

# CrayoLED™

## UV-C LED

PRODUCT DATASHEET | October 2022

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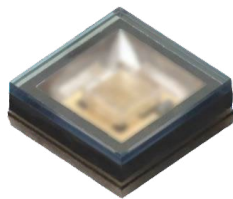
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# CrayoLED™ UV-C LED

## H-SERIES | CLH-N3S

The CrayoLED™ H-series UV-C LED (CLH-N3S) is designed to reliably provide pure radiation over its robust lifetime. Its flexible design empowers UV-C applications including surface disinfection and air and water purification.



### FEATURES & BENEFITS

Package Size (L x W x H): 3.5 mm x 3.5 mm x 1.26 mm

Peak Wavelength (typ.): 275 nm

L70 Estimated Lifetime: 10,000 hours

Wall Plug Efficiency: 5 %

Built-in ESD Protection Zener Diode: 5 kV

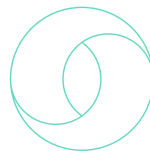
REACH, RoHS, and IEC-62471 Compliant

### APPLICATIONS

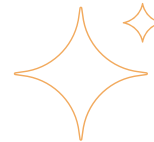


Water purification

Grey water reuse



Air purification



Surface disinfection

Food processing



Life sciences

## Electrical - Optical Characteristics at $T_A = 25\text{ °C}^1$ and $I_F = 350\text{ mA}$

Parameter (Typical)	Symbol	Min	Typ.	Max	Unit
Peak Wavelength	$\lambda_p$		275		nm
Forward Voltage	$V_F$		6		V
Spectrum Half-width	$\Delta\lambda$		11		nm
Viewing Angle	$2\Phi_{1/2}$		120		degrees
Thermal Resistance (junction – solder point)	$R_{\theta JS}$		6		°C/W

Note 1:  $T_A$  = Ambient temperature, °C

Equipment and processes:

- Measurement test setup were done using a LED mounted on a star MCPCB board,  $R_{\theta JS} = 12\text{ °C/W}$
- Variations of test conditions and utilization of other equipment may result in deviation of the specified values. All LEDs are tested by CrayoNano's industry approved measurement. Values are for reference only.

## Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Forward Current $T_A = 25\text{ °C}$	$I_F$	500	mA
Power Dissipation $T_A = 25\text{ °C}$	$P_D$	3	W
Operating Temperature <sup>1</sup>	$T_{opr}$	-40~85	°C
Junction Temperature	$T_J$	110	°C
Storage Temperature	$T_{stg}$	-40~100	°C
ESD <sup>2</sup>	$V_{ESD}$	5	kV

Note 1: Operating Temperature ( $T_{opr}$ ) represents the temperature of the surface onto which the package is mounted on

Note 2: ESD testing method : EIAJ4701/300 (304) Human Body Model (HBM) 1.5 kΩ,100 pF

Note 3: The LED is not designed for reverse operation.

Additional notes:

- Tolerance is as follows:
  - Radiant Flux:  $\pm 7\%$
  - Peak Wavelength:  $\pm 3\text{ nm}$
- Equipment and processes.
  - Measurement test setup were done using a LED mounted on a star MCPCB board,  $R_{\theta JS} = 12\text{ °C/W}$
  - Variations of test conditions and utilization of other equipment may result in deviation of the specified values. All LEDs are tested by CrayoNano's industry approved measurement. Values are for reference only.
- Operating the LED at or beyond the listed maximum ratings for prolonged periods of time may affect device reliability and cause permanent damage.

Specifications may change without notice due to continuous improvements and innovations.

## Bin Code Structures at $T_A = 25^\circ\text{C}$ , $I_f = 350\text{ mA}$

Radiant Flux Bins ( $\Phi$ [mW]) <sup>1</sup>		
Group	Minimum Radiant Flux	Maximum Radiant Flux
AA	70	80
AB	80	90
AC	90	100
AD	100	110
BA	110	120

Wavelength (Peak $\lambda$ [nm]) <sup>1</sup>		
Group	Minimum Wavelength	Maximum Wavelength
1	270	280

Forward Voltage Groups ( $V_F$ [V])		
Group	Minimum Forward Voltage	Maximum Forward Voltage
1A	5.0	5.5
1B	5.5	6.0
1C	6.0	6.5
1D	6.5	7.0

## Bin Code on Label

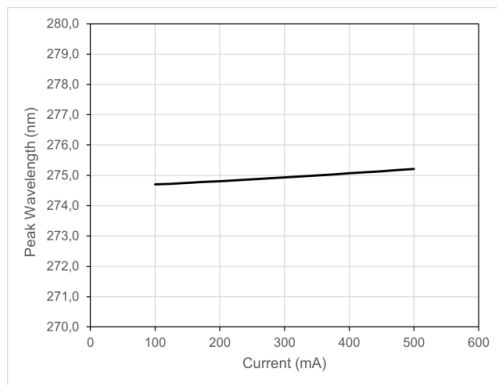
Example: AA – 1 – 1B

Radiant Flux	Peak Wavelength	Forward Voltage
AA	1	1B

**Note 1: The primary bins available are in black font. The bin distribution per shipment will be decided by CrayoNano. Other wavelength bins may be available in the future. Please contact sales for further information.**  
Specifications may change without notice due to continuous improvements and innovations.

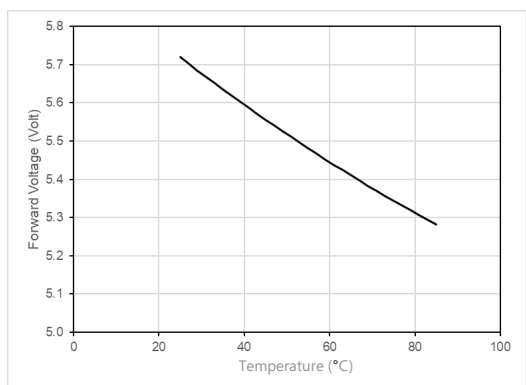
## Typical Characteristic Curves

PEAK WAVELENGTH VS FORWARD CURRENT



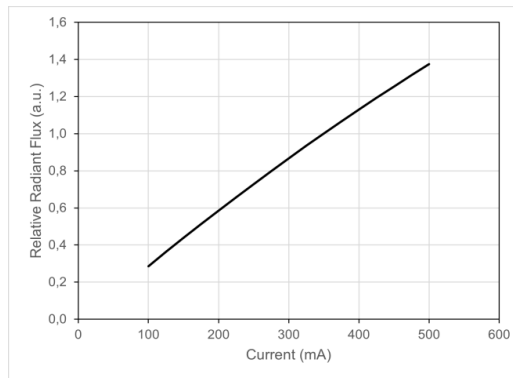
Test Conditions:  $T_A = 25^\circ\text{C}$

FORWARD VOLTAGE VS AMBIENT TEMPERATURE



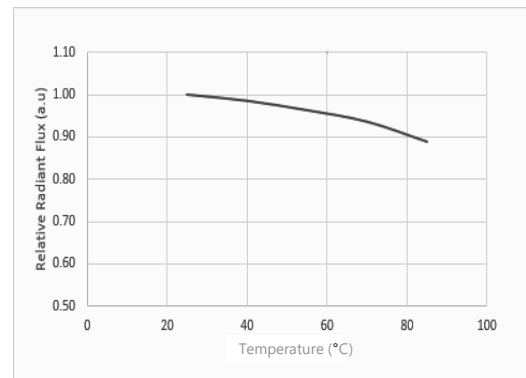
Test Conditions:  $I_{FP} = 350\text{ mA}$

RELATIVE RADIANT FLUX VS FORWARD CURRENT



Test Conditions:  $T_A = 25^\circ\text{C}$

RELATIVE RADIANT FLUX VS AMBIENT TEMPERATURE



Test Conditions:  $I_{FP} = 350\text{ mA}$

Note 1: All characteristics shown are for reference only and are not guaranteed.

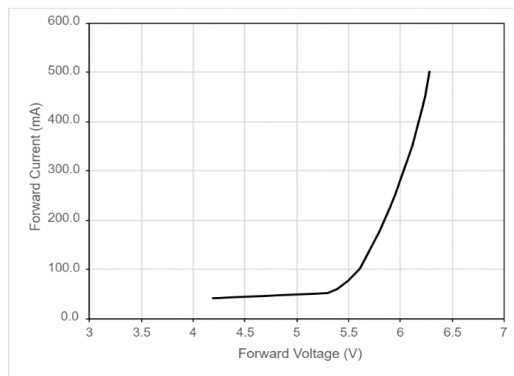
Equipment and processes:

- Measurement test setup were done using a LED mounted on a star MCPCB board,  $R_{\theta JS} = 12^\circ\text{C/W}$
- Variations of test conditions and utilization of other equipment may result in deviation of the specified values. All LEDs are tested by CrayoNano's industry approved measurement. Values are for reference only.

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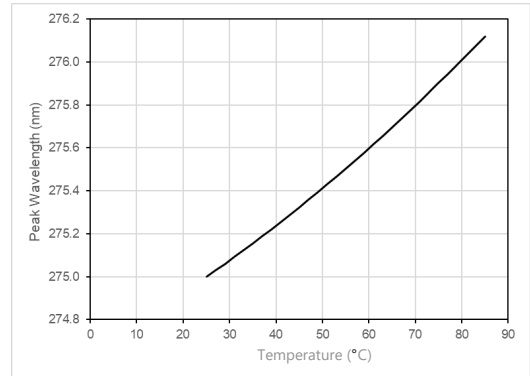
## Typical Characteristic Curves

**FORWARD CURRENT VS FORWARD VOLTAGE**



Test Conditions:  $T_A = 25\text{ °C}$

**PEAK WAVELENGTH VS AMBIENT TEMPERATURE**



Test Conditions:  $I_{FP} = 350\text{ mA}$

Note 1: All characteristics shown are for reference only and are not guaranteed.

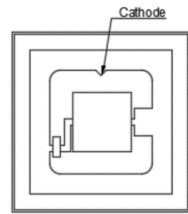
: Equipment and processes:

- Measurement test setup were done using a LED mounted on a star MCPCB board,  $R\theta_{JS} = 12\text{ °C/W}$
- Variations of test conditions and utilization of other equipment may result in deviation of the specified values. All LEDs are tested by CrayoNano's industry approved measurement. Values are for reference only.

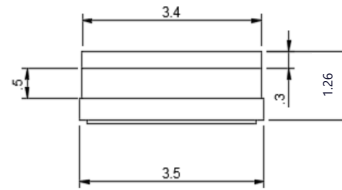
*Specifications may change without notice due to continuous improvements and innovations.*

## Mechanical dimensions (Unit: mm, Tolerance: ±0.2)

LED frontside view



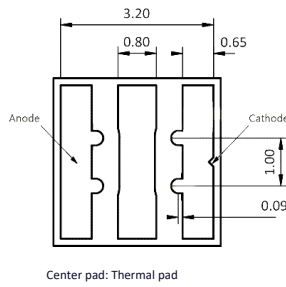
LED sideview



### DETAILS:

- Substrate Material: AlN
- Glass Window Material: Quartz
- Electrodes Material: Au
  - Thickness: 0.05 μm
- Weight: 37 mg

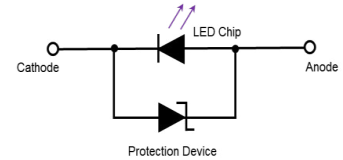
LED backside view



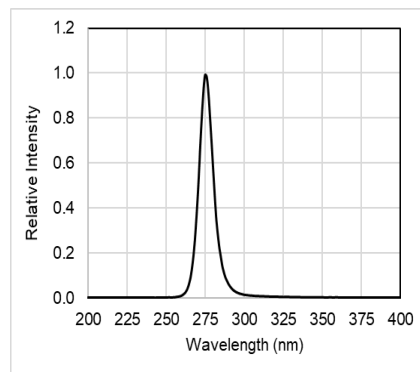
Suggested solder mask design



Packaged LED Circuit

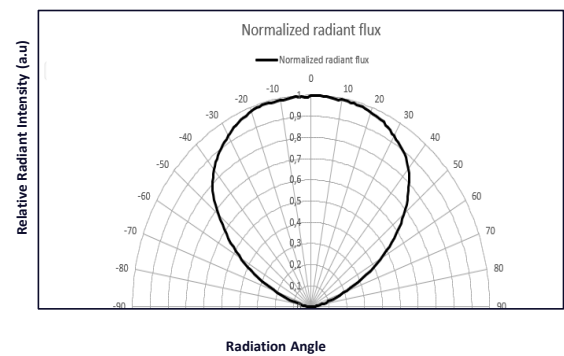


## SPECTRUM



Test Conditions:  $T_A = 25\text{ }^\circ\text{C}$ ,  $I_{FP} = 350\text{ mA}$

## RADIATION PATTERN



Test Conditions:  $T_A = 25\text{ }^\circ\text{C}$ ,  $I_{FP} = 350\text{ mA}$

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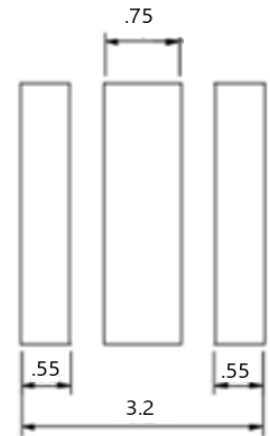
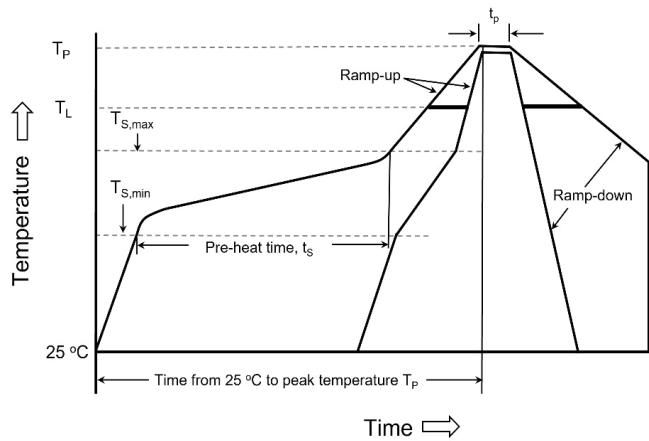
## Recommended Soldering Guidelines

Reflow soldering is the recommended method for assembling LEDs on a circuit board.

Product complies to MSL 3 acc. to JEDEC J-STD-020E.

### Recommended Reflow Soldering Conditions

### Solder Pattern



#### Profile Feature

#### Pb-Free Assembly (SnAgCu)

Ramp-up rate (from $T_{S,max}$ to $T_P$ )	1 °C/second max.
Minimum pre-heat temperature ( $T_{S,min}$ )	100 °C - 150 °C
Maximum pre-heat temperature ( $T_{S,max}$ )	180 °C - 200 °C
Pre-heat time (from $T_{S,min}$ to $T_{S,max}$ )	60 – 120 seconds
Liquid phase temperature ( $T_L$ )	217 °C
Time to maintain temperature above $T_L$	50 – 80 seconds
Peak temperature of the package ( $T_P$ )	260 °C
Time to develop within 5 °C of peak temperature ( $t_p$ )	20 – 40 seconds
Ramp-down rate (from $T_P$ to $T_L$ )	3 °C/second max.
Time from 5 °C to peak temperature	maximum 4 minutes

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## Recommended Soldering Guidelines

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- CrayoLED UV-C LEDs are generally compatible with industry-standard SMT mounting methods.
- We recommend strict adherence to the "Recommended Reflow Soldering Conditions" shown on the page 8 for soldering.
- A temperature-controlled convection oven with Nitrogen atmosphere is recommended for best results.
- Suitable materials for reflow compatibility should be tested; examples of possible materials are printed circuit board (PCB) or metal-core PCB,.
- After opening the Aluminium ESD protective bag, LEDs should be soldered within 24 hours.
- We do not recommend reflow-soldering UV-C packages more than once or re-working already-mounted UV-C LED packages as this increases the risk of damaging the LEDs.
- Please ensure that the surface the UV-C LEDs are mounted on is flat to ensure optimal LED adhesion and soldering quality.
- We do not recommend applying pressure or force on top of the UV-C LEDs while they are hot or are being reflow-soldered.
- Appropriate non-metallic nozzles that will not scratch the top surface of the UV-C LEDs need to be properly selected to avoid damages during the pick-and-place process.
- Manual mounting of the UV-C LEDs using a soldering iron or hot plate is not recommended.

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## Test Conditions for Characterization and Reliability

Test	Reference Standard	Test Conditions	Test Duration
Resistance to Soldering Heat (Reflow Soldering)	EIAJ ED-4701/300 (301)	T <sub>aid</sub> = 260 °C, 2 reflows, Precondition: 30 °C, 70 % RH, 168 hrs	-
Room Temperature Operating Life (RTOL)	EIAJ ED -4701 /100 (101)	T <sub>A</sub> = 25 °C, I <sub>F</sub> = 350 mA	1000 hours
Room Temperature Operating Life (RTOL)	EIAJ ED -4701 /100 (101)	T <sub>A</sub> = 25 °C, I <sub>F</sub> = 500 mA	1000 hours
Wet High Temperature Operating Life (WHTOL)	EIAJ ED -4701/100 (102)	60 °C, RH = 90 %, I <sub>F</sub> = 350 mA	500 hours
High Temperature Storage Life (HTSL)	EIAJ ED-4701/200 (201)	T <sub>A</sub> = 100 °C	1000 hours
Low Temperature Storage Life (LTSL)	EIAJ ED-4701/200 (202)	T <sub>A</sub> = -40 °C	1000 hours
Thermal Shock	EIAJ ED-4701 /100 (105)	-40 °C to 100 °C 30 min dwell/transfer time : 10 sec 1 cycle = 1 hr	100 cycles
Vibration	EIAJ ED-4701/300 (403)	200 m/s <sup>2</sup> , 100~2000~100 Hz, 4 cycles, 4 min, each X, Y, Z	48 minutes
Electrostatic Discharge (ESD)	EIAJ ED-4701/300 (304)	HBM, 5 kV, 1.5 Ω, 100 pF, 3 pulses, alternately positive or negative	3 times Negative/ Positive

## Failure Criteria

Items	Symbol	Test Conditions	Criteria
Forward Voltage	V <sub>F</sub>	I <sub>F</sub> = 350 mA	Initial Value x 1.1
Radiant Flux	Φ <sub>e</sub>	I <sub>F</sub> = 350 mA	< Initial Value x 0.7

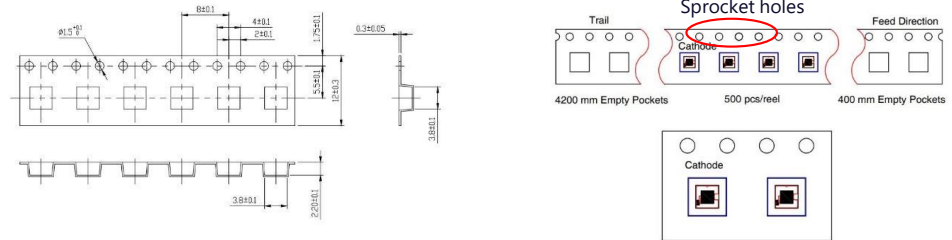
*Specifications may change without notice due to continuous improvements and innovations.*

## Packing Structure

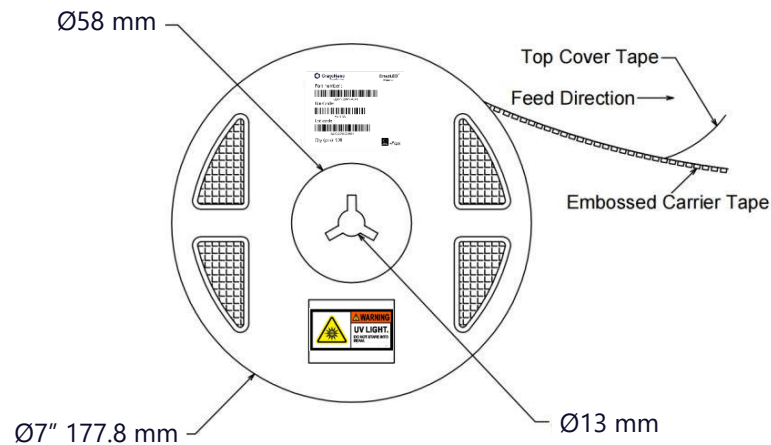
Reeled moisture sensitive products (qty : 500 pcs) are packed in a dry bag containing desiccant and a humidity card per JEDEC-STD-033.

One reel shipped per cardboard carton (L x W x H dimensions: 225 x 205 x 40 mm).

## Taping



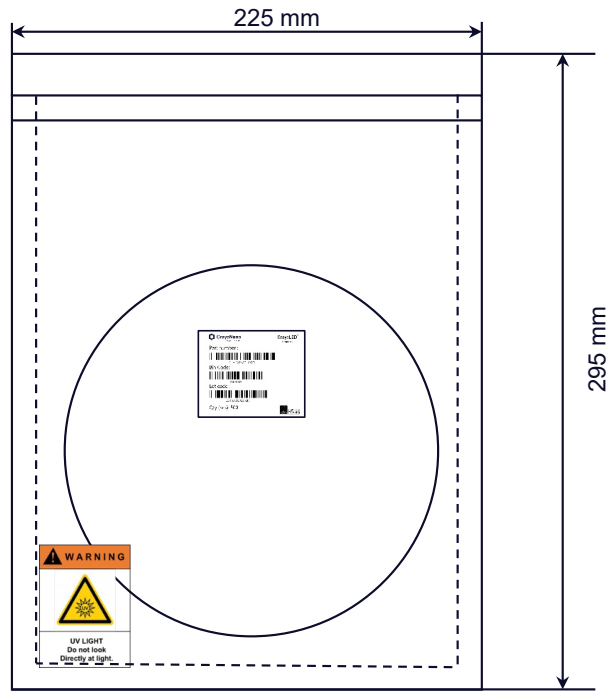
## Tape and Reel



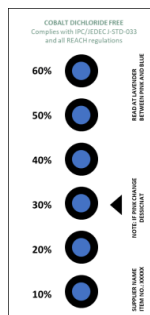
Specifications may change without notice due to continuous improvements and innovations.

### Electrostatic Discharge (ESD) Bag and Contents

ESD Aluminium bag



Humidity card



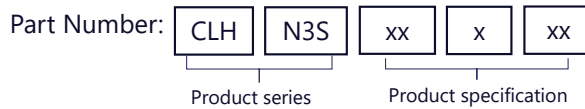
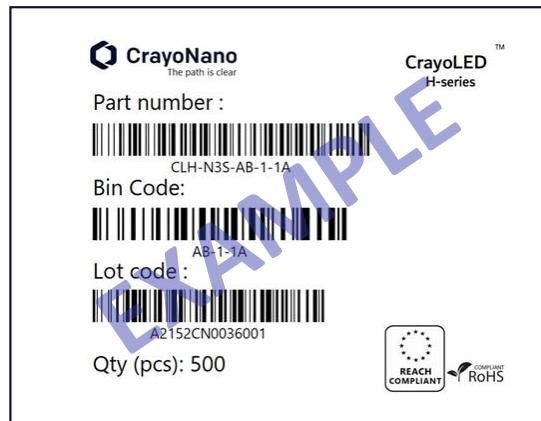
Desiccant bag



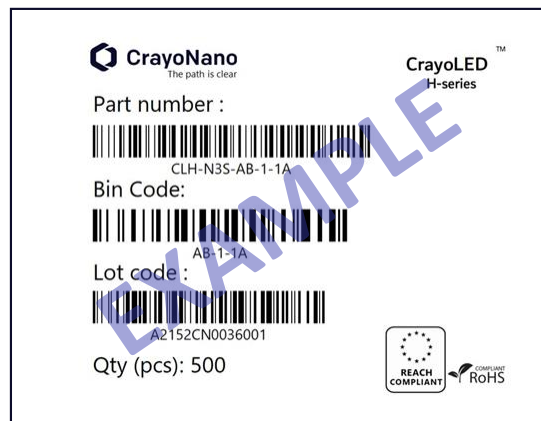
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## Product Label

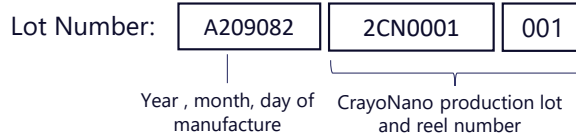
### Tape/Reel Label: Specifying Model Name, Rank, Rack, Quantity and Lot Number



N: AIN  
3S: LED size  
xx: Power bin  
x: Wavelength bin  
xx: Vf Bin



N: AIN  
3S: LED size  
AB: Power bin  
1: Wavelength bin  
1A: Vf Bin



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## Product Label

**Shipping box label:** Specifying Customer, Date, Model Name, Quantity, Customer Part No, Outbox ID, Rank Qty

 The path is clear	 REACH COMPLIANT	 RoHS	
Customer: CrayoNano AS	PO No.: 2021 -CT112	Product name: H-series	
Carton No.: 1/1	Ship No.: 202588457426841		
Qty: 10	Pack No.: 04720909086		
MSL Level: (#)	Memo:		

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## Cautions on Use

### Moisture Barrier Bags

- Product complies with JEDEC MSL 3 or equivalent and is shipped in moisture barrier bags (with silica desiccant).
- Absorbed moisture in the LED package may vaporize and expand during soldering, which can damage the optical characteristics of the LEDs.

### Storage

- Always store packaged LEDs inside the moisture barrier bags (with desiccant) when not being used in order to minimize moisture absorption.
- Any unused LEDs should be stored in moisture barrier bags with absorbent material or desiccants.
- If LEDs have exceeded the storage time or the desiccants have faded or expired, we recommend baking the LEDs at 60 deg. C for at least 24 hours.
- LEDs should be kept away from volatile organic compounds as well as hazardous, acidic, and corrosive substances such as sulfur, chlorine, hydrofluoric acid, etc. Failure to do so may result in mechanical degradation of the LED package and/or decrease in electrical and optical performance.
- Avoid exposure to sudden temperature changes or high humidity levels.
- Avoid condensation.

	Conditions	Temperature	Humidity	Time
<b>Transportation Storage</b>	Before Opening Aluminum Bag	18 °C ~ 30 °C	30-60 % RH	Within 15 months from Delivery Date
<b>Baking</b>	LED has been left outside of Aluminum bag for an extended time	60 °C ± 5 °C	< 10 % RH	At least 24 hours

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## Cautions on Use

### Cleaning

- Do not clean the LEDs without testing the cleaning process. Improper cleaning may damage the LED.
- Pretests should be conducted with the actual cleaning process and cleaning agents to validate that the process will not damage the LEDs.
- Do not clean LEDs using excessive mechanical force.
- Refer to application notes for recommended cleaning methods.

### Thermal Management

- Thermal management and proper heat dissipation is extremely important for the design and the use of the LED. It will greatly affect the performance and reliability of the UV-C LED package and must be seriously considered throughout the lifetime of the LED.
- The Absolute Maximum Junction Temperature ( $T_J$ ) as specified in the Product Specification (page 3) must not be exceeded under any circumstances.
- The LED's junction temperature may vary while in operation and is dependent on the module/system design, including but not limited to: PCB thermal resistance, the LED's density on the PCB assembly, thermal interface material specification, circuit material, PCB structure, ambient temperature and condition, etc.
- Ensure that when using the LEDs for the chosen application, heat is not concentrated in any particular area and is properly managed in the system/assembly.
- The operating current should be determined by considering the temperature conditions surrounding the LED (i.e.  $T_A$ ). Ensure that when operating the LED, proper measures are taken to dissipate the heat.
- To calculate the LED's junction temperature, the following two formulas can be used:

$$1) T_J = T_A + R_{\theta JA} \times W$$

$T_J$  = LED Junction Temperature: °C

$T_A$  = Ambient Temperature: °C

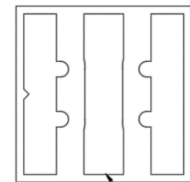
$T_s$  = Soldering Point Temperature (Die Heat Sink): °C

$R_{\theta JA}$  = Thermal Resistance from Junction to Ambient: °C/W

$R_{\theta JS}$  = Thermal Resistance from Junction to  $T_s$  Measurement Point: °C/W

$W$  = Input Power ( $I_F \times V_F$ ): W

$$2) T_J = T_s + R_{\theta JS} \times W$$



$T_s$  Measurement Point

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## Cautions on Use

### Electrostatic Discharge (ESD)

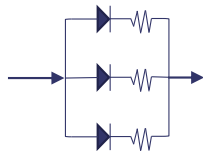
- The LEDs are sensitive to static electricity or surge voltage.
- If excessive current or voltage occurs in the circuit, it may damage the LED.
- When handling LEDs, the following measures against ESD are actively recommended:
  - grounded wrist strap, ESD footwear, clothes and floor
  - grounded workstation equipment and tools
  - ESD table/shelf mat made of conductive materials
- Ensure that LEDs are not exposed to transient excessive voltage (e.g., ESD, lightning surge):
  - tools, jigs and machines are properly grounded
  - appropriate ESD materials and equipment are used in the work area
  - the system/assembly is designed to provide ESD protection for the LED
- To avoid electrostatic discharge when using tools or equipment with glass or plastic insulation:
  - dissipate static charge with conductive materials
  - prevent charge generation with moisture
  - neutralize the charge with ionizers



## Cautions on Use

### Recommended Circuit

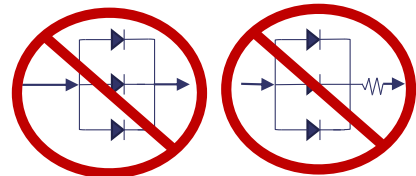
- The circuit must be designed to ensure that the Absolute Maximum Ratings are not exceeded for each LED.
- Each LEDs must be operated at a constant current condition, preferably using a driver IC controller.
- The LED is designed to operate at a forward current. Operating LEDs using reverse current or reverse voltage can damage the Zener diode and potentially cause device failures and strongly not recommended. If the LEDs are used in an environment where reverse voltages are applied continuously, electrochemical migration may damage the LED.
- Ensure that no voltage is applied in the forward/reverse direction while the LED is OFF. When not in use for a long period of time, the system's power should be turned OFF to avoid electrical surge that can damage the LEDs.
- LEDs are sensitive to driving current surge. It is strongly recommended to integrate protection circuitry. Slight voltage shifts may cause a forward current change leading to LED burn out. Ensure that transient excessive voltage (e.g., lightning surge) is not applied to the LEDs.
- In general, individual LEDs may have a varying forward voltage. Different forward voltages in parallel connections via a single resistor can result different forward currents to each LED, which can output different radiant flux values.
- Matrix circuits with a single resistor for each LED are recommended to avoid radiant flux fluctuations.
- LEDs may be operated in a series connection with a single constant current source. Please note that one LED failure can affect the system.
- If the LEDs are used for outdoor application, ensure that necessary measures are taken (e.g., protecting the LED from water, salt and high humidity).



Recommended circuit in parallel connection: separate resistors to be used for each LED



Recommended circuit in series connection



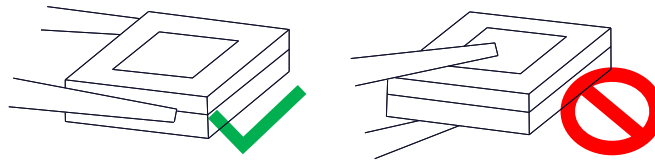
Circuits without individual resistors for each LED, have potential exposure to current surges.

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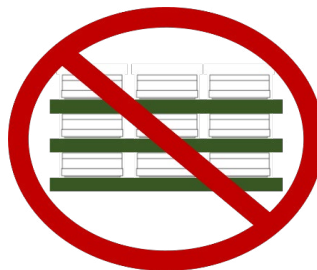
## Cautions on Use

### Handling Precautions

- **Refer to CrayoNano's Application Note: Handling, Processing and Usage document**
- Do not handle the LEDs with bare hands
- Avoid contaminating the LED's surface, which may affect the optical characteristics
- CrayoNano recommends the use of vacuum tweezers, plastic tweezers, or Teflon coated tweezers when handling the LED package manually
  - When manually handling the product with tweezers, only contact the side of the package and be careful not to apply excessive force to the glass. The glass can be cut, deformed, and/or chipped, potentially causing mechanical damage and catastrophic failures.



- When populating boards in SMT production avoid excessive mechanical pressure on the product.
- Test and verify materials in the system or assembly (for example: the PCB) before use.
- Do not stack boards, assemblies with LEDs mounted on them. When boards are stack on top of another, the glass may get damaged, resulting in a scratch , chip or detachment of the glass, leading to defect and potential performance degradation.



*Specifications may change without notice due to continuous improvements and innovations.*

## Cautions on Use

### Eye Safety

- The evaluation of eye safety occurs according to the standard IEC 62471:2006 (Photo biological safety of lamps and lamp systems). CrayoNano's UV-C LED is classified as Risk Group 3 according to IEC 62471:2006. when operating at nominal operating conditions.
  - When operating conditions are below or above the recommended nominal current (for example: with an optic or higher driving current) the risk group classification will be out of the scope of CrayoNano's test classification and will need to be tested by customer.
- During operation, the LED emits high intensity ultraviolet (UV) light, which is intense, hazardous and harmful to skin and eyes. UV Light is also a known potential carcinogen. If human eyes or skin are exposed to this light, it may cause damage to them.
  - Avoid direct or indirect exposure to UV light when LED is operational (i.e.: through an optical device or microscope).
  - Precautions must be taken with the use of UV light protective glasses and proper skin protection.
- Attach warning labels on products/systems that use UV LEDs and in all necessary documents (e.g., specification, manual, catalogues) and on packaging materials.

## CAUTION: UV RISK GROUP 3



### RoHS/REACH Compliance

Our products are RoHS and RoHS 3 compliant, which took effect 2019 July 22, and Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) directive 1907/2006 EC as related to the restriction of the use of certain hazardous substances in electrical and electronic equipment.

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- Each user of devices assumes full responsibility to become educated in and to protect from harmful irradiation.
- CrayoNano specifically disclaims all liability for harm arising from buyer's use or misuse of UV-C devices either in development or end-use.
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## Glossary

- 1) LED:** A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The wavelength of the emitted light is determined by the energy gap of the semiconductor.
- 2) Forward Voltage:** The forward voltage is measured during a current pulse of typically 25 ms, with an internal reproducibility of  $\pm 0.05$  V and an expanded uncertainty of  $\pm 0.1$  V (acc. to GUM with a coverage factor of  $k = 3$ ).
- 3) Thermal Resistance:**  $R_{th\ max}$  is based on statistic values ( $6\ \sigma$ ).
- 4) Typical Values:** Due to the special conditions of the manufacturing processes of semiconductor devices, the typical data or calculated correlations of technical parameters can only reflect statistical figures. These do not necessarily correspond to the actual parameters of each single product, which could differ from the typical data and calculated correlations or the typical characteristic line.
- 5) Characteristic curve:** In the range where the line of the graph is broken, you must expect higher differences between single devices within one packing unit.
- 6) Operating Temperature ( $T_{opr}$ ):** represents the temperature of the surface onto which the package is mounted on.
- 7) Tolerance of Measure:** Unless otherwise noted in drawing, tolerances are specified with  $\pm 0.2$  and dimensions are specified in mm.
- 8) Tape and Reel:** LED shipping and package materials. All dimensions and tolerances are specified acc. IEC 60286-3 and specified in mm.
- 9) Wavelength:** Wavelengths are tested at a current pulse duration of 25 ms and a tolerance of  $\pm 3$  nm.
- 10) Pulsed forward current,  $I_{fp}$ :** Non-continuous wave forward current applied to the LEDs to obtain the characteristic curves.

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