Simple Procedure for measuring dark noise with ImageJ

The Signal-to-noise ratio (SNR) is the ratio of the input referenced signal level (N_{sin}) to the input referenced noise level (N_{noise}) at a given illumination level. SNR is typically calculated as:

$$SNR = 20\log (N_{sin} / N_{noise})$$

And, as expected with the equation above, a saturated signal level will produce the highest SNR value assuming the noise is not significantly increased. However, what value is a saturated signal other than knowing the pixel is saturated.

At saturated signal levels when the illumination is very high, photon-shot noise is the dominate noise source. At low light levels which are typical at high frame rates with very short exposure times, the dominant noise is the read noise.

For low illumination levels, the SNR increase with exposure at 20 dB per decade.

$$SNR = 20\log (N_{sin} / N_{noise})$$

At high illumination levels, the SNR increase with exposure at 10 dB per decade.

$$SNR = 10\log (N_{sin} / N_{noise})$$

In some SNR measurements, you may see 10 log or 20 log used and the reason for the two numbers has to do with the illumination level and dominant noise source.

We measure the RMS noise level by taking consecutive image pairs at a given illumination level, then subtracting the two images and determine the standard deviation of the difference between the two images. In the case of measuring dark noise, cap the lens for the two images. Subtract image b from a and determined the std dev of the resulting histogram. Then multiply the std dev by .707. This is your dark noise level. If you take the dark noise level and divided this value into the ADC range (12-bit = 4096) of the camera, you have the SNR ratio. Next, take the log of the s/n ratio and multiplied by 20 for the resultant dB value.

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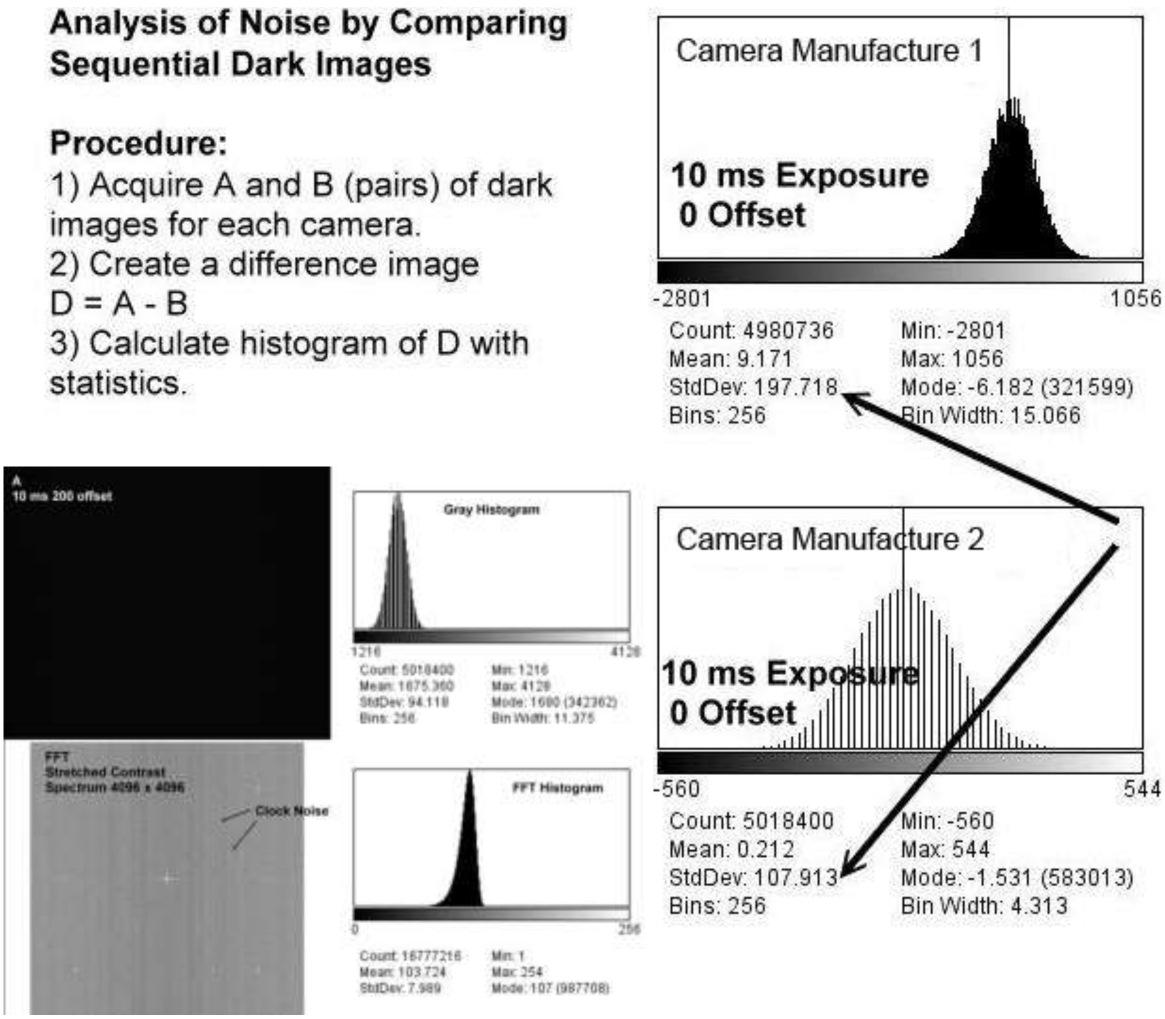
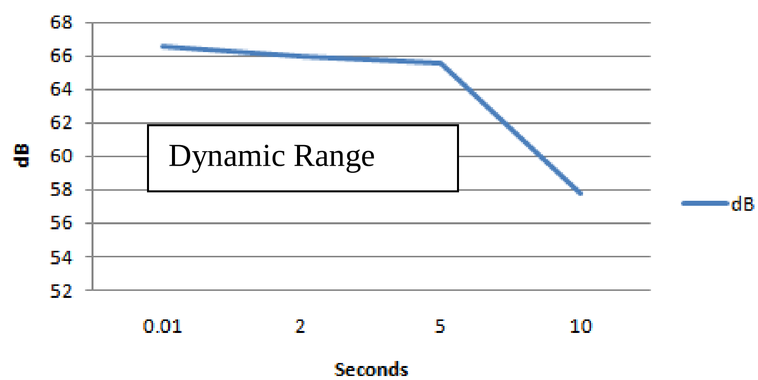
If you do this for various illumination levels and plot the results, you have a plot of the cameras dynamic range.





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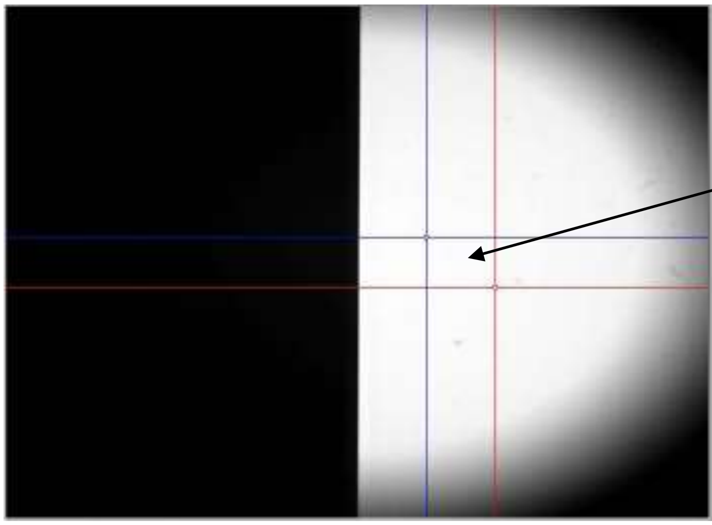
A similar method is to take the RMS noise using a half-moon target as shown below. Take the Average signal level and background levels of an image. The difference between signal and background values is the signal value. The square root of the sum of variances from the signal region is the RMS noise.



50 x 50 pixel average

The dark noise can be calculated by taking the difference of image A-B. Finding the histogram of the differences and taking the square root of the sum of these variances in the area above will give the RMS noise. In this case, the noise is derived from the signal difference rather than the dark level. This is done to get around the black level clamp that mask the dark noise level, assuming the clamp can be turned off.

In the ISO 12232 standard for sensitivity, there are two SNR type of measurements, saturated-based and noise-based. Noise-based measurements are the preferred method which produces the best indication on camera sensitivity.

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