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High Speed Camera for Fast Moving Objects

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Abstract.

This paper describes an intelligent high speed video camera system for industrial application. The system is based on a specially designed high speed DSP platform. This architecture gives us opportunity to achieve real-time image processing to the information from the sensor internally into the camera device. The camera is based on a modular construction which gives the advantage of flexibility to use different sensors according the specifications of the analyzed objects.

1 Introduction

We introduce a system for capturing multi-thousand frame-per-second (fps) digital images using a high speed image sensor. Even at full frame rate our system supports continuous streaming of digital image sequence from the cameras. Creating a stand alone high-speed camera with implemented all functions and blocks in one body is our main purpose. This architecture would provide us a lot of state of the art functions and possibilities like non expensive system, mobility, mounting in different environments and flexibility. To cover all the requirements, our system had to be designed to cover following points:

- To track high speed objects with different shape and dimensions
- To determine the movement vector of the object
- To determine image characteristics
- To control automatically the exposure and lens adjustments
- Buffering the image sequence in the camera
- Recording data for archive or post processing
- Standard digital interface for data stream
- Low consumption
- Low light operation

2 Decision

Our team used following methodology for system design:

- system architecture design
- component verification
- schematic design
- PCB design
- Prototyping
- Software tools
- Adjustments including the use of image processing
- Tests

After deep research for the available systems and components, our team decided to use the following architecture (Figure 1).

Image sensor – image sensor which we use is 128×96 pixels with 580 fps. The structure of the sensor is shown at Figure 2.

The sensor is with 20 um$\times$20 um pixel size, which gives us excellent sensitivity (22 Volt/lux.s). Type of sensor is CMOS this allows to achieve low consumption and small mechanical dimensions system design. As is seen from Figure 2 all sensor controls are implemented into the chip and all adjustments are made via serial interface. We can control sensor parameters directly via DSP.

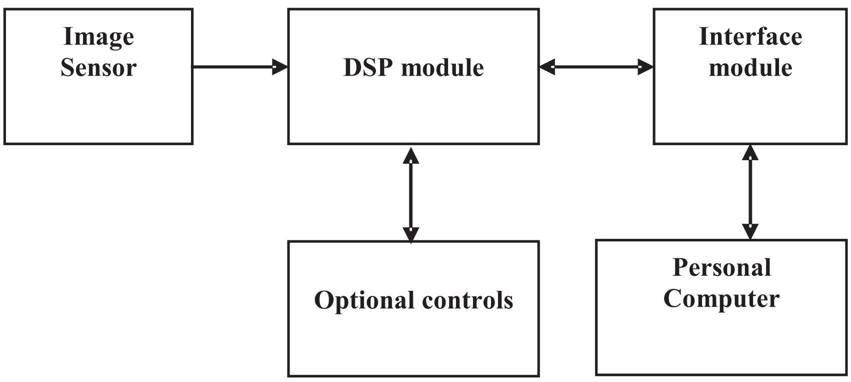

Figure 1. System architecture.

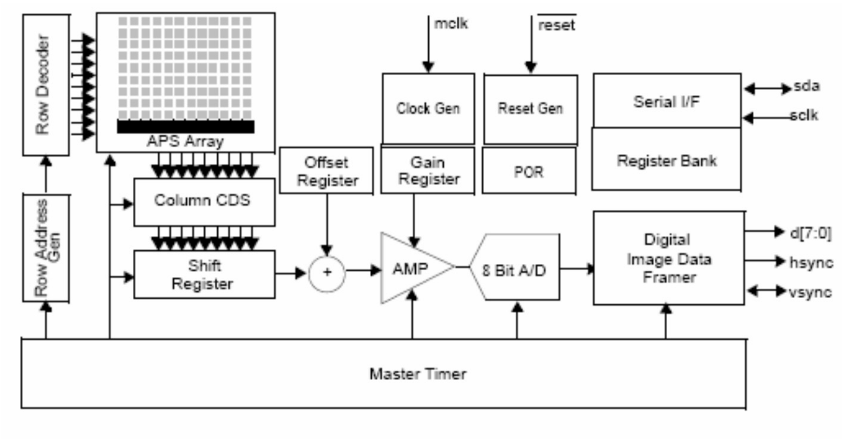

Figure 2. Image sensor blocks.

DSP module – this is the heart of the camera. The structure of this module is shown at Figure 3.

DSP which we use is of the company Analog Devices. It is from BlackFin family with 32 bit architecture and working frequency of up to 400 MHz. For internal for the camera image buffering we use 64 MB PC133 SDRAM in which we can buffer up to 8 sec. of image sequence. DSP module can make image processing before send data to the personal computer.

Interface module – this module connects the camera to visualization or storage device – we have used for this purpose personal computer as it is universal and not expensive decision. Due to module architecture of the camera we offer two types of standard interfaces – USB 2.0 or Ethernet 10/100. USB interface is

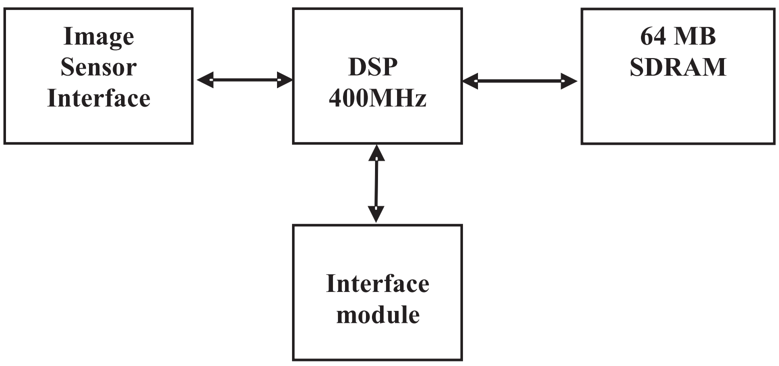

Figure 3. DSP module structure.

preferred by us because of its speed. System supports USB 2.0 high-speed specification, which means that theoretically we can achieve 480 Mb/s transfer rate. The real continuous transfer rate which we achieved is 80 Mb/s. This speed give opportunity to capture lossless data at full speed of the sensor (580 fps) without compression and information losses. Ethernet 10/100 module is very convenient if there is built Local Area Network or the camera must be installed far away from the computer. The real continuous transfer rate, which we can achieve via Ethernet interface, is around 24 Mbit/s. This speed does not give the opportunity to transfer lossless all image sequence. Maximum image rate without compression is around 200 fps or 8 seconds at 580 fps which are buffered in the internal memory. Camera configured for Ethernet architecture can be adjusted for broadcasting image sequence and in this way multiple recipients can use the results. Other advantage of LAN is that one computer can collect information from multiple cameras. Different configurations are given at Figure 4 and Figure 5.

Figure 4. USB connection architecture.

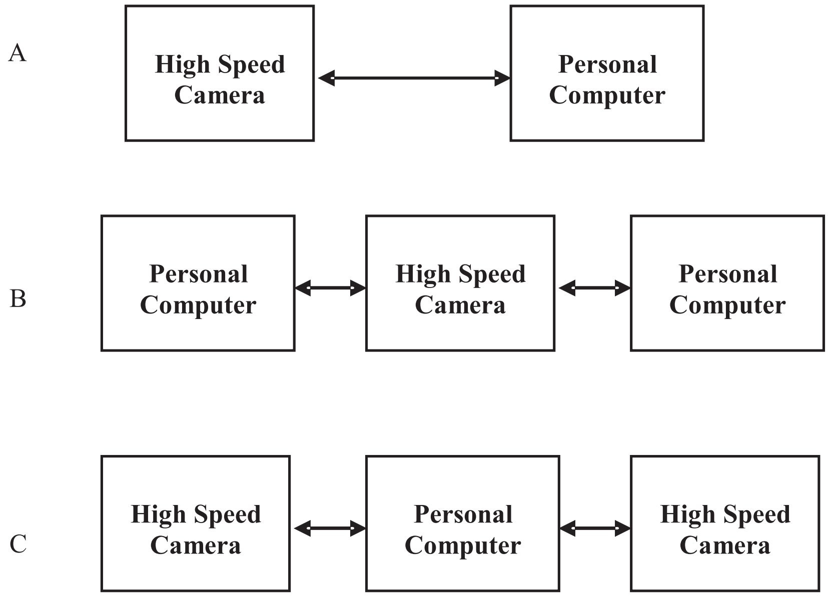

Figure 5. Ethernet 10/100 connection architectures: A – point to point, B – multiple computers, C – multiple cameras.

3 Results

At Figure 6 are given some photos of the high speed camera modules and already ready system.

Figure 6. High speed digital camera.

4 Conclusion

Our team succeeded to develop very flexible high speed digital camera. It can be used in very large fields of applications like astronomy to track fast moving objects like meteors or explosion detections.

References

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