Application Note

Akademie věd České republiky
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3D Anaglyph Demo

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Revision history

Rev.	Date	Author	Description
0	4.6.2015	Z.P.	Document created
1			
2			

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1 Introduction

For implementation of image sensor interface for stereo computer vision, the precise synchronization of triggers must be implemented to get consistent input for consequent image/video processing steps. For this reason we have implemented synchronized stereo interfaces for Xilinx Development board ZC702 equipped with two FMC IMAGEON boards with two ON Semiconductor Vita2000 CMOS image sensors (one sensor per FMC board). Furthermore, we have also implemented synchronous video to stream conversion chains. The synchronous operation of sensors and the chain is demonstrated by the simple 3D demo application described in this document. The demo does not use any external DDR buffers for synchronization of both video streams.

The fact that both streams of video pixels are precisely synchronous is demonstrated by implementation of 3D anaglyph image for video output interface. The 3D effect is created by displaying the red component from one CMOS sensor and the remaining color channels from other. This can be done per-pixel because of the precise synchronization of two pixel streams coming from image sensors. The new composed video stream is then connected to HDMI output interface. The 3D video can be viewed by red-cyan glasses.

2 Description

The whole demo consists of: ZC702 board which boots configuration bitstream from SD card, two FMC IMAGEON boards attached to ZC702 FMC1 and FMC2 slots and two image sensors connected to FMC IMAGEON extension boards. Both image sensors should be for 3D demo equipped with the identical optics and attached to slidebar mount which ensures coplanar attachment. All components can be seen in Figure 1.

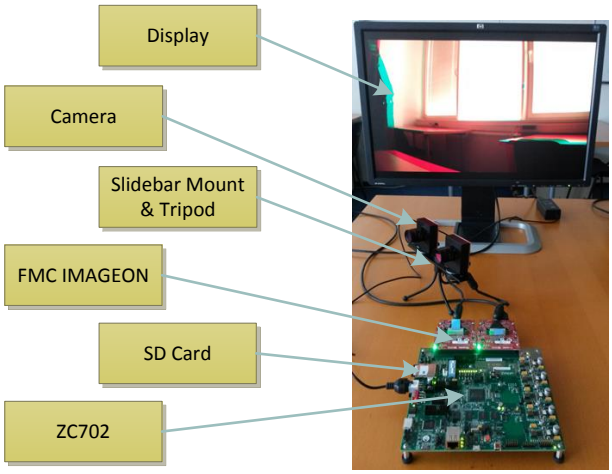

Figure 1: 3D Demo Setup

2.1 FPGA Design

The design structure inside FPGA is shown in Figure 2. Only the most important video blocks and their logical interconnection structure including Vita2000 CMOS sensor interfaces and HDMI output are shown. The video stream consists of “Vita Receiver” block responsible for communication with Vita2000 sensor. Its output is video signal connected to “Video to Stream” conversion, where the video signal is translated to pixel data stream without timing relation. Block “Color Interpolation” converts raw CMOS pixel data to RGB. First video stream (at the top of the figure) is considered as timing master, where the trigger timing is created and standard RGB video stream is created. The second branch is implemented as a slave. It takes trigger timing from master branch and establishes data communication with sensor in sync with the master branch. The demo uses control signals from block “Vita Receiver” and “Color Interpolation” and continually checks if the blocks in both branches are exactly synchronous. If any of them fails the system tries to reestablish synchronous mode back again. When both video streams are synchronous it is possible directly combine their color channels to implement 3D anaglyph. After that, the video signal is created back from combined pixel data and sent to HDMI output.

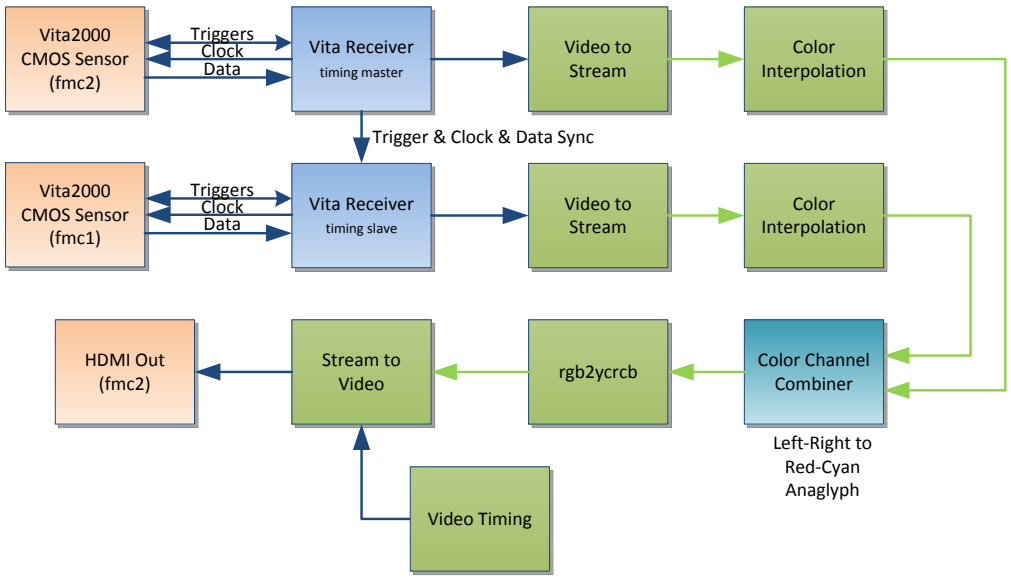

Figure 2: FPGA Architecture of 3D Demo

3 Used tools and resources

1. 2x FMC IMAGEON board with 2x Vita2000 CMOS image sensor [2].
2. Image sensor mount including slidebar for proper alignment.
3. ZC702 Development Board from Xilinx with SD card containing bootable image [1].
4. PC with serial terminal for initial setup.
5. Red-cyan glasses to view 3D anaglyph.

4 How to Setup Demo

To run the demo please follow these steps and recommendations:

1. Connect 2x FMC IMAGEON extension board to ZC702 board.
2. Connect 2x image sensor to FMC IMAGEON. We recommend for successful initialization to keep the lens covers on at the beginning.
3. Connect power cable to ZC702 and mini-USB cable to USB UART connector on ZC702.
4. Connect PC monitor capable of HDMI input 1920x1080p60.
5. Power the ZC702 on.
6. Wait until video is shown on monitor. The demo tries a while to get two synchronized streams coming from sensors. Once it succeeds, it shows the first video stream, then the second stream. In the end, 3D anaglyph is created.
7. If the screen is black in this step, remove lens cover.
8. Once demo is running and both video signals can be seen mixed on monitor. The terminal at the same time shows the menu, see Figure 3, and allows you to adjust precisely video streams by following procedure:
    a. Send '1' to terminal. It activates display of first camera video only in full color.
    b. Adjust camera focus and iris to get sharp and bright image, adjustments can be located on camera lens barrel.
    c. If the focus and iris setting is not sufficient, you can adjust exposure time for both cameras by pressing 'e', or adjust analog 'g' or digital 'd' gains. Exposure time is set as percentage of one frame time at 60FPS, i.e. 50 means 50% shutter opened and 50% closed for each of 60FPS. Max value is 99 because the rising and falling edge of trigger signal must always exist. Analog gain is equal 1.0 when set to 0 integer value. Maximum is 10. Digital gain is 1.0 when set to 128. The default setting is exposure = 90, analog gain = 0 (1.0f), and digital gain = 128 (1.0f).
    d. Send '2' to terminal and do the same with second camera.
    e. Start 3D mode by sending 3 or 4 to serial terminal. Difference between both is the left-right or right-left alignment of video streams. Use '3' if your cables from cameras to FMC IMAGEON are crossed which is also default setting.
    f. Adjust optical axis angle of both cameras until images of both cameras in 3D mode are properly aligned.
    g. Best results can be reached in uniform lighting conditions, cameras mounted on slidebar as close to each other as possible. Displayed objects in camera view are in reasonable distances, i.e. not too close etc.

The meaning of terminal menu items is summarized in

Activation	*Menu Item*	*Description*
a	`Init ALL`	Resets video chain, reinitializes again CMOS sensors, reestablishes synchronous mode of operation, **gains and exposure time is NOT resetted**.
1	`Show master video stream`	Shows master video stream to output for adjustments
2	`Show slave video stream`	Shows master video stream to output for adjustments
3	`Show 3D analyph for red-cyan glasses (crossed camera cables)`	Activate 3D anaglyph mode, when image sensor cables are crossed from sensor to FMC extension board

Activation	Menu Item	Description
4	Show 3D anaglyph for red-cyan glasses	Activate 3D anaglyph mode, straight cables
e	Set exposure for bots sensors	Sets master exposure time which is applied automatically also to slave branch
g	Set analog gain	(option available only when '1' or '2' was chosen beforehand) Sets value of analog gain, default = 0 (gain = 1.0), range 0-10
d	Set digital gain	(option available only when '1' or '2' was chosen beforehand) Sets value of digital gain, default = 128 (digital gain = 1.0), range 0-4095

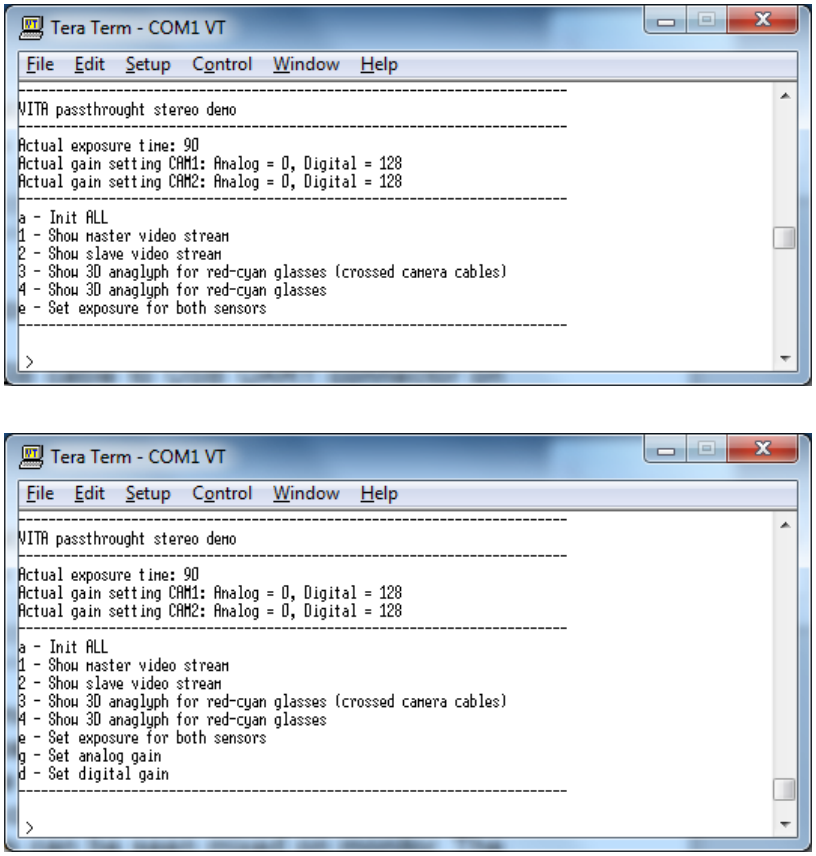

Figure 3: Confiuration of demo, terminal screens

5 Package contents

```
cdrom - bst                ZC702 bootable image for SD card
      - doc                This documentation
```

6 References

[1] ZC702, http://www.xilinx.com/products/boards-and-kits/ek-z7-zc702-g.html
[2] FMC IMAGEON, https://www.em.avnet.com/Support%20And%20Downloads/FMC_IMAGEON_HG_20120907.pdf