HOW TO ?

Understand global shutter

C-BLUE ONE

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Table

Glossary

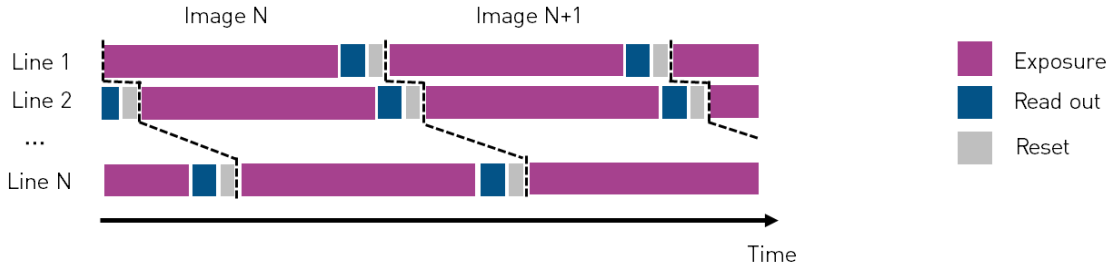
- **HDR**: High Dynamic Range
- **ADU**: Analog Digital Unit
- **HG**: High Gain
- **LG**: Low Gain
- **ADC**: Analog to Digital Converter
- **NUC**: Non Uniformity Correction
- **IWR**: Integrate While Read
- **ITR**: Integrate Then Read
- **FPS**: Frames Per Second
- **CDS**: Correlated Double sample

A short introduction to global shutter .....

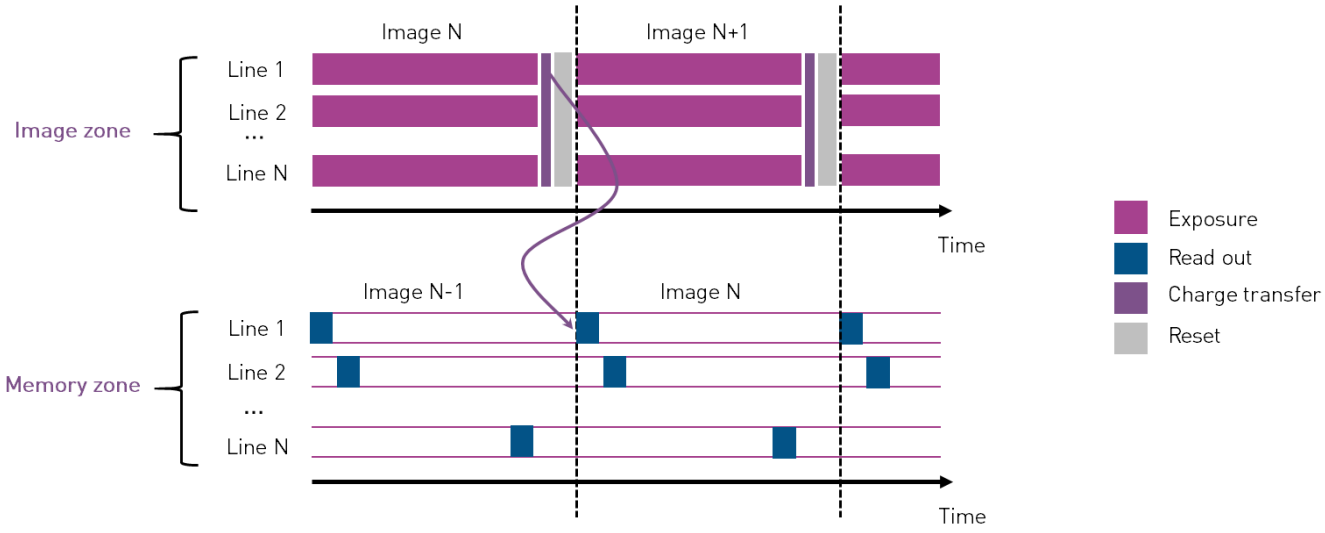
C-BLUE One is a high performance scientific CMOS camera. The 1608-by-1104 pixels sensor can be run at 662 FPS in full frame. To ensure the lowest latency, the camera uses CoaXPress 2.0 cables. A key feature of the camera to enable artefact-free acquisitions in dynamic imaging is the global shutter mode.

For a CMOS sensor, there are two ways to acquire an image:

1. **Rolling shutter.** The acquisition is made one line after the other, the sensor reads each line of the array sequentially. Pixels are exposed with a temporal shift from one line to the next.



2. **Global shutter.** The full array is exposed entirely at once. All the pixels begin and end the exposure simultaneously. At the end of exposure, the image is transferred to the memory. Then, the image is read-out while the next one is being exposed.



The acquisition mode is an intrinsic characteristic of the camera. However, it is important to understand the differences that will occur in an experimental context when using a camera with rolling or global shutter.

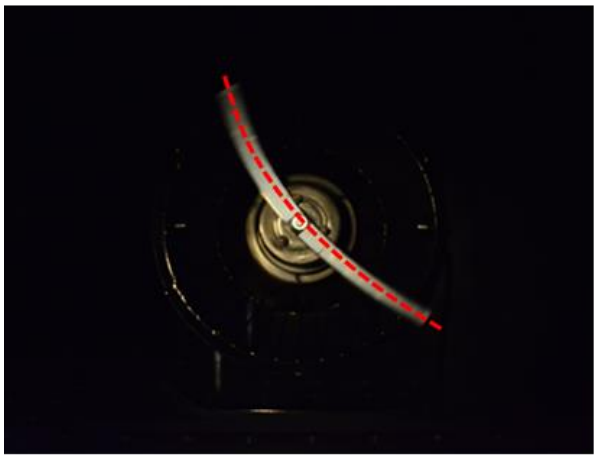
Global shutter is highly advantageous for dynamic imaging applications. **Let's see why.**

Artefact free. In rolling shutter when the image readout speed cannot match the object's motion, there is temporal under sampling. A spatial distortion of the moving object, often referred to as the 'rolling shutter effect' appears. The larger the object and the faster the movement, the worst is the distortion. Additionally, as the sensor gets larger and with a higher resolution, the readout of the sensor will take longer, hence, the distortion will get worse.

This artefact is different from motion blur which occurs in both global and rolling shutter when the integration time is too long compared to the object's speed.

A well-known example of the rolling shutter effect occurs when imaging the rotation of blades or propellers. The figure below shows images of a rotating fan acquired in both rolling shutter mode (with a Nikon D500 camera) and global shutter mode (with C-BLUE One). Significant spatial distortion of the fan propellers is visible when using rolling shutter.

Rolling shutter



Nikon D5200
(1/1250, F/9, ISO 2000)

Global shutter

C-BLUE 1
(FPS 481, TINT 0,08 ms, GAIN High 24 dB)

Temporal correlation. Even in the absence of distortion the top and the bottom of an image acquired in rolling shutter will not be captured at the exact same time point. Different regions of the image are not correlated in time to other regions. Whereas with global shutter, all pixels are exposed at the same time, allowing for accurate temporal correlation of different areas of the sensor.

Simpler and faster synchronization. Synchronizing a rolling shutter camera to other components, such as a light source, can be difficult due to the time delay between the lines of the sensor. This may result in slower cycle times and frame rates relatively to those achievable in global shutter.

Why is C-Blue One a game changer? .....

Rolling shutter uses simpler pixel architecture than global shutter. Therefore usually rolling shutter is less noisy than global shutter, this is why this architecture is used in scientific applications but with all its drawbacks. **With C-Blue One, simultaneously and for the first time a global shutter architecture and low noise is made possible, which is a major improvement for fast acquisition scientific applications.**

By combining a global shutter and high framerates (up to 662 FPS in full frame) to very low noise, C-BLUE One opens new perspectives for applications that simultaneously require truthful/deformation-free images, high temporal resolution, and high sensitivity.

ABOUT FIRST LIGHT IMAGING: When astronomers and engineers design a new scientific instrument, there is a very special moment. It happens the first time the instrument is set on the telescope, looking at the sky. When light coming from the universe trickles down the system and ultimately falls on the detector. From this moment on, observations can begin, theories can be tested, science can be made.

We call this moment the First Light.

At First Light Imaging, we make the invisible visible. Since 2011, we design and manufacture cutting-edge scientific cameras that combine exceptional sensitivity and very high frame rates in both the visible and infrared (SWIR) spectra, based on state-of-the-art sensors (EMCCD, CMOS, e-APD, and InGaAs). Coming from French academic research laboratories, multiple award-winning, First Light Imaging focuses on providing customers in astronomy, research, biology, and high-end industry with the utmost performance capabilities.

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