Technology Brief

NVIDIA High Definition Video Processor brings HDTV to the Masses

Introduction

Few events in the consumer electronics industry have been as highly anticipated as the roll out of digital television. This entertainment milestone has been reached in most major cities. Unfortunately, the biggest entry barrier is the cost of the digital set. Most digital televisions are still in the $4000 to $6000 range, and typically consumers must also purchase a set-top decoder box, costing an additional $1000 to$1500, to receive digital broadcasts. These prices are well above what most consumers will pay for the superior picture and audio quality. This technical brief outlines the digital television technology delivered in the new NVIDIA™ GeForce2 GTS™, and explains how this technology could remove the current obstacles and help bring digital television to the masses.

HDTV Benefits

High-definition television (HDTV) leverages a high-resolution digital television format capable of reproducing a 16:9 aspect ratio and Dolby™ Digital sound. HDTV products can reproduce 720 and 1080 resolutions (progressive and interlace) and receive all 18 possible digital TV broadcast formats. These capabilities results in the clearest picture possible today, with minimal scan lines, less flicker and greater depth of field.

Normal TV – 210,000 pixels

HDTV – 2.1 Million Pixels

NVIDIA High Definition Video Processor Benefits

With NVIDIA's High Definition Video Processor— HDVP —consumers gain cost-effective solutions for viewing HDTV content using an existing PC and a low-cost DTV receiver. The NVIDIA GeForce2 GTS delivers this groundbreaking HDTV and high definition (HD) timeshifting capability while other vendors are still just talking about the possibilities.

DTV and HDTV Details

The tables in this section list the formats specified by the American Television Standards Committee (ATSC), all of which are supported by the NVIDIA HDVP. Included are standard-definition TV (SDTV) modes and the high-definition modes for HDTV.

ATSC FORMATS

Horizontal Size	Vertical Size	Aspect Ratio		60 fps Progressive	30 fps Interlace	30 fps Progressive	24fps Progressive	NVIDIA HDVP
		16:9	4:3					
1920	1080	Yes	No	No	Yes	Yes	Yes	Yes
1280	720	Yes	No	Yes	No	Yes	Yes	Yes
720	480	Yes	Yes	Yes	Yes	Yes	Yes	Yes
640	480	No	Yes	Yes	Yes	Yes	Yes	Yes

Common Abbreviations

i, p	Interlace, Progressive
480i	640x480 Interlace
480p	720x480 Progressive
720p	1280x720 Progressive
1080i	1920x1080 Interlace
1080p	1920x1080 Progressive

TYPICAL USAGE OF THE DIFFERENT FORMATS

Formats	Typical Usage Model
1080i30	High definition live action/sport events
1080p24	High definition film-originated content
720p60	High definition live action/sport events
720p24	High definition film-originated content
480p60	Standard definition live action/sport events
480i30	Standard definition content

16:9 VS 4:3 ASPECT RATIO

HDTV will also introduce different viewing dimensions. Today's television programs are designed to fit TV screens with a width-to-height ratio of about 4:3, which can also be expressed as 16:12. By comparison, HDTV programming will be broadcast in a ratio similar to movie theater screens: 16:9. As a result, broadcast HDTV movies will not have to be reformatted or cropped when transmitted to our homes. Sports viewers will also enjoy the 16:9 format because it will allow an expanded view of the field and action.

DTV DEADLINES FOR BROADCASTERS

Date	Description
5/1/1999	All affiliates of ABC, CBS, NBC and Fox in the top 10 markets must be on the air. About 30% of the TV households (TV HH) in the US are in these markets.
11/1/1999	Affiliates of ABC, CBS, NBC and Fox in the top 30 markets must be on the air (53% of TV HH).
5/1/2002	All other commercial television stations must be on the air (100% of TV HH).
4/1/2003	Stations must transmit at least 50% of their analog channel's programming on the digital channel as well.
5/1/2003	All other noncommercial television stations must be on the air.
4/1/2004	DTV stations must transmit at least 75% of their analog channel's programming.
4/1/2005	DTV stations must transmit 100% of their analog channel's programming.

CURRENT STATUS OF THE MAJOR NETWORKS

Broadcaster	Others	Movie	Target Rollout
ABC	95% of the time will be 480p60	5% will be 720p24 or 720p60	Now
CBS	97% of the time will be 480i	3% will be 1080i	Now
NBC	97% of the time will be 480p60	3% will be 1080i	Now
FOX	100% will be 480p30	Most likely 1080i	
PBS		720p	KQED in San Francisco began broadcasting in HD last year
TCI and other local San Francisco bay area commercial station		720p	Will start 2H/00
DSS		720p and 1080i	DIRECTV started broadcasting in 1999 (HBO and Pay Per View) Hughes Network to start 1080i broadcast in 2H/00

DIGITAL TV CONTENT PROTECTION: SCRAMBLING SCHEMES

Teresterial HDTV broadcasts (25 percent of the base of viewers) will begin without any scrambling method. Cable companies and some other broadcasters will use two levels of protection: protected content for movies and protected viewing to verify that a viewer is authorized to receive a broadcast. The copy protection technical working ATSC group is still trying to agree upon a single scrambling scheme, with Intel's proposal currently considered the frontrunner (1394 Digital). This copy protection scheme will be similar to the Content Scrambling System (CSS) as used in DVD copy protection. The protected-viewing scrambling methods will continue to vary from region to region (as they do now.)

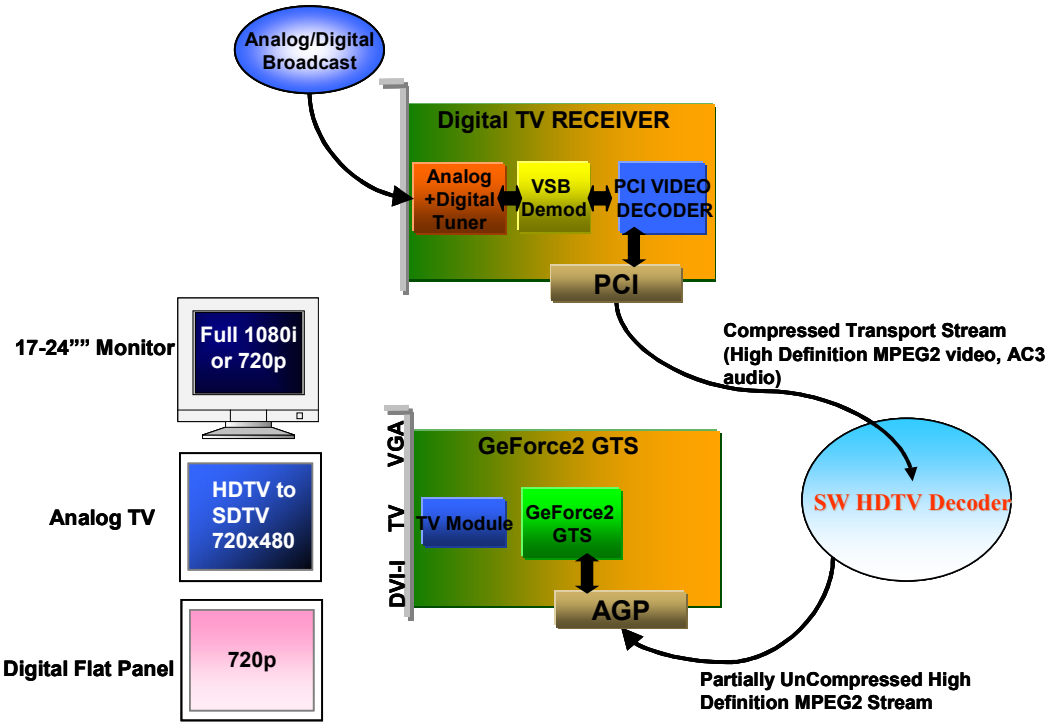
THE ULTIMATE HOME THEATRE PC

The goal of the NVIDIA HDVP solution, as implemented in the GeForce2 GTS, is to provide a cost-effective implementation for HDTV playback and make it available to a wider range of audiences. HDTV on the PC is now possible simply by combining a cost effective DTV tuner with the NVIDIA HDVP hardware accellerated HDTV processor. The installed base of more than 30-million 17- to 24-inch PC monitors can display HDTV content without requiring the consumer to purchase an expensive HDTV set. In addition, with NVIDIA HDVP technology,

1080i and 720p high-definition content can be downscaled using NVIDIA's HDVP high-quality downscaler to standard definition TV (SDTV) resolution, facilitating the display of HDTV content on any analog TV set.

Alternatively, imagine a combination HDTV processor and DVD player, capable of time shifted recording and the ability to drive large screen HDTV displays.

FIGURE1. NVIDIA HDVP USAGE MODEL AS IMPLEMENTED ON GEFORCE2 GTS.



NVIDIA HDVP IMPLEMENTATION

The HDTV video format is based on the MPEG2 video coding standard, but at much higher resolutions (1920x1080 or 1280x720 vs 720x480). In this coding standard, motion vectors are used to describe the movement of pixels from one successive frame of video to the next. By storing the movements of blocks of pixels, as opposed to the pixels themselves, MPEG2 achieves significant compression. From a graphics integration perspective, motion compensation refers to the process of decoding delta information (output of the inverse discrete cosine transformation – IDCT - data from the software decoder) and movement information (motion vectors) into frames of video. This process is the most CPU intensive part of the MPEG2 decode process.

Unlike competitive solutions, the second-generation, highly optimized and efficient motion compensation (MC) engine of the NVIDIA GeForce2 GTS is capable of handling HDTV resolution and bandwidth requirements. The GPU's MC logic is shared with the 3D pipeline, which means it can scale gracefully with GeForce2 GTS's massive fillrate.

NVIDIA has throughly analyzed the integration of inverse discrete cosine transformation (IDCT) and concluded that it does not make sense to integrate IDCT alone. To make IDCT work, the hardware must also do sparse

encoding (like zig-zag, run-level coding). Before IDCT, the data format was 12-bit integer. If the data for every block is sent to the chip every decode, the performance would be less than that for 8-bit pixel difference data (which is what is required on an MC implementation).

In summary, to make IDCT work efficiently compared to a stand-alone yet highly optimized MC implementation, significant hardware logic must be added. Because of the complexity of this additional hardware, integrating a complete MPEG2 pipeline becomes the better choice.

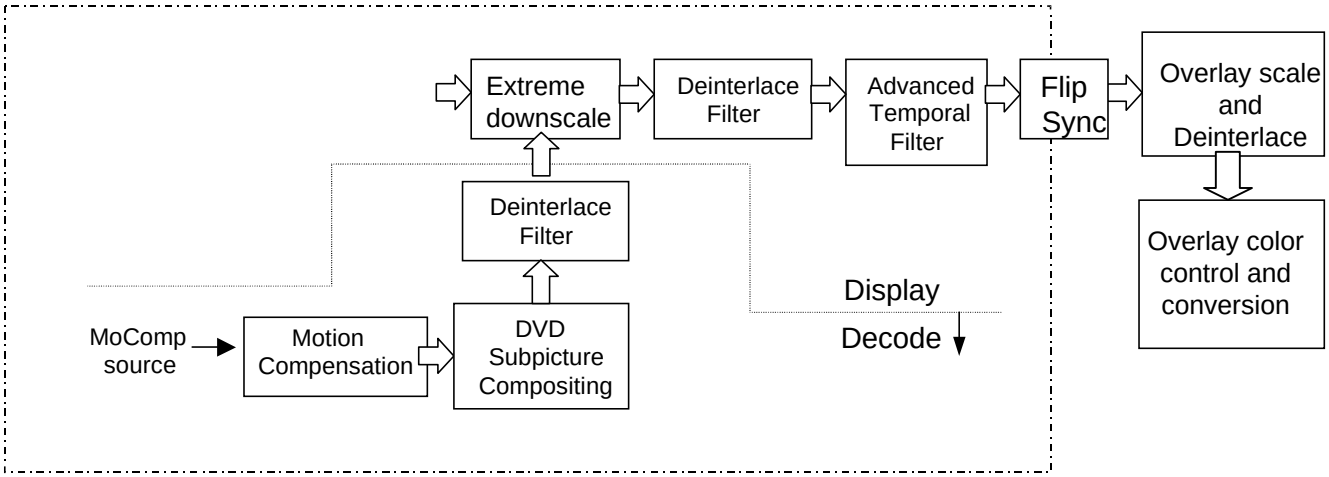
SUPERIOR UP AND DOWN SCALING ENGINE

NVIDIA's HDVP's high-quality filter, with five horizontal and three vertical taps, enable GeForce2 GTS to downscale 1080i and 720p video to 480p (SDTV resolution) and display it on any standard analog TV. For performance details, refer to the latest MadOnion video2000 benchmark. The high-quality scaling engine is essential for users who wish to enjoy HDTV playback without upgrading to a significantly more expensive HDTV set.

VIDEO PROCESSING SUPERPIPELINE (ADVANCED DE-INTERLACED AND TEMPORAL FILTER)

De-interlacing is required to display interlaced content on a progressive display such as a monitor where fields (top and bottom) come in at a rate of 60 fields per second and have to be converted to frames at 30 frames per second. The two most simple and common methods of de-interlacing are *weave* and *bob*. Weave is defined as combining the two adjacent fields to generate a frame. While this works well on still images, it creates annoying feathering (combing) artifacts with motion video. Bob is the process of zooming in on each field (enlarge by a factor of two) in the vertical direction, displaying them successively, and shifting the bottom field by one scan line. The bob method works well even with motion video, but suffers from a shimmering artifact due to a loss in picture resolution. This is most obvious with text and stationary objects/logos overlayed on top of live video.

With the NVIDIA HDVP, its possible to use the video post-processing superpipeline to create two additional filters—an advanced de-interlace and a temporal filter—to handle interlaced content such as 1080i. A temporal filter is used to blend the current frame with the previous frame. This significantly reduces the shimmering and jittering artifacts associated with a bob process. An advanced de-interlaced filter supports a similar process where a field is blended with its opposite field. This further reduces the interlace artifacts. A decoder can intelligently switch between these filters, according to the motion vectors, to achieve the best 1080i display on a monitor.



INDEPENDENT HARDWARE COLOR ENHANCEMENTS

Unlike competitive solutions, the NVIDIA HDVP has dedicated hardware-based color enhancements for the video overlay. These include brightness, contrast, hue, and saturation. These enhancements offer the flexibility of adjusting the look and feel of just the video window, without affecting the entire desktop.

HIGH-DEFINITION AND ANALOG TIMESHIFTING: DIGITAL VCR APPLICATIONS

Another compelling video application that was recently introduced to the market is timeshifting playback. Timeshifting playback is the ability to pause, rewind, and fast forward live TV. This type of application requires simultaneous decode and encode of MPEG2 in real time. Some GPU vendors are just starting to support timeshifting playback with analog TV and standard MPEG2 resolution (720x480 or in some cases 720x240). With the NVIDIA HDVP, viewers can enjoy not only analog timeshifting playback, but also HD timeshifting playback.

Conclusion

With the availability of HD broadcast to more than half of the market segments, HDTV playback is becoming one of the most compelling video applications. NVIDIA's HDVP allows mainstream high-performance processors to support all 18 ATSC formats with a simple and cost-effective DTV receiver card. The biggest entry barrier is the cost of a HDTV set. By removing this entry barrier, NVIDIA's HDVP technology enables:

- A well-balanced and cost effective HDTV solution
- HDTV playback on more than 30-million installed 17- to 24-inch PC monitors
- High-quality HDTV to SDTV playback on more than 250-million standard analog TVs

GeForce2 GTS is the first GPU to implement NVIDIA's HDVP technology, which helps the deployment and acceptance of HDTV playback and HD Timeshifting applications to the masses.