About electronic and mechanical shutters

In an attempt to alleviate any confusion regarding the operation of, and the interaction between, the mechanical and electronic shutter in the Viper FilmStream Camera, we would like to provide the following for your information.

First of all, any CCD imaging device is sensitive to light at all times. Photons generate free electrons whenever light is falling on the sensor. If the camera is used with only the mechanical shutter, this process of generating free electrons only stops when the shutter blocks the light.

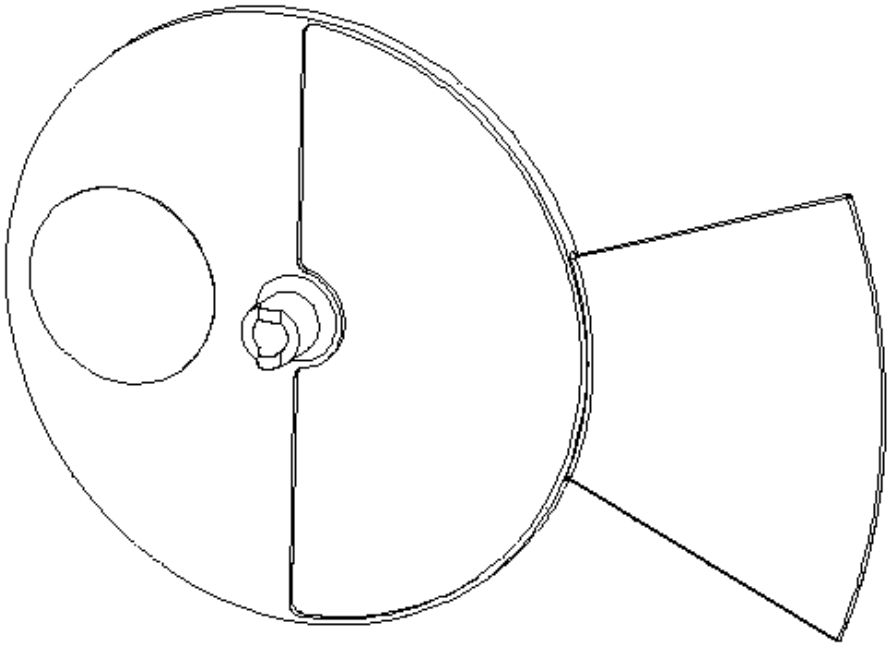

Figure 1. The mechanical shutter

The mechanical shutter as depicted in figure 1 has a fixed size, so there are no mechanical changes being made to adjust the exposure time. With only a mechanical shutter the shutter angle would be 312 degrees. In the Viper FilmStream Camera, the width of the mechanical shutter blade is already accounted for in the shutter angle settings of the camera setup menu. The electronic aspects of shutter angle settings via variable exposure time are accomplished as described further on.

While we cannot prevent electrons from being generated by light, we can decide whether we want to use them as imaging electrons that are captured electronically by applying voltages to sensor pins. We can decide to dump generated electrons in the substrate of the sensor by changing the voltage on the pins.

So how to create a variable exposure time in the sensor?

1. Light entering the lens and camera prism generates electrons in the pixels
2. Until such time as we are ready to start sensor exposure time we can decide to dump the collected electrons to the substrate, where they can be dissipated and not generate any image material.
3. At a subsequent, calculated point in time, integration as an image on the pixel begins, building up a charge on the CCD.
4. When the CCD completes its charge cycle during the imaging period, the mechanical shutter spins into position, blocking the light, ending the exposure time, the imaging cycle.
5. With the mechanical shutter covering the sensor, the charge is transported quickly to the storage area of the sensor. This storage area of the sensor is identical to optical portion of the sensor system, except that it is permanently covered, allowing no light input, and it is separate from the imaging portion of the sensor system.
6. After the charge is transported, the mechanical shutter rotates out the closed phase, once again exposing the CCD to the outside light path, and we start a new charge / transfer cycle at the beginning.

By changing the timing between step 3 and step 4 in the above procedure we can tune the exposure time to the CCD, or the shutter angle.

What happens when the mechanical shutter is switched off?

If the mechanical shutter is switched off, generation of electrons continues even during transport of the charged image from the imaging portion of the sensor, to the storage portion. This may (depending upon the highlights in the image) cause vertical stripes across highlights, also known as smear.

Suppose we have a one-pixel highlight and a shutter angle of 180 degrees, i.e. an exposure time of 1/48 second.
There is one pixel actually seeing the highlight for 1/48th second, and the pixels that have to go past the position of the highlight during the transport to the storage area only see the highlight for a very short interval while they are transported. This passing through one pixel position takes far less than a microsecond.
The smearing level is proportional to the ratio of transport and exposure. So, in scenes with no highlights you can switch off the shutter without getting any visible smear, provided that the electronic shutter time is not too short. In practice: when the electronic shutter angle is not set below 180 degrees. When set at the maximum of 353 degrees, even two stops overexposure is allowable without resulting in smear.

So, why switch off the mechanical shutter?

As 24P has a slow frame repetition in comparison to PAL or NTSC video, it is not necessary to switch the shutter off when shooting CRT screens. Shooting CRT's with the Viper FilmStream Camera has the advantage that CRTs can be "shot" directly by simply "tuning" the exposure time / Shutter Angle even when the mechanical shutter is on.

So, the only remaining reasons to switch off the mechanical shutter are:

- To gain some sensitivity because the shutter angle can then be increased from 316 tot 353 degrees
- To create more motion blur
- To get a full-frame exposure to derive super-motion speeds in post. For example, suppose you want to get double-speed pictures with 180 degrees effective shutter angle. Then you expose at maximum shutter angle, and only use every odd frame to create a new sequence that has exactly the same look as a 12 frame per second camera at 180 degrees shutter angle. In the same way, 6, 3, 2, 1 frames per second cameras can exactly be simulated.