

PERSYST™

COLOR GRAPHICS
DISPLAY ADAPTER
FOR THE IBM® PC.

HOW TO INSTALL IT.
HOW TO USE IT.

PERSYST™

INVENTORY CHECKLIST

Your **PERSYST™ Color Graphics Display Adapter** carton contains the following:

- Color Graphics Display Adapter (Board)
- Card Guide
- Installation Guide
- Limited Warranty (Printed on Back of Inventory Checklist)

If any items are missing or damaged, consult your place of purchase for the procedure to follow in order to correct the problem.

Insert this documentation in the *Guide to Operations* (in the section reserved for add-on options) which you received with your IBM Personal Computer.

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COLOR GRAPHICS DISPLAY ADAPTER INSTALLATION AND TECHNICAL REFERENCE GUIDE

Manual Number 16-00250-00

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1.0 INTRODUCTION

Your PERSYST™ Color Graphics Display Adapter is designed to allow you to attach a variety of displays to your IBM Personal Computer (PC). You can use this adapter to interface the following display types to your system:

- IBM Color Display.
- IBM-Compatible Color Display.
- Monochrome or Color Composite Display.
- Radio Frequency (RF) Modulator for use with televisions.

The Color Graphics Display Adapter also allows you to attach a lightpen to your system. Some typical uses for a lightpen are (1) screen graphics and text editing; (2) menu selection; (3) symbol sensing; and (4) Integrated Circuit (IC) masking and schematic design.

Designed around the Motorola 6845 CRT (Cathode Ray Tube) controller device, the adapter is programmable regarding raster and character parameters. This flexibility is essential to create customized graphics on your screen.

The adapter operates in one of four modes — medium-resolution graphics mode, high-resolution graphics mode, low-resolution alphanumeric mode, or high-resolution alphanumeric mode. The medium-resolution graphics mode allows a 320-horizontal x 200-vertical pixel matrix (dots of light on the screen), and the high-resolution graphics mode allows a 640-horizontal x 200-vertical pixel matrix. The pixels can be displayed in a variety of colors. The low-resolution alphanumeric mode is 40 characters by 25 rows and the high-resolution alphanumeric mode is 80 characters by 25 rows.

The adapter contains 16 kilobytes (KB) of dynamic memory as display memory for storing information to be output to the screen. The processor may access this memory at any time without causing disturbances to the screen images in all modes except the high-resolution (80 x 25) alphanumeric mode. (In the high-resolution alphanumeric mode, accesses should be made **ONLY** during retrace intervals. See Section 4.2.) No parity is provided on the display memory.

The adapter gives you 256 different character codes in sixteen colors and uses a 2732-type Erasable-Programmable Read-Only Memory (EPROM) device as the character generator. Because the device can be programmed easily, you have the option of customizing character sets to fit your needs.

This 4-KB character generator contains the fonts (dot patterns) for the characters. That is, it provides two complete 256-character sets — one that contains characters in which the vertical lines are two dots thick and one that contains characters in which the vertical lines are one dot thick.

You select the character set that you want to use by a jumper located on the board. (See Section 3.0.)

1.1 FEATURES

The major features of the Color Graphics Display Adapter are listed below:

- Offers both direct-drive (Intensity-Red-Green-Blue, IRGB) and composite-video color outputs.
- Uses a 15.750 kiloHertz (KHz) horizontal rate.
- Provides two alphanumeric modes — a 40-character x 25-row mode for low-resolution (color TV) displays and an 80-character x 25-row mode for high-resolution displays.
- Offers two graphics modes — a 320 x 200 pixels, medium-resolution mode with four colors and a 640 x 200 pixels, high-resolution mode with one color.
- Supports color mode with 16 colors or black and white mode.
- Allows choice of the following character attributes: blinking, blanked (security fields), intensity, and reverse video.
- Uses 16 KB of display memory for storing alphanumeric and graphics information.
- Allows Direct Memory Access (DMA) operations of the display memory.

- Displays a 7 x 7 dot character in an 8 x 8 dot grid.
- Provides 256 displayable characters:
 - 16 special characters for game support.
 - 15 characters for word processing editing support.
 - 96 characters for the standard ASCII character set.
 - 48 characters for foreign language support.
 - 48 characters for business block graphics support — allows drawing of charts, boxes, and tables using single and double lines.
 - 16 selected Greek characters.
 - 15 selected scientific notation characters.
- Allows easy creation of custom character sets because the character generator is a 2732-type 4KB x 8 EPROM device.
- Provides a lightpen interface.
- Supports a user-supplied RF modulator.
- Allows **NO MORE** than two low-power Schottky (LS) loads on any input/output (I/O) slot pin, which prevents the backplane signals from becoming overloaded.
- Is **TOTALLY** compatible with IBM Color Graphics Display Adapter software.
- Provides **ALL** functions available on the IBM Color Graphics Display Adapter.

1.2 ORGANIZATION OF THIS GUIDE

This guide explains how to install and use the PERSYST Color Graphics Display Adapter. Technical information is also included to aid you in programming and using the adapter for your specialized needs.

The first three sections of this guide contain information necessary for installing the adapter. The information in Section 4.0 **IS ONLY** useful for the user that requires more in-depth technical information than is necessary for installing and operating the adapter as a “turn-key” addition to the PC. That section explains how to program the adapter and use it with your specialized applications programs.

The contents of each section of the guide are briefly outlined below:

1.0 INTRODUCTION

Gives an overview of the Color Graphics Display Adapter and describes this guide.

2.0 PREINSTALLATION INFORMATION

Lists the tools you will need to install the Color Graphics Display Adapter in the your personal computer and explains how to remove the system unit cover.

3.0 INSTALLATION INSTRUCTIONS

Lists the steps for installing the Color Graphics Display Adapter in your personal computer.

4.0 TECHNICAL INFORMATION

Presents the technical information necessary for programming and using the Color Graphics Display Adapter for specialized tasks. The board registers and operational modes are explained.

APPENDIX A: CHARACTER AND TEXT ATTRIBUTE VALUES

Lists the hexadecimal and decimal values for the characters and text attributes.

APPENDIX B: QUICK REFERENCE CHARACTER CHART

Provides a quick reference tool for the character set.

APPENDIX C: CONNECTOR PINOUTS

Lists the connector pinouts for the 9-pin direct-drive connector, the composite phone jack connector, the lightpen 6-pin strip, and the RF modulator 4-pin strip.

2.0 PREINSTALLATION INFORMATION

2.1 TOOL REQUIREMENTS

The tools listed below are the only tools that you will need to install your Color Graphics Display Adapter:

- Medium-sized, flat blade screwdriver.
- Small-sized, flat blade screwdriver.
- A 3/16" nutdriver or 3/16" wrench.
- A pair of small needlenose pliers.

2.2 REMOVING THE SYSTEM UNIT COVER

In order to gain access to the expansion slots, the system unit must be disconnected from the other system components and the unit cover removed. The steps listed below explain how to prepare your unit for the Color Graphics Display Adapter installation.

1. Place the system unit switch to the OFF position.
2. Place power switches for external equipment to the OFF position (printer, TV/monitor, and so forth).
3. Unplug the system unit and other optional equipment from the wall outlet.
4. Disconnect all cables from the rear panel of the system unit.
5. Remove the keyboard and optional equipment from the system work area.
6. Position the system unit to allow easy access to the rear panel.

7. Remove the cover mounting screws located on the rear panel using a flat blade screwdriver. (The number of screws depends on the model of your PC.)

The PC-XT and upgraded version of the PC (64 to 256 KB on the motherboard) have five screws; the original PC has two screws. The screws are located in the upper and lower left- and right-hand corners and the upper center of the back panel. Turn the screws counterclockwise (CCW); once removed, place the screws in a safe place. See Figure 2-1 for screw location.

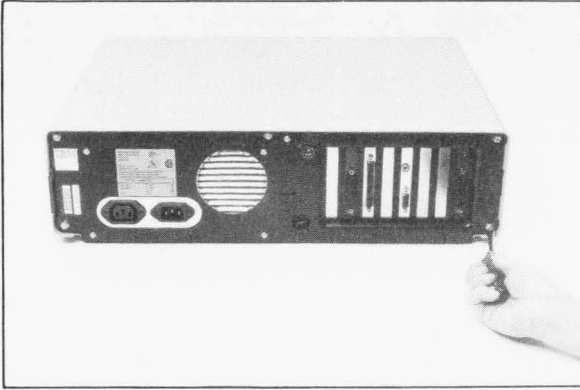


Figure 2-1. Removing the Cover Mounting Screws.

- Carefully slide the system unit cover forward from the rear as shown in Figure 2-2. When the cover will go no further, tilt the cover up and remove from the base. Set the cover aside in a safe place.

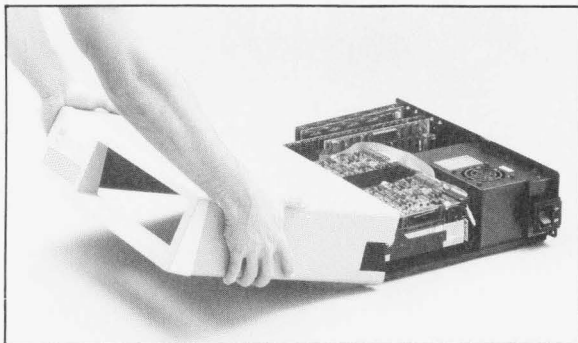
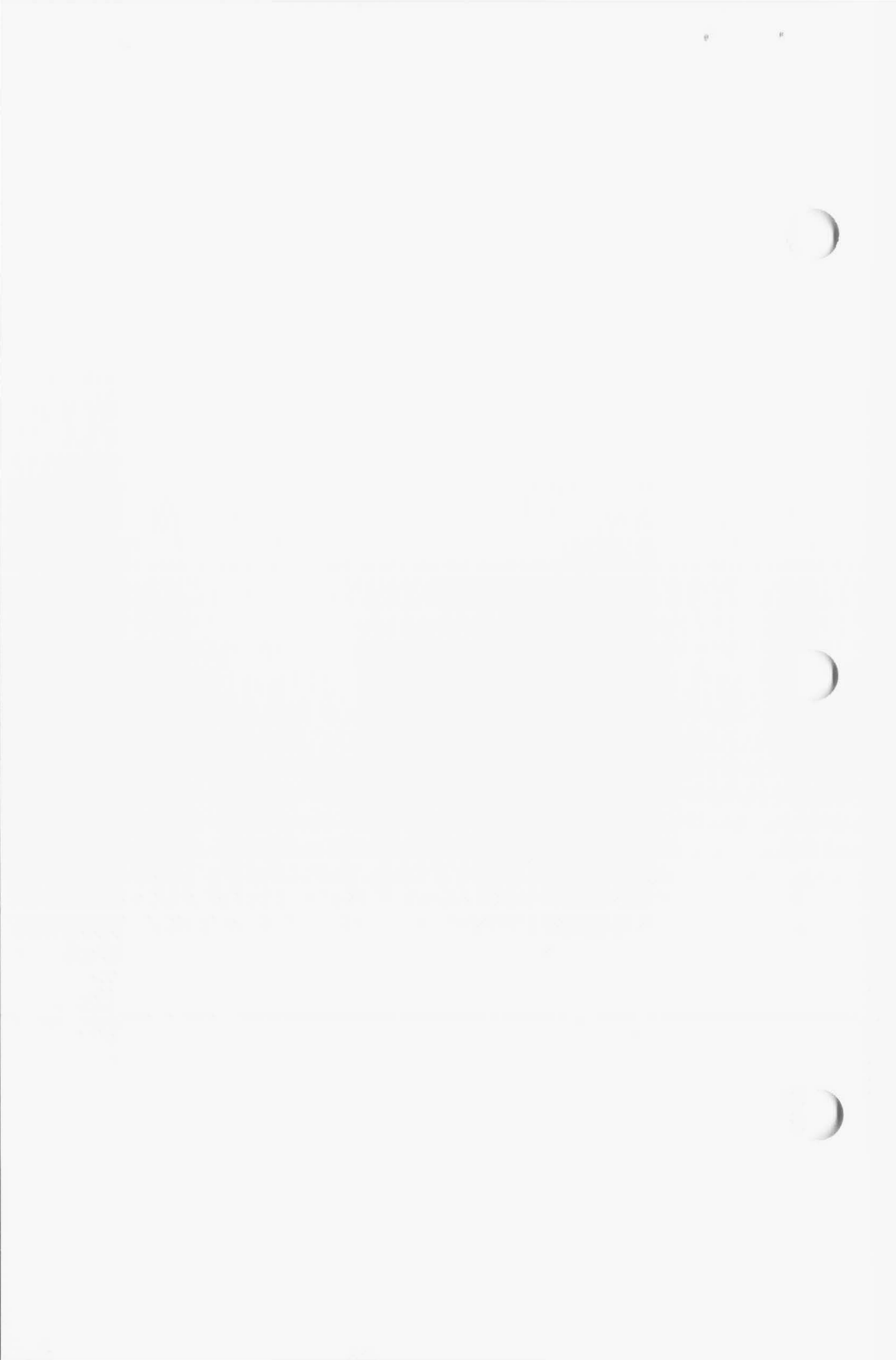


Figure 2-2. Removing the System Unit Cover.



3.0 INSTALLATION INSTRUCTIONS

Except for the choice of character set, your PERSYST Color Graphics Display Adapter is designed to be installed in your system without any changes or adjustments to the board. Two character sets are available — one in which the vertical lines of each character are two dots wide, and one in which the vertical lines of each character are one dot wide.

The factory configuration gives you the character set that has vertical lines that are two dots wide. If you want to use this character set, install your Color Graphics Display Adapter without any changes or adjustments.

If you want characters with vertical lines that are one dot wide, remove the jumper between E1 and E2 located toward the left side of the board. See Figure 3-1 for the location of the jumper on the board and for the general locations of other components.

The choice between the character sets depends on your preference and your display type. The two-dot character set does not appear as crisp and clean as the one-dot set and the space between characters is generally larger with the one-dot set. However, on some displays the one-dot set may appear to have horizontal lines that are thicker than the vertical lines.

NOTE

Only one color adapter may be installed in the IBM PC at a time. If an IBM Color Graphics Display Adapter or a PERSYST Color Graphics Display Adapter is already installed in your PC, **DO NOT** install this adapter! Damage to the PC and the color adapter may result if more than one color adapter is installed in the system.

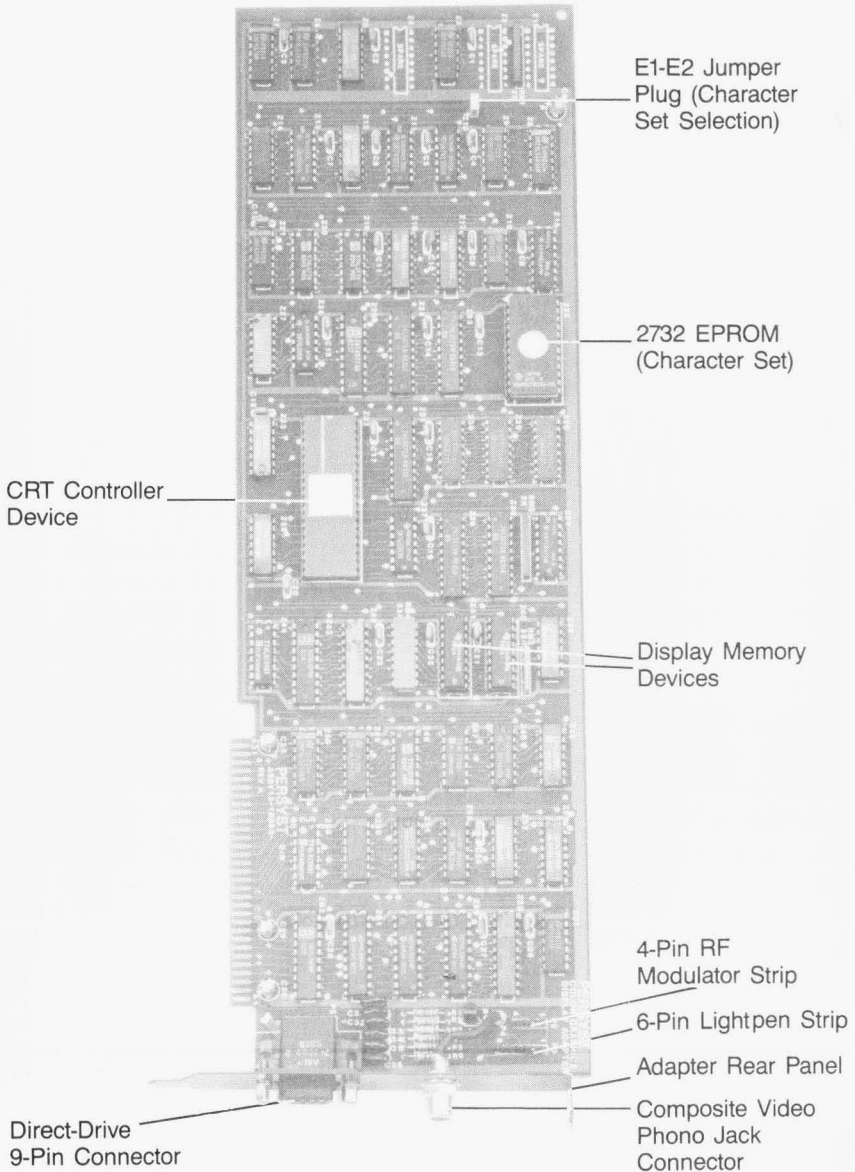


Figure 3-1. Jumper and Component Locations.

3.1 INSTALLING THE COLOR GRAPHICS DISPLAY ADAPTER

The following steps explain how to install your Color Graphics Display Adapter.

1. Facing the disk drives, look at the inside left rear of your system unit. Several expansion slots are available for additional boards; you can install your Color Graphics Display Adapter in one of the unused, full-sized slots.
2. Using a flat blade screwdriver or a 3/16" nutdriver, remove the screw that holds the system expansion slot cover in place by turning it counterclockwise (CCW). See Figure 3-2.

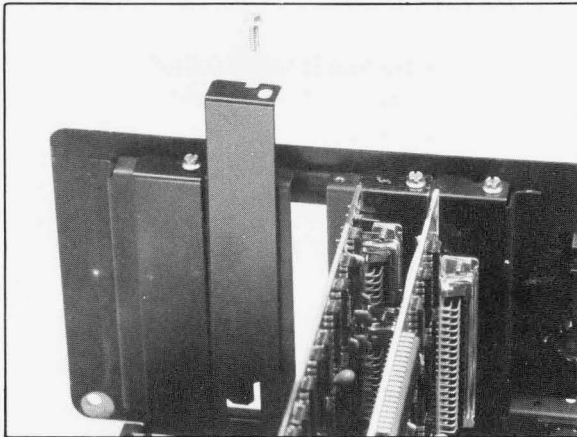


Figure 3-2. Removing the System Expansion Slot Cover.

3. Install the card guide that was supplied with your Color Graphics Display Adapter using the holes in the front of the system unit that are aligned with the selected slot. See Figure 3-3.

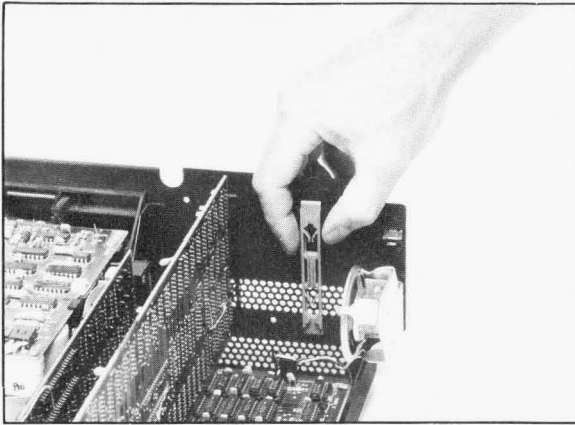


Figure 3-3. Installing the Card Guide.

4. Insert the Color Graphics Display Adapter into the IBM motherboard connector, fitting the module rear panel over the unit rear panel. The adapter slides down between the grooves of the card guide and fits into the motherboard connector, which faces up from the motherboard. See Figure 3-4. Press down firmly on the Color Graphics Display Adapter to be sure that it is securely seated in the connector.

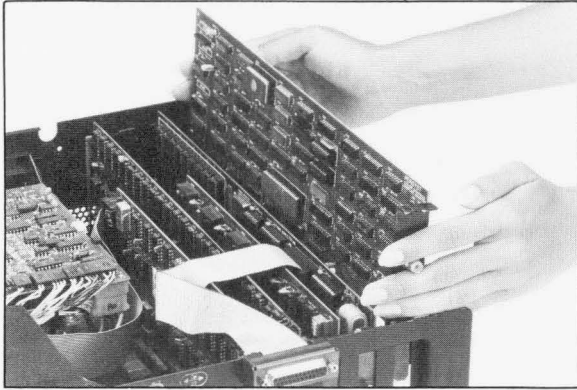


Figure 3-4. Seating the Color Graphics Display Adapter in the IBM Motherboard.

5. Reinstall the screw that was removed in Step 2.
6. Replace the system unit cover and reassemble the system. (Perform the steps listed in Section 2.2 in the REVERSE order.)

3.2 CONNECTING EXTERNAL EQUIPMENT TO THE COLOR GRAPHICS DISPLAY ADAPTER

External equipment (primarily the monitor) is connected to the Color Graphics Display Adapter by the connectors that are now available on the rear panel of the system unit. These two connectors now protrude through the rear panel of the system unit. (See Figure 3-1 for the location of these connectors on the board.)

The small, 9-pin connector on the rear panel of the system unit is the color display connector. The phono jack connector (the small, round connector) is the composite video output. If you are connecting a direct-drive (IRGB) monitor, make the connection with the 9-pin connector. If you are connecting a monitor type that uses composite video output, connect the monitor using the phono jack connector.

Check the specifications of your monitor to determine which type (direct-drive or composite video) of monitor you are connecting.

NOTE

DO NOT install an IBM Monochrome Display or other compatible monochrome monitor to the Color Graphics Display Adapter. If you connect a monitor (monochrome) that has a horizontal frequency **OTHER THAN** 15.750 kiloHertz (KHz), you will permanently and severely damage the monochrome monitor.

The following steps describe the connection of a direct-drive monitor to the board.

1. Attach the connector at the end of the IBM Color Graphics Display (or other compatible monitor) cable to the small, 9-pin connector on the Color Graphics Display Adapter which is available on the rear panel of the system unit.

Make sure that the connector is seated by firmly pressing the cable connector onto the pins on the rear panel.

2. To ensure that the cable is not accidentally pulled loose from the Color Graphics Display Adapter, turn each screw located on the color display cable connector clockwise (CW) until snug. Do not over tighten these screws.

If you are installing a monitor that does not have a standard 9-pin connector, refer to Appendix C for the connector pinouts.

The following steps describe the connection of a composite video monitor to the board.

1. Insert the RCA-type phono jack in the phono jack connector on the rear panel of the board. (See Figure 3-1.)

NOTE

If you get **NO** video or a weak video image, you may not have reinstalled the screw that attaches the board to the system unit. See Step 5 in Section 3.1. This screw **MUST** be installed when using a composite video monitor.

If you are installing a composite video monitor that does not have a standard RCA-type phono connector refer to Appendix C for the connector pinouts.

If you are installing a lightpen or a Radio Frequency (RF) modulator, refer to Appendix C for the connector pinouts.

4.0 TECHNICAL INFORMATION

This section gives you detailed technical information about the Color Graphics Display Adapter. The various operating modes of the adapter are explained, and information for programming those modes is given.

This type of information is important primarily to the user who wants to write programs that switch between the operating modes or who want to customize or specialize the operation of the board for specific uses.

The information in this section is **NOT** necessary to operate the adapter in your system. Any software running on the IBM PC provides programming considerations so that the adapter operates correctly. You will need this technical information **ONLY** if you wish to program the adapter.

Also, you may refer to the IBM *Technical Reference* manual for the specifications of the IBM Color Display and related technical information.

4.1 INTRODUCTION

This section is organized to explain the operation of the adapter in terms of registers and modes. That is, an overview of the hardware and registers is presented first. The implementation of the various modes is then explained. The function of each register must be understood before the bit-functions within the register can be explained in relationship to a specific mode. Because the bits in the registers may have multiple functions depending on the mode of operation, the detailed information about each bit is presented after the general descriptions of the registers.

This organization, thus, divides the information into two major categories — (1) register descriptions and (2) display memory organization. The first category covers programming the Cathode Ray Tube (CRT) controller device (Motorola 6845) and explanations of the hardware registers of the Color Graphics Display Adapter. The second category relates the memory organization used for each mode of operation — the specific bits of the registers in relationship to that mode of operation.

4.2 REGISTER DESCRIPTIONS

In order to program using the registers on the adapter and in the CRT controller device, you must be able to address those locations. Table 4-1 shows the input/output (I/O) register addresses for the various registers that are discussed in subsequent subsections.

The I/O address decode is from hex 3D0 through hex 3DF. The bit assignment for each I/O address is given in Table 4-1. (All addresses are listed in hexadecimal.)

Table 4-1. I/O Address and Bit Map.

I/O Register Address	Function
3D0	Not Used
3D1	Not Used
3D2	Not Used
3D3	Not Used
3D4 *	6845 Index Register
3D5 *	6845 Data Register
3D6	Not Used
3D7	Not Used
3D8	Mode Select Register
3D9	Color Select Register
3DA	Display Status Register
3DB	Clear Lightpen
3DC	Preset Lightpen
3DD	Not Used
3DE	Not Used
3DF	Not Used

* The 6845 Index and Data Registers are used to program the CRT controller to interface the high-resolution IBM Color Graphics Display.

CRT Controller Registers

The Color Graphics Display Adapter is designed around the Motorola 6845 CRT controller device, which is responsible for all synchronization signals to the monitor and for the raster scanning process. The CRT controller must be programmed with the correct timing values. If improper synchronization signals are received, the color monitor circuits will be damaged. Before you complete any other task in programming the adapter, you must first program the CRT controller (6845 device).

System configurations that will use both a Monochrome Display Adapter and a Color Graphics Display Adapter, must first ensure that the CRT controller is programmed for the appropriate adapter. Usually monochrome and color adapters use different horizontal frequencies. The correct timing (frequency) synchronization is vital to correct operation of the adapters. Damage to either monitor/display may occur if the timing is not correct.

Also, if you are writing software that will initialize the system, you must ensure that the CRT controller is correctly programmed for the adapter that is to be initialized on power-up.

Table 4-2 summarizes the 6845 internal data registers as to function and parameters. For the IBM Color Display, the values must be programmed into the 6845 to ensure proper initialization of the device.

Table 4-2. 6845 Internal Data Registers.

Reg Num	Register Function	Program Units	40x25 Alpha Modes	80x25 Alpha Modes	Graphic Modes
R0	Horizontal Total	Characters	38	71	38
R1	Horizontal Displayed	Characters	28	50	28
R2	Horizontal Sync Position	Characters	2D	5A	2D
R3	Horizontal Sync Width	Characters	0A	1A	0A
R4	Vertical Total	Characters	1F	1F	7F
R5	Vertical Total Adjust	Scan Lines	06	06	06
R6	Vertical Displayed	Character Rows	19	19	64
R7	Vertical Sync Position	Character Rows	1C	1C	70
R8	Interlace Mode	----	02	02	02
R9	Maximum Scan Line Address	Scan Lines	07	07	01
R10	Cursor Start	Scan Lines	06	06	06
R11	Cursor End	Scan Lines	07	07	07
R12	Start Address (High Byte)	----	00	00	00
R13	Start Address (Low Byte)	----	00	00	00
R14	Cursor Address (High Byte)	----	---	---	---
R15	Cursor Address (Low Byte)	----	---	---	---
R16	Lightpen (High Byte)	----	---	---	---
R17	Lightpen (Low Byte)	----	---	---	---

The CRT controller is programmed by first writing the desired register number to the index register (hex 3D4) and then writing the desired contents of that register to the data register (hex 3D5).

Mode Select Register

The Mode Select Register allows you to select the mode of operation; the bit assignments for this register are described in Figure 4-1.

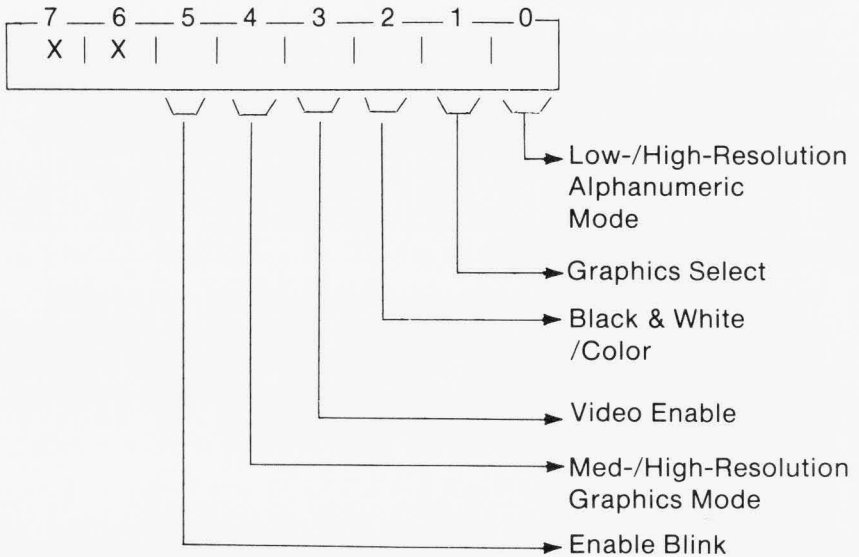


Figure 4-1. Mode Select Register (Hex 3D8).

Each bit shown in Figure 4-1 is described in the following paragraphs.

LOW-/HIGH-RESOLUTION ALPHANUMERIC MODE

This bit selects either the high- or low-resolution alphanumeric mode. Writing a logic 1 to this bit selects the high-resolution alphanumeric mode (80 characters x 25 rows). If this bit is OFF or 0, the low-resolution alphanumeric mode is selected.

This bit is used in conjunction with the GRAPHICS SELECT bit. These two bits should never be programmed as logic 1s at the same time. A logic 1 in the GRAPHICS SELECT bit selects the graphics mode and thus, conflicts if the high-resolution alphanumeric mode is also selected (logic 1).

GRAPHICS SELECT

This bit selects the graphics mode. Writing a logic 1 to this bit selects the graphics mode. If this bit is OFF or 0, the graphics mode is not selected.

This bit and the HIGH-RESOLUTION ALPHANUMERIC MODE bit should not be programmed to logic 1s at the same time. A logic 1 in the GRAPHICS SELECT bit selects the graphics mode, and thus, conflicts if the high-resolution alphanumeric mode is also selected (logic 1).

BLACK & WHITE/COLOR

This bit affects the composite video output **ONLY** — it has **NO** affect on the direct-drive (Intensity-Red-Green-Blue) IRGB output. When programmed to a logic 1, this bit selects the black and white mode of operation. All alphanumerics and graphics are displayed in black and white only. No color is displayed.

VIDEO ENABLE

The VIDEO ENABLE bit is used to blank the entire screen display. A logic 1 in this bit enables the video display, and thus, allows characters or graphics information to be visible on the screen.

If this bit is OFF or 0, no information is visible on the screen. It appears blank.

MED-/HIGH-RESOLUTION GRAPHICS MODE

This bit, when used in conjunction with the graphics select bit, selects between the medium- and high-resolution graphics modes. Both bits must be programmed to a logic 1 to select high-resolution graphics mode.

If the GRAPHICS SELECT bit is set to 1 and the MED-/HIGH-RESOLUTION GRAPHICS MODE bit is 0, the medium-resolution graphics mode is selected.

This bit has no meaning if the GRAPHICS SELECT bit is not programmed to a logic 1.

ENABLE BLINK

This bit, when used in conjunction with the GRAPHICS SELECT bit, causes the blinking attribute to be enabled or disabled. The GRAPHICS SELECT bit must be programmed to a logic 0 (alphanumeric mode selected) for this bit to have meaning.

The ENABLE BLINK bit causes bit 7 of each character attribute byte to behave as a blink attribute bit. If any character has bit 7 of its character attribute byte set and the ENABLE BLINK bit is a logic 1, then those characters blink (or flash). (See Section 4.3, Alphanumeric Modes.)

Color Select Register

The Color Select Register determines the colors used with the various modes. The bit configurations may change for each mode. The bit assignments are described in Figure 4-2.

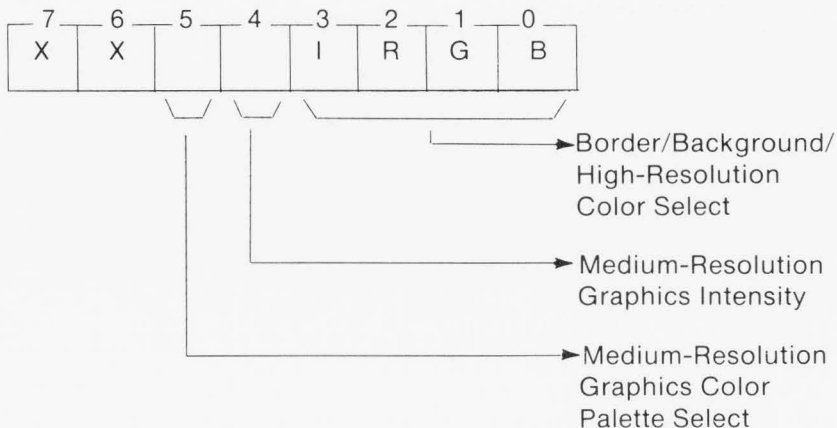


Figure 4-2. Color Select Register (Hex 3D9).

Each bit shown in Figure 4-2 is described in the following paragraphs.

BORDER/BACKGROUND/HIGH-RESOLUTION COLOR SELECT

These four bits (I=Intensity, R=Red, G=Green, and B=Blue) select the following: (1) the border color in the alphanumeric modes; (2) the background color in the medium-resolution graphics mode; and (3) the pixel color in the high-resolution graphics mode.

The border of the display grid are those horizontal and vertical pixels that are not counted in the display matrix (320 x 200 or 640 x 200).

In the alphanumeric modes, this bit selects the border color, which may be one of sixteen colors.

In the high-resolution graphics mode, this bit controls the color of the dots that are ON or lit on the screen. The dots may be one of sixteen colors on a black background/border.

In the medium-resolution graphics mode, this bit controls the color of the border/background (border and background merge together); sixteen colors are available for the border/background in this mode.

See High-Resolution Graphics Mode in this section for the sixteen possible colors.

MEDIUM-RESOLUTION GRAPHICS INTENSITY

This bit is the intensity bit in the medium-resolution graphics mode. Used in conjunction with the MEDIUM-RESOLUTION GRAPHICS COLOR PALETTE SELECT bit, it intensifies the desired color palette. When this bit is ON or 1, the intensified colors are selected. (See Section 4.3, Medium-Resolution Graphics Mode.)

MEDIUM-RESOLUTION GRAPHICS COLOR PALETTE SELECT

This bit selects the desired color palette for the medium-resolution graphics mode. Two color palettes are available:

Palette	Palette
Red	Cyan (Light Blue)
Green	Magenta (Purple)
Brown	White
Background Color	Background Color

Status Register

The Status Register shows the status of the retrace intervals for horizontal and vertical retrace. This register also shows the status of the lightpen operations. The bit assignments for this register are shown in Figure 4-3.

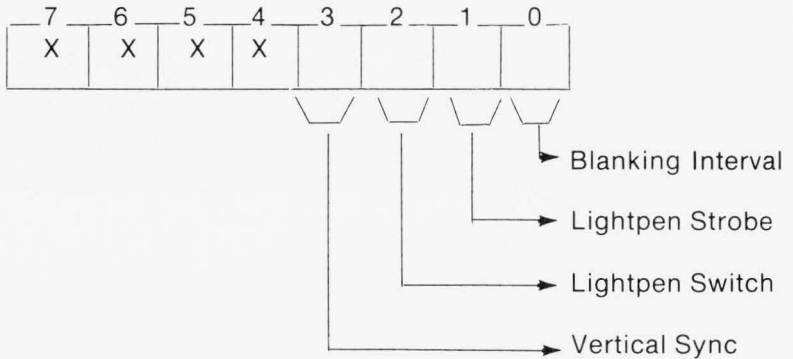


Figure 4-3. Status Register (Hex 3DA).

BLANKING INTERVAL

When a logic 1, this bit shows that the electron beam of the display device is retracing horizontally or vertically. During that time, a memory access in high-resolution alphanumeric mode can be made without disturbing the screen image.

This bit is **ONLY** important when using the high-resolution (80 x 25) alphanumeric mode because accesses to memory **OTHER THAN** during blanking can cause interference on the screen image.

LIGHTPEN STROBE

The LIGHTPEN STROBE bit is asserted (changed to a 1) by the lightpen when the electron beam of the color display crosses the lightpen lens.

This bit is also presented to the CRT controller when asserted. The CRT controller saves (latches) the current display address where the bit was asserted. That is, the position of the electron beam is saved (latched) to the lightpen registers by the CRT controller at the time the bit is asserted.

Thus, this bit in the Status Register can be polled for an asserted condition and, when a 1 is detected, the CRT controller lightpen registers can be read to determine the position of the lightpen on the screen.

LIGHTPEN SWITCH

This bit is an undebounced image of the switch on the front of the lightpen. That is, when the switch on the lightpen is pressed, this bit bounces between 1 and 0 until a continuous 1 is asserted.

Debouncing (or verification of the 1 condition) must be carried out in software so that a valid depression of the lightpen switch can be accurately recorded.

VERTICAL SYNC

This bit is a copy of the vertical sync signal sent to the display; it indicates when the electron beam of the display is retracing to the upper left corner of the screen (vertical retrace).

During this retrace time, accesses can be made to memory without interference on the screen image because the electron beam is not writing dots on the screen (important ONLY in high-resolution alphanumeric mode).

Lightpen Information

Two I/O register addresses are reserved for lightpen information. These two addresses and operations in conjunction with the lightpen bits in the Status Register are described in the following subsections.

PRESET LIGHTPEN

An I/O access to the preset lightpen address (3DC) causes the LIGHTPEN STROBE bit in the Status Register to be asserted (changed to 1).

When this action occurs, no additional triggering can be made to the CRT controller lightpen registers.

CLEAR LIGHTPEN

An I/O access to the clear lightpen address (3DB) causes the LIGHTPEN STROBE bit in the Status Register to be cleared (changed from 1 to 0).

Subsequently, the LIGHTPEN STROBE bit can be asserted by either accessing the preset lightpen address or by a detection of the electron beam by the lightpen.

Thus, an I/O access to this address effectively "arms" the lightpen circuitry.

4.3 DISPLAY MEMORY ORGANIZATION

The PERSYST Color Graphics Display Adapter supports medium- (320 horizontal x 200 vertical) and high-resolution (640 horizontal x 200 vertical) graphics, and low- (40 characters x 25 rows) and high-resolution (80 characters x 25 rows) alphanumeric data. The steps for programming each mode are described in the following subsections; the memory organization for each mode is also explained.

Medium-Resolution Graphics Mode

The medium-resolution graphics mode uses a 320 horizontal x 200 vertical pixel display. Four colors may be viewed simultaneously. This mode supports both composite video and direct drive (IRGB) outputs. All 16 kilobytes (KB) of memory are required in medium-resolution graphics mode operation.

To establish the medium-resolution graphics mode as the operational mode, complete the following steps:

1. Reset (to 0) the VIDEO ENABLE bit in the Mode Select Register (hex 3D8).
2. Program the CRT controller with the appropriate values to operate in the graphics mode (hex 3D4 and 3D5). See Table 4-2.
3. Set (to 1) the VIDEO ENABLE and GRAPHICS SELECT bits in the Mode Select Register (hex 3D8).

Completion of these steps ensures that the Color Graphics Display Adapter is in the medium-resolution graphics mode; thus, no potential damage to the monitor can occur as the mode is selected.

In the medium-resolution graphics mode, the display memory can be accessed at any time without disturbing the screen image. The display memory is organized as two banks of 8000 bytes each, for even and odd lines of graphics information. Table 4-3 shows the memory addresses of the display memory and the function carried out in each address space.

Table 4-3. Display Memory Addresses for Medium-Resolution Graphics Mode.

Memory Address	Function
B800	Even Scan Lines (0, 2, 4, ..., 198)
B9F3F	
	Unused
BA000	Odd Scan Lines (1, 3, 5, ..., 199)
BBF3F	
	Unused
BBFFF	

Each byte of memory corresponds to four consecutive pixels (dots) on the display. Each pixel is represented by two bits, giving four possible combinations or four colors simultaneously displayed.

Figure 4-4 shows the layout of a byte of memory with each dot represented by two bits — Ca and Cb.

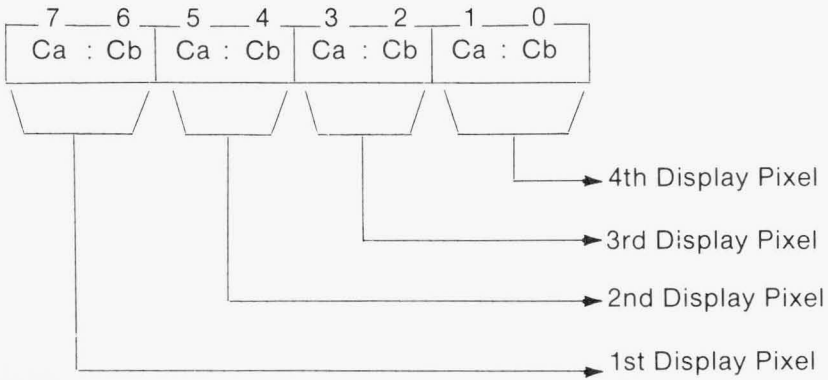


Figure 4-4. Memory Byte Layout for Medium-Resolution Graphics Mode.

The Ca and Cb bits of each pixel produce the color of **THAT** pixel based on the combination of bits that are ON or 1. Table 4-4 shows the colors produced by the various combinations of 1s and 0s. An explanation of how to select the color set follows the table.

Table 4-4. Color Sets for Pixels.

Ca	Cb	Color Set 1	Color Set 2	Color Set 3	Color Set 4	Color Set 5	Color Set 6
0	0	The background color selected in the Color Select Register (Hex 3D9)*					
0	1	Green	Light Green	Cyan	Light Cyan	Cyan	Light Cyan
1	0	Red	Light Red	Magenta	Light Magenta	Red	Light Red
1	1	Brown	Yellow	White	Bright White	White	Bright White
* The background color selected is also used for the border color around the 320 x 200 dot grid.							

The color sets referenced in Table 4-4 are selected by programming the Color Select Register (hex 3D9) as follows:

To Select Set 1:

Reset (to 0) the GRAPHICS INTENSITY and COLOR PALETTE SELECT bits in the Color Select Register (hex 3D9).

To Select Set 2:

Set (to 1) the GRAPHICS INTENSITY bit and reset (to 0) the COLOR PALETTE SELECT bit in the Color Select Register (hex 3D9).

To Select Set 3:

Reset (to 0) the GRAPHICS INTENSITY bit and set (to 1) the COLOR PALETTE SELECT bit in the Color Select Register (hex 3D9).

To Select Set 4:

Set (to 1) the GRAPHICS INTENSITY and COLOR PALETTE SELECT bits in the Color Select Register (hex 3D9).

To Select Set 5:

Reset (to 0) the GRAPHICS INTENSITY bit. Set (to 1) the BLACK & WHITE/COLOR bit in the Mode Select Register (hex 3D8). The COLOR PALETTE SELECT bit in the Color Select Register (hex 3D9) is a "don't care".

To Select Set 6:

Set (to 1) the GRAPHICS INTENSITY bit. Set (to 1) the BLACK & WHITE/COLOR bit in the Mode Select Register (hex 3D8). The COLOR PALETTE SELECT bit is a "don't care" in the Color Select Register (hex 3D9).

NOTE

Color sets 5 and 6 are not supported on a video composite color display. The BLACK & WHITE/COLOR bit causes no color information to be sent to a composite display.

High-Resolution Graphics Mode

The high-resolution graphics mode uses a 640 horizontal x 200 vertical pixel display in black and white only. This mode supports both the composite video and direct drive (IRGB) outputs. All 16 KB of display memory are required in high-resolution graphics mode.

To establish the high-resolution graphics mode as the operational mode, complete the following steps:

1. Reset (to 0) the VIDEO ENABLE bit in the Mode Select Register (hex 3D8).
2. Program the CRT controller with the appropriate values to operate in the graphics mode (hex 3D4 and 3D5). See Table 4-2.

3. Set (to 1) all four BORDER/BACKGROUND/ HIGH RESOLUTION COLOR SELECT bits in the Color Select Register (hex 3D9), selecting an intensified white for all ON pixels.
4. Set (to 1) the VIDEO ENABLE, GRAPHICS SELECT, BLACK & WHITE/COLOR, and HIGH RESOLUTION GRAPHICS MODE bits in the Mode Select Register (hex 3D8).

Completion of these steps ensures that the Color Graphics Display Adapter is in the high-resolution graphics mode; thus, no potential damage to the monitor can occur as the mode is selected.

In the high-resolution graphics mode, the display memory can be accessed at any time without disturbing the screen image. The display memory is organized as two banks of 8000 bytes each, for even and odd lines of graphics information. Table 4-5 shows the memory addresses of the display memory and the function carried out in each address space.

Table 4-5. Display Memory Address for the High-Resolution Graphics Mode.

Memory Address	Function
B8000	Even Scan Lines (0, 2, 4, ..., 198)
B9F3F	
	Unused
BA000	Odd Scan Lines (1, 3, 5, ..., 199)
BBF3F	
	Unused
BBFFF	

Each byte of memory corresponds to eight consecutive pixels (dots) on the display. Each pixel is represented by one bit.

Figure 4-5 shows the layout of a byte of memory.

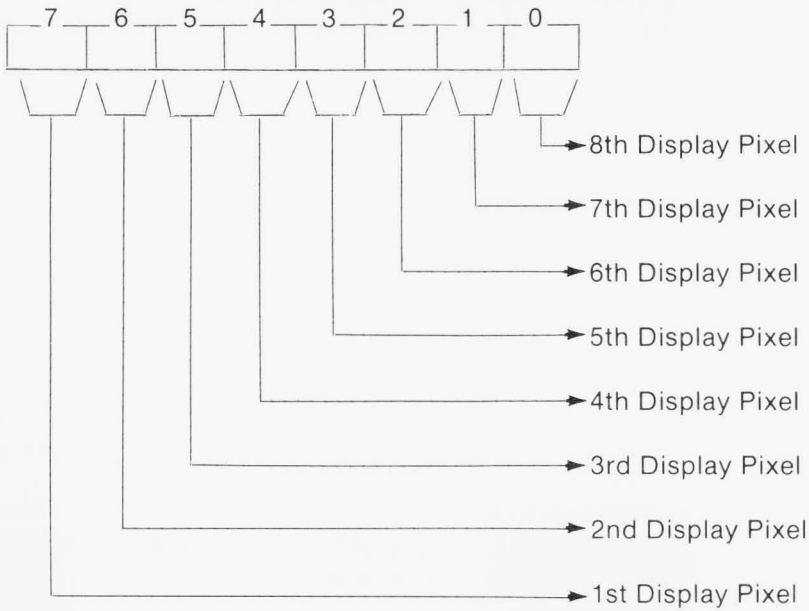


Figure 4-5. Memory Byte Layout for High-Resolution Graphics Mode.

All OFF pixels are displayed as black; also, the border area around the 640 x 200 pixel matrix is black.

The actual color of the pixels that are ON can be varied by writing a specific value to the BORDER/BACKGROUND/HIGH RESOLUTION COLOR SELECT bits of the Color Select Register (hex 3D9). See Table 4.6 for the available color choices and the corresponding bit patterns. This color selection is **ONLY** valid on direct-drive monitors. On a composite monitor, black and white is shown regardless of the color selection.

Alphanumeric Modes

The PERSYST Color Graphics Display Adapter supports low- and high-resolution alphanumeric modes. The low-resolution mode is 40 characters x 25 rows, and the high-resolution mode is 80

characters x 25 rows. The low-resolution mode is suitable for color TV-type applications, where the display device has a rather low level of resolution ability.

Two character fonts are available for the alphanumeric modes. In the primary font, the vertical lines are two pixels wide; in the secondary font, the vertical lines are one pixel wide.

With the secondary font, the characters are thinner and are, therefore, easier to see. However, many display devices cannot resolve the difference between the thin vertical lines and thicker horizontal lines. The result is nonproportional characters.

The PERSYST Color Graphics Adapter is shipped with the primary font selected. Font selection is made by the jumper plug between E1 and E2, located in the left center of the board. (See Figure 3-1 for the jumper location.) To select the primary font, the jumper is installed; to select the secondary font, the jumper is not installed.

The 2732-type Erasable-Programmable Read-Only Memory (EPROM) device used as the character generator can be reprogrammed or replaced for custom fonts. It supports two sets of 256 different character codes.

To establish the low- or high-resolution alphanumeric mode as the operational mode, complete the following steps:

1. Reset (to 0) the VIDEO ENABLE bit in the Mode Select Register (hex 3D8).
2. Program the CRT controller with the appropriate values to operate in the desired alphanumeric mode (hex 3D4 and 3D5). See Table 4-2.
3. Set (to 1) the VIDEO ENABLE bit and reset (to 0) the GRAPHICS SELECT bit in the Mode Select Register (hex 3D8).
4. If high-resolution alphanumeric mode is to be selected, set (to 1) the HIGH RESOLUTION ALPHANUMERIC MODE bit in the Mode Select Register (hex 3D8) plus the bits described in Step 3.

Completion of these steps ensures that the Color Graphics Display Adapter is in the proper alphanumeric mode; thus, no potential damage to the monitor can occur as the mode is selected.

The character set contains alphanumeric and block graphics. Each character in the display memory has a corresponding character attribute. Each character code is on an **EVEN** address, and the corresponding attribute code for that character is on the next consecutive **ODD** address in display memory.

In the low-resolution alphanumeric mode, one screen display requires 2000 bytes of memory. In the high-resolution alphanumeric mode, one screen display requires 4000 bytes of memory. Thus, the 16 KB display memory can contain eight pages of 25 rows of 40 characters each (low-resolution) and four pages of 25 rows of 80 characters each (high-resolution). The starting address of the display memory is hex B8000.

Each row of the screen occupies a specific position in display memory relative to the start address of the display as programmed in the CRT controller Start Address registers. To find a character position in memory, use the following formula:

1. Take the Start Address value in the CRT controller Start Address registers.
2. Add the column position (0 to 79 or 0 to 39) of the character.
3. Add the row position (0 to 24) of the character times 40 for low-resolution mode or times 80 for high-resolution mode.
4. Double the result.
5. Add the start address B8000 of the display memory.

The character code is the even address and the attribute is the next consecutive (odd) address. The bits in the character code and character attribute bytes are defined in Figure 4-6.

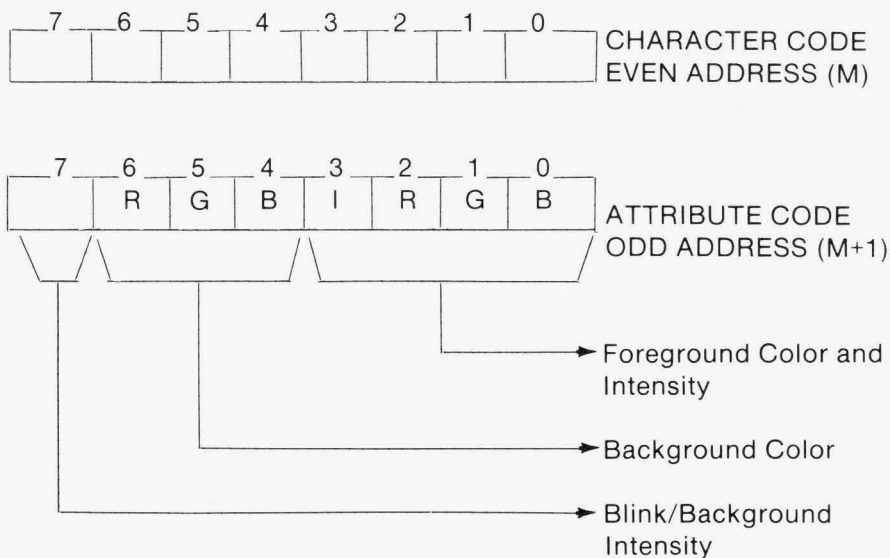


Figure 4-6. Character Code and Attribute Bytes.

The adapter decodes the character attribute byte as defined in Figure 4-6. The BLINK/BACKGROUND INTENSITY bit acts as a blinking attribute if the ENABLE BLINK bit in the Mode Select Register is set (1). Otherwise, this bit operates in conjunction with the BACKGROUND COLOR bits of the attribute byte to allow sixteen backgrounds as well as the usual sixteen foreground colors.

The FOREGROUND and BACKGROUND COLOR bits in the attribute byte select sixteen colors as shown in Table 4-6.

Table 4-6. Foreground and Background Color Selection Bit Configurations.

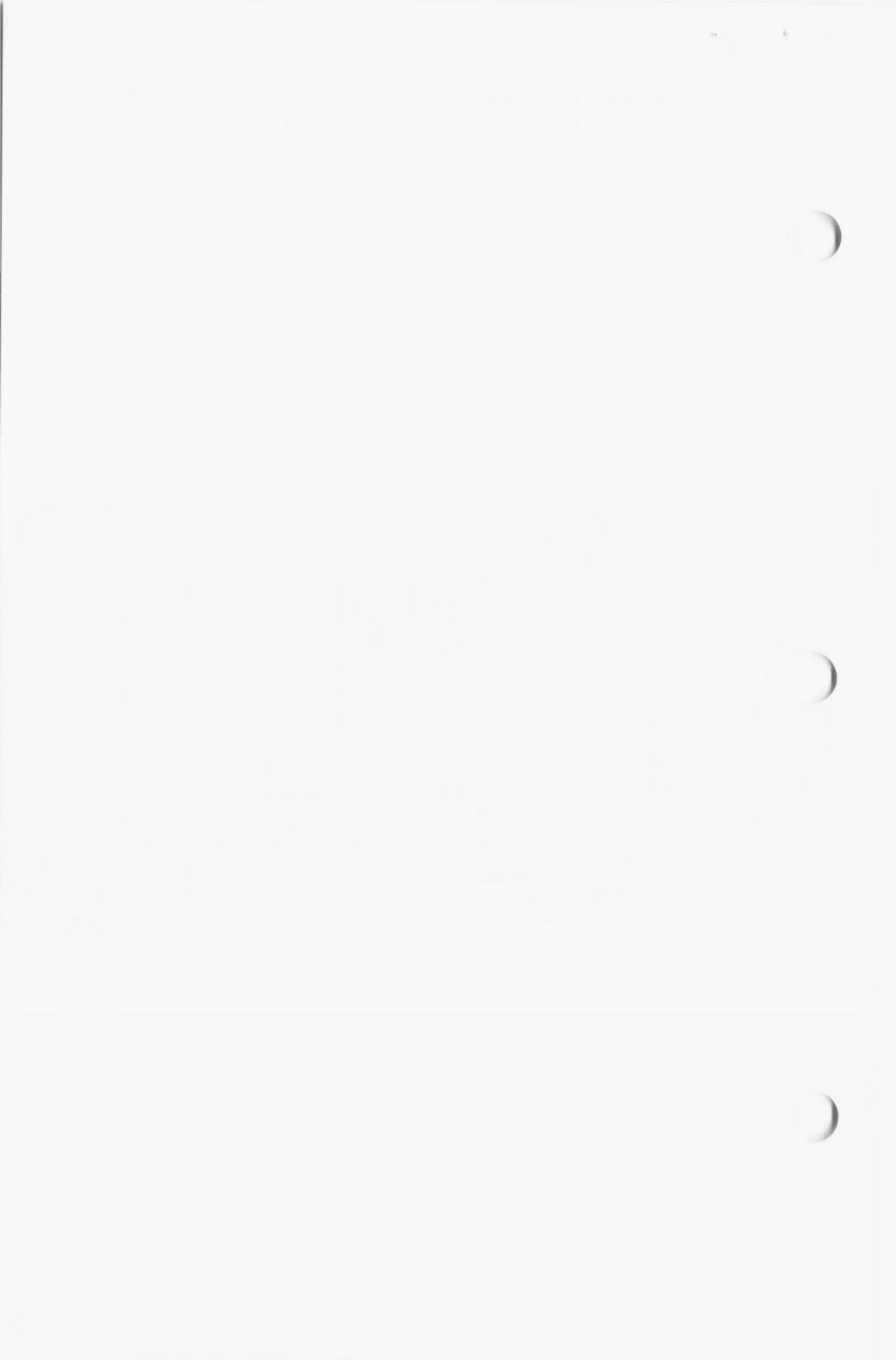
I	R	G	B	Resulting Color
0	0	0	0	Black
0	0	0	1	Blue
0	0	1	0	Green
0	0	1	1	Cyan
0	1	0	0	Red
0	1	0	1	Magenta
0	1	1	0	Brown
0	1	1	1	White
1	0	0	0	Gray
1	0	0	1	Light Blue
1	0	1	0	Light Green
1	0	1	1	Light Cyan
1	1	0	0	Light Red
1	1	0	1	Light Magenta
1	1	1	0	Yellow
1	1	1	1	High Intensity White

If the low-resolution alphanumeric mode is selected (40 characters x 25 rows), memory accesses can be made to the display memory at any time without causing interference to the screen. In high-resolution alphanumeric mode (80 characters x 25 rows), however, interference on the screen results if a memory access is completed at any time **OTHER THAN** during "blanking". To avoid this interference, accesses to the display memory must be completed during the "blanking interval" (retrace time).

That is, accesses to display memory should be made when the electron beam of the display is retracing. To determine when the beam is retracing, monitor the Status Register and access display memory only when the BLANKING INTERVAL bit is at a logic 1.

Alternately, the display can be blanked by resetting (to 0) the VIDEO ENABLE bit in the Mode Select Register. While the screen is blanked, memory accesses can be made and the display then reenabled. Thus, the display interference cannot be seen; however, this method causes a noticeable "flicker" of the entire screen image.

The display memory can be read from and written to using Direct Memory Access (DMA). The DMA device on the motherboard can be programmed to access the display memory directly. However, at least one wait-state (but no more than three wait-states) is inserted by the Color Graphics Display Adapter. The duration of the wait-state may vary because the processor/monitor access must be synchronized with the circuitry on the adapter.



APPENDIX A: CHARACTER AND TEXT ATTRIBUTE VALUES

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
00	0	Blank(Null)	Black	Black
01	1	☺	Black	Blue
02	2	☹	Black	Green
03	3	♥	Black	Cyan
04	4	♦	Black	Red
05	5	♣	Black	Magenta
06	6	♠	Black	Brown
07	7	•	Black	Light Gray
08	8	◐	Black	Dark Gray
09	9	◯	Black	Light Blue
0A	10	◑	Black	Light Green
0B	11	♂	Black	Light Cyan
0C	12	♀	Black	Light Red
0D	13	♪	Black	Light Magenta
0E	14	♫	Black	Yellow
0F	15	☀	Black	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
10	16	▶	Blue	Black
11	17	◀	Blue	Blue
12	18	↕	Blue	Green
13	19	!!	Blue	Cyan
14	20	¶	Blue	Red
15	21	§	Blue	Magenta
16	22	■	Blue	Brown
17	23	↕	Blue	Light Gray
18	24	↑	Blue	Dark Gray
19	25	↓	Blue	Light Blue
1A	26	→	Blue	Light Green
1B	27	←	Blue	Light Cyan
1C	28	└	Blue	Light Red
1D	29	↔	Blue	Light Magenta
1E	30	▲	Blue	Yellow
1F	31	▼	Blue	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
20	32	Blank Space	Green	Black
21	33	!	Green	Blue
22	34	"	Green	Green
23	35	#	Green	Cyan
24	36	\$	Green	Red
25	37	%	Green	Magenta
26	38	&	Green	Brown
27	39	'	Green	Light Gray
28	40	(	Green	Dark Gray
29	41	)	Green	Light Blue
2A	42	*	Green	Light Green
2B	43	+	Green	Light Cyan
2C	44	,	Green	Light Red
2D	45	-	Green	Light Magenta
2E	46	.	Green	Yellow
2F	47	/	Green	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
30	48	0	Cyan	Black
31	49	1	Cyan	Blue
32	50	2	Cyan	Green
33	51	3	Cyan	Cyan
34	52	4	Cyan	Red
35	53	5	Cyan	Magenta
36	54	6	Cyan	Brown
37	55	7	Cyan	Light Gray
38	56	8	Cyan	Dark Gray
39	57	9	Cyan	Light Blue
3A	58	:	Cyan	Light Green
3B	59	;	Cyan	Light Cyan
3C	60	<	Cyan	Light Red
3D	61	=	Cyan	Light Magenta
3E	62	>	Cyan	Yellow
3F	63	?	Cyan	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
40	64	@	Red	Black
41	65	A	Red	Blue
42	66	B	Red	Green
43	67	C	Red	Cyan
44	68	D	Red	Red
45	69	E	Red	Magenta
46	70	F	Red	Brown
47	71	G	Red	Light Gray
48	72	H	Red	Dark Gray
49	73	I	Red	Light Blue
4A	74	J	Red	Light Green
4B	75	K	Red	Light Cyan
4C	76	L	Red	Light Red
4D	77	M	Red	Light Magenta
4E	78	N	Red	Yellow
4F	79	O	Red	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
50	80	P	Magenta	Black
51	81	Q	Magenta	Blue
52	82	R	Magenta	Green
53	83	S	Magenta	Cyan
54	84	T	Magenta	Red
55	85	U	Magenta	Magenta
56	86	V	Magenta	Brown
57	87	W	Magenta	Light Gray
58	88	X	Magenta	Dark Gray
59	89	Y	Magenta	Light Blue
5A	90	Z	Magenta	Light Green
5B	91	[	Magenta	Light Cyan
5C	92	\	Magenta	Light Red
5D	93	]	Magenta	Light Magenta
5E	94	^	Magenta	Yellow
5F	95	_	Magenta	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
60	96	`	Brown	Black
61	97	a	Brown	Blue
62	98	b	Brown	Green
63	99	c	Brown	Cyan
64	100	d	Brown	Red
65	101	e	Brown	Magenta
66	102	f	Brown	Brown
67	103	g	Brown	Light Gray
68	104	h	Brown	Dark Gray
69	105	i	Brown	Light Blue
6A	106	j	Brown	Light Green
6B	107	k	Brown	Light Cyan
6C	108	l	Brown	Light Red
6D	109	m	Brown	Light Magenta
6E	110	n	Brown	Yellow
6F	111	o	Brown	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
70	112	p	Light Gray	Black
71	113	q	Light Gray	Blue
72	114	r	Light Gray	Green
73	115	s	Light Gray	Cyan
74	116	t	Light Gray	Red
75	117	u	Light Gray	Magenta
76	118	v	Light Gray	Brown
77	119	w	Light Gray	Light Gray
78	120	x	Light Gray	Dark Gray
79	121	y	Light Gray	Light Blue
7A	122	z	Light Gray	Light Green
7B	123	{	Light Gray	Light Cyan
7C	124	|	Light Gray	Light Red
7D	125	}	Light Gray	Light Magenta
7E	126	~	Light Gray	Yellow
7F	127	△	Light Gray	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
Values 80 to FF hex flash or blink if the BLINK ENABLE bit is set. Otherwise, the background colors are intensified.				
80	128	Ç	Black	Black
81	129	ü	Black	Blue
82	130	é	Black	Green
83	131	â	Black	Cyan
84	132	á	Black	Red
85	133	à	Black	Magenta
86	134	ã	Black	Brown
87	135	ç	Black	Light Gray
88	136	ê	Black	Dark Gray
89	137	ë	Black	Light Blue
8A	138	è	Black	Light Green
8B	139	ï	Black	Light Cyan
8C	140	î	Black	Light Red
8D	141	í	Black	Light Magenta
8E	142	À	Black	Yellow
8F	143	Á	Black	White




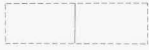












APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
90	144	É	Blue	Black
91	145	æ	Blue	Blue
92	146	Æ	Blue	Green
93	147	ø	Blue	Cyan
94	148	ö	Blue	Red
95	149	õ	Blue	Magenta
96	150	û	Blue	Brown
97	151	ü	Blue	Light Gray
98	152	ÿ	Blue	Dark Gray
99	153	ö	Blue	Light Blue
9A	154	ÿ	Blue	Light Green
9B	155	ç	Blue	Light Cyan
9C	156	£	Blue	Light Red
9D	157	¥	Blue	Light Magenta
9E	158	Pt	Blue	Yellow
9F	159	ƒ	Blue	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
A0	160	á	Green	Black
A1	161	í	Green	Blue
A2	162	ó	Green	Green
A3	163	ú	Green	Cyan
A4	164	ñ	Green	Red
A5	165	Ñ	Green	Magenta
A6	166	̂	Green	Brown
A7	167	̄	Green	Light Gray
A8	168	̇	Green	Dark Gray
A9	169	⌈	Green	Light Blue
AA	170	⌋	Green	Light Green
AB	171	½	Green	Light Cyan
AC	172	¼	Green	Light Red
AD	173	ı	Green	Light Magenta
AE	174	<<	Green	Yellow
AF	175	>>	Green	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
B0	176		Cyan	Black
B1	177		Cyan	Blue
B2	178		Cyan	Green
B3	179		Cyan	Cyan
B4	180		Cyan	Red
B5	181		Cyan	Magenta
B6	182		Cyan	Brown
B7	183		Cyan	Light Gray
B8	184		Cyan	Dark Gray
B9	185		Cyan	Light Blue
BA	186		Cyan	Light Green
BB	187		Cyan	Light Cyan
BC	188		Cyan	Light Red
BD	189		Cyan	Light Magenta
BE	190		Cyan	Yellow
BF	191		Cyan	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
C0	192		Red	Black
C1	193		Red	Blue
C2	194		Red	Green
C3	195		Red	Cyan
C4	196		Red	Red
C5	197		Red	Magenta
C6	198		Red	Brown
C7	199		Red	Light Gray
C8	200		Red	Dark Gray
C9	201		Red	Light Blue
CA	202		Red	Light Green
CB	203		Red	Light Cyan
CC	204		Red	Light Red
CD	205		Red	Light Magenta
CE	206		Red	Yellow
CF	207		Red	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
D0	208		Magenta	Black
D1	209		Magenta	Blue
D2	210		Magenta	Green
D3	211		Magenta	Cyan
D4	212		Magenta	Red
D5	213		Magenta	Magenta
D6	214		Magenta	Brown
D7	215		Magenta	Light Gray
D8	216		Magenta	Dark Gray
D9	217		Magenta	Light Blue
DA	218		Magenta	Light Green
DB	219		Magenta	Light Cyan
DC	220		Magenta	Light Red
DD	221		Magenta	Light Magenta
DE	222		Magenta	Yellow
DF	223		Magenta	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
E0	224	α	Brown	Black
E1	225	β	Brown	Blue
E2	226	Γ	Brown	Green
E3	227	π	Brown	Cyan
E4	228	Σ	Brown	Red
E5	229	σ	Brown	Magenta
E6	230	μ	Brown	Brown
E7	231	τ	Brown	Light Gray
E8	232	Φ	Brown	Dark Gray
E9	233	θ	Brown	Light Blue
EA	234	Ω	Brown	Light Green
EB	235	δ	Brown	Light Cyan
EC	236	∞	Brown	Light Red
ED	237	ϕ	Brown	Light Magenta
EE	238	ϵ	Brown	Yellow
EF	239	\cap	Brown	White

APPENDIX A (CONTINUED)

Value		Character Symbol	Text Attribute	
Hex	Dec		Background	Foreground
F0	240	≡	Light Gray	Black
F1	241	±	Light Gray	Blue
F2	242	≥	Light Gray	Green
F3	243	≤	Light Gray	Cyan
F4	244	†	Light Gray	Red
F5	245	‡	Light Gray	Magenta
F6	246	÷	Light Gray	Brown
F7	247	≈	Light Gray	Light Gray
F8	248	○	Light Gray	Dark Gray
F9	249	●	Light Gray	Light Blue
FA	250	•	Light Gray	Light Green
FB	251	√	Light Gray	Light Cyan
FC	252	η	Light Gray	Light Red
FD	253	²	Light Gray	Light Magenta
FE	254	■	Light Gray	Yellow
FF	255	BLANK	Light Gray	White

APPENDIX B: QUICK REFERENCE CHARACTER CHART

Decimal Value	Hex Value								
	0	1	2	3	4	5	6	7	
0	0	BLANK (NULL)	▶	BLANK (SPACE)	0	@	P	'	p
1	1	😊	◀	!	1	A	Q	a	q
2	2	😬	↕	"	2	B	R	b	r
3	3	♥	!!	#	3	C	S	c	s
4	4	♠	π	\$	4	D	T	d	t
5	5	♣	♫	%	5	E	U	e	u
6	6	♠	■	&	6	F	V	f	v
7	7	•	↕	'	7	G	W	g	w
8	8	⬛	↑	(	8	H	X	h	x
9	9	◯	↓	)	9	I	Y	i	y
10	A	⬛	➡	*	:	J	Z	j	z
11	B	♂	←	+	;	K	[	k	{
12	C	♀	L	,	<	L	\	l	|
13	D	🎵	↔	—	=	M	]	m	}
14	E	🎵	▲	.	>	N	^	n	~
15	F	☀	▼	/	?	O	_	o	△

APPENDIX B: QUICK REFERENCE CHARACTER CHART

Decimal Value	Hex Value	128	144	160	176	192	208	224	240
		0	0	Ç	É	á	⋮	⌒	⌒
1	1	ü	æ	í	⋮	⌒	⌒	β	±
2	2	é	Æ	ó	⋮	⌒	⌒	Γ	≥
3	3	â	ô	ú	|	⌒	⌒	π	≤
4	4	ä	ö	ñ	⌒	—	⌒	Σ	ı
5	5	à	ò	Ñ	⌒	+	⌒	σ	ı
6	6	ã	û	ä	⌒	⌒	⌒	μ	÷
7	7	ç	ù	ö	⌒	⌒	⌒	τ	≈
8	8	ê	ÿ	ï	⌒	⌒	⌒	ϕ	○
9	9	ë	ö	⌒	⌒	⌒	⌒	θ	●
10	A	è	ü	⌒	⌒	⌒	⌒	Ω	•
11	B	ï	ç	½	⌒	⌒	■	δ	√
12	C	î	£	¼	⌒	⌒	■	∞	∞
13	D	ì	¥	ı	⌒	⌒	■	φ	2
14	E	Ä	ŕ	«	⌒	⌒	■	€	■
15	F	Å	f	»	⌒	⌒	■	∩	BLANK FF

APPENDIX C: CONNECTOR PINOUTS

C.1 DIRECT-DRIVE CONNECTOR PINOUTS

Figure C-1 shows a drawing of the 9-pin connector used to connect a direct-drive monitor.

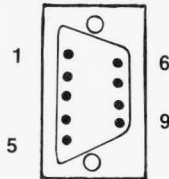


Figure C-1. 9-Pin Connector.

Figure C-2 shows the pinouts of the 9-pin connector used to connect a direct-drive monitor.

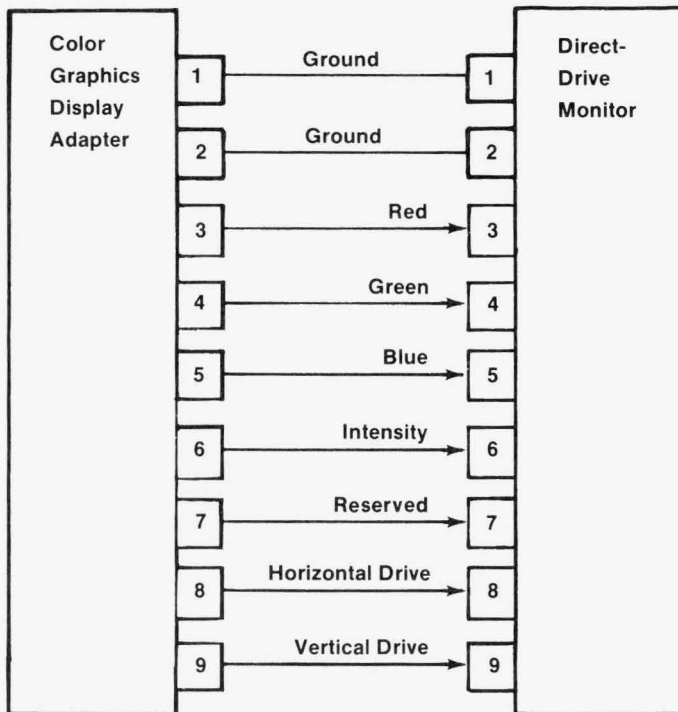


Figure C-2. Pinouts for 9-Pin Connector.

C.2 VIDEO COMPOSITE PHONO JACK PINOUTS

Figure C-3 shows the composite phono jack. Figure C-4 lists the pinouts for the phono jack connector.

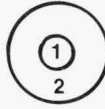


Figure C-3. Phono Jack.

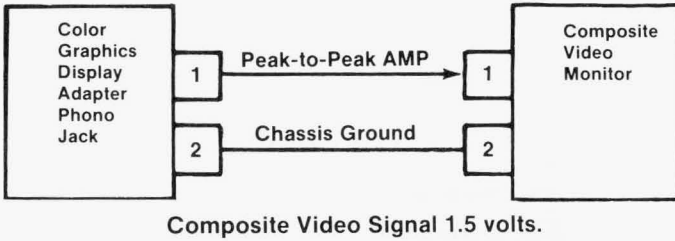


Figure C-4. Phono Jack Pinouts.

C.3 LIGHTPEN AND RF MODULATOR PINOUTS

Figure C-5 shows the pinouts for the 6-pin strip for a lightpen connector. See Figure 3-1 for the 6-pin strip location on the board.

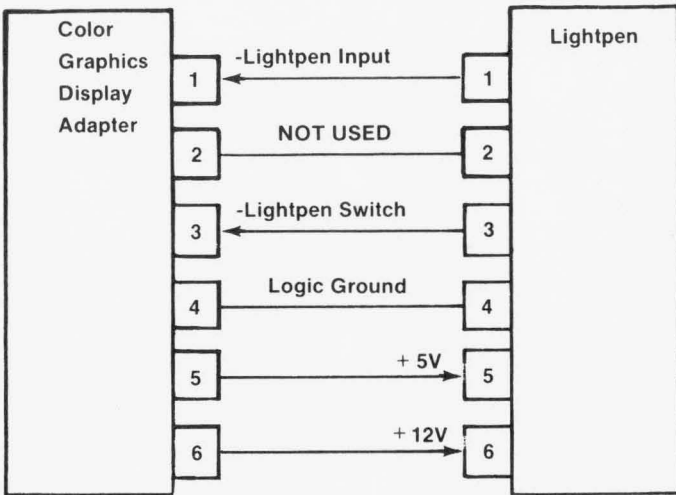


Figure C-5. Lightpen Pinouts.

Figure C-6 shows the pinouts for the 4-pin strip for the RF modulator connector. See Figure 3-1 for the 4-pin strip location on the board.

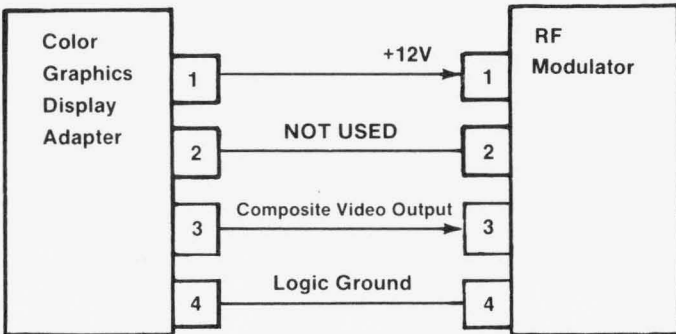


Figure C-6. RF Modulator Pinouts.

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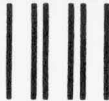
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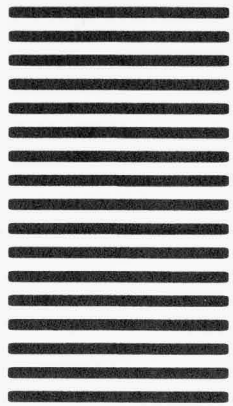


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