

TESTING THE LIMITS OF PCI/AGP VIDEO CARDS ON WINDOWS XP PROFESSIONAL

OBJECTIVE:

The objective of this lab is to experiment with a variety of configurations of video cards within a PC running Windows XP to better understand the inherent limitations of running multiple video cards on such a system. This lab will seek to answer the following questions:

- How many PCI/AGP cards will the OS recognize
- How many PCI/AGP cards can the OS properly manage
- How does the OS select (prioritize) the Primary and Secondary monitors
- What causes conflicts between multiple cards

EQUIPMENT/SOFTWARE USED:

Hardware:

- HP Vectra v1400 MT
- 6 S3 Trio Video Adapters – FRU 75H9213
- 4 Dell flat-panel monitors
- Trident PCI video card
- NVIDIA AGP video card

Software:

- Benchmarking software – <http://www.freshdevices.com/freshdiag.html>
- Windows XP Professional

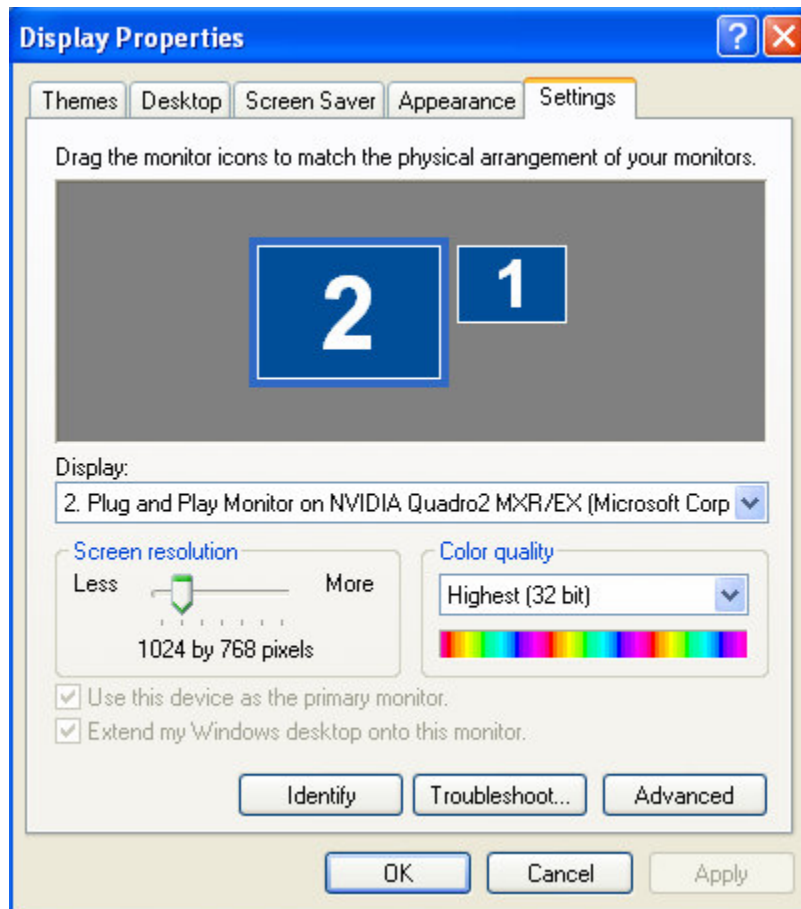
PROCEDURES:

To begin this lab, it was first necessary to obtain a Windows XP based PC with multiple PCI slots, along with a variety of video cards. An Hp Vectra v1400 MT was obtained with one built-in NVIDIA AGP card as well as four available PCI slots. Six spare PCI video cards (S3 Trio) were obtained from The Cage.

In order to properly analyze any results from these experiments, it was also necessary to obtain some type of benchmarking standard. Free benchmark software was obtained from <http://www.freshdevices.com/freshdiag.html>. This software was run on the obtained PC in order to discover the computer's default configurations and settings. Please see the "Benchmark Video Device Configuration" in the Appendix for complete details of the results of this examination.

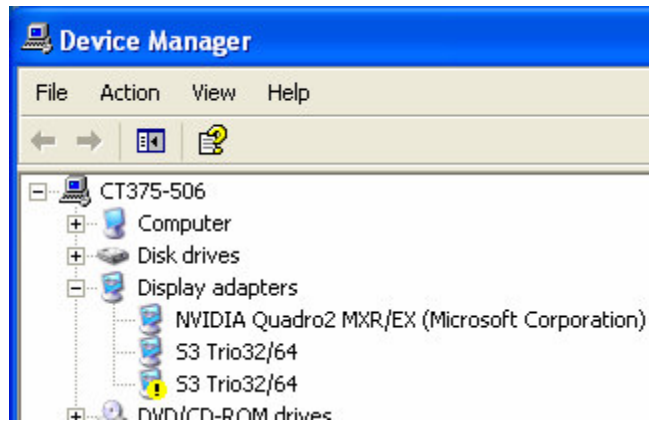
The computer's default configuration was for one NVIDIA AGP display. No other video devices were discovered or configured on the machine. The next step was to then shutdown the machine, plug in one of the VGA PCI cards, and then start the machine back up. A second flat-panel monitor was connected to the video card. While booting up, the PCI card display the system BIOS information rather than the AGP video card. At some point during the boot process (a point we could not properly identify due to a lack of output during the boot process of Windows) the AGP card then became the primary display and the other monitor shut off.

The diagnostics software showed that the computer recognized the two different displays. Using the windows display properties dialog, the secondary display (S3 Trio) was activated. This display could then be used to "extend" the windows desktop onto the second monitor (see properties dialog below).



Upon verifying that the computer could recognize and control both monitors, it was then decided to attempt to plug in a third device. The computer was shut down and a second S3 Trio card was inserted, totaling two PCI cards and one AGP card. A third flat-panel display was plugged into this new device. The computer was then started. During the boot process, the BIOS detected the new card and used that as the primary display device. Once again, at some point during the Windows startup process the display changed to the AGP card. Once the computer finished booting up, the benchmark diagnostics software showed only two devices: the AGP NVIDIA and PCI

S3Trio. The Windows device manager showed that three video devices were detected, but indicated that only two of these devices could be enabled.



Once again, using the properties dialog, the secondary monitor could be enabled, but only two display devices could be used simultaneously. The lowest S3 Trio on the PCI bus was the one that Windows selected as the secondary device, keeping the AGP as the primary device.

In order to determine whether or not the conflict was caused by identical video cards using the same device driver, it was then necessary to shut down the machine and replace the second S3 Trio with the Trident PCI card. This is a lower-memory card manufactured by a different company than the S3 Trio, thus using completely different device drivers.

Upon rebooting the machine with the Trident card, the BIOS recognized the Trident as the Primary device but died shortly after booting up with the following error: 0600-ae : video memory error. Further information indicated that the Trident had smaller video memory than the previous card, thus indicating either a hardware change or a card failure. It was known that the hardware was changed, so the boot process was then continued without any testing of the devices.

The same results were obtained as with the previous attempt to use three cards. The Trident (lowest on the PCI bus) was selected as the secondary device, while the NVIDIA was selected as the primary device. All three devices were recognized by the OS, but only the AGP and Trident were usable. The diagnostic software also reported the same.

From these results, a hypothesis was formulated that the last video card on the PCI bus would always be selected as the secondary device. This hypothesis was tested by inserting another S3Trio into the last slot of the PCI bus, thus totaling four devices. The hypothesis was confirmed. The BIOS selected the last device on the PCI bus as the primary display. The OS did the same, prioritizing the AGP as the primary, and the last device on the bus as the secondary. Windows device manager recognized all four video cards, but would only allow two to function.

The next step in this experimental process was to attempt, through Windows, to control which device was selected as the secondary device. Through the Windows device manager it is possible to disable specific devices. The secondary device (the last on the bus) was disabled through the Windows device manager. It was then necessary to reboot the machine. Upon a successful reboot, Windows had indeed disabled the last device on the bus, but would still not allow the other devices to be enabled or used. Thus with the last device disabled, Windows would only allow one display to function.

The final experiment was to remove the AGP device and test only the PCI devices. Once again, both the BIOS and Windows selected the last device on the PCI bus as the primary device. The device manager recognized all three PCI cards, but would only allow one to be used. The other two devices were permanently disabled. Thus Windows only allows the use of one PCI video card per PCI bus.

REPORT:

A variety of configurations with PCI and AGP video cards gave the following results:

- The system BIOS (for the HP Vectra) selects the last video device on the PCI bus as the primary display device
- Windows XP Professional can support one and only one AGP video device and one and only one PCI video device simultaneously
- Windows XP selects the last video device on the PCI bus as the primary device if no AGP device is detected
- Windows XP will select an AGP device as the primary device even in the presence of a PCI video device
- Windows will select the last video device on the PCI bus as the secondary device if an AGP device is also present
- The manufacturer of the video device does not affect the ability of Windows to enable more than one of either AGP or PCI video devices
- Windows will not allow the user to select the primary or secondary devices among many possible devices, although it will allow the user to switch the primary and secondary devices between the two

From these results it can be proposed that there are limitations to the number of video devices that can be used simultaneously in one PC. The system BIOS and the OS prioritize video devices separately from one another and do not use the same method to prioritize the devices (although they seem to use the same method when only PCI devices are used). The limitation for how many devices can be plugged into the PC does not appear to be hardware-related due to the fact that all devices are recognized by the PC. Thus one might draw the conclusion that the issue lies somewhere in the way that the devices interact with the OS or processor. The conflict might be in the memory range that the devices use for video. If there is a standard range of memory set aside for video use, then multiple cards would cause conflict such as those witnessed during the experimental process.

CONCLUSIONS:

The results of this lab can be considered a success in light of the fact that each objective of the lab was met. Consider the following questions:

- How many PCI/AGP cards will the OS recognize?
 - The OS will recognize as many as can physically fit into the available space (PCI or AGP)
- How many PCI/AGP cards can the OS properly manage
 - The OS can only manage up to two video devices. One must be AGP while the other must be PCI
- How does the OS select (prioritize) the Primary and Secondary monitors
 - The OS will always choose an AGP device as the primary device if one is present while the secondary (or primary if no AGP device is present) device will always be the last video device on the PCI bus
- What causes conflicts between multiple cards
 - This conflict is not a hardware conflict and thus must be a software conflict such as conflicting memory space or standard IRQ or port settings specified by video device drivers

This lab provided the opportunity to not only learn the limitations of the Windows operating system with display devices, but also heightened the participant's knowledge of how both the system BIOS and OS interact with the video devices that are present. Important differences in how the OS prioritizes and communicates between AGP and PCI devices were learned. One suggestion for future study would be to analyze and rewrite a video display device driver to change the memory range and IRQ settings in an attempt to determine whether or not the device would still function. If so, one might then ask if multiple PCI or AGP devices could then be used due to the fact that the device drivers do not conflict in any way.

Overall, this lab was valuable in teaching about PC video devices and how they function together with the OS and with other video devices. Some of the limitations of these devices were also exposed and analyzed.

APPENDIX:

Benchmark Video Device Configuration

Display Adapters

This module contains information about display adapters that are currently installed in your computer.

Adapters: NVIDIA Quadro2 MXR/EX (Microsoft Corporation)

General Information

Device Name	NVIDIA Quadro2
MXR/EX (Microsoft Corporation)	
Device ID	\\.\DISPLAY3
BIOS Date	04/01/96
BIOS Version	S3 86C765 Video
BIOS. Version 1.01-05A	

Display Settings

Color Depth	32 Bits
Maximum Color Colors	4,294,967,296
Vertical Resolution	768 Pixels
Horizontal Resolution	1,024 Pixels
Pixel Diagonal	51 Pixels
Pixel Height	36 Pixels
Pixel width	36 Pixels
Technology	Raster Display
Vertical Refresh	60 Hz
Pixels Per Inch Width	96 ppi
Pixels Per Inch Height	96 ppi
Number of Color Planes	1
Number of Device-Specific Fonts	0
Relative Width of Device Pixel Used for Line Drawing	36
Relative Height of Device Pixel Used for Line Drawing	36
Diagonal width of Device Pixel Used for Line Drawing	51
Preferred Horizontal Drawing Alignment (Accelerated)	Any Alignment

State Flags

Primary Display	Yes
Removable Display	No
VGA Compatible	Yes
Part of The Desktop	Yes
Pseudo Device	No
Has More Display Modes	Yes
Multi Driver	No
Remote Display Connected	No
Connected	Yes

Clip Capabilities

Supports clipping rectangle	Yes
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Curve Capabilities

Supports curves	Yes
Can draw circles	Yes
Can draw pie wedges	Yes
Can draw chord arcs	Yes
Can draw ellipses	Yes
Can draw interiors	Yes
Can draw wide borders	Yes
Can draw styled borders	Yes
Can draw wide and styled borders	Yes
Can draw rounded rectangles	Yes

Line Capabilities

Supports lines	Yes
Can draw a polyline	Yes
Can draw a marker	Yes
Can draw multiple markers	Yes
Can draw interiors	Yes
Can draw styled lines	Yes
Can draw wide lines	Yes
Can draw wide and styled lines	Yes

Polygon Capabilities

Supports polygons	Yes
Can draw alternate-fill polygons	Yes
Can draw rectangles	Yes
Can draw a single scanline	Yes
Can draw interiors	Yes
Can draw styled borders	Yes
Can draw wide borders	Yes
Can draw wide and styled borders	Yes
Can draw winding-fill polygons	Yes

Raster Capabilities

Requires banding support	No
Capable of transferring bitmaps	Yes
Supports bitmaps larger than 64K	Yes
Supports SetDIBits and GetDIBits functions	Yes
Supports SetDIBitsToDevice function	Yes
Capable of performing flood fills	Yes
Supports 16-bit windows 2.0 features	Yes
Specifies a palette-based device	No
Capable of scaling	No
Supports StretchBlt function	Yes
Supports the StretchDIBits function	Yes

Text Capabilities

Character output precision	Yes
Stroke output precision	Yes
Stroke clip precision	Yes
90-degree character rotation	No
Any character rotation	No
Can scale independently in the x- and y-directions	No
Capable of doubled character for scaling	No
Uses Integer multiples only for character scaling	No
Uses any multiples for exact character scaling	No
Can draw double-weight characters	No
Can italicize	No
Can underline	Yes
Can draw strikeouts	Yes
Can draw raster fonts	Yes
Can draw vector fonts	Yes
Cannot scroll using a bit-block transfer	No

Shading and Blending Capabilities

Supports Shading and Blending	Yes
Handles SourceConstantAlpha in AlphaBlend function	No
Can GradientFill rectangles	No
Can GradientFill triangles	No
Can handle per-pixel alpha in AlphaBlend	No
Can handle premultiplied alpha in AlphaBlend	No

Color Management Capabilities

Supports Color Management	Yes
Can accept CMYK color space ICC color profile	No
Can perform ICM on either the device driver or the device itself	No
Supports GetDeviceGammaRamp and SetDeviceGammaRamp	Yes

S3 Trio Configuration

Display Adapters

This module contains information about display adapters that are currently installed in your computer.

Adapters: S3 Trio32/64

General Information

Device Name	S3 Trio32/64
Device ID	\\.\DISPLAY1
BIOS Date	04/01/96
BIOS Version	S3 86C765 video
BIOS. Version	1.01-05A

Display Settings

Color Depth	0 Bits
Maximum Color	~
Vertical Resolution	0 Pixels
Horizontal Resolution	0 Pixels
Pixel Diagonal	0 Pixels
Pixel Height	0 Pixels
Pixel width	0 Pixels
Technology	Vector Plotter
Pixels Per Inch Width	0 ppi
Pixels Per Inch Height	0 ppi
Number of Color Planes	0
Number of Device-Specific Brushes	0
Number of Device-Specific Pens	0
Number of Device-Specific Fonts	0
Entries in Device Color Table	0
Relative Width of Device Pixel Used for Line Drawing	0
Relative Height of Device Pixel Used for Line Drawing	0
Diagonal Width of Device Pixel Used for Line Drawing	0
Preferred Horizontal Drawing Alignment (Accelerated)	Any Alignment

State Flags

Primary Display	No
Removable Display	No
VGA Compatible	Yes
Part of The Desktop	No
Pseudo Device	No
Has More Display Modes	No
Multi Driver	No
Remote Display	No
Connected	Yes

Clip Capabilities

Supports clipping rectangle	No
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Curve Capabilities

Supports curves	Yes
Can draw circles	No
Can draw pie wedges	No
Can draw chord arcs	No
Can draw ellipses	No
Can draw interiors	No
Can draw wide borders	No
Can draw styled borders	No
Can draw wide and styled borders	No
Can draw rounded rectangles	No

Line Capabilities

Supports lines	Yes
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Can draw a polyline	No
Can draw a marker	No
Can draw multiple markers	No
Can draw interiors	No
Can draw styled lines	No
Can draw wide lines	No
Can draw wide and styled lines	No
Polygon Capabilities	
Supports polygons	Yes
Can draw alternate-fill polygons	No
Can draw rectangles	No
Can draw a single scanline	No
Can draw interiors	No
Can draw styled borders	No
Can draw wide borders	No
Can draw wide and styled borders	No
Can draw winding-fill polygons	No
Raster Capabilities	
Requires banding support	No
Capable of transferring bitmaps	No
Supports bitmaps larger than 64K	No
Supports SetDIBits and GetDIBits functions	No
Supports SetDIBitsToDevice function	No
Capable of performing flood fills	No
Supports 16-bit windows 2.0 features	No
Specifies a palette-based device	No
Capable of scaling	No
Supports StretchBit function	No
Supports the StretchDIBits function	No
Text Capabilities	
Character output precision	No
Stroke output precision	No
Stroke clip precision	No
90-degree character rotation	No
Any character rotation	No
Can scale independently in the x- and y-directions	No
Capable of doubled character for scaling	No
Uses Integer multiples only for character scaling	No
Uses any multiples for exact character scaling	No
Can draw double-weight characters	No
Can italicize	No
Can underline	No
Can draw strikeouts	No
Can draw raster fonts	No
Can draw vector fonts	No
Cannot scroll using a bit-block transfer	No
Shading and Blending Capabilities	
Supports Shading and Blending	Yes
Handles SourceConstantAlpha in AlphaBlend function	No
Can GradientFill rectangles	No
Can GradientFill triangles	No
Can handle per-pixel alpha in AlphaBlend	No
Can handle premultiplied alpha in AlphaBlend	No
Color Management Capabilities	
Supports Color Management	Yes
Can accept CMYK color space ICC color profile	No
Can perform ICM on either the device driver or the device itself	No
Supports GetDeviceGammaRamp and SetDeviceGammaRamp	No

S3 Trio Configuration

Display Adapters

This module contains information about display adapters that are currently installed in your computer.

Adapters: S3 Trio32/64

General Information

Device Name	S3 Trio32/64
Device ID	\\.\DISPLAY1
BIOS Date	04/01/96
BIOS Version	S3 86C765 video
BIOS. Version 1.01-05A	

Display Settings

Color Depth	0 Bits
Maximum Color	~
Vertical Resolution	0 Pixels
Horizontal Resolution	0 Pixels
Pixel Diagonal	0 Pixels
Pixel Height	0 Pixels
Pixel width	0 Pixels
Technology	Vector Plotter
Pixels Per Inch Width	0 ppi
Pixels Per Inch Height	0 ppi
Number of Color Planes	0
Number of Device-Specific Brushes	0
Number of Device-Specific Pens	0
Number of Device-Specific Fonts	0
Entries in Device Color Table	0
Relative Width of Device Pixel Used for Line Drawing	0
Relative Height of Device Pixel Used for Line Drawing	0
Diagonal Width of Device Pixel Used for Line Drawing	0
Preferred Horizontal Drawing Alignment (Accelerated)	Any Alignment

State Flags

Primary Display	No
Removable Display	No
VGA Compatible	Yes
Part of The Desktop	No
Pseudo Device	No
Has More Display Modes	No
Multi Driver	No
Remote Display	No
Connected	Yes

Clip Capabilities

Supports clipping rectangle	No
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Curve Capabilities

Supports curves	Yes
Can draw circles	No
Can draw pie wedges	No
Can draw chord arcs	No
Can draw ellipses	No
Can draw interiors	No
Can draw wide borders	No
Can draw styled borders	No
Can draw wide and styled borders	No
Can draw rounded rectangles	No

Line Capabilities

Supports lines	Yes
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Can draw a polyline	No
Can draw a marker	No
Can draw multiple markers	No
Can draw interiors	No
Can draw styled lines	No
Can draw wide lines	No
Can draw wide and styled lines	No
Polygon Capabilities	
Supports polygons	Yes
Can draw alternate-fill polygons	No
Can draw rectangles	No
Can draw a single scanline	No
Can draw interiors	No
Can draw styled borders	No
Can draw wide borders	No
Can draw wide and styled borders	No
Can draw winding-fill polygons	No
Raster Capabilities	
Requires banding support	No
Capable of transferring bitmaps	No
Supports bitmaps larger than 64K	No
Supports SetDIBits and GetDIBits functions	No
Supports SetDIBitsToDevice function	No
Capable of performing flood fills	No
Supports 16-bit windows 2.0 features	No
Specifies a palette-based device	No
Capable of scaling	No
Supports StretchBlt function	No
Supports the StretchDIBits function	No
Text Capabilities	
Character output precision	No
Stroke output precision	No
Stroke clip precision	No
90-degree character rotation	No
Any character rotation	No
Can scale independently in the x- and y-directions	No
Capable of doubled character for scaling	No
Uses Integer multiples only for character scaling	No
Uses any multiples for exact character scaling	No
Can draw double-weight characters	No
Can italicize	No
Can underline	No
Can draw strikeouts	No
Can draw raster fonts	No
Can draw vector fonts	No
Cannot scroll using a bit-block transfer	No
Shading and Blending Capabilities	
Supports Shading and Blending	Yes
Handles SourceConstantAlpha in AlphaBlend function	No
Can GradientFill rectangles	No
Can GradientFill triangles	No
Can handle per-pixel alpha in AlphaBlend	No
Can handle premultiplied alpha in AlphaBlend	No
Color Management Capabilities	
Supports Color Management	Yes
Can accept CMYK color space ICC color profile	No
Can perform ICM on either the device driver or the device itself	No
Supports GetDeviceGammaRamp and SetDeviceGammaRamp	No

Trident Configuration

Display Adapters

This module contains information about display adapters that are currently installed in your computer.

Adapters: Trident Video Accelerator 96XX/938X

General Information

Device Name	Trident Video
Accelerator 96xx/938X	
Device ID	\\.\DISPLAY1
BIOS Date	02/13/96

Display Settings

Color Depth	16 Bits
Maximum Color	65,536 Colors
Vertical Resolution	600 Pixels
Horizontal Resolution	800 Pixels
Pixel Diagonal	51 Pixels
Pixel Height	36 Pixels
Pixel width	36 Pixels
Technology	Raster Display
Vertical Refresh	60 Hz
Pixels Per Inch Width	96 ppi
Pixels Per Inch Height	96 ppi
Number of Color Planes	1
Number of Device-Specific Fonts	0
Relative width of Device Pixel Used for Line Drawing	36
Relative Height of Device Pixel Used for Line Drawing	36
Diagonal width of Device Pixel Used for Line Drawing	51
Prefered Horizontal Drawing Alignment (Accelerated)	Any Alignment

State Flags

Primary Display	No
Removable Display	No
VGA Compatible	Yes
Part of The Desktop	Yes
Pseudo Device	No
Has More Display Modes	No
Multi Driver	No
Remote Display	No
Connected	Yes

Clip Capabilities

Supports clipping rectangle	Yes
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Curve Capabilities

Supports curves	Yes
Can draw circles	Yes
Can draw pie wedges	Yes
Can draw chord arcs	Yes
Can draw ellipses	Yes
Can draw interiors	Yes
Can draw wide borders	Yes
Can draw styled borders	Yes
Can draw wide and styled borders	Yes
Can draw rounded rectangles	Yes

Line Capabilities

Supports lines	Yes
Can draw a polyline	Yes
Can draw a marker	Yes
Can draw multiple markers	Yes

Can draw interiors	Yes
Can draw styled lines	Yes
Can draw wide lines	Yes
Can draw wide and styled lines	Yes
Polygon Capabilities	
Supports polygons	Yes
Can draw alternate-fill polygons	Yes
Can draw rectangles	Yes
Can draw a single scanline	Yes
Can draw interiors	Yes
Can draw styled borders	Yes
Can draw wide borders	Yes
Can draw wide and styled borders	Yes
Can draw winding-fill polygons	Yes
Raster Capabilities	
Requires banding support	No
Capable of transferring bitmaps	Yes
Supports bitmaps larger than 64K	Yes
Supports SetDIBits and GetDIBits functions	Yes
Supports SetDIBitsToDevice function	Yes
Capable of performing flood fills	Yes
Supports 16-bit windows 2.0 features	Yes
Specifies a palette-based device	No
Capable of scaling	No
Supports StretchBit function	Yes
Supports the StretchDIBits function	Yes
Text Capabilities	
Character output precision	No
Stroke output precision	No
Stroke clip precision	No
90-degree character rotation	No
Any character rotation	No
Can scale independently in the x- and y-directions	No
Capable of doubled character for scaling	No
Uses Integer multiples only for character scaling	No
Uses any multiples for exact character scaling	No
Can draw double-weight characters	No
Can italicize	No
Can underline	Yes
Can draw strikeouts	Yes
Can draw raster fonts	Yes
Can draw vector fonts	Yes
Cannot scroll using a bit-block transfer	No
Shading and Blending Capabilities	
Supports Shading and Blending	Yes
Handles SourceConstantAlpha in AlphaBlend function	No
Can GradientFill rectangles	No
Can GradientFill triangles	No
Can handle per-pixel alpha in AlphaBlend	No
Can handle premultiplied alpha in AlphaBlend	No
Color Management Capabilities	
Supports Color Management	Yes
Can accept CMYK color space ICC color profile	No
Can perform ICM on either the device driver or the device itself	No
Supports GetDeviceGammaRamp and SetDeviceGammaRamp	No