SPX2954

250mA Low Dropout Voltage Regulator

Description

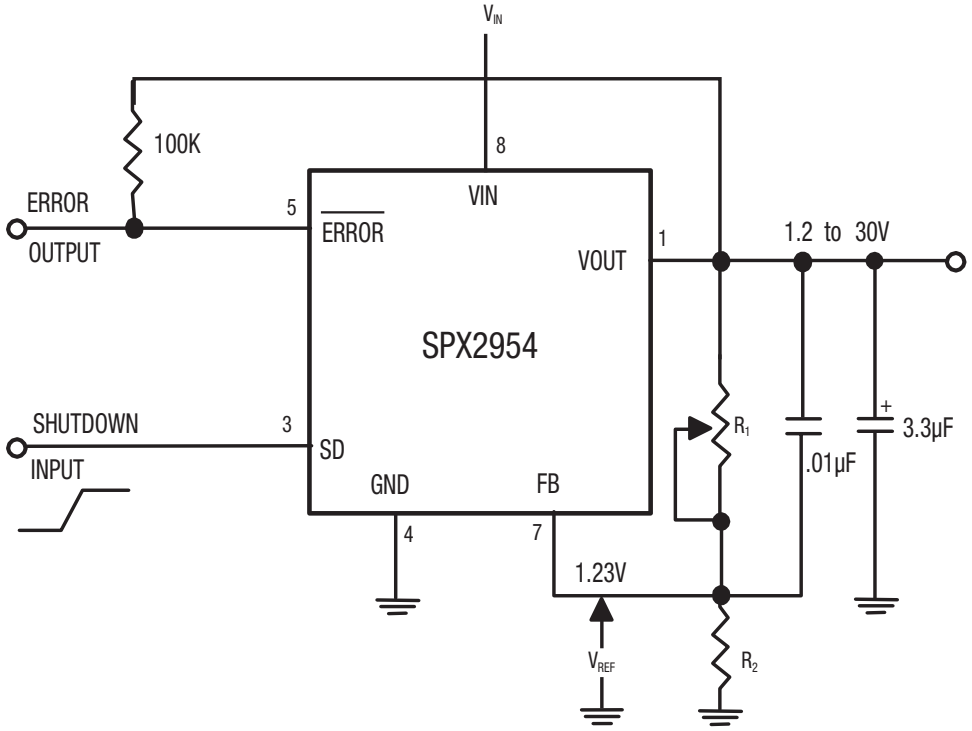
The SPX2954 and SPX2954A are low power voltage regulators. These devices are an excellent choice for use in battery-powered applications such as cordless telephones, radio control systems, and portable computers. The SPX2954 and SPX2954A feature low quiescent current and low dropout voltage (typ. 20mV at 100µA and 310mV at 250mA). This includes a tight initial tolerance (0.5% for SPX2954A), extremely good load and line regulation (0.05% typ.), and very low output temperature coefficient (20 ppm/°C typ.), making the SPX2954/SPX2954A useful as a low-power voltage reference.

The error flag output feature is used as a power-on reset for warning of a low output voltage, due to a falling input voltage. The logic-compatible shutdown feature enables the regulator to be switched ON and OFF. The SPX2954/SPX2954A is offered in a 3-pin SOT-223 package and an 8-pin SOIC package.

FEATURES

- 5.0V and 3.3V versions at 250mA output
- Accurate 0.5% for SPX2954A
- Very low quiescent current
- Low dropout: 310mV at 250mA
- Extremely tight load and line regulation
- Very low temperature coefficient
- Current and thermal limiting
- Need only 1µF for stability
- Direct replacement for LP2954
- Error flag warns of output dropout
- Logic-controlled electronic shutdown
- Programmable output from 1.24V to 30V

Typical Application



Typical Application

Absolute Maximum Ratings

Stresses beyond the limits listed below may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Power Dissipation..... Internally Limited

Lead Temperature (soldering, 5 seconds)..... 260°C

Storage Temperature ..... -65°C to 150°C

Operating Junction Temperature Range ..... -40°C to 125°C

Input Supply Voltage ..... -0.3V to 30V

Feedback Input Voltage..... -1.5V to 30V

Shutdown Input Voltage ..... -0.3V to 30V

Error Comparator Voltage ..... -0.3V to 30V

ESD Rating..... 2kV Min

Electrical Characteristics

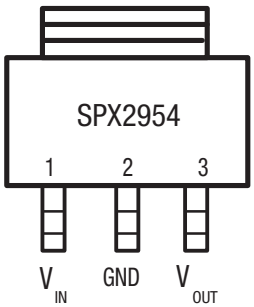
Unless otherwise noted: $V_{IN} = V_O + 1V$, $I_L = 100\mu A$, $C_L = 1\mu F$[2] $T_A = 25°C$.

Parameter	Conditions	SPX2954A			SPX2954			Units
		Min	Typ	Max	Min	Typ	Max	
3.3V Versions								
Output Voltage	$T_J = 25°C$	3.284	3.3	3.317	3.267	3.3	3.333	V
	$-25°C \le T_J \le 85°C$	3.267	3.3	3.333	3.251	3.3	3.350	
	Full Operating Temp.	3.260	3.3	3.340	3.234	3.3	3.366	
Output Voltage	$100\mu A \le I_L \le 250mA$; $T_J \le T_{MAX}$	**3.251**	**3.3**	**3.350**	**3.201**	**3.3**	**3.399**	V
5V Versions								
Output Voltage	$T_J = 25°C$	4.975	5.0	5.025	4.950	5.0	5.050	V
	$-25°C \le T_J \le 85°C$	4.950	5.0	5.050	4.925	5.0	5.075	
	Full Operating Temp.	4.940	5.0	5.060	4.900	5.0	5.100	
Output Voltage	$100\mu A \le I_L \le 250mA$; $T_J \le T_{MAX}$	**4.925**	**5.0**	**5.075**	**4.850**	**5.0**	**5.150**	V
All Voltage Options								
Output Voltage Temperature Coefficient[1]			20	100		50	150	ppm/°C
Line Regulation[3]	$V_O + 1V \le V_{IN} \le 30V$; I[4]		0.03	0.10		0.04	0.20	%
Load Regulation[3]	$100\mu A \le I_L \le 250mA$		0.04	0.20		0.10	0.30	%
Dropout Voltage[5]	$I_L = 1mA$		60	100		60	100	mV
	$I_L = 100mA$		290	450		290	450	
	$I_L = 250mA$		310	500		310	500	
Ground Current	$I_L = 1mA$		150	170		150	170	µA
	$I_L = 100mA$		3	6		3	6	mA
	$I_L = 250mA$		10	14		10	14	
Current Limit	$V_{OUT} = 0$		270	550		270	550	mA
Thermal Regulation Output Noise, 10Hz to 100kHz			0.05	0.2		0.05	0.2	%/W
	$C_L = 1\mu F$		430			430		μV_{rms}
	$C_L = 200\mu F$		160			160		μV_{rms}
	$C_L = 3.3\mu F$, Bypass = 0.01µF from pin 7 to Pin 1 (8 pin versions)		100			100		μV_{rms}
8-Pin Version Only								
Reference Voltage		1.220	1.235	1.250	1.210	1.235	1.260	V
	Over Temp[6]	1.190		2.270	1.185		1.285	V
Feedback Pin Bias Current			40	60		40	60	nA
Vref Temperature Coefficient			20			50		ppm/°C
Feedback I_{BIAS} Temperature Coefficient			0.1			0.1		nA/°C

Parameter	Conditions	SPX2954A			SPX2954			Units
		Min	Typ	Max	Min	Typ	Max	
Error Comparator								
Output Leakage Current	V_{OH} = 30V		0.01	1		0.01	1	µA
Output Low Voltage	$V_{IN} = V_O$ - 0.5V; I_{OL} = 400µA		150	250		150	250	mA
Upper Threshold Voltage(7)		40	60		40	60		mA
Lower Threshold Voltage(7)			75	95		75	95	mV
Hystersis(7)			15			15		mV
Shutdown								
Input Logic Voltage	Low (Regulator ON)		1.3	0.7		1.3	0.7	V
	High (Regulator OFF)	2.0			2.0			
Shutdown Input Current	V_S = 2.4V		30	50		30	50	µA
	V_S = 30V		400	800		400	800	
Regulator Output Current in Shutdown(8)			3	10		3	10	µA
Thermal Resistance Θ_{JA}								
SOIC-8			128.4					°C/W
SOT-223			62.3					°C/W

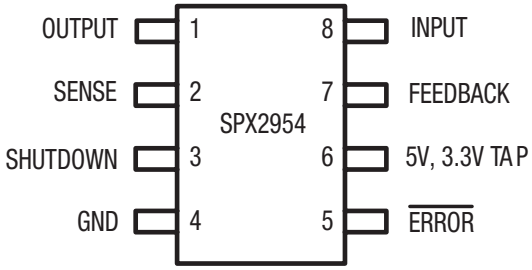
NOTES:
1. Output or reference voltage temperature coefficients defined as the worst case voltage change divided by the total temperature range.
2. Unless otherwise specified all limits guaranteed for T_J = 25°C, V_{IN} = 6V, I_L = 100µA and C_L = 1µF. Additional conditions for the 8-pin versions are feedback tied to 5V tap and output tied to output sense (V_{OUT} = 5V) and $V_{SHUTDOWN} \le 0.8V$.
3. Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation.
4. Line regulation for the SPX2954 is tested at I_L = 1mA.
5. Dropout voltage is defined as the input to output differential at which the output voltage drops 100mV below its nominal value measured at 1V differential. At very low values of programmed output voltage, the minimum input supply voltage of 2V (2.3V over temperature) must be taken into account.
6. $V_{REF} \le V_{OUT} \le (V_{IN}$ - 1V), $2.3 \le V_{IN} \le 30V$, $100\mu A \le I_L \le 250mA$, $T_J \le T_{JMAX}$.
7. Comparator thresholds are expressed in terms of a voltage differential at the feedback terminal below the nominal reference voltage measured at 6V input. To express these thresholds in terms of output voltage change, multiply by the error amplifier gain = V_{OUT}/V_{REF} = (R1 + R2)/R2. For example, at a programmed output voltage of 5V, the error output is guaranteed to go low when the output drops by 95mV x 5V/1.235 = 384mV. Thresholds remain constant as a percent of V_{OUT} as V_{OUT} is varied, with the dropout warning occurring at typically 5% below nominal, 7.5% guaranteed.
8. $V_{SHUTDOWN} \ge 2V$, $V_{IN} \le 30V$, V_{OUT} = 0, Feedback pin tied to 5V/3.3V Tap.

Pin Configurations



Front View

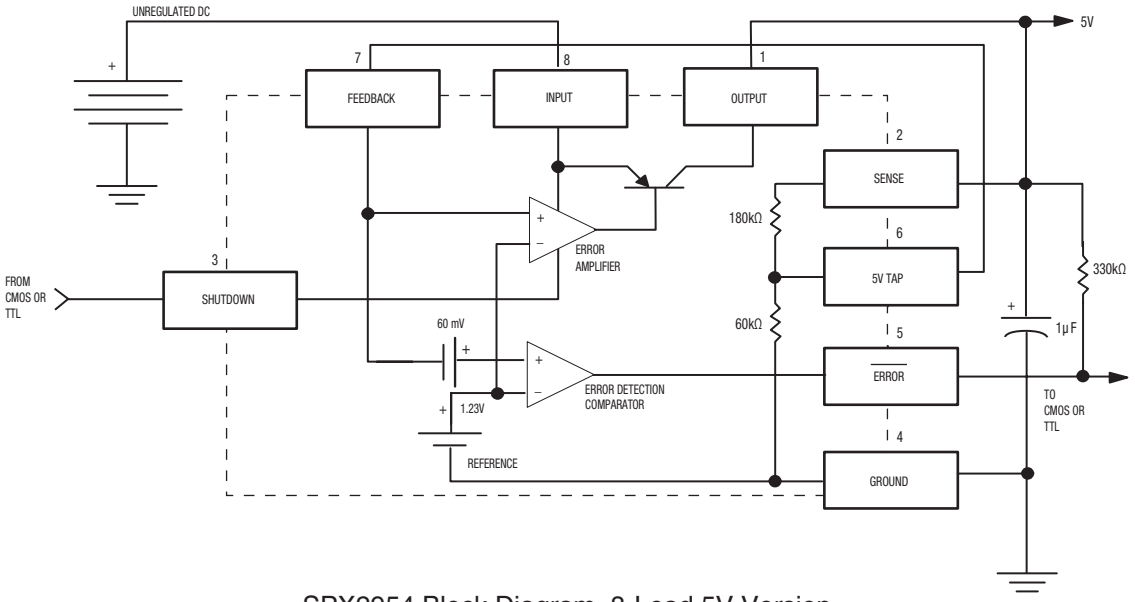
SOT-223 Package (M3)



Top View

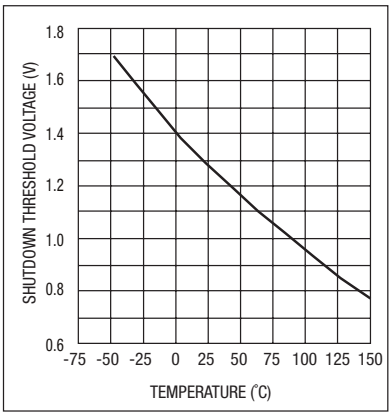
8-Pin Surface Mount (S)

Functional Block Diagram

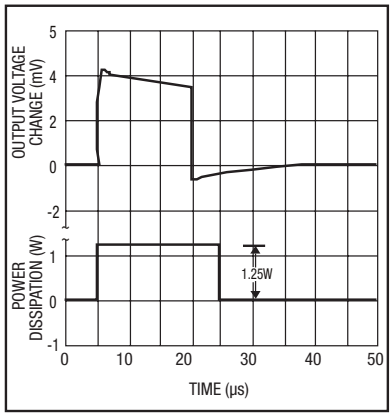


SPX2954 Block Diagram, 8-Lead 5V Version

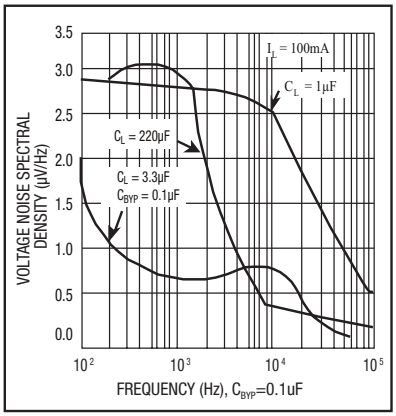
Typical Performance Characteristics



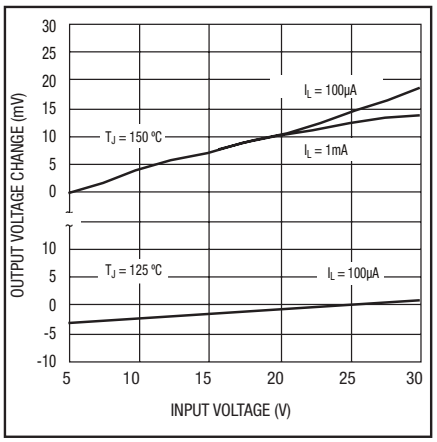
Shutdown Threshold Voltage



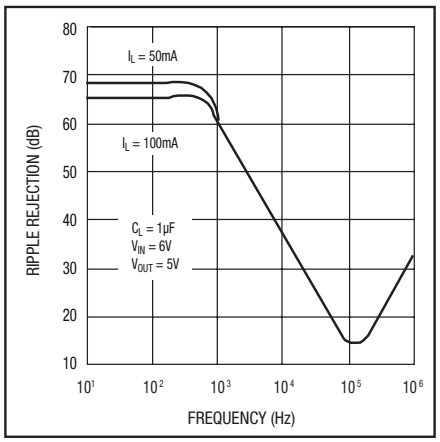
Thermal Response



Output Noise

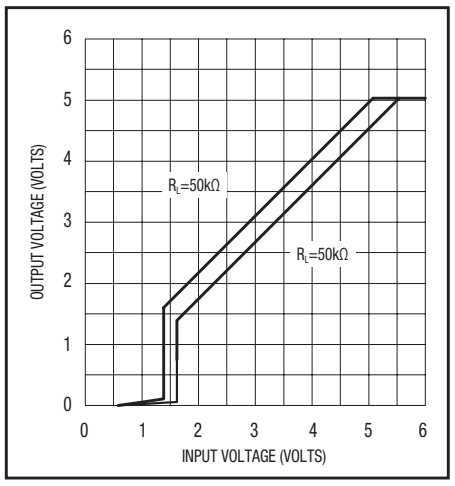


Line Regulation

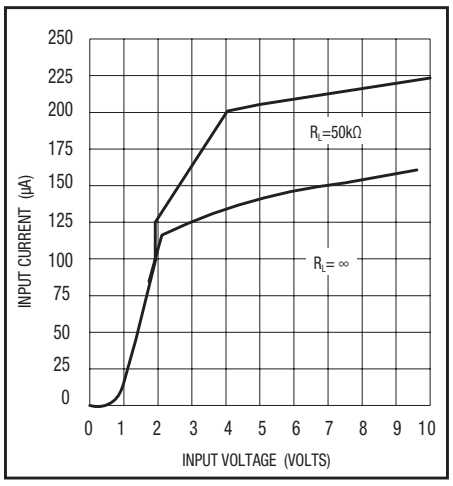


Ripple Rejection

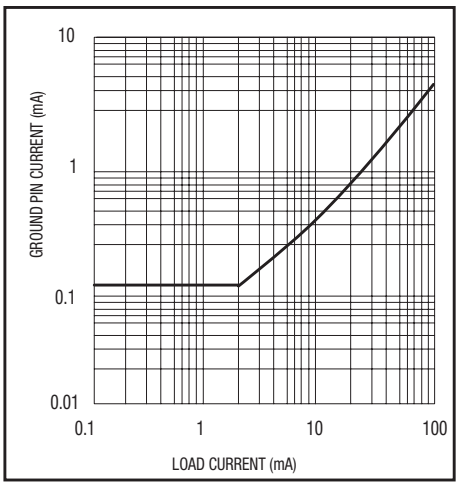
Typical Performance Characteristics (Continued)



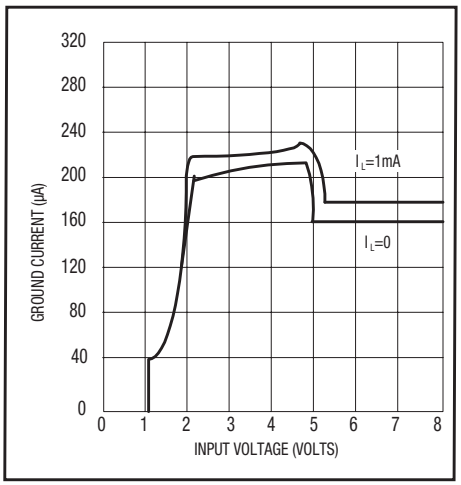
Dropout Characteristics



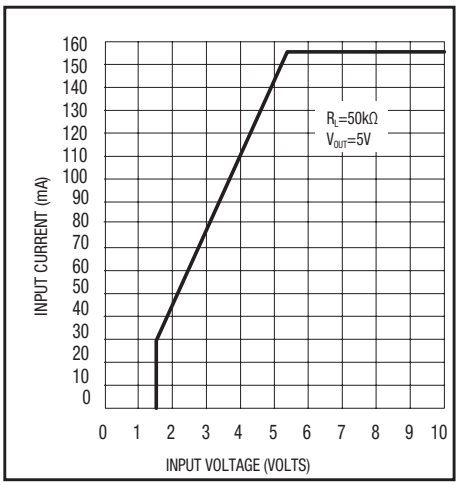
Input Current



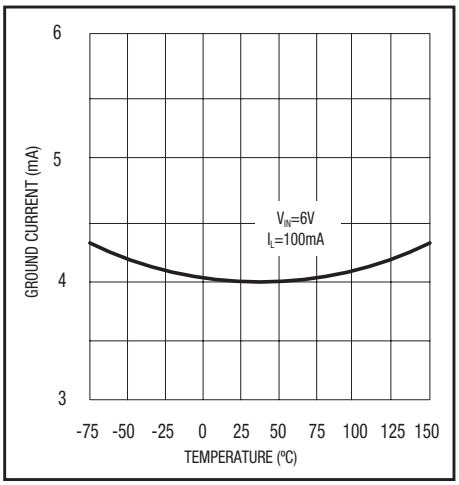
Quiescent Current



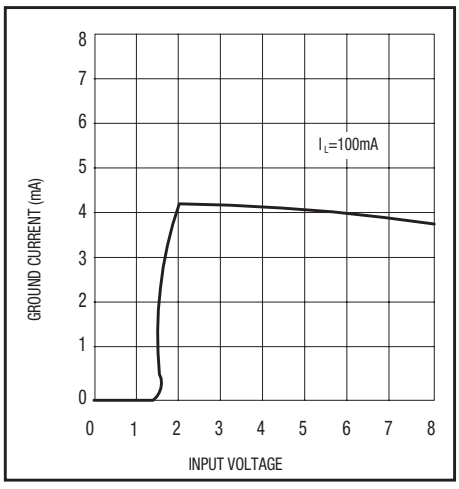
Ground Current



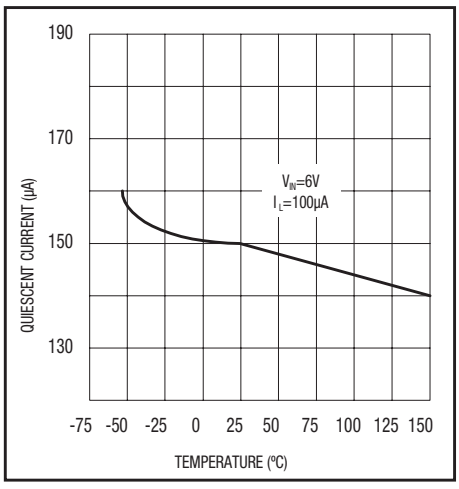
Input Current



Ground Current

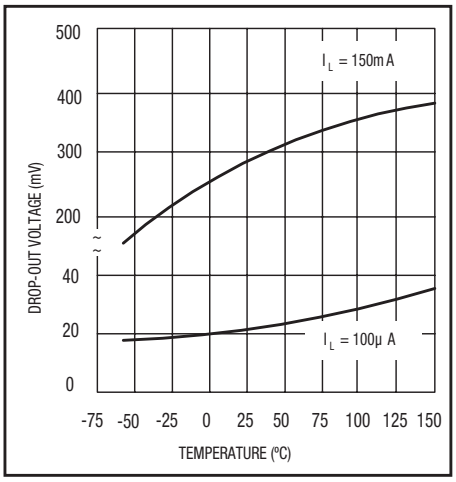


Ground Current

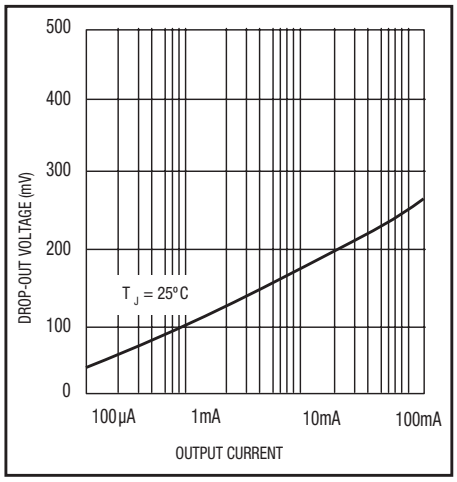


Quiescent Current

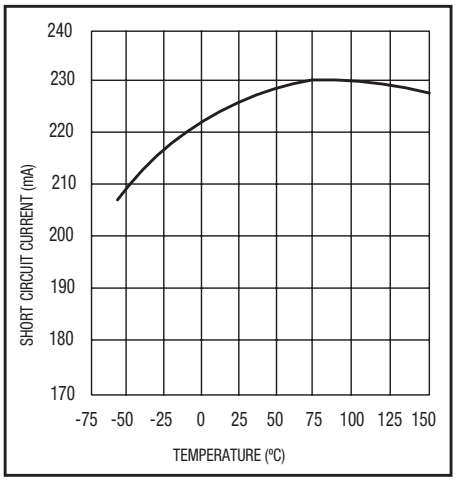
Typical Performance Characteristics (Continued)



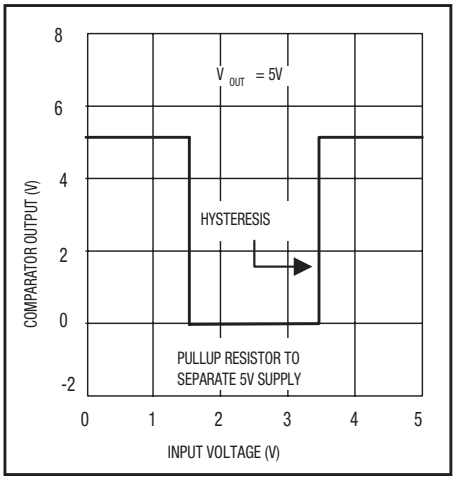
Drop-Out Voltage



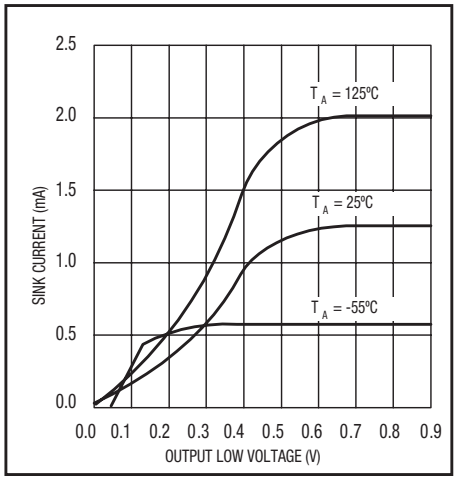
Drop-Out Voltage



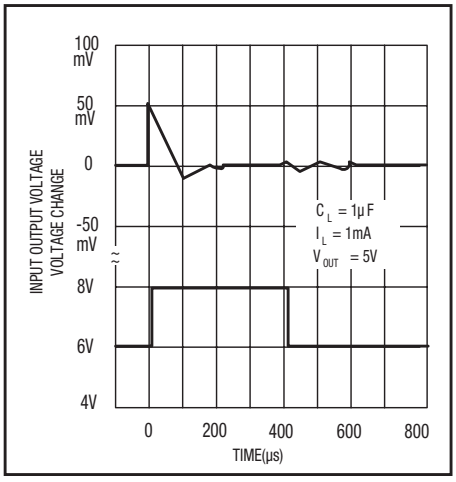
Short Circuit Current



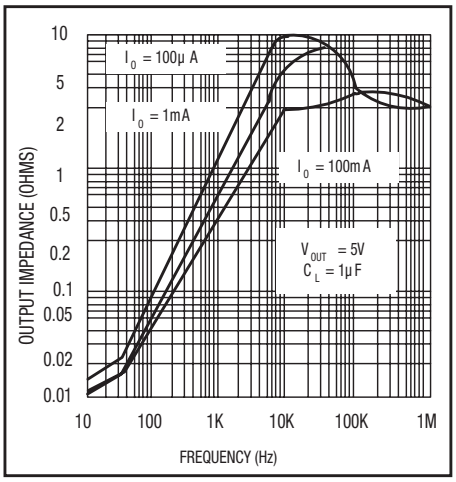
Error Comparator Output



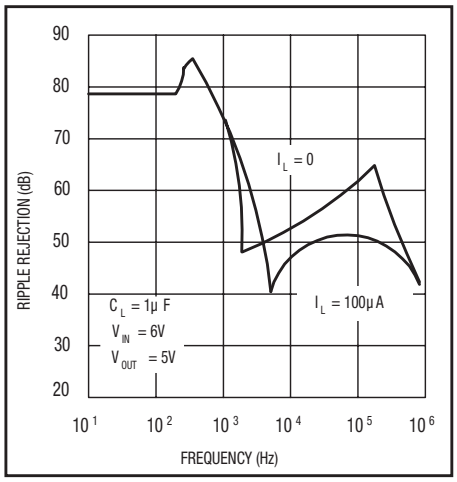
Comparator Sink Current



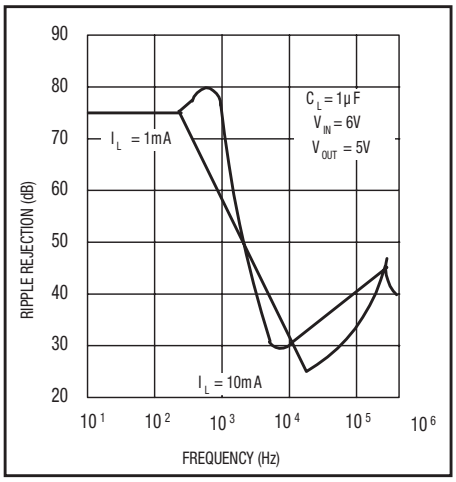
Line Transient Response



Output Impedance

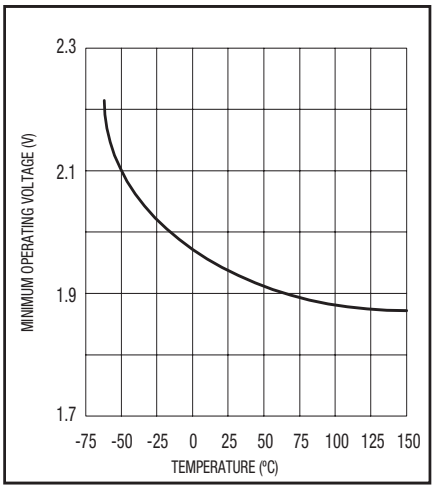


Ripple Rejection

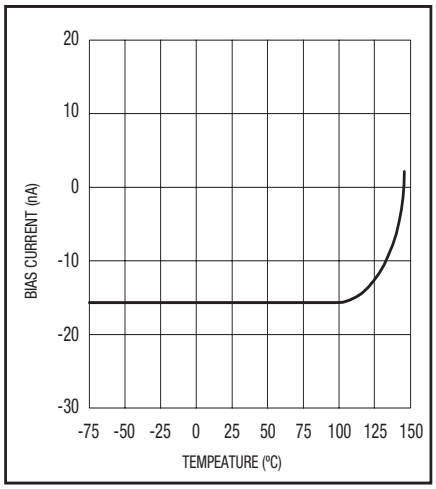


Ripple Rejection

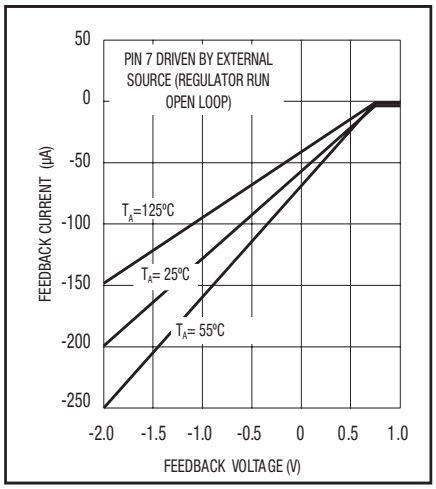
Typical Performance Characteristics (Continued)



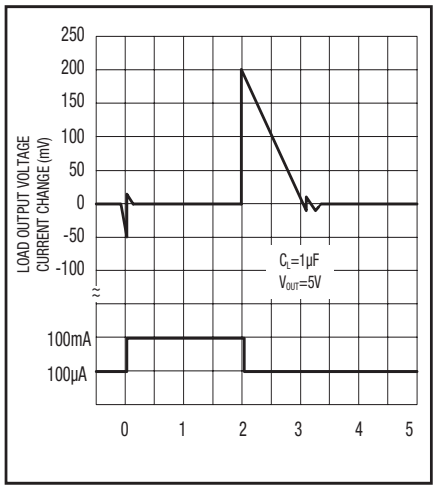
Minimum Operating Voltage



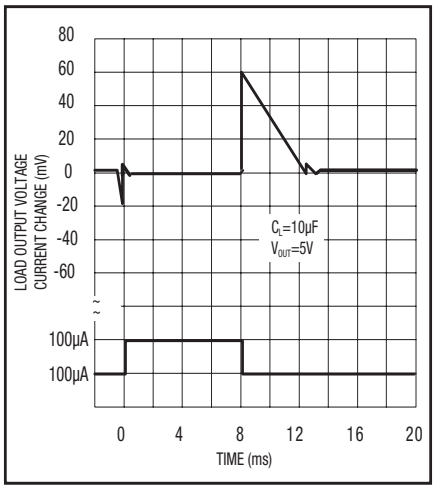
Feedback Bias Current



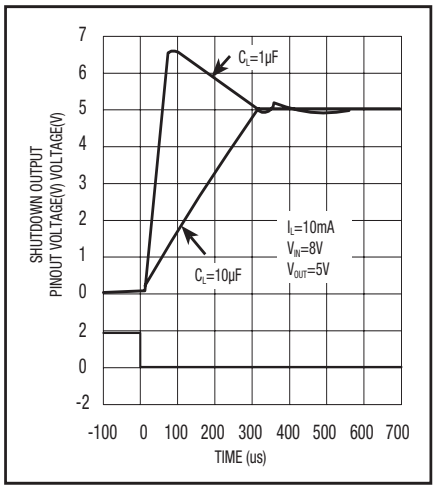
Feedback Pin Current



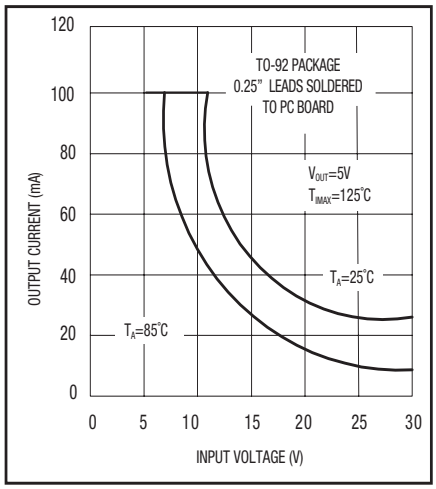
Load Transient Response



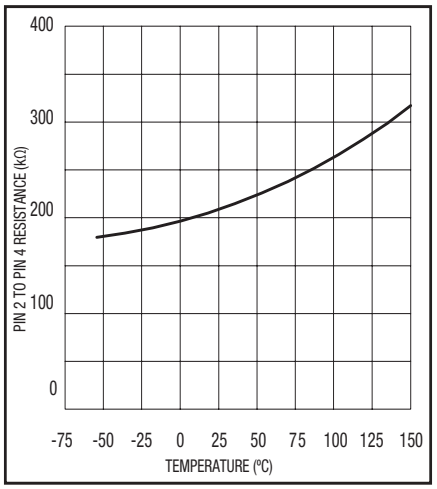
Load Transient Response



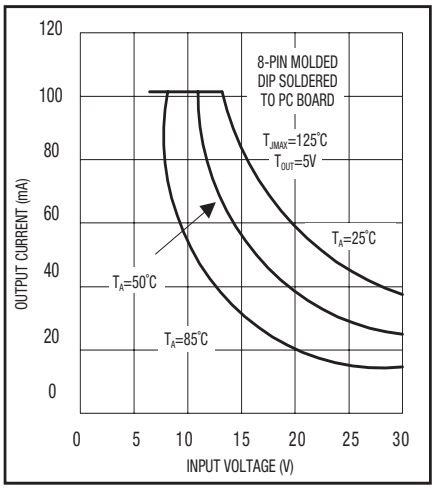
Enable Transient



Maximum Rated Output



Divider Resistance



Maximum Rated Output Current

Applications Information

External Capacitors

The stability of the SPX2954 requires a 1µF or greater capacitor between output and ground. Oscillation could occur without this capacitor. Most types of tantalum or aluminum electrolytic works fine here. For operations below -25°C solid tantalum is recommended since the many aluminum types have electrolytes that freeze at about -30°C. The ESR of about 5Ω or less and resonant frequency above 500kHz are the most important parameters in the value of the capacitor. The capacitors value may be increased without limit.

At lower values of output current, less output capacitance is required for stability. For the currents below 10mA the value of the capacitor can be reduced to 0.33µF and 0.1µF for 1mA. More output capacitance is needed for the 8-pin version at voltages below 5V since it runs the error amplifier at lower gain. At worst case 3.3µF or greater must be used for the condition of 150mA load at 1.23V output.

The SPX2954 unlike other low dropout regulators will remain stable and in regulation with no load in addition to the internal voltage divider. This feature is especially important in applications like CMOS RAM keep-alive. When setting the output voltage of the SPX2954 version with external resistors, a minimum load of 1µA is recommended.

If there is more than 10 inches of wire between the input and the AC filter capacitor or if a battery is used as the input then a 1µF tantalum or aluminum electrolytic capacitor should be placed from the input to the ground.

Instability can occur if there is stray capacitance to the SPX2954 feedback terminal (pin 7). This could cause more problems when using a higher value of external resistors to set the output voltage. This problem can be fixed by adding a 100pF capacitor between output and feedback and increasing the output capacitor to at least 3.3µF.

Error Detection Comparator Output

The comparator produces a logic low output whenever the SPX2954 output falls out of regulation by more than around 5%. This is around 60mV offset divided by the 1.235 reference voltage. This trip level remains 5% below normal regardless of the programmed output voltage of the regulator.

Figure 1 shows the timing diagram depicting the ERROR signal and the regulator output voltage as the SPX2954 input is ramped up and down. The ERROR signal becomes low at around 1.3V input, and goes high around 5V input (input voltage at which V_{OUT} = 4.75). Since the SPX2954's dropout voltage is load dependent, the input voltage trip point (around 5V) will vary with the load current. The output voltage trip point (approx. 4.75V) does not vary with load.

The error comparator has an open-collector output, which requires an external pull-up resistor. Depending on the system requirements the resistor may be returned to 5V output or other supply voltage. In determining the value of this resistor, note that the output is rated to sink 400mA, this value adds to battery drain in a low battery condition. Suggested values range from 100k to 1MΩ. If the output is unused this resistor is not required.

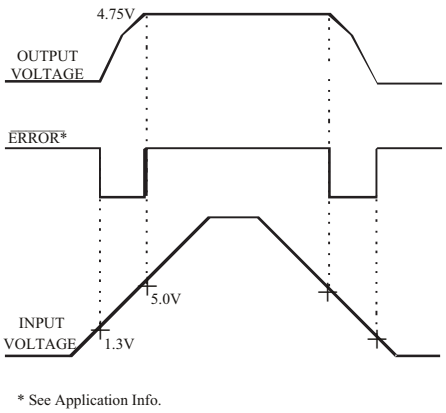


Figure 1. Error Output Timing

Programming the Output Voltage of SPX2954

The SPX2954 may be pin-strapped for 5V using its internal voltage divider by tying Pin 1 (output) to Pin 2 (sense) and Pin 7 (feedback) to Pin 6 (5V Tap). Also, it may be programmed for any output voltage between its 1.235V reference and its 30V maximum rating using an external pair of resistors. Refer to the below equation for the programming of the output voltage:

$$V_{OUT} = V_{REF} \times (1 + R_1/R_2) + I_{FB}\, R_1$$

The V_{REF} is 1.235 and I_{FB} is the feedback bias current, nominally -20nA. The minimum recommended load current of 1µA forces an upper limit of 1.2MΩ on value of R_2 . If no load is presented the I_{FB} produces an error of typically 2% in V_{OUT} which may be eliminated at room temperature by trimming R_1. To improve the accuracy choose the value of R2 = 100k this reduces the error by 0.17% and increases the resistor program current by 12µA. Since the SPX2954 typically draws 60µA at no load with Pin 2 open-circuited, this is a small price to pay.

Reducing Output Noise

It may be an advantage to reduce the AC noise present at the output. One way is to reduce the regulator bandwidth by increasing the size of the output capacitor. This is the only way that noise can be reduced on the 3 lead SPX2954 but is relatively inefficient, as increasing the capacitor from 1µF to 220µF only decreases the noise from 430µV to 160µVRMS for a 100kHz bandwidth at 5V output. Noise can be reduced fourfold by using a bypass capacitor across R_1, since it reduces the high frequency gain from 4 to unity. Pick

$$C_{BYPASS} \approx (1 / 2\pi R_1 \times 200Hz)$$

or choose 0.01µF. When doing this, the output capacitor must be increased to 3.3µF to maintain stability. These changes reduce the output noise from 430µV to 100µVRMS for a 100kHz bandwidth at 5V output. With the bypass capacitor added, noise no longer scales with output voltage so that improvements are more dramatic at higher output voltages.

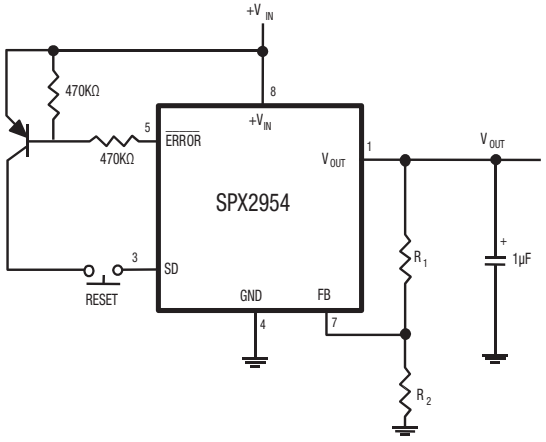


Figure 2. Latch Off when Error Flag Occurs

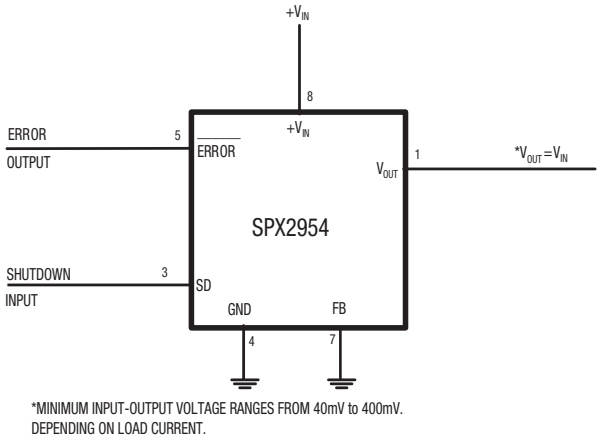


Figure 3. Wide Input Voltage Range, Current Limiter

Applications Information (continued)

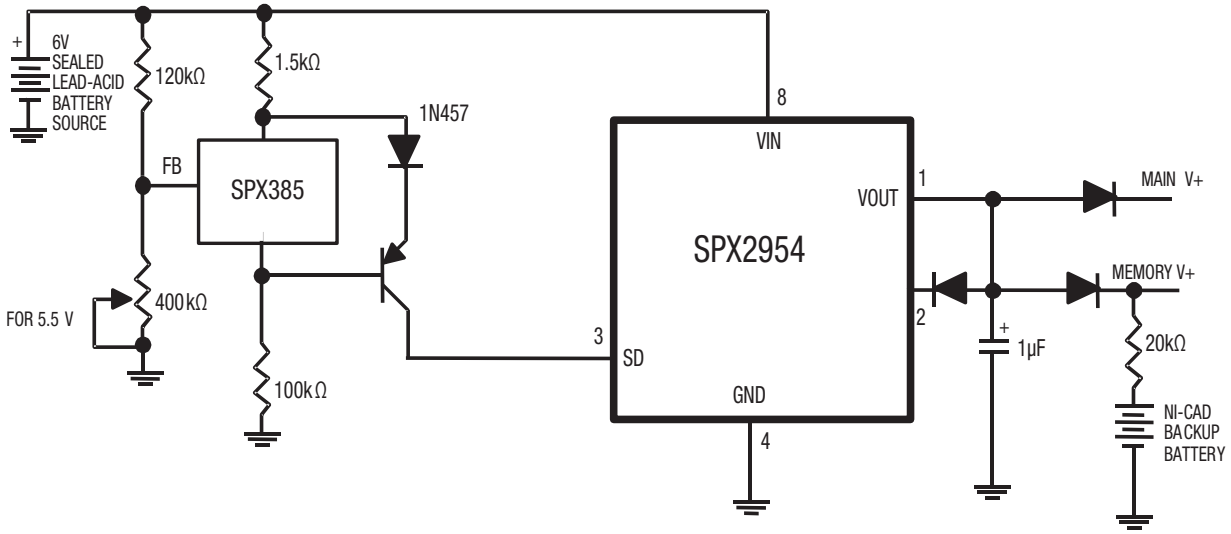


Figure 4. Low Battery Disconnect

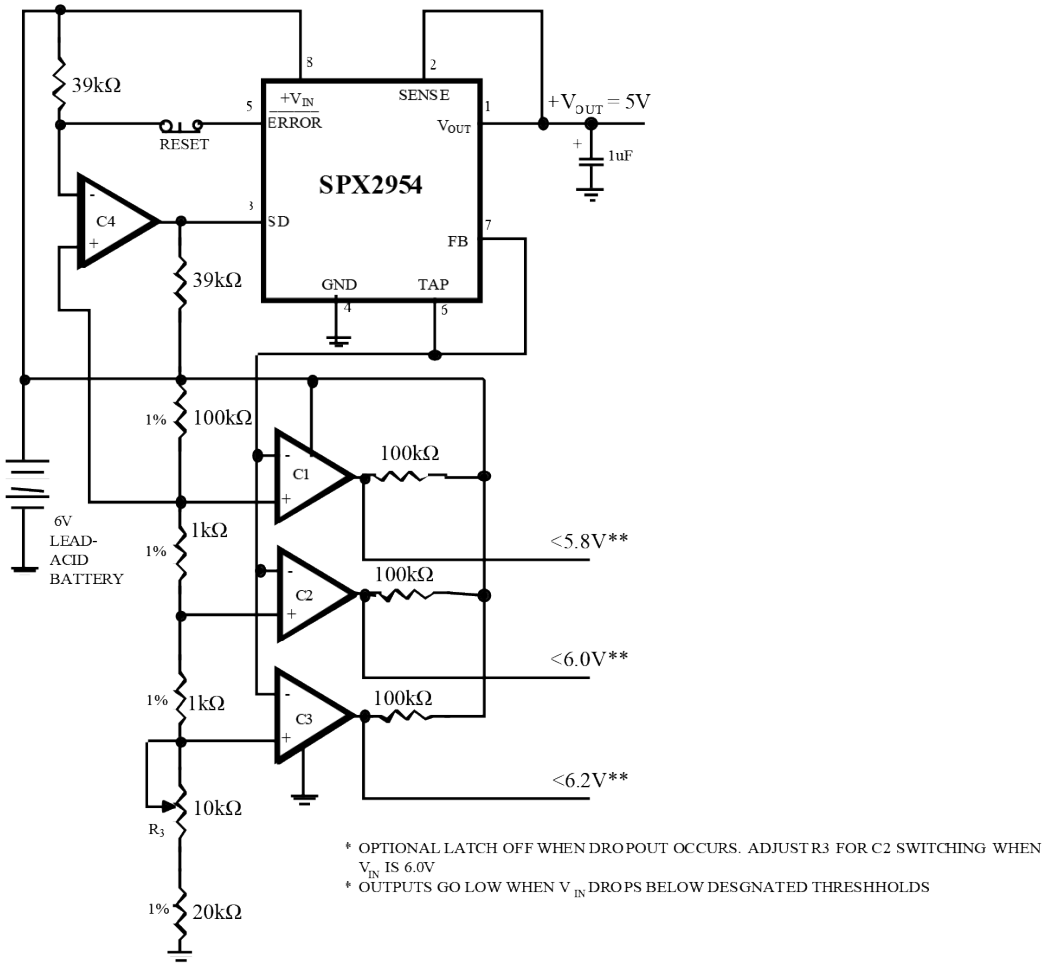


Figure 5. Regulator with State of Charge Indicator

Applications Information (continued)

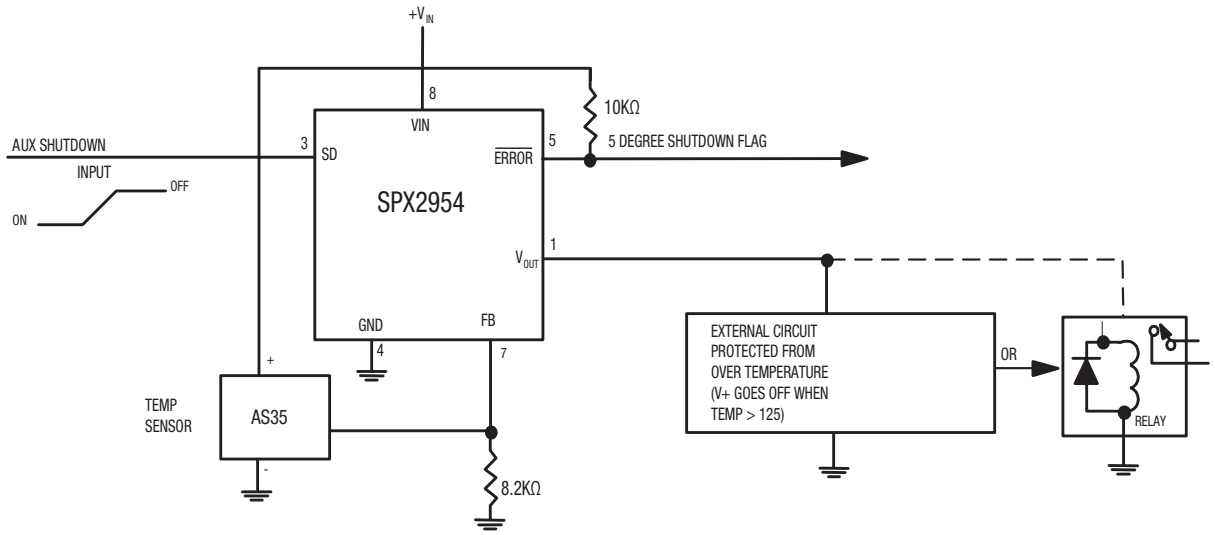


Figure 6. System Over Temperature Protection

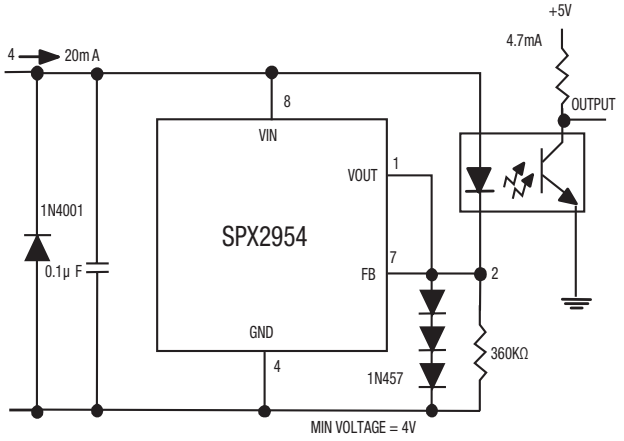


Figure 7. Open Circuit Detector for 4mA to 20mA Current Loop

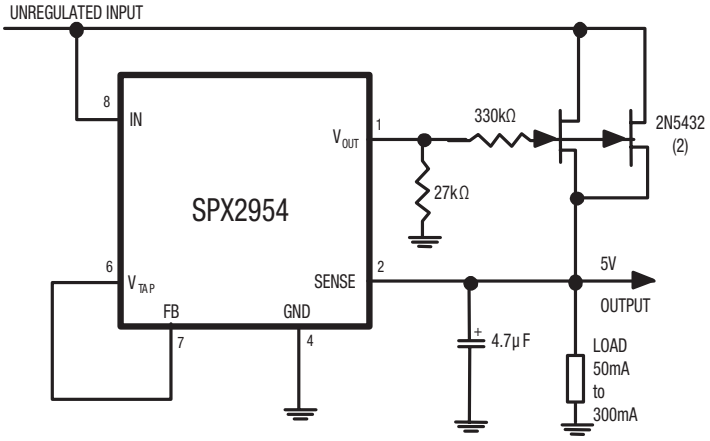
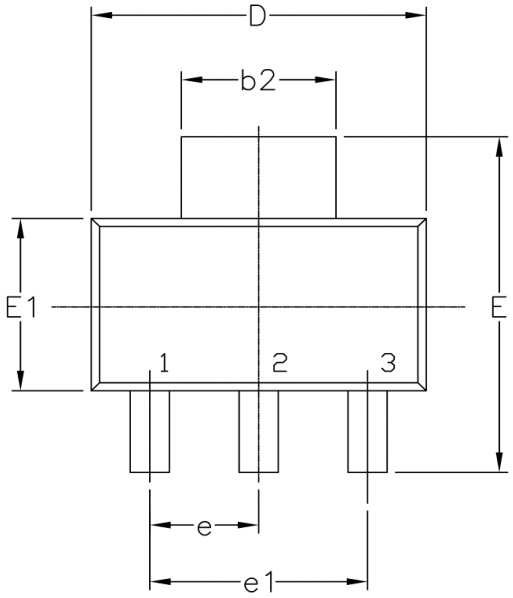


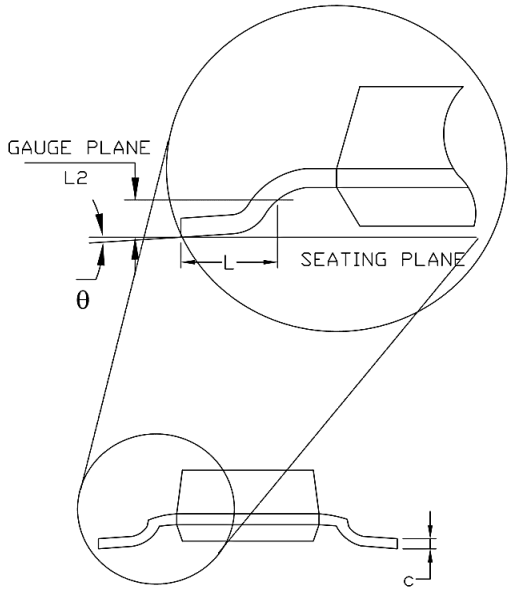
Figure 8. 300mA Regulator with 0.75V

Package Description

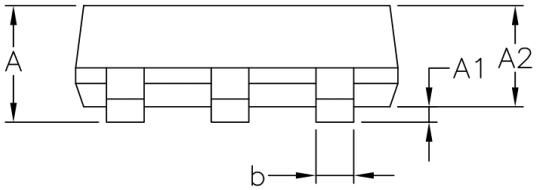
SOT-223-3



TOP VIEW



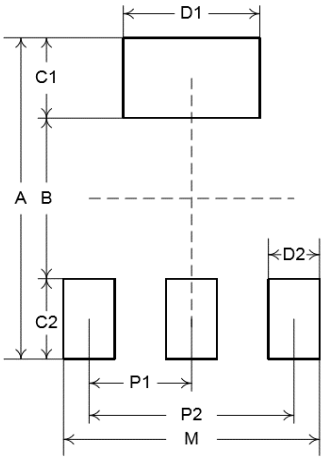
FRONT VIEW



BOTTOM VIEW

3 Pin SOT−223 JEDEC TO−261 Variation AA						
SYMBOLS	DIMENSIONS IN MM (Control Unit)			DIMENSIONS IN INCH (Reference Unit)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	—	—	1.80	—	—	0.071
A1	0.02	—	0.10	0.001	—	0.004
A2	1.50	1.60	1.70	0.060	0.063	0.067
b	0.66	0.76	0.84	0.026	0.030	0.033
b2	2.90	3.00	3.10	0.114	0.118	0.122
c	0.23	0.30	0.35	0.010	0.012	0.014
D	6.30	6.50	6.70	0.248	0.256	0.264
E	6.70	7.00	7.30	0.264	0.276	0.287
E1	3.30	3.50	3.70	0.130	0.138	0.146
e	2.30 BSC			0.091 BSC		
e1	4.60 BSC			0.182 BSC		
L	0.75	—	—	0.030	—	—
L2	0.25 BSC			0.010 BSC		
θ	0°	—	10°	0°	—	10°
N	3			3		

TERMINAL DETAILS



SYMBOLS	Footprint Dimension
A	8.0
B	4.0
C1	2.0
C2	2.0
D1	3.2
D2	1.2
M	5.8
P1	2.3
P2	4.6

TYPICAL RECOMMENDED LAND PATTERN

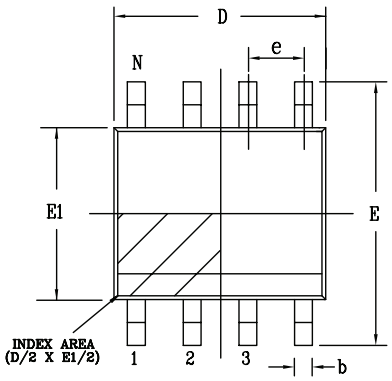
Drawing No. : POD-00000098

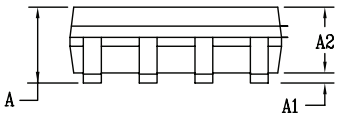
Revision: B

Package Description (Continued)

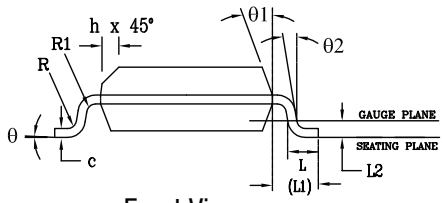
SOIC-8

Top View





Side View



Front View

PACKAGE OUTLINE NSOIC .150" BODY JEDEC MS-012 VARIATION AA						
SYMBOLS	COMMON DIMENSIONS IN MM (Control Unit)			COMMON DIMENSIONS IN INCH (Reference Unit)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.35	—	1.75	0.053	—	0.069
A1	0.10	—	0.25	0.004	—	0.010
A2	1.25	—	1.65	0.049	—	0.065
b	0.31	—	0.51	0.012	—	0.020
c	0.17	—	0.25	0.007	—	0.010
E	6.00 BSC			0.236 BSC		
E1	3.90 BSC			0.154 BSC		
e	1.27 BSC			0.050 BSC		
h	0.25	—	0.50	0.010	—	0.020
L	0.40	—	1.27	0.016	—	0.050
L1	1.04 REF			0.041 REF		
L2	0.25 BSC			0.010 BSC		
R	0.07	—	—	0.003	—	—
R1	0.07	—	—	0.003	—	—
q	0°	—	8°	0°	—	8°
q1	5°	—	15°	5°	—	15°
q2	0°	—	—	0°	—	—
D	4.90 BSC			0.193 BSC		
N	8					

Drawing No: POD-00000108

Revision: A

Ordering Information[1]

Part Number	Operating Temperature Range	Lead-Free	Package	Packaging Method	Accuracy	Output Voltage (V)
SPX2954AM3-L-5-0/TR	-40°C ≤ T_J ≤ 125°C	Yes[2]	SOT-223-3	Reel	0.5%	5.0
SPX2954M3-L-3-3/TR				Reel	1%	3.3
SPX2954M3-L-5-0/TR				Reel	1%	5.0
SPX2954M3-L-3-3[3]				Tube	1%	3.3
SPX2954AS-L-5-0/TR[3]			SOIC-8	Reel	0.5%	5.0

NOTE:
1. Refer to www.exar.com/SPX2954 for most up-to-date Ordering Information.
2. Visit www.exar.com for additional information on Environmental Rating.
3. NRND - Not Recommended for New Design.
4. TO-220, TO-92, and TO-263 package options no longer available.

Revision History

Revision	Date	Description
1A	July 2017	Updated to Maxlinear logo. Updated format and ordering information table. Pin configurations moved to page 4. Removed information related to packages no longer available.

Corporate Headquarters:
5966 La Place Court
Suite 100
Carlsbad, CA 92008
Tel.:+1 (760) 692-0711
Fax: +1 (760) 444-8598
www.maxlinear.com

High Performance Analog:
48720 Kato Road
Fremont, CA 94538
Tel.: +1 (510) 668-7000
Fax: +1 (510) 668-7001
Email: powertechsupport@exar.com
www.exar.com