



Memo Title: MityCCD Noise Analysis Summary
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This document explores some of the sources of noise in the MityCCD scientific camera. The level of contribution of each type of noise changes with the type of sensor and the application.

The major sources of noise are:

Shot Noise From Dark Current – Dark current is a thermally generated current, which stems from impurities in the silicon. Dark current in CCDs can be significantly reduced by cooling. Dark current itself is not a problem, since it is, on average, repeatable and can be subtracted off from images. Shot noise is a quantum noise effect related to the discreteness of photons and electrons [2]. It is a statistical component of the dark current and can be quantified as the square-root of the dark current.

Readout Noise – Readout noise contribution in a CCD is due to the readout electronics of the CCD, i.e. the on-chip amplifier.

Electronics Noise – Electronics noise is the noise generated due to the external hardware and gain circuitry in a CCD scientific camera.

The total system noise can be defined by the equation below [1].

$$\text{Total Noise} = \sqrt{(\text{Readout Noise}^2 + \text{Shot Noise}^2 + \text{Electronics Noise}^2)}$$

For short exposures, i.e. little or negligible contribution due to dark current shot noise the total noise can be calculated as

$$\text{Total Noise} = \sqrt{\text{Readout Noise}^2 + \text{Electronics Noise}^2}$$

The table below shows a comparison of some of the CCD scientific cameras offered by Critical Link and their performance.



CCDsp Model	MityCCD-E3011BI	MityCCD-E3011-BI DD	MityCCD-E3011- FI DD	MityCCD-E3011-FI	MityCCD-E3011-OE	MityCCD-H7031-1008	MityCCD-H9973-1008	MityCCD-H9971-1008	MityCCD-H10141-1008
Sensor	Back Illuminated	Back Illuminated, Deep Depletion	Front Illuminated , Deep Depletion	Front Illuminated	Open Electrode	Back Illuminated	Front Illuminated	Front Illuminated	Back Illuminated
Resolution	1024 x 256	1024 x 256	1024 x 256	1024 x 256	1024 x 256	1024 x 250	1024 x 252	1024x252	1024 x 250
Pixel Size	26 μm x26 μm	26 μm x26 μm	26 μm x26 μm	26 μm x26 μm	26 μm x26 μm	24 μm x24 μm	24 μm x24 μm	24 μm x24 μm	12 μm x12 μm
Typical Peak Output Signal	500 K ē/pixel	700 K ē/ pixel	700 K ē/ pixel	500 K ē/ pixel	300 K ē/ pixel	320 K ē/ pixel	480 K ē/ pixel	300 K ē/ pixel	75 K ē/ pixel
Temperature (from 20°C)	-55°C	-55°C	-55°C	-55°C	-55°C	-15°C	-15°C	-15°C	-15°C
Cooled Dark Current	.5ē/pixel/second	700 ē/pixel/second	300 ē/pixel/second	0.05 ē/pixel/second	0.1ē/pixel/second	1.5 ē/pixel/second	TBD	1.5 ē/pixel/second	0.8ē/pixel/second
Total Camera Noise (1ms exposure)	13.3 ē rms	14.0 ē rms	12.4 ē rms	12.4 ē rms	12.4 ē rms	11.4 ē rms	TBD	6.5 ē rms	TBD

Table 1 : MityCCD Camera Performance Summary



References

- [1] Hamamatsu Photonics K.K., Solid State Division, "Basic Imaging Concepts," Available: <http://learn.hamamatsu.com/articles/microscopyimaging.html> [Accessed: September 28, 2009].
- [2] Encyclopedia of Laser Physics and Technology, "Shot Noise", http://www.rp-photonics.com/shot_noise.html [Accessed :September 28, 2009].