APPLICATION NOTES:
seddLED3.5 (A3E-THG)

Introduction

seddLED (Smart Embedded Digital Driver LED) is the world's first digital LED which combines RGB LED, LED Driver and advanced ISELED® communication protocol integrated into a single package. It is a revolutionary approach for automotive ambient lighting with fully-calibrated RGB LED to target coordinates. seddLED3.5 A3E-THG-60-1 is pre-calibrated to D65 white point with an accuracy within 3 SDCM steps at 60lumen.

This document provides guidelines on how to drive the seddLED3.5 with the focus on the LED package design, PCB design, microcontroller and ISELED® module to module connection setup. All functions can be controlled via the microcontroller unit (MCU) that provides the ISELED® serial communication protocol.

List of Abbreviations and Acronyms

API	Application Programming Interface
CAN	Controller Area Network
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
GND	Ground
LIN	Local Interconnect Network
MCU	Microcontroller Unit
PCB	Printed Circuit Board

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2. **Temperature Compensation for Red LED**

3. **Surface Mounting Guideline**

1. User Application Development Setup

This section provides guidelines to the development of seddLED3.5 LED typical application setup. Selection of right external component and PCB layout is critical to ensure proper functionality and heat dissipation when daisy-chain many seddLED3.5 LED together onto a small PCB surface.

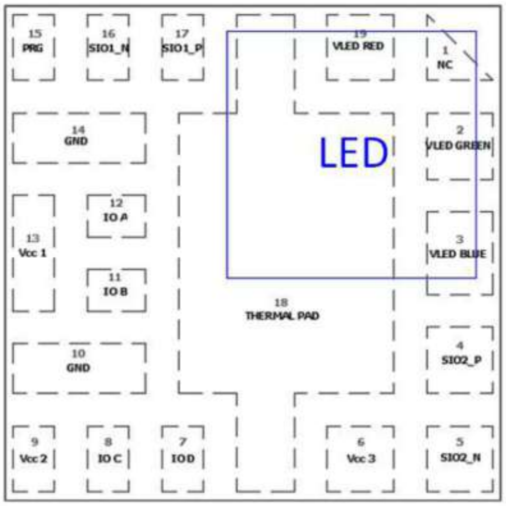
1.1 seddLED3.5 A3E-THG-60-1

Function and Features:

- Small package outline (LxWxH) of 6.0 x 6.0 x 1.22mm.
- Superior corrosion resistant.
- Serial communication with ISELED® compliance.
- Qualified according to JEDEC moisture sensitivity Level 2.
- Bi directional, half-duplex, 2MBit/s, serial communication.
- D65 White point calibration.
- Brightness & color stability over temperature.
- 8-bit brightness resolution for red, green, and blue LED.
- channel temperature compensation for excellent color uniformity.
- Build-in diagnostic functions.
- Auto addressing of LED via the serial bus in daisy chain.
- Environmentally friendly, RoHS compliance.
- Compliance to automotive standard; AEC-Q102 & AEC-Q100.

1.1.2 A3E-THG Pin out

Please follow this pin-out for connection and pin functionality:



Top view

Pin No.	Pin Name	Function	Description
1	NC	-	Pad With No Electrical Function, Can Be Soldered With Adjacent Pad
2	V_{LED_Green}	Supply	Voltage Supply Pin to Green LED Anode Terminal
3	V_{LED_Blue}	Supply	Voltage Supply Pin to Blue LED Anode Terminal
4	SIO2_P	I/O	Serial Communication Interface Slave Side, Positive Polarity
5	SIO2_N	I/O	Serial Communication Interface Slave Side, Negative Polarity
6	V_{cc_3}	Supply	Voltage Supply To ISELED IC#3
7	IO_D	I/O	I/O Pin For Component Testing. Should Be Electrical Isolated For Customer Board Mounting
8	IO_C	I/O	I/O Pin For Component Testing. Should Be Electrical Isolated For Customer Board Mounting
9	V_{cc_2}	Supply	Voltage Supply To ISELED IC#2
10	GND	Supply	Component Ground
11	IO_B	I/O	I/O Pin For Component Testing. Should Be Electrical Isolated For Customer Board Mounting
12	IO_A	I/O	I/O Pin For Component Testing. Should Be Electrical Isolated For Customer Board Mounting
13	V_{cc_1}	Supply	Voltage Supply To ISELED IC#1
14	GND	Supply	Component Ground
15	PRG	Supply	Need To Connect To Ground For Proper IC Operation
16	SIO1_N	I/O	Serial Communication Interface Master Side, Negative Polarity
17	SIO1_P	I/O	Serial Communication Interface Master Side, Positive Polarity
18	Thermal Pad	-	Electrical Isolated Thermal Pad. No Electrical Function
19	V_{LED_Red}	Supply	Voltage Supply Pin to Red LED Anode Terminal

1.2. Microcontrollers (MCU)

Below companies offer a broad portfolio of supporting microcontrollers (MCUs) to control of ISELED-based LED chains.

1.2.1 NXP Semiconductors

NXP’s 32-bit Arm Cortex-M based, automotive-qualified S32K1 system controllers support the ISELED protocol with an ISELED software driver available for use with its production-grade Software Development Kit (SDK) or in the AUTOSAR environment.
Visit NXP's website to learn more about their S32K-ISELED LED lighting solution:
https://www.nxp.com/design/design-center/development-boards-and-designs/s32k-iseled-led-lighting-solution:S32K-ISELED

1.2.2 Microchip Technology Inc

Microchip, as part of its scalable offering with cost efficient 8-, 16-, and 32-bit MCU solutions, provides ISELED protocol-enabled MCUs with proven ISELED software drivers, temperature sustainability from -40 to 150°C, and a low-risk development path.
User also can get more information regarding the evaluation license and Microchip ISELED® custom part number, please click below link:
https://www.microchip.com/en-us/solutions/automotive-and-transportation/body-electronics/iseled-protocol-ambient-lighting

1.2.3 Renesas

Renesas’ ISELED enabled RH850/F1KM Family of 32-bit automotive microcontrollers (MCUs) offers high performance balanced with very low power consumption over a wide and scalable range of products. This family offers rich functional safety and embedded security features needed for new and advanced automotive applications.
ISELED Supported System Controllers
https://iseled.com/controllers.html#Renesas

1.2.4 YTMicro

YTMicro offers 32-bit ARM-based M-Cortex MCUs with a variety of Features. Its YTM32B1L (Low) and YTM32B1M (Mid) Family are supporting ISELED.
Visit YTMicros's website to learn more about their solutions.
https://ytmicro.com/
https://iseled.com/controllers.html#YTMicro

1.3. Basic External Component guide

Figure 1 shows a typical setup layout for seddLED3.5 LED, connecting MCU and next ISELED compatible devices.

- seddLED3.5 is a mixed signal LED driver and controller chip. Each device is individually addressable via a bidirectional, half-duplex, 2Mbps, CRC-protected serial bus.
- Low ESR capacitors must be placed in parallel to the VCC supply rail and VLED rail to help filter out noise and voltage spikes that may be present on the power supply lines. By placing capacitors close to the VCC rail, they help stabilize the power supply voltage. This ensures that the ICs receive a steady and clean voltage, which is crucial for their proper operation. The dimensioning of the capacitors depends on the PCB layout and the supply concept.
- Incoming data (SIO1_P) and clock (SIO1_N) can be connected with ESD protection diode in parallel to GND, for protection against voltage spike to the SIO1_P and SIO1_N.
- First communication connection in between microcontroller to the seddLED3.5 is based on single-ended format. Thus, for each line, please add-on 1K pull-up resistor in parallel to the 5V supply.
- Last device's SIO2_P and SIO2_N can be terminated with ESD protection device as well.
- As the incoming supply must be kept within 4.5V – 5.5V, it's recommended to install 5.5V zener to protect against over-voltage.

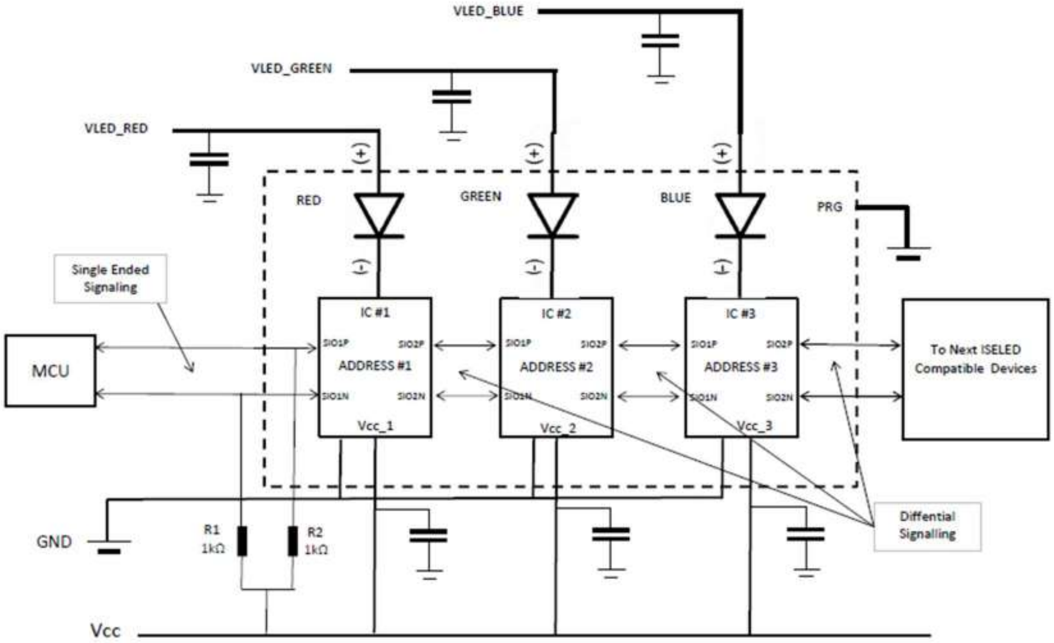


Figure 1: Typical Application Layout

1.4 PCB design guide, pin-per-pin explanation:

Figure 2 below shows a brief schematic from MCU to the first and subsequent seddLED3.5 LED.

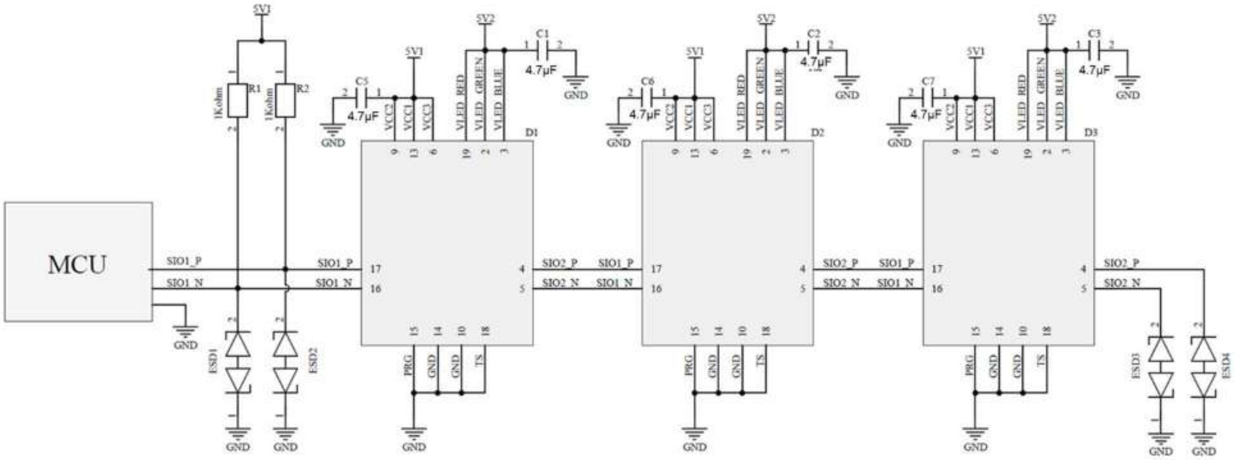


Figure 2: PCB schematic

- seddLED3.5 LED needs to be powered up with 5V supply.
- Communication protocol from first device to microcontroller (both data and clock) is configured to be single-ended format whereby communication protocol in between devices is configured into low voltage differential signal for better noise suppression capability.
- Please keep the first device to MCU within the same PCB to enable good reliability of single-ended data transmission.
- A dedicated ground plane is desirable as it offers lowest possible inductance for current to return to its source.
- There must be a common ground connecting seddLED3.5 and MCU together to ensure common mode voltage reference over digital communication path.
- Connection from 1st seddLED3.5 LED to 2nd seddLED3.5 LED is configured with differential format. User does not need to worry about the conversion from single-ended format to differential format. All will be taken care by seddLED3.5 LED internal module.

2. Temperature Compensation

2.1 Non-Linear Compensation

A3E-THG-60-1 is special calibrated to D65 white color at 60lm. To further improve the D65 white color mixed homogeneity across full operating temperature, we recommend to use non-linear compensation. Figure 3, 4 & 5 shows the Red, True Green & Blue LED brightness in non-linear temperature compensation. Figure 6 show the in D65 white color mixed improvement of non-linear temperature. We can observe significant D65 white color mixed improvement at extreme cold and hot temperature.

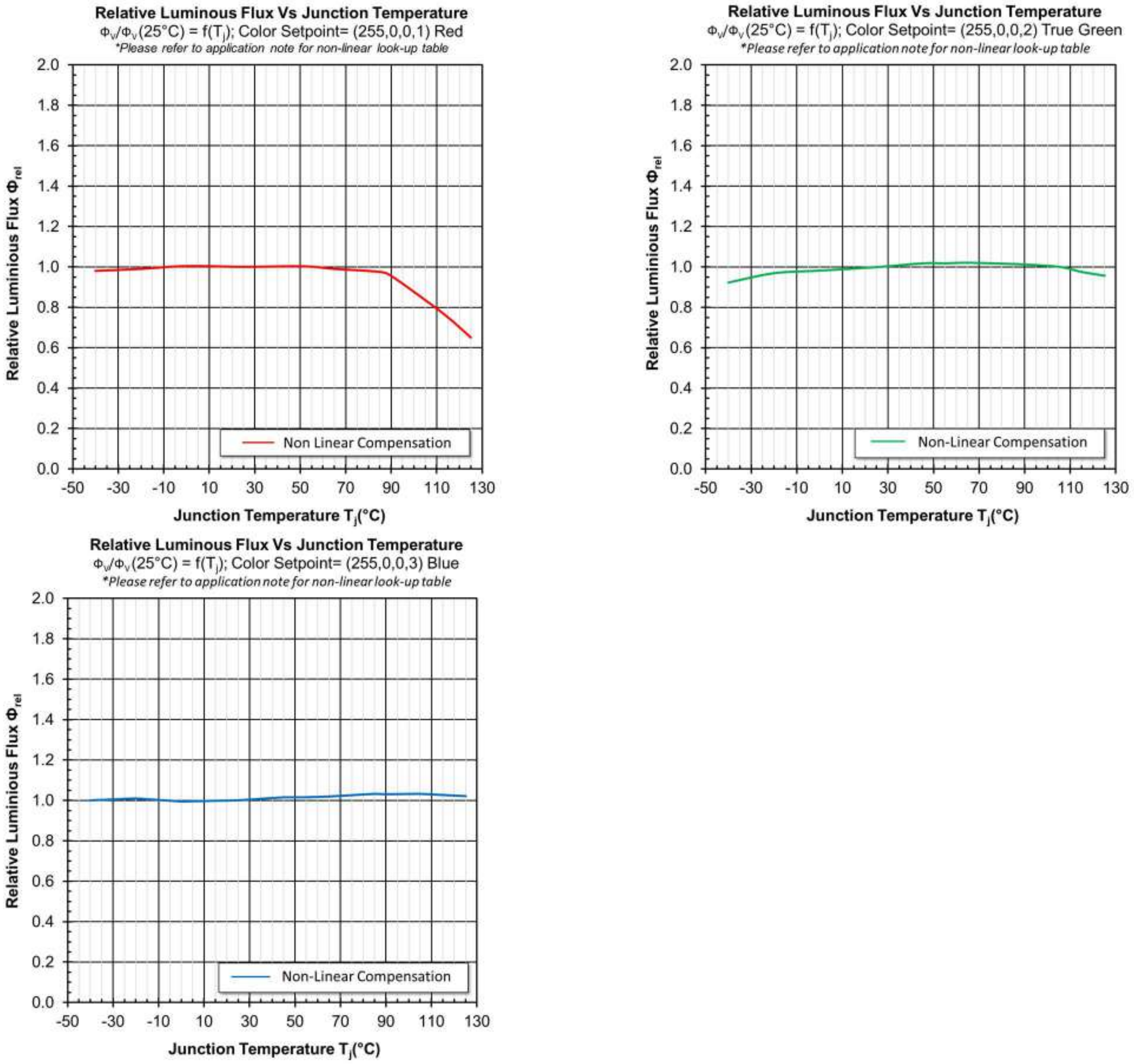


Figure 3,4,5: Red, True Green & Blue LED brightness in non-linear temperature compensation

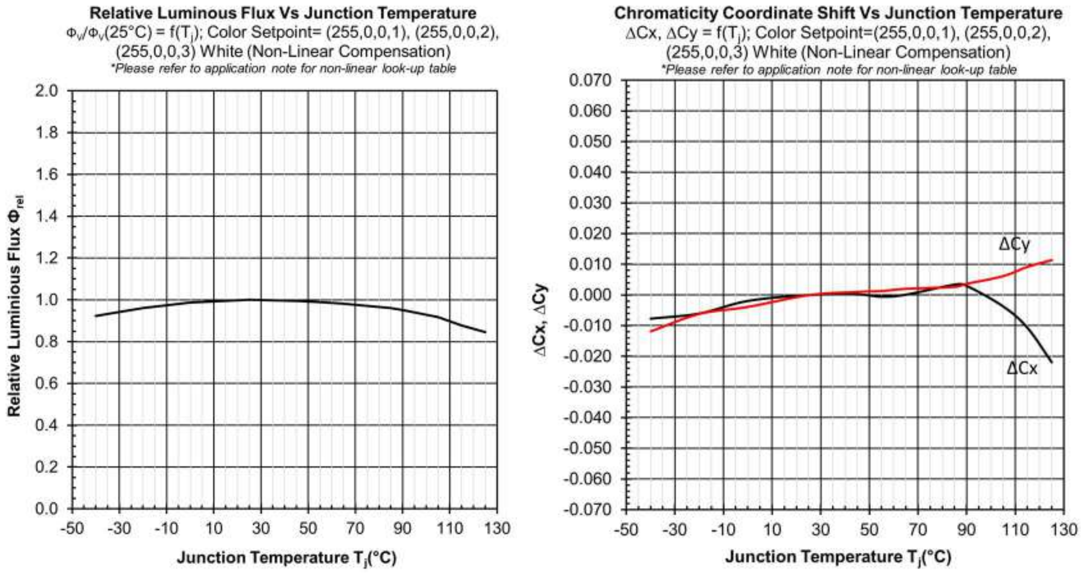


Figure 6: Non-Linear compensation D65 Brightness (left) and D65 Color (right)

2.2 Non-linear temperature compensation look up table

Look-up table for non-linear temperature compensation entry for Red, True Green & Blue LED is written with increasing values from LUT Address 10 to LUT Address 0. Figure 8 shows the example of the table for each entry. Look up Table API command need to be written into microcontroller source code main interface right after INIT strip command. During debugging mode, this source code will need to be flashed into MCU memory to operate as usual. These setting will manually overwrite the linear compensation TC_BASE and TC_OFFSET values pre-recorded in the OTP of the seddLED3.0.

API command (reference to NXP S32Kxx series):

digLED_ReturnType digLED_Set_TC_Lookup(uint16_t LUT_Adr, uint16_t LUT_Value, uint16_t Address, uint8_t StripNr);

@param LUT_Adr	0-10: 4-bit look-up table entry (address)
@param LUT_Value	0-511: 9-bit look-up table value, in increasing values
@param Address	0-4079: Address of the target LED. 0 addresses all LEDs of the chain.
@param StripNr	Number of the strip on which the commands will be sent

Red		True Green		Blue	
LUT_Address	LUT_Values	LUT_Address	LUT_Values	LUT_Address	LUT_Values
0	511	0	511	0	501
1	470	1	496	1	502
2	360	2	481	2	503
3	330	3	466	3	504
4	285	4	451	4	505
5	273	5	436	5	506
6	248	6	421	6	507
7	223	7	406	7	508
8	208	8	391	8	509
9	185	9	376	9	510
10	160	10	361	10	511

Figure 7: Non-linear temperature compensation look-up table entry

These 11 values will not store permanently in the OTP and need to be set again by the host after every reset.

Below steps give an example command for the INIT of the strip and how to set these 11 values with the NXP MCU. The INIT command may only be executed after power-up or hardware reset or after a CAL_RESET command has been executed. Otherwise, it is considered an illegal command and the undefined command error status bit is set, if an INIT command is encountered.

1. INIT of LED strip with example of NXP digLED_Init_Strip command

   Example Usage:

   uint32_t nrOfLEDs = 9; //in the multiple of 3

   digLEDResultStrip1.chainLength = nrOfLEDs;

   digLED_InitStrip (&testInitType, &digLEDResultStrip1, STRIP1);

   delay (100000);

```
appState = OPERATION_ONGOING;
digLED_Init_Strip(&testInitType, &digLEDResultStrip1, strip);
while (appState == OPERATION_ONGOING);
delay(100000);
```

2. Set 11 values of non-linear look-up table with example of NXP digLED_Set_TC_Lookup command

   //red

```
        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(0, 511, 1, strip);//105C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(1, 470, 1, strip);//90.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(2, 360, 1, strip);//76C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(3, 330, 1, strip);// 61.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(4, 285, 1, strip);//47C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(5, 273, 1, strip);// 32.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(6, 248, 1, strip);//18C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
```

```
        digLED_Set_TC_Lookup(7, 223, 1, strip);//3.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(8, 208, 1, strip);//-11C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(9, 185, 1, strip);//-25.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(10, 160, 1, strip);//-40C
        while (appState == OPERATION_ONGOING);


    //true green

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(0, 511, 2, strip);//105C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(1, 496, 2, strip);//90.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(2, 481, 2, strip);//76C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(3, 466, 2, strip);// 61.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(4, 451, 2, strip);//47C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(5, 436, 2, strip);// 32.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(6, 421, 2, strip);//18C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(7, 406, 2, strip);//3.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(8, 391, 2, strip);//-11C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(9, 376, 2, strip);//-25.5C
        while (appState == OPERATION_ONGOING);

        appState = OPERATION_ONGOING;
        digLED_Set_TC_Lookup(10, 361, 2, strip);//-40C
        while (appState == OPERATION_ONGOING);
```

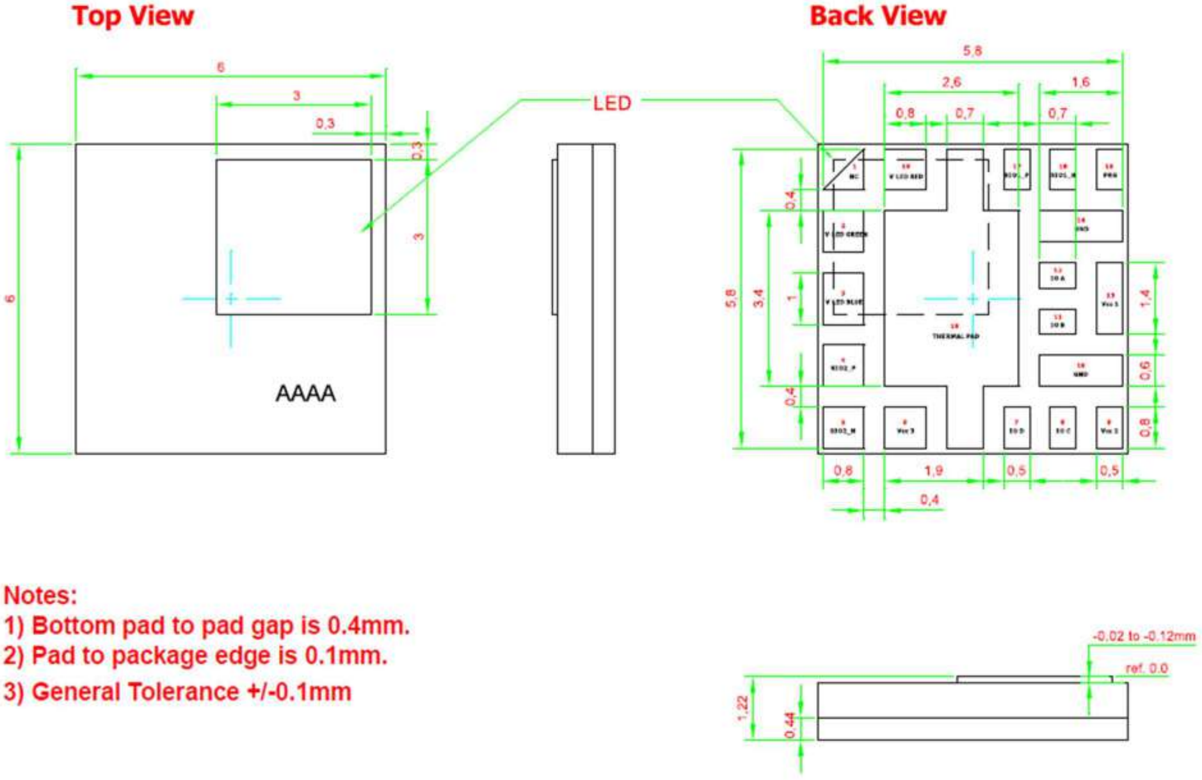
//blue

```
appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(0, 501, 3, strip);//105C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(1, 502, 3, strip);//90.5C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(2, 503, 3, strip);//76C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(3, 504, 3, strip);// 61.5C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(4, 505, 3, strip);//47C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(5, 506, 3, strip);// 32.5C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(6, 507, 3, strip);//18C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(7, 508, 3, strip);//3.5C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(8, 509, 3, strip);//-11C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(9, 510, 3, strip);//-25.5C
while (appState == OPERATION_ONGOING);

appState = OPERATION_ONGOING;
digLED_Set_TC_Lookup(10, 511, 3, strip);//-40C
while (appState == OPERATION_ONGOING);
```

Please refer to respective MCU supplier for the API command if different MCU is used. However, the non-linear temperature compensation look-up table entry (figure 7) will remain the same.

3.0. Surface Mounting Guideline

3.1 A3E-THG Package Outline



Notes:
1) Bottom pad to pad gap is 0.4mm.
2) Pad to package edge is 0.1mm.
3) General Tolerance +/-0.1mm

Remarks:
A3E-THG is an Optoelectronic Multichip Module. This package consists of a high-power RGB LED & IC drivers packaged on a ceramic substrate. User should strictly follow the recommended soldering reflow profile in pg.31.

Figure 8: A3E-THG Package Outline

3.2 Standard Soldering Process:

The seddLED3.5 package soldering surfaces are plated with gold (Au) and are therefore RoHs compliant. The component is designed to be compatible to the existing industry SMT process and IR-reflow. Anyway, this product is using solder material with low melting point during LED component assembly. Customer should use solder paste with peak reflow temperature <228°C during SMT process. The recommended soldering profiles are as per described in the datasheet.

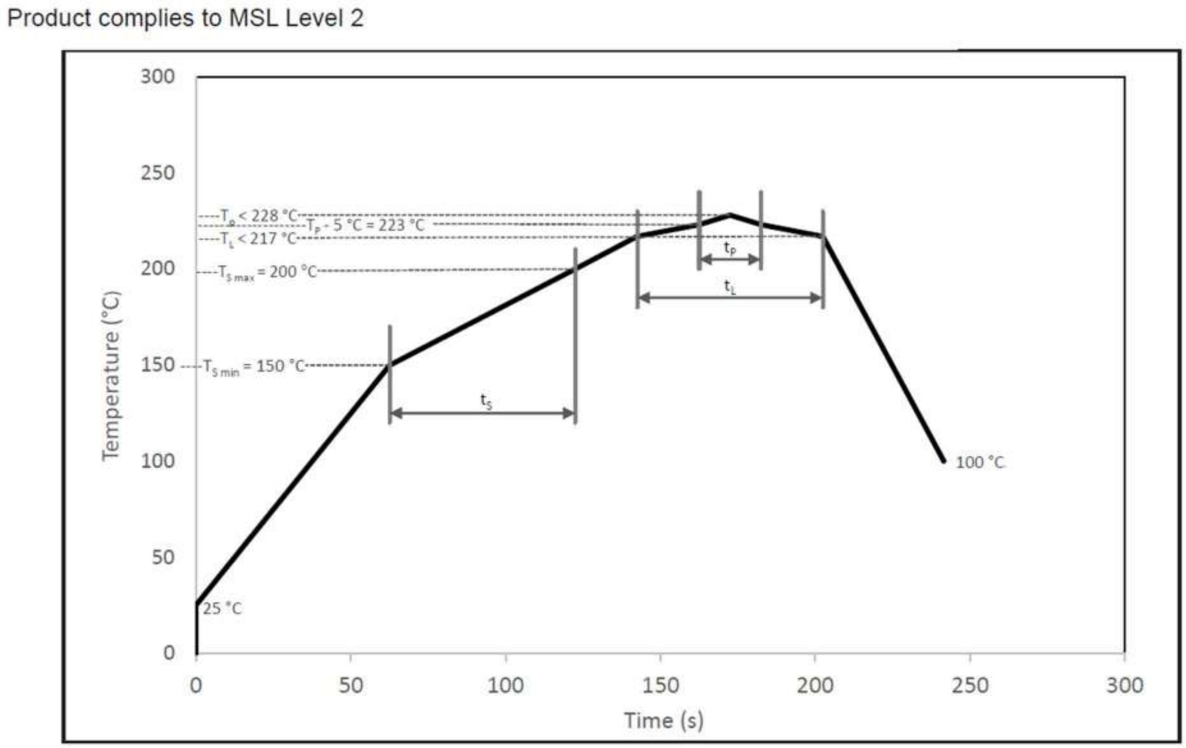
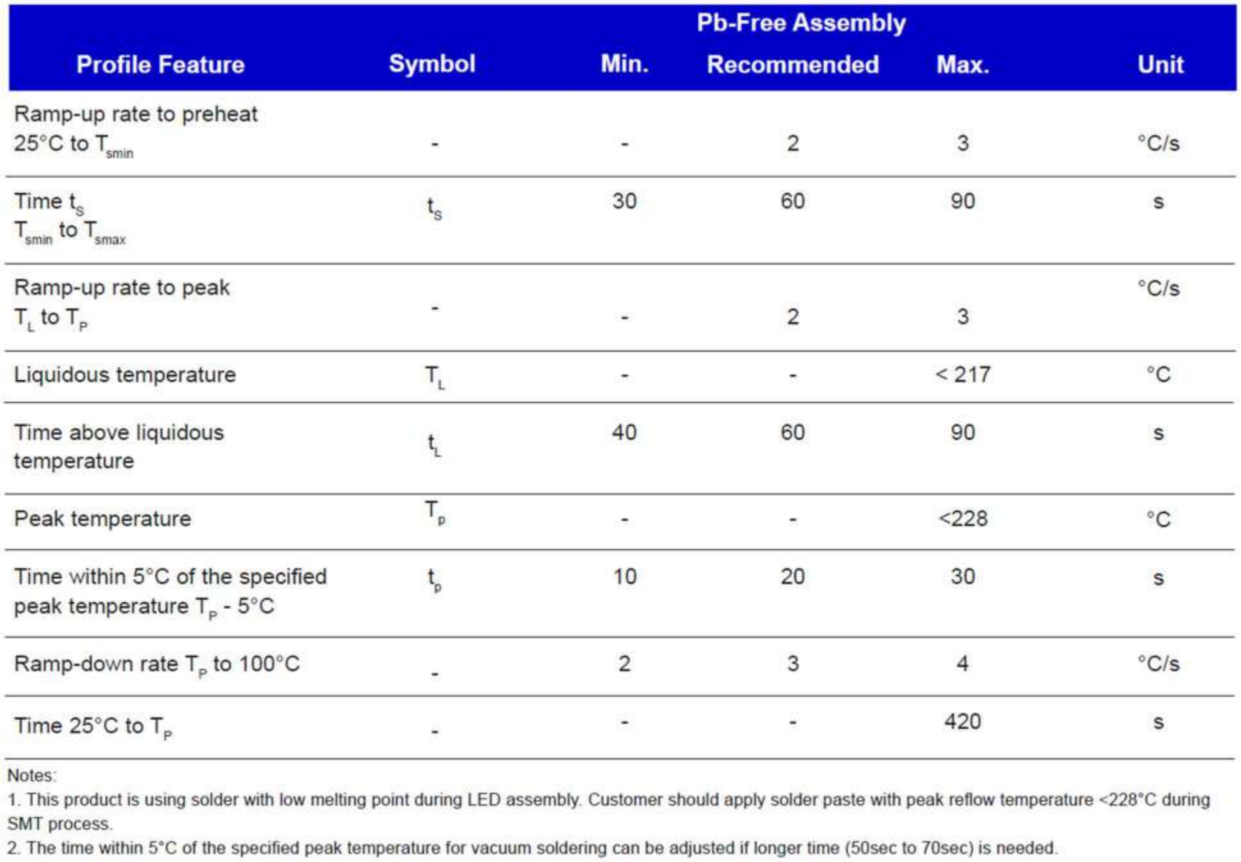


Figure 9: Recommended Reflow Soldering Profile



			Pb-Free Assembly		
Profile Feature	Symbol	Min.	Recommended	Max.	Unit
Ramp-up rate to preheat 25°C to T_{smin}	-	-	2	3	°C/s
Time t_S T_{smin} to T_{smax}	t_S	30	60	90	s
Ramp-up rate to peak T_L to T_P	-	-	2	3	°C/s
Liquidous temperature	T_L	-	-	< 217	°C
Time above liquidous temperature	t_L	40	60	90	s
Peak temperature	T_p	-	-	<228	°C
Time within 5°C of the specified peak temperature T_P - 5°C	t_p	10	20	30	s
Ramp-down rate T_P to 100°C	-	2	3	4	°C/s
Time 25°C to T_P	-	-	-	420	s

Notes:
1. This product is using solder with low melting point during LED assembly. Customer should apply solder paste with peak reflow temperature <228°C during SMT process.
2. The time within 5°C of the specified peak temperature for vacuum soldering can be adjusted if longer time (50sec to 70sec) is needed.

3.3 Surface Mounting – Factors to Consider:

This application note provides a guideline for the surface mounting of seddLED3.5. The following parameters have to be considered in order to optimize the surface mounting performance.

- Solder pad size
- Solder stencil size
- Solder paste thickness
- Nozzle
- Solder quality check

Solder Pad Size

The recommended solder pad design is as illustrated in the data-sheet.

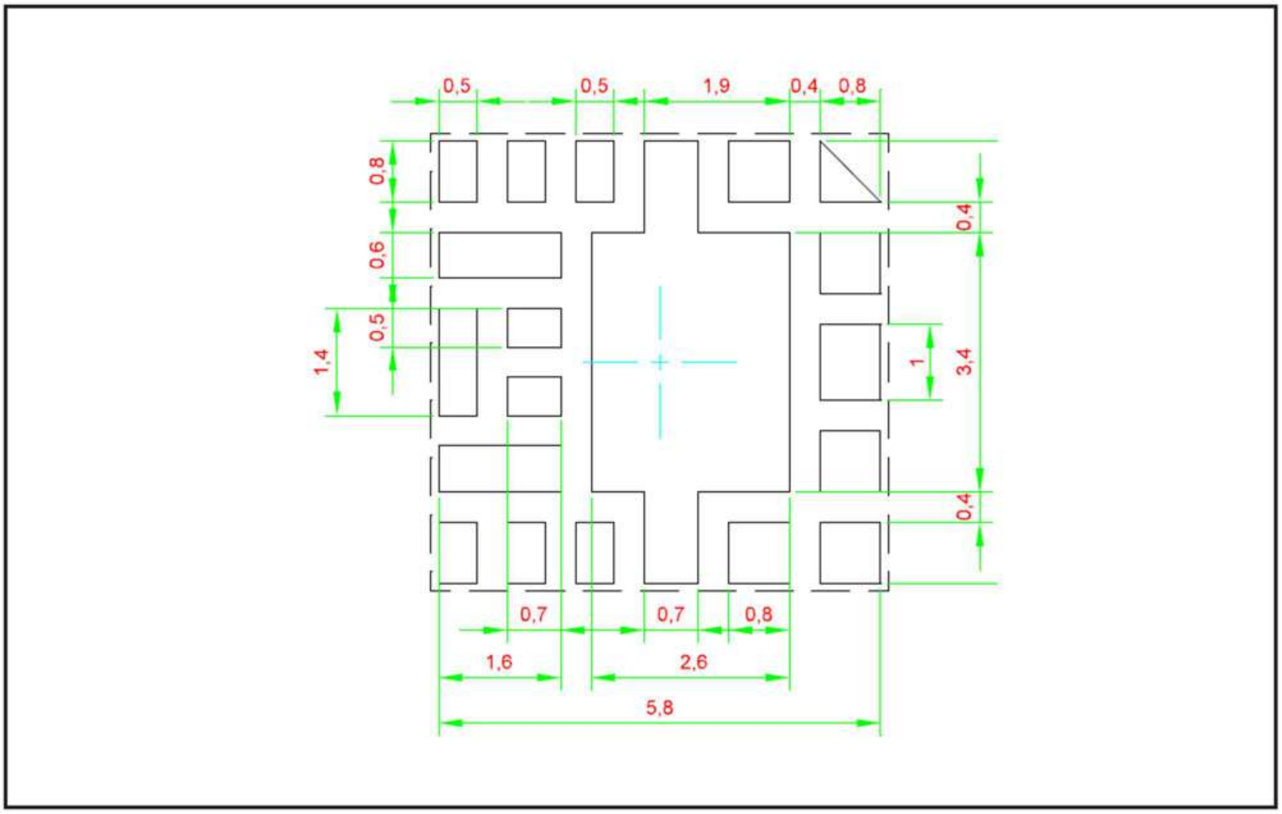


Figure 10: Recommended solder pad size

Solder Stencil Size

In order to minimize solder bridging problems, it is common to design stencil aperture size smaller than the recommended solder pad. Excessive amount of solder paste deployed will result to tilted parts and inaccurate placement position. It is recommended that the aperture is reduced to 80% of the recommended solder pad design.

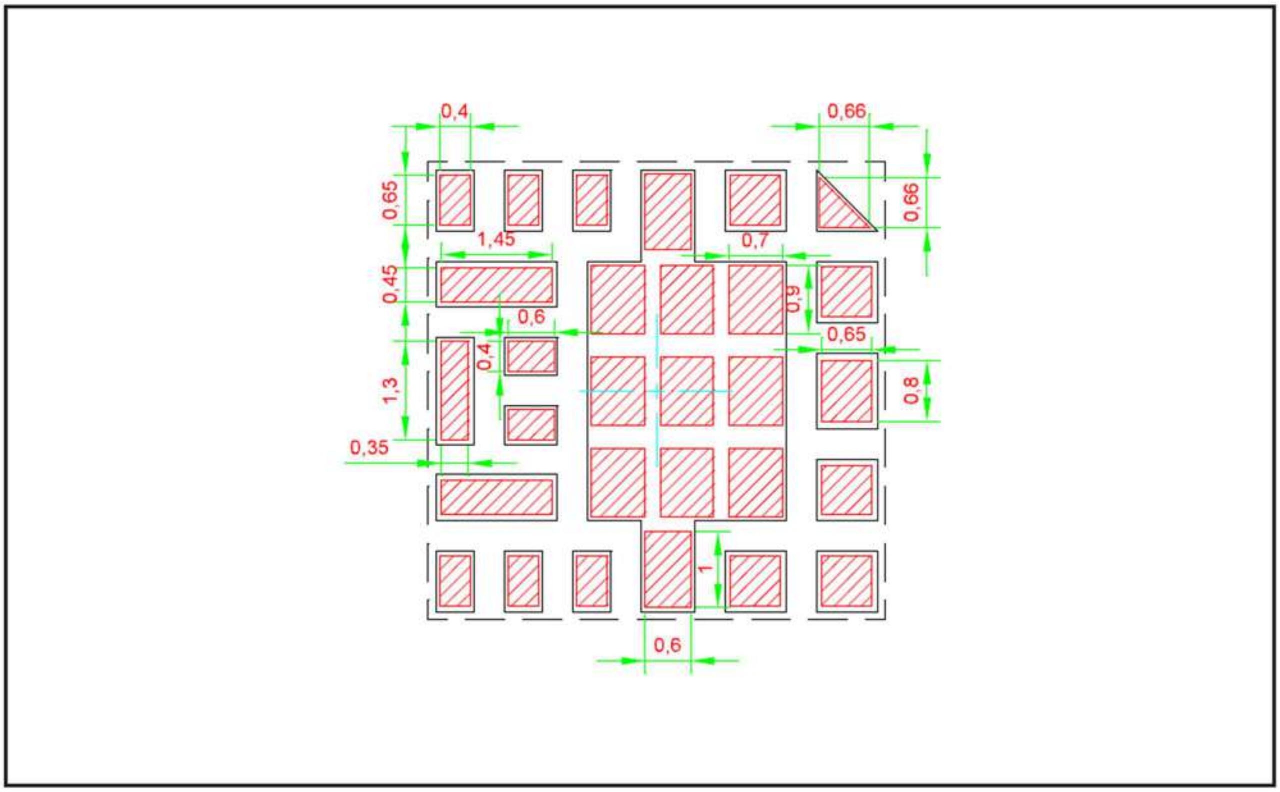


Figure 11: Recommended solder stencil size

Solder Paste Thickness

We recommend using minimum solder paste in order to achieve a good solder formation. A solder paste thickness of 0.125 mm will be optimum.

Nozzle

Pick and place machine should be able to process seddLED3.5 devices with the required placement accuracy. Care should be observed that the surface of the nozzle which is in contact with the LED is flat and smooth. Pick up area should be observed for this seddLED3.5 as shown in

Figure 12. Parameter settings for the pick and place process should also be evaluated to ensure no damage to the LEDs. For recommended nozzle design, please refer to our *Recommended Pick and Place Tools for LEDs from DOMINANT Opto Technologies* application note.

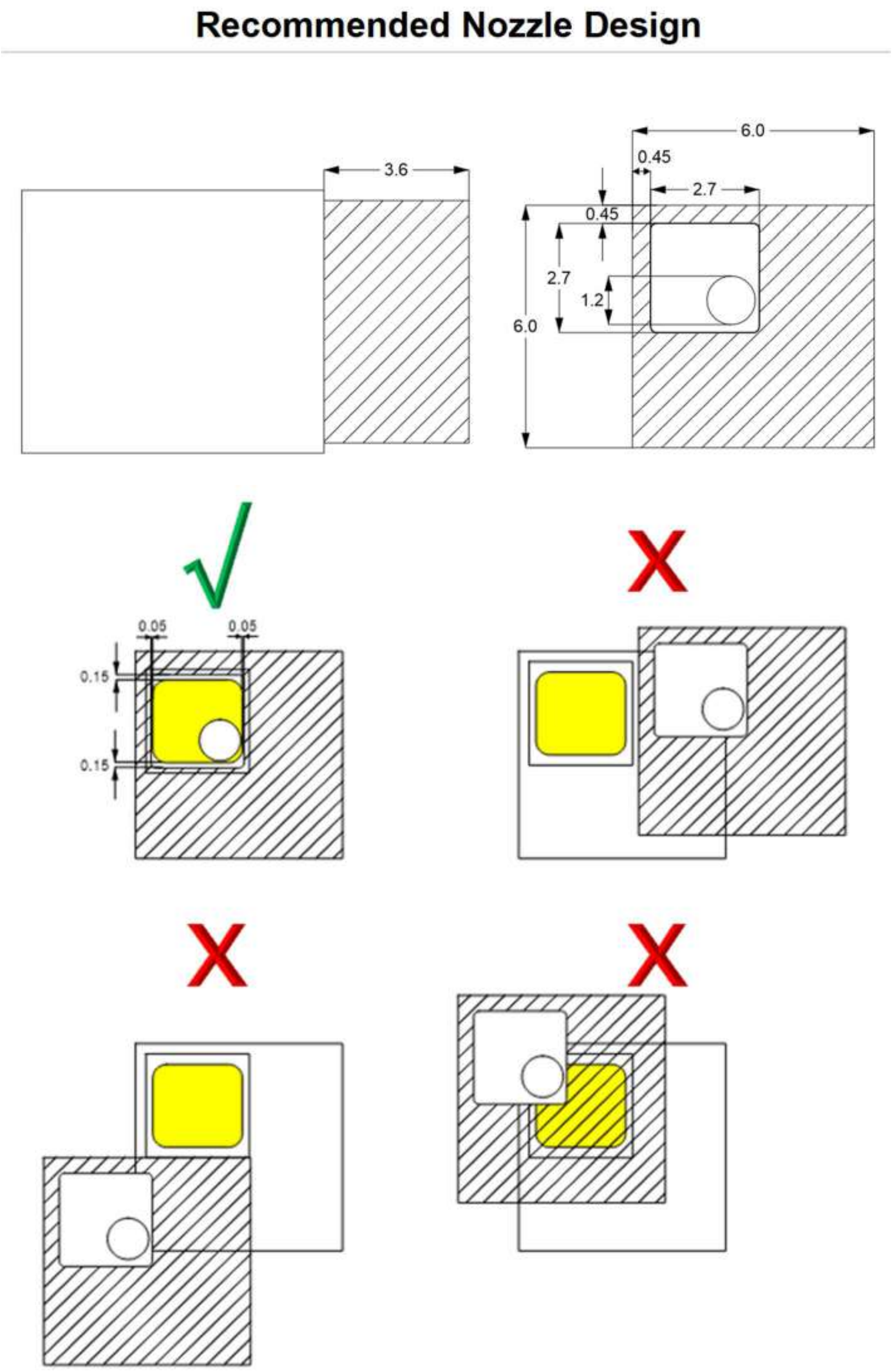


Figure 12: Recommended nozzle size and pick up area

The keep-out areas for the nozzle, which should prevent the risk of wire bond damage, are shown in diagram below:

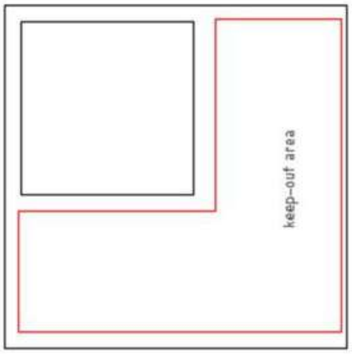


Figure 13: Example of good solder formation

Solder Quality Check after SMT Process

For seddLED3.5, the primary soldering surfaces are at the bottom of the LED component.

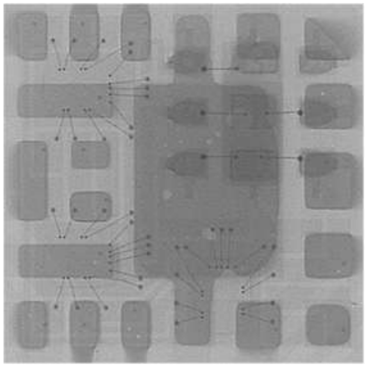


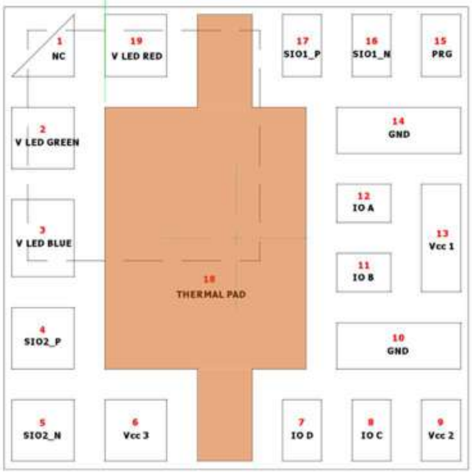
Figure 14: Example of good solder formation

Solder Paste Type

Dominant has tested the Innolot solder paste example AIM REL22 solder paste with satisfactory results. However, since application environments vary widely, we recommend that customers perform their own solder paste evaluation in order to ensure it is suitable for the targeted application.

Printed Circuit Design for Enhance Heat Dissipation

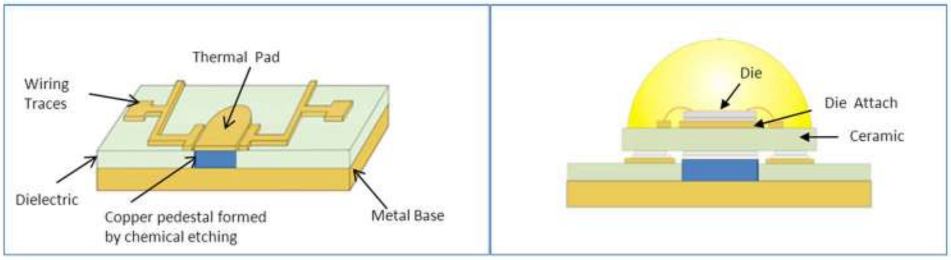
For seddLED3.5, the base substrate is built with high thermal conductivity ceramic substrate, so all the lead can be primary thermal path to carry heat away from the package. Since this package consists of a high-power RGB LED & IC, the heat density per area size is high, it is recommended to use MCPCB to surface mount this LED to enhance heat dissipation performance.



For seddLED3.5 package, there is an electrically insulated thermal pad, thus provide more freedom to designer to utilize method below to enhance package heat dissipation:

MCPCB With Isolated Thermal Post

With the new development in MCPCB process, now it is possible to selectively laminate FR4 on the etched/stamped aluminum/copper core. The LED electrical isolated thermal pad can be directly soldered to the bulk aluminum/copper core. This new concept eliminated the thermal bottleneck faced by conventional MCPCB which insulator layer is sandwiched in between laminated FR4 and metal core.



Available Metal Base: Copper (390W/m°C) and Cu-Aluminum Alloy (15/85 Cu/Al, 230W/m°C)

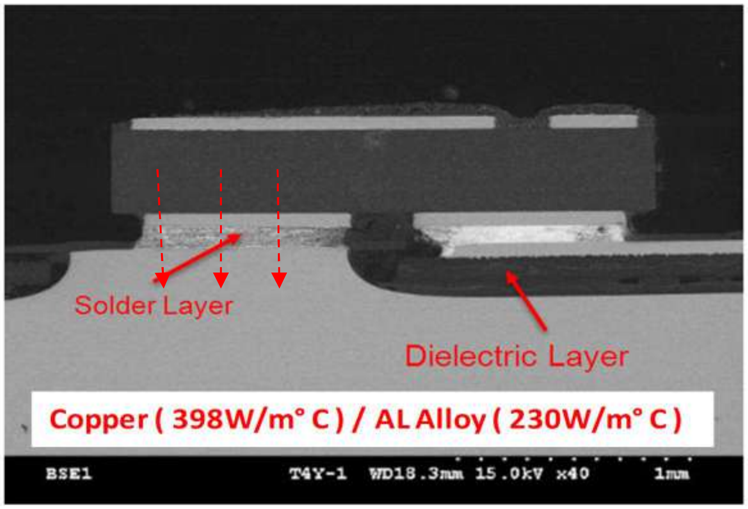


Figure 15: Direct Thermal Path from LED Insulated Thermal Pad to Copper Base Of MCPCB

Storage Method after SMT

For PCB assembly that mounted with seddLED3.5, it should not be stack together after IR reflow, else it would have high chance of damaging the LED. Recommended method is having a dedicated carrier so that each PCB assembly is with at least 5mm away from each other.

Figure 16: Example of carrier to store the LED

Handling Precautions

1. For manual handling, anti-static/conductive plastic tweezers should be use to pick up seddLED3.5. Avoid touching sensitive area such as the LES and white silicone overcoat area during pick up.

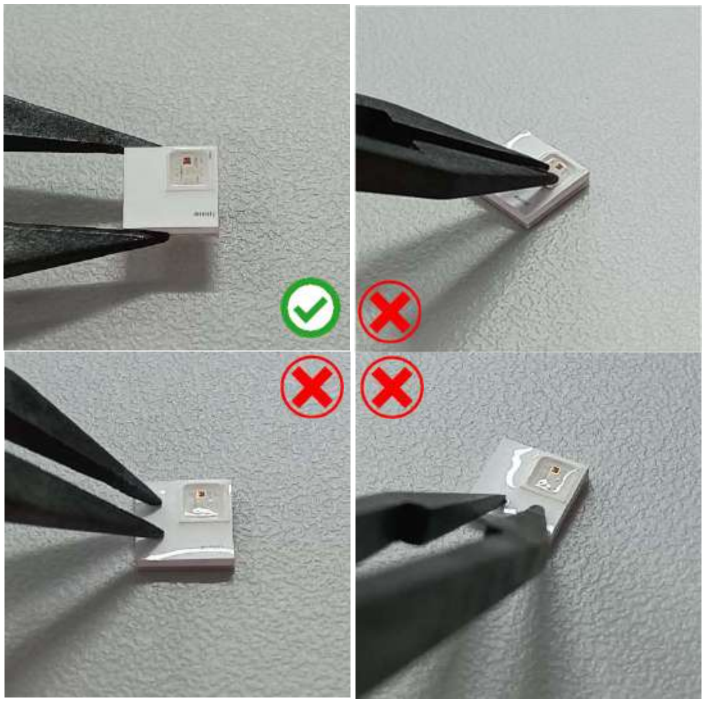


Figure 17: Example of correct and wrong method on LED handling

2. A better alternative for manual handling of seddLED3.5 package is using vacuum suction pen. The suction tip should be made of a soft material such as rubber to minimize the mechanical force exerted onto sensitive area. Care should be taken to avoid the soft material from contaminating the top side surface of the LED emitting area.

Figure 18: Example of vacuum suction pen

4.0 Light Bar Functionality Check After SMT

It is common practice to perform Read Diagnostic and light up test to check for any light bar anomalies as part of End Of Line Testing after SMT. Please refer to the ISELED API user guide for the Read Diagnosis explanation. For seddLED devices, recommended light up check condition is set to 50% of device full intensity. At intensity setting less than 100%, the random PWM generator in seddLED IC will be activated to check for the memory integrity and whether there is any issue of loading up the calibrated data from One Time Programmable memory of IC to IC internal register. The random PWM generator will be disabled when the device intensity is set at 100%. Device failing the memory integrity check will show sign of flickering or display random color compare to normal devices when light up at 50% of device full intensity.

5. Revision History

Changes	Date
Initial Release	07 Apr 2026