Application Note:

Interline Image Sensor

Smear

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Revision 0

May 4, 2000

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1 Description

Smear is an excess signal that appears in the vertical CCD of an interline device that is illuminated by a bright spot. The image artifact appears as a dim vertical band that extends above and below the spot from the top to the bottom of the image. Smear results from light leakage into the vertical shift registers as a charge packet is clocked through a brightly illuminated area. Excessive smear is visually objectionable and reduces the dynamic range. The smear signal is proportional to the illumination intensity and the vertical height of the spot.

This procedure follows the long established practice (for video devices) of referring the smear to a measurement made using a bright spot that illuminates 10% of the vertical height of the device active area. The smear *Smr* is the ratio of the smear signal to the bright spot signal, expressed as a percentage (%), or in decibels (dB).

To measure the smear, the sensor is illuminated with light from a tungsten source filtered with an IR-cutoff filter. A bright LED source may also be used for smear measurements. The image on the device should be a box-shaped spot whose vertical height is 10% of the vertical height of the active imager area. The smear signal should be the same intensity above and below the bright spot. The amplitude of the spot should produce a sensor output approximately 70% of the device saturation signal. The electronic shutter is not used for this measurement.

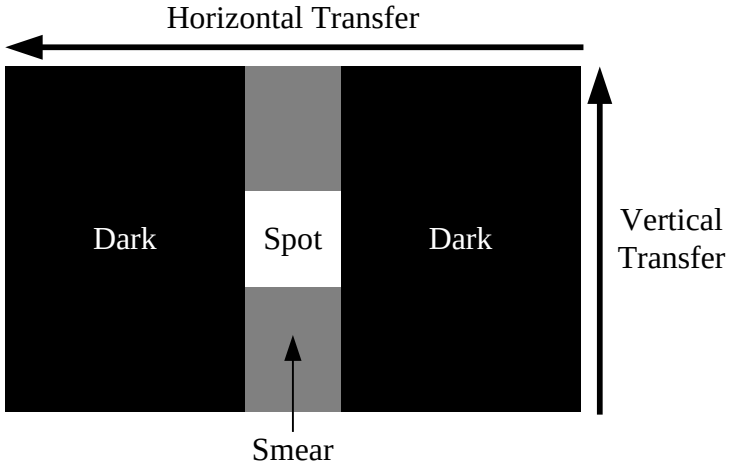

Figure 1 - Image regions used for smear measurement.

Sensor output pixel voltages are measured within the three regions shown in Figure 1. The output voltages V_{dark}, V_{spot} and V_{smear} are recorded. These pixel voltages are measured by recording the means of histograms obtained using rectangular regions of interest falling within the dark area, bright spot, and smear area. Each region of interest encloses at least 1000 pixels to improve the signal to noise ratio of the measurement.

The smear is calculated from the formula:

$$Smr = \frac{V_{smear} - V_{dark}}{V_{spot} - V_{dark}} \quad (1)$$

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2 Alternate Measurement Method

The smear values for modern interline devices are low (< 0.03 %) which makes performing the measurement difficult. An alternative procedure is to insert a neutral density filter of transmission T_{ND}, measure the spot signal V_{Tspot} and dark reference V_{Tdark} in the usual way and then, by removing the ND filter, use a much higher light level when measuring the smear signal V_{smear} and dark reference V_{dark}. The sensor at the bright spot will be saturated with the ND filter removed, but as long as the antiblooming feature of the device is functioning the smear measurement will be valid. The ratio of the two light levels must be known and this may be accomplished by using a calibrated ND filter to switch between light levels. The smear is then given by the modified formula:

$$Smr = \frac{V_{smear} - V_{dark}}{\left(V_{Tspot} - V_{Tdark}\right) / T_{ND}} \frac{L/10}{H_V} \tag{2}$$

where L is the number of active lines in the imager and H_V is the vertical height of the spot (in lines) actually used to perform the measurement.

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3 Examples

3.1 Traditional Method

Conditions:
800 by 600 pixel sensor
Frame Time = 100 milliseconds
Integration Time = Frame Time (no electronic shutter)
Spot Size = 80 by 60 pixels
Well Capacity = 4000 counts
V_{spot} = 3000 counts
V_{smear} = 103 counts
V_{dark} = 100 counts

The smear is calculated as:

$$Smr = \frac{103\text{cnts} - 100\text{cnts}}{3000\text{cnts} - 100\text{cnts}}$$

Smear = 0.1%

3.2 Electronic Shutter used

This example shows how the electronic shutter will effect the measurement of smear. All conditions are the same as used in the previous example, except the electronic shutter cuts the spot signal in half. The smear signal will remain the same. With the same amount of light and the same frame time, the charge leakage into the vertical shift registers will remain the same.
Conditions:
800 by 600 pixel sensor
Frame Time = 100 milliseconds
Integration Time = 50 milliseconds
Spot Size = 80 by 60 pixels
Well Capacity = 4000 counts
V_{spot} = 1500 counts
V_{smear} = 103 counts
V_{dark} = 100 counts

The smear is calculated as:

$$Smr = \frac{103\text{cnts} - 100\text{cnts}}{1500\text{cnts} - 100\text{cnts}}$$

Smear = 0.2%