Honeywell

SERIES 60 LEVEL 6

TYPE PRM9101
PRINTER ADAPTER MANUAL

Doc. No. 71010221-300 Order No. FL18, Rev. 2

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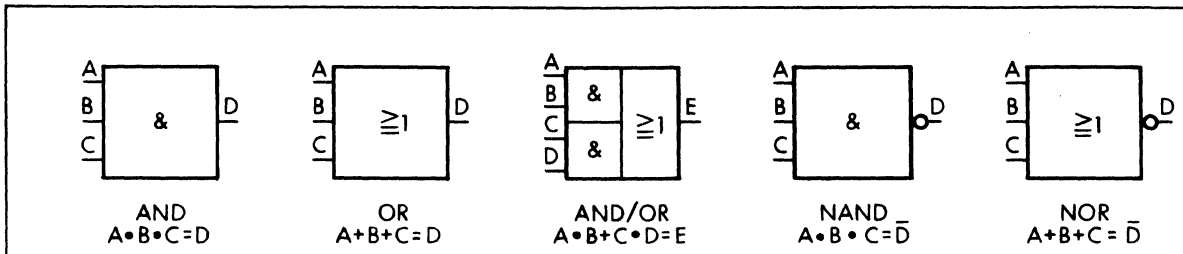

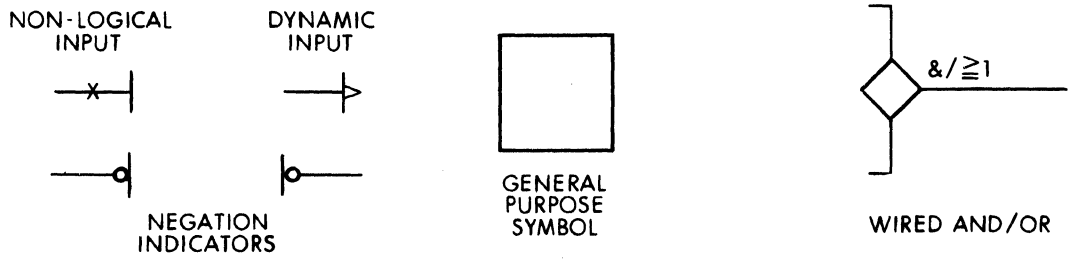

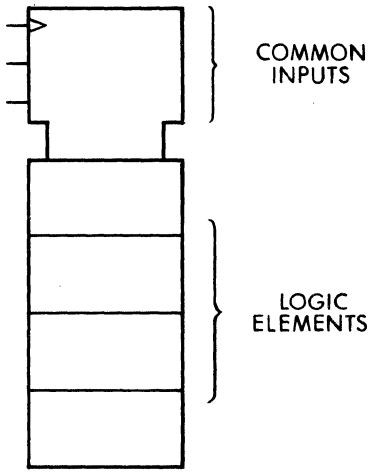

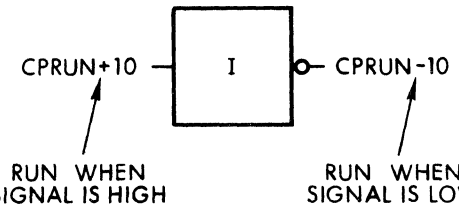

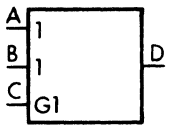

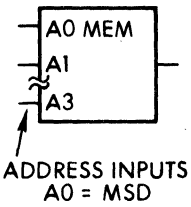

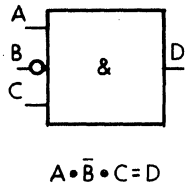

USE OF NEGATION INDICATOR

1 INTRODUCTION

1.1 SCOPE OF THIS MANUAL

This manual describes the Model PRM9101 Printer Adapter and printers that form the printer attachment for the Model 6/34, 6/36 and 6/43 configurations of the Series 60 Level 6 computer line. The printer attachment consists of a multiple device controller (MDC), a printer adapter, a serial or line printer, and associated cables. The MDC, a microprogrammed peripheral device controller attached to the Series 60 Level6 Megabus* network, can support up to four low- to medium-speed peripheral devices via a configurable series of adapters. Each device is attached to the MDC through a device adapter which contains all hardware unique to the particular device. Adapters and device-specific firmware resident within the MDC control dialogue between the device and the central processor. Firmware (Rev. 2.0) interprets the various instructions issued by the central processor unit program and causes defined results to occur.

Figure 1-1 illustrates the relationship of printer attachment components to the system.

1.2 PRINTER ADAPTER DESCRIPTION

The printer adapter logic board (BD2PTR) functionally contains a collection of logic functions that control data flow and signals between the MDC and printer. The adapter consists of four logically integrated elements (Figure 1-2) that perform specific functions:

- Control Logic - Controls the loading of data into the data buffer and execution of firmware commands

*Trademark of Honeywell Information Systems Inc.

- Data Buffer - Stores each data byte for proper synchronization of signals to the printer
- Line Driver - Sends and controls the pulse shape of data to the printer
- Input Multiplexer - Selects various status information and data for firmware examination.

Line printing is initiated by issuing a I/O instruction that specifies the starting byte address of the first data record in main memory to be printed and the number of data records to be printed. The MDC takes the address of the data off the bus; firmware loads the contents of that address into the data buffer; the adapter converts each byte to a printable character. Control logic decodes firmware commands for loading the data buffer and strobes the printer until the specified number (range) of characters has been printed. The input multiplexer provides a means for firmware to examine various conditions within the adapter and printer.

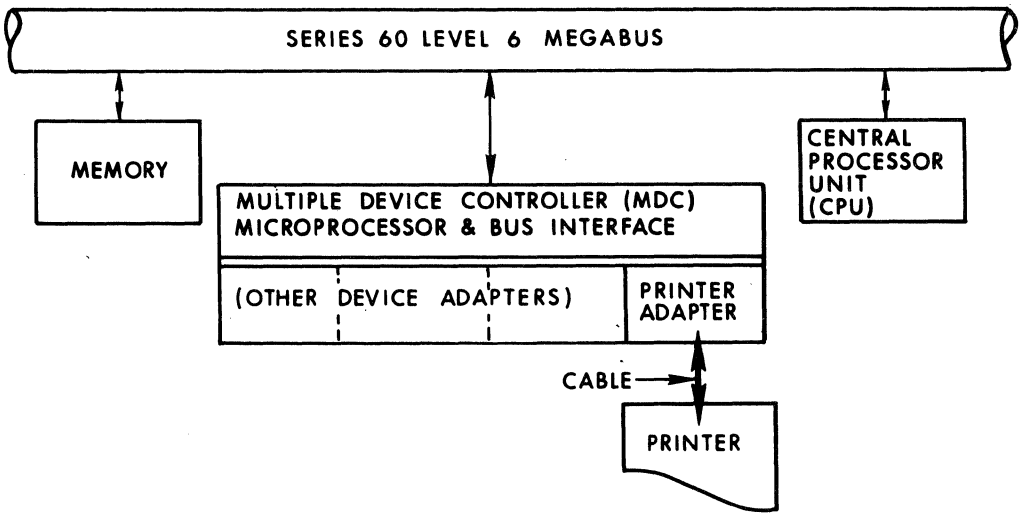

Figure 1-1 MDC, Printer Adapter, and Printer Interface

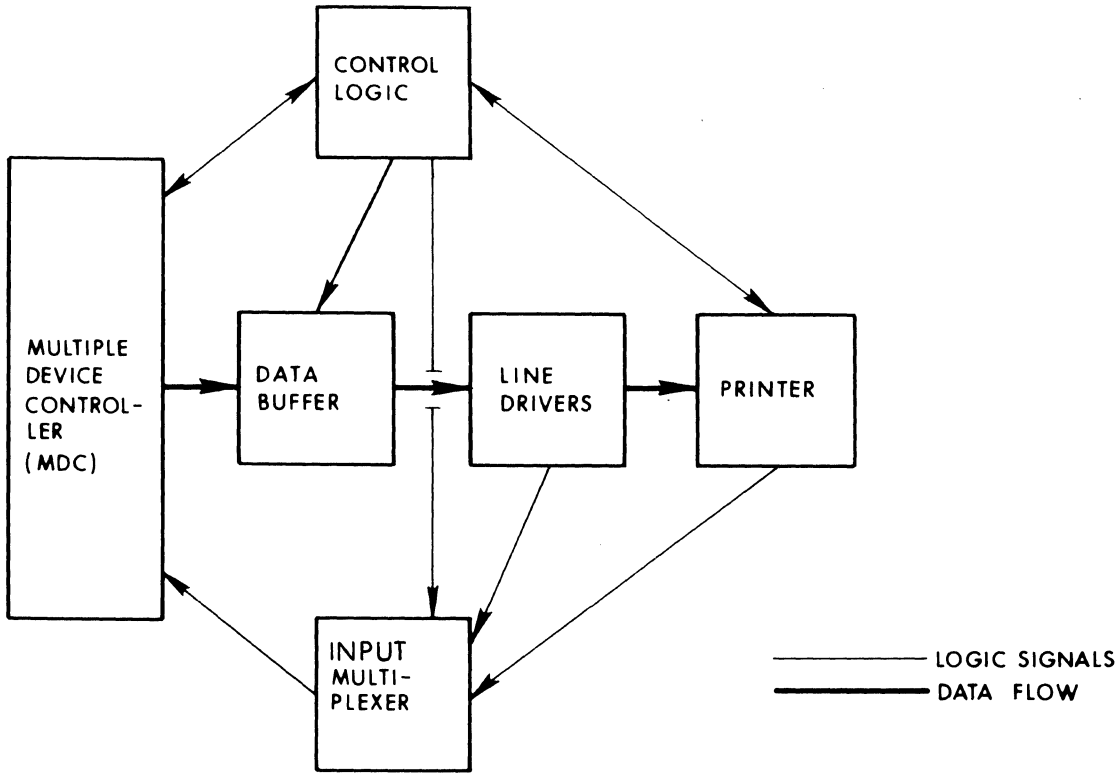

Figure 1-2 Data Flow Through Printer Adapter

1.3 PRINTER ADAPTER FUNCTIONS

In programming the printer adapter, software builds a data buffer in main memory capable of storing up to 136 characters to be printed, depending on the device. I/O commands are then issued to specify both the type of operation to be performed and the range and address of the data buffer. Interface signals between the printer adapter and the printer determine the readiness of the device and provide for the transfer of information from the buffer to the printer. The printer adapter can be set to interrupt after each line is printed, or it can be programmed in the noninterrupt mode.

1.3.1 Data Handling

The size of the data buffer in main memory is expressed in bytes and should be less than or equal to one print line. Each byte contains one character. The number of bytes to be transferred can be even or odd; the starting address can be on any byte boundary. The MDC fetches 16-bit words from memory but transmits only the specified number of bytes to the printer. Only one line at a time can be executed by the printer.

The range (size) of the data buffer should be limited to the line length of the attached printer. If the data buffer's size exceeds its limit, the printers react as follows:

- Line Printer - Characters in excess of 136 are output by the printer adapter but are ignored by the printer
- Serial Printer - Characters in excess of 132 overprint beginning in column 1.

Data to be transmitted from the MDC to the printer is in standard 7-bit ASCII format and is placed on the I/O bus in the following manner. Each memory location used for transfer contains code for two print characters. The first character is transferred from the eight most significant bits (left byte) of the location; the next character is transferred from the eight least significant bits (right byte) of that same location. Bits 0 and 8 are ignored; their condition has no effect on the characters to be printed (see Figure 1-3). All subsequent transfers alternate, in like manner, between left and right bytes until the end of range occurs. The address register is incremented by two only after righthand bytes have been transferred.

1.3.2 Device Interface

The printer is functionally connected to the MDC via the printer adapter. To transfer data from the MDC to the printer, appropriate I/O instructions are issued by software. Then firmware resident in the MDC tests for appropriate conditions and informs the MDC when the printer is ready to perform an operation. The starting byte address of the first data record in memory to be printed and the range count of the number of bytes to be printed are transferred to the MDC. (Range is specified as a two's complement integer, which must be positive for the MDC.) If the MDC is not busy, the information is accepted and placed in the data stream for transmission to the printer.

Data transfers are in byte mode, i.e., two characters per word. For single spacing operations, printing of one line takes approximately 150 milliseconds on a line printer and one second on a serial matrix printer. Each additional line space operation requires an additional 50 milliseconds (at 300 lines per minute) on a line printer and 0.1 second on a serial matrix printer. For example, to triple space and print a line requires 250 milliseconds on a line printer and 1.2 seconds on a serial matrix printer. After a complete line has been printed, the device goes not busy, enabling data to be sent to the print buffer for the next line print or space operation.

When only spacing operations are to be performed, no range or address information is required. However, an IOLD software instruction must be issued to start the I/O task execution. An I/O instruction is issued with the appropriate bits set to specify whether to skip to top of form, space forward from one to 15 lines, or to space forward to a specified VFU channel if the VFU option is employed.

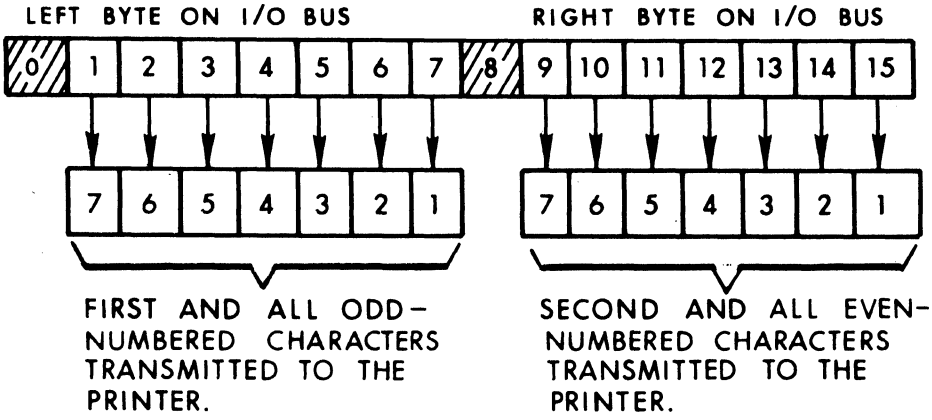

Figure 1-3 Data Transfer to Printer

1.4 SUPPORTED DEVICES

The printer adapter supports two serial matrix printers, a number of line printers, and related optional equipment (see Table 1-1). There is no restriction on the number of like peripheral devices that can be attached to the system. For example, four line printers could be attached to one MDC and supported by hardware and software. Additional low- to medium-speed peripheral devices can be attached by connecting a second MDC to the system.

1.4.1 Line Printers

Line printers are free-standing uppercase/lowercase peripheral devices attached to the system by a 50-foot cable. Series 60 Level 6 supports the line printers listed in Table 1-1. All models have 136 print positions and are available with a Vertical Format Unit (VFU) option (PRF9102). The attachable VFU permits variable format spacing through use of a 12-channel paper tape. Figure 1-4 illustrates a typical line printer.

1.4.2 Serial Matrix Printer

The serial matrix printer (Figure 1-5) is a desktop I/O devices with uppercase/lowercase printing capabilities; it is attached to the system by a 50-foot I/O cable. Two available models of the serial matrix printer are PRU9101 and PRU9102 (see Table 1-1). Both models have 132 print positions and are available with an optional stand. The serial matrix printer can be located up to 50 feet from the MDC.

Table 1-1 Supported Printers and Optional Equipment

DEVICE TYPE	TYPE NUMBER	DESCRIPTION			ADDITIONAL FEATURES
		LINES/MIN	CHARACTER SET	COLUMNS	
Serial Matrix Printer	PRU9101	60	64	132	Mounting Stand PRF9101
	PRU9102		96	132	
Line Printer	PRU9103	240	96	136	12-Channel VFU PRF9102
	PRU9104	300	64	136	
	PRU9105	440	96	136	
	PRU9106	600	64	136	
	PRU9108	660	96	136	
	PRU9109	900	64	136	

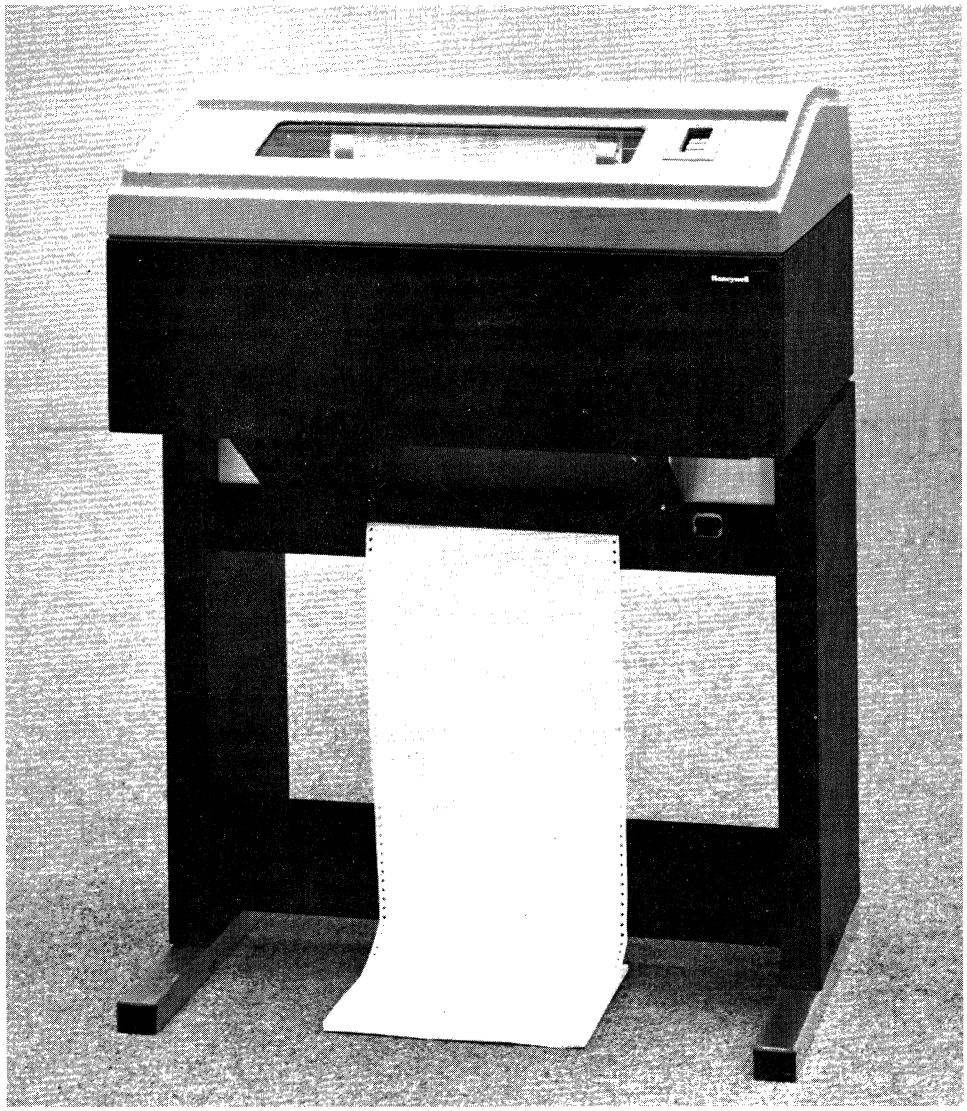

Figure 1-4 Line Printer

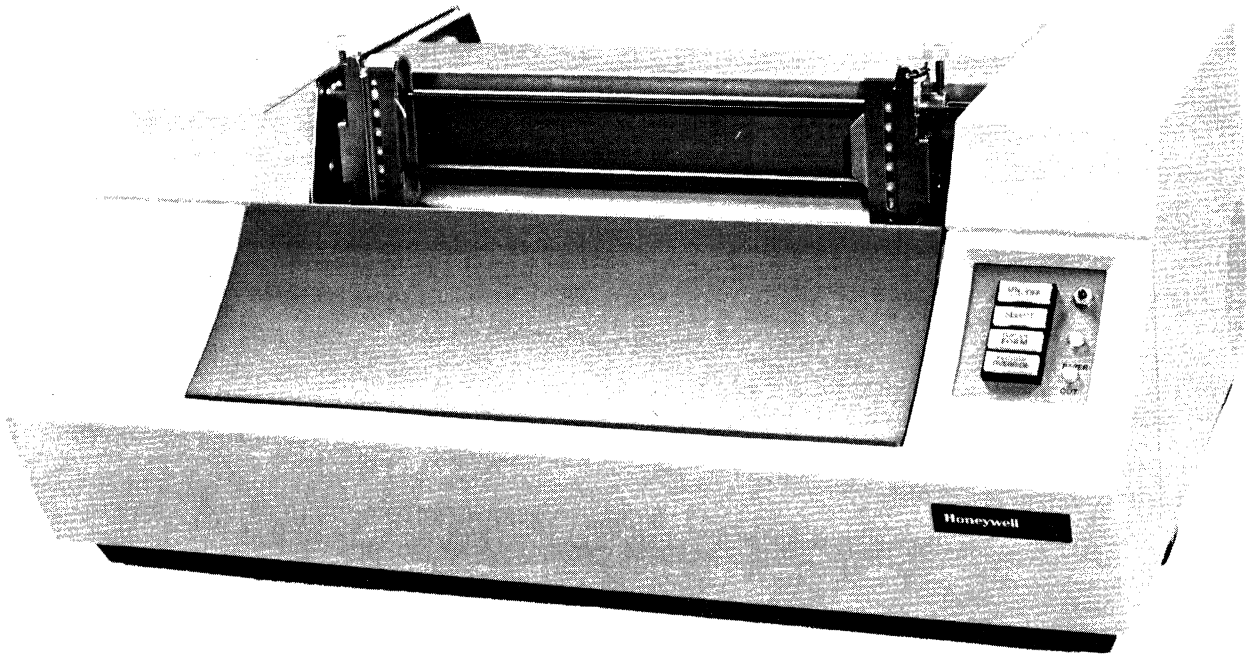

Figure 1-5 Serial Matrix Printer

1.5 TYPES OF OPERATIONS

Serial matrix and line printers can perform the following operations:

- Print one line
- Space forward n lines ($n \leq 15$)
- Space forward n lines and print
- Skip to top of form
- Skip to top of form and print.

In addition, line printers having the VFU capability can perform the following operations:

- Space to VFU channel m ($m \leq 12$)
- Space to VFU channel m and print.

1.6 APPLICABLE DOCUMENTS

This manual primarily contains information necessary for the user to understand the printer adapter and its relationship to the MDC. More detailed information concerning operations of the various available printers, e.g., operator controls and indicators, is contained in the appropriate reference manuals listed in Table 1-2.

The user is assumed to have a basic familiarity with line printer operations and assembly language programming and to have read the reference material listed in Table 1-2.

Table 1-2 Reference Documentation

TITLE	DOCUMENT NO.	ORDER NO.
Type MDC9101 Multiple Device Controller Manual	71010220-200	FL19
Model 34/36 Systems Manual	71010200-200	FL35
Model 43 Systems Manual	71010316-100	FN36
Type PRM9101 Printer Adapter Reference Manual	71010371-200	FL27
Line Printer Operator's Instruction Card	-	AT22
Serial Printer Operator's Instruction Card	-	AT23
Level 6 Control Panel and Peripherals Manual	-	AT04
Level 6 Minicomputer Handbook	-	AS22
Circuit Descriptions Reference Manual	71010206-200	FL47

1.7 PRINTER CHARACTER SETS

Table 1-3 lists all 128 ASCII character codes formed by seven bits. However, depending upon the type of printer installed, only 64 or 96 characters can be handled by a printer. The ASCII characters which are not printed by either a 64- or a 96-character printer are shown in column 1 of Table 1-3. When the adapter detects any of these characters in an output data message, it folds the character over so that the horizontally corresponding character in column 2 is printed by the device. For example, if a hex 00 (NUL) is detected by the adapter, a hex 20 (space) is printed, or if a hex 10 (DLE) is detected, a hex 30 (0) is printed. Note, however, that three of the characters listed in column 1, namely, LF (Line Feed), FF (Form Feed), and CR (Carriage Return) are still sent to the printers as control characters by the firmware in the MDC. When these control characters are initiated by firmware, the adapter allows them to be sent to the printer for control purposes without foldover. Details on the logic for performing foldover are covered in subsection 2.3.4.

Another foldover is performed by the adapters when a 64-character printer is installed and characters listed in column 4 of Table 1-3 are found in the data message. When this occurs, the adapter folds the character over so that the corresponding character in column 3 is printed by the device. For example, if a hex 61 (a) is detected, a hex 41 (A) is printed. Details on the logic used for performing this foldover are covered in subsection 2.3.4.

Table 1-4 shows the character set for a 64-character printer as seen from the I/O bus. Table 1-5 shows the character set for a 96-character printer as seen from the I/O bus.

Table 1-3 Printer Character Codes

COLUMN 1		COLUMN 2		COLUMN 3		COLUMN 4	
USASCII CONTROL CODES (NOT PRINTED)		96-CHARACTER PRINT SET					
		64-CHARACTER PRINT SET					
HEXADECIMAL CODE	CONTROL CHARACTER	HEXADECIMAL CODE	PRINTED CHARACTER	HEXADECIMAL CODE	PRINTED CHARACTER	HEXADECIMAL CODE	PRINTED CHARACTER
00	NUL	20	space	40	@	60	
01	SOH	21	!	41	A	61	a
02	STX	22	"	42	B	62	b
03	ETX	23	#	43	C	63	c
04	WOR	24	$	44	D	64	d
05	ENQ	25	%	45	E	65	e
06	ACK	26	&	46	F	66	f
07	BEL	27	'	47	G	67	g
08	BS	28	(	48	H	68	h
09	HT	29	)	49	I	69	i
0A	LF	2A	*	4A	J	6A	j
0B	VT	2B	+	4B	K	6B	k
0C	FF	2C	,	4C	L	6C	l
0D	CR	2D	-	4D	M	6D	m
0E	SO	2E	.	4E	N	6E	n
0F	SI	2F	/	4F	O	6F	o
10	DLE	30	0	50	P	70	p
11	DC1	31	1	51	Q	71	q
12	DC2	32	2	52	R	72	r
13	DC3	33	3	53	S	73	s
14	DC4	34	4	54	T	74	t
15	NAK	35	5	55	U	75	u
16	SYN	36	6	56	V	76	v
17	ETB	37	7	57	W	77	w
18	CAN	38	8	58	X	78	x
19	EM	39	9	59	Y	79	y
1A	SS	3A	:	5A	Z	7A	z
1B	ESC	3B	;	5B	[	7B	{
1C	FS	3C	<	5C	\	7C	|
1D	GS	3D	=	5D	]	7D	}
1E	RS	3E	>	5E	^	7E	~
1F	US	3F	?	5F	-	7F*	□

For 64-character and 96-character sets, ASCII codes in column 1 are converted (folded over) to the corresponding hexadecimal codes in column 2 before printed.

For 64-character set, ASCII codes in column 4 are converted (folded over) to the corresponding hexadecimal codes in column 3 before being printed.

*Serial printer leaves space.

Table 1-4 Character Set for 64-Character Printers

B4	B3	B2	B1	COL / ROW	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
B8					0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
B7					0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
B6					0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
B5					0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
0	0	0	0	0	SPACE	0	SPACE	0	@	P	@	P	SPACE	0	SPACE	0	@	P	@	P
0	0	0	1	1	!	1	!	1	A	Q	A	Q	!	1	!	1	A	Q	A	Q
0	0	1	0	2	"	2	"	2	B	R	B	R	"	2	"	2	B	R	B	R
0	0	1	1	3	#	3	#	3	C	S	C	S	#	3	#	3	C	S	C	S
0	1	0	0	4	$	4	$	4	D	T	D	T	$	4	$	4	D	T	D	T
0	1	0	1	5	%	5	%	5	E	U	E	U	%	5	%	5	E	U	E	U
0	1	1	0	6	&	6	&	6	F	V	F	V	&	6	&	6	F	V	F	V
0	1	1	1	7	'	7	'	7	G	W	G	W	'	7	'	7	G	W	G	W
1	0	0	0	8	(	8	(	8	H	X	H	X	(	8	(	8	H	X	H	X
1	0	0	1	9	)	9	)	9	I	Y	I	Y	)	9	)	9	I	Y	I	Y
1	0	1	0	A	*	:	*	:	J	Z	J	Z	*	:	*	:	J	Z	J	Z
1	0	1	1	B	+	;	+	;	K	[	K	[	+	;	+	;	K	[	K	[
1	1	0	0	C	,	<	,	<	L	\	L	\	,	<	,	<	L	\	L	\
1	1	0	1	D	-	=	-	=	M	]	M	]	-	=	-	=	M	]	M	]
1	1	1	0	E	.	>	.	>	N	^	N	^	.	>	.	>	N	^	N	^
1	1	1	1	F	/	?	/	?	O	-	O	-	/	?	/	?	o	-	O	-

Basic Character set of Line Printer

Table 1-5 Character Set for 96-Character Printers

B4	B3	B2	B1	COL / ROW	0	1	2	4		5	6	7	8	9	A	B	C	D	E	F
B8					0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
B7					0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
B6					0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
B5					0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
0	0	0	0	0	SPACE	0	SPACE	0	@	P	`	p	SPACE	0	SPACE	0	@	P	`	p
0	0	0	1	1	!	1	!	1	A	Q	a	q	!	1	!	1	A	Q	a	q
0	0	1	0	2	"	2	"	2	B	R	b	r	"	2	"	2	B	R	b	r
0	0	1	1	3	#	3	#	3	C	S	c	s	#	3	#	3	C	S	c	s
0	1	0	0	4	$	4	$	4	D	T	d	t	$	4	$	4	D	T	d	t
0	1	0	1	5	%	5	%	5	E	U	e	u	%	5	%	5	E	U	e	u
0	1	1	0	6	&	6	&	6	F	V	f	v	&	6	&	6	F	V	f	v
0	1	1	1	7	'	7	'	7	G	W	g	w	'	7	'	7	G	W	g	w
1	0	0	0	8	(	8	(	8	H	X	h	x	(	8	(	8	H	X	h	x
1	0	0	1	9	)	9	)	9	I	Y	i	y	)	9	)	9	I	Y	i	y
1	0	1	0	A	*	:	*	:	J	Z	j	z	*	:	*	:	J	Z	j	z
1	0	1	1	B	+	;	+	;	K	[	k	{	+	;	+	;	K	{	k	{
1	1	0	0	C	,	<	,	<	L	\	l	|	,	<	,	<	L	\	l	|
1	1	0	1	D	-	=	-	=	M	]	m	}	-	=	-	=	M	}	m	}
1	1	1	0	E	.	>	.	>	N	^	n		,	>	.	>	N	^	n	
1	1	1	1	F	/	?	/	?	O	-	o	NOTE	/	?	/	?	O	-	o	NOTE

NOTE: Serial printer prints this as space; line printer prints a box.

Basic Character Set of Serial Printer

II
THEORY OF OPERATION

2.1 FIRMWARE

The standard printer device that can be attached to the MDC can be either a line printer or a serial matrix printer. Whenever a printer is placed on line, its demand line generates a data service request. In response to this initial request, firmware updates the status in the MDC scratch pad memory area and clears the data service request.

When an Input/Output Load (IOLD) printer software command is sent to the MDC, firmware examines the task word to determine if a spacing operation is required. If a skip to top of form operation is to be performed, firmware loads the data buffer of the adapter with an ASCII form feed code and passes it through the line driver to the printer.

If a line spacing operation is to be performed (bits 12-15 of the task word), firmware first checks the adapter identification code to determine whether the printer has the vertical format unit (VFU) option. If no VFU option is specified, firmware issues a line feed code to the data buffer register; this code passes through the line driver and appears at the printer for execution when the Strobe signal is received. However, if the option is specified, firmware sends the task word to the data buffer register, sets the VFU Sequence line in the printer, and sends a strobe signal to the printer. Printer logic decodes this data and spaces forward the specified number of spaces or performs a channel advance.

When all spacing operations are complete, firmware allows data to be sent from the CPU's memory to the data buffer register in exactly the same manner as it does for the line feed code. Before sending data, however, firmware starts a 65-millisecond single-shot signal so as to allow sufficient time for firmware to receive an end-of-form status signal from the printer. Following this delay, the end-of-operation flip-flop causes a nondata service request. When all data has been sent to the printer and firmware senses the end of operation, firmware updates the device status, terminates printer activity, and returns control to the MDC.

2.2 HARDWARE OVERVIEW DESCRIPTION

The printer adapter provides device-specific hardware that is used with the Multiple Device Controller (MDC) firmware to control and effect successful transcription of data onto an attached line printer or serial matrix printer. In addition to device and MDC interface connections, the printer adapter hardware has four major logic elements:

- Control logic
- Data buffer
- Line drivers
- Input multiplexer

Figure 2-1 presents an overview block diagram illustrating major printer adapter logic elements and control and data lines necessary for connecting the adapter to the MDC and printer device.

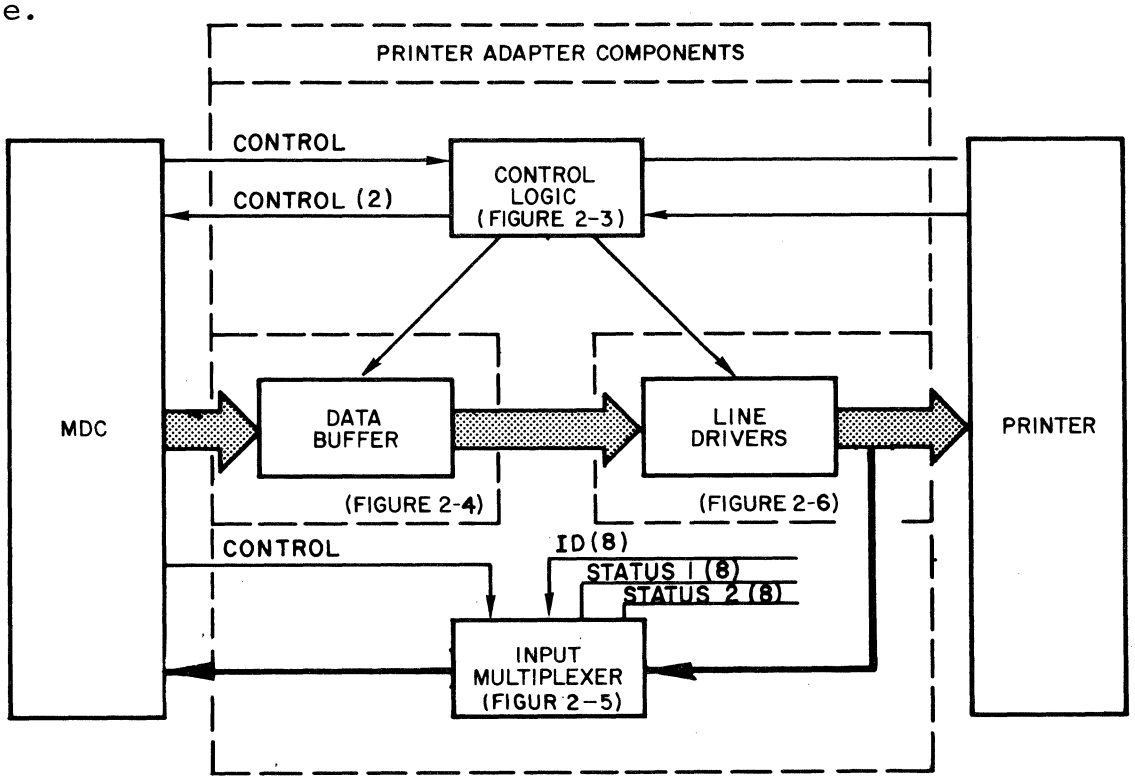

Figure 2-1 Printer Adapter, Major Block Diagram

2.2.1 MDC/Printer Adapter Interface

Data flows from the MDC to the adapter via 8 output lines. Input information is transferred from the adapter to the MDC by the input multiplexer via 8 input lines. There are also 13 control lines between the MDC and adapter. See Figure 2-2 and Table 2-1 for the functional description of all the above lines.

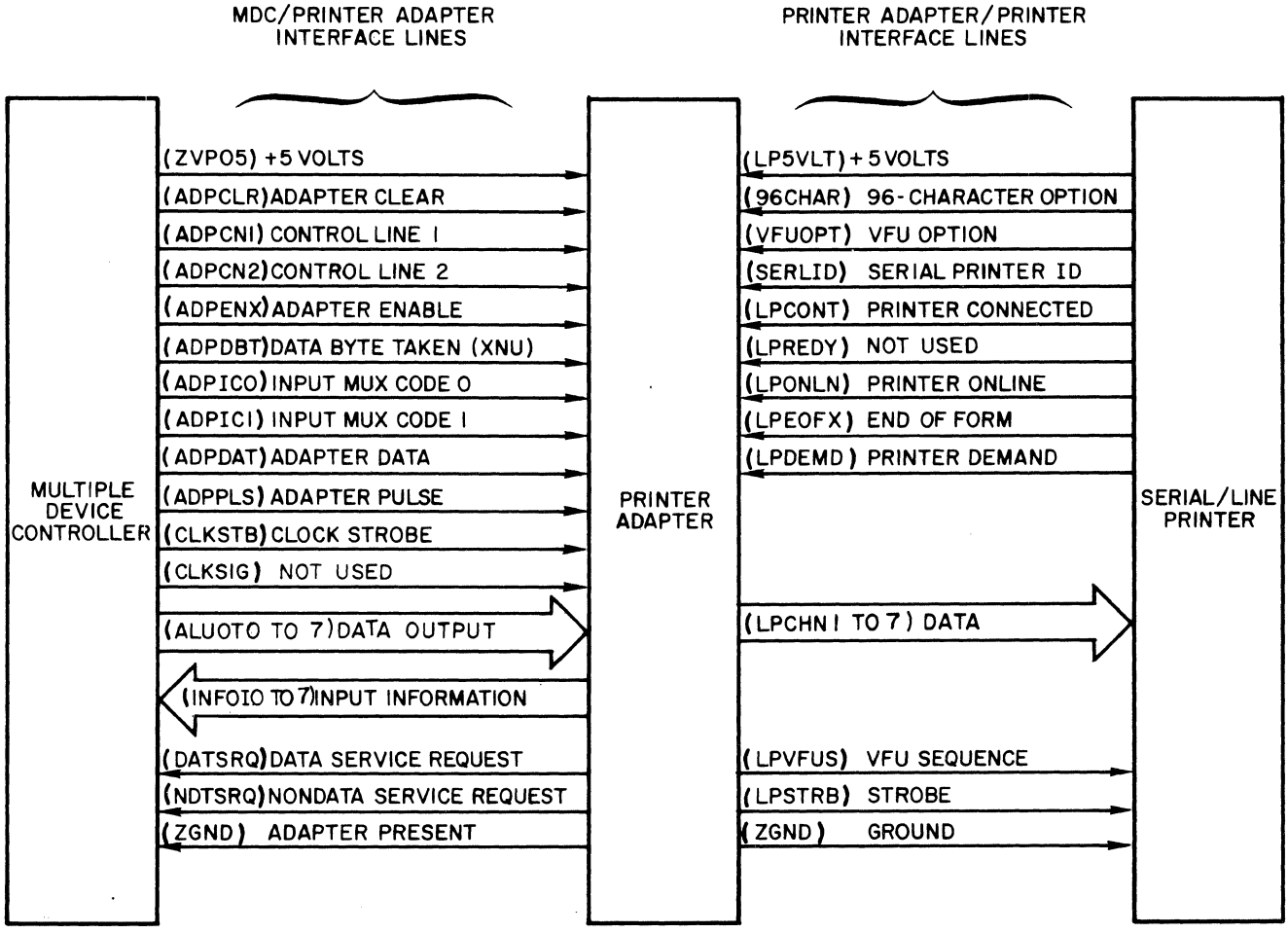

Figure 2-2 MDC/Adapter/Printer Interface

Table 2-1 MDC/Adapter Interface Line Definitions
(Sheet 1 of 2)

LINE	DEFINITION
ADPCLR	The Adapter Clear line is true when the system is master cleared or enabled under a firmware command; ADPCLR clears the major logic areas of the adapter.
ADPCN1 ADPCN2	Control Line 1 and Control Line 2 are used for device-specific-operations. Control Line 1 is used to control the vertical form of unit sequence (VFUSEQ) and end of form (LPEOFF) logic. Control Line 2 is used to control end of operation (ENDOPR), non data service request (NDTSRQ), and data service request (DATSEQ) logic.
ADPENX	Adapter Enable high allows the MDC to process information from the adapter. When the line is disabled, the printer adapter is inaccessible.
ADPDBT	Not used.
ADPIC0 ADPIC1	These adapter input code lines are used to select one of four inputs to the input multiplexer which will be sent to the MDC. These inputs are data (a diagnostic check), ID code, adapter status 1, and adapter status 2.
ADPDAT	The ADPDAT line is used to load the data buffer.
ADPPLS	The Adapter Pulse line is used to generate a control strobe to the printer.
CLKSTB	Clock Strobe is a signal sent from the MDC to the printer adapter and is used as a clock strobe from the MDC. CLDSTB generates one clock strobe for each microinstruction generated by the MDC.
CLKSIG	Not used.
ALUOT0 to ALUOT7	The eight ALU output lines extend from the MDC to the printer adapter and are used in conjunction with Control Lines 1 and 2 to perform specific adapter operations, and in conjunction with ADPDAT to load data from the MDC into the data buffer.
INFOI0 to INFOI7	The eight input multiplexer data lines are used to transfer wraparound data, ID code, and adapter status 1 or 2 information from the printer adapter to the MDC.
DATSRQ	The Data Service Request line is true when the printer adapter requests a byte of data from the MDC, or when the printer goes on-line.

Table 2-1 MDC/Adapter Interface Line Definitions
(Sheet 2 of 2)

LINE	DEFINITION
NDTSRQ	The Nondata Service Request line indicates to the MDC that the printer adapter has a nondata service request to be processed (e.g., a change in device state).
ZGND	The Adapter Present line is designated by a ground (ZGND) on pin 24 of the MDC/adapter connector. When ZGND is true, it notifies the MDC that an adapter is present in that port position.

2.2.2 Printer Adapter/Printer Interface

There are seven data and eleven control lines between the printer adapters and the printer. See Figure 2-2 and Table 2-2 for the functional description of all the above lines.

2.2.3 Control Logic

Printer adapter control logic performs general supervisory tasks that control the loading of data into the data buffer register, the transferral of data for printing to line drivers, and the print operation on the output device. Specifically, control logic hardware performs the following functions:

- Requests firmware to transmit data upon printer demand.
- Passes vertical format unit (VFU) information to the printer.
- Sends a strobe signal to the line printer to indicate that information on the data lines is valid.
- Stores a signal indicating completion of vertical spacing operations.
- Stores end-of-form (EOF) information as received from the printer.
- Requests firmware to update the printer's status after changing to an off-line state or when an end of operation is detected.

2.2.4 Data Buffer

The data buffer is an 8-bit register that receives one data byte from the MDC and stores it until it is transmitted to the line drivers. The data buffer retains the data byte long enough for line driver logic to stabilize the data lines to the printer.

Only seven of the eight bits of the data byte are sent to the printer; the eighth bit is used to enable one of the three control characters, i.e., CR (Carriage Return), FF (Form Feed), and LF (Line Feed), to be sent via firmware or to enable foldover of control characters. The operation of foldover is discussed in subsection 1.7. The logic required to effect foldover is discussed in subsection 2.3.4.

2.2.5 Line Drivers

Line driver logic consists of eight slope controlled drivers, one for each of seven line channels for transmitting data to the printer and one for the vertical format unit option. Line drivers receive their input from the data buffer. Slope controlled line drivers prevent signal interference between the lines.

2.2.6 Input Multiplexer

The MDC controls the input multiplexer to select the transfer of one of four bytes of data or information:

1. A readout of a data byte sent out to the printer. This is used for diagnostic purposes.
2. An identification byte (ID) which notifies the MDC of what specific type printer is installed.
3. Status 1 - status information on adapter and printer.
4. Status 2 - status information on adapter and printer.

Details on the input multiplexer logic and the information carried by the input signals are covered in subsection 2.2.3.

Table 2-2 Adapter/Device Interface Line Definitions

LINE	DEFINITION
96CHAR	Indicates a 96-character set printer is attached.
VFUOPT	Indicates a printer with a 12-channel vertical format unit option is attached.
SERLID	Indicates a serial printer is attached.
LPCONT	Indicates the cable is connected between adapter and printer.
LPREDY	Not used.
LPONLN	Indicates printer is on line.
LPEOFX	Indicates printer has spaced to the end of form.
LPDEMD	Indicates the printer has requested data.
LPCHN1-7	Indicates data from the adapter to the printer.
LPVFUS	Indicates the data is for the vertical format unit.
LPSTRB	Indicates that the data (LPCHN1-7) is valid.

2.3 FUNDAMENTAL HARDWARE DESCRIPTION

The following discussion presents detailed logic descriptions of the four major elements of the printer adapter as shown in Figure 2-1.

2.3.1 Control Logic

Figure 2-3 is an intermediate block diagram of the major control logic elements and controlling interconnecting signals. These logic elements include:

- End-of-form logic
- End-of-form delay logic
- Strobe logic
- Vertical format unit sequence logic
- Data service request logic
- Nondata service request logic

2.3.1.1 End of Form

As shown in Figure 2-3 (A), whenever the printer spaces up to or beyond the end of form, a flip-flop is set, and a status signal is sent to the input multiplexer (see subsection 2.3.3). This End-of-Form flip-flop is then reset when the firmware issues an ALUOT3 signal after it receives the next IOLD instruction. A clear signal also resets the flip-flop. For diagnostic purposes, the flip-flop can also be set by an ALUOT3 signal when Control Line 1 of the adapter is high.

2.3.1.2 End of Form Delay

When the MDC sends a spacing command to the printer, it must allow time for mechanical positioning before checking the end of form status. Consequently, as shown in Figure 2-3 (B), after each spacing command the firmware starts an end-of-form delay by causing Control Line 2 and ALUOT4 to be true. This delay is 30 ms if a 600 LPM printer is installed and 65 ms if the installed printer has a speed less than 600 LPM. After the delay, the end-of-operation flip-flop is set, causing both a nondata service request signal to be sent to the MDC and a status signal to the input multiplexer. The end-of-operation flip-flop is then reset by the firmware by means of the ALUOT0 and Control Line 2 prior to sending out further data to the printer. A clear signal also resets the flip-flop. For diagnostic purposes the flip-flop can also be set by an ALUOT7 signal when Control Line 2 of the adapter is true.

2.3.1.3 Strobe Logic

A strobe signal is sent to the printer to notify it that the data on the line drivers is valid (see Figure 2-3, C). The printer then takes the character from the lines and takes appropriate action. To generate the strobe, the MDC firmware enables the Printer Strobe flip-flop by enabling the adapter and then issues an adapter pulse.

The next clock strobe from the MDC then sets the flip-flop and a strobe signal is sent out to the printer. To ensure that the strobe signal to the printer is at least 500 nanoseconds long, the firmware issues two consecutive Adapter pulse signals, thereby forcing the flip-flop to maintain the output strobe for the required 500 nanoseconds. The flip-flop is reset on the clock strobe after the Enable Strobe signal goes low, or when the adapter is cleared.

2.3.1.4 Vertical Format Unit (VFU) Sequence

The VFU option controls vertical spacing in the printer. The logic for performing this function is shown in Figure 2-3(D).

When vertical spacing is required, firmware enables the adapter and raises Control Line 1 and ALUOT4. This enables the VFU sequence flip-flop, which is set on the next clock strobe from the MDC. The output of the flip-flop is then slope-controlled and sent to the printer via a line driver. The VFU sequence flip-flop is reset when the data buffer of the adapter is loaded for printing the next line.

2.3.1.5 Data Service Requests

Whenever the printer requires data for printing, it signals the adapter via the Printer Demand (LPDEMD) interface line. As shown in Figure 2-3 (E), this signal sets the data service request flip-flop, which sends a signal to the MDC. The flip-flop is then reset when the firmware strobes the printer, or issues a Control Line 2 signal with ALUOT2 high. Note that the flip-flop is also reset by a clear signal. For diagnostic purposes, the firmware may also set the data service request flip-flop by issuing a control Line 2 signal with ALUOT5 high.

2.3.1.6 Nondata Service Request

Whenever the printer goes off line, a nondata service request is sent from the adapter to the MDC. The logic that generates this service request is shown in Figure 2-3(F). Note that the flip-flop can also be set by an End-of-Operation signal after the end of form one-shot times out. (See Subsection 2.3.1.2.) The nondata service request flip-flop is reset when the firmware issues a Control Line 2 signal with ALUTOT1 high.

2.3.2 Data Buffer Register

Figure 2-4 shows the data buffer logic for the printer adapter. The buffer actually consists of two 4-bit synchronous load registers which are parallel loaded and output a parallel byte to the line drivers. The MYDATA input to the register causes the register to be a parallel input/output device rather than a shift register. Firmware loads the register by placing the data on the ALUOT lines and then causing a register strobe (REGSTB) signal to be generated. When the data is loaded into the register, it is simultaneously sent to the line driver logic. Data remains stored in the buffer until the next load operation or when the firmware clears the adapter.

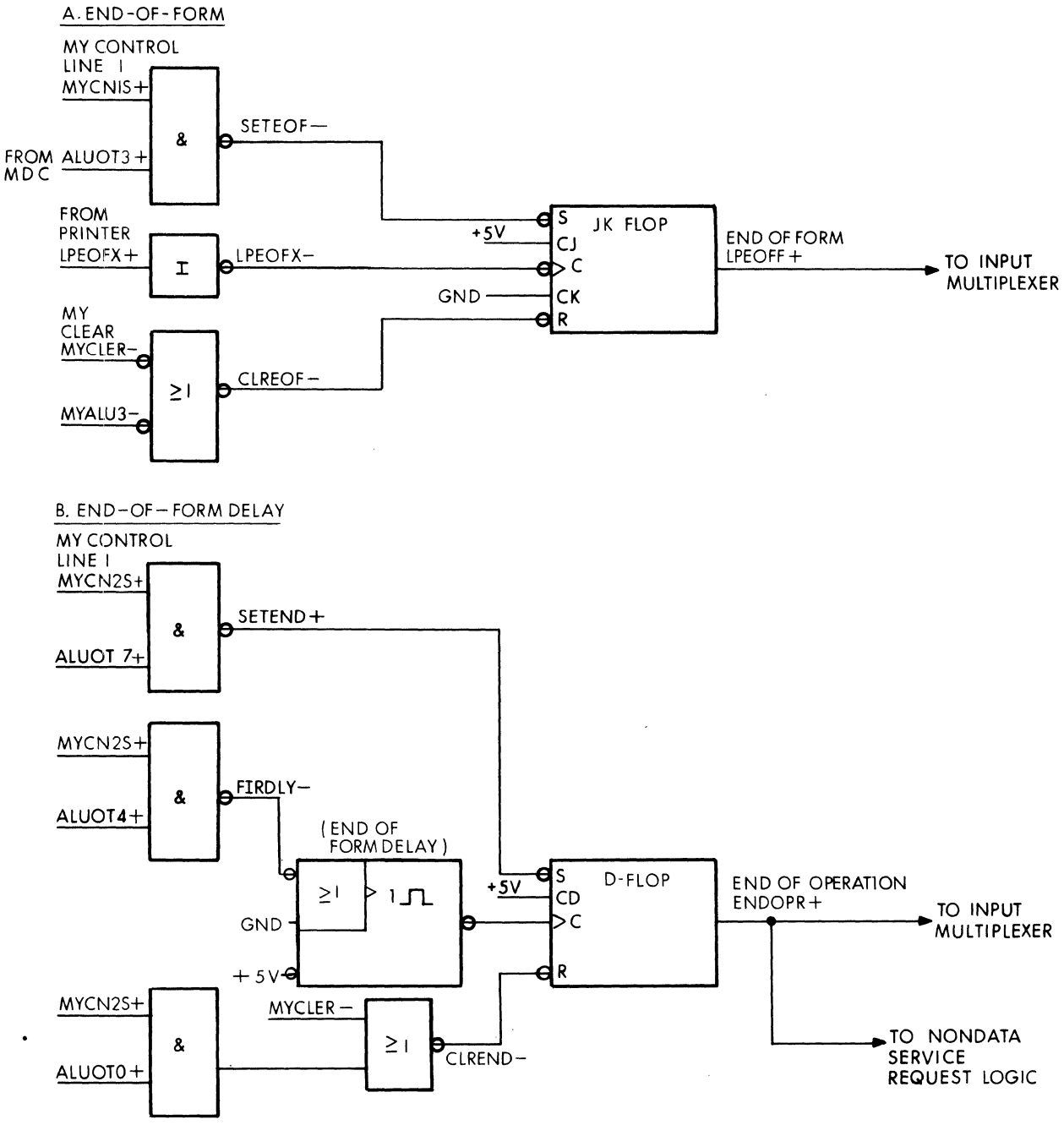

Figure 2-3 Control Logic (Sheet 1 of 2)

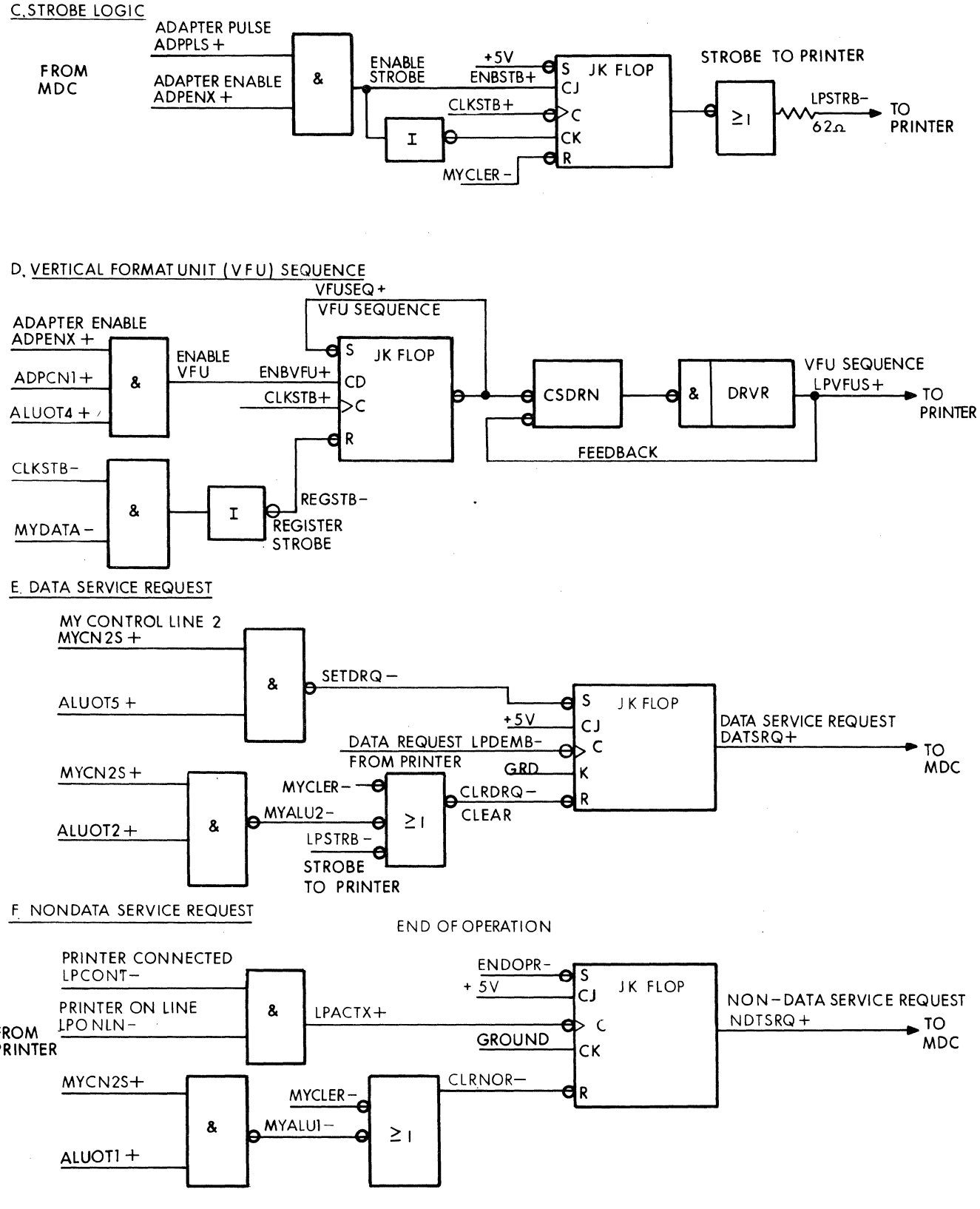

Figure 2-3 Control Logic (Sheet 2 of 2)

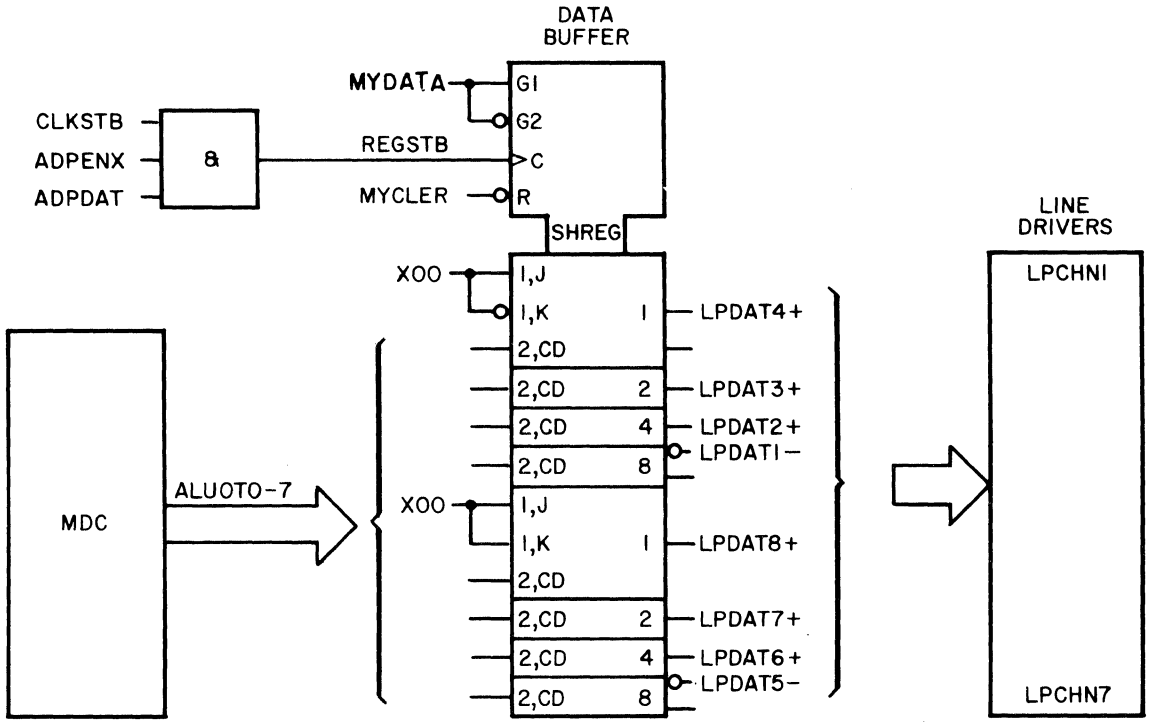

Figure 2-4 Data Buffer

2.3.3 Input Multiplexer

The input multiplexer (see Figure 2-5) allows the adapter to send a data byte, identification, or status information to the MDC. Depending upon the setting of the code lines from the MDC, one of four bytes of information can be sent to the MDC:

1. Input data (DATA)
2. Identification (ID code)
3. Status 1
4. Status 2.

The setting of the code lines and the Enable line are under control of the MDC firmware. The Enable line is required because the multiplexer is a tristate device. When the multiplexer is not enabled, all its outputs are at infinite impedance (floating), thereby disconnecting all logical inputs from the multiplexer to the MDC. When the multiplexer is enabled, the state of each bit of the selected byte into the MDC is determined by the state of the connected bit into the multiplexer from the adapter. The multiplexer disconnecting capability allows multiplexer inputs from other adapters on the MDC to be in parallel, but only inputs of the enabled one are entered into the MDC logic.

The data byte sent to the MDC via the input multiplexer is used for diagnostic purposes. The byte is a reading of the output of the 7 data-carrying line drivers (LPCHN1 through LPCHN7) plus the bit 8 output of the data buffer (LPDAT8).

The ID code is used by software to determine the type device associated with the channel. The adapter supplies only the least significant byte of the two-byte software ID code word. The most significant byte is supplied by the MDC and is always hexadecimal 20. The byte furnished by the adapter is shown in Table 2-3. The bit configuration for the adapter ID byte depends upon the lines hooked up between the adapter and printer (see Table 2-2 and Figure 2-2).

The first status byte (status 1) is used by the MDC to form the most significant byte of a two-byte status word which it forms for software. (Refer to Table 2-4.) Firmware of the MDC inputs this byte and modifies it for software at:

1. The end of execution of every ouput address and range (IOLD) command
2. Master Clear
3. Output control command with either the Initialize or Stop I/O bits set

The second status byte (status 2) into the multiplexer from the adapter provides information to the process firmware of the MDC so that it can determine operational hardware states of the adapter. The only bit used in this byte is bit 7. This bit notifies the MDC when the end-of-form delay one-shot has timed out (ENDORP). See subsection 2.3.1.2 for details.

2.3.4 Line Drivers

Figure 2-6 shows the line drivers which carry the data from the adapter to the printer. Also shown is the logic to perform character foldover as decribed in subsection 1.7. Note that, in addition to sending data to the printer, the adapter sends it two control signals namely, a strobe and VFU sequence signal. The logic for generating and transmitting these signals is discussed in subsection 2.2.1.

The line drivers (CSDRN) have slope controlled driver networks which limit signal rise and fall times to 300 nanoseconds, thereby preventing crosstalk between the lines in the device cable. The foldover process is performed by manipulating the bit 6 output to the printer. Whenever bit 7 and bit 8 of the data buffer are not set, line driver 6 to the printer is set. This performs the foldover conversion from column 1 to column 2 as shown in Table 1-3, regardless of whether a 64- or 96-character printer is installed. Whenever a 96-character printer is installed, the state of line driver 6 out to the printer is the same as that in the data buffer. Whenever a 64-character printer is installed (96 character not true), if the bit 7 of the data buffer is set, line driver 6 out to the printer is reset. This performs the foldover from column 4 to column 3 as shown in Table 1-3. Whenever bit 8 from the data buffer is set, it indicates that the firmware is sending a line feed (LF), form feed (FF) or carriage return (CR) control signal to the printer. In this case, line driver 6 out to the printer is reset. All outputs of the line drivers are sent back to the input multiplexer for diagnostic purposes.

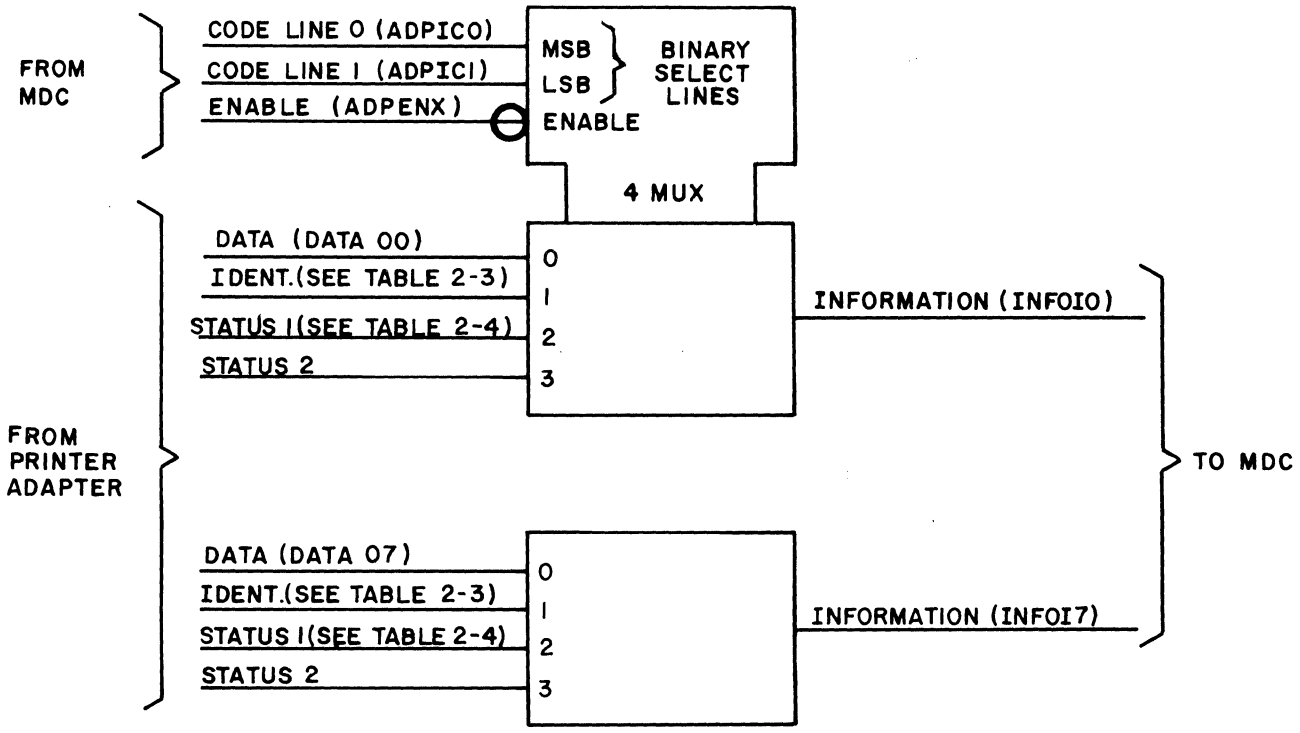

Figure 2-5 Input Multiplexer

Table 2-3 ID Code Development

DEVICE	ID CODE (HEX)		ADAPTER ID BYTE							
	MDC	ADAPTER	0	1	2	3	4	5	6	7
Line Printer 64 characters without VFU option	20	00	0	0	0	0	0	0	0	0
Line Printer 64 characters with VFU option	20	01	0	0	0	0	0	0	0	1
Line Printer 96 characters without VFU option	20	02	0	0	0	0	0	0	1	0
Line Printer 96 characters with VFU option	20	03	0	0	0	0	0	0	1	1
Serial Printer 64 characters	20	04	0	0	0	0	0	1	0	0
Serial Printer 96 characters	20	06	0	0	0	0	0	1	1	0

Table 2-4 Status 1 Inputs

BIT	MNEMONIC	DESCRIPTION
0	LPACTX	Line printer active. Connected to adapter and on-line.
1	NDTSRQ	Nondata service request. (See subsection 2.3.1.6 for details.)
2	Not used	
3	LPEOFF	Printer at end of form. (See subsection 2.3.1.1 for details.)
4	VFUSEQ	Vertical spacing sequence singla is being sent to a line printer with an installed VFU option. (See subsection 2.3.1.4 for details.)
5	DATSRQ	Data service request. (See subsection 2.3.1.5 for details.)
6	Not used	
7	Not used	

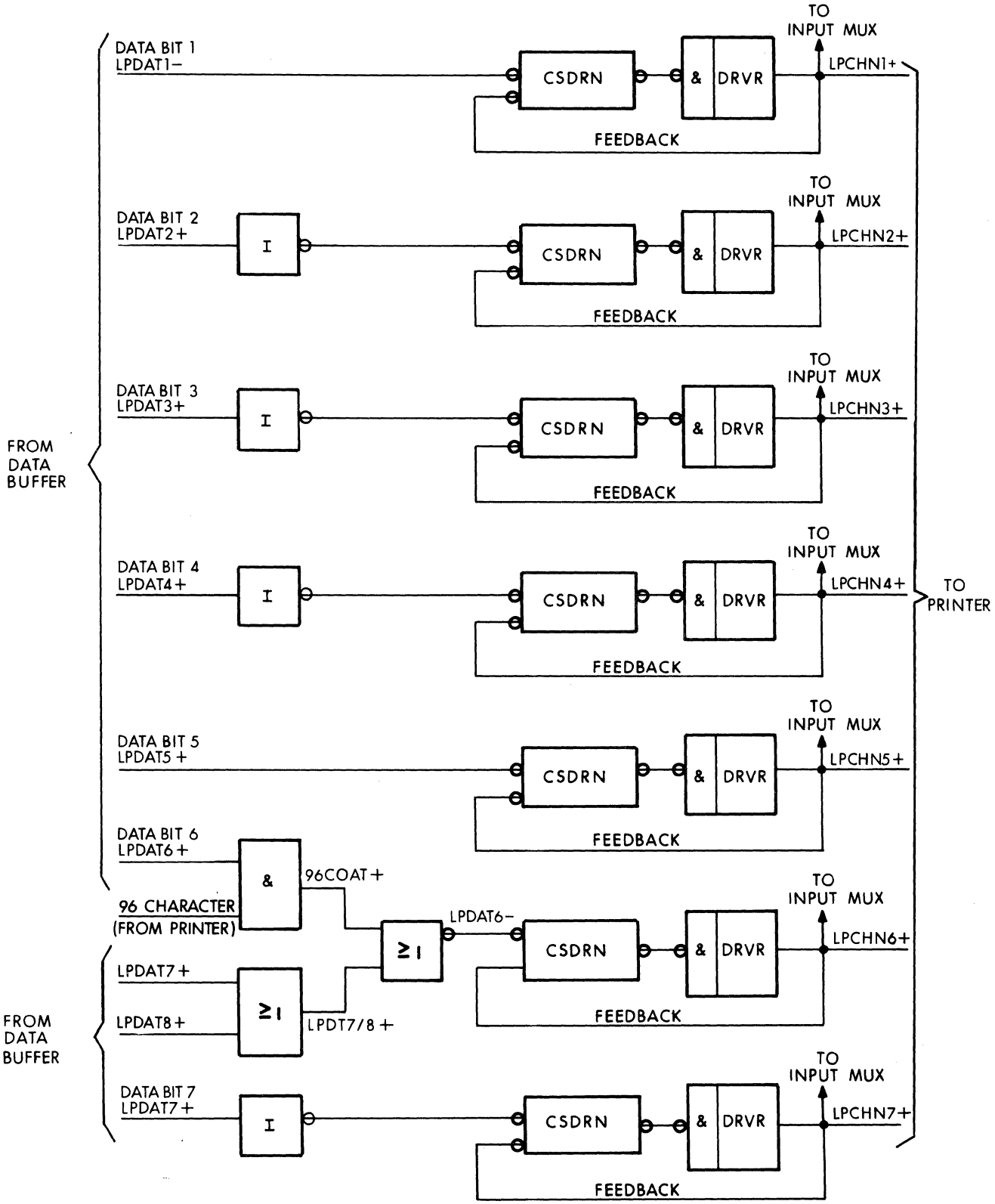

Figure 2-6 Line Driver Logic

III
THEORY OF OPERATION - CYCLE FLOW

The firmware (Rev. 2.0) associated with the printer adapter is located in the Microprogram Control Store section of the Multiple Device Controller (MDC). Subsection 3.1 describes the quadrant of the Scratch Pad Memory (SPM) in the MDC that is dedicated to the adapter. An overview flowchart with supporting intermediate flowcharts is shown later in this section. Note that several firmware commands are required to perform functions called out in these flowcharts. Details on the precise function of these firmware commands are commented on in the firmware listing provided with the MDC documentation.

3.1 SCRATCH PAD MEMORY

Scratch pad memory (SPM) is a 256-byte block of memory designed for storing device-specific information. It is divided into quadrants, each containing 64 addressable locations. The topology for each quadrant is identical. One quadrant is reserved for storing printer adapter information. Software generates most information stored in SPM locations; however, several locations contain device-specific information. Table 3-1 defines SPM locations containing unique printer adapter information, and Figure 3-1 shows device-specific word bit structures.

Two scratch pad locations have particular significance to printer adapter firmware: DMA1 and MON1. When set, bit 2 of the DMA control byte, DMA1, indicates that a software error has been detected; i.e., and invalid I/O channel has been specified.

Bits 1 and 4 of the channel monitor byte, MON1, determine I/O channel busy status and end-of-print range, respectively. For more complete descriptions of these scratch pad locations, refer to Section IV of the Type MDC9101 Multiple Device Controller Manual.

3.1.1 Task Words (TSK1 and TSK2)

The task words are written into SPM by software. The printer adapter firmware uses TSK1 to make decisions regarding printer operations and take optional procedures. The bit decoding is shown in Figure 3-1. TSK2 is not used.

3.1.2 Device Identification Code (DID1)

This location is used to store the printer identification byte. This byte (Table 2-3), together with the MDC ID byte, is used by software for identification purposes. (See Figure 3-1).

3.1.3 Line Feed Counter (WL01)

This location stores the contents of the line feed counter. Firmware use the counter to control the printer line feed operation. (See Figure 3-1).

3.1.4 Not Done Flag (WL02)

Firmware uses this location to store the status of the print/space operations. (See Figure 3-3).

3.1.5 Vertical Format Information (WL03)

This location is used by firmware to store the spacing information for the Vertical Format Unit (VFU) when that option is installed on the attached printer. (See Figure 3-1).

Table 3-1 Printer-Specific Locations in the Scratch Pad Memory

ADDRESS (HEXADECIMAL)	MNEMONIC	CONTENTS
06	TSK1	Least significant bits of task word
07	TSK2	Most significant bits of task word
18	STS1	Least significant bits of software status word
19	STS2	Most significant bits of software status word
24	MON1	Channel monitor
25	DMA1	Direct memory access control byte
26	DID1	Least significant bits of device identification code
2E	WL01	Work location 1; used for line feed counter
2F	WL02	Work location 2; bit 0 used for NDONE flag
30	WL03	Contains VFU information (5 least significant bits of task word)

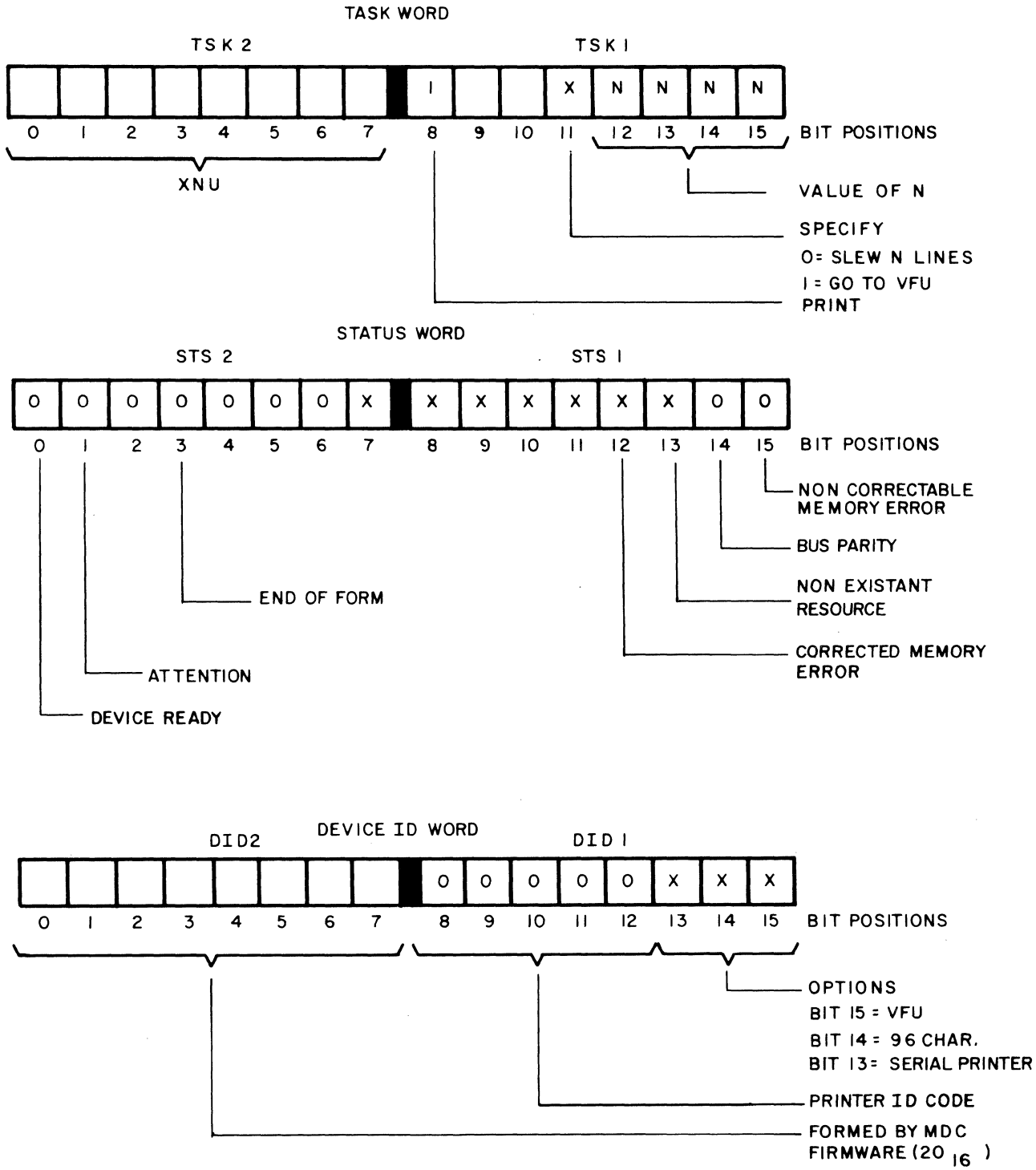

Figure 3-1 Device-Specific Word Bit Structures (Sheet 1 of 2)

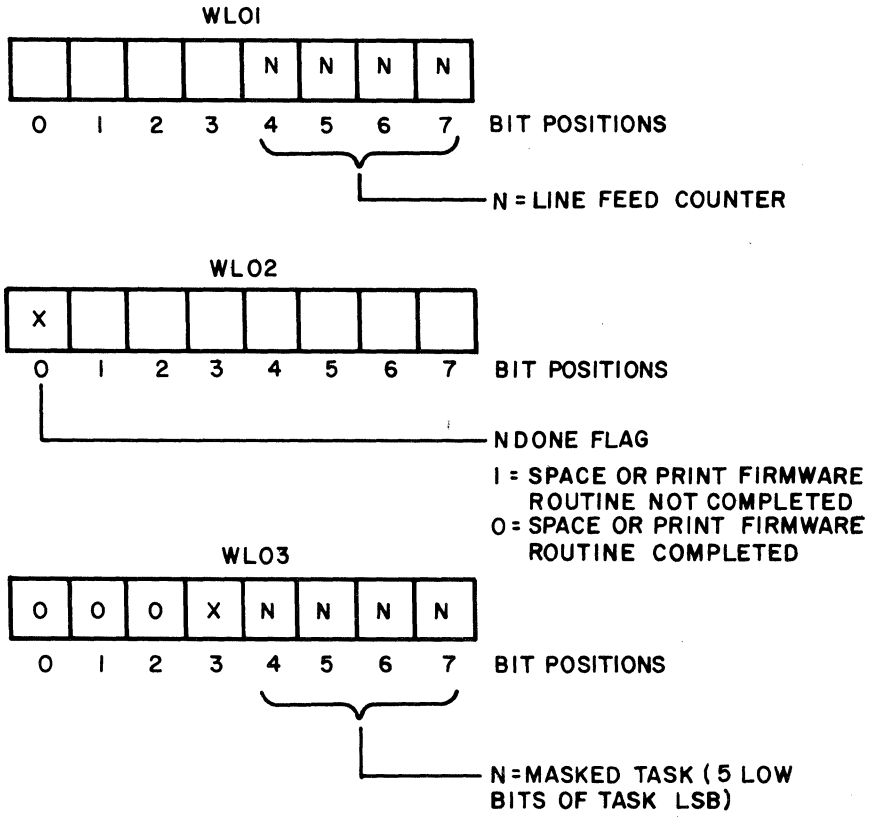

Figure 3-1 Device-Specific Word Bid Structures
(Sheet 2 of 2)

3.2 SOFTWARE STATUS WORD

The Software Status Word is shown in Figure 3-1 and described in the following subsections.

3.2.1 Device Ready

This bit indicates that the device is on line with no device faults and the medium loaded and that no further manual intervention is required to place it under program control. Note that a change of state of this bit will cause the Attention bit (bit 1) to be set, resulting in an interrupt (if the interrupt level is nonzero).

3.2.2 Attention

The Attention bit is set whenever the Device Ready bit changes state. Any change of operational status of the device (e.g., load/unload of media or device fault) will be reported to software in this way.

Whenever the Attention bit is set, an interrupt is attempted (if the interrupt level is nonzero). If a previously initiated operation is in progress when a device state change is sensed, the resultant interrupt (with the Attention bit set) will serve as notification of both the end of the operation and the device state change.

This bit is reset by an Initialize command (Output Control Word), and Input Status Word Command, an Output Task Word command, or a Master Clear on the Megabus.

3.2.3 End of Form

This bit indicates that the printer has detected an End of Form condition, by spacing to or past a predetermined position (on paper) or by spacing under control of channel 11 of the VFU option to a predetermined position. This bit is reset by an IOLD or Initialize command.

3.2.4 Corrected Memory Error

This bit indicates that during execution of the previous operation, main memory detected and corrected a memory read error. The data that was delivered to the MDC was assumed to be correct.

3.2.5 Nonexistent Resource

This bit is set whenever the CP attempts a write or read request bus cycle and does not receive a response.

This bit is reset by an Initialize command (Output Control Word), an Output Task Word command, or a Master Clear on the Megabus.

3.2.6 Bus Parity Error

This bit is set whenever the MDC detects a parity error on either byte of the data bus during an output bus cycle (i.e., odd function code), during a second half memory read cycle, or when a parity error is detected in bits 0-7 of the address bus during an Output Address command.

This bit is reset by an error-free Input Status Word command or an Initialize (via a Master Clear or an error-free Output Control Word command).

3.2.7 Noncorrectable Memory Error

This bit indicates that during execution of the previous operation main memory detected a memory read error which the EDAC algorithm could not correct. The data that was delivered to the MDC was incorrect. Occurrence of this condition will not cause termination of the operation in progress (but may result in bad data written on the medium). This bit is reset by an Initialize command (Output Control Word), an Output Task Word command or a Master Clear on the Megabus.

3.3 FIRMWARE CYCLE FLOW

This section describes firmware required for printer adapter functions. As shown in Figure 3-2 adapter firmware is composed of four major areas:

- Initialization
- Task initiation
- Task execution - line spacing and print operations
- Task termination

Figure 3-3, an intermediate flow chart, describes firmware for each area in more detail. For even greater detail, the printer adapter firmware listing (refer to the MDC Reference Manual) contains actual microinstructions comprising each firmware subroutine.

NOTE

Figure 3-3 was generated by Autoflow, a copyrighted computerized flowcharting program. For descriptions of symbology and nomenclature used within the figure, refer to Section IV of the Type MDC9101 Multiple Device Controller Manual.

3.3.1 Initialization

Initialization firmware is entered upon initial power up, at master clear time, or upon a software output Initialize command. The firmware pointers are set at this time to the task initialization firmware. Status is then updated, and firmware control returns to the MDC Start Wait routine.

3.3.2 Task Initiation

Firmware for task initiation provides a series of tests to determine conditions that exist at the time the printer adapter firmware is called to execute a task. Conditions checked by firmware include the following:

- I/O channel status check (software command or device request)
- Channel validity check (channel number for output)
- Printer status check (device ready check)
- Top-of-form check
- VFU option check

} task decode and initiation

If the printer I/O channel is not busy (bit 1 of channel monitor [MON] reset), firmware branches to location PR:CYCLEUP within the Exit routine (EXIT) to set the attention flag (bit 1 of status bit 1), update the printer's status, and return to the Interrupt routine (STARTINTPT).

The invalid I/O channel check (bit 2 of DMA1 set), prevents erroneous software from executing on an illegal (input) channel to the printer. Software errors of this type cause firmware to branch to the Error routine, PR:DIR:ERR, and terminate processing.

The printer status check ensures that the printer is ready. If the printer is not ready to accept data transfers, e.g., is not on line, the Exit routine, PR:EXIT, performs various termination operations, updates the printer status words, and returns to the Interrupt routine, STARTINTPT.

If the top-of-form code is specified by the task word, firmware permits a form feed control character (FF) to be strobed to the printer, clears the data service request, and branches to the Space Request routine, PR:SPACERQ, for further spacing operations, if desired.

Top of form is specified if an ASCII form feed code is sent to the printer. Otherwise, bit 7 of the device identification code, DID1, is tested to determine if the VFU hardware option is installed. If the VFU option is not installed (bit 7 = 0), firmware branches to the Space routine (PR:SPACE) to skip the appropriate number of lines. The five least significant bits of the task word are output to the printer (bit 12 is complemented). The printer VFU option electronics now perform the desired operation.

3.3.3 Task Execution

Printer adapter firmware supports two line spacing subroutines. PR:TOPOFOM, the Form Feed subroutine, causes paper in the printer to skip to the top of the next page before printing operations commence, as described above. PR:SPACE, the Line Feed routine, causes the printer device to skip forward up to 15 lines, after which processing branches to the Print routine, PR:PRINT.

The Print routine processes print requests via the data service request routine, PR:DATSVRQ. When firmware detects that data is to be printed via bit 0 of Task Word 1, the data is transmitted in byte format from the MDC to line drivers through a data buffer. Data is taken from main memory via the MDC STARTDMAOT firmware routine, converted to printable ASCII characters, and strobed to the printer.

When printing is complete (range = 0), firmware branches to the Data Service Request Termination routine, PR:DONE. This routine strobes a carriage return (CR) character to the printer, terminating that print line, clears the data service request (DATSRQ), and branches to the Nondata Service Request routine, PR:NDTSVRQ.

Nondata service request firmware, PR:NDTSVRQ, consists of a set of tests to determine conditions for branching out of the printer adapter firmware; it can be entered from the following routines:

- PR:PRINT - During task initiation if no print request exists
- PR:DONE - During processing after a carriage return (CR) has been sent to the printer.
- PR:DONEFLG - During processing after the NDONE flag has been set.

3.3.4 Task Termination

PR:EXIT is the entry point of the termination firmware. It can be entered during initialization if the printer is not ready or the I/O channel is not available, or during data transfer processing after the completion of a print operation. Upon entering PR:EXIT, firmware first clears the end-of-operation and nondata service request flip-flops in the adapter. Then the firmware checks to see if channel 11 of the VFU was used in the current operation. If channel 11 was used, the end-of-form bit (bit 11) in the status word is left set, and if channel 11 was not used, bit 11 is reset. After setting or resetting bit 11, the firmware enters the STARTPRINT routine. During this routine, the firmware sets the attention flag (bit 1 of status byte 2) if the I/O channel is not busy, updates the printer status, and suspends processing if other devices demand servicing at this time. When processing resumes, the firmware enables the loading of the Initiation routine (PRINTERGO), sets the NDONE flag and control byte 2 to zero, and returns to the MDC Interrupt routine.

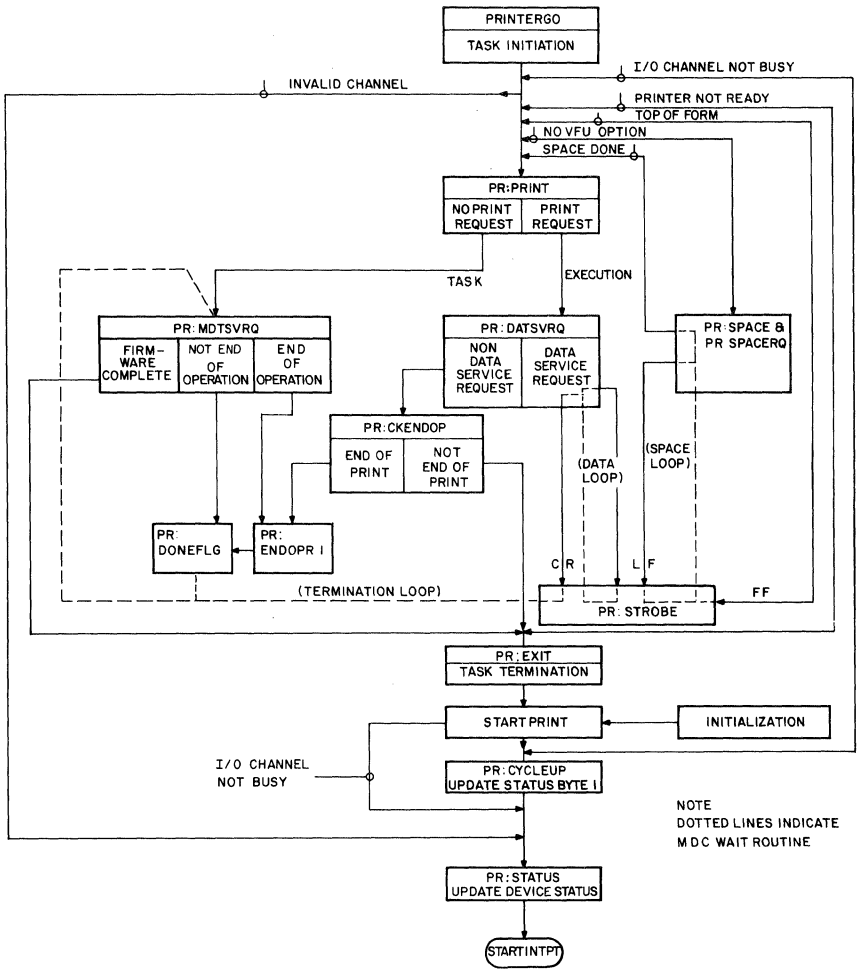

Figure 3-2 Functional Flow Chart for Printer Adapter Firmware

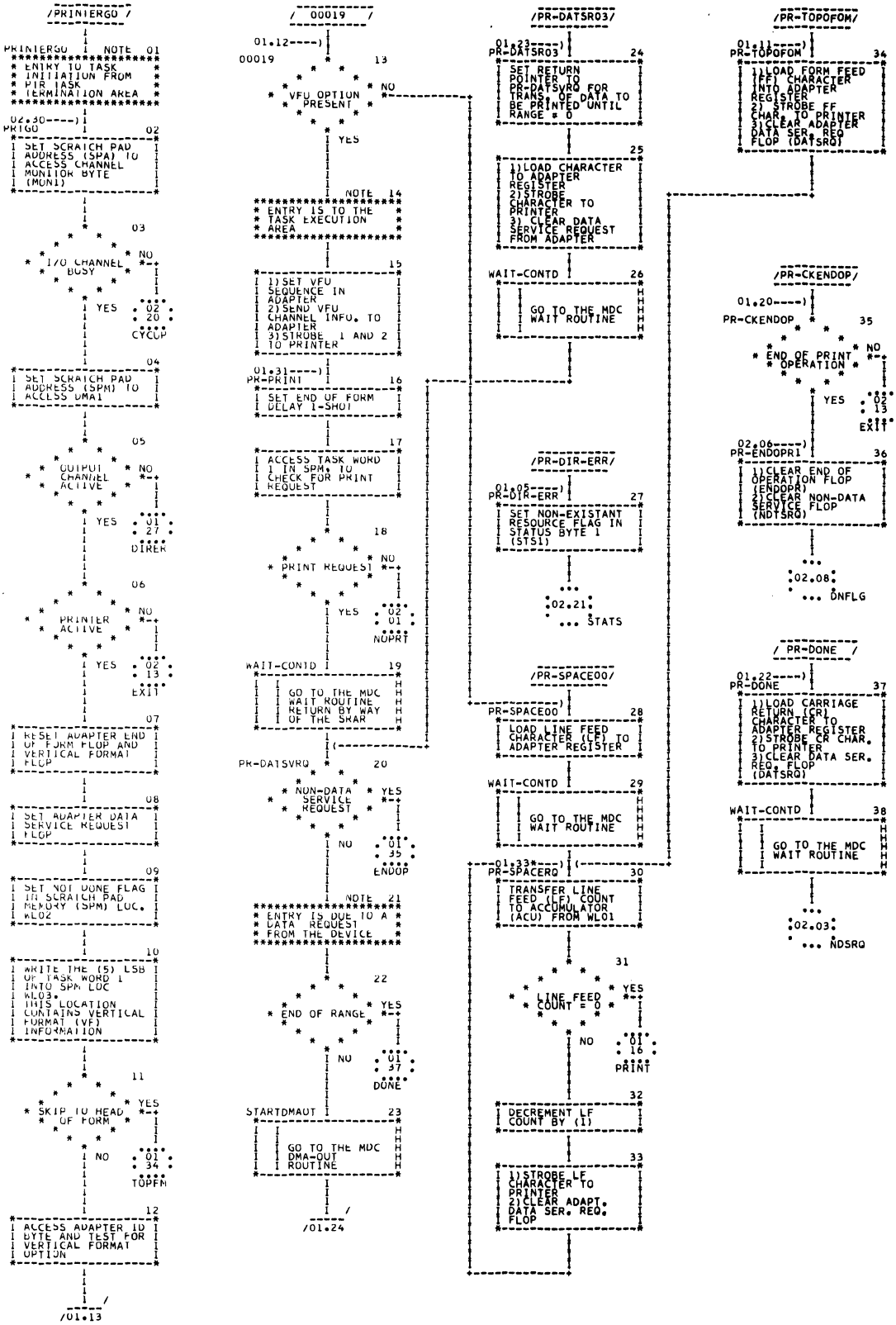

Figure 3-3 Printer Adapter Firmware Intermediate Flowchart (Sheet 1 of 2)

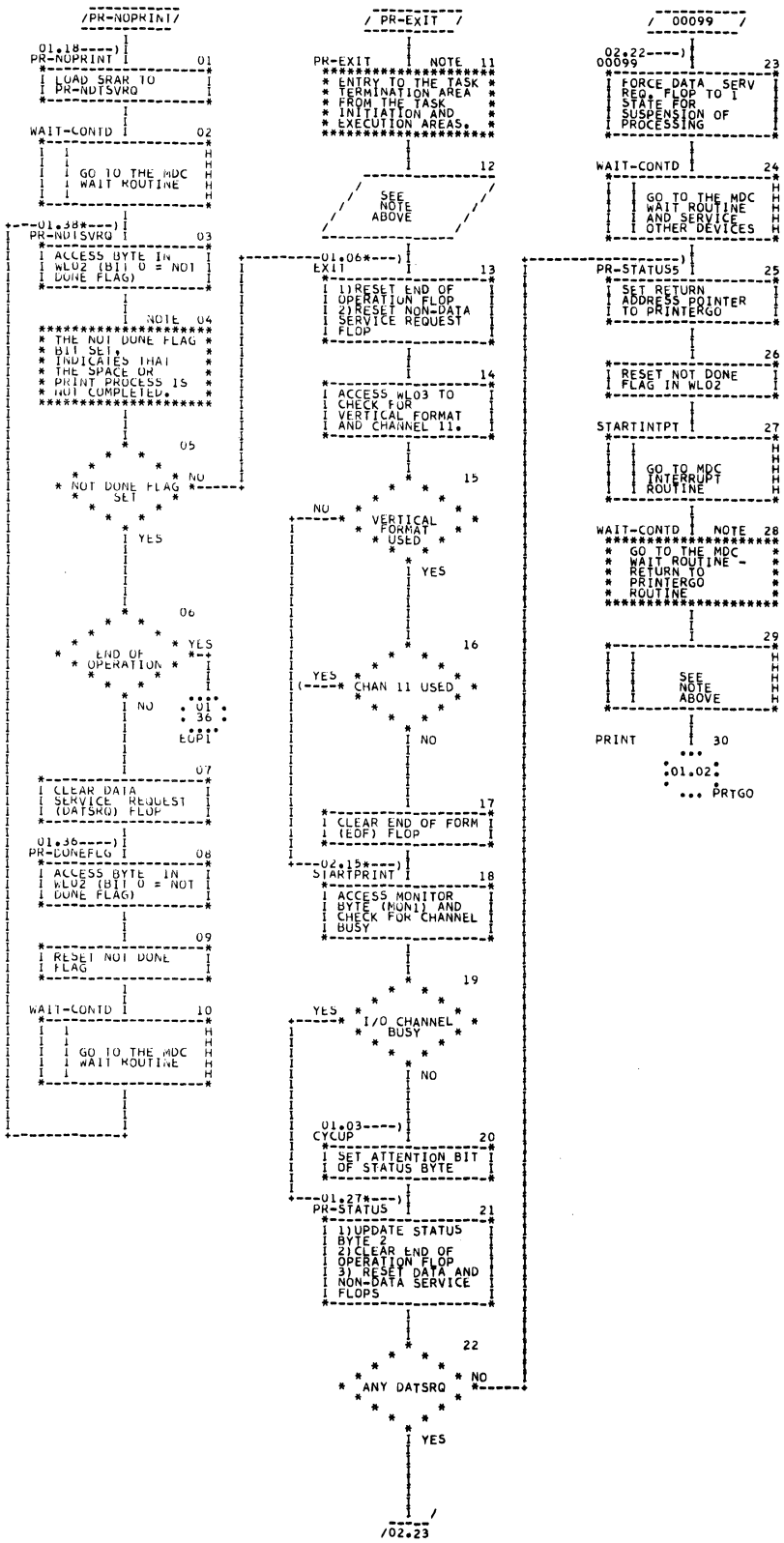

Figure 3-3 Printer Adapter Firmware Intermediate Flowchart (Sheet 2 of 2)

Appendix A
Installation

Tables A-1 and A-2 show the pin to pin relationship of signals within each of the two shielded cables used to connect the printer adapter to the line or serial printers.

This cable data is provided as supplemental reference material in the event that cable pin/signal information should be required for installation or maintenance purposes.

Table A-1 Adapter/Line Printer Cable Signals

NAME	PADDLE BOARD PIN NUMBER	PRINTER CONN. PIN NUMBERS
ZGNDY01	1	D, J, N, T, X b, k, c
LPCHN1+	2	B
LPCHN2+	3	F
LPCNH3+	4	L
LPCHN4+	5	R
LPCHN5+	6	V
LPCHN6+	7	Z
LPCHN7+	8	n
96CHAR+	9	a
VFUOPT+	10	e
LPCONT-	11	x
—	12	—
—	13	—
LPREDY+	14	CC
LPONLN+	15	y
LPVFUS+	16	p
LPEOFX+	17	M
LPDEMD+	18	E
—	19	—
LP5VLT+	20	HH
—	21	—
—	22	—
—	23	—
—	24	—
—	25	—
—	26	—
LPSTRB+	27	j
ZGNDY01	28	EE, AA, C, P, m, s, v, h

Table A-2 Adapter/Serial Printer Cable Signals

NAME	PADDLE BOARD PIN NUMBER	PRINTER CONN. PIN NUMBERS
ZGNDY01	1, 10, 11, 12	20, 21, 22, 23, 24, 25, 26, 35
LPCHN1+	2	2
LPCHN2+	3	3
LPCHN3+	4	4
LPCHN4+	5	5
LPCHN5+	6	6
LPCHN6+	7	7
LPCHN7+	8	8
96CHAR+	9	36
VFUOPT+	10	—
LPCONT-	11	—
SERLID-	12	—
—	13	—
—	14	—
LPONLN+	15	32
—	16	—
LPEOFX+	17	14
LPDEMD+	18	10
—	19	—
LP5VLT+	20	18
—	21	—
—	22	—
—	23	—
—	24	—
—	25	—
—	26	—
LPSTRB+	27	1
ZGNDY01	28	19, 28, 29, 16

APPENDIX B
GLOSSARY

This glossary describes terms and mnemonics having special meaning for the printer adapter.

Glossary of Printer Adapter Firmware Terms
(Sheet 1 of 2)

TERM	DEFINITION
ACU	Accumulator; 8-bit register used for storing results of ALU operations
AD1	Adapter data register; 8-bit register used by the printer adapter as the print buffer
AD3/AD4	Adapter status registers 1 and 2; during write operations, used as control bytes 1 and 2, respectively, for setting functional firmware bits.
Attention Flag	Bit 1 of status byte 1; used to indicate that the printer has changed state (on or off line)
Channel Not Busy	MDC condition; no programmed I/O activity in progress on the device
DATSRQ	Data service request; signal sent to the MDC to indicate that the adapter requested a data byte
Device Online	I/O device condition; indicates that device is powered up and ready to service information
DID1/DID2	Most significant and least significant bytes, respectively, of the device identification code
Direct Memory Access (DMA)	Procedure of making direct access to consecutive locations of memory a specific number (range) of times.
DMA1	Direct memory access flag byte; 8-bit control byte set and reset by Bus Request firmware routine
Identification Code	Two scratch pad memory locations used to identify the input/output device (see DID1/DID2)
MDC Firmware Routines	A set of common routines used by I/O device processes to perform such functions as data transfers and interrupts; e.g., WAIT routine
MON1	Channel monitor flag byte; 8-bit control byte.
NDTSRQ	Nondata service request; signal sent to the MDC to indicate a change in state of the device, e.g., from on line to off line
PR:aa...a	Up to 10-character entry point name to routine within printer adapter firmware
Range	Number of data characters to be transferred to the printer
Software Status Word	Two scratch pad memory locations used by software; consists of two bytes: STS1, least significant byte, and STS2, most significant byte

Glossary of Printer Adapter Firmware Terms
(Sheet 2 of 2)

TERM	DEFINITION
SPA	Scratch pad address; address of any location within scratch pad memory
STS1/STS2	Least significant and most significant bytes, respectively, of software status word. (See Figure 3-3.)
Task Word	Two scratch pad memory locations used by software to specify type of space and print operations to be performed by the next IOLD command; consists of two bytes: TSK1, least significant byte, and TSK2, most significant byte. (See Figure 3-1.)
VFU	Vertical format unit
VFUSEQ	VFU sequence bit within adapter control byte 1 (AD3)
WL01	Work location 1 of SPM; 8-bit scratch pad memory used by printer adapter firmware as a line feed counter (See Figure 3-3.)
WLO2	Work location 2 of SPM; 8-bit scratch pad memory, bit 0 of which is used for NDONE flag. (See Figure 3-1.)
WL03	Work location 3 of SPM; 8-bit scratch pad memory used for storing the 5 low-bits of the LSB of the Task Word. (See Figure 3-1.)
RFU	Reserved for future use
NDONE	Firmware flag stored in WL02; indicates operation done when in Zero state
IOLD	Input/Output Load, a software instruction which loads address and range, causing execution of a task.

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