FastEye—A 1 MP High-speed Camera with Multiple ROI running at up to 64'000 fps

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Visually monitoring fast-changing scenes and processes is a challenge for standard industrial camera systems as smearing and rolling-shutter effects impair the quality of the recorded images. To address these problems, the FastEye high-speed camera system was developed. It features a CMOS image sensor with global shutter, frame rates of up to 64'000 frames per second and a user-friendly USB 3.0 interface.

Capturing fast moving objects with a minimum of smearing effects and other artifacts is one of the main challenges with respect to high-speed camera design. High frame rates, short exposure times and low noise levels are therefore crucial elements for high quality imaging of rapidly changing scenes. Here, we present the FastEye high-speed camera, featuring a 1024×1280 pixel image sensor, which was developed at CSEM. Multiple regions of interest (ROI) can be set, with exposure times down to 500 ns, enabling frame rates of up to 64'000 frames per second (fps). A USB 3.0 interface provides connectivity to a computer, where the sensor and the acquisition logic can easily be controlled via Matlab.

Figure 1 shows the implemented VIA1M imaging sensor. It features 12 µm pixel pitch, full well capacity of > 150 ke- and achieves a SNR of > 52 dB. A row readout time of 1 µs combined with parallel top-half and bottom-half sampling allows frame rates of up to 2'000 frames per second at full resolution. By reducing the number of active rows, the time for reading out a frame is linearly reduced, making 32 x higher frame rates possible at the minimum resolution (32×1120 pixel).

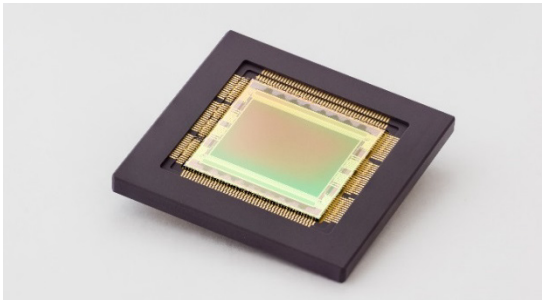

Figure 1: VIA1M image sensor.

A Xilinx Kintex-7 FPGA is used for interfacing the image sensor, making it possible to achieve the high data rates and bus widths required for reading out the parallel image data. The FPGA controls the sensor timing and functionality. It translates commands received via USB into sensor signals and buffers the captured images in on-board RAM before streaming them out to the connected PC. Firmware can be loaded through the USB interface, enabling simple updates of both the FPGA and the sensor firmware. Pixels are sorted in real-time inside the programmable logic, reducing image reconstruction time in software. For specific applications, further pre-processing capabilities, such as computer vision algorithms or object detectors, could be configured within the available FPGA logic, simplifying post-processing of the images. The Matlab script provides abstracted commands for controlling the sensor settings like the exposure time or frame periods. Additionally, it allows different customised settings to be stored in a user-friendly format such that image-acquisition sequences can be easily set up.

The camera features an input for external trigger sources, allowing events to be captured automatically without any human interaction required. In order to support a large number of objectives, which might be necessary for certain applications, the camera is equipped with a standardized Nikon F mount or alternatively with a Nikon C mount. Figure 2 shows the FastEye system with a normal 50 mm objective mounted.

Figure 2: FastEye camera.

The FastEye camera can be used for a wide range of applications where rapid movements need to be captured:

- Testing–Crash tests for mechanical qualification processes.
- Security–Surveillance of fast changing environments or mounted on moving platforms.
- Industrial–Monitoring moving parts of machines to detect anomalies and predict failures.
- Automotive–Obstacle detection within limited reaction time.

In Figure 3, a frame from a 2 kfps video is displayed showing the impact of a water droplet during the camera tests.

Figure 3: Screenshot from a test video recorded with FastEye.

Here we have shown a user friendly high-speed camera, offering 500 ns exposure times with 1 MP resolution for industrial applications.