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Opto Semiconductors

How to drive the intelligent RGB OSIRE® E4633i with ISELED® concept

Application Note

Valid for:
KRTBI DVLM31.31
KRTBI DVLM32.31

Abstract

The OSIRE® E4633i is an intelligent RGB-LED which is based on the ISELED® concept (Integrated Smart Ecosystem Light Emitting Diode). It integrates a controller chip from INOVA Semiconductors GmbH into an RGB LED. This enables the direct calibration of the LED and this calibration data is placed in a one-time-programmable (OTP) memory of the controller chip. The fast data rate of the controller offers dynamic light effects in milliseconds. The OSIRE® E4633i ensures easy and secure addressing via the ISELED® protocol as well as color homogeneity and stability. The small package and serial bus reduces the space and interconnections required. This application note provides information on how to drive the OSIRE® E4633i, with the focus on the package design, technical advantages, the master microcontroller, driving schemes, PCB design and assembly recommendations.

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A. General information

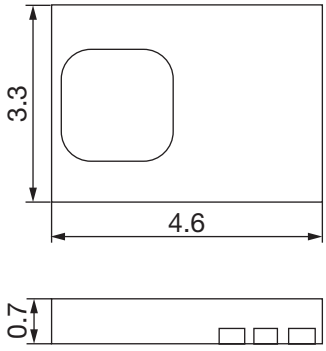
Interior design is becoming more and more important in the automotive industry. Especially light design is a major topic, where intelligent LEDs, such as the OSIRE® E4633i offering new possibilities.

Package and design

The OSIRE® E4633i integrates an RGB-LED and an LED controller into a small 4.6 mm x 3.3 mm x 0.7 mm package. Thereby this product is available in two different product types. Both have a 13-lead pre-mold SMT package and top emitting chips. The “KRTBI DVLM32.31” type offers a linear orientation of the RBG chips, whereas a delta orientation is provided by the “KRTBI DVLM31.31”. Figure 1 shows a comparison of the chip orientation and the package dimensions. Both designs feature an integrated INOVA ASIC.

Figure 1: OSIRE® E4633i with linear and delta orientation of the RGB chips

Package dimensions:



KRTBI DVLM32.31: linear orientation

KRTBI DVLM31.31: delta orientation

Technical advantages

This dynamic light source offers variable color and brightness control. A controllable chain of multi-color LEDs with up to 4079 LEDs is also possible. additional functions can also be enabled, such as situational information for the driver. Even communication between autonomous vehicles and visual communication between other road users is imaginable.

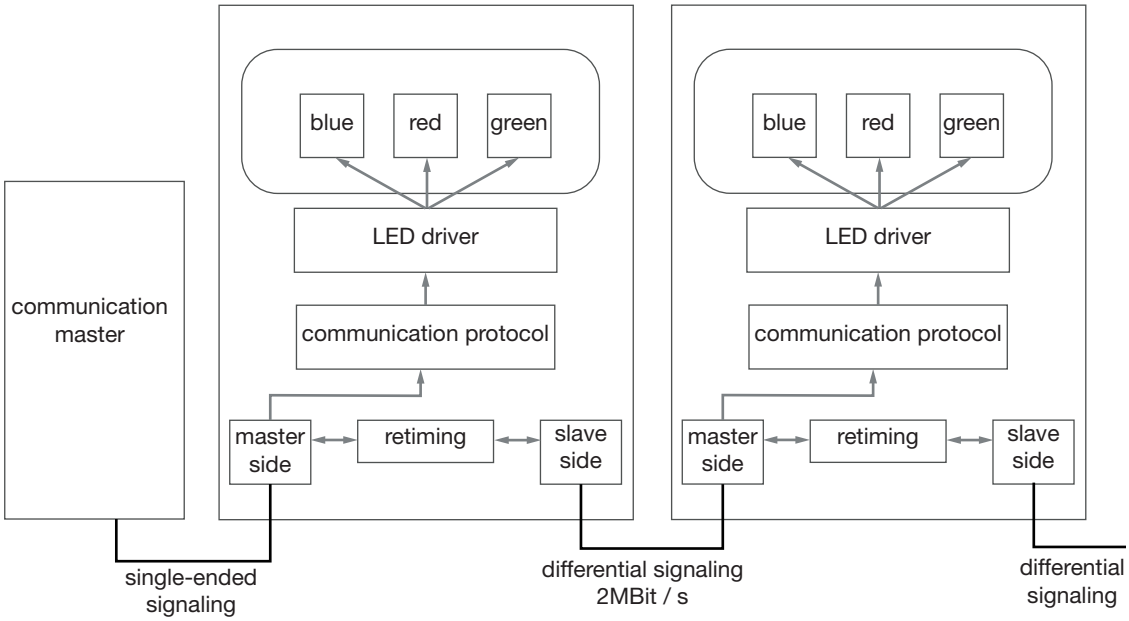
The OSIRE® E4633i is based on the ISELED® concept and comes with an integrated controller chip from INOVA Semiconductors. It enables the direct calibration of the LEDs and this data is saved to a one-time-programmable (OTP) memory. This integration reduces the space demand in applications in comparison to standard light sources with additional external drivers.

The colors of the LED can be set through constant-current regulators (CCR). These CCRs again have an independent brightness regulator. To guarantee color stability over temperature, a fixed temperature sensor is installed. It is placed in close proximity to the chip and controls the junction temperature T_J every 2 seconds. The automatic adjustment of the red LED based on the pulse width of a PWM signal is thus ensured.

An integrated logic control unit (LCU) and a control communication unit (CCU) offer a 12-bit-address, whereby a controllable chain of 4079 individual OSIRE® E4633i LEDs is possible. The two-way master-slave-communication

offers a diagnostic function for all data, including the pad voltage, temperature and status. Communication between the microcontroller and the first OSIRE® E4633i of the chain is “single-ended”. Further communication runs differentially with a two-wire line, which improves electromagnetic compatibility (EMC). The propagation delay between the OSIRE® E4633i entrance and exit takes about 3 µs. An optional cyclic redundancy check (CRC) is available. If it is used, the downstream is performed with an 8-bit shift register and the upstream runs with a 4-bit shift register. The propagation delay is higher with an active CRC function. Figure 2 shows a schematic drawing of the serial communication.

Figure 2: Schematic drawing of the serial communication



B. Master microcontroller

The OSIRE® E4633i has an integrated calibration-free controller from INOVA Semiconductors. To run this controller, various solutions with a master microcontroller are possible. OSRAM Opto Semiconductors can only list possible microcontroller manufacturer that supports the ISELED® driver. For any questions on the ISELED® driver, licenses and information about the protocol, please contact INOVA Semiconductors.

Contact:

Inova Semiconductors GmbH
Stefan Hoffmann
Senior Application Engineer
Phone: +49 89457475756
E-Mail: shoffmann@inova-semiconductors.de

NXP Semiconductors

The advantage of using a microcontroller from NXP Semiconductors is that the ISELED® driver library is available for free. To benefit from this advantage, it is necessary to register the software with an activation code. If this activation code

is not already available, please contact gps.software@nxp.com or your NXP Semiconductors sales representative to obtain an activation code.

Without an ISELED® custom part number (S32K144EVB-Q100 and S32K1xxx µC's), only the license for the evaluation is included and the sending commands are limited to a maximum of 10,000. After resetting the strip with a delay of 1 s the commands can be sent again.

With the ISELED® custom part number a license for evaluation and production is included. This means that full functionality is available.

Contact:

NXP Semiconductors
Yiling Zhang
Product Manager
Phone: +49 8992103738
E-Mail: yiling.zhang@nxp.com

Microchip Technology Inc.

Microchip Technology is offering a free evaluation license upon request. This is for evaluation purpose and limited to 3 months usage but can be extended with renewals. In addition Microchip Technology will offer a production based licensing condition as well. Please contact Microchip Technology in this case.

Contact:

Microchip Technology Inc.
E-Mail: iseled@microchip.com

Other microcontroller manufacturers

Currently no library is available for other microcontroller manufacturers. For a full license and information about the protocol INOVA Semiconductors needs to be contacted.

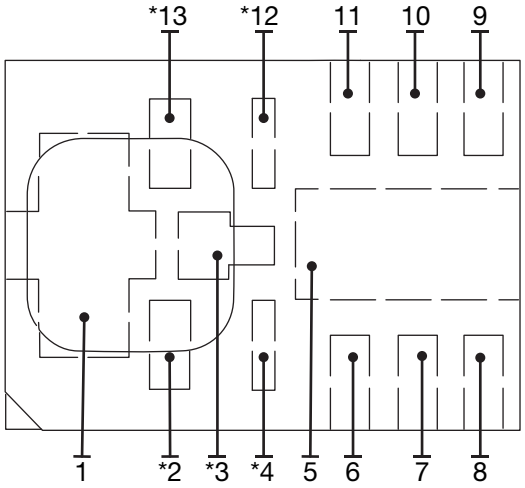
C. Using the OSIRE® E4633i without internal IC

It is also possible to drive the OSIRE® E4633i without the integrated IC for additional applications, like for example:

- Applications with increased safety, where the external control takes over in case of fault.
- If just one color is used and the brightness should be at its maximum.

Therefore, the common anode (PIN 1) must have a 5 V DC supply. The three colors have their cathode on PIN 2 (blue) PIN 3 (red) and PIN 13 (green). An electrical connection to PIN 4 and PIN 12 (additional cathodes) is not required. Please note that for this application the appropriate PINs must be contacted and therefore the appropriate solder pad design, as described in Figure 10, must be used. Figure 3 provides an overview of the PIN description.

Figure 3: PIN description of the OSIRE® E4633i



PIN	PIN	Description
1	Common anode RGB	5 V Supply
2	Cathode Blue	*No electrical connection required for normal operation.*
3	Cathode Red	*No electrical connection required for normal operation.*
4	Cathode Blue	*No electrical connection required for normal operation.*
5	Ground	Ground
6	SIO 1 P	Serial communication Interface Master Side, positive polarity
7	SIO 1 N	Serial communication Interface Master Side, negative polarity
8	PRG	Must be connected to Ground for proper operation
9	5V	5 V Supply
10	SIO 2 N	Serial communication Interface Slave Side, negative polarity
11	SIO 2 P	Serial communication Interface Slave Side, positive polarity
12	Cathode Green	*No electrical connection required for normal operation.*
13	Cathode Green	*No electrical connection required for normal operation.*

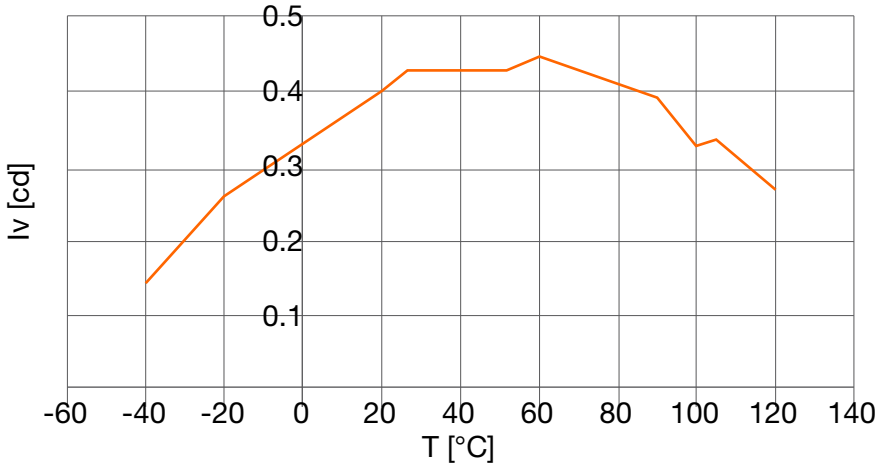
PIN 9 (the internal IC) must be supplied with 5 V DC and PIN 5 must be connected to GND during the external driving procedure. The PWM values of the OSIRE® E4633i must be set to 0, so internal drivers are in OFF state. Before returning to the normal operating mode with the internal IC, all external drivers must be set to the OFF state with high resistance to GND.

D. Temperature compensation of red

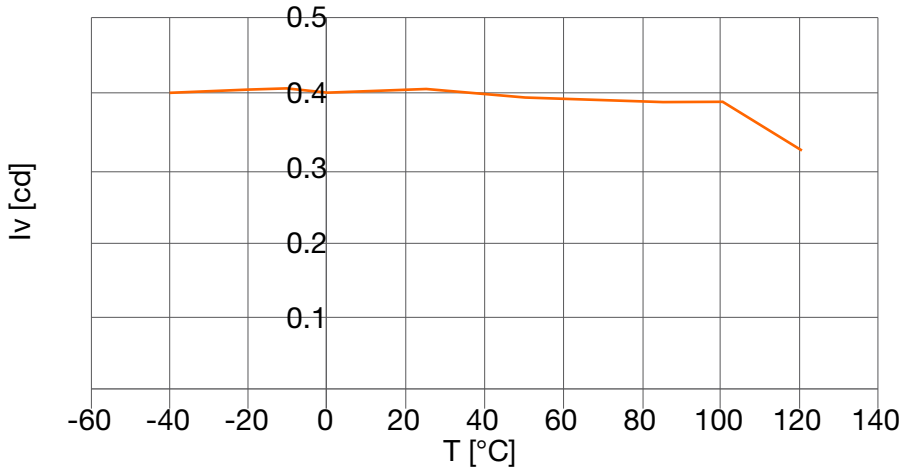
As the brightness of red LEDs is very sensitive to temperature, the internal static memory provides a linear temperature compensation of the red LED. To achieve better temperature compensation (TC), non-linear compensation is recommended. Figure 4 shows the difference in LED brightness with a linear and a non-linear temperature compensation.

Figure 4: LED brightness depending on temperature with linear and non-linear TC of the red LED

Temperature compensation of Red by PWM
(linear adjustment based on internal calculation included in Inova IC)



Improved temperature compensation of Red by PWM
(non-linear adjustment, calculation included in Inova IC but setting after each init necessary)



To realize non-linear brightness compensation over temperature, OSRAM Opto Semiconductors recommends an 11-step-value model, as shown in the look-up table in Figure 5. Data is based on LED measurements with a calibration brightness of 1.4 Cd @ D65 and a brightness stabilization of the red chip in the -40 °C to 105 °C temperature range.

Figure 5: 11-step look-up table for the best TC of the red LED

LUT_Adress	LUT_Value
0	492
1	400
2	332
3	288
4	248
5	229
6	201
7	185
8	166
9	157
10	118

These 11 values must be saved in the volatile memory of the internal IC and must be saved again after every reset. The following steps describe the commands for the init of the strip and how to set these 11 values with the NXP Semiconductors microcontroller. A short delay must be set after each value. Figure 6 shows an example of a command.

1. Reset strip (necessary as otherwise a wrong LED status flag will be read)
2. Init of strip: (e.g. by NXP “digLED_Init_Strip”)

   With following setting:

   testInitType.crcEnable = 1;

   testInitType.firstLedAdr = 1;

   testInitType.tempCmpEnable = 1;

   testInitType.voltSwing = 0;
3. Set 11-step look-up table to obtain best TC of RED: (e.g. by NXP “digLED_Set_TC_Lookup”)

   For LUT 0 to 10

   digLED_Set_TC_Lookup (uint16_t LUT_Adr,

   uint16_t LUT_Value,

   uint16_t Address,

   uint8_t stripNr);

Figure 6: Example of a TC command

```
unsigned int LUT_Value[11]={492,400,332,288,248,229,201,185,166,157,118};


digLED_Reset (0);
                        delay(2000);

                        strip1=0;

                        digLEDResultStrip1.chainLength = nrOfLEDs;

                                    digLED_Init_Strip(&testInitType, &digLEDResultStrip1, strip1);
                                    delay(2000);

                                    for(int i=0; i<=10; i++)
                                    {
                                    digLED_Set_TC_Lookup (i,
                                                LUT_Value[i],
                                                            0,
                                                            strip1);
                                    delay(1500);
                                    }
```

If another master controller is used, please refer to chapter "B. Master microcontroller". The 11-step look up table (Figure 5) for the non-linear compensation will remain the same.

E. Brightness boost

The OSIRE® E4633i make it possible to boost the brightness of the LED, as a non-standard operation. Therefore, the volatile memory of the internal IC can be used. However, after each reset the brightness boost commands must be set again, if they should be continued used.

The standard calibration is white D65 with PWM maximum at 1.4 cd. Before setting it to a higher value, the PWM values of each LED must be read out individually for each LED. To boost the brightness, the PWM can be set to a maximum of 4095. When leaving the standard operation mode, care must be taken that the IC temperature is not higher than 125 °C.

To set the individual brightness, it is recommended to use the following steps and commands:

1. Reset strip (necessary because otherwise an incorrect LED status flag will be read)
2. Init of strip if not already done: (e.g. by NXP “digLED_Init_Strip”)

   With the following setting:

   testInitType.crcEnable = 1;

   testInitType.firstLedAdr = 1;

   testInitType.tempCmpEnable = 1;

   testInitType.voltSwing = 0;
3. Read out PWM max values (for each LED individually)

4. Set the percentile for the PWM max value of the LEDs higher (max. possible 4095)
5. Turn the LEDs on by setting intensity RGB (0-255)

To go back to the operating mode with the OSRAM Opto Semiconductors standard calibration with non-linear brightness compensation for red, the following steps should be used:

1. Reset strip
2. Init strip
3. Set 11-step look-up table for the best TC of red (chapter "D. Temperature compensation of red")
4. Turn LEDs on by setting intensity RGB (0-255)

F. PCB design recommendations

A well-designed PCB layout is essential. In general a EMC-friendly PCB design should be created. To avoid signal reflection on high-speed serial communication interfaces (SCI), all the lines should be as short as possible and should also be of the same length. There should be no line crossing and no vias between the lines.

Depending on the number of devices in the chain, the voltage drop on supply and ground wire resistance should be considered.

The following design guidelines should be considered for single-ended signal lines:

- Keep the lines as short as possible.
- Design the line-ground loop with min. area.
- Design no line crossing and no vias between single-ended lines.
- An off-board design is not recommended.

The following design guidelines should be considered for signal lines:

- Design the lines on-board in parallel and at the same length.
- Design no line crossing and no vias between differential lines.
- Keep the signal lines as short as possible.
- Off-board only shielded or twisted pairs with additional components. Detailed information may be requested from INOVA Semiconductors.
- The ground level shift must be low. Please note that it is temperature-dependent.

Recommendations for external components

It is recommended to consider the following guidelines for external components:

- Connect to each common anode (PIN1) min.1 µF low ESR ceramic capacitor (C1.1-n).
- A 100 nF capacitor (C2.1-n) should be set as close as possible to the 5 V IC supply (PIN9).
- Pull-up resistors are required due to single-ended communication between the microcontroller and the 1st LED, or if a microcontroller (e.g. INLC100Q16 from INOVA Semiconductors) is used instate of the 1st LED. Please place a 1K pull-up resistor (R1 & R2) in parallel to the 5 V supply.
- The communication lines of the 1st and last device can be connected with ESD protection diodes (ESD1 – ESD4), for protection against voltage spikes higher than 2 kV.
- It must be ensured that the max. rating supply voltage 5.5 V (e.g. Z-diode 5.5 V) is observed.

Figure 7 shows a typical application layout with a focus on the recommendations provided. Figure 8 describes the recommendation from Inova Semiconductors for two PCBs with cable connection. For further information on this variation of connecting external components, please refer to Inova Semiconductors.

Figure 7: Typical application layout with recommendations for external components

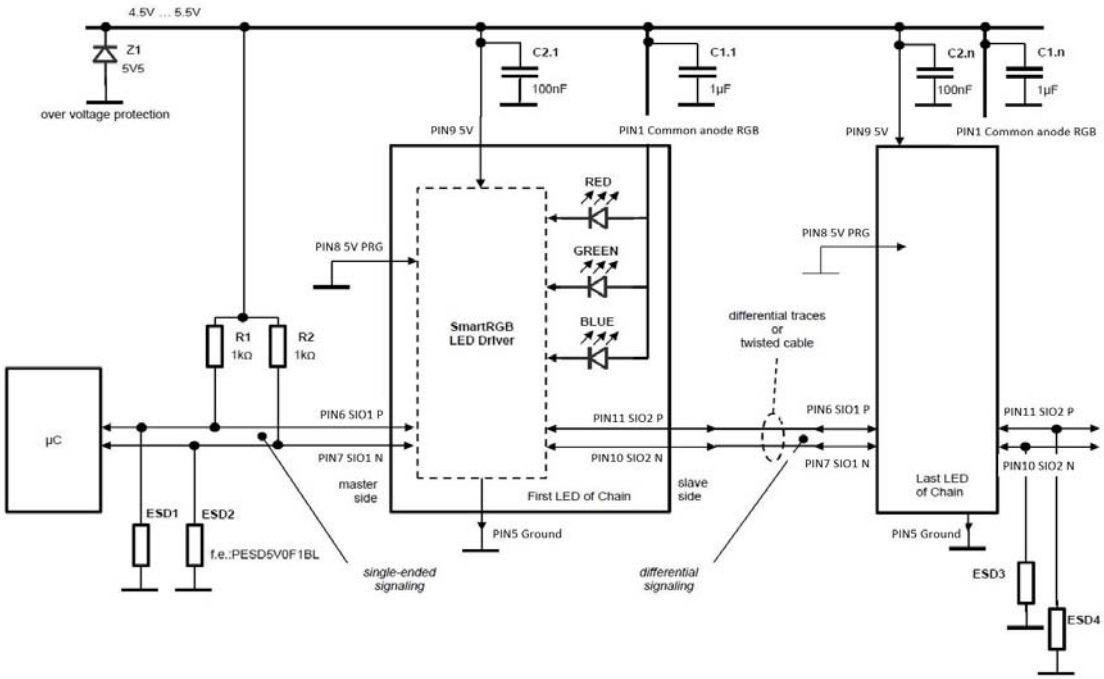
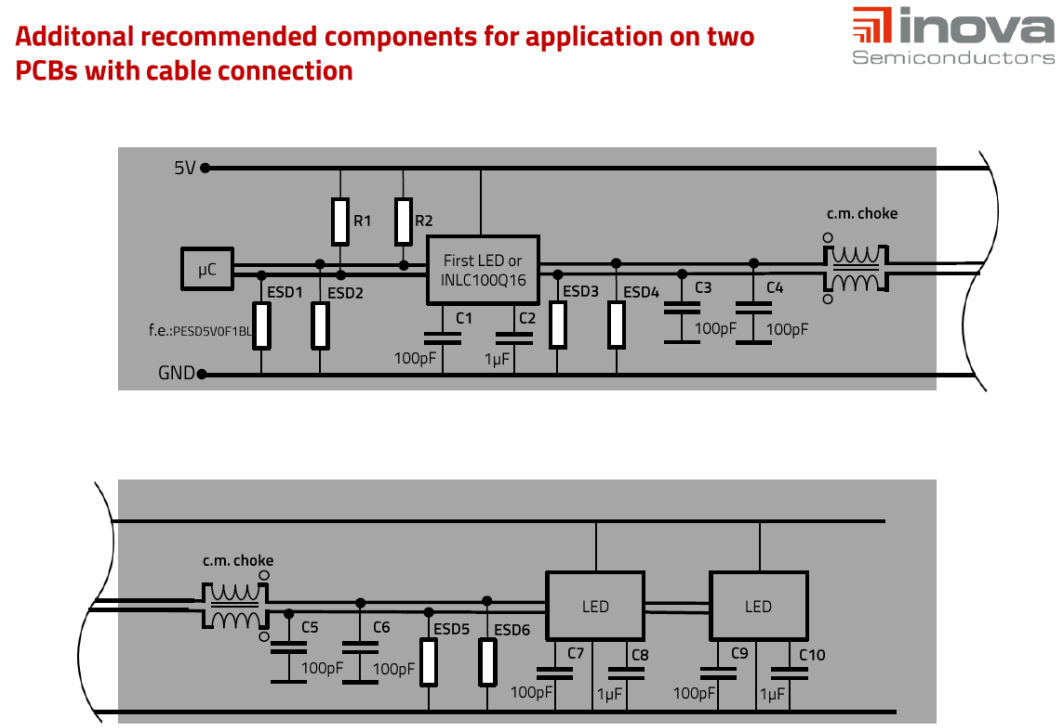


Figure 8: Two PCBs with a cable connection from Inova Semiconductors



G. Assembly recommendations

As is the case with all LEDs from OSRAM Opto Semiconductors, the OSIRE® E4633i also fulfills the current RoHS guidelines (European Union and China), which means that it does not contain lead or other defined hazardous substances.

ESD stability

Although there is no additional ESD protection included, the LED provides at least 2 kV ESD stability. It is assigned to the “Class 2 HBM” category in accordance with ANSI / ESDA / JEDEC JS-001. With this class the OSIRE® E4633i can be considered as uncritical for processing and assembly by means of state-of-the-art SMT equipment aligned with ESD precautions. To achieve higher ESD protection on the system level, additional ESD protection must be applied.

Cleaning

Any direct mechanical or chemical cleaning of the LED should be avoided. Isopropyl alcohol (IPA) can be used if cleaning is mandatory. Other substances, and especially ultrasonic cleaning, are generally not recommended.

For dusty LEDs, simple cleaning by means of purified compressed air (e.g. central supply or spray can) is recommended. In order to ensure that the

compressed air does not contain any oil residues, the use of a spray can is recommended. A maximum pressure of 4 bar at a distance of 20 cm to the component is also recommended.

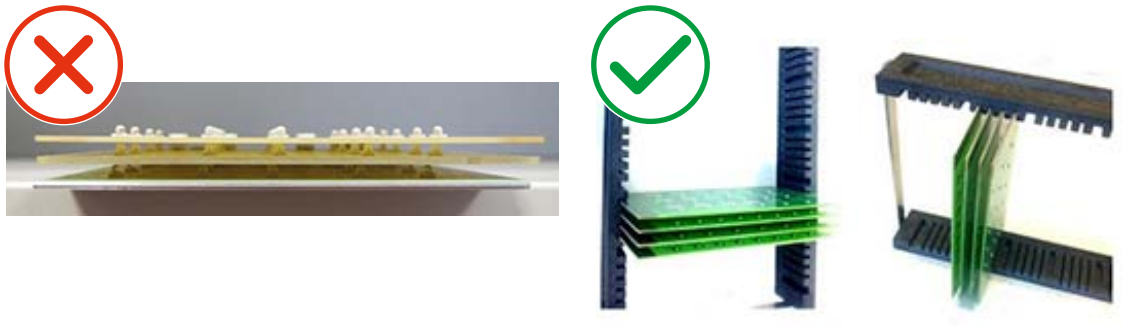
In any case, all the materials and methods should be tested beforehand, particularly as to whether or not damage can be associated with the component.

Precautions and storage

In general, LEDs are packaged in tape and on reels. For storage and dispatch, the reels are packed in vacuum-sealed dry bags together with desiccants. It is generally recommended to leave the reels in their original package until they are assembled, and to store components under ambient conditions of ≤ 10 % RH during processing. Drying cabinets with dry nitrogen (N_2) or dry air are suitable for this type of storage. The OSIRE® E4633i complies with moisture-sensitive Level 2 (MSL 2) according to JEDEC J-STD- 020E.

A suitable storage system should be used to ensure that assembled LED boards are not stacked on top of each other (Figure 9). To avoid the risk of damage to the assembled LEDs, make sure that they are not exposed to compression forces of any kind. Furthermore, the LED of the assemblies must also not be touched directly.

Figure 9: Correct storage



Manual handling

Although manual handling and assembly is possible, automatic placement is strongly recommended. Special care must be taken if the OSIRE® E4633i is handled manually.

Solder pad design

Since the solder pad effectively creates the direct contact between the LED and the circuit board, the design of the solder pad contributes decisively to the performance of the solder connection. The design has an influence on solder joint reliability and heat dissipation.

In most cases, it is therefore advantageous to use the recommended solder pad, since it has been individually adapted to the properties and conditions of the LED. The corresponding solder pad is also indicated in the data sheet of each LED. Based on the given solder pad design, an optimized balance between good

processability, the smallest possible positioning tolerance and a reliable solder connection can be achieved.

Figure 10 shows the recommended solder pad design for applications operating also without the internal IC, like described in chapter "C. Using the OSIRE® E4633i without internal IC".

Figure 11 shows the recommended solder pad design for applications that are operating entirely with the internal IC.

Figure 10: Recommended solder pad design (possibility for operating without the internal IC)

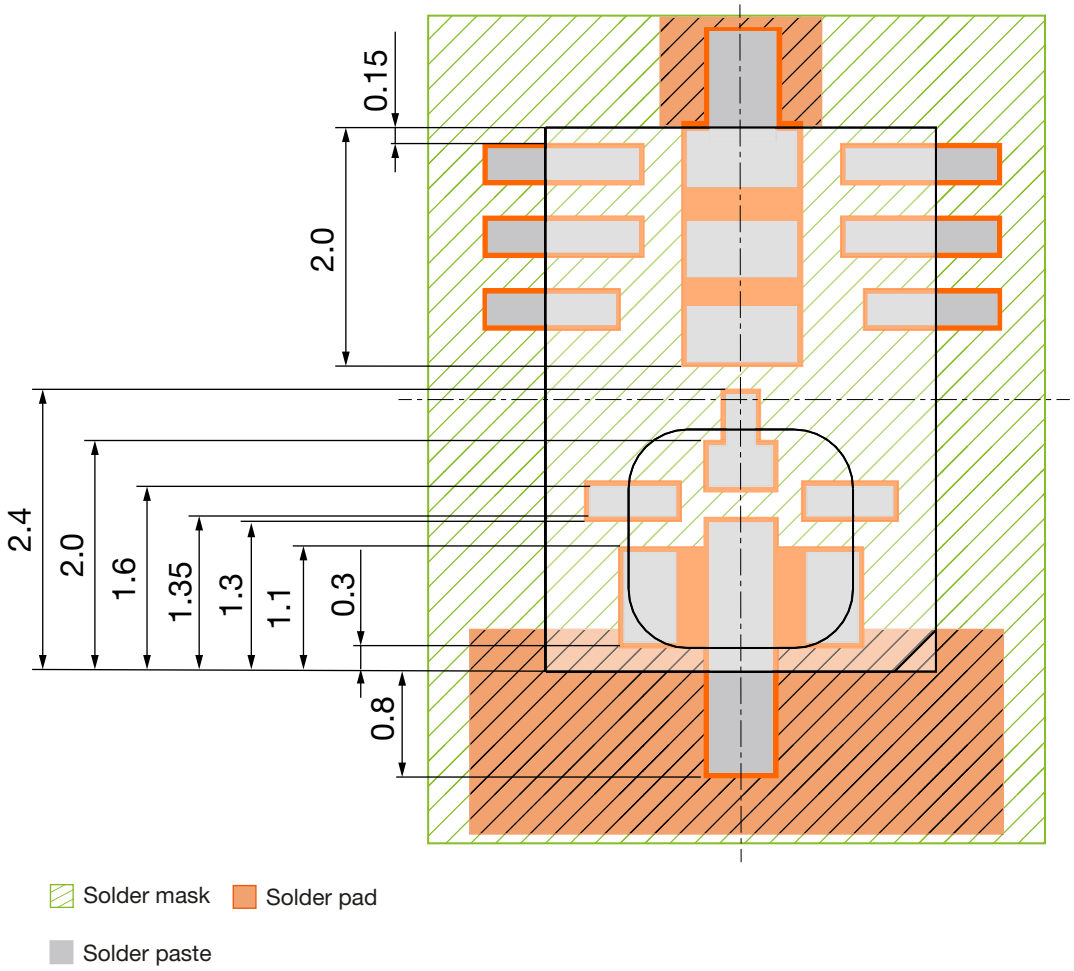


Figure 10: Recommended solder pad design (possibility for operating without the internal IC)

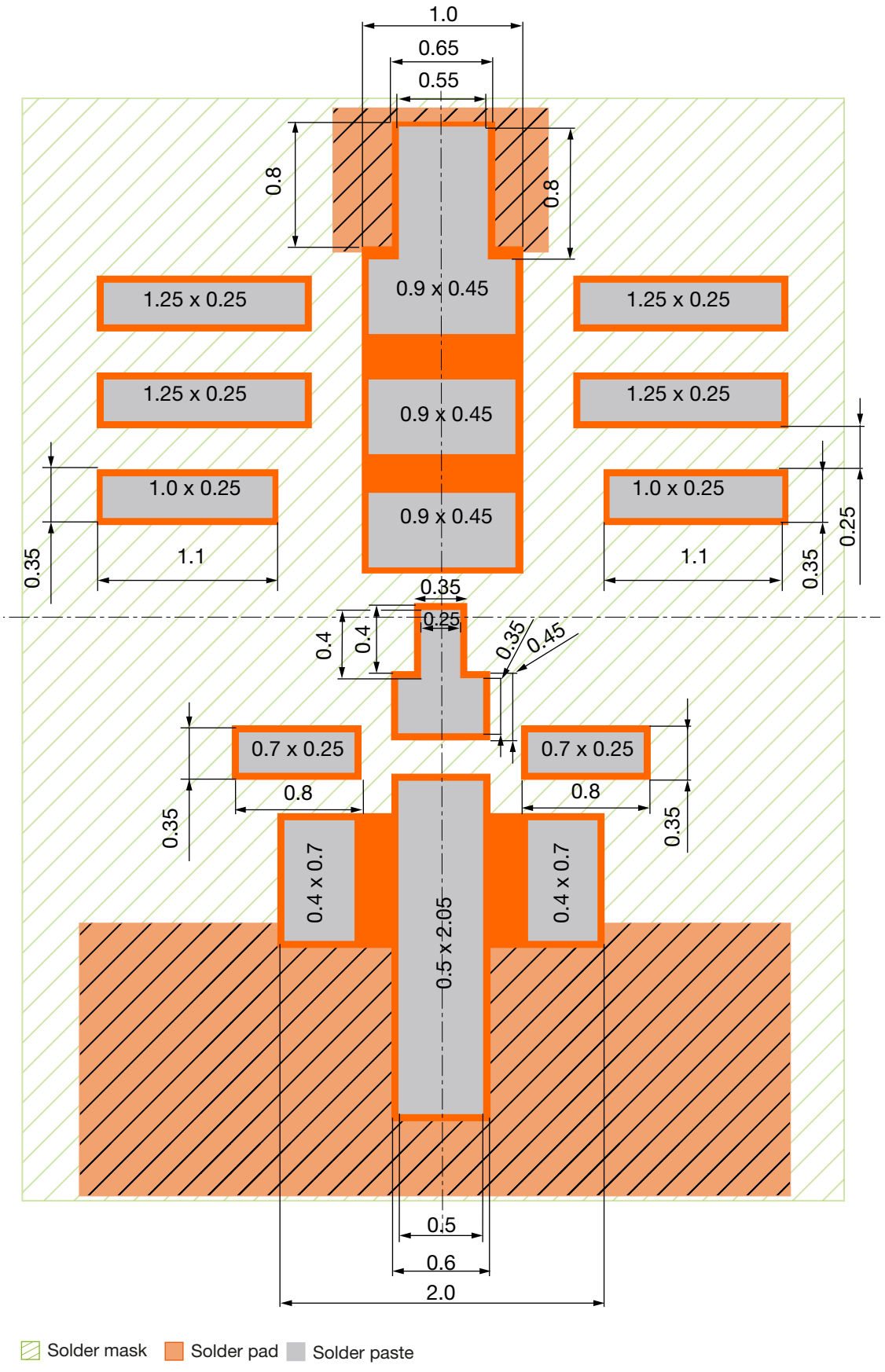


Figure 11: Recommended solder pad design for operating entirely with the internal IC

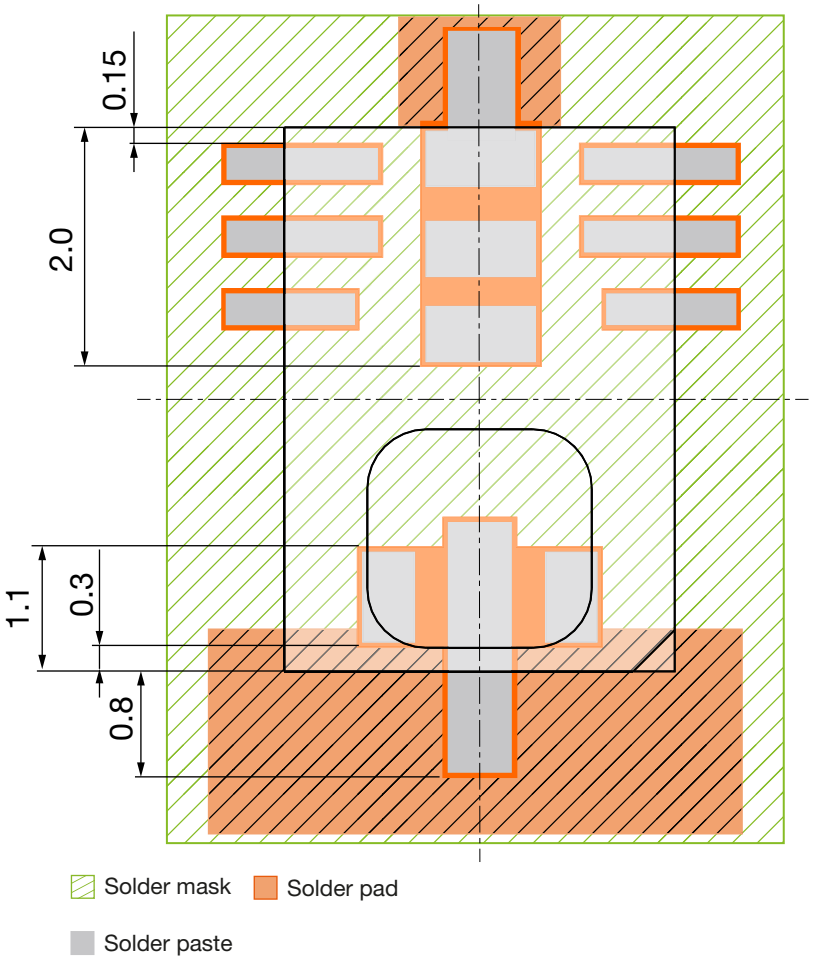
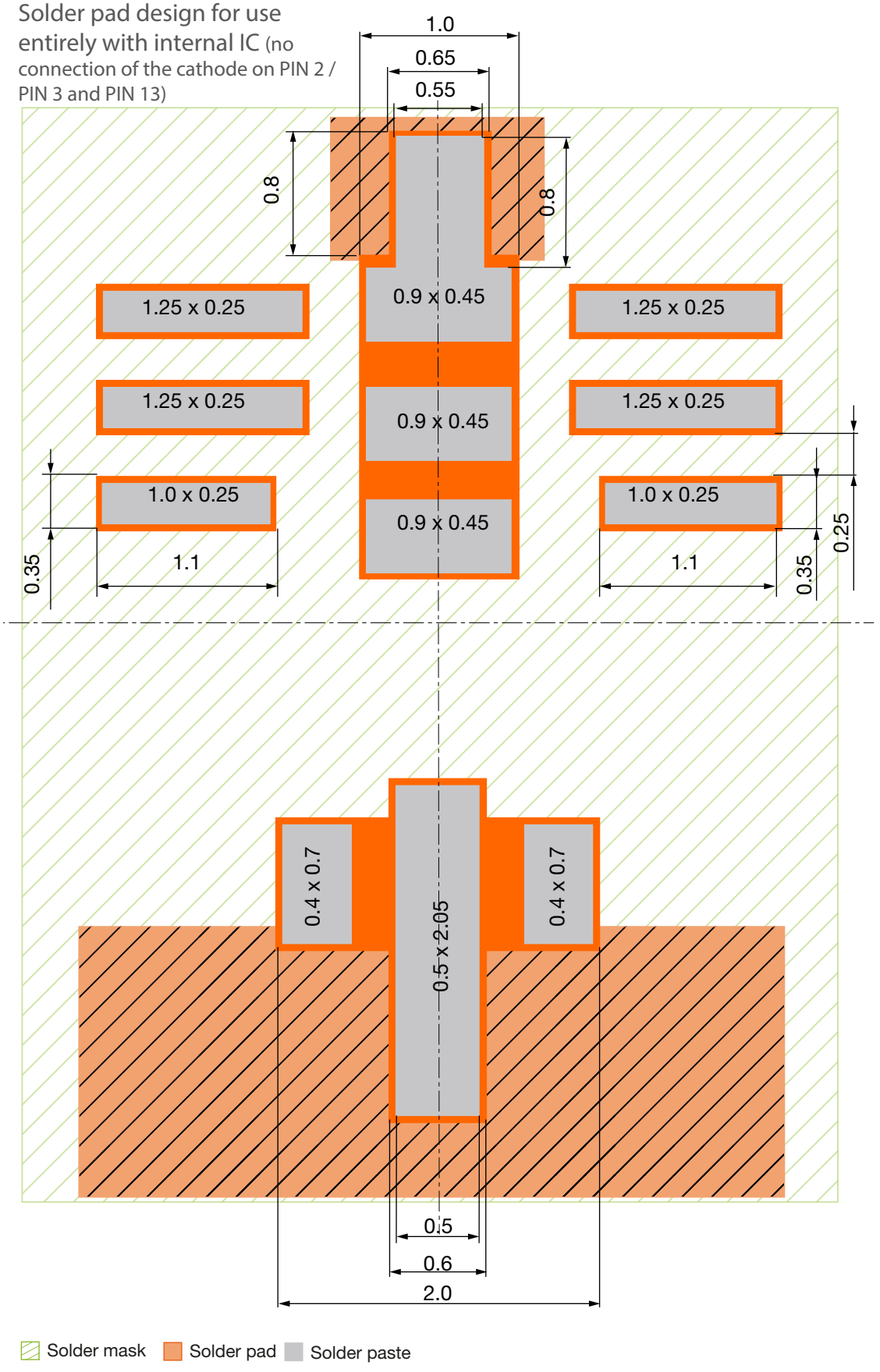


Figure 11: Recommended solder pad design for operating entirely with the internal IC



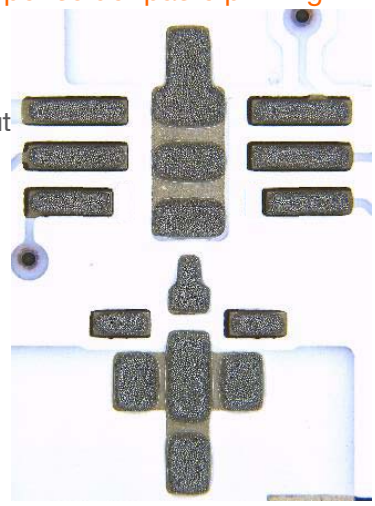
Solder stencil

In the SMT process, solder paste is normally applied by stencil printing. The design of the printing stencil and an accurate working process influence the amount and quality of the paste deposit applied. Proper solder paste printing increases the solder quality. Effects such as solder bridges, solder spray and/or other soldering defects are largely determined by the design of the stencil apertures and the quality of the stencil printing (e.g. positioning, cleanliness of the stencil, etc.). For the OSIRE® E4633i a stencil thickness of 120 µm is recommended. A uniform solder joint thickness is recommended to produce reliable solder joints and obtain an appropriate optical alignment.

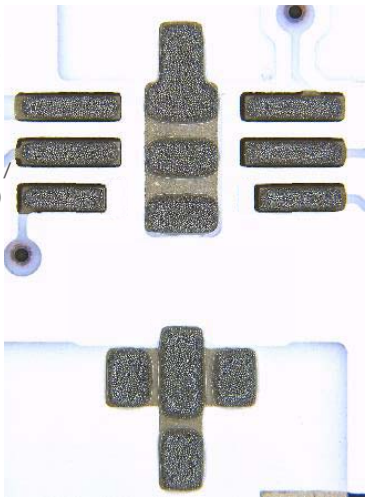
For the paste printing process OSRAM Opto Semiconductors has successfully used the standard SAC 305 Type 3 solder paste (HERAEUS F640 SAC 305 Type 3). For process evaluation, process control and failure prevention it is recommended to check the solder paste volume with SPI (Solder Paste Inspection) regularly. Figure 12 shows an example of proper solder paste printing.

Figure 12: Proper solder paste printing

Solder pad design (for the possibility to operate without internal IC)



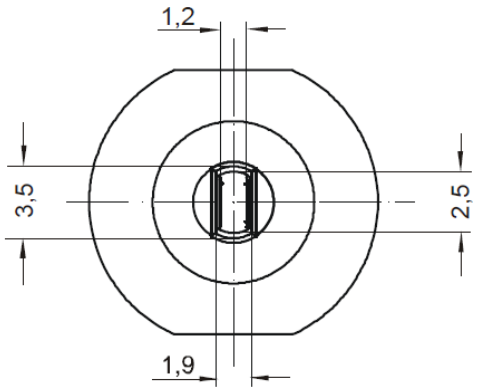
Solder pad design for use entirely with internal IC (no connection of the cathode on PIN 2 / PIN 3 and PIN 13)



Pick-and-place nozzle design

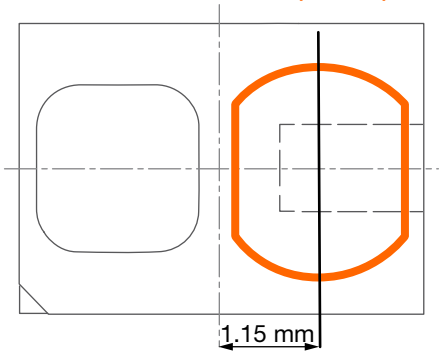
When processing by means of automated placement machines, care should be taken to use an appropriate pick-and-place tool and to ensure that the process parameters comply with the package's characteristics. An example of a suitable pick-and-place nozzle is given in the form of the SIPLACE tool number 2035, also shown in Figure 13.

Figure 13: Recommended pick-and-place nozzle



The light emitting area of the OSIRE® E4633i should not be touched, as mechanically sensitive parts such as LED chips and bond wires are located in this area. Safe pick-up can be performed off-center of the package. The schematic representation in Figure 14 describes the pick-up area for the nozzle.

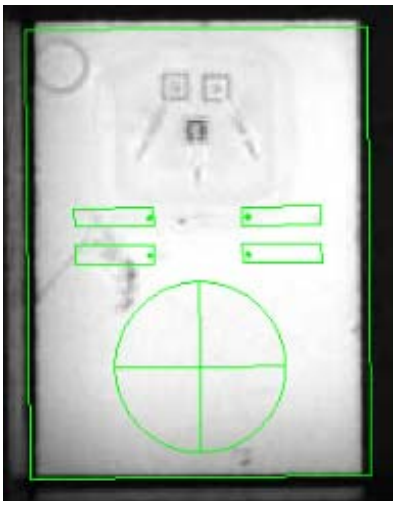
Figure 14: Recommended pick-up area



Vision System

Figure 15 shows an example of how to teach the footprint of the OSIRE® E4633i into the ASM Siplace Vision System. For recognition purposes, it is recommended to teach in the terminals of the component and not the outline of the part.

Figure 15: Teaching the OSIRE® E4633i into the ASM Siplace Vision System



Reflow soldering

Supported by 8 side wetting indicators, the OSIRE® E4633i features a good self-alignment during soldering additionally (Figure 16). These wetting indicators improve the solder joint reliability as visual wetting indicators and help that the component does not tilt during soldering.

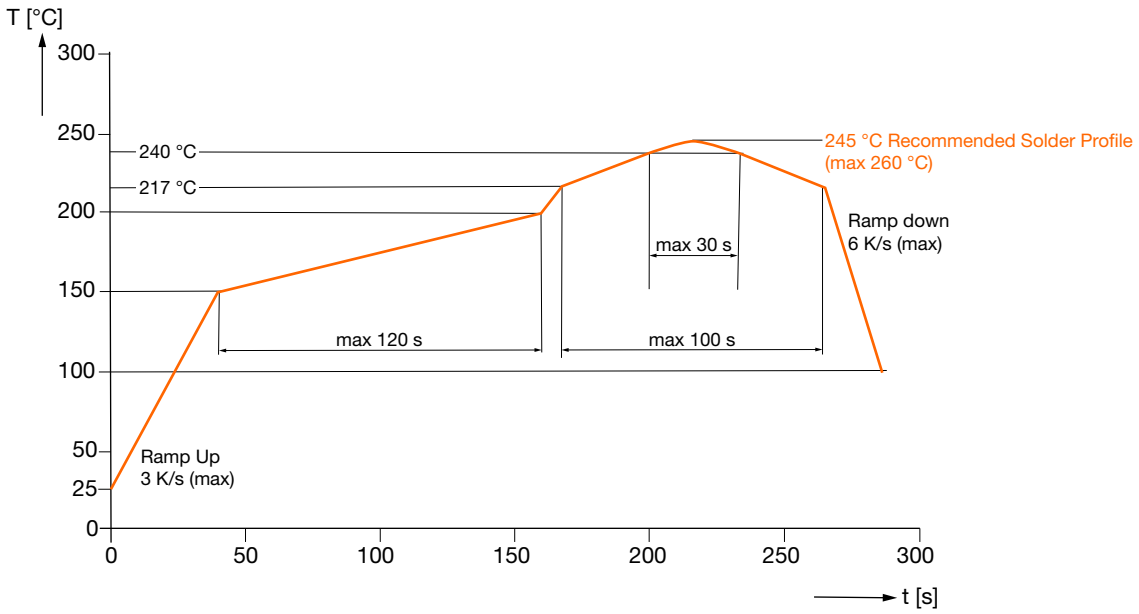
Figure 16: Wetting indicators of the OSIRE® E4633i

Soldered example

Generally, the OSIRE® E4633i is compatible with existing industrial SMT processing methods, so that current populating techniques can be used for the mounting process. The individual soldering conditions for each LED type according to JEDEC can be found in the respective data sheet. A standard reflow soldering process with forced convection under standard N_2 atmosphere is recommended for mounting the component, in which a typical lead-free SnAgCu metal alloy is used as solder. Figure 17 shows the temperature profile for lead-free soldering with the recommended peak temperature of 245 °C. In this context, it is recommended to check the profile on all new PCB materials and designs. As a good starting point, the recommended temperature profile

provided by the solder paste manufacturer can be used. The maximum temperature for the profile as specified in the data sheet should however not be exceeded.

Figure 17: Temperature profile for lead-free reflow soldering according to JEDEC J-STD-020E



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www.ledlightforyou.com

ABOUT OSRAM OPTO SEMICONDUCTORS

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