Global shutter

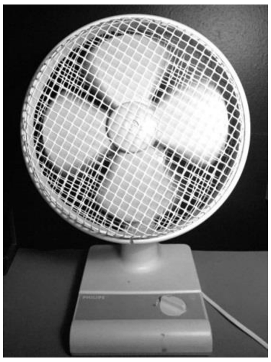
APPLICATION NOTE

Introduction

High-speed imaging is used for many applications. In-line process- and quality control systems use high-speed cameras for automated inspection of parts or to read the barcode of products moving down the manufacturing line. Traffic surveillance cameras need to record license plates of cars moving at motorway speeds in a split of a second. Advanced driver assist systems in modern cars uses high-speed cameras to detect inadvertent lane changes and unexpected threats. Other applications include recording of motion pictures and sports events when slow motion playback is desired, analysis of failure mechanisms of mechanical parts, as well as various R&D applications in which fast processes are being studied.

Problem

CMOS sensors have become the standard for imaging applications due to faster readout and lower cost than CCD sensors but with similar sensitivity. Traditionally such sensors have an electronic so-called rolling shutter mechanism as this is the simplest design and gives the highest fill-factor. With this type of shutter, blocks of pixels are exposed sequentially so that there is a time lag between the light exposure of the first and the last pixels in the sensor array. This works well for imaging of relatively slow moving objects that does not change much during the time it takes to expose all the pixels. But for fast moving objects the different parts of the sensor will capture a changed image, resulting in artefacts such as skewing and bending of objects, or even making objects look like they break up in several parts. Solid objects looking like wobbling gelatin is another common artefact if the object or the camera is vibrating. To prevent these artefacts high-speed imaging requires a so-called global shutter that provides simultaneous and uniform exposure of the whole image sensor. Electronic global shutter function can be implemented in CMOS sensors but this requires more transistors in each pixel area, thus increasing the complexity of the design as well as reducing the fill factor. This translates into a more expensive image sensor with lower sensitivity.



Left: Image captured using a simple rolling shutter sensor. Right: Same sensor together with LC-Tec's X-FOS(G2)-CE-AR global shutter.

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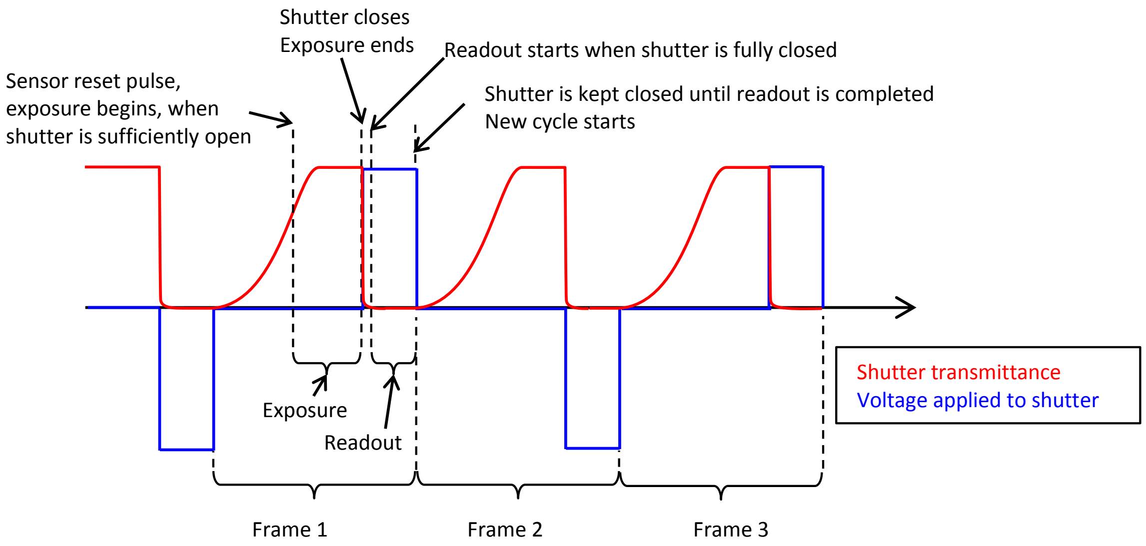
Solution

One way to circumvent the problems with electronic global shuttering for CMOS sensors is to use a global shutter in form of a liquid crystal (LC)-based fast optical shutter. In this way the exposure control is decoupled from the electronic circuitry and readout, allowing for a simpler CMOS design. The pixel area can be fully utilized for light harvesting to give optimized image quality. This is a way to achieve high quality, high-speed imaging at a competitive cost. LC-Tec's **X-FOS(G2)-CE-AR** fast optical shutter offers high-speed operation together with high contrast between open and closed states, making it ideal for high-speed camera applications. The shutter is comprised of LC cells sandwiched between crossed polarizers. As a voltage is applied to the LC cell the birefringence is tuned, the polarization state is modulated, and hence the transmittance through the shutter is controlled. By clever device design the reliable and ruggedized X-FOS(G2)-CE-AR offers a contrast ratio exceeding 120,000:1. Closing and opening times are less than 50µs and 1.6ms, respectively.

The figure below shows the proposed camera operation. First the image sensor pixels are set and held in a reset state until the start of the image capture. Then the shutter is opened and when fully open the pixels in the image sensors are set to start to record. The shutter is kept open for the desired duration to get sufficient light exposure and is then globally closed. Finally the pixels are read out in whatever readout mode suitable for the image sensor chip. Note that this does not have to be a parallel readout as the pixels are no longer exposed to light and the information is safely retained until the start of the next capture frame. When the readout has been completed the cycle can start over again and the next frame is recorded. Frame rates up to 500 FPS can be achieved, making this a competitive solution for area scan cameras.



Main characteristics

	X-FOS(G2)-CE-AR
Open state transmittance	29.0%
Contrast	≥120,000:1
Closing time (T_{100}-T_{10})	≤50µs
Opening time (T_0-T_{90})	≤1.6ms
Size	Custom designing up to 14 x 16 inches

For more information, please contact us at: info@lc-tec.se.