

ams NanEye2D

Datasheet

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Tobelbader Strasse 30, 8141 Premstaetten, Austria

Phone +43 3136 500-0

ams-osram.com

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NanEye2D Miniature camera module

1 General description

NanEye2D is a miniature sized image sensor for vision applications where size is a critical factor. The ability of the camera head to drive a signal through long cables makes this the ideal component for minimal diameter endoscopes.

With a footprint of just 1 mm x 1 mm, it features a 249 x 250 resolution with a high sensitive 3-micron rolling shutter pixel, with large full well capacitance. The sensor has been specially designed for medical endoscopic applications where high SNR is mandatory. The sensor has a high frame rate of about 43 to 62 fps to permit SNR enhancement and a smooth, low delay display over a wide range of standard interfaces.

The sensor includes a 10-bit ADC and a bit of serial LVDS data interface. The sensor is able to drive the signal through a cable length of up to 3 m.

The data line is semi duplex, such that configuration can be communicated to the sensor in the frame brake.

The exposure time, dark level and analogue gain can be programmed over the serial configuration interface.

1.1 Key specifications

Table 1: Key specifications of NanEye2D

| Parameter | Value | Remark |
|-----------------------|----------------------------|---|
| Resolution | 62 kP, 249 (H) x 250(V) | |
| Pixel size | 3 µm x 3 µm | |
| Optical format | 1/15" | |
| Pixel type | 3T FSI | |
| Shutter type | Rolling shutter | |
| Color filters | RGB (Bayer Pattern) or B&W | |
| Micro lenses | No | |
| Programmable register | Sensor parameter | Exposure time, dark level and analog gain |
| Programmable gain | 4 steps -1.6/1/2.4/6.5dB | Analog |
| Exposure times | 0.07 – 25 ms | Register configurable |

| Parameter | Value | Remark |
|---------------------------------------|------------------------|------------------------------|
| Number of defect pixel ⁽¹⁾ | <10 | |
| Defect pixel cluster ⁽²⁾ | 0 | |
| ADC | 10-bit | Column ADC |
| Frame rate | 43-62 fps | Adjustable over power supply |
| Output interface | 1x LVDS @ 38 Mbps | @50 Hz |
| Size ⁽³⁾ | 1 x 1 mm -10 µm/+30 µm | |

- (1) A pixel is considered a defect pixel if in dark or at any homogeneous illumination level its value deviates more than 200 DN with the settings of INVERSE_GAIN= 2, OFFSET=3, VRST_PIXEL = 1, VREF_CDS = 2 rows in reset = 1, VDDD = 2.0 V from the median value of its 8 nearest neighbors. (In case of RGB color sensors, the nearest neighbors are considered from each color plane individually). Analysis is done at room temperature.
- (2) A defect pixel cluster is any region of 5 x 5 pixels, which contains more than 1 defect pixel.
- (3) Lens edge chipping up to 100 µm is allowed.

1.2 Key benefits & features

The benefits and features of NanEye2D, Miniature camera module are listed below:

Table 2: Key benefits and features of NanEye2D

| Benefits | Features |
|--|--|
| Compact size design for applications with strict size restrictions | Footprint of 1 mm x 1 mm with 4 contact pads |
| Adjustable frame rate | Frame rate of 43-62 fps @ 249 x 250 resolution |
| Envision the unseen | 62k pixel resolution using 3 µm highly sensitive pixel, with reduced noise and higher light efficiency by increased resolution, having a sharp and accurate image |
| Designed with focus on cost efficiency | All-in-one cost-optimized complete camera module solution including optics & cable for easy integration, being ideal for single-use application. Pre-assembled cable eliminates the complexities of cable procurement and attachment |
| Digital interface | Possible to drive a signal through an endoscope of up to 3 m with low EMI |

1.3 Electro-optical characteristics

Table 3: Electro-optical parameters of NanEye2D⁽¹⁾⁽²⁾

| Parameter | Gain=0 | Gain=1 | Gain=2 | Gain=3 | Unit |
|--|--------|--------|--------|--------|-----------------------|
| Gain value | -1.6 | 1 | 2.4 | 6.5 | dB |
| Responsivity | 4.6 | 5.5 | 7.2 | 11.5 | DN/nJ/cm ² |
| Full well capacity | 17 | 15.8 | 13.5 | 6.8 | ke- |
| QE | 30 | 30 | 30 | 30 | % |
| Temporal read noise in dark / dark noise | 1 | 1.1 | 1.6 | 2.6 | DN |
| Dynamic range | 56 | 58 | 53 | 49 | dB |
| SNR max | 44 | 41 | 40 | 38 | dB |
| DSNU | 2.8 | 3.5 | 4.7 | 7 | DN |
| PRNU | 5.0 | 4.8 | 5.0 | 5.2 | % |
| FSD | 655 | 890 | 834 | 808 | DN |

(1) Measured on a B&W sensor at 625 nm illumination. The values are all without software correction.

(2) The settings used to get these values are those recommended by the European Machine Vision Association standard 1288 for the Machine Vision Sensors and Cameras: <https://www.emva.org/standards-technology/emva-1288/>

Table 4: Lens configuration

| Parameter | F#2.7 FOV90° | F#4.0 FOV90° ⁽¹⁾ | F#6.0 FOV90° ⁽¹⁾ | F#2.8 FOV120° | F#4.0 FOV120° ⁽¹⁾ | F#2.4 FOV160° ⁽¹⁾ |
|---|-----------------|--------------------------------|--------------------------------|------------------|---------------------------------|---------------------------------|
| F# number | 2.7 | 4.0 | 6.0 | 2.8 | 4.0 | 2.4 |
| FOV (diagonal in air) | 90° | 90° | 90° | 120° | 120° | 160° ⁽²⁾ |
| FOV (diagonal in water) | 62° | 62° | 62° | 86° | 86° | 95° |
| Max distortion (diagonal in air) | 23% | 23% | 23% | 50% | 50% | 80% |
| Max distortion (diagonal in water) | 7.5% | 7.5% | 7.5% | 16% | 16% | 20% |
| EFL (mm) | 0.66 | 0.66 | 0.66 | 0.5 | 0.5 | 0.45 |
| Aperture (μm) | 220 | 176 | 120 | 176 | 120 | 180 |
| MTF @ ½ Nyquist @ center (simulated) | 69% | 73% | 65% | 66% | 73% | 57% |
| MTF @ ½ Nyquist @ 50% diagonal filed Tangential (simulated) | 47% | 51% | 51% | 53% | 58% | 47% |
| Best focus (mm) | 13 | 10 | 10 | 8 | 8 | 10 |
| Depth of focus | 5 - 40 | 3.5 - 50 | 3 - 50 | 4 - 40 | 3 - 50 | 4 - 50 |

| Parameter | F#2.7 FOV90° | F#4.0 FOV90° ⁽¹⁾ | F#6.0 FOV90° ⁽¹⁾ | F#2.8 FOV120° | F#4.0 FOV120° ⁽¹⁾ | F#2.4 FOV160° ⁽¹⁾ |
|------------------|-----------------|--------------------------------|--------------------------------|------------------|---------------------------------|---------------------------------|
| Module size (mm) | 1x1x1.69 | 1x1x1.72 | 1x1x1.74 | 1x1x1.48 | 1x1x1.43 | 1x1x1.40 |

- (1) These NanEye2D product variants are discontinued.
(2) Full effective FOV cannot be guaranteed due to lens shading effects in the corners.

Figure 1: B&W spectral response

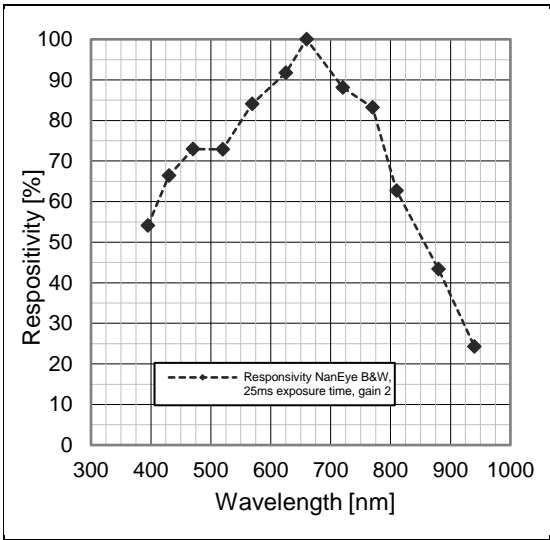


Figure 2: RGB spectral response

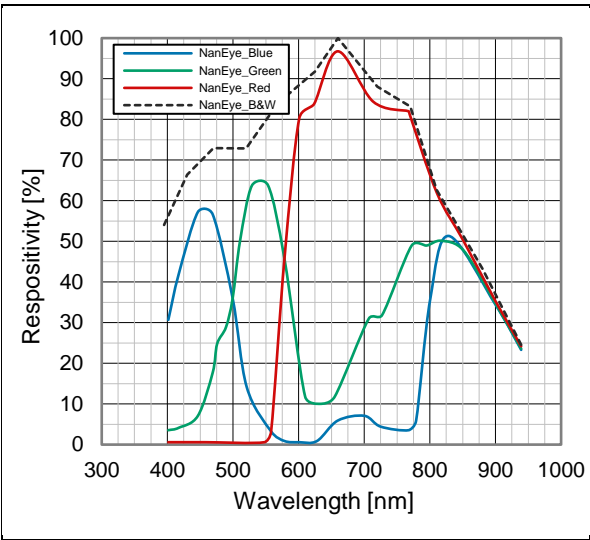


Figure 3: Frame rate vs. voltage⁽¹⁾⁽²⁾

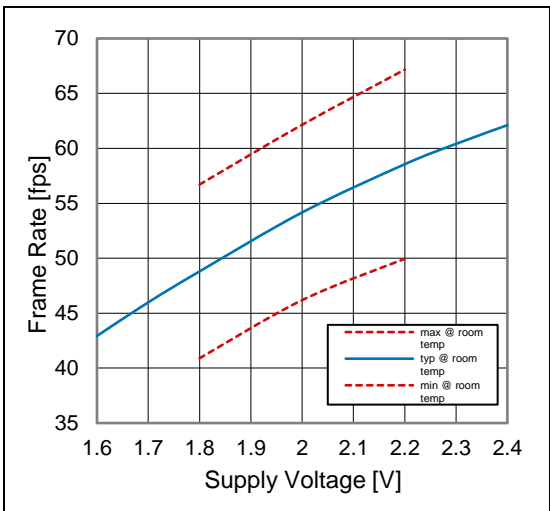
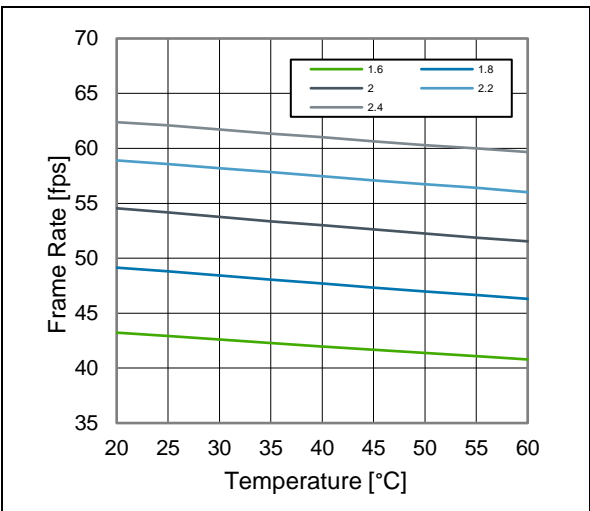
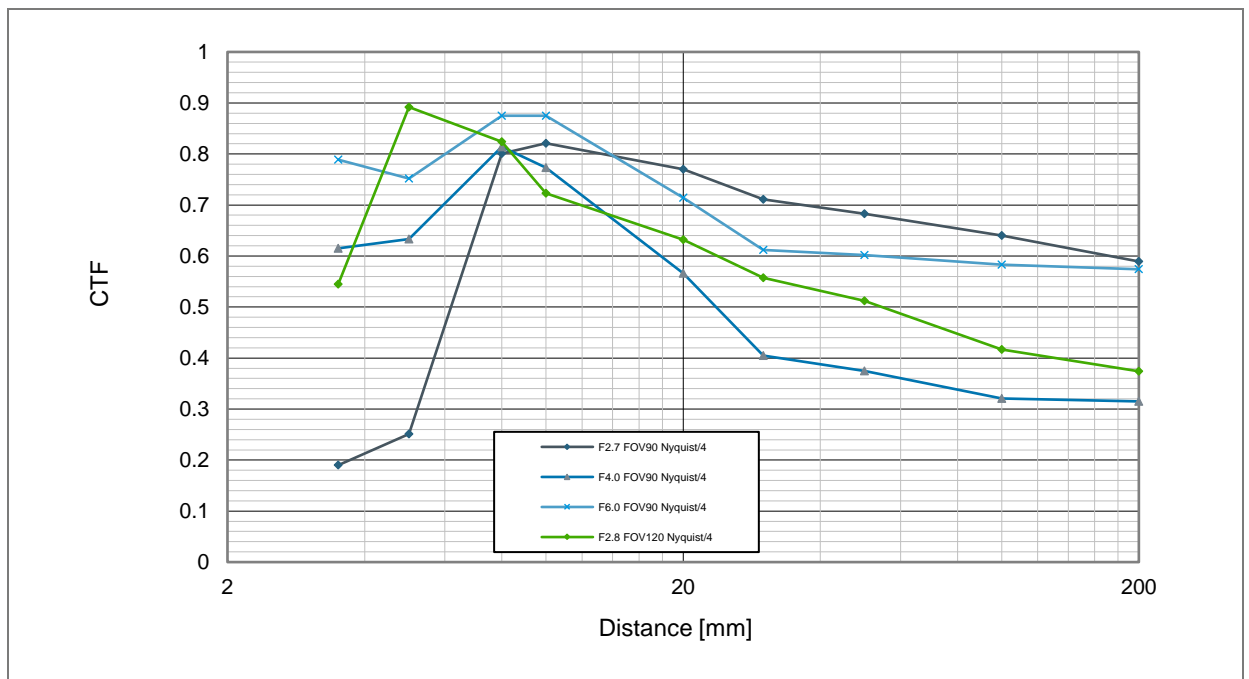


Figure 4: Frame rate vs. temperature⁽²⁾



- (1) Min/max values based on current available test results are for SGA parts without cable. Limits may be adjusted when additional test data is available.
- (2) The frame rate is dependent on VDD sensor supply voltage. For as long as the frame rate is maintained >38 Fps the sensor supply can be set lower than 1.8 V down to 1.6 V minimum.

Figure 5: NanEye2D CTF measurements



1.4 Applications

- Medical Applications
 - Endoscopy
 - Intraoral scanning
- Industrial Applications
 - Industrial endoscopy
 - Robotics
 - IoT (Internet of Things)
- Wearable Devices
 - Eye tracking
 - Virtual / Augmented reality
 - Gesture recognition

2 Ordering information

| Q number | Material title | Chroma | Package | Optics | Delivery form | Delivery quantity (MOQ) |
|-------------|----------------------|--------|---------------|---------------|---------------|-------------------------|
| Q65114A3395 | NE2D_CHIP_B&W_SGA | B&W | SGA | No lens | Tray | 400 |
| Q65114A3340 | NE2D_RGB_V90F2.7_2m | RGB | Cabled module | FOV90°; F2.7 | Spool | 1 |
| Q65114A3341 | NE2D_RGB_V120F2.8_2m | RGB | Cabled module | FOV120°; F2.8 | Spool | 1 |

Information:

As a module, the device is mounted on a flat ribbon cable measuring up to 2 m in length that connects to the base station. However, if the customer requirements are discussed, it may be possible to assemble a slightly longer cable (up to 3 m).

Information:

Device traceability is based on the serial numbers labeled on the spools. Only applicable for the cabled version.

CAUTION:

The NanEye2D Module is NOT supplied sterile! Medical use of the system, not integrated into a medical device, may lead to serious harm, illness or death!

Attention:

The NanEye2D device, as is, was not made to be waterproof or liquid proof. It should be integrated into a tool or endoscope in such a way that the potting material, or adhesive, will seal all sides of the camera module, except the optical front window, from direct contact with water and/or liquids. Using the module without any protection has a high potential for damage, such as scratching on the side wall painting, breaking of the cable and even leaking water/liquids into it.

3 Pin assignment

3.1 Pin diagram

Table 5: Pin assignment SGA (Top View)

| | 1 | 2 |
|---|------|-------------|
| A | VDDD | SDA / DATA+ |
| B | VSS | SCL / DATA- |

Table 6: Pin assignment module cable (Camera Front View)

| | 1 | 2 | 3 | 4 | 5 | 6 |
|-----------------------------|------|-------------|-------------|-------------|------|------|
| 4-wire cable | VSS | SDA / DATA+ | SCL / DATA- | VDDD | | |
| 6-wire cable ⁽¹⁾ | LED- | VSS | SDA / DATA+ | SCL / DATA- | VDDD | LED+ |

(1) Please note that NanEye2D version with LED ring is a discontinued product.

Figure 6: 4-wire cable pinout

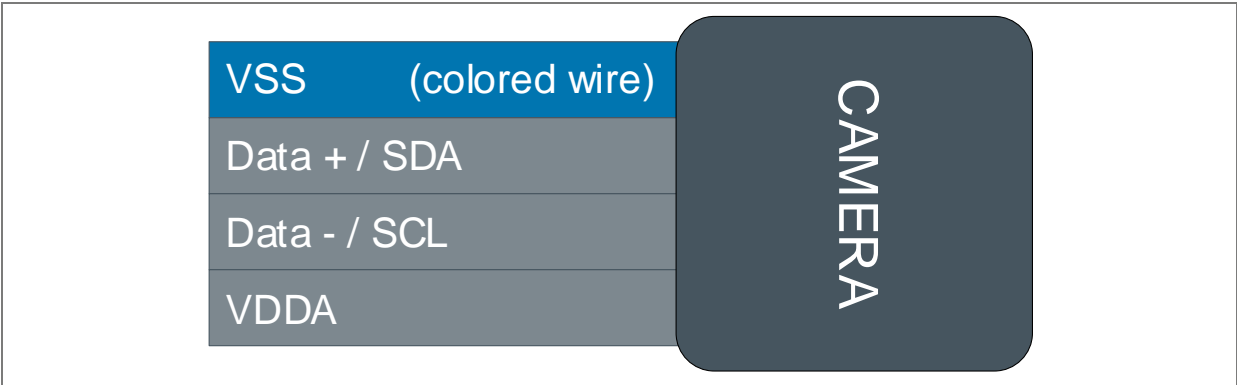
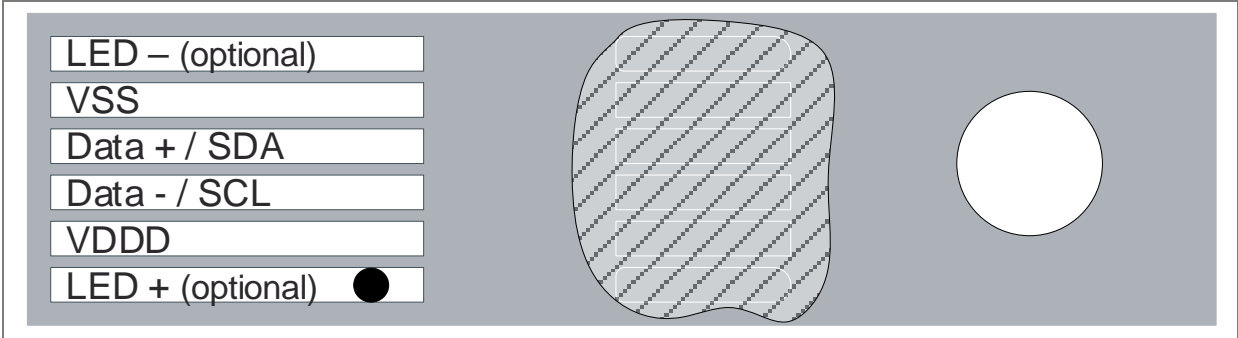


Figure 7: 6-wire cable FlexPCB connector pinout



3.2 Pin description

Table 7: Pin description of NanEye2D

| Pin number | | | Pin name | Pin type ⁽¹⁾ | Description |
|------------|--------------|--------------|-------------|-------------------------|--------------------------------------|
| SGA | Cable 4-wire | Cable 6-wire | | | |
| | | 1 | LED- | AO | LED cathode |
| B1 | 1 | 2 | VSS | VSS | Ground supply |
| A2 | 2 | 3 | SDA / DATA+ | DIO | Serial data input, LVDS pos. output |
| B2 | 3 | 4 | SCL / DATA- | DIO | Serial clock input, LVDS neg. output |
| A1 | 4 | 5 | VDDD | Supply | Positive supply |
| | | 6 | LED+ | AI | LED anode |

(1) Explanation of abbreviations:
DIO Digital Input/Output
AI Analog Input
AO Analog Output

4 Absolute maximum ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under “Operating Conditions” is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 8: Absolute maximum ratings of NanEye2D

| Symbol | Parameter | Min | Max | Unit | Comments |
|---|---------------------------------------|------|-------------------|------|--|
| Electrical parameters | | | | | |
| V _{VDD} | Supply voltage to ground | -0.5 | 3 | V | |
| V _{SCL} , V _{SDA} | Input pin voltage to ground | -0.5 | 3 | V | |
| Electrostatic discharge | | | | | |
| ESD _{HBM} | Electrostatic discharge HBM | ± 1 | | kV | JEDEC JESD22-A114F |
| Temperature ranges | | | | | |
| T _A | Operating ambient temp | -20 | 60 ⁽¹⁾ | °C | VRST_PIX = 0 (1.2V) |
| T _{100C} | Max time around 100 °C ⁽²⁾ | | 2 | min | |
| T _{150C} | Max time around 150 °C | | 10 | sec | |
| T _{BODY} | Package body temperature | | 260 | °C | IPC/JEDEC J-STD-020 ⁽³⁾ |
| | Number of reflow cycles | | 1 | | Due to the small pad pitch, standard reflow process may need to be adjusted to achieve reliable solder result. |
| Storage conditions (modules + cable) | | | | | |
| T _{STRG} | Storage temp range | - | 30 | °C | |
| RH _{NC_STRG} | Storage humidity | - | 60 | % | Not applicable if products are kept sealed inside the original MBB (Moisture Barrier Bag) |
| | Shelf life | - | 4 | year | |
| Storage conditions (SGA) | | | | | |
| T _{STRG_SGA} | Storage temp range | - | 40 | °C | |
| RH _{NC_STRG_SGA} | Storage humidity | - | 90 | % | According to MSL 3 storing conditions mentioned on MBB (Moisture Barrier Bag) |
| | Shelf life | - | 1 | year | |

| Symbol | Parameter | Min | Max | Unit | Comments |
|------------------|--|-----|-----|------|---|
| MSL level | | | | | |
| MSL_SGA | Moisture sensitivity level SGA without Lenses | | 3 | | Represents a floor life time of 168h |
| MSL_M+CABLE | Moisture sensitivity level Lens module with cable | | N/A | | Max floor life time including storage time max. 4 years @ max. 30 °C & 60 % rel. humidity |

- (1) NanEye2D can withstand temperatures of 80 °C with no loss of communication. The only change on its performance it's the slight increase on the dark current/noise, which is normal for high temperatures.
- (2) UV curing process is in our conviction not causing any harm to the sensor.
- (3) The reflow peak soldering temperature (body temperature) is specified according to IPC/JEDEC J-STD-020 "Moisture/Reflow Sensitivity Classification for Non-hermetic Solid State Surface Mount Devices." The lead finish is tin/silver (96.5% Sn, 3.5% Ag).

5 Electrical characteristics

Table 9: Electrical characteristics of NanEye2D

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|--|--------------------------|---------------------|-----------------------|-----------------------|
| V _{DDD} | Supply voltage | | (1.6 ⁽¹⁾)1.8 | 2.1 | 2.4 | V |
| V _{N_{RMS}V_{DDD}} | RMS noise on V _{DDD} | | | | 5 | mV |
| V _{N_{PP}V_{DDD}} | Peak to peak noise on V _{DDD} | | | | 20 | mV |
| P _{CLK} | Internal pixel clock (adjustable via V _{DDD}) | | | 2.8 | | MHz |
| B _{CLK} | Bit clock for serial data transmission (12x Pclk) | | 30 | 33.6 | 46 | MHz |
| J _{DATA} | Jitter data clock | | -20 | | 20 | % of B _{CLK} |
| P _{tot_1.6} | Total power consumption | V _{DDD} =1.6 V ⁽¹⁾ | 1.5 | 3.1 | 4.7 | mW |
| P _{tot_1.7} | Total power consumption | V _{DDD} =1.7 V ⁽¹⁾ | 2.0 | 3.8 | 5.5 | mW |
| P _{tot_1.8} | Total power consumption | V _{DDD} =1.8 V | 2.6 | 4.6 | 6.7 | mW |
| P _{tot_2.1} | Total power consumption | V _{DDD} =2.1 V | 4.6 | 7.5 | 10.5 | mW |
| P _{tot_2.4} | Total power consumption | V _{DDD} =2.4 V | 6.8 | 11.5 | 16.1 | mW |
| Digital upstream interface | | | | | | |
| V _{IL} | SCL, SDA low level input voltage | | -0.3 | | 0.22*V _{DDD} | V |
| V _{IH} | SCL, SDA high level input voltage | | 0.71*V _{DDD} | | V _{DDD} +0.3 | V |
| T _S | Setup time for upstream configuration relative to SCL | | 3 | | | ns |
| T _H | Hold time for upstream configuration relative to SCL | | 3 | | | ns |
| f _{SCL} | SCL frequency | | | | 2.5 | MHz |
| LVDS downstream interface | | | | | | |
| V _{CM} | Common mode output voltage (DATA±) | | 0.4 | V _{DDD} /2 | V _{DDD} -0.4 | V |
| I _{DATA+,DATA-} | LVDS output signal current | | 300 | 500 | 600 | µA |
| | Data line impedance | Recommended | | 120 | | Ω |
| | LVDS differential peak-peak swing | 120 Ω | | 60 | | mV |
| T _{slew, rising} | Output slew rate of rising edge | | | 3 | | ns |
| T _{slew, falling} | Output slew rate of falling edge | | | 3 | | ns |

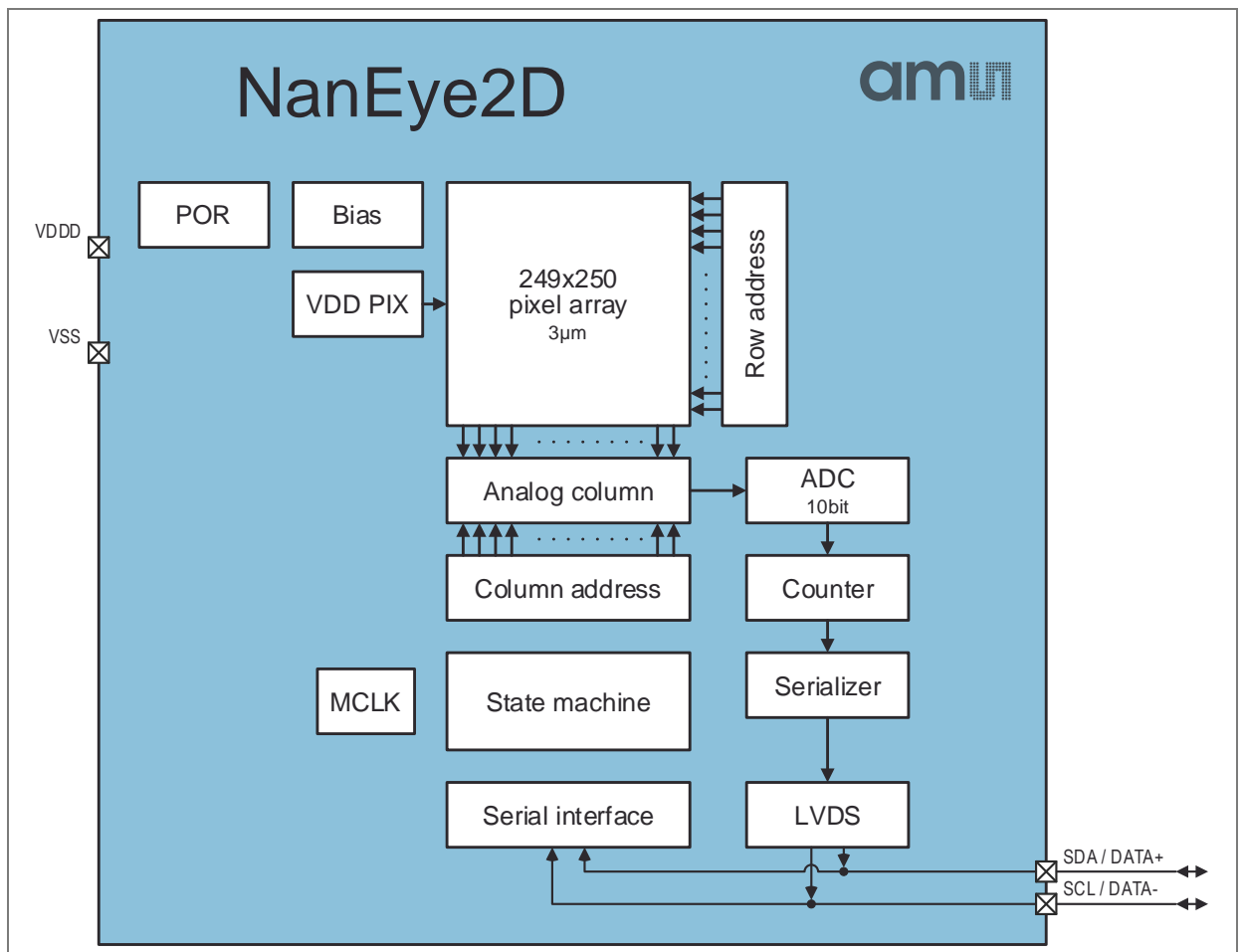
(1) The frame rate is dependent on VDD sensor supply voltage. For as long as the frame rate is maintained >38 Fps the sensor supply can be set lower than 1.8 V down to 1.6 V minimum.

6 Functional description

6.1 Sensor architecture

Figure 8 shows the image sensor architecture. The internal state machine generates the necessary signals for image acquisition. The image is stored in the pixels (rolling shutter) and is read out sequentially, row-by-row. On the pixel output, an analog gain is possible. The pixel values then pass to a column ADC cell, in which ADC conversion is performed. The digital signals are then read out over a LVDS channel.

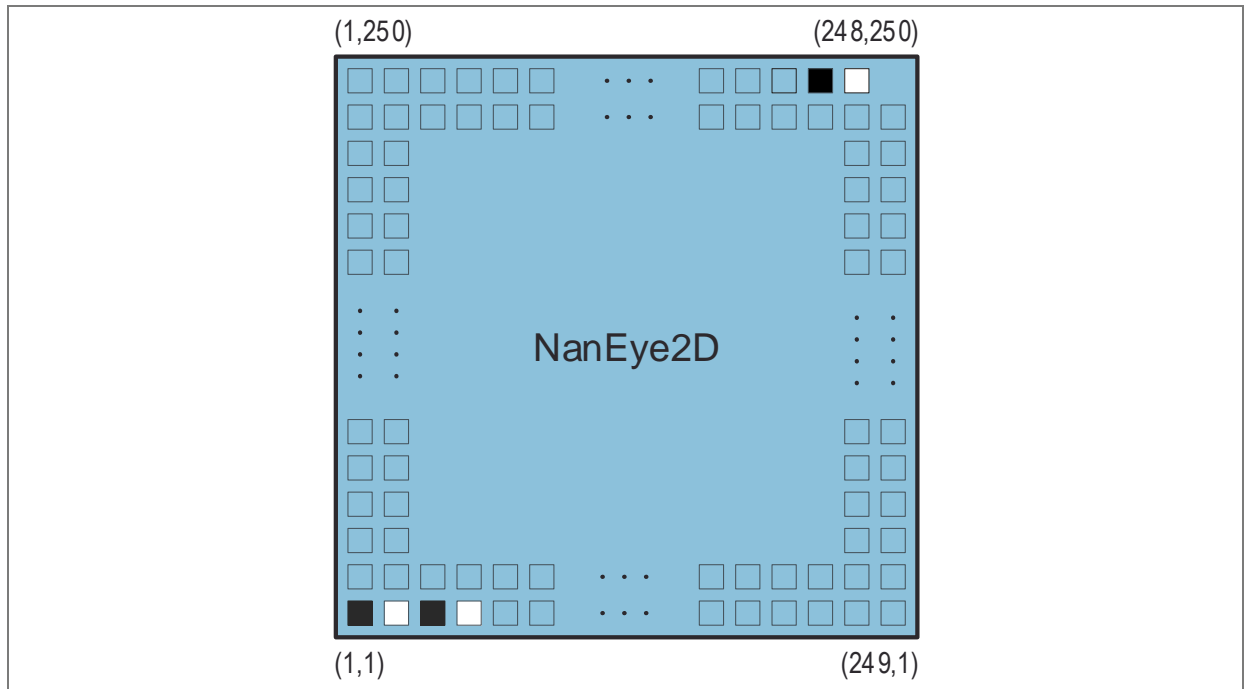
Figure 8: Functional blocks of NanEye2D



6.1.1 Pixel array

The pixel array consists of 249 x 250 square rolling shutter pixels with a pitch of 3 μm (3 μm x 3 μm). This results in an optical area of 747 μm x 750 μm (1.06 mm diameter).

Figure 9: Pixel array



The pixels are designed to achieve maximum sensitivity with low noise.

There are two electrical black pixels and two electrically saturated pixels on the lower left corner and one black pixel and one white pixel on the upper right corner, which may be used to check consistency of received data.

6.1.2 Analog front end

The analog front end consists of 2 major parts, a column amplifier block and a column ADC block.

The column amplifier prepares the pixel signal for the column ADC. The column ADC converts the analog pixel value to a 10-bit value and can apply a gain. All gain and offset settings can be programmed using the I²C interface.

6.1.3 LVDS block

The LVDS block converts the digital data coming from the column ADC into standard serial LVDS data running at around 30 Mbps. During transfer of the image data, the pixel values are transmitted in bit serial manner with 12 bits and embedded clock (start bit (1-bit) + data (10 bits) + stop bit (1-bit)). The sensor has one LVDS output pair.

6.1.4 State machine

The state machine will generate all required control signals to operate the sensor. The clock is derived from an on-chip master clock generator running at about 2.5 MHz. This sequencer can be programmed through the I²C interface. A detailed description of the registers and sensor programming can be found in section 6.5 and 7 of this document.

6.1.5 Single ended serial interface

The single ended serial interface is used to load the register with data. It is multiplexed with the LVDS interface, data can be sent in the frame windows of the receiving image information. The data in this register is used by the state machine and ADC block while driving and reading out the image sensor. Features like exposure time, gain and offset can be programmed using this interface. Section 6.5 and 7 contain more details on register programming.

6.1.6 Optics

The optional optics available for the sensor is a high-performance miniature lens module. It will be directly mounted on the image sensor and has its best focus position defined by design, so no mechanical set of focus is needed. The material is based on B33 (Borofloat glass). The design is made in such a way that the surface towards the object is flat, so the lens performance is not influenced by the medium between the object and lens. Only the opening angle of the lens is reduced when the system operates in water.

6.2 Driving the NanEye2D

The NanEye2D image sensor is a CMOS based system on chip, which means that no external component close to the sensor is needed to run the sensor, not even an external capacitor.

6.2.1 Supply voltage

The sensor operates from a single supply voltage VDDD. All blocks are supplied by this voltage. In addition, a VDDPIX (reset voltage for the pixels) is generated internally.

For reference, schematic and external components please refer to section 8 Application information.

6.2.2 Start-up sequence

The chip is fully self-timed. After power on, the sensor performs an internal power on reset, and then starts autonomous operation and transmission of image data in rolling shutter mode, using maximum exposure time.

6.2.3 Reset sequence

No special reset sequence needed.

6.2.4 Frame rate

If required, the sensor data rate can be modulated slightly by adjusting the sensor supply voltage (see Figure 3 and Figure 4). If multiple sensors are to be synchronized, this is possible by dynamically adjusting the supply voltage to control the frame rate.

6.3 Matrix readout

After power on, the sensor starts to loop autonomously at the sequence as detailed below:

Figure 10: Sequence of operation graph

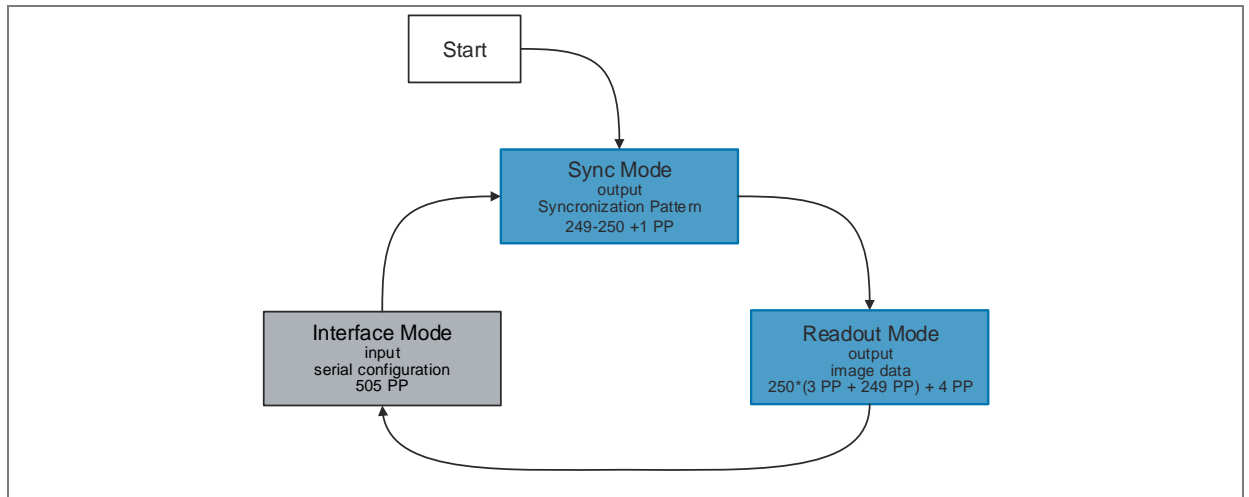


Table 10: Sequence of operation

| Phase # | Status | Start bit | Data XOR | Interface status | Duration | Function |
|---|---|-----------|----------|----------------------------|---------------------|---|
| 1.1 | Transmission of continuous 0 | 0 | Yes | LVDS out | 3 PP ⁽¹⁾ | Row 1 Readout |
| 1.2 | Transmission of 249 pixel values (first pixel is black) | 1 | Yes | LVDS out | 249 PP | |
| 2.1 | Transmission of continuous 0 | 0 | Yes | LVDS out | 3 PP | Row 2 Readout |
| 2.2 | Transmission of 249 pixel values (first pixel is black) | 1 | Yes | LVDS out | 249 PP | |
| Readout of all 250 rows, repeat x.1 and x.2 consecutively | | | | | | |
| 250.1 | Transmission of continuous 0 | 0 | Yes | LVDS out | 3 PP | Row 250 Readout |
| 250.2 | Transmission of 248 pixel values (first pixel is black) | 1 | Yes | LVDS out | 248 PP | |
| 251 | Transmission of continuous 0 | 0 | No | LVDS out | 4 PP | Indication for end of frame |
| 252 | Time for Serial configuration ⁽²⁾ | -- | -- | Serial configuration input | 505 PP | Register configuration |
| 253 | Transmission of synchronization pattern before start of frame, continuous 0 | 0 | Yes | LVDS out | 249 - 250 PP | Resynchronization with sensor data & pixel clock |
| 253a | At the end of the synchronization pattern, a random bit sequence (can be all 0) is transmitted while switching to the first start of line identification. | X | Yes | Change to readout state | 1 PP | Change of state; do filter this word and ignore it. |

| Phase # | Status | Start bit | Data XOR | Interface status | Duration | Function |
|----------------|--------|-----------|----------|------------------|----------|----------|
| Restart at 1.1 | | | | | | |

- (1) PP = Pixel Period
- (2) It is recommended to drive the data bus during the entire upstream communication phase, even if no register data is sent to the sensor. This is to avoid picking up of EMI on the non-driven lines floating during the communication.



CAUTION:

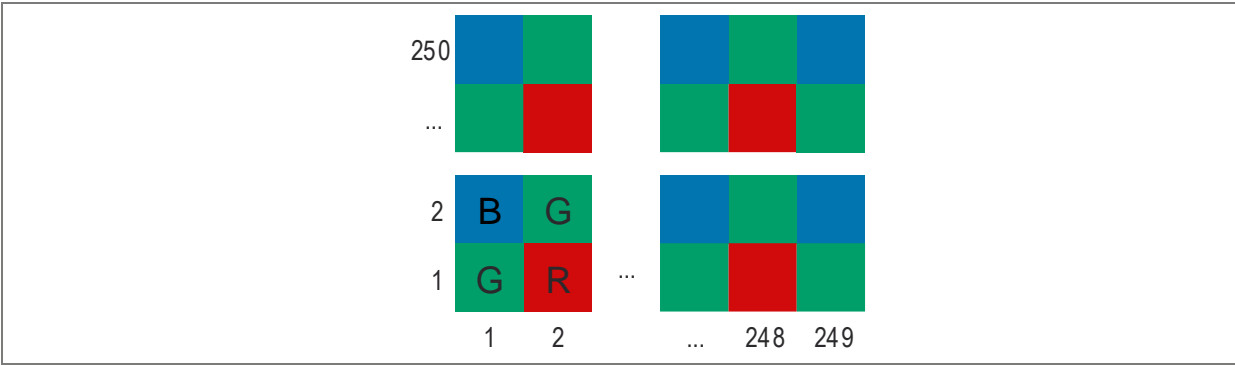
The sensor is fully self-timed and cycles between the downstream and the upstream mode. Therefore, it is the user's responsibility to tristate the upstream drivers of the serial configuration link prior to the start of data transmission from the sensor. If the bus is still driven by the upstream configuration buffers when the sensors start downstream of the first pixel's information, these may not be captured correctly.

Due to the limited current output from the sensor, it is not expected that conflicting drive of the data lines will permanently destroy the sensor, however this condition would seriously degrade the data integrity and is not qualified in terms of device reliability and lifetime.

6.3.1 Color filters

When a color version of the NanEye2D is used, the color filters are applied in a Bayer pattern. The first pixel read-out, pixel (1,1), is the bottom left one and has a green filter.

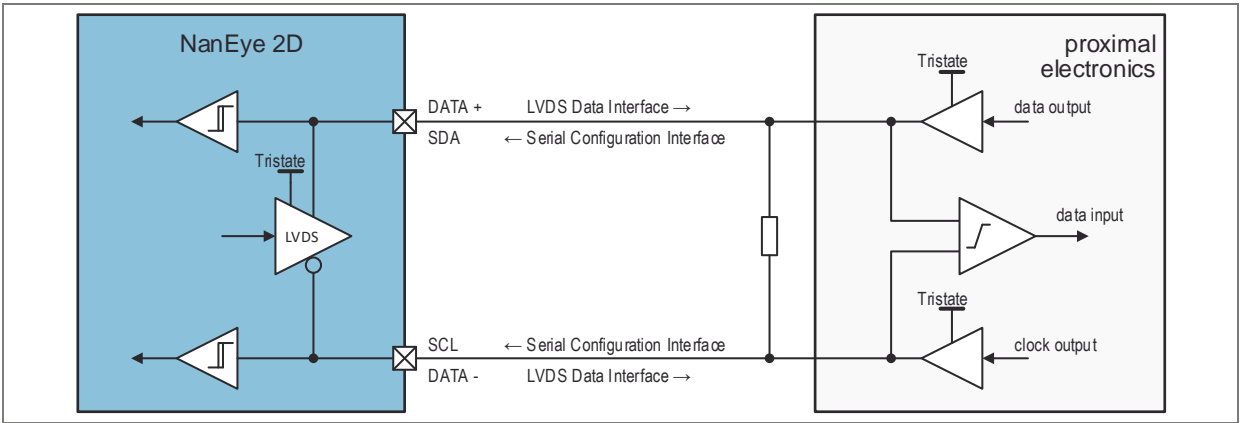
Figure 11: Colored version bayer pattern matrix



6.4 Serial interface

The chip features a bi-directional data interface. During transfer of the image data, the pixel values are transmitted in a bit serial manner over an LVDS channel with an embedded clock. After each frame, the data interface is switched for a defined time to an upstream configuration interface. This needs synchronization every time it passes from the upstream to a new downstream mode at the image receiver side. The positive LVDS channel holds the serial configuration data, and the negative channel holds the serial interface clock.

Figure 12: Data interface between sensor and proximal electronics



6.4.1 LVDS data interface (Downstream)

The NanEye_2D chip works with an on-chip clock of ~2.5 MHz. The image data on chip is generated as a 10-bit representation. A start and a stop bit are then added to the data. The bit serial data interface then transmits the data at 12 x 2.5 MHz bit rate ($\pm 20\%$), ~ 30 MHz.

6.4.1.1 Data word

The data word is EXOR gated with the serial clock before sending bit serial according to the following scheme:

Table 11: Data word encoding

| Bit # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------|-------|----------------------|---|---|---|---|---|---|---|---|-----|------|
| Function | Start | Pixel Data (10 bits) | | | | | | | | | | Stop |
| Content | 1 | MSB | | | | | | | | | LSB | 0 |

An example of this is:

- 10 bits data word: 0110001101
- Including start and stop bits: 101100011010
- 12 bits word EXOR with the data clock:
 - 10 10 10 10 10 10 10 10 10 10 10 10 - data clock (main clock)
 - 11 00 11 11 00 00 00 11 11 00 11 00 - 12-bit data @ data clock frequency
 - 01 10 01 01 10 10 10 01 01 10 01 10 - data word result
 - Start of Row

The start of a line identification consists in 3x sending the word 00 with start and stop bits also at 0.

Table 12: Start of line word encoding

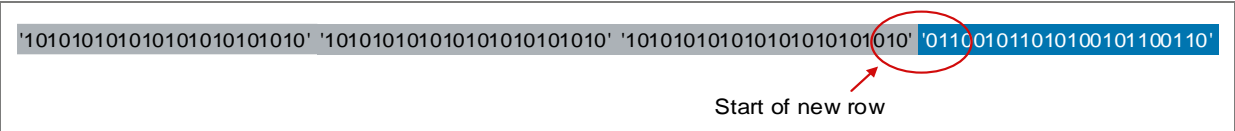
| Bit # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------|-------|---|---|---|---|-----------|---|---|---|---|----|------|
| Function | Start | | | | | Start Row | | | | | | Stop |
| Content | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

An example of this is:

- 10 bits data word: 0000000000
- Including start and stop bits: 000000000000
- 12 bits word EXOR with the data clock:
 - 10 10 10 10 10 10 10 10 10 10 10 10 - data clock (main clock)
 - 00 00 00 00 00 00 00 00 00 00 00 00 - 12-bit at 0's @ data clock frequency
 - 10 10 10 10 10 10 10 10 10 10 10 10 - start of line word result

The resulting start word is sent 3x at the start of a new row. The beginning of a new row can be easily identified by the detection of the first start bit:

Figure 13: Start of row identification



6.4.2 Serial configuration interface (Upstream)

The upstream data interface consists of a single 16-bit write only register. The register is written by sending a 4-bit update code, followed by a 3-bit register address (only register 00 is implemented) and 16-bit register data.

Maximum frequency of SCL can be 2.5 MHz.

All data is written from MSB to LSB. Data is captured on the rising edge of SCL. It is recommended to change SDA on the falling edge of SCL to grant maximum setup and hold times.

The table below indicates the sequence of writing update code, register address and register data.

Table 13: Register update sequence

| #Rising edge of SCL after reset | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | ... | 22 | 23 | 24 |
|---------------------------------|-------------|---|---|---|------------------|---|---|---------------------------|---|-----|----|----|-------|
| Function | Update code | | | | Register address | | | Register content (16-bit) | | | | | Reset |
| Content | 1 | 0 | 0 | 1 | 0 | 0 | 0 | MSB | | | | | LSB |

The content of the input shift register is updated to the effective register, once a correct update code (1001) has been received and shifted by 24 clocks. The input shift register is reset to all 0's 24 clocks after the first high value as the SDA input is received, regardless of whether a correct update code is detected or not.

6.5 Sensor programming

This section explains how the NanEye2D can be programmed using the on-board registers.

6.5.1 Exposure time control

Exposure time is defined based on the amount of rows in reset, set by user. The NanEye2D sensor features a rolling shutter, which means one row is selected for readout while a defined number of previous rows are in reset, and all the other rows are in integration. The range goes from [0 - 248] lines. The default value is 1 "N_{rows_in_reset} = 00000001".

The effective exposure time thus is given by the formula:

Equation 1:

$$T_{exp} = \frac{\max[N_{rows} - N_{rows_in_reset}; 2]}{N_{rows}} \times F_{time}$$

Where:

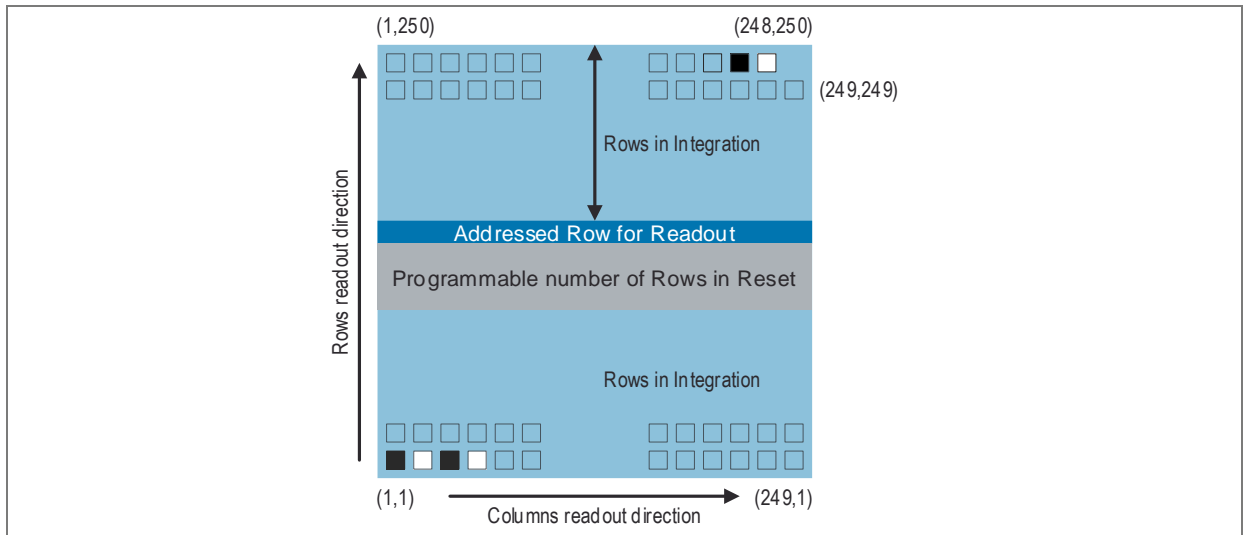
T_{exp} = The effective exposure time

N_{rows} = 250

$N_{rows_in_reset}$ = Register setting *rows_in_reset* [0 ...248]

F_{time} = The time for a frame readout (22.7 ms for NanEye 2D @ VDD = 2.1 V)

Figure 14: Row readout operation



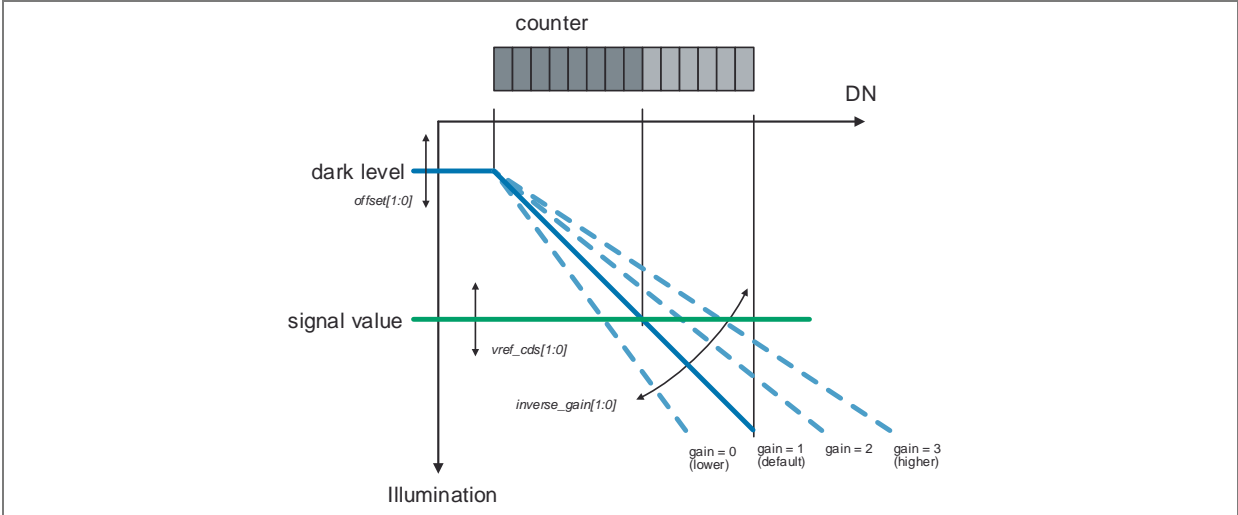
6.5.2 Offset and analog gain

It is a 10-bit full linear ADC. The architecture of the ADC allows to program several parameters:

- Voltage Reference for signal (*vref_cds*[1:0])
- Ramp Gain (*inverse_gain*[1:0])
- Ramp Offset Voltage (*offset*[1:0])

See the configurable values in section 7 Register description.

Figure 15: ADC settings



7 Register description

7.1 Detailed register description

Table 14: CONFIGURATION register⁽¹⁾

| Addr: 00h | | CONFIGURATION | | |
|-----------|-----------------|---------------|--------|--|
| Bit | Bit name | Default | Access | Bit description |
| 15:14 | VREF_CDS[1:0] | 10b | WO | Sets CDS reference voltage: 0: 1.3 V 1: 1.4 V 2: 1.5 V (recommended) 3: 1.6 V |
| 13:12 | VRST_PIXEL[1:0] | 10b | WO | Sets pixel reset voltage: 0: 1.2 V 1: 1.3 V (recommended) 2: 1.4 V (do not use)⁽²⁾ 3: 1.5 V (do not use) |
| 11:10 | OFFSET[1:0] | 01b | WO | Sets ADC ramp offset (dark level): 0: 1.3 V 1: 1.4 V 2: 1.5 V 3: 1.6 (recommended) |

| Addr: 00h | | CONFIGURATION | | |
|-----------|--------------------|---------------|----|--|
| 9:8 | INVERSE_GAIN[1:0] | 10b | WO | Sets inverse ADC ramp gain: 0: Gain = 3 1: Gain = 2 2: Gain = 1 3: Gain = 0 |
| 7:0 | ROWS_IN_RESET[7:0] | 01h | WO | Sets number of rows in reset (exposure time): 0: 0 rows (not recommended) ⁽³⁾ 1: 1 row 2: 2 rows ... 248: 248 rows 249: do not use ... 255: do not use |

- (1) The parameters in bold are the sensor default values. The recommended values are also specified for proper sensor operation.
- (2) It is recommended to set VRST_PIXEL[1:0] to 01b (1.3 V) direct after startup of the sensor.
- (3) “Soft Rest Mode” will increase the brightness but also FPN.



CAUTION:

The PCB connector may short VDDD and LED+ inside the socket during insertion or removal. Switch off the LED supply before plugging in/out the PCB connector or use appropriate protection.

8.2 Supply generation

Having an LDO to generate a dedicated low noise supply is recommended. It has to be kept in mind that the cable is about 7 Ω per meter in length. So, for different cable length and clock speeds used it should be verified that the supply voltage at the sensor is within the required range.

8.3 External components

Figure 17: External components LVDS

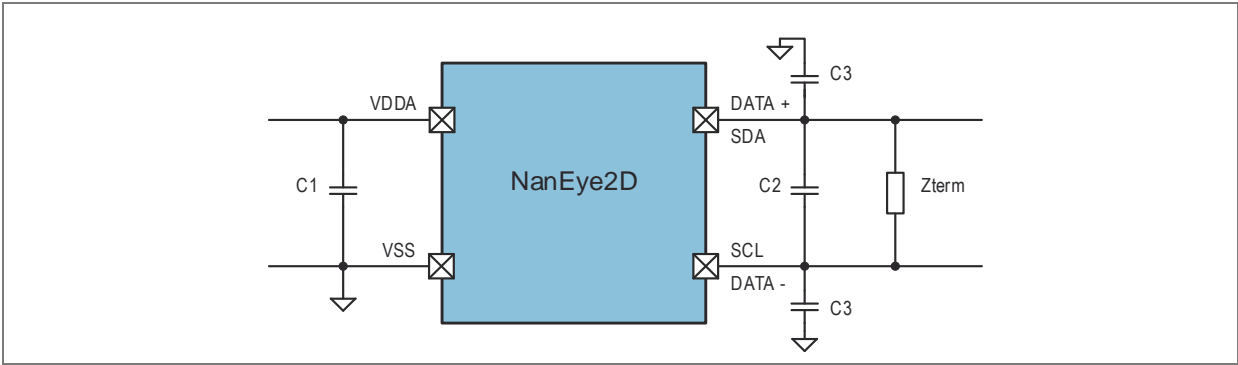
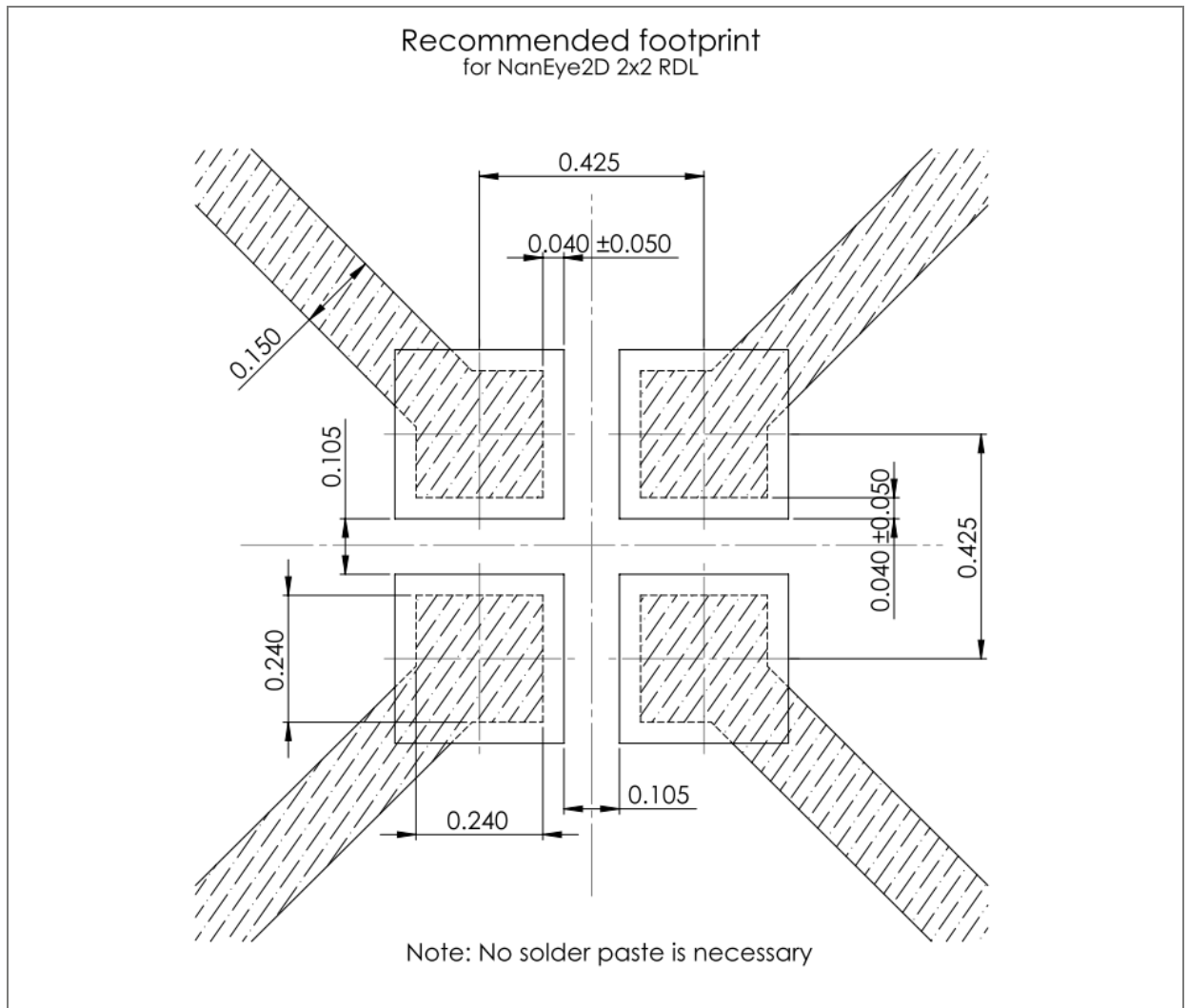


Table 15: External components recommendations

| Component | Description | Nominal value | Unit |
|-----------|--|---------------|----------|
| C1 | Power supply decoupling | >100 | nF |
| C2 | Differential load on LVDS lines (parasitics) | <3 | pF |
| C3 | Single ended load on LVDS lines (parasitics) | <5 | pF |
| Zterm | Impedance of LVDS termination | 120 | Ω |

8.4 PCB layout

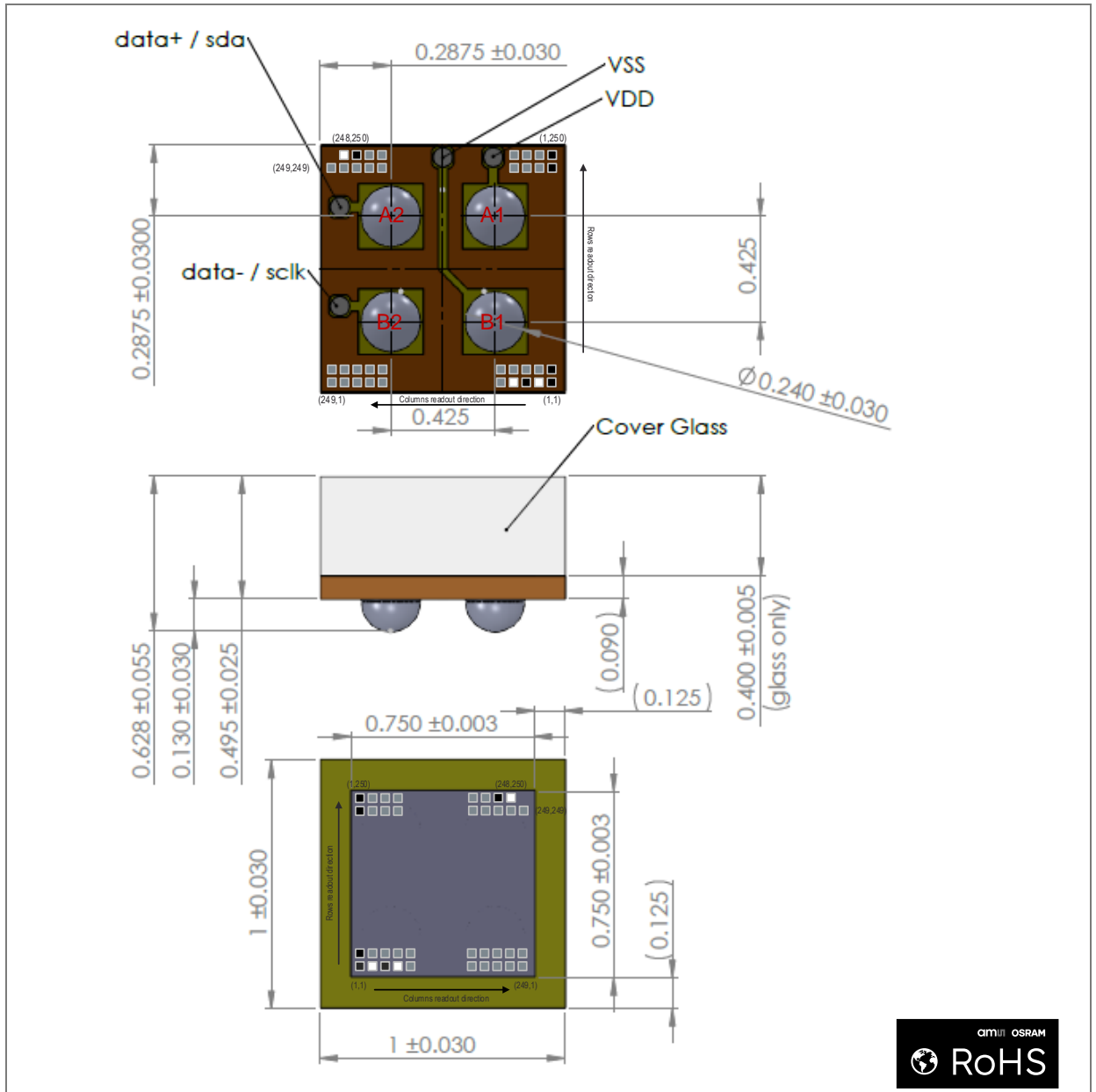
Figure 18: SGA 2x2 footprint and layout⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾



- (1) All dimensions are in millimeters. Angles in degrees.
- (2) If not otherwise noted all tolerances are ± 0.05 mm.
- (3) This package contains no lead (Pb).
- (4) This drawing is subject to change without notice.

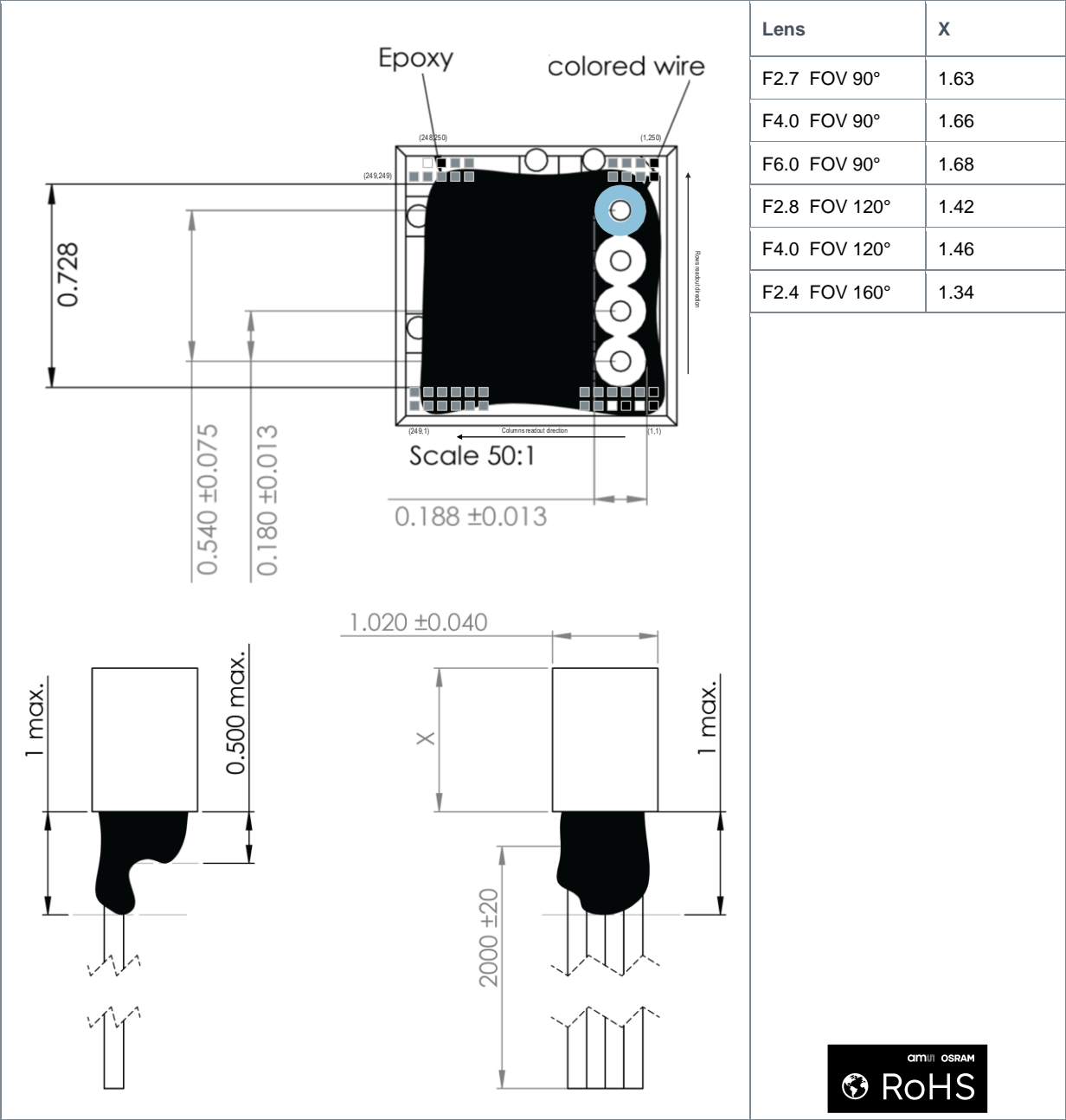
9 Package drawings & markings

Figure 19: NanEye2D SGA 2x2 package outline drawing round contacts (Showing Pixel Positions)⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾⁽⁵⁾



- (1) All dimensions are in millimeters. Angles in degrees.
- (2) If not otherwise noted all tolerances are ± 0.04 mm.
- (3) This package contains no lead (Pb).
- (4) The pixels shown in the drawing are for information only. Its dimensions are not up to scale, as well as its positions are not precisely aligned with the chip.
- (5) This drawing is subject to change without notice.

Figure 20: NanEye2D with lens and cable soldered dipped (Bended) package outline drawing (Showing Pixel Positions)⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾⁽⁵⁾



- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Dimensioning and tolerancing conform to ASME Y14.5M-1994.
- (3) N is the total number of terminals.
- (4) This package contains no lead (Pb).
- (5) This drawing is subject to change without notice.



Connector

LED- (optional)

VSS

D+

D-

VDD

LED+ (optional)

15

LED- (optional)

VSS

Data+

1.75

3.50

Ø1.50

VDD

Data-

LED+ (optional)

4

0.35

0.50

Camera cable Soldering Covered by Epoxy

0.335

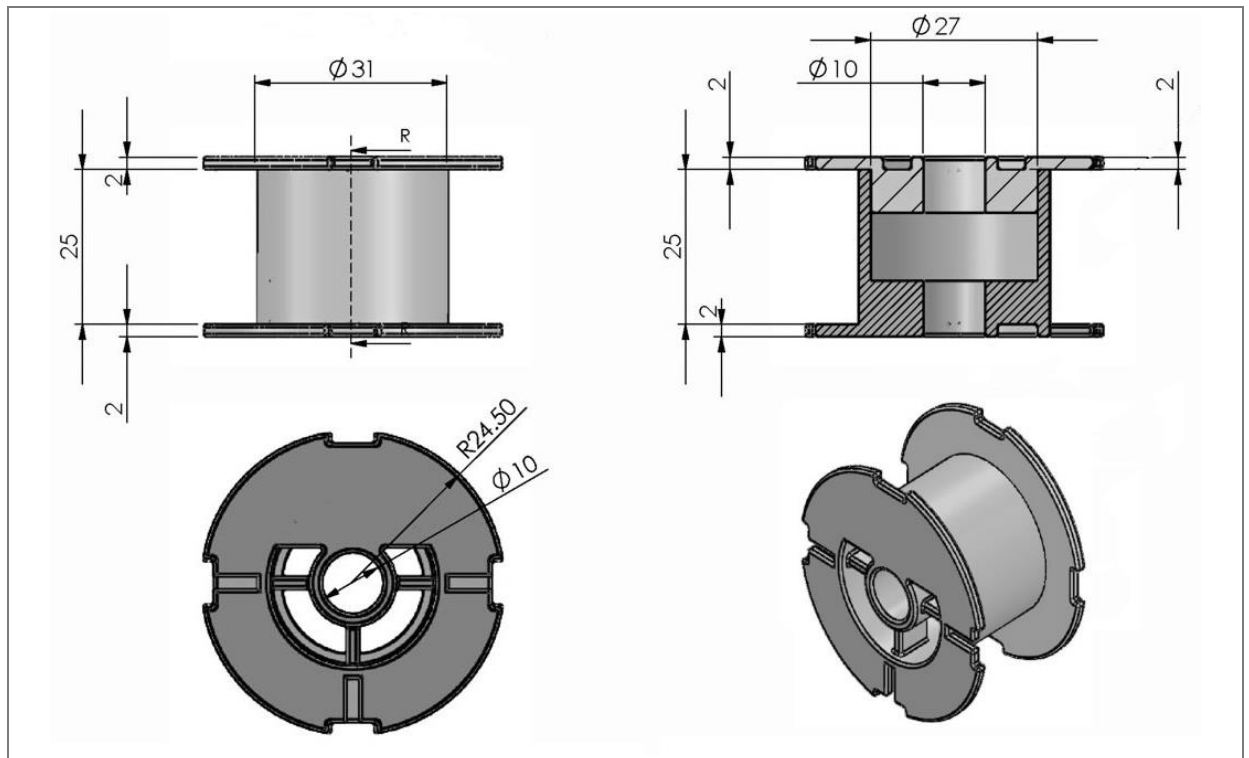
OSRAM

RoHS

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10 Tape & reel information

Figure 22: Spool dimensions for module plus cable shipments⁽¹⁾⁽²⁾⁽³⁾



- (1) All dimensions are in millimeters. Angles in degrees.
- (2) If not otherwise noted all tolerances are ± 0.1 mm.
- (3) This drawing is subject to change without notice.

[illegible]

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11 Appendix

11.1 Evaluation system

Optionally with the NanEye2D Module, ams OSRAM provides a base station and software to run the device on a PC in real-time with all necessary image corrections. The complete system consists of the module, the USB base station and the PC software. For more information, please check the ams-osram.com webpage.

11.2 Application notes

For more details on the sensor, please check the application notes/guides at ams OSRAM [webpage](#).

12 Revision information

| Document status | Product status | Definition |
|-----------------------|-----------------|---|
| Product Preview | Pre-development | Information in this datasheet is based on product ideas in the planning phase of development. All specifications are design goals without any warranty and are subject to change without notice |
| Preliminary Datasheet | Pre-production | Information in this datasheet is based on products in the design, validation or qualification phase of development. The performance and parameters shown in this document are preliminary without any warranty and are subject to change without notice |
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| Changes from previous released version to current revision v10-00 | Page |
|---|------|
| Document contents transferred to new ams OSRAM datasheet template | |
| Moved Key Specification table | 4-5 |
| Updated Key Benefits & Features table | 5 |
| Moved Electro-Optical Characteristics Info | 6-8 |
| Updated Ordering information section | 9 |
| Block Diagram moved to Section 6 | 15 |
| Added Supply Generation Section | 28 |
| Added External Components Section | 28 |
| Moved Application Notes Section | 35 |

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

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Headquarters

ams-OSRAM AG
Tobelbader Strasse 30
8141 Premstaetten
Austria, Europe
Tel: +43 (0) 3136 500 0

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