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IBM Personal System/2™ Displays and Display Adapters

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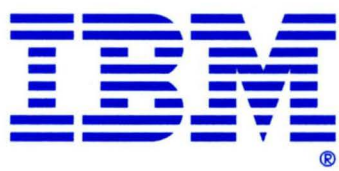

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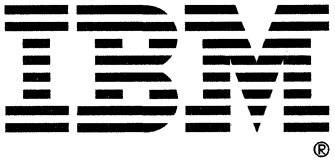

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Foreword

IBM Personal System/2™ Seminars and Proceedings provide information about new product announcements and enhancements to existing products, and are intended to assist independent developers in their hardware and software development efforts.

Over the past several years, the success of the IBM Personal Computer family was due in part to the efforts of independent developers, whose hardware and software products have become widely used. For its part, IBM helped these vendors by holding relevant technical seminars and publishing the proceedings of those seminars. The result was a mutually beneficial partnership and transfer of technical knowledge.

With the advent of the Personal System/2 family, IBM's seminar program will continue. Through these seminars and the corresponding Proceedings, IBM will address the independent developers' need for technical information about the latest IBM products. In these and future Proceedings, you will find technical information about subjects such as:

- IBM computer design and architecture
- IBM computer components and their interaction
- Memory capacities, speeds, transfer rates
- Input/output device capacities, speeds, access methods and rates
- Graphics and display technologies, programming considerations
- Printing technologies, programming considerations
- Operating system high level interfaces
- Development tools: capabilities, languages, program verification aids
- Compatibility considerations
- Communications: capabilities, offerings, statistics
- Enhancements to existing IBM hardware and software products
- Hints, tips and techniques to enhance your productivity

Through these seminars and proceedings, IBM intends to maintain its partnership with independent developers and assist them in successfully producing hardware and software products for the IBM Personal System/2 Family.

Personal System/2 is a trademark of the IBM Corporation.

IBM Personal System/2 Displays and Adapters

Overview

The new family of display products for the new IBM Personal System/2 products and the current family of IBM Personal Computers consists of displays, display adapters, and supporting software. The new products use the latest technologies to provide enhanced function and improved performance for text, graphics, and image applications on IBM Personal System/2 and IBM Personal Computer products. The family of products has been carefully designed to offer a range of price, function and performance characteristics to satisfy the requirements of a broad range of IBM Personal System/2 and IBM Personal Computer users.

Key characteristics of the new display products are:

- Compatibility:

  The new display products have been architected to be compatible and consistent with the existing IBM Color/Graphics Monitor Adapter (CGA) and the IBM Enhanced Graphics Adapter (EGA), while offering many new features. Existing applications can use the compatibility modes of the new display adapters. In many cases this will be an interim step to exploiting the enhanced functions and display modes of the new products.

- Configuration flexibility:

  The new display hardware offers a wide range of configuration options.

  Four new display units are offered, ranging from a monochrome display with a 12″ CRT, to a 16″ color display. A new analog interface is common to all of the new displays, which enables any one of them to be attached to any of the new display adapters, although certain configurations are preferred for specific applications.

  The new system units provide a display adapter integrated with the system board as a standard feature. This minimizes the price of the new adapter interface hardware, and provides a standard minimum level of display function in the system unit. Optional feature cards are available to provide additional function for applications that want to take advantage of further increases in function, performance and screen content offered.

- New Function and High Content Screen Modes:
  - New high content screen modes are provided. A new standard for graphics and image displays of 640 x 480 pels addressability is established and is available with all new system units. The 320 x 200 APA mode is extended to 256 colors for high quality color imaging, and is available with all new system units. For high content display requirements, a standard of 1024 x 768 pels addressability is established.
  - With the new 640 x 480 and 1024 x 768 modes, pels have a unity aspect ratio for ease of programming.
  - 200 line modes are double scanned to 400 lines for improved legibility.
  - New alpha modes use 720 x 400 resolution for improved legibility and higher screen content.
  - A loadable color and monochrome palette is standard for all the adapters, providing a selection from 256K colors or 64 grayscales.
  - Hardware assisted drawing capability is provided on the advanced function adapter.

- Programming Support:

  New operating systems and software products support the new display products, giving total system solutions in both stand-alone and communicating environments.

A summary of the main characteristics of the new hardware products follows:

IBM Personal System/2 Monochrome Display 8503

The 8503 is a low cost monochrome display that uses a 12" (nominal) CRT with white phosphor. It has a multi-mode capability and can operate in:

640 x 480 APA mode

720 x 400 text mode

compatibility modes, including 350 line and 400 line text and APA modes.

IBM Personal System/2 Color Display 8512

The 8512 is a low cost multi-mode color display, using a 14" (nominal) CRT with a 0.41mm stripe pitch shadow mask. It can operate in:

640 x 480 APA mode

720 x 400 text mode

compatibility modes, including 350 line and 400 line text and APA modes.

IBM Personal System/2 Color Display 8513

The 8513 is a high quality multi-mode color display, using a 12" (nominal) CRT with a 0.28mm pitch shadow mask. It can operate in:

640 x 480 APA mode

720 x 400 text mode

compatibility modes, including 350 line and 400 line text and APA modes.

IBM Personal System/2 Color Display 8514

The 8514 is a high quality, high content color display, using a 16" (nominal) CRT with a 0.31mm shadow mask. It has a multi-mode capability, and can operate in:

1024 x 768 APA mode

640 x 480 APA mode

720 x 400 text mode

compatibility modes, including 350 line and 400 line text and APA modes.

IBM Personal System/2 Model 30 Video Subsystem

The display interface hardware located in the IBM Personal System/2 Model 30 system unit features new modes for text graphics and images, while maintaining a low price and compatibility with the existing IBM Color/Graphics Monitor Adapter. When configured with the 8503 monochrome display, this hardware is ideally suited for applications where text is most often used, together with occasional use of graphics and images. When configured with the 8512, it provides a low-cost system for color text graphics and image applications.

IBM Personal System/2 Model 50, 60, 80 Video Subsystem

The display interface hardware located in the IBM Personal System/2 Models 50, 60, and 80 system units is compatible with the IBM Color/Graphics Monitor Adapter and the IBM Enhanced Graphics Adapter. It contains all the modes of the IBM Personal System/2 Model 30 display interface hardware, and also provides new modes for text (720 x 400) and graphics (640 x 480). When configured with a 8503 monochrome display or a 8513 color display, this hardware provides a quality of text, graphics and image suitable for environments requiring a high daily system utilization.

IBM Personal System/2 Display Adapter

The IBM Personal System/2 Display Adapter adapter card provides similar function to that of the IBM Personal System/2 Model 50, 60, 80 Video Subsystem, and can be installed in an IBM Personal Computer, IBM Personal Computer XT, IBM Personal Computer XT/286, IBM Personal Computer AT, or an IBM Personal System/2 Model 30.

IBM Personal System/2 Display Adapter 8514/A

The 8514/A adapter card provides advanced display functions for the IBM Personal System/2 Models 50, 60 and 80 System Units which enhances the function provided by the integrated adapter. The modes of the integrated adapter continue to be available. The 8514/A provides hardware assist for advanced text image and graphics applications, and supports the high screen content - 1024 x 768 - of the 8514 color display. For applications that require the advanced function support of the 8514/A but do not require the high screen content provided by the 8514, the 8503 monochrome display or the 8513 color display would be appropriate using an APA addressability of 640 x 480.

Configuration Options

Figure 1 shows allowable combinations of displays, adapters and system units. An "x" indicates an allowable configuration, and a "P" indicates a preferred configuration, where the functional capabilities of the display and adapter provide a close match.

System Unit	Display Adapter	Display						
		5151	5153	5154	8503	8512	8513	8514
PC, XT, XT286, AT	Mono	x						
	CGA		x					
	EGA			x				
	Personal System/2 Display Adapter				P	x	P	x
Personal System/2 Mod 30	Integrated Adapter				P	P	x	x
	Personal System/2 Display Adapter				P	x	P	x
Personal System/2 Mod 50, 60, 80	Integrated Adapter				P	x	P	x
	8514/A				x	x	x	P

Figure 1. Display Configurations

Figure 2 summarizes the modes available with the new display and display adapters.

					Display Adapter					
BIOS Mode	Resolution	Colors	Chars	Type	Mono	CGA	EGA	PS/2 m 30	VGA	8514 /A
0, 1	320x200	16	40x25	A/N		Y	Y		Y	
2, 3	640x200	16	80x25	A/N		Y	Y		Y	
0*,1*	320x350	16	40x25	A/N			Y		Y	
2*,3*	640x350	16	80x25	A/N			Y		Y	
0#,1#	320x400	16	40x25	A/N				Y	Y	
2#,3#	640x400	16	80x25	A/N				Y	Y	
0+,1+	360x400	16	40x25	A/N					Y	
2+,3+	720x400	16	80x25	A/N					Y	
4, 5	320x200	4	40x25	APA		Y	Y	Y	Y	
6	640x200	2	80x25	APA		Y	Y	Y	Y	
7	720x350	mono	80x25	A/N	Y		Y		Y	
7+	720x400	mono	80x25	A/N					Y	
D	320x200	16	40x25	APA			Y		Y	
E	640x200	16	80x25	APA			Y		Y	
F	640x350	mono	80x25	APA			Y		Y	
10	640x350	16	80x25	APA			Y		Y	
11	640x480	2	80x30	APA				Y	Y	
12	640x480	16	80x30	APA					Y	
13	320x200	256	40x25	APA				Y	Y	
8514 /A mode	640x480	256	80x34	APA						Y
	1024x768	256	85x38	APA						Y
	1024x768	256	46x51	APA						Y

Figure 2. Summary of Adapter Modes

Notes:

1. 200 line modes are double-scanned to give 400 lines with the new adapters.
2. The number of colors shown for the EGA and the 8514/A is based on additional memory features being installed.
3. With the 8514/A adapter, all modes of the native adapter coexist.
4. "*" signifies EGA enhanced mode
5. "#" signifies a Personal System/2 Model 30 enhanced mode
6. "+" signifies VGA enhanced mode

Software Support: The new operating systems, IBM Operating System/2 Standard Edition and the IBM Operating System/2 Extended Edition, together with new versions of IBM Personal Computer DOS provide comprehensive support for the new display products.

Support provided by the IBM Operating System/2 Standard Edition and the IBM Operating System/2 Extended Edition includes:

- The ability to view multiple application windows on the screen simultaneously
- Screen menu support
- A user interface which is rich in function and consistent across applications
- An application programming interface providing advanced alphanumerics and graphics support
- Communications support (in IBM Operating System/2 Extended Edition).

Virtual Device Interface support is available for use with both IBM Operating System/2, and IBM Personal Computer DOS for all of the new displays and adapters.

With IBM Personal Computer DOS, communications support is provided through the IBM 3270 Workstation Program, which also offers support for multiple concurrent host and Personal Computer sessions, new releases of the IBM 3270 Emulation Programs, and the IBM Local Area Network program.

The IBM GDDM PCLK program can be used with the 3270 Workstation Program and the 3270 Emulation Programs to provide access to the wide range of mainframe graphics applications available through the Graphical Data Display Manager program.

IBM Personal System/2 Monochrome Display 8503

Introduction

The IBM Personal System/2 Monochrome Display 8503 is a high-quality display for text graphics, and gray shade imaging. It features a 12-inch CRT with an etched dark faceplate. The phosphor is paper white with a persistence which allows scrolling without smearing.

The IBM Personal System/2 Monochrome Display 8503 can be used with:

- The Integrated Adapters of the IBM Personal System/2 Models 30, 50, 60 and 80
- The IBM Personal System/2 Display Adapter 8514/A
- The IBM Personal System/2 Display Adapter.

The Personal System/2 Monochrome Display 8503 is a direct drive analog input display with the capability of simultaneously presenting 64 shades of gray when operated with the adapters listed above. Please note that the human eye will not be able to distinguish all 64 shades. Even 16 shades are barely distinguishable except when adjacent to each other. 64 shades are provided to smooth transitions (shading) from one distinguishable shade of gray to another.

The Personal System/2 Monochrome Display 8503 is a multi-mode display, having the ability to operate over a range of vertical modes. It will sense polarities of the horizontal and vertical synchronization pulses and use this information to program three vertical modes: 350, 400, or 480 scan lines to be displayed in the fixed data area. The horizontal deflection rate is 31.5Khz and it has the ability to operate with a vertical deflection rate from 50 Hz to 70 Hz non-interlaced. 70Hz frame rate is the IBM default rate for all IBM modes where possible. 70Hz was chosen to provide flicker free operation. This is especially important when one chooses to do text operations with a black on white screen (worst case for flicker). The IBM adapters, however, have white on black as the default mode for text operations. The nominal useable area of the screen for data display is 207 mm horizontally and 155 mm vertically (8.15 x 6.10 inches).

The Personal System/2 Monochrome Display 8503 has up to 720 horizontal pels addressable.

When operating in the 640 x 480, 60Hz mode, displayed pels have a unity aspect ratio so as to simplify programming for graphics and image applications. Pel unity aspect ratio, or square pels, simply means the distance between individual pels is the same in both the vertical and horizontal directions.

The Personal System/2 Monochrome Display 8503 provides many ergonomic features through its physical characteristics. Paper white phosphor is employed to provide a realistic environment for document processing and gray shade imaging. The persistence of the phosphor along with refresh rates selected give a bright flicker free image. Reflections from the face of the CRT are minimized by means of an etched faceplate. Contrast has been improved by providing a darkened faceplate. A detachable tilt/swivel stand is provided as standard with the display. The tilt/swivel stand allows the operator to adjust the display for personal convenience. It also allows the screen to be positioned to minimize glare and reflections from light sources such as overhead lights and windows.

Operator controls and indicators consist of a power on/off switch, brightness control, contrast control, and a green power-on indicator.

As a service aid, the Personal System/2 Monochrome Display 8503 has a self-test mode to assist in determining if the fault is in the display or the video adapter. With the signal cable disconnected, a signal is injected into the input of the video section of the display. A white screen being visible on the screen indicates the fault is very likely not in the display.

Personal System/2 Monochrome Display 8503 Characteristics

The following tables summarize the Monochrome Display 8503 characteristics:

Nominal CRT size	12 inch
Data area excluding active border:	
H X V (mm)	207 x 155
H X V (inches)	8.15 x 6.10
Aspect ratio	4 x 3
Video interface	analog
Sync interface	TTL
Bandwidth	30 MHz

Vertical Characteristics Used With IBM Adapters

Vertical Operating Mode	**1**	**2**	**3**	**4**
Sync Signal Polarities (H,V)	+,-	-,+	-,-	+,+
Data Area Scan Lines	350	400	480	not app.
Plus Border Scan Lines	12	14	16	not app.
Displayed Scan Lines/Frame	362	414	496	not app.
Frame Rate (Hz)	70.08	70.08	59.95	not app.
Frame Blanking Time (ms)	2.765	1.112	0.921	not app.

Horizontal Characteristics Used With IBM Adapters

Addressable Pels Per Line	640	720
Plus Border Pels	16	18
Maximum Pels Per Line	656	738
Line Rate (kHz)	31.47	31.47
Line Blanking Time (us)	5.72	5.72
Maximum Video Clock Frequency (Mhz)	25.17	28.32

8503 Physical Characteristics

```
Size:  The dimensions of the Personal System/2
       Monochrome Display 8503 were selected to
       provide size compatibility with the
       Personal System/2 and are as follows:

     Width:----------------  321 mm (12.6 in.)
     Depth:----------------  311 mm (12.2 in.)
     Height (with stand)---  312 mm (12.5 in.)
     Height (without stand-  277 mm (10.9 in.)

Weight:-------------------   8.5 kg (18.8 lb.)

Power Cable:  Connects to an appliance coupler on
              the display and plugs into a
              properly grounded wall electrical
              outlet.
     Length----------------  1.8 m (6 ft.)

Signal Cable:
     Length----------------  1.8 m (6 ft.)
                         hardwired to display unit

     Note: Longer length provides more flexibility
           in installation.

Signal Cable Connector----  15 pin miniature "D" type
```

Note: The Signal Cable Connector was selected for the following reasons:

- Prevent plugging it into the wrong receptacle
- Allow video adaptor sensing of display type (mono, color, line rate)
- Allow for extended future capabilities.

Cooling: Natural convection only; no fan in unit

Models: There are three models of the Monochrome Display 8503

- Northern Hemisphere 100 - 125 VAC nominal, 50/60 Hz +/- 3 Hz
- Northern Hemisphere 200 - 240 VAC nominal, 50 Hz +/- 3 Hz
- Southern Hemisphere 200 - 240 VAC nominal, 50 Hz +/- 3 Hz.

Operator Controls/Indicators

- Power on/off switch: Located on the right side of the display.
- Green power on light: Located on the front of the display.
- Brightness control, with detent at normal position: Located on the left side of the display behind the contrast control.
- Contrast control: Adjustable by operator for visual comfort. Located on the left side of the display forward of the brightness control.
- Tilt/Swivel Stand: An attached tilt/swivel stand is provided as standard with each Monochrome Display 8503. It is capable of being removed by the operator. The range of the swivel is 90 degrees in each direction. The range of the tilt is from down 5 degrees to up 20 degrees.

IBM Personal System/2 Color Display 8512

Introduction

The IBM Personal System/2 Color Display 8512 is a high quality, medium resolution display for text, graphics, and imaging. It features a 0.41mm stripe pitch 14-inch CRT with an etched dark faceplate. The phosphor is P22 with a persistence which allows scrolling without smearing.

The Personal System/2 Color Display 8512 Display can be used with:

- The Integrated Adapters of the IBM Personal System/2 Models 30, 50, 60 and 80
- The IBM Personal System/2 Display Adapter 8514/A
- The IBM Personal System/2 Display Adapter.

The Personal System/2 Color Display 8512 is a direct drive analog input display with capability of simultaneously presenting 256 colors from a palette of 256k colors when operated with the adapters listed above.

The nominal usable area of the screen for data display is 240 mm horizontally and 180 mm vertically (9.45 x 7.09 inches).

The Personal System/2 Color Display 8512 is a multi-mode display, having the ability to operate over a range of vertical modes. It will sense polarities of the horizontal and vertical synchronization pulses and use this information to program three vertical modes; 350, 400, or 480 scan lines to be displayed in the fixed data area. The horizontal deflection rate is 31.5Khz and it has the ability to operate with a vertical deflection rate from 50 Hz to 70 Hz non-interlaced. 70 Hz frame rate is the IBM default rate for all IBM modes where possible. 70 Hz was chosen to provide flicker free operation.

The Personal System/2 Color Display 8512 has up to 720 horizontal pels addressable.

When operating in the 640 x 480, 60 Hz mode, displayed pels have a unity aspect ratio so as to simplify programming for graphics and image applications. Pel unity aspect ratio, or square pels, simply means the distance between individual pels is the same in both the vertical and horizontal directions.

The Personal System/2 Color Display 8512 provides many ergonomic features through its physical characteristics. The persistence of the phosphor and the refresh rates have been selected to give a bright image and to minimize flicker. Reflections from the face of the CRT are minimized by means of an etched faceplate. Contrast is enhanced by providing a darkened faceplate. A detachable tilt/swivel stand is available as an option. The tilt/swivel stand allows the operator to adjust the display for personal convenience. It also allows the screen to be positioned to minimize glare and reflections from light sources such as overhead lights and windows.

Operator controls and indicators consist of a power on/off switch, brightness control, contrast control, and a green power-on indicator.

As a service aid, the Personal System/2 Color Display 8512 has a self-test mode to assist in determining if the fault is in the display or the video adapter. With the signal cable disconnected, a white signal is injected into the input of the video section of the display. A white screen being visible on the screen indicates the fault is very likely not in the display.

Personal System/2 Color Display 8512 Characteristics

The following tables summarize the Color Display 8512 characteristics:

Nominal CRT Size	14 inch
Phosphor Stripe Pitch	0.41 mm
Data Area including border:	
H X V (mm)	240 x 180
H X V (inches)	9.45 x 7.09
Aspect ratio	4 x 3
Video Interface	Analog
Sync Interface	TTL
Bandwidth	28 Mhz

Vertical Characteristics Used With IBM Adapters

Vertical Operating Mode	**1**	**2**	**3**	**4**
Sync Signal Polarities (H,V)	+,-	-,+	-,-	+,+
Data Area Scan Lines	350	400	480	not app.
Plus Border Scan Lines	12	14	16	not app.
Displayed Scan Lines/Frame	362	414	496	not app.
Frame Rate (Hz)	70.08	70.08	59.95	not app.
Frame Blanking Time (ms)	2.765	1.112	0.921	not app.

Horizontal Characteristics Used With IBM Adapters

Addressable Pels Per Line	640	720
Plus Border Pels	16	18
Maximum Pels Per Line	656	738
Line Rate (kHz)	31.47	31.47
Line Blanking Time (us)	5.72	5.72
Maximum Video Clock Frequency (MHz)	25.17	28.32

8512 Physical Characteristics

```
Size:
    Width:----------  355 mm (13.97 in.)
    Depth:----------  394 mm (15.51 in.)
    Height (with stand)---  370 mm (14.57 in.)
    Height (without stand-  304 mm (11.97 in.)

Weight:
    With stand------------  15 kg (33 lb.)
    Without stand---------  13.5 kg (30 lb.)

Power Cable:  Connects to an appliance coupler on
              the display and plugs into a
              properly grounded wall electrical
              outlet.
    Length----------  1.8 m (6 ft.)

Signal Cable:
    Length----------  1.8 m (6 ft.)
                      hardwired to display unit

    Note: Longer length provides more flexibility
          in installation.

Signal Cable Connector----  15 pin miniature "D" type
```

Note: The Signal Cable Connector was selected for the following reasons:

- Prevent plugging it into the wrong receptacle
- Allow video adaptor sensing of display type (mono, color, line rate)
- Allow for extended future capabilities.

Cooling: Natural convection only; no fan in unit

Models: There are three models of the Color Display 8512:

- Northern Hemisphere 100 - 125 VAC nominal, 50/60 Hz +/-3 Hz
- Northern Hemisphere 200 - 240 VAC nominal, 50 Hz +/-3 Hz
- Southern Hemisphere 200 - 240 VAC nominal, 50 Hz +/-3 Hz.

Operator Controls/Indicators

- Power on/off switch: Located on the right side of the display
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- Brightness control, with detent at normal position: Located on the left side of the display behind the contrast control.
- Contrast control: Adjustable by operator for visual comfort: located on the left side of the display forward of the brightness control.
- Tilt/Swivel Stand: A tilt/swivel stand is available as an option with the Color Display 8512. It is capable of being attached and removed by the operator. The range of the swivel is 90 degrees in each direction. The range of the tilt is from down 5 degrees to up 20 degrees.

IBM Personal System/2 Color Display 8513

Introduction

The IBM Personal System/2 Color Display 8513 is a high quality, high resolution display for text, graphics, and imaging. It features a .28mm dot pitch 12-inch CRT with an etched dark faceplate. The phosphor is P22 with a persistence which allows scrolling without smearing.

The IBM Personal System/2 Color Display 8513 can be used with:

- The Integrated Adapters of the IBM Personal System/2 Models 30, 50, 60, and 80
- The IBM Personal System/2 Display Adapter 8514/A
- The IBM Personal System/2 Display Adapter.

The Personal System/2 Color Display 8513 is a direct drive analog display with the capability of simultaneously presenting 256 colors from a palette of 256K colors when operated with the adapters listed above.

The nominal usable area of the screen for data display is 207mm horizontally and 155mm vertically (8.15 x 6.10 inches) in the 350 line and 480 line modes. It is 207mm horizontally and 150mm vertically (8.15 x 5.91 inches) in the 400 line mode. The data area height in this mode was made slightly different from the other modes to reduce the effects of moire fringing.

The Personal System/2 Color Display 8513 is a multi-mode display, having the ability to operate over a range of vertical modes. It will sense polarities of the horizontal and vertical synchronization pulses and use this information to program three vertical modes; 350, 400, or 480 scan lines to be displayed in the fixed data area. The horizontal deflection rate is 31.5Khz and it has the ability to operate with a vertical deflection rate from 50 Hz to 70 Hz non-interlaced. 70 Hz frame rate is the IBM default rate for all IBM modes where possible. 70 Hz was chosen to provide flicker-free operation.

The Personal System/2 Color Display 8513 has up to 720 horizontal pels addressable.

When operating in the 640 x 480, 60 Hz mode, displayed pels have a unity aspect ratio so as to simplify programming for graphics and image applications. Pel unity aspect ratio, or square pels, simply means the distance between individual pels is the same in both the vertical and horizontal directions.

The Personal System/2 Color Display 8513 provides many ergonomic features through its physical characteristics. The persistence of the phosphor and the refresh rates have been selected to give a bright image and to minimize flicker. Reflections from the face of the CRT are minimized by means of an etched faceplate. Contrast is enhanced by providing a darkened faceplate. A detachable tilt/swivel stand is provided as standard with the display. The tilt/swivel stand allows the operator to adjust the display for personal convenience. It also allows the screen to be positioned to minimize glare and reflections from light sources such as overhead lights and windows.

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Personal System/2 Color Display 8513 Characteristics

The following tables summarize the Personal System/2 Color Display 8513 characteristics:

Nominal CRT Size	12 inch	
Phosphor Dot Matrix Pitch	0.28 mm	
Data Area Including Border: Vertical Mode	350 & 480	400
H X V (mm)	207 x 155	207 x 150
H X V (inches)	8.15 x 6.10	8.15 x 5.91
Aspect Ratio	4 x 3	4.1 x 3
Video Interface	Analog	
Sync Interface	TTL	
Bandwidth	30 Mhz	

Vertical Characteristics When Used With IBM Adapters

Vertical Operating Mode	**1**	**2**	**3**	**4**
Sync Signal Polarities (H,V)	+,-	-,+	-,-	+,+
Data Area Scan Lines	350	400	480	not app.
Plus Border Scan Lines	12	14	16	not app.
Displayed Scan Lines/Frame	362	414	496	not app.
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   Depth:----------  362 mm (14.5 in.)
   Height (with stand)---  312 mm (12.5 in.)
   Height (without stand-  277 mm (10.9 in.)

Weight:----------  10.5 kg (23 lb.)

Power Cable:  Connects to an appliance coupler on the
              display and plugs into a properly
              grounded wall electrical outlet.

   Length----------  1.8 m (6 ft.)

Signal Cable:
   Length----------  1.8 m (6 ft.) hardwired
                       to display unit
   Note: Longer length provides more flexibility in
         installation.

Signal Cable Connector----15 pin miniature "D" type
```

Note: The Signal Cable Connector was selected for the following reasons:

- Prevent plugging it into the wrong receptacle
- Allow video adaptor sensing of display type (mono, color, line rate)
- Allow for extended future capabilities.

Cooling: Natural convection only; no fan in unit

Models: There are three models of the Color Display 8513:

- Northern Hemisphere 100 - 125 VAC nominal, 50/60 Hz +/- 3 Hz
- Northern Hemisphere 200 - 240 VAC nominal, 50 Hz +/- 3 Hz
- Southern Hemisphere 200 - 240 VAC nominal, 50 Hz +/- 3 Hz.

Operator Controls/Indicators

- Power on/off switch: Located on the right side of the display.
- Green power on light: Located on the front of the display.
- Brightness control, with detent at normal position: Located on the left side of the display behind the contrast control.
- Contrast control: Adjustable by operator for visual comfort, located on the left side of the display forward of the brightness control.
- Tilt/Swivel Stand: An attached tilt/swivel stand is provided as standard with each Color Display 8513. It is capable of being removed by the operator. The range of the swivel is 90 degrees in each direction. The range of the tilt is from down 5 degrees to up 20 degrees.

IBM Personal System/2 Color Display 8514

Introduction

The IBM Personal System/2 Color Display 8514 is a high quality, high content color display for the IBM Personal System/2 family. It is a general purpose display for the professional user for text, image and graphics applications where high quality and high content color display is required. The 8514 uses a 16" (15"V) (nominal) color CRT in landscape format to display up to 1024 pels horizontally by 768 pels vertically. The usable area of the screen for data display is 283 mm horizontally x 212 mm vertically (11.1 x 8.3 inches).

The 8514 display can be used with:

- The Integrated Adapters of the IBM Personal System/2 Models 30, 50, 60 and 80.
- The IBM Personal System/2 Display Adapter 8514/A
- The IBM Personal System/2 Display Adapter.

The IBM Personal System/2 Display Adapter 8514/A is the preferred display adapter for the 8514 display, with its ability to display 1024 x 768 pels in 256 colors selected from a palette of 256K colors. In this configuration, the 8514 display provides productivity gains for general purpose applications and addresses the special requirements of advanced text image and graphics applications. The high content 8514 display is particularly suitable for applications that use:

- Multiple screen windows
- High content displays, for example in spreadsheet and word processing applications
- Mixed text graphics and image
- Complex charts
- Technical drawings
- Full page-width displays with WYSIWYG format.

The 8514 display can also be used with the IBM Personal System/2 integrated adapters and the IBM Personal System/2 Display Adapter. These adapters have the capability of displaying 640 x 480 pels with 16 colors from a palette of 256k colors. These configurations are appropriate for users who prefer to work with a physically larger screen, and also where a future requirement for a 1024 x 768 capability is envisaged (using the 8514/A adapter).

The 8514 is a multi-mode display, having the ability to operate under a range of line and frame rates. This provides the ability to display the new modes of the 8514/A as well as the modes of the integrated display adapter (including the MPA, CGA and EGA emulation modes), while using the full viewable area of the 8514 screen, and preserving the aspect ratio of the original modes. The line and frame rates for individual modes are selected according to the polarity of the vertical and horizontal sync. signals (see "Personal System/2 Color Display 8514 Characteristics" on page 15 for details).

When operating in 1024 x 768 and 640 x 480 modes, displayed pels have a unity aspect ratio, so as to simplify programming for graphics and image applications.

The 8514 provides superior ergonomic characteristics through its physical characteristics. Medium persistence phosphors are used with refresh rates selected to give a bright flicker free image. Reflections from the face of the CRT are minimized by means of an anti-reflective etch treatment to the face of the CRT.

A tilt and swivel mechanism is provided as standard with the display.

The 8514 is converged for life in the factory: no customer adjustments are necessary.

The cathode ray tube used by the 8514 display has a high resolution precision in-line gun, with a black matrix, tricolor phosphor dot arrangement.

As a service aid, the Personal System/2 Color Display 8514 has a self-test mode to assist in determining if the fault is in the display or the video adapter. With the signal cable disconnected, a white signal is injected into the input of the video section of the display. A white screen being visible on the screen indicates the fault is very likely not in the display.

Personal System/2 Color Display 8514 Characteristics

The following tables summarize the 8514 display characteristics:

Nominal CRT size	16 inch (15 inch V)
Data Area including border: H X V (mm) H x V (inches)	 283 x 212 11.1 x 8.3
CRT Orientation	Landscape
Scan Orientation	Horizontal
Phosphor Dot Matrix Pitch	 0.309 (diagonal) 0.365 (vertical)
Video Interface	Analog
Pel Spacing (1024x768 mode)	0.276 mm 3.62 pel/mm (92 pel/inch)
Spot Size	1.1 mm (typical) 1.3 mm (worst case)

Display operating mode	**A**		**B**		**C**	**D**
Sync signal polarity H,V	+,-		-,+		-,-	+,+
Displayed scan lines/frame	362		414		496	768
Maximum pels per line	738		738		656	1024
Data Area used by IBM display adapters	**MODE**					
	0*,1* 2*,3* F, 10	7	0, 1 2, 3 4, 5 6,13 D, E	0+,1+ 2+,3+ 7+	11, 12 and 8514/A mode	8514/A mode
Displayed scan lines plus border scan lines	350 12	350 12	400 14	400 14	480 16	768 0
Pels per line plus border pels	640 16	720 18	640 16	720 18	640 16	1024 0
Note: Each of these modes uses the full data area specified above.						
Line rate (kHz)	31.47		31.47		31.47	35.52
Line blanking time (us)	5.72		5.72		5.72	5.35
Interlace ratio	1:1		1:1		1:1	2:1
Frame rate (Hz)	70.08		70.08		59.94	43.48
Frame blanking time (us)	2765		1112		922	690
Maximum video clock frequency (MHz)	28.32		28.32		25.18	44.91

Figure 3. Summary of the 8514 Display Characteristics

8514 Physical Characteristics

```
Size:  The dimensions of the Personal System/2
       Color Display 8514 are as follows:

    Width:---------------  400 mm
    Depth:---------------  415 mm
    Height:--------------  320mm without
                             tilt/swivel unit
    Height:--------------  360mm with
                             tilt/swivel unit

Weight:------------------  20 Kg.
Signal Cable:

    Length---------------  1.8 m (6 ft.) hardwired
                             to the display unit.

   Signal Cable Connector-- 15 pin miniature
                              "D" type
Power Cable--------------- 1.8 meters long
```

Cooling: The maximum heat output of the unit is 100W (190 VA) Cooling is by natural convection only: there is no fan in the unit.

Operator Controls/Indicators

- Power
- Brightness, with detent at normal setting
- Contrast, with detent at normal setting
- Tilt/Swivel: A tilt and swivel mechanism is provided as standard and can be attached to the base of the display. The range of swivel is plus/minus 90 degrees. The range of tilt is from down 5 degrees to up 20 degrees.

Models

There are 3 models of the 8514 display:

Low Voltage, Northern Hemisphere

High Voltage, Northern Hemisphere

High Voltage, Southern Hemisphere

Power Requirements

- Low voltage model: 115V, 100W (190VA) maximum, 47 to 63 Hz
- High voltage model: 220V, 100W (190VA) maximum, 47 to 63 Hz

IBM Personal System/2 Model 30 Video Subsystem

The video subsystem resides on the system board. The video logic is composed of a memory controller gate array, a video formatter gate array, 64K of multiport dynamic memory, an 8K static RAM character generator, and a 256 x 18 color palette with three 6-bit digital-to-analog converters (DAC).

All IBM Color/Graphics Adapter (CGA) video modes are supported. All CGA graphics modes are double scanned from 200 to 400 lines. This architecture is not a bit plane design, so the Enhanced Graphics Adapter modes are not supported as part of the base system board video support. The light pen is not supported.

The IBM Personal System/2 Model 30 video uses Interrupt 10H at the BIOS level to maintain compatibility with the IBM Color/Graphics Adapter.

In addition to the modes compatible with the IBM Color/Graphics Adapter, two new modes were added. The additional modes are 320 by 200 (double scanned to 400 lines) graphics (256 colors of 256K colors available) and 640 x 480 graphics (2 of 256K colors available).

Display Support

The video subsystem supports four new analog displays:

- IBM Personal System/2 Monochrome Display 8503
- IBM Personal System/2 Color Display 8512
- IBM Personal System/2 Color Display 8513
- IBM Personal System/2 Color Display 8514.

All displays can support operation at a scan frequency of 31.5 kHz in a non-interlaced format. The polarity of the two synchronization signals output to the display determines the number of horizontal scans.

The IBM Personal System/2 automatically configures the video to support the display attached. When the system senses the presence of an analog monochrome display, BIOS sums the R, G, and B colors and outputs the video signal to pin 2 (green).

The 8503 Monochrome Display has a 12-inch diagonal tube with a medium persistence paper-white phosphor. This monitor helps provide a useful tool for document processing and gray shade imaging. When an application written for the color modes is run on the monochrome display, BIOS sums the colors into 64 monochrome gray shades without requiring any change to the application software.

The 8512 Color Display has a 14-inch diagonal tube with a .41 millimeter stripe pitch format and short persistence phosphors. The 8513 Color Display has a 12-inch diagonal tube with a .28 millimeter dot pitch format and short persistence phosphors. Both monitors provide a useful tool for displaying text and graphics information as well as high quality color images.

The 8514 Color Display has a 16-inch diagonal tube with a 0.309 (diagonal) dot matrix pitch. It uses medium persistence phosphors.

Each display connects to a 15-pin, subminiature, D-shell connector at the rear of the system. The monitor cable is six feet in length.

A BIOS call (AH = 1AH) has been added to read the type of display attached.

Text Modes

In text modes, the character box is an 8 x 16 box. The character font table is loaded into the character generator. All 16 scan lines are able to be programmed into the character generator.

Graphics Modes

In the graphics modes, the character font table in BIOS is used to create the character pels. For most graphic modes, the character box is an 8 x 8 character box that is double scanned to create an 8 x 16 character box and, therefore, not all 16 lines are programmable.

The 640 x 480 mode is not double scanned. Thirty character rows are displayed in this mode. This

mode provides a square pel representation when used with displays that provide a 4 x 3 aspect ratio.

Video Mode Summary

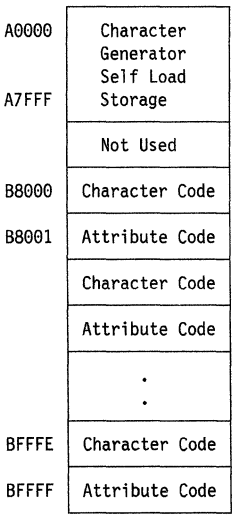
The following is a summary of video modes supported in BIOS.

BIOS Mode	Type	Colors	Alpha Format	Buffer Start	Char Box Size	Screen Pages	Resolution	Refresh Rate
0, 1	A/N	16/256K	40x25	B8000	8x16	8	320x400	70Hz
2, 3	A/N	16/256K	80x25	B8000	8x16	8	640x400	70Hz
4, 5	APA	4/256K	40x25	B8000	8x8	1	320x200	70Hz
6	APA	2/256K	80x25	B8000	8x8	1	640x200	70Hz
11	APA	2/256K	80x30	A0000	8x16	1	640x480	60Hz
13	APA	256/256K	40x25	A0000	8x8	1	320x200	70Hz

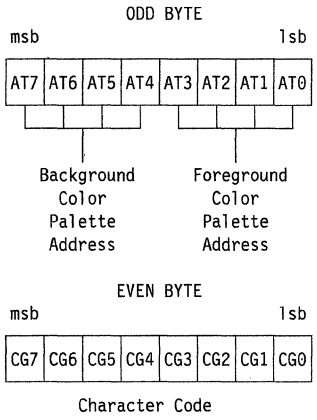
When a 31.5 kHz analog monochrome monitor is connected to the IBM Personal System/2 Model 30, the maximum number of colors in the table above will be replaced with a value of 64 gray shades.

Video Buffer Organization

The following shows the memory mapping of the display buffer used by BIOS in text modes 0 to 3:

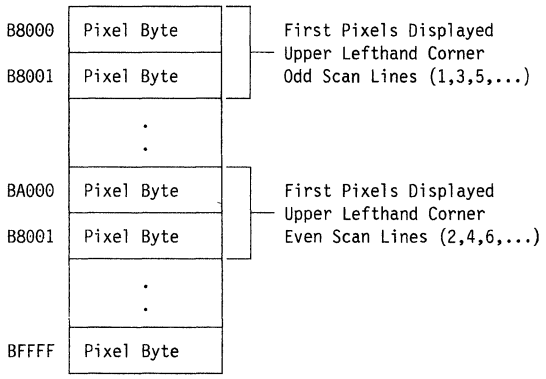


Two bytes define each character on the display screen. The character code in the even byte can reference up to 256 characters held in the character generator. The odd byte defines the attribute information which is divided into two 4-bit addresses for the background and foreground colors. Sixteen colors are available for the foreground and sixteen colors are available for the background. However, when character blinking is enabled, the most significant bit of the attribute byte, AT7, is reserved for turning on or off the blink for that character, and thus leaves only 8 colors available for a background color. Likewise, when using 512 characters out of the character generator, AT3, is used to select between the low or high order 256 characters in the character generator. In this case, there are only 8 colors available for the foreground color. Bit 4 of the Character Generator Interface and Sync Polarity Register, 3D4h, Index 12h, enables 512 character selection. Blink is enabled by bit 5 in the CGA Mode Control Register, 3D8h. The format for the two bytes is as follows:



CGA Graphics Modes

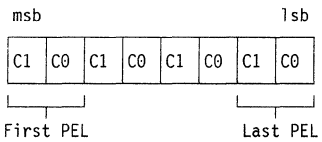
The following shows the memory mapping for the graphics modes 4 through 6:



Even and odd scan lines are separated by 8K bytes and are compatible with the IBM Color/Graphics Adapter.

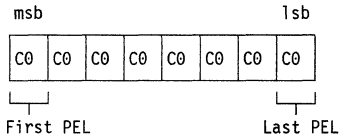
When in graphics modes 4, 5, and 6, the first addressable scan line is fetched starting at address B8000H. This data is then double scanned or automatically duplicated on the second physical scan line on the screen. The second addressable scan line is fetched at address BA000H and is double scanned also. Conceptually, double scanning simply involves double dotting the pixels in the vertical direction.

The format for the pixel byte in modes 4 and 5 is as follows:



In modes 4 and 5, the bit pair C1 and C0 select one of four colors for each pel from one of two color sets. The colors are selected through the CGA Border Control Register (BCR), 3D9h. When bit 5 of the Border Control Register is set to 1, color set 1 is chosen. When bit 4 of this register is set to 1, an intensified color set 0 or color set 1 is selected--whichever was chosen with bit 5. Bits 4 and 5 set to a 1 is the default. Bit 4 of the BCR, C1 and C0 of the pixel byte and bit 5 of the BCR become the palette address. Bits 3 through 0 of the BCR select the background color, which is selected when C1 and C0 are 00. The default palette in this mode is the CGA-compatible palette.

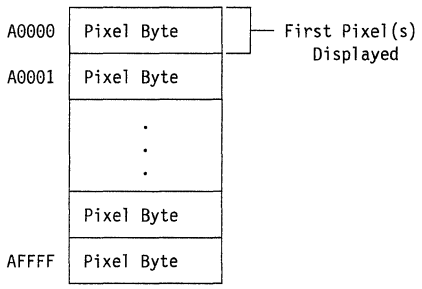
The format for the pixel byte in mode 6 is as follows:



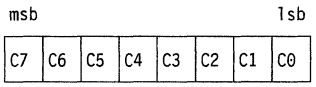
In this mode, one bit defines each pel. If bit 2 in the CGA Mode Control Register, 3D8h, is 1, the foreground color comes from palette address, 7h. If this bit is 0, the foreground color comes from the palette address specified in the CGA Border Control Register, bits 3-0. The background color always maps to palette address 00h. The default color 0 is black and the default color 7 is white.

New Graphics Modes

The following shows the memory mapping for modes 11h and 13h:



The video buffer for the 320 x 200 x 256 color and 640 x 480 x 2 color graphics mode is addressed linearly.



In mode 11h, the pixel definition is the same as in mode 6. In mode 13h, one byte of data is used to define one pixel on the display screen. A pixel is defined by the C7-C0 bits in the memory byte.

Palette Interface

The color palette has 256, 18-bit read/write data registers, an 8-bit write address register and an 8-bit read address register. Each data register is divided into three 6-bit data areas, one for each color (R, G, B). Loading each data register takes three CPU I/O writes in the sequence of red, then green, then blue.

Note: Bits 6 and 7 are unused in these palette writes and should be set to 0.

The palette supports both a single register write operation and a burst load operation.

To maintain software compatibility, programmers should use the BIOS interface when loading the color palette. BIOS supports two calls for setting and two calls for reading the color registers. The calls are through interrupt 10H with (AH) = 10H. The value in the AL register determines the specific operation:

10H - Set individual color register

12H - Set block of color registers

15H - Read individual color register

17H - Read block of color registers

1BH - Sum color values to gray shades.

For an individual register load, the address for the specific color register (0 - 255) is loaded into the BX register. The DH, CH, and CL registers contain the red, green and blue values, respectively.

The second call supports setting a block of color registers. Using this call, one to 256 color values can be set or read with a single BIOS call. The BX register contains the address for the first register to be set, and CX contains the number of registers to set. The value contained in ES:DX points to a table of color values, where each table entry contains the red, green and blue values for a color.

To sum the color values to gray shades, BIOS calculates a weighted sum (30% red, 59% green, and 11% blue), and then writes the sum into the red, green, and blue components of the color register. The original data for these color registers is not retained.

RAM-Loadable Character Generator

The character generator is RAM loadable. Four 8x16 character fonts of 256 characters each may be stored in the video buffer at A0000H. Two of these fonts may be loaded into and displayed from the character generator at any one time. A BIOS call (AH=11H) is provided to load the character generator.

Personal System/2 Video

The video on the IBM Personal System/2 Models 50, 60 and 80 is generated by the IBM Video Graphics Array (VGA) chip and its associated circuitry (see Figure 4 on page 22). The associated circuitry consists of the video memory and a video Digital-to-Analog Converter (DAC). The 256K bytes of video memory are formed from four 64K x 8 memory maps. The red, green, and blue (RGB) outputs from the video DAC drive any of the IBM 31.5 kHz analog displays. Hereafter, the VGA chip and its associated circuitry are referred to as "VGA".

All video modes available on the IBM Monochrome Adapter, IBM Color/Graphics Adapter, and IBM Enhanced Graphics Adapter are supported, regardless of which analog display is connected. All VGA modes are available on all of the supported analog displays. Colors are displayed as shades of grey when the monochrome analog display is connected.

New Modes

New modes available are: 640 x 480 graphics in both 2 and 16 colors; 720 x 400 alphanumeric in both 16-color and monochrome; 360 x 400 16-color alphanumeric; and 320 x 200 graphics with 256 colors. In addition, all 200-line modes are double-scanned by VGA and displayed as 400 lines on the display. This means that each one-pixel-high horizontal scan line will be displayed twice on the display, providing improved legibility.

The VGA chip does the interfacing between the CPU and video memory. All data passes through the VGA chip when the CPU writes to or reads from video memory. The VGA chip controls the arbitration for video memory between the CPU and the CRT Controller function contained within the VGA chip. The user does not need to write to the display buffer during non-active display time to prevent snow on the screen; the VGA chip automatically prevents this from happening. The CPU will experience better performance when accessing the display buffer during non-active display times, because less interference from the CRT Controller function is occurring.

Video memory addressing is controlled by the VGA chip. The starting address of the video memory is programmable to three different starting addresses for compatibility with previous video adapters. BIOS will program the VGA chip appropriately during a video mode set.

Character Sets

In alphanumeric modes, the CPU writes ASCII character code and attribute data to video memory maps 0 and 1 respectively. The character generator is stored in video memory map 2 and is loaded by BIOS during an alphanumeric video mode set. BIOS downloads the character set font generator data from system ROM. Three fonts are contained in ROM. Each of these fonts contains dot patterns for 256 different characters. Two of the fonts are identical to those provided by the IBM Monochrome Display Adapter, the IBM Color/Graphics Adapter, and the IBM Enhanced Graphics Adapter. The third font is a new 9 x 16 character font. Up to eight 256-character fonts can be loaded into video memory map 2 at one time (EGA allows up to four). A BIOS interface exists to load user-defined fonts. As on EGA, BIOS calls select which of the fonts is actually used to form characters and to redefine the intensity bit in the attribute byte as a switch between two 256-character fonts. This allows 512 characters to be displayed on the screen at one time.

Video DAC

The VGA chip formats the information stored in video memory into an 8-bit digital value that is sent to the video Digital-to-Analog Converter (DAC). This 8-bit value allows access to a maximum of 256 registers inside the video DAC. For example, in the 2-color graphics modes, only two different 8-bit values would be presented to the video DAC; in the 256-color graphics mode 256, different 8-bit values would be presented to the video DAC. Each register inside the video DAC contains a color value that is selected from a choice of 256K colors; therefore, each color displayed on the screen is selected from a choice of 256K colors.

The DAC outputs three analog color signals (red, green, and blue) which are sent to the display's 15-pin connector. The monochrome analog display is concerned with only the green analog output, which is used to determine the shade of grey that will be displayed.

Video Enable/Disable

A BIOS call is used to enable/disable VGA. Disable means that VGA will not respond to video memory or I/O reads or writes. The contents of registers and video memory are preserved with the values present when the disable is invoked; VGA will continue to generate valid video output if it was doing so before it was disabled.

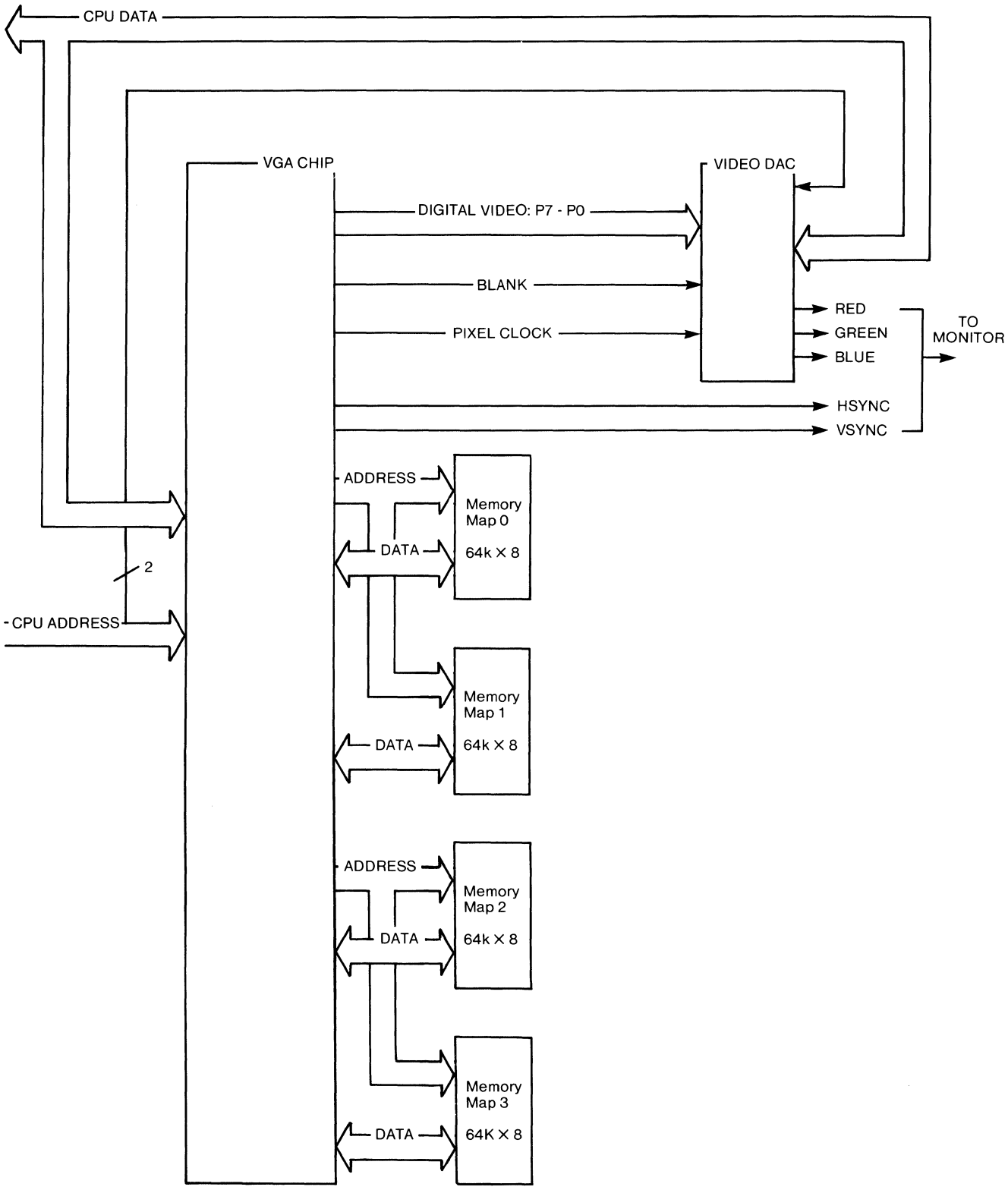


Figure 4. Video Subsystem

Personal System/2 Video Modes

The following table describes the video modes supported by BIOS:

MODE #	TYPE	COLORS	ALPHA FORMAT	BUFFER START	BOX SIZE	MAX. PAGES	VERTICAL FREQ.	RESOLUTION	DOUBLE SCAN ?	BORDER ?
0, 1	A/N	16/256K	40 × 25	B8000	8 × 8	8	70 Hz	320 × 200	YES	NO
2, 3	A/N	16/256K	80 × 25	B8000	8 × 8	8	70 Hz	640 × 200	YES	YES
0*, 1*	A/N	16/256K	40 × 25	B8000	8 × 14	8	70 Hz	320 × 350	NO	NO
2*, 3*	A/N	16/256K	80 × 25	B8000	8 × 14	8	70 Hz	640 × 350	NO	YES
0+, 1+	A/N	16/256K	40 × 25	B8000	9 × 16	8	70 Hz	360 × 400	NO	NO
2+, 3+	A/N	16/256K	80 × 25	B8000	9 × 16	8	70 Hz	720 × 400	NO	YES
4, 5	APA	4/256K	40 × 25	B8000	8 × 8	1	70 Hz	320 × 200	YES	NO
6	APA	2/256K	80 × 25	B8000	8 × 8	1	70 Hz	640 × 200	YES	YES
7	A/N	-	80 × 25	B0000	9 × 14	8	70 Hz	720 × 350	NO	YES
7+	A/N	-	80 × 25	B0000	9 × 16	8	70 Hz	720 × 400	NO	YES
D	APA	16/256K	40 × 25	A0000	8 × 8	8	70 Hz	320 × 200	YES	NO
E	APA	16/256K	80 × 25	A0000	8 × 8	4	70 Hz	640 × 200	YES	YES
F	APA	-	80 × 25	A0000	8 × 14	2	70 Hz	640 × 350	NO	YES
10	APA	16/256K	80 × 25	A0000	8 × 14	2	70 Hz	640 × 350	NO	YES
11	APA	2/256K	80 × 30	A0000	8 × 16	1	60 Hz	640 × 480	NO	YES
12	APA	16/256K	80 × 30	A0000	8 × 16	1	60 Hz	640 × 480	NO	YES
13	APA	256/256K	40 × 25	A0000	8 × 8	1	70 Hz	320 × 200	YES	YES

Figure 5. BIOS Video Modes

Modes 0 through 6 emulate the support provided by the IBM Color/Graphics Adapter (CGA). Mode 7 emulates the support provided by the IBM Monochrome Display Adapter (MDA). Modes D, E, F, 0*, 1*, 2*, 3*, and 10 emulate the support provided by the IBM Enhanced Graphics Adapter (EGA).

When a color analog display is used, each color is selected from a choice of 256K colors. When the monochrome analog display is used, each color is displayed as a shade of grey and selected from a choice of 64 shades.

All Modes Supported on All Displays

Previous adapters have required that a video mode's corresponding display be attached. For example, EGA requires that the Enhanced Color Display be attached to run mode 3* and the Monochrome Display to run mode 7. All Personal System/2 video modes are available on all the supported analog displays. Colors are displayed as shades of grey when the monochrome analog display is connected. Circuitry on the Personal System/2 system board detects which type of analog display is connected (color or monochrome). BIOS maps (sums) the colors into shades of grey. See the BIOS Interface Manual for more information on summing.

Auxiliary Video Connector

The Auxiliary Video Connector (AVC) is a 20-pin connector located in line with one of the Micro Channel Connectors on the system board. This connector allows video data from VGA to be passed to an option card, or allows the system board video buffers to be turned off and video from the option card to drive the video DAC and the 15-pin output connector that drives the analog display. The full Micro Channel is available for use by the option card.

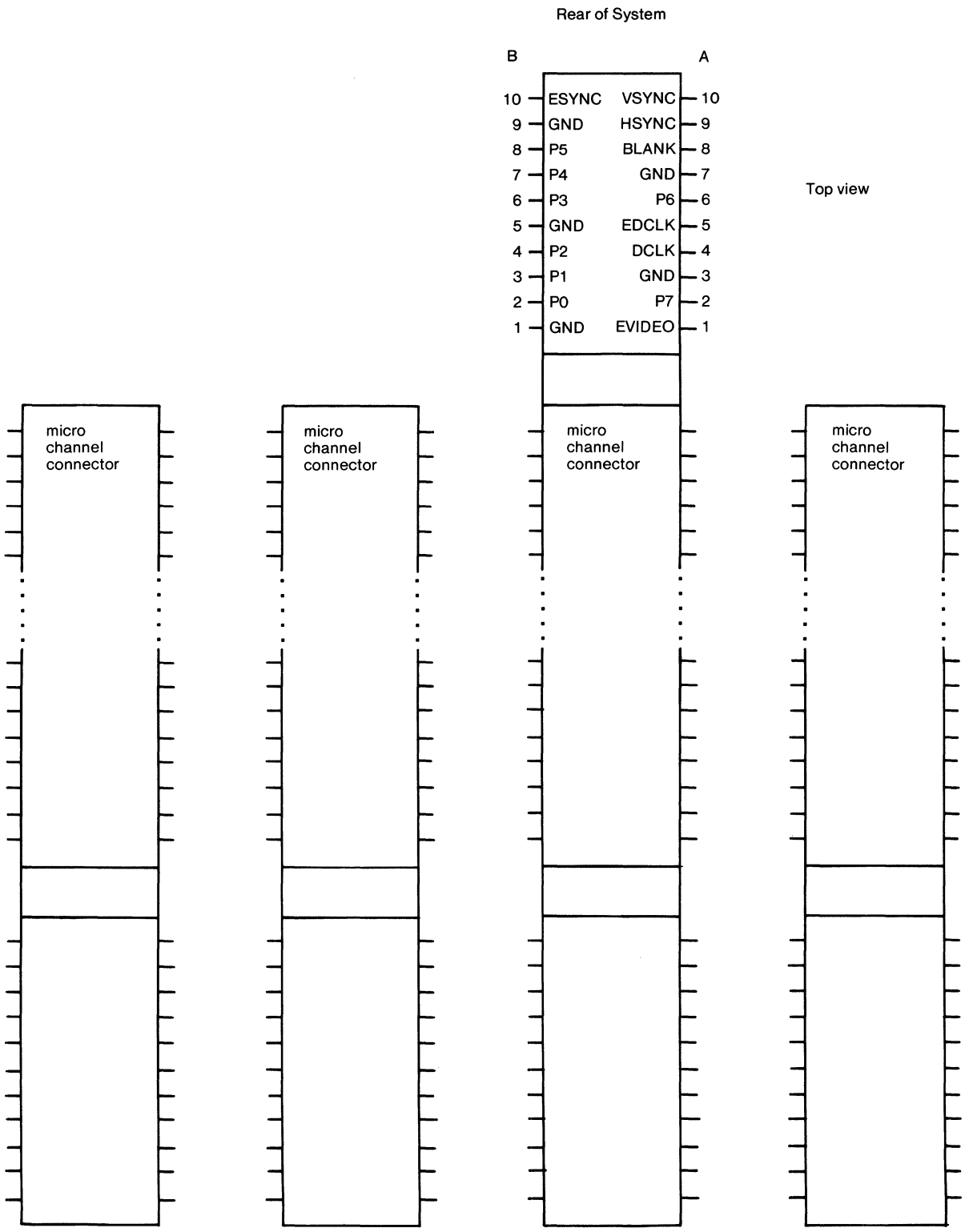


Figure 6. Auxiliary Video Connector Pinout

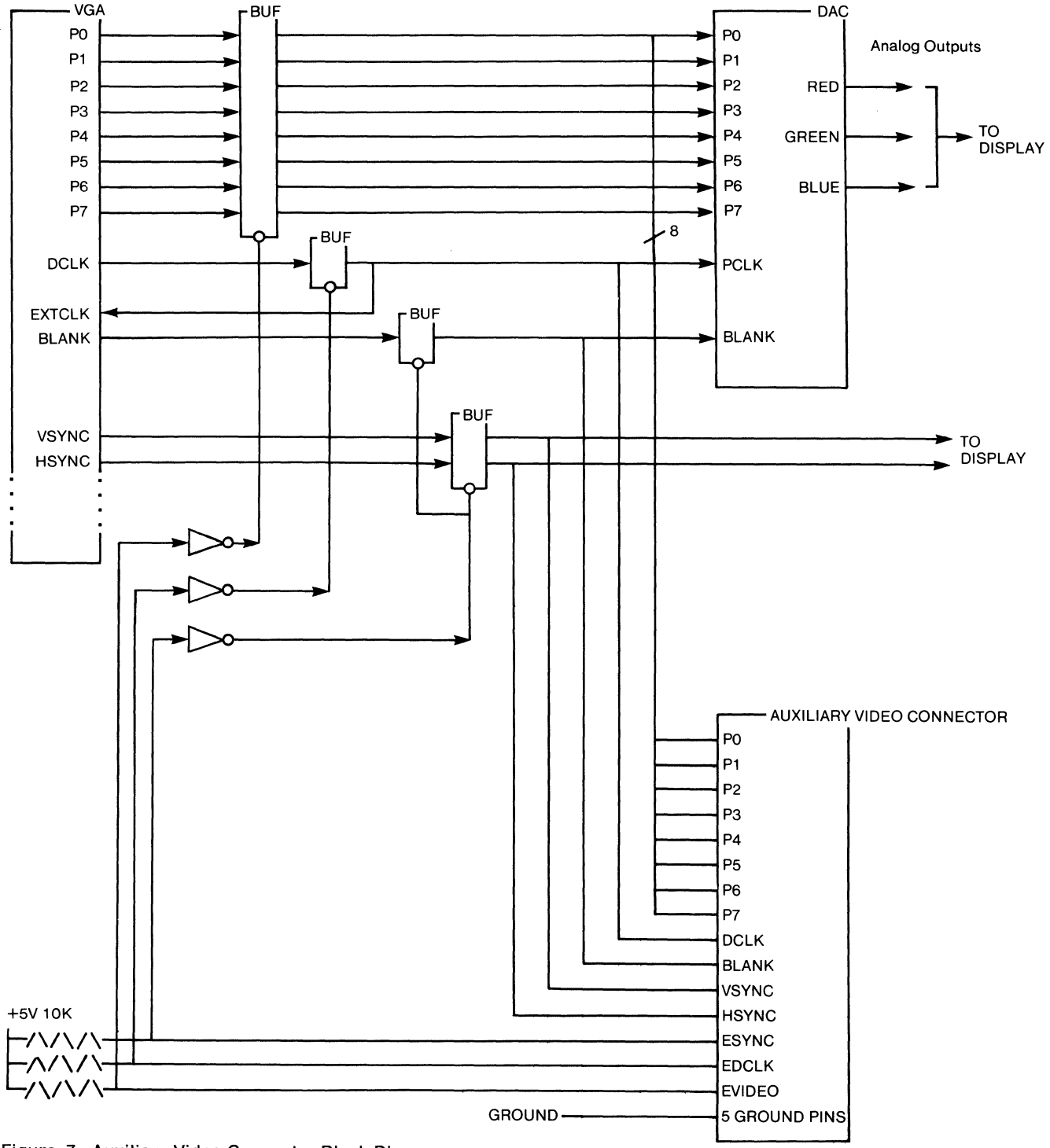


Figure 7. Auxiliary Video Connector Block Diagram

AVC Signal Descriptions

VSYNC

This signal is the vertical sync signal used to drive the display. See also the ESYNC signal description.

HSYNC

This signal is the horizontal sync signal used to drive the display. See also the ESYNC signal description.

BLANK

This signal is connected to the BLANK input of the video DAC and when active (= 0V) tells the DAC to drive its analog color outputs to 0V. See also the ESYNC signal description.

P7 - P0

These eight signals contain digital video information and comprise the pixel address inputs to the video DAC. See also the EVIDEO signal description.

DCLK

This signal is the video pixel clock that is used by the video DAC to latch the digital video signals (P7 - P0). P7 - P0 are latched on the rising edge of DCLK inside the DAC.

This signal is also connected to the EXTCLK input of the VGA chip, and may be driven by the AVC and used as the input clock to the VGA chip. When this configuration is used, *the VGA chip may not be the source of the digital video signals presented to the DAC (P7 - P0); rather, P7 - P0 must be driven from the AVC.* See also the EDCLK signal description.

ESYNC

This signal is the output enable signal for the buffer that drives the BLANK, VSYNC, and HSYNC signals. ESYNC is tied to +5V through a pull-up resistor so that an open circuit on the ESYNC pin produces +5V.

When the ESYNC signal = +5V, BLANK, VSYNC, and HSYNC are sourced from the VGA chip's BLANK, VSYNC, and HSYNC outputs respectively. When the ESYNC signal = 0V, BLANK, VSYNC, and HSYNC are driven from the AVC.

EVIDEO

This signal is the output enable signal for the buffer that drives the P7 - P0 signals. EVIDEO is tied to +5V through a pull-up resistor so that an open circuit on the EVIDEO pin produces +5V.

When the EVIDEO signal = +5V, P7 - P0 are sourced from the VGA chip's P7 - P0 outputs. When the EVIDEO signal = 0V, P7 - P0 are driven from the AVC.

EDCLK

This signal is the output enable signal for the buffer that drives the DCLK signal. EDCLK is tied to +5V through a pull-up resistor so that an open circuit on the EDCLK pin produces +5V.

When the EDCLK signal = +5V, the DCLK signal is sourced from the VGA chip's DCLK output, and received by the AVC and DAC.

When EDCLK = 0V, DCLK is driven from AVC to the EXTCLK input of the VGA chip and to the DAC. When this configuration is used, the VGA chip may not be the source of the digital video signals presented to the DAC (P7 - P0); rather P7 - P0 must be driven from the AVC. If EXTCLK is to be used as the input clock for the VGA chip, the Miscellaneous Output Register in the VGA chip must be programmed to select clock source 2.

Color Mapping

The Enhanced Graphics Adapter (EGA) allows a maximum of 16 different colors to be displayed at one time. EGA contains palette registers that allow each color to be selected from a choice of 64 possible colors. The six bits necessary to form the 64 possible colors comprise the information sent to the digital display connected to the EGA card.

A specific example is shown:

Consider 640 x 350 graphics mode (Mode hex 10). Assume the EGA card is being used and an Enhanced Color Display is attached. This means the six digital color signals being driven to the display from the EGA card are defined as (MSB)R'B'G' RGB(LSB). Assume that palette register hex A has been programmed to have a value of hex 3. If a dot on the screen has attribute hex A (Light Green), then the 4-bit attribute hex A from video memory will select palette register hex A. The contents of register

hex A, hex 3A, are sent to the display. Note that the primary and secondary green bits are turned on, but only the secondary bits for red and blue (thus producing light green on the display):

Color Mapping

	R′	B′	G′	R	G	B
$3A_{HEX}$ =	1	1	1	0	1	0_{BINARY}

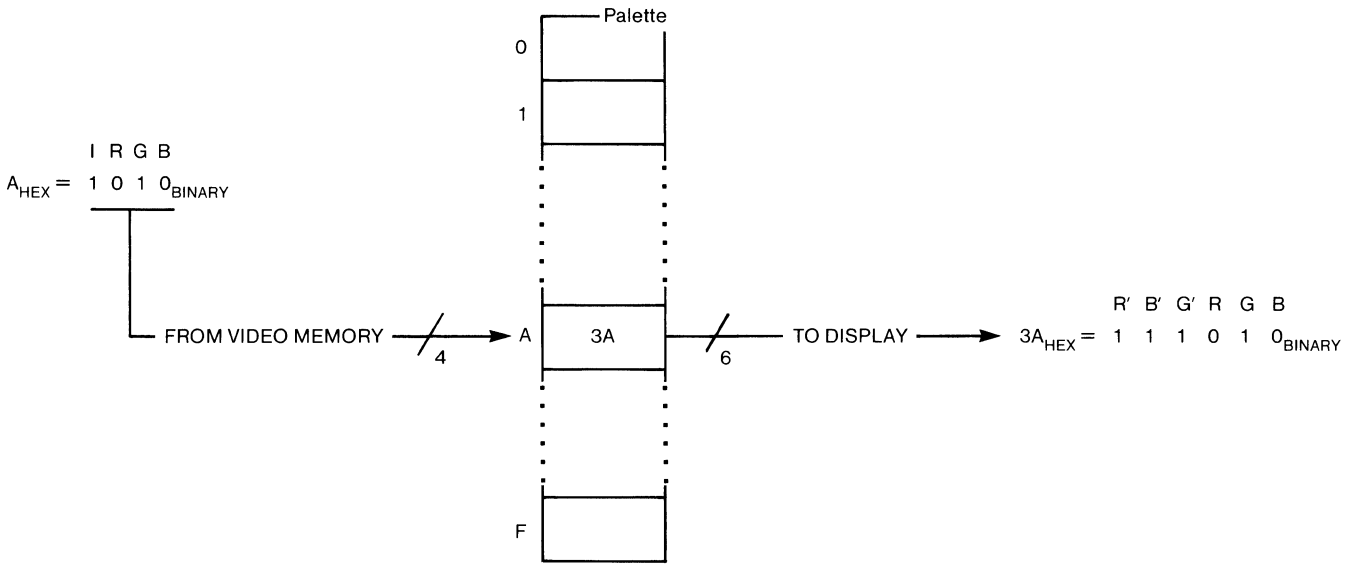


Figure 8. EGA Color Mapping Example

The VGA video system allows a maximum of 256 different colors to be displayed at one time. The VGA video system contains a video Digital-to-Analog Converter (DAC) that also contains color look-up table (CLUT) registers. The VGA chip formats information stored in video memory into an 8-bit digital value that is sent to the video DAC. This 8-bit value selects one of the CLUT registers, each of which is 18 bits wide. The 18 bits are broken down into three 6-bit fields, one each for red, green, and blue. This allows each color displayed to be chosen from a choice of 256K colors. The video DAC converts the 18-bit value contained in the CLUT register to three analog signals (red, green, and blue) that are sent to the analog display.

Assume the same application described previously is running on VGA. Assume the Color Select Register contains 0, and CLUT register hex 3A contains hex 15, hex 3F, and hex 15 in its red, green, and blue fields, respectively. The 4-bit attribute hex A from

video memory will select palette register hex A as on EGA. Two bits from the Color Select Register are appended to the six-bit value from palette register hex A to form the 8-bit value sent to the video DAC. Because the Color Select Register contains 0, the value sent to the DAC is hex 3A. The CLUT register hex 3A in the DAC is accessed, which causes its contents to be sent to the digital-to-analog converters. Since the CLUT register hex 3A contains hex 15, hex 3F, and hex 15 in its red, green, and blue fields, respectively, the value sent to the analog display will be light green.

The mechanism described above functions in a similar fashion for all other video modes *except* mode hex 13 (256 color 320 x 200 Graphics). In this mode the palette registers are programmed so that the 8-bit attribute stored in video memory is sent intact to the video DAC. Do not modify the palette registers in this mode.

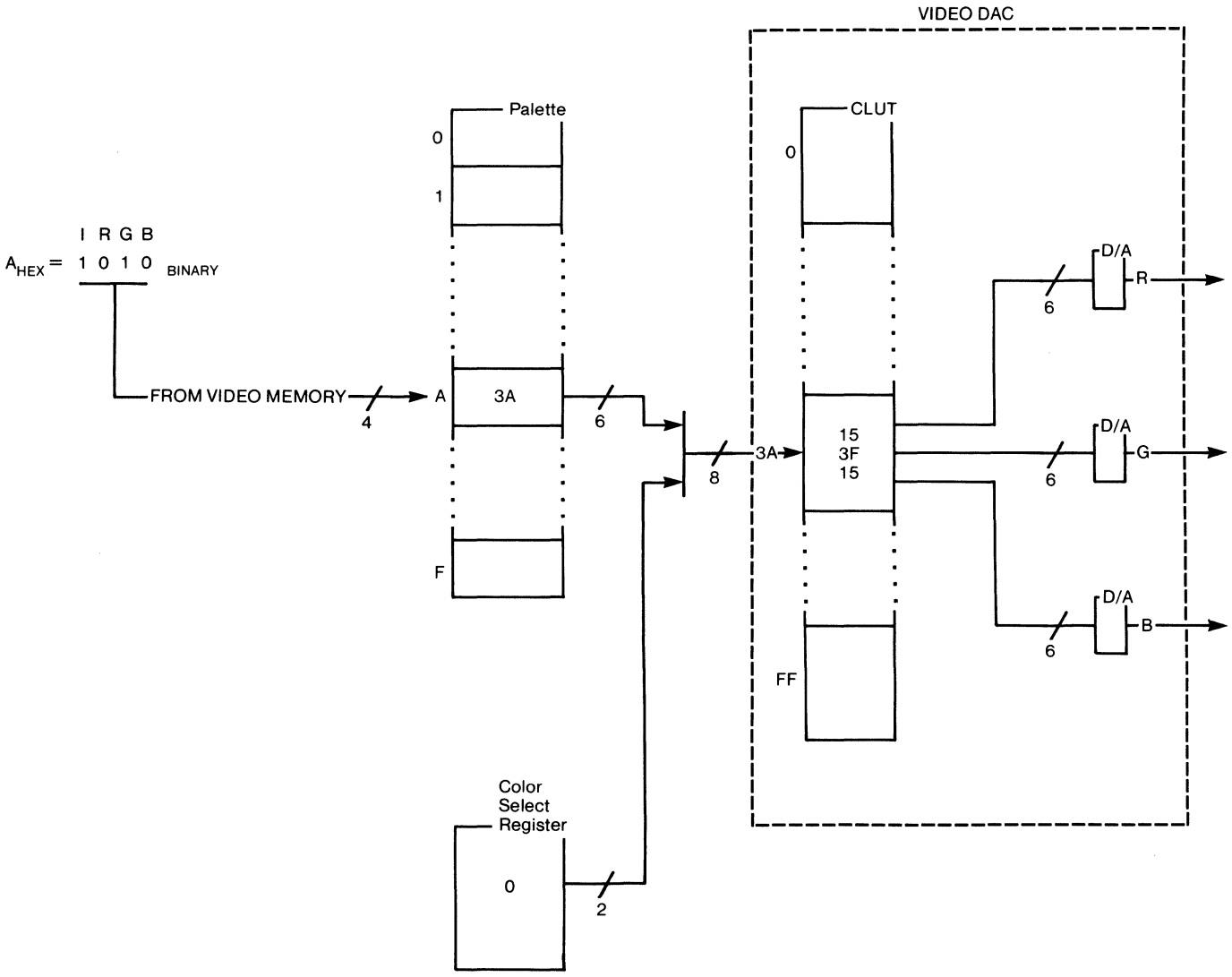
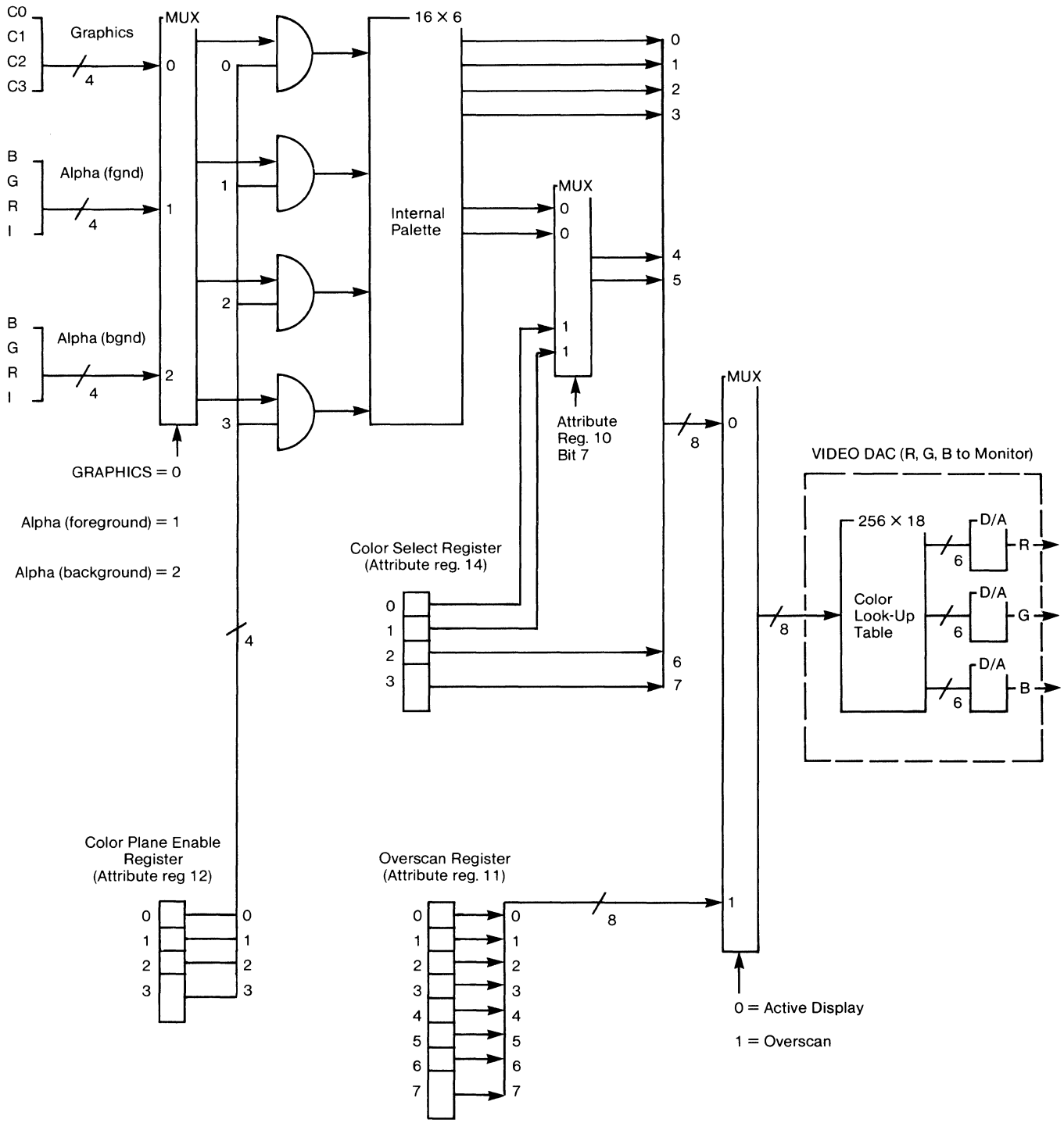


Figure 9. VGA Color Mapping Example



*Except 256 color mode: The 8-bit attribute stored in memory is sent to the DAC. DO NOT MODIFY INTERNAL PALETTE IN THIS MODE.

Figure 10. VGA Color Mapping*

VGA Support Functions

Horizontal Pel Panning

Horizontal pel panning allows the programmer to shift the video image one or more pel positions to the left on the analog display. The horizontal pel panning register in the attribute section of the VGA chip allows the video image to be panned up to 8, 7 or 3 pel positions depending on the video mode. In modes that use 9 pels per character box (0+, 1+, 2+, 3+, 7, 7+) the video image can be panned up to 8 pel positions using the pel panning register. In all other modes, except mode hex 13, the pel panning register will provide for panning of up to 7 pel positions. 3 pel positions can be panned in mode hex 13. Continuous pel panning can be achieved by incrementing the pel panning register (once each vertical retrace period) until the maximum value for a given mode is reached, then resetting pel panning to zero and incrementing the display start address in the CRT controller subsection of the VGA chip. As the video image is panned to the left, data will be panned into the video image from the right. The data panned into the image will be that which is immediately following the normal end of line data in video memory. This means that if the data following the normal end of line data is the start of the next scan line (as is the default for modes set by BIOS), then data panned onto the right side of the display will come from the left side of the next lower graphics scan line or alphanumeric character line. This wrap-back effect can be avoided by using the logical line width register in the CRT controller subsection to provide space between scan lines in video memory. Normally, the logical line width register is programmed with the scan line character width. Increasing this value will provide extra memory bytes between each line. Note that BIOS will not support this feature because individual character, and pel addressing will be changed.

Smooth Scrolling

The VGA chip provides support for vertical smooth scrolling in alphanumeric modes via the preset row scan register in the CRT controller subsection. This register determines which scan line of the first character row begins the display. When set to zero (the default value), the display begins with the top (zero) scan line of each character box on the first row, displaying each character in its entirety. When programmed to a non-zero value, the display starts somewhere in the middle of each character box, showing some lower portion of the characters. Vertical smooth scrolling can be achieved by stepping the preset row scan register (once each vertical retrace period) from zero to one less than the character box height. The second character row can then be smooth scrolled into the first character row by resetting the preset row scan register to zero, and loading the start address registers with the address of the second character row. The appearance of vertical smooth scrolling is that the top row of characters moves up and is scrolled off the top of the display, while a new row of characters is scrolled onto the bottom of the display. The new row of characters is the character row that follows the original last row in video memory.

Split Screen

The VGA chip supports a dual screen display. The top portion of the display is designated as screen A, and the bottom portion of the display is designated as screen B as shown in Figure 11.

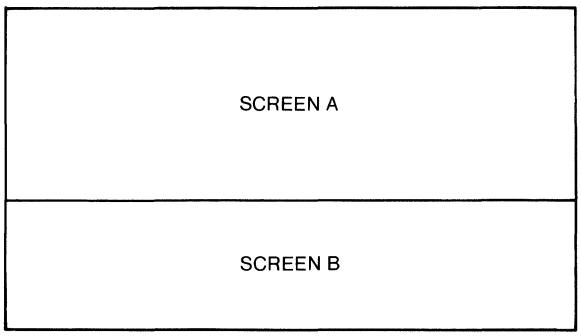


Figure 11. Dual Screen Definition

Figure 12 on page 31 shows the screen mapping for a system containing a 32K byte alphanumeric storage buffer. The VGA Video Subsystem has a 32K byte storage buffer in alphanumeric mode. Information displayed on screen A is defined by the start address high and low registers (hex 0C and hex 0D) of the CRT Controller subsection of the VGA chip. Information displayed on screen B always begins at address hex 0000. Even though this example is for an alphanumeric mode, a split screen is possible for graphics modes also.

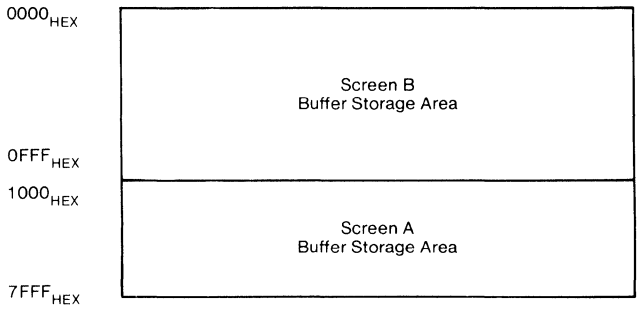


Figure 12. Screen Mapping within the Display Buffer Address Space

The Line Compare Register of the CRT Controller subsection is utilized to perform the split screen function. The CRT controller subsection has an internal horizontal scan line counter, and logic which compares the horizontal scan line counter value to the Line Compare Register value and clears the memory address generator when a compare occurs. The linear address generator then sequentially addresses the display buffer starting at location zero.

Screen B can be smoothly scrolled onto the display by updating the Line compare in synchronization with the vertical retrace signal. Note that in video modes that are double scanned (modes 0, 1, 2, 3, 4, 5, 6, hex D, hex E, and hex 13), the line compare register should be programmed with even numbers only. The information on screen B is immune from scrolling operations which utilize the Start Address registers to scroll through the Screen A address map, and from operations which use the preset row scan register.

The pel panning compatibility bit in the attribute mode control register determines whether or not horizontal pel panning operations on screen A will affect screen B. If this bit is logical zero, then screen B will pan with screen A. If this bit is logical one, then screen B will be immune to the panning operation of screen A.

Logical Memory Read and Write Modes

The VGA chip provides various memory read and write modes that relieve some of the burden of graphics memory manipulation. Two read and four write modes are available. These are described below.

Read Modes

There are two ways to do video memory reads. When read type 0 is selected using the Graphics Mode Register, the video memory returns to the CPU the 8-bit value determined by the logical decode of the memory address, and the Read Map Select Register if applicable. When read type 1 is selected using the Graphics Mode Register, the 8-bit value returned will be the result of the color compare operation controlled by the Color Compare and Color Don't Care Registers. The data flow for the color compare operations is illustrated in Figure 13 on page 32.

The color compare logic is designed for use in modes that use the video memory maps as bit planes. In mode hex 12, for example, maps 3, 2, 1, and 0 are intensity, red, green, and blue bit planes respectively. This means that a byte in a given map contains that bit plane's value for 8 consecutive PELs on the display. For instance the first byte of map 0 would contain the blue bit for the first 8 PELs on the display.

The color compare logic compares a byte from each map with that map's corresponding bit in the color compare register. Each bit in a map's byte is compared with the corresponding color compare bit, yielding an 8-bit intermediate result that is a 1 in each bit position where a match is found. If a map's corresponding color don't care register bit is a 0, that map's 8-bit intermediate result is forced to all 1's, indicating valid compares in all bit positions. The four intermediate results (one for each map) are compared in a bit-wise fashion, returning an 8-bit result to the CPU that is a 1 in each bit position where all four maps have a match.

For example, in mode hex 12, assume the Color Compare Register contains 0101_{Binary}, the Color Don't Care Register contains 0111_{Binary}, and maps 2, 1, and 0 contain 01111111_{Binary}, 01000000_{Binary}, and 11011111_{Binary} respectively. The intermediate results for maps 3, 2, 1, and 0 would be 11111111_{Binary}, 01111111_{Binary}, 10111111_{Binary}, and 11011111_{Binary} respectively. The value returned to the CPU would be 00011111_{Binary}.

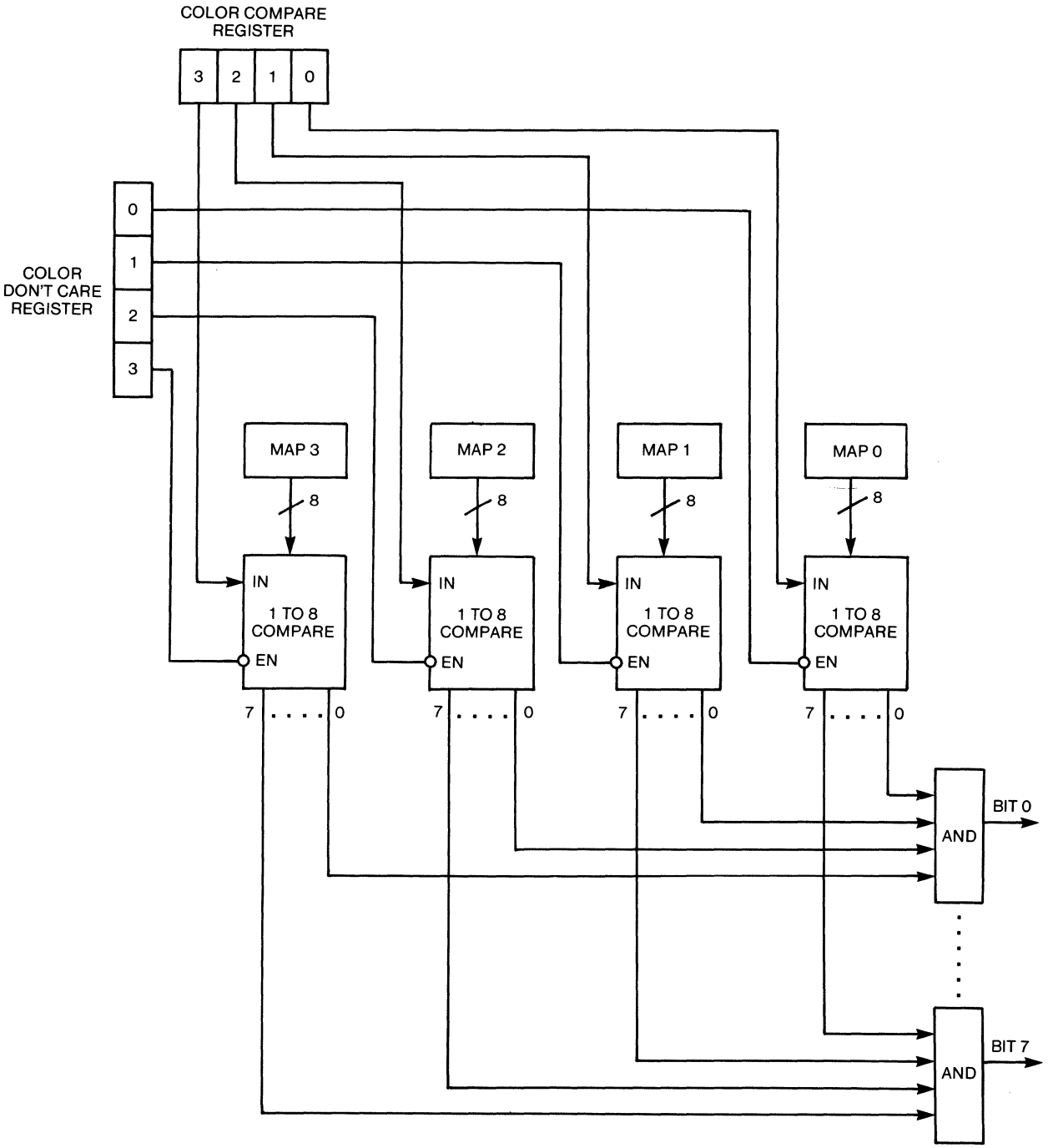


Figure 13. VGA Color Compare Operations

Write Modes

One of the four available write modes is selected by programming the Graphics Mode Register. Figure 14 on page 34 describes the data flow for write operations and is referred to in the following paragraphs. As with the color compare logic, the write logic is designed to support modes that use the video memory maps as bit planes. In mode hex 12 for example, maps 3, 2, 1, and 0 are the intensity, red, green, and blue bit planes respectively. This means that a byte in a given map contains that bit plane's value for 8 consecutive PELs on the display. For instance, the first byte of map 0 would contain the blue bit for the first 8 PELs on the display.

Write Mode 00: In write mode 00_{Binary}, the 8 bits of incoming CPU data are right rotated by the number of bits specified in the Data Rotate Register, with the old least significant bit becoming the new most

significant bit. If the set/reset function is disabled for a map, this rotated 8-bit value is sent to the logic function unit for that map. If the set/reset function is enabled for a map, the bit contained in the Set/Reset Register for that map is expanded to 8 bits and that value is sent to the logic function unit for that map. (Expanded means that the set/reset bit is repeated 8 times; if the set/reset bit is 1, its expansion is 11111111_{Binary}.) The set/reset function is enabled by setting a map's corresponding bit = 1 in the Enable Set/Reset Register.

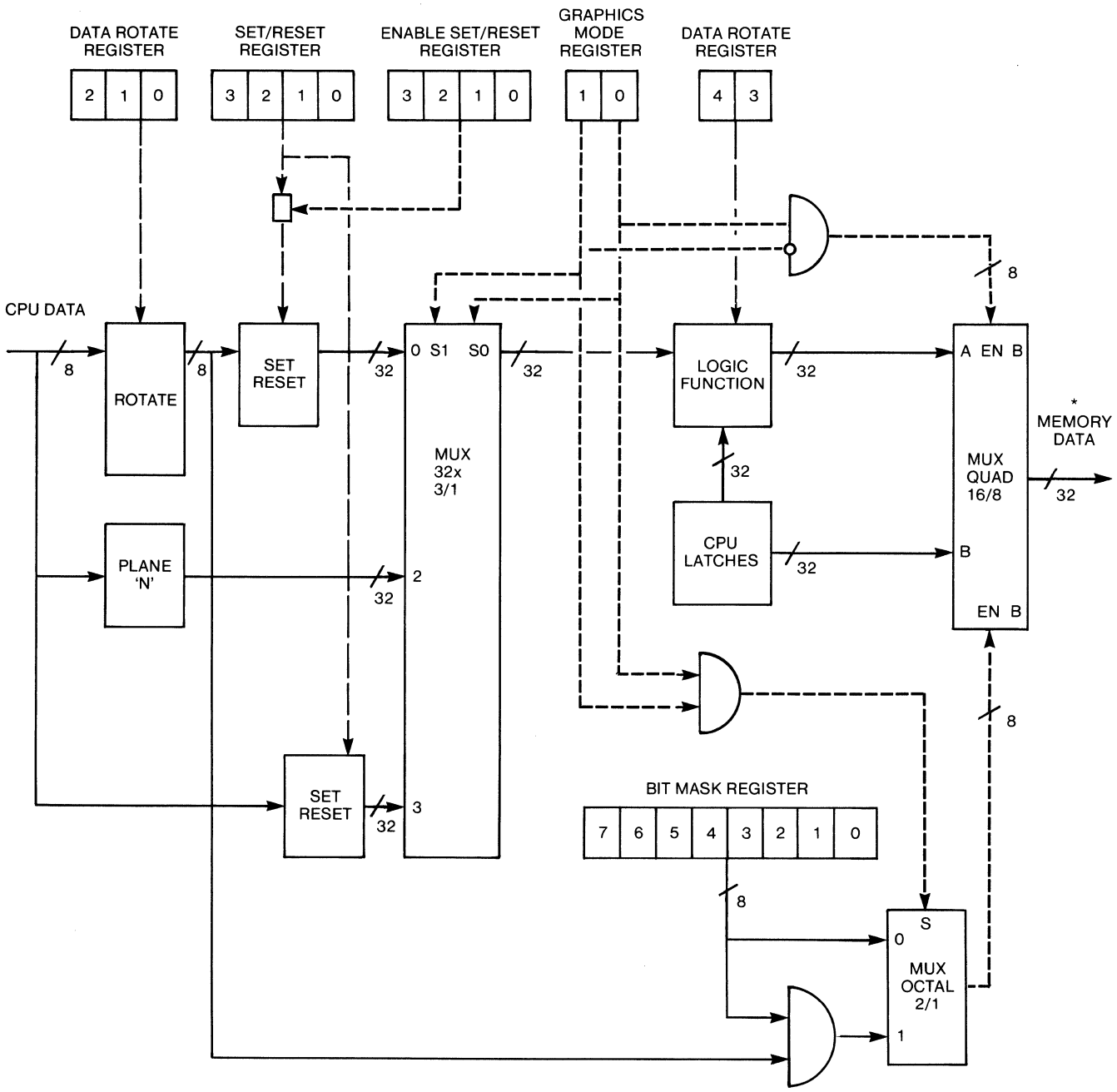
The logic function unit inputs an 8-bit value for each memory map as described above as well as an 8-bit CPU latch value for each map. (The CPU latches contain 32 bits of data from the last read from video memory.) The logic function unit performs logical operations based on the function specified by the function select bits in the Data Rotate Register. The 32-bit output of the logic function unit (8 bits per map) is operated on by the 8-bit-wide Bit Mask Register. If any bit in the Bit Mask Register is a logical one, then the corresponding bit in each map's 8-bit value will take on the value stored in the CPU latches for that bit. (This means that the corresponding bit in each map will be unaffected by the write IF the memory write operation was preceded by a memory read to the same address.) The data resulting from the bit mask operation is written to the four memory maps.

Write Mode 01: In write mode 01_{Binary}, the contents of the CPU latches are written out to the four memory maps. The CPU latches contain 32 bits of data from the last read from video memory. This mode is useful for filling a large number of memory locations with the same value.

Write Mode 10: In write mode 10_{Binary}, the four least-significant bits of the 8 bits of incoming CPU data are each expanded out to 8 bits of data and presented to the logic function unit. CPU data bits 3, 2, 1, and 0 are expanded out to 8 bits of data for maps 3, 2, 1, and 0 respectively. The logic function unit and Bit Mask Register operate as described in the second paragraph under "Write Mode 00" on page 32.

Write Mode 11: In write mode 11_{Binary}, the 8 bits of incoming CPU data are right rotated by the number of bits specified in the Data Rotate Register, with the old least significant bit becoming the new most significant bit. This rotated value is logically "anded" with the contents of the Bit Mask Register to form a mask value whose use is described below.

The bit contained in the Set/Reset Register for each map is expanded to 8 bits and that value is sent to the logic function unit for that map. (Note that the Enable Set/Reset Register has no effect.) The logic function unit inputs an 8-bit value for each memory map as described above as well as an 8-bit CPU latch value for each map. (The CPU latches contain 32 bits of data from the last read from video memory.) The logic function unit performs logical operations based on the function specified by the function select bits in the Data Rotate Register. The 32-bit output of the logic function unit (8 bits per map) is operated on by the 8-bit mask value that is formed as described above. If any bit in the mask value is a logical one, then the corresponding bit in each map's 8-bit value will take on the value stored in the CPU latches for that bit. The data resulting from the bit mask operation is written to the four memory maps.



*Which maps are actually written with data is under the control of the CPU memory address and depending on the mode selected, the Map Mask Register.

Figure 14. Data Flow for VGA Memory Write Operations

IBM Personal System/2 Display Adapter

Adapter Overview

The IBM Personal System/2 Display Adapter is a display adapter card that provides the same function as the Integrated Video Graphics Array (VGA) on the IBM Personal System/2 family. The IBM Personal System/2 Display Adapter can be installed in:

- An IBM Personal Computer
- An IBM Personal Computer XT
- An IBM Personal Computer XT/286
- An IBM Personal Computer AT
- An IBM Personal System/2 Model 30.

The adapter uses the same Video Graphics Array, Palette, Digital to Analog Convertor (DAC) and memory modules as the integrated versions of the adapter. This ensures that a high level of compatibility with the VGA is achieved at the hardware level. In order to achieve a similar level of software compatibility, the adapter contains a ROM module that overwrites the system Video BIOS with a level of BIOS which is functionally the same as that provided with the new system units.

When the IBM Personal System/2 Display Adapter is installed in an IBM Personal System/2 Model 30 system unit, the integrated display adapter is disabled by BIOS.

The display attachment capability for the IBM Personal System/2 Display Adapter is the same as for the integrated adapters, ie:

- IBM Personal System/2 Color Display 8513
- IBM Personal System/2 Color Display 8514
- IBM Personal System/2 Monochrome Display 8503
- IBM Personal System/2 Color Display 8512.

Adapter Functions

The following functions are identical to those of the IBM Personal System/2 integrated adapter:

- Support of all mono, CGA, EGA and VGA modes
- Same character sets as the VGA
- Support for both EGA and VGA palettes
- VGA register compatibility
- VGA Video BIOS support.

Adapter Differences from the VGA

As a consequence of differences in packaging and PS/2 bus arrangements, the following differences with the VGA adapter exist:

- Video Feature Connector

  The same signals are provided as for the VGA, but the physical connector is different. For details, please refer to the IBM Personal System/2 Display Adapter Technical Reference manual.

- Video enable/disable

  Access to the video enable/disable register is via an intermediate register. However, the support of this function through BIOS is identical.

- Hardware interrupt

  Because of conflicting requirements of adapters for interrupts between existing IBM Personal Computers and the IBM Personal System/2, the IBM Personal System/2 Display Adapter does not support the vertical sync interrupt on level 2. This permits the IBM Personal System/2 Display Adapter to coexist with other adapters which use level 2 interrupts, for example 3270 communication adapters. For applications that wish to read the display state, a register is available that can be polled to achieve a capability similar to using the vertical sync interrupt.

- BIOS Equipment flag support

  This flag is not automatically set by BIOS during a mode change as it is for the VGA. IBM Personal System/2 Display Adapter use of the equipment flag is consistent with existing IBM Personal Computer use of the flag, and

applications must set the flag when changing between mono or color modes.

- Mono Alpha Attribute

  The Personal System/2 Display Adapter displays a mono mode reverse video intensified character as white on white.

Adapter Differences from the MCGA

The Personal System/2 Display Adapter is compatible with the MCGA on the Personal System/2 Model 30 at the BIOS level. The hardware implementation of the display buffers is also compatible. This should ensure that most MCGA applications will run on this adapter providing allowances are made for the following exceptions:

- Hardware Interrupts

  These are not supported on the Personal System/2 Display Adapter (see "Adapter Differences from the VGA" on page 35).

- Support of All Modes All Monitors

  The Personal System/2 Display Adapter requires that the equipment flag is correctly set prior to changing between Color or Mono modes (see "Adapter Differences from the VGA" on page 35).

- Module Disable

  This is compatible at the BIOS level but not at the hardware level.

- Mono Attribute

  The Personal System/2 Display Adapter displays a Reverse Video Intensify character as White on White.

- Default Modes

  The Personal System/2 Display Adapter defaults to Mode 7 when a Mono display is attached.

Physical Characteristics

The adapter is packaged as a single card, occupying a full-length card slot. It provides the following connector interfaces:

- Display monitor connector
- Video feature connector

Dual Screen Operation

The only permitted dual display adapter configurations are an IBM Personal System/2 Display Adapter with either an IBM Color/Graphics Display Adapter or an IBM Monochrome Display and Printer Adapter. This dual screen capability is available with the IBM Personal Computer, the IBM Personal Computer XT, the IBM Personal Computer XT/286, and the IBM Personal Computer AT, but not with the IBM Personal System/2 Model 30.

The display attached to the IBM Personal System/2 Display Adapter will always be the primary display.

The following rules define which display modes are allocated to each adapter in the dual adapter configurations.

1. The IBM Monochrome Display and Printer Adapter will always support the monochrome modes.
2. The IBM Color/Graphics Adapter will always support the color modes.
3. The IBM Personal System/2 Display Adapter in a system containing an IBM Color/Graphics Adapter will support the monochrome modes regardless of the display attached to it.
4. The IBM Personal System/2 Display Adapter, in a system containing an IBM Monochrome Display and Printer Adapter, will support the color modes regardless of the display attached to it.
5. The IBM Personal System/2 Display Adapter is installed in the IBM Personal System/2 Model 30. Display switching is supported through the BIOS interface (AH=12H, BL=35H).

Note: In Dual Screen configurations, some of the Video BIOS calls are not fully supported. For details, see the IBM Personal System/2 Display Adapter Technical Reference.

IBM Personal System/2 Display Adapter 8514/A

Overview

The IBM Personal System/2 Display Adapter 8514/A is an optional feature that provides an advanced function display adapter for the IBM Personal System/2 models 50, 60 and 80.

The 8514/A provides:

- *High screen content:* new display modes of 1024 (horizontal) x 768 (vertical) and 640 (horizontal) x 480 (vertical) displayable pixels with 16 colors or grayscales from a palette of 256K colors or 64 grayscales.

  A Memory Expansion Kit is available, consisting of pluggable memory modules, which increases the number of colors that can be displayed to 256 from a palette of 256K, and the number of grayscales to 64.

- *Advanced text image and graphics:* adapter hardware support for high performance text image and graphics operations.

- *Video Graphics Array compatibility:* all of the display modes provided by the integrated display adapter of the system unit continue to be available on the display attached to the 8514/A.

The 8514/A can be used with the following system units:

- IBM Personal System/2 Model 50, Model 60, and Model 80

  The 8514/A uses a single card slot position in the system unit.

... and the following displays:

- IBM Personal System/2 Color Display 8514
- IBM Personal System/2 Color Display 8512
- IBM Personal System/2 Color Display 8513
- IBM Personal System/2 Monochrome Display 8503.

The 8514 is the preferred display for the 8514/A, having the ability to display up to 1024 x 768 pixels with 256 colors from a palette of 256k colors/64 grayscales.

The 8512 and 8513 color displays and the 8503 monochrome display can also be used, with an addressability of 640 x 480 pixels and up to 256 colors from a palette of 256K colors/ 64 grayscales. The advanced text image and graphics adapter functions are available with these displays. They are suitable where the high performance advanced functions of the 8514/A are required in conjunction with a more compact color or monochrome display unit.

The IBM Personal System/2 Display Adapter 8514/A, with its increased screen content and high performance capability provides productivity gains for general purpose applications, and addresses the special requirements of advanced text image and graphics applications. Users will find the 8514/A especially effective in the following areas:

- Multiple screen windows, taking advantage of the high content screen
- Wide screen layouts: for example a 12 column-month spread sheet on a single screen, giving productivity improvements by reducing the need for scrolling operations and offering easier assimilation of larger quantities of data.
- Ability to display complex charts and technical drawings
- Mixed text graphics and image documents
- Ability to display high quality fonts with proportional spacing, anti-aliasing, etc.
- Full page-width displays with WYSIWYG format.

The 8514/A adapter is supplied with a programming interface, referred to as the Adapter Interface. This document describes both the adapter hardware functions and the Adapter Interface functions. For a description of all of the Adapter Interface orders, refer to the "IBM Personal System/2 Display Adapter 8514/A Technical Reference", Form number S68X-2248.

Operating Modes

8514/A has two modes of operation selected under program control:

- Video Graphics Array mode, i.e. modes provided by the integrated display adapter in the system unit
- Advanced Function mode.

VGA is the power-up mode of the adapter. Advanced Function mode and VGA mode are selected by programming calls using the Adapter Interface code (see "8514/A Adapter Interface" on page 42 for details).

All of the function of the VGA is available for program compatibility. When the adapter is in VGA mode, the output from the integrated adapter in the system board passes to the 8514/A adapter palette and DAC for display on the screen attached to the 8514/A. See Figure 15 for details.

The VGA and the 8514/A each has its own set of bit planes. The VGA bit planes and the 8514/A bit planes can be updated, independently of which bit planes are being displayed. Switching between VGA and Advanced Function mode is rapid because it is not necessary to reload the bit planes.

In Advanced Function mode, the 8514/A can operate with either 640 x 480 or 1024 x 768 pel addressability. 1024 x 768 pel addressability is available only with the 8514 display.

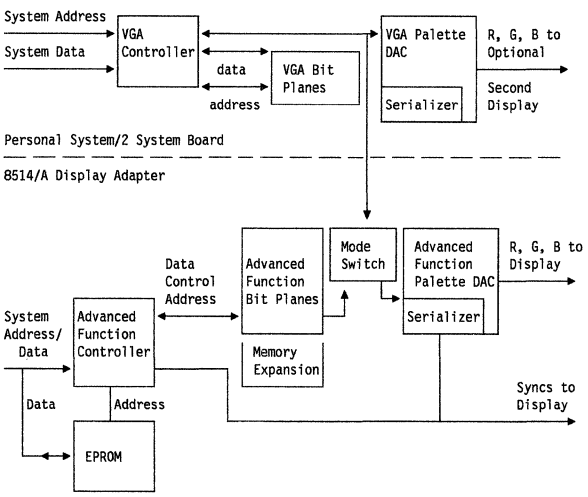


Figure 15. 8514/A Logic Overview

Advanced Function Mode Operations

Overview

The 8514/A provides the following Advanced Function capabilities:

- Screen formats of 1024 x 768 and 640 x 480 pels
- Advanced text and alphanumerics support
- BIT-BLT
- Graphics: hardware assist for lines and areas
- Color and gray-scale capability: up to 256 colors selected from a palette of 256K colors, or 64 grayscales selected from a palette of 64
- Rectangular scissor
- Enhanced mix control.

Text and Alphanumeric Support

Two types of character support are available:

Alphanumeric Support

Alphanumeric support provides fixed-size character cells. They are generally used for basic alphanumeric operations like listing directory contents and entering commands. Character attributes such as foreground and background color with intensify are supported for compatibility with Personal Computer VGA alphanumeric modes, as well as 3270 extended attributes including loadable symbol sets. Blinking is not supported.

Two character size options and character arrangements are available in 1024 x 768 mode to allow the user to select a character size and character density appropriate to a given application. These options, available with the 8514 display, are:

- 38 rows of 85 characters, using a 12 x 20 character cell
- 51 rows of 146 characters, using a 7 x 15 character cell.

The larger formats offer productivity gains by reducing the number of scroll operations needed, for example when cross-referencing data in different parts of a spread-sheet, and by easier assimilation of larger amounts of data on a single display. For example, on a spreadsheet it is possible to view 12

column-months of data on a single screen, whereas with a smaller display it is necessary to scroll over more than one screen.

In 640 x 480 mode, an 8 x 14 character cell is used, giving an arrangement of 34 rows of 80 characters.

When writing characters to the screen using alphanumeric support, the alphanumeric data replaces any existing data in the cell positions written. If the application requires that the data overwritten by alphanumeric characters should be retained, it is necessary to save the contents of the bit planes.

Alternatively, the bit planes can be subdivided into two groups or layers for alphanumeric and APA operations. (The default palette is designed to be used with two layers with 4 planes in each.)

Fonts

Up to 4 alphanumeric fonts may be addressed at any time. Three fonts are provided with the adapter, one for each of the font sizes listed earlier. Each of the fonts contains 5 code pages as shown below, giving support for a range of national languages.

437: Multilingual
850: Multilingual
860: Portuguese
863: Canadian/French
865: Nordic

User defined alphanumeric fonts are also supported. Fonts may be defined in terms of bit maps or in a special short vector format.

Advanced Text

With advanced text, characters can be of variable size and can be placed at any position in the bit buffers. Explicit support is provided for defining characters in terms of images (bit maps) or in a special short vector format. Characters can also be defined using the graphics drawing orders provided by the Adapter Interface, though there is no explicit support for this.

Image characters can be defined up to a maximum size of 255 x 255 pixels with provision for proportionally spaced characters. They can be defined as single plane or multi-plane characters. By a suitable palette load, multi-plane characters can use the grayscale capability of the adapter to provide anti-aliased fonts.

High performance text operations can be achieved by the use of:

- High speed BIT-BLT operations
- Hardware assisted line drawing for text defined in terms of vectors
- Use of a high speed cache in the adapter for bit-map fonts.

These performance aids provide support for the manipulation of high quality WYSIWYG fonts on the screen in functions like text insertion with dynamic word, line and paragraph spill.

BIT-BLT

A comprehensive set of Bit Block Transfer (BIT-BLT) instructions are provided by the 8514/A adapter. Rectangular arrays of data may be moved at high speed in either direction between PS/2 memory and bit planes, between bit planes, and within a bit plane. Source and destination areas may overlap. A full set of logical mix operations are available. Programs can initiate BIT-BLT functions on any rectangular area, leaving the function to complete independently.

When using BIT-BLT operations, data may be addressed either across the planes or through the planes, as shown in Figure 16 on page 40.

BIT-BLT functions are fundamental to effective implementation of advanced text and image applications, as well as for use in functions like pop-up menus.

BIT-BLT operations are often used in conjunction with bit-plane enable/disable calls to allow manipulation of user-defined groups of planes.

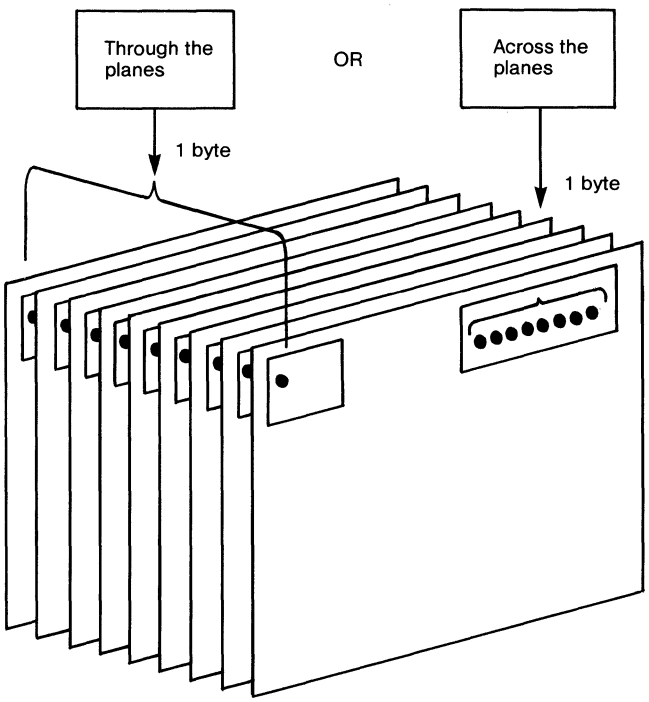


Figure 16. BIT-BLT addressing

Graphics

Hardware assist is available for high performance line and area drawing.

Lines and polylines are supported with absolute or relative coordinates. Eight user-selectable line styles are provided. The user can also define line styles to be used. Two line thickness options are provided.

Areas may be defined with solid color or with a color pattern. The color pattern, which is user definable, may be monochrome or multicolored. Complex areas may be defined in which the area boundary crosses itself. A full set of logical operations is available with these functions, so that lines and areas can be overpainted, underpainted, or XORed etc.

Color/Grayscale Capability

The base 8514/A adapter provides four bit planes and supports 16 colors selected from a palette of 256K colors: when used with a monochrome display, 16 grayscales selected from a palette of 64 are available.

When the IBM Personal System/2 8514 Memory Expansion Kit feature is fitted, the number of bit planes is eight, enabling 256 simultaneous colors to be displayed from a palette of 256K, or 64 grayscales from a palette of 64.

When the 8514/A adapter is operating in 640 x 480 advanced function mode, there is sufficient memory for eight bit planes and the display of 256 colors without the IBM Personal System/2 8514 Memory Expansion Kit feature being fitted. However, these planes are addressable as two separate groups of four planes each and not as a single group eight planes deep. This means that when performing drawing operations, it is necessary to use the drawing order on each group of four bit planes separately in order to create 256 colors. In many applications this configuration can be most effectively used with 2 banks in 16 color mode. The second bank can be used either for menus and help panels, or for off screen storage of bit maps.

Palettes

The video output from the adapter uses a palette (color lookup table). This allows applications to select the actual colors (or gray levels) that appear on the display from a greater range of colors than provided by mapping the number of bits per pel to fixed colors. The palette is a loadable RAM that translates the number of bits per pel into three analog signals that drive the red, green, and blue guns of the display. The adapter palette provides a 64-level analog output to each gun, and therefore provides a choice of 256k colors or 64 gray levels. The number of colors that can be displayed on the screen at any one time depends on the number of bit planes installed and enabled for access.

Note that in a system with the 8514/A adapter installed there are two palettes, one on the 8514/A adapter and one in the base system unit. The display attached to 8514/A uses the 8514/A palette.

When the advanced function mode has been selected, loading the 8514/A palette will not affect the VGA palette, and loading the VGA palette will not affect the 8514/A palette. When the VGA mode is selected, loading the VGA palette through BIOS loads both the VGA palette and the 8514/A palette. By this means, the display attached to the 8514/A adapter uses a palette corresponding to the mode that is currently active. However care must be taken in the case of multi-tasking operation, where, for example, a foreground task runs in Advanced Function mode and a background task runs in VGA mode. If the background task updates the VGA palette, this change is not reflected in the 8514/A palette. Therefore, when the VGA task subsequently runs in

the foreground, it is necessary to read the VGA palette and load it into the 8514/A adapter. More details of these types of operations are described under "8514/A Adapter Programming Support" on page 42.

Bit Plane Enable/Disable: Bit planes can be selected independently to enable or disable update and/or display. This allows the bit planes to be used in two or more groups with rapid switching between each group. This technique could be used for example to allow one group of bit planes to be used for alphanumeric information (such as menus or help panels) and another set for graphics pictures. Switching between the two would effectively be instantaneous.

Default Palettes: Default palettes are available for both VGA modes and advanced function modes. A default VGA palette is loaded by BIOS (optionally) when there is a VGA mode change: the actual palette that is loaded depends on the mode that is selected. In advanced function mode, the default palette is loaded optionally when the HOPEN command of the Adapter Interface is issued.

The default advanced function palette supplied is the same as the 16 color default loaded by BIOS for VGA. For the 8514/A, the default palette is duplicated for bit planes 0 to 3 and 4 to 7. This palette is suitable for dealing with bit planes in two banks of four: for example using one bank as a separate layer for holding alphanumeric information which can be updated independently while the other bank is being displayed.

VGA mode 13 provides a default 256 color palette. This palette can be selected for Advanced Function mode applications if required, by:

- Selecting VGA mode
- Selecting mode 13 with the option to load a default palette
- Selecting Advanced Function mode, NOT using the option to load a default palette.

Scissor

A rectangular scissor is provided to enable areas of the screen to be masked to allow fast update of the bit planes. Application programs may take advantage of this function in a number of ways, for example, for high performance pop-up menus and for multiple screen windows.

Although the scissor is rectangular, complex shapes can be achieved by overlaying multiple scissors.

Color Mixing

For drawing operations like BIT-BLT, line and area drawing, information written into the bit planes can be combined with information already contained in the bit planes, using a full set of logical and arithmetic mix operations. Operations provided include:

Logical AND, OR, Exclusive-Or

Overpaint, Underpaint

Arithmetic Add, Subtract

Arithmetic mean

Maximum and minimum.

Dual Screen

A second screen may also be attached to the VGA port of the system board. The second screen can show information in VGA modes while the 8514/A screen shows information in advanced function mode.

The display that is attached to the 8514/A is always the primary display and all BIOS display calls return or load data that is appropriate to this display. This ensures that all single screen VGA applications appear correctly on the display that is attached to the 8514/A. If the display that is attached to the VGA port is not the same type (i.e. Mono or Color) as that attached to the 8514/A, then the data on the VGA display may be corrupted.

Dual screen applications can avoid potential problems by:

- Using only VGA mono modes
- Using colors that give consistent results on all displays
- Requesting the user as to the type of display that is attached to the VGA and then loading a suitable palette.

8514/A Adapter Programming Support

Overview

The IBM Personal System/2 Display Adapter 8514/A adapter is programmable using either a high-level Application Programming Interface or, at a low level, the Adapter Interface.

Two Application Programming Interfaces are provided:

1. The IBM Operating System/2 Presentation Manager provides an API for advanced alphanumerics and graphics with a variety of language bindings. A development toolkit is provided.

   This API is recommended for those applications that wish to take advantage of the Systems Application Architecture conformance, multiple concurrent application windows, high level language Application Programming Interface, application development toolkit and enhanced end user interface of the IBM Operating System/2 Presentation Manager.

2. Virtual Device Interface (VDI) drivers are available to enable applications written to the Graphics Development Toolkit to run with the 8514/A adapter. The VDI drivers to be used with the IBM Personal Computer Graphics Development Toolkit Version 1.2 are available separately and can be ordered using form number S68X-2280. The VDI drivers to be used with the IBM Operating System/2 Graphics Development Toolkit are included with the IBM Operating System/2 Graphics Development Toolkit.

The 8514/A adapter is provided with a programming interface called the Adapter Interface. The Adapter Interface provides access to all of the functions available in the hardware, and is the only adapter interface that will be published.

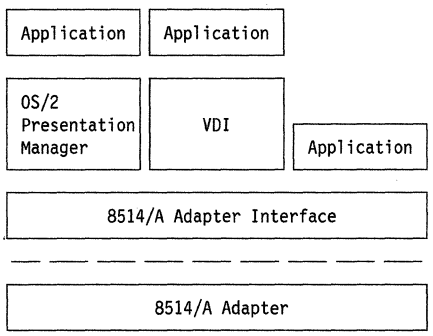


Figure 17. 8514/A Programming Interfaces

Programming to the Adapter Interface is significantly easier than programming directly to the hardware because the interface handles much of the complexity of the hardware register interface and supports commonly required display functions. Performance at the Adapter Interface is comparable with programming directly to the hardware.

It should be recognized however, that even though the Adapter Interface offers certain advantages, particularly in the performance area and the ability to exercise close control of all the adapter functions, it does not offer the same level of ease of use, multitasking, multiple window capability and application portability as is provided by the IBM Operating System/2 Presentation Manager.

The use of the Presentation Manager API and the Virtual Device Interface is not described further here. The following section describes the Adapter Interface.

8514/A Adapter Interface

The Adapter Interface is a low-level programming interface for the 8514/A adapter. It is a call interface which supports commonly used display adapter functions in a convenient form. It can be used with IBM Personal Computer Assembler Language or with higher level languages such as IBM Personal Computer C, or IBM Personal Computer Pascal.

The Adapter Interface Installation Diskette

The Adapter Interface is supplied on a diskette with the 8514/A adapter. The installation diskette contains:

- the Adapter Interface code
- an installation program

- a short demonstration program in C

  This program is supplied with source code written in IBM Personal Computer C, together with C language macros.

- three character fonts, each with 5 code pages.

Application Developers Tutorial

For application developers who are coding directly to the Adapter Interface, the *IBM Personal System/2 Display Adapter 8514/A: Adapter Interface Application Developers Tutorial*, Form Number S68X2279, is available. The tutorial provides documentation with guidance on using the Adapter Interface, together with a diskette. The diskette contains a number of utilities for the 8514/A adapter and a palette tutorial.

In addition to the tutorial, application developers writing to the Adapter Interface will require the *IBM Personal System/2 Display Adapter 8514/A Technical Reference*, form number S68X-2248, which gives a detailed description of all of the Adapter Interface calls.

Using the 8514/A Adapter Interface

The adapter interface provides a number of display adapter functions, each of which has an entry point. To call one of the functions, the programmer has to:

- Specify the address of a parameter block containing parameters for this call
- Call the entry address of the function.

To simplify programming, language bindings can be used. A set of macros for the IBM Personal Computer C Compiler are supplied with the adapter installation diskette. Similar bindings could be developed for other languages, for example, IBM Personal Computer Assembler, or IBM Personal Computer Pascal.

A typical Adapter Interface call, for example, to draw a polyline through the points (X0,Y0), (X1,Y1), (X2,Y2) ... (Xn,Yn) is of the form:

```
HLINE X0,Y0,X1,Y1,X2,Y2...Xn,Yn
```

The exact format depends on the programming language being used. The length of the order is defined separately in a control block.

Configurations Supported: The Adapter Interface supports the IBM Personal System/2 Display Adapter 8514/A with either 4- or 8-bit planes installed.

Supported screen resolutions are:

1024 x 768 and
640 x 480

Coordinate and Addressing Systems

The Adapter Interface uses screen coordinates: x,y coordinate pairs used in Adapter Interface calls are integer pairs which map directly to pixel positions on the screen.

At each x,y coordinate position is a group of up to 8 bits, one for each bit plane, which defines a color index. The color index, in conjunction with the palette, controls the color or grayscale that is displayed at that position on the screen.

Coordinates are expressed as either 2-byte absolute coordinates or 1-byte relative coordinates.

The adapter coordinate range is greater than the screen coordinate range to allow objects with parts that fall outside of the screen area to be displayed without wrapping.

Adapter Interface Calls

In the following sections, some of the Adapter Interface calls are described. The list is not comprehensive. It is provided to give a general view of the Adapter Interface functions available. For a comprehensive list, please refer to the *IBM Personal System/2 Display Adapter 8514/A Technical Reference*.

Alphanumerics: In this context, alphanumerics means characters in fixed size cells, in contrast to text which means characters of variable size with character origins located on an all-points-addressable basis.

Alphanumeric calls available are:

- HSMODE: set cell size option
- ABLOCKMFI: write character block to bit planes in 3270 format
- ABLOCKCGA: write character block to bit planes in CGA format
- AXLATE: assign alphanumeric attribute color index table
- AERASE: erase rectangle of character cells
- ASCROLL: scroll rectangle of character cells
- ASFONT: set character font
- ACURSOR: set cursor position
- ASCUR: set cursor shape.

HSMODE is used to select from one of three character arrangements, ranging from 34 rows of 80 characters to 51 rows of 146 characters. Note that the 51 x 146 arrangement is only available with the 1024 x 768 screen.

ABLOCKMFI and ABLOCKCGA write a block of characters from PS/2 memory to the bit planes. Characters are defined by character code points and character attributes. Character attributes used are:

- Foreground color
- Background color
- Underscore
- Reverse video
- Overstrike
- Opaque/transparent background.

Blinking is not supported. ABLOCKMFI uses a 3270-like format and ABLOCKCGA uses a CGA-like format.

AXLATE is used to select the foreground and background character colors from the current palette.

ASCROLL copies a rectangular array of characters on the screen to provide a vertical scroll or horizontal pan capability. Scrolling is on a character basis, not a pel basis. The rectangle is user defined so that scrolling on a screen window can be implemented conveniently.

ASFONT loads one of four character sets. Character sets supplied with the adapter or user defined sets may be used.

ACURSOR and ASCUR are used to control the position of the cursor on the screen and the style of the displayed cursor respectively.

Text: Text characters can be of variable size and can be placed at any position in the bit buffer. Text calls provided are:

- HSCS: set character set
- HCHST: draw character string at specified position
- HCCHST: draw character string at current position
- HXLATE: assign multi-plane text color index table.

HSCS specifies the address in PS/2 memory of the character set to be used. HCHST and HCCHST define a string of code points to be written to the screen bit buffer. A high speed cache in a non-displayed area of the bit buffer is used in these operations. As characters are used, character definitions are stored in the cache, so that they can be subsequently retrieved from the cache when the code point is used again. Retrieval from the cache is significantly faster than retrieval from PS/2 memory.

Character sets used may be either monochrome or multicolored. Multicolored characters are obtained by defining the character bit matrix in three layers. In the case of multicolored characters, HXLATE is used to define a color index for each of the eight combinations available at each pel position of the character.

Drawing Lines: The line drawing calls are:

- HLINE: Line/polyline at a specified position
- HCLINE: Line/polyline at the current position
- HRLINE: Relative line/polyline at a specified position
- HCRLINE: Relative line/polyline at the current position.

Each of these calls can draw a single line or a series of connected lines (polyline). For HLINE and HRLINE, the starting point of the polyline is specified as an absolute screen address. For HCLINE and HCRLINE the starting point of the polyline is the current position.

HLINE and HCLINE specify absolute coordinate pairs (2-byte coordinates): HRLINE and HCRLINE specify coordinates relative to the start of the current line (1-byte coordinates).

The line type can be set using the HSLT call, and the line width can be set using the HSLW call. HSLT specifies either a user-defined line type or one of eight lines styles provided. HSLW specifies a line width of either 1 pel or 3 pels.

Drawing Markers: Calls to draw markers are:

- HMRK: Draw a set of markers starting at a specified position
- HCMRK: Draw a set of markers starting at the current position
- HSMARK: Set marker shape.

HSMARK allows the user to specify a marker symbol, which is an image array of user defined height and width. It can be either monochrome or multicolored. In the case of multicolored markers, a color index byte is specified for each pel position of the marker.

Drawing Areas: Calls for drawing areas are:

- HBAR: Begin area
- HEAR: End area
- HRECT: Rectangular area.

The area to be drawn is specified by a series of line drawing calls following HBAR and preceding HEAR. The area is automatically closed by a straight line between start and end points if start and end points are not coincident.

For areas that are rectangular, the HRECT call is available: it has a higher performance than HBAR/HEAR for rectangular areas.

Lines defining the area may cross so as to form one or more closed shapes. If the area is to be shaded, the parts to be shaded are identified by an odd number of boundary crossings by a horizontal line drawn from the edge of the screen.

The calls available for shading areas are:

- HSPATT: Set area fill pattern shape
- HSPATTO: Set pattern reference point.

HSPATT allows the user to specify a rectangular bit array of maximum size 32 x 32 to define the area fill pattern. The pattern may be either monochrome or multicolored. If it is multicolored, a 1-byte color index is specified for each pel position of the fill pattern. Multicolored shading patterns are not available with the HRECT call.

The HSPATTO call is available to allow the user to set a reference point or origin for an area fill pattern. This allows the user to ensure that there is a continuous pattern in the case of adjacent areas on the screen which use the same pattern.

Image calls: The following calls are available for operating on rectangular bit arrays (i.e. BITBLT calls):

- HBBW: Copy from PS/2 memory to bit planes
- HCBBW: Copy from PS/2 memory to bit planes at current position
- HBBR: Copy from bit planes to PS/2 memory
- HBBCHN: BITBLT chained operation
- HBBC: Copy from bit planes to bit planes.

These BIT-BLT operations specify a rectangular array of bits to be moved from PS/2 memory to bit planes, from bit planes to bit planes, or from bit planes to PS/2 memory. Two data formats are available:

- Through the bit planes, where one byte of data represents the contents of bit planes at a single pel position on the screen.
- Across the bit planes. In this case, one bit of the source represents one pel position on the screen. If the bit is a one, the foreground color with the foreground mix is written into the bit buffer. If it is a zero, the background color with the background mix is written into the bit planes.

See Figure 16 on page 40 for details.

Except for the HBBC call, the actual data move operation is specified by one or more HBBCHN chained calls. The HBBCHN call can be used to break down large BIT-BLT transfers in shorter operations, so as to re-use a buffer area in PS/2 storage for example.

Text Image and Graphics Attributes:
A comprehensive set of attribute controls are available for use with drawing orders to determine:

- The color that is written into the bit planes
- How the color is combined with information already in the bit planes
- To enable and disable selected bit planes
- To specify a rectangular window that is enabled for update.

Available calls for these functions are:

- HSCOL: set foreground color
- HSBCOL: set background color
- HSHS: set hardware scissor
- HSBP: set bit plane controls
- HSMX: set mix controls
- HSCMP: set color comparison register.

HSCOL and HSBCOL set the foreground and background color to be used in subsequent drawing operations.

HSHS defines a rectangular area within which screen update is enabled. When drawing a line for example, only that part of the line which falls within the scissor rectangle is used to update the screen buffer. The scissor function is useful for operations like windowing and drawing menus. More complex scissor shapes can be achieved by repeating drawing operations with a set of rectangular clip windows.

HSBP specifies which group of bit planes are enabled for update. This allows the user to operate with two or more bit plane groups, each holding different types of information, for example a text group, a graphics group and a menu group. Switching between groups

is very rapid. Alternatively, a group of bit planes can be used in non-display mode as a save or work area.

HSMIX defines the manner in which the data generated as a result of a drawing operation is combined with data already in the bit buffer. Mix operations provided include:

- Logical AND, OR, Exclusive-Or
- Overpaint, Underpaint
- Arithmetic Add, Subtract
- Arithmetic mean
- Maximum and minimum.

HSCMP sets the value of a color comparison register. The register value is compared with the color index at each pixel position following a drawing operation. The comparison may be:

- Greater than
- Greater than or equal
- Equal
- Not equal
- Less than
- Less than or equal.

If the result of the comparison is true the contents of the bit plane are not changed, otherwise the contents of the bit plane are updated according to the current mix rules.

This technique is used to underpaint objects, i.e. draw objects which are partially obscured by previously drawn objects, and for layering where several objects are drawn in several overpainted/underpainted layers.

Program Control and Query: A number of other calls are available, which are not listed here, which allow the using program to:

- Open and close the Adapter Interface. These commands set the adapter into Advanced Function mode or VGA mode. There are options on the Adapter Interface "open" call to clear bit planes and to set a default palette.
- Query calls, which are used to determine, for example,

  The current position

  The default palette

  The alphanumeric arrangement currently selected

  The number of bit planes

  The screen size in pels

  Whether a mono or color screen is attached.
- Save and restore calls which are used for example in task switching applications.

Compatibility Considerations

The new display adapters have been designed to achieve a high level of compatibility both with earlier adapters - the MDPA, CGA and EGA - and with each other. Differences are described in the individual sections. The following items should be noted for application compatibility across systems:

- Power on default mode

  There are differences in some cases between the display mode selected at power on time by the different systems. It is recommended that the display mode should be explicitly set at the start of an application for compatibility across systems.

- Use of equipment flags

  The Personal System/2 Display Adapter requires that the equipment flags are correctly set prior to a mode change, in common with the IBM Personal Computer, Personal Computer XT and Personal Computer AT. Integrated adapters of the IBM Personal System/2 set these flags automatically. For applications that may be transferred across systems, it is recommended that the application ensures that equipment flags are correctly set prior to a mode change.

- Note also the other differences between the Personal System/2 adapter and the VGA listed in the section describing the Personal System/2 under "Adapter Differences from the VGA" on page 35.

Summary

These new all-points-addressable displays and optional display adapters offer a range of function and performance characteristics to satisfy the requirements of a broad range of personal computer users.

At the low end, the integrated adapter of the IBM Personal System/2 Model 30 supports existing CGA modes and provides new text image and graphics modes. It is typically configured with the 8503 monochrome display for text intensive applications when color is not required, or with the 8512 color display to provide a low-cost color text image and graphics capability.

A medium level of function is provided by the Video Graphics Array integrated in the IBM Personal System/2 Models 50, 60 and 80. The VGA supports CGA modes, the new modes of the IBM Personal System/2 Model 30, and additional modes for text image and graphics. It is typically configured with the 8503 monochrome display or the 8513 color display to produce quality text image and graphics suitable for high daily use environments.

A high level of function and performance is generated by the 8514/A display adapter, with advanced text image and graphics functions built into the adapter. This adapter can configure the 8514 color display to support applications that require a large screen, advanced functions and maximum addressability and colors.

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