Introduction to PureVideo Technology

Today's consumers want fluid, crystal-clear digital video, whether they are using a PC, or consumer electronics (CE) device. They also demand better than DVD-quality television recording and playback on their high-definition monitors and televisions.

In today's market, CE video players use expensive video processors to perform effects like progressive scan de-interlacing, inverse 3:2 & 2:2 pull-down correction, and video scaling. PC-based video quality is often viewed as a compromise because of the limited processing capabilities of the CPU. The NVIDIA GeForce 6 and 7 Series GPUs with PureVideo™ technology changed the rules by adding the video processing horsepower needed to overcome the PC video compromise and provide crisp, clear, stutter-free, vibrant high definition video that rivals the finest high-end home theater systems today.

PureVideo technology lets you experience astonishing, lifelike HD-DVD playback on your PC with dedicated hardware acceleration for current and future HD standards. A combination of a hardware video processor and video decode software, PureVideo technology delivers stunning video to any display by supercharging your PC's video capabilities with high-definition video in all formats. The result is superb picture clarity, and precise, vivid colors on any display.

New PureVideo Features

With the introduction of the NVIDIA® GeForce™ 7800 GTX GPU, Release 75 ForceWare drivers and the new NVIDIA PureVideo Decoder v1.01, PureVideo features now include:

- High-Definition Spatial-Temporal De-Interlacing (GeForce 7800GTX only)
- Seamless playback of high-definition ATSC and DVB MPEG-2 transport streams files
- 2:2 Pull-down Correction

System Configuration

In order to experience PureVideo technology, NVIDIA encourages you to conduct competitive, side-by-side tests. It is **highly recommended** that you assemble two identical systems using same-class GPUs, as well as the DVD/MPEG-2 decoders provided by each graphics card manufacturer.

Recommended System Configurations

	NVIDIA	**Competitive**
CPU	Intel Pentium 4 3.0 GHz or higher	Intel Pentium 4 3.0 GHz or higher
Motherboard/chipset	Intel i915	Intel i915
RAM	512 MB or higher	512 MB or higher
DVD Drive	Yes	Yes
Operating System	Windows XP SP2	Windows XP SP2
DirectX	9.0c	9.0c
Application	Windows Media Player 10	Windows Media Player 10
Graphics Processor	GeForce 7800 GTX PCI-E	ATI Radeon X850 PCI-E
Graphics Driver	ForceWare™ 77.62	Catalyst 5.5
MPEG-2 Decoder	NVIDIA PureVideo Decoder 1.01.127	ATI MMC Player 9
Monitor	CRT running at 60 or 70 Hz	CRT running at 60 or 70 Hz
Multi-Display Mode	Single monitor mode	Single monitor mode

NOTE: NVIDIA recommends using a CRT monitor because it is the best way to isolate and analyze video quality artifacts rather than display artifacts found on different display monitors. For example, digital flat panels can introduce artifacts during video playback, including:

- Aspect ratio conversion
- Frame rate conversion
- Unpredictable pixel artifacts

Configuring Windows Media Player 10

Windows Media® Player 10 is designed to operate using the complete video mixing renderer path for image processing and display, or it can use video mixing renderer for display decode and overlay for video post processing. PureVideo's dedicated video processors and advanced video processing algorithms accelerate and enhance both legacy overlay applications and new video mixing renderer applications like Windows® XP Media Center Edition.

For this review, NVIDIA recommends the use of Windows Media Player since it is a popular media player that is freely available to all users worldwide. Windows Media Player allows users to toggle between hardware overlay mode and video mixing renderer (VMR) mode. Users can switch between each mode from Windows Media Player Video Acceleration Settings.

For this review, it is recommended you use overlay mode to see the full benefit of PureVideo technology. It is not recommended that you use VMR because of the following issues with Windows Media Player 10 VMR implementation:

- VMR does not support 2D BLITS on VSync which can cause text to shimmer during video playback on all GPUs.
- Using a 60 Hz monitor with 1080i MPEG-2 content can cause frames to drop incorrectly and the result is stutter

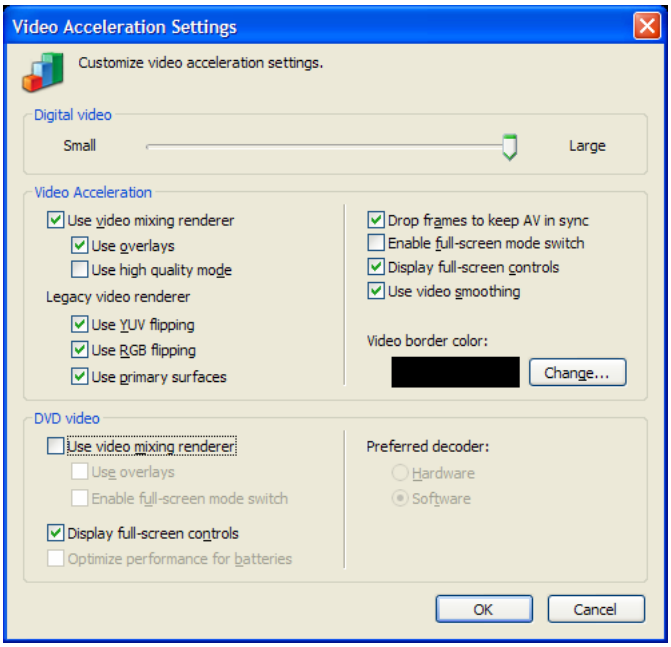

Figure 1 Windows Media Player Video Acceleration Settings

To set up Windows Media Player 10 for **hardware overlay** mode, follow these steps:

- Click on "**Tools**" > "**Options**" on the menu bar
- Click on the "**Performance**" tab

- Click on the "**Advanced"** button
- Under the "**Video Acceleration**" section check "**Use video mixing renderer**" and "**Use overlays**"
- Under the "**DVD video**" section an uncheck "**Use the video mixing renderer**" and "U**se overlays**" This is the equivalent settings to force the rendering path to be the same as the Video Acceleration section, in overlay mode.
- Make sure "**Enable full-screen mode switch**" is turned off. This will ensure that when you fullscreen the application all of the filtering and scaling accelerated in PureVideo are not affected by changing the display resolution
- After adjusting the Performance settings make sure the Repeat mode is turned on under "**Play"** > "**Repeat"**.

NOTE: There is a known issue with Windows Media Player 10 that when you queue up many clips to play in a playlist or every few seconds, every second clip will revert from overlay mode to VMR7 mode and will not do de-interlacing. This will result in bad quality video playback. It is recommended that you only queue up a single clip at a time in order to keep the video in overlay mode.

Configuring NVIDIA PureVideo Decoder

The NVIDIA PureVideo Decoder can be configured from Windows Media Player once an MPEG-2 or DVD file has been started. Once playback has started, check the Windows taskbar for a new NVIDIA icon that has the name "NVIDIA Decoders" (Figure 2). Right mouse click on that icon and select "**Decoder Properties**". That will launch the NVIDIA PureVideo Decoder Properties (Figure 3).

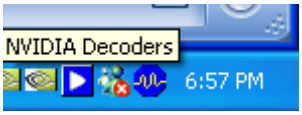

Figure 2 NVIDIA PureVideo Decoders taskbar icon

When playing an MPEG-2 file, there are two property pages: Video and Color. When playing a DVD movie there are four property pages: Video, Color, Audio, and Karaoke.

Please note that some settings in the PureVideo Decoder Properties are not compatible with Windows Media Player or Windows Media Center. These settings are: **Display Type**, **TV Overscan Correction**, and **Enhanced nView Support**. All of the other settings can be used to adjust the decoder or provide more information on the video clip.

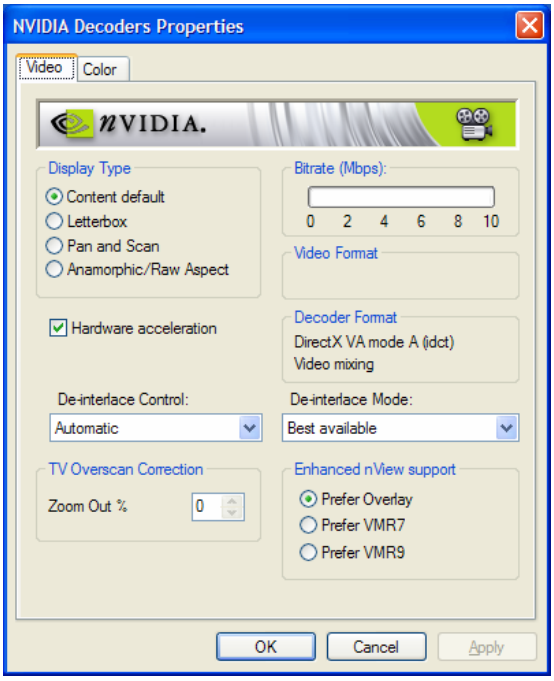

Figure 3 NVIDIA PureVideo Decoder Properties

Generating Screenshots

For overlay mode it is recommended that you use a dedicated workstation capture card to acquire all screenshots. All screenshots in this document were generated using a high end workstation with 2 GB of memory and a RAID 0 using a Unigraf UFG-03-HD capture card. This card can capture the output of a DVI connector directly into uncompressed video for offline analysis and for generating screenshots. Make sure you capture all movies and/or pictures in an uncompressed format that is in the same color space as the DVI is outputting, such as AVI for video and BMP for pictures.

If you choose to run in VMR mode, screenshots can be captured by pressing the "PrtScrn" button to capture the entire Windows Desktop and pasting that into Microsoft Paint. If you wish to capture only a single application window, you can use "Alt-PrtScrn" to capture only the active window.

Measuring CPU Utilization

To measure the benefits of offloading video processing from the CPU onto a GPU, you must use a performance analyzer tool that allows you to measure utilization over time. For most users, the Windows Taskbar Manager Performance tab will give you accurate results at any given point in time. However, to perform accurate reviews, you need to track and save the total CPU utilization for each instance in time and graph it later on. For doing any advanced CPU utilization savings graph, NVIDIA recommends using the Windows XP Performance Monitor.

Setting up Performance Monitor

1. Click on **start**, **run**, and type **perfmon.msc**: this will start the Windows XP Performance Monitor (perfmon)
2. Under "**Performance Logs and Alerts**", click on **Counter Logs**.
3. Right click on the right window and choose "**New Log Settings**", entering a name of **"CPU Utilization"**. (pressing "**OK"** brings up the properties of our new counter log)
4. **"General"** tab: Click the "**Add Counters…**" button, on the left choose **"% Processor Time"**, and on the right choose **"_Total"**, click the "**Add**" button to add the counter and click "**Close"** to close the dialogue box. Next, set the "**Sample data every**" "**Interval**" to "**1**" second.
5. "**Log Files"** tab: Choose "**Text File (comma delimited)**" for the "**Log file type**", and then click the "**Configure…**" button, set your log file save location and press "**OK**".
6. "**Schedule**" tab: Choose "**Start log**" "**Manually (using the shortcut menu)**", and then "**Apply**" and "**OK**" to close the dialogue.

Using the Counter Log

With your "**CPU Utilization Counter**" selected ("**Performance Logs and Alerts**" > "**Counter Logs**" > "**CPU Utilization**"), you can now use the "**Play**" and "**Stop**" button in Performance Monitor to start and stop logging of CPU Utilization. The output file is a .CSV file, native to excel. With Microsoft Excel you can produce performance graphs, which makes it very simple to analyze the information you need.

General Usage

1. Make sure your video playback application is running, and the video file (if applicable) is loaded (run part of the video for one complete cycle).
2. Delete any old CPU utilization log files
3. Start Performance Monitor and your CPU Utilization Counter, waiting for the CPU Utilization to normalize (should be zero or very close to zero)
4. Start your video playback application.
5. At the same time, stop your video application and stop your CPU Utilization Counter (perfmon). You'll now have a .csv file logged to your location called **'CPU Utilization_000001.csv'** with the per second log data.

Testing PureVideo Features

All features below were tested using PCI-Express based graphics cards using the system configuration in the above section.

> **NOTE**: The pictures captured below are used to demonstrate video quality but are still only single frames captured. The best way to compare is with two identical PC systems, set up side-by-side, with the same video playing back on the same loop.

Spatial-Temporal De-Interlacing

Explanation

Content that comes over satellite, cable, and from DVD is interlaced data, targeted for TVs, that uses two pictures to provide full picture detail. Since the pictures are taken at different times and then are weaved (interlaced) together, feathering can appear along the moving edges. Many consumer progressive scan TVs and most PCs demonstrate this bothersome feathering video glitch. PureVideo technology uses the PC industry's most advanced algorithm to remove motion artifacts and maintain full image detail providing a smooth video.

Recommended Content

- Test clip "**\Test_Videos\De-Interlacing\pendulum_BW.mpg**" (additional pendulum clips are included in that directory to offer more testing)
- Test clip "**\Test_Videos\De-Interlacing\a14b_HM_Text_Symbols.mpg**" to test horizontal de-interlacing
- Test clip "**\Test_Videos\De-Interlacing\a15_VM-textNicons.mpg**" to test vertical de-interlacing.
- Reference DVD "**Video Essentials**" – Banned From the Ranch Entertainment (UPC # 47715-0711-2). Browse to **Title 19** > **Chapter 1**. At There are a few sections of this chapter that provide good de-interlacing test materials. Those points are
  - 1 min 15 secs with the bridge. Notice the cables in the bridge as the camera pans
  - 2 mins 13 secs with the buildings. Notice that there are good vertical and horizontal sections to look at.
  - 2 mins 46 secs with the American flag. This picture shows high contrast of colors between the colors on red and white on the flag will show the de-interlacing quality of GPUs

- Any MGM DVD's opening sequence with the lion. As the content comes in, there will usually be some horizontal corruption patterns.

How to Test

To test spatial-temporal de-interlacing on NVIDIA PureVideo GPUs you must first set the "**De-interlace Control**" to "**Smart**" mode and the "**De-interlace Mode**" to "**Best available**". It is the default setting, but if you have changed it, follow the instructions under "**Configuring PureVideo DVD Decoder"** to make this change. Now load the one of the recommended content and press play. The screenshots below were created using the file "**\Test_Videos\De-Interlacing\pendulum_BW.mpg**".

Comparison (and what to look for)

In this video you will notice "jaggies" and bad quality video:

- At perfect horizontal or vertical areas you should see no jaggies or artifacts on the pendulum arm (Figures 4 and 5)
- The ball should appear to be rounded and not have jaggies or stairstep artifacts (Figures 4 and 5)
- As the arm of the pendulum as it reaches its height or any non-vertical angle you will see the typical stair step artifact that is common with 3D aliasing. This effect is a symptom of bad video quality and bad de-interlacing. (Figures 6 and 7)

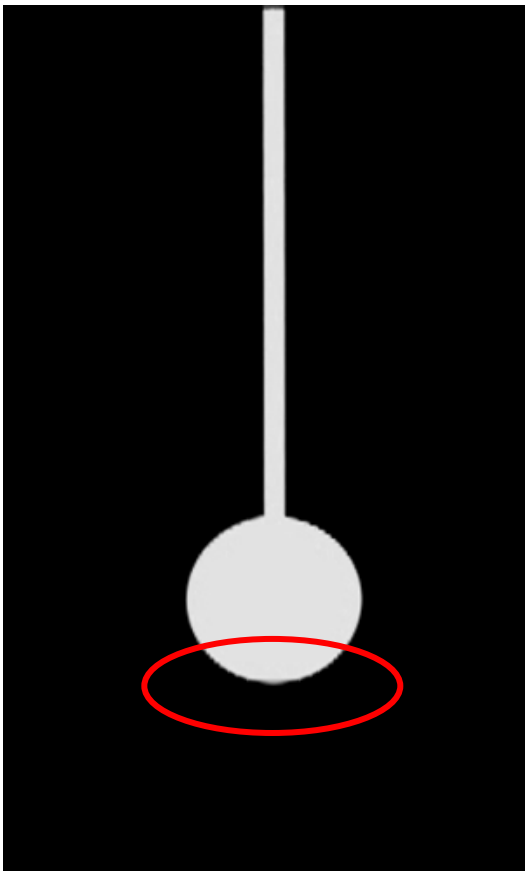

Figure 4 NVIDIA De-interlacing

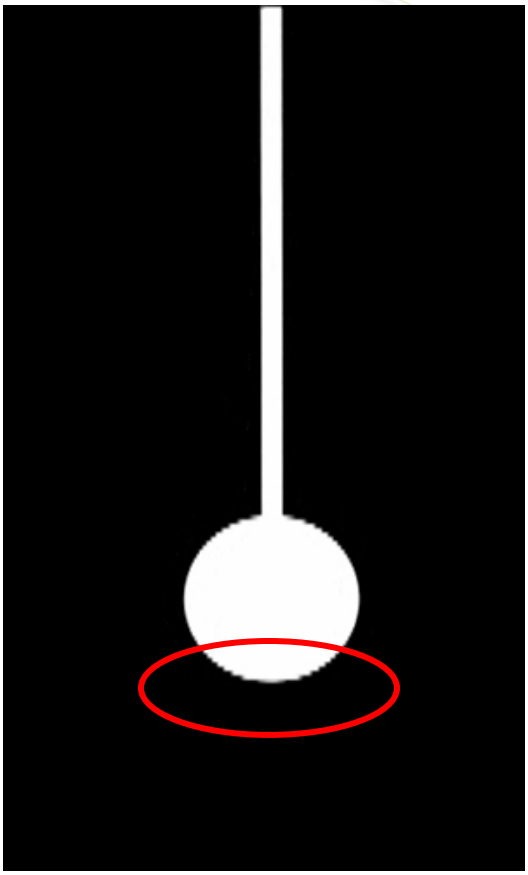

Figure 5 ATI De-interlacing

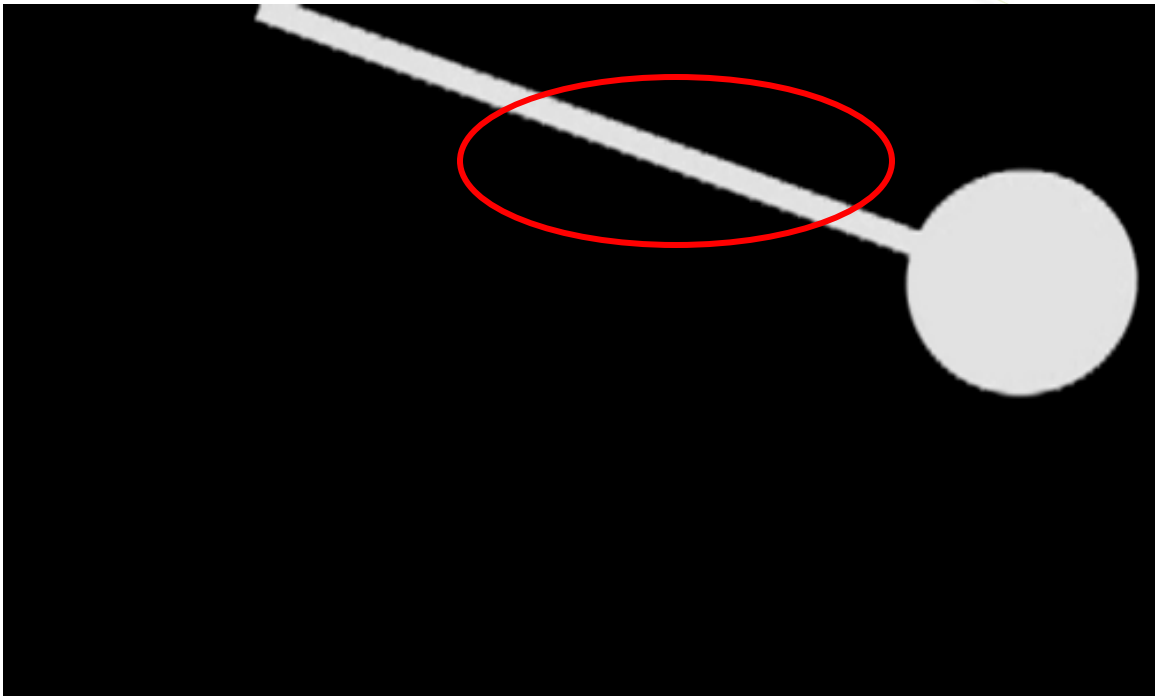

Figure 6 NVIDIA De-interlacing

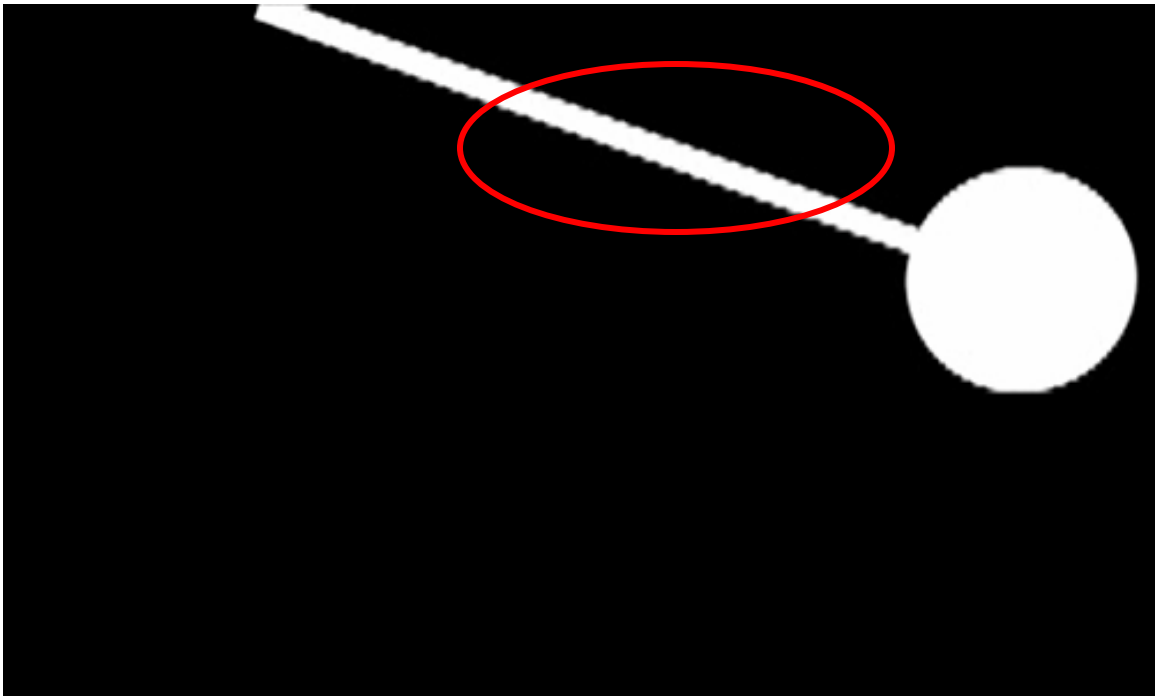

Figure 7 ATI De-interlacing

Inverse Telecine (Inverse 3:2 and 2:2 pulldown)

Explanation

Most high-quality content starts out as film that is shot at 24 frames per second. When it is broadcast as TV programs or saved on DVD it is converted to 30 frames per second to conform to broadcast standards. This conversion process is called telecine (3:2 or 2:2 pull-down). Since the additional frames are simply made up from fields in the original content when converting back to progress frames, this simple conversion can yield images that are blurry. NVIDIA PureVideo technology recovers the original film content to show a clear picture frame after frame and provides hardware acceleration on GeForce 6 and 7 Series GPUs in a process called inverse telecine (inverse 3:2 or 2:2 pulldown correction).

Recommended Content

- Test clip "**\Test_Videos\Inverse Telecine\Inverse_telecine.mpg**"
- **Digital Video Essentials** – A Joe Kane Production. **Program Menu** > **Program Guide** > **Reference Materials** > **Motion Patters 1.78:1** and then browse to **Chapter 5**.
- **Galaxy Quest (widescreen)** – DreamWorks (UPC # 6706-86017-2). Animated root menu of the DVD is badly encoded as well as the theatrical trailer Grooves chrome of the car
- **Looney Tunes Golden Collection Vol 2 (4 disk set)** – Warner Bros – (ISBN 0-7907-8650-8). **Disk 4 chapters 4 and 5** are completely encoded wrong as interlaced video with progressive_frame flag set to true. To compare and see what non GeForce 6 or 7 series GPUs produce, watch the same clip using the de-interlacing set to "automatic" mode

How to Test

To test inverse telecine on NVIDIA PureVideo GPUs you must first make sure the "**De-interlace Control**" is set to "**Smart**" mode and the "**De-interlace Mode**" to "**Best available**". Follow the instructions under "**Configuring PureVideo DVD Decoder"** to access the decoder properties and verify these settings. Now load one of the recommended content and press play.

The screenshots below were created using the "**\Test_Videos\Inverse Telecine\Inverse_telecine.mpg**" and the DVD "**Digital Video Essentials**".

Comparison

In this clip you will notice "jaggies" in certain areas of the screen as the trolley moves across the screen at the following locations (Figures 8 and 9):

- At the edge of the tracks on the ground
- Top of the trolley against the background of the city

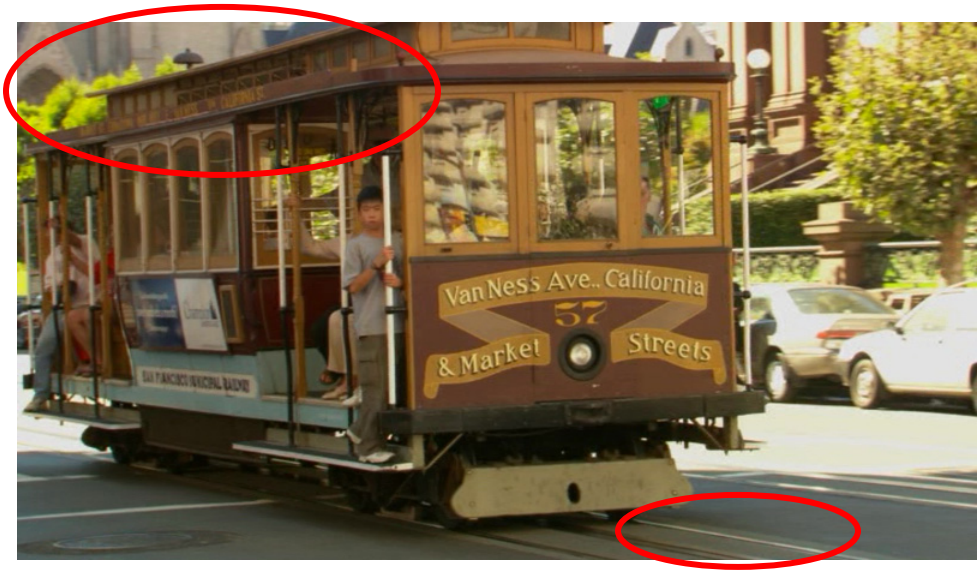

Figure 8 NVIDIA PureVideo Inverse Telecine

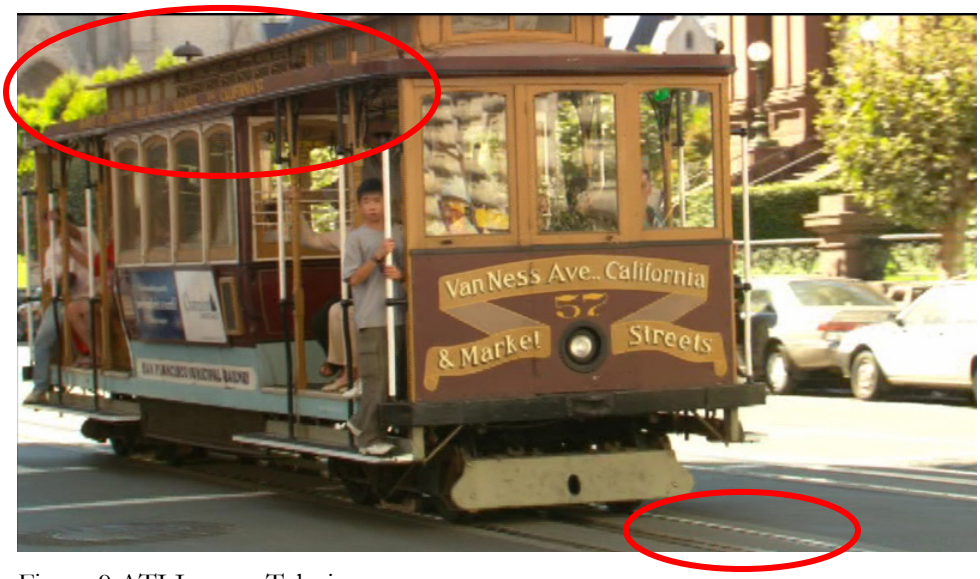

Figure 9 ATI Inverse Telecine

Another recorded content for showing inverse telecine is on the reference DVD "Digital Video Essentials". Once that DVD is in browse to Program Menu > Program Guide > Reference Materials > Motion Patters 1.78:1 and then browse to Chapter 5. Make sure you have configured Windows Media Player to playback in slow mode so you can see the artifacts. That setting is under Play > Play Speed > Slow.

As the radar pattern sweeps clockwise, correctly detecting and fixing the inverse telecine will display smoothly on screen as seen in Figure 10. Not detecting the inverse telecine will result in the color gradient being out of sequence as seen in the Figure 11.

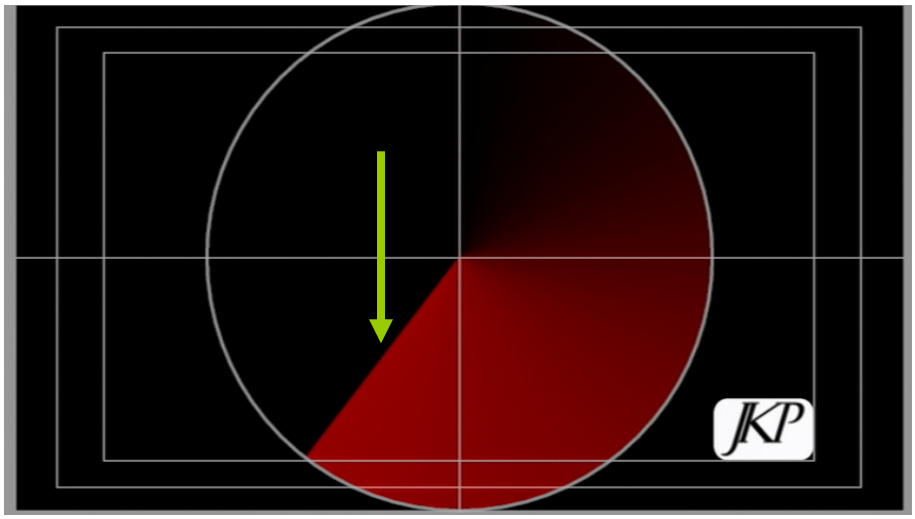

Figure 10 NVIDIA Purevideo De-interlacing

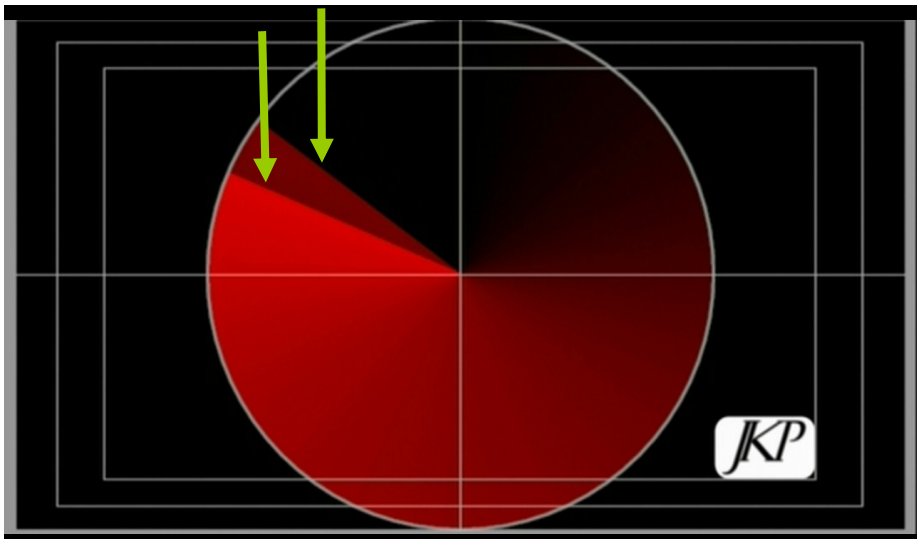

Figure 11 ATI De-interlacing

Bad Edit Detection (3:2 & 2:2 Correction)

Definition

A further problem with video in 3:2 and 2:2 pull-down format is that post-conversion video editing can disrupt the normal 3:2 and 2:2 cadence. Basic inverse telecine solutions do not affect the deviation form. The resulting fields are used out of order so that every video frame displayed has jagged edge artifacts. NVIDIA PureVideo technology uses advanced processing to overcome the disrupted field sequence to display perfect picture detail frame after frame for smooth, natural looking video.

Recommended Content

- Test clip "**\Test_Videos\Bad Edit\3_2_Bad_Edit.mpg**"
- **Friends Season Finale** – Time Warner. Around the 24 minute Joey and Ross are playing foosball. You will notice as the camera pans down the foosball table appears to shimmer.
- **Titanic (Wide Screen)** – Paramount (ISBN 0-7921-5743-5). At the end of chapter 8 going into chapter 9 (00:47:23) watch the railing on the top deck of the ship. This is a typical chapter break scenario where our Inverse 3:2 kicks in and helps minimize the bad edit to a very small flicker. In normal "**automatic**" flag based mode this is a bad flicker that lasts much longer.
- **The Cable Guy** – Columbia Pictures (ISBN 0-8001-4168-7) Side B (Standard). During the medieval fight scene there is a bad edit at 00:38:26.
- **Léon (PAL DVD)** – During the shooting practice scene at 00:49:55.

How to Test

To test bad edit correction on NVIDIA PureVideo GPUs you must make sure the "**De-interlace Control**" is set to "**Smart**" and the "**De-interlace Mode**" is set to "**Best available**". Follow the instructions under "**Configuring PureVideo DVD Decoder"** to access the decoder properties and verify these options.

Now load one of the recommended content and press play. The screenshots below were created using the "**\Test_Videos\Bad Edit\3_2_Bad_edit.mpg**" on each machine and click play.

Comparison (and what to look for)

In this video you will notice "jaggies" as the camera moves past the fire engine (Figures 12 and 13):

- Grooves in the chrome of the car
- Ring around the car's front light
- Windshield wipers

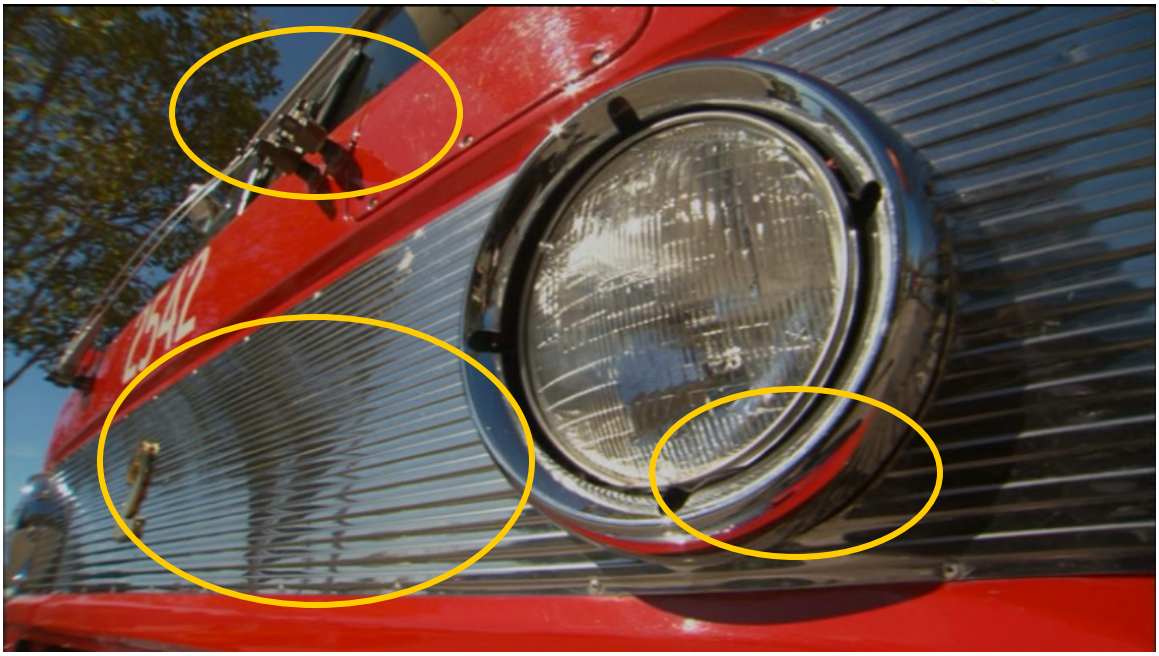

Figure 12 NVIDIA PureVideo Bad Edit Correction

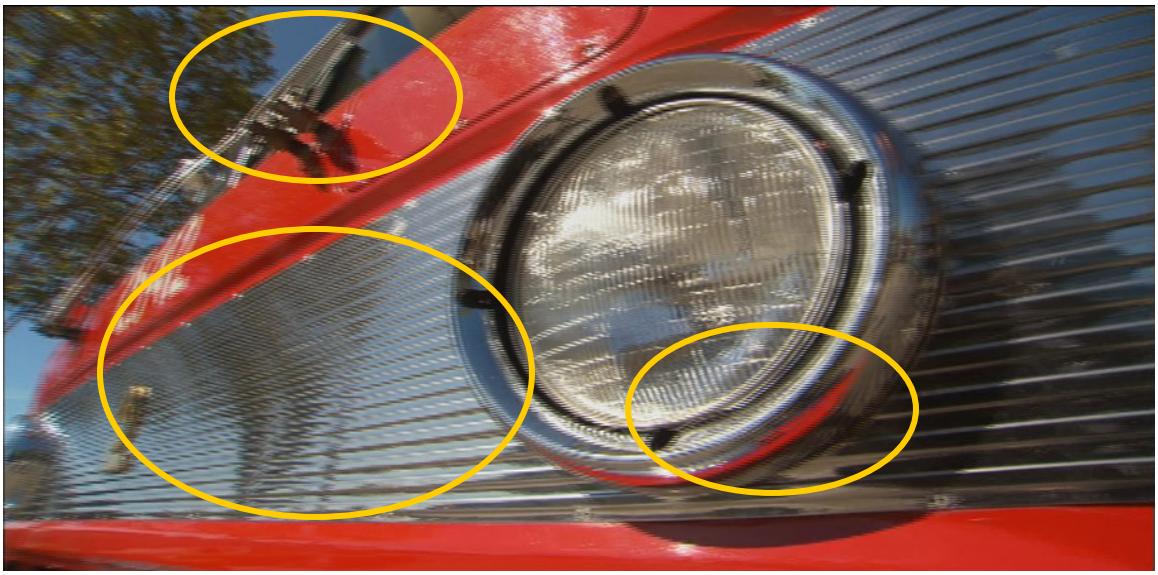

Figure 14 ATI Competitive Bad Edit Correction

Windows Media Video 9 Acceleration

Explanation

Microsoft's Windows Media Video 9 (WMV9) HD format was recently accepted by the SMPTE HD-DVD consortium as a new HD format. Windows Movie Maker software comes bundled with Windows XP to make it easy for consumers to edit and save their favorite videos. These videos are saved in the .WMV format. NVIDIA GeForce 6 and 7 Series GPUs are the first families of GPUs to include dedicated hardware to accelerate playback of WMV and WMV-HD content for fluid full frame rate video even on systems with entry-level CPUs. Previous generations of NVIDIA GPUs were not able to support WMV9 decode acceleration and often times HD WMV9 content would drop frames.

How to Test

The default install of Windows Media Player 10 does not support DXVA decode acceleration of WMV9 content. Windows Media Center Edition 2005 does have acceleration for WMV9, but there is not a switch (on/off) to measure the performance advantage offered by NVIDIA GPUs.

Part 1 No Graphics Processor Acceleration

Download WMV HD content from:

http://www.nzone.com/object/nzone_hdcontent_home.html

Open a WMV HD file with Windows Media Player and maximize the window. Let the video run through one complete cycle before you begin to record CPU Usage data. Save and analyze your log data file in Excel and product graphs showing the CPU chart over time.

Part 2 Graphics Processor DXVA Acceleration

After you have completed Part 1, you must enable GPU acceleration of WMV9 through DXVA by installing the following updates for Windows Media Player 10 from Microsoft:

http://www.support.microsoft.com/kb/891122/

http://www.support.microsoft.com/default.aspx?scid=kb;en-us;888656

Now open the same video file and follow the exact instructions above to measure CPU utilization and the savings that PureVideo technology delivers for WMV9 decode acceleration.

Comparison (and what to look for)

The CPU utilization data should show a higher CPU utilization with a graphics processor that does not accelerate WMV9 through DXVA. High definition WMV9 files ensure that you saturate the graphics processor to its limit.

Windows Media Player 10 also has additional tools that let you view the number of frames that are dropped during video playback of WMV9 files only. This is an additional tool that you can used to determine the bitrate of the content, what the framerate of the encoded content is and what the actual framerate is after the frames are dropped (Figure. 15). This tool can be access under **View** > **Statistics** > **Advanced**. You can use this tool to see if the GPU is not providing acceleration for WMV9 decode.

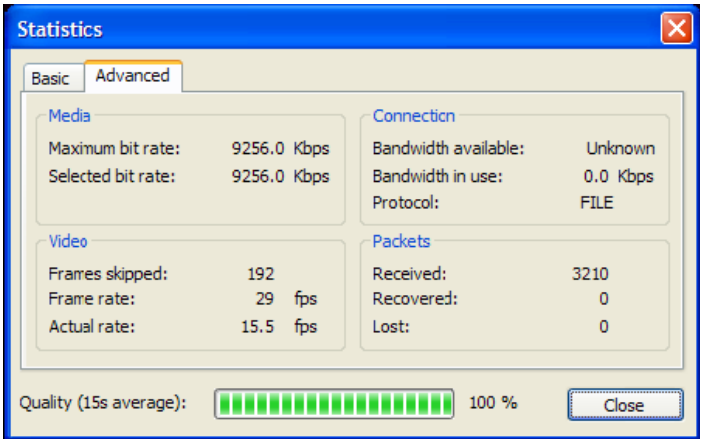

Figure 15 Windows Media Player 10 Statistics

Appendix

Advanced Windows Media Player 10 Settings

The following describes how to switch between overlay and VMR, and discusses some of the major settings on the Video Acceleration Settings.

Video Acceleration (applies to all video files played off the hard disk)

Video mixing renderer (VMR)

This check will toggle non advanced BLIT mode. There is no post processing that will happen to any video playback except for scaling. Functionally it is the same to only check this box and not checking it at all. It is recommended that you check this box in order to access the settings underneath it.

Use overlays

This uses the hardware overlay for post processing and display. However, the VMR interface is still used for flipping. This is the recommended setting to use for these tests.

Use high quality mode

This uses the high quality VMR BLIT (DI BLIT X) to do de-interlacing and other advanced post processing features. This mode will showcase NVIDIA's high quality VMR pipeline when all of the issues from Microsoft are resolved with playback. It is not recommended at this time to toggle this mode.

Legacy video renderer

These settings affect how to playback video when using the hardware overlay mode. It is recommended that you leave all checkboxes enabled for optimal playback.

DVD video (applies to DVD videos played from disc)

For DVD playback, Microsoft's control panels for Windows Media Player have many functionality bugs in it. Therefore it is necessary to explain each setting.

Use video mixing renderer (VMR)

Although the control panel is labeled VMR, this check will toggle hardware overlay mode advanced BLIT post processing including de-interlacing and scaling. It will not use the VMR path for post processing. It is recommended that you only check this box.

Use overlays

There is currently a Windows Media Player bug that even if you check the box to enable this feature, Windows Media Player still uses VMR high quality mode and is subject to the limitations of Windows Media Player listed above.

Enable Full screen mode switch

This setting will change the desktop resolution to the target resolution of the DVD. It is not recommended that you toggle this feature in order to see the benefit of scaling in resolution higher than DVD (720x480).

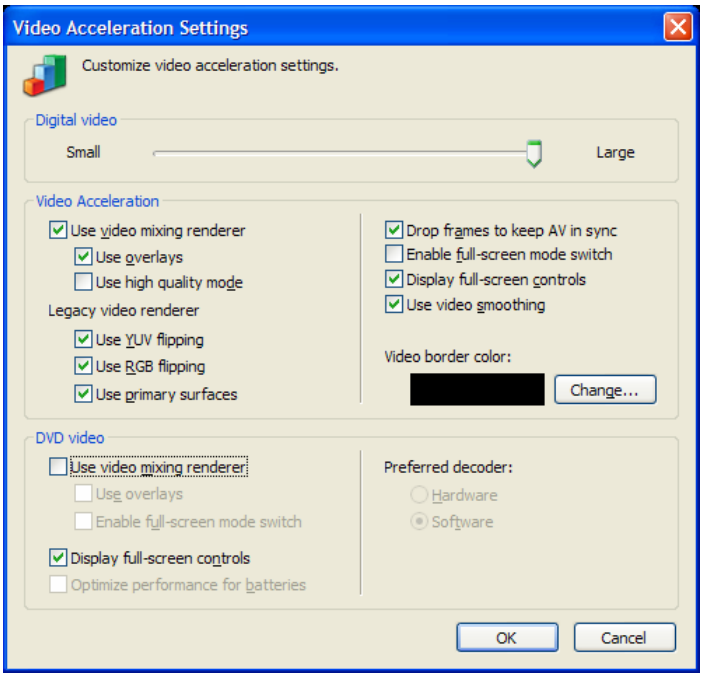

Figure 16 Windows Media Player Video Acceleration Settings

NOTE: There is a known issue with NVIDIA drivers when using video mixing renderer mode for display and post processing effects that turns off scaling of video when you re-size it in the application. NVIDIA is working to fix this driver issue and will keep you apprised of any driver updates.

NVIDIA PureVideo Decoder Properties

The following describes the Video Properties pages of the NVIDIA PureVideo Decoder.

Bitrate (Mbps)

Displays the bitrate of MPEG-2 or DVD videos that are currently playing. For most DVDs the bitrate is between 3 and 8 Mbps.

Hardware Acceleration

Toggling this checkbox will enable or disable MPEG-2 DXVA hardware acceleration on graphics processors.

Decoder Format

This section lists two pieces of information about video files currently being decoded.

The first line indicates the level of MPEG-2 DXVA acceleration offered by a graphics processor when "Hardware Acceleration" is checked. The second line indicates the rendering path used to display the video that is playing back.

De-Interlace Control

Automatic - NVIDIA PureVideo Decoder reads the source type and automatically selects video or film mode, depending on the source.

Smart (Default) - This option lets the decoder pick the best de-interlacing method to use and is the only technique to do inverse telecine (3:2 pulldown) and bad edit detection.

Film - Forces film mode and does not apply de-interlacing.

Video - Forces video mode and applies de-interlacing. Choose this option if you see combing or feathering artifacts in the video.

De-Interlace Mode

Best Available - (Default) Let the NVIDIA PureVideo Decoder read the source type to see if it is video or film. If it is video, the decoder applies the best de-interlacing method (see descriptions below), based on the graphics capabilities of your system.

Display Fields Separately - This method creates a complete frame from each field. Playback is at field rates (60 Hz). For video that consists of fast movements or panning, this method avoids combing or feathered artifacts, but with some loss of image quality.

Depending on system capabilities, the menu lists the equivalent VMR deinterlacing mode—**VMR Vertical Stretch**.

Combine Fields - This method combines both fields into one frame. Playback is at frame rates (30 Hz). For video that consists of minimal movement, this method provides the best image quality. **Blend Fields** - *Not available on all systems.* This method combines sequential fields with a smoothing filter to generate de-interlaced frames. Playback is at frame rates (30 Hz).

Depending on system capabilities, the menu lists the equivalent VMR deinterlacing mode—**VMR Median Filtering**.

Adaptive - *Not available on all systems.* This method blends the moving sections of the image and combines the non-moving sections. Playback can be at field rate (60 Hz) or frame rate (30 Hz).

Depending on system capabilities, the menu lists the equivalent VMR deinterlacing mode—**VMR Adaptive**.

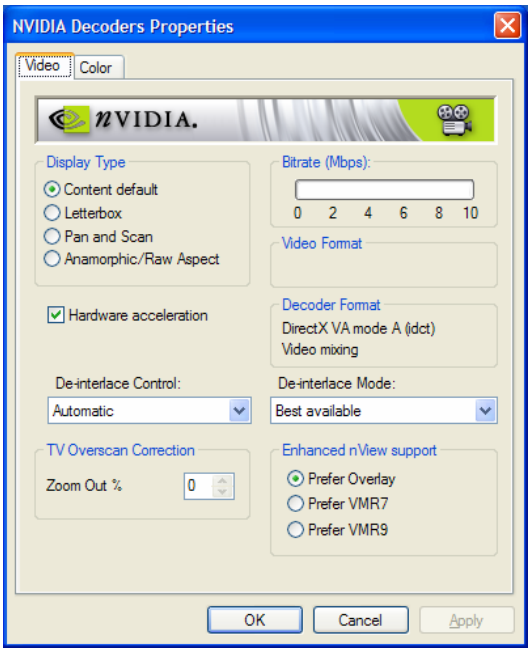

Figure 17 NVIDIA PureVideo Decoder Properties