Image Acquisition Application using USB 3.0 Device IP Core Application Note

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System Level Solutions, Inc. (SLS) is a leading provider of innovative design IPs, VLSI and embedded systems solutions, for the development of SoC platform products, announced the availability of a USB 3.0 Image Acquisition Application using SLS USB 3.0 Device IP Core.

This application note is intended to present USB 3.0 as an interface for the next generation camera development. It describes the benefits of the USB3.0 standard, application design architecture and advantages of using SLS USB 3.0 device IP core for such applications.

USB 3.0 Technology

The Universal Serial Bus is one of the most common digital interfaces found today. SuperSpeed USB, also known as USB 3.0, is the next generation of the popular plug and play Universal Serial Bus interface specification. The high bandwidth of USB 3.0 delivers a transfer speed of roughly 5Gb/s, which is five folds faster than the widely used GigE interface and 10 times faster than USB 2.0.

USB 3.0 offers following advantages over the other machine vision interface:

- Low power consumption and higher capacity
- Higher bandwidth up to 5Gbps
- Low cpu usage
- Reduce image corruption
- Power and data over the same passive cable to five meters (more with active cables)
- Allows to use multiple camera using USB 3.0 Hub
- Low difficulty of system integration

Why Choose SLS USB 3.0 for Image Acquisition Application?

Reasons to choose USB 3.0 for your next machine vision application is simple:

High bandwidth, Widely deployed and Camera control interface

All major PC vendors now shipping their products with USB 3.0 support. Some vendors have chosen to use a third party USB 3.0 Device Controller, integrating the controller with a sensor and creating a USB 3.0 camera. However, this limits the camera vendor's ability to modify the device controller and delays USB 3.0 related fixes and improvements to the end customer. While SLS has developed own USB 3.0 device IP Core on FPGA interfacing to an external PHY chip, as well as it's very own device driver. This gives full control over the imaging pipeline, allowing vendors to deliver features and improvements to customers much quicker.

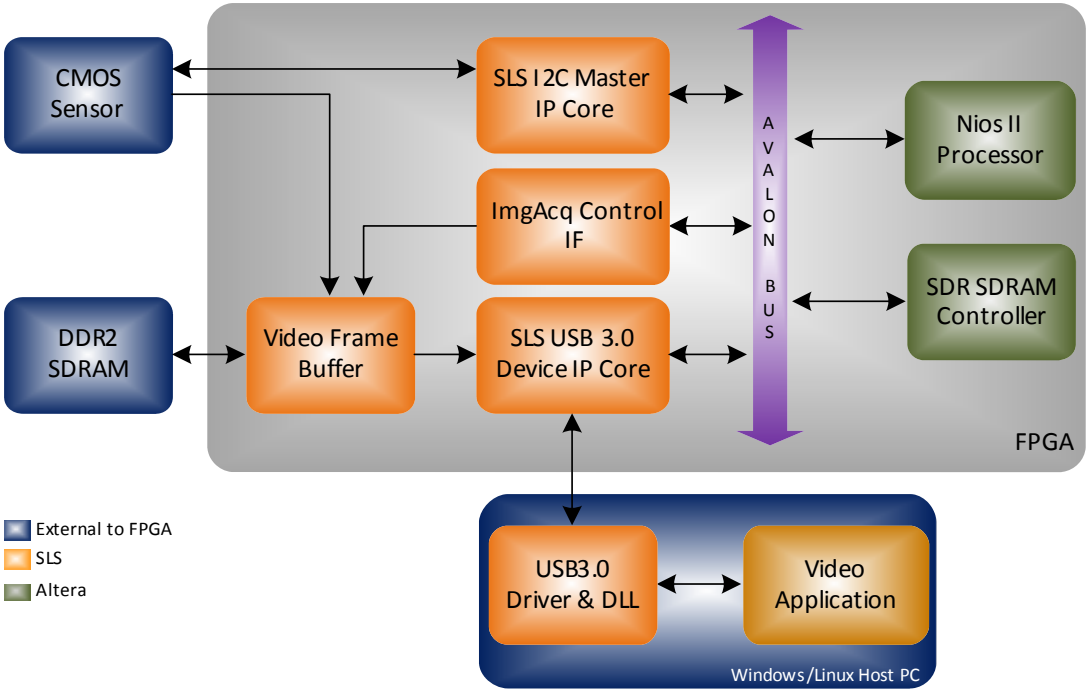
SLS have developed it's own custom library which supports Windows and Linux Operating System (OS). This library is very user friendly which allows you to control CMOS sensor to make the development faster. Also, USB 3.0 supports direct memory access which allows the data to be written directly to memory reducing CPU processing load.

In this application, we have achieved full HD quality (1080p) with 60fps video streaming output using SLS USB 3.0 Device IP Core with 3.1 MP CMOS camera. This application can be upgraded to support higher resolution camera at the maximum data rate.

Design Architecture

Following is the architectural block diagram of the application implemented on hardware.

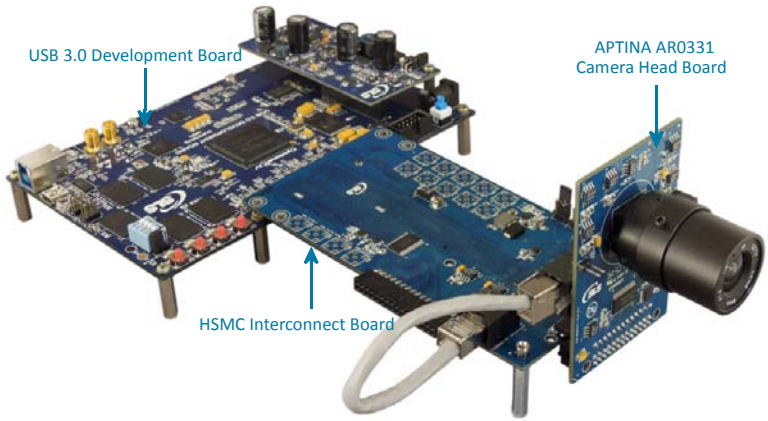
Figure 1. Design Architecture Block Diagram



As shown in the block diagram, a CMOS camera sensor data is being transferred over USB 3.0 interface using SLS USB 3.0 Device. The Nios II processor is used to control peripherals such as memory controller, I2C master and enumeration of the USB 3.0 Device on Host PC running with Windows or Linux Operating System (OS).

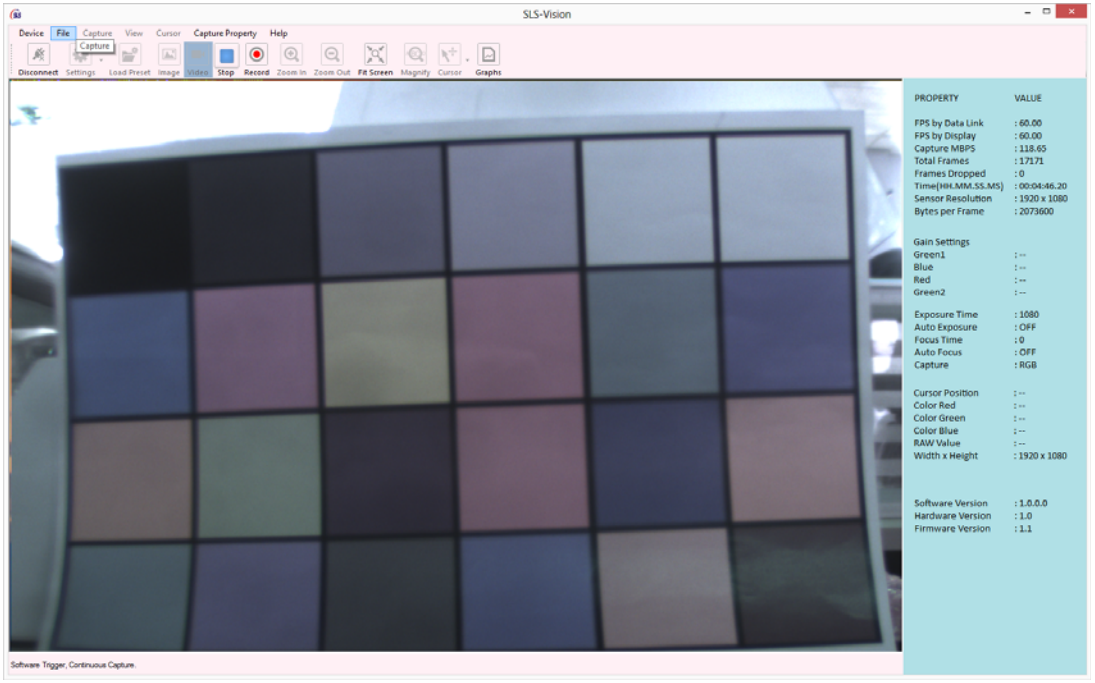
The CMOS sensor is getting configured through SLS I2C Master IP Core. Once it is configured, it outputs the data in Video Frame Buffer. The Video Frame Buffer is used to match the data rate between CMOS sensor and USB 3.0. It outputs the first pixel as soon as the first 256 pixels from CMOS sensor are written in frame buffer. Figure 2 shows the hardware setup used in the application.

Figure 2. Hardware Setup



The ImgAcq Control IF interface controls the input image frame to the Video Frame Buffer when the capture command is executed by host application. The capture command from host application activates the FPGA design to transfer COMS sensor data to host machine. As per block diagram the data path would be CMOS Sensor > Video Frame Buffer > USB30 IP Core > Host PC. The host application processes captured data and displays it on the screen. The application displays the captured data along with the frame details and it's resolution. It allows to capture series of frame and making a video of captured images. Figure 3 shows the Host application.

Figure 3. Host PC Application



Achievement

- Imaging Sensor: **AR0331 CMOS Sensor**
- Lens Mount: **CS Mount**
- Image Resolution: **3.1 MP, 1920 x 1080 Full HD**
- Image Compression: **No**
- Frame Rate: **60 fps**
- Color Pattern: **Bayer RGB**
- Digital Interface: **USB 3.0 (backward compatible to USB2.0)**
- Operating System: **Windows and Linux**

Applications

- Industrial Automation and Machine vision
- Traffic Surveillance
- Aviation and defence
- Visualization
- Object Tracking
- Printing Technology
- Measuring Technology
- Medical Imaging
- 3 D Scanning
- Metrology
- Research Work
- Life science

Enhancement

In this application, the device throughput is limited due to CMOS sensor. The transfer rate can be increased by changing the CMOS sensor with higher resolution and frame rate.

Conclusion

SLS USB 3.0 camera interface is designed to fill the gap between Gigabit Ethernet and Camera Link and to replace older USB 2.0 and FireWire interfaces. SLS USB 3.0 solution opens a wealth of possibilities for faster and cheaper camera products.

Further Information

For more information about USB 3.0, refer to http://www.slscorp.com/ip-cores/communication/usb-30-device.html.

For more information about Image Acquisition Application, write us at info@slscorp.com.

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