

Description

LC101N is a current control IC that uses a low-saturated PNP bipolar transistor in the power block. The saturation voltage of the saturated condition is small and can be designed with minimal losses in the case of driving with a constant current source. The constant current value is set up by the resistor connected between the FB terminal and the LO pin, and you can drive the LED in the constant current condition. LC101N is available in an 8-pin DFN package for surface mounting.

Features

- Maximum current is 150 mA
- Low input-output voltage difference design is achieved by low saturation voltage;
 $V_{DIF(max.)} = 0.35\text{ V}$ ($I_o = 150\text{ mA}$)
- Reference voltage of 200 mV reduces the sense resistor loss
- Optimal balance operation can be realised in parallel connection of multiple LED strings
- Protections
Overcurrent Protection (OCP): Foldback
Thermal Shutdown (TSD): Auto-restart

Package

DFN 8



*Not to scale

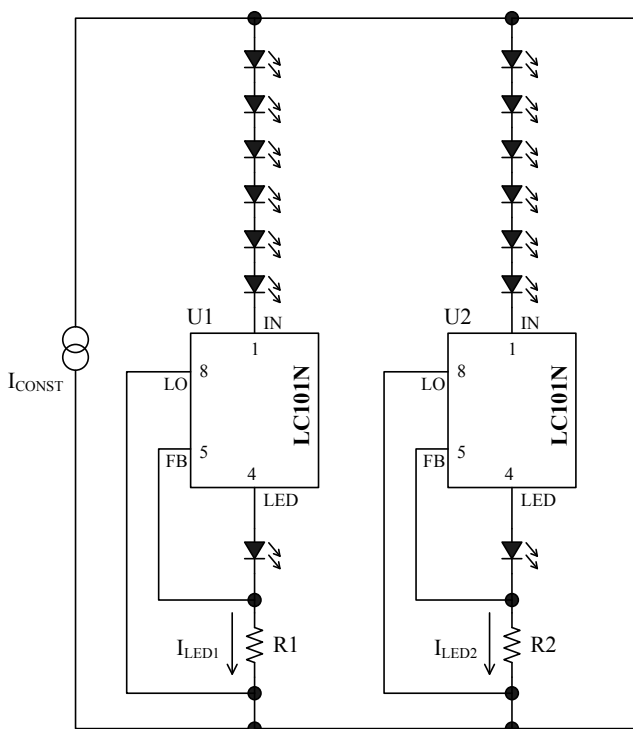
Electrical Characteristics

- Maximum input voltage: 35 V
- Maximum output current: 150 mA
- Reference voltage for the constant current control: 200 mV
- Power Dissipation: 1.3 W

Applications

- LED Lightings
- Back light system for LCD-Touch-panels, etc.

Typical Application



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LC101N

1. Absolute Maximum Ratings

- Unless otherwise specified $T_A = 25\text{ }^\circ\text{C}$, the LO pin is reference voltage level.

Parameter	Symbol	Rating	Units	Notes
DC input voltage	V_{IN}	35	V	
LED pin voltage	V_{LED}	V_{IN}	V	
FB pin voltage	V_{FB}	5	V	
Allowable Power Dissipation	P_D	1.3	W	Reference layout pattern mounting on the FR4 double-sided PCB. Refer to Section 12.2.2.
Junction Temperature	T_j	- 40 to 125	$^\circ\text{C}$	
Storage Temperature	T_{stg}	- 40to 80	$^\circ\text{C}$	

* When the junction temperature of the IC becomes $110\text{ }^\circ\text{C}$ (min.) or more, the thermal shutdown (TSD) activates.

2. Recommended Operating Conditions

- Unless otherwise specified $T_A = 25\text{ }^\circ\text{C}$, the LO pin is reference voltage level.

Parameter	Symbol	Min.	Max.	Units	Notes
IN – LO Voltage	V_{IN}	2.4	*	V	
Output Current	I_{LED}	15	150*	mA	
Operating Ambient Temperature	T_{OP}	- 20	+ 80	$^\circ\text{C}$	

* Since the between V_{IN} and I_{LED} has following relationship, the value of V_{IN} is different by condition. Allowable power dissipation, P_D is calculated by Figure 5-1.

$$P_{D(MAX)} = (V_{IN} - V_{LED}) \times I_{LED(MAX)} \quad (1)$$

3. Electrical Characteristics

- Unless otherwise specified $T_A = 25\text{ }^\circ\text{C}$, the LO pin is reference voltage level.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Reference Voltage	V_{FB}	$V_{IN} = 4\text{ V}, I_{LED} = 15\text{ mA}$	0.194	0.200	0.206	V
Reference Voltage Temperature Coefficient ⁽¹⁾	$\Delta V_{FB/TA}$	$T_j = 25\text{ }^\circ\text{C to } 100\text{ }^\circ\text{C}$		-0.02		mV/ $^\circ\text{C}$
Voltage Difference between Input and Output ⁽²⁾	ΔV_{DIF}	$I_{LED} \leq 50\text{ mA}$			0.18	V
		$I_{LED} \leq 150\text{ mA}$			0.35	V
Overcurrent protection threshold Current	I_{S1}	$V_{IN} = 4\text{ V}, V_{LED} = 90\%$	160			mA
Thermal Shutdown Temperature ⁽¹⁾	T_{SD}		110	130		$^\circ\text{C}$

⁽¹⁾ Design assurance.

⁽²⁾ The saturation voltage between the IN pin and the LED pin.

4. Thermal Resistance

- Unless otherwise specified $T_A = 25\text{ }^\circ\text{C}$, the LO pin is reference voltage level.

Parameter	Symbol	Rating	Units	Notes
Junction to Ambient Thermal Resistance	θ_{j-A}	65	$^\circ\text{C/W}$	
Junction to Case Thermal Resistance	θ_{j-TOP}	27	$^\circ\text{C/W}$	Marking surface

5. Derating Curve

Figure 5-1 shows the thermal derating curve that the IC is mounted on the pattern layout example of Section 12.2.2, and is calculated based on the junction temperature 110 °C. When the junction temperature becomes 110 °C or more, thermal shutdown might be activated.

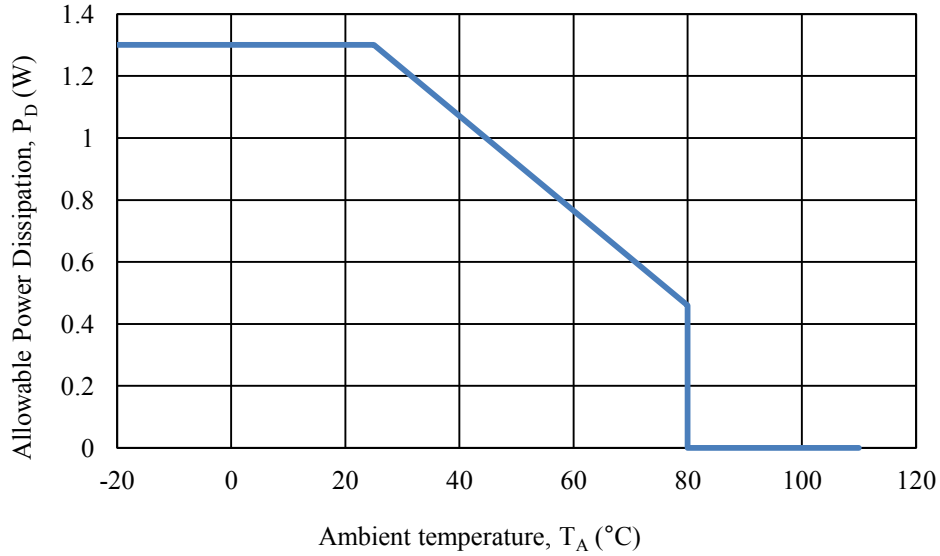


Figure 5-1 Thermal Derating Curve

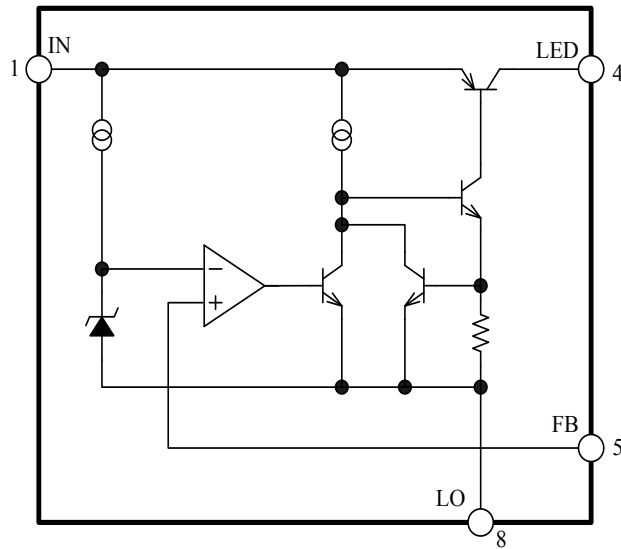
• Junction Temperature Calculation

The junction temperature, T_j is calculated by using Equation (2)

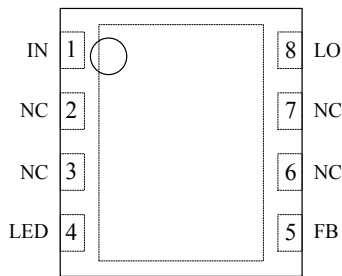
$$T_j = P_D \times \theta_{j-TOP} + T_{TOP} \text{ (°C)} \tag{2}$$

where, $\theta_{j-TOP} = 27 \text{ °C/W}$ and T_{TOP} is the measurement temperature of marking surface.

6. Block Diagram

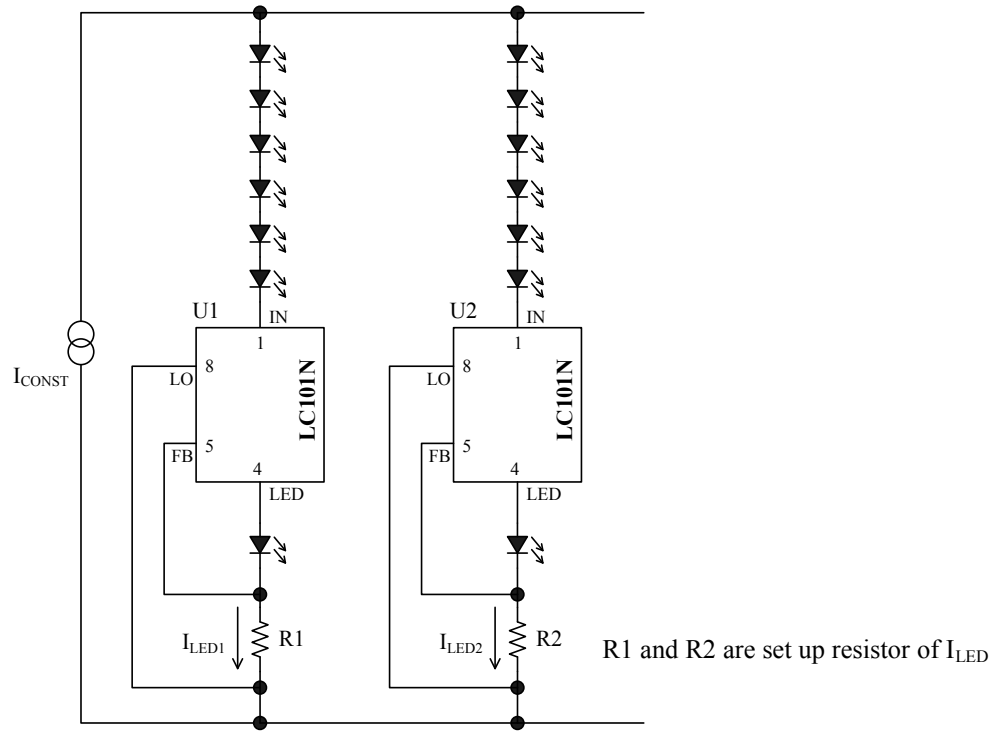


7. Pin Configuration Definitions



Pin	Name	Descriptions
1	IN	Constant current source input
2	NC	Not connected
3	NC	Not connected
4	LED	Output pin to LED
5	FB	LED current detection signal input (positive side)
6	NC	Not connected
7	NC	Not connected
8	LO	LED current detection signal input (negative side)

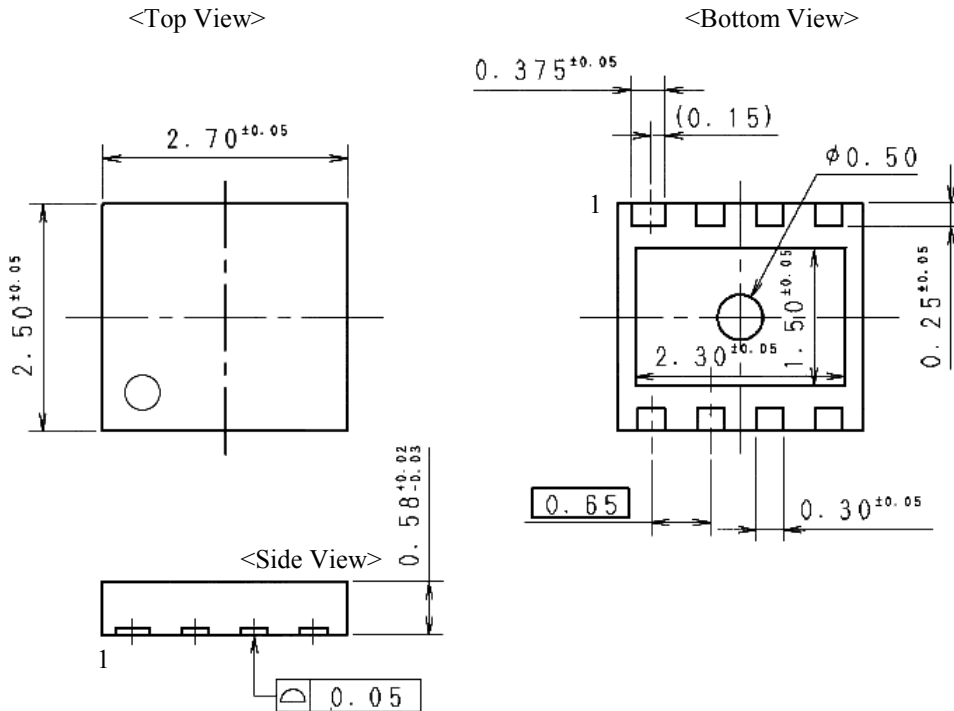
8. Typical Application



LC101N

9. External Dimensions

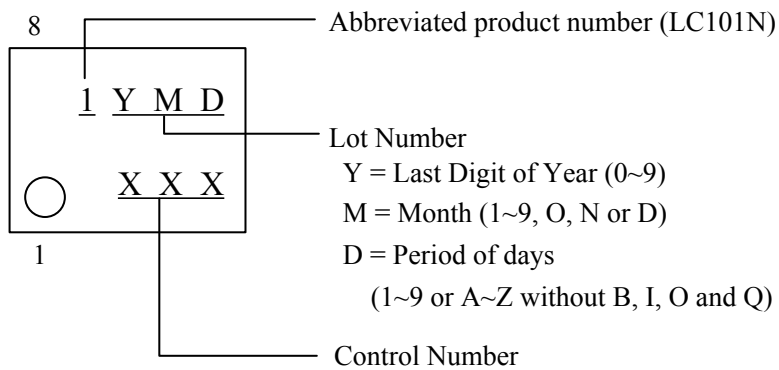
- DFN8



NOTES:

- Dimension is in millimeters
- Pb-free. Device composition compliant with the RoHS directive
- Width of 1 pin is 0.375 mm, the others are 0.3mm
- In order to release temperature The heat slug of the back surface should heat dissipation to the pattern of PCB.

10. Marking Diagram



11. Operational Description

11.1 Basic operation

The current control of the LC101N is quite simple. The both end voltage of the setup resistor R1 which is connected between the FB terminal and the LO pin. So that it becomes constant, the emitter-collector voltage of the internal PNP-transistor is linear-controlled by the error amplifier.

Figure 11-1 shows the basic circuit of LC101N.

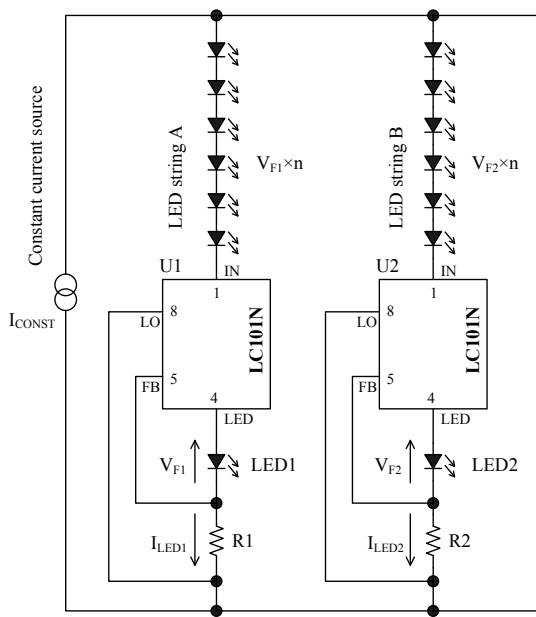


Figure 11-1 LC101N basic circuit

LED current, I_{LED} is calculated by Equation (3).

$$I_{LED} = \frac{V_{FB}}{R1} \quad (3)$$

From Equation (3), the setup resistor, R1 is calculated by Equation (4).

$$R1 = \frac{V_{FB}}{I_{LED}} \quad (4)$$

The reference voltage, V_{FB} for the constant current control is 200 mV. The both end voltage of R1 is controlled to become equal to V_{FB} .

The loss of R1, P_{R1} is calculated by Equation (5).

$$P_{R1} = I_{LED}^2 \times R1 = V_{FB} \times I_{LED} \quad (5)$$

Table 11-1 shows the calculation result of relationship of I_{LED} , R1, and P_{R1} .

Table 11-1 The loss of R1, P_{R1}

I_{LED} (mA)	R1 (Ω)	P_{R1} (mW)
50	4	10
100	2	20
150	1.33	30

In addition, the loss of the IC, P_D is calculated by Equation (6).

$$P_D = (V_{IN} - V_{LED}) \times I_{LED} \quad (6)$$

where, V_{IN} is the voltage between the IN pin and the LO pin, and V_{LED} is the voltage between the LED pin and LO pin.

11.2 Power Supply

The power supply should use the constant-current source. If the constant-voltage source is used, the voltage difference between input and output that does not require for LED becomes the loss of the IC.

Though it will operate with the constant-voltage source, if the input-output voltage difference becomes larger than necessary, and all of surplus will be loss in this IC

The ability of power supply, P_{IN} is required to satisfy following equation.

$$P_{IN} \geq \{(V_F \times n) + 2.4\} \times I_{CONST} \quad (7)$$

where, N is number of LED in series, V_F is forward voltage of LED, and I_{CONST} is the constant current of power supply.

For example, LED current is set to 50 mA in Figure 11-1. The constant current of power supply, I_{CONST} , is set fewer than the total current value of LED-strings A and B (100mA), because the drooping characteristic of constant-current source is considered. In this case, I_{CONST} is set 95 mA.

If $V_F = 3V$ and $n = 7$, P_{IN} becomes as follows:

$$P_{IN} \geq \{(3 \times 7) + 2.4\} \times 92 = 2.22 \text{ (W)}$$

11.3 Current Balance Operation

If All LEDs have same V_F , and the same current flows to LED-string A and B, the power loss of IC becomes minimum because the circuit is controlled by the constant-current source, I_{CONST} and the internal transistor is a saturated condition.

However, the complete equilibrium state is impossible by characteristic variations of V_F . If each V_{F2} of LED string B is smaller than V_{F1} of LED string A by 0.1 V.

In this case,

$$0.1(\text{V}) \times 7(\text{pcs}) = 0.7(\text{V})$$

is applied to between the IN pin and the LED pin of LC101N. Since the LED string B current, I_{LED2} , is controlled to constant by R2, the loss of LC101N of LED string B side is following value, and is enough acceptable value.

$$0.7(\text{V}) \times 50(\text{mA}) = 35(\text{mW})$$

If it is operated in the constant current source, the voltage applied to the LED string, it becomes the minimum requirement value of the LED-string with the highest V_F . When the constant current source is used, the necessary voltage for LED string with the highest total VF is supplied.

Thus, LC101N reduces the current concentration by V_F fluctuation and, the brightness unevenness.

11.4 Operable voltage of LC101N

Operating conditions of LC101N are as follows:

- The minimum difference voltage between the IN pin and the LED pin is higher than the ΔV_{DIF} .
- The voltage of the IN pin is higher than 2.4V(min.) against the LO pin.

One LED is added to the LED pin and setup resistor as shown in Figure 11-1 in order to have enough voltage between the IN pin and the LO pin.

11.5 Overcurrent Protection (OCP)

The LC101N have the fold-back characteristics in overcurrent protection (OCP) as shown in Figure 13-2. The short circuit current does not return to completely 0 A, because start-up characteristics is considered. Thus, be careful to heat generation.

When OCP is activated, the LED pin voltage decreases. Then, the difference voltage between input and output is increased, and the temperature of IC increases. In this case, Thermal shutdown might activate (refer to Section 11.6).

11.6 Thermal Shutdown (TSD)

LC101N has the Thermal Shutdown (TSD). The junction temperature of the IC chip, T_j , is detected. When T_j is increase to $T_{\text{SD}} = 130\text{ }^\circ\text{C}$ (typ.), the drive current of the internal PNP transistor is limited.

Since the minimum activation temperature of the TSD is $110\text{ }^\circ\text{C}$, T_j should be set less than $110\text{ }^\circ\text{C}$ in thermal design.

TSD does not have hysteresis. When T_j decreases to T_{SD} or less, the IC returns to normal operation automatically.

When TSD is activated under the overcurrent condition, following condition is repeated and output voltage waveform, V_{LED} , becomes intermittent oscillation (refer to Figure 13-4).

Overcurrent condition →
 V_{LED} decreases →
 I_{LED} decreases →
 junction temperature T_j decreases →
 automatically restart →
 Overcurrent condition....

- Notice of TSD

The purpose of the TSD is the protection of IC from temporary heat generation. TSD does not guarantee the operation including reliabilities under the continuous heat generation conditions, such as short circuit for a long time.

Since the temperature of LC101N which is connected to the LED depends on the mounting location (distance) and the wiring method, TSD might be activated by the thermal of LEDs.

12. Design Notes

12.1 External Components

All components are required for matching to the condition of use.

12.1.1 LED current setup resistor, R1

Reference voltage of LC101N, V_{FB} , controls the LED current, is 200 mV. The IC controls so that the V_{FB} and both end voltage of setup resistor R1 is equal. Because the V_{FB} is low voltage, the resistor should not be selected wirewound resistors to prevent malfunction in transient state including start/stop operation.

In addition, lead of the resistor of through hole type should be short to reduce the back electromotive voltage by the parasitic inductance. R1 is recommended surface device, and should be as close to LC101N as possible.

If the problem occurs at the open-short test of resistor, please considering the series-parallel connection of the resistor.

R1 setup is as shown in Table 11-1.

12.2 Pattern Layout

12.2.1 PCB Trace Layout and Component Placement

- Setup resistance, R1, should be as close to the FB pin and the LO pin as possible as shown in Figure 12-1.
- The layout between the FB pin and the LED string should be avoided to parallel with switching trace. Noise is superimposed to the FB pin by induction, the LC101N might be malfunction.

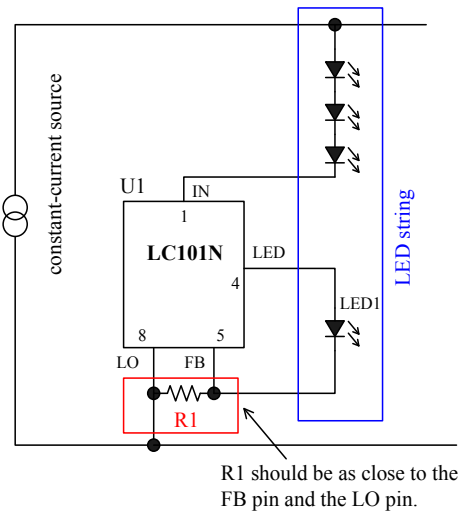


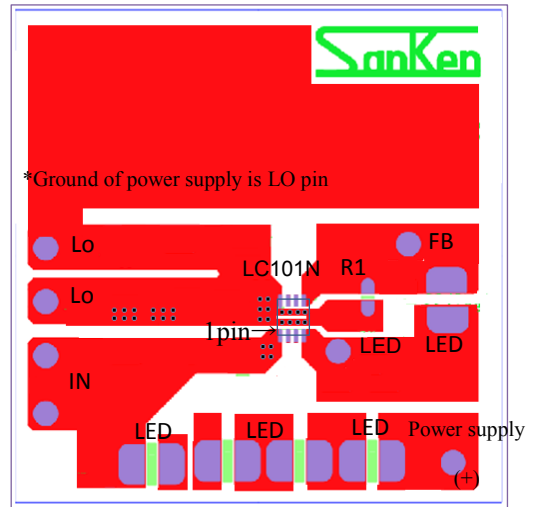
Figure 12-1 Important locations of the pattern layout

12.2.2 Pattern Layout Example

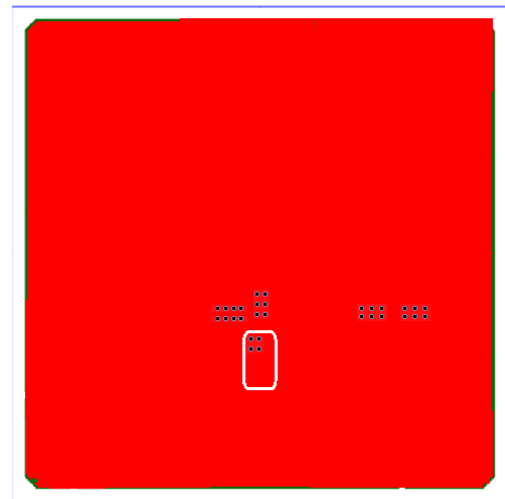
Figure 12-2 shows the pattern layout example, and Table 12-1 shows this PCB information.

Table 12-1 PCB information of pattern layout example

Items	Information
PCB type	double-sided
Size(Outline)	40 mm × 40 mm
Substrate thickness	t = 1.6 mm
Copper foil thickness	35 μm



(A) Top View



(B) Bottom View

Figure 12-2 Pattern layout example

12.2.3 Land Pattern Example

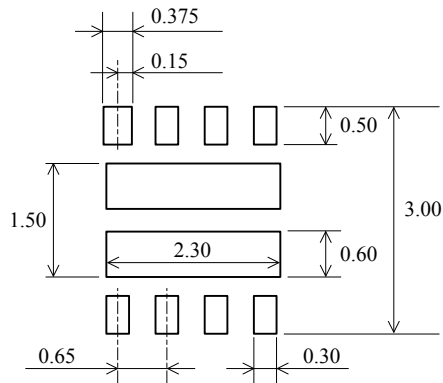


Figure 12-3 Land pattern example (not to scale)

13. Typical Performance Curves

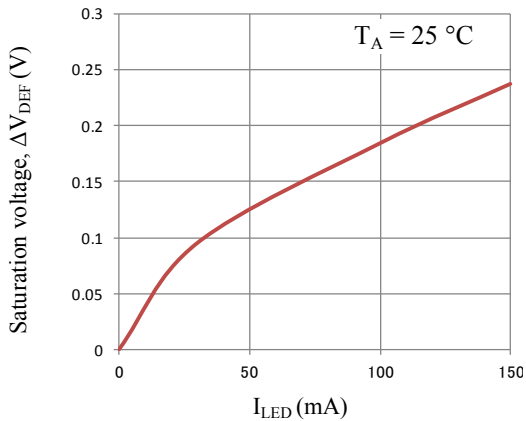


Figure 13-1 Saturation voltage characteristic

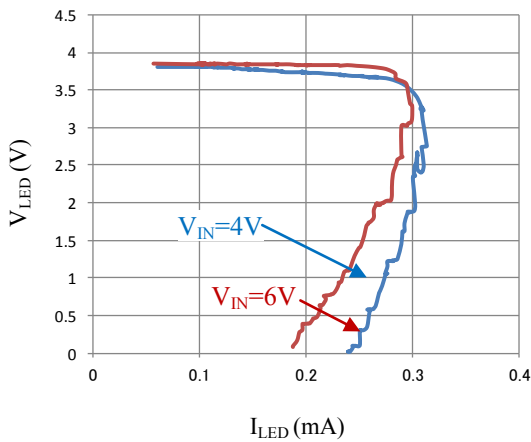


Figure 13-2 Overcurrent characteristic

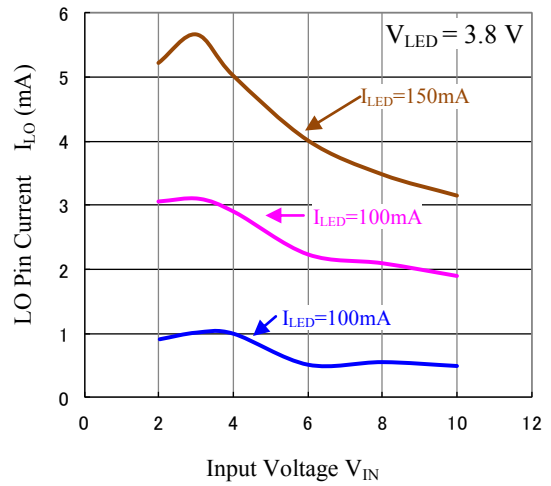


Figure 13-3 LO Pin Current

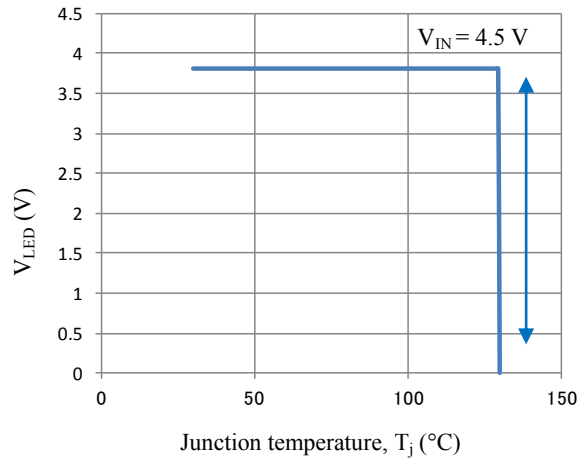
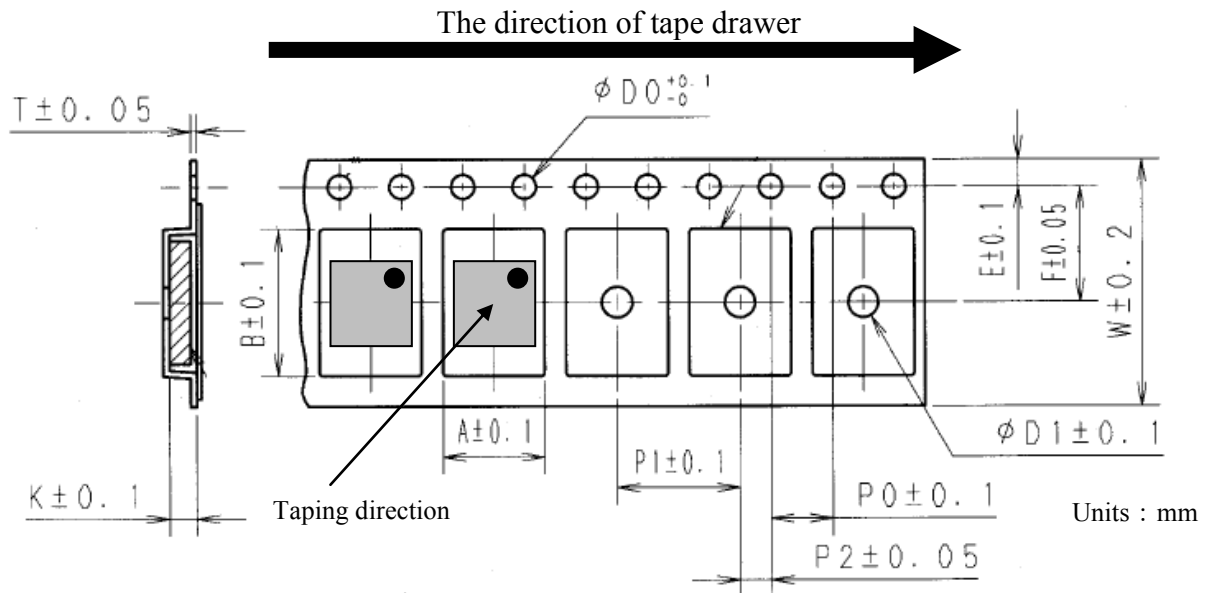
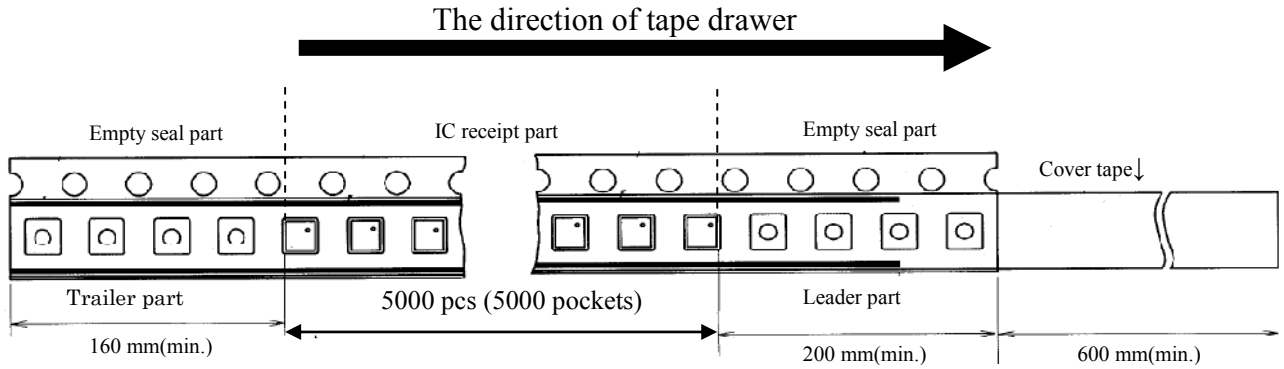


Figure 13-4 Thermal shutdown characteristic

14. Packing Specifications

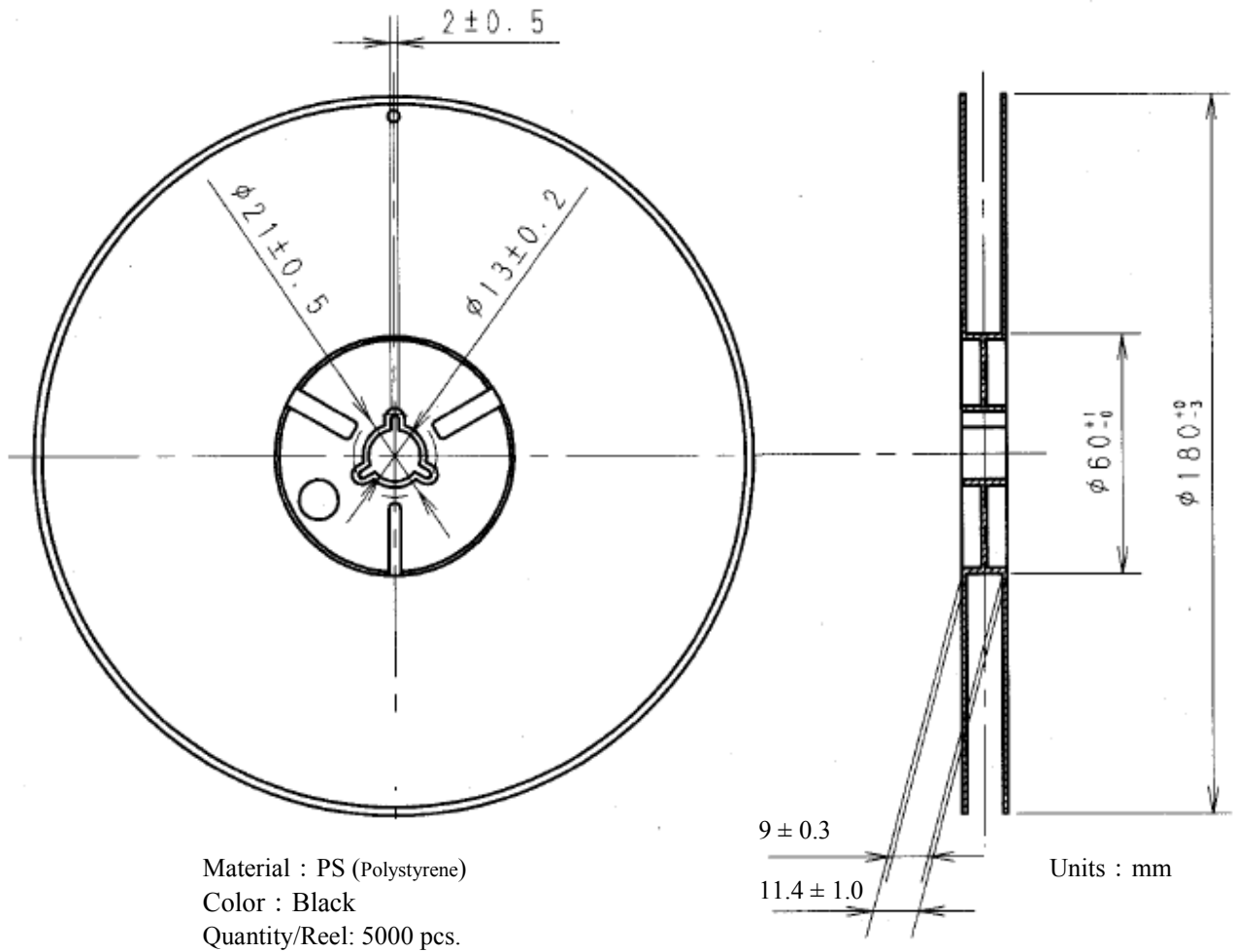
14.1 Emboss and Carrier Tape Specification



W	E	F	P0	P1	P2	A	B	D0	D1	T	K
8.0	1.75	3.5	4.0	4.0	2.0	3.1	2.8	1.5	1.1	0.2	0.75

Figure 14-1 Emboss and carrier tape dimensions

14.2 Reel Specifications



Material : PS (Polystyrene)
Color : Black
Quantity/Reel: 5000 pcs.

Figure 14-2 Reel dimensions

15. Recommended Reflow Temperature Profile

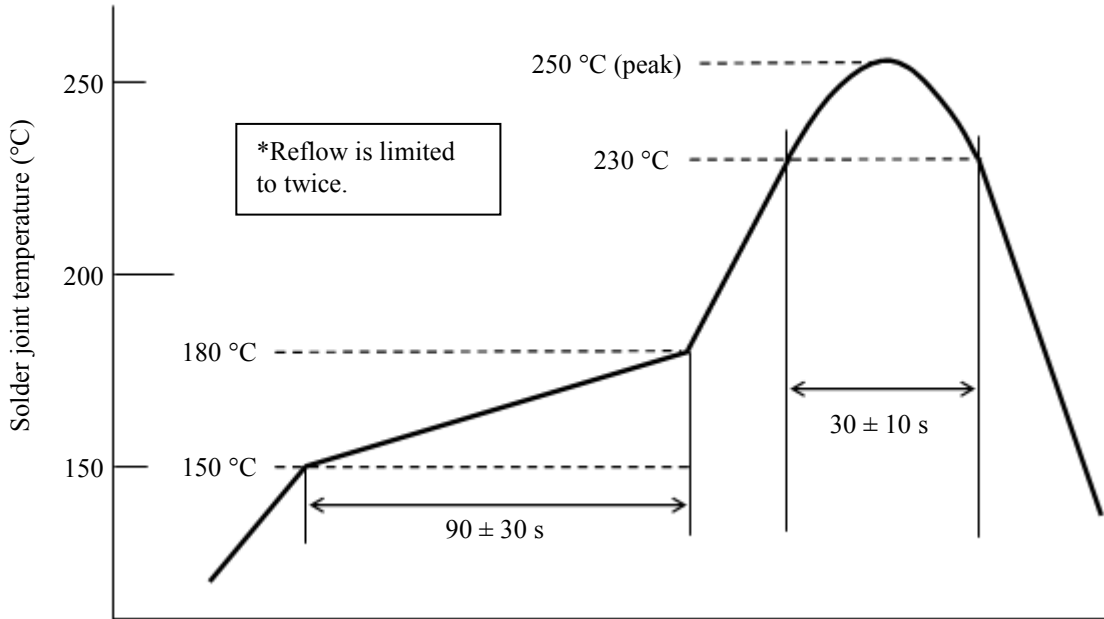


Figure 15-1 Recommended reflow temperature profile

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