

Accelerating Video Development on FPGAs Using the Xilinx XtremeDSP Video Starter Kit

Try a video development methodology that is processor-friendly, generates highly optimized results, and does not require VHDL or Verilog knowledge.

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Along with next-generation video compression standards, the industry shift from basic video processing to more complex and integrated processing solutions are driving system requirements for video performance beyond what stand-alone DSPs can deliver. FPGAs such as the Xilinx® Spartan™-3A DSP fill this gap for cost-sensitive military, automotive, medical, consumer, industrial, and security applications by providing more than 20 GMACs of DSP performance for less than \$30. FPGAs uniquely provide logic, embedded processing, OS support, and drivers to offer a complete end-to-end solution for video.

It is not that developers lack understanding about the performance benefits of FPGAs that prevent their use in video applications; rather, it's a lack of experience with the design flow. This is especially true for traditional DSP program developers accustomed to programming in C.

You can achieve FPGA performance gains by exploiting the flexibility of the device to configure a hardware architecture optimized for a particular application. This flexibility adds a degree of freedom to the development process that also contributes to its complexity.

The XtremeDSP™ Video Starter Kit (VSK) provides a complete and easy-to-use design environment. Example applications and full support for standard Xilinx tool flows help accelerate the design process yet still allow for end-product differentiation.

Introducing the XtremeDSP VSK – Spartan-3A Edition

The XtremeDSP Video Starter Kit – Spartan-3A Edition is a video development platform comprising the Spartan-3A DSP 3400A development platform, the FMC-video daughtercard, and a VGA camera.

The Spartan-3A DSP 3400A development platform, which you can purchase separately, is built around the Spartan-3A DSP XC3SD3400A device. This device provides 126 embedded DSP blocks for implementing coprocessing and high-performance video processing systems.

The FMC-video daughtercard extends the video I/O capabilities of the Spartan-3A DSP 3400A development platform by including the following additional interfaces:

- DVI-I input, both digital and analog
- Composite input and output
- S-video input and output
- Two camera inputs

Video Development Tools

You can create video applications for the VSK without RTL knowledge or experience using the Xilinx Embedded Development Kit (EDK) and System Generator for DSP. EDK is a comprehensive solution for designing embedded programmable systems and includes the Platform Studio tool suite, embedded IP cores, and the MicroBlaze™ embedded processor.

System Generator for DSP enables the use of The MathWorks Simulink/MATLAB modeling environment for FPGA design by providing a Simulink blockset of more than 100 Xilinx-optimized DSP building blocks.

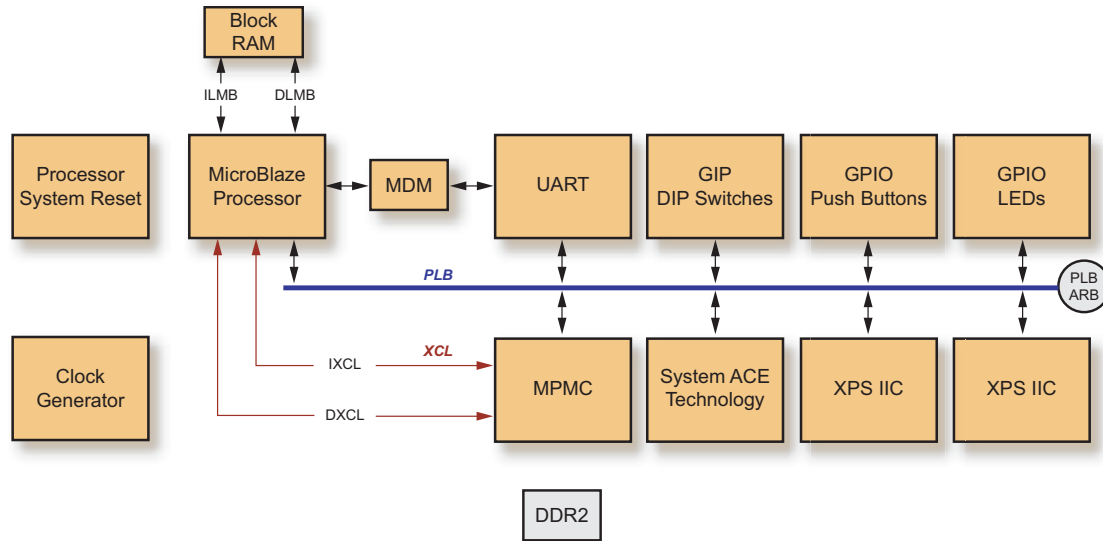


Figure 1 – Base platform block diagram

Developing Video Applications Using the Base Platform

An embedded system called the base platform provides the framework from which you can develop video applications using the VSK. The base platform is an embedded system created using the Xilinx Platform Studio base system builder (BSB) and includes a MicroBlaze embedded processor.

This framework provides a starting point for new designs or serves as an easy migration path for existing applications developed on processor-based systems. You can recompile any C code created for external processors on the MicroBlaze processor with minimal effort; once ported, the high-performance video chains can migrate from software to the FPGA fabric.

To assist in this migration, the VSK includes an IP library of custom peripherals that you can easily add to the base system using Platform Studio. You can connect to the video interfaces, manage data frames, and perform memory access and basic video processing. These custom peripherals include:

- DVI in
- DVI out
- Camera
- Video frame buffer controller (VFBC)
- Video processing pipeline

The Xilinx VFBC is ideal for video applications where the hardware control of two-dimensional data is required to achieve real-time operation. This is typical of motion estimation, video scaling, on-screen displays, and video capture used in video surveillance, video conferencing, and video broadcasts.

Jump-Start Development Using VSK Reference Designs

The VSK provides three reference designs for jump-starting the development of

video applications running on Xilinx FPGAs. Each reference design is built on the base platform and uses custom peripherals from the VSK IP library. Table 1 lists each reference design and the video processing and connectivity capabilities that it illustrates. These reference designs are intended to serve as a starting point from which further development may occur. Figure 2 shows how the DVI pass-through reference design interfaces into the base system.

Reference Design	Functionality Description
DVI Pass-Through	<ul style="list-style-type: none"> • Capturing a video stream from the input port • Performing real-time image processing on the video stream • Displaying the processed video
DVI Frame Buffer	<ul style="list-style-type: none"> • Capturing a video stream from a DVI source • Buffering the video stream in external memory • Displaying the buffered video • Reporting memory bandwidth utilization data
Camera Frame Buffer	<ul style="list-style-type: none"> • Capturing a video stream from a camera • Performing processing on the video stream • Buffering the video stream in external memory • Displaying the processed video at a different rate • Using a microprocessor to configure various aspects of the video pipeline

Table 1 – VSK reference design summary

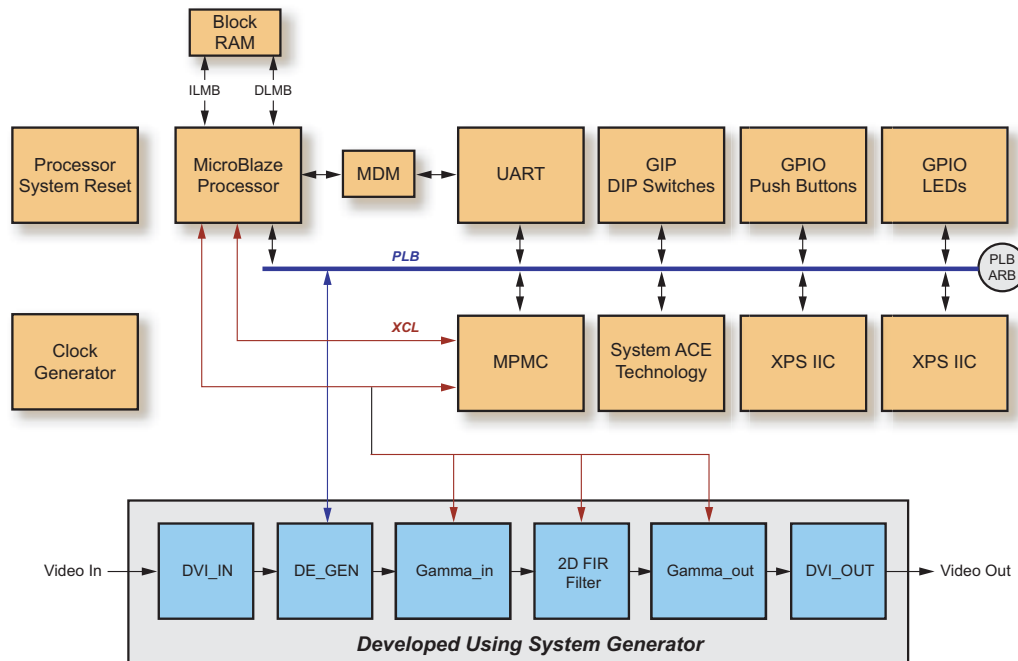


Figure 2 – Base system with video pipeline

Using Model-Based Design to Create Video Applications

Accelerating video applications on FPGAs requires that performance-critical operations migrate from software running on processors to hardware. The VSK supports a variety of hardware design flows. This includes flows that leverage strong hardware design backgrounds using VHDL/Verilog and flows that accommodate little or no hardware design experience by leveraging more abstract modeling environments including C, MATLAB, and Simulink.

Simulink from The MathWorks is a model-based design environment that you can use to develop algorithmic models of video systems. The MathWorks provides an optional video and imaging blockset for Simulink that provides a rich set of video building blocks for easily processing streaming video and visualizing the results at each step in the model.

You can initially model the video processing algorithm itself abstractly using floating-point data types and high-level video and imaging blocks, refining the algorithm as you consider the trade-offs associated with complexity, system cost, and performance.

System Generator for DSP enables the use of Simulink for Xilinx FPGA designs by

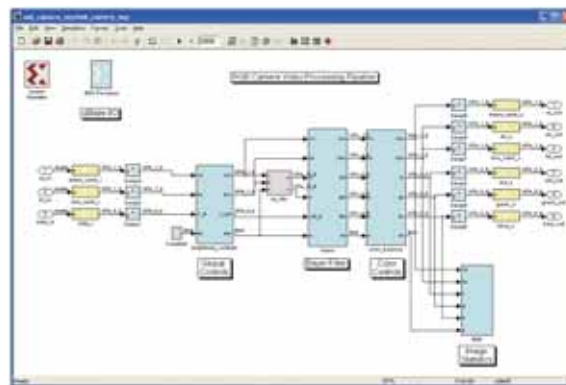


Figure 3 – System Generator diagram for a camera video processing pipeline

providing a rich set of DSP building blocks, optimized for Xilinx devices. Tight integration allows DSP designs captured in System Generator to be converted into custom peripherals for Platform Studio and connected to the base system using the processor local bus or Fast Simplex Link bus.

Figure 3 shows an example of a camera video processing pipeline created using System Generator, which is included in the camera frame buffer reference designs shipped with the VSK.

System Generator supports hardware-in-the-loop co-simulation using the Spartan-3A DSP 3400A development platform. You can use this platform to accelerate the per-

formance of Simulink simulations up to 1,000x. This acceleration enables video algorithm development and debugging using real-time video streams read into Simulink through The MathWorks data acquisition toolbox.

Conclusion

The XtremeDSP Video Starter Kit – Spartan-3A DSP Edition keeps development costs low by providing a complete video development solution for under \$1,600. The DSP and embedded design tools included enable rapid FPGA development of the video system without requiring RTL design experience.

DSP-optimized FPGA platforms such as the Virtex-5 SXT device, Virtex-4 SX device, and Spartan-3A DSP are particularly well suited to meet both the cost and performance requirements of high-performance video and image processing applications in security, broadcast, industrial, consumer, medical, and automotive applications – while insulating products against early obsolescence.

For more information, visit www.xilinx.com/s3adsp.vsk.