Low I_Q, Low Dropout 500mA Fixed Voltage Regulator

Features

- Low Noise : 50μV_{RMS} (100Hz to 100kHz)
- Low Quiescent Current : 50μA (No load)
- Low Dropout Voltage : 170mV (@500mA)
- Very low Shutdown Current : < 0.5uA
- Fixed Output Voltage : 1.3V ~ 3.4V
- Stable with 4.7uF Output Capacitor
- Stable with Aluminum, Tantalum or Ceramic Capacitors
- Reverse Current Protection
- No Protection Diodes Needed
- Built in Thermal Protection
- Built in Current Limit Protection
- Controlled Short Circuit Current : 150mA
- Fast Transient Response
- Short Setting Time
- SOT-23-5, SOT-89, SOT-89-5, SOT-223, SO-8, TO-252 and TO-252-5 Packages
- Lead Free Available (RoHS Compliant)

Applications

- Notebook Computer
- PDA or Portable Equipments
- Noise-Sensitive Instrumentation Systems

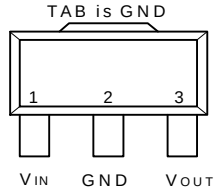
General Description

The APL5501/2/3 is micropower, low noise, low dropout linear regulator. Operate from 2.7V to 6V input voltage and deliver up to 500mA. Typical output noise is just 50μV_{RMS} with the addition of an external 0.1μF bypass capacitor in BP pin and typical dropout voltage is only 170mV at 500mA loading . Designed for use in battery-powered system, the low 50uA quiescent current makes it an ideal choice.

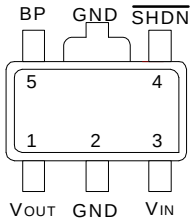
Design with an internal P-channel MOSFET pass transistor, the APL5501/2/3 maintains a low supply current, independent of the load current and dropout voltage. Other features include reverse current protection, thermal-shutdown protection, current limit protection to ensure specified output current and controlled short-circuit current. The APL5501/2/3 regulator comes in a miniature SOT-23-5, SOT-89, SOT-89-5, SOT-223, SO-8, TO-252 and TO-252-5 packages.

Pin Configuration

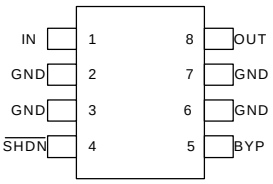
APL5501



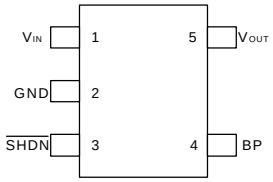
SOT-89 (Top View)



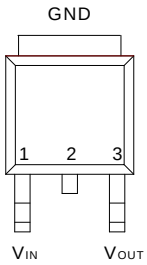
SOT-89-5 (Top View)



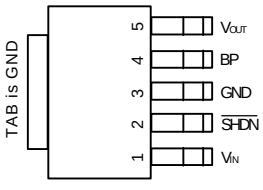
SO-8 (Top View)



SOT-23-5 (Top View)



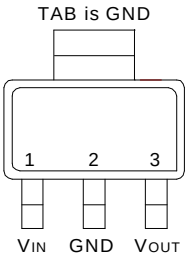
TO-252 (Top View)



TO-252-5 (Top View)

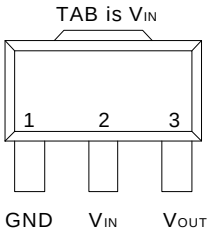
Pin Configuration (Cont.)

APL5501



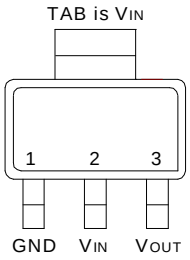
SOT-223 (Top View)

APL5502



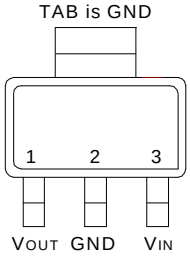
SOT-89 (Top View)

APL5502



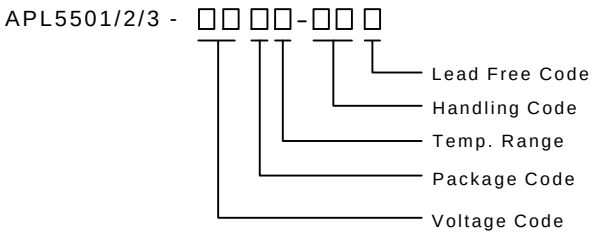
SOT-223 (Top View)

APL5503



SOT-223 (Top View)

Ordering and Marking Information



Package Code
B : SOT-23-5 D : S OT-89 D5 : SOT-89-5
U : TO-252 U5 : TO-252-5 V : SOT-223
K : SO-8
Temp. Range
C : 0 to 70 °C
Handling Code
TR : Tape & Reel
Voltage Code :
13 : 1.3V ~ 34 : 3.4V
Lead Free Code
L : Lead Free Device Blank : Original Device

APL5501/2/3 - 13 D/V/K :	APL5501/2/3 XXXXX13	XXXXX - Date Code , 13 - 1.3V
APL5501/2/3 - 13 U :	13 APL5501/2/3 XXXXX	XXXXX - Date Code , 13 - 1.3V

Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte in plate termination finish; which are fully compliant with RoHS and compatible with both SnPb and lead-free soldiering operations. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J STD-020C for MSL classification at lead-free peak reflow temperature.

Marking Information

SOT-23-5 package

Product Name	Marking	Product Name	Marking	Product Name	Marking
APL5501-13B	517X	APL5501-21B	51FX	APL5501-28B	51MX
APL5501-14B	518X	APL5501-22B	51GX	APL5501-29B	51NX
APL5501-15B	519X	APL5501-23B	51HX	APL5501-30B	51OX
APL5501-16B	51AX	APL5501-24B	51IX	APL5501-31B	51PX
APL5501-17B	51BX	APL5501-25B	51JX	APL5501-32B	51QX
APL5501-18B	51CX	APL5501-26B	51KX	APL5501-33B	51RX
APL5501-19B	51DX	APL5501-27B	51LX	APL5501-34B	51SX
APL5501-20B	51EX				

The last character “X” in the marking is for data code.

Pin Description

PIN		I/O	Description
No.	Name		
1	V_{IN}	I	Supply voltage input.
3	$\overline{SHDN}$ (Note1)	I	Shutdown control pin, low = off , high = normal. Don't leave open.
2	GND		Ground pins of the circuitry, and all ground pins must be soldered to PCB with proper power dissipation.
4	BP(Note1)	O	Bypass signal pin in fixed output type device
5	V_{OUT}	O	Output pin of the regulator.

Note1: These pins do not exist in 3-pin package.

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{IN}, V_{OUT}	Input Voltage or Out Voltage	6.5	V
$\overline{SHDN}$	Shutdown Control Pin	6.5	V
$R_{TH,JA}$	Thermal Resistance - Junction to Ambient	SOT-89 : 180 SOT-223 : 135 SO-8 : 150 SOT-23-5 : 260	°C/W
$R_{TH,JC}$	Thermal Resistance - Junction to Case	SOT-89 : 38 SOT-223 : 15 SO-8 :20 SOT-23-5 : 130	°C/W
P_D	Power Dissipation	Internally Limited	W
T_J	Operating Junction Temperature Control Section Power Transistor	 0 to 125 0 to 150	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C
T_L	Lead Temperature (Soldering, 10 second)	260	°C

Electrical Characteristics

Unless otherwise noted these specifications apply over full temperature, V_{IN}=3.6V, C_{IN}=1µF, C_{OUT}=4.7µF, SHDN=V_{IN}, T_J=0 to 125°C. Typical values refer to T_J=25°C.

Symbol	Parameter	Test Conditions	APL5501/2/3			Unit
			Min.	Typ.	Max.	
V_{IN}	Input Voltage		2.7		6	V
V_{OUT}	Output Voltage	V_{OUT}+1.0V< V_{CC}<6.0V, 0mA< I_{OUT} < I_{MAX}	V_{OUT} -2%	V_{OUT}	V_{OUT} +2%	V

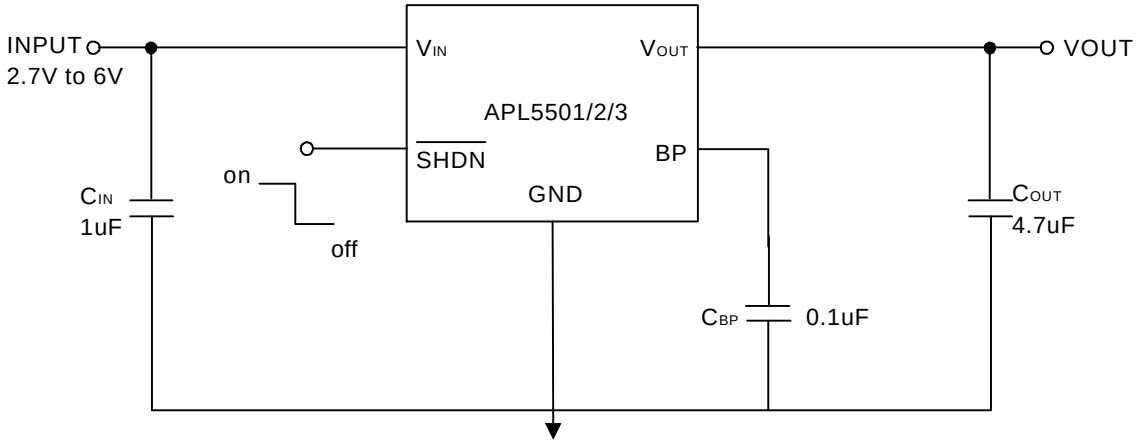
Electrical Characteristics

Unless otherwise noted these specifications apply over full temperature, V_{IN}=3.6V, C_{IN}=1µF, C_{OUT}=4.7µF, SHDN=V_{IN}, T_J=0 to 125°C. Typical values refer to T_J=25°C.

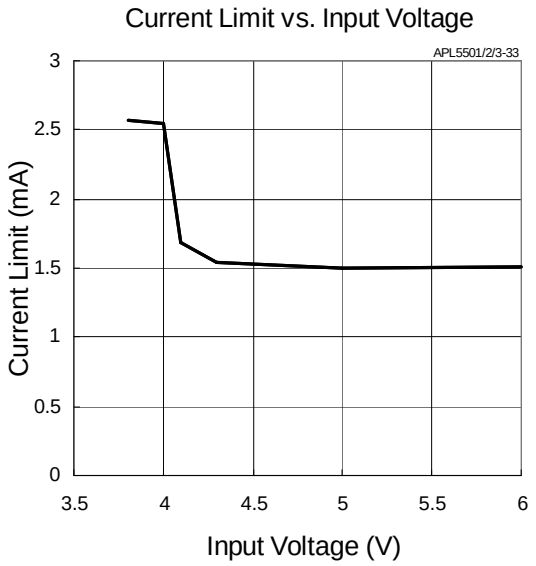
Symbol	Parameter	Test Conditions		APL5501/2/3			Unit
				Min.	Typ.	Max.	
I_{LIMIT}	Circuit Current Limit	V_{IN}=4.3V			0.7		A
I_{SHORT}	Short Current	V_{OUT}=0V			200		mA
I_{OUT}	Load Current			500			mA
REG_{LINE}	Line Regulation	V_{OUT}+0.5V< V_{CC}<6.0V, I_{OUT} = 1mA			4	10	mV
REG_{LOAD}	Load Regulation	V_{IN} =V_{OUT}+1.0V, 0mA< I_{OUT} < I_{MAX}			1	6	mV
V_{DROP}	Dropout Voltage(Note2)	I_{OUT} =500mA	1.3V≤V_{OUT}<1.5V		1100	1300	mV
			1.5V≤V_{OUT}<2V		900	1050	
			2V≤V_{OUT}<2.5V		500	700	
			2.5V≤V_{OUT}<3.4V		280	380	
PSRR	Ripple Rejection	F≤1kHz, 1Vpp at V_{IN} = V_{OUT}+1.0V		55	65		dB
I_Q	Quiescent Current	No load			50	100	µA
		I_{OUT}=500mA			370	450	
	Shutdown Supply Current(Note3)	Shutdown = low I_{OUT}=0, V_{CC} =6.0V			0.01	1	µA
	Noise(Note3)	100Hz<f<100kHz, typical load, C_{BP}=0.01µF, C_{OUT} = 1µF			50		µVrms
		100Hz<f<100kHz, typical load, C_{BP}=0.1µF, C_{OUT} = 1µF			40		
	Shutdown Recovery Delay(Note3)	C_{BP}=0.01µF,C_{OUT}=1µF, no load			7		ms
		C_{BP}=0.1µF,C_{OUT}=1µF, no load			70		
OTS	Over Temperature Shutdown				150		°C
	Over Temperature Shutdown Hysteresis	Hysteries			10		°C
TC	Output Voltage Temperature Coefficient				50		ppm/°C
C_{OUT}	Output Capacitor			4.2	4.7	5.2	µF
	ESR			0.02	0.1	1	Ohm
	Shutdown Input Threshold(Note3)	V_{OUT}+1.0V< V_{IN} <6.0V		0.4	0.7	1.6	V
$I_{\overline{SHDN}}$	Shutdown input Bias current(Note3)	$V_{\overline{SHDN}}$=V_{IN}			0.01	100	nA
	Input Reverse Leakage current	V_{OUT}-V_{IN}=0.1V			0.1	0.5	µA
	Reverse Protection Threshold				11	50	mV

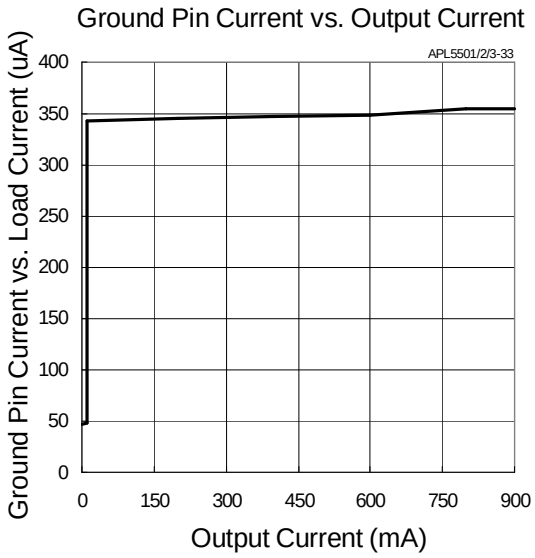
Note 2 : Dropout voltage definition : V_{IN}-V_{OUT} when V_{OUT} is 2% below the value of V_{OUT} for V_{IN} = V_{OUT} + 0.5V
Note 3 : For 5-pin devices only.

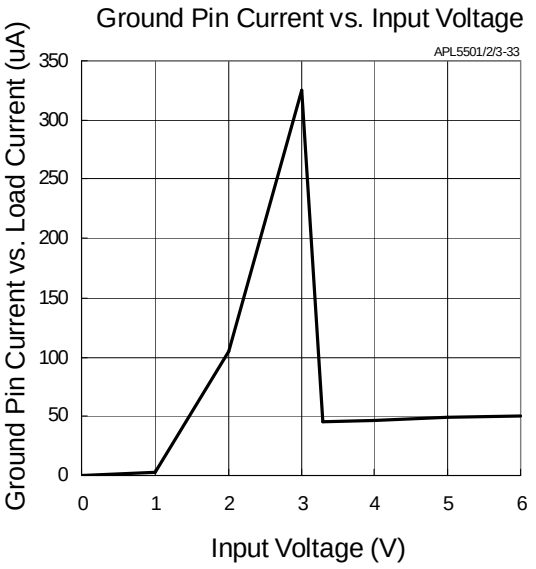
Application Circuit

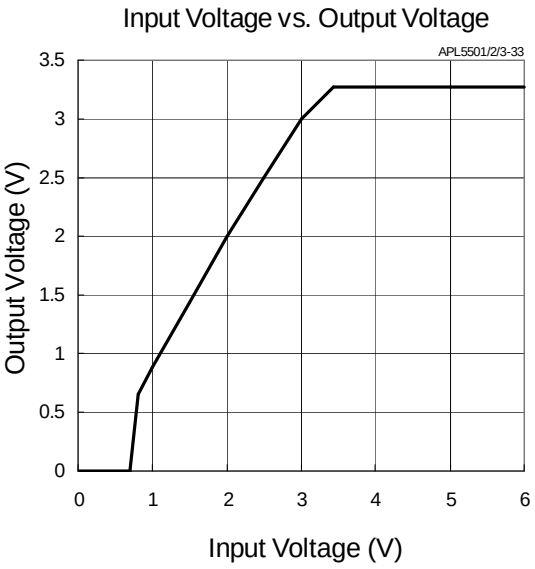


Typical Characteristics



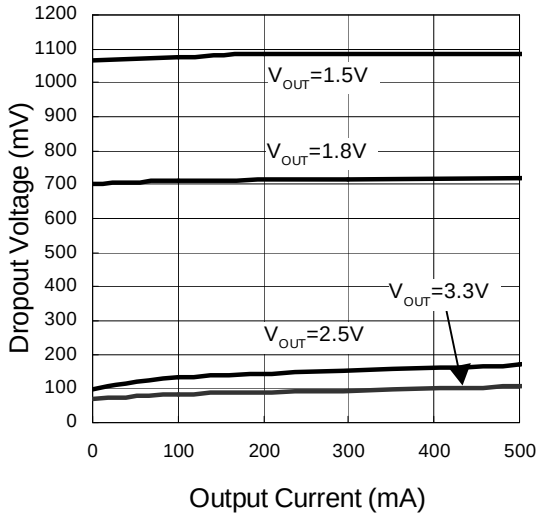




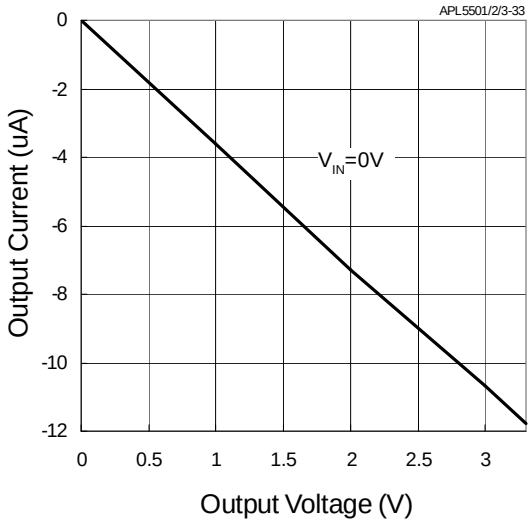


Typical Characteristics

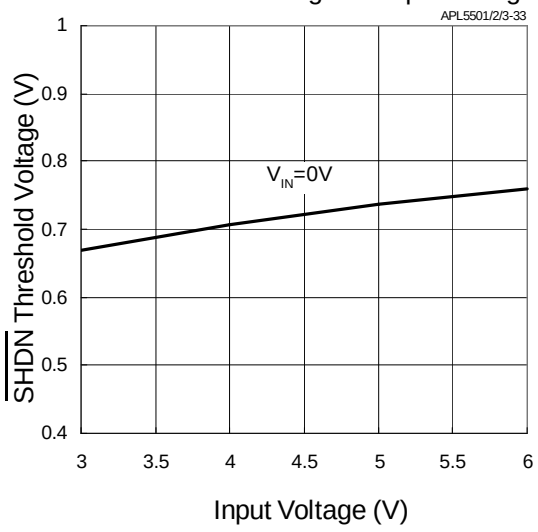
Dropout Voltage vs. Output Current



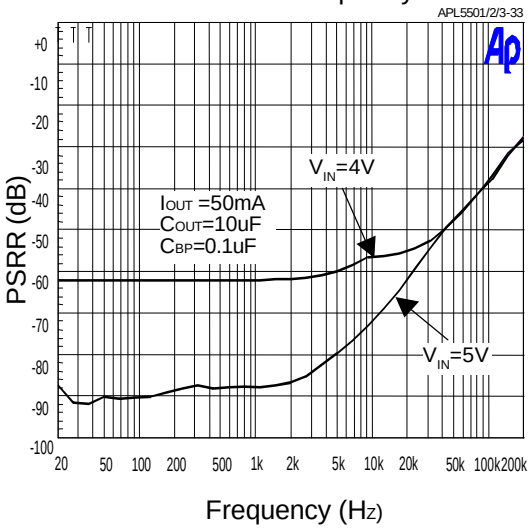
Output Current vs. Output Voltage



SHDN Threshold Voltage vs. Input Voltage

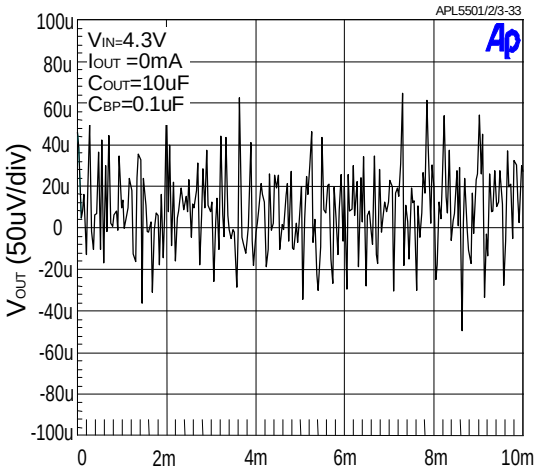


PSRR vs. Frequency

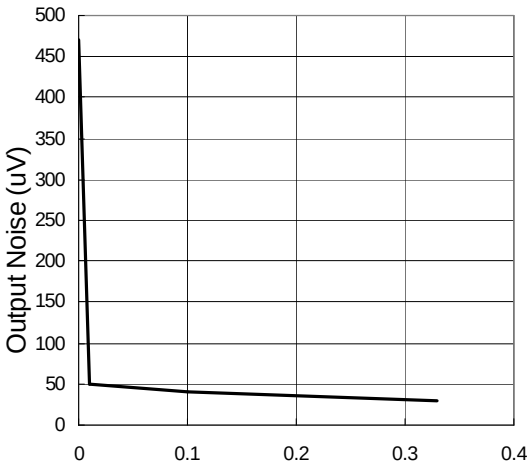


Typical Characteristics

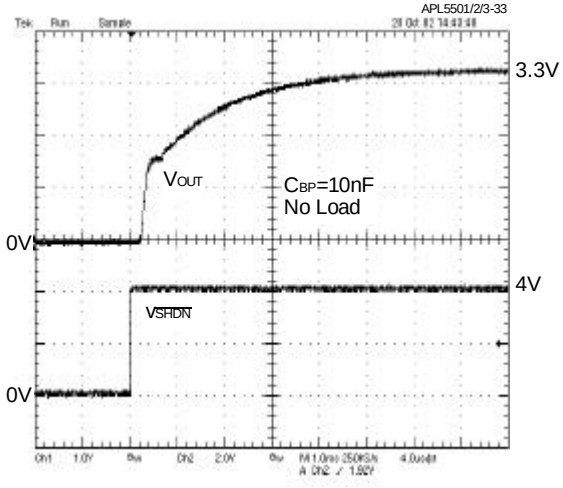
Output Noise



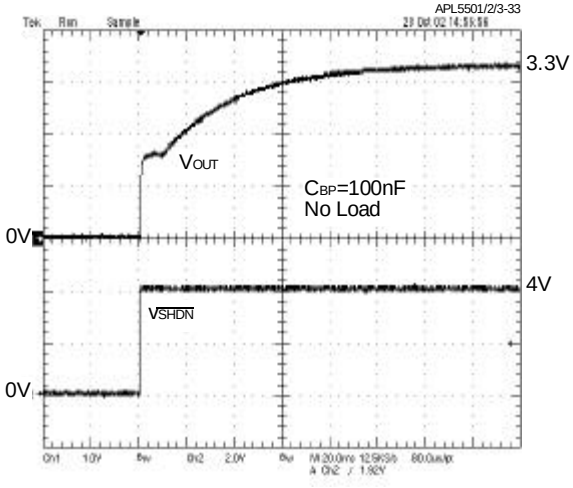
Output Noise vs. Bypass Capacitor



Shutdown Exit Delay

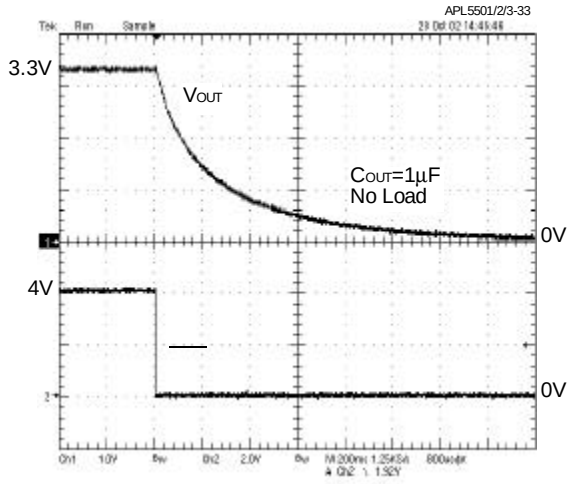


Shutdown Exit Delay



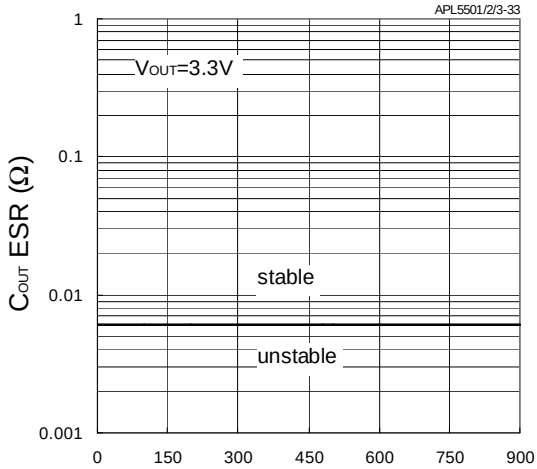
Typical Characteristics

Entering Shutdown



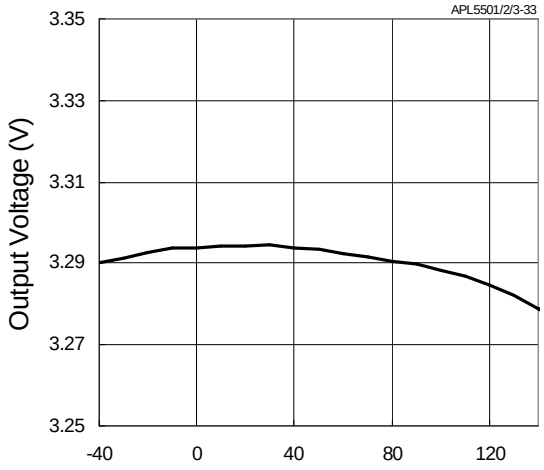
Time (200ms/div)

Region of Stable ESR vs. Load Current



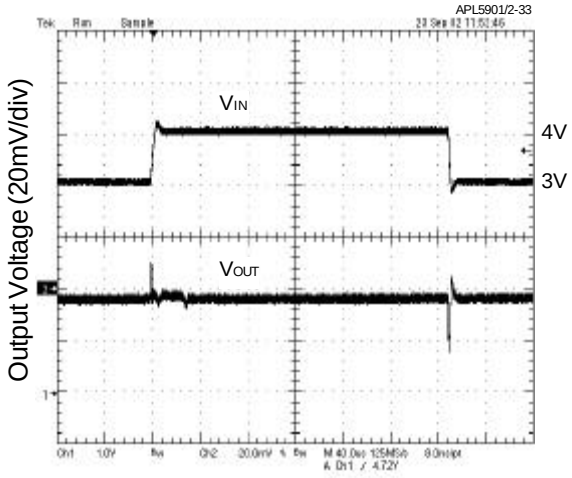
Load Current (mA)

Output Voltage vs. Temperature



Temperature (°C)

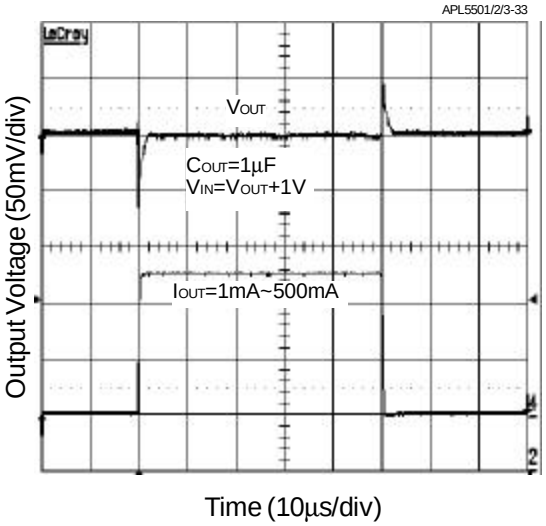
Line-Transient Response



Time (40µs/div)

Typical Characteristics

Load-Transient Response



Application Information

Capacitor Selection and Regulator Stability

The APL5501/2/3 use at least a 1uF capacitor on the input, and this capacitor can be Aluminum, Tantalum or Ceramic capacitor. The input capacitor with larger value and lower ESR provides better PSRR and line-transient response. The output capacitor also can use Aluminum, Tantalum or Ceramic capacitor, and a minimum value of 1uF and ESR above 0.06Ω is recommended. The curve of the stable region in typical characteristics shows the appropriate output capacitor ESR for different load current stable operation. A larger output capacitor can reduce noise and improve load-transient response, stability, and PSRR. Note that some ceramic dielectrics exhibit large capacitance and ESR variation with temperature. When using this capacitor, a minimum 10uF or more may be required to ensure the stability at low temperature operation. Use a bypass capacitor at BP pin for low output nvise. Increasing the capacitance will slightly decrease the output noise, but increase the start-up time.

Load-Transient Considerations

The APL5501/2/3 load-transient response graphs in typical characteristics show the transient response. A step change in the load current from 0mA to 500mA at 1us will cause a 100mV transient spike. Larger output capacitor and lower ESR can reduce transient spike.

Input-Output (Dropout)Voltage

The minimum input-output voltage difference (dropout) determines the lowest usable supply voltage. In battery-powered systems, this will determine the useful end-of-life battery voltage. Because the APL5501/2/3 use a p-channel MOSFET pass transistor, the drop-out voltage is a function of drain-to-source on-resistance ($R_{DS(ON)}$) multiplied by the load current.

Reverse Current Protection

The APL5501/2/3 have an internal reverse protection, it does not need an external schottky diode to connect the regulator input and output. If the output voltage is forced above the input voltage by more than 11mV, the IC will be shutdown and the ground pin current is below 0.1uA.

Shutdown/Enable

The APL5501/2/3 have an active high enable function. Force EN high (>1.6V) enables the regulator, EN low (<0.4V) disables the regulator and enter the shutdown mode. In shutdown mode, the quiescent current can reduce below 1uA. The EN pin cannot be floating, a floating EN pin may cause an indeterminate state on the output. If it is no use, connect to V_{IN} for normal operation.

Current Limit

The APL5501/2/3 have a current limit protection. The ouptut voltage will drop close to zero volt, when load current reaches the limit, and then the load current will be limited at 150mA after output voltage is below 0.7V. When the load current back to the value where limiting started, the output voltage and current will return to normal value. When output is shorted to ground, the APL5501/2/3 will keep short circuit current at 150mA .

Thermal Protection

Thermal protection limits total power dissipation in the device. When the junction temperature exceeds T_J=+150°C, the thermal sensor generates a logic signal to turn off the pass transistor and allows IC to cool. When the IC's junction temperature is down by 10°C, the thermal sensor will turn the pass transistor on again, resulting in a pulsed output during continuous thermal protection. Thermal protection is designed to protect the APL5501/2/3 in the event of fault conditions. For continuous operation, do not exceed the absolute maximum junction temperature of T_J=+150°C.

Operating Region and Power Dissipation

The thermal resistance of the case to circuit board, and the rate of air flow all control the APL5501/2/3's maximum power dissipation. The power dissipation across the device is $P_D = I_{OUT}(V_{IN}-V_{OUT})$ and the maximum power dissipation is:

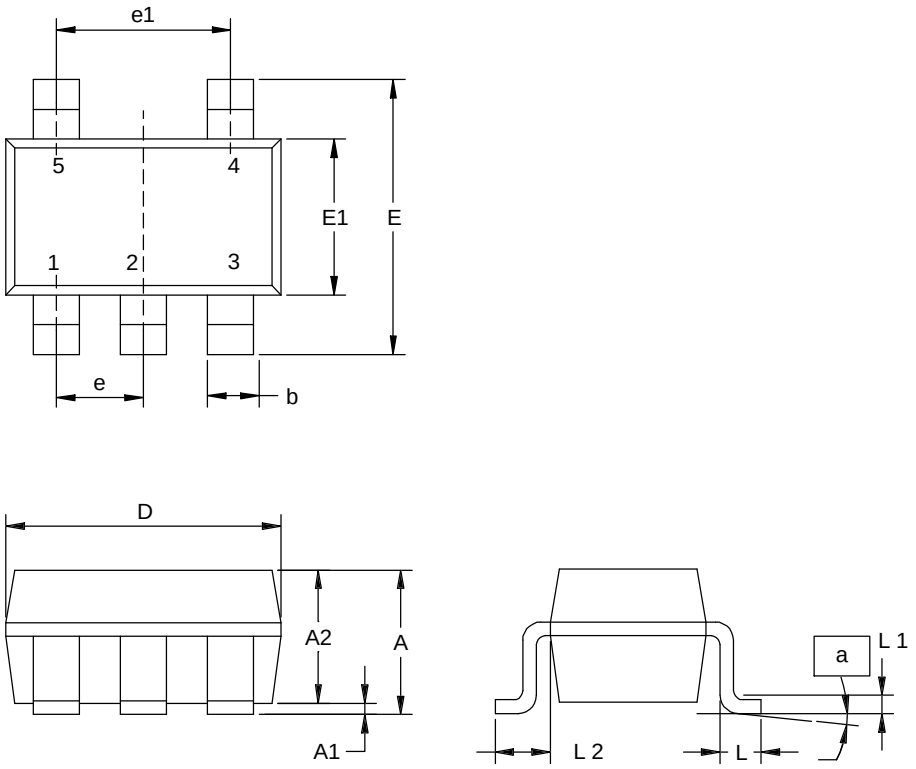
$P_{DMAX} = (T_J-T_A) / (\theta_{JC} + \theta_{CA})$

where T_J-T_A is the temperature difference between the junction and ambient air, θ_{JC} is the thermal resistance of the package, and θ_{CA} is the thermal resistance through the printed circuit board, copper traces, and other materials to the ambient air.

The GND pin of the APL5501/3 provide an electrical connection to ground and channeling heat away. If power dissipation is large, connect the GND pin to ground using a large pad or ground plane, can improve the problem of over heat of IC.

Packaging Information

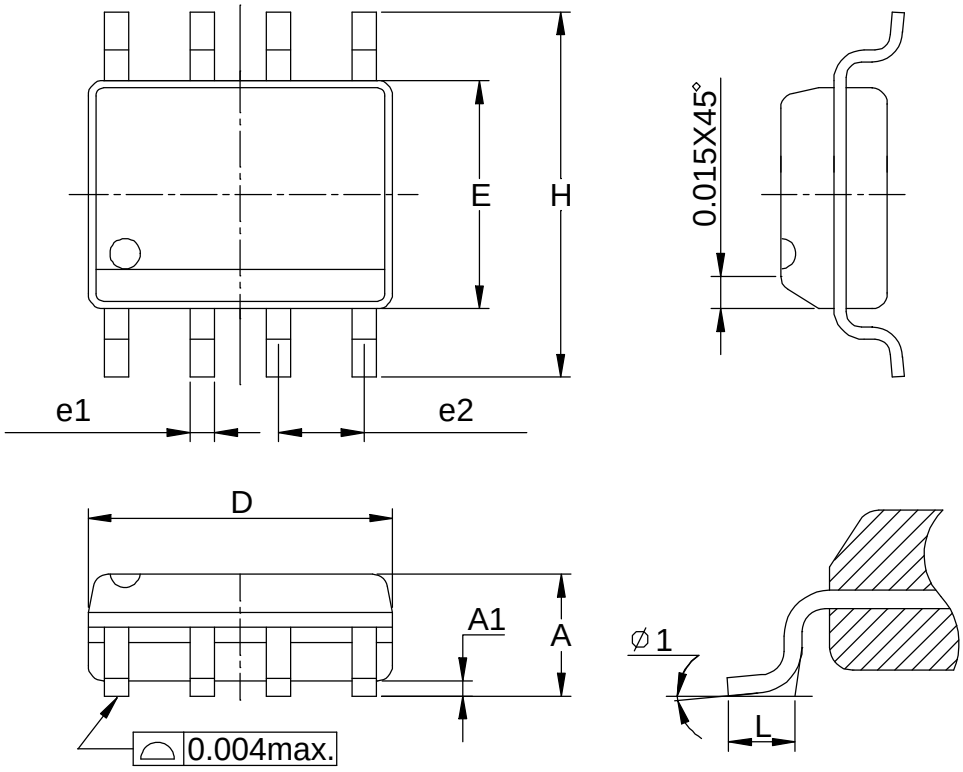
SOT-23-5



Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.95	1.45	0.037	0.057
A1	0.05	0.15	0.002	0.006
A2	0.90	1.30	0.035	0.051
D	2.8	3.00	0.110	0.118
E	2.6	3.00	0.102	0.118
E1	1.5	1.70	0.059	0.067
L	0.35	0.55	0.014	0.022
L1	0.20 BSC		0.008 BSC	
L2	0.5	0.7	0.020	0.028
N	5		5	
α	0°	10°	0°	10°

Packaging Information

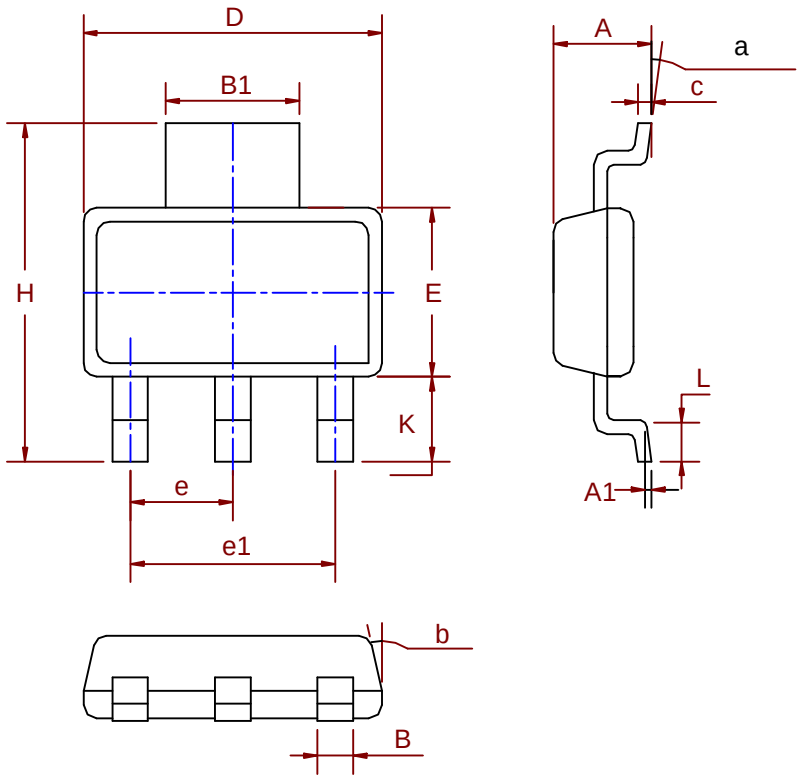
SOP-8 pin (Reference JEDEC Registration MS-012)



Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
D	4.80	5.00	0.189	0.197
E	3.80	4.00	0.150	0.157
H	5.80	6.20	0.228	0.244
L	0.40	1.27	0.016	0.050
e1	0.33	0.51	0.013	0.020
e2	1.27BSC		0.50BSC	
ϕ 1	8°		8°	

Packaging Information

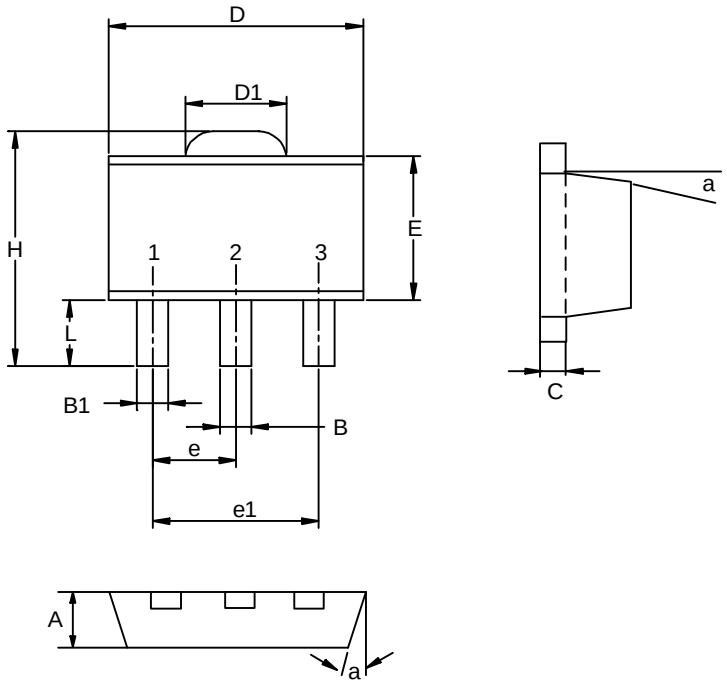
SOT-223(Reference JEDEC Registration SOT-223)



Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.50	1.80	0.06	0.07
A1	0.02	0.08		
B	0.60	0.80	0.02	0.03
B1	2.90	3.10	0.11	0.12
c	0.28	0.32	0.01	0.01
D	6.30	6.70	0.25	0.26
E	3.30	3.70	0.13	0.15
e	2.3 BSC		0.09 BSC	
e1	4.6 BSC		0.18 BSC	
H	6.70	7.30	0.26	0.29
L	0.91	1.10	0.04	0.04
K	1.50	2.00	0.06	0.08
α	0°	10°	0°	10°
β	13°		13°	

Packaging Information

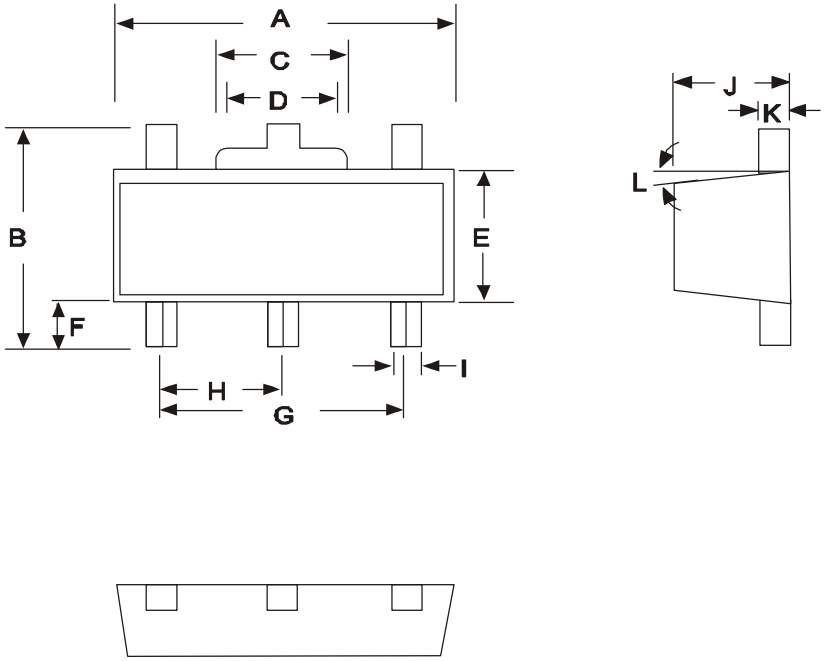
SOT-89 (Reference EIAJ ED-7500A Reg stration SC-62)



Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.40	1.60	0.055	0.063
B	0.40	0.56	0.016	0.022
B1	0.35	0.48	0.014	0.019
C	0.35	0.44	0.014	0.017
D	4.40	4.60	0.173	0.181
D1	1.35	1.83	0.053	0.072
e	1.50 BSC		0.059 BSC	
e1	3.00 BSC		0.118 BSC	
E	2.29	2.60	0.090	0.102
H	3.75	4.25	0.148	0.167
L	0.80	1.20	0.031	0.047
α		10°		10°

Packaging Information

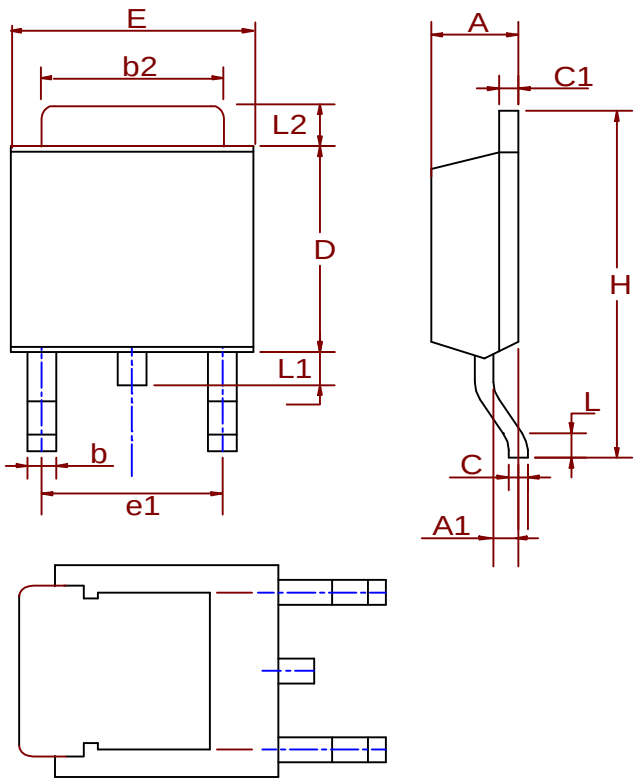
SOT-89-5



Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	4.40	4.60	0.17	0.18
B	4.05	4.25	0.16	0.17
C	1.50	1.70	0.06	0.07
D	1.30	1.50	0.05	0.06
E	2.40	2.60	0.09	0.1
F	0.80	-	0.03	-
G	3.00 REF		0.12 REF	
H	1.50 REF		0.06 REF	
I	0.40	0.52	0.01	0.02
J	1.40	1.60	0.05	0.06
K	0.35	0.41	0.01	0.02
L	5 TYP		0.2 TYP	

Packaging Information

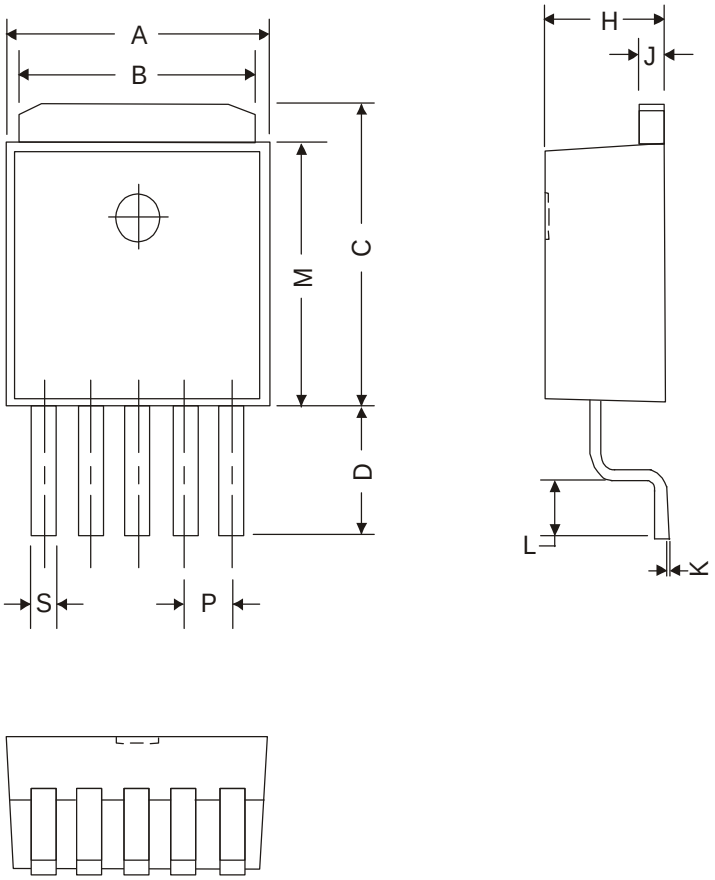
TO-252(Reference JEDEC Registration TO-252)



Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	2.18	2.39	0.086	0.094
A1	0.89	1.27	0.035	0.050
b	0.508	0.89	0.020	0.035
b2	5.207	5.461	0.205	0.215
C	0.46	0.58	0.018	0.023
C1	0.46	0.58	0.018	0.023
D	5.334	6.22	0.210	0.245
E	6.35	6.73	0.250	0.265
e1	3.96	5.18	0.156	0.204
H	9.398	10.41	0.370	0.410
L	0.51		0.020	
L1	0.64	1.02	0.025	0.040
L2	0.89	2.032	0.035	0.080

Packaging Information

TO-252-5

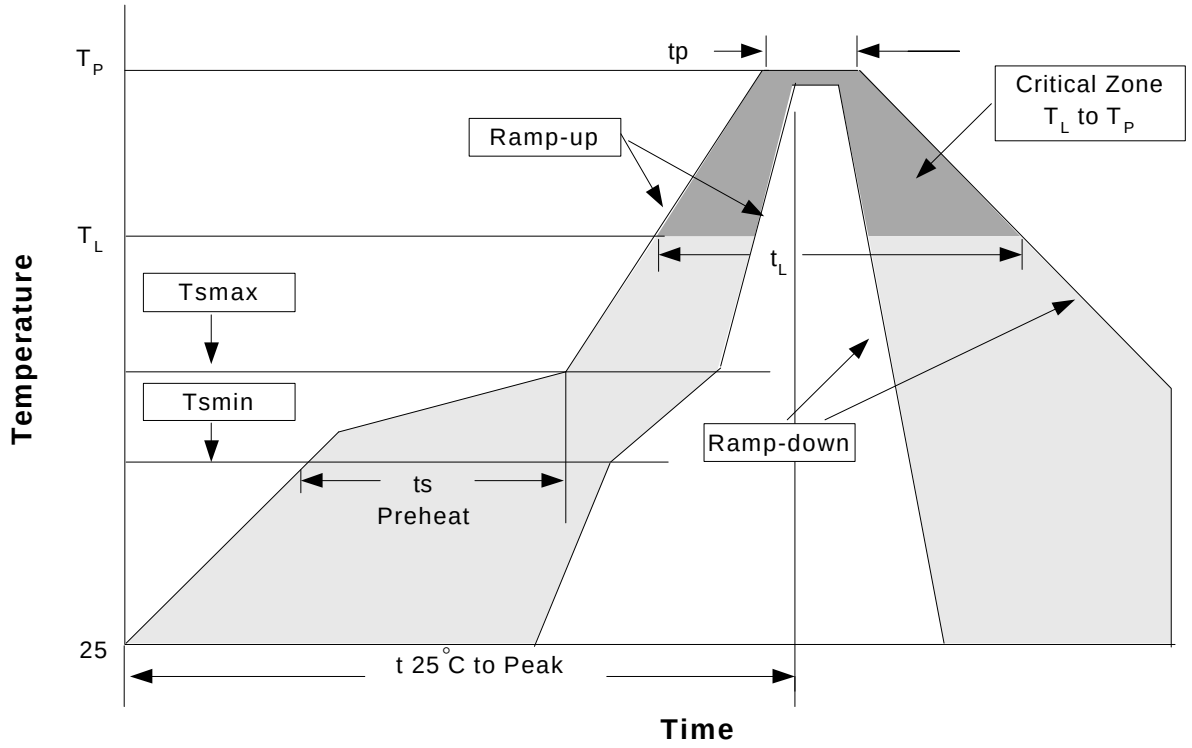


Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	6.40	6.80	0.25	0.26
B	5.20	5.50	0.20	0.21
C	6.80	7.20	0.26	0.27
D	2.20	2.80	0.08	0.11
P	1.27 REF		0.05 REF	
S	0.50	0.80	0.02	0.03
H	2.20	2.40	0.08	0.09
J	0.45	0.55	0.01	0.02
K	0	0.15	0	0.006
L	0.90	1.50	0.03	0.06
M	5.40	5.80	0.21	0.22

Physical Specifications

Terminal Material	Solder-Plated Copper (Solder Material : 90/10 or 63/37 SnPb), 100%Sn
Lead Solderability	Meets EIA Specification RSI86-91, ANSI/J-STD-002 Category 3.

Reflow Condition (IR/Convection or VPR Reflow)



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate (T_L to T_P)	3°C/second max.	3°C/second max.
Preheat - Temperature Min (Tsmin) - Temperature Max (Tsmax) - Time (min to max) (ts)	100°C 150°C 60-120 seconds	150°C 200°C 60-180 seconds
Time maintained above: - Temperature (T_L) - Time (t_L)	183°C 60-150 seconds	217°C 60-150 seconds
Peak/Classificatioon Temperature (Tp)	See table 1	See table 2
Time within 5°C of actual Peak Temperature (tp)	10-30 seconds	20-40 seconds
Ramp-down Rate	6°C/second max.	6°C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.

Notes: All temperatures refer to topside of the package .Measured on the body surface.

(mm)

Classification Reflow Profiles(Cont.)

Table 1. SnPb Entectic Process – Package Peak Reflow Temperatures

Package Thickness	Volume mm^3 <350	Volume mm^3 ³350
<2.5 mm	240 +0/-5°C	225 +0/-5°C
≥2.5 mm	225 +0/-5°C	225 +0/-5°C

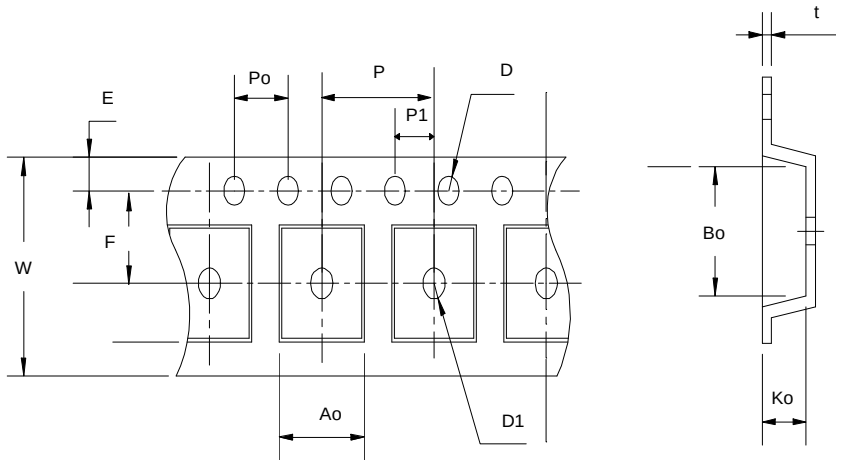
Table 2. Pb-free Process – Package Classification Reflow Temperatures

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260 +0°C*	260 +0°C*	260 +0°C*
1.6 mm – 2.5 mm	260 +0°C*	250 +0°C*	245 +0°C*
≥2.5 mm	250 +0°C*	245 +0°C*	245 +0°C*
*Tolerance: The device manufacturer/supplier **shall** assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.			

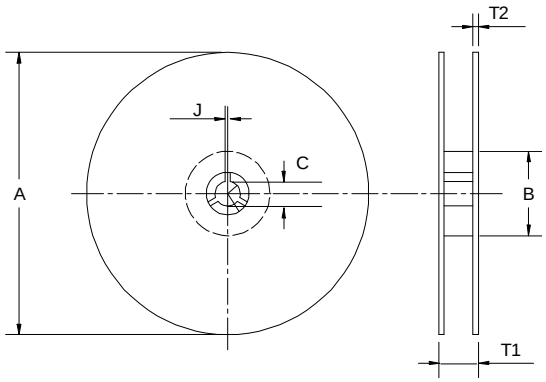
Reliability Test Program

Test item	Method	Description
SOLDERABILITY	MIL-STD-883D-2003	245°C, 5 SEC
HOLT	MIL-STD-883D-1005.7	1000 Hrs Bias @125°C
PCT	JESD-22-B,A102	168 Hrs, 100%RH, 121°C
TST	MIL-STD-883D-1011.9	-65°C~150°C, 200 Cycles
ESD	MIL-STD-883D-3015.7	VHBM > 2KV, VMM > 200V
Latch-Up	JESD 78	10ms, 1_{tr} > 100mA

Carrier Tape & Reel Dimensions



Carrier Tape & Reel Dimensions(Cont.)



Reel Dimensions

Application	A	B	C	J	T1	T2	W	P	E
SOP- 8	330 ± 1	62 +1.5	12.75+ 0.15	2 ± 0.5	12.4 ± 0.2	2 ± 0.2	12± 0. 3	8± 0.1	1.75±0.1
	F	D	D1	Po	P1	Ao	Bo	Ko	t
	5.5± 1	1.55 +0.1	1.55+ 0.25	4.0 ± 0.1	2.0 ± 0.1	6.4 ± 0.1	5.2± 0. 1	2.1± 0.1	0.3±0.013
Application	A	B	C	J	T1	T2	W	P	E
SOT-89	178 ±1	70 ± 2	13.5 ± 0.15	3 ± 0.15	14 ± 2	1.3 ± 0.3	12 + 0.3 12 - 0.1	8 ± 0.1	1.75± 0.1
	F	D	D1	Po	P1	Ao	Bo	Ko	t
	5.5 ± 0.05	1.5± 0.1	1.5± 0.1	4.0 ± 0.1	2.0 ± 0.1	4.8 ± 0.1	4.5± 0.1	1.80± 0.1	0.3±0.013
Application	A	B	C	J	T1	T2	W	P	E
SOT-223	330±1	62±1.5	12.75± 0.15	2 ± 0.6	12.4 +0.2	2± 0.2	12 ± 0.3	8 ± 0.1	1.75± 0.1
	F	D	D1	Po	P1	Ao	Bo	Ko	t
	5.5 ± 0.05	1.5+ 0.1	1.5+ 0.1	4.0 ± 0.1	2.0 ± 0.05	6.9 ± 0.1	7.5± 0.1	2.1± 0.1	0.3±0.05
Application	A	B	C	J	T1	T2	W	P	E
TO-252	330 ±3	100 ± 2	13 ± 0. 5	2 ± 0.5	16.4 + 0.3 -0.2	2.5± 0.5	16+ 0.3 - 0.1	8 ± 0.1	1.75± 0.1
	F	D	D1	Po	P1	Ao	Bo	Ko	t
	7.5 ± 0.1	1.5 +0.1	1.5± 0.25	4.0 ± 0.1	2.0 ± 0.1	6.8 ± 0.1	10.4± 0.1	2.5± 0.1	0.3±0.05

(mm)

Cover Tape Dimensions

Application	Carrier Width	Cover Tape Width	Devices Per Reel
SOP- 8	12	9.3	2500
SOT- 89	12	9.3	1000
SOT- 223	12	9.3	2500
TO- 252	16	13.3	2500

Customer Service

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