

1A Low Dropout Fast Response Positive Adjustable Regulator and Fixed 1.2V, 1.8V, 2.5V, 2.85V, 3.3V and 5V

Features

- **Guaranteed Output Voltage Accuracy within 2%**
- **Fast Transient Response**
- **Guaranteed Dropout Voltage at Multiple Currents**
- **Load Regulation : 0.1% Typ.**
- **Line Regulation : 0.03% Typ.**
- **Low Dropout Voltage : 1.1V Typ. at I_{OUT} =1A**
- **Current-Limit : 1A Typ. at T_J=25°C**
- **On-Chip Thermal Limiting : 150°C Typ.**
- **Adjustable Output : 1.25~10.7V**
- **Standard 3-pin TO-220, TO-252-3, TO-263-3 and SOT-223 Power Packages**
- **Lead Free and Green Devices Available (RoHS Compliant)**

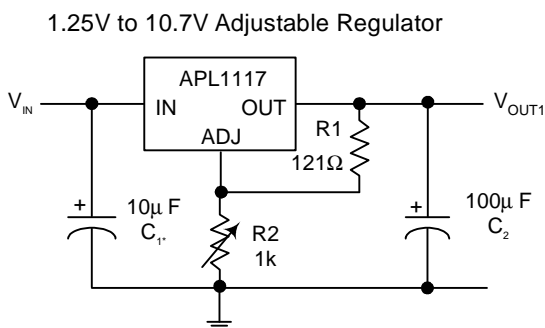
Applications

- **Active SCSI Terminators**
- **Low Voltage Logic Supplies**
- **Post Regulator for Switching Power Supply**

General Description

The APL1117 is a low dropout three-terminal adjustable regulators with 1A output current capability. In order to obtain lower dropout voltage and faster transient response, which is critical for low voltage applications, the APL1117 has been optimized. The device is available in an adjustable version and fixed output voltages of 1.2V, 1.8V, 2.5V, 2.85V, 3.3V, and 5V. The output available voltage range of an adjustable version is from 1.25 to 10.7V with an input supply below 12V. Dropout voltage is guaranteed at a maximum of 1.3V at 1A. Current limit is trimmed to ensure specified output current and controlled short-circuit current. On-chip thermal limiting provides protection against any combination of overload that would create excessive junction temperatures. The APL1117 is available in the industry standard 3-pin TO-220, TO-252-3, TO-263-3, and the low profile surface mount SOT-223 power packages which can be used in applications where space is limited.

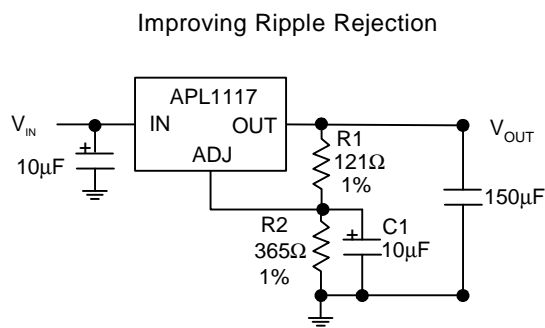
Simplified Application Circuits



* Needed if device is far from filter capacitors

$$V_{OUT} = 1.250V \times \frac{R1 + R2}{R1}$$

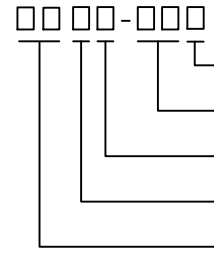


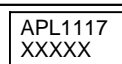
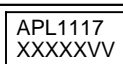
5V Regulator with Shutdown



* C1 improves ripple rejection. X_C should be approximately equal to R1 at ripple frequency

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.

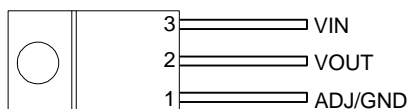
Ordering and Marking Information

<p>APL1117 □□□□-□□□□</p>  <p>Assembly Material</p> <p>Handling Code</p> <p>Temperature Range</p> <p>Package Code</p> <p>Voltage Code</p>	<p>Package Code F : TO-220 G : TO-263-3 U : TO-252-3 V : SOT-223</p> <p>Operating Ambient Temperature Range C : 0 to 70 °C</p> <p>Handling Code TU : Tube TR : Tape & Reel</p> <p>Voltage Code 12 : 1.2V 18 : 1.8V 25 : 2.5V 28 : 2.85V 33 : 3.3V 50 : 5V Blank : Adjustable Version</p> <p>Assembly Material L : Lead Free Device G : Halogen and Lead Free Device</p>
<p>APL1117 F/G/U:</p>   <p>XXXXX - Date Code ; VV-Voltage Code</p>	
<p>APL1117 V:</p>   <p>XXXXX - Date Code ; VV-Voltage Code</p>	

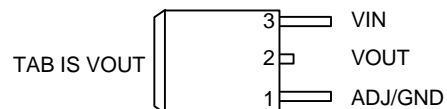
Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020D for MSL classification at lead-free peak reflow temperature.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

Pin Configuration

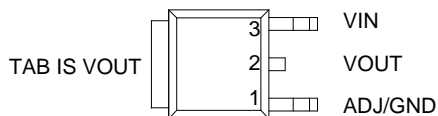
Front View for TO-220



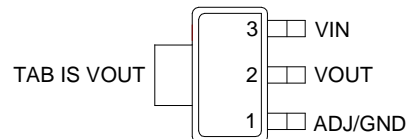
Front View for TO-263-3



Front View for TO-252-3



Front View for SOT-223



Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{IN}	Input Voltage APL1117, APL1117-33 APL1117-50 APL1117-12, APL1117-18, APL1117-25, APL1117-28	15 13 9	V
T_J	Junction Temperature Range	0 to 150	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C
T_{SDR}	Maximum Lead Soldering Temperature, 10 Seconds	260	°C

Note 1: The values here show the absolute maximum rating, and for normal usage please refer the test condition in Electrical Characteristics Table.

Recommended Operating Conditions

Symbol	Parameter	Range	Unit
T_A	Ambient Temperature	0 ~ 70	°C
T_J	Junction Temperature	0 ~ 125	°C

Electrical Characteristics

Unless otherwise noted, these specifications apply over $C_{IN} = 10\mu F$, $C_{OUT} = 10\mu F$, and $T_A = 0$ to $70^\circ C$. Typical values refer to $T_A = 25^\circ C$.

Symbol	Parameter	Test Conditions	APL1117			Unit
			Min.	Typ.	Max.	
V_{REF}	Reference Voltage	$10mA \leq I_{OUT} \leq 1A$, $1.4V \leq (V_{IN} - V_{OUT}) \leq 10.75V$, $T_J = 0 \sim 125^\circ C$	1.225	1.250	1.275	V
V_{OUT}	Output Voltage					V
	APL1117-12	$T_J = 0 \sim 125^\circ C$, $0 \leq I_{OUT} \leq 1A$, $2.65V \leq V_{IN} \leq 9V$	1.176	1.200	1.224	
	APL1117-18	$T_J = 0 \sim 125^\circ C$, $0 \leq I_{OUT} \leq 1A$, $3.25V \leq V_{IN} \leq 9V$	1.764	1.800	1.836	
	APL1117-25	$T_J = 0 \sim 125^\circ C$, $0 \leq I_{OUT} \leq 1A$, $3.95V \leq V_{IN} \leq 9V$	2.450	2.500	2.550	
	APL1117-28	$T_J = 0 \sim 125^\circ C$, $0 \leq I_{OUT} \leq 1A$, $4.25V \leq V_{IN} \leq 9V$	2.790	2.850	2.910	
	APL1117-33	$T_J = 0 \sim 125^\circ C$, $0 \leq I_{OUT} \leq 1A$, $4.75V \leq V_{IN} \leq 12V$	3.235	3.300	3.365	
REG_{LINE}	Line Regulation					%
	APL1117	$I_{OUT} = 10mA$, $1.5V \leq (V_{IN} - V_{OUT}) \leq 10.75V$ (Note 2)	-	0.03	0.2	
	APL1117-12	$I_{OUT} = 0A$, $2.65V \leq V_{IN} \leq 9V$ (Note 2)	-	1	6	
	APL1117-18	$I_{OUT} = 0A$, $3.25V \leq V_{IN} \leq 9V$ (Note 2)	-	1	6	
	APL1117-25	$I_{OUT} = 0A$, $3.95V \leq V_{IN} \leq 9V$ (Note 2)	-	1	6	
	APL1117-28	$I_{OUT} = 0A$, $4.25V \leq V_{IN} \leq 9V$ (Note 2)	-	1	6	
	APL1117-33	$I_{OUT} = 0A$, $4.75V \leq V_{IN} \leq 12V$ (Note 2)	-	1	6	
APL1117-50	$I_{OUT} = 0A$, $6.45V \leq V_{IN} \leq 12V$ (Note 2)	-	1	6		

Electrical Characteristics (Cont.)

Unless otherwise noted, these specifications apply over $C_{IN} = 10\mu F$, $C_{OUT} = 10\mu F$, and $T_A = 0$ to $70^\circ C$. Typical values refer to $T_A = 25^\circ C$.

Symbol	Parameter	Test Conditions	APL1117			Unit
			Min.	Typ.	Max.	
REG _{LOAD}	Load Regulation APL1117	$(V_{IN}-V_{OUT})=3V, 0 \leq I_{OUT} \leq 1A$ (Note 2)	-	0.1	0.4	%
	APL1117-12	$V_{IN} = 2.65V, 0 \leq I_{OUT} \leq 1A$ (Note 2)	-	1	10	
	APL1117-18	$V_{IN} = 3.25V, 0 \leq I_{OUT} \leq 1A$ (Note 2)	-	1	10	
	APL1117-25	$V_{IN} = 3.95V, 0 \leq I_{OUT} \leq 1A$ (Note 2)	-	1	10	mV
	APL1117-28	$V_{IN} = 4.25V, 0 \leq I_{OUT} \leq 1A$ (Note 2)	-	1	10	
	APL1117-33	$V_{IN} = 4.75V, 0 \leq I_{OUT} \leq 1A$ (Note 2)	-	1	10	
	APL1117-50	$V_{IN} = 6.45V, 0 \leq I_{OUT} \leq 1A$ (Note 2)	-	1	10	
V _D	Dropout Voltage	$I_{OUT} = 100mA$ (Note 3) $I_{OUT} = 500mA$ (Note 3) $I_{OUT} = 1A$ (Note 3)	-	1 1.05 1.1	1.1 1.2 1.3	V
I _{LIMIT}	Current-Limit	$(V_{IN}-V_{OUT}) = 5V, T_J = 25^\circ C$	1000	-	-	mA
I _{ADJ}	Adjust Pin Current APL1117	$(V_{IN}-V_{OUT}) = 3V, I_{OUT} = 10mA$	-	60	120	μA
ΔI_{ADJ}	Adjust Pin Current Change APL1117	$10mA \leq I_{OUT} \leq 1A,$ $1.4V \leq (V_{IN}-V_{OUT}) \leq 10.75V$	-	0.2	5	μA
I _O	Minimum Load Current APL1117	$(V_{IN}-V_{OUT}) = 10.75V$ (Note 4)	-	1.7	-	mA
PSRR	Ripple Rejection	$f_{RIPPLE} = 120Hz, V_{RIPPLE} = 1V_{P-P}, (V_{IN}-V_{OUT}) = 3V$	60	75	-	dB
T _R	Thermal Regulation	$T_J = 25^\circ C, 30ms$ Pulse	-	0.01	0.02	%/W
T _S	Temperature Stability		-	0.5	-	%
L _S	Long-Term Stability	$T_J = 125^\circ C, 1000Hrs.$	-	0.3	-	%
V _N	RMS Output Noise	$T_J = 25^\circ C, 10Hz \leq F \leq 10kHz, (\% \text{ of } V_{OUT})$	-	0.003	-	%
V _D	Dropout Voltage	$I_{OUT}=100mA$ (Note2) $I_{OUT}=500mA$ (Note2) $I_{OUT}=1A$ (Note2)	-	1 1.05 1.1	1.1 1.2 1.3	V
I _{LIMIT}	Current-Limit	$(V_{IN}-V_{OUT})=5V, T_J=25^\circ C$	1000	-	-	mA
I _{ADJ}	Adjust Pin Current APL1117	$(V_{IN}-V_{OUT})=3V, I_{OUT}=10mA$	-	60	120	μA
ΔI_{ADJ}	Adjust Pin Current Change APL1117	$10mA \leq I_{OUT} \leq 1A,$ $1.4V \leq (V_{IN}-V_{OUT}) \leq 10.75V$	-	0.2	5	μA
I _O	Minimum Load Current APL1117	$(V_{IN}-V_{OUT})=10.75V$ (Note 4)	-	1.7	-	mA
PSRR	Ripple Rejection	$f_{RIPPLE}=120Hz, V_{RIPPLE}=1V_{P-P}, (V_{IN}-V_{OUT})=3V$	60	75	-	dB
T _R	Thermal Regulation	$T_J=25^\circ C, 30ms$ Pulse	-	0.01	0.02	%/W
T _S	Temperature Stability		-	0.5	-	%
L _S	Long-Term Stability	$T_J=125^\circ C, 1000Hrs.$	-	0.3	-	%
V _N	RMS Output Noise	$T_J=25^\circ C, 10Hz \leq F \leq 10kHz, (\% \text{ of } V_{OUT})$	-	0.003	-	%

Electrical Characteristics (Cont.)

Unless otherwise noted, these specifications apply over $C_{IN} = 10\mu F$, $C_{OUT} = 10\mu F$, and $T_A = 0$ to $70^\circ C$. Typical values refer to $T_A = 25^\circ C$.

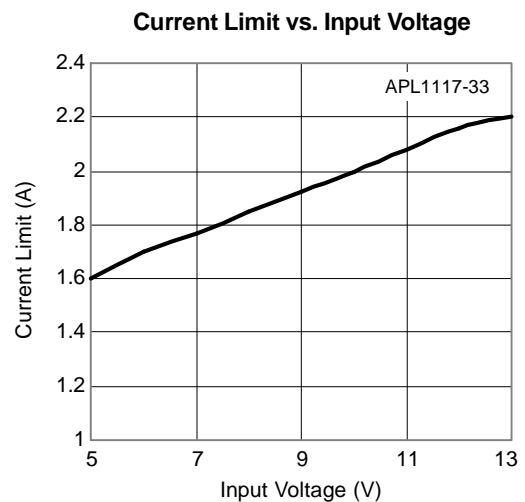
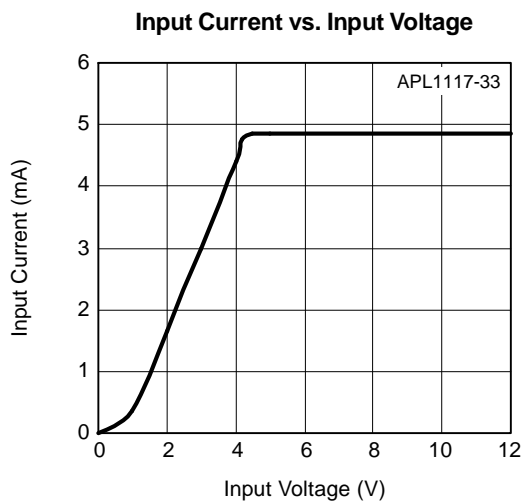
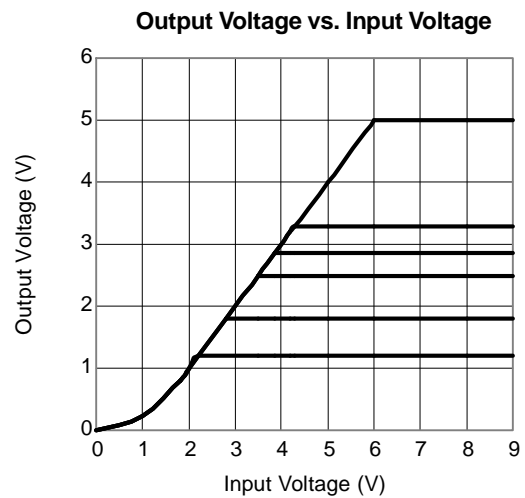
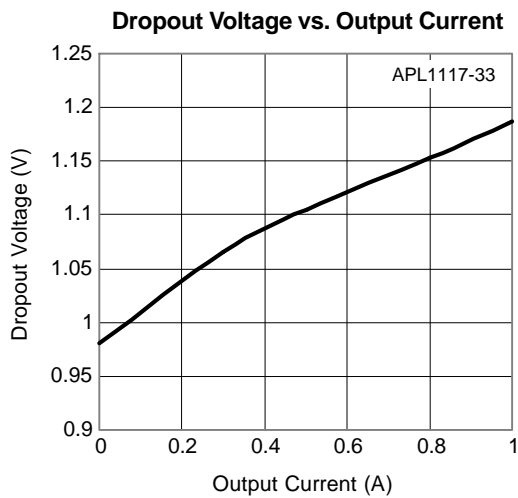
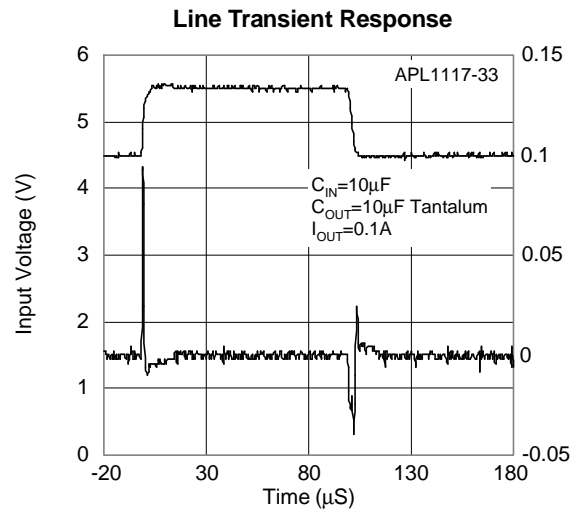
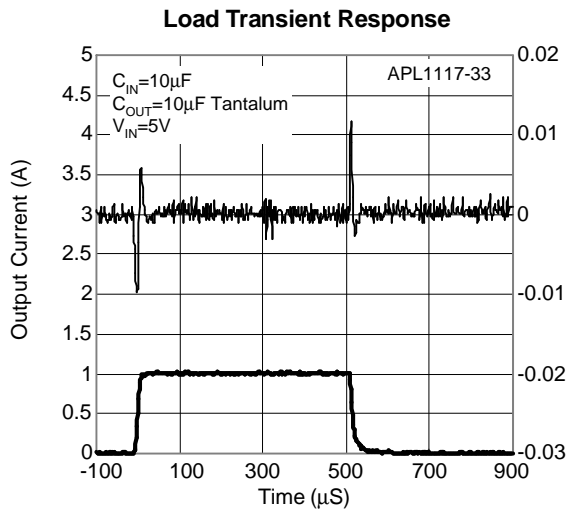
Symbol	Parameter	Test Conditions	APL1117			Unit
			Min.	Typ.	Max.	
θ_{JC}	Thermal Resistance Junction to Case	SOT-223 TO-252 TO-263 TO-220	-	15 10 3 3	-	$^\circ C/W$
OT	Over-Temperature Point		-	150	-	$^\circ C$
I_Q	Quiescent Current APL1117-12,18,25,28 APL1117-33,50	$V_{IN} \leq 9V$ $V_{IN} \leq 12V$	-	5.5 5.5	10 10	mA

Note 2: See thermal regulation specifications for changes in output voltage due to heating effects. Load line regulations are measured at a constant junction temperature by low duty cycle pulse testing.

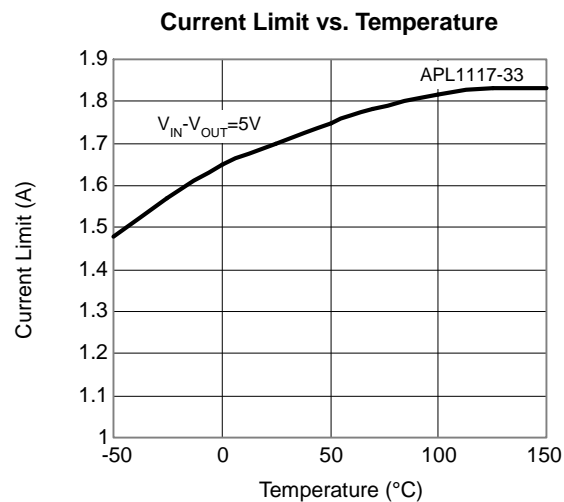
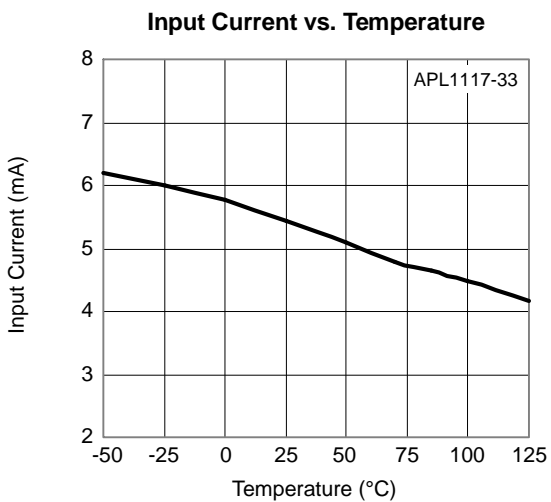
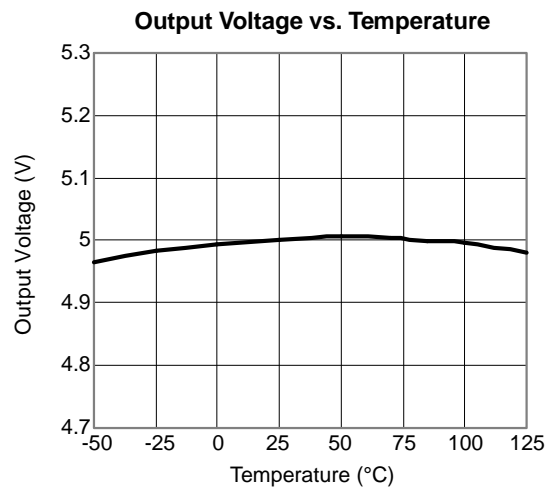
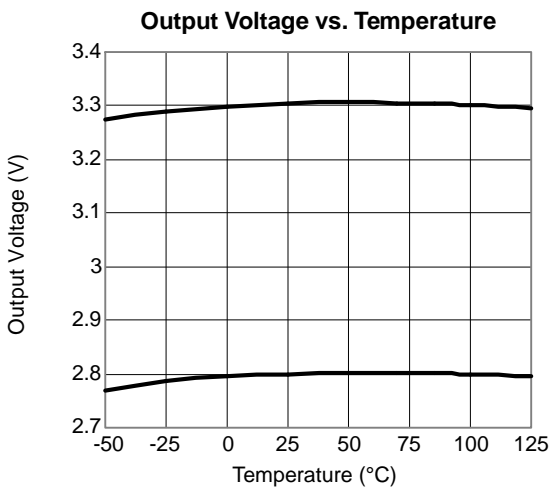
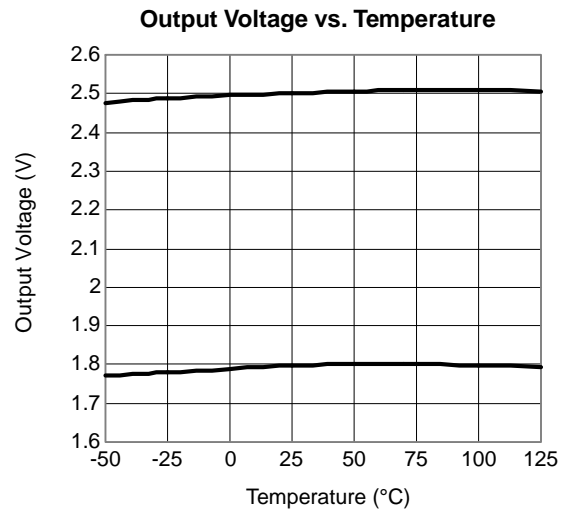
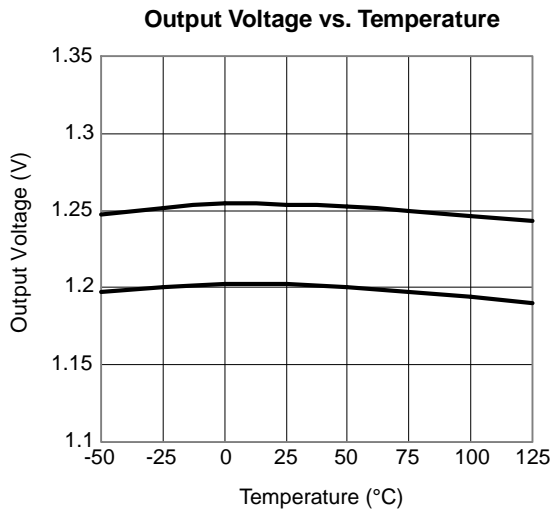
Note 3: Dropout voltage is specified over the full output current range of the device. Dropout voltage is defined as the minimum input/output differential measured at the specified output current. Test points and limits are also shown on the Dropout Voltage curve.

Note 4: Minimum load current is defined as the minimum output current required to maintain regulation.

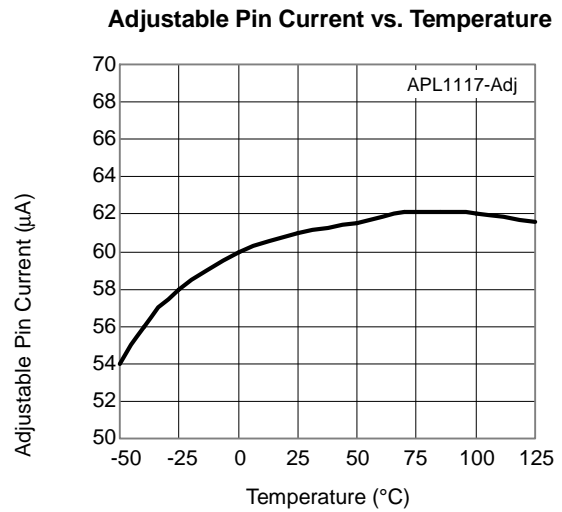
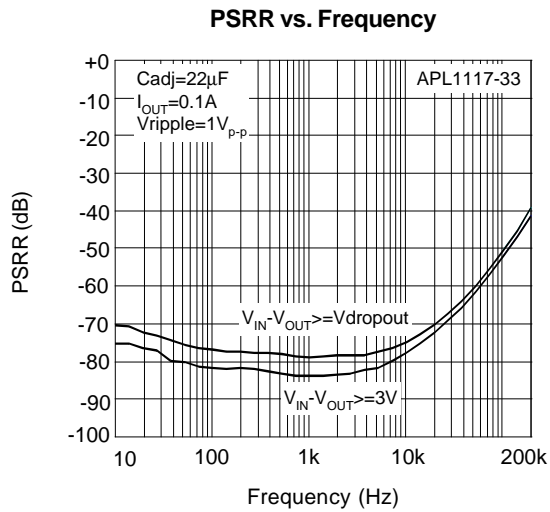
Typical Operating Characteristics



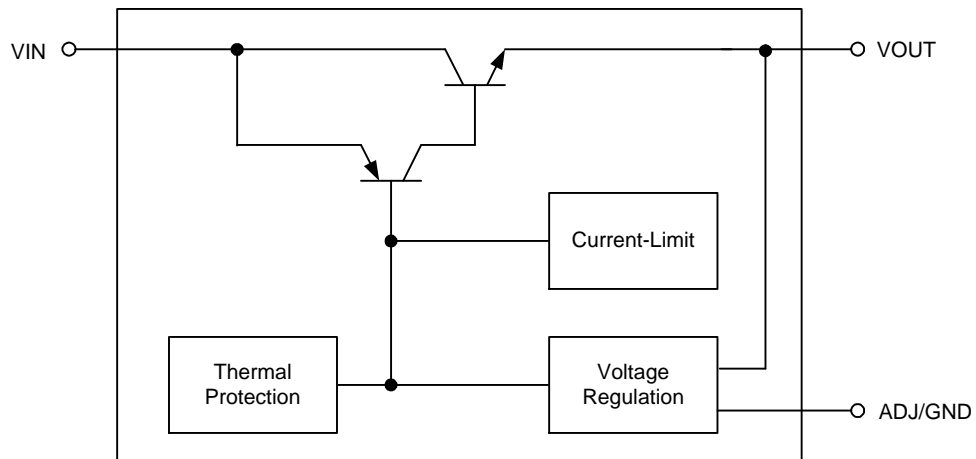
Typical Operating Characteristics (Cont.)



Typical Operating Characteristics (Cont.)



Block Diagram



Application Information

Output Voltage

The APL1117 develops a 1.25V reference voltage between the output and the adjust terminal. By placing a resistor between these two terminals, a constant Current is caused to flow through R1 and down through R2 to set the overall output voltage. Normally, this current is chosen to be the specified minimum load current of 10mA. For fixed voltage devices R1 and R2 are included in the device.

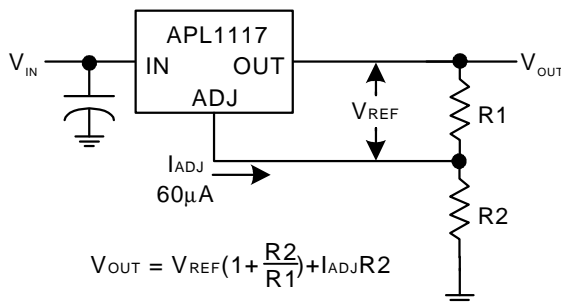


Figure 1. Basic Adjustable Regulator

Load Regulation

When the adjustable regulator is used, load regulation will be limited by the resistance of the wire connecting the regulator to the load. The data sheet specification for load regulation is measured at the output pin of the device. Best load regulation is obtained when the top of the resistor divider (R1) is tied directly to the output pin of the device not to the load. For fixed voltage, devices the top of R1 is internally connected to the output, and the ground pin can be connected to low side of the load. If R1 is connected to the load, R_p is multiplied by the divider ratio, the effective resistance between the regulator and the load would be:

$$R_p \times \left(1 + \frac{R_2}{R_1}\right), R_p = \text{Parasitic Line Resistance}$$

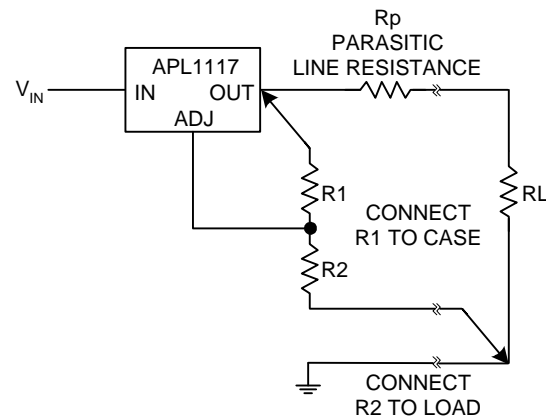


Figure 2. Connections for Best Load Regulation

Input Capacitor

An input capacitor of 10µF or greater is recommended. Tantalum or aluminum electrolytic capacitors can be used for bypassing. Larger Values will improve ripple rejection by bypassing the input to the regulator.

Output Capacitor

The APL1117 requires an output capacitor to maintain stability and improve transient response. Proper capacitor selection is important to ensure proper operation. The APL1117 output capacitor selection is dependent upon the ESR (equivalent series resistance) of the output capacitor to maintain stability. When the output capacitor is 10µF or greater, the output capacitor should have an ESR less than 1Ω. This will improve transient response as well as promote stability. A low-ESR solid tantalum capacitor works extremely well and provides good transient response and stability over temperature.

Aluminum electrolytics can also be used, as long as the ESR of the capacitor is <1Ω. The value of the output capacitor can be increased without limit. Higher capacitance values help to improve transient response and ripple rejection and reduce output noise.

Application Information (Cont.)

Ripple Rejection

The curves for Ripple Rejection were generated using an adjustable device with the adjust pin bypassed. With a 22μF bypassing capacitor, 75dB ripple rejection is obtainable at any output level. The impedance of the adjust pin capacitor, at the ripple frequency, should be $R1$. R1 is normally in the range of 100Ω to 200Ω. The size of the required adjust pin capacitor is the function of the input ripple frequency. At 120Hz, with R1=100Ω, the adjust pin capacitor should be 13μF. For fixed voltage devices and adjustable devices without an adjust pin capacitor, the output ripple will increase as the ratio of the output voltage to the reference voltage (VOUT /VREF).

Thermal Consideration

The APL1117 regulators have thermal protection to limit junction temperature to 150°C. However, the device is recommended to be operated under 125°C.

A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. Figure 3&4 show for the TO-252-3 and SOT-223 the measured values $\theta_{(J-A)}$ for different copper area sizes using a 2 layers, 1.6mm, and 6Sq. cm FR-4 PCB with 2oz. copper and a ground plane layer on the backside area used for heatsinking. It can be used as a rough guideline in estimating thermal resistance. Both the TO-252-3 and SOT-223 packages use a copper plane on the PCB and the PCB itself as a heatsink. To optimize the heat sinking ability of the plane and PCB, solder the tab of the package to the plane.

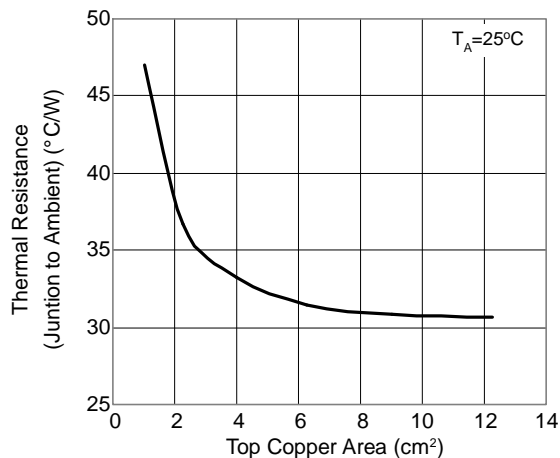


Figure 3. $\theta_{(J-A)}$ vs. copper area for the TO-252-3 package

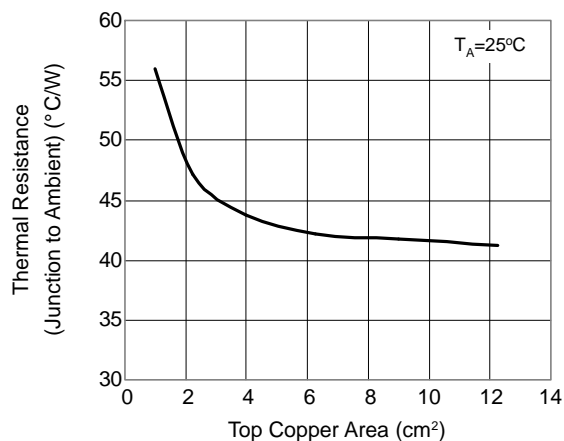


Figure 4. $\theta_{(J-A)}$ vs. copper area for the SOT-223 package

The thermal resistance for each application will be affected by thermal interactions with other components on the board. Some experimentation will be necessary to determine the actual value.

The power dissipation of APL1117 is equal to:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT}$$

Maximum junction temperature is equal to:

$$T_{JUNCTION}^{(Note)} = T_{AMBIENT} + (P_D \times \theta_{JA})$$

Note: $T_{JUNCTION}$ must not exceed 125°C

Safe Operation Area

Using the experiment result of previous Thermal Consideration (choose the one with 1.5cmx1.5cm polygen area) and $\theta_{(J-A)}=50^\circ\text{C/W}$ spec, the safe operation area of APL1117 in TO-252-3 and SOT-223 packages can be obtained as Figure 5.

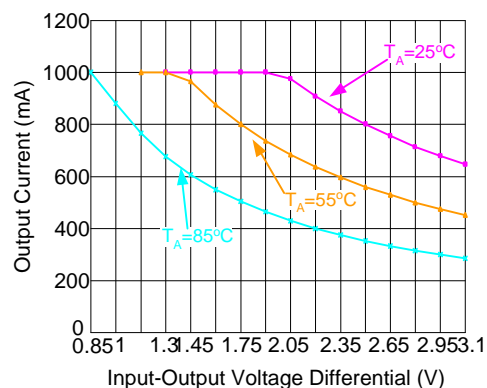
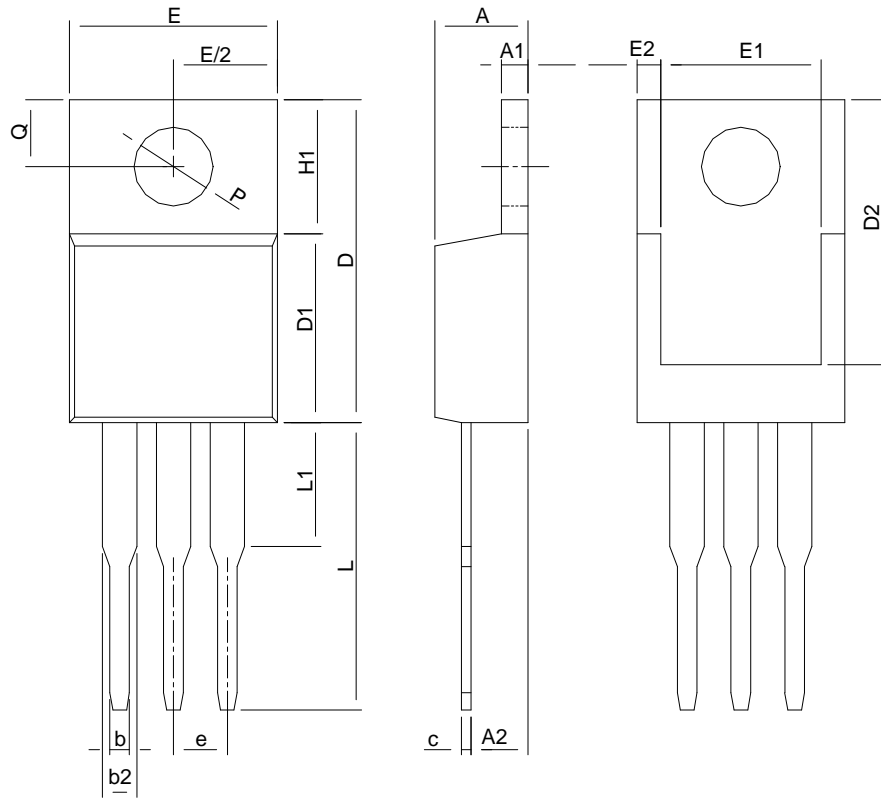


Figure 5. Safe Operation Area of APL1117 in TO-252-3 and SOT-223 packages (limited by Power Dissipation with $T_{JUNCTION} < 125^\circ\text{C}$)

Package Information

TO-220

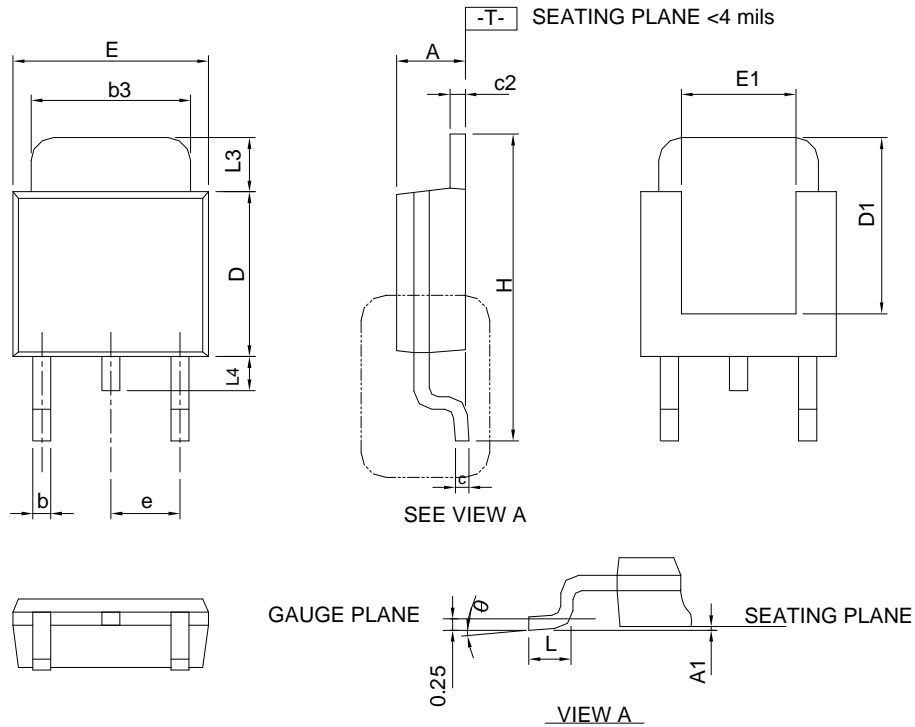


DIMENSIONS	TO-220			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	3.56	4.83	0.140	0.190
A1	0.51	1.40	0.020	0.055
A2	2.03	2.92	0.080	0.115
b	0.38	1.02	0.015	0.040
b2	1.14	1.78	0.045	0.070
c	0.36	0.61	0.014	0.024
D	14.22	16.51	0.560	0.650
D1	8.38	9.02	0.330	0.355
D2	12.19	12.88	0.480	0.507
E	9.65	10.67	0.380	0.420
E1	6.86	8.89	0.270	0.350
E2		0.76		0.030
e	2.54 BSC		0.100 BSC	
H1	5.84	6.86	0.230	0.270
L	12.70	14.73	0.500	0.580
L1		6.35		0.250
P	3.53	4.09	0.139	0.161
Q	2.54	3.43	0.100	0.135

Note: Follow JEDEC TO-220 AB.

Package Informaion

TO-252-3

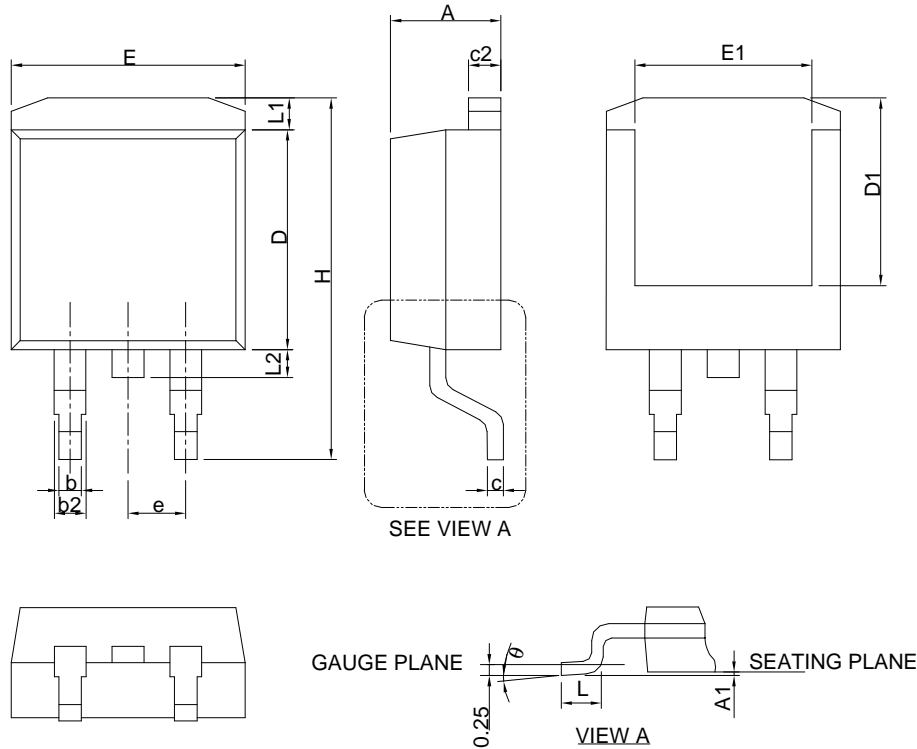


SYMBOL	TO-252-3			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	2.18	2.39	0.086	0.094
A1		0.13		0.005
b	0.50	0.89	0.020	0.035
b3	4.95	5.46	0.195	0.215
c	0.46	0.61	0.018	0.024
c2	0.46	0.89	0.018	0.035
D	5.33	6.22	0.210	0.245
D1	4.57	6.00	0.180	0.236
E	6.35	6.73	0.250	0.265
E1	3.81	6.00	0.150	0.236
e	2.29 BSC		0.090 BSC	
H	9.40	10.41	0.370	0.410
L	0.90	1.78	0.035	0.070
L3	0.89	2.03	0.035	0.080
L4		1.02		0.040
θ	0°	8°	0°	8°

Note : Follow JEDEC TO-252 .

Package Information

TO-263-3

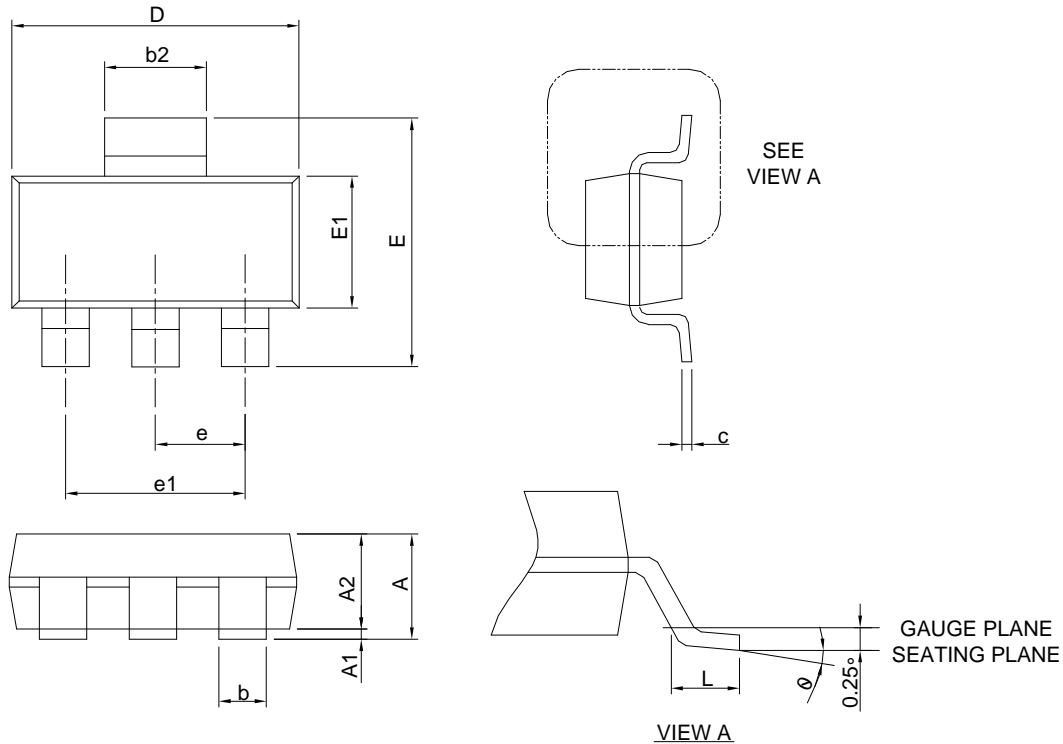


SYMBOL	TO-263-3			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	4.06	4.83	0.160	0.190
A1	0.00	0.25	0.000	0.010
b	0.51	0.99	0.020	0.039
b2	1.14	1.78	0.045	0.070
c	0.38	0.74	0.015	0.029
c2	1.14	1.65	0.045	0.065
D	8.38	9.65	0.330	0.380
D1	6.00	9.00	0.236	0.354
E	9.65	11.43	0.380	0.450
E1	6.22	9.00	0.245	0.354
e	2.54 BSC		0.100 BSC	
H	14.61	15.88	0.575	0.625
L	1.78	2.79	0.070	0.110
L1		1.68		0.066
L2		1.78		0.070
θ	0°	8°	0°	8°

Note : Follow JEDEC TO-263 AB.

Package Information

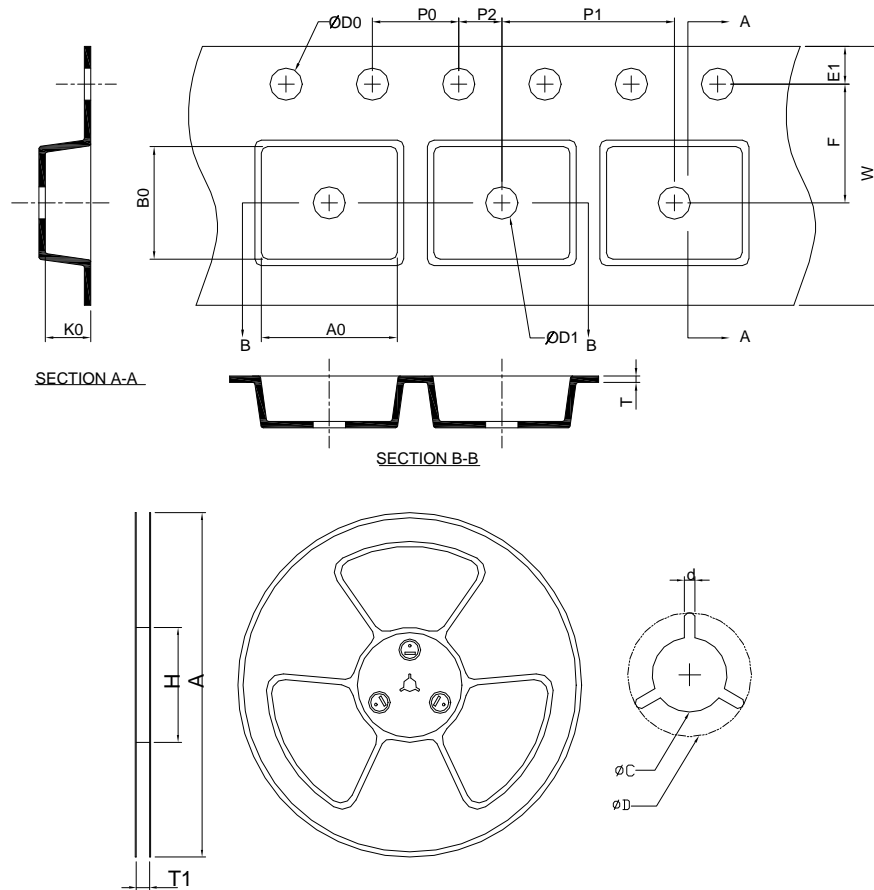
SOT-223



SYMBOL	SOT-223			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.80		0.071
A1	0.02	0.10	0.001	0.004
A2	1.50	1.70	0.059	0.067
b	0.66	0.84	0.026	0.033
b2	2.90	3.10	0.114	0.122
c	0.23	0.33	0.009	0.013
D	6.30	6.70	0.248	0.264
E	6.70	7.30	0.264	0.287
E1	3.30	3.70	0.130	0.146
e	2.30 BSC		0.091 BSC	
e1	4.60 BSC		0.181 BSC	
L	0.75		0.030	
θ	0°	10°	0°	10°

Note : 1. Follow from JEDEC TO-261 AA.
 2. Dimension D and E1 are determined at the outermost extremes of the plastic exclusive of mold flash, tie bar burrs, gate burrs, and interlead flash, but including any mismatch between the top and bottom of the plastic body.

Carrier Tape & Reel Dimension



Application	A	H	T1	C	d	D	W	E1	F
TO-252-3	330.0 ±2.00	50 MIN.	16.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	16.0 ±0.30	1.75 ±0.10	7.50 ±0.05
	P0	P1	P2	D0	D1	T	A0	B0	K0
	4.0 ±0.10	8.0 ±0.10	2.0 ±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.80 ±0.20	10.40 ±0.20	2.50 ±0.20
Application	A	H	T1	C	d	D	W	E1	F
TO-263-3	330.0 ±2.00	50 MIN.	24.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	24.0 ±0.30	1.75 ±0.10	11.5 ±0.10
	P0	P1	P2	D0	D1	T	A0	B0	K0
	4.0 ±0.10	16.0 ±0.10	2.0 ±0.10	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	10.8 ±0.20	16.1 ±0.20	5.2 ±0.20
Application	A	H	T1	C	d	D	W	E1	F
SOT-223	320.0 ±2.00	50 MIN.	12.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	12.00 ±0.30	1.75 ±0.10	5.50 ±0.05
	P0	P1	P2	D0	D1	T	A0	B0	K0
	4.00 ±0.10	8.00 ±0.10	2.00 ±0.50	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.90 ±0.20	7.50 ±0.20	2.10 ±0.20

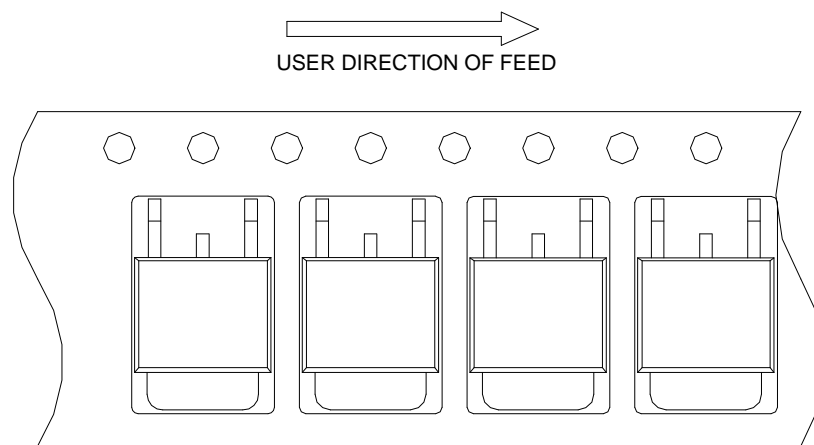
(mm)

Devices Per Unit

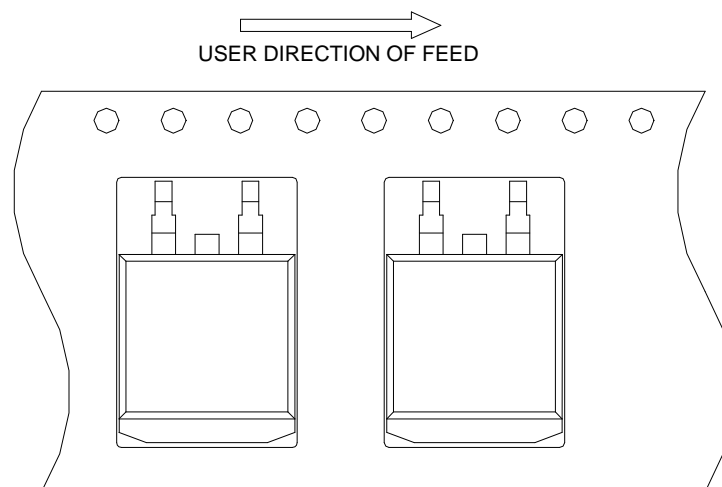
Package Type	Unit	Quantity
TO-252-3	Tape & Reel	2500
TO-263-3	Tape & Reel	800
SOT-223	Tape & Reel	2500

Taping Direction Information

TO-252-3

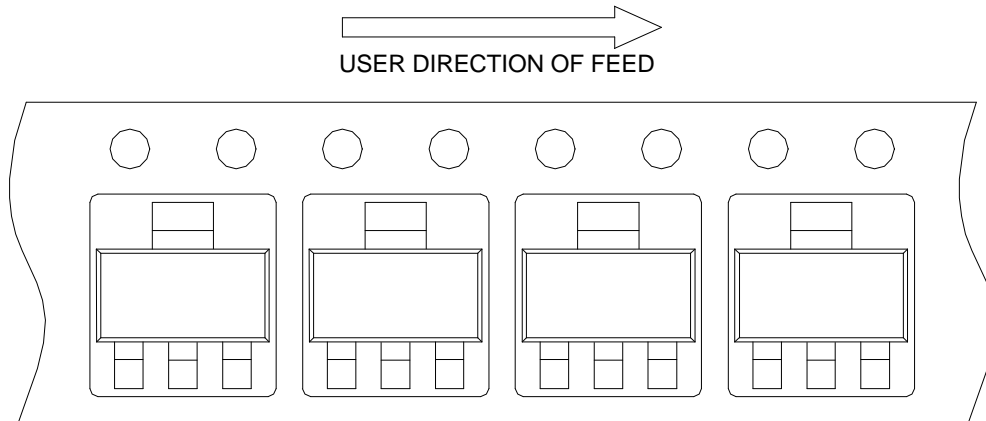


TO-263-3

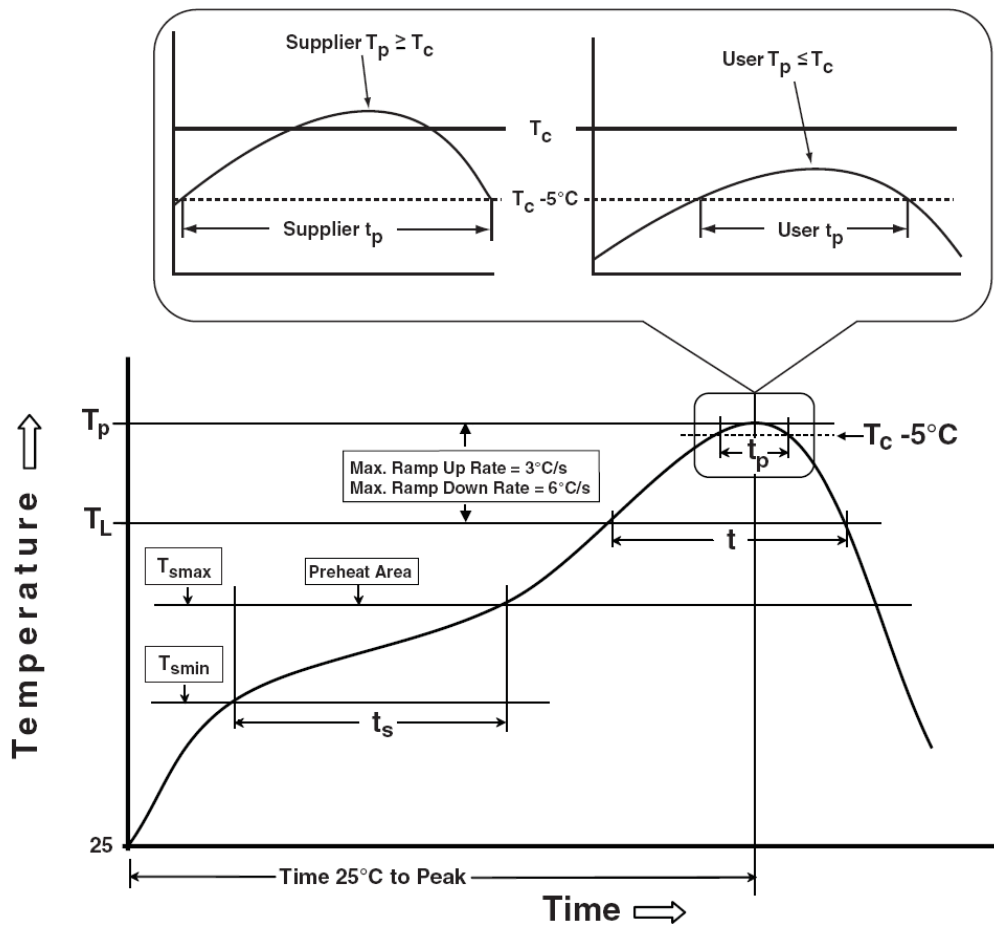


Taping Direction Information

SOT-223



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak		
Temperature min (T_{smin})	100 °C	150 °C
Temperature max (T_{smax})	150 °C	200 °C
Time (T_{smin} to T_{smax}) (t_s)	60-120 seconds	60-120 seconds
Average ramp-up rate (T_{smax} to T_p)	3 °C/second max.	3°C/second max.
Liquidous temperature (T_L)	183 °C	217 °C
Time at liquidous (t_L)	60-150 seconds	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 ³ <350	Volume mm ³ ≥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 ³ <350	Volume mm ³ 350-2000	Volume mm ³ >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, 1 _{tr} 100mA

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