Develop Professional Digital Video Applications

Xilinx FPGAs, tools, and design support will enable you to be first to market and best in market.

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Digital video is rapidly replacing the traditional analog video signal throughout the video broadcast chain. From the content source in the studio or remote news site, through the editing, storage, and transmission processes, to the set-top boxes and digital television sets in consumers' homes, digital video is now firmly established throughout the broadcast industry.

Many digital video standards remain subject to change and refinement, however. Others are still going through the standardization process. In this uncertain period, it is both difficult and expensive for suppliers of professional digital video equipment to stay abreast of new developments. Digital video equipment designs require flexibility to meet current standards and to adapt to emerging standards, even after deployment in the field. Xilinx FPGAs and Internet Reconfigurable Logic (IRL™) technology provide this flexibility, allowing you to update your equipment rapidly as standards evolve.

A variety of resources are available to help developers use Xilinx FPGAs in professional digital video applications. This article describes some of the tools and design support available from Xilinx to help you gain a competitive edge in the digital video equipment market.

Hardware Aids

The Xilinx MicroBlaze™ and Multimedia Development Board is available from Xilinx distributors to help you develop and test digital video algorithms, including video format conversion, video compression, and image processing. The board accepts an analog composite video input, decodes it into digital component video, and processes the digital video in a Virtex™-II FPGA. The processed video is then converted back to analog and is available on the board's outputs as composite, S-video, RGB, or SVGA video.

Reference Designs and App Notes

Xilinx has created a number of reference designs and application notes for professional digital video applications. Many of these reference designs are tailored to run on the MicroBlaze and Multimedia Development Board, but are also applicable to real-world digital video applications. The reference designs and application notes focus on three different areas of professional digital video applications: scan-line processing, serial digital interface, and video compression.

Scan Line Processing

The scan line processing section of the MicroBlaze and Multimedia Development Board is illustrated in the block diagram shown in Figure 1; relevant "XAPP" application notes are also displayed.

This scan line processing section accepts NTSC (National Television Standards Committee) or PAL (phase alternating line) composite analog video and converts

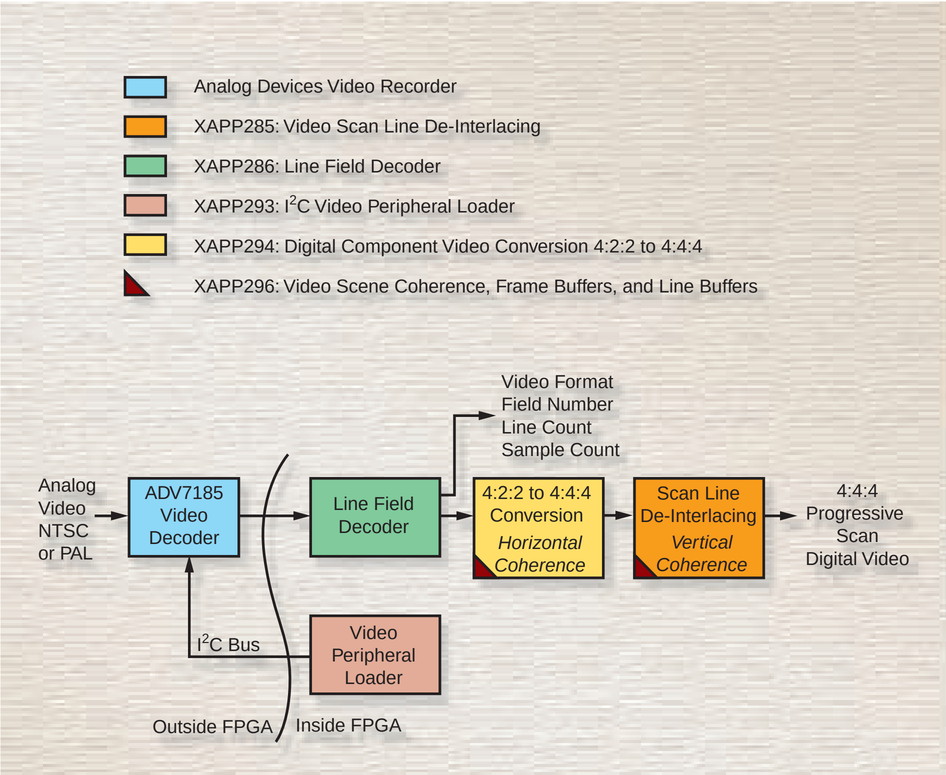

Figure 1 - Scan line processing section

it to progressive-scan, 4:4:4 component digital video in a series of steps. An Analog Devices ADV7185 video decoder converts the analog video to digital video. The other conversion steps are implemented in the Virtex-II FPGA.

The line field decoder on the development board examines the digital video and determines the video format (NTSC or PAL). It also synchronizes to the digital video stream, providing the current video line and sample counts to the other video processing blocks.

The ADV7185 video decoder generates interlaced component digital video having chroma components at half the horizontal resolution of the luma component. This is 4:2:2 component video. The 4:2:2 to 4:4:4 conversion block converts the video from the decoder to 4:4:4 component video having equal resolution of chroma and luma components. As a last step, the video is de-interlaced to create a progressive-scan video signal.

The video peripheral loader initializes the video encoder and decoder chips on the development board using the I^{2}C bus.

Future application notes will describe the processing of the progressive 4:4:4 video generated by the scan line processing section in a frame buffer environment. Some of these frame-oriented functions are 2D image scaling, image enhancement, and noise removal.

Serial Digital Interface

The ANSI/SMPTE 259M-1997 standard specifies how to transport digital video serially over video coax cable. This standard, commonly called SDI (serial digital interface), is now widely used to distribute digital video throughout television studios and video production centers over the video coax cable previously used to transport analog video.

Figure 2 shows a block diagram of a typical SDI video link, along with a list of pertinent application notes. Ancillary data, such as digital audio, is inserted into the inactive portions of the digital video stream. Error detection handling (EDH) packets are calculated and inserted. The digital video is then encoded, serialized, and transmitted through the coax cable. At the receiving end, the data and clock are recovered from the serial bitstream and the bitstream is decoded, framed, and de-serialized. Finally, a processor implements error detection and extracts the ancillary data from the digital video data.

The digital video test pattern generator creates pathological test cases designed to stress the equalization and clock-and-data recovery units in an SDI receiver. The XAPP248 application note on SDI also includes reference designs to generate industry standard color bar video test patterns.

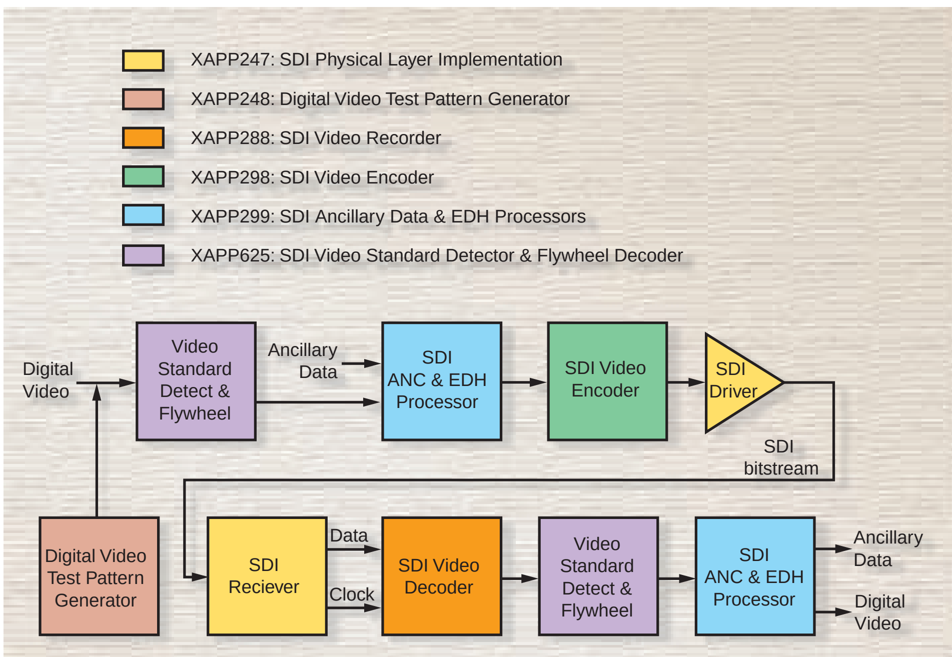

Figure 2 - Serial digital interface section

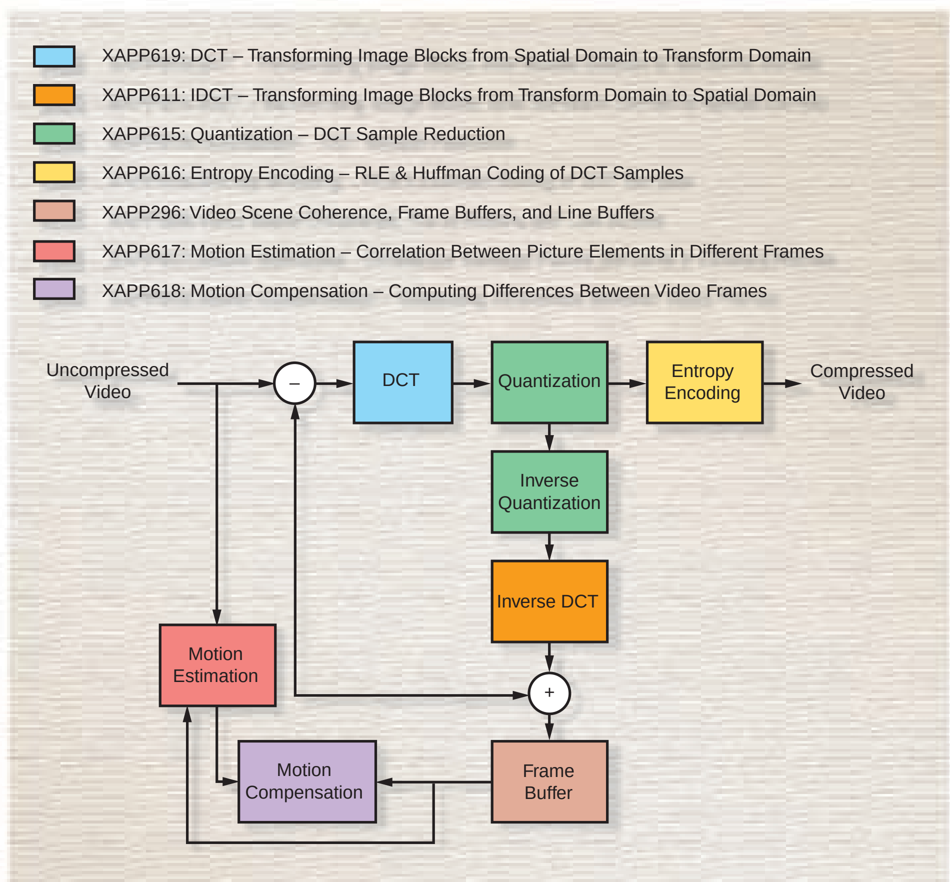

Figure 3 - Typical video compression system

Video Compression

Digital video compression and decompression are an integral part of most professional digital video systems. As shown in Figure 3, a set of application notes is available that describes some of the fundamental building blocks used in many video compression standards, including MPEG-2. Figure 3 also shows how these functions are used in a typical video compression system.

The discrete cosine transform (DCT) function reduces an image block into spatial frequency components. This transformation sorts the information in the image block, separating the higher frequency components from the lower frequency components. With the image de-composed in this manner, it is possible for the compression scheme to take advantage of the human visual system's lower sensitivity to the higher frequency components of the image.

After transformation by the DCT, quantization compresses the higher frequency components of the image more than the lower frequency components. The lower frequency components are quantized in small steps while the high frequency components are quantized in larger steps or are altogether discarded and converted to zeros.

Entropy encoding further compresses the quantized data by run-length encoding into short codewords. Variable length coding is also used to assign shorter codewords to commonly occurring data sequences and longer codewords to infrequent data sequences.

Additional significant compression of video images is achieved by taking advantage of the temporal coherence of the image. In most video images, a frame of video usually only has minor differences from the previous frame. Many video compression schemes take advantage of temporal coherence by periodically transmitting a full reference frame and then sending only the arithmetic differences for successive frames. Motion estimation identifies portions of the image that have moved from the previous video frame. Motion compensation generates the arithmetic differences between the frames based on the motion vectors found by motion estimation.

A good reference book on video compression is *Image and Video Compression: Algorithms and Architectures – Second Edition*, by Vasudev Bhaskaran and Konstantinos Konstantinides (1997, Kluwer Academic Publishers, ISBN:0792399528).

Conclusion

Xilinx has development tools and technical support to assist you in using a Xilinx FPGA as the video processing engine of a digital video application. Digital video reference designs and application notes from Xilinx provide the building blocks for profession digital video applications. Because the reference designs are supplied with complete source code, they can be combined and customized to suit the requirements of your specific application.

Using Xilinx components and reference designs will allow you to:

- Integrate a variety of video functions in one FPGA device as opposed to implementation in several separate ASICs.
- Customize video functions that previously were inaccessible inside ASICs.
- Update field equipment to new video standards by reconfiguring the FPGA via Xilinx IRL technology.
- Reduce development costs and shorten design cycles.

The application notes, reference designs, and FPGA product information are all available on the Xilinx website at *www.xilinx.com*. The MicroBlaze and Multimedia Development Board is available through Xilinx sales representatives and distributors, who can be found at *www.xilinx.com/company/contact.htm*.