White Paper

Using Stratix II GX in HDTV Video Production Applications

Introduction

The television broadcasting market is rapidly shifting from the established methods of analog video capture and distribution to digital television (DTV), which provides three main benefits: the unparalleled resolution and clarity of high-definition (HD) television, the capability to transmit multiple streams of standard definition television (SDTV) programming provided by multicasting, and the transmission of compressed digital broadcast streams. In 1996, the Federal Communications Commission (FCC) approved a new standard for digital television and governments are placing requirements on broadcasters to set schedules that identify when analog signals will be fully replaced by digital signals. In North America, the FCC is aggressively pushing for analog shutoff as early as December 2006.

One of the benefits of DTV is the much higher resolution or clarity of the video as compared with traditional analog signals. However, while the HD signals provide the best high-definition television video (HDTV), they require complex, high-performance hardware.

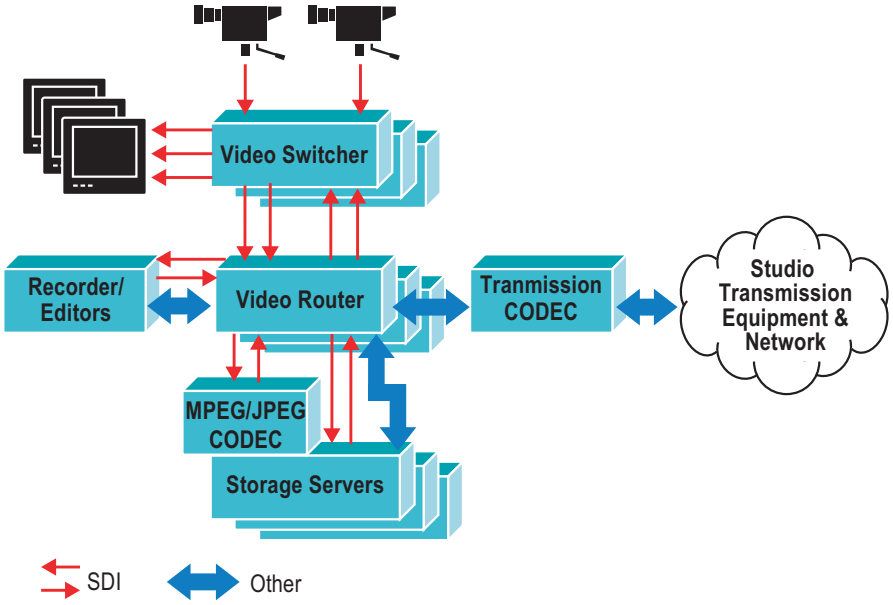
The feature-rich architecture of the Altera® Stratix® II GX device family offers hardware designers the best solution to create and transmit HDTV signals. Stratix II GX devices are the next generation family of the very popular Stratix GX device family from Altera. With its faster transceivers, more logic, and more memory, the Stratix II GX device family offers system designers a faster path to their next generation designs. The Stratix II GX devices offer up to 20 full, duplex-transceiver channels capable of operating at up to 6.375 gigabits per second (Gbps) per channel. The Stratix II GX device solution provides system designers with flexibility, performance, integration, and design resources unavailable in any other solution.

HDTV Video Production Application Requirements

The HDTV video production environment must support a network comprised of various equipment sets operating at HD data-transfer rates, as shown in Figure 1. Video and embedded audio is transported between equipment over coaxial cables using the Serial Digital Interface (SDI) transmission standard. The HD standard for SDI requires up to 1.485-Gbps serial data rates, as defined by the Society of Motion Picture and Television Engineers (SMPTE) specification 292M.

In addition to the high-speed serial data rates required, typical digital broadcast equipment requires digital signal processing (DSP), logic functions, and an abundance of memory. The Stratix II GX device family includes features that support these requirements, such as high-speed transceivers, dedicated DSP circuitry, programmable logic, and TriMatrix memory—including support for high-speed memory interfaces such as DDR, DDRII, RLDRAM II, and QDR II SRAM. The advanced architecture in Stratix II GX devices allows designers to implement HDTV functionality with the performance they need.

Figure 1. DTV Video Production Network



As Figure 1 illustrates, a DTV video production environment contains various equipment sets, such as video switches and routers, storage servers, professional-grade cameras, and monitors, as well as recording, editing, encoding, and decoding equipment. The video switcher creates the video stream that is broadcast through television distribution channels, mixing live video from multiple cameras as well as pre-recorded video from the storage servers, video tape or digital recorders (VTRs or VDRs), and editors to create a fluid video program. The video switchers also feed studio monitors directly, allowing the user, most often a producer, to see the input and output video from the switchers. Video data is typically compressed and decompressed with MPEG compression algorithms for storage or transmission to the end viewers.

Stratix II GX Transceivers for HD-SDI

The Stratix II GX devices support the 1.485-Gbps serial data speeds of HD-SDI on 4 to 20 full-duplex transceiver channels. The transceiver circuitry integrates clock data recovery (CDR) and serializer-deserializer (SERDES) capabilities. The CDR circuit requires an external reference clock to train its voltage-controlled oscillator (VCO) which in turn extracts a clock which is phase and frequency aligned with incoming data, eliminating any clock-to-data skew. The SERDES converts the high-speed serial data to a slower parallel format that can be processed in the FPGA logic array on the receive side. The data is converted back to a high-speed serial signal on the transmit side. Four transceivers are grouped into a quad block and independent data rate receive and transmit are possible within the same quad.

In many cases, video production equipment receives or transmits one or more SDI signals. In the case of switches and routers, multiple SDI signals are received and transmitted from a single piece of equipment. Figure 2 shows a typical hardware flow for the SDI signal when it is received by studio equipment that interfaces with multiple SDI inputs. Each SDI input channel requires a cable equalizer device to improve the signal quality after the signal is transmitted over coaxial cable over 100 meters in length. Once an equalized SDI signal has been received, the Stratix II GX CDR circuitry extracts the clock from the data using the studio reference clock signal. The serial data is then converted to parallel, low-speed data. Stratix II GX logic elements (LEs) can be used to perform SDI input signal processing functions such as framing, descrambling, audio embedding, and synchronization of the signals to the same clock edge. Stratix II GX LEs and memory can also be used to perform routing functions such as multiplexing SDI signals. In the future, the industry will need higher data rates than the existing HD-SDI data rates in video production facilities for applications where users can transmit multiple SDI channels on a single link or for higher resolution displays such as 1080p. The current solutions require a dual-link HD-SDI, whereas a 3 Gbps or greater link can combine multiple links into one. With Stratix II GX transceivers running up to 6.375 Gbps, users can scale their designs to handle new protocols which require higher data rates.

Figure 2. Input Processing Flow on SDI Channels

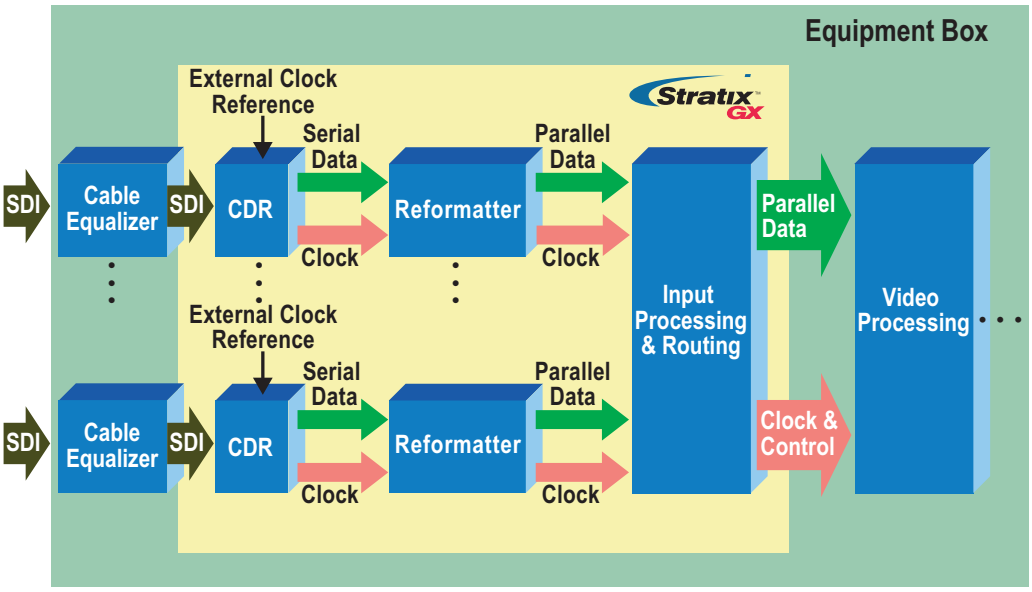
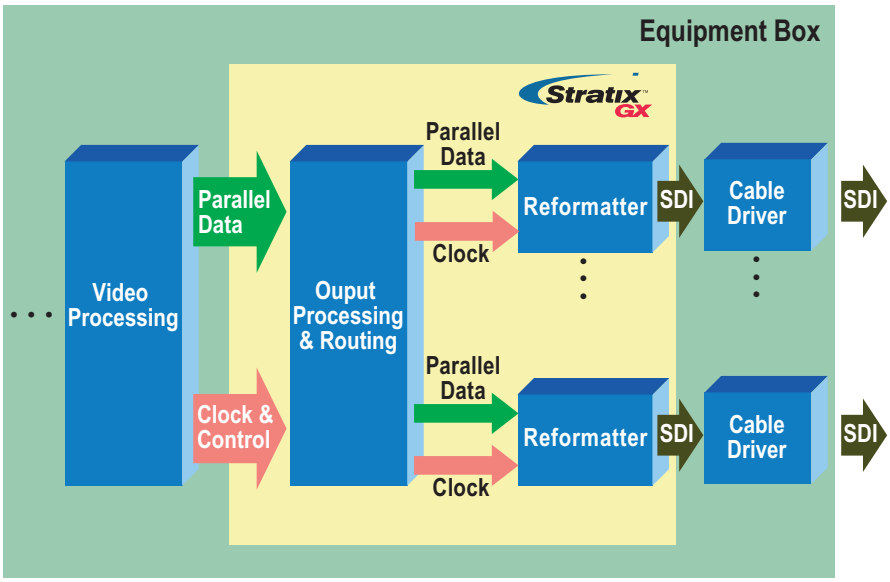


Figure 3 shows the data flow for the output of SDI signals from video production equipment. Stratix II GX devices can perform the necessary output video processing functions and then transmit SDI format video at HD speeds to cable drivers, which boost the signal strength and transmit the video stream over coaxial cable up to 100 meters in length. Stratix II GX devices can also receive the Audio Engineering Society and European Broadcasting Unit (AES3/EBU) audio signals on its LVDS I/O pins which can then be embedded into the SDI stream or vice versa—the audio data from the SDI stream can be de-embedded and transmitted out on LVDS pins.

Figure 3. Output Processing Flow on SDI Channels



The density and range of transceiver channels, available in Stratix II GX devices, allows designers to implement the video data processing, CDR, and SERDES functions for several SDI channels within a single Stratix II GX device. Table 1 shows Stratix II GX transceiver channels details.

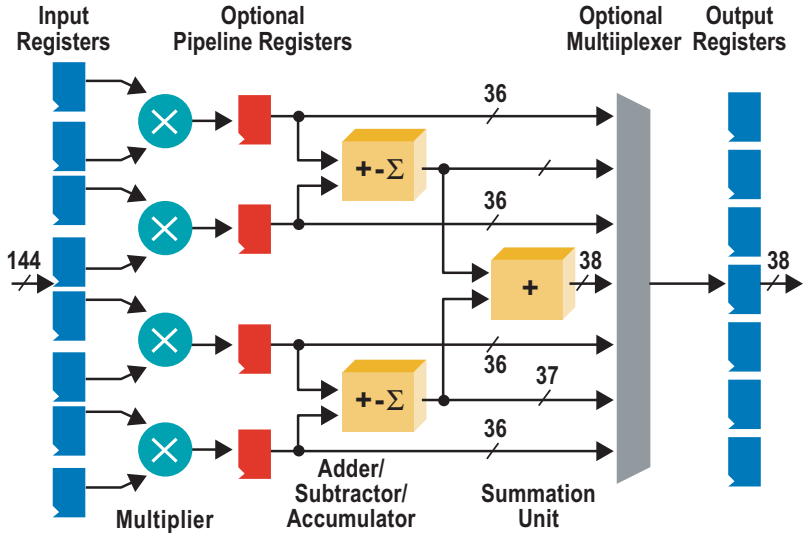
Table 1. Stratix II GX Transceiver Channels

Device	6.375-Gbps CDR Channel	Equivalent LEs	M512 RAM	M4K RAM	MRAM	Total Memory Bits	18-Bit × 18-Bit Multipliers	PLLs
EP2SGX30C	4	33,880	202	144	1	1,369,728	64	4
EP2SGX30D	8							
EP2SGX60C	4	60,440	329	255	2	2,544,192	144	8
EP2SGX60D	8							
EP2SGX60E	12							
EP2SGX90E	12	90,960	488	408	4	4,520,448	192	8
EP2SGX90F	16							
EP2SGX130G	20	132,540	699	609	6	6,747,840	252	8

Performing Video Processing in DSP Blocks

Stratix II GX device DSP blocks provide a powerful solution for implementing high-performance DSP applications. The DSP blocks are dedicated circuitry that provide predictable and very high-speed signalling performance without congesting the FPGA interconnect routing. The Stratix II GX architecture enables designers to implement a large number of parallel multipliers in each device. Each DSP block is capable of running at up to 450 MHz. Figure 4 illustrates the Stratix II GX DSP block architecture.

Figure 4. Stratix II GX DSP Block Architecture



The Stratix II GX DSP blocks provide ample performance to process an HD video signal plus any overhead data. These blocks provide fast and efficient processing for functions such as multiplication, filtering, color-space conversion, error detection and correction, or JPEG and MPEG encoding and decoding.

TriMatrix Memory For HD Video

The Stratix II GX devices feature TriMatrix™ memory, which is composed of three sizes of embedded RAM blocks providing a total of over 6.7 Mbits of RAM. TriMatrix memory includes 512-bit M512 blocks, 4-Kbit M4K blocks, and 512-Kbit M-RAM blocks, each of which can be configured to support a wide range of features. The M512 and M4K blocks can operate at up to 312 MHz and the M-RAM blocks can operate at up to 300 MHz.

The TriMatrix RAM blocks provide features like true dual-port memory, embedded shift-register functionality, mixed-clock mode, and configurable memory-width dimensions. These features, along with the density and range of RAM blocks in the Stratix II GX devices, provide an optimal solution for storing multiple horizontal-video lines. The performance allows designers to easily process 10- or 20-bit HD video signals plus overhead.

In addition, TriMatrix memory blocks can be used to implement additional multipliers. Refer to the "*DSP Blocks in Stratix II and Stratix II GX Devices*" chapter in the *Stratix II GX Device Handbook* for details on using the memory blocks for high-speed multiplication functions.

Reference Designs

Altera also provides a number of reference designs for broadcast infrastructure vendors who plan to quickly move into the new era of digital television. By providing these designs, which typically address standard interfaces such as SDI or the AES3/EBU standards, Altera lets the designers focus on their core competencies and reduce their time to the market. In addition to the designs, Altera's field is equipped with demonstration boards to evaluate the reference designs. Details of the reference designs can be found at Altera's broadcast reference designs web page.

Conclusion

Stratix II GX devices are ideal solutions for designing professional video production equipment for HDTV and SDTV broadcasting. The Stratix II GX feature-rich device, with HD capable transceivers, integrated DSP blocks, TriMatrix memory, and leading edge programmable logic, provides the flexibility, cost structure, and shortened time-to-market needed for the development of professional HDTV applications. Altera is presently working on converting the SDI reference design into a megacore. The megacore support for Stratix II GX will be available in the Quartus® II design software, Version 6.0.

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