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Multiple MIPI CSI-2™ Camera Solution Using FPGAs
Agenda

• History & adoption of MIPI CSI-2℠ image sensors
• FPGAs in Imaging/Video applications
• Applications for multiple MIPI CSI-2 image sensors with FPGAs
• Summary
Evolution of Image Sensor interfaces

In 90’s & 2000s parallel interface was the norm
In the next decade various proprietary interfaces were introduced

Parallel CMOS interface
subLVDS / HiSPI interface / etc.

~ 2-3MP
As Mobile Platforms Explode, So does MIPI CSI-2℠
Because of mobile popularity everyone drifted to CSI-2℠

- Just like a decade ago when PC components were used broadly, as mobile adoption exploded, so did the acceptance of MIPI CSI-2
Imaging Applications using FPGAs

- Defense & Aviation
- HMI & Displays
- Time Lapse Camera
- Automotive
- Surveillance & IP Cameras
- Machine Vision & Medical
- Infrared Camera
Why Use FPGAs?

• Need multiple MIPI CSI-2 or other camera inputs and an AP/ISP does not have those

• An FPGA can implement a complete ISP
  – The embedded memory, math blocks and logic are a good match

• FPGA may perform some processing allowing for a lower cost AP/ISP

• Require multiple ISP engines

• Newer capabilities that are not available with an AP/ISP
FPGAs in imaging/video applications

Bridging is the simplest designs
Acceleration requires more performance & capabilities
Processing & Aggregating with FPGAs

Processing could be in an embedded processor or with FPGA fabric, memory and Math blocks (DSP blocks)

Aggregation leverages the large I/O capability of FPGAs and the fabric
Key Blocks used in FPGAs for imaging

Math Blocks/DSP

Memory Blocks

I/O Gearing

Processor/Micro

AP/uP/uC
Multi-Camera Applications with MIPI CSI-2

- 3D camera / Virtual Reality
- Dual Surveillance
- Multiple Image Sensor HDR
- 180 Degree Surveillance
- 360 Degree Panorama
- Surround View Automotive
- Depth Detection Applications
- Drone Usage
Although ISP devices often have multiple camera inputs they often benefit from an FPGA, which helps in synchronizing the image sensors & arranging them.
The FPGA can arrange the image in a side by side or a top bottom configuration. This makes it easier for the ISP or AP to process the image.
Dual Surveillance camera

Although ISP devices often have multiple camera inputs they often benefit from an FPGA which can arrange the image

- Both images are recovered in the FPGA
- The FPGA combines the two images into one for the ISP – often a top bottom configuration
- This allows an ISP to process the two images as one, but the output can be split into two images
Each image sensor captures frames at exactly the same time. A short, medium and long exposure is used for each.
Image Sensor HDR processing

Short, medium and long exposure images. Processed using local and global tone mapping, motion artifact correction, etc.
180 degree Surveillance camera

The image stitching function is more easily done in an FPGA. In this design, the entire ISP could also be in the FPGA.
180 Degree Surveillance FPGA Function

- Multiple images are recovered in the FPGA
- The frames are stored likely in external memory
- The FPGA performs an analysis to determine where to merge the image
- The images are stitched together
- Also likely a smoothing technique is used
- The image output is then processed in the FPGA or formatted and passed onto the ISP or AP
Each image sensor frames are captured and combined. Image processing could be in the FPGA or AP/ISP.

360 Degree Cameras

- Image Buffer Memory
- FPGA with stitching, fisheye correction, etc
- SoC / AP

CSI-2
360 Degree Cameras

- The FPGA performs an analysis to determine where to merge the images
- The images are stitched together
- Depending on the output format, fisheye correction may be implemented
- The image output is then processed in the FPGA or formatted and passed onto the ISP or AP
Surround View Automotive

FPD3 Link to MIPI CSI-2

FPD3 Link to MIPI CSI-2

Frame Buffer memory

FPGA

Camera Video Processor

CSI-2
Surround View Application

- The FPGA implements the stitching of the images
- It formats the image for the ISP/AP
- or FPGA processes the image and drives the display
- FPGA could add overlay such as directional lines
Multi camera for depth detection

The FPGA processes all the images and provides the lowest possible latency for highest accuracy & response.

Could be one or more pairs

Image Buffer Memory

FPGA syncs dual camera pairs & does the processing

Digital Video Processor
Multi cameras for Depth-Based Analytics

The FPGA or AP computes 3D point cloud from a top-down stereo pair.

Depth-based analytics can distinguish adults, kids, people from shopping carts for accurate people counting.

The FPGA synchronizes each camera pair and processes what each camera pair sees.

Parallel processing of the FPGA gives quickest response & accuracy.
These dual cameras allow a drone to "see"

The FPGA can merge, mux, pre-process, and run analytics pre-processing before the AP gets involved for 3D point cloud.
Summary

• Rapid adoption of MIPI CSI-2 in applications such as surveillance, automotive, drones, robotics and machine vision
• FPGAs provide a big advantage in multiple camera design due to parallel processing, abundant I/Os and easy interfacing with ISP/AP/Processors
• Most multi-camera applications require a mid-range FPGA which can optimize costs and performance (low-power, reliability and security)
Thank you for attending MIPI Devcon 2017

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