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## **Lu120 and Lw620 Dual Slope Configuration Application Note**

### **Explanation of How the Dual Slope Works**

The dual slope feature of these cameras enables the capturing of images with a greater dynamic range.

One of the most difficult things for cameras is to capture images with very bright areas in the Field Of View (FOV) along with very dark areas. In order to be able to see details in the bright areas, the camera needs to use a low exposure value. This causes details in the darker areas to not be visible. To get the details in the darker areas, the exposure needs to be higher and thereby saturating the bright areas and losing details. Many applications require balancing how much exposure is applied so that they can get a reasonable detail in both areas.

To overcome this issue, the Lu120 and Lw620 cameras have a mode whereby they can increase the dynamic range of the visible data. This mode is referred to as the dual slope mode. When the camera is in this mode, it is able to get details out of the brighter areas and the darker ones within the same image. In simple terms, the camera takes two images, one with a large exposure and one with a small exposure and combines them together into one image. The process to combine these images is as follows. The user selects a threshold value. This threshold value determines the pixel intensity whereby the camera will select when it should use a pixel from one of the images taken (bright image or dark image). The camera first looks at the image taken with the longer exposure. If a pixel's intensity is greater than the predefined threshold value, it will take the same pixel in the short exposure image instead.

The actual process in which this is achieved is as follows. The camera is initially set to a really long exposure, say  $E_l$ . A threshold value,  $T$ , is determined and set in the camera. Finally, a short exposure,  $E_s$ , is set in the camera. When an dual slope image is taken, the camera exposes every pixel at the same time. When the integration time reaches  $E_l - E_s$ , the camera resets all pixels that are above the  $T$  threshold value down to the  $T$  threshold value. The camera continues integrating until it reaches the total exposure,  $E_l$ . This produces an image that has high dynamic range. There is detail in the brighter areas of the FOV while still maintaining detail in the darker areas. Below are some pictures taken with and without dual slope enabled.

Figure 1 shows an image taken with the Lw620 with a long exposure. The exposure used was 16.7ms. As you can see it is really hard to get details in the upper windows, where the image is saturating.



**Figure 1 Image taken with Lw620 with long exposure**



**Figure 2 Image taken with Lw620 with short exposure**

Figure 2 shows an image taken with a short exposure, 1 ms. In this image, you are getting the tree detail in the upper windows but little to no detail in the rest of the image.

In Figure 3, you can see both the detail in the upper windows and the detail in the rest of the image. To achieve this image, the threshold value was set to 80, the  $E_i$  exposure value was set to 16.7ms and the  $E_s$  exposure value was set to 1 ms.

### Simple Analogy on How the Dual Slope Works

I will try to use an analogy to explain how the dual slope works on a pixel basis.

Let's say you have two cars, one Ferrari, and one Ford Escort. If at the start line the Ferrari is traveling at a rate of 100 mph and the Escort is traveling at 50 mph. In one hour, the Ferrari will be 100 miles ( $100\text{mph} * 1\text{h} = 100$  miles) from the starting point while the Escort is only 50 miles away ( $50\text{mph} * 1\text{h} = 50$  miles). We create a reset point at the 60 mile marker. Any cars that past this marker after one hour will be reset back to this point. Since the Ferrari reached this point and pasted it in well under one

hour, it is driven back to the 60 mile marker while the Escort stays in the same place at the 50 mile marker. The race is resumed with both of them traveling at the same rate of speed as they did prior to the reset. Twelve minutes later, the Ferrari is at the 80 mile marker ( $100\text{mph} * 0.2\text{h} + 60$  miles = 80 miles) while the Escort is at the 60 mile marker ( $50\text{mph} * 0.2\text{h} + 50$  miles = 60 miles). Since the Ferrari is traveling twice as fast as the Escort, they will never be at the same position at any given time (with the exception of at the starting line).

Taking this analogy and applying it to the Lw620's dual slope algorithm, the Ferrari would be a pixel exposed to a bright light that saturates quickly and the Escort would be a pixel exposed to a dim light. As the sensor is exposing the pixels, the bright pixel will saturate quickly. At some point in time that is defined by the knee point, the bright pixel is reset to the knee value and resumes exposure. The dim pixel value is not affected at the knee point. Both pixels continue to expose at the same rate they did prior to the knee point reset. These pixels continue to integrate until the final exposure is reached. Their respective



**Figure 3 Image taken with Lw620 with dual slope enabled**

new voltage is sampled to give each pixel its final pixel value.

### **Implementation of the Dual Slope**

These cameras have two different applications of the multislope (dynamic range), one for video mode and one for still mode. The ways in which they are applied differ. Both methods will be explained below.

For Video Multislope:

To setup the video multislope, call the following function:

```
LucamSetProperty(m_hCamera, LUCAM_PROP_VIDEO_KNEE, fValue, 0);
```

Where "fValue" can be integer values of 0-3 for the Lu120 and value of 0-255 for the Lw620.

The values above represent predefined knee points. They refer to voltage points (threshold values) defined by the hardware. A value of 0 turn off the multislope and value 1-3 turn it on. When using multislope, the imager sensor exposes the array for the maximum exposure. It does not use the exposure value programmed in the register. Instead this value is used as the new exposure for the values that exceed the threshold value. Values 2-3 are only noticeable in 16 bit mode.

For Still Multislope (only available with the Lu120):

To setup the still multislope, call the following functions to set the individual knee positions:

```
LucamSetProperty(m_hCamera, LUCAM_PROP_STILL_KNEE1_EXPOSURE, fValue, 0);  
LucamSetProperty(m_hCamera, LUCAM_PROP_STILL_KNEE2_EXPOSURE, fValue, 0);  
LucamSetProperty(m_hCamera, LUCAM_PROP_STILL_KNEE3_EXPOSURE, fValue, 0);
```

Where "fValue" can be any exposure smaller than the overall exposure.

In this mode, the overall exposure is defined by the exposure value set in the exposure register. The individual knee positions can be set. They represent the time where the imager sensor will reset all values. The imager will reset the imager sensor at total exposure - knee exposure. All values that are saturated will be reset and will be integrated with the new exposure value. All three knee values can be used to almost eliminate all over saturated pixels.

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