Calumino Thermal Sensor Datasheet (Preliminary)

20x15 Infrared Array, CTS3001 - STSCTG30N140

Features and Benefits

- 20x15 pixels thermal sensor
- < 80 mK NETD @ 7.5 Hz
- Factory calibrated
- < 30 mW power consumption @ 60 Hz
- Operating temperature -10°C to 65°C
- MIPI CSI-2 output interface
- Configurable frame rate from 1 to 60 Hz
- 140° x 100° (H x V) Field of View
- Full integration and technical support provided for fast time to market

Application Examples

- Presence detection/person localization
- Smart building lighting and HVAC control
- Non-contact temperature measurement
- Home automation
- Continuous asset temperature monitoring
- Intruder detection for security systems
- Hotel room occupancy and facility management
- Aged care wellbeing monitoring
- Many more…

About

The Calumino Thermal Sensor (CTS), built on the Cantilever technology principle, is a next-generation thermal sensing platform engineered for AI-driven applications.

The CTS3001 outputs an 8-bit raw uncorrected image via MIPI CSI-2 and contains on-board memory with calibration parameters. A downstream MIPI capable processor uses the stored calibration parameters to output a thermal image with true temperatures.

Calumino also offers MIPI capable processing modules for fast integration, as well as precompiled C++ libraries tailored to the CTS's native performance, to obtain thermal imagery data.

Table of Contents

1. Key specifications

Table 1: *STSCTG30N140 general specifications*

Parameters	Typical Values
Resolution [infrared pixel]	20x15
Frame rate	7.5 Hz (typical)
Spectral detection range	8-12µm (LWIR)
Thermal sensitivity / NETD	80 mK typical @ 7.5 Hz
Thermal accuracy[1]	Factory calibrated to ± 2°C
Output and control interface	MIPI (data stream), I^2C (control, memory, and peripherals)
Output format	8-bit raw uncorrected image (640 x 480)
Power consumption	27 mW typical @ 7.5 Hz
Power supply	3.3V
Physical interface	18-pin, 0.5mm pitch FFC connector
Operating temperature range	-10˚C - 65˚C
Dynamic temperature range	-20˚C - 70˚C
Weight	< 3 g
Dimensions	30 mm x 14 mm x 9 mm
Field of View (H x V)	140° x 100°

[1] At flood illumination and at $T_{ambient}$ = 25°C

2. Absolute maximum ratings

Do not exceed the maximum limits specified in Table 2 as this could cause permanent damage or reliability issues.

Table 2: *Absolute maximum ratings*

Parameter	Maximum Rating
Supply voltage (V_{DD})	0 V – 4.0V
Digital I/O (MIPI_D0_N, MIPI_D0_P, MIPI_D1_N, MIPI_D1_P, MIPI_CK_N, MIPI_CK_P, I2C_SCL, I2C_SDA)	0 V – 4.0V
Storage Temperature	-10 °C to 65 °C
Storage Humidity (non-condensing)	80 %RH
Operating Temperature (TO)	-10 °C to 65 °C
Operating Humidity (non-condensing)	70 %RH
ESD Immunity (housing)	±15kV air, ±8kV contact
ESD Immunity (connector pins)	1 kV Human Body Model 250V Charged Device Model

3. Product performance

3.1. Focal plane array

The focal plane array (FPA) has natively 20x15 infrared pixels (shown in Figure 1).

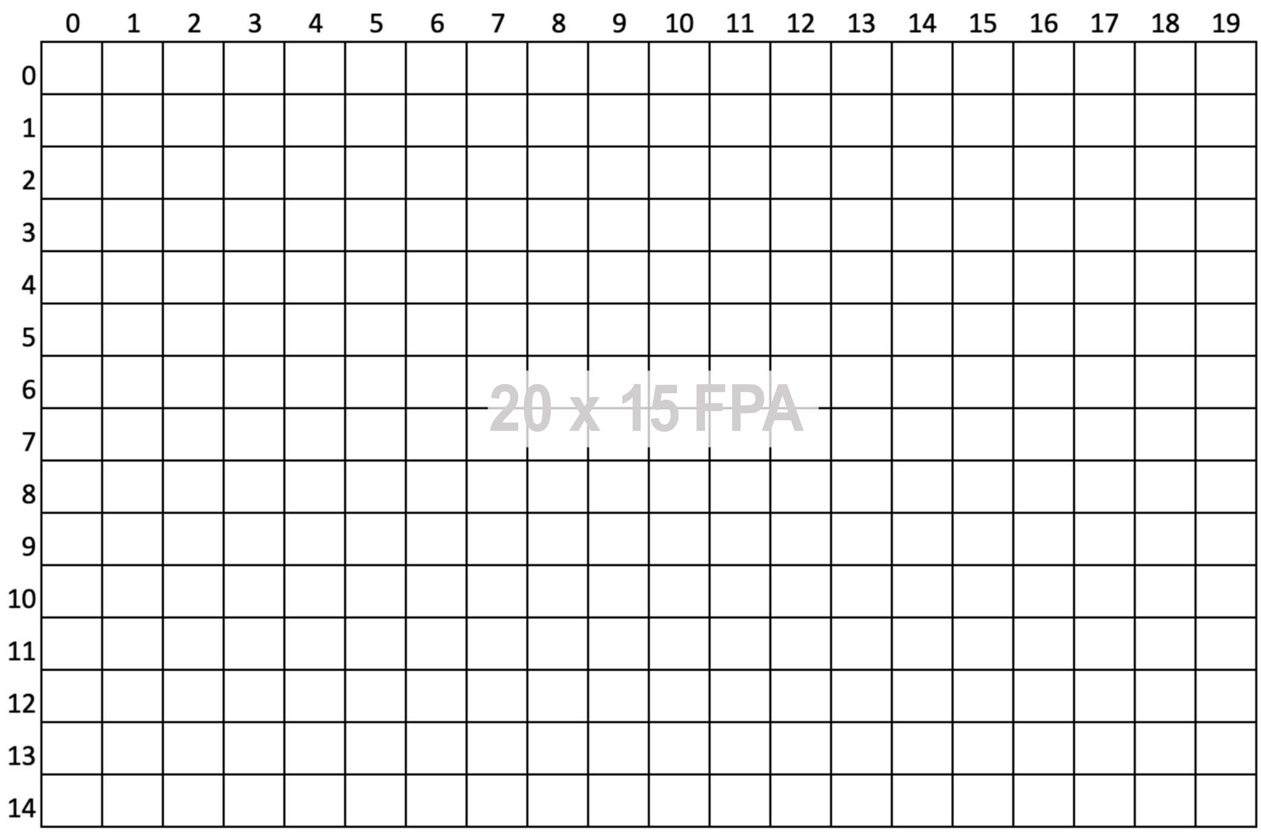

***Figure 1**: STSCTG30N140 FPA dimensions*

3.2. Typical optical performance specifications

***Table 3:** Typical lens specification*

Lens Type	HxV FOV (°) (typical)	F#	Clear Aperture (mm)	Relative Illumination (XFOV)	Distortion (XFOV)	Focus
STSCTG30N140	140x100	0.66	1.4	76 %	64 %	Fixed

3.3. Pixel resolution

Table 4: *Pixel resolution*

Sensor Specifications	Min	Typ	Max	Units
X-axis Resolution for STSCTG30N140	-	20	-	pixels
Y-axis Resolution for STSCTG30N140	-	15	-	pixels

3.4. Defective pixel limitations

This requirement describes the number and location/grouping of defective pixels allowable in the sensor.

Pixels, inside the image circle active area, that do not respond to incident IR radiation or that do not meet the specified dynamic range are classified as defective. By factory default, in the output thermal image, every defective pixel is replaced with interpolated values from neighbouring non-defective pixels.

Defective pixels and clusters of defective pixels are defined in the active area of the FPA only.

Table 5: *Defective pixel limitations*

Defect Specifications	Value	Comments
Total defective pixels (maximum)	9 (3%)	The total count of defective pixels within the image circle.
2x2 defective pixel clusters	0	Cluster refers to any grouping of defective pixels in which a defective pixel is adjacent to another defective pixel.

3.5. Temperature accuracy

The specifications in Table 1 assume that the sensor is operating in thermal equilibrium.

The temperature accuracy is determined at factory calibration (within 10 hours) with following test conditions:

- Ambient temperature 25°C ± 2°C
- CTS internal temperature rate of change: < 0.0005 °C/s (i.e. isothermic conditions)
- Blackbody reference source emissivity: >0.98
- Blackbody reference source accuracy: ±0.03°C
- Distance between unit under test to blackbody reference source: <10cm (flood illumination)

Note that the temperature accuracy or radiometric accuracy depends on the following factors:

1. Ambient temperature
2. Thermal conductivity of unit, temperature and parasitic heat sources within the enclosure where unit is mounted in
3. Object temperature
4. Distance between unit and object
5. Transmission between unit and object
6. Object emissivity and reflectivity
7. Object size
8. Object location within the FOV
9. Other environmental conditions

Note that the temperature accuracy of the CTS will degrade over time, depending on its operating temperature. For reliable, long term radiometric temperature output we recommend performing an in-field calibration depending on customer needs and operating conditions.

In-field calibration of a thermal sensor involves adjusting its readings to match actual temperatures under real operating conditions. This is done by comparing the sensor's output to a trusted reference, such as a calibrated blackbody or precision thermometer, and applying correction factors or offsets to improve accuracy.

4. Electrical integration

4.1. General

STSCTG30N140 outputs raw data in real time via a MIPI CSI-2 interface, as well as via I^{2}C for reading configuration parameters, unit identification details, optical parameters, and the on-board temperature sensor.

Raw MIPI data must be converted into a thermal image using Calumino's provided algorithms which are available as an IP block for several microcontrollers.

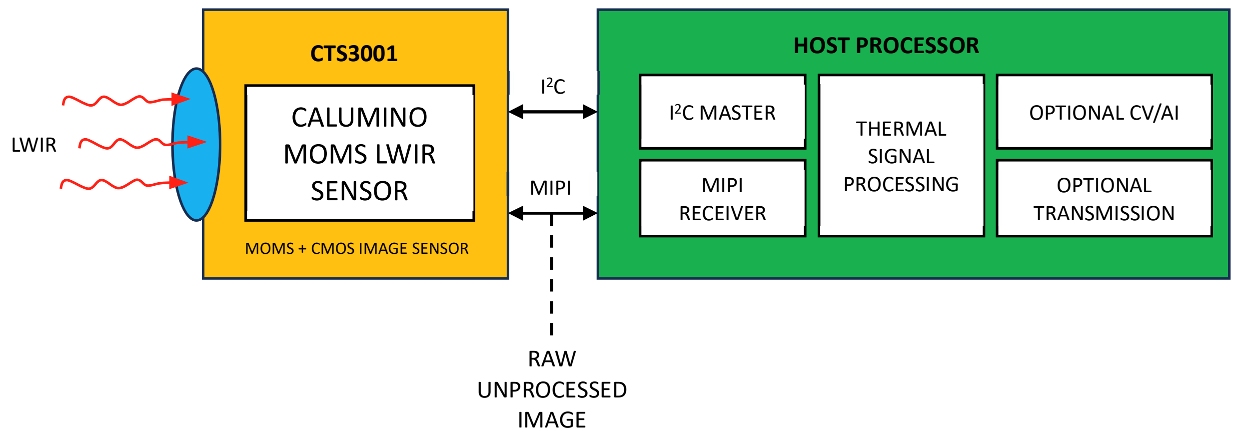

Figure 2: High level system diagram if CTS3001 and downstream host processor communication

4.2. Initialisation flowchart

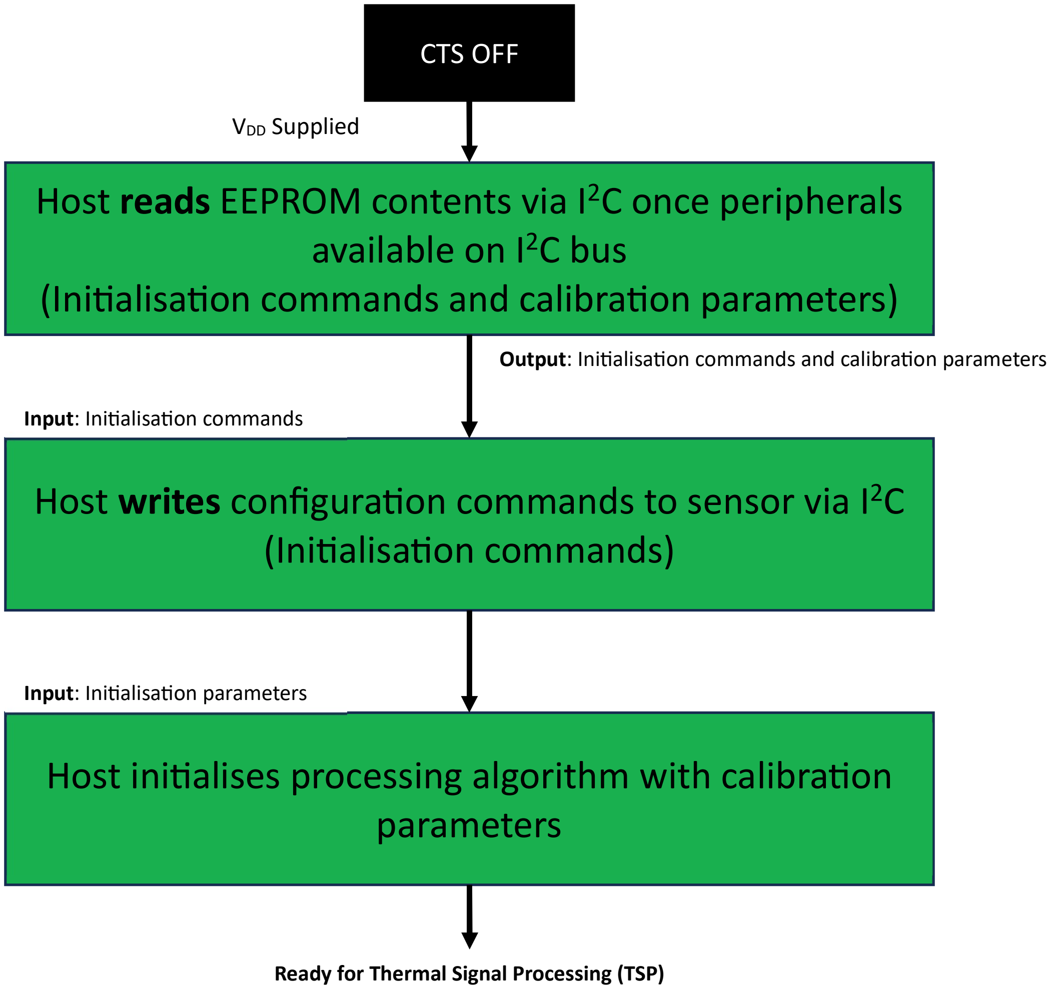

Figure 3: Required initialisation flowchart

4.3. Electrical specifications

Table 6: *Electrical specifications*

Parameter	Symbol	Min.	Typ.	Max.	Units
Supply voltage	V_{DD}	3.0	3.3	4.0	V
I/O Voltage	V_{IO}	1.7	1.8	1.9	V
Supply current	I_{DD}	-	8	35	mA
Input logic low voltage*	V_{IL}	0	0	0.3	V
Input logic high voltage*	V_{IH}	1.5	1.8	V_{IO}	V
Bootup time (first frame ready for readout)	T_{START}	-	200	-	ms

**Excluding MIPI*

CTS functionality may be affected by alternating current (AC) induced power rail voltage oscillations, or if electrostatic charges are brought close to the CTS module. It is necessary to ensure adequate grounding is established in the circuitry powering the CTS and that the CTS is shielded from electrostatic interference during operation.

4.4. MIPI interface

STSCTG30N140 contains a MIPI slave interface which outputs a raw uncorrected image with a CRC error detecting code at up to 60 frames per second (FPS).

The MIPI channel utilises 2 differential data lanes (4 channels total) as shown in Error! Reference source not found.. The function pinout for the CTS SPI connector is listed in Table 7:

- Data Lane 0 Negative
- Data Lane 0 Positive
- Clock Lane Negative
- Clock Lane Positive

Important note: It is imperative that the host PCB requires 100 Ω differential traces for the MIPI lines. Alternatively, Calumino can support with fast integration through a packaged MIPI to SPI module that performs all required thermal conversion and SPI interface.

STSCTG30N140 also contains an I^{2}C interface providing access to internal memory for accessing configuration parameters (1 time read) as well as real time on-board temperature readings (continuous reading).

- I2C SCL – Clock signal provided by host
- I2C SDA – Bidirectional data line

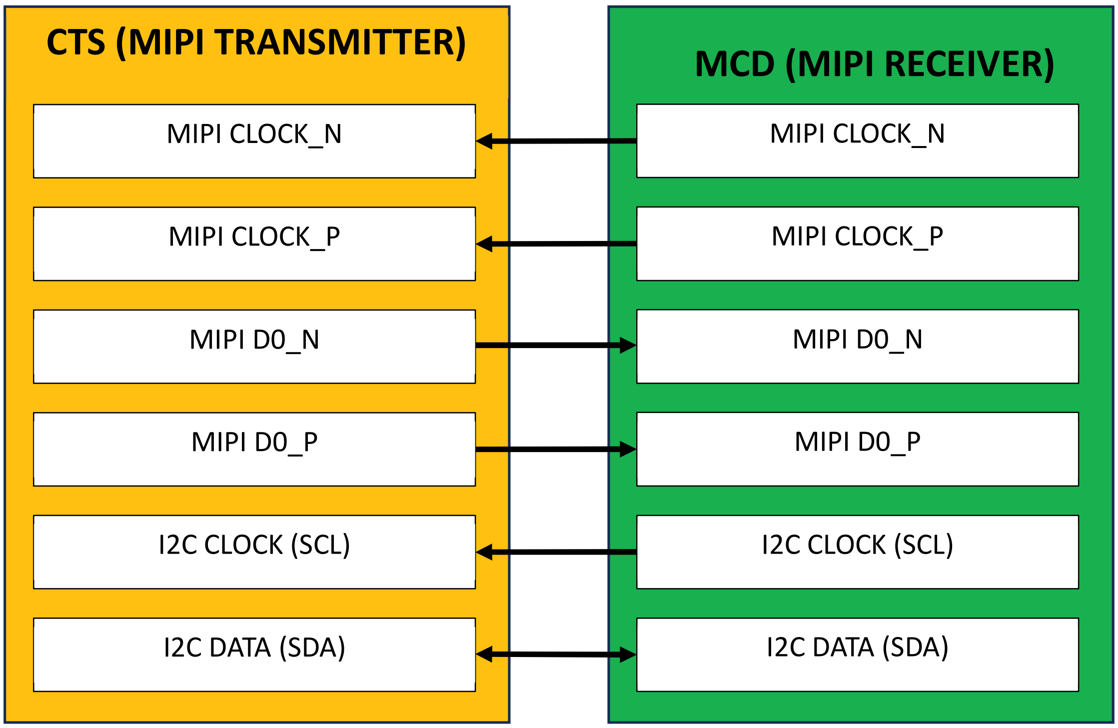

Figure 4: MIPI and I2C channels (I/O) schematic diagram

4.5. MIPI connector pinout

The mating connector type is Molex 505110-1892 (female), and the mating cable type is Molex 015020018x. Host must have the same or similar connector for integration, and it is recommended that cable length does not exceed 200mm.

Note that it is not recommended to plug in and out the connector repeatedly.

***Table 7:** Required user connector pinout for the on board 18-pin connector*

Connector Pin Number	Pin Description	STATE
1	GND – Ground	GND
2	MIPI_D0_N	O
3	MIPI_D0_P	O
4	GND – Ground	GND
5	MIPI_CLK_N	I
6	MIPI_CLK_P	I
7	GND – Ground	GND
8	MIPI_D1_N	O
9	MIPI_D1_P	O
10	GND – Ground	GND
11	IS_INT	O
12	XSHUTDN	I
13	GND – Ground	GND
14	Power Enable	I
15	CMOS Trig	I
16	I2C_SCL	I
17	I2C_SDA	I/O
18	3V3	PWR

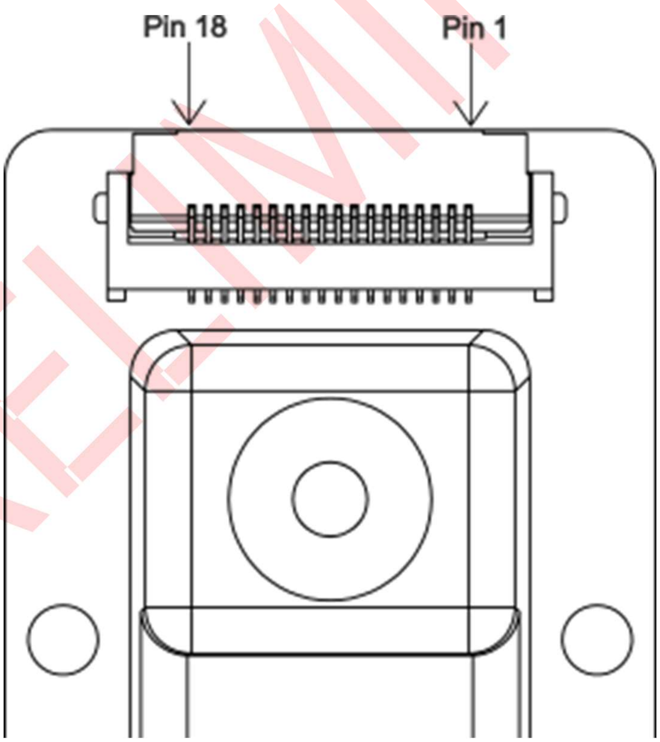

Figure 5: Top view of CTS showing user connector Pin 1 & Pin 18

4.6. Available EEPROM memory locations

Table 8: *Memory location* ***details***

Parameter Name	Comment	EEPROM Memory Address
SERIAL_NUMBER_LOW	CTS Serial Number (Low 32-bit Word)	0x00000250
SERIAL_NUMBER_HIGH	CTS Serial Number (High 32-bit Word)	0x00000254
CENTRE	Lens Centre Coordinates (X*256, Y*256)	0x00000260

4.7. Memory address descriptions

The CTS internal memory is structured as 32-bit registers.

4.7.1. SERIAL_NUMBER

Size: 8 bytes

The unique identifier of the CTS hardware, which can be used to identify unique factory calibration characteristics of each device. Expressed as an unsigned 64-bit hexadecimal string.

To form the hexadecimal string, both SERIAL_NUM_LOW and SERIAL_NUM_HIGH must be combined as follows:

SERIAL_NUMBER = TO_HEX_STR (SERIAL_NUM_LOW + SERIAL_NUM_HIGH * 2^{32}))

A real example is shown below:

SERIAL_NUM_LOW = 6636321
SERIAL_NUM_HIGH = 74565

SERIAL_NUMBER = TO_HEX_STR (6636321 + 74565*2^{32})
SERIAL_NUMBER = TO_HEX_STR (320254243062561)
SERIAL_NUMBER = 0x1234500654321

Bits 0-63: CTS Serial Number

4.7.2. CENTRE

Size: 4 bytes

Estimated optical centre of the lens, as determined during factory calibration. Values are read as coordinates in the final thermal image (i.e., for a typical [20, 15] size CTS, the optical centre would be at [10.0, 7.5]).

Bits 0-9: Horizontal centre of lens, multiplied by 10. User must divide by 10 to get the final value.
Bits 10-19: Vertical centre of lens, multiplied by 10. User must divide by 10 to get the final value.

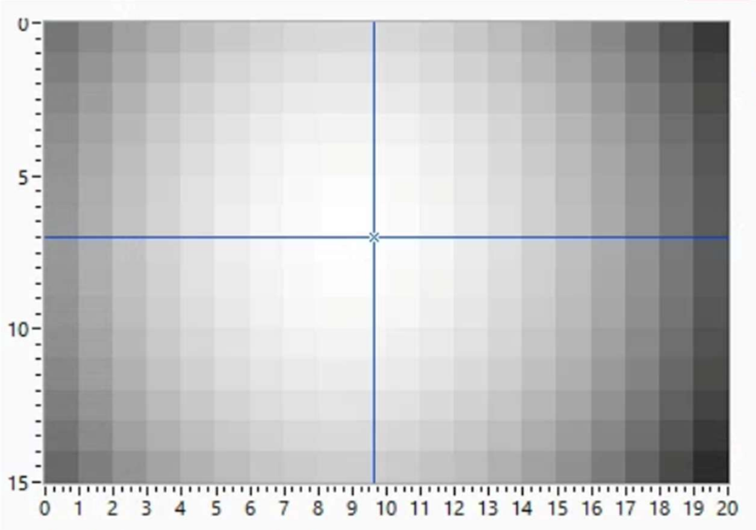

Figure 6: *Example 20x15 CTS output image of a CTS showing a slight decentration. The blue lines represent the center lines of the focal plane array (FPA), as reported in metadata and measured in IR pixels.*

Note that STSCTG30N140 units have a vignetting effect visible in the thermal image due to the extremely wide FOV. This "image circle" is related to the optical center of the lens as well as the response of each pixel to incident infrared radiation. It is recommended to crop the image circle from the final thermal image as shown in Figure 7.

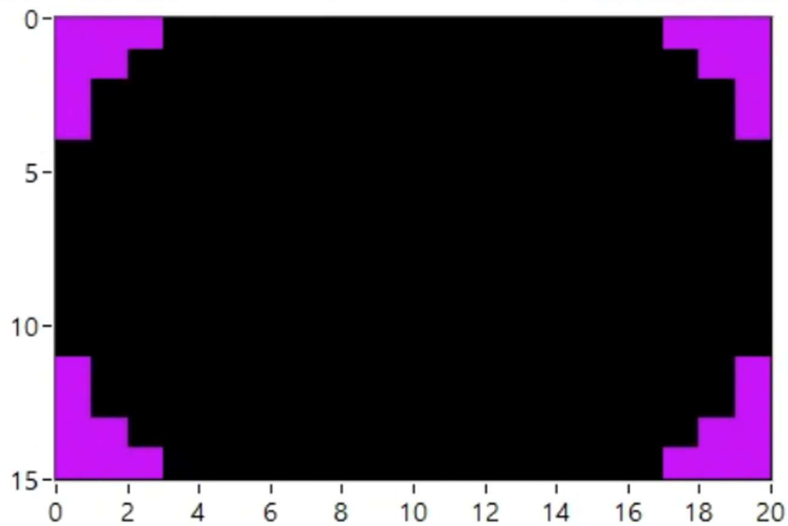

Figure 7: *Example recommended masking of image circle pixels from the final thermal image. The image circle pixels are stored in CTS memory and can be read from EEPROM memory via I^2C.*

5. Mechanical integration

5.1. Design guidelines

Please ensure that the following design guidelines are met when integrating the CTS into the final product or as a solution in its final installation location:

- CTS lens must be clear and free from contamination. Please ensure that no dust, particles, or grime obstructs the optical path. Before operation, make sure to remove the lens cover, and ensure that the lens remains optically clean throughout the operation.
- CTS should not be exposed to strong UV radiation, as it may degrade the infrared anti-reflective coating.
- CTS should be integrated within an enclosure that ensures a dust-and dirt-free environment for optimal operation.
- CTS must always be operated in a non-condensing environment, as condensation on the lens or within the optical path will degrade the CTS performance.
- Product integration should consider thermal management and CTS should be placed as far as possible from heat generating sources such as power regulators, high-current components, and processors.

5.2. Handling instructions

The CTS must be handled with care, so the module enclosure (housing) is mechanically isolated from its counter-mounting surface. As the module enclosure has a functional purpose (part of the optical light path inside the module), do not handle or touch the exposed optical components, and only handle the sensor housing with powder-free latex or nitrile gloves. If any mechanical pressure or shock is applied to the exposed optical components, as shown below in Figure 7 with red arrows indicated areas, the sensor performance may degrade.

For integration the CTS shall be adhered onto a supporting structure along the entire backside of the sensor. Handling pressure shall only be applied around areas of the green arrows. Pressure along the direction of the red arrows must be avoided.

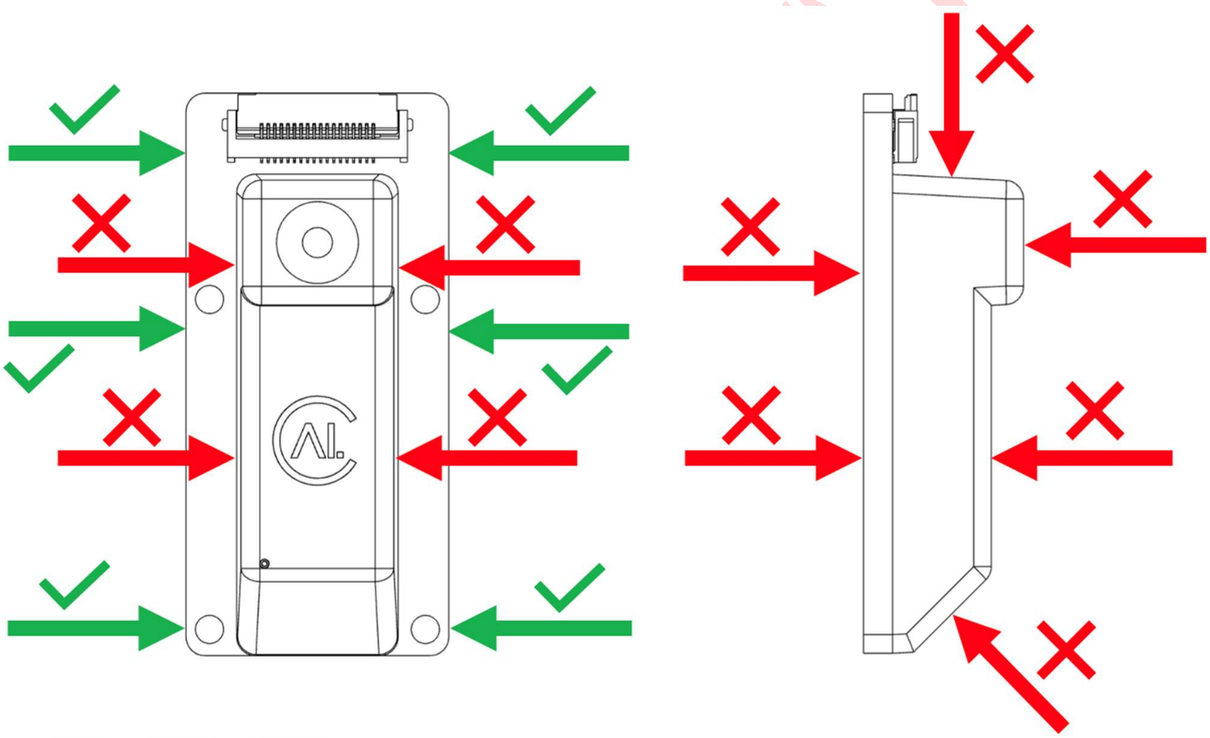

Figure 8: *Mechanical drawing of STSCTG30N140 showing green arrow indicators on locations where force can be applied for handling purposes (<1N) on the CTS module, and red arrow indicators on where force (>0.1N) must not be applied on the CTS module enclosure.*

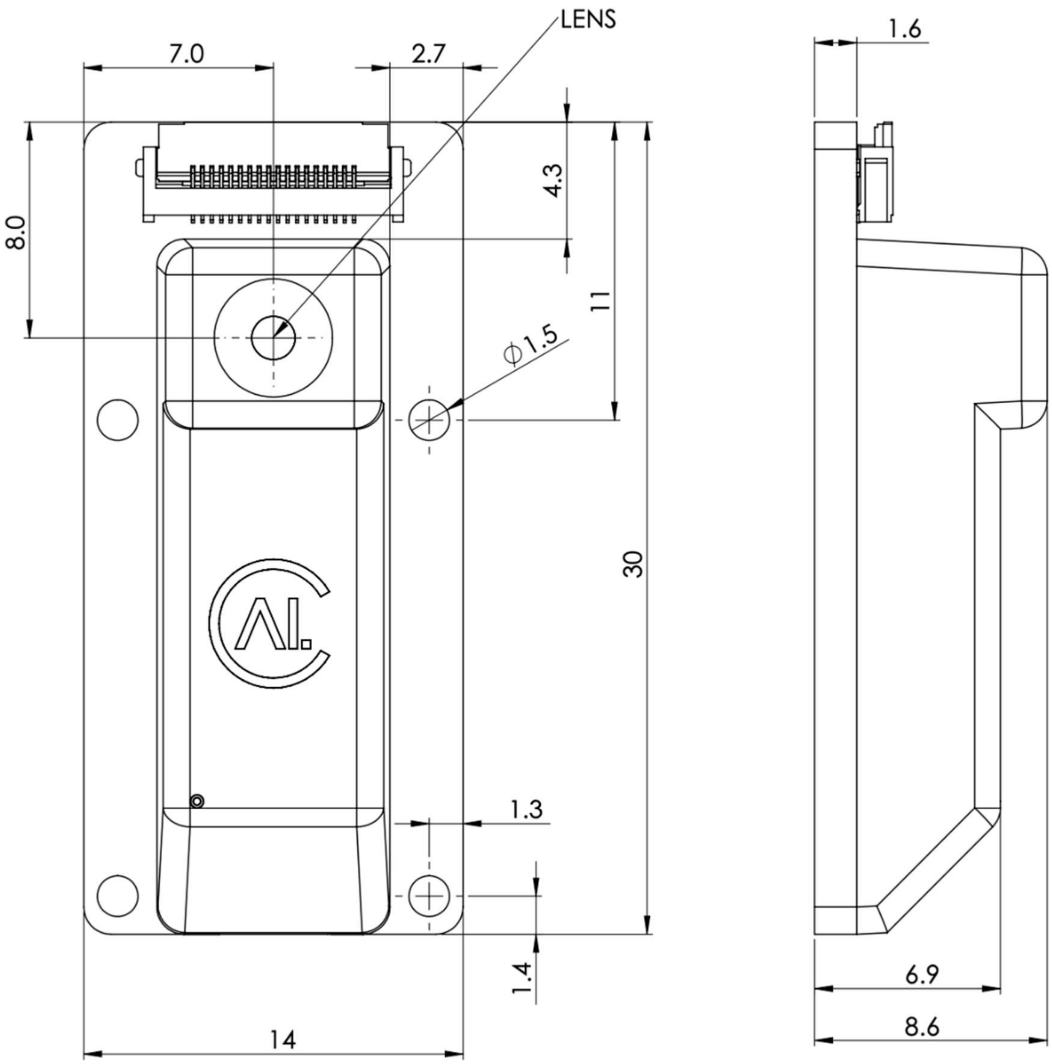

***Figure 9**: Mechanical drawing of STSCTG30N140*

Figure 10: *Recommended handling touch points of the CTS module. Gloves should always be worn when handling the sensor*

Calumino recommends using a thermally conducting adhesive tape to provide a preferential heat transfer path between the sensor and the supporting structure coupled to the thermal mass. The following adhesive specifications should be followed to permanently mount the sensor:

Table 9: Recommended Adhesive Tape Properties

Property	Minimum Value
Thermal Impedance	5.8 °C cm^2 / W
Thermal Conductivity	0.6 W/m-K
Dielectric Constant	3.2
Thickness	0.25 mm
Surface Resistivity	1.6 x 10^{11} Ω-cm
Tape Type	Filled Acrylic Polymer

Note that the thermally conducting adhesive tape also serves as a protection to static buildup and discharge.

STSCTG30N140 sensor does not come pre-packaged with any thermally conductive adhesive tape. For enquiries regarding the thermally conducting tape, please contact Calumino.

Do not use the CTS in environments prone to frequent vibrations as oscillation could lead to functionality and performance degradations of the sensor.

6. Environmental and reliability testing

For STSCTG30N140 qualification, a set of samples goes through environmental and reliability testing according to international standards.

Table 10: *Environmental and Reliability Tests*

Test	Description	Conditions	Standard
High temperature (operational)	Evaluate the ability of electronic equipment to withstand exposure to high temperature conditions over an extended period of time	65°C, 500h	IEC-60068-2-2:2007 (Test Be)
Drop test (customer housing)[2]	Involves placing the equipment a generic customer housing and repeated drop/impact on various faces and edges	50mm, 200mm, 750mm, (6 surfaces, 12 edges)	IEC 60068-2-31:2008 (Test Ec)
Humidity cycling /thermal shock	Evaluate the ability of electronic equipment to withstand exposure to cyclic changes in temperature and humidity as well as thermal shock	-10°C to 65°C, 93%RH 10 cycles/days	IEC-60068-2-38:2009 (Test Z/AD)
Electro-static discharge immunity test	Evaluate the ability of electronic equipment to withstand electrostatic discharge by applying high voltage discharge to the device under test	10x ESD pulses of ±8kV (air, direct, plates)	IEC 61000-4-2:2008

All sample units chosen need to meet the datasheet requirements as well as the reliability requirements. The units are tested to Calumino standards and qualified based on performance measured.

[2] Under testing

7. Nomenclature

Table 1112: *Nomenclature*

Abbreviation	Definition
2D	Two Dimension
CMOS	Complementary Metal Oxide Semiconductor
CRC	Cyclic Redundancy Check
CTS	CALUMINO Thermal Sensor
EOL	End Of Life
FOV	Field Of View
FPA	Focal Plane Array
FPS	Frames Per Second
Gen	Generation
HFOV	Horizontal Field of View
IR	Infrared
LED	Light Emitting Diode
LWIR	Long Wave Infrared
MOMS	Micro Opto Mechanical System
NC	Not Connected
NETD	Noise Equivalent Temperature Difference
OEM	Original Equipment Manufacturer
RH	Relative Humidity
SCL	Serial Clock
SDA	Serial Data
SPI	Serial Peripheral Interface
VFOV	Vertical Field of View

8. Revision history

Table 13: *Revision history details*

Revision	Date	Change
0.1	12 Nov 2025	Initial release of preliminary datasheet

9. Contact information

Please contact our customer service team for assistance: support@calumino.com