Characterisation report

Session session | IMX477 / SBGGR12_CSI2P

SENSOR
IMX477
4056 × 3040, BGGR

RAW
12 bits
SBGGR12_CSI2P

CONVERSION
2.327 e⁻/ADU
PTC · gain 1.000

TEMPERATURE
26.0 °C
8 missing telemetry readings

Results summary

Main results and limitations of interpretation.

PTC curve

TO CONFIRM

Conversion gain: 2.327 e⁻/ADU

Dynamic range: 11.21 stops

Saturation observed; effective capacity and dynamic range calculated from the usable RAW range.

Quantities not established are marked unavailable.

Dark-current analysis

VALIDATED

Typical current: unresolved against offset drift.

Thermal analysis status: VALIDATED.

Exposures: 8 steps, from 0.1 to 300.0 s

Status describes the analysis, not the measured current.

Measurement quality

Analysis validity status, independently of the measured result.

Raw data format (RAW)	VALIDATED
Read noise	VALIDATED
PTC / linearity	TO CONFIRM
Dark current	VALIDATED
Thermal stability	VALIDATED

Interpretation criteria

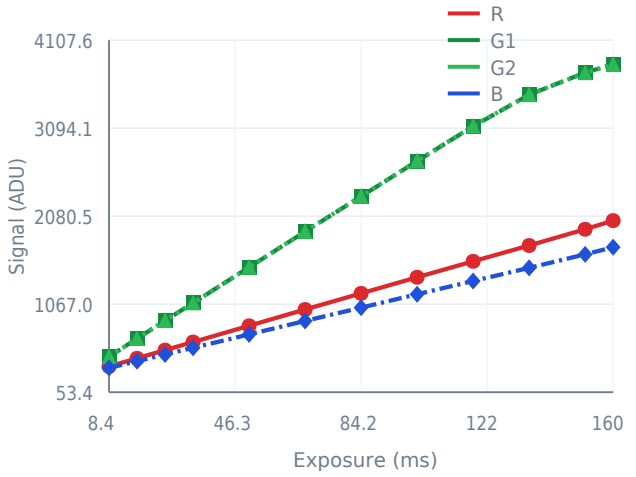
Conclusions prioritise stable, reproducible measurements.

- Conversion gain is estimated in the linear region of the PTC.
- Points near saturation characterise clipping, not the linear fit.
- Long dark exposures can be interpreted if temperature remains stable.
- Temperature is quantised to degrees, with a 2 °C peak-to-peak margin.
- On resuming acquisition, only thermal telemetry is missing; images are retained.

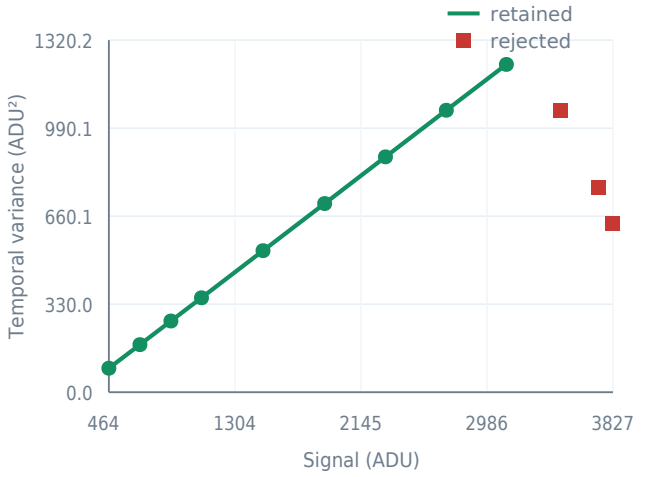
Measurement plots

Signals, read noise and thermal drift

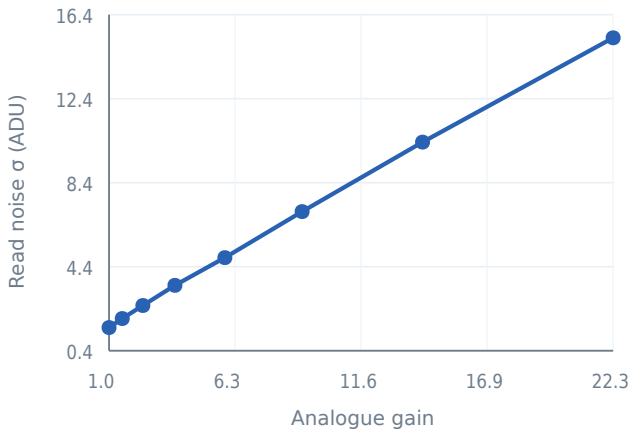
Response curve / linearity



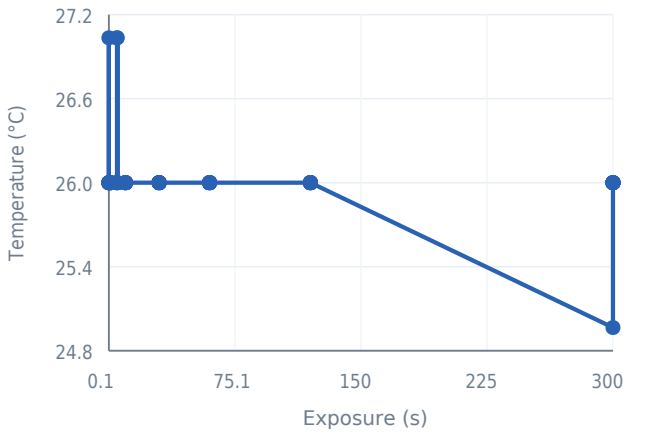
Photon transfer curve (PTC)



Read noise



Long dark exposures: temperature



Interpretation

The PTC slope provides an estimate of conversion gain.

Usable dynamic range combines the raw data (RAW) range and read noise.

Long dark exposures are conclusive only at a stable temperature.

Statuses describe analysis validity, independently of the scientific result.

Characterisation report

Detailed data and decision criteria

Raw data calibration (RAW)

Converted black level and usable range at native bit depth.

Native bit depth: 12 bits

Source black level: 64 · 10 bits; converted RAW black level: 256

RAW white code: 4095; usable range: 3839 ADU

PTC calibration

Linear region, uncertainty and observed saturation.

Gain: 1.000; conversion: 2.3271 e⁻/ADU ± 0.0011

R²: 1.0000; acquired / retained / rejected levels: 12/9/3

Maximum clipping: 0.27032; threshold: 0.000100; saturation: observed

Observed white code: 3827 ADU; effective capacity before saturation: 8310.33 e⁻; dynamic range: 11.21 stops / 67.47 dB

Read noise

Pair differences; noise σ = standard deviation(A−B)/√2.

Analogue gain	R (ADU)	G1 (ADU)	G2 (ADU)	B (ADU)	Overall (ADU)	Overall (e⁻)
1.000	1.492	1.529	1.529	1.494	1.512	3.518
1.556	1.935	1.949	1.949	1.934	1.942	2.928
2.427	2.556	2.572	2.571	2.554	2.563	2.492
3.779	3.514	3.533	3.540	3.516	3.525	2.212
5.885	4.833	4.861	4.902	4.833	4.847	1.962
9.143	7.021	7.063	7.153	7.025	7.044	1.841
14.222	10.328	10.382	10.505	10.334	10.358	1.753
22.261	15.284	15.375	15.538	15.294	15.335	1.669

Conversion to e⁻ unavailable at gains without a corresponding valid PTC.

Dark current and hot pixels

Normal population, positive tail and global black-level drift.

Exposures analysed: 100 000 · 1 000 000 · 5 000 000 · 10 000 000 · 30 000 000 · 60 000 000 · 120 000 000 · 300 000 000 µs

Median slope: -0.00544 ADU/pixel/s; p90: 0.00903; p99: 0.04031

Normal population: typical current unresolved against offset drift.

Hot pixels detected from changes with exposure time: per-pixel regression.

Threshold: max(10 × |median|, 6 × 1.4826 MAD) = 0.0544 ADU/pixel/s.

Tracked sample: 16 060 pixels; 75 detected (0.47%).
Global black-level drift: -0.001092 ADU/pixel/s ± 0.000922; R²=0.189; slope not significant

Temperature

Thermal summary for long dark exposures.

Thermal stabilisation: 60 s pause between steps

Dark exposures: Tmin 25.0 °C, Tmax 27.0 °C, range 2.0 °C

Temperature / log10(exposure) correlation: r = -0.59

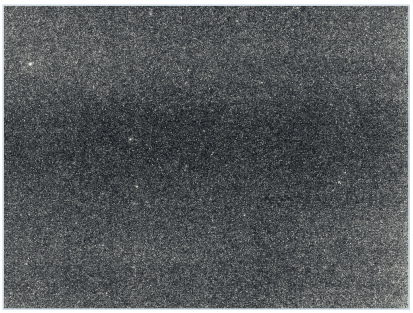
Thermal analysis status: VALIDATED

Derived spatial products

Spatial analysis of long dark exposures

Master dark - reduced view

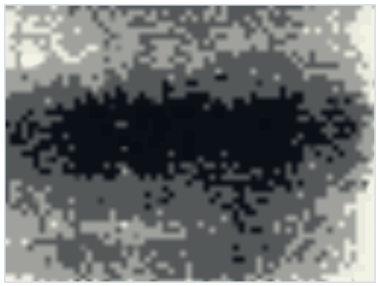
Full-sensor median master, area downsampled · ADU



Robust scale: 254.911 to 258.764 ADU

Low-frequency structure (reduced view)

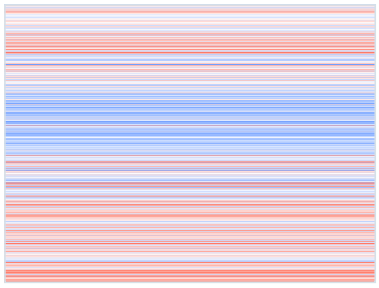
Bayer 2 × 2 averages · direct blocks of 32 × 32 cells
64 × 64 pixels · median per block · interpolated rendering · ADU



Robust scale: 255.490 to 256.277 ADU

Horizontal component

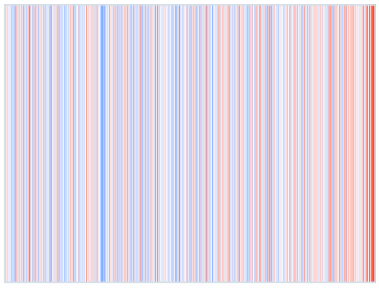
Reduced view · rendered map, mean per row
(reduced master − low frequency) · ADU



Scale: -0.213 to +0.213 ADU

Vertical component

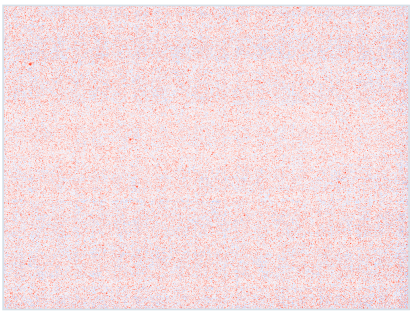
Reduced view · rendered map, mean per column
(reduced master − low frequency) · ADU



Scale: -0.212 to +0.212 ADU

High-frequency residual

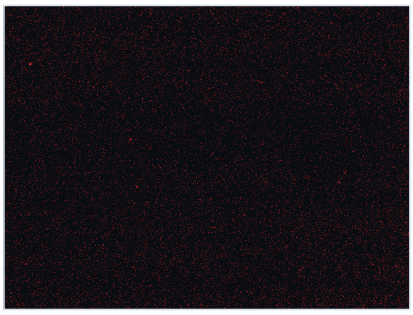
Reduced view · master − background − rows − columns · ADU



Scale: -2.854 to +2.854 ADU

Spatial hot-pixel candidates

Reduced view · threshold 1.9521 ADU · binary mask



Detected: 33283 / 785408 (4.24%)

Session: 20261006-000849_libcamera

Algorithm: spatial_dark_analysis 1.1 · Sensor: IMX477 · CFA BGGR

Master: integer temporal median of 10 frames, 4056 × 3040 pixels · 300.000 s · gain 1.000

View: area downsampling of the full-sensor master to 1024 × 767 pixels.

Native full-sensor measurements: integer median master; p99.9 mask; direct blocks of 32 × 32 Bayer cells.

Native profiles: Bayer mean − block median; median per row/column; centred profiles.

RMS of centred profiles: population standard deviation.

Rendered maps: horizontal/vertical components = row/column means of (reduced master − low-frequency background).

Low-frequency map rendered with bilinear interpolation; native measurements without interpolation.

Spatial candidates: reduced-view cells, not photosites; threshold median(|residual|) + 6 MAD, fallback max(1e−9, p98).

Multi-gain PTC characterisation

Performance versus analogue gain

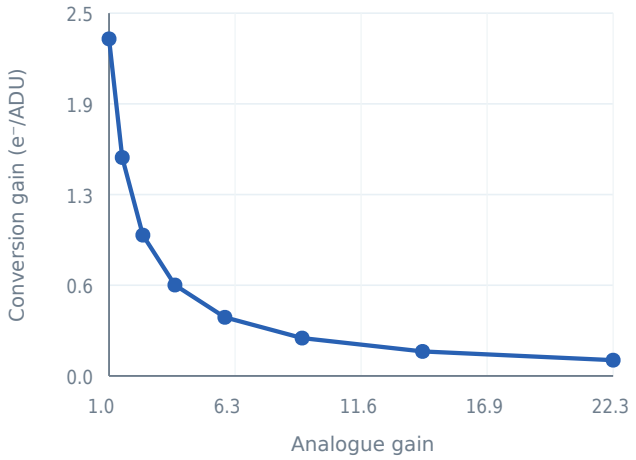
Measured analogue gains: 8

Regime change: no statistically demonstrated break

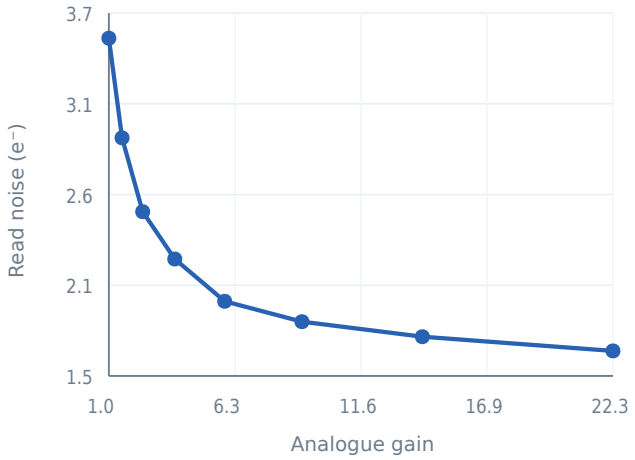
Selected continuous model: c(g)=exp(polynomial(log g)), degree 3, BIC 9.44, monotonic

Power-law comparison: C = 2.328; p = 0.987

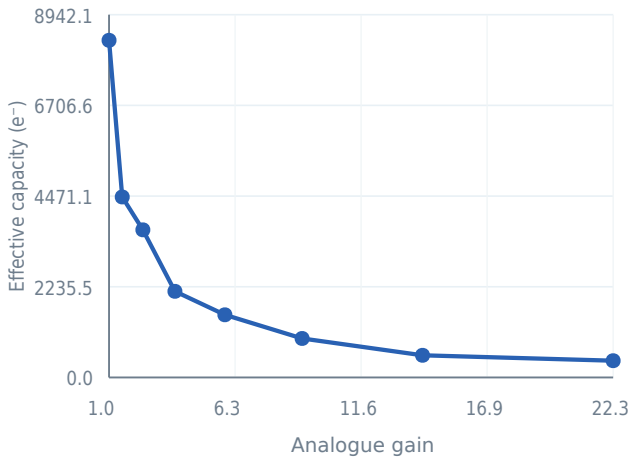
Conversion gain



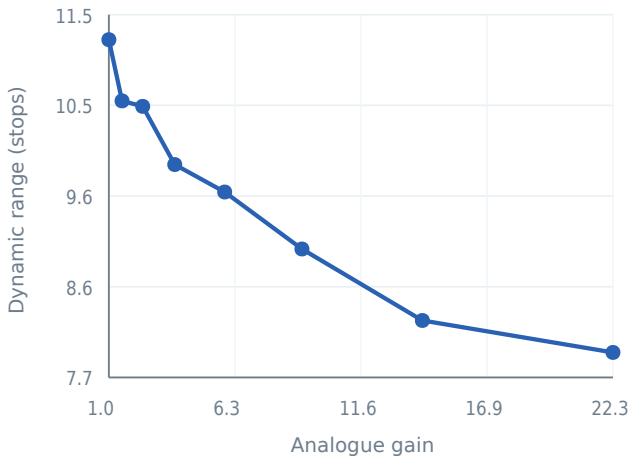
Read noise



Effective capacity before saturation



Usable dynamic range



Interpreting the results

Increasing analogue gain generally reduces read noise expressed in electrons, but also reduces the maximum charge measurable before saturation.

A candidate break must outperform the best continuous model (ΔBIC ≥ 6 and resampling p-value ≤ 0.01); it still requires confirmation through an independent campaign and is neither an optimal gain nor a recommended setting.

Multi-gain PTC details

Levels, pairs, effective capacity and clipping

All gains with a valid PTC are shown.

Effective capacity before saturation: instrumental limit derived from the usable RAW range and conversion gain. It is not the physical capacity of the photosite.

Gain requested	Gain actual	Conversion e⁻/ADU ± uncertainty	Levels acquired / retained / rejected	Pairs	Retained signal (ADU)	Effective capacity (e⁻)	Clipping overall
1.000	1.000	2.3271 ± 0.0011	12/9/3	120	463.5 to 3116.0	8 310	observed
1.558	1.556	1.5080 ± 0.0016	12/9/3	120	412.1 to 2433.1	4 449	observed
2.427	2.427	0.9720 ± 0.0017	12/7/5	120	495.8 to 2655.7	3 639	observed
3.780	3.779	0.6276 ± 0.0007	12/9/3	120	440.2 to 2837.9	2 123	observed
5.889	5.885	0.4048 ± 0.0005	12/6/6	120	541.3 to 2552.6	1 545	observed
9.173	9.143	0.2614 ± 0.0003	12/8/4	120	478.7 to 2928.5	961	observed
14.290	14.222	0.1692 ± 0.0002	12/9/3	120	428.5 to 2666.2	546	observed
22.261	22.261	0.1088 ± 0.0002	12/6/6	120	525.2 to 2400.7	413	observed

Clipping observed globally through the fraction of photosites at white code; clipping by CFA channel is not measured.