

### Features

- **100mW High Side MOSFET**
- **1A Continuous Current**
- **Wide Supply Voltage Range: 1.5V to 5.5V**
- **Current-Limit and Short-Circuit Protections**
- **Under-Voltage Lockout Protection**
- **Reverse Current Blocking when Switch Disabled**
- **Over-Temperature Protection**
- **Logic Level Enable Input**
- **UL Approved-Fild No. E328191**
- **UL-CB Scheme IEC/EN62368-1 Certified**
- **TUV IEC/EN62368-1 Certified**
- **Lead Free and Green Devices Available (RoHS Compliant)**

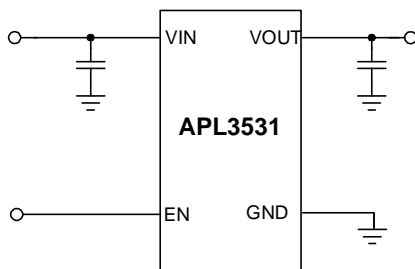
### Applications

- **TFT LCD Modules**
- **Notebook and Desktop Computers**
- **USB Ports**
- **High-side Power Protection Switches**

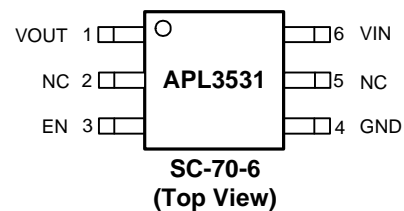
### General Description

The APL3531 is a power-distribution switch with some protection functions that can deliver current up to 1A. The device incorporates a 100mΩ N-channel MOSFET power switch that is controlled by an enable logic pin and dedicated to soft-start ramp-up rate control that can be used in application where the inrush current is concerned. The device integrates some protection features, including current-limit protection, short-circuit protection, over temperature protection, and UVLO. The current-limit and short-circuit protection can protect down-stream devices from catastrophic failure by limiting the output current at current-limit threshold during over-load or short-circuit events. The over-temperature protection function shuts down the N-channel MOSFET power switch when the junction temperature rises beyond 140°C and will automatically turns on the power switch when the temperature drops by 20°C. The UVLO function keeps the power switch in off state until there is a valid input voltage present. The device is available in lead free SC-70-6 packages.

### Simplified Application Circuit

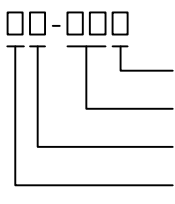


### Pin Configuration



ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

### Ordering and Marking Information

<p>APL3531    □□ - □□□</p>  <p>Assembly Material Handling Code Temperature Range Package Code</p>	<p>Package Code S6 : SC-70-6 Operating Ambient Temperature Range I : -40 to 85°C Handling Code TR : Tape &amp; Reel Assembly Material G : Halogen and Lead Free Device</p>
<p>APL3531    S6:    <span style="border: 1px solid black; padding: 2px;">31X</span>    X - Date Code</p>	

Note : ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020D for MSL classification at lead-free peak reflow temperature. ANPEC defines "Green" to mean lead-free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

### Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V <sub>IN</sub>	VIN to GND Voltage	-0.3 ~ 6	V
V <sub>OUT</sub>	VOUT to GND Voltage	-0.3 ~ 6	V
V <sub>EN</sub>	EN to GND Voltage	-0.3 ~ 6	V
I <sub>OUT</sub>	IOUT output current	Internal Limited	A
T <sub>J</sub>	Maximum Junction Temperature	-40 ~ 150	°C
T <sub>STG</sub>	Storage Temperature	-65 ~ 150	°C
T <sub>SDR</sub>	Maximum Lead Soldering Temperature (10 Seconds)	260	°C

Note1: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ <sub>JA</sub>	Junction-to-Ambient Resistance in Free Air <sup>(Note 2)</sup>	340	°C/W

Note 2: θ<sub>JA</sub> is measured with the component mounted on a high effective thermal conductivity test board in free air.

**Recommended Operating Conditions (Note 3)**

Symbol	Parameter	Range	Unit
V <sub>IN</sub>	VIN Input Voltage	1.5~5.5	V
I <sub>OUT</sub>	OUT Output Current	0 ~ 1	A
T <sub>A</sub>	Ambient Temperature	-40 ~ 85	°C
T <sub>J</sub>	Junction Temperature	-40 ~ 125	°C

Note 3: Please refer to the typical application circuit.

**Electrical Characteristics**

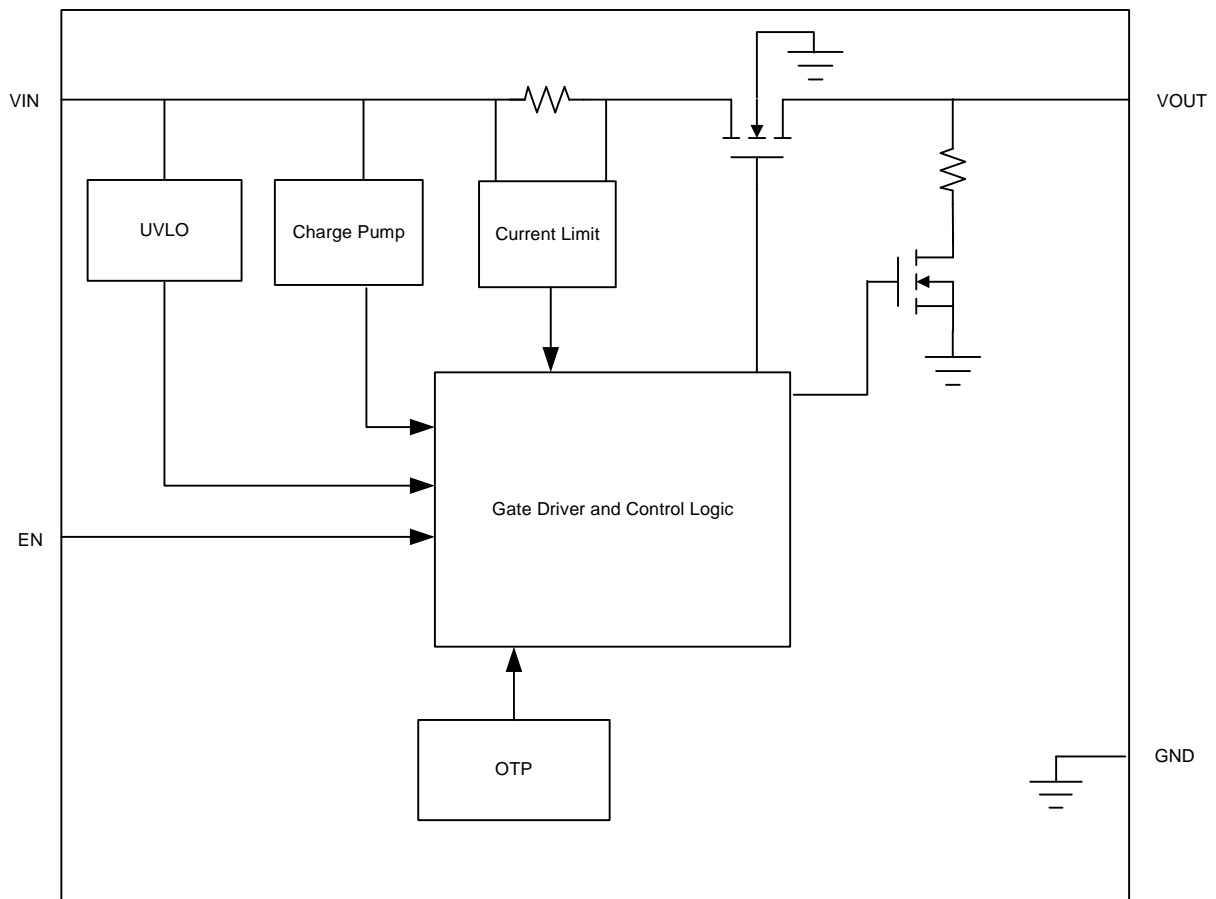
Unless otherwise specified, these specifications apply over V<sub>IN</sub>=5V, V<sub>EN</sub>=5V. Typical values are at T<sub>A</sub>=25°C.

Symbol	Parameter	Test Conditions	APL3531			Unit	
			Min	Typ	Max		
<b>SUPPLY CURRENT</b>							
	VIN Supply Current	V <sub>IN</sub> =1.8V, V <sub>EN</sub> =0V, No load	-	-	1	μA	
		V <sub>IN</sub> =1.8V, V <sub>EN</sub> =5V, No load	-	30	60	μA	
	Leakage Current	V <sub>OUT</sub> =GND, V <sub>EN</sub> =0V	-	-	1	μA	
	Reverse Leakage Current	V <sub>IN</sub> =GND, V <sub>OUT</sub> =5V, V <sub>EN</sub> =0V	-	-	1	μA	
<b>POWER SWITCH</b>							
R <sub>DS(ON)</sub>	Power Switch On Resistance	V <sub>IN</sub> =5V, I <sub>OUT</sub> =1A	-	100	130	mΩ	
		V <sub>IN</sub> =3.3V, I <sub>OUT</sub> =1A	-	-	130	mΩ	
		V <sub>IN</sub> =1.8V, I <sub>OUT</sub> =1A	-	-	130	mΩ	
<b>UNDER-VOLTAGE LOCKOUT</b>							
	VIN UVLO Threshold Voltage	V <sub>IN</sub> rising	-	1.2	-	V	
	VIN UVLO Hysteresis		-	0.2	-	V	
<b>CURRENT LIMIT AND SHORT CIRCUIT PROTECTIONS</b>							
I <sub>LM</sub>	Current Limit Threshold	V <sub>IN</sub> =5V	1	2	3	A	
	Short Circuit current	V <sub>IN</sub> =5V	-	0.8	-	A	
<b>EN INPUT PIN AND SOFT START</b>							
V <sub>IH</sub>	Input Logic High	V <sub>IN</sub> =5V	-	1.0	-	V	
	Input Hysteresis	V <sub>IN</sub> =5V	-	0.1	-	V	
	Input Current	V <sub>IN</sub> =5V	-	-	1	μA	
	VOUT Discharge Resistance	V <sub>IN</sub> =1.8V, V <sub>EN</sub> =0V	-	500	-	Ω	
t <sub>D(ON)</sub>	Turn on Delay Time	from EN rising edge 50% to Vout rising 90%	V <sub>IN</sub> =3.3V	-	-	500	μs
			V <sub>IN</sub> =5V	-	-	750	μs
t <sub>D(OFF)</sub>	Turn off Delay Time		-	3	-	μs	
t <sub>SS</sub>	Output Soft Start Time	V <sub>IN</sub> =5V	0.2	-	1	ms	
<b>OVERT-TEMPERATURE PROTECTION (OTP)</b>							
T <sub>OTP</sub>	Over-Temperature Threshold	T <sub>J</sub> rising,	-	140	-	°C	
	Over-Temperature Hysteresis		--	20	-	°C	

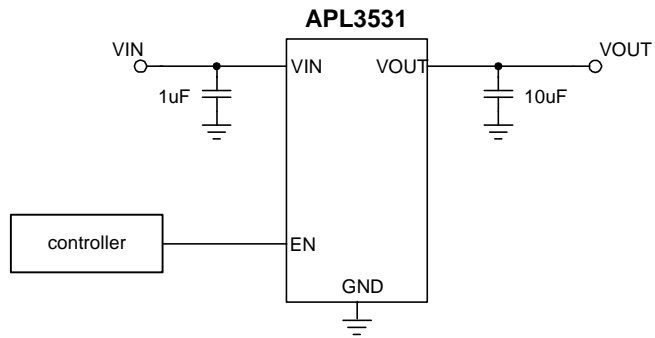
### Pin Description

PIN	NAME	Description
1	VOUT	Output Voltage Pin. The output voltage follows the input voltage. When EN is low the output voltage is discharged by an internal resistor.
2, 5	NC	No connection.
3	EN	Enable Input. Pull this pin to high to enable the device and pull this pin to low to disable device. The EN pin cannot be left floating.
4	GND	GND.
6	VIN	Power Supply Input. Connect this pin to external DC supply.

### Block Diagram



## Typical Application Circuit



## Function Description

### Under-voltage Lockout (UVLO)

The APL3531 power switch is built-in an under-voltage lockout circuit to keep the output shuts off until internal circuitry is operating properly. The UVLO circuit has Hysteresis and a de-glitch feature so that it will typically ignore undershoot transients on the input. When input voltage exceeds the UVLO threshold, the output voltage starts a soft-start to reduce the inrush current.

### Power Switch

The power switch is an N-channel MOSFET with a low  $R_{DS(ON)}$ . The internal power MOSFET does not have the body diode. When IC is off, the MOSFET prevents a current flowing from the VOUT back to VIN and VIN to VOUT.

### Current Limit Protection

The APL3531 power switch provides the current limit protection. During current limit, the devices limit output current at current limit threshold. For reliable operation, the device should not be operated in current limit for extended period time.

### Short Circuit Protection

When the output voltage drops, which is caused by the over load or short-circuit, the devices limit the output current down to a safe level. The short circuit current-limit is used to reduce the power dissipation during short-circuit condition. If the junction temperature is over the thermal shutdown temperature, the device will enter the thermal shutdown.

### Soft-Start

The APL3531 provides an internal soft-start circuitry to control rise rate of the output voltage and limit the current surge during start-up.

### Over-Temperature Protection

When the junction temperature exceeds 140°C, the internal thermal sense circuit turns off the power FET and allows the device to cool down. When the device's junction temperature cools by 20°C, the internal thermal sense circuit will enable the device, resulting in a pulsed output during continuous thermal protection. Thermal protection is designed to protect the IC in the event of over-temperature conditions. For normal operation, the junction temperature cannot exceed  $T_{j,+125^{\circ}\text{C}}$ .

## Application Information

### Input Capacitor

A 1 $\mu$ F ceramic bypass capacitor from  $V_{IN}$  to GND, located near the APL3531, is strongly recommended to suppress the ringing during short-circuit fault event. Without the bypass capacitor, the output short may cause sufficient ringing on the input (from supply lead inductance) to damage internal control circuitry.

### Output Capacitor

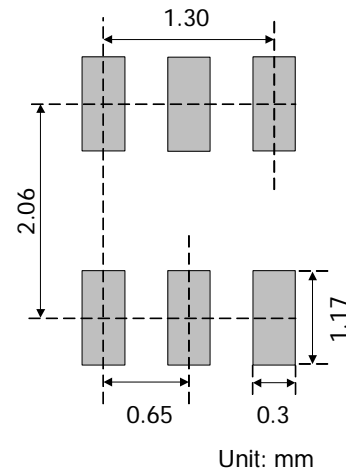
A low-ESR 10 $\mu$ F, aluminum electrolytic or tantalum between  $V_{OUT}$  and GND is strongly recommended to reduce the voltage droop during hot-attachment of downstream peripheral. Higher-value output capacitor is better when the output load is heavy. Additionally, bypassing the output with a 0.1 $\mu$ F ceramic capacitor improves the immunity of the device to short-circuit transients.

### Layout Consideration

The PCB layout should be carefully performed to maximize thermal dissipation and to minimize voltage drop, droop and EMI. The following guidelines must be considered:

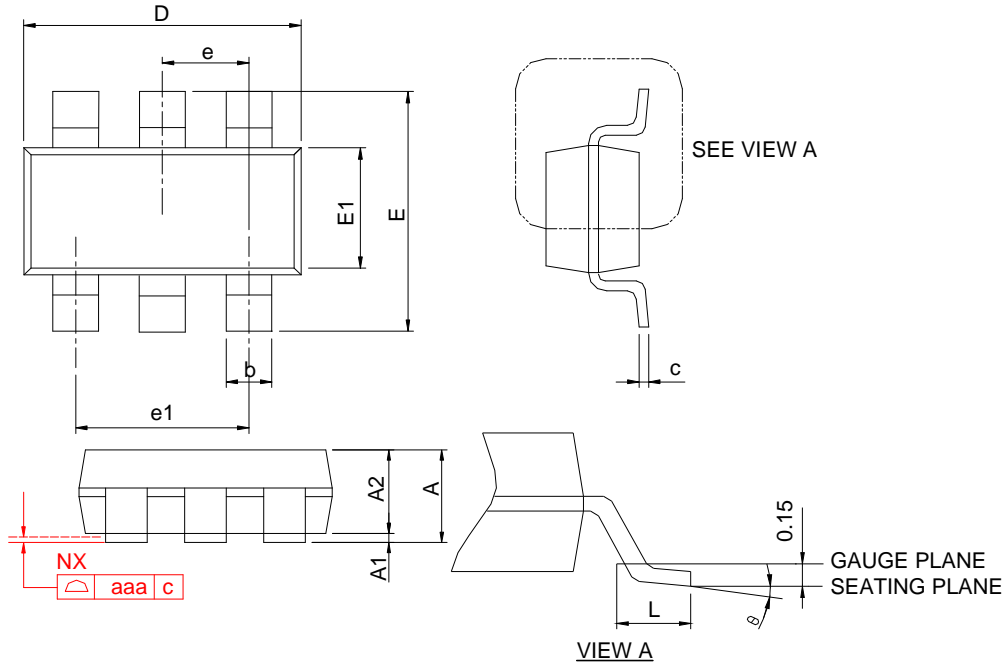
1. Please place the input capacitors near the  $V_{IN}$  pin as close as possible.
2. Output decoupling capacitors for load must be placed near the load as close as possible for decoupling high frequency ripples.
3. Locate APL3531 and output capacitors near the load to reduce parasitic resistance and inductance for excellent load transient performance.
4. The negative pins of the input and output capacitors and the GND pin must be connected to the ground plane of the load.
5. Keep  $V_{IN}$  and  $V_{OUT}$  traces as wide and short as possible.

### Recommended Minimum Footprint



Package Information

SC-70-6

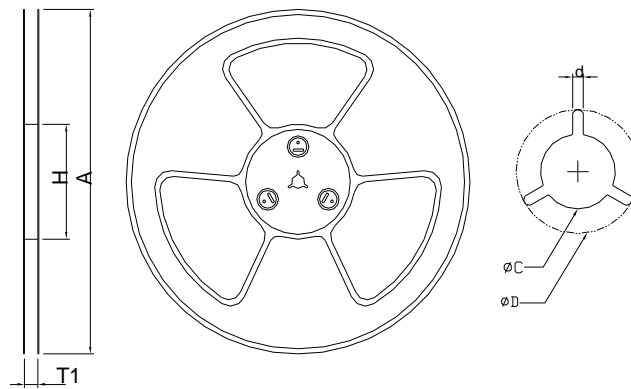
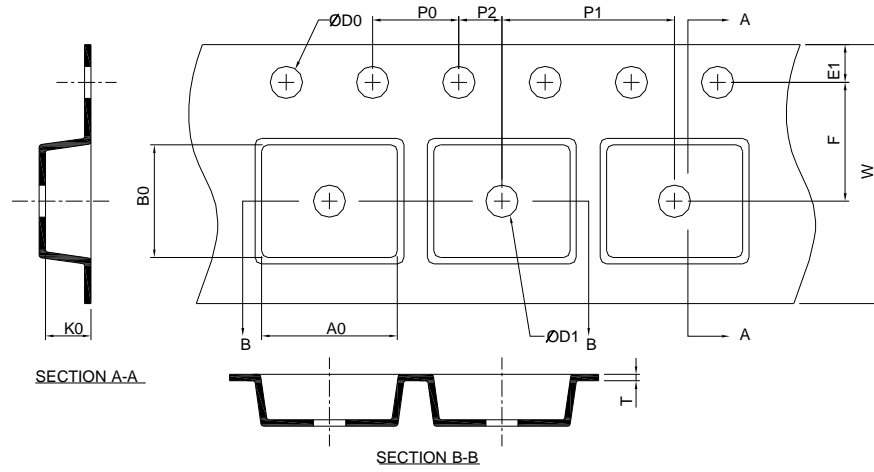


SYMBOL	SC-70-6			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.80	1.10	0.031	0.043
A1	0.00	0.10	0.000	0.004
A2	0.80	1.00	0.031	0.040
b	0.15	0.30	0.006	0.012
c	0.08	0.25	0.003	0.010
D	1.90	2.20	0.075	0.087
E	2.00	2.40	0.079	0.095
E1	1.15	1.35	0.045	0.053
e	0.65 BSC		0.026 BSC	
e1	1.30 BSC		0.051 BSC	
L	0.15	0.45	0.006	0.018
θ	0°	8°	0°	8°
aaa	0.10		0.004	

Note : 1. Followed from JEDEC MO-223 AA.  
 2. Dimension D and E1 do not include mold flash, protrusions or gate burrs.  
 Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.



### Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
SC-70-6	178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.50±0.05
	P0	P1	P2	D0	D1	T	A0	B0	K0
	4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.00 MIN.	0.6+0.00 -0.40	2.40±0.20	2.40±0.20	1.20±0.20

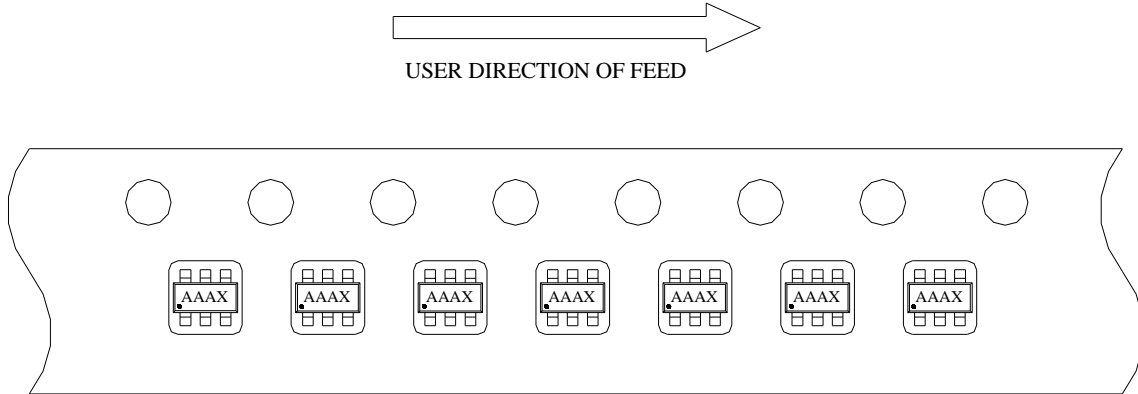
(mm)

### Devices Per Unit

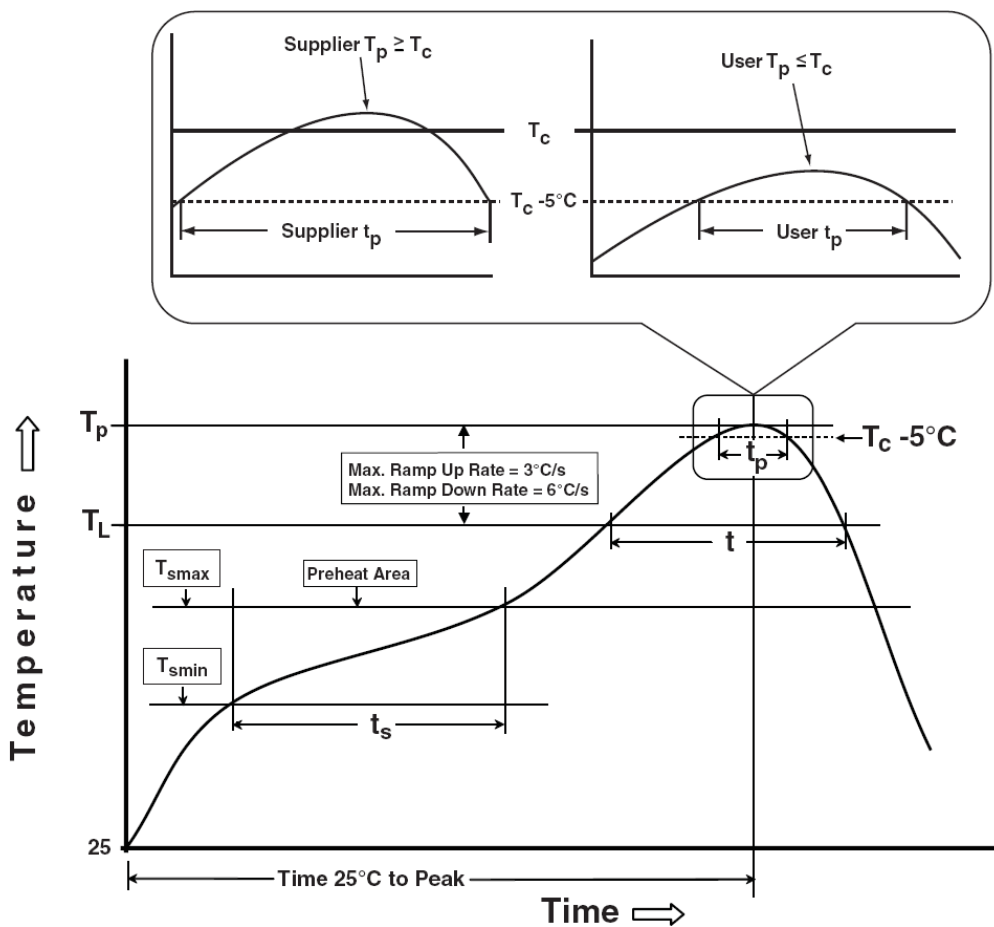
Package Type	Unit	Quantity
SC-70-6	Tape & Reel	3000

## Taping Direction Information

SC-70-6



## Classification Profile



### Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
<b>Preheat &amp; Soak</b> Temperature min ( $T_{smin}$ ) Temperature max ( $T_{smax}$ ) Time ( $T_{smin}$ to $T_{smax}$ ) ( $t_s$ )	100 °C 150 °C 60-120 seconds	150 °C 200 °C 60-120 seconds
Average ramp-up rate ( $T_{smax}$ to $T_p$ )	3 °C/second max.	3 °C/second max.
Liquidous temperature ( $T_L$ ) Time at liquidous ( $t_L$ )	183 °C 60-150 seconds	217 °C 60-150 seconds
Peak package body Temperature ( $T_p$ )*	See Classification Temp in table 1	See Classification Temp in table 2
Time ( $t_p$ )** within 5°C of the specified classification temperature ( $T_c$ )	20** seconds	30** seconds
Average ramp-down rate ( $T_p$ to $T_{smax}$ )	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.
* Tolerance for peak profile Temperature ( $T_p$ ) is defined as a supplier minimum and a user maximum. ** Tolerance for time at peak profile temperature ( $t_p$ ) is defined as a supplier minimum and a user maximum.		

Table 1. SnPb Eutectic Process – Classification Temperatures ( $T_c$ )

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> ≥350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2. Pb-free Process – Classification Temperatures ( $T_c$ )

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> 350-2000	Volume mm <sup>3</sup> >2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm – 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

### Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HOLT	JESD-22, A108	1000 Hrs, Bias @ $T_j=125^\circ\text{C}$
PCT	JESD-22, A102	168 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	500 Cycles, -65°C~150°C
HBM	MIL-STD-883-3015.7	VHBM ≥ 2KV
MM	JESD-22, A115	VMM ≥ 200V
Latch-Up	JESD 78	10ms, $I_{tr} \geq 100\text{mA}$

## Customer Service

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