Graphics Adapters

This chapter presents the PC 98 requirements and recommendations for graphics adapters.

The key design goal is to ensure that graphics hardware behaves consistently across a wide range of applications. Graphics-related issues for PC 98 are based on the need of the system to provide fast, high-quality graphics rendering. For example, new games applications that require 3-D graphics or advanced graphics applications such as computer-aided design (CAD) demand improved support in graphics hardware.

Requirements for MPEG and DVD playback, video input and capture devices, and display monitors are defined in the "Video and Broadcast Components" and "Monitors" chapters in Part 4 of this guide. Requirements for OpenGL support are defined in the "Workstation PC 98" chapter in Part 2 of this guide.

Contents

System Requirements for Graphics Adapters

This section summarizes the PC 98 system requirements for graphics adapters. For exceptions and guidelines for the internal display on mobile PCs, see the "Mobile PC 98" chapter in Part 2 of this guide.

1. Graphics adapter uses PCI, AGP, or another high-speed bus

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	AGP required

Recommended: Pipelined Accelerated Graphics Port (AGP) attachment with optional sideband addressing and double-clocked data transfer mode.

Entertainment PC 98 systems must use AGP or an integrated graphics subsystem that meets or exceeds AGP performance levels. For AGP requirements, see the "Plug and Play and Bus Design for Graphics Adapters" section later in this chapter.

2. System uses WC with higher-performance processors

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	Required

Write combining (WC) of successive stores to the frame buffer is a requirement for systems that use Pentium Pro and Pentium II or compatible processors.

3. Primary graphics adapter works normally with default VGA mode driver

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	Required

The default video graphics array (VGA) driver is required for installing the operating system, and the primary adapter must support 4-bit planar VGA mode as described in the Windows DDK. Secondary adapters in multiple monitor configurations do not need to provide VGA compatibility.

4. Adapter and driver support multiple adapters and multiple monitors

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	Required

System expansion buses that allow graphics adapters such as PCI and AGP can support the simultaneous use of more than one graphics adapter in the system. Each graphics adapter can support one or more attached monitors, but this is not a requirement.

The device drivers for each graphics adapter must provide the required support to allow the presence of multiple adapters and multiple monitors. The hardware and BIOS support consist of Plug and Play-related configuration and resource require- ments that ensure automatic support for use of more than one graphics adapter and for simultaneous display on two or more monitors. For details, see the "Multiple- Adapter and Multiple-Monitor Support" section later in this chapter.

5. Adapter supports television output if system does not include large-screen monitor

Consumer PC 98	Office PC 98	Entertainment PC 98
Recommended	Recommended	Required

Recommended: Support both NTSC and PAL output.

Support for television output is a requirement for Entertainment PC 98 systems that do not include a large-screen entertainment monitor. The ability to connect to and use a standard NTSC or PAL television as a large display surface is key to the ability to deliver realistic television, movie, and game experiences. For mobile PCs, television-output capabilities can be used to enable on-screen presentation graphics in the conference room.

The NTSC system must support 640×480 at 60 Hz. The PAL system must support 640×480 and 800×600 at 50 Hz. For information about the related requirements, see the "PC 98 Television Output Requirements" section later in this chapter. This recommendation might become a requirement in the future for Consumer PC systems.

If there is a large-screen monitor included with the system, television output support is not required. For information about requirements for large-screen monitors, see "Monitors" in Part 4 of this guide.

Graphics Adapters Basic Features

This section defines basic PC 98 feature requirements for graphics adapters.

6. Adapter meets PC 98 general device requirements
Required

This includes the PC 98 requirements for a Plug and Play device ID, automated software-only settings for device configuration, device drivers and Windows-based installation, and icons for external connectors. For more information, see the "Basic PC 98" chapter in Part 2 of this guide.

7. Screen resolution and local memory capacity meet PC 98 minimum requirements

Consumer PC 98	*Office PC 98*	*Entertainment PC 98*
Required	*Required*	*Required*

Recommended: $1024 \times 768 \times 24$ bpp and $1280 \times 1024 \times [8, 15, 16, 24]$ bpp.

The adapter must support all VESA standard timings for all PC 98 required resolutions, including $640 \times 480 \times [8, 15, 16, 24]$ bpp, $800 \times 600 \times [8, 15, 16, 24]$ bpp, and $1024 \times 768 \times [8, 15, 16]$ bpp.

For a mobile PC's external display support, the graphics subsystem must support the Basic PC 98 requirements. For a mobile PC's internal display, see the requirements in the "Monitors" chapter in Part 4 of this guide.

For any PC 98 system that requires quality rendering of 2-D graphics, the minimum support is double buffering for up to $800 \times 600 \times 16$ bpp. For any PC 98 system that requires 3-D rendering in any fashion, whether using software or hardware acceleration, the minimum requirements are $800 \times 600 \times 16$ bpp double-buffered, Z buffer, and 1.25-MB local texture cache. On AGP systems, there is no requirement for local texture cache.

For future 3-D titles, the high triangle content will make increased demands on graphics bandwidth. High-performance designs for systems such as Entertainment PC 98 or Consumer PC 98 that will support Direct3D applications should provide sufficient 3-D texture access to meet the 3-D performance recommendations defined in the item "Hardware meets PC 98 3-D accelerator performance requirements" later in this chapter.

Texture compression can provide additional effective texture memory, and it also increases the effective memory bandwidth that is available.

Note: When the user selects 1024×768 resolution, by default the graphics adapter must use a non-interlaced refresh rate. A graphics adapter can default to 1024×768 interlaced mode in either of the following situations:

- The attached monitor is not DDC-compatible and the user has not selected a monitor type in the display control panel.

- The monitor does not support 1024×768 non-interlaced mode, as determined from the Extended Display Identification Data (EDID) or registry settings.

8. Adapter meets VESA specifications for ergonomic timing rates
Required

Recommended: 85 Hz for 1024×768, non-interlaced.

The graphics adapter must support, at a minimum, the ergonomic timings documented in the current version of *VESA and Industry Standards and Guidelines for Computer Display Monitor Timing* for all resolutions up to 1280×1024 that are supported by the monitor. The minimum required support is 75 Hz for 1024×768, non-interlaced. Higher scan rates are preferable under standards published by VESA.

9. All supported color depths are enumerated
Required

The driver and INF file must enumerate all modes supported so that applications can choose their preferred color depth. The driver and INF file must follow the following guidelines for enumeration:

- At a minimum, either 5:5:5 or 5:6:5 modes must be supported.

- If only 5:5:5 mode is supported, the driver must also enumerate this as 16-bpp mode. This is required because some applications only look for 16-bpp support and will run in 8-bit mode if they fail to find a 16-bit mode.

- If both 5:5:5 and 5:6:5 modes are supported, both modes are enumerated.

For each color depth supported, color ordering must be implemented as shown in the following list. Color ordering is shown in the following table from the most-significant bit (MSB) to the least-significant bit (LSB.)

Mode	Color ordering
15 bpp	1 undefined, 5 red, 5 green, 5 blue (URRR RRGG GGGB BBBB)
16 bpp	5 red, 6 green, 5 blue (RRR RRGGG GGGB BBBB)
24 bpp	8 red, 8 green, 8 blue (RRRR RRRR GGGG GGGG BBBB BBBB)
32 bpp	8 undefined, 8 red, 8 green, 8 blue (UUUU UUUU RRRR RRRR GGGG GGGG BBBB BBBB)

10. Graphics operations use relocatable registers only
Required

VGA registers must not be used to perform graphics operations such as bit blting, palette setting, and pointer movement. The registers used for these graphics operations can be either I/O locations or memory-mapped locations, but must be relocatable. Normal system operation—except for system startup and mode setting—should never require use of base VGA registers.

DirectDraw and Direct3D functionality must be independent of VGA. This means that graphics require VGA only for initialization.

11. Adapter supports downloadable RAMDAC entries for image color matching
Required

For graphics adapters that support 24-bit or higher displays, downloadable RAM digital-to-analog converter (RAMDAC) entries should be included to perform gamma correction in hardware. This capability supports the related requirement to use VGA only for system initialization.

This capability is also one of the most frequently requested features from independent software vendors (ISVs). For example, it supports transition effects in Internet Explorer 4.0 and other applications.

Image color matching (ICM) uses this capability to ensure that gamma is correct in the monitor and that games applications use this for palette switches.

12. Adapter supports DDC monitor detection
Required

This requirement is based on the *Display Data Channel Standard, Version 2.0* (DDC), which defines the communication channel between the display and host system. The software can use this information to properly manage output to the various displays and to prevent the disabling of television output if no monitor is attached.

Hardware Acceleration for Video Playback

This section presents the PC 98 requirements for graphics adapters support for video playback.

13. Adapter supports video overlay surface with scaling

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	Required

The graphics adapter must be able to support a minimum of one off-screen video overlay surface the has following characteristics:

- **Size.** Support 720 × 480 or larger.
- **Screen Resolutions.** The video overlay must be fully operative at a minimum screen resolution of 800 × 600 at 60 Hz and color depths of 8 bpp and 16 bpp.

  Recommended: Full support at 1280 × 1024 and below, with color depths of 8, 16, 24, and 32 bpp.
- **Color formats.** The required formats include the following:
  - YUV 4:2:2 YUY2: A packed-pixel byte stream for every pixel in the order of Y1, U, Y2, V.
  - YUV 4:2:2 UYVY: A packed-pixel byte stream for every pixel in the order of U, Y1, V, Y2.
  - YUV 4:2:0 YV12: A system-board byte stream for the entire plane in the order of Y plane, V plane, U plane.

  The YUV color space and intensity range are defined by the ITU-R BT.601-4 standard (previously called CCIR-601), where U is CB and V is CR. These formats use less memory while maintaining high quality, and YUV is the native format for many image and video compression standards.
- **Scaling.** Up/down scaling to any size window, with bilinear interpolation (referred to as "hardware arithmetic stretching" in *PC 97 Hardware Design Guide*).

  For Consumer PC 98 and Office PC 98, the down-scaling hardware must support bilinear interpolation or better for size reductions from 1:1 up to a 2:1 ratio. For Entertainment PC 98, bilinear interpolation or better is required for all size reductions. Notice that for down-scaling ratios greater than 2:1, other filtering techniques might provide higher quality images and better performance.

  Recommended: Additional independent and resizable overlays for support of picture-in-picture (PIP) video features and multiple video conferencing windows. For example, the graphics adapter should support overlay using a different color key, or one overlay using a color key while another does not. The support should also allow the overlays to be zoomed independently.

14. Hardware supports VGA destination color keying for video rectangle

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required with DVD-Video	Required

Recommended: Support for alpha-blended overlay per pixel to support
DVD-Video subpicture information and enhanced user interface designs.

This is a requirement for video overlays. The compositing of the video plane
under the VGA plane with the VGA pixels must be independently controllable for
each VGA pixel. This VGA destination color keying must function in all video
modes, using either a specific color/color range (on 4-bit, 8-bit, 16-bit, and 24-bit
SVGA modes) or additional alpha blending bits in the color plane bits (on 15-bit
and 32-bit SVGA modes).

This color keying of the VGA will allow certain VGA pixels to be replaced by
the underlying video pixels on a pixel-by-pixel basis. This feature enables VGA
video overlays, controls, Windows pop-up menus, dialog boxes, and so on. Color
keying must also work at the same time as any vertical/horizontal scaling that is
active for the underlying video.

15. Video port meets PC 98 specifications if present on graphics adapter

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	Required

All graphics adapters that use a video port connection or that enable end users to make
such a connection to a video device are subject to this requirement.
The video port is a dedicated connection between video devices, such as an MPEG-2
decoder or TV tuner, and the graphics adapter, either implemented as a hard-wired
connection on the same board as the graphics adapter or implemented between
separate devices using a cable connection.
PC 98 systems are required to use a video port connection for hardware MPEG-2
decoders. It is also recommended that a video port connection be used for
television tuners.

For a graphics adapter that includes a video port, for MPEG-2 or otherwise, the following requirements must be met:

- **Accessibility.** The video port must be accessible directly from an on-board decoder. The video port must also be accessible from decoders on separate cards using a cable connection.

- **Autoflipping.** The video port must support automated overlay and video port buffer flip on video port Vsync.

- **IRQ.** The video port must generate an interrupt request (IRQ) when vertical synchronization (Vsync) occurs. The kernel-mode video transport component of DirectDraw 5.0 can use this IRQ to perform autoflips. This capability allows fields to be skipped by the video port and also prevents an irregular synchronization from overwriting its buffers. This also enables capture of video port and vertical blanking interval (VBI) data.

- **Driver.** The driver must support DirectDraw VPE, which provides a key element of video playback support in DirectX 5.0. This support, as documented in the DirectX 5.0 DDK, must be incorporated to ensure that the graphics adapter and video port take advantage of VPE capabilities in the operating system.

  For more information, see the white paper on DirectDraw VPE and kernel-mode video transport at http://www.microsoft.com/hwdev/devdes/.

Recommended: The following hardware design guidelines are recommended to support high-quality video playback:

- **Maximum height.** The graphics adapter should support a register that limits the maximum height of the field that gets written into memory.

- **Separate pitch and start addresses.** The overlay and the video port should support separate pitch and start addresses. This allows the bob algorithm to be used while the video is interleaved, which makes switching between bob and weave modes possible.

- **Standard video port.** It is expected that an advanced video port specification will be standardized by the VESA Video Port committee within the PC 98 time frame. It is strongly recommended that MPEG-2 implementations on all PC systems and retail adapters comply with this standard as soon as possible after standardization. This will become a requirement in future versions of these design guidelines.

For more information about requirements related to video ports, see the "System Requirements for Video and Broadcast Components" section of the "Video and Broadcast Components" chapter in Part 4 of this guide.

16. Adapter supports MPEG-2 motion compensation acceleration
Recommended

For products that use MPEG-2 software decoders, MPEG-2 motion compensation acceleration is recommended. Microsoft plans to support motion compensation acceleration under DirectX in 1998.

Specifically, this recommendation refers, but is not limited, to the following:

- Motion compensation of YUV 4:2:0 planar surfaces (versus YUV 4:2:2 packed pixel surfaces) to decrease system memory bandwidth requirements
- Full-precision motion compensation (for example, use 9 bits for an 8-bit signed error term) to prevent degradation of video quality
- Bus mastering of error terms and vectors to and from AGP memory (versus system memory) to increase memory bandwidth and CPU cache efficiencies

For more guidelines on MPEG-2 video performance and quality, see the "Video and Broadcast Components" chapter in Part 4 of this guide.

Multiple-Adapter and Multiple-Monitor Support

This section defines the PC 98 requirements for ensuring system support for multiple adapters and multiple monitors. This support ensures that if the user adds a second adapter, resources will automatically be available and the operating system can automatically manage multiple display adapters.

The actual implementation a user might employ could be one of the following:

- Multiple adapters added to the PC system
- A single adapter with a single controller supporting two monitors
- A single adapter with multiple controllers supporting multiple monitors
- Any combination of these scenarios

The support planned for both Windows and Windows NT requires multiple-adapter compatibility in both the graphics adapter and its driver. With this new multiple-adapter/multiple-monitor support, a single adapter that supports multiple monitors can display independent screen images. This support is beyond the current simultaneous display features of some mobile PCs, which simultaneously show the same Windows desktop on two monitors.

The operating-system support for multiple adapters and multiple monitors requires allowing any secondary graphics adapters to be enabled in VGA mode, thus requiring that VGA for the previous adapter be temporarily disabled.

The support for multiple monitors also assumes that for monitors attached to the same system, but showing different images simultaneously, the different displays might have differing X,Y resolutions, color depths, refresh rates, and display capabilities.

For technical details about implementing driver support for multiple adapters and multiple monitors, see the Windows NT 5.0 DDK.

17. Extended resources can be dynamically relocated after system boot
Required

To ensure Plug and Play for multiple-adapter/multiple-monitor capabilities, all non-VGA standard display resources (also known as extended resources, such as register sets and so on) must be capable of being dynamically relocated after system boot.

This is an extension of the "Graphics operations use relocatable registers only" requirement earlier in this chapter. It also is an addition to the "General Plug and Play Requirements" section later in this chapter.

18. VGA resources can be disabled by software
Required

A means must be provided to allow a driver to disable its adapter from decoding standard VGA addresses. The purpose of this is to ensure that the adapter is independent of all other graphics adapters in the system. The adapter must remain fully functional without the VGA addresses. See also the "Graphics operations use relocatable registers only" requirement earlier in this chapter.

Hardware Acceleration for 2-D Graphics

This section summarizes PC 98 guidelines related to 2-D DirectDraw graphics features, which can be implemented as hardware acceleration features.

Entertainment PC 98 systems require hardware acceleration for 2-D graphics. Individual items in this section are marked as required or recommended for that system type.

In general, hardware acceleration for 2-D graphics is not required for Office PC 98 systems. The specific items in this section are required or recommended only if a hardware manufacturer chooses to implement hardware acceleration in a graphics adapter. For workstations, it is recommended that the OEM choose graphics adapters that provide hardware acceleration to support high-quality graphics for use with professional graphics applications.

The items for DirectDraw acceleration in this section are presented in order of importance.

19. Frame buffer can be accessed directly by applications

Consumer PC 98	*Office PC 98*	*Entertainment PC 98*
Required	*Required*	*Required*

The visible frame buffers must be accessible. It must be possible for applications to perform direct frame buffer accesses at any time, even while asynchronous accelerator operations are being executed. Without this capability, drivers cannot support DirectDraw or Direct3D on Windows NT, and operations on Windows will not be fully robust.

Some hardware keeps the information in its frame buffers in a format that does not correspond to the linear format that is standard in DirectDraw, such as tiling the pixels to exploit the 2-D coherence of image data. If this is the case, the hardware must perform translations so that DirectDraw surfaces that are being accessed directly appear linear. The hardware performing this translation might be a limited resource, but it must be able to perform translations on at least seven DirectDraw surfaces simultaneously. Support for eight surfaces is recommended.

20. Adapter and driver support linear-mapped, low-resolution modes

Consumer PC 98	*Office PC 98*	*Entertainment PC 98*
Required	*Required*	*Required*

This is required for all PC 98 system types, including systems with LCD displays. All graphics adapters currently support linear-mapped low-resolution modes. There is minimal additional driver work to support this.

Decreasing the size of the frame buffer decreases the average polygon size and increases the frame rate for a given scene. These additional modes provide support for software rendering games and software Direct3D.

If low-resolution support is implemented in the hardware, the following low-resolution modes are required:

$320 \times 200 \times 16$ bpp	$320 \times 240 \times 16$ bpp	$640 \times 400 \times 16$ bpp
$320 \times 200 \times 8$ bpp	$320 \times 240 \times 8$ bpp	$640 \times 400 \times 8$ bpp

The following low-resolution modes are recommended:

$400 \times 300 \times 16$ bpp	$512 \times 384 \times 16$ bpp
$400 \times 300 \times 8$ bpp	$512 \times 384 \times 8$ bpp

Note: In Windows, low-resolution capabilities must not be defined in the registry so that they do not appear in the display control panel. In Windows NT, the control panel automatically filters out these modes.

21. Adapter supports transparent blter

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	Required

This is required for all PC 98 system types. There is no restriction on source size. A transparent blter can perform a blt with a source key transparent color. This assumes that the blter is asynchronous with the host processor.

22. Hardware supports double buffering with no tearing

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	Required

This is required for all PC 98 system types and must be performed in synchronization with the VBI.

The hardware must support a mechanism for swapping buffers without visible artifacts such as "tearing." The mechanism for doing this is at the discretion of the hardware designer, but it should support tear-free double buffering for both full-screen and non-occluded windowed applications.

Notice that the blts must be performed in synchronization with the vertical scan line to avoid tearing. The ability to read the current scan line supports blting or writing to the screen without tearing. Also, in some contexts such as video playback, this support eliminates the need for a back buffer.

For information about the upper limits of resolution to be supported, see the requirement, "Screen resolution and local memory capacity meet PC 98 requirements," earlier in this chapter.

23. Hardware supports programmable blter stride

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Recommended	Required

This is required for all PC 98 system types as part of the required support for textures. A programmable blter stride ensures that Windows can use linear memory. A fixed stride forces Windows to use rectangular memory management, with all the related inefficiencies. It must be possible to specify different strides for the source and destination on blts.

Hardware Acceleration for 3-D Graphics

This section summarizes guidelines related to Microsoft Direct3D technologies that can be implemented as hardware acceleration features. Supporting the items in this section can result in improved performance and improved memory use.

For all PC 98 systems, the graphics subsystem needs to support 3-D acceleration because the new Internet Explorer 4.0 shell for both Windows 98 and Windows NT 5.0 requires support for 3-D graphics. If 3-D acceleration capabilities are not available in the hardware, then it will be performed automatically in the software using Direct3D under both Windows 98 and Windows NT 5.0.

System designs must include 3-D acceleration capabilities in the hardware when the target market for the system uses 3-D graphical applications. For example, all Consumer PC 98 systems should incorporate 3-D hardware acceleration because games and similar applications use demanding 3-D graphics.

Office PC 98 systems designed for use with CAD or graphics-design applications also require 3-D hardware acceleration. However, in these requirements it is assumed that the typical office system does not require hardware acceleration.

24. Hardware supports RGB rasterization

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	Required

In RGB mode under Direct3D, shading across a surface is accomplished by independently interpolating all color components. The following capabilities are required for red-green-blue (RGB) rasterization:

- Support $800 \times 600 \times 16$ bpp at 75 Hz in full-screen, 3-D graphics mode.

- All required features available at the same time; for example, turning off specular highlights in order to enable fog is not acceptable.

- Flat and Gouraud shading.

- MIP-mapped textures.

- Bilinear or better filtered textures (rather than point-sampled), with perspective correction.

- Alpha blending, including support for the following modes defined for Direct3D in the DirectX 5.0 DDK:

Required	Recommended
D3DBLEND_DESTCOLOR	D3DBLEND_BOTHINVSRCALPHA
D3DBLEND_INVDESTCOLOR	D3DBLEND_BOTHSRCALPHA
D3DBLEND_INVSRCALPHA	D3DBLEND_DESTALPHA
D3DBLEND_INVSRCCOLOR	D3DBLEND_INVDESTALPHA
D3DBLEND_ONE	D3DBLEND_SRCALPHASAT
D3DBLEND_SRCALPHA	
D3DBLEND_SRCCOLOR	
D3DBLEND_ZERO	

  For source RGB alpha blending, transparent primitives are blended with the background, but the background transparency is not updated. This method provides good visual accuracy if there are not too many overlapping transparent objects.

- Depth-based fog of an arbitrary color, where depth is defined as distance perpendicular to the screen.

- Support for per-vertex fog.

  Recommended: Support for range-based and table-based fog, where range is the radial distance from the eye point.

- Edge anti-aliasing, which can require a separate call to define the edge.

  Recommended: Polygon anti-aliasing for higher visual quality, which does not require a separate call to define the edge.

- Specular highlighting.

  Recommended: Use of dedicated interpolants.

The Direct3D reference rasterizer in the DirectX 5.0 DDK supports all of these capabilities.

25. Hardware supports multi-texturing

Consumer PC 98	Office PC 98	Entertainment PC 98
Recommended	Recommended	Required

Multi-texturing hardware can apply multiple textures to a polygon. The common application of multi-texturing is map-based techniques for diffuse lighting and specular reflections.

To implement this capability, support is required for two or more sets of independent texture coordinates. It is recommended that hardware support the combining of at least two textures in a single pass.

The following texture combination operations are required:

- MODULATERGB: Component-wise multiplication of both texture colors
- MODULATELPHA: Multiply colors of one texture by the alpha of the other
- ADD: Component-wise addition of both textures
- BLEND: Linear combination of textures weighted by a scalar specified in a register or in a polygon alpha

Multi-texturing is used to compute the texture value that participates in the pixel pipeline implemented in Direct3D in DirectX 5.0. It is independent of the alpha blending stage that has existed in Direct3D since its inception.

This technique should work in combination with fog and alpha blending, but need not operate at the same time as other advanced filtering.

For more information, see the paper on multi-texturing and DirectX available on the web site at http://www.microsoft.com/hwdev/devdes/.

26. Hardware supports texture formats

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Required	Required

For PC 98 hardware that implements 3-D acceleration, the hardware must support palletized textures. Pallet entries use the corresponding nonpalletized formats shown in the following table.

Required	Recommended
8-bit palletized	4-bit palletized
1:5:5:5 ARGB	8:8:8:8 ARGB
4:4:4:4 ARGB	0:5:6:5 ARGB
	4:2:2 YUV

27. Hardware complies with texture size limitations

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	*Recommended*	*Required*

MIP mapping requires that textures of size 1×1 be supported. To meet PC 98 requirements, a 3-D accelerator must support this lower limit on texture size.

The texture units must support square and non-square power-of-two textures ($2^n \times 2^m$) up to 256×256.

Recommended: The texture unit should support non-power-of-two width and height. This enables the texture mapping unit to be used to emulate blts. Also, it is recommended that the texture unit support an upper limit of 2048×2048 rather than the required 256×256.

28. Hardware supports destination RGB alpha blending

Consumer PC 98	Office PC 98	Entertainment PC 98
Recommended	*Recommended*	*Recommended*

For destination RGB alpha blending, primitives are blended with the background, updating not only the colors in the frame buffer but also a cumulative transparency that can affect the rendering of subsequent primitives.

29. Hardware supports Z comparison modes and Direct3D-compatible formats

Consumer PC 98	Office PC 98	Entertainment PC 98
Recommended	*Recommended*	*Required*

It is required for Entertainment PC 98 systems and recommended for other system types that 3-D hardware support 16-bit minimum, unsigned, lockable Z buffer format and all Z comparison modes.

Hardware that supports Z buffering must support clearing of the Z buffer through the DirectDraw depth-fill blt mechanism. However, DirectX 5.0 enables Z buffers to be cleared at the same time as destination surfaces. It is recommended that PC 98 hardware support simultaneous clearing of color and Z buffers using the DirectX 5.0 mechanism.

30. Hardware meets PC 98 3-D accelerator performance requirements

Consumer PC 98	Office PC 98	Entertainment PC 98
Recommended	Recommended	Required

These performance capabilities are required for Entertainment PC 98 systems and recommended for other system types.

The 3-D rendering subsystem should have triangle setup capability implemented in hardware that is capable of processing triangles at a sustained rate in excess of 1 million triangles per second. Each triangle is assumed to be 1 visible pixel in area, front facing, textured, and composed of three vertices, where each vertex contains a diffuse and specular color component. Rendering conditions should be 16 bpp, bilinear textured, Z buffered, and alpha blended. Triangles should be ordered such that the Z check always passes (that is, the current triangle is in front of all previously rendered triangles).

The 3-D rendering subsystem should be capable of filling triangles at a sustained rate in excess of 40 million pixels per second. Each triangle is assumed to be 10,000 visible pixels in area, with the same attributes as described for triangle setup in the previous paragraph. Rendering conditions are also the same as for triangle setup. Supporting 60 million pixels per second is recommended.

PC 98 Television Output Requirements

This section summarizes the key design issues and requirements for television output capabilities, which are recommended for all PC 98 system types and required for any Entertainment PC 98 system that does not include a large-screen entertainment monitor.

The requirements in this section apply only if the television output capability is present on a PC 98 system or on a graphics adapter that supports television output capabilities. Some television output capabilities listed in this section are required for Entertainment PC 98 only.

The required support allows an NTSC or PAL television to be used as a primary or secondary display surface for the Windows operating system and for Windows-based applications. Such a display surface allows more realistic game, video, and multimedia experiences for users who want to use a large-screen television that they already own.

If television output capabilities are provided in a PC 98 system, support is required for either NTSC or PAL standards. NTSC refers to the television standards first developed in the United States and used in Canada, Japan, and Mexico. PAL refers to the television standards first developed in Germany and used in Austria, Belgium Brazil, Denmark, Finland, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom.

For more information about world television standards, see the web site at http://www.bbc.co.uk/aberdeen/eng_info/.

31. Adapter supports both NTSC and PAL output
Recommended

It is recommended that the television output adapter supports both output standards. If NTSC is supported, then the NTSC system must support 640×400 and 640×480 at 60 Hz. If PAL is supported, then the PAL system must support 640×480 and 800×600 at 50 Hz.

Whether either or both output standards are supported, software must be capable of independently enabling and disabling television and VGA output.

Note: For NTSC, the 60-Hz mode described in this section is actually 59.940 Hz.

32. Default boot mode supports appropriate locale

Consumer PC 98	*Office PC 98*	*Entertainment PC 98*
Required	*Required*	*Required*

PC 98 systems and graphics adapters must enable television output automatically as the primary display if a VGA monitor is not attached, defaulting to modes compatible with television output in the geographic region for which the adapter was localized. NTSC adapters should default to 60-Hz modes; PAL adapters should default to 50-Hz modes. Ideally, an adapter would support both modes and provide a safe means for the default selection to be changed by a user.

33. Adapter supports underscan scaling

Consumer PC 98	*Office PC 98*	*Entertainment PC 98*
Required	*Recommended*	*Required*

For Consumer PC 98 and Entertainment PC 98 systems, the television output adapter must be able to correct horizontal and vertical overscan using hardware scaling. This allows 640×480 resolution modes to fit onto NTSC displays and 800×600 resolution modes to fit onto PAL displays.

Driver software must be capable of enabling and disabling scaling and also of adjusting scaling for compatibility with a variety of television monitors. As television monitors age, overscan reduces, so less scaling is required.

34. Adapter supports flicker filter
Required

The television output adapter must use multi-line (3-tap minimum) hardware filtering techniques for flicker reduction. Enable, disable, and adjust capabilities for the flicker filter must be software controllable. Also, overscan should be software-enabled when the PC is playing full-screen video.

35. Adapter provides proper termination
Required

Proper termination is required so that optimal picture quality from any connector does not require displays to be attached to other connectors. For example, a VGA monitor must not be required in order for the S-Video output to appear properly.

36. Adapter supports RCA-style composite video and S-Video connectors

Consumer PC 98	*Office PC 98*	*Entertainment PC 98*
Recommended	*Recommended*	*Required*

Compared to RCA-style composite video, S-Video dramatically improves the picture quality of the NTSC or PAL scan converter. This standard is designed to reduce cross talk between chrominance and luminance signals and to increase the luminance bandwidth capability of the television. For a description of this standard, see http://www.bbc.co.uk/aberdeen/eng_info/.

A Solent Club for Amateur Radio and Television (SCART; also called Peritel) connector can be supported for European markets, but is not required for North American markets. Notice that most European television sets have two SCART sockets. One allows stereo audio and composite video I/O switchable to RGB inputs. The other supports switching from composite input to S-Video input. The first can be used to connect a satellite receiver for RGB capability. The other can be used to connect a VCR using S-Video for television output. A camcorder usually has connections for composite video, stereo audio, and S-Video. For a description of the SCART standard, see the web site at http://www.bbc.co.uk/aberdeen/eng_info/.

37. Adapter supports both VGA and television output
Required

Recommended: Simultaneous output to VGA monitor and television.

In addition to television output, the PC 98 system also must support VGA output to ensure that users with existing large-screen VGA monitors can use this output capability.

38. Software supports positioning

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Recommended	Required

Software must be able to program the television output hardware to position the television image in increments of 4 pixels horizontally and 4 scan lines vertically.

39. Software supports detection of television connection

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Recommended	Required

For Consumer PC 98 and Entertainment PC 98 systems, software must be able to read the television output hardware to detect whether a television is attached to S-Video or composite output connectors. (Detection of a VGA monitor is achieved using the separate DDC requirement for graphics adapters and monitors.)

This is required to allow the operating system and graphics drivers to correctly support display output during the startup sequence (for example, determining what resolution and refresh rate to use) and to allow the applications to adjust their user interfaces appropriately to the screen capabilities.

PC 98 Design for Graphics Adapters

This section summarizes requirements related to the PC 98 design initiatives defined in Part 1 of this guide.

Plug and Play and Bus Design for Graphics Adapters

The items in this section summarize PC 98 requirements for Plug and Play and other resource-related and bus-related capabilities. The specifications in this section are required for all PC 98 systems.

Note: See also the "Graphics operations use relocatable registers only" requirement in the "Graphics Adapters Basic Features" section earlier in this chapter.

General Plug and Play Requirements

The requirements in this section ensure easy configuration.

40. Each device has a Plug and Play device ID
Required

The device must have a unique device ID using the format required for its bus. For example, a PCI device must comply with PCI 2.1 and also must provide a Subsystem ID and Subsystem Vendor ID, as defined in the "PCI" chapter in Part 3 of this guide.

Note: Multiple-monitor support allows Display class devices to be initialized independent of the system initialization process. For this reason, system-board and add-on display devices cannot use the VGA BIOS POST routine to populate the Subsystem Vendor ID because the device's POST code might not be executed until later in the process, after device enumeration occurs. For system-board devices, the system BIOS should populate the Subsystem Vendor ID at power on. Add-on display adapters should provide a method for populating the Subsystem Vendor ID at the point when power is applied and the device is initialized to the state that is ready for POST.

41. System supports conflict resolution, VGA compatibility, and extended registers
Required

When the end user changes or adds a graphics adapter to the system, setting resource assignments must not require changing jumpers or switches on either the card or the system board. The system must be able to automatically relocate the resources used by a graphics adapter on the system board when a graphics adapter expansion card is added to the system. In the event of an irreconcilable conflict with other devices on the system, the system must be able to disable one of the adapters in order to prevent the system from stalling.

The system must support the VGA graphics standard for application compatibility and for the Windows clean-boot error-recovery process. If a VGA BIOS exists on the graphics adapter, it must be able to configure its base address to C0000h and one alternate address (minimum) to prevent conflicts.

Extended resources are additional I/O ports, direct-access frame buffers, or data transfer areas on a graphics adapter that use more resources than does standard VGA. The Windows configuration manager must be able to map the resources to avoid conflicts with other system devices. At least one alternate configuration must be provided for each non-VGA display resource in the event of conflict during the IPL boot.

The software drivers and VGA BIOS (if used) must be able to use alternate configuration register addresses. The system must be able to dynamically disable or relocate VGA resources from C0000h. It must also be possible to re-enable these resources upon system reboot or reset.

For additional related requirements for multiple monitor support, see the "Multiple-Adapter and Multiple-Monitor Support" section earlier in this chapter.

BIOS and Option ROM Requirements for Graphics Adapters

The requirements in this section relate to BIOS support for graphics adapters.

42. Chips support linear packed-pixel frame buffer, relocatable above 16 MB
Required

Note: For DirectDraw, the graphics adapter's chip set must support linear access to the frame buffer by the host.

Windows is optimized for a graphics adapter with a packed-pixel frame buffer at all supported resolutions. Memory-mapped packed-pixel frame buffers also provide a fast and simple interface between Windows and the graphics adapter. The Windows DIB engine provides a very fast display by writing directly to packed-pixel frame buffers, and this architecture requires that the hardware developer write only a small, simple device driver.

For optimized support with Windows, a linear packed-pixel frame buffer is required over a bank-switched frame buffer. Use 32-bit addresses to allow the linear frame buffer to be placed above the 16-MB ISA boundary, which enables a system to be populated with large amounts of RAM.

If memory or other resources conflict with the frame buffer being mapped into a linear address space, the page frame address can be used with minimal degradation of performance.

43. Option ROM supports DDC2B
Required

This requirement does not apply for systems that use RISC-based processors. The option ROM for the graphics adapter must meet current DDC host requirements documented in *Display Data Channel Standard, Version 2.0*, Level B (DDC2B), published by VESA. This standard defines the functions that support the data channel between the graphics adapter and a DDC-compliant monitor.

44. BIOS setup utility provides option to force use of system-board graphics
Recommended

The OEM should provide an option in the system BIOS setup utility to force the system-board graphics device to be used (that is, to ignore and leave disabled any PCI graphics adapters). This option would ensure that a user with a PCI hot-docking system is always able to undock, because the VGA device will be in the mobile unit.

45. BIOS supports large frame buffers for graphics adapters
Required

The BIOS must support large frame-buffer graphics adapters that have up to 256 MB of frame buffers.

AGP Requirements

This section defines the PC 98 requirements for AGP.

46. AGP meets PC 98 implementation guidelines
Required

The following are the PC 98 requirements for AGP cards:

- Compliant with PCI 2.1, including the PC 98 requirements for Subsystem ID and Subsystem Vendor ID.

- Compliant with *Accelerated Graphics Port Interface Specification, Revision 1.0* or higher. This means the card has an AGP capability pointer with a working AGP capability structure that has the following characteristics:

  - A minimum request-queue depth of 1 DWORD (RQ value of 0).

  - A minimum speed of 1*x*.

  - A workable AGP_ENABLE.

  - System implementation of a Graphics Address Remapping Table (GART).

- Compliance with the *PCI Bus Power Management Interface Specification, Revision 1.0* or higher, including the Configuration Space registers and the device state (D*x*) definitions.

Requirements for PCI Graphics Adapters

The requirements in this section apply for graphics adapters that use the PCI bus.

47. PCI graphics device supports IRQ and correctly populates PCI BARs

Consumer PC 98	Office PC 98	Entertainment PC 98
Required	Recommended	Required

Proper IRQ support is necessary for optimal support of video playback. The display driver for Windows queries the actual device to find its register locations and so on. The PCI base address registers (BARs) must be populated correctly for this information to be correct in the registry.

On adapters that do not support IRQ, the Interrupt Pin Register (3Dh) should be zero (0).

48. PCI system-board graphics device is not hidden from Plug and Play enumeration
Required

Some current implementations cause problems for supporting multi-monitor capabilities with system-board graphics devices. Some system vendors hide the system-board graphics adapter from the PCI bus when another graphics adapter is detected in the system. The system-board device must disable the PCI device rather than hiding it.

Power Management for Graphics Adapters

This section summarizes the specific power management requirements for graphics adapters.

49. Graphics adapter complies with device class power management reference specification
Required

The *Display Device Class Power Management Reference Specification, Version 1.0* or higher, provides definitions of the OnNow device power states (D0–D3) for display and graphics devices. The specification also covers device functionality expected in each power state and the possible wake-up event definitions for the class, if any. Power states D0 and D3 are required; D1 and D2 are optional for graphics adapters.

50. Graphics adapter complies with VBE/Core 2.0 extensions for power management
Required

The *VESA BIOS Extension Standard/Core Functions 2.0* (VBE/Core 2.0) specification defines extensions to VGA ROM BIOS services for power management.

Device Drivers and Installation for Graphics Adapters

This section summarizes the requirements for graphics adapters. The specifications in this section are required for all PC 98 systems.

For additional related requirements for multiple-monitor support, see the "Multiple-Adapter and Multiple-Monitor Support" section earlier in this chapter.

51. Device drivers and installation meet PC 98 requirements
Required

The manufacturer does not need to supply a driver for a device if the device passes PC 98 compliance testing using a driver provided with the operating system. If the manufacturer supplies a driver, then the requirements for device drivers and installation are defined in the "Basic PC 98" chapter in Part 1 of this guide. The basic requirements include driver support for unattended installation and Help file support if special driver parameters are used.

Note: For Windows, the display driver (.DRV) component that is loaded and called by the Windows Graphics Device Interface (GDI) is a Win16 module.

52. Driver does not bypass any Microsoft-provided system components
Required

The driver must not bypass or patch any Microsoft-provided system components. For Windows, this includes Gdi.exe, Kernel.exe, User.exe, Dibeng.dll, Mmsystem.dll, Ddraw.dll, D3d*.dll, and so on.

For Windows NT, this requirement applies for all files normally installed in the System32 directory, including but not limited to Win32k.sys, Ntoskrnl.exe, Gdi32.dll, User32.dll, and Mcdsrv32.dll.

53. Applications provided with device meet Win32 requirements
Required

Any Windows-based applications provided with the device must meet Microsoft requirements for software compatibility as defined in the Win32 SDK.

54. Driver supports dynamic color bit-depth change
Required

The graphics adapter must operate properly and must not fail when asked by the operating system to change the color depth.

Graphics Adapters References

The following represents some of the references, services, and tools available to help build hardware that is optimized to work with Windows operating systems.

Accelerated Graphics Port Interface Specification, Revision 1.0
  http://developer.intel.com

Design guidelines for DirectX, multiple-monitor/multiple-adapter support, and white paper on DirectDraw VPE and kernel-mode video transport
  http://www.microsoft.com/hwdev/devdes/

Display Data Channel Standard, Version 2.0
VESA BIOS Extension Standard/Core Functions 2.0 (VBE/Core 2.0)
*VESA and Industry Standards and Guidelines for Computer Display
      Monitor Timing*
Specification for Video Interface Port, Version 1.1
  Video Electronics Standards Association (VESA)
  2150 North First Street, Suite 440
  San Jose, CA 95131-2029
  Telephone: (408) 435-0333
  Fax: (408) 435-8225
  http://www.vesa.org

Display Device Class Power Management Reference Specification, Version 1.0
  http://www.microsoft.com/hwdev/onnow.htm

PCI Local Bus Specification, Revision 2.1 (PCI 2.1)
PCI Bus Power Management Interface Specification, Revision 1.0
  Phone: (800) 433-5177
  http://www.pcisig.com

Windows, Windows NT, and DirectX DDKs
  MSDN Professional membership

World television and S-Video interface standards
  http://www.bbc.co.uk/aberdeen/eng_info/

Checklist for Graphics Adapters

If a recommended feature is implemented, it must meet the PC 98 requirements for that feature as defined in this document.

Consumer PC 98	Office PC 98	Entertainment PC 98

1. Graphics adapter uses PCI, AGP, or another high-speed bus
Required   *Required*   *AGP required*

2. System uses WC with higher-performance processors
Required   *Required*   *Required*

3. Primary graphics adapter works normally with default VGA mode driver
Required   *Required*   *Required*

4. Adapter and driver support multiple adapters and multiple monitors
Required   *Required*   *Required*

5. Adapter supports television output if system does not include large-screen monitor
Recommended   *Recommended*   *Required*

6. Adapter meets PC 98 general device requirements
Required

7. Screen resolution and local memory capacity meet PC 98 minimum requirements
Required   *Required*   *Required*

8. Adapter meets VESA specifications for ergonomic timing rates
Required

9. All supported color depths are enumerated
Required

10. Graphics operations use relocatable registers only
Required

11. Adapter supports downloadable RAMDAC entries for image color matching
Required

12. Adapter supports DDC monitor detection
Required

13. Adapter supports video overlay surface with scaling
Required   *Required*   *Required*

14. Hardware supports VGA destination color keying for video rectangle
Required   *Required with DVD-Video*   *Required*

15. Video port meets PC 98 specifications if present on graphics adapter
Required   *Required*   *Required*

16. Adapter supports MPEG-2 motion compensation acceleration
Recommended

17. Extended resources can be dynamically relocated after system boot
Required

18. VGA resources can be disabled by software
Required

Consumer PC 98	Office PC 98	Entertainment PC 98
19. Frame buffer can be accessed directly by applications		
Required	*Required*	*Required*
20. Adapter and driver support linear-mapped, low-resolution modes		
Required	*Required*	*Required*
21. Adapter supports transparent blter		
Required	*Required*	*Required*
22. Hardware supports double buffering with no tearing		
Required	*Required*	*Required*
23. Hardware supports programmable blter stride		
Required	*Recommended*	*Required*
24. Hardware supports RGB rasterization		
Required	*Required*	*Required*
25. Hardware supports multi-texturing		
Recommended	*Recommended*	*Required*
26. Hardware supports texture formats		
Required	*Required*	*Required*
27. Hardware complies with texture size limitations		
Required	*Recommended*	*Required*
28. Hardware supports destination RGB alpha blending		
Recommended	*Recommended*	*Recommended*
29. Hardware supports Z comparison modes and Direct3D-compatible formats		
Recommended	*Recommended*	*Required*
30. Hardware meets PC 98 3-D accelerator performance requirements		
Recommended	*Recommended*	*Required*
31. Adapter supports both NTSC and PAL output		
Recommended		
32. Default boot mode supports appropriate locale		
Required	*Required*	*Required*
33. Adapter supports underscan scaling		
Required	*Recommended*	*Required*
34. Adapter supports flicker filter		
Required		
35. Adapter provides proper termination		
Required		
36. Adapter supports RCA-style composite video and S-Video connectors		
Recommended	*Recommended*	*Required*
37. Adapter supports both VGA and television output		
Required		
38. Software supports positioning		
Required	*Recommended*	*Required*

Consumer PC 98	Office PC 98	Entertainment PC 98

39. Software supports detection of television connection
Required   *Recommended*   *Required*

40. Each device has a Plug and Play device ID
Required

41. System supports conflict resolution, VGA compatibility, and extended registers
Required

42. Chips support linear packed-pixel frame buffer, relocatable above 16 MB
Required

43. Option ROM supports DDC2B
Required

44. BIOS setup utility provides option to force use of system-board graphics
Recommended

45. BIOS supports large frame buffers for graphics adapters
Required

46. AGP meets PC 98 implementation guidelines
Required

47. PCI graphics device supports IRQ and correctly populates PCI BARs
Required   *Recommended*   *Required*

48. PCI system-board graphics device is not hidden from Plug and Play enumeration
Required

49. Graphics adapter complies with device class power management reference specification
Required

50. Graphics adapter complies with VBE/Core 2.0 extensions for power management
Required

51. Device drivers and installation meet PC 98 requirements
Required

52. Driver does not bypass any Microsoft-provided system components
Required

53. Applications provided with device meet Win32 requirements
Required

54. Driver supports dynamic color bit-depth change
Required