Hewlett-Packard 7310A Graphics Printer Interface Manual

RS-232-C/CCITT V.24
RS-423-A
8-Bit Duplex

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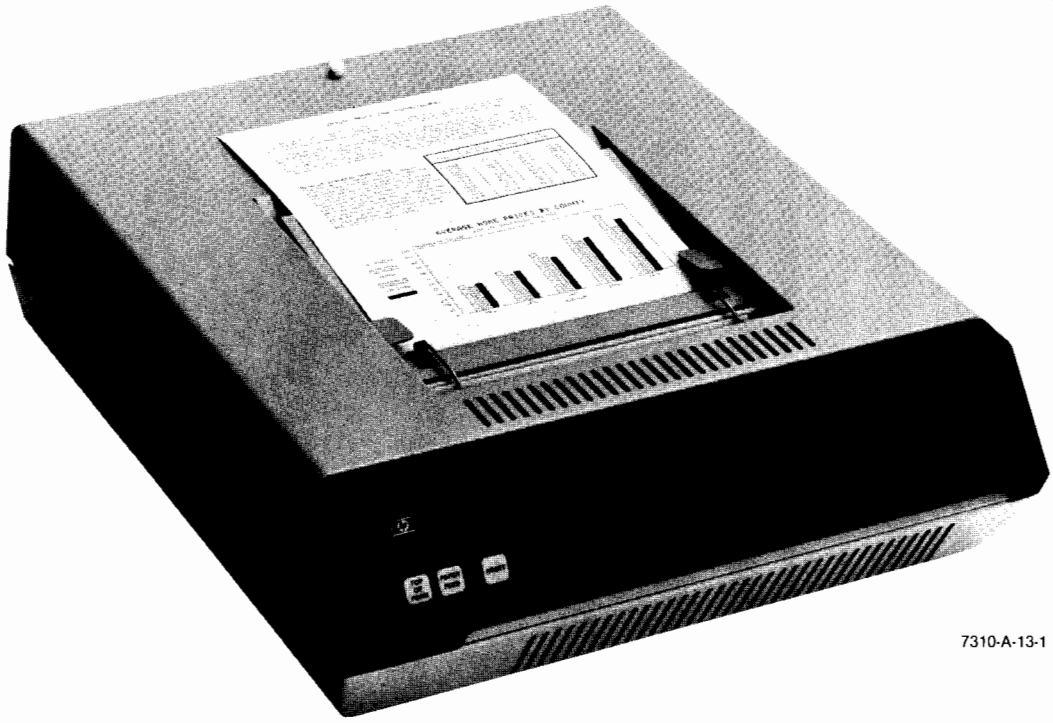

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	NO: If not purchased as above	Return to HP (2)
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Response Time	4 hours	8 hours	12 hours	Quote

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Chapter 1
General Information

Introduction

The 7310A Interface Manual defines and describes the operating characteristics and requirements of the optional interfaces available for the Hewlett-Packard 7310A Printer. This manual is a supplement to the 7310A Graphics Printer User's Manual, part number 07310-90001, and is intended to serve as a reference document. All text, forms, and graphics functions and all specifications and characteristics discussed in the User's Manual pertain to each of the interfaces described here, with the following exception: The soft reset (i.e. pressing the reset button once) does not reset the interface when using the RS-232-C/CCITT V.24 or RS-423-A interface.

The following interface options are discussed in this manual.

- Option 050, RS-232-C/CCITT V.24
- Option 051, RS-423-A
- Option 052, 8-Bit Duplex
- Option 240, Printer Subsystem for Hewlett-Packard 2640-series alphanumeric terminals having dual tape cartridges or device control firmware installed. Option 240 provides the 7310A 8-bit duplex interface, one HP 13232J printer cable and one HP 13238A 8-bit duplex register module interface for the terminal.

For a discussion of the HP-IB interface, consult the 7310A Graphics Printer User's Manual.

Hardware

Each 7310A interface consists of a circuit board and connector which are factory installed in the 7310A printer. Connecting cables are not provided except as part of the Option 240 Printer Subsystem. A compatible external connector and hood (no cable) are provided with Option 052.

Task of an Interface

When connecting a 7310A Graphics Printer to a controller, it is helpful to understand what an interface does and why it is necessary. Ideally, all controllers and peripheral devices would conform to some standard that specified the characteristics of their input/output connections, making all such devices "plug-to-plug" compatible. Unfortunately, no such standard exists. Most of today's connection or interface standards deal only with electrical characteristics and functions of signals, leaving other characteristics undefined. As a result, there are four major areas of concern when connecting a peripheral device to a controller: mechanical compatibility, electrical compatibility, data compatibility, and time compatibility. It is the task of the interface to provide the necessary compatibility in these areas.

Mechanical Compatibility

The simplest requirement for an interface to meet is that of providing mechanical compatibility. This consists of merely supplying the appropriate connector at each end of the interface and wiring the connectors in such a way that each input line at one end of the interface is connected to its corresponding output line at the other end (figure 1-1). If there were no other incompatibilities to overcome, this pair of connectors would constitute the entire interface. In practice, things are rarely this simple.

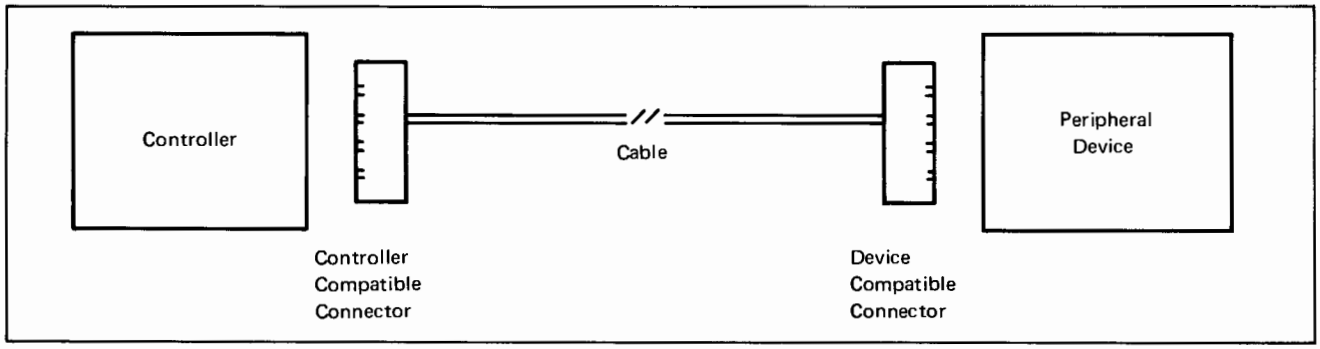


Figure 1-1. Sample Interface Diagram

Electrical Compatibility

A second function of an interface is to match the electrical characteristics (i.e., current and voltage levels, sometimes called logic levels) of the controller to those of its peripheral.

Data Compatibility

Once an interface has made the controller and its peripheral device mechanically and electrically compatible, they are capable of exchanging messages as electrical signals over wires

called data lines. To exchange these messages, it is necessary for both devices to use the same data representation. But just as two humans who do not speak the same language may need a translator, data messages between a controller and a peripheral may also require some sort of format translation. Each device may use whichever internal data representation it finds most convenient, yet each will input and output all data in some standard representation such as ASCII (American Standard Code for Information Interchange). The 7310A utilizes ASCII code, which is made up of 8-bit packages called "bytes" and has representations for numerical digits, upper-case and lower-case letters, common typewriter symbols (#, $, %, =, ?, etc.), and special control characters (carriage return, line feed, etc.).

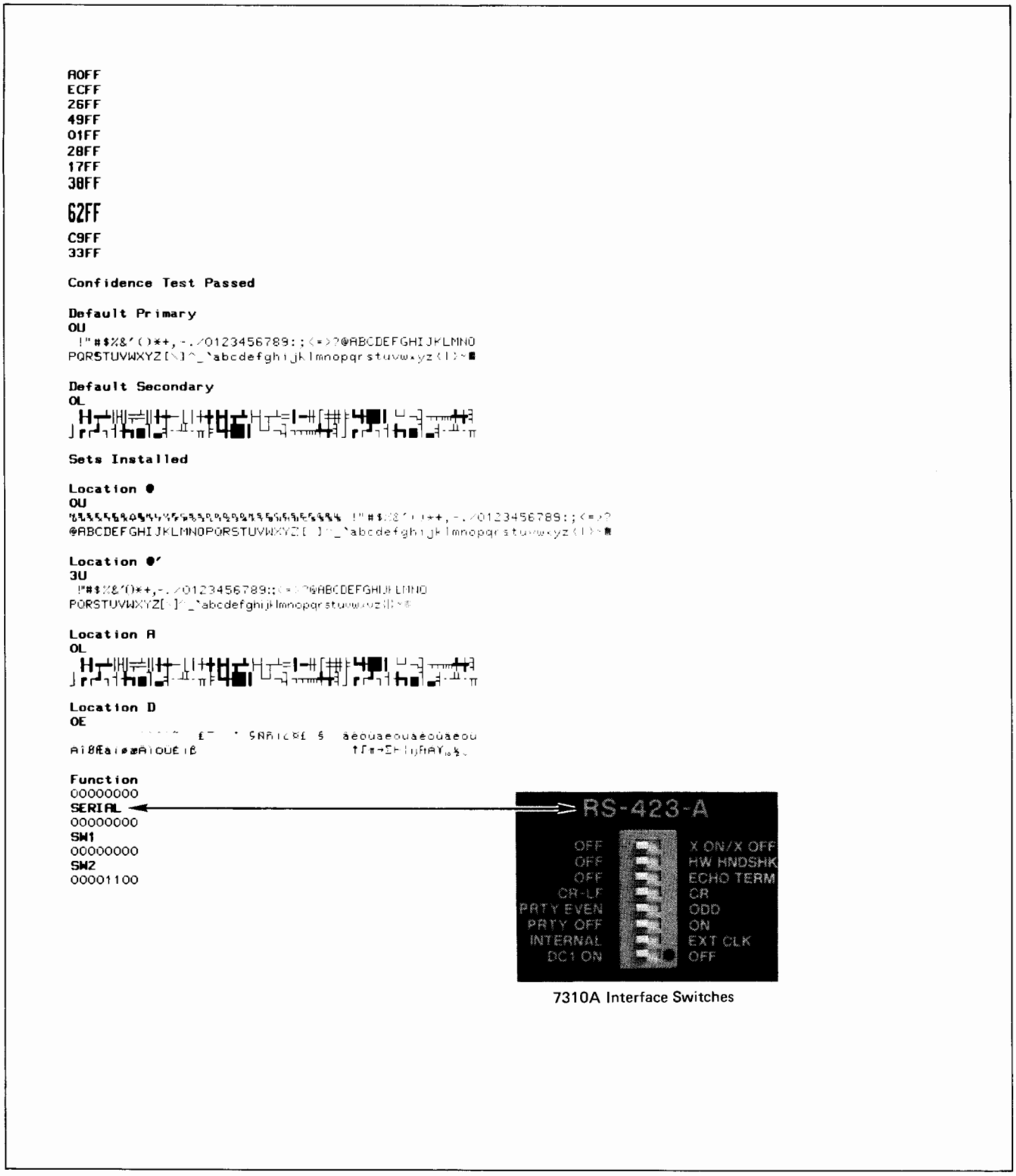
Timing Compatibility

Humans have the remarkable ability to talk and listen at the same time (or at least in rapid succession) without losing too much of the content of the conversation. This is because our speaking and listening rates are well matched. Controllers and their peripheral devices, on the other hand, have such a wide range of operating speeds that a much more orderly mechanism is required for successful transfer of data messages. Providing timing compatibility (sometimes called the handshake function), along with other miscellaneous control operations, is the fourth major task of the interface.

The chapters which follow give detailed information about the way each 7310A graphics printer interface implements these functions.

The Confidence Test

As explained in the 7310A Graphics Printer User's Manual, the confidence test performs a self-test of the printer's internal logic and memory circuitry. The resulting printout identifies various characteristics of the printer including the settings of the rear panel interface switches. The installed interface is identified on the printout by name or by type (by name for HP-IB and 8-Bit Duplex, by type ("Serial") for RS-232-C/CCITT V.24 and RS-423-A) followed by a line showing the interface switch settings at the time the confidence test was run. When read from left to right, the values correspond with the switches as they appear from top to bottom on the rear panel. A value of 0 means the switch was set to the left, and 1 indicates the switch was set to the right.



7310A Interface Switches

Figure 1–2. Confidence Test

Chapter 2

Option 050: RS-232-C/CCITT V.24, and Option 051: RS-423-A

Introduction

Options 050 and 051 are point-to-point serial interfaces operating in full duplex, asynchronous data transfer mode at rates up to 19,200 baud. The differences between the RS-232-C/CCITT V.24 and RS-423-A interfaces are limited to four characteristics: the connector, the interchange circuit definitions, the cable length restrictions, and the voltage levels. These differences are detailed in the mechanical and electrical compatibility discussions.

Option 050 Description

Option 050 (figure 2-1) provides the RS-232-C interface installed in the 7310A Graphics Printer. The interface conforms to the EIA Standard for RS-232-C and is the U.S. counterpart to the worldwide CCITT V.24 interface.

Option 051 Description

Option 051 (figure 2-2) provides the RS-423-A interface installed in the 7310A Graphics Printer. The interface conforms to the EIA Standard for RS-423-A.

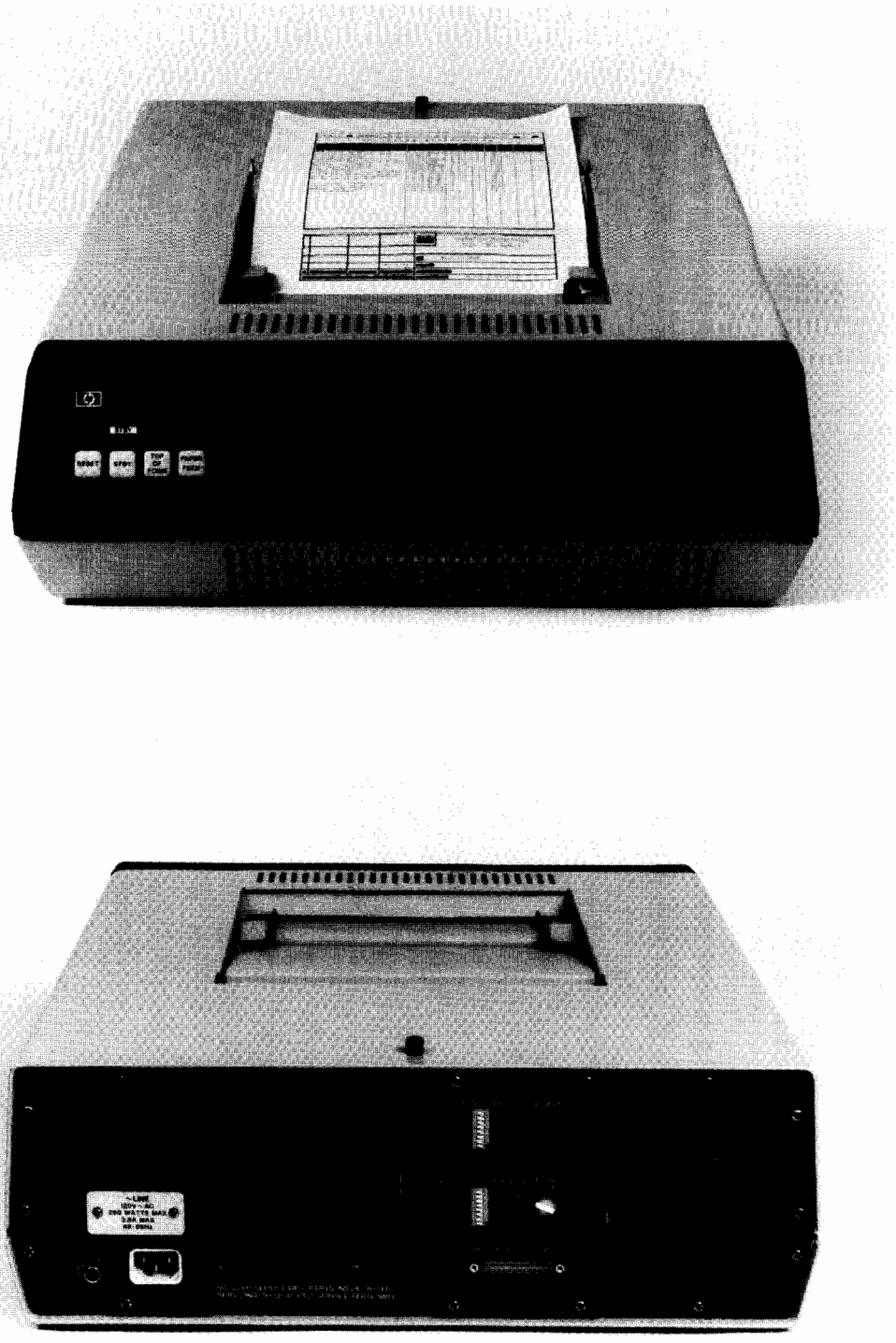


Figure 2-1. 7310A Graphics Printer With Option 050

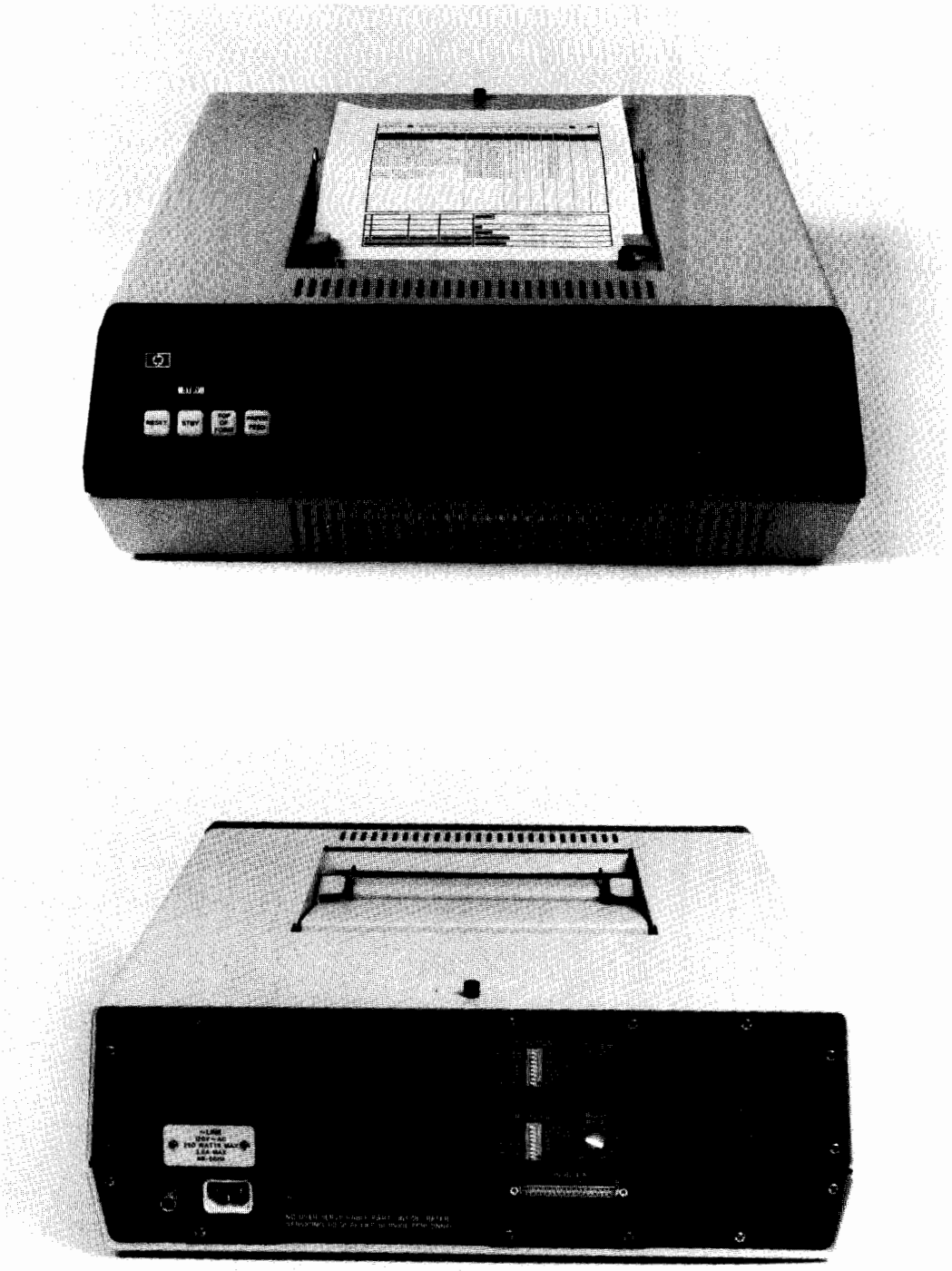


Figure 2-2. 7310A Graphics Printer With Option 051

Rear Panel Interface Switches

The 7310A rear panel interface switches for options 050 and 051 are factory set to the left. It is not necessary to reset the printer after changing a switch setting.

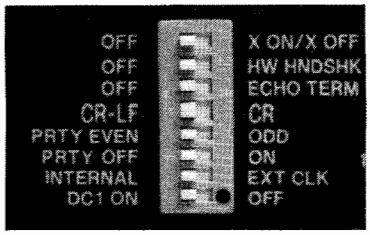


Figure 2-3. RS-232-C/CCITT V.24 and RS-423-A Interface Switches

Soft Handshake, OFF:XON/XOFF

This switch makes the printer compatible with a variety of controllers by defining the soft handshake protocol to be used. When set to OFF no XON/XOFF characters are transmitted.

When set to XON/XOFF the printer transmits an X-on character (**DC1**) when it is ready to receive data and transmits an X-off character (**DC3**) when it cannot accept more data.

Hardwire Handshake, OFF:HW HNDSHK

When set to OFF the Data Terminal Ready line is on, indicating a ready condition, and the Secondary Request line is off for the RS-232-C/CCITT V.24 interface. (Terminal Ready line is on for the RS-423-A interface.)

When set to HW HNDSHK the printer's handshake capability is transmitted to the controller through the Data Terminal Ready (CD) and Secondary Request (SCA) lines for RS-232-C/CCITT V.24 (through the Terminal Ready line for RS-423-A).

	RS-232-C/CCITT V.24	RS-423-A
OFF	Data Terminal Ready (CD) = On Secondary Request (SCA) = Off	Terminal Ready (TR) = On
HW HNDSHK	CD On = Ready CD Off = Busy SCA On = Ready SCA Off = Busy	TR On = Ready TR Off = Busy

Echo Terminator, OFF:ECHO TERM

When set to OFF all data received by the printer is interpreted. When set to ECHO TERM the data echoed by the controller during the printer's response to an output command is ignored by the 7310A until it receives a line feed character.

Response Terminator, CR-LF:CR

When set to CR-LF the 7310A terminates all responses to the controller with a carriage return line feed. When set to CR the printer terminates its responses with a carriage return character only.

Set Parity, PRTY EVEN:ODD

When set to PRTY EVN the printer checks to see if data received contains even parity; the printer also generates even parity for its responses. When set to OFF, odd parity is checked and generated. This switch is ignored if the Parity On or Off switch is turned off.

Parity On or Off, PRTY OFF:ON

This switch turns parity checking and generation in the 7310A on or off. Parity is ignored when the 7310A character set selection (SI/SO:BIT 8) function switch is set to BIT 8. Parity is also ignored during the receipt of binary (graphics) data, regardless of the state of this switch.

Clock Frequency, INTERNAL:EXT CLK

The clock frequency switch determines how the baud rate is specified by the 7310A rear panel baud rate selection switch. When set to INTERNAL the rate is determined by the baud rate selection switch. When set to EXT CLK the baud rate is generated by an external clock hookup.

Output Trigger, DC1 ON:OFF

The output trigger applies to all response requests. When set to DC1 ON, the DC1 character triggers an output response from the 7310A whenever a command requesting status is received. When set to OFF the 7310A delays for 100 milliseconds after receiving a response request before it sends the response. The DC1 character is not needed to trigger a response when the output trigger switch is off.

Mechanical Compatibility

The 7310A printer connects to a controller by means of a cable. The cable must be mechanically compatible with the 7310A cable connector described here.

Connector, Interchange Circuits, and Cable Length for Option 050, RS-232-C/CCITT V.24

Option 050 contains a 25-pin female connector, with the interchange circuits (also called signal lines) described in table 2-1. The operational cable length maximum is 15 metres (50 feet).

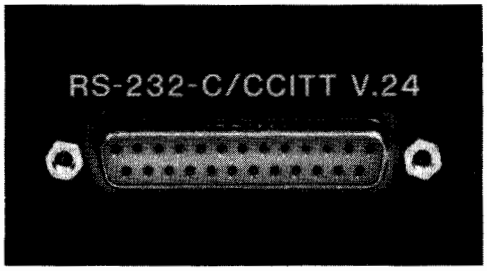


Figure 2-4. RS-232-C/CCITT V.24 Connector

Table 2-1. RS-232-C/CCITT V.24 Interchange Circuits

Circuit & Direction	CCITT Equivalent	Pin #	Description
AA	101	1	Protective Ground
BA →	103	2	Transmitted Data
BB ←	104	3	Received Data
CA →	105	4	Request to Send (always on)
AB	102	7	Signal Ground
←		17	External Clock 16x Baud Rate*
SCA →	120	19	Secondary Request to Send (normally off)
CD →	108.2	20	Data Terminal Ready (normally on)

→ = Output from the 7310A; ← = Input to the 7310A

*Maximum external clock frequency is 307,200 Hz (16 x 19,200) at 50% duty cycle. External clock line is TTL compatible.

Connector, Interchange Circuits, and Cable Length for Option 051, RS-423-A

Option 051 contains a 37-pin female connector, with interchange pin circuits described below. The operational cable length maximum is 60 metres (200 feet).

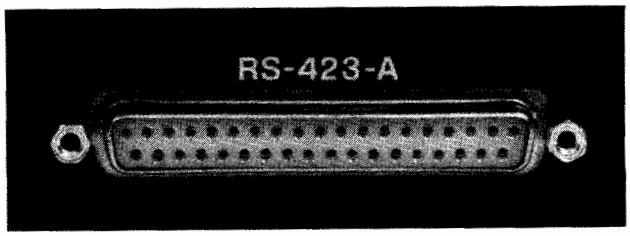


Figure 2-5. RS-423-A Connector

Table 2-2. RS-423-A Interchange Circuits

Circuit & Direction	Pin #	Description
	1	Shield
SD →	4	Send Data
SD RET →	22	Send Data Return (Ground)
RD ←	6	Receive Data
RD RET ←	24	Receive Data Return (Ground)
RS →	7	Request to Send (always on)
RS RET →	25	Request to Send Return (Ground)
RT ←	8	Receive Timing (External Clock 16 x Baud Rate)*
TR →	12	Terminal Ready (normally on)
TR RET →	30	Terminal Ready Return (Ground)
SG	19	Signal Ground (Common for Clock)
SC →	37	Send Common

→ = Output from the 7310A; ← = Input to the 7310A.

*Maximum external clock frequency is 307,200 Hz at 50% duty cycle. Ext. clock line is TTL compatible.

Electrical Compatibility

With both Options 050 and 051 data is passed from the controller to the 7310A printer over data lines using two voltage levels to represent the two possible states of a binary digit or bit,

1 or 0. The voltage levels must be compatible for the two devices. Voltage levels for the interchange circuits (tables 2-1 and 2-2) and their meanings are shown in table 2-3.

Table 2-3. RS-232-C/CCITT V.24 and RS-423-A Voltage Levels

RS-232-C/CCITT V.24 Interchange Voltage:	-5 to -15V	+5 to +15V
RS-423-A Interchange Voltage:	-4 to -6V	+4 to +6V
Data Circuits Binary State: Signal Condition:	1 Marking	0 Spacing
Control Circuits Function:	Off	On
The external clock line is a TTL compatible input. It represents one low power Schottky load. High Level = 2 to 5 V, Low Level = 0 to 0.7V.		

Data Compatibility

For purposes of data transfer there are two important data characteristics which must be considered for the controller and the peripheral to be compatible – the number of bits and the format of those bits in the data representation that is used in each device. The 7310A uses 8-bit ASCII code (as well as 8-bit binary data in raster transfer) which is formatted as discussed below.

Another aspect of data transfer involves the need some controllers have to know what is happening with the peripheral at any given point in time; these controllers request and interpret information about the peripheral's status.

Data Formatting

With the asynchronous transmission of the RS-232-C/CCITT V.24 and RS-423-A interfaces, the data bytes are not locked into system timing as they would be in synchronous transmission. Consequently the controller can send the data bytes to the printer with almost any spacing between them. To tell the beginning and end of a word, it is necessary to add some bit groupings called start and stop bits to the data.

Start and Stop Bits

Each byte of data that is transmitted over the data line must be preceded by a start bit in order for the printer to distinguish the start of data transfer from the normal marking (low) state of the idle line (table 2-1). The transition from the marking state to the spacing (high) state (start bit, logic 0) lets the printer know that a byte of data is being transmitted. Likewise a stop bit (logic 1) is needed to signal the end of a transmission. The stop element is maintained until the next data character is ready to be transmitted.

The 7310A requires two stop bits at 110 baud, one stop bit for all other rates.

Table 2-4. Asynchronous Mode Transmission Without Parity

start bit	8 data bits	stop bit(s)

Parity Selection

Because of the nature of serial I/O transmission, data on the line may be susceptible to "dropping bits," that is, having a bit sent as a 0 being received as a 1. In order to detect when this happens a scheme called parity checking may be used. The controller will supply an extra bit, that is not part of the data itself, to be sent with each character. This parity bit is set in such a way that the total number of bits (both data and parity) set to a 1 is always even or always odd.

When the 7310A rear panel interface switch is set to PRTY OFF, the 7310A interprets the data format as shown in table 2-4. When the parity selection switch is set to ON the printer interprets the data as shown in table 2-5. The choice of odd or even parity selection is left up to the operator who must communicate this choice to the 7310A by setting the PRTY EVEN/ODD interface switch. The printer will then check to see that each byte of data has an even or an odd number of 1's, and when it detects an error it will indicate this by setting a bit in a status byte. Status is discussed next.

Table 2-5. Asynchronous Mode Transmission With Parity

start bit	7 data bits	parity bit	stop bit(s)

Status

Certain escape sequence commands allow the controller to query the printer about its status at any particular time. Not all controllers are capable, however, of reading the printer's response, so status request commands are useful only in systems capable of accepting input from the printer. Ten milliseconds are required between consecutive status request commands. The response includes a parity bit if parity is selected.

Three rear panel interface switches work in conjunction with the status commands.

Output Trigger

When the output trigger switch is set to DC1 ON, all status commands sent by the controller must be followed by a **DC1** character to trigger the response from the 7310A. When the output trigger switch is set to OFF, the **DC1** character is not needed after the escape sequence. The OFF setting causes the 7310A to delay for 100 milliseconds after receiving the command before it responds.

Echo Terminator

The echo terminator switch setting depends upon the echo characteristics of the controller. Refer to the controller manual for information about the serial I/O port in order to determine the proper setting to use with your system.

In most cases, a controller without echo capability will require the switch to be set to OFF. When the echo terminator switch is set to OFF, all data received by the 7310A is interpreted as valid data (i.e. the controller is not echoing the printer's response to a status request back to the printer).

The switch should generally be set to ECHO TERM for a controller which echoes the printer's response back to the printer. This setting causes the 7310A to ignore the echoed information and to resume its normal response upon receipt of a line feed character.

Response Terminator

The response terminator switch is also related to the controller's echo capability. When the controller does not echo, the response terminator switch setting is irrelevant as far as the 7310A is concerned; the printer will respond according to the switch setting. Consult the controller's reference manual to determine if the response termination is of concern to the controller in this situation.

When the controller does have echo capability, the response terminator switch controls whether or not a response from the 7310A terminates with a carriage return line feed or only with a carriage return. When set to CR-LF, the 7310A terminates all responses to the controller with a carriage return line feed. This setting is used with controllers which echo without concatenating a line feed character at the end of the echo.

When set to CR, the printer terminates its responses with a carriage return character only. This is the appropriate response when the controller uses a line feed character to terminate the echo.

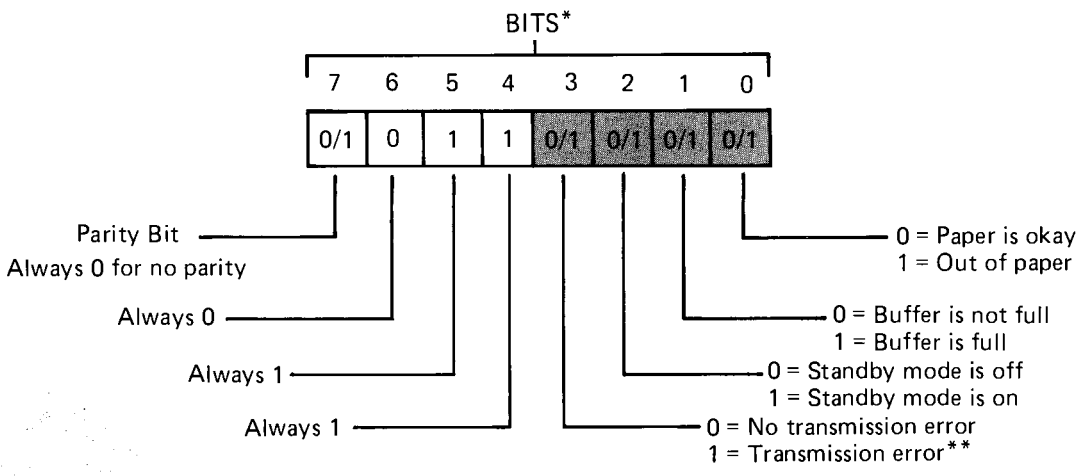
The Immediate Response Command, **ESC?**

The **ESC?** command may be used to demand an immediate response from the printer. This could be used, for example, when the 7310A fails to respond to the printer status request **ESC^**, or when the printer should be printing but is not.

The **ESC?** command preempts other data and commands which have been transmitted to the printer but not yet processed. The 7310A responds with one byte of information which reports four conditions: lost data due to a buffer overflow, standby mode status (controlled by the front panel standby switch), buffer status (i.e. the printer can accept data when the buffer is not full but cannot accept data when the buffer is full), and whether or not the printer is out of paper.

Table 2-6 diagrams the information bits contained in the byte which the 7310A returns in response to the **ESC?** command. The response is in the form of an ASCII character with a binary value shown in table 2-7. The four information bits of concern to the programmer are shaded in the table.

Table 2-6. Meaning of Response to **ESC?** Command



*Bit 3 is cleared by the ESC? command, ESCE command, or a hard reset.
Bit 0 is cleared by installing a roll of paper.

**Transmission errors include:

- A parity error which occurs when the expected parity (odd or even) is not detected by the 7310A.
- A framing error which occurs when a valid stop bit is not detected at the end of every character (indicating the controller and printer transmission rates need to be properly synchronized).
- A buffer overflow error which occurs when more bytes are received by the printer than the available input buffer space (use of a handshake protocol will prevent this error).

Table 2-7. Binary Responses to **ESC?** and **ESC^** Commands

ASCII Character	Equivalent Forms		
	Binary	Hex	Dec
0	00110000	30	48
1	00110001	31	49
2	00110010	32	50
3	00110011	33	51
4	00110100	34	52
5	00110101	35	53
6	00110110	36	54
7	00110111	37	55
8	00111000	38	56
9	00111001	39	57
:	00111010	3A	58
;	00111011	3B	59
<	00111100	3C	60
=	00111101	3D	61
>	00111110	3E	62
?	00111111	3F	63

The Printer Status Request Command, **ESC^**

The **ESC^** command requests the printer to return status information which it does with an escape sequence of the format:

ESC/(6 bytes)CR(LF)

The 6 bytes of data are comprised of the ASCII characters shown in table 2-7. Each of the 6 bytes contains four significant bits of information (shaded in table 2-7) which correspond from left to right with bits 3 to 0 in the bytes defined below.

Byte 0 (leftmost of the 6 bytes):

Bit 3: 0 = No secondary character set available
1 = Secondary character set available

Bit 2: 0 = Bit-8 character set selection protocol
1 = SI/SO character set selection protocol

Bit 1: 0 = No error, character set available
1 = Character set error

Bit 0: 0 = USASCII is primary character set
1 = USASCII is not the primary character set

Byte 1:

Bit 3: 0 = SI state active
1 = S0 state active

Bit 2: 0 = Underline enhancement not set
1 = Underline enhancement set

Bit 1: 0 = Reverse print enhancement not set
1 = Reverse print enhancement set

Bit 0: 0 = Bold face enhancement not set
1 = Bold face enhancement set

Byte 2:

Bits 3-0 = Truncated binary value of line spacing (lines/inch)

Byte 3:

Bit 3: 0 = Auto page on
1 = Auto page off

Bit 2: 0 = Eject on
1 = Eject off

Bit 1: 0 = US size paper
1 = A4 size paper

Bit 0: 0 = Default page size
1 = Page size other than default

Byte 4:

Bit 3: 0 = X-On/X-Off handshake off
1 = X-On/X-Off handshake on

Bit 2: 0 = Echo terminate off
1 = Echo terminate on

Bit 1: 0 = Enhancement reset at carriage return off
1 = Enhancement reset at carriage return on

Bit 0: 0 = USASCII fixed character spacing
1 = USASCII proportional character spacing

Byte 5:

Bit 3: 0 = No parser error
1 = Parser error

Bit 2: 0 = Paper supply is okay
1 = Out of paper

Bit 1: Always 0

Bit 0: 0 = No power up reset has occurred
1 = Power up reset has occurred since last status request. The **ESCE** command also resets the bit to zero.

Timing Compatibility

When using a serial interface, the characters of the message are transmitted in a "serial" fashion, one-by-one, and the bit patterns for each character are also sent serially, one bit after another along the single data line. This requires some rather sophisticated timing considerations. The speed of the controller and the printer must be exactly matched or the faster device will have to slow down and wait for the slower device to process the data in order to avoid data loss.

Baud Rate

The first timing factor to consider is that of matching the data transmission speeds of the devices. This is done by setting the baud, or transmission, rates of the controller and the printer to be equal. The baud rate is simply how many bits per second are going to be

transmitted, including any start and stop bits. The 7310A receives and transmits data at standard baud rates of 110, 150, 300, 1200, 2400, 4800, 9600, and 19,200 baud.

To set the rate, turn the baud rate selection dial on the printer's rear panel to the desired number. The dial is operative only when the 7310A rear panel clock frequency switch is set to INTERNAL.

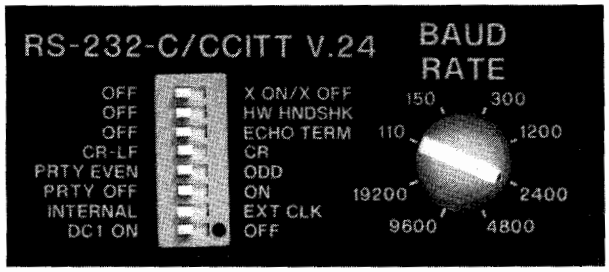


Figure 2-6. Baud Rate and Clock Frequency Switches

When using an external clock the clock rate is 16 times the desired baud rate with a maximum clock rate of 307,200 Hz (16 x 19,200) at 50% duty cycle. For example, if the desired rate is 600 baud, provide 16 x 600 or 9600 Hz external clock input to the external clock circuit (pin # 17 for RS-232-C/CCITT V.24, pin # 8 for RS-423-A).

Input Buffer

The 7310A uses an input buffer to synchronize the processing of data with the transmission rate. The buffer operates on a first in, first out basis, accepting data from the controller and holding it, if necessary, until the printer is free to process and print it. The buffer holds 112 bytes of data at a time.

In normal operation, all characters enter the 7310A input buffer except for null characters (ASCII 0), which are characters the controller sends to the printer as part of a synchronizing operation, and enquire characters (ASCII 5). When the printer is in display functions mode, however, all characters including null and enquire characters enter the buffer and are printed. There is a delay between the time display functions mode is turned on and the null and enquire characters begin to print because the command to turn on display functions must travel through the 112-byte buffer before it is executed. The null and enquire characters immediately following the command are not printed.

CAUTION

When operating under graphics soft handshake (discussed in the 7310A User's Manual), the binary data transfer commands **ESC*b ⟨number of bytes⟩V** and **ESC*b⟨number of bytes⟩W** are limited to 100 bytes of data rather than the normal 999. More than 100 bytes may cause a data overrun to occur in the input buffer. (This is not true with other handshakes.)

Handshake Protocol

To complete the timing synchronization it is necessary for the printer to communicate with the controller about the availability of buffer space for accepting more input data. It does so through a process called "handshaking." The 7310A printer with option 050 or 051 incorporates three types of handshaking protocol in order to be compatible with a large variety of controllers. One of the three, the enquire/acknowledge handshake mode, is always in effect; either of the other two may be selected as required. It is recommended that one of the two switch-selectable handshake modes (X-On/X-Off and Hardwire Handshake) always be used when the controller has the capability to do so.

Enquire/Acknowledge Handshake Mode

The enquire/acknowledge handshake mode is always in effect.

NOTE

Do not confuse the enquire/acknowledge handshake mode with the graphics soft handshake which is controlled by the 7310A rear panel function switch OFF:ENQ/ACK and which is discussed in the 7310A User's Manual.

When the controller is ready to send a message, it sends an enquire character, **ENQ** (ASCII 5), to the printer. In essence, this is a request to see if the printer has room in the buffer to accept more data. As soon as the printer has room for at least 100 bytes of data, it sends an acknowledge character, **ACK** (ASCII 6), back to the controller. The controller can then send up to 100 bytes. This enquire/acknowledge process is repeated each time the controller wants to send data to the printer.

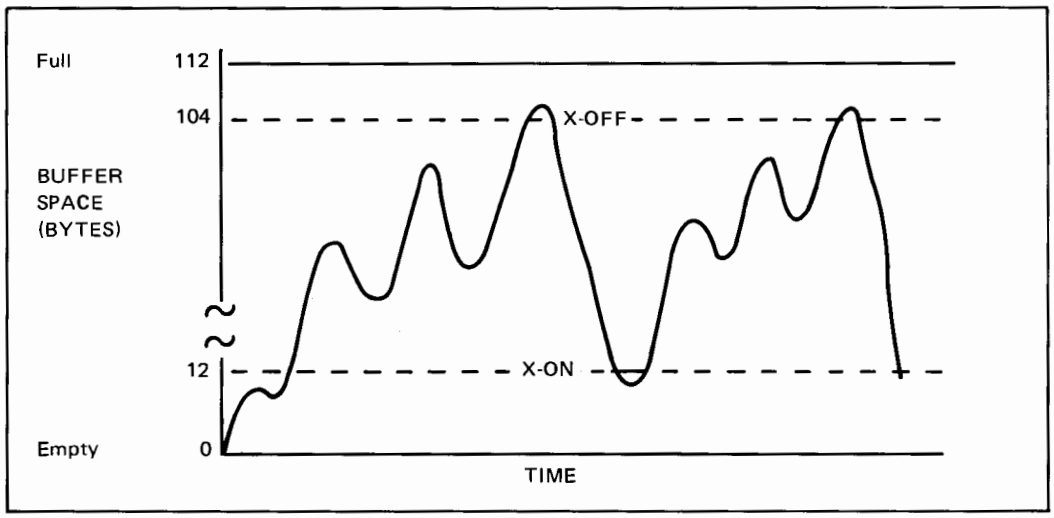
NOTE

When a controller does not have the ability to accept incoming data from a peripheral device, it must not send an enquire character to the printer because the printer will respond with an acknowledge character, possibly creating a problem for the controller.

X-On/X-Off Handshake Mode

The 7310A rear panel interface switch OFF:X ON/X OFF selects the X-On/X-Off handshake mode. When the printer has a minimum of 100 bytes of input buffer room available it sends an X-On character (represented by a **DC1** character, ASCII 17) to the controller. The controller can then send data to the printer as long as the 7310A input buffer contains room. When the input buffer has only 8 bytes of room remaining the printer sends an X-Off character (represented by a **DC3** character, ASCII 19) to the controller. The following buffer space diagram illustrates how the buffer fills and empties.

Table 2-8. Buffer Control Using The X-On/X-Off Handshake Mode



CAUTION

If the controller continues to transmit data after receiving an X-Off character the 7310A will send another X-Off character after each byte of data it receives as long as the buffer contains 8 or less empty bytes of space. The receipt of multiple X-Off characters may cause an error in some controllers.

Hardwire Handshake Mode

The 7310A rear panel interface switch OFF:HW HNDSHK, when set to HW HNDSHK, selects the hardwire handshake mode (sometimes called "hardware" handshake).

When the hardwire handshaking protocol is enabled, the printer temporarily stops data transmission from the controller by signaling a "busy" condition when the input buffer contains only 8 empty spaces. For RS-232-C/CCITT V.24 the busy condition is signaled by setting the Data Terminal Ready (CD) and Secondary Request to Send (SCR) lines off (low). (For RS-423-A the Terminal Ready line is set off.) The lines remain off until there is room for 100 more bytes, then they are set high where they remain until the buffer is filled again to within 8 bytes of capacity.

If a busy condition is signalled during the transmission of a character, the entire character will be completed before transmission is interrupted.

When the hardwire handshake mode is not enabled, with RS-232-C/CCITT V.24 the Data Terminal Ready (CD) line is always on and the Secondary Request to Send (SCR) line is always off. (For RS-423-A the Terminal Ready Line is on.)

The Standby Button

The 7310A front panel contains an additional button for the RS-232-C/CCITT V.24 and RS-423-A interface options 050 and 051. This "standby" button acts as a printer interrupt switch. Pushing the button puts the printer in a standby mode during which printing stops and the 7310A immediately signals the controller, via the selected handshake method, that it will not accept any more data at this time.

Pushing the button again disables the standby mode, causing processing to resume. As soon as the buffer empties to the appropriate level the handshake protocol indicates to the controller that the printer is ready for more data.

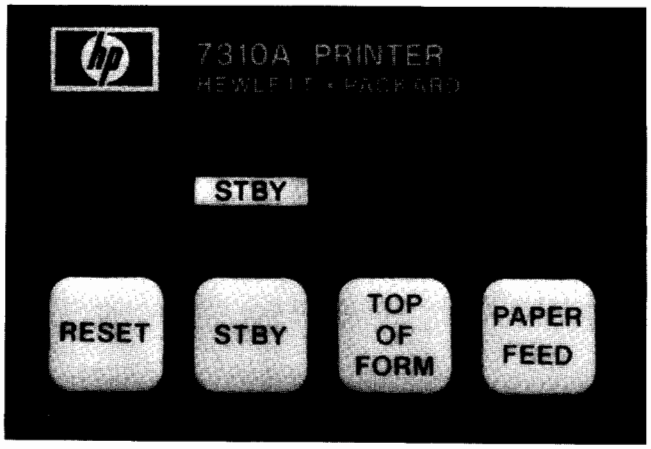


Figure 2-7. 7310A Standby Button

Chapter 3

Option 052: 8-Bit Duplex, and Option 240: Printer Subsystem

Introduction

Options 052 and 240 for the 7310A Graphics Printer provide a general purpose 8-bit duplex interface operating in a bit parallel, byte serial, asynchronous data transfer mode. These interfaces provide compatibility with HP 2640-series terminals using the 8-bit duplex register interface and with HP 21XX and other controllers following the 2-wire or 4-wire handshake protocol defined in this chapter.

Option 052 Description

Option 052 (figure 3-1) includes the 8-bit duplex interface in the 7310A Graphics Printer, and one external cable connector and hood.

Option 240 Description

Option 240 (figure 3-2) is a printer subsystem for use with HP 2640-series terminals having dual tape cartridges or device control firmware installed. Option 240 includes the 8-bit duplex interface in the 7310A Graphics Printer, a Hewlett-Packard 13232J printer cable, and a Hewlett-Packard 13238A duplex register module interface (part number 02640-60031) for the terminal.

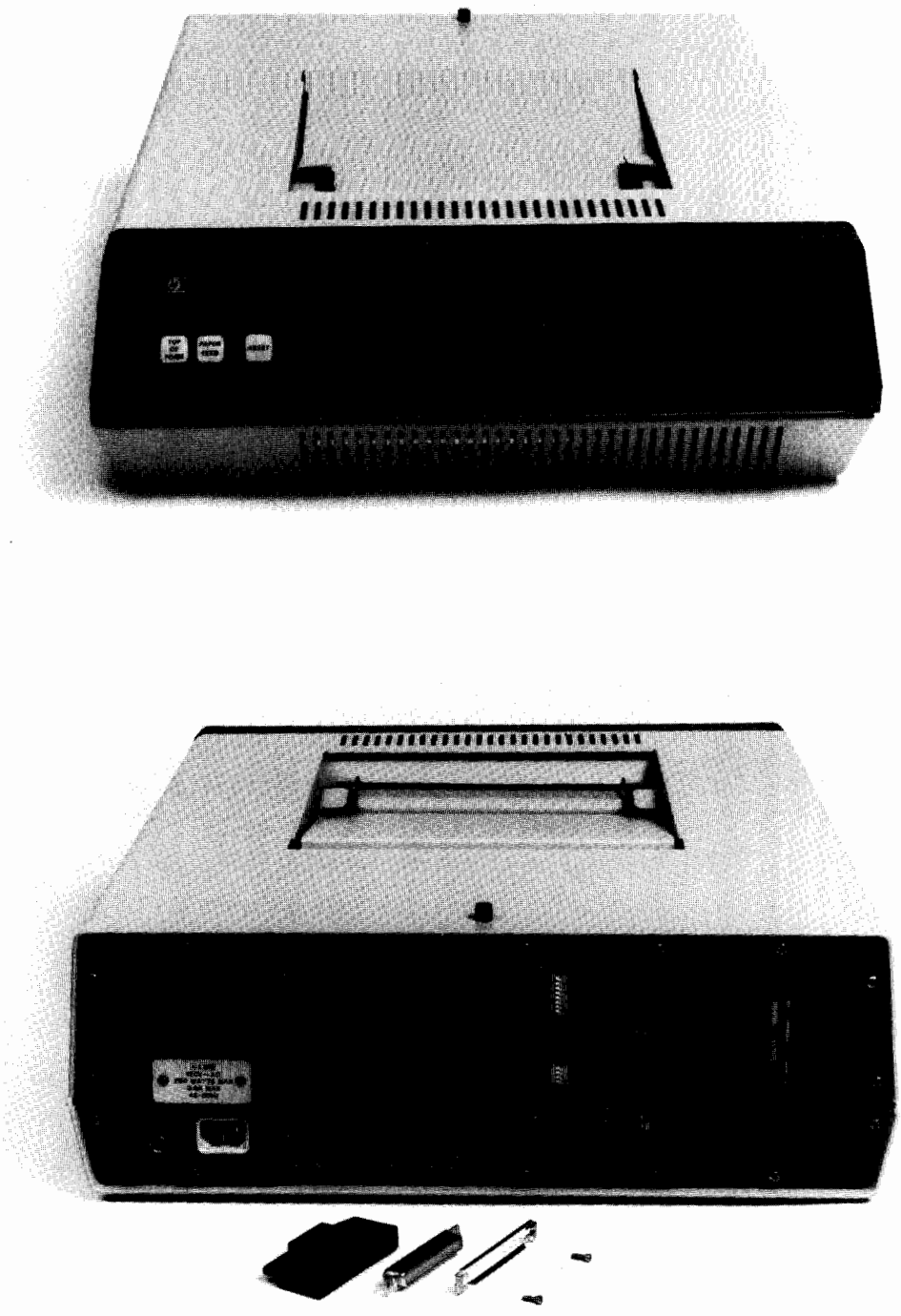


Figure 3-1. 7310A Graphics Printer With Option 052

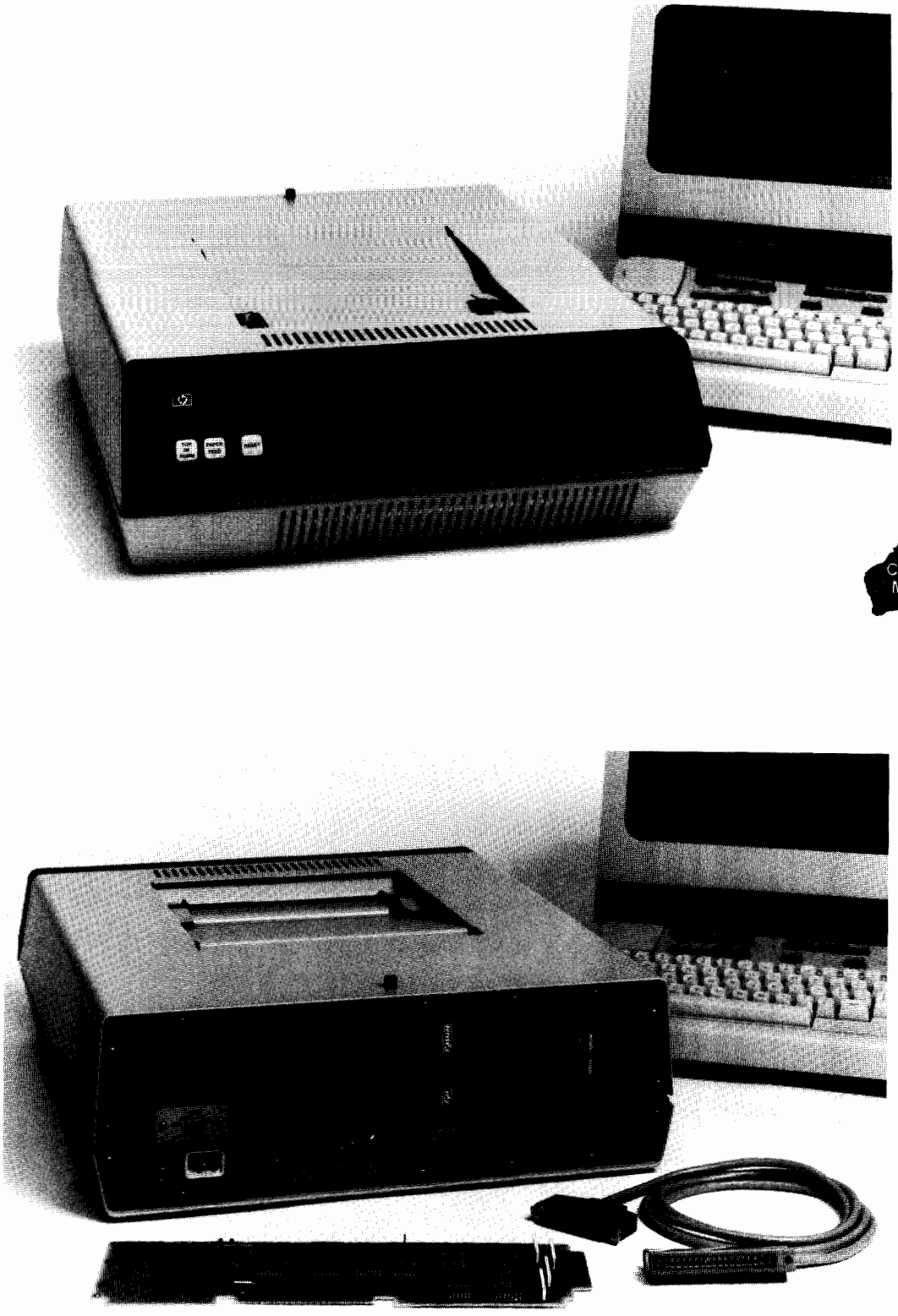


Figure 3-2. 7310A Graphics Printer With Option 240

Rear Panel Interface Switches

The 7310A rear panel interface switches for Options 052 and 240 are factory set to the left, at settings 4 WIRE, CTL NEG, FLAG NEG, and CR-LF.

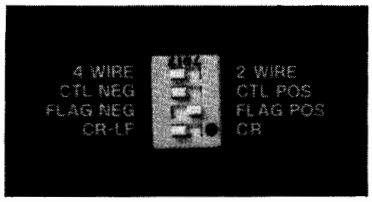


Figure 3-3. 8-Bit Duplex Interface Switches

Handshake Control Lines, 4 WIRE:2 WIRE

The handshake control lines are used to synchronize data transfer between the controller and the printer. When set to 4 WIRE, four lines (two control lines and two flag lines) are used. When set to 2 WIRE, one control line, one flag line, and an optional I/O direction indicator line are available for data transfer.

Control Line Logic, CTL NEG:CTL POS

This switch sets the handshake control lines for negative or positive true logic. CTL NEG sets logic to low level true. CTL POS sets the logic to high level true.

Flag Line Logic, FLAG NEG:FLAG POS

This switch sets the handshake flag lines for negative or positive true logic. FLAG NEG sets the logic to low level true. FLAG POS sets the logic to high level true.

Response Terminator, CR-LF:CR

This switch enables the 7310A printer to correspond to the response protocol of the controller or terminal with which it is used. When set to CR-LF the 7310A terminates all responses except the acknowledge response (ACK) with a carriage return followed by a line feed. When set to CR it terminates responses with only a carriage return.

Mechanical Compatibility

The 7310A printer connects to a controller by means of a cable whose connection must be mechanically compatible with the 7310A interface described here. The external cable

connector and hood provided with the Option 052 interface are to be attached to the printer end of the system interface cable. The Option 240 printer subsystem includes a cable with connectors at both the terminal end and the printer end.

Connector, Interchange Circuits, and Cable Length for 8-Bit Duplex Interface

The 8-bit duplex interface contains a 37-pin male connector, with the pin interchange circuits (also called signal lines) described below. The operational cable length maximum is 10 metres (30 feet). The interface provides a data signal rate of 16K bytes/second at 10 metres.

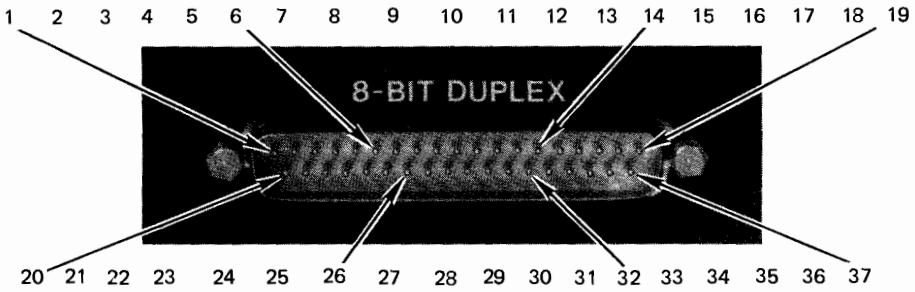


Figure 3-4. 8-Bit Duplex Connector

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Table 3-1. 8-Bit Duplex Interchange Circuits

Circuit*	Direction	Pin #	Description
$\overline{\text{CTL 1}}$	←	9	Control line for input data on 4-wire handshake; for both input and output data on 2-wire handshake. With negative logic the line is normally high; it goes low when the controller has data to transfer.
$\overline{\text{CTL 2}}$	←	1	Control line for output data on 4-wire handshake. With negative logic the line is normally high; it goes low when the controller is ready to read data.
$\overline{\text{FLG 1}}$	→	11	Flag line for input data on 4-wire handshake; for both input and output data on 2-wire handshake. With negative logic the line is normally low; it goes high during the handshake process.
$\overline{\text{FLG 2}}$	→	3	Flag line for output data on 4-wire handshake. With negative logic the line is normally low (ready to transfer); it goes high (indicating not ready to transfer) during the handshake process.

Table 3-1. 8-Bit Duplex Interchange Circuits (Continued)

Circuit*	Direction	Pin #	Description
$\overline{\text{RESET}}$	←	5	Normally set high, when pulled low this line causes a hard reset but it does not set bit 0 of byte 5 in the printer status request. This line must be asserted for at least 100 μs for the printer to respond.
$\overline{\text{Input}}$/Output	←	7	Indicates direction of data flow for 2-wire handshake. When used, low indicates data is from the controller to the printer; high indicates the controller expects to read data from the printer. When not used, the line stays high. Note: The I/O line only prevents data from being output. If left unconnected, input data will still be accepted; when the controller requests a response from the printer, the controller must read that response before sending more data.
$\overline{\text{DI 0}}$	←	28	Data input lines. Least significant bit = $\overline{\text{DI 0}}$.
$\overline{\text{DI 1}}$	←	29	
$\overline{\text{DI 2}}$	←	30	
$\overline{\text{DI 3}}$	←	31	
$\overline{\text{DI 4}}$	←	32	
$\overline{\text{DI 5}}$	←	14	
$\overline{\text{DI 6}}$	←	13	
$\overline{\text{DI 7}}$	←	12	
$\overline{\text{DO 0}}$	→	15	Data output lines. Least significant bit = $\overline{\text{DO 0}}$.
$\overline{\text{DO 1}}$	→	16	
$\overline{\text{DO 2}}$	→	17	
$\overline{\text{DO 3}}$	→	18	
$\overline{\text{DO 4}}$	→	19	
$\overline{\text{DO 5}}$	→	20	
$\overline{\text{DO 6}}$	→	21	
$\overline{\text{DO 7}}$	→	22	

Table 3-1. 8-Bit Duplex Interchange Circuits (Continued)

Circuit*	Direction	Pin #	Description
$\overline{\text{PWR UP RSET}}$	→	23	The line goes low when a front panel hard reset or power-up reset has occurred since the last time the printer responded to a printer status request command **ESC^**, or received a reset command **ESCE**. The line returns high just before the printer sends the carriage return character after receiving the **ESC^** command, or upon receipt of a reset command, **ESCE**.
$\overline{\text{OUT OF PAPR}}$	→	24	The line goes low when an out-of-paper condition is encountered and the 7310A has cleared the remaining paper from the printer. The line returns high when paper is loaded in the printer.
SHIELD		25	Case ground.
COMMON		26	Signal ground.
COMMON		27	Signal ground.

→ = Output from the 7310A; ← = Input to the 7310A.

*All circuits use negative true logic (indicated with a bar above the circuit name) except FLG 1, FLG 2, CTL 1, and CTL 2, which are controlled by the interface switches.

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Installing The Option 240 Printer Subsystem

Installation of the terminal duplex register module accompanying Option 240 should be performed according to installation instructions in the reference manual for your terminal. Jumpers C and F on the terminal duplex register PCA must be installed (figure 3-5), and the terminal's keyboard interface PCA must have jumper N installed. Set the rear panel interface switches to the factory settings 4 WIRE, CTL NEG, FLAG NEG, and CR-LF, (figure 3-3).

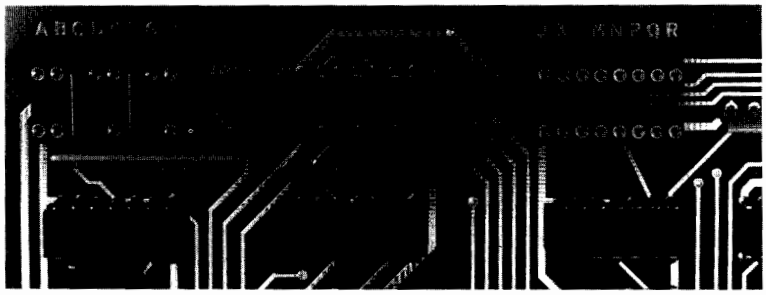


Figure 3-5. Terminal 8-Bit Duplex Register Settings for General Use

Using the 7310A In An HP 9871 Configuration

When the 7310A is to be configured to replace the Hewlett-Packard 9871A printer in an existing installation, set the rear panel interface switches to 4 WIRE, CTL NEG, FLAG POS, and CR-LF (figure 3-6).

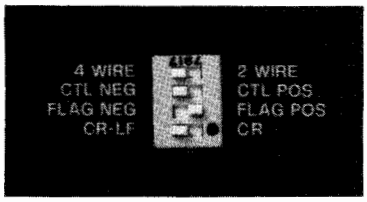


Figure 3-6. 7310A Interface Switches for 9871 Configuration

Electrical Compatibility

Voltage Levels and Logic Conventions

Because the interface is implemented in terms of high and low voltage levels and the controller deals with bits (ones and zeros), there are two ways of assigning a correspondence between them. We can assign either high = 1 and low = 0, or high = 0 and low = 1. Both methods are in common use and the choice of one or the other is usually determined by other design considerations within the controller. These two conventions have been given the names positive-true logic and negative-true logic.

Table 3-2. Logic Conventions

Positive-True Logic:	High = True = 1
	Low = False = 0
Negative-True Logic:	High = False = 0
	Low = True = 1

Circuits using negative-true logic are indicated with a bar above the circuit name, as can be seen in table 3-1.

All output drivers are 7404 with open-collector outputs and an external 1 kilohm pull-up resistor.

All input buffers are 74LS241 with P-N-P Schmitt-trigger inputs and an external 1 kilohm pull-up resistor.

NOTE

Inputs and outputs are TTL compatible and are not protected against voltages greater than 5.5 volts or less than 0 volts.

Data Compatibility

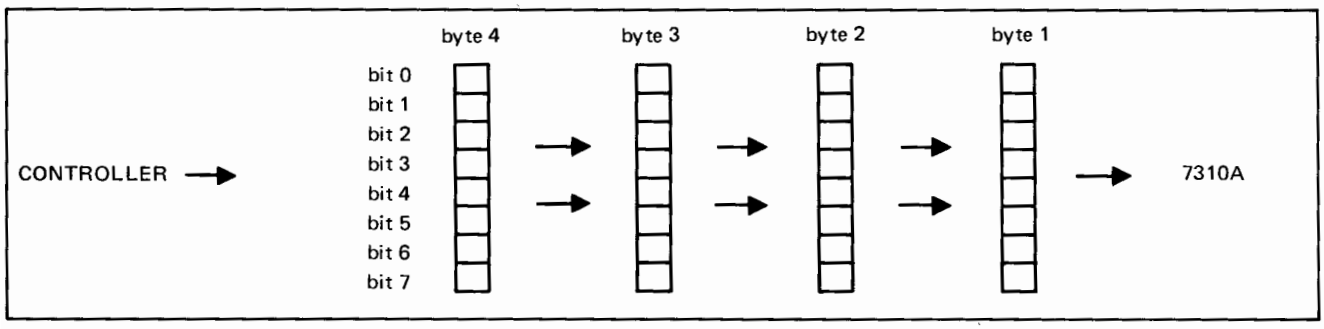
For purposes of data transfer there are two important characteristics which must be considered for the controller and the peripheral to be compatible — the number of bits, and the format of those bits in the data representation that is used in each device. These are discussed below under Data Formatting.

Another aspect of data transfer involves the need some controllers have to know what is happening with the peripheral at any given point in time; these controllers request and interpret information about the peripheral's status.

Data Formatting

The 7310A uses 8-bit ASCII code (as well as 8-bit binary data in raster transfer). With the 8-bit duplex interface the format of the data is byte-serial, bit parallel, meaning all 8 bits of a byte are transmitted at one time (on the 8 data input lines) but each byte is transmitted one at a time.

Table 3-3. 8-Bit Duplex Data Format



Status

Certain escape sequence commands allow the controller to query the printer about its status at any particular time. Not all controllers are capable, however, of reading the printer's response, so status request commands are useful only in systems capable of accepting input from the printer. One of the rear panel interface switches, the response terminator, works in conjunction with the status command.

Response Terminator

The response terminator switch controls whether or not a response from the 7310A to the controller terminates with a carriage return line feed or only with a carriage return. When set to CR-LF, the 7310A terminates each response with a carriage return character followed by a line feed character. When set to CR, the printer terminates each response with only a carriage return character. The correct setting depends upon the requirements of the controller.

The Printer Status Request Command, **ESC^**

The **ESC^** command requests the printer to return status information which it does, after receiving the DC1 (ASCII 17) trigger, with an escape sequence of the format:

ESC\(6 bytes)CR(LF)

The 6 bytes of data are comprised of the ASCII characters shown in table 3-4.

Table 3-4. Binary Responses to **ESC^** Command

ASCII Character	Equivalent Forms		
	Binary	Hex	Dec
0	00110000	30	48
1	00110001	31	49
2	00110010	32	50
3	00110011	33	51
4	00110100	34	52
5	00110101	35	53
6	00110110	36	54
7	00110111	37	55
8	00111000	38	56
9	00111001	39	57
:	00111010	3A	58
;	00111011	3B	59
<	00111100	3C	60
=	00111101	3D	61
>	00111110	3E	62
?	00111111	3F	63

Each of the 6 bytes contains four significant bits of information (shaded in table 3-4) which correspond from left to right with bits 3 to 0 in the bytes defined below.

Byte 0 (leftmost of the 6 bytes):

Bit 3: 0 = No secondary character set available
1 = Secondary character set available

Bit 2: 0 = Bit-8 character set selection protocol
1 = SI/SO character set selection protocol

Bit 1: 0 = No error, character set available
1 = Character set error

Bit 0: 0 = USASCII is primary character set
1 = USASCII is not the primary character set

Byte 1:

Bit 3: 0 = SI state active
1 = SO state active

Bit 2: 0 = Underline enhancement not set
1 = Underline enhancement set

Bit 1: 0 = Reverse print enhancement not set
1 = Reverse print enhancement set

Bit 0: 0 = Bold face enhancement not set
1 = Bold face enhancement set

Byte 2:

Bits 3-0 = Truncated binary value of line spacing (lines/inch)

Byte 3:

Bit 3: 0 = Auto page on
1 = Auto page off

Bit 2: 0 = Eject on
1 = Eject off

Bit 1: 0 = US size paper
1 = A4 size paper

Bit 0: 0 = Default page size
1 = Page size other than default

Byte 4:

Bit 3-2 = Always 0

Bit 1: 0 = Enhancement reset at carriage return off
1 = Enhancement reset at carriage return on

Bit 0: 0 = USASCII fixed character spacing
1 = USASCII proportional character spacing

Byte 5:

Bit 3: 0 = No error
1 = Syntax error*

Bit 2: 0 = Paper supply is okay
1 = Out of paper

Bit 1: Always 0

Bit 0: 0 = No power up reset has occurred
1 = Power up reset has occurred since last status request. The **ESCE** command also resets the bit to zero.

*A syntax error generally occurs when there is an error in an escape sequence command sent by the controller.

Timing Compatibility

The main difficulty in sending and receiving sequences of characters is one of timing. If the speed of the controller and its peripheral are not exactly matched, the faster device will somehow have to slow down the pace of its I/O operations so that it will not get ahead of the slower device. This is accomplished through "handshake" methods.

Handshake Protocol

The 7310A printer with Option 052 or 240 incorporates three types of handshake in order to be compatible with a variety of controllers. One of these, the enquire/acknowledge handshake mode, is always in effect; one of the other two must be selected by the rear panel handshake control line switch, 4 WIRE:2 WIRE.

Enquire/Acknowledge Handshake Mode

The enquire/acknowledge handshake mode is always in effect. Do not confuse this handshake mode with the graphics soft handshake which is controlled by the 7310A rear panel function switch OFF:ENQ/ACK and discussed in the 7310A User's Manual.

When the controller is ready to send a line of data, it sends an enquire character, **ENQ** (ASCII 5), to the printer. In essence, this is a request to see if the printer is ready to accept the full line. When the printer has sufficient space it sends an acknowledge character, **ACK** (ASCII 6), back to the controller. This enquire/acknowledge process can be repeated each time the controller wants to send a line of data to the printer.

NOTE

When a controller does not have the ability to accept incoming data from a peripheral device, it must not send an enquire character to the printer because the printer will respond with an acknowledge character, possibly creating a problem for the controller.

Two-Wire Handshake Mode

The two-wire handshake mode uses a single control and flag line pair, CTL 1 and FLG 1, to synchronize data flow, with the optional I/O direction line indicating whether the 7310A is expected to receive or transmit data. The two-wire handshake mode is selected by setting the handshake control line interface switch on the 7310A rear panel to 2 WIRE.

Four-Wire Handshake Mode

The four-wire handshake mode uses two control and two flag lines to synchronize data flow. One set, CTL 1 and FLG 1, is dedicated to input data. The second set, CTL 2 and FLG 2, is dedicated to output data. The four-wire handshake mode is selected by setting the handshake control line interface switch to 4 WIRE.

Timing Diagrams

The handshake process discussed above involves several lines changing their states in a definite time sequence. The exact relationship of these lines during the sequence of events is shown in the timing diagrams which follow.

Time proceeds along the horizontal axis from left to right, and the states (high/low) of the lines of interest are shown one above another. A vertical line drawn through the diagram represents the same instant in time for all of the lines. The time points may be indefinite, such as **t0** which shows the state of the signal lines at some point before the handshake begins, or they may be definite such as **t1** on the Input Data diagram (table 3-5) which shows the point at which the data on the lines begins to change. When the interval between two time points is fixed by some requirement of the system, the time interval is specified

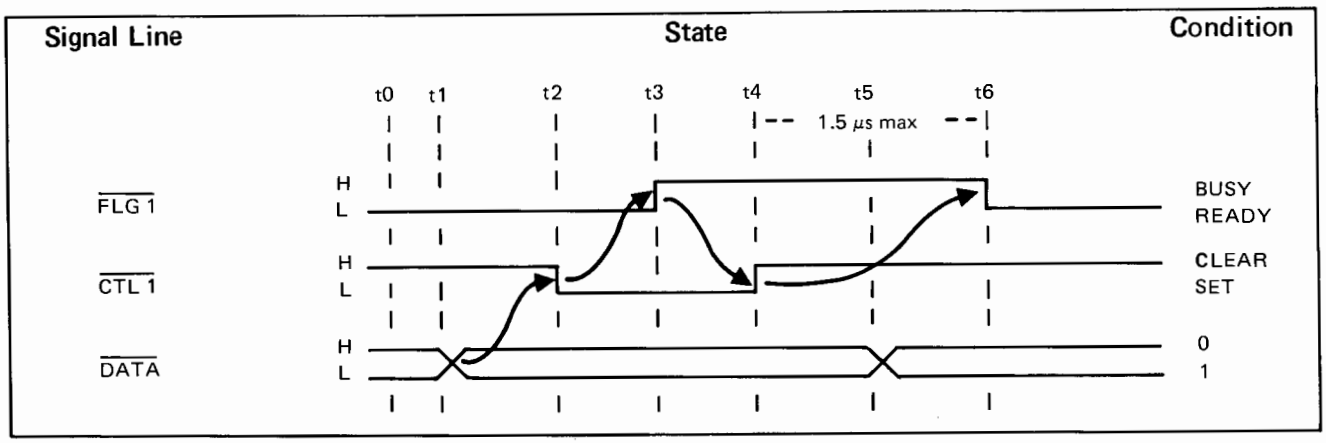
(see **t3** and **t4** in the Output Data diagrams, tables 3-6 and 3-7). When not specified, there is no restriction on the time that may elapse between two events.

The states of the CTL and FLG lines are definite (high or low) within each time interval. The handshake timing diagram cannot, however, show the data lines as being either high or low during a given interval since the state of these lines depends on the data that is being exchanged. In this case, the two parallel lines in the diagrams simply represent a stable state on the data lines that may be either high or low, while the crossover represents the time during which data on these lines is in a state of transition.

NOTE

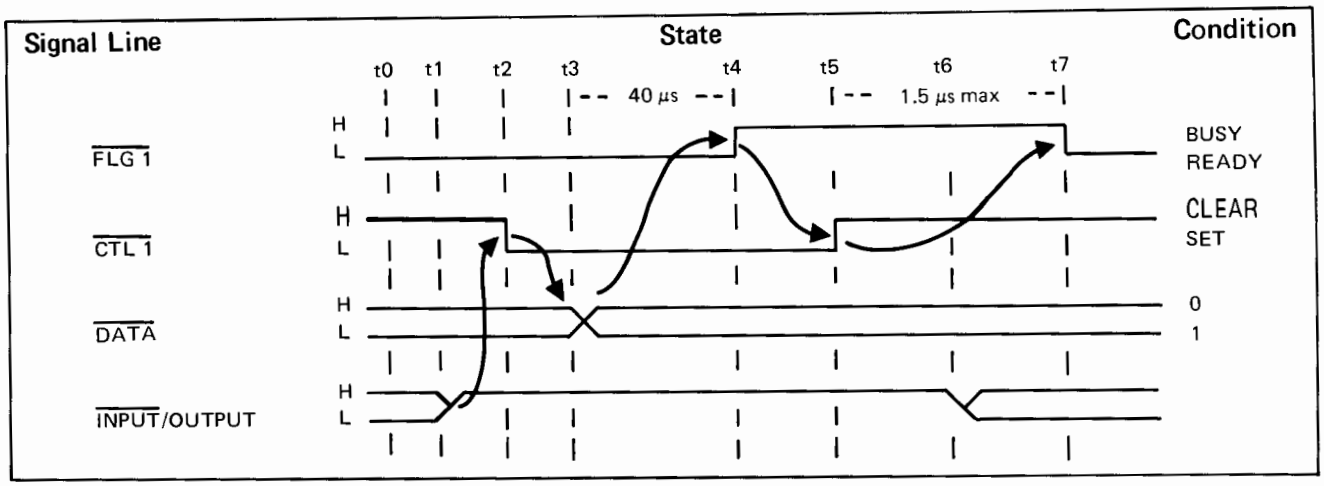
The 7310A will indicate ready at **t0** even though it may not be, as would be the case if it were out of paper.

Table 3-5. Input Data 2-Wire and 4-Wire Handshake Protocol (FLG and CTL assumed negative true)



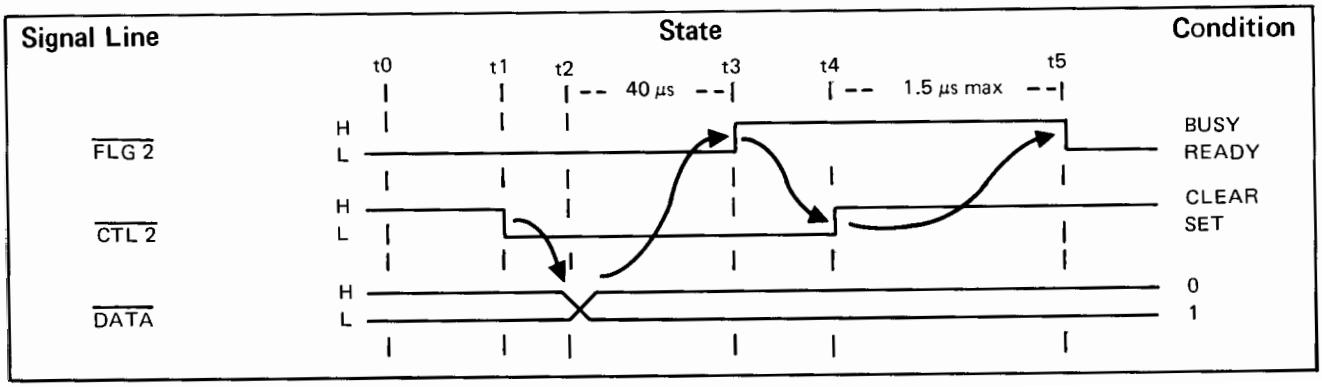
The Input Data diagram shows that at some time **t0** before a data transfer begins, the FLG 1 line is ready (low), the CTL 1 line is in its normal clear state (high), and the data lines are stable, still containing the last character received. At time **t1** the data lines receive new data. The controller sets CTL 1 low at **t2** to inform the printer that the data is valid and available on the data lines. The 7310A accepts the data and responds at **t3** by setting FLG 1 high. This is the busy state and indicates that the printer has read the data. When the controller sees FLG 1 high it clears the CTL 1 line at **t4**. Depending on the controller, the data may remain valid or become invalid (**t5**). At **t6**, within 1.5 μs of **t4**, the printer sets the FLG 1 line back to the ready condition, indicating it's ready to accept more data. All lines are back to the same state they were in at **t0** and are ready to repeat the entire handshake cycle for the next data transfer.

Table 3-6. Output Data 2-Wire Handshake Protocol



The Output Data diagram shows that at some time **t0** before a data transmission begins, the FLG 1 line is ready (low), the CTL 1 line is in its normal clear state, the data lines are stable, and the I/O line, if used, can be either high or low depending on the direction of the last data transmission. At **t1** the I/O line goes high indicating the flow of data is from the printer to the controller. At **t2** the controller sets CTL 1 low, indicating it is ready to receive the data. The printer outputs the data to the data lines which become valid at **t3**. The data has 40 µs to settle; at **t4** the printer sets FLG 1 to the busy state indicating to the controller that the data is on the data lines and is valid. The controller reads the data and releases control at **t5** indicating it is through with the data. At **t6** the I/O line (if used) may or may not change from high to low to indicate the direction flow of the following data. At **t7** the printer sets FLG 1 ready again, within 1.5 µs of **t5**, returning to the same state as **t0**.

Table 3-7. Output Data 4-Wire Handshake Protocol



The Output Data diagram for the 4-wire handshake is similar to the one for the 2-wire handshake with two exceptions; the flag and control lines are FLG 2 and CTL 2 rather than FLG 1 and CTL 1, and the I/O line is always high so is not shown. At time t**0** before a data transmission begins, the FLG 2 line is ready (low), the CTL 2 line is in its normal clear state (high), and the data lines are stable but not valid. At t**1** the controller indicates it is ready to receive data by setting CTL 2 low. The printer outputs the data to the data lines at t**2**. The data has 40 μs to settle down before the printer sets FLG 1 to the busy state at **t3**, indicating to the controller that the data is on the data lines and is valid. The controller reads the data and releases control at **t4** indicating it is through with the data. At **t5**, within 1.5 μs the printer sets FLG 2 ready, returning once again to the ready state of **t0**.

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