1/3-Inch Wide-VGA CMOS Digital Image Sensor

MT9V023 RCCC Rev 3 Sensor Core Characteristics

For the latest MT9V023 RCCC data sheet, refer to Aptina Imaging's Web site: www.aptina.com

Introduction

This document defines typical sensor core characteristics for Aptina Imaging's MT9V023 RCCC CMOS digital image sensor. The values, as well as the measurement conditions, are defined. For a complete description, refer to the MT9V023 RCCC 1/3-inch wide-VGA CMOS digital image sensor data sheet. The specifications contained in this document do not supersede the specifications listed in the referenced data sheet.

Table 1: MT9V023 Rev 3 Image Sensor Core Characteristics

Symbol	Parameter	Measurement Conditions	Min	Typ[1]	Max	Unit	Remarks
Sg	Clear response	Condition 1	645	721	797	LSB[2]	^tINT = 1/60s
Rr	Response comparison	Condition 1	0.382	0.443	0.504		^tINT = 1/60s
Rb		Condition 1	NA	NA	NA		^tINT = 1/60s
VSAT	Pixel saturation signal	Condition 2	–	1022	NA	LSB	Gain = 0x01
σt	Readout noise	Condition 3	–	5.193	–	LSB	Gain = 0x04
		Condition 3	–	1.601	–		Gain = 0x01
VDARK	Dark current	Condition 4	–	641	–	LSB/s	T_S = 55°C, Gain = 0x01
PRNU	Photoresponse nonuniformity	Condition 5	–	0.66	–	%	Gain = 0x01
DSNU	Dark signal nonuniformity	Condition 6	–	0.044	–	%	Gain = 0x04
SNR	Signal-to-noise ratio	Condition 5	–	39.17	–	dB	Gain = 0x01
DynR	Dynamic range	Condition 6	–	57.72	–	dB	Gain = 0x04
Lag	Lag	Condition 7	–	–	–	%	

Notes:
1. Average based on over 30 sensors
2. LSB = least significant bit.

‡Products and specifications discussed herein are for evaluation and reference purposes only and are subject to change by Aptina without notice. Products are only warranted by Aptina to meet Aptina's production data sheet specifications.

Description of Measurement Conditions

All measurements are done at nominal power supply voltages, at default settings, and at ambient room temperature except where noted. For µlens shifted array, measurements are performed in the window 32 × 32 pixels (or 16 x 16 for each color plane) in the center of pixel array. All measurements in the dark are performed across the whole pixel array.

Measurement Condition 1

A standard pattern box (luminance 706 cd/m^2, color temperature of 3100K halogen source) is used as an illumination source. A lens with F5.6 and a standard CM500 IR-cut filter (t = 1mm) is used to project image from uniformly illuminated surface of the pattern box to the sensor. Signals from different color planes (V_{C1}, V_{C2}, V_{C3}, and V_R) are measured in LSB on the sensor output, at 16 by 16 pixels central window of each color plane, as an average of 128 frames, at default integration time and minimum recommended gain. Values of dark signals, (see Condition 6) are subtracted from light signals. Clear pixel response and response comparison are calculated according to the following formula:

$$\begin{aligned} V_C &= (V_{C1} + V_{C2})/2 \\ S_g &= V_C(\mathrm{LSB}) \\ R_r &= V_{rR}/V_C \end{aligned} \qquad (EQ\ 1)$$

Measurement Condition 2

Illumination source and lens-filter are the same as in condition 1. Image sensor characteristics are calculated for green pixels only, as an average of 16 frames, 16 x16 pixels windows for Clear1 and Clear2 color planes, in LSB on the sensor output. Saturation signal is measured at exposure 10 times higher than exposure corresponding to 50% of saturation on the sensor output at minimum recommended gain:

$$V_{SAT} = (V_{C1SAT} + V_{C2SAT})/2 \qquad (EQ\ 2)$$

Measurement Condition 3

The array is isolated from light. Readout noise (σt) is measured as average temporal noise across the whole pixel array, as an average for Clear1 and Clear2 color planes. Readout noise is measured in LSB on the sensor output, using 128 frames, default integration time with two different settings for gain: min recommended and max analog gain.

Measurement Condition 4

The array is isolated from light. Dark current is measured at maximum analog gain, across the whole pixel array, in LSB/s on the sensor output, at a sensor temperature equal to 55°C.

Measurement Condition 5

Illumination source and lens-filter are the same as in condition 1. PRNU (an average for Clear1 and Clear2 color planes) is calculated as a ratio of fixed pattern noise to the signal. The signal is equivalent to 50 percent of saturation (exposure time is adjusted), at minimum analog gain, using the 16 by 16 pixel windows for Clear1 and Clear2 color planes, using 128 frames. Values of dark signals (see condition 6) are subtracted from light signals:

$$PRNU_{C1} = (FPN_{C1}/V_{C1}) \times 100\%$$
$$PRNU_{C2} = (FPN_{C2}/V_{C2}) \times 100\% \quad \text{(EQ 3)}$$
$$PRNU = (PRNU_{C1} + PRNU_{C2})/2$$

SNR (an average of Clear1 and Clear2 color planes) is calculated as a ratio of clear pixel signal to temporal noise at the signal equivalent to 50 percent of saturation (exposure time is adjusted), at minimum recommended gain, using 128 frames,16 x 16 pixel windows for Clear1 and Clear2 color planes averaged over 128 frames, according to the next formula:

$$SNR_{C1} = 20(\log_{10})(V_{C1}/\sigma_{tC1})$$
$$SNR_{C2} = 20(\log_{10})(V_{C2}/\sigma_{tC2}) \quad \text{(EQ 4)}$$
$$SNR = (SNR_{C1} + SNR_{C2})/2$$

Measurement Condition 6

The array is isolated from light. Dark signal nonuniformity is measured across the whole pixel array at default settings except gain, which is set to its maximum analog value. Dark signal nonuniformity (an average of Clear1 and Clear2 color planes) is calculated as a ratio of measured fixed pattern noise to the saturation signal (see condition 2):

$$DSNU_{C1} = [(FPN_{C1}/\text{max analog gain})/V_{C1sat}] \times 100\%$$
$$DSNU_{C2} = [(FPN_{C2}/\text{max analog gain})/V_{C2sat}] \times 100\% \quad \text{(EQ 5)}$$
$$DSNU = (DSNU_{C1} + DSNU_{C2})/2$$

Dynamic range (an average of Clear1 and Clear2 color planes) is calculated as a ratio of a saturation signal (see condition 2) to readout noise measured at maximum analog gain (see condition 3) according to next formula:

$$DynR_{C1} = 20(\log_{10})((V_{C1sat}/\sigma_{tC1}) \times \text{max analog gain})$$
$$DynR_{C2} = 20(\log_{10})((V_{C2sat}/\sigma_{tC2}) \times \text{max analog gain}) \quad \text{(EQ 6)}$$
$$DynR = (DynR_{C1} + DynR_{C2})/2$$

Measurement Condition 7

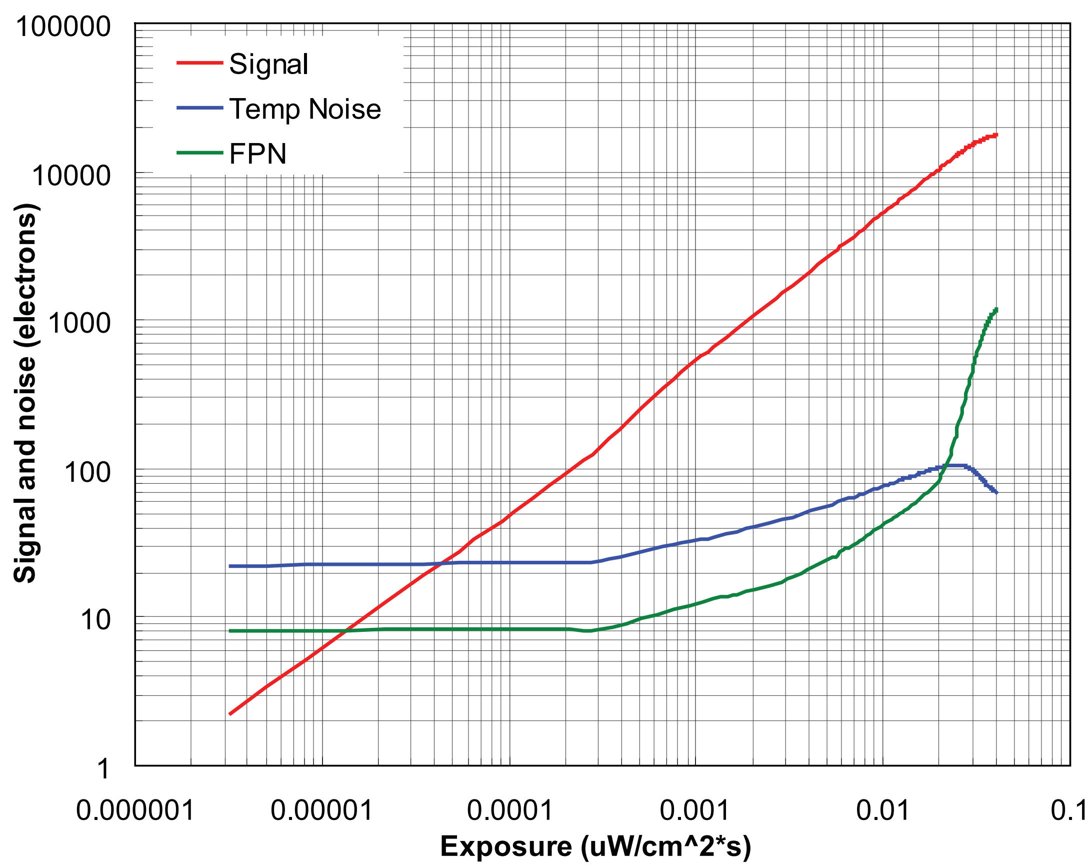
The array is illuminated by single strobe light during the frame blank time. Lag is calculated as a difference in signals between the first dark frame after illumination and an isolated dark frame over the signal in an illuminated frame. The lag is calculated for the light pulse exposure corresponding to 40 percent of saturation. Measurements are completed using default register settings except integration time.

Supplementary Plots

Typical Photon Transfer Curves

Figure 1 represents the photon transfer curves for signal and noise over the specified exposure range. The sensor array is illuminated from a Davidson Optronic TVO system using a green spectral filter with a maximum output at 550±5 nm and full width half maximum (FWHM) = 40 nm. Signal-to-noise ratio is calculated for green pixels only. During measurements, Gain was adjusted to optimal for each value of exposure.

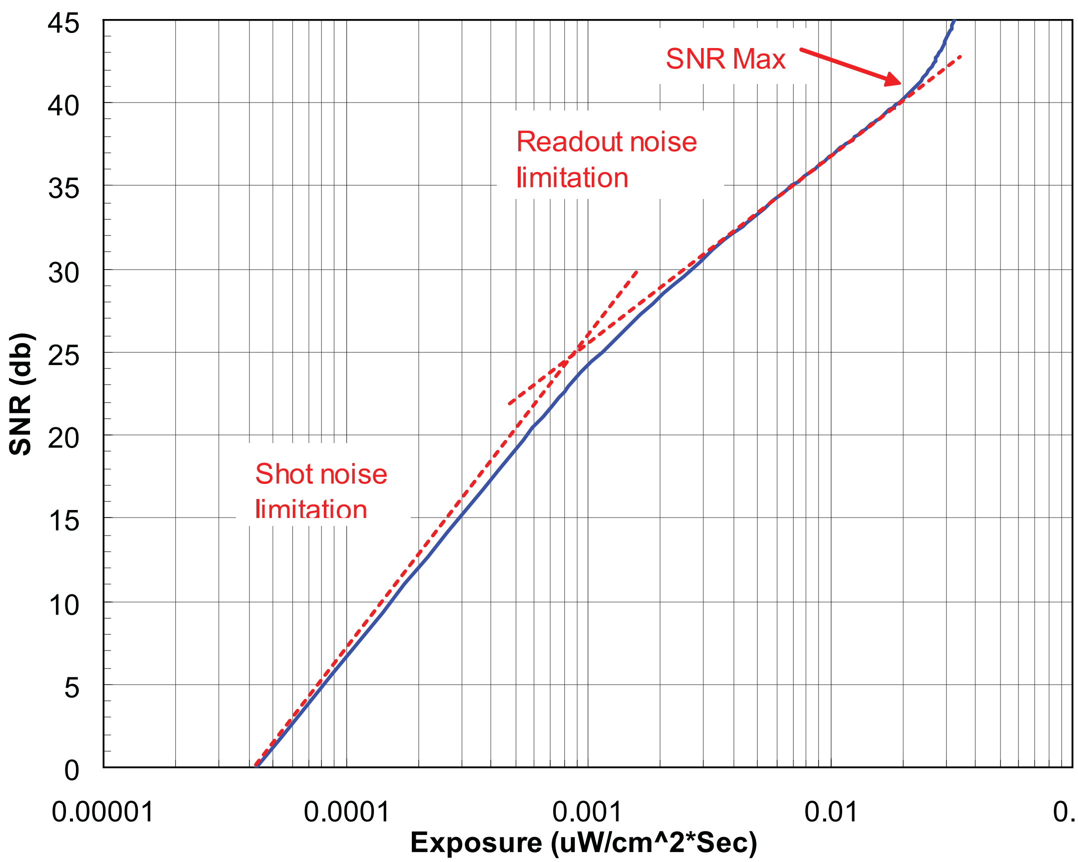
Figure 1: Typical Photon Transfer Curves



Typical Signal-to-Noise Ratio as a Function of Exposure

Figure 2 shows the relationship between signal-to-noise ratio and exposure. The array is illuminated from a Davidson Optronic TVO system using a green spectral filter with a maximum output at 550±5 nm and FWHM = 40 nm. Signal-to-noise ratio is calculated for clear pixels only. During measurements, gain was adjusted to be optimal for each value of exposure.

Figure 2: Typical Signal-to-Noise Ratio as a Function of Exposure



Typical Transaction Factor as a Function of Gain

Figure 3 shows the relationship between transaction factor and gain. Transaction factor, in units of LSB/e-, is obtained by sweeping the ASC gain from minimum to maximum.

The array is illuminated from Davidson Optronic TVO system using a green spectral filter with a maximum output at 550±5 nm and FWHM = 40 nm.

Figure 3: Typical Transaction Factor as a Function of Gain

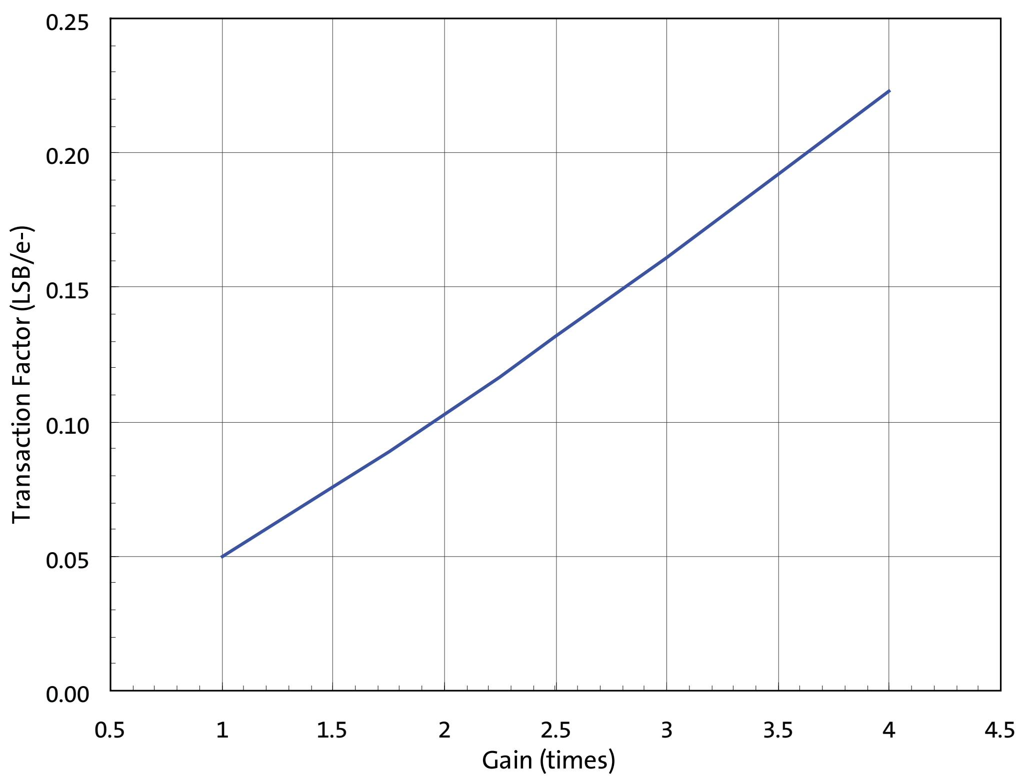
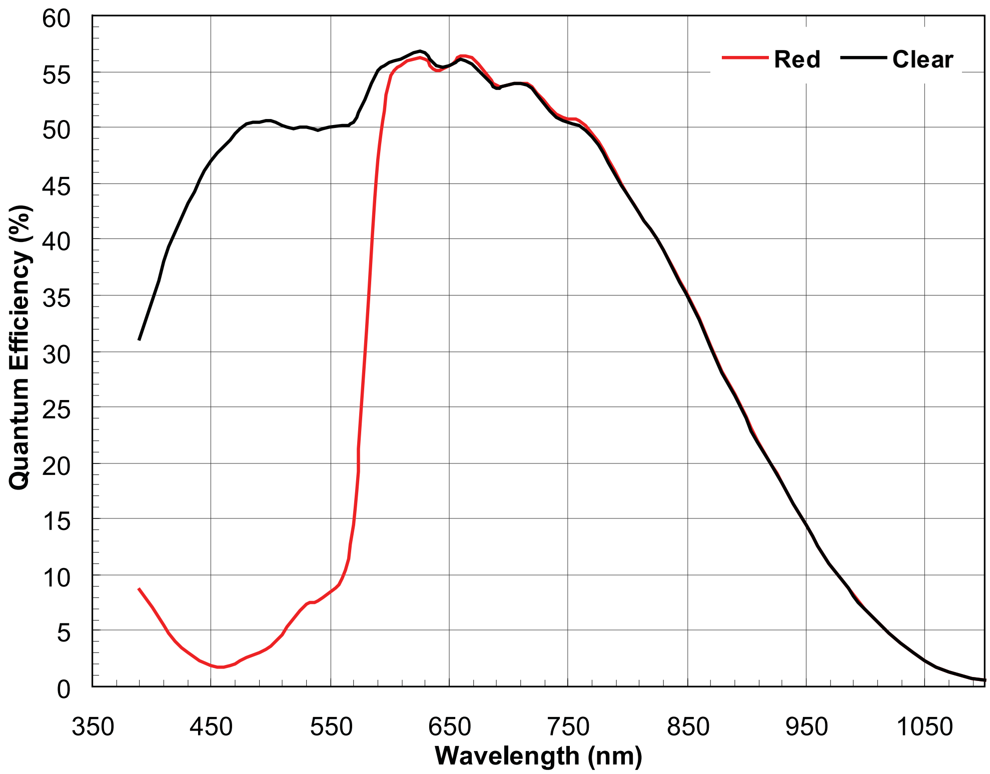


Figure 4 specifies the quantum efficiency of the sensor core based on the wavelengths for red and clear. Aptina recommends using an IR-cut filter that minimizes transmittance at wavelengths above 650nm.

Figure 4: Typical Spectral Characteristics



Revision History

Rev. A 06/17/2008

- Initial release

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