Low I_Q, Low Dropout 150mA Fixed Voltage Regulator

Features

- **Low Noise: 60μV_{RMS} (100Hz to 100kHz)**
- **Low Quiescent Current: 50μA**
- **Low Dropout Voltage: 300mV (V_{OUT}(Nominal) = 3.0V Version @150mA)**
- **Very low Shutdown Current: < 0.5μA**
- **Fixed Output Voltage: 1.3V, 1.4V, 1.5V, 1.6V, 1.7V, 1.8V, 1.9V, 2.0V, 2.1V, 2.2V, 2.3V, 2.4V, 2.5V, 2.6V, 2.7V, 2.8V, 2.85V, 2.9V, 3.0V, 3.1V, 3.2V, 3.3V, 3.4V, 3.5V, 4.3V,4.75V, 4.8V, 4.9V, 5.0V**
- **Stable with 1μF 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: 50mA**
- **Fast transient Response**
- **Short Setting Time**
- **SOT-23-5 Package**
- **Lead Free and Green Devices Available (RoHS Compliant)**

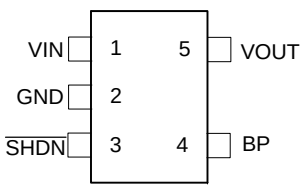
Applications

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

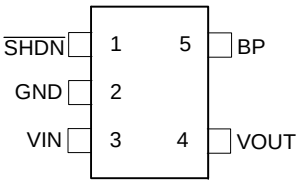
General Description

The APL5151/5152/5153/5154 is low-power and low dropout linear regulator, which can operate in the rage of 2.7V to 6V input voltage and deliver up to 150mA output current. Typical dropout voltage is only 300mV (typical) at 150mA output current. The APL5151/5152/5153/5154 regulators with low 50μA quiescent current are ideal for battery powered system appliances. The APL5151/5152/5153/5154 regulator is stable with a 1μF ceramic capacitor. The features of current limit, short circuit current limit, and over-temperature protection protect the device from current over loads and over temperature. The APL5151/5152/5153/5154 regulator is available in a SOT-23-5 package.

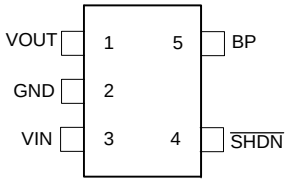
Pin Configuration



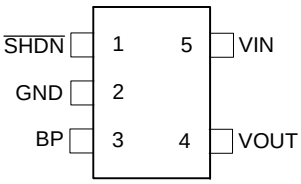
APL5151



APL5152

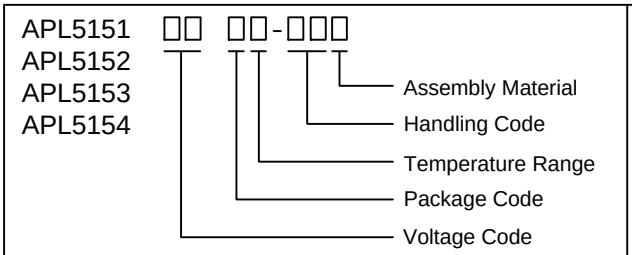


APL5153



APL5154

Ordering Marking and Information



Package Code
B : SOT-23-5
Temperature Range
C : 0 to 70 °C I : -40 to 85 °C
Handling Code
TR : Tape & Reel
Voltage Code :
13 : 1.3V ~ 50 : 5.0V (see below for details)
Assembly Material
L : Lead Free Device
G : Halogen and Lead Free Device

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-020C 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).

Product Name	Marking	Product Name	Marking	Product Name	Marking	Product Name	Marking
APL5151-13B	1517X	APL5152-13B	1527X	APL5153-13B	1537X	APL5154-13B	1547X
APL5151-14B	1518X	APL5152-14B	1528X	APL5153-14B	1538X	APL5154-14B	1548X
APL5151-15B	1519X	APL5152-15B	1529X	APL5153-15B	1539X	APL5154-15B	1549X
APL5151-16B	151AX	APL5152-16B	152AX	APL5153-16B	153AX	APL5154-16B	154AX
APL5151-17B	151BX	APL5152-17B	152BX	APL5153-17B	153BX	APL5154-17B	154BX
APL5151-18B	151CX	APL5152-18B	152CX	APL5153-18B	153CX	APL5154-18B	154CX
APL5151-19B	151DX	APL5152-19B	152DX	APL5153-19B	153DX	APL5154-19B	154DX
APL5151-20B	151EX	APL5152-20B	152EX	APL5153-20B	153EX	APL5154-20B	154EX
APL5151-21B	151FX	APL5152-21B	152FX	APL5153-21B	153FX	APL5154-21B	154FX
APL5151-22B	151GX	APL5152-22B	152GX	APL5153-22B	153GX	APL5154-22B	154GX
APL5151-23B	151HX	APL5152-23B	152HX	APL5153-23B	153HX	APL5154-23B	154HX
APL5151-24B	151IX	APL5152-24B	152IX	APL5153-24B	153IX	APL5154-24B	154IX
APL5151-25B	151JX	APL5152-25B	152JX	APL5153-25B	153JX	APL5154-25B	154JX
APL5151-26B	151KX	APL5152-26B	152KX	APL5153-26B	153KX	APL5154-26B	154KX
APL5151-27B	151LX	APL5152-27B	152LX	APL5153-27B	153LX	APL5154-27B	154LX
APL5151-28B	151MX	APL5152-28B	152MX	APL5153-28B	153MX	APL5154-28B	154MX
APL5151-285B	151αX	APL5152-285B	152αX	APL5153-285B	153αX	APL5154-285B	154αX
APL5151-29B	151NX	APL5152-29B	152NX	APL5153-29B	153NX	APL5154-29B	154NX
APL5151-30B	151OX	APL5152-30B	152OX	APL5153-30B	153OX	APL5154-30B	154OX
APL5151-31B	151PX	APL5152-31B	152PX	APL5153-31B	153PX	APL5154-31B	154PX
APL5151-32B	151QX	APL5152-32B	152QX	APL5153-32B	153QX	APL5154-32B	154QX
APL5151-33B	151RX	APL5152-33B	152RX	APL5153-33B	153RX	APL5154-33B	154RX
APL5151-34B	151SX	APL5152-34B	152SX	APL5153-34B	153SX	APL5154-34B	154SX
APL5151-35B	151TX	APL5152-35B	152TX	APL5153-35B	153TX	APL5154-35B	154TX
APL5151-43B	151βX	APL5152-43B	152βX	APL5153-43B	153βX	APL5154-43B	154βX
APL5151-475B	1514X	APL5152-475B	1524X	APL5153-475B	1534X	APL5154-475B	1544X

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

Ordering Marking and Information (Cont.)

Product Name	Marking	Product Name	Marking	Product Name	Marking	Product Name	Marking
APL5151-48B	151XX	APL5152-48B	152XX	APL5153-48B	153XX	APL5154-48B	154XX
APL5151-49B	151YX	APL5152-49B	152YX	APL5153-49B	153YX	APL5154-49B	154YX
APL5151-50B	151ZX	APL5152-50B	152ZX	APL5153-50B	153ZX	APL5154-50B	154ZX

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

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{IN}, V_{OUT}	Input Voltage, Output Voltage	6.5	V
$V_{\overline{SHDN}}$	Shutdown Control Pin Voltage	6.5	V
$R_{TH,JA}$	Thermal Resistance – Junction to Ambient	260	°C/W
$R_{TH,JC}$	Thermal Resistance – Junction to Case	130	°C/W
P_D	Power Dissipation	Internally Limited	W
T_J	Maximum Junction Temperature	0 to 150	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C
T_{SDR}	Maximum Lead Temperature (Soldering, 10 second)	260	°C

Note 1: Stresses beyond the absolute maximum rating may damage the device and operating in the absolute maximum rating conditions may affect device reliability.

Note 2: The maximum allowable power dissipation at any T_A (ambient temperature) is calculated using: P_D (max) =(T_J – T_A) / θ_{JA}; T_J = 125°C. Exceeding the maximum allowable power dissipation will result in excessive die temperature.

Pin Description

PIN		Function
NO.	NAME	
1	VIN	Input Supply Pin. Provides power to the IC, V_{IN} can range from 2.7V to 6V and should be bypassed with at least a 1µF capacitor to GND.
2	GND	Ground. Solder to a large ground plane for heatsinking.
3	$\overline{SHDN}$	Active-Low Shutdown Input. $\overline{SHDN}$ is a digital input that turns the regulator on or off. Drive $\overline{SHDN}$ high to turn on the regulator, drive it low to turn it off. Connect this pin to VIN if it is not used.
4	BP	Reference-Noise Bypass. Bypass with a 0.01uF ceramic capacitor for reduced noise at the output.
5	VOUT	LDO Output. Sources up to 150mA. Bypass with at least a 1µF capacitor to GND.

Electrical Characteristics

Unless otherwise noted these specifications apply over full temperature , V_{IN}=3.6V, C_{IN}=C_{OUT}=1µF, $\overline{SHDN}$=V_{IN}, T_A= -40 to 85°C . Typical values refer to T_A=25°C .

Symbol	Parameter	Test Conditions		APL5151/2/3/4			Unit
				Min.	Typ.	Max.	
V_{IN}	Input Voltage			2.7		6	V
V_{OUT}	Output Voltage	V_{OUT}+1.0V< V_{IN}<6.0V, 0mA< I_{OUT} < I_{MAX}		V_{OUT} -2%	V_{OUT}	V_{OUT} +2%	V
I_{LIMIT}	Circuit Current Limit	V_{IN}=V_{OUT}+1V		250	300	350	mA
I_{SHORT}	Short Current	V_{OUT}=0V		40	50	60	mA
I_{OUT}	Load Current			150			mA
REG_{LINE}	Line Regulation	V_{OUT}+0.5V< V_{IN}<6.0V, 0mA< I_{OUT} < I_{MAX}			4	10	mV
REG_{LOAD}	Load Regulation	V_{IN} =V_{OUT}+1.0V, 0mA< I_{OUT} < I_{MAX}			1	6	mV
	Load Transient	V_{IN}=V_{OUT}+1V, I_{OUT}=1mA-150mA in 1µs			70	150	mV
PSRR	Ripple Rejection	f≤1kHz, 1Vpp at V_{IN} = V_{OUT}+1.0V C_{BP} = 0.1µF, C_{OUT} = 1µF		45	55		dB
V_{DROP}	Dropout Voltage(Note)	I_{OUT} =150mA	1.3V≤ V_{OUT} <1.5V		1.2	1.4	V
			1.5V≤ V_{OUT} <2.0		1	1.2	
			2.0V≤ V_{OUT} <2.5		0.7	0.8	
			2.5V≤ V_{OUT} <3		0.3	0.4	
			3V≤ V_{OUT} ≤5		0.2	0.3	
I_Q	Quiescent Current	No load			50	80	µA
		I_{OUT} = 150mA			135	170	
	Shutdown Supply Current	$V_{\overline{SHDN}}$=0V I_{OUT}=0, V_{IN}= 6.0V			0.01	1	µA
	Noise	100Hz<f<100kHz, C_{BP} = 0.1µF, C_{OUT} = 1µF			80		µVrms
		100Hz<f<100kHz, C_{BP} = 0.33µF, C_{OUT} = 1µF			60		
	Shutdown Recovery Delay	C_{BP} = 0.1µF, C_{OUT} = 1µF, no load			4		ms
		C_{BP} = 0.33µF,C_{OUT} = 1µF, no load			13.2		
OTS	Over Temperature Shutdown				150		°C
	Over Temperature Shutdown Hysteresis	Hysteresis			10		°C
TC	Output Voltage Temperature Coefficient				50		ppm/°C

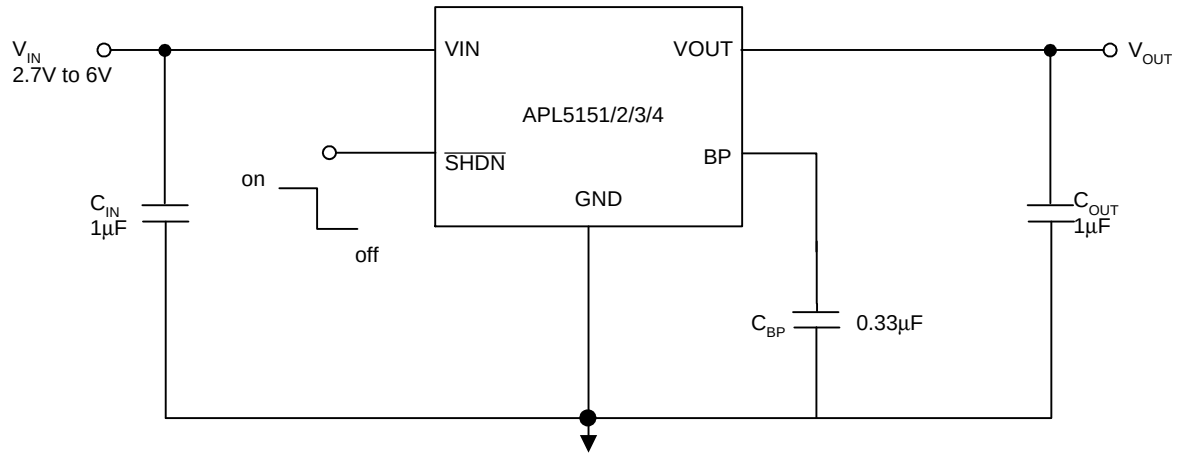
Electrical Characteristics (Cont.)

Unless otherwise noted these specifications apply over full temperature , V_{IN}=3.6V, C_{IN}=C_{OUT}=1µF, $\overline{SHDN}$=V_{IN}, T_A= -40 to 85°C . Typical values refer to T_A=25°C .

Symbol	Parameter	Test Conditions	APL5151/2/3/4			Unit
			Min.	Typ.	Max.	
C_{OUT}	Output Capacitor		0.8	1.0	2.6	µF
	ESR		0.02	0.1	1	Ω
	Shutdown Input Threshold	V_{OUT}+1.0V< V_{IN} <6.0V	0.4	1.6	2.5	V
$I_{\overline{SHDN}}$	Shutdown Input Bias Current	$V_{\overline{SHDN}}$ = 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

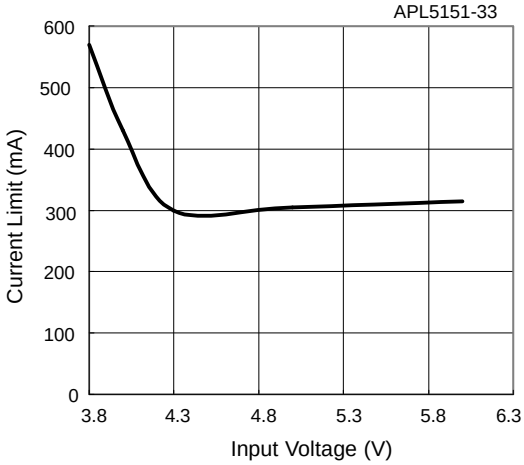
Note: Dropout voltage definition : V_{IN}-V_{OUT} when V_{OUT} is 2% below the value of V_{OUT} for V_{IN} = V_{OUT} + 0.5V.

Typical Application Circuit

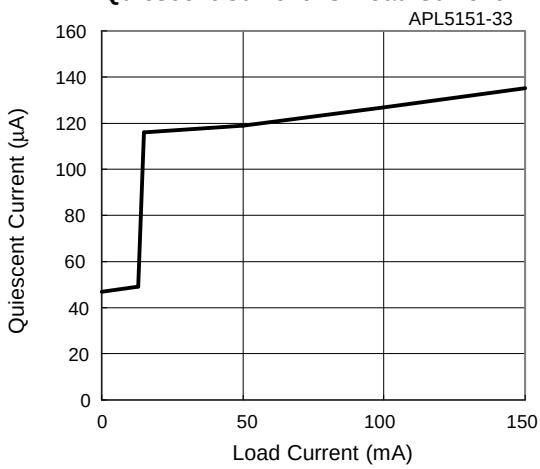


Typical Operating Characteristics

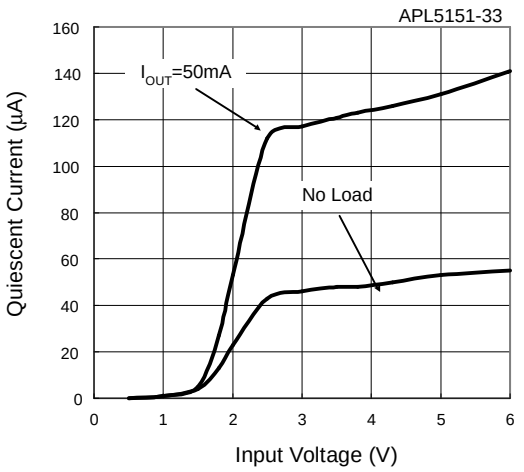
Current Limit vs. Input Voltage



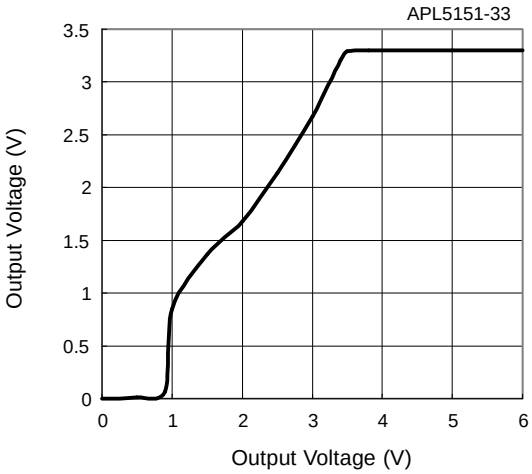
Quiescent Current vs. Load Current



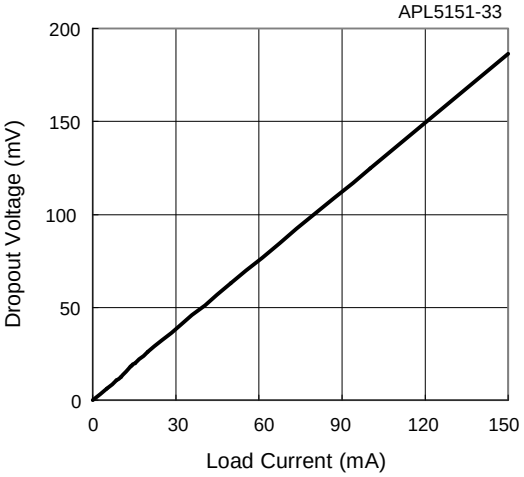
Quiescent Current vs. Input Voltage



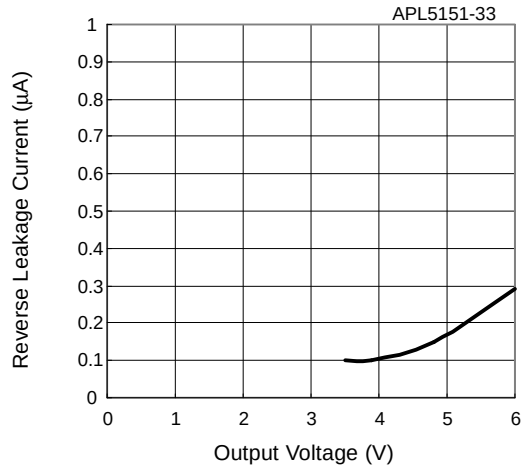
Input Voltage vs. Output Voltage



Dropout Voltage vs. Load Current

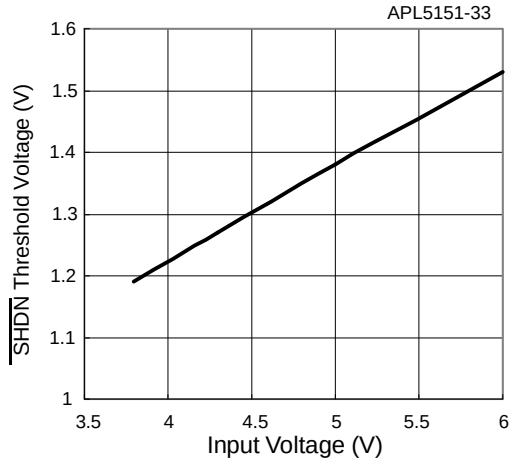


Reverse Leakage Current vs. Output Voltage

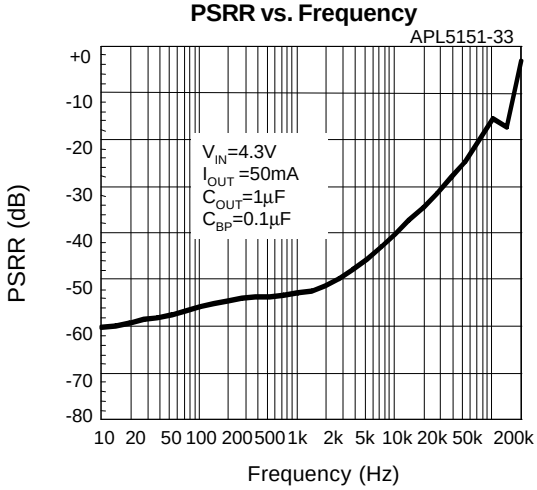


Typical Operating Characteristics (Cont.)

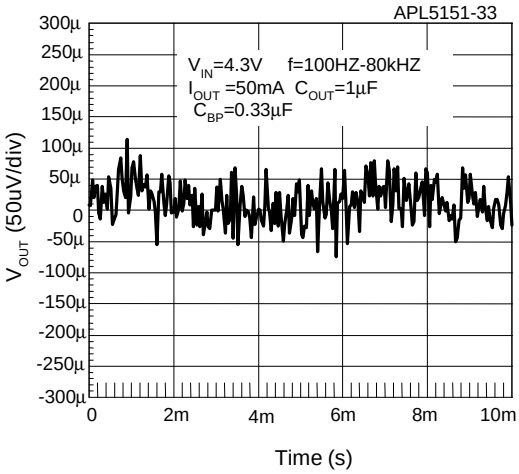
$\overline{SHDN}$ Threshold Voltage vs. Input Voltage



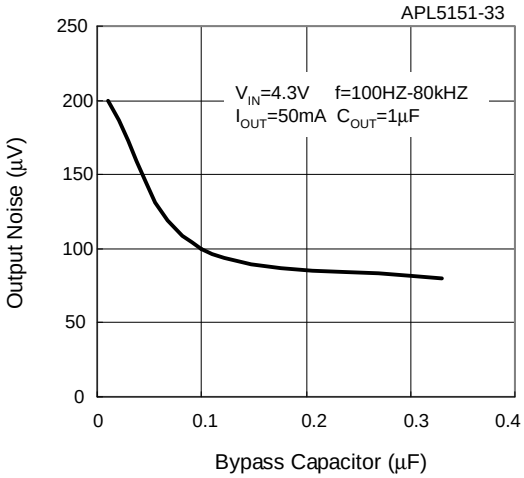
PSRR vs. Frequency



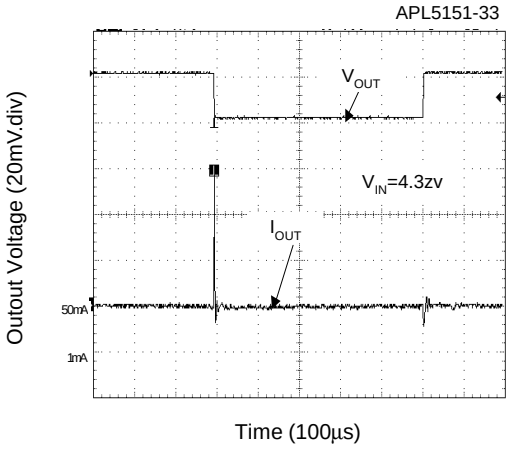
Output Noise



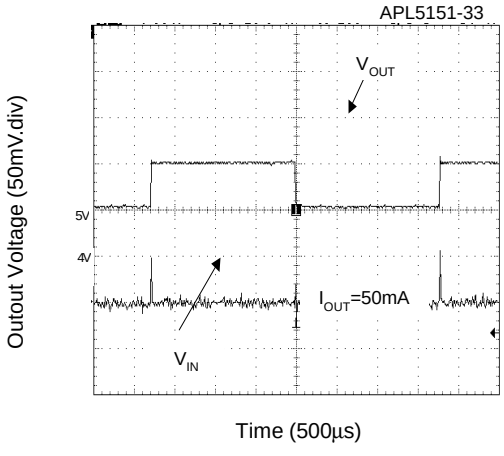
Output Noise vs. Bypass Capacitor



Load-Transient Response

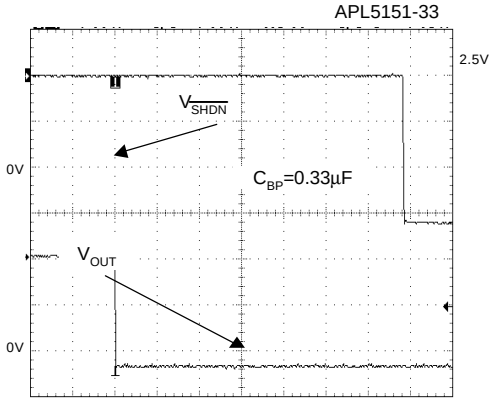


Line-Transient Response

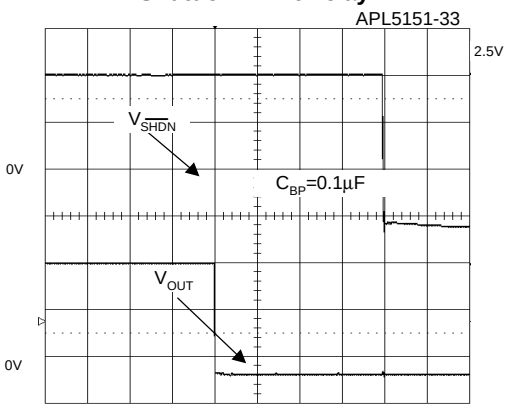


Typical Operating Characteristics (Cont.)

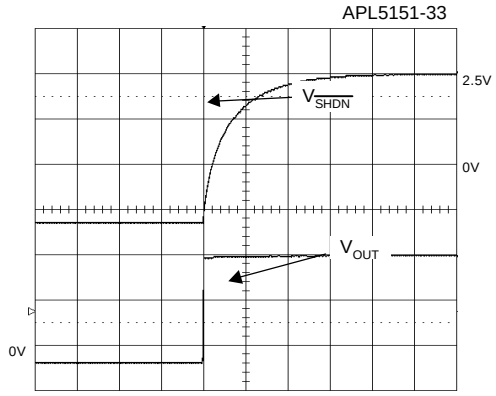
Shutdown Exit Delay



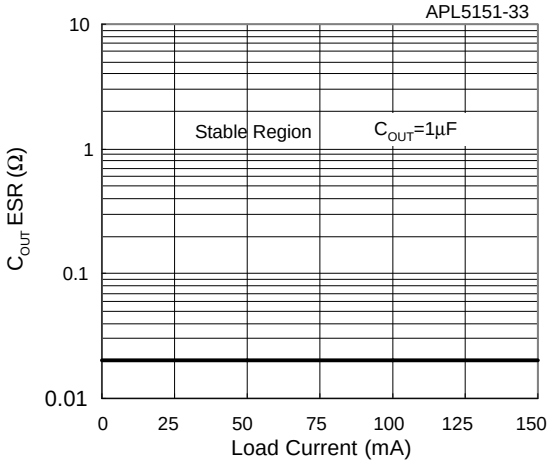
Shutdown Exit Delay



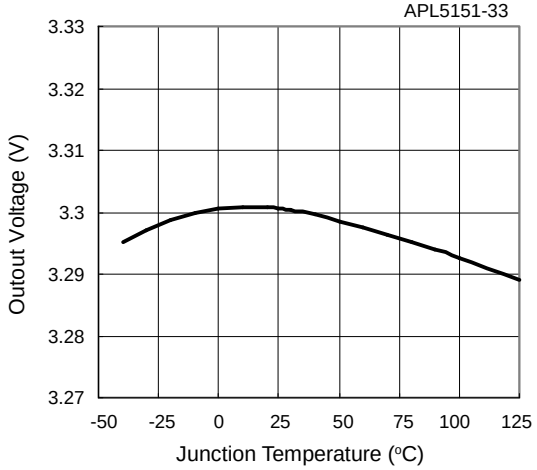
Entering Shutdown



Region of Stable C_{OUT} ESR vs. Load Current



Output Voltage vs. Junction Temperature



Application Information

Capacitor Selection and Regulator Stability

The APL5151/2/3/4 uses at least a 1μF 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 1μF 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 2.2μF or more may be required to ensure the stability at low temperature operation. Use a bypass capacitor at BP pin for low output noise. Increasing the capacitance will slightly decrease the output noise, but increase the start-up time (See Shutdown Exit Delay and Output Noise vs. Bypass Capacitor graph in the Typical Operating Characteristics).

Load-Transient Considerations

The APL5151/5152515/5153/5154 load-transient response graphs in Typical Operating Characteristics show the transient response. A step change in the load current from 1mA to 50mA at 1us will cause a 60mV 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 APL5151/5152/5153/5154 uses a p-channel MOSFET pass transistor, the dropout voltage is a function of drain-to-source on-resistance ($R_{DS(ON)}$) multiplied by the load current.

Reverse Current Protection

The APL5151/5152/5153/5154 has an internal reverse protection, so it is not necessary to use 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 0.1μA.

Current Limit

The APL5151/5152/5153/5154 provides a current limit circuitry, which monitors and controls P-MOS?s gate voltage, limiting the output current to 300mA. For reliable operation, the device should not be operated in current limit for extended period time. When output is shorted to ground, the APL5151/5152/5153/5154 will keep short circuit current at 50mA

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 APL5151/5152/5153/5154 in the event of fault conditions. For continuous operation, the junction temperature cannot exceed T_J=+125°C.

Operating Region and Power Dissipation

The thermal resistance of the case to circuit board, and the rate of air flow all control the APL5151/5152/5153/5154'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:

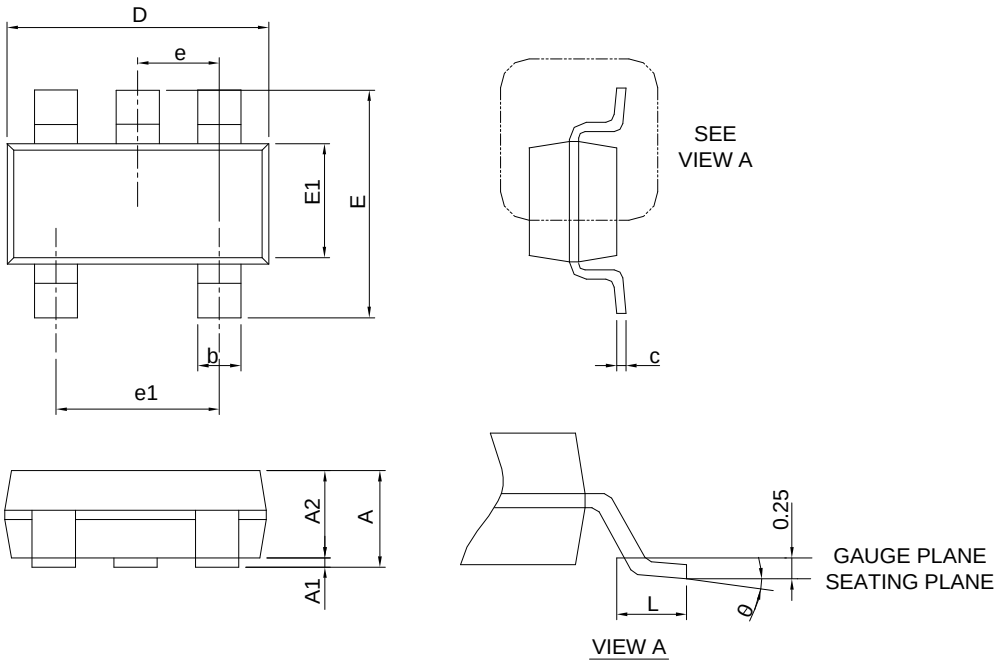
$$P_{DMAX} = (T_J-T_A) / (\theta_{JC}+\theta_{CA})$$

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 APL5151/5152/5153/5154 provides 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.

Package Information

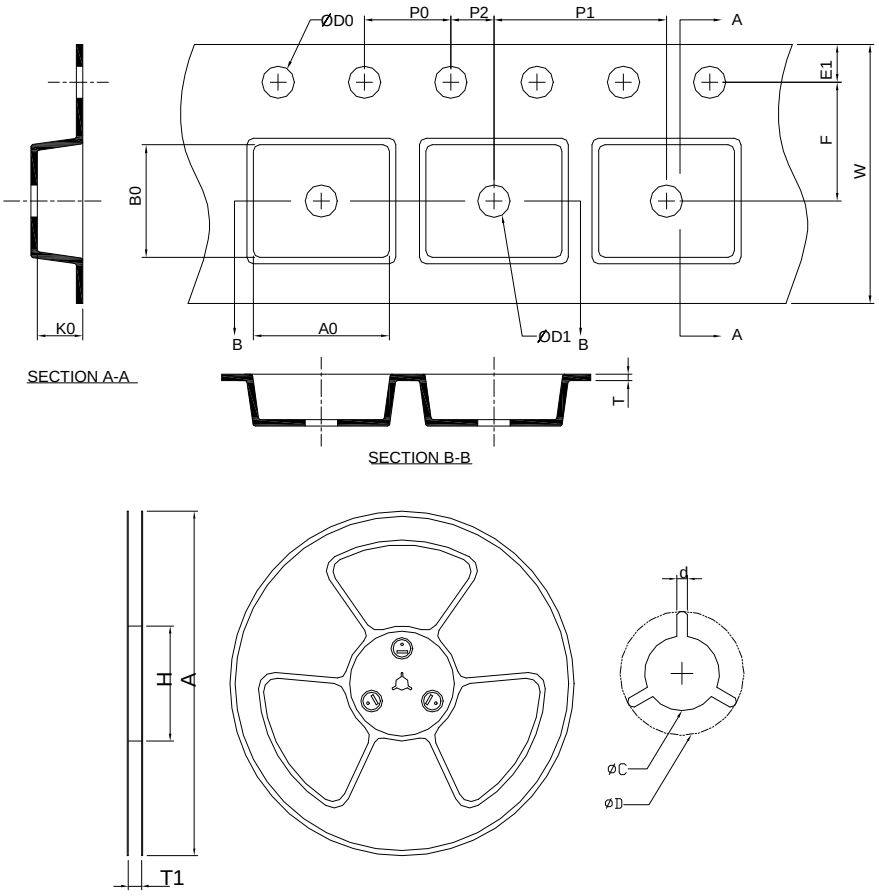
SOT-23-5



SYMBOL	SOT-23-5			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.45		0.057
A1	0.00	0.15	0.000	0.006
A2	0.90	1.30	0.035	0.051
b	0.30	0.50	0.012	0.020
c	0.08	0.22	0.003	0.009
D	2.70	3.10	0.016	0.122
E	2.60	3.00	0.102	0.118
E1	1.40	1.80	0.055	0.071
e	0.95 BSC		0.037 BSC	
e1	1.90 BSC		0.075 BSC	
L	0.30	0.60	0.012	0.024
θ	0°	8°	0°	8°

Note : 1. Follow JEDEC TO-178 AA.
2. Dimension D and E1 do not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.

Carrier Tape & Reel Dimensions



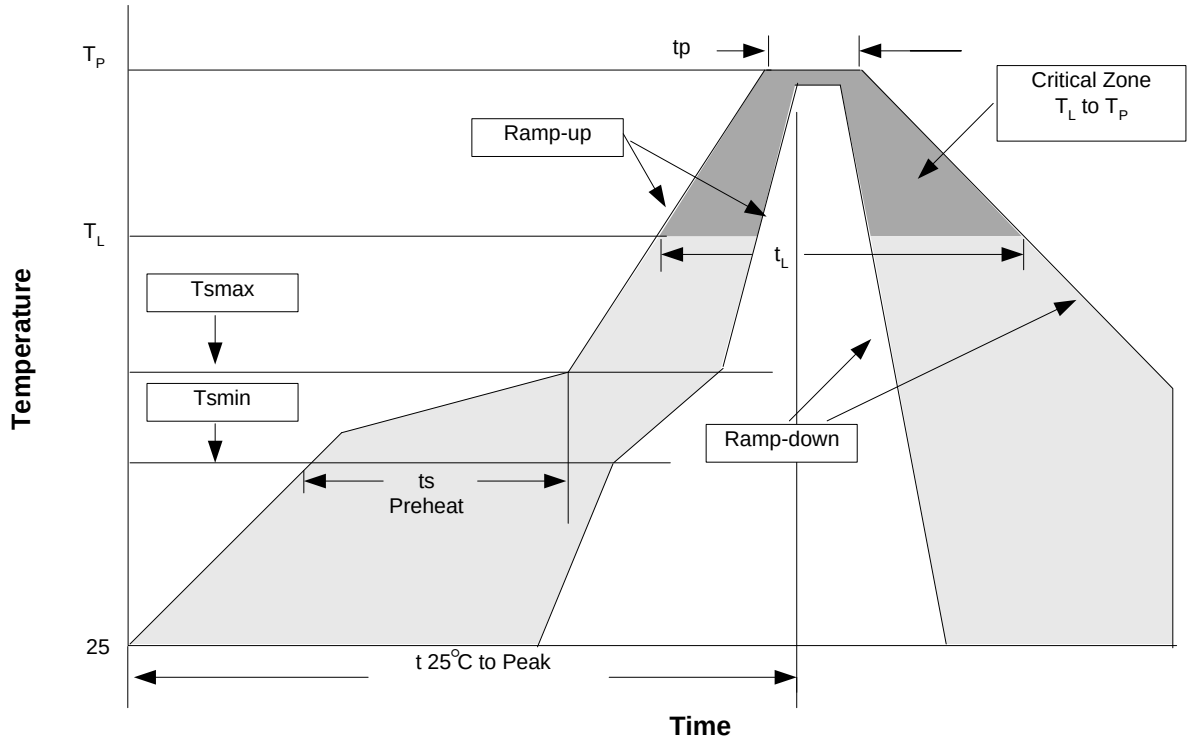
Application	A	H	T1	C	d	D	W	E1	F
SOT-23-5	178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	4.0±0.10	2.0±0.10	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	3.20±0.20	3.10±0.20	1.50±0.20

(mm)

Devices Per Unit

Package Type	Unit	Quantity
SOT-23-5	Tape & Reel	3000

Reflow Condition (IR/Convection or VPR Reflow)



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

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/Classification 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.

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

Classification Reflow Profiles (Cont.)

Table 1. SnPb Eutectic 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.

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