# Imatest Test Lab Services Report Normalized Stray Light Test 

Report ID: SAMPLE01

Requested by: Customer
Prepared by: Imatest, LLC
Date: June 11, 2024

## Device under test (DUT)

| Attribute | Notes |
| :---: | :---: |
| Description | - OnSemi Demo3 kit <br> - AR0231 iGBA121 demo3 rev 0 sensor board <br> - 3.6 mm fixed focus lens |
| DUT-specific settings | - Sensor operated in single-exposure standard dynamic range mode (not a multi-exposure HDR mode) <br> - Sensor Preset: Linear Parallel Full Resolution <br> - Default gain settings (LCG2x) <br> - White Balance and Color Correction disabled |
| Image properties | - Images were saved in 12-bit raw format <br> - Raw images were demosaiced and converted to grayscale (mean of 3 channels) in post, saved as PNGs with size $1928 \times 1208$ <br> - A mean dark level of 168 DN was subtracted from the images during analysis |


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## Test equipment and setup

| Equipment | Purpose |
| :--- | :--- |
| Imatest stray light LED <br> source V2 (prototype) | For illumination of the DUT with a collimated <br> point-like source |
| Imatest Benchtop Test <br> Stand (BTS) | For alignment of the DUT and source |
| Imatest Motorized <br> Gimbal | For holding the DUT <br> For alignment of the DUT and source <br> For changing the angle of the source WRT the <br> DUT <br> For holding the spectroradiometer |
| Filter stand with <br> constant transmission <br> neutral density (ND) <br> filter, OD 2.5 | For attenuating the source to obtain an <br> unsaturated reference image |
| JETI calibrated <br> spectroradiometer | For light level measurements |

JETI calibrated spectroradiometer


For light level measurements

## Light source

| Attribute | Value |
| :--- | :--- |
| Description | Imatest Stray Light LED Source V2 (prototype) with white LED |
| Angular diameter of the projected <br> source | 0.11 degrees |
| Half divergence angle of the beam | $\sim 0.055$ degrees within working distance (collimated) |
| Distance from DUT to source | 840 mm |
| Usable beam diameter at DUT <br> location | 25 mm |
| Center of rotation | Front end of front optical element on DUT |
| Light intensity \& spectrum | Illuminance: 256.1 lux <br> Irradiance (380-780nm): 0.7912 watts per meter-squared <br> (See slide 7 for spectral irradiance measurements) |

 (See slide 7 for spectral irradiance measurements)

## Test method

The DUT is rotated in front of a collimated point-like light source with the image deliberately exposed to reveal measurable stray light. Linear images are captured at a series of angles, with the source positioned in and outside of the field of view (FOV) of the DUT. The images are processed into stray light metric images using Imatest software.

The selected metric is per-pixel normalized stray light. Normalized stray light measures the response from stray light in the image relative to the response from the on-axis direct image of the source.

To obtain a normalization factor, a separate on-axis reference image was captured with the direct image of the source deliberately exposed to avoid saturation (see slide 6). To prevent saturation, the DUT integration time was reduced and a constant transmission neutral density filter was placed in the path of the collimated beam. The level (digital number) from the direct image of the source was derived from the reference image and the known difference in exposure between the reference image and test images was taken into account to calculate a normalization factor representing the level (DN) from the direct image of the source at the test image exposure. The test image data were then normalized by this factor to produce metric images containing floating-point data.

## Direct reference image

## A ND2.5 filter is placed in the path of the collimated beam to capture an on-axis <br> reference image containing the unsaturated direct image of the source

3200\% zoom


DUT integration time: 0.00380682 ms
The direct image of the source was aligned with the numeric center of the image, corresponding to on-axis, or a field angle of zero.

## Light level measurements

Measured spectral irradiance of the collimated beam at the DUT location


Illuminance: 256.1 lux Irradiance (380-780nm): 0.7912 W/m^2
CCT: 5763 K

An equivalent measurement with the ND2.5 filter in the path of the beam shows that the filter has constant transmission. However, the measurement is noisy due to low light level.


## Results: Normalized stray light

180-degree horizontal sweep with 1-degree increments
DUT integration time: 41.9914 ms
Illuminance: 256.1 lux
Light source angular size: 0.11 degrees

## Results summary

Results are presented as color-mapped stray light metric images, with both linear and logarithmic scaling, alongside certain summary metrics and a corresponding plot.

To produce the metric images, the test image data were normalized by a factor of $4.28348 \mathrm{E}+9 \mathrm{DN}$. This represents the theoretical level (above saturation level) from the direct image of the on-axis light source at the test image exposure.
The minimum measurable stray light from this test is $2.3345 \mathrm{E}-10$, corresponding to 1 DN above the mean dark level ( 168 DN ). Any stray light below this level cannot be measured from the as-exposed images. The maximum measurable stray light from this test is $9.1654 \mathrm{E}-7$, corresponding to 1 DN beneath saturation level ( 4095 DN ). Any stray light above this level cannot be measured from the as-exposed images.

## Observations:

- Several distinct ghost artifacts are present throughout the image while the source is both inside and outside the FOV
- The magnitude of these artifacts is measured to range between about $2 \mathrm{E}-8$ and $9 \mathrm{E}-7$. Some of these artifacts saturate ( $>9.1654 \mathrm{E}-7$ ) when the source is near on-axis.
- One artifact strongly resembles the form of the light source object, i.e., it appears as a ghost image of the light source, and is most prominent at field angles between 9 and -12 degrees. Other artifacts do not necessarily resemble the light source object and may be blurred when induced by a light source with larger angular size than that which was used for the test.
- A distinct flash appears on the left side of the image when the source is just outside the FOV between source field angles of -56 and -60 degrees. The level from this flash ranges from 2E-8 up to saturation level (> 9.1654E-7).
- The level of veiling glare throughout the image when source is in the center of the FOV is about 5E-9 at its lowest (at the corners) and increases with pixels closer to the direct image of the source, up to saturation level (>9.1654E-7).


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Illuminance: 256.1 lux
Light source angular size: 0.11 degrees


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Log (base 10) scaling:


| Mean | Max |
| :--- | :--- |
| $3.26 \mathrm{E}-10$ | $5.23 \mathrm{E}-08$ |

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Log (base 10) scaling:


| Mean | Max |
| :--- | :--- |
| $3.29 \mathrm{E}-10$ | $5.25 \mathrm{E}-08$ |

DUT integration time: 41.9914 ms
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Log (base 10) scaling:


| Mean | Max |
| :--- | :--- |
| $3.42 \mathrm{E}-10$ | $5.21 \mathrm{E}-08$ |

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| Mean | Max |
| :--- | :--- |
| $2.23 \mathrm{E}-09$ | $5.25 \mathrm{E}-08$ |

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Log (base 10) scaling:


Stray Light Level vs Source Field Angle (Highlighted: $56^{\circ}$ )


| Mean | Max |
| :--- | :--- |
| $5.32 \mathrm{E}-09$ | $2.59 \mathrm{E}-07$ |

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Log (base 10) scaling:



| Mean | Max |
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| $3.40 \mathrm{E}-08$ | $9.17 \mathrm{E}-07$ |

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DUT integration time: 41.9914 ms
Illuminance: 256.1 lux
Light source angular size: 0.11 degrees


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Light source angular size: 0.11 degrees


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Log (base 10) scaling:


| Mean | Max |
| :--- | :--- |
| $3.60 \mathrm{E}-10$ | $4.79 \mathrm{E}-08$ |

DUT integration time: 41.9914 ms
Illuminance: 256.1 lux
Light source angular size: 0.11 degrees


Log (base 10) scaling:


| Mean | Max |
| :--- | :--- |
| $3.41 \mathrm{E}-10$ | $4.39 \mathrm{E}-08$ |

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Illuminance: 256.1 lux
Light source angular size: 0.11 degrees


Log (base 10) scaling:



DUT integration time: 41.9914 ms
Illuminance: 256.1 lux
Light source angular size: 0.11 degrees


Log (base 10) scaling:


| Mean | Max |
| :--- | :--- |
| $3.22 \mathrm{E}-10$ | $4.93 \mathrm{E}-08$ |

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Illuminance: 256.1 lux
Light source angular size: 0.11 degrees


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