



## High Current Boost LED Driver

### General Description

VAS1350 is a PFM mode boost LED driver with external power MOSFET. By adjusting external sense resistor, VAS1350 can deliver up to several amperes output current and suitable for high power LED array applications.

VAS1350 operates from a 5V to hundreds of voltages input range. Its overvoltage protection can avoid damage to circuit of open load and a dedicated analog input (ADJ) enables a wide range of analog dimming from 0.5V to 2.4V.

VAS1350 provide excellent protection functions, such as MOSFET over current protection,  $R_{CS}$  short protection,  $R_{OVP}$  short to ground protection, UVLO and over heat protection, LED open protection.

VAS1350 is available with SOP8 package.

### Application

- Landscape lighting
- Street lamp
- Indoor LED lighting
- LED backlighting

### Features

- 10V gate driver
- Multiple protections
  - $R_{CS}$  short protection
  - OVP short-to-GND protection
  - Output over voltage protection
  - Over temperature protection
- Wide input range up to hundreds of voltages in system
- No compensation capacitors

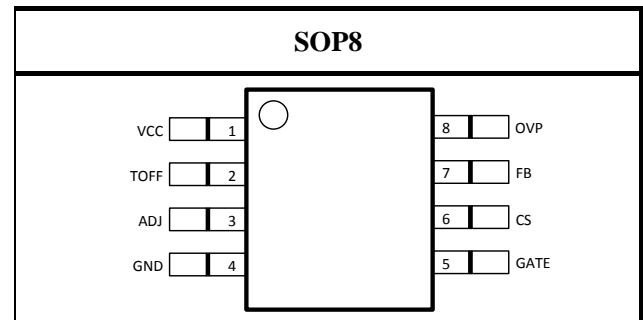
### Ordering Information

Order Number	Package Type	Temp. Range
VAS13500ID08E	SOP8	-40 °C to 85°C

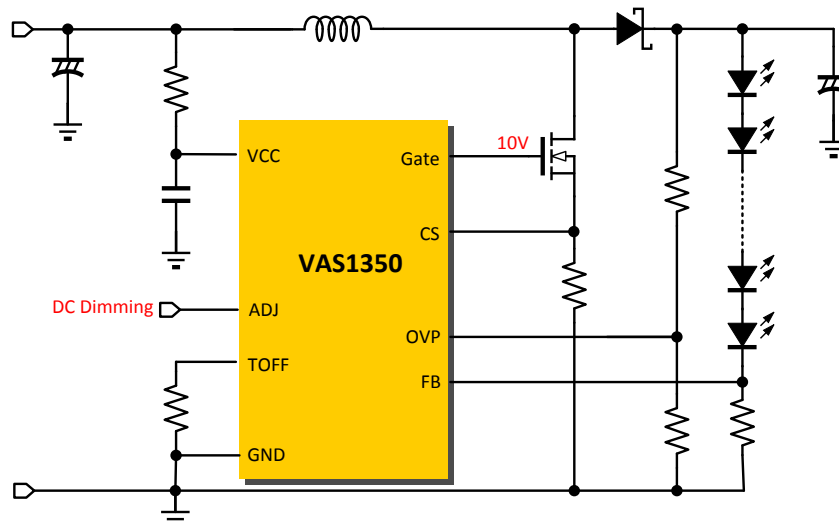
I: Industry, -40~85°C  
08 : Pin Number

D: SOP  
E: ROHS

### Pin Configuration

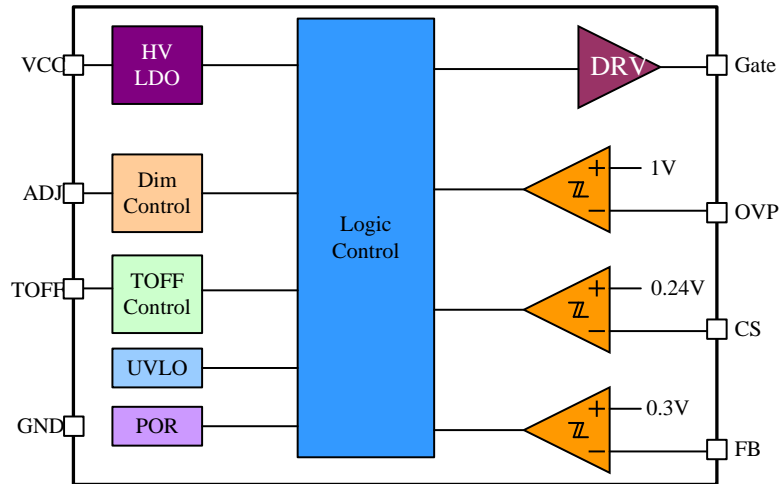


### Typical Application Circuit





## Block Diagram



## PIN Description

PIN NO.	Name	Description
1	VCC	Power supply input.
2	TOFF	Set the shortest off time of the NMOS by connecting a resistor
3	ADJ	Multi-function On/Off and brightness control pin: <ul style="list-style-type: none"> <li>• Drive to voltage below 0.5V to turn off output current</li> <li>• Leave floating for normal operation, PIN CS threshold <math>V_{CSTH}=0.24V</math>, PIN FB threshold <math>V_{FBTH}=0.31V</math></li> <li>• Drive with DC voltage (<math>0.5V &lt; V_{ADJ} &lt; 2.4V</math>) to adjust CS/FB threshold from 50mV/65mV to 0.24V/0.31V</li> </ul>
4	GND	Ground
5	GATE	Gate Drive Output. Connect to the gate of an external N-MOSFET
6	CS	The input peak current detecting pin
7	FB	The output current sense pin
8	OVP	Overvoltage protection detecting pin. If the pin voltage higher than 1V, the NMOS closed



### Absolute Maximum Ratings<sup>(Note1)</sup>

Parameters	Maximum Ratings
VCC to GND	-0.3V to 44V
CS, ADJ, TOFF, OVP, FB to GND	-0.3V to 6V
Gate to GND	-0.3V to 18V
Operating temperature	range -40°C to +85°C
Junction temperature	-40°C to +150°C
Storage temperature	range -65°C to +150°C
ESD(HBM)	±2000V

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

### Electrical Characteristics

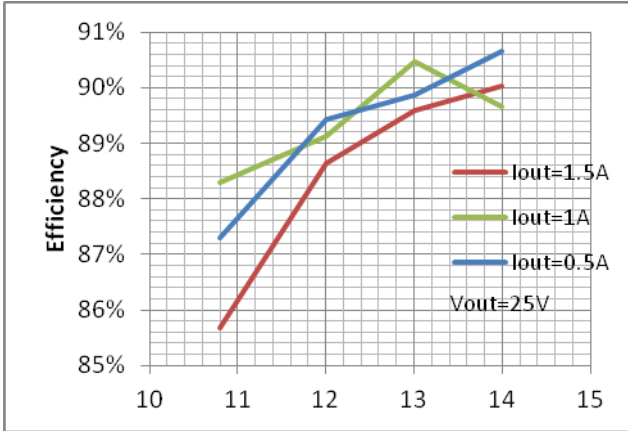
Typical case<sup>(Note2)</sup>: VCC=12V, T<sub>A</sub>=25°C(unless otherwise specified)

Symbol	Parameter	Condition	spec			Unit
			Min.	Typ.	Max.	
V <sub>INDC</sub>	Input Voltage Range		5		40	V
UVLO	Under voltage Lockout	VCC Rising		4.5	5	V
ΔUVLO	UVLO Hysteresis			0.2		V
I <sub>Q</sub>	Quiescent Current	VCC=12V		400	600	μA
		VCC=40V				
V <sub>CSTH</sub>	Input Peak Current Threshold	ADJ floating		240		mV
T <sub>BLANK</sub>	Input Current Blanking Time	V <sub>CS</sub> =V <sub>CSTH</sub> +50mV		300		ns
T <sub>OFF</sub>	Minimum Constant Off time	R <sub>EXT</sub> =24KΩ		1		μs
V <sub>ADJ</sub>	Peak Current Control Threshold Low			0.5		V
	Peak Current Control Threshold High			2.4		V
T <sub>SD</sub>	OTP Threshold			160		°C
T <sub>SD_HYS</sub>	OTP Hysteresis			20		°C
V <sub>FBTH</sub>	Output Current Feedback Threshold		0.285	0.31	0.335	V
V <sub>OVP_TH</sub>	Over Voltage Protection Threshold		0.95	1	1.05	V
V <sub>OVP_HYS</sub>				±5%		

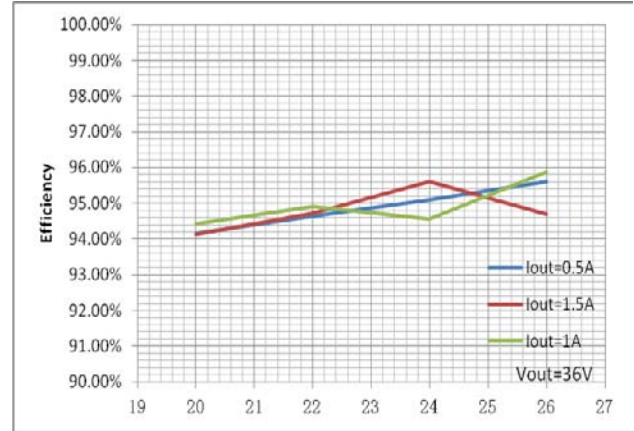
Note 2: Production testing of the device is performed at 25°C. Functional operation of the device and parameters specified over other temperature range, are guaranteed by design, characterization and process control.



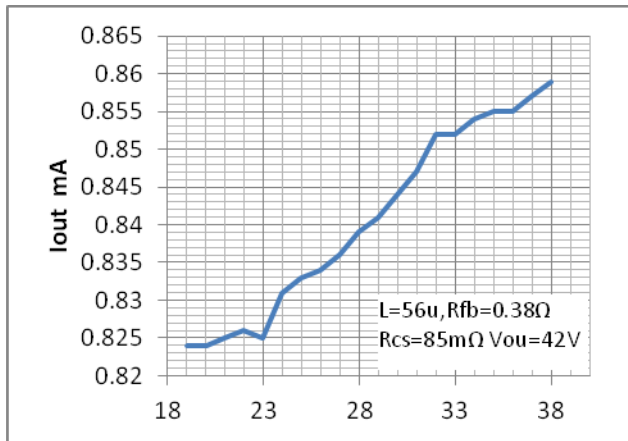
### Typical Performance Characteristics



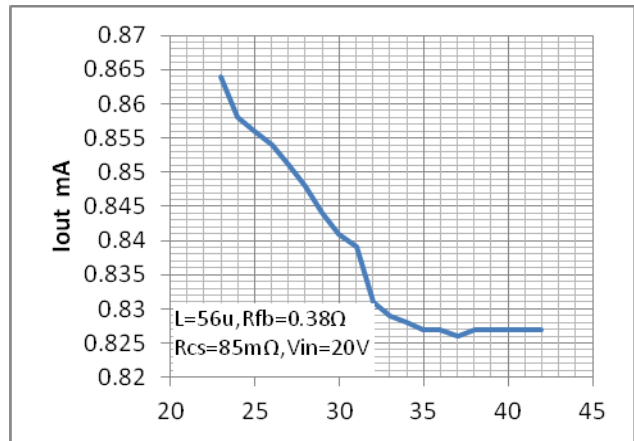
Vin VS efficiency



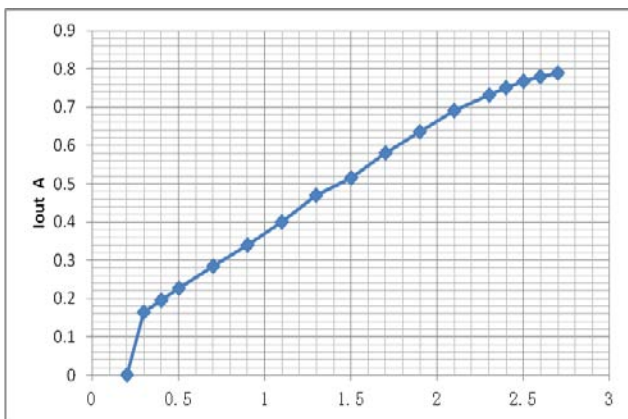
Vin VS efficiency



Vin VS Iout



Vout VS Iout

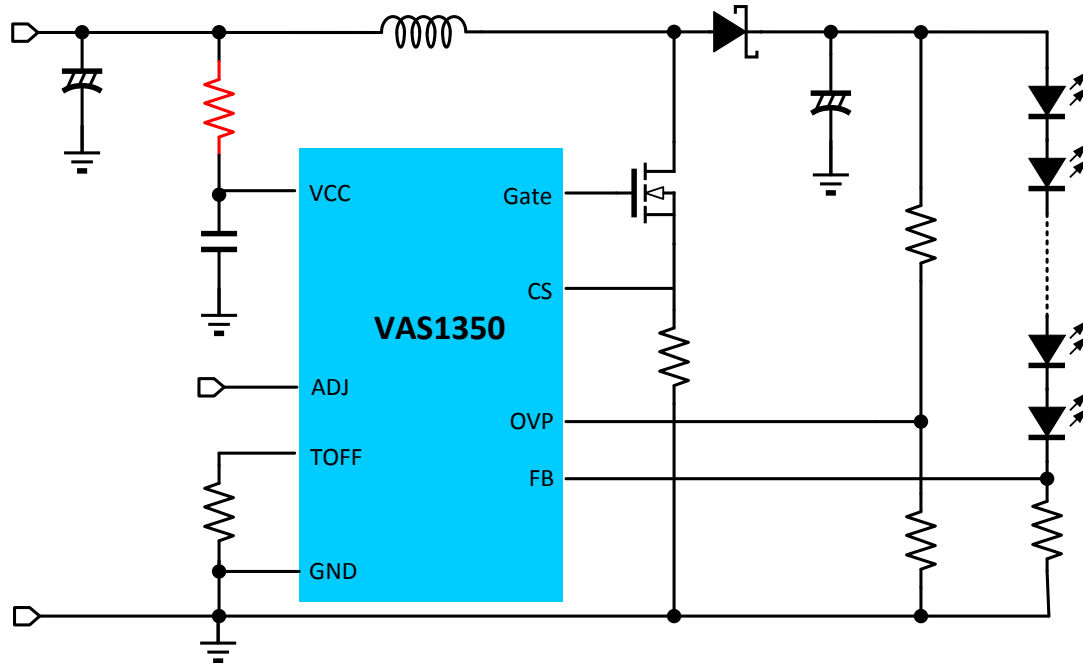


V<sub>ADJ</sub> VS I<sub>OUT</sub>

## Application Information

### 1. Power supply voltage > 40V application

When power supply voltage is greater than 40V, an input resistor and a low ESR ceramic capacitor is needed to clamp the voltage at VCC pin. The circuit may be as follows:



### 2. Under-Voltage Lockout (UVLO)

When VCC voltage drops and is less than 4.3V, VAS1350 stops operation; when VCC voltage rises greater than 4.5V, VAS1350 restarts to operation.

### 3. LED Current Setting

LED current can be set by:

$$I_{LED} = \frac{0.31}{R_{FB}}$$

In order to get more accurate LED current, 1% or higher accuracy resistor is recommended.

### 4. Over Voltage Setting

In some cases, LED open for example, the FB connect to GND by a small resistor, the FB voltage almost is 0V, VAS1350 continue to work at maximum duty cycle and output voltage rises. When the OVP voltage (which is  $V_{OUT}$  voltage resistor divider) rises to  $V_{OVPTH}$  (1.05V typical), VAS1350 internal logic force external MOSFET OFF, then output voltage drops to  $V_{OVPTH}-0.1$  (0.95V typical), VAS1350 internal logic release and chip work again.

In most cases, output OVP voltage should be set to 1.2 times or 5V greater than normal operation voltage, OVP voltage can be set by:

$$V_{OVP} = V_{OVPTH} \times \left( 1 + \frac{R_1}{R_2} \right), \text{ } R_1 \text{ is upper resistor connect between OVP to } V_{OUT}, R_2 \text{ is lower}$$

resistor that connect between OVP to GND.

### 5. Dimming



VAS1350 has both analog and PWM dimming by utilize multifunction ADJ pin, the function describe as below:

- 1) Drive to voltage below 0.5V to turn off output current
- 2) Leave floating for normal operation, PIN CS threshold  $V_{CSTH}=0.24V$ , PIN FB threshold  $V_{FBTH}=0.31V$ .
- 3) Drive with DC voltage ( $0.5V < V_{ADJ} < 2.4V$ ) to adjust CS/FB threshold from 50mV/65mV to 0.24V/0.31V linearly.

### 6. Input Peak Current Control

VAS1350 limit the input peak current by set  $R_{CS}$  which connect between CS and GND. The input average current can be got by:

$$I_{avg(in)} = \frac{V_{out} \times I_{out}}{V_{in} \times \eta}, \text{ the } \eta \text{ is system efficiency, say } 90\%.$$

Mostly, set input peak current 1.5 times average current is enough.

$$I_{peak(IN)} = 1.5 \times I_{avg(IN)} = \frac{V_{CSTH}}{R_{CS}}$$

Where  $V_{CSTH}$  value determined by ADJ pin:

If then  $V_{CSTH}=V_{ADJ}/10$

If  $V_{ADJ} \geq 2.4V$ , then  $V_{CSTH}=0.24V$

If ADJ floating, then  $V_{CSTH}=0.24V$

### 7. Input Capacitor Selection

Input capacitor provides transient current for system, a 100 $\mu$ F or larger, low ESR capacitor is recommended.

### 8. Minimum Turn-Off time Setting

Minimum turn-off time is set by the formula:

$$T_{OFF(MIN)} = 40 \times 10^{-12} \times R_{EXT}$$

### 9. Inductor selection

The inductor quantity is related to system working frequency. Larger inductor quantity reduce lower working frequency and switching dissipation on MOSFET, but larger inductor need more copper line and increase ESR, the conductor dissipation increases. The system working frequency calculate formula:

$$f = 1/(T_{OFF} + T_{ON})$$

Inductor current ripple:

$$I_{RIPPLE} = 2 \times (I_{peak(IN)} - I_{avg(IN)})$$

NMOS turn on time  $T_{ON}$ :

$$T_{ON} = \frac{L \times I_{RIPPLE}}{V_{IN} - I_{AVG} (R_{CS} + R_L + R_{DS(on)})}$$

NMOS turn-off time  $T_{OFF}$ :



$$T_{OFF} = \frac{L \times I_{RIPPLE}}{V_{OUT} + V_D - V_{IN} - I_{AVG(IN)} \times R_L}$$

Note that : Must guarantee  $T_{OFF} > T_{OFF(MIN)}$  at normal operation

Where:

$V_{IN}$  is the supply voltage (V)

$V_{OUT}$  is the output voltage (V)

$I_{RIPPLE}$ : Inductor current ripple(A)

L is the inductor (H)

$R_L$  is the parasitic resistance ( $\Omega$ )

$I_{peak(IN)}$ : Inductor peak current (A)

$I_{AVG(IN)}$  is the required LED current (A)

$R_{DSON}$  is the switch resistor of NMOS ( $\Omega$ )

$V_D$  is the diode forward voltage at the required load current (V)

Example:

For  $V_{IN}=12V$ ,  $L=47\mu H$ ,  $R_L=0.64\Omega$ ,  $I_{AVG}=333mA$  and  $V_D=0.36V$

$$T_{ON} = \frac{(47 \times 10^{-6} \times 0.067)}{12 - 3.4 - 0.612} = 0.39 \mu s$$

$$T_{OFF} = \frac{(47 \times 10^{-6} \times 0.067)}{3.4 + 0.36 + 0.322} = 0.77 \mu s$$

This gives an operating frequency of 862 kHz and a duty circle of 0.33.

VAS1350 recommend the system working frequency is from 20KHz to 200KHz, 20KHz or less working frequency will induce audio noise, 200KHz or high will induce higher power dissipation and reduce system efficiency.

The inductor rated current must greater than ripple current.

### 10. Output Capacitor

22uF or larger, low ESR, aluminum capacitor is recommended.

### 11. Schottky Diode

The Schottky diode rated current should great than output current and reverse block voltage should great than output OVP voltage

### 12. MOSFET Selection

The N-MOSFET break-down voltage must larger than the output OVP voltage.

The MOSFET  $R_{DSON}$  is related to its power dissipation and system efficiency.

$$T_{LOSS} = I^2 \times R_{DS(ON)} = \left( \frac{V_{OUT} \times I_{OUT} \times Duty}{V_{IN} \times \eta} \right)^2 \times R_{DS(ON)}$$

An N-MOSFET with rated current 5 times input peak current is recommended.

### 13. PCB Layout

Careful PCB layout is critical to achieve low switching losses and stable operation, also to avoid EMI.

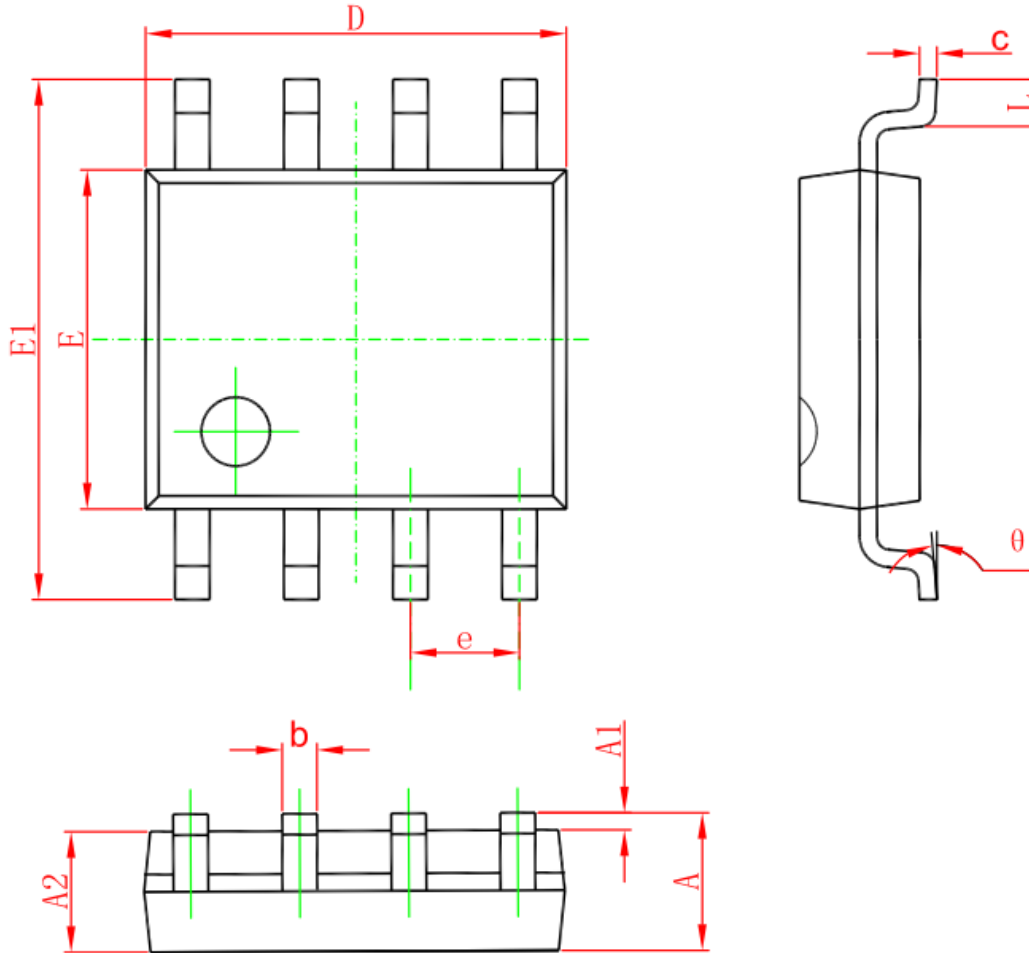
For large current loop, the line should be wide and short enough to reduce noise and power dissipation, especially the GND path of  $R_{FB}$  & VAS1350, which will improve the

Decoupling capacitor C1, C2, C3 should be as close to the chip to enhance the filtering effect. The junction of NMOS's drain and inductor, Schottky diode is a fast switching node, these devices should



be placed together, and to avoid interference cross or long parallel lines with these junctions is not recommended.

**Package Information (SOP8)**

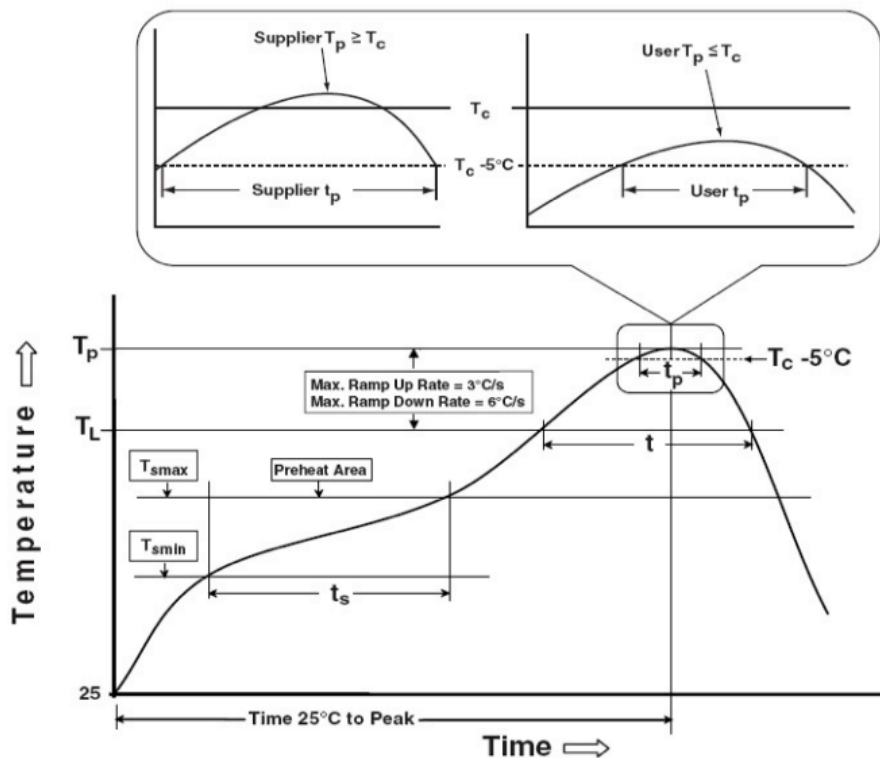


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°



### Classification Reflow Profiles

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature min (T <sub>smin</sub> )	150°C
Temperature max(T <sub>smax</sub> )	200°C
Time (T <sub>smin</sub> to T <sub>smax</sub> ) (t <sub>s</sub> )	60 -120 seconds
Average ramp-up rate (T <sub>smax</sub> to T <sub>p</sub> )	3°C/second max.
Liquidous temperature (T <sub>L</sub> )	217 °C
Time at liquidous (t <sub>L</sub> )	60 -150 seconds
Peak package body temperature (T <sub>p</sub> )*	Max 260°C
Time (t <sub>p</sub> )* * within 5°C of the specified classification temperature (T <sub>c</sub> )	Max 30 seconds
Average ramp-down rate (T <sub>p</sub> to T <sub>sma</sub> x)	6°C/second max.
Time 25 °C to peak temperature	8 minutes max



Classification Profile

### ! CAUTION

#### Storage Conditions

- 1) This product should be used within 12 months after delivered. Store in manufacturer’s package keeping the seal of aluminum coated baggage or tightly re-closed box with the following conditions. [Temperature: 8°C...30°C, Humidity: 30%...70%R.H.]
- 2) Keep the seal of aluminum coated baggage immediately before usage.
- 3) After breaking the seal of aluminum coated baggage, this product should be used within 1 week on the following conditions.[Temperature:≤30°C, Humidity:≤60%R.H.]