General Description

The SIC976XD are built-in HV start-up and IC power supply circuit, main line power up constant current LED regulators with high current accuracy which applies to single stage step-down power factor corrected LED drivers. 600V power MOSFET is integrated, which can significantly simplify the design of LED lighting system.

High accuracy of output current is achieved by sampling the output current directly. Quasi Resonant (QR) Buck topology reduces the switching losses and largely increases the efficiency. The SIC976XD are supplied from the main line, the V_{DD} power supply resistors and power feedback circuits from LED chips are not needed, save cost and help for assemble efficiency.

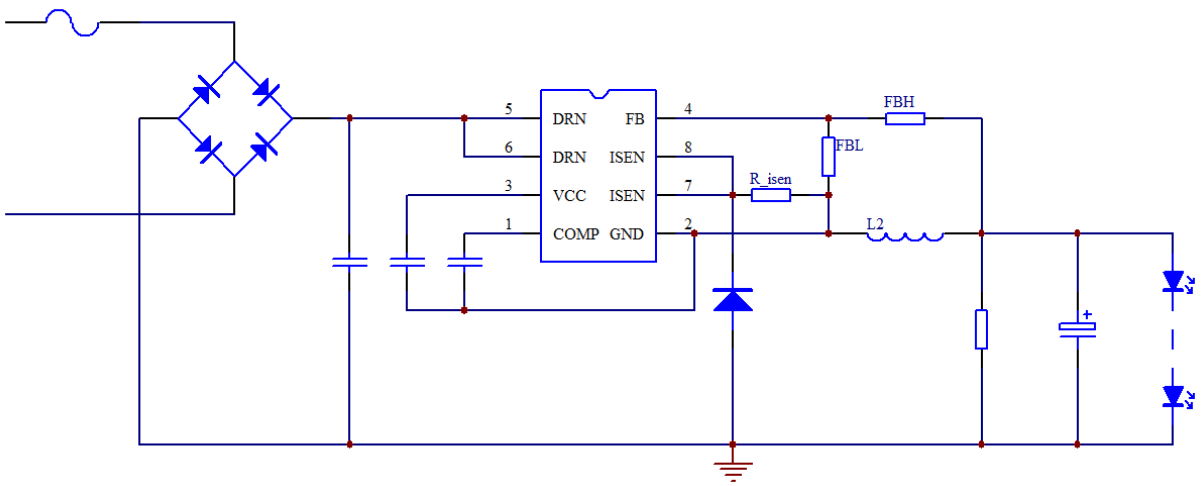
The SIC976XD have multi-protection functions which largely enhance the safety and reliability of the system, including V_{DD} over-voltage protection, V_{DD} UVLO, short-circuit protection, LED open protection, cycle-by-cycle current limit and over-temperature protection.

The SIC9762D available in SOP-7 package, SIC9763D available in SOP-7 & DIP-7package, SIC9764D available in DIP-7 package, SIC9767D available in SOP-7 package.

Features

- Active PFC for High power factor and low THD
- ±3% LED output current accuracy
- Built-in HV start-up and IC power supply circuit
- 600V high voltage MOSFET integrated
- Quasi-Resonant (QR) Buck topology
- System efficiency up to 95%
- Ultra low start up & operating current
- Cycle-by-cycle current limit
- LED short protection
- LED open protection
- Over-temperature protection

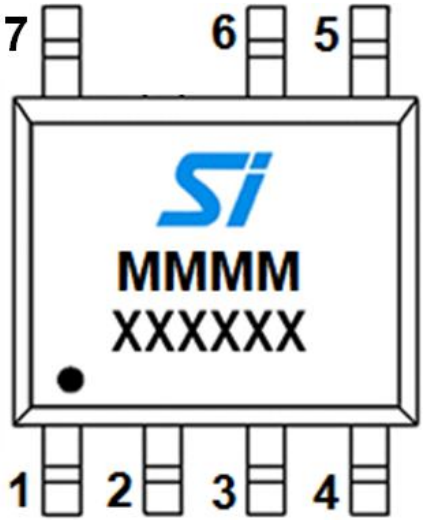
Typical Application



Ordering Information

Part Number	Package	Package Method	Marking
SIC9762D（SOP-7）	SOP-7	Tape 4,000pcs/Roll	Si 9762D XXXXXX
SIC9763D（SOP-7）	SOP-7	Tape 4,000pcs/Roll	Si 9763D XXXXXX
SIC9763D（DIP-7）	DIP-7	Tube 50pcs/Tube	Si SIC9763D XXXXXX
SIC9764D（DIP-7）	DIP-7	Tube 50pcs/Tube	Si SIC9764D XXXXXX
SIC9767D（SOP-7）	SOP-7	Tape 4,000pcs/Roll	Si 9767D XXXXXX

Pin Assignment

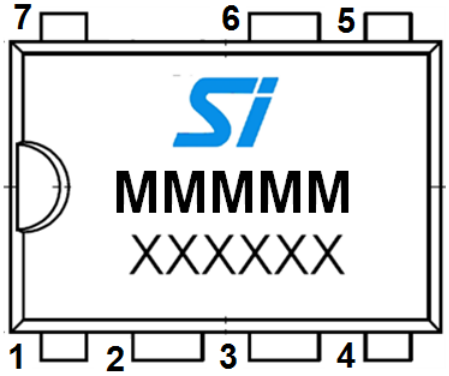


SOP-7 Products

"Si"-Logo of SI Semiconductors

MMMM--Part Number

XXXXXX--Date Code



DIP-7 Products

"Si"-Logo of SI Semiconductors

MMMM--Part Number

XXXXXX--Date Code

Pin Description

Pin	Pin Name	Description
1	COMP	Compensation Pin for Internal Error Amplifier. Connect a capacitor between the pin and GND to compensate the internal feedback loop.
2	GND	Ground.
3	VDD	Power Supply Pin. This pin supplies current to the internal start-up circuit. This pin must be bypassed with a capacitor nearby.
4	FB	Voltage Loop Feedback Pin. FB is used to detect LED open by sampling the output voltage.
5/6	DRAIN	DRAIN of the MOSFET.
7	ISEN	Output Current Sense Pin. The pin is used for output current control.

Recommended Operation Conditions

Products	Symbol	Range	Unit
SIC9762D	$I_{LED}1$	<150 @V_{OUT}=80V	mA
	$I_{LED}2$	<180 @V_{OUT}=36V	
SIC9763D	$I_{LED}1$	<180 @V_{OUT}=80V	mA
	$I_{LED}2$	<240 @V_{OUT}=36V	
SIC9764D	$I_{LED}1$	<300 @V_{OUT}=80V	mA
	$I_{LED}2$	<350 @V_{OUT}=36V	
SIC9767D	$I_{LED}1$	<300 @V_{OUT}=80V	mA
	$I_{LED}1$	<350 @V_{OUT}=36V	

Absolute Maximum Ratings

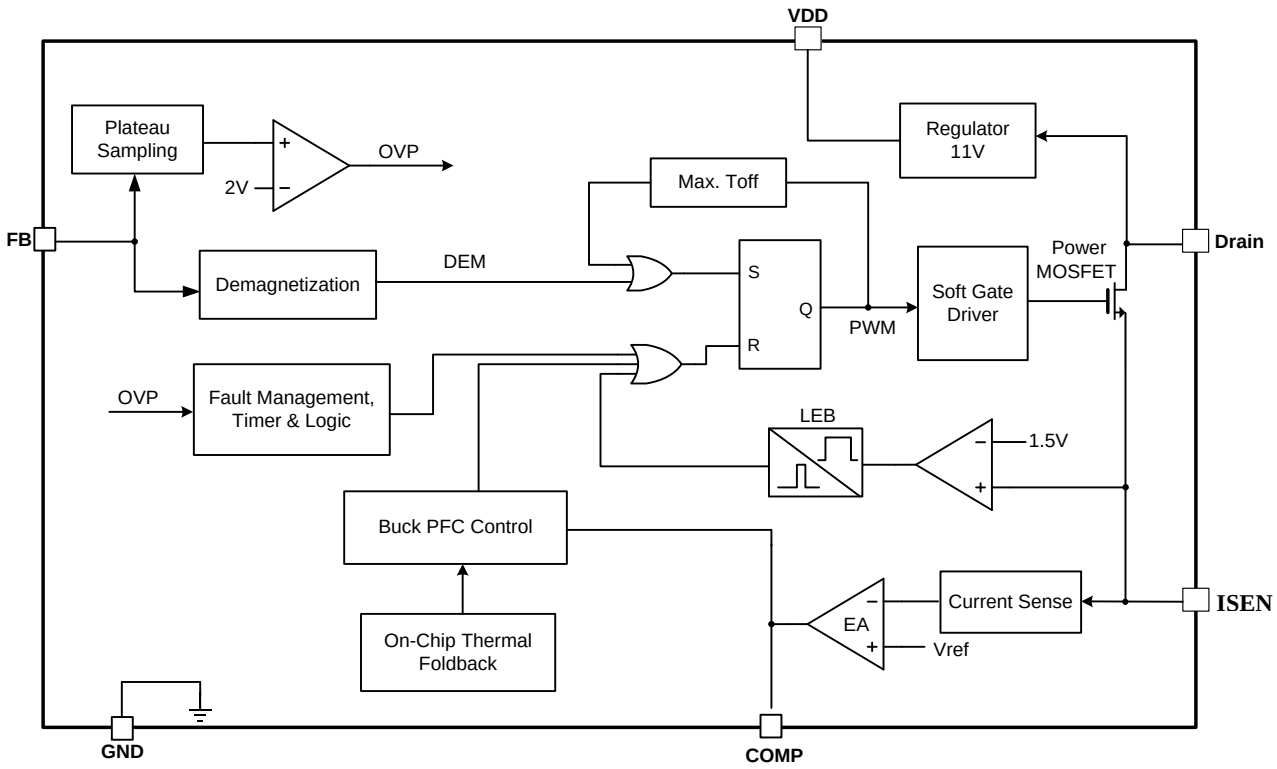
Parameter	Symbol	Parameter Range	Unit
Voltage On DRAIN Pin	VDRN	-0.3～600	V
Voltage On ISEN Pin	VISEN	-0.3～7	V
Voltage On COMP Pin	Vcomp	-0.3～7	V
Voltage On FB Pin	VFB	-0.3～7	V
Maximum Operation Current	IDDMAX	10	mA
Maximum Power Dissipation (Ta=25°C)	P_{tot}	0.45@ SOP-7	W
		0.90 @DIP-7	
Thermal Resistance Junction-ambient	Rthj-a	145@ SOP-7	℃/W
		80@DIP-7	
Operating Junction Temperature	TJ	-40～150	℃
Storage Temperature Range	TSTG	-55～150	℃
ESD		2,000	V

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability。

Electronic Characteristics

T_C =25°C,V_{DD} =11V,unless otherwise specified							
Parameter		**Symbol**	**Test Conditions**	**Min**	**Typ**	**Max**	**Unit**
VDD Turn On Threshold Voltage		V_{DD_ON}	VDD Rising	10.5	11.5	13	V
VDD Turn Off Threshold Voltage		V_{DD_UVLO}	VDD Falling	7.5	8.5	9.0	V
VDD Start Up Current		I_{ST}	VDD= V_{DD_ON}-1V		300	700	uA
VDD Operating Current		I_{OP}	F =7KHZ	80	150	300	uA
VDD Clamp Voltage		V_{DD_CLAMP}	5mA		14		V
FB Falling Edge Threshold Voltage		V_{FB_FALL}	FB Falling		0.2		V
FB Over Voltage Protection Threshold		V_{FB_OVP}		1.9	2.0	2.1	V
Min. Degaussing time		T_{OFF_MIN}			2		us
Max. Degaussing time		T_{OFF_MAX}		195	270	350	us
ISEN Peak Voltage Limitation		V_{ISEN_LMIT}		1.4	1.5	1.6	V
OCP Leading Edge Blanking Time		T_{LEB}			300		ns
Switch off Delay Time		T_{DELAY}			100		ns
Internal Reference Voltage		V_{REF}		194	200	206	mV
COMP Low Clamp Voltage		V_{COMP_L}			0.7		
COMP High Clamp Voltage		V_{COMP_H}			3		
SIC9762D	Power MOSFET Rds(on)	$R_{DS(ON)}$	V_{GS}=15V/ I_{DS}=0.5A		6.5	7.0	Ω
SIC9763D					3.5	4.0	
SIC9764D					2.3	3.0	
SIC9767D					2.2	2.4	
Breakdown Voltage		BV_{DSS}	V_{GS} =0/ I_{DS} =250uA	600			V
Drain Leakage Current		I_{DSS}	V_{GS} =0/ V_{DS} =600V			1	uA
Over-temperature Protection		T_{REG}			150		℃

Functional Block Diagram



Applications Information

Functional Description

The SIC976XD are constant current LED regulator which applies to non-isolation step-down LED system with power factor correction. 600V power MOSFET is integrated, which can significantly simplify the design of LED lighting system. SIC976XD work in Quasi-Resonant (QR) mode can achieve excellent load regulation, high efficiency and low BOM cost.

Start Up

The SIC976XD built-in HV start-up and IC power supply circuit, the V_{DD} power supply resistors and power feedback circuits from LED chips are no needed. After system power up, the 11V regulator charges V_{DD} hold-up capacitor to 11V by drawing a current from the voltage on the Drain pin, whenever the internal power MOSFET is off. When the power MOSFET is on, the charging device runs off of the energy stored in the V_{DD} hold-up capacitor. V_{DD} hold up capacitor is charged by the internal HV startup circuit through Drain pin. When V_{DD} pin voltage reaches the turn on threshold, the IC begins working. The COMP pin is pulled up to 0.7V quickly, then the IC begins to work at low switching frequency (typical 3.5KHz.The COMP pin voltage rises up gradually, thus the inductor peak current also rises up. The LED current hence achieves a soft start without over shoot.

Constant Current Control

The SIC976XD controls the output current from the information of the current sensing resistor. The output LED mean current can be calculated as:

$$I_{LED} = \frac{V_{ISEN}}{R_{ISEN}}(A)$$

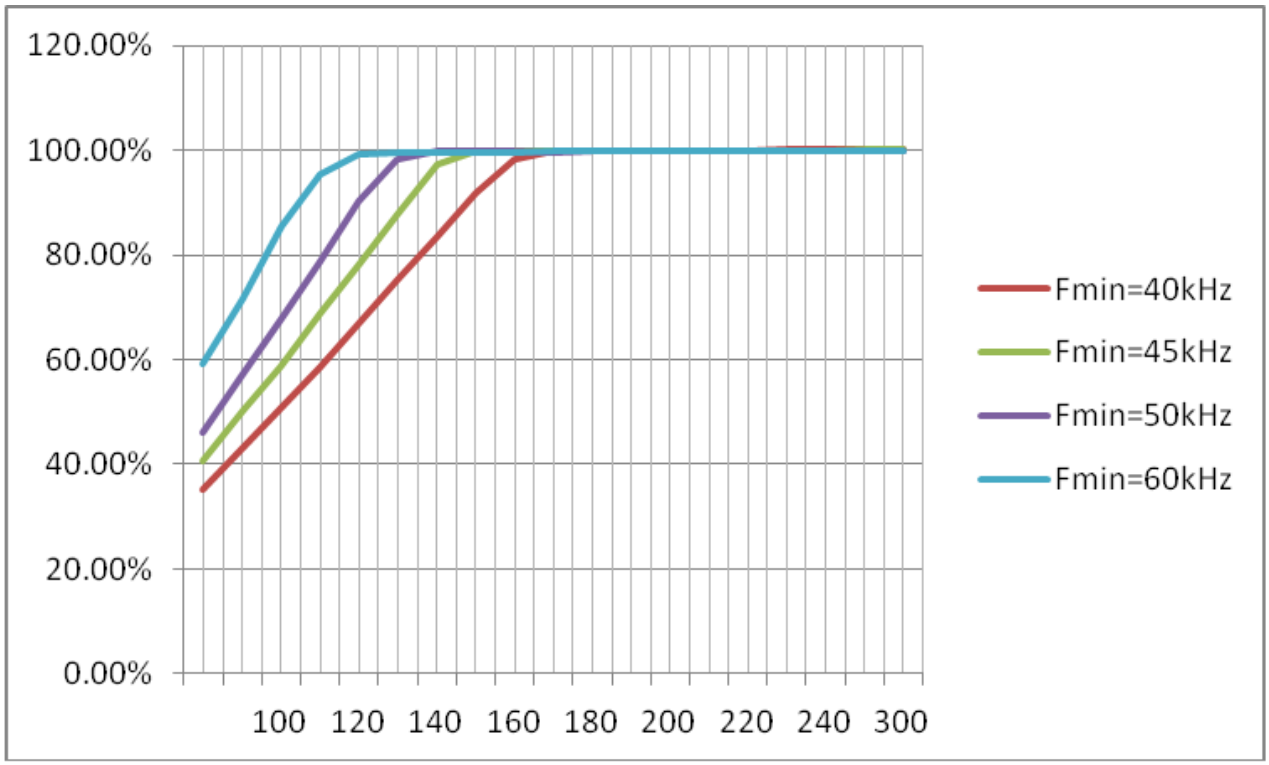
Where

V_{ISEN} –200mV typically;

RI_{SEN} – The sensing resistor connected between ISEN and GND.

Intelligent automatic current control

Also the SIC976XD will drop the output current to limit the temperature when the AC input voltage drop too much, the curve depends on the duty-cycle and the frequency, which could be change by Lp setting.
The output current curve is show as below fig. for Vo=54, Io=150mA application.

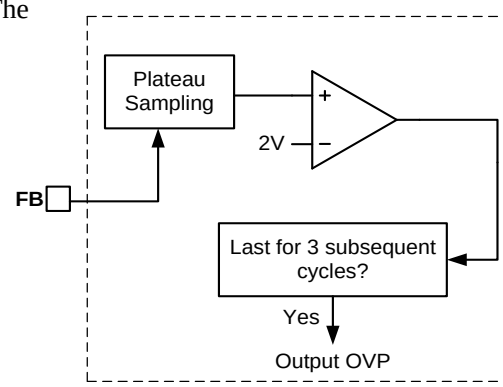


Feedback Network

The SIC976XD senses the output current zero crossing information through the feedback network, the FB falling threshold voltage is set to 0.2V. If the sampled plateau voltage exceeds the OVP threshold (2V), an internal counter starts counting subsequent OVP events. If OVP events are detected in successive 3 cycles, the controller assumes a true OVP and it stops all switching operations, as shown in Fig.1. The counter has been

added to prevent incorrect OVP detection which might occur during ESD or lightning events. If the output voltage exceeds the OVP threshold less than 3 successive cycles, the internal counter will be cleared and no fault is asserted. Output OVP is auto-recovery mode protection. The ratio of FB upper resistor to lower resistor can be set as：

$$\frac{R_{FBL}}{R_{FBL}+R_{FBH}}=\frac{2.0V}{V_{OVP}}$$



Where,

RFBL: The lower resistor of the feedback network

RFBH: The upper resistor of the feedback network

V_{OVP}: Output over voltage setting point

It is recommended that the FB lower resistor set to 2KΩ-5KΩ.

Leading Edge Blanking (LEB)

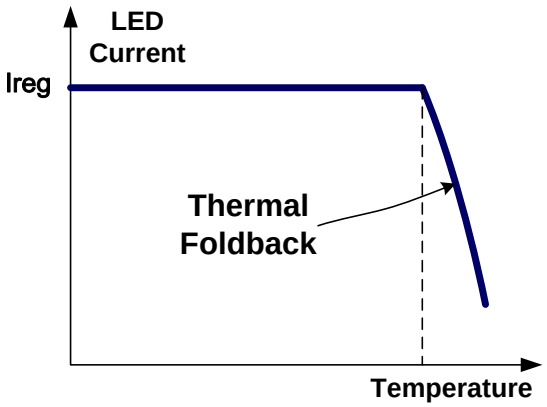
Each time the power MOSFET is switched on, a turn-on spike occurs across the sensing resistor. The spike is caused by primary side capacitance and secondary side rectifier reverse recovery. To avoid premature termination of the switching pulse, an internal leading edge blanking circuit is built in. During this blanking period (300ns, typical), the PWM comparator is disabled and cannot switch off the gate driver.

Soft Totem-Pole Gate Driver

The SIC976XD have a soft totem-pole gate driver with optimized EMI performance.

LED Over Temperature Protection

When SIC976XD's temperature are too high the output current will be decrease as shown in Fig. on the right. The output power and thermal dissipation are also reduced. The system temperature is regulated and the system reliability is improved. The thermal regulation temperature is set to 150℃ internally.



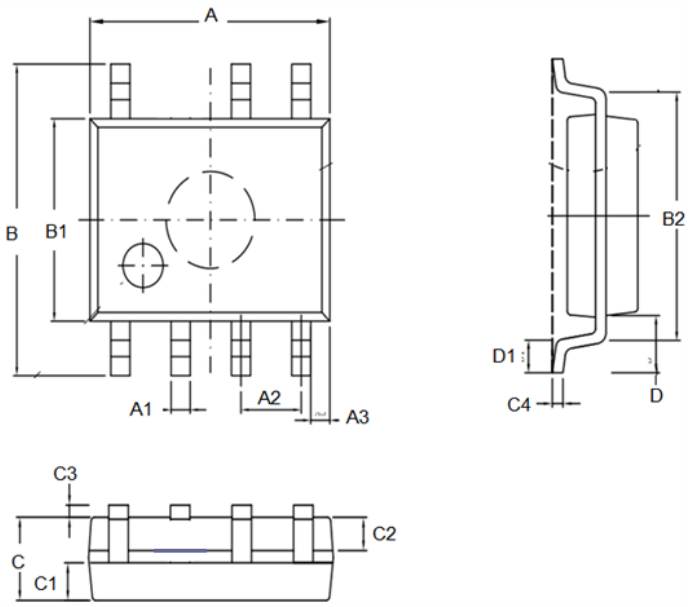
PCB Layout Guidelines:

Bypass Capacitor: The bypass capacitor on V_{DD} pin should be as close as possible to the V_{DD} and GND pins.
Ground Path: The power ground path for current sense resistor should be short and wide, and it should be as close as possible to the IC ground (pin 2) , otherwise the LED output current accuracy maybe affected. The IC signal ground for COMP and FB components should be connected to the IC GND pin with short traces and should be away from the power ground path.
The Area of Power Loop: The area of main current loop should be as small as possible to reduce EMI radiation.
FB Pin: The feedback resistor divider should be as close as possible to the FB pin, and the trace must keeps away from dynamic node of the inductor (DRAIN pin trace), otherwise the FB pin OVP function might have risk to be mis-triggered by the system noise.
DRAIN Pin： To increase the copper area of DRAIN pin for better thermal dissipation. However too large copper area may compromise EMI performance.

SOP-7 封装机械尺寸
SOP-7 MECHANICAL DATA

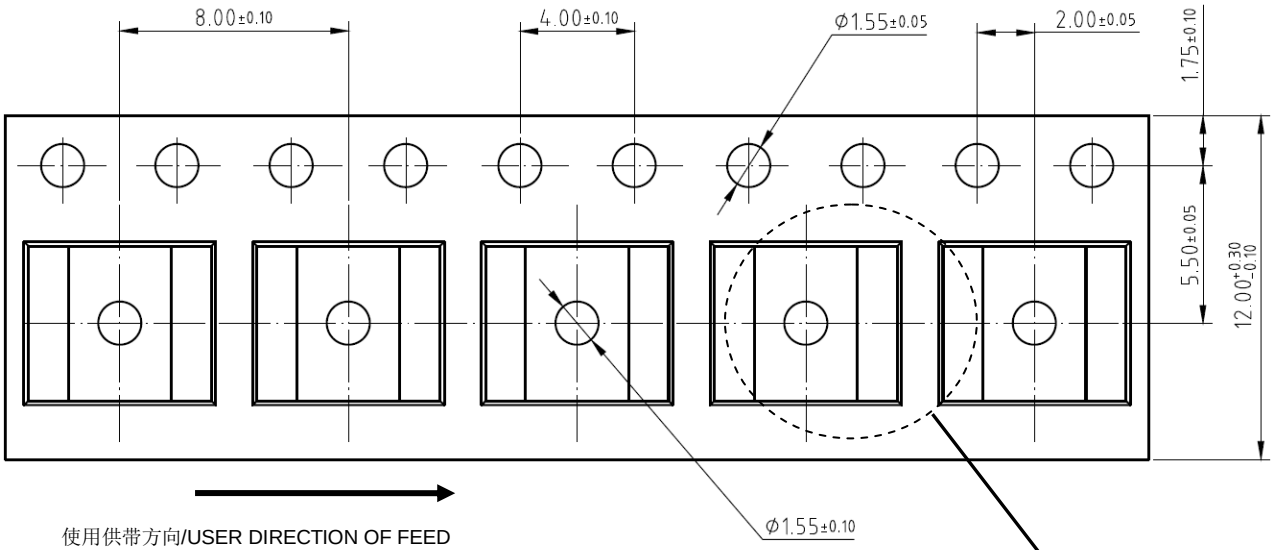
单位:毫米/UNIT：mm

符号 SYMBOL	最小值 min	典型值 nom	最大值 max	符号 SYMBOL	最小值 min	典型值 nom	最大值 max
A	4.80		5.00	C	1.30		1.50
A1	0.37		0.47	C1	0.55		0.75
A2		1.27 TYP		C2	0.55		0.65
A3		0.41 TYP		C3	0.05		0.20
B	5.80		6.20	C4	0.19	0.20TYP	0.23
B1	3.80		4.00	D		1.05TYP	
B2		5.0TYP		D1	0.40		0.62

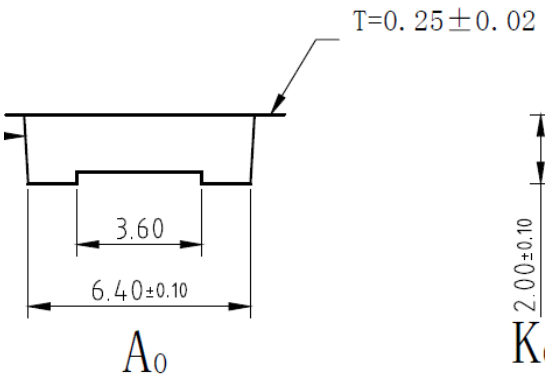


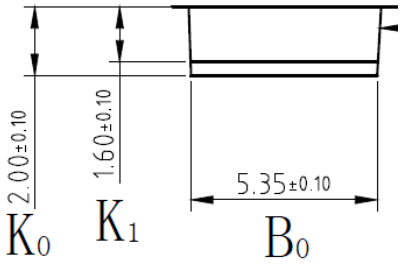
SOP-7/8 (13")编带规格
SOP-7/8 (13")TAPE AND REEL DATA

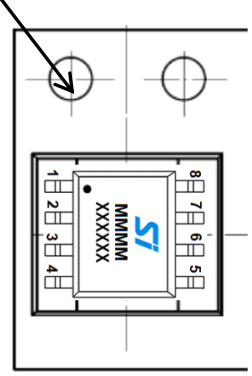
单位:毫米/UNIT：mm



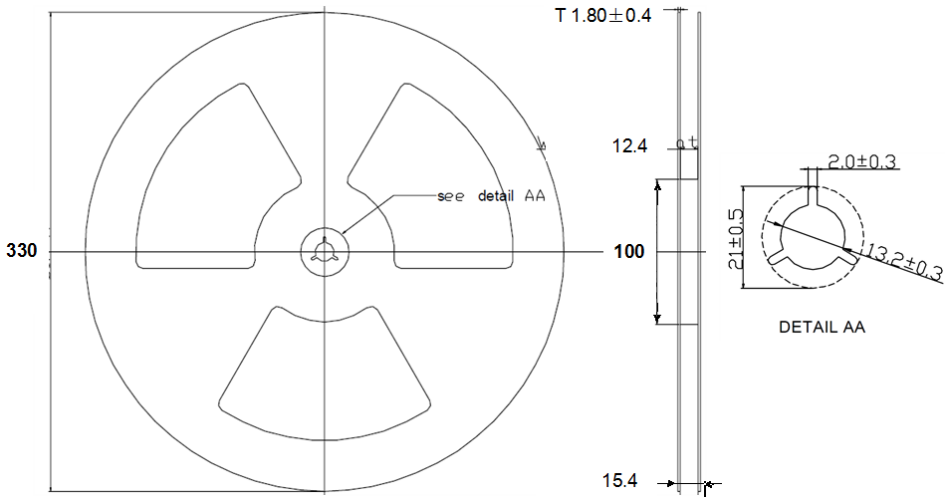
使用供带方向/USER DIRECTION OF FEED







器件定位示意图/UNIT ORIENTATION

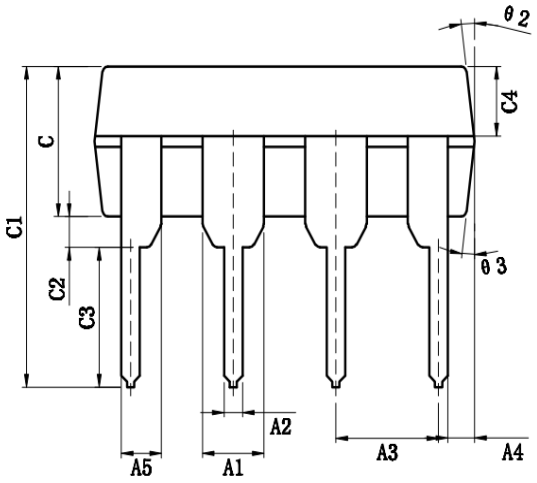


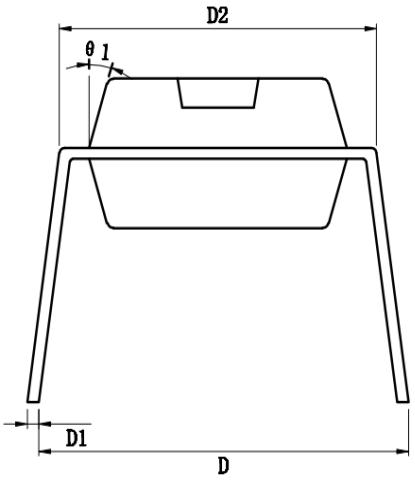
13"卷盘/REEL

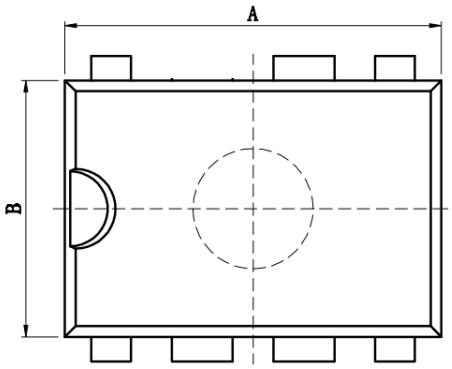
DIP-7 封装机械尺寸
DIP-7 MECHANICAL DATA

单位:毫米/UNIT：mm

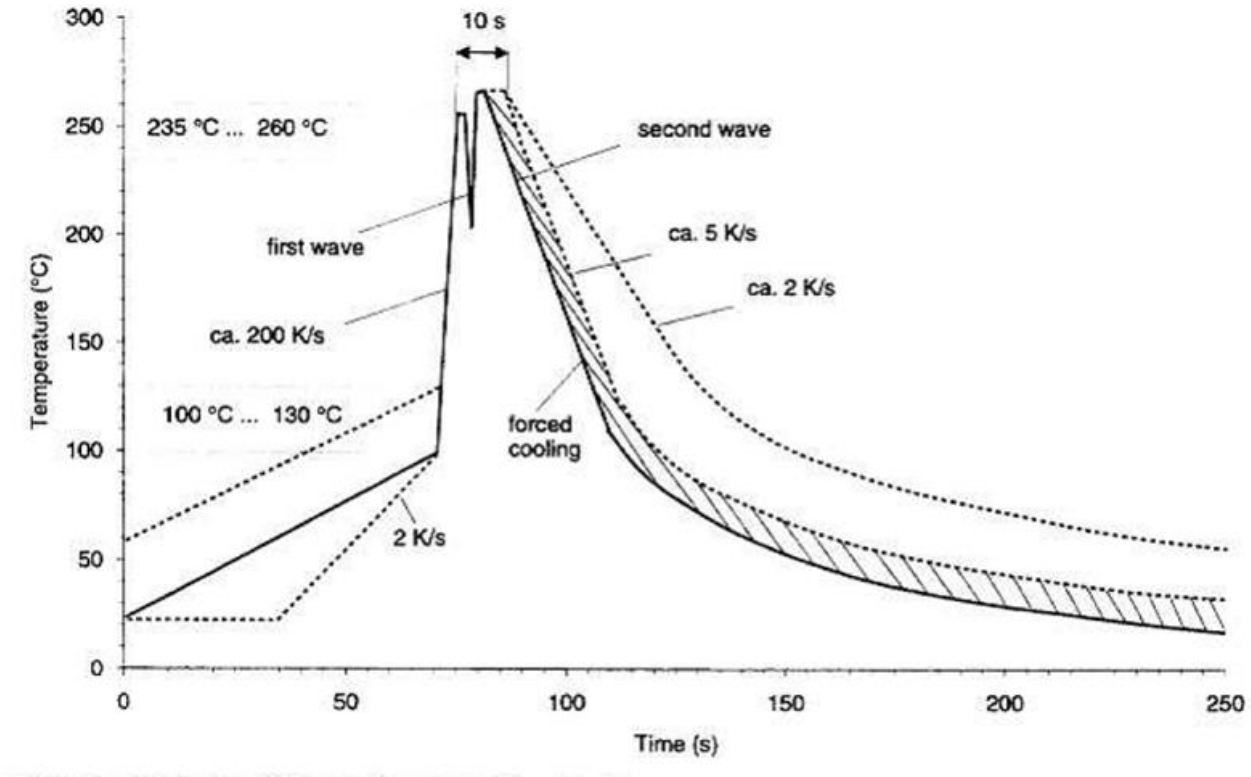
符号 SYMBOL	最小值 min	典型值 nom	最大值 max	符号 SYMBOL	最小值 min	典型值 nom	最大值 max
A	9.10		9.50	C2		0.50TYP	
A1	1.474		1.574	C3	3.20		3.40
A2	0.41		0.51	C4	1.47		1.57
A3	2.44		2.64	D	8.00		8.80
A4		0.51TYP		D1	0.244		0.264
A5		0.99TYP		D2	7.45		7.87
B	6.10		6.40	Θ1		17°TYP4	
C	3.20		3.40	Θ2		10°TYP4	
C1	6.80		7.40	Θ3		8°TYP	



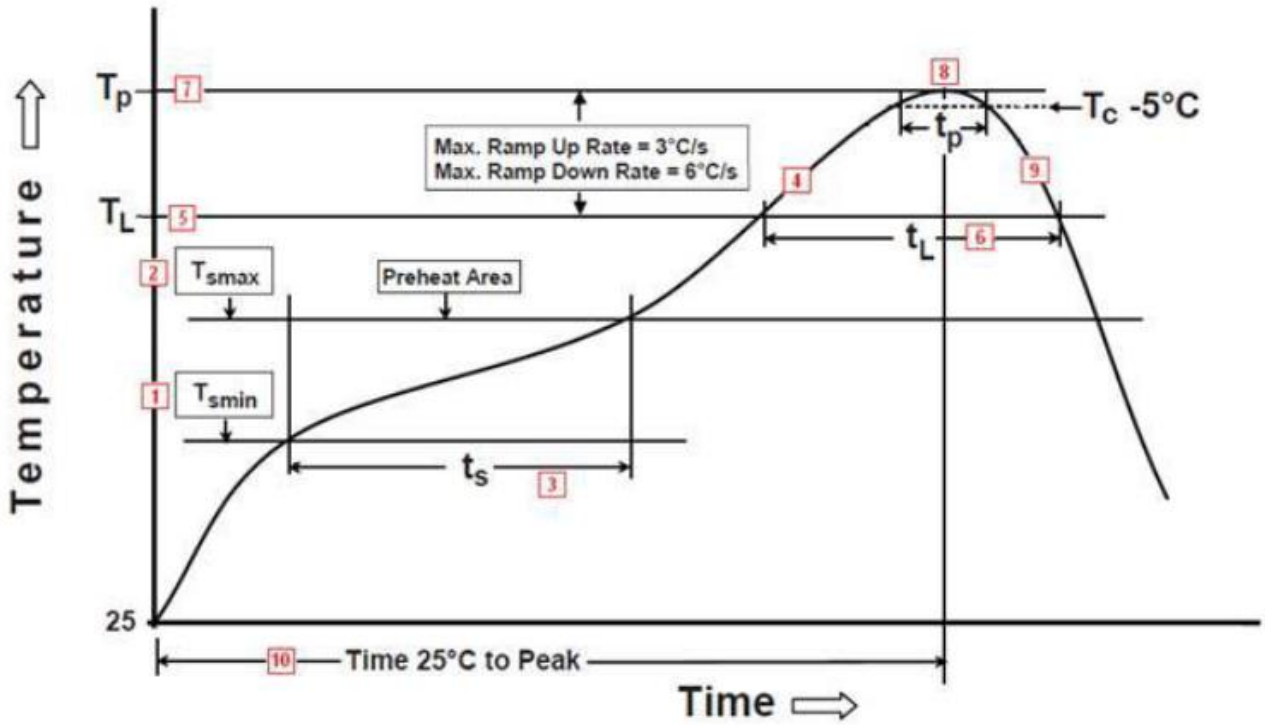




SI Guidelines for wave-soldering



SI Reflow Soldering



Tabular form for soldering profile data:

Key	Par.	Profile Feature	Pb free Process
R.1	Tsmin	Minimum pre-heating temperature	150 °C
R.2	Tsmax	Maximal pre -heating temperature	200 °C
R.3	t s	Pre-heating duration (Tsmin to Tsmax)	120 sec
R.4	dT/dt up	Average ramp-up rate (Tsmax to Tp)	3 °C/sec max.
R.5	TL	Liquidus temperature	217 °C
R.6	t_L	Time duration at liquidus	Min. 90 sec
R.7	Tp	Peak package body temperature	Min. 250°C for package < 350 mm3 Min. 245°C for package > 350 mm3
R.8	t p	Time within 5 °C of the specified classification temperature T_C	Min. 30 sec
R.9	dT/dt down	Average ramp-down rate (Tp to Tsmax)	6 °C/sec max.
R.10	T_{Peak}	Time 25 °C to peak temperature	8 minutes max.

Revision history

Revision	Release data	Description
1.0	2017-12-12	First version