) cause the current page printing to change?

8. Are the Baud rate, Parity, and Duplex switches found on all HP 2631A printers?

9. Who should be responsible for preventative maintenance on a HP 263X family product which is under Service Contract to HP?

Answers are found on page 6

1. The plate attached next to the power module on the rear of the unit.

2. A - The revision of the unloaded PCB
   1716 - Date code describing the electrical characteristics of the Loaded PCB
   46 - The division code identifing which Hewlett-Packard Division manufactured the PCB

3. NO. In some cases the service request flag is set and the interrupt serviced during the next scan of the mainline routine.

4. 24 milliseconds

5. Random Access Memory (RAM) is used for the basic buffer storage. Read Only Memory (ROM) is where the device controlling programs and USASC II to Dot Matrix conversion codes are stored.

6. NO

7. NO. It is necessary to go through either the power-on sequence or press the reset button in order to get the changes to occur.

8. NO. It is only found on printers which contain a serial interface.

9. The Customer

MODULE 2

Performance Specifications/Options

Overview:

It will be useful to know what options are available and what the product specifications are before working on a device of any kind. Equipment which is portable like the 263X family can easily be moved from one application to another in which it may not function as it did in the previous application or possibly not function at all. You should be aware that these situations can and do exist and should become identifiable by inspection.

Objective:

After completing this Module, you should be able to:

a. Identify the physical, performance, and electrical characteristics of the devices in the 263X product family.

b. Identify when a site does not meet the environmental requirements for the product.

c. Identify if a product shipment contains all the pieces necessary for the application to work, i.e. the correct option was ordered, all the pieces of the ordered option were in the shipment.

Approximate time
for completion:

Learning Activities:

a. Read Section I: 1-3, 1-5 Section II: 2-3, 2-4, 2-8 of the 2630 family Service Manual

b. Read or review Section 1 of the 2630 family Reference Manual

c. Read Section 2 of the 2631A Operators Manual

d. Read Section 2 of the 2631G Operators Manual

e. Read Appendix A, Static

Evaluation:

Check your understanding of the resource material by taking the self-test on the next page.

1. What power options are available for the 263X family of products?

____

2. What printer/terminal options contain either the terminal or CPU interface card and cable as part of the option?

____

3. Is the papershelf always grounded to the pedestal?

____

____

4. Can a static discharge cause power supply module fuses to blow?

____

____

____

Answers are found on page ... 10

1. 100 Vac, 120 Vac, 220 Vac, 240 Vac

2. Options 210 and 240

3. NO. Paint may cover the hooks and/or slots that hold the papershelf acting as an insulator.

4. YES. It can't be stressed enough that static can cause many hardware related symptoms. Be on the alert for applications where paper is being stacked on any type of the floor covering, this situation is very static prone.

Remember -- Be especially sensitive to Customers who are experiencing static discharge problems. It may appear to you that the customer's problem may be static related when in fact he has an actual hardware failure or power/grounding problems.

MODULE 3

PCA Functions

<u>Overview</u>:

The troubleshooting strategy for the 263X family is board replacement. Given this strategy it is essential to know what functions are performed on each board so that a logical process of fault determination can be applied to failure analysis. In this module, we will look at the various functions performed and some of the signals generated on each board in the unit.

<u>Objective</u>:

After completing this Module, you should be able to identify the major functions performed on each of the following Assemblies:

a. Power Electronics Printed-Circuit Assembly (PCA)

b. Control PCA

c. Printer Logic PCA/Raster Logic PCA

d. Encoder Assy

e. Front Panel PCA

f. Keyboard PCA

<u>Approximate time for completion:</u> ______________________________

<u>Learning Activities</u>:

Read Section III : 3-4, 3-5, 3-8, 3-10, 3-11 and 3-12 of the <u>2630 family Service Manual</u>

<u>Evaluation</u>:

Check your understanding of the resource material by taking the self-test on the next page.

1. List the primary functions contained on the Power Electronics PCA.

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2. List the primary functions contained on the 2631A Control PCA.

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3. List the primary functions contained on the Printer Logic PCA.

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____

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4. In the compressed mode which phase signals from the encoder are used for horizontal line positioning?

____

____

____

5. How many dot columns are there per character cell?

____

6. Located on the top, center of the Power Electronics PCA are three indicator lamps. What are these lamps used for?

____

____

____

7. Where can you find the I/O and RAM Timing Circuits?

8. What does the term "OVERDRIVE" refer to as it is used in the 263X products?

9. Where is the auto-underline mode enabled?

Answers are on page ... 14

1. DC Voltages. Drive Logic for the print head, paper stepper motor, and servo motor. Miscellaneous driver and detection logic for the speaker, optional character counter, paper-out switch, and power-up reset.

2. Paper control, servo motor control (print head motion), and data handling control up to, and including, printing.

3. Servo control, encoder and position circuits, character generation and control registers, crash stop detection, and generation of paper strobe signal for paper advance.

4. Phases A & B

5. 10

6. Monitoring the presence of the three regulated supply voltages; +5V, +12V, -12V.

7. Control PCA

8. There is a -40V pulse applied to the low side of the print head coils for about 140 microseconds which allows a faster rise time for the current through the print head coils, effectively accelerating the print hammers.

9. Printer Logic Board

MODULE 4

Serial I/O Interface

Overview:

Many applications for the 263X family require Serial I/O capabilities. Since customers configure their own terminals and modems, you will frequently be called to repair a hardware failure which turns out to be a configuration error. Dealing with devices which are not hard-wired to their mainframe makes it necessary to have a general understanding of RS 232C protocol. We will, in this Module, discuss RS 232C protocol and the basic components which make up the Serial I/O Interface.

Objective:

After completing this Module, you should be able to:

a. Define the basic elements contained on the Serial I/O Interface.

b. Define basic RS 232C Data Communications protocol.

c. Understand the functions of the switches/jumpers on the Serial I/O Interface.

Approximate time for completion: ____________________

Learning Activities:

a. Read Section III: 3-14 of the 2630 family Service Manual

b. Read Section 5 of the 2630 family Reference Manual

Evaluation:

Check your understanding of the resource materials by taking the self-test on the next page.

1. What is the primary function of the Serial I/O Interface?

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2. The control panel allows 5 directly selectable baud rates as well as external clock. How many actual baud rates can be selected by the Serial I/O Interface?

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____

____

3. Why does the Serial I/O Interface need a Universal Asychronous Receiver Transmitter (UART)?

____

____

____

4. Does the Serial I/O Interface handle both RS 232C level signals as well as current loop?

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5. What is the state of request to send (CA) at both modems in a full duplex network?

____

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____

6. What RS 232C signal tells the Interface that the modem's power is on?

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7. What "on" signal must the modem see from the Interface to know that the terminal is powered on?

____

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8. What signal does the modem need to send to the terminal in order for the terminal to transmit data to the modem?

____

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9. The terminal transmits a character to the CPU, the CPU transmits the character back to the terminal where it is printed. Is this half or full duplex operation?

____

____

10. On the 02631-60159 Interface board, the following configuration exists:

Switch S1	Switch S2	Switch S3	W5/W6		W9/W10	
11010001	00000100	0	Out	Installed	Out	Installed

What states have been selected by this configuration?

____

____

____

11. Is the 2631A/2635A supported on the Bell 202S modem?

____

12. What is the maximum signal current level allowed for the current Loop Interface?

____

____

Answers are on page ... 18

1. To receive data from the remote controller (ie. CPU) in a serial form, then convert the data to parallel form to transmit it over the internal bidirectional bus lines.

2. 15 baud rates

3. The UART is the heart of the Serial I/O Interface, it actually performs all of the serial to parallel and parallel to serial conversions. The remainder of the card is control and receivers/ transmitters.

4. NO. Only the extended Serial Interface board has that capability.

5. On, True

6. Data Set Ready (CC)

7. Data Terminal Ready (CD)

8. Clear to Send (CB)

9. Full duplex

10. Full duplex operation (SI-1, 2, 3, 7 and 8 have no effect when S1-4 is selected)
    8 Bit Data Enabled
    Auto-disconnect Enabled
    Data Signal Speed Select (CH) held low
    Delete trap enabled
    Clear to send (CB) from the modem must come true indicating modem is ready to transmit (W9/W10)
    Clock rate X8 (W5/W6)
    2400 Baud Selected

11. YES. Table 5-12 of the 2630 family Reference Manual

12. 100 mA.

MODULE 5

8-Bit Parallel Interfaces

Overview:

In this Module, we will look at the different 8-bit parallel Interfaces available for the 263X family of printer/terminals and their primary applications.

Objective:

After completing this Module, you should know:

a. What the primary application is for both the 8-bit parallel TTL (02631-60046) and the 8-bit parallel differential (02631-60008) Interfaces.

b. What the signal distance considerations are for each Interface.

c. How to identify which Interface is installed in the unit by inspection of the connector on the rear of the printer.

Approximate time for completion: ______________________________

Learning Activities:

a. Read Section III: 3-13 (8-bit Parallel Interfaces) of the 2630 family Service Manual

b. Read Section 6 of the 2630 family Reference Manual

Evaluation:

Check your understanding of the resource material by taking the self-test on the next page.

1. How does the processor know when an 8-bit parallel Interface is installed?

2. What is the maximum distance that a Differential Interface (02631-60008) can drive its signal?

3. Can the 8-bit parallel TTL Interface (02631-60046) drive signals greater distances than the Differential Interface?

4. Which parallel Interface would be shipped as standard from the manufacturing division with the 12845B Interface Kit to be used in the HP 1000 environment?

5. What is the primary application for the 8-bit parallel TTL Interface?

Answers are on page ... 21

1. An identifying bit is put onto the data bus by the processor; if this bit is returned to the process (by way of the identification logic), the processor then knows that it is talking to an 8-bit parallel Interface.

2. 500 Feet

3. NO. If you need long distances, you will need to use a Serial Interface.

4. 8-bit Differential. This interface can be readily identified by the Winchester MRA 505, 50 pin connector on the rear of the unit.

5. HP 264X Series Terminals. The interface can be readily identified by the cinch DCM, 37 pin, D-Subminiature socket connector located at the rear of the printer.

MODULE 6

HP-IB Interface

Overview:

This Module will present some of the HP-IB commands which are available for the 263X family of printers and terminals. We will also look at how the HP-IB is interfaced and possible problems as a result of incorrect configuration.

Objective:

After completion of this Module, you should be able to configure the HP-IB switches on the rear of the rear of the terminal.

Approximate time for completion: ______________________________

Learning Activities:

a. Read Section III: 3-13 HP-IB Parallel Interface in the 2630 family Service Manual

b. Read Section 7 of the 2630 family Reference Manual

Evaluation:

Check your understanding of the resource material by taking the self-test on the next page.

1. What is the function of the PHI Chip on the HP-IB Interface?

2. What are the two primary commands necessary to send/receive data or status on the HP-IB Bus?

3. List the functions which can be performed by using the secondary listen command.

4. What is the maximum parallel poll address which can be given to the device?

5. Assume you have two 2631A printers, one is addressed to 5 (octal) the other to 7 (octal). If unit addressed 7 (octal) has been configured with the 'LA' switch "on" and data is sent down the bus to unit addressed 5 (octal) will anything occur at the unit addressed 7 (octal)?

6. If the Service Request (SRQ) switch is open, can the unit interrupt the CPU for service?

Answers are on page ... 24

SELF-TEST ANSWERS

1. It does all the HP-IB Control Handshake protocol and data transfers.

2. My Talk Address (MTA) and My Listen Address (MLA).

3. Clear, self-test, print SLEW, poll mask, data, loopback and print mode.

4. 8 (octal)

5. YES. All data on the bus regardless of address will be printed on unit addressed 7 (octal).

6. NO

MODULE 7

Tieing it all Together

Overview:

The intent of this Module is to try to tie all of the various board functions together with the firmware that controls them in order to give you a more thorough understanding of how each of the segments of the device interrelate. We will concern ourselves with the design criteria, how characters are generated, how horizontal and vertical positioning is accomplished, and what part of the microprocessor and its firmware programs play in all of this.

Objective:

After completion of this Module, you should be able to:

a. Know why HP chose the design it used in developing the 263X family of printers/terminals.

b. Describe how USASCII data gets converted into hammer drive signals.

c. Determine what takes place when the print head moves from one character cell to another and how the microprocessor knows this has happened.

d. Define the program parts that make up the device firmware and what each program contributes to the OVERALL control of the device.

Approximate time for completion: ______________________________

Learning Activities:

Read Pages 2-19 of the NOV. 78 - Hewlett-Packard Journal, APPENDIX C

NOTE - Read all the materials in these sections carefully, including the sections in boxes. This will help you tie all the various machine functions together.

MODULE 7 Cont.

Evaluation:

Check your understanding of the resource material by taking the self-test on the next page.

1. Is it possible to print consecutive horizontal dots in a character cell?

2. How many contiguous spaces does the firmware optimization routine need to see before accelerating the printhead to skip over these spaces?

3. Explain how the print hammers are fired when printing a character once a cell boundary has been crossed and the new character's USASCII representation is available at the microprocessor.

4. What are the major signals generated by the Encoder which are used for printhead position?

5. The programs resident in firmware are divided into five parts, name these parts.

6. Can print lines with embedded executable control codes print from right to left?

7. Each paper step strobe which is issued from the printer logic PCA to the Power Electronics PCA causes how much linear movement of the paper stepper motor?

____

____

____

8. I/O protocols for the various types of Interfaces used in the 263X family of devices is different. How is this handled in the firmware?

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9. Where are the self-test firmware routines stored?

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Answers are on page ... 29

1. In general, NO. The only exceptions are high density and graphics and this is only available on the G and B models.

2. 10 characters in the A, G and B. The accelerated speed is 35 inches/second.

3. Transfer of the 7-bit USASCII character from the microprocessor to the character latch sets a flip-flop which produces the signal "print go". This enables the power electronics to be responsive to the succeeding dot-position pulses from the head position logic. As each slot in the encoder disc is encountered, the resulting dot-position pulse triggers the hammer enable and overdrive one-shot pulse generators. The output of the character ROM then determines which hammers will be fired. For a block diagram presentation, refer to Figure 2 page 10 of the HP Journal article.

4. Once the printhead home position is established, horizontal print position is determined by up/down counters which are driven by the dot-position signal generated by the encoder. The phase relationship of the encoder signals when sensed by the edge detector logic generates a set or reset condition for the direction flip-flop which is used by the servo positioning circuits to know which direction to command the printhead.

5. Main system firmware, the printer driver firmware, the I/O driver firmware, the self-test firmware, and the keyboard/control panel firmware.

6. NO

7 1/72 inch. This means that twelve steps are required for the standard six lines/inch spacing on nine for eight lines/inch.

8. Each I/O board carries its own firmware program thus the problem of different protocols is eliminated.

9. In the I/O ROM's on the I/O PCA's.

MODULE 8

Controlling the Terminal/Printer

Overview:

In this Module, we want to look at how you control the terminal/printer from either the keyboard or host computer. You will also look at the default conditions for the terminal/printer in order to gain an understanding of how the device should respond in its standard configuration and how to put the device into that configuration.

Objective:

After completing this module, you should be able to:

a. Perform the functions of the terminal/printer through control codes and escape sequences.

b. Know when the terminal/printer is in the default configuration and what functions are selected in that state.

Approximate time for completion: ____________________

Learning Activities:

Read Section 3, Appendix A and Appendix B of the 2630 family Reference Manual

Evaluation:

Check your understanding of the resource material by taking the self-test on the next page.

1. What state does the terminal come up in when the reset button is depressed?

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2. What is the default configuration for "view mode" on the 2635/2639A terminals? For 2635B?

____

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____

3. If you want to select the secondary character set for current printing, how is this done?

____

____

____

4. How do you generate Parameterized (multi-level) escape sequences?

____

____

____

5. If the terminal/printer has been placed in the off-line state by use of the on/off-line switch, can it be placed on-line by use of escape sequences? If so, what sequence is required?

____

____

____

Answers are on page ... 32

1. The terminal will configure itself to the default configuration.

2. View mode is "on" for the A family and "off" for the B.

3. From the terminal you can depress the control key while typing capital N (shift out) and for the printer, you need to transmit to the printer over the data lines an octal 16 (shift out). The escape code sequence ESC) A will also enable the secondary set.

4. Multi-Level escape sequences follow the convention of "ESC" control code followed by ampersand (&), a lower case letter, and a value parameter or parameters. Upper case parameters (terminator) signify the end of the sequence. For intermediates terminators, you use a lower case parameter instead. Ie., ESC&k1s0V; this escape code sequence will select expanded mode (5CPI) printing and disable view mode. For further explanation, see note on page 3-5 of 2630 family Reference Manual.

5. NO. This condition is known as a hard off-line state.

MODULE 9

Differences in the 2631G

Overview:

In this Module, we will point out the differences between the 2631G and the 2631A.

Objective:

After completion of this Module, you should be able to know which parts used on the 2631G are unique and not compatible with the 2631A.

Approximate time for completion: ______________________________

Learning Activities:

Read Section III: 3-6, 3-7, and 3-9 of the 2630 family Service Manual

Evaluation:

Check your understanding of the resource material by taking the self-test on the next page.

1. What is the primary function of the PROM PCA?

____

____

____

2. What board in the 2631A is replaced by the Raster Control PCA in the 2631G?

____

____

____

3. Can you interchange the Encoder Assembly between the 2631A and the 2631G?

____

____

4. What do the LED's on the Raster Control PCA tell you?

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Answers are on page ... 35

1. Extended memory capability. In some cases, RAM will not be physically loaded on this board, and only portions of PROM will actually be installed, depending on selected options.

2. Printer Logic PCA

3. NO. The 2631A has two tracks, one with 100 slots, the other with 167 slots. The 2631G also has two tracks, one with 100 slots, the other with <u>144</u> slots.

4. They give you failure status as a result of any self-test failure. LED 1 will blink at approximately a 1 Hz rate during normal operation.

MODULE 10

263XB Differences

Overview:

The 2630B was an evolutionary step for the 263X family of character printers and printing terminals. It was designed to address problems encountered by the 2630A version, has more features and a lower manufacturing cost. The result is a greatly enhanced machine. It uses the same basic physical package as the "A" version, but it has a completely new set of electronics and new firmware.

Objective:

After this Module, you should be able to:

a. Distinguish a 263XB machine from a 263XA.

b. Discuss the added capabilities of the 263XB.

Approximate time for completion: ________________________________

Learning Activities:

Study Appendix C, "The 263XB".

Evaluation:

Check your comprehension by taking the self-test on the next page.

1. What advantages does the 2630B encoder have over the 263XA?

2. How does the 263XB power supply increase head life?

3. How was self-test changed?

4. Why was the top plane connector removed?

5. How can a 2631B be readily identified?

Answers are on page ... 38

1. The 263XB encoder does not require adjustment. It has gone to a single track system allowing for a larger variety of print pitches.

2. The 263XB power supply increases head life by driving the head at a cooler temperature. It also provides head protect circuitry.

3. Self-test has been expanded to contain extensive subtests and a more thorough self-analysis.

4. The top plane was susceptible to breakage and requires drivers with high failure rates.

5. A 2631B can be readily identified by the logo and by the two banks of switches on the operator control panel.

MODULE 11

Self-Test

Overview:

The internal self-test provided in 263X family printers is designed to locate failures to a module level. This handy troubleshooting tool indicates by the sounding or absence of tones and printing which areas of the unit are working. The print out indicates which character set option(s) are installed as well as showing print quality.

This Module has been divided into two sections. Section A covers the 263XA and 2631G Self-Test. Section B discusses the 263XB Self-Test.

Objective:

At completion of this Module, you should be able to:

a. Initiate Self-Test on a 263X printer

b. Explain each section of the Self-Test

c. Determine the character sets installed in a unit from its Self-Test

d. Locate a failure in a unit from its Self-Test

Approximate time for completion:

Learning Activities: 263XA and 2631G

Carefully study the following manual sections:

a. Read Section IV: 4-27, 4-28, 4-29, 4-30 of the 2630 family Service Manual

b. Read "Common Symptoms and Possible Causes" Appendix B in this publication.

Learning Activities: 263XB

a. Read Sections 4-30, 31 of the 2630B family Service Manual

b. Read Sub-test routine of the 2630B family Reference Manual

c. Read Appendix C in this publication

Evaluation:

Perform the Self-Test on your 263X then check your understanding of it by taking the student self-tests (Section A and B) on the next pages. Keep a copy of the self-test with your evaluation.

1. What is initially checked in the Self-Test?

2. What is checked by driving the head from one side to the other?

3. Does your 263X have an alternate character set(s) installed?

4. After beeping twice, your printer attempts to print but no characters are visible. The tines (ballistic wires) appear to be tapping lightly against the paper. What PCA would you suspect?

5. Your customer complains of dropped characters. What is probably failing?

6. The LED's on your 2631G Raster Logic Board are all off except one which is flashing. What is wrong?

7. All LED's on the power supply are lit except the +12 volts. What should be checked first?

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8. How is the ripple print feature of the 2631G enabled?

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Answers are on page ... 44

Perform the standard Self-Test and all of the sub-tests appropriate to your unit. Test your knowledge by answering the following questions.

1. Does your 263X have an alternate character set?

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2. What is checked by driving the head from one side to the other?

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3. What does the beep indicate?

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4. After the print out is complete, the lights on the front panel do not turn off but begin to flash. What is wrong?

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5. How is the ripple print feature on the 263XB family enabled?

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6. How can you easily tell from Self-Test that the speed is too slow?

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Answers are on page ... 45

1. The Self-Test initially performs a check sum on the ROM's except for character sets, and tests the RAM's and real-time clock.

2. Servo movement is checked by driving the head. Servo drive time, column count and the direction bit are checked.

3. This is determined by checking the second line of Self-Test. If it is blank, no set is installed.

4. The Power PCA should be checked as the over drive pulse is apparently missing.

5. The control board could cause dropped characters.

6. This is a normal function. Nothing is wrong.

7. Check the 12 volt fuse first.

8. Press the test switch twice within 30 milliseconds.

1. Check the second line in the Self-Test. If the line is blank, there is no alternate character set installed.

2. Servo movement is checked. Servo drive time and the direction bit are checked.

3. The beep indicates that the memory stack test, ROM test, RAM test and address test have been completed successfully.

4. The interface test failed.

5. To invoke this test press S2,0s

6. Press S 3 s and observe the ON LINE LED on the front panel.

MODULE 12

Removal/Replacement, Alignments/Adjustments

Overview:

In this section, you will actually remove and replace the PCA's in a working unit. You will also be required to perform all of the alignments and adjustments.

Objective:

After completion of this Module, you will be able to:

a. Remove and replace all major assemblies.

b. Make all electrical and mechanical alignments and adjustments.

Approximate time for completion: ______________________________

Learning Activities:

Complete the 2631/2635 Replacement and Alignment Sound-On-Slide Program

Read Section IV of the 2630 family Service Manual

Evaluation:

The evaluation for this Module will be the successful completion of all sections of the 2631/2635 Replacement and Alignment Sound on-Slide program.

STATIC

A major frustration has been static discharges which cause a variety of incorrect actions by the printer. Due to the many possible manifestations, static is freqeuntly interpreted as a hardware failure. The problem develops because static charges are generated either by the head/ribbon motion during printing, or by external sources, e.g., an operator touching the unit after crossing a carpeted floor. Several hundred volts can be generated per page. As the paper stacks the total charge accumulates until it reaches a level sufficient to allow discharge. Some configurations discharge at a few hundred volts while others may exceed 5000. The discharge can affect virtually any portion of the printer but the most common symptoms are:

1. Left margin excursion in increments of several characters to several inches.
2. Top of forms in the VFC may shift by one to several lines.
3. Random unspecified form feeds.
4. Spontaneous loss of on-line status.
5. Random loss of data.
6. Malformed characters.
7. Occasional blowing of eight amp fuses.

Static discharge is a problem with any device handling paper. It is not considered to be a "bug" although some devices have proved to be fairly sensitive to static. There are two approaches to the problem, namely prevention of charge build up and hardening of the device to RFI and induced voltages. The recommended actions are:

1. Ground the base plate of the device to the pedestal or table it sits on.
2. Stack paper on a grounded surface, preferably on the paper shelf of the pedestal or into a wire basket. Do not stack on the floor. Be certain that there is a ground path of some kind from the paper stack to the base plate. Note that some pedestal paper shelves are not necessarily grounded. Paint may cover the hooks and/or slots that hold them. Scrape the paint as required to establish continuity.
3. Be certain that all internal grounds are properly installed.
4. Verify that the third wire ground is properly connected in the wall socket, and verify that it is a good ground.
5. Attach a tinsel strip (02631-60255) to the case so that paper passes over it. The tinsel is not required to protect units of series 1817 or greater, however, it will aid in paper stacking.

COMMON SYMPTOMS AND POSSIBLE CAUSES

Symptom	Possible Cause
POWER ON indicator not illuminated	1. Power cord not connected. 2. Line fuse in power module is bad. 3. No current from power outlet. 4. Indicator light is bad (fan will operate). 5. Front switch panel or keyboard cable is disconnected.
Machine not going through power up	1. If head drives slowly to right, check left crash stop. 2. Bad control board. 3. Bad interface PCA. 4. Top connector bad or on backwards.
Print quality very light or smudged	1. Print head out of adjustment. 2. Ribbon cartridge needs replacing. 3. Print head needs cleaning. 4. Print head bracket on carriage assembly is loose. 5. Bent or improperly seated lead screw - check for pattern of light and dark.
Missing dots or ragged characters	1. Print head out of adjustment. 2. Print head needs cleaning. 3. Bad print head. 4. Printer/raster logic PCA is bad. 5. Servo speed too high. 6. Encoder out of alignment. 7. Bad power supply.
Random dots missing in characters	1. Encoder alignment. 2. Servo speed adjustment. 3. Dirty head. 4. Too much head to platen gap.
Paper does not advance	1. Paper not properly loaded, check tractors and paper alignment. 2. Paper perforations damaged. 3. Paper is catching on box. 4. Bad paper drive circuitry (printer/raster logic PCA, power electronics PCA, stepper motor). 5. Paper guide too tight. 6. Bad "O" ring on paper drive clutch.
Circuit breaker trips	1. Defective print structure or lead screw (excessive friction on guide bars). 2. Print head movement obstructed (paper jammed, ribbon jammed). 3. Servo motor is bad.

Symptom	Possible Cause
Paper tearing or separating on multipart forms	1. Paper binding or dragging, check paper path. 2. Multipart forms not entering unit through the bottom opening. 3. Print head needs adjustment. 4. Paper guide too tight.
Fails ROM/RAM portion of self-test	1. Control PCA is bad. 2. Memory information circuits on I/O interface PCA bad. 3. Clock circuits on printer logic PCA bad. 4. Power electronics PCA is bad.
Fails I/O test or power-on routine portion of self-test	1. I/O interface PCA bad. 2. Control PCA bad. 3. Power electronics PCA bad. 4. Front panel/keyboard bad.
Fails servo movement portion of self-test	1. Circuit breaker tripped, reset and try again. 2. Printer/raster logic PCA bad. 3. Power electronics PCA bad. 4. Control PCA bad. 5. Servo motor, lead screw, guide rails, or carriage may be bad. 6. Encoder PCA bad or needs alignment. 7. Front panel/keyboard bad.
Printing portion of self-test fails or is bad.	1. Print head or associated fuses on power electronics PCA are bad. 2. Power electronics PCA bad. 3. Printer/raster logic PCA bad. 4. Control PCA bad. 5. Encoder PCA bad or encoder alignment needed. 6. I/O interface PCA bad.
+5 LED off or noticeably different intensity	1. Check fuses on power electronics PCA. 2. Check +5V source. 3. Replace power electronics PCA. 4. Check crimps in cables P10 and P16.
+12 LED off or noticeably different intensity	1. Check fuses on power electronics PCA. 2. Check +12V source. 3. Replace power electronics PCA. 4. Check crimps in cables P10 and P16.
-12 LED off or noticeably different	1. Check fuses on power electronics PCA. 2. Check -12V source. 3. Replace power electronics PCA. 4. Check crimps in cables P10 and P16.

Symptom	Possible Cause
Power fuses open repeatably	1. Print head coil is shorted (F1, F2). 2. Ribbon cable to head is bad. 3. Servo cable to head is bad. 4. Static turns on SCR (CR10) and blows fuse (F1).
Random shifting of left margin in and out.	1. If shift is by dot columns, check encoder alignment. 2. If shift is by complete characters, check encoder alignment and head location circuits (printer/raster logic PCA and control PCA). 3. Check crash stops. 4. Check for static.
Occasional stepping of left margin to the right	1. Static electricity. 2. Intermittent left crash stop. 3. Bad printer logic PCA. 4. Bad control PCA. 5. Noisy motors. 6. Be sure stand or table is grounded to the unit chassis ground. 7. Encoder alignment drifting.
Print density (darkness) varies between left and right side of platen	1. Loose head or bracket. 2. Defective print structure. 3. Defective head. 4. Bad power PCA.
Character tilted (not vertical)	1. Loose head or bracket. 2. Defective head. 3. Defective bracket.
Top or bottom dots missing	1. Head bracket bent or tipped up or down. 2. Bad head. 3. Bad power PCA. 4. Defective ribbon.
Extra line feeds	1. Firmware bugs. Replace control board with 02631-60205.
Print while slewing	1. Firmware bugs. Replace control board with 02631-60205.
Random dropping of characters	1. Firmware bugs. Replace control board with 02631-60205.
Deformed characters	1. Firmware bugs. Replace control board with 02631-60205.
12" forms and VFC problems	1. Firmware bugs. Replace control board with 02631-60205.

Symptom	Possible Cause
Over printing while changing print mode in middle of line	1. Firmware bugs. Replace control board with 02631-60205.
Paper out restart problems	1. Firmware bugs. Replace control board with 02631-60205.
On-line before complete power-up with HP-IB	1. Firmware bugs. Replace control board with 02631-60205.
Tab peculiarities	1. Firmware bugs. Replace control board with 02631-60205.
Lockup caused by back-space after line wrap-around	1. Firmware bugs. Replace control board with 02631-60205.

THE 263XB FAMILY OF PRINTING TERMINALS

The primary areas addressed in the design of the 263XB's were those that would make them more reliable, useable, or cheaper. From outside they are distinguishable by the new logo designating them as a 263XB and from slight changes to the front panel and keyboard. The front panel now includes two banks of switches and the keyboard has some additional buttons and lettering for operator control.

Internally, the encoder is now nonadjustable and capable of a greater variety of print pitches. The top connector between the I/P PCA and the control PCA has been eliminated along with the drivers for them. They were susceptible to breakage and the drivers had failure rates. The power supply has been improved. They now drive the heads at a cooler temperature and provide for head protection. The servo loop has also been redone and provides better speed control of head motion.

Self-test has been expanded to allow for a more thorough self analysis and a larger variety of tests. One of the tests allows the print head to be adjusted, thereby eliminating the need for an oscilloscope. There is also an expanded status read back.

There are many additional forms handling and operator convenience features. These include true programmable vertical forms control, more control over both vertical and horizontal pitch, programmable left and right margins, programmable page and text lengths, auto-perforations skip, improved keyboard "feel", and a serial I/O that is configurable without removing the cover.

The 263XB's are a functional superset of the 263XA's, and have all of the escape code driven functions found in them, in addition to expanded features.

INTER-OFFICE SERVICE MEMO

TO: "MAILS"

FROM: BOISE DIVISION SERVICE ENGINEERING GROUP

SUBJECT: SUPPORT RECAP II - 2631A/35A/39A/31G

In order that the CE can be kept up-to-date on the service notes and other correspondence regarding 263XA Family, the original Support Recap has been updated.

This memo is not all inclusive, but should serve as a valuable source of general information.

EH:jmg 2-80/46

HEWLETT PACKARD

2631A/35A/39A EXCHANGE PCA's FSI CONFIGURATION

As a review of the changes since introduction of the 2631A/35A/39A/31G, check your service kits against the following:

(1) DESCRIPTION	(2) PART NUMBER	(3) REPLACED BY	(4) REPLACED BY	(5) P/N AND/OR MIN. SERIES CODE ACCEPTABLE IN FSI
Power Electronics PCA	02631-60001(-69001)			02631-69001 series 1819 or up
Control PCA	02631-60004(-69004)	02631-69101	02631-69205	02631-69205
Printer Logic PCA	02631-60005(-69005)	02631-69081		02631-69081 series 1832 or up
HP-IB	02631-60006(-69006)	02631-69090		02631-69090 series 1851 or up
8-Bit Diff. I/O PCA	02631-60008(-69008)			02631-69008 series 1746 or up
Maximum RS232 I/O PCA	02631-60009(-69009)	02631-69083	02631-69159	02631-69159
Current Loop I/O PCA	02631-60021(-69021)	02631-69084		02631-69084 or 02631-60021
Minimum RS232 I/O PCA	02631-60043(-69043)	02631-69082	02631-69159	02631-69159 or 02631-69082
8-Bit TTL I/O	02631-60046(-69046)			02631-69046 series 1804 or up
Extended Serial I/O PCA	02631-60164(-69164)			02631-69164
Keyboard PCA	02635-60001(-69001)			02631-69001
Control Board	02635-60013(-69013)	02635-69017	02631-69205	02631-69205

NOTE

The control PCA's, 02631-60101, 02635-60017, 02631-60205, can only be used with power electronics PCA series 1811 and up.

2631G EXCHANGE PCA'S FSI CONFIGURATION

MCC Control PCA	02631-60089(-69089)	02631-69089
Print Control PCA	02631-60100(-69100)	02631-69100
PROM PCA	02631-60102(-69102)	02631-69102
HP-IB PCA	02631-60145(-69145)	02631-69145

2631A/35A/39A NON-EXCHANGE PARTS

Description	Part Number	Replaced By	Replaced By	Acceptable* In FSI
Encoder PCA	02631-60037			Series 1847 or greater
Crash stop cable assy	02631-60016			02631-60016
Encoder disc assy	02631-60032			02631-60032
Head mounting bracket	02631-60223			02631-60223
Head mounting bracket	02635-60024			02635-60024

2631G NON-EXCHANGE PARTS

Description	Part Number	Replaced By	Replaced By	Acceptable* In FSI
Encoder PCA	02631-60163			02631-60163
Encoder disc	02631-60162			02631-60162
Head mounting bracket	02631-60223			02631-60223

* Part number and/or minimum series code acceptable in FSI

FRONT PANELS AND KEYBOARDS FOR 263X FAMILY

Review the following information when ordering parts for front panels and keyboard for the 263X Family.

The 2635A/39A keyboard assembly (HP P/N 02635-60012) includes three basic parts:

1. 02635-60001 (-69001 exchange) — Alpha numeric PCA. Order from CSD.
2. 02635-60002 (no exchange) — Numeric PCA. Order from CPC.
3. 02635-00012 (no exchange) — Metal facia assembly. Order from CPC.

The 2631A/31G front panel part numbers have been updated to include the complete assembly including facia and key caps.

1. 02631-60087 (no exchange) — Parallel front panel. Order from CPC.
2. 02631-60088 (no exchange) — Serial front panel. Order fron CPC.

The key caps do not have separate part numbers, so the complete assembly must be replaced for electronic as well as cosmetic failures. Refer to the above part numbers when ordering replacment parts.

"A" PRIME CORRECTIONS

The "A" prime control board (HP P/N 02631-60205) corrects the following firmware bugs:

1. EXTRA LINE FEEDS - when VFC commands are mixed with ordinary line feed characters, extra line feeds could randomly occur. Unwanted line feeds could also be generated when print modes are mixed on a single line. A third case of an extra line feed occurs when an escape sequence to enter display functions mode is at the beginning of a line (or right after a CR LF) and the unit prints bidirectionally.
2. PRINT WHILE SLEWING - at times a printer will print a line while executing a form feed. This problem is rare and apparently occurs randomly. Some printers exhibit this problem more than others.
3. RANDOM DROPPING OF CHARACTERS - characters may be missing from text, and appear as a blank. This is most likely to occur just after a backspace character and at the end of a line, but can occur anywhere.
4. DEFORMED CHARACTERS - some printers experience "scrunched" characters at the right justified margin in right to left printing. This is particularly noticeable with zeros. The first three characters after a print mode change are also susceptible to being deformed due to excess print head speed. The printer will tend to deform or print half of some characters at baud rates very close to 110 baud. Other baud rates are not as frequently affected.
5. 12" FORMS AND VFC - in certain circumstances, a VFC command will cause "0" line feeds to occur, i.e. the printer will stay on the same line. This happens when the printer is 1) strapped for 12" page, 2) set in 8 LPI spacing, and 3) started from reset and goes to next VFC TOP. Then while at this 11" position on line 88, more VFC commands are issued.
6. OVERPRINTING WHEN CHANGING PRINT MODE IN MIDDLE OF LINE - a pause of between 400 to 800 milliseconds between a character and the next character after this type of print mode change may be located incorrectly and unrepeatably on the page.
7. PAPER OUT RESTART PROBLEM - the paper out restart is not 100% reliable when the printer tries to skip over blanks on a line in which it runs out of paper. It will stop in the middle of a line rather than the end to wait for more paper. When it restarts, the second half of the line will be printed beginning in column one, and overprinting the first half on the line.
8. ON-LINE BEFORE COMPLETE POWER UP WITH HP-IB - the default switch settings are not taken when a remote HP-IB device sends the reset followed by on-line commands. Instead, it comes up on normal print mode and 12 LPI.
9. TAB PECULARITIES - valid tab set positions are possible from 1 through 240. Tab sets commanded beyond 240 are ignored. There is not a text in the "tab execute" code to check for next print beyond the tab set region. Thus, the firmware simply looks for a bit set in the suceeding RAM locations to those used for tabbing. An erroneous tab will occur when the first set bit is found.
10. LOCKUP CAUSED BY BACKSPACE AFTER LINE WRAPAROUND - after the printer wraps around from one line to the next, it is possible to cause complete lockup by backspacing into the crash-stop. It will then not respond to any key except reset.

All FSI's should contain the new 02631-69205 A prime board. If a customer is being impacted by firmware bugs, an A prime upgrade may be obtained through extended warranty on approval of Boise Service Support.

BUGS

1. Ribbon snagging can occur in any machine if the head to too close to the platen, and some heads are quite sensitive to this distance. A few may have imperfections such as a small burr on a wire which can catch the ribbon threads. The designated head to platen distance is 0.019 inch, though some heads have been found to operate best at gaps of up to 0.026 inch. On machines that are subject to snagging, try a wider gap before replacing the head. Snagging is also associated with sudden speed changes such as occur when print modes are changed while printing a line. A bent lead screw can also cause ribbon snagging.

2. The circuit breaker on the print mechanism assembly may pop for a variety of causes. This thermal breaker is activated when current through the breaker remains above 3 amps for an extended period of time. The lead screw, helix nut, carriage, and rails can all contribute to driving the servo current above this limit and popping the breaker. The white lead screw nut seems to particularly aggravate the problem. If a unit has been popping breakers, the lead screw and rails should be thoroughly cleaned with isopropyl alcohol. Check to see that the carriage and head move freely on the rails and that the lead screw isn't bent Any binding or friction in this area should be corrected. A temporary fix is to carefully apply a thin film of dry lubricant until a new print mechanism can be obtained. It is believed this will cause future problems however, so only utilize lubricants as a last resort.

SELF-TEST AND PROBLEM DIAGNOSIS

The following discussion on self-test is separated into two parts: the first part discusses the self-test as it is performed by the 2631A, 2635A, and 2639A; the second part describes the 2631G self-test. All the self-test functions can be initiated by a control code, but the descriptions given below involve the manual activation of self-test. One of the major differences between the units is that the 2631G is non-destructive to preprogrammed printer configurations (i.e. horizontal tabs, print modes, etc), while the other units return to their power-up default conditions.

Self-Test (all except 2631G)

The self-test feature is a GO/NO GO check to verify proper operation on the unit and as a diagnostic tool to aid in problem location.

To perform self-test from the operator control panel or keyboard, the unit must be off-line with no existing fault conditions. Press and release the SELF-TEST switch to activate the self-test routine. When the switch is pressed, the following occurs:

1. ROM's and RAM's are tested. A check sum is performed on the ROM's, but the character set is not tested. A test of the RAM's and the real-time clock is also performed. An audible tone sound if all tests function correctly.

2. Servo movement is checked. If the carriage is not in the "home" position (column 1), the carriage will first drive to the left. From the "home" position the carriage will drive right to the right crash stop, then reverse and drive to the "home" position again. The unit checks to ensure that the servo drives the carriage from one side to the other within eight seconds. The following conditions must be satisfied to sound the tone a second time: a) servo drive time not exceeded, b) column count must be within bounds (column 1 at "home", columns 135 - 145 at right crash stop), and c) direction bit is correct.

3. Test the I/O. The self-test program tests the I/O dependent on which I/O option is installed.

4. The power-on routine is initiated and the unit is reset to all power-on default conditions. In a remote-initiated self-test, the unit will still reset to its default condition and the program settings will have to be reconfigured. The I/O power-on is handled individually and is not executed until self-test termination.

5. The primary character set is printed. The order of the printing test is: l) two lines at 6 LPI (normal), b) two lines at 8 LPI, c) one line each of compressed expanded, and auto-underline modes, d) display functions is set, then the full primary character set is printed, followed by a carriage return and a line feed. The printout will actually contain more than one line for the expanded mode and the display functions mode. Note the second line will try to access the alternate character set. If present, it will be displayed; if not, a full blank line will be printed.

6. If your unit is a 2639A terminal with an extended serial interface installed, an additional line is printed and it contains four groups of four characters which represent the current interface status. If the self-test fails this status line is the only portion of the printout that will be printed. Refer to the self-test discussion in the Extended Serial Interface Reference Manual, HP P/N 02639-90902, for a complete description of this status line.

Self-Test (2631G)

The TEST switch on the operator control panel initiates a routine which tests the unit to determine if it is in proper operating condition. To perform self-test from the operator control panel, press and release the SELF-TEST switch. When the switch is pressed self-test begins and is generally the same as described previously with the primary difference found in the printout.

Immediately after the interface test has been completed, default conditions for the self-test are established, a check sum is performed on the character set ROM's, then the unit performs the printing test. The order of the printing test is: two lines at 6 LPI (line per inch), and in 10 characer per inch density, one line at 8 LPI, one line each of the other character densities (14.4 cpi, 7.2 cpi, 5 cpi), one line in the auto-underline mode, one line of the graphics display, one line each for all character sets installed in the unit, and one line of the display functions with the full primary character set. The symbols displayed to the left of each character set line are the identity codes for each set. NOTE: If a secondary character set has not been selected or is not present, the second line of the printout will be blank.

A continuous ripple print feature is also part of the printer's self-test function. It is accessed by pressing the TEST switch twice within 30 milliseconds. Once invoked, this test pattern will be repeated continuously, and can only be terminated by pressing the RESET switch (pressing the RESET switch to terminate ripple print will cause programmable information to be lost and return the unit to power-on default conditions).

If the LINE FEED switch is pressed when the unit is printing the continuous ripple print portion of self-test, the unit will print on the same line 27 times before performing a line feed. Each toggling of the LINE FEED switch will toggle the overprint mode. The unit must be reset to cancel this operation.

An additional aid for the service personnel has been included on the 2631G. This aid consists of a row of LED's along the top edge of the raster logic PCA. Following a self-test failure, an error indication will be displayed on the row of LED's (provided that the hardware is operating sufficiently to display the error code). The error indications listed in the table at the bottom of this page should be viewed from the front of the unit, and read from left to right, LED 1 (the leftmost LED) will always be blinking. A power-on reset or successful completion (LED 1 blinking, all other extinguished). NOTE: The LED's on the raster logic PCA are not an all-inclusive visual diagnostic for self-test failures. Certain failures will also prevent the LED's from indicating error codes, depending upon which hardware has caused the self-test to be incomplete.

Self-Test Error Indications

LED Indication	Failure
# 0 0 0 0 0 0 1	First Kword of ROM failed.
# 0 0 0 0 0 1 0	Second Kword of ROM failed.
# 0 0 0 0 0 1 1	Third Kword of ROM failed.
# 0 0 0 0 1 0 0	Fourth Kword of ROM failed.
# 0 0 0 0 1 0 1	Fifth Kword of ROM failed.
# 0 0 0 0 1 1 0	Sixth Kword of ROM failed.
# 0 0 0 0 1 1 1	Seventh Kword of ROM failed.
# 0 0 0 1 0 0 0	Eighth Kword of ROM failed.
# 0 0 1 0 0 0 1	First Kword of RAM failed (16 bits).
# 0 0 1 0 0 1 0	Second Kbyte of RAM failed (8 bits).
# 0 0 1 0 0 1 1	Third Kbyte of RAM failed (8 bits).
# 0 1 0 0 0 0 0	Real-time clock test failed.
# 0 1 1 0 0 0 0	Servo test failed.
# 1 0 0 0 0 0 0	I/O test failed.

- indicates a blinking lamp.

0 - indicates that the lamp is OFF.

1 - indicates that the lamp is ON.

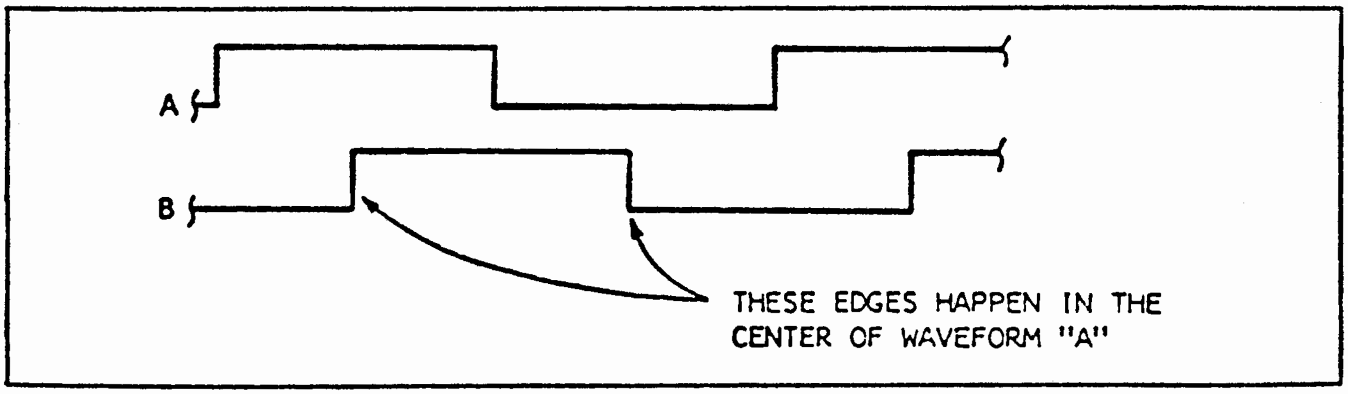
ADJUSTMENT PROCEDURE

Encoder Assembly Alignment

To properly align the encoder assembly, a dual trace, 10 MHz oscilloscope is required. Perform the following steps.

1. Set the main power switch to OFF.
2. Disconnect the helix nut from the carriage to prevent rotation of the lead screw from driving the print head into the crash stops. This can be accomplished by removing the three screws on the lower right side of the carriage. Next, move the carriage to the center of the print mechanism.
3. If the encoder assembly is to be replaced or if the 90° phase shift is off, use a #3 pozi to remove the screw securing the right end of the print structure to the base. Also, loosen the two screws holding the left end of the print structure. The encoder may now be replaced and/or adjusted. It is attached to the side plate with two screws which can now be accessed by raising the right end of the print mechanism.
4. While holding down the RESET switch, apply power to the unit. Release the RESET switch. The lead screw should be driven counterclockwise, when viewed from the right side of the print mechanism. If, upon release of the RESET switch, the lead screw rotation appears to be too rapid, performing step 5 will correct this apparent runaway condition.
5. Connect the channel A and channel B scope probes to test points A and B on the printer/raster logic PCA. Adjust potentiometers A & B on the encoder PCA for 50% duty cycle with the scope sync set on the channel being adjusted.
6. Move the scope probes to test points C and D. Adjust potentiometers C and D on the encoder PCA for 50% duty cycle with the scope sync set on the channel being adjusted.
7. Set the scope sync on test point A. Loosen the screw holding the encoder assembly and move the encoder inward as far as possible, then back it out slightly until the waveform on following page is observed.

8. Repeat steps 5 through 7 until no further adjustment is necessary.
9. Move the scope sync probes to test points C and D again and verify a similar waveform to that shown in the following figure. (The frequency of the waveform will vary from the waveform observed in step 7.) Note that the 90° phase shift must occur on A vs. B and C vs. D simultaneously. It is a trial and error process to find an encoder position that satisfies this.
10. Remove power from the unit.
11. Tighten both encoder assembly mounting screws carefully to avoid disturbing the alignment. The measurements in steps 5 and 6 should be repeated to ensure that the alignment has not changed.
12. Replace and/or tighten all print mechanism securing screws.



Encoder Waveform

Paper Guide Adjustment

Needed adjustment on the upper guide may be indicated when the paper perforations are elongating or tearing, or if the paper guide begins rubbing against the ribbon guide. When adjustment to the paper guide is required, proceed as follows:

1. Set the main power switch to OFF.
2. Loosen the three print mechanism mounting screws, two on the left side (front and rear), and one on the right side (center).
3. If your unit is a 2631A or 2631G, remove the switch panel assembly.
4. Release the two cable clamps which secure the print head ribbon to the base beneath the print mechanism, and remove the cable from the clamps.
5. Without straining the cables at the left side of the print mechanism, bring the bottom of the print mechanism forward and up until the print mechanism can rest on its back.
6. Slightly loosen the four screws which secure the forward paper guide to the print structures.
7. Adjust the gap across the top of the paper guides between the forward and rear paper guides to 0.6mm (0.024 inch).
8. Carefully tighten the mounting screws of the forward paper guide while rechecking the gap at the right and left sides.
9. Place the print mechanism upright and perform steps 1 through 4 in reverse order.

Servo Speed Adjustment

This adjustment allows the print speed to be adjusted to the speed specification of 180 characters per second. Proceed as follows:

1. Set the main power switch to OFF.
2. Connect an oscilloscope input lead to test point C or D and ground on the printer logic PCA, then sync the oscilloscope for the channel being used.
3. Set the main power switch to ON.
4. Press and release the SELF-TEST switch.

NOTE

> The following adjustment can be accurately performed only during the printing portion of self-test and only while lines 1, 3, and 4 (also line 2 if the alternate character set is installed) are printing. The unit must be in the NORMAL print mode and off-line. A handy alternative is to dump data to the device from the CPU. It is easier to adjust that way then by use of self-test. On the 2631G, pressing the SELF-TEST switch twice will provide a continuous ripple print for this adjustment. Press RESET to end this ripple print mode.

5. Adjust R1 (labeled SPEED) on the printer/raster logic PCA for a pulse every 556 usec (1800Hz) on the oscilloscope display. The trace on the display represents the print speed only while the unit is printing. During carriage return or skip modes, the trace is of no value for this adjustment.

CAUTION

> Do not attempt to increase the print speed of the unit by adjusting R1 for pulses having a frequency in excess of 556 µsec. Poor print quality or damage to the unit may result.

6. Repeat steps 4 and 5 as many times as necessary to achieve a pulse width of 556 µsec.
7. Set the main power switch to OFF and disconnect the oscilloscope leads.

Printer Logic/Raster Logic PCA

If a new printer logic PCA (in 2631A, 2635A, and 2639A) or raster logic PCA (in 2631G) is installed in the unit, the encoder assembly alignment MUST be checked. Component differences of different PCA's can alter the adjustment. Be certain to check the servo speed also as it can change and affect print quality.

SYSTEM SOFTWARE PROBLEMS

A class of problems exist which result from hardware and/or software incompatibilities between the printer and the CPU. These can be mistaken for hardware failures in the printer, when in fact they are system integration problems. The most common are:

1. On HP 3000 systems, the computer fails to recognize paper out on the printer and will send data even though it has not received an "ACK" in response to its "ENQ." The result is loss of data. This should be corrected in the Athena MIT.

2. When using half duplex modem with the HP 3000, there is not official support. The configuration should be avoided.

3. With an RS232 interface, it is possible to have data overruns if no protocol is used, the result is a loss of data. In most cases, a printed data loss will occur at an average line length of about 40 characters. This is due to the fact that paper movement takes several character times to complete. The solution is to go to slower baud rates or to implement a protocol to monitor printer busy. The easiest to use is ENQ/ACK as it is available on all interfaces. The 02631-69164 can implement the additional protocols of Xon/Xoff, busy line, and external clock. Note that with calculators there is no way to implement a protocol during list operations. Therefore, there is no solution to data rate problems except to use baud rates.

4. Many devices, among them the 264X CRTs, insert null and/or delete characters into the data stream. With such a device, escape sequences are not recognized. The solution is to use the 02631-69159 PCA to trap nulls and deletes. With this interface, all escape sequences except remote on-line and off-line will work.

5. Care must be taken when using the 263X Family attached to the 264X with the 13250B interface. Since no protocol is used, baud rates in excess of 1200 should not be used and with short lines that may be too fast. The data rate limitation can be avoided by using the 02631-69164 extended serial I/O which can implement multiple hardware protocols.

6. The 2648 HP-IB support does not transmit display enhancements to the printer. Thus, when using the 2631G, especially, the printed sheet may not be the same as the screen display. This will occur with the shared peripheral interface if alternate character sets or other display enhancements invoked with escape sequences are used. If data is transmitted by the CPU through the 2648, the problem does not occur.

7. When a 263X terminal is used with some non-HP systems, such as IBM, a conflict of assumptions can exist. IBM terminals come up in receive mode while HP devices come up in transmit. Thus, they ignore each other. One solution is to use the 02631-69164 PCA which can do either. If that is not an acceptable solution, contact factory support. The problem exists with half duplex main channel support, and not with full duplex systems.

8. The 264X CRT's utilize a "line by line" method of selecting alternate character sets and automatic underlining mode. The 263X family, however, enters an alternate character set of underline mode and remains there until directed to a new configuration or reset. Therefore, after the 264X has gone to the next line it no longer is in an alternate mode while the 263X is still receiving and printing as though it was in the alternate set. This causes problems when dumping directly from the CRT screen to the printer.

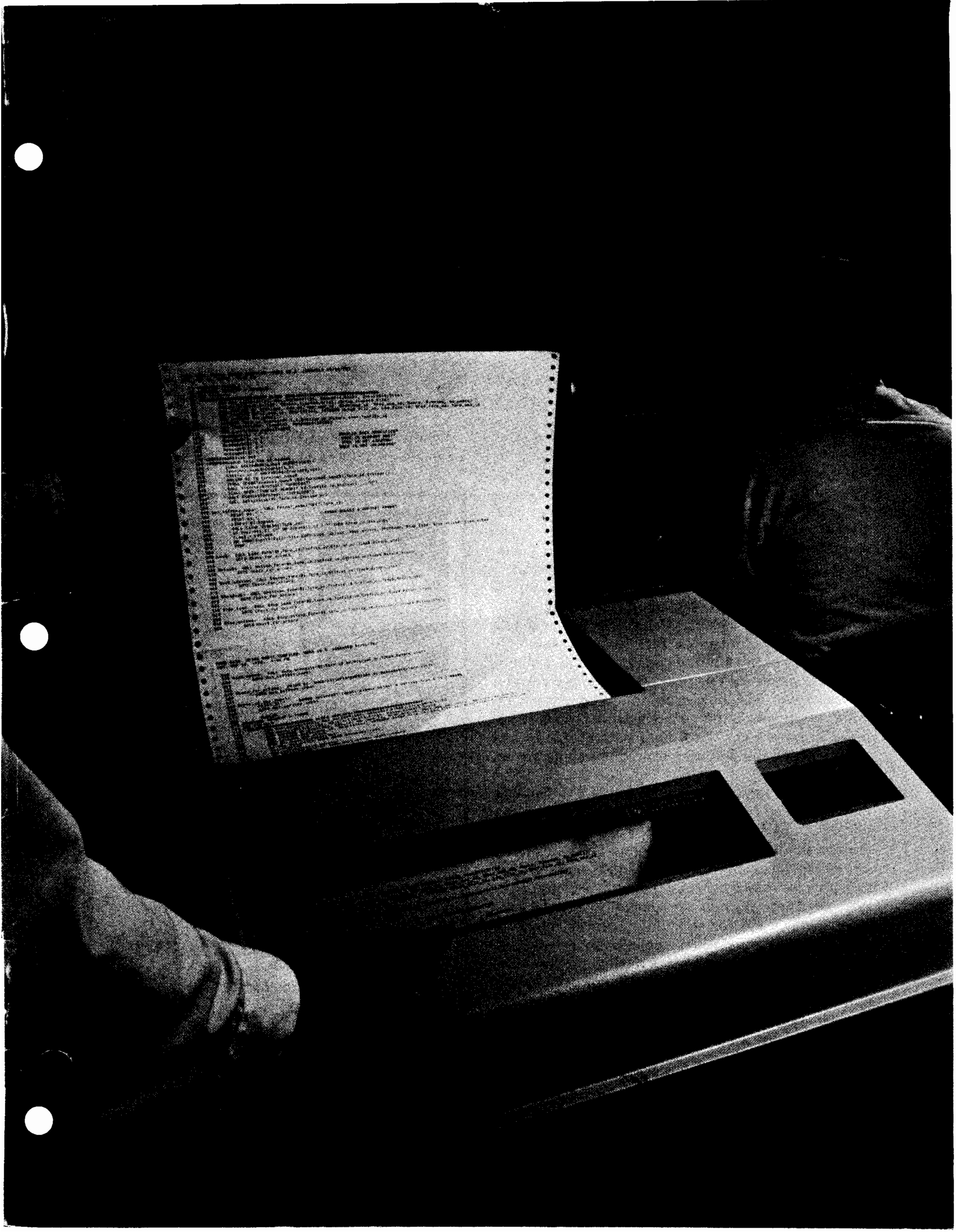
Service Notes

Description	Issue Date
Power Electronics PCA	4/78
Control PCA's	6/78
Control PCA's	4/78
Power Electronics Rev. B	5/78
Printer Logic PCA	6/78
HP-IB Interface	6/78
Encoder Assembly	8/78
Option 051 Adapter	9/78
Print Structure	10/78
Option 008 Roman Ext. Character Set	12/78
Printer Logic PCA	12/78
Operator Service	1/79
Switch Settings Serial I/O	1/79
MC^2, PHI, and CHI Chips	2/79
Head Mounting Bracket Assembly	2/79
263X Family Print Head	2/79
Encoder Assembly	3/79
Motherboard	7/79
Fan Assembly	8/79
8-Bit Differential I/O	8/79
Character Set PCA	8/79
Flame Sprayed Cases	8/79
9825A Character Set	10/79
All Character Set PCA	12/79

APPENDIX E

HEWLETT-PACKARD JOURNAL

November, 1978



Printer and Printing Terminal Gain Versatility and Mechanical Simplicity with Microprocessor Control

A 180-character-per-second dot-matrix printing mechanism achieves high throughput by skipping over blanks and printing in either direction under microprocessor control. Versatility is enhanced with variable horizontal pitch, a full 128-USASCII-character set, and flexible interfacing.

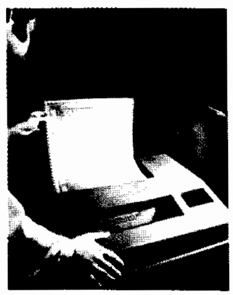
by Todd M. Woodcock

IN MOST COMPUTER SYSTEMS, the final product resulting from data collection, storage computation, and manipulation is a printed page that transmits information to a person. At present, devices that produce these pages fall into the general category of *printers*. With the possible exception of tape and disc drives, these are the only devices in a computer system whose role is primarily mechanical.

Since computer systems range from compact desktop units to elaborate multiprocessing mainframe units, it is not surprising that the available printers range from those that basically resemble typewriters to high-speed machines that produce complete pages at rates faster than one per second. Nevertheless, although each computer system requires a somewhat different set of printer capabilities, there are several identifiable printer groupings within which the performance requirements are essentially alike.

One such grouping would be in the low- to medium-speed range, defined as about 200 lines per minute. Printers capable of this speed typically are used as small system printers where they are generally dedicated to only a few users and are not required to supply the massive throughput typical of the larger systems. These printers are generally used for program listings and for short jobs such as might be needed by small businesses, scientific investigations, and individual programmers during program development. In these applications, the printing rate is most often measured in lines per minute, since traditional line printers with their fast, parallel interfacing are most easily adapted to this measure of performance.

When combined with a keyboard, a printer becomes a terminal and is generally used as a system console or a remote terminal. The performance of terminals is most often measured in terms of their transmission rates, with those capable of operating at data rates of 1200 baud and above being classified as



Cover: *The end result of most computer processes is a printed page, requiring the use of a mechanical device that often restricts the computer's throughput rate and print flexibility. Described in this issue are print mechanisms that have a mechanical simplicity conducive to higher print speeds. Microprocessor-control contributes to the simplicity while enhancing versatility.*

In this Issue:

high-performance terminals. The printing mechanism for a high-performance terminal, however, would be in the 200-lines-per-minute range.

A basic electrical difference between terminals and printers is the interfacing. Printers have traditionally used parallel interfacing where the machine receives data usually on seven or eight parallel lines with several other lines provided for paper control and handshaking. A terminal traditionally interfaces through a serial protocol in which data is transferred as a pulse train on a single line. In general, serial data transfer occurs at standardized rates of 10, 30, 60, 120, or 240 characters per second.

A New Printing Mechanism

At the inception of a new printer project at Hewlett-Packard, we felt that a high-performance printing mechanism could be adapted to fulfill the needs of users of both high-performance terminals and medium-speed printers, a significant portion of the total market. The design criteria for the new mechanism were based on:

- Performance
- Flexibility
- Long life
- Cost of ownership.

In a sense, a figure of merit for such a machine could be expressed as:

$$\frac{\text{Performance} \times \text{Flexibility} \times \text{Life}}{\text{Cost of Ownership}}$$

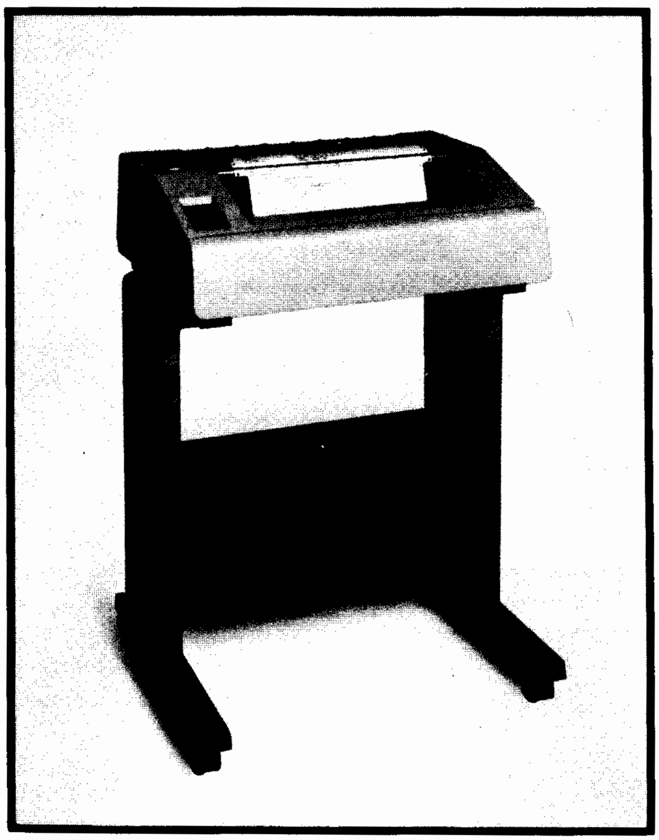


Fig. 1. *Model 2631A Printer is designed for either table-top or pedestal mounting. Microprocessor control of the dot-matrix printing operation contributes to the printer's versatility while simplifying the printing mechanism. A high throughput rate is obtained with a print speed of 180 characters per second plus the ability to print in either direction and to slew past strings of blank spaces. Model 2631G, which can also print raster-style graphics, is identical in appearance.*

The performance requirements were fairly well specified by the applications in which the machines would be used. As keyboard terminals, they should operate at a throughput of 120 characters per second. In the serial environment, however, the effective throughput is often characterized by mechanical overhead rather than the actual printing rate. For example, a machine that requires one second to advance the paper to the next line can never exceed a rate of 60 lines per minute no matter how fast the printing rate.

Overhead is also involved in any computational procedures within the machine. The machine must react to any control codes that alter the response of the machine to the characters in the data stream in sufficient time to cause the proper action at the proper time. For example, a printer must respond to any command sequence within one character period or risk losing the next character in the data sequence. Therefore, to ensure data integrity a printer must be designed with a considerable print-speed margin of safety. In appreciation of the overhead requirements of a high-performance terminal, we determined that the minimum print rate required to allow continuous 120 character/second operation under average conditions would be about 165 characters/second. To provide a comfortable safety margin, we aimed for a printing speed of 180 characters/second.

The result of this design effort is shown in Figs. 1 and 2. The Model 2631A Printer (Fig. 1) is a versatile dot-matrix printer capable of printing at a speed of 180 characters/second. The Model 2635A Keyboard Terminal uses the same printing mechanism and can work with serial data streams at rates up to 9600 baud, depending on the chosen interface protocol. Two others have evolved from this first pair: the Model 2631G Printer that prints raster-style graphics as well as alphanumerics, and the Model 2639A Terminal that has a versatile, asynchronous, serial interface, allowing its use with a variety of computer systems.

Dot-Matrix Printing Provides Flexibility

The method used to print a character determines to a great degree the overall flexibility of a printing mechanism. Type slugs that print one fully formed

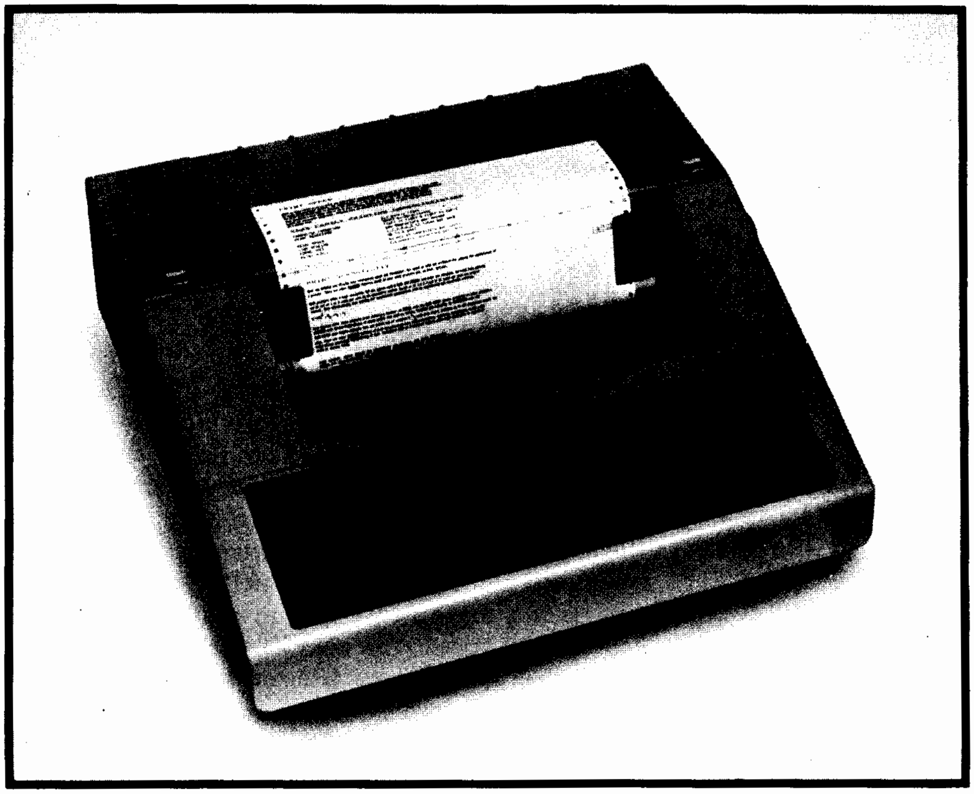


Fig. 2. *Model 2635A Terminal (and the identical-looking Model 2639A) uses the same printing mechanism as the Model 2631A Printer. A wide selection of interface options enable its use with a variety of computer systems. Symbols are paired on the keys in the traditional typewriter arrangement, making it easy for the user to convert from typewriter to terminal operation, and a 10-key numeric pad speeds the entry of numerical data.*

character per impact are not readily adapted to automatic changes of the character set because the entire wheel, ball, or cylinder that contains the type slugs must be changed. The most flexible method of printing is the dot-matrix method in which the individual dots in a matrix are selectively energized to form the desired characters (Fig. 3).

Dot-matrix printing can be done with mechanical simplicity by thermally pulsing dots on a printhead in contact with thermally-sensitive paper. However, the applications we envisaged for the new printers would often require multiple copies, so we chose to use an electromechanical method of impacting dot-shaped hammers on an inked ribbon and paper. This technique also has the advantage of not requiring special paper.

Although the mechanics of dot-matrix printing can be simplified to the repetitive use of a single dot, the controller that directs this operation is considerably more complex than that required for a full-font printing mechanism. Not only must the character be properly placed on the page, but each dot must be properly sequenced and positioned so as to produce a correctly formed character. Full-font printing needs an information rate of only one identifiable code per character whereas a dot-matrix character composed, say, of twenty dots needs to have twenty times as much information processed, and hence needs twenty times the control speed. The trade-off is the ability to print any character that may be constructed from a matrix of dots.

The manner in which a character is printed is crucial to the utility of the machine. To be useful as a keyboard terminal, each character the machine prints must be visible to the person operating the keyboard as soon as it is printed. We chose, therefore, to use a movable ballistic matrix printhead (Fig. 4), a type of device that has already proven its reliability in widespread use.

The ballistic matrix printhead used in the new machines has nine tungsten wires arranged in a vertical column. Each wire is associated with a coil that drives an armature forward when energized. The armature in turn propels the tungsten wire but when the armature closes against the coil's pole pieces, it stops while the wire continues its forward motion with enough energy to form a dot by impacting the ribbon and paper against the platen. The wire then rebounds and comes to rest at its initial position. As the printhead moves along the paper, the coils are selectively energized "on the fly" to print the dots that form each character.

The character cell, a 10×9 dot matrix, is diagrammed in Fig. 5. An uppercase character is formed in the upper seven rows of the matrix, leaving the bottom two rows for descenders and underlining. Columns 0, 8, and 9 are left blank to form the intercharacter spacing. Even though all the dot positions in columns 1 through 7 are available to form a character, every other dot is omitted in the horizontal lines so that no hammer is required to print dots successively in adjacent columns. Since there is an upper limit to hammer

The firmware for the 2630
printing subsystem performs
two basic functions. It
controls the printing hard-
ware and interfaces ASCII
characters from the main
system buffer for decoding.

Fig. 3. *Example of the new mechanism's printing, shown here actual size. The mechanism forms characters by selectively activating the dots in a 7 × 9 matrix. The use of nine dots in each column enables the printing of lower-case descenders and of simultaneous underlining. Impact printing permits the printing of multiple-part forms.*

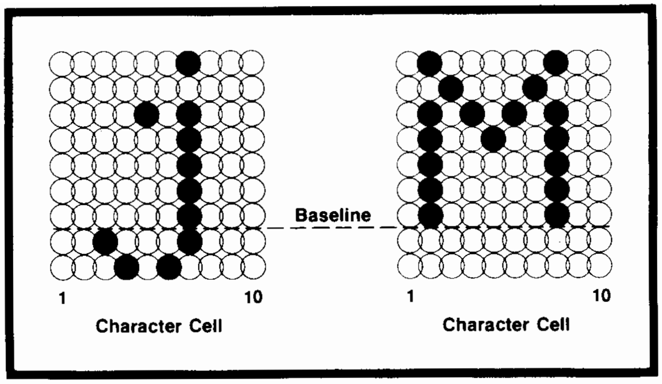


Fig. 5. *The character cell consists of a 10×9 overlapping dot-matrix. The seven upper rows are used for upper case characters while the lower two are used for descenders and underlines.*

repetition rate, this dot skipping allows an increase in printhead scan speed with resulting higher throughput. The slight overlap of adjacent columns partially masks the fact that the lines were formed with non-adjacent dots.

As mentioned previously, dot-matrix printing enables the printing of any character that can be formed by dots. The new printer and terminal contain a full 128-USASCII*-character set that includes upper- and lower-case letters, numbers, symbols, and control codes. A special 128-character set can be included at the same time and selected under program control. Either character set can be changed by changing the appropriate ROM.

*USASCII: United States of America Standard Code for Information Interchange.

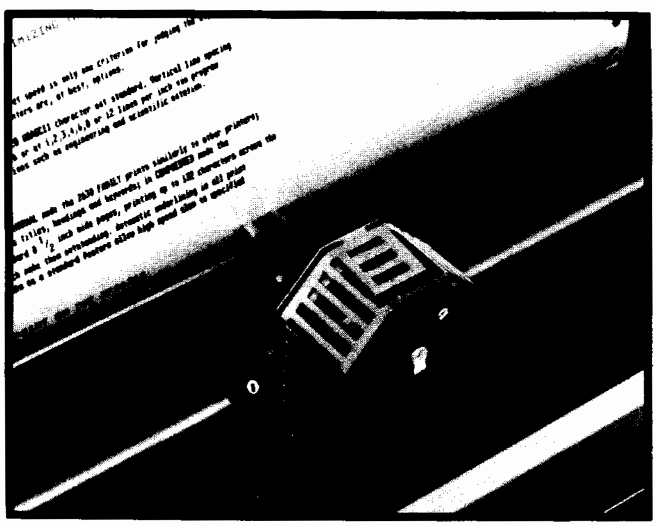


Fig. 4. *Moving printhead allows the line being printed on the 2635A Terminal to be seen. Whenever 0.6 second elapses since the last character was entered, the printhead moves to the right so the most recent character is visible. The printhead returns immediately to its previous position when it prints the next character. Every other dot is printed in the horizontal lines to permit a faster print rate.*

Cartridge Ribbon

The ribbon and ribbon advancing mechanism were also viewed as areas critical to the general utility of the printing mechanism. Consequently, the ribbon is placed in a cartridge that spans the width of the print line, enabling easy replacement with a minimum of contact or mess (Fig. 6). In the Models 2631A and 2631G Printers, the ribbon slants such that the print head impacts the ribbon along the top edge when at the left side of the paper, and along the bottom edge at the right side. Wear is thus distributed over the entire ribbon. In the Models 2635A and 2639A Terminals, the printhead always contacts the ribbon along the top edge so the line being printed can be seen (a roller guides the ribbon away from the paper on the left side of the printhead). A Moebius turn where the continuously-circulating ribbon enters the cartridge inverts the ribbon on each pass so wear is distributed over a greater area.

The cartridge was designed to hold 55 metres of ribbon so at least ten million characters of acceptable print per cartridge can be obtained in any of these machines. In subsequent testing on the 2631A Printer, cartridges provided as many as fifty million characters, albeit lightly printed. Considering that an average college textbook contains about two million characters, a single cartridge ribbon could print between five and twenty-five books, demonstrating the economy of this type of printing.

The ribbon drive mechanism is harnessed to the motion of the printhead servo motor so that whenever the printhead moves from right to left, the ribbon is advanced to the right. Thus, under all conditions of printhead motion, there is fresh ribbon on which to print. This simple system is less costly and more conservative of energy than a system that requires a separate, constantly running motor.

Fig. 6. *Full-width ribbon cartridge is easily replaced.*

Designed for Long Life

The mechanical components of the printer were designed so that lubrication would not be required, contributing to the low cost of ownership. For example, the printhead carriage uses dry-contact fluorocarbon sleeve bearings and the tractor drive shaft rides in a self-lubricating acetal plastic bearing. Similarly, the printhead leadscrew nut is made of a self-lubricating plastic. The other rotating parts of the machine incorporate sealed ball bearings. The result of this design approach is a mechanically simple, easily maintained machine.

The new machines have sucessfully completed HP's standard class B environmental testing which includes tests under conditions of high and low temperatures, high and low humidity, vibration, and shock. In addition, 35 printers were cycled two hours on and one-half hour off continuously under computer control, 24 hours a day, seven days a week, for 22 weeks. A number of potential problems were uncovered and corrected during this test.

As a result of this test, it can be stated with 90% confidence level that the mean number of characters between failures (MCBF) for these machines exceeds 316 million. Printing with a 40% average printed page density, 316 million characters would fill 65,000 pages of computer paper. On the average, the printing mechanism will operate 2400 hours in normal use before a failure can be expected.

Organization

From the systems standpoint, both the keyboard terminals and the printers are viewed as having four basic components: the printing mechanism, the device electronics, the controller, and the package. The device electronics, such as the power supply, servo system, and control switches, were already partially defined once the basic printing mechanism was identified.

The controller, however, although invisible to the user, is the determining factor in both performance and flexibility. To provide the multitude of features required by the diverse applications of the printing mechanism, the controller must be powerful, versatile, and at the same time compact. This need was met by the Hewlett-Packard CMOS silicon-on-sapphire MC^2 controller,[1] which was being developed at the time the printer project was getting under way. A number of support devices such as read-only memories (ROMs) and read-write memories (RAMs) were also being developed so all of the necessary controller functions would be available with this family.

The control program resides in 4K 16-bit words in ROM distributed between the processor and interface printed-circuit boards. The program common to both the keyboard terminals and the printers (exclusive of interfacing) resides in 2K words on the processor board. An additional 1K words is required by each machine. With the loading of this particular block, the processor board gains an identity specific to either the keyboard terminal or the printer.

The interface ROM located on the interface board contains 1K words. Thus, the interface can be changed by changing just one board, since each interface board carries with it sufficient program memory to control its particular functions. In addition, various interfaces, although appearing to be different, often require identical signals, the arrangement of the signals and the connector being the only differences. To take advantage of this situation, an adapter was designed to fit between the connector (at the back of the machine) and the interface board. This allows a single interface board to be used for several different interface configurations.

The control firmware closes all of the control loops within the machine. Because of the great decision-making power of the MC^2 processor, a number of optimization routines were made possible. For example, the print head normally moves at 18 inches/s, the maximum allowed by the hammer action while printing in the normal mode (10 characters/inch). Normally it would step through spaces at the same rate. An optimization routine, however, looks at the number of contiguous spaces in a line, and if more than 10 occur, it accelerates the printhead so it skips over the spaces at high speed.

A further improvement uses the microprocessor to store incoming data in a buffer, and if an entire line is buffered before the printing of the previous line is completed, the new line is tested to determine whether it should be printed in the forward or reverse direction. This decision is based upon a number of criteria, including the presence or absence of control codes (such as form feed or line feed), the column positions of the first and last printable characters in the line, and the position of the last character printed in the previous line. In each case, the quickest means of printing the line is used, whether forward or reverse. Similarly, spaces at the beginning and end of a line are processed to determine where printing should begin so that the printhead can be moved directly to that position. With these and other optimizing routines, the controller improved the effective printing rate significantly.

Control by Escape Sequences

The character-serial environment of the printer and terminal allow escape sequences (control codes) to be imbedded in the data stream. The traditional dependence on separate control lines and their associated driver software are thereby avoided.

The use of escape sequences to control operation provides the user with a considerable degree of flexibility in formatting. For example, underlining may be implemented simultaneously with printing, and the three print modes—NORMAL, COMPRESSED, EXPANDED—may be enabled at any point in a line of print. In the EXPANDED mode, the machines print five widened characters per inch for use in headings and other areas where special attention is desired. Variable line spacing and the intermixed use of NORMAL and COMPRESSED characters enable information to be formatted for emphasis in a way that is not possible with constant character and line spacing. The COMPRESSED mode, which prints at 16.7 characters/inch, is also useful for printing the standard 14-inch wide, 132-column computer printout on 8½×11-inch paper for notebook use or easier filing. The microprocessor, incidentally, monitors the incoming data stored in the input buffer and if the lines contain escape sequences that affect the following characters, it prevents the mechanism from attempting to print from right to left.

Escape-sequence control also extends to other machine functions. For example, a printer used for logging data in a remote location may be sent an escape sequence via a telephone line to initiate an internal self-test routine. The printer may then be asked by another escape sequence to transmit its status and the results of the self test back to the host computer. In this way, a single operator can keep track of a number of remote printers.

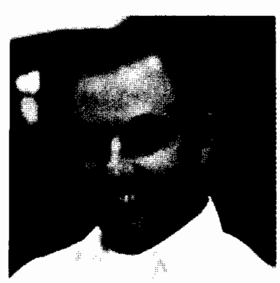
Details of the print mechanism design are described in the article that follows.

Acknowledgments

The design of the new printers and terminals required contributions from many people. In addition to those mentioned in the following article, major contributions were made by Gary Campbell, who developed the print-line buffer management and the microdiagnostics, Mark Anderson, who designed the processor and memory boards, Randy Mazzei, who did the industrial design, and Bob Carlson and Lyle Loeser who were involved in the all-important tool engineering. Doug Ballard, Larry Beck, Mike Harrigan, and Pat Donnelly were involved in the early design stages before transferring to other projects. Clyde Gregg contributed the computer diagnostics, Lamar Goats developed the thorough-going reliability verification testing, and Gary Gapp did the all-encompassing product performance testing. Overall guidance and support was provided by Jim Barnes, R and D manager.

Reference

1. B.E. Forbes, "Silicon-on-Sapphire Technology Produces High-Speed Single-Chip Processor," Hewlett-Packard Journal, April 1977.



Todd M. Woodcock

Todd Woodcock joined HP in 1975 as a designer of thermal print mechanisms and then became project manager for the 2631A and 2635A printers. Before coming to HP, Todd worked as a fruit harvesting equipment designer, an optical vision analyzer designer and a nuclear plant engineer. Todd is a 1964 BA graduate in German and speech and a 1974 BSME graduate from the University of California at Berkeley. After graduation in 1964, Todd served as a lieutenant in the U.S. Navy Reserve for three years. Born in Evanston, Illinois, he now lives in Boise, Idaho, with his wife and three daughters, ages 17, 3, and ½ years. Todd's favorite pastimes are fishing, hunting, camping and fly tying. A real cooking enthusiast, Todd won first place for his rye bread in the 1976 Western Idaho State Fair.

Managing Dot-Matrix Printing with a Microprocessor

by John J. Ignoffo, Michael J. Sproviero, Phillip R. Luque and Kenneth B. Wade

THROUGH USE OF MICROPROCESSOR control, a reliable, high-performance printing mechanism built with minimum labor and material costs was achieved for the Models 2631A and 2631G Printers and the 2635A and 2639A Printing Terminals.

The mechanism (Fig. 1) has few moving parts. The printhead carriage, moved by a 25-mm-per-revolution leadscrew, slides on two steel guide rails. The position of the printhead is accurately controlled by the machine's microprocessor, which issues commands to a hardware velocity servo loop to move the head either right or left at a controlled velocity during printing. The use of a microprocessor resulted in a control system that is much simpler than a hardware position-control system.

During printing operations, the printhead carriage speed ranges from 1 inch/second, when printing with a data input of 110 baud, to 18 inches/second with a printing rate of 180 characters/second, the maximum speed allowed by the print hammers. At any printing speed, the velocity must be controlled within 5% so smooth carriage motion, and hence evenly formed characters, result. During nonprinting movement, the carriage accelerates to 35 inches/second.

Paper motion is also controlled by the microprocessor. Paper advance is provided by a set of tractors driven by a step motor. A custom-made motor that has 180 steps per revolution was chosen so spacings of both six and eight lines per inch are possible with the tractors directly coupled to the motor. This direct drive eliminated a number of mechanical parts. A clutch decouples the drive shaft from the motor for manual fine adjustment of preprinted forms.

Character Generation

Characters are transferred from the internal buffer memory to the paper by the following sequence of events. As the printhead moves, either left or right, an interrupt is generated by the head-position logic at the end of each print cell (between column 9 of one cell and column 0 of the adjacent cell). When the print position read by the microprocessor is the desired one for the next character, the interrupt causes the microprocessor to transfer the seven-bit ASCII-coded

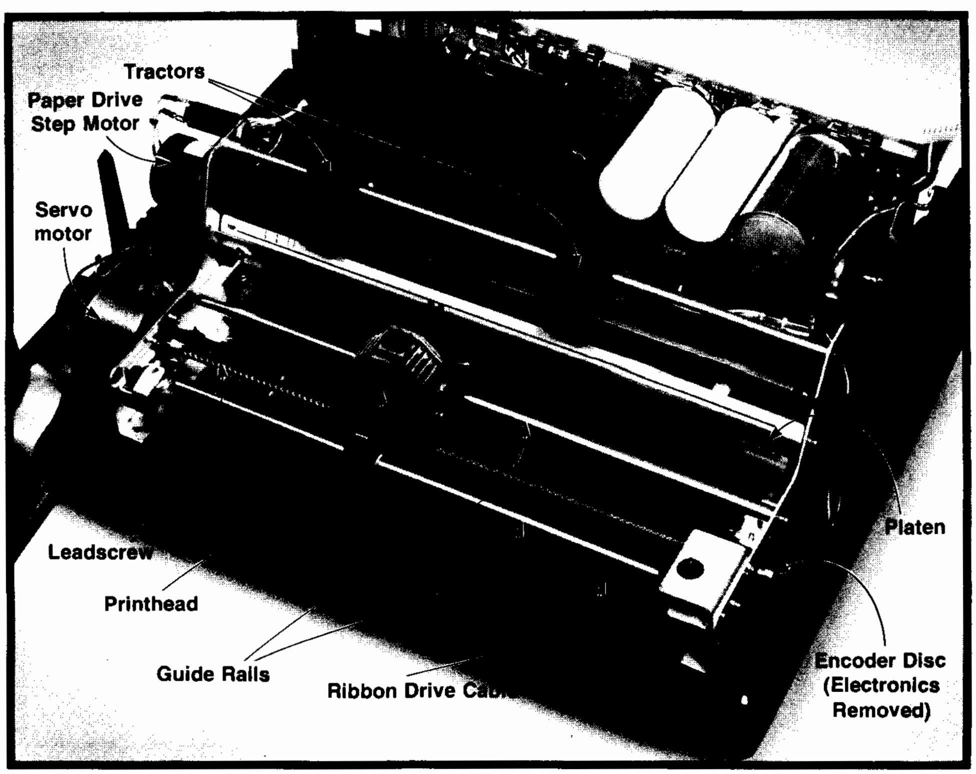


Fig. 1. *Printing mechanism has few moving parts. The same mechanism is used in both the printers and the printing terminals.*

Mechanical Design of a Durable Dot-Matrix Printer

The reliability of any mechanical device is usually inversely proportional to the number of moving parts. The Models 2631A and 2631G Printers and 2635A and 2639A Printing Terminals were designed to be as mechanically simple as possible. The use of a microprocessor reduced the printhead positioning mechanism to a servomotor-driven leadscrew and mating nut. The use of a custom-made step motor in the paper-advance mechanism enabled direct coupling of the step motor to the forms-tractor drive shaft. The few remaining moving parts were designed with sealed roller or dry-contact bearings so periodic lubrication is not required. Preventive maintenance consists simply of cleaning the fan filter and the printhead.

A photo of the mechanism is shown in Fig. 1 on page 8. The print structure assembly is the basis of the printer mechanism. During manufacture, two guide rails, the steel platen, and two end plates are accurately positioned in a fixture, drilled, and pinned together. No further adjustments are needed, or even possible. This assembly provides parallelism within 0.05 mm between the carriage line of travel and the platen, assuring good print quality for the life of the machine.

The front surface of the platen is ground to a 19-mm radius. As the paper wraps around this surface it conforms closely to the radius, thereby presenting a solid surface on which to print.

The carriage, molded of fiberglass-reinforced polycarbonate, includes the two slider bearings and other features for holding the printhead connector and for attaching the head-drive cable, the ribbon cartridge drive cable, and the leadscrew nut. A bracket attached to the top surface holds the printhead. The bracket includes an eccentric-link mechanism for adjusting the head-to-platen gap to obtain optimum print quality with multiple-part forms of varying thicknesses. The self-aligning printhead has an average life of 130 million characters but if replacement is ever necessary, it is easily done by the user.

The 75-mm long main slider bearing is insert-molded into the carriage. The other bearing, whose purpose is to resist the torque applied by the leadscrew, floats in the carriage to accommodate variations in guide-rail spacing. Both bearings have a glass-reinforced structural shell and a fabric liner containing Teflon. These do not require hardened rails or lubrication, and are unaffected by paper and ribbon debris.

The ribbon-drive cable anchors at one end to the carriage, passes around a ribbon-drive pulley at the right side of the printer mechanism, back across the printer to an idler pulley at the left side, and around the pulley back to the carriage. A spring keeps it taut. Unidirectional clutches in the ribbon-drive pulley rotate the ribbon drive shaft during right-to-left motion of the carriage but disengage during left-to-right motion.

The Package

Two structural-foam packages were designed with identical features for holding the printing mechanism and the basic electronic components. Many design details are molded in to reduce the number of parts, the assembly time, and consequently the cost. An aluminum plate on the bottom provides electrical shielding, mounting points for rubber feet, and a smooth guideway for paper fed in from the rear (paper may be fed in from the bottom when either machine is mounted on the optional pedestal).

The only difference between the packages is the extension on the terminal package for holding the keyboard. A single access cover was designed such that merely by changing inserts in the mold, parts are provided for both the terminal and the printer. Controls that are not needed by the casual user—for example, the baud-rate switch—are concealed beneath this cover.

—Robert Cort

character to a latch (Fig. 2). These seven bits become part of the 10-bit character-generator ROM address. The remaining three bits are dot-column position bits derived from a four-bit counter that counts pulses from an optical encoder attached to the leadscrew. Encoding logic maps columns 8 and 9 into column 0, all of which are blank, to give the intercharacter spacing, thereby obtaining the three dot-column position bits, used in the character address, from the four-bit counter output.

Transfer of the seven-bit ASCII character to the latch sets a flip-flop called PRINT GO. This enables the power electronics to be responsive to the succeeding dot-position pulses from the head-position logic. As each slot in the encoder disc is encountered, the resulting dot-position pulse triggers the hammer-enable and overdrive one-shot pulse generators. The output of the character ROM then determines which hammers will be fired. Two ROMs are provided, each storing 128 characters, thus allowing two character sets to be available at any time.

The overdrive pulse places a large voltage across the print head coils during the initial part of the hammer pulse to shorten the coil current rise time.

Printing at each column position continues until the next cell interrupt occurs. This resets the PRINT GO flip-flop which inhibits printing until the microprocessor transfers another character to the character latch.

Printhead Positioning

A diagram of the head drive servo control circuit is shown in Fig. 3. An electrical current proportional to velocity is obtained by gating a current sink with constant-width pulses triggered by the optical encoder disk attached to the leadscrew. The average current through this sink is thus proportional to carriage velocity. This current is summed with a source current proportional to the commanded velocity, generated by a microprocessor-controlled current source. The error voltage obtained at the current-summing node is buffered and applied to a slew-rate limiting amplifier which, by limiting the rate at which the servo motor accelerates, limits the power

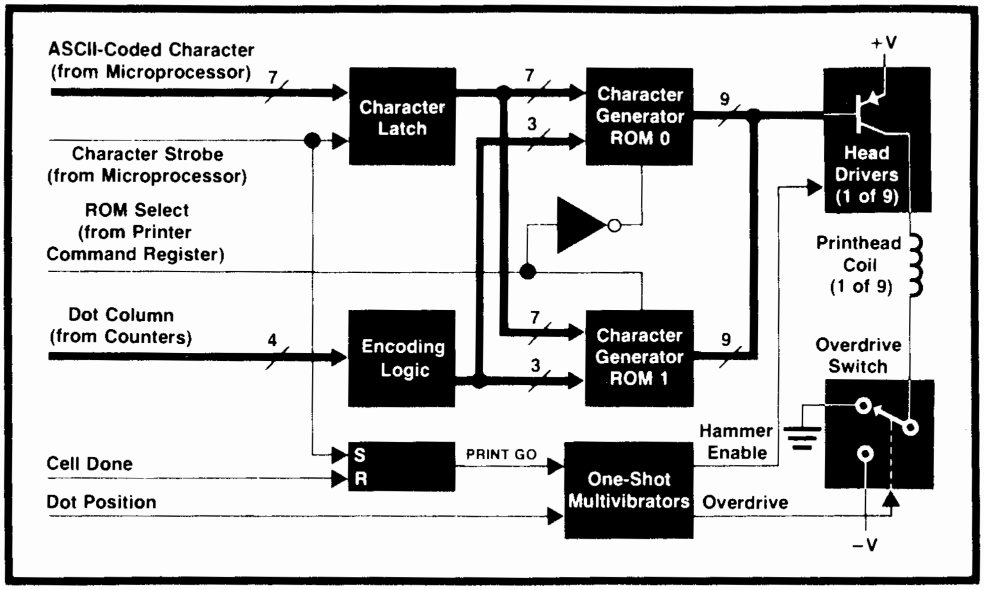


Fig. 2. *Dot generation control circuits determine which printhead hammers will be fired at each dot-column position in a character.*

dissipated in the servo motor. Without limiting, the servo motor could overheat if it were repeatedly accelerated to a high speed, as when skipping blank spaces.

The slew-rate limiting amplifier is an emitter-follower that has a capacitive load. When the error voltage rises rapidly, the transistor turns off and the output rise time is determined by the rate at which the capacitor charges through the emitter resistor. Small voltage changes and rapidly decreasing voltages,

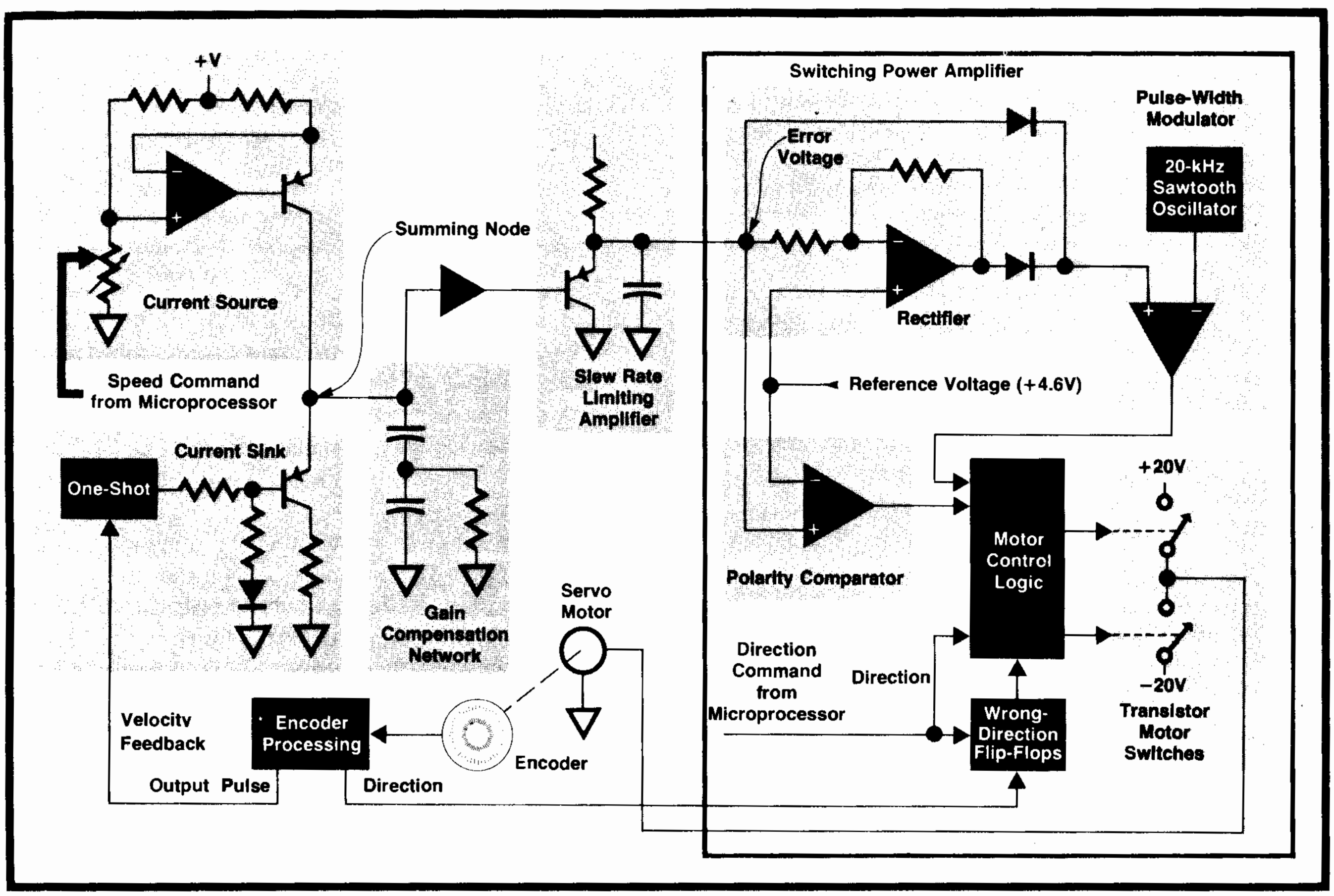


Fig. 3. *Simplified block diagram of the printhead servo control circuits. The servomotor is driven by a switching power amplifier to reduce energy dissipation.*

An Impact Graphics Printer

A second version of the Model 2631A Printer was designed as a hard-copy output for the Models 2647A and 2648A Graphics Terminals.[1] On ordinary paper, including multipart forms, this printer (Model 2631G) reproduces any raster display presented on the graphics terminals, printing a complete 720×360 dot display in 57 seconds or less.

Although capable of printing graphics material, Model 2631G retains all the alphanumeric printing capability of the Model 2631A. An escape sequence in the input data stream converts printer operation from alphanumerics to graphics and another escape sequence converts back to alphanumeric operation.

In addition to graphics capabilities, Model 2631G has some other new capabilities. One is the ability to retain several character sets simultaneously and use them interchangeably. One of the new character sets is a high-density set for use where superior print quality is required. With this character set, the machine prints overlapping dots in the horizontal lines, rather than skipping every other dot position as the 2631A does. Print speed, however, is limited to a maximum of 90 characters per second in this mode.

More flexible forms handling is another new capability. The user may now specify a page length and the text length (top and bottom margins). The 8-channel vertical forms control then adjusts to the specified text length—e.g., if the specified text length is six inches and the command "slew to the next half page" is given, the print line will be moved to three inches below the top of the text. In addition, with page and text lengths specified, an AUTOMATIC PERFORATION SKIP mode causes the printer to skip automatically to the top line of the next page when it reaches the bottom margin on the present page.

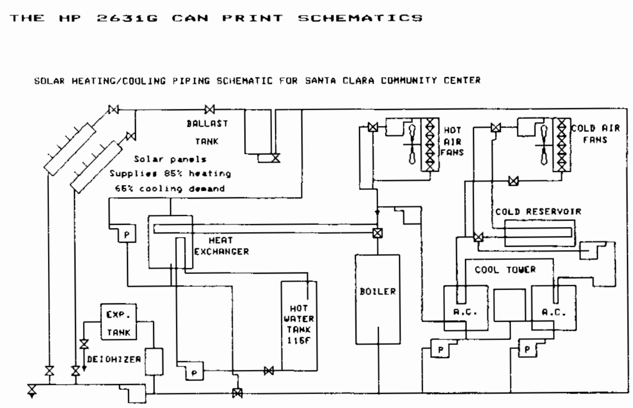
Graphics Operation

The new printer accepts graphics information in raster form line by line in 8-bit bytes, with the 0's and 1's in each byte representing the blanks and dots of a contiguous string of horizontal dot positions in a raster line. The printer accepts and stores eight lines of data in a buffer, and then prints the eight lines simultaneously while accepting and storing the next eight lines in a second buffer.

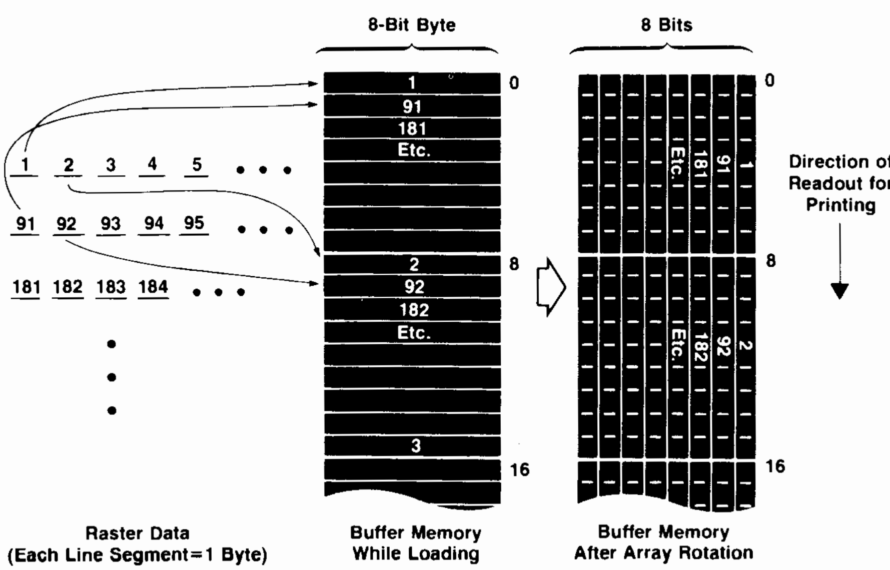
One of the problems that had to be solved was how to organize the data so the eight lines could be presented to the printing hardware in a usable form. This is done by regrouping the data as it is loaded into the buffer as shown below.

After the buffer is loaded, the data is withdrawn in arrays of eight 8-bit bytes. Each array is rotated 90° and then returned to memory. The word stored at each address in memory now has the proper dot pattern for printing the dots at the corresponding dot positions in all eight raster lines simultaneously.

This method of printing the dots required a change in the dot-generation control circuits (see Fig. 2, page 10). The character ROMs shown in Fig. 2 have been replaced by a RAM and the microprocessor loads the dot data from the graphics buffer into the RAM so the dot-printing circuits can access the data for printing as described on pages 8 and 9.



Another change was one made to the leadscrew encoder disc. The second track now has 144 slots so 72 dots per inch can be printed in the graphics mode, which matches the 72 dot-per-inch vertical resolution of the printer. Consequently, when printing alphanumerics the COMPRESSED print mode has a pitch of 14.4 characters per inch. By allowing the dot position counter to count every other dot, this can be expanded to give a



pitch of 7.2 characters per inch. The 2631G thus has four print widths (5, 7.2, 10, and 14.4 characters per inch).

Alphanumeric Operation

Dot patterns for printing alphanumerics are also supplied to the printing RAM by the microprocessor. The microprocessor accesses the character ROMs to find the dot patterns for the specified characters and then supplies them to the printing RAM.

Direct access to the character ROMs on the part of the microprocessor now gives a greater degree of flexibility in handling multiple character sets. Each character set now has an identifying symbol, and whenever one of these symbols is imbedded in the data stream, the microprocessor searches through all the character ROMs to find the location of the desired characters. This allows character sets to share the same characters. For example, European languages and English use the same Roman alphabet and differ only in the use of accents and a few special characters. Only the accents and special characters are stored in the European character ROM since the microprocessor accesses this ROM only when needed. Otherwise, it uses the English ROM. Thus, there is room to place special characters for several languages in a single ROM, giving the printer multilanguage capability without the need to change ROMs.

Reference

1. P.D. Dickinson, "Versatile Low-Cost Graphics Terminal Is Designed for Ease of Use", Hewlett-Packard Journal, Jan. 1978.

however, pass through the amplifier with little change.

The output of the slew-rate limiting amplifier drives a switching power amplifier that in turn drives the servomotor. If a linear amplifier were used, it would need to be capable of supplying at least 20V to drive the servomotor at high speed during carriage return. While printing at slow speed, however, only 5V may be needed but the motor may draw 2 amperes. A linear amplifier would thus need to dissipate $(20 - 5)\,V \times 2A = 30W$. The switching transistors, on the other hand, dissipate only 2W each in this situation.

The error voltage node is set up so that if it is above a reference voltage (+4.6V), the voltage applied to the servo motor tends to accelerate the motor in the commanded direction. If the error voltage is below the reference, a deceleration voltage is applied.

The magnitude of the motor drive is obtained by rectifying the difference between the error voltage and the reference, thereby converting a difference voltage of either polarity to a unipolar voltage. This voltage is applied to a comparator which functions as a pulse-width modulator. The other input to the comparator is a 20-kHz sawtooth waveform, so the output of the comparator is a rectangular wave whose width is proportional to the error voltage. This waveform is applied to the motor control logic that controls the

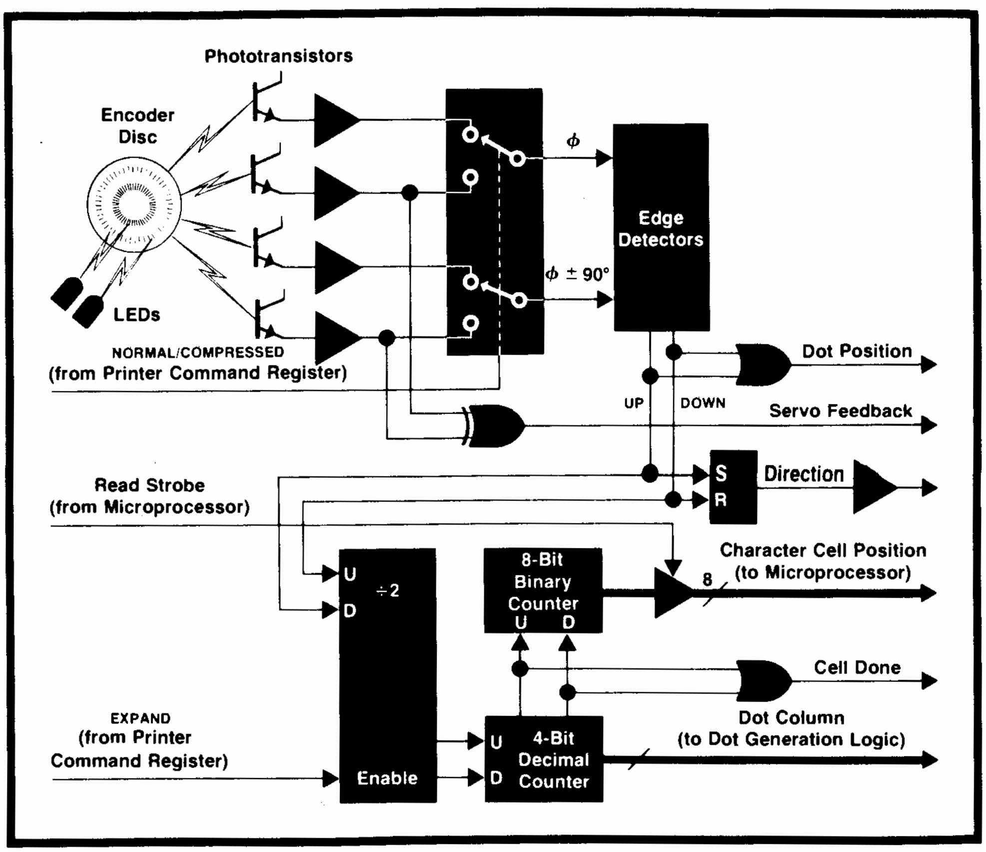


Fig. 4. *Circuits that determine the printhead position.*

power applied to the servomotor.

The polarity of the motor drive is likewise obtained by comparing the error signal to the reference. The resulting polarity signal is applied to the motor control logic along with the commanded direction signals. If the actual head direction differs from the commanded direction, one of two flip-flops will be set. The outputs of these flip-flops are connected to the motor control logic such that if the head is moving in the wrong direction, full power (100% pulse width) is applied to the servomotor to bring it to a stop. Once the motor changes direction, the flip-flop is reset and the servo loop returns to the linear mode.

Position Control

The circuits that determine the carriage position are shown in Fig. 4. The optical encoder disk attached to the leadscrew has two tracks that determine the printing pitch (horizontal spacing) of the characters. The standard track contains 100 slots per revolution to produce a pitch of 10 characters/inch (NORMAL mode). The second track has 167 slots per revolution (except in the Model 2631G Graphics Printer) and is used for COMPRESSED printing at 16.7 characters/inch. This second track is also used for velocity feedback in the carriage servo-drive system.

Each encoder track is sensed by two LED-phototransistor pairs that are spaced to produce two signals 90° out of phase with respect to each other. Edge detectors monitor the phototransistor outputs to determine the direction of printhead motion and generate an appropriate count pulse (an UP pulse for motion to the right and a DOWN pulse for motion to the left). These pulses set or reset the DIRECTION flip-flop. They are also ORed together to create the DOT POSITION pulse.

The UP/DOWN count pulses are also fed to an up/down counter chain that keeps track of the printhead position as the head moves across the page. The counter has a four-bit decimal-count stage that indicates the dot column within a character cell followed by a binary stage that contains the number of the cell. The counters keep track of the number of character spaces (logical print positioning) rather than the actual position of the head since the print mode (pitch) may change several times in a line. The microprocessor can read the cell number so it has access to this information when commanding the printhead carriage to move to any position along a line of print.

As explained previously, the dot-column data from the counter is used by the character generation logic as part of an address in the character generator ROM.

Several printing features are handled by the hardware. One is auto underline. When the microprocessor is commanded to invoke auto underlining, it sets a bit in the printer command register that replaces the data for the printhead's bottom hammer with the least-significant bit of the dot-column counter. Thus, dots are printed on the bottom dot position of the odd-numbered columns, forming an underline.

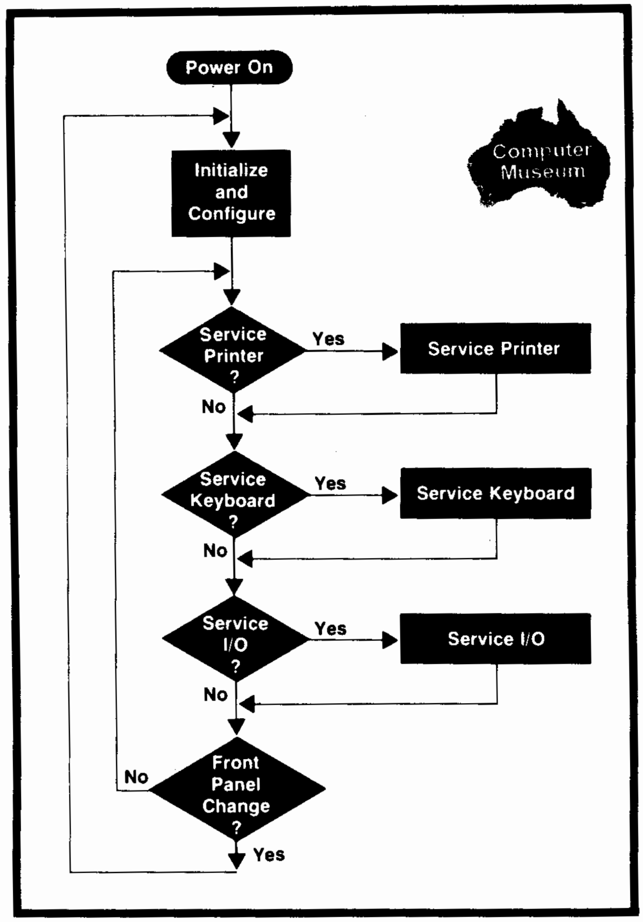


Fig. 5. *Basic idle loop executed by the microprocessor.*

The print mode (pitch) is determined by two bits in the printer command register. One of these bits determines which encoder track will supply inputs to the edge detectors (Fig. 4) and thus determines the choice of NORMAL or COMPRESSED modes. The other bit, used in the EXPAND mode in conjunction with the NORMAL track, enables ÷2 logic preceding the dot-column counter. This allows every other UP or DOWN pulse only to be counted by the dot-column counter, causing each column to be printed twice in succession.

System Firmware

The programs resident in firmware within the new printers and printing terminals are divided into five parts. These include the main system firmware, the printer driver firmware, the I/O driver firmware, the self-test firmware, and the keyboard/control-panel firmware. The driver portions are mainly concerned

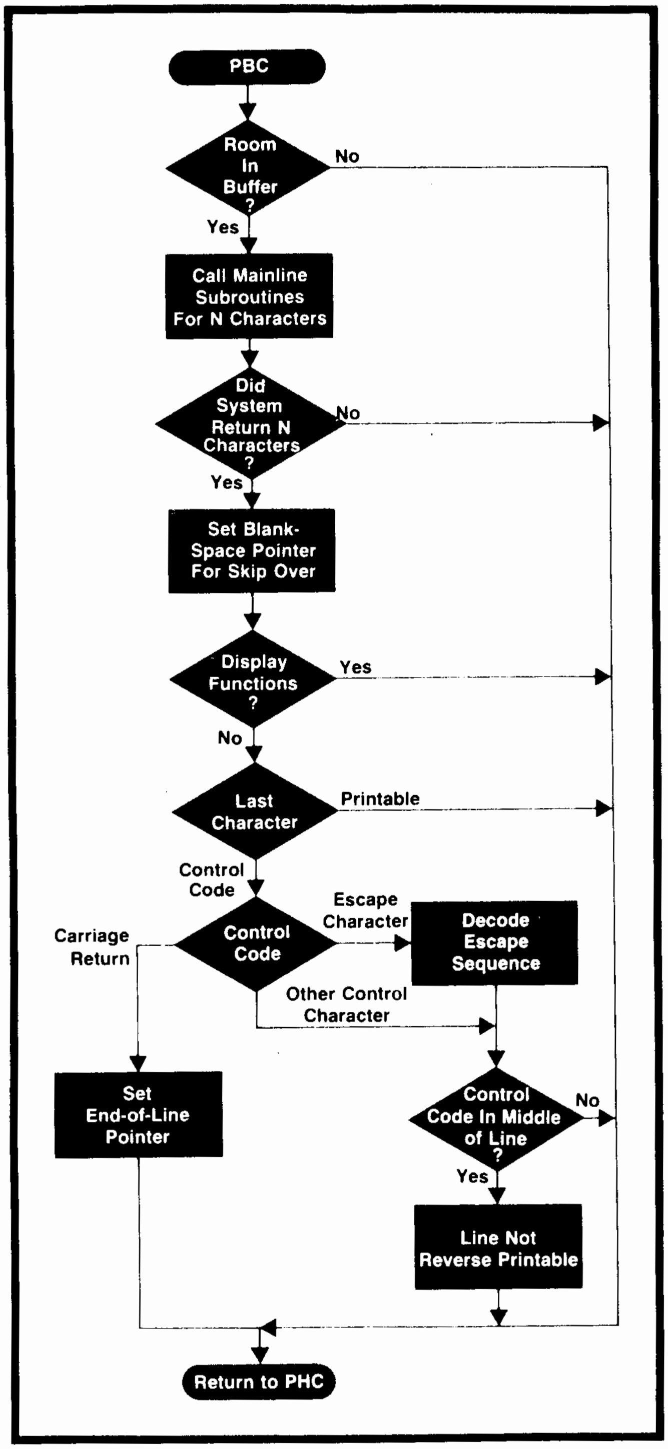


Fig. 6. *Printer buffer control (PBC) flowchart.*

with controlling hardware while the system firmware provides data-path handling functions and a common set of general utilities for the drivers. The total amount of memory is 4K 16-bit words of ROM and 512 16-bit words of RAM.

The system firmware normally executes a basic idle loop, as shown in Fig. 5, but is driven out of the loop by interrupts. When an interrupt occurs, the processor saves the present state of the machine and transfers control to the interrupting routine. Upon conclusion of the interrupt routine, the processor restores the previous machine state and resumes execution from the point of interrupt. If the interrupt does not require fast response, the processor merely sets a flag for the appropriate driver and continues with the main program. The flagged driver is subsequently called when the processor reaches that point in the main idle loop where the flag (called a service request) is tested.

The processor responds to three sources of interrupts. These include the interface (I/O) hardware, the printer hardware, and the 2-ms real-time clock. The printer and I/O functions are purely interrupt driven while the keyboard is scanned at 10-ms intervals using the real-time clock. The 10-ms scan time is fast enough to detect all keystrokes but slow enough to ignore switch bounce. The processor keeps track of the keys down on the previous scan to provide 2-key rollover.

Since the processor handles the keyboard scan and converts the ASCII codes for the keys by a table-lookup algorithm, the keyboard hardware is extremely simple and inexpensive. Yet, keyboard scanning and ASCII conversion require only about 2% of the processor's time.

System firmware functions are detailed in the following list.

- Provide a power-up initialization routine.
- Handle all interrupts; also provide a firmware mechanism using the real-time clock to allow any driver, such as move head to the right for viewing, to suspend itself for a specified time period.
- Call proper drivers as needed.
- Provide a queuing structure so drivers can use queues with system calls, implemented with source and sink drivers. For example, in local mode the keyboard driver is a source and the printer is a sink for the keyboard queue.
- Scan the remote/local and full/half-duplex switches and maintain internal data paths according to the selected mode.

Printing Firmware

The firmware that controls printing performs two general functions: monitoring and controlling the printing hardware, and interfacing information with the microprocessor operating system. The internal language consists of ASCII-coded eight-bit characters.

The print driver firmware has two major subroutines. One, the printer buffer control, receives characters and places them in a printer line buffer. The other, the printer hardware control, contains all

Interfacing to a 180-Character/Second Printer/Terminal

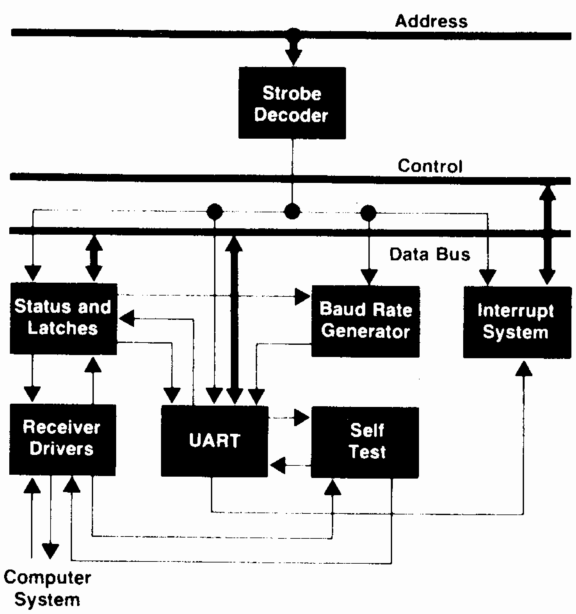
The Models 2631A/G Printers and 2635A/39A Printing Terminals were designed so that the interface I/O can be changed to match different I/O protocols simply by changing one printed-circuit board. To permit this, the machine's firmware is divided so that 1K of the 4K words of operating firmware is on the I/O pc board. Each I/O board thus carries its own firmware, making it easier to adapt the machine to different computer systems.

The self-test routines for the entire machine are also included in the I/O ROM so the self test can include tests for the particular I/O in use.

I/O cards have been designed for both serial and parallel data inputs. In either case, each character is transmitted as an eight-bit byte. Since the characters used by the machines can all be encoded in seven bits, the eighth bit may be used as a parity bit—options allow the parity protocol to be either odd or even—or it may be used to designate which of the machine's two character sets is to be used for that character.

To permit this I/O flexibility, there are seven entry points in the first seven addresses of the I/O firmware. These are:

1. I/O mainline. This is called by the machine's operating routine whenever service is required. It performs many functions based upon the flags set by other routines. It may also set its own service requests to reenter at a later time. After a particular service is performed, the I/O mainline clears the service request and checks for any more requests.
2. I/O power on. This routine, called once during reset, initializes any words or hardware prior to the machine becoming operational. It also brings up the hardware with the designated parity and baud rate.
3. Interrupt. It is in this routine, called by the I/O card itself, that characters are received and transmitted. In the case of the serial I/O, considerable processing is done by this routine but with the parallel I/O, because of its faster byte-by-byte transfer, the flag for the I/O mainline service request is set and the interrupt is handled later.
4. Scanner. This point is entered every few milliseconds as the operating system has time. The serial I/O uses this point to monitor outside control lines while the parallel I/O returns immediately to the operating system.
5. Self-test I. Directs the I/O firmware to a routine that tests the I/O hardware. The results of the test are returned by way of an internal register to the calling program.
6. Self-test II. This causes the I/O to power up to resume normal communications with the outside world following the self test.
7. I/O status. This routine is called when the machine has received an external request for machine status.



Serial I/O

Serial data is accepted asynchronously, that is, the data is not synced with the machine's internal clock. When no data is being transmitted between the machine and the computer, the communication line is held in a marking (logic high) state. When a character is to be transmitted, the line is put into the space (logic low) state for one bit period and then the eight bits are transmitted, least significant bit first. After the eight bits, the line goes back to the mark state and remains there until the next character is transmitted.

Although the new machines are capable of printing at a speed of 180 characters per second, they may be used with computers that transmit at rates up to 960 characters per second. To cope with high data rates, the approach here is to use the ENQ/ACK handshake (enquiry/acknowledge), as used with the HP 2640 series CRT Terminals. With the ENQ/ACK system, the computer sends 80 characters followed by the ASCII ENQ character (05_{16}). The characters are stored in the machine's I/O buffer and when the ENQ character is received, the machine checks the buffer to see if there is room for 80 more characters. If there is room, it transmits the ACK character (06_{16}) and the computer then sends another 80 characters followed by the ENQ character. If there is not room, the machine delays sending the ACK character until room for 80 more characters becomes available.

The ENQ/ACK system makes more efficient use of computer time than do systems that intentionally slow the character transmission rate by inserting non-printing characters to slow the effective rate.

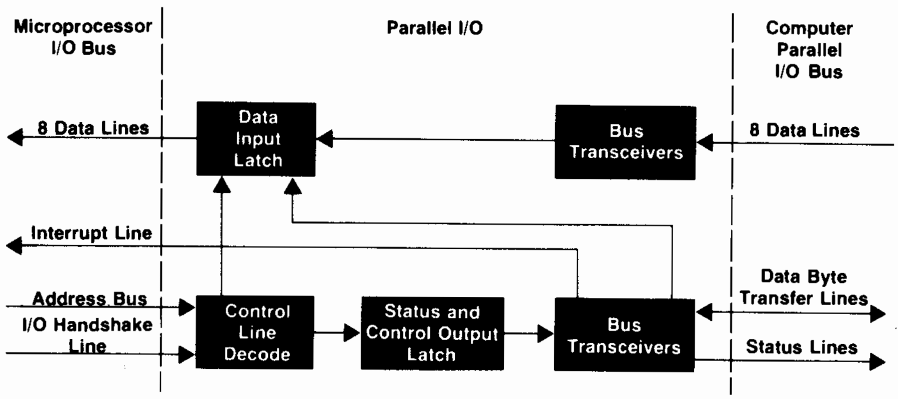
A block diagram of the I/O hardware is shown at left. Operation is controlled by the strobe decoder that decodes the I/O's read and write pulses for controlling data bus use. The heart of the hardware, however, is the UART (universal asynchronous receiver/transmitter). It receives the serial data, checks the parity if used, deletes the start and stop bits, and presents the character bits in parallel to the main data bus. Another portion of the UART accepts a character to be transmitted, adds start, stop, and parity bits, and transmits them.

The self-test block allows the UART to transmit characters to itself, thereby testing the UART and the circuits that support it. Incoming data is ignored and outgoing data is suspended during the I/O self test.

The interrupt system generates an interrupt for the main processor whenever the UART receives a character or becomes ready to transmit another character. It also identifies itself to the processor as the interrupt generator.

The block labelled Status and Latches accepts and latches control signals from the data bus for controlling the outgoing lines and other functions on the board. The status portion transmits configuration information, set into DIP switches on the I/O board and read by the I/O firmware, to the data bus for controlling protocol and various operating modes.

(continued)



It is in the firmware interrupt routine that characters are received and transmitted. Upon entry to this routine, the UART is immediately checked for a character, since they could arrive as often as one per millisecond. Incoming characters are checked for parity and framing errors and whether or not they are ENQs. If an ENQ is received, a flag is set for the transmitter routine to check for buffer room and send an ACK. After the character is checked, it is put into the system queue and the transmitter routine is entered. In the transmitter routine, special characters like ACK, STX, and ETX, and terminal status are checked first, then the system queue is checked for characters.

Parallel I/O

In the standard parallel interface, the machine's processor handles the input data on a byte-by-byte basis, controlling all handshakes through the control line decode circuit, shown in the block diagram above. Good service response is required on the part of the processor to insure accurate data transfer. The CMOS SOS microprocessor used in the machine is capable of doing this.

Upon receipt of a byte, the processor services the interrupt and sets up a service-request call to the I/O from the main operating system. When the next free time occurs, the data input latch is read and the interface is prepared for another byte of data.

On every service, the processor loads the status latch so the latch always contains the current status, in case the system computer should request status.

HP-IB Interface

The HP-IB interface I/O is basically similar to the standard parallel I/O except that the data input and output latches are replaced by a CMOS SOS integrated circuit.[1] This IC, together with bipolar three-state transceivers, provides a complete logical and electrical interface to the interface bus defined by IEEE-488-1975. It handles the bus protocol and handshakes involved in data transfer and provides buffering for inbound and outbound data transfer through two FIFO queues that can be accessed by the machine's processor. Up to eight bytes of data can be transferred to the I/O before an interrupt requiring service from the processor is generated.

In this interface I/O, the control line decode enables the IC when the machine's processor talks to it, and it also enables a switch that places the HP-IB address, set by a switch on the rear panel, on the processor's data bus. Another switch places the I/O in the listen-always mode so the machine will respond to whatever is on the HP-IB bus.

The HP-IB I/O can operate at high speed up to the limit of the HP interface bus (1 megabyte/second) or it can operate in the print-and-space mode without any loss of printer capability.

–Gerard Carlson
Michael Lee
Roy Foote

Reference

1. J. W. Figueroa, "PHI, the HP-IB Interface Chip," Hewlett-Packard Journal, July 1978

printing firmware overhead as well as control of hardware functions. Both subroutines execute as non-interrupting routines and comprise about 95% of the printing firmware. The remainder involves paper feed and buffer-to-printhead subroutines that operate under interrupt control to service time-critical functions rapidly.

Separation of the driver into two sections evolved naturally because of the timing differences between the processing of characters by the printer buffer control (PBC) and their printing by the printing hardware control (PHC). The PBC first writes characters to the line buffer and then the PHC writes the buffer to the printhead hardware for printing. Both routines maintain separate configuration states that may affect logical decisions.

Printer processing begins when the PBC calls a routine in the microprocessor operating system specifying the number of character spaces available for the next line and the starting location in the line buffer (Fig. 6). The routine then transfers characters stored in the input queue to the line buffer. Transfer stops when the number of characters requested is transferred, or when the entire queue is transferred if less than the requested number, or if a control character is received. The PBC examines the last character to see if it is a control code and if so, determines whether or not it is executable by the printing mechanism. Non-executables—for example, "inverse video"—are eliminated, printables require no further attention, while executable control codes, including escape sequences, cause additional processing. Because con-

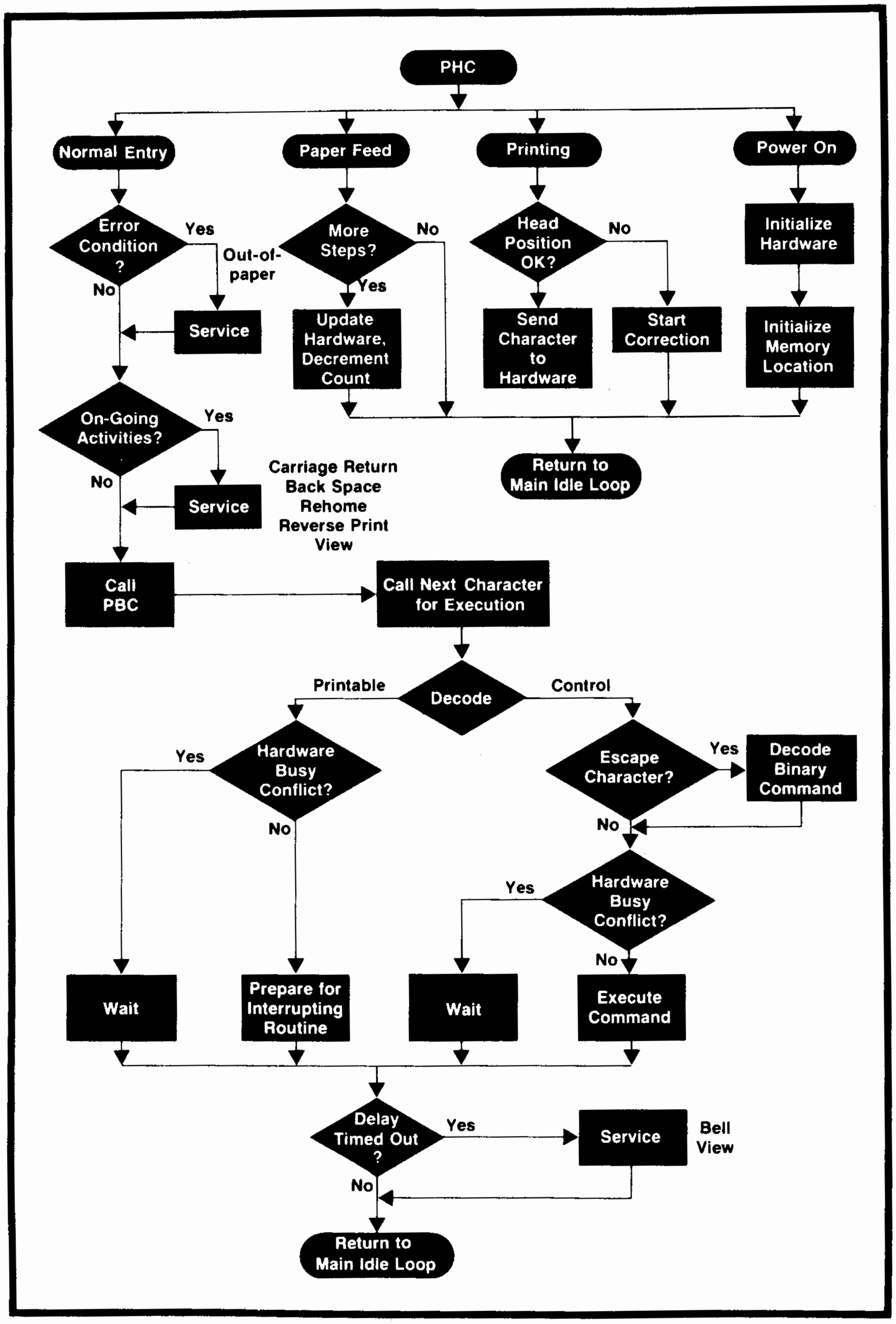


Fig. 7. *Printer hardware control (PHC) flowchart.*

trol codes can affect characters that follow, print lines with imbedded executable control codes cannot be printed right to left. If the machine is in the DISPLAY FUNCTIONS mode, the original data stream remains unaltered so control codes can be printed.

Escape sequences are fully decoded and replaced in the line buffer by an escape character followed by an eight-bit binary code that represents the specific command. The line is terminated when the carriage-return character is encountered. This end-of-line condition, which is marked by a pointer, prevents further loading into the buffer until printing of the present line is completed.

If the PHC is printing left to right, characters are removed from the buffer left to right and the PBC fills in the next line as space becomes available. The PBC examines the incoming data and places a buffer pointer where the first non-blank character appears.

Thus, the printhead can be moved directly to this position when this line is printed, ignoring the blank spaces. The PBC also performs the tab function by inserting blank characters in the buffer.

When the PHC reaches the end-of-line pointer for the present line, a last call is made to the PBC in an attempt to complete the next line. If the next line is complete and is right-to-left printable, trailing blanks are stripped off and the distances from the printhead to the start and end of the next line are determined. If the head is closer to the end of the next line, a reverse print line is started.

Left-to-right print lines proceed through the buffer at print time until the end-of-line pointer is encountered. Right-to-left printing starts at the rightmost printable and proceeds back towards the first printable in the line. When right-to-left printing is completed, the buffer readout pointer is moved to one position to the right of where the rightmost printable was. Control codes at the end of the line are then processed by normal left-to-right processing.

The actual printing and execution of control sequences are handled by the PHC (Fig. 7). First, possible error conditions are checked, then existing tasks are serviced, then the next character is processed, and finally real-time clock counters (out-of-paper alarm, move head for viewing) are checked.

Entry to the main portion of the driver is by way of the system poll loop when the printing service-request flag is set. This flag can be set by a hardware interrupt (printhead crossing a cell boundary), by a printer delay word timing out, or when a character is placed in an otherwise empty system queue. On each pass through the driver, directly after each PBC call, a routine is called to get the next character from the line buffer. The next print location in a printed line is maintained in memory and the actual head position is in the printhead position counter. The head is then commanded to the character position one to the left of the next print position, if printing left to right, or one to the right if printing right to left. From there it is commanded to move in the proper direction at the indicated print speed. When the print velocity command is strobed to hardware, the PHC enables the PRINT GO flip-flop (Fig. 2) to be set by the next character position interrupt. With this interrupt, the printer interrupt routine is entered. This routine checks for the correct print position, then strobes the character to hardware for printing. The next-printing location is then updated and the PRINT GO flip-flop control bit is lowered so it can be cleared when the head reaches the end of the current print cell. The main entry is called again during the next system poll so that contiguous printables can be serviced.

The next-character routine skips over blank characters by simply incrementing or decrementing the next-print location in memory. If more than ten blanks occur in succession, the head is moved rapidly to the next printing location upon completion of the present printing character.

The PHC acts as a position controller for the print head carriage by giving a velocity command to the hardware and then reading the position of the head as feedback for updating the velocity input. Print speed is a function of the present print mode and the number of characters to be printed. The print-speed routine is called each time through the driver. As inputs, it uses the present print mode, the state of the repeat key (in the printing terminals), and the number of characters left to be printed. This enables lower speeds for keyboard entry, a repeat speed for repeat character input, or full speed, when sufficient characters are buffered, with controlled deceleration at the ends of lines.

Like the PBC, the PHC maintains its own DISPLAY-FUNCTION-mode state so that control codes can be printed and not acted upon. The exceptions are the carriage-return character and the command that terminates DISPLAY FUNCTIONS. When a carriage return character is encountered, it's symbol is printed and then a return and a line feed are executed. In the same way, the terminate-DISPLAY-FUNCTIONS symbol is printed and then that mode is terminated.

The four bits maintained in memory that control the printing mode (auto-underline, alternate character set, COMPRESSED and EXPANDED print modes) are updated each time their escape commands are encountered. Then, with each print strobe, a copy of the printing mode state is written to hardware so printing modes are selected on a character-by-character basis. This allows intermixing of character sets and print modes on a given line.

Paper Control

Paper motion can be commanded by a line-feed character, a form-feed character, or a vertical format control (VFC) command. VFC commands are escape sequences that select one of eight possible predefined position stops on a page.

When a paper motion command is received (line feed, form feed, etc.), the microprocessor allows the in-progress printing operations to complete and then initiates paper feed by triggering a state machine that generates the phased signals for advancing the motor to the next step. The paper feed routine calculates the number of steps required to move the paper to the next stop position. This number is stored in a memory location for step counting. Similarly, a line-feed or a form-feed causes the memory to be updated with the number of steps required.

Once the memory is loaded, a 2-ms real-time clock delay is set. When the delay times out, the paper-feed interrupting routine is entered. This routine enables the hardware to step the paper drive, decrement the paper-feed memory count, and check it for zero. If it is not zero, another 2-ms delay is set for the next step.

Each step advances the motor 1/72 inch so twelve steps are required for the standard six lines/inch spacing or nine for eight lines/inch. Firmware counters maintained by the microprocessor keep track of the line count. Other line spacings of one, two, three, four, and twelve lines/inch can be programmed.

SPECIFICATIONS
HP Models 2631A and 2631G Printers, 2635A and 2639A Printing Terminals

PRINTING
TECHNIQUE: 7×9 dot matrix, impact.
SPEED: 180 characters/second; bidirectional.
LINE LENGTH: 136 characters at 10 cpi, 68 at 5 cpi, and 227 at 16.7 cpi.

CHARACTER SET: 128 ASCII.

FORM WIDTH: Edge perforated, 31-mm (1.22 in) perforation-to-perforation, to 400-mm (15.748 in) edge-to-edge.

FORMS HANDLING:
Forms tractors are standard; feed rate: 176.6 mm/s (6.95 in/s).
8-channel fixed vertical form control (for 11-inch long forms).

Single space	Slew to top of next page
Double space	Slew to next half page
Triple space	Slew to next quarter page
Slew to bottom of current page	Slew to next tenth page

Horizontal tabbing, up to 227 tabs.
Variable horizontal and vertical pitch.
1-6 copies up to 0.43-mm total thickness.

POWER: 100, 120, 220, 240 Vac, +10%, -12%, 48-66 Hz, 140VA max non-printing, 265VA max printing.

RELIABILITY:
An extensive reliability testing program was implemented in which 330 million characters were printed on each of 35 machines for a total of 11.5 billion characters. Preliminary results show that the mean number of printed characters between failures (MCBF), excluding print head and ribbons, exceeds 300 million. The printhead itself is good for an average of 130 million characters, and the average ribbon life is 10 million characters.

The 2630 family is recommended for 1 million characters per day, resulting in a mean time between failures (MTBF) of approximately 1 year. Basic monthly maintenance charges are based on this level of usage.

PRODUCT SAFETY: These products are listed by Underwriters Laboratories Inc. in the following categories:
Electronic Data Processing Equipment (EMRT)
Office Appliances and Business Equipment (QAOT)
Teaching and Instruction Equipment (WYFW)
They are also certified by the Canadian Standards Association as Data Processing Equipment.

ENVIRONMENTAL
TEMPERATURE: 0 to 55°C (32 to 131°F) operating.
HUMIDITY: 5% to 95% (non-condensing) excluding media.
VIBRATION: 0.38 mm (0.015 in) p-p, 5-55 Hz, 3 axes.
SHOCK: 30g, 11 ms, ½-sine shock pulse. Also type tested to qualify for normal shipping and handling in original shipping container.

HP Model 2631A Printer Only

SIZE: 215 mm H × 640 mm W × 489 mm D (8½ × 25¼ × 18½ in).

WEIGHT: 23.5 kg (51 lb) without stand.

OPTIONAL SECOND CHARACTER SETS: Swedish/Finnish, Norwegian/Danish, French, German, Spanish, United Kingdom, Cyrillic, Katakana, Extended Roman, Math symbols.

CONTROLS AND INDICATORS
PRINT MODE switch: EXPANDED, NORMAL, COMPRESSED.
VERTICAL PITCH switch: 6/8 lpi (sets default value). 1,2,3,4 and 12 lpi selectable through escape sequences imbedded in data stream.
DISPLAY FUNCTIONS button and indicator (prints control characters but does not execute them).
ON LINE/OFF LINE button and indicator.

SELF-TEST button	RESET button.
FORM FEED button	LINE FEED button.

POWER ON indicator.
POWER switch, fuse, and line voltage selector on rear panel.
PAPER OUT audible alarm.

INTERFACE:
STANDARD: General purpose differential line driver compatible with HP 12845B interface board for 2100 and 1000 series computers.
OPTIONAL: General-purpose TTL interface for HP 2640 series CRT terminals, RS232C/CCITT V.24 with or without modem control, 20 mA current loop, and IEEE 488-1975 interface bus.

PRICE IN U.S.A.: $3150.

HP Model 2631G Graphics Printer

Same as Model 2631A Printer except that it accepts raster-format graphics display data from HP 2647A and 2648A CRT Graphics Terminals, has a more flexible vertical forms control, can have multiple secondary character sets, has available an optional line-draw character set and an optional high-density character set.

HORIZONTAL PITCH: 5, 7.2, 10, and 14.4 characters per inch.

RESOLUTION IN GRAPHICS MODE: 72 × 72 dots/inch.

INTERFACE: IEEE 488-1975 interface bus.

PRICE IN U.S.A.: $4250.

HP Model 2635A Printing Terminal Only

SIZE: 215 mm H × 640 mm W × 595 mm D (8½ × 25¼ × 23 in).

WEIGHT: 25½ kg (56 lb).

KEYBOARD: Full ASCII keyboard with typewriter compatible key locations. Caps lock and repeat keys. 15-key numeric pad. Enhanced 2-key rollover.

CONTROLS AND INDICATORS

TERMINAL RESET Button	REMOTE/LOCAL Switch
SELF TEST button	AUTO LINE FEED button
SET TAB button	CLEAR TAB button
DISPLAY FUNCTIONS	POWER ON indicator
DATA SET READY indicator	CLEAR TO SEND indicator

POWER switch, fuse, and line voltage selector on rear panel

INTERFACE: RS232C asynchronous interface for type 103 modems.
DATA RATE: 110, 150, 300, 1200, 2400 baud switch selectable.
TRANSMISSION MODE: Full or half duplex, switch selectable.
PARITY: odd, even, or none, switch selectable.
OPTIONS: 20-mA current loop (full duplex only) and RS232C for type 202 modems.

PRICE IN U.S.A.: $3450.

Model 2639A Printing Terminal

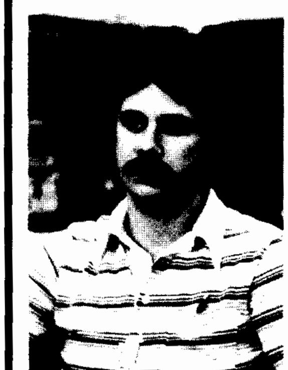
Same as Model 2635A except has flexible interface that makes RS232C and current loop selectable with split transmit/receive baud rates, and also has asynchronous ASCII interface with standard 1-K byte input buffer; "printer busy" state can be selected at 100, 90, 80, 70, 60, 50, 40, or 30 percent of buffer full, or "printer not busy" state can be selected at 0, 10, 20, 30, 40, 50, 60, or 70 percent of buffer full. Supports either X-ON/X-OFF or ENQ/ACK protocols.

PRICE IN U.S.A.: $4025.

MANUFACTURING DIVISION: BOISE DIVISION
11311 Chinden Boulevard
Boise, Idaho 83707 U.S.A.

Kenneth B. Wade

With HP since 1975, Ken Wade was responsible for the main firmware for the 2630 family. Prior to HP, Ken worked in logic and software design. Born in Aberdeen, Washington, he received his BSEE degree from the University of Washington in 1970 and his MS in computer science from the University of Santa Clara in 1978. Ken lives with his wife and three children in Boise, Idaho, and is involved in church activities, cub scouts, basketball, volleyball and chess.



Michael J. Sproviero

An HP employee since 1972, Mike Sproviero is project leader for the 2631G Printer. He started as production engineer on disc and magnetic tape drives at HP's Mountain View Division, then moved to the Boise Division. Born in Gustine, California, he received his BSEE degree in 1972 from the University of Santa Clara and MSEE degree in 1978 from the University of Idaho. Mike lives in Boise, Idaho, with his wife and son, and enjoys tennis, camping and skiing.

Phillip R. Luque

Phil Luque joined HP's Santa Rosa Division in 1973 where he worked on the 8754A network analyzer before moving to to HP's Boise Division in 1975 where he designed the lead screw servo for the 2631A/G printer. Born and raised in Boise, Idaho, Phil is a 1972 BSEE and a 1973 MEEE graduate of Brigham Young University. Phil lives with his wife and three children (ages 1, 3 and 5) in Boise, and keeps active doing church work, folk dancing and working around the house.

John J. Ignoffo, Jr.

John Ignoffo is electronic hardware designer for the 2631A/G printers and also designed the character sets. With HP since 1975, John is a 1971 BSEE and a 1973 MSEE graduate of the University of Santa Clara. Between graduation and HP, he worked in printer research. Born in San Francisco, John was recently married and lives in Boise, Idaho. He is fond of skiing, and listening to music, and is a member of the board of directors of a local theater group.

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