Rolling shutter effect – unavoidable?
Using rolling shutter with global start

Capturing moving objects with rolling shutter sensors produces bizarre results. Helicopters fly with bended propellers or vehicles are distorted along their direction of travel. Is a rolling shutter sensor unsuitable for capturing moving objects? The answer is no, thanks to special operating modes such as the global start mode of the 5 MPix sensor MT9P031STM from ON Semiconductor.

Background

Basically, the requirements for an image capture are always the same: recording of an event or subject with a recognizable and distortion-free result. The exposure duration is controlled via an electronic shutter, that is, how long light falls on the photosensitive surface. The image is recorded in the sensor in four phases:

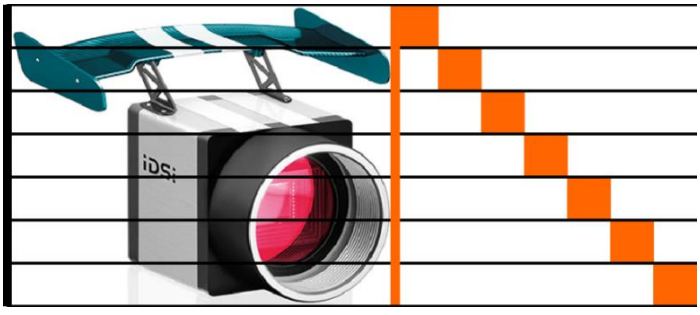
- Reset pixels of the rows to be exposed
- Exposure of pixel rows
- Charge transfer on the sensor
- Data readout

There are two different methods: First, the global simultaneous recording using global shutter, which is mostly used in CCD sensors. Second, the time-rolling recording using rolling shutter which is used in CMOS sensors.

Functioning of global and rolling shutter

Global shutter

The functioning of global shutter sensors corresponds to the classical clapperboard: all pixels are exposed simultaneously.



Global shutter

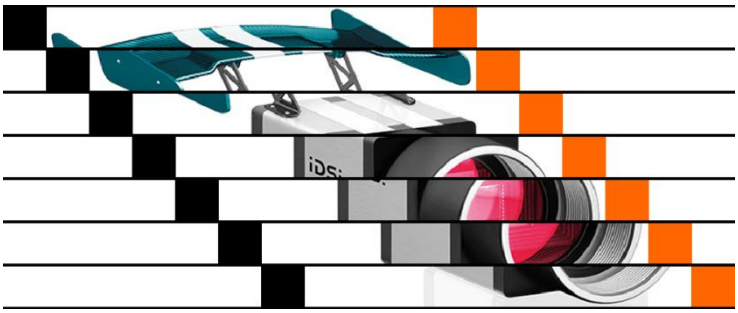
First, all pixel rows are reset. Afterwards the exposure starts. At the end of the exposure, all rows are simultaneously moved to a darkened area of the sensor. The pixels are then read out row by row and transferred as digital values.

All uEye CCD sensors as well as some CMOS sensors use the global shutter method.

Advantages	Disadvantages
All rows are exposed simultaneously	Smallest pixel size 3.45 µm
No compromises on applications	Requires complex and expensive sensor technology
No „distortions“ of captured objects	Occuring of hot pixels at high temperature and long exposure time

Rolling shutter

The rolling shutter works like a camera with a focal-plane shutter, that means the rows are not simultaneously but sequentially exposed and read-out from top to bottom.



Rolling shutter

On a rolling shutter sensor, the pixel rows are reset and exposed one row after another. At the end of the exposure, the lines are read out sequentially. As this results in a time delay between the exposure of the first and the last sensor rows, captured images of moving objects are distorted or stretched.

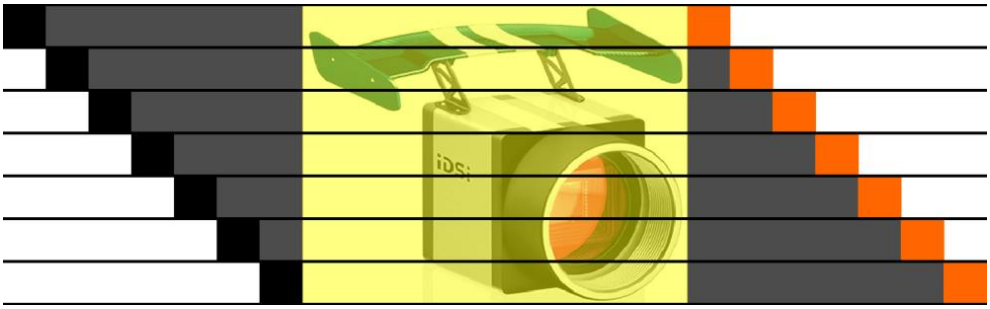
Advantages	Disadvantages
Very high resolution with small optical format	Moving objects causes artefacts during image recording
More noise-free compared to global shutter	The shutter moves from top to bottom
No memory cell: simple pixel structure, allows very small pixels up to 0.9 µm	Rolling shutter effect: positional error when capturing moving objects

Avoiding the rolling shutter effect

Global exposure window

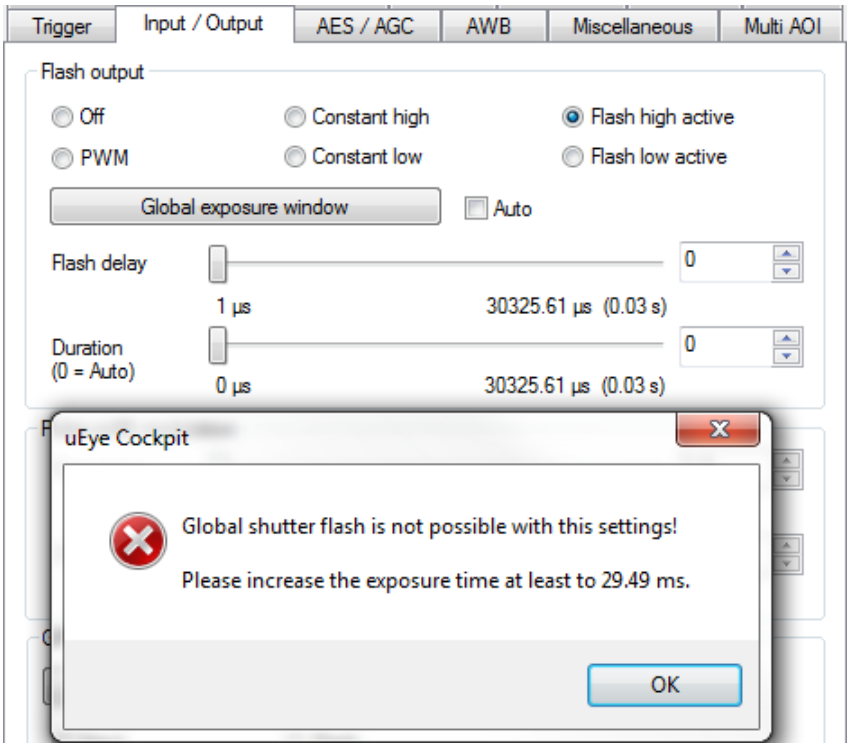
To counteract the disadvantages of the rolling shutter, especially the rolling shutter effect, you can use a global exposure window in uEye Cockpit. This allows implementing a global flash functionality which exposes all rows of a rolling shutter sensor simultaneously like a global shutter sensor. Keep in mind the following items:

- Your application supports flashing
- Make sure that no ambient light falls in.



Rolling shutter with global exposure window

For the global exposure window, you set a delay time by which the flash activation is delayed. You can also specify the flash duration.

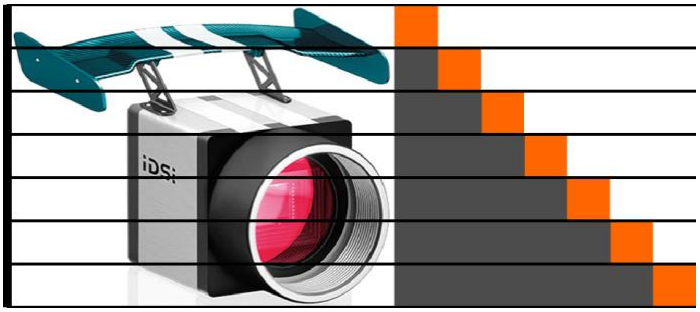


Global exposure window in uEye Cockpit

If you set the global exposure window, the driver calculates automatically the right flash timing. If the set exposure time is too short you will get a hint with the minimum exposure time. It may take a few images until the flash timing is adjusted.

Rolling shutter with global start

A further possibility offers rolling shutter sensors with a special mode, the global start mode.



Rolling shutter with global start

The global start mode ensures that the exposure of all rows starts simultaneously. For best results, use a flash for this mode.

No light is allowed to fall on the sensor outside the flash period because otherwise the image brightness will be distributed unevenly.

Summary

Due to the huge progress in CMOS technology, the problems like limited long exposure or rolling shutter effect have hardly any effect on applications.

As CMOS sensors have a different design, they have a higher pixel density and thus a greater resolution than CCD sensors.

Shutter modes of CMOS sensors

Camera	Global shutter	Rolling shutter	Rolling shutter with global start
UI-122x/UI-322x/UI-522x	x		
UI-124x/UI-324x/UI-524x	x	x	x
UI-125x/UI-325x/UI-525x	x	x	x
UI-146x/UI-546x		x	
UI-148x/UI-348x/UI-548x		x	x
UI-149x/UI-549x		x	
UI-154x/UI-554x		x	
UI-155x/UI-555x		x	
UI-158x/UI-358x/UI-558x		x	x
UI-164x/UI-564x		x	
UI-3013XC		x	

Camera	Global shutter	Rolling shutter	Rolling shutter with global start
UI-306x	x		
UI-336x/UI-536x	x		
UI-337x/UI-537x	x		
UI-359x		x	

For more information on configuring and using the different shutter modes, refer to the uEye manual at http://en.ids-imaging.com/manuals-ueye.html.

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