Test Lab Services Report

Canon EOS 40D DSLR Sensor Characterization Based on EMVA 1288

Report ID: SAMPLE02

Requested by:

Customer

Prepared by:

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Overview

The EMVA 1288 standard is an initiative of the European Machine Vision Association to define a unified method for the objective measurement and analysis of specification parameters for image sensors, particularly those used in the computer vision industry. Its goal is to define reliable and reproducible measurement procedures and data presentation guidelines to simplify the comparison of cameras and image sensors. Models for both linear and non-linear sensor responses are presented in Version 4.0 of the standard.

In this report, measurements and analyses are made to quantify the linearity, sensitivity, noise, nonuniformity, and dark current of a Canon EOS 40D DSLR sensor according to the methods described in the EMVA 1288 4.0 standard.

The linear 4.0 release of the EMVA 1288 standard is only applicable to sensors that adhere to the assumptions of the linear model, which assumes that:

1. The sensor has a response that increases linearly with the number of incident photons.
2. The temporal noise is comprised only of dark noise and photon shot noise.
3. Temporal noise between pixels is statistically independent.

In comparison, the general model applies to sensors with non-linear responses or internal reprocessing, and treats the sensor or camera as a black box, assuming that:

1. The characteristic curve (sensor response) is not necessarily linear.
2. The temporal noise includes shot noise plus all unknown noise sources.
3. Temporal noise between pixels is NOT necessarily statistically independent.

These and additional assumptions are described in detail in the official standard documentation. Data capture processes for both models are identical, such that only the subsequent analyses differ them. Both the linear and general models can be applied to the Canon EOS 40D DSLR sensor, which exhibits a linear response. This report details the results obtained by each method.

For more information on the EMVA 1288 standard, visit www.emva.org.

Summary Sheet for Sensor Channel 1 at 445 nm

Type of data	14-bit RGGB	Gain	ISO 200
Exposure control	By exposure time	Environmental temp	22°C
Exposure time	1/8000 to 1 [s]	Camera body temp	---
Frame rate	---	Internal temperature(s)	---
Data transfer mode	USB 2.0	Wavelength cntr, FWHM	445 nm, 16 nm

Photon Transfer

Blue Channel Photon Transfer

Signal-to-Noise Ratio

Blue Channel SNR
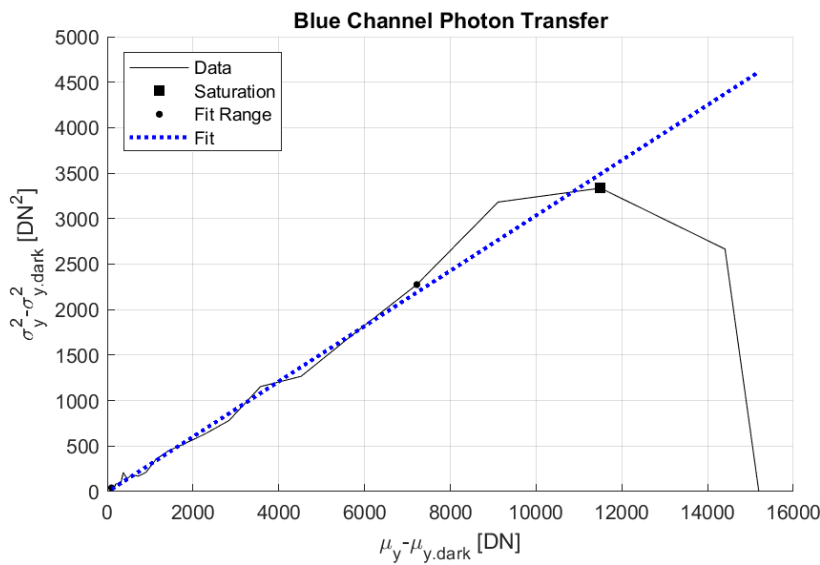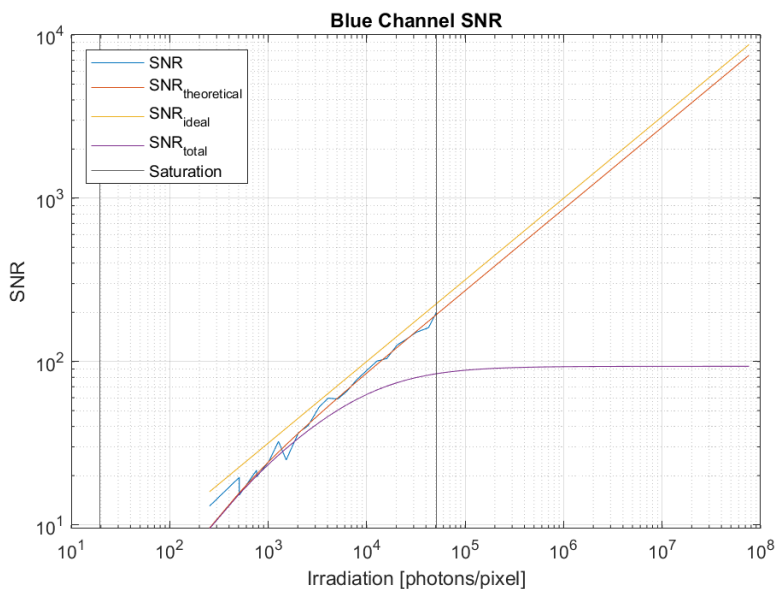
Quantum efficiency	
η	73.9%
Overall System Gain	
K	0.304 DN/e-
1/K	3.29 e-/DN
Temporal dark noise	
σ_d	14.0 e-
$\sigma_{y.dark}$	4.28 DN
Signal-to-noise ratio	
SNR_{max}	194
	45.8 dB
$1/ SNR_{max}$	0.52%
Absolute sensitivity threshold	
$\mu_{e.min}$	14.6 e-
$\mu_{e.min.area}$	0.45 e-/μm^2
Saturation capacity	
$\mu_{e.sat}$	37589 e-
$\mu_{e.sat.area}$	1153 e-/μm^2
Dynamic range	
DR	2589
	68.3 dB
Spatial nonuniformities	
$DSNU_{1288}$	1.71 e-
$DSNU_{1288.col}$	0.51 e-
$DSNU_{1288.row}$	0.52 e-
$DSNU_{1288.pix}$	1.55 e-
$PRNU_{1288}$	1.07%
$PRNU_{1288.col}$	0.79%
$PRNU_{1288.row}$	0.50%
$PRNU_{1288.pix}$	0.52%
Linearity error	
LE	2.14%
Dark current	
$\mu_{c.mean}$	0.19 e-/s
$\mu_{c.var}$	0.31 e-/s

Summary Sheet for Sensor Channel 2 at 520 nm

Type of data	14-bit RGGB	Gain	ISO 200
Exposure control	By exposure time	Environmental temp	22°C
Exposure time	1/8000 to 1 [s]	Camera body temp	---
Frame rate	---	Internal temperature(s)	---
Data transfer mode	USB 2.0	Wavelength cntr, FWHM	520 nm, 35 nm

Photon Transfer

Green (Blue Row) Channel Photon Transfer

Signal-to-Noise Ratio

Green (Blue Row) Channel SNR
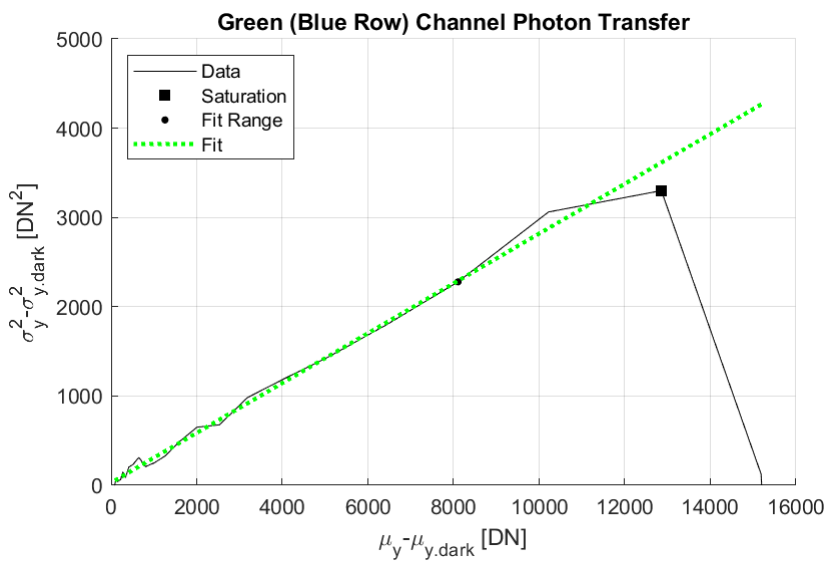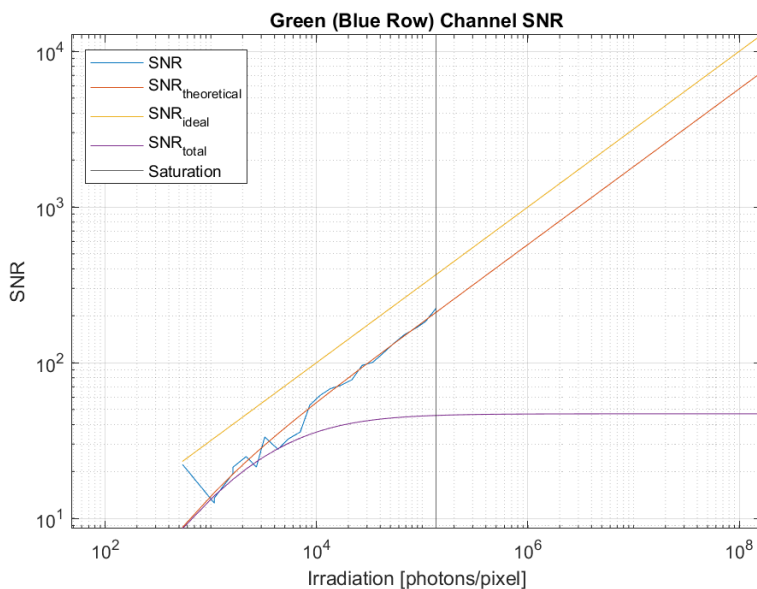
Quantum efficiency	
η	33.0%
Overall System Gain	
K	0.279 DN/e$^-$
1/K	3.59 e$^-$/DN
Temporal dark noise	
σ_d	15.3 e$^-$
$\sigma_{y.dark}$	4.27 DN
Signal-to-noise ratio	
SNR$_{max}$	211
	46.5 dB
1/ SNR$_{max}$	0.47%
Absolute sensitivity threshold	
$\mu_{e.min}$	15.8 e$^-$
$\mu_{e.min.area}$	0.49 e$^-$/μm^2
Saturation capacity	
$\mu_{e.sat}$	44498 e$^-$
$\mu_{e.sat.area}$	1365 e$^-$/μm^2
Dynamic range	
DR	2821
	69.0 dB
Spatial nonuniformities	
DSNU$_{1288}$	0.95 e$^-$
DSNU$_{1288.col}$	0.47 e$^-$
DSNU$_{1288.row}$	0.51 e$^-$
DSNU$_{1288.pix}$	0.65 e$^-$
PRNU$_{1288}$	2.13%
PRNU$_{1288.col}$	1.81%
PRNU$_{1288.row}$	0.97%
PRNU$_{1288.pix}$	0.57%
Linearity error	
LE	1.29%
Dark current	
$\mu_{c.mean}$	0.42 e$^-$/s
$\mu_{c.var}$	0.43 e$^-$/s

Summary Sheet for Sensor Channel 3 at 520 nm

Type of data	14-bit RGGB	Gain	ISO 200
Exposure control	By exposure time	Environmental temp	22°C
Exposure time	1/8000 to 1 [s]	Camera body temp	---
Frame rate	---	Internal temperature(s)	---
Data transfer mode	USB 2.0	Wavelength cntr, FWHM	445 nm, 35 nm

Photon Transfer

Green (Red Row) Channel Photon Transfer

Signal-to-Noise Ratio

Green (Red Row) Channel SNR
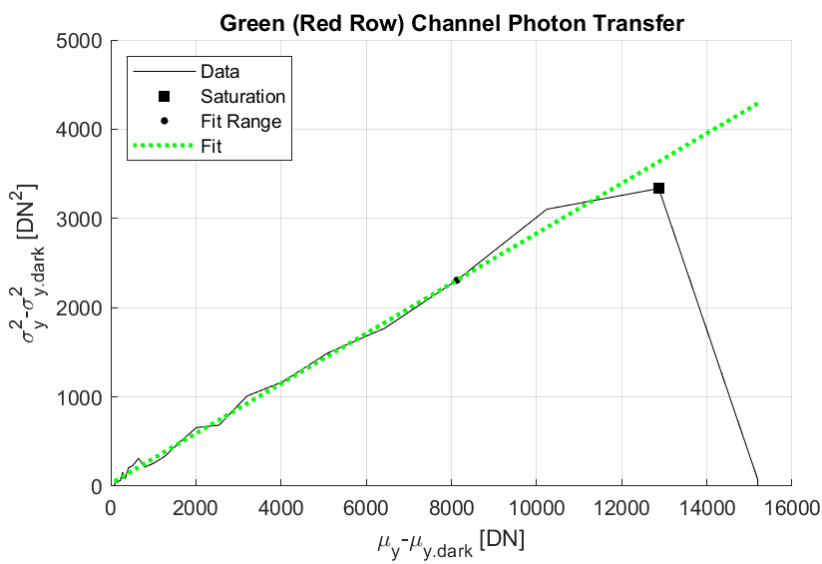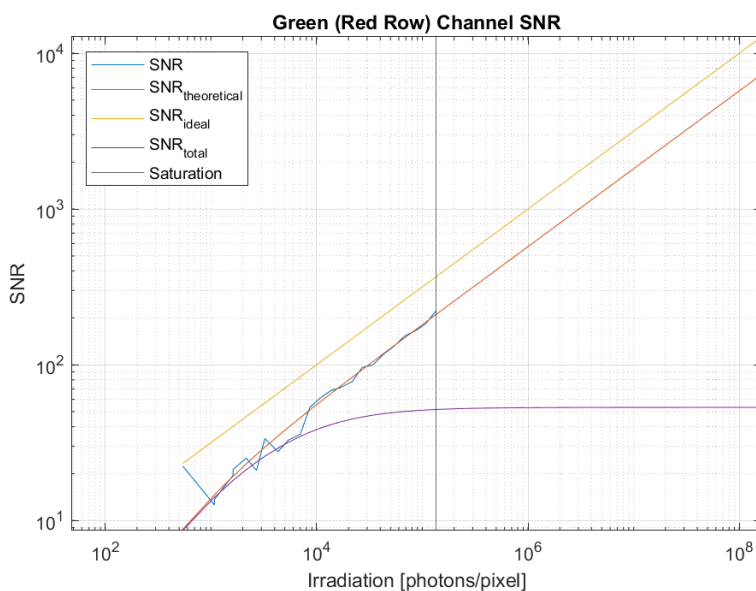
Quantum efficiency	
η	32.9%
Overall System Gain	
K	0.280 DN/e$^-$
1/K	3.57 e$^-$/DN
Temporal dark noise	
σ_d	15.3 e$^-$
$\sigma_{y.dark}$	4.29 DN
Signal-to-noise ratio	
SNR$_{max}$	211
	46.5 dB
1/ SNR$_{max}$	0.47%
Absolute sensitivity threshold	
$\mu_{e.min}$	15.8 e$^-$
$\mu_{e.min.area}$	0.49 e$^-$/μm^2
Saturation capacity	
$\mu_{e.sat}$	44403 e$^-$
$\mu_{e.sat.area}$	1362 e$^-$/μm^2
Dynamic range	
DR	2828
	69.0 dB
Spatial nonuniformities	
DSNU$_{1288}$	1.02 e$^-$
DSNU$_{1288.col}$	0.47 e$^-$
DSNU$_{1288.row}$	0.08 e$^-$
DSNU$_{1288.pix}$	0.90 e$^-$
PRNU$_{1288}$	1.89%
PRNU$_{1288.col}$	1.63%
PRNU$_{1288.row}$	0.77%
PRNU$_{1288.pix}$	0.54%
Linearity error	
LE	1.33%
Dark current	
$\mu_{c.mean}$	0.44 e$^-$/s
$\mu_{c.var}$	0.42 e$^-$/s

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Summary Sheet for Sensor Channel 4 at 635 nm

Type of data	14-bit RGGB	Gain	ISO 200
Exposure control	By exposure time	Environmental temp	22°C
Exposure time	1/8000 to 1 [s]	Camera body temp	---
Frame rate	---	Internal temperature(s)	---
Data transfer mode	USB 2.0	Wavelength cntr, FWHM	635 nm, 18 nm

Photon Transfer

Red Channel Photon Transfer

Signal-to-Noise Ratio

Red Channel SNR
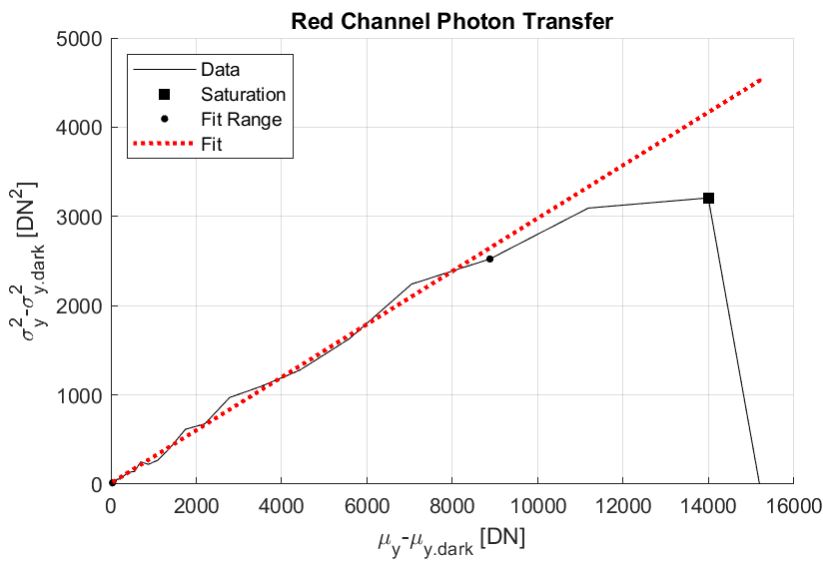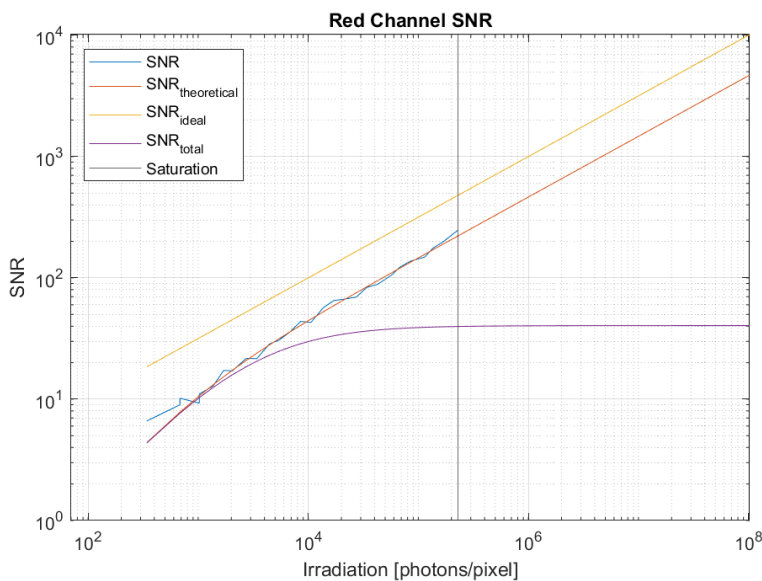
Quantum efficiency	
η	21.5%
Overall System Gain	
K	0.297 DN/e$^-$
1/K	3.37 e$^-$/DN
Temporal dark noise	
σ_d	14.4 e$^-$
$\sigma_{y.dark}$	4.28 DN
Signal-to-noise ratio	
SNR$_{max}$	221
	46.9 dB
1/ SNR$_{max}$	0.45%
Absolute sensitivity threshold	
$\mu_{e.min}$	14.9 e$^-$
$\mu_{e.min.area}$	0.46 e$^-$/μm^2
Saturation capacity	
$\mu_{e.sat}$	49018 e$^-$
$\mu_{e.sat.area}$	1503 e$^-$/μm^2
Dynamic range	
DR	3302
	70.4 dB
Spatial nonuniformities	
DSNU$_{1288}$	0.83 e$^-$
DSNU$_{1288.col}$	0.56 e$^-$
DSNU$_{1288.row}$	0.08 e$^-$
DSNU$_{1288.pix}$	0.60 e$^-$
PRNU$_{1288}$	2.47%
PRNU$_{1288.col}$	2.22%
PRNU$_{1288.row}$	0.83%
PRNU$_{1288.pix}$	0.71%
Linearity error	
LE	1.99%
Dark current	
$\mu_{c.mean}$	0.37 e$^-$/s
$\mu_{c.var}$	0.42 e$^-$/s

Device Details

Table 1: Device Summary

Spec	Canon EOS 40D
Sensor Type	CMOS
Sensor Size	22.2 x 14.8 mm
Pixel Dimensions	3888 x 2592
MP	10.1
F/#	f/9.2
Pixel Pitch	5.71 μm