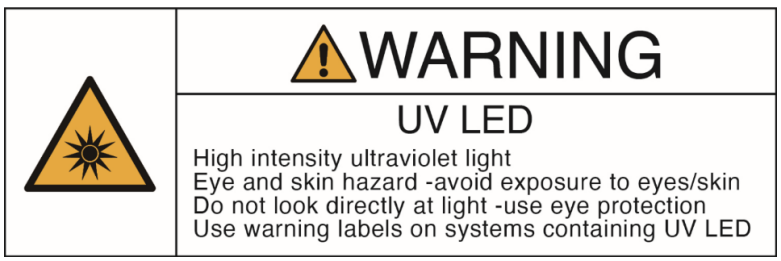
Application Note

(UVC LED Assembly)



Ref_CE-0883P-202206

1. Drive of LED

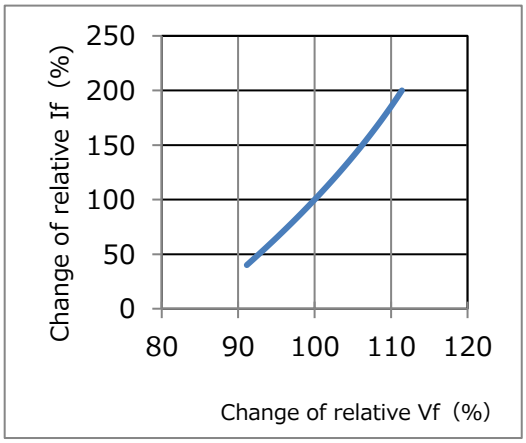
● We recommend constant current driving of the LED in order to assure stable light emission and reliability

1-1. Introduction

Importance of understanding characteristics

As LEDs, which are diode products, have various factors to consider, it is necessary to have a grasp of the implications of each characteristic prior to applying a driver to them. For example, forward current If changes drastically in response to change of forward voltage Vf. The example in Figure 1-1 shows that when the temperature conditions are stable, If rises by more than 80% when Vf rises by 10 %. Change of If has a great impact on light emission and heat generation of the LED. Notably, a strict control of If is required for a high-power lighting LED because it is driven by a large current. In addition, as Vf changes with temperature, heat dissipation of the LED is very important. Please take appropriate measures with regard to each characteristic when you drive our LEDs by consulting their specifications and application notes.

Fig. 1-1. Vf-If characteristics



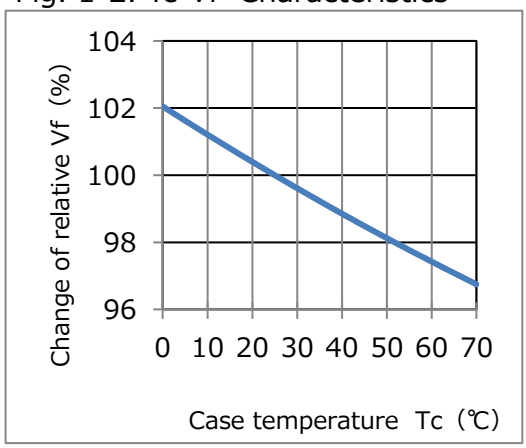
1-2. Constant current drive method (recommended)

For assuring a stable drive

"Constant current drive method" is a method by which a constant current is continuously supplied to the LED even under conditions where VF is changed by heat generation. Using this method enables the drive to be relatively stable even if environmental conditions change.

Generally, VF of LED to supply a fixed current tends to drop when the temperature rises (Figure 1-2). We recommend the constant current drive method in order to assure a stable emission output and reliability.

Fig. 1-2. Tc-Vf Characteristics



● By constant voltage drive method, brightness may become unstable with change in temperature

1-3. Constant voltage drive method

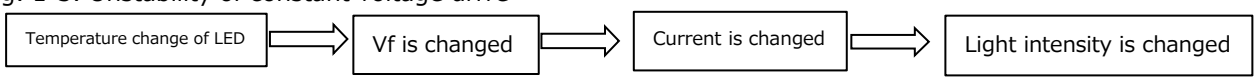
Notes on driving with constant voltage

In contrast to the constant current drive method, which maintains a constant current, the method which keeps the voltage constant is called "Constant voltage drive method."

As described above, Vf of an LED to supply a fixed current tends to drop when temperature rises. For example, in Figure 1-2, the same current flows from Vf which is lower by 3% when case temperature Tc is 70°C, compared to Tc of 25°C. In other words, it means that when the LED is driven with a certain constant voltage, larger current flows when the case temperature rises.

When the constant voltage drive method is used, under conditions where the LED's temperature is not stable because of change in environmental temperature, the temperature change will lead to a change in Vf as Figure 3 shows. As the brightness of the LED depends on the current, the brightness may become unstable as a result. Thus, when the constant voltage drive method is used, it is necessary to predict the temperature in actual use and take appropriate measures such as connecting a current-limiting resistor.

Fig. 1-3. Unstability of constant voltage drive



1-4. Precautions for inrush current

Avoid exceeding the maximum rating

When UVC LED Assembly is connected to capacitive load such as a condenser, an instantaneous inrush current may be produced when the power is turned ON or OFF. It happens, for example, when the power is turned ON or OFF in the secondary side of a power supply circuit with the current flowing.
We recommend usage that avoids generation of inrush current as much as possible. However, if generation cannot be avoided, please take measures so as not to exceed the absolute maximum rating of the LED.

1-5. Connection between various LEDs

In series connection is recommended

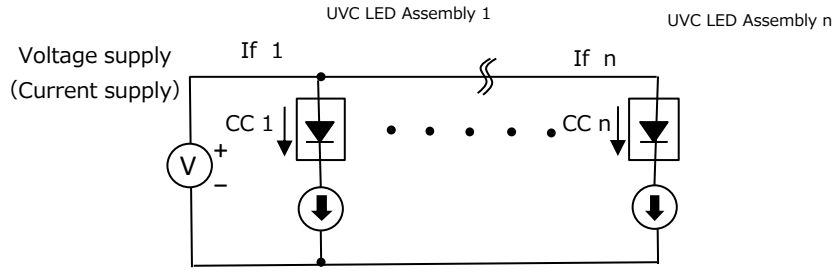
When more than one UVC LED Assembly is connected, the current that flows between the Assemblies will be uniform if they are connected in series. We recommend in series connection in order to assure a stable emission output and reliability. When connecting the Assemblies in parallel, variation of VF between each Assembly must be taken into consideration. In order to apply a uniform current between each UVC LED Assembly which has different VF characteristics, measures must be taken such as connecting an appropriate current resistor with each UVC LED assembly in series, considering temperature conditions in actual use.

1-6. Parallel connection of LEDs

Figure below shows an example of connection of n numbers of UVC LED Assemblies.

With constant-current circuits

Fig. 1-4. Example of building a constant-current circuit for each UVC LED Assembly line

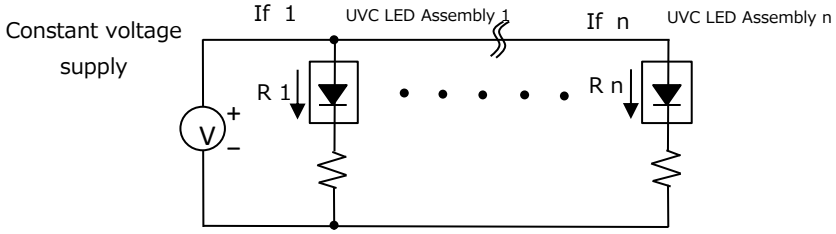


■If 1, If n
=>Current of each UVC LED Assembly

■CC 1, CC n
=>Constant-current circuit

With current-limiting resistors

Fig. 1-5. Example of applying current-limiting resistors to each UVC LED Assembly line



■If 1, If n
=>Current of each UVC LED Assembly

■R 1, R n
=>Current-limiting resistor

2. Heat dissipation design

● **The product has a heat dissipation structure that can efficiently conduct heat emitted by LED**

2-1. Introduction

Importance of a heat dissipation design

Dice of UVC LED emit light and heat in proportion to the input power. However, the surface area of UVC LED package is so small that heat dissipation into the air from the package itself is not practical. Therefore, an external heat dissipator such as a heatsink is required, and the structure up to the connecting area will be a heat dissipation structure that mainly uses heat conduction.

In UVC LED package, control of junction temperature Tj[℃] of light emitting dice is very important. However, as it is difficult to measure Tj[℃] directly, measuring the temperature (case temperature) Tc[℃] of a certain part of outer area of UVC LED Assembly is required in order to keep the temperature below the absolute maximum rating.

This section aims to enable users to utilize performance of UVC LED Assembly as much as possible by showing the detailed structure of heat dissipation as well as materials required in design.

2-2. UVC LED assembly structure and operating range

Understanding junction temperature

Figure 2-1 is an example of cross section of UVM001 connected to an outer heatsink.

It has a laminated structure in which UVC LED is mounted on aluminum substrate by soldering. Aluminum substrate of outer part of the UVC LED Assembly is connected to a heatsink thermally through heat-dissipating TIM. As described above, heat generated at the junction area of light emitting dice is conducted to the UVC LED package, then to solder, aluminum substrate, TIM and finally to heatsink by mainly using heat conduction.

Here, the heat resistance from the junction area of UVC LED to aluminum substrate of outer part of the package becomes Rj-c, which is the unique thermal resistance value of UVC LED Assembly.

Thus, the following formula is established.

$$Tj = Rj\text{-}c \cdot Pd + Tc$$

Further, the thermal resistance of TIM in external part of the package is R-TIM[℃/W], and the thermal resistance of heatsink is Rh[℃/W], ambient temperature is Ta[℃] respectively.

Figure 2-2 shows equivalent thermal resistance corresponding to cross section of Figure 2-1. As shown in this figure, the thermal resistance of Rj-c, R-TIM, and Rh are connected in series between the junction temperature Tj and ambient temperature Ta.

Here, R-TIM, which is the thermal resistance of outer package, and Rh can be Rc-a collectively.

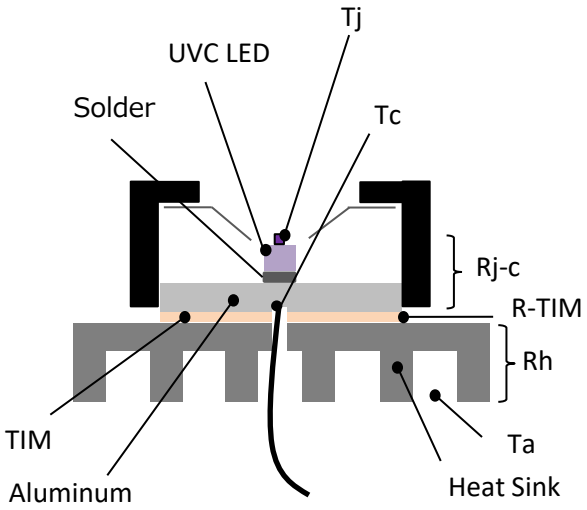
Thus, the following formula is also established.

$$Tj = (Rj\text{-}c + Rc\text{-}a) \cdot Pd + Ta$$

$$Tc = Rc\text{-}a \cdot Pd + Ta$$

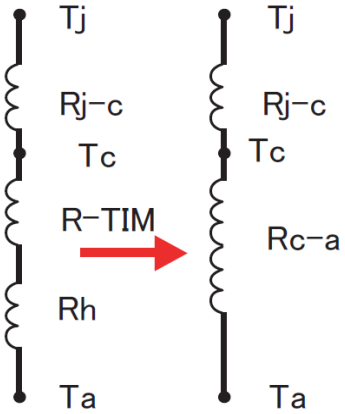
Please confirm case temperature (Tc) in accordance with forward voltage characteristics described in specifications so that it does not exceed the maximum rating.

Fig. 2-1. Cross section of UVM001



Thermocouple is installed by drilling a hole in heat sink and TIM. Then Tc is measured.

Fig. 2-2. Thermal resistance connection of UVM001



Make use of correlation between thermal resistance outside the package and ambient temperature when designing the external heat dissipation structure

2-3. Thermal design outside the UVC LED Assembly

Points with regard to the external heat dissipation structure

The following calculation will give a rough guide as to the external heat dissipation structure that keeps Tj and Tc of the package at or below the standard temperature.

The thermal resistance outside the package Rc-a[℃/W], which is the combination of the heat-dissipation TIM and the heatsink, is limited by the input power Pd [W], the ambient temperature Ta[℃], and the thermal resistance of the package Rj-c[℃/W], i.e.,

$$Tj = (Rj\text{-}c + Rc\text{-}a) \cdot Pd + Ta \qquad Rc\text{-}a = (Tj - Ta) / Pd - Rj\text{-}c$$

This can be converted into

$$Rc\text{-}a = -Ta / Pd + Tj / Pd - Rj\text{-}c$$

This Rc-a, obtained when Tj is at the maximum (Tj max), is a rough estimate that keeps Tj at or below the standard temperature.

On the other hand, the relationship between Rc-a and Tc can be expressed by the following formula.

$$Tc = Rc\text{-}a \cdot Pd + Ta$$

This can be converted into

$$Rc\text{-}a = (Tc - Ta) / Pd$$

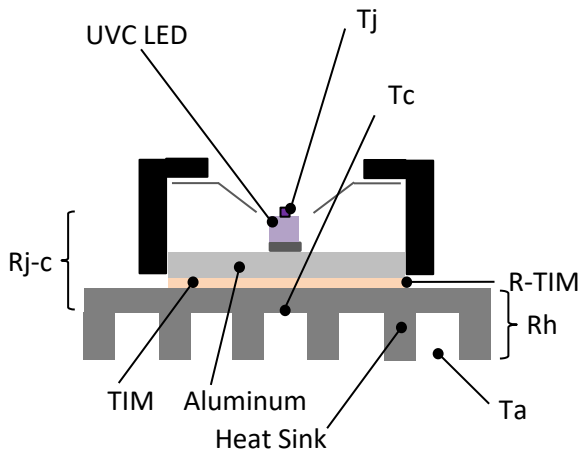
This Rc-a, obtained when Tc is at the maximum (Tc max) is a rough estimate that keeps Tc at or below the standard temperature. Therefore, use the above calculation as a guide when selecting the external heat dissipation parts, and ultimately conduct thermal verification on actual devices.

When several pieces of UVM001 are installed with a single heatsink, heat dissipation is not smoothly conducted due to interference from heat generated between the products that are next to each other. Therefore, please allow sufficient space for installation, use a larger heatsink and a fan to make sure that the products are appropriately cooled.

As UVM002/UVM003 has a heatsink, please confirm case temperature (Tc) in accordance with forward voltage characteristics at Tc point in Figure 2-3 of the heatsink so that it will not exceed the absolute maximum ratings.

For details, please refer to Data Sheet.

Figure 2-3. Cross section of UVM002/UVM003



Performance of a heatsink depends on the direction in which it is installed.

It is important that warm air does not remain in proximity to the heatsink.

Make sure to check Tc under the final installation conditions.

3. Precautions for use of UVC LED Assembly

3-1. Introduction

Various kinds of UVC

Ultraviolet rays have a shorter wavelength than that of visible light, and the word ultraviolet ray is a general term for electromagnetic waves which have a wavelength in the range of between 100 nm to 400 nm.
As shown in Figure 3-1, ultraviolet rays are classified into three groups in accordance with the wavelength, which are called UVC(200～280nm), UVB(280～315nm), and UVA(315～400nm) respectively. (By the standards of International Electrotechnical Commission)

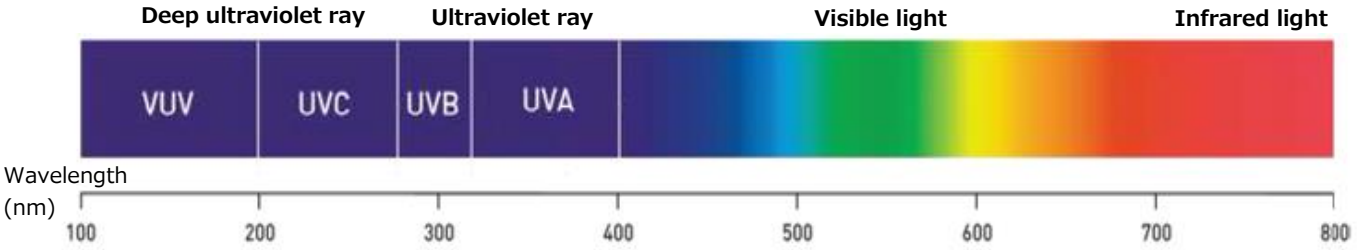


Fig. 3-1 Classification by wavelength

The UVC LED used for this product has the peak wavelength in the range of between 260 nm to 270 nm. UVC light does not exist in nature on earth but is created artificially. It has been widely used for disinfection lamps since World War II, and in recent years, solution of disinfection and inactivation of virus through UVC LED has been developed (Fig. 3-2). As Figure 3-3 "Disinfection effect according to equivalent radiated power wavelength" shows, the product has a strong disinfection effect and is dangerous to living organisms, so please pay appropriate attention to the handling of the product.

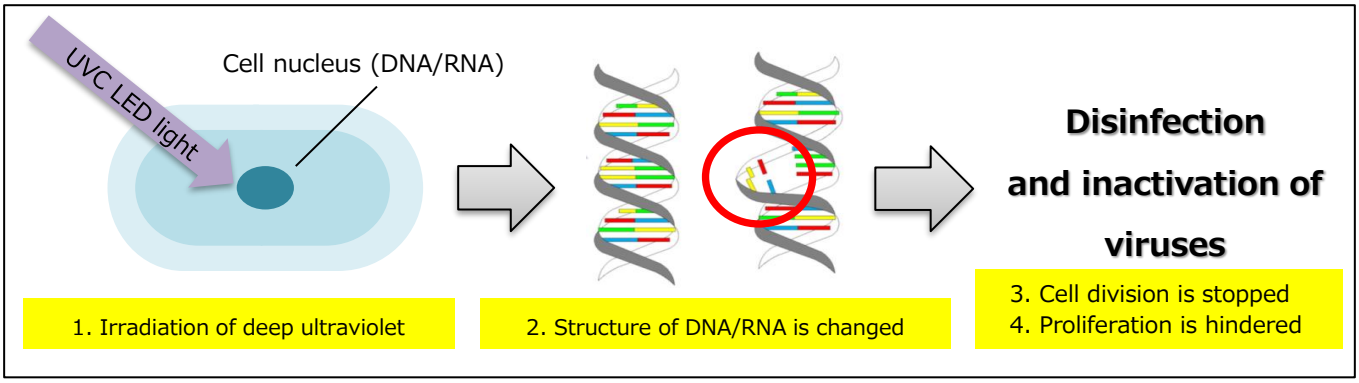


Fig. 3-2 Process of disinfection and inactivation of viruses through UVC LED

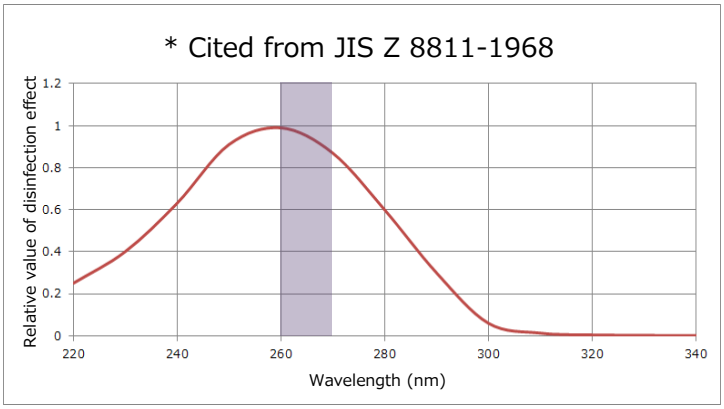


Fig.3-3 Disinfection effect according to equivalent radiated power wavelength

3-2. Main effects on living creatures and the human body from ultraviolet

Main effect on human body from ultraviolet

Figure 3-4 shows effect on human body in accordance with wavelength range.

Type of ultraviolet	UVA	UVB	UVC
Wavelength range (nm)	400 ~ 315	315 ~ 280	280 ~ 200
Effect on human body	Suntan of skin	Damage of DNA Suntan of skin Skin cancer Keratitis Cataract	Damage of DNA Skin cancer Keratitis

Fig. 3-4 Main effect on human body by ultraviolet

The threshold limit value (TLV) for exposure of human eyes and skin to ultraviolet has been approved internationally and is also established in JIS standards. Please do not look at UVC light of this product directly or irradiate the skin with the UVC light. As degree of effect differs in accordance with wavelength, irradiance and time for irradiation, make sure not to be exposed.
TLV is the abbreviation of Threshold Limit Value, which is the safety standard value for factors that ACGIH (American Conference of Governmental Industrial Hygienists) has provided.

Please take measures such as using protective glasses, gloves, long-sleeved wear, long pants, and mask to decrease risk of exposure.

3-3. Handling precautions for UVC LED Assembly

- This product is a product that emits deep ultraviolet rays (UVC).
  UVC has a strong influence on cells, so direct exposure to the body is dangerous.

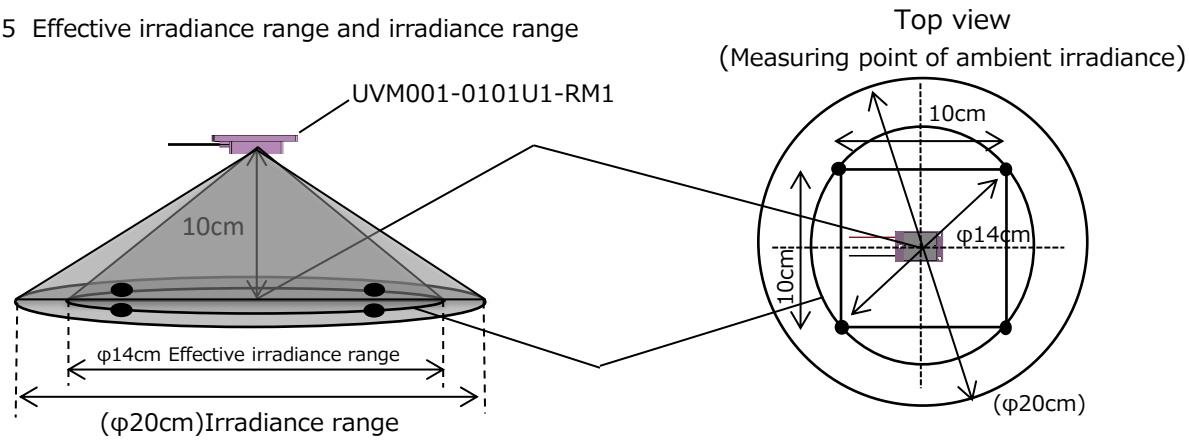
- JISZ8812 defines the allowable amount of ultraviolet rays, which is 4.6 mJ / cm^2 (8 hours a day) for 260 nm and 3 mJ / cm^2 (8 hours a day) for 270 nm.
  As it may affect the human body even from long distances, please take measures such as using protective glasses or gloves to prevent direct exposure of ultraviolet rays to the human body when looking directly at UVC light or lighting the reflected light.
  Do not look at UVC lighting source directly because there is a risk of eye pain or visual impairment.
  Also, pay attention not only to the direct light itself but also to reflected light.
  Irradiating the skin directly with UVC light may cause skin irritation.

- Disassembling or modifying the product may cause a part to drop off, fire, electric shock, or injury.

- If you connect or disconnect the power supply line or operate the product with wet hands, you may receive an electric shock.

- If you notice a strange odor or smoke, cease operation immediately. It may cause a fire or electric shock.
- Covering or sealing the product may cause heat to build up inside and it may cause a fire or malfunction.
- Do not use for any purpose other than sterilization.
- Do not add excessive shock by a dropping and so on. It may cause a malfunction or an unexpected accident.
  Do not touch the area near the irradiation window or place anything on it.
  It may cause a malfunction or an unexpected accident.
- Plants are sensitive to UV light. Depending on the type of plant, the leaves may wilt or die.
- Ensure the power supply system of this product is separate from lighting equipment and other equipment.
- Ultraviolet rays deteriorate wallpaper or resin products, etc. Also, if you irradiate at a short distance, the color of such may change rapidly. Please be careful regarding deterioration and discoloration of the object exposed to light.
- Do not touch the area near the irradiation window with your bare hands during or immediately after irradiation. The irradiation window and its surroundings may be hot during or immediately after irradiation.
- We are not liable for any personal or property damage caused to you or a third party due to UV exposure.
- Please make sure that UVC light outside the irradiation area does not affect the human body or the irradiated object in advance.
  Example: For UVM001-0101U1-RM1, irradiation area is approximately 20 cm in diameter even if it is outside the effective irradiance range. (Fig. 3-5)
  The irradiation area may depend on the installation conditions, so please confirm it in the usage environment.

Fig.3-5 Effective irradiance range and irradiance range



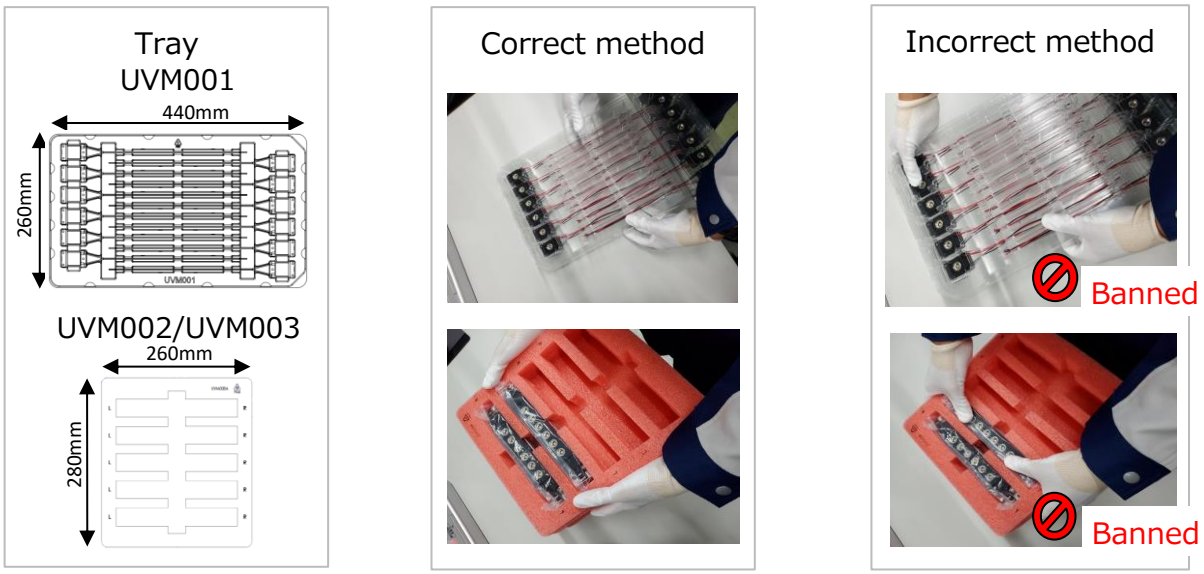
- We recommend using the product at ±10% of rated current, at which characteristics will be stable.
- Please avoid applying excess voltage such as lighting surge to LED.
- Using the product in a high temperature and high humidity environment may deteriorate the product and lead to a decrease in radiant flux. Make sure to conduct a test before use.
- Do not use the product in an environment where condensation forms, because it may cause a leak and lead to a decrease in radiant flux.

● Handling precautions for UVC LED Assembly : Details 1

Precautions for handling of trays

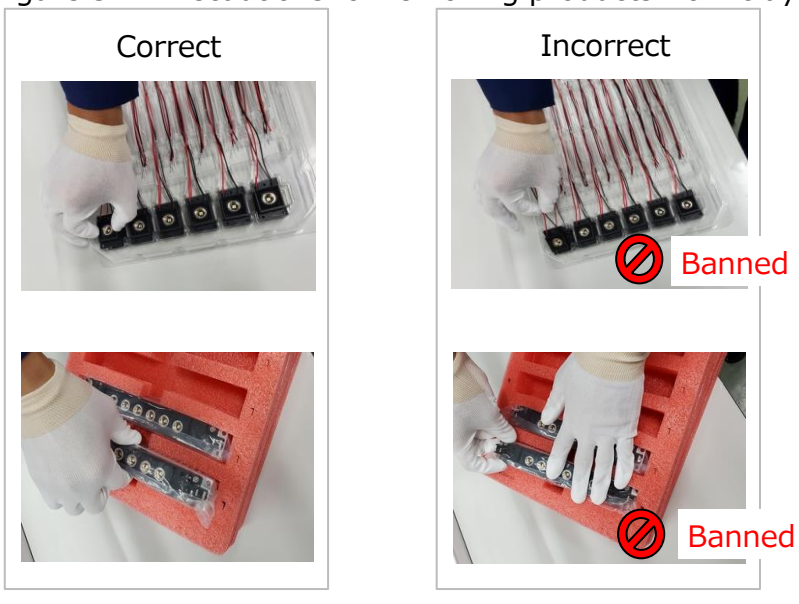
UVM001, UVC LED Assembly products, are delivered on an anti-static tray. When carrying the tray, please handle the outer part of the tray only. If pressure is applied to the inner part of the tray (pockets for placing products), the bottom of the tray may touch the products and result in malfunctioning. Therefore, please ensure that neither fingers nor any part of the hands touch the inner part of the tray (Fig. 3-6).
UVC LED Line Assemblies such as UVM002 and UVM003 are delivered in pockets of trays made of polyethylene foam. Please pay the same attention as with UVM001 when carrying the tray.

Figure 3-6 How to carry a tray



When removing products from the tray, a flat surface free of dust, moisture and oil is recommended.
Please use anti-static gloves and do not touch the products with bare hands (Fig. 3-7).
Also, avoid using a tool with a sharp edge such as a pair of tweezers, as it may damage the products.

Figure 3-7 Precautions for removing products from tray

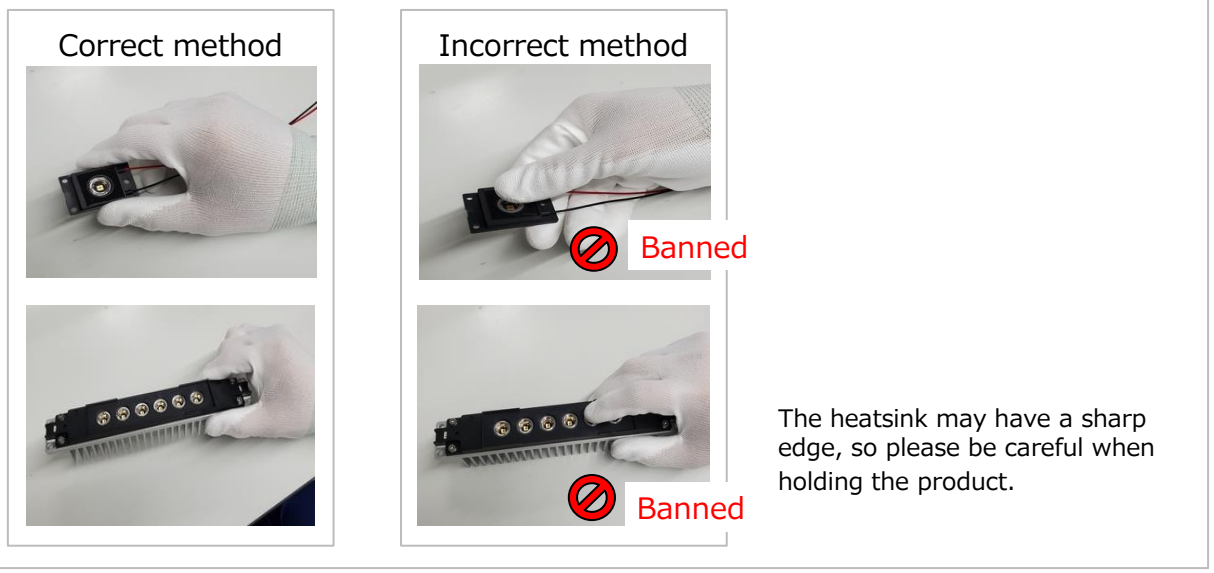


● Handling precautions for UVC LED assembly : Details 2

Precautions for holding a product

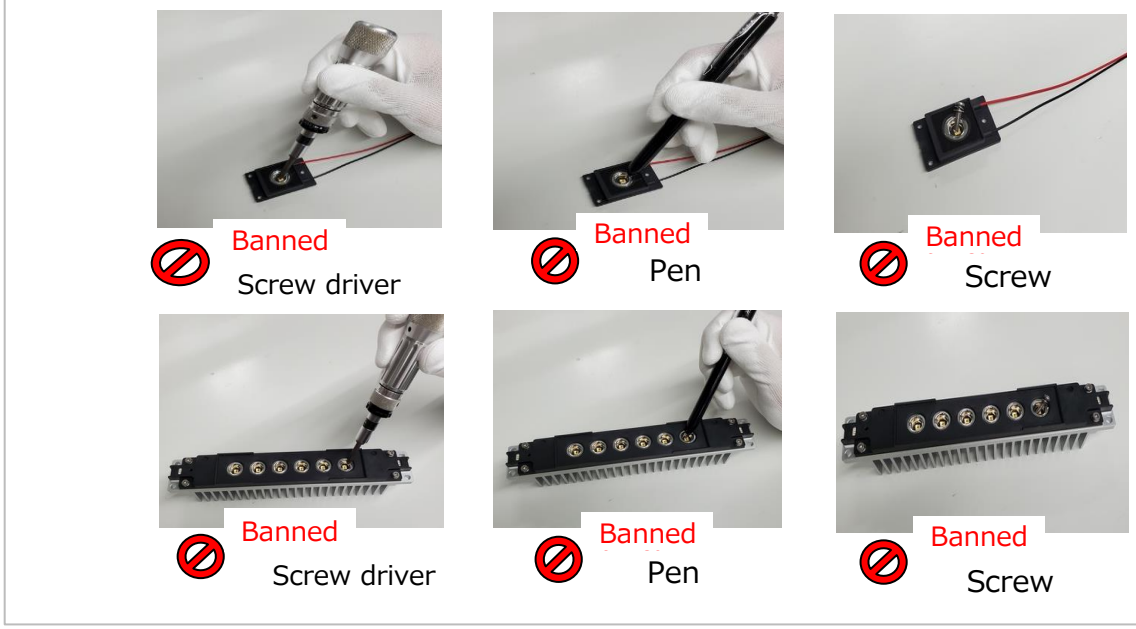
The way of holding a product may impact on the optical characteristics and service life of the product. Especially, please ensure not to apply pressure to the UVC LED, reflector and glass window, as it may result in non-lighting of the product (Fig. 3-8).
When holding a product, please wear anti-static gloves and avoid touching the product with bare hands. If you touch the reflector or glass window with bare hands, the surface may retain foreign matter and this may impact optical characteristics.

Figure 3-8 How to hold a product



Also, please make sure that sharp tools such as a screwdriver or a screw do not touch the reflector or glass area of the product (Fig. 3-9).

Figure 3-9 Incorrect handling of the product



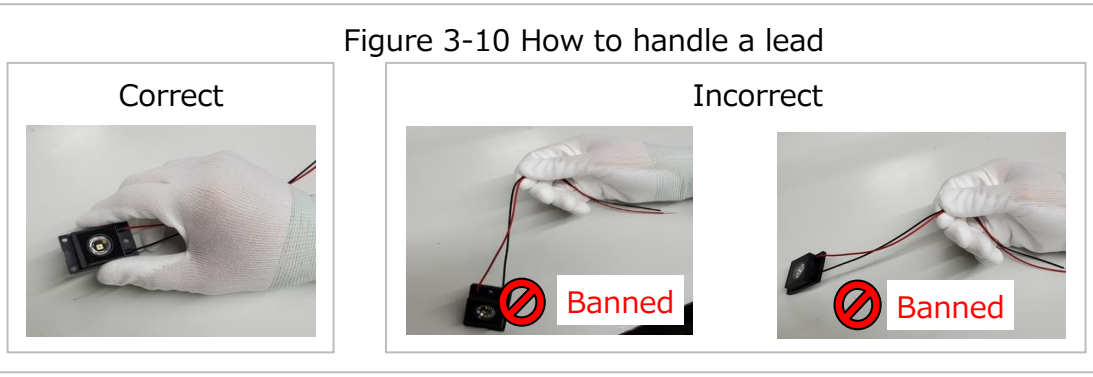
● Handling precautions for UVC LED Assembly : Details 3

Precautions for handling of a lead

How to hold a lead:

Do not handle the product by holding the lead. This may impact on the function, performance and reliability of the product. When holding a product that has a lead, please hold the sides of the product and do not touch the lead. (Fig. 3-10)

Figure 3-10 How to handle a lead



Precautions for handling of a lead

Avoid actions described below as they may impact on the function, performance and reliability of the product (Fig. 3-11).

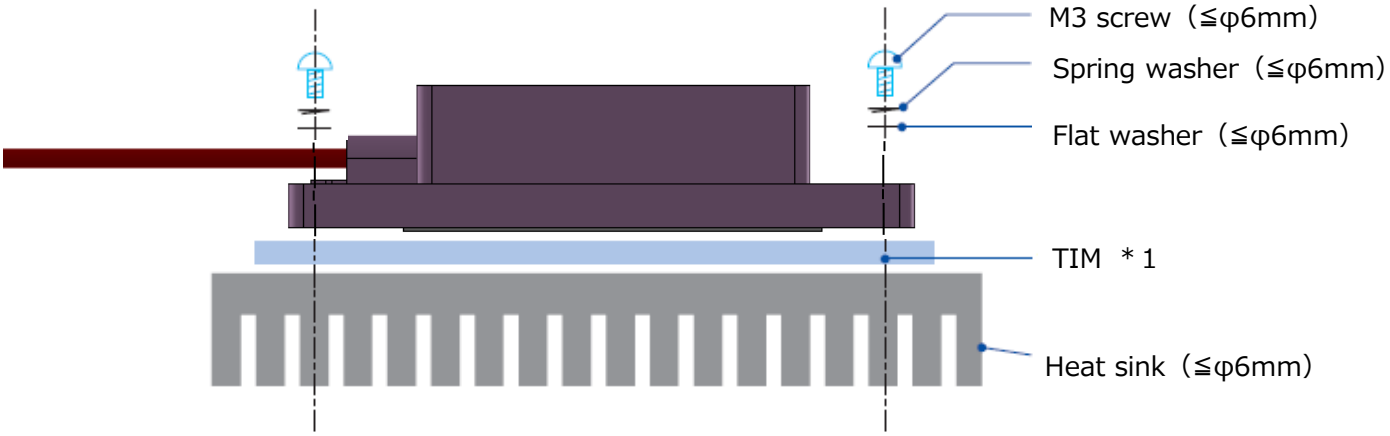
Figure 3-11 Incorrect handling of a lead

● Installation method　1

How to fix UVM001

We recommend installing UVM001 (UVC LED Assembly) by using TIM (thermal interface material).
A heatsink can be fixed with M3 screws.
When removing TIM, please confirm that the heatsink is flat, and Tc is in the operating temperature range in the specifications.
Tightening torque of M3 screw is TYP0.4N･m and MAX0.6N･m.
Places of screw holes for M3 screws are described below.
Please attach the UVC LED Assembly by temporarily tightening the left and right screws and then conducting final tightening of the screws to prevent the application of an excessive stress or strain on them.
To enhance heat dissipation of the product, please use TIM between the LED package and heatsink (Fig. 3-12).

Figure 3-12 Recommended installation method（M3 screw）



＊1　Additional guide

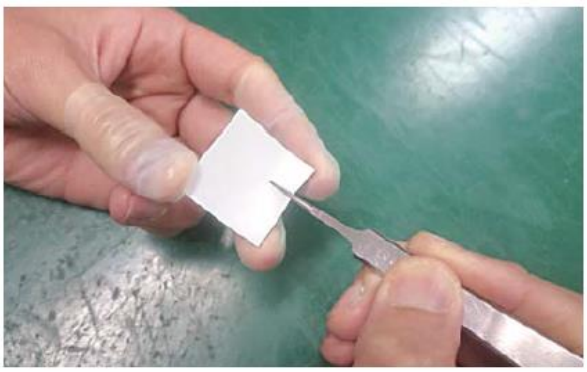
Please refer to Fig. 3-13a and 3-13b for handling of TIM.

i) If you use a grease-like TIM, screen printing is recommended

ii) If you use a TIM sheet, pay attention not to allow bubbles to become included.

Figure 3-13a
Reference photo of grease-like TIM

Figure 3-13b
Reference photo of a TIM sheet



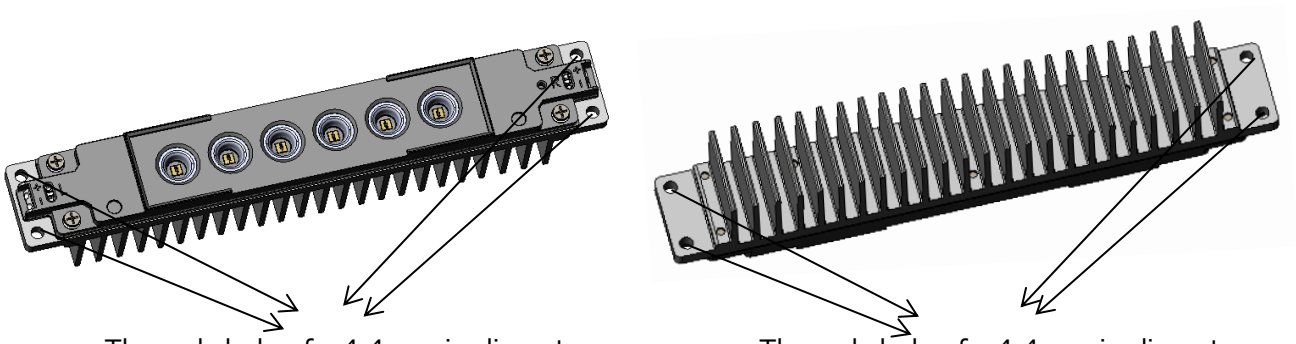
*Note:
Please do not touch the light emitting glass when printing grease-like TIM or attaching a TIM sheet.

Installation method 2

How to fix UVM002/UVM003 Line UVC LED and Line Assembly

UVC LED Line Assemblies UVM002/UVM003 have a heatsink.
Please use through-holes in each of the four corners of the heatsink to fix the product (Fig.3-14).

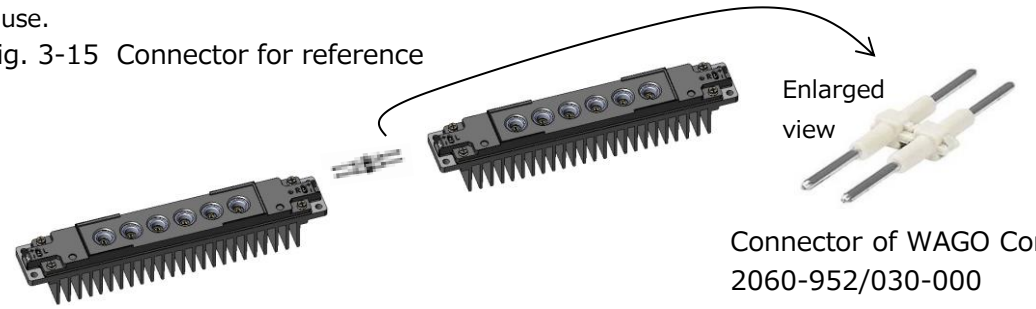
Figure 3-14 Through-holes used for fixing of UVM002,UVM003



How to connect UVM002/UVM003 Line UVC LED and Line Assembly

If you intend to gain longer linear light emission, please connect up to two products.
To connect products, we recommend connection of leads described in the specifications.
Connector in Figure 3-15 can be used for connection, but please evaluate the status in the usage environment before use.

Fig. 3-15 Connector for reference



Connector of WAGO Corporation
2060-952/030-000