IBM

Personal Computer Hardware Reference Library

Technical Reference

Options and Adapters

Volume 1

6137804

IBM

Personal Computer
Hardware Reference
Library

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Options and Adapters

Volume 1

Revised Edition (April 1984)

Federal Communications Commission Radio Frequency Interference Statement

Warning: The equipment described herein has been certified to comply with the limits for a Class B computing device, pursuant to Subpart J of Part 15 of the FCC rules. Only peripherals (computer input/output devices, terminals printers, etc.) certified to comply with the Class B limits may be attached to the computer. Operation with non-certified peripherals is likely to result in interference to radio and TV reception. If peripherals not offered by IBM are used with the equipment, it is suggested to use shielded grounded cables with in-line filters if necessary.

CAUTION
The product described herein is equipped with a grounded plug for the user's safety. It is to be used in conjunction with a properly grounded receptacle to avoid electrical shock.

Preface

The options and adapters manual is the second part of the *Technical Reference* publication. It is designed to be used in conjunction with any of the *Technical Reference* system unit manuals.

The information in this publication is for reference, and is intended for hardware and program designers, programmers, engineers, and anyone else with a knowledge of electronics and/or programming who needs to understand the design and operation of the options and adapters available for the IBM Personal Computer family of products.

This manual is modular in format, with each module providing information about a specific option or adapter available for the IBM Personal Computer family of products. Modules having a large amount of text contain individual indexes.

The modules are grouped by type of device. To find a specific module:

1. Locate the full length hard tab with the type of device (Displays, Printers, Storage Devices, etc.) printed on it that describes the option or adapter you need information about.

2. Open the book to that section.

3. Leaf through that section to find the proper module.

The front matter of this manual also provides a "System to Adapter Compatibility Chart," to identify the adapters supported by each system, and an "Option to Adapter Compatibility Chart," to identify the options supported by each adapter.

Notes:

System to Adapter Compatibility Chart

The following chart identifies the adapters supported by each system.

	IBM Personal Computer	IBM Personal Computer XT	IBM Portable Personal Computer	IBM Personal Computer AT	IBM Expansion Unit
64KB Memory Module Kit	Yes	Yes	Yes	No	No
64/256KB Memory Expansion Option	Yes	Yes	Yes	No	No
128KB Memory Expansion Option	No	No	No	Yes	No
256KB Memory Expansion Option	Yes	Yes	Yes	No	No
512KB Memory Expansion Option	No	No	No	Yes	No
Monochrome Display and Printer Adapter	Yes	Yes	No	Yes	No
Color/Graphics Monitor Adapter	Yes	Yes	Yes	Yes	No
Printer Adapter	Yes	Yes	Yes	No	Yes
5 1/4 inch Diskette Drive Adapter	Yes	Yes	Yes	No	No
Fixed Disk Drive Adapter	Yes	Yes	No	No	Yes

System to Adapter Compatibility Chart (Part 1 of 2)

	IBM Personal Computer	IBM Personal Computer XT	IBM Portable Personal Computer	IBM Personal Computer AT	IBM Expansion Unit
Fixed Disk and Diskette Adapter	No	No	No	Yes	No
Asynchronous Communications Adapter	Yes	Yes	Yes	No	Yes
Serial/Parallel Adapter	No	No	No	Yes	No
Binary Synchronous Communications Adapter	Yes	Yes	Yes	Yes	Yes
Synchronous Data Link Control (SDLC) Adapter	Yes	Yes	Yes	Yes	Yes
Cluster Adapter	Yes	Yes	Yes	Yes	Yes
Game Control Adapter	Yes	Yes	Yes	Yes	Yes
Prototype Card	Yes	Yes	Yes	No	Yes
Prototype Adapter	No	No	No	Yes	No
Enhanced Graphics Adapter	Yes	Yes	No	Yes	No
Professional Graphics Controller	No	Yes	No	Yes	Yes
GPIB Adapter	Yes	Yes	Yes	Yes	Yes
Data Acquisition Adapter	Yes	Yes	Yes	Yes	Yes
P C Network	Yes	Yes	Yes	Yes	No

System to Adapter Compatibility Chart (Part 2 of 2)

Option to Adapter Compatibility Chart

Because some adapters perform multiple functions, the following chart identifies the options supported by each adapter.

	Slimline Diskette Drive	Double Sided Diskette Drive	5 1/4″ Diskette Drives	High Capacity Diskette Drive	Fixed Disk Drive	20MB Fixed Disk Drive	Monochrome Display	Color Display	Graphics Printer	Compact Printer	Color Printer	RF Modulator	Light Pen	Joystick	Enhanced Graphics Display	Professional Graphics Display	Data Acquisition and Control Adapter Distribution Panel
5 1/4″ Diskette Drive Adapter	X		X														
Fixed Disk Drive Adapter					X												
Fixed Disk and Diskette Drive Adapter		X		X		X											
Color Graphics Monitor Adapter								X				X	X				
Monochrome Display and Printer Adapter							X		X		X						
Printer Adapter									X		X						
Asynchronous Communications Adapter										X							
Serial/Parallel Adapter									X	X	X						
Game Control Adapter														X			
Enhanced Graphics Adapter															X		
Professional Graphics Controller																X	
Data Acquisition and Control Adapter																	X

X - Adapter compatible with Option

Option to Adapter Compatability Chart

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Personal Computer Hardware Reference Library

IBM Expansion Unit

IBM Expansion Unit

6361468

Contents

Description

The IBM Expansion Unit option enhances the system unit by adding expansion slots in a separate unit. This option consists of an extender card, expansion unit cable, and the expansion unit. The expansion unit contains a power supply, an expansion board, and a receiver card. This option utilizes one expansion slot in the system unit to provide seven additional expansion slots in the expansion unit.

Expansion Unit Cable

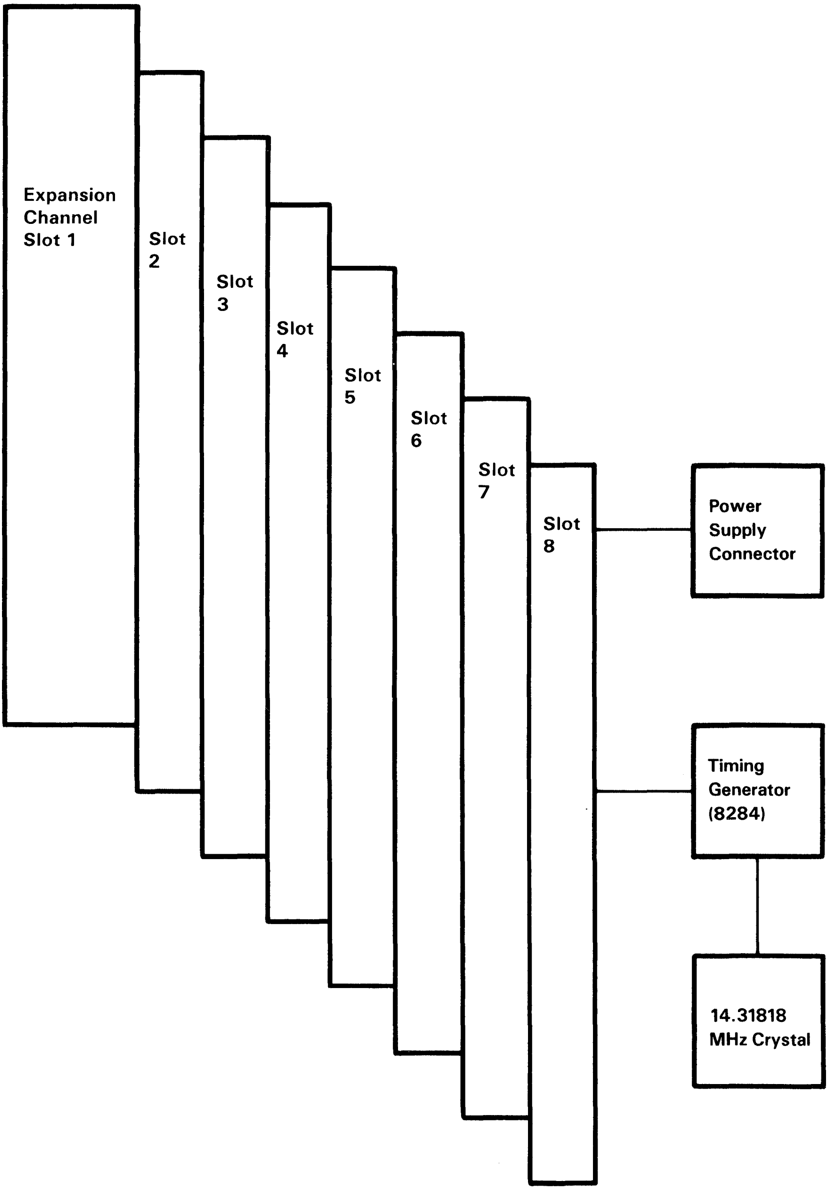
The expansion unit cable consists of a 56-wire, foil-shielded cable terminated on each end with a 62-pin D-shell male connector. Either end of the expansion unit cable can be plugged into the extender card or the receiver card.

Expansion Board

The expansion board is a support board that carries the I/O channel signals from the option adapters and receiver card. These signals, except 'osc,' are carried over the expansion unit cable. Because 'osc' is not sent over the expansion cable, a 14.31818-MHz signal is generated on the expansion board. This signal may not be in phase with the 'osc' signal in the system unit.

Decoupling capacitors provided on the expansion board aid in noise filtering.

The following is a block diagram of the expansion board.



Expansion Board Block Diagram

Power Supply

The expansion unit dc power supply is a 130-watt, 4 voltage-level switching regulator. It is integrated into the expansion unit and supplies power for the expansion unit and its options. The dc output voltages for the power supply are listed in the following table:

Voltage (Vdc)	Current (Amps)		Regulation (Tolerance)	
Nominal	Minimum	Maximum	+ %	- %
+ 5.0	2.3	15.0	5	4
- 5.0	0.0	0.3	10	8
+ 12.0	0.4	4.2	5	4
- 12.0	0.0	0.25	10	9

Vdc Output

All power levels are regulated with overvoltage and overcurrent protection. The input is fused and is either 120 Vac or 220/240 Vac. If dc overload or overvoltage conditions exist, the supply automatically shuts down until the condition is corrected. The supply is designed for continuous operation at 130 watts.

The power supply is located at the right rear of the expansion unit. It provides two separate connections for power to the fixed disk drives and supplies operating voltages to the expansion board through two "keyed" connectors that plug into a 12-pin male connector on the expansion board.

Vac Output

The receptacle at the rear of the power supply is a nonstandard connector designed to be used only for the IBM Monochrome Display. The power supply provides a filtered ac output that is switched on and off with the main power switch. The maximum current available at this output is 1 ampere for the 120-volt power supply and 0.5 amperes for the 220/240-volt power supply.

Overvoltage and Overcurrent Protection

Voltage Nominal Vac	Type Protection	Rating Amps
110	Fuse	5
220	Fuse	3

Power On/Off Cycle: When the power supply is switched Off for a minimum of 1.0 second, and then switched On, the 'power good' signal is regenerated.

The 'power good' signal indicates that there is adequate power to continue processing. If the power goes below the specified levels, the 'power good' signal triggers a system shutdown.

This signal is the logical AND of the dc output-voltage 'sense' signal and the ac input-voltage 'fail' signal. This signal is TTL-compatible up-level for normal operation or down-level for fault conditions. The ac 'fail' signal causes 'power good' to go to a down-level when any output voltage falls below the regulation limits.

The dc output-voltage 'sense' signal holds the 'power good' signal at a down level (during power-on) until all output voltages have reached their respective minimum sense levels. The 'power good' signal has a turn-on delay of at least 100 ms but no greater than 500 ms.

The sense levels of the dc outputs are shown in the following table.

Output (Vdc)	Minimum (Vdc)	Sense Voltage Nominal (Vdc)	Maximum (Vdc)
+ 5	+ 4.5	+ 5.0	+ 5.5
- 5	- 4.3	- 5.0	- 5.5
+ 12	+ 10.8	+ 12.0	+ 13.2
- 12	- 10.2	- 12.0	- 13.2

Extender Card

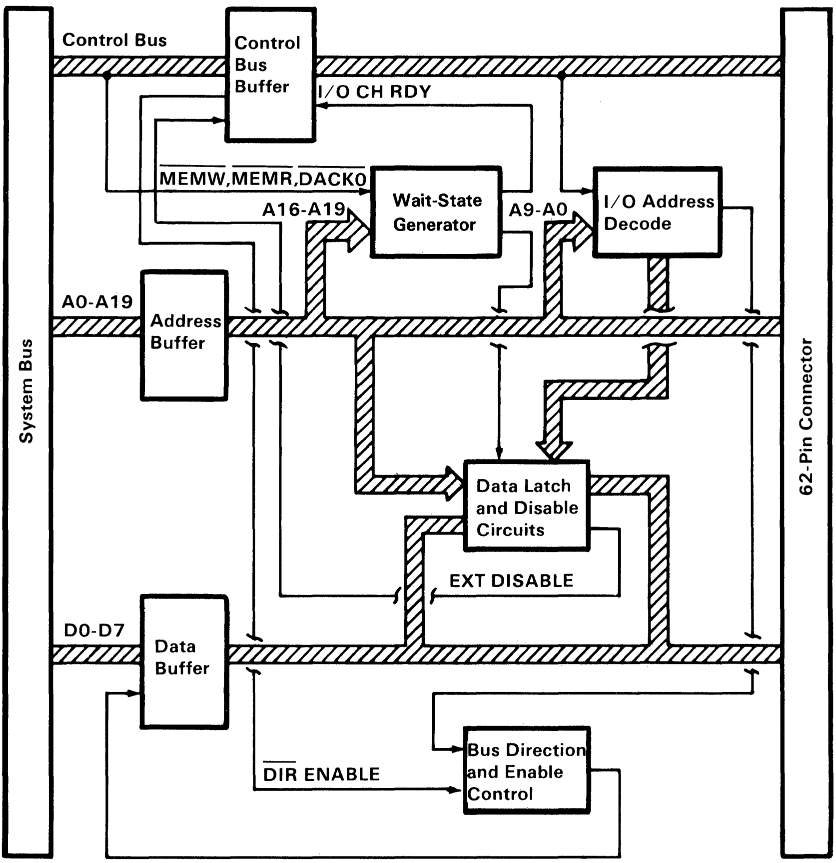
The extender card is a four-plane card. It re-drives the I/O channel to provide sufficient power to avoid capacitive effects of the cable. The extender card presents only one load per line of the I/O channel.

The extender card has a wait-state generator that inserts a wait state on memory-read and memory-write operations (except refreshing) for all memory contained in the expansion unit. The address range for wait-state generation is controlled by switch settings on the extender card.

The dual-in-line package (DIP) switch on the extender card should be set to indicate the maximum contiguous read/write memory in the system unit. The extender card switch settings are described under "Switch Settings" in the *Guide to Operations* manual. Switch positions 1 through 4 correspond to address bits hex A19 to hex A16.

The DIP-switch settings determine which address segments have a wait state inserted during memory-read and memory-write operations. Wait states are required for any memory, including ROM on option adapters, in the expansion unit. Wait states are not inserted in the highest segment, hex addresses F0000 to FFFFF (segment F).

The following is a block diagram of the extender card.

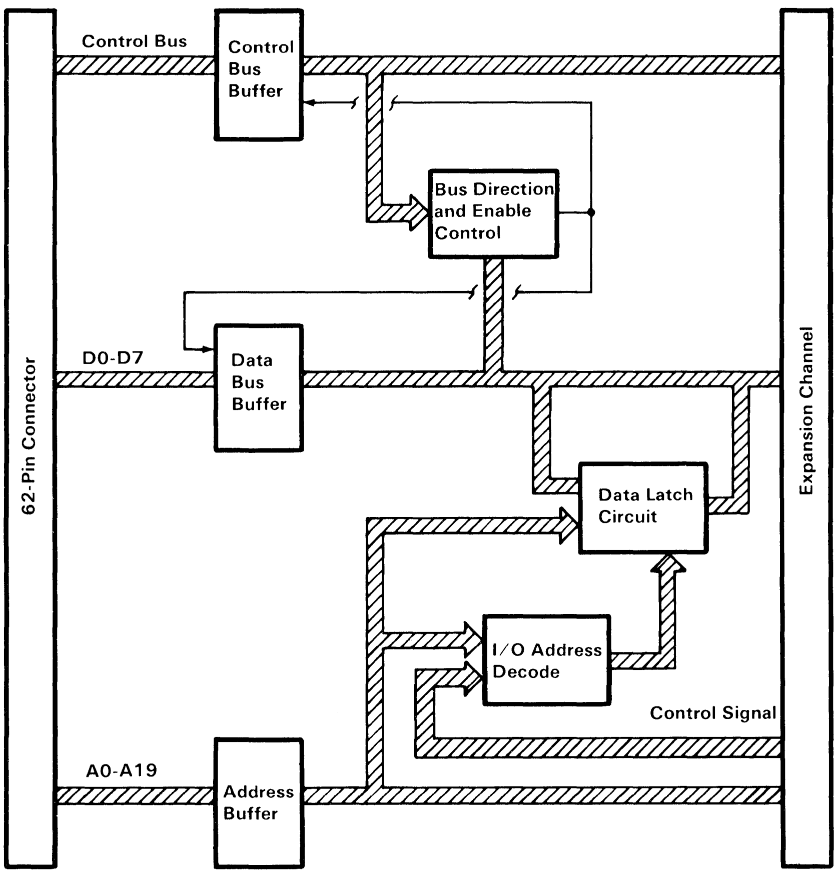


Extender Card Block Diagram

Receiver Card

The receiver card is a four-plane card that fits in expansion slot 8 of the expansion unit. It re-drives the I/O channel to provide sufficient power for additional options and to avoid capacitive effects. Directional control logic is contained on the receiver card to resolve contention and direct data flow on the I/O channel. Steering signals are transmitted back through the expansion unit cable for use on the extender card.

The following is a block diagram of the receiver card.



Receiver Card Block Diagram

Programming Considerations

Several registers associated with the Expansion Unit option are programmable and readable for diagnostic test purposes. The following figures indicate the locations and functions of the registers on the extender card and receiver card.

Location	Function
Memory FXXXX(*)	Write to memory to latch address bits
Port 210	Write to latch expansion bus data (ED0 - ED7)
Port 210	Read to verify expansion bus data (ED0 - ED7)
Port 211	Read high-order address bits (A8 - A15)
Port 211	Write to clear wait test latch
Port 212	Read low-order address bits (A0 - A7)
Port 213	Write 00 to disable expansion unit
Port 213	Write 01 to enable expansion unit
Port 213	Read status of expansion unit D0 = enable/disable D1 = wait-state request flag D2-D3 = not used D4-D7 = switch position 1 = Off 0 = On
(*) Example:	Write to memory location F123:4 = 00 Read Port 211 = 12 Read Port 212 = 34
(All values in hexadecimal)	

Extender Card Registers

Location	Function
Memory FXXXX(*)	Write to memory to latch address bits
Port 214	Write to latch data bus bits (D0 - D7)
Port 214	Read data bus bits (D0 - D7)
Port 215	Read high-order address bits (A8 - A15)
Port 216	Read low-order address bits (A0 - A7)
(*) Example:	Write to memory location F123:4 = 00 Read Port 215 = 12 Read Port 216 = 34
(All values in hexadecimal)	

Receiver Card Registers

The expansion unit is automatically enabled upon power-up. Both the extender card and receiver card will be written to, if the expansion unit is not disabled when writing to FXXXX. However, the system unit and the expansion unit are read back separately.

Interface

All signals found on the system unit's I/O channel will be provided to expansion slots in the expansion unit, with the exception of the 'osc' signal and the system unit's power supply voltages.

A 'ready' line on the expansion channel makes it possible to operate with slow I/O or memory devices. If the channel's I/O 'ch rdy' line is not activated by an addressed device, all microprocessor-generated memory cycles take five microprocessor clock cycles per byte for memory in the expansion unit.

The following table contains a list of all the signals that are re-driven by the extender and receiver cards, and their associated time delays. The delay times include the delay due to signal propagation in the expansion unit cable. Assume a nominal cable delay of 3 ns. As such, device access will be less than 260 ns.

Signal	Nominal Delay (ns)	Maximum Delay (ns)	Direction (*)
A0 - A19	27	39	Out
AEN	27	39	Out
DACK0 - DACK3	27	39	Out
$\overline{\text{MEMR}}$	27	39	Out
$\overline{\text{MEMW}}$	51	75	Out
$\overline{\text{IOR}}$	51	75	Out
$\overline{\text{IOW}}$	27	39	Out
ALE	27	39	Out
CLK	27	39	Out
T/C	27	39	Out
RESET	27	39	Out
IRQ2 - IRQ7	36	(**)	In
DRQ1 - DRQ3	36	(**)	In
I/O CH RDY	36	51	In
$\overline{\text{I/O CH CK}}$	36	51	In
D0 - D7 (Read)	84	133	In
D0 - D7 (Write)	19	27	Out

(*) With resepct to the system unit.

(**) Asynchronous nature of interrupts and other requests are more dependent on microprocessor recognition than electrical signal propagation through expansion logic.

Specifications

Size	
Height	142 mm (5.5 in.)
Width	500 mm (19.6 in.)
Depth	410 mm (16.1 in.)
Weight	14.9 kg (33 lb)
Power Cable	
Length	1.83 m (6 ft)
Size	18 AWG
Signal Cable	
Length	1 m (3.28 ft)
Size	22 AWG

Physical Specifications

Voltage (Vac)			**Frequency (Hz)**	**Current (Amps)**
Nominal	Minimum	Maximum	± 3 Hz	Maximum
110	90	137	60	3 at 90 Vac
220/240	180	259	50	1.6 at 180 Vac

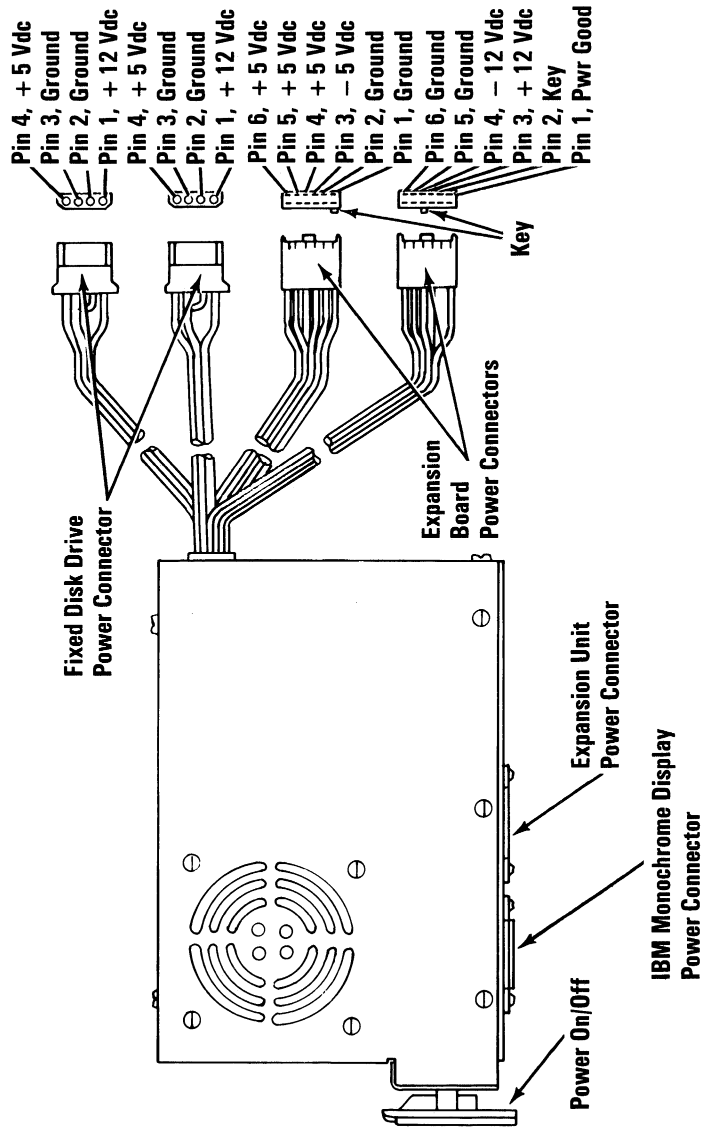
Input Requirements

Environment	
Air Temperature	
System On	15.6 to 32.2°C (60 to 90°F)
System Off	10 to 43°C (50 to 110°F)
Humidity	
System On	8 to 80%
System Off	20 to 80%
Heat Output	717 BTU/hr

Additional Specifications

Power Supply

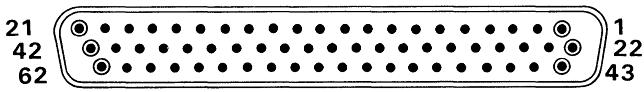
The power supply pin configurations and locations follow:



Power Supply and Connectors

Extender Card and Receiver Card

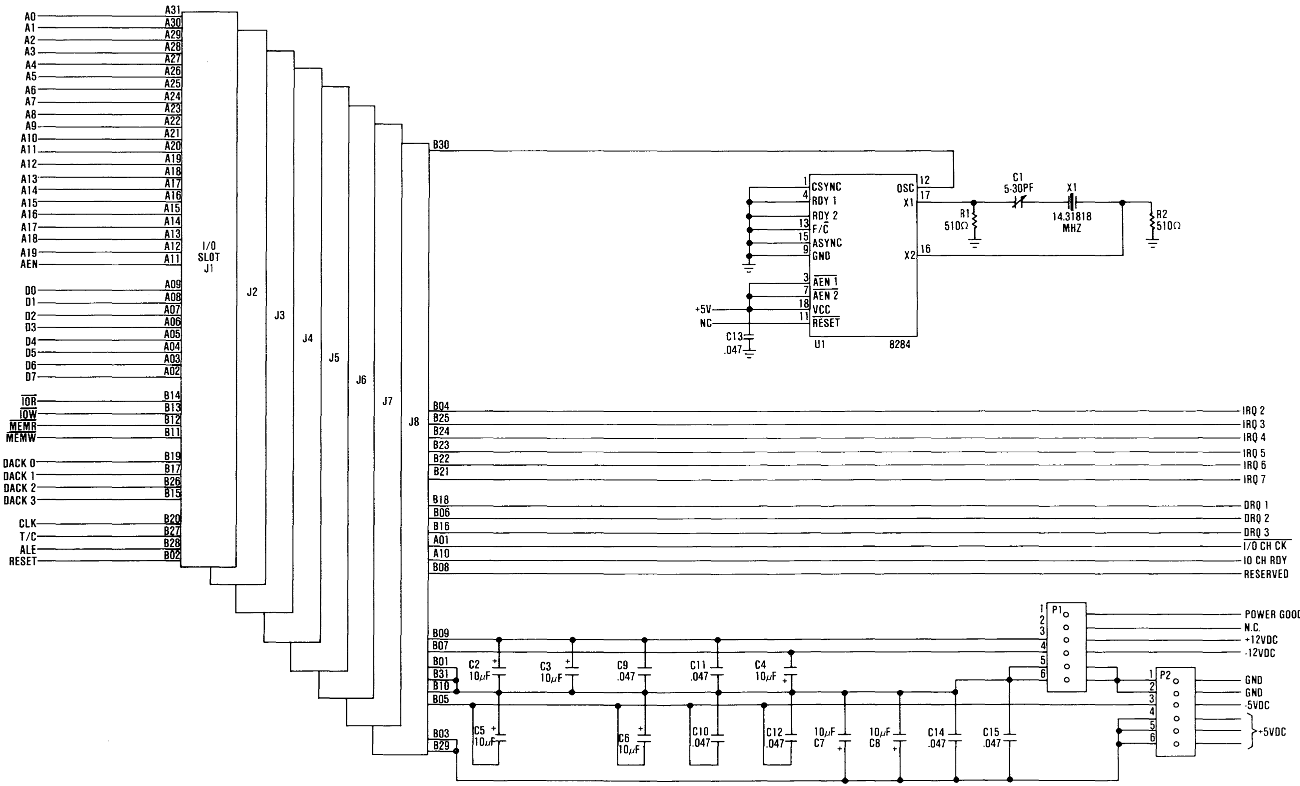
The extender card and receiver card rear-panel connectors are the same. Pin and signal assignments for the extender and receiver cards are shown below.



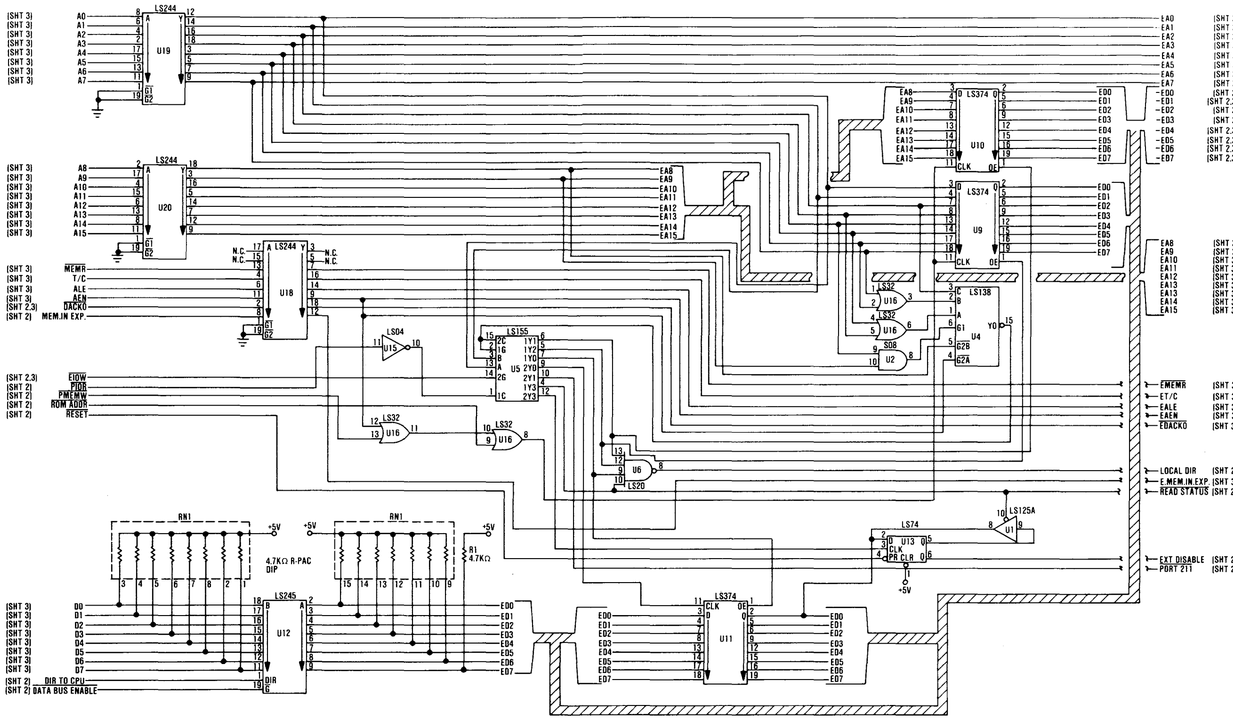
Pin	Signal	Pin	Signal	Pin	Signal
1	+E IRQ6	22	+E D5	43	+E IRQ7
2	+E DRQ2	23	+E DRQ1	44	+E D6
3	+E DIR	24	+E DRQ3	45	+E I/O CH RDY
4	+E ENABLE	25	RESERVED	46	+E IRQ3
5	+E CLK	26	+E ALE	47	+E D7
6	-E MEM IN EXP	27	+E T/C	48	+E D1
7	+E A17	28	+E RESET	49	-E I/O CH CK
8	+E A16	29	+E AEN	50	+E IRQ2
9	+E A5	30	+E A19	51	+E DO
10	-E DACKO	31	+E A14	52	+E D2
11	+E A15	32	+E A12	53	+E D4
12	+E A11	33	+E A18	54	+E IRQ5
13	+E A10	34	-E MEMR	55	+E IRQ4
14	+E A9	35	-E MEMW	56	+E D3
15	+E A1	36	+E A0	57	GND
16	+E A3	37	-E DACK3	58	GND
17	-E DACK1	38	+E A6	59	GND
18	+E A4	39	-E IOR	60	GND
19	-E DACK2	40	+E A8	61	GND
20	-E IOW	41	+E A2	62	GND
21	+E A13	42	+E A7		

E = Extended

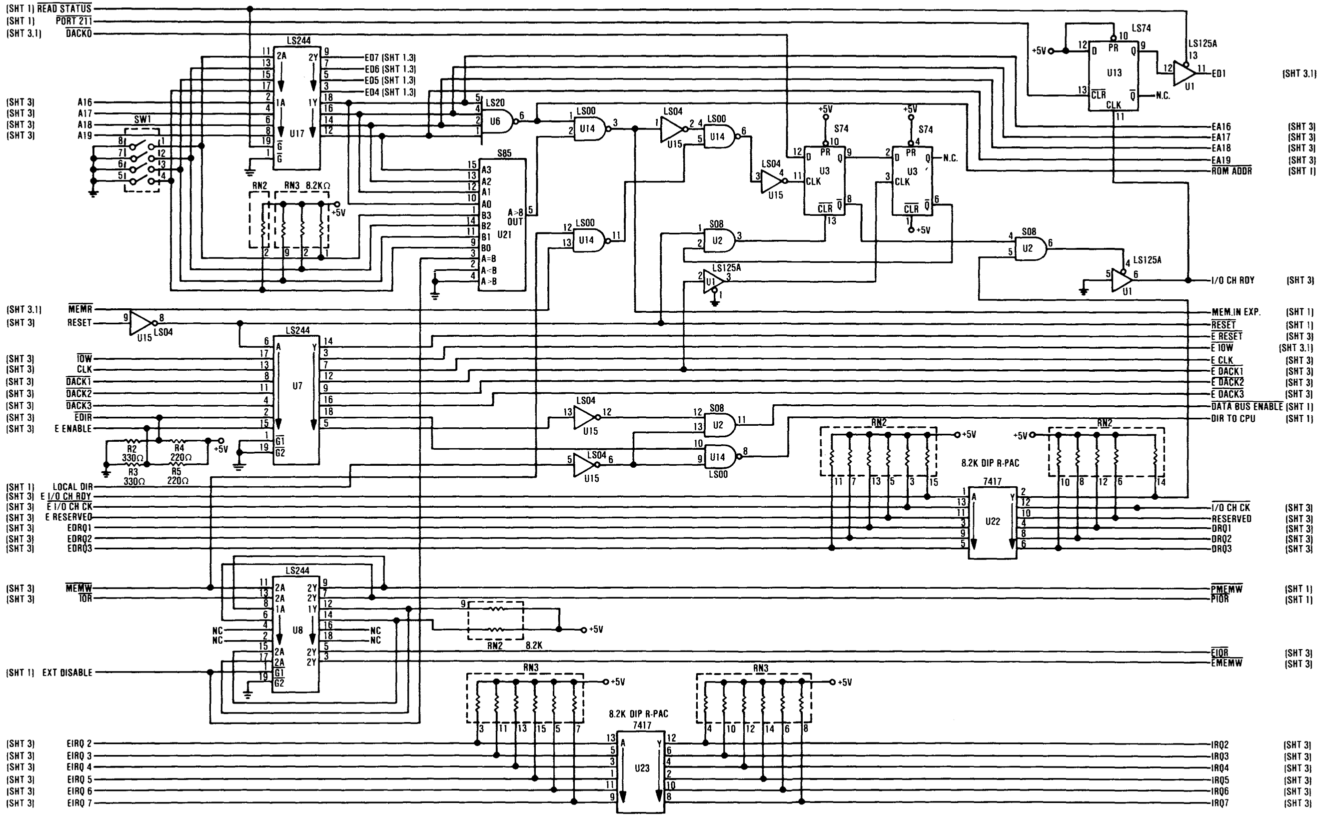
Connector Specifications



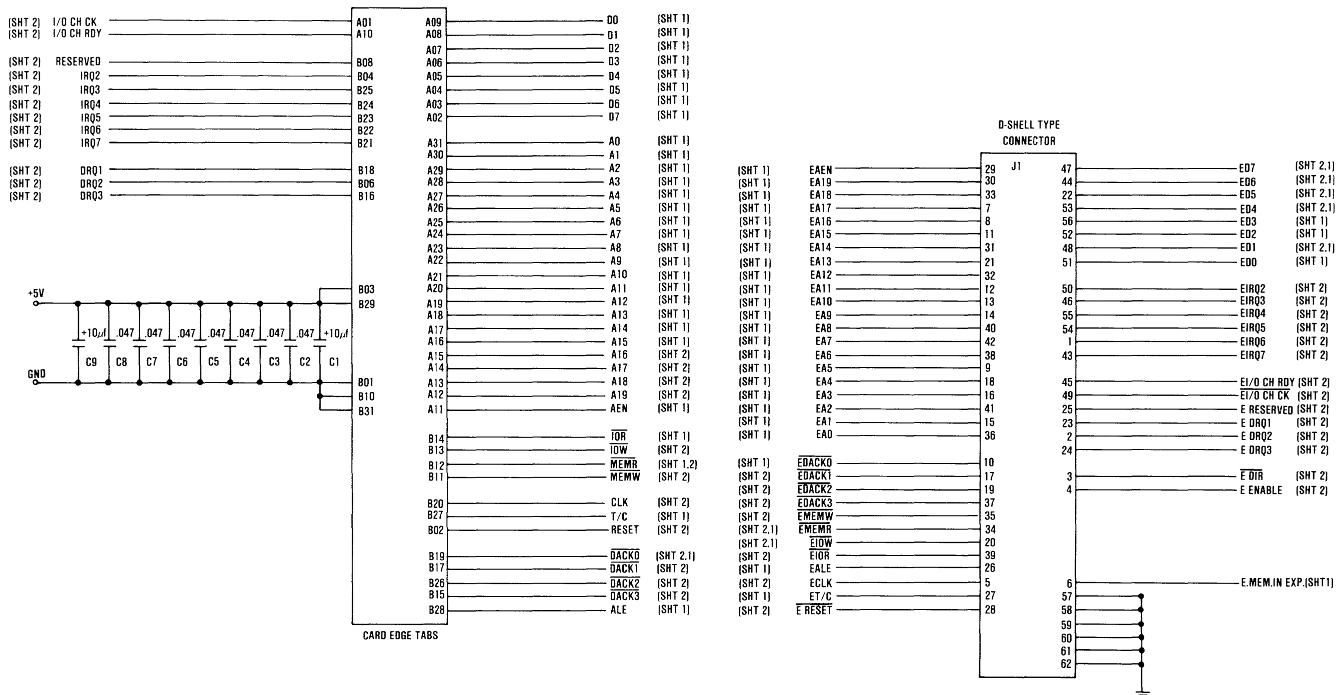
Expansion Board (Sheet 1 of 1)



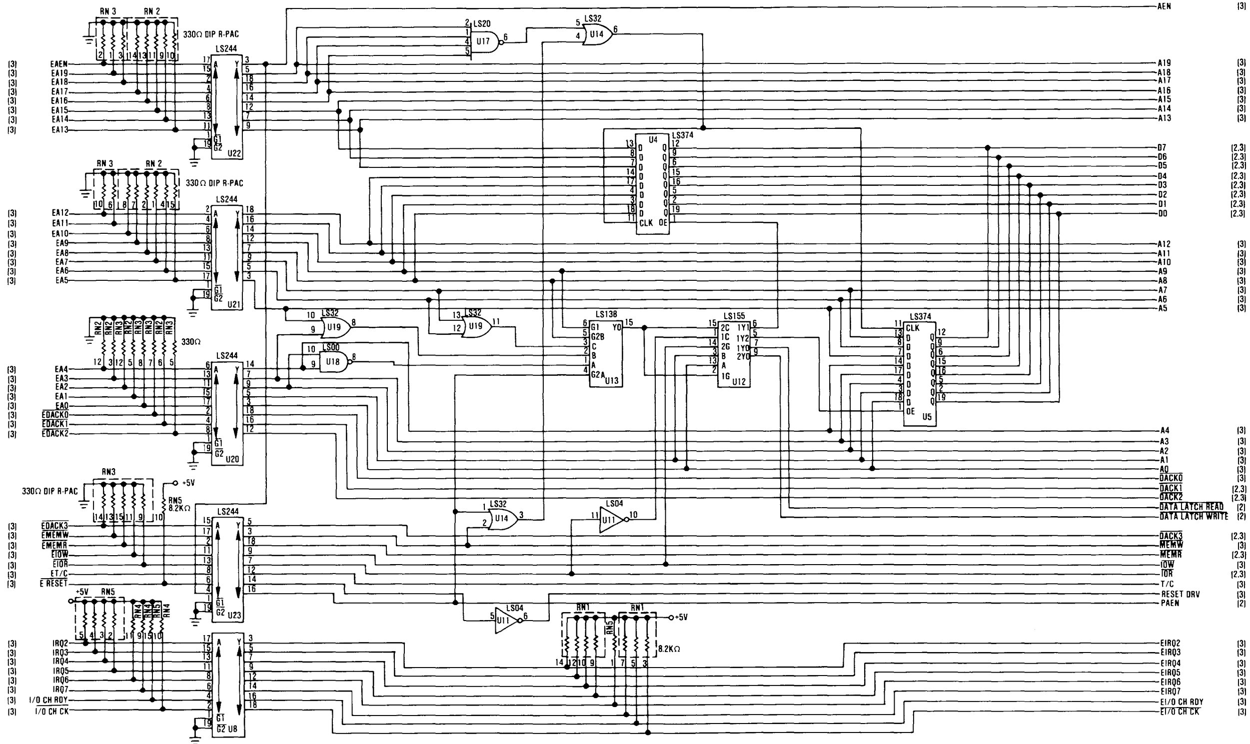
Extender Card (Sheet 1 of 3)



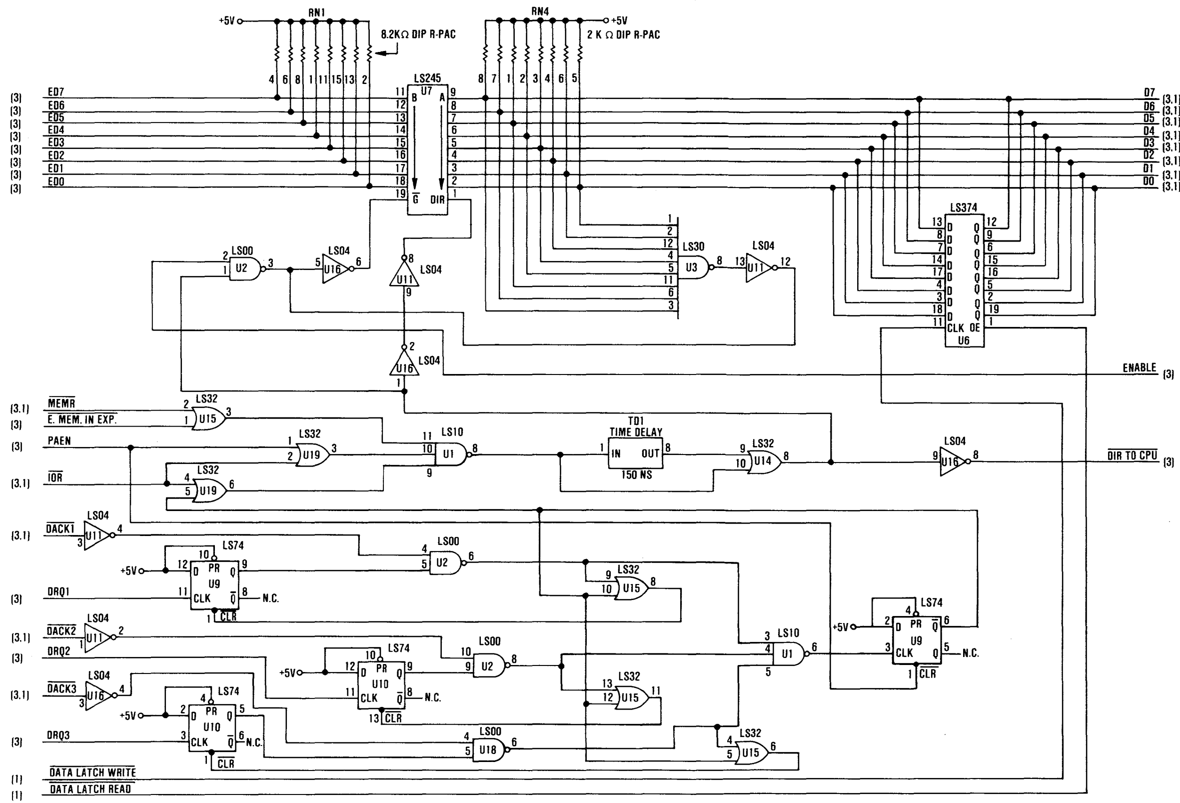
Extender Card (Sheet 2 of 3)



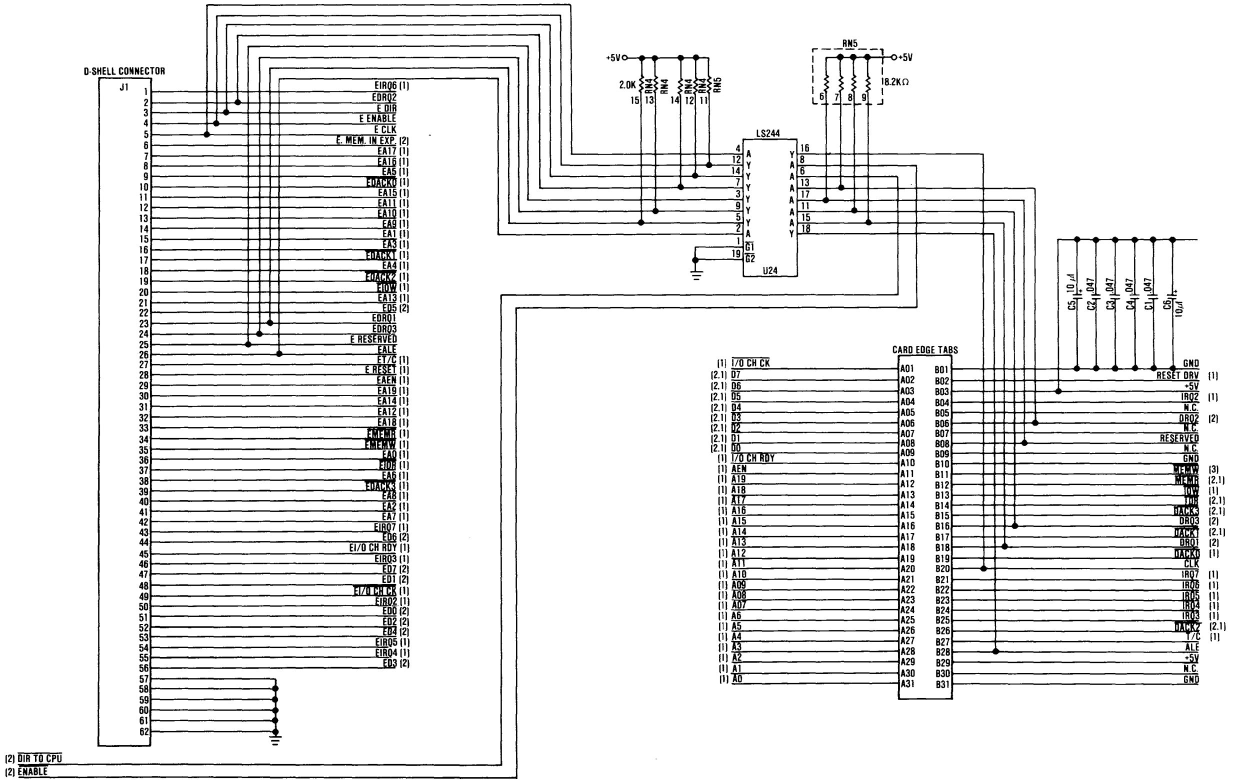
Extender Card (Sheet 3 of 3)



Receiver Card (Sheet 1 of 3)



Receiver Card (Sheet 2 of 3)



Receiver Card (Sheet 3 of 3)

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IBM Monochrome Display

6361474

IBM Monochrome Display

Contents

Description

The high resolution IBM Monochrome Display connects to the system unit through two cables. One cable is a signal cable from the display adapter to the display, and the other provides power to the display from the system unit. This arrangement eliminates the need for a wall outlet and allows the system-unit Power switch to control power to the display. The display unit has a 28.3 cm (11.5 in.) diagonal, 90° deflection cathode ray tube (CRT). The display may be placed on the system unit or on a nearby table or desk. Brightness and contrast controls are on the front surface and are easily accessible to the operator.

The characteristics of the display are as follows:

- Screen
  - High-persistence, green phosphor (P39).
  - Etched surface to reduce glare.
  - Presentation of 80 characters wide by 25 rows deep.
  - Characters are defined in a 14 PEL-high by 9 PEL-wide matrix.
- Video Signal
  - Maximum bandwidth of 16.257 MHz at -3dB
- Vertical Drive
  - Screen refreshed at 50 Hz with 350 lines of vertical resolution and 720 lines of horizontal resolution
- Horizontal Drive
  - Positive level, TTL-compatibility, at a frequency of 18.432 kHz

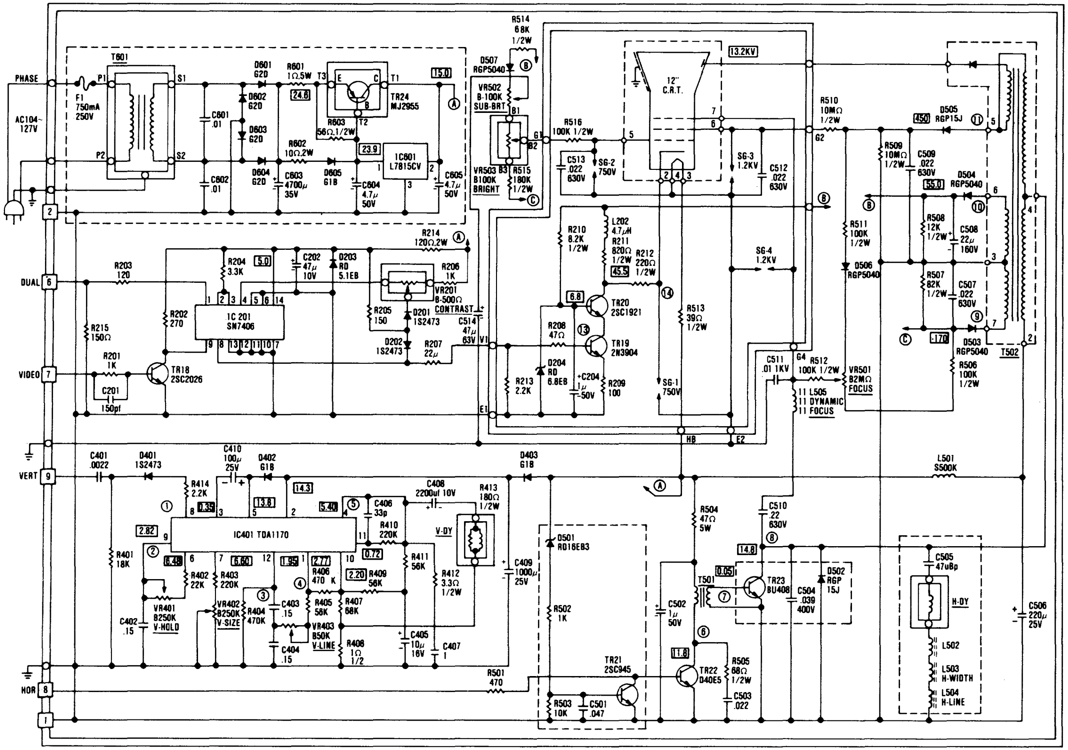
Specifications

Size	
Height	280 mm (11 in.)
Length	380 mm (14.9 in.)
Depth	350 mm (13.7 in.)
Weight	7.9 kg (17.3 lb)
Heat Output	325 BTU/hr
Power Cable	
Length	0.914 m (3 ft)
Size	18 AWG
Signal Cable	
Length	1.22 m (4 ft)
Size	22 AWG

Physical Specifications

Logic Diagrams

The IBM Monochrome Display has two models: a 110-Vac model and a 220/240-Vac model. A logic diagram for each follows.



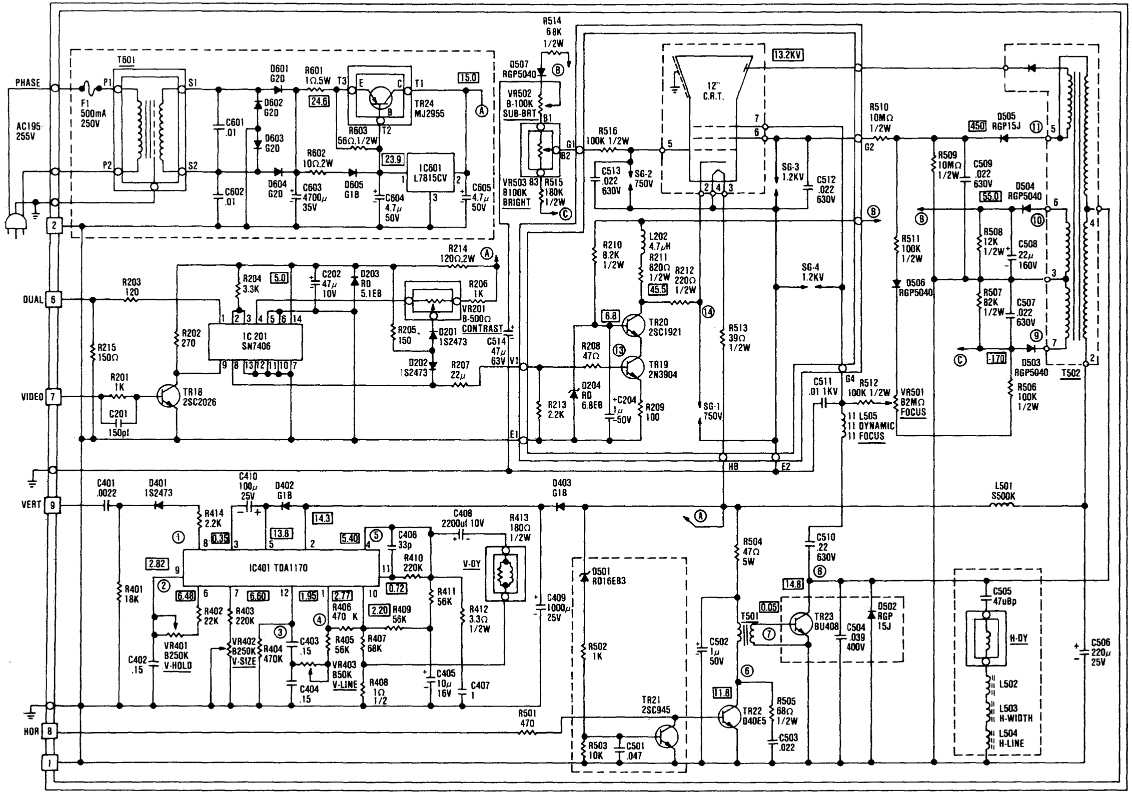
110Vac Monochrome Display (Sheet 1 of 1)

DANGER

HAZARDOUS VOLTAGES UP TO 450 VOLTS EXIST ON THE PRINTED CIRCUIT BOARDS

NOTES:
1. RESISTOR VALUES ARE IN (OHM) Ω K = 1000Ω M = 1,000,000Ω
2. ALL RESISTOR ARE 1/4W EXCEPT WHERE OTHERWISE INDICATED.
3. ALL CAPACITORS ARE 50V EXCEPT WHERE OTHERWISE INDICATED.
4. CAPACITORS VALUES ARE μF UNLESS OTHERWISE INDICATED μ = μF = 10^{-6}.
5. AC WIRING INFORMATION
   PHASE = BLACK/BROWN WIRE
   NEUTRAL = WHITE/BLUE WIRE
   GROUND = GREEN AND YELLOW WIRE

IMPORTANT: THE PHASE WIRE MUST GO TO THE FUSED SIDE OF TRANSFORMER.



DANGER

HAZARDOUS VOLTAGES UP TO 450 VOLTS EXIST ON THE PRINTED CIRCUIT BOARDS

NOTES:
1. RESISTOR VALUES ARE IN (OHM) Ω K = 1000Ω M = 1,000,000Ω
2. ALL RESISTOR ARE 1/4W EXCEPT WHERE OTHERWISE INDICATED.
3. ALL CAPACITORS ARE 50V EXCEPT WHERE OTHERWISE INDICATED.
4. CAPACITORS VALUES ARE μF UNLESS OTHERWISE INDICATED μ = μF = 10^{-6}.
5. AC WIRING INFORMATION
   PHASE = BLACK/BROWN WIRE
   NEUTRAL = WHITE/BLUE WIRE
   GROUND = GREEN AND YELLOW WIRE

IMPORTANT: THE PHASE WIRE MUST GO TO THE FUSED SIDE OF TRANSFORMER.

220/240Vac Monochrome Display (Sheet 1 of 1)

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IBM Portable Personal Computer Display

6361472

IBM Portable Personal Computer Display

Contents

Description

The IBM Portable Personal Computer Display attaches internally to the Color/Graphics Monitor Adapter in the system unit and to the power supply. A cable provides the composite drive signals from the Color/Graphics Monitor Adapter to the display. Another cable provides dc power to the display from the power supply.

The IBM Portable Personal Computer Display is designed to blank out the color-burst signal generated by the Color/Graphics Monitor Adapter. Blanking keeps the color-burst signal from appearing on the composite video screen.

The display is a 228.6 mm (9 in.), amber cathode ray tube (CRT). Brightness and Contrast controls on the front panel are easily accessible.

The characteristics of the display are as follows:

Screen

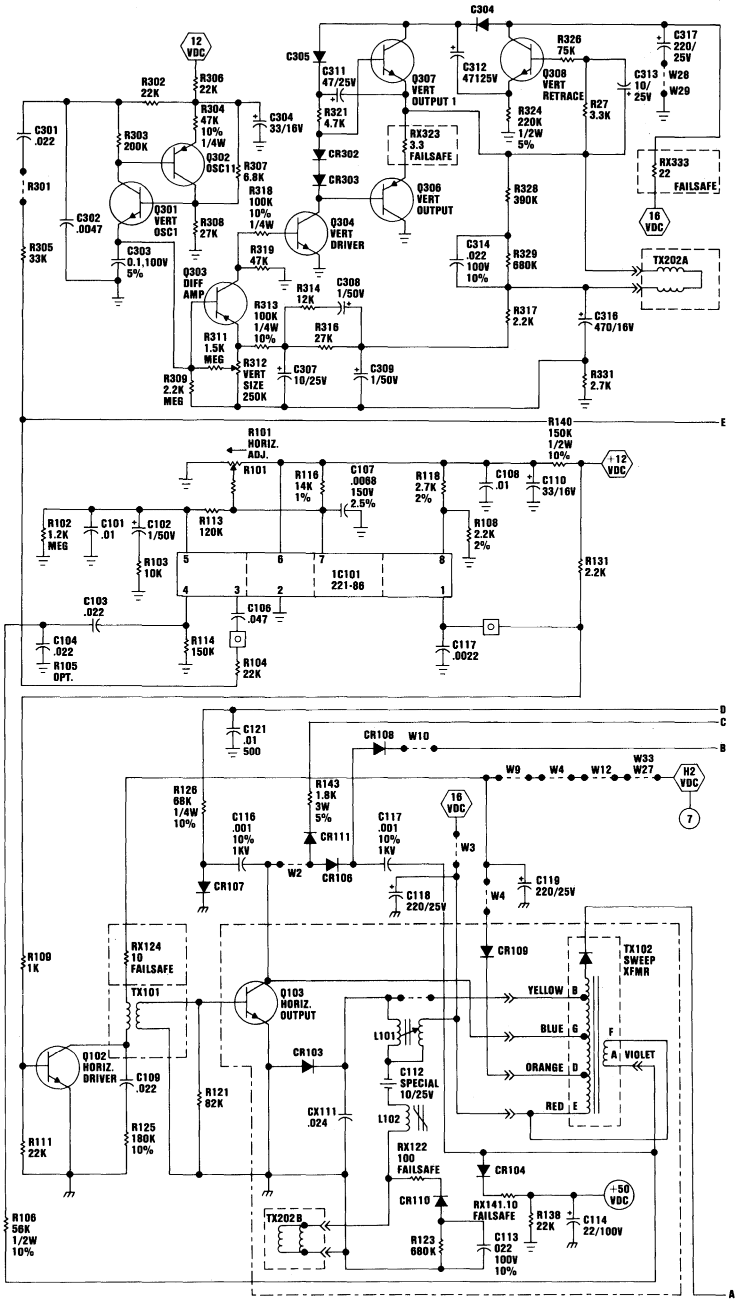
- Medium-persistence, amber phosphor (LA)
- Etched surface to reduce glare
- 80-character by 25-line image
- Characters are defined in a 8 PEL-high by 8 PEL-wide matrix

Composite Video Signal

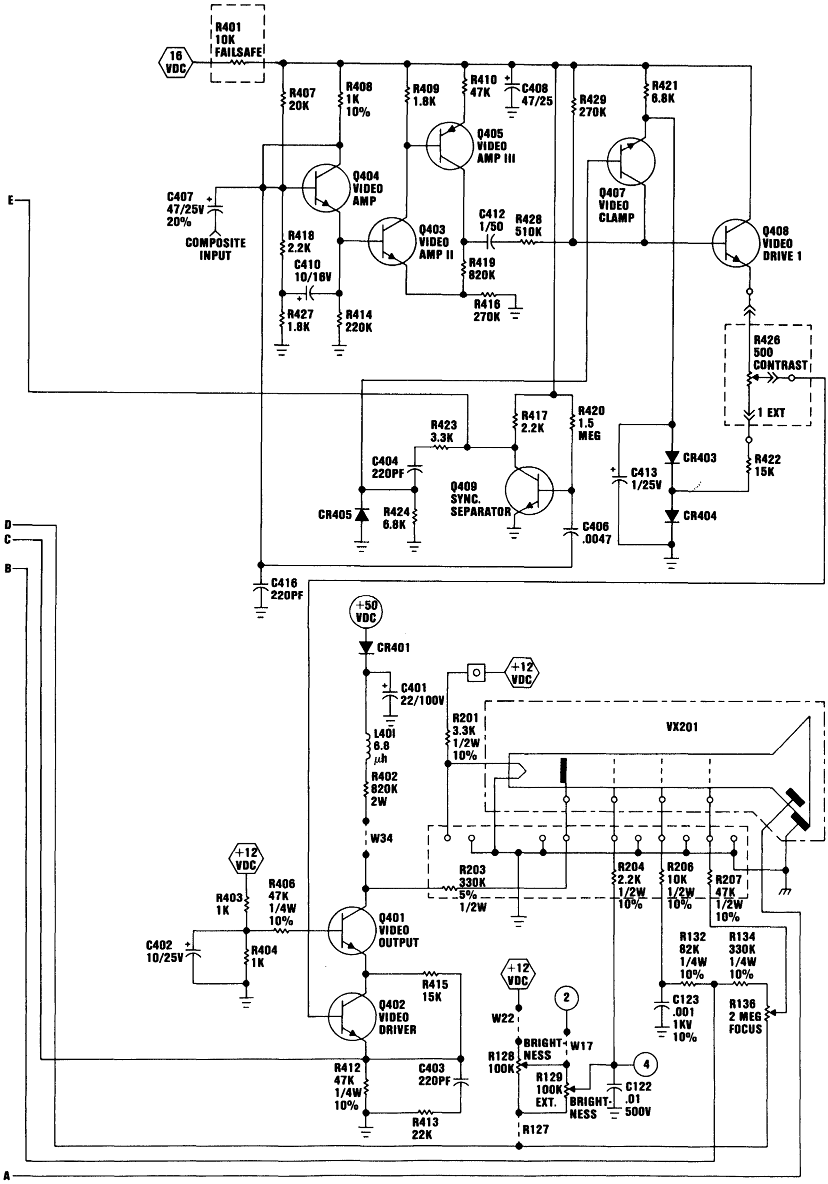
- 1.5 Vdc (peak to peak)
- 60 Hz refresh rate
- 15.75 kHz horizontal scan rate

Logic Diagrams

The following pages contain the logic diagrams for the IBM Portable Personal Computer Display.



Portable Personal Computer Display (Sheet 1 of 2)



Portable Personal Computer Display (Sheet 2 of 2)

Notes:

Personal Computer Hardware Reference Library

IBM Color Display

6361470

IBM Color Display

Contents

Description

The IBM Color Display connects to the system unit with a signal cable of approximately 1.5 meters (5 feet) in length. This signal cable is a direct-drive interface from the Color/Graphics Monitor Adapter.

A second cable provides power to the display from an electrical outlet. The display unit has its own power control and indicator and will accept either 120-volt 60-Hz or 220-volt 50-Hz power. The power supply in the display automatically switches to match the applied power.

The display has a 340-millimeter (13-inch) CRT. The display may be placed on the system unit or on a nearby table or desk. The front panel of the display has a Power-On control, Power-On indicator, Brightness control, and Contrast control. The rear panel has the Vertical Hold and Vertical Size controls.

The characteristics of the IBM Color Display are as follows:

- Screen
  - High contrast (black).
  - Displays up to 16 colors when used with the IBM Color/Graphics Monitor Adapter.
  - Presentation of 80 characters wide by 25 rows deep.
  - Characters are defined in an 8 PEL-high by 8 PEL-wide matrix.
- Video Signal
  - Red, green, and blue signals, and intensity are independent.

- Vertical Drive
  - Positive synchronous, TTL-compatible
  - Frequency 50/60 Hz
  - Non-interlaced operation
- Horizontal Drive
  - Positive-level, TTL compatibility, at a frequency of 15.75 kHz.

Specifications

Size	
Height	297 mm (11.7 in.)
Length	392 mm (15.4 in.)
Depth	407 mm (15.6 in.)
Weight	11.8 kg (26 lb)
Heat Output	240 BTU/hr
Power Cable	
Length	1.83 m (6 ft)
Size	18 AWG
Signal Cable	
Length	1.5 m (5 ft)
Size	22 AWG

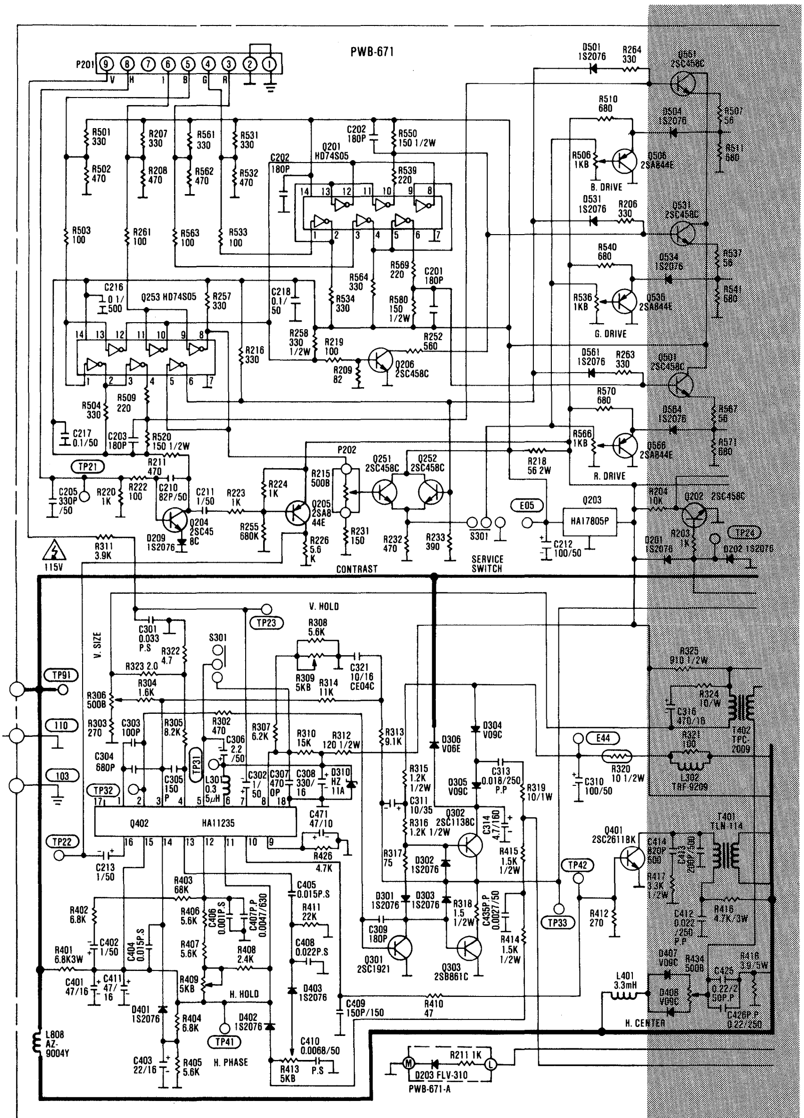
Physical Specifications

Logic Diagram

The following pages contain the logic diagram for the IBM Color Display.

DANGER

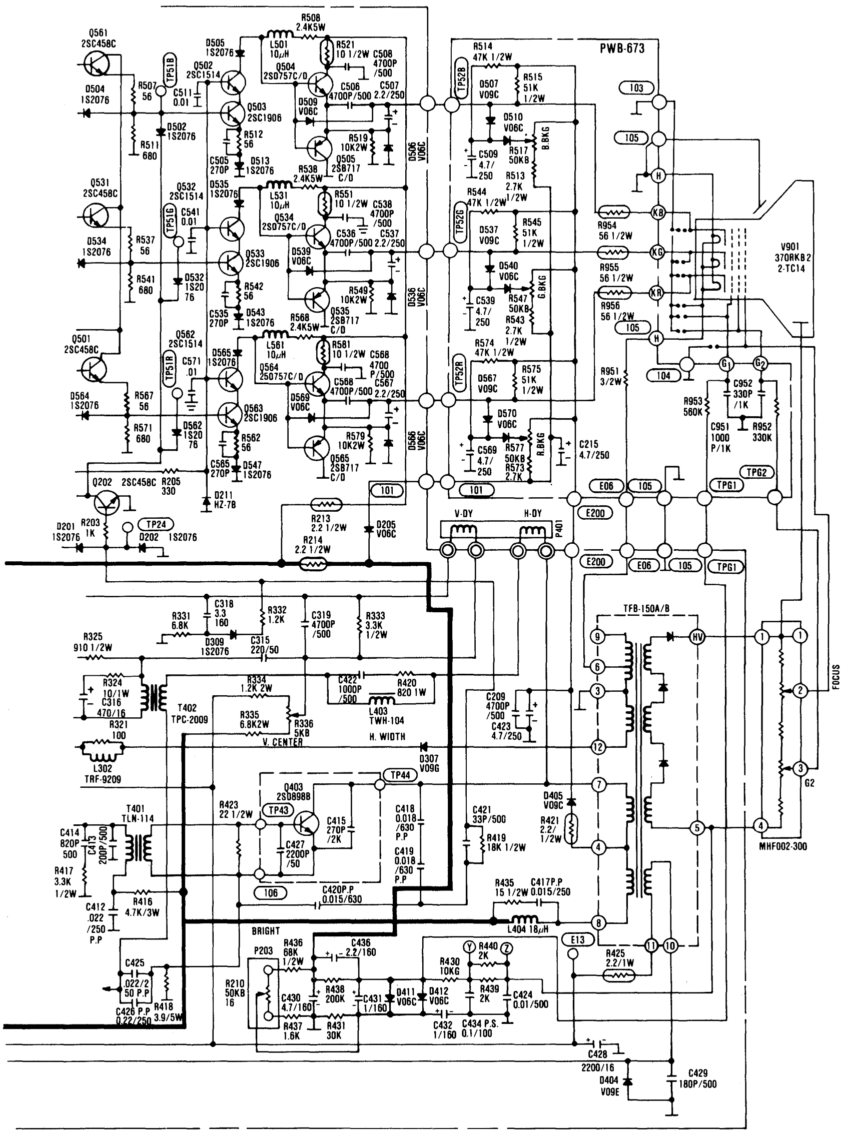
HAZARDOUS VOLTAGES UP TO 450 VOLTS EXIST ON THE PRINTED CIRCUIT BOARDS



Color Display (Sheet 1 of 1)

DANGER

HAZARDOUS VOLTAGES UP TO 450 VOLTS EXIST ON THE PRINTED CIRCUIT BOARDS



Notes:

IBM

Personal Computer Hardware Reference Library

IBM Enhanced Color Display

IBM ENHANCED COLOR DISPLAY

Contents

Description

The IBM Enhanced Color Display is an advanced color display capable of operating in two separate modes. Mode 1 is a 16 color 640 by 200 overscan mode with a horizontal scan frequency of 15.75 kHz. Mode 2 is a 64 color 640 by 350 mode with a horizontal scan frequency of 21.8 kHz. Both modes are non-interlaced. The monitor determines which mode to operate in by decoding the vertical sync polarity.

The IBM Enhanced Color Display attaches to the system unit by a signal cable that is approximately 3.5 feet (1.07 meters) in length. This signal cable provides a direct-drive interface from the IBM Personal Computer.

A second cable provides ac power to the display from a standard wall outlet. The display has its own power control and indicator. Three models are provided. Model 001 is for northern hemisphere operation and operates on 120 volts 50/60 Hz. Model 002 is for northern hemisphere operation and operates on 220/240 volts 50/60 Hz. Model 003 is for southern hemisphere operation and operates on 220/240 volts 50/60 Hz.

The display has a 13-inch, high-contrast CRT. The CRT and analog circuits are packaged in an enclosure so the display may sit either on top of the system unit or on a nearby tabletop or desk. Front panel controls and indicators include: Power-On control, Power-On indicator, Brightness and Contrast controls. Additional controls on the rear of the display are: Vertical Size 1 and Vertical Size 2. There are two service controls on the rear of the unit, black level adjustment and contrast default value adjustment.

Operating Characteristics

Screen

- Etched anti-glare screen
- 0.31mm dot mask
- Displays 16 or 64 colors depending on the mode selected

User Controls

- Brightness control affects the contribution of all input bits by controlling the gain of the video stages. The display contains a protection circuit which may overide this control.
- Contrast control affects the contribution of the least significant bits only. When pushed in, the contrast control is rendered inoperative and contrast is determined by the setting of the contrast default value adjustment on the rear of the display. Pulling the contrast control knob out engages the front contrast control.
- V. Size 1 control controls the vertical size of the screen in mode 1.
- V. Size 2 control controls the vertical size of the screen in mode 2.

Service Controls

- Black level adjust control is adjusted to make the raster lines just disappear when black input signal is supplied.
- Contrast default value control is used to set the contrast value when the front contrast control is pushed in. Normally adjust for best brown color.

Vertical Sync

- Uses polarity of Vertical Sync signal to automatically select Mode 1 or Mode 2 operation. Mode 1 is selected by a normally low positive going TTL pulse. Mode 2 is selected by a normally high negative going TTL pulse.

- Screen may be refreshed from 50 to 60 Hz. At 60 Hz there are either 200 or 350 vertical lines of resolution depending on the mode selected.

- 700 μsec retrace time

Horizontal Sync

- Normally low, positive going TTL pulse

- In Mode 1, 15.75 kHz.

- In Mode 2, 21.8 kHz.

- 6 μsec retrace time

When operating in Mode 1, the display maps the 4 input bits into 16 of the possible 64 colors as shown in the following chart.

I	R	G	B	Color	R r	G g	B b
0	0	0	0	Black	0 0	0 0	0 0
0	0	0	1	Blue	0 0	0 0	1 0
0	0	1	0	Green	0 0	1 0	0 0
0	0	1	1	Cyan	0 0	1 0	1 0
0	1	0	0	Red	1 0	0 0	0 0
0	1	0	1	Magenta	1 0	0 0	1 0
0	1	1	0	Brown	1 0	0 1	0 0
0	1	1	1	Gray 1	1 0	1 0	1 0
1	0	0	0	Gray 2	0 1	0 1	0 1
1	0	0	1	Light Blue	0 1	0 1	1 1
1	0	1	0	Light Green	0 1	1 1	0 1
1	0	1	1	Light Cyan	0 1	1 1	1 1
1	1	0	0	Light Red	1 1	0 1	0 1
1	1	0	1	Light Magenta	1 1	0 1	1 1
1	1	1	0	Light Yellow	1 1	1 1	0 1
1	1	1	1	White	1 1	1 1	1 1

Note: The R G and B are the most significant bits. The r g and b are the least significant bits.

Specifications

Size:

Length - 15.4 in (392 mm)

Depth - 15.6 in (407 mm)

Height - 11.7 in (297 mm)

Weight:

32 lbs

Heat Output:

300 BTU/hr

Power Cable:

Length - 6 ft (1.83 m)

Size - 18 AWG

Signal Cable:

Length - 3.5 ft (1.07 m)

Connector Information

The signals that are on the pins vary with the driver card being used and the mode in which it is operating. All signals are expected to be TTL levels supplied by totem pole drivers.

Pin	Mode 1 (16 Color)	Mode 2 (64 Color)
1	Shield Gnd	Ground
2	Signal Gnd	r
3	Red	R
4	Green	G
5	Blue	B
6	Intensity	g
7	Unused	b
8	Horiz Sync	Horiz Sync
9	Vert Sync	Vert Sync

Note: The R G and B are the most significant bits. The r g and b are the least significant bits.

IBM

Personal Computer
Hardware Reference
Library

PROFESSIONAL GRAPHICS DISPLAY

IBM Personal Computer Professional Graphics Display Technical Reference

6138159
August 15,1984

Contents

Description

The IBM Personal Computer Professional Graphics Display is a 640-by-480 PEL color raster display for medium- and high-function graphics and alphanumerics. It operates with separate red, green, and blue analog signals and is can support an infinite number of colors.

The Professional Graphics Display attaches to the system unit through a signal cable that is approximately 1.5 meters (4.9 feet) in length. This cable provides a direct-drive connection from the IBM Professional Graphics Controller. The cable consists of shielded, twisted-pair lines, and has a 9-pin, subminiature, D-shell connector at the system-unit end. The pins have the following functions:

	Signal Name/Description	Pin	
Professional Graphics Display	Red Video	1	Professional Graphics Controller
	Green Video	2	
	Blue Video	3	
	Horizontal and Vertical Sync	4	
	Mode Control	5	
	Ground for Pin 1	6	
	Ground for Pin 2	7	
	Ground for Pin 3	8	
	Ground for Pins 4 and 5	9	

A second cable provides power to the display from a standard wall outlet. The display has its own power control and indicator. Depending on the model number, it accepts either 100 to 127 Vac at 50 to 60 Hz, or 200 to 240 Vac at 50 to 60 Hz.

The display has a 340-millimeter (13-inch) cathode ray tube (CRT). The CRT and analog circuits are enclosed so the display may be placed on top of the system unit or on a nearby tabletop or desk. Front-panel controls and indicators are the Power-On indicator, Power-On control, and Contrast and Brightness controls.

Operating Characteristics

Screen

- High-contrast, antireflection
- Displays an infinite number of colors
- 640 horizontal PELs by 480 vertical PELs

Video Signal

- Maximum video bandwidth of 17 MHz
- Red, green, blue, and synchronization signals are all independent

Synchronization

- Active low, TTL-compatible, at frequencies of 30.12 kHz horizontal, and 60.02 kHz vertical (non-interlaced)

Mode Control

- Active low
- Expands the screen capacity to 400 lines.

Specifications

Size:

Length: 392 mm (15.4 in.)

Depth: 407 mm (15.6 in.)

Height: 297 mm (11.7 in.)

Weight: 14.5 kg (32 lb)

Power Dissipation:

87 Watts Maximum

Power Cable:

Length: 1.8 m (6 ft)

Size: 18 AWG

Signal Cable:

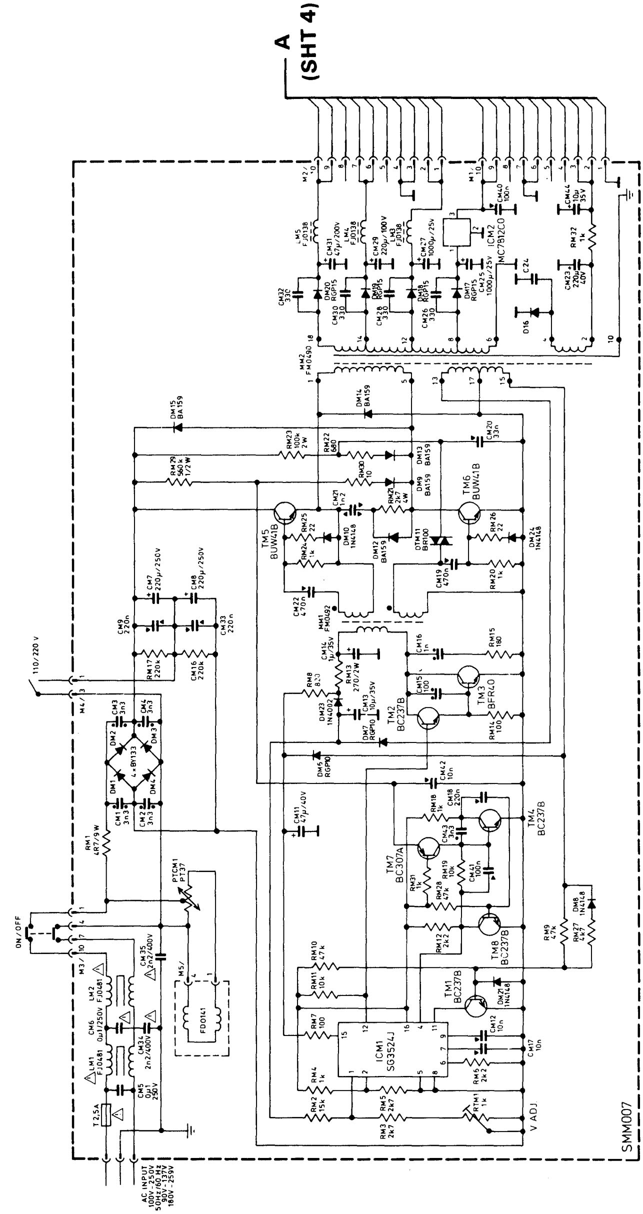
Length: 1.5 m (4.9 ft)

Size: 28 AWG

Notes:

Logic Diagrams

The following are the logic diagrams of the Professional Graphics Display:



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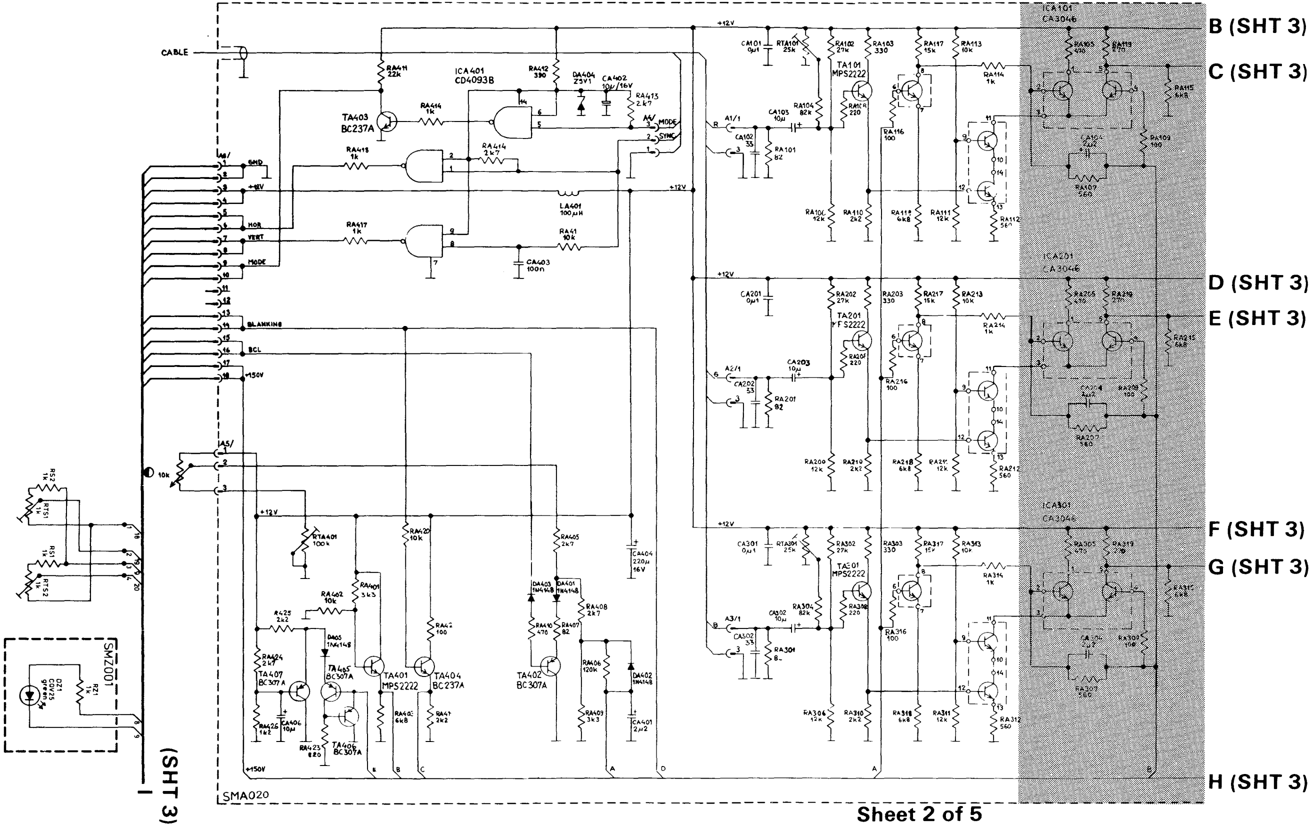
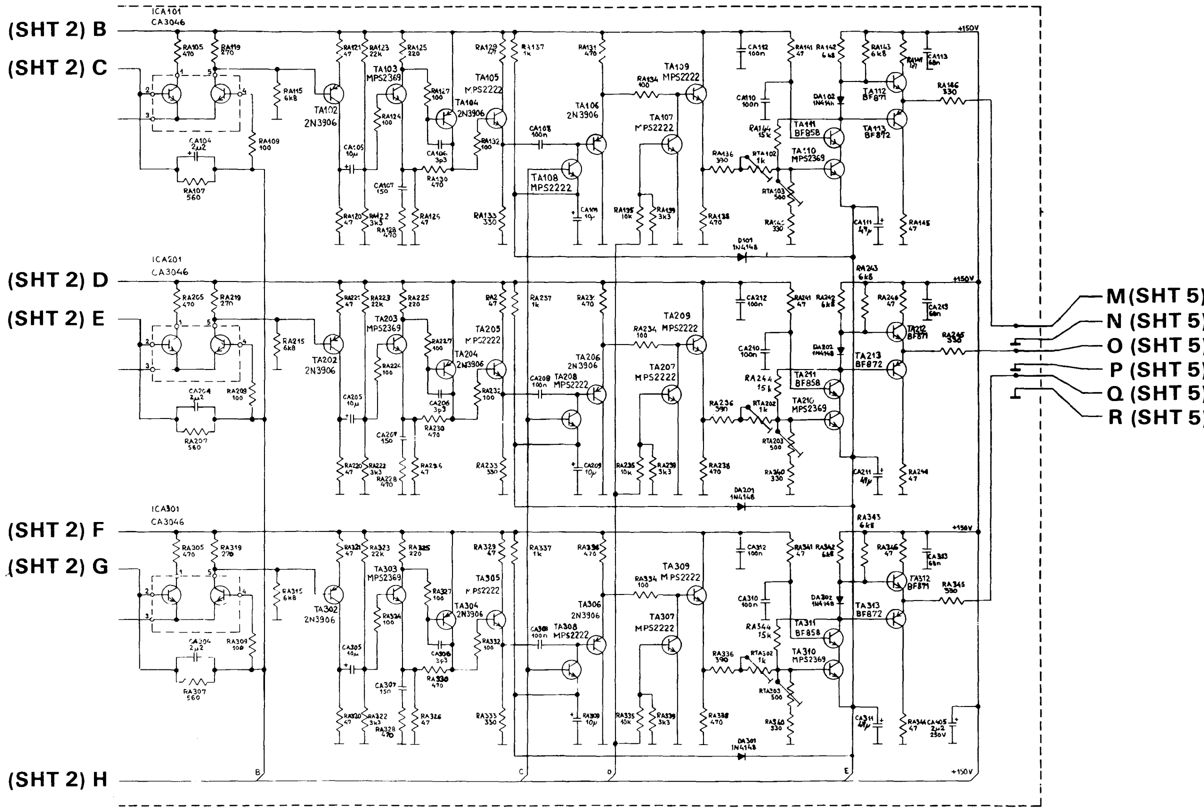
August 15, 1984



Sheet 2 of 5


(SHT 2) B
(SHT 2) C
(SHT 2) D
(SHT 2) E
(SHT 2) F
(SHT 2) G
(SHT 2) H
ICA101
CA3046
ICA201
CA3046
ICA301
CA3046
+150V
M(SHT 5)
N (SHT 5)
O (SHT 5)
P (SHT 5)
Q (SHT 5)
R (SHT 5)

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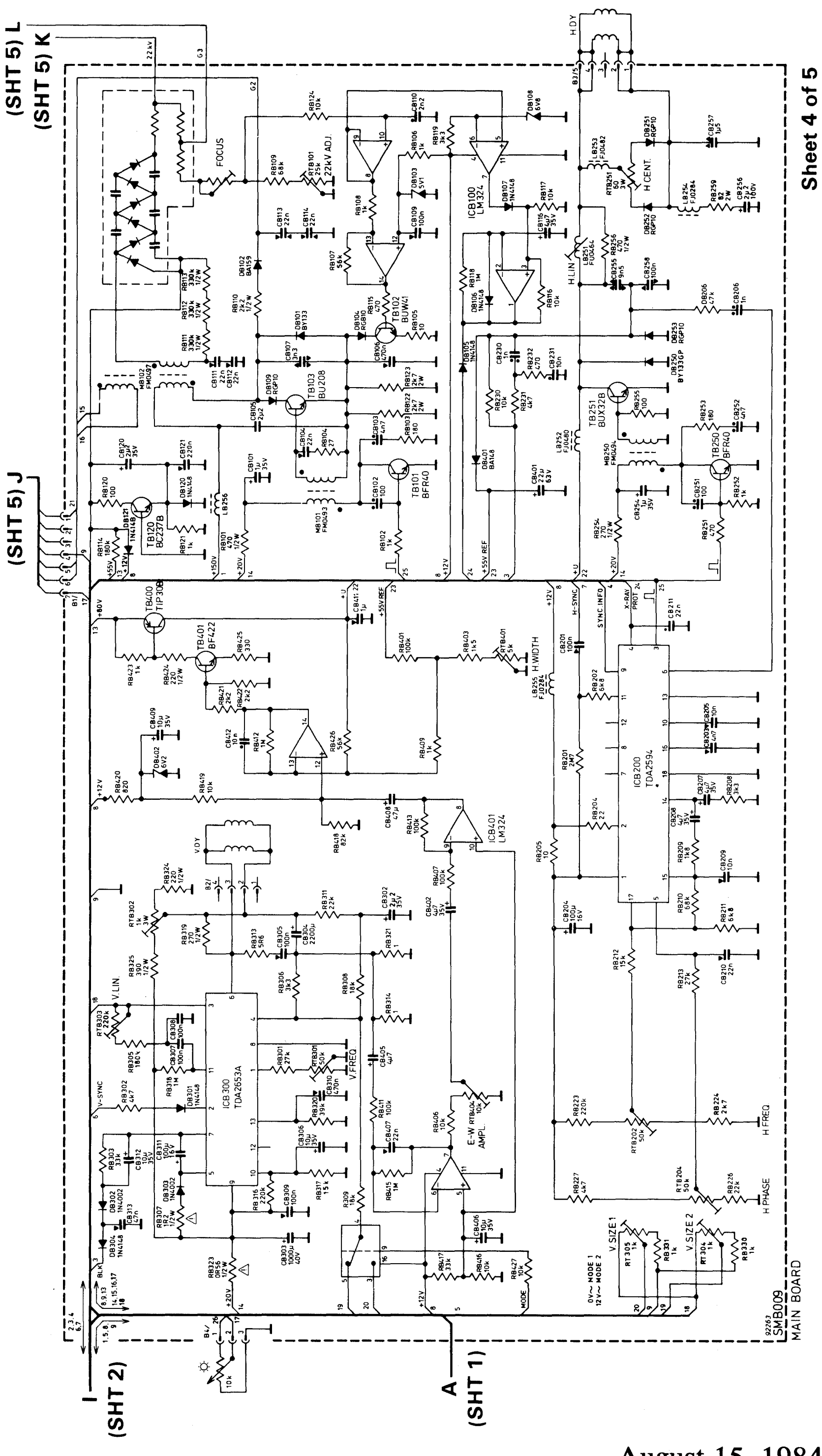
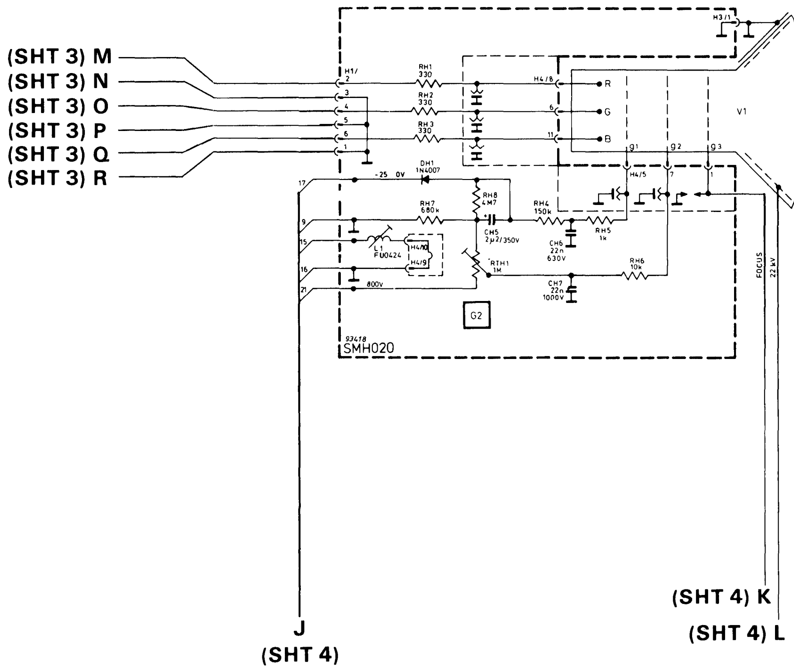

Sheet 4 of 5
SMB009
MAIN BOARD


(SHT 3) M
(SHT 3) N
(SHT 3) O
(SHT 3) P
(SHT 3) Q
(SHT 3) R
RH1 330
RH2 330
RH3 330
R
G
B
V1
DH1 1N4007
-25 0V
RH8 4M7
RH7 680k
RH4 150k
RH5 1k
CH5 2μ2/350V
CH6 22n 630V
L1 FU0424
RTH1 1M
RH6 10k
CH7 22n 1000V
800V
G2
SMH020
FOCUS
22 kV
(SHT 4) K
(SHT 4) L
J
(SHT 4)

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IBM

Personal Computer
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IBM Graphics Printer

6361480

IBM Graphics Printer

Contents

Description

The IBM Graphics Printer is a self-powered, stand-alone, tabletop unit. It prints in two directions at 80 characters per second (cps).

A 9-wire print head is used to print characters in a 9-by-9 dot matrix. The IBM Graphics Printer can print in a compressed mode of 132 characters per line, in a standard mode of 80 characters per line, in a double-width compressed mode of 66 characters per line, and in a double-width mode of 40 characters per line. The printer can print double-size characters and double-strike characters.

Besides printing the standard ASCII 96-character uppercase and lowercase character sets, the IBM Graphics Printer has additional capabilities including: an extended character set for international languages, subscript, superscript, an underline mode, and programmable graphics. It can also accept commands setting the line-feed control desired for the application.

The printer unit obtains ac power from a standard 120-Vac wall outlet. A 220-Vac model and a 240-Vac model are also available. A 1.83 m (6 ft) signal cable connects the printer to the system unit's Printer Adapter or combination Monochrome Display and Printer Adapter. The cable is a 25-lead shielded cable with a 25-pin D-shell connector at the system unit end, and a 36-pin connector at the printer end.

Programming Considerations

Printer Control Codes

On the following pages you will find codes for printer characters, controls, and graphics. You may want to keep them handy for future reference. The examples given in the "Printer Function" descriptions are written in the BASIC language. The "Input" description is given when more information is needed for programming considerations.

ASCII decimal values for the printer control codes can be found under "Graphics Printer Character Set."

The descriptions that follow assume that the printer dual-in-line package (DIP) switches have not been changed from their factory settings.

Printer Code	Printer Function
BEL	**Bell** Sounds the printer buzzer for 1 second. Example: LPRINT CHR$(7);
CAN	**Cancel** Clears the printer buffer. Control codes, except SO, remain in effect. Example: LPRINT CHR$(24);
CR	**Carriage Return** Ends the line that the printer is on and prints the data remaining in the printer buffer. (No Line Feed operation takes place.) **Note:** IBM Personal Computer BASIC adds a Line Feed unless CHR$(128) is added; for example, CHR$(141). Example: LPRINT CHR$(13);
DC2	**Device Control 2 (Compressed Off)** Cancels the Compressed print mode. Example: LPRINT CHR$(18);
DC4	**Device Control 4 (Double Width Off)** Cancels the Double Width print mode. Example: LPRINT CHR$(20);
ESC	**Escape** Signals the printer that the next data sent is a printer command. Example: LPRINT CHR$(27);

Printer Code	Printer Function
ESC A	**Escape A (Sets Variable Line Feeding)** Format: ESC A;n; Escape A sets the line-feed to n/72 inch. The example that follows sets line feeding to 24/72 inch. ESC 2 must be sent to the printer before the line feeding will change. For example, ESC A;24 (text) ESC 2 (text). The text following ESC A;24 will be at the previously set line-feed increment. The text following ESC 2 will be printed with the new line-feed increment of 24/72 inch. Any increment between 1/72 and 85/72 may be used. Example: LPRINT CHR$(27);CHR$(65);CHR$(24); CHR$(27);CHR$(50); **Note:** How to enter "n": When "n" is actually transferred to the printer as data, it is transferred in the form of a 7-bit binary number. In the case of "ESC A+24," actual output to the printer is performed as <1B>H<41>H<18>H in hexadecimal code.
ESC C	**Escape C (Set Lines per Page)** Format:ESC C;n; Sets the page length. ESC C command must be followed by a value to specify the length of page desired. (Maximum form length for the printer is 127 lines.) The example below sets the page length to 55 lines. The printer defaults to 66 lines per page when powered on or reset. Example: LPRINT CHR$(27);CHR$(67); CHR$(55); **Escape C (Set Inches per Page)** Format:ESC C;n;m; Escape C sets the length of the page in inches (one inch is 25.4 millimeters). This command requires a value of 0 (zero) for n, and a value between 1 and 22 for m. Example: LPRINT CHR$(27);CHR$(67);CHR$(0); CHR$(12);
ESC D	**Escape D (Set Horizontal Tab Stops)** Format: ESC D;n_1;n_2;...n_k;NUL; Sets the horizontal tab stop positions. The example that follows sets the horizontal tab stop positions at printer columns 10, 20, and 40. They are followed by CHR$(0), the Null code. They must be given in ascending numeric order. Tab stops can be set between 1 and 80. When the printer is in the Compressed print mode, tab stops can be set up to 132. The Graphics Printer can have a maximum of 28 tab stops. The HT Code (CHR$(9)) is used to execute a tab operation. Example: LPRINT CHR$(27);CHR$(68);CHR$(10); CHR$(20);CHR$(40);CHR$(0);

Printer Code	Printer Function
ESC E	**Escape E (Emphasized)** Sets the printer to the Emphasized print mode. The speed of the printer is reduced to half speed during the Emphasized print mode. Example: LPRINT CHR$(27);CHR$(69);
ESC F	**Escape F (Emphasized Off)** Cancels the Emphasized print mode. Example: LPRINT CHR$(27);CHR$(70);
ESC G	**Escape G (Double Strike)** Sets the printer to the Double Strike print mode. The paper is spaced 1/216 inch before the second pass of the print head. Example: LPRINT CHR$(27);CHR$(71);
ESC H	**Escape H (Double Strike Off)** Cancels the Double Strike mode. Example: LPRINT CHR$(27);CHR$(72);
ESC J	**Escape J (Sets Variable Line Feeding)** Format: ESC J;n; When ESC J is sent to the printer, the paper will advance in increments of n/216 inch. The value of n must be between 1 and 255. The example that follows sets the line feed to 50/216 inch. ESC J is canceled after the line feed takes place. Example: LPRINT CHR$(27);CHR$(74);CHR$(50);

Printer Code	Printer Function
ESC K	**Escape K (480 Bit-Image Graphics Mode)** FormatESC K;n_1;n_2;v_1;v_2;...v_k; Changes from the Text mode to the 480 Bit-Image Graphics mode. n_1 and n_2 are one byte each, and together specify the number of bit-image data bytes ($_k$) to be transferred. v_1 through v_k are the bytes of the bit-image data. The number of bit-image data bytes ($_k$) is equal to $n_1 + 256n_2$ and cannot exceed 480 bytes. At every horizontal position, each byte can print up to 8 vertical dots. The least significant bit of the byte corresponds to the bottom dot; the most significant bit of the byte corresponds to the top dot. Bit-image data may be mixed with text data on the same line. **Note:** Assign values to n_1 and n_2 as follows: n_1 represents values from 0 through 255. n_2 represents the values of either 0 or 1 with a weight of 256. The (z)s in the following description of n_1 and n_2 can be either 1's or 0's.

n_2

0	0	0	0	0	0	0	Z
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}

n_1

Z	Z	Z	Z	Z	Z	Z	Z
2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Printer Code	Printer Function
ESC K Cont.	Data sent to the printer.

Data A	ESC	K	n_1	n_2	Data B	Data C	ESC	K	n_1	n_2	Data D
Text Data			Length of bit image data		Bit-image data $v_1 - v_k$	Text data			Length of bit image data		Bit-image data $v_1 - v_k$

←——— 480 bit-image positions ———→

Note: Assume a total of 20 characters of text data (data A and data C). In Text mode, 20 characters correspond to 120 bit-image positions (20 x 6 = 120). The printable portion left for Bit-Image Graphics data (data B and data D) is 360 bit-image positions (480 - 120 = 360).

Example:

```
1 'OPEN PRINTER IN RANDOM MODE WITH LENGTH
OF 255
2 WIDTH "LPT1:",255
3 OPEN "LPT1:" AS #1
4 PRINT #1,CHR$(13);CHR$(10);
5 SLASH$=CHR$(1)+CHR$(02)+ CHR$(04)+CHR$(08)
6 SLASH$=SLASH$+CHR$(16)+CHR$(32)+
CHR$(64)+CHR$(128)+CHR$(0)
7 GAP$=CHR$(0)+CHR$(0)+CHR$(0)
8 NDOTS=480
9 'ESC K N1 N2
10 PRINT #1,CHR$(27);"K";CHR$(NDOTS MOD 256);
CHR$ (FIX (NDOTS/256));
11 'SEND NDOTS NUMBER OF BIT IMAGE BYTES
12 FOR I=1 TO NDOTS/12 'NUMBER OF SLASHES TO PRINT
USING GRAPHICS
13 PRINT #1,SLASH$;GAP$;
14 NEXT I
15 CLOSE
16 END
```

This example will give you a row of slashes printed in the Bit-Image Graphics mode.

Printer Code	Printer Function
ESC L	**Escape L (960 Bit-Image Graphics Mode)** Format: ESC L;n_1;n_2;v_1;v_2;...v_k; Changes from the Text mode to the 960 Bit-Image Graphics mode. The input is similar to ESC K. The 960 Bit-Image Graphics mode prints at half the speed of the 480 Bit-Image Graphics mode, but can produce a denser graphic image. The number of bytes of bit-image data ($_k$) is $n_1 + 256n_2$ but cannot exceed 960. n_1 is in the range of 0 to 255.
ESC N	**Escape N (Set Skip Perforation)** Format ESC N;n; Sets the Skip Perforation function. The number following ESC N sets the value for the number of lines of Skip Perforation. The example shows a 12-line skip. This will print 54 lines and advance the paper 12 lines. The value of n must be between 1 and 127. ESC N must be reset anytime the page length (ESC C) is changed. Example: LPRINT CHR$(27);CHR$(78);CHR$(12);
ESC O	**Escape O (Cancel Skip Perforation)** Cancels the Skip Perforation function. Example: LPRINT CHR$(27);CHR$(79);
ESC S	**Escape S (Subscript/Superscript)** Format: ESC S;n; Sets the printer to the Subscript print mode when ESC S is followed by a 1, as in the example that follows. When ESC S is followed by a 0 (zero), the printer will print in the Superscript print mode. Example: LPRINT CHR$(27);CHR$(83);CHR$(1);
ESC T	**Escape T (Subscript/Superscript Off)** Cancels printing in the Subscript or Superscript print mode. Example: LPRINT CHR$(27);CHR$(84);
ESC U	**Escape U (Unidirectional Printing)** Format: ESC U;n; The printer will print from left to right when ESC U is followed by a 1. When ESC U is followed by a 0 (zero), the left to right printing operation is canceled. The unidirectional printing (ESC U) ensures a more accurate print-start position for better print quality. Example: LPRINT CHR$(27);CHR$(85);CHR$(1);

Printer Code	Printer Function
ESC W	**Escape W (Double Width)** Format: ESC W;n; Sets the printer to the Double Width print mode when ESC W is followed by a 1. This mode must be canceled with ESC W followed by a 0 (zero) Example: LPRINT CHR$(27);CHR$(87);CHR$(1);
ESC Y	**Escape Y (960 Bit-Image Graphics Mode Normal Speed)** Format: ESC Y n_1;n_2;v_1;v_2;...v_k; Changes from the Text mode to the 960 Bit-Image Graphics mode, at normal speed. The printer cannot print dots on consecutive dot positions. The input of data is similar to ESC L.
ESC Z	**Escape Z (1920 Bit-Image Graphics Mode)** Format: ESC Z;n_1;n_2;v_1;v_2;...v_k; Changes from the Text mode to the 1920 Bit-Image Graphics mode. The input is similar to the other Bit-Image Graphics modes. ESC Z can print only every third dot position.
ESC 0	**Escape 0 (1/8-Inch Line Feeding)** Sets paper feeding to 3.175 mm (1/8 in.). Example: LPRINT CHR$(27);CHR$(48);
ESC 1	**Escape 1 (7/72-Inch Line Feeding)** Sets paper feeding to 2.47 mm (7/72 in.). Example: LPRINT CHR$(27);CHR$(49);
ESC 2	**Escape 2 (Start Variable Line Feeding)** ESC 2 is an execution command for ESC A. If no ESC A command is given, line feeding returns to 4.23mm (1/6 in.). Example: LPRINT CHR$(27);CHR$(50);
ESC 3	**Escape 3 (Variable Line Feeding)** Format: ESC 3;n; Changes the paper feeding to n/216 inch. The example that follows sets the paper feeding to 1/4 inch The value of n must be between 1 and 255. Example: LPRINT CHR$(27);CHR$(51);CHR$(54);
ESC 6	**Escape 6 (Select Character Set 2)** Selects Character Set 2. (See "Graphics Printer Character Set 2" later in this section.) Example: LPRINT CHR$(27);CHR$(54);

Printer Code	Printer Function
ESC 7	**Escape 7 (Select Character Set 1)** Selects character set 1. (See "Graphics Printer Character Set 1" later in this section.) Character set 1 is automatically selected when the printer is set to on or reset. Example: LPRINT CHR$(27);CHR$(55);
ESC 8	**Escape 8 (Ignore Paper End)** Allows the printer to print to the end of the paper. The printer ignores the Paper End switch. Example: LPRINT CHR$(27);CHR$(56);
ESC 9	**Escape 9 (Cancel Ignore Paper End)** Cancels the Ignore Paper End command. ESC 9 is automatically selected when the printer is set to on or reset. Example: LPRINT CHR$(27);CHR$(57);
ESC -	**Escape Minus (Underline)** Format: ESC -;n; ESC - followed by a 1, prints all of the following data with an underline. ESC - followed by a 0 (zero), cancels the Underline print mode. Example: LPRINT CHR$(27);CHR$(45);CHR$(1);
ESC <	**Escape Less Than (Home Head)** The print head will return to the left margin to print one line following ESC <. Example: LPRINT CHR$(27);CHR$(60);
FF	**Form Feed** Advances the paper to the top of the next page. **Note:** The location of the paper when the printer is set to on, determines the top of the page. The next top of page is 279.4 mm (11 in.) from that position. ESC C can be used to change the page length. Example: LPRINT CHR$(12);
HT	**Horizontal Tab** Tabs to the next horizontal tab stop. Tab stops are set every 8 columns when the printer's power is applied and can be changed with ESC D. Example: LPRINT CHR$(9);

Printer Code	Printer Function
LF	**Line Feed** Advances the paper up one line. Line spacing is 4.23 mm (1/6 in.) unless reset by ESC A, ESC 0, ESC 1, ESC 2 or ESC 3. Example: LPRINT CHR$(10);
NUL	**Null** Used with ESC B and ESC D as a list terminator. NUL also is used with other printer control codes to select options (for example, ESC S). Example: LPRINT CHR$(0);
SI	**Shift In (Compressed)** Changes the printer to the Compressed print mode. Example: LPRINT CHR$(15);
SO	**Shift Out (Double Width)** Changes the printer to the Double Width print mode.

Printer Control Code Quick Reference

This is an alphabetic listing of the descriptions of the printer control codes. You will find it helpful to locate the code you need to perform a certain job, or determine the ASCII decimal value quickly, once you are familiar with the control codes.

Note: ASCII values greater than 27 must be preceded by the ESC code (ASCII value 27).

Description	Code	ASCII Value
Alarm	BEL	7
Audible alarm	BEL	7
Bell	BEL	7
Buzzer	BEL	7
Cancel	CAN	24
Cancel data	CAN	24
Cancel double-strike printing	ESC H	72
Cancel double-width by line	DC4	20
Cancel double-width (lines)	ESC W	87
Cancel emphasized printing	ESC F	70
Cancel ignore paper end	ESC 9	57
Cancel perforation skip	ESC O	79
Cancel subscript/superscript	ESC T	84
Carriage return	CR	13
Character set 1 select	ESC 7	55
Character set 2 select	ESC 6	54
Character spacing 10 per inch	DC2	18
Character spacing 17.1 per inch	SI	15
Clear printer buffer	CAN	24
Command designator	ESC	27
Command end	NUL	0
Command prefix	ESC	27
Command start	ESC	27
Command terminator	NUL	0
Compressed On	SI	15
Compressed print	SI	15
Condensed print	SI	15
Data cancel	CAN	24
Double-strike printing	ESC G	71
Double-strike printing Off	ESC H	72

Description	Code	ASCII Value
Double-width-by-line Off	DC4	20
Double-width-by-line On	SO	14
Double-width On (lines)	ESC W	87
Double-width printing (lines)	ESC W	87
Eject form	FF	12
Eject paper	FF	12
Emphasized printing	ESC E	69
Emphasized printing Off	ESC F	70
Escape	ESC	27
Feed line	LF	10
Form feed	FF	12
Graphics, 480 bit-image	ESC K	75
Graphics, 960 bit-image, 1/2 speed	ESC L	76
Graphics, 960 bit-image, full speed	ESC Y	89
Graphics 1920 bit-image	ESC Z	90
Head, home	ESC <	60
Home head	ESC <	60
Horizontal tab	HT	9
Horizontal tab stops set	ESC D	68
Ignore paper end	ESC 8	56
Ignore paper end, cancel	ESC 8	56
Length-of-page set in inches	ESC C	67
Length-of-page set in lines	ESC C	67
Line-feed, set 1/6 inch	LF	10
Line-feed, set 1/8 inch	ESC 0	48
Line-feed, set 7/72 inch	ESC 1	49
Line-feed, set variable	ESC 3	51
Line-feed, set variable	ESC A	65
Line-feed, set variable	ESC J	74
Line-feed, start variable	ESC 2	50
Line-feed, set variable	ESC J	74
Null	NUL	0
Page eject	FF	12
Page length, set in inches	ESC C	67
Page length, set in lines	ESC C	67
Paper eject	FF	12
Paper end, ignore	ESC 8	56
Perforation skip Off	ESC O	79
Perforation skip set	ESC N	78

Description	Code	ASCII Value
Print double-width one line	SO	14
Print double-width multiple lines	ESC W	87
Print emphasized	ESC E	69
Print emphasized Off	ESC F	70
Print 10 characters per inch	DC2	18
Print unidirectional On/Off	ESC U	85
Printer buffer, clear	CAN	24
Return carriage	CR	13
Select character set 1	ESC 7	55
Select character set 2	ESC 6	54
Set 1 (character set 1)	ESC 7	55
Set 1/8-inch line feed	ESC 0	48
Set 2 (character set 2)	ESC 6	54
Set 7/72-inch line feed	ESC 1	49
Set variable line feed	ESC 3	51
Set horizontal tab stops	ESC D	68
Set page length in lines	ESC C	67
Set page length in inches	ESC C	67
Set perforation skip	ESC N	78
Set variable line feed	ESC A	65
Skip perforation Off	ESC O	79
Skip perforation On	ESC N	78
Start 7/72 inch line feed	ESC 1	49
Start double-strike print	ESC G	71
Start double-width print by line	SO	14
Start double-width print (lines)	ESC W	87
Start emphasized print	ESC E	69
Start perforation skip	ESC N	78
Start subscript/superscript	ESC S	83
Start variable line feed	ESC 2	50
Start underline	ESC –	45
Stop double-strike print	ESC H	72
Stop double-width by line	DC4	20
Stop double-width print (lines)	ESC W	87
Stop emphasized print	ESC F	70
Stop perforation skip	ESC O	79
Stop subscript/superscript	ESC T	84
Stop superscript/subscript	ESC T	84
Stop underline	ESC –	45

Description	Code	ASCII Value
Stops, horizontal tabs, set	ESC D	68
Subscript/superscript Off	ESC T	84
Subscript/superscript On	ESC S	83
Tab horizontal	HT	9
Tab stops, horizontal, set	ESC D	68
Tabs horizontal set	ESC D	68
Underline On	ESC –	45
Unidirectional printing Off	ESC U	85
Unidirectional printing On	ESC U	85
Variable line feed	ESC 3	54
Variable line feed set	ESC 3	65
Variable line feed set	ESC J	74
Vertical tabs set	ESC B	66

Print Mode Combinations

The IBM Graphics Printer can use any of the combinations of print modes listed in the following table. The print mode can be changed at any place within a line. Modes can be selected and combined if they are in the same vertical column.

Printer Modes											
Normal	X	X	X								
Compressed					X	X	X				
Emphasized									X	X	X
Double Strike	X				X				X		
Subscript		X				X				X	
Superscript			X				X				X
Double Width	X	X	X		X	X	X		X	X	X
Underline	X	X	X		X	X	X		X	X	X

Graphics Printer Character Set

The tables on the following pages show each character with its respective ASCII value.

0	1	2	3	4	5	6	7	8	9
NUL							BEL		HT
10	11	12	13	14	15	16	17	18	19
LF	VT	FF	CR	SO	SI			DC2	
20	21	22	23	24	25	26	27	28	29
DC4				CAN			ESC		
30	31	32	33	34	35	36	37	38	39
		SP	!	"	#	$	%	&	'
40	41	42	43	44	45	46	47	48	49
(	)	*	+	,	—	.	/	0	1
50	51	52	53	54	55	56	57	58	59
2	3	4	5	6	7	8	9	:	;
60	61	62	63	64	65	66	67	68	69
<	=	>	?	@	A	B	C	D	E
70	71	72	73	74	75	76	77	78	79
F	G	H	I	J	K	L	M	N	O
80	81	82	83	84	85	86	87	88	89
P	Q	R	S	T	U	V	W	X	Y
90	91	92	93	94	95	96	97	98	99
Z	[	\	]	^	_	`	a	b	c
100	101	102	103	104	105	106	107	108	109
d	e	f	g	h	i	j	k	l	m
110	111	112	113	114	115	116	117	118	119
n	o	p	q	r	s	t	u	v	w
120	121	122	123	124	125	126	127	128	129
x	y	z	{	¦	}	~	DEL	NUL	

Graphics Printer Character Set 1 (Part 1 of 2)

130	131	132	133	134	135	136	137	138	139
					BEL		HT	LF	VT
140	141	142	143	144	145	146	147	148	149
FF	CR	SO	SI			DC2		DC4	
150	151	152	153	154	155	156	157	158	159
		CAN			ESC				
160	161	162	163	164	165	166	167	168	169
á	í	ó	ú	ñ	Ñ	a̲	o̲	¿	⌐
170	171	172	173	174	175	176	177	178	179
¬	½	¼	¡	«	»	░	▒	▓	│
180	181	182	183	184	185	186	187	188	189
┤	╡	╢	╖	╕	╣	║	╗	╝	╜
190	191	192	193	194	195	196	197	198	199
╛	┐	└	┴	┬	├	─	┼	╞	╟
200	201	202	203	204	205	206	207	208	209
╚	╔	╩	╦	╠	═	╬	╧	╨	╤
210	211	212	213	214	215	216	217	218	219
╥	╙	╘	╒	╓	╫	╪	┘	┌	█
220	221	222	223	224	225	226	227	228	229
▄	▌	▐	▀	α	β	Γ	Π	Σ	σ
230	231	232	233	234	235	236	237	238	239
μ	τ	Φ	Θ	Ω	δ	∞	$\varnothing$	ϵ	$\cap$
240	241	242	243	244	245	246	247	248	249
$\equiv$	$\pm$	$\geq$	$\leq$	⌠	⌡	$\div$	$\approx$	°	▪
250	251	252	253	254	255				
-	$\sqrt{}$	^{n}	^{2}	■	SP				

Graphics Printer Character Set 1 (Part 2 of 2)

0	1	2	3	4	5	6	7	8	9
NUL			♥	♦	♣	♠	BEL		HT
10	11	12	13	14	15	16	17	18	19
LF		FF	CR	SO	S1			DC2	
20	21	22	23	24	25	26	27	28	29
DC4	§			CAN			ESC		
30	31	32	33	34	35	36	37	38	39
		SP	!	"	#	$	%	&	'
40	41	42	43	44	45	46	47	48	49
(	)	*	+	,	—	.	/	0	1
50	51	52	53	54	55	56	57	58	59
2	3	4	5	6	7	8	9	:	;
60	61	62	63	64	65	66	67	68	69
<	=	>	?	@	A	B	C	D	E
70	71	72	73	74	75	76	77	78	79
F	G	H	I	J	K	L	M	N	O
80	81	82	83	84	85	86	87	88	89
P	Q	R	S	T	U	V	W	X	Y
90	91	92	93	94	95	96	97	98	99
Z	[	\	]	^	_	`	a	b	c
100	101	102	103	104	105	106	107	108	109
d	e	f	g	h	i	j	k	l	m
110	111	112	113	114	115	116	117	118	119
n	o	p	q	r	s	t	u	v	w
120	121	122	123	124	125	126	127	128	129
x	y	z	{	¦	}	~		ç	ü

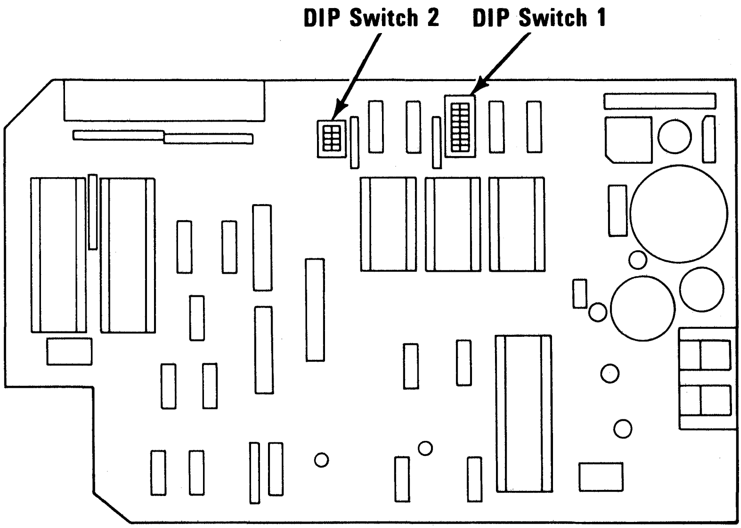
Graphics Printer Character Set 2 (Part 1 of 2)

130	131	132	133	134	135	136	137	138	139
é	â	ä	à	å	ç	ê	ë	è	ï
140	141	142	143	144	145	146	147	148	149
î	ì	Ä	Å	É	æ	Æ	ô	ö	ò
150	151	152	153	154	155	156	157	158	159
û	ù	ÿ	ö	ü	¢	£	¥	₧	ƒ
160	161	162	163	164	165	166	167	168	169
á	í	ó	ú	ñ	Ñ	ª	º	¿	⌐
170	171	172	173	174	175	176	177	178	179
¬	½	¼	¡	«	»	░	▒	▓	│
180	181	182	183	184	185	186	187	188	189
┤	╡	╢	╖	╕	╣	║	╗	╝	╜
190	191	192	193	194	195	196	197	198	199
╛	┐	└	┴	┬	├	─	┼	╞	╟
200	201	202	203	204	205	206	207	208	209
╚	╔	╩	╦	╠	═	╬	╧	╨	╤
210	211	212	213	214	215	216	217	218	219
╥	╙	╘	╒	╓	╫	╪	┘	┌	█
220	221	222	223	224	225	226	227	228	229
▄	▌	▐	▀	α	β	Γ	Π	Σ	σ
230	231	232	233	234	235	236	237	238	239
µ	τ	Φ	Θ	Ω	δ	∞	ø	∈	∩
240	241	242	243	244	245	246	247	248	249
≡	±	≥	≤	⌠	⌡	÷	≈	°	▪
250	251	252	253	254	255				
-	√	n	2	■	SP				

Graphics Printer Character Set (Part 2 of 2)

DIP-Switch Settings

There are two DIP switches on the control circuit board. In order to satisfy the user's specific requirements, desired control modes are selectable by the DIP switches. The functions of the switches and their preset conditions at the time of shipment are as shown in the following figures.



Location of Printer DIP Switches

Switch Number	Function	On	Off	Factory-Set Condition
1-1	Not Applicable	—	—	On
1-2	CR	Print Only	Print & Line Feed	On
1-3	Buffer Full	Print Only	Print & Line Feed	Off
1-4	Cancel Code	Invalid	Valid	Off
1-5	Not Applicable	—	—	On
1-6	Error Buzzer	Sound	Does Not Sound	On
1-7	Character Generator	Set 2	Set 1	Off
1-8	SLCT IN Signal	Fixed Internally	Not Fixed Internally	On

Functions and Conditions of DIP Switch 1 (Graphics)

Switch Number	Function	On	Off	Factory-Set Condition
2-1	Form Length	304.8 mm (12 inches)	279.4 mm (11 inches)	Off
2-2	Line Spacing	3.175 mm (1/8 inch)	4.23 mm (1/6 inch)	Off
2-3	Auto Feed XT Signal	Fixed Internally	Not Fixed Internally	Off
2-4	1 Inch Skip Over Perforation	Valid	Not Valid	Off

Functions and Conditions of DIP Switch 2 (Graphics)

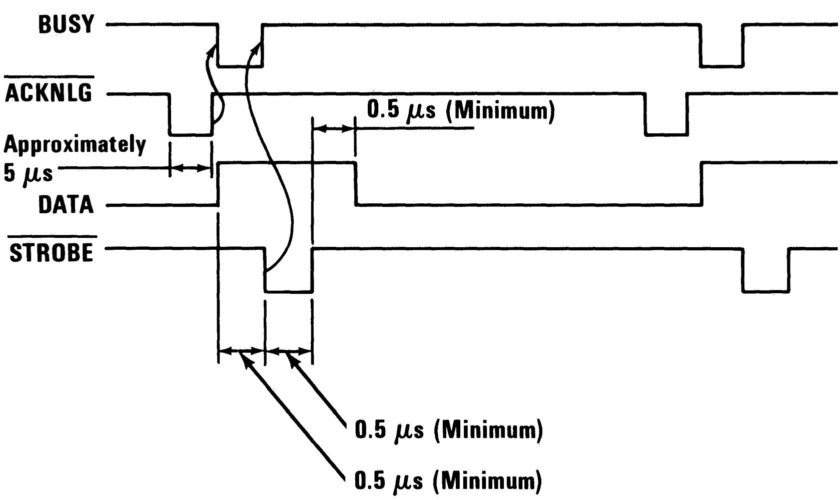
Interface

Specifications:

- Data transfer rate: 1000 cps (maximum)
- Synchronization: By externally-supplied –STROBE pulses.
- Handshaking –ACKNLG or BUSY signals.
- Logic level: Input data and all interface control signals are compatible with the TTL level.

Connector type: 57-30360 (Amphenol)

Data Transfer Sequence:



Parallel Interface Timing Diagram

Specifications

Size	
Height	107 mm (4.2 in.)
Width	400 mm (15.7 in.)
Depth	305 mm (12 in.)
Weight	5.5 kg (12 lb)
Power Cable	
Length	1.83 m (6 ft)
Size	18 AWG
Signal Cable	
Length	1.83 m (6 ft)
Size	22 AWG

Physical Specifications

Voltage (Vac)			**Frequency (Hz)**	**Current (Amps)**	**Power (Watts)**
Nominal	Minimum	Maximum	± 3 Hz	Maximum	Maximum
120	104	127	60	1.0	100
220	198	242	50/60	0.5	100
240	216	264	50/60	0.5	100

Electrical Specifications

Print Method	Serial-impact wire matrix	
Print Speed	80 cps	
Print Direction	Bidirectional with logical seeking	
Number of Pins in Head	9	
Line Spacing	4.23 mm (1/6 in.) or programmable	
Printing Characteristics		
Matrix	9 x 9	
Graphic Character	See "Graphics Printer Character Set" tables.	
Printing Sizes		
	Characters per inch	Maximum characters per line
Normal	10	80
Double Width	5	40
Compressed	17.1	132
Double Width-Compressed	8.25	66
Subscript	10	80
Superscript	10	80
Media Handling		
Paper Feed	Adjustable sprocket pin feed	
Paper Width Range	101.6 mm (4 in.) to 254 mm (10 in.)	
Copies	One original plus two carbon copies (total thickness not to exceed 0.3 mm (0.012 in.)). Minimum paper thickness is 0.064 mm (0.0025 in.).	
Paper Path	Rear	
Interfaces		
Standard	Parallel 8-bit Data and Control Lines	
Inked Ribbon		
Color	Black	
Type	Cartridge	
Life Expectancy	3 million characters	
Environmental Conditions		
Operating Temperature	5 to 35°C (41 to 95°F)	
Operating Humidity	10 to 80% non-condensing	
Heat Output	341 BTU/hr (maximum)	

Printer Specifications

Connector Pin Assignments

Signal Pin No.	Return Pin No.	Signal	Direction	Description
1	19	$\overline{\text{STROBE}}$	In	STROBE pulse to read data in. Pulse width must be more than 0.5 μs at receiving terminal. The signal level is normally "high"; read-in of data is performed at the "low" level of this signal.
2	20	DATA 1	In	These signals represent information of the 1st to 8th bits of parallel data respectively. Each signal is at "high" level when data is logical "1" and "low" when logical "0."
3	21	DATA 2	In	
4	22	DATA 3	In	
5	23	DATA 4	In	
6	24	DATA 5	In	
7	25	DATA 6	In	
8	26	DATA 7	In	
9	27	DATA 8	In	
10	28	$\overline{\text{ACKNLG}}$	Out	Approximately 5 μs pulse; "low" indicates that data has been received and the printer is ready to accept other data.
11	29	BUSY	Out	A "high" signal indicates that the printer cannot receive data. The signal becomes "high" in the following cases: 1. During data entry. 2. During printing operation. 3. In "offline" state. 4. During printer error status.

Connector Pin Assignment and Descriptions of Interface Signals (Part 1 of 3)

Signal Pin No.	Return Pin No.	Signal	Direction	Description
12	30	PE	Out	A "high" signal indicates that the printer is out of paper.
13	–	SLCT	Out	This signal indicates that the printer is in the selected state.
14	–	$\overline{\text{AUTO}}$ $\overline{\text{FEED XT}}$	In	With this signal being at "low" level, the paper is automatically fed one line after printing. (The signal level can be fixed to "low" with DIP SW pin 2-3 provided on the control circuit board.)
15	–	NC		Not used.
16	–	OV		Logic GND level.
17	–	CHASSIS-GND	–	Printer chassis GND. In the printer, the chassis GND and the logic GND are isolated from each other.
18	–	NC	–	Not used.
19-30	–	GND	–	"Twisted-Pair Return" signal; GND level.
31	–	$\overline{\text{INIT}}$	In	When the level of this signal becomes "low" the printer controller is reset to its initial state and the print buffer is cleared. This signal is normally at "high" level, and its pulse width must be more than 50 µs at the receiving terminal.

Connector Pin Assignment and Descriptions of Interface Signals (Part 2 of 3)

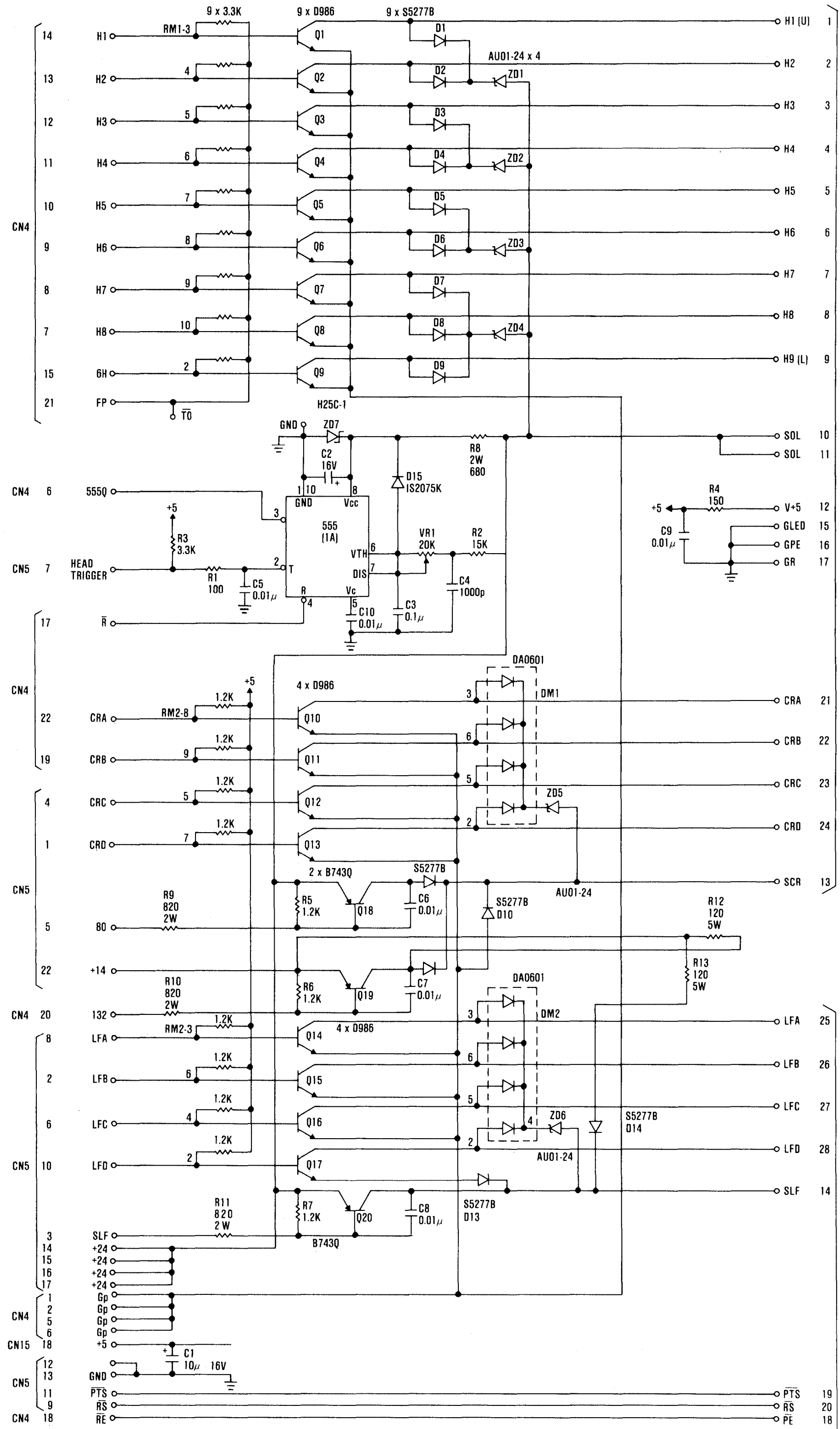
Signal Pin No.	Return Pin No.	Signal	Direction	Description
32		$\overline{\text{ERROR}}$	Out	The level of this signal becomes "low" when the printer is in "Paper End" state, "Offline" state and "Error" state.
33	—	GND	—	Same as with pin numbers 19 to 30.
34	—	NC	—	Not used.
35				Pulled up to + 5 Vdc through 4.7 k-ohms resistance.
36	—	$\overline{\text{SLCT IN}}$	In	Data entry to the printer is possible only when the level of this signal is "low." (Internal fixing can be carried out with DIP SW 1-8. The condition at the time of shipment is set "low" for this signal.)

Notes:
1. "Direction" refers to the direction of signal flow as viewed from the printer.
2. "Return" denoted "Twisted-Pair Return" and is to be connected at signal-ground level.
   When wiring the interface, be sure to use a twisted-pair cable for each signal and never fail to complete connection on the return side. To prevent noise effectively, these cables should be shielded and connected to the chassis of the system unit and printer, respectively.
3. All interface conditions are based on TTL level. Both the rise and fall times of each signal must be less than 0.2 μs.
4. Data transfer must not be carried out by ignoring the $\overline{\text{ACKNLG}}$ or BUSY signal. (Data transfer to this printer can be carried out only after confirming the $\overline{\text{ACKNLG}}$ signal or when the level of the BUSY signal is "low.")

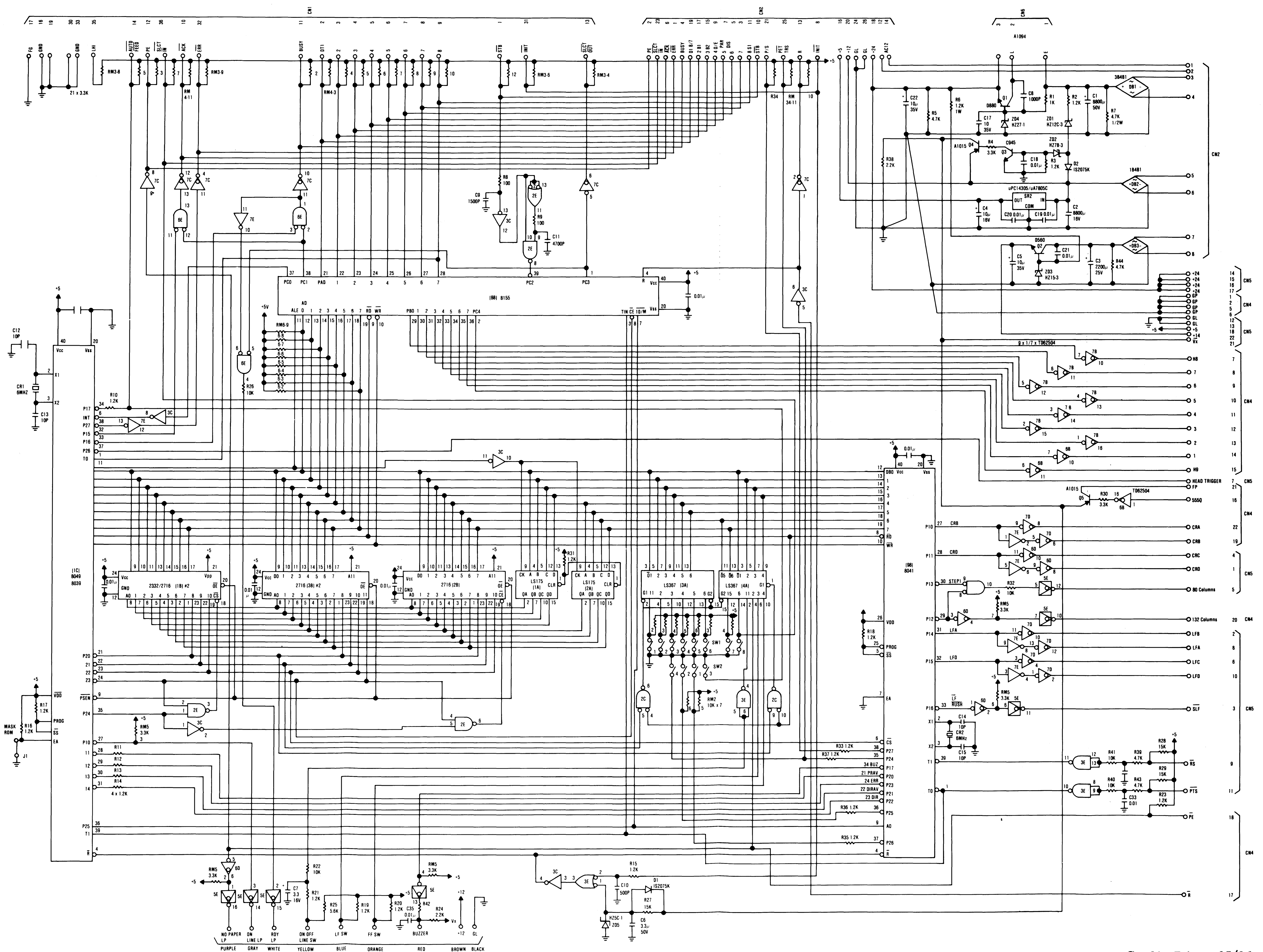
Connector Pin Assignment and Descriptions of Interface Signals (Part 3 of 3)

Logic Diagrams

The following page and foldout contain the logic diagrams for the the IBM Graphics Printer.



Graphics Printer (Sheet 1 of 2)



Graphics Printer (Sheet 2 of 2)

Personal Computer
Hardware Reference
Library

IBM Personal Computer Color Printer

6361478

IBM Color Printer

Contents

Description

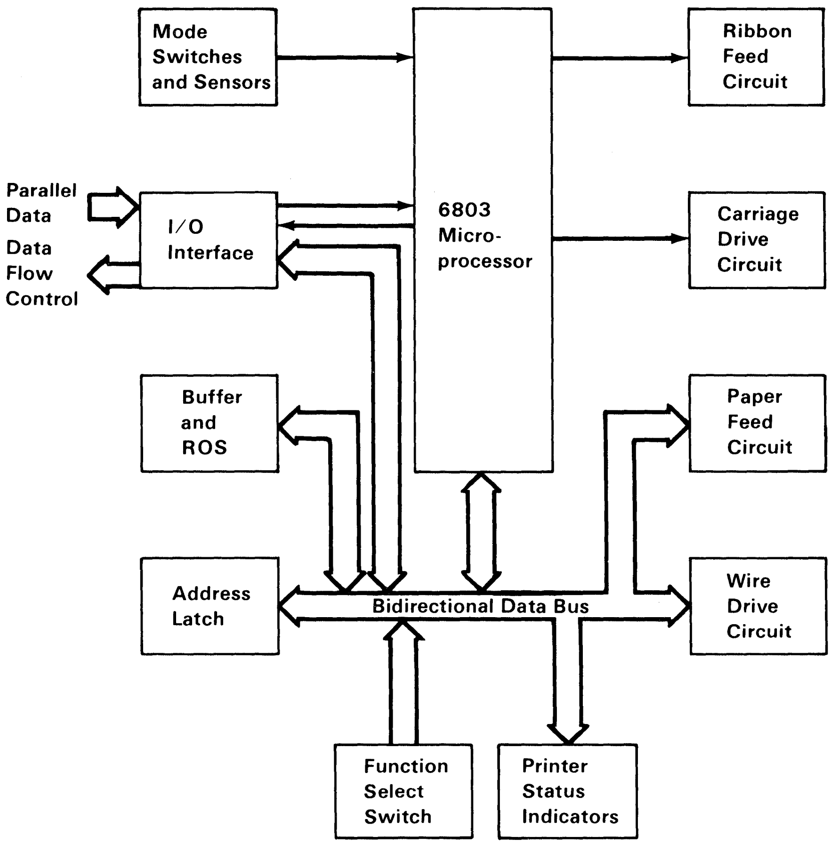
The IBM Personal Computer Color Printer is a tabletop, wire matrix, color printer. It attaches to the system unit's Printer Adapter or combination Monochrome Display and Printer Adapter through a standard printer cable, which has a 25-pin connector on the system unit end and a 36-pin connector on the printer end.

When the Color Printer is ready to accept data, the system unit sends the data and control codes through the printer cable to the printer's input/output (I/O) board. The I/O board directs the data and control codes to a buffer. The 6803 Microprocessor on the printer's controller circuit board monitors the buffer constantly and decides when and how to print the information based on the control codes.

The 6803 Microprocessor takes a character from the buffer and compares the character against a table to determine what dots to print. If the character is a control character, the microprocessor compares the character against a control-character table so that it knows what action to take.

When the 6803 Microprocessor reads a line-ending character, it determines whether it would be faster to move to the right margin and print backwards or to the left margin to begin printing. This ability, called *logic seeking*, allows faster printer output.

The following block diagram shows the operation of the IBM Personal Computer Color Printer.



Color Printer Block Diagram

Major Subsystems

The three major electromechanical subsystems of the printer are the I/O subsystem, controller subsystem, and print subsystem. Each subsystem is controlled by the 6803 Microprocessor mounted on the controller circuit board. The power-supply regulator circuits are an integrated portion of the controller card.

The I/O Subsystem

The I/O circuit board contains the circuits needed to direct the parallel data from the computer and interface cable to the printer's controller circuit board for processing. The I/O board also contains the circuits for directing operational status signals between the printer and the system unit.

Controller Subsystem

The controller subsystem consists of a 6803 Microprocessor and its peripheral interface and memory devices, which are mounted on the controller circuit board. The controller line buffer accepts data from the computer through the printer's I/O board. The controller decodes the data, then sends the data to the print subsystem for printing.

The controller also controls operation of the paper and ribbon feed. These circuits are activated by programming or by a function-select switch. Power regulation and distribution within the printer are also controlled by the controller board.

The power regulator circuit, which is part of the controller circuit board, receives 5, 10, and 40 volts ac from the power supply transformer. It rectifies and distributes the different voltages to the various circuits and motors in the printer.

Print Subsystem

The print subsystem prints the data received from the controller. The subsystem consists of the following:

- Print head and carriage assembly
- Carriage drive motor and belt
- Left-margin sensor
- Paper feed assembly
- Ribbon drive assembly

The print head contains nine print wires. The print wires are staggered in two vertical columns with five wires in one column and four wires in the other. This arrangement is designed to allow overlapping of print dots. Selectively driving the wires against the ribbon and paper as the print head is moved across the platen, results in the printing of high-quality characters.

The print head is mounted on a carriage which is driven bidirectionally by the carriage drive stepper motor and drive belt. The left-margin sensor is used to signal the controller that the print head is at the home position.

The paper feed assembly is made up of a tractor assembly, paper stepper motor, and a paper-out sensor. It feeds the forms into position and holds the paper stationary while printing. Continuous forms are fed by pin belts in the tractor assembly, and single sheets of paper are fed by pressure rolls in the paper path. The pin belts and pressure rolls are driven by a drive shaft, drive belt, and the paper stepper motor.

The ribbon feed assembly drives the ribbon between the paper and the print head at a constant speed. It consists of a ribbon cartridge, ribbon drive motor, and a ribbon feed path made up of two rollers, two fixed posts, and a print-head ribbon guide. The ribbon cartridge contains a continuous loop of pre-inked 19-mm (3/4-in.) wide ribbon. The ribbon is pulled from the cartridge, around two guide posts, through the print-head ribbon guide, around two more ribbon posts, and "stuffed" back into the cartridge by two "stuffing" wheels.

In order to print different colors, the ribbon is shifted up and down by the color control mechanism, which is made up of a motor and cam assembly. The cam pivots the complete ribbon feed assembly to four different levels that match the four color bands on the ribbon.

6803 Microprocessor

The 6803 Microprocessor and its peripheral devices, which are mounted on the controller circuit board, direct all operations of the printer. This 8-bit single-chip microprocessor unit (MPU) functions as a monolithic MPU requiring one +5-Vdc power supply and is TTL-compatible. On-chip resources include parallel I/O and a three function programmable timer. Some of the other features include:

- Enhanced 6800 MPU instruction set
- 8 x 8 multiply instruction
- Upward-source and object-code compatibility with the 6800 MPU
- Expanded operation to 64K-byte address space
- 29 parallel I/O and 2-handshake control lines
- Internal clock generator with divide-by-4 output

The program-controlled operating mode determines the configuration of 18 of the 40 MPU pins available, location (internal or external) of interrupt vectors, and type of external bus. The configuration of the remaining 22 pins is not dependent on the operating mode.

Twenty nine pins are organized as three 8-bit ports and one 5-bit port. Each port consists of at least a data register and a write-only data-direction register. The data-direction register is used to define whether corresponding bits in the data register are configured as an input (clear) or output (set).

When the port is used as a "data port" or "I/O port," it is controlled by the port data direction register and the programmer has direct access to the port pins using the port Data Register. Port pins are labeled as Pij, where "i" identifies one of four ports and "j" indicates the particular bit. The operating mode determines the configuration of Port 3, Port 4, SC1, SC2, and the physical location of the interrupt vectors.

The mode used by the 6803 MPU is called the Expanded Multiplexed mode. Expanded Multiplexed mode refers to the type of bus it supports. In this mode, Port 3 functions as a time-multiplexed address/data bus with address valid on the negative edge of Address Strobe (AS), and data valid while "E" (which is a timing signal), is high. Port 4 provides address lines A8 to A15.

Programming Considerations

Printer Control Codes

The following pages list, in alphabetic order, the printer control codes with a description of each. Some knowledge of BASIC programming is necessary to insert printer control codes in your program. An example of each code in BASIC is at the end of each description. The "Format" information is given where more information is needed for programming considerations.

> **Note:** All combinations of printing qualities, character spacings, and types are valid. For example, you can print in emphasized print, double-width, and underline all at the same time.

The printer can accept parameters for the ESC commands in either of two formats:

- Binary
- ASCII Character

Although the default format is binary (as used in all examples in the "Printer Control Codes" section), the command, ESC @;n;, can be used to select either format.

This command affects only certain numeric parameters which follow ESC control codes. Parameters not affected by this command are those which select On or Off (1 or 0) because the Color Printer operates on only the least significant bit of n in these commands. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1 and any even-numbered ASCII decimal value gives the same result as n=0.

Parameters affected by this command are given in the following three examples:

1. A parameter defining numeric values.

   In ASCII format these parameters must be stated as decimal characters, with each numeric field terminated with a non-numeric character (semicolon recommended). For example, to select the near letter quality type font, (ESC I3) the command is: LPRINT CHR$(27); CHR$(73);"3;";

   In binary format the command is: LPRINT CHR$(27); CHR$(73); CHR$(3);

2. A parameter defining lists of values ending in NUL.

   In ASCII format these parameters must be stated as decimal numeric characters, with each numeric field terminated with a non-numeric character (semicolon recommended) , with the final NUL being a second semicolon. For example, to set tabs at columns 10 and 40, (ESC D) the command is: LPRINT CHR$(27); CHR$(68);"10;40;;";

   In binary format the command is: LPRINT CHR$(27); CHR$(68);CHR$(10);CHR$(40);CHR$(0);

3. A two byte parameter (n1;n2;) defining the amount of data to be printed after the command.

   In ASCII format this parameter must be sent as a single decimal numeric value (0 to XXXX) terminated with a non-numeric character (semicolon recommended). For example, to print twenty eight bytes in bit-image graphics, (ESC K) the command is: LPRINT CHR$(27); CHR$(75);"28;":FOR X = 1 TO 28: LPRINT CHR$(255);: NEXT X

   In binary format the command is: LPRINT CHR$(27); CHR$(75);CHR$(28);CHR$(0);: FOR X = 1 TO 28: LPRINT CHR$(255);: NEXT X

Printer Code	Printer Function
BEL	**Audible Alarm** Sounds the printer buzzer for 1 second or less. The buzzer may be turned off with DIP Switch 8. Example: LPRINT CHR$(7);
BS	**Backspace** Moves the print head one character width to the left. The character width is determined by the selected character spacing. Example: LPRINT CHR$(8);
CAN	**Clear Data** Clears the printer memory of all data waiting to be printed following the last received line ending code. If the initialize function is set On by ESC ? (Set Initialize Signal Function), all control codes, except SO (Double-Width printing), remain in effect. If the initialize function is set Off by ESC ?, all control codes are cleared and the printer is set to the values set by the DIP switches. (See "ESC ?" for more details about the initialize function.) Example: LPRINT CHR$(24);
CR	**Carriage Return** Causes the printer to print the data that follows CR beginning at the left margin. No line-feed operation takes place unless DIP Switch 4 is On or ESC 5 (automatic line-feed) has been sent. **Note**: IBM Personal Computer BASIC (and many other programs) automatically sends LF (line feed) with CR. If you do not want LF sent after CR, use ASCII decimal value 141 from Character Set 1 instead of ASCII decimal value 13. Example: LPRINT CHR$(13);
DC1	**Select Printer** Sets the printer to accept data from the system unit. Example: LPRINT CHR$(17);
DC2	**10 Characters per Inch Print** Selects character spacing of 10 characters per inch. Example: LPRINT CHR$(18);

Printer Code	Printer Function
DC3	**Deselect Printer** Sets the Color Printer so it will not accept data from the system unit. A printer must be initialized by the system or control panel buttons or selected using DC1 (Select Printer) to accept data. Example: LPRINT CHR$(19);
DC4	**Cancel Double-Width Printing by Line** Ends double-width printing by line which was started by SO. Example: LPRINT CHR$(20);
ESC	**Command Prefix** Sets the printer to accept the next data sent as a printer command. (See the following list.) Example: LPRINT CHR$(27);
ESC A	**Store Text Line Spacing** Format: ESC A;n; ESC A stores a line-feed value of n/72 inch. ESC 2 (Start Text Line Spacing) must then be sent before the line spacing will change. For example, to store a line-feed value of 24/72 inch, the code is ESC A 24. However, until ESC 2 is sent, any text following the ESC A 24 will space at the previously set line-feed increment. The text following the ESC 2 will be printed with a new line-feed increment of 24/72 inch. Any increment between 1/72 and 85/72 may be used. Example: LPRINT CHR$(27);CHR$(65);CHR$(n);
ESC a	**Select Automatic Ribbon-Band Shift** Causes the ribbon to shift one color band at the end of each page. This command is used with an all-black ribbon to extend the ribbon life. Example: LPRINT CHR$(27);CHR$(97);
ESC B	**Set Vertical Tabs** Format: ESC B;n_1;n_2;...n_{64};NUL; Sets the vertical tab-stop positions. The power-on default is without vertical tab stops set. n_1 through n_{64} represent tab-stop positions by line number. The topmost line of the page is line 0. Tab-stop positions must be received in ascending numeric order and cannot exceed the set page length. Up to 64 positions are recognized by the Color Printer. The positions do not take effect until NUL is received.

Printer Code	Printer Function
ESC B. Cont.	Once vertical tab stops are set, they remain in effect until new ones are specified or all tab stops are set to the power-on defaults by ESC R (Set All Tabs to Power-On Defaults). If no vertical tab stops are set, the Vertical Tab (VT) command behaves as a Line Feed (LF) command. ESC B followed only by NUL cancels all vertical tab stops. The form length must be set by the ESC C command (Set Page Length in Lines) prior to setting vertical tab stops. Example: LPRINT CHR\$(27);CHR\$(66);CHR\$(n_1); CHR\$(n_2);...CHR\$(n_{64});CHR\$(0);
ESC b	**Select Band 4** Selects ribbon band 4 (black). The printer will continue to print with band 4 until a command to change the ribbon band is received. Example: LPRINT CHR\$(27);CHR\$(98);
ESC C	**Set Page Length in Lines** Format: ESC C;n; Sets the page length in lines. The number of lines n is converted to inches using the current line spacing. ESC C must be followed by a value, n, that specifies the desired length of page in lines. Maximum page length for this printer is 127 lines. This command also sets the current position of the paper as the top-of-form. **Note**: Automatic perforation-skip (ESC N) and vertical tabs (ESC B) may need to be reset after changing the page length. Example: LPRINT CHR\$(27);CHR\$(67);CHR\$(n);
ESC C 0	**Set Page Length in Inches** Format: ESC C;0;n; Sets the page length in inches. This command requires a value of n between 1 and 22. The power-on default is set with DIP Switch 6. This command also sets the current position of the paper as the top-of-form. **Note**: Automatic perforation-skip (ESC N) and vertical tabs (ESC B) may need to be reset after changing the page length. Example: LPRINT CHR\$(27);CHR\$(67);CHR\$(0); CHR\$(n);

Printer Code	Printer Function
ESC c	**Select Band 3** Selects ribbon band 3. The actual color printed will depend on the ribbon being used. The printer will continue to print with band 3 until a command to change the ribbon band is received. Example: LPRINT CHR$(27);CHR$(99);
ESC D	**Set Horizontal Tabs** Format: ESC D;n_1;n_2;...n_{28};NUL; Sets the horizontal tab-stop positions represented by n_1 through n_{28}. The power-on default is a tab stop set at column 8 and every eighth column thereafter. The printer recognizes up to 28 horizontal tab stops. They must be in ascending numeric order and followed by NUL. Tab stops can be set between 1 and the maximum column count for the character spacing in effect. ESC D immediately followed by NUL will clear all horizontal tabs. ESC R (Set All Tabs to Power-On Defaults) may be used to set horizontal tabs to the power-on default. **Note**: Setting a tab at column 0 clears all tabs and the following tabs will be considered data. Example: LPRINT CHR$(27);CHR$(68);CHR$($n_1$); CHR$(n_2);...CHR$($n_{28}$);CHR$(0);
ESC d	**Variable Forward Space** Format: ESC d;n_1;n_2; Places the next printed character n_1;n_2/120 inch to the right of the last dot of the current character. The position may be beyond the right margin setting. If the position is beyond the physical end of the line, the next character will be printed at the left end of the printer. n_1 and n_2 are binary numbers that specify the number of 1/120-inch increments the next printed character is to be placed to the right. n_1 represents values from 0 to 255, and n_2 represents values from 0 to 255 times 256. Example: LPRINT CHR$(27);CHR$(100);CHR$($n_1$);CHR$(n_2);
ESC E	**Emphasized Printing** Changes the printer to emphasized printing. Characters are double struck with the smallest possible horizontal offset between strikes. Example: LPRINT CHR$(27);CHR$(69);

Printer Code	Printer Function
ESC e	**Variable Backspace** Format: ESC e;n_1;n_2; Places the next printed character n_1;n_2/120 inch to the left of the last dot of the current character. The position may be beyond the left margin setting. If the specified position is beyond the physical left end of the printer, the next character will be printed at the left end of the printer. n_1 and n_2 are binary numbers that specify the number of 1/120-inch increments the next printed character is to be placed to the left. n_1 represents values from 0 to 255, and n_2 represents values from 0 to 255 times 256. Example: LPRINT CHR$(27);CHR$(101);CHR$($n_1$);CHR$(n_2);
ESC F	**Cancel Emphasized Printing** Ends emphasized printing started by ESC E. Example: LPRINT CHR$(27);CHR$(70);
ESC G	**Double-Strike Printing** Sets the printer to double-strike printing. Characters are struck twice with no horizontal offset between strikes. Example: LPRINT CHR$(27);CHR$(71);
ESC H	**Cancel Double-Strike Printing** Ends double-strike printing started by ESC G. Example: LPRINT CHR$(27);CHR$(72);
ESC I	**Change Printing Quality** Format ESC I;n; Selects the printing quality. When n is 1, data processing quality is selected; when n is 2, text quality is selected; when n is 3, letter quality is selected. Each printing quality selection produces a different spacing of the dots that make up a character. Each character box is: with data-processing quality selected, 8 by 9 dots; with text quality selected, 24 by 9 dots; and with near-letter quality selected, 36 by 18 dots. Example: LPRINT CHR$(27);CHR$(73);CHR$(n);
ESC J	**Variable Line Space** Format: ESC J;n; Advances the paper in increments of n/144 inch. The value of n must be between 1 and 255. Line spacing of 14/144 is recommended for bit-image graphics using eight bits. ESC J is canceled after the line space takes place. The value of n is not stored. Example: LPRINT CHR$(27);CHR$(74);CHR$(n);

Printer Code	Printer Function
ESC K	**1108 Bit-Image Graphics** Format: ESC K;n_1;n_2;v_1;v_2;...v_{1108}; Sets dot spacing to 84 by 84 dots per inch in 1:1 aspect ratio, to 70 by 84 dots per inch in 5:6 aspect ratio (see "ESC n (Set Aspect Ratio)"). All bit-image graphics is printed from left to right. If the graphics data exceeds the space remaining on the line, the data to be printed beyond the end of the line is printed at the left margin on the next line. n_1 and n_2 are binary numbers that specify the number of bit-image data bytes to be transferred. n_1 represents values from 0 to 255, and n_2 represents values from 0 to 4 times 256. The total number of bit-image data bytes is equal to $n_1 + n_2 \times 256$ and cannot exceed 1108 (the total number of dot positions in a 13.2 inch line). Bit-image graphics is printed using eight of the nine print-head wires (the bottom wire is not used). v_1 through v_{1108} are bit-image data bytes, each of which represents a set of 8 dots in a vertical line. The horizontal position of these 8 dots is determined by the position of the bit-image data byte within the v_1 through v_{1108} series. v_1 is printed at the starting position followed in order from left to right by v_2 through v_{1108}. Each bit of a bit-image data byte represents a vertical dot position at the horizontal position represented by that bit-image data byte. The lowest value, or least significant bit (Bit 0), represents the bottom dot position, and the highest value, or most significant bit (Bit 7), represents the top dot position.

Printer Code	Printer Function
ESC K Cont.	In the following table the left-hand column of (•)s represents dot positions within a vertical line. The right-hand column shows the corresponding bit number within a bit-image data byte. (The bits are numbered 7 through 0, from left to right.) **Dot Position** — **Bit Number** Top • – 7 • – 6 • – 5 • – 4 • – 3 • – 2 • – 1 Bottom • – 0 For example: if v_1 is binary 10000000 (decimal 128), only the top dot prints in that horizontal position; if v_1 is binary 00000001 (decimal 01), only the bottom dot prints; and if v_1 is binary 11111111 (decimal 255), all eight dots print. Example: LPRINT CHR$(27);CHR$(75);CHR$($n_1$); CHR$(n_2);CHR$($v_1$);CHR$(v_2); ... CHR$($v_{1108}$);
ESC L	**2216 Bit-Image Graphics (half-speed)** Format: ESC L;n_1;n_2;v_1;v_2;...v_{2216}; Sets dot spacing to 168 by 84 dots per inch in 1:1 aspect ratio, to 140 by 84 dots per inch in 5:6 aspect ratio (see "ESC n (Set Aspect Ratio)"). 2216 bit-image graphics (half-speed) prints at one-half the speed of 2216 bit-image graphics (ESC Y) for improved print quality and the ability to print consecutive dot positions. n_1, n_2, v_1, and v_2 through v_{2216} represent the same values as in 1108 bit-image graphics (ESC K). Refer to the description of ESC K for a complete description of these values. The total number of bit-image data bytes cannot exceed 2216 (the total number of dot positions in a 13.2-inch line). Example: LPRINT CHR$(27);CHR$(76);CHR$($n_1$); CHR$(n_2);CHR$($v_1$);CHR$(v_2); ... CHR$($v_{2216}$);
ESC M	**Automatic Line Justification** Format: ESC M;n; Justifies the right margin. Automatic justification is started when n is 1, and stopped when n is 0. The printer adjusts the spaces between words in the text so that the last character of the words at the end of the lines all print in the last position of the line. Thus both the left and right margins appear as straight lines. This gives a block appearance to the printed text. Automatic line justification can be used with any of the character spacings.

Printer Code	Printer Function
ESC M Cont.	**Notes**: 1. Lines are not right justified if the text is less than 75% of the specified line length. If a line fails the greater than 75% rule, the remaining portion of the text is tested. 2. If the justification results in a word wrap condition, the remaining text is treated as separate lines and follows the above rule. 3. Control codes in the datastream cause the text before the control code to be printed based on the justification rules. The remainder of the text is justified between the current print position and the right margin. 4. If the last line of a paragraph, or any line of data, is not to be justified, use the control code sequence, backspace (BS) and carriage return (CR). 5. The Color Printer operates only on the least significant bit of n. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1, and any even-numbered ASCII decimal value gives the same result as n=0. Example: LPRINT CHR$(27);CHR$(77);CHR$(n);
ESC m	**Select Band 2** Selects ribbon band 2. The actual color printed depends on the ribbon being used. The printer will continue to print with band 2 until a command to change the ribbon band is received by the printer. Example: LPRINT CHR$(27);CHR$(109);
ESC N	**Set Automatic Perforation-Skip** Format: ESC N;n; Specifies the number of lines to be skipped at the end of each page. This causes the printer to automatically skip over the perforation between pages of continuous forms. The number of lines n, is converted to inches using the line-spacing in effect. The value of n must be between 1 and 127. ESC N must be reset anytime the page length is changed by ESC C (Set Page Length in Lines) or by ESC C 0 (Set Page Length in Inches). Example: LPRINT CHR$(27);CHR$(78);CHR$(n);

Printer Code	Printer Function
ESC n	**Set Aspect Ratio** Format: ESC n;x; Sets the printer to a 5:6 or 1:1 aspect ratio. When x is 1, the aspect ratio is set to 1:1; when x is 0, the aspect ratio is set to 5:6. With the 5:6 aspect ratio selected, graphics are printed to match the shape that appears on the display. The 1:1 aspect ratio is recommended for bit-image graphics to improve quality and simplify bit-position calculations. The power-on default is the 5:6 aspect ratio. **Note**: The Color Printer operates only on the least significant bit of n. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1, and any even-numbered ASCII decimal value gives the same result as n=0. Example: LPRINT CHR$(27);CHR$(110);CHR$(x);
ESC O	**Cancel Automatic Perforation-Skip** Cancels the automatic perforation-skip function. Example: LPRINT CHR$(27);CHR$(79);
ESC P	**Proportional Spacing** Format: ESC P;n; Starts proportional spacing when n is 1. Stops proportional spacing when n is 0. Proportional spacing gives each different character a different amount of space on the line. That is, narrow characters, such as i, are given a small amount of space on the line relative to a broader character, such as M. This is similar to the way people write characters and gives a more balanced look to the text. Many books are printed in proportional spacing, as is this one. The distance of a forward space is 10 units; the distance of a backspace is determined by the last printed character or space, if the printing of the character or the space was the last carriage movement. Normal processing of all control codes continues during proportional spacing. **Note**: The Color Printer operates only on the least significant bit of n. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1, and any even-numbered ASCII decimal value gives the same result as n=0. Example: LPRINT CHR$(27);CHR$(80);CHR$(n);

Printer Code	Printer Function
ESC Q 2	**Deselect Specific Printer** Format: ESC Q;2; Sets only the Color Printer so it will not accept data from the system unit. The printer must be initialized by the system or selected using DC1 (Select Printer) to accept data. Example: LPRINT CHR$(27);CHR$(81);CHR$(2);
ESC R	**Set All Tabs to Power-On Defaults** Sets all tabs, horizontal and vertical, to the power-on defaults. Example: LPRINT CHR$(27);CHR$(82);
ESC S	**Subscript or Superscript Printing** Format: ESC S;n; ESC S followed by 1 changes the printer to subscript printing. ESC S followed by 0 changes the printer to superscript printing. ESC S is canceled by ESC T. **Notes**: 1. If line feed (LF) codes are issued while in subscript or superscript printing, the line feed does not change the subscript or superscript setting. For example, if in superscript printing, the line feed causes the paper to advance to the superscript position of the next line. 2. The Color Printer operates only on the least significant bit of n. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1, and any even-numbered ASCII decimal value gives the same result as n=0. Example: LPRINT CHR$(27);CHR$(83);CHR$(n);
ESC SI	**Compressed Printing** Alternate command for SI. Example: LPRINT CHR$(27);CHR$(15);
ESC SO	**Double-Width Printing by Line** Alternate command for SO. Example: LPRINT CHR$(27);CHR$(14);

Printer Code	Printer Function
ESC T	**Cancel Subscript or Superscript** Ends subscript or superscript printing started by ESC S. **Note**: If ESC T is issued when not printing in subscript or superscript, it is acknowledged and ignored. Example: LPRINT CHR$(27);CHR$(84);
ESC U	**Unidirectional Printing** Format: ESC U;n; When n is 1, sets the printer to print from left to right only. ESC U 0 returns the printer to normal two-direction printing. Unidirectional printing ensures a more accurate printing start position for better print quality. **Note**: The Color Printer operates only on the least significant bit of n. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1, and any even-numbered ASCII decimal value gives the same result as n=0. Example: LPRINT CHR$(27);CHR$(85);CHR$(n);
ESC W	**Continuous Double-Width Printing** Format: ESC W;n; ESC W 1 changes the printer to double-width printing. ESC W 0 ends the double-width printing started by ESC W 1. ESC W 1 is not canceled by a line ending code and must be canceled by ESC W 0. **Note**: The Color Printer operates only on the least significant bit of n. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1, and any even-numbered ASCII decimal value gives the same result as n=0. Example: LPRINT CHR$(27);CHR$(87);CHR$(n);

Printer Code	Printer Function
ESC X	**Set Left and Right Margins** Format: ESC X;n_1;n_2; The numbers, n_1 and n_2, are selected in relation to the left side of the printer, with n_1 representing the left margin and n_2 the right margin. The value of n_1 or n_2 is the column of the page you wish to set as the left or right margin. n_2 must be greater than n_1 by 1.27 cm (1/2 inch) or more, and cannot be greater than 13.2 times the character-spacing (in characters per inch) in effect. If n_2 is greater than this limit, the right margin will be set at the maximum allowable length. Data is printed beginning in column n_1. Column n_2 is considered the last printable position of the line. If a word to be printed exceeds the right margin, a carriage-return and line-feed are inserted before the word, and the word is printed on the next line. The margins are converted to inches based on the current character-spacing setting. The power-on default is set with DIP Switch 5. **Note**: Both n_1 and n_2 must be included in the command or the results will be unpredictable. Example: LPRINT CHR$(27);CHR$(88);CHR$($n_1$);CHR$(n_2);
ESC Y	**2216 Bit-Image Graphics** Format: ESC Y;n_1;n_2;v_1;v_2;...v_{2216}; Sets dot spacing to 168 by 84 dots per inch in 1:1 aspect ratio, to 140 by 84 dots per inch in 5:6 aspect ratio (see "ESC n (Set Aspect Ratio)") and prints at normal printing speed. ESC Y graphics cannot print dots in consecutive horizontal dot positions. If consecutive dot positions are specified, the printer will not print the second dot. n_1, n_2, v_1, and v_2, through v_{2216} represent the same values as in 1108 Bit-Image Graphics (ESC K). Refer to the description of ESC K for a complete description of these values. The number of bit-image databytes cannot exceed 2216 (the total number of dot positions in a 13.2-inch line). Example: LPRINT CHR$(27);CHR$(89);CHR$($n_1$);CHR$(n_2); CHR$($v_1$);CHR$(v_2); ...CHR$($v_{2216}$);
ESC y	**Select Band 1** Selects ribbon band 1. The actual color printed depends on the ribbon being used. The printer will continue to print with band 1 until a command to change the ribbon band is received by the printer. Example: LPRINT CHR$(27);CHR$(121);

Printer Code	Printer Function
ESC Z	**4432 Bit-Image Graphics** Format: ESC Z;n_1;n_2;v_1;v_2;...v_{4432}; Sets dot spacing to 336 by 84 dots per inch in 1:1 aspect ratio, to 280 by 84 dots per inch in 5:6 aspect ratio (see "ESC n (Set Aspect Ratio)"). 4432 bit-image graphics prints at one-half the speed of 1108 bit-image graphics (ESC K) for improved print quality. ESC Z graphics can print only every third consecutive horizontal dot position. If consecutive dot positions are specified, the printer will ignore the second and third dots. n_2, v_1, v_2, and v_{4432} represent the same values as in 1108 bit-image graphics (ESC K). Refer to the description of ESC K for a complete description of these values. The number of bit-image databytes cannot exceed 4432 (the total number of dot positions in a 13.2-inch line). Example: LPRINT CHR$(27);CHR$(90);CHR$($n_1$);CHR$(n_2); CHR$($v_1$);CHR$(v_2); ...CHR$($v_{4432}$);
ESC 0	**1/8 Inch Line Spacing** Sets line spacing to 8 lines per inch. Example: LPRINT CHR$(27);CHR$(48);
ESC 1	**6/72 Inch Line Spacing** Sets line spacing to 6/72 inch. Example: LPRINT CHR$(27);CHR$(49);
ESC 2	**Start Text Line Spacing** ESC 2 is an execution command for ESC A (Set Text Line Spacing). If no ESC A command has been given, line spacing returns to 6 lines per inch. Example: LPRINT CHR$(27);CHR$(50);
ESC 3	**Graphics Line Spacing** Format: ESC 3;n; Sets line spacing to n/144 inch. Line spacing of 14/144 is recommended for bit-image graphics using eight bits. The value of n must be between 1 and 255. Example: LPRINT CHR$(27);CHR$(51);CHR$(n);
ESC 4	**Set Top of Page** Sets the current vertical position as the top-of-page. Example: LPRINT CHR$(27);CHR$(52);

Printer Code	Printer Function
ESC 5	**Automatic Line Feed** Format: ESC 5;n; When n is 1, automatic line feeding starts; the printer will line-feed each time a code that indicates the end of a line, such as CR, is received. When n is 0, automatic line feeding stops. **Note**: The Color Printer operates only on the least significant bit of n. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1, and any even-numbered ASCII decimal value gives the same result as n=0. Example: LPRINT CHR$(27);CHR$(53);CHR$(n);
ESC 6	**Select Character Set 2** Selects character set 2. (See "Character Set 2.") Character Set 2 contains most characters and symbols used in non-English languages. The power-on default for Character Set is set with DIP Switch 1. **Note**: Some programs use the control codes in Character Set 1 that have ASCII decimal values above 128. These control codes are not in Character Set 2. The use of Character Set 2, therefore, may not give the desired results with some programs. Example: LPRINT CHR$(27);CHR$(54);
ESC 7	**Select Character Set 1** Selects character set 1. (See "Character Set 1".) Character Set 1 contains characters and symbols commonly used in the English language, along with some common, non-English, characters and symbols. The power-on default for Character Set is set with DIP Switch 1. Example: LPRINT CHR$(27);CHR$(55);
ESC –	**Continuous Underline** Format: ESC –;n; When n is 1-all of the following data is underlined. ESC – followed by 0 cancels underlining. **Note**: The Color Printer operates only on the least significant bit of n. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1, and any even-numbered ASCII decimal value gives the same result as n=0. Example: LPRINT CHR$(27);CHR$(45);CHR$(n);

Printer Code	Printer Function
ESC :	**12 Characters per Inch Printing** Sets character spacing to 12 characters per inch. Example: LPRINT CHR$(27);CHR$(58);
ESC <	**Move Carriage to Home Position** Returns the print head to the left side of the printer to print the line following the command. No line feed occurs. Example: LPRINT CHR$(27);CHR$(60);
ESC ?	**Set Initialize Signal Function** Format: ESC ?;n; Defines what the printer does when an initialize signal is received. The initialize signal is a hardware signal sent to the printer by the system unit when called for by the program being used. This signal is commonly called for when a program is first loaded. When n is 1, the initialize function is set On; when n is 0, the initialize function is set Off. When the initialize function is On, the initialize signal causes the printer to clear all data from the printer memory and set all printer functions to the power-on defaults. Some of the data may not have been printed and will be lost. When the initialize function is Off, the initialize signal causes the printer to insert CAN (Clear Data) into the data in the printer memory. The CAN, when processed by the printer, clears the printer memory of all data waiting to be printed following the-last received line-ending code. All control codes are cleared and the printer is set to the values set by the DIP switches. This allows a printing job to be completed before the printer is reset for the next application. The power-on default is the initialize function set Off. **Note**: The Color Printer operates only on the least significant bit of n. Therefore, any odd-numbered ASCII decimal value gives the same result as n=1, and any even-numbered ASCII decimal value gives the same result as n=0. Example: LPRINT CHR$(27);CHR$(63);CHR$(n);

Printer Code	Printer Function
ESC @	**Select Control-Value Data Type** Format: ESC @;n; Allows the printer to accept certain parameters for the ESC commands in either of two forms: binary or ASCII character. When "n" is 1 (odd) ASCII is selected. When "n" is 0 (even) Binary is selected. **Note**: See "Programming Considerations at the Beginning of this section for a detailed explanation of this command. Example: LPRINT CHR$(27);CHR$(64);CHR$(n);
ESC \	**Print All Characters** Format: ESC \ ;n_1;n_2; Allows the printing of all characters. This includes characters that are normally recognized by the printer as control codes. This code (ESC \) allows the printer to print the special symbols assigned to these ASCII values. If no character is assigned to a decimal value received by the printer, a space character is printed. No control code functions are performed when this command is in effect. n_1 and n_2 are binary numbers that specify the number of characters to be printed. n_1 represents values from 0 to 255, and n_2 represents values from 0 to 255 times 256. Example: LPRINT CHR$(27);CHR$(92); CHR$($n_1$);CHR$(n_2);
ESC]	**Reverse Line Feed** Causes the printer to move the paper down one line space as defined by DIP Switch 2 or by printer control codes, ESC A and ESC 2, ESC 0, ESC 1, or ESC 3. Example: LPRINT CHR$(27);CHR$(93);
ESC ^	**Print Any Character** Allows the printer to print any character each time the command is received. This includes characters normally recognized by the printer as control codes. This code (ESC ^) allows the printer to print the special symbols assigned to these ASCII values. If no character is assigned to a decimal value received by the printer, a space character is printed. Example: LPRINT CHR$(27);CHR$(94);

Printer Code	Printer Function
FF	**Form Feed** Advances the paper to the next top-of-form position. The top-of-form position is set by the position of the paper when power is switched On, or by ESC 4, ESC C, or the control-panel buttons. The next top-of-form is determined by the form length defined by DIP Switch 6, ESC C, or ESC C 0. Example: LPRINT CHR$(12);
HT	**Horizontal Tab** Moves the print head to the next horizontal tab stop. If the next horizontal tab stop is beyond the right margin, the character following HT is printed at the left margin. Tab stops are set with ESC D. A tab stop every 8 columns is the power-on default. Example: LPRINT CHR$(9);
LF	**Line Feed** Advances the paper one linespace, as defined by DIP Switch 2 or by printer control codes; ESC A and ESC 2, ESC 0, ESC 1, or ESC 3. Example: LPRINT CHR$(10);
NUL	**Command End** Used with control commands as a command list terminator. NUL is also used with other printer control codes to select options. Example: LPRINT CHR$(0);
SI	**Compressed Printing** Causes the printer to begin compressed printing. Character spacing in compressed printing is 17.1 characters per inch. Example: LPRINT CHR$(15);
SO	**Double-Width Printing by Line** Causes the printer to start double-width printing. Double-width printing prints the characters twice as wide as the current character spacing. This results in half as many characters per inch. A Carriage Return, Line Feed or DC4 (End Double-Width Printing by Line) cancels the SO command. Example: LPRINT CHR$(14);

Printer Code	Printer Function
VT	**Vertical Tab** Advances the paper to the next vertical tab-stop position. If the next vertical tabstop is beyond the bottom of the page, the paper is placed at the first line of the next page. If no vertical tab stops are set, the VT command is treated as a line-feed (LF) command. Example: LPRINT CHR$(11);

Printer Control Code Quick Reference

This is an alphabetic listing of the descriptions of the printer control codes. You will find it helpful in locating the code you need to perform a certain job, or to determine the ASCII decimal value quickly, once you are familiar with the control codes.

> **Note:** ASCII values greater than 27 must be preceded by the ESC code (ASCII value 27).

Description	Code	ASCII Value
10 characters-per-inch print	DC2	18
12 characters-per-inch print	ESC :	58
17.1 characters-per-inch print	SI	15
Alarm	BEL	7
All-characters print	ESC \	92
Aspect ratio set	ESC n	110
Audible alarm	BEL	7
Auto justification On/Off	ESC M	77
Auto line feed On/Off	ESC 5	53
Auto perforation skip Off	ESC O	79
Auto perforation skip On	ESC N	78
Auto ribbon-band shift	ESC a	97
Auto ribbon shift	ESC a	97
Backspace	BS	8
Backspace n increments	ESC e	101
Backspace variable	ESC e	101
Band 1	ESC y	121
Band 2	ESC m	109
Band 3	ESC c	99
Band 4	ESC b	98
Bell	BEL	7
Black ribbon band	ESC b	98
Buzzer	BEL	7

Description	Code	ASCII Value
Cancel	CAN	24
Cancel auto line feed	ESC 5	53
Cancel data	CAN	24
Cancel double-strike printing	ESC H	72
Cancel double-width by line	DC4	20
Cancel double-width printing (lines)	ESC W	87
Cancel emphasized printing	ESC F	70
Cancel perforation skip	ESC O	79
Cancel proportional spacing	ESC P	80
Cancel subscript	ESC T	84
Cancel superscript	ESC T	84
Carriage return	CR	13
Change color (see ribbon band desired)		
Change printing quality	ESC I	73
Character quality set	ESC I	73
Character set 1 select	ESC 7	55
Character set 2 select	ESC 6	54
Character spacing, 12 per inch	ESC :	58
Character spacing, 10 per inch	DC2	18
Character spacing, 17.1 per inch	SI	15
Character under decimal 32, print	ESC ^	94
Characters under decimal 32, print	ESC \	92
Clear data	CAN	24
Clear horizontal tabs	ESC R	82
Clear tabs	ESC R	82
Clear vertical tabs	ESC R	82
Color band 1	ESC y	121
Color band 2	ESC m	109
Color band 3	ESC c	99
Color band 4	ESC b	98

Description	Code	ASCII Value
Command designator	ESC	27
Command end	NUL	0
Command prefix	ESC	27
Command start	ESC	27
Command terminator	NUL	0
Compressed On	SI	15
Compressed print	SI	15
Condensed print	SI	15
Control-data value-type set	ESC @	64
Data clear	CAN	24
Data-processing quality set	ESC I	73
Data-value type set	ESC @	64
Deselect printer	DC3	19
Deselect specific printer	ESC Q	81
Double-strike printing	ESC G	71
Double-strike printing Off	ESC H	72
Double-width-by-line Off	DC4	20
Double-width-by-line On	SO	14
Double-width On/Off (lines)	ESC W	87
Eject form	FF	12
Eject paper	FF	12
Emphasized printing	ESC E	69
Emphasized printing Off	ESC F	70
Escape	ESC	27
Feed line	LF	10
Form feed	FF	12
Form, set top of	ESC 4	52
Forward space variable	ESC d	100
Graphics, 1108 bit-image	ESC K	75
Graphics, 2216 bit-image, 1/2 speed	ESC L	76
Graphics, 2216 bit-image, full speed	ESC Y	89

Description	Code	ASCII Value
Graphics, 4432 bit-image, 1/2 speed	ESC Z	90
Graphics, line-feed set	ESC 3	51
Head, home	ESC <	60
Home head	ESC <	60
Horizontal tab	HT	9
Horizontal tab stops set	ESC D	68
Incremental backspace	ESC e	101
Initialize function set	ESC ?	63
Justification On/Off	ESC M	77
Length-of-page set in lines	ESC C	67
Length-of-page set in inches	ESC C 0	67 0
Line-feed	LF	10
Line-feed, auto On/Off	ESC 5	53
Line-feed, reverse	ESC]	93
Line-feed, set 1/8 inch	ESC 0	48
Line-feed, set 6/72 inch	ESC 1	49
Line-feed, set graphics	ESC 3	51
Line-feed, store text	ESC A	65
Line-feed, start text	ESC 2	50
Line-feed, variable	ESC J	74
Margins set	ESC X	88
Near-letter quality, set	ESC I	73
Null	NUL	0
Page eject	FF	12
Page length, set in inches	ESC C 0	67 0
Page length, set in lines	ESC C	67
Paper eject	FF	12
Perforation skip Off	ESC O	79
Perforation skip set	ESC N	78
Print all characters	ESC \	92
Print character under decimal 32	ESC ^	94

Description	Code	ASCII Value
Print double-width one line	SO	14
Print double-width multiple lines	ESC W	87
Print emphasized	ESC E	69
Print emphasized Off	ESC F	70
Print quality set	ESC I	73
Print 10 characters per inch	DC2	18
Print 12 characters per inch	ESC :	58
Print unidirectional On/Off	ESC U	85
Printer deselect	DC3	19
Printer deselect specific	ESC Q	81
Printer select	DC1	17
Proportional spacing On/Off	ESC P	80
Quality set	ESC I	73
Return carriage	CR	13
Reverse line feed	ESC]	93
Ribbon band 1	ESC y	121
Ribbon band 2	ESC m	109
Ribbon band 3	ESC c	99
Ribbon band 4	ESC b	98
Ribbon band auto shift	ESC a	97
Select character set 1	ESC 7	55
Select character set 2	ESC 6	54
Select color (see ribbon band desired)		
Select printer	DC1	17
Set 1 (character set 1)	ESC 7	55
Set 1/8-inch line feed	ESC 0	48
Set 2 (character set 2)	ESC 6	54
Set 6/72-inch line feed	ESC 1	49
Set aspect ratio	ESC n	110
Set data-processing quality	ESC I	73

Description	Code	ASCII Value
Set data-value type	ESC @	64
Set graphics line feed	ESC 3	51
Set horizontal tab stops	ESC D	68
Set initialize function	ESC ?	63
Set left margin	ESC X	88
Set margins	ESC X	88
Set near-letter quality	ESC I	73
Set page length in lines	ESC C	67
Set page length in inches	ESC C 0	67 0
Set perforation skip	ESC N	78
Set right margin	ESC X	88
Set text quality	ESC I	73
Set top-of-form	ESC 4	52
Set vertical tabs	ESC B	66
Space forward variable	ESC d	100
Specific printer deselect	ESC Q	81
Start 6/72 inch line feed	ESC 1	49
Start auto line feed	ESC 5	53
Start double-strike print	ESC G	71
Start double-width print by line	SO	14
Start double-width print (lines)	ESC W	87
Start emphasized print	ESC E	69
Start graphics line feed	ESC 3	51
Start perforation skip	ESC N	78
Start proportional spacing	ESC P	80
Start subscript	ESC S	83
Start superscript	ESC S	83
Start text line feed	ESC 2	50
Start underline	ESC –	45
Stop auto line feed	ESC 5	53
Stop double-strike print	ESC H	72

Description	Code	ASCII Value
Stop double-width by line	DC4	20
Stop double-width print (lines)	ESC W	87
Stop emphasized print	ESC F	70
Stop perforation skip	ESC O	79
Stop proportional spacing	ESC P	80
Stop subscript	ESC T	84
Stop superscript	ESC T	84
Stop underline	ESC –	45
Stops, horizontal tabs, set	ESC D	68
Stops, vertical tabs, set	ESC B	66
Store text line feed	ESC A	65
Subscript Off	ESC T	84
Subscript On	ESC S	83
Superscript Off	ESC T	84
Superscript On	ESC S	83
Tab horizontal	HT	9
Tab stops, horizontal, set	ESC D	68
Tab stops, vertical, set	ESC B	66
Tab vertical	VT	11
Tabs clear	ESC R	82
Tabs horizontal set	ESC D	68
Tabs vertical set	ESC B	66
Text line-feed store	ESC A	65
Text line-feed start	ESC 2	50
Text quality set	ESC I	73
Top-of-form set	ESC 4	52
Underline On/Off	ESC –	45
Unidirectional printing On/Off	ESC U	85
Variable backspace	ESC e	101
Variable forward space	ESC d	100
Variable line feed	ESC J	74
Vertical tabs set	ESC B	66
Vertical tab	VT	11

Printing in Color

The IBM Personal Computer Color Printer is capable of printing in 8 colors when the process color ribbon is used. The 4 colors of the ribbon are selected by: ESC b (Select Band 4) for black, ESC c (Select Band 3) for cyan, ESC m (Select Band 2) for magenta, and ESC y (Select Band 1) for yellow. You can print four additional colors, orange, green, violet, and brown, by printing the data twice. Print the data in one color and then print over the data in a second color according to the table below. When printing data twice to mix colors, always print the lighter color first to avoid contaminating the ribbon.

Color Desired	Ribbon Bands to Mix
Orange	Bands 1 (ESC y) and 2 (ESC m)
Green	Bands 1 (ESC y) and 3 (ESC c)
Violet	Bands 2 (ESC m) and 3 (ESC c)
Brown	Bands 2 (ESC m) and 4 (ESC b)

To mix colors, data must be sent to the printer in the following order: printer control code to select the first color, data to be printed, carriage return with no line feed, printer control code to select the second color, repeat the data to be printed. For example, to print "IBM Personal Computer" in green, you must; select band 1 (yellow) with ESC y, print "IBM Personal Computer", return the carriage with no line feed with ASCII decimal value 141 from "Character Set 1," select band 3 (cyan) with ESC c, and print "IBM Personal Computer." To do this, type the following:

```
LPRINT CHR$(27);CHR$(121);"IBM Personal
Computer";CHR$(141);CHR$(27);CHR$(99;)"IBM Personal
Computer"
```

Note: The above example is for use with "Character Set 1."

Color Printer Character Set 1

0	1	2	3	4	5	6	7	8	9
NUL	☺	☻	♡	◇	♧	♤	BEL	BS	HT
10	11	12	13	14	15	16	17	18	19
LF	VT	FF	CR	SO	SI	►	DC1	DC2	DC3
20	21	22	23	24	25	26	27	28	29
DC4	§	▬	↨	CAN	↓		ESC	∟	↔
30	31	32	33	34	35	36	37	38	39
▲	▼	SP	!	"	#	$	%	&	'
40	41	42	43	44	45	46	47	48	49
(	)	*	+	,	—	.	/	0	1
50	51	52	53	54	55	56	57	58	59
2	3	4	5	6	7	8	9	:	;
60	61	62	63	64	65	66	67	68	69
<	=	>	?	@	A	B	C	D	E
70	71	72	73	74	75	76	77	78	79
F	G	H	I	J	K	L	M	N	O
80	81	82	83	84	85	86	87	88	89
P	Q	R	S	T	U	V	W	X	Y
90	91	92	93	94	95	96	97	98	99
Z	[	\	]	^	_	`	a	b	c
100	101	102	103	104	105	106	107	108	109
d	e	f	g	h	i	j	k	l	m
110	111	112	113	114	115	116	117	118	119
n	o	p	q	r	s	t	u	v	w
120	121	122	123	124	125	126	127	128	129
x	y	z	{	¦	}	~		NUL	ü

Color Printer Character Set 1 (Continued)

130	131	132	133	134	135	136	137	138	139
é	â	ä	à	å	BEL	BS	HT	LF	VT
140	**141**	**142**	**143**	**144**	**145**	**146**	**147**	**148**	**149**
FF	CR	SO	SI	É	DC1	DC2	DC3	DC4	ò
150	**151**	**152**	**153**	**154**	**155**	**156**	**157**	**158**	**159**
û	ù	CAN	Ö		ESC	£	¥	₧	ƒ
160	**161**	**162**	**163**	**164**	**165**	**166**	**167**	**168**	**169**
á	í	ó	ú	ñ	Ñ	ª	º	¿	⌐
170	**171**	**172**	**173**	**174**	**175**	**176**	**177**	**178**	**179**
¬	½	¼	¡	«	»	░	▒	▓	│
180	**181**	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**
┤	╡	╢	╖	╕	╣	║	╗	╝	╜
190	**191**	**192**	**193**	**194**	**195**	**196**	**197**	**198**	**199**
╛	┐	└	┴	┬	├	─	┼	╞	╟
200	**201**	**202**	**203**	**204**	**205**	**206**	**207**	**208**	**209**
╚	╔	╩	╦	╠	═	╬	╧	╨	╤
210	**211**	**212**	**213**	**214**	**215**	**216**	**217**	**218**	**219**
╥	╙	╘	╒	╓	╫	╪	┘	┌	█
220	**221**	**222**	**223**	**224**	**225**	**226**	**227**	**228**	**229**
▄	▌	▐	▀	α	β	Γ	π	Σ	σ
230	**231**	**232**	**233**	**234**	**235**	**236**	**237**	**238**	**239**
μ	τ	Φ	Θ	Ω	δ	∞	$\varnothing$	ϵ	$\cap$
240	**241**	**242**	**243**	**244**	**245**	**246**	**247**	**248**	**249**
$\equiv$	$\pm$	$\geq$	$\leq$	⌠	⌡	$\div$	$\approx$	°	•
250	**251**	**252**	**253**	**254**	**255**				
·	$\surd$	^{n}	^{2}	■	SP				

Color Printer Character Set 2

0	1	2	3	4	5	6	7	8	9
NUL	☺	☻	♡	◇	♧	♤	BEL	BS	HT
10	11	12	13	14	15	16	17	18	19
LF	VT	FF	CR	SO	SI	►	DC1	DC2	DC3
20	21	22	23	24	25	26	27	28	29
DC4	§	▬	↨	CAN	↓		ESC	∟	↔
30	31	32	33	34	35	36	37	38	39
▲	▼	SP	!	"	#	$	%	&	'
40	41	42	43	44	45	46	47	48	49
(	)	*	+	,	—	.	/	0	1
50	51	52	53	54	55	56	57	58	59
2	3	4	5	6	7	8	9	:	;
60	61	62	63	64	65	66	67	68	69
<	=	>	?	@	A	B	C	D	E
70	71	72	73	74	75	76	77	78	79
F	G	H	I	J	K	L	M	N	O
80	81	82	83	84	85	86	87	88	89
P	Q	R	S	T	U	V	W	X	Y
90	91	92	93	94	95	96	97	98	99
Z	[	\	]	^	_	`	a	b	c
100	101	102	103	104	105	106	107	108	109
d	e	f	g	h	i	j	k	l	m
110	111	112	113	114	115	116	117	118	119
n	o	p	q	r	s	t	u	v	w
120	121	122	123	124	125	126	127	128	129
x	y	z	{	¦	}	~		Ç	ü

Color Printer Character Set 2 (Continued)

130	131	132	133	134	135	136	137	138	139
é	â	ä	à	å	ç	ê	ë	è	ï
140	141	142	143	144	145	146	147	148	149
î	ì	Ä	Å	É	æ	Æ	ô	ö	ò
150	151	152	153	154	155	156	157	158	159
û	ù	ÿ	Ö	Ü	¢	£	¥	₧	ƒ
160	161	162	163	164	165	166	167	168	169
á	í	ó	ú	ñ	Ñ	ª	º	¿	⌐
170	171	172	173	174	175	176	177	178	179
¬	½	¼	¡	«	»	░	▒	▓	│
180	181	182	183	184	185	186	187	188	189
┤	╡	╢	╖	╕	╣	║	╗	╝	╜
190	191	192	193	194	195	196	197	198	199
╛	┐	└	┴	┬	├	─	┼	╞	╟
200	201	202	203	204	205	206	207	208	209
╚	╔	╩	╦	╠	═	╬	╧	╨	╤
210	211	212	213	214	215	216	217	218	219
╥	╙	╘	╒	╓	╫	╪	┘	┌	█
220	221	222	223	224	225	226	227	228	229
▄	▌	▐	▀	α	β	Γ	π	Σ	σ
230	231	232	233	234	235	236	237	238	239
µ	τ	Φ	Θ	Ω	δ	∞	ø	ε	∩
240	241	242	243	244	245	246	247	248	249
≡	±	≥	≤	⌠	⌡	÷	≈	°	■
250	251	252	253	254	255				
–	√	n	2	■	SP				

All Printable Characters

0	1	2	3	4	5	6	7	8	9
NUL	☺	☻	♡	◇	♧	♤	•	◘	○
10	11	12	13	14	15	16	17	18	19
◙	♂	♀	♪	♫	☼	►	◄	↕	!!
20	21	22	23	24	25	26	27	28	29
¶	§	▬	↨	↑	↓	→	←	∟	↔
30	31	32	33	34	35	36	37	38	39
▲	▼	SP	!	"	#	$	%	&	'
40	41	42	43	44	45	46	47	48	49
(	)	*	+	,	—	.	/	0	1
50	51	52	53	54	55	56	57	58	59
2	3	4	5	6	7	8	9	:	;
60	61	62	63	64	65	66	67	68	69
<	=	>	?	@	A	B	C	D	E
70	71	72	73	74	75	76	77	78	79
F	G	H	I	J	K	L	M	N	O
80	81	82	83	84	85	86	87	88	89
P	Q	R	S	T	U	V	W	X	Y
90	91	92	93	94	95	96	97	98	99
Z	[	\	]	^	_	`	a	b	c
100	101	102	103	104	105	106	107	108	109
d	e	f	g	h	i	j	k	l	m
110	111	112	113	114	115	116	117	118	119
n	o	p	q	r	s	t	u	v	w
120	121	122	123	124	125	126	127	128	129
x	y	z	{	¦	}	~		Ç	ü

All Printable Characters (Continued)

130	131	132	133	134	135	136	137	138	139
é	â	ä	à	å	ç	ê	ë	è	ï
140	141	142	143	144	145	146	147	148	149
î	ì	Ä	Å	É	æ	Æ	ô	ö	ò
150	151	152	153	154	155	156	157	158	159
û	ù	ÿ	Ö	Ü	¢	£	¥	₧	ƒ
160	161	162	163	164	165	166	167	168	169
á	í	ó	ú	ñ	Ñ	ª	º	¿	⌐
170	171	172	173	174	175	176	177	178	179
¬	½	¼	¡	«	»	░	▒	▓	│
180	181	182	183	184	185	186	187	188	189
┤	╡	╢	╖	╕	╣	║	╗	╝	╜
190	191	192	193	194	195	196	197	198	199
╛	┐	└	┴	┬	├	─	┼	╞	╟
200	201	202	203	204	205	206	207	208	209
╚	╔	╩	╦	╠	═	╬	╧	╨	╤
210	211	212	213	214	215	216	217	218	219
╥	╙	╘	╒	╓	╫	╪	┘	┌	█
220	221	222	223	224	225	226	227	228	229
▄	▌	▐	▀	α	β	Γ	π	Σ	σ
230	231	232	233	234	235	236	237	238	239
μ	τ	Φ	Θ	Ω	δ	∞	Ø	ε	∩
240	241	242	243	244	245	246	247	248	249
≡	±	≥	≤	⌠	⌡	÷	≈	°	●
250	251	252	253	254	255				
·	√	^{n}	^{2}	■	SP				

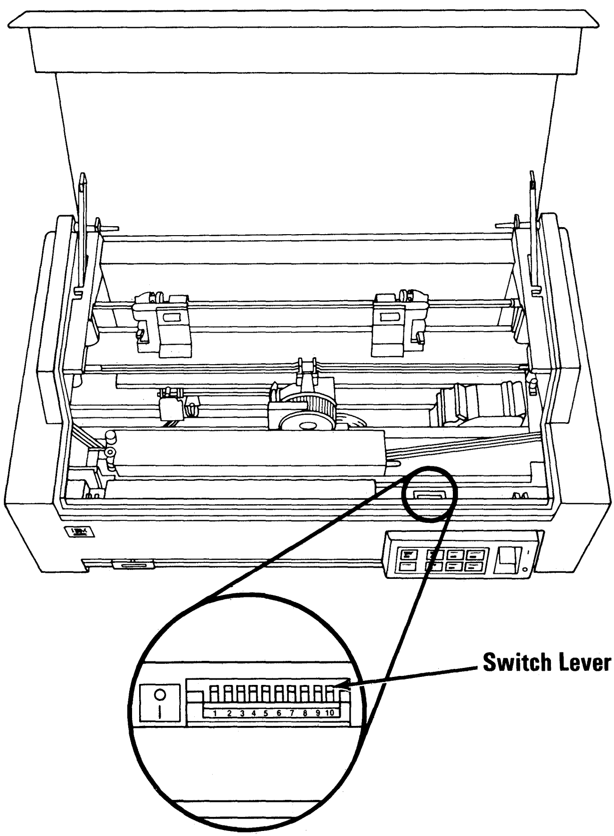
DIP-Switch Settings

Many of the printer functions can be manually set with a 10-position dual in-line package (DIP) switch. Although these same functions are programmable, the printer defaults to the values set by the DIP switch.

The DIP switches must be set prior to switching the printer's power to On. The printer logic reads the DIP-switch settings only at power-on or printer initialization.

> **Note:** Some programs use the control codes in Character Set 1 that have ASCII decimal values above 128. These control codes are not in Character Set 2. The use of Character Set 2, therefore, may not give the desired results with some programs.

The charts on the following page describe the functions available through the DIP-switch settings.



Location of Printer DIP Switch

Switch	Setting	Function
1	On	Selects Character Set 2 (see "Character Set 2")(see "Note" below)
1	Off	Selects Character Set 1 (see "Character Set 1")
2	On	Sets line spacing to 8 lines per inch
2	Off	Sets line spacing to 6 lines per inch
3	On	Sets automatic 1-inch perforation skip
3	Off	No automatic perforation skip
4	On	Sets automatic line feed on carriage return
4	Off	No automatic line feed on carriage return
5	On	Sets printer to a 13.2-inch print line
5	Off	Sets printer to an 8-inch print line.
6	On	Selects 12-inch page length
6	Off	Selects 11-inch page length
7	On	Sets automatic ribbon-band shift (use with all-black ribbon)
7	Off	No automatic ribbon-band shift (use with color)
8	On	Does not allow audible alarm to sound
8	Off	Allows audible alarm to sound

DIP-Switch Settings — 1 Through 8

Switch 9	Switch 10	Quality and Spacing Set
Off	Off	Data processing quality, 12 characters per inch, (see "Note" below)
Off	On	Data processing quality, 10 characters per inch
On	Off	Text quality, 10 characters per inch
On	On	Near letter quality, 10 characters per inch

DIP-Switch Settings — 9 and 10

Switches 9 and 10 select the printing quality and character spacing. See "ESC I" in "Printer Control Codes" for a description of the printing qualities.

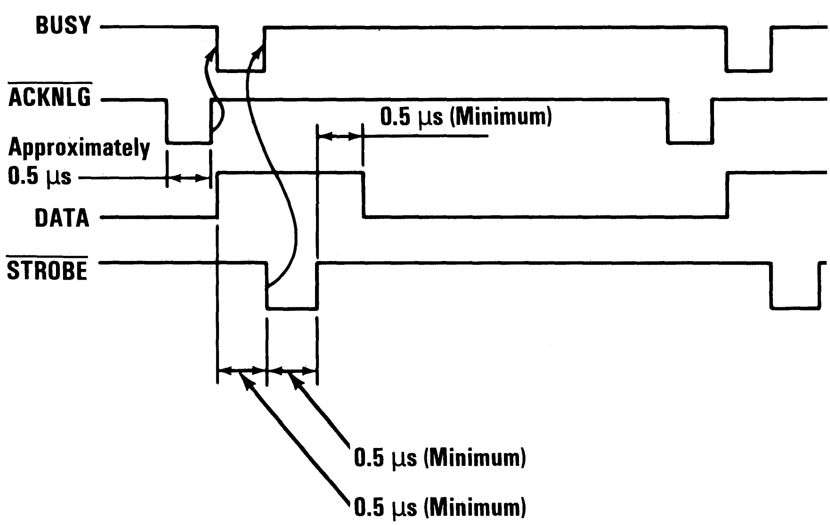
> **Note:** When switches 9 and 10 are Off, the printer prints with a 1-inch page length with no perforation skip. Switches 3 and 6 are overridden. This is the self-test setup.

Interface

Specifications:

- Data transfer rate: 1000 CPS (max.)
- Synchronization: By externally supplied STROBE pulses.
- Handshaking: -ACKNLG or +BUSY signals.
- Logic level: Input data and all interface control signals are TTL-compatible.
- Connector type: 57-30360 (AMPHENOL), or equivalent, 36-pin connector on printer end of cable.

Data Transfer Sequence:



Parallel Interface Timing Diagram

Specifications

Size	
Height	24.4 cm (10 in.)
Width	57.8 cm (22.75 in.)
Depth	35.43 cm (14 in.)
Weight	18.4 kg (40 lb)
Power Cable	
Length	1.98 m (6.5 ft)
Size	28 AWG
Signal Cable	
Length	1.89 m (6 ft)
Size	3 by 18 AWG

Physical Specifications

Voltage (Vac)			**Frequency (Hz)**	**Current (Amps)**	**Power (Watts)**
Nominal	Minimum	Maximum	± 3 Hz	Maximum	Maximum
100	90	118	50/60	1.5	135
120	102	139	60	1.5	135
200	180	236	50/60	1.0	135
220	190	264	50/60	1.0	135

Electrical Specifications

Print Method	Wire matrix	
Print Speed		
Data Processing Quality	200 cps	
Text Quality	110 to 150 cps	
Near Letter Quality	30 to 40 cps	
Print Direction	Bidirectional with logic seeking	
Number of Pins in Head	9 (4- and 5-column arrangement)	
Size of Pins in Head	.356-mm (0.014-in.) wire diameters	
Line Spacing	4.23 mm (1/6 in.) or programmable	
Printing Characteristics		
Matrices	Data processing: 9 x 9 Text: 24 x 9 Near-letter: 36 x 18 Block graphic: 24 x 14	
Character Sets	See "Color Printer Character Sets" 1 and 2.	
Printing Sizes		
	Characters per inch	Maximum characters per line
Normal	10	132
Double Width	5	66
Compressed	17.1	225.7
Double Width-Compressed	13.3	175.5
Proportional	12 (average)	158.4 (average)
Subscript	10	132
Superscript	10	132
Media Handling		
Paper Feed	Forms tractor feed and friction feed	
Speed	127 mm (5.0 in.) per second	
Paper Width Range		
Forms tractor feed	76.2 to 406.4 mm (3 to 16 in.)	
Friction feed	177.8 to 304.8 mm (7 to 12 in.) (216 to 432 mm (8.5 to 17 in.) adjustable length)	
Paper Weight		
Continuous forms	Single part: 15 to 20 lb bond Multipart: 12 to 15 lb, 6 to 8 lb carbon	
Single sheet	15 to 20 lb bond	

Printer Specifications (Part 1 of 2)

Media Handling (continued)		
Copies		
Continuous forms	1 to 4 parts	
Single sheet	1 part only	
Paper Path		
Continuous forms	Front, bottom, and rear	
Single sheet	Front	
Interfaces	Standard parallel 8-bit Data and Control lines	
Inked Ribbon		
Type	Cartridge (all ribbons)	
Color		
Process Ribbon	COLOR	BAND
	Yellow	1
	Magenta	2
	Cyan	3
	Black	4
Primary Ribbon	COLOR	BAND
	Red	1
	Green	2
	Blue	3
	Black	4
Environmental Conditions		
Operating Temperature	10 to 40°C (50 to 104°F)	
Operating Humidity	10 to 80% non-condensing	
Heat Output	140 BTU/hr (maximum)	
Memory Allocation		
Internal	2K bytes	
Data	6K bytes	
Reserved	8K bytes	
Total	16K bytes	

Printer Specifications (Part 2 of 2)

Connector Pin Assignments

Printer connector-pin assignments and descriptions of signals are provided in the following chart.

Connector Pin Assignment		
Signal Pin No.	**Signal**	**Description**
1	-STROBE	-STROBE pulse to read data in. Pulse width must be more than 0.5µs at receiving terminal. The signal level is normally high (logical 1); data is read at the low (logical 0) level.
2	DATA 1	These signals represent information of the 1st to 8th bits of parallel data respectively.
3	DATA 2	
4	DATA 3	
5	DATA 4	
6	DATA 5	
7	DATA 6	
8	DATA 7	
9	DATA 8	
10	-ACKNLG	Approx. 0.5µs pulse. A low signal indicates that the printer is ready to accept other data.
11	+ BUSY	A high signal indicates that the printer cannot receive data. The signal becomes high in the following cases: 1. During data entry 2. During printing operation 3. In offline state 4. During printer error status
12	+ PE	A high signal indicates that the printer is out of paper.
13	+ SLCT (ENABLE)	A high signal indicates that the remote control select feature has not deselected the printer. The signal level goes high upon going ready or receiving a DC 1 (SELECT). If currently ready but deselected, it goes low upon receiving a DC 3 (DESELECT).
14	-AUTO FEED	Not used
15		Not used
16	0v	Logic GND level.

Connector Pin Assignment (Part 1 of 2)

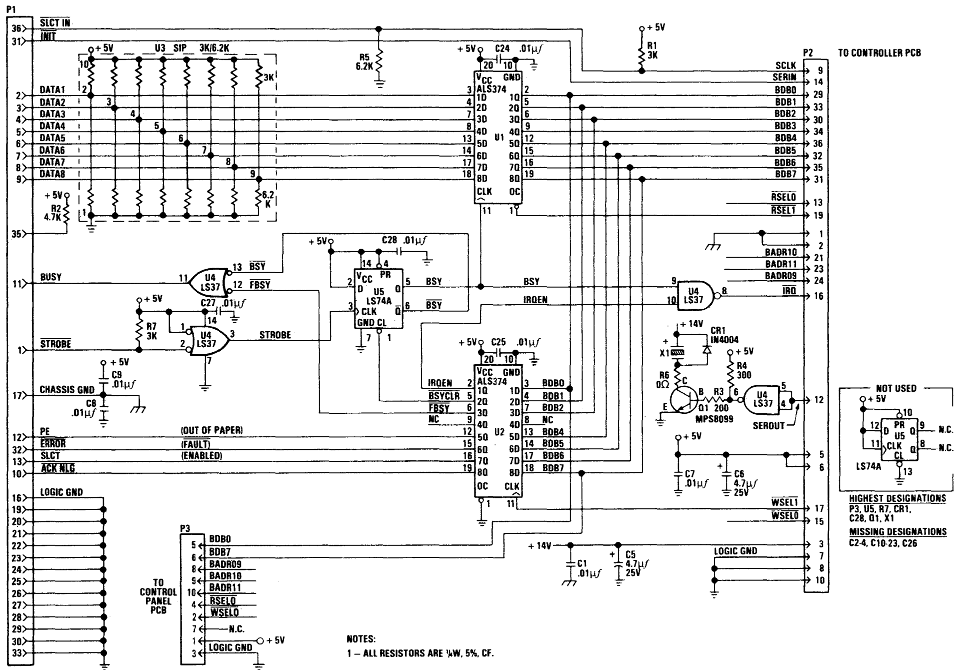
Connector Pin Assignment		
Signal Pin No.	**Signal**	**Description**
17	CHASSIS GND	Printer chassis ground (GND). In the printer, the chassis GND and the logic GND are isolated from each other.
18		Not used
19-30	GND	TWISTED-PAIR RETURN logic GND level.
31	-INIT	When the level of this signal becomes low, the printer controller is reset to its initial state, and the print buffer is cleared. This signal is normally at high level, and its pulse width must be more than 50 µs at the receiving terminal.
32	-ERROR	The level of this signal becomes low when the printer is in: 1. Paper Out state 2. Offline state 3. Error state
33	GND	TWISTED-PAIR return logic GND level.
34		Not used
35		Not used
36		Not used

Connector Pin Assignment (Part 2 of 2)

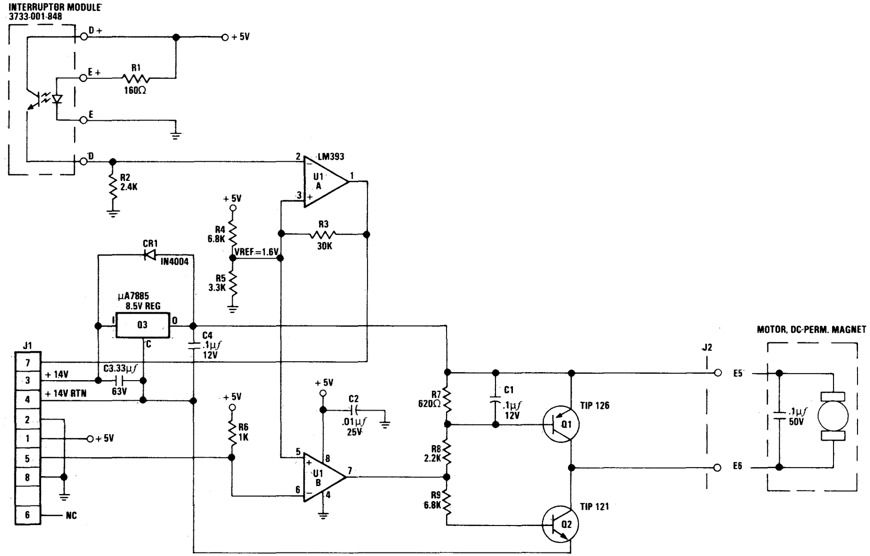
Notes:

1. All interface conditions are based on TTL-level signals. The rise and fall time of each signal must be less than 0.2 microseconds.

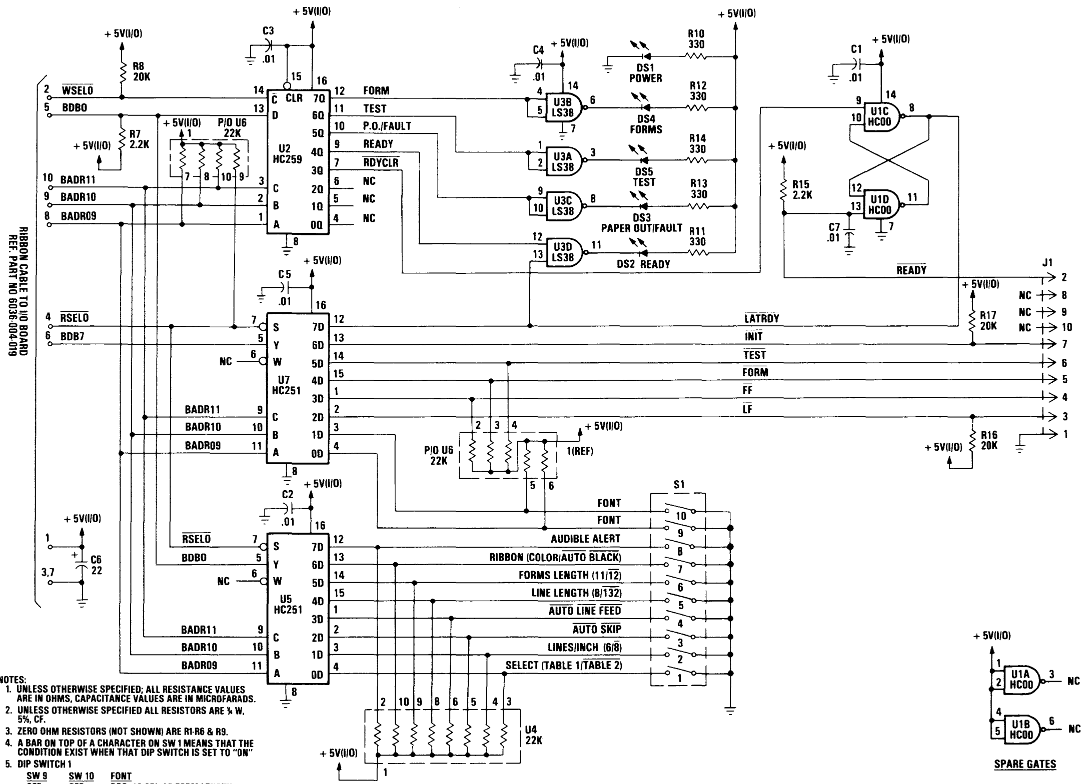
2. Data must not be transmitted until the –ACKNLG signal and +BUSY signal go low.



Color Printer — I/O Board (Sheet 1 of 1)



Color Printer — Color Shift (Sheet 1 of 1)

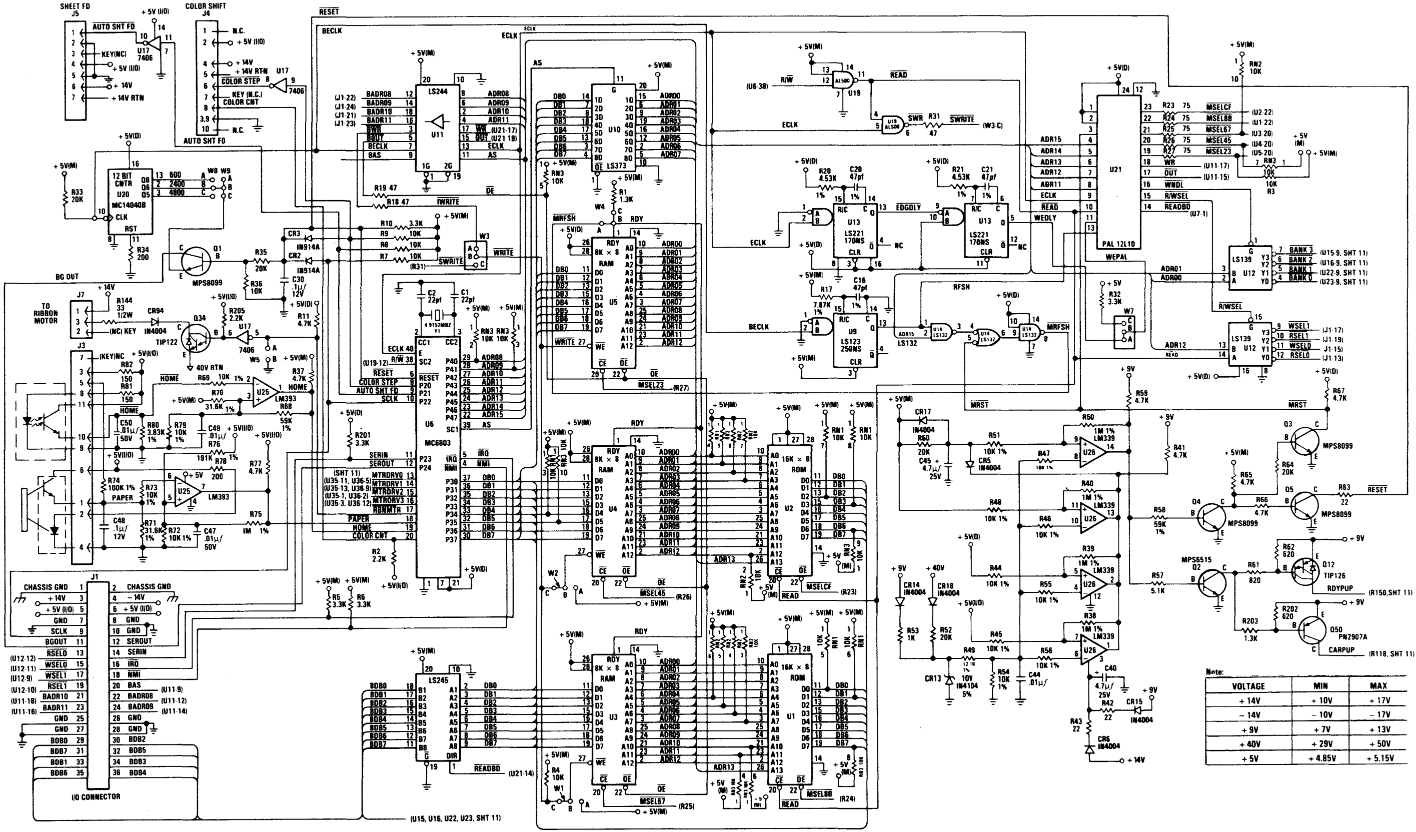


NOTES:

1. UNLESS OTHERWISE SPECIFIED; ALL RESISTANCE VALUES ARE IN OHMS, CAPACITANCE VALUES ARE IN MICROFARADS.
2. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE ¼ W, 5%, CF.
3. ZERO OHM RESISTORS (NOT SHOWN) ARE R1-R6 & R9.
4. A BAR ON TOP OF A CHARACTER ON SW 1 MEANS THAT THE CONDITION EXIST WHEN THAT DIP SWITCH IS SET TO "ON"
5. DIP SWITCH 1

SW 9	SW 10	FONT
OFF	OFF	DPQ, 12 CPI, 1" FORM LENGTH
OFF	ON	DPQ, 10 CPI
ON	OFF	TEXT QUALITY, 10 CPI
ON	ON	LETTER QUALITY, 10 CPI

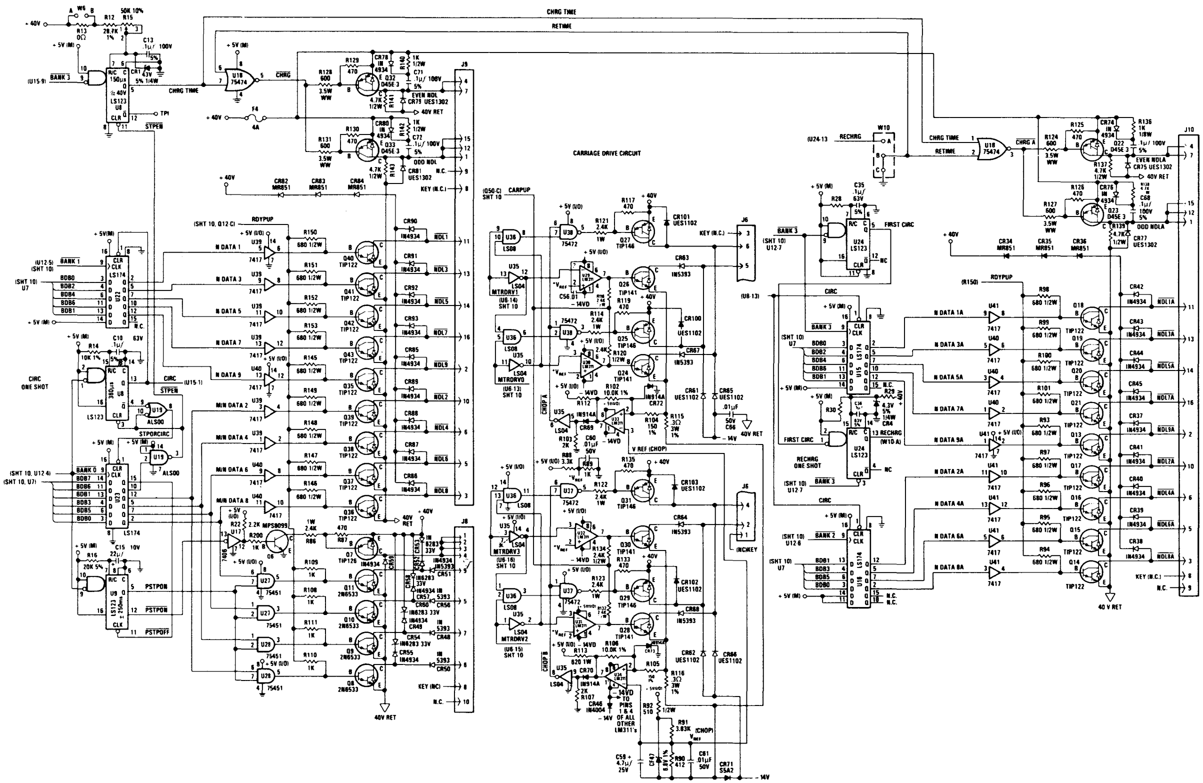
Color Printer — Control Panel (Sheet 1 of 1)



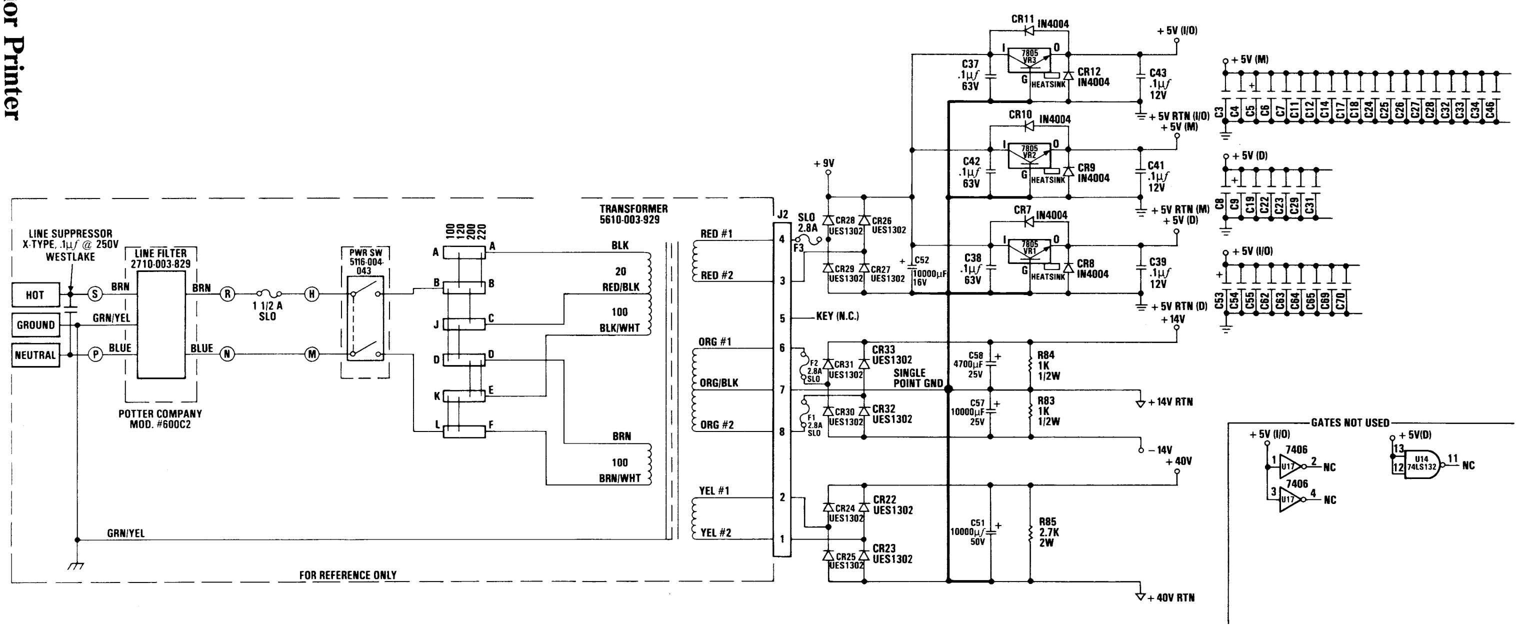
Note:

VOLTAGE	MIN	MAX
+ 14V	+ 10V	+ 17V
− 14V	− 10V	− 17V
+ 9V	+ 7V	+ 13V
+ 40V	+ 29V	+ 50V
+ 5V	+ 4.85V	+ 5.15V

Color Printer — Controller Board (Sheet 1 of 3)



Color Printer — Controller Board (Sheet 2 of 3)



Color Printer — Controller Board (Sheet 3 of 3)

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IBM PC Compact Printer

6361476

IBM Compact Printer

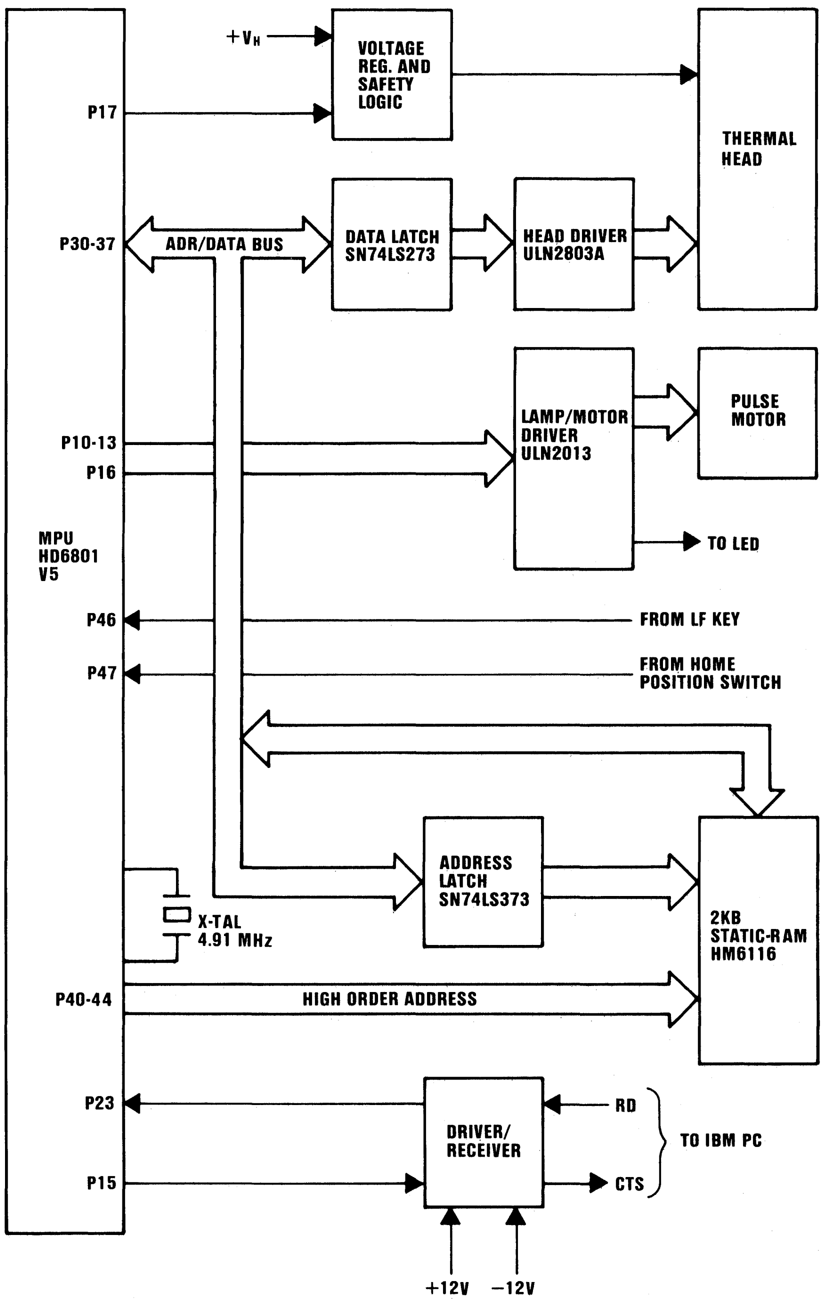
Contents

Description

The IBM PC Compact Printer is a stand-alone, tabletop unit that plugs into a standard, 120-Vac wall outlet. Using a print head with eight print elements and thermal-sensitive paper, the printer can print characters from the standard ASCII, 96-character, uppercase and lowercase character set, and prints the characters in a 5-by-8 dot matrix at 50 characters per second (cps). The printer prints in one direction (left-to-right) and has four print modes. In the standard mode, the printer prints 80 characters per line; in the compressed mode, 136 characters per line; in the double-width mode, 40 characters per line, and in the compressed double-width mode, 66 characters per line. The IBM PC Compact Printer can also underline characters, has an extended character set for international languages, and can accept special characters in all-points-addressable mode to do graphics or draw special characters under program control.

The printer has a 1.89 meter (6-foot), 16-lead, printer cable. This cable connects to the 25-pin D-shell connector of an Asynchronous Communications Adapter (primary or alternate) through the use of the IBM PC Compact Printer Connector Adapter.

The following is a block diagram of the IBM PC Compact Printer.



Compact Printer Block Diagram

Programming Considerations

Printer Control Codes

The following pages list, in alphabetic order, the printer control codes with a description of each. Some knowledge of BASIC programming is necessary to insert printer control codes in your program. An example of each code in BASIC is given at the end of each description. The "Format" information is given where more information is needed for programming considerations.

Printer Code	Printer Function
CAN	**Cancel** Clears the printer memory of all data waiting to be printed following the last-received line-ending code. Resets the printer to the power-on defaults. Example: LPRINT CHR$(24);
CR	**Carriage Return** Causes the printer to print the data that follows CR beginning at the left margin. No line-feed operation takes place unless ESC 5;1 (Automatic Line-Feed) has been sent. **Notes:** 1. IBM Personal Computer BASIC (and many other programs) automatically sends LF (line feed) with CR. 2. If no data precedes the CR, or if all preceding data is spaces, the printer does not carriage return. If automatic line feed is On, the paper is advanced one line space. Example: LPRINT CHR$(13);
DC2	**Device Control 2 (Compressed Off)** Ends printing in the Compressed mode. Example: LPRINT CHR$(18);
DC4	**Device Control 4 (Double Width Off)** Ends printing in the Double Width mode. Example: LPRINT CHR$(20);
ESC	**Escape** Sets the printer to accept the next data sent as a printer command. (See the following list.) Example: LPRINT CHR$(27);

Printer Code	Printer Function
ESC B	**Escape B (Set Vertical Tabs)** Format: ESC B;n_1;n_2;...n_{64};NUL; Sets the vertical tab-stop positions. The power-on default is no vertical tab stops set. n_1 through n_{64} represent tab-stop positions by line number. The topmost line of the page is line 0. Tab-stop positions must be received in ascending numeric order and cannot exceed the set page length. Up to 64 positions are recognized by the Compact Printer. The positions do not take effect until NUL is received. Once vertical tab stops are set, they remain in effect until new ones are specified or all tab stops are set to the power-on defaults by ESC R (Clear Tabs). (If the printer is reset or switched Off, set tab stops are cleared.) If no vertical tab stops are set, the Vertical Tab (VT) command behaves as a Line Feed (LF) command. ESC B followed only by NUL clears all vertical tab stops. The form length must be set by the ESC C command (Set Lines per Page) prior to setting vertical tab stops. Example: LPRINT CHR$(27);CHR$(66);CHR$($n_1$); CHR$(n_2);...CHR$($n_{64}$);CHR$(0);
ESC C	**Escape C (Set Lines per Page)** Format: ESC C;n; Sets the page length in number of lines (n). The ESC C command must be followed by a value to specify the length of page desired. (Maximum form length for the printer is 127 lines.) The printer default is 66 lines per page when switched On or reset. Example: LPRINT CHR$(27);CHR$(67);CHR$(n);
ESC D	**Escape D (Set Horizontal Tab Stops)** Format: ESC D;n_1;n_2;...n_{28};NUL; Sets the horizontal tab-stop positions represented by n_1 through n_{28}. The power-on default is a tab stop set at column 8 and every eighth column thereafter. The printer recognizes up to 28 horizontal tab stops. They must be in ascending numeric order and followed by NUL. Tab stops can be set between 1 and 80 in standard print mode; between 1 and 136 in compressed print mode. ESC D immediately followed by NUL will clear all horizontal tabs. ESC R (Clear Tabs) may be used to set horizontal tabs to the power-on default. Example: LPRINT CHR$(27);CHR$(68);CHR$($n_1$); CHR$(n_2);...CHR$($n_{28}$);CHR$(0);

Printer Code	Printer Function
ESC K	**Escape K (560 Bit-Image Graphics Mode)** Format: ESC K;n_1;n_2;v_1;v_2;...v_{560}; Changes the printer to the Bit-Image Graphics mode. Dot density is 70 by 70 dots per inch. If the graphics data exceeds the space remaining on the line, the printer ignores the excess data. 7 bytes of bit-image data equal 1 standard-width character. n_1 and n_2 are binary numbers that specify the number of bit-image data bytes to be transferred. n_1 represents values from 0 to 255, and n_2 represents values from 0 to 2 times 256. The total number of bit-image data bytes is equal to n_1 + (n_2 x 256) and cannot exceed 560. All eight of the print-head thermal dots are used to print bit-image graphics. v_1 through v_{560} are bit-image data bytes, each of which represents a set of 8 printable dots in a vertical line. The horizontal position of these 8 dots is determined by the position of the bit-image data byte within the v_1 through v_{560} series. v_1 is printed at the starting position followed in order from left to right by v_2 through v_{560}. Each bit of a bit-image data byte represents a vertical dot position at the horizontal position represented by that bit-image data byte. The lowest value, or least significant bit (bit 0), represents the bottom dot position, and the highest value, or most significant bit (bit 7), represents the top dot position. In the following table the left-hand column of (•)'s represents dot positions within a vertical line. The right-hand column shows the corresponding bit number within a bit-image data byte. (The bits are numbered 7 through 0, from left to right.) **Dot Position** **Bit Number** Top • – 7 • – 6 • – 5 • – 4 • – 3 • – 2 • – 1 Bottom • – 0 For example, if v_1 is binary 10000000 (decimal 128), only the top dot prints in that horizontal position; if v_1 is binary 00000001 (decimal 01), only the bottom dot prints; and if v_1 is binary 11111111 (decimal 255), all eight dots print. Example: LPRINT CHR$(27);CHR$(75);CHR$($n_1$); CHR$(n_2);CHR$($v_1$);CHR$(v_2); ... CHR$($v_{560}$);

Printer Code	Printer Function
ESC N	**Escape N (Set Skip Perforation)** Format: ESC N;n; Specifies the number of lines to be skipped at the end of each page. This causes the printer to automatically skip over the perforation between pages of continuous forms. The number of lines n, is converted to inches using the line-spacing in effect. The value of n must be between 1 and 127. ESC N must be reset anytime the page length (ESC C) is changed. The default for skip perforation is 25.4 mm (1 in.). Example: LPRINT CHR$(27);CHR$(78);CHR$(n);
ESC O	**Escape O (Cancel Skip Perforation)** Cancels the Skip Perforation function. Example: LPRINT CHR$(27);CHR$(79);
ESC R	**Escape R (Clear Tabs)** Resets all tab stops, both horizontal and vertical, to the power-on defaults. Example: LPRINT CHR$(27);CHR$(82);
ESC W	**Escape W (Continuous Double-Width Print)** Format: ESC W;n; Changes the printer to double-width printing when ESC W is followed by 1. This mode is not canceled by a line feed or DC4. It is canceled when ESC W is followed by 0 (zero). Example: LPRINT CHR$(27);CHR$(87);CHR$(n);
ESC 0	**Escape Zero (1/9-Inch Line Feed)** Changes the line feed to 2.82 mm (1/9 in.). This produces 9 lines per inch. Example: LPRINT CHR$(27);CHR$(48);
ESC 1	**Escape One (1/9-Inch Line Feed)** Changes the line feed to 2.82 mm (1/9 in.). This produces 9 lines per inch. ESC 1 functions the same as ESC 0. Example: LPRINT CHR$(27);CHR$(49);
ESC 2	**Escape Two (1/6-Inch Line Feed)** Resets line spacing to 4.23 mm (1/6 in.). This produces 6 lines per inch and is the power-on default for vertical line spacing. Example: LPRINT CHR$(27);CHR$(50);

Printer Code	Printer Function
ESC 5	**Automatic Line Feed** Format: ESC 5;n; When n is 1, automatic line feeding starts; the printer will line-feed each time a code that indicates the end of a line, such as CR, is received. When n is 0, automatic line feeding stops. Example: LPRINT CHR$(27);CHR$(53);
ESC –	**Escape Minus (Underline)** Format: ESC –;n; ESC – followed by 1, causes all of the following data to be printed with an underline. ESC – followed by 0 (zero), cancels the underlining. Example: LPRINT CHR$(27);CHR(45);CHR$(n);
ESC <	**Escape Less Than (Home Head)** Returns the print head to the left margin to print the line following ESC <. This occurs for one line only. Example: LPRINT CHR$(27);CHR$(60);
FF	**Form Feed** Advances the paper to the top of the next page. The location of the paper, when the printer Power switch is set to On, is the top-of-page position. The next top-of-page is determined by the form length as defined by the power-on default, 279 mm (11 in.), or as set by ESC C. Always separate multiple Form Feed commands with spaces. Example: LPRINT CHR$(12);
HT	**Horizontal Tab** Causes the carriage to move to the next horizontal tab stop. Tab stops are set with ESC D. A horizontal tab stop every 8 columns is the power-on default. Example: LPRINT CHR$(9);
LF	**Line Feed** Advances the paper one line space. Line spacing is 4.23 mm (1/6 in.) unless reset by ESC 0, ESC 1, or ESC 2. Example: LPRINT CHR$(10);
NUL	**Null** Used with control commands as a command list terminator. NUL is also used with some printer control codes to select options. Example: LPRINT CHR$(0);

Printer Code	Printer Function
SI	**Shift In (Compressed On)** Causes the printer to begin compressed printing. This command is canceled by DC2 (Compressed Off). Example: LPRINT CHR$(15);
SO	**Shift Out (Double Width)** Causes the printer to start double-width printing. Double-width printing prints the characters twice as wide as the current character spacing. This results in half as many characters per inch. A Carriage Return, Line Feed or DC4 (Double Width Off) cancels the SO command. Example: LPRINT CHR$(14);
VT	**Vertical Tab** Advances the paper to the next vertical tab-stop position. If no vertical tab stops are set, the VT command is treated as a line-feed (LF) command. Vertical tab stops are set with ESC B. Example: LPRINT CHR$(11);

Printer Control Code Quick Reference

Note: ASCII values greater than 27 must be preceded by the ESC code (ASCII value 27).

Description	Code	ASCII Value
Cancel	DC2	24
Carriage return	CR	13
Compressed character off	DC2	18
Double width off	DC4	20
Escape	ESC	27
Vertical tab set	ESC B	66
Lines per page set	ESC C	67
Horizontal tab stops set	ESC D	68
Graphics mode (bit-image)	ESC K	75
Skip perforation	ESC N	78
Cancel skip perforation	ESC O	79
Tabs clear	ESC R	82
Double width (multiple lines)	ESC W	87
Line feed (2.82 mm (1/9 in.))	ESC 0	48
Line feed (2.82 mm (1/9 in.))	ESC 1	49
Line feed (4.23 mm (1/6 in.))	ESC 2	50
Line feed (automatic)	ESC 5	53
Underline	ESC -	45
Home head	ESC <	60
Form feed	FF	12
Tab (horizontal)	HT	9
Line feed	LF	10
Null	NUL	0
Compressed character	SI	15
Double width	SO	14
Tab (vertical)	VT	11

Print Mode Combinations

The following figure shows the print-mode combinations possible with the IBM PC Compact Printer. Modes shown with XXX in the same column can be combined.

A print mode can be changed at any time within a line; however, the double-width mode affects the entire line.

Allowable Mode Combinations					
Standard	XXX				
Compressed		XXX		XXX	XXX
Double-Width			XXX	XXX	XXX
Underline	XXX	XXX	XXX		XXX

Allowable Mode Combinations

Compact Printer Character Set

0	1	2	3	4	5	6	7	8	9
NUL			♥	♦	♣	♠	•	◘	HT
10	11	12	13	14	15	16	17	18	19
LF	VT	FF	CR	SO	SI	►	◄	DC2	‼
20	21	22	23	24	25	26	27	28	29
DC4	§	▬	↨	CAN	↓	→	ESC	∟	↔
30	31	32	33	34	35	36	37	38	39
▲	▼	SP	!	"	#	$	%	&	'
40	41	42	43	44	45	46	47	48	49
(	)	*	+	,	—	.	/	0	1
50	51	52	53	54	55	56	57	58	59
2	3	4	5	6	7	8	9	:	;
60	61	62	63	64	65	66	67	68	69
<	=	>	?	@	A	B	C	D	E
70	71	72	73	74	75	76	77	78	79
F	G	H	I	J	K	L	M	N	O
80	81	82	83	84	85	86	87	88	89
P	Q	R	S	T	U	V	W	X	Y
90	91	92	93	94	95	96	97	98	99
Z	[	\	]	^	_	`	a	b	c
100	101	102	103	104	105	106	107	108	109
d	e	f	g	h	i	j	k	l	m
110	111	112	113	114	115	116	117	118	119
n	o	p	q	r	s	t	u	v	w
120	121	122	123	124	125	126	127	128	129
x	y	z	{	¦	}	~	DEL	Ç	ü

Compact Printer Character Set (continued)

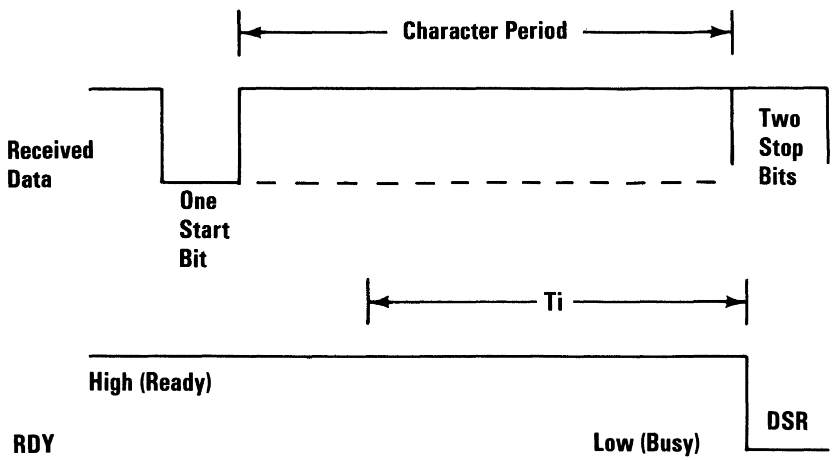
130	131	132	133	134	135	136	137	138	139
é	â	ä	à	å	ç	ê	ë	è	ï
140	141	142	143	144	145	146	147	148	149
î	ì	Ä	Å	É	æ	Æ	ô	ö	ò
150	151	152	153	154	155	156	157	158	159
û	ù	ÿ	ö	ü	¢	£	¥	₧	ƒ
160	161	162	163	164	165	166	167	168	169
á	í	ó	ú	ñ	Ñ	ª	º	¿	⌐
170	171	172	173	174	175	176	177	178	179
¬	½	¼	¡	«	»				
180	181	182	183	184	185	186	187	188	189
190	191	192	193	194	195	196	197	198	199
200	201	202	203	204	205	206	207	208	209
210	211	212	213	214	215	216	217	218	219
220	221	222	223	224	225	226	227	228	229
				α	β	Γ	π	Σ	σ
230	231	232	233	234	235	236	237	237	239
μ	τ	Φ	Θ	Ω	δ	∞	$\varnothing$	ϵ	$\cap$
240	241	242	243	244	245	246	247	248	249
$\equiv$	$\pm$	$\geq$	$\leq$	⌠	⌡	$\div$	$\approx$	°	▪
250	251	252	253	254	255				
-	$\sqrt{}$	n	2	■	SP				

Interface

Specifications:

- Data transfer rate: 1200 bps (maximum)
- Synchronization: Internal clocking
- Handshaking: CTS (Clear to Send) Pacing
- Logic level: Input data and all interface control signals are EIA levels

Serial Interface Timing Diagram



Compact Printer Serial Interface Timing Diagram

Specifications

Size	
Height	88.9 mm (3.5 in)
Width	312.4 mm (12.3 in)
Depth	221 mm (8.7 in)
Weight	3.0 kg (6.6 lb)
Power Cable	
Length	1.98 m (6.5 ft)
Size	28 AWG
Signal Cable	
Length	1.89 m (6 ft)
Size	3 by 18 AWG

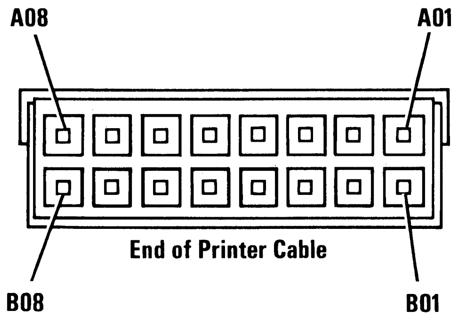
Physical Specifications

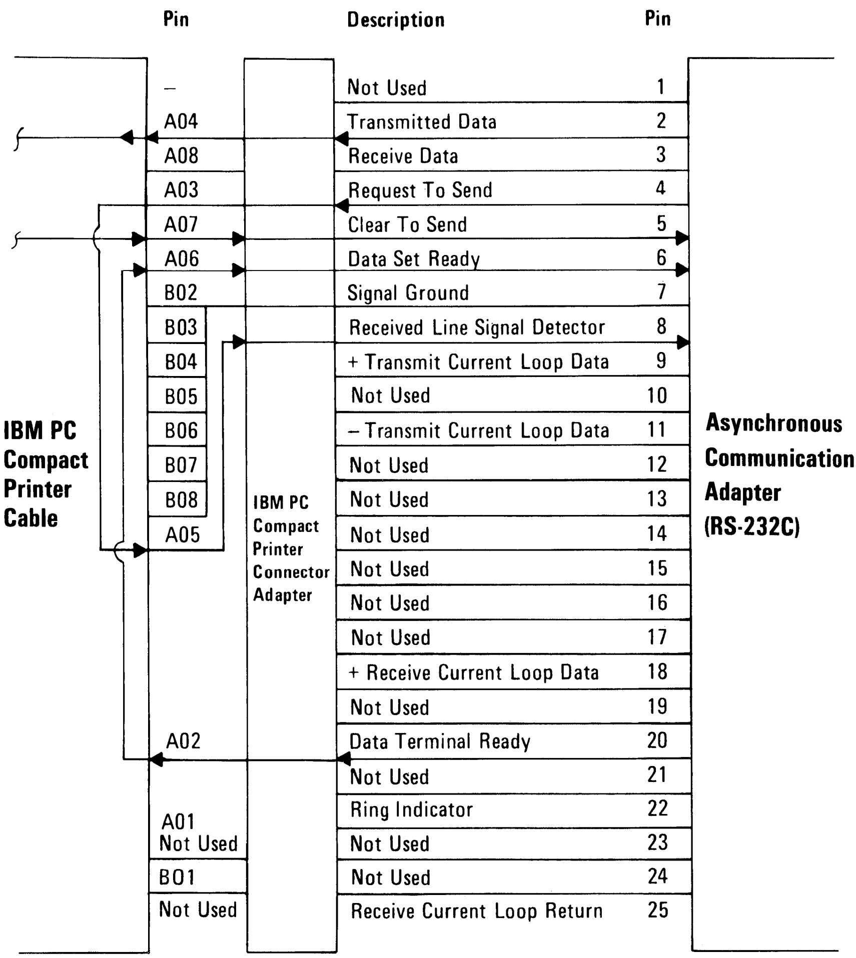
Voltage (Vac)			**Frequency (Hz)**	**Current (Amps)**	**Power (Watts)**
Nominal	Minimum	Maximum	± 3 Hz	Maximum	Maximum
120	108	132	60	0.25	36

Electrical Specifications

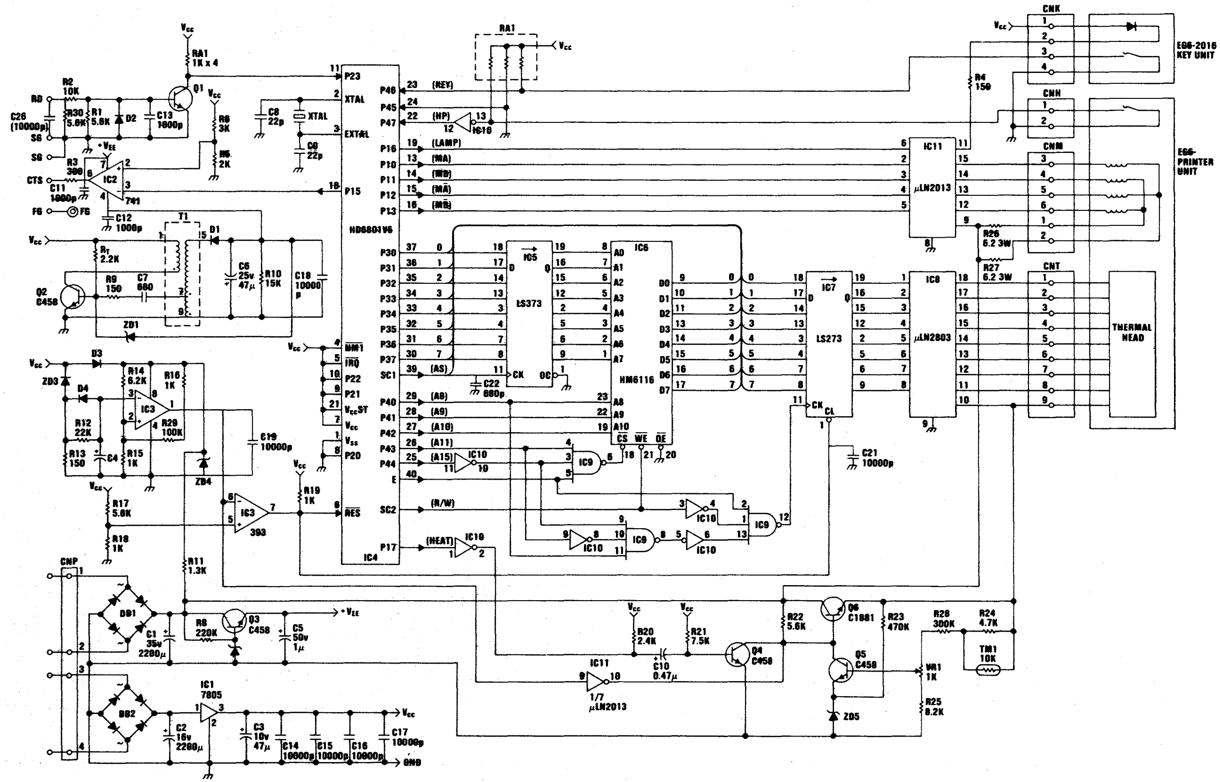
Print Method	Thermal, non-impact, dot-matrix	
Print Speed	50 cps	
Print Direction	Left to right only	
Print Elements in Head	8	
Line Spacing	4.23 mm (1/6 in.) or 2.82 mm (1/9 in.)	
Printing Characteristics		
Matrix	5 x 8	
Character Set	See "Compact Printer Character Set" tables.	
Graphics	APA (All Points Addressable)	
Printing Sizes		
	Characters per inch	Maximum characters per line
Normal	10	80
Double Width	5	40
Compressed	17.5	136
Double Width-Compressed	8.75	66
Media Handling		
Paper Feed	Friction feed	
Paper Width	216 mm (8-1/2 in.)	
Copies	Single sheet only	
Paper Path	Top	
Interface	Serial data and control lines	
Print Color	Black	
Environmental Conditions		
Operating Temperature	5 to 40°C (41 to 104°F)	
Operating Humidity	10 to 80% non-condensing	
Heat Output	54.6 BTU/hr (maximum)	

Printer Specifications





Note: An IBM PC Compact Printer Connector (as shown in the diagram above) is required to connect the Compact Printer to an IBM Asynchronous Communications Adapter (primary or alternate).



Compact Printer (Sheet 1 of 1)

Notes:

IBM 5-1/4" Diskette Drive

6361486

Contents

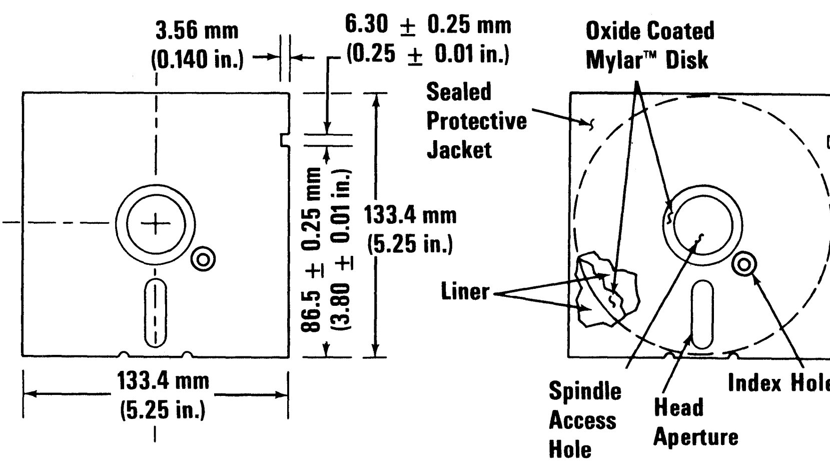
Description

The system unit has space and power for one or two 5-1/4 inch diskette drives. A drive can be single-sided or double-sided with 40 tracks for each side. The diskette drive is a self-contained unit consisting of a spindle drive system, a read positioning system, and a read/write/erase system.

The diskette drive uses modified frequency modulation (MFM) to read and write digital data, with a track-to-track access time of 6 milliseconds.

The IBM 5-1/4" Diskette Drive uses a standard 133.4 millimeter (5.25 inch) diskette. Single-sided, double-density, soft-sectored diskettes are used for single-sided drives. Double-sided drives use double-sided, double-density, soft-sectored diskettes.

This recording medium is a flexible magnetic disk enclosed in a protective jacket. The protected disk, free to rotate within the jacket, is continuously cleaned by the soft fabric lining of the jacket during normal operation. Read/write/erase head access is made through an opening in the jacket. Openings for the drive hub and diskette index hole are also provided. The following figure is a simplified drawing of the diskette used with the IBM 5-1/4" Diskette Drive.



Recording Medium

To insert a diskette, the operator raises the latch at the front of the diskette drive and inserts the diskette in the slot. Plastic guides in the slot ensure the diskette is in the correct position. Closing the latch centers the diskette and clamps it to the drive hub. After 250 milliseconds, the servo-controlled dc motor starts and drives the hub at a constant speed of 300 rpm. The head positioning system, which consists of a 4-phase stepper-motor and band assembly with its associated electronics, moves the magnetic head so it comes in contact with the desired track of the diskette. The stepper-motor and band assembly uses one-step rotation to cause a one-track linear movement of the magnetic head. No operator intervention is required during normal operation. During a write operation, a 0.33-millimeter (0.013-inch) data track is recorded, then tunnel-erased to 0.30 millimeter (0.012 inch). If the diskette is write-protected, a Write Protect sensor disables the drive's circuitry, and an appropriate signal is sent to the interface.

Data is read from the diskette by the data-recovery circuitry, which consists of a low-level read amplifier, differentiator, zero-crossing detector, and digitizing circuits. All data decoding is done by the adapter card.

The diskette drive also has the following sensor systems:

1. The Track 00 switch, which senses when the head/carriage assembly is at track 00.

2. The Index sensor, which consists of an LED light source and phototransistor. This sensor is positioned to generate a digital signal when an index hole is detected.

3. The Write Protect sensor disables the diskette drive's electronic circuits whenever a write-protect tab is applied to the diskette.

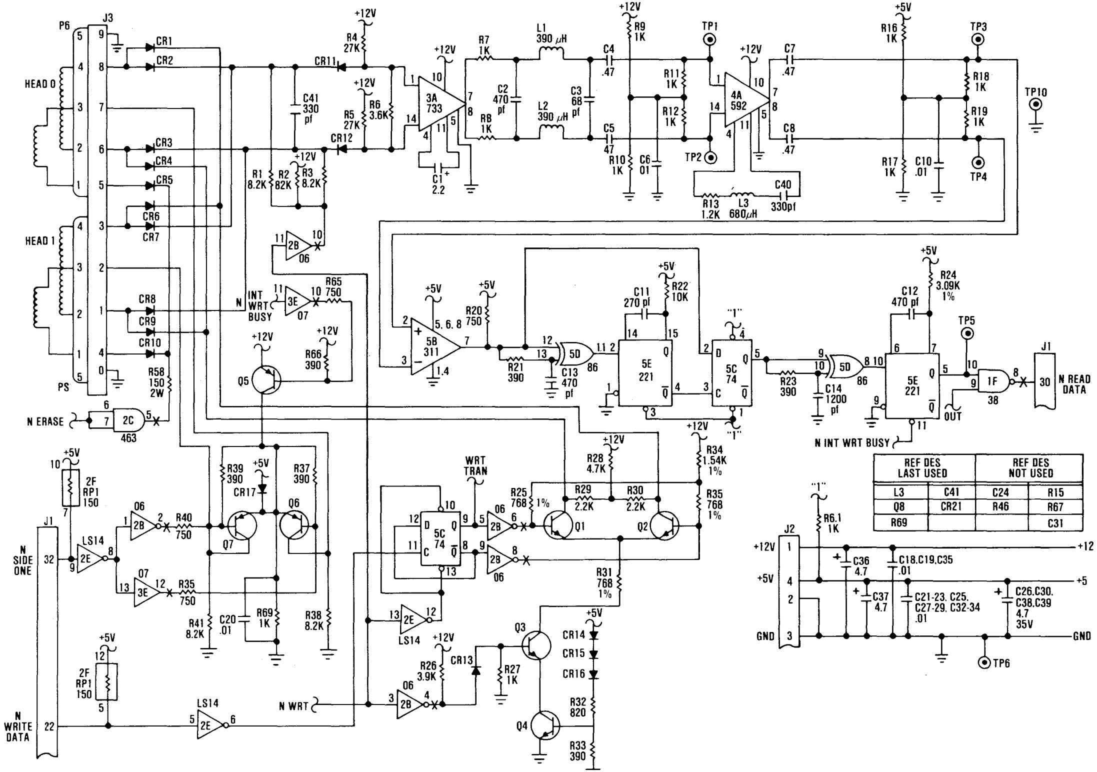
For interface information and programming considerations, refer to "IBM 5-1/4" Diskette Drive Adapter" in this manual.

Specifications

Size (maximum)	
Height	86 mm (3.4 in.)
Width	149 mm (5.9 in.)
Depth	203 mm (8.0 in.)
Weight	2.04 kg (4.5 lb)
Power	+12 Vdc ± 5%, (900 mA average) +5 Vdc ± 5%, (600 mA average)
Media	Industry-compatible 5-1/4 inch diskette
Tracks per Inch	48
Number of Tracks	40
Temperature (exclusive of media)	
Operating	10 to 44°C (50 to 112°F)
Non-operating	-40 to 60°C (-40 to 140°F)
Relative humidity (exclusive of media)	
Operating	20 to 80% (non-condensing)
Non-operating	5 to 95% (non-condensing)
Seek Time	6 ms track-to-track
Head Settling Time	15 ms (last track addressed)
Error Rate	
Recoverable	1 per 10^9 bits read
Irrecoverable	1 per 10^{12} bits read
Seek Errors	1 per 10^6 seeks
Head Life	20,000 hours (normal use)
Media Life	3.0 X 10^6 passes per track
Disk Speed	
Long term	300 rpm ± 1.5%
Instantaneous	300 rpm ± 3.0%
Start Time	500 ms (maximum)
Transfer Rate	250K bps
Recording Mode	MFM

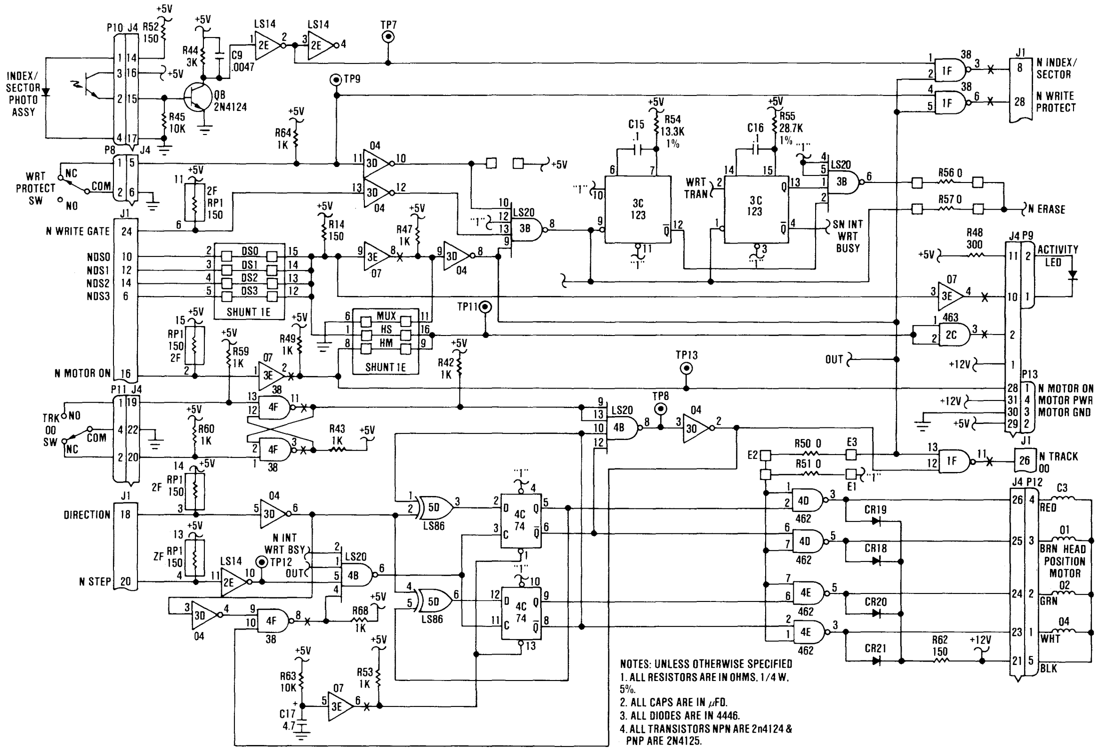
Mechanical and Electrical Specifications

4 Diskette Drive

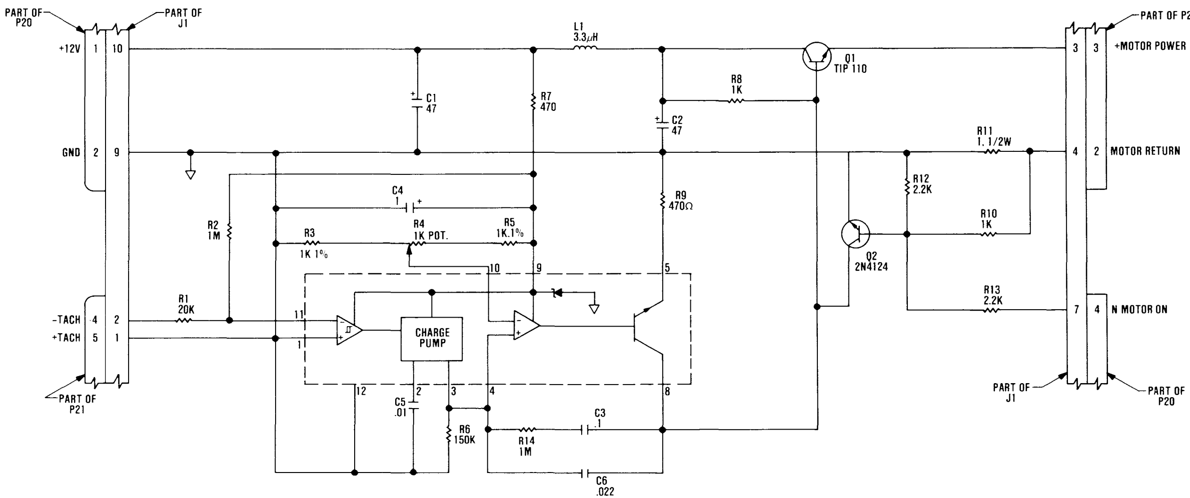


REF DES LAST USED		REF DES NOT USED	
L3	C41	C24	R15
Q8	CR21	R46	R67
R69			C31

5-1/4 Inch Diskette Drive — Type 1 (Sheet 1 of 3)

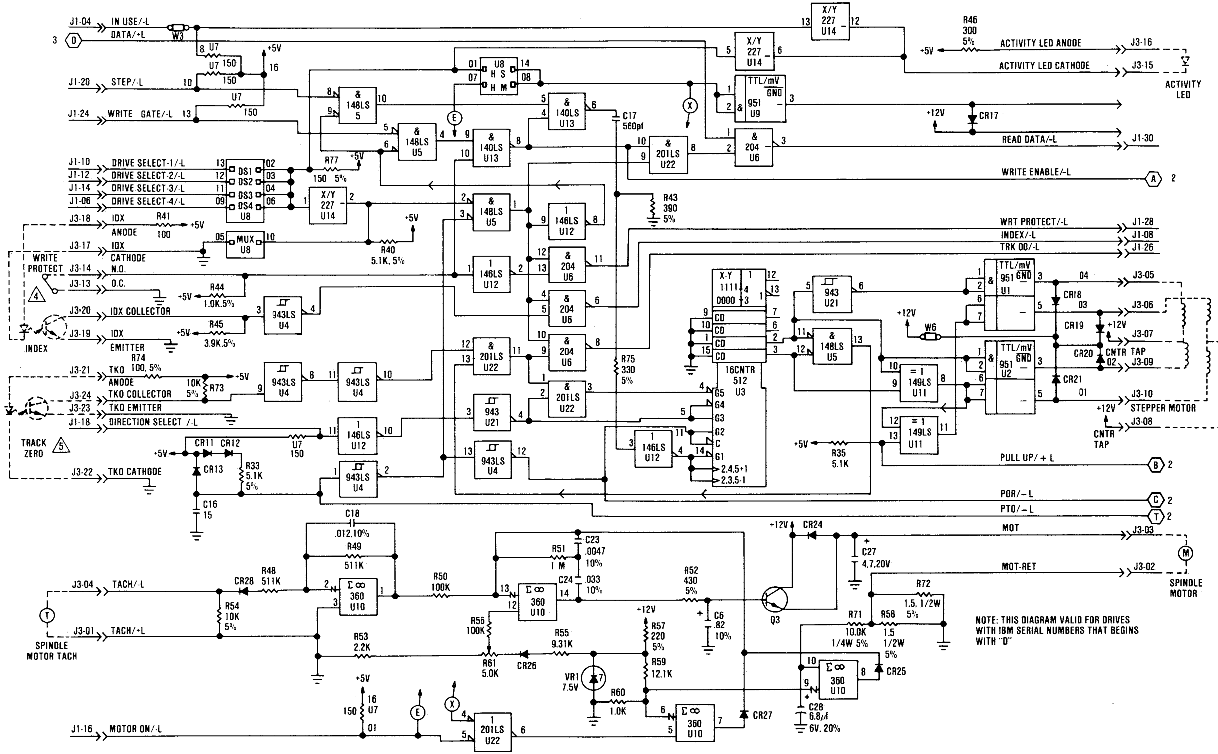


5-1/4 Inch Diskette Drive — Type 1 (Sheet 2 of 3)

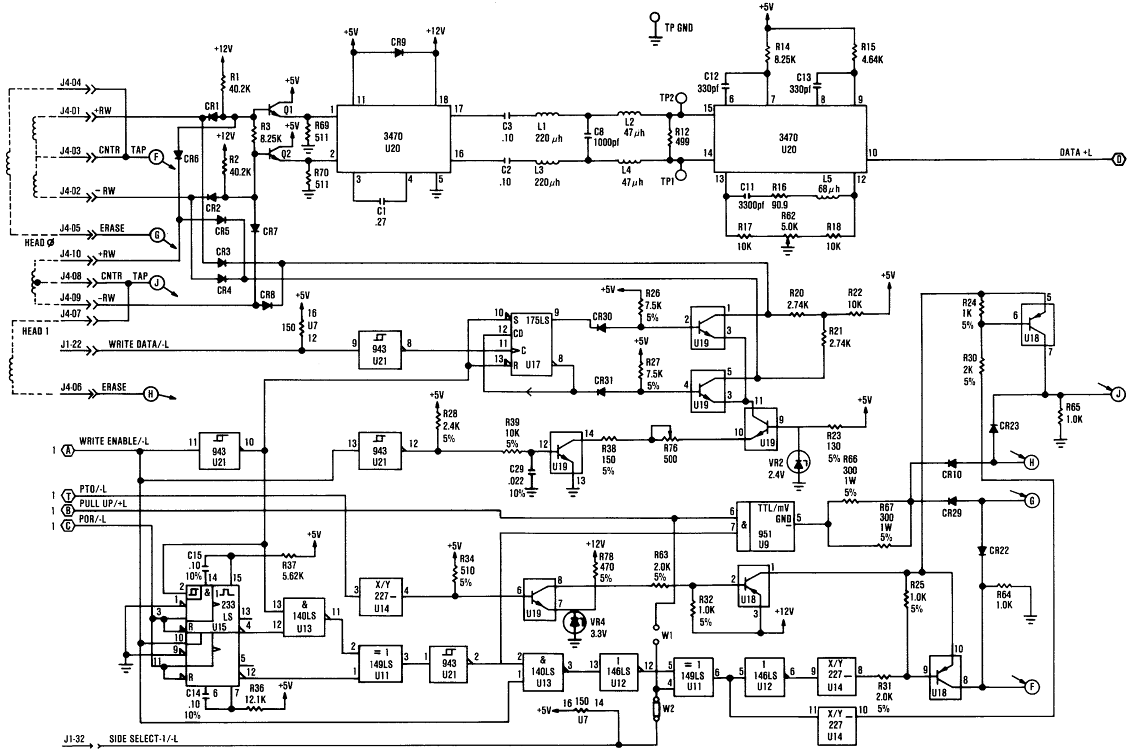


NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE IN OHMS, +5%, 1/4W.
2. 1% RESISTORS ARE 1/8W.
3. CAPACITORS ARE IN μF, +20%, 35V.

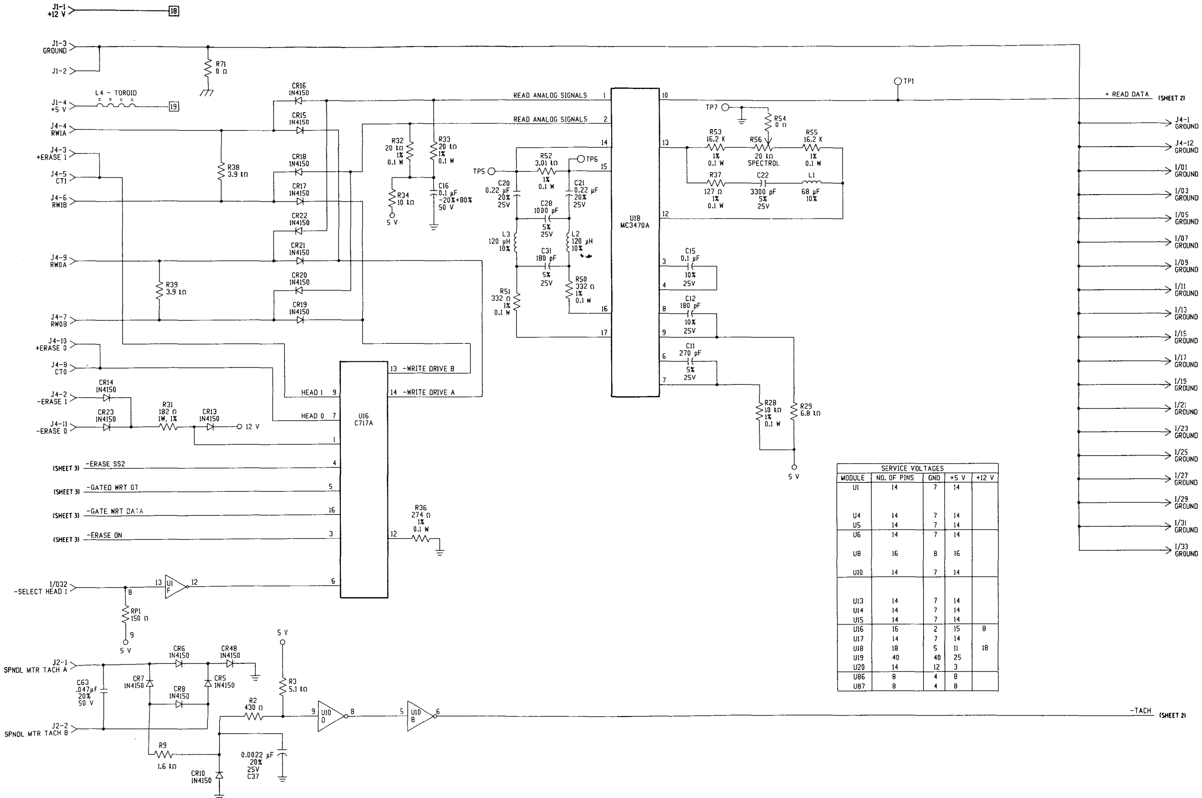
5-1/4 Inch Diskette Drive — Type 1 (Sheet 3 of 3)



5-1/4 Inch Diskette Drive — Type 2 (Sheet 1 of 2)

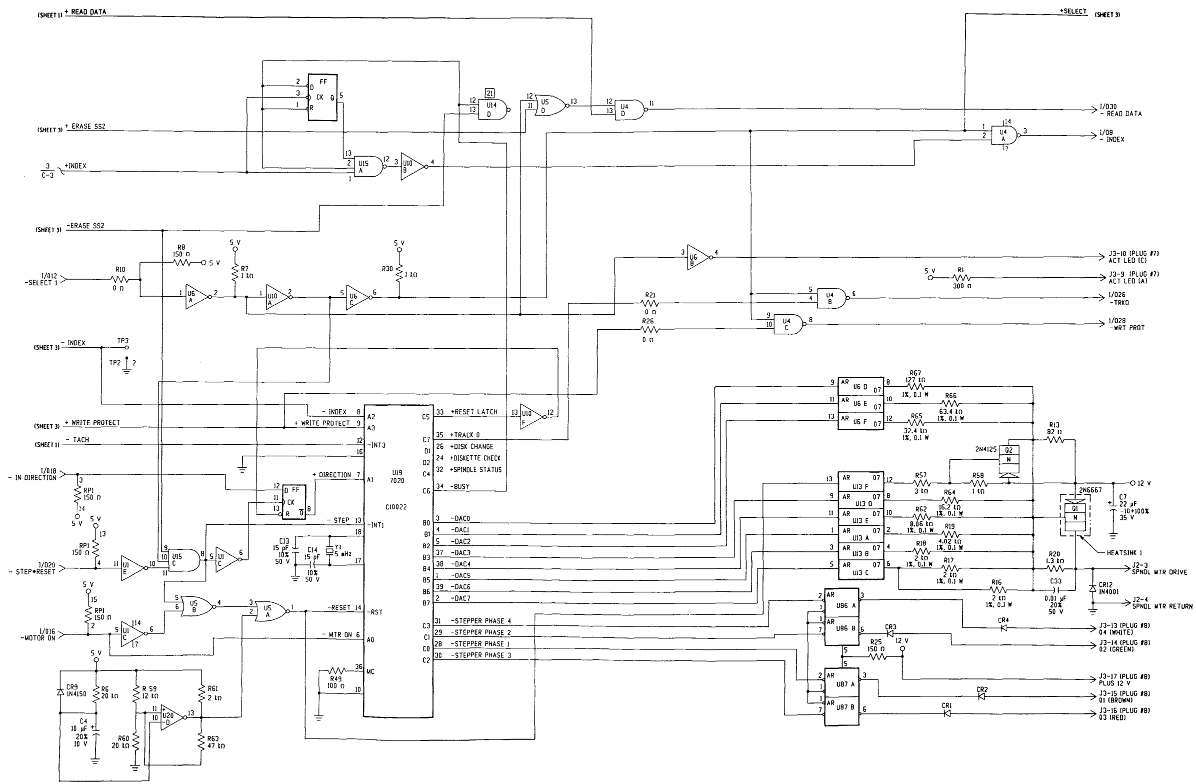


5-1/4 Inch Diskette Drive - Type 2 (Sheet 2 of 2)

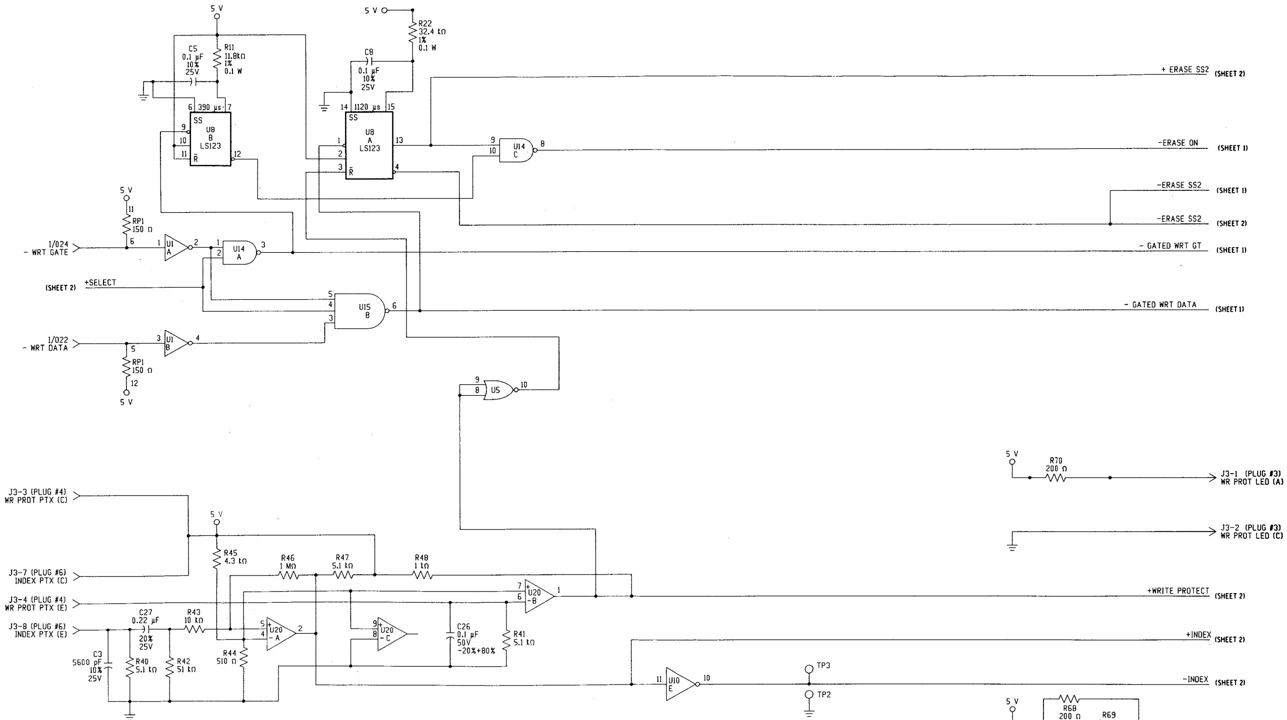


SERVICE VOLTAGES				
MODULE	NO. OF PINS	GND	+5 V	+12 V
U1	14	7	14	
U4	14	7	14	
U5	14	7	14	
U6	14	7	14	
U8	16	8	16	
U10	14	7	14	
U13	14	7	14	
U14	14	7	14	
U15	14	7	14	
U16	16	2	15	8
U17	14	7	14	
U18	18	5	11	18
U19	40	40	25	
U20	14	12	3	
U86	8	4	8	
U87	8	4	8	

5-1/4 Inch Diskette Drive - Type 3 (Sheet 1 of 3)



5-1/4 Inch Diskette Drive - Type 3 (Sheet 2 of 3)



5-1/4 Inch Diskette Drive - Type 3 (Sheet 3 of 3)

IBM

Personal Computer
Hardware Reference
Library

IBM Slimline Diskette Drive

6361484

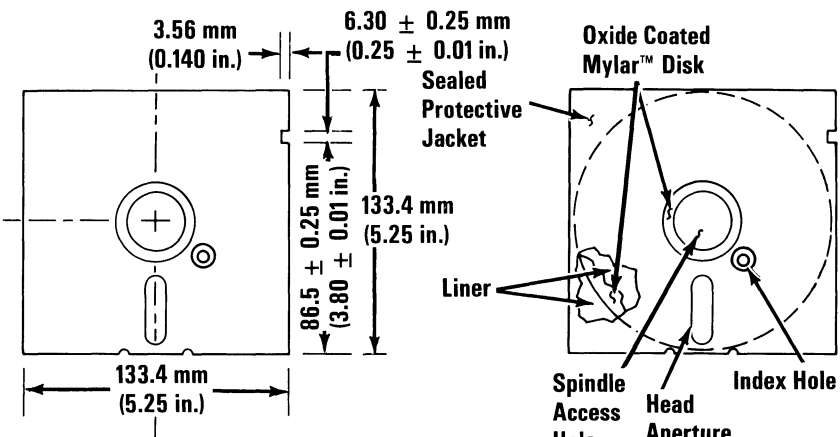
IBM Slimline Diskette Drive

Contents

Description

The IBM Portable Personal Computer has space and power for one or two 5-1/4 inch slimline diskette drives. Each drive can use single-sided or double-sided diskettes with 40 tracks on each side. The drive is completely self contained, and consists of a spindle drive system, a head positioning system, and a read/write/erase system.

The recording medium is a flexible magnetic disk enclosed in a protective jacket. The protected disk, free to rotate within the jacket, is continuously cleaned by the soft fabric lining of the jacket during normal operation. Read/write/erase head access is made through an opening in the jacket. Openings for the drive hub and diskette index hole are also provided. The following figure is a simplified drawing of the diskette used with the IBM 5-1/4 Diskette Drive.



Recording Medium

To load a diskette, the operator twists the latch at the front of the diskette drive counter-clockwise and inserts the diskette into the slot. Plastic guides in the slot ensure the diskette is in the correct position. Twisting the latch clockwise centers the diskette and clamps it to the drive hub. After 250 milliseconds, the servo-controlled dc motor starts and drives the hub at a constant speed of 300 rpm.

The diskette drive uses modified frequency modulation (MFM) to read and write digital data with a track to track access time of 6 milliseconds. It reaches operating speed in 0.5 seconds and drives the hub at a constant 300 rpm.

The head positioning system, which consists of a 4-phase stepper-motor and band assembly with its associated electronics, moves the magnetic head so it comes in contact with the desired track of the diskette. The stepper-motor and band assembly uses one-step rotation to cause a one-track linear movement of the magnetic head. No operator intervention is required during normal operation. During a write operation, a 0.33 millimeter (0.013-inch) data track is recorded, then tunnel-erased to 0.30 millimeter (0.012 inch). If the diskette is write-protected, a write-protect sensor disables the drives circuitry, and an appropriate signal is sent to the interface.

Data is read from the diskette by the data-recovery circuitry, which consists of a low-level read amplifier, differentiator, zero-crossing detector, and digitizing circuits. All data decoding is done by the adapter card.

The diskette drive also has the following sensor systems:

- The track 00 switch, which senses when the head/carriage assembly is at track 00.

- The index sensor, which consists of a light emitting diode (LED) light source and phototransistor. This sensor is positioned so that a digital signal is generated when the index hole is detected.

- The write-protect sensor disables the diskette-drive write circuits whenever the diskette has a write-protect tab.

For interface information and programming considerations, refer to "IBM 5-1/4" Diskette Drive Adapter" in this manual.

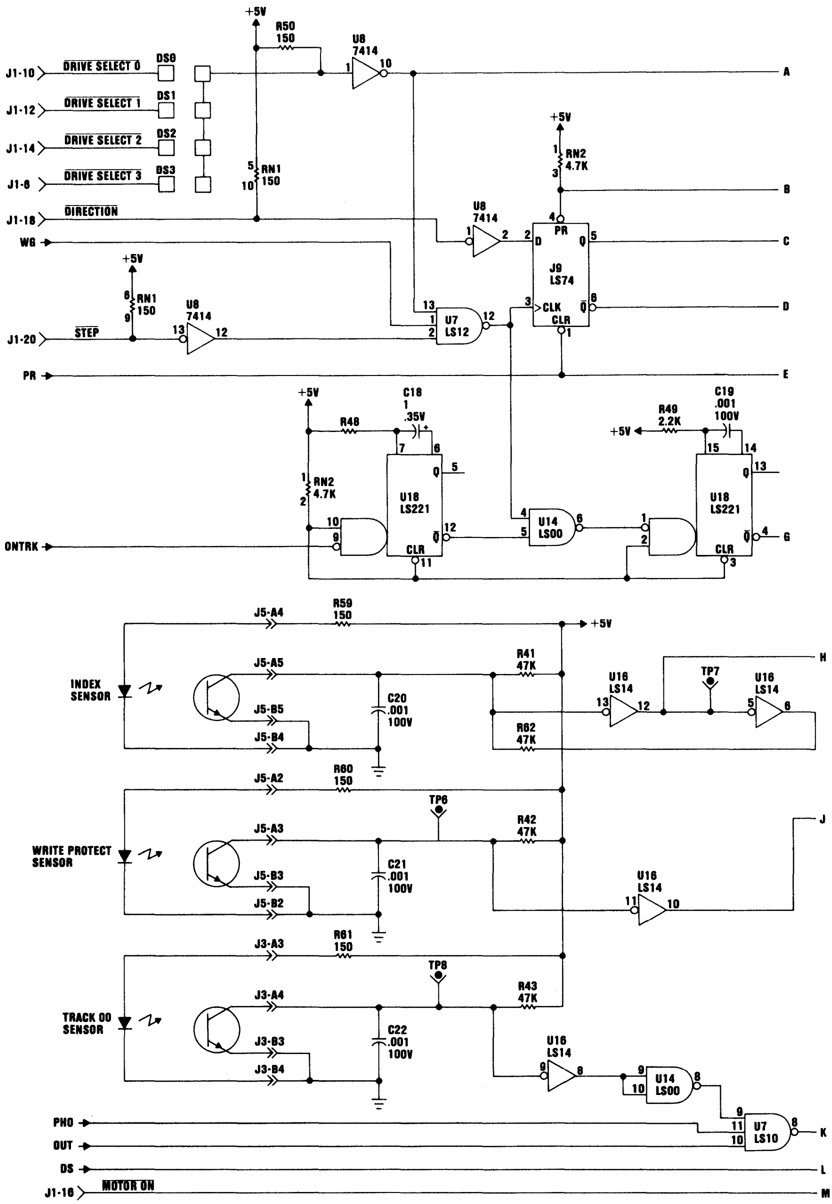
Specifications

Size (maximum)	
Height	42 mm (1.6 in.)
Width	146 mm (5.8 in.)
Depth	203 mm (8.0 in.)
Weight	1.1 kg (2.4 lb)
Power	+12 Vdc ±5% +5 Vdc ±5%
Media	Industry-compatible 5-1/4 inch diskette
Tracks per Inch	48
Number of Tracks	40
Temperature (exclusive of media)	
Operating	10 to 50°C (41 to 122°F)
Non-operating	-40 to 60°C (-40 to 140°F)
Relative humidity (exclusive of media)	
Operating	20 to 80% (non-condensing)
Non-operating	5 to 95% (non-condensing)
Seek Time	6 ms track-to-track
Head Settling Time	21 ms (from last step pulse)
Error Rate	
Recoverable	1 per 10^9 bits read
Irrecoverable	1 per 10^{12} bits read
Seek Errors	1 per 10^6 seeks
Head Life	20,000 hours (normal use)
Media Life	3.0 X 10^6 passes per track
Disk speed	
Long Term	300 rpm ±1.5%
Instantaneous	300 rpm ±3.0%
Start Time	500 ms (maximum)
Transfer Rate	250K bits/sec
Recording Mode	MFM

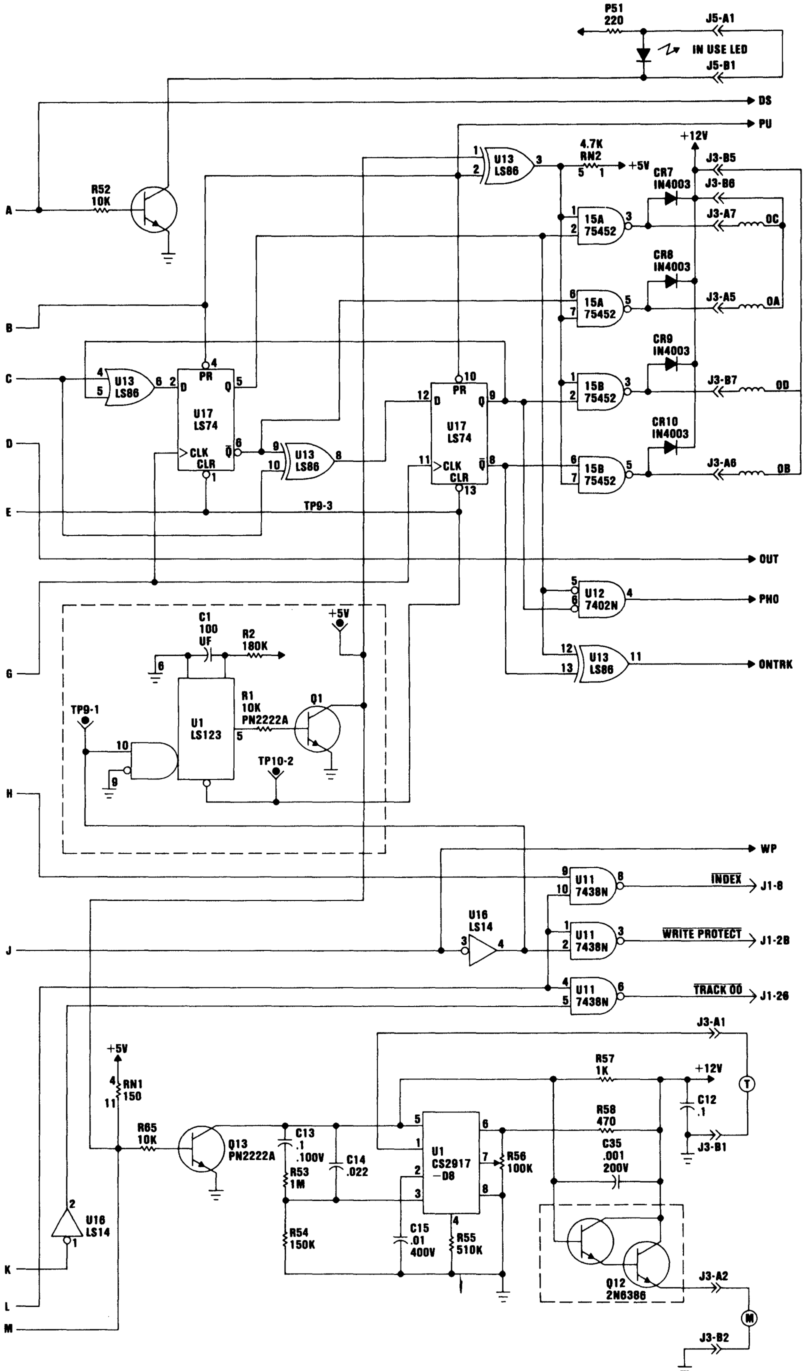
Mechanical and Electrical Specifications

Logic Diagrams

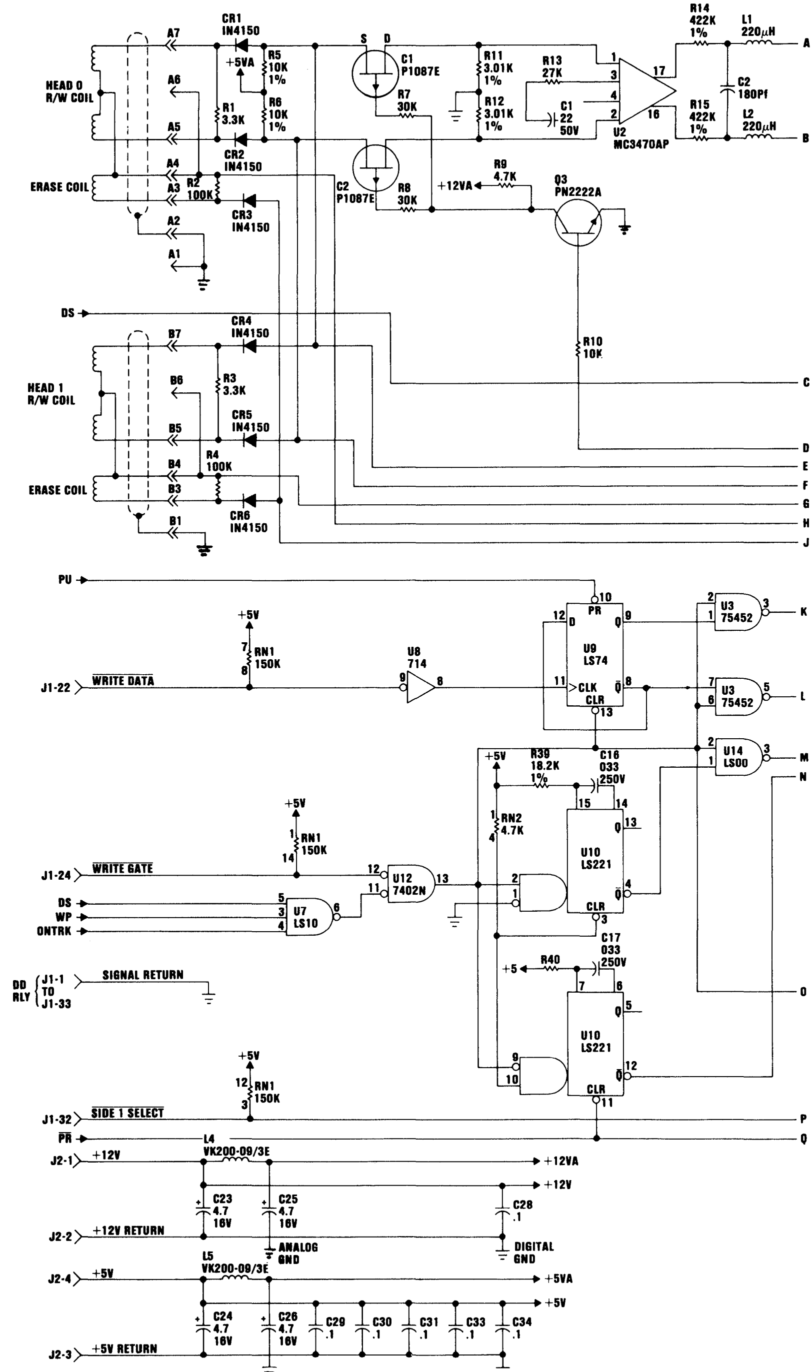
The following pages contain the logic diagrams for the IBM Slimline Diskette Drive.



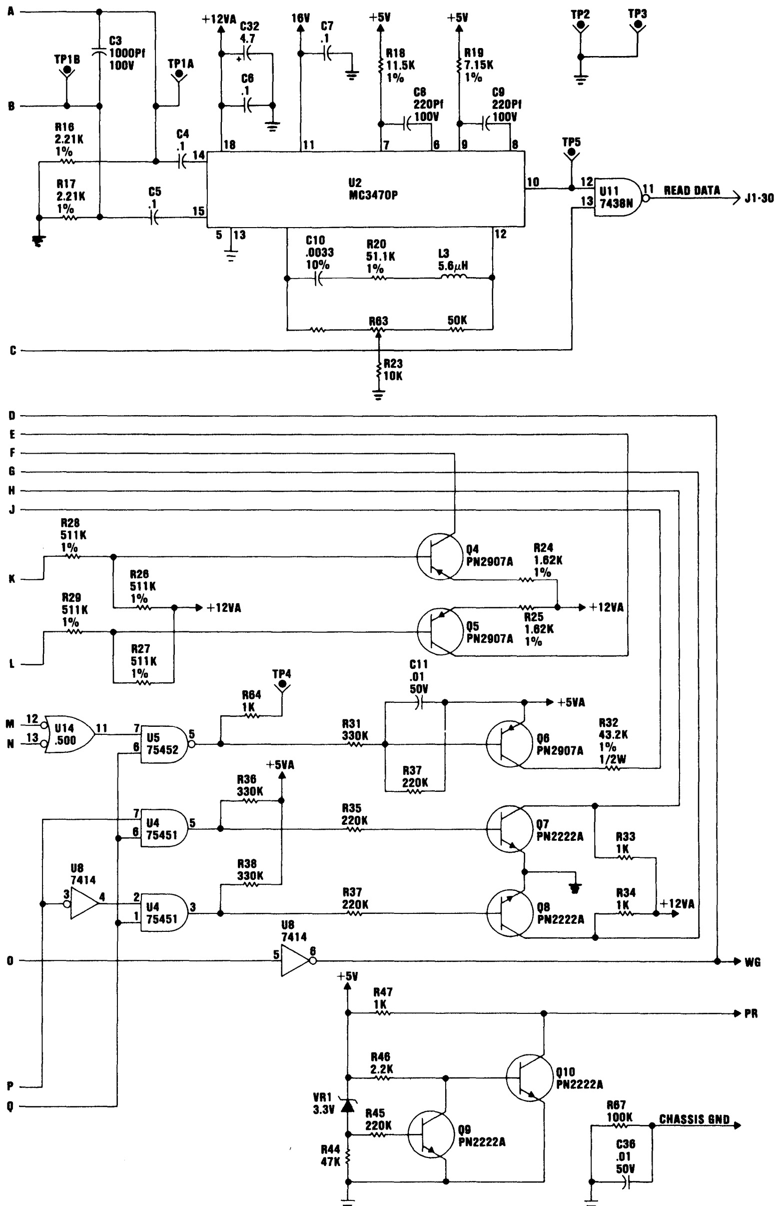
Slimline Diskette Drive (Sheet 1 of 4)



Slimline Diskette Drive (Sheet 2 of 4)



Slimline Diskette Drive (Sheet 3 of 4)



Slimline Diskette Drive (Sheet 4 of 4)

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Double Sided Diskette Drive

for

IBM Personal Computer AT® and IBM Personal Computer XT

6139788

March 17, 1986

Notes:

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Notes:

Description

The IBM Personal Computer Double Sided Diskette Drive is a direct-access device that can store 320/360Kb of data on a dual-sided 5-1/4 inch diskette. All data format and access control is in the system. The following figure describes the type of diskette required by this drive.

Characteristic	Requirement
Certification	Double sided 48 TPI 40 tracks per surface Soft Sector
Recording density	5,876 bits per inch
Media coercivity	300 to 350 Oersteds
Jacket	Standard 5-1/4 inch

Diskette Requirements

The signals for operating the diskette drive are generated through the IBM Personal Computer AT Fixed Disk and Diskette Drive Adapter or the IBM Personal Computer Diskette Adapter.

Interfaces

The diskette drive has two types of interface: control and dc power. The following figure shows the signals and pin assignments for the control interface.

Signal Name	I/O	Signal Pin	Ground Pin
Reserved	-	2	1
Reserved	-	4	3
-Drive Select 3	I	6	5
-Index	O	8	7
-Drive select 0	I	10	9
-Drive select 1	I	12	11
-Drive select 2	I	14	13
-Motor On	I	16	15
-Direction Select	I	18	17
-Step	I	20	19
-Write Data	I	22	21
-Write Gate	I	24	23
-Track 00	O	26	25
-Write Protect	O	28	27
-Read Data	O	30	29
-Side 1 Select	I	32	31
Reserved	-	34	33

Control Interface (P1/J1)

Following are the signals and pin assignments for the dc power interface.

Signal Name	Pin
+ 12 Vdc	1
+ 12 Vdc Return	2
+ 5 Vdc Return	3
+ 5 Vdc	4

Power Interface (P2/J2)

All signals operate between +5 Vdc and ground with the following definitions:

Inactive Level: +2.5 to +5.25 Vdc

Active Level: 0.0 to +0.4 Vdc

All outputs from the drive can sink 40 mA at the active level. The system provides pull-up registers.

Input Signals

All input signals are active when low.

Drive Select 0 through 3

These '-drive select' signals enable or disable all other drive interface signals, except '-motor on'. When '-drive select' is at the active level, the drive is enabled. When it is at the inactive level, all controlled inputs are ignored, and all drive outputs are disabled. The enabled or disabled condition of the drive is established within 500 nanoseconds after a change to the select input, excluding head-load time and settling times.

-Motor On

An active level of this signal starts the drive motor. There must be a 750 millisecond delay after '-motor on' becomes active before any read or write operation starts.

-Direction Select

This signal determines the direction the read/write head moves when the step signal is pulsed. An active level indicates away from the center of the diskette (out); an inactive level indicates toward the center of the diskette (in). Any change in the '-direction select' signal must be made at least 1 microsecond before the leading edge of the step pulse, and at least 1 microsecond after the trailing edge of the step pulse.

-Step

This signal causes the read/write heads to move in the direction determined by the '-direction select' signal. Motion is started each time the signal changes from an active to inactive level (at the trailing edge of the pulse).

-Write Data

Each time this signal changes from the inactive to active level, the current through the read/write heads reverses, and writes a data bit. This signal is enabled when '-write gate' is at the active level. A 250-nanosecond active pulse of this signal causes a bit to be written on the diskette. These pulses may occur with either a 4, 6, or 8-microsecond spacing (±0.5%).

-Write Gate

An active level of this input enables the write current circuits, and the '-write data' input controls the writing of information. Transitions of '-write gate' occur 4 to 8 microseconds before the first significant data bit, and 4 to 8 microseconds after the last significant data bit. After deactivating '-write gate', deactivation of '-drive select' and '-motor on', and changing '-side 1 select' must be delayed 1 millisecond, because the erase head is active for this period.

-Side 1 Select

This signal determines which side of the two-sided diskette will be used for reading or writing. An inactive level of this signal selects the read/write head on the 0 side of the diskette; an active level selects the 1 side. A 100-microsecond delay must be allowed after switching from one head to the other before starting to read or write.

Output Signals

-Index

When the drive senses the index hole in the diskette, it generates a 1- to 8-microsecond active pulse on this line.

-Track 00

An active level of this signal means that the read/write heads are at Track 00 (the outermost track).

-Write Protect

An active level of this signal means that a diskette without a write-protect notch is in the drive. The drive will not write when a protected diskette is loaded.

-Read Data

A 250-nanosecond active pulse is provided on this line for each bit detected on the diskette. These pulses may occur with either 4, 6, or 8-microsecond spacing.

Drive-In-Use Indicator

The Drive-In-Use indicator lights when the drive is selected.

Specifications

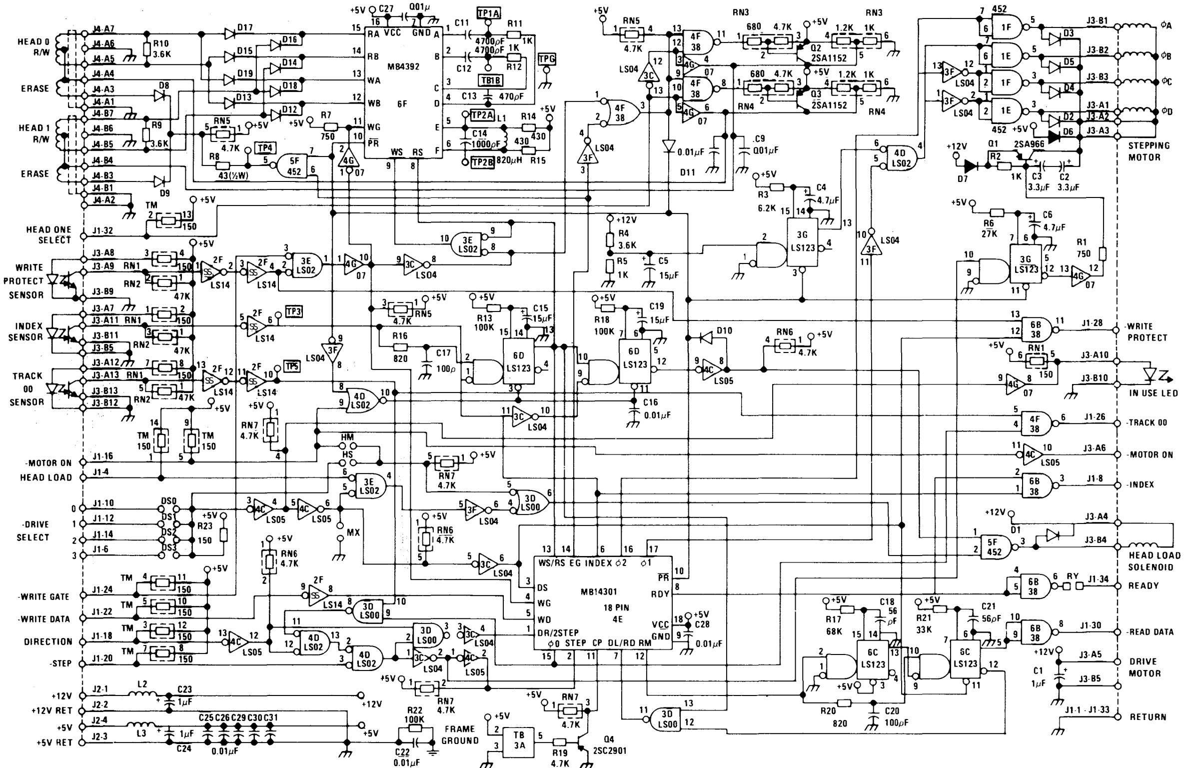
The following figures show the physical, and performance specifications for this drive.

Power Dissipation	11 W (Typical)
Operating Limits	
Ambient Temperature	10 to 50 Degrees C (41 to 114.8 Degress F)
Relative Humidity	8 to 80%
Maximum Wet Bulb	26.7 Degrees C (84 Degrees F)
Non-Operating Limits	
Ambient Temperature	-40 to 60 Degrees C (-40 to 140 Degrees F)
Humidity	No Condensation
Mechanical Dimensions	
Width	146.0 mm (5.8 in.)
Height	41.0 mm (1.6 in.)
Depth	203.2 mm (8.0 in.)
Weight	1.6 kg (3.52 pounds)

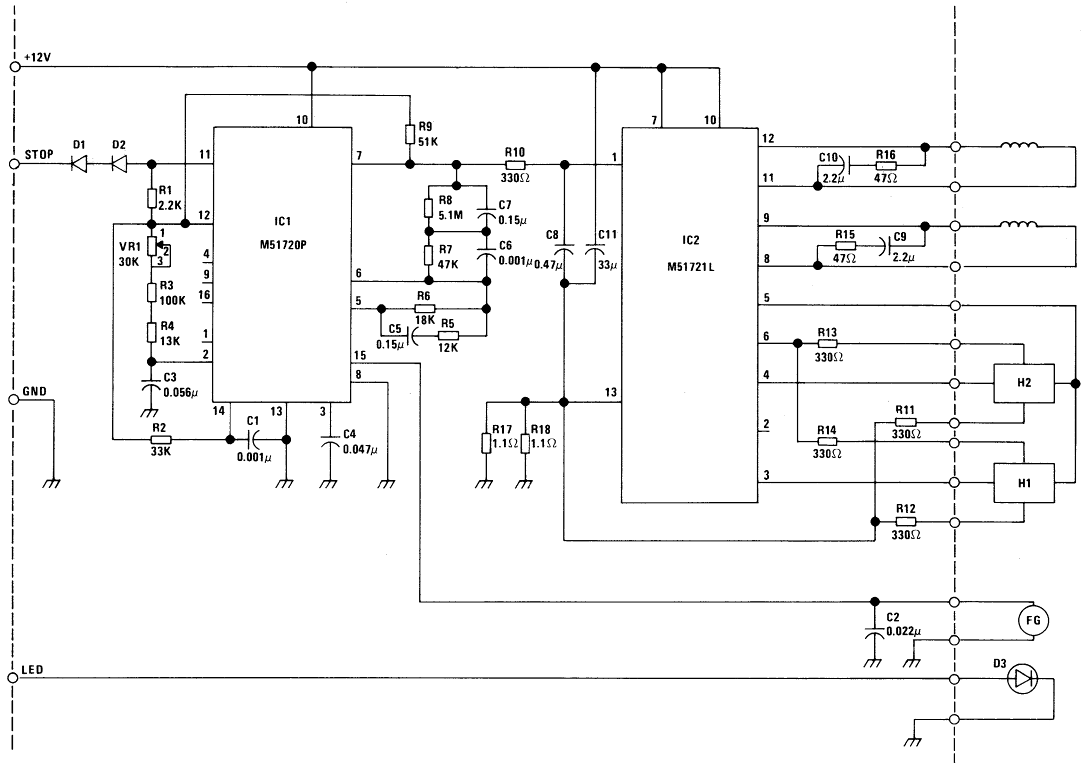
Physical Specifications

Capacity Unformatted	500 Kb
Capacity Formatted	
9 Sectors Per Track	368.6Kb
8 Sectors Per Track	320.0Kb
Recording density	5,876 bits per inch
Track Density	48 TPI(tracks per inch)
Cylinders	40
Tracks	80
Encoding Method	MFM
Rotational Speed	300 RPM ± 1.5%
Transfer Rate	250K bits per second
Latency (Average)	100 ms
Access Time:	
Average	81 ms
Track to Track	6 ms
Settling Time	15 ms
Head Load Time	0 ms
Motor Start Time	500 ms

Performance Specifications



Double Sided Diskette Drive (Sheet 1 of 2)



Double Sided Diskette Drive (Sheet 2 of 2)

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High Capacity Diskette Drive

IBM PERSONAL COMPUTER AT HIGH CAPACITY DISKETTE DRIVE

Contents

Notes:

Description

The IBM Personal Computer AT High Capacity Diskette Drive is a direct-access device that can store 1.2Mb of data on a dual-sided 5-1/4 inch diskette. All data format and access control is in the system. The following figure describes the type of high-density diskette required by this drive. Diskettes, which meet these specifications may not be used in either a 160/180Kb or a 320/360Kb diskette drive.

Characteristic	Requirement
Certification	Double Sided 96 TPI 80 Tracks/Surface Soft Sector
Recording Density	9,646 Bits Per Inch
Media Coercivity	600 to 650 Oersteds
Jacket	Standard 5-1/4 Inch

Diskette Requirements

The signals for operating the diskette drive are generated through the IBM Personal Computer AT Fixed Disk and Diskette Drive Adapter.

> **Note:** This drive also can read diskettes formatted for a 320/360Kb dual-sided drive or a 160/180Kb single-sided drive.

Interfaces

The diskette drive has two types of interface: control and dc power. The following show the signals and pin assignments for the control interface.

Signal Name	I/O	Signal Pin	Ground Pin
-Reduced Write	I	2	1
Reserved	-	4	3
-Drive Select 3	I	6	5
-Index	O	8	7
-Drive Select 0	I	10	9
-Drive Select 1	I	12	11
-Drive Select 2	I	14	13
-Motor On	I	16	15
-Direction Select	I	18	17
-Step	I	20	19
-Write Data	I	22	21
-Write Gate	I	24	23
-Track 00	O	26	25
-Write Protect	O	28	27
-Read Data	O	30	29
-Side 1 Select	I	32	31
-Diskette Change	O	34	33

Control Interface (P1/J1)

The signals and pin assignments for the dc power interface are as follows:

Signal Name	Pin
+12 Vdc	1
+12 Vdc Return	2
+5 Vdc Return	3
+5 Vdc	4

DC Power Interface (P2/J2)

All signals operate between +5 Vdc and ground with the following definitions:

Inactive Level: +2.5 to +5.25 Vdc

Active Level: 0.0 to +0.4 Vdc

All outputs from the drive can sink 40 mA at the active level. The system provides pull-up registers.

Input Signals

Following are descriptions of the input signals.

-Reduced Write

The inactive state of this signal indicates that high-density media is present requiring normal write currents, and the active state indicates low-density media is present, requiring a reduced write current.

-Drive Select 0, 1, 2, and 3

The Drive Select signals enable or disable all other drive interface signals, except '-motor on'. When '-drive select' is at the active level, the drive is enabled. When it is at the inactive level, all controlled inputs are ignored, and all drive outputs are disabled. The enabled or disabled condition of the drive is established within 500 nanoseconds after a change to the '-drive select' input, excluding head-load time and settling time.

-Motor On

The spindle motor runs when this input is active. The drive requires a 750 millisecond delay after '-motor on' becomes active before a read or write operation.

-Direction Select

If this input is at a inactive level the '-step' input signal moves the heads away from the drive spindle. An active level causes the opposite. This input is stable for a minimum of 1 microsecond before and after the trailing edge of the step pulse.

-Step

A 1-microsecond active pulse on this input causes the read/write heads to move one track. The state of '-Direction Select' at the trailing edge of the Step pulse determines the direction of motion.

-Write Data

A 150-nanosecond pulse on this input causes a bit to be written on the disk if '-Write Gate' is active. These pulses may occur with either a 2, 3, 3.3, 4, 5, or 6.67-microsecond spacing ±0.5%. When Write Gate is inactive, pulses do not appear on this input.

-Write Gate

An active level of this input enables the write current circuits, and the '-Write Data' input controls the writing of information. Transitions of this line occur 4 to 8 microseconds before the first significant data bit, and 4 to 8 microseconds after the last significant data bit. Making this input inactive removes all current from the read/write heads and allows the read circuits to operate within 590 microseconds. All motor-start, head-settle, and head-load times are complied with before the line becomes active.

-Side 1 Select

This signal determines which side of the two-sided diskette will be used for reading or writing. An inactive level of this signal selects the read/write head on the 0 side of the diskette; an active level selects the 1 side. A 100-microsecond delay must be allowed after switching from one head to the other before starting to read or write.

Output Signals

Following are descriptions of the output signals.

-Index

When a diskette's index hole aligns with the hole in the diskette jacket, a 1- to 8-millisecond active pulse is generated on this line.

-Track 00

This signal is active when the upper head is on Track 00.

-Write Protect

An active level of this signal means that a diskette without a write-protect notch is in the drive. The drive will not write when a protected diskette is loaded.

-Read Data

Each bit detected provides a 150-nanosecond active pulse on this line. These pulses may occur with either a 2, 3, 3.33, 4, 5, or 6.67-microsecond spacing ±0.5%.

-Diskette Change

This output is active unless a diskette is present and a step pulse is received when the drive is selected.

Drive-in-Use Indicator

The Drive-in-Use indicator lights when the drive is selected.

Specifications

The following figures show the physical and performance specifications for this drive.

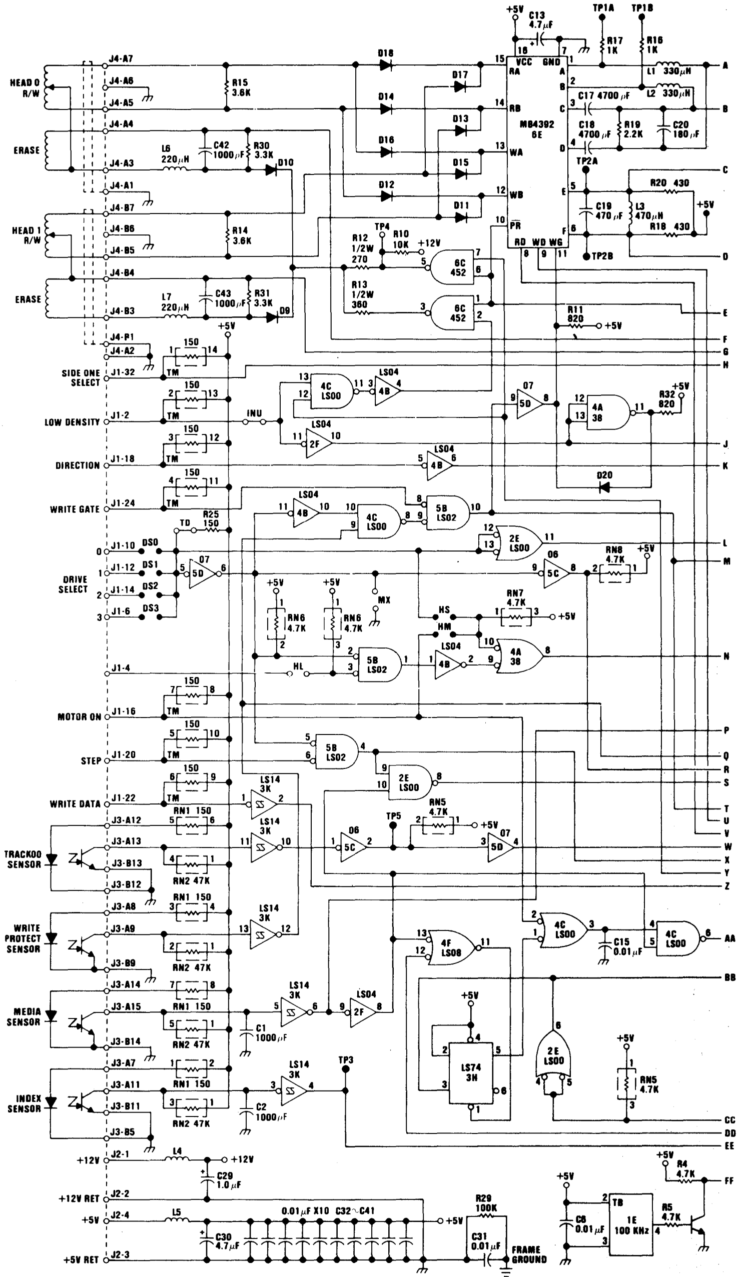
Power Dissipation	11 W (TYP)
Operating Limits	Ambient Temperature 5 to 46 Degrees Celsius (41 to 114.8 Degrees Fahrenheit) Relative Humidity 20 to 80 % Maximum Wet Bulb 29 Degrees Celsius (84 Degrees Fahrenheit)
Non-operating Limits	Ambient Temperature -40 to 60 Degrees Celsius (-40 to 140 Degrees Fahrenheit) Humidity no Condensation
Mechanical Dimensions	Width 146.0 mm (5.8 in) Height 41.0 mm (1.6 in) Depth 203.2 mm (8 in)
Weight	1.6 kg

Physical Specifications

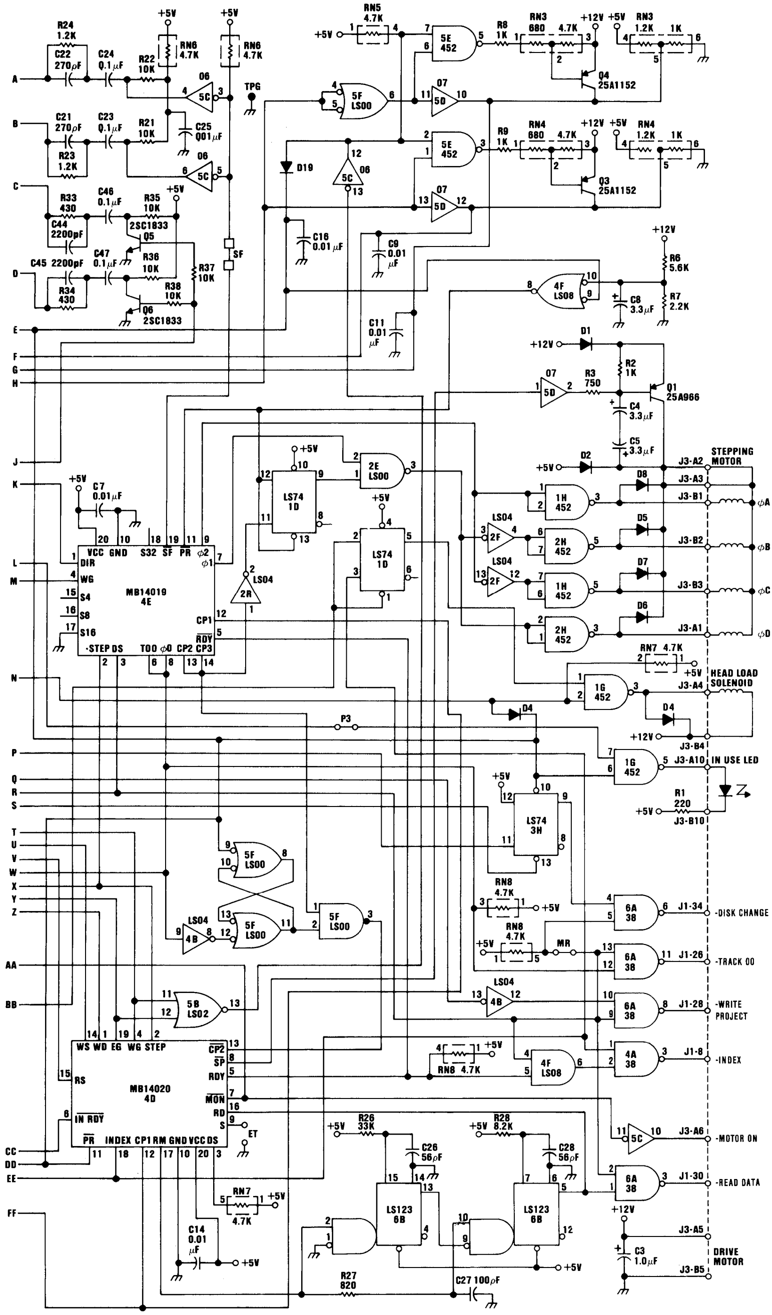
Capacity Unformatted	1604Kb
Capacity Formatted	
15 Sectors Per Track	1.2Mb
Recording Density	9646 Bits Per Inch
Track Density	96 TPI
Cylinders	80
Tracks	160
Encoding Method	MFM
Rotational Speed	360 RPM
Transfer Rate	500K Bits/Second
Latency (Average)	83 ms
Access Time	
Average	91 ms
Track to Track	3 ms
Settling Time	18 ms
Head Load Time	50 ms
Motor Start Time	750 ms

Performance Specifications

Logic Diagrams



High Capacity Diskette Drive (Sheet 1 of 2)



High Capacity Diskette Drive (Sheet 2 of 2)

IBM

Personal Computer Hardware Reference Library

Double Sided Diskette Drive

IBM PERSONAL COMPUTER AT DOUBLE SIDED DISKETTE DRIVE

Contents

Notes:

Description

The IBM Personal Computer AT Double Sided Diskette Drive is a direct-access device that can store 320/360Kb of data on a dual-sided 5-1/4 inch diskette. All data format and access control is in the system. The following figure describes the type of diskette required by this drive.

Characteristic	Requirement
Certification	Double-Sided 48 TPI 40 Tracks/Surface Soft Sector
Recording Density	5876 Bits Per Inch
Media Coercivity	300 to 350 Oersteds
Jacket	Standard 5-1/4 Inch

Diskette Requirements

The signals for operating the diskette drive are generated through the IBM Personal Computer AT Fixed Disk and Diskette Drive Adapter.

Interfaces

The diskette drive has two types of interface: control and dc power. The following figure shows the signals and pin assignments for the control interface.

Signal Name	I/O	Signal Pin	Ground Pin
Reserved	-	2	1
Reserved	-	4	3
-Drive Select 3	I	6	5
-Index	O	8	7
-Drive Select 0	I	10	9
-Drive Select 1	I	12	11
-Drive Select 2	I	14	13
-Motor On	I	16	15
-Direction Select	I	18	17
-Step	I	20	19
-Write Data	I	22	21
-Write Gate	I	24	23
-Track 00	O	26	25
-Write Protect	O	28	27
-Read Data	O	30	29
-Side 1 Select	I	32	31
Reserved	-	34	33

Control Interface (P1/J1)

Following are the signals and pin assignments for the dc power interface.

Signal Name	Pin
+12 Vdc	1
+12 Vdc Return	2
+5 Vdc Return	3
+5 Vdc	4

Power Interface (P2/J2)

All signals operate between +5 Vdc and ground with the following definitions:

Inactive Level: +2.5 to +5.25 Vdc

Active Level: 0.0 to +0.4 Vdc

All outputs from the drive can sink 40 mA at the active level. The system provides pull-up registers.

Input Signals

All input signals are active when low.

Drive Select 0 through 3

These '-drive select' signals enable or disable all other drive interface signals, except '-motor on'. When '-drive select' is at the active level, the drive is enabled. When it is at the inactive level, all controlled inputs are ignored, and all drive outputs are disabled. The enabled or disabled condition of the drive is established within 500 nanoseconds after a change to the select input, excluding head-load time and settling times.

-Motor On

An active level of this signal starts the drive motor. There must be a 750 millisecond delay after '-motor on' becomes active before any read or write operation starts.

-Direction Select

This signal determines the direction the read/write head moves when the step signal is pulsed. An active level indicates away from the center of the diskette (out); an inactive level indicates toward the center of the diskette (in). Any change in the '-direction select' signal must be made at least 1 microsecond before the leading edge of the step pulse, and at least 1 microsecond after the trailing edge of the step pulse.

-Step

This signal causes the read/write heads to move in the direction determined by the '-direction select' signal. Motion is started each time the signal changes from an active to inactive level (at the trailing edge of the pulse).

-Write Data

Each time this signal changes from the inactive to active level, the current through the read/write heads reverses, and writes a data bit. This signal is enabled when '-write gate' is at the active level. A 250-nanosecond active pulse of this signal causes a bit to be written on the diskette. These pulses may occur with either a 4, 6, or 8-microsecond spacing ($\pm$0.5%).

-Write Gate

An active level of this input enables the write current circuits, and the '-Write Data' input controls the writing of information. Transitions of this line occur 4 to 8 microseconds before the first significant data bit, and 4 to 8 microseconds after the last significant data bit. After deactivating '-write gate', deactivation of '-drive select' and '-motor on', and changing '-side 1 select' must be delayed 1 millisecond, because the erase head is active for this period.

-Side 1 Select

This signal determines which side of the two-sided diskette will be used for reading or writing. An inactive level of this signal selects the read/write head on the 0 side of the diskette; an active level selects the 1 side. A 100-microsecond delay must be allowed after switching from one head to the other before starting to read or write.

Output Signals

-Index

When the drive senses the index hole in the diskette, it generates a 1- to 8-microsecond active pulse on this line.

-Track 00

An active level of this signal means that the read/write heads are at Track 00 (the outermost track).

-Write Protect

An active level of this signal means that a diskette without a write-protect notch is in the drive. The drive will not write when a protected diskette is loaded.

-Read Data

A 250-nanosecond active pulse is provided on this line for each bit detected on the diskette. These pulses may occur with either 4, 6, or 8-microsecond spacing.

Drive-in-Use Indicator

The Drive-in-Use indicator lights when the drive is selected.

Specifications

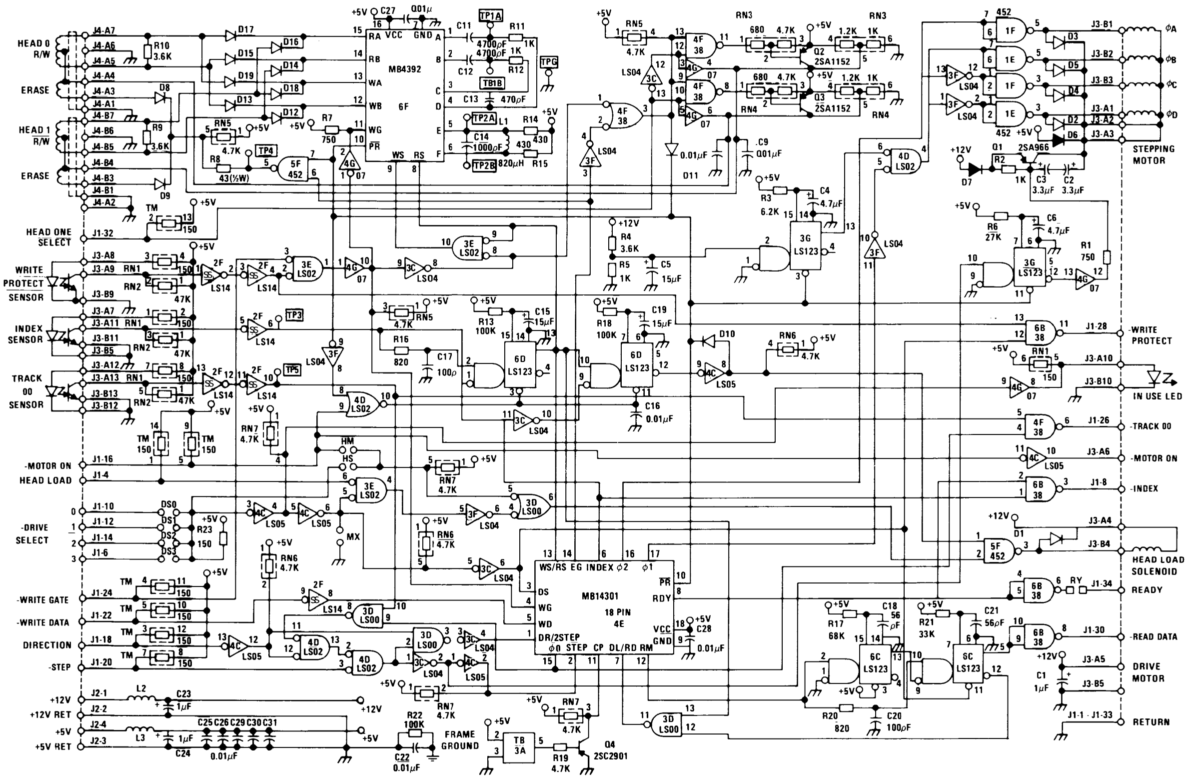
The following figures show the physical, and performance specifications for this drive.

Power Dissipation	11 W (Typical)
Operating Limits	Ambient Temperature 5 to 46 Degrees C (41 to 114.8 Degrees Fahrenheit) Relative Humidity 20 to 80 % Maximum Wet Bulb 29 Degrees Celsius (84 Degrees Fahrenheit)
Non-Operating Limits	Ambient Temperature -40 to 60 Degrees C (-40 to 140 Degrees Fahrenheit) Humidity no Condensation
Mechanical Dimensions	Width 146.0 mm (5.8 in) Height 41.0 mm (1.6 in) Depth 203.2 mm (8 in)
Weight	1.6 kg

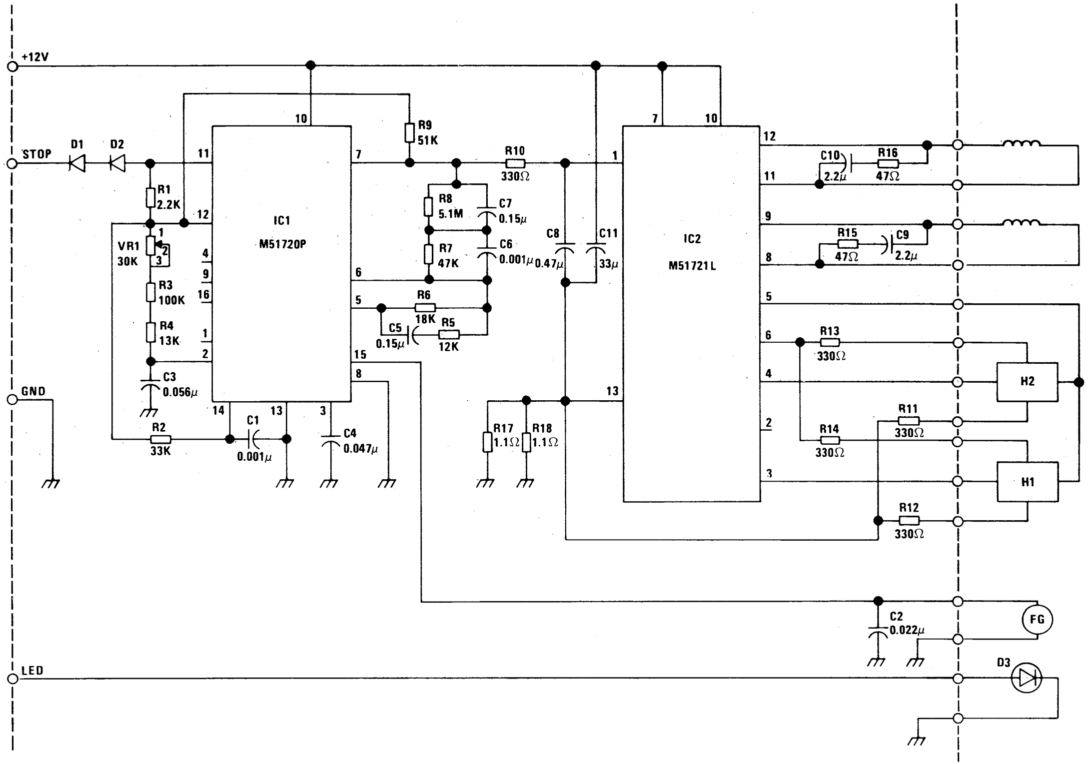
Physical Specifications

Capacity Unformatted	500Kb
Capacity Formatted:	
9 Sectors Per Track	368.6Kb
8 Sectors Per Track	320.0Kb
Recording Density	5876 Bits Per Inch
Track Density	48 TPI
Cylinders	40
Tracks	80
Encoding Method	MFM
Rotational Speed	300 RPM
Transfer Rate	250K Bits/Second
Latency (Average)	100 ms
Access Time:	
Average	81 ms
Track to Track	5 ms
Settling Time	20 ms
Head Load Time	50 ms
Motor Start Time	750 ms

Performance Specifications



Double Sided Diskette Drive (Sheet 1 of 2)



Double Sided Diskette Drive (Sheet 2 of 2)

Personal Computer
Hardware Reference
Library

IBM Personal Computer 3.5″–720KB Diskette Drive

6183315

March 17, 1986

Notes:

Contents

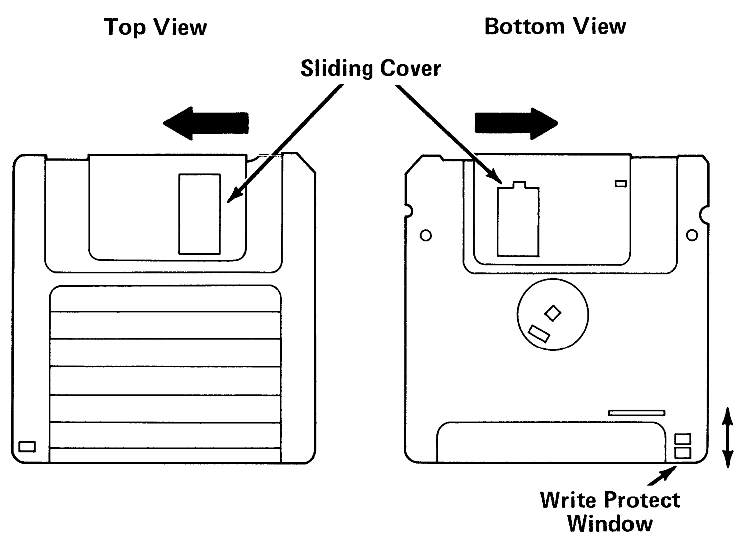
Notes:

Description

The IBM Personal Computer 3.5"– 720KB Diskette Drive is a direct-access device containing a spindle drive system, a head positioning system, and a read/write/erase system. The drive uses double-sided diskettes with 80 tracks on each side. Each diskette has a formatted capacity of 720K.

3.5" Diskette

This diskette is a flexible magnetic disk with a metal hub enclosed in a protective hard plastic cover. The disk is free to rotate within the cover and is continuously cleaned by the cover's soft fabric lining. The diskette's write-protect feature is enabled by sliding the plastic window in the corner of the diskette cover to the open position. A sliding metal cover is provided to protect the diskette when it is out of the drive. The following figure is a simplified drawing of the diskette used with the 3.5"–720KB Diskette Drive.



Operation

When a diskette is being inserted, metal guides ensure it is in the correct position. The diskette then drops down onto the spindle motor. The spindle motor engages the metal hub of the diskette through a pin-to-hole arrangement called the *chucking* mechanism. The chucking mechanism provides precise positioning of the diskette. The upper read/write head is then lowered onto the diskette. (The lower head is fixed and does not move vertically.) The spindle system spins the diskette at a constant speed of 300 revolutions per minute (rpm). A sensor generates an index signal once per rotation of the spindle motor. The two read/write heads are positioned over the desired track of the diskette by a stepper motor. One step of the stepper motor results in a one-track linear movement of the read/write heads. An optical sensor generates a signal when the heads are over track 00.

During a write operation, data is provided to the drive in modified frequency modulation (MFM) coded form by a diskette drive adapter.

> **Note:** Refer to the "System-to-Adapter Compatibility Chart" and "Option-to-Adapter Compatibility Chart" in the front of the *Technical Reference* Options and Adapters manual for systems and types of diskette drive adapters compatible with this drive.

The read/write heads record a track of 0.115 mm (0.0045 in.) nominal width, within a 0.1875 mm (0.00738 in.) track pitch. The area between the tracks is erased by an erase head. If the diskette is write-protected, the drive's write-protect sensor inhibits the write operation.

During a read operation, the signal from the head is amplified and filtered by read-recovery circuitry, which consists of a low-level read amplifier, differentiator, zero-crossing detector, and digitizing circuits. The data is then transferred as MFM data to the diskette drive adapter.

To remove a diskette, push the diskette eject button to the rear. This raises the upper head from the diskette, lifts the diskette off the spindle motor, and ejects the diskette approximately 11mm

(7/16 in.). A signal is sent from the drive to the diskette adapter indicating that the diskette has been ejected. The signal is reset when a diskette is inserted and the diskette drive adapter selects and steps the drive.

Interface

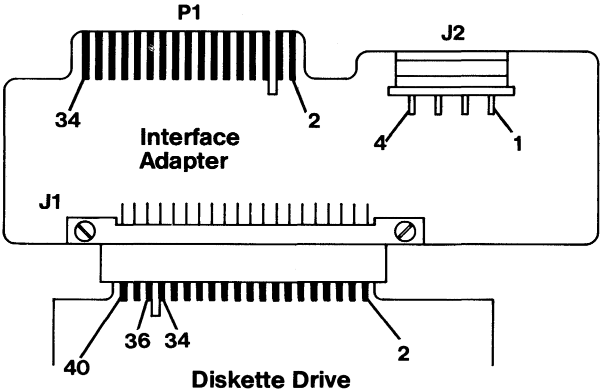
The diskette drive connects to a diskette drive adapter through an internal, daisy-chained, flat cable (data/control cable). An interface adapter is used to connect the drive's 40-pin edge connector to the 34-pin data/control cable and the 4-pin power connector. The following figure shows the signals and pin assignments for the drive's 40-pin edge connector.

Note: Assignments for pins 1 through 34 are the same on both sides of the interface adapter. Pins 37 through 40 go to the 4-pin power connector.

Signal Name	I/O	Signal Pin	Ground Pin
Reserved	-	2	1
Reserved	-	4	3
-Drive Select 3	O	6	5
-Index	O	8	7
-Drive Select 0	I	10	9
-Drive Select 1	I	12	11
-Drive Select 2	I	14	13
-Motor On	I	16	15
-Direction Select	I	18	17
-Step	I	20	19
-Write Data	I	22	21
-Write Gate	I	24	23
-Track 00	O	26	25
-Write Protect	O	28	27
-Read Data	O	30	29
-Side 1 Select	O	32	31
-Diskette Change	O	34	33
Reserved	-	36	35
+ 5 Vdc	-	38	37
+12 Vdc	-	40	39

3.5"– Diskette Interface

A key slot is located between pins 34 and 36. Pins 35 and 36 are grounded on the drive.



Diskette Drive Interface Adapter

Input Signals

All input signals are active when low.

-Drive Select 0 through 3

These '-drive select' signals enable or disable all other drive interface signals, except '-motor on'. When '-drive select' is active, the drive is enabled. When it is inactive, all controlled inputs are ignored, and all drive outputs are disabled. If, at this time, the '-motor on' signal is also inactive, the drive is in low power *standby mode*. When the drive is not in standby mode, the maximum '-drive select' delay time is 500 nanoseconds. When the drive is in standby mode, all signals except '-track 00' and '-write protect' have a maximum delay of 500 nanoseconds.

-Motor On

An active level of this signal starts the spindle motor. There must be a 750-millisecond delay after '-motor on' becomes active before a read or write operation starts. When inactive, this signal causes the spindle motor to decelerate and stop.

-Direction Select

When this signal is inactive, the '-step' signal moves the heads away from the drive spindle; when active, toward the drive spindle. Any change in the '-direction select' signal must be made at least 1 microsecond before the leading edge of the '-step' pulse, and at least 1 microsecond after the trailing edge of the '-step' pulse.

-Step

A 1-microsecond active pulse of this signal causes the read/write heads to move one track. The state of '-direction select' at the trailing edge of the '-step' pulse determines the direction of motion.

-Write Data

A 250-nanosecond pulse of this signal causes a bit to be written if '-write gate' is active. These pulses may occur with either a 2, 3, 3.3, 4, 5, or 6.67-microsecond spacing ±0.5%. When '-write gate' is inactive, pulses do not appear on this input.

-Write Gate

When active, this signal enables the write current circuits, and the '-write data' signal controls the writing of information. Transitions of this line occur 4 to 8 microseconds before the first significant data bit, and 4 to 8 microseconds after the last significant data bit. Making this signal inactive removes all current from the read/write heads and allows the read circuits to operate within 590 microseconds. All motor-start, head-settle, and head-load times are met before the line becomes active.

-Side 1 Select

Making this signal active selects the upper head; otherwise the lower head is selected.

Output Signals

-Index

When the drive senses an '-Index', it generates a 1- to 8-microsecond active pulse on this line.

-Track 00

When active, this signal indicates that the read/write heads are at Track 0 (the outermost track).

-Write Protect

When active, this signal indicates that a diskette with an open write-protect window (write-protected diskette) is in the drive, and the drive will not write.

-Read Data

A 250-nanosecond active pulse is provided on this line for each bit detected on the diskette. These pulses may occur with either 4, 6, or 8-microsecond spacing.

-Diskette Change

This signal is active unless a diskette is present and a step pulse is received by the diskette adapter when the drive is selected. The presence of a diskette is determined by a media sensor.

Drive-In-Use Indicator

The Drive-In-Use indicator lights when the drive is selected.

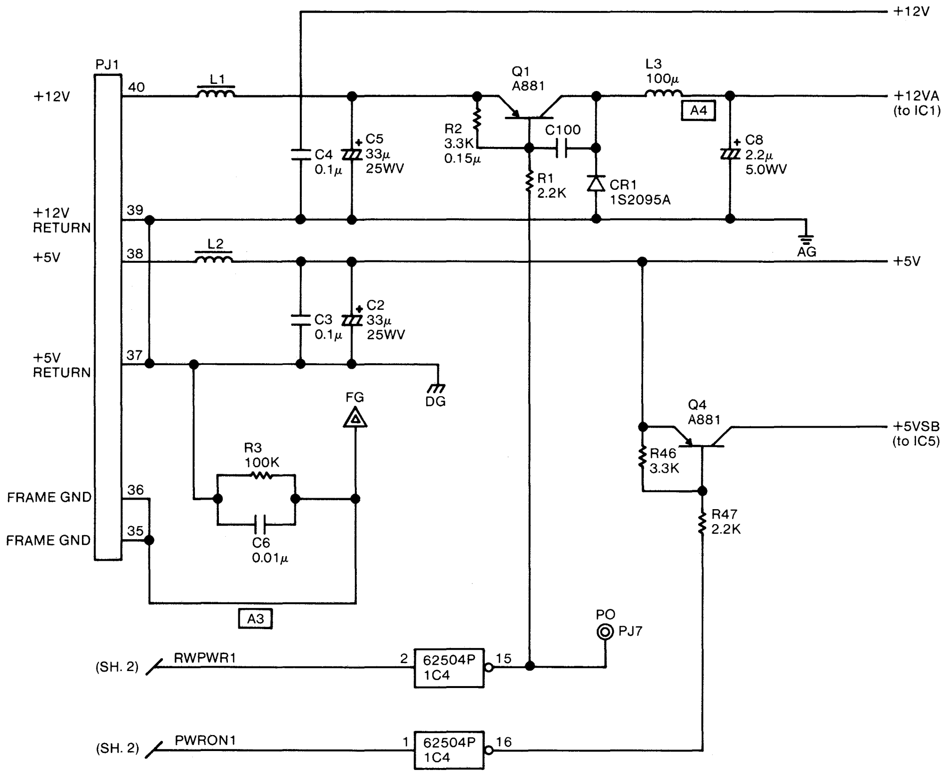
Specifications

Size (maximum)	
Height	42 mm (1.63 in.)
Width	102 mm (4.0 in.)
Depth	156 mm (6.1 in.)
Weight	0.86 kg (1.9 lb.)
Power	+12 Vdc ± 10% +5 Vdc ± 10%
Media	3.5" ANSI X3B8/83-14 compatible
Capacity Unformatted	1.0M bytes 500 K bytes per side 6.25 K bytes per track
Capacity Formatted	720K bytes
Track Density	135 tracks per inch
Tracks	80
Number of Heads	2
Transfer Rate	250K bits per second (MFM)
Access Time	
Track-to-Track	6 ms
Head Settle Time	15 ms
Head Load Time	0 ms
Motor Start Time	750 ms (maximum)
Temperature (exclusive of media)	
Operating	0.6 to 51.7°C (33 to 125°F)
Non-operating	-40 to 60°C (-40 to 140°F)
Relative Humidity (exclusive of media)	
Operating	5 to 95% (non-condensing)
Non-operating	5 to 95% (non-condensing)
Disk Speed	
Long Term	300 rpm ± 1.5%
Instantaneous	300 rpm ± 1.5%
Error Rate	
Recoverable	1 per 10^{9} bits read
Irrecoverable	1 per 10^{12} bits read
Seek Errors	1 per 10^{6} seeks
Head Life	Approximately 360,000,000 wear revolutions with less than 10% signal loss
Media Life	4.0 X 10^{16} passes per track

Specifications

Logic Diagrams

The following are logic diagrams for the IBM Personal Computer 3.5" – 720KB Diskette Drive.



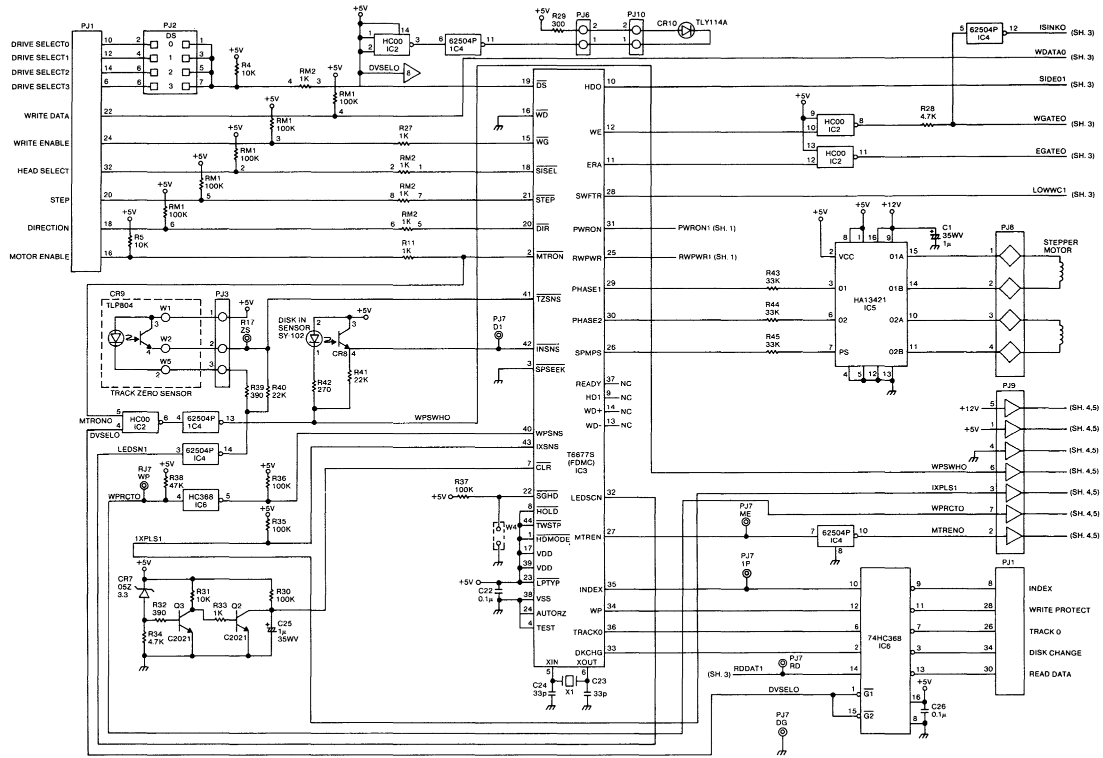
Note 1: Unless Otherwise Specified
R; 1/4W 5%
C; 50WV
(Same On Following Pages)

Note 2: Test Pin Assignment

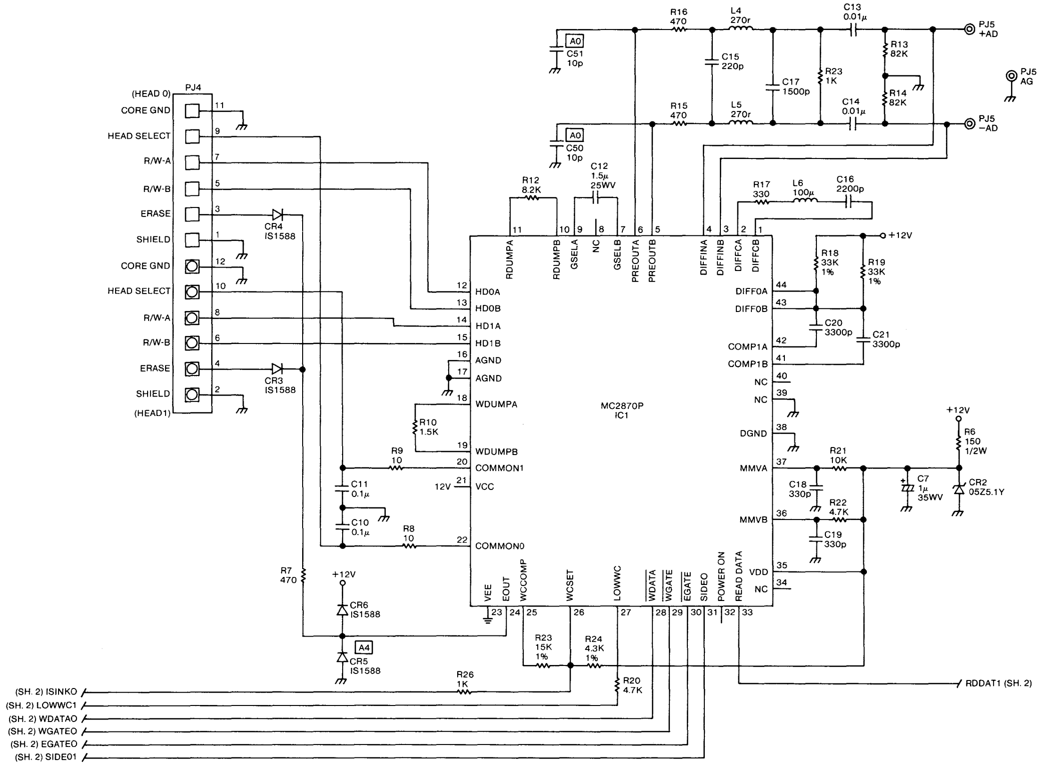
MARKING	SIGNAL NAME
+AD	ANALOG DATA +
−AD	ANALOG DATA −
AG	ANALOG GROUND
RD	READ OUT DIGITAL DATA
DG	DIGITAL GROUND
ZS	TRACK ZERO
WP	WRITE PROTECT
DI	DISK IN
IP	INDEX PULSE
ME	MOTOR ENABLE
PO	RW PWR ON

Note 3: All Odd-numbered Pins in PJ1 are Grounded (except 35 Pin) A3

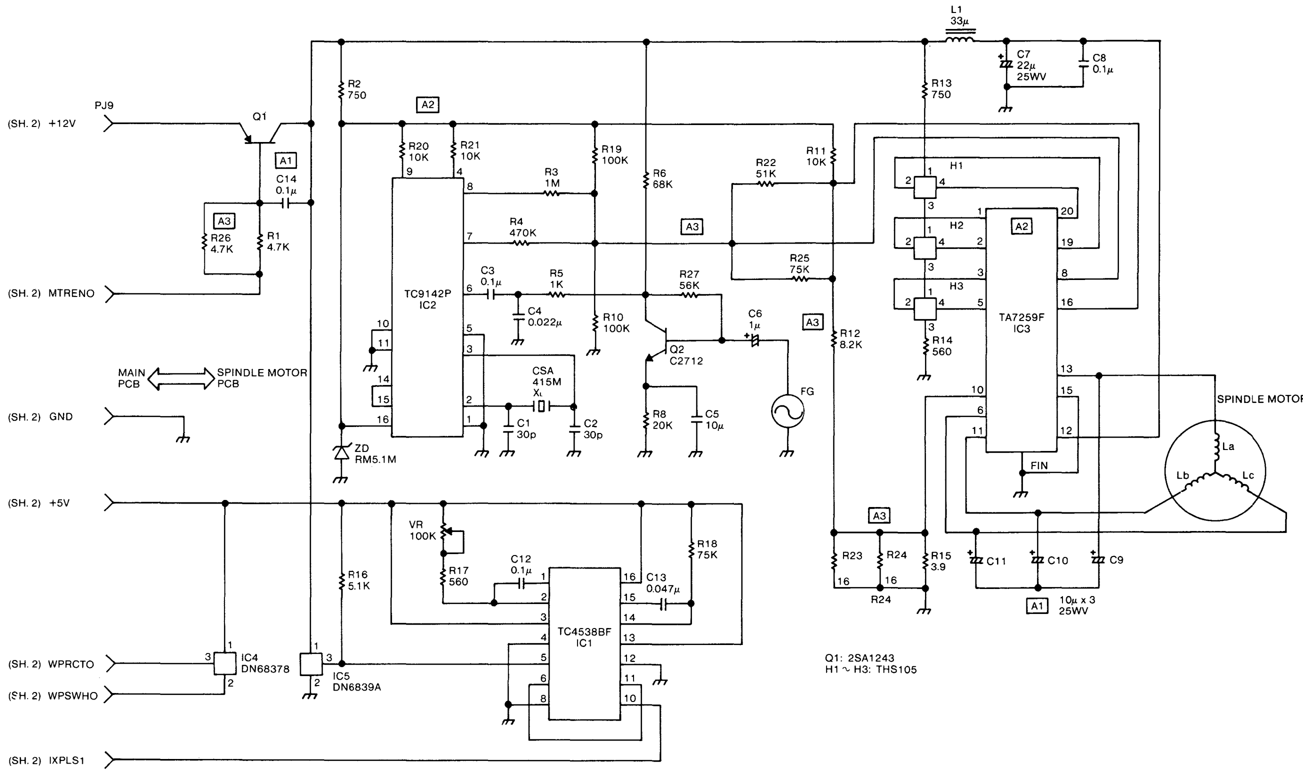
3.5" — 720KB Diskette Drive (Sheet 1 of 5)



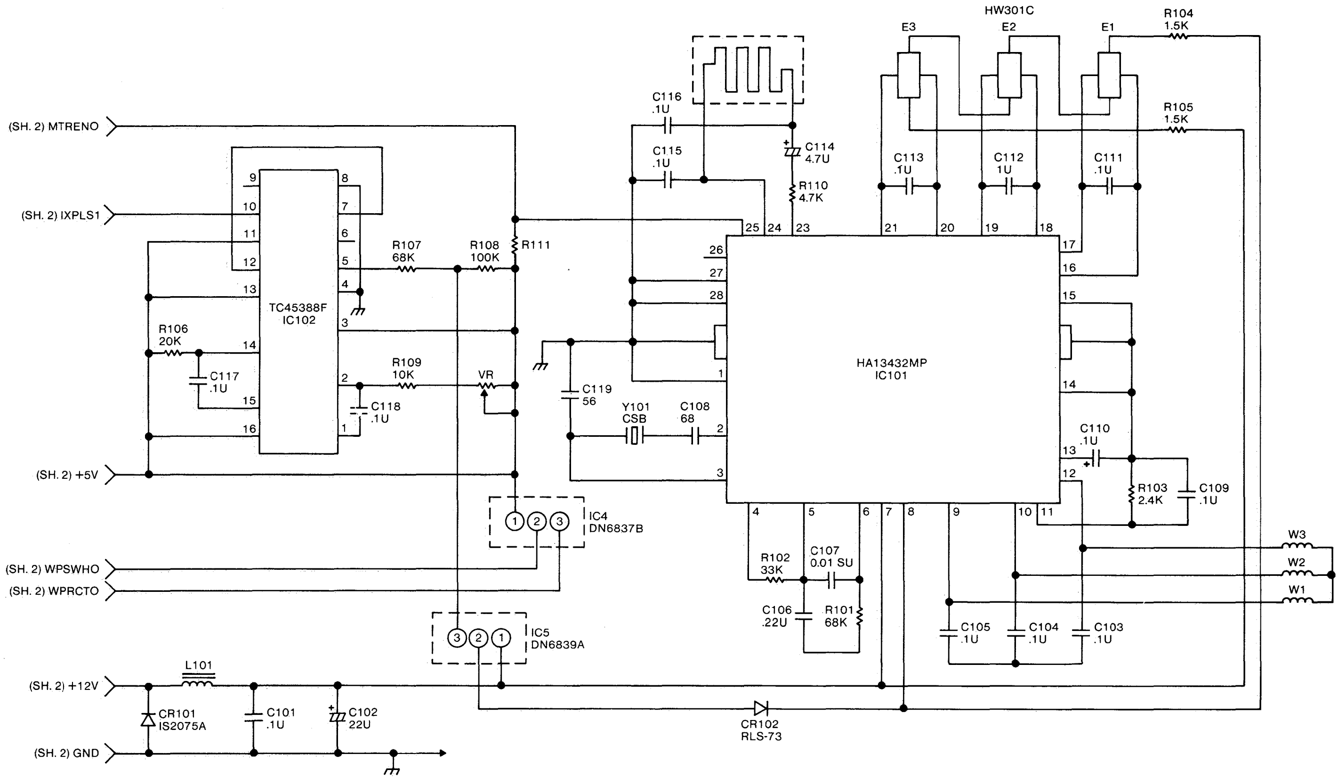
3.5" – 720KB Diskette Drive (Sheet 2 of 5)



3.5" – 720KB Diskette Drive (Sheet 3 of 5)



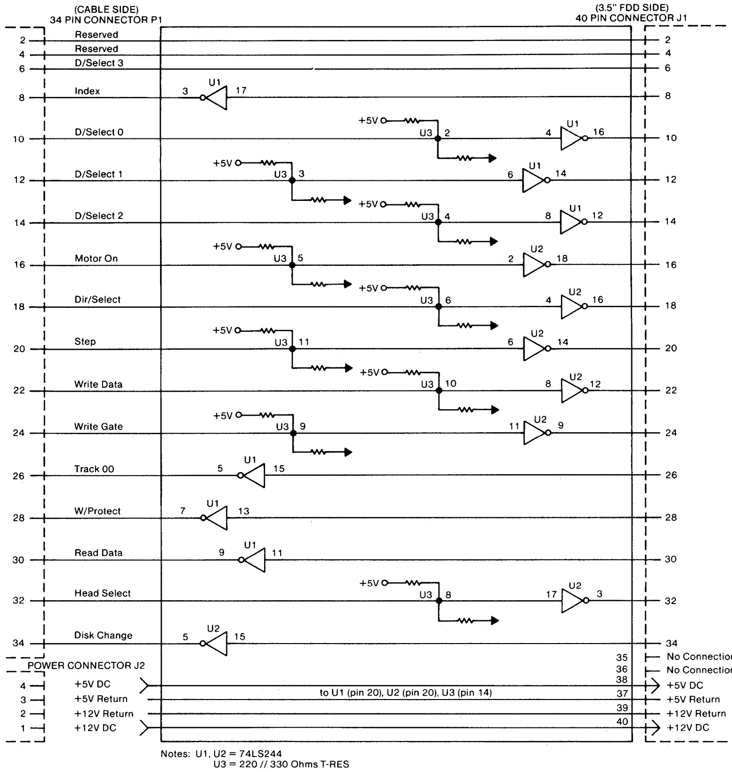
3.5" – 720KB Diskette Drive (Sheet 4 of 5)



3.5" – 720KB Diskette Drive (Sheet 5 of 5)

Adapter Card

The following is a logic diagram for the Adapter Card.



Adapter Card Logic Diagram

Notes:

Personal Computer
Hardware Reference
Library

IBM 10MB Fixed Disk Drive

6361482

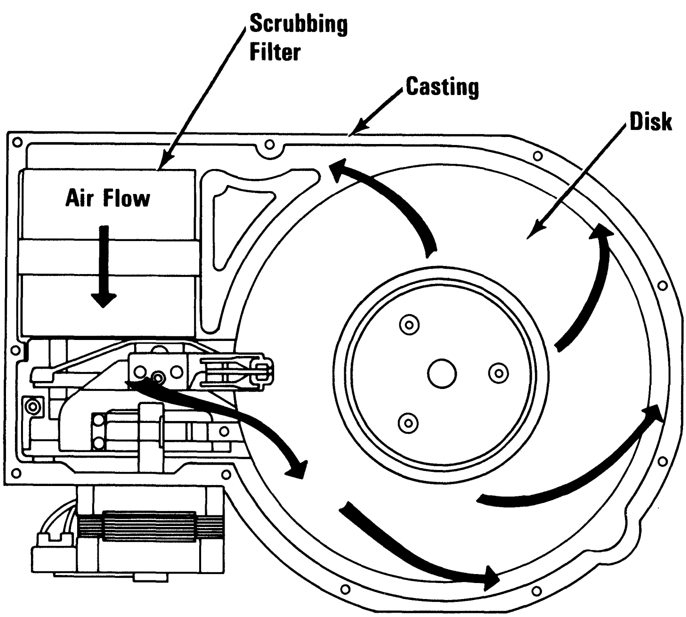
IBM 10MB Fixed Disk Drive

Contents

Description

The IBM 10MB Fixed Disk Drive is a random-access storage device that uses two non-removable 5-1/4 inch disks for storage. Each disk surface employs one movable head to service 306 cylinders. The total formatted capacity of the four heads and surfaces is 10M bytes (17 sectors per track with 512 bytes per sector and a total of 1224 tracks).

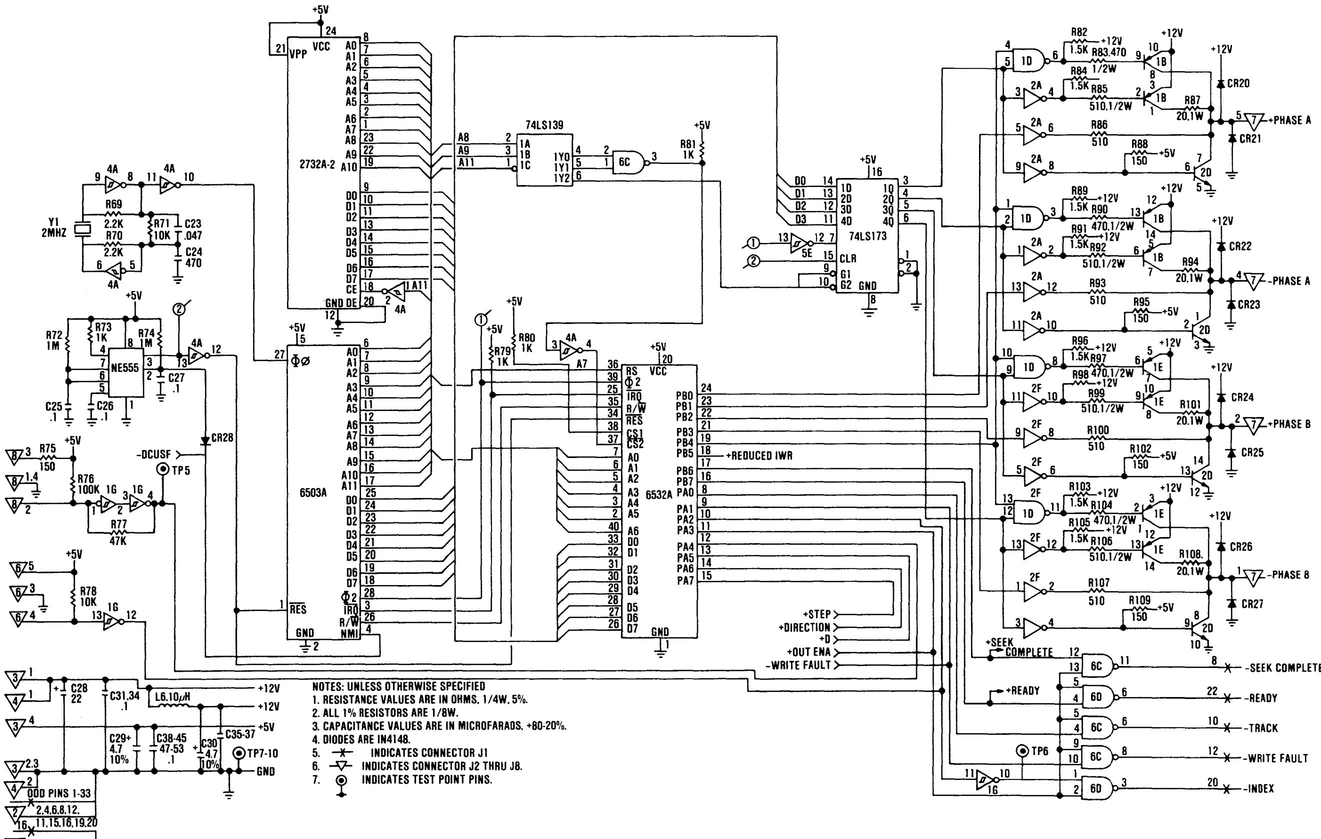
An impact-resistant enclosure provides mechanical and contamination protection for the heads, actuator, and disks. A self-contained air recirculating system, which consists of an internal filter and a breather filter, maintains a clean-air environment. Thermal isolation of the stepper and spindle motor assemblies from the disk enclosure results in a very low temperature rise within the enclosure. This isolation provides a greater off-track margin and the ability to perform read and write operations immediately after power-up with no thermal stabilization delay.



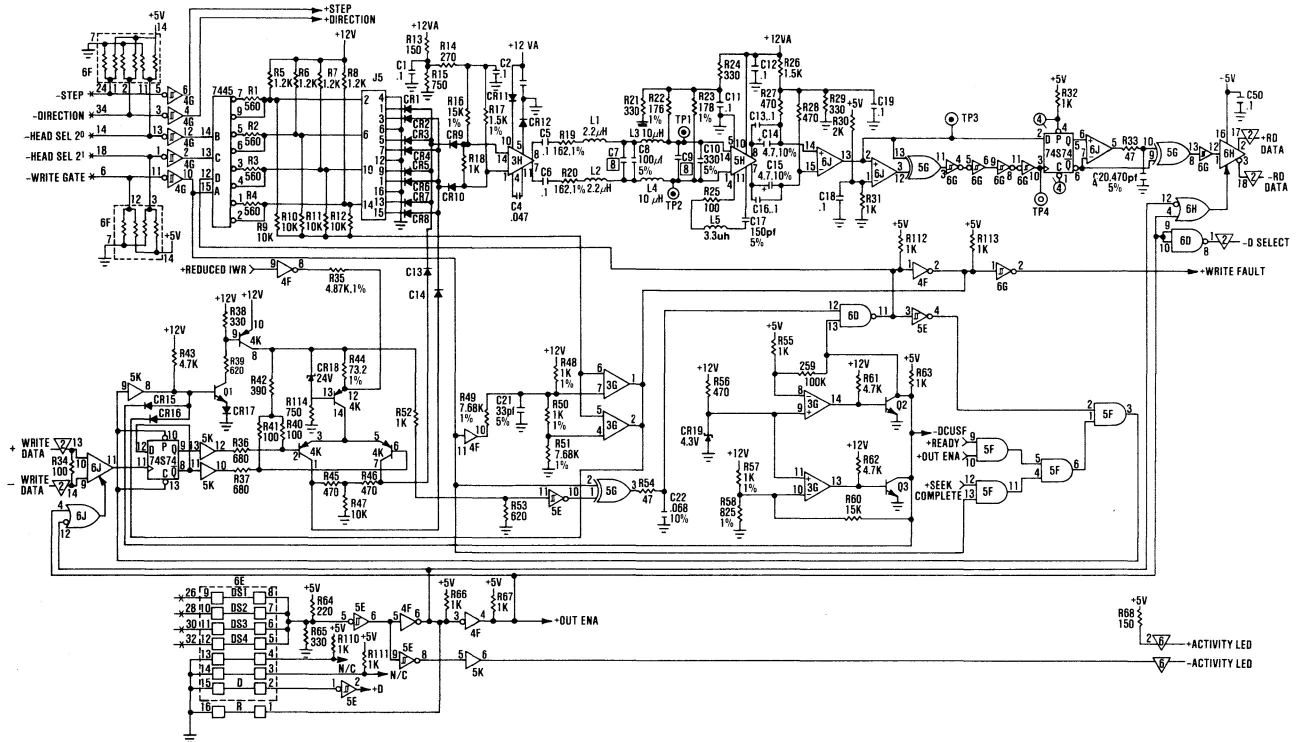
Specifications

Size (maximum)	
Height	82.55 mm (3.25 in.)
Width	146.05 mm (5.75 in.)
Depth	203 mm (8.0 in.)
Weight	2.08 kg (4.6 lb)
Power	+12 Vdc ± 5%, 1.8 A (4.5 A maximum) +5 Vdc ± 5%, 0.7 A (1.0 A maximum)
Maximum Ripple	1% with equivalent resistive load
Media	Rigid media disk
Track Density	345 tracks per inch
Number of Tracks	1224
Temperature	
Operating	4 to 50°C (40 to 122°F)
Non-operating	-40 to 60°C (-40 to 140°F)
Relative humidity	
Operating	8 to 80% (non-condensing)
Maximum Wet Bulb	26°C (78°F)
Shock	
Operating	10 Gs
Non-operating	20 Gs
Access Time	3 ms track-to-track
Average Latency	8.33 ms
Error Rates	
Recoverable	1 per 10^{10} bits read
Irrecoverable	1 per 10^{12} bits read
Seek Errors	1 per 10^{6} seeks
Design Life	5-years (8,000 hours MTF)
Disk speed	3600 rpm ± 1%
Transfer Rate	5.0M bps
Recording Mode	MFM

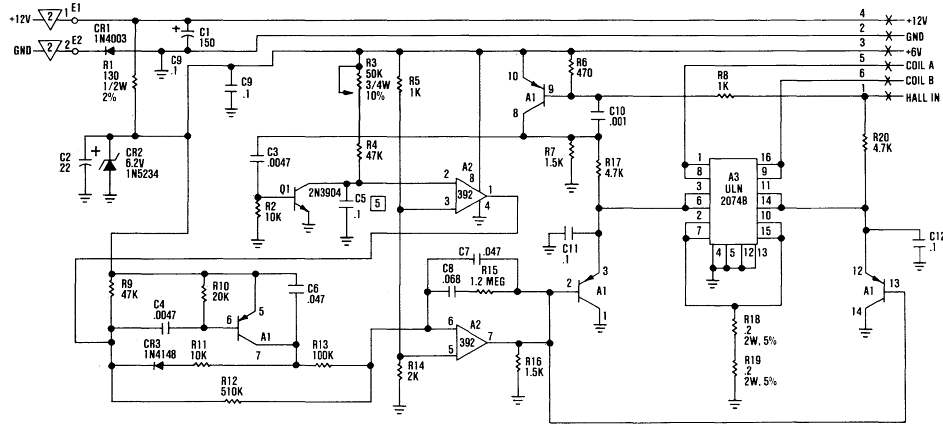
Mechanical and Electrical Specifications



Fixed Disk Drive — Type 1 (Sheet 1 of 3)

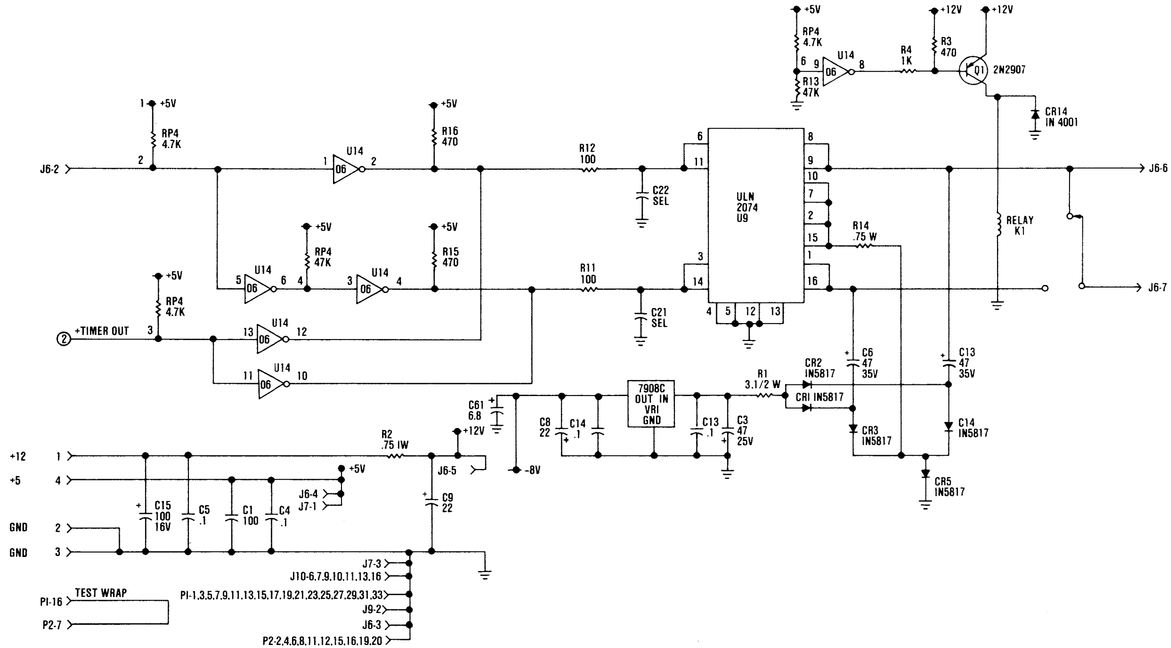


Fixed Disk Drive — Type 1 (Sheet 2 of 3)



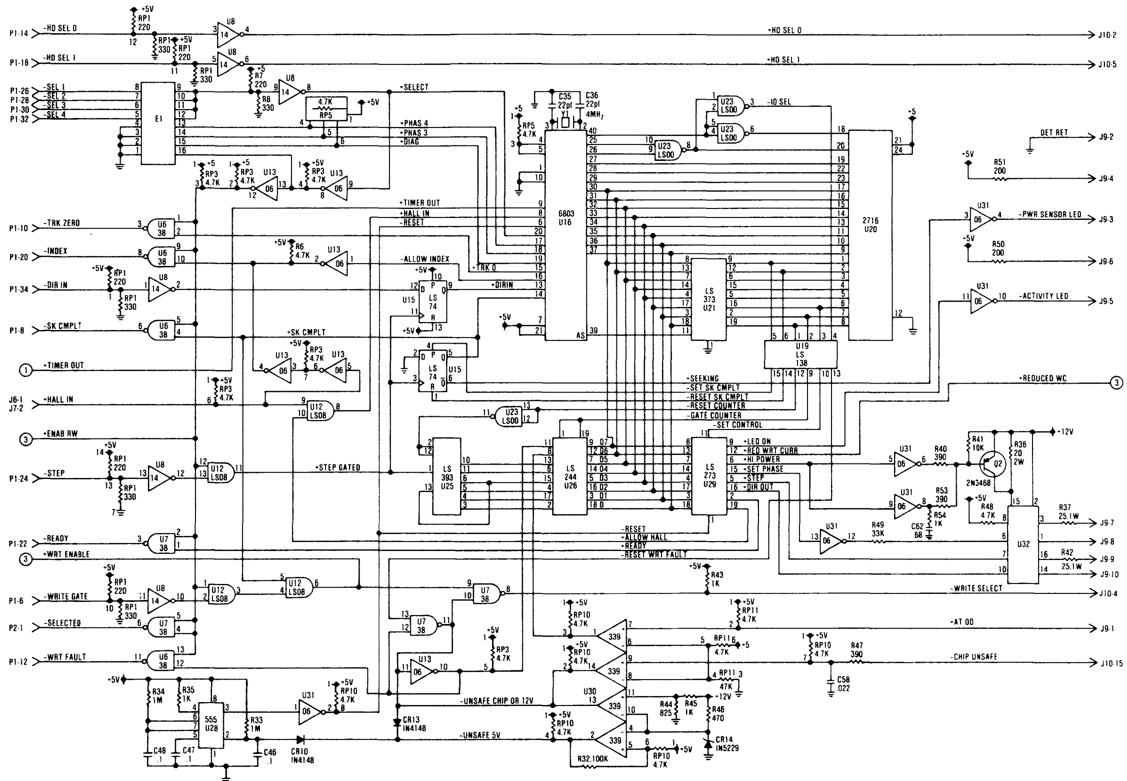
NOTES (UNLESS OTHERWISE SPECIFIED):
1. ALL RESISTORS ARE IN OHMS 1/4W, 5%.
2. ALL CAPACITORS ARE IN MICROFARADS, 10%.
3. —✕— INDICATES J1.
4. [2] INDICATES J2.
[5] C5, POLYCARBONATE 50V, 10%.

Fixed Disk Drive — Type 1 (Sheet 3 of 3)

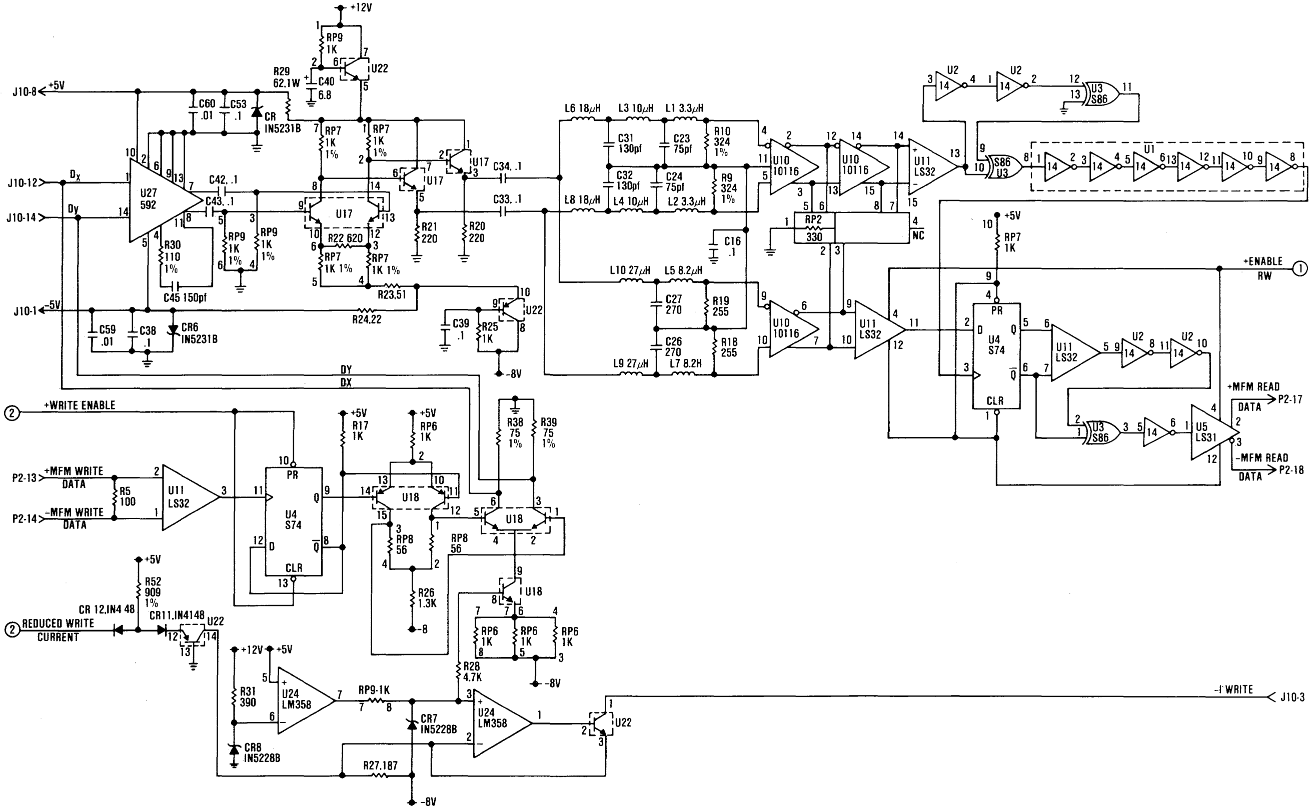


NOTES:
1. SHEET TO SHEET CONNECTION IS AS FOLLOWS:
SHEET NO.
2. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/4W 5% VALUE IN OHMS
CAPACITORS +80-20% VALUE IN µf
3. E1 IS A PROGRAMMABLE JUMPER SOCKET

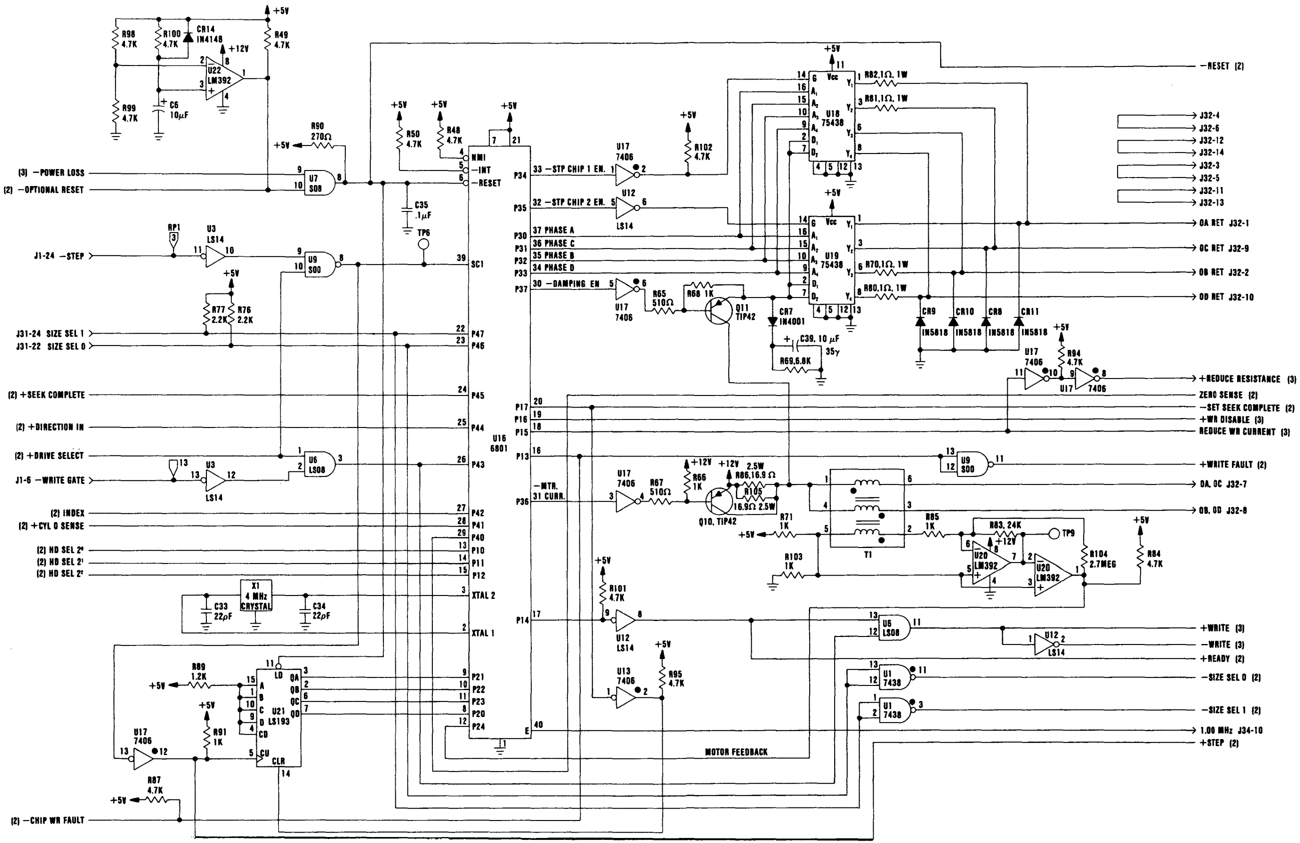
Fixed Disk Drive — Type 2 (Sheet 1 of 3)



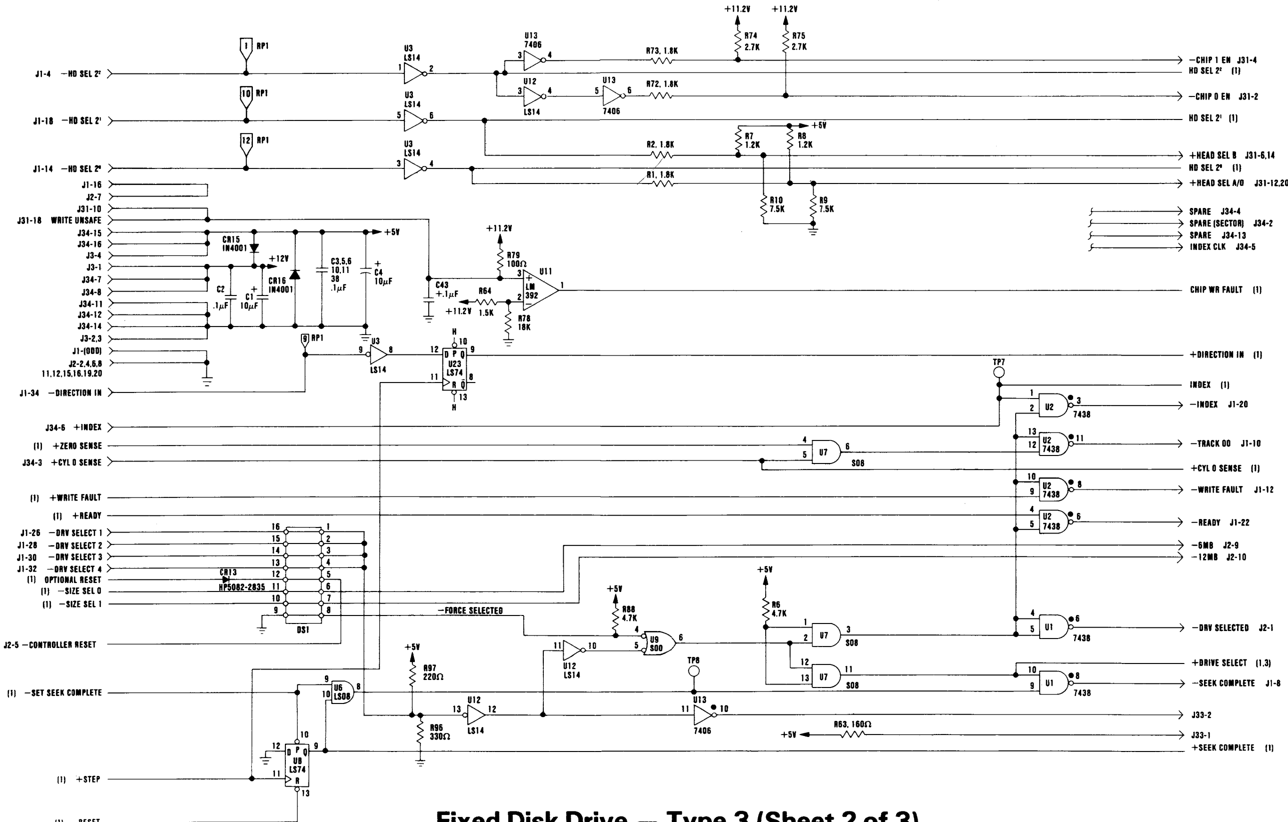
Fixed Disk Drive — Type 2 (Sheet 2 of 3)



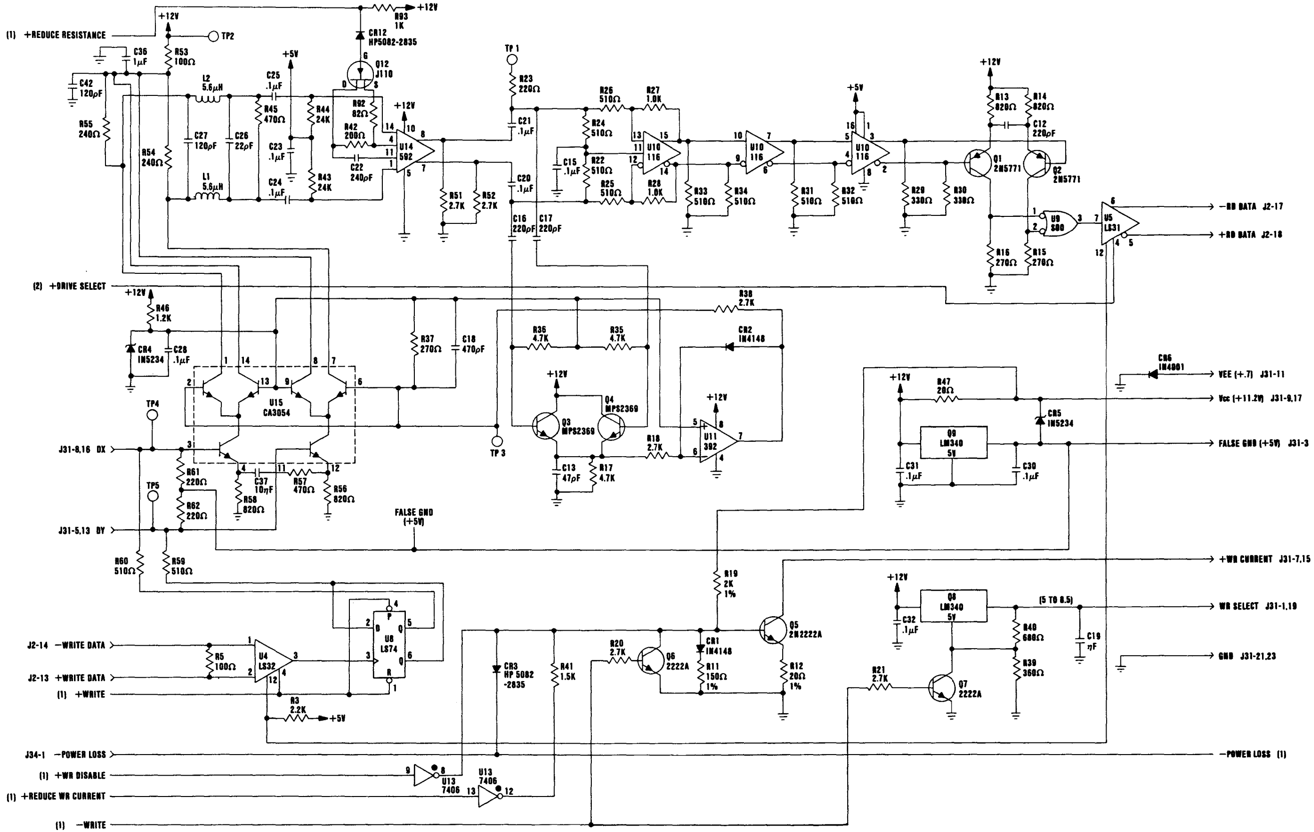
Fixed Disk Drive — Type 2 (Sheet 3 of 3)



Fixed Disk Drive — Type 3 (Sheet 1 of 3)



Fixed Disk Drive — Type 3 (Sheet 2 of 3)



Fixed Disk Drive — Type 3 (Sheet 3 of 3)

Notes:

IBM

Personal Computer
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IBM Personal Computer 20MB Fixed Disk Drive

1521498

March 17, 1985

Notes:

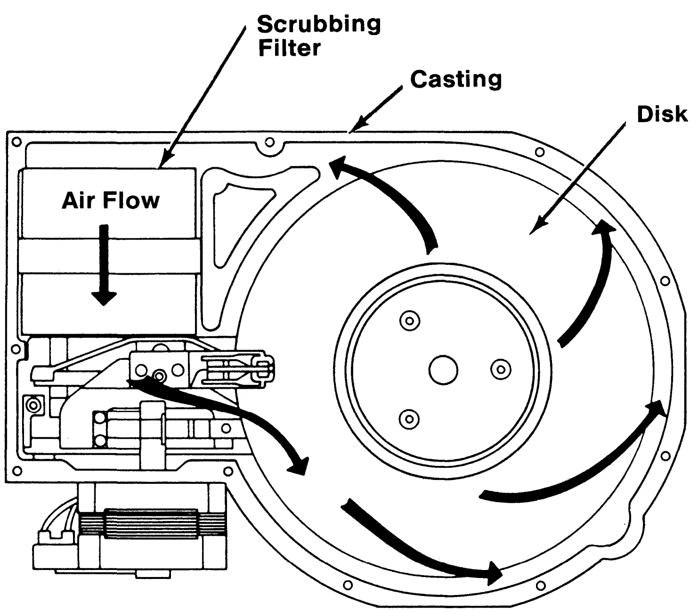
Contents

Notes:

Description

The IBM Personal Computer 20MB Fixed Disk Drive is a direct-access device that can store up to 20M (1M = 1,048,576 bytes) of formatted data. The average access time is 85 milliseconds using a servo positioner.

An impact-resistant enclosure provides mechanical and contamination protection for the heads, actuators, and disks. A self-contained air recirculating system, which consists of an internal filter and a breather filter, maintains a clean-air environment. Thermal isolation of the stepper and spindle motor assemblies from the disk enclosure results in a very low temperature rise within the enclosure. This isolation provides a greater off-track margin and the ability to perform read and write operations immediately after power-up with no thermal stabilization delay.



Interfaces

The interfaces of this drive are divided into three categories: control, data transfer, and dc power.

The control interface is a 34-pin printed circuit board (PCB) edge connector. The signals and pin assignments are as follows.

Signal Name	Signal Pin	Ground Pin
Reserved	2	1
-Head select 2	4	3
-Write gate	6	5
-Seek complete	8	7
-Track 000	10	9
-Write fault	12	11
-Head select 0	14	13
Reserved	16	15
-Head select 1	18	17
-Index	20	19
-Ready	22	21
-Step	24	23
-Drive select 1	26	25
-Drive select 2	28	27
-Drive select 3	30	29
-Drive select 4	32	31
-Direction in	34	33

Control Interface

The data transfer interface is a 20-pin PCB connector. The signals and pin assignments are as follows.

Signal Name	Signal Pin
-Drive Selected	1
+MFM Write Data	13
-MFM Write Data	14
+MFM Read Data	17
-MFM Read Data	18
Grounds	2, 4, 6, 8, 10, 11, 12, 15, 16, 19, 20
Reserved	3, 5, 7, 9

Data-Transfer Interface

The dc power interface is a 4-pin PCB connector. The signals and pin assignments are as follows.

Signal Name	Pin
+12 Vdc	1
+12 Vdc Return	2
+5 Vdc Return	3
+5 Vdc	4

DC Power Interface

Control Input Signals

The control input signals are of two types: those that are multiplexed in a multiple drive system, and those intended to do the multiplexing. These input signals have the following specifications.

- Active=Low=True: 0.0 to 0.4 Vdc at 40 mA
- Inactive=High=False: 2.5 to 5.25 Vdc at 0 mA

The following are descriptions of the control input signals.

-Write Gate

The active level of this signal allows data to be written on the disk and prohibits any step pulses from moving the heads. The inactive level allows data to be read from the disk, and allows the step pulse to move the heads.

-Head Select 0, 1, and 2

These three signals enable the selection of each read/write head in a binary-coded sequence. The '-head select 0' signal is the least significant. Heads are numbered 0 through 8. When all head-select signals are inactive, head 0 is selected.

-Direction In

This signal defines the direction the read/write heads move when '-step' is pulsed. An inactive level defines the direction as out, and if a pulse is applied to '-step', the read/write heads move away from the center of the disk. An active level defines the direction as in, and the read/write heads move toward the center of the disk.

-Step

This signal causes the read/write heads to move in the direction defined by the '-direction in' signal. The motion starts when the '-step' signal changes from active to inactive (the trailing edge of this signal pulse). Any change in '-direction in' is made at least 100 nanoseconds before the leading edge of the step pulse. This drive supports two methods of stepping or seeking:

Slow Seek The read/write heads move at the rate of incoming step pulses. The minimum time between successive steps is 3 milliseconds and the minimum pulse width is 2 microseconds.

Buffered Seek The adapter's controller may burst step pulses to the drive until the time after the last pulse exceeds 200 microseconds or the maximum number of step pulses is received (1 for each track). The drive starts motion of the heads after receiving the first step pulse. Step pulses are sent to the drive every 70 to 200 microseconds.

-Drive Select Signals 1, 2, 3, and 4

When one of these signals is active, it connects that drive to the control lines. The drive select lines are daisy-chained and all drives are jumpered to respond to drive 1.

The fixed disk drive provides a 220/230 ohm termination for a single '-drive select' signal.

Output Control Signals

The drive control signals are open collector outputs that can sink a maximum of 40 mA in the active state, with a maximum output voltage of 0.4 Vdc. When the output is in the inactive state, the collector's cutoff current is a maximum of 250 microamperes.

-Seek Complete

This signal goes active when the read/write heads settle on the final track at the end of a seek. Reading or writing is not attempted when '-seek complete' is inactive. The following situations force '-seek complete' inactive:

- When power-on starts a recalibration sequence because the read/write heads are not over track 0
- When less than 2 microseconds have elapsed after the leading edge of a step pulse or a series of step pulses
- If the +5 or +12 Vdc fluctuates or is lost momentarily but restored.

The '-seek complete' signal returns to the active level no later than 100 milliseconds after the trailing edge of the last step pulse.

-Track 000

This signal is at an active level when the drive's read/write heads are at the outermost track.

-Write Fault

This signal means that a condition at the drive is causing improper operation of the disk. An active level of this signal prevents further writing and stepping at the drive until drive power is switched off.

This signal goes active when any of the following conditions occur:

- Write current exists in the head without '-write gate' active, or no write current exists in the head with '-write gate' active and '-drive select' active.
- A step pulse is received while '-write gate' is active.
- Multiple heads are selected when '-write gate' is active.
- DC voltages are out of tolerance.
- An off track condition is detected while '-write gate' is active.
- The '-write gate' signal is active when write is disabled by the drive electronics.

-Index

The drive provides this output signal once each revolution to indicate the beginning of a track. This signal normally is inactive and goes active to indicate an index. Only the change from inactive to active is valid (leading edge of the pulse).

-Ready

When this signal and '-seek complete' are active, the drive is ready to read, write, or seek, and the I/O signals are valid. An inactive level of this signal prevents all writing and seeking.

The '-ready' signal is inactive four times during drive operation:

- At power-up time, '-ready' remains inactive until:
  - Access recalibration to track 0 is complete.
  - Spindle speed is stable within ±1.0% of nominal (10 revolution average).
- Spindle speed deviates ±1.0% of nominal (10 revolution average).
- The '-write fault' signal is active.

Data-Transfer Signals

All signals associated with the transfer of data between the drive and the system are differential (pairs of balanced signals) and are not multiplexed.

Two pairs of balanced signals are used for the transfer of data: 'write data' and 'read data'. The following describes the data-transfer signals.

MFM Write Data

This is a differential pair that defines signal shifts written on the track. When '+MFM write data' goes more positive than '-MFM write data', flux reverses on the track, provided that '-write gate' is active. The system drives '-MFM write data' to an active level when in the read mode.

MFM Read Data

Read data is sent to the system through the differential pair of 'MFM read data' lines. When '+MFM read data' goes more positive than '-MFM read data', flux reverses on the track of the selected head.

Specifications - Type 13

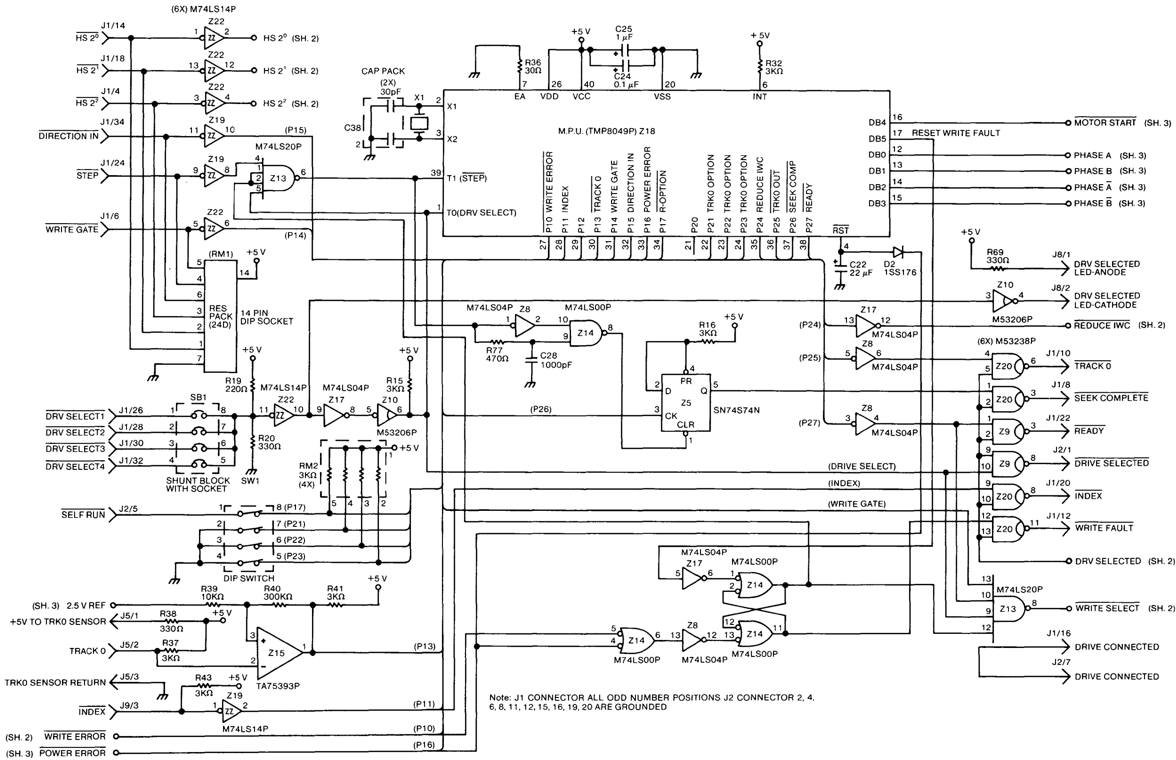
Size (maximum)	
Height	82.5 mm (3.25 in.)
Width	146 mm (5.75 in.)
Depth	203.2 mm (8.0 in.)
Weight	2.8 kg (6.16 lb.)
Power	+12 Vdc ± 5%, 1.0 A (2.0 A maximum) +5 Vdc ± 5%, 0.75 A (0.8 A maximum)
Maximum Ripple (0 to 15 MHz)	100 mV, peak-to-peak
Media	Rigid media disk
Track Density	350 tracks per inch
Number of Tracks	2448
Formatted Capacity	21.3 M bytes
Bytes/Sector	512
Sectors/Track	17
Number of Cylinders	306
Number of Heads	8
Temperature	
Operating	10 to 45°C (50 to 113°F)
Non-Operating	-40 to 65°C (-40 to 140°F)
Relative Humidity	
Operating	8 to 80% (non-condensing)
Non-Operating	5 to 80% (non-condensing)
Maximum Wet Bulb	26°C (78.8°F) (non-condensing)
Shock	
Operating	10 Gs
Non-Operating	25 Gs
Access Time	
Track-to-Track	20 ms (average)
Average	85 ms (traverse 1/3 Tracks)
Maximum	200 ms
Average Latency	8.33 ms
Error Rates	
Recoverable (16 retries-soft)	1 per 10^{10} bits read
Non-recoverable	1 per 10^{12} bits read
Seek Errors	1 per 5 X 10^{6} seeks
Design Life	5 years (20,000 hours MTBF)
Disk Speed	3600 rpm ± 0.5%
Transfer Rate	5.0M bps
Recording Mode	MFM

Specifications - Type 13

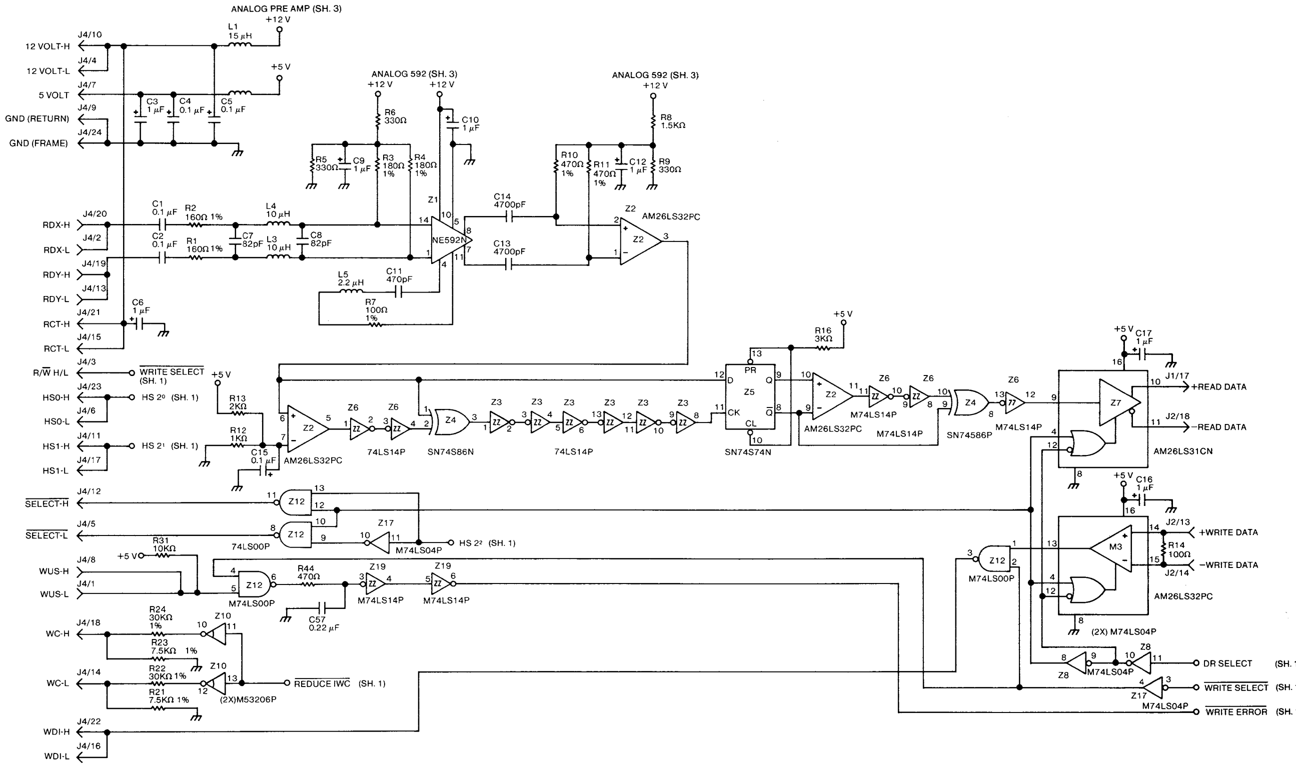
Specifications - Type 2

Size (maximum)	
Height	82.5 mm (3.25 in.)
Width	146 mm (5.75 in.)
Depth	203.2 mm (8.0 in.)
Weight	0.59 kg (1.3 lb.)
Power	+12 Vdc ± 5%, 1.0 A (2.0 A maximum) +5 Vdc ± 5%, 0.75 A (0.8 A maximum)
Maximum Ripple (0 to 15 MHz)	100 mV, peak-to-peak
Media	Rigid media disk
Track Density	580 tracks per inch
Number of Tracks	2460
Formatted Capacity	20.1 M bytes
Bytes/Sector	512
Sectors/Track	17
Number of Cylinders	615
Number of Heads	4
Temperature	
Operating	10 to 45°C (50 to 113°F)
Non-Operating	-40 to 65°C (-40 to 140°F)
Relative Humidity	
Operating	8 to 80% (non-condensing)
Non-Operating	5 to 80% (non-condensing)
Maximum Wet Bulb	26°C (75.8°F) (non-condensing)
Shock	
Operating	10 Gs
Non-Operating	25 Gs
Access Time	
Track-to-Track	20 ms (average)
Average	85 ms (traverse 1/3 Tracks)
Maximum	200 ms
Average Latency	8.33 ms
Error Rates	
Recoverable (16 retries-soft)	1 per 10^{10} bits read
Non-recoverable	1 per 10^{12} bits read
Seek Errors	1 per 5 X 10^{6} seeks
Design Life	5 years (20,000 hours MTBF)
Disk Speed	3600 rpm ± 0.5%
Transfer Rate	5.0M bps
Recording Mode	MFM

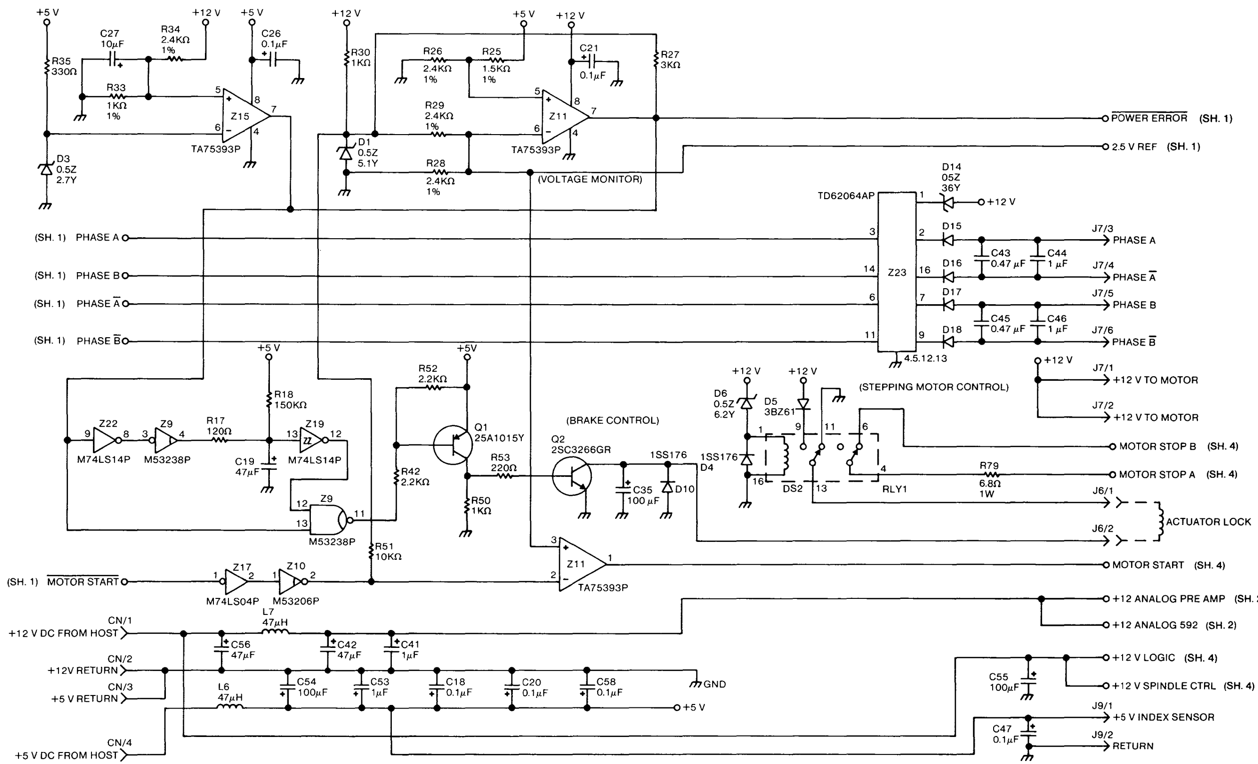
Specifications - Type 2



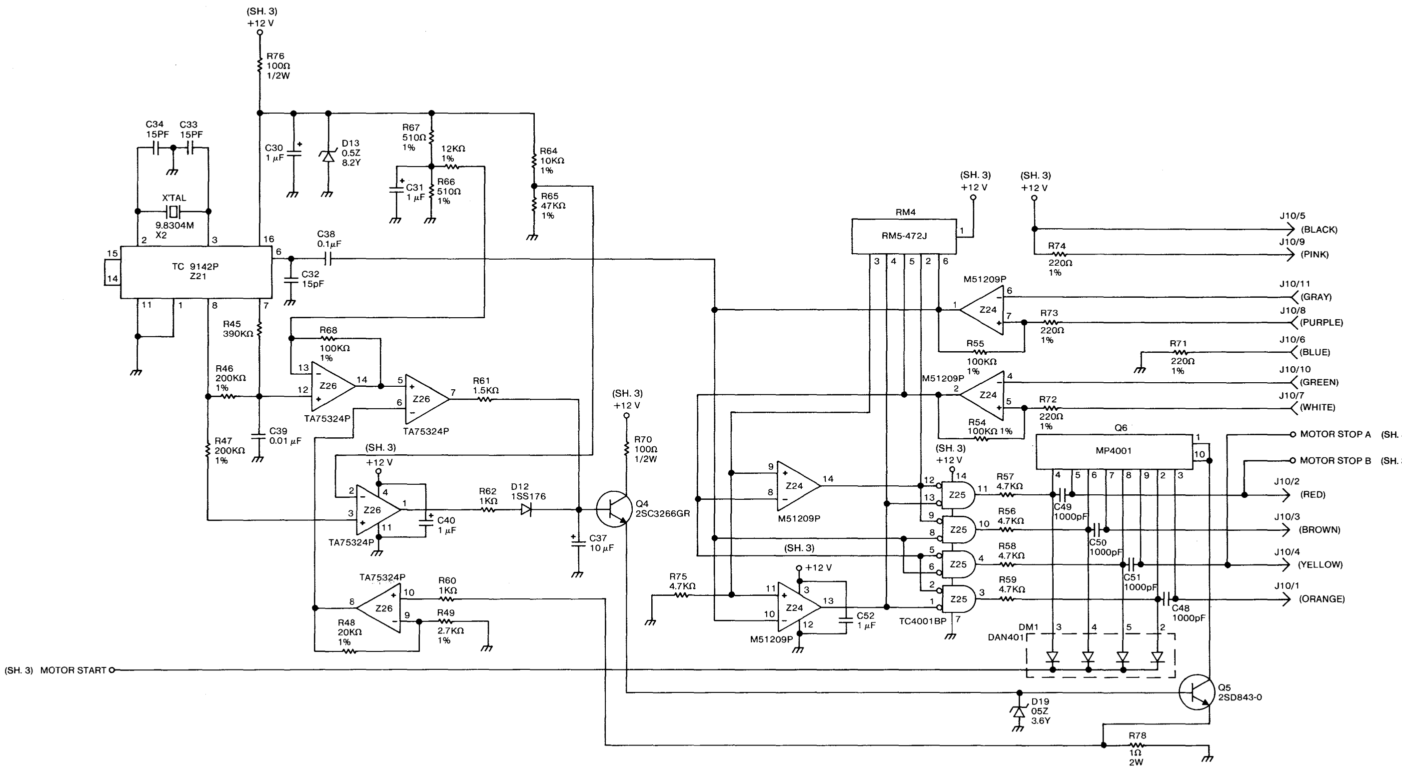
20MB Fixed Disk Drive - Type 13 (Sheet 1 of 4)



20MB Fixed Disk Drive - Type 13 (Sheet 2 of 4)



20MB Fixed Disk Drive - Type 13 (Sheet 3 of 4)



20MB Fixed Disk Drive - Type 13 (Sheet 4 of 4)

IBM

Personal Computer Hardware Reference Library

20MB Fixed Disk Drive

IBM PERSONAL COMPUTER AT 20MB FIXED DISK DRIVE

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Description

The IBM Personal Computer AT 20MB Fixed Disk Drive is a direct-access device that can store up to 20Mb of formatted data. The average access time is 40 milliseconds using a quasi closed-loop servo positioner.

Interfaces

The interfaces of this drive are divided into three categories: control, data transfer, and dc power.

The control interface is a 34 pin printed circuit board (PCB) edge connector. The following shows the signals and pin assignments.

Signal Name	Signal Pin	Ground Pin
-Head Select 3	2	1
-Head Select 2	4	3
-Write Gate	6	5
-Seek Complete	8	7
-Track 000	10	9
-Write Fault	12	11
-Head Select 0	14	13
Reserved	16	15
-Head Select 1	18	17
-Index	20	19
-Ready	22	21
-Step	24	23
-Drive Select 1	26	25
-Drive Select 2	28	27
-Drive Select 3	30	29
-Drive Select 4	32	31
-Direction In	34	33

Control Interface

The data transfer interface is a 20 Pin PCB connector. The signals and pin assignments are as follows:

Signal Name	Signal Pin
-Drive Selected	1
+MFM Write Data	13
-MFM Write Data	14
+MFM Read Data	17
-MFM Read Data	18
Ground	2, 4, 6, 8, 11, 12, 15, 16, 19

Data-Transfer Interface

The dc power interface is a 4-pin PCB connector. The signals and pin assignments follow.

Signal Name	Pin
+12 Vdc	1
+12 Vdc Return	2
+5 Vdc	4
+5 Vdc Return	3

DC Power Interface

Control Input Signals

The control input signals are of two types: those that are multiplexed in a multiple drive system, and those intended to do the multiplexing. These input signals have the following specifications.

- Active: 0.0 to 0.4 Vdc at 40 mA

- Inactive: 2.5 to 5.25 Vdc at 0 mA

The following are descriptions of the control input signals.

-Write Gate

The active level of this signal allows data to be written on the disk. The inactive level allows data to be read from the disk, and allows the step pulse to move the heads.

-Head Select 0, 1, 2, and 3

These four signals enable the selection of each read/write head in a binary-coded sequence. '-Head Select 0' is the least significant. Heads are numbered 0 through 15. When all Head Select signals are inactive, head 0 is selected.

-Direction In

This signal defines the direction the read/write heads move when '-Step' is pulsed. An inactive level defines the direction as out, and if a pulse is applied to '-Step', the read/write heads move away from the center of the disk. An active level defines the direction as in, and the read/write heads move toward the center of the disk.

-Step

This signal causes the read/write heads to move in the direction defined by the '-Direction In' signal. The motion starts when the '-Step' signal changes from active to inactive (the trailing edge of this signal pulse). Any change in '-Direction In' is made at least 100 nanoseconds before the leading edge of the step pulse. This drive supports two methods of stepping or seeking:

Slow Seek The read/write heads move at the rate of incoming step pulses. The minimum time between successive steps is 3 milliseconds and the minimum pulse width is 2 microseconds.

Buffered Seek The adapter's controller may burst step pulses to the drive until the time after the last pulse exceeds 200 microseconds or the maximum number of step pulses is received (1 for each track). The drive starts motion of the heads after receiving the first step pulse. Step pulses are sent to the drive every 35 microseconds.

-Drive Select Signals 1 through 4

When one of these signals is active, it connects that drive to the control lines. Making the appropriate jumper connections at the drive determines which select line of the interface activates that drive.

The fixed disk drive provides a 220/230 ohm termination for a single 'drive select' signal. The signal lead that is terminated is the one that selects the drive based on the position of the drive select jumpers.

Output Control Signals

The drive control signals are open collector outputs that can sink a maximum of 40 mA in the active state, with a maximum output voltage of 0.4 Vdc. When the output is inactive, the collector's cutoff current is a maximum of 250 microamperes.

-Seek Complete

This signal goes active when the read/write heads settle on the final track at the end of a seek. Reading or writing is not attempted when '-Seek Complete' is inactive. The following situations force '-Seek Complete' inactive:

- When power-on starts a recalibration sequence because the read/write heads are not over track 0.
- When less than 5 microseconds have elapsed after the trailing edge of a step pulse or a series of step pulses.
- If the +5 or +12 Vdc fluctuates or is lost momentarily but restored.
- If the drive attempts to retry a seek after settling on a track.

-Seek Complete returns to the active level no later than 100 milliseconds (1 second if a seek retry occurs) after the trailing edge of the last -Step pulse.

-Track 000

This signal is at an active level when the drive's read/write heads are at the outermost track.

-Write Fault

This signal means that a condition at the drive is causing improper operation of the disk. An active level of this signal prevents further writing and stepping at the drive until drive power is switched off.

This signal goes active when any of the following conditions occur:

- Write current exists in the head without '-Write Gate' active, or no write current exists in the head with '-Write Gate' active and '-Drive Selected' active
- More than one seek retry between Seek commands from the controller
- A step pulse is received while '-Write Gate' is active.

-Index

The drive provides this output signal once each revolution to indicate the beginning of a track. This signal normally is inactive and goes active to indicate '-Index'. Only the change from inactive to active is valid (leading edge of the pulse).

-Ready

When this signal and '-Seek Complete' are active, the drive is ready to read, write, or seek, and the I/O signals are valid. An inactive level of this signal prevents all writing and seeking.

'-Ready' is inactive four times during drive operation:

- At power-up time '-Ready' remains inactive until:
  - Access recalibration to track 0 is complete.
  - Spindle speed is stable within ±0.5% of nominal (10 revolution average).
  - Drive self-check is complete.
- Spindle speed deviates ±0.5% of nominal (10 revolution average).
- '-Write Fault' is active.
- DC voltages are out of tolerance.

Data-Transfer Signals

All signals associated with the transfer of data between the drive and the system are differential (pairs of balanced signals) and are not multiplexed.

Two pairs of balanced signals are used for the transfer of data: '-Write Data' and '-Read Data'. The following describes the data-transfer signals.

MFM Write Data

This is a differential pair that defines signal shifts written on the track. When '+MFM Write Data' goes more positive than '-MFM Write Data', flux reverses on the track, provided that '-Write Gate' is active. The system drives '-MFM Write Data' to an active level ('-MFM Write Data' more negative than '+MFM Write Data') when in the read mode.

To ensure data integrity, the controller applies a write-precompensation of ±12 nanoseconds to all write data on cylinders 300 and greater.

MFM Read Data

Read data is sent to the system through the differential pair of MFM Read Data lines. When '+MFM Read Data' goes more positive than '-MFM Read Data', flux reverses on the track of the selected head.

Overlapped Seek

The drive supports overlapped-seek operations. An overlapped seek occurs when the drive is deselected 20 microseconds after the last step pulse is sent. Another drive is then selected, and the '-Step' and '-Direction In' signals are set by the operation desired. The controller provides at least 100 nanoseconds of hold time on '-Step' and '-Direction In' after '-Drive Select' is deactivated.

Specifications

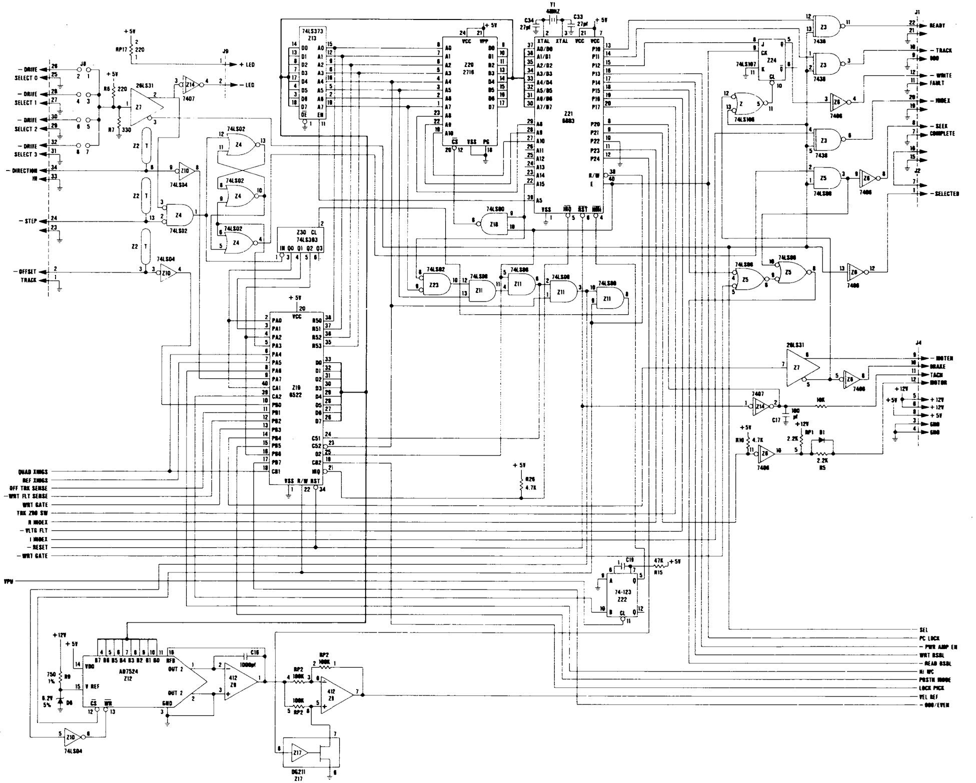
The following figures list the internal and performance specifications of this drive.

Rotational speed	3573 rpm ±0.5%
Cylinders	615 + Landing Zone
R/W Heads	4
Index	1

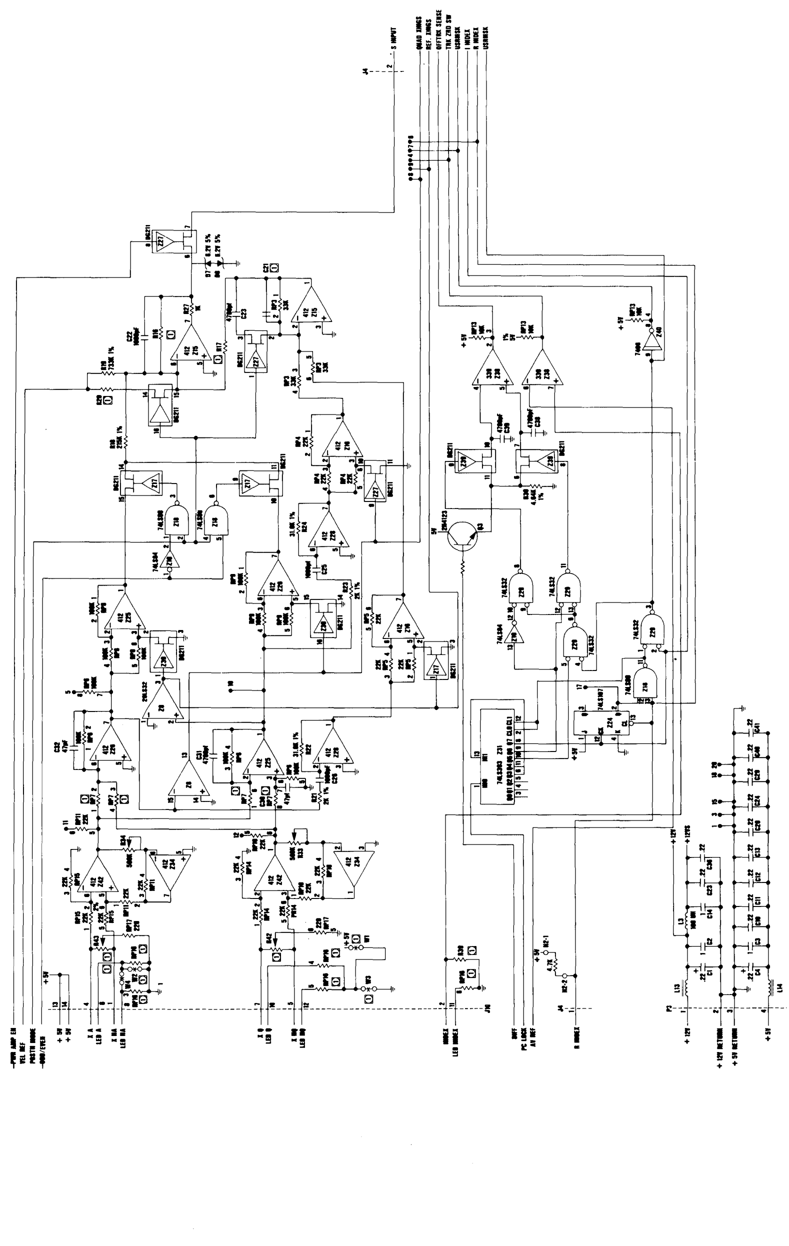
Internal Specifications

Formatted Capacity	20Mb
Bytes/Sector	512
Sectors/Track	17
Transfer Rate	5M Bits/Second
Access Time	
Track-to-Track	2 ms
Average	40 ms
Maximum	85 ms
Settling	12 ms
Average Latency	8.4 ms
Track Density	750 TPI

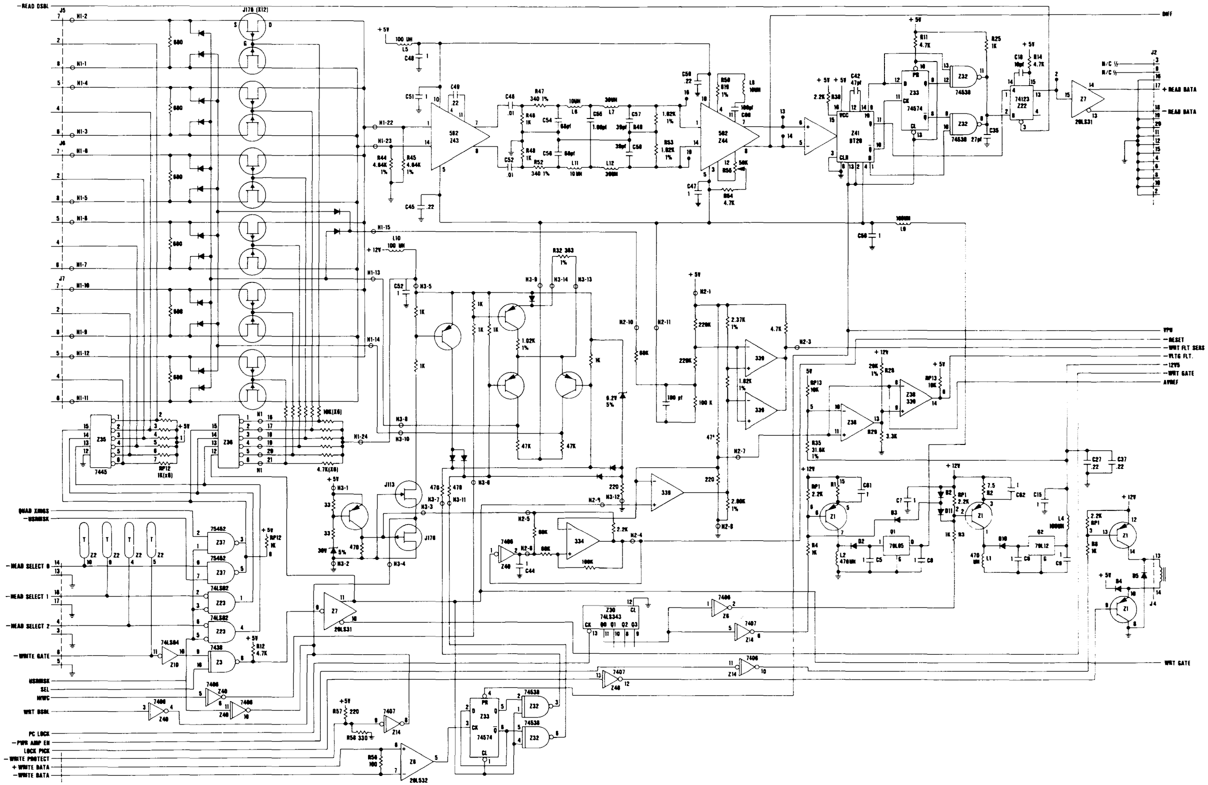
Performance Specifications



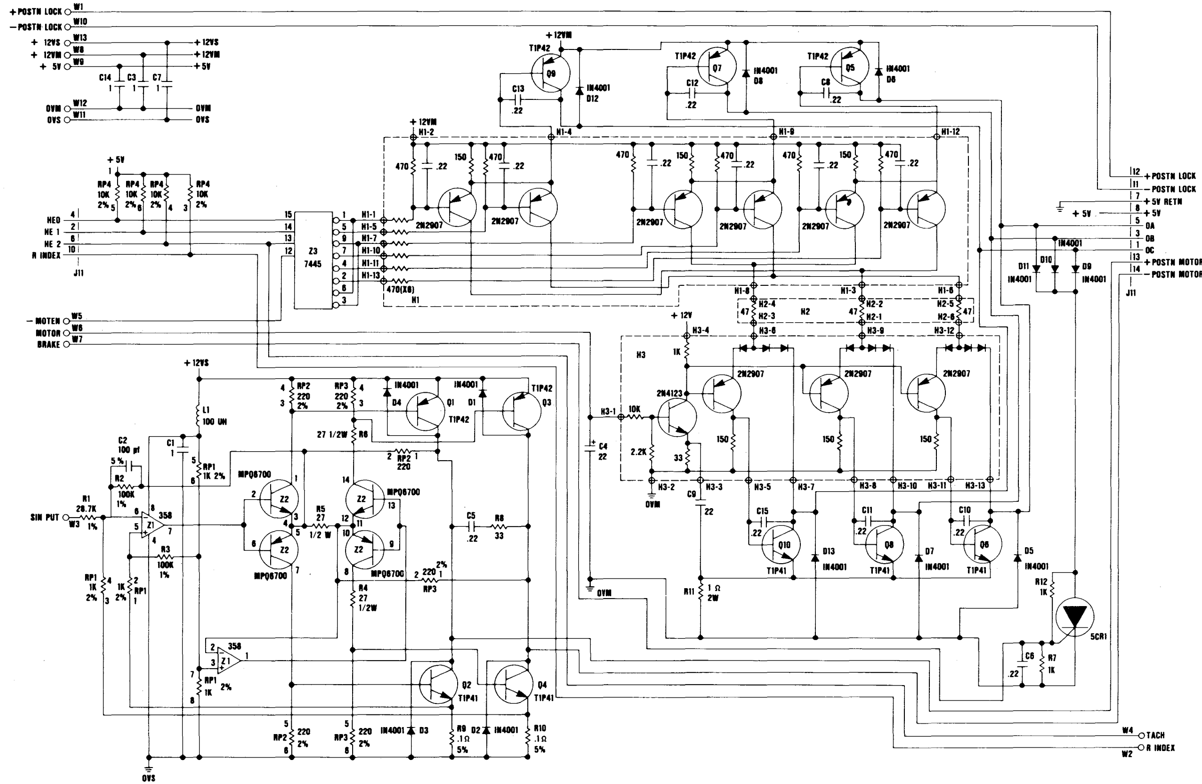
20MB Fixed Disk Drive (Sheet 1 of 4)



20MB Fixed Disk Drive (Sheet 2 of 4)



20MB Fixed Disk Drive (Sheet 3 of 4)



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Personal Computer Hardware Reference Library

IBM Personal Computer AT 30MB Fixed Disk Drive

30MB FIXED DISK DRIVE

August 15, 1985

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August 15, 1985

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Description

The IBM Personal Computer AT 30MB Fixed Disk Drive is a direct-access device that can store up to 30M of formatted data. The average access time is 40 milliseconds using a servo positioner.

Interfaces

The interfaces of this drive are divided into three categories: control, data transfer, and dc power.

The control interface is a 34-pin printed circuit board (PCB) edge connector. The signals and pin assignments are as follows.

Signal Name	Signal Pin	Ground Pin
-Head select 3	2	1
-Head select 2	4	3
-Write gate	6	5
-Seek complete	8	7
-Track 000	10	9
-Write fault	12	11
-Head select 0	14	13
Reserved	16	15
-Head select 1	18	17
-Index	20	19
-Ready	22	21
-Step	24	23
-Drive select 0	26	25
-Drive select 1	28	27
-Drive select 2	30	29
-Drive select 3	32	31
-Direction in	34	33

Control Interface

The data transfer interface is a 20-pin PCB connector. The signals and pin assignments are as follows.

Signal Name	Signal Pin
-Drive Selected	1
+MFM Write Data	13
-MFM Write Data	14
+MFM Read Data	17
-MFM Read Data	18
Grounds	2, 4, 6, 8, 10, 11, 12, 15, 16, 19, 20
Reserved	3, 5, 7, 9

Data-Transfer Interface

The dc power interface is a 4-pin PCB connector. The signals and pin assignments are as follows.

Signal Name	Pin
+12 Vdc	1
+12 Vdc Return	2
+5 Vdc Return	3
+5 Vdc	4

DC Power Interface

Control Input Signals

The control input signals are of two types: those that are multiplexed in a multiple drive system, and those intended to do the multiplexing. These input signals have the following specifications.

- Active: 0.0 to 0.4 Vdc at 40 mA
- Inactive: 2.5 to 5.25 Vdc at 0 mA

The following are descriptions of the control input signals.

-Write Gate

The active level of this signal allows data to be written on the disk. The inactive level allows data to be read from the disk, and allows the step pulse to move the heads.

-Head Select 0, 1, 2, and 3

These four signals enable the selection of each read/write head in a binary-coded sequence. The '-head select 0' signal is the least significant. Heads are numbered 0 through 15. When all head-select signals are inactive, head 0 is selected.

-Direction In

This signal defines the direction the read/write heads move when '-step' is pulsed. An inactive level defines the direction as out, and if a pulse is applied to '-step,' the read/write heads move away from the center of the disk. An active level defines the direction as in, and the read/write heads move toward the center of the disk.

-Step

This signal causes the read/write heads to move in the direction defined by the '-direction in' signal. The motion starts when the '-step' signal changes from active to inactive (the trailing edge of this signal pulse). Any change in '-direction in' is made at least 100 nanoseconds before the leading edge of the step pulse. This drive supports two methods of stepping or seeking:

Slow Seek	The read/write heads move at the rate of incoming step pulses. The minimum time between successive steps is 3 milliseconds and the minimum pulse width is 2 microseconds.

Buffered Seek The adapter's controller may burst step pulses to the drive until the time after the last pulse exceeds 200 microseconds or the maximum number of step pulses is received (1 for each track). The drive starts motion of the heads after receiving the first step pulse. Step pulses are sent to the drive every 35 microseconds.

-Drive Select Signals 0, 1, 2, and 3

When one of these signals is active, it connects that drive to the control lines. Making the appropriate jumper connections at the drive determines which select line of the interface activates that drive.

The fixed disk drive provides a 220/230 ohm termination for a single '-drive select' signal. The signal lead that is terminated selects the drive based on the position of the drive select jumpers.

Output Control Signals

The drive control signals are open collector outputs which can sink a maximum of 40 mA in the active state, with a maximum output voltage of 0.4 Vdc. When the output is in the inactive state, the collector's cutoff current is a maximum of 250 microamperes.

-Seek Complete

This signal goes active when the read/write heads settle on the final track at the end of a seek. Reading or writing is not attempted when '-seek complete' is inactive. The following situations force '-seek complete' inactive:

- When power-on starts a recalibration sequence because the read/write heads are not over track 0
- When less than 2 microseconds have elapsed after the leading edge of a step pulse or a series of step pulses

- If the +5 or +12 Vdc fluctuates or is lost momentarily but restored

- If the drive attempts to retry a seek after settling on a track

The '-seek complete' signal returns to the active level no later than 100 milliseconds (1 second if a seek retry occurs) after the trailing edge of the last step pulse.

-Track 000

This signal is at an active level when the drive's read/write heads are at the outermost track.

-Write Fault

This signal means that a condition at the drive is causing improper operation of the disk. An active level of this signal prevents further writing and stepping at the drive until drive power is switched off.

This signal goes active when any of the following conditions occur:

- Write current exists in the head without '-write gate' active, or no write current exists in the head with '-write gate' active and '-drive select' active

- More than one seek retry between Seek commands from the controller

- A step pulse is received while '-write gate' is active

- An off track condition is detected while '-write gate' is active

- The '-write gate' signal is active when write is disabled by the drive electronics

-Index

The drive provides this output signal once each revolution to indicate the beginning of a track. This signal normally is inactive and goes active to indicate an index. Only the change from inactive to active is valid (leading edge of the pulse).

-Ready

When this signal and '-seek complete' are active, the drive is ready to read, write, or seek, and the I/O signals are valid. An inactive level of this signal prevents all writing and seeking.

The '-ready' signal is inactive four times during drive operation:

- At power-up time, '-ready' remains inactive until:
  - Access recalibration to track 0 is complete.
  - Spindle speed is stable within ±0.25% of nominal (10 revolution average).
  - Drive self-check is complete.
- Spindle speed deviates ±0.5% of nominal (10 revolution average).
- The '-write fault' signal is active.
- DC voltages are out of tolerance.

Data-Transfer Signals

All signals associated with the transfer of data between the drive and the system are differential (pairs of balanced signals) and are not multiplexed.

Two pairs of balanced signals are used for the transfer of data: 'write data' and 'read data.' The following describes the data-transfer signals.

MFM Write Data

This is a differential pair that defines signal shifts written on the track. When '+MFM write data' goes more positive than '-MFM write data,' flux reverses on the track, provided that '-write gate' is active. The system drives '-MFM write data' to an active level ('-MFM write data' more negative than '+MFM write data') when in the read mode.

MFM Read Data

Read data is sent to the system through the differential pair of 'MFM read data' lines. When '+MFM read data' goes more positive than '-MFM read data,' flux reverses on the track of the selected head.

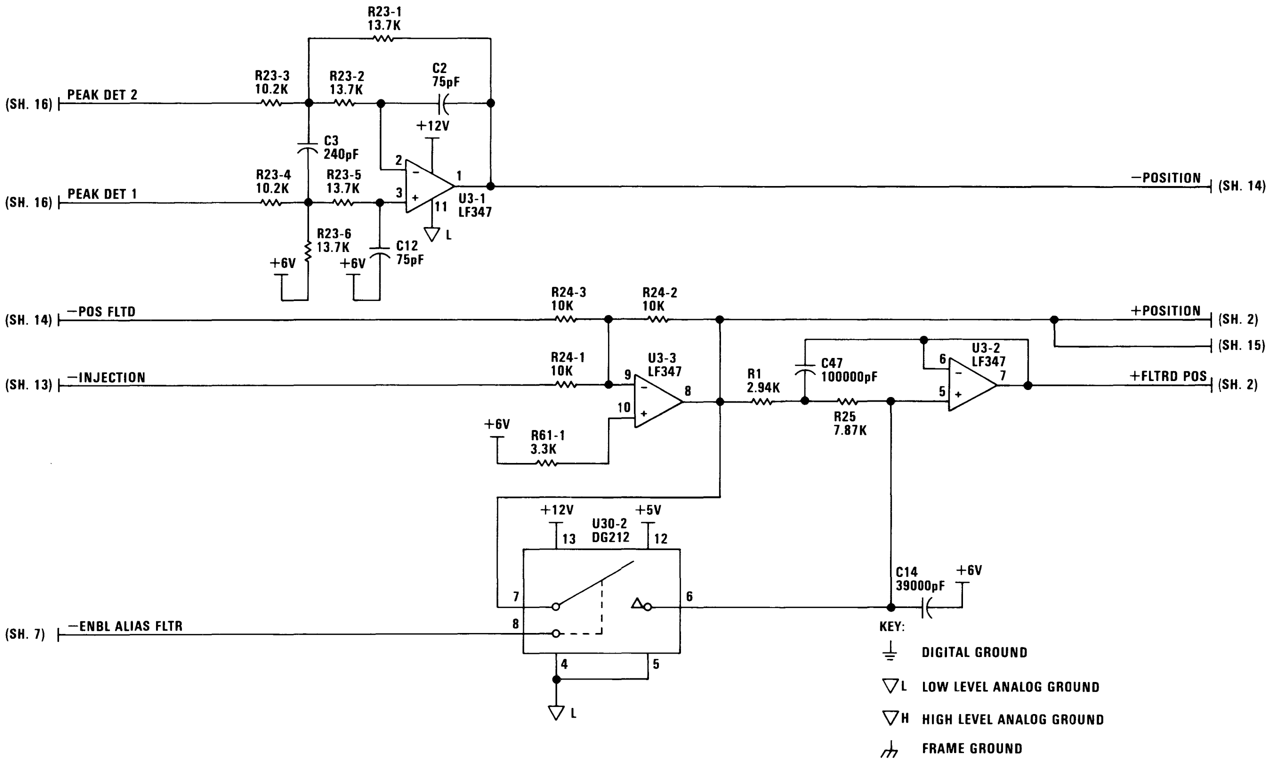
Overlapped Seek

The drive supports overlapped-seek operations. An overlapped seek occurs when the drive is deselected 20 microseconds after the last step pulse is sent. Another drive is then selected, and the '-step' and '-direction in' signals are set by the operation desired. The controller provides at least 100 nanoseconds of hold time on '-step' and '-direction in' after '-drive select' is deactivated.

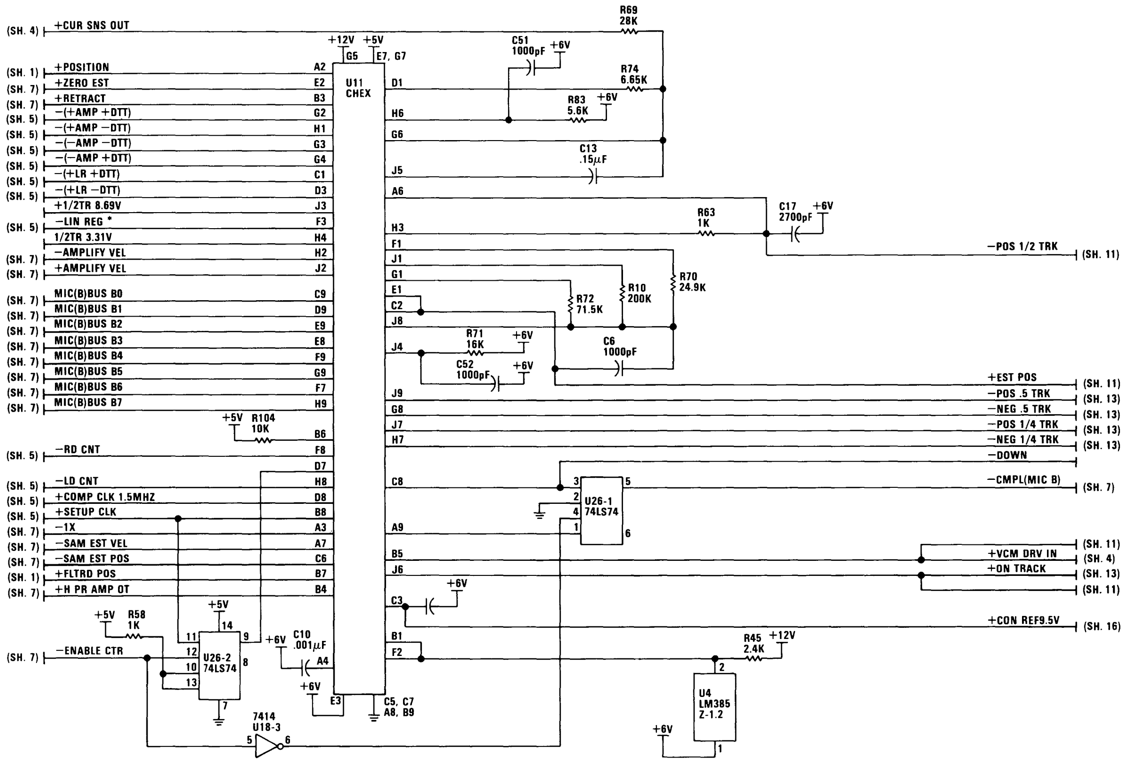
Notes:

Specifications

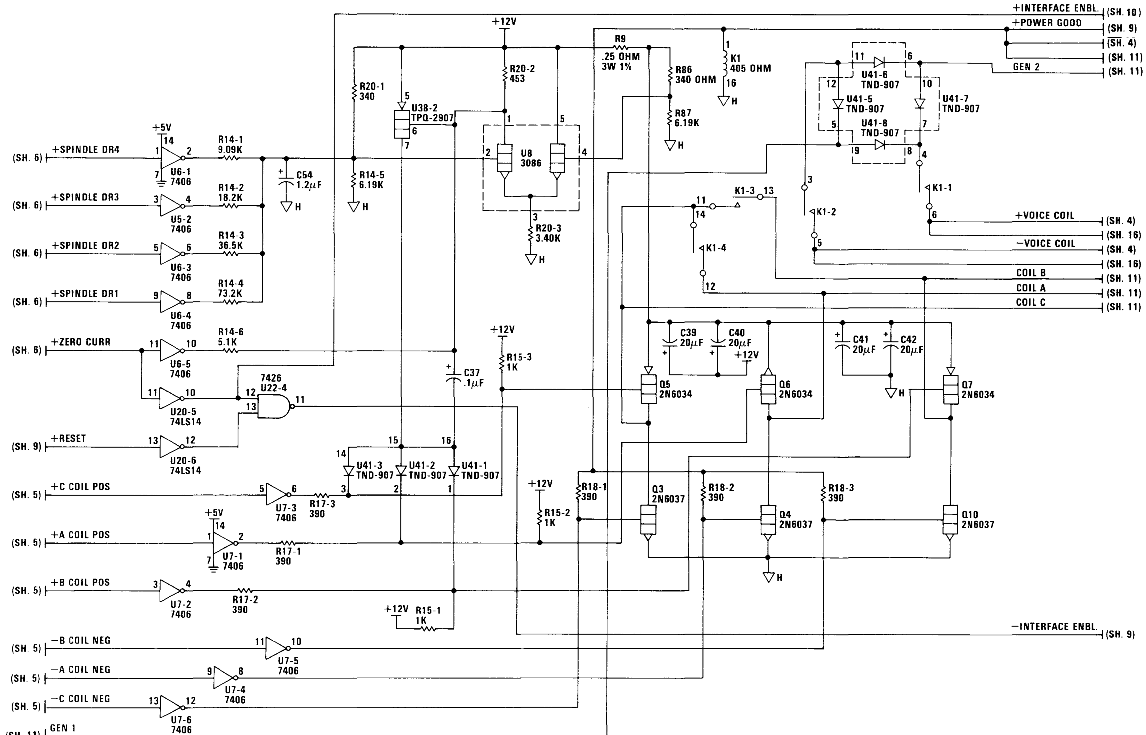
The internal specifications of this drive are listed in the BIOS Fixed Disk Parameter Table, under "Real-Time Clock/CMOS RAM Information" in Section 1 of the IBM Personal Computer AT *Technical Reference* manual. The fixed disk type is on the defect label on the drive.



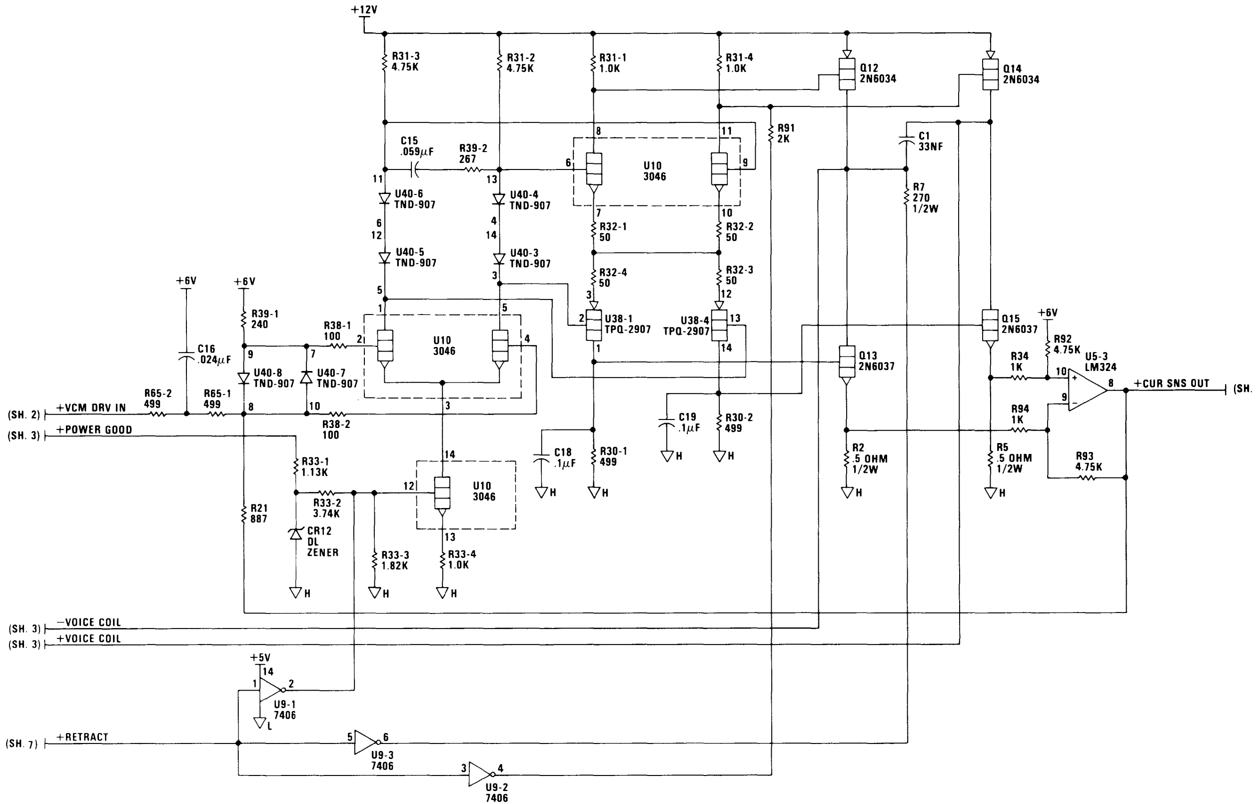
30MB Fixed Disk (Sheet 1 of 18)



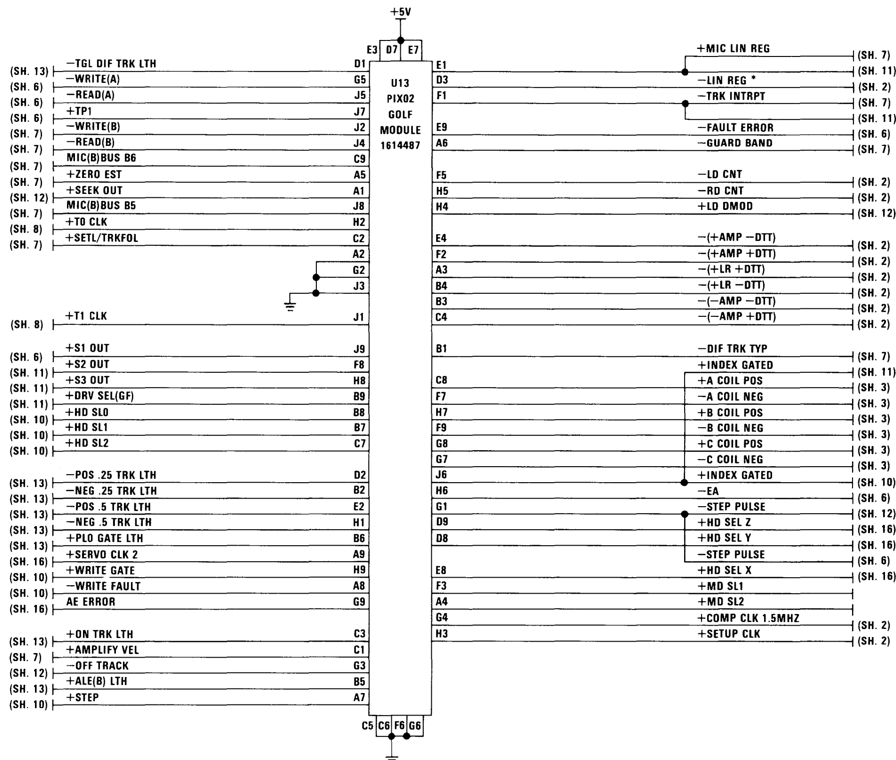
30MB Fixed Disk (Sheet 2 of 18)



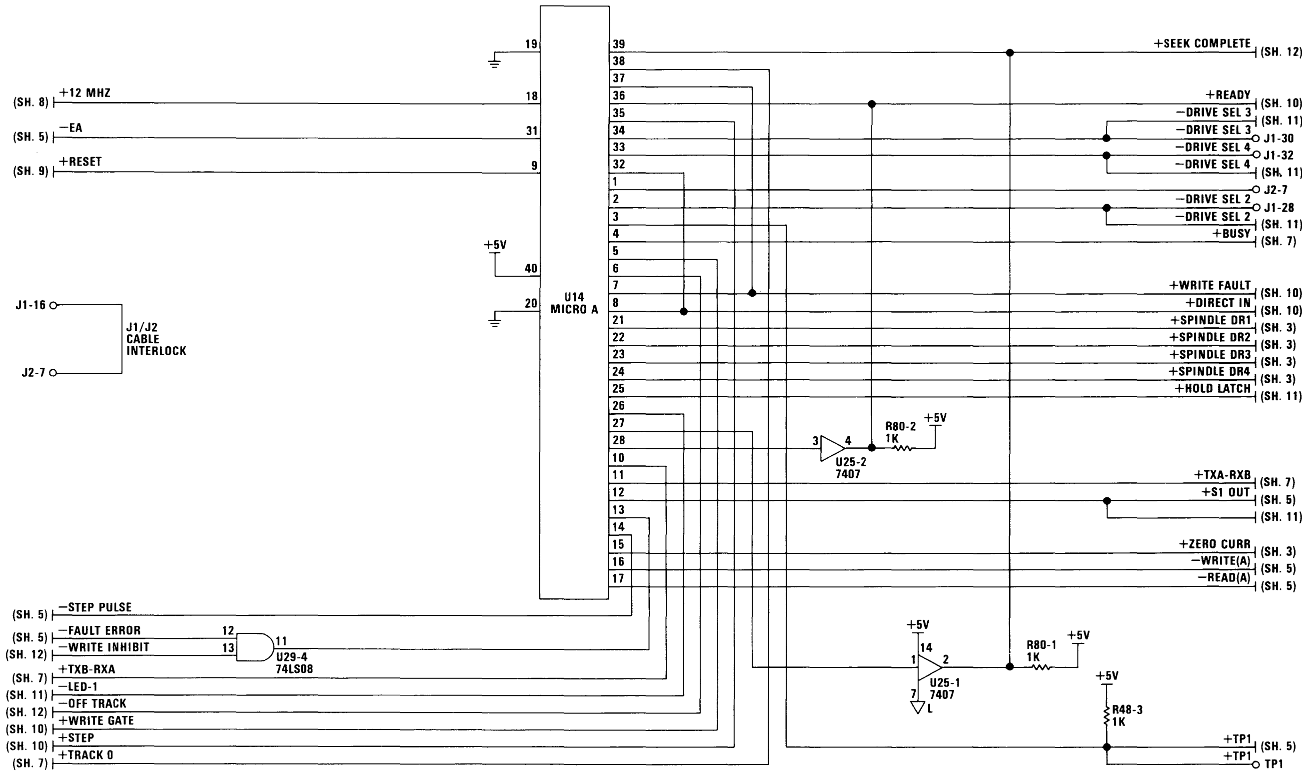
30MB Fixed Disk (Sheet 3 of 18)



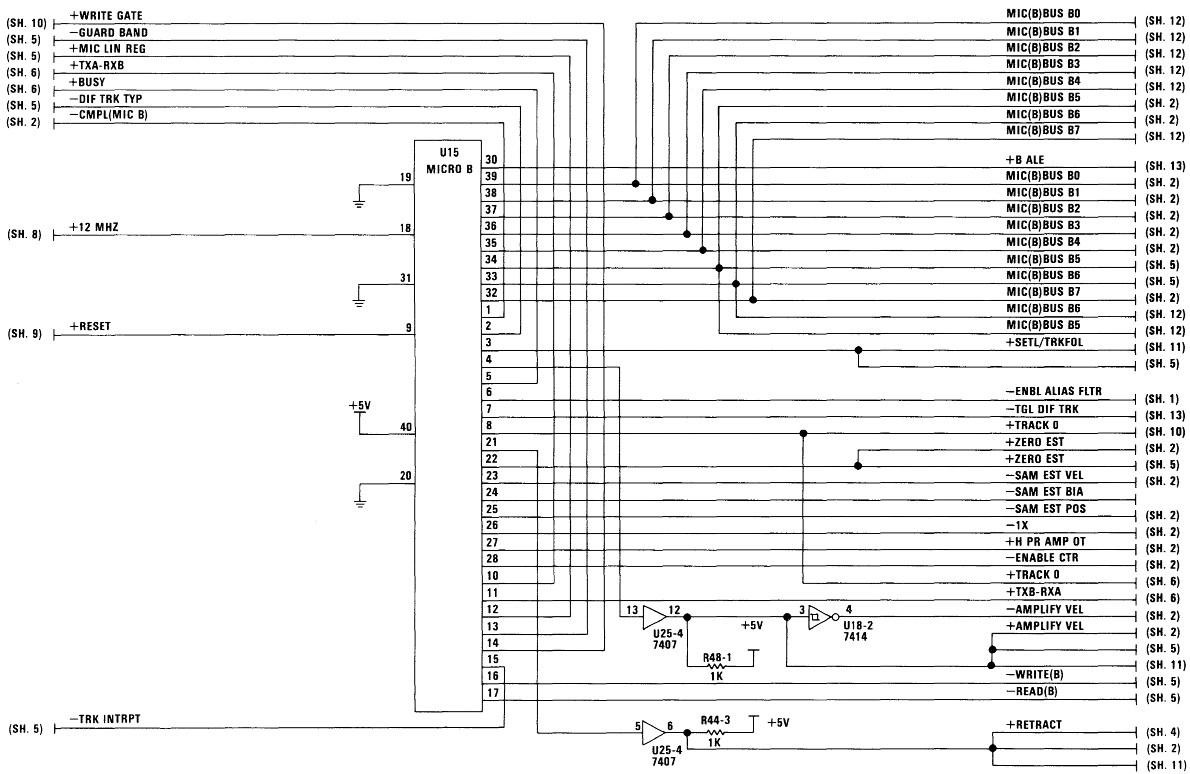
30MB Fixed Disk (Sheet 4 of 18)



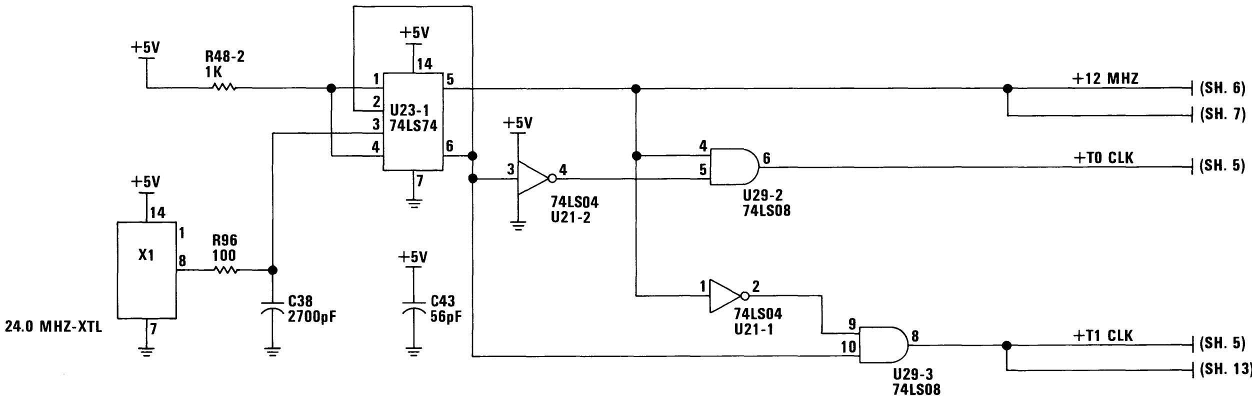
30MB Fixed Disk (Sheet 5 of 18)



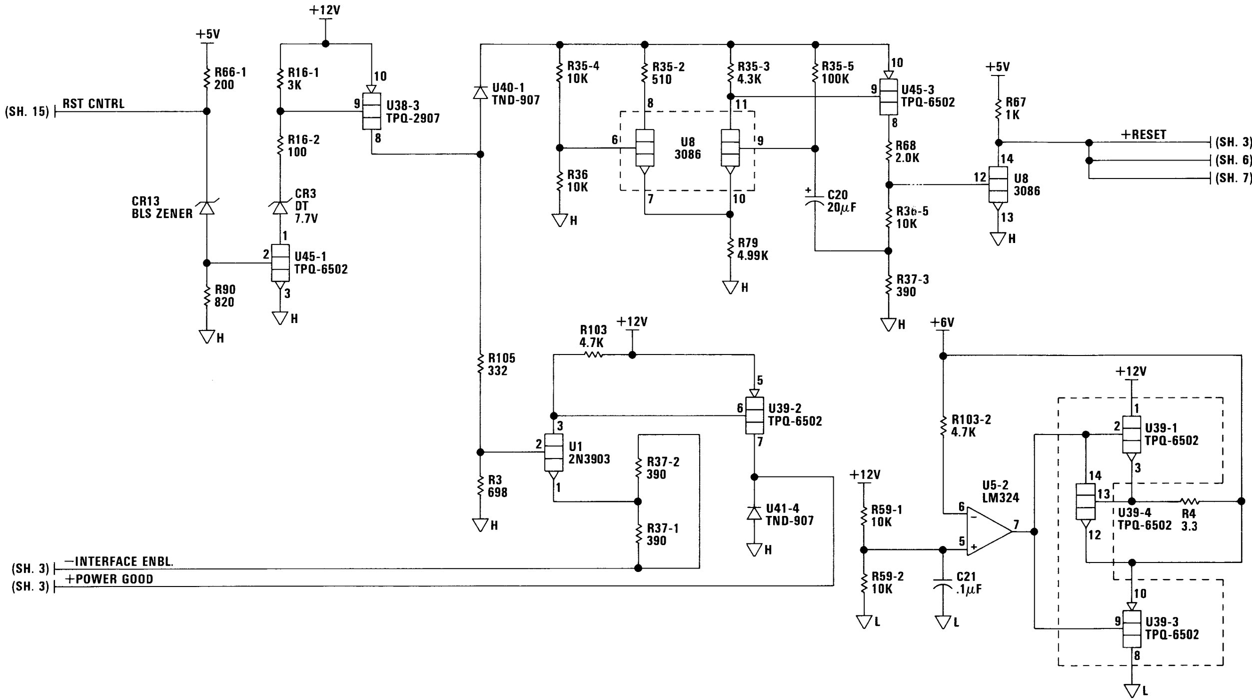
30MB Fixed Disk (Sheet 6 of 18)



30MB Fixed Disk (Sheet 7 of 18)

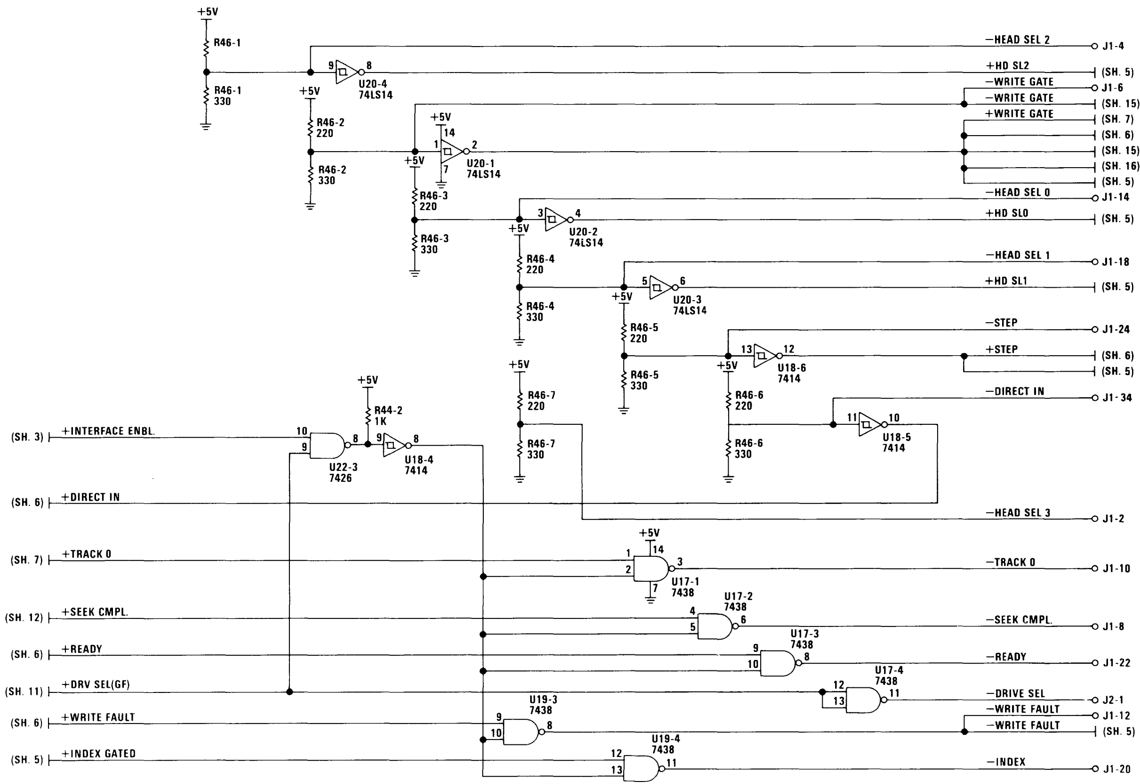


30MB Fixed Disk (Sheet 8 of 18)

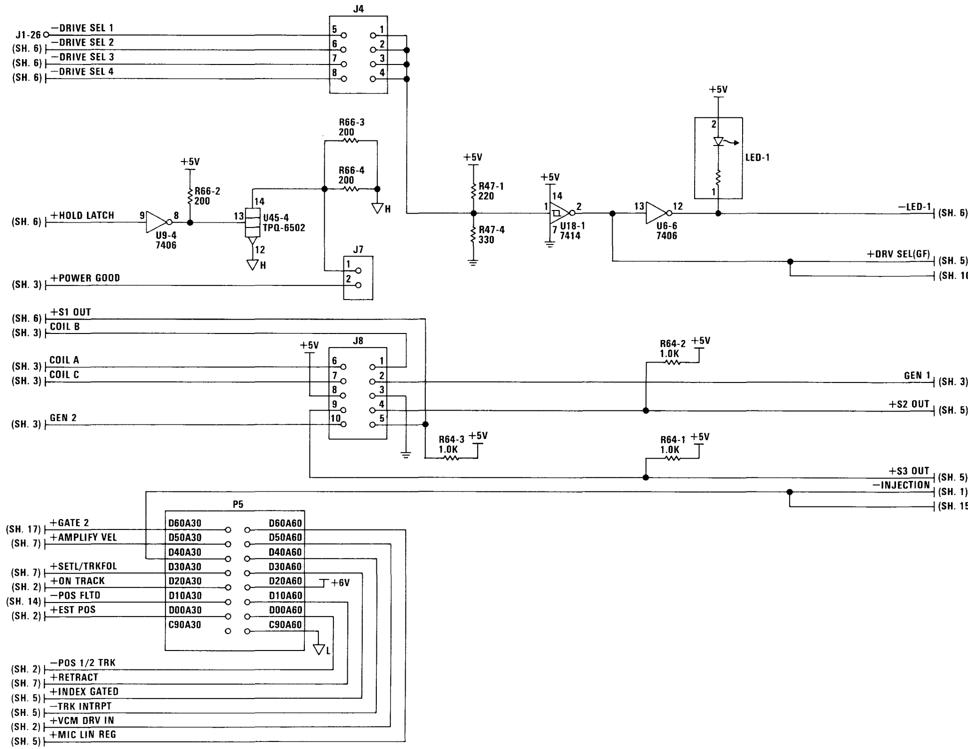


30MB Fixed Disk (Sheet 9 of 18)

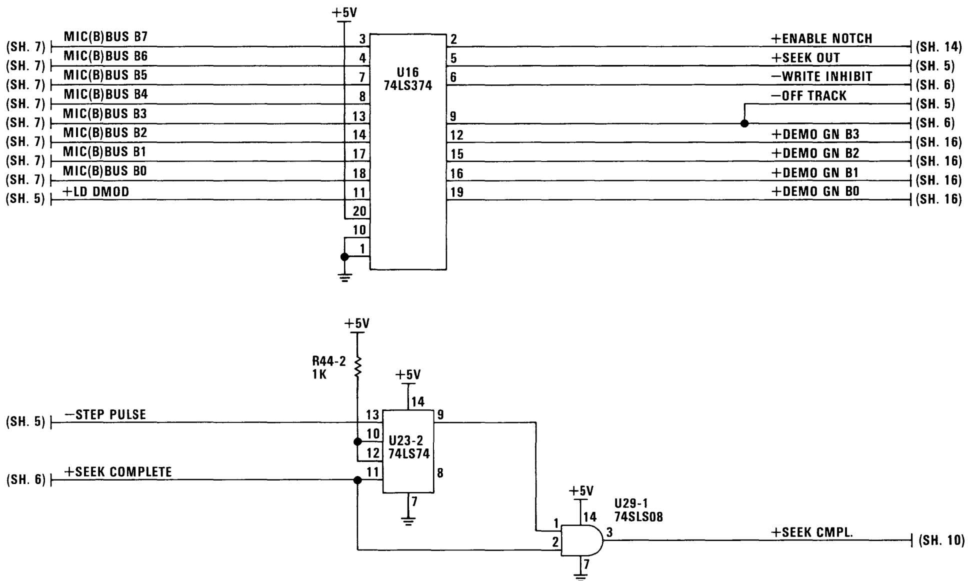
August 15, 1985



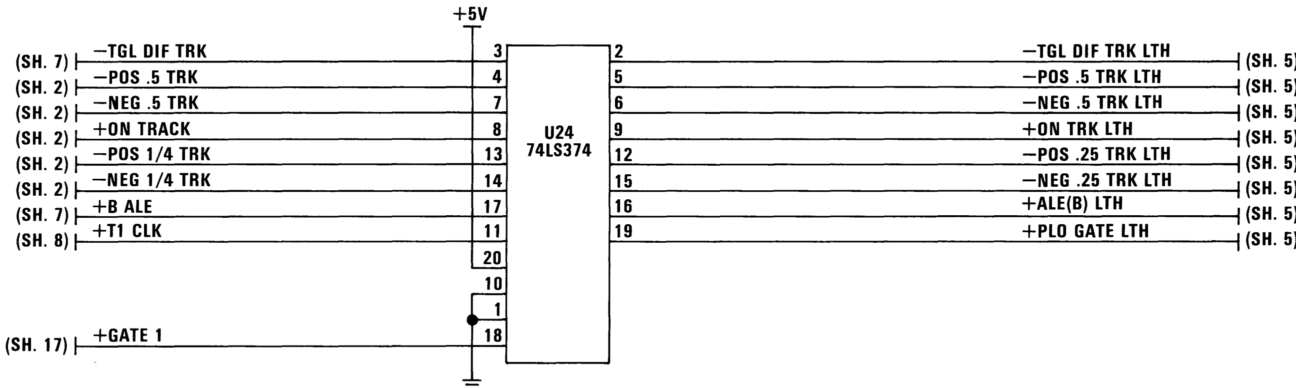
30MB Fixed Disk (Sheet 10 of 18)



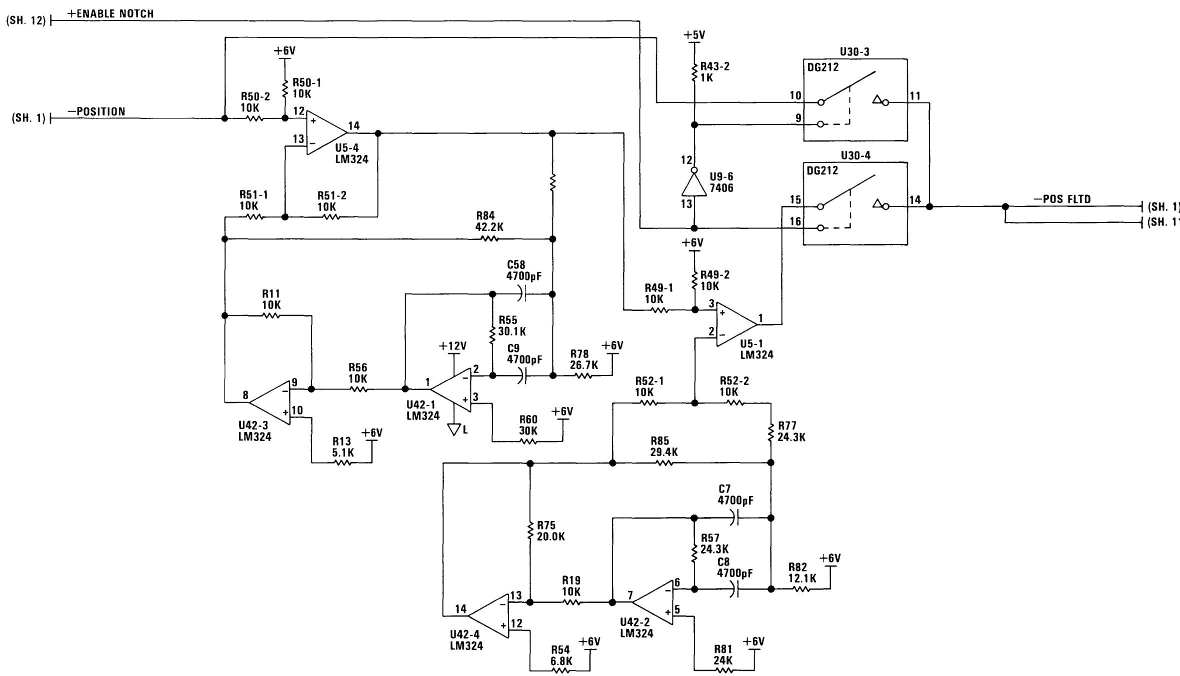
30MB Fixed Disk (Sheet 11 of 18)



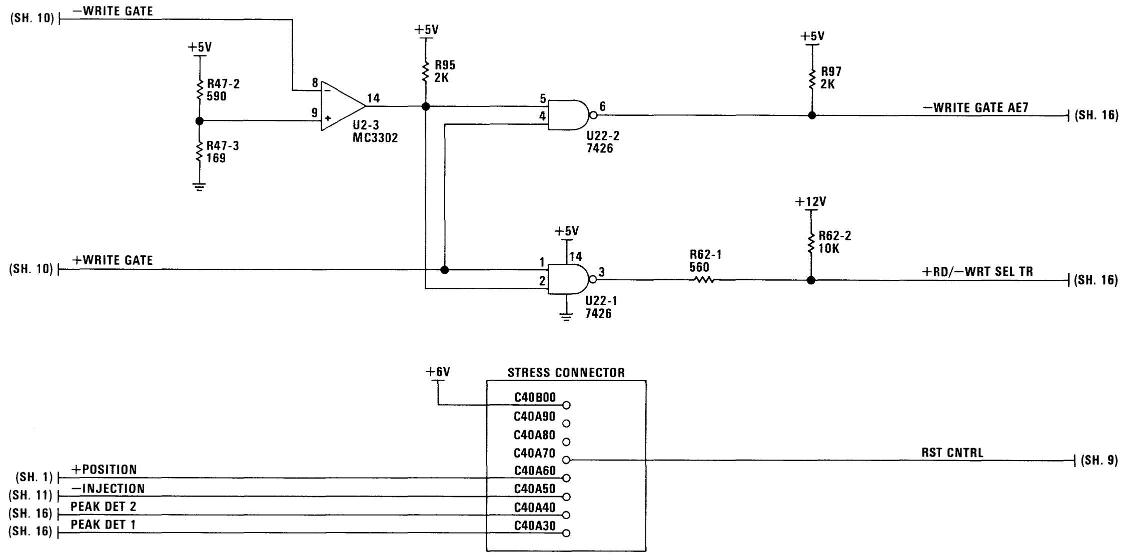
30MB Fixed Disk (Sheet 12 of 18)



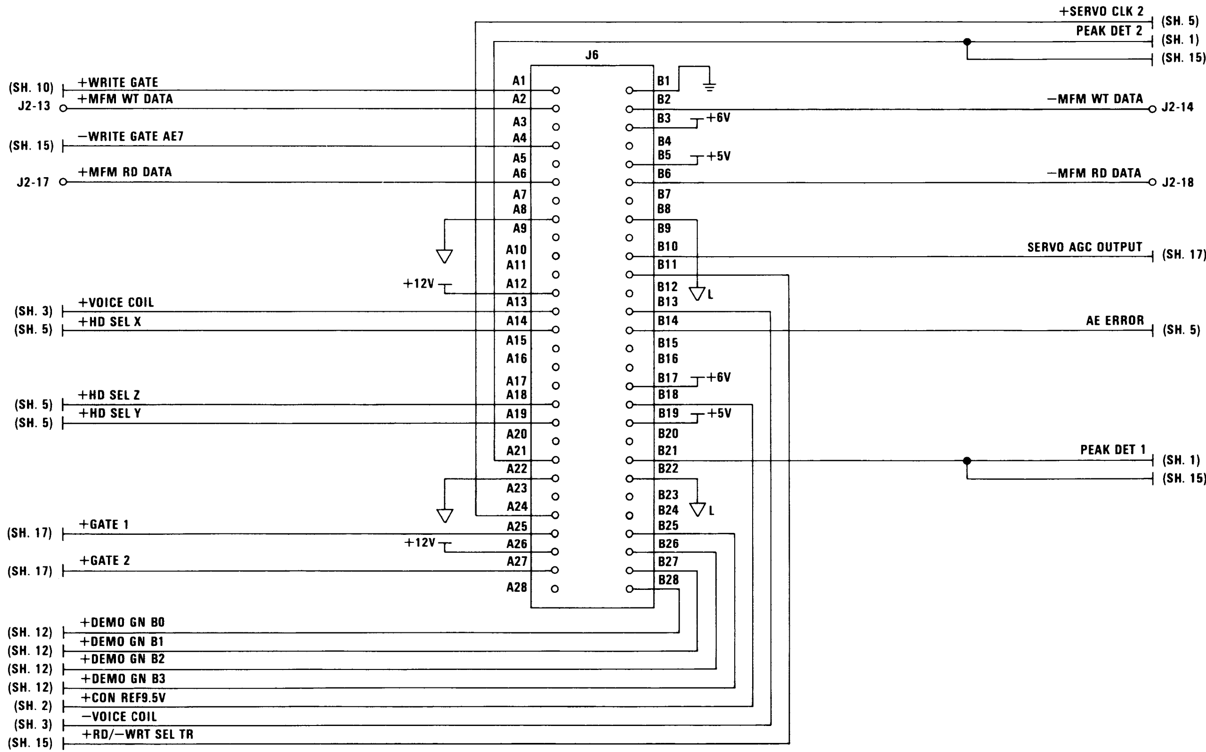
30MB Fixed Disk (Sheet 13 of 18)



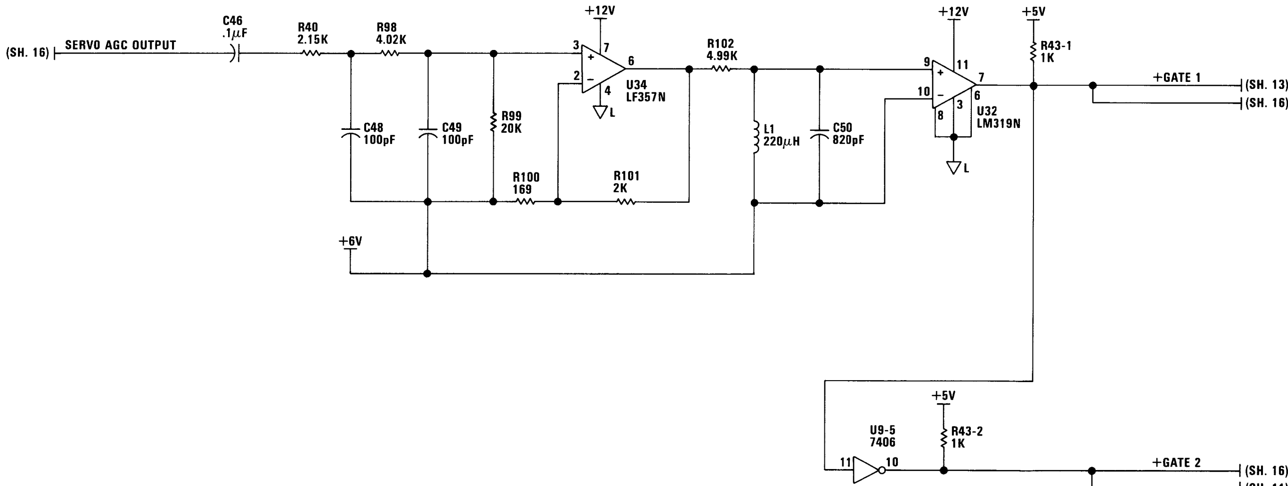
30MB Fixed Disk (Sheet 14 of 18)



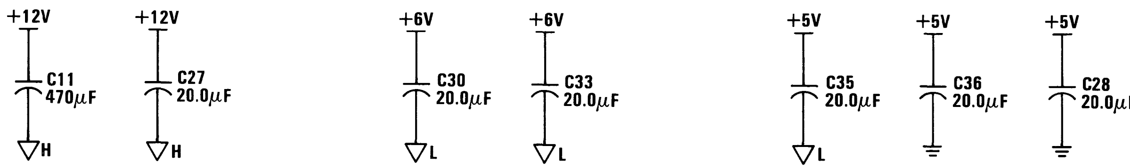
30MB Fixed Disk (Sheet 15 of 18)



30MB Fixed Disk (Sheet 16 of 18)



30MB Fixed Disk (Sheet 17 of 18)



30MB Fixed Disk (Sheet 18 of 18)

Notes:

IBM

Personal Computer Hardware Reference Library

IBM 64/256KB Memory Expansion Option and 64KB Memory Module Kit

6361488

IBM 64/256 Memory Expansion Option and 64KB Memory Module Kit

Contents

Description

The 64KB Memory Module Kit and the 64/256KB Memory Expansion Option are available for the IBM Personal Computer family of products. Depending upon the amount of memory currently installed on the system board, memory module kits can be added to provide a maximum of 256KB of RAM without using any of the system unit expansion slots for a memory expansion option. The system board must be populated to the maximum 256KB of RAM before a 64/256KB Memory Expansion Option can be installed.

The IBM 64/256KB Memory Expansion Option has four banks of nine pluggable sockets. Each bank will accept a 64KB Memory Module Kit, consisting of 9 (64K by 1) modules with 16-pin industry-standard parts. The base 64/256K expansion option comes with modules installed in bank 0, providing 64K of memory. The kits must be installed sequentially into banks 1, 2, and 3. The following chart shows how the 64KB Memory Module Kit can be installed on the system board and the 64/256KB Memory Expansion Option.

	Minimum Memory	Maximum Memory	Number of 64K Memory Module Kits	Memory Module Type
64/256K System Board	64K	256K	1, 2, or 3	64K by 1 Bit, 16 pin
64/256K Memory Option	64K	256K	1, 2, or 3	64K by 1 Bit, 16 pin

In addition to the memory modules, the memory expansion option contains the following circuits: bus buffering, dynamic memory timing generation, address multiplexing, and card-select decode logic.

Dynamic-memory refresh timing and address generation are functions that are performed by the system board and made available in the I/O channel for all devices.

The 64/256KB Memory Expansion Option is parity checked. If a parity error is detected, a latch is set and an I/O 'channel check' line is activated, indicating an error to the microprocessor.

To allow the system unit to address the expanded memory provided by the 64KB Memory Module Kit or the 64/256K Memory Expansion Option, refer to the *Guide to Operations* manual for the proper memory-expansion-option switch settings.

Switch-Configurable Start Address

The 64/256KB Memory Expansion Option must be configured to reside at a sequential 64K memory address boundary within the system address space. This is done by setting dual-in-line package (DIP) switches on the option. The 64/256KB expansion option has a small DIP module containing eight switches. The switches are used to set the card start address as follows:

Number	64/256K Options
1	ON: A19 = 0; OFF: A19 = 1
2	ON: A18 = 0; OFF: A18 = 1
3	ON: A17 = 0; OFF: A17 = 1
4	ON: A16 = 0; OFF: A16 = 1
5	ON: Select 64K
6	ON: Select 128K
7	ON: Select 192K
8	ON: Select 256K

DIP Module Start Address

The following method can be used to determine the switch settings for the 64/256K memory expansion option.

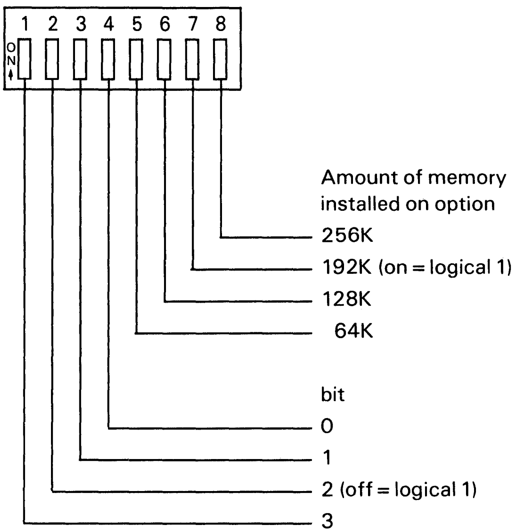
Starting Address = xxxK

$$\frac{xxxK}{64K} = \text{Decimal value}$$

Convert decimal value to binary

Bit	3	2	1	0
Bit value . .	8	4	2	1

Switch



Operating Characteristics

The system board operates at a frequency of 4.77 MHz, which results in a clock cycle of 210 ns.

Normally four clock cycles are required for a bus cycle so that an 840-ns memory cycle time is achieved. Memory-write and memory-read cycles both take four clock cycles, or 840 ns.

Access and cycle times for memory used on the 64/256 Memory Expansion Option are:

	64K by 1 Bit
Access	200 ns
Cycle	345 ns

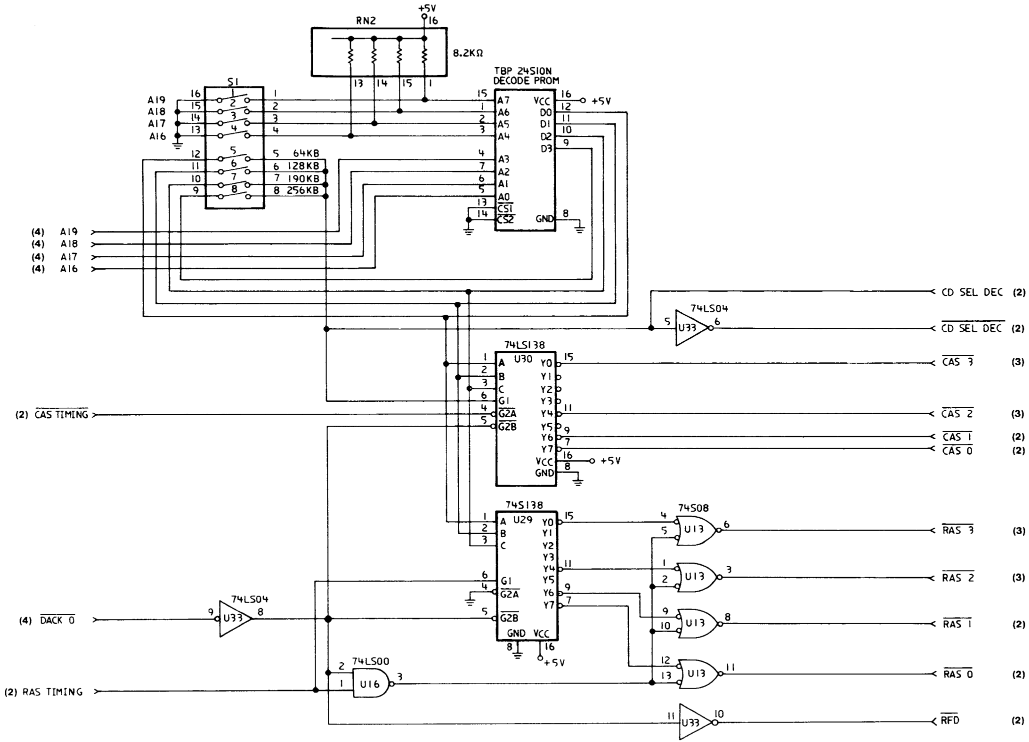
The 64K by 1 modules require only one voltage level of +5 Vdc, and require 128 refresh cycles every 2 ms. Absolute maximum access times are:

	64K by 1 Bit
From $\overline{\text{RAS}}$	200 ns
From $\overline{\text{CAS}}$	115 ns

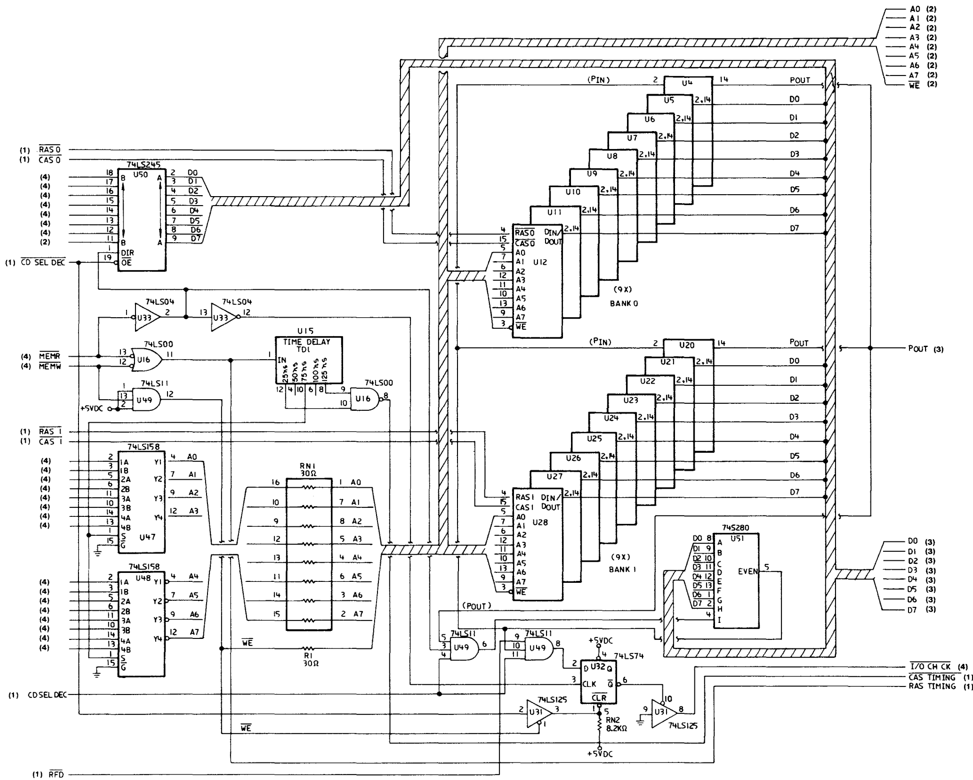
Specifications

Pin	64K by 1 Bit Module (used on 64/256K option and 64/256K system board)
1	N/C
2	Data In* *
3	– Write
4	– RAS
5	A0
6	A2
7	A1
8	– 5 Vdc
9	A7
10	A5
11	A4
12	A3
13	A6
14	Data Out * *
15	– CAS
16	GND
17	*
18	*
*64K by 1 bit modules have 16 pins. * *Data In and Data Out are tied together on Data Bits 0-7 (three state bus).	

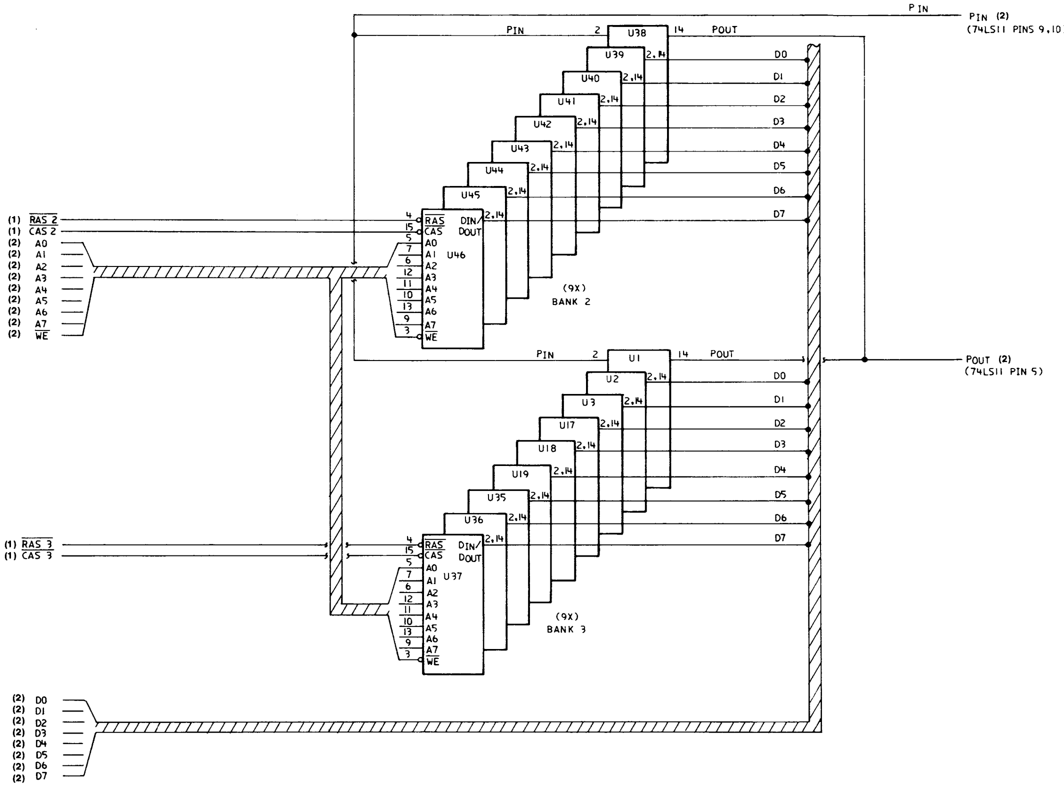
Memory Module Pin Configuration



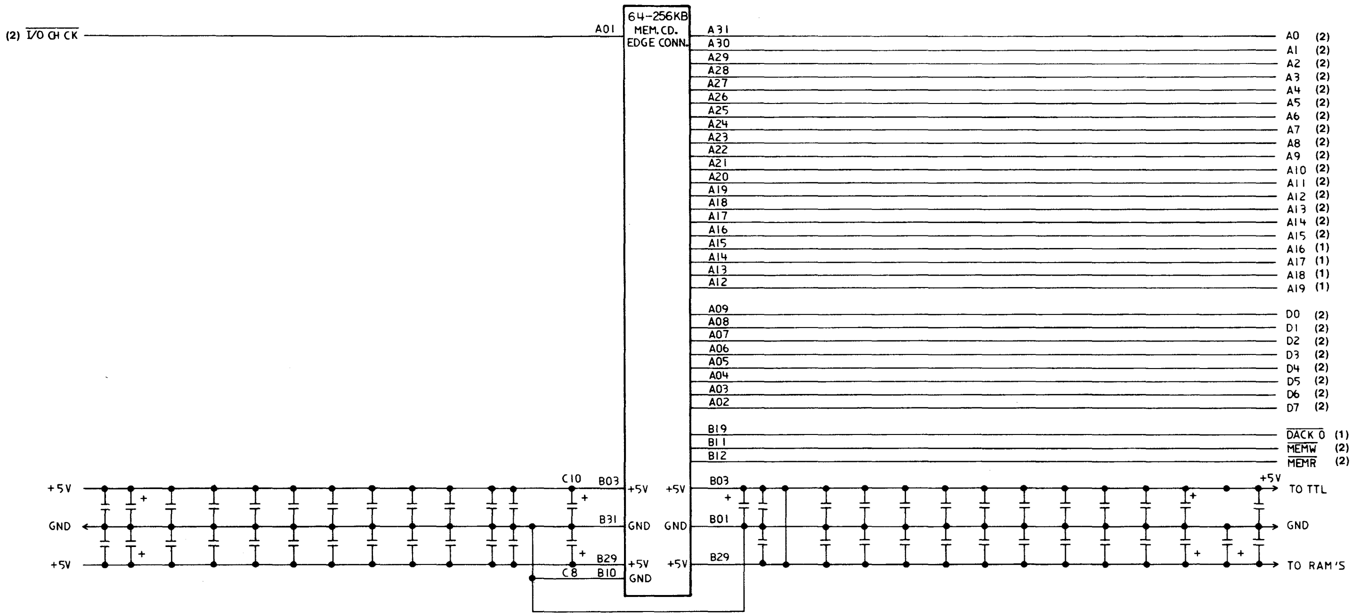
64/256KB Memory Expansion Option (Sheet 1 of 4)



64/256KB Memory Expansion Option (Sheet 2 of 4)



64/256KB Memory Expansion Option (Sheet 3 of 4)



64/256KB Memory Expansion Option (Sheet 4 of 4)

IBM

Personal Computer

IBM 256KB Memory Expansion Option

6138355

Contents

Notes:

Description

The IBM 256KB Memory Expansion Option is available for the IBM Personal Computer family of products. The system board must be populated to the maximum 256KB of RAM before the IBM 256KB Memory Expansion Option can be installed.

The IBM 256KB Memory Expansion Option has four pluggable sockets. Each socket will accept a 64KB Memory Module, consisting of one (64K by 9) 32-pin D RAM Module. The 256KB expansion option comes with all four modules installed providing 256KB of memory.

In addition to the memory modules, the memory expansion option contains the following circuits: bus buffering, dynamic memory timing generation, address repowering, and card-select decode logic.

Dynamic-memory refresh timing and address generation are functions that are performed by the system board and made available in the I/O channel for all devices.

The 256KB Memory Expansion Option is parity checked. If a parity error is detected, a latch is set and an I/O 'channel check' line is activated, indicating an error to the microprocessor.

To allow the system unit to address the expanded memory provided by the IBM 256KB Memory Expansion Option, refer to the *Guide to Operations* manual for the proper memory-expansion-option switch settings.

Switch-Configurable Start Address

The 256KB Memory Expansion Option must be configured to reside at a sequential 64KB memory address boundary within the system address space. This is done by setting dual-in-line package (DIP) switches on the option. The IBM 256KB Memory Expansion Option has a small DIP module containing eight switches. The switches are used to set the card start address as follows:

Number	256KB Options
1	ON: A19=0; OFF:A19=1
2	ON: A18=0; OFF:A18=1
3	ON: A17=0; OFF:A17=1
4	ON: A16=0; OFF:A16=1
5	ON: Select 64KB
6	ON: Select 128KB
7	ON: Select 192KB
8	ON: Select 256KB

DIP Module Start Address

The following method can be used to determine the switch settings for the 256KB memory expansion option.

Starting Address = xxxKB

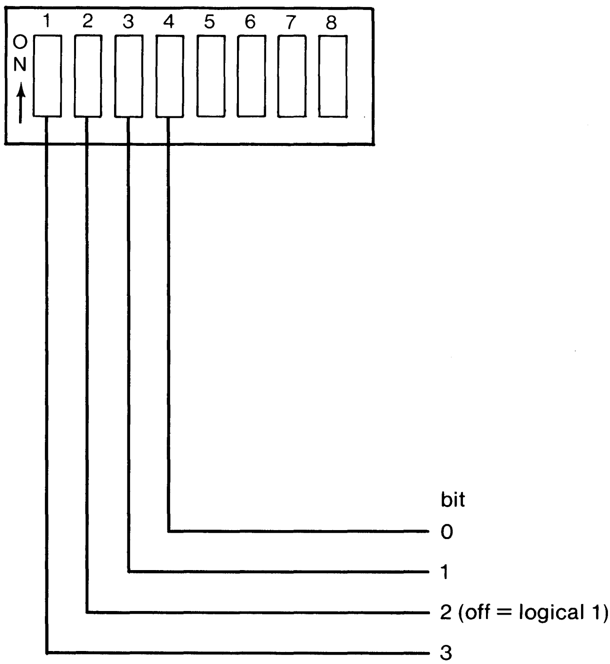
= Decimal value

64KB xxxKB

Convert decimal value to binary

Bit. 3 2 1 0
Bit value. . . . 8 4 2 1

Switch



Operating Characteristics

The system board operates at a frequency of 4.77 MHz, which results in a clock cycle of 210 ns.

Normally four clock cycles are required for a bus cycle so that an 840-ns memory cycle time is achieved. Memory-write and memory-read cycles both take four clock cycles, or 840 ns.

Access and cycle times for memory used on the IBM 256KB Memory Expansion Option are:

Time.	256KB Card
Access	290 ns
Cycle	840 ns

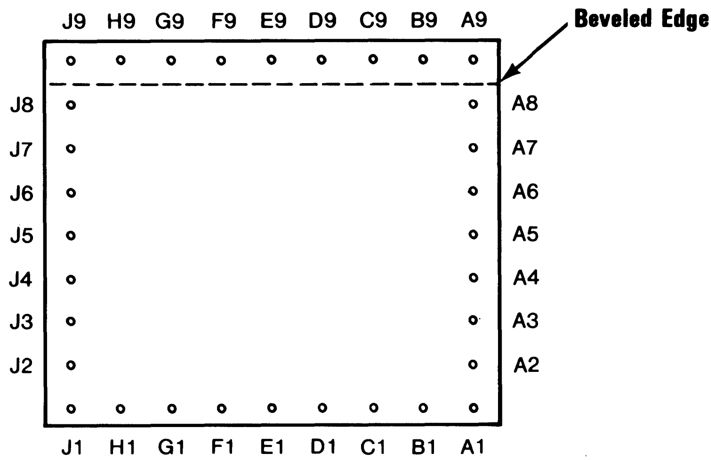
Access/Cycle Times

Voltage Requirements

The IBM 256KB Memory Expansion card requires 3 voltage levels: +12Vdc, +5Vdc, and –5Vdc.

Specifications

This is the pin side view of the IBM 64KB 32-Pin D RAM Module.

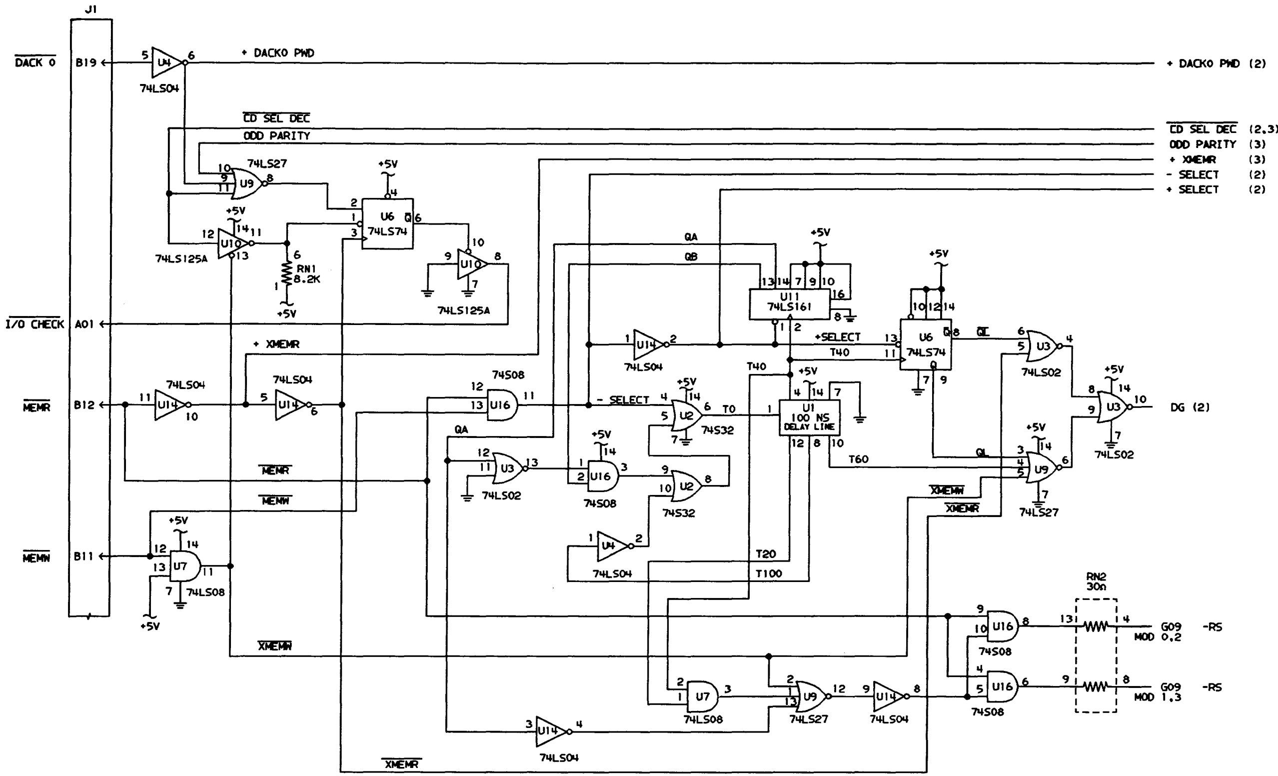


Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
A1	D4	B9	A14	J8	A1	B1	+8.5 Vdc
A2	D3	C9	A09	J7	A0	C1	–2.2 Vdc
A3	D2	D9	A11	J6	A7	D1	D5
A4	D1	E9	A12	J5	A5	E1	D6
A5	D0	F9	A13	J4	A3	F1	D7
A6	CS	G9	RS	J3	A2	G1	D8
A7	DG B	H9	A10	J2	A4	H1	+5 Vdc
A8	DG A	J9	A06	J1	GND		
A9	A8						

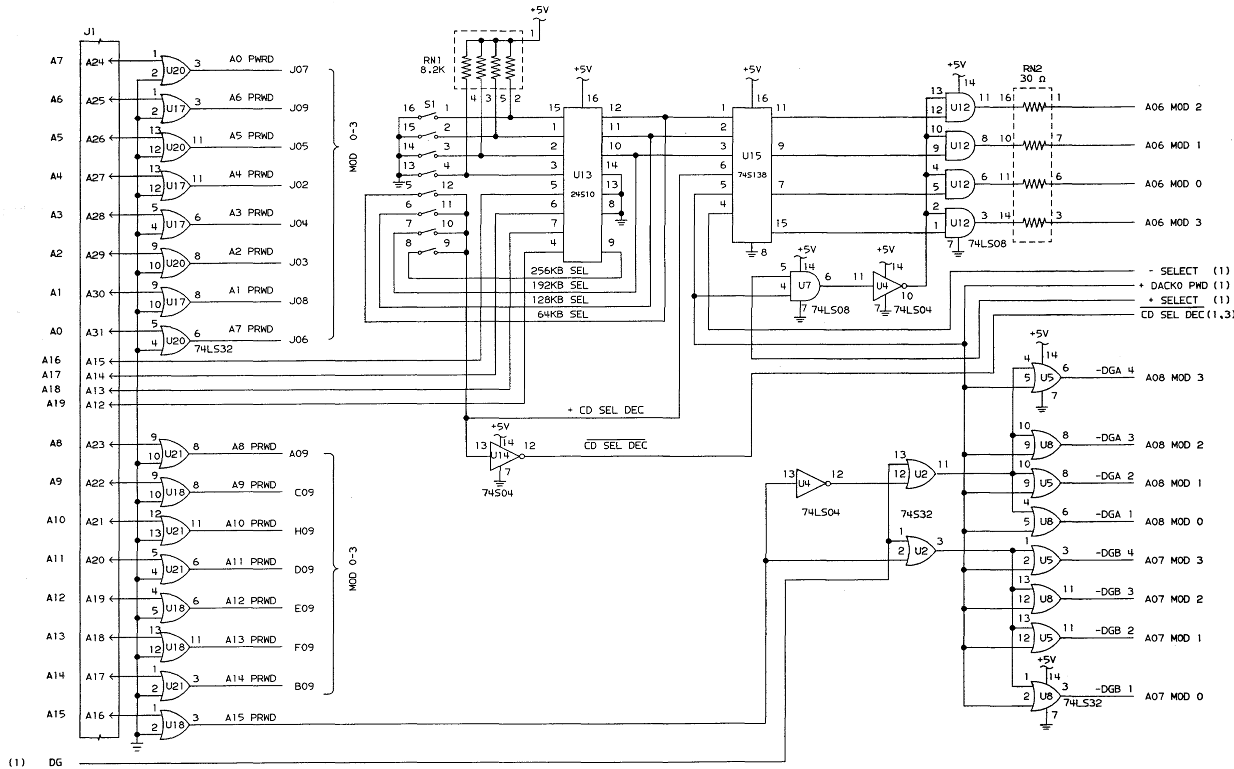
The +8.5, +5 and -2.2Vdc are developed on the 256KB Memory Expansion Adapter.

IBM 64KB Memory Module Pin Configuration

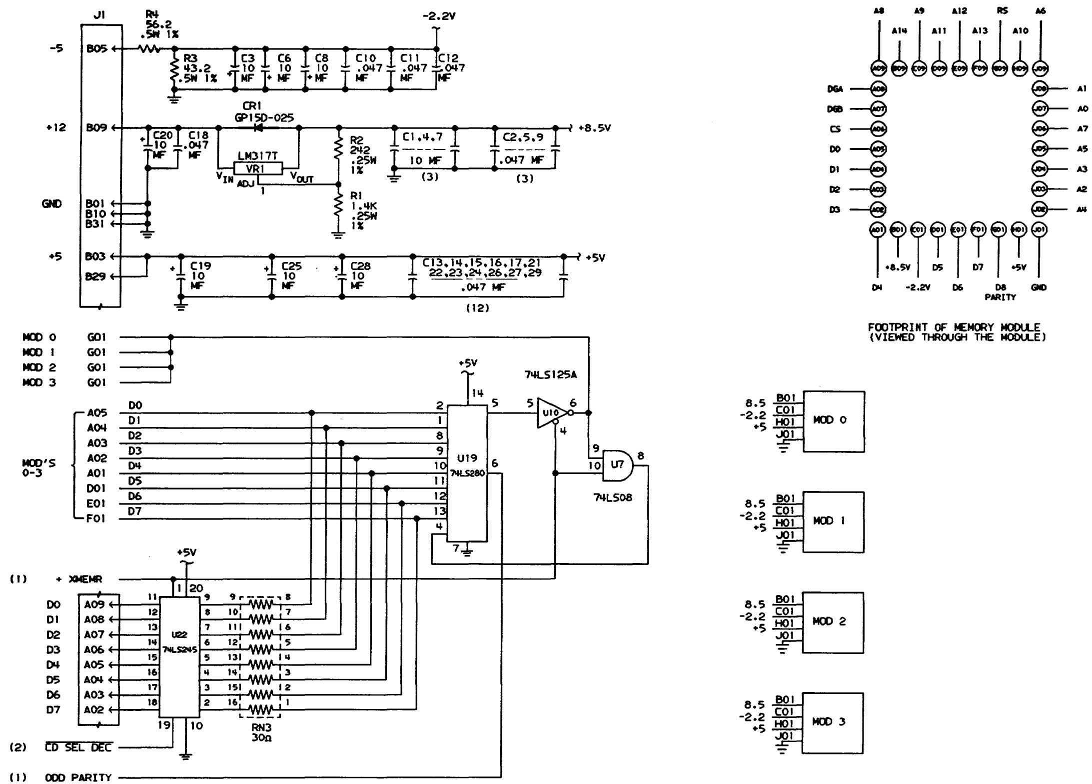
Notes:



256KB Memory Expansion Option (Sheet 1 of 3)



256KB Memory Expansion Option (Sheet 2 of 3)



256KB Memory Expansion Option (Sheet 3 of 3)

Notes:

IBM

Personal Computer Hardware Reference Library

128KB Memory Expansion Option

IBM PERSONAL COMPUTER AT 128KB MEMORY EXPANSION OPTION

Contents

Notes:

Description

The IBM Personal Computer AT 128Kb Memory Expansion Option has 18 RAM modules (64Kb x 1) for a total capacity of 128Kb.

Memory Cycles

Memory read and write commands require a 1-wait-state, 3-clock memory cycle. Data moves as a byte (8 data bits and 1 parity bit) or as a word (16 data bits and 2 parity bits) and is parity-checked on the adapter. A parity error causes an I/O channel check (non-maskable interrupt) to the system.

I/O Channel Check

When the I/O channel check occurs, a non-maskable interrupt (NMI) results. Bits 6 and 7 of hex address 0061 are the status bits used to determine the source of the NMI (bit 6 is I/O channel check, and bit 7 is system board parity check). Writing to the failing card will clear the status bit.

Addressing

This adapter responds to addresses from hex 080000 to hex 09FFFF.

Specifications

Voltage Tolerances

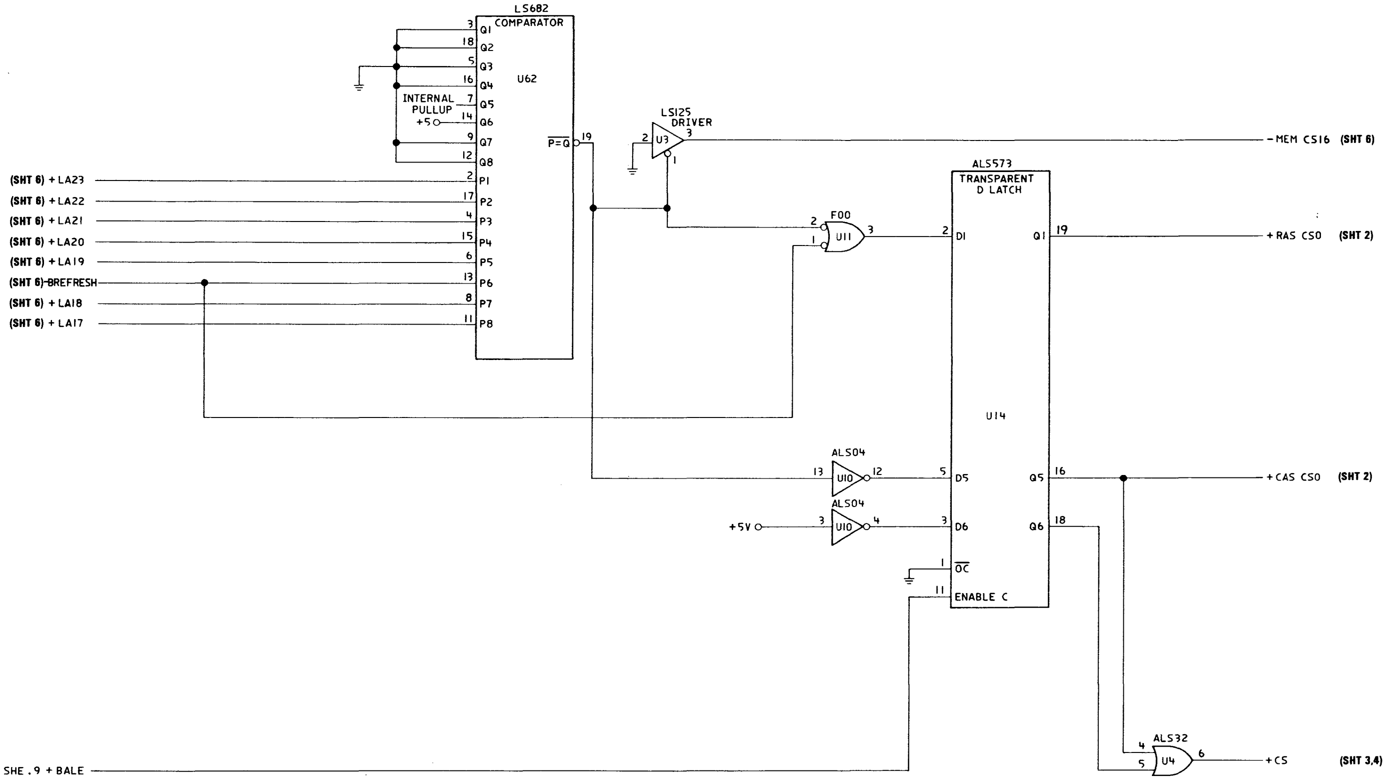
The maximum variation of the +5 Vdc is ±5% at the adapter pins.

Power Dissipation

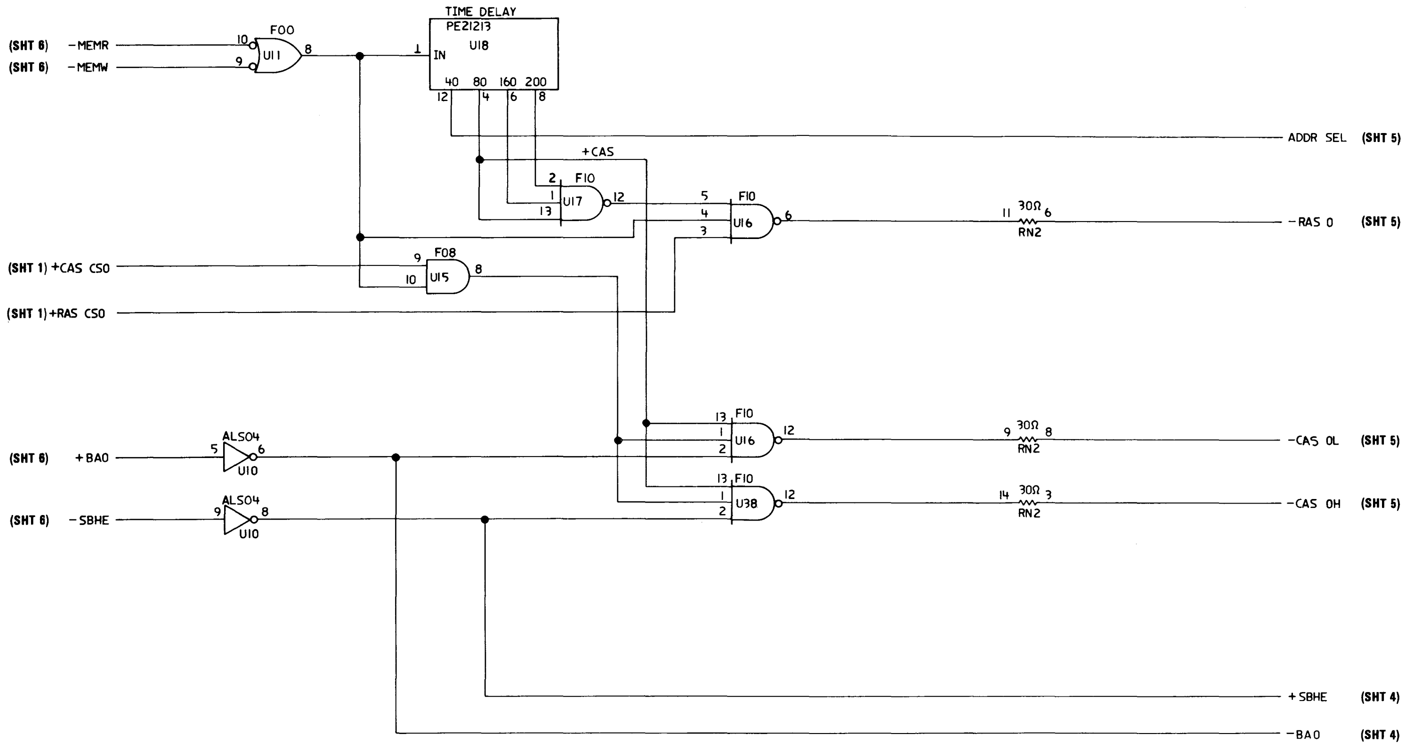
The +5 Vdc power used by the adapter is a maximum of 5.25 watts, and the maximum current used is 1 ampere.

Temperature Variation

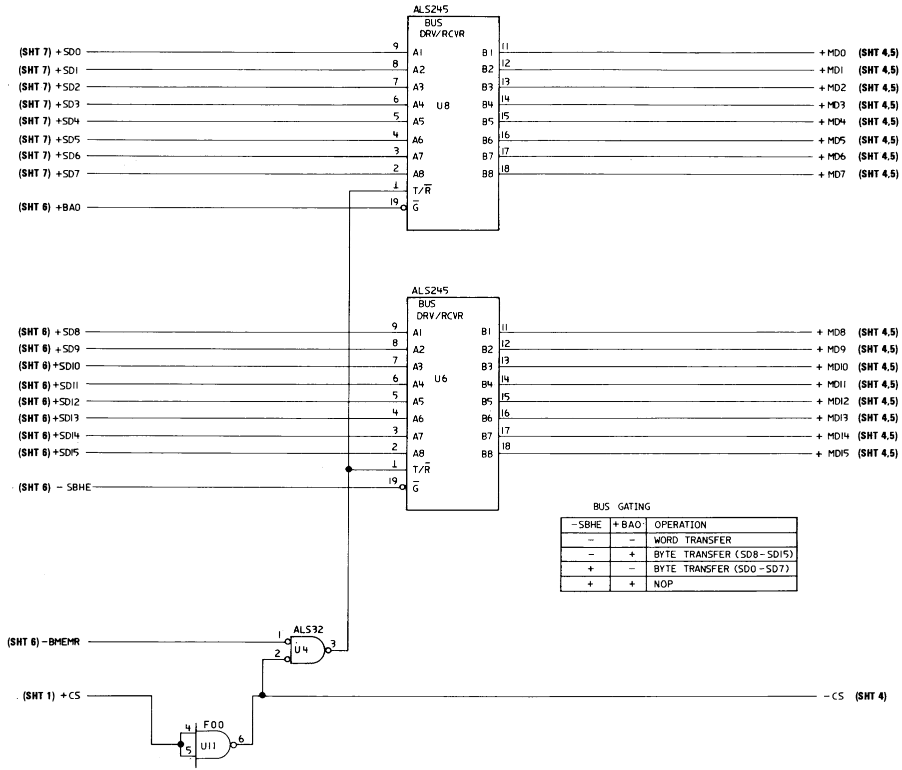
The adapter will operate between 10 and 50 degrees Celsius (50 and 122 degrees Fahrenheit).



128KB Memory Expansion Option (Sheet 1 of 7)



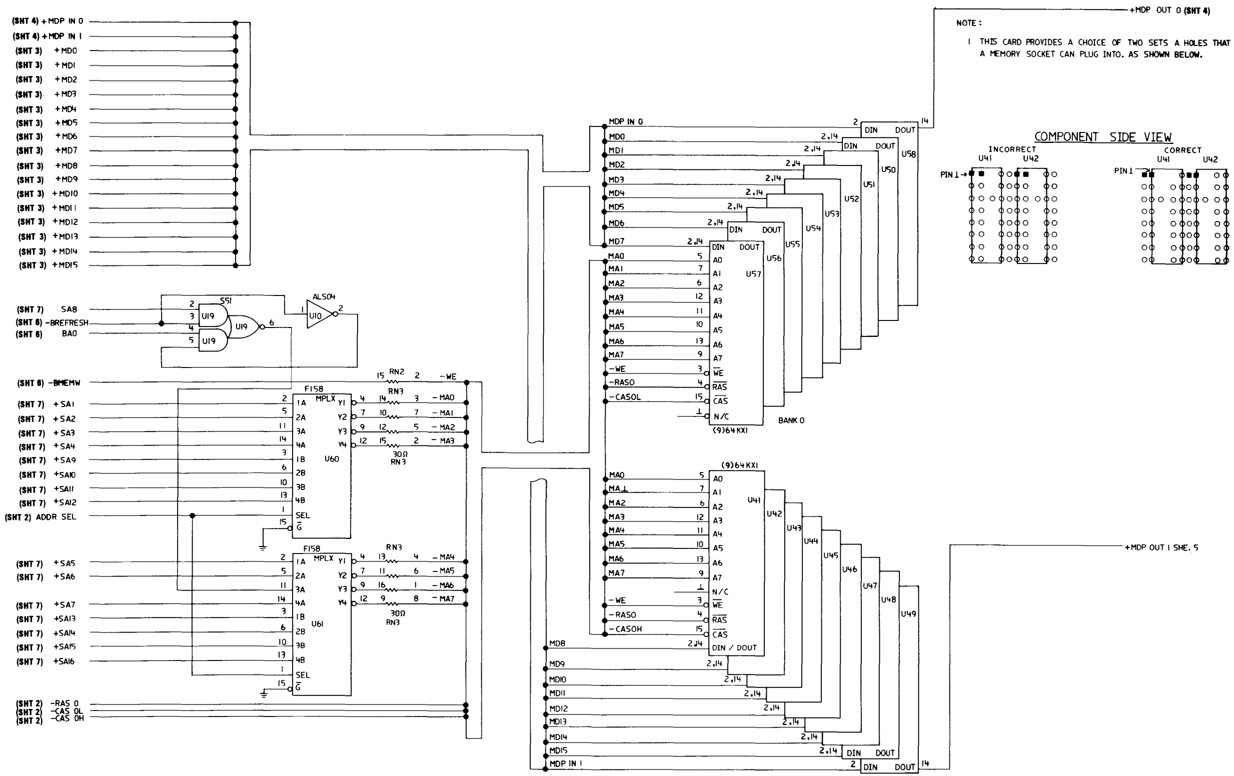
128KB Memory Expansion Option (Sheet 2 of 7)



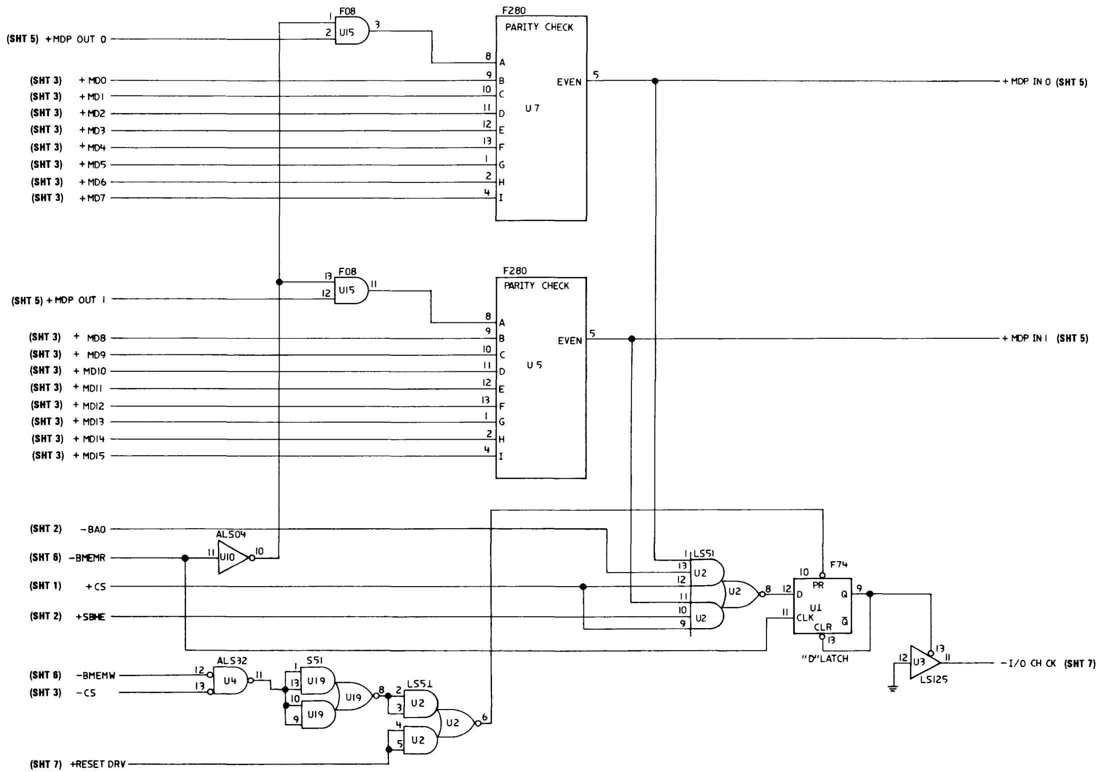
BUS GATING

−SBHE	+BA0	OPERATION
−	−	WORD TRANSFER
−	+	BYTE TRANSFER (SD8-SD15)
+	−	BYTE TRANSFER (SD0-SD7)
+	+	NOP

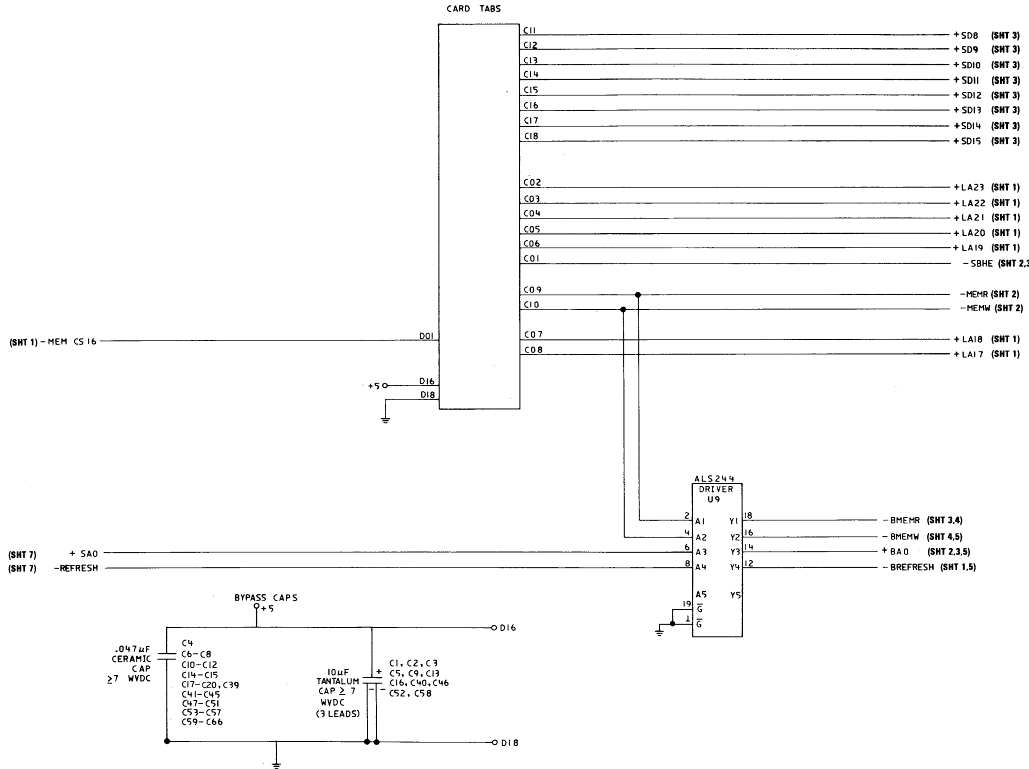
128KB Memory Expansion Option (Sheet 3 of 7)



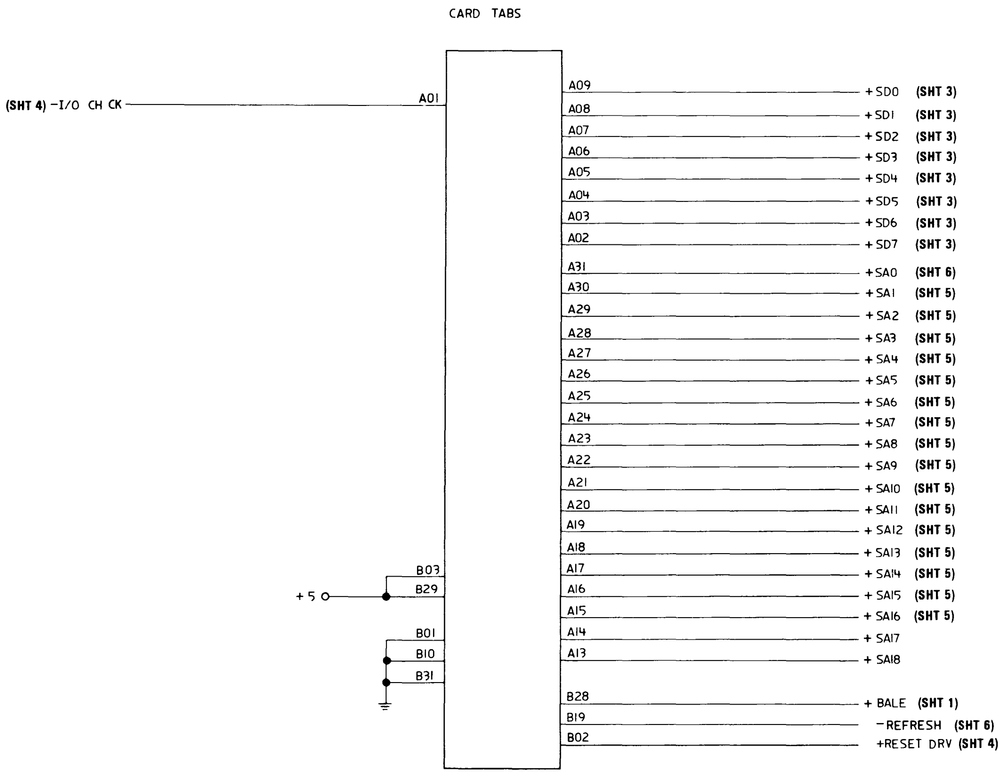
128KB Memory Expansion Option (Sheet 4 of 7)



128KB Memory Expansion Option (Sheet 5 of 7)



128KB Memory Expansion Option (Sheet 6 of 7)



128KB Memory Expansion Option (Sheet 7 of 7)

Notes:

Personal Computer
Hardware Reference
Library

512KB Memory Expansion Option

IBM PERSONAL COMPUTER AT 512KB MEMORY EXPANSION OPTION

Contents

Notes:

Description

The IBM Personal Computer AT 512Kb Memory Expansion option has 36 RAM modules (128Kb x 1) for a total capacity of 512Kb.

Memory Cycles

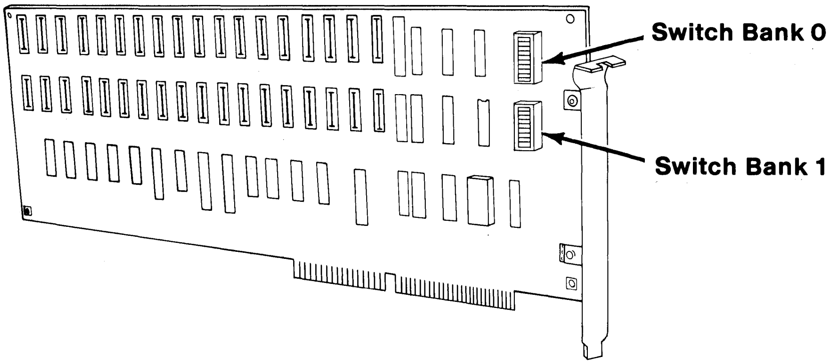
Memory read and write commands require a 1-wait-state, 3-clock memory cycle. Data moves as a byte (8 data bits and 1 parity bit) or as a word (16 data bits and 2 parity bits) and is parity-checked on the adapter. A parity error causes an I/O channel check (non-maskable interrupt) to the system.

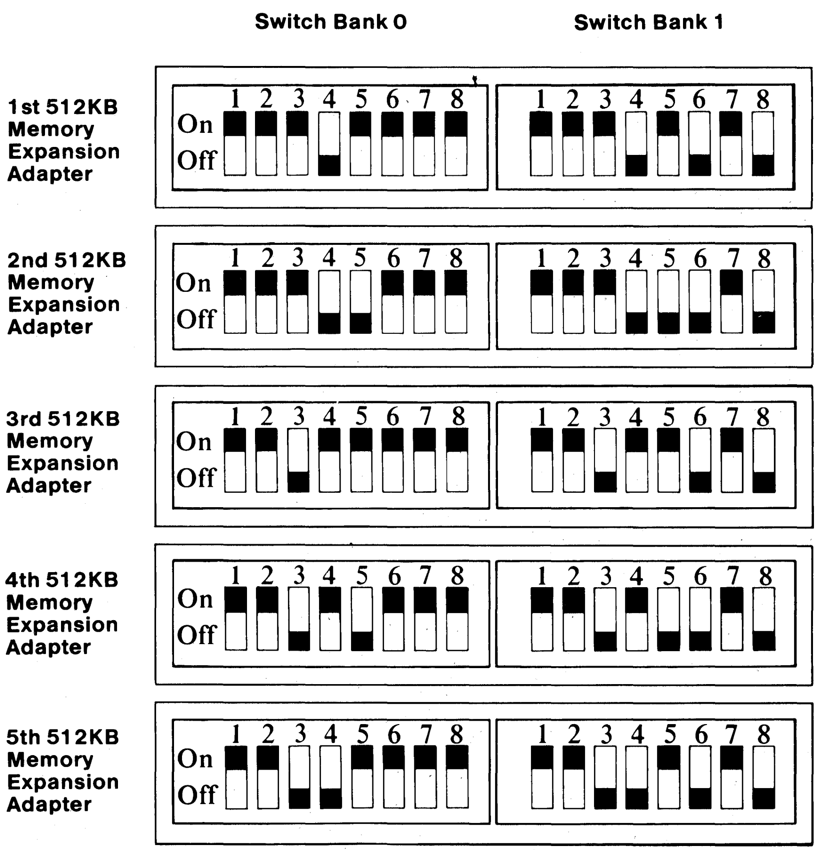
Memory Address Switches

There are two banks of memory address switches on each memory adapter. These switches are set to values for the first, second, third, etc. memory adapter in the system.

The first memory expansion adapter must start at address space hex 100000. If more than one adapter is installed, no gaps between memory are allowed. All expansion memory must be one contiguous block starting at address hex 100000.

The figure on the following page shows the switch settings for each adapter.


Switch Bank 0
Switch Bank 1


Switch Bank 0
Switch Bank 1
1st 512KB Memory Expansion Adapter
2nd 512KB Memory Expansion Adapter
3rd 512KB Memory Expansion Adapter
4th 512KB Memory Expansion Adapter
5th 512KB Memory Expansion Adapter
1 2 3 4 5 6 7 8
On
Off

I/O Channel Check

When the I/O channel check occurs, a non-maskable interrupt (NMI) results. Bits 6 and 7 of hex address 0061 are the status bits used to determine the source of the NMI (bit 6 is I/O channel check, and bit 7 is system board parity check). Writing to the failing card will clear the status bit.

Specifications

Voltage Tolerances

The maximum variation of the +5 Vdc is ±5% at the adapter pins.

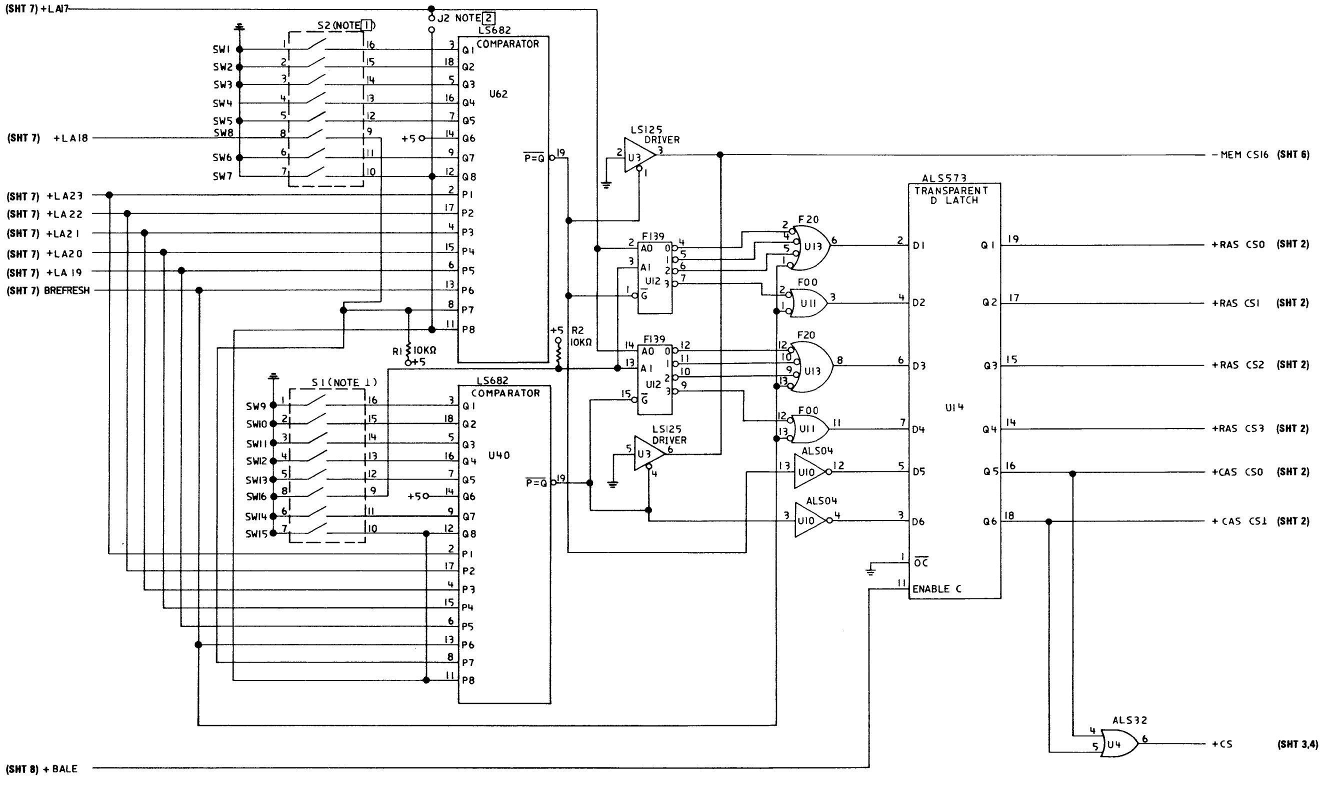
Power Dissipation

The +5 Vdc power used by the adapter is a maximum of 5.25 watts, and the maximum current used is 1 ampere.

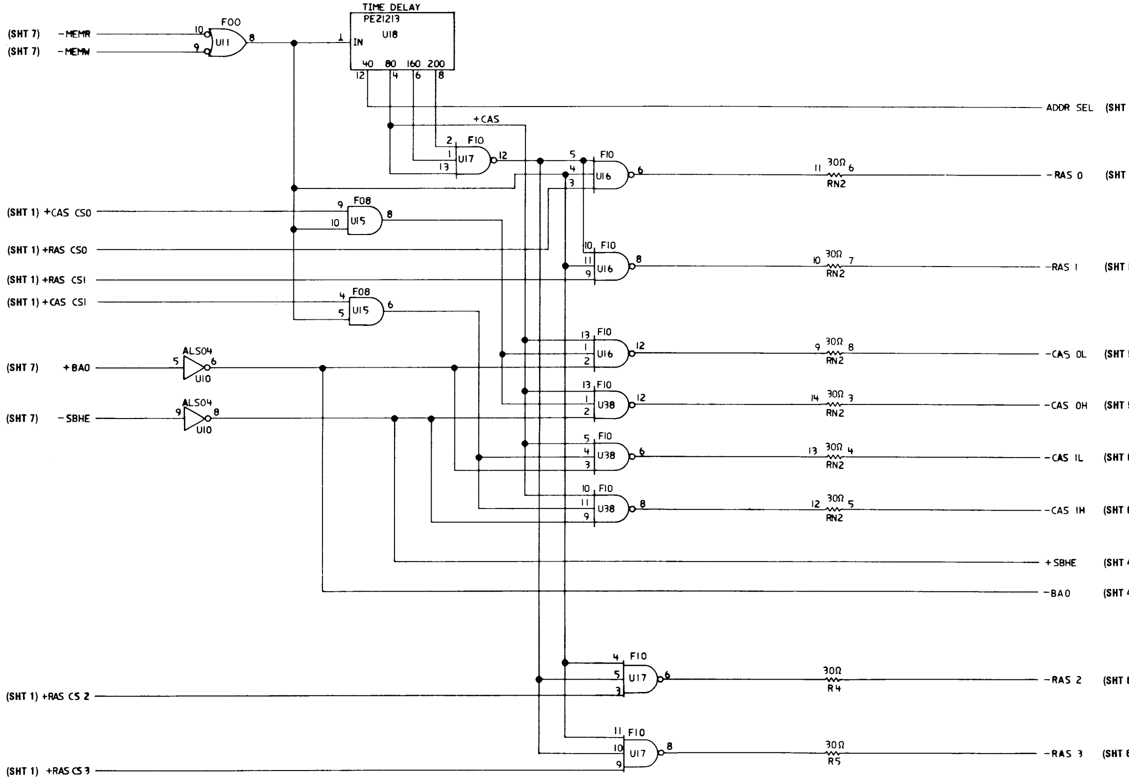
Temperature Variation

The adapter will operate between 10 and 50 degrees Celsius (50 and 122 degrees Fahrenheit).

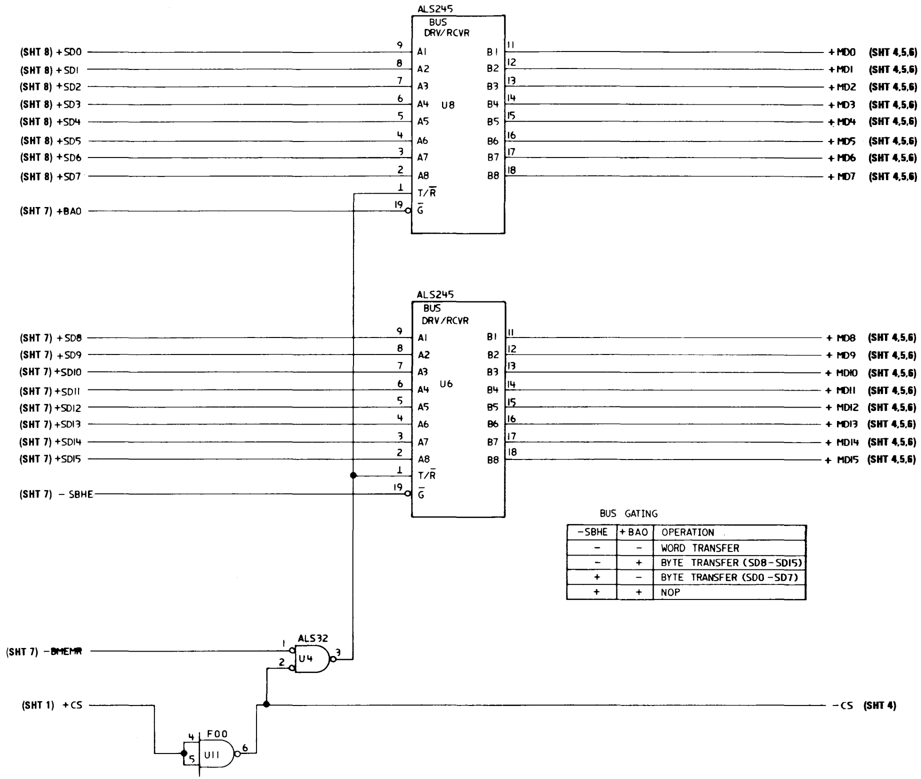
Notes:



512 KB Memory Expansion Option (Sheet 1 of 8)



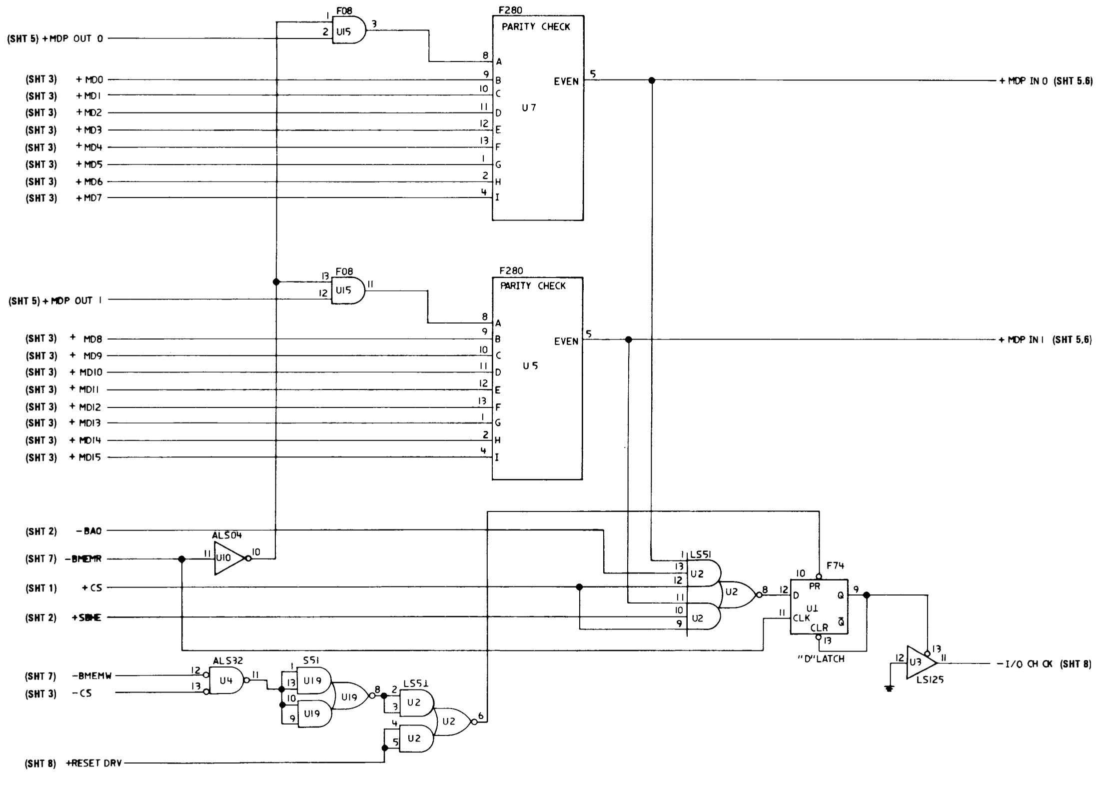
512 KB Memory Expansion Option (Sheet 2 of 8)



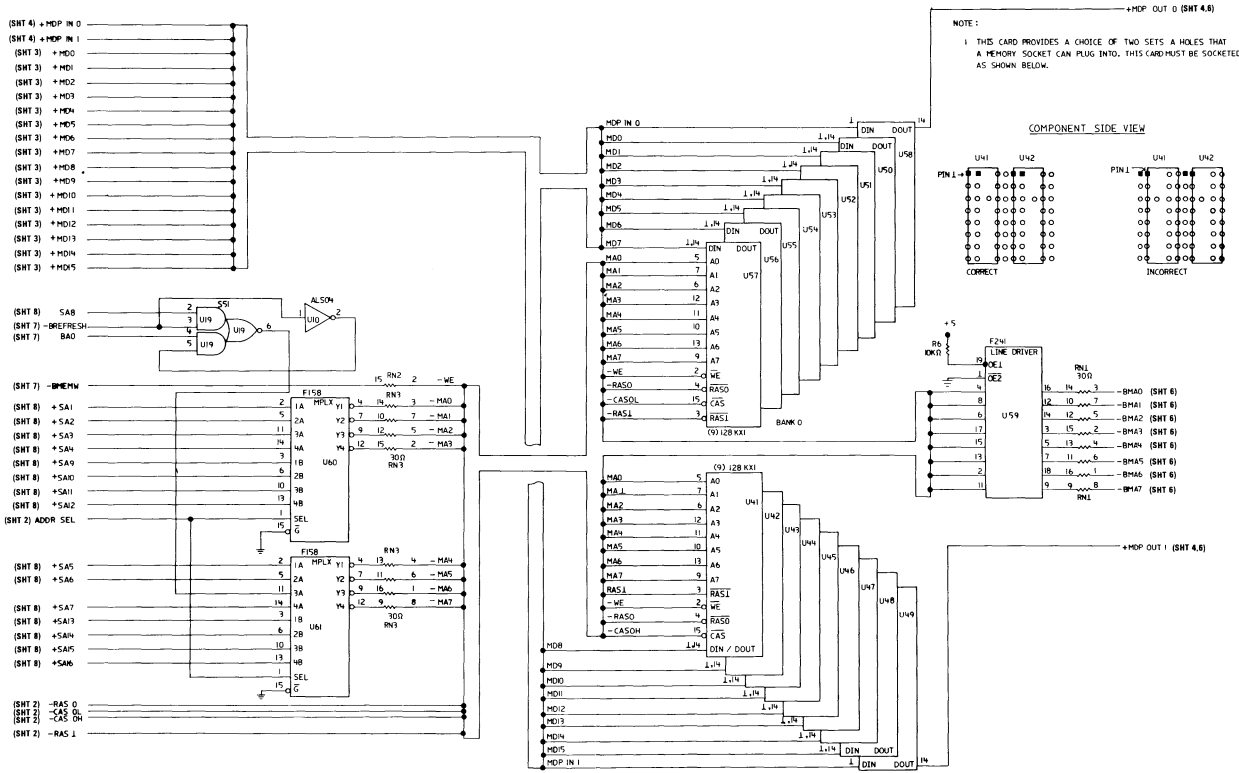
BUS GATING

−SBHE	+BA0	OPERATION
−	−	WORD TRANSFER
−	+	BYTE TRANSFER (SD8-SD15)
+	−	BYTE TRANSFER (SD0-SD7)
+	+	NOP

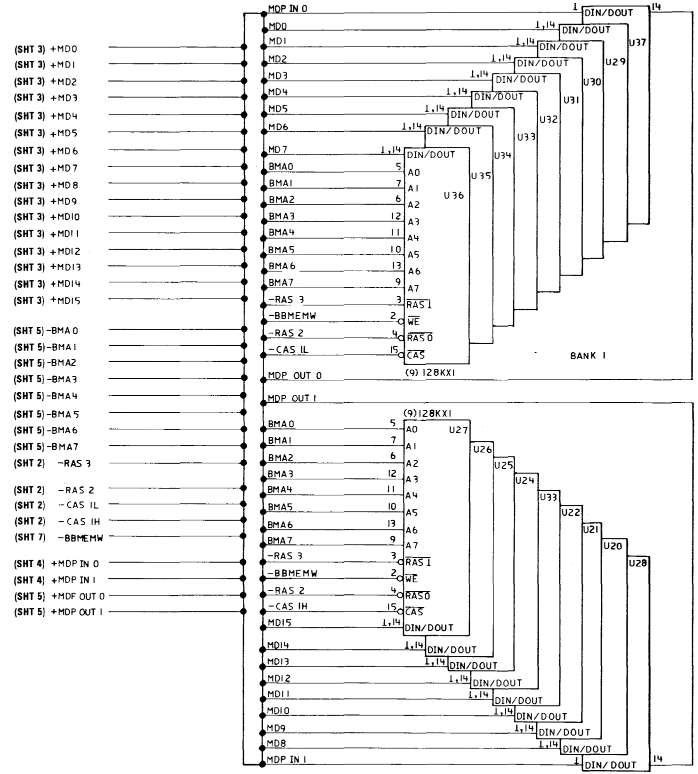
512 KB Memory Expansion Option (Sheet 3 of 8)



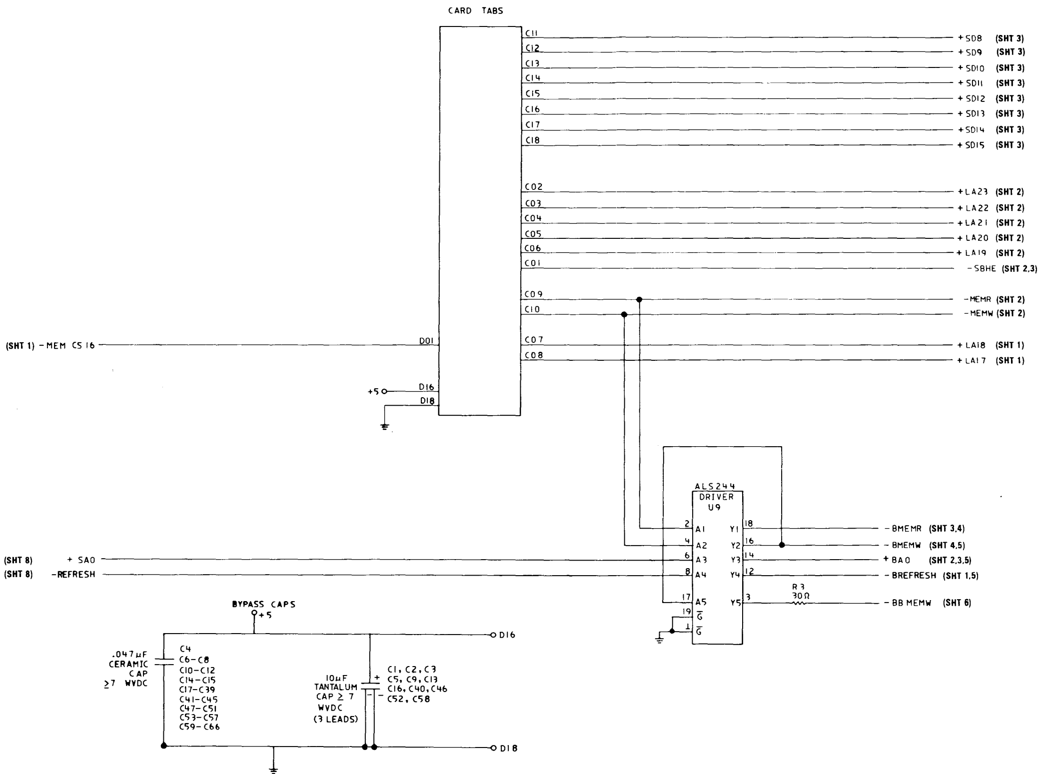
512 KB Memory Expansion Option (Sheet 4 of 8)



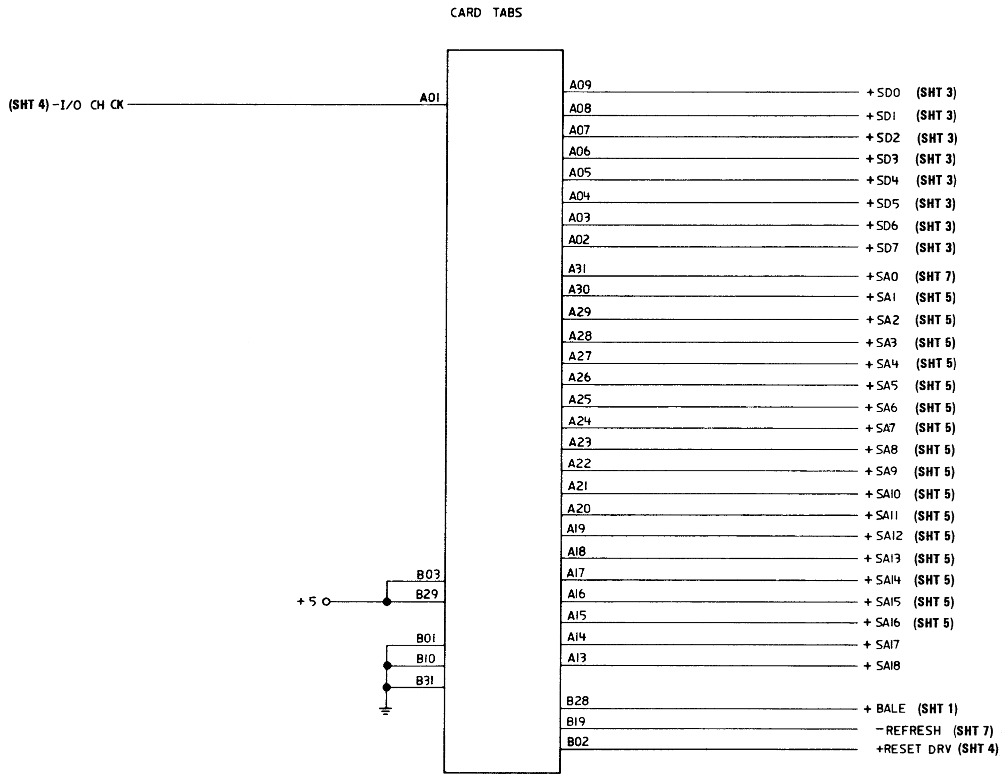
512 KB Memory Expansion Option (Sheet 5 of 8)



512 KB Memory Expansion Option (Sheet 6 of 8)



512 KB Memory Expansion Option (Sheet 7 of 8)



512 KB Memory Expansion Option (Sheet 8 of 8)

IBM

Personal Computer
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IBM Personal Computer AT®
128KB/640KB Memory
Expansion Option

6183312

March 18, 1986

Contents

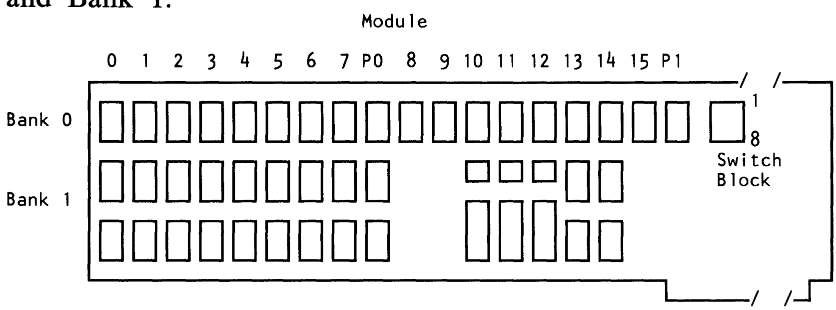
Notes:

Description

The IBM PERSONAL COMPUTER AT® 128KB/640KB Memory Expansion Option is a variable-size memory adapter designed to:

- Increase the size of base memory by 128K to allow full 640K real mode memory addressing
- Increase the size of expansion memory by 512K without using an additional I/O slot.

The option has two banks of pluggable sockets, Bank 0 and Bank 1.



Memory Module Location

Bank 1 is the 128K bank. It contains eighteen 64K by 1 dynamic random access memory (DRAM) modules. The 128K is base memory residing at address hex 80000 through hex 9FFFF. Bank 0 is the 512K bank. This bank may be populated by an IBM Personal Computer AT 512KB Memory Module Kit, consisting of eighteen 256K by 1 DRAM modules. The 512K is expansion memory residing at an address determined by the option's dual-inline-package (DIP) switch settings.

Operating Characteristics

Memory-read (MEMR) and memory-write (MEMW) operations require a 1-wait-state, 3-clock memory cycle. Data moves as a byte (8 data bits and 1 parity bit) or as a word (16 data bits and 2 parity bits) and is parity-checked on the adapter.

I/O Channel Check

If a parity error is detected, a latch is set and an I/O 'channel check' line is activated; the result being a non-maskable interrupt (NMI) indicating an error to the system unit's microprocessor. The status bits (I/O channel check and system-board parity check) determine the source. Writing to the failing option clears the status bit.

Memory Address Switches

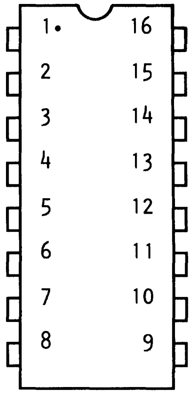
An eight-position DIP module is mounted on the option. Its switch assignments are as follows:

Switch Number	Switch Assignments	
1	ON:LA23 = 0	OFF:LA23 = 1
2	ON:LA22 = 0	OFF:LA22 = 1
3	ON:LA21 = 0	OFF:LA21 = 1
4	ON:LA20 = 0	OFF:LA20 = 1
5	ON:LA19 = 0	OFF:LA19 = 1
6	ON:Bank 0 populated	OFF:Bank 0 not populated
7	ON:Bank 1 populated	OFF:Bank 1 not populated
8	ON:Reserved	OFF:Bank 1 memory is 128K

DIP Module Switch Assignments

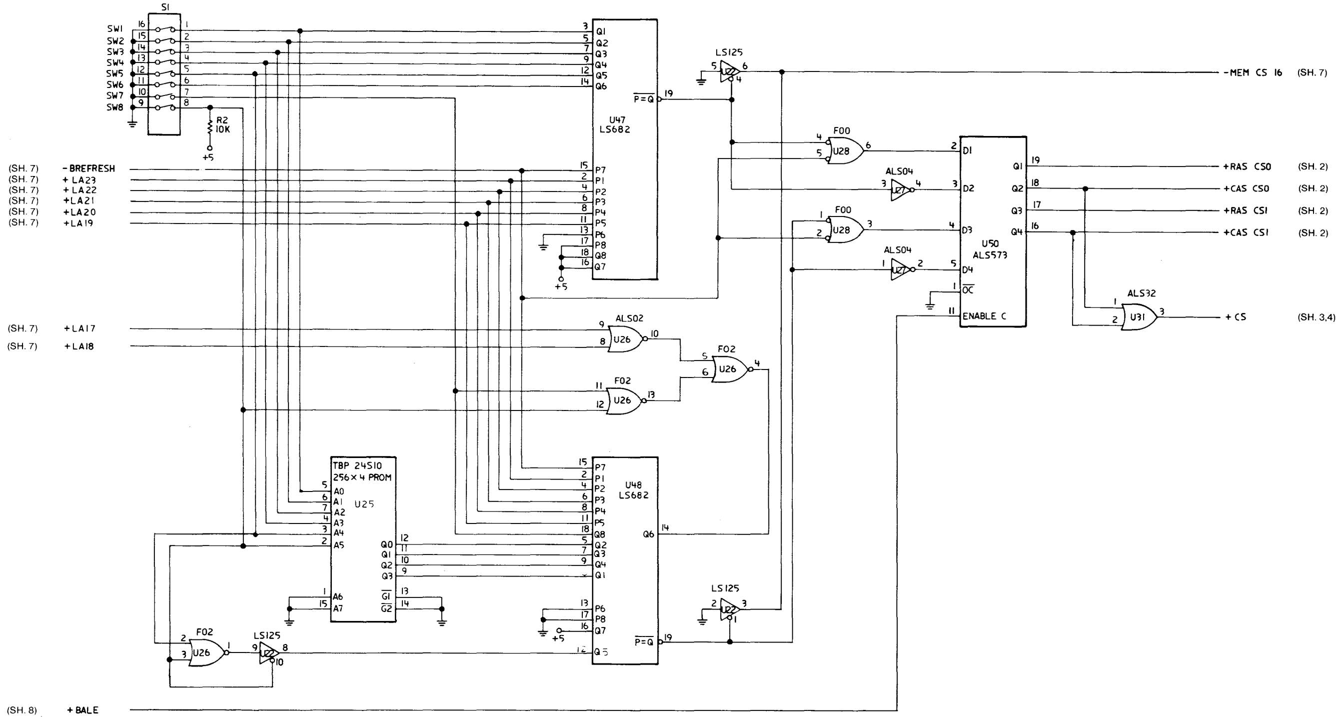
The first 512K of expansion memory must start at address space hex 100000. If additional memory expansion options are installed, no gaps between memory are allowed. All expansion memory must be one contiguous block starting at address hex 100000.

Specifications

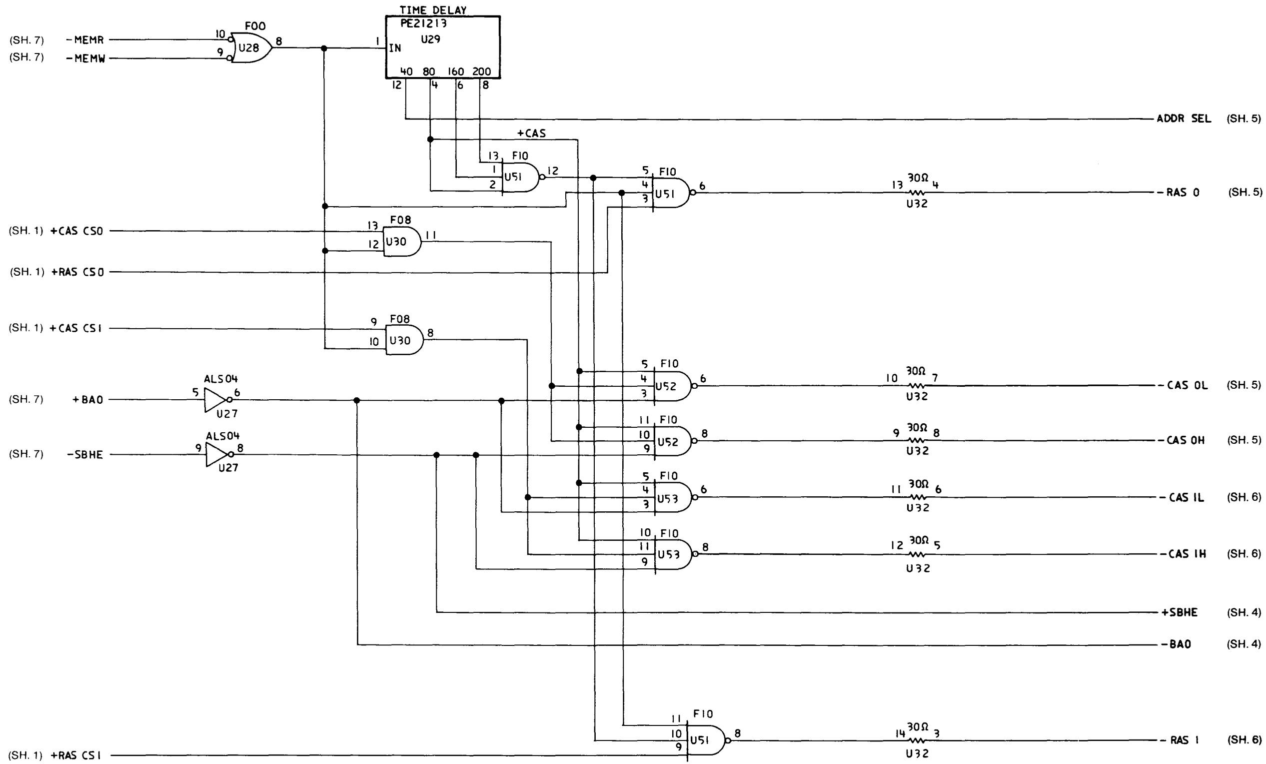


Pin	256K by 1 bit Module	64K by 1 Bit Module
1	A8	N/C
2	Data In *	Data In *
3	-Write	-Write
4	-RAS	-RAS
5	A0	A0
6	A2	A2
7	A1	A1
8	+5 Vdc	+5 Vdc
9	A7	A7
10	A5	A5
11	A4	A4
12	A3	A3
13	A6	A6
14	Data Out *	Data Out
15	-CAS	-CAS
16	GND	GND
* Data In and Data Out are tied together on Data Bits 0 - 7 (three state bus)		

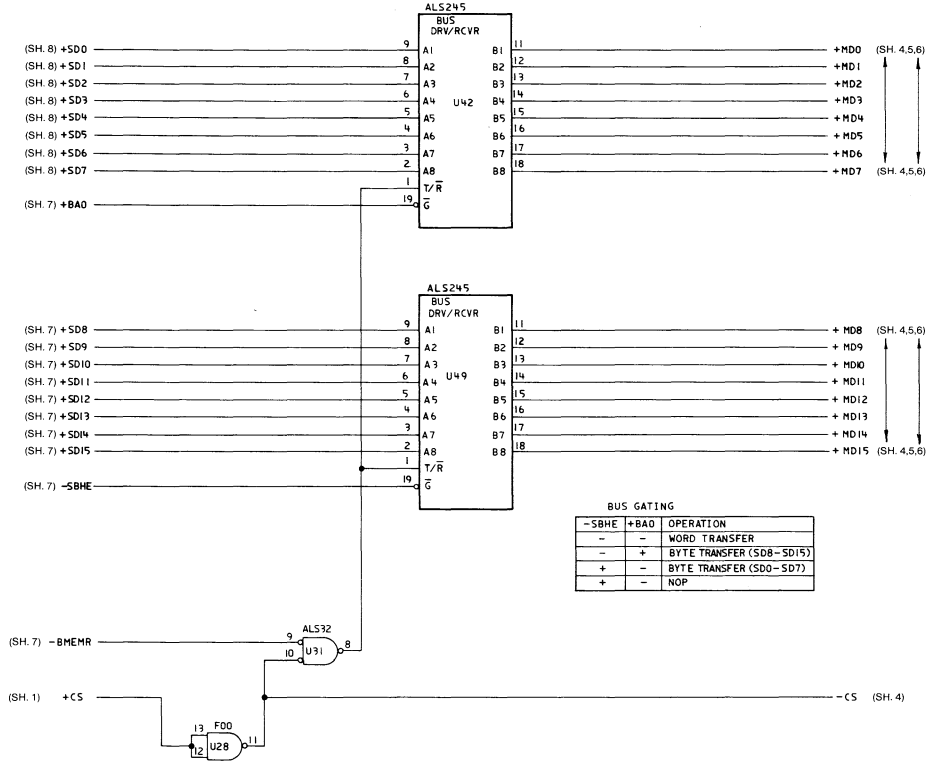
Memory Module Pin Configuration



128/640 Memory Card (Sheet 1 of 8)



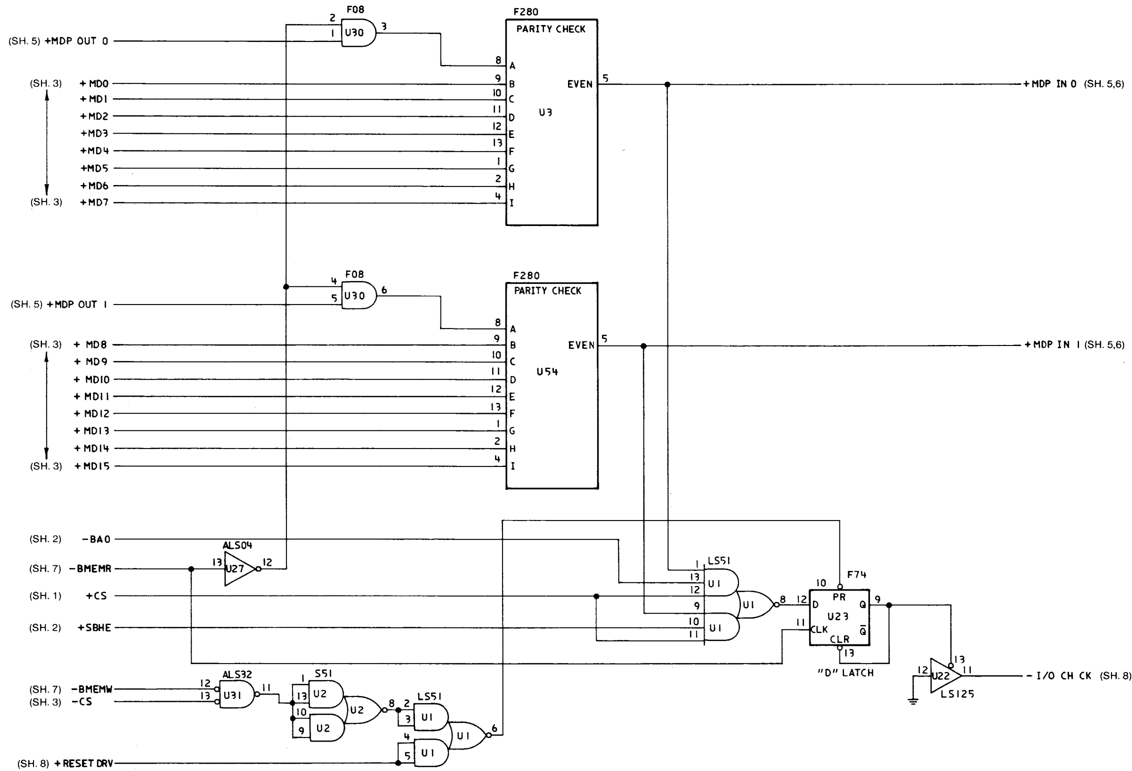
128/640 Memory Card (Sheet 2 of 8)



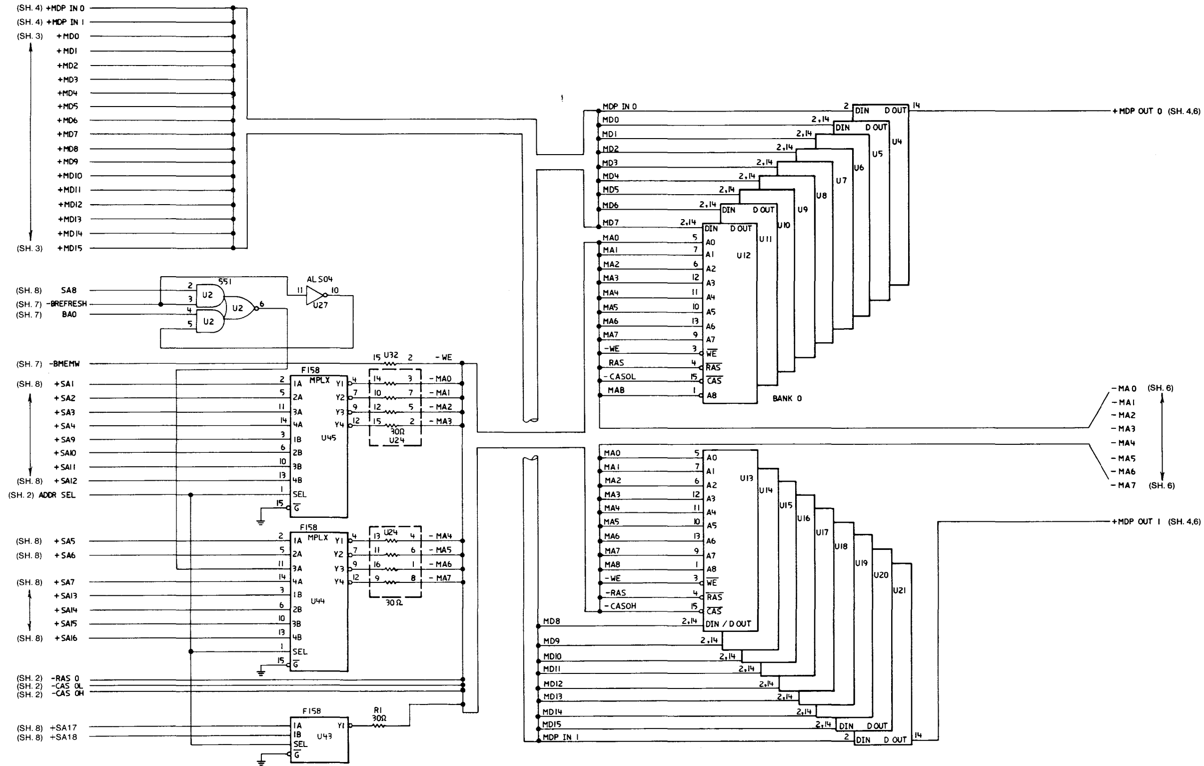
BUS GATING

-SBHE	+BA0	OPERATION
–	–	WORD TRANSFER
–	+	BYTE TRANSFER (SD8–SD15)
+	–	BYTE TRANSFER (SD0–SD7)
+	–	NOP

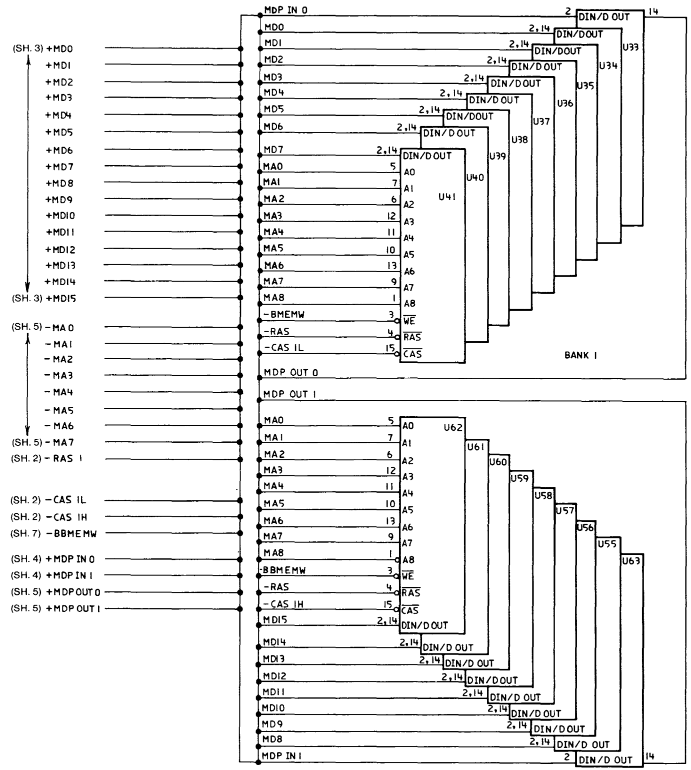
128/640 Memory Card (Sheet 3 of 8)



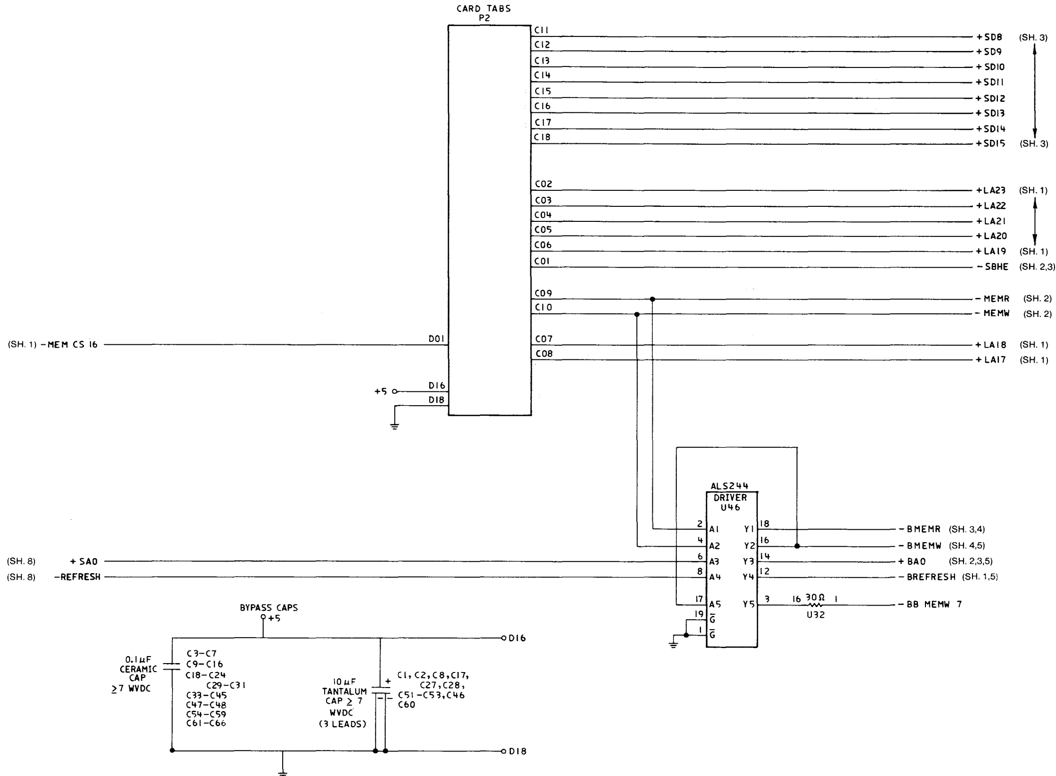
128/640 Memory Card (Sheet 4 of 8)



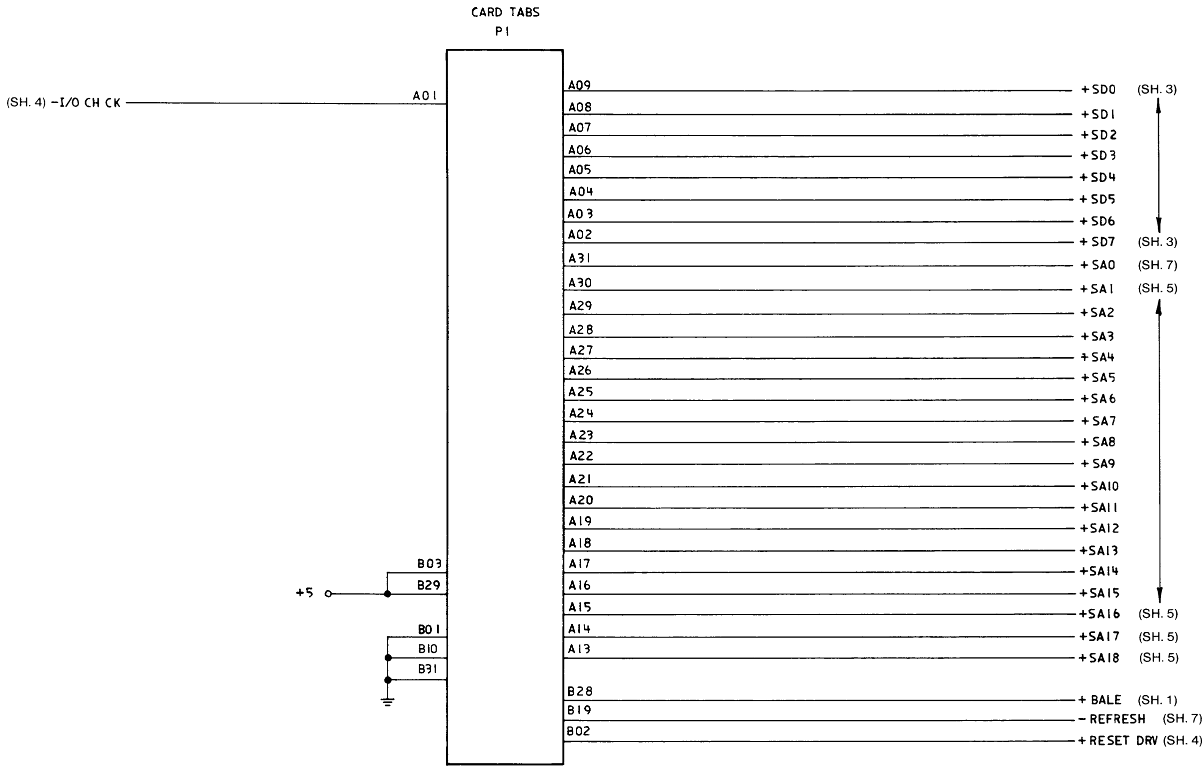
128/640 Memory Card (Sheet 5 of 8)



128/640 Memory Card (Sheet 6 of 8)



128/640 Memory Card (Sheet 7 of 8)



128/640 Memory Card (Sheet 8 of 8)

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IBM Personal Computer AT®
512KB/2MB Memory
Expansion Option

6183310

March 18, 1986

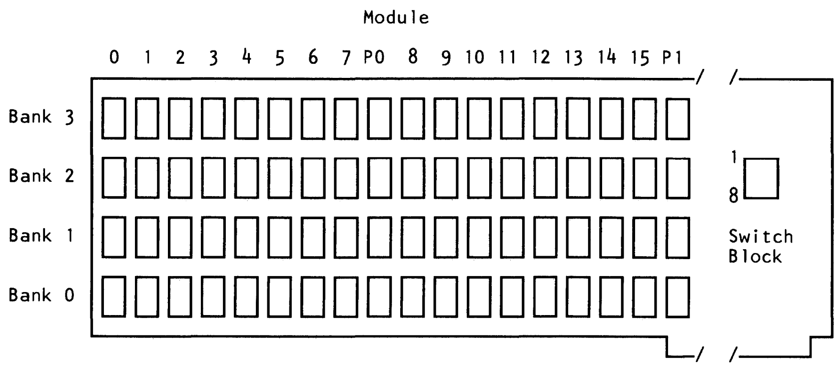
Contents

Notes:

Description

The IBM PERSONAL COMPUTER AT® 512KB/2MB Memory Expansion provides 512K of additional random access memory (RAM) and can be expanded to provide a total of 2M of additional RAM.

Four 18-socket banks accept 256K-by-1 dynamic RAM (DRAM) modules. Bank 0 is fully populated. Banks 1, 2, and 3 may be populated by using three IBM Personal Computer AT 512KB Memory Module Kits, consisting of eighteen 256K-by-1 DRAM modules each.



Memory Module Location

Operating Characteristics

Memory-read (MEMR) and memory-write (MEMW) operations require a 1-wait-state, 3-clock memory cycle. Data moves as a byte (8 data bits and 1 parity bit) or as a word (16 data bits and 2 parity bits) and is parity-checked on the adapter.

I/O Channel Check

If a parity error is detected, a latch is set and an '-I/O channel check' line is activated; the result is a non-maskable interrupt (NMI) indicating an error to the system unit's microprocessor. The status bits (I/O channel check and system-board parity check) determine the source. Writing to the failing option clears the status bit.

Memory Address Switches

An eight-switch DIP module is mounted on the memory expansion option. These switches set the starting address for each option above the 1M system board RAM. The switch assignments for the starting address for Bank 0 are as follows:

Switch Number	Switch Assignments	
1	ON:LA23 = 0	OFF:LA23 = 1
2	ON:LA22 = 0	OFF:LA22 = 1
3	ON:LA21 = 0	OFF:LA21 = 1
4	ON:LA20 = 0	OFF:LA20 = 1
5	ON:LA19 = 0	OFF:LA19 = 1
6	Not Used.	
7	Not Used.	
8	Not Used.	

Switch Assignments

The address of the first expansion memory option must start at address space hex 100000. If additional memory expansion options or IBM Personal Computer AT 512KB Memory Module Kits are installed, no gaps between memory are allowed. All expansion memory must be one contiguous block starting at address hex 100000.

Notes:

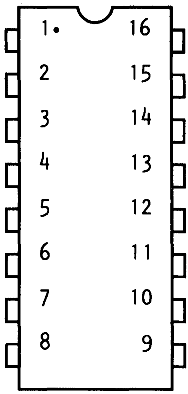
1. An expansion option must be fully populated before another can be installed.

2. In order to determine the total expansion memory installed check bytes hex (30 & 31) in CMOS RAM.

Programming

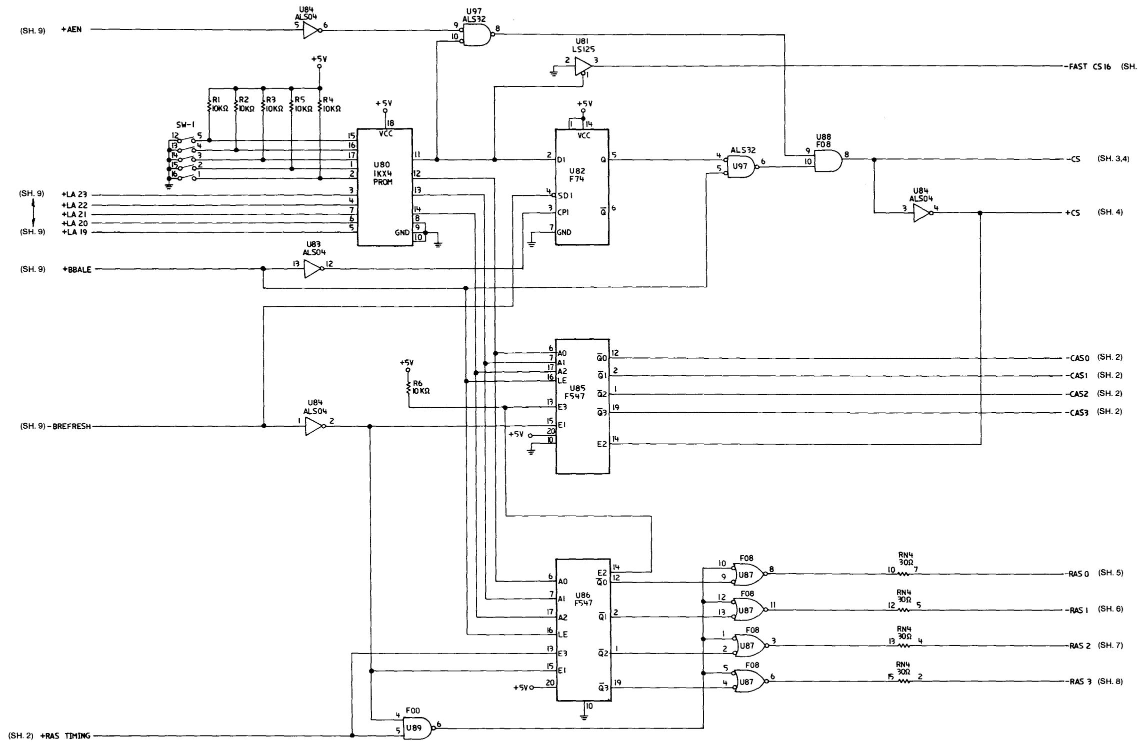
Programs that test for memory by writing and reading until a data error is detected, must write back to the failing card to clear possible parity checks. This is required for a partially populated 512KB/2MB Memory Expansion.

Specifications

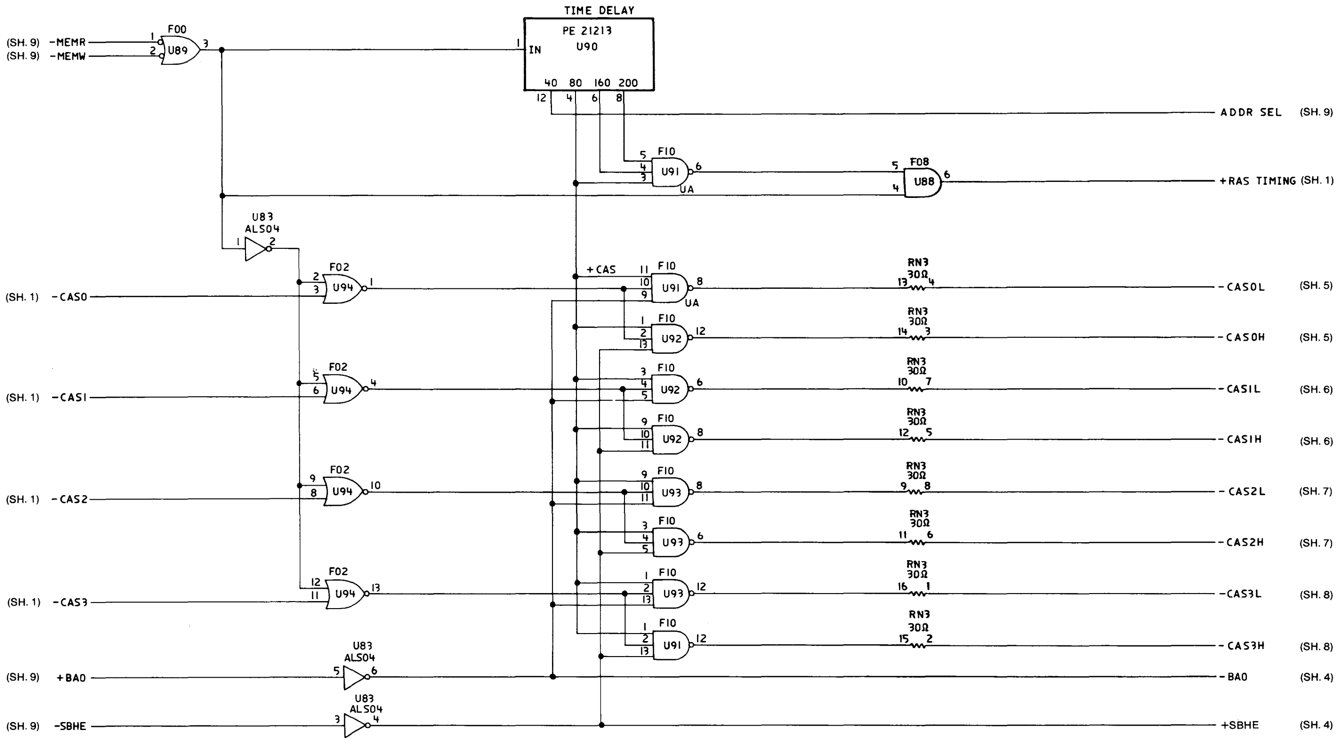


Pin	256 by 1 Bit Module
1	A8
2	Data In *
3	-Write
4	-RAS
5	A0
6	A2
7	A1
8	+5 Vdc
9	A7
10	A5
11	A4
12	A3
13	A6
14	Data Out *
15	-CAS
16	Ground
* Data In and Data Out are tied together on Data Bits 0-7 (three state bus).	

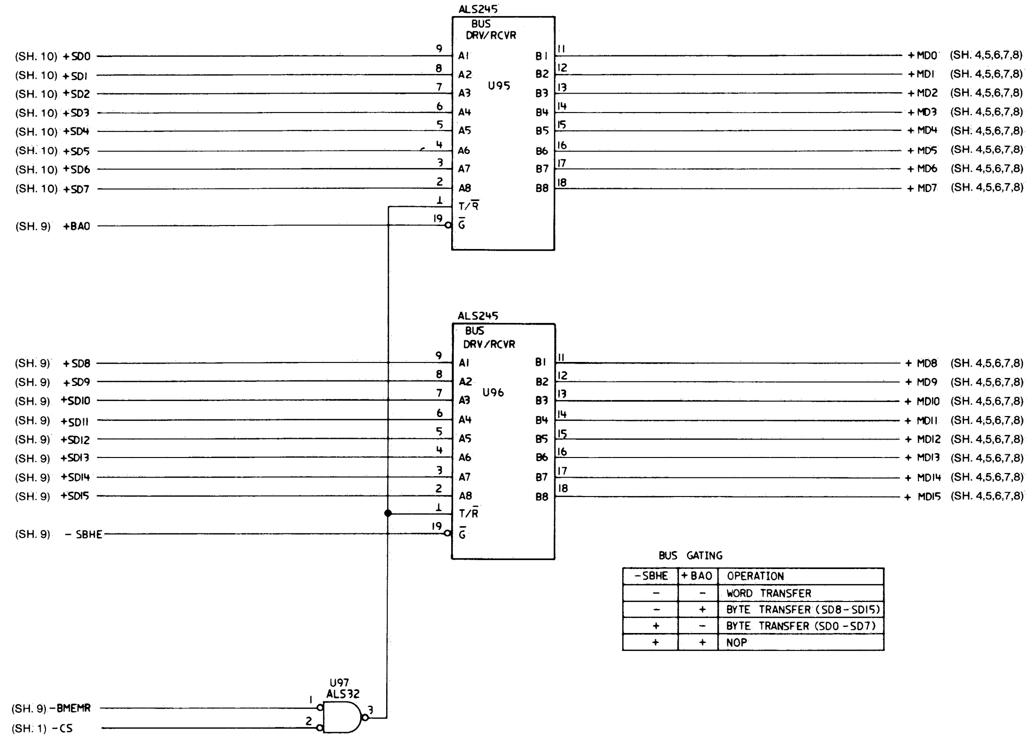
Memory Module Pin Configuration



512KB/2MB Memory Card (Sheet 1 of 10)



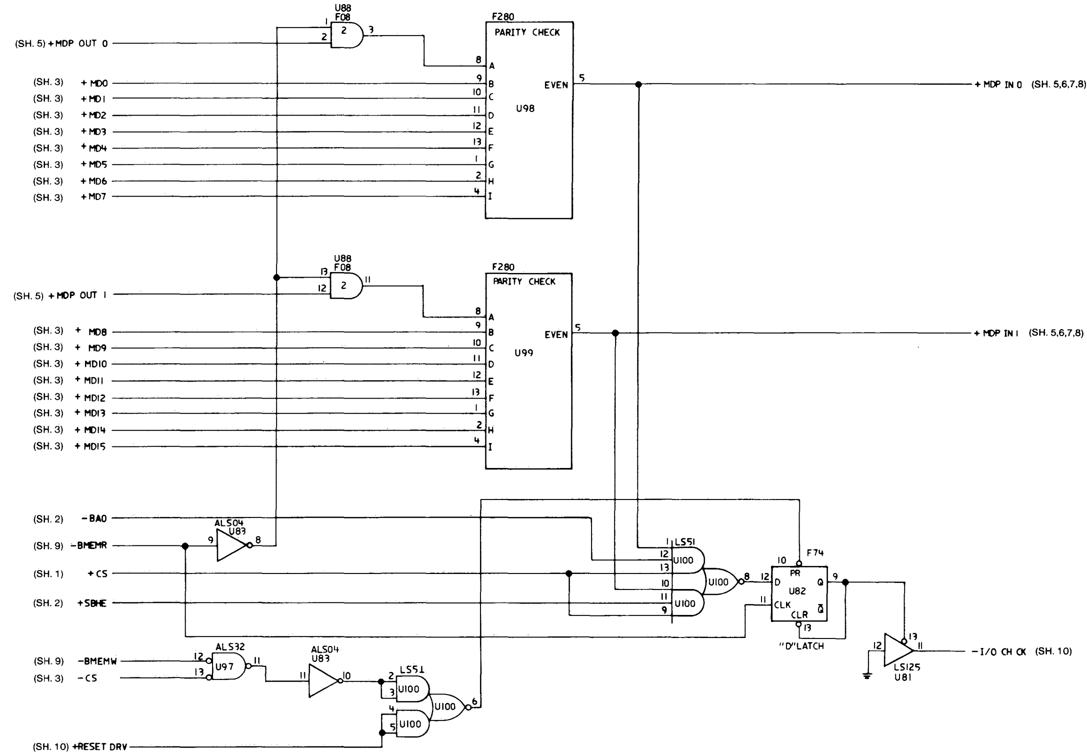
512KB/2MB Memory Card (Sheet 2 of 10)



BUS GATING

-SBHE	+BA0	OPERATION
–	–	WORD TRANSFER
–	+	BYTE TRANSFER (SD8-SD15)
+	–	BYTE TRANSFER (SD0-SD7)
+	+	NOP

512KB/2MB Memory Card (Sheet 3 of 10)



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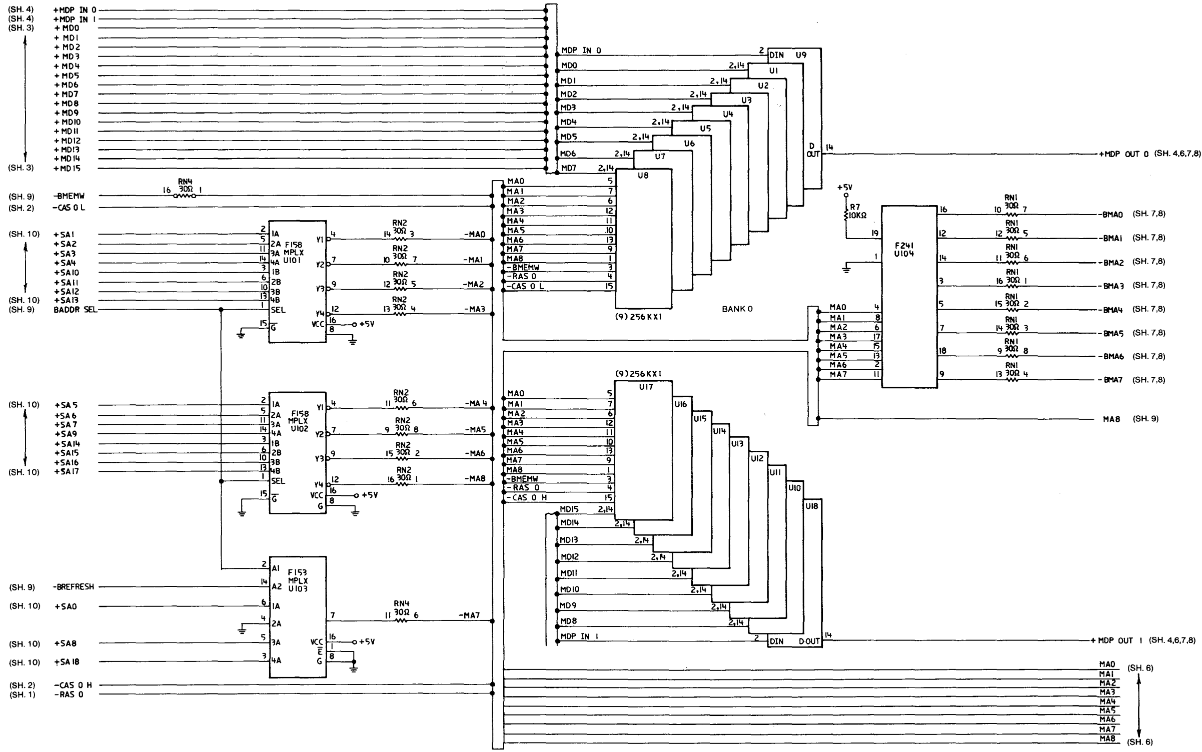
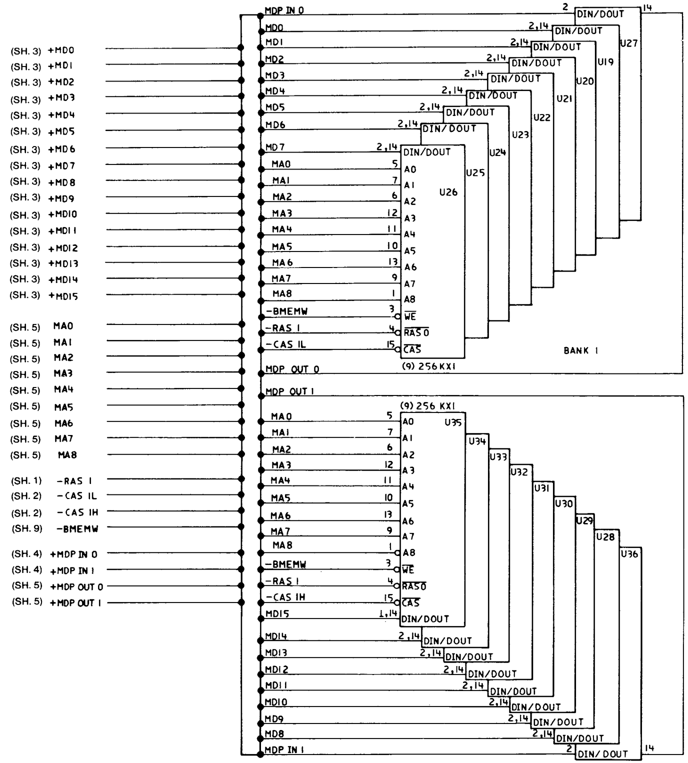
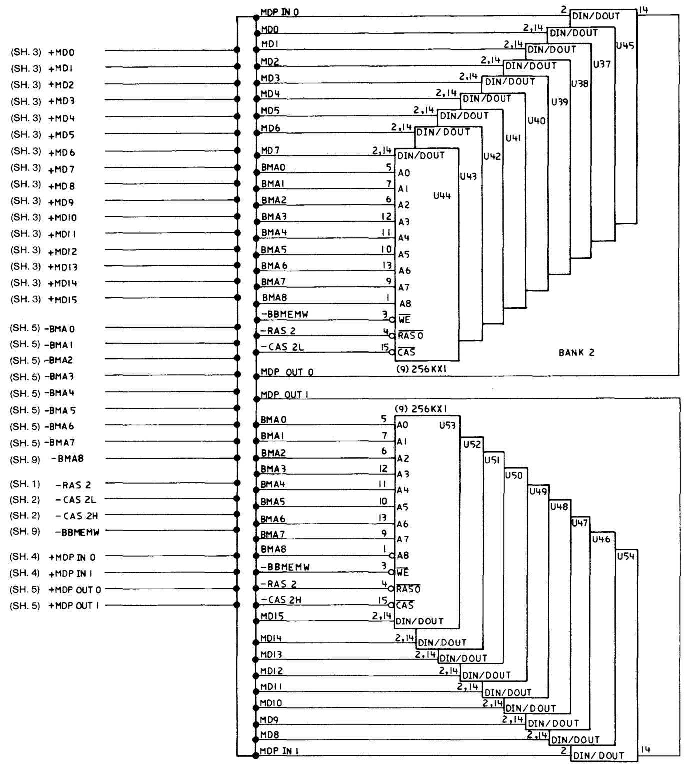


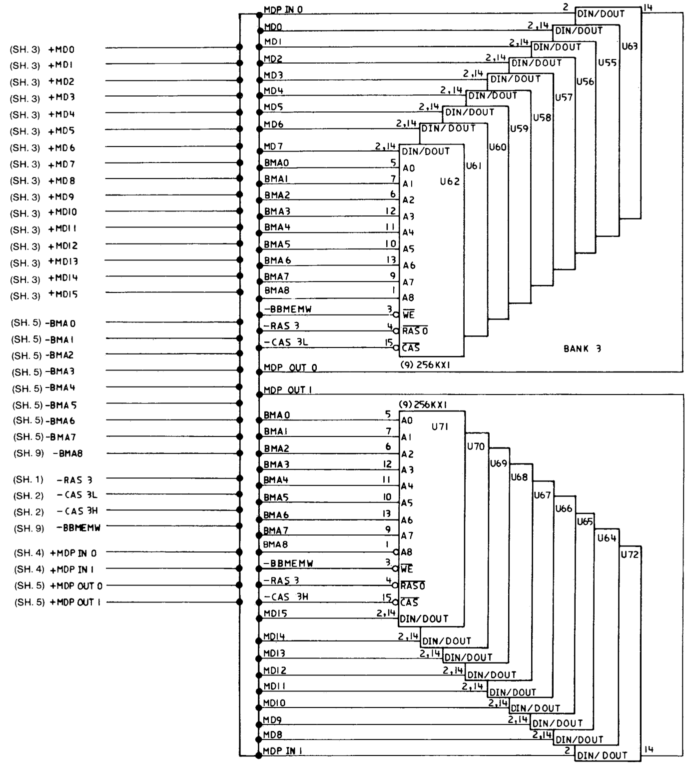
512KB/2MB Memory Card (Sheet 5 of 10)



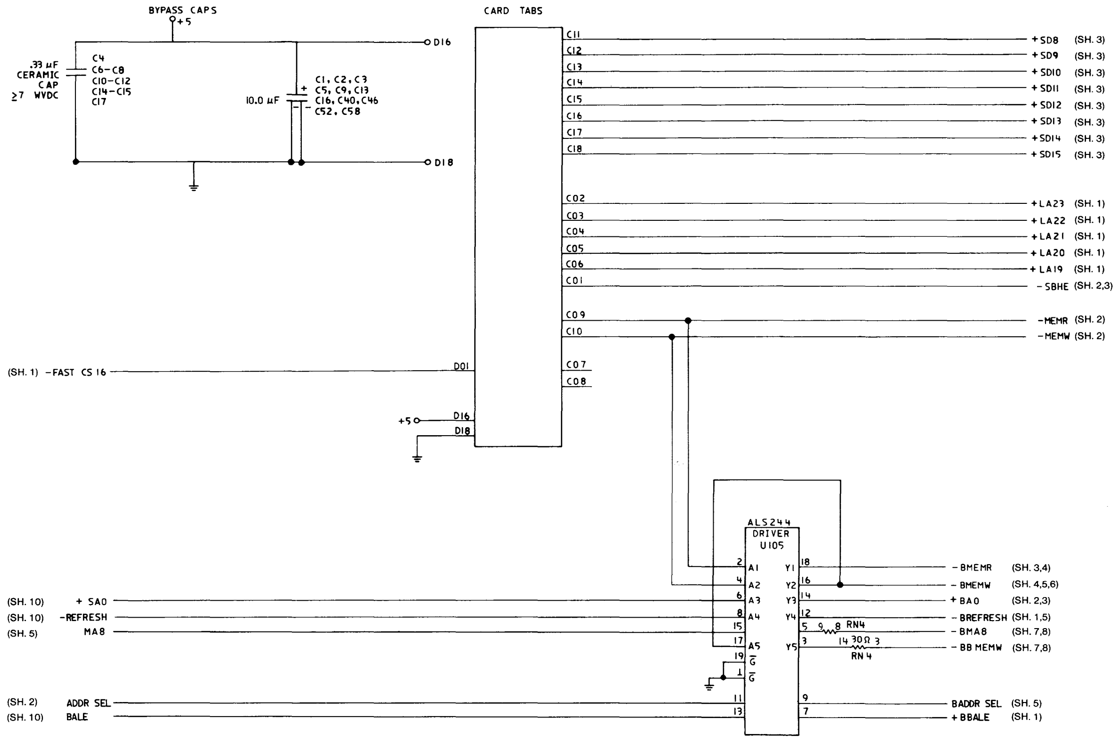
512KB/2MB Memory Card (Sheet 6 of 10)



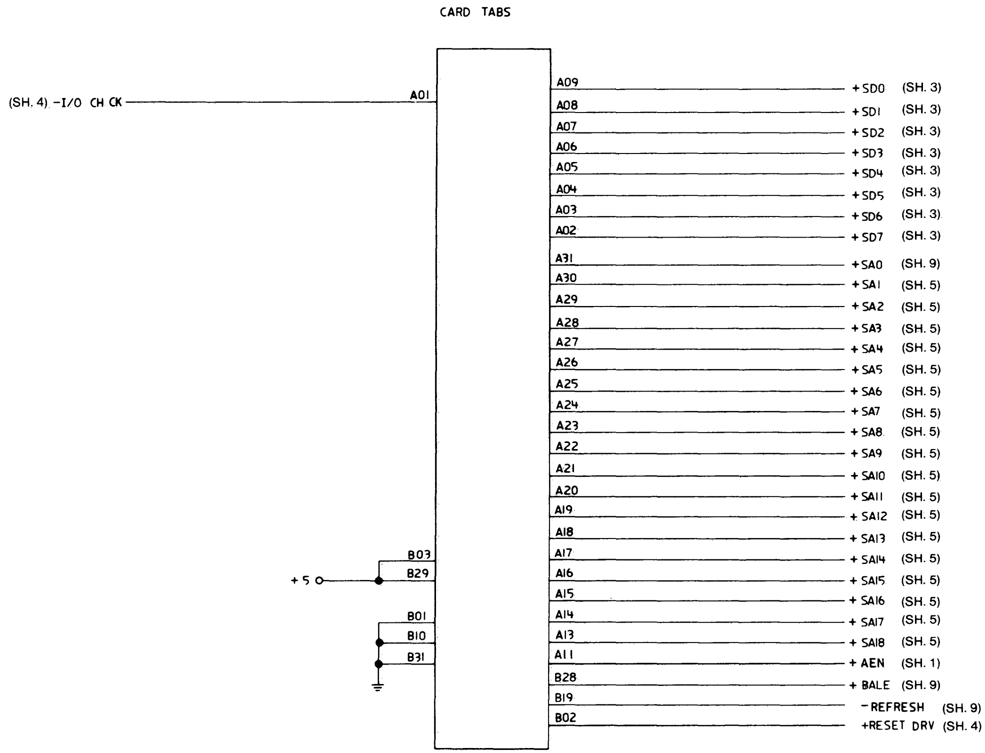
512KB/2MB Memory Card (Sheet 7 of 10)



512KB/2MB Memory Card (Sheet 8 of 10)



512KB/2MB Memory Card (Sheet 9 of 10)



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Volume 1

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